Analysis and design of value production strategies and business models in the telecommunications industry

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Selbstverständlich wäre diese Arbeit ohne die uneingeschränkte Rücksichtnahme und das Verständnis meines privaten Umfeldes nicht von einem glücklichen Autor beendet worden.

Berlin, im Februar 2012 Jochen Wulf

Abstract

This cumulative dissertation contains a collection of articles, which address strategic challenges of firms in the telecommunications sector from different perspectives and with heterogeneous research methodologies.

One research focus is the analysis of the impact of sector convergence in the ICT industry on the competitive environment and value production strategies of telecommunication firms. Traditional value production strategies are more and more challenged due to an increasing competition and intensifying inter-firm interdependencies of ICT firms from the formerly relatively autonomous sectors software, hardware, telecommunications and media. It is shown in this dissertation, that sector convergence has an influence on diversification performance of ICT firms. The role of software development and application operation in the value creation of ICT firms is further analyzed. The results show a strong importance of software based applications for telecommunication firms. An in-depth assessment of cross-sector competition in telecommunications demonstrates a strong mutual competition of media and telecommunication firms. In order to support the realization of the business potential, which results from sector convergence, a methodology for a demand-oriented identification of modular wholesale services is designed.

A second research focus addresses the technological and economic approaches to and challenges of IP service distribution. In addition to the distribution of services over centralized Internet servers, there are alternative distribution approaches, which use dedicated transport capacities or distributed server infrastructures. An exploratory analysis shows that business models for service distribution differ significantly from each other. They, however, address similar consumer requirements with regard to distribution quality and costs. An in-depth evaluation of the value propositions of distribution technologies shows that their suitability dominantly depends on different characteristics of service production and consumption. The introduction of a quality differentiation on the data transport level across a single operator's network boundaries (inter-provider Quality-of-Service) requires a novel interconnection regime. Such a new regime, in contrast to the present interconnection regime in the Internet, must set incentives for a compliance to quality assurances and support a differentiated pricing. The simulation based assessment of a market scenario for the introduction of inter-provider Quality-of-Service describes the impact of regime design on the competitive position of access and transit service providers in the interconnection market.

This dissertation is written in English, because the majority of articles included were submitted in English. The dissertation incorporates just one German article, which has not been translated.

Kurzbeschreibung

Unter dem Titel *Analyse und Entwicklung von Wertschöpfungsstrategien und Geschäftsmodellen in der Telekommunikationsindustrie* vereinigt diese kumulative Dissertation eine Sammlung von Aufsätzen, die sich mit wettbewerbsstrategischen Herausforderungen von Telekommunikationsunternehmen aus unterschiedlichen Blickwinkeln und unter Zuhilfenahme verschiedenartiger Forschungsmethoden beschäftigen.

Ein Forschungsschwerpunkt ist dabei die Analyse der Auswirkungen der Sektorenkonvergenz in der IKT-Industrie auf das Geschäftsumfeld und Wertschöpfungsstrategien von Telekommunikationsunternehmen. Aufgrund des zunehmenden Wettbewerbs und sich intensivierender zwischenbetrieblicher Abhängigkeiten von IKT-Unternehmen, die den vormals verhältnismäßig autonomen Sektoren Software, Hardware, Telekommunikation und Medien angehören, werden traditionelle Wertschöpfungsstrategien zunehmend hinterfragt. Im Rahmen dieser Arbeit wird gezeigt, dass sich Sektorenkonvergenz auf den Erfolg von Diversifikationsstrategien von IKT-Unternehmen auswirkt. Darüber hinaus wird betrachtet, welche Rolle die Entwicklung und der Betrieb von Softwareanwendungen in der Wertschöpfung von IKT-Unternehmen einnehmen. Die Analysen decken insbesondere die hohe Bedeutung des Marktes softwarebasierter Anwendungen für Telekommunikationsunternehmen auf. Eine eingehende Untersuchung des sektorenübergreifenden Wettbewerbs in der Telekommunikation lässt darüber hinaus auf einen starken gegenseitigen Wettbewerb von Medien- und Telekommunikationsunternehmen schließen. Um die Erschließung neuer Geschäftspotenziale zu unterstützen, welche sich aus der Sektorenkonvergenz für Telekommunikationsunternehmen ergeben, wird in dieser Arbeit eine Methode entwickelt, modulare Wholesale-Dienste nachfrageorientiert zu identifizieren.

Ein zweites Forschungsfeld adressiert die technologischen und ökonomischen Ansätze und Herausforderungen bei der Distribution von IP-Diensten. Neben der traditionellen Internet-basierten Distribution von Diensten über zentralisierte Server bestehen alternative Distributionsansätze, die auf dedizierte Transportkapazitäten oder verteilte Serverinfrastrukturen zurückgreifen. Eine explorative Untersuchung unterschiedlicher Geschäftsmodelle zur Distribution lässt erkennen, dass sie sich zwar signifikant unterscheiden, jedoch ähnliche Kundenbedürfnisse im Bezug auf Qualität und Kosten der Distribution adressieren. Eine tiefgehende Analyse des Wert-Angebots unterschiedlicher Distributionstechnologien zeigt, dass ihre dienstspezifische Eignung maßgeblich von verschiedenen Eigenschaften der Diensteproduktion und –konsumption abhängig ist. Die Einführung einer Qualitätsdifferenzierung auf Datentransportebene über die Netzgrenzen verschiedener Betreiber hinweg (Inter-Provider Quality-of-Service) erfordert die Etablierung eines neuartigen Zusammenschaltungsregimes. Im Gegensatz zum Zusammenschaltungsregime des gegenwärtigen Internets muss ein solches Regime Anreize zur Einhaltung der Qualitätszusagen setzen und eine qualitätsdifferenzierte Abrechnung unterstützen. Die simulationsbasierte Untersuchung eines Marktszenarios zur Einführung von Inter-Provider Quality-of-Service beschreibt die Auswirkung der Regimegestaltung auf die Wettbewerbsposition von Zugangsdienste- und Transitdiensteanbietern im Zusammenschaltungsmarkt.

Diese Arbeit ist in englischer Sprache verfasst, da es sich bei den einbezogenen Artikeln vorwiegend um englischsprachige Artikel handelt. Es wurde lediglich ein deutscher Artikel verwendet, hier wurde von einer Übersetzung abgesehen.

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Index of Abbreviations

ACE	Agent-based Computational Economics
ARPU	Average Revenues per User
BAK	Bill and Keep
BE	Best Effort
CDN	Content Delivery Network
CRM	Customer Relationship Management
DiffServ	Differentiated Services
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DTAG	Deutsche Telekom AG
GSM	Global System for Mobile Communication
ICSS	International Carrier Sales & Solutions
ICT	Information and Communication Technologies
IKM	Chair of Information and Communication Management
IntServ	Integrated Services
IP	Internet Protocol
IPTV	Internet Protocol Television
ISDN	Integrated Service Digital Network
ISP	Internet Service Provider
LAN	Local Area Network
M2M	Machine to Machine
MAN	Metropolitan Area Network
MDF	Main Distribution Frame
NGN	Next Generation Network
NSP	Network Service Provider

OSI	Open Systems Interconnection
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Service
RPP	Receiving Party Pays
RSVP	Resource Reservation Protocol
SDP	Service Delivery Platform
SIC	Standard Industrial Classification
SIM	Subscriber Identity Module
SPP	Sending Party Pays
TC	Telecommunication
TCC	Telecommunication Company
TCP	Transmission Control Protocol
TV	Television
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network

1. Introduction

1.1. Initial situation

In recent years, the Information and Communication Technology (ICT) industry is characterized by an increasing degree of competition and cooperation of firms from the telecommunication, the information technology and the media sectors [Zerdick et al. 2000, 130-135]. This trend is referred to as convergence [Stieglitz 2003b, 25-32]. Dynamics in the ICT industry can be perceived on the technology as well as on the product level. On the technology level, technology innovations have an impact on formerly unrelated sectors. As a result, ICT firms from different sectors jointly rely on the same resources or integrate their resources in order to create and address new markets. This process is referred to as technology convergence. As an example, smartphones have been developed by integrating technologies from the consumer electronics, the computer hardware, the telecommunication, and the software sectors. In contrast to traditional phones, smartphones have stronger computing capabilities and better connectivity. They combine functionalities of portable media players, cameras, touchscreen phones, GPS navigators, and gaming equipment in one device. Providers from different ICT sectors cooperate in order to exploit this new market. For example, in the Open Handset Alliance, mobile operators, software companies, semiconductor companies and handset manufacturers jointly develop open standards for smartphones [OHA 2011]. On the product level, innovations lead to substitutive or complementary relationships of products from formerly unrelated markets. As an example, the Internet increasingly evolves into a new distribution channel for TV services. At the same time, cable TV networks have been updated and allow the realization of Internet access services. As a consequence, fixed and cable TV network operators increasingly address identical markets.

The market for traditional telecommunication services, in the last few years, is subject to a commoditization [OECD 2011; Rotert et al. 2009]. The main drivers of this evolution include a constant decrease of revenues, stagnating average revenues per user (ARPU), the entry of alternative service providers and an increased platform competition. The market for telecommunication services has in the last six years been suffering a constant decrease of revenues. In contrast, adjacent ICT sectors such as the Software and IT-services sector have mostly experienced an opposing evolution. This trend is depicted in Figure 1-1. Some Internet services such as online advertising services are even subject to a strong market growth [BITKOM 2010a].

Traditional telecommunication services are to a large part subject to a stagnation or decrease of ARPUs. As an example, providers of mobile voice and data services suffered a drop in ARPUs per SIM-card of up to 23.5% between 2007 and 2010. Table 1-1 provides an overview of the average revenues per SIM card generated by the four largest German mobile network operators.

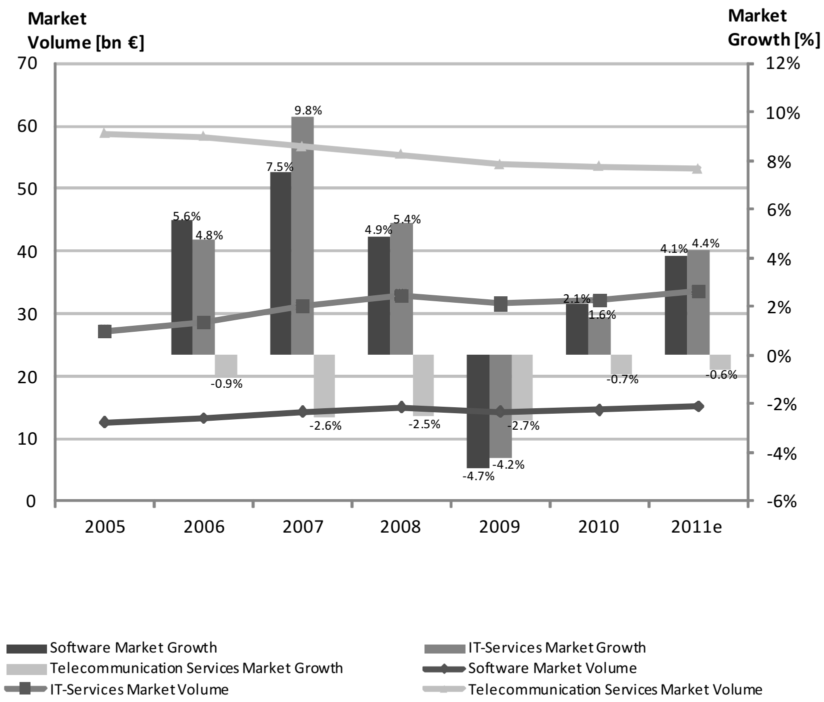

Figure 1-1: German ICT market – market volume and growth [BITKOM 2008; BITKOM 2010b]

Mobile Network Operator	Monthly ARPU per SIM-card in Euro			
	Q4/2007	Q4/2008	Q4/2009	Q1/2010
Deutsche Telekom	17.0	15.0	15.0	15.0
Vodafone	17.9	16.2	15.8	15.7
E-Plus	16.6	14.5	13.3	12.7
Telefónica o2	19.4	16.9	15.3	14.8

Table 1-1: Average monthly revenues per SIM card of German mobile network operators [Gerpott 2010]

In addition to decreasing revenues and ARPUs, markets for traditional telecommunication services such as fixed-line voice services are characterized by an increasing competitive pressure [BNetzA 2009]. The entry of an increasing number of alternative service providers leads to a greater variety of offerings in markets, which have traditionally been dominated by incumbent network operators such as the Deutsche Telekom in Germany. Exemplarily this trend can be demonstrated for the market for telephone mainlines. Figure 1-2 describes the evolution of the German market between 2004 and 2010. In this period of time, alternative service providers increased their market share from 7.8% (2m lines) to an estimated 35.2% (13.6m lines) [BNetzA 2011, 73; BNetzA 2007, 10].

Platform competition, in addition to increased competitive pressure due to market entry, in some cases further intensifies competition. In the fixed-line voice market, for example, the variety of technologies applied strongly increased between 2004 and 2010 (see Figure 1-2). Whereas in 2004, Integrated Services Digital Network (ISDN) and analogous services were predominantly offered, VoIP over unbundled DSL and over cable TV networks gained significant market shares in 2010.

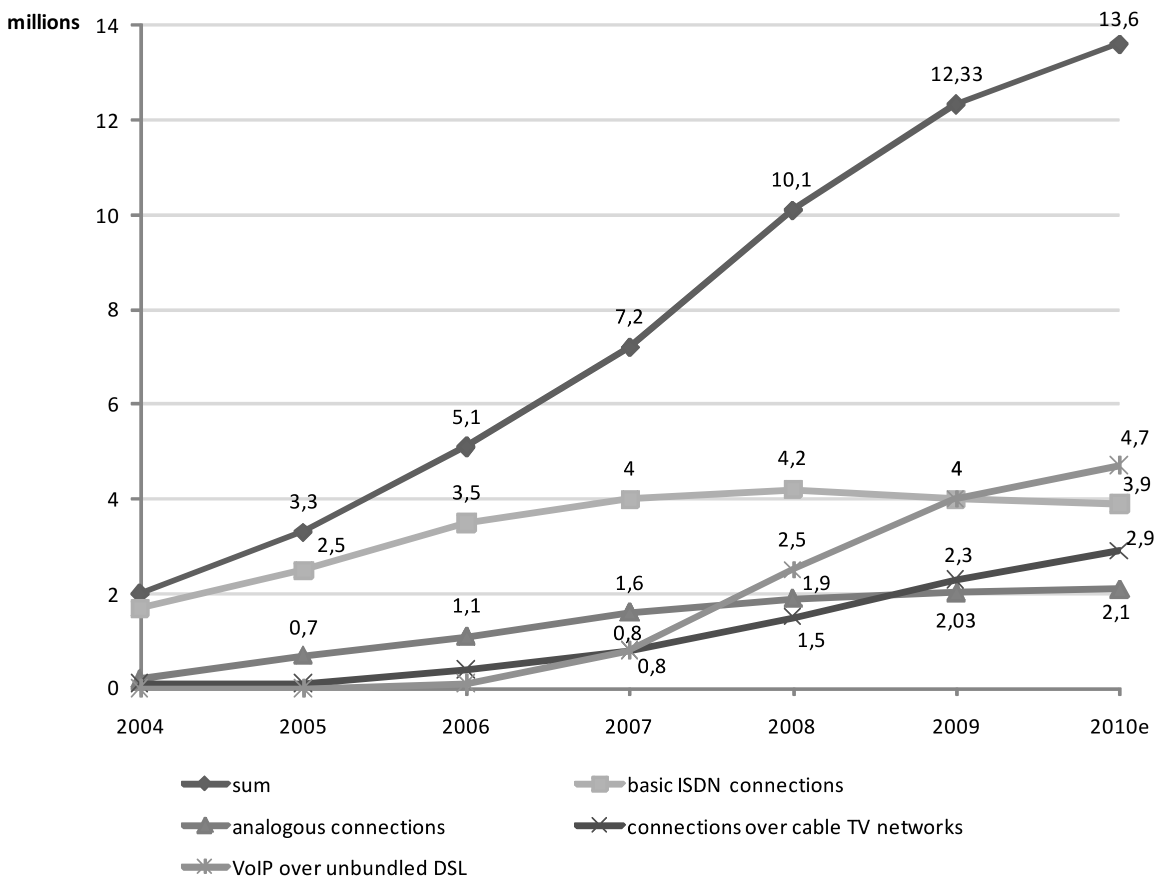

Figure 1-2: Volume of German market for telephone mainlines of alternative network operators [BNetzA 2011, 73]

As a reaction to competitive pressures, stagnating ARPUs and low market growth, telecommunication service providers are considering various strategic measures [Picot et al. 2008; Gerpott 1998, 208-231]: geographical diversification, concentric or vertical diversification into markets with a high market growth, and an adaption of business and revenue models in the core markets.

A central objective for geographical diversification is to exploit the growth potential of unsaturated markets [Jakopin 2006]. Whereas for telecommunication services such as mobile voice services, the German market is already saturated [BNetzA 2011, 86], markets in other geographical regions are in earlier diffusion phases. As an example, the European mobile network operator Vodafone in 2005 was active in 27 countries [Ahlert et al. 2007, 50-54]. Among those were countries in Africa, Eastern Europe, Asia and the Middle East, whose markets had high annual growth rates of up to 59% [Ahlert et al. 2007, 38].

In contrast to the market for telecommunication services, other ICT market segments exhibit a more positive growth (see Figure 1-1). Concentric and vertical diversification strategies of telecommunication service providers aim at leveraging internal production and/or marketing resources for a successful entry into adjacent ICT market segments with high growth prospects [Meffert 2000, 245-246; Ansoff 1966, 152]. As an example, many telecommunication network operators are providing so called quadruple play offerings [Hofbauer 2008], which in addition to voice and Internet access services include IPTV and video on demand services. Telecommunication network operators view IPTV services as an attractive field of business, because IPTV services are predicted to gain significant market shares in the TV market [PwC 2008, 21].

Through the adaption of business and revenue models in core markets telecommunication service providers try to simultaneously enable cost and differentiation advantages [Gerpott 1998, 209]. In the course of such strategies, firms focus on their core markets and disinvest from market segments without growth perspectives. With regard to the value chain for telecommunication services (see Section 2.3.2) firms potentially have manifold positioning options. Picot et al. [2008] identify a general trend towards specialization for vertically integrated telecommunication service providers. As a result, there is an increasing focus either on efficient network operation or on service innovations and marketing. As an example, Orange Austria outsources the operation of its entire multi-vendor mobile network to the network equipment provider Alcatel Lucent [2010].

1.2. Research objectives

As a consequence of the developments in the telecommunications sector described in the prior section, telecommunication companies are confronted with two major challenges regarding the design of value creation strategies: Firstly, telecommunication companies are required to adjust diversification strategies to the ongoing convergence in the ICT industry. Secondly, business models around network transport, which is the core business of network operators, need to be adapted to the technological and economic evolution in service distribution. The conducted research addresses these two challenges and is therefore grouped into two fields.

One field is dedicated to the analysis of value production strategies in the ICT industry (see Section 1.2.1). Due to the increasing degree of competitiveness and interdependencies of firms from the sectors software, hardware, telecommunications, and media, which in the past were relatively independent, traditional value production strategies are challenged [Fransman 2002; Li/ Whalley 2002; Peppard/Rylander 2006; Zerdick et al. 2000, 130-135]. The objective of the research in this field is to analyze how firms react to convergence in the ICT industry and to evaluate resulting business prospects for telecommunication companies.

Field of research	Research question	Section	Associated publication
ICT industry convergence and value production strategies of telecommunication companies	How does industry convergence affect diversification performance in the ICT industry?	3.1	[Wulf/Zarnekow 2011a]
	How is software specific value creation interrelated with other value creation segments in the ICT industry?	3.2	[Wulf/Zarnekow 2010a]
	How does cross-sector competition affect competitive strategies of telecommunication companies?	3.3	[Wulf/Zarnekow 2011b]
	How are demand oriented wholesale services designed in order to exploit new business opportunities in the telecommunications market related with ICT industry convergence?	3.4	[Wulf et al. 2009a]
ICT service distribution	Which business models for IP distribution are distinguishable and how do their characteristics differ?	4.1	[Wulf 2011]
	Which are the distinctive value propositions of different technologies supporting the distribution of ICT services?	4.2	[Wulf/Zarnekow 2010b]
	How does competitive behavior affect a network operator’s performance in a QoS interconnection market with a Sending-Party-Pays regime?	4.3	[Wulf et al. 2011a]

Table 1-2: Overview of research questions

The second field of research addresses technological and economic approaches as well as prospects for service distribution (see Section 1.2.2). Apart from the traditional distribution of content from a central server, there are different technologies and business models used [Faratin 2007; Leighton 2009; Saroiu et al. 2002]. Examples include Content Delivery Networks, P2P Distribution and the use of dedicated capacities. Furthermore, IP networks increasingly have the capability for a differentiated handling of traffic using Quality-of-Service (QoS) technologies [Gozdecki et al. 2003; Zarnekow et al. 2007; Zhao et al. 2000]. The research in this field aims at exploring the distinct value propositions and business models for service distribution and assessing prospects for network operators. Table 1-2 provides an overview of the individual research questions, which are further motivated in the following subsections.

1.2.1. Value production strategies of telecommunication companies

The higher degree of competitiveness and firm interdependency driven by convergence in the ICT industry increases the complexity of strategic decision-making for telecommunication companies. The strategic placement in ICT firm networks for a joint service provisioning, standards setting, and resource development [Gulati et al. 2000] determines the competitive position of telecommunication companies. With regard to industry convergence, researchers discuss two contrasting strategies with different objectives: diversification and concentration [Katz 1996; Gambardella/Torrisi 1998; Pennings/Puranam 2001]. Whereas diversification under convergence potentially allows the realization of synergies [Gambardella/Torrisi 1998], concentration is associated with high resource efficiency [Katz 1996]. State-of-the-art quantitative research on ICT convergence focuses mainly on empirically identifying the phenomenon of convergence per se. It scarcely addresses convergence related firm strategies and objectives. To fill this gap, this research aims at identifying and distinguishing strategies of ICT firms which are exposed to industry convergence. More precisely, the research is dedicated to assessing the objectives of diversification strategies under convergence as well as the interrelationship of convergence, firm diversification and firm performance. The following research question is posed:

How does industry convergence affect diversification performance in the ICT industry?

Software specific value creation activities such as application development and operation play an important role in the telecommunication sector as well as in other adjacent ICT sectors. For hardware equipment vendors, software often represents a complementary product, which is required in order to provide consumer value [Cottrell/Koput 1998]. For telecommunication services, software applications become increasingly important due to convergence effects

[Messerschmitt 1996]. In the media sector software based systems are used for personalization, content distribution and differentiated pricing [Schumann/Hess 2006, 49-79]. As a consequence firms from these sectors increasingly develop, operate and offer software applications [Helander 2004, 23 and 67]. Many academic publications describe changes in value creation with qualitative methodologies [Basole 2009; Fransman 2002; Li/Whalley 2002; Peppard/Rylander 2006; Zerdick et al. 2000, 130-135]. In contrast quantitative approaches for the analysis of value creation structures in the ICT industry are rather scarce. In order to address this gap this research has an objective to quantitatively evaluate the interrelationship between software specific value creation and the telecommunication segment as well as other value creation segments in the ICT industry. Part of the research is therefore directed towards the following research question:

> How is software specific value creation interrelated with other value creation segments in the ICT industry?

The commercial environment of telecommunications companies is affected considerably by cross-sector competitive and cooperative relationships in the formerly mostly independent software, hardware, media and telecommunications sectors. These convergence phenomena [Stieglitz 2003; Katz 1996] continue to represent a major strategic challenge for telecommunications companies. The result of this convergence is a greater degree of interaction between the companies of the relevant sectors with regard to the adding of value [Zerdick et al. 2000, 130-135]. The diversification activities of a company determine the sectors in which it is competitively active and also indicate whether competitive advantages can be generated by integrating different product-specific value-creating processes [Ansoff 1966, 149-135; Porter 1985, 317-363]. Articles published on cross-sector competition in the information and communications technology sectors (ICT sectors) predominantly use qualitative and argument-based deductive methodologies to demonstrate the consequences of increasing integration in the value creation activities of ICT companies and to determine the strategic implications for telecommunication companies. It is a goal of this research to test the available qualitative descriptions of cross-sector competition in the telecommunications sector by means of quantitative examinations. Hence, a focal research question is as follows:

> How does cross-sector competition affect competitive strategies of telecommunication companies?

In the market for telecommunication services, current wholesale service portfolios often have a strong focus on network services that provide basic data transport functionalities [DTAG 2007]. The evolution of telecommunication networks is driven by a trend towards all-IP networks and network access integration [Fransman 2007]. Modern multi-layered network architectures separate applications from network technology. As a consequence, end customer services are decoupled from network services. A service delivery platform offers standardized interfaces to services, manages service usage and facilitates the *bottom-up* development of end customer services [Pavlovski 2007]. Such environments create new service opportunities for wholesalers by enabling the design of higher-value wholesale service portfolios with a strong end customer focus, which go far beyond the offering of traditional network services. New business opportunities for telecom wholesale service providers, which are enabled by these developments, are often subsumed under the label *Enabling Services* [Steingröver/Richter 2008]. However, up to this date neither a common understanding of Enabling Services nor a thorough analysis of the business potentials associated with Enabling Services has been achieved. This research aims to fill this gap by providing a precise definition of Enabling Services and introducing a value-based model for the segmentation of Enabling Services. New wholesale services are up to this date mainly discussed in the context of all-IP Next Generation Network (NGN) [Knightson et al. 2005] architectures, where services are identified based upon technological feasibility rather than end customer demand. This research has an objective to combine the technological with a customer oriented view. In order to allow a more comprehensive, market-driven identification of potential future wholesale services, the following research question is posed:

How are demand oriented wholesale services designed in order to exploit new business opportunities in the telecommunication market related with ICT industry convergence?

1.2.2. ICT service distribution

Internet Protocol (IP) [Postel 1981] based distribution refers to the delivery of information goods and services over IP networks such as the Internet or dedicated IP networks. Distribution management for tangible goods encompasses all activities associated with warehousing and transporting goods to customers as well as the associated information and controlling tasks. The objective is to deliver the right goods at the right time in the right amount and quality and meanwhile optimally balance the quality and the costs of the delivery service [Schulte 1995]. Even though the economics of information goods and services are fundamentally different [Shapiro/Varian 1999], the objectives for the distribution of tangible goods also hold for the distribution of information goods. Whereas traffic is routed in a best-effort class on the Internet, dedicated networks can exclusively reserve capacity for a specific service. Therefore, dedicated IP networks are not exposed to congestion and enable better distribution quality. Prior research scarcely investigates the different business models for IP based distribution. This research aims to outline their distinct characteristics and value propositions. As a consequence, the following research question is formulated:

> Which business models for IP distribution are distinguishable and how do their characteristics differ?

Despite the richness of e-business research, the economic aspects associated with technologies for electronic distribution of information services have scarcely been addressed. Several authors [Faratin 2007; Leighton 2009; Saroiu et al. 2002] distinguish various distribution methods in the Internet (e.g., centralized hosting, Content Delivery Networks, peer-to-peer file sharing systems). They describe technical implementations and find significant differences in traffic characteristics, but do not compare attributes related to distribution performance. From the perspective of an information service provider, the specific differences between the value propositions of different distribution methods remain largely unclear. Neither academic nor non-academic literature provides appropriate decision support for the choice of a distribution method and states which service requirements are met by which distribution method. An objective of this research is to compare the different technologies for IP based distribution, and to outline their distinct characteristics and their abilities to provide value in specific application contexts (value propositions). Therefore, the following research question is formulated:

> Which are the distinctive value propositions of different technologies supporting the distribution of ICT services?

Many network operators provide QoS-based IP services within the boundaries of their networks and operate IP networks with QoS in parallel to their Internet infrastructure. For instance, IPTV services can be realized with dedicated capacity in the access network. In order to guarantee end-to-end quality across network boundaries, network interconnection must support packet differentiation with multiple transport classes. The implementation of QoS across network boundaries requires the negotiation of dedicated interconnection agreements between network operators (QoS interconnection) [Briscoe/Rudkin 2005; Hwang/Weiss 2000]. A critical aspect in QoS interconnection is the design of payment regimes, which determine the direction of financial flows [Dodd et al. 2009]. Whereas interconnection in the current Internet purely bases on the Bill-and-Keep (BAK) regime, advanced charging capabilities in IP networks and the broadening scope of IP services promote the adoption of service-oriented charging approaches. In the context of QoS interconnection, several authors advocate the introduction of a Sending-(Network)-Party-Pays (SPP) regime [Briscoe/Rudkin 2005; Dodd et al. 2009; Kruse 2008]. Economics research on interconnection to date mainly focuses on the economic efficiency of interconnection from an overall market perspective [Laffont et al. 2003; Valletti and Cambini 2005]. In contrast, the consequences of the introduction of an SPP regime for network operators' strategies and performances have scarcely been examined. This research has an objective to analyze the effects of competitive strategic behavior on a network operator's performance in an interconnection market with a SPP regime. Thus, the following research question is posed:

How does competitive behaviour affect a network operator's performance in a QoS interconnection market with a Sending-Party-Pays regime?

1.3. Research methodology

This dissertation has been created in the course of the author's employment as a research assistant at the Chair of Information and Communication Management (IKM) at the Technische Universität Berlin between 2007 and 2011. An important component of the research strategy at the IKM is to integrate industry projects and academic research in order to guarantee the applicability of research results. The research conducted in the course of this dissertation was for the majority of times accompanied by projects with partners from the telecommunications industry. Research questions were often motivated by insights gained in the projects. In addition, research results often allowed derivations of practice oriented implications for the project work. Because of the close interdependency of the project and research work, the industry projects are shortly described in the following. Table 1-3 provides an overview of the industry projects, partners and objectives.

The project entitled *Enabling Services – Business Opportunities for Wholesale Service Providers in the Telecommunications Industry* was carried out between 03/2007 and 01/2008 in a cooperation with Deutsche Telekom (DTAG) International Carrier Sales & Solutions (ICSS) and the Institute of Information Management at the University of St. Gallen (HSG).

Project Title	Partners	Period	Objectives
Enabling Services – Business Opportunities for Wholesale Service Providers in the Telecommunications Industry [Brenner et al. 2008]	DTAG ICSS, HSG	03/2007 – 01/2008	- Specification of a precise definition of Enabling Services - Creation of a value-based model for the segmentation of Enabling Services - Identification of possible revenue streams for telecom wholesale service providers
Quality-of-Service Business Models [Zarnekow et al. 2008b]	DTAG Zentrum Wholesale, HSG	02/2008 – 08/2008	- Assessment of models for cooperative QoS provisioning - Identification of viable QoS business models for retail and wholesale telecommunication service providers - Evaluation of scenarios for the introduction of QoS regimes
IP Traffic Revenues [Wulf et al. 2009c]	DTAG Zentrum Wholesale, HSG	01/2009 – 06/2009	- Analysis of CDN market, ISP activities and business models - Assessment of current CDN activities within the Deutsche Telekom - Design of guidelines for a consolidated CDN strategy
Impact of QoS business models on future fixed and mobile network design [Wulf et al. 2010c], [Wulf et al. 2011c]	T-Labs, DTAG Zentrum Wholesale	07/2009 – 03/2011	- Creation of a typology of QoS business models - Production of business model and market opportunity analyses - Quantitative evaluation of market introduction scenarios

Table 1-3: Overview of industry projects

The initial situation of the project can be described as follows: Technological developments, especially the convergence of telecommunication and IT networks, break up the traditional role allocation within the media, IT and telecommunications industry. New business opportunities for telecom wholesale service providers, which are enabled by these developments, are often subsumed under the label *Enabling Services*. However, neither a common understanding of Enabling Services nor a thorough analysis of the business potentials associated with Enabling Services had been achieved. The project aimed to fill this gap by providing a precise definition of Enabling Services and introducing a value-based model for the segmentation of Enabling Services and the description of possible revenue streams for Telecom Wholesale Service Providers. The results of the project included the identification of a generic value chain for the production of end customer services, a segmentation of Enabling Services along this value chain and the discussion of potential business opportunities for Deutsche Telekom Wholesale Center. The project provided inspirations for three academic publications: [Zarnekow et al. 2008a], [Wulf et al. 2009a] and [Wulf et al. 2009b].

The project *Quality-of-Service Business Models* was carried out between 02/2008 and 08/2008 in cooperation with DTAG Zentrum Wholesale and the Institute of Information Management at the University of St. Gallen. The focal objective of this project was the analysis and development of QoS business models. Internet data transmission bases on the best-effort principle: all data packets are treated equally, regardless of their origin. The actual quality of best-effort transport is therefore decided upon by network operators based on economic considerations. Complementarily to best-effort transport, a multitude of technological methods has been developed in order to improve the distribution of IT services over the Internet, few of which have up to date been applied in practice. In academic research there is a long ongoing and vital discussion on the evolution and design of technologies that enable the management and control of QoS for Internet based IT services. Whereas technological aspects have been extensively discussed, from an industry perspective, there is a strong need for a structured research on economic aspects of QoS. Within the project different models for the cooperative provisioning of QoS were assessed from a wholesale as well as from a retail perspective. Furthermore, two possible QoS interconnection regimes (best-effort and sending-party-pays) were compared. Different aspects with regard to the introduction of QoS, such as pricing models and cooperative strategies, were analyzed. The project gave inspiration for academic research in the area of service distribution ([Wulf/Zarnekow 2010b], [Wulf 2011]).

The project *IP traffic revenues* was carried out in cooperation with DTAG Zentrum Wholesale and the Institute of Information Management at the University of St. Gallen between 01/2009 and 06/2009. The objective of this project was to analyze the network operators' activities in the Content Delivery Network (CDN) market and to provide recommendations and guidelines for a consolidated CDN strategy for DTAG Wholesale. In a first step, the CDN offerings of network operators were investigated and contrasted with each other through desk research. Furthermore, an analysis of service offerings of independent CDN providers was carried out. In a second step, several interviews were conducted in order to assess current CDN activities within DTAG. In a third step, recommendations for a consolidated CDN strategy were created, which covered the specification of products, target customers, strategic resources, competition and cooperation strategies as well as side-effects on the traditional wholesale business. The project provided ideas for the following academic publications: [Wulf et al. 2010a], [Wulf/Zarnekow 2010b] and [Wulf 2011].

The project *Impact of QoS business models on future fixed and mobile network design* was carried out in cooperation with the Deutsche Telekom Laboratories (T-Labs) and DTAG Zentrum Wholesale between 07/2009 and 03/2011. The objective of this project was to analyze the economic factors which have an impact on the application of QoS platforms in the telecommunications industry. The result of the first project phase was a typology of QoS business models distinguishing four types: transit/access, delivery, portal and service. The delivery and portal business models were selected for a comprehensive business model and market opportunity analysis in phase 2, in which Osterwalder's business model ontology [Osterwalder 2004] and Porter's five forces framework [Porter 1985] were applied. In the third phase, two focal aspects regarding the introduction of QoS business models were quantitatively evaluated: substitution effects and the Sending-Party-Pays (SPP) regime. The substitution effects between QoS and best-effort services were assessed for the case of the market for IP based TV services applying a Lotka-Volterra model [Morris/Pratt 2003]. The evolution of the interconnection market with a Sending-Party-Pays (SPP) regime was analyzed by means of agent based computational economics (ACE) [Tesfatsion/Judd 2006]. The project gave inspirations for the following publications: [Wulf et al. 2010b], [Wulf et al. 2010c], [Wulf et al. 2010d], [Wulf et al. 2011a] and [Wulf et al. 2011b].

Research methodologies in information systems research are classifiable along two dimensions: research paradigm and degree of formalization [Wilde/Hess 2006]. With respect to the research paradigm, behavioral are distinguished from constructivist approaches. Behavioral science is oriented towards the analysis of the behavior and the influence of existing information systems in organizations. Constructivist approaches aim at producing scientific value with the design and evaluation of solutions in the form of models, methodologies and systems. With respect to the degree of formalization, qualitative are distinguished from quantitative approaches. Results of qualitative research are predominantly informal and represented in natural language whereas quantitative research predominantly produces numerical representations. With respect to the research methodologies applied, the articles are structured in a portfolio as depicted in Table 1-4. The references in black letters represent the articles included in this dissertation, whereas the references in grey are other publications by the author.

		Paradigm	
		behavioral	constructivist
Degree of formalization	qualitative	• [Wulf et al. 2010a]: case studies • [Wulf 2011]: case studies • [Limbach et al. 2011b]: case studies • [Limbach et al. 2011c]: case studies • [Schultz et al. 2011]: case studies	• [Zarnekow et al. 2008a]: argumentative-deductive analysis • [Wulf et al. 2009a]: reference model[1] • [Wulf et al. 2009b] : argumentative-deductive analysis • [Wulf et al. 2010b]: reference model • [Wulf et al. 2010e]: argumentative-deductive analysis • [Wulf/Zarnekow 2010c]: argumentative-deductive analysis
	quantitative	• [Wulf/Zarnekow 2010a]: quantitative empirical CSA* • [Wulf/Zarnekow 2010b]: quantitative empirical CSA* • [Wulf/Zarnekow 2011a]: quantitative empirical CSA* • [Wulf/Zarnekow 2011b]: quantitative empirical CSA*	• [Hau et al. 2008a]: formal-deductive analysis • [Hau et al. 2008b]: formal-deductive analysis • [Wulf et al. 2010d]: formal-deductive analysis • [Wulf et al. 2011a]: simulation • [Limbach et al. 2011a]: simulation • [Wulf et al. 2011b]: formal-deductive analysis
* CSA: cross-sectional analysis			

Table 1-4: Portfolio of research methodologies applied (based on [Wilde/Hess 2006])

[1] Reference modeling as applied in [Wulf et al 2009a] is classified as a qualitative approach, because there was no formal modeling language used.

It was a dedicated objective in the research process to apply research methodologies from different quadrants in order to increase the scope and applicability of research results. The research methodologies applied include case studies, reference modeling, quantitative empirical cross-sectional analysis and simulation.

- *Case studies analysis* is applied in order to study complex phenomena in their natural context [Yin 1994]. The units of observation are studied comprehensively. Behavioral patterns are interpreted as phenotypes of the reality constructed by the units of observation. In [Wulf 2011] case study analysis is employed in order to identify business models for service distribution in IP networks.
- *Reference modeling* has the objective to produce reusable models of simplified or optimized systems [Fettke/Loos 2004]. In [Wulf et al 2009a] it is applied to design a process for the specification of Enabling Services.
- *Quantitative empirical cross-sectional analysis* is a non-recurring investigation and quantitative evaluation of a large sample [Wilde/Hess 2007]. A cross-sectional characterization of the sample allows drawing conclusions for the basic population. In [Wulf/Zarnekow 2010b] central characteristics of information services are evaluated by means of discriminant analyses in order to identify the main aspects influencing delivery quality and costs. In [Wulf/Zarnekow 2010a], [Wulf/Zarnekow 2011a] and [Wulf/Zarnekow 2011b] diversification activities of ICT firms are analyzed in order to characterize competition across industry boundaries and the interrelationship of industry convergence and firm strategies.
- In a *simulation* the behavior of a system is modeled formally [Wilde/Hess 2007]. System states are represented by specific parameter settings. Implications are derived in the course of model construction as well as through the evaluation of endogenous system characteristics. In [Wulf et al. 2011a], agent based computational economics [Tesfatsion/Judd 2006] is used to quantitatively evaluate a market scenario for QoS interconnection.

Detailed explanations of the different research methodologies are presented in the individual articles in the Chapters 3 and 4.

1.4. Composition and structure

This dissertation, following a cumulative approach, is composed of a selection of publications listed in Table 1-5.

Title	Published in	Reference	JQ[1]	WI[2]
How do ICT firms react to convergence? An analysis of diversification strategies	European Conference on Information Systems (ECIS 2011)	[Wulf/ Zarnekow 2011a]	B / 178	A
Softwarebezogene Wertschöpfung im Wertschöpfungsnetzwerk der Informations- und Kommunikationsindustrie	Multikonferenz Wirtschaftsinformatik (MKWI 2010) (Best Paper Award)	[Wulf/ Zarnekow 2010a]	D / 643	C
Cross-sector competition in telecommunications - an empirical analysis of diversification activities	Business & Information Systems Engineering (BISE)	[Wulf/ Zarnekow 2011b]	B / 198	A
Specifying Enabling Services in Telecommunications Service Systems	Americas Conference on Information Systems (AMCIS 2009)	[Wulf et al. 2009a]	D / 547	B
Technologies for the Electronic Distribution of Information Services - A Value Proposition Analysis	Electronic Markets	[Wulf/ Zarnekow 2010b]	C / 296	A
Service Distribution in IP-Networks - A Business Model Analysis	Electronic Communications of the EASST	[Wulf 2011]	n/a	n/a
Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario	International Conference on Information Systems (ICIS 2011)	[Wulf et al. 2011a]	A / 35	A

[1]Rating / Rank Jourqual [VHB 2011]; [2]Category WI-Orientierungslisten [WKWI 2008]

Table 1-5: Overview of publications included into the dissertation

These publications were selected from the complete body of work of the author (see Table 6-8 in the appendices) by taking into account two criteria: publication quality and coherence. Publication quality was guaranteed by orienting the publication process at well accepted publication rankings ([VBH 2011, WKWI 2008], see Table 1-5). Coherence was created through thematically grouping the publications into two chapters and through the additional discussion of superordinate research objectives, fundamentals and conclusions. The overall structure of this dissertation is depicted in Figure 1-3.

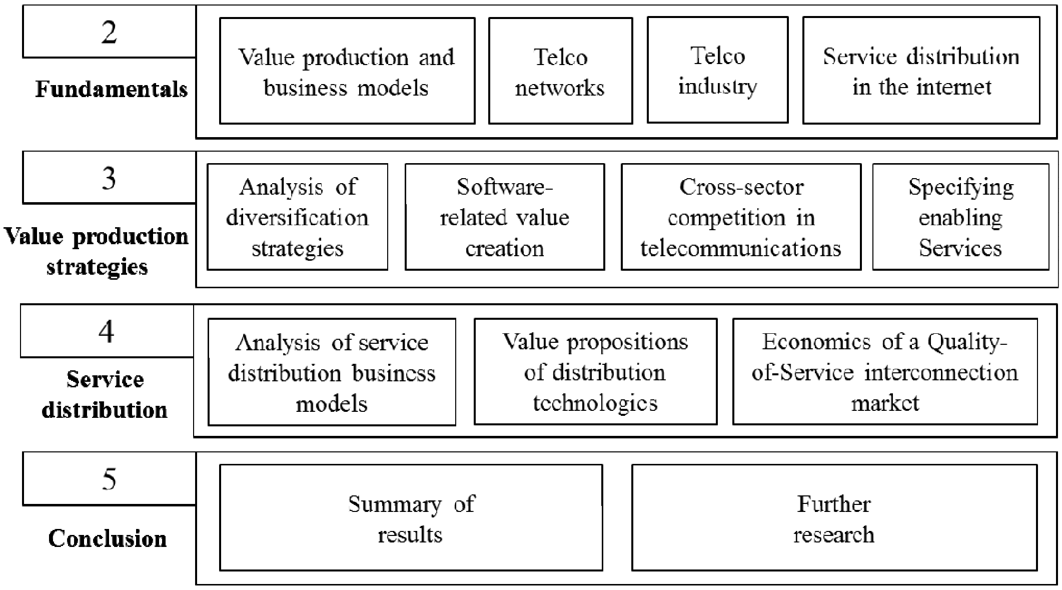

Figure 1-3: Structure of the dissertation

Chapter 2 presents the joint theoretical foundations of all publications. A brief summary of the basic economic concepts of value production strategies, business models and industry convergence is given in Section 2.1. The technological fundamentals of telecommunication networks, i.e. architecture and protocols, are presented in Section 2.2. The structure of the telecommunications industry in terms of the services provided, industry value chains and actors is discussed in Section 2.3. The economic and technological aspects of service distribution in the Internet are addressed in Section 2.4. This section includes a discussion of quality degradation effects in telecommunication networks, Quality-of-Service concepts, technologies and economics as well as Content Delivery Networks.

Chapter 3 consists of four articles, which address value production strategies in the ICT industry. Section 3.1 presents an analysis of diversification strategies of firms in converging ICT sectors. The role of software development and operation in the value creation network of the ICT industry is discussed in Section 3.2. The subsequent Section 3.3 evaluates cross-sector competition in the telecommunications industry. A methodology for specifying Enabling Services in telecommunications service systems is presented in Section 3.4.

Chapter 4 addresses technological and economic approaches for service distribution and consists of three articles. An analysis of business models for service distribution in IP networks is presented in Section 4.1. The value propositions of different distribution technologies are assessed in detail in Section 4.2. The economics of a novel distribution technology, inter-provider Quality-of-Service, is subject to discussion in Section 4.3.

The conclusion in *Chapter 5* consists of a summary of the core results (Section 5.1) and a discussion of further research issues with respect to ICT convergence strategies and the evolution and sustainability of the Internet ecosystem in Section 5.2.

2. Fundamentals

Telecommunication refers to the technical procedures of the sending, transmission and reception of any kind of messages in the form of symbols, speech, or sound via telecommunication infrastructures [TKG 2004, §3]. This dissertation generally discusses economic prospects of technological developments in the telecommunications industry with a focus on service distribution business models. For this reason, this chapter presents fundamental theories and concepts in the fields of value production strategies and business models (Section 2.1), telecommunication infrastructures (Section 2.2), telecommunications industry structure (Section 2.3) and service distribution in IP networks (Section 2.4).

2.1. Value production strategies and business models in convergent industries

Value production strategies, business models and industry convergence have been extensively discussed in prior economic literature from a theoretical as well as from an application-oriented perspective. Since the three concepts represent important foundations for the research in this dissertation, they will be shortly presented in the following subsections.

2.1.1. Firm strategy and value production

In economic literature there are manifold approaches for defining the term strategy and no definition which is universally valid [Haertsch 2000, 43-45]. Chandler [1962, 13] defines strategy *as the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals*. The long-term objective usually consist of achieving a sustainable competitive advantage [Porter 1996, 68]: *Strategy is the creation of a unique and valuable position involving a different set of activities*. Strategic positions in this sense base on customers' needs and customers' accessibility as well as on the variety of services offered. In order to reach and secure a unique position, a company is required to allocate the required resources. This idea is emphasized in the definition provided by Barney [1997, 27]: *Strategy is a pattern of resource allocation that enables firms to maintain or improve their performance.*

Andrews [1980, 18] distinguishes business strategy from corporate strategy. Business strategy is *the determination of how a company will compete in a given business and position itself among its competitors*. A key issue in business strategy is the determination of a sustainable competitive position in a given business field. Corporate strategy, in contrast, *defines the businesses in which a company will compete, preferably in a way that focuses resources to convert distinctive competence into competitive advantage*.

The businesses of a company are predominantly determined by a firm's diversification strategy [Penrose 1959; Gort 1962; Rumelt 1974; Berry 1975]. There are multiple levels of diversification including the diversification of customer segments, geographic regions, products, and tangible and intangible resources. The objectives of diversification depend on its type, which is determined by the customers addressed and the resources applied. *Horizontal diversification* refers to the offering of heterogeneous products over identical distribution channels. In *concentric diversification*, firms leverage the relatedness of production resources. A major objective for horizontal and concentric diversification is to realize synergies through the application of shared resources and capabilities. Synergies lead to a market position, in which the overall market capabilities of a firm are superior to the mere sum of its capabilities in subsegments [Ansoff 1965, 65]. *Vertical diversification* describes the situation in which a firm offers products from successional production stages of a single production chain. Vertical diversification is subsumed under vertical integration. Its objective is to gain a dominant position in value networks through the control of successional production stages [Perry 1989]. *Conglomerate diversification* refers to the offering of heterogeneous products which are unrelated in the customers addressed as well as in the resources applied. Its main objective is the diversification of overall business risk [Amit/Livnat 1988].

Porter [1985, 38-39] uses the value chain to analyze a firm's business and corporate strategies: V*alue activities are the discrete building blocks of competitive advantage*. The firm specific configuration of an activity determines the firm's competitive position within an industry sector in terms of costs and service differentiation. Furthermore, linkages within the value chain also determine the vertical and the industry scope of a firm. The value chain concept views the firm *as a collection of discrete but related production functions* [Porter 1985, 39]. The core building blocks of Porter's approach are the concepts of value, value activities and value chains:

- *Value* is the *amount buyers are willing to pay for what a firm provides them* [Porter 1985, 38].
- *Value activities* are the physically and technologically distinct activities a firm performs [Porter 1985, 38].
- *Value chain* is a collection of interlinked value activities. Value chains can be described on the business unit, on the firm or on an industry level. On an industry level, the value chain is a reflection of the collective value chains of competitors [Porter 1985, 58].

The generic value chain of a firm consists of value activities carried out independent of a firm's specific service or industry focus [Porter 1985, 36-48]. Porter distinguishes primary activities, which directly contribute to products and services and secondary activities, which provide the basis for the primary activities. Primary activities include inbound logistics, operations, outbound logistics, marketing and sales, as well as customer service. The secondary activities are procurement, technology development, human resource management and firm infrastructure.

Pil and Holweg [2006] introduce the term *value grid* describing a value activity network of vertical chains and horizontal tiers. Value activities are linked vertically with their upstream and downstream neighbors in production chains. Value activities pertaining to a similar stage of production (tier) are linked horizontally. The value grid represents the foundation for the definition of firm specific value production strategies through the integration of activities, which are linked in a vertical, horizontal or diagonal fashion.

2.1.2. Business models

Traditional concepts in strategic management such as the firm or the industry, according to Amit and Zott [2000] and Stähler [2002, 36], fail to accurately capture the economic impact of ICT. For this reason, many researchers, particularly in the field of IS research, use the business model as the unit of analysis [Hedman/Kalling 2003]. Business models have received considerable attention in economic research. Comprehensive overviews and discussions on the economic literature on business models are provided by Osterwalder [2004, 23-39] and Stähler [2002, 31-64]. An early definition of the term business model was proposed by Timmers [1998]: A business model is *an architecture for the product, service and information flow, including a description of various business actors and their roles and a description of the potential benefits for the various business actors and a description of the sources of revenues.*

Various authors have specified approaches for differentiating business model components [Afuah/Tucci 2003; Stähler 2002, 40-52; Alt/Zimmermann 2001; Hamel 2000, 59-118; Weill/Vitale 2001, 29-54]. Osterwalder [2004] designed a synthesis of the different architectural approaches in the form of a business model ontology with four main pillars [Wulf et al. 2010b]:

- *Product*: The central component in the product pillar is the value proposition. It provides an overall view of a company's bundle of products and services that are of value to the customer. Key elements, which are defined in a value proposition, include the product offerings, the value reasoning, and the value level. The product offering describes which products and services are bundled to create a value proposition. The value reasoning captures why a value proposition is valuable to the customer, e.g., by reducing risks or by reducing effort. The value level of a company's offer allows a firm to compare itself to its competitors by defining the degree of innovation and excellence. Key linkages of the value proposition are established to target customers and capabilities.

- *Customer interface*: The customer interface pillar consists of the building blocks target customer, distribution channel and relationship. The target customer segments specify the types of customers a company wants to address. The distribution channels describe how a company delivers value to its customers either directly or indirectly through intermediaries. The customer relationship is characterized by the mechanisms (such as personalization, trust or brand) used to establish ties with a customer segment.

- *Infrastructure management*: The infrastructure management pillar specifies the way a company creates value. It describes the abilities, which are necessary to provide its value propositions and maintain its customer interface. Key elements include the key activities, key resources and key partners. The key activities (value configuration) of a firm describe the arrangement of one or several activities in order to provide a value proposition. The key resources are inputs to the value-creation process. They are the source of the capabilities a firm needs in order to provide its value propositions. The key partnerships are voluntarily initiated cooperative agreements formed between two or more independent companies in order to carry out a project or specific activity jointly by coordinating the necessary capabilities, resources and activities.
- *Financial management*: The financial management dimension is composed of the company's revenue model and its cost structure. Together they determine the firm's profit- or loss-making logic and therefore its ability to survive in competition. Key elements are the revenue stream and pricing element as well as cost elements. The revenue stream and pricing element describes an incoming money stream from the value offered by the company. Furthermore it defines what mechanism is used to determine the price of this value offered. The cost elements represent monetary cost drivers of service provisioning. They are related to resource utilization and key activities.

2.1.3. Strategic implications of industry convergence

The term industry convergence, even though it has often been used by researchers and practitioners to describe cross-industry evolutions, is rarely defined in a strict manner [Katz 1996]. Convergence, according to Merriam-Webster [2011], very generally means *the merging of distinct technologies, industries, or devices into a unified whole*. Industry convergence, in conformance with this definition, refers to a process, in which formerly distinct industries become indiscernible from each other. An industry (German: Branche), from a market-oriented perspective, is understood as a grouping of firms which produce closely related substitutes [Porter 1980, 5]. From a resource-based perspective, an industry can also be defined as a grouping of firms with similar resources [Bettis 1998].

Industry convergence, due to the two different industry definitions, can be defined from a technological as well as from a product perspective [Gambardella and Torrisi 1998; Stieglitz 2003b, 25-32]. If technological innovations form substantial production resources for formerly unrelated industries, one speaks of technology convergence [Rosenberg 1963]. Technology convergence is caused by technology substitution or technology integration [Stieglitz 2003a]. Technology substitution means the replacement of different technological resources in established industries by a new technology. Technology integration refers to the combination of various technologies, which formerly were distinctively associated with different industries [Iansiti 1995]. From a product perspective, industry convergence is caused by novel substitutive or complementary relationships of established products from different industries [Greenstein 1997, Yoffie 1996; Katz 1996]. Convergence in substitutes occurs if consumers perceive products from distinct industries as interchangeable. Convergence in complements manifests itself in a super-additive value, a bundling of products proposes to consumers.

Technological change and convergence have an impact on the consistency of industries by altering the internal competitive landscape and the external industry boundaries [Porter 1985, 175-176]. Bettis and Hitt [1995] speak of a new competitive landscape, in which industry boundaries are increasingly blurring due to an increasing rate of technological change and diffusion. In such a competitive environment, strategic alliances play an increasingly important role. Cooperation strategies, which are directed towards the exploitation of shared resources, are often encouraged by complementary product convergence and technology integration. In both cases, cooperation strategies allow firms to address new markets without the necessity to develop all required strategic resources internally.

Apart from cooperation, convergence significantly influences diversification and vertical integration strategies [Katz 1996; Gambardella/Torrisi 1998; Pennings/Puranam 2001]. A common strategic response to convergence is the diversification into adjacent industries [Wirtz 2001]. Diversification is potentially beneficial particularly in the case of substitutive product convergence [Stieglitz 2003b, 295-296]. An indirect market entry through the offering of hybrid products allows the exploitation of established resources. It nevertheless also bears high risks due to the unknown demand for hybrid products. Convergence, in the case of technology substitution, in the long run often stimulates a vertical disintegration [Stieglitz 2003b, 229-231]. This is because suppliers of the new substitutive technologies are likely to have competitive advantages over incumbent firms through specialization. As a consequence, incumbents follow cooperation or concentration strategies in order to realize technology access.

2.2. Telecommunication networks

Telecommunication infrastructures encompass all resources which enable the transmission of signals by wire, radio, optical and other electromagnetic infrastructures. Examples include satellite networks, fixed and mobile terrestrial networks, electricity networks being used for data transmission, radio and television broadcasting networks, as well as cable TV networks [TKG 2004, §3]. With regard to the accessibility of networks, open networks are distinguished from private networks [Jung/Warnecke 1998, 4-4]. Open networks are operated by network operators for public access. The use of technical infrastructure for the support of communication in public networks is only restricted by the general terms and conditions of a network operator. Data exchange between open networks is realized through network interconnections. In contrast, private networks are only accessibly to a well-defined user group and serve the demand for internal communication among these users.

Essential network design aspects include the network architecture (Section 2.2.1) as well as communication protocols (Section 2.2.2).

2.2.1. Architecture of telecommunication networks

Telecommunication networks consist of three elementary components: end systems, transmission lines and switching elements [Tanenbaum 2003, 34-35]. End systems are machines which host user programs (applications). Such systems are connected by telecommunication networks. *Transmission lines* are used to transmit data over distance. Exemplary mediums include copper, fiber glass, or the air. *Switching elements* are specialized computers which connect three or more transmission lines. They are mostly referred to as routers. There are different approaches for determining the transmission lines data is carried on from sender to receiver [Obermann/Horneffer 2009, 13-14, Jung/Warnecke 1998, 1-44-1-46]. In circuit switching, an end-to-end path from sender to receiver (circuit) is reserved for a communication session. This approach is particularly suitable for services with relatively fixed data rates such as voice communication. In circuit switching, capacity is blocked regardless of the actual usage. Moreover, the establishing and closing of a circuit requires additional capacities. Both aspects potentially cause inefficiencies in capacity usage. Circuit switching is used for providing PSTN (Public Switched Telephone Network) and GSM (Global System for Mobile Communication) telephony services [Jung/Warnecke 1998, 3-17, 3-60]. In packet switching, messages are split into segments (packets), which are sent out successively. The packets are stored and forwarded by the nodes in the network on the way from the sender to the receiver. Storing and forwarding is based on routing algorithms. The packet switching principles potentially allow a higher efficiency in the usage of transport capacities. If packets take different paths, this may cause a high variance in latency (jitter) and the out-of-order delivery of data packets. Packet switching is traditionally used to realize communication in computer networks (e.g., Ethernet, Internet).

From a geographical perspective, three network types are distinguished [Tanenbaum 2003, 31-36; Obermann/Horneffer 2009, 11]. *Local Area Networks (LAN)* are private networks, usually located within buildings or campuses. They locally connect terminals such as workstations, desktop computers and laptops. *Metropolitan Area Networks (MAN)* cover metropolitan areas such as cities or industrial areas. They are either private or public and, like LANs, do not contain switching elements. *Wide Area Networks (WAN)* connect hosts over large geographic regions (mostly on a national or continental scale). They usually are owned by telephone or Internet service providers and consist of transmission lines and switching elements.

From a functional perspective, telecommunication networks can be partitioned into three sections [Obermann/Horneffer 2009, 11-12] as depicted in Figure 2-1. The general network partitioning is explained for the case of fixed line access with twisted pair copper lines. The basic structuring, however, is for a large part transferrable to other access technologies and network designs.

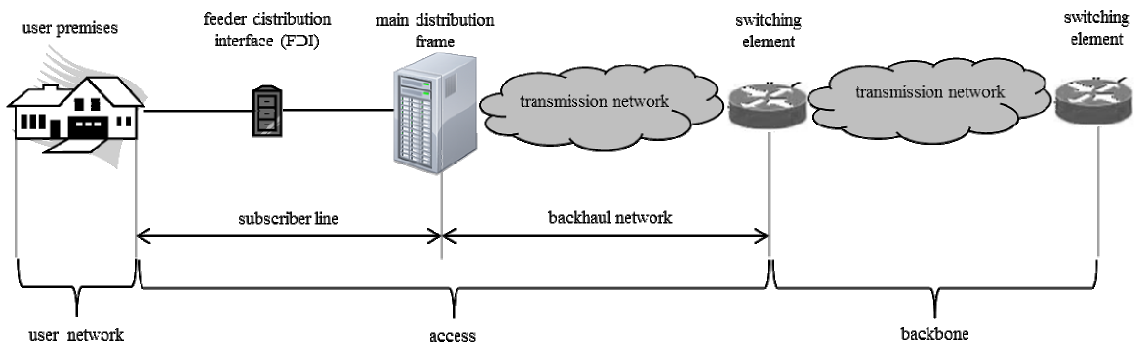

Figure 2-1: General partitioning of telecommunication networks [Obermann/Horneffer 2009, 12]

- *User networks* are located within the facilities of the private users or firms. While private users usually have Internet access and obtain voice services, firms regularly operate LANs and run business telephone systems.

- *Access networks* are located between the network termination device at the user facilities and the first switching element in the network (such as IP routers or voice switches). Access networks can be further distinguished into the subscriber line and the backhaul network.

    - The *subscriber line* is the network section between the network termination and a main distribution frame (MDF, [Obermann/Horneffer 2009, 12]). In traditional PSTN- and DSL-networks, the MDF represents the node in which the dedicated lines to the subscribers are terminated. At this location, traffic is concentrated for further transport. The subscriber line is more generally referred to as last mile. Apart from the twisted pair copper cables, other wireless and fixed line technologies are used to realize last mile communication [Tanenbaum 2003, 110-204]. Exemplary fixed line media include coaxial cables, optical fiber and power lines. Among the wireless technologies are cellular radio systems, wireless local loop systems and satellite systems.

    - The *backhaul network* connects a MDF with a switching element. From a geographical perspective, backhaul networks either represent MANs or WANs. For data transmission in backhaul networks, optical fiber and microwave systems are mainly used.

- *Backbone networks* connect switching nodes over long distances. They contain the switching logic and represent optical fiber WANs.

2.2.2. Protocol layers

In order to realize a flexible and at the same time standardized communication management, communication protocols are organized in layers. Each layer encapsulates specific functionalities and provides them to the upper layer through standardized interfaces [Tanenbaum 2003, 42-46]. The layer models most widely known are the OSI reference model and the TCP/IP reference model.

The OSI (Open Systems Interconnection) reference model [Day 1995, Tanenbaum 2003, 54-61] consists of seven layers. It builds upon the transmission mediums, which are often referred to as *Layer 0*. The lowest OSI layer (L1) is called *physical layer* and is dedicated to the transmission of raw bits over communication channels. Whereas transmission delay and bit errors potentially occur, the bit order is not affected on this layer. Design issues mostly concern mechanical and electrical interfaces. Exemplary issues include voltages, pin layouts, connection establishment and termination, as well as signal modulation. The main task in the *data link layer* (L2) is to deal with transmission errors in the physical layer. For this reason, input data is packaged into labeled data frames which are transmitted sequentially. The data link layer implements an acknowledgement scheme. The reception of frames is acknowledged by the receiver only if frames are transmitted correctly. In case of frame loss or frame errors, the frame is retransmitted by the sender. In addition to error correction, the data link layer deals with flow regulation coordinating the data processing of sender and receiver as well as bidirectional traffic. Protocols on the *network layer* (L3) determine the route of data packets from sender to receiver. The determination of such routes can be based on static tables but also can be decided upon dynamically based on the current network load. Therefore, the control of congestion within a network and the management of traffic loads (traffic engineering) is an important task on the network layer. Whereas network layer protocols are decided upon by each network provider individually, interworking must be guaranteed to enable communication between end systems in different networks. Layer 3 protocols are the highest layer protocols used in all network nodes. In contrast to the lower layers, *transport layer* (L4) protocols manage end-to-end communication and are only implemented in the end systems. The transport layer ensures that end-to-end data exchange is carried out correctly and that the messages are delivered in the right order. In order to meet upper layer requirements for transport quality, transport layer protocols establish, manage and terminate connections between end systems. Data packages are segmented and communication is adapted to congestion. The main purpose of the *session layer* (L5) is to provide dialogue control to applications. It provides token management to coordinate operations between applications. Moreover, it supports synchronization by inserting checkpoints into a data stream. After crashes, such checkpoints are used to determine the data which needs to be retransmitted. The *presentation layer* (L6) converts data between the specific representations used in end systems and standardized representations used in a network. For examples, end systems might use different representations for strings and integers, which are translated back and forth into an abstract representation in the presentation layer. On the *application layer* (L7), protocols allow applications to communicate over communication networks. They enable the communication of heterogeneous programs on different end systems by providing standardized mechanisms to determine communication partners and synchronize communication. As discussed in [Tanenbaum 2003, 63-67], the OSI reference model is mainly used to discuss and structure the use of protocols in communication networks. Due to the high complexity of the protocol stack and to inefficiencies in operation, the complete protocol stack, which is specified by International Standards Organization [Obermann/Horneffer 2009, 22] is rarely implemented.

As depicted in Table 2-1, different protocols and standards are used in different network sections. Layers 1 and 2 are relevant in all network sections. They manage message exchange between neighboring nodes. The network layer (L3) is only relevant in end systems and in the backbone. It manages end-to-end transport. The upper layers are dedicated to the communication of end systems and are not relevant for the other network sections [Obermann/Horneffer 2009, 22]. Many protocols cannot be clearly classified according to the OSI layers. For example, ISDN specifies communication on the physical layer in the end systems and the subscriber line, but is also relevant for determining end-to-end paths on the transport layer in the backbone.

The stack of protocols used in the Internet is referred to as the TCP/IP reference model [Tanenbaum 2003, 58-61]. Its core component is the Internet Protocol (IP), which specifies functionalities on the network layer in the OSI model [Tanenbaum 2003, 475-518]. Comparable to the shape of an hourglass, protocols on other layers are used in combination with the IP protocol (see Figure 2-2).

The TCP/IP protocol stack includes protocols on the OSI transport layer (e.g., transmission control protocol - TCP and user datagram protocol - UDP) and the OSI application layer (e.g., file transfer protocol - FTP, simple mail transfer protocol - SMTP, domain name system - DNS). The presentation and the session layers are not included. The physical and data link layer are joined in a layer which is referred to as host-to-network layer.

No.	Layer	End System	Last Mile	Backhaul	Backbone
"L0"	Transmission Medium	Twisted pair copper, coaxial, fiber optic cables, power lines, wireless transmission	Twisted pair copper, coaxial, fiber optic cables, power lines, wireless transmission	Fiber optic cables, microwave links	Fiber optic cables
L1	Physical	POTS, ISDN, Ethernet, FDDI, Token Ring, DECT, WLAN, PLC, Bluetooth, ZigBee	POTS, ISDN, xDSL, FTTx, Ethernet (EFM), WIMAX, GSM, UMTS	PDH, SDH, WDM (CWDM), Ethernet	PDH, SDH, WDM (CWDM)
L2	Data Link	Ethernet, FDDI, Token Ring	ATM, Ethernet, PPPoE	ATM, Ethernet, PPPoE, RPR, GFP	PPP/HDLC, Ethernet, ATM, FR, GFP
L3	Network	IP, ISDN	N/A	N/A	IP, ISDN, POTS
L4	Transport	TCP, UDP	N/A	N/A	N/A
L5	Session	NetBIOS, Session Announcement Protocol	N/A	N/A	N/A
L6	Presentation	MIME, ASCII	N/A	N/A	N/A
L7	Application	http, ftp, SMTP, telnet	N/A	N/A	N/A

Table 2-1: Exemplary media, protocols and standards in OSI layers and network sections (based on [Obermann/Horneffer 2009, 23])

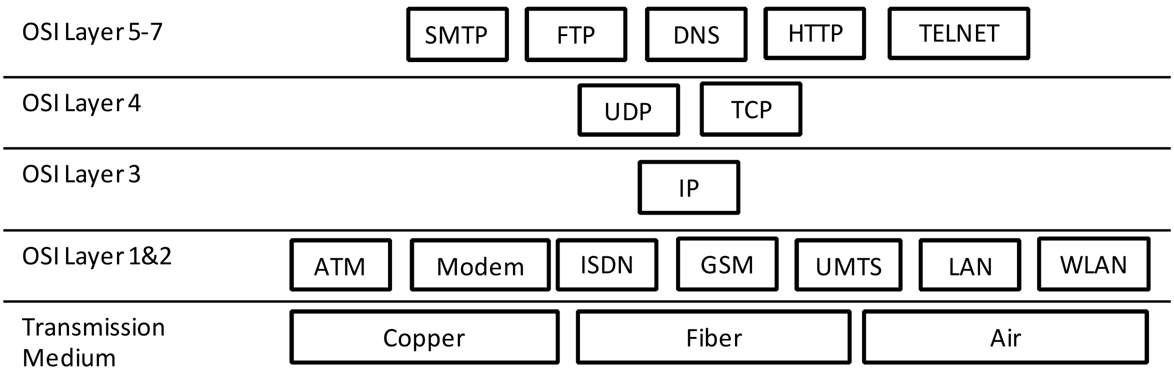

Figure 2-2: Internet hourglass model (based on [Karrer 2008], [Tanenbaum 2003, 58-61])

2.3. Telecommunications industry

The telecommunications industry is further characterized by the services offered, the typical value creation activities and the market actors. Subsection 2.3.1 introduces various approaches for structuring service offerings in the telecommunications industry. Subsection 2.3.2 discusses generic industry value chains. In Subsection 2.3.3, different segmentations of telecommunication service providers are presented.

2.3.1. Telecommunication services

Telecommunication services exclusively or in a larger part carry out the transmission of signals over telecommunication networks [TKG 2004, §3]. Telecommunication services are classifiable according to several characteristics.

With respect to the level of added value and the customer group, telecommunication services are distinguished into retail and wholesale services.

- *Retail services* are offered to end customers for consumption. In contrast to wholesale services, retail services are neither further processed, nor resold. Retail services can be further distinguished into private and business customer services [Pelzel 2000, 14-20].
    - *Private customer services* predominantly are highly standardized offerings for private consumers. They are characterized by a high usability and relatively low charges. Exemplary private customer services are the Internet access via Asymmetric Digital Subscriber Line (ADSL), ISDN voice services and Short Message Services (SMS).
    - *Business customer services* predominantly are customized offerings with larger capacities, which meet higher quality and security requirements. Exemplary business customer services are the Internet access via Symmetric Digital Subscriber Line (SDSL) and Private Branch Exchange (PBX) voice services.

- *Wholesale services* are provided to wholesale customers, which procure preliminary services to establish their own telecommunication service offerings. Therefore, wholesale customers are telecommunication service providers as well, which either operate their own telecommunication infrastructures or focus on the reselling of telecommunication services. For example, Internet access providers regularly make use of transit services or leased lines offered by wholesale service providers in order to establish the connection to the global Internet.

According to the degree of integration with the telecommunication infrastructure, telecommunication services are traditionally classified into basic services, supplementary services and value added services [Jung/Warnecke 1998, 3-4].

- *Basic services* carry out the transmission of information for users between geographically distinct endpoints in the chosen mode of communication (e.g., speech). They are further distinguished into bearer services and teleservices [Jarrett 1999].
    - *Bearer services* offer the transmission of information independent of the applications used for information processing. Bearer services have predefined bitrates and may include functions for the establishing and termination of connections. The mode of communication is up to the users, which are required to have compatible terminals. Exemplary bearer services include permanent circuit connections, layer 2 Ethernet transport and ATM cell relay services.
    - *Teleservices* include the definition of communication functions at the users' terminals. The compatibility of the service specific user terminals is guaranteed through extensive specifications, e.g., regarding the coding and format of the transmitted information. Exemplary teleservices include the plain old telephone (POTS) service, SMS, teletext services, fax services and Internet access services.
- *A supplementary service* supports the usage of a basic service or provides supplementary functionalities. Therefore, it must be offered in a bundle with the basic service. In the realm of voice services, exemplary supplementary services include conference calls, toll-free numbers and caller identification. Supplementary services cannot only be offered to end customers but also to wholesale customers. For example, traffic management functionalities provided to wholesale customers are also viewed as supplementary services.
- *Value added services* are not bound to specific basic service offerings. The value added regularly consists of the processing of information or the support of transactions, for example based on a server infrastructure. Telecommunication providers view value added services as a business opportunity to market further offerings in addition to basic and supplementary services. Since such services nowadays are by the majority of-

fered by independent content providers, the term value added service increasingly looses relevancy and is substituted by alternative terms, which further specify provider and customer groups or the value being provided [Wirtz 2000, 87-96].

According to the telecommunication infrastructure involved, the following main service segments can be differentiated [BNetzA 2009]:

- *Fixed network access services* encompass services provided by operators of fixed network access infrastructures (excluding cable TV networks), such as Internet access, voice services and supplementary services (such as premium rate numbers). The offers of voice service resellers and virtual Internet service providers, which offer Internet access services without owning access infrastructures, also belong to this class of services.
- *Cellular mobile services* include mobile voice, SMS and mobile data services offered by operators of cellular mobile radio networks as well as by service providers without own radio network infrastructures.
- *Leased line services* provide dedicated permanent connections between two endpoints (except unbundled local loops). Such lines potentially involve access, concentration, as well as backbone network infrastructures. Leased line services include the offerings for wholesale customers as well as for retail business customers.
- *Carrier services* cover carrier interconnection (e.g., IP transit, voice interconnection), the shared usage of facilities (collocation), the leasing of the access infrastructure (local loop unbundling) as well as wholesale services for DSL-resale, debt collection and preselection services.
- *Cable TV network services* include the TV, Internet access and voice services provided by cable TV network operators.

This service segmentation is not exhaustive. Other telecommunication services such as trunked radio services, audio broadcasting and value added services are not included. Table 2-2 provides an overview of the revenues generated within these service segments in the German market between 2004 and 2008. More than two-thirds of the revenues in 2008 were generated by fixed network access and cellular mobile services. Leased line and carrier services only generated 12.5% of the market volume. Other services, which include value added services, accounted for 13.2%.

Revenues in billion €	2004	2005	2006	2007	2008	2009e
Overall market	66,8	67,3	66,3	63,9	62,3	60,3
Fixed network access services	24,7	22,5	21,7	21,1	20,1	19,3
Cellular mobile services	22,8	23,0	23,1	23,2	22,8	21,7
Leased line services	0,9	1,0	1,0	1,0	1,0	1,0
Carrier services	7,6	7,8	7,6	6,7	6,8	6,6
Cable TV network services	2,9	3,0	3,0	3,1	3,3	3,4
Others	8,0	9,9	9,9	8,8	8,2	8,3

Table 2-2: Telecommunication service revenues in Germany [BNetzA 2009]

2.3.2. Value production in telecommunications

There are different approaches for systemizing the value production in telecommunications by applying value chain modeling [Dengler 2000; Fransman 2007; Maitland et al. 2002; Sabat 2002]. Exemplarily, the value chain specification by Dengler [2000, 92-97] is presented. Dengler distinguishes the following value creation segments in order to give a holistic description of value production in the telecommunications industry:

- *Component production*: In this value production segment hardware components are produced which are required to build telecommunication systems.
- *Systems production:* This value production segment encompasses the production of complex hardware and software systems, which support the provisioning of telecommunication services. Such systems can be further differentiated into transmission systems, switching systems and user terminals (see Section 2.2.1).
- *Systems integration:* This segment covers all activities which are oriented towards the installation and deployment of the above systems in order to set up telecommunication networks.
- *Network operation:* The value activities in network operation guarantee network availability and at the same time optimize network efficiency.
- *Provisioning of basic and supplementary services:* While network operation focuses on network and component availability, this segment of activities is oriented towards the provisioning of basic and supplementary services based on network operation. Both value activity segments are closely linked.

- *Provisioning of value added services:* This segment covers all activities, which support the origination, storage and processing of the information transported over telecommunication networks.
- *Marketing:* The marketing activities for branding, bundling and pricing play a predominant role in the telecommunications industry and are in some cases institutionally separated from service provisioning, billing and distribution.
- *Charging, billing and customer support:* This activity segment covers all activities related with the collecting and analysis of user and usage data, the imposing of charges as well as invoicing. Such activities are highly automated and supported by complex IT systems. Customer support makes use of the same data because it is closely linked with charging and billing.
- *Distribution:* Distribution activities focus on distributing telecommunication services such as basic and value added services. Network operators can either directly distribute their services to retail customers or offer wholesale products to third party telecommunication services providers such as resellers.

Value creation in the telecommunications industry, according to Zerdick et al. [2000, 132-135], is closely interrelated with value creation in the adjacent media and information technology industries. Media firms primarily produce media content. Telecommunication companies operate telecommunication networks and carry out the transmission of information. Information technology firms produce and operate hardware and software for information processing. The increasing structural coupling of the traditionally separated value creation processes in the media, telecommunications and information technology sectors (convergence) leads to an increasing dissolution of the market boundaries, the emergence of a multimedia market and an inter-sector competition for core resources and customers. Value creation in the emerged multimedia market can be structured into six core activities [Zerdick et al. 2000, 135]:

- *Reception appliances:* This activity segment covers the production and distribution of terminals to receive, make use of and consume content and services. Reception appliances are mainly produced and distributed by telecommunication equipment providers (e.g., mobile phones) and information technology firms (e.g., notebooks).
- *Value added services:* The provisioning of value added services, which primarily base on information processing at the reception appliances and servers, is mainly the core competency of software firms and providers of Internet services.
- *Navigation:* Navigation refers to the *use of hardware and software components to facilitate and improve orientation within and control of the physical infrastructure* [Zerdick et al. 2000, 134]. Navigation is supported through operating systems, browsers and intelligent agents. It is mainly a core competency of information technology firms.

- *Transmission:* The transmitting of information requires the use of transmission and switching systems and as such represents a core competency of telecommunication network operators.
- *Packaging:* The bundling of services and the customization of content according to user preferences and requirements (packaging) is mainly carried out by content and portal providers.
- *Contents:* The production of content, such as films, music and news articles, is traditionally carried out by media firms.

2.3.3. Actors in the telecommunications industry

Whereas traditionally telecommunication services have often been produced and marketed in a vertically integrated fashion, convergence leads to a deconstruction of traditional value chains in telecommunications [Basole 2009; Fransman 2002; Li/Whalley 2002; Peppard/Rylander 2006; Zerdick et al. 2000]. As a consequence, telecommunication service providers participate in complex strategic networks [Gulati et al. 2000] and are forced to continually adapt competitive and cooperative strategies.

Following transaction cost economics [Perry 1989], telecommunication companies either vertically integrate successive value production stages or follow horizontal concentration strategies [Fransman 2002]. Vertical integration potentially allows the internalization of synergies and the establishing of market power. Horizontal concentration and cooperation potentially increase firm agility and allow the pooling of resources owned by different service providers. There are various conceptual approaches for the specification of roles taken by actors in interfirm networks as a result of concentration and integration decisions in telecommunications [Gerpott 2003; Heckmann 2005; Kaleelazhicathu et al. 2004].

According to the primary activities in a value chain [Porter 1985, 36-48] at the industry level, which are allocated to a specific actor in the telecommunications industry, one can differentiate the following actors [Dengler 2000, 92; Gerpott 2003]:

- *Suppliers:* For service production, telecommunication service providers use network equipment, terminal and server hardware as well as system software provided by independent suppliers.
- *Service producers:* Depending on the type of telecommunication service, service producers develop and operate software applications for information processing, create and aggregate content, or operate communication systems.
- *Service distributors:* In equivalence to the distribution of physical goods, telecommunication services are provided over telecommunication networks, which are established and operated by network operators.

- *Billing service providers:* As a central activity in marketing, charging and billing for telecommunication services can be carried out by third party providers, which operate billing systems and act as a financial intermediary.
- *Reseller:* The reseller is not involved in service production but resells third party services and focuses on marketing activities (such as branding and pricing).

With regard to the OSI reference model, one can differentiate the following providers of telecommunication services [Limbach et al. 2011c, Van Ooteghem et al. 2008]:

- *Providers of passive network infrastructure:* Passive network infrastructure includes dark fiber, cables, ducts and rights of way among others. Such infrastructure supports communication on the OSI-layer 1 only. Systems for the support of the upper layers are not operated by providers of this class.
- *Providers of active network infrastructure:* Active network infrastructure includes systems for securing the data link, as well as switches and routers. Therefore providers of active network infrastructure support communication on the OSI-layers 2 and 3.
- *Content and service providers:* Consumer oriented content and services are designed on the OSI-layers 4-7. Providers run central infrastructures for information processing or support such capabilities at the consumer terminals.

With regard to the telecommunication network infrastructure involved, one distinguishes the following telecommunication network operators (based on [Heckmann 2005]):

- *Backbone providers:* Backbone providers transmit information without having a relationship to end customers. Typically, their infrastructures support data transport over long distances.
- *Access network providers:* Access network providers connect end customers over access infrastructures, which are often highly distributed. They establish connections with other network operators in order to realize data transit or termination. They aggregate the data in concentration networks and hand it over to interconnected network operators. Access and concentration network infrastructure is not always owned by the customer facing provider which in some cases makes use of third party passive or active network infrastructures. With respect to the medium mostly used to realize customer access, one can further identify the following access network providers:
    - *Fixed network operators:* Fixed network operators provide access over twisted pair copper cables, which were originally rolled out and used for the analogue telephony.
    - *Cable TV network operators:* The cable TV network was originally used for TV and radio broadcasting only. Network upgrades enable a bidirectional data

transport and the realization of unicast services such as Internet access and voice over IP.

  - *Mobile network operators:* Mobile network operators use radio cell infrastructures to provide mobile customer access over radio frequencies, which are usually licensed by state authorities.

- *Collocation infrastructure providers:* Collocation infrastructure providers operate data centers for the housing of network and IT infrastructure. In addition to housing, collocation services can include operation and maintenance. Such facilities are used by network operators to establish interconnections.

- *Exchange point operators:* Exchange point operators provide platforms for the exchange of Internet traffic between Internet service providers. Internet exchange points represent essential components of the Internet backbone infrastructure, because their services are used by Internet service providers to establish a broad connectivity.

Many researchers identify an increasing interrelationship of firms, which belong to traditionally distinct sectors in the ICT industry [Li/Whalley 2002; Zerdick et al. 2000]. Technology and process innovations lead to a blurring of traditional sector boundaries (convergence) [Yoffie 1996; Katz 1996]. Hence, actors from the following adjacent ICT sectors play an important role as suppliers, competitors, cooperation partners, substitutors or customers in telecommunications: hardware components and equipment, software, as well as media. By affiliation to an ICT sector, actors influencing the telecommunications industry can be grouped as follows:

- *Media firms:* Media firms produce, publish and sell content such as films, music and textual information. As well they aggregate content from different sources according to consumer preferences and convert it into a suitable format.

- *Software firms:* Software firms are dedicated to the development and operation of software applications. Apart from offering on-premises software, software firms provide access to software applications over the Internet (software as a service [Buxmann et al. 2008]). As well, software firms complement telecommunication service offerings with hosting and content delivery services [Pathan/Buyya 2008].

- *Hardware firms*: Hardware firms produce hardware components and integrate them in hardware equipment. Hardware components such as semiconductors and wire products represent essential parts of all kinds of hardware equipment. Hardware equipment firms are grouped into providers of telecommunications equipment (such as routers and switches) as well as into providers of terminals (such as PCs, laptops and smartphones) and servers.

- *Telecommunication firms:* Telecommunication firms establish, operate and manage telecommunication networks. They also provide telecommunication services such as Internet access, PSTN-telephony services and short messaging services.

2.4. Service distribution in the Internet

The emergence of a multitude of services with heterogeneous requirements on the underlying transport infrastructure is a central trend in the telecommunications industry. As a consequence, latency, security and reliability in data transport gain increasing importance. Such new services can be supported by a differentiated handling of data in telecommunication networks as well as by the application of novel hosting and caching technologies. For the implementation of a differentiated data delivery across network boundaries, not just technological but also economic barriers need to be removed. Both are subject to discussion in the following subsections.

2.4.1. Quality degradation effects in telecommunication networks

Due to the ongoing global diffusion of the Internet as well as increasing broadband capacities the requirements on data transport are subject to change. Traditional applications and services such as Email or web browsing demand relatively low data rates and are robust to marginal delays in data transmission. With the introduction of real-time services with high data volumes, such as IPTV, video streaming, video telephony and online gaming, quality requirements of consumers and content providers have increased significantly [Brenner et al. 2007; Jay/Plückebaum 2008]. Figure 2-3 characterizes selected Internet services with respect to quality sensitivity and data rate.

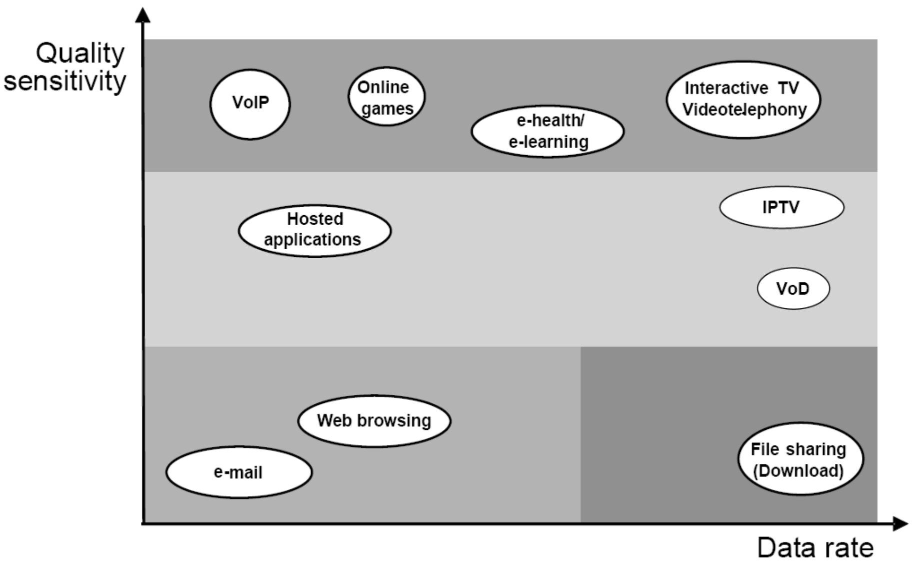

Figure 2-3: Quality sensitivity and data rates of selected Internet services [Brenner et al. 2007]

Disruptions in data transport can, due to the increasing usage of the Internet infrastructure by companies and public institutions, have severe consequences. Companies and public institutions more and more make use of infrastructures and business process support systems via remote access over the Internet in order to save capital and operational expenses [Repschläger/Zarnekow 2011]. Internet breakdowns therefore directly interfere with economic productivity. The economic stability and technological robustness of the Internet are becoming increasingly important [Agapi et al. 2011].

Data packets in the Internet are handled in accordance with the so called best-effort principle [Clark/Fang 1998]. Packets are treated equally regardless of service specific quality requirements. In the event of a buffer overflow at a router, packets are dropped without taking into account the specific service and usage context. Outages in the Internet can be caused by router misconfigurations, IP routing failures and physical link failures [Agapi et al. 2011; Katz-Bassett et al. 2008].

The effect of a transport disruption is dependent on the quality sensitivity of a service or application. Whereas the effect on P2P-filesharing services or emails might be low, a disruption most likely impedes further usage of real-time services such as video telephony. Figure 2-4 schematically depicts the willingness to pay (WTP) for three Internet services with different quality sensitivities in relation to the degree of traffic load in the Internet. At the traffic level X_S, the transmission quality does not affect any of the three services. At the traffic level X_Z, only the service with the lowest quality sensitivity (D_1) does not suffer, whereas the service with the highest quality sensitivity (D_3) is not consumed any more.

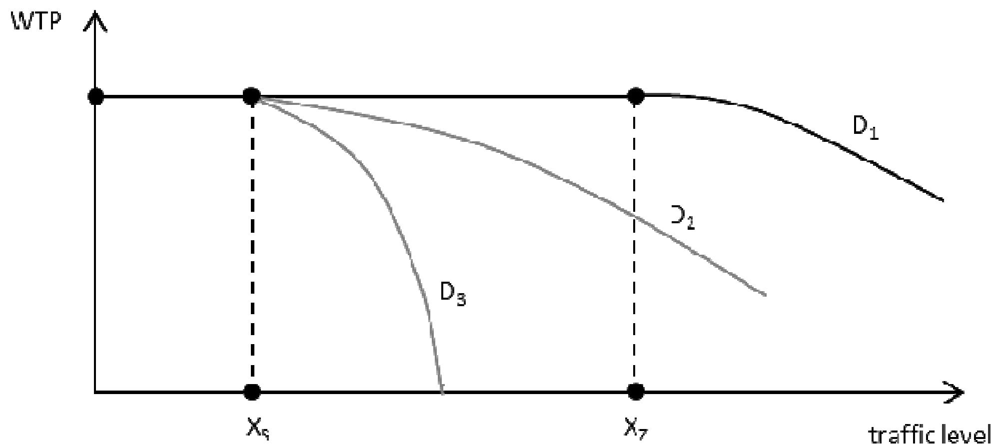

Figure 2-4: Reduction in Quality-of-Service with increasing traffic load in the Internet [Brenner et al. 2007]

Due to the best-effort principle, different services compete for one and the same capacity. This situation potentially causes so called crowding-out effects [Kruse 2010]: In the event of capacity bottlenecks real-time services are blocked out by asynchronous services, which are not affected by the decrease of transmission quality. The unhindered growth of asynchronous services with high data volumes such as P2P-filesharing and buffered video streams increases the likelihood of capacity bottlenecks and therefore potentially endangers the realization of real-time services.

2.4.2. Definition of Quality-of-Service and quality classes

In order to avoid quality degradation and crowding-out effects, different strategies and technologies are applied, which are subsumed under the notion of QoS. In telecommunications research, the term QoS is used heterogeneously to describe concepts of service quality [Wulf/Zarnekow 2010c]. As discussed by Gozdecki et al. [2003], the term QoS is used to describe the customer's service quality assessment (ICT service quality), technical parameters of service performance (technical service levels) as well as data transmission performance metrics (QoS in the narrower sense). Externally, i.e., in the relationship between service provider and user, service quality stands for the general comparison of inherent service characteristics as expected and perceived by users. Internally, i.e., among parties involved in service production, the service performance comprises all performance related parameters of a service described in technical terms (technical service levels), such as response and transaction times, availability and reliability. These parameters are affected by the inter-working of server, distribution, and client systems. QoS in the narrower sense has two typical characteristics [Xiao/Ni 1999; Zarnekow 2008c; Zhao et al. 2000]:

- The *ability to differentiate* individual services within a network and treat them differently.
- The *allocation of quality parameters*, which are generally agreed upon in advance, to services.

Throughout this work, QoS is understood as the capability to define quality requirements for specific services and to treat services differently according to the predefined requirements. QoS can be characterized by the data transmission performance parameters bandwidth, delay, packet loss, and jitter [Zarnekow 2008c; Zhao et al. 2000]. The bandwidth defines the effective volume of data per time unit being transmitted between communication end points. The delay comprises the length of time that a data package takes from the sender to the recipient. Packet loss defines the number of data packets that are lost in the transmission from the sender to the receiver. Jitter describes the fluctuation in the delay. Figure 2-5 summarizes the interrelationships between Quality-of-Service, Technical Service Levels and ICT Service Quality.

From a technical perspective, QoS can be clearly defined by specifying bandwidth, latency, jitter and packet loss. However, consumer requirements base on a subjective perception and often cannot be defined and metered with quantitative measures. Consumer requirements must be translated by the transport provider into technical QoS parameters. A key issue in QoS research is to determine what is considered as satisfactorily for specific ICT services.

The relationship of ICT service quality, also referred to as Quality-of-Experience (QoE) in telecommunications research [ITU 2007; Kilkki 2008; Van Moorsel 2001], and QoS is largely unknown and subject to ongoing research. For few ICT services, such as voice and multimedia services, some authors analyze the contribution of QoS parameter values to the overall quality [Ghinea/Thomas 1998; Reichl 2007]. Nevertheless, up to the present, a generally accepted framework on how QoS parameters influence the components of ICT service quality has not been established.

Figure 2-5: Quality-of-Service and ICT Service quality [Wulf/Zarnekow 2010c]

An individual translation and negotiation of QoS-parameters is overly complex. For this reason, QoS methodologies base on class of service concepts [Marchese 2007, 5-8; Gozdecki et al. 2003]. Class of service concepts define bounds for the QoS parameters to precisely describe what is considered an appropriate quality for specific service classes such as interactive or multimedia services. Data packets of a specific QoS class are forwarded by the network provider in such a manner that class specific QoS requirements are met. Table 2-3 provides an exemplary class of service concept.

Regularly, data transport involves the interconnection of various network providers. Since the end-to-end quality is dominantly influenced by the weakest performing operator in the transport chain, the noncompliance of a single operator impedes end-to-end QoS assurances. It therefore must be ensured in the course of the handover of data at the network boundaries, that the classification of a data packet into a QoS class remains unmodified. In order to enable QoS across network boundaries (end-to-end QoS), network providers must agree on a standardized class of service concept as well as charging mechanisms, which incentivize the compliance to QoS assurances [Briscoe/Rudkin 2005].

Quality class	Typical services	Technical QoS parameters	
Interactive	Voice Telephony / Conferencing Video Telephony / Conferencing Online-Gaming Interactive TV Feedback	Bandwidth: Delay (one way): Jitter: Packet Loss:	16 – 500 Kbps 100 – 200 ms < 30 ms < 1 %
Multimedia	Broadcast TV Video on Demand Streaming Audio Internet Radio Voice Messaging	Bandwidth: Delay (one way): Jitter: Packet Loss:	384 Kbps – 14 Mbps 400 – 1000 ms < 1000 ms < 0.1 %
Critical	Business Applications e.g., SAP, eHealth	Bandwidth: Delay (one way): Jitter: Packet Loss:	16 Kbps – 16 Mbps 100 – 200 ms < 100 ms < 0.1 %
Best Effort	E-Mail Web-Browsing P2P Internet Downloads	Bandwidth: Delay (one way): Jitter: Packet Loss:	up to line rate < 2000 ms n.a. n.a.

Table 2-3: Exemplary class of service concept [Brenner et al. 2008]

2.4.3. Approaches for supporting Quality-of-Service in data transmission

The current practice to avoid capacity bottlenecks is the over-provisioning of capacities which is oriented at the peak loads. Network capacities are expanded as soon as the load factor at peak times reaches a critical threshold. As a consequence, the provided capacity often is many times higher than the average data load [Menth et al. 2009]. Figure 2-6 schematically depicts excess capacity as a function of capacity demand and supply in the case of over-provisioning.

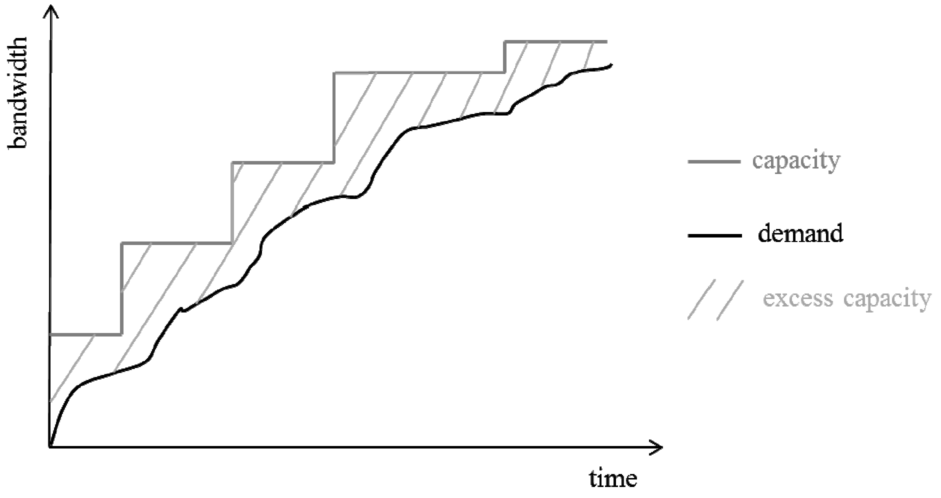

Figure 2-6: Capacity demand and supply in the case of over-provisioning

Due to the increasing usage of video-on-demand or IPTV services, which address private consumers and which demand high data volumes, the ratio of average to peak traffic is decreasing. This trend is exemplarily demonstrated with data of overall traffic at the German Commercial Internet Exchange (DE-CIX) in Figure 2-7. As a consequence to the decreasing average-to-peak-ratio, there is a growth in capacity provided and a decrease of the load factor.

In order to achieve higher load factors and high infrastructure efficiency without affecting quality-sensitive services, two alternative technological approaches are discussed: capacity reservation and traffic prioritization [Jay/Plückebaum 2008; Zarnekow et al. 2007].

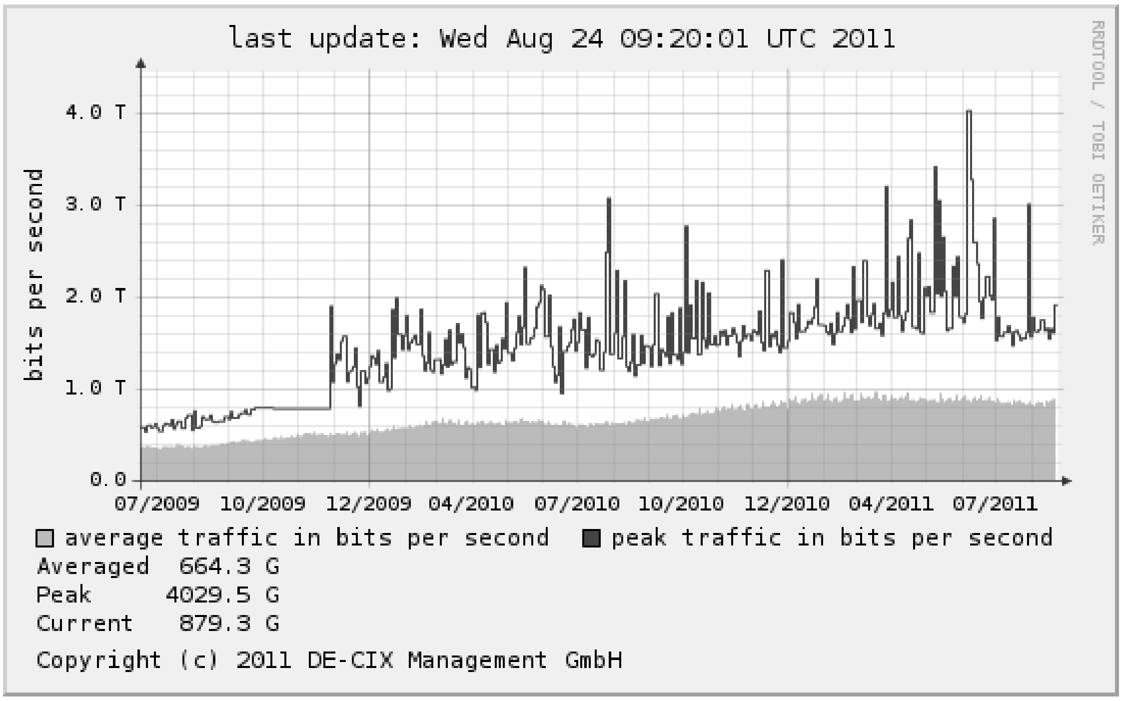

Figure 2-7: DE-CIX average traffic and peak traffic 07/2009-07/2011 [DECIX 2011]

Capacity reservation refers to the routing of traffic in dedicated or virtual tunnels. A widely accepted standard for capacity reservation is the Integrated Services (IntServ) [Braden et al. 1994] standard in combination with the Resource Reservation Protocol (RSVP) [Braden et al. 1997]. Through IntServ/RSVP, fixed resources are allocated to an end-to-end route for the duration of a connection in accordance with the quality requirements and a traffic specification, which must be provided in advance. Whereas this approach allows the assurance of absolute quality guarantees, the implementation of IntServ/RSVP is considered to be highly complex, poorly scalable and expensive [Zarnekow et al. 2007]. This is mainly due to the fact that, for each communication, a reservation must be sustained at each router of the path.

In traffic prioritization, Internet services are classified with a predefined classes of service concept. The data packets of a service are treated with a priority, which is predetermined by the allocation to a class of service [Marchese 2007, 5-8; Gozdecki et al. 2003]. On the technical level, traffic prioritization is realized by using different queues for each quality class at each router [Jay/Plückebaum 2008]. Data packets are assigned to a queue based on the information on their QoS class (classification). Queues of a higher priority class are preferentially processed (scheduling). Classification and scheduling in the case of traffic prioritization are depicted schematically in Figure 2-8.

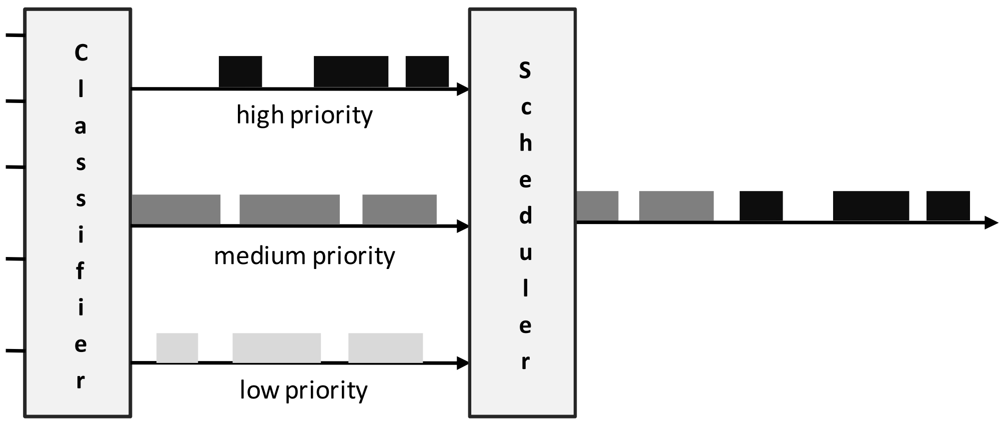

Figure 2-8: Classification and scheduling in the case of traffic prioritization [Jay/Plückebaum 2008]

Individual technical QoS parameters are only assured with a statistical probability. Traffic prioritization does not allow absolute QoS guarantees, because network overloads are not precluded. For the technical realization, the Differentiated Services (DiffServ) standard is used [Nichols et al. 1998]. DiffServ uses 6 bits in the IP-header (Differentiated Services Code Point), which theoretically allows the differentiation of 64 classes. Traffic prioritization, in contrast to capacity reservation, is scalable because classification is carried out at the ingress routers and no status information must be kept at the routers.

Capacity reservation and traffic prioritization as well require the employment of excess capacities. But since, in contrast to over-provisioning, additional QoS management functions are in use, higher load factors are enabled. None of the three technologies is generally considered more efficient for the support of QoS in the Internet. The specific costs of a QoS technology are influenced by the network architecture, the bandwidth required and the structure of the Internet traffic. In comparison to over-provisioning, however, traffic prioritization is considered to cause a significant decrease of production costs in many application scenarios [Rodriguez de Lope et al. 2008].

2.4.4. Quality-of-Service interconnection

Many network operators provide QoS-based IP services within the boundaries of their networks and operate IP networks with QoS in parallel to their Internet infrastructure. For instance, IPTV services can be realized with dedicated capacity in the access network. In order to guarantee end-to-end quality across network boundaries, network interconnection must support packet differentiation with multiple transport classes. The implementation of QoS across network boundaries requires the negotiation of dedicated interconnection agreements between network operators (QoS interconnection) [Briscoe/Rudkin 2005; Hwang/Weiss 2000].

The design of a payment regime, which determines the direction of financial flows, is a central and controversial issue in the course of the implementation of inter-provider QoS. Interconnection charges, in combination with end user charges, represent a fundamental component of Internet pricing [Laffont et al. 2003]. Economic research on Internet pricing emphasizes its influence on network and economic efficiency [Falkner et al. 2000]. Network efficiency is determined by the utilization levels of network resources. Pricing is considered a means to improve or optimize network efficiency by influencing demand in order to increase overall utilization [Gupta et al. 1999]. Economic efficiency describes the overall utility level of network operators and customers. If the demand for capacity exceeds the supply, pricing is a means to improve or optimize economic efficiency by supporting a preferential treatment of data which provides a high utility [MacKie-Mason/Varian 1995a]. Apart from supporting traffic differentiation, pricing is acknowledged to set incentives for network investments in order to increase capacity. As argued by MacKie-Mason and Varian [1995b] as well as Valletti and Cambini [2005], pricing plays a pivotal role in signaling to expand capacity where it improves economic efficiency.

Interconnection in the current Internet bases on the Bill-and-Keep (BAK) regime. In this regime, network operators with mutual interests exchange traffic without payments (peering) [Faratin et al. 2007; Norton 2002a]. A peering partner, which hands over traffic, is not viewed as the customer of termination services. For this reason, the termination is paid for by downstream customers, which receive the traffic (bill). Revenues generated by a peering partner through connecting upstream customers are not passed on (keep). In an interconnection without mutual interests a network service provider pays the interconnection partner for forwarding its data to the rest of the Internet and for delivering data (IP transit).

With the introduction of all-IP networks, alternative interconnection regimes are discussed [Vogelsang 2006]. In contrast to BAK, alternative interconnection regimes are oriented at the usage of network elements (Element-based Charging) or the capacity required in peak times (Capacity-based Charging). In contrast to BAK, such regimes require the exchange of payments. With regard to the direction of payments in interconnections, one differentiates between Sending-Party-Pays (SPP) and Receiving-Party-Pays (RPP). In an SPP regime, the initiating party pays for the end-to-end data transport. The transport fees cascade along the data stream. In an RPP regime, the receiving party pays for the end-to-end data transport. The transport fees cascade in the opposite direction of the data stream.

Dodd et al. [2009] argue that BAK is only suitable for situations in which the distribution of costs among the two peering network operators aligns exactly with the distribution of benefits between the initiating and the receiving party. As a consequence, the efficiency of a payment regime depends on service specific demand and cost conditions. Figure 2-9 schematically depicts how the distribution of costs and benefits determine the efficiency of a payment regime. If the share of benefits of the initiating party is higher than the share of costs of the originating party, SPP is considered efficient. If the share of benefits of the receiving party is higher than the share of costs of the terminating party, RPP is regarded more suitable.

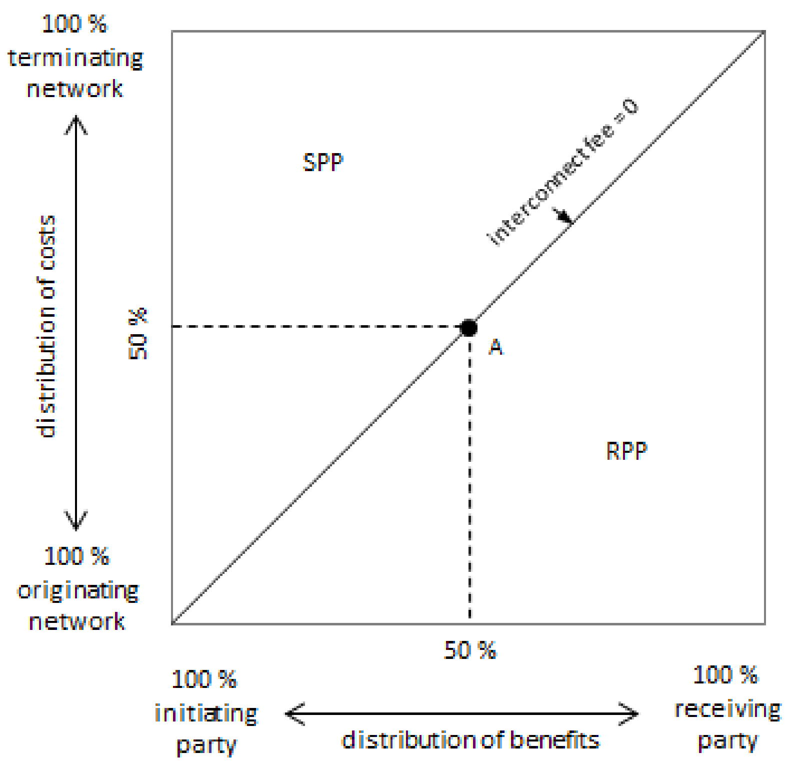

Figure 2-9: Retail benefits and network costs as determinants of payment regime efficiency [Dodd et al. 2009]

The argumentation by Dodd et al. [2009] is subject to some limitations. If there are repeated interactions or direct compensations between the initiating and the receiving parties, efficient message exchange can be achieved regardless of the payment regime in place. Furthermore, the model only applies for the direct interconnection of the terminating and originating network. The inclusion of additional network operators, which provide transit services, leads to a higher model complexity and potentially alters the model outcomes.

In spite of these limitations, the argumentation by Dodd et al. [2009] motivates a flexibilization of payment regimes. Advanced charging capabilities in IP networks and the broadening scope of IP services promote the adoption of service-oriented charging approaches. In the context of QoS interconnection, several authors advocate the introduction of an SPP regime [Briscoe/Rudkin 2005; Dodd et al. 2009; Kruse 2008]. Kruse [2008] argues that in the BAK and RPP regimes there is no guarantee that the receiver is willing to pay for QoS data delivery. In contrast to BAK and RPP, SPP facilitates the assurance of QoS payments. It also provides strong incentives against socially undesirable traffic such as spam [Briscoe/Rudkin 2005, Dodd et al. 2009]. This is due to the fact that SPP is the only payment regime, in which the receiving party does not need to pay for undesired traffic and the initiating party is burdened with the transport costs.

2.4.5. Content delivery networks

As an alternative to QoS, hosting and caching technologies are employed in order to improve technical service levels for service distribution. Most notably, CDNs account for significant shares of the overall Internet traffic. As stated by Labovitz et al. [2009], CDN providers produce over 10% of the inter-domain traffic in the Internet. The CDN provider Akamai [2011] even claims to carry as much as 20% of the overall Internet traffic on its' CDN platform. Figure 2-10 depicts the evolution of inter-domain traffic percentages of the top 5 CDN providers between 06/2007 and 05/2009.

A CDN is a network of interconnected servers that are distributed around the Internet [Buyya et al. 2008]. CDNs can be defined as *trusted overlay networks that offer high performance delivery of common Web objects, static data, and rich multimedia content by distributing content load among servers that are close to the clients* [Pallis/Vakali 2006]. Modern CDNs are capable of handling a large variety of data, not only static web content, but also multimedia content and interactive applications. The objective of CDNs as articulated by [Pathan/Buyya 2008] is to *improve network performance by maximizing bandwidth, improving accessibility and maintaining correctness through content replication.* Through the distribution of content to cache servers, which are located in geographical proximity to consumers, CDNs improve response times, the reliability of content delivery and the availability of content. CDNs indirectly also have an influence on QoS attributes such as latency, jitter and packet loss, because delivery routes are shortened.

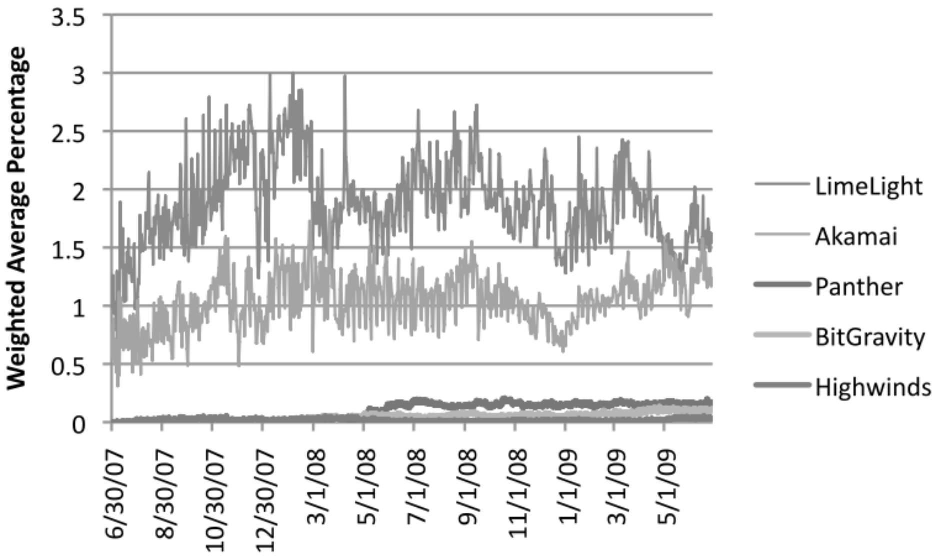

Figure 2-10: Largest CDN providers' traffic percentages of the inter-domain traffic in the Internet [Labovitz et al. 2009]

From a technological perspective, CDNs can be differentiated by their structural characteristics, their strategies for content and distribution management and their request routing system [Pathan/Buyya 2008]. The *structural characteristics* are the degree of integration with the network, the servers used, the relationships between the constituent components, protocols employed to coordinate the interaction of CDN elements and the type of content supported:

- Regarding the *degree of integration between the CDN infrastructure and the telecommunication network*, one differentiates between overlay CDNs and network CDNs. In overlay CDNs, application-specific servers and caches are exclusively responsible for content distribution. In network CDNs, routers and switches play an active role by identifying and forwarding content requests according to predefined policies.

- There are two *types of servers* used in CDNs. Origin servers host the original content resource. Replica servers only hold copies of content but may serve as reference for communication with consumers. An origin server, for updating content, communicates with the replica servers.

- The *relationships between structural CDN components* determine how replications are produced and how caching is carried out. A client may communicate with a surrogate server or directly with the origin server. In order to route client requests network elements can be employed. Proxy caches, which are application level network services, additionally can be used and organized in arrays or meshes.

- *Interaction protocols* for CDNs are used in the communication of network elements, such as load-balancing routers, as well as of caches (e.g., Network Element Control Protocol, Web Cache Control Protocol, Cache Array Routing Protocol, Internet Cache

Protocol). These protocols define the types and formats of messages, which are exchanged for coordinating request-routing or for inter-cache communication.

The strategies for *content distribution and management* cover the placement of surrogates, content selection and delivery, content outsourcing as well as cache organization [Pathan/Buyya 2008].

- *Surrogates* can either be placed within the network of a single ISP or in the networks of multiple ISPs. Placement strategies aim to balance end-to-end response times and the bandwidth required to transfer replicated content.
- Strategies for *content selection and delivery* determine how content is distributed from the origin to replica servers. They must balance download times and server loads. It is either an option to outsource the entire set of objects to replicas or to only select partial sets based on specific content selection approaches.
- The choice of an *outsourcing practice* specifies how the content is delivered from the origin to the replica servers. Content can either be actively forwarded by origin servers (push-based approach) or demanded by the replica servers (pull-based). Furthermore, replica servers may or may not cooperate to deliver the content in the case of cache misses.
- *Cache organization* includes caching techniques as well as the frequency of cache updates. Caching techniques determine how information on the location of content is managed and how caches cooperate in order to deliver content. Cache update strategies define how the consistency and freshness of the content stored by a caches is ensured.

The request routine system is responsible for routing client requests to surrogate servers [Pathan/Buyya 2008]. Request routing algorithms select a cache server for content delivery either taking into account server loads and network congestion or by using non-adaptive approaches. Request-routing mechanisms are primarily responsible for informing the client about the server selected for outbound delivery.

Clients, in addition to servers, can also be used for the storage of replicated content and outbound delivery. For this task, clients are organized in so called Peer-to-Peer (P2P) networks [Androutsellis-Theotokis/ Spinellis 2004; De Boever 2007; Kwok et al. 2002]. P2P networks can be defined as *distributed systems consisting of interconnected nodes able to self-organize into network topologies with the purpose of sharing resources such as content, […] without requiring the intermediation or support of a global centralized server or authority* [Androutsellis-Theotokis/Spinellis 2004]. In contrast to server based CDNs, P2P networks are decentralized and do not particularly aim at improving distribution performance [Pathan/Buyya 2008]. Whereas in CDNs, the number of replication servers is relatively stable, the number of peers in P2P networks is subject to high volatility. P2P networks are primarily used to locate and efficiently distribute files in the case of high traffic volatility as well as to manage heavy traffic. CDN and P2P technologies are increasingly integrated in hybrid approaches in order to combine the high distribution quality of CDNs with the cost effectiveness of P2P Distribution systems [Ha et al. 2010].

From an economic perspective, CDNs significantly impact the market for Internet connectivity by accounting for a large amount of traffic. Hau et al. [2011] analyze how the presence of CDNs changes the access provider's ability to extract rents from content providers. It is shown through a simplistic model, that the emergence of CDNs creates the possibility for access providers to charge monopolistic prices. As a consequence, the growth of CDNs potentially brings about a shift of rents from consumers and content providers to access providers. Hau et al. [2011] further argue that the possibility for traffic differentiation does exist in the Internet, regardless of the introduction of QoS technologies, and does not inevitably lead to adverse effects in the connectivity market. The shift of revenues potentially fosters access network investments. But a monopoly situation potentially also motivates adverse behavior of monopolistic access providers, such as the degradation of standard peering quality.

From an internal resource-based perspective, the CDN market represents a potential field of business for network operators [Chappell 2009]. Many network operators include CDN offerings in their service portfolio [Rayburn 2011]. This is partially due to the existence of synergies between network operation and CDN provisioning [Wulf et al 2010a]. The ownership of backbone (1) and access networks (2) as well as the relationships to end customers (3) and content providers (4) represent potential sources for such synergies.

The established network of interconnections of network operators in combination with a *global network* reach (1) represents a strategic resource to enable high quality content delivery. In contrast to pure CDN providers, network operators are to a smaller degree dependent on bandwidth from third party network operators. Higher traffic rates within their core network potentially cause scale effects through lower marginal unit costs. Network ownership also represents a basis for network monitoring capabilities. The awareness of traffic bottlenecks and information about optimal routes is a prerequisite for efficient content delivery and almost exclusively in the possession of network operators [Poese et al. 2010]. The ownership of network infrastructures additionally allows the implementation of content request routing mechanisms into routers and switches. Such routing mechanisms are on a large scale only realizable by network operators and potentially provide advantages to the overlay routing approach applied by pure CDN providers. The strategic value of network ownership for CDN provisioning is largely determined by the specificity of the ability to carry out network monitoring and network based routing. The positive effect of backbone network ownership on CDN provisioning may, moreover, be substituted by the application of caching mechanisms, which also have the objective to allow high delivery quality under economies of scale. This strongly depends on application characteristics such as real-time and bandwidth requirements.

The ownership of the *access network* (2) represents a critical capacity bottleneck in content delivery [Hau et al. 2011]. Hence, the control over access networks including information on current traffic load is potentially of strategic value to CDN providers. In addition, network operators own collocation facilities and in some cases also server and caching infrastructures in strategic network locations which they can make use of for CDN provisioning. In most countries, however, third party providers are granted the usage of access networks and facilities at regulated prices.

The established *relationship to end customers* (3) for Internet access is a potential basis for the realization of economies of scope in content delivery. The marketing of access-content bundles in combination with charging and billing proposes a significant value to content providers. As it is very time and cost intensive to establish end customer relationships, it particularly represents a valuable resource to content providers not well established in the market.

The established *relationship to content providers* (4) potentially also represents a strategic resource with respect to the network operators' CDN activities. Most network operators already maintain relationships to content providers by offering services such as IP transit and additionally own well known brands. A CDN offering complements network operators' service portfolios and opens up opportunities for up- or cross-selling activities. Established content provider relationships in combination with a well established brand therefore lowers the barriers for network operators to enter the CDN market.

3. Value production strategies of telecommunication companies in the ICT industry

One central component of the research conducted in the course of this dissertation addresses convergence in the ICT industry and the analysis of its impact on value production strategies of telecommunication companies. A special focus lies on the identification of business opportunities and risks as well as on the derivation of strategic recommendations for telecommunication companies. *Table 3-1* provides an overview of the individual publications, which are included in this section.

Title	Published in	Reference	Section
How do ICT firms react to convergence? An analysis of diversification strategies	Proceedings of the 19th European Conference on Information Systems (ECIS 2011)	[Wulf/ Zarnekow 2011a]	3.1
Softwarebezogene Wertschöpfung im Wertschöpfungsnetzwerk der Informations- und Kommunikationsindustrie	Proc. of Multikonferenz Wirtschaftsinformatik (MKWI 2010) (Best Paper Award)	[Wulf/ Zarnekow 2010a]	3.2
Cross-sector competition in telecommunications - an empirical analysis of diversification activities	Business & Information Systems Engineering (BISE), Issue 5/2011	[Wulf/ Zarnekow 2011b]	3.3
Specifying Enabling Services in Telecommunications Service Systems	15th Americas Conference on Information Systems (AMCIS 2009)	[Wulf et al. 2009a]	3.4

Table 3-1: Publications addressing value production strategies in the ICT industry

Section 3.1 addresses the general impact of convergence on the ICT industry and analyzes how convergence influences the performance of diversifying firms. Section 3.2 is dedicated to the role of software-related value creation and analyzes the interdependencies of adjacent ICT sectors and the software sector. Section 3.3 focuses on cross-sector competition in the telecommunications sector and assesses diversification strategies of telecommunication firms in neighboring ICT sectors. In Section 3.4 a methodology for the specification of preliminary services is presented, which are offered by telecommunication companies to explore cross-sector business opportunities.

3.1. How do ICT firms react to convergence? An analysis of diversification strategies

Title	How do ICT firms react to convergence? An analysis of diversification strategies
Authors	Jochen Wulf (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Proceedings of the 19th European Conference on Information Systems (ECIS)
Research objectives	- Identify and distinguish strategies of ICT firms which are exposed to industry convergence - Assess diversification objectives of ICT firms under convergence - Analyze the interrelationship of convergence, firm diversification and firm performance
Methodology	- Analysis of segment associations based on segment profiles of 7832 ICT firms - Operationalization of convergence through segment betweenness centrality - OLSQ regressions with convergence and diversification operators as well as measures for synergy and allocation efficiency
Results and implications	- Diversification represents a strategy often adopted by ICT firms under convergence - Degree of *convergedness* of market segments influences the value of resources and capabilities of diversified firms - Diversification not generally superior to alternative convergence strategies (e.g., concentration, cooperation)

Table 3-2: Summary of [Wulf/Zarnekow 2011a]

Convergence represents a dominant force in the evolution of the ICT industry. In converging industries, the identification and analysis of strategies to efficiently leverage firm resources and to configure firm cooperation represents a challenging task. Diversification is considered a central firm strategy with regard to convergence. Former research has mainly focused on the phenomenon of ICT convergence per se. In this article, we analyze how ICT firms react to convergence. Network analysis techniques are applied to assess the degree to which ICT market segments are exposed to convergence. Based on this assessment, we evaluate firm diversification strategies in the case of convergence with a focus on diversification objectives and firm performance. The data analysis provides two major implications. Firstly, convergence creates synergy potentials for diversifying ICT firms. Secondly, diversification does not generally allow ICT firms, which are exposed to convergence, a more efficient application of resources. The research objectives, methodology and results are summarized in Table 3-2. Even though the term convergence is often cited in ICT research, empirical analyses addressing ICT convergence and firm strategies are rather scarce. This work provides such an analysis by applying a novel research approach based on network analysis.

3.1.1. Introduction

The ICT industry is subject to strong dynamics. Industry evolution is influenced by product and process innovations [Utterback/Abernathy 1975]. Technology and product innovations regularly lead to discontinuities, which potentially render strategic firm resources useless [Henderson/Clark 1990]. Industry convergence is a special type of industry evolution, which effects formerly unrelated industries in parallel and leads to an alignment of the industries' target markets [Yoffie 1996; Katz 1996]. Industry convergence is a widely acknowledged phenomenon, particularly with respect to the ICT industry [Farber/Baran 1977; Collis et al. 1997]. In spite of the maturity of this phenomenon in research, the continuous strategic alignment to dynamics in the ICT industry, which are caused by convergence processes, remains a challenging issue for ICT firms.

A current example for the importance of convergence strategies for ICT firms is related to the diffusion of smart-phone applications. A multitude of such applications represent substitutes for traditional products and services such as telephony, messaging, car navigation, gaming, and digital cameras. Incumbent service providers, which are threatened by these offers, react in different ways: some develop smartphone applications themselves and break up their vertical integrated business model. As an example, the car navigation service provider TomTom, which traditionally offers navigation devices, now provides a navigation app for the iPhone. Others leverage their established distribution channels by entering into strategic coalitions with smartphone providers, such as AT&T with Apple, and try to secure revenues for their traditional services. A third strategy is to diversify products in order to stay competitive. The gaming console provider Nintendo for example included Internet browsing features, a camera, and multiple software applications into its product Nintendo DS.

It is a challenge for practitioners and researchers to identify and analyze effective strategies which guarantee a sustainable competitive advantage under convergence effects. The strategic placement in ICT firm networks for a joint service provisioning, standards setting, and resource development [Gulati et al. 2000] determines the competitive position of firms. Here, convergence researchers highlight two contrasting strategies: diversification and concentration [Katz 1996; Gambardella/Torrisi 1998; Pennings/Puranam 2001]. Diversification under convergence potentially allows the realization of synergies [Gambardella/Torrisi 1998]. Concentration is associated with high resource efficiency [Katz 1996].

Empirical research on ICT convergence focuses mainly on the phenomenon of convergence per se and scarcely addresses convergence related firm strategies and objectives. To fill this gap, this research studies diversification strategies. We analyze whether diversification represents a widely pursued strategy to address convergence. Moreover, the objectives of diversification are analyzed and implications regarding the performance of diversification under convergence are drawn.

3.1.2. ICT convergence and firm diversification

Convergence in ICT

Technology innovations potentially have an impact on the consistency of industries by altering the internal competitive landscape and the external industry boundaries [Porter 1985]. If such innovations form substantial production resources for formerly unrelated industries, one speaks of technology convergence [Rosenberg 1963]. We distinguish between the convergence of technologies and the convergence of industries: if products from different industries are becoming substitutes or bundles in a single product, these industries increasingly address identical markets. This process is referred to as industry convergence [Yoffie 1996; Katz 1996]. Stieglitz [2003a] emphasizes the inequality of these two concepts: technology convergence does not inevitably lead to industry convergence. This is shown by Gambardella and Torrisi [1998] in a study on the electronics industry. Greenstein and Khanna [1997] distinguish between two forms of convergence: convergence in substitutes occurs if consumers perceive products from distinct industries as interchangeable. Convergence in complements manifests itself in a super-additive value, a bundling of products proposes to consumers.

More than 30 years ago, Farber and Baran [1977] perceived technology convergence in the computing industry and the telecommunications industry driven by the complementary application of computing and data transport capacities. As a consequence to technology convergence, several authors described the convergence of the following sectors into a single ICT industry: hardware (components and equipment), software, telecommunications, and media [Collis et al. 1997; Yoffie 1996]. Katz [1996] discussed the several strategic implications of ICT convergence: convergence stimulates competition in ICT. As a reaction, firms either diversify or establish coalitions and focus on core activities. This leads to a horizontal structuring of the ICT industry with competition taking place on the component rather than on the system level. The bundling of complementary products increases the potential for product differentiation. Additionally, convergence increases the importance of network effects and standards, because the competitive advantage of firm coalitions is significantly dependent on the extent to which cooperation partners aggregate components in integrated service offerings.

Several authors highlight three courses of action, which are central for the strategic management with regard to industry convergence: diversification, concentration and cooperation [Katz 1996; Gambardella/Torrisi 1998; Pennings/Puranam 2001]. Through diversification, firms leverage resources, which become valuable to a different industry, by extending their field of action to this industry [Gambardella/Torrisi 1998]. Through coalitions, ICT firms provide shared access to resources, which are required to address markets of convergent industries or collectively establish such resources [Basole 2009; Duysters/Hagedoorn 1998].

The analysis of empirical studies on ICT convergence and firm strategies (Table 3-3) shows that many authors do not distinguish between ICT convergence and convergence related firm strategies. The studies mostly use data on patents for the operationalization of technological convergence. As a measure for industry convergence, all authors utilize data on mergers, acquisitions, and strategic collaborations. The degree and breadth of merging, acquisition, and collaboration activities of firms is set equal to the degree of industry convergence. The studies largely ignore, that concentration on core markets also represents a possible firm strategy to confront an increase of competition due to convergence. Moreover, these approaches do not cover diversification, which is based on internal resources rather than on mergers and acquisitions

Some authors compare technology and industry convergence and mostly show that a broad technology base does not necessarily imply firm diversification on the market layer. Former studies generate heterogeneous results with respect to the presence of industry convergence. Pennings and Puranam [2001], Palmberg and Matikainen [2006] and Khansa and Liginlal [2009] provide evidence for industry convergence while Basole [2009] does not clearly identify this phenomenon and Duysters and Hagedoorn [1998] even produce contrary findings. Three studies carry out longitudinal studies and perform regressions with Herfindahl indexes of patent and M&A activities as independent variables. Pennings and Puranam [2001], Khansa and Liginlal [2009], as well as Basole [2009] apply network analysis and use network metrics such as the node cohesiveness and centrality to evaluate convergence in the ICT industry.

Author	Research Focus	Operationalization of Convergence	Operationalization of Firm Strategies	Type and Method of Analysis	Results
Duysters and Hagedoorn [1998]	- effect of technological convergence on computer and telecommunications equipment companies	- sectoral distribution of patents - sectoral distribution of alliances		- longitudinal - linear regression (dependent variable: time)	- no evidence of convergence effect
Gambardella and Torrisi [1998]	- relation of technological with industry convergence in electronics industry	- ratio of technology to downstream diversification as an indicator for convergence	- number of patents per firm and sector - number of acquisitions, subsidiaries, and collaborative agreements per firm and sector	- longitudinal - correlation and comparison of Herfindahl indexes - OLSQ regressions to analyze diversification - performance relation	- evidence of technological convergence in electronics industry - no evidence of industry convergence
von Tunzelmann [1999]	- convergence as initiator of corporate change	- sectoral distribution of patents per industry - effects of corporate changes on patent Herindahl indexes		- longitudinal - regressions of Herfindahl indexes from distribution of patent fields per industry (dependent variable: time)	- no evidence of technological convergence
Pennings and Puranam [2001]	- impact of industry convergence in the digital imaging industry	- number of mergers and acquisitions - number of strategic alliances		- longitudinal - firm relation network analysis (clique, component membership, degree centrality and density)	- growing market overlap in imaging industries
Palmberg and Matikainen [2006]	- internal and external diversification in Finnish telecom industry	- sectoral distribution of patents per industry - sectoral distribution of R&D partners per industry		- longitudinal - comparison of Herfindahl indexes of patents and R&D alliances per industry	- internal stronger than external diversification - increase in the breadth of external diversification
Khansa and Liginlal [2009]	- impact of ICT convergence on information security industry	- inter-sector M&A activities		- longitudinal - cohesiveness of M&A network	- increasing convergence in ICT
Basole [2009]	- analysis of inter-firm relations in a converging mobile ecosystem	- firm relationships (alliance, partnership, JV, buyer/supplier/customer)		- cross-sectional - comparison of network metrics of current and emerging industry segments	- no clear evidence for ecosystem convergence

Table 3-3: Overview of empirical studies on ICT convergence and firm strategies

Firm diversification- Strategies and objectives

Firm diversification represents a focal issue in strategic management. Its impact on firm performance has been subject to extensive research [Penrose 1959; Gort 1962; Ansoff 1965; Rumelt 1974; Berry 1975; Porter 1985]. Authors have addressed multiple levels of diversification including the diversification of customer segments, geographic regions, products, and tangible and intangible resources. Following Ansoff [1965, 132], we consider a firm to be diversified if it offers heterogeneous products.

The objectives of diversification depend on its type, which is determined by the customers addressed and the resources applied. *Horizontal diversification* refers to the offering of heterogeneous products over identical distribution channels. In *concentric diversification*, firms leverage the relatedness of production resources. A major objective for horizontal and concentric diversification is to realize synergies through the application of shared resources and capabilities. Synergies are rooted in the interrelationships among business units [Porter 1985, 317 – 363] and result in a market position, in which the overall market capabilities of a firm are superior to the mere sum of its capabilities in sub-segments [Ansoff 1965, 65]. *Vertical diversification* describes the situation in which a firm offers products from successional production stages of a single production chain. Vertical diversification is subsumed under vertical integration. Its objective is to gain a dominant position in value networks through the control of successional production stages [Perry 1989]. *Conglomerate diversification* refers to the offering of heterogeneous products which are unrelated in the customers addressed as well as in the resources applied. Its main objective is the diversification of overall business risk [Amit/Livnat 1988]. Albeit being subject to research for decades, the nature of the relationship between diversification and performance remains an open research issue. Studies on this relationship yield inconsistent and partly contradictory results [Palich et al. 2000].

The role of ICT in diversification research is twofold: ICT has been considered as a source of synergy [Tanriverdi 2006; Tanriverdi/Lee 2008]. Moreover, ICT is analyzed as a moderator on diversification performance [Ravichandran et al. 2009].

ICT convergence strategies - Research objectives and hypotheses

Former research has already addressed the issues of ICT convergence and firm strategies but lacks the ability to measure industry convergence and related firm strategies independently. The objective of this article is to study diversification as a strategic reaction to industry convergence in ICT. As we do not explicitly study technological convergence, convergence is always to be understood in the sense of industry convergence for the rest of this article, unless stated otherwise. For the analysis, we adopt a state oriented rather than a process oriented definition of convergence and diversification: convergence (diversification) refers to the state of being converged (diversified).

Whereas former researchers do not distinguish between convergence and firm diversification, this relationship is subject to analysis in this work. On the one hand, firm diversification is used for measuring convergence. On the other, concentration and cooperation are acknowledged as alternative firm reactions to convergence. Hence, the following hypothesis is called into question: *firms, which are directly exposed to ICT convergence, exhibit a higher degree of diversification than firms without such an exposure (H1).* As implied by Gambardella and Torrisi [1998], convergence can be regarded as an enabler of related diversification. Technology convergence broadens the applicability of resources in formerly unrelated industries. Firms, which own such resources, can therefore potentially realize synergies through diversification: *the degree of convergence, an ICT firm is exposed to, has a positive influence on the synergy potential of diversification (H2).* Lang and Stulz [1994] argue that diversified firms have the option to distribute excess resources over multiple divisions whereas single product firms can only use external markets. As a firm often has better information about its markets than external investors, an internal resource allocation potentially yields advantages over external markets. For this reason, a potential motivation for convergence related diversification is to reach a higher efficiency in the utilization of excess resources: *firms which diversify are able to realize higher allocation efficiency under the exposure to ICT convergence than firms which pursue a concentration strategy (H3).*

3.1.3. Empirical analyses

The data base used in this work was retrieved by selecting all firms from Thomson ONE Banker, which were active in at least one ICT related market segment in 2009, and consists of 7832 firms. For each firm, an entry contains up to eight four-digit SIC codes, which classify market segments.

Montgomery [1982] discussed the disadvantages of this classification scheme for diversification analyses, which are mainly due to the assumption of equidistances between SIC classes. The classification has been established based on production and market oriented differentiation criteria, which are subject to change over time. This is particularly valid for the ICT industry, in which technological production resources and markets are constantly further developed. For this reason, ICT products from the five sectors hardware components, hardware equipment, software, telecommunications, and media are not clearly allocated into groups at the three or two digit level. Therefore, the SIC is not adequate for the analysis of ICT sector diversification. To address this flaw, we manually grouped ICT related SIC codes into five sectors (Table 3-4). In order to guarantee the completeness and validity of the SIC selection and classification, the results were verified by three industry experts. The ICT sector classification serves as a basis for the analysis of firm strategies addressing ICT convergence as presented below.

Sector	Description	Examples	Market Segments (SIC Codes)
Hardware Components	production of material and components required to produce hardware equipment	-semiconductors -wire products	3671, 3672, 3674, 3675, 3676, 3677, 3678, 3679, 3691, 3692, 3694, 3695, 3699
Hardware Equipment	production of communication terminals and network infrastructure components	-computers -mobile phones -routers	3571, 3572, 3575, 3577, 3578, 3579, 3651, 3652, 3661, 3663, 3669
Software	development of software and Internet applications and value adding tasks such as training and systems design	-computer programming services -information retrieval services	7370, 7371, 7372, 7373, 7374, 7375, 7376, 7377, 7378, 7379, 7382
Telecommunications	provisioning of telecommunication services, network operation and management	-PSTN and GSM telephony -DSL Internet access	4812, 4813, 4822, 4899
Media	production and management of text, graphical and multimedia content	-publishing of newspapers -advertising services -motion picture production	2711, 2721, 2731, 2741, 4832, 4833, 4841, 7311, 7312, 7313, 7319, 7812, 7819, 7822, 7829

Table 3-4: Definition of ICT sectors

Betweenness as an indicator for convergence in the network of ICT market segments

For the identification of convergence, we study the network consisting of ICT market segments and segment associations. An association describes the relatedness of the input factors and the customer markets of the two segments and is calculated with the following measure:

$$z(a,b) = |A \cap B| / |A \cup B|.$$

A (B) represents the group of firms, which is active in the SIC segment a (b). z(a,b) describes the share, which is active in both segments, of the firms, which are active in either segment. The concept of ICT market segment relatedness bases on the theory of within-industry diversification, which explains diversification through the relatedness of resources required for production and of customer markets addressed [Li/Greenwood 2004; Tanriverdi/Lee 2008].

The SIC associations serve as a basis for the identification of convergence. The SIC codes as nodes and their associations as weighted edges form an undirected weighted network [Opsahl et al. 2010]. This network resembles a value network [Pil/Holweg 2006] in which each market segment represents a value activity which is marketed externally.

In order to study the consistency of this network, traditional network analysis techniques are applied [Freeman 1979]. The betweenness centrality of a node describes the degree to which it lies on the shortest paths of the flows between all other nodes [Opsahl et al. 2010]. It allocates high values to nodes, which lie on connection paths between two weakly connected network components. In market segment networks, a sector is a cluster of segments, which are characterized by a strong segment relatedness [Li/Greenwood 2004]. Convergence leads to a connecting of two sectors. A special importance is attached to the segments on the bridge between the two convergent sectors: products within these segments are directly or indirectly subject to substitutive or complementary product convergence. From this follows that segments which are subject to convergence are characterized by a high betweenness centrality. Under the assumption, that the ICT industry is not subject to divergence, the betweenness centrality signals the degree of convergence, a segment is exposed to.

ICT convergence and firm diversification (H1)

This section is dedicated to the testing of the relationship between convergence and firm diversification (H1). In order to operationalize the degree to which a firm is exposed to convergence effects, we utilize the betweenness centrality of market segments and define the betweenness centrality of a firm as the maximum betweenness centrality of a firm's market segments.

For the operationalization of diversification, multiple measures have been proposed: Gort [1962, 26] counts the industries a firm is active in. We use three such counting measures differentiating industries at the sector level as explained above (Table 3-4), at the SIC2, and at the SIC4 level. Jacquemin and Berry [1979] introduce an entropy measure formulating total diversification as a weighted average of intra-sector diversification plus inter-sector diversification. Caves et al. [1980, 199] introduce a measure which differentiates between diversification at the SIC1, SIC2, and SIC3 level, and allocate stronger weights to higher diversification levels. Jacquemin and Berry [1979] and Caves et al. [1980] propose to weight the products or sectors by the sales ratio in order to take into account the relative importance of the products to a firm. As this data is not available for the firms included in our analysis, we did not introduce such weights. Although this limits the explanatory power of the diversification measures, the measures do provide insights into product related firm activities. As such, they allow quantitative statements about the heterogeneity of diversification strategies, especially with regard to the issue of ICT sector diversification.

In order to study the relationship between convergence and diversification we took the firm betweenness centrality as the single independent variable and carried out five OLSQ regressions with the different diversification measures as single dependent variable. The diversification measures basing on the 4- or 2-digit SICs and the firm betweenness centrality measure are weakly related measures, because they are both derived from firms' market segment integration behaviour. In contrast, the number of sectors is not derived from market segment integration and exhibits the highest R-value. Therefore, the results do not indicate a high measure-relatedness. The results show that firm betweenness centrality indeed has a positive impact on firm diversification (Table 3-5). This suggests that firms which are exposed to convergence diversify stronger than firms without such an exposure. The regression of the sector diversification yields the most significant result compared to the regressions of the other diversification measures. A possible explanation is that the intra-class relatedness and the inter-class differences are stronger for the sector classification defined above (Table 3-4) than for the SIC at the 2-digit level.

Independent Variable[a]		Mean	Std.				
Firm Betweenness Centrality		149.162	119.513				
Information about Dependent Variable			Regression Analysis				
Dependent Variable	Mean	Std.	R^2	F[b]	Beta	T[c]	Durbin-Watson
Number of Sectors	1.256	0.514	.077	654.672*	.278	25.587*	1.950
Number of 4-digit SICs	3.140	1.919	.037	300.966*	.192	17.348*	1.781
Number of 2-digit SICs	2.407	1.650	.005	40.981*	.072	6.402*	1.776
Caves et al. (1980)	0.796	0.595	.017	133.873*	.130	11.570*	1.840
Jacquemin & Berry (1979)	2.375	2.051	.049	405.300*	.222	20.132*	1.807
[a]number of observations: 7832, [b]overall fit, [c]regressant, *p<.001							

Table 3-5: Firm diversification and firm betweenness centrality - OLSQ regressions

Synergy (H2)

In this section, the relationship between firm betweenness centrality and the ability of a firm to realize synergies (H2) is analyzed. For this analysis, only firms with a high level of diversification are taken into account. More precisely, we use the number of sectors as the diversification measure and select firms which are active in two sectors and above. We operationalize diversification synergy (SYN) by the following measures: return on assets (ROA), return on investments (ROI), return on sales (ROS), cost of goods sold to sales (CGS), net income per employee (IPE), and selling general and administrative expenses to sales (SGS). For each synergy measure, we carried out an OLSQ regression with the firm betweenness centrality (CENTR) as the independent variable and the sales (SALES) and 2 digit SIC sector memberships (SICx) as control variables (Table 3-6). The regressions have the following general form:

$SYN_i = CONST + a_1{*}CENTR_i + a_2{*}SALES_i + a_3 * SIC27_i + a_4 * SIC35_i + a_5 * SIC36_i + a_6 * SIC48_i + a_7 * SIC73_i + a_8 * SIC78_i$ where $SICx_i = 1$ if firm i offers a product in the 2 digit sector x and $SICx_i = 0$ otherwise.

Except for the regressions of costs of goods sold to sales and net income per employee, all regressions identify the firm betweenness centrality to be a significant driver of diversification synergy. This implies that diversifying firms, which are strongly exposed to ICT convergence, are able to realize stronger asset and sales specific synergies than diversifying firms, which are not exposed to convergence. The data does not verify a significant employee related productivity increase with convergence neither does it suggest a decrease. The same holds for the positive relationship of convergence and the cost of goods sold to sales.

SYN		ROA	ROI	ROS	CGS	IPE	SGS
R^2		.024	.027	.023	.032	.075	.048
F		3.180**	2.821**	2.978**	4.083***	6.904***	4.402***
No. of Observations		1027	836	1025	1004	691	705
Durbin-Watson		1.963	1.951	2.096	2.096	1.807	1.963
CENTR	Beta	.071	.065	.065	.034	.055	-.081
	T	2.202**	1.832*	2.009**	1.051	1.459	-2.128**
SALES	Beta	.063	.060	.086	-.059	.184	-.079
	T	2.035**	1.746*	2.765***	-1.877*	4.935***	-2.125**
SIC27	Beta	.029	-.030	.006	-.027	.006	.119
	T	.863	-.814	.167	-.807	.158	2.930***
SIC35	Beta	.038	.041	-.053	.081	-.071	-.007
	T	1.065	1.048	-1.485	2.278**	-1.684*	-.160
SIC36	Beta	.007	-.009	-.053	.075	-.021	-.071
	T	.180	-.206	-1.359	1.888*	-.455	-1.561
SIC48	Beta	.121	.111	.047	-.021	.132	-.059
	T	3.296***	2.738*	1.272	-.577	3.072***	-1.360
SIC73	Beta	.031	.039	-.017	-.061	.073	.020
	T	.861	.974	-.468	-1.668*	1.730*	.481
SIC78	Beta	-.049	-.065	-.043	.019	-.015	.028
	T	-1.566	-1.862*	-1.372	.610	-.389	.744
CONST	T	-3.719***	-2.612*	-1.274	20.832***	-.892	8.050
*p<0.1, **p<0.05, ***p<0.01							

Table 3-6: Diversification synergy and firm betweenness centrality - OLSQ regressions

Allocation efficiency (H3)

In this section, the allocation efficiency of diversifying firms is compared to the allocation efficiency of non-diversifying firms under the exposure to convergence (H3). For this analysis, only firms with a high betweenness centrality (of 216 and above) are taken into account. We perform regressions with the number of sectors (DIV) as the independent variable and the sales (SALES) and 2 digit SIC sector memberships (SICx) as control variables (Table 3-7). Regressions have the following general form:

$ALLO_i = CONST + a_1*DIV_i + a_2*SALES_i + a_3 * SIC27_i + a_4 * SIC35_i + a_5 * SIC36_i + a_6 * SIC48_i + a_7 * SIC73_i + a_8 * SIC78_i$ where $SICx_i = 1$ if firm i offers a product in the 2 digit sector x and $SICx_i = 0$ otherwise.

Allocation efficiency (ALLO) is operationalized by the following measures: alpha (ALPHA), Tobin's Q (TOQ), return on equity per share (ROE), return on investment (ROI), return on sales (ROS), and return on assets (ROA). The regressions only yield significant results for the efficiency measures Tobin's Q, return on sales and return on assets. Under convergence effects, diversification is generally not found to be more efficient with respect to resource allocation than concentration. The sector diversification has a significant impact on the return on assets. Since this influence is negative, one can deduce that concentration generally allows a more efficient asset allocation than diversification in the presence of convergence effects. This finding puts into question the universality of diversification as a profitable convergence strategy.

ALLO		ALPHA	TOQ	ROE	ROI	ROS	ROA
R^2		.006	.022	.023	.018	.026	.028
F		.673	3.081**	1.572	1.101	1.894*	4.921***
No. of Observations		910	1098	534	480	579	1360
Durbin-Watson		2.092	1.881	1.843	1.825	2.077	2.004
DIV	Beta	-.037	-.005	.126	-.022	.077	-.103
	T	-.782	-.112	1.981**	-.337	1.278	-2.624***
SALES	Beta	-.008	-.023	-.026	.010	.087	.003
	T	-.224	-.748	-.585	.219	2.066**	.121
SIC27	Beta	-.017	.002	-.012	.005	-.002	.048
	T	-.501	.060	-.266	.115	-.041	1.664*
SIC35	Beta	-.043	.037	-.012	.006	.052	.024
	T	-1.174	1.112	-.257	.133	1.195	.804
SIC36	Beta	.038	-.037	-.038	-.053	.012	.099
	T	1.044	-1.154	-.812	-1.062	.269	1.958**
SIC48	Beta	-.012	-.011	.061	.111	.026	.134
	T	-.311	-.307	1.134	2.027**	.511	3.349***
SIC73	Beta	.018	.134	-.089	.014	-.115	.052
	T	.446	3.628***	-1.614	.242	-2.173**	1.108
SIC78	Beta	.014	.021	.016	.020	.033	-.161
	T	.379	.659	.375	.427	.798	-5.637***
CONST	T	.085	3.645***	-.223	.852	-1.109	-.217
*p<0.1, **p<0.05, ***p<0.01							

Table 3-7: Convergence related allocation efficiency and diversification - OLSQ regressions

3.1.4. Discussion of results

The first part of the analysis focuses on diversification as a common strategic firm reaction to convergence. The results (Table 3-5) indicate that the degree, to which a firm is exposed to ICT convergence, positively influences a firm’s tendency towards diversification. There are two explanatory approaches for this relationship. As analyzed in Gambardella and Torrisi [1998] and Palmberg and Matikainen [2006], many ICT firms continually expand their technological competencies. This is merely interpreted as a necessity for guaranteeing a sustainable competitive position rather than as a preparation for diversification. Nevertheless, a multi-technology strategy [Granstrand 1998] often represents a necessary condition for the diversification of ICT firms. This is particularly the case for the development of hybrid products, which integrate characteristics of formerly unrelated products. Smartphones are exemplary hybrid products, which comprise of phone, camera, and computer functionalities. Convergence processes such as the creation of hybrid products lead to an increase of the relatedness of the underlying technological resources. Technological diversification enables to offer hybrid products in an integrated fashion. This is particularly attractive if the management of firm networks would require a high coordination effort. A good example of the two polar strategies can be found in the smartphone market: whereas Apple pursues an integration strategy for the production of the iPhone, the Open Handset Alliance, a consortium of 65 firms, jointly developed a competing open source software platform for smartphones. Whereas such an alliance provides the ability to pool resources, a vertical integration strategy potentially allows a more efficient resource development and utilization [Perry 1989; Katz 1996]. Another explanation for the convergence related diversification in ICT is related to the degree of the specificity of product market resources, such as technological resources or distribution channels. Traditional markets with highly specific product market resources are characterized by high entry barriers, which represent obstacles for firm diversification. The ICT industry is characterized by a high degree of innovation and market dynamics, which lowers the specificity of market resources required for market entrance [Henderson/Clark 1990].

The analysis of convergence related synergy effects in diversification (Table 3-6, H2) reveals significant asset specific synergies. In contrast, employee related synergies are not identified. From this it follows that quantifiable ICT specific assets play a more important role as sources of synergies in convergence related diversification than the intangible knowledge of ICT experts in the company. This conclusion must nevertheless be put into perspective, because financial reports do not provide an accurate basis for a distinguished analysis of employee related firm capabilities. In addition to asset synergies, the analysis also reveals synergies in the organizational and management related capabilities: the ratio of selling, general, and administrative expense to sales decreases significantly with an increase of firm betweenness centrality. This suggests, that convergence in ICT yields a high synergy potential with respect to operational expenses, which are not directly allocated to a specific ICT product such as marketing and engineering expenses. This is in contrast to the product specific expenses, which are not subject to convergence related synergies as expressed by the measure cost of goods sold to sales.

The comparison of the allocation efficiency of diversifying and non-diversifying firms under convergence (Table 3-7, H3) only provides a significant result with regard to return on assets: the degree of diversification is found to have a negative influence. Regarding the other measures for allocation efficiency, mixed but insignificant results are generated. This implies that diversification is in many cases not the most efficient strategy for a firm's application of ICT resources in convergent markets. Here, the focus on core markets and the formation of coalitions, in which a joint access to shared resources is provided, represent alternatives with similar or better prospects of success. Through coalitions, the synergy potential of ICT convergence can potentially be realized more efficiently than through diversification. As suggested by the formation of cooperative firm networks in ICT [Katz 1996; Basole 2009], the benefits of a resource pooling often outweigh the coordination costs in ICT coalitions.

3.1.5. Interim conclusion

The motivation for this research was the identification and discussion of convergence specific firm strategies. It was successfully shown, that diversification indeed represents a strategy often adopted by ICT firms. ICT Convergence opens up various potentials: on the ICT asset, as well as on operational ICT management layer, the exposure to convergence allows diversifying firms to realize stronger synergies. This implies that firms continually must analyze their technological resources and their operational processes with regard to changed synergy potential. We were able to show that the degree of *convergedness* of sectors influences the value of resources and capabilities of diversified firms in market segments on the bridge between these sectors. Dependent on the degree of industry dynamics, this value is subject to change over time. Nevertheless, the analyses also suggested that diversification is not generally superior to alternative convergence strategies. Having identified a new synergy potential, firms therefore must carefully consider the consequences of diversification as opposed to cooperation and concentration strategies.

As a main difference to prior research, the presented approach allows to differentiate between industry convergence and firm strategies. The identification of convergence based on network characteristics allows to distinguish strategies under convergence and to further analyze them. As such, this approach represents a novel method for analysing convergence. Following prior research on ICT diversification [Khansa/Liginlal 2009, Basole 2009] network analysis is applied to study the network of market segments in the ICT industry. The authors newly introduce the application of measures to analyze weighted networks [Opsahl et al. 2010]. Node betweenness centrality is used as a measure for sector convergence in the ICT industry. In doing so, we assume that sectors are characterized by strong market segment relatedness. We adopt a purely state oriented view on convergence and are not able to capture industry dynamics. However, the stationary convergence measure quantifies the degree to which a market segment bridges the divide between sectors and as such describes the degree to which a market segment is exposed to sector convergence. The inclusion of longitudinal data could strengthen the results and further allow the identification of sector specific differences.

In diversification research, the identification of synergies represents a widely discussed research issue [Palich et al. 2000]. A main achievement of this study is the identification of such synergies in the context of ICT convergence. Moreover, even though the term convergence is often cited in ICT research, there is a research gap regarding the relationship of convergence and firm strategies in ICT, which has been addressed in this article.

This research focused on ICT specific markets and did not take into account the firms' activities in other markets. Even though this limits the explanatory power of the results received, it allowed the deduction of ICT specific conclusions. The formation of strategic coalitions represents a second alternative convergence strategy discussed by many researchers. The analysis of such coalitions would potentially yield complementary results. Another follow-on research issue addresses the determinates of a successful diversification under convergence. Diversification success is potentially influenced by characteristics of the specific sectors (such as resource similarities) or firm specific attributes (such as its absorptive capacity).

3.2. Software-related value creation in the value creation network of the ICT industry

Title	Softwarebezogene Wertschöpfung im Wertschöpfungsnetzwerk der Informations- und Kommunikationsindustrie – Eine empirische Analyse
Authors	Jochen Wulf (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Multikonferenz Wirtschaftsinformatik 2010 (Best Paper Award)
Research objectives	- Analyze the interrelationship of software specific value activities with value activities of firms from other industries - Assess the position of software firms in ICT value networks consisting of firms from the hardware component, hardware equipment, telecommunication, software and media industries - Evaluate the degree of dependency of other industries on the software industry
Methodology	- Analysis of industry associations based on industry segment profiles of 34142 firms listed in the database Thomson ONE Banker - Contingency analyses in order to evaluate the positioning of the value segment software in the ICT value network - Interdependency analyses to assess the interrelationship of the software segment with other value segments
Results and implications	- Software firms play important roles in value networks of ICT firms - Strong mutual dependency between the value segments software and hardware equipment - Unilateral dependencies of the value segments telecommunication and media on the software segment

Table 3-8: Summary of [Wulf/Zarnekow 2010a]

In [Wulf/Zarnekow 2010a], the theory of value creation networks and its application to the ICT industry is presented. Subsequently the consistency of the ICT value creation network is analyzed by means of a cluster analysis in order to specify the scope of value activities relevant for ICT firms. In order to verify qualitative statements on the role of software firms in the ICT industry, the position of the value creation segment software in the ICT value network is analyzed. The results confirm the central position of the value creation segment software in the ICT value network. The findings show strong mutual dependencies between the value segments software and hardware equipment. Furthermore, the results reveal unilateral dependencies of the value segments telecommunication and media on the software segment. Table 3-8 provides a summary of this publication. This article was originally published in German and a translation into English was refrained from.

3.2.1. Einleitung

Netzwerkphänomene wurden in der ökonomischen Forschung vielfach untersucht. Ein Großteil der Arbeiten fokussiert dabei auf Unternehmensnetzwerke. Diese bestehen aus zwischenbetrieblichen und häufig langfristigen Verbindungen von Unternehmen, die kooperativ Wert schöpfen [Norman/Ramirez 1993; Gulati et al. 2000; Jarillo 1988]. Hierbei steht im Vordergrund, wie Rollen allokiert und die Zusammenarbeit zwischen Unternehmen gestaltet wird. Grundlegend für die Ausgestaltung von Unternehmensnetzwerken ist das Abhängigkeitsverhältnis von Wertschöpfungsaktivitäten, das in Wertschöpfungsnetzwerken abgebildet wird. In diesen werden die im Unternehmensnetzwerk zu verrichtenden Wertschöpfungsaktivitäten abgebildet und in Verbindung gesetzt [Porter/Millar 1985; Pil/Holweg 2006]. Im Vordergrund steht hier also nicht die Rollenverteilung der Unternehmen sondern die zu verrichtenden Aktivitäten und deren Interrelationen.

Insbesondere der Analyse des Wertschöpfungsnetzwerks der Informations- und Kommunikationsindustrie kommt eine besondere Bedeutung zu, da hier aufgrund von technologischen und ökonomischen Einflüssen die Wertschöpfungsstruktur eine starke Dynamik besitzt [Basole 2009; Li/Whalley 2002; Turel/ Yuan 2006]. Viele wissenschaftliche Arbeiten beschreiben die sich verändernden Wertschöpfungsstrukturen anhand qualitativer Aussagen [Basole 2009; Fransman 2002; Li/Whalley 2002; Peppard/Rylander 2006; Zerdick et al. 2000, 130-135]. Demgegenüber wurden quantitative Analysen zu Wertschöpfungsstrukturen in der Informations- und Kommunikationstechnik (IKT) Industrie, die in dieser Arbeit im Fokus stehen, in der wissenschaftlichen Literatur bisher spärlich publiziert.

Durch Innovationen werden in der IKT Industrie neuartige Wertschöpfungskonstellationen geschaffen und zwingen Unternehmen, aus Wettbewerbsgründen strategische Neupositionierungen im Wertschöpfungsnetz vorzunehmen. Die Analyse und Identifikation von Aktivitätenassoziationen innerhalb von Wertschöpfungsnetzen ist für Unternehmen von strategischem Wert, weil sie den Handlungsraum von Unternehmen definieren, Wertschöpfungsprozesse transparent machen und die Identifikation von Unternehmensstrategien erleichtern.

So strebt beispielsweise British Telecom in einem aufgrund des Markteintrittes von Internet-Telefonie Anbietern veränderten IKT Wertschöpfungsnetz mit der Bereitstellung einer Entwicklungsplattform für Kommunikationsdienste im Internet und einer Abkehr vom Angebot vertikal integrierter Kommunikationsdienste eine Neupositionierung an [British Telecom 2009]. Aus diesem Beispiel lässt sich eine wachsende Bedeutung der softwarebezogenen Wertschöpfung für die Telekommunikationsindustrie ableiten und mit Hilfe einer Wertschöpfungsanalyse genauer untersuchen. So können Rückschlüsse auf Strategien von Telekommunikations- und Softwareunternehmen gezogen werden (siehe Kapitel 3.2.3).

In dieser Arbeit wird die Theorie der Wertschöpfungsnetzwerke und ihre Anwendung auf die IKT Industrie vorgestellt (Kapitel 3.2.2). Anschließend wird die Konsistenz des IKT Wertschöpfungsnetzes untersucht, um so den strategischen Entscheidungsraum von IKT Unternehmen auf klar definierte Wertschöpfungssegmente einzugrenzen. Des Weiteren wird in Kapitel 3.2.3 die Positionierung des Wertschöpfungssegmentes Software im IKT Wertschöpfungsnetz analysiert, um qualitative Aussagen über die Rolle der Softwarebranche für die IKT Industrie zu verifizieren. Im Fazit (Kapitel 3.2.4) werden Limitationen des methodischen Forschungsansatzes diskutiert und ein Ausblick auf zukünftige Forschungsaktivitäten gegeben.

3.2.2. Theorie der Wertschöpfungsnetzwerke und ihre Anwendung auf die IKT Industrie

Das Wertschöpfungsnetzwerk als Handlungsfeld von Unternehmen

Der Begriff der Wertschöpfungskette wurde von Porter [1985] geprägt. Er beschreibt die Gesamtheit der Primär- und Sekundäraktivitäten eines Unternehmens [Porter/Millar 1985]. Primäraktivitäten tragen zu der Erstellung eines Produktes oder einer Dienstleistung unmittelbar bei, Sekundäraktivitäten stellen die Grundlagen zur Durchführung der Primäraktivitäten bereit. Unternehmensaktivitäten beeinflussen sich gegenseitig in ihren Kosten und ihrer Effektivität. Deshalb müssen Unternehmen Aktivitäten koordinieren und aufeinander abstimmen. Wertschöpfungsketten von Unternehmen derselben Industrie sind in einen größeren Aktivitätenfluss eingebettet, der von Porter und Millar [1985] als Value System bezeichnet wird. In diesem System werden Aktivitäten eines Unternehmens mit den Aktivitäten von Zulieferern und Kunden in Verbindung gesetzt. Die Art dieser Verbindungen und Abhängigkeiten determinieren dabei die Wettbewerbsposition eines Unternehmens, deren Ausgestaltung ist somit für Unternehmen von strategischem Wert.

Pil und Holweg [2006] beschreiben ein Wertschöpfungsnetz aus parallelen vertikalen Wertschöpfungsketten und horizontalen Wertschöpfungsstufen als potentielles zweidimensionales Handlungsfeld von Unternehmen. In diesem Handlungsfeld integrieren Unternehmen Wertschöpfungsaktivitäten, die in der Vertikalen, der Horizontalen oder der Diagonalen zueinander in Beziehung stehen. In vertikaler Richtung werden von einem Unternehmen auf der Nachfrager- oder Zuliefererseite Aktivitäten wahrgenommen, um auf die gesamte Wertschöpfungskette eine bessere Kontrolle ausüben zu können. In der Horizontalen werden Aktivitäten innerhalb einer Wertschöpfungsstufe ausgeführt, die auf verschieden Wertschöpfungsketten Einfluss nehmen. Hierdurch können Risiken diversifiziert und dabei bestehende Ressourcen effizienter eingesetzt sowie neuartige Produkt- und Dienstleistungsangebote erstellt werden. In der Diagonalen werden Aktivitäten in verschiedenen Wertschöpfungsketten und -stufen ausgeführt, um potentielle Versorgungsengpässe zu vermeiden oder positive Nachfrageeffekte auf das Kerngeschäft zu erzeugen. Table 3-9 zeigt Beispiele für die verschiedenen Assoziationsarten von Wertschöpfungsaktivitäten.

Assoziationsart	Unternehmen	Wertschöpfungsaktivitäten	Strategisches Ziel
Vertikal	Nokia	Endgeräteherstellung, Markenbildung, Kundenbeziehungsmanagement	Kundenbindung
Horizontal	British Telecom	Mobile und Festnetzbasierte Sprachdienste	Wertschöpfungsintegration
Diagonal	Apple	Endgeräteherstellung, Online Musik Geschäft	Erzeugung von Kunden Lock-Ins

Table 3-9: Assoziationsarten von Wertschöpfungsaktivitäten (basierend auf [Pil/Holweg 2006])

Wie aus der Arbeit von Pil und Holweg [2006] hervorgeht, sind Wertschöpfungsaktivitäten nicht isoliert zu betrachten sondern bilden ein komplexes und verwobenes Wertschöpfungsnetz. Den Positionierungsentscheidungen von Unternehmen innerhalb des Wertschöpfungsnetzes liegen wechselseitige Abhängigkeiten der integrierten Aktivitäten zugrunde, die ökonomisch begründet sind. Die Aufdeckung solcher Abhängigkeiten ist für Unternehmen von strategischem Wert, da sie Rückschlüsse auf Unternehmensstrategien und Wettbewerbssituationen zulässt und so für eine höhere Transparenz des Handlungsraumes von Unternehmen sorgen und eine Entscheidungsgrundlage zur Gestaltung von Unternehmensnetzwerken bietet.

Das IKT Wertschöpfungsnetzwerk und die Rolle der Softwareindustrie

Wie bereits im Konzept des Value Systems ersichtlich, lassen sich Wertschöpfungsaktivitäten gemäß ihrem Abhängigkeitsgrad in branchenspezifische Wertschöpfungsnetzwerke abgrenzen und gruppieren. Eine solche Abgrenzung definiert den Aktionsbereich von Unternehmensnetzwerken und gibt einen Überblick über die strategisch relevanten Geschäftsfelder dazugehöriger Unternehmen.

Nach Porter und Millar [1985] lassen sich Aktivitäten von Unternehmen einer Branche zusammenfassen. Bezogen auf die Informations- und Kommunikationswirtschaft ist eine solche Gruppierung jedoch nicht eindeutig vorzunehmen: Aufgrund der in wissenschaftlicher Literatur viel zitierten Konvergenz der Branchen Telekommunikation, Software, Endgeräte und Medien [Li/Whalley 2002; Zerdick et al. 2000, 130-135] lassen sich hier klare Abgrenzungen nicht mehr vornehmen. Viele Forschungsarbeiten nehmen eine Neugruppierung der IKT Wertschöpfungsaktivitäten, Branchen und Firmen vor [Basole 2009; Fransman 2002; Li/Whalley 2002; Peppard/Rylander 2006; Zerdick et al. 2000, 130-135]. Fransman [2002] präsentiert ein Ebenenmodell der IKT Aktivitäten und differenziert die Ebenen *Equipment & Software, Network, Connectivity, Navigation & Middleware* sowie *Applications induding contents packaging*. Diese Arbeit beschreibt eine vertikale, kettenartige Anordnung von Wertschöpfungsaktivitäten aus den oben genannten Branchen. Direkte Abhängigkeiten bestehen vornehmlich innerhalb der Ebenen sowie zwischen Aktivitäten benachbarter Ebenen. Zerdick et al. [2000, 130-135] identifizieren einen fortgeschrittenen Prozess, der zur vollständigen Auflösung der Grenzen zwischen den Branchen Telekommunikation, Informationstechnologie (Software und Hardware) sowie Medien in einem Multimedia Markt führt. Im Gegensatz zu Fransman [2002] heben Zerdick et al. [2000] einen hohen Komplexitätsgrad des neu entstehenden Wertschöpfungssystems hervor: Im Multimedia Markt seien die ehemals vertikalen Wertschöpfungsaktivitäten stark miteinander verknüpft. Es wird eine generische Wertschöpfungskette vorgestellt, deren Einzelaktivitäten potentiell aus allen drei Sektoren bedient werden.

Die zitierten Arbeiten zur Konvergenz fokussieren nicht speziell auf dem Software Sektor, jedoch werden in ihnen softwarebezogene Wertschöpfungsaktivitäten als Bestandteile der IKT Dienstleistungsproduktion angesehen. Die Integration und Koordination der einzelnen Wertschöpfungsaktivitäten wird als eigenständige Aktivität aufgefasst und als Dienstintegration und Dienstbereitstellung bezeichnet. In ihrer Analyse des Software-Wertschöpfungsnetzwerkes hebt Helander [2004, 23 & 67] die wichtige Rolle der mit Softwareproduktion und Anwendungsbetrieb verbundenen Aktivitäten für andere Industrien, vor allen Dingen in den Bereichen Industrielle Automatisierung, Telekommunikation und Elektronik hervor. Die Entwicklung und Bereitstellung softwarebasierter Dienste und Anwendungen in diesen Bereichen werde als Katalysator des Kerngeschäftes angesehen. Dies drückte sich unter anderem darin aus, dass viele Unternehmen, deren Kerngeschäft nicht im Softwarebereich einzuordnen ist, zusätzlich Software entwickeln und vertreiben. Für Hardwareequipmenthersteller ist Software ein Komplementärprodukt, da nur die Kombination von Wertschöpfungsaktivitäten beider Segmente Nutzen stiften kann [Cottrell/Koput 1998]. In der Telekommunikationsbranche spielt Software aufgrund von Konvergenzeffekten eine zunehmend wichtige Rolle. So stellt Messerschmitt [1996] fest, dass Telekommunikationsanwendungen sich von *Networked Computing* Anwendungen nicht mehr unterscheiden und deshalb Anwendungen vermehrt softwarebasiert auf programmierbaren Endgeräten umgesetzt werden. Internet Telefonie ist hierfür ein gutes Beispiel. In der Medienbranche werden softwarebasierte Systeme unter Anderem zur Personalisierung von Inhalten, zur Erschließung elektronischer Vertriebskanäle und zur Ausgestaltung differenzierter Preisstrategien benötigt [Schumann/Hess 2006, 49-79].

3.2.3. Empirische Untersuchung

Die im vorigen Abschnitt vorgestellten Aussagen zur Entwicklung des IKT Wertschöpfungsnetzwerkes und der Position der dem Softwaresektor zuzuordnenden Aktivitäten in diesem

Netzwerk sind überwiegend qualitativer Natur. In diesem Kapitel wird eine empirische Analyse des IKT Wertschöpfungsnetzwerkes durchgeführt. Im Fokus steht insbesondere die Wertschöpfung der Softwarebranche.

Forschungsthesen

Aus den vorhandenen wissenschaftlichen Arbeiten zum IKT Wertschöpfungsnetzwerk lassen sich Hypothesen ableiten, die in der quantitativen Auswertung untersucht werden sollen. Die Hypothesen H1 und H2 sind konstitutiv für die Existenz eines IKT Wertschöpfungsnetzwerks:

- *H1: Zwischen den Wertschöpfungsaktivitäten der Segmente Hardware Komponenten, Hardware Equipment, Software, Telekommunikation und Medien bestehen starke Abhängigkeiten*
- *H2: Als IKT Wertschöpfungsnetzwerk lassen sich diese Aktivitäten klar von anderen Wertschöpfungsaktivitäten abgrenzen.*

Die dritte Hypothese H3 beschreibt die wichtige Rolle des Softwaresektors im IKT Wertschöpfungsnetzwerk zur Bereitstellung von IKT Endprodukten und Dienstleistungen.

- *H3: Die Wertschöpfungsaktivitäten des Segmentes Software stehen in starker Verbindung zu den Segmenten Hardware, Medien sowie Telekommunikation, deren Wertschöpfung sich in einem signifikanten Abhängigkeitsverhältnis zum Softwaresegment befindet.*

Im anschließenden Abschnitt werden Datenbasis und Untersuchungsmethode vorgestellt. Die Hypothesen H1 bis H3 werden dann in den folgenden Abschnitten untersucht.

Datenbasis und Untersuchungsmethode

Als Datenbasis für die folgende Analyse dient ein Datensatz der Datenbank Thomson ONE Banker, der für 34142 börsennotierte Unternehmen bis zu 8 Standard Industrial Classification (SIC) Codes aufführt, die absteigend geordnet nach ihrem Umsatzanteil Wertschöpfungsaktivitäten von Unternehmen beschreiben. Wertschöpfungsaktivitäten wurden dabei in Segmente eingeteilt. Table 3-10 beschreibt die Klassifizierung der dem IKT Wertschöpfungsnetzwerk zugehörigen Wertschöpfungssegmente.

Um Aussagen über die wechselseitigen Beziehungen von Wertschöpfungssegmenten treffen zu können, wurde folgendes Assoziationsmaß definiert:

$$z(a,b) = |A \text{ AND } B| \,/\, |A \text{ OR } B|$$

Hierbei ist A (B) die Menge aller Firmen, die im Wertschöpfungssegment a (b) aktiv sind. Die Funktion z(a,b) setzt die Anzahl der Firmen, die gleichzeitig in a und b aktiv sind, in Beziehung zu der Anzahl aller Firmen, die in a oder b aktiv sind. Diesem Assoziationsmaß liegt das im Abschnitt 3.2.2 formulierte Prinzip zugrunde, dass die Motivation zur Integration von Wertschöpfungsaktivitäten durch die Assoziation der Wertschöpfungsaktivitäten begründet ist.

Segment	Beschreibung	Beispiele	SIC Kodierung (Auswahl)
Hardware Komponenten	Produktion von Material und Komponenten, die zur Herstellung von Hardware-equipment benötigt wird	-Halbleiter -Drähte und Leitungen	3671, 3672, 3674, 3675, 3676, 3677, 3678, 3679, 3691, 3692, 3694, 3695, 3699
Hardware Equipment	Produktion von Kommunikationsendgeräten und Netzwerkequipment	-Computer -Mobiltelefonie -Router	3571, 3572, 3575, 3577, 3578, 3579, 3651, 3652, 3661, 3663, 3669
Software	Entwicklung von Software und Internetanwendungen sowie damit verbundene Beratungs- und Ausbildungsleistungen	-Software-entwicklung -Informations-dienste	7370, 7371, 7372, 7373, 7374, 7375, 7379, 7382
Telekommunikation	Bereitstellung von Kommunikationsdiensten sowie Netzmanagement und -betrieb	-PSTN und GSM Telefonie -DSL Internet Zugang	4812, 4813, 4822, 4899
Medien	Produktion und Management von Text, grafischen und multimedialen Inhalten	-Publikation von Zeitungen -Werbedienste -Filmproduktion	2711, 2721, 2731, 2741, 7311, 7312, 7313, 7319

Table 3-10: IKT Wertschöpfungssegmente

Basierend auf dem Assoziationsgrad der einzelnen Wertschöpfungssegmente wurde im ersten Schritt eine Clusteranalyse [Everitt 1993] durchgeführt. Ziel dieser Analyse war die Gruppierung von Wertschöpfungssegmenten, die ein ähnliches Assoziationsprofil aufweisen: Wertschöpfungssegmente, zwischen denen ein starker Zusammenhang besteht und die sich gleichzeitig von außenstehenden Segmenten gut abgrenzen lassen, wurden dabei in Gruppen zusammengefasst. Hierzu wurde eine hierarchische Clusteranalyse mit einer Cluster-Methode durchgeführt, die das arithmetische Mittel der Distanzen aller Objekte zweier Cluster als Maß für die Distanz zwischen diesen Clustern verwendet (*Linkage zwischen den Gruppen*) und als Distanzmaß die quadratische euklidische Distanz benutzt. Da der flache Verlauf der durchschnittlichen Distanz zwischen den Clustern in Abhängigkeit von der Clusteranzahl die Bestimmung einer optimalen Clusteranzahl gemäß des Elbow-Kriteriums [Everitt 1993, 100] nicht zulässt, wurden aus Gründen der Übersichtlichkeit acht Cluster erzeugt.

Anschließend wurde mit Hilfe von Kontingenzanalysen [Wickens 1989, 17-50] die Positionierung des Wertschöpfungssegmentes Software im IKT Wertschöpfungsnetz genauer untersucht. Im Fokus dieser Untersuchung stand die Fragestellung, ob Firmen, die im Segment Software aktiv sind, sich im Bezug auf ihr Engagement in weiteren Segmenten des IKT Wertschöpfungsnetzwerks signifikant von anderen IKT-Firmen unterscheiden. Um signifikante Assoziationen zwischen der Softwareaktivität und Aktivitäten in weiteren Segmenten zu ermitteln, wurden X^2-Tests nach Pearson durchgeführt sowie Kontingenzkoeffizienten berechnet.

Identifikation des IKT Wertschöpfungsnetzwerkes

Die Assoziationen zwischen den Wertschöpfungssegmenten wurde mit Hilfe der Visualisierungssoftware Graphviz [Ellson et al. 2004] grafisch dargestellt. Diese benutzt Verfahren der multidimensionalen Skalierung, um Knoten gemäß der Länge der kürzesten Pfade anzuordnen. So werden Cluster als Netzwerk benachbarter Knoten sichtbar. Die Größe der Knoten repräsentiert die Anzahl der Unternehmen, die diesem Wertschöpfungssegment zugeordnet sind. Die Kantenlänge beschreibt den Grad der Assoziation zwischen zwei Wertschöpfungssegmenten. Um die Darstellung übersichtlich zu gestalten, wurden nur Assoziationen berücksichtigt, die einen Schwellwert von 2,5% nicht unterschreiten. Wie in Figure 3-1 veranschaulicht, werden die fünf IKT Aktivitätssegment (in der oberen Bildhälfte gekennzeichnet durch eine graue Füllung) in unmittelbarer Nachbarschaft zueinander angeordnet und durch die Positionierung am oberen Rand des gesamten Netzwerks von den anderen Aktivitäten abgegrenzt.

Das Ergebnis der Clusteranalyse bestätigt die beiden konstitutiven Eigenschaften des IKT Wertschöpfnetzes (Thesen H1 und H2). Table 3-11 enthält die resultierende Clustereinteilung der Wertschöpfungssegmente. Das Cluster Nummer 1 repräsentiert dabei das IKT Wertschöpfungsnetz. Somit ist es gelungen, die qualitativen Aussagen früherer Arbeiten bezüglich der Existenz des IKT Wertschöpfungsnetzes mit Hilfe eines quantitativen Verfahrens zu bestätigen. Diese Ergebnisse rechtfertigen auch die weitgehende Beschränkung der Analyse der Position des Wertschöpfungssegmentes Software auf die Assoziation zu anderen IKT Wertschöpfungssegmenten im anschließenden Abschnitt.

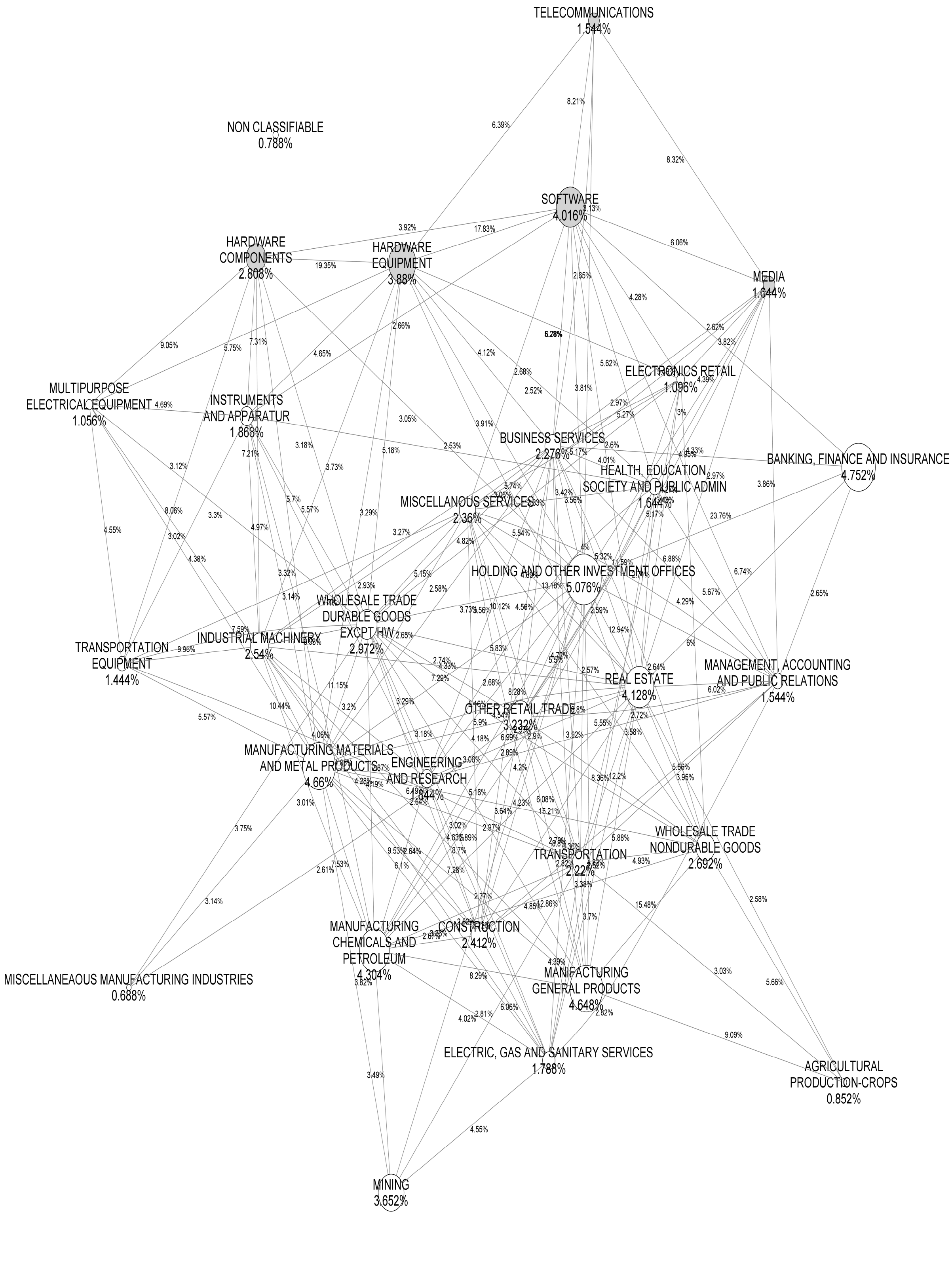

Figure 3-1: Visualisierung des gesamten Wertschöpfungsnetzwerks

Cluster	Wertschöpfungssegmente
1	Hardware components, hardware equipment, software, telecommunications, media
2	Electronics retail, construction, transportation, other retail trade, real estate, miscellaneous services, business services, engineering and research, management, accounting and public relations, health, education, society and public admin
3	Agricultural production-crops, manufacturing general products, manufacturing chemicals and petroleum, wholesale trade nondurable goods
4	Mining, electric, gas and sanitary services
5	Manufacturing materials and metal products, industrial machinery, multipurpose electrical equipment, transportation equipment, instruments and apparatus, wholesale trade durable goods except hardware
6	Miscellaneous manufacturing industries
7	Banking, finance and insurance, holding and other investment offices
8	Non classifiable

Table 3-11: Gruppierung der Wertschöpfungssegmente

Wertschöpfung der Softwareindustrie im IKT Wertschöpfungsnetzwerk

Um Signifikanzen in Assoziationen des Wertschöpfungssegmentes Software mit anderen IKT Wertschöpfungssegmenten festzustellen, wurden die Komplementäraktivitäten (d.h. die zusätzlichen Aktivitäten) von Softwarefirmen mit Hilfe von Kontingenzanalysen den Komplementäraktivitäten von anderen IKT-Firmen gegenübergestellt. Table 3-12 fasst die Analyseergebnisse zusammen: in Spalte zwei wird deutlich, dass Firmen, die sich im Softwarebereich engagieren, seltener in der Produktion von Hardware Komponenten tätig sind (6,4%) als andere IKT Firmen, die sich in den Segmenten Hardwareequipment, Telekommunikation oder Medien engagieren (21,2%). Durch den X^2-Test kann die Hypothese des Nicht-Bestehens dieses Assoziationsunterschiedes bei einem Signifikanzniveau von 99% abgelehnt werden.

Die geringe Assoziation zwischen Software- und Hardwarekomponentensegment wird insbesondere durch einen Vergleich von Software- und Hardwareequipmentsegment plausibel: in der Produktion von Endgeräten werden Hardwarekomponenten direkt benötigt. Deshalb kann eine gleichzeitige Kontrollausübung über beide Aktivitäten von strategischem Wert sein. Hingegen sind Synergieeffekte zwischen Komponentenherstellung und softwarespezifischen Aktivitäten schwerer auszumachen. Jedoch weist der Kontingenzkoeffizient C auf keinen starken Assoziationsunterschied hin.

	Hardware Components	Hardware Equipment	Telecom-munications	Media
Anzahl von Softwarefirmen mit Komplementäraktivität in	220 (6,4%)	1020 (29,7%)	360 (10,5%)	276 (8,0%)
Anzahl von Nicht-Software-IKT-Firmen mit Komplementäraktivität in	844 (21,2%)	1006 (24,9%)	346 (7,4%)	215 (4,9%)
X^2 (Pearson)	326,986*	21,607*	24,807*	33,003*
C	0,206	0,054	0,055	0,065

*: $\mathbf{X^2}$>9.210, **: C>0.300

Table 3-12: Kontingenzanalysen zur Positionierung des Wertschöpfungssegmentes Software im IKT Wertschöpfungsnetz

Mit den Segmenten Hardwareequipment, Telekommunikation und Medien (Spalten 3-5) weist das Softwaresegment einen stärkeren Assoziationsgrad auf als die anderen IKT Segmente. Zwar lassen sich mit Hilfe des Kontingenzkoeffizienten keine starken Assoziationsunterschiede nachweisen, jedoch lässt sich mit Hilfe des X^2-Tests auch keine Gleichartigkeit der Assoziationsgrade feststellen. Auch wenn sich die Validität der Hypothese H3 also nicht durch Abgrenzung des Softwaresegmentes von anderen IKT-Wertschöpfungssegmenten in einer Kontingenzanalyse statistisch nachweisen lässt, bestätigen die beobachteten Assoziationsmaße (Zeile 2 in Table 3-12), dass sich Softwarefirmen im Vergleich zu IKT Firmen, die keine Softwareaktivitäten ausführen, überdurchschnittlich häufig auch in den Segmenten Hardwareequipment, Telekommunikation und Medien engagieren.

Um Erkenntnisse über die Richtung der Assoziation vom Softwaresegment mit anderen Wertschöpfungssegmenten zu erhalten, wurden Firmen im Gegensatz zu den vorherigen Analysen den einzelnen Segmenten ausschließlich auf Basis ihrer primären SIC Kodierung (Primäraktivität) zugeordnet. Hierbei gehen die Autoren von der Prämisse aus, dass eine Sekundäraktivität aufgrund ihres betriebswirtschaftlich fundierten Einflusses auf die Primäraktivität von Firmen ausgeführt wird. Auch wenn diese Prämisse keinen allgemeinen Geltungsanspruch besitzt, so wird sie von den Ausführungen in Abschnitt 3.2.2 gestützt. Figure 3-2 zeigt die Ergebnisse dieser Analyse. Die Breite eines Pfeiles (a→b) stellt dabei den Anteil der Firmen eines Primärwertschöpfungssegments (a) dar, die mit Nebenaktivitäten in einem anderen Segment (b) unternehmerisch aktiv ist. Es wurden hierbei nur Segmente miteinbezogen, in denen mindesten 5% der Firmen Nebenaktivitäten im Bereich Software aufweisen, oder in denen Softwarefirmen zu mindestens 5% mit Nebentätigkeiten aktiv sind. Neben dem starken gegenseitigen Abhängigkeitsverhältnis mit dem *Hardware Equipment* Sektor fallen hierbei vor allem die starken einseitigen Abhängigkeiten der Segmente *Telecommunications, Management, Accounting and Public Relations* sowie *Media* vom Softwaresegment auf. Diese Beobachtung bestätigt die Hypothese H3 in Bezug auf die gerichtete Abhängigkeit der Segmente Hardware Equipment, Telekommunikation und Medien vom Softwaresegment.

Während sich beispielsweise Telekommunikationsunternehmen stark im Softwaresegment engagieren, ist dies umgekehrt nicht der Fall. Hieraus lässt sich ableiten, dass softwarebezogene Komplementäraktivitäten für Telekommunikationsunternehmen strategischen Wert besitzen, telekommunikationsbezogene Komplementäraktivitäten für Softwareunternehmen jedoch nicht. Wie vielfältige Beispiele, etwa das Engagement von Netzbetreibern bei der Entwicklung des Betriebssystems Android [OHA 2009] oder der Einsatz des IPTV Systems Mediaroom der Firma Microsoft beim IPTV-Angebot T-Home Entertain der Deutschen Telekom [Microsoft 2008], zeigen, beruht die Erstellung von Dienstleistungen im Bereich Telekommunikation vielfach auf dem Beitrag softwarebezogener Wertschöpfungsaktivitäten.

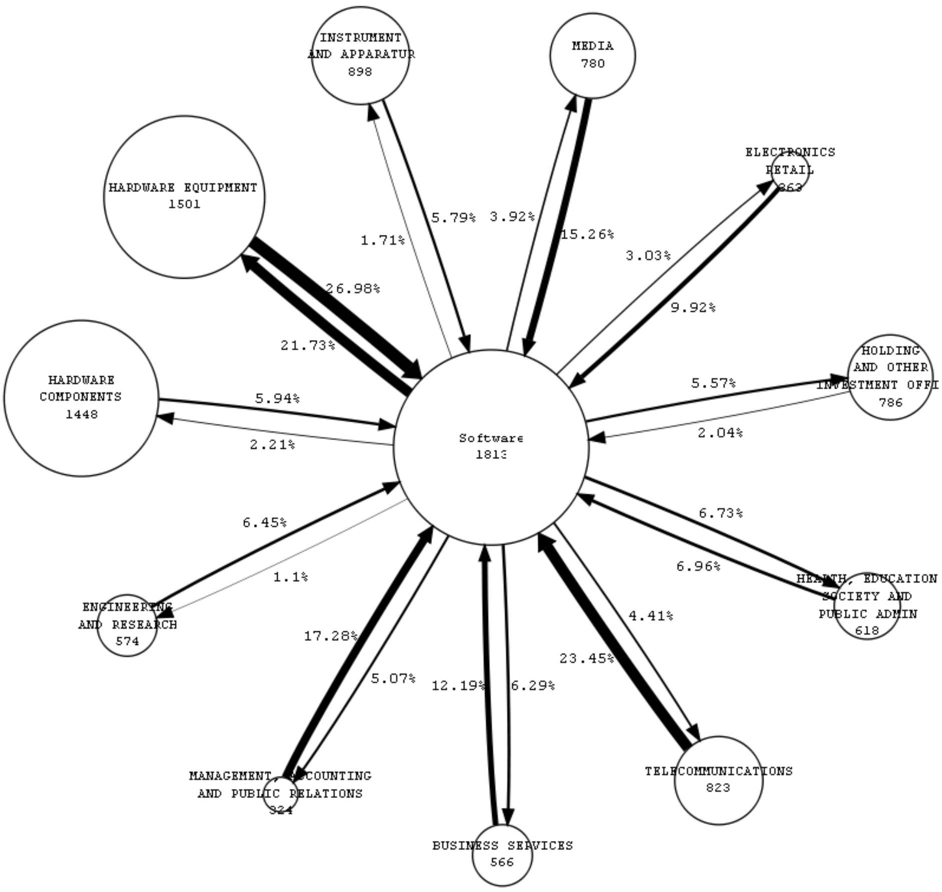

Figure 3-2: Abhängigkeitsverhältnis des Wertschöpfungssegmentes Software zu anderen Wertschöpfungssegmenten

Insbesondere aufgrund der Entwicklung des Internets lassen sich für Softwareunternehmen neue Geschäftsfelder erschließen. So können beispielsweise Medien- und Telekommunikationsdienste softwaregestützt über das Internet bereitgestellt werden. Wie aus Figure 3-2 hervorgeht, werden Kompetenzen in der Softwareentwicklung und im Softwarebetrieb in vielfältigen Branchen benötigt. Softwareunternehmen können über die enge Bindung mit

Hardwareequipmentherstellern hinaus unabhängig agieren und ihre Wertschöpfung flexibel in benachbarten Branchen einbringen. Gleichzeitig werden Unternehmen benachbarter Branchen im Softwaresegment aktiv und verändern die marktspezifische Wettbewerbssituation. So bietet zum Beispiel die Detecon International GmbH, die ursprünglich als Beteiligung der Deutschen Bundespost zur Erbringung von Beratungsdienstleistungen im Bereich der Fernmeldetechnik gegründet wurde, heute auch IT Beratungsleistungen an [Detecon 2009].

3.2.4. Zwischenfazit

In dieser Arbeit wurde basierend auf Daten über Wertschöpfungsaktivitäten von Unternehmen das IKT Wertschöpfungsnetzwerk analysiert. Dabei konnten die vielfach nur qualitativ vorgenommenen Aussagen über die Existenz eines IKT Wertschöpfungsnetzes bestehend aus Wertschöpfungsaktivitäten der Segmente Hardwarekomponenten, Hardwareequipment, Software, Telekommunikation und Medien empirisch bestätigt werden. Des Weiteren konnte gezeigt werden, dass das Wertschöpfungssegment Software eine zentrale Position im IKT Wertschöpfungsnetz einnimmt: insbesondere für Firmen, die Wertschöpfung in den Segmenten Hardwareequipment, Medien und Telekommunikation durchführen, stellen Softwareaktivitäten wichtige Komplementäraktivitäten dar.

Basierend auf dem in dieser Arbeit verwendeten Datensatz können Assoziationen zwischen Aktivitäten nur aufgrund von innerbetrieblich integrierter Wertschöpfungen identifiziert werden. Zwischenbetriebliche Kooperationen weisen ebenfalls auf Aktivitätenassoziationen hin. Des Weiteren wurden bei dieser Analyse lediglich umsatzerzeugende Wertschöpfungsaktivitäten berücksichtigt, nicht jedoch innerbetriebliche Aktivitäten, die keinen außerbetrieblichen Wert darstellen. Auch wenn diese Limitationen die Aussagekraft der erzielten Ergebnisse schmälern, so stellen sie die Plausibilität der Ergebnisse dennoch nicht in Frage, da bei der Definition des Assoziationsmaßes auf die betriebswirtschaftlichen Argumente zur innerbetrieblichen Integration von umsatzerzeugenden Wertschöpfungsaktivitäten fokussiert wurde.

Im Rahmen der in dieser Arbeit vorgestellten Analyse wurden Wertschöpfungsaktivitäten im IKT Sektor in grob-granulöse Segmente eingeteilt. Diese Einteilung war für die Untersuchung der diskutierten Hypothesen zweckmäßig, lässt allerdings tiefer gehende Aussagen bezüglich der Assoziationen von Wertschöpfungsaktivitäten und der Zusammensetzung des IKT Wertschöpfungsnetzwerkes nicht zu. Deshalb begründet diese Arbeit weitere, auf das IKT Wertschöpfungsnetzwerk beschränkte Analysen basierend auf fein-granulösen Wertschöpfungssegmenten.

3.3. Cross-sector competition in telecommunications – An empirical analysis of diversification activities

Title	Cross-sector competition in telecommunications - an empirical analysis of diversification activities
Authors	Jochen Wulf (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Business & Information Systems Engineering (Issue 5/2011)
Research objectives	- Provide an analysis of cross-sector competition in telecommunications and the strategic implications - Test the available qualitative descriptions of cross-sector competition in the telecommunications industry by means of quantitative examinations - Assess the extent and objectives of telecommunications-related diversification activities and provide and outlook on market developments
Methodology	- Analysis of segment associations based on segment profiles of 34,142 stock-market quoted companies - Industry clustering in order to quantitatively assert the existence of the ICT industry - Contingency and dependency analyses for the assessment of significant cross-sector competition levels
Results and implications	- Concentration of structural linkages between the media, software, hardware equipment, hardware component and telecommunications sectors - High level cross-sector competition with the media industry suggests strong economies of scope under shared marketing resources - Strong diversification activities of telecommunication firms in the software sector implies increasing technological interdependencies and growth strategies

Table 3-13: Summary of [Wulf/Zarnekow 2011b]

Cross-sector competition in the information and communications technology sectors (ICT sectors) constitutes a key strategic challenge for telecommunications companies. Due to increasing convergence, value creation is resulting in a greater degree of interaction. The diversification potential of telecommunications businesses is therefore changing with respect to associated ICT sectors, such as hardware, software and media. [Wulf/Zarnekow 2011b] analyzes cross-sector competition in the telecommunications industry on the basis of the diversification activities of ICT companies. A concentration of competitive interdependence in the ICT sectors is demonstrated using a cluster analysis of 34,142 companies. The cross-sector activities of telecommunications companies are investigated using contingency and dependency analyses, and the diversification-related competition in the telecommunications sector is also analyzed. With regard to the telecommunications sector, particularly high level cross-sector competition with the media industry is identified, as well as strong diversification activities in the software sector. The results are used to derive the potentials and risks that have a significant bearing on the structure of the cross-sector competitive environment of telecommunications companies. A summary of this article is provided in Table 3-13.

3.3.1. Introduction

The competitive environment of a company is significantly shaped by the sector to which it belongs [Porter 1980, 5], that is, by the group of companies that produce closely-related substitutes. The commercial environment of telecommunications companies (TCCs) is also affected considerably by cross-sector competitive and cooperative relationships in the formerly mostly independent software, hardware, media and telecommunications sectors. These so-called convergence phenomena [Stieglitz 2003, 25; Katz 1996, 1079-1095] continue to represent a major strategic challenge for the TCCs. Internet telephony is an obvious, contemporary example. Whilst in the past speech services were predominantly offered by TCCs on the basis of circuit switching technology, software and Internet providers are now in a position to address this market. The result of this convergence is a greater degree of interaction between the companies of the relevant sectors with regard to the adding of value [Zerdick et al. 2000, 130-135]. The diversification activities of a company determine the sectors in which it is competitively active and also indicate whether competitive advantages can be generated by integrating different product-specific, value-creating processes [Ansoff 1966, 149-135; Porter 1985, 317-363].

Articles published on cross-sector competition in the information and communications technology sectors (ICT sectors) predominantly use qualitative and argument-based deductive methodologies to demonstrate the consequences of increasing integration in the value creation activities of ICT companies and to determine the strategic implications for companies. As suggested in articles by Mayring [2001] and by Srnka and Koeszegi [2007], we make use of quantitative analysis procedures to generalise the already available qualitative results and broaden the investigation (generalisation model). By means of an examination of the hypotheses used (and to an extent contradictorily discussed) by the quoted authors, our work tests the available qualitative descriptions of cross-sector competition in the telecommunications industry. Our findings show that the results of qualitative studies can only be partially generalised and lead to the company strategic implications outlined in Section 3.3.4.

3.3.2. Cross-sector competition in the telecommunications industry

Basic objectives regarding cross-sector competition

Diversification means the widening of corporate activities to encompass new products and/or markets [Schüle 1992, 8]. In the context of this work, three different types of diversification are considered [Meffert 2000, 245-246; Ansoff 1966, 152]: horizontal, vertical and also lateral diversification. Under horizontal diversification, the existing product programme is extended around related products, the manufacture or marketing of which is able to make use of already available resources, thus allowing synergies to be harnessed. The addressing of marketing and/or technologically-linked product market areas is often referred to as concentric diversification although this, as Meffert [2000, 245-246] has shown, can be regarded as a subset of horizontal diversification. Vertical diversification is characterised by an increase in the depth of a programme. With regard to lateral diversification (also referred to as conglomerate diversification), companies enter new product and market areas with no related links to their previous business and thereby become involved in very diverse fields of commercial activity.

With regard to diversification objectives, there are four that are given particular emphasis [Schüle 1992, 10-11; Lubatkin 1983, 219]. These objectives are growth (1), competitiveness (2), profit (3), and risk reduction (4). In cases where company markets become unattractive due to saturation or high levels of competitive intensity, diversification may be used in an attempt to reverse falling turnover and profits and allow new growth potential to be tapped (1). Diversification can help companies to enhance their competitive capacity (2). With horizontal diversification, for example, advantageous wholesale and retail pricing levels can be achieved due to economies of scale [Lubatkin 1983, 219]. Regarding vertical diversification, the independence of upstream and downstream competitive processes is reduced and a company’s relative competitive position is, therefore, increased (Ehrmann 1999, 44). Diversification can also be linked to the objective of increasing profit (3). If, in relation to separate production, the joint production of the diversified product programme promises increased efficiency based on economies of scope or scale, synergies can be realised and resource profitability increased [Schüle 1992, 15]. With horizontal diversification, according to Lubatkin [1983, 220], synergies can be realised by means of accessing production and marketing resources and due to the existence of learning/experience curve effects. Vertical diversification can give rise to objective, temporal and spatial linkage effects [Lindstädt 2006, 65]. Diversification can also be used to eliminate non-systematic risks (4) [Schüle 1992, 16].

Porter [1985, 317-363] refers to value chain linkages as the justification for the development of synergies in diversified companies. Tangible linkages lie in the chances of different business units to share value creating activities, since the same consumers, marketing channels, technologies and other factors are needed. Intangible linkages arise due to the transfer of management knowledge between different value chains.

Characteristics of cross-sector competition in the telecommunications industry

The telecommunications sector has been exposed to powerful changes as a result of the deconstruction of established value chains [Li/Whalley 2002, 451-472]. The evaluation of structural analyses of the industry in this section provides an overview of value chain linkages and diversification activities in the telecommunications sector. Table 3-14 summarises the evidence obtained from structural analyses of the ICT sectors in the form of the participating actors and the value creation levels. The core value-creating activities of the TCCs traditionally concentrate on network operation and the provision of data transport services which, for technical reasons, are directly linked to network operation [Dengler 2000, 92-94]. All authors focus their analyses of ICT sectors alongside the telecommunications industry on players from the hardware (components and equipment), software and Internet applications and media sectors. The hardware components sector includes the production of materials and components (e.g., semiconductors) required for the manufacturing of hardware equipment [Dengler 2000, 92]. Hardware equipment manufacturers address the market for network equipment (transmission and switching systems) and terminal equipment [Dengler 2000, 93; Maitland 2002, 492-493]. Software and Internet application providers are usually further segregated into middleware or platform operators and service providers [Kuo/Yu 2006, 1347-1356; Fransman 2007, 32]. Media companies devote themselves to the provision and marketing of text, graphic and multimedia content [Zerdick et al. 2000, 38-268; Wirtz 2006, 671-696]. Some authors [Gerpott 1998, 4-14; Dengler 2000; 92-97; Wirtz 2006, 671-696] include the roles of media, software and Internet service providers in the provider of value-added services designation. According to Zerdick et al. [2000, 132-135], convergence leads to considerable linkage within value adding processes and to competitive strategy interdependencies. This is, however, limited to those sectors named. Other sectors, such as transport, health and social welfare and the energy and water industries are not included in the analyses made by any of the authors, even though ICT also has a major role in these sectors [Muenchner Kreis 2010, 122-127]. Such restrictions are neither based on justifications or empirical evidence provided by the authors and is, therefore, questioned in the context of the present work. The hypothesis of a concentration of structural integration in the ICT sectors can be examined on the basis of company-specific diversification activities. Where there is strong structural integration between two sectors, the products manufactured are offered integrated to a large extent:

H1: The diversification activities of companies in the telecommunications, hardware, software and media sectors are limited to a great extent to these self-same ICT sectors – according to the articles presented, a concentration of structural integration in the ICT sectors can be assumed. Concentration is reflected in the diversification activities of ICT companies in such a way that diversification activities outside the ICT sectors are pursued to a much lesser extent.

With regard to the question of whether business involvement outside the core value creation area for TCCs can provide business potential over the long term, the authors come to heterogeneous and partly contradictory conclusions. Ehrmann [1999, 46], for example, states that integrated providers would benefit from advantages in efficiency and strong competition would lead to vertical company mergers. Wirtz [2006, 696] believes continuing sector convergence accelerates the trend towards integrated media and Internet related companies. Gerpott [1998, 216-220] sees the broadening of business activities in the field of multi-media services as an important strategic option for TCCs. He makes a distinction here between communication multi-media services for facilitating the symmetrical interaction of a small number of users (e.g., telemedicine and telelearning) and the distribution multi-media services aimed at disseminating information to a large number of users with feedback options (e.g., video-on-demand and teleshopping). In addition to the range of value-adding services, Kuo and Yu [2006, 1353-1354] see the following possible roles for TCCs in the context of mobile communications: invoice processing, offering of portals for personal and terminal equipment-specific information and intermediating between end customers and third-part providers through the deployment of proprietary marketing capacities, end customer access and user information. Other authors are critical of the commercial broadening of TCCs and see a concentration strategy combined with company cooperation as one promising more in terms of success. According to Maitland [2002, 491-492], integrated business models of European UMTS market telecommunications operators that go beyond the simple provision of access services cannot be successfully established. In contrast, the focus on data transport, based on the technological and commercial complexity of developing and operating 3G networks, could represent a stable strategy. Dengler [2000, 234] also sees the disintegration of previously integrated TCCs as a feasible, and for some companies an expected, alternative action. The contradictory conclusions reached by the authors regarding business potential outside the sphere of TCC core value creation justify examination of the following hypothesis:

H2: TCCs pursue significant diversification activities in other ICT sectors. – Where TCCs have a high degree of diversification in other ICT sectors, characteristic multi-product strategies, which reach over into other ICT sectors, can be recognised.

Author	Aim of the article	Methodology	Actors	Value-adding levels
Brousseau and Quelin [1996, 1205-1230]	Analysis of cooperative strategies in the value added services industry	Segmentation of 125 value added service providers	Telecommunications, communications, network control and on-line information service providers	Data transport, communications management, information editing and processing
Gerpott [1998, 4-14]	Discussion of telecommunications service provider strategies in the German telecommunications market	Evaluation of case studies and foreign telecommunications market macro-data	Telecommunication equipment manufacturers (switching and transmission systems, terminal equipment), systems operators (network operators, basic service providers), value-adding service providers, telecommunication service retailers	-
Ehrmann [1999, 33-48]	Discussion of framework conditions for a workable competitive telecommunications market in Germany	Argument-based deductive analysis of market structure determinants	Network operators, switched resellers, switchless resellers, retailers	Network management, transport, speech and data switching, speech and data services, speech and data premium rate services, branding, customer care, billing, sales
Zerdick et al. [2000, 38-268]	Analysis of factors affecting competitiveness and company strategies in the multi-media market	Argument-based deductive analysis and integration of the latest academic literature and thinking	-	Contents, packaging, transmission, navigation, value added services, reception appliances
Dengler [2000, 92-97]	Depiction of the strategic challenges and trading options of integrated telecommunications service providers	Synthesis of empirical theory, scientific knowledge and practical observation	Equipment manufacturers (hardware and software), network operators, value-added service providers, services retailers	Component manufacture, system manufacture, system integration, system/network operation, creation of basic services, creation of value-added services, packaging/brands/pricing policies, invoicing, customer care, sales

Author (cont'd)	Aim of the article (cont'd)	Methodology (cont'd)	Actors (cont'd)	Value-adding levels (cont'd)
Maitland et al. [2002, 485-504]	Identification of the influencing factors and challenges of introducing UMTS to the European market for mobile data	Argument-based deductive analysis	Network Operators, Network Equipment and Handset Manufacturers, Internet Service Providers, Application Service Providers, Mobile Virtual Network Operators	Network & Handset Equipment Manufacturing, Middleware, Content, Application Development and Provisioning, Internet Access, Portal Development & Provisioning, Network Operation, Network Access, Sales of Service and Client Hardware
Sabat [2002, 505-535]	Overview of value creation and the actors in the dynamic market for mobile packet-based services	Evaluation and segmentation of ICT company product portfolios	-	Handset supply, Network Systems and Equipment, Network Operation, Transport, Hosting, System Integration, Content Production, Content Enhancement/Aggregation, Delivery
Wirtz [2006, 671-696]	Depiction of processes in media and Internet management	Argument-based deductive analysis, integration of the latest academic literature and thinking, and portrayal of case studies	Media companies, telecommunications companies, hardware and software companies, companies involved in e-commerce	Content and service creation, content and service aggregation, value creation services, transmission/connection, navigation/user interface
Kuo and Yu [2006, 1347-1356]	Challenges and development options for 3G telecommunication operators involved in mobile commerce	Argument-based deductive analysis	Technology Platform Vendors, Infrastructure and Mobile Equipment Vendors, Application Platform Vendors, Application Developers, Content Developers, Content Aggregators, Mobile Portal Providers, Mobile Network Operators, Mobile Service Providers, Mobile Equipment Retailers	-
Fransman [2007, 1-106]	Analysis of the new European ICT ecosystem and derivation of the implications for regulation and control	Evaluation of the financial accounts of 157 ICT companies	-	Equipment and Software Layer, Network Layer, Connectivity Layer, Navigation and Middleware Layer, Content / Application / Services Layer

Table 3-14: Structural analyses of the ICT industry

Some of the authors also include in their structural analyses of the ICT sector the question of whether the core business of the TCCs, network operation and the provision of network-based services, is at all affected by the entry into the telecommunications market of players from other sectors. In respect thereof, Gerpott [1998, 260] identifies significant business potential for TC equipment manufacturers that, due to their high levels of technical expertise in telecommunications network development (system integration), can also gain a foothold in network operation. Furthermore, software and hardware companies can thrive in the telecommunications market, since the capacity and performance of the hardware and software deployed increases both the functionality and cost of TC networks and affects the provision of new services [Gerpott 1998, 258]. According to Zerdick et al. [2000, 100], the introduction of open, decentralised and intelligent network structures facilitates the market entry of new groups of providers such as, for example, those offering cross-network management services and data mining services for processing customer information. Dengler [2000, 177-183] sees competition from application and service integrators that concentrate on sales and customer contact and buy in and package third party applications and services. In contrast, Kuo and Yu [2006, 1353] are of the opinion that the central competitive strategic resources of the TCCs are difficult to imitate. They identify, inter alia, network infrastructure, brand popularity and end customer access. The heterogeneous conclusions reached by the authors regarding the diversification potential within the telecommunications sector of competitors from outside the sector points to the need for a detailed examination of the following hypothesis:

H3: A significant proportion of companies from other ICT sectors demonstrate diversification activities within the telecommunications sector – some authors identify significant business potential within the telecommunications sector for companies from other sectors. This potential has the power to affect the level of diversification within the telecommunications sector.

3.3.3. Empirical investigations

Quantitative diversification analyses have been used by various authors to evaluate cross-sector competition in other sectors [Basole 2009; Khansa/Liginlal 2009; Pennings/Puranam 2001]. The authors quoted evaluate M&A activities and also, to an extent, other forms of company cooperation (e.g., alliances and joint ventures), in order to operationalize cross-sector integration. In contrast to these articles, an operationalizing approach, which is also able to encompass internal diversification, has been chosen for the following analysis. The information used for the examination of the questions posed in the preceding sections is taken from the database records of Thomson ONE Banker, which lists up to 8 four-digit coded Standard Industrial Classification (SIC) classes for 34,142 stock-market quoted companies. The four-digit SIC classes are used to classify the products marketed by any one company. The SIC classes in the database company entries are arranged according to the company-specific share of turnover of the given product. In order to facilitate analysis at generic sector level, the four-digit SIC classes were allocated unique sectors.[2]

Cluster analysis

The hypothesis of a concentration of cross-sector competition in the ICT sectors (H1) is examined using the following association measure which describes the proportion of companies in the two sectors that are active in both sectors (degree of association):

$$z(a,b) = |A \cap B| / |A \cup B|$$

With A (B) being the set of all firms active in sector a (b). So, for example, of the 1318 telecommunications companies and 1403 media companies recorded, 226 firms are active in both sectors and the degree of association z(telecommunications, media) is, therefore, 8.3%.

Cluster	Sectors
1	Hardware components, hardware equipment, software, telecommunications, media
2	Electronics retail, construction, transportation, other retail trade, real estate, miscellaneous services, business services, engineering and research, management, accounting and public relations, health, education, society and public admin
3	Agricultural production-crops, manufacturing general products, manufacturing chemicals and petroleum, wholesale trade nondurable goods
4	Mining, electric, gas and sanitary services
5	Manufacturing materials and metal products, industrial machinery, multipurpose electrical equipment, transportation equipment, instruments and apparatus, wholesale trade durable goods except hardware
6	Miscellaneous manufacturing industries
7	Banking, finance and insurance, holding and other investment offices
8	Non classifiable

Table 3-15: Allocation of sectors resulting from cluster analysis

A cluster analysis [Everitt 1993, 55-89] was carried out, based on the degree of association of the individual sectors[3]. The aim of this analysis was to group the sectors with similar associa-

[2] A description of SIC class and sector allocation can be found in Table 6-1 and Table 6-2 of the appendices.

[3] The degree of association of all sectors is given in the appendices in Table 6-4.

tion profiles. A hierarchical cluster analysis was carried out with a cluster methodology employing the arithmetic mean of the distances of all objects of the two clusters as the dimension for the distance between the clusters (linkage between the groups) and the quadratic Euclidian distance being used as the distance dimension. In an agglomerated procedure based on the narrowest partition, the two clusters with the smallest distance were merged in each step. The Elbow criterion [Everitt 1993, 100] was used to determine the optimum cluster number.

Since the value increase of the clustering coefficient assumes a local maximum between seven and eight clusters, the number of clusters was set to a value of eight.[4]

Table 3-15 shows the allocation of sectors to the eight clusters. The cluster analysis assigns the ICT sectors *hardware components, hardware equipment, software, telecommunications* and *media* to one cluster (Cluster 1). This shows that the ICT sectors are strongly associated with each other and, simultaneously, weakly associated to other sectors.

Contingency analyses

Hypothesis H2 was examined using contingency analyses [Wickens 1989, 17-50] based on the significant diversification activities pursued by the TCCs in other ICT sectors. It was investigated whether, in respect of their involvement in the other four ICT sectors (focus sectors), companies active in the telecommunications sector differ significantly from other ICT firms. A contingency analysis was carried out for each of the four focus sectors – hardware components, hardware equipment, software and media, as follows: the set of ICT companies with a primary SIC class not allocated to the focus sector were chosen as the population. The primary SIC class of a company is determined by the product with the greatest share of turnover. The companies making up the population were subsequently divided into four disjoint groups, based on their involvement in the telecommunications sector (telecommunications – yes or no) and in the focus sector (focus sector – yes or no). The number of companies in each group was determined and, using this value, a Pearson X^2 test was carried out [Wickens 1989, 39-41] and the Cramér contingency coefficient [Cohen 1988, 223-227] calculated. The group strengths and the results of the analysis are shown in Table 3-16. The X^2 values clearly show that there is no identical strength of involvement of telecommunications companies and of other ICT firms in the respective focus sectors. Regarding the involvement in the media and hardware component focus sectors, the Cramér contingency coefficient highlights a small, though not unimportant distinction. The distinction is that TCCs are strongly involved in the media sector. Furthermore, TCCs less frequently offer products from the hardware components sector than other ICT companies.

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[4] Figure 6-1 in the appendices shows the dependence of clustering coefficient on cluster number. Table 6-3 in the appendices shows the dependence of the clustering coefficient on the number of clusters and the respective difference to the previous value.

Focus sector		Hardware components		Hardware equipment		Software		Media	
Cardinality of the population		*7413*		*7462*		*6877*		*7836*	
		Yes	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Telecommunications	Yes	*83 (1.1%)*	*1235 (16.7%)*	*278 (3.7%)*	*1040 (13.9%)*	*360 (5.2%)*	*956 (13.9%)*	*209 (2.7%)*	*1109 (14.2%)*
	No	*981 (13.2%)*	*5114 (69%)*	*1748 (23.4%)*	*4396 (58.9)*	*1198 (17.4%)*	*4361 (63.4%)*	*282 (3.6%)*	*6236 (79.6%)*
X^2 (Pearson)		*85**		*30**		*20**		*248**	
C (Cramérs V)		*0.107***		*0.063*		*0.054*		*0.178***	

*: Significance level p<0.001 for X^2>10.83 [Wickens 1989, 39-41]; **C>0.1 [Cohen 1988, 224]

Table 3-16: Contingency analyses of the diversification activities of telecommunications companies

Dependency analysis

A dependency analysis was carried out in order to analyze the diversification activities in the telecommunications sector of companies from external sectors (H3). For the purpose of deciding between the diversification activities of TCCs inside external sectors and those of companies from external sectors inside the telecommunications sector, the companies were assigned to individual sectors solely on the basis of their primary sectors. The assigned sector of the primary SIC class is designated as the primary sector. Directional relationships $x_a(b)$ were determined on the basis of this allocation, with these indicating the proportion of firms in a primary sector (a) with secondary activities in another sector (b):

$$x_a(b) = |A_{Prim} \cap B| / |A_{Prim}|$$

A_{Prim} is the set of all firms having primary sector *a*, and B is the set of all firms active in sector *b*. During the analysis, only directional relationships from or to the telecommunications sector were considered. Only directional relationships with values exceeding 5% were subsequently included in the discussion (Figure 3-3).

Two performance indicators were determined: the dependency indicator ($d(a,b)$) represents the absolute value of the difference between the directional relationships of the two sectors:

$$d(a,b) = |x_a(b) - x_b(a)|$$

A high value indicates a disparity in the diversification-specific potential of the companies in the two sectors (one-sided dependency). The association strength indicator ($r(a,b)$) shows for two sectors the ratio of companies for which the primary SIC class is allocated to one of the two sectors and for which a further SIC class is allocated to the other sector compared to the entire set of companies having a or b primary sectors. A high value indicates strong association:

$$r(a,b) = (|A_{Prim} \cap B| + |B_{Prim} \cap A|) / |A_{Prim} \cup B_{Prim}|$$

A strong and two-sided association exists between the telecommunication and media sectors. The software sector also shows a strong association, though in this case the association is one-sided. The third strongest and somewhat one-sided association is to the hardware equipment sector. In addition, telecommunications companies are very active in holdings and other investment offices and offer general business services such as equipment rental and leasing, or personnel supply services. Since, according to the cluster analysis, these sectors cannot be allocated to the ICT sectors, they are not considered further.

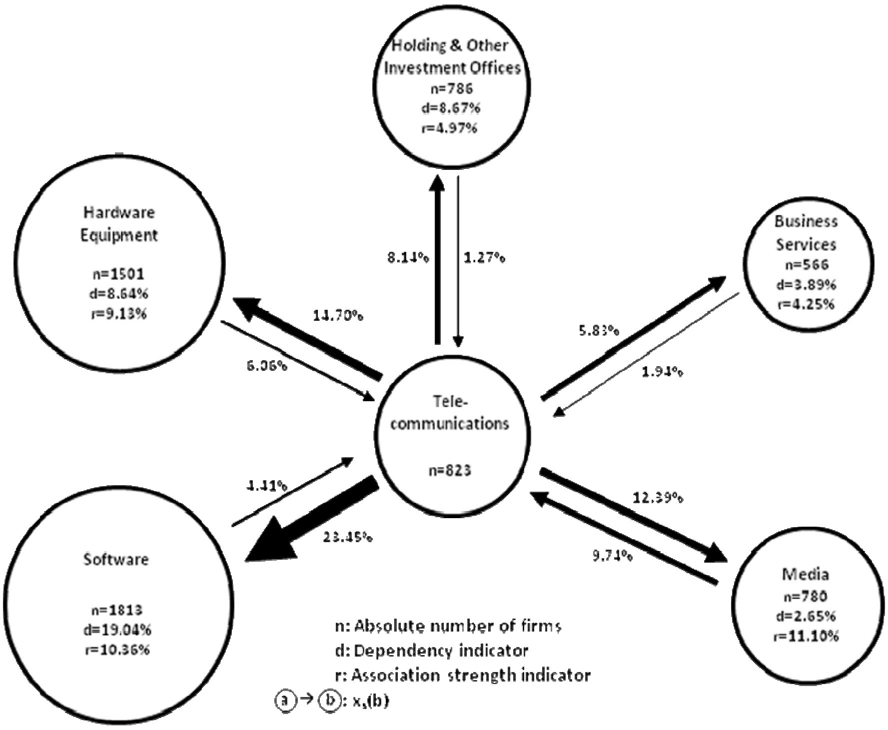

Figure 3-3: Directional relationships in the telecommunications sector

3.3.4. Interpretation and implications

The concentration of structural linkages to the media, software, hardware equipment, hardware component and telecommunications sectors was confirmed using cluster analysis, since these five sectors are assigned to one cluster and hypothesis H1 is, therefore, confirmed. Competitive strategies of ICT companies are, therefore, concentrated to a significant degree on the ICT sectors. At the time of the assessment, it was also established that ICT-related market convergence effects remained limited to the ICT sectors. The results of the cluster analysis justify focusing the analysis of cross-sector competition in the telecommunications industry on the ICT sectors.

The extent and objectives of TCC diversification activities and the telecommunications-related diversification activities of other ICT companies is discussed below (Table 3-17).

Sector	Areas of cross-sector competition	Diversification effects (Schüle 1992, 10-11; Lubatkin 1983, 219)	Sample activities and products of telecommunications companies
Media	Preparation, packaging and marketing of textual, graphical and multi-media content - Video - Music - News	- Economies of scope under shared marketing resources - Increased competitiveness due to narrowing of the market via exclusive marketing and distribution channel usage	- Vodafone - Formula1 live - Hansenet -Alice homeTV - NetCologne - CityNetTV - Versatel – Online gaming - Deutsche Telekom - Liga total! - freenet - freenet.de Internet portal
Software and Internet applications	Software-based value-added services and platforms - Internet search - Email - Internet telephony - Content distribution - Invoice processing	- Participation in growth in software-based value-added services market - Economies of scope via cross-selling in private and business client segments - Economies of scope via joint use of the technological infrastructure	- Kabel Deutschland - Internet search - Arcor - Email - Deutsche Telekom - Webconferencing - at&t - Video Transport - BT - Wholesale Content Connect
Hardware equipment	System integration and operation of the telecommunication networks - Capacity management - Field services management - Network monitoring - Network control	- Linkage effects due to the integration of equipment production, system integration and network operation	- Global Crossing - Network management - Deutsche Telekom - Global networks - BT - 21 Century network programme
	Production and marketing of communications terminal equipment - Set-top boxes - Netbooks - Mobile telephones	- Economies of scope due to shared marketing - Linkage effects due to the integration of data transportation and terminal equipment	- Deutsche Telekom T - Entertain Set-top box - Vodafone - UMTS stick - 1&1 - Smartpad - o2 - Xda Smartphone

Table 3-17: Diversification effects in the telecommunications industry

The contingency analysis reveals a structural integration of the **media and telecommunications** sectors. Dependency analysis confirms this to be a two-sided relationship. From the diversification theory perspective, profitability increase effects can be achieved with horizontal distribution as a result of economies of scope. These come into being due to the shared use of marketing resources, such as billing relationships or information on consumer preference for the marketing of broadband access and media services to private customers. These types of market resources, often classified under the superordinate term *end customer access*, are seen as central to the monetising of media services [Clemons 2009, 15-41; Rams 2001, 1-4] and also play a strategic role in sales of aggregation platforms and portals [Maitland et al. 2002, 492]. Furthermore, due to market narrowing effects, the competitive position with respect to competing TCCs can be improved by the exclusive marketing of media services [Ehrmann 1999, 44]. On the other hand, media companies – especially those in the radio and television business – have developed their own transmission capacities, since the exclusive use of distribution channels under vertical diversification can significantly strengthen market position with respect to competitors [Gerpott 1998, 259].

The contingency and dependency analyses point to a stronger than average, one-sided association in the **telecommunication and software** sectors. TCCs develop software-specific competences, since these types of resources, due to convergence effects, may increasingly be regarded as complementary to, or as a substitute for, existing TCC sales. Messerschmitt [1996, 1167-1186] has established that, in many cases, telecommunications applications no longer differ from networked computing applications and, therefore, such applications are increasingly realised based on software and programmable terminal equipment. These types of substitution effect are noticeable both in the end customer (e.g., instant messaging versus texting) and the wholesale business (e.g., content distribution versus Internet transit). The functionality and cost of the telecommunications networks and the provision of new services are, according to Gerpott [1998, 258], increasingly dependent on the performance and capacity of the hardware and software deployed. With regard to service provision, software-based invoice processing, personalisation and distribution systems are increasingly being used [Jakopin 2006, 39; Sabat 2002, 521-522; Wulf/Zarnekow 2010, 3-19]. In order to guarantee a significant share in value creation, TCCs are striving to offer differentiated value-added services, in respect of which the provision of software-specific resources is becoming increasingly important [Dengler 2000, 203; Zerdick et al. 2000, 101]. With this rationale, TCC diversification activities are coupled with growth targets. In marketing, economies of scope can be achieved by means of cross-selling, both in the private and business customer segments. In addition, as a result of the shared use of invoice processing systems, user databases and server infrastructures, economies of scope can also be achieved at the technical resource level. It can be concluded from the weak involvement of software companies in the telecommunications sector that, for software companies, the costs of diversification, due to expenses linked with coordination, efficiency losses and reduced flexibility [Porter 1985, 331-335], outweigh any diversification advantages.

Based on the results of the contingency analysis, the association of the **telecommunications and hardware equipment** sectors is less pronounced. Despite that, cluster and dependency analyses do show a certain level of significance. In the dependency analysis, it can be seen that the association is weak and one-sided. Based on the high affinity of the necessary resources for hardware equipment production, development of the telecommunications networks (system integration) and network operation, strong linkage effects may be assumed.

For this reason, network component manufacturers in particular pursue integration strategies. Due to the binding of TCCs to hardware manufacturer systems, via potential product-product or product-user incompatibility and accompanying investment specifity, strong vendor lock-in effects can develop with hardware equipment being integrated into telecommunications networks [Bastian 2002, 66-76]. In addition to pursuing multi-vendor strategies, TCCs address these difficulties by outsourcing network operation [Chaudhury/Terfloth 2008, 1-7]. In the main, terminal equipment and network transport only offer customer added-value when combined. Economies of scope can therefore be achieved by means of integrated marketing. Standards are mostly used for the integration of terminal equipment and network infrastructure – for configuring the data communication of mobile telephones and TV equipment, for example. In many cases, however, the basic economic and technical conditions existing between the TCC and the terminal equipment provider are directly negotiated as, for example, is the case with Amazon's *Kindle* e-book or the Tollcollect road toll's *On board unit*. In the case of non-standard integration, TCCs can make use of linkage effects by integrating data transport and terminal equipment, thereby improving their competitive position in the terminal equipment market. Deutsche Telekom's IP-TV (Telekom Entertain) is an example of the above, with the set-top box being marketed together with the data connection.

In summary, it is determined that TCCs in the media, software and hardware equipment sectors pursue significant diversification activities and that hypothesis H2 can be confirmed in respect of these activities. Regarding the involvement of companies from other ICT sectors in the telecommunications industry, it can be said that firms from the media and hardware equipment sectors have significant involvement but that hypothesis H3 has to be rejected regarding firms from the software and hardware components sectors.

3.3.5. Interim outlook

This article has looked at the diversification activities and their objectives in relation to the telecommunications sector. Due to the theoretical framework employed and the available data, the results obtained are subject to certain limitations. Cross-sector competition has been discussed in the context of diversification theory. In addition to the diversification objectives discussed in this article, there are other aspects that have not been considered here but which can play a role in cross-sector competition. Company-specific insourcing and outsourcing barriers [Gerybadze 2005, 457-474; Picot 1991, 349-353] are examples of such aspects.

Despite potentially advantageous diversifications effects, a high degree of diversification can also be detrimental. Porter [1985, 331-335] emphasises that, in addition to coordination costs, there can be unfavourable levels of both efficiency and flexibility. Since the ICT sectors are characterised by high innovation dynamics and weak barriers to entry, any over-high degree of diversification can bring with it serious competitive disadvantages. In relation to vertically integrated TCCs, organisational inflexibility and a lack of customer-specific problem-solving skills are criticised [Gerpott 1998, 13; Maitland et al. 2002, 491]. When presenting the advantages of telecommunications-specific diversification, it is clear that the technical advantages of vertical diversification can be claimed only in the case of a few web-based services such as, for example, IPTV. Whereas the telecommunications market was previously dominated by vertically-integrated companies, value chain disintegration is henceforth predicted. This, due to changes in the competitive environment (such as, for example, more flexible company cooperation), is leading to stronger customer orientation and the increased opening of technical platforms [Dengler 2000, 184; Henneking et al. 2010, 17-21]. Due to the high degree of specialisation involved, the competitive positions of the TCCs are crucially influenced by their cooperative relationships [Zerdick 2000, 177-184]. Economies of scale and scope also play a strategic role [Sabat 2002, 533]. These can be strengthened by horizontal diversification, as shown in the examples of joint marketing and access to technical resources. Although in the context of this work, concentration of competitive interdependence within the ICT sectors has been stated, this has the potential to go beyond the limits of the ICT sectors in the future, due to the increased potential of horizontal diversification. Examples in this respect are the transport sector, health and social welfare and the energy and water supply industries [Muenchner Kreis 2010, 122-127]. Since ICT is gaining increasing influence in these sectors, cross-sector synergies could result.

In summary, stronger vertical concentration and horizontal diversification offer TCCs a multitude of strategic options. Network operation can, for example, be outsourced [Chaudhury/Terfloth 2008, 1-7] or brand, pricing policies and sales can be grouped together in a business model approach, which Dengler [2000, 204] refers to as application and services integration. Furthermore, a focus on the intermediation between end customer and service provider or on the provision of *infrastructure-as-a-service* services and the operation of ICT infrastructures are possible future options [Kuo/Yu 2006, 1354-1355; Henneking et al. 2010, 23-25].

Since the conclusions reached here regarding the future development of the TCC competitive environment are purely qualitative in nature, further research will be necessary in the analyses accompanying these developments. Here, it will be of particular interest to note in which specific combinations concentration integration and cooperation strategies will bring about commercial success.

3.4. Specifying Enabling Services in telecommunications service systems

Title	Specifying Enabling Service in Telecommunications Service Systems
Authors	Jochen Wulf, Rüdiger Zarnekow (TU Berlin), Thorsten Hau, Walter Brenner (University of St. Gallen)
Published in	15th Americas Conference on Information Systems (AMCIS2009)
Research objec-tives	- Derive a well defined conceptualization of Enabling Services taking into account telecommunication value chains and architectures (e.g., Service Delivery Platform) - Specify a structured approach to identify new economic prospects in the telecommunication wholesale market - Define a methodology for the specification of preliminary services for ICT service providers using state-of-the-art scientific approaches
Methodology	- Literature overview of preliminary technological and economic work - Usage of Service Science and Engineering concepts and models - Case study with a European telecommunications company in 2007
Results and implications	- Definition of a three step process for the specification of Enabling Services in accordance with Service Engineering principles - Conceptualization of platform based function modules, so called Enabling Services, based on concepts of Service Science. - Application example for the three step process: Trend analysis, val-ue chain for the production of ICT services, Enabling Services for Packaging

Table 3-18: Summary of [Wulf et al. 2009a]

In telecommunications, increasingly complex service systems evolve which have the objective to produce ICT services. The increased complexity is due to the convergence of the industry sectors information technology, telecommunications and media. Telecommunication network operators are challenged to modify their business strategies: they cannot any more produce ICT services in a vertically integrated fashion but need to market preliminary services as suppliers for other ICT service providers. For this task, modular service concepts known from Service Science and IS research can be employed. ICT service modules, so called Enabling Services, are provided on Service Delivery Platforms to support service development. In [Wulf et al. 2009a], an Enabling Service conceptualization is developed. Based on a case study, a process for the specification of Enabling Services is presented. A summary of this article is shown in Table 3-18.

3.4.1. Introduction

The evolution of service systems in telecommunications is mainly driven by technological innovations such as the development of high capacity all-IP networks and multi-access terminals. The merging of the branches telecommunications, information technologies and media in recent years is commonly referred to as *convergence in ICT* [Nystrom/Hacklin 2005]. Due to the development of new business models for ICT services und the emergence of new content and service providers, network operators increasingly take the role of preliminary service providers [Li/Whalley 2002]. ICT service providers independently develop services based on a standardized infrastructure, mostly IP-networks [Fransman 2007]. These services are also referred to as *over-the-top* services in non-academic literature. By developing Enabling Services network operators try to identify and provide attractive preliminary services for these ICT service providers [Wulf et al. 2008]. Up to the present, neither the economic meaning of Enabling Services in telecommunications has been discussed in research, nor methods for the design of Enabling Services have been proposed.

TV over Internet is a suitable example: Throughout decades, carriers controlled TV services on most stages of the value chain (i.e., from network operation up to distribution). Today Internet-TV providers, such as Zattoo, Joost or Babelgum, increasingly manage to attract customers. These ICT service providers only source the connectivity of their servers to the IP network and require a broadband IP access at the end customer's side. Without the cost-intensive operation of networks, they are capable to offer TV services, mostly based on advertisement-financed business models. Network providers could carry out the distribution and quality transport of the content of Internet-TV service providers as an Enabling Service. In order to facilitate the transport of data-intensive content via IP networks, carriers need to establish the required basis by building server networks, installing route optimization technologies and extending network capacity. Based on these technologies, carriers are able to market the quality transport as an Enabling Service.

Simultaneously, industrialization concepts are introduced in the IT sector [Zarnekow et al. 2006]: Systems and methods are being developed to adjust IT services with end customers and at the same time enable a cost efficient production. It is envisioned to reach a high degree of division of labour and automation based on standardized production techniques. Regarding technology, this is supported by systems and architecture concepts such as virtualization technologies, and service oriented architectures, which enable the development of customer oriented products based on standardized and preconfigured modules.

During the development of Enabling Services, telecommunication network operators are also facing the challenge to produce cost efficiently and at the same time to enable the development of customer oriented services. For this reason, in this paper concepts of IT service management are employed in order to create a conceptualization of Enabling Services as well as a structured process to specify Enabling Services.

3.4.2. Literature review

Service Science, Management and Engineering (SSME) is a research discipline, which deals with the specific characteristics of services and the derivable requirements and methods for the design and management of services [Buhl et al. 2008; Chesbrough/Spohrer 2006; Demirkan et al. 2008]. Services are defined as the application of competence and knowledge to create value between providers and receivers, which work together to coproduce value in complex value chains or networks, referred to as service systems [Spohrer et al. 2007]. Based on the constitutive attributes of services [Corsten 2001], some authors present conceptualizations of services [e.g., Bullinger et al. 2003], which emphasize on specific characteristics on three dimensions: In the potential dimension the focus is on the design and organization of production capacities. The process dimension addresses the design of production processes and particularly the integration of customers. In the outcome dimension the focus is on the precise definition of required service levels, which is important due to the intangibility of services. Based on this conceptualization, various authors design methods and techniques for the design of services (service engineering) [Boehmann et al. 2003; Edvardsson/Olsson 1996; Uebernickel et al. 2006]. [Zarnekow et al. 2006] give an overview of the management activities required to realize a customer orientation and industrialization for IT services. [Boehmann et al. 2003] design the concept of modular IT service architectures, which supports the industrialization of IT services.

In telecommunications research, some authors address the issue of the impact of convergence [Fransman 2001; Li/Whalley 2002]. Another focus of research is the technological design of Next-Generation-Networks and platforms in telecommunications [Knightson et al. 2005; Magedanz et al. 2007; Muller 2006; Pavlovski 2007]. The identification of requirements, which emerge from company and market situations and concern the design of services and technological architectures as well as the associated design and management techniques are poorly addressed in telecommunications research and are subject of this publication.

In the following, a common understanding of ICT services is established (Section 3.4.3) and a conceptualization of platform based service modules in telecommunications is presented (Section 3.4.4). Subsequently, a structured process for the specification of Enabling Services is presented (Section 3.4.5) and applied in the course of a case study (Section 3.4.6).

3.4.3. ICT service model

Before we discuss ICT service modules and their specification, a short overview of the general design layers of services is given.

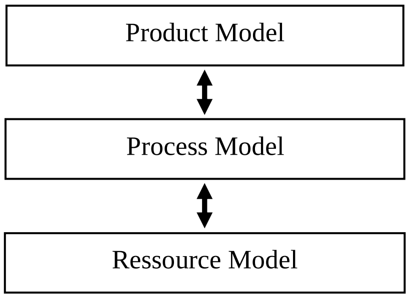

Figure 3-4: Descriptive model for services

As depicted in Figure 3-4, for the modeling of services, one differentiates the following layers [Scheer et al. 2004; Bullinger et al. 2003]: the product model, the process model and the resource model. At the product model layer the service offering for the end customer is described. For each product of a service provider, all characteristic features, namely the value propositions and the target customer groups, are presented. Services can address private consumers, e.g., voice services like mobile telephony, and business processes of professional consumers, e.g., the operation of payroll accounting as a service. On the process model layer, it is described, which activities are necessary for the production of services. Internal production activities as well as customer interactions are regarded. On the resource model layer, it is described, how human resources and ICT production systems (networks, servers, data storage disks etc.) are used. For each process activity, required subtasks including the provisioning of hardware resources and the operation of application systems are allocated. E.g., for the activity *transmission of location information* the operation of data base applications and servers is required, in order to save and update location information, as well as the operation of network infrastructure, which enables the communication between the database and terminals.

In order to enable an industrial production of ICT services, resource management can be carried out with the help of modular service architectures and platforms [Boehmann et al. 2003]. Preliminary ICT services are then offered as modules. Platforms allow accessing distributed ICT production systems via well defined interfaces and coordinate the provisioning of ICT services at run-time.

3.4.4. Enabling service definition

In telecommunication network architectures, a modular concept is introduced, which is referred to as Service Delivery Platform (SDP). Even though SDPs are being developed and already in use, there does not exist a generally accepted conceptualization. From the existing literature about SDPs [Muller 2006; Pavlovski 2007], some central characteristics of SDPs can be identified: SDPs are IT Platforms. They are software applications, which are accessible via well defined interfaces. SDPs provide functionalities for the support of ICT service development (e.g., search and retrieval of modules), for the support of ICT service operation (e.g., coordination at runtime) and for the support of ICT service management (e.g., charging and billing). Additionally, SDPs also provide means for developers to integrate and distribute their

Enabling Services. Enabling Services offered on SPDs are network agnostic: They run on heterogeneous physical networks and software implementations. Based on the specific application context of the end user (e.g., terminal and access network), they make use of appropriate network functionalities. For this work SDPs are defined as follows: Service Delivery Platforms (SDPs) are IT environments, which support the development, the provisioning and the management of ICT services and provide preconfigured modules with network agnostic functionalities.

Within these architectures, preliminary services are designed as reusable, technology-oriented service modules with well defined interfaces. On the economic level, these modules are benchmarked by their value contribution to the ICT services: They are perceived as enablers of ICT services on the preliminary services level. For this reason, we refer to the service modules in the ICT sector as Enabling Services: Enabling Services are well defined software modules and accessible via a Service Delivery Platform. As preliminary services, they support the production process of ICT services. They are provided in order to support ICT service development and provisioning. E.g., the coordinates of a person's present location can be transmitted by an Enabling Service. This preliminary service enables the development of location based services.

The platform based marketing of service modules has the advantage for telecommunication network operators to foster innovation in ICT service development on a wide basis. Through the opening of the access to formerly proprietary systems, they can potentially profit from the innovative power of a multitude of developers. Through profit sharing business models, platform providers have the option to directly participate in the success of service providers. As a side effect, the core business of network operators, the network transport, is stimulated: an increase of ICT service usage has a direct relationship to higher infrastructure capacity usage.

This aspect becomes obvious in Apple's iPhone SDK business model: For the iPhone, Apple offers a development platform with a multitude of programming interfaces, the iPhone Software Development Kit (SDK). Already after a short amount of time after its launch, a lot of applications have been developed on this platform. The marketing of these applications is carried out through the App Store, which is controlled by Apple. 30% of the profit is retained by Apple. Through the offering of a great variety of applications, Apple's core product, the iPhone, is enhanced.

3.4.5. Specifying Enabling Services – A structured approach

Service engineering concepts for the development and management of general services have been adapted to the specific context of ICT services [Boehmann et al. 2003]. But the specifics of the development of Enabling Services have, up to the present, poorly been addressed by researchers. As presented above, a primary objective of service engineering is the design of a resource model for a given service. Being preliminary services of ICT services, Enabling Services are a subject of design in such resource models. For this reason, Enabling Service design is a subtask in service engineering. Many methods in service engineering suggest a customer oriented design of services, which is based on the descriptive model for services. Service concept and production processes are designed based on customer requirements (top-down approach). The given infrastructure is only taken into account and matched to modules at the lowest layer, during the design of resources (bottom-up approach). The definition of Enabling Services, presented in the previous section, suggests a structured approach to the specification of Enabling Services, which is oriented at the methods of service engineering: Enabling Services implement ICT service modules, which support an end customer service production process. The specification can therefore be carried out in three steps (Figure 3-5):

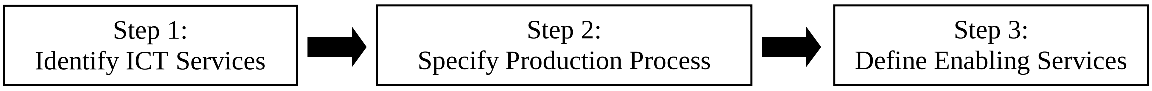

Figure 3-5: Steps for the specification of Enabling Services

In the first step, ICT services, which are to be supported by a platform, are identified based on customer requirements. Trend analysis and customer surveys evaluate the service demand. Thereafter, customer requirements are defined, which are addressed by a service offering. Finally, feasibility studies can be carried out and the profitability of a service can be assessed.

In a second step, activities are specified, which are required for the production of ICT services. A functional decomposition of the selected ICT services is carried out. The identified activities form the starting point to the functional design of Enabling Services in the next step. These activities are structured in a business process for the production of an ICT service. For process modeling, modeling techniques well known from Business Engineering can be employed [Scheer 2000; Oesterle 1995].

In the third step, Enabling Services are identified to support process functions. Function modules are defined, which completely or partially support a function as an application with a software interface. Modules are functional units of a manageable size, which are independent from their application context and have well defined interfaces [Boehmann et al. 2003]. Each identified module is further specified in an Enabling Service definition. Such a definition contains interface and functionality descriptions and serves as a basis for Enabling Service implementation.

Regarding the scope of functionalities, which are provided by Enabling Services, there is no agreement reached in applied and academic research. A standardization effort, the Open Service Access (OSA) [Unmehopa et al. 2006], identifies few basic SDP modules, which can be regarded as the least common denominator. Table 3-19 gives an overview of selected module concepts from applied and academic research. Mostly, only functionalities have been taken into account, which can be implemented in Next-Generation-Networks [Knightson et al. 2005].

A comprehensive portfolio of Enabling Services needs to be developed in order to reach the objective of SDPs and Enabling Service development: to efficiently support ICT service providers during service development. Ideally, the main value proposition of service development is the aggregation of preconfigured Enabling Services and not any more the independent development of custom-tailored individual solutions.

Name	Author	Function Scope of Modules
OSA/Parlay API [Unmehopa et al. 2006]	Parlay Group	Call Control, User Interaction, Mobility, Terminal Capabilities, Data Session Control, Generic Messaging, Connectivity Manager, Account Management, Charging, Policy Management, Presence and Availability Management, Multi-Media Messaging, Service Broker
OMA Service Environment (OSE) [OMA 2005]	Open Mobile Alliance	Broadcasting, Content Delivery, Device Management, Digital Rights Management, Game Service, Location, Messaging, Charging, Presence & Availability, Push to talk, Security
Sprint Business Mobility Framework	Sprint	Location, Presence and Messaging
Web21C SDK	British Telecom	Authentication, Call Flow, Conference Call, Inbound SMS, Messaging Voice Call

Table 3-19: Function scope of SDP modules

3.4.6. Case study

In the following, a case study is presented, which was carried out at a European telecommunications company in 2007. It was the objective to create a companywide shared understanding of Enabling Services. Based on this understanding, fields of action for the creation of an Enabling Service portfolio were identified.

In the first step, a trend analysis for the ICT service market was carried out, in order to make predictions about the future demand for ICT services (Table 3-20). In the course of this trend analysis, various market surveys were analyzed [BITKOM 2007; Gartner 2006; Pohler et al. 2006; Wirtz et al. 2006] and trends were extracted, which have a sustainable impact on an ICT service segment. Based on these findings, ICT services were selected, which are to be supported by Enabling Services. For example, in the segment communication services, the trend convergence has been considered important: in this context, it refers to the substitution of traditional circuit-switched telephony by IP-based packet-switched telephony. Video conferencing is an ICT service, which is directly effected by this trend. IP-based technology offers manifold opportunities to implement innovative video conferencing services in the future. Such implementations can be supported by Enabling Service offerings.

ICT Service Segment	Trends	ICT Services	
Information Services	Self promotion and participation Information reduction Automated Processing Data Usability	Mobile Search Location Aware Services / Navigation	User generated content Videocasting and Podcasting
Communication Services	Convergence Communication as a Service Ubiquity	VoIP IP Telephony Single Phone Unified Communications	Unified Messaging Video Conferencing Web Conferencing
Transaction Services	User Empowerment Personalization	Web Self Services Community Marketing E-Marketing	Preference Management Mobile Marketing and Advertising E-Payment
Enterprise Services	Flexibility	Utility Computing Network Outsourcing	Software as a Service
Entertainment Services	Fast Accessibility Mobility Terminal Convergence	IPTV Mobile TV Broadcasting Mobile TV Streaming Video Streaming	Video on Demand Pay-per-View Digital Music / Video Distribution Gaming and Online Gaming

Table 3-20: Trend analysis for ICT services

In the second step, a general value chain for the production of the previously identified ICT services was created (Figure 3-6). The value chain is subdivided into four segments: Content, Application, Infrastructure, and Delivery and Management. The linear design of the value chain does not necessarily imply that all segments and activities have to be processed consecutively. The intention is to provide an overview of all required activities. Activities in all four segments are a necessary prerequisite to provide a complete end customer service over a telecommunication network.

The *Content* segment consists of the activities content creation, content aggregation, and packaging. The term *content* does not only refer to information and entertainment content, which is paid for by consumers, but also to user generated content and advertising. Content creation covers all tasks that are needed to produce content such as research, script writing and editing. Content aggregation, as the second activity, includes the gathering of content from heterogeneous sources and the digital rights management. Packaging is the last activity in this segment and encompasses the bundling of content according to customer needs.

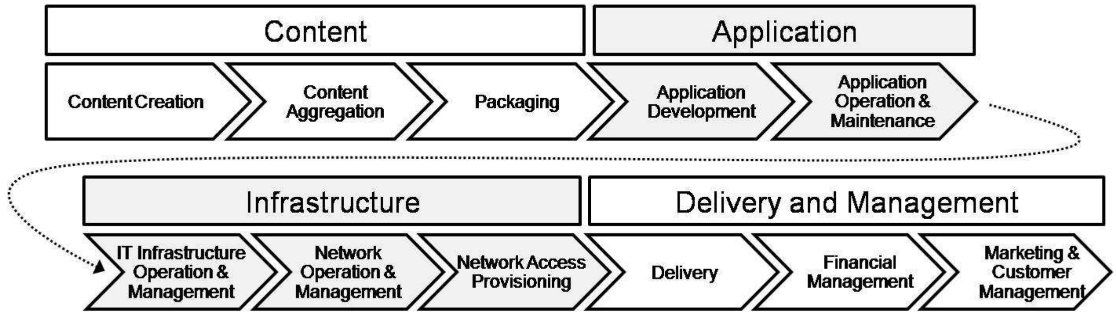

Figure 3-6: Value chain for the production of ICT services

The *Application* segment comprises all tasks for the creation of software, which supports the production of end customer services. Application operation and maintenance is a prerequisite for the provisioning of applications, e.g., in Application Service Provisioning (ASP) solutions. The *Infrastructure* segment is subdivided into IT infrastructure operation and management, network operation and management, and network access provisioning. The IT infrastructure operation and management activity focuses on acquiring and managing hardware resources to run applications. Network operation and management consists of providing data transportation services and network management. Network access provisioning includes the provisioning, management and sales of network access. The *Delivery and Management* segment of the value chain comprises all ICT service specific activities which require a direct end customer relationship. Delivery covers all tasks that are related to providing terminals and software for the access of end customer services and to the management of the content appearance on the terminal devices. Financial management tasks include the accounting of end customer services as well as of all preliminary services that are used in the production process. Tasks in the last activity in the value chain focus on the management of marketing, CRM and customer support.

For all of these value chain activities, functional modules are defined in the last step, which support these activities. For these functional modules, interface and function descriptions are created, which jointly define an Enabling Service. Table 3-21 lists functional modules for the activity packaging, in which content is adapted to specific end customer requirements. E.g., the transmission of status information of end users is a functional module, which is potentially used during packaging. With such information, content can be edited according to a customer's requirements, e.g., by creating and sending a text message either as an email or as an SMS.

Enabling Service	Function Description
License Issuing	Check terminal data, Control user identity, Retrieve product ID, Create license, Save license
Usage Authorization Control	Check terminal data, Control user identity, Control product ID, Retrieve license, Analyze license, Submit control information
Location Information Transmission	Control user ID, Retrieve and transmit location information
Transmission of Status Information	Control user ID, Retrieve and transmit status information
User Profile Transmission	Control user ID, Retrieve and transmit user profile
Customer Terminal Equipment Information Transmission	Control user ID, Check status, Retrieve terminal ID, Transmit terminal information

Table 3-21: Enabling services for packaging

This way, a multitude of Enabling Services were specified. Not all of them are implemented by the telecommunications network operator. The issue, which Enabling Services can be marketed efficiently, is not analyzed during this specification process. It should be addressed separately by carrying out market surveys. Thereafter, the selected Enabling Services need to be implemented, the required production environment needs to be installed and the Enabling Services need to be integrated in a SDP.

3.4.7. Interim conclusion and outlook

Due to the emergence of complex service systems in telecommunications, formerly vertically integrated telecommunication network operators are increasingly under pressure to redesign their business models [Li/Whalley 2002]. Whereas *over the top* service providers, which are new to the market, partially realize high profit margins, the data transport, which is the core business of telecommunication network operators, has been degraded to pure commodity [Nystroem/Hacklin 2005]. New technologies offer the opportunity to telecommunication network operators to market new products. For product development, they can make use of established methods from IS research: This paper establishes a conceptualization of platform based function modules, so called Enabling Services, based on concepts of Service Science. Such a conceptualization is a prerequisite for the introduction of modular service platforms in telecommunications. Present implementations reveal that the introduction of modular service architectures in telecommunications is in an early stage. In contrast, in the IT sector, service oriented architectures are already popular. The presented case study demonstrates that there are more opportunities for the marketing of Enabling Services than just the modularization of existing telecommunication systems und functionalities. Comprehensive module offerings are required to enable an efficient service development.

Additional research efforts are required regarding economic as well as technological issues: It is necessary to technologically realize the concepts of Enabling Services and SDPs presented in this work. The question must be answered, whether it is possible to satisfy customer requirements in modular service architectures, e.g., regarding security and response times. Economically, it must be analyzed, which Enabling Services are required as a foundation for future ICT service implementations and which role will be played by telecommunication network operators. In addition to the development of Enabling Services, it is also possible to integrate third party service modules into one's platform. This raises the question, how platform concepts can support the distributed production of ICT services. In the telecommunications ecosystem, which is growing due to convergence [Li/Whalley 2002], modular ICT concepts can be employed for the customer oriented allocation of production tasks [Hoogeweegen et al. 1999]. In order to analyze such consequences of the introduction of modular platforms in telecommunications from the micro- and the macroeconomic perspective, additional research activities are required.

As described in [Maglio et al. 2006], technology is not the only resource, which must be engineered and managed in service systems. People, knowledge and organizations are equally important resources. Hence, the installation of SDPs will not be sufficient to enable efficient, effective and sustainable ICT service provisioning in telecommunications service systems. Resulting research issues address the management of such resources to optimally enable cooperation within service systems, e.g., by providing shared informational resources or by setting cooperation incentives [Spohrer et al. 2007].

4. Technological and economic approaches for service distribution

A central field of research conducted in the course of this dissertation deals with technological and economic approaches for service distribution. The emerging technologies and business models, which address the distribution of IP services, potentially have a strong impact on the market for data transport services such as IP transit and peering [Faratin et al. 2007]. For this reason, the research in this field aims at exploring the different distribution business models and strategies in the telecommunications industry. Table 4-1 provides an overview of the publications included in this section.

Title	Published in	Reference	Section
Service Distribution in IP-Networks - A Business Model Analysis	Electronic Communications of the EASST, Vol. 37, 2011	[Wulf 2011]	4.1
Technologies for the Electronic Distribution of Information Services - A Value Proposition Analysis	Electronic Markets 20(1), 2010	[Wulf/ Zarnekow 2010b]	4.2
Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario	Proceedings of the International Conference on Information Systems (ICIS 2011)	[Wulf et al. 2011a]	4.3

Table 4-1: Publications addressing technological and economic approaches for service distribution

In Section 4.1, different business models for service distribution are systematically discussed and compared. Section 4.2 compares the value propositions of different technologies for information service distribution. The strategic consequences of a novel technology for service distribution (inter-provider QoS) are evaluated in Section 4.3.

4.1. Service distribution in IP-networks - A business model analysis

Title	Service Distribution in IP-Networks - A Business Model Analysis
Authors	Jochen Wulf (TU Berlin)
Published in	Electronic Communications of the EASST, Vol. 37, pp. 1-13, 2011
Research objectives	- Creating systematic models of IP based distribution business models presently found in practice - Investigating the different technical options and their implications with respect to business models for IP based distribution - Analyzing different business models for IP based distribution, their distinct characteristics and value propositions
Methodology	- Using reference business models to analyze economics of service distribution in IP-networks in four dimensions: activities and roles, technological resources, value proposition, as well as revenue model and cost structure - Generalizing characteristics of business models found in practice following an inductive approach - Presentation of four case studies (Strato AG, BT Vision, Akamai, BitTorrent)
Results and implications	- Identification of four business models for service distribution in IP-networks: Centralized Internet Hosting, Direct Homing, Content Delivery Networks, P2P Distribution - Business models for service distribution in IP-networks significantly differ from each other in the allocation of roles, in the financial flows as well as in the data flows - Value propositions of the distribution business models mainly address quality and cost aspects. However, they are not clearly distinguishable

Table 4-2: Summary of [Wulf 2011]

In [Wulf 2011] different business models for the distribution of content and services over IP networks are analyzed and their distinct characteristics and value propositions are outlined. Four business models are distinguished: Centralized Internet Hosting, Direct Homing, Content Delivery Networks and P2P Distribution. In contrast to prior research, it is focused on the ability of present technology to support distribution quality. Moreover, the required value chain activities and roles, technological resources, as well as revenue models and cost structures are discussed. Following an inductive approach, it is generalized from business models in practice. Case studies are presented in order to demonstrate, how these business models are implemented. This structured business model analysis demonstrates the different courses of action of providers regarding the IP based distribution of their content and services. Research design and results are summarized in Table 4-2.

4.1.1. Introduction

Distribution management for tangible goods encompasses all activities associated with warehousing and transporting goods to customers as well as the associated information and controlling tasks. The objective is to *deliver the right goods at the right time in the right amount and quality* and meanwhile optimally balance the quality and the costs of the delivery service [Schulte 1995]. Even though the economics of information goods and services are fundamentally different [Shapiro/Varian 1999], the objectives for the distribution of tangible goods also hold for the distribution of information goods.

Internet Protocol [Postel 1981] based distribution refers to the delivery of information goods and services over IP networks, which include the Internet but also dedicated IP networks. Whereas traffic is routed in a best-effort class on the Internet, dedicated networks can exclusively reserve capacity for a specific service. Therefore, dedicated IP networks are not exposed to congestion and enable better distribution quality.

The distribution of information goods over the Internet has been subject to a discourse in research since the immense growth of the Internet in the late 1990s. Hess [1999] analyzes the state of the art for Internet distribution in the German media market. Gayer and Shy [2003] acknowledge the importance of Internet distribution and distinguish between two fundamental Internet distribution channels: the distribution from a central server and the distribution via peer-to-peer (P2P) distribution channels. Dubosson-Torbay et al. [2004] outline business models for the distribution of music over the Internet. Prior research does not sufficiently analyze the different technical options and their implications with respect to business models for IP based distribution.

Two issues have a significant impact on the present and future evolution of IP based distribution, namely network congestion and digital rights management (DRM). As Internet traffic grows at a high speed, it is discussed whether network capacity will be able to handle the future traffic load [Nemertes 2007]. Active traffic throttling already is enforced by some network operators [Anderson 2008]. Traffic throttling and network congestion endanger the quality of IP based distribution business models, which depend on best-effort IP traffic. Secondly, the entertainment industry has suffered tremendous losses due to digital piracy and for this reason engages DRM technology for a better protection of the digital products [Sundararajan 2004]. The requirement to operate a DRM system imposes significant challenges to service distribution over IP networks.

The objective of this work is to analyze the different business models for IP based distribution and to outline their distinct characteristics and value propositions. We follow an inductive approach by creating systematic models of IP based distribution business models, which are presently found in practice. We present case studies in order to demonstrate, how these models are applied.

This paper is structured as follows: In Section 4.1.2, the general components of IP based distribution business models are described. In Section 4.1.3, we present four distinct IP based distribution business models, i.e., Centralized Internet Hosting, Direct Homing, Content Delivery Networks and P2P Distribution. Section 4.1.4 comprises a case study for each business model. The paper concludes with a summary and an outlook in Section 4.1.5.

4.1.2. General characteristics of IP based distribution business models

According to Timmers [1998], a definition of a business model consists of various aspects. Firstly, it comprises an architecture for the product, service and information flows and a description of the various business actors and their roles. Secondly, it encompasses a description of the potential benefits for the various business actors as well as a description of the sources of revenues. Osterwalder and Pigneur [2002] identify four important pillars of business models: *product innovation, infrastructure management, customer relationship* and *financials*. The *product innovation* deals with aspects related to the offering of a firm, i.e., the value proposition, the target customers and the core capabilities. The *customer relationship* describes how a firm goes to market and maintains customer contact. It comprises an information strategy, distribution channels and trust establishment mechanisms. The *infrastructure management* determines the configuration of a value system, which is required to create value propositions. It is composed of an activity configuration, the partner network and a firm's resources. The *financials* segment defines a company's revenue model, cost structure and profit model.

In this article, we focus on general characteristics of IP based distribution business models rather than on specific instantiations. Based on the analysis of the above mentioned business model classifications, we selected the following aspects to be relevant for our business model descriptions:

- the value proposition,
- the value chain activities,
- the roles in IP based distribution,
- the technological resources, as well as
- the revenue model and cost structure.

Other business model aspects, such as customer relationship management, were not taken into account. Such aspects cannot be generalized due to their specificity to a concrete business model implementation.

Value proposition of IP based distribution

Similar to the distribution of physical goods, the core value proposition of IP based distribution is the delivery of goods and services in the *right time, and to the right amount and quality* [Schulte 1995]. Customers of information services and goods are not capable to distinguish between the influences of different actors of IP based distribution on the overall service quality. Hence, all actors of IP based distribution must cooperate during value creation (end-to-end principle). Quality of Experience, that is how a customer perceives the quality of a specific service in an IP based distribution system, is highly dependent on the specific service and customer and therefore hardly generalizable. However, for each type of service, bounds for certain technical parameters can be used to precisely describe what is considered an appropriate service quality. These technical characteristics of IP based distribution are subsumed under the term Quality-of-Service (QoS) in prior research [Zarnekow et al. 2007; Zhao et al. 2000]. QoS describes the allocation of the following quality parameters to a service: bandwidth, delay, jitter and packet loss. The *bandwidth* defines the maximum volume of data per time unit being transmitted over a particular network connection. The *delay* comprises the length of time that a data package takes from the sender to the recipient. *Jitter* describes the fluctuation in the delay. *Packet loss* defines the number of data packets that are lost in the transmission from the sender to the receiver. The *right time* in IP based distribution is determined by bandwidth, delay and jitter, the *right amount and quality* of a good is influenced by the packet loss.

Value chain activities for IP based distribution

Timmers [1998] recommends employing the value chain conceptualization [Porter/Millar 1985] for a systematic approach to identifying architectures for business models. In this conceptualization, a company’s activities are divided into *technologically and economically distinct activities it performs to do business*.

In traditional operational distribution management one distinguishes between the following value activities [Schulte 1995]: Warehousing, consignment, packaging, shipment, and transport. The specific characteristics of information goods [Shapiro/Varian 1999] affect the operational tasks for distribution over IP networks. Through an analysis of these characteristics, we identified the following core value activities for IP based distribution outlined in Figure 4-1: The *service production activities* encompass content creation, aggregation and packaging. As the information overflow in the Internet leads to a shortfall of attention, an emphasis is put on the customization of information goods, carried out during content creation and packaging. As information goods involve high production costs but negligible costs and time for reproduction, warehousing of stocks and consignment is not necessary. Instead, an information good is stored on a server. As a reaction to a download request, it is reproduced, packaged and fed into the IP network. These tasks form the *hosting activities*. For the *transport activities*, different rules are applicable than for the traditional logistics of tangible goods since transport is carried out over telecommunication networks. Since many information goods are requested and consumed almost simultaneously, route optimization (i.e. QoS) has even a higher priority than in traditional logistics. Due to the complex structure of IP networks, transport often includes the passing on of IP packages between autonomous networks (transit) in addition to the delivery to the end customer (termination). In the *consumption activity*, the information good is consumed by end customers after delivery.

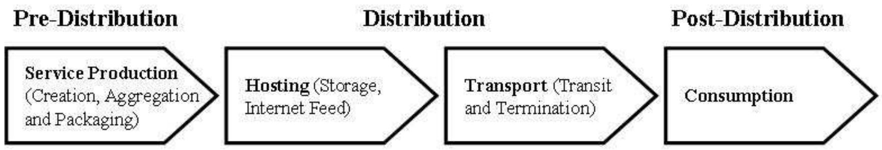

Figure 4-1: Value chain for Internet distribution

Roles in IP based distribution

In IP distribution, one can identify the following roles: Content Providers (CP), Network Service Providers (NSP), Hosting Providers (HP), Content Delivery Network Providers (CDN), Distribution Software Providers (DSP), and End Customers (EC).

CPs create, aggregate and/or package content. By content, we not only refer to classical information and entertainment services, but also to B2B and communication services and user generated content. Providers of information goods rely on a good quality in IP based distribution in order to guarantee satisfactory service provisioning. They most often make use of distribution service providers for this task. Under the term distribution service providers we subsume HPs, NSPs, CDNs and DSPs. HPs operate servers and make content accessible from IP networks [Gautam 2005]. NSPs, operate IP networks and offer network access to CPs, HPs as well as to ECs [Fransman 2007]. In this work, we consider the HP to be a sub-role of NSPs, because NSPs most often also carry out hosting or at least maintain close relationships to HPs. CDNs manage content distribution over a network of hosting servers applying technologies such as caching and route optimization [Vakali/Pallis 2003; Hosanagar et al. 2005]. DSPs develop peer-to-peer (P2P) software for a client side optimization of content distribution [Androutsellis-Theotokis/Spinellis 2004]. ECs acquire access to IP networks from NSPs. They consume services offered by the CP and can be classified as being either private or business customers. In P2P Distribution, ECs also host content.

Technological resources for IP based distribution

An important aspect of business models is the type of resources, which are required. In this work, we particularly focus on the technological infrastructure such as networks, storage and processing capacity and software [Wade/Hulland 2004]. For a large part, IP based distribution relies on a communication network infrastructure, i.e. wire line and wireless transmission networks [Tanenbaum 2003]. The Internet is a network of networks, formed by interconnected autonomous systems (AS), which are largely owned by companies with commercial interests. As peering (settlement free interconnection) and transit (charge based interconnection) agreements are negotiated individually, the Internet represents an economically very complex and often inefficient system of interconnections [Faratin et al. 2007]. Due to this reason, interconnections represent potential bottlenecks for IP based distribution. Data is either passed through the Internet as best-effort traffic or through dedicated capacity, which requires additional routing and capacity management systems.

Apart from the transmission infrastructure, the location, connection and processing capacity of the hosting servers has a significant impact on IP based distribution. The strategic decision on where to host content is one of the main competencies of CDNs, which operate server networks. Lastly, also P2P systems are increasingly employed for IP based distribution [Androutsellis-Theotokis/Spinellis 2004].

Revenue model and cost structure

The revenue model characterizes the revenue streams within IP based distribution. According to Wirtz and Kleineicken [Wirtz/Kleineicken 2000], revenue models can be characterized into either being transaction based or non-transaction based as well as into generating direct or indirect revenues. Direct revenues are directly charged at end customers, whereas indirect revenues are drawn from a third party. Revenues are transaction based if they are collected in the course of a single transaction or user interaction. Otherwise, revenues are referred to as non-transaction based. The ability to impose transaction based charges yields the advantage to closely tailor distribution prices and services to the type of transaction and as such to reach better price and service differentiation.

Main revenue sources with respect to IP services are ECs and advertisers [Wirtz/Kleineicken 2000]. For simplicity reasons, advertisement based financing is excluded in the following business cases. For distribution business models with direct revenues, advertisement based funding has a direct impact on the distribution business model but does not fundamentally alter its structure. IP transit payments between NSPs are also part of IP based distribution revenue models. Since they are not in the focus of this analysis, such payments are not taken into account.

The cost structure describes all the costs, which are incurred by a company to conduct service delivery. Costs significantly differ among IP based distribution business models. At the one extreme, IP based distribution potentially entails heavy capital and operational expenses for network or server infrastructure. At the other extreme, intelligent software based routing and distribution applications, which are far less cost intensive, can also have a significant impact on distribution quality.

4.1.3. IP based distribution business models

Four generally different business models for IP based distribution can be distinguished: Centralized Internet Hosting, Direct Homing, Content Delivery Networks and P2P Distribution. They are depicted in Figure 4-2 and discussed with respect to the above presented aspects in the following.

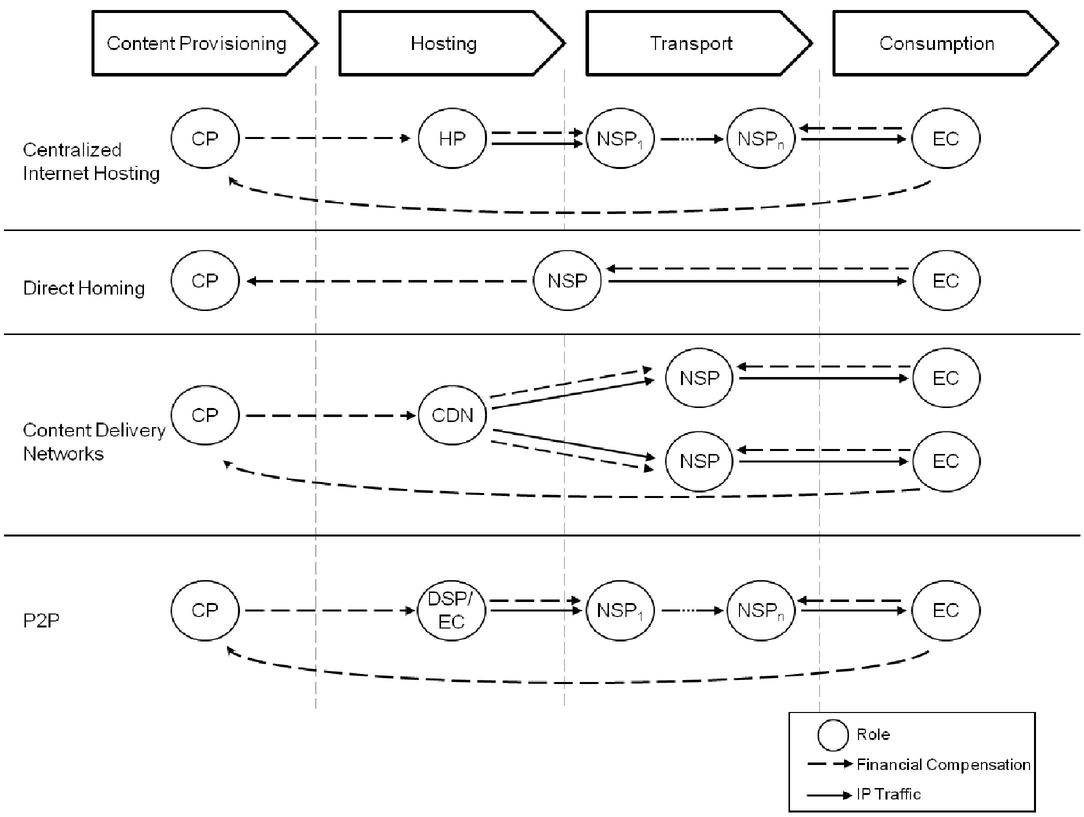

Figure 4-2: IP distribution business models

Centralized Internet Hosting

Activities and Roles - The Centralized Internet Hosting business model represents the traditional distribution method: A CP assigns hosting either to an independent HP or to a NSP. For simplicity reasons, only the second case is discussed. The HP/NSP connects the hosting servers to the Internet and makes the content accessible. It is then in the NSP's domain to further route the traffic.

Technological Resources - The Centralized Internet Hosting distribution does not require resources additional to the classical hosting and network infrastructure. The content is only hosted and accessible at a single location. That is, a HP maintains a single access point to the infrastructure of one or various NSPs. Thus a HP requires only a central data centre infrastructure. NSPs pass on or terminate the traffic through their established interconnection or access network facilities.

Value Proposition - The distribution via Centralized Internet Hosting is suitable to make content accessible on the Internet, which does not need to fulfil high quality demands. The QoS highly varies, depending on the EC's location and the specific route: Whereas the QoS will most likely be perfectly acceptable if the EC is connected to the same NSP as the HP, QoS quickly exceeds acceptance thresholds, if traffic is passed on through various interconnections. The CP has no influence on the routing and as such no influence on distribution quality. In hosting contracts, HPs generally only give guarantees with respect to server uptimes, but not with respect to QoS.

Revenue Model and Cost Structure - The IP based distribution business model does only allow indirect and transaction independent revenue models. Billing is carried out by CPs, distribution providers (HPs and/or NSPs) only receive a share: HPs charge per stored and accessed data volume, NSPs charge for access capacity. In both cases, charges are independent from individual transactions.

Direct Homing

Activities and Roles - In the Direct Homing distribution model, a CP directly contracts the access provider of its EC for distribution. The NSP carries out hosting and data transport. As the NSP already maintains a relationship to the ECs, it often also manages billing and takes over content related tasks such as content aggregation in a content portal.

Technological Resources - Distribution via Direct Homing often is realized on dedicated networks. IP traffic is not routed as part of the best-effort Internet class, but as a privileged class or through reserved capacities. Routing through dedicated networks does not necessarily imply the need to install separate hardware, but requires at least a reconfiguration of routing systems.

Value Proposition - In contrast to Centralized Internet Hosting, the Direct Homing traffic is never routed through interconnections. In addition, the usage of dedicated networks enables a more reliable and configurable QoS. That is why Direct Homing distribution meets stricter QoS requirements and is especially suited for TV and video services.

Revenue Model and Cost Structure - In this business model, direct revenue models are often applied: NSPs charge for the package of content and distribution and pass on a license fee to the CPs. Also, transaction dependent revenue models are possible: As the NSP controls hosting and termination and often also manages content portals (such as online video shops or pay per view TV portals), it is possible to impose charges per transaction and also configure the QoS closely to the service requirements. Routing through dedicated networks does not necessarily imply the need to install separate hardware, but requires at least additional costs in the installation and operation of routing systems. Hosting and termination are carried out by the same party. This leads to synergies which potentially result in lower costs and better quality.

Content Delivery Networks

Activities and Roles - In the CDN business model, the CP tasks a CDN with hosting its content and with managing IP transit. The CDN operates a network of hosting servers and maintains transit agreements with a multitude of NSPs. Ideally the CDN interconnects directly with the access provider of the EC.

Technological Resources - The core technology of this business model is a complex network of hosting servers operated by CDNs. Content is distributed and cached on these servers based on an optimization strategy, which takes into account the location of the ECs. In addition to caching, CDNs also apply prefetching and route optimization technologies [Vakali/Pallis 2003].

Value Proposition - The quality of distribution is highly dependent on the CDN's efficiency of server management and route optimization. For cacheable content, significant improvements in the QoS can be realized in comparison to Centralized Internet Hosting. For non-cacheable content, the CDN technology cannot tap its full potential, because no caching can be applied.

Revenue Model and Cost Structure – In the CDN business model, only indirect revenue models are realized, i.e. CPs charge the ECs and pay a hosting fee to the CDNs. The CDNs offer different technologies for different types of content, and as such are able to realize service and price differentiation. Nevertheless, transaction based charges are not imposed.

P2P Distribution

Activities and Roles - In the P2P Distribution business model content distribution is managed by P2P software applications running on the ECs' clients. The software application, which controls content distribution, is provided by a DSP, which sometimes also maintains additional hosting servers. ECs in this business model not only are consumers but also carry out hosting.

Technological Resources – Required resources for P2P Distribution are limited to the P2P software and an established Internet connection of the uploading and the downloading parties. To enable content protection, a DRM system needs to be installed additionally, which for example activates content after the download is finished (superdistribution) [Mori/Kawahara 1990]. Such a system can also be used for billing. Optionally, the DSP also installs and operates seeding servers to improve QoS.

Value Proposition – The quality of IP based distribution in P2P business models is dependent on various factors: Firstly, the P2P application and the implemented mechanisms for exchanging content have a dominant impact on service quality. Secondly, in all P2P applications, QoS is dependent on characteristics of the seeding clients, such as the number of seeds, their upload bandwidth and their location. Additionally, dependent of the route between seed and client, the network as well has influence on QoS. Bottlenecks such as interconnections or access bandwidth limitations have a negative impact on QoS. Also, NSPs can actively disturb P2P traffic, which is referred to as throttling. The complexity of these factors leads to a high variance and low predictability of P2P QoS.

Revenue Model and Cost Structure – P2P Distribution providers usually have an indirect revenue model, which is not transaction based. But, dependent on the P2P system and the specific contract, transaction based revenue models are possible. The P2P business model requires very little investments into network and hardware infrastructure. Having implemented an effective P2P Distribution system, DSPs can offer services at relatively low costs.

4.1.4. IP based distribution case studies

In order to illustrate, how the above presented business models are applied in practice, a single case study is further described for each business model in the following.

Centralized Internet Hosting - Strato AG

The Strato AG [STRATO AG 2008] is a German corporation, which provides web hosting services, and which operates dedicated and virtual servers. For web hosting, it offers preconfigured service packages with fixed storage space and limited traffic volume from up to 1€ per month. In addition to hosting, it also provides software systems to support content provisioning, e.g., to enable homepage development. The Strato AG is owned by freenet AG, a German NSP with a proprietary IP backbone. According to the general terms and conditions, the Strato AG guarantees an average availability of its servers of 99%, excluding downtimes due to maintenance jobs in the customer's interest and excluding external interferences. Additionally it explicitly excludes guarantees concerning data throughput. It operates two large data centers in Karlsruhe and Berlin and maintains traffic exchanges with Hurricane Electric (US), German freenet, British Cable&Wirless and Swisscom (among others).

For SMEs with low website traffic, this is the common and most economic way of making their information accessible on the Internet.[5] But as traffic exchange points often represent bottlenecks for traffic throughput, this business model is not adequate for traffic intensive multimedia content and content with high end-to-end quality requirements.

Direct Homing - BT Vision

In the United Kingdom, British Telecom (BT) Retail offers an entertainment service called BT Vision [BT 2008]. This service uses the Internet Protocol to deliver on demand films and

[5] E.g., http://www.david-berlin.de/ is the homepage of a youth hostel in Berlin, Germany. From the published information about the hosting AS number, this website is hosted by Strato AG (AS 6724).

video streams, TV, and music. BT manages hosting, data transport and also content related tasks: BT aggregates content from film and music companies, TV channels and soccer leagues and hosts a Video-on-Demand (VoD) portal. It cooperates with Hollywood studios such as Buena Vista, Sony BMG and Dreamworks. High Definition Television content is also offered but must be downloaded before it can be viewed. BT Vision is only available for BT Retail's broadband access customers. It is realized by reserving 1.6 Mbit/s of the available access bandwidth for the VoD content in a QoS session. Customers require a set-top-box to make use of this offer. In their terms and conditions, BT does not give any quality guarantees: *We aim to provide a continuous, high-quality service but we do not guarantee either the quality of the service or that the service will be available at all times. From time to time faults in the service may occur. We will repair these faults as soon as we can.* [BT 2008] Nevertheless, through their capacity reservation technology, BT is able to offer better QoS than distributors which rely on the Internet technology. BT does not impose compulsory monthly payments, but charges on a pay per view basis. It also offers flat rates for specific offers such as pay TV channels. In both cases, BT generates direct and transaction based revenues. A percentage of this revenue is forwarded as a license fee to the CPs.

Similar Direct Homing business models are realized by other NSPs. In all cases, they are only applied for entertainment services, such as IPTV and VoD. Due to necessary investments into infrastructure management and customer premises, this business models is not applicable for low revenue services with less QoS requirements.

Content Delivery Network - Akamai

Akamai Technologies Inc. is an American company providing a distributed computing platform for Internet content and application delivery [Akamai 2008b]. Its services are focussed on hosting and route optimization. Akamai is neither involved in content provisioning nor does it own IP backbone infrastructure. To improve QoS, Akamai develops and employs several technologies such as caching, route optimization and intelligent prefetching. As a basis, Akamai operates its EdgePlatform, a network of about 34000 rented servers deployed in 70 countries. Akamai's services are used by many companies such as Amazon.com, Audi, Fujitsu, HP and NBC. For Audi, Akamai distributes marketing video streams, manages model configurators and accelerates Audi's Web-based content management system [Akamai 2008c]. According to their own claims, it is possible to improve latency and throughput by at least a factor of 10 compared to Centralized Internet Hosting [Akamai 2008b]. For a streaming service, Akamai charges around 50 Eurocents per Gigabyte as a hosting fee [Bleich 2008]. Akamai offers content specific services and prices, but does not impose transaction based charges. Also, it relies on a strictly indirect revenue model.

P2P Distribution - BitTorrent

BitTorrent, Inc. is an American corporation, which develops P2P Distribution technology [BITTORRENT 2008]. BitTorrent develops a software, which enables to publish, search and download digital content. The BitTorrent Delivery Network Accelerator (DNA) speeds up video streams and software downloads. A central component is a P2P client, which integrates existing content hosting servers to seed the managed P2P network. It enables to draw on peers rather than the hosting server, if possible. It includes advanced bandwidth management to fully leverage available capacity without disrupting other applications. DNA reference customers include Aeria Games, a dynamic gaming community of Massive Multiplayer Online games and IAHGames, a leading publisher, operator and distributor of online and console games in Southeast Asia. As a value proposition, BitTorrent promises a traffic offload from the hosting server of about 50%. QoS improvements are also predicted but not guaranteed. With the DNA, BitTorrent implements an indirect and non transaction based revenue model in accordance with the above presented P2P Distribution business model.

4.1.5. Interim summary and outlook

In this work, we gave an overview of current business models for IP based distribution. In contrast to prior research, we focused on the ability of present technology to support distribution quality. Following an inductive approach, we generalized from business models in practice. In some cases, these business models are not disjoint, e.g., Direct Homing and P2P Distribution can be applied jointly.

In order to enable or support new data intensive real-time services, IP based distribution providers constantly further develop distribution technologies which enhance distribution and at the same time take into account the performance and capacity limitations of IP networks and the Internet. As demonstrated by successful IP based distribution business models such as AKAMAI, there is a demand for the support of quality distribution, which is superior to the plain Centralized Internet Hosting business model. In conjunction with the refinement of distribution technologies, new distribution business models continue to emerge. E.g., the refinement of P2P technologies [Aggarwal et al. 2007] potentially leads to new distribution business models.

The structured presentation of business models in this work serves a twofold purpose. Firstly, it makes transparent the different options content and service providers face with respect to distribution. As such, it can support the decision, which distribution method fits best to a specific content or service. Secondly, these models can serve as a basis for the development of future distribution business models.

4.2. Technologies for the electronic distribution of information services - A value proposition analysis

Title	Technologies for the Electronic Distribution of Information Services - A Value Proposition Analysis
Authors	Jochen Wulf (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Electronic Markets Vol. 20(1), 2011
Research objectives	- Comparison of the value propositions of different technologies for information service distribution - Provisioning of decision support for the choice of distribution method - Identification of service requirements met by different distribution methods
Methodology	- Literature analysis of academic research on distribution technologies and distribution economics - Discriminant analysis of 103 information services with regard to service production and consumption characteristics and distribution methods - Content analysis research by multiple IT service experts
Results and implications	- There is no distribution technology which generally provides a superior distribution quality - Distribution technologies vary strongly with respect to the information services they support - Different characteristics concerning service production and consumption have a strong influence on the quality provided by distribution technologies

Table 4-3: Summary of [Wulf/Zarnekow 2010b]

Since the original design and deployment of the Internet architecture, the economic and technological requirements regarding the distribution quality of web-based information services have changed drastically. Business models have evolved that particularly address quality and cost aspects of information service distribution, e.g., Content Delivery Networks and peer-to-peer distribution. In addition, network operators apply differentiated routing technologies in dedicated infrastructures to guarantee a superior Quality-of-Service (QoS). The research published in [Wulf/Zarnekow 2010b] compares the value propositions of technologies for information service distribution. 103 information services were analyzed by means of discriminant analyses in order to identify the main aspects influencing delivery quality and costs. The results indicate that the value propositions differ with regard to the type of services they support rather than with regard to direct QoS criteria, such as latency and packet loss. The insights derived from this work support information service vendors in their choice of a distribution provider. Table 4-3 summarizes the research objectives, the methodology and the results of this research.

4.2.1. Introduction

The electronic distribution of information services has been subject to a discourse in research since the immense growth of the Internet in the late-1990s. In e-business research, a rich variety of issues concerning the application of web-based information services to support business processes have been addressed [Amit/Zott 2001; Timmers 1998].

Physical distribution is defined as the collective term for the range of activities involved in the movement of goods from the point of production to the final point of sale, such as warehousing and transportation [McKinnon 1988, 33]. The objective of distribution is to meet customer desires with regard to the amount of delivered goods and the time and place of delivery. Distribution providers must thereby optimize the balance between quality and costs of delivery [Bowersox et al. 1986, 19]. Even though the economics of information services are fundamentally different [Demirkan et al. 2008; Shapiro/Varian 1999], the objectives for the distribution of tangible goods also hold for the distribution of information services over communication networks (electronic distribution). Despite the richness of e-business research, the economic aspects associated with technologies for electronic distribution have scarcely been addressed.

Several authors [Faratin 2007; Leighton 2009; Saroiu et al. 2002] differentiate between three major distribution methods in the Internet: centralized hosting, Content Delivery Networks, and peer-to-peer file sharing systems. They describe technical implementations and find significant differences in traffic characteristics, but do not compare attributes related to distribution performance. In this paper, a fourth distribution method, called Direct Homing, is taken into account which is commonly used in practice and is based on proprietary IP networks or a modification of the public Internet architecture [Huston 2000, 399-406, ISO 1989, Xiao/Ni 1999]: in Direct Homing scenarios, network operators reserve dedicated infrastructure or perform traffic differentiation in order to meet high performance requirements of specific services, such as IP TV.

Electronic distribution has evolved into a large commercial market. According to an industry report [Frost & Sullivan 2008], the Content Delivery Network (CDN) market earned over $700 million in 2007, and is predicted to increase earnings by up to 400% by 2013. A highly rated target segment for CDN providers is the delivery of Video on Demand content, i.e. the streaming of multimedia content from distributed servers. Other companies promise the same value proposition as CDN providers, i.e. high speed, reliability and efficiency, based on the peer-to-peer (P2P) distribution technology [Androutsellis-Theotokis/Spinellis 2004]. P2P technology is, for example, used to distribute IP TV content in quasi real-time to global audiences.

From the perspective of an information service provider, the specific differences between the value propositions of the four mentioned distribution methods remain largely unclear. The CDN provider Akamai and the P2P distributor BitTorrent, for example, both target download and streaming delivery [BitTorrent 2009; Akamai 2009]. An exemplary service level agreement of Akamai’s CDN service does not quantify performance improvement guarantees [Onecle 2009]. Neither academic nor non-academic literature provides appropriate decision support for the choice of a distribution method and states which service requirements are met by which distribution method.

The objective of this paper is to compare the different technologies for IP based distribution, and to outline their distinct characteristics and their abilities to provide value in specific application contexts (value propositions). 103 information services were analyzed in order to deduce the distinctive value propositions of their associated distribution methods. We argue that information services reveal inherent characteristics of the underlying distribution methods.

This article is structured as follows: in Section 4.2.2, the relationship between information service quality and service distribution is described. In Section 4.2.3, four distinct IP based distribution methods, i.e. Centralized Hosting, Direct Homing, Content Delivery Networks and P2P Distribution are explained. In Section 4.2.4, a set of information service characteristics, which potentially bear a relationship to distribution performance, are identified. These relationships are verified by performing discriminant analyses in Section 4.2.5. The article concludes with a summary in Section 4.2.6.

4.2.2. Information service quality and distribution

Service science researchers have identified a set of constitutive characteristics of services [Demirkan et al. 2008; among others]. These characteristics lead to specific requirements on service distribution and explain its importance (Figure 4-3).

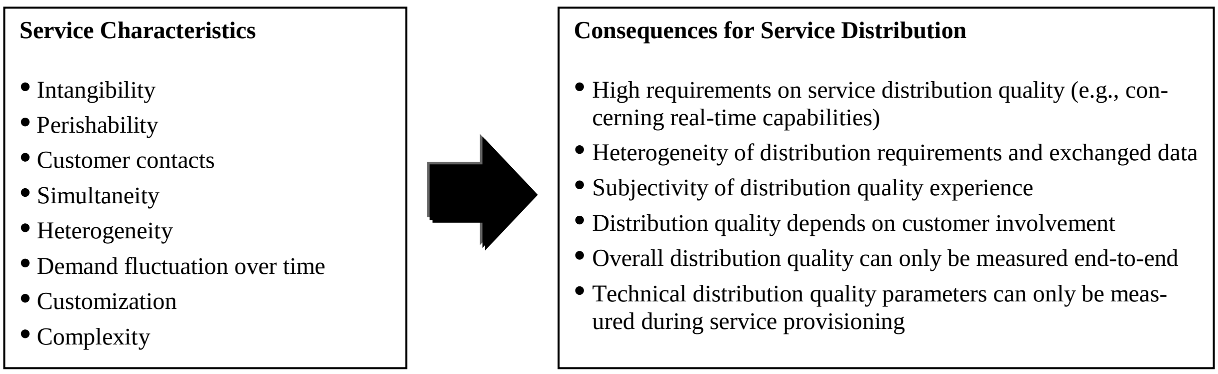

Figure 4-3: Service characteristics and consequences for service distribution

Firstly, the simultaneity of service production and consumption inhibits the preproduction and storage of services and imposes high quality requirements, e.g., concerning real-time service delivery. Secondly, the wide range of potential services results in heterogeneous requirements for service distribution. This makes it difficult to find a standard solution for the distribution of a service. Thirdly, the overall evaluation of the service quality as experienced by a consumer is, to a large extent, subjective. For this reason, requirements for a satisfactory service delivery cannot entirely be generalized. In addition, service delivery requires a direct customer involvement. As a consequence, the distribution quality, to a certain degree, depends on a customer's involvement (e.g., on the access capacity the customer allocates). Due to the intangibility of services the overall distribution quality can only be measured at the customer end, because this is the location at which a service is consumed. Intermediate measurements only allow predictions of overall service quality. Lastly, services are perishable. That is why technical parameters of distribution quality can only be measured at the exact time of service provisioning.

The general concept of service quality has been subject to extensive research in business sciences. It can be assessed by comparing a user's expectations and perceptions of the performance level for a range of service attributes [Parasuraman et al. 1985]. Accordingly, the International Organization for Standardization states: *The quality of something can be determined by comparing a set of inherent characteristics with a set of requirements […] A quality characteristic is tied to a requirement and is an inherent feature or property of a product, process, or system* [ISO 2005]. A requirement is understood as an expectation or a need of a user. Various authors discuss the types of requirements which are to be taken into account in an information service quality assessment [Liao/Cheung 2008; Liu/Arnett 2000; Zeithaml et al. 2000; Zeithaml et al. 2002]. Zeithaml et al. [2002], for example, define the following attributes: information availability and content, usability, privacy/security, graphic style, and fulfilment. Such attributes represent the factors relevant to a user's perception of service quality.

In telecommunications research, the term Quality-of-Service (QoS) is used heterogeneously to describe various concepts of service quality. As discussed by Gozdecki et al. [2003], the term QoS is used, on the one hand, to describe the customer's service quality assessment (business oriented view) and, on the other hand, to define technical parameters of service and network performance (technology oriented view). Figure 4-4 depicts both views. Externally, i.e. in the relationship between service provider and user, service quality describes the general comparison of inherent service characteristics as expected and perceived by users. Internally, i.e. among the parties involved in service production, service performance comprises all performance related parameters of a service described in technical terms, such as speed, accuracy, availability and reliability. These parameters are affected by the inter-working of server, distribution and client systems.

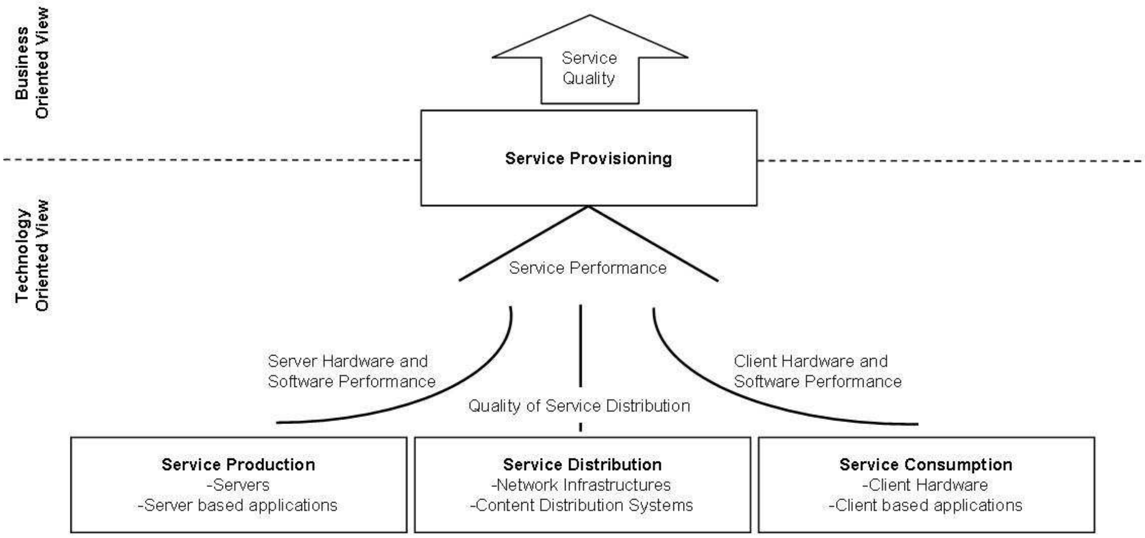

Figure 4-4: Quality-of-Service distribution and service quality

The Quality-of-Service distribution represents one component of service performance, as depicted in Figure 4-4. It is determined by all systems involved in the delivery of content from the originating servers to the end user terminals, such as routing, forwarding and caching systems [Tanenbaum 2003, 343 et sqq.]. Similar to the network performance concept [Xiao et al. 1999; Zhao et al. 2000], it can be characterized by four quality parameters: bandwidth, delay, packet loss and jitter. *Bandwidth* defines the effective volume of data per time unit being transmitted between communication end points. *Delay* comprises the length of time that a data package takes from the sender to the recipient. *Packet loss* defines the number of data packets that are lost in the transmission from the sender to the receiver. *Jitter* describes the fluctuation in the delay. Since it is a function of delay, it is not separately taken into account in the following analyses. Several authors define performance levels for classes of services (CoS) [Marchese 2007, 5-8; Gozdecki et al. 2003]. CoS concepts define bounds for the QoS parameters to precisely describe what is considered an appropriate quality for specific service classes, such as real-time conversational or near real-time interactive services.

4.2.3. Technologies for information service distribution

Different technological approaches have evolved since the development of the Internet architecture to support information service distribution. These technologies are generally classified into four categories, summarized in Table 4-4. In this section, a short overview of each technology is given.

Distribution Method	Definition	Key Characteristics	References	Business Model Case Examples
Centralized Internet Hosting	Centralized Internet Hosting refers to the use of *one or a small number of collocation sites to host content* [Leighton 2009].	-central server, multiple clients -Internet based	-Leighton [2009] -Tanenbaum [2003, 4] -Underwood [2001]	-bluehost (Web Hosting) -Go Daddy (Web Site Hosting) -HostGator.com (Domain Hosting) -1&1 (Web Hosting)
Direct Homing	Direct Homing is the distribution of services via networks, which are able to provide high QoS through technologies such as resource reservation or traffic prioritization [Xiao/Ni 1999].	-proprietary (mostly single) network -configured access lines -QoS through capacity reservation or packet differentiation	-Huston [2000, pp 399-406] -Xiao/Ni [1999] -Zhao et al. [2000]	-AT&T (U-Verse) -Swisscom (Bluewin) -BT (BT Vision) -T-Home (T-Entertain)
CDN based distribution	*CDNs act as trusted overlay networks that offer high-performance delivery of common Web objects, static data, and rich multimedia content by distributing content load among servers that are close to the clients.* [Vakali/Pallis 2003]	-multiple servers, multiple clients -Internet based	-Dilley et al. [2002] -Pallis/Vakali [2006] -Pathan/Bukay [2008] -Vakali/Pallis [2003]	-Akamai (Application Performance Solutions) -Amazon (Cloud-front) -Limelight (LimelightDELIVER) -Edgecast (Content Delivery)
Peer-to-Peer distribution	*Peer-to-peer systems are distributed systems consisting of interconnected nodes able to self-organize into network topologies with the purpose of sharing resources such as content, […] without requiring the intermediation or support of a global centralized server or authority.* [Androutsellis-Theotokis/Spinellis 2004]	-client to client communication -Internet based	-Androutsellis-Theotokis/Spinellis [2004] -De Boever [2007] -Kwok et al. [2002]	-BitTorrent (DNA) -Sharman Networks (KaZaA) -Joost N.V. (joost) -Kontiki (Enterprise Video Delivery)

Table 4-4: Information service distribution technologies and case examples

The Internet was originally designed to support highly robust communication. The first commercial World Wide Web services supported the retrieval of textual HTTP pages. Data was exchanged between centralized servers and distributed clients via the IP protocol based on the best-effort principle (Centralized Internet Hosting) [Leighton 2009; Tanenbaum 2003, 4; Underwood 2001]. Today, many information services are still hosted centrally. Tchibo.de, for example, a popular German online store, is hosted by the managed services provider Easynet [Easynet 2009]. Early Internet services did not impose high QoS requirements. But since the original development of the OSI basic reference model [ISO 1989], the requirements of information services distributed via the Internet have changed radically [Faratin 2007]. Services with high real-time requirements are disturbed if transported across large network distances where packets have to traverse multiple network interconnection points and packet delay exceeds tolerable bounds. Content providers in the Internet are confronted with extreme demand peaks (such as flash crowds) [Pathan/Buyya 2008] because the Internet has become a mass medium. Data intensive services have emerged due to growing access capacity, which further increases the risk of transportation overloads.

Two different approaches have emerged to support information services which cannot satisfactorily be realized through centralized hosting and best-effort transmission [Faratin 2007; Leighton 2009; Xiao 2008]: the introduction of a QoS service model (as applied in Direct Homing), and the installation of Internet overlay structures (i.e. CDNs or P2P networks). The goal of a QoS service model is to enable a QoS which is superior to the best-effort QoS in the Internet. This is realized by a modification of the traditional Internet architecture: technologies, which allow packet differentiation or capacity reservation, must be introduced [Xiao/Ni 1999; Zhao et al. 2000; Huston 2000, 399]. A QoS service model can either be realized on a dedicated infrastructure, or by modifying the present architecture of the public Internet. Presently, the QoS service model is mostly realized in proprietary networks. For this reason, content distribution via the QoS service model is only realized in close cooperation between content and network providers: the content is directly homed on the QoS capable network, which provides a direct customer access to the content provider (Direct Homing). Well known examples in practice are the IP TV offerings of network providers, such as AT&T (U-Verse), BT (BT Vision) or Deutsche Telekom (T-Entertain).

In contrast, Internet overlay structures do not alter the traditional Internet architecture, but provide value added functionality on the application layer: *An Overlay is a set of servers deployed across the Internet that […] in some way take responsibility for the forwarding and handling of application data in ways that are different from or in competition with what is part of the basic Internet* [Clark et al. 2005]. Two overlay technologies for content delivery have emerged which are specifically designed to optimize QoS and delivery costs of IP distribution: CDNs and P2P networks, as pointed out by Faratin [2007] and Saroiu et al. [2002].

CDN providers operate a network of servers which are placed in multiple autonomous systems and strategically distributed across the Internet [Dilley et al. 2002; Pallis/Vakali 2006, Pathan/Bakay 2008; Vakali/Pallis 2003]. In order to improve QoS performance, e.g., transmission delay and the effective bandwidth, objects such as large files or multimedia content are strategically distributed across these servers. In addition to caching, CDN providers apply technologies such as prefetching, route optimization, and sophisticated request routing mechanisms. As an example, France Televisions implements its Video on Demand offering via the Content Delivery Network of the CDN provider Akamai [Akamai 2008a].

P2P Distribution systems [Androutsellis-Theotokis/Spinellis 2004; De Boever 2007; Kwok et al. 2002] are designed to make use of resources provided by end customers, such as storage space and processing power, in order to establish a distributed storage medium through which information service providers are able to distribute their content. In addition to content replication and caching, P2P systems provide functionalities, such as the distributed positioning and routing of objects, secure storage, access control, and authentication. Blizzard Entertainment, for example, partners with BitTorrent Inc. to distribute the software for the game World of Warcraft via P2P technology [Blizzard 2009]. In contrast to Pathan and Bakay [2008] and in line with Leighton [2009] and Saroiu et al. [2002], CDNs are distinguished from P2P networks: whereas CDN providers centrally manage a network of surrogate servers, P2P networks are established through the contributions of independent peers.

In the following, a set of information service characteristics is presented which potentially bear a relationship to distribution performance. These relationships are then tested in the subsequent section.

4.2.4. Determinates of distribution quality

The Quality-of-Service distribution can be measured directly through the delay, error tolerance and effective bandwidth (equates to data load per second), provided by the distribution mechanism. Requirements of information services on the distribution quality are taken from the CoS conceptualizations [Marchese 2007, 5-8]. Information service providers are, nevertheless, unable to estimate the potential quality of a distribution technology prior to implementation. Moreover, the end-to-end measurement of distribution quality for a representative set of customers is a very complex task due to the constitutive service characteristics, as explained above.

Information services expose heterogeneous requirements, not only on the Quality-of-Service distribution, but also on its implementation. The way information services are created and consumed, potentially has a direct impact on the performance of a specific distribution technology. The novel approach of the following analysis is the identification of dependencies of the quality provided by a service distribution technology based on the characteristics of service production and consumption (cf. Figure 4-5). These potential characteristics were identified in expert interviews and through an analysis of the literature on distribution technologies as presented above.

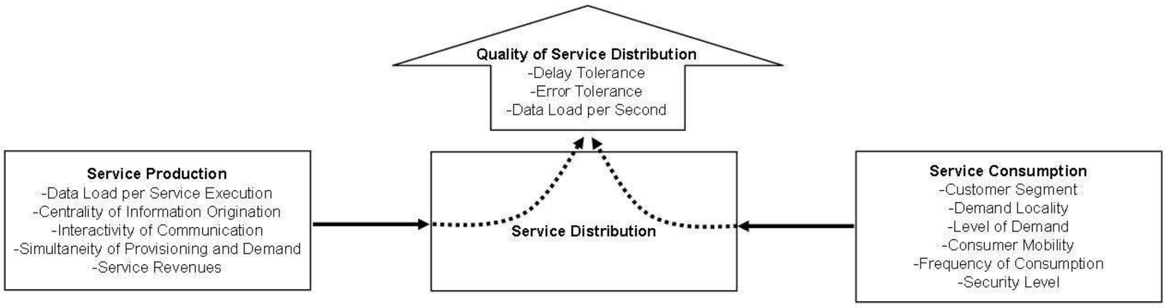

Figure 4-5: Characteristics of information services influencing the Quality-of-Service distribution

Relevant characteristics of service production are the data load per service execution, the centrality of information origination, the interactivity of communication, the simultaneity of provisioning and demand, and the service revenues. *Data load per service execution* describes how much traffic load a single service execution generates. Traffic load, being a main cost factor, is an important aspect in content distribution and influences technological decisions such as content caching strategies and server localization. *Centrality of information origination* describes how data originates and is fed into the network. Central information origination implies that content originates at a central location and, as such, can be distributed from a central server. In contrast, distributed information origination implies that content is produced at distributed locations, e.g., the end customers' clients. Content distribution must, in this case, be carried out from distributed locations, which leads to different prerequisites, e.g., concerning the application of route optimization strategies. *Interactivity of communication* characterizes the traffic flow between communication end points: in non-interactive communication, a request by a client is typically followed by a large downstream traffic flow from a server. In interactive communication, traffic flows between end points have similar characteristics. Interactivity of communication plays an important role in content distribution, e.g., regarding the importance of route optimization technologies and the efficiency of content prefetching. Real-time services are characterized by a *simultaneity of the provisioning and demand* for this content. As there exists no time for caching, such services rely mostly on route optimization strategies. In contrast, elastic services are characterized by a time gap between information provisioning and demand, and for this reason allow the application of buffering and caching technologies. *Service revenues*, i.e. the revenues a service provider generates per service execution, potentially provide information about the willingness of a service provider to invest in high distribution quality. Distribution technologies vary strongly with regard to the capital and operational expenses they induce. Low revenues do not allow high investments in service distribution and signal an end customer's tolerance for low distribution quality. In contrast, high revenues provide information service providers with more flexibility to invest in high distribution quality.

The relevant characteristics of service consumption are the customer segment, demand locality, level of demand, consumer mobility, consumption frequency, and security level. The *customer segment*, e.g., business or private customers, potentially has an impact on the service distribution: business-to-business services in general impose stricter requirements on distribution quality, e.g., regarding service availability and reliability, than business-to-consumer services. The *locality of demand* also has a significant impact: in order to meet a global service demand, comprehensive distribution technology implementations need to be applied, which often require higher investments than meeting a demand that is restricted to a small, well defined geographical area. The *level of demand* describes whether a service is considered a niche or a mass service. A niche service imposes different requirements for content delivery than a mass customer service. This affects the efficiency of technologies such as caching and capacity reservation. *Consumer mobility* also influences service delivery: In the case where a service is solely consumed from a single access line, such an access line can be explicitly configured prior to service distribution. In contrast, mobile services do not allow a pre-configuration of access lines, because such services must be available on multiple access lines, which cannot be determined in advance. There also exists a relationship between the *frequency of service consumption* and the efficiency of content distribution technologies: the more regularly a service is consumed, the more efficient is application of refined distribution technologies, such as the installation of local caches. The *security level* of an information service describes the requirements of a service customer regarding the security of data exchange. Sensitive customer data needs to be protected more strictly than information, which is open to the public and does not carry any security risks. This affects, for example, the employment of public infrastructure.

4.2.5. Value proposition analysis

103 IP based services were analyzed in order to identify differences in the value propositions of the four distribution technologies presented above.[6] The services reveal insights into the value propositions of the distribution technologies they rely on.

Research methodology

The analysis was carried out according to the directives for content analysis research [Kassarjian 1977; Kolbe/Burnett 1991].[7] Adequate sampling was ensured by pre-analyzing reference customer lists and use cases of distribution providers before making representative sample selections. The distribution methods of the samples were verified by employing various network tools such as traceroute and WHOIS.

[6] A complete list of the services analyzed is provided in the appendices (Table 6-7).

[7] Refer to Table 6-5 in the appendices for a summary of the directives and conformance justifications.

Criterion	Class (Number of Observations)					Mean Value	Standard Deviation
	1	**2**	3	4	5		
Centrality of Information Origination	decentral (37)	central (66)	/	/	/	1.64	0.48
Consumer Mobility	static (21)	distributed stationary access (59)	on the move (23)	/	/	2.02	0.66
Customer Segment	pure B2C (71)	no specific focus (20)	pure B2B (12)	/	/	1.43	0.69
Data Load per Second	< 64 kbitps (0)	[64 kbitps - 384 kbitps) (17)	[384 kbitps - 1 Mbps) (44)	[1 Mbps - 4 Mbps) (35)	>= 4 Mbps (7)	3.31	0.83
Data Load per Service Execution	< 1 MB (0)	>=1 MB (21)	>=15 MB (55)	>=500 MB (20)	>=5GB (7)	3.13	0.81
Delay Tolerance	<= 100ms (24)	(100ms – 1s] (11)	(1s – 4s] (36)	(4 s – 6s] (9)	>6s (23)	2.96	1.43
Demand Locality	regional (4)	country (36)	continent (16)	global (47)	/	3.03	0.98
Error Tolerance	0% (68)	<=0,3% (0)	<=1% (19)	>1% (16)	/	1.83	1.21
Frequency of Consumption	>= 1 per year (15)	>= 1 per month (21)	>= 1 per week (14)	>= 1 per day (36)	>= 1 per hour (17)	3.18	1.33
Interactivity of Communication	one-way communication (65)	two-way communication (control and content data flows) (13)	two-way communication (homogeneous data flows) (25)	/	/	1.61	0.85
Level of Demand	niche service (19)	regular service (37)	mass service (47)	/	/	2.27	0.76
Security Level	noncritical data (41)	data allowing end customer privacy intrusion (34)	strategic business data (20)	data critical with regard to legal and regulatory issues (8)	/	1.95	0.95
Service Revenues (in US$)	none (2)	(0-10) (48)	[10-100) (35)	[100-1000) (10)	>=1000 (8)	2.75	0.95
Simultaneity of Provisioning and Demand	asynchronous (60)	quasi synchronous (delay tolerant) (8)	real-time (35)	/	/	1.76	0.93

Table 4-5: Criteria Categories

The selected services were classified with respect to the direct distribution quality criteria and the characteristics of service production and consumption presented in the previous section. Table 4-5 contains a listing of the categories for each criterion.

In order to guarantee data validity, the classification was carried out independently by five IT service experts, who were carefully chosen with respect to three selection criteria: education, work experience in the IT services field, and expertise in IT service application, development, and management. These selection criteria ensured that the judges were familiar with the analyzed information services and their underlying technologies, and ultimately guaranteed the judges' capability to produce accurate classifications.[8]

Prior to coding, the judges were familiarized with the criteria and category definitions. Judges were asked to carry out the following process steps during categorization: service and business model research, service testing, and research on service usage. Service and business model research comprised the retrieval of information about the service type, service technologies, target customers and underlying business models from the service provider. This process step supplied valuable information for criteria such as the customer segment, service

[8] For an overview of the judges' qualifications, readers are referred to Table 6-6 in the appendices.

revenues and security level. The definition of a service type, based on CoS conceptualizations, supported the determination of delay tolerance, error tolerance, and data load per second for a specific service. In a second step, judges used and tested the services where possible. In order to track technical service parameters, such as data loads, judges were provided with network and communication monitoring tools. In combination with their personal usage experience with services of similar types, testing gave valuable insights for criteria, such as the simultaneity of provisioning and demand, centrality of information origination and consumer mobility. In a third step, judges were asked to gather information on the usage and diffusion of a service from information technology research companies and web traffic monitoring providers. This information was required for the categorization of criteria such as the level of demand and demand locality. After having followed these process steps, judges were asked to categorize an information service for all predefined criteria, and to leave blanks where a clear category distinction could not be detected. After collecting the results from all judges, abnormal value discrepancies were jointly analyzed and, in case of obvious misclassifications, eliminated in a post valuation round. The five classifications were merged in a final step by calculating mean values.

Discriminant analyses [Klecka 1980] were carried out on this data. The results indicate the relative importance of a criterion for the choice of a distribution method. For each distribution method, the group of services supported by this specific method was distinguished from the rest and insights were gained into the discriminatory effect of service criteria. In each case, a univariate ANOVA and a stepwise discriminant analysis were performed. In the following section, all service criteria which were considered significant in both tests are discussed.

Centralized Hosting

Centralized hosting technology represents the traditional distribution method within IP networks. Content is hosted on a single server which is connected to the network. Packets are routed through interconnected networks to the requesting client. QoS in pure centralized hosting distribution varies highly, depending on the end customer's location and the specific route: thus QoS will most likely be perfectly acceptable if the end customer is connected to the same network service provider as the hosting provider or if traffic does not have to traverse large distances. QoS may exceed acceptance thresholds if traffic is exchanged over large distances through various interconnected networks. Both tests show that demand locality is the most significant criterion with respect to the choice for centralized hosting distribution (Table 4-6): the more demand is limited to a specific region, the more effective centralized hosting becomes as a distribution mechanism. This is well in line with the argument above that interconnections and geographical distance have a significant negative impact on QoS. The tests also reveal that centralized hosting is particularly suitable for services with a low data load per service execution. Hosting providers charge per stored and accessed data volume; network service providers charge for access capacity. Moreover, data transport becomes more expensive if more interconnections are involved. Content providers, therefore, only choose centralized hosting for services with low data volume. In addition, low error tolerance is well supported by centralized hosting. This result suggests that highly error tolerant services, such as video conferencing, telephony, and multimedia streaming, are generally not provided through centralized hosting.

	Univariate Analysis			Stepwise Discriminant Analysis[a,b,c]			
	Group Mean 'Centralized Hosting' (n=27)	Group Mean 'others' (n=76)	F for Group Mean Equality Test	F to Remove	F to Enter	Wilks-Lambda (Removal & Entry Criterion)	Discriminant Loadings[d]
DemandLocality	2.259	3.303	28.365***	31.580***		.793	.651
DataLoadperExec	2.630	3.303	15.623***	12.237***		.676	.483
ErrorTolerance	1.148	2.079	13.314***	11.106***		.669	.446
ConsumerMobility	2.1111	1.9868	.712		3.312	.582	.169
CentralityOfInfoOrg	1.5556	1.6711	1.145		3.197	.582	-.128
SimultanProvDem	1.3704	1.8947	6.630**		3.155	.583	.051
ServiceRevenues	2.3333	2.8947	7.447***		2.540	.586	.088
LevelOfDemand	2.0370	2.3553	3.613*		2.537	.586	-.016
DelayTolerance	2.8889	2.9868	.093		1.720	.591	-.119
SecurityLevel	2.2222	1.8553	3.008*		1.335	.593	-.033
DataLoadPerSec	3.0741	3.3947	3.042*		1.071	.595	.105
FrequencyOfCons	3.1111	3.2105	.110		.434	.599	.131
CustomerSegment	1.2593	1.4868	2.163		.176	.600	.245
InteractivityOfCom	1.4074	1.6842	2.114		.029	.601	.153

***p < 0.01, **p < 0.05, *p < 0.10

[a]Minimal partial F-statistic for acceptance: 3.84, Maximal partial F-statistic for exclusion: 2.71

[b]Wilks Lambda of Discriminant Function: 0.601, Number of Steps: 3

[c]Class mean values of discriminant function: Centralized Hosting=-1.35, others=0.48

[d]Correlation between discriminating variables and the canonical discriminant function

Table 4-6: Discriminatory service criteria for Centralized Hosting

Direct Homing

Within Direct Homing, IP traffic is not routed as part of the best-effort Internet class, but instead as a privileged class or through reserved capacities. Consumer mobility is the dominant selection criterion for Direct Homing (Table 4-7). This is caused by the fact that Direct Homing only supports service consumption with guaranteed end-to-end QoS from pre-configured access lines. Thus, end customers cannot make use of reserved capacities from arbitrary access points, but only from dedicated access points. Hence, this technology is not adequate for mobile end customer services. IP TV with guaranteed QoS, for example, is installed with a configured router on a single access line.

	Univariate Analysis			Stepwise Discriminant Analysis[a,b,c]			
	Group Mean 'Direct Homing' (n=20)	Group Mean 'others' (n=83)	F for Group Mean Equality Test	F to Remove	F to Enter	Wilks-Lambda (Removal & Entry Criterion)	Discriminant Loadings[d]
ConsumerMobility	1.000	2.265	143.381***	400.532***		.385	-.336
ErrorTolerance	2.900	1.578	23.688***	104.456***		.155	.137
DataLoadPerSec	3.250	3.325	.132	33.869***		.100	-.010
InteractivityOfCom	2.600	1.373	48.757***	9.182***		.081	.196
ServiceRevenues	3.850	2.482	49.721***	7.588***		.080	.198
FrequencyOfCons	4.500	2.867	31.314***	4.915**		.078	.157
DelayTolerance	1.150	3.398	65.040***	4.061**		.077	-.227
SimultanProvDem	2.800	1.506	43.997***		1.875	.072	.266
CustomerSegment	2.100	1.265	29.887***		.095	.074	.179
CentralityOfInfoOrg	1.200	1.747	25.786***		.898	.073	-.083
DataLoadperExec	3.800	2.964	20.289***		.026	.074	.116
SecurityLevel	2.700	1.771	17.813***		.360	.074	.164
LevelOfDemand	1.900	2.361	6.307**		.371	.074	-.020
DemandLocality	2.700	3.108	2.822*		1.585	.073	.066

***p < 0.01, **p < 0.05, *p < 0.10

[a]Minimal partial F-statistic for acceptance: 3.84, Maximal partial F-statistic for exclusion: 2.71

[b]Wilks Lambda of Discriminant Function: 0.074, Number of Steps: 7

[c]Class mean values of discriminant function: DH=7.14, others=-1.72

[d]Correlation between discriminating variables and the canonical discriminant function

Table 4-7: Discriminatory service criteria for Direct Homing

A highly reliable and configurable QoS with low latency is aspired through the privileged treatment of Direct Homing traffic. This is especially valuable for services with a high degree of interactivity, such as Voice over IP (VoIP). The tests affirm that directly homed services are indeed characterized by a high level of interactivity and error tolerance. As data transport is carried out on predetermined routes, interactive services can be supported more effectively than by other distribution technologies. The high error tolerance of directly homed services suggests that Direct Homing is often used for error tolerant services such as voice and streaming services. Traffic differentiation or routing through dedicated networks does not necessarily imply the need to install separate hardware, but requires at least additional investments in the installation and operation of routing systems. As Direct Homing is often more cost intensive than other distribution methods, Direct Homing is only adequate for services with a high frequency of consumption and for services which generate high revenues. Otherwise, the high investments are not justifiable. In contrast to intuition, Direct Homing does not primarily address a B2B service context. Direct Homing represents the only distribution technology, where delay tolerance is a significant criterion. In contrast to the other distribution methods, where the direct discriminatory effect of delay tolerance is insignificant, this aspect is directly taken into account for Direct Homing.

Content Delivery Networks

CDN providers operate a complex network of edge servers. Content is distributed from and cached on these servers based on strategies which take into account the location of end customers, as well as network and server characteristics. CDNs, in contrast to Direct Homing, support a high customer mobility during service consumption (Table 4-8).

	Univariate Analysis			Stepwise Discriminant Analysis[a,b,c]			
	Group Mean 'CDN' (n=30)	Group Mean 'others' (n=73)	F for Group Mean Equality Test	F to Remove	F to Enter	Wilks-Lambda (Removal & Entry Criterion)	Discriminant Loadings[d]
ConsumerMobility	2.400	1.861	16.264***	24.990***		0.796	0.530
ServiceRevenues	2.900	2.694	0.994	23.533***		0.787	0.131
CentralityOfInfoOrg	1.900	1.528	14.212***	12.356***		0.714	0.495
LevelOfDemand	2.467	2.181	3.089*	5.241**		0.667	0.231
DataLoadperExec	3.133	3.139	0.001		3.211	0.613	0.257
DataLoadPerSec	3.467	3.250	1.441		2.712	0.616	0.382
InteractivityOfCom	1.267	1.764	7.604***		1.517	0.623	-0.255
ErrorTolerance	1.733	1.889	0.349		1.146	0.626	0.077
DelayTolerance	3.500	2.722	6.605**		1.050	0.626	0.209
DemandLocality	3.367	2.875	5.514**		0.949	0.627	0.149
FrequencyOfCons	2.800	3.347	3.621*		0.491	0.630	-0.154
SimultanProvDem	1.633	1.819	0.837		0.338	0.631	-0.177
CustomerSegment	1.300	1.486	1.519		0.254	0.631	-0.103
SecurityLevel	1.833	2.014	0.757		0.017	0.633	-0.097

***p < 0.01, **p < 0.05, *p < 0.10

[a]Minimal partial F-statistic for acceptance: 3.84, Maximal partial F-statistic for exclusion: 2.71

[b]Wilks Lambda of Discriminant Function: 0.633, Number of Steps: 4

[c]Class mean values of discriminant function: CDN=1.17, others=-0.49

[d]Correlation between discriminating variables and the canonical discriminant function

Table 4-8: Discriminatory service criteria for CDNs

CDN service coverage is not limited to configured access lines and networks. CDNs support mobile services and are well suited to deliver services such as video streaming, which are consumed en-route. CDN technology relies on a single central origin server, that contains core service information and that directs content or requests to the edge servers. On the other hand, CDN is not well suited for services without a central origination of information, such as communication services in which each end customer feeds data into the network. For such services, content caching on the edge servers cannot be carried out efficiently. Content caching becomes more efficient with higher cache hit ratios, i.e. the ratio of cached versus total documents requested. For this reason, CDNs particularly address services with a mass customer focus. For niche services, cache hit ratios tend to be low, which decreases the efficiency of cache networks. As the content needs to be transported to the edge servers prior to its distribution to end customers, this distribution method does not seem adequate for services where the origination of information coincides with the demand for this information. However, this hypothesis cannot be confirmed. CDN providers constantly improve their capabilities to support real-time services, e.g., through the development of route optimization technologies. For quasi real-time services such as live streaming, CDN technology is widely applied [Pathan/Buyya 2008].

P2P Distribution

P2P Distribution does not require large capital expenses. The main resource is P2P software running on end customers' clients with established network connections. Content providers do not need to constantly feed content into the network from central servers and therefore save transit costs. As overall distribution costs increase with the global nature of demand, P2P especially addresses services with a global demand (Table 4-9). This is the most important criterion for choosing P2P Distribution. In the case of a strictly local service demand, services could be distributed via centralized hosting without significant distribution costs. In case of a global demand, content distribution via P2P incurs significantly less transit costs. As content providers do not have to feed content into the network for each customer request, this distribution method is particularly attractive for services which generate low revenues and do not justify investments in a costly distribution technology with high QoS guarantees. Hence, cost savings in distribution are a dominant decision factor. More than in other distribution methods, content is exposed to the risk of manipulation. Since content is cached by third party clients prior to its distribution, the risk of unauthorized service access or service modification is high compared to other distribution methods. For services with high security requirements (e.g., file storage and exchange services for businesses), this risk is generally not tolerable.

	Univariate Analysis			Stepwise Discriminant Analysis[a,b,c]			
	Group Mean 'P2P' (n=26)	Group Mean 'others' (n=77)	F for Group Mean Equality Test	F to Remove	F to Enter	Wilks-Lambda (Removal & Entry Criterion)	Discriminant Loadings[d]
DemandLocality	3.692	2.805	18.476***	20.026***		0.782	-0.584
ServiceRevenues	2.154	2.948	15.639***	8.677***		0.708	0.537
SecurityLevel	1.231	2.195	24.426***	4.224**		0.678	0.671
InteractivityOfCom	1.462	1.662	1.074		2.401	0.635	0.366
SimultanProvDem	1.500	1.844	2.684		1.557	0.640	0.400
DataLoadperExec	3.115	3.130	0.006		1.255	0.642	0.190
CustomerSegment	1.231	1.494	2.831*		1.081	0.643	0.350
ConsumerMobility	2.269	1.935	5.246**		1.053	0.644	-0.462
DelayTolerance	3.808	2.675	13.761***		0.609	0.647	-0.381
DataLoadPerSec	3.423	3.273	0.637		0.596	0.647	0.019
ErrorTolerance	1.846	1.831	0.003		0.071	0.650	-0.052
CentralityOfInfoOrg	1.769	1.597	2.505		0.028	0.650	-0.187
FrequencyOfCons	2.692	3.351	4.916**		0.006	0.651	0.289
LevelOfDemand	2.577	2.169	5.928**		0.004	0.651	-0.322

***p < 0.01, **p < 0.05, *p < 0.10

[a]Minimal partial F-statistic for acceptance: 3.84, Maximal partial F-statistic for exclusion: 2.71

[b]Wilks Lambda of Discriminant Function: 0.651, Number of Steps: 3

[c]Class mean values of discriminant function: P2P=-1.25, others=0.42

[d]Correlation between discriminating variables and the canonical discriminant function

Table 4-9: Discriminatory service criteria for P2P Distribution

4.2.6. Interim summary

In this article, the quality provided by different technologies for information service distribution is discussed. An analysis of 103 information services was carried out in order to identify the main characteristics influencing an information service providers choice of a specific distribution method. An underlying assumption of this approach is that the information services analyzed are best supported by their associated distribution methods and, as such, allow deductions on the value proposition of the distribution technologies. This assumption is justified by the rationale that firms seek an optimal distribution choice. The results of our analysis reveal that distribution technologies vary strongly with respect to the information services they support. A set of characteristics concerning service production and consumption was identified which have a strong influence on the quality provided by distribution technologies. Distribution technologies and their significant service characteristics are summarized in Table 4-10.

From the set of hypotheses, i.e. the set of characteristics which were taken into account, several were proven irrelevant: most notably, criteria directly describing the Quality-of-Service distribution, namely packet delay and data load per second, have an insignificant influence on the choice of a distribution technology. This means that there is no distribution technology which generally provides a superior distribution quality. Instead, information service providers need to match their individual service characteristics to the technological capabilities of distribution methods for an optimal choice. Moreover, the simultaneity of provisioning and demand and the customer segment are irrelevant service criteria. From this it follows that the analyzed distribution technologies all have real-time capabilities and that none is specifically tailored for a business or an end consumer service scenario.

Distribution Technology	Significant Service Characteristics
Centralized Hosting	Local demand, low data load per service execution, low error tolerance
Direct Homing	Low consumer mobility, high error tolerance, high interactivity of communication, high service revenues, high frequency of consumption, low delay tolerance
Content Delivery Networks	High consumer mobility, high centrality of information origination, high level of demand
P2P Distribution	Global demand, low service revenues, low security level

Table 4-10: Distribution technologies and their significant service characteristics

This work represents an initial analysis comparing the capabilities of service distribution technologies. The results provide information service providers with practical guidance in their choice of a distribution provider. They allow the selection of a distribution method based on a matching of service characteristics and capabilities of distribution technologies.

Distribution technologies are constantly being enhanced. CDN and P2P technologies, for example, are most recently being applied jointly to reach a more efficient service distribution. Blizzard Entertainment uses AKAMAI’s CDN and BitTorrent’s P2P technology to distribute its World of Warcraft Software [Blizzard 2009]. The future evolution of information service distribution is dependent on deeper insights into the quality of information services and the influence of distribution performance. Zeithaml et al. [2000] state that a negative perception of information service quality result from several gaps, two of which are critical for service distribution: the information gap represents differences between customer requirements and a service provider's beliefs about requirements. The design gap describes discrepancies between the identified requirements and the implemented service. By filling the information gap, service providers gain a more profound understanding of the constitutive characteristics of service quality. This knowledge is a prerequisite for service implementation. The design gap is closed by correctly matching requirements with service specifications and by achieving these specifications during service operation. In this phase, the required Quality-of-Service distribution for specific information services is identified. This work represents an approach to close these gaps by establishing a relationship between service requirements and distribution methods which are currently in operation. A clear understanding of both gaps is a prerequisite for the further development and effective application of distribution technologies.

4.3. Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario

Title	Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario
Authors	Jochen Wulf, Felix Limbach, Rüdiger Zarnekow (TU Berlin), Michael Düser (T-Labs)
Published in	International Conference on Information Systems (ICIS), Shanghai, 2011
Research objectives	- Evaluation of the consequences of a SPP regime for the interconnection market - Analysis of the effects of competitive strategic behavior on a network operator‘s performance in a QoS interconnection market - Assessments of prospects and threats regarding the introduction of an SPP regime for IP interconnection
Methodology	- Design of a market scenario for QoS interconnection which incorporates general characteristics of today’s best-effort interconnection regarding pricing and costs as well as market participants - Application of agent based computational economics (ACE) to analyze emergent market characteristics resulting from competitive interactions of network operators - Single and stepwise regressions to identify the influence of transit provider properties such as the number of interconnections and the traffic demand on market shares
Results and implications	- Access providers in the SPP regime collect a large share of transport revenues - Transit providers can benefit from network effects associated with the installation of interconnections in the introduction phase as well as from their scope - A progressive disintermediation of transit providers in the growth and saturation phase is observable

Table 4-11: Summary of [Wulf et al. 2011a]

The assurance of end-to-end Quality-of-Service (QoS) in the Internet requires quality differentiation across network boundaries (inter-provider QoS). There is a controversial debate of practitioners and academic researchers on the introduction of QoS in the Internet and its economic consequences. [Wulf et al. 2011a] contributes to this debate by analyzing a market scenario for the formation of inter-provider QoS with agent-based simulations. Based on market data of the best-effort interconnection market and heterogeneous market samples, we simulate the development of multi-network QoS infrastructures in a Sending-Party-Pays (SPP) regime. For different market phases, we analyze the progression of market shares and the influence of transit providers' distinctive properties, such as the number of interconnections and the data demand, on their market shares. The results allow an identification and specification of economic developments in an inter-provider QoS market. We show that a network operator's data demand and geographical presence determine market shares in the analyzed expert scenario. As a consequence, the market position of access providers is strengthened in the long term. Our analysis supports the assessment of to the date unknown prospects and threats regarding the introduction of an SPP regime for QoS interconnection. Table 4-11 summarizes research objectives, methodology and results and implications.

4.3.1. Introduction

Data transport in the Internet is managed by a large number of network operators, who independently own and operate physically and logically separated networks (autonomous systems) [Crémer et al. 2000]. Interconnection of these networks is a prerequisite for the large scope and accessibility of the Internet. Since network operators have commercial interests, interconnection is subject to market mechanisms which have been analyzed in previous research [Crémer et al. 2000; Economides 2006; Laffont et al. 2003].

Internet routing bases on the best-effort (BE) principle. It is characterized by the fact that Internet Protocol (IP) packets are treated equally independent of their affiliation to specific service types. Certain IP services have high-quality requirements regarding data transport which are not fully met by today's best-effort Internet infrastructure [Crémer et al. 2000; Faratin et al. 2007; Kruse 2010; Shenker et al. 1996]. Often cited examples include video conferencing, HDTV, telemedicine and software-as-a-service. Such services require a differentiation in data transport which is referred to as Quality-of-Service (QoS) [Gozdecki et al. 2003].

Many network operators provide QoS-based IP services within the boundaries of their networks and operate IP networks with QoS in parallel to their Internet infrastructure. For instance, IPTV services can be realized with dedicated capacity in the access network. In order to guarantee end-to-end quality across network boundaries, network interconnection must support packet differentiation with multiple transport classes. The implementation of QoS across network boundaries requires the negotiation of dedicated interconnection agreements between network operators (QoS interconnection) [Briscoe/Rudkin 2005; Hwang/Weiss 2000].

A critical aspect in QoS interconnection is the design of payment regimes, which determine the direction of financial flows [Dodd et al. 2009]. Whereas interconnection in the current Internet purely bases on the Bill-and-Keep (BAK) regime, advanced charging capabilities in

IP networks and the broadening scope of IP services promote the adoption of service-oriented charging approaches. In the context of QoS interconnection, several authors advocate the introduction of a Sending-(Network)-Party-Pays (SPP) regime [Briscoe/Rudkin 2005; Dodd et al. 2009, Kruse 2008]. Economics research on interconnection to date mainly focuses on the economic efficiency of interconnection from an overall market perspective [Laffont et al. 2003; Valletti/Cambini 2005]. In contrast, the consequences of the introduction of an SPP regime for network operators' strategies and performances have scarcely been examined. This article has the objective to analyze the effects of competitive strategic behavior on a network operator's performance in an interconnection market with a SPP regime.

We analyze a market scenario for inter-provider QoS by applying an agent-based simulation approach. As a basis for a quantitative evaluation of inter-provider QoS strategies we model the technological and economic conditions of a QoS interconnection market. The model incorporates general characteristics of today's best-effort interconnection market regarding pricing and costs as well as market participants. Furthermore, we assume the implementation of a SPP regime. For different market phases we analyze market shares and the influence of transit provider properties such as the number of interconnections and the traffic demand. The results allow an identification and specification of possible developments in an inter-provider QoS market. As such, the analysis supports the assessment of prospects and threats regarding the introduction of an SPP regime for IP interconnection.

4.3.2. Inter-provider Quality-of-Service: principles and research issues

The Internet interconnection market

The Internet interconnection market offers services which enable a data exchange between content providers and access network operators and ensure a high service coverage due to the interconnection of independent IP networks (IP interconnection) [Faratin et al. 2007]. As such, IP interconnection constitutes a core business segment of Internet service providers [Wierstra et al. 2001]. The Internet consists of more than 30,000 network operators [Dhamdhere/Dovrolis 2008; Huston 1999] which can be divided into four network classes: large transit provider (LTPs), small transit providers (STPs), content providers (CPs) and enterprise customers (ECs) [Dhamdhere/Dovrolis 2008; Norton 2003]. They differ in terms of their business objectives and interconnection strategies. *LTPs* own a global backbone network and have a large number of transit customers. Their primary business objective is to facilitate a universal accessibility of Internet service providers. *STPs* limit their field of activity to regional areas and provide access and transit services to private and business customers. Their primary business objective is the maximization of market share and profit in regional markets. *CPs* either provide Internet based services and content themselves or offer hosting and content distribution services. They try to ensure data transport in the required quality at minimum costs. *ECs* are companies which operate autonomous systems and provide Internet access to end-customers. Comparable to CPs, the business objective of ECs regarding interconnection is the minimization of interconnection costs and the insurance of the required transport quality.

LTPs, STPs, CPs and ECs as well as their interconnections form a multi-tier system [Cremer et al. 2000]. Network operators of a lower tier purchase transit services provided by network operators of a higher tier. Due to symmetric interests, network operators of the same tier exchange traffic without payment [Baake/Wichmann 1999]. Therefore, two basic interconnection types can be distinguished: transit and peering [Faratin et al. 2007; Norton 2002a]. *Transit* is a business relationship in which a provider offers its customer access to the entire Internet. The customer purchases bandwidth for his incoming and outgoing traffic (Committed Data Rate). In a *peering* relationship, network operators provide each other access to their own networks and to the networks of their customers without exchange of payments. Network operators agree on peering-based on the assumption that their traffic exchange generates symmetric transport costs and profits. The symmetry assumption, which represents the foundation for the economic stability of the multi-tier interconnection, is increasingly put into question [Faratin et al. 2007; Norton 2002b]. A group of transit providers has specialized on providing services to content providers and therefore has fundamentally different interests than operators of access networks (*eyeball networks*). As the relationship between content providers and end-customers is subject to indirect network effects a strong mutual interest in interconnection does exist. However, the interconnection regime is exposed to strong dynamics because of asymmetrical characteristics of the network operators' target markets [Faratin et al. 2007; McPherson 2009].

Definition of Quality-of-Service

Recent developments in telecommunications and broadband Internet industries are characterized by the emergence of a variety of new services such as video conferencing, Internet-based TV, multiplayer online computer games or software-as-a-service. These new offerings have increasingly higher requirements regarding real-time capabilities, security and reliability, as well as technical characteristics such as bandwidth and latency. Thus, QoS is becoming an increasingly important factor in Internet infrastructure design and operation. A differentiated handling of data traffic potentially supports the development and establishment of such new services [Cremer et al. 2000; Faratin et al. 2007; Huston 1998]. QoS is defined as the capability to assign quality parameters to services and to enable a differentiated service handling [Gozdecki et al. 2003; Zarnekow et al. 2008c; Zhao et al. 2000].

Payment regime for inter-provider Quality-of-Service

The design of a payment regime is a central and controversial issue in the course of the implementation of inter-provider QoS. Interconnection charges, in combination with end user charges, represent a fundamental component of Internet pricing [Laffont et al. 2003]. Economic research on Internet pricing emphasizes the role of network and economic efficiency

[Falkner et al. 2000]. Network efficiency is determined by the utilization levels of network resources. Pricing is considered a means to improve or optimize network efficiency by influencing demand in order to increase overall utilization [Gupta et al. 1999]. Economic efficiency describes the overall utility level of network operators and customers. If the demand for capacity exceeds the supply, pricing is a means to improve or optimize economic efficiency by supporting a preferential treatment of data which provides a high utility [MacKie-Mason/Varian 1995a]. Apart from supporting traffic differentiation, pricing is acknowledged to set incentives for network investments in order to increase capacity. As argued by MacKie-Mason and Varian [1995b] as well as Valletti and Cambini [2005], pricing plays a pivotal role in signaling to expand capacity where it improves economic efficiency.

With regard to the general direction of interconnection payments, Dodd et al. [2009] differentiate three payment regimes, neither of which is considered to be universally efficient: Receiving-Party-Pays (RPP), SPP and BAK (Figure 4-6). In an SPP regime, the initiating party pays for the end-to-end data transport. The transport fees cascade along the data stream. In an RPP regime, the receiving party pays for the end-to-end data transport. The transport fees cascade in the opposite direction of the data stream. In the BAK regime, content providers (CP) and enterprise customers (EC) compensate transit providers (TP) not only for data termination but also for data delivery. Two TPs agree to peer without the exchange of payments if this is mutually beneficial.

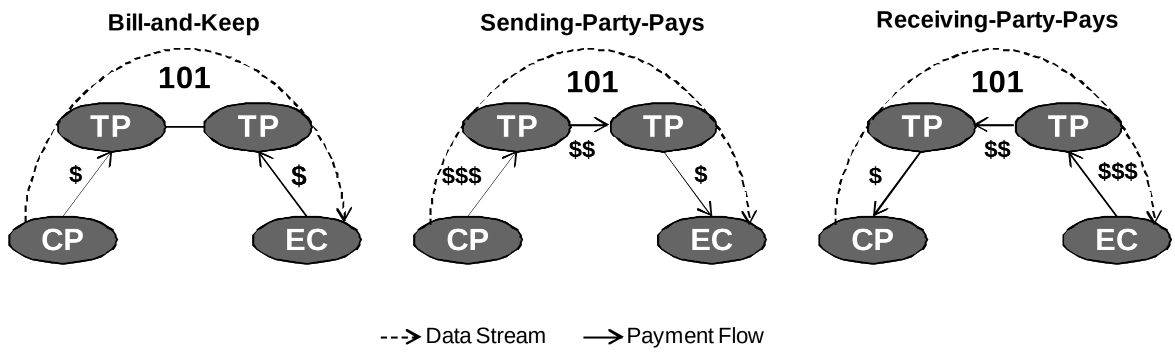

Figure 4-6: Bill-and-Keep and Sending-Party-Pays regimes

Dodd et al. [2009] argue that BAK is only suitable for situations in which the distribution of costs among the two peering network operators aligns exactly with the distribution of benefits between the initiating and the receiving party. As a consequence, the efficiency of a payment regime depends on service specific demand and cost conditions. Kruse [2008] argues that in the BAK and RPP regimes there is no guarantee that the receiver is willing to pay for QoS data delivery. In contrast to BAK and RPP, SPP facilitates the assurance of QoS payments. It also provides strong incentives against socially undesirable traffic such as spam [Briscoe and Rudkin 2005, Dodd et al. 2009].

To date, inter-provider QoS has not been implemented on a large-scale. However, the high level of maturity of QoS technologies along with the ability to manage end-to-end data transport and the support for session-based charging strongly promote the implementation of QoS interconnections with tailored interconnection regimes [Dodd et al. 2009]. Steingroever [2008] states that QoS interconnection with SPP would fundamentally alter network operators' business options. However, the competitive strategic behavior in a QoS interconnection market with a SPP regime and the impact of competitive strategic behavior on a network operator's performance has scarcely been analyzed. State of the art research on QoS interconnection has mainly focused on network and economic efficiency (see above) as well as the technological design of QoS protocols and architectures [Briscoe/Rudkin 2005, Zhao et al. 2000].

Research objective and assumptions

The contribution of this paper is an analysis of a QoS interconnection market scenario which is based on the SPP regime. We aim to study the influence of a network operator's distinctive characteristics on its market share during different market phases. Furthermore, we assess the existence of first mover advantages. For the analysis of the scenario we assume that central characteristics of today's interconnection market remain static and that a demand for QoS services does exist. Particularly, we take as a premise that the geographic presence and the fundamental strategies of transit and access providers remain unchanged. Secondly, we assume a constant transit price distribution as well as a constant traffic demand and supply of network operators. For the analysis we only consider revenues and costs directly associated with network interconnections. These assumptions are further motivated and explained in the next section.

4.3.3. Agent-based simulation model

Methodology and validation

Agent-based computational economics (ACE) is the computational study of economic processes modeled as dynamic systems of interacting agents [Tesfatsion/Judd 2006]. ACE enables the analysis of emergent phenomena resulting from repeated interactions of heterogeneous agents. Thus, agent-based simulations can be used for a structured examination of macro systems, in which the overall development depends on autonomous decisions of a large number of market players. The use of this research methodology is particularly useful when the decision behavior of agents is mutually dependent, agents engage in dynamic relationships with other agents and structural changes on the macro level is not simulation input but simulation result [North/Macal 2007].

ACE has been used in numerous publications for the analysis of techno-economic issues [LeBaron/Tesfatsion 2008]. Furthermore, several authors have used ACE in order to assess the best-effort interconnection market and the development of the Internet topology [Chang et al. 2006; Dhamdhere/Dovrolis 2009; Li et al. 2004]. However, this previous work provides only limited implications for the development of a QoS interconnection market.

According to Moss [2008] agent-based simulations can be modeled and validated following two different approaches. The first approach requires the availability of empirical data for the emergent phenomena of a system. Such data can be used to validate and calibrate the agent-based simulation model [LeBaron/Tesfatsion 2008; Windrum et al. 2007]. As a QoS interconnection market does not exist to the date of writing, the validation and calibration approach cannot be pursued. The second approach is applied to formulate and specify expert prognoses and scenarios that allow a closer assessment of opportunities and threads in an uncertain future. Following this approach, our modeling assumptions base on qualitative expert statements and extrapolations of best-effort interconnection market characteristics.

Simulation data

Information	Description	Derived model characteristics	Data source
Traffic level	Overall bandwidth used by a network operator	Data demand (I), data supply (C)	[PeeringDB 2010]
Traffic ratio	Network operator's volume ratio of data sent to data received (Classes: Heavy Outbound/Inbound, Mostly Outbound/Inbound, Balanced)	Traffic demand (I), traffic supply (C), network classification (CP, EC)	[PeeringDB 2010]
Cities of presence	Cities in which a network operator operates interconnections	Similarity of network operators ($SimilarityIndex_{ij}$)	[PeeringDB 2010]
Transit ratio	A network operator's ratio of the number of transit providers to the sum of transit providers and customers	Network classification (LTP, STP, CP, EC)	[CAIDA 2010]
Transit price	Data set on historical and present IP Transit prices	Transit price mean, distribution, scaling effect	[TeleGeography 2010a]
Quality premium	Average price differential between high-and low-quality VPN offerings	Premium price for QoS-transit compared to IP Transit	[TeleGeography 2010b]

Table 4-12: Modeling data and sources

We assign agent properties from publicly available data sets that describe the interconnection market and characterize network operators and pricing strategies (Table 4-12). PeeringDB [2010] is a publicly accessible database that contains information about network operators provided to facilitate interconnection negotiations. CAIDA [2010] is a record which specifies network operators' interconnections derived from routing data [Mahadevan et al. 2006]. Based on a third data source TeleGeography [2010a] and TeleGeography [2010b] we infer transit prices and a quality premium for QoS-transit.

The simulation model consists of agent characteristics, a revenue and cost model as well as a market model. All components are described below.

Classification of network operators and interconnection strategies

In the current best-effort Internet network operators are classified in a tier system according to their network resources and business relations. Members of the different layers differ with respect to their interconnection strategies. We assume that LTPs and STPs pursue QoS interconnection strategies similar to those in the best-effort interconnection market. LTPs and STPs use their scope to handle QoS traffic and act as a hub for traffic generated by ECs and CPs. A key strategic objective is to maximize transport volume [Dhamdhere/Dovrolis 2008; Norton 2002b]. For this reason, LTPs and STPs try to directly or indirectly interconnect with the largest possible number of end-users and content providers. The primary interest of ECs is to satisfy the end-customer demand for QoS data [Dhamdhere/Dovrolis 2008]. In the SPP regime, the data originator bears the costs for data transport. Primarily receiving traffic, ECs are indifferent regarding transport costs. Therefore, ECs are pursuing a scope strategy in order to meet the end-customer demand. Provided that CPs reach a critical threshold of end-customers, they minimize transportation costs [Dhamdhere/Dovrolis 2008; Norton 2003]. The broadband penetration rate of 66% in the USA and Germany [OECD 2010] provides a benchmark for the percentage of end-customers economically reachable and is used as the threshold value in the model. Summing up, ECs, LTPs and STPs try to extend their scope while CPs are also interested in minimizing transport costs.

For the allocation of agents to the network operator classes, we use their transit and traffic ratios (definitions see Table 4-12). Figure 4-7 depicts the classification procedure. Networks without transit customers are classified as CPs, if they originate more traffic than they terminate (I<C), and otherwise as ECs. In the majority of cases, transit providers do not only handle third party traffic (off-net traffic), but also terminate or originate traffic within their own network (on-net traffic). Whereas LTPs largely focus on the transit business and therefore are characterized by low transit ratios, STPs to a larger degree handle off-net traffic. Nearly coinciding with Dhamdere and Dovrolis [2008], we limit the group of LTPs to a size of 32 by considering transit providers with a transit ratio of less or equal to 10% to be LTPs and other transit providers to be STPs.

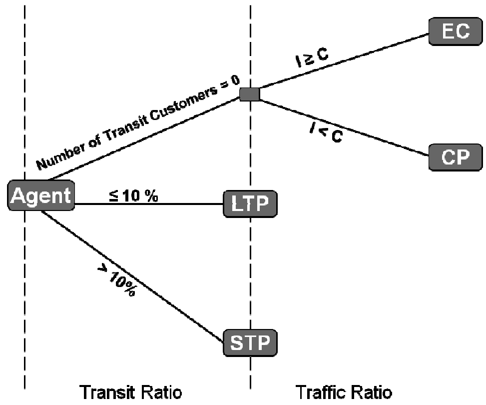

Figure 4-7: Classification of network operators

In order to simulate QoS interconnection negotiations we use the following procedure. The agent, which is in turn of establishing an interconnection, creates a ranked list of its preferred interconnection partners. The order of the ranked list is determined by the operator specific interconnection strategy and the expected costs and revenues which are calculated based on traffic supply and demand. Following a scope strategy implies to maximize overall traffic through establishing additional interconnections. Networks following a cost minimization strategy maximize the average savings per traffic unit achievable through an interconnection. An interconnection is established with the highest ranked operator which also values the interconnection. That is, every established interconnection either increases the operators' scope or reduces their average data transport costs.

In the best-effort Internet, the cancellation of interconnections (de-peering) represents an important means for price negotiations [Faratin et al. 2007]. In contrast, an SPP regime for QoS is based on the premise that network operators are able to receive sufficient compensation for the use of their network infrastructure. Therefore, de-peering does not lead to competitive advantages and is not taken into account.

Geographical presence

In our model, we consider the geographic scope of networks in terms of their cities of presence. For simplicity reasons we assume that networks enter into interconnection negotiations if and only if they have at least one city of presence in common. Furthermore, we assume that the similarity of two networks increases with the number of cities in which both networks are present. The degree of similarity of a network operator j to a network operator i is quantified with the following formula:

$$SimilarityIndex_{ij} = G_{ij} / A_i$$

G_{ij} denotes the number of cities in which network operator i and network operator j both are present. A_i denotes the overall number of cities of presence of i.

Data demand and supply

A network operator's volume of data demand (I_i) is calculated as follows:

$I_i = TrafficLevel_i * On\text{-}Net\text{-}TrafficRatio_i * TerminationRate_i$

The parameters of this formula are determined using the information on an operator's traffic level as well as the assumptions provided in Table 4-13. Following Renesys [2010] we set the On-NetTrafficRatio ((I+ C)/TrafficLevel) of LTPs to 30% and assume 50% for STPs. Since ECs and CPs do not offer transit, their On-NetTrafficRate is 100%. The parameters of the network operators' TerminationRates will be assigned to the values of the traffic ratio classes as presented in Table 4-13. For proving model robustness, we vary the values for the On-Net-TrafficRatio, the OriginationRate and the TerminationRate as explained further below.

Network type	On-Net-TrafficRatio$_i$:		Traffic Ratio Class		Origina-tionRa-te$_i$:	Termina-tionRa-te$_i$:
	(I_i+C_i) / $TrafficLevel_i$				C_i / (I_i+C_i)	I_i / (I_i+C_i)
EC (C=0)	1		Heavy out-bound	(I<<C)	0.1	0.9
STP	0.5		Mostly out-bound	(I<C)	0.3	0.7
LTP	0.3		Balanced	(I=C)	0.5	0.5
CP (I=0)	1		Mostly in-bound	(I>C)	0.7	0.3
			Heavy in-bound	(I>>C)	0.9	0.1

Table 4-13: Traffic properties and network types

In order to quantify the volume of data supply (C_i) we assume that a network operator *i*'s demand for data originated by a network operator *j* increases with the similarity of *j* to *i* ($SimilarityIndex_{ij}$). Based on *i*'s traffic level and traffic ratio we determine the popularity (p_{ij}) of the data supplied by *j* for *i* as follows:

$p_{ij} = TrafficLevel_i * On\text{-}Net\text{-}TrafficRate_i * OriginationRate_i * SimilarityIndex_{ij}$

We calculate the popularity of all data sources *j* for the data sink *i*, create an ordered list of all data source popularities p_{ij} greated than zero and assign a rank r_{ij} to each data source *j*. That is, the data source with the highest popularity will be assigned to rank one and so on. As proposed by Dhamdhere and Dovrolis [2009] and Chang et al. [2005], we quantify the traffic stream (T_{ji}) of each of the n traffic sources j to the traffic sink i using the Zipf distribution:

$$T_{ji} = \frac{\frac{1}{r_{ij}^{0.8}}}{\sum_{k=1...n} \frac{1}{k^{0.8}}} I_i$$

Subsequently, a network operator's data supply C_i can be derived as follows:

$$C_i = \sum_j T_{ij}$$

With all the network operators' data demand and supply as well as the network interconnections the traffic flows are calculated. Routing is carried out based on the routing algorithm of Gao and Wang [2002].

Revenue and cost model

The analysis conducted in this work is limited to interconnection policies as well as revenues and costs which are directly related to QoS interconnection. We calculate transit fees for QoS-transit assuming a percentage markup on the best-effort transit fees. As a basis for calculation, we evaluate a transit price database [TeleGeography 2010a] describing provider (i) specific IP Transit offers for a location with monthly costs and data rates (v). In order to determine a volume dependent cost function $K_i\ (v)$, we carry out a non-linear regression with the data on transit offers at the DECIX in Frankfurt (in Q1, 2010). We are able to identify a scaling effect and a company-specific price component m_i with a coefficient of determination of R^2 = 0.989:

$$K_i(v) = v^{0.857} * m_i$$

For the scaling effect, a 95% confidence interval with a minimum value of 0.843 and maximum value of 0.872 is specified. For the company-related price component m_i we determine an average of \$ 23.28 and a standard deviation of \$2.9. Strong regional price variations can be observed in transit prices. However, these price fluctuations are not part of the analysis as such costs are faced by all providers and regional competition is not included in the study. In order to estimate a QoS mark-up for transit we assess prices for three different quality classes of VPN offerings provided by TeleGeography [2010b]. On avergage, a markup of 19.9% is determined for the high quality class in comparison to the base class. Following this observation, the QoS data transit fee of a network operator is set to 120% of its IP Transit fee.

In addition to considering the revenues and costs generated by an interconnection, it is necessary to incorporate the revenues of source network providers which are used for financing the data transport. However, since the focus of the analysis is on interconnection strategies, the revenues and costs for end-user access and content distribution will not be considered in detail. In accordance with the premise of a positive demand for QoS transport, we assume that source network operators can cover the costs for data transport using content distribution revenues. Interconnection related revenues can thus be calculated with the transit cost function, the price mark-up and the transit revenues generated by traffic flows.

Market model

At the beginning of each period, the data demand and the data supply are determined for each agent. Interconnection negotiations of individual agents in the simulation are not carried out simultaneously, but successively. In a random order an agent is provided with the opportunity to enter into interconnection negotiations. Once an interconnection is established or no more potential partners exist, the next agent is selected. On average every agent is selected once per period. At the end of each period a routing schedule is calculated based on the topology resulting from newly established and existing interconnections. Thereafter, data routing is carried out and the revenues and costs of each agent are calculated. Figure 4-8 provides an overview of the entire simulation process.

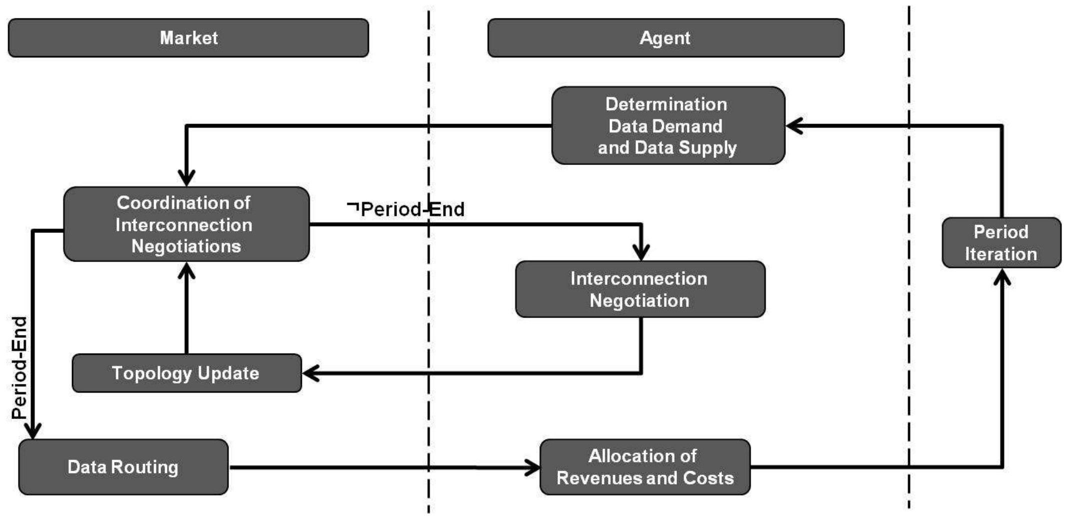

Figure 4-8: Overview simulation process

4.3.4. Market simulation analyses

The model described above is implemented using the Java-based development and simulation environment Repast in version 1.2.0 [Repast 2010]. The simulation implementation, setup and results are presented in this section.

Simulation setup and robustness

The simulation setup bases on a set of 13 test cases which are randomly drawn from the PeeringDB [2010] database. A network operator sample is referred to as a test case. Table 4-14 provides an overview of the operator class sizes in the test cases and in the peeringDB [2010].

Network Operator Class	PeeringDB	Test case												
		1	2	3	4	5	6	7	8	9	10	11	12	13
	#	#	#	#	#	#	#	#	#	#	#	#	#	#
CP	539	12	12	20	13	19	21	16	20	17	18	14	16	18
EC	669	21	24	16	25	16	11	16	16	20	21	24	22	20
LTP	32	2	2	0	1	1	0	1	1	0	2	0	0	0
STP	464	15	12	14	11	14	18	17	13	13	9	12	12	12
Total	1704	50	50	50	50	50	50	50	50	50	50	50	50	50

Table 4-14: Operator class sizes

Table 4-14 indicates that the number and size of the test cases cover only a small portion of the overall Internet ecosystem. Following LeBaron and Tesfatsion [2008] we argue that small-scale models can be well suited for assessing macroeconomic regularities, particularly in cases in which large-scale models lead to prohibitively high computation times. Since the routing algorithm has a complexity of $O(N^3)$ [Gao/Wang 2002] and is applied multiple times during interconnection negotiation and for the actual exchange of data the presented model is not suitable for simulating large test cases. We decided against selecting stratified samples from the basic population as this approach would contradict our intention to identify regularities in a brought spectrum of possible results.

In order to demonstrate the robustness of our model the values for the On-Net-TrafficRatio, the Origination- and the TerminationRate as well as the scaling factor of the cost function are varied in such a manner that no test case is run with the same parameter constellation. This simulation setup is necessary as no a priori information is available that would indicate the emergent influence of the model parameter variation. Moreover, the robustness analysis ensures that within a certain parameter range simulation results are reproducible [Windrum et al. 2007]. Following Hamby [1995] we vary the model parameters in a local sensitivity analysis within a parameter range of 20%. For 6 free model parameters with 3 possible values per parameter 13 parameter settings have to be assessed in order to observe the result variation in an isolated parameter. With the same parameter setting each test case is run twice in order to incorporate the influence of the random agent negotiation order into the test for robustness. Thus, 26 simulations were analyzed in total.

Market share analysis

According to product life cycle theory the development of the market for QoS-data-transport can be divided into the introduction, growth and saturation phases [Hooley 1995]. In the *introduction phase*, the first interconnections are established. It is characterized by a strong growth of the overall demand saturation degree. In the last period of the introduction phase, the overall demand saturation degree equals the strategy threshold of the CPs (66%, see above). Around this period, CPs change their scope strategies into price-sensitive strategies. In contrast to the introduction phase, most CPs adopt a price-sensitive behaviour in the *growth phase*. In the last period of the growth phase the demand for data transport is fully saturated for the first time. In the *saturation phase*, all CPs try to reduce their transport costs. From the last period of the saturation phase on, no further interconnections can be established. A potential *degeneration phase* is not considered in this analysis because of the assumption of a constant and positive demand for QoS transport.

In order to analyze market evolution, network operators are classified according to their volume of data supply and their volume of data demand. For classification, we calculate the ratio of demand (I/(C+I)). Figure 4-9 provides the class definitions and shows the average share of revenues (market share) of network operators per class and period. It also depicts the relative change of the average costs for the end-to-end transport of data in relation to the previous period.

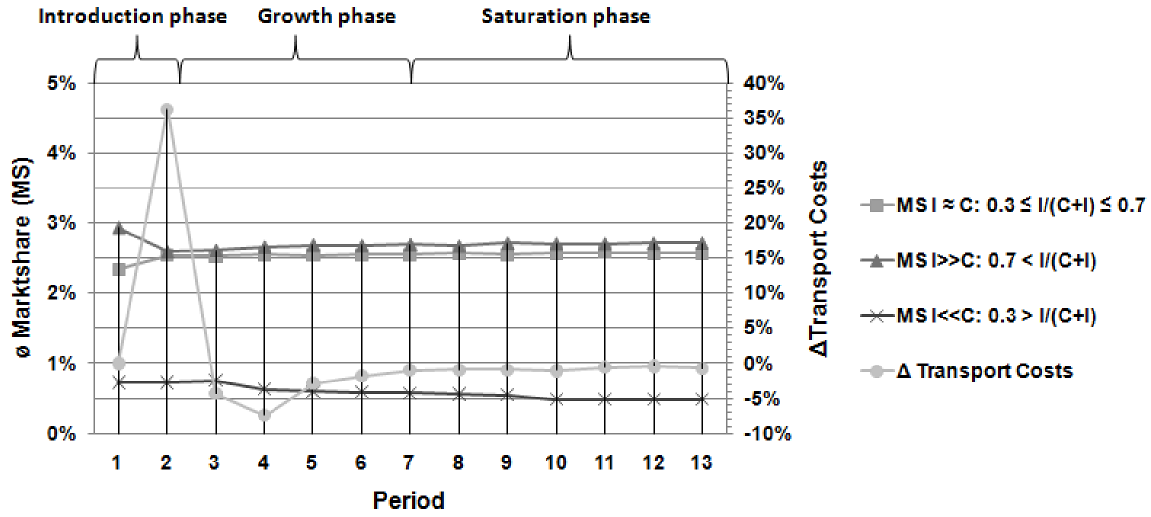

Figure 4-9: Average market shares of network operator classes

The introduction phase is characterized by a strong increase of end-to-end transport costs. To achieve a high level of demand saturation, CPs are willing to accept high costs for data transport in this phase. In the growth and saturation phases, transport costs are decreasing gradually. In all market phases, network operators with a low ratio of demand (I<<C) are characterized by an average market share which is significantly lower than the market share of networks operators with a higher ratio of demand (I≈C and I>>C).

Analysis of market share determinants

In a next step, the market share distribution of transit providers (LTPs and STPs) is explored. For each simulation run and market phase, the influence of specific network characteristics on a transit provider's market share in the last period of the market phase is quantified. The assessed characteristics include C, I, the company-specific price component (m_i), an operator's rank in the random order of entry into negotiations (1stDec), the number of potential interconnection partners (#Part) and the number of interconnections already established (# Con). The influence of the network characteristics on the market share is examined by using linear regression analyses. In these regression analyses the specific network characteristic represents the single independent and the share of revenues of a transit provider the dependent variable. Non-linear relationships were assessed as well, but did not reveal additional findings. Table 4-15 provides the number of significant, very significant and non-significant correlations between a network characteristic and the market share in the 26 simulation runs for the three market phases.

Phase[a)]	P1			P2			P3		
	*	**	n.s.	*	**	n.s.	*	**	n.s.
C	2	13	11	5	19	2	3	23	0
I	4	14	8	0	22	4	0	25	1
m	2	0	24	3	0	23	3	1	22
1stDec	3	1	22	0	0	26	1	0	25
#Con	1	21	4	6	14	6	7	9	10
#Part	8	7	11	2	15	9	4	14	8

[a)] P1: Introduction Phase, P2: Growth Phase, P3: Saturation Phase
* significant [Level of Significance α = 5%]
** very significant [Level of Significance α =1%]
n.s. not significant

Table 4-15: Number of correlations between operator characteristics and market share

The results indicate a high share of significant and very significant correlations in at least one market phase for the independent variables C, I, #Con and #Part. In contrast, there are no significant correlations for m and 1stDec in the majority of cases in all of the three market phases.

Subsequently, we perform a stepwise regression analysis in order to analyze the relative influence of a network characteristic on the market share (Table 4-16). We only take into account the four network characteristics with a high share of significance in the correlation analyses above. Instead of analyzing each simulation run individually, we combine the data from all simulation runs in a single data basis. A network characteristic is included into (excluded from) the model if the level of significance of its partial correlation coefficient is lower than 0.05 (higher than 0.1).

P[b)]	R	F	Included Variables[a)]	Beta	Sig.
P1	0.751	146.451	#Con	0.544	0
			I	0.208	0.002
			C	0.127	0.045
P2	0.736	134.076	I	0.308	0
			#Part	0.387	0
			C	0.207	0.005
P3	0.753	238.072	I	0.634	0
			#Part	0.212	0

[a)] Inclusion: Sig.< 0.05, Exclusion Sig. > 0.1
[b)] P1: Introduction Phase, P2: Growth Phase, P3: Saturation Phase

Table 4-16: Results of stepwise regression

In the introduction phase #Con, I and C are included into the model. #Con has the highest partial correlation. In the growth phase #Part, I and C are considered significant by this order of importance. In the saturation phase, I has by far the highest partial correlation, #Part is also included. The partial correlation of C in the saturation phase is low even though there is a high share of significant correlations in the single regressions (Table 4-15).

4.3.5. Interpretation

The analyses produce significantly different results for the three market phases and therefore indicate a characteristic evolution of the QoS interconnection market. In the *introduction phase* #Con is the most important driver of market success, as indicated by the stepwise regression. Average end-to-end transport costs increase strongly. This implies that the average path length is increasing and the proportion of cheap direct interconnections (i.e. interconnections between originating and terminating networks) is low. As a consequence, transit providers have the ability to establish traffic hubs. The results indicate the presence of network effects in the introduction phase. Under the presence of network effects, the number of interconnections of a network operator has a positive influence on the operator's benefits related with an interconnection [Katz/Shapiro 1985]. Markets with network effects are characterized by strong positive feedback effects which potentially lead to a strong dominance of a market participant. The number of interconnections established by a network operator is considered the core resource for attracting additional interconnection partners and for increasing the market share in the introduction phase. In the *growth phase*, #Con loses its strategic importance and the average costs for the end-to-end transport decrease. Both aspects suggest a weakening of network effects and an increase in the number of direct interconnections (disintermediation). #Part, which is primarily influenced by a network's geographical scope, becomes the main factor determining market share. As an implication, disintermediation most strongly affects transit providers with a limited geographical scope, as global network operators are able to serve a higher number of customers (ECs and CPs) due to their larger scope. In the *saturation phase*, there is a further decrease of the average transport costs. *I* represents the most important factor determining market share. This implies that disintermedation of transit providers further progresses, as a high proportion of direct interconnections leads to a high importance of *I*. In direct interconnections in a SPP regime, revenue generation is only driven by *I*, not by *C*. For this reason, *C* becomes irrelevant.

The lack of influence of the company-specific price component for the interconnection revenues can be explained by the fact that the proposed model is based on the SPP regime. In this regime, the establishment of a direct connection between the source and sink network always has a cost minimizing effect. Therefore a disintermediation of LTPs and STPs occurs independently of an operator's transit price. A similar trend towards disintermediation can be observed in the best-effort Internet. A higher degree of interconnections and the increasing amount of direct connections enables the bypassing of Tier 1 network operators [Faratin et al. 2007; McPherson 2009; Norton 2003]. The analysis does not reveal first mover advantages. The order of negotiation entry, randomly set by the market mechanism, has no significant influence on the market share. However, simulations with greater time distances between the entry of market participants could produce differing results, at least for the introduction and growth phases.

Both, the market share analysis and the analysis of the market share determinants highlight the importance of *I*. The simulations show that in a SPP regime for the most part transport revenues are allocated to the terminating network operators.

4.3.6. Interim conclusion

Limitations

The simulation results are subject to complexity-reducing modeling assumptions concerning the decision behavior of network operators, the modeling of transport costs and QoS demand, as well as the simulation procedure. The contribution of our research consists in the identification of emergent phenomena in the context of the expert scenario and its core assumptions. Beyond the findings in our scenario, the following issues are likely to have an effect on a QoS interconnection market. The decision behavior of network operators is based on a limited set of decision parameters and on two general strategies. In interconnection negotiations other factors may have an influence. For example, neither local cost differences nor the costs for the internal network transport are taken into account in the presented model. Therefore, we are not able to analyze market segment specific behavior. Furthermore, a positive demand for QoS transport is assumed. There are interdependencies between best-effort and QoS data transport, which have an effect on this demand and require further investigation. Also, we did not take into account end-customer behavior and competition in the access market. Such a competition is likely to further increase dynamics in an inter-provider QoS market.

Summary and implications

In this work we constructed a market scenario in order to assess the consequences of the implementation of QoS interconnection in an SPP regime. We focused on the progression of the network operators' market shares throughout the market phases and the influence of different operator characteristics. The simulation model is limited to factors which directly affect QoS interconnection strategies and market behavior. Hence, we only considered revenues and costs which are directly associated with interconnection.

We constructed 13 test cases, each consisting of 50 randomly selected network operators. With each test case, we carried out two simulation runs. The results demonstrate that access providers in the SPP regime collect a large share of transport revenues. Moreover, transit providers can benefit from network effects associated with the installation of interconnections in the introduction phase. In addition to data demand, the scope of a network operator has a positive effect on the market share. In the simulations, we observed a progressive disintermediation of transit providers in the growth and saturation phase.

In order to meet the increasing requirements on the Internet infrastructure, many access network providers face heavy investments. Operator representatives articulate an interest for a stronger financial contribution of content providers with regard to these investments. They criticize a lack of financial accountability in the best-effort Internet for the volume of data content providers generate [Ganley/Allgrove 2006]. They argue that due to the growth of the data volume in the best-effort Internet, the returns on access network investments cannot be guaranteed based on the present business models. The analyses in this paper demonstrate that the implementation of a QoS interconnection market in combination with an SPP regime potentially strengthens the market position of access providers.

5. Conclusion

In the market for telecommunication services, decreasing revenues and an increased market and platform competition give rise to a modification of business models and value creation strategies. Convergence in the ICT industry changes the competitive environment of telecommunication companies and the prospects of cooperation and diversification strategies. In this research, it was investigated which kinds of business prospects convergence brings about for telecommunication companies to avoid a commoditization of core products and to allow the exploitation of novel fields of business. In the following subsection research results are summarized. Subsection 5.2 discusses open research issues and the need for further investigations.

5.1. Summary of results

In order to assess convergence related business potentials for telecommunication companies in the ICT industry, the general effect of industry convergence on diversification performance was analyzed in a first step. It was successfully shown, that diversification indeed represents a strategy often adopted by ICT firms, which are exposed to convergence. ICT convergence opens up various potentials: on the ICT asset, as well as on the operational ICT management layer, the exposure to convergence allows diversifying firms to realize stronger synergies. This implies that telecommunication firms are obliged to continually analyze their technological resources and their operational processes with regard to a changed synergy potential. An additional offering of content and Internet applications or hardware devices might generate stronger synergies due to convergence, particularly through the use of shared technological resources or distribution channels. It was shown that the degree of *convergedness* of sectors influences the value of resources and capabilities of diversified firms. Nevertheless, the analyses also suggested that diversification is not generally superior to alternative convergence strategies. Telecommunication companies therefore should not consider diversification as a panacea for revenue shortfalls but instead carefully analyze the consequences of diversification compared to cooperation and concentration strategies.

> ICT convergence has a positive impact on diversification performance. For telecommunication companies, which are exposed to convergence, diversification is however not generally superior to cooperation or concentration strategies.

Even though the concentration of structural linkages between the media, software, hardware equipment, hardware component and telecommunications sectors is widely acknowledged, it has scarcely been assessed by means of quantitative analyses. The research successfully showed that all sectors can be allocated to an ICT value network, which is characterized by strong inter-sector linkages and weak external links. The research further uncovered the central role software firms play in the ICT value network. With respect to the telecommunications sector, software development and application operation has an increasingly important function due to substitution and complementarity effects [Helander 2004, Messerschmitt 1996]. The analyses revealed a unilateral dependency of the value segment telecommunication on the software segment. This result implies that telecommunication companies, for the provisioning of telecommunication services, rely on complementary software and engage in software specific activities in order to broaden their service portfolio.

> In ICT value networks, software firms play important roles. There is a unilateral dependency of the value segment telecommunication on the software segment.

The analyses of cross-sector competition in telecommunications provided further insights into activities of telecommunication companies in adjacent industry sectors. A high level of competition between telecommunication and media firms was detected. This is in many cases likely to arise from strong economies of scope for shared marketing resources. Furthermore, an integration of telecommunication and media activities potentially increases competitiveness through an exclusive access to marketing or distribution channels. The analyses moreover assert strong diversification activities of telecommunication companies in the software sector. Explanations include higher growth prospects in the software market and economies of scope due to cross-selling and the joint use of technological infrastructure. Telecommunication companies are also engaged in the hardware equipment sector. This is due to linkage effects through the integration of network and terminal equipment production, system integration and network operation. It is further explained through economies of scope in the shared marketing of terminal equipment and telecommunication services.

> There is a high level of cross-competition between the media and telecommunication sectors. Diversification strategies of telecommunication companies are further focused on the software and hardware equipment sectors.

Apart from identifying prosperous fields of business in adjacent ICT sectors, it is furthermore a strong challenge for telecommunication companies to substantiate and implement diversification strategies. The development of functionalities in all-IP NGNs, for example, is up to this date mainly oriented at technological feasibility rather than on end customer demand. In this research, an integrated approach combining the technological with a customer-oriented view was adapted. This allows a more comprehensive, market-driven identification of potential future wholesale services and diversification prospects. The conducted research established a conceptualization of platform based function modules based on concepts of service engineering. Present implementations reveal that the introduction of modular service architectures in telecommunications is in an early stage. In contrast, in the IT sector, service oriented architectures are already popular. In this research, a three-step process for the specification of Enabling Services was defined, which conforms to service engineering principles. The case study demonstrated that the scope of Enabling Services exceeds modularized functionalities of existing telecommunication systems.

> The application of service engineering principles allows a market-driven identification and implementation of modular wholesale services (*Enabling Services*) in the telecommunications industry.

Apart from the exploitation of novel fields of business through diversification, telecommunication companies face significant changes in their core business, particularly with respect to the technologies applied for data transport and the diversity of services transported. The emergence of novel technologies and business models for service distribution has a significant impact on the telecommunication business and was therefore subject to further investigation.

This research provided an overview of the current business models for IP based distribution. Following an inductive approach, we generalized from business models in practice. Four approaches were distinguished: Centralized Internet Hosting, Direct Homing, Content Delivery Networks and P2P Distribution. They significantly differ from each other in the allocation of roles, in the financial flows as well as in the data flows. In order to assess business model design, four case studies were presented. The analysis of the case studies demonstrated that value propositions of the distribution models mainly address quality and cost aspects. However, the value propositions are not clearly distinguishable from each other. In order to enable or support new data intensive real-time services, IP based distribution providers constantly further develop distribution technologies which enhance distribution and at the same time take into account the performance and capacity limitations of IP networks and the Internet. As demonstrated by successful IP based distribution business models such as AKAMAI [Akamai 2008b], there is a demand for the support of quality distribution, which is superior to the plain Centralized Internet Hosting business model.

The business models for service distribution in IP-networks significantly differ in their allocation of roles, in the financial and in the data flows. Their value propositions all address quality and cost aspects. The value propositions are, however, not clearly distinguishable from each other.

The main characteristics influencing an information service provider's choice of a specific distribution method were identified. The results of the investigation revealed that distribution technologies vary strongly with respect to the information services they support. A set of characteristics concerning service production and consumption was identified, which have a strong influence on the quality provided by distribution technologies. Centralized hosting is particularly suitable for services with a local demand and low data loads. Direct Homing is only applicable for services with low consumer mobility and satisfies high real-time requirements. The business potential of Direct Homing, for network operators, therefore depends on the emergence and evolution of real-time services with low mobility requirements such as online gaming, video conferencing or video surveillance. CDNs especially support services with high consumer mobility and a high level of demand. An engagement of network operators in the CDN market requires solutions, which span fixed and mobile access platforms, and potentially also the cooperation of various network operators in order to support the consumer’s need for high mobility. P2P Distribution is adequate for services with a global demand and low security requirements. Due to the global demand, P2P distribution imposes high costs for inter-domain traffic on network operators, which can be reduced through technologies for a cooperative traffic control by applications providers and network operators [Xie et al. 2008]. From the set of characteristics which were taken into account, several were proven irrelevant. Most notably, criteria directly describing the QoS of distribution, namely packet delay and data load per second, have an insignificant influence on the choice of a distribution technology. This means that there is no distribution technology which generally provides a superior distribution quality. Instead, information service providers need to match their individual service characteristics to the technological capabilities of distribution methods for an optimal choice.

There is no distribution technology which generally provides a superior distribution quality. Different characteristics of service production and consumption have a strong influence on the quality provided by distribution technologies.

The introduction of a quality differentiation across network boundaries (inter-provider QoS) in the Internet potentially enables fundamentally novel value propositions for service distribution. However, there is a controversial debate of practitioners and academic researchers about the economic consequences of the introduction of QoS in the Internet. The payment regime, in particular, strongly influences competitive behavior and market outcomes in a QoS interconnection market. Several researchers argue in favor of the implementation of a SPP regime. Nevertheless, it is generally accepted that there is no payment regime which is globally efficient for all service contexts. This research contributed to the debate on QoS interconnection and payment regimes by analyzing a market scenario for the formation of inter-provider QoS with agent-based simulations. Based on market data of the best-effort interconnection market and heterogeneous market samples, the development of multi-network QoS infrastructures in a Sending-Party-Pays (SPP) regime was simulated. For different market phases the progression of market shares and the influence of transit providers' distinctive properties, such as the number of interconnections and the data demand, on their market shares were analyzed. The results allowed an identification and specification of economic developments in an inter-provider QoS market. We showed that a network operator's data demand and geographical presence determine market shares in the analyzed expert scenario. As a consequence, access providers collect a large share of transport revenues in an SPP regime. Transit providers can benefit from network effects associated with the installation of interconnections in the introduction phase as well as from their scope. However, a progressive disintermediation of transit providers in the growth and saturation phase was observable.

> The implementation of a QoS interconnection market in combination with an SPP regime potentially strengthens the market position of access providers. In contrast, transit providers face risks of a progressive disintermediation.

5.2. Further research

This dissertation gives rise to further research questions in the fields of ICT convergence and the evolution of the Internet ecosystem. The research on convergence successfully demonstrated a general interrelationship between sector convergence and firm diversification. It was also shown, however, that diversification does not generally represent a dominant strategy in the case of convergence. As a consequence, there are environmental conditions other than sector convergence, which significantly drive diversification success. The simple adjacency of ICT sectors does not represent a sufficient condition for a stagnating firm to generate higher profit margins through the diversification into a sector with higher growth rates. Several drivers of diversification performance were discussed with respect to the telecommunications sector. Most notably, synergies may arise through the following effects: economies of scope through the use of shared marketing resources, scale effects on shared technological infrastructures and linkage effects through technology integration. Failure stories such as the engagement of the telecommunication firm Telefonica in the media sector through the acquisition of the production company Endemol [WIWO 2007] show that the reliability of synergy effects is subject to conditions. Diversification potentially brings about detrimental consequences such as high coordination costs, inefficiencies and organizational inflexibilities. The particular conditions, which influence diversification performance in the case of sector convergence, deserve further attention. Rather than studying diversification on a generic scale, further research could take into account contingency factors such as organizational capabilities as well as the particular resource base of a firm. The application of case study research and the focus on context-specific conditions could shed further light on the interrelationship of sector convergence and diversification performance.

With respect to the further evolution of the Internet ecosystem, there is an ongoing fundamental debate about the sustainability of current Internet business models with two opposing standpoints. One party argues that, on the basis of current financing models in the Internet, future transport revenues will not be sufficient to finance the required network investments [A.T. Kearney 2010; Nemertes 2007; Watlington et al. 2005]. According to their argumentation, traffic consumption is steeply increasing due to the emergence and dissemination of data intensive services such as IPTV and video-on-demand. The traffic increase requires investments for building out access networks which are estimated to be immensely high [A.T. Kearney 2010]. The situation is further aggravated by the fact that flat-rate pricing plans do not incentivize consumers to limit data consumption. Representatives of some network operators, in particular, call for a stronger involvement of content providers in the funding of access network investments: *The network builders are spending a fortune constructing and maintaining the networks that Google intends to ride on with nothing but cheap servers. It is enjoying a free lunch that should, by any rational account, be the lunch of the facilities providers.* [Mohammed 2006] It is claimed that, without a significant modification of revenue allocation schemes, the stability of the Internet is endangered.

The other party takes an opposing view by arguing that replacement costs for telecommunication equipment are mostly lower than depreciation charges [Odlyzko 2009]. According to their argumentation, the current traffic growth figures of around 50% p.a. can be maintained without a strong increase of traffic investments due to the declining prices for network equipment. The content provider Google even begins to build out experimental high-speed broadband networks under its own initiative in order to accelerate fiber rollout in the US [Google 2011]. If this project proved to be successful, Google could effectively take the wind out of the sails of network operators, which favor a reallocation of revenues [Higginbotham 2011].

Members of all segments in the Internet ecosystem acknowledge the importance of unhindered business model innovations for a sustainable Internet growth [CEO 2011]. They, inter alia, highlight two aspects: optimized interconnection schemes and managed services beyond best-effort. With regard to interconnection, the implementation of inter-provider QoS could represent a new source for innovation and an enabler for infrastructure investments. The increasing dependency on the Internet through the growth of cloud services [BITKOM 2010c] such as Software and Infastructure as a Service motivates further research in this area. Efforts for the implementation of inter-provider QoS are currently in an early stage. Agreements between the different stakeholders must be reached with regard to technological (e.g., class definitions) and economic (e.g., charging) aspects. In this work, a scenario for inter-provider QoS was presented, which focused on a specific interconnection regime (SPP). Further economic analyses are required to evaluate the coexistence of different interconnection regimes for tiered quality classes. A coexistence of the BAK regime for best-effort traffic and the SPP-regime for high-quality traffic, for example, might incentivize network operators to favour one traffic class over the other or to exploit arbitrage effects. Moreover, the creation of quantitative analyses, which compare different QoS regimes with respect to overall efficiency and suitability to specific service scenarios, would further contribute to the discussion on future interconnection regimes.

The introduction of managed services beyond best-effort potentially fosters innovation in the market for consumer services [CEO 2011]. Even though the term managed service is often used in the telecommunications sector, there is no common understanding of its meaning. For this context, a managed service is defined as a service provided by a network operator, which requires service-level guarantees regarding QoS, security or bandwidth [Weldon 2010]. Exemplary managed services include IPTV services, video conferencing services and inter-site data transfers with a guaranteed bandwidth. The provisioning of content delivery as a managed service represents a novel field of business for access network operators. Apart from developing CDNs for their own network, access providers also discuss the formation of CDN federations [Rayburn 2011; Wulf et al. 2010d]. Through a cooperation, access network operators would significantly increase platform size in terms of connected content providers and consumers and thus enter competition with established CDN providers. Up to the present, however, it represents an open research issue how access network operators effectively could create synergies between network provisioning and content delivery. Novel technological innovations in this field show that there indeed is potential for such synergies [Poese et al. 2010]. Future economic research in this field could focus on the identification and quantification of such synergies.

Apart from data delivery for human users, machine-to-machine (m2m) communication is predicted a strong growth in the upcoming years [Cisco 2011]. Embedded systems which exchange status and control information are being implemented in many technological devices. Application scenarios often mentioned address the following fields: e-energy (smart metering, smart grid), transportation and logistics (object tracking, navigation, toll-collect, e-diagnostics), smart homes (home surveillance, home automation, fire alarm) and healthcare (health monitoring, person authentication and tracking) [Atzori et al. 2010]. Network operators, because of their ability to design managed services specifically tailored for m2m communication, are considered to have a competitive advantage in the market for m2m services [Van Landegem/Viswanathan 2008]. The connection of objects with a unique identification to the Internet (Internet of Things) [Fleisch 2010] could, on a large scale, have a significant impact on the volume and type of data traffic exchanged in the Internet. The Internet infrastructure, according to Atzori et al. [2010], needs to be modified in order to efficiently support transmission control for m2m communication. The required modifications, economic consequences and business prospects, however, are unclear and require further research.

Access network providers and consumer service providers, in the traditional Internet, were indirectly interconnected through transit providers. The trend towards a direct interconnection of access network providers to consumer service providers [Labovitz et al. 2010] allows the estalishing of novel business and revenue models [Balaji et al. 2005, TATA 2008, Wulf et al. 2010b]. Access network providers, in order to differentiate themselves from their competitors, can for example distribute licensed content. This approach is followed by Verizon, among others, with the online streaming service ESPN3 [Sietmann 2011]. Access providers establish themselves as delivery platforms which mediate between content providers and consumers. In such a situation, two-sided market mechanisms come into effect [Rochet/Tirole 2003]. The analysis and design of flexible pricing strategies, which take into account cross-side network externalities, represents a major challenge for researchers and practitioners in the course of the design of business and pricing models for managed services.

From today’s perspective, the future consumer demand for QoS in data transport is unforeseeable. The future evolution of data consumption, capacity supply and Internet performance strongly influences the economics of IP service distribution. Studies of the Internet performance reveal significant problems due to mostly temporary routing instabilities even within Europe and the US [Katz-Bassett et al. 2008]. Causes of network downtime include router misconfigurations, IP routing failures and physical link failures [Agapi et al. 2011]. The growth of Internet usage increases the likelihood of a bandwidth crisis, particularly in the wireless spectrum [Pope/Shim 2010]. If there were no performance problems in the Internet and no scarcity in competitive markets for Internet connectivity, QoS business models would merely represent a means for price discrimination [Odlyzko 2009]. In the case of increasing overflows of transport capacities and routing instabilities, in contrast, QoS approaches become inevitable in order to secure market efficiency [MacKie-Mason/Varian 1995b]. The economic success of business models for service distribution in IP networks critically depends on Internet performance and the scarcity of transport capacities. Service differentiation and network investment strategies, due to the high significance of the Internet for society, are also of great interest to regulators and policy-makers [Frieden 2008, Holznagel et al. 2010]. It is therefore an important task of academic research to monitor the market for data transport continuously and deduce recommendations for market participants and policy-makers in order to guarantee a sustainable market development.

A network operator's ability to differentiate service characteristics plays a strategic role in the market for data transport. A technology trend in telecommunication networks, which draws great attention, is the decoupling of network equipment and forwarding intelligence through the introduction of a switching protocol (Software-defined networking) [McKeown et al. 2008]. Whereas traditionally forwarding intelligence was tightly integrated with the network equipment, the use of novel software and protocols allows the installation of central network operating systems and a flexible configuration and virtualization of network resources. This novel concept provides the foundation for innovations in data transport such as an integrated load balancing of network and server traffic [Handigol et al. 2009] and an application aware traffic aggregation and engineering [Das et al. 2011]. According to McKeown, network operators presently lack the ability to customize their services with regard to security and reliability characteristics. Improved differentiation through a software-defined networking would, in his opinion, lead to healthier competition and boost innovation [Goth 2011]. An improved ability to technologically differentiate and customize transport services brings about new economic challenges. The consumer requirements for specific services need to be translated into QoS parameters and other technical service levels for data transport. Whereas this translation has up to the present mostly been done on the general level of service classes, software-defined networking potentially allows a service specific configuration of technical service parameters. It still represents a major challenge for researchers and practitioners, however, to identify and characterize the interrelationship of service specific QoE and QoS. With an increased flexibility in resource allocation, it furthermore represents an important research issue how to assign scarce resources to services in an efficient and at the same time fair manner. Resource allocation and pricing have been subject to extensive research [Panagiotis et al. 2002]. Many propositions have not been applied in practice due to high implementation complexity. An increased flexibility in network management potentially also allows a higher variability in the pricing of data transport. Theoretical pricing approaches, which dynamically allocate resources based on network load and consumer utility [Mac-Kie-Mason/Varian 1995b], must be reassessed and adjusted in relation to the technological developments. New approaches to charging and price differentiation potentially could represent the basis for fundamental business model innovations in the market for data transport.

6. Appendices

6.1. Supplementary material for the diversification analysis

SIC class and sector allocation

ICT Industry Sector	Description	Exemplary Products and Services	Market Segments (SIC Codes)
Hardware Components	production of material and components required to produce hardware equipment	-semiconductors -wire products	3671, 3672, 3674, 3675, 3676, 3677, 3678, 3679, 3691, 3692, 3694, 3695, 3699
Hardware Equipment	production of communication terminals and network infrastructure components	-computers -mobile phones -routers	3571, 3572, 3575, 3577, 3578, 3579, 3651, 3652, 3661, 3663, 3669
Software	development of software and Internet applications and value adding tasks such as training and systems design	-computer programming services -information retrieval services	7370, 7371, 7372, 7373, 7374, 7375, 7376, 7377, 7378, 7379, 7382
Telecommunications	provisioning of telecommunication services, network operation and management	-PSTN and GSM telephony -DSL Internet access	4812, 4813, 4822, 4899
Media	production and management of text, graphical and multimedia content	-publishing of newspapers -advertising services -motion picture production	2711, 2721, 2731, 2741, 4832, 4833, 4841, 7311, 7312, 7313, 7319, 7812, 7819, 7822, 7829

Table 6-1: Allocation of SIC classes and ICT sectors

The SIC classes are structured in a four-digit, dendritic hierarchy based on production and market-orientated differentiation criteria. The structure is mainly orientated to generic levels of value-adding and distinguishes, inter alia, the single digit SIC classes of manufacturing, services, wholesale and retail. Since the five ICT sectors do not uniquely assign SIC classes to a higher hierarchy level (SIC level 1-3), the authors adopted a four-digit SIC class allocation for the five sectors – hardware equipment, software, telecommunications, hardware components and media. The results of the literature analysis of value creation in the ICT sector were used (Table 3-14) to identify ICT-specific four-digit SIC classes and for sector allocation. The sector allocations (Table 6-1) were checked by three independent specialists in order to ensure their completeness and validity.

In order to achieve the full allocation of four-digit SIC classes and sectors, the non ICT-specific four-digit SIC classes were also allocated to sectors when preparing the cluster analysis (Table 6-2). The allocations were then checked by the three independent experts. Allocation was based on the SIC hierarchy. With the objective of keeping sector size deviation to a minimum while also maintaining clear sector separation, SIC classes on the second or third hierarchy levels, as well as the remaining four-digit SIC classes, were allocated to sectors. The size of a sector is determined by the number of active companies within it.

Sector	**Products**	**SIC classes**
ELECTRONICS RETAIL	GENERAL MERCHANDISE STORES; RADIO, TELEVISION, CONSUMER ELECTRONICS, AND MUSIC STORES	53, 573, 5945, 5946, 5961
AGRICULTURAL PRODUCTION-CROPS	AGRICULTURAL PRODUCTION-CROPS; AGRICULTURAL PRODUCTION-LIVESTOCK AND ANIMAL SPECIALTIES; AGRICULTURAL SERVICES; FORESTRY; FISHING, HUNTING, AND TRAPPING	01, 02, 07, 08, 09
MINING	METAL MINING; COAL MINING; OIL AND GAS EXTRACTION; MINING AND QUARRYING OF NONMETALLIC MINERALS, EXCEPT FUELS	10, 12, 13, 14
CONSTRUCTION	BUILDING CONSTRUCTION-GENERAL CONTRACTORS AND OPERATIVE BUILDERS; HEAVY CONSTRUCTION OTHER THAN BUILDING CONSTRUCTION-CONTRACTORS; CONSTRUCTION-SPECIAL TRADE CONTRACTORS	15, 16, 17
MANIFACTURING GENERAL PRODUCTS	FOOD AND KINDRED PRODUCTS; TOBACCO PRODUCTS; TEXTILE MILL PRODUCTS; APPAREL AND OTHER FINISHED PRODUCTS MADE FROM FABRICS AND SIMILAR MATERIAL; LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE; FURNITURE AND FIXTURES; PAPER AND ALLIED PRODUCTS	20, 21, 22, 23, 24, 25, 26
MANUFACTURING CHEMICALS AND PETROLEUM	CHEMICALS AND ALLIED PRODUCTS; PETROLEUM REFINING AND RELATED INDUSTRIES	28, 29
MANUFACTURING MATERIALS AND METAL PRODUCTS	RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS; LEATHER AND LEATHER PRODUCTS; STONE, CLAY, GLASS, AND CONCRETE PRODUCTS; PRIMARY METAL INDUSTRIES; FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT	30, 31, 32, 33, 34

INDUSTRIAL MACHINERY	ENGINES AND TURBINES; FARM AND GARDEN MACHINERY AND EQUIPMENT; CONSTRUCTION, MINING, AND MATERIALS HANDLING MACHINERY AND EQUIPMENT; METALWORKING MACHINERY AND EQUIPMENT; SPECIAL INDUSTRY MACHINERY, EXCEPT METALWORKING MACHINERY; GENERAL INDUSTRIAL MACHINERY AND EQUIPMENT; REFRIGERATION AND SERVICE INDUSTRY MACHINERY; MISCELLANEOUS INDUSTRIAL AND COMMERCIAL MACHINERY AND EQUIPMENT	351, 352, 353, 354, 355, 356, 358, 359
MULTIPURPOSE ELECTRICAL EQUIPMENT	ELECTRIC TRANSMISSION AND DISTRIBUTION EQUIPMENT; ELECTRICAL INDUSTRIAL APPARATUS;HOUSEHOLD APPLIANCES;ELECTRIC LIGHTING AND WIRING EQUIPMENT	361, 362, 363, 364
TRANSPORTATION EQUIPMENT	TRANSPORTATION EQUIPMENT	37
INSTRUMENTS AND APPARATUR	MEASURING, ANALYZING AND CONTROLLING INSTRUMENTS; PHOTOGRAPHIC, MEDICAL AND OPTICAL GOODS	38
MISCELLANEAOUS MANUFACTURING INDUSTRIES	MISCELLANEOUS MANUFACTURING INDUSTRIES	39
TRANSPORTATION	RAILROAD TRANSPORTATION; LOCAL AND SUBURBAN TRANSIT AND INTERURBAN HIGHWAY PASSENGER TRANSPORTATION; MOTOR FREIGHT TRANSPORTATION AND WAREHOUSING; UNITED STATES POSTAL SERVICE; WATER TRANSPORTATION; TRANSPORTATION BY AIR; PIPELINES, EXCEPT NATURAL GAS; TRANSPORTATION SERVICES	40, 41, 42, 43, 44, 45, 46, 47
ELECTRIC, GAS AND SANITARY SERVICES	ELECTRIC, GAS, AND SANITARY SERVICES	49
WHOLESALE TRADE DURABLE GOODS EXCPT HW	MOTOR VEHICLES AND MOTOR VEHICLE PARTS AND SUPPLIES; FURNITURE AND HOMEFURNISHINGS; LUMBER AND OTHER CONSTRUCTION MATERIALS; METALS AND MINERALS, EXCEPT PETROLEUM; HARDWARE, AND PLUMBING AND HEATING EQUIPMENT AND SUPPLIES; MACHINERY, EQUIPMENT, AND SUPPLIES; MISCELLANEOUS DURABLE GOODS	501, 502, 503, 505, 507, 508, 509, 5043, 5044, 5046, 5047, 5048, 5049
WHOLESALE TRADE NONDURABLE GOODS	WHOLESALE TRADE; NONDURABLE GOODS	51
OTHER RETAIL TRADE	BUILDING MATERIALS, HARDWARE, GARDEN SUPPLY, AND MOBILE HOME DEALERS; FOOD STORES, AUTOMOTIVE DEALERS AND GASOLINE SERVICE STATIONS; APPAREL AND ACCESSORY STORES; HOME FURNITURE AND FURNISHINGS STORES; HOUSEHOLD APPLIANCE STORES; EATING AND DRINKING PLACES; DRUG STORES AND PROPRIETARY STORES; LIQUOR STORES; USED MERCHANDISE STORES, FUEL DEALERS; RETAIL STORES, NOT ELSEWHERE CLASSIFIED	52, 54, 55, 56, 571, 572, 58, 591, 592, 593, 598, 599, 5941, 5942, 5943, 5944, 5947, 5948, 5949, 5962, 5963

BANKING, FINANCE AND INSURANCE	DEPOSITORY INSTITUTIONS; NONDEPOSITORY CREDIT INSTITUTIONS; SECURITY AND COMMODITY BROKERS, DEALERS, EXCHANGES, AND SERVICES; INSURANCE CARRIERS; INSURANCE AGENTS, BROKERS, AND SERVICE	60, 61, 62, 63, 64
REAL ESTATE	REAL ESTATE	65
HOLDING AND OTHER INVESTMENT OFFICES	HOLDING AND OTHER INVESTMENT OFFICES	67
MISCELLANOUS SERVICES	HOTELS, ROOMING HOUSES, CAMPS, AND OTHER LODGING PLACES; PERSONAL SERVICES; AUTOMOTIVE REPAIR, SERVICES, AND PARKING;MISCELLANEOUS REPAIR SERVICES; MOTION PICTURE THEATERS; VIDEO TAPE RENTAL; DANCE STUDIOS, SCHOOLS, AND HALLS; BOWLING CENTERS; MISCELLANEOUS AMUSEMENT AND RECREATION SERVICES	70, 72, 75, 76, 783, 784, 791, 793, 799
BUSINESS SERVICES	CONSUMER CREDIT REPORTING AGENCIES, MERCANTILE REPORTING AGENCIES; SERVICES TO DWELLINGS AND OTHER BUILDINGS; MISCELLANEOUS EQUIPMENT RENTAL AND LEASING; PERSONNEL SUPPLY SERVICES	732, 734, 735, 736, 7381, 7383, 7384, 7389
ENGINEERING AND RESEARCH	ENGINEERING, ARCHITECTURAL, AND SURVEYING SERVICES; RESEARCH, DEVELOPMENT, AND TESTING SERVICES	871, 873
MANAGEMENT, ACCOUNTING AND PUBLIC RELATIONS	ACCOUNTING, AUDITING, AND BOOKKEEPING SERVICES; MANAGEMENT AND PUBLIC RELATIONS SERVICES	872, 874
HEALTH, EDUCATION, SOCIETY AND PUBLIC ADMIN	HEALTH SERVICES; LEGAL SERVICES; EDUCATIONAL SERVICES; SOCIAL SERVICES; MUSEUMS, ART GALLERIES, AND BOTANICAL AND ZOOLOGICAL GARDENS; MEMBERSHIP ORGANIZATIONS; PRIVATE HOUSEHOLDS; SERVICES, NOT ELSEWHERE CLASSIFIED; EXECUTIVE, LEGISLATIVE, AND GENERAL GOVERNMENT, EXCEPT FINANCE; JUSTICE, PUBLIC ORDER, AND SAFETY;PUBLIC FINANCE, TAXATION, AND MONETARY POLICY, ADMINISTRATION OF HUMAN RESOURCE PROGRAMS; ADMINISTRATION OF ENVIRONMENTAL QUALITY AND HOUSING PROGRAMS; ADMINISTRATION OF ECONOMIC PROGRAMS; NATIONAL SECURITY AND INTERNATIONAL AFFAIRS	80, 81, 82, 83, 84, 86, 88, 89, 91, 92, 93, 94, 95, 96, 97
NON CLASSIFIABLE	NON CLASSIFIABLE	9999

Table 6-2: Allocation of SIC classes to non-ICT-sectors

Clustering coefficient

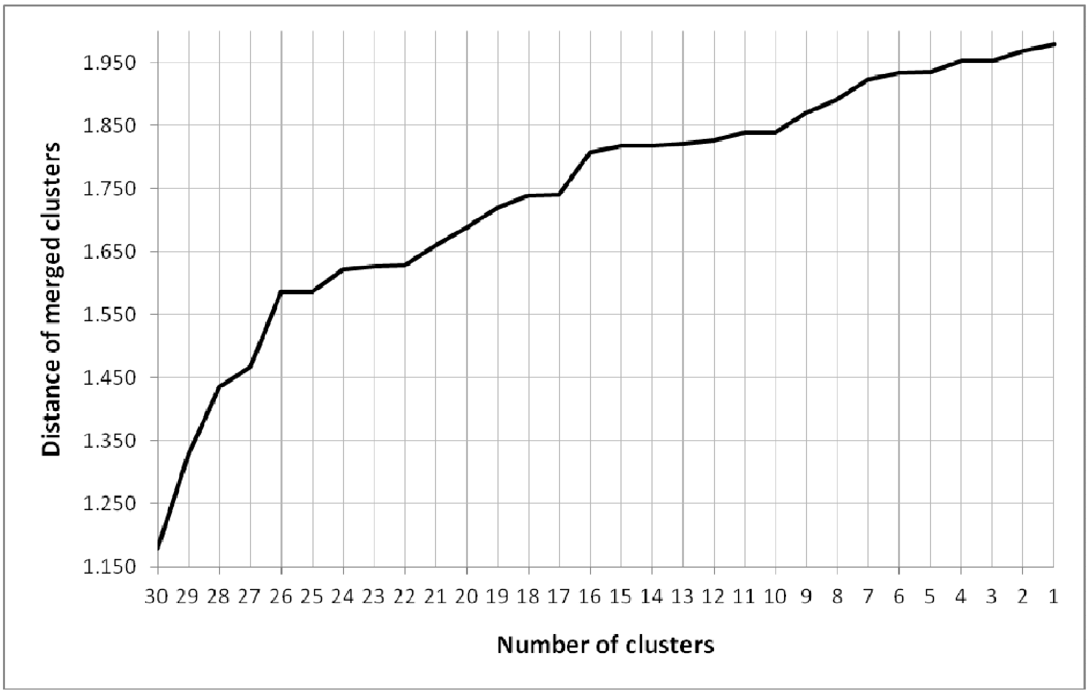

Figure 6-1: Clustering coefficient curve

Number of clusters	Distance of merged clusters (clustering coefficient)	Difference to the previous value
30	1.179	
29	1.330	.151
28	1.436	.106
27	1.467	.031
26	1.587	.120
25	1.587	.000
24	1.621	.034
23	1.627	.005
22	1.629	.002
21	1.659	.030
20	1.688	.029
19	1.720	.032
18	1.740	.020
17	1.742	.002
16	1.807	.065
15	1.817	.011
14	1.818	.001
13	1.821	.003
12	1.827	.006
11	1.839	.011
10	1.839	.000
9	1.870	.031
8	1.891	.021
7	1.923	.032
6	1.933	.010
5	1.935	.002
4	1.953	.018
3	1.953	.000
2	1.968	.015
1	1.980	.011

Table 6-3: Clustering coefficient and difference to previous value

Sector association

SECTOR	CODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Hardware Components	1																														
Hardware Equipment	2	19.4																													
Software	3	3.9	17.8																												
Telecommunications	4	2.3	6.4	8.2																											
Media	5	0.6	2.5	6.1	8.3																										
Electronics Retail	6	1.1	5.3	4.3	2.2	3.8																									
Agricultural Production-Crops	7	0.2	0.4	0.4	0.4	0.8	0.6																								
Mining	8	0.4	0.3	0.6	0.4	0.2	0.1	0.6																							
Construction	9	1.5	2.2	1.6	1.9	1.1	1.6	1.4	2.1																						
Manufacturing General Products	10	1.2	1.3	0.9	0.6	2.1	1.5	9.1	0.8	2.4																					
Manufacturing Chemicals and Petroleum	11	2.2	1.2	1.0	0.4	0.9	1.1	2.4	3.5	2.7	8.3																				
Manufacturing Materials and Metal Products	12	5.7	3.3	1.6	1.0	0.8	0.8	1.0	3.8	6.1	7.3	7.5																			
Industrial Machinery	13	7.2	3.7	1.8	0.5	0.9	0.8	0.7	1.6	4.2	2.6	3.0	10.4																		
Multipurpose Electrical Equipment	14	9.1	5.8	1.2	1.1	0.4	1.2	0.6	0.3	1.8	1.3	1.2	4.4	8.1																	
Transportation Equipment	15	3.1	2.0	0.8	0.4	0.6	0.7	0.8	0.7	1.9	1.7	1.1	5.6	10.0	4.6																
Instruments and Apparatur	16	7.3	4.7	2.7	1.0	0.7	1.0	0.2	0.2	1.2	1.1	4.1	3.3	5.0	4.7	3.0															
Miscellaneous Manufacturing Industries	17	1.1	1.3	0.7	0.3	1.7	1.5	0.6	0.5	0.5	2.2	1.5	3.1	2.1	1.5	1.7	1.5														
Transportation	18	0.8	1.2	1.9	1.2	2.3	4.3	3.0	2.8	4.9	3.7	2.8	3.0	2.1	0.7	4.1	0.8	0.5													
Electric, Gas and Sanitary Services	19	1.6	1.2	1.1	1.9	0.6	0.8	1.3	4.6	6.1	2.2	4.0	3.4	2.6	2.1	0.7	0.7	0.4	4.4												
Wholesale Trade Durable Goods except HW	20	3.2	5.2	1.8	0.6	1.6	3.3	1.4	2.4	6.2	5.2	4.3	11.2	9.9	3.3	7.6	5.6	3.8	4.2	2.9											
Wholesale Trade Non-Durable Goods	21	1.1	2.2	1.1	0.5	2.5	4.3	5.7	1.5	2.1	15.5	12.9	4.2	1.8	0.8	0.9	1.4	2.1	4.9	2.4	7.0										
Other Retail Trade	22	0.9	2.2	1.7	1.3	3.4	11.6	2.4	1.2	3.0	8.8	4.6	3.2	1.4	1.2	2.4	1.5	2.6	6.1	2.3	7.3	12.2									

Banking, Finance and Insurance	**23**	0.5	1.2	2.6	0.8	1.0	1.0	0.6	0.5	1.5	1.7	0.6	1.0	1.0	0.3	1.2	0.5	0.3	1.9	0.8	1.5	1.2	2.2								
Real Estate	**24**	1.9	3.1	2.6	1.7	3.0	5.2	2.6	1.6	15.2	5.9	3.6	5.2	2.7	1.3	1.8	1.5	1.3	8.4	3.4	5.8	5.7	8.8	6.7							
Holding and other Investment Offices	**25**	3.1	3.9	3.8	2.7	3.0	1.8	1.9	2.5	4.2	4.8	3.1	4.3	2.0	1.6	1.7	1.3	1.3	3.9	2.8	3.7	3.6	5.5	23.8	12.9						
Miscellaneous Services	**26**	1.6	2.4	2.7	1.8	5.3	5.2	1.7	0.9	5.9	2.9	2.1	2.7	2.9	1.8	3.1	1.3	2.0	8.3	2.0	5.2	2.6	10.1	2.5	13.2	5.5					
Business Services	**27**	1.9	4.1	6.8	3.1	5.2	3.0	0.9	0.9	4.5	2.8	1.6	2.6	3.3	0.8	1.8	1.9	1.3	4.7	2.2	4.8	2.6	4.4	4.3	5.3	3.6	5.7				
Engineering and Research	**28**	2.2	1.8	2.3	1.1	1.1	0.6	1.1	2.1	8.7	1.0	9.5	2.9	3.2	2.1	2.4	4.0	0.5	2.3	3.1	3.3	1.7	1.2	0.6	3.0	2.7	1.7	3.6			
Management, Accounting and Public Relations	**29**	1.3	2.2	5.0	2.0	3.9	1.7	2.1	1.0	6.4	1.7	1.5	1.6	1.6	0.6	1.2	0.7	0.5	4.0	2.8	2.4	2.1	2.7	2.7	6.0	6.0	4.0	6.9	5.6		
Health, Education, Society and Public Admin	**30**	0.8	2.5	5.6	2.1	4.4	2.0	1.1	0.4	2.2	1.1	2.9	1.1	1.3	0.5	1.0	2.5	0.6	2.1	2.5	2.2	1.8	2.6	1.4	2.7	2.5	3.4	4.0	4.6	5.7	
Non Classifiable	**31**	1.3	1.2	1.2	1.3	1.4	0.9	1.0	0.8	1.4	1.6	1.5	1.3	1.7	0.8	1.2	1.1	1.1	1.5	1.4	1.6	1.1	1.6	1.5	1.5	1.2	1.7	2.2	1.1	0.8	1.3

Table 6-4: Degrees of sector assocation

6.2. Supplementary material for the value proposition analysis

Objectivity	Definition of rules and procedures	Reporting of categories and definitions
	Judge training	Presentation of category definition prior to coding
	Unit measure pretesting	Pretesting conducted by authors
	Judge independence	Engagement of four non-authoring judges
	Multiple judges	
Systematization	Prohibition of bias between category selection and thesis	Avoidance of result predetermination by definition of categories in cooperation with independent experts and based on literature
	Hypothesis testing	Hypothesis formulation and foundation
Sampling Methods	Generalizability of sample	Selection of representative published use cases
	Manageability of sample size	Sample size of 103 applications
Reliability	Categorical reliability	Clear definition of categories
	Interjudge reliability	Introduction of feedback cycle to avoid interjudge disagreements

Table 6-5: Conformance with content-analysis research directives (based on [Kolbe/Burnett 1991])

Judge	Education	Work Experience in the IT services field	Expertise in IT Service Application, Development, and Management
1	Information Engineering and Management (MSc)	6 years	Application Programming, Software Engineering, Network Technologies, IT Service Management
2	Industrial Engineering and Management (MSc)	3 years	Web Design, IT Service Quality Management, Internet Technologies
3	Information Systems Management (MSc)	8 years	Application Programming, Software Engineering, IT Service Management
4	Industrial Engineering and Management (BSc)	1 ½ years	Web Design, IT Service Management, Internet Technologies
5	Computer Sciences (BSc)	3 years	Application Programming, Network Technologies, Server Configuration

Table 6-6: Information on Judge Qualifications

Name of Information Service	**Information Service Provider**	**Type Description**	**Distribution Technology**	**Distribution Provider**
ICQ / AOL Instant Messenger	AOL	Instant Messenger, Internet Telephony	P2P	AOL
20th Century Fox Films	20th Century Fox	Video Streaming	P2P	Vuze
301 Records Music Album	301 Records	Music Download	P2P	Kazaa
ABS-CBN TV	ABS-CBN Global	TV Streaming	CDN	EdgeStream
Aeria Game Patches	Aeria Games	Game Distribution	P2P	BitTorent
Altnet Musical Download Service	Altnet	Music Download	P2P	Kazaa
amazon.de Web Shop	Amazon	Online Shop	IP Transit	Level3
AMD Drivers	AMD	Driver Download	CDN	Akamai
Audi Website	Audi AG	Business Internet Representation	CDN	Akamai
B2B-trade.net	B2B-Trade Ltd. & Co. KG	B2B Marketplace	IP Transit	Hosteurope
morgenpost.de	Berliner Morgenpost	News Portal	IP Transit	Arcor

bild.de	BILD digital GmbH & Co. KG	News Portal	IP Transit	Colt Telecommunica-tions
billiger.de	billiger.de	Information Aggregator	IP Transit	IP Exchange GmbH
Bluewin TV	Swisscom	TV, Video Streaming	Direct Homing	Swisscom
Bollywood Movies	IndiaFM.com	Movie Download	P2P	Kazaa
Music Video Streaming	Sony BMG	TV, Video Streaming	Direct Homing	BT
Business Connect Professional	Swisscom	VoIP	Direct Homing	Swisscom
Business Video 1000MXP	T-Systems	Video Conferencing	Direct Homing	T-Systems
Cathay Pacific Airways Web-site	Cathay Pacific Airways	Website	CDN	Akamai
CNBC Homepage	CNBC	News Portal	CDN	Akamai
Comedy Central Series	Comedy Central	Video Streaming	P2P	BitTorent
tagesspiegel.de	Der Tagesspiegel	News Portal	IP Transit	IP Exchange GmbH
DirecTV VoD	DirecTV	TV Streaming	CDN	Technicolor EDS
DreamWorks Video Clips	DreamWorks	Clip Stream	CDN	Limelight Networks
Ebay.de Transaction Platform	eBay	Online Auction House	IP Transit	Level3
Electronic Arts Games Soft-ware	Electronic Arts	Software Download	CDN	Limelight Networks
End Customer VoIP	Private End Customers	VoIP	Direct Homing	Telefonica Deutschland GmBH
End Customer VoIP	Private End Customers	VoIP	Direct Homing	o2
End Customer VoIP	Private End Customers	VoIP	Direct Homing	Arcor
End Customer VoIP	Private End Customers	VoIP	Direct Homing	HanseNet
End Customer VoIP	Private End Customers	VoIP	Direct Homing	1&1
Equant Managed IP-VPN	Equant	IP VPN	Direct Homing	Equant
ESA Portal	ESA	Clip Stream	CDN	Akamai
FAZ.net	F.A.Z. Electronic Media GmbH	News Portal	IP Transit	Versatel
ftd.de	Financial Times Deutsch-land	News Portal	IP Transit	Gruner+ Jahr AG & Co
France Televisions VoD	France Televisions	Video on Demand	CDN	Akamai
GameShadow Software Download	GameShadow	Software Download	CDN	Limelight Networks

Geizkragen.de	Geizkragen	Information Aggregator	IP Transit	DTS Systeme
Google Apps	Google Inc.	SaaS	IP Transit	Google
Google Talk	Google	Instant messenger, Internet Telephony	P2P	Google
guenstiger.de	guenstiger.de	Information Aggregator	IP Transit	Inet People Hostmaster
handelsblatt.com	Handelsblatt	News Portal	IP Transit	circ IT GMbH
Hostel Website	Hostel David	Hostel Web Representa-tion	IP Transit	Strato AG
IAHGame Patches	Infocomm Asia Holdings Pte Ltd (IAHGames)	Software Download	P2P	BitTorent
Intel Driver Download	Intel	Software Download	CDN	Akamai
InterContinental Website	InterContinental Hotel Group	Website	CDN	Akamai
Intra Select VPN	T-Systems	IP VPN	Direct Homing	T-Systems
L'Equipe Homepage	L'Equipe	News Portal	CDN	Akamai
Lionsgate Films	Lionsgate	Video Download	P2P	BitTorent
Machinima Films	Machinima	Movie and Clip Download	P2P	Vuze
Managed IP-VPN	Global Crossing	IP VPN	Direct Homing	Global Crossing
Managed IP-VPN	TFM Networks	IP VPN	Direct Homing	TFM Networks
Managed Voice over IP Net-works	T-Systems	VoIP	Direct Homing	T-Systems
Maxdome VoD	ProSiebenSat.1 Media & United Internet	Video on Demand	CDN	Akamai
Ministry of Sound TV	Ministry of Sound	Music	P2P	Vuze
MSNBC Webcast	MSNBC	Clip Stream	CDN	Limelight Networks
Music Album "The Morning Benders"	+1 Records	Music Download	P2P	Lime Wire
Mydeo Enterprise Media Delivery	Mydeo	Clip Stream	CDN	Limelight Networks
MySpace Website	MySpace	Social Network	CDN	Limelight Networks
neu.de Website	Neu.de GmbH	Partnerbörse	IP Transit	Colt Telecommunica-tions
NXTbook Media Online Brochures	NXTbook Media	print materials for web use	CDN	Mirror Image
NY Post Homepage	NY Post	News	CDN	Akamai
Orvis Web Shop	Orvis	Online Store	CDN	Mirror Image
PanTerra On-Demand Plat-	SUTHERLAND NET-	SaaS	Direct	Panterra Networks

form SaaS	WORKS		Homing	
Paramount Pictures VoD	Paramount	Video Download	P2P	BitTorent
PetStore Web Shop	PetStore	Online Store	CDN	Mirror Image
Rajshri Media VoD	Rajshri Media	Video on Demand	CDN	Limelight Networks
Sage Club Website	Sage Club	Club Homepage	IP Transit	Neue Medien Muennich GmbH
SAP for medium sized businesses	AlliedPanels Entwicklungs- und Produktions GmbH	SaaS	Direct Homing	Freudenberg IT
SchuelerVZ Website	Verlagsgruppe Georg von Holtzbrinck GmbH	Social Network	CDN	Panther Express
Second Life	Linden Labs	Software Download	IP Transit	Amazon
Sega Software	Sega	Game Distribution	P2P	BitTorent
shopwahl.de Website	LeGuide.com Group	Shopping Directory	IP Transit	Colt Telecommunications
Showtime Films	Showtime	Movie, Series	P2P	Vuze
Siemens A&D Software	Siemens A&D	Software Download	CDN	Akamai
Sipgate Internet Telephony	Sipgate	Internet Telephony	P2P	Sipgate
Skype Internet Telephony	eBay	Instant messenger, Internet Telephony, Filesharing	P2P	eBay
Sony Ericsson Software	Sony Ericsson	Software Download	CDN	Akamai
Sony Pictures Films	Sony Pictures	Movie	P2P	Vuze
Spacenations Online Game	Spacenations	Browsergame	IP Transit	IPX Server GmbH
SPD Website	SPD	Website	IP Transit	PIRONET NDH AG
Superbowl Commercial Clips	IFILM	Video, TV, Games	CDN	Limelight Networks
StudiVZ Website	Verlagsgruppe Georg von Holtzbrinck GmbH	Social Network	CDN	Panther Express
tchibo.de Website	Tchibo	Online Shop	IP Transit	Easynet GmbH
Ten Mile Tide Music Album	Ten Mile Tide	Music	P2P	Kazaa
TheCrown Online Game	TheCrown	Browsergame	IP Transit	manitu hosting
T-home Entertainment VoD	Deutsche Telekom	TV, Video Streaming	Direct Homing	DTAG
Triumph VoIP	Triumph	VoIP	Direct Homing	DTAG
U-Verse VoD	AT&T	TV, Video Streaming	Direct Homing	AT&T
Videoload VoD	Deutsche Telekom	Video Streaming	IP Transit	DTAG
Warner Bros. Films	Warner Bros.	Video Download	P2P	BitTorent
welt.de Website	Die Welt	News Portal	IP Transit	Arcor

Windows Live Messenger	Microsoft	Instant messenger, Internet Telephony	P2P	Microsoft
World of Warcraft Software	Blizzard	Software Download	CDN	Limelight Networks
World of Warcraft Software	Blizzard	Software Download	P2P	BitTorent
www.blog.de Website	Mokono GmbH	Blog Site	IP Transit	IP Exchange GmbH
Yahoo Messenger	Yahoo	Instant messenger, Internet Telephony, Filesharing	P2P	Yahoo
Zattoo IP TV	Zattoo	P2P TV	P2P	Zattoo
ZDF Mediathek VoD	ZDF	Video On Demand	CDN	Akamai

Table 6-7: List of analyzed information services

6.3. Complete list of publications

Title	Authors	Journal/Conference	Reference
Economics of Quality-of-Service	Hau, T., Wulf, J., Zarnekow, R. and Brenner, W.	19th European Regional Conference of the International Telecommunications Society, 2008	[Hau et al. 2008a]
Enabling Services: A New Business Perspective in Telecommunications	Zarnekow, R., Wulf, J., Brenner, W. and Sidler, A.	17th Biennial Conference of the International Telecommunications Society (ITS08), 2008	[Zarnekow et al. 2008a]
Economics of Quality-of-Service	Hau, T., Wulf, J., Zarnekow, R. and Brenner, W.	9. Internationale Tagung Wirtschaftsinformatik, 2008	[Hau et al. 2008b]
Enabling Services - Spezifikation plattformbasierter Vorleistungen in der Telekommunikation	Wulf, J., Hau, T., Zarnekow, R. and Brenner, W.	INFORMATIK 2009, 2nd Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2009), 39. Jahrestagung der Gesellschaft für Informatik e.V. (GI), 2009	[Wulf et al. 2009b]
Specifying Enabling Services in Telecommunications Service Systems	Wulf, J., Hau, T., Zarnekow, R. and Brenner, W.	15th Americas Conference on Information Systems (AMCIS2009), 2009	[Wulf et al. 2009a]
Softwarebezogene Wertschöpfung im Wertschöpfungsnetzwerk der Informations- und Kommunikationsindustrie	Wulf, J. and Zarnekow, R.	Proc. of Multikonferenz Wirtschaftsinformatik (MKWI2010) (Best Paper Award), 2010	[Wulf/Zarnekow 2010a]
Carrier Activities in the CDN Market: an Exploratory Analysis and Strategic Implications	Wulf, J., Hau, T., Zarnekow, R. and Brenner, W.	14th International Conference on Intelligence in Next Generation Networks (ICIN), 2010	[Wulf et al. 2010a]
Strategic Options for Next Generation Network-based Business Models	Wulf, J., Gegner, J. and Zarnekow, R.	3rd Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2010) auf der INFORMATIK 2010. (GI), 2010	[Wulf et al. 2010e]
Analysis of QoS platform cooperation strategies	Wulf, J., Limbach, F. and Zarnekow, R.	21th European Regional Conference of the International Telecommunications Society, 2010	[Wulf et al. 2010d]
Technologies for the Electronic Distribution of Information Services - A Value Proposition Analysis	Wulf, J. and Zarnekow, R.	Electronic Markets 20(1), 2010	[Wulf/Zarnekow 2010b]
Analysis of future telecommunication business models using a business model ontology	Wulf, J., Zarnekow, R. and Dueser, M.	9th Conference on Telecommunications Internet and Media Techno Economics (CTTE), 2010	[Wulf et al. 2010b]
Economic Aspects of Quality-of-Service for Internet based IT Services	Wulf, J. and Zarnekow, R.	In Praeg, C.-P. and Spath, D.(Eds): Quality Management for IT Services - Perspectives on Business and Process Performance. IGI Global Publishing, 2010	[Wulf/Zarnekow 2010c]
Service Distribution in IP-Networks - A Business Model Analysis	Wulf, J.	Electronic Communications of the EASST, Vol. 37, 2011	[Wulf 2011]

A methodology for analysing substitution effects between QoS and best-effort based services	Wulf, J., Dueser, M. and Zarnekow, R.	10th Conference of Telecommunication, Media and Internet Techno-Economics (CTTE), 2011	[Wulf et al. 2011b]
How do ICT firms react to convergence? An analysis of diversification strategies	Wulf, J. and Zarnekow, R.	Proceedings of the 19th European Conference on Information Systems (ECIS), 2011	[Wulf/Zarnekow 2011a]
Revenue distribution in a quality-centric Internet interconnection market	Limbach, F., Wulf, J., Zarnekow, R. and Dueser, M.	17th Americas Conference on Information Systems (AMCIS), 2011	[Limbach et al. 2011a]
The New Role of Developers in the Mobile Ecosystem: An Apple and Google Case Study	Schultz, N., Wulf, J., Zarnekow, R., Nguyen, Q.T.	International Conference on Intelligence in Next Generation Networks (ICIN), Berlin, 2011	[Schultz et al. 2011]
Cross-sector competition in telecommunications - an empirical analysis of diversification activities	Wulf, J. and Zarnekow, R.	Business & Information Systems Engineering (BISE), Issue 5/2011	[Wulf/Zarnekow 2011b]
A typology of cooperation strategies in the telecommunications industry – An exploratory analysis and theoretical foundations	Limbach, F., Wulf, J., Zarnekow, R., Düser, M.	22nd European Regional ITS Conference Budapest, 2011	[Limbach et al. 2011b]
Kooperationstreiber in der Telekommunikationswirtschaft	Limbach, F., Wulf, J., Zarnekow, R., Düser, M.	4th Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2011) auf der INFORMATIK, 2011	[Limbach et al. 2011c]
IT service management in the academic curriculum: comparing an Australian and German experience	Cater-Steel, A., Zarnekow, R., Wulf, J.,	15th Pacific Asia Conference on Information Systems: Quality Research in Pacific Asia (PACIS 2011), 7-11 July 2011, Brisbane, Australia, 2011	[Cater-Steel et al. 2011]
Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario	Wulf, J., Limbach, F., Zarnekow, R. and Dueser, M.	International Conference on Information Systems (ICIS 2011), Shanghai, 2011	[Wulf et al. 2011a]

Table 6-8: Complete list of publications

6.4. Final project reports and presentations

Title	Authors	Type	Month of Publication, Reference
Enabling Services Business Opportunities for Wholesale Service Providers in the Telecommunication Industry	Zarnekow, Brenner, Wulf, Sidler	Report	January 2008 [Brenner et al. 2008]
Quality-of-Service Business Models	Zarnekow, Brenner, Wulf, Hau	Presentation	September 2008 [Zarnekow et al. 2008b]
CDN Business Models	Zarnekow, Brenner, Wulf, Hau	Presentation	May 2009 [Wulf et al. 2009c]
QoS Business Models for Telecommunications Network Operators	Wulf, Zarnekow, Düser	Report	May 2010 [Wulf et al. 2010c]
QoS Business Models – Quantitative Modeling	Wulf, Limbach, Zarnekow, Düser	Presentation	January 2011 [Wulf et al. 2011c]

Table 6-9: List of final project reports and presentations

References

[Afuah/Tucci 2003]

Afuah, A., Tucci, C., Internet Business Models and Strategies, Boston, McGraw Hill, 2003

[Agapi et al. 2011]

Agapi, A., Birman, K., Broberg, R., Cotton, C., Kielmann, T., Millnert, M., Payne, R., Surton, R., Renesse, R., Routers for the Cloud: Can the Internet Achieve 5-Nines Availability?, Internet Computing, IEEE, Vol.15, Iss.5, pp. 72-77, Sept.-Oct. 2011

[Aggarwal et al. 2007]

Aggarwal, V., Feldmann, A., Scheideler, C., Can ISPS and P2P users cooperate for improved performance?, in: ACM SIGCOMM Computer Communications Review, Vol. 37, pp. 29-40, 2007

[Ahlert et al. 2007]

Ahlert, D., Berentzen, J., Klinke, R., Markenadaptionsentscheidungen bei der Internationalisierung von Dienstleistungen am Beispiel der europäischen Mobilfunkbranche, Projektbericht Iss. 12, Hrsg.: Ahlert, D., Münster 2007

[Akamai 2008a]

Akamai, Case Study – France Television Interactive, Akamai Technologies, Inc. Website, 2008, http://www.akamai.com/html/customers/case_study_francetv.html, accessed: 04.06.2009

[Akamai 2008b]

Akamai, Powering a Better Internet, Akamai Internet Representation, 2008, http://www.akamai.com, accessed: 15.06.2008

[Akamai 2008c]

Akamai, Audi AG satisfies customers and dealers around the world with accelerated web content, Akamai Case Study 2008

[Akamai 2009]

Akamai, Akamai: The Leader in Web Application Acceleration and Performance Management, Streaming Media, Akamai Technologies, Inc. Website, 2009, http://www.akamai.com, accessed: 19.05.2009

[Alcatel Lucent 2010]

Alcatel Lucent, Orange Austria renews managed services contract with Alcatel-Lucent, Alcatel Lucent website news entry, 2010, http://www.alcatel-lucent.com/wps/portal/!ut/p/kcxml/04_Sj9SPykssy0xPLMnMz0vM0Y_QjzKLd4x3tXDUL8h2VAQAURh_Yw!!?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=News_Releases_2010/News_Article_002005.xml, accessed 01.09.2011

[Alt/Zimmermann 2001]

Alt, R., Zimmermann, H., Introduction to Special Section – Business Models, Electronic Markets Vol. 11, Iss. 1, pp. 3–9, 2001

[Amit/Livnat 1988]

Amit, R., Livnat, J., Diversification strategies, business cycles and economic performance, in: Strategic Management Journal, Vol. 9, Iss. 2, pp. 99-110, 1988

[Amit/Zott 2000]

Amit, R., Zott, C., Value Drivers of e-Commerce Business Models, INSEAD Working Paper, INSEAD, Fontainebleau, 2000

[Amit/Zott 2001]

Amit, R., Zott, C., Value creation in e-business, in: Strategic Management Journal, Vol. 22, Iss. 6/7, pp. 493–520, 2001

[Anderson 2008]

Anderson, N., Comcast FCC filing shows gap between hype, bandwidth reality, ars technica, 2008, http://arstechnica.com/news.ars/post/20080213-comcast-discloses-network-management-practices.html, accessed: 25.07.2011

[Andrews 1980]

Andrews, K.R., The concept of corporate strategy, 2nd ed. Homewood, Ill.: Richard D. Irwin, 1980

[Androutsellis-Theotokis/Spinellis 2004]

Androutsellis-Theotokis, S., Spinellis, D., A Survey of Peer-to-Peer Content Distribution Technologies, in: ACM Computing Surveys, Vol. 36, Iss. 4, pp. 335-371, 2004

[Ansoff 1965]

Ansoff, H.T., Corporate strategy, McGraw-Hill, New York, 1965

[Ansoff 1966]

Ansoff, H.I., Management-Strategie, 1. Auflage, Verlag Moderne Industrie, München, 1966

[Arsanjani 2004]

Arsanjani, A., Service-Oriented Modelling and Architecture, IBM developerWorks, 2004

[A.T. Kearney 2010]

A.T. Kearney, A Viable Future Model for the Internet, A.T. Kearney White Paper., 2010, http://www.atkearney.com/images/global/pdf/Viable_Future_Model_for_Internet.pdf, accessed: 31.08.2011

[Atzori et al. 2010]

Atzori, L., Iera, A., Morabito, G., The Internet of Things: A survey, Computer Networks, Vol. 54, Iss. 15, pp. 2787-2805, 2010

[Baake/Wichmann 1999]

Baake, P., Wichmann, T., On the economics of Internet peering, in: Netnomics, Vol. 1, Iss. 1, pp. 89-105, 1999

[Balaji et al. 2005]

Balaji, T.S., Landers, B., Kates, J., Moritz, B, A carrier's perspective on creating a mobile multimedia service, Commun. ACM, Vol. 48, Iss. 7, pp. 49-53, 2005

[Barney 1997]

Barney, J.B., Gaining and Sustaining Competitive Advantage, Addisson-Wesley, Reading, Massachusetts, 1997

[Basole 2009]

Basole, R.C., Visualization of Interfirm Relations in a Converging Mobile Ecosystem, in: Journal of Information Technology, Vol. 24, Iss. 2, pp. 144-159, 2009

[Bastian 2002]

Bastian, N.P., Lieferantenfinanzierung im Telekommunikationsmarkt, Gabler, Wiesbaden, 2002

[Berry 1975]

Berry, C.H., Corporate Growth and Diversification, Princeton University Press, Princeton, 1975

[Bettis 1998]

Bettis, R.A., Comment on ‘Redifining Industry Structure for the Information Age’ by J.L.Sampler, Strategic Management Journal, Vol. 16, pp. 357-361, 1998

[Bettis/Hitt 1995]

Bettis, R.A., Hitt, M.A., The New Competitive Landscape, Strategic Management Journal, Vol. 16, pp. 7-19, 1995

[BITKOM 2007]

BITKOM, Zukunft digitale Wirtschaft, Technical Report, Bitkom e.V. and Roland Berger Strategy Consultants, 2007

[BITKOM 2008]

BITKOM, Studienreihe zur Heimvernetzung - Treiber und Barrieren der Heimvernetzung, Studie 3 der UAG 1 der AG 8 (IT-Gipfel) erstellt im Auftrag des BITKOM durch das Institut für Information, Organisation und Management, Lehrstuhl Prof. Dr. Dres. h.c. Arnold Picot, Ludwig-Maximilians-Universität München, Oktober 2008

[BITKOM 2010a]

BITKOM, Online-Werbung legt auch 2010 kräftig zu, Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V. Presseinformation, 2010, http://www.bitkom.org/files/documents/BITKOM-Presseinfo_Online-Werbung_22_07_2010.pdf, accessed: 12.08.2011

[BITKOM 2010b]

BITKOM, Marktzahlen Oktober 2010 - Kurzfassung, 2010, http://www.bitkom.org/files/documents/ITK-Marktzahlen_Oktober_2010_Kurzfassung.pdf, accessed: 13.06.2011

[BITKOM 2010c]

BITKOM, Cloud Computing mit extrem starkem Wachstum, BITKOM Presseinformation, 06.10.2010, http://www.bitkom.org/files/documents/BITKOM_Presseinfo_Cloud_Konferenz_06_10_2010.pdf, accessed: 12.09.2011

[BitTorrent 2008]

BitTorrent, BitTorrent Internet Representation, 2008, http://www.bittorrent.com/, accessed: 25.07.2011

[BitTorrent 2009]

BitTorrent, Reduce content delivery bills, BitTorrent, Inc. Website, 2009, http://www.bittorrent.com/dna?csrc=splash, accessed: 05.06.2009

[Bleich 2008]

Bleich, H., Verteile und herrsche: Content-Delivery-Netzwerke als heimliche Macht im Web, in: c't– Magazin für Computertechnik, Vol. 18, pp. 160-163, 2008

[Blizzard 2009]

Blizzard, Blizzard Downloader F. A. Q. Blizzard Entertainment, Inc. Website, 2009, http://www.worldofwarcraft.com/info/faq/blizzarddownloader.html, accessed: 04.06.2009

[BNetzA 2007]

Bundesnetzagentur, Tätigkeitsbericht Telekommunikation 2006 und 2007, 2007, http://www.bundesnetzagentur.de/SharedDocs/-Downloads/DE/BNetzA/Presse/Berichte/2007/TaetigkeitsberichtTK2006_07Id12186pdf.pdf?__blob=publicationFile, accessed: 29.06.2011

[BNetzA 2009]

Bundesnetzagentur, Tätigkeitsbericht Telekommunikation 2008 und 2009, 2009, http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/BNetzA/Presse/Berichte/2009/TaetigkeitsberichtTK20082009_Id17897pdf.pdf?__blob=publicationFile, accessed: 01.06.2011

[BNetzA 2011]

Bundesnetzagentur, Jahresbericht 2010, 2011, http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/BNetzA/Presse/Berichte/2011/Jahresbericht2010pdf.pdf?__blob=publicationFile, accessed: 29.06.2011

[Boehmann et al. 2003]

Boehmann, T., Junginger, M., Krcmar, H., Modular Service Architectures: A Concept and Method for Engineering IT Services, 36th Annual Hawaii International Conference on System Sciences, Hawaii, Big Island, 2003

[Bowersox et al. 1986]

Bowersox, D.J., Closs, D. J., Helferich, O. K., Logistical management: a systems integration of physical distribution, manufacturing support, and materials procurement, Macmillan, New York, 1986

[Braden et al. 1994]

Braden, R., Clark, D. and S. Shenker, Integrated Services in the Internet Architecture: An Overview, IETF RFC 1633, July 1994

[Braden et al. 1997]

Braden, B., Zhang, L., Berson S., Herzog, S., Jamin, S., Resource ReSerVation Protocol (RSVP) -- Version 1 Functional Specification, IETF RFC 2205, September 1997

[Brenner et al. 2007]

Brenner, W., Zarnekow, R., Dous, M., Kruse, J., Quality in the Internet – Technical and economic development prospects, Technical Report of the Institute of Information Management, University of St. Gallen, March, 2007

[Brenner et al. 2008]

Brenner, W., Zarnekow, R., Wulf, J., Sidler, A., Enabling Services - Business Opportunities for Wholesale Service Providers in the Telecommunication Industry, Deutsche Telekom Wholesale Report, St.Gallen/Berlin, January 2008

[Briscoe/Rudkin 2005]

Briscoe, B., Rudkin, S., Commercial models for IP-Quality-of-Service interconnect, in: BTTJ Special Edition on IP-Quality-of-Service, Vol. 23, Iss. 2, pp. 171-195, 2005

[British Telecom 2009]

British Telecom, Ribbit Developer Platform, 2009, http://developer.ribbit.com, accessed: 11.09.2009

[Brousseau/Quelin 1996]

Brousseau, E., Quelin, B., Asset specificity and organizational arrangements: The case of the new telecommunications services market, Industrial and Corporate Change, Vol. 5, Iss. 4, pp. 1205-1230, 1996

[BT 2008]

BT, BT Vision - TV you want, when you want it, BT Internet Representation, 2008, http://www.btvision.bt.com/, accessed: 25.07.2011

[Buhl et al. 2008]

Buhl, H.U., Heinrich, B., Henneberger, M., Krammer, A., Service Science, in: Wirtschaftsinformatik, Vol. 50, Iss. 1, pp. 60-65, 2008

[Bullinger et al. 2003]

Bullinger, H. J., Fähnrich, K. P., Meiren, T., Service engineering—methodical development of new service products, in: International Journal of Production Economics, Vol. 85, pp. 275-287, 2003

[Buxmann et al. 2008]

Buxmann, P., Hess, T., Lehmann, S., Software as a service, in: Wirtschaftsinformatik, Vol. 50, Iss. 6, pp. 500–503, December 2008

[Buyya et al. 2008]

Buyya, R., Pathan, M., Vakali, A., Content delivery networks: State of the art, insights, and imperatives, Springer, Berlin, 2008

[CAIDA 2010]

Cooperative Association for Internet Data Analysis (CAIDA), AS Relationships, 2010, http://www.caida.org/data/active/as-relationships/index.xml, accessed: 05.07.2010

[Cater-Steel et al. 2011]

Cater-Steel, A., Zarnekow, R., Wulf, J., IT service management in the academic curriculum: comparing an Australian and German experience, In: 15th Pacific Asia Conference on Information Systems: Quality Research in Pacific Asia (PACIS 2011), 7-11 July 2011, Brisbane, Australia, 2011

[Caves et al. 1980]

Caves, R., Porter, M.E., Spence, A.M., Competition in the Open Economy, Harvard University Press, Cambridge, 1980

[CEO 2011]

CEO Roundtable – Working Group 1, Possible new business models for the Internet, Second CEO Roundtable on broadband investment to sustain Internet growth, Brussels, 13.07.2011, http://ec.europa.eu/information_society/newsroom/cf/document.cfm?action=display&doc_id=868, accessed: 02.09.2011

[Chandler 1962]

Chandler, A.D., Strategy and Structure: Chapters in the History of the American Industrial Enterprise, The MIT Press, Cambridge, MA, 1962

[Chang et al. 2005]

Chang, H., Jamin, S., Mao Z.M., Willinger, W., An empirical approach to modeling inter-AS traffic matrices, Proceedings of the 5th ACM SIGCOMM conference on Internet Measurement, Berkeley, pp. 139-152, 2005

[Chang et al. 2006]

Chang, H., Jamin, S., Willinger, W., To peer or not to peer: Modeling the evolution of the Internet‘s AS-level topology, Proceedings of the 25th IEEE International Conference on Computer Communications, Barcelona, pp. 1-12, 2006

[Chappell 2009]

Chappell, C., CDNs: the business case, Capacity Magazine, pp. 20-22, May 2009

[Chaudhury/Terfloth 2008]

Chaudhury, R., Terfloth, C., The lure of network outsourcing - promise and pitfalls for telecom operators, Oliver Wyman Report, pp. 1-7, 2008

[Chesbrough/Spohrer 2006]

Chesbrough, H., Spohrer, J., A research manifesto for services science, in: Communications of the ACM, Vol. 49, Iss. 7, pp. 35–40, 2006

[Cisco 2011]

Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015, Cisco White Paper, February 1, 2011

[Clark/Fang 1998]

Clark, D., Fang, W., Explicit Allocation of Best-Effort Packet Delivery Service, IEEE/ACM Transactions on Networking, 1998

[Clark et al. 2005]

Clark, D., Lehr, W., Bauer, S., Faratin, P., Sami, R., Wroclawski, J., The Growth of Internet Overlay Networks: Implications for Architecture, Industry Structure and Policy, Proceedings of the 34th Telecommunications Policy Research Conference (TPRC 05), USA, VA, Arlington, 2005

[Clemons 2009]

Clemons, E., Business models for monetizing Internet applications and web sites, in: Journal of Management Information Systems, Vol. 26, Iss. 2, pp. 15-41, 2009

[Cohen 1988]

Cohen. J., Statistical power analysis for the behavioral sciences, Second edition, Lawrence Erlbaum, New Jersey, 1988

[Collis et al. 1997]

Collis, D.J., Bane, P.W., Bradley, S.P., Winners and Losers – Industry Structure in the Converging World of Telecommunications, Computing, and Entertainment, in: Yoffie, D.E. (Hrsg.), Competing in the Age of Digital Convergence, Harvard Business School Press, Boston, 1997

[Constantiou/Courcoubetis 2001]

Constantiou, I.D., Courcoubetis, C.A., Information asymmetry models in the Internet connectivity market, in: Economics and the Internet 2: Proceedings of the 4th Internet Economics Workshop, T. Wichmann (Hrsg.), Berlin, pp. 41-50, 2001

[Corsten 2001]

Corsten, H., Dienstleistungsmanagement, 4. Auflage, Oldenbourg, 2001

[Cottrell/Koput 1998]

Cottrell, T., Koput K., Software variety and hardware value: a case study of complementary network externalities in the microcomputer software industry, in: Journal of Engineering and Technology Management, Vol. 15, Iss. 4, pp. 309-338, 1998

[Crémer et al. 2000]

Crémer, J., Rey, P., Tirole, J. 2000, Connectivity in the commercial Internet, in: The Journal of Industrial Economics, Vol. 48, Iss. 4, pp. 433-472, 2000

[Das et al. 2011]

Das, S., Yiakoumis, Y., Parulkar, G., McKeown, N., Singh, P., Getachew, D., Desai, P, Application-aware aggregation and traffic engineering in a converged packet-circuit network, Optical Fiber Communication Conference and Exposition (OFC/NFOEC), 2011 and the National Fiber Optic Engineers Conference, March 2011

[Day 1995]

Day, J.D., The (Un)Revised OSI Reference Model, in: Computer Communication Review, Vol. 25, pp. 39-55, October 1995

[De Boever 2007]

De Boever, J., Peer-to-Peer Networks as a Distribution and Publishing Model, Proceedings of the 11th International Conference on Electronic Publishing, Austria, Vienna, pp. 175-188, 2007

[DECIX 2011]

German Commercial Internet Exchange (DE-CIX), Traffic Statistics, 2011, http://www.de-cix.net/content/network/Traffic-Statistics.html, accessed: 24.08.2011

[Demirkan et al. 2008]

Demirkan, H., Kauffman, R., Vayghan, J., Fill, H., Karagiannis, D., Maglio, P., Service-oriented technology and management: Perspectives on research and practice for the coming decade, in: Electronic Commerce Research & Applications, Vol. 7, Iss. 4, pp. 356-376, 2008

[Dengler 2000]

Dengler, J., Strategie integrierter Telekommunikationsdiensteanbieter, 1. Auflage, Deutscher Universitäts-Verlag, Wiesbaden, 2000

[Detecon 2009]

Detecon, Detecon Historie, 2009, http://www.detecon.com/de/ueber_detecon/historie.html, accessed: 08.09.2009

[Dhamdhere/Dovrolis 2008]

Dhamdhere, A., Dovrolis, C., Ten years in the evolution of the Internet ecosystem, Proceedings of the 8th ACM SIGCOMM conference on Internet measurement, ACM Press, New York, pp. 183-196, 2008

[Dhamdhere/Dovrolis, C. 2009]

Dhamdhere, A., Dovrolis, C., An agent-based model for the evolution of the Internet ecosystem, in: Communication Systems and Networks and Workshops, First International, Bangalore, pp. 1–10, 2009

[Dilley et al. 2002]

Dilley, J., Maggs, B., Parikh, J., Prokop, H., Sitaraman, R., Weihl, B., Globally distributed content delivery, in: Internet Computing, IEEE, Vol. 6, Iss. 5, pp. 50-58, 2002

[Dodd et al. 2009]

Dodd, M., Jung, A., Mitchell, B., Paterson, P., Reynolds, P., Bill-and-keep and the economics of interconnection in next-generation networks, in: Telecommunications Policy, Vol. 33, Iss. 5-6, pp. 324-337, 2009

[DTAG 2007]

Deutsche Telekom AG, Produktportfolio International – IST-Portfolio und Entwicklung, DTAG ICSS Presentation, 29.01.2007

[Dubosson-Torbay et al. 2004]

Dubosson-Torbay, M., Pigneur, Y., Usunier, J., Business Models for Music Distribution after the P2P Revolution, WEDELMUSIC '04: Proceedings of the Web Delivering of Music, in: Fourth International Conference, IEEE Computer Society, pp. 172-179, 2004

[Duysters/Hagedoorn 1988]

Duysters, G., Hagedoorn, J., Technological Convergence in the IT Industry: The Role of Strategic Technology Alliances and Technological Competencies, in: International Journal of the Economics of Business, Vol. 5, Iss. 3, pp. 355-368, 1988

[Easynet 2009]

Easynet, Easynet - Facts and Figures. Easynet Group Inc. Website, 2009, http://www.easynet.com/gb/en/about/fastFacts.aspx?SecondaryNavID=52, accessed: 04.06.2009

[Economides 2006]

Economides, N., The economics of the Internet backbone, in: S. K. Majumdar, I. Vogelsang, M. Cave (Hrsg.), Handbook of telecommunications economics: Technology evolution and the Internet, Second edition, Elsevier, Amsterdam, pp. 375-412, 2006

[Edvardsson/Olsson 1996]

Edvardsson, B., Olsson, J., Key concepts for new service development, in: Service Industries Journal, Vol. 16, Iss. 2, pp. 140–164, 1996

[Ehrmann 1999]

Ehrmann, T., Markt- und Wertschöpfungsstrukturen in der Telekommunikation, in: Fink, D., Wilfert A. (Hrsg.), Handbuch Telekommunikation und Wirtschaft, Vahlen, München, pp. 33-48, 1999

[Ellson et al. 2004]

Ellson, J., Gansner, E.R., Koutsofios, E., Graphviz and dynagraph static and dynamic graph drawing tools, AT&T Labs - Research, Technical report, USA, New Jersey, pp. 1-23, 2004

[Everitt 1993]

Everitt, B. S., Cluster Analysis, Third edition, Edward Arnold, London, 1993

[Falkner et al. 2000]

Falkner, M., Devetsikiotis, M., Lambadaris, I., An Overview of Pricing Concepts for Broadband IP Networks, in: IEEE Communications Review, Vol. 3, Iss. 2, 2000

[Faratin 2007]

Faratin, P., Economics of Overlay Networks: An Industrial Organization Perspective on Network Economics, Proceedings of the Joint Workshop on The Economics of Networked Systems and Incentive-Based Computing (NetEcon+IBC), in conjunction with ACM Conference on Electronic Commerce (end customer'07), USA, California, San Diego, 2007

[Faratin et al. 2007]

Faratin, P., Clark, D., Gilmore, P., Bauer, S., Berger, A., Lehr, W., Complexity of Internet interconnections: Technology, incentives and implications for policy, Proceedings of the 35th telecommunications and communications policy research conference, Arlington, pp. 1–31, 2007

[Farber/Baran 1977]

Farber, D.J., Baran, P., The Convergence of Computing and Telecommunications Systems, in: Science, Vol. 195, pp. 1166-1170, 1977

[Fettke/Loos 2004]

Fettke, P., Loos, P., Referenzmodellierungsforschung, in: Wirtschaftsinformatik, Vol. 46, Iss. 5, pp. 331-340, 2004

[Fleisch 2010]

Fleisch, E., What is the Internet of Things? An economic perspective, Economics, Management & Financial Markets, Vol 5, Iss. 2, pp. 125-157, 2010

[Fransman 2001]

Fransman, M., Evolution of the telecommunications industry into the Internet age, in: Communications and Strategies, Vol. 43, pp. 57–113, 2001

[Fransman 2002]

Fransman, M., Mapping the evolving telecoms industry: the uses and shortcomings of the layer model, in: Telecommunications Policy, Vol. 26, Iss. 9-10, pp. 473-483, 2002

[Fransman 2007]

Fransman, M., Innovation in the new ICT ecosystem, in: Communication & Strategies, Vol. 68, pp. 89-110, 2007

[Freeman 1979]

Freeman, L.C., Centrality in social networks: Conceptual clarification, in: Social Networks, Vol.1, pp. 215–239, 1979

[Frieden 2008]

Frieden, R., A Primer on Network Neutrality, Intereconomics: Review of European Economic Policy, Springer, Vol. 43, Iss. 1, pp. 4-15, January 2008

[Frost & Sullivan 2008]

Frost & Sullivan, World Video Content Delivery Networks Market, Frost & Sullivan Market Engineering Report #N425-70, 2008

[Gambardella/Torrisi 1998]

Gambardella, A., Torrisi, S., Does Technological Convergence Imply Convergence in Markets? Evidence from the Electronics Industry, in: Research Policy, Vol. 27, pp. 445-463, 1998

[Ganley/Allgrove 2006]

Ganley, P., Allgrove, B., Net neutrality: A user‘s guide, in: Computer Law & Security Report, Vol. 22, Iss. 6, pp. 454-463, 2006

[Gao/Wang 2002]

Gao, L., Wang, F., The extent of AS path inflation by routing policies, in: Global Telecommunications Conference, Amherst, pp. 2180-2184, 2002

[Gartner 2006]

Gartner, Hype Cycle for the Telecommunications Industry, Technical Report, Gartner Inc., 2006

[Gautam 2005]

Gautam, N., Pricing issues in web-hosting services, in: Journal of Revenue and Pricing Management, Vol. 4, Iss.1, pp. 7-23, 2005

[Gayer/Shy 2003]

Gayer, A., Shy, O., Internet and peer-to-peer distributions in markets for digital products, in: Economics Letters, Vol. 81, Iss. 2, pp. 197-203, 2003

[Gerpott 1998]

Gerpott, T.J., Wettbewerbsstrategien im Telekommunikationsmarkt, Schäffer-Poeschel, Stuttgart, 1998

[Gerpott 2003]

Gerpott, T.J., Unternehmenskooperationen in der Telekommunikationswirtschaft, in: Zentes, J.; Swoboda, B.; Morschett, D. (Hrsg.), Kooperationen, Allianzen und Netzwerke, Gabler, Wiesbaden, pp. 1087-1110, 2003

[Gerpott 2010]

Gerpott, T.J., Wettbewerbs- und Regulierungsimplikationen der 900 MHz-Frequenzausstattung von Mobilfunknetzbetreibern in Deutschland, in: Gerpott, T.J.; Holznagel, B. (Hrsg.), Flexibilisierung der Frequenznutzung – Ökonomische und juristische Analysen, B&S Siebenhaar, Berlin, pp. 7-81, 2010

[Gerybadze 2005]

Gerybadze, A., Strategisches Management in vertikalen Kooperationen und Leistungsverbünden, in: Zentes, J., Swoboda, B., Morschett, D. (Hrsg.), Kooperationen, Allianzen und Netzwerke, 2. Auflage, Gabler, Wiesbaden, pp. 457-474, 2005

[Ghinea/Thomas 1998]

Ghinea, G., Thomas, J.P., QoS impact on user perception and understanding of multimedia video clips, MULTIMEDIA ’98: Proc. 6th ACM Int. Conference on Multimedia, New York, NY, USAACM Press, pp. 49–54., 1998

[Google 2011]

Google, Fiber Blog. The latest news from the Google Fiber team, 2011, http://googlefiberblog.blogspot.com/, accessed: 01.09.2011

[Gort 1962]

Gort, M., Diversification and integration in American industry, Princeton University Press, Princeton, 1962

[Goth 2011]

Goth, G., Software-Defined Networking Could Shake Up More than Packets, Internet Computing, IEEE, Vol.15, Iss. 4, pp.6-9, July-Aug. 2011

[Gozdecki et al. 2003]

Gozdecki, J., Jajszczyk, A., Stankiewicz, R., Quality-of-Service terminology in IP-networks, in: IEEE Communications Magazine, Vol. 41, Iss. 3, pp. 153-159, 2003

[Granstrand 1998]

Granstrand O., Towards a theory of the technology-based firm, in: Research Policy, Vol. 27, Iss. 5, pp. 465-489, 1998

[Greenstein/Khanna 1997]

Greenstein, S., Khanna, T., What does industry convergence mean?, in: Yoffie D.B. (Hrsg.), Competing in the age of digital convergence, Harvard Business School Press, Boston, pp. 201-226, 1997

[Gulati et al. 2000]

Gulati, R., Nohria, N., Zaheer, A., Strategic networks, in: Strategic Management Journal, Vol. 21, Iss. 3, pp. 203-215, 2000

[Gupta et al. 1999]

Gupta, A., Stahl, D.O., Whinston, A.B., The Economics of Network Management, in: Communications of the ACM, Vol. 42, Iss. 9, pp. 57-63, 1999

[Ha et al. 2010]

Ha, I., Wildman, S., Bauer, J., P2P, CDNs, and Hybrid Networks: The Economics of Internet Video Distribution, International Telecommunications Policy Review, Vol. 17, Iss. 4, pp. 1-22, 2010

[Haertsch 2000]

Haertsch, P, Wettbewerbsstrategien für Electronic Commerce, EUL Verlag, Lohmar/Köln, 2000

[Hamby 1995]

Hamby, D.M., A comparison of sensitivity analysis techniques, in: Health Physics, Vol. 68, Iss. 2, pp. 195-204, 1995

[Hamel 2000]

Hamel, G., Leading the revolution, Harvard Business School Press, Boston, 2000

[Handigol et al. 2009]

Handigol, N., Seetharaman, S., Flajslik, M., McKeown, N., Johari, R., Plug-n-Serve: Load-Balancing Web Traffic using OpenFlow, ACM SIGCOMM Demo, Aug 2009

[Hau et al. 2008a]

Hau, T., Wulf, J., Zarnekow, R., Brenner, W., Economics of Quality-of-Service, 19th European Regional Conference of the International Telecommunications Society, 2008

[Hau et al. 2008b]

Hau, T., Wulf, J., Zarnekow, R., Brenner, W., Economics of Quality-of-Service, 9. Internationale Tagung Wirtschaftsinformatik, 2008

[Hau et al. 2011]

Hau, T., Burghardt, D., and Brenner, W, Multihoming, Content Delivery Networks, and the market for Internet connectivity, Telecommunications Policy, Vol. 35, Iss. 6, pp. 532-542, 2011

[Heavy Reading 2007]

Heavy Reading, Internet TV, Over-the-Top Video, & the Future of IPTV Services, Heavy Reading Report, Vol. 5, Iss. 10, 2007

[Heckmann 2005]

Heckmann, O., A System-oriented Approach to Efficiency and Quality-of-Service for Internet Service Providers, Online-Edition, Technische Universität, Darmstadt, 2005

[Hedman/Kalling 2003]

Hedman, J., Kalling, T., The business model concept: theoretical underpinnings and empirical illustrations, European Journal of Information Systems, Vol. 12, Iss. 1, pp. 49-59, 2003

[Helander 2004]

Helander, N.,Value-creating networks: an analysis of the software component business, PhD Thesis, Acta Universitatis Ouluensis, 2004

[Henderson/Clark 1990]

Henderson, R., Clark, K., Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms, in: Administrative Science Quarterly, Vol. 35, pp.9-30, 1990

[Henneking et al. 2010]

Henneking, K.M., Theobaldt, L., Ettelbrück, B., Wöhler-Moorhoff, F., dos Reis, D., Think 2032, Detecon Consulting Report, pp. 17-25, 2010

[Hess 1999]

Hess, T., Das Internet als Distributionskanal für die Medienindustrie - Entwicklungstendenzen im deutschen Markt, Vol. 41, Iss. 1, pp. 77-82, 1999

[Higginbotham 2011]

Higginbotham, S., Google Fiber and Creating the Next Generation IPS, GigaOm, 18.04.2011, http://gigaom.com/broadband/google-fiber-medin/, accessed: 01.09.2011

[Hofbauer 2008]

Hofbauer, C., Geschäftsmodelle Quadruple Play – Eine Einschätzung der Entwicklung in Deutschland, Gabler, Wiesbaden, 2008

[Holznagel et al. 2010]

Holznagel, B., Picot, A., Deckers, S., Grove, N., Schramm, M., Strategies for Rural Broadband: An economic and legal feasibility analysis, aus der Reihe: Markt- und Unternehmensentwicklung / Markets and Organisations, Gabler, 2010

[Hoogeweegen et al. 1999]

Hoogeweegen, M., Teunissen, W., Vervest, P., Wagenaar, R., Modular network design: using information and communication technology to allocate production tasks in a virtual organization, in: Decision Sciences, Vol. 30, pp. 1073-1103, 1999

[Hooley 1995]

Hooley, G.J., The lifecycle concept revisited: aid or albatross?, in: Journal of Strategic Marketing, Vol. 3, Iss. 1, pp. 23–39, 1995

[Hosanagar et al. 2005]

Hosanagar, K., Krishnan, R., Chuang, J., Choudhary, V., Pricing and Resource Allocation in Caching Services with Multiple Levels of Quality-of-Service, in: Management Science, Vol. 51, pp. 1844-1859, 2005

[Huston 1998]

Huston, G., ISP survival guide, Strategies for running a competitive ISP, Wiley, New York, 1998

[Huston 1999]

Huston,G., Interconnections, peering and settlements, in: Internet Global Summit (INET), The Internet Society, June 1999

[Huston 2000]

Huston, G., Internet Performance Survival Guide: QoS Strategies for Multiservice Networks, John Wiley & Sons, Inc, 2000

[Hwang/Weiss 2000]

Hwang, J., Weiss, M.B.H., Market-based QoS interconnection economy in the next-generation Internet, Former Departments, Centers, Institutes and Projects, Paper 65, 2000

[Iansiti 1995]

Iansiti, M., Technology integration: Managing technological evolution in a complex environment, Research Policy, Vol. 24, Iss. 4, pp. 521-542, 1995

[ISO 1989]

ISO, Open Systems Interconnection--Basic Reference Model, International Organization for Standardization, Ref. Iss. 7498, Switzerland, Geneva 1989

[ISO 2005]

International Organization for Standardization (ISO), Quality Management Systems - Fundamentals and Vocabular, Third edition, 9000:2005(E), Switzerland, Geneva, 2005

[ITU 2007]

International Telecommunication Union, Definition of Quality of Experience, ITU-T Delayed Contribution D.197, 2007

[Jacquemin/Berry 1979]

Jacquemin, A.P., Berry, C.H., Entropy measure of diversification and corporate growth, in: Journal of Industrial Economics, Vol. 27, pp. 359-369, 1979

[Jakopin 2006]

Jakopin, N.M., Einflussfaktoren des Internationalisierungserfolgs von Mobilfunknetzbetreibern, DUV, Wiesbaden, 2006

[Jarillo 1988]

Jarillo, J. C., On strategic networks, in: Strategic Management Journal, Vol. 9, Iss. 1, pp. 31-41, 1988

[Jarrett 1999]

Jarrett, D.W., Definition of Bearer Services and Teleservices and Services for Consideration by the 802.16 Systems Requirements Task Group, IEEE P802.16 Broadband Wireless Access Working Group, 21.06.1999

[Jay/Plückebaum 2008]

Jay, S., Plückebaum, T., Strategien zur Realisierung von Quality-of-Service in IP-Netzen, Wissenschaftliches Insititut für Infrastruktur und Kommunikationsdienste (WIK), Diskussionsbeitrag Nr. 315, Bad Honnef, Dezember 2008

[Jung/Warnecke 1998]

Jung, V., Warnecke, H.-J., Handbuch für die Telekommunikation, Springer-Verlag, Berlin, 1998

[Kaleelazhicathu et al. 2004]

Kaleelazhicathu, R.K., Gjerde, I.G., Smura, T., Hämmäinen, H., Tesch, T., Business Models in Telecommunications, Techno-economics of integrated communication systems and services, Deliverable 3, 2004

[Karrer et al. 2008]

Karrer, R. Eardley, P., Eggert, L., Ford, M.,Sarolahti, P.,Widera, R., Winter, R.,Towards A Unified Internet Control Architecture, International Conference on Future Internet Technologies (CFI 2008), Seoul, June 2008

[Kassarjian 1977]

Kassarjian, H.H., Content Analysis in Consumer Research, in: Journal of Consumer Research, Vol. 4, Iss. 6, pp. 8-18, 1977

[Katz 1996]

Katz, M.L., Remarks on the economic implications of convergence, in: Industrial and Corporate Change, Vol. 3, pp. 1079-109, 1996

[Katz/Shapiro 1985]

Katz, M. L. and Shapiro, C., Network externalities, competition, and compatibility, in: The American economic review, Vol. 75, Iss. 3, pp. 424-440, 1985

[Katz-Bassett et al. 2008]

Katz-Bassett, E., Madhyastha, H., John, J., Krishnamurthy, A., Wetherall, D., Anderson, T., Studying black holes in the Internet with Hubble, In Proceedings of the 5th USENIX Symposium on Networked Systems Design and Implementation (NSDI'08), Jon Crowcroft and Mike Dahlin (Eds.). USENIX Association, Berkeley, CA, USA, pp. 247-262, 2008

[Khansa/Liginlal 2009]

Khansa, L., Liginlal, D., Will the Information Security Industry Die? Applying Social Network Analysis to Sturdy Industry Convergence, in: AMCIS 2009 Proceedings, Paper 523

[Kilkki 2008]

Kilkki, K., Quality of Experience in Communications Ecosystem, In Socio-Economic Issues in Future Generation Internet, J.UCS Special Iss., April 2008

[Klecka 1980]

Klecka, W.R., Discriminant analysis, Quantitative Applications in the Social Sciences Series, Thousand Oaks, CA: Sage Publications, 1980

[Knightson et al. 2005]

Knightson, K., Morita, N., Towle, T., NGN architecture: Generic principles, functional architecture, and implementation, in: IEEE Communications Magazine, Vol. 43, pp. 49-56, 2005

[Kolbe/Burnett 1991]

Kolbe, R.H., Burnett, M. S., Content-Analysis Research: An Examination of Applications with Directives for Improving Research Reliability and Objectivity, in: Journal of Consumer Research, Vol. 18, Iss. 2, pp. 243-250, 1991

[Kruse 2008]

Kruse, J., Network neutrality and Quality-of-Service, in: Intereconomics, Vol. 43, Iss. 1, pp. 25-30, 2008

[Kruse 2010]

Kruse, J. 2010, Priority and Internet quality, in: Promoting New Telecom Infrastructures, Markets, Policies and Pricing, M. Falch and J. Markendahl (Hrsg.), Edward Elgar Publishing, Cheltenham, pp. 160-174, 2010

[Kuo/Yu 2006]

Kuo, Y., Yu, C., 3G telecommunication operators’ challenges and roles: A perspective of mobile commerce value chain, in: Technovation, Vol. 26, Iss. 12, pp. 1347-1356, 2006

[Kwok et al. 2002]

Kwok, S.H., Lang, K.R., Tam, K.Y., Peer-to-peer technology business and service models: risks and opportunities, in: Electronic Markets, Vol. 12, Iss. 3, pp. 175-183, 2002

[Labovitz et al. 2009]

Labovitz, C., Iekel-Johnson, S., McPherson, D., Oberheide, J., Jahanian, F., ATLAS Internet Observatory 2009 Annual Report, Presentation at the 47th North American Network Operators’ Group (NANOG) Meeting, October 19, 2009

[Labovitz et al. 2010]

Labovitz, C., Iekel-Johnson, S., McPherson, D., Oberheide, J., Jahanian, F., Internet inter-domain traffic, SIGCOMM '10: Proceedings of the ACM SIGCOMM, 2010

[Laffont et al. 2003]

Laffont, J. J., Marcus, S., Rey, P. and Tirole, J., Internet interconnection and the off-net-cost pricing principle, in: The RAND Journal of Economics, Vol. 34, Iss. 2, pp. 370-390, 2003

[Lang/ Stulz 1994]

Lang, L.H.P., Stulz, R.M., Tobin's q, corporate diversification, and firm performance, in: Journal of Political Economy, Vol. 102, Iss. 6, pp. 1248-1280, 1994

[LeBaron/Tesfatsion 2008]

LeBaron, B. and Tesfatsion, L., Modeling Macroeconomies as Open-Ended Dynamic Systems of Interacting Agents, in: American Economic Review, Vol. 98, Iss. 2, pp. 246-250, 2008

[Leighton 2009]

Leighton, T., Improving performance on the Internet, in: Communications of the ACM, Vol. 52, Iss. 2, pp. 44-51, 2009

[Li et al. 2004]

Li, L., Alderson, D., Willinger, W. and Doyle, J., A first-principles approach to understanding the Internet‘s router-level topology, Proceedings 2004 conference on Applications, technologies, architectures, and protocols for computer communications, Portland, pp. 3-14, 2004

[Li/Greenwood 2004]

Li, S.X. Greenwood, R., The effect of within-industry diversification on firm performance: synergy creation, multi-market contact and market structuration, in Strategic Management Journal, Vol. 25, Iss. 12, pp. 1131-1153, 2004

[Li/Whalley 2002]

Li, F., Whalley, J., Deconstruction of the telecommunications industry: from value chains to value networks, in: Telecommunications Policy, Vol. 26, pp. 451-472, 2002

[Liao/Cheung 2008]

Liao, Z., Cheung, M.T., Measuring consumer satisfaction in Internet banking: a core framework, in: Communications of the ACM, Vol. 51, Iss. 4, pp. 47-51, 2008

[Limbach et al. 2011a]

Limbach, F., Wulf, J., Zarnekow, R., Düser, M., Revenue distribution in a quality-centric Internet interconnection market, Proceedings of the 17th Americas Conference on Information Systems (AMCIS), 2011

[Limbach et al. 2011b]

Limbach, F., Wulf, J., Zarnekow, R. and Düser, M., A typology of cooperation strategies in the telecommunications industry – An exploratory analysis and theoretical foundations, 22nd European Regional ITS Conference Budapest, 18-21 September, 2011

[Limbach et al. 2011c]

Limbach, F., Wulf, J., Zarnekow, R. and Düser, M., Kooperationstreiber in der Telekommunikationswirtschaft, 4th Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2011) auf der INFORMATIK 2011, Berlin, 2011

[Lindstädt 2006]

Lindstädt, H., Ziele, Motive und Kriterien für Unternehmenszusammenschlüsse, in: Wirtz, B.W. (Hrsg.), Handbuch Mergers & Acquisitions Management, Gabler, Wiesbaden, pp. 57-78, 2006

[Liu/Arnett 2000]

Liu, C., Arnett, K.P., Exploring the factors associated with Web site success in the context of electronic commerce, in: Information & Management, Vol. 38, Iss. 1, pp. 23-33, 2000

[Lubatkin 1983]

Lubatkin, M., Mergers and the performance of the acquiring firm, in: Academy of Management Review, Vol. 8, Iss. 2, pp. 218-255, 1983

[MacKie-Mason/Varian 1995a]

MacKie-Mason, J.K., Varian, H.R., Pricing the Internet, in: Sichel, W., Alexander, D.L. (Hrsg.), Public Access to the Internet, MIT Press, Cambridge, pp. 269-314, 1995

[MacKie-Mason/Varian 1995b]

MacKie-Mason, J.K., Varian, H.R., Pricing Congestible Network Resources, in: IEEE Journal on Selected Areas in Communications, Vol. 13, pp.1141-1149, 1995

[Magedanz et al. 2007]

Magedanz, T., Blum, N., Dutkowski, S., Evolution of SOA concepts in telecommunications, in: Computer, Vol. 40, Iss. 11, pp. 46–50, 2007

[Maglio et al. 2006]

Maglio, P. P., Srinivasan, S., Kreulen, J. T., Spohrer, J., Service systems, service scientists, SSME, and innovation, in: Communications of the ACM, Vol. 49, Iss. 7, pp. 81-85, 2006

[Mahadevan 2006]

Mahadevan, P., Krioukov, D., Fomenkov, M., Dimitropoulos, X., Claffy, K. C. and Vahdat, A., The Internet AS-level topology: three data sources and one definitive metric, in: SIGCOMM Computer Communication Review, Vol. 36, Iss. 1, pp. 17-26, 2006

[Maitland et al. 2002]

Maitland, C.F., Bauer, J.M., Westerveld, R., The European market for mobile data: evolving value chains and industry structures, in: Telecommunications Policy, Vol. 26, Iss. 9, pp. 485-504, 2002

[Marchese 2007]

Marchese, M., QoS over Heterogeneous Networks, John Wiley & Sons Inc., NJ: Hoboken, 2007

[Mayring 2001]

Mayring, P., Kombination und Integration qualitativer und quantitativer Analyse, in: Forum Qualitative Sozialforschung, Vol. 2, Iss. 1, Art. 6, 2001

[McKeown et al. 2008]

McKeown, N., Anderson, T., Balakrishnan, H., Parulkar, G., Peterson, L., Rexford, J., Shenker, S., Turner, J., OpenFlow: enabling innovation in campus networks, ACM SIGCOMM Computer Communication Review, Vol. 38, Iss. 2, pp. 69–74, April 2008

[McKinnon 1988]

McKinnon, A., Physical Distribution, in: Marshall, J.N. (Hrsg.), Services and Uneven Development, Oxford University Press, Oxford, pp. 133-159, 1988

[McPherson 2009]

McPherson, D., ATLAS Internet Observatory – Bandwith Bandwagon: An ISOC Briefing Panel, 2009, http://www.isoc.org/isoc/conferences/bwpanel/docs/20091111_bandwidth_mcpherson.pdf, accessed: 25.05.2010

[Meffert 2000]

Meffert, H., Marketing: Grundlagen marktorientierter Unternehmensführung, Konzepte - Instrumente – Praxisbeispiele, 9. Auflage, Gabler, Wiesbaden, 2000

[Menth et al. 2009]

Menth, M., Duelli, M., Martin, R., Milbrandt, J., Resilience Analysis of Packet-Switched Communication Networks, IEEE/ACM Transactions on Networking, Vol.17, Iss. 6, pp. 1950-1963, 2009

[Merriam-Webster 2011]

Merriam-Webster, Definition of convergence, Merriam-Webster Online Dictionary, 2011, http://www.merriam-webster.com/dictionary/convergence, accessed: 20.11.2011

[Messerschmitt 1996]

Messerschmitt, D. G., The convergence of telecommunications and computing: what are the implications today?, Proceedings of the IEEE, Vol. 84, Iss. 8, pp. 1167-1186, 1996

[Microsoft 2008]

Microsoft, CeBIT 2008, Microsoft und Deutsche Telekom präsentieren IPTV-Angebot, 2008, http://www.microsoft.com/germany/presseservice/detail.mspx?id=532130, accessed: 21.09.2009

[Mohammed 2006]

Mohammed, A., Verizon executive calls for end to Google's 'free lunch, Washington Post, 07.02.2006, http://www.washingtonpost.com/wp-dyn/content/article/2006/02/06/AR2006020601624.html, accessed: 01.09.2011

[Montgomery 1982]

Montgomery, C.A., The measurement of firm diversification: Some new empirical evidence, in: Academy of Management Journal, Vol. 25, pp. 299-307, 1982

[Mori/Kawahara 1990]

Mori, R., Kawahara, M., Superdistribution: The concept and the architecture, in: Transaction of the IEICE, Vol. 73, Iss. 7, pp. 1133-1146, 1990

[Morris/Pratt 2003]

Morris, S.A., Pratt, D., Analysis of the Lotka-Volterra competition equations as a technological substitution model, Technological Forecasting and Social Change, Vol. 70, Iss. 2, pp. 103-133, 2003

[Moss 2008]

Moss, S., Alternative Approaches to the Empirical Validation of Agent-Based Models, in: Journal of Artificial Societies and Social Simulation, Vol. 11, Iss. 1, pp. 1-17, 2008

[Muenchner Kreis 2010]

Münchner Kreis, Offen für die Zukunft – Offen in die Zukunft, Internationale Delphi Studie 2030, 2010

[Muller 2006]

Muller, P. A., Service Oriented Architectures for convergent Service Delivery Platforms, Technical Report, Eurescom, France Télécom Group, 2006

[Nemertes 2007]

Nemertes, The Internet Singularity, Delayed: Why Limits in Internet Capacity Will Stifle Innovation on the Web, Nemertes Research, 2007

[Nichols et al. 1998]

Nichols K., Blake, S., Baker, F., Black, D., Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers, IETF RFC 2474, December 1998

[Norman/Ramirez 1993]

Norman, R., Ramirez. R., From Value Chain to Value Constellation: Designing Interactive Strategy, in: Long Range Planning, Vol. 26, Iss. 6, pp. 151-151, 1993

[North/Macal 2007]

North, M.J., Macal C. M., Managing business complexity, Discovering strategic solutions with agent-based modeling and simulation, Oxford University Press, New York, 2007

[Norton 2002a]

Norton, W.B., A business case for ISP peering, Equinix White Paper, 2002, http://drpeering.net/AskDrPeering/blog/articles/Internet_Peering_White_Papers_files/A%20Business%20Case%20for%20Peering%201.4.pdf, accessed: 11.06.2010

[Norton 2002b]

Norton, W.B., The art of peering: The peering playbook, Equinix White Paper, 2002, http://www.init7.net/lots2005/the_art_of_peering.pdf, accessed: 23.06.2010

[Norton 2003]

Norton, W.B., The evolution of the U.S. Internet peering ecosystem, Equinix White Paper, 2003, http://dev.nanog.org/meetings/nanog31/presentations/norton.pdf, accessed: 11.06.2010

[Nystroem/ Hacklin 2005]

Nystroem, A.G., Hacklin, F., Operator value creation through technological convergence: the case of VoIP, 16th European Regional Conference, International Telecommunications Society (ITS), 2005

[Obermann/Horneffer 2009]

Obermann, K., Horneffer, M., Datennetztechnologien für Next Generation Networks: Ethernet, IP, MPLS und andere, Vieweg+Teubner | GWV Fachverlage GmbH, Wiesbaden, 2009

[Odlyzko 2009]

Odlyzko, A., Network Neutrality, Search Neutrality, and the Never-ending Conflict between Efficiency and Fairness in Markets, Review of Network Economics, Vol. 8, Iss. 1, Article 4, 2009

[OECD 2010]

OECD, OECD Broadband Portal, 2010, http://www.oecd.org/sti/ict/broadband, accessed: 22.10.2010

[OECD 2011]

OECD, OECD Communications Outlook 2011, OECD Publishing, 2011

[Oesterle 1995]

Oesterle, H., Business in the Information Age, Heading for New Processes, First edition, Springer, Berlin, 1995

[OHA 2009]

Open Handset Alliance, Android | Official Website, 2009, http://www.android.com, accessed: 18.09.2009

[OHA 2011]

Open Handset Alliance, Industry Leaders Announce Open Platform for Mobile Devices, OHA Internet representation, 5.11.2007, http://www.openhandsetalliance.com/press_110507.html, accessed: 04.07.2011

[OMA 2005]

OMA, Open Mobile Alliance Service Environment, OMA Specification V1.0.2., 2005

[Onecle 2009]

Onecle, Sample Contracts – Master Services Agreement – Akamai Technologies Inc. Onecle Inc, 2009, http://contracts.onecle.com/akamai/msa.shtml, accessed: 25.04.2009

[Opsahl et al. 2010]

Opsahl, T., Agneessens, F., Skvoretz, J., Node centrality in weighted networks: Generalizing degree and shortest paths, in: Social Networks, Vol. 32, pp. 245-251, 2010

[Osterwalder 2004]

Osterwalder, A., The Business Model Ontology - a proposition in a design science approach, Ph.D. thesis, in : Institut d'Informatique et Organisation, University of Lausanne, Ecole des Hautes Etudes Commerciales HEC, Switzerland, Lausanne, 2004

[Osterwalder/ Pigneur 2002]

Osterwalder, A., Pigneur, Y., An e-Business Model Ontology for Modeling e-Business Bled, in: Electronic Commerce Conference, Bled, Slovenia, 2002

[Palich et al. 2000]

Palich, L., Cardinal, L., Miller, C., Curvilinearity in the diversification-performance linkage: An examination of over three decades, in: Strategic Management Journal, Vol. 21, Iss. 2, pp. 155-174, 2000

[Pallis/Vakali 2006]

Pallis, G., Vakali, A., Insight and Perspectives for Content Delivery Networks, in: Communications of the ACM, Vol. 49, Iss. 1, pp. 101-106, 2006

[Palmberg/Martikainen 2006]

Palmberg, C. Martikainen, O., Diversification in response to ICT convergence – Indigenous capabilities versus R&D alliances of the Finnish telecom industry, in: The Journal of Policy, Regulations and Strategy for Information and Media, Vol. 8, Iss. 4, pp. 67-84, 2006

[Panagiotis et al. 2002]

Panagiotis, T., Teneketzis, D., Mackie-Mason, J.K., A market-based approach to optimal resource allocation in integrated-services connection-oriented networks, Operations Research, Vol. 50, Iss. 4, pg. 603, 2002

[Parasuraman/Zeithaml 1985]

Parasuraman, A., Zeithaml, V.A., Berry, L.L., A Conceptual Model of Service Quality and Its Implications for Future Research, in: Journal of Marketing, Vol. 49, Iss. 4, pp. 41-50, 1985

[Pathan/Buyya 2008]

Pathan, M., Buyya, R., A Taxonomy of CDNs, in: Buyya, R., Pathan, M., Vakali, A. (Hrsg.), Content Delivery Networks, Springer-Verlag, pp. 33-77, 2008

[Pavlovski 2007]

Pavlovski, C., Service delivery platforms in practice, IP Multimedia Systems (IMS) Infrastructure and Services, Communications Magazine, Vol. 45, pp. 114-121, 2007

[PeeringDB 2010]

PeeringDB, PeeringDB-Datenbank, 2010, https://www.peeringdb.com, accessed: 09.06.2010

[Pelzel 2000]

Pelzel, R.F., Deregulierte Telekommunikationsmärkte, Springer-Verlag, Berlin, 2000

[Pennings/Puranam 2001]

Pennings, J., Puranam, P., Industry convergence & Firm Strategy: new directions for theory and research, ECIS Conference, The Future of Innovation Studies, Netherlands, Eindhoven, 2001

[Penrose 1959]

Penrose, E., The Theory of the Growth of the Firm. John Wiley and Sons, New York, 1959

[Peppard/Rylander 2006]

Peppard, J., Rylander, A., From Value Chain to Value Network: Insights for Mobile Operators, in: European Management Journal, Vol. 24, Iss. 2-3, pp. 128-141, 2006

[Perry 1989]

Perry, M.K., Vertical Integration: Determinants and Effects, in: Schmalensee, R., Willig, R.D. (Hrsg.), Handbook of Industrial Organization, Amsterdam, pp. 183-255, 1989

[Picot 1991]

Picot, A., Ein neuer Ansatz zur Gestaltung der Leistungstiefe, in: Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung, Vol. 43, Iss. 4, pp. 336-357, 1991

[Picot 2007]

Picot, A., Tiefgreifende Veränderungen im Ecosystem der Telekommunikationsindustrie, in: Picot, A., Freyberg, A. (Hrsg.), Infrastruktur und Services - Das Ende einer Verbindung? Die Zukunft der Telekommunikation - Tagungsband, pp. 13-27, 2007

[Picot et al. 2008]

Picot, A., Wernick, C., Grove N., Aktuelle Treiber auf Telekommunikationsmärkten und ihre Auswirkungen auf Geschäftsmodelle und Erlösquellen festnetzbasierter Carrier, Insitut für Information, Organisation und Management, Working Paper, LMU München, 2008

[Pil/Holweg 2006]

Pil, F.K., Holweg, M., Evolving from Value Chain to Value Grid, in: MIT Sloan Management Review, Vol. 47, Iss. 4, pp. 72-79, 2006

[Poese et al. 2010]

Poese, I., Frank, B., Ager, B., Smaragdakis, G., Feldmann, A., Improving content delivery using provider-aided distance information, In Proceedings of the 10th annual conference on Internet measurement (IMC '10), ACM, New York, NY, USA, pp. 22-34, 2010

[Pohler et al. 2006]

Pohler, M., Beckert, B., Schefczyk, M., Technologische und ökonomische Langfristperspektiven der Telekommunikation, Schlussbericht an das Bundesministerium für Wirtschaft und Technologie, Technische Universität Dresden und Frauenhofer Institut für System- und Innovationsforschung, 2006

[Pope/Shim 2010]

Pope, M.B., Shim, J.P., The Looming Bandwidth Crunch—Legitimate Crisis, or Cyberspace Chicken Little?, Communications of the Association for Information Systems, Vol. 27, Article 43, 2010

[Porter 1980]

Porter, M.E., Competitive Strategy, Free Press, New York, 1980

[Porter 1985]

Porter, M.E., Competitive Advantage, Free Press, New York, 1985

[Porter 1996]

Porter, M.E., What is strategy?, in: Harvard Business Review, Vol. 74, Iss. 6, pp. 61-77, 1996

[Porter/Millar 1985]

Porter, M.E., Millar, V., How information gives you competitive advantage, in: Harvard Business Review, Vol. 63, Iss. 4, pp. 149-160, 1985

[Postel 1981]

Postel, J., Internet Protocol, Darpa Internet Program Protocol Specification, 1981

[PwC 2008]

PricewaterhouseCoopers, IPTV – Das neue Fernsehen?, PwC Report, 2008, http://pic.tv1.de/media/tv1/easyonair/files/IPTV-Das-neue-Fernsehen.pdf, accessed: 30.06.2011

[Rams 2001]

Rams, W., Kundenbindung im deutschen Mobilfunkmarkt: Determinanten und Erfolgsfaktoren in einem dynamischen Marktumfeld, DUV, Wiesbaden, 2001

[Ravichandran et al. 2009]

Ravichandran, T., Liu, Y., Han, S., Hasan, I., Diversification and Firm Performance: Exploring the Moderating Effects of Information Technology Spending, in: Journal of Management Information Systems, Vol. 25, Iss. 4, pp. 205-240, 2009

[Rayburn 2011]

Rayburn, D., Telcos And Carriers Forming New Federated CDN Group Called OCX (Operator Carrier Exchange), Streamingmedia Blog, 27.06.2011, http://blog.streamingmedia.com/the_business_of_online_vi/2011/06/telco-and-carriers-forming-new-federated-cdn-group-called-ocx-operator-carrier-exchange.html, accessed: 28.08.2011

[Reichl 2007]

Reichl, P., From ‘quality-of-service’ and ‘quality-of-design’ to ‘quality-of-experience’: A holistic view on future interactive telecommunication services, Proc. 15th Int. Conf. Software, Telecommun. and Computer Networks, pp. 1-6., Sep. 2007

[Renesys 2010]

Renesys, IP-Backbone: Hard sell, not so much, 2010, http://www.renesys.com/blog/2009/11/ip-backbone-hard-sell-not-so-m.shtml, accessed: 15.07.2010

[Repast 2010]

Repast, Repast Simphony, 2010, http://repast.sourceforge.net/, accessed: 22.03.2010

[Repschläger/Zarnekow 2011]

Repschläger, J., Zarnekow, R., Cloud Computing in der IKT-Branche, Band 2: Research Papers in Information Systems Management, Universitätsverlag der TU Berlin, 2011

[Rochet/Tirole 2003]

Rochet, J.C., Tirole, J., Platform Competition in Two-sided Markets, Journal of the European Economic Association, Vol. 1, Iss. 4, pp. 990-1029, June 2003

[Rodriguez de Lope et al. 2008]

Rodriguez de Lope, L., Hackbarth, K., Garcia, A.E., Plückebaum, T., Ilic, D., Cost models for Next Generation Networks with Quality-of-Service parameters, Proceedings Networks 2008, Budapest, November 2008

[Rosenberg 1963]

Rosenberg, N., Technological Change in the Machine Tool Industry, 1840-1910, in: Journal of Economic History, Vol. 23, Iss. 4, pp. 414-443, 1963

[Rotert et al. 2009]

Rotert, M., Summa, H., Koller, P., Wilms, S., Morath, J., Jakopin, N., Riegel, L., Die deutsche Internetwirtschaft 2009-2012 – Überblick, Trends und Treiber, eco Verband der deutschen Internetwirtschaft e.V. / Arthur D. Little, 2009

[Rumelt 1974]

Rumelt, R.P., Strategy, Structure, and Economic Performance, Harvard University Press, Boston, 1974

[Sabat 2002]

Sabat, H.K., The evolving mobile wireless value chain and market structure, Telecommunications Policy, Vol. 26, Iss. 9, pp. 505-535, 2002

[Saroiu et al. 2002]

Saroiu, S., Gummadi, K.P., Dunn, R.J., Gribble, S.D., Levy, H.M., An analysis of Internet content delivery systems, Proceedings of the 5th Symposium on Operating Systems Design and Implementation, USA, San Francisco, 2002

[Scheer 2000]

Scheer, A.W., ARIS - Business Process Modeling, 2. Auflage, Springer, Heidelberg, 2000

[Scheer et al. 2004]

Scheer, A.W., Grieble, O., Klein, R., Model-based Engineering, in: Geberl, S., Weinmann, S., Wiesner, D. (Hrsg.) Impulse aus der Wirtschaftsinformatik, 5, Liechtensteinisches Wirtschaftsinformatik-Symposium an der Fachhochschule Liechtenstein, Physika, Heidelberg, pp. 17-33, 2004

[Schüle 1992]

Schüle, F.M., Diversifikation und Unternehmenserfolg, Eine Analyse empirischer Forschungsergebnisse, Dissertation, Universität München, Gabler, Wiesbaden, pp. 8-16, 1992

[Schulte 1995]

Schulte, C., Logistik, 2. Auflage, Vahlen, Munich, 1995

[Schultz et al. 2011]

Schultz, N., Wulf, J., Zarnekow, R., Nguyen, Q.T., The New Role of Developers in the Mobile Ecosystem: An Apple and Google Case Study, International Conference on Intelligence in Next Generation Networks (ICIN), Berlin, 2011

[Schumann/Hess 2006]

Schumann, M., Hess, T., Grundfragen der Medienwirtschaft: eine betriebswirtschaftliche Einführung, 3. Auflage, Springer, Berlin, 2006

[Shapiro/Varian 1999]

Shapiro, C., Varian, H.R., Information rules: a strategic guide to the network economy, Harvard Business School Press, 1999

[Shenker et al. 1996]

Shenker, S., Clark, D., Estrin, D., Herzog, S., Pricing in computer networks: Reshaping the research agenda, in: Telecommunications Policy, Vol. 20, Iss. 3, pp. 183-201, 1996

[Sietmann 2011]

Sietmann, R., Schmalspur - Der Kampf gegen die Netzneutralität zielt auf die Vereinnahmung des Internet, c’t Magazin für Computertechnik, Iss. 8, pp. 158-165, 2011

[Spohrer et al. 2007]

Spohrer J., Maglio P.P., Bailey J., Gruhl D., Steps toward a science of service systems, IEEE Computer, Vol. 40, Iss. 1, pp. 71–77, 2007

[Srnka/Koeszegi 2007]

Srnka, K.J., Koeszegi, S.T., From Words to Numbers - How to Transform Qualitative Data into Meaningful Quantitative Results: Guidelines and Exemplary Study, in: Schmalenbach Business Review, Vol. 59, Iss. 1, pp. 29-57, 2007

[Stähler 2002]

Stähler, P., Geschäftsmodelle in der digitalen Ökonomie - Merkmale, Strategien und Auswirkungen, Josef Eul Verlag, Lohmar, 2002

[Steingroever 2008]

Steingroever, M., Migration to NGN: The wholesale manager's perspective, in: Journal of Telecommunications Management, Vol. 1, Iss. 4, pp. 339–550, 2008

[Steingroever/Richter 2008]

Steingroever, M., Richter, J., Enabling Services - New Revenue Potentials for Telecommunications Wholesale, Detecon International GmbH, 2008

[Stieglitz 2003a]

Stieglitz, N., Digital Dynamics and Types of Industry Convergence – The Evolution of the Handheld Computers Market in the 1990s and beyond, in: The Industrial Dynamics of the New Digital Economy, Christenen, Maskell (Hrsg.), Edward Elgar, London, 2003

[Stieglitz 2003b]

Stieglitz, N., Strategie und Wettbewerb in konvergierenden Märkten, Deutscher Universitäts-Verlag, Wiesbaden, 2003

[STRATO AG 2008]

STRATO AG, Webhosting, Online Shops and Server, Strato AG Internet Representation, 2008, http://www.strato.de, accessed: 25.07.2011

[Sundararajan 2004]

Sundararajan, A., Managing Digital Piracy: Pricing and Protection, in: Information Systems Research, Vol. 15, Iss. 3, pp. 287-308´, 2004

[Tanenbaum 2003]

Tanenbaum, A.S., Computer networks, Fourth edition, Upper Saddle River, NJ: Prentice-Hall, 2003

[Tanriverdi 2006]

Tanriverdi, H., Performance Effects of Information Technology Synergies in Multibusiness Firms, in: MIS Quarterly, Vol. 30, Iss. 1, pp. 57-77, 2006

[Tanriverdi/Lee 2008]

Tanriverdi, H., Lee, C., Within-industry Diversification and Firm Performance in the Presence of Network Externalities: Evidence from the Software Industry, in: Academy of Management Journal, Vol. 51, Iss. 2, pp. 381-397, 2008

[TATA 2008]

TATA Communications, Content Services - Tata Communications Experience, TATA Communications Presentation, July 2008, http://www.tatacommunications-ts.com/downloads/casestudies/Content%20Services.pdf, accessed: 12.09.2011

[TeleGeography 2010a]

TeleGeography, Transit Database, 2010, http://www.telegeography.com, accessed: 30.06.2010

[TeleGeography 2010b]

TeleGeography, Enterprise Network Pricing Database, 2010, http://www.telegeography.com, accessed: 29.06.2010

[Tesfatsion/Judd 2006]

Tesfatsion, L., Judd, K.L, Agent-based computational economics, Elsevier, Amsterdam, 2006

[Timmers 1998]

Timmers, P., Business Models for Electronic Markets, in: Electronic Markets, Vol. 8, Iss. 2, pp. 3-8, 1998

[TKG 2004]

Telekommunikationsgesetz, 22.06.2004, http://bundesrecht.juris.de/bundesrecht-/tkg_2004/gesamt.pdf, accessed: 31.05.2011

[Turel/Yuan 2006]

Turel, O., Yuan, Y., Investigating the dynamics of the m-commerce value system: a comparative viewpoint, in: International Journal of Mobile Communications, Vol. 4, Iss. 5, pp. 532-557, 2006

[Uebernickel et al. 2006]

Uebernickel, F., Bravo-Sanchez C., Zarnekow, R., Brenner, W., IS Service Engineering: A process model for the development of IS services, Online Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS), 2006

[Underwood 2001]

Underwood, K., Web Hosting: An Overview, Gartner Technical Report, 2001

[Unmehopa et al. 2006]

Unmehopa, M., Vemuri, K., Bennett, A., Parlay / OSA: From Standards to Reality, John Wiley & Sons, 2006

[Utterback/Abernathy 1975]

Utterback, J.M., Abernathy, W.J., A dynamic model of process and product innovation, in: Omega, Vol. 3, Iss. 6, pp. 639-656, 1975

[Vakali/Pallis 2003]

Vakali, A., Pallis, G., Content Delivery Networks: Status and Trends, in: IEEE Internet Computing, IEEE Computer Society, Vol. 7, Iss. 6, pp. 68-74, 2003

[Valetti/Cambini 2005]

Valletti, T., Cambini, C., Investments and Network Competition, in: RAND Journal of Economics, Vol. 23, Iss. 2, pp. 446-467, 2005

[Van Landegem/Viswanathan 2008]

Van Landegem, T., Viswanathan, H., Anywhere, Anytime, Immersive Communications, Enriching Communications, Vol. 2, Iss. 1, 2008, http://www.alcatel-lucent.com/enrich/v2i12008/article_c4a3.html, accessed: 13.09.2011

[Van Moorsel 2001]

Van Moorsel, A., Metrics for the Internet Age: Quality of Experience and Quality of Business, HP Labs Technical Report HPL-2001-179, July 2001

[Van Ooteghem et al. 2008]

Van Ooteghem, J., Verbrugge, S., Casier, K., Pickavet, M., Demeester, P., Future proof strategies towards fiber to the home, ICT-Public & Private Interplay Next Generation Communication conference (ICT-PPI), Seville, Spain, 10-12 December 2008

[VHB 2011]

Verband der Hochschullehrer für Betriebswirtschaft e.V., VHB-Jourqual Gesamtübersicht JQ 2.1, VHB Website, 2011, http://vhbonline.org/service/jourqual/vhb-jourqual-21-2011/jq21/, accessed: 18.08.2011

[Vogelsang 2006]

Vogelsang, I., Abrechnungssysteme und Zusammenschaltungsregime aus ökonomischer Sicht, Gutachten im Auftrag der BNetzA, 2006

[von Tunzelmann 1999]

von Tunzelmann, G.N., ’Convergence’ and corporate change in the electronics industry, in: The Organization of Economic Innovation in Europe, Gambardella, A., Malerba, F. (Hrsg.), Cambridge University Press, Cambridge, pp. 125-157, 1999

[Wade/Hulland 2004]

Wade, M., Hulland, J., Review: The resource-based view and information systems research - Review, extension, and suggestions for future research, in: MIS Quarterly, Vol. 28, Iss. 1, pp. 107-142, 2004

[Watlington et al. 2005]

Watlington, J., Gillett, S., Lehr, W., Bauer, S., The Broadband Incentive Problem, Broadband Working Group, MIT Communications Futures Program (CFP), Cambridge University Communications Research Network, September, 2005

[Weill/Vitale 2001]

Weill, P., Vitale, M.R., Place to space: Migrating to eBusiness Models, Harvard Business School Press, Boston, 2001

[Weldon 2010]

Weldon, M., Managed Services Declaration, Telecommunications Industry Association (TIA) Comments- Open Internet Docket, 14.01.2010, http://www.tiaonline.org/gov_affairs/fcc_filings/documents/Managed_Services_Declaration_01.14.10.pdf, accessed: 12.09.2011

[Wickens 1989]

Wickens T.D., Multiway Contingency Tables Analysis for the Social Sciences, Lawrence Erlbaum Associates, Hillsdale, 1989

[Wierstra et al. 2001]

Wierstra, E., Kulenkampff, G., Schaffers, H., A framework for analyzing strategies of Internet Service Providers, in: Netnomics, Vol. 3, Iss. 1, pp. 35-65, 2001

[Wilde/Hess 2006]

Wilde, T., Hess, T., Methodenspektrum der Wirtschaftsinformatik: Überblick und Portfoliobildung, Institut für Wirtschaftsinformatik und Neue Medien der Ludwig-Maximilians-Universität München, Arbeitsbericht Nr. 2, 2006

[Wilde/Hess 2007]

Wilde, T., Hess, T., Forschungsmethoden der Wirtschaftsinformatik: Eine empirische Untersuchung, in: Wirtschaftsinformatik, Vol. 49, Iss. 4, pp. 280-287, 2007

[Windrum et al. 2007]

Windrum, P., Fagiolo, G., Moneta, A., Empirical Validation of Agent-Based Models: Alternatives and Prospects, in: Journal of Artificial Societies and Social Simulation, Vol. 10, Iss. 2, pp. 1-19, 2007

[Wirtz 2000]

Wirtz, B.W., Electronic Business, Gabler Verlag, Wiesbaden, 2000

[Wirtz 2001]

Wirtz, B., Reconfiguration of Value Chains in Converging Media and Communications Markets, Long Range Planning, Vol. 34, pp. 489-507, 2001

[Wirtz 2006]

Wirtz, B.W., Medien- und Internetmanagement, 5. Auflage, Gabler, Wiesbaden, 2006

[Wirtz et al. 2006]

Wirtz, B.W., Burda, H., Raizner, W., Deutschland Online 4 - Die Zukunft des Breitband-Internets, Technical Report, Deutschland Online, 2006

[Wirtz/Kleineicken 2000]

Wirtz, B., Kleineicken, A., Geschäftsmodelltypen im Internet, in: Wirtschaftsstudium, Vol. 11, pp. 628-635, 2000

[WIWO 2007]

Wirtschaftswoche, Telefonica verkauft „Big Brother”- Firma Endemol, 14.05.2007, http://www.wiwo.de/unternehmen-maerkte/telefonica-verkauft-big-brother-firma-endemol-225573/, accessed: 31.08.2011

[WKWI 2008]

Wissenschaftlichen Kommission Wirtschaftsinformatik im Verband der Hochschullehrer für Betriebswirtschaft e.V., WI-Orientierungslisten, in: Wirtschaftsinformatik, Vol. 50, Iss. 2, pp. 155-163, 2008

[Wulf 2011]

Wulf, J., Service Distribution in IP-Networks - A Business Model Analysis, Electronic Communications of the EASST, Vol. 37, pp. 1-13, 2011

[Wulf et al. 2008]

Wulf, J., Zarnekow, R., Sidler, A., Brenner, W., Enabling Services - A new business perspective in Telecommunications, 17th Biennial Conference, International Telecommunications Society (ITS), 2008

[Wulf et al. 2009a]

Wulf, J., Hau, T., Zarnekow, R., Brenner, W., Specifying Enabling Service in Telecommunications Service Systems, 15th Americas Conference on Information Systems (AMCIS2009), San Francisco, 2009

[Wulf et al. 2009b]

Wulf, J., Hau, T., Zarnekow, R., Brenner, W., Enabling Services - Spezifikation plattformbasierter Vorleistungen in der Telekommunikation, INFORMATIK 2009, 2nd Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2009), Lübeck, 2009

[Wulf et al. 2009c]

Wulf, J., Hau, T., Zarnekow, R., Brenner, W., CDN Business Models, Deutsche Telekom Presentation, June 2009

[Wulf et al. 2010a]

Wulf, J., Hau, T., Zarnekow, R., Brenner, W., Carrier Activities in the CDN Market: an Exploratory Analysis and Strategic Implications, 14th International Conference on Intelligence in Next Generation Networks (ICIN), Berlin, 2010

[Wulf et al. 2010b]

Wulf, J., Zarnekow, R., Dueser, M., Analysis of future telecommunication business models using a business model ontology, 9th Conference on Telecommunications Internet and Media Techno Economics (CTTE), Ghent, 2010

[Wulf et al. 2010c]

Wulf, J., Düser, M., Zarnekow, R., QoS Business Models for Telecommunications Network Operators, Deutsche Telekom Report, May 2010

[Wulf et al. 2010d]

Wulf, J., Limbach, F., Zarnekow, R., Analysis of QoS platform cooperation strategies, 21th European Regional ITS Conference, Copenhagen, 2010

[Wulf et al. 2010e]

Wulf, J., Gegner, J. and Zarnekow, R., Strategic Options for Next Generation Network-based Business Models, 3rd Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2010) auf der INFORMATIK 2010, 2010

[Wulf et al. 2011a]

Wulf, J., Limbach, F., Zarnekow, R., Düser, M., Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario, International Conference on Information Systems (ICIS 2011), Shanghai, 2011

[Wulf et al. 2011b]

Wulf, J., Zarnekow, R., Dueser, M., A methodology for analysing substitution effects between QoS and best-effort based services, 10th Conference on Tele-communications Internet and Media Techno Economics (CTTE), Berlin, 2011

[Wulf et al. 2011c]

Wulf, J., Limbach, F., Düser, M., Zarnekow, QoS Business Models – Quantitative Modeling, Deutsche Telekom Presentation, February 2011

[Wulf/Zarnekow 2010a]

Wulf, J., Zarnekow, R., Softwarebezogene Wertschöpfung im Wertschöpfungsnetzwerk der Informations- und Kommunikationsindustrie – Eine empirische Analyse, Multikonferenz Wirtschaftsinformatik (MKWI 2010), Göttingen, 2010

[Wulf/Zarnekow 2010b]

Wulf, J., Zarnekow, R., Technologies for the electronic distribution of information services - a value proposition analysis, in: Electronic Markets, Vol. 20, Iss. 1, pp. 3-19, 2010

[Wulf/Zarnekow 2010c]

Wulf, J., Zarnekow, R., Economic Aspects of Quality-of-Service for Internet based IT Services, In: Praeg., C.P., Spath, D. (Hrsg.), Quality Management for IT Services – Perspectives on Business and Process Performance, IGI, 2010

[Wulf/Zarnekow 2011a]

Wulf, J., Zarnekow, R., How do ICT firms react to convergence? An analysis of diversification strategies, Proceedings of the 19th European Conference on Information Systems (ECIS), Helsinki, 2011

[Wulf/Zarnekow 2011b]

Wulf, J., Zarnekow, R., Cross-sector competition in telecommunications - an empirical analysis of diversification activities, in: Business & Information Systems Engineering, Vol. 3, Iss. 5, pp. 289-298, 2011

[Xiao 2008]

Xiao, X.P., Technical, commercial and regulatory challenges of QoS, An Internet service model perspective, Morgan Kaufmann, Amsterdam, 2008

[Xiao/Ni 1999]

Xiao, X., Ni, L.M., Internet QoS: A Big Picture, IEEE Network, pp. 8-18, March-April 1999

[Xie et al. 2008]

Xie, H., Yang, Y., Krishnamurthy, A., Liu, Y.,Silberschatz, A., P4P: Provider Portal for Applications, ACM SIGCOMM Computer Communication Review, Vol. 38, Iss. 4, 2008

[Yin 1994]

Yin, R.K., Case Study Research, Design and Methods, Second edition, Sage Publications, Beverly Hills, CA, 1994

[Yoffie 1996]

Yoffie, D., Competing in the age of digital convergence, California Management Review, Vol. 38, Iss. 4, pp. 31-53, 1996

[Zarnekow et al. 2006]

Zarnekow, R., Brenner, W., Pilgram, U., Integrated Information Management. Applying Successful Industrial Concepts in IT, First edition, Springer, Berlin, 2006

[Zarnekow et al. 2007]

Zarnekow, R., Brenner, W., Dous, M., Quality-of-Service Business Models for the Broadband Internet, in: 18th European Regional Conference of the International Telecommunications Society, 2007

[Zarnekow et al. 2008a]

Zarnekow, R., Wulf, J., Brenner, W., Sidler, A., Enabling Services: A New Business Perspective in Telecommunications, 17th Biennial Conference of the International Telecommunications Society (ITS08), 2008

[Zarnekow et al. 2008b]

Zarnekow, R., Brenner, W., Wulf, J., Hau, T., Abschlussdokumentation Projekt QoS Geschäftsmodelle, Deutsche Telekom Presentation, August 2008

[Zarnekow et al. 2008c]

Zarnekow, R., Brenner, W., Dous, M., Geschäftsmodelle für die Umsetzung von Quality-of-Service im Breitband-Internet, in: Multikonferenz Wirtschaftsinformatik 2008, M. Bichler, T. Hess, H. Krcmar, U. Lechner, F. Matthes, A. Picot, B. Speitkamp and P. Wolf (Hrsg.), Gito, Berlin, pp. 1059-1070, 2008

[Zeithaml et al. 2000]

Zeithaml, V. A., Parasuraman, A., Malhotra, A., A conceptual framework for understanding e-service quality: Implications for future research and managerial practice, Working paper, MA: Marketing Science Institute, Cambridge, 2000

[Zeithaml et al. 2002]

Zeithaml, V.A., Parasuraman, A., Malhotra, A., Service Quality Delivery Through Web Sites: A Critical Review of Extant Knowledge, in: Journal of the Academy of Marketing Science, Vol. 30, Iss. 4, pp. 362-375, 2002

[Zerdick et al. 2000]

Zerdick, A., Picot, A., Schrape, K., Artope, A., Goldhammer, K., Heger, D.K., Lange, U.T., Vierkan, E., Lopez-Escobar, E., Silverstone R., E-Conomics: Strategies for the Digital Marketplace, Springer, Berlin, 2000

[Zhao et al. 2000]

Zhao, W., Olshefski, D., Schulzrinne, H., Internet Quality-of-Service : an Overview, Working Paper, Columbia University, New York, 2000