FUNDAÇÃO GETULIO VARGAS
ESCOLA DE ADMINISTRAÇÃO DE EMPRESAS DE SÃO PAULO

BENJAMIN HARDER

Voice Over IP 2.0

An Analysis of Limits and Potential of IP2IP Telecommunication

SÃO PAULO
2012

BENJAMIN HARDER

Voice Over IP 2.0
An Analysis of Limits and Potential of IP2IP Telecommunication

Dissertação apresentada à Escola de Administração de Empresas de São Paulo da Fundação Getúlio Vargas, como requisito para obtenção de título de Mestre em Gestão Internacional

Campo de conhecimento: Gestão E Competividade Em Empresas Globais

Orientador: Prof. Dr. Gilberto Sarfati

SÃO PAULO
2012

Harder, Benjamin.
Voice over IP 2.0 – An Analysis of Limits and Potential of IP2IP Telecommunication / Benjamin Harder. - 2012.
104 f.

Orientador: Gilberto Sarfati
Dissertação (MPGI) - Escola de Administração de Empresas de São Paulo.

1. Tecnologia da informação. 2. Telefonia pela internet. 3. Rede de computadores - Protocolos. 4. Skype (Recurso eletrônico). I. Sarfati, Gilberto. II. Dissertação (MPGI) - Escola de Administração de Empresas de São Paulo. III. Título.

CDU 681.324

BENJAMIN HARDER

Voice Over IP 2.0
An Analysis of Limits and Potential of IP2IP Telecommunication

Dissertação apresentada à Escola
de Administração de Empresas de São
Paulo da Fundação Getúlio Vargas, como
requisito para obtenção de título de Mestre
em Gestão Internacional

Campo de conhecimento: Gestão E
Competividade Em Empresas Globais

Data de aprovaçao:
23/4/2012

Banca examinadora:

____
Prof. Dr. Gilberto Sarfati

____
Prof. Dr. Sérvio Túlio Prado Júnior

____
Prof. Dr. Ricardo R. Rochman

Abstract

Internet Telephony (VoIP) is changing the telecommunication industry. Oftentimes free, VoIP is becoming more and more popular amongst users. Large software companies have entered the market and heavily invest into it. In 2011, for instance, Microsoft bought Skype for 8.5bn USD. This trend increasingly impacts the incumbent telecommunication operators. They see their main source of revenue – classic telephony – under siege and disappear.

The thesis at hand develops a most-likely scenario in order to determine how VoIP is evolving further and it predicts, based on a ten-year forecast, the impact it will have on the players in the telecommunication industry.

The paper presents a model combining Rogers' diffusion and Christensen's innovation research. The model has the goal of explaining the past evolution of VoIP and to isolate the factors that determine the further diffusion of the innovation. Interviews with industry experts serve to assess how the identified factors are evolving.

Two propositions are offered. First, VoIP operators are becoming more important in international, corporate, and mobile telephony. End-to-end VoIP (IP2IP) will exhibit strong growth rates and increasingly cannibalize the telephony revenues of the classic operators. Second, fix-net telephony in SMEs and at home will continue to be dominated by the incumbents. Yet, as prices for telephony fall towards zero also they will implement IP2IP in order to save costs.

By 2022, up to 90% of the calls will be IP2IP. The author recommends the incumbents and VoIP operators to proactively face the change, to rethink their business strategies, and to even be open for cooperation.

Keywords:

Innovation; Diffusion; Disruptive Innovation; Technology Management; Technology S-Curve; Business Model; Telecommunication; Voice over IP; VoIP; Scenario; Mobile Internet; Trend Analysis; Skype; Microsoft Communicator; Lync; Telephony; PSTN; Mobile Applications; IT; Information Technology; P2P; Peer-To-Peer

Title Page:

The pictures inserted on the title page show views onto the library of the University of St.Gallen (left side) and of Fundação Getúlio Vargas (right side). The pictures and university logos were obtained from the websites of the respective institutions.

Acknowledgements

First and foremost, I thank my friends, my family, and particularly my parents. They have always encouraged me, stood by my side, inspired and supported me – not only for this thesis, but throughout my entire academic career and life.

Also, I wish to thank the academic supervisors and co-supervisors of my thesis for their guidance and insightful inputs:

Prof. Dr.	Martin Hilb	(Supervisor HSG)
Prof. Dr.	Gilberto Sarfati	(Supervisor FGV)
Prof. Dr.	Roman Lombriser	(Co-Supervisor HSG)
Prof. Dr.	Sérvio Túlio Prado Júnior	(Co-Supervisor FGV)

With their advice and continuous feedback they gave me orientation and confidence, and helped me to better structure my research approach. Moreover, by pointing out possible changes to my drafts they repeatedly contributed to a significantly improved and refined final outcome.

Furthermore, my thank goes to the people at the University of St.Gallen and Fundação Getúlio Vargas. On the one hand, I thank the people in the administration of the two institutions. They made my double-degree programme possible and offered great support, thereby allowing me to fully concentrate on writing my thesis. In this regard, I wish to especially thank Professor Tales Andreassi and Maria Cecilia Menezes. On the other hand, I appreciate the valuable inputs of my fellow students and the inspiring conversations we had together.

Finally, I especially thank the people who generously offered their time for giving me an interview for this thesis:

Prof. Dr.	Henning Schulzrinne	(United States Federal Communications Commission)
Prof. Dr.	Guido Schuster	(University of Applied Sciences of Eastern Switzerland)
	Stefan Hagenbuch	(Microsoft Schweiz GmbH)
	Jens Hünerberg	(Accenture AG)
	Peter Kopp	(Siemens Building Technologies – Siemens Schweiz AG)
	Daniel Rincón Hanna	(Swisscom AG)

All of them very openly shared their knowledge with me, which helped me to better understand the topic, to grasp the most important trends in the industry, and to anticipate how Voice over IP will develop further.

Many thanks to all of you,

Benjamin Harder

Table of Contents

1. Introductory Section ... 1

1.1. Problem Analysis ... 1

1.2. Goal ... 3

1.3. Research Design ... 3

1.4. Definitions ... 5

1.5. Delimitation of research area ... 6

2. General Theoretical Section ... 7

2.1. Introduction into Scenario Technique ... 7

2.2. Diffusion of Innovations and S-Curve Model ... 11

2.2.1. Innovation ... 11

2.2.2. Diffusion ... 13

2.2.3. Rate of Adoption ... 14

2.2.4. Relation between Innovation S-Curve and Rogers' Diffusion Model ... 16

2.3. The History of Telecommunications ... 18

2.4. Comparing VoIP and PSTN ... 21

2.4.1. Network Architecture ... 21

2.4.2. Advantages and Disadvantages ... 26

2.5. The First Wave of VoIP ... 30

2.5.1. Business Models in 2004 ... 30

2.5.2. Expected Diffusion Process Around 2004-2006 ... 32

2.6. Look Through the Rear Mirror: VoIP 1.0 a Revolution? ... 34

2.6.1. Competing Revolution: Mobile Telephony ... 34

2.6.2. Upshift of PSTN-Curve: There's Life in the Old Dog Yet ... 36

2.6.3. Downshift of VoIP-Curve: Inability to Deliver Value ... 37

2.6.4. Effective Impact of VoIP from 2000-2010 ... 39

2.7. Road Ahead: All over IP? ... 40

2.8. Conclusion of the General Theoretical Section ... 43

3. Specific Empirical Section ... 45

3.1. Empirical Objective ... 45

3.2. Empirical Methodology ... 45

3.3. Limits of the Empirical Study ... 46

3.4. Empirical Findings: Factor Analysis of Supply Side ... 46

3.4.1. Business Model ... 46

3.4.1.1. The Operator's Incentive to Advance VoIP ... 46

3.4.2. Customer Base ... 49

3.4.2.1. Adoption Awareness ... 49

3.4.2.2. Network Integration ... 50

3.4.3. Regulatory Aspects ... 52

3.4.3.1. Lawful Interception ... 52

3.4.3.2. Emergency Services ... 53

3.4.3.3. Anti-Trust Legislation for OTTs ... 55

3.4.4. Incumbent Telecommunication Operators ... 56
3.4.4.1. Defensive Moves ... 56
3.4.4.2. Pro-active Reactions ... 57
3.5. Empirical Findings: Factor Analysis of Demand Side ... 59
3.5.1. Reliability ... 59
3.5.1.1. Network Accessibility ... 59
3.5.1.2. Permanence of Connection ... 60
3.5.2. Quality ... 60
3.5.2.1. Guaranteed Service Level of the Network ... 60
3.5.2.2. Voice Codecs ... 61
3.5.3. Price ... 62
3.5.3.1. Switching Costs ... 62
3.5.3.2. Costs Per Call ... 63
3.5.4. Functionality ... 66
3.5.4.1. Additional Features ... 66
3.5.4.2. Operability Advantages ... 66
3.5.5. Convenience ... 67
3.5.5.1. User Experience ... 67
3.5.5.2. Backward Compatibility ... 69
3.5.6. Security ... 70
3.5.6.1. Data Privacy ... 70
3.5.6.2. Encryption ... 71
3.6. Synthesis and Discussion of Results: Most-Likely Scenario ... 71
3.6.1. Residential Telephony ... 71
3.6.2. Business Telephony in Small and Medium Enterprises ... 72
3.6.3. Business Telephony in Larger or International Companies ... 73
3.6.4. Mobile Telephony ... 73
3.6.5. The Big Picture ... 75
4. Concluding Section ... 76
4.1. Practical Recommendations ... 76
4.1.1. For Telecommunication Providers ... 76
4.1.2. For Software Companies ... 78
4.2. Possible Areas for Further Investigations ... 79
Appendix ... 81
A1. Summary of Scenario Factor Analysis ... 81
A2. List of Figures ... 83
A3. List of Exhibits ... 84
A4. List of Abbreviations ... 85
A5. List of Interview Partners ... 86
A6. Interview Guide ... 88
A7. List of Literature ... 92
A8. List of Internet Sources ... 99
A9. Declaration auf Authorship ... 104

1. Introductory Section

1.1. Problem Analysis

"Within 10 years, there will not be much left other than Voice over IP." [1]

Dorgham Sisalem (2004)[2]

Since Alexander Graham Bell patented the telephone in 1876 much has changed in the telecommunication industry. Constant advances in technology have increased the reliability and quality of today's telecommunication channels, and allowed for innovations such as the mobile phone or the internet. (Huss & Kollrich, 2011; Shiratori & Atiquzzaman, 2004)

This progress has brought multifaceted consequences. First, our society has been transformed into an "information society" that demands efficient and unimpeded access to information sources, and that therefore strongly relies on telecommunication services (OFCOM, 2010). The internet usage reflects this change. Over the last twenty years, the medium has become an essential part of almost everyone's life. Today, the transformation process in continued by mobile internet that daily attracts more users and renders the access to information omnipresent for our society (BFS, 2011; BITKOM, 2010; Rao, Angelov, & Nov, 2006).

Secondly, the advances in technology also caused traditionally distinct media, such as television, telephony or internet to move closer together and the boundaries between them to blur or even to vanish (Bonnekoh, 2006). In accordance with Schumpeter's (1943) theory of innovation and creative destruction, such technological approximation induces change in the industry. On the one hand it enables novel business opportunities to arise; on the other hand new solutions threat established value chains and sometimes even endanger incumbent companies in their mere existence. (Nyström & Hacklin, 2005; Rao, Angelov, & Nov, 2006; Wirtz, 2001)

One innovation that exemplifies this convergence and which in the last ten years has been discussed extensively in both literature and corporate boardrooms is Voice over IP (VoIP) (Nyström & Hacklin, 2005; Shiratori & Atiquzzaman, 2004). The inner workings of VoIP fundamentally differ from traditional telephony. The latter establishes a direct connection between the communication partners through the strictly hierarchically organized telephone network. Once the route has been established it is exclusively reserved for this call and cannot be used for other services (e.g. the transmission of calls of other people). The terminology refers to this kind of connection as "circuit switching". VoIP, in contrast, uses "packet switching". The voice signals on either caller's side are digitised and split into data packets that then are transmitted over the internet to the conversation partner, where they are aggregated once again and converted to sound signals. The route the

[1] Own translation from German. Original: "In spätestens 10 Jahren wird es praktisch nichts anderes mehr geben [als VoIP]" (Hilmar, 2004, p. 162).

[2] Dr. Dorgham Sisalem worked as a researcher and head of department at the Fraunhofer Institute for Open Communication Systems and is now Director of Strategic Architecture at Tekelec, a NASDAQ-listed telecommunication-equipment manufacturing company.

data packets take to arrive at their destination is not pre-defined and can vary for every single packet. (Hensel & Wirsam, 2008; Lyytinen & Rose, 2003)

The difference in their technical nature is responsible for a set of virtues that VoIP exhibits over traditional telephony, for instance cost advantages. On the consumer side, VoIP allows users to terminate the contract for the telephone subscriber line, as it is substituted by the internet access. Furthermore, VoIP significantly lowers infrastructure and maintenance costs, as a separate infrastructure for telephone services besides the internet infrastructure can be eliminated. Finally, many VoIP operators offer free calls between their clients, for which the costs per call are reduced (Franke, Hannemann, Kietzmann, & Lehmkuhl, 2005; NAIRSC, 2004; US FCC, 2010). On the operator side, VoIP allows for an almost infinite number of concurrent calls, while the capacity of the traditional telephone network is fairly limited. VoIP operators therefore can allocate overhead costs to more customers and hence enjoy a clear cost advantage. Moreover, VoIP is more flexible than traditional telephony that requires large investments if additional functional services are to be offered, while VoIP services often only need a software enhancement for delivering the same benefits. (!Dol, 2010; Bonnekoh, 2006; Henkel, 2009; Jackson, Shorter, & Forcht, 2009)

It hardly surprises that when market penetration of VoIP slowly gained traction there was a wide consensus amongst both practitioners and researchers that the technology had large potential to bring about change to the telecommunication industry (NAIRSC, 2004; Oliver Wyman, 2004; Rao, Angelov, & Nov, 2006; Winkelhage, 2005). Michael Powell, Head of the US Federal Communications Commission (US FCC) at that time summoned a “VoIP Revolution” (Kapustka, 2004) and some experts even considered incumbent telecommunication operators as an endangered species that would soon be replaced by VoIP operators (Franke, Hannemann, Kietzmann, & Lehmkuhl, 2005; Winkelhage, 2005). The opening quotation of this paper accentuates this notion.

In short, the established telecommunication operators were expected to struggle with the new competition. In 2004, market research suggested an annual decrease in revenues of 6-9% for European landline operators over the next years (Henkel, 2009). The sombre forecast seemed reasonable, indeed, as VoIP was growing at a breath-taking speed. Founded in 2002, the revenue of US-based VoIP provider Skype, for instance, already exceeded 7m USD in 2004 and hovered around 60m USD in 2005 (Thor, 2011).

Only four years later, however, the initial euphoria about VoIP had vanished. The anticipated “VoIP revolution” had not taken place and the large and incumbent telecommunication providers were still the strongest operators in the market. Furthermore, between June 2005 and October 2007, as many as 256 VoIP start-ups shut their doors, destroying billions of shareholder value (Bell, 2008; myVoipProvider, 2009). Jonathan Christensen, general manager for audio and video at Skype, summarized the situations as follows (Dinan, 2008):

“VoIP is dead!”
Jonathan Christensen (2008)

1.2. Goal

It is the objective of the paper at hand to examine the phenomenon Voice over IP more closely and to shed light on its potential to penetrate and to bring about change to the telecommunication industry. The reader on the one hand is offered an analysis of the status quo and how telecommunications and VoIP in particular have evolved to present. On the other hand, the factors behind the diffusion of VoIP are studied and a most-likely scenario is derived how VoIP will evolve in the future. Based on this outlook, conclusions for traditional telecommunication operators and software companies are drawn.

In short, the following main research questions shall be answered in this thesis:

(1) How has VoIP impacted the telecommunication industry to date?

(2) What is the potential of VoIP 2.0 / IP2IP to substitute traditional telephony?

   a. What are the drivers of IP2IP diffusion?
   b. What is the most likely-scenario of how IP2IP will develop?
   c. What are the consequences of this evolution for incumbent telecommunication operators?
   d. What is the future role of software companies due to this evolution?

As a subset of these questions, also the following ones shall be addressed:

(1) How has the telecommunication industry evolved to date?
(2) What are PSTN, VoIP and IP2IP and what is the difference between them?
(3) Why do certain authors consider VoIP to be dead?
(4) What are strategies for telecommunication operators to react to the diffusion of VoIP and IP2IP?
(5) What are critical considerations for software companies entering the telecommunication market?
(6) What are research gaps that could be eliminated in the future?

1.3. Research Design

This thesis follows a qualitative and inductive approach. It is inductive, as the goal of the thesis is not to test an existing hypothesis or reject a certain theory, but rather to find answers to the research questions formulated above. Thus, the aim is to develop rather than to test a theory, and the hypotheses are the output of this exploratory process (Flick, 2009; Schmid, 2010).

The research process is a qualitative one, as it is the objective of the thesis to holistically understand the phenomenon VoIP in its totality and context by means of qualitative data, rather than explaining a selective number of relationships with a limited number of quantitative variables (Mintzberg, 1979; Schmid, 2010). As Punch (2005, p. 56) puts it, qualitative data is “empirical information about the world, not in form of numbers”, enabling qualitative research to closely capture real-life phenomena. Thus, the chosen qualitative research approach allows for an in-depth, fine-grained and nuanced understanding of the topic (Langley, 1999; Mayring, 2002; Punch, 2005; Yin, 2009).

Primarily, this thesis builds on literature on the topic, including books, articles in journals and newspapers, business reports and electronic documents. Given the fast rate of change to which the topic VoIP is subjected, close attention has been paid to mainly rely on recent sources. As it is inevitable that the outcome of qualitative research is subjectively influenced to a certain degree by the researcher (c.f. Punch, 2005, p. 58) the conclusions drawn are verified by interviews with industry experts. Although this may not alleviate subjectivity entirely, it still helps to mitigate the problem.

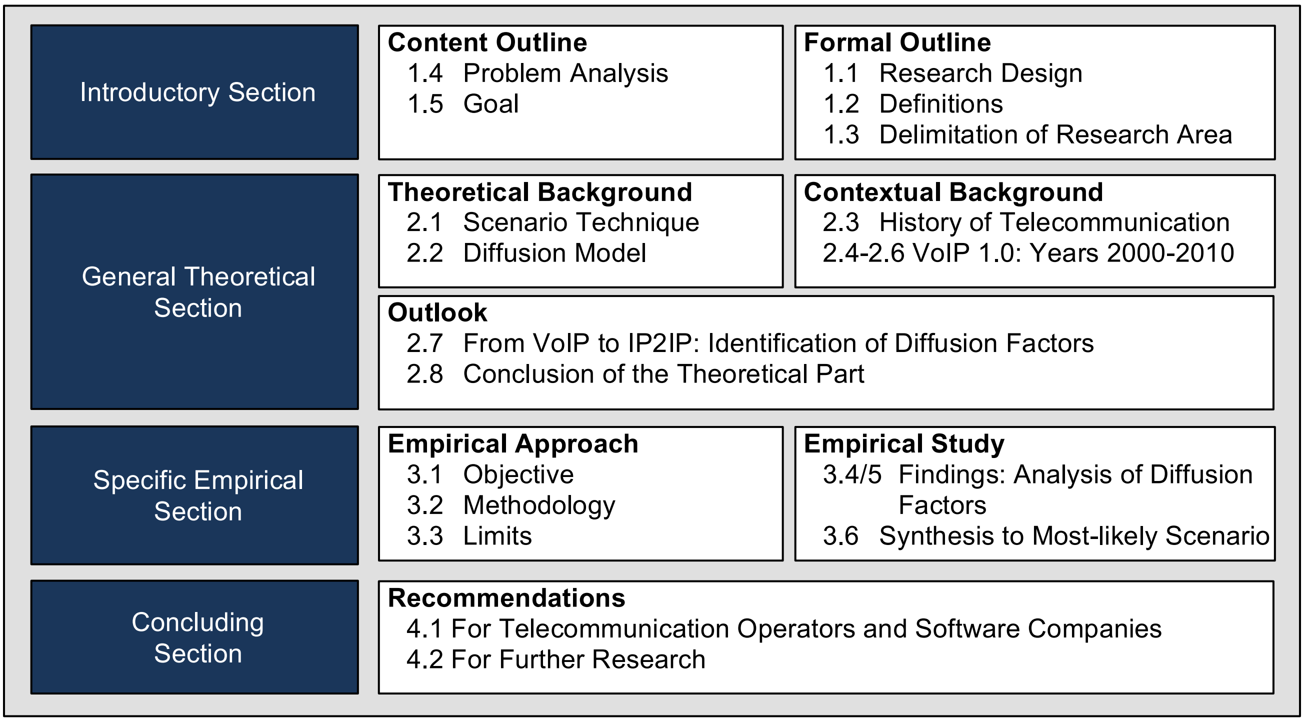


Figure 1: Research Design.

Source: Own illustration.

As is shown in Figure 1, this paper has been divided into four sections. In the introductory section, the research goal and questions are stated, which provides the rough content outline for this paper. Furthermore, the research approach is presented, essential definitions are provided and the scope of this investigation is defined.

In chapters 2.1 and 2.2, the theoretical frameworks are introduced upon which this thesis is built. In chapter 2.1, light is shed on the scenario technique that is used in chapters 3.4-3.6 to develop a most-likely scenario of how IP2IP telecommunication will evolve. Chapter 2.2 is concerned with Everett M. Rogers' Diffusion Model (1962, 2003) and the link of it to Clayton M. Christensen's S-Curves (1992a, 1992b). Also, the line between the terms "innovation", "idea" and "invention" is drawn.

The contextual background of this thesis is provided by chapters 2.3 thru 2.6. First, the main events since the invention of the telephone until 2004 in the area of fix and mobile telephony and the internet are summarized. Then, the first wave of VoIP (VoIP 1.0) is examined more closely. On the one hand, the technological aspects by which VoIP differs from traditional telephony are presented (chapter 2.4). On the other hand, chapters 2.5 and 2.6 study the impact VoIP 1.0 has had on the telecommunication industry up to the present day and the degree to which it has released its attributed revolutionary potential.

Chapter 2.7 takes a leap forward and seeks, with the lessons learnt from the past, to contour the future of VoIP (VoIP 2.0/IP2IP) and to isolate the factors that determine for diffusion of IP2IP telecommunication. Finally, chapter 2.8 summarizes the findings of the general theoretical section.

It is the goal of the specific empirical section to develop a most-likely scenario of how IP2IP telecommunication will diffuse (chapter 3.6). Therefore, the drivers behind the diffusion process identified in chapter 2.7 are examined more closely (chapters 3.4 and 3.5). The findings in these two chapters are substantiated through interviews with industry experts, which shall help – as has been stated above – to increase the objectivity of this paper. The goal, methodology and limits of the empirical approach are expounded in chapters 3.1 thru 3.3.

The concluding section identifies how the developed most-likely scenario of IP2IP diffusion will affect telecommunication operators and software companies. Plus, recommendations are given how these companies may deal with the anticipated future (chapter 4.1). Ultimately, chapter 4.2 highlights areas for possible future research.

1.4. Definitions

The terms “PSTN”, “VoIP”, “IP2IP”, “Diffusion” and “Innovation” are essential parts of this thesis, and in literature numerous definitions of them exist. A disambiguation therefore is indispensable, which will be done in greater depth in the general theoretical section. Other terms that require explanation and serve as a base for the understanding of this paper are defined below.

Telecommunications: The exchange of information over distance by electronic means (c.f. TechTarget, 2007).

Network: The arrangement by which the telecommunication services are transmitted between the participants (e.g. internet; telephone network).

Telecommunication Provider: A company operating parts of the telecommunications network. In this thesis, with telecommunication provider/operator/carrier the company is meant that interconnects the end-user to the network.

Incumbent Telecommunication Provider: The “incumbents” are the classic telecommunication providers such as Deutsche Telekom or AT&T that for long time in history were state-owned monopolists. In many countries still today they control large shares of the market. Often they are referred to as “Incumbent Local

Exchange Carriers" (ILECs). Since many markets have been liberalized, they now increasingly face competition from the "Competitive Local Exchange Carriers" (CLECs). (ITWissen, 2012)

Telephone: The device that people use to make phone calls.

Telephony: The technology that allows people to make phone calls (Unuth, n.d.).

Telephony User: The human being that uses the telephony device. Synonyms: Consumer; Customer.

Telephony Client: The technical solution that enables the consumer to use the telephony service. This may either be a hardware device such as a classic telephone, or a software solution.

1.5. Delimitation of research area

The thesis at hand aims to provide a general understanding of what VoIP is, how it evolved to date, and it seeks to develop a most-likely scenario of how its on-going development will impact the telecommunication industry going forward. With this objective the paper targets managers as its audience. For a more technical discussion of the topic, the reader is relegated to the contributions of other authors, such as Camarillo & García-Martín (2008), Shatzkamer & Wierenga (2011), Sauter (2009, 2011), or, for a study of the legal frameworks surrounding VoIP to Bonnekoh (2007), Cannon, 2005), Henkel (2009), Landgrebe (2006), Meisel & Levin (2003), Meisel & Needles (2005), or Nieminen (2004).

The data processed for building the most-likely scenario in chapters 3.4 thru 3.6 has mainly been retrieved from sources that are linked to Germany and Switzerland. Thus, although the conclusions drawn from this thesis may also be valid for other geographical regions, the effective development may also considerably differ outside of these two countries. Furthermore, the most-likely scenario is developed for the year 2022, which translates to a ten-year forecast. Given the large ambiguity to the factors behind the diffusion of VoIP, however, the diffusion may also occur faster or slower than anticipated.

2. General Theoretical Section

2.1. Introduction into Scenario Technique

It is the goal of the general theoretical section to provide the theoretic and contextual background for the development of the most-likely scenario in the specific empirical section. A scenario is an internally consistent view of how the world will look in the future based on a range of assumptions (Chermack, 2011; Porter, 1985). In other words, the development of scenarios helps to anticipate the future industry landscape and to estimate how a multitude of factors with undetermined statuses will impact it. Scenario technique is a structured method for reducing complexity with the purpose of reaching a more comprehensive system understanding. It acknowledges the uncertainty inherent in every forecast by breaking down the total ambiguity to sub-issues that are more assessable in order to arrive at a more communicable, tangible and substantiated overall projection. (Grienitz & Schmidt, 2010; Odenthal & Hess, 2008; Wolf, Zerres, & Zerres, 2010)

According to Odenthal & Hess (2008, p. 105ff), the clear definition of the parameters, i.e. the industry, time horizon and geographical scope, is a prerequisite for the development of any scenario. Furthermore, scenarios should always fulfil three criteria:

(1) **Likelihood:** The events should have the potential to become reality.
(2) **Coherence:** The events should logically fit each other.
(3) **Uniqueness:** Each scenario should be different from the others.

Conway (2003) argues that two extreme scenarios set the boundaries of all scenarios that have a somewhat reasonable chance to occur. Beyond these extreme scenarios, the criteria likelihood is not fulfilled anymore (cf. Wolf, Zerres, & Zerres, 2010). The "Plausible Range" forms the set of scenarios that have an even in-

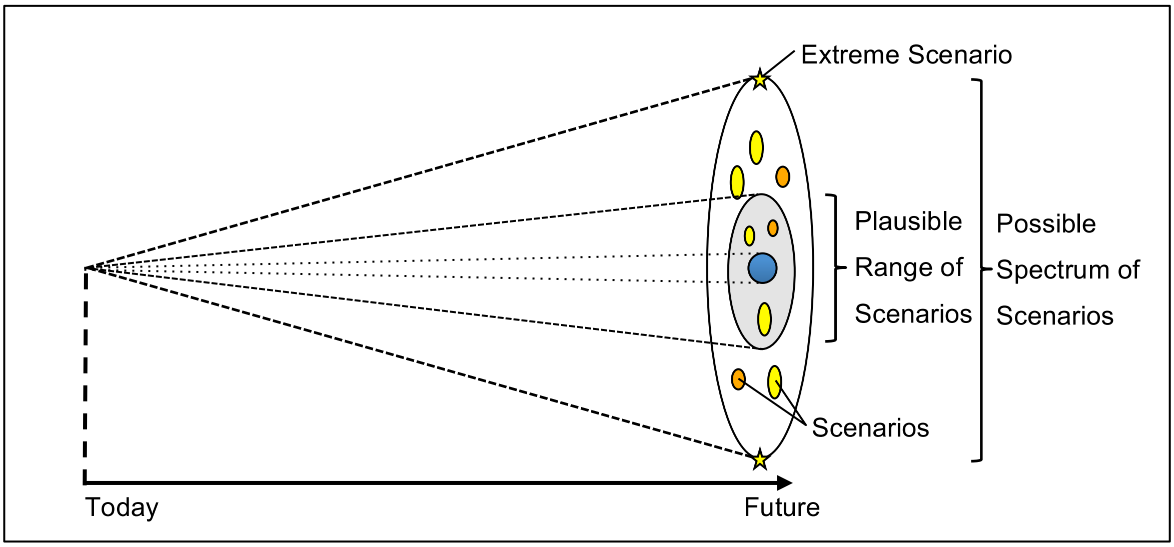


Figure 2: The Scenario Funnel.

Source: Own illustration, adopted from Conway (2003), Geschka & Hammer (1990) and Haag & Scharf (2004).

creased probability to materialize, as is depicted in Figure 2. Of all the scenarios, the one that has the highest likelihood to prevail is commonly referred to as the “Most-likely Scenario” (Odenthal & Hess, ibid.).

Various authors have suggested the following three steps to generate sophisticated scenarios, a process which is illustrated in Figure 3. With the set parameters in mind (i.e. industry, geographical scope, and time range), in the first step factors that are likely to have a future impact are identified both within the company and its surroundings. These factors then are positioned on an impact-uncertainty matrix. (Gausemeier, 2004; Odenthal & Hess, 2008)

In order to prevent a loss of focus, the entirety of factors is narrowed down to the most relevant ones, i.e. those with a large impact on the future. These factors, the so-called “Scenario Drivers”, can be divided into two categories; the certain ones on the one hand, and the uncertain ones on the other hand. They differ from each other in the sense that the certain scenario drivers affect every scenario in the same, predictable and almost certain way, while there is ambiguity to uncertain scenario drivers. Therefore, in a second step, uncertain factors require a separate and more thorough examination in which the range of their possible states is determined.

In the third and final step, the certain and uncertain factors are aggregated to scenarios. The scenarios differ from each other as a result of the differences in the underlying assumptions made during the assessments of the uncertain factors. The “Most-likely Scenario” is the one that is formed by sum of all uncertain scenario drivers in their most likely state and the high-impact certain scenario drivers. (Finke & Siebe, 2001; Gausemeier, 2004; Odenthal & Hess, 2008)

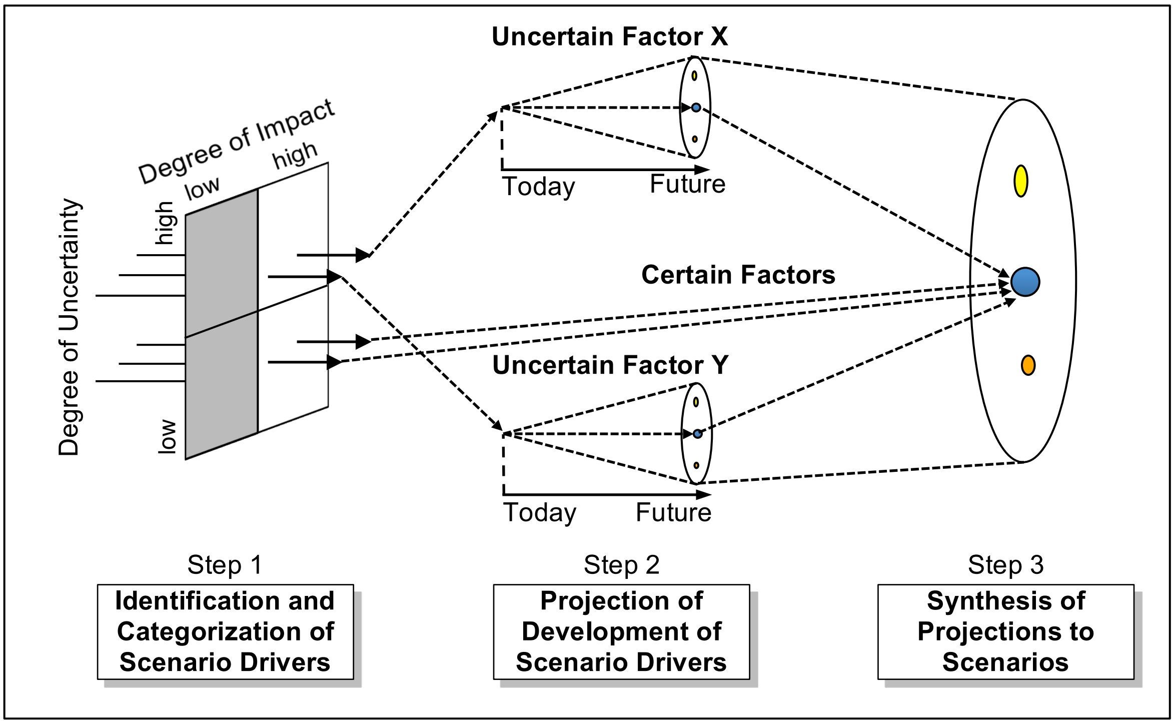


Figure 3: Development of Scenarios in Three Steps.

Source: Own illustration, adopted from Finke & Siebe (2001), Gausemeier (2004) and Odenthal & Hess (2008).

An example shall concretize this introduction to the scenario technique. Assume the development of attractiveness of the steel industry in Switzerland in 1983 over five years was to be assessed. In this case, the general requirement is met that the industry, time horizon and geographical scope should be clearly defined when elaborating scenarios (c.f. Odenthal & Hess, 2008).

Plenty of factors exist to determine the attractiveness of such industry, and certainly a PESTLE analysis or Porter's Five-Forces model could help to identify many of them (Allen, 2001; Porter, 1995). These factors would then be placed on the impact-uncertainty matrix. For the example at hand the number of factors that have been identified has been limited to four – one example for each quadrant of the matrix (see Figure 4).

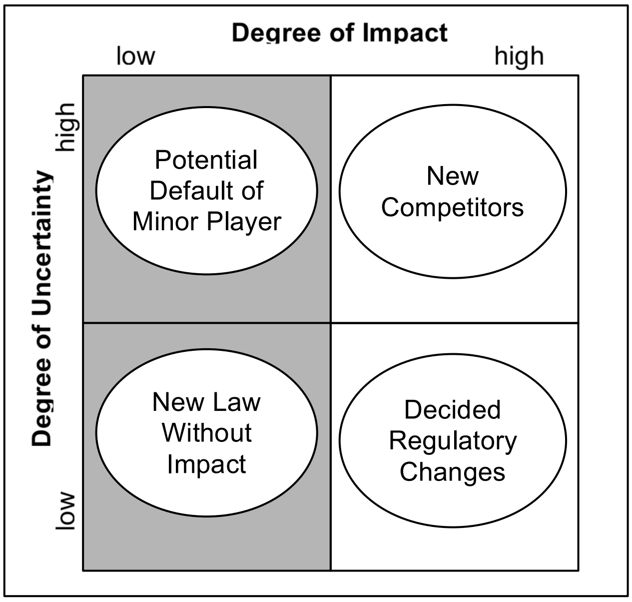


Figure 4: Example of Impact-Uncertainty Matrix.

Source: Own illustration, adopted from Odenthal & Hess (2008).

The default of a competitor would have an effect on the overall profitability of the steel industry and hence its attractiveness. But because the company in question is only a small player, the effect would probably be negligible. Furthermore, for an external observer it is difficult to assess the likeliness of this event ex-ante, as the necessary data is not publicly available. Given the low impact and high uncertainty of this event, it classifies for the top left quadrant of the impact-uncertainty matrix.

Strict environmental laws usually impose severe constraints on steel companies and therefore lower the market attractiveness. In Switzerland, the proposal of introducing a law to protect the environment was first discussed in parliament in 1965. However, it took until 1983 – a total of 18 years – until the law was finally coming into effect (BAFU, 1988). By then, most companies had already adopted a much more responsible behaviour, for which they were not affected by the new regulation. The example illustrates an event that at first glance seems to have an impact on the attractiveness of the industry, but has to be classified as irrelevant due to its low impact given the contextual situation.

Because of the little impact certain factors have – such as the ones presented above – they are disregarded when elaborating the projections of the future market attractiveness; in contrast to high-impact factors.

For instance, if another new law recently had passed in parliament that would tighten the capital regulations for industry companies the situation would be different than with the environmental law discussed above[3]. Assume that once effective the new law would require steel companies to hold a significantly larger portion of equity on their books than in the past. Higher capital requirements directly lower the return on equity and therefore have a strong and direct impact on the industry attractiveness. First, as the impact is substantial, this factor qualifies as "Scenario Driver" for which it should be considered when building the scenarios. Secondly, as the law has already been approved in parliament and it is only a matter of time until it will come into effect, there is no ambiguity about how the factor will affect the future. Due to this definitiveness, the new law qualifies as "Certain Scenario Driver", and every scenario should account for its impact. To better disclose the certain scenario drivers that are considered in the scenario generation process, it makes sense to depict them in a list, as is illustrated in Figure 5.

Certain Driver	Certain End-Point
Law on Capital Requirements	At Least 50% Equity Required
Driver X	Description of End-Point
Driver …	Description of End-Point

Figure 5: Example of Certain Scenario Driver Analysis.

Source: Own illustration, adopted from Odenthal & Hess (2008).

Finally, an example of an "Uncertain Scenario Driver", a high-impact factor with a somewhat uncertain outcome shall complete this introduction to scenario technique.

Competitors entering the market can cause an oversupply of steel, the fall of prices, or a battle for clients. All these events have a large impact on the industry attractiveness (Porter, 1995). However, whether competitors will enter the market or not is uncertain and assumptions must be made. The range of assumptions is limited by the most extreme states that are reasonable (c.f. Figure 6). In the next step, the value of this range is chosen that corresponds to the type of scenario one is trying to evaluate. For instance, if an optimistic scenario is to be built, a more optimistic value within the identified boundaries of possible states is chosen. Thus, identifying the range of possible outcomes and selecting a value on this range according to the scenario type one is trying to build helps to state and quantify the assumptions behind the overall scenario.

The entirety of certain scenario drivers and uncertain scenario drivers in their state corresponding to the scenario one is trying to build (e.g. optimistic) are aggregated to the overall scenario. As every overall scenario relies on different values of the ranges of the uncertain scenario drivers, each overall scenario fulfils the criteria of being "unique" (cf. Odenthal & Hess, 2008).

[3] This example is purely fictional and has the sole purpose of serving as an illustration of the scenario technique.

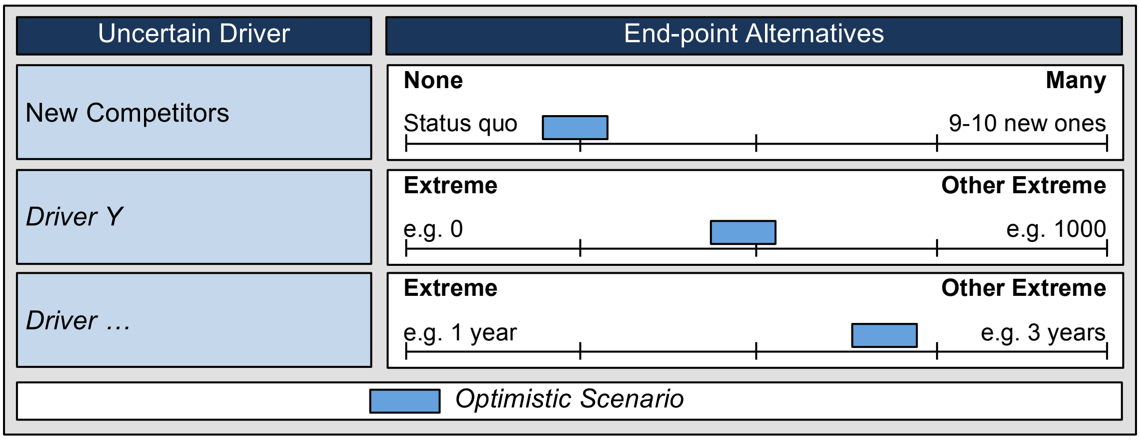


Figure 6: Example of Uncertain Scenario Driver Analysis.

Source: Own illustration, adopted from Odenthal & Hess (2008).

2.2. Diffusion of Innovations and S-Curve Model

In abstract terms the paper at hand is an analysis of the diffusion potential of an innovation. Therefore, hereafter a second theoretical concept is introduced that takes a closer look at the diffusion process of innovations and the factors determining the speed by which innovations substitute one another.

2.2.1. Innovation

In the academic discussion a generally accepted definition of the term "Innovation" is missing, and often it is confused with other concepts that are similar yet different, i.e. "idea", "creativity" or "invention". Following Levitt (2002), the term "creativity" refers to the ability of the mind to produce unconventional, new and great ideas. The "idea" hence is an outcome of "creativity", a purely abstract product only existing in the mind of a person. The term "invention" reaches further, and it describes an event, when an idea is converted to a real-life object (c.f. Roberts, 2007; Amidon, 1998). But what is "Innovation"? The following quotes of well-respected authors of the economic sphere shall help to explain the difference between this and the aforementioned terms:

Joseph Schumpeter (1912): *Innovation defined as ideas applied successfully in practice, for instance the introduction of new goods, new methods of production, the opening of new markets, the conquest of new sources of supply, etc.* (Schumpeter, 1912, as cited in Howlett, 2010, p. 3).

Victor A. Thompson (1965): *Innovation is the generation, acceptance and implementation of new ideas, processes, products or services in an applied setting* (Thompson, 1965, as cited in Jenny, 2006).

Peter F. Drucker (1986): *[Innovation is] change that creates a new dimension of performance* (Drucker, 1986, p. 276, as cited in Keuber, Schomann, & Zimmermann, 2010, p. 259).

Michael E. Porter (1990): *Innovation is a new way of doing things that is commercialized. It is turning ideas into cash* (Porter, 1990, as cited in Van Latesteijn & Andeweg, 2011, p. 5).

Jose Campos (n.d., ca. 1999): *Innovation is the ability to deliver new value to a customer* (Campos, as cited in Bobiatynski, Gehrmann, & Krause, 2005, p. 53).

Theodore Levitt (2002): *Creativity is thinking up new things. Innovation is doing new things* (Levitt, 2002, as cited in Hindle, 2008, p. 263).

Everett M. Rogers (2003): *Innovation is an idea, practice, or object perceived as new by an individual or other unit of adoption* (Rogers, 2003, p. 36).

Edward B. Roberts (2007): *The invention process covers all efforts aimed at creating new ideas and getting them to work* (Roberts, 2007, p. 36).

Most of the cited definitions share the understanding that a core aspect of "Innovations" is that they are more than just put into practice, i.e. that they are commercialized or deployed in an internal setting (c.f. Campos, as cited in Bobiatynski et al., 2005; Porter as cited in Van Latesteijn & Andeweg, 2011; Schumpeter as cited in Howlett, 2010; Thompson as cited in Jenny, 2006). Roberts (2007, p. 36) summarizes this notion precisely: "*Innovation = Invention + Exploitation".*

Etymologically, at the radical of the word "Innovation" the Latin word "novum" is found, which can be translated into "newness" or "renewal", another important facet of innovations (Jenny, 2006, p. 7). Hübner (2002, p. 10) distinguishes between objective and subjective newness. *Objective newness* describes the emergence of an innovation that is new to the world, which therefore can happen just once for a given innovation. *Subjective newness*, in contrast, considers an innovation as new as long as it is perceived as such by the unit of adoption. Thus, following the latter definition, innovation can happen more than once.

In adoption of the definitions above and oriented at the concept of subjective newness, the term "Innovation" shall be defined as follows for the subsequent use in this paper:

> *Innovation is the generation, acceptance and implementation of ideas, processes, products or services in an applied setting in a way that is perceived as new by a unit of adoption.*

The scientific contributions of the recent years to the topic innovation management have resulted in rich discussions, pointing out various aspects of innovations and proposing many ways of how to categorize them (Carayannis & Wetter, 2004; Schöberl, 2008).

Foster (1986), for instance, studied the relationship between incumbent firms and emerging innovations and he found that often companies entrench themselves and fail to see the end of an innovation life cycle. As a result, in his view, companies building on newer innovations often replace incumbent firms. Christensen (1992a; 1992b) refuted this absolute notion of "attacker's advantage", yet he adopted and refined the S-Curve Model Foster had introduced and he, together with Bower, suggested a distinction into *sustaining* and *disruptive technologies* (Christensen & Bower, 1995). Later, Christensen (2006, p. 43) argued that using the term *technology* in this context was misleading, because it is not the technology of an innovation per se that is disruptive, but the impact it has on the business model of the incumbent firms. In this context, the term "business model" shall be understood as follows (Osterwalder & Pigneur, 2010, p. 14):

A business model describes the rationale of how an organization creates, delivers and captures value.

Therefore, Christensen refined his earlier distinction into *sustaining (SI)* and *disruptive innovation (DI).* While SI enhance the business models of the incumbent firms by giving customers something more or better in the attributes they already value, DI result in a very different value proposition and challenge the existing business models (Christensen, 2006; Christensen & Bower, 1995). Often, a DI initially underperforms existing products of the mainstream market, for which it is financially unattractive the leading incumbent firms. However, over time, subsequent developments raise the performance of the DI above the level of the existing products. As a result, the DI becomes satisfactory for mainstream customers and begins to challenge existing business models. (Schöberl, 2008)

In literature the SI/DI concept is certainly amongst the most debated categorizations for innovations. Other classifications that received similar levels of attention include the categorizations *radical vs. incremental*, *pull vs. push*, and *product vs. process*. However, due to the limitation to the extent of this paper, these concepts cannot be analysed in more depth at this point, and reader is relegated to the fruitful contributions on the subject of other authors (c.f. Griffin, 2011; Robert, 1998; Stummer, Günther & Köck, 2010; Vahs & Burmester, 2002).

2.2.2. Diffusion

Numerous authors have contributed to diffusion research and a multitude of definitions of the term exist. Adopting the innovation definition from the previous chapter, "Diffusion" can roughly be understood as the process by which an innovation becomes spread and adopted more widely in an applied setting (cf. Brockhoff, 1999; Rogers, 2003; Königstorfer, 2008; Oxford Dictionaries, 2010).

Basic sources that strongly influenced the field of diffusion research are the Theory of Reasoned Action (TRA; c.f. Fishbein & Ajzen, 1975; 1980), the Theory of Planned Behaviour (TPB; cf. Ajzen, 1985; Ajzen & Madden, 1986) and the Theory of Diffusion of Innovations (Rogers, 1962; 2003).

TRA, and its extended concept, TPB, aim to describe "virtually any human behaviour" (Fishbein & Ajzen, 1980, p. 4), including the adaption of innovations. In other words, TRA/TPB seek to explain diffusion by raising the question "How does an individual choose whether to adapt an innovation?" Thus, these theories analyse how the characteristics of an individual and his or her surroundings influence him or her to follow a certain behavioural pattern (Königstorfer, 2008). TRA/TPB strongly influenced much of the later Anglo-American acceptance and adoption research, such as the Technology Acceptance Model (TAM; cf. Davis, 1986), the TAM2 (cf. Venkatesh & Davis, 2000), the Motivational Model (Davis, Bagozzi & Warshaw, 1992), the Diffusion Process Model (Gatignon & Robertson, 1985), or the Unified Theory of Acceptance and Use of Technology (cf. Venkatesh, Morris; Davis & Davis, 2003). In the Anglo-American research the TAM today is the most widely used model for explaining the acceptance of technologies. (Königstorfer, 2008; Rivera Green, 2005)

Rogers' diffusion theory is often used to explain the accumulated adoption of an innovation in a society over time. As Rogers' analyses the adoption process on a society-level, the characteristics of the individual are much less important compared to the theories that are rooted in the TRA/TPB model, which primarily analyse the adoption process of a single individual. Rogers seeks to explain diffusion mainly, but not exclusively, by the characteristics of an innovation. (Königstorfer, 2008)

It is the objective of this paper to analyse the potential and limits of the voice over IP technology for which the unit of adoption is the society. Given this focus, this paper draws on the diffusion model of Rogers in order to explain the diffusion process, rather than on other conventional models that focus more on the individual rather than the society as a whole.

Rogers (2003, p. 11) defines the term "Diffusion" as follows, which shall serve as the basis for this paper:

> *Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.*

Figure 7 summarizes the distinction of the innovation-related terms.

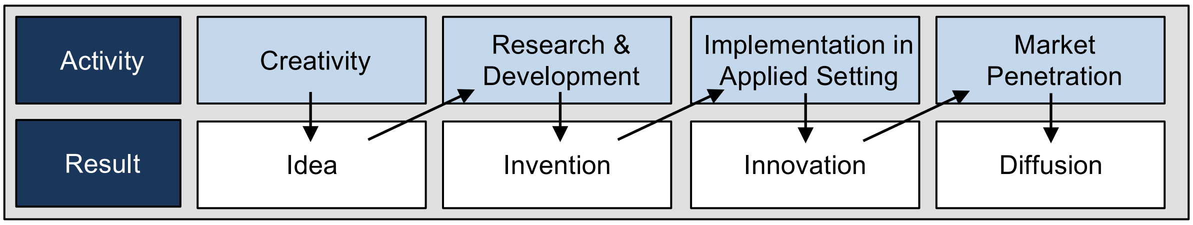


Figure 7: Distinction of Innovation-Related Terms.

Source: Own illustration, adopted from Brockhoff (1999, p. 38).

2.2.3. Rate of Adoption

The "Rate of Adoption" is the "relative speed by which an innovation is adopted by members of a social system". Essentially, it determines how fast a diffusion process takes place (Rogers, 2003, p. 221). Rogers identifies five factors that influence this rate of adoption (see also summary in Figure 8).

(I) Perceived Attributes of Innovations

The five attributes (1) *relative advantage*, (2) *compatibility*, (3) *complexity*, (4) *trialability*, and (5) *observability* provide a standard classification scheme to describe innovations in universal terms. *Relative advantage* is the degree to which an innovation supersedes a preceding one in terms of economic profitability, social prestige, or other specific types of advantage (Rogers, ibid. p. 229). *Compatibility* measures the degree to which an innovation is consistent with the needs of potential adopters, their past experiences and existing values (Rogers, ibid., p. 240). *Complexity* expresses how difficult an innovation is to use and understand. *Trialability* measures the extent of potential adopters' possibility to experiment with an innovation before adopting it, and *Observability* defines the degree to which a potential adopter can observe others adopting an innovation and the impact it has on them (Rogers, ibid., p. 257ff). The higher the relative advantage, compatibility, trialability and observability of an innovation, and the smaller its complexity, the higher the rate of adoption generally is. In his research Rogers (ibid., p. 221) found that up to 89% of the variance in the rate of adoption of innovations is explained by these five variables.

(II) Type of Innovation-Decision

It can be the individual, the society or an authority that decides whether or not an innovation is adopted. An *optional* decision occurs when an individual independent of the decisions of other members in the system decides to adopt or reject an innovation. Although the individual is free in its decision, it may still be influenced by community-level factors. *Collective* decisions are made by the consensus among the members of a system. Once the choice whether to adopt or reject an innovation is made, usually all units in the system must conform to the decision. *Authority* decisions are made by relatively few individuals who possess power, status or technical expertise. Individual members of the system who usually only have limited influence on such a decision simply have to comply with and implement it. Generally, *authority* decisions yield the fastest rate of adoption. (Rogers, ibid., p.28ff)

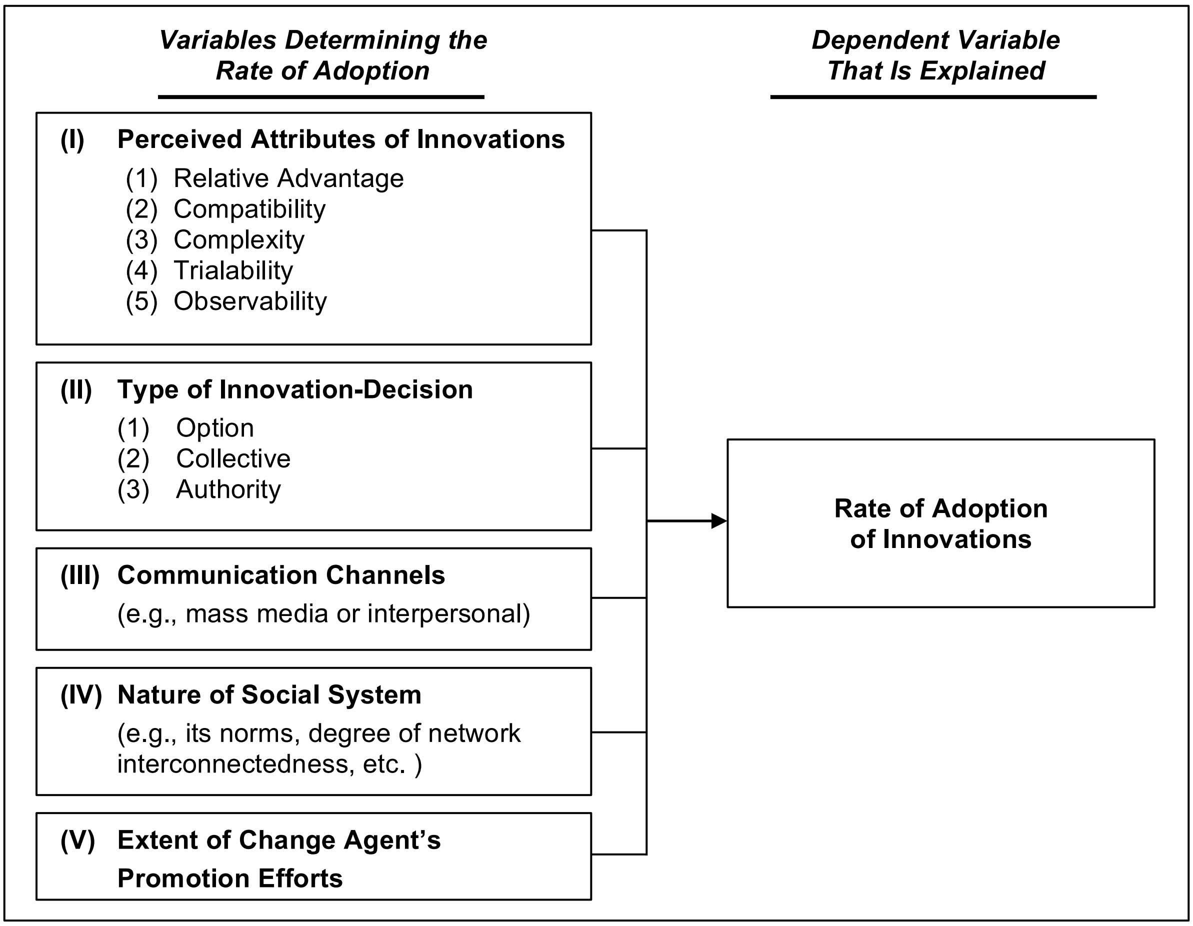


Figure 8: Variables Determining the Rate of Adoption of Innovations.

Source: Rogers (2003, p. 222).

(III) Communication channels

According to Rogers, diffusion is the process by which an innovation is communicated to the members of a social system (cf. definition above). The *communication channel* is the means by which this communication process takes place in order to convey the innovation from one individual to another. Rogers distinguishes two types of such channels. *Mass media channels* that involve a mass medium such as television or radio are usually the most rapid and efficient means to inform potential adopters about the existence of an innovation. *Interpersonal channels*, such as face-to-face communication, by contrast, are more effective in persuading an individual to accept and adopt a new innovation. Thus, the mixture of the two types of communication directly influences the rate of adoption (Rogers, ibid., p.18)

(IV) Nature of the Social System

Rogers (ibid., p. 37) defines a *social system* as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal". The units within such social system share an understanding of values and norms, which gives the system structure, stability and regularity. An innovation that conforms with the social system normally has a higher rate of adoption than an innovation that is conflicting with it. (Rogers, ibid. p.37f)

(V) Change Agent's Promotion Efforts

Due to their technical competence, social accessibility, and conformity to the systems' norms, some individuals in a social system earn an opinion leadership. This allows them to influence others in their decision whether or not to adopt an innovation. Thus, the opinion leaders' attitude towards an innovation has a direct impact on the rate of adoption of the society as a whole. (Rogers, ibid. p. 26ff)

2.2.4. Relation between Innovation S-Curve and Rogers' Diffusion Model

The innovation S-Curve framework suggests that the magnitude of performance improvement resulting from research and engineering efforts in a certain period of time differs as the innovation becomes more mature (Christensen, 1992a). While an SI enhances existing products and business models, a DI represents a new S-curve that underperforms the existing products in the markets at first, but because of this changing magnitude of performance improvement over time, outperforms them in the long run. Once that happens, the DI becomes a serious threat to existing business models, as the mainstream market starts shifting towards the DI. This has been discussed in chapter 2.2.1.

How fast an innovation diffuses is, as has been conceptualized by Rogers, measured by the rate of adoption of innovations. This rate is determined strongest by the perceived attributes of an innovation (c.f. chapter 2.2.2). If the degree by which an innovation is superior in terms of relative advantage, compatibility, complexity, trialability, and observability is considered as performance, the S-Curve model and Rogers Diffusion Model relate to each other as is depicted in Figure 10. The larger the performance differential between a

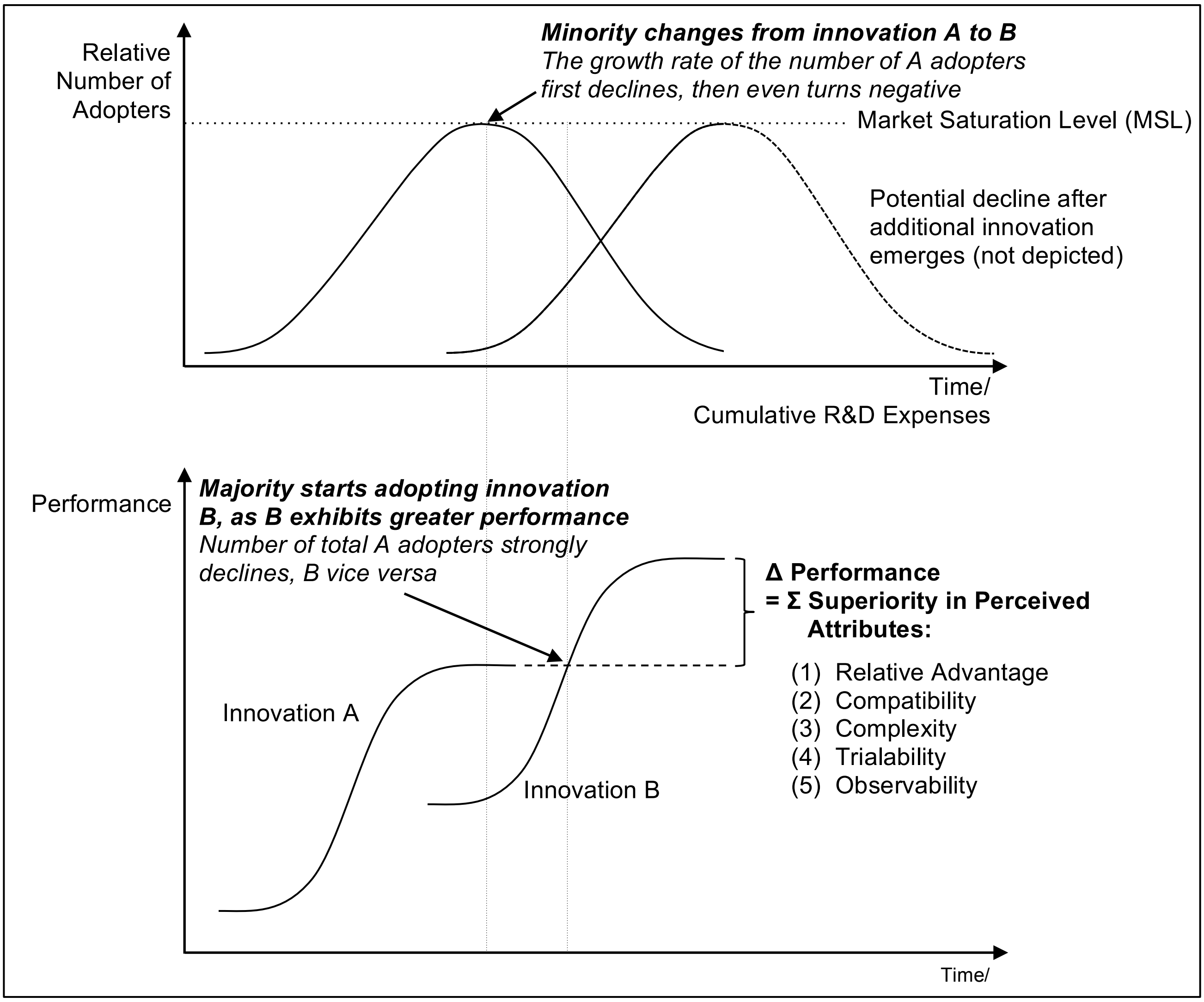


Figure 10: The Innovation S-Curve and the Rate of Adoption Combined – The S-Curve Adoption Model.

Source: Own illustration, adopted from Christensen (1992a; 1992b; 2006), Foster (1986), Hensel & Wirsam (2008), and Rogers (1962; 2003).

dominating innovation and an new, outperforming one is, the larger the incentive for people is to change and the faster the transition process will take place.

Concluding the introduction of the theoretic frameworks serving as the basis of this thesis, Figure 9 presents how they will be applied throughout this work.

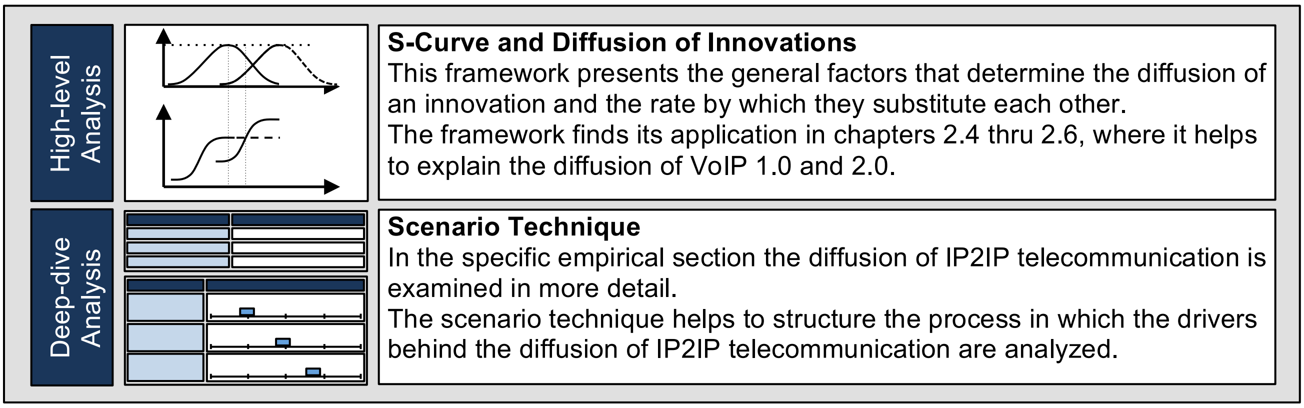


Figure 9: Use of the Introduced Theoretical Frameworks.

Source: Own illustration. Small graphs adopted from the authors indicated in the respective illustrations.

2.3. The History of Telecommunications

Who does not know the past is unable to understand the present and, even less, to anticipate the future.
(Alby, 2008)

The following chapter takes the reader on a journey through the evolution of telecommunications. Highlighting the most important innovations, the reader is offered the overall context and tendencies since the invention of the telephone, and a grasp of how the history repeats itself in the realm of telecommunications.

It was in 1833 when Carl Friedrich Gauss and Wilhelm Weber discovered how to transmit electric signals over distance by using a twin wire. In this moment, the phenomenon that today is referred to as telecommunications was born, as the two researchers unknowingly had paved the way for the later invention of the telephone (Bonnekoh, 2007). The first to transmit sound over an electrical wire was Philipp Reis during an experiment conducted in 1860. In 1870 the Italian-American Antonio Meucci was the first to patent a telephone tentatively, but the patent voided in 1871 after Meucci's financial problems to pay for it (Königstorfer, 2008; Carroll, 2002). Nine years later, Alexander Graham Bell, patented the telephone two hours before the Elisha Gray, who also had invented a phone (Gorman, Mehalik, Carlson, & Oblon, 1993). To this day, there is controversy over who the true innovator of the telephone is (Badach, 2005).

While in the United States the stationary (also referred to as "fix-net") telephony expanded rapidly, in Germany by 1962 the degree of household penetration was still as low as 14%. Only by 1973 the majority of households possessed a phone (Rammert, 1994).

Until the end of the 1960ies the fixed telephony technology was only altered by few inventions[4]. In the 1970ies, the introduction of the push-button phone facilitated the use of the telephone device and speeded up the penetration of the households. At the same time, the digitalization of large parts of the network with ISDN granted more than one connection per access point allowing for simultaneous use of a multitude of services. For instance, ISDN permitted to concurrently use the connection for internet access or sending faxes while a phone call was in progress. In addition, the routing process in the switching centres that earlier had been done manually was automated, which increased the reliability of the network. (Badach, 2005; Bonnekoh, 2007)

The mobile telecommunication evolved very differently. After the invention of the telephone, only little time passed until the cornerstone for mobile telecommunication was laid. In 1896, the Italian and later Nobel-prize winner Guglielmo Marconi patented a device that was capable to "detect and register electrical waves" (Alby, 2008, p. 3). The British Royal Navy bought the technology, as it enabled its fleet to communicate on sea. At that time, war ships were the ideal place to implement the new technology because the batteries

[4] For instance the Strowger switch that was invented in 1888.

necessary to run it were so big that they required a large carrying capacity, which was provided by these ships (Alby, ibid.).

After the turn of the century, the first basic and non-military services based on radio technologies were launched. In the United States, for instance, the police used radio technologies to page their action force that then called back to the control room via regular telephones. During WWII, mobile communication technologies were developed further and used as an advantage on the battlefield. Benefitting from the progress, after the war the first commercial mobile telephone service was launched in the United States (Alby, 2008; Königstorfer, 2008). In the beginning, however, the service level was very limited. In New York, only a maximum of 730 people could subscribe who then had to fight for one of the twelve communication channels. Moreover, it was normal that users accidentally landed in a conversation between other participants (Alby, 2008).

Soon, other countries followed and launched their own commercial mobile phone networks[5]. Common standards were missing, for which the first generation of mobile phones could only be used in one country and often just with one service provider. Apart from these network incompatibilities, the first generation of mobile phones also had a series of drawbacks. For instance, when a mobile phone left the reach of an antenna, the connection was lost. An automatic handover (so-called "Roaming") to the next closest antenna did not yet take place. Furthermore, the caller had to know in which area the mobile phone was located in order to establish a connection, as the number under which the mobile phone could be reached depended on the its location. The price for a first-generation mobile phone was higher than the average annual salary of a worker, which is why the largest part of the population was excluded form the use of the innovation. Plus, the mobile phones were still heavy and bulky for which they mostly were built into the trunks of cars. In addition to these inconveniencies, also serious problems existed. For example, the first networks could easily be tapped because they were analogue and unencrypted. (Alby, ibid.)

Even before the first multinational mobile communication standards or roaming networks existed, the first mobile telecommunication systems using satellites rather than terrestrial network infrastructure were launched. Although they were used as alternatives to the latter during the 1980ies and they had the clear advantage that they allowed for mobile telecommunication even in areas where no terrestrial network could be accessed, they soon were relegated to a niche existence. Alby (ibid.) offers three explanations why this happened. First, the increased transmission power that is needed to communicate with satellites requires a larger antenna. As a result satellite phones are bulkier than regular mobile phones and do not fit into trouser pockets, which reduces their suitability as everyday mobile devices drastically. Secondly, because both the devices and the airtime sell with significant price mark-up, satellite telephony cannot compete with terrestrial mobile telecommunication on the mainstream market. Finally, early satellite phones had similar problems as terrestrial mobile phones: They were not compatible with other satellite networks. Terrestrial mobile

[5] E.g. Sweden (1955), Germany (1958)

communication, however, early harmonized the networks, for which it became the dominant system. (Alby, ibid.)

In 1982 the way for the breakthrough of terrestrial mobile communication was paved. It was the year when the Groupe Spécial Mobile (GSM[6]) was founded with the aim of developing an inter-compatible and pan-European mobile telecommunication standard that would get the teething problems of earlier mobile networks out of the way. The resulting GSM standard was launched in 1991. Today ca. 90% of the worldwide mobile telecommunication technologies are based on it. (Alby, ibid.; GSMA, 2012)

The internet had its beginning already in the late 1969, and the email was invented in 1972 (Lewis, 2006; Sigler, 2010). However, it was only in 1991 when Tim Berners-Lee, scientist at the Swiss research facility "CERN", presented the World Wide Web (WWW), thereby opening to the larger public what previously was primarily the domain of scientists and the military. In the years following this event the number of internet users exploded. Yet, browser incompatibilities, the lack of coding standards or integrated development frameworks and slow and expensive connections (28.8 Kbit/s or 56.6 Kbit/s) made early contacts with the medium a painful experience. In the subsequent years, large investments into Digital Subscriber Lines (DSL) were undertaken to provide sufficient bandwidth to deal with the sharply increasing data transfer volumes and to accelerate the speed of the connections. (Alby, ibid.)

Text functions such as SMS enhanced mobile telecommunication in 1995. But telecommunications services were still expensive and only available to a minority of the population. More popular were pager services such as the "Scall" of T-Mobile in Germany that permitted customers receiving messages consisting of numbers each of which had an agreed meaning. 113, for example, could be defined as "Call me back" upon which the user would do so by using a stationary phone. (Alby, ibid.)

In 1997, the Wireless Application Protocol (WAP) brought the internet to the mobile phone. However, similar to the beginnings of the stationary internet, the WAP was slow because the GSM networks only offered speed rates between 9.6[7] and 14.4 Kbit/s (Sauter, 2009). Furthermore the content was unstructured, interleaved, and the unpleasant user experience resulting thereof hindered the technology to become a major breakthrough. The Swedish company Ericsson a year later presented the Global Packet Radio Services (GPRS) technology that would bring enhanced speed (115.2 Kbit/s) and that would, similar to the introduction of ISDN, allow the mobile device to stay connected to the internet without blocking a voice channel. In Germany, the technology went on air in 2001. In 2006, the launch of Enhanced Data Rates for GSM Evolution (EDGE) standard increased the velocity of the mobile internet once more to 473.6 Kbit/s and made the connection more stable. For instance, while on GPRS the streaming of videos was still a strictly "meditative matter" (Alby, ibid., p. 24), under EDGE the buffering time became tolerable. However, when EDGE was intro-

[6] Today, GSM no longer stands for „Groupe Spécial Mobile" but for the mobile communication standard the committee drafted: the Global System for Mobile Communication.
[7] All indicated speeds refer to the theoretical capacity. The actual speed may differ and be considerably lower.

duced, DSL had already gained a strong foothold in stationary internet and had replaced the slow dial-up connections with accesses providing speeds of 1 Mbit/s or higher (Sauter, 2009). As a result, despite the significant speed increase EDGE had brought, in the eyes of the users mobile internet was still disappointingly slow. In addition, the prices for the service continued to be exorbitantly high. (Alby, ibid.)

In 2004, the idea of using the internet connection rather the traditional telephone network to transport voice signals was not new. Already during the 1990ies, first attempts to do so had been undertaken, but the high cost and the slow speed of the internet access, and technical immaturity had prevented Voice over IP from becoming a serious alternative to traditional telephony.

By 2004, however, the technologies backing VoIP had made significant progress, and so had the internet connections. As a result, in this and the following years a sharp increase of the number of VoIP operators could be observed. In Germany, for instance, in 2004 alone the number of operators went up from 15 to 40 (Alby, ibid.). Practically over night VoIP had become a threat to incumbent telecommunication providers. Many industry experts heralded a “VoIP Revolution” and shared the opinion that the technology would substitute many incumbent firms in the next 10-15 years (c.f. Bonnekoh, 2007; Kapustka, 2004; Oliver Wyman, 2004; Rao, Angelov, & Nov, 2006).

The current chapter offered the reader a selection of events that shaped the telecommunication industry until 2004 and examples were drawn from the evolution of the regular telephony, the mobile telecommunication and the internet. The last innovation that was introduced – Voice over IP – is examined in more detail in the subsequent chapters.

2.4. Comparing VoIP and PSTN

2.4.1. Network Architecture

As was briefly indicated in the introductory section, traditional telephony and VoIP differ significantly in the way they connect the call participants. The following chapter gives an overview and compares the two technologies. As this chapter is rather technical, the reader might find Figure 11 helpful for the understanding of the differences.

Traditional telephony relies on a strictly hierarchically organized and centrally managed network, the PSTN[8] (Henkel, 2009). Originally, calls were passed to the next level in the hierarchy – a layer with larger geographical reach – for onward routing if within a local cluster the call could not be established. In Germany for instance, not including the international prefix, in total five hierarchical layers existed. Later technological progress brought automated electromechanical circuit switching, which permitted to flatten the hierarchy. Today, the PSTN in Germany is organized in three layers: The local layer (VE:O), the layer for far calls (VE:F) and the layer for international calls (VE:A). Internationally, the number of layers differs but generally the struc-

[8] PSTN stands for Publicly Switched Telephone Network

ture is similar to the one found in Germany. The entirety of these layers is referred to as the "Backbone" of the PSTN network. (Hauser, 2010)

Exhibit 1: Private Branch Exchange (PBX)

PBXs are machines within companies that separate the telephone network into a company-internal and external network. While few outgoing lines are shared with all internal participants, internally every participant has his or her own extension number. This yields twofold benefits. On the one hand, costs are lowered because calls to internal numbers are no longer routed via the fee-based PSTN network but through the private internal and settlement-free network. Secondly, the number of outside subscriber lines can be reduced, which reduces subscription and infrastructure costs (Payne, 1999). In addition, PBXs usually enhance the PSTN network with functionalities that are not provided by the telecommunication operators, such as ACD, IVR or VMS*.

An ACD allows to screen and queue incoming calls, and to route them to the correct internal phone. An IVR is a system in which a computer voice interacts with the caller, receives his or her keypad inputs and channels him or her accordingly. VMS is a coverage point for unanswered calls, which records and stores messages and provides further additional services. (Sulkin, 2002)

* ACD stands for Automatic Call Distributor, IVR for Interactive Voice Response and VMS for Voice Messaging System

Access to the PSTN backbone is provided via a twisted-copper-pair analogue subscriber line connected to the local exchange. This part of the PSTN network is referred to as the local loop and includes the network interface at the premises of the caller (CPE, e.g. the telephone sockets), the access line leading to the local exchange and the components at the local exchange where these access lines terminate. Residential services are usually connected directly to the local exchange, business phones often via a private branch exchange (PBX – c.f. Exhibit 1). (!Dol, 2010)

In this PSTN hierarchy, calls are established via the shortest route between the participants. From the beginning to the end of a call the transportation way of the voice signals, the so-called routing, remains the same. During this period, the link is reserved exclusively for the on-going call. Hence, other data or calls cannot be transmitted through the same route at the same time. As was stated in the introduction, this type of routing is referred to as "Circuit Switching". (Bonnekoh, 2007; Henkel, 2009)

VoIP works differently. In broad terms, VoIP transmits the voice signals through the internet rather than the PSTN network. More detailed, VoIP technology digitizes the voice signals, encrypts and compresses them into data packets, and sends those packets over the internet to the conversation partner. Therefore, this type of routing is referred to as "Packet Switching". Arrived at their destination, the packets are aggregated and reconverted into sound signals.

Besides the voice signals each packet contains a header containing the destination address to ensure the packet finds its way through the internet. Because the route the packets take to arrive at their destination is not pre-defined and can vary for every single packet, some packets may arrive earlier than others. As the order of the packets therefore may shift during the transmission process, the header also contains a sequence number that ensures the packets are re-assembled in the correct order. In contrast to PSTN, under VoIP technologies unused transmission capacity available for other uses, e.g. e-mails, web browsing, or calls of

Exhibit 2: ENUM/DNS Service

ENUM stands for E.164 Number Mapping*. It is a service that associates registered VoIP numbers with IP addresses. Not all SIP-based VoIP providers support ENUM, but those that do not only verify if the destination PSTN number is a subscriber of their own network, but subsidiarily also verify if it is registered in ENUM. If it is, ENUM resolves the destination number into an IP address and the call is routed via the internet rather than the fee-based PSTN network. Therefore, these calls normally are free of charge, even if the VoIP operator of the caller and the callee are not identical. (Meinberg, 2008)

ENUM is a service provided by the Domain Name System (DNS). The DNS is a hierarchical system that maps internet domain names with IP addresses. This directory lookup service is an essential part for the internet, as it ensures that users can navigate the internet by using easy-to-remember domain names (e.g. www.google.com) rather than the numerical identifier of internet devices, the IP address**. In other words, without the DNS users would have to remember the numerical address of an internet source – the IP. Not only is this highly cumbersome, but also error-prone, because many IP addresses per default are not statically assigned to institutions/clients but change several times during a month. Domain names are easy to remember and forward users directly to the correct underlying IP address, even if it changes over time. SIP takes advantage of the DNS by providing URI***-formatted addresses to its clients that the DNS then resolves into IP addresses. SIP-URI addresses are easy to remember, as they have the same format as email addresses****, Thus, if a SIP user knows the SIP-URI address of the callee, he or she can directly establish a free-of-charge call – even without knowing the IP address. (Badach, 2007; Ganguly & Bhatnagar, 208; Meinberg, 2008)

* An E.164 number is a regular PSTN telephone number.
** For instance, the IPv4 address of the website of Google on January 1st, 2012 is http://209.85.148.105 and IPv6: http://[2a00:1450:8005:0:0:0:0:0].

*** URI stands for <u>U</u>niform <u>R</u>esource <u>I</u>dentifier.
**** E.g. sip:benjamin.harder@providername.com.

other people, because the routing is dynamic rather than exclusive and pre-defined. (Badach, 2005; Hensel & Wirsam, 2008; Lyytinen & Rose, 2003; Mager, 2004)

Unless additional network infrastructure is provided, VoIP devices are only reachable by other VoIP clients as an interconnection to the PSTN network is absent. Skype, for instance, provides its users with a contact manager displaying a list of other users that are online. Upon request, the program connects the participants by exchanging the IP addresses of the VoIP clients. From a classic PSTN phone, Skype users normally cannot be called.

VoIP clients may also be reached under a regular telephone number. This, however is only possible if somewhere in the network the client’s IP address mapped with a PSTN number, and vice versa. Such assignation is made by changeover points in the network, by devices called gateways. In other words, gateways are machines that make the PSTN and VoIP networks interoperable. (Bonnekoh, 2007; Hensel & Wirsam, 2008; Meinberg, 2008)

Traditionally, special phones or dedicated computer software were the only means by which VoIP could be used. Today, many more clients exist. In addition to the aforementioned, regular PSTN phones nowadays can either be equipped with <u>A</u>nalogue <u>T</u>elephone <u>A</u>dapters (ATAs), or be connected to special routers, which provides them with VoIP functionality. Or, dedicated software applications turn smart phones, tablet computers or PDAs[9] into VoIP devices. (Bonnekoh, 2007; Hensel & Wirsam, 2008; Meinberg, 2008)

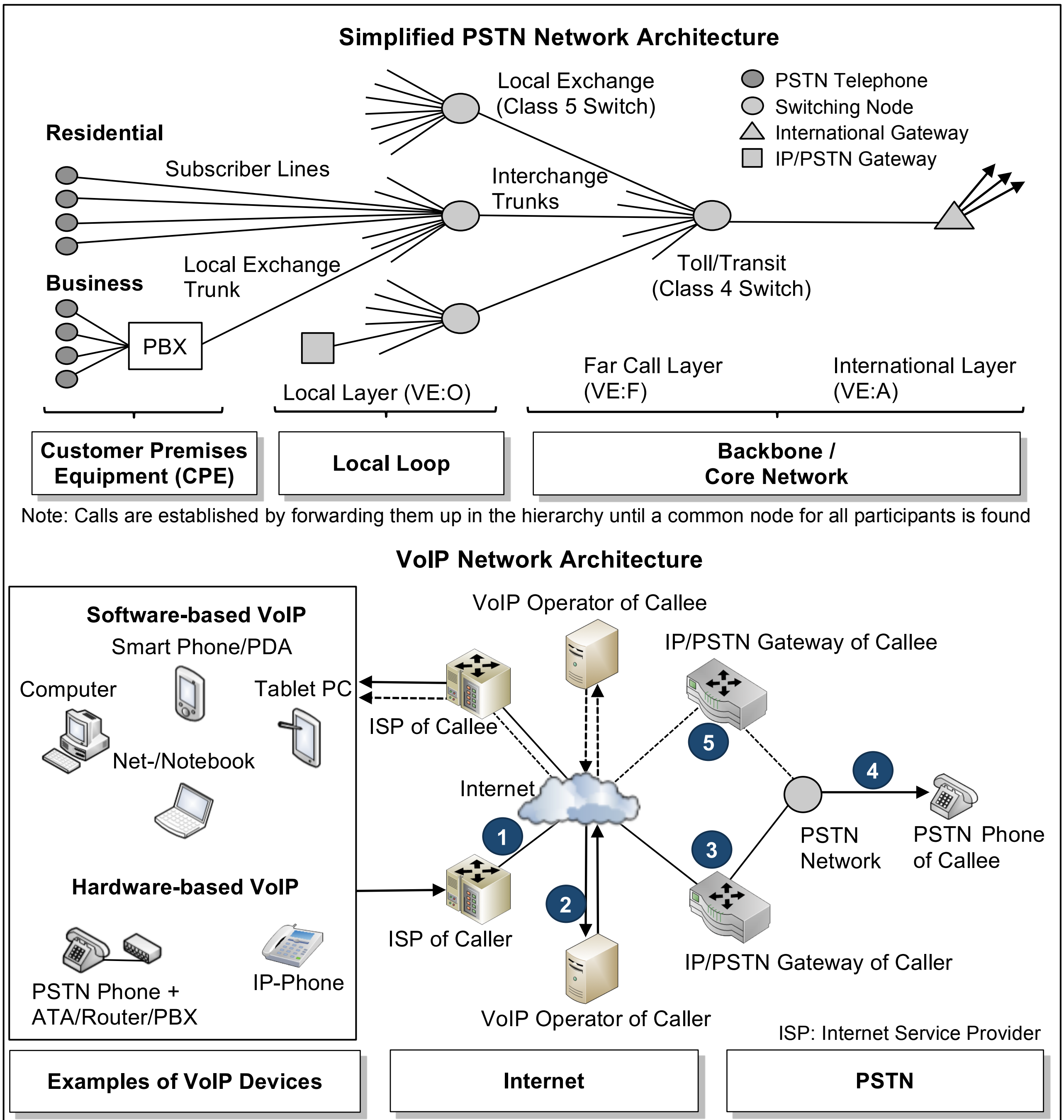
[9] PDA stands for <u>P</u>ersonal <u>D</u>igital <u>A</u>ssistant

The operators of the PSTN networks make the use of their infrastructure subject to tariffs. Therefore, if a VoIP user dials a PSTN number, he or she usually is charged a fee. Such call is routed from the internet through a gateway onto the PSTN network, where it reaches its destination. The call is routed through another gateway back onto the internet, if the PSTN number in fact belongs to another VoIP client rather than a traditional PSTN phone. In order to save the PSTN fees, VoIP operators therefore verify before forwarding VoIP calls to the PSTN network whether the destination PSTN number belongs to another customer of their VoIP network. If applicable, the call is routed directly through the internet rather than through the PSTN loop. As no costs occur for such on-net calls – that is VoIP calls between two clients of the same VoIP provider – they are usually free of charge. Some VoIP providers even check if the dialled PSTN number belongs to a VoIP client of other VoIP operators by conducting an ENUM-lookup (see Exhibit 2) and connect participants, if applicable, free of charge through the internet. (Meinberg, 2008; Trick & Weber, 2009)

In terms of underlying architecture, the PSTN network is highly structured by standards developed by the International Telecommunication Union (ITU). Such clear standards are missing for VoIP, and various competing protocols exist. The most widely used ones are SIP[10], H.323 and the Skype protocol. For transporting the voice data packets, all of them (and many other VoIP protocols, too) make use of the readily available Real Time Protocol (RTP). For initiating the transmission and preparing the voice signals – that is digitalizing, encrypting, compressing, packetizing, addressing, etc. -, however, the protocols fundamentally differ. (Analysys, 2004 Durkin, 2003; Perkins, 2003; Bonnekoh, 2007)

The standards also vary in their degree of modifiability and complexity. Without going into too much technical detail, the Skype protocol, for instance, is proprietary and only used in the program of the same name. H.323 is a fully-fledged media transmission architecture with a broad range of functionalities. It is a framework constituted by a set of further protocols with hundreds of interacting elements. Therefore, its implementation is rather complex. Notwithstanding, today it can be found in many modern telephone systems. SIP is the standard that took over the leading role from H.323 and is capable of setting up transmissions for voice, video or any other data. It does not provide its own audio and video standards (so-called codecs), but negotiates upon initiation of the call between the parties what codecs are supported and adjusts the modalities of the call accordingly. One side advantage SIP has over H.323 is that it produces messages that are encoded in ASCII format, which is plain text, while H.323 produces binary code, which is unreadable for human beings. SIP therefore is easier to understand and maintain. SIP is also the protocol that enables the aforementioned ENUM service that allows for free calls between VoIP users of different VoIP providers (see Exhibit 2). (Durkin, 2004; Bonnekoh, 2007; Henkel, 2008; Virgo Publishing, 2006)

[10] SIP stands for Session Initiation Protocol



1. If the caller knows the IP address or the SIP-URI of the callee, or a contact manager such as the one by Skype provides the IP address, a direct connection between the participants via the ISPs is established. As the traffic is usually not routed via the infrastructure of the VoIP providers but through a direct connection between the participants, no cost arise for the VoIP operators, for which these calls usually are free of charge.
2. If the caller dials a PSTN number, the caller's VoIP operator verifies if the dialled number belongs to one of its own VoIP customers. If applicable, the VoIP operator establishes a direct connection between the participants, without routing the voice signals over the PSTN. Again, the data packets are directly exchanged between the clients without involvement of the servers of the VoIP operator. Therefore, these on-net calls usually are free. Certain VoIP operators also verify via an ENUM-lookup whether a PSTN number belongs to some other VoIP operator in order to establish a direct, internet-based and settlement-free call.
3. The call is passed onto the fee-based PSTN network through a gateway if no direct IP-connection can be established between the participants.
4. If the dialled PSTN number belongs to a traditional phone, the call is routed through the PSTN hierarchy until it reaches the premises of the callee. The PSTN phone rings.
5. If the dialled PSTN number belongs to a VoIP device, a gateway passes the call once more onto the internet and forwards it to the callee's VoIP provider, where the data packets then are forwarded to the current IP address of the callee. The VoIP device rings.

Figure 11: Comparison of the PSTN and VoIP Network Architecture.

Source: Own illustration, adopted from !DoI (2010)

2.4.2. Advantages and Disadvantages

Despite the fact that the transmission of the voice signals based on VoIP technologies seems to be more complex than through the fine-tuned PSTN network, there are many arguments that speak in favour of VoIP (Hensel & Wirsam, 2008). This chapter therefore elaborates the pros and cons of the respective technologies that arise from the architecture differences that were presented in the previous chapter.

(I) Advantages of PSTN: An important characteristic of the PSTN network is its reliability. The network is virtually always available. Even in case of a power outage the PSTN phone is working, as it is powered through the PSTN network (Clark, 2004; Ledford, 2005; Mohmand, 2007). A study on the availability of the AT&T PSTN network, the largest one in the world at the time of the study, found that over 40 years the network had only been down for 2 hours in total, which equates to a reliability greater than 99.999% (Zorpette, 1989 as cited in Kuhn, 1997)! Furthermore, as the routing between two participants is reserved for exclusive use of the call, the quality of the voice transmission is good and stable (OFCOM, 2002).

PSTN numbers are composed by the elements defined in the ITU-T E.164 numbering plan. This numbering system ensures that geographic areas are reachable under the same prefix. As usually a premium is charged for far-distance calls, the PSTN numbers that indicate where the callee is more or less help the caller to anticipate costs. In addition, the fact that PSTN numbers indicate geographical locations help the authorities to locate and assist the caller quickly in case of an emergency (Analysys, 2004; Meisel & Needles, 2005).

In many countries, the PSTN network was long protected and operated by a government-controlled monopolist, for which the industry is strongly regulated. However, the rather rigid legislations can be perceived as an advantage for the market players, as the well-defined rules, norms and standards set clear market conditions with little ambiguity (c.f. Clark, 2004; Henkel, 2009; Nieminen, 2004; Sadowski & Straathof, 2005).

(II) Disadvantages of PSTN: An often-cited argument against PSTN is the cost intensity of the necessary infrastructure. As has been stated in the previous chapter, the PSTN network relies on a hierarchy built on numerous gateways, terminals, switch boxes, frame relays, PBXs, etc. In other words: costly hardware. Investment and maintenance costs therefore are significant for telecommunication operators as well as for corporate customers. The high fees that are charged for long distance calls reflect the expensiveness of the network such calls require for connecting the participants (Jackson, Shorter, & Forcht, 2009).

In addition, services beyond the traditional one-on-one calls often require alterations in the hard- and/or software of the network elements, e.g. the switch boxes. As third-party companies, such as Cisco Systems, Ericsson, or Siemens, produce these operators often have to wait until their devices support the requested feature, unless they seek close collaboration with the aforementioned manufacturers. Providing new services therefore can be a lengthy and prohibitively costly or, in case of carrier-overlapping change, a sheer impossible undertaking (!Dol, 2010; Bell, 2008; Bonnekoh, 2007; Rao, Angelov, & Nov, 2006).

PSTN dedicates its lines, as was mentioned earlier, exclusively for a call in progress. For this reason, the length of calls is an important variable in the PSTN network. According to !Dol (2010), most calls are relatively short, for which switch boxes were engineered for call durations of three minutes or less. The carrying capacity of the PSTN network soon is exceeded if the average call duration exceeds this limit, or if many people attempt to use the PSTN network simultaneously. For this reason, in many regions of the world the increasing number of people using a PSTN dial-up connection for accessing the internet puts a strain on the PSTN network, as the average internet session lasts one hour (!Dol, ibid.).

(III) Advantages VoIP: Undoubtfully the most-often cited advantage of VoIP is its large cost saving potential. First, for users infrastructure and maintenance costs are significantly reduced, as by combining the internet and telephone network the PSTN infrastructure becomes redundant. For instance, it typically required businesses with a PSTN infrastructure to cable hundreds of pairs of copper lines to connect their workers to the PBX. With VoIP, this infrastructure can be eliminated entirely by using the high-speed internet connection instead (Jackson, Shorter, & Forcht, 2009). In other words, under PSTN every additional workplace required a new wire to be cabled from the PBX to the worker's telephone. Under VoIP, connecting a suitable device to the internet connection is sufficient. Hence, not only did VoIP reduce the costs for the infrastructure, but it also made it much more flexible and efficient.

Secondly, VoIP allows users to circumvent the expensive tariffs charged for long-distance and international calls. Because calls are passed onto the PSTN network through gateways close to the callees' local exchange, only minimal PSTN routing fees occur. For companies operating globally this yields significant cost advantages. For instance, VoIP allows centralizing call centres because no matter where the callee is located only local tariffs have to be paid, while with a PSTN network such centralization would be tremendously costly because of the expensive long-distance calls. Likewise, VoIP enables companies to create their own worldwide intranet. Calls routed within such private IP network are free of charge, as they never enter the PSTN network. Hence, VoIP drastically lowers the costs for corporate communication among globally dispersed subsidiaries.

The consulting company Soreon Research estimates that within five years after changing to VoIP, SMEs save up to 31% in respect to their former telephony expenses and that for large enterprises the cost saving potential is likely to be even greater (Soreon Research, 2005; see also !Dol, 2010; Bonnekoh, 2007; Christensen, Anthony, & Roth, 2001; Hensel & Wirsam, 2008; Jackson, Shorter, & Forcht, 2009). Analyses by Oliver Wyman, another consultancy, support these findings (c.f. Oliver Wyman, 2004).

Another advantage of VoIP is that it enables "nomadic" use of a telephone number. As was explained in chapter 2.4.1, gateways map PSTN numbers belonging to a VoIP client to the corresponding IP addresses. Hence, wherever the callee is located, for establishing a connection it is sufficient that the gateway forwards the call to the current IP address of the callee's VoIP device. Thus, VoIP makes local numbers globally portable without roaming cost. For business users who frequently travel and make long-distance calls this is a valuable feature. (Hensel & Wirsam, 2008; Jackson, Shorter, & Forcht, 2009; Wolf & Barnes, 2011).

In VoIP networks additional services can often be realized through software updates and upgrades. Therefore, the costs for implementing functionalities such as group or video calls, simultaneous data transmissions, unified messaging systems[11], etc. are marginal. Furthermore, in comparison with the PSTN network, where most alterations need the consent of many stakeholders, changes in a VoIP network can often be realized quickly and unilaterally, as the technology is more flexible (Christensen, Anthony, & Roth, 2001; Fischer, 2008; Rao, Angelov, & Nov, 2006).

Finally, while PSTN reserves a dedicated route for the exclusive use of a call, under VoIP unused bandwidth capacity is available for other uses. Imagine a call has been established but nobody speaks. On the PSTN network, other users could not benefit of the idle line, as it is reserved for the established, yet mute call. Under VoIP, less traffic is caused, for which reason more bandwidth is available for the internet usage of other people. (Hensel & Wirsam, 2008).

(IV) Disadvantages of VoIP: In telecommunications the quality of the signal is a crucial factor, for which highly reliable and qualitatively outstanding networks are a prerequisite. In telephone networks the term "Quality of Service" (QoS) measures this factor and has long been one of the major points of critique against VoIP (c.f. Badach, 2007; Jackson, NAIRSC, 2004; Shorter & Forcht, 2009; OFCOM, 2002; Sadowski & Straathof, 2005)

The quality of the voice signals transmitted by VoIP directly correlates with the quality of the internet connection. A slow internet connection may cause data packets to arrive delayed at their destination[12] or make a higher rate of compression necessary, a process in which a part of the signal quality is lost. Single packets may also arrive late because of the different routes the individual packets take to arrive at their destination. As a result, the order the packets arrive at their destination differs from the order they were sent[13]. Therefore, the receiver's VoIP device needs to gather the incoming packets and put them into the right order before it is able to reassemble and convert them back into sound signals. While delays below 100ms are barely noticeable and 150ms are acceptable, delays larger than 300ms make a conversation impossible because the participants constantly interrupt each other. If during the transmission more than 5% of the data packets are lost, for instance because of a congested switching centre, the acoustic signal can be distorted. More than 40% of lost packages make a conversation impossible. (Henkel, 2009)

[11] Unified Messaging Systems (UMS) integrate different electronic media, such as e-mail, SMS, Fax, etc., into one single interface, e.g. the user's inbox (Avaya, 2009; Fischer, 2008)

[12] The expression „Latency“ refers to the delay of the voice data packets due to other network traffic (cf. Henkel, 2009; OFCOM, 2002)

[13] The expression „Jitter“ refers to the differences in the time individual packets require for arriving at their destination due to different routing (cf. Henkel, 2009; OFCOM, 2002)

Equally important is the availability of the network. In 2006, a 98% service level was considered to be a positive value for IT systems. Although the number seems high it is far from the reliability of the PSTN network. The 2% in which the system is not running translate into almost 29 minutes per day, which can be particularly fatal for businesses if such outage occurs during peak times (Buchner, 2006; c.f. Chong & Matthews, 2004).

Many of the QoS objections are sustained by investigations and reports of the period 2004-2007. While some of the problems still exist today, others have been mitigated or solved in the meantime. Responsible for this progress are advances of the VoIP technology but also of the underlying internet infrastructure. Problems such as packet loss have been tackled with more intelligent codecs that are capable of reconstructing voice signals even in situations where a considerable percentage of the data packages have been lost (Henkel, 2009). Delays beyond the threshold of 50-150ms often caused just spoken words to be repeated back to the speaker. On the one hand, echo cancellers, pieces of software that have been integrated into VoIP solutions to detect and filter out echoes, have mitigated this problem (Wallingford, 2005). On the other hand, a significantly increase of available bandwidth has also reduced delays. With regards to reliability, experts state that VoIP systems may match the 99.999% of classic telephony if adequately managed. This, however, requires professional network management, as well as investments into emergency power systems for preventing outages (Buchner, 2006; Ledford, 2005; Sadowski & Straathof, 2005; Schedel, 2004). An investigation conducted in 2006 found that VoIP can provide equal or better speech quality than regular ISDN calls if the VoIP elements are properly designed (Ulseth & Stafsnes, 2006). Yet, for all the progress, one basic rule has not been altered: If the quality of the internet connection is bad, so is the quality of the VoIP call. Still today, this equation sometimes is tested.

Besides QoS issues, another disadvantage VoIP users still face is summarized by the words usability and user-friendliness. Most VoIP providers equip their clients with working out-of-the-box kits providing the basic call functions. To fully benefit from the advantages VoIP provides, however, such as the free ENUM calls a certain technical affinity is a prerequisite for setting up the devices. Plus, a large number of VoIP operators also lack the support of ENUM as they fear for their gateway-linked revenues.

The mobility of VoIP numbers can be regarded as an advantage, but also as a disadvantage. In favour of it speaks that VoIP allows users to be reached under the same number worldwide. However, at the same time it also makes tracing the call origination difficult. This can be problematic in situations where fast help by emergency services is delayed because the telephone number is no longer tied to a geographical region. Furthermore, certain VoIP providers do not even provide access to emergency numbers, which may have drastic consequences for callers in urgent need of such service. (Jackson, Shorter, & Forcht, 2009; Mohmand, 2008; US FCC, 2012).

Finally, many experts raise security concerns against VoIP, despite the fact that on average VoIP systems are considered more secure than regular PSTN transmissions. The notion is underpinned by breaches into heavily guarded VoIP systems, for instance the AES-256 encrypted Skype algorithm in 2010, which demonstrated that even strongly protected VoIP systems are vulnerable against intruders and need constant security fortification (Badach, 2007; Der Spiegel, 2010).

2.5. The First Wave of VoIP

In a nutshell, not only was VoIP capable of providing value-adding functions beyond the regular exchange of voice signals but it also offered significant cost saving potential. Quality and reliability problems as well as lack of access to emergency services were serious drawbacks VoIP suffered from, but technological progress was likely to mitigate those in the short to middle term. The innovation of VoIP induced change in the telecommunication industry and laid the ground for new business models.

2.5.1. Business Models in 2004

At the very core of their business rationale, all telephony operators serve the same purpose, namely providing the customers with the possibility of talking with other people over distance. Despite the fact that a detailed examination would reveal that countless different models existed how the telecommunication operators generated value for their customers, most of operators in 2004 can be described by one of the following five provider types[14]:

Incumbent Operators:

(I) PSTN Operators: The fixed telephone network was mainly controlled by former state-owned monopolists that provided classic telephony services with a high degree of quality and reliability. Often, their product portfolio also included high-speed internet access (DSL). Examples: AT&T, Deutsche Telekom (c.f. Sadowski & Straathof, 2005; Sietmann, 2009)

(II) Mobile Telephony Operators: The second type of operator provided telephony services through GSM based cellular networks that were interconnected with the PSTN. In terms of cost, signal quality and reliability, mobile telephony was inferior to PSTN. The mobility aspect was what customer valued about this type of telephony. Examples: China Mobile, Vodafone, América Móvil (c.f. Bell, 2008; Sadowski & Straathof, 2005)

VoIP-based Telephony Operators:

(III) Internet Service Providers (ISPs): Many ISPs turned into telephony operators as VoIP technologies matured. For them, internet telephony was a welcome additional revenue stream that was realizable at marginal costs. A customer base upon which the ISPs could rely already existed and only needed being leveraged.

[14] Many telecommunication providers are vertically integrated companies for which concrete companies may be described by more than one of the presented types of operators. This applies also for the companies that were chosen as examples. With separate business units they simultaneously engage in the market with more than one operator model. Hence, although the companies were assigned to the categories according to the value propositions they primarily are known for, specific business units of the companies may better fit the description of one of the other operator models.

Upfront investments were relatively low as the necessary network infrastructure was already installed except for IP/PSTN gateways that were necessary to pass the calls from the IP network to the PSTN and vice versa. Examples: Cablecom UPC, Tiscali (c.f. Deloitte, 2005; Oliver Wyman, 2004)

(IV) Over-The-Top (OTT)[15] VoIP2PSTN: To customers who already had an internet service provider yet another business model was offered. All customers had to do was to connect the VoIP device they received from their VoIP operator to their already working internet connection. The device then registered the user's current IP address with the VoIP provider, so that in case of an incoming call the provider knew where to the call should be routed. In case of an outgoing call, the call was either passed onto the PSTN network at the operator's facilities, or, in case of an on-net call, directly routed to the IP address of the callee (c.f. Figure 11). Operator model IV only differs from the previous one in the fact that the company that provides the internet access is not the same as the one that provides the telephony service. The inner workings of this service, however, are identical.

The VoIP devices that were deployed mostly had the same appearance as classic PSTN phones. Residential customers often used dedicated VoIP phones, or a traditional PSTN phone with an ATA adaptor. Because the user experience did not change – the devices still looked the same and had the classic number pad for dialling – probably 99% of the customers did not even know that they were actually using a VoIP-based telephony solution. In corporate telephony, VoIP-capable PBX (IP-PBX) or VoIP supporting computer software were implemented.

Given the similarity to classic telephony, for customers who had a free choice between internet and telephony provider[16], the business models (III) and (IV) were in direct competition with the PSTN telephony of the incumbents, and the main differentiator of these VoIP business models was price. Examples of OTT VoIP2PSTN operators: Vonage, MagicJack (c.f. Jackson, Shorter, & Forcht, 2009; Landgrebe, 2006; Oliver Wyman, 2004)

(V) OTT VoIP2VoIP: In contrast to the aforementioned business models, the primary objective of operator type (V) was to enable telephony amongst internet users. Often, a software programme was deployed as VoIP client. At first, many of these networks even lacked interoperability with the PSTN. With this limitation this type of business model was hardly a substitute for classic telephony, as people that were not part of the same VoIP network could not be reached. In addition, if the users switched off their computer on which the software application was running they no longer could be reached. Only later, these two problems were mitigated to a certain degree. Some of the operators launched stand-alone phones that made a permanently

[15] Over-the-top (OTT) refers to a situation where a service (e.g. VoIP) is provided by a different company than the one that provides the internet access. Skype, for example, is a typical example of an OTT provider, as the company uses an existing internet connection for its VoIP service but does not provide the internet access itself.

[16] In many countries many internet providers required their customers to also have a telephony subscription, for which customers could not freely choose between independent providers for both services.

running computer dispensable. Others also started offering paid-for in- and outbound calls from and to the PSTN[17] network.

In terms of usability, reliability, and quality OTT VoIP2VoIP operators could not compete with the offerings of the other presented types of operators. The business model found its application in isolated groups (so-called "communities") where all relevant people used the same software, for instance internally in company networks, or within social groups. As this model was not a viable telephone substitute for most people, they continued to also use phones with PSTN access for everyday use. For sporadic international calls, however, many people decided to benefit from the low rates this kind of operator offered.

As their share in the market for international calls grew, the PSTN interconnection fees became an important source of cash for this kind of operator. Traditionally, however, revenue streams were mainly generated with premium functions, such as group calls or video telephony services, or fees for support or advertisement. Examples: MSN Messenger, ICQ, Skype, Later: Google Talk, Lync (c.f. Henkel, 2008; Hensel & Wirsam, 2008; Landgrebe, 2006; Rao, Angelov, & Nov, 2007)

2.5.2. Expected Diffusion Process Around 2004-2006

With the many advantages inherent to VoIP and a wide variety of business models in place capable of delivering them, many experts shared the view that VoIP would have a long lasting impact on the industry. Some

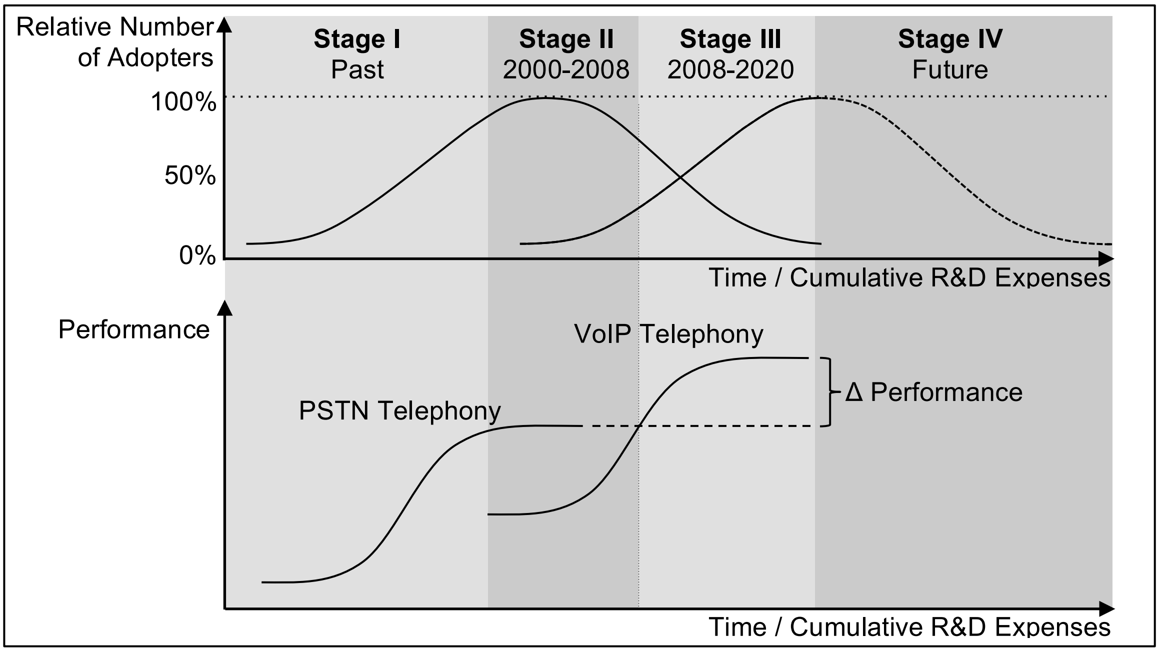


Figure 12: The First Wave of VoIP as Expected in 2004.

Source: Own illustration.

even attested revolutionary potential to the technology. Much indicated that the diffusion of VoIP would follow the classic pattern that was introduced in chapter 2.2 and that the business model of PSTN incumbents

[17] E.g. Skype launched its SkypeOut service that allows for PSTN calls only in 2004, two years after the company's foundation (Hines, 2004)

would soon be substituted (c.f. Winkelhage, 2005). The life cycles of the PSTN and VoIP business models and the process by which they substitute each other are depicted in Figure 12 and explicated below (c.f. Clark, 2004; Winkelhage, 2004; Kapustka, 2004; NAIRSC, 2004; Franke, Hannemann, Kietzmann, & Lehmkuhl, 2005).

Stage I / Past: The first stage comprises all events since the invention of the phone that made PSTN what it was in 2004; the doubtlessly dominating and most reliable network for voice telecommunication (see 2.3 for a recapitulation of the PSTN history).

Stage II / Short-Term Evolution: Although VoIP had its roots in the 1990s the first serious commercial VoIP ventures entered the market place after the turn of the millennium. Much suggested that VoIP was a text-book example of a disruptive innovation (c.f. chapter 2.2.1 for a review of DI) with the potential of giving a good shake to the industry incumbents. At the beginning, VoIP was clearly inferior to PSTN, which was caused by a range of factors: Quality and reliability issues, interoperability problems with the prevalent PSTN network and a limited range of capable devices, to cite only a few drawbacks (refer to chapter 2.4 for a more detailed comparison between PSTN and VoIP). Yet, experts agreed that its performance would take off once improvements in VoIP technology and the underlying internet infrastructure would solve the initial teething problems.

Qualitatively on a par, cost-wise advantageous, and clearly superior in terms of features, VoIP was considered likely to even outperform PSTN in the medium term, causing thereby a customer migration towards the new VoIP-based business models. In Germany, for instance, at the end of 2005 already 10% of the citizens used VoIP, and 30% stated that they would switch to it if the quality of VoIP matched or exceeded the one of PSTN (Henkel, 2009; Oliver Wyman, 2004). Directly affected by the change, the incumbent monopolists such as Deutsche Telekom, British Telecom, or France Télécom were expected to see their revenues decline by billions of euros (Deloitte, 2005; Winkelhage, 2005). As Deloitte (2005) put it: “The substitution of their [the incumbents] products through VoIP is not a scenario of the future, but has already begun.”

Stage III: Medium-term Outlook: By 2008, the quality of VoIP was expected to have surpassed the one of PSTN, fuelling the irreversible shift from PSTN to VoIP-based business models. Market analyses forecasted strong growth for VoIP (c.f. Deloitte, 2005; Gartner, 2003; Oliver Wyman, 2004), in particular for corporate telephony: “Any company would be negligent not to consider utilizing VoIP technologies in their business”, as Jackson, Shorter, and Forcht (2009, p. 107) observe. On the question how fast VoIP would become the leading standard in the market forecasts provided varying answers. In Landgrebe’s (2006) outlook, for instance, a worldwide market penetration of 12% in 2009 and a 30% penetration of all European households in 2010 are envisioned. By 2020, he believed VoIP to have entirely replaced PSTN. Gartner Dataquest assumed an even stronger growth, with more than half of the industry’s revenues in 2010 generated by VoIP telephony (Gartner Dataquest as cited by Oliver Wyman, 2004). The figures are not directly comparable because Gartner Dataquest’s numbers also include business telephony, while Landgrebe only forecasted residential VoIP usage. Notwithstanding, the pictures the medium-term outlooks drew at the time are unequivocal: VoIP was likely to gradually replace PSTN and the market shares of the incumbents were prone to decline (c.f. Gartner, 2003; Sadowski & Straathof, 2005).

Stage IV: Long-term Perspective: The last stage in the S-Curve Adoption Model depicts the decline and substitution of an innovation by a superior one. It is the stage that completes the life cycle of every innovation. VoIP will be challenged in its leading role for voice transmissions when alternatives arise that outperform it. This, for instance, could take place when the network on which VoIP is based – the internet – comes to the end of its life cycle and is replaced by an even more advanced network (c.f. Virgo Publishing, 2006). Stage IV is mentioned here for providing a complete picture of the life cycle of VoIP. Yet, as the substitution of VoIP is not the object of investigation of this paper and will most likely not happen anytime soon either, Stage IV will not be tackled anymore in the following chapters.

2.6. Look Through the Rear Mirror: VoIP 1.0 a Revolution?

Headlines in the years 2007/08 that read "VoIP is Dead" (Skype General Manager Jonathan Christensen) or "Who Killed the VoIP Revolution?" (Bloomberg BusinessWeek) indicate that not everything went as predicted (Bell, 2008; Dinan, 2008). The website myVoipProvider reports that between June 2005 and October 2007 as many as 256 VoIP enterprises ceased their operations and a look into the industry revealed that the incumbent PSTN operators were still the most dominant players (Bell, 2008; myVoipProvider, 2009). This disillusioning picture is rather surprising, given the enthusiasm that accompanied VoIP in the first place. What had happened to the proclaimed "revolution"? The S-Curve Adoption Model serves to answer this question.

The upper part of the model visualizes the substitution process of an innovation. Accordingly, in Figure 12 the substitution process of PSTN through VoIP is depicted and the chart implicitly suggests that VoIP assumes the decrease of PSTN. As VoIP has not released the revolutionary potential it has been conceded, this part of the model must look different than anticipated. Yet, the upper part only displays the consequences that arise from the lower part of the model, which compares the performance of competing innovations. Hence, it is there where the reasons can be found why VoIP did not took off as has been proclaimed. In essence, three factors that hereafter will be examined may be identified that changed the diffusion process of VoIP in the course of 2001-2010[18].

2.6.1. Competing Revolution: Mobile Telephony

In most developed countries fixed telephony peaked around the year 2000[19] and was then gradually substituted. As Figure 12 suggests, the innovation that was expected to replace PSTN was VoIP. Mobile telephony

[18] For a complete understanding of the implications of the first aspect that is presented (chap. 2.6.1), the Y-axis of the upper part of the model is of crucial importance. The reader therefore is offered a more thorough description of the ordinate in Exhibit 3.

[19] 1997-99: AT, FI, JP, NO, SW; 2000-01: BE, CA, DK, IT, UK, NL, US; 2002-10: CH, DE, FR, SP, PO (Suko, 2011)

was not considered to be a substitute, as to that point user trends indicated that mobile telephony would complement PSTN, rather than substitute it. At home or work people were expected to use a fixed phone, while on the road they would rely on the more expensive and unreliable mobile telephony. The U.K. Office of Telecommunications (OFTEL, 2001, p. 41) holds: "The advent of the mobile [phone] has, to a significant degree, expanded the market for making calls, rather than substituting for fixed calls, implying that a large majority of mobile calls are complementary to fixed calls." The development of user numbers of fixed and mobile telephony until 2000 supported this view. Although the number of mobile telephony users exploded and in some countries even already exceeded the number of fix-net subscribers, also the number of the latter was still constantly growing, and not decreasing. (Gruber & Verboven, 2001; SUKO, 2011)

During the first decade of the new millennium, however, prices for mobile telephony dropped, reliability of the networks increased and the number of people using mobile telephony skyrocketed. Especially for price sensitive users and one-person households mobile phones became an alternative and many decided to no longer keep a fixed telephone at home. In Switzerland, between 2001 and 2010 mobile telephones replaced ca. 17% of all residential fixed telephones (Anthony, & Roth, 2001; Bell, 2008; Christensen, SUKO, 2011).

Exhibit 3: The "Relative Number of Adopters"

In the S-Curve Adoption Model the "Relative Number of Adopters" is calculated by bringing the number of people that use one of competing innovations in relation to the greatest number of people that use the first innovation in the analysed timeframe. Hence, "Relative Number of Adopters" in mathematical terms is a fraction and the denominator is given by the absolute number of adopters of the first innovation that use it at the peak of its life cycle. In the nominator stands the number of people using one of the competing innovations at a given point in time. In the case presented in Figure 12, the denominator is the maximum number of people that adopt PSTN, and the nominator is the number of people that use either PSTN or VoIP at a given point in time.

The upper part of Figure 12 shows how adopters switch over from PSTN to VoIP over time. Strictly speaking, the chart is not entirely correct as it falls short of taking into account two things. First, over time population usually grows. Secondly, the performance enhancement of new innovations is likely to turn a certain number of people that were reluctant to adopt the first innovation into users. For these two reasons, the market saturation level of later innovations is likely to be greater than the market saturation level of the first innovation. As the market saturation level is nothing else than the denominator of "Relative Number of Adopters", the market saturation level of a later innovation is therefore likely to exceed 100%, for which the market saturation level line should actually have a positive slope.

As it is not the goal, however, to compare the relative market sizes for competing innovations but to show how innovations substitute one another, market growth would distort the picture, as the curves would no longer be comparable. For this reason, market growth (or decline) has been disregarded which results in the constant market saturation level line. The upper part of the S-Curve Adoption Model hence answers the question: **"After the number of people using the first innovation peaks, to what percentage will this innovation be substituted by a outperforming one at a given point in time?"** In the case of Figure 12, the upper part of the model answers the question: **"After the number of PSTN subscribers peaks, to what percentage will fixed PSTN telephony be replaced by another, outperforming innovation (e.g. VoIP) at a given point in time (e.g. 2005)?"**

This fact explains why the first wave of VoIP-based business models could not reach a 100% market saturation level anymore: 17% of the former fixed telephony market had been absorbed by mobile telephony. Still, however, VoIP could have replaced PSTN in the remaining 83% of the households that still used fixed telephony. Figures spoke a different language, though. In 2010, out of those 83% only meagre 6% of the Swiss households used a VoIP phone. Including corporate telephony, VoIP only accounted for about 10% of the total fixed telephony (BAKOM, 2009; SUKO, 2011). In Germany, the number was higher with 22% but it still fell short of the expectations made in 2004 (Bundesnetzagentur, 2011).

2.6.2. Upshift of PSTN-Curve: There's Life in the Old Dog Yet

Another reason why less people than expected decided to switch to VoIP is provided by an upshift of the PSTN performance curve, which prolonged the life cycle of the PSTN network. Around 2001 the PSTN network was believed to have come to its maturity in terms of performance. Little room for progress was conceded to the network due to the fact that its infrastructure was known to be costly and less flexible for changes than VoIP. In Figure 12 a stagnating PSTN-performance-curve reflects this fact. PSTN subscribers were expected to gradually switch to the improving VoIP solutions. However, it came different: It was VoIP that breathed new life into the legacy PSTN network.

As VoIP technology progressed, incumbent operators soon adopted VoIP in their backbone (c.f. Figure 11) and turned it into a Next Generation Network (NGN). NGNs are networks that allow to telecommunication providers to offer any telecommunication service (e.g. telephony, radio, internet or television) through one combined physical network with a high degree of quality and reliability (QoS). Hence, while conventionally services have been transported through purposely-built and dedicated networks, on NGNs service functions are completely decoupled from the underlying transport technologies and voice is only one service amongst others that is transported through the network. (Obermann & Horneffer, 2009; Sietmann, 2009)

For end-customers this alteration remained unnoticed, as they continued to be connected to the local exchanges through the same PSTN subscriber line. Only at the local exchange, the way their call was routed onward radically changed. Had calls before been passed through the hierarchical levels of the PSTN backbone until a common node with the callee was found, they after the modernization were directly routed over the internet to the local exchange of the callee, leaving out the higher levels of the PSTN hierarchy (Henkel, 2009; Sietmann, 2009).

Changing to backbone-VoIP not only enabled the incumbent telecommunication operators to reduce their infrastructure, but it also granted them to add new services more flexibly than with the legacy PSTN backbone. For instance, the new IP infrastructure helped the incumbent PSTN operators to retain corporate clients that switched their PSTN telecommunication infrastructure to an IP-based system because the operators could connect IP-based PBXs directly to the IP backbones ("SIP trunking"; c.f. Fischer, 2008). The modernized backbone also opened new markets to the incumbents, such as the leasing business of IP-PBXs to companies. (Badach, 2007; Landgrebe, 2006; T-Systems, 2007; Virgo Publishing, 2006)

The enhancement of the backbone had a strong impact on the cost figures of the incumbents. British Telecom, for instance, was estimated to save up to 43% of its cost due to the network improvement (Henkel, 2009).

Concluding this chapter, the performance curve of PSTN shifted up, because implementing VoIP in the backbone of the PSTN incumbents lowered costs for them and permitted them to offer additional features in a flexible way, which previously only had been possible for VoIP operators. Therefore, the life cycles of the PSTN-based business models were prolonged, and the shift to VoIP was delayed.

2.6.3. Downshift of VoIP-Curve: Inability to Deliver Value

Not only did the performance enhancement of the PSTN network and the shift towards mobile telephony cut into the substitution potential of VoIP-based business models[20], various aspects also resulted in a lower VoIP performance than was anticipated. The attributes of innovations that were introduced in chapter 2.2.2 shed light on this downshift of the VoIP-performance curve.

Compatibility: The telephone functionalities offered by the PSTN incumbents satisfied the needs of most customers. Therefore, they had no imminent need to switch to a VoIP provider that offered more features. Plus, most customers had had the same provider for a long time, as historically monopolists controlled the telecommunications industry. VoIP start-ups therefore first had to find a way to break the strong ties between the incumbents and their customers. Many of the VoIP providers did not make it past this step, because oftentimes customers valued the tested, trusted and working relation with the incumbent operator more than saving few dollars per month. Also, many customers did not change, as their potential benefit was not great enough to compensate for the efforts and risks that were connected with leaving the incumbent. Those VoIP operators who made it past this step and successfully convinced customers to change then had to find a way to protect their business model against other VoIP providers. Also in this step, many failed because of the low entry barriers for other VoIP operators, and because those customers switched to VoIP operators were price sensitive and prone to change again.

For companies that already had a customer base – a description that mainly applies to ISPs – it was easier to launch VoIP services than for operators that had to start from scratch. In many countries, however, the incumbent PSTN operators did not suffer fierce competition from ISPs, as the incumbents themselves where the largest DSL providers[21]. Oftentimes, the incumbents only offered DSL in combination with a telephony contract. Thus, if a customer wanted to change the telephony operator, he or she also had to look for a new DSL provider. For saving that trouble, many people did not switch. Only since 2001 and 2007, in Germany and

[20] VoIP-based business model here refers to telephony where the device of the end-user is based on VoIP technology. Hence, telephony where the subscriber line is based on PSTN but the backbone on VoIP does not fall under this category, as the end-user does not use a VoIP device but a traditional PSTN phone.

[21] For instance, the largest PSTN incumbents of Switzerland and Germany are Swisscom and Deutsche Telekom, respectively, which at the same time are the largest DSL operators.

Switzerland, respectively, the regulator requires the incumbents to also offer DSL without telephony service (so-called “unbundled access” or “naked DSL”). (BAKOM, 2007; CallMagazin, 2001; Pourasghar & Hermes, 2006)

Besides time effort and inconveniencies, switching to smaller ISPs with a VoIP bundle had another disadvantage for customers. As the backbones of the PSTN networks gradually were modernized to NGNs, the incumbents started to offer free on-net calls. Because the majority of the people remained with the incumbents, those who did switch away faced increased costs to call those who had remained, as they were not part of the same network anymore. (Bell, 2008; Gurov, 2005; Swisscom, 2011a).

Relative Advantage: More flexibility allowing for more features was mentioned as one of the central advantages of VoIP (c.f. chapter 2.4.2). Most residential customers, however, did not have use for fancy features such as group calls or follow-me functions, did not have the appropriate devices that supported functions such as video-telephony, or did not have the knowledge of how to use it. Therefore, for many customers the only differentiator between the offerings was price, not features. The cost-advantages inherent to VoIP business models were, however, eradicated by the above-mentioned PSTN-backbone enhancement. In addition, the fact that most VoIP providers built their own proprietary networks also prevented VoIP to entirely release its cost-saving potential; many VoIP operators did not or could not interconnect their network with other VoIP providers, and did neither support common concepts such as the ENUM, for which calls were still routed through the fee-based PSTN network, yielding no cost advantage for the end-users compared to PSTN (Bell, 2008; Wallingford, 2005; von Bomhard, 2006). For example, still today Skype charges a customer that dials a PSTN number, even if it ultimately belongs to a VoIP device. Because Skype does not interoperate with other VoIP protocols, the program fails to establish a (theoretically possible) direct internet connection and needs to route the call through the fee-based PSTN network.

Complexity: For businesses switching from a PSTN-based telephony infrastructure to a VoIP-enabled system oftentimes not only is costly, but also a difficult process. Due to the complexity of the PSTN network architecture that interconnects multiple systems across many interfaces, changing the entire infrastructure at once rarely is a feasible option. Rather, certain elements of the architecture are gradually migrated to an IP-based solution (Christensen, Anthony, & Roth, 2001). Thus, it should not surprise that a “revolution” failed to appear in the corporate telephony market. Notwithstanding, in 2007 already two-thirds of all PBX shipped were VoIP rather than PSTN-based, and VoIP penetration among US business is expected to increase from 42% in 2007 to 79% in 2013 (Pan, 2010).

Trialability: Many software-based VoIP operators provided their software applications free to download and their services on a pre-paid basis. Due to the low cost for trying this kind of VoIP, trialability was high. Yet, the viability to substitute the PSTN phone suffered from the fact that such software-based VoIP client required a permanently switched on computer. Those VoIP providers that used hardware VoIP clients, for instance a VoIP-phone, an ATA adaptor or an IP-PBX, in contrast, required an upfront investment. Thus, trialability was lower and only customers with a high involvement decided to commit themselves to such up-front investment. Hence, in terms of trialability VoIP did not have a clear advantage over PSTN, which contributed to the fact that the VoIP and PSTN performance curves were closer together than expected.

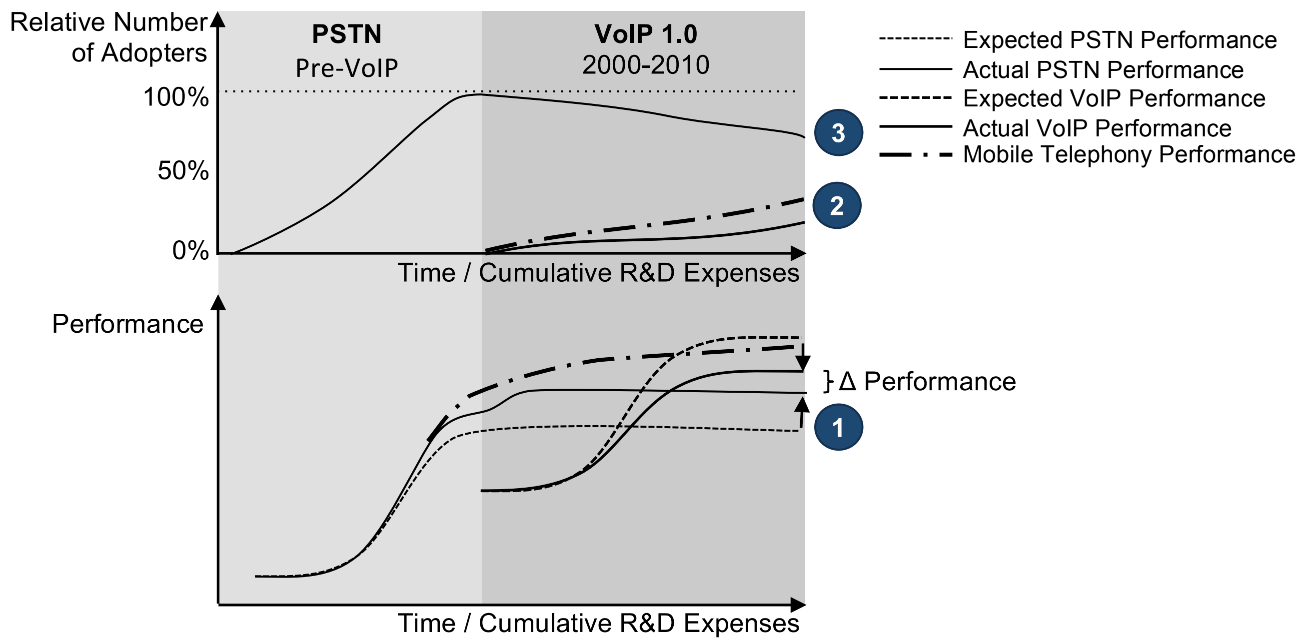
Observability: Residential users hardly learnt about the advantages of VoIP from their peers. First, even if a person occasionally used the VoIP phone of a peer, he or she would probably not even have noticed that it was a VoIP phone, as it still had the same appearance as a classic PSTN telephone. Secondly, the main advantage of VoIP was lower costs. These costs, however, were only observable on the phone bill at the end of the month. As usually only the person who has to pay the bill notices the cost reduction, and telephone costs neither are a topic that usually dominates discussions in social settings, people did not learn from each other about VoIP. Hence, in terms of observability VoIP did not excel PSTN in the area of residential telephony. In business telephony, were costs are analysed by various people and business units are benchmarked against each other a clear pressure exists to reduce costs of any kind. Therefore, the observability of the impact of VoIP was higher, which is one of the reasons why VoIP found wider implementation in companies.

2.6.4. Effective Impact of VoIP from 2000-2010

Summarizing the points above, VoIP and PSTN-based business models in terms of performance were closer together than was expected. On the one hand, the PSTN curve shifted up, because the incumbent operators took advantage of VoIP and modernized their backbone. On the other hand, the VoIP curve shifted down, because customers frequently failed to see the value that switching to a VoIP provider could bring for them. Finally, VoIP also had a hard stand in establishing itself on the market, because fixed telephony increasingly became substituted through the mobile phone.

Does this mean the "VoIP Revolution" did not take place? The answer is yes, with a little bit of no. In corporate telephony, many of the large enterprises indeed did switch to VoIP. Yet, the modernization of the corporate infrastructure occurred more incrementally than revolutionary. In residential telephony, the impact was lower as PSTN incumbents could successfully compete with the aspects customers valued: price, quality and reliability. Thus, for the end-customers VoIP-based business models did not greatly revolutionize telephony. For incumbent telecommunication operators, however, VoIP revolutionized their PSTN backbone and reduced costs tremendously. The provocative statement "VoIP is dead!" can be interpreted in such way that VoIP-based business models had failed to overthrow the incumbents, but instead had been beaten by their own technology (Bell, 2008).

In conclusion, rather than shifting customers away, VoIP helped the incumbents to fortify their position and to prolong the life cycle of PSTN. As their business model was enhanced rather than overthrown, VoIP can in fact be considered as a sustaining rather than a disruptive innovation. Figure 13 depicts schematically the substitution process of PSTN telephony that occurred between 2000 and 2010.



1. Contrary to expectations, the performance of the PSTN network increased again when the operators modernized the network's backbone with a VoIP-capable Next Generation Network. The PSTN curve shifted up. Due to several reasons, however, the performance of other VoIP business models was lower than was expected. The VoIP curve shifted down. In addition, parts of the market perceived mobile telephony superior to fixed telephony and as a substitute. Therefore, the mobile telephony performance line is above the VoIP and PSTN performance.
2. The performance advantage of VoIP-based business models was smaller than expected in 2004. Consequently, also the rate of adoption was lower than anticipated. In Switzerland, for instance, more PSTN telephony was substituted by mobile telephony than by VoIP.
3. As a result of the lower rate of VoIP adoption, the life cycle of PSTN was prolonged. The trend towards mobile telephony, however, accelerated the decline of PSTN-based business models.

Figure 13: The Shift of Fixed Telephony To Alternative Innovations between 2000 and 2010.

Source: Own illustration.

2.7. Road Ahead: All over IP?

By the end of the year 2011, many companies have switched to VoIP, but the majority of households are still connected to the traditional PSTN network. For them, telephony has become cheaper because the incumbents, as reaction to the aggressive tariff models of the VoIP providers, have cut their prices. Therefore, many households have not seen an advantage in changing to a VoIP provider but have remained with the incumbent PSTN operator. Hence, one might be tempted to conclude that VoIP – except for the price reductions it has induced – has had little effect on residential telephony. However, unnoticed by most end-users, by now the backbones of most PSTN operators have successively been modernized to NGN infrastructures, as has been explicated in chapter 2.6. Therefore, today the majority of calls somewhere in between the caller and the callee are routed over the internet – including those of PSTN customers.

In the arena of mobile telephony VoIP has had little effect until 2011. For the time being the vast majority (~90%) of cellular calls is still transported over non-IP-based GSM connections (GSMA, 2012). Only in seldom occasions, for instance expensive international calls, mobile VoIP is used. Multiple reasons exist why mobile VoIP has not skyrocketed yet: Lack of awareness, lack of possession of a smart phone, short battery cycles, expensive data plans for mobile internet, expensive international roaming, cumbersome VoIP software, low voice quality, compatibility issues, etc. (Dickson, 2009; EON, 2011; Quincent, 2011).

Regardless the problems mobile VoIP still has, internet telephony has taken the next step. For the first time in history, VoIP is no longer only competing with fixed telephony, but it is also capable of replacing the incumbent mobile telephony. Figure 14 depicts such IP to IP (IP2IP) telecommunication in its purest form. That a shift towards IP networks is underway is not pure theory: "WhatsApp" is the best example. When the application ("app") was launched, it revolutionized the texting market. The program allows sending instant messages to other WhatsApp clients. The messages are, in contrast to SMS, sent free of charge[22]. The company entered the market in 2009, in 2010 already more than 1 million people were using the program, and although no numbers have been published for 2011, estimates suggest that user counts go into the tens of millions. Hence, in developed countries with high smart phone penetration rates, the IP-based app has indeed started to seriously cannibalize the SMS market. (Bradshaw, 2011)

WhatsApp is not the only example that stands for the fast change that is underway. What WhatsApp is for texting, Viber is for calling. When Viber users dial a PSTN number, Viber verifies whether the conversation partner is also registered with Viber and eventually establishes a VoIP connection. The download and usage of Viber is entirely free. The application even supports high-definition video telephony. That also this feature is completely free of charge goes without saying (Tele-Service, 2011).

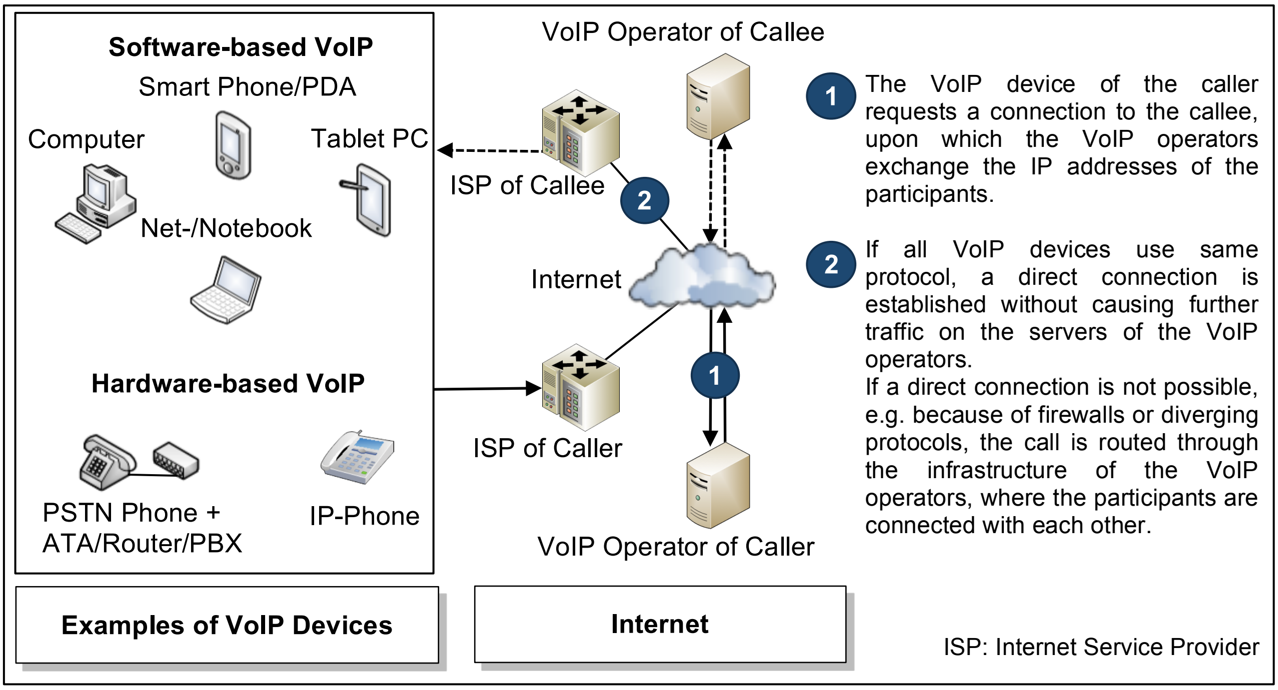


Figure 14: Example of a Pure IP2IP Network Architecture.

Source: Own illustration.

[22] The download of the application is not free, but negligibly inexpensive. Already few text messages amortize the investment.

With VoIP capable of reaching out to both fixed and mobile users, the question rises if a second wave of VoIP is about to start that will finally revolutionize the industry. Will VoIP finally replace classic telephony? Will people switch to programs like Skype or Viber to make their calls? If so, which program will prevail? Will telephony as a service be free and all users will pay for is the internet data volume they consume? Will telephone numbers be replaced by alternative address systems, e.g. e-mail addresses? What will the role of the incumbent telephony operators be?

	Critical Criteria	***Factors***
Supply Side	**Business Model**	- Operator's Incentive
	Customer Base	- Adoption Awareness - Signaling Compatibility
	Regulatory Aspects	- Lawful Interception - Emergency Services - Anti-trust Legislation
	Incumbent Competitors	- Defensive Moves - Pro-active Reactions
Demand Side	**Reliability**	- Network Accessibility - Permanence of Connection
	Quality	- Network Service Level - Voice Codecs
	Price	- Switching Cost - Costs per Call
	Functionality	- Additional Features - Operability
	Convenience	- User Experience - Backward Compatibility
	Security	- Data Privacy - Encryption

Figure 15: Criteria Determining the Future of VoIP.

Source: Own Illustration.

How VoIP will evolve and what consequences it will bring to the industry depends on a multitude of factors. On the supply side, for being successful competitors with VoIP-based business models must overcome the resistance and defensive moves of the incumbent operators, gain the awareness of the customers, establish customer relations and reach a critical mass with their user base. These are issues VoIP operators struggled with in the past. At the same time, they must face and deal with regulatory aspects. Furthermore, VoIP operators need to find new business models that allow them to convert their user base into revenue – another aspect that turned out to be difficult for many providers of VoIP 1.0 solutions. On the demand side, if VoIP is to significantly alter the industry, in the consumers' perception VoIP must excel classic telephony in in terms of reliability, quality, price, functionalities, convenience, and security.

Figure 15 exhibits the criteria that are likely to have a high impact on the diffusion of VoIP. Each criterion consists of several factors, and in the specific empirical each of these factors is looked at separately. In the words of the introduced scenario technique (c.f. chapter 2.1), Figure 15 summarizes the scenario drivers[23]. The synthesis of the scenario drivers will then serve as the base for the development of the most-likely scenario of how VoIP will evolve in the future.

2.8. Conclusion of the General Theoretical Section

The General Theoretical Section explicated what innovation is and presented the S-Curve Model by Christensen et al. and the Diffusion Model by Rogers. The two models were integrated to the S-Curve Adoption Model that compares competing innovations in terms of their performance and diffusion. The framework holds that the aggregated number of people that adopt an innovation directly depends on the degree by which it is superior to other competing innovations in terms of perceived attributes.

A synopsis of the history from the early beginnings of telecommunication until 2004 revealed that classic telephony had evolved rather steadily and without significant disruptions. Innovations such as the Strowger switch or the change from plug boards over electromechanical to digital circuit switching enhanced rather than revolutionized the PSTN network. The same chapter also touched on the evolutions of the internet and the mobile telephony and it was noted that both made significant progress in the last two decades, have induced change in our society and have made access to information and the internet omnipresent.

Chapter 2.4 compared Voice over IP and PSTN and the network architectures behind the two technologies. While PSTN uses a highly reliable circuit-switched network that dedicates lines for the exclusive use of a call, VoIP packetizes voice signals and transmits the data packets on varying routes over the internet. VoIP was found to be much more flexible and to offer cost and feature advantages over PSTN, while being inferior in terms of quality of service.

The outlook for VoIP in 2004 was a shining one. Quality of service issues were expected to be solved soon and VoIP to replace the traditional telephony, because its superiority in terms of features and costs. However, in the retrospective it can be noted that the first wave of VoIP showed less impact at the customer site than was expected and was less of a disruptive nature than of a sustaining one. First, much more than VoIP it was the advent of mobile telephony that impacted the telecommunication industry in the period 2000-2010, as it started to partially replace fixed telephony. Because the first wave of VoIP only competed with fixed telephony it had actually entered a shrinking market, for which it was difficult for it to gain traction. Furthermore, customers were less enthusiastic about fancy features that VoIP could provide and they valued more the quality and simplicity classic telephony offered and the trusted relation to their telephony provider. Thirdly, the incumbent telephony operators modernized their PSTN backbone to NGN networks, which ena-

[23] In accordance with the introduced scenario technique, factors with low impact were not listed.

bled them to cut costs dramatically. This allowed them to compete with the low tariffs of the VoIP-based business models.

By the end of 2011, technological progress has made internet ubiquitous and has enhanced the capabilities of mobile phones. On more recent smart phone generations it is possible to install applications that allow making phone calls over the internet rather than via the classic telephone network. Consequently, VoIP has arrived at a point where it is capable of substituting not only fixed but also mobile telephony.

Applications such as WhatsApp or Viber have demonstrated with impressive growth rates that the consumers meet free IP-based telecommunication services with interest. At the same time, WhatsApp & Co. have made clear that for classic telecommunication operators a bumpy road lays ahead, as for them telephony and messaging services make up significant percentage of their revenues, which are now under siege.

VoIP is in a position to radically change the telecommunication industry if consumers perceive it to be superior to classic telephony. This depends on a range of criteria that were summarized in Figure 15. At the same time, VoIP operators must find ways to bring their value offerings to the market and their potential clients. In the course of this process they not only need to establish customer relations, but must also deal with adverse issues such as regulatory aspects or defensive moves by incumbents.

For each of the criteria in Figure 15 factors have been identified on which the future development of VoIP depends. In the Specific Empirical Section, each of these factors will be scrutinized and interviews with industry experts will serve as the base to assess how these factors will evolve. The entirety of factors will be synthesized into a most-likely scenario that will indicate how VoIP is going to evolve and what potential it has to replace traditional mobile and fixed telephony.

3. Specific Empirical Section

3.1. Empirical Objective

Figure 15 identified the factors that determine the further diffusion of VoIP and the impact it will have on the telecommunication industry. In the now following Specific Empirical Section each of these factors is studied separately and the reader is offered how each is likely to evolve. The entirety of analyses of these factors is then aggregated to the most-likely scenario of how VoIP will evolve over the next ten years. In the words of the introduced scenario technique (c.f. chapter 2.1), in the Specific Empirical Section the certain and uncertain scenario drivers are studied and aggregated to the overall scenario that has the highest likelihood to materialize.

3.2. Empirical Methodology

The assessment of the factors is, besides secondary sources such as industry reports and market forecasts, based on primary data obtained from interviews with industry experts. The conducted interviews were of a semi-structured type, as the interviewer followed a prepared list of questions but flexibly asked additional questions in case of unforeseen contingencies that aroused during the interview (Lindlof & Taylor, 2011; see questionnaire in Appendix A6).

As was pointed out in chapter 1.3, interviews were conducted to bring in a third-party perspective and lower the certain degree of subjectivity that is inherent to qualitative research. Furthermore, given the fast pace by which the industry is changing, only primary data may compensate for the often recent but already outdated secondary sources.

As also the views of the interviewed experts only represent subjective opinions, measures were taken to arrive from biased notions to more objective insights. On the one hand, all experts were, with only small variations, asked the same set of questions, for which a comparison of the answers was possible. On the other hand, the experts were chosen in a way so that they viewed the topic from different angles, which allowed deriving well-balanced insights.

All interviewees had years of experience with VoIP, either through working in the field of VoIP deployment or due to related research. Therefore, they were highly qualified as experts and they could offer valuable insights. Furthermore, they were representatives of reputable institutions, including Microsoft (a leading software company), Swisscom (the largest incumbent telecommunication operator in Switzerland), Accenture (a renowned technology advisory firm), Siemens Building Technologies (a company that developed and implemented VoIP solutions on large scale), and HSR (a Swiss university offering high-level education and research in the area of information technology). A list of the interview partners and their backgrounds can be found in Appendix A5. At this place it shall particularly be highlighted that for this thesis also an interview with Professor Dr. Henning Schulzrinne was conducted, who was a driving force behind the development of VoIP. Prof. Dr. Schulzrinne is the chief technology officer of the United States Federal Communications Commission, the highest regulatory authority for telecommunications of the United States, and professor at the Columbia University, where he formerly also was chair in the Department of Computer Science.

Unless stated differently, the insights presented in chapters 3.4 and 3.5 are based on the aggregated results obtained from the conducted interviews.

3.3. Limits of the Empirical Study

Models are abstractions that rise above the messy details and help to understand the essence of what the phenomena are and how they operate (Christensen, 2006). Being such abstractions, they to a certain degree inherently are imprecise. Furthermore, in accordance with the introduced scenario technique, some factors were not analysed due the low degree of impact they were expected to have on the most-likely scenario. The findings of this thesis would be seriously distorted if a factor was disregarded that would in fact have a significant impact.

In total six interviews were conducted with experts that represented views of different players in the industry. While this approach helped arrive at a more balanced outlook it must be noted that per view type only one representative was interviewed. For instance, Prof. Dr. Henning Schulzrinne was the only person interviewed that represented the view of a regulator. Interviews with more than one expert per category would have strongly increased the validity of this thesis. Due to the limited availability of suitable interview partners, such substantiation regrettably was not possible. Finally, the majority of the interview partners had strong ties to Germany and especially Switzerland. Thus, the findings may have been skewed in this regard and might only be applicable with limitations to other geographical areas.

3.4. Empirical Findings: Factor Analysis of Supply Side

3.4.1. Business Model

3.4.1.1. The Operator's Incentive to Advance VoIP

For its diffusion VoIP depends on institutions that promote it. Any institution, however, only advances VoIP if in return it sees a benefit from doing so. Benefits can be either of altruistic or monetary nature. The earlier introduced ENUM concept is located on the altruistic side. As was explained in Exhibit 2, ENUM is a DNS service that allows for settlement-free internet routing. This means in practice that operators supporting the concept do not earn any money for ENUM-bound calls. Not surprisingly, many VoIP operators are reluctant to adopt the concept and they prefer to pass their customers via a gateway onto the PSTN network, as for this interconnection they can charge fees – even if the callee's device is also a VoIP client. A glance at Figure

16 reveals that in the case of Germany since February 2007 the total number of ENUM entries has only slightly increased and is stagnating at roughly 8000 entries at the end of 2011.

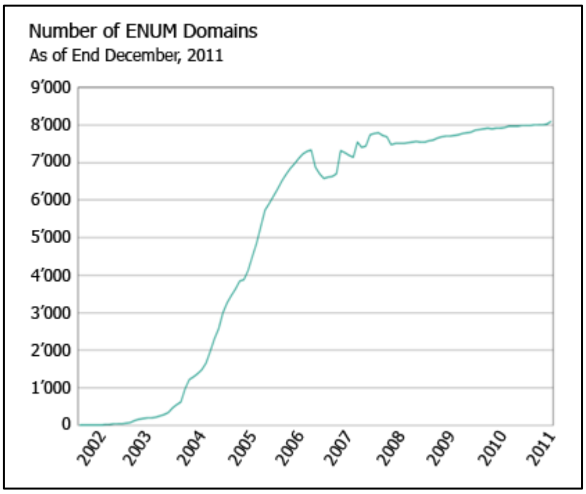


Figure 16: Development of ENUM Domain Registrations in Germany.

Source: Denic (2012).

Much more important than altruistic considerations are monetary incentives if institutions are to promote VoIP diffusion.

Today, telecommunication providers make two types of revenues. On the one hand, they earn money for the monthly subscription fees, and they charge for calls on a time-metered basis. Already, however, this traditional revenue scheme has seen alterations, and going forward other business models will prevail, resulting in different money inflows for the companies. In some segments, it is even conceivable that telephony as a service will be free. In the following, some of the monetary incentives shall be described that cause companies to promote VoIP.

For Software Companies:

At the workplace, companies like Cisco or Microsoft (MS) offer OTT VoIP services. Rather than charging for the telephony service on a time-metered basis, these companies generate their revenues through the sale of software licences and services. As for business customers the reliability of VoIP programs is crucial, also in the future they will agree to pay for well-maintained software programs and hardware.

In the private segment (fix and mobile), Microsoft's subsidiary Skype offers its software client for free; neither the program license nor on-net calls are subject to fees. Today, Skype generates its profit mainly from international calls bound to the PSTN network, and also tries to sell premium features such as video telephony for calls with more than two participants. Skype is the largest OTT VoIP provider and yet the firm's current business model faces one problem. More and more people are starting to use Skype, for which participants no longer pay for outbound PSTN-calls, but use the free on-net (Skype-to-Skype) calls. One way around this problem for Skype would be to start charging low fees for their software, or for on-net calls. Yet, the interviewed experts agreed that with the many free alternatives on the market users would probably soon abandon Skype and migrate towards a free solution. Alternatively, Skype could decide foster the sale of its premium functions, whilst keeping the basic version free. However, there are doubts in the market that a conversion-to-premium of a large share of the customers would occur (c.f. Rincón Hanna, 2011).

A more viable scenario is that Skype will start adding advertisements to its software clients in order to generate revenues. Given the company can gather knowledge about the consumer behaviour, it may use this information to improve the targeting of the advertisement. For instance, by measuring the frequency and duration of calls between two participants, Skype could derive indicators about the intensity of social relationship and use this insight in combination with other data to improve advertisement effectiveness (c.f. Rincón Hanna, 2011).

Furthermore, Microsoft is likely to seek interconnection of Skype with Microsoft Office Communicator/Lync, MSN Messenger/Windows Live and Facebook Chat[24], which would for instance allow Lync users to make free calls to Skype clients and vice versa. Such integrated network would interconnect millions of people in a free telephone network. Yet, Microsoft may use this large and free network as a value proposition for corporate customers, which would be willing to pay for a more advanced VoIP client (Lync), customer service, support, and premium functions.

Besides Microsoft, also two other large IT firms offer VoIP solutions: Apple and Google. Their clients compete in the area of end-consumer VoIP, but not in the market for corporate internet telephony. At this point of time Google does not seem to make big efforts to promote its client GoogleTalk. Apple, in contrast, includes its VoIP client Facetime on most products it ships. To the user Facetime seems free, as the software is pre-installed on the devices and does not need to be purchased separately.

However, as Facetime cannot be used on other hardware than the one provided by Apple, strictly speaking Facetime is not free but included in the purchasing price of the devices. Besides the revenues caused by the sale of the hardware, Apple has two more ways to generate money inflows with Facetime. First, similar to Microsoft, Apple also uses its VoIP client to gather valuable information about the user behaviour, which the company uses to improve its devices further, which it then sells back to the users, thereby generating even more sales. Secondly, Apple's market power allowed the company in many countries to conclude deals with telecommunication operators that would let it participate in the revenues stemming from mobile internet traffic caused by Apple devices. In other words, customers might use the application Facetime free of charge. However, if they use Facetime on a mobile internet connection of a provider with whom Apple has an agreement, a fraction of what the users pay for the mobile data traffic to the provider ultimately goes to Apple. Hence, Apple is able to generate revenues from a seemingly free service.

In conclusion, for software companies ecosystem revenues are the most-likely ones to occur in the private segments, stemming from the sale of premium functions, advertisement, and cross-selling of products. Little – if any – money, however, is likely to be generated by telephony as such. Also in the business segment the acceptance of time-metered telephony is decreasing, yet they are willing to pay quality, service and support.

For Incumbents:

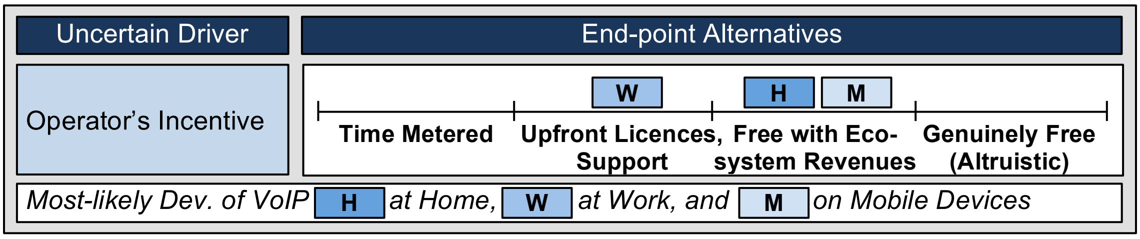
Not only IT companies have an incentive to promote VoIP. Also for the operators of the mobile non-IP networks UMTS/GSM migrating their customers towards a VoIP solution makes sense if doing so allows them to build back their legacy networks. Having to maintain separate legacy networks is costly; eliminating them

[24] Note that Office Communicator / Lync, MSN Messenger/Windows Live, Skype and Facebook all belong – at least partially – to the Microsoft imperium. Today, Skype and Facebook are already interconnected.

may therefore reduce expenses. Furthermore, new antennas are usually confronted with resistance of environmental activists. This problem could be mitigated if modern antennas were deployed as replacement for older, more harmful ones. One network that indeed could substitute GSM (and possibly in the long-term also UMTS) is Long Term Evolution (LTE). However, the rollout of LTE is still in an early stage, for which at least in the short-term the incumbent mobile telephony operators will not consider switching to a VoIP solution.

In the area of residential telephony, market competition is high and there is also a substitution pressure through mobile telephony. Margins therefore are low. Many operators have even started to offer fixed telephony entirely for customers that subscribe for other services, e.g. internet access or television. Thus, time-metered telephony is becoming less common. In order to support this kind of business model, PSTN operators had to cut costs and switched their backbone to a VoIP/NGN network. What has not changed in most cases, however, are the subscriber lines from the CPE to the local exchange (the so-called "last mile"), for which the class-5 switches at the local exchange in many cases still are circuit-switched (c.f. Virgo, 2012). Network maintenance costs would be further reduced if also this part of the network was migrated because the entire legacy PSTN infrastructure at the local exchanges could be eliminated.

Yet, despite this incentive, as long as the current system (PSTN subscriber lines plus NGN backbone) works, the incumbents are not likely to alter it, as such undertaking would incur costs while only yielding small benefits. There, however, where new telephony infrastructure needs to be installed, or where the existing local exchanges need to be renewed in any case, the incumbents are likely to deploy "Last-mile VoIP" in order to sustain their services-bundle business model with free telephony.



3.4.2. Customer Base

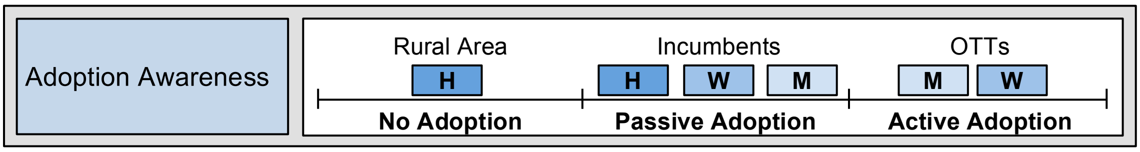
3.4.2.1. Adoption Awareness

As was repeatedly explicated in this thesis, a large share of today's PSTN calls are already routed through a VoIP solution in the backbone of the carriers without the consumers noticing it. The subscriber lines to the local exchanges, however, have not been modernized. Notwithstanding, as was explicated in the last chapter, also this part will gradually be upgraded.

There are limitations to this modernization. In remote rural areas with little population density, switching to VoIP often does not make sense. Therefore, last-mile VoIP will not, or only slowly be implemented. In other areas this seamless migration will take place unnoticed by most consumers; the telephony device will continue to look the same, only the transportation technology it uses will be different.

Consequently, in many cases it will be the incumbent telephony provider that decides when users will switch to VoIP – namely when the provider upgrades its PSTN network. As has been stated in the last chapter, this operator-driven implementation will occur, but rather slow and first in new households and subsequently in areas, where the existing telephone network needs to be overhauled and a change to VoIP financially makes sense. Most households will adopt VoIP in such passive form because they are not interested in technology and do only use their telephone for classic phone calls, but do not seek additional features VoIP could provide. Similarly, also the adoption in many SMEs[25] will be carrier-driven, as for many of them additional features are not of importance. An average butcher, for instance, only needs the telephone for making phone calls, but does not rely on video telephony or group calls.

In contrast, the majority of large companies will, if they have not done yet, adopt VoIP proactively in their institutions, for reasons that have been mentioned earlier in this thesis. For them the adoption is a deliberate process driven by the IT department. Equally deliberate and proactive is the adoption of VoIP in cases, where OTT applications are installed to use VoIP, because the process of setting up such applications is a conscious one. OTT solutions are partially adopted by private consumers as a substitute for residential PSTN telephony (e.g. for international calls), or on the mobile device to circumvent the fees of the mobile network operator. Often, the adoption of mobile OTT VoIP is driven by end-consumer word-of-mouth influence[26].



3.4.2.2. Network Integration

The technologies on which VoIP networks are based differ from one another. If users of two distinct networks are to talk to each other, the operators need to provide some sort of interconnection between the networks. Yet, the degree of integration that operators offer varies. Four options are discussed in turn.

No Integration: Some operators have no incentive to interconnect their network to any other network and they lock their customers within their strictly controlled ecosystem. One example is Apple's Facetime that only allows users to interconnect with other Facetime clients; gateways to the PSTN network or other VoIP services are not available. The reason for this approach is simple. For using Facetime the user needs to buy an Apple device. If Apple switched to an open standard or made Facetime available on non-Apple platforms it would lose one of the revenue streams that finance the program.

[25] SMEs stands for Small and Medium Enterprises.
[26] E.g. "Add me on Skype!" / "Do you have Viber?" – "You don't have it? Why don't you install it? It's free, cool and so easy to use!"

Via a Gateway: Operators usually run their entire telephone network with one technology. As soon as calls need to be routed onto networks of other operators, however, the signalling technology oftentimes is a different one, for which the call needs to be converted. This task is realized by dedicated gateways. For such inter-provider connections, users usually pay an interconnection fee. In the business area a call from a Lync[27] to Cisco's Unified Communications client, for instance, is possible and users pay a yearly fee for this interconnection (c.f. Microsoft Technet, 2012). Residential customers that use a VoIP phone usually are interconnected trough a gateway to the PSTN network, as otherwise they would only be able to call other VoIP subscribers that are within the reach of the operator's IP network (c.f. Figure 11). For the interconnection to the PSTN network users are charged a fee.

Via Compatible Clients: If caller and callee use distinct networks with different signalling technologies, gateways are just one option how the participants can be interconnected. It is also possible that one of the clients is capable of abandoning the own default protocol and adapts to the one of the other client. The following analogy shall clarify this difference: A German-speaking and an English-speaking person need to communicate with each other. The gateway solution works like a translator. It mediates between the participants and exchanges the converted voice signals. Also in the case of compatible clients both participants speak different languages. However, at least one of the two participants is capable of speaking both languages, for which an interpreter/gateway becomes redundant. In practice, VoIP clients that support multiple protocols are rare[28].

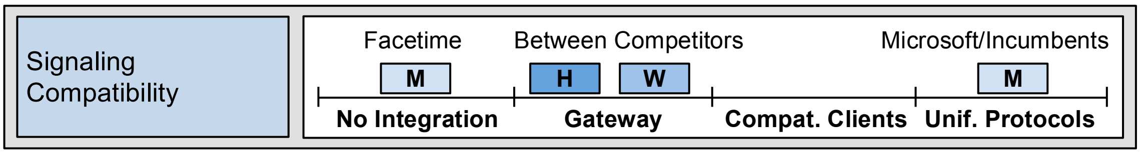
Unified Protocol: Unifying the underlying protocols is another way how networks may be made interoperable. Mainly operators that shoot for the mass market and the highest possible market penetration opt for this strategy. Given the high integration efforts such unification requires it is most likely to occur where one company operates all networks that are to be unified. In practice, Microsoft is one example of company that could pursue an integration of its three VoIP communication platforms Lync, Windows Live and Skype. While the use of gateways could be a short-term solution, in the middle term it is very likely that Microsoft unifies the network technologies by migrating them to one common protocol, as this will reduce the overall integration efforts. The above introduced analogy shall visualize this fact: If a company had German-speaking, Spanish-speaking, Polish-speaking and Portuguese-speaking employees, it could hope that in conversations the participants would either be able to speak the other's language (compatible clients approach) or that interpreters between all the participants would enable the exchange of information (gateway approach). Clearly, with every additional language present the required effort to exchange the information streams would increase exponentially. By defining English as the common language and teaching that language to all employees is the approach of unified protocol, and reduces the translation efforts.

[27] Microsoft Lync (Lync) is an enterprise software application for real-time communication. Formerly, the program was called Microsoft Office Communicator.

[28] The only one known to the author at the time this thesis was written is an application called Fring.

Going forward, in the private area competing types of OTT VoIP ecosystems will be found. Even though it would be desirable from a consumer perspective to have one client that integrates all networks, this will not materialize, as all operators have an interest to keep their network exclusive. While some operators aim for the mass market and make their clients interoperable with many platforms, yet closed towards other VoIP applications (e.g. WhatsApp, the Microsoft clients, Viber), others even restrict the platforms on which they run, as the main source of revenue are the platforms (e.g. Facetime). Only if they can charge for the interconnection, the operators will interconnect their network to the ones of other VoIP operators. Networks under control of one single operator, however, are likely to be integrated in order to create value with large, interconnected customer bases.

The same applies for the network of the incumbents; they have a direct interest that calls to their networks are expensive. Why? The incumbents have the largest networks in terms of user numbers. If calls to their networks were cheap, individual customers could consider switching to competitors. With inter-operator calls being expensive, however, calls are costly for those people that switch because most callees are subscribers of the incumbents' networks. Therefore, individual customers are reluctant to switch away from the incumbents and so is everybody else. For this reason the incumbents are capable of retaining their customers. Within their network the incumbents offer calls for free or at low rates on a per-call basis, collect flat-rated subscription fees, and co-offer additional services where possible (c.f. 3.4.1).



3.4.3. Regulatory Aspects

3.4.3.1. Lawful Interception

With an increasing number of people switching to VoIP governments have become more concerned with regulating VoIP telecommunication, and attempts to govern it similarly to traditional telephony have been made. Many geographical regions already have laws in place that apply to classic telecommunication providers as well as commercial VoIP operators. Amongst these provisions are the obligations for operators to track traffic, to identify the identity of the call participants, and to implement mechanisms that allow for the lawful interception/wiretapping, e.g. in case of illegal activities.

The specific rules the providers need to comply with differ for every country and sometimes a difference is made between operators that offer an interconnection with the PSTN network and IP2IP purists. Voice chats in computer games, for example, are in most countries not subject to telecommunication rules in spite of being VoIP applications, because they are not interconnected with the PSTN network.

In the future it is conceivable that the legislator will distinguish between private and public telephony. The former refers to calls that are exclusive in the sense that callers can decide whom they wish to talk to and whom they want to exclude from participating. This category includes classic telephony, but also VoIP operators such as Skype, Viber, or Vonage. Public telephony in contrast describes those areas where voice signals are exchanged non-exclusively and not with the primary purpose of telephony. This description applies, for instance, to the above cited example of computer games that offer voice interaction between random participants. As such open networks have more social control legal provisions will be less strict. Although the distinction into categories will help to better govern the telecommunication market, also in the forthcoming years some ambiguity and room for interpretation will remain – in particular when it comes down to the question how a specific service of a certain operator has to be categorized. (see also Kheterpal, 2011).

Telephony operators will comply with stricter policies where such are enacted, as not doing so could cause severe penalties and also result in their license being withdrawn. Yet, for telecommunication operators providing governments with a backdoor to their network is a twofold challenge. On the one hand, the operators must put in place appropriate measures that enable the authorities' access. In particular for peer-to-peer (P2P) operators (e.g. Skype) that do not route the calls through a central entity but establish a direct connection between the call participants the implementation of such interception capabilities is challenging (Seedorf, 2008). On the other hand, the operators must protect their backdoors from illicit access. The example of Vodafone Greece demonstrates that a failure of complying with these requirements can be costly. In 2006, the company was fined USD 100m because hackers had been able to monitor mobile phone users through the backdoor port of the Vodafone network (Brabant, 2006).

Certain Driver	Certain End-Point
Lawful Interception	Full Compliance of Operators

3.4.3.2. Emergency Services

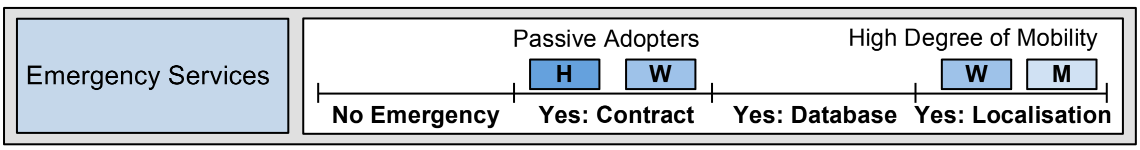
In most countries of the world emergency services are organized regionally. As the traditional telephone number belonged to a certain geographic region, callers in need were directly connected to the correct coordination centre. With VoIP the link between number and locality is no longer given. A caller with a São Paulo-based number for example could be located anywhere in the world. Therefore, before connecting him or her to an emergency centre VoIP providers first need to determine the current position of the caller.

Three systems exist how providers solve this problem. In residential VoIP, often the internet access provider is also the VoIP operator. Because a contract between the caller and the company exists the address of the caller is known. To avoid that the address from where the call is originating is different from the one stated in the contract, this type of operator technically prevents the consumer from using the VoIP telephone in other locations. This kind of VoIP is unproblematic in terms of emergency localisation and will apply to most users that will adopt VoIP passively/operator-driven (c.f. chapter 3.4.2). For OTT providers, in contrast, the address of the caller is often not known because a contractual relation with a verified address is lacking. OTTs[29] often use one of the other two options.

The first type of OTT provider requires users to register their location in a database. In case of an emergency, such provider rather than verifying where the caller is actually located connects him or her according to the entry in the database to the corresponding emergency centre. This system has the drawback that if the entry in the database is out-dated, the caller is connected wrongly. The second type of operator relies on a technically more advanced system. In fixed OTT VoIP, the IP address may serve as an indicator where the caller is located. Deriving the localisation from the IP address, however, is often imprecise, or may even be completely wrong if the caller uses an internet connection that contains certain technical elements such as a proxy server or a VPN[30].

In the area of mobile VoIP, because cellular devices usually communicate with multiple antennas simultaneously, triangulation reveals the user's position quite accurately. Hence, the operator that controls the last mile of the mobile internet connection is able to determine the current position of the caller. If this internet carrier is the same company as the one that provides the VoIP service, this system works well to interconnect the caller to the correct emergency service. Yet, in mobile VoIP only in rare occasions the ISP and the VoIP operator are the same company. More often, OTTs provide the VoIP service and OTTs, in contrast to the internet carriers, cannot access the information where the caller is located; and internet carriers until today are not required to pass along this information to the OTT. Therefore, for OTTs it oftentimes is virtually impossible to determine the position of the caller, except if the callers' device has a built-in GPS module that provides the information. As a result most mobile VoIP OTTs explicitly exclude the access to emergency services in their terms of contract or require the user to register with a database as was explained before.

Going forward, regulations regarding emergency services are expected to be tightened. In case of emergency, the caller's location will have to be determined precisely, sometimes even as accurate as the storey level. In the United States, for instance, in the foreseeable future a decree is likely to be passed that will require internet carriers to forward the position information to the OTT VoIP providers, enabling them to comply with the revised policies. Chances are high that within ten years the locality determination for VoIP telephony will be much more accurate than today and that also OTTs by law are required to provide access to emergency services. This does not, however, apply to OTT VoIP that does not primarily serve a telephony function, e.g. in-game voice chats (c.f. chapter 3.4.3).



[29] OTTs stands for Over-The-Top Operators
[30] VPN stands for Virtual Private Network

3.4.3.3. Anti-Trust Legislation for OTTs

As a rule of thumb, telecommunication providers with large customer bases attract even more consumers because of the free or low-cost on-net calls they offer to their clients. Hence, it is a frightening scenario for the incumbent operators that an OTT network emerges with a large customer base, because the rise of such network could induce a pull effect triggering a mass customer migration.

By interconnecting the user bases of its separate products, Microsoft would indeed be in a position to quickly establish such large customer base[31]. Yet, anti-trust regulations put limits to such integration. When in the mid-90ties Microsoft decided to integrate its Internet Explorer as an inherent component of every Windows operating system it shipped, as well as when it included its Media Player by default in every installation, the company was found guilty of having violated competition laws in the United States and the European Union, respectively. In both cases, Microsoft was fined with record-high penalties.

Lync, Windows Live, Skype, Facebook, Xbox Live, and Hotmail interconnected would turn Microsoft into the world's biggest VoIP OTT operator from one day to the next. Not surprisingly, with such product and user base convergence the company is walking on a very thin line and is watched with Argus' eyes by competitors and regulators.

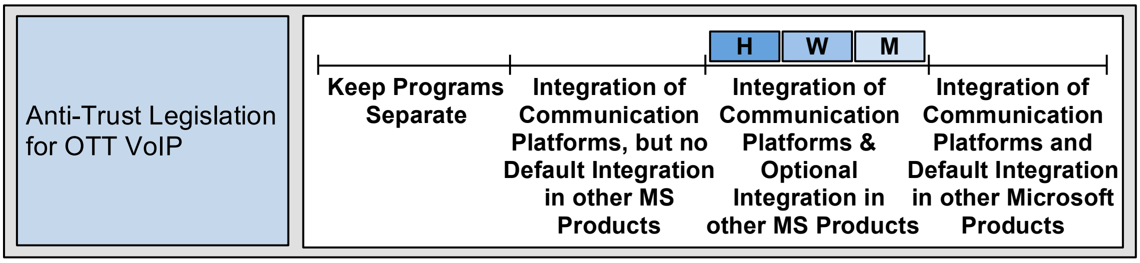
It would be even more critical from a market competitiveness point of view if Microsoft included its VoIP client by default on every Windows 8, Office 365 or Exchange Server it ships, because other OTTs would likely to be crowded out of the market, similar to what happened to Netscape when the Internet Explorer became a fix component of the Windows operating system. Given the past experiences, Microsoft will pay close attention to not breaking anti-trust laws again, but yet it will try to converge its user bases. This process will be vigilantly be observed by incumbent operators.

Given the strong lobbies and ties these telecommunication operators traditionally have with governments, one should not underestimate their power. Notwithstanding, on June 17th, 2011, the US Federal Trade Commission gave its antitrust approval for Microsoft to buy Skype, and on October 7th the European Commission followed suit (O'Brien, 2011a; Reuters, 2011). With their approval it seems reasonable to assume that interconnecting Microsoft's products per se would not be considered as a violation of antitrust laws by the regulators. More disputed, however, would be the default inclusion of a VoIP client in software applications that do not primarily serve communication purposes, e.g. Windows 8 or Office 365.

With the lessons learnt from the past, it is quite unlikely that Microsoft implements an own VoIP client by default in its other products, but it is highly probable that Microsoft will make it very easy for its customers to install it if they wish to do so. This, for instance, could be realized through an online software portal (so-

[31] As of 2011, Hotmail served roughly 350M users per month (Brownlow, 2012); Facebook had 483M daily users in December 2011 (Facebook, 2012); Windows Live Messenger in February 2010 had roughly 130M a day (Oiaga, 2010); Skype in September 2011 had 65M daily users (Caukin, 2011). No data on the user numbers of for Microsoft Office Communicator/Lync has been disclosed.

called "App-Store") that is well integrated with Microsoft's product portfolio. Or, Microsoft could ask a customer who buy a different product (e.g. Windows 8) if he or she also would also like to install a VoIP client and offer the own client in a selection that also contains competing products. This is the approach how internet browsers are installed on operating systems nowadays. Upon termination of the installation of Windows 7, for example, the consumer is asked whether he or she also wishes to an install a web browser, and Microsoft's Internet Explorer if offered amongst a choice of competing browsers (e.g. Chrome, Safari, or Firefox).



3.4.4. Incumbent Telecommunication Operators

3.4.4.1. Defensive Moves

As was stated earlier, in many countries the incumbent telecommunication operators are often also the dominant internet service providers. Therefore, it is in their power to take technical, legal and commercial actions to prevent or at least delay the deployment of VoIP in order to protect their telephony revenues.

Technically, an ISP has two options. It can either make the use of VoIP impossible by taking certain measures, or make the user experience so frustrating that people themselves decide not to use it. The ISP can make it impossible by blocking the ports or IP addresses that are necessary for VoIP programs to run or by monitoring the internet traffic and filtering out data packages that belong to VoIP applications[32]. The ISP can make VoIP an unpleasant experience by identifying and intentionally delaying VoIP packages, thereby causing interruptions in the flow of speech and low quality.

Discriminating data packages depending on their content or even completely eliminating them, however, is a clear violation of one of the basic principles of the internet: the net neutrality. As Tim Wu, professor at Columbia University holds: "Network neutrality is best defined as a network design principle. The idea is that a maximally useful public information network aspires to treat all content, sites, and platforms equally." (Wu as cited in Patterson, 2010, p. 2843). Hence, techniques as the ones described above the network lower the quality of the internet. Therefore, in the United States the regulator bans ISPs from using such measures and also in Europe cases are known where governments prohibited ISPs from blocking certain services through DPI, for instance in the Netherlands where the incumbent KPN was banned from blocking WhatsApp and Skype on its mobile data network. As a consequence of the dispute, the concept of network neutrality was

[32] A technology called „Deep Packet Inspection" (DPI) makes such monitoring and elimination of undesired packages a fairly easy untertaking for ISPs.

even enshrined into a Dutch national law (O'Brien, 2011b). Going forward, it is likely that more countries will adopt similar laws, and that even on the level of the European Union landmark decisions will be taken.

Legally, ISPs may put into their terms of agreement that OTT VoIP products are not allowed on their network. In Germany, for instance, all operators of fast mobile internet networks have put such restrictions in place. Yet, going back in history to when DSL came up, also in the area of fixed internet most ISPs did not allow the usage of OTT VoIP. As time went by, however, competition between the operators, and the pressure from customers and regulators eliminated this constraint. It is therefore likely that going forward also in the area of mobile internet such legal barriers will not prevail.

Commercially, ISPs may bundle their internet offering with a telephony subscription. In fixed telephony, as has been stated before, the regulator already has forced ISPs to offer also "naked" DSL access, without bundling it to a telephone subscription. In the area of mobile telephony, however, internet access is still only available in combination with a mobile telephony subscription, which means that in fact mobile telephony and mobile internet are still bundled. With the importance of mobile internet rising, legal steps by the regulator breaking this tie are likely.

Defensive Moves	Mitigated through Regulation/Competition

3.4.4.2. Pro-active Reactions

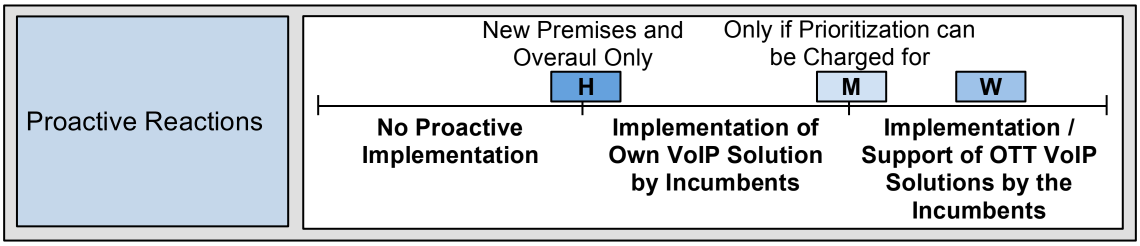
The fixed telephony market is shrinking and cost pressure is high. Therefore, as was stated earlier, incumbents have an interest to proactively implement end-to-end VoIP if it allows them to reduce costs. However, incumbents may also promote IP2IP proactively if it opens new business opportunities for them. In the business area, for instance, Swisscom, the largest Swiss telecommunication operator, implements Microsoft Exchange and Lync solutions at the sites of corporate clients. Although Swisscom thereby cannibalizes its traditional telephony revenues, the additional revenue streams resulting from the implementation, maintenance and hosting services compensate for them.

Furthermore, it was explicated that LTE is a new fast mobile internet network that is currently being deployed and that could replace legacy mobile networks. It is important to note that LTE is an all-IP based network and that in its technical specifications no special provisions for voice telecommunication have been made. Thus, as there is no dedicated voice channel, any voice over the LTE network would in fact be a VoIP solution. In the last chapter the possibilities were discussed that the incumbents have to block or delay the diffusion of VoIP. However, exactly because LTE does not have a dedicated voice channel, the technology can actually be a chance for the operators, rather than a threat.

Recapitulating chapter 2.4.2, for VoIP the QoS the underlying network is of crucial importance. First, LTE operators may offer their own VoIP telephony services with a guaranteed quality[33]. With such offering, they could differentiate themselves from OTT providers, as the OTTs lack the ability to guarantee the quality of the connection due to the fact that they do not control the internet access. But also, the incumbents might consider using techniques such as DPI to prioritize VoIP packages of OTT VoIP operators rather than to delay or filter them, and charge a premium fee for this prioritization service. Hence, although users will not pay the LTE network operators for OTT phone calls on a time metered basis, users will still pay, in addition to the consumed data volume, a premium for having a subscription plan that ensures a high level of service quality, because such plan is required for real-time applications such as VoIP. Moreover, such pro-active approach would also save the incumbents the trouble to develop their own VoIP applications.

In certain countries (e.g. the Netherlands), making traffic prioritization subject to tariffs is against the law, as it violates the earlier introduced concept of net neutrality. In such countries, where a discrimination against the degree of network quality cannot be realized, not only will the incentives for operators to invest into their expensive networks be lowered, but also will the costs for the subscription plans be increased, independently of whether customers use real-time services, or not. This is what actually could be observed in the Netherlands after the ban of traffic prioritization in 2011 (Preuschat, 2011).

As long as jitter and latency[34] problems are frequent, and the ISP operators have no monetary incentive to prioritize packages of OTT VoIP providers, no big shift away from the incumbents to OTT providers will take place in the mobile arena because the OTT's quality of service is not guaranteed. In residential telephony the incumbent operators are already equipping many new customers with cost-advantageous VoIP devices rather than PSTN hardware. Thus, a shift at the CPE and not only in the incumbents' backbones towards VoIP has already set in. Going forward, incumbents will migrate their customers step-by-step where it yields a cost advantage, e.g. if class-5 PSTN switches need to be replaced anyways and implementing a VoIP solution realizes a cost reduction. Unless such overhaul, however, is necessary the existing PSTN architecture will remain largely unchanged. In business telephony, incumbents are more proactive and implement, maintain, and service OTT solutions as business partners of OTT providers.



[33] Again, most customers would not notice that the offered service is VoIP, as the devices continue to look like regular mobile phones.

[34] See footnotes 12 and 13 (page 28).

3.5. Empirical Findings: Factor Analysis of Demand Side

3.5.1. Reliability

3.5.1.1. Network Accessibility

A fast internet connection is a prerequisite for VoIP services. Most households fulfil this criterion as they are subscribers of a DSL offering, which provides them with fixed high-speed internet. In Switzerland, for instance, the law requires telecommunication operators to make internet of at least 1 Mbit/s[35] accessible to all Swiss households. Also in the business area, broadband internet connections are prevalent.

For mobile VoIP users may either rely on a WLAN connection, or use a cellular 3G/4G network. While WLAN connections are reliable and fast, they come with the disadvantage that they only have a limited reach. It is technically possible to extend WLAN networks by setting up various access points that are distributed over a certain area that repeat the WLAN signal. Such extension, however, is only possible on a limited scale (e.g. on a school campus or office). However, the handover of the client from one access point to the next does oftentimes not take happen fast enough to avoid the signal of the VoIP call from being interrupted. Hence, it is possible to use VoIP on extended WLAN networks, but if the person is moving the call might be interrupted repeatedly.

Figure 17: 3G/4G Network Coverage in Germany, including UMTS, HSDPA, and LTE Networks of Vodafone.

Source: Vodafone (2012). Similar data is also available for Deutsche Telekom (2012).

Thus, while WLAN might be an option for mobile VoIP in a limited locale (e.g. an office), for unimpeded mobility a cellular connection is necessary (e.g. 3G or 4G). Such high-speed mobile internet networks are currently in the stage of being deployed. Many rural areas still lack fast mobile internet. This can be observed in Figure 17 the current situation for Germany was depicted. The red spots indicate areas that lack 3G or 4G access.

The German state ruled LTE to first be deployed in rural areas and that only once those regions are served urban areas may be connected. Therefore, the deployment of LTE is likely to cause the red spots on the map to disappear quite rapidly, making cellular high-speed internet soon accessible everywhere. It is expected that by 2013, 90% of all regions with up to 20'000 habitants will be served with LTE (com!,

[35] 1 Mbit/s applies as of April 1st, 2012. For this service, the operator may charge maximally CHF 55 per month. Before, the minimal speed was 600Kbit/s, which would have already sufficed for VoIP, and the price was higher at CHF 69 per month (SF, 2011).

2011). By January 1st, 2016, LTE operators are legally required to serve 90% of the entire German population. (Bundesnetzagentur, 2010)

Today, many LTE operators bind their customers to one specific antenna. If out of reach of that antenna, users cannot connect to the network for which reason their mobility is limited to a small area. In Germany, for instance, all LTE operators have this restriction in place. Hence, as with WLAN, LTE at this moment does not serve for replacing mobile telephony. Notwithstanding, once LTE will have been deployed on a large scale it is likely that such restrictions will be removed (c.f. chap. 3.4.4).

Network Accessibility	Granted due to Imposed Rural LTE Deployment

3.5.1.2. Permanence of Connection

One essential requirement for solutions that are to substitute classic telephony is that the end-devices are permanently reachable for incoming calls. In the area of fixed VoIP telephony, the advent of additional hardware (e.g. VoIP phones) has made a permanently running computer redundant and permanent DSL connections with flat-rate pricing models ensure the VoIP devices are always connected.

In the mobile area, however, due to several reasons (e.g. battery capacity, tariff models), the internet connections are usually only switched on if the user actually uses it, but they are switched off during standby. Hence, mobile VoIP at this point of time lacks permanent connectivity. Advances of technical nature that come with LTE and competition between the telecommunication operators are likely to mitigate the issues, for which going forward both in the area of mobile and fixed VoIP clients will permanently be reachable (c.f. Gemalto, n.d.).

Permanence of Connection	Granted with LTE Deployment

3.5.2. Quality

3.5.2.1. Guaranteed Service Level of the Network

As was already stated various times in this thesis the quality of the internet connection directly corresponds with the quality of a VoIP call. Where the VoIP and internet are offered by the same company, the quality of the internet connection usually is not an issue as the ISP can guarantee that sufficient bandwidth is reserved for VoIP and it can prioritize the service. In case of OTT VoIP, however, the situation is different, because OTTs cannot guarantee any bandwidth, as controlled by the ISP.

Yet, although OTTs cannot guarantee the quality of service in fixed private VoIP this is rarely a problem. Usually, sufficient bandwidth is available, for which OTT VoIP works smoothly even if not preferred over other internet traffic. In the business area, contracts between companies and ISPs often include clauses defining the quality and service level the internet connection needs to fulfil. As these terms are set rigidly frictionless usage of OTT VoIP is possible.

More problematic is QoS of OTT VoIP in cellular networks. The volume of mobile internet traffic is exploding. Between 2010 and 2015, Cisco (2011) expects the data traffic to further increase 26-fold, and that mobile VoIP will exhibit a CAGR of 42%. The question comes up if the mobile internet networks are up to the task of dealing with this increased load, and if OTT VoIP will run smoothly given it lacks prioritization and competes with much other traffic.

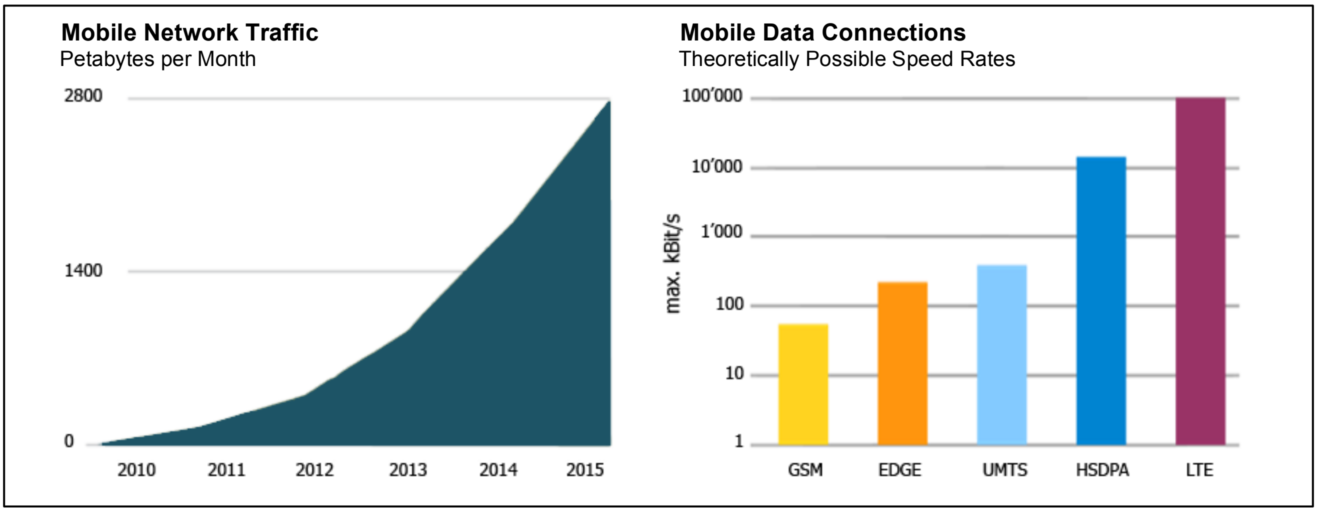


Figure 18: Evolution of Mobile Data Networks.

Source: Cisco (2011); Breuer (2011).

Depicted on the right side of Figure 18 is the evolution of the speed rates of the mobile internet networks. As can be seen on the logarithmic scale, LTE will provide speed rates that are up to 100 times higher than UMTS. Together with the further development of sub-standards of LTE and UMTS (e.g. HSDPA+), the networks are therefore likely to be capable of absorbing the strain.

Network Service Level	Granted by Fixed & Mobile Broadband Internet

3.5.2.2. Voice Codecs

Codecs[36] are pre-defined routines that determine how the voice signals are digitised, compressed, transmitted and later re-converted back into audio signals. Classic codecs simply translated voice signals into bits and bytes, transmitted them and converted them back. Yet, in case of jitter or other network issues the acoustic signal was distorted. Modern codecs circumvent this issue by three measures. First, many codecs are capable of so-called packet-loss concealment. In case packages have been lost during transportation (and hence some of the voice signals are missing), modern codecs takes appropriate steps to hide this fact from the user. For instance, if only few packages have been lost, the codecs simply reproduce the same sound again that was contained in the previous packet. Hence, the missing packet is replaced through a copy of the previous one. For the human ear this is barely noticeable while a short silence would be. If more packages are delayed, the codecs wait for a certain time period until they have gathered sufficient data packages for reproducing the sound signals. As this waiting leads to a delay, once the reproduction sets in the codecs accelerate

[36] Widely used audio codecs for VoIP are G.711 or G.729.

the sound signals in order to bring the conversation back to real-time. For the human ear also this trick is not noticeable.

Moreover, modern codecs have stronger compression algorithms. Hence, even if the network is heavily loaded the lean voice data packages are transmitted successfully. Furthermore, many codecs today adapt their degree of compression to the available bandwidth. Hence, if more bandwidth is available, the codecs reduce their compression efforts, thereby consuming less processing power of the VoIP devices, which in case of mobile devices is beneficial for the battery. In case of less bandwidth, codecs lower quality if necessary and compress more heavily, consuming more processing power. In practice, Lync is one example of VoIP client that has such measures implemented.

By today, audio codecs seen significant improvements. In the road ahead, even more progress can be expected, which will lead to an increase in quality of VoIP, even in case of slow internet connections.

Voice Codecs	Highly Developped, Ensuring VoIP Quality

3.5.3. Price

3.5.3.1. Switching Costs

For many telephony users monetary considerations play a vital role in their decision whether or not to adopt VoIP. Two distinct monetary aspects exist; on the one hand, the costs that arise per call, and on the other hand the expenses that occur in the process switching from PSTN to VoIP. The switching costs are the subject of this chapter, while the costs per call are tackled in the next one.

For residential customers, switching costs are low as VoIP operators usually equip them with inexpensive modems or ATA adaptors that enhances their legacy device with VoIP capabilities. Hence, from the user side no or little investment is required. The situation is different if consumers wish to take full advantage of all additional features that may be built around VoIP, e.g. video telephony. Then, suitable devices need to be purchased. If OTT software applications are used, for instance for international calls, switching costs are also low as the download of such applications usually is free and a paid-for subscription plan is not required.

For using VoIP on mobile devices users need smart phones that are capable of running OTT software applications. Switching costs occur if potential users do not yet possess such smart phone. As smart phones sell with a significant price mark-up in comparison to regular mobile phones, it takes its time until the majority of the market possess such advanced devices. As Figure 19 reveals, however, already today in developed markets the penetration with smart phones amongst the 18-49 year old population is high and almost half of this strata uses smart phones. In Singapore it is even a large majority. Only amongst the generations older than 50 the possession rate is significantly lower. As time goes by, however, also this segment will adopt exhibit more smart phones per capita, simply because the current strata of the 30-49 year olds is turning older.

As a measure of customer retention, many telecommunication operators offer new mobile phones to their subscribers once their contract plan expires if they renew it. Such subscription plans usually last between two and four years, for which this is the time period after which the average user replaces his or her cell phone. Hence, over the next four years the degree of the people that do not yet possess a smart phone will decrease due to two reasons. On the one hand, some of the people that currently are still bound to a subscription plan that included a classic cell phone at the time it was signed may switch to a smart phone once their contract expires and is renewed. On the other hand, because users that currently possess a smart phone will sell their current device once they renew their contract and get a newer smart phone, people that traditionally could not afford such an expensive device will have the possibility to acquire one for less money on the second-hand market (e.g. Ebay). Worldwide, the smart phone penetration was growing at 70% in 2011, and the number of devices in 2013 is expected to reach 2bn (Kadtke, 2012).

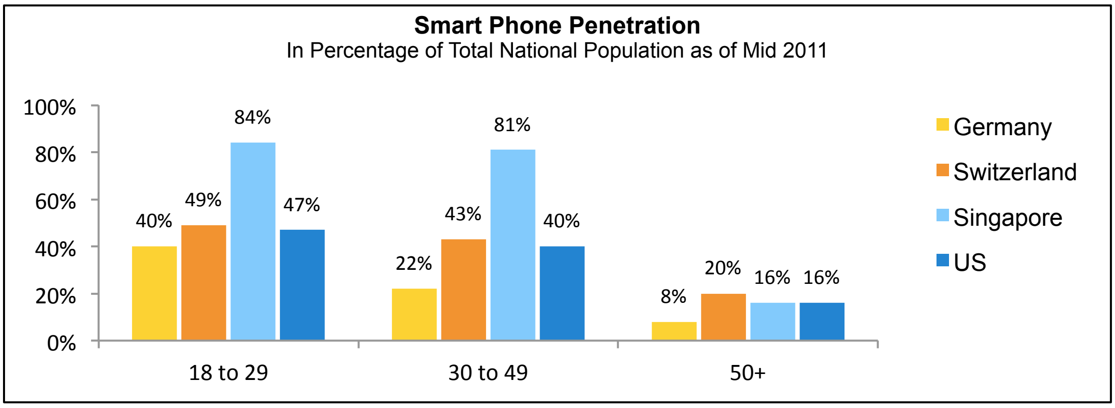
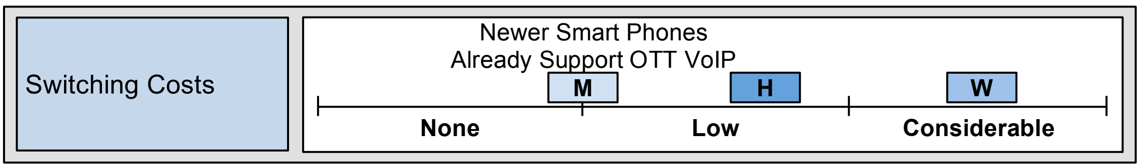


Figure 19: Smart Phone Penetration in Select Countries.

Source: OurMobilePlanet (2011).

In corporate telephony switching cost are significant because much of the existing hardware has to be replaced in order to migrate from PSTN to VoIP. Though, because operability increases and cost savings on a per-call basis offset the initial investments soon, many of the large companies have already switched. In addition, as larger companies usually possess over an internal IT department, the knowledge and capacity to migrate to VoIP are available. For SMEs switching costs may also be considerable. Yet, there an internal IT department that may organize and conduct the migration process is often lacking. As a result, for SMEs the adoption velocity is lower than for larger firms.



3.5.3.2. Costs Per Call

When analysing the costs for VoIP calls two things need to be separated. One is the fee that arises for the telephony service as such; it is the premium that is paid for VoIP, but which does not have to be paid for other internet services (e.g. watching YouTube videos or web-browsing). The other is the costs that arise for the transportation of data packages; costs that would also occur if the connection was used for services other than VoIP. These two elements are the reason why VoIP calls may incur costs despite the fact that VoIP as a telephony service may be free. This chapter analyses the two items separately in turn.

Premium for Telephony Service:

Traditional telephony was time-metered and the longer a call lasted the more the caller was charged for it. Calls to other telecommunication operators were subject to so-called interconnection fees that were usually defined by the government. Already today, this model has seen changes. In residential telephony, incumbents have started offering unlimited calls for a monthly flat-rate tariff to other subscribers of their network, and sometimes even to fix and mobile customers of other operators. With the complete transition towards all-IP networks also the interconnection fees will eventually disappear as they have their legitimation in circuit-switched networks where calls actually had to be routed through dedicated infrastructure. This will lower the price for telephony further.

Few years back, the revenues of the incumbent operators consisted of the basic subscription fees for the telephony access plus the incomes stemming from time-metered calls and SMS (see Figure 20). Today, a change in the revenue structure can be observed and low-priced bundles have gained importance. These bundles usually consist of flat-rated telephony-related elements (e.g. free calls to fix and mobile numbers or hundred included SMS), internet access, and sometimes even television. By offering an entire ecosystem in a bundled manner the incumbents aim to retain their customers. The price of these bundles as well as for the individual elements contained in them is prone to fall further due to competition between operators.

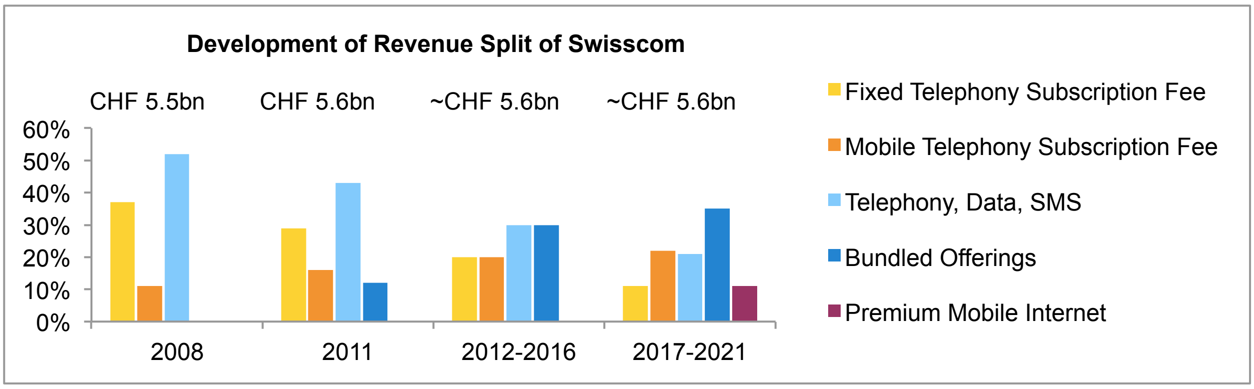


Figure 20: Development of Revenue Split of Swisscom.

Source: NZZ (2012); 2017-2012 Own Estimate

Going forward, one will observe that an increasing share of the incumbents' revenues stem from bundled offerings. However, in the long-term it is likely that regulators will oblige the incumbents to also offer unbundled mobile internet access. This will cause data-volume- and quality-oriented tariff models to gain importance in the mobile area. This will be explained in more detailed below under *Cost for Data Traffic*.

Also in corporate telephony, time-metered telephony has become rare. Today, flat-rate tariffs are the widely applied standard and in companies that have switched to VoIP solutions oftentimes calls are even entirely free as long as they stay within certain networks. For instance, companies that have deployed Lync may join so-called “Federations” with other companies that also use Lync. Configured in such way, the software application is capable of establishing free VoIP calls between any members of such federation. Hence, if two companies are in a federation together their employees may call one each other for free. Lync may also be connected to certain VoIP solutions of other providers. While on a per-call basis no fees are charged, the usage of the gateway between the other providers’ and Microsoft’s network is subject to a low, annual flat-fee. Over the next ten years, such free or inexpensive network alliances will gain importance in the corporate segment.

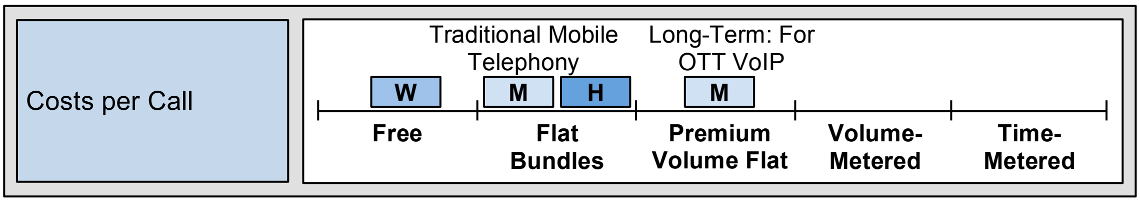
Costs for Data Traffic:

VoIP causes data traffic. On fixed internet connections data flat-rates are prevalent, which is why for VoIP calls no additional costs for the data transmission arise. On mobile internet connections in contrast, fees for data traffic are still a considerable cost driver. Frequently, ISPs charge for data consumption on a pay-as-you-go basis. Alternatively, they define volume contingents within which the consumption of mobile data traffic is free, but beyond which additional fees are due. This model is referred to as capped flat-rate. In the domestic setting, the price for data connections has been decreasing over the last years and it is unlikely that this trend will be reversed in the future.

In the international setting, mobile data traffic is still tremendously pricy because the roaming fees for data connections remain exorbitantly high. Many regulators, including the European Commission, are looking into measures to reduce international data roaming fees though. In addition, international operators have started offering own roaming-free data plans (e.g. Vodafone). Hence, also internationally mobile internet traffic is likely to become cheaper.

To date, mobile internet on cell phones is oftentimes only offered in a bundle with a telephony contract. As on-net calls are usually free of charge, for consumers it does not make sense to use OTT VoIP for calls bound to other subscribers of the same cellular network. However, where flat-rated mobile telephony offerings are absent (e.g. for international calls from the mobile phone or if the callee is subscribed to a different network operator), adoption of OTT VoIP will happen faster, as the data volume-metered VoIP option oftentimes is more economic than time-metered telephony.

As was stated earlier in chapter 3.4.4.2, it is conceivable that going forward ISPs will charge a premium for guaranteeing a high service level and quality for OTT VoIP. While some private users may accept interruptions in VoIP calls and do not purchase the quality guarantee, many others will be willing to pay a bit more if it ensures them an excellent quality for OTT VoIP. This applies especially for corporate clients that use OTT VoIP to interact with suppliers, investors, clients or co-workers.



3.5.4. Functionality

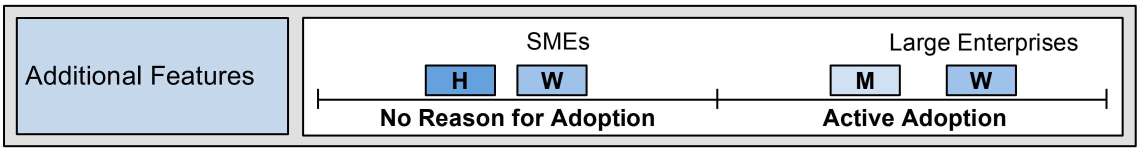
3.5.4.1. Additional Features

Strictly speaking, the term VoIP only refers to the transmission of voice signals over the internet. In the broader context, however, VoIP is an essential part in many internet-based applications. In the corporate arena, for instance, VoIP is a core element of unified communications (UC) platforms that enable people to communicate and collaborate.

In fact, UC is not a new concept. Already the invention of ISDN enabled UC elements such as video conferences or telephony calls with more than two participants. However, most people were not aware of the existence of these services, did not know how to use the equipment properly, did not even possess the necessary devices, or were not willing to pay the prohibitively expensive connection fees. The advent of VoIP has made the use of UC functions not only much more affordable, but the clients have also become much more user-friendly. Hence, while VoIP in a narrow sense only refers to voice communication over the internet, in a broader sense it has enabled UC to become more widely used. Large companies that rely on the advanced features of UC therefore have proactively implemented VoIP, not only because of the advantages of VoIP itself, but also to fully exploit the potential of the services encompassing the technology.

Similarly, mobile telephony users will proactively adopt VoIP not only because of cost reductions, but because it enables them to use their smart phone for enhanced functions, e.g. video telephony. The demand of video telephony will sharply increase in the coming years, in particular for calls between people that are socially close, e.g. family, friends. This again will foster the diffusion of VoIP.

Private fix-net customers or SMEs mainly use their devices to make simple phone calls and additional features beyond an answering machine are oftentimes not valued. These customer segments will therefore only switch to a VoIP solution proactively should the quality of such solution be notably better than the classic telephony and affordable. Beautiful features, however, will not affect them in their decision.



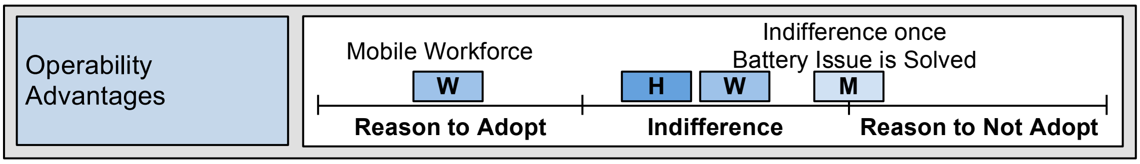
3.5.4.2. Operability Advantages

Besides the cost advantages and features that are built around VoIP, the technology is also implemented because of the enhanced operability it provides. In contrast to classic telephony, devices only need to be plugged to an internet connection rather than being cabled individually. Furthermore, fix-net numbers become mobile and can be used anywhere in the world. In particular for companies with a highly mobile workforce such operability advantages are a key reason for implementing VoIP.

Over the recent years, the operability and mobility of VoIP has even been increased. At the beginning, dedicated hardware was required to use the technology, and this hardware had to be taken along if consumers wanted to use VoIP elsewhere. Later, all that was needed was a software client to be installed on computers. Today, a trend towards cloud-based clients can be observed. Cloud-based refers to software solutions that run on the internet and can be accessed via a web-browser, but do not require any installation on the local device anymore. Hence, all consumers need is a device with a web-browser. Although the cloud-based concept is relatively new, first VoIP clients of this type already exist and going forward cloud-based solutions will more and more substitute other installation- or hardware-based clients.

For residential customers and SMEs, operability issues are of little importance due to the fact that it is the idea of the fixed phone to be stationary. Hence, fix-net phones usually are not moved around. For mobility, users rely on the mobile phone. The only criterion that matters to them is whether the telephone works. Hence, operability advantages will not cause the residential customer segment to switch to VoIP.

In the area of mobile VoIP, to date the battery capacity of smart phones is a serious constraint. The cellular internet connection, complex software architecture of OTT VoIP clients, and touchscreen displays eat up lots of battery power, thereby requiring the cell phone to be recharged within short period of time, and all to often even after less than a day. As a consequence the battery power until now has limited OTT VoIP in replacing classic mobile telephony. In the forthcoming years more efficient software architectures, more energy efficient cellular internet connections and improving battery technologies are likely to mitigate this problem. Per annum, battery capacities tend to increase 10% and new revolutionary technologies[37] are in the pipeline that may completely solve this issue.



3.5.5. Convenience

3.5.5.1. User Experience

The more compatible an innovation is with the experiences users have made in the past the faster its adoption rate is (c.f. chapter 2.2.2). In the case or residential telephony and SMEs where even PSTN operators gradually shift their customers to VoIP this compatibility is very high, as for the user in the entire transition

[37] IBM, for instance, is currently investigating the possibility to build lithium batteries that work in reaction with the surrounding air.

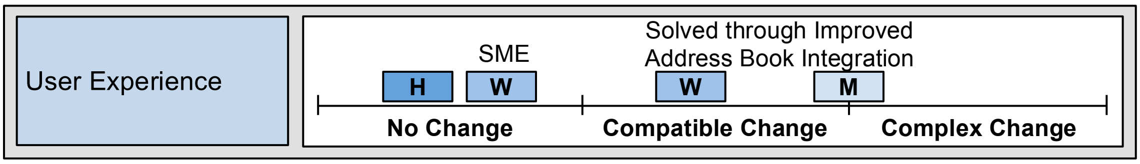
process the appearance of the phone and the way of using it are not altered. Only if private fix-net users decide to take advantage of more advanced services the user experience changes, for instance if customers use OTT VoIP such as Skype for making international calls. The user experience is changed, because they no longer use their phone to make such calls, but instead rely on a software client installed on their computer. Another example can be found in the small fraction of consumers that use their television with an integrated camera and VoIP client for video telephony. The named examples, however, only apply to niche markets. Also going forward the majority of the residential telephony users will rely on classic telephones.

What can be observed, though, is that younger generations, cost aware users and one-person-households have started to substitute their fixed phone through a mobile one because with the advent of affordable flat-rated contracts for mobile telephony the cost advantages of fixed telephony have been eroded. In families, however, the fixed phone continues to be a standard item in households, as it fulfils three functions. First, it is the point of contact for matters that concern the family, and not just an individual, e.g. invitations to a dinner. Second, it allows parents to control by whom their children are called. And third, the fixed phone is often used by older generations, who do not possess mobile phones. In the forthcoming years, however, also amongst the youngest and the older generations the penetration with mobile phones will increase, which will make the stationary phone also in families more redundant. Hence, the number of fix-net subscribers is expected to continue to fall and stabilize at a lower level.

The introduction of VoIP in corporate telephony has, in contrast to residential telephony, oftentimes changed the user experience. In order to save costs, many companies decided to use software clients rather than hardware phones. Given the obvious difference between the two, people are aware of the change. Yet, while in the beginning corporate VoIP clients were rather complicated, newer ones are intuitive, user-friendly and well-integrated in other software applications that many of the users are already familiar with. Lync, for instance, is interconnected with the Microsoft Outlook address book that many people are familiar with. Upon choosing a contact here, Lync is capable of establishing a free VoIP call.

In mobile VoIP a main factor determining user experience is the address book. Already today, callers hardly ever digit numbers, but select the callee’s name in the contact manager/address book of the smart phone. Hence, for being consistent with past experiences, it must be possible to start VoIP calls from the contact manager rather than from a separate application that has its own address book. Indeed, newer smart phones already are capable of aggregating more information then just name and telephone number under an address book entry. For instance, also email addresses may be stored, one can post on somebody’s Facebook wall, or the callee’s availability can be displayed. Going forward, the integration of the address books of VoIP solutions into the contact manager of the smart phone will become more frequent. The caller may then decide how to contact the callee. By calling the cell phone? Or the stationary phone? Per Skype?

Today, integrating the various communication channels into the contact manager of the smart phone still requires a certain technical affinity from the user. With Microsoft bringing the address books of Skype, Lync, Facebook, Hotmail, etc. closer together, such aggregation is likely to become more straight-forward in the near future.



3.5.5.2. Backward Compatibility

Classic telephone numbers were instructions that indicated how a call was to be routed through the circuit-switched telephone network. Today, with the IP backbone and emerging end-to-end VoIP connections, they longer serve as switching instructions, but have become placeholders for addresses. Yet, also as address placeholders the importance of telephone number has declined. Nowadays, as was stated above, most people rely on address books that are integrated into the telephony devices. There, the user selects the name of the callee and automatically the telephone number is dialled that is stored behind the callee's address book entry. Hence, rather than typing a number, one oftentimes "dials" a name in the contact manager.

As address book entries can also store other information than just telephone numbers, it is conceivable that the legacy telephone number is substituted by a different addressing system. For instance, instead of the telephone numbers Skype usernames could be stored. Or Facebook profiles. Many smart phones already today allow to integrate Facebook profiles into the smart phone's contact manager, and for texting the users may decide whether to send a paid-for SMS, or a free[38] private message on Facebook over the internet. With Skype and Facebook being integrated it is conceivable that going forward one will also be able to decide whether to contact the callee via a classic telephone number, or via a VoIP solution, e.g. the Skype/Facebook interface.

Notwithstanding, for several reasons also in ten years the PSTN number will still be the dominant addressing system. First, fixed phones have a long lifecycle and the majority of today's devices do not support any addressing system other than the classic one. In addition, in rural areas and economically less endowed regions the penetration with smart phones is low, for which a change to a different, internet-based addressing system is unlikely. Plus, although Skype has a large user base, it is far from being a generally accepted addressing standard. Without a dominant standard, however, the established and worldwide unified, accepted and deployed E.164 numbering system is unlikely to be replaced.

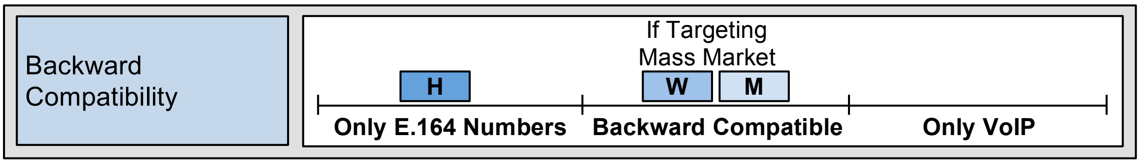
Furthermore, changing away from the telephone number to some other system (Skype username, Facebook profile, email address, etc.) would require a major rethinking for most of the people. For an average user, for

[38] Sending a message over the internet may still incur costs as data traffic is caused (c.f. chapter 3.5.3.2). Data traffic for such message, however, is negligible.

instance, it may not be easy to understand that somebody can be called by dialling an email address. Such change in the minds takes time.

Lastly, many private users feel emotionally connected to their telephone number and also for many businesses the classic number has certain significance. For instance, mainly large and professional institutions use the prefix 0800 in Switzerland, for which telephone numbers beginning with it radiate seriousness. The attempt abandon the E.164 numbering plan in favour of some other addressing system would therefore face some hesitation.

For the reasons stated, in the medium term no considerable shift away from the E.164 addressing system will occur. Therefore, even if going forward a majority of the market switches to VoIP solutions (e.g. Lync, Skype), clients shooting for the mass market need to retain backward compatibility to the PSTN network, as otherwise a large number of people could not be reached. Indeed, for some time more the PSTN will remain the fall-back network that connects everyone that cannot be connected through a direct IP connection.



3.5.6. Security

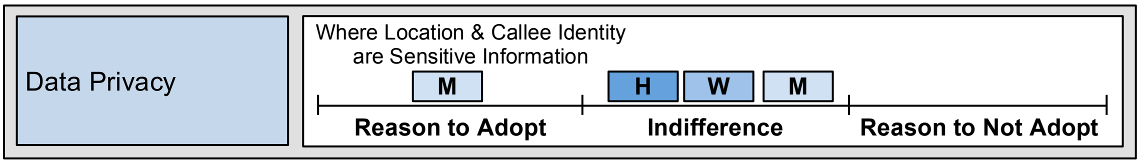
3.5.6.1. Data Privacy

For private users data privacy is often less of a problem than for business customers. For them, data such as addresses of clients or investors, business documents, etc. may be core assets. Integrating various address books (e.g. Lync, Outlook, Skype, Facebook, etc.) into one contact manager that stores a backup in a synchronized internet database (e.g. the address book of Google's Android[39]) is a trust issue. Questions like "Is my data secure against unauthorized access?", "To what extend can the host of the database (e.g. Google) retrieve the information is stored in it?", or "What are the information that are exchanged between the local device and the database?" are serious concerns that deserve attention and require a transparent answer. Yet, as the large operators behind the databases containing the address books (Microsoft; Google; Apple; SAP; etc.) are professional IT firms that fulfil highest standards of privacy, data concerns on the level of the address books is unlikely to impede the diffusion of VoIP. At the most, it will slow down the cross-platform integration.

In fact, data privacy considerations may even be a reason for users to switch to an OTT VoIP solution, as it allows them to reduce the quantity of information that can be gathered by external institutions about their communication behaviour. In Germany, for instance, the telecommunication operator Deutsche Telekom (DT AG) monitored many customers and created detailed logs on where they were, whom they called, whom

[39] Android is the operating system by Google that runs on many smart phones.

they met, etc.[40] With the obtained data, DT AG was capable of drawing profiles of the customers, revealing their interests, preferences, habits, etc. Given that the company was controlling the infrastructure of the cellular network as well as for the actual interconnection of the participants, all the company had to do was to aggregate the available information. Had the customers only used DT AG for accessing the cellular internet, but an OTT VoIP operator for setting up the call, then DT AG would only have had information about the caller's location, but not about whom he or she was calling.



3.5.6.2. Encryption

As was stated in the previous chapter, data privacy is vital for corporate telephony as a high degree of confidentiality is key. Therefore, reliable cryptographic techniques are of fundamental importance. Already today, VoIP has stronger encryption algorithms in place than classic telephony. Yet, attacks are frequent and also strong algorithms have seen breaches. Notwithstanding, it is beyond doubt that in the forthcoming years even stronger techniques will be developed that foster VoIP security and counter illicit interception.

Encryption	Further Development of Encryption Techniques

3.6. Synthesis and Discussion of Results: Most-Likely Scenario

As became evident in the analysis of the diffusion factors four customer segments need to be separated when determining the potential and limits of the diffusion of IP2IP telecommunication; in large-scale business, SME, residential, and mobile telephony VoIP is evolving differently. The most-likely ten-year scenarios are discussed in turn for these categories. In other words, the findings of the individual factor analyses of chapters 3.4 and 3.5 are aggregated to the overall scenarios for the four identified segments; the core information is synthesized from of the factor analysis summary tables in Appendix A1.

3.6.1. Residential Telephony

In the recent past the backbones of most PSTN networks has been migrated to NGN solutions. Therefore, most calls already today are routed at least partially over VoIP. Of this modernization, however, the subscriber line – the "last mile" in the network – has largely remained unaffected; oftentimes it is still the same old, classic telephone network. In order to move fixed telephony to an end-to-end VoIP solution, also this part of the network would need to be upgraded. Yet, neither on the supplier nor on the demand side large incentives exist to strongly push such undertaking.

[40] Biermann (2011) visualizes impressivly with real data how transparent the life of an individual was to DT AG at the example of green party politician Malte Spitz.

On the supply side the telecommunication operators find themselves in a market that has been liberalized and intensified competition has led to drastic price erosion over the last ten years. Furthermore, the fix-mobile substitution trend is responsible for the market to actually shrink, which makes investments into it unattractive. In addition, the current infrastructure has been paid for and is still working. As replacing it through VoIP enabled solutions would require additional outlays, incentives to do so are small. As a result, only where the maintenance of the existing infrastructure is too costly, additional households need to be connected, or defective equipment has to be replaced deploying VoIP makes sense for the incumbents.

On the demand side the aforementioned price erosion caused customers to be less price sensitive. As switching to an OTT provider would only save them little money, most people stay with the incumbent. Also, switching away would make calling other participants that remain with the incumbent more expensive, as they before could be reached through free on-net calls.

What people value most is the stability and acoustic quality of the call. Only if in these aspects VoIP would excel the PSTN network, people would actively seek to change. If an OTT IP2IP operator offered fancy additional features, however, most people would not consider switching, as they are not interested in them. The fix-net telephone reflects this fact; despite all the progress, the device for many years has remained quite unchanged in terms of appearance and functionalities.

In conclusion, a shift towards end-to-end VoIP is underway in residential telephony. However, the change is slow and mainly carrier-driven. It is difficult to anticipate what percentage of the market will eventually switch to an IP2IP by 2022. Some of the experts suggested up to 90%. Certain is, however, that in areas where a migration for the carrier does not result in cost-savings in comparison with maintaining the existing infrastructure, change will be slow or might even not materialize at all (e.g. rural areas). OTT IP2IP (e.g. Skype) will continue to play an insignificant role in residential telephony, except for niche occasions such as international calls. There, monetary incentives are higher for customers, and an increasing number of calls will be done through OTT IP2IP rather than through the classic PSTN network or carrier-owned VoIP network.

3.6.2. Business Telephony in Small and Medium Enterprises

For many SMEs the same scenario as for residential telephony applies. On the one hand, the firms have invested into their infrastructure that is still working. Thus, why bothering to upgrade? On the other hand, many SMEs have little use for the large range of features that encompass VoIP. What would a hairdresser need group calls or a unified communications system for? Therefore, SMEs are rather passive in the adoption of VoIP.

For most customers in the SME segment – identical to residential telephony – what matters is the quality of the call, and that the solution is easy to use and stable. On what technology the telephones run is not of importance to the users. Hence, although IP2IP telecommunication will eventually be implemented, this process will be carrier-driven and most customers will not notice a change, as the end-device will still look like a traditional phone. Because of price insensitivity, low cost savings potential, and little use for advanced features SMEs will not seek to change proactively. Notwithstanding, one expert argued that despite the low incentives for operators roughly 90% of all calls would be routed through IP2IP networks within ten years.

3.6.3. Business Telephony in Larger or International Companies

In corporate telephony, the relative advantage of VoIP is much greater than in residential and SME telephony. One strong argument in favour of VoIP is certainly the cost saving potential arising from the elimination of the redundant PSTN infrastructure and the lowered or even eliminated calling fees. Another aspect is the operability gain that accounts for the mobility of the workforce. Equally important, however, is the fact that IP2IP is a central component of unified communication systems that provide much value to companies and which are gaining importance. Therefore, in business telephony IP2IP is implemented much more proactively and faster pace than in the two segments that were discussed before.

However, IP2IP is not likely to cause a “revolution” in the corporate segment. Rather, it will induce gradual change that will take some time. Three reasons speak for this. First, switching an entire company to IP2IP is complex from a technical standpoint. Secondly, such undertaking may encounter user aversion and political resistance from within the company that need to be overcome. Thirdly, today’s corporate VoIP software solutions that are to replace the installed telephony systems often still lack some of the sophisticated features traditional PBXs provide. Therefore, a part of the corporate telephony segment will only switch to software solutions offered by companies such as Cisco, Avaya, or Microsoft once the VoIP products will have been developed further and match the old PBX systems in terms of functionalities.

Notwithstanding, by 2022 the large majority of the business segment will use VoIP solutions. End-to-end VoIP will first be realized internally, and later in federations with important stakeholders, e.g. suppliers, main investors, key customers. Beyond these federations, however, the outgoing VoIP calls will still be bound to regular telephone numbers. Whether for such calls an IP2IP connection will be established depends on whether the carrier already upgraded the subscriber line on the callee’s side.

3.6.4. Mobile Telephony

Although WhatsApp is an IP2IP application for texting and not voice, the advent of it left the first IP2IP footprints in the mobile telecommunication market. What made the success of WhatsApp possible is the increasing share of the population that uses smart phones, the speed of the mobile internet that has sharply risen, and the price of it which that has continuously fallen.

By today, IP2IP has not exhibited the same success for voice yet; first reason being that telephony is more time-sensitive than texting. If a text message arrives five seconds late remains unnoticed by the receiver but if a voice data package is that late a conversation becomes impossible. WLAN would be fast enough for OTT VoIP, but lacks true mobility. Cellular networks in contrast would provide the desired mobility but do not prioritize OTT VoIP, for which it oftentimes is an unpleasant experience. OTT operators cannot prioritize their service, as they do not control the internet access. With mobile data traffic skyrocketing, QoS of OTT VoIP is even more at risk, as the voice data competes with much other data for bandwidth. Yet, more advanced and adaptive voice codecs and the deployment of LTE not only are likely to be capable of absorbing the strain, but will also mitigate QoS issues for cellular OTT VoIP.

The second reason why IP2IP in voice has not had the same success as in texting yet, is because to date a dominant network has not prevailed. Microsoft's Skype/Facebook alliance seems promising to emerge as such given their already integrated and large user bases and the possibility to interconnect further user bases, e.g. Lync or Windows Live. Apple and Google, however, dominate the smartphone operating system market and with that the platforms on which mobile IP2IP clients are installed. Therefore, the latter two companies have an advantage in integrating a proprietary IP2IP client as standard on their mobile phones, thereby increasing the convenience for the customers. If and which OTT network will eventually become dominant has yet to be seen and depends on many factors, including decisions taken by the regulators.

Thirdly, as most mobile data connections still are volume metered or capped volume metered, and international roaming for data is prohibitively expensive, OTT VoIP could not compete with regular mobile telephony yet. Going forward, prices for data connections are expected to fall though, which will fuel the usage of OTT VoIP clients on smart phones.

Going forward OTT IP2IP telephony is expected to become increasingly important and to challenge traditional mobile telephony. As IP2IP solutions are and will largely not be interconnected to other IP2IP providers, people will decide which solution(s) to use. It is conceivable that for each community (e.g. friends, family, company) they will use a different solution, similar to how it is done today on the computer. To people outside such communities calls will still be bound to classic telephone numbers, as a competing and generally accepted addressing standard (e.g. email address) is still absent. As was stated earlier, however, also calls bound to PSTN numbers could turn into IP2IP calls if the carriers upgrade the subscriber lines of the participants. Such carrier-driven modernization could also materialize in the mobile area, if carriers decided dismount their legacy networks in order to cut back maintenance costs and overcome eventual resistance against the deployment of antennas for newer networks by environmentalists. However, if such carrier-driven migration will already take place within 10 years is difficult to anticipate. Although LTE would theoretically be capable of replacing the GSM network, many technical questions remain unanswered, for instance how the telecommunication providers will deal with the fact that LTE lacks a dedicated voice channel. What seems certain, however, is that within communities OTT IP2IP will become increasingly important and challenge the mobile telephony of the incumbents.

3.6.5. The Big Picture

Ultimately, telecommunications is moving towards IP2IP. It is a reality and has already begun; in all segments analysed above, both for texting and for voice. WhatsApp made the first step on the road towards IP2IP in the area of texting, further solutions for voice will follow and drastic improvements to IP2IP quality will be seen.

The speed of adoption of IP2IP telephony varies, however, between the segments, and also whether the IP2IP solution will be provided by OTT operators or incumbents. A large share of the fix-net market will adopt IP2IP without noticing it in the moment the incumbent carriers upgrade their networks. Hence, even if much modernization will take place over the next ten years, many consumers will be unaware of this fact, as the user experience will remain the same as today – an observation that mainly applies for residential and SME customers. In the corporate and mobile segment IP2IP is implemented more proactively. This will happen not only because of operability and cost considerations, but also because of the value-adding services encompassing and building onto the technology; e.g. video telephony for mobile users, or unified communication systems for business clients.

In conclusion, IP2IP in the segments SME and residential has more the character of a sustaining innovation, while in the other two segments its nature is more disruptive; the innovation is first underperforming, but in the long-run it will undermine the prevalent business model as the technology becomes more mature. IP2IP will not revolutionize the market overnight, but it will beyond doubt gradually alter it. In the long-term IP2IP is unavoidable, it is the future. The price for telephony as a service will decline further and eventually fall towards zero. The question arises: How will the incumbents deal with the change, and what will the role of OTT software companies be?

4. Concluding Section

4.1. Practical Recommendations

4.1.1. For Telecommunication Providers

The road ahead for telecommunication providers seems bumpy. And it is. Prices are tumbling, competition is intensifying through OTT and non-OTT providers, and regulators limit the space in which the incumbents may manoeuvre. Notwithstanding, it would be short-sighted to conclude that the incumbents are to be substituted by IP2IP telephony over the next ten years. Cogent reasons speak against it.

First, the majority of the users in the fix-net segments SME and home lack incentives to switch to OTT providers. They are price insensitive and not inclined to meddle with their working and paid-for infrastructure. Furthermore, by switching to an OTT they would forego the free on-net calls in the extensive network of the incumbents. In addition, they are not interested in additional features; all they care about is the robustness, convenience, and quality of their devices and calls – criteria in which the incumbents excel.

Secondly, incumbents may pack fix-net telephony into bundles with other services, for instance mobile telephony contracts, television subscription plans, or internet access. By doing so, the incumbents foster their customer retention and lower the incentives for their customers to switch to OTT providers.

Thirdly, users deciding to switch to OTT telephony still need an internet connection that transports the voice data packages back and forth. As many incumbents are also the largest internet service providers both on the fixed and the mobile market they are in control of these connections and of what is transported on them. This gives the incumbents power; not only are they a prerequisite for any OTT service, but with the regulating power of the connection they control the quality of the OTT service. This notion is most important for mobile and business telephony where the importance of OTT telephony is growing.

Summarizing the points above, the incumbents are not substituted as in the segments residential and SME the customers have no incentives to switch and because the incumbents have measures to retain them, and because in the segments business and mobile the incumbents are needed to provide the internet connection on which OTT telephony runs.

The counter-argument is valid that by being relegated to the mere transport function the incumbents forego the revenues from the telephony services and although OTT telephony causes increased volumes of data traffic, the cash inflows for the data transportation do not offset the reduction in telephony revenues. This is problematic for the incumbents because even though revenues are lower they still need to maintain, modernize and deploy new and costly infrastructure. The incumbents have two possible ways of how to address this dilemma.

They can try to fight this trend by taking commercial, legal, and technical measures (c.f. chapter 3.4.4). Regulators and competition limit the options that are at the incumbents' disposal, but those available may slow down the diffusion of OTT IP2IP. As long as neither the market nor regulators exert pressure on the incumbents to change their way of conducting business, such defensive tactics seem feasible strategies to retain customers and protect telephony revenues. However, if business models building on such approach are sustainable is questionable. In the long run, large shares of the mobile and business telephony markets will switch to OTT providers; in the texting market IP2IP solutions are already skyrocketing, and voice is ready to take off. Moreover, regulators on all levels are revising laws and increasingly limit defensive moves of the incumbents.

The more recommendable approach is to accept the on-going changes and to look for constructive ways for coping with them. First, if the revenues stemming from data traffic do not suffice for covering the infrastructure financing needs, prices should be raised. Consumers will accept them, as they do not have another choice; they need the incumbents' network for OTT services. Competition will follow such a price rise, as all telecommunication providers face the same problem.

Secondly, incumbents should identify possibilities how to benefit from the changing consumer behaviours. For instance, the incumbents could use their technical knowledge for prioritizing rather than delaying time-sensitive OTT services and charge a premium for this privilege. In practice the incumbents could offer data plans that ensure high quality of service for customers who want to use Skype on their mobile phones for making calls. In comparison to normal data plans, for the QoS promise the incumbents would charge a premium. In more general terms, the incumbents should discriminate customers according their needs and offer adequate service level agreements (SLAs). The past has shown that customers oftentimes struggled with understanding SLAs and in consequence rejected them. Therefore, transparent communication and stringent marketing efforts are imperative for the incumbents to successfully launch data plans with distinct SLAs.

Finally, incumbents should seek new business opportunities that open up with the rise of OTT operators. In the business area, for instance, incumbents have earned the trust of their customers and built up solid customer bases. The incumbents could use these assets in order to implement OTT solutions at the customers' sites and become responsible for maintenance and customer care. By partnering with the OTTs the incumbents could create win-win situations for all involved parties; the OTT companies would not need to tediously build up their own customer relations and take care of labour intensive tasks such as maintenance, and the incumbents could save themselves a piece of the OTT telephony market. The Swiss incumbent Swisscom is a showcase example for this proactive partner strategy. The firm partners with Microsoft, and is responsible for the hosting of Lync server farms, the deployment and maintenance of the product at the customers' sites and customer relations management. Although Swisscom by promoting OTT VoIP telephony cannibalizes its telephony revenues, as a service provider it has tapped into a new business segment that compensates for it.

4.1.2. For Software Companies

The importance of OTT telephony is rising and software clients by companies such as Microsoft, Apple, Google, WhatsApp, and Viber have great potential of conquering large shares of the market, in particular in the business and mobile segments. To date, although no dominant standard prevailed each network already interconnects millions of users. Despite the large user numbers, however, the companies should be aware that generating revenues might be challenging.

In the private area users mainly use software-based OTT IP2IP telephony because it is free. Would an OTT provider such as Skype start charging fees for IP2IP connections, people soon would move to a competing provider. In the past also cross-selling of premium functions (e.g. group chat; video telephony) has proved to be difficult, as for most of these functions other OTT software applications exist that are free of charge. It is intuitive that it is tricky for an OTT provider to convince people to pay for a service they could have for free with a competitor.

In residential telephony, software-based OTT telephony is mainly used for making international calls. However, only for PSTN-bound calls users are willing to pay, whereas for IP2IP connections (e.g. Skype-to-Skype) customers are reluctant to do so. As the number of people with a VoIP account (e.g. Skype) is increasing, more and more calls are IP2IP connections. In mobile telephony, most calls are IP2IP connections. Hence, OTT providers need to find other, indirect ways to generate profits.

First, aggregated data about the user behaviour may contribute to the development of new and improved products that could then be sold back to the users of the free OTT clients or to premium segments. This is on the one hand what Apple does with Facetime; they sell improved hardware back. Microsoft on the other hand uses the insights from its free software clients to improve the paid-for Lync client.

Secondly, OTTs may display advertisement on their fee clients. The OTTs should gather and process user data in order to make such advertisements accurately targeted on the user's interest. This would increase the marketing effectiveness, thereby boosting revenues.

Finally, OTTs shooting for the mass market should offer two clients. A free and basic one and one with more features, better quality and customer support for segments that are willing to pay for it. Particularly business clients are willing to pay for OTT telephony if this ensures them high quality. Running such a dual strategy allows OTTs to generate revenues directly from the premium customers and to use the free clients to extend the network, which again is used as a sales argument for the premium clients.

As OTT telephony is a typical service with network effects[41], reaching a critical mass with the user base is imperative. Close attention should be paid to viral, word-of-mouth marketing, as this will allow the user base to grow exponentially. In addition, software companies should try to leverage their user bases of other products in order to promote their IP2IP telephony solutions. Microsoft, for instance, should interconnect its Facebook, Skype, Windows Live and Lync address books, thereby creating one huge IP2IP network. Microsoft could enhance its IP2IP network even further by integrating a client for its IP2IP network into other software applications such as Windows or Office. This, however, should be done with care, as antitrust laws might be violated.

Finally, rather than seeing the incumbents as legacy companies offering out-dated telephony services, OTTs should consider collaborating with them. First, the incumbents may have political, legal, technical, or commercial means to torpedo OTT VoIP networks. Secondly, with their solid customer relations they could prove to be valuable business partners helping OTTs to penetrate the market.

4.2. Possible Areas for Further Investigations

The thesis at hand identified how IP2IP is diffusing and how this evolution will impact the players on the telecommunication market. The findings presented mainly apply to Switzerland and Germany but might also be valid for other wealthy and developed countries. Yet, the author recommends conducting further empirical studies to test this suggestion, and to ascertain how the diffusion of IP2IP depends on macroeconomic factors such as the BIP per capita, the average age, or the density of the population.

In addition, quantitative research could shed light on the impact IP2IP will have on specific incumbents over time. A comparative analysis could contrast strategies of concrete incumbents in order to determine what factors determine whether they successfully prevail in the fast changing and towards all-IP moving market.

With regards to software companies, valuable insight could be derived from studying the diffusion of the IP2IP networks of the three competitors Microsoft, Apple, and Google. First, one could identify the factors that determine the success of the companies in developing a dominating and generally accepted IP2IP network and the benefits from doing so.

Secondly, as the importance of the telephone number is declining it would be insightful to learn what its future role will be, and what the limits and potentials of alternative addressing systems (e.g. SIP-email addresses; Facebook/Skype accounts, etc.) are to substitute it. In this context, light could also be shed on the question whether proprietary addressing systems (e.g. Skype contacts) even have the potential of becoming generally accepted standards, or if it is more likely that an open standard drafted by a public institution such as the ITU-T is to prevail.

[41] Network effect refers to the situation where people deciding to adopt a product/service cause even more people to use it. Hence, the more people already use a product/service, the more people have an incentive to do so, too. (c.f. Hensel & Wirsam, 2008)

Thirdly, small IP2IP companies such as WhatsApp or Viber provide promising grounds for investigation. One could explore the factors that enable the steep market growth of these companies, and what their future perspectives are given that they are in competition with large software companies such as Microsoft or Apple. With reference to the last point, from a marketing perspective an analysis of the importance of social media, network effects and virality could yield especially revealing insights.

Finally, much room for seminal future research in a relatively unexplored field lies in the legal area. VoIP has evolved at enormous pace in the recent years, for which the regulation could not keep up with the rapid changes. Yet, as legal frameworks are being drafted and put in place, both on a national and multinational level, it would be insightful to learn how landmark decisions of courts (e.g. on the network neutrality) impact the diffusion of IP2IP.

Appendix

A1. Summary of Scenario Factor Analysis

In chapters 3.4 and 3.5 semi-structured interviews helped in the analysis of the factors that determine the diffusion process of VoIP. Hereafter, two tables summarize for the supply and the demand side, respectively, how the various factors are most likely to evolve, based on the insights derived from the expert interviews.

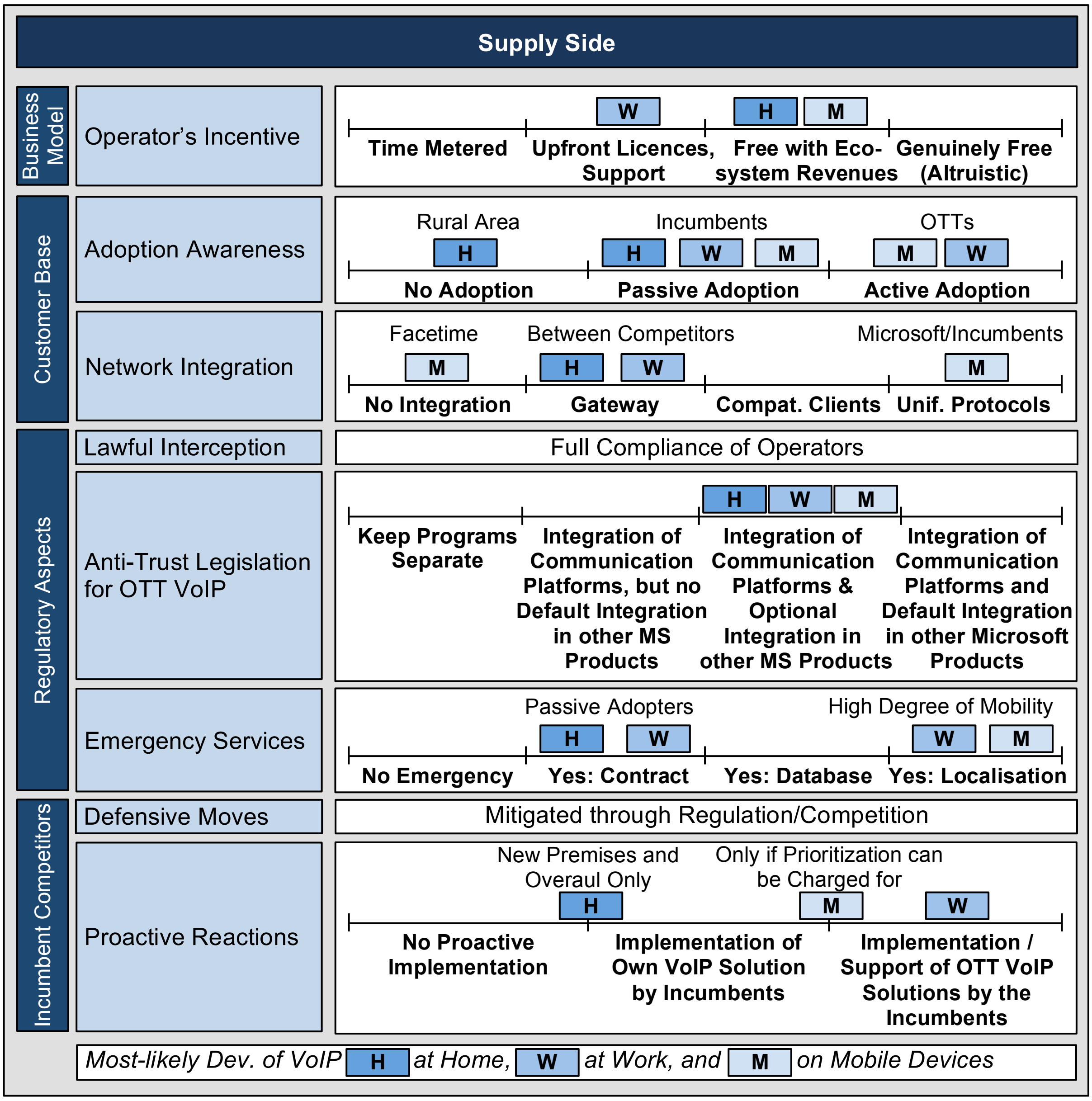


Figure 21: Scenario Factor Analysis for Supply Side.

Source: Own illustration.

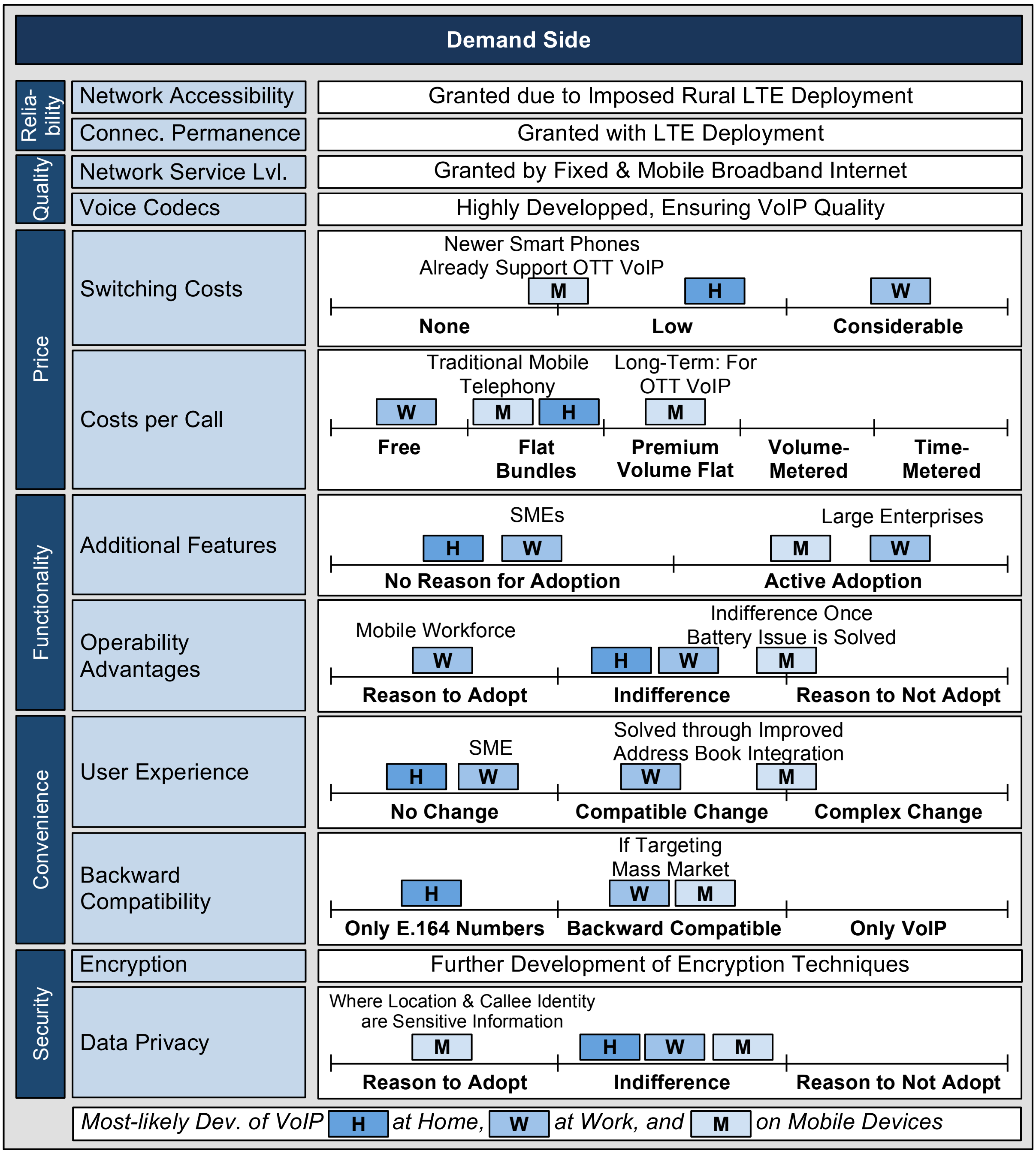


Figure 22: Scenario Factor Analysis for Demand Side.

Source: Own illustration.

A2. List of Figures

Figure 1: Research Design. 4
Figure 2: The Scenario Funnel. 7
Figure 3: Development of Scenarios in Three Steps. 8
Figure 4: Example of Impact-Uncertainty Matrix. 9
Figure 5: Example of Certain Scenario Driver Analysis. 10
Figure 6: Example of Uncertain Scenario Driver Analysis. 11
Figure 7: Distinction of Innovation-Related Terms. 14
Figure 8: Variables Determining the Rate of Adoption of Innovations. 15
Figure 10: The Innovation S-Curve and the Rate of Adoption Combined – The S-Curve Adoption Model. 17
Figure 9: Use of the Introduced Theoretical Frameworks. 17
Figure 11: Comparison of the PSTN and VoIP Network Architecture. 25
Figure 12: The First Wave of VoIP as Expected in 2004. 32
Figure 13: The Shift of Fixed Telephony To Alternative Innovations between 2000 and 2010. 40
Figure 14: Example of a Pure IP2IP Network Architecture. 41
Figure 15: Criteria Determining the Future of VoIP. 42
Figure 16: Development of ENUM Domain Registrations in Germany. 47
Figure 17: 3G/4G Network Coverage in Germany, including UMTS, HSDPA, and LTE Networks of Vodafone. . 59
Figure 18: Evolution of Mobile Data Networks. 61
Figure 19: Smart Phone Penetration in Select Countries. 63
Figure 20: Development of Revenue Split of Swisscom. 64
Figure 21: Scenario Factor Analysis for Supply Side. 81
Figure 22: Scenario Factor Analysis for Demand Side. 82

A3. List of Exhibits

Exhibit 1: Private Branch Exchange (PBX) 22
Exhibit 2: ENUM/DNS Service 23
Exhibit 3: The "Relative Number of Adopters" 35

A4. List of Abbreviations

3G	Third Generation Network
4G	Fourth Generation Network
ACD	Automatic Call Distributor
App	Application
ASCII	American Standard Code for Information Exchange
ATA	Analogue Telephone Adaptor
bn	Billion
c.f.	Lat. confer; refer to
ca.	Circa
CAGR	Compound annual growth rate
chap.	Chapter
CHF	Swiss Franc
CLEC	Competitive Local Exchange Carrier
CPE	Customer Premises Equipment
DI	Disruptive Innovation
DNS	Domain Name System
DPI	Deep Packet Inspection
DSL	Digital Subscriber Line
DT AG	Deutsche Telekom AG
E.164	International Telephone Number System
e.g.	Lat. exempli grata; for example
EDGE	Enhanced Data Rates for GSM Evolution
ENUM	E.164 Number Mapping
EUR	Euro
f.	Following page
ff.	Following pages
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications. Originally Groupe Spécial Mobile (Fr.)
i.e.	Lat. id est; in other words
ibid.	Lat. ibidem; the same place
ILEC	Incumbent Local Exchange Carriers
IP	Internet Protocol
IP-PBX	VoIP-enabled PBX
IP2IP	End-To-End VoIP
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
IVR	Interactive Voice Response
k	Thousand
Kbit/s	Kilobits per second
LAN	Local Area Network
LTE	Long Term Evolution
m	Million
Mbit/s	Megabit per second
MS	Microsoft
n.d.	no date
NGN	Next Generation Network
p.	Page
P2P	Peer to Peer
PBX	Private Branch Exchange
PC	Personal Computer
PDA	Personal Digital Assistant
PSTN	Publicly Switched Telephone Network
QoS	Quality of Service
RTP	Real Time Protocol
SI	Sustaining Innovation
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SMS	Short Message Service
UC	Unified Communications
UMS	Unified Messaging System
UMTS	Universal Mobile Telecommunications System
URI	Uniform Resource Identifier
US	United States of America
US FCC	US Federal Communications Commission
USD	US Dollar
VE:A	Ger. Vermittlungseinheit Ausland; international layer
VE:F	Ger. Vermittlungseinheit Fern; far-call layer
VE:O	Ger. Vermittlungseinheit Ort; local layer
VMS	Voice Messaging System
VoIP	Voice over IP
VPN	Virtual Private Network
WAN	Wide Area Network
WAP	Wireless Application Protocol
WIFI	Wireless Fidelity
WLAN	Wireless Area Network
www	World Wide Web

A5. List of Interview Partners

The tables below present information about the interviewed experts, including their knowledge background and current occupation. The tables are sorted in chronological order based on the dates of the interviews.

Institution	**Swisscom AG**
Description of Institution	Swisscom AG is the leading telecommunication provider of Switzerland. In the mobile telephony, for instance, Swisscom has a 62% market share. The now privatized firm emerged from the former state-owned monopolist "Telecom PTT" (Swisscom, 2011c).
Interviewee	Daniel Rincón Hanna
Academic Title(s)	Masters in Systems Engineering from Loughborough University MBA from International Institute for Management Development (IMD)
Work Position(s)	Strategy Manager SME
Represented View	Incumbent Telecommunication Operator
Interviewee Background	Consulting, strategic planning and technology assessment in the areas internet, telecommunications, and media (e.g. during former employment at Deloitte, Arthur D. Little and ARM).
Date of Interview	January 17th, 2012
Interview Duration	60 min

Institution	**University of Applied Sciences of Eastern Switzerland (HSR)**
Description of Institution	HSR is a renowned, application-oriented research and education facility with primary focus on natural sciences.
Interviewee	Guido Schuster
Academic Title(s)	Prof. Dr.
Work Position(s)	Director of the Master Research Unit "Sensor, Actuator, and Communication Systems" Professor for Electrical Engineering at HSR
Represented View	Research and Teaching
Interviewee Background	Former senior director and Chief Technology Officer of the 3Com Internet Communications business division. Co-founded unit that built first commercially available SIP telephony system.
Date of Interview	January 18th, 2012
Interview Duration	75 min

Institution	**Siemens Building Technologies – Siemens Schweiz AG**
Description of Institution	Siemens Building Technologies is a business division of Siemens AG. The firm is specialized in providing advanced building technologies and services, and itself has more than 40.000 employees worldwide.
Interviewee	Peter Kopp
Academic Title(s)	Dipl. El. Ing. HTL
Work Position(s)	IT Innovation and Architecture
Represented View	Corporate large-scale VoIP adopter
Interviewee Background	Evaluated both in-house and external VoIP systems. Responsible for the implementation of these systems within Siemens Building Technologies.
Date of Interview	January 20th, 2012
Interview Duration	90 min

Institution	**Microsoft Schweiz GmbH**
Description of Institution	Microsoft is one of the largest software houses worldwide. The company developed – amongst many other services and products –the Windows operating system and Office (Word, Excel, etc.) and runs services such as Hotmail, MSN Messenger/Windows Live, and Lync. The firm owns Skype and partially also Facebook. Microsoft Schweiz GmbH is the Swiss subsidiary which, internationally seen, is the 13th largest subsidiary in terms of revenues and the leading one in Europe measured by revenue generated per PC. MS Office Communicator, the predecessor of Lync, was developed in Switzerland.
Interviewee	Stefan Hagenbuch
Academic Title(s)	-
Work Position(s)	Product Marketing Manager – Unified Communications
Represented View	Software Company; Over-the-top VoIP
Interviewee Background	IT projects management, technology implementation and knowledge transfer. Former Partner Technology Specialist for Microsoft. Currently responsible for the marketing of Microsoft Exchange and Lync within Switzerland.
Date of Interview	January 25th, 2012
Interview Duration	90 min

Institution	**Accenture AG**
Institution Description	Accenture is a global management consulting, technology services and outsourcing company with more than 244'000 employees. It helps clients to identify technology trends, enter new markets, increase revenues in existing markets, and to improve operational performance. In 2011, Accenture generated 25.5bn USD net revenues. (Accenture, 2012)
Interviewee	Jens Hünerberg
Academic Title(s)	Dipl.-Inform.
Work Position(s)	Manager at Accenture AG with focus on Networks and Communications
Represented View	External Advisory Perspective
Interviewee Background	Worked as consultant, project leader, manager, and CEO for several IT companies, some with special focus on VoIP (e.g. e-fon AG). Formerly scientist at the Fraunhofer FOKUS research institute.
Date of Interview	January 23th, 2012
Interview Duration	90 min

Institution	**United States Federal Communications Commission (US FCC)**
Description of Institution	The FCC is an independent US government agency overseen by Congress. It regulates telecommunications over radio, television, wire, satellite and cable on the entire US territory. Amongst other duties, it is responsible for revising regulations, strengthening the defence of the nation's communications infrastructure and encouraging competition, innovation, and investment in the telecommunications market. (FCC, 2012)
Interviewee	Henning Schulzrinne
Academic Title(s)	Prof. Dr.
Work Position(s)	Chief Technology Officer of the US FCC Professor at the Department of Computer Science at Columbia University
Represented View	Regulator
Interviewee Background	Professor in the Department of Electrical Engineering and former Chair of the Department of Computer Science at Columbia University, New York. PhD from University of Massachusetts. Worked at AT&T Bell Laboratories, Murray Hill and GMD Fokus, Berlin. Co-author of the Internet standards-track protocols RTP, RTSP, SIP, GIST, and LoST. (Columbia, n.d.)
Date of Interview	January 24th, 2012
Interview Duration	45 min

A6. Interview Guide

The expert interviews were conducted in German, Swiss-German and English. In three cases, the interview took place over the phone, the other ones were conducted in personal meetings. The questionnaire that was used during the interviews is inserted below. Given that the interviews were conducted in several languages, note that for the non-English interviews translations of this questionnaire were used. Furthermore, the set of questions should not be understood as a rigid, unchangeable corset. Instead, in accordance with the technique of semi-structured interviews, the outline of questions was a flexible guidance and served as a tool for steering the interview. Hence, where appropriate, additional questions not listed in the questionnaire were asked (e.g. for clarification) or the mentioned ones were reformulated. Moreover, the questions commencing with a letter (e.g. “a.”) were only raised if they promised additional insights or if the conversation was about to drift away from the main topic.

Introduction of Thesis Background:

With technological progress of networks and mobile phones internet has become ubiquitous. Today’s advanced portable telephones – modern smart phones – are capable of running additionally installed software programs such as Skype, Facetime, GoogleTalk, or WhatsApp.

These applications allow users to make free Voice over IP (VoIP) phone calls that use the internet to transmit the voice data, rather than the time metered telephone network. While mainly end-consumers use the aforementioned programs, similar software applications also exist in the area of corporate telephony. One example is Lync, the successor of Microsoft Communicator.

Needless to say, for incumbent telecommunication operators such VoIP solutions are a challenge to the business model, as a significant portion of their revenue comes from voice telephony that now is being cannibalized by free alternatives.

In my thesis I would like to show how internet telephony is evolving and what impact VoIP will have on the telecommunication industry. In particular, I seek to determine the effect the diffusion of the technology will have on todays’ incumbent telecommunication providers and what role software companies will play in the future.

Interview Questions:

1. Status Quo of VoIP Diffusion

1. What in your opinion is the current state and importance Voice over IP? Has it revolutionized the telecommunication industry?
   a. What effect has VoIP had for customers? What were the effects for the carriers?
   b. What are the pros and cons of the technology?
   c. To what degree have SMEs, large companies and private households switched to VoIP? What is the market penetration of mobile VoIP?
   d. Are these rates compared to other countries rather high, low, or about average? If different – what are the reasons for this difference?
   e. What experiences have you made with VoIP? What effect has VoIP had on your institution? How long did the implementation process take?

2. VoIP vs. PSTN: Outlook

2. VoIP is more than just a substitute for regular telephony. It enables voice quality superior to classic telephony and it is also the base of advanced functions such as video or group calls. To me it seems that internet telephony has lots of advantages to offer compared to normal telephony. In your opinion, will telephony as we know it today still exist the future?
   a. How will telephony look in the future? Will VoIP substitute classic telephony? Will we all be using programs such as Skype, Viber or Lync? If so, what is the time-horizon of such change? What is the importance of video telephony in this process?
   b. On what does it depend whether the various adopter categories (SMEs, large corporations, mobile phone users, households) switch to VoIP? How fast will this change materialize? Is Quality of Service (QoS) still an issue?
   c. Will telephony as a service become free in the future?

3. Fix-Mobile Substitution

3. Since the turn of the millennium on can observe that the number fixed telephony subscribers has been declining. In the same period the users of mobile telephony has skyrocketed. What in your opinion is the future of the fixed phone? Is it a legacy element that is gradually substituted through the cell phone, or will we still need fixed telephones in the future?
   a. Is mobile telephony an adequate substitute for fixed telephony? Or are there also aspects that speak in favour of fixed phones?
   b. Will new technologies such as LTE/Wimax/HSDPA+ be up to the task of providing high quality VoIP telephony on the mobile phone? Could the growth of mobile data traffic eventually put a strain to the quality of service of VoIP on the mobile phone?
   c. In Germany, providers such as Vodaphone or Deutsche Telekom prohibit the usage of programs like Skype on their LTE network. In your opinion, what is the reason for these limitations? Are these limitations likely to hold up? What aspects determine whether they do?

4. VoIP Impact on Incumbents

4. For incumbent telecommunication operators such as AT&T, Swisscom, or Deutsche Telekom every call that is routed through the internet rather than through the classic telephone network translates to lost revenue. Is VoIP a threat for them?
   a. How will VoIP change the role of the incumbents? Are they gradually being relegated from voice carrier to internet access provider?
   b. How would you assess the impact of VoIP will have in the next ten years on the revenues of the incumbent telephony operators in the segments mobile, business and private telephony?
   c. What are possible strategies for the incumbents to defend their revenues? Will they be successful?
   d. Are there also positive aspects of VoIP for the incumbent operators? (e.g. Lync Hosting)

5. Convergence of OTT Communication Platforms

5. MSN Messenger, Hotmail, Facebook, Lync and Skype. All of these software applications have three things in common. First, all of them are used to communicate. Secondly, all of them have large user bases. And thirdly, they all belong, at least partly, to Microsoft. Microsoft would indisputably become the largest telecommunication provider if it interconnected the user bases of the separate programs, meaning that it would be possible to call a Lync user from a Skype account, for instance. In your view, is such a convergence of the communication platforms likely and feasible?
   a. If not: Facebook and Skype are already interconnected. And Microsoft's CEO Steve Balmer said after the acquisition of Skype: "We think we're going to be able to do even more fantastic things together", referring to a possible integration of Lync and Skype. Why do you believe an integration is unlikely / unfeasible?

5. Convergence of OTT Communication Platforms

b. Microsoft could also implement an interconnected communication client as a standard on all its Windows operating systems, office packages (Word, Excel, etc.) and Windows phones, thereby reaching an even larger user base and faster acceptance. Do you see any problematic issues in the convergence of the communication products or the implementation of the integrated solution in other products? Could there be any legal issues?

c. Already today instead of exchanging phone numbers people often say "Add me on Facebook, my email address is XYZ". Hence, it is conceivable that going forward the telephone number as the dominant addressing system could disappear altogether and be replaced by a different system, for instance email addresses. Then I would simply say: "Call me on benjamin.harder@skype.com". Do you think such a change is feasible? And is it likely? On what does it depend?

6. Business Case for OTT VoIP

6. If Microsoft promoted such convergence, what could be their incentive? What is their business case?
   a. What are revenue streams that come to your mind that Microsoft could generate with a free VoIP solution (e.g. Skype)?
   b. If nothing: Still, Microsoft paid 8.5bn USD for Skype. Obviously, the company would not pay that much money if it would not expect any profits from doing so?

7. Apple and Google

7. We have discussed a lot about Microsoft and the potential the company has due to the large user bases of its communication platforms. However, their share in the smart phone market is rather small. There they compete with Google and Apple, which have significantly higher numbers of Android and iPhone users. Both companies also offer own VoIP programs. Google offers "GoogleTalk", Apple promotes its "Facetime". What would the competitors' reaction be if Microsoft started to push an integrated communication client?
   a. Would they try to push their own program more aggressively? Or would they eventually interconnect their programs to the Microsoft solution? (E.g. that Facetime users could be called form a Skype account). What are considerations that speak in favour or against an integration of programs?
   b. Is one of the companies likely to get their communication platform accepted as the dominant standard? If so, on what does it depend that the general public accepts one of the platforms as the leading standard? Which one is it likely to be?

8. Signaling Convergence: Towards Integrated Networks

8. We have talked about how callers could be interconnected with each other with regards to the addressing system. We have learnt that by interconnecting various communication platforms the exchange of the address information would be facilitated. For instance, instead of calling a phone number, a Facebook account could be called. Another aspect I would like to discuss now, and which is of rather technical nature, is how the underlying VoIP protocols are evolving. If two networks use different standards, e.g. SIP or H.323, an interconnection is difficult. Skype, for instance, uses its own, proprietary protocol. Do you believe that going forward we will see a convergence towards one protocol?
   a. If so, which standard is likely to prevail? Why?
   b. What speaks in favour of unifying protocols?
   c. Are there other ways of interconnecting protocols efficiently, without unifying them?
   d. Will on open protocol or a proprietary one prevail? Why?

9. Impact of VoIP on the Telecommunications Ecosystem

9. Before we have discussed the implications VoIP has had and will have on the incumbent telecommunication providers, consumers, and software companies. There are more types of companies that are or will be affected by VoIP. Just shortly, what is your opinion on the impact of VoIP on the following types of companies?
   a. VoIP operators in fix-net telephony that also are Internet Service Providers at the same time (e.g. UPC Cablecom)
   b. VoIP operators in fix-net telephony that are not Internet Service Providers (e.g. SIPgate, MagicJack)
   c. PBX Producers (e.g. Cisco)
   d. Producers of Corporate Communication Platforms (e.g. Avaya)
   e. Providers of mobile telephony applications that rely on the income from this business model (e.g. WhatsApp, Viber)

10. End

10. I am at the end of my questions. Before we stop, is there anything you would like to add?

A7. List of Literature

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl, & J. Beckmann, *Springer series in social psychology* (pp. 11-39). Berlin: Springer.

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behaviour: attitudes, intentions and perceived behavioral control. Journal of Experimental Social Psychology, 22 (5), 453-474.

Alby, T. (2008). *Das mobile Web.* München: Carl Hanser Verlag.

Allen, M. (2001). *Analysing the Organisational Environment.* Hertfordshire, United Kingdom: Select Knowledge.

Allot. (2011). *Allot Mobile Trends - Global Mobile Broadband Traffic Report.* Woburn, MA: Allot Communications.

Amidon, D. (1998). *Collaborative Innovation and the Knowledge Economy.* Vancouver: The Society of Management Accountants of Canada.

Analysys. (2004). *Final Report for the European Commission - IP Voice and Associated Convergent Services.* Brussels: ECSC-EC-EAEC.

Avaya. (2009). *White Paper Unified Communications.* Frankfurt/Main: Avaya.

Badach, 2. (2005). *Voice over IP - Die Technik, Grundlagen und Protokolle für Multimedia-Kommunikation* (2. Auflage ed.). München: Carl Hanser Verlag GmbH.

Badach, A. (2007). *Voice over IP - Die Technik.* München: Carl Hanser Verlag.

BAFU. (1988). *Erläuterungen zum USG.* Bern: Bundesamt für Umweltschutz.

BFS. (2011). *Internet in den Schweizer Haushalten.* Neuchâtel: Eidgenössisches Departament des Innern (EDI) - Bundesamt für Statistik (BFS).

Bobiatynski, E., Gehrmann, U., & Krause, M. (2005). *Wachsumskonzepte im Dienstleistungsmarkt.* Erlangen: Publicis Corporate Publishing.

Bonnekoh, M. (2006). *Voice over IP - Rechtsprobleme der Konvergenz von Internet und Telefonie.* Berlin: LIT Verlag.

Bower, J. L., & Christensen, C. M. (1996, January-February 43-53). Disruptive Technologies: Catching the Wave. HBR.

Brockhoff, K. (1999). *Forschung und Entwicklung* (5th Edition ed.). München: Oldenburg.

Buchner, M. (2006, June 6). 29 Minuten Ausfall täglich sind zu viel. Frankfurter Allgemeine Zeitung.

Bundesnetzagentur. (2011). *Jahresbericht 2010.* Bonn: Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen.

Camarillo, G., & García-Martín, M. A. (2008). *The 3G IP Multimedia Subsystem (IMS)* (2nd Edition ed.). West Sussex, England: John Wiley & Sons.

Cannon, R. (2005). State Regulatory Approaches to VoIP: Policy, Implementation, and Outcome. Federal Communications Law Journal, 57 (3), 479-510.

Carayannis, E. G., & Wetter, J. (2004). *The nature and Dynamics of Discontinuous vs. Disruptive Innovations and the S-Curve: Technology vs. Market Pull & Push Forces and Learning Curve Effects.* Washington D.C.: George Washington University.

Carroll, R. (2002, June 17). Bell did not invent telephone, US rules. The Guardian.

Chermack, T. J. (2011). *Scenario Planning In Organizations.* San Francisco: Berrett-Koehler Publishers.

Chong, H. M., & Matthews, H. S. (2004). *Comparative Analysis of Traditional Telephone and Voice-over-Internet Protocol (VoIP) Systems.* Washington DC: IEEE International Symposium on Electronics and the Environment.

Christensen, C. M. (1992a). Exploring the Limits of the Technology S-Curve. Part I: Component Technologies. Production and Operations Management, 4 (1), 334-357.

Christensen, C. M. (1992b). Exploring the Limits of the Technology S-Curve. Part II: Architectural Technologies. Production and Operations Management, 1 (4), 358-366.

Christensen, C. M. (1997). *The Innovator's Dilemma - When New Technologies Cause Great Firms to Fail.* Boston: Harvard Business School Press.

Christensen, C. M. (2006). The Ongoing Process of Building a Theory of Disruption. Product Innovation Management, 23 (1), 39-55.

Christensen, C. M., Anthony, S. D., & Roth, E. A. (2001). *Innovation in the Telecommunications Industry.* Boston: Clayton M. Christensen and Associates.

Cisco. (2011). *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015.* San Jose: Cisco Systems Inc.

Collins, A., Fadiora, T., Groom, C., & Smitha, E. (2005). White Paper on Internet Pricing: Regulatory Implications and Future Issues. Tallahassee: Florida Public Service Commission.

com! (2011). LTE-Netzausbau. *Das Computer-Magazin* (7), 19.

ComCom. (2011). *Tätigkeitsbericht 2010.* Bern: Eidgenössische Kommunikationskommission.

Conway, M. (2003). *An Introduction to Scenario Planning.* Victoria, Australia: Thinking Futures.

Davis, F. D. (1986). *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* Sloan School of Management. Massachusetts: MIT.

Davis, F. D., Bagazzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. Journal of Applied Social Psychology, 35 (2), 1111-1132.

Dean, S. C. (2009). *Service Provider Transformation.* Luxembourg: Skype.

Deloitte. (2005). *Gefahr und Chance von VoIP für Deutschland.* Berlin: Deloitte & Touche.

Der Spiegel. (2010, July 9). *Netzwelt*. From IT-Security - Hacker knackt Skype Verschlüsselung.

Dickson, F. (2009). *Mobile VoIP—Transforming the Future of Wireless Voice.* InStat, Mobile Applications & Services. Scottsdale: NPD Group.

Drucker, P. F. (1985). *Innovation and Entrepreneurship: Practice and Principles.* New York: Harper & Row.

Duffy, J. (2003, December 8). Portability's debut comes up short. NetworkWorld, 20 (49), p. 33.

Durkin, J. F. (2004). *Voice Enabling The Data Network: H.323, MGCP, SIP, QoS, SLAs, and Security* (2nd Edition ed.). Indianapolis: Cisco Systems.

Ebstein, S. (2005). *Voice over IP - Szenarien über die Diffusion von VoIP.* St.Gallen: Universität St.Gallen.

Ebstein, S.-F. (2005). *Voice over IP - Szenarien überr die Diffusion von VoIP.* St.Gallen: Universität.

Elixmann, D., Höckels, A., Kiesewetter, W., Neumann, K.-H., Schimmel, U., Schwab, R., et al. (2003). *Studie im Auftrag von Bundesamt für Kommunikation (BAKOM), Biel, Schweiz.* Bad Honef: wik consult.

Facchi, C. (1995). *Methodik zur formalen Spezifikation des ISO-OSI-Schickenmodells.* München: Utz.

Fink, A., & Siebe, A. (2001). *Erfolg durch Szenario-Management. Prinzip und Werkzeuge der strategischen Vorausschau.* Frankfurt: Campus.

Fischer, J. (2008). *VoIP Praxislehrfaden - IP-Kommunikation für Sprache, Daten und Video Planen, Implementieren und Betreiben.* München: Carl Hanser Verlag.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research.* Massachusetts: Addison-Wesley.

Fishbein, M., & Ajzen, I. (1980). *Understanding Attitudes and Predicting Social Behaviour.* Englewood Cliffs, NJ: Prentice Hall.

Flick, U. (2009). *An Introduction to Qualitative Research* (4th Edition ed.). London: Sage.

Foster, R. N. (1986). *Innovation: The Attacker's Advantage.* London: Macmillan.

Franke, M., Hannemann, U., Kietzmann, M., & Lehmkuhl, F. (2005, May 23). Kommunikation - Ganz Günstig, bitte! Focus, pp. 102-113.

Funk, J. L. (2008). The co-evolution of technology and methods of standard setting: the case of the mobile phone industry. Berlin: Springer-Verlag.

Ganguly, S., & Bhatnagar, S. (2008). *VoIP - Wireless, P2P and New Enterprise Voice over IP.* West Sussex: John Wiley & Sons Ltd.

Gatignon, H., & Robertson, T. S. (1985). A Propositional Inventory for New Diffusion. Research. Journal of Consumer Research, 11 (4), 849-867.

Gausemeier, J. (2004). Die Szenario-Analyse als Basis für Kompetenzmanagement. In L. v. Rosenstiel, *Strategisches Kompetenzmanagement* (pp. 42-61). Wiesbaden: Gabler Verlag.

Gemalto. (2011). *Long Term Evolution with Gemalto.* Austin, TX: Gemalto.

Geschka, H., & Hammer, K. (1990). Die Szenario-Technik in der strategischen Unternehmensplanung. In D. Hahn, & B. Taylor, *Strategische Unternehmensplanung - Strategische Unternehmensführung. Stand und Entwicklungstendenzen.* (pp. 313-336). Heidelberg: Heidelberg.

Godin, B. (2008). *In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation.* Montreal: INRS.

Gonçalves, R., & Ribeiro, R. (2005). Skype and the New Regulatory Framework. Communications & Strategies, 59 (3), 141-158.

Gorman, E., Mehalik, E., Carlson, W., & Oblon, M. (1993). Alexander Graham Bell, Elisha Gray, and the Speaking Telegraph. History of Technology, 15, 1-56.

Grayson, M., Shatzkamer, K., & Wierenga, K. (2011). *Building the Mobile Internet (Networking Technology).* Indianopolis: Cisco Press.

Grienitz, V., & Schmidt, A. (2010). Scenario-based generation of business models considering market constraints. *Proceedings of the 2010 Industrial Engineering REsearch Converence* (pp. 1-7). Siegen: Department of Industrial Engineering University of Siegen.

Griffin, R. W. (2011). *Management* (10th Edition ed.). Masen, OH: South-Western Cengage Learning.

Gruber, H., & Verboven, F. (2001). DP2440 The Evolution of Markets Under Entry and Standards Regulation - The Case of Global Mobile Telecommunications. International Journal of Industrial Organization, 19 (7), 1189-1212.

Haag, J., & Scharf, A. (2004). Bewertung der Erfolgschancen neuer Produkte auf der Basis von Zukunftsszenarien. Forschungsforum Schriftreihe Marketing, 2, 1-46.

Hagedoorn, J. (1996). Innovation and Entrepreneurship: Schumpeter Revisited. Industrial and Corporate Change, 5 (3), 883-896.

Hauser, B. J. (2010). *Lehrbuch der Kommunikationstechnik: Einführung in die Kommunikations- und Netzwerktechnik für Studium und Berufsausbildung.* Borsdorf: winterwork.

Henkel, J. (2009). *Voice over IP- Rechtliche und regulatorische Aspekte der Internettelefonie.* Hamburg: Verlag Dr. Kovač.

Hensel, M., & Wirsam, J. Diffusion von Innovationen. In K. Aur-Srnka, K. Bellmann, R. Bronner, F. Himpel, & D. Schmidt-Gallas, *Spektrum wirtschaftswissenschaftliche Forschung.* Wiesbaden: Gabler.

Hilmar, S. (2004). Lebenslang Telefon für 999 Dollar. *Der Spiegel* (51), 162-168.

Hindle, T. (2008). *Guide to Management Ideas and Gurus.* London: Profile Books Ltd.

Howlett, R. J. (2010). *Innovation through Knowledge Transfer.* Berlin: Springer.

Hübner, H. (2002). *Integratives Innovationsmanagement: Nachhaltigkeit als Herausforderung für ganzheitliche Erneuerungsprozesse.* Berlin: Erich Schmidt Verlag.

Information Gatekeepers. (2010). TDM and VoIP Traffic. VoIP Monthly Newsletter, 8 (2), 1-15.

Information Gatekeepers. (2010). VoIP Penetration to Reach 79 percent of U.S. Businesses by 2013, According to In-Stat. VoIP Monthly Newsletter, 8 (1), 1-15.

Jackson, C., Shorter, J. D., & Forcht, K. A. (2009). Replacing Traditional Telephony with VoIP. Issues of Information Systems, 10 (2), 107-112.

Jackson, C., Shorter, J. D., & Forscht, K. A. (2009). Replacing Traditional Telephony With VoIP. Issues in Information Systems, 10 (2), 107-112.

Jenny, W. M. (2006). *Innovation partnerships between small and large firms: possibilities and threats.* Göttingen: Cuvillier Verlag.

Karpinski, R. (2011). VoIP hits the road. Enterpreneur, 42.

Keith, B. A. (2007). *Guidelines For Voice over Internet Protocol (VoIP) Computer Telephony.* Ft Meade: Committee on National Security Systems.

Keuber, F., Schomann, M., & Zimmermann, K. (2010). *Innovatives IT-Management: Management von IT und IT-gestütztes Management* (2. Auflage ed.). Wiesbaden: Gabler Verlag.

Königstorfer, J. (2008). *Akzeptanz von technologischen Innovationen. Nutzungsentscheidungen von Konsumenten dargestellt am Beispiel von mobilen Internetdiensten.* Wiesbaden: Gabler.

Kuhn, D. R. (1997). Sources of failure in the public switched telephone network. IEEE Computer Society, 30 (4), 31-36.

Landgrebe, J. (2006). Liberalisierung und Regulierungsmanagement im Telekommunikationsmarkt. In A. Picot, R. Reichwald, & E. Franck, *Markt- und Unternehmensentwicklung* (pp. 1-223). Wiesbaden: GWV Fachverlag GmbH.

Langley, A. (1999). Strategies for Theorizing from Process Data. Academyof Management Review, 24 (4), 691-710.

Ledford, J. L. (2005). Cut the cord! The Consumer's guide to VoIP. Florence, KY: Thomson Course Technology.

Levitt, T. (2002). Creativity is Not Enough. Harvard Business Review, 80 (8), 1-11.

Lewis, T. G. (2006). *Critical Infrastructure Protection in Homeland Security.* Hoboken, New Jersey: John Wiley & Sons.

Lindlof, T. R., & Taylor, B. C. (2011). *Qualitative Communication Research Methods* (3rd Edition ed.). Thousand Oaks: Sage Publications Inc.

Lyytinen, K., & Rose, G. M. (2003). The Distruptive Nature of Information Technology Innovations: The Case of Internet Computing in Systems Development Organizations. MIS Quarterly, 27 (4), 557-596.

Mager, R. (2004). *IP-Telefonie: Marktpotenziale, Strategien und Auswirkungen.* Berlin-Offenbach: Vde Verlag.

Majumdar, S. K., Vogelsang, I., & Cave, M. E. (2005). *Handbook of Telecommunication Economics* (Vol. II). Amsterdam: Elsevier B.V.

Mayring, P. (2002). *Einführung in die Qualitative Sozialforschung* (5. Aufl. ed.). Weinheim/Basel: Beltz Verlag.

Meinberg, M. (2008). *Voice over IP.* Berlin: LIT Verlag.

Meisel, J. B., & Levin, S. L. (2003). The FCC and the Internet's challenges to traditional regulatory policy. info, 5 (2), 8-16.

Meisel, J. B., & Needles, M. (2005). Voice over Internet Protocol (VoIP) development and public policy implications. info, 7 (3), 3-15.

Mohmand, A. S. (2008). *VoIP: Voice Over Internet Protocol Architecture and Features.* Raleigh, NC: Lulu Enterprises.

NAIRSC. (2004). *VoIP Primer - Voice over Internet Protocol.* National Aging Information and Referral Support Center. Washington DC: National Association Of State Units On Aging.

Nieminen, K. (2004). *VoIP Regulation.* Helsinki: Helsinki University of Technology.

Niklowitz, M. (2005, April 27). Voice Over IP: Das Sparpotenzial für KMU ist riesig. Handelszeitung.

Nyström, A.-G., & Hacklin, F. (2005). *Operator Value-Creation Through Technological Convergence - The Case of VoIP.* Berlin: Freie Universität Berlin.

Obermann, K., & Horneffer, M. (2009). *Datennetztechnologien für Next Generation Networks.* Wiesbaden: Vieweg + Teubner.

Odenthal, S., & Hess, F. (2008). *Business Presentations.* St.Gallen: University St.Gallen.

OFCOM. (2002). *Merkblatt VoIP.* Bern: Federal office for communications.

OFCOM. (2010). *On the Status of the Information Society in Switzerland 2010.* Biel: Information Society Coordination Office - Federal Office of Communications (OFCOM).

OFTEL. (2001). *Effective Competition Review: Mobile.* London: Office of Telecommunications.

Oliver Wyman. (2004). *Oliver Wyman-Studie zur Internet-Telefonie ("Voice over IP"): Die Lawine rollt immer schneller.* München: Oliver Wyman.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation.* Echandens: Self-Published.

Pan, H. (2010). *VoIP Monthly Newsletter February 2010.* Boston: Information Gatekeepers INc.

Patterson, M. R. (2010). Non-Network Barriers to Network Neutrality. Fordham Law Review, 78 (6), 2843-2872.

Perkins, C. (2003). *RTP - Audio and Video for the Internet.* Boston: Pearson Education.

Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: The Free Press.

Porter, M. E. (1990). *The Competitive Advantage of Nations.* New York: The Free Press.

Porter, M. E. (1995). *Wettbewerbsstrategie: Methoden zur Analyse von Branchen und Konkurrenten* (8th Edition ed.). (V. Brandt, & C. T. Schwoerer, Trans.) Frankfurt a.M.: Campus Verlag.

Pourasghar, D., & Hermes, S. (2006). *Convergence of television, telephony and internet access (triple play).* München: GRIN Verlag.

Punch, K. F. (2005). *Introduction to Social Research* (2nd Edition ed.). London: Sage.

Rammert, W. (2005, January 15). Eine Frage der Kultur - Luxusgerät oder Massenartikel. Neue Zürcher Zeitung, p. 68.

Rao, B., Angelov, B., & Nov, O. (2006). Fusion of Disruptive Technologies: Lessons from the Skype Case. European Management Journal, 24 (2-3), 174-188.

Ringland, G. (2006). *Introduction to Scenario Planning.* Hoboken, NJ: John Wiley & Sons, Ltd.

Rivera Green, I. F. *The Emancipatory Potential of a New Information System and its Effect on Technology Acceptance.* 2005: University of Pretoria.

Robert, M. (1998). *Strategy pure & simple II: how winning companies dominate their competitors.* New York: McGraw-Hill.

Roberts, E. B. (2007). Managing Invention and Innovation. Research Technology Management, 50 (1), 35-54.

Rogers, E. M. (1962). *Diffusion of Innovations.* New York: The Free Press.

Rogers, E. M. (1976). New Product Adoption and Diffusion. Journal of Consumer Research, 2 (4), 290-102.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th Edition ed.). New York: The Free Press.

Sadowski, B., & Straathof, B. (2005). *VoIP under the EU Regulatory Framework: Preventing Foreclosure?* Eindhoven Centre for Innovation Studies, Department of Technology Management. Eindhoven: Technische Universiteit Eindhoven.

Sauter, M. (2009). *Beyond 3G - Bringing Networks, Terminals and the Web Togheter.* Hoboken, New Jersey: John Wiley & Sons.

Schedel, S. (2004). *Wege zu VoIP - Konvergenztechnologie.* Berlin: Swiemens AG.

Schieb, J., & Müller, M. (2006). *Voice over IP - Telefonieren übers Internet.* Kilchberg: SmartBooks Publishing AG.

Schmid, T. (2010). *Qualitative Research: Research Design and Data Collection.* Institute of Management. St.Gallen: University St.Gallen.

Schöberl, M. (2008). Responses of incumbent firms in the face of disruptive strategic innovations. In H. Hungenberg, & G. Seliger, *Schriftenreihe des Instituts für Untenehmensplaung* (pp. 1-387). Berlin: Pro Business GmbH.

Schumpeter, J. (1912). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interests and the BUsiness Cycle.* Cambridge: Harvard University Press.

Schumpeter, J. A. (1943). *Capitalism, Socialism and Democracy.* New York: Harper & Row.

Seedorf, J. (2008). Lawful Interception in P2P-Based VoIP Systems. In H. Schulzrinne, R. State, & S. Niccolini, *Principles, Systems and Applications of IP Telecommunications. Services and Security for Next Generation Networks.* Heidelberg: Springer-Verlag.

Shiratori, N., & Atiquzzaman, M. (2004). *Recent Advances in Communication and Internet Technology.* Dordrecht: Kluwer Adacemic Publishers.

Sietmann, R. (2009). Heise. *C't Magazin* (24), 90.

Sigler, C. (2010). *Online-Medienmanagement: Grundlagen - Konzepte - Herausforderungen.* Wiesbaden: Gabler Verlag.

Sisalem, D., & Ehlert, S. (2006). *Multimedia Services in the Internet.* Berlin: Fraunhofer Institute for Open Communication Systems.

Soreon Research. (2005). *Voice over IP und Traditionelle Telefonie im TCO-Vergleich.* Kreuzlingen: Soreon Research.

Stummer, C., Günther, M., & Köck, A. M. (2010). *Grundzüge des Innovations- und Technologiemanagements.* Wien: Facultas Verlags- und Buchhandels AG.

SUKO. (2011). *Haushalte und Bevölkerung: Telefoninfrastruktur.* Bern: OFS-BFSUST.

Sulkin, A. (2002). *PBX systems for IP telephony.* Columbus, OH: McGraw-Hill.

T-Systems. (2007). *White Paper - Voice over Internet Protocol.* Frankfurt: T-Systems Enterprise Services GmbH.

Tele-Service. (2011). Viber turns to spirit for quality HD mobile VoIP calling. Tele-Service News, 23 (3), 45.

Thompson, V. A. (1965). Bureaucracy and Innovation. Administrative Science Quaterly, 10 (1), 1-20.

Thor, A. (2011). *Das Skypebuch - Internettelefonie. Alles über Skype.* Berlin: Rhombos Verlag.

Trick, U., & Weber, F. (2009). *SIP, TCP/IP und Telekommunikationsnetze.* München: Oldenburg Wissenschaftsverlag GmbH.

Ulseth, T., & Stafsnes, F. (2006). VoIP speech quality - Better than PSTN? *Telektronikk* (1), 119-129.

US FCC. (2010). *Voice over Internet Protocol (VoIP) - FCC Consumer Facts.* US Federal Communications Commission. Washington DC: Consumer & Governmental Affairs Bureau.

Utterback, J. (1996). *Mastering the Dynamics of Innovation.* Bosten: Harvard Business School Press.

Vahs, D., & Burmester, R. (2002). *Innovationsmanagement.: Von der Produktidee zur erfolgreichen Vermarktung.* (2nd Edition ed.). Stuttgart: Schäffer-Poeschel.

Van Latesteijn, H., & Andeweg, K. (2011). *The TransForum Model: Transforming Agro Innovation Toward Sustainable Development.* Berlin: Springer.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. Management Science, 46 (2), 186-204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. MIS Quarterly, 27 (3), 425-478.

Wallingford, T. (2005). *Switching to VoIP.* Sebastopol, CA: O'Reilly Media Inc.

Widmer, U. (2002). *Entbündelung der letzten Meile – Ohnmacht trotz Regulierung? Die Situation in der Schweiz im Vergleich zur EU.* bern: Dr. Widmer & Partner Rechtsanwälte.

wik consult. (2002). *Anhang I: Schweizer Telekommunikationsmarkt.* Bad Honef: wik consult.

Winkelhage, J. (2005, September 6). Internettelefonie nimmt zweiten Anlauf - und setzt sich durch. Frankfurter Allgemeine Zeitung, p. 18.

Wirtz, B. W. (2001). Reconfiguration of Value Chains in Converging Media and Communication Markets. Long Range Planning, 34 (4), 489-506.

Wolf, E., Zerres, C., & Zerres, M. (2010). *Szenario-Technik.* Hamburg: Universität Hamburg.

Wolf, H., & Barnes, R. (2011). *VoIP emergency calling: foundations and practice.* West Sussex: John Wiley & Sons Ltd.

Yin, R. K. (1999). *Case study research. Designs and methods.* London: Sage.

Zhang, J., Chan, S., & Fang, X. (2005). *Enterprise User Adoption of VoIP.* School of Computer Science, Telecommunications, and Information Systems. Chicago, IL: DePaul University.

Zorpette, G. (1989). Keeping the phone lines open. IEEE Spectrum, 26 (6), 32-36.

A8. List of Internet Sources

!Dol. (2010, September 24). *!Dol*. Retrieved January 2, 2012 from PSTN Infrastructure: http://codeidol.com/telecommunications/telecommunications-essentials/The-PSTN/The-PSTN-Infrastructure/

Accenture. (2012). *Accenture - High Performance Delivered*. Retrieved March 1, 2012 from Company Description: http://www.accenture.com/us-en/company/overview/description/Pages/index.aspx

AllVoIPNews. (2011, April 24). *VoIP Business and Virtual PBX*. Retrieved December 10, 2011 from 10.2 Percent Wireless Revenue Growth: http://www.allvoipnews.com/10-2-percent-wireless-revenue-growth.html

BAKOM. (2007, September 25). *Schweizerische Eidgenossenschaft*. Retrieved January 15, 2012 from Änderung des Fernmeldegesetzes: http://www.bakom.admin.ch/dokumentation/gesetzgebung/00512/00871/index.html?lang=de

BAKOM. (2009, December 11). *Schweizerische Eidgenossenschaft*. Retrieved January 15, 2012 from Situation auf dem Fernmeldemarkt 2008: http://www.bakom.admin.ch/dokumentation/Newsletter/01315/03294/03296/index.html?lang=de

Bell, I. (2008, November 3). *Bloomberg Businessweek*. Retrieved June 21, 2011 from Who Killed The VoIP Revolution: http://www.businessweek.com/technology/content/oct2008/tc20081031_668626.htm

Biermann, K. (2011, March 3). *Zeit Online*. Retrieved March 4, 2012 from Betrayed By Your Own Data: http://www.zeit.de/digital/datenschutz/2011-03/data-protection-malte-spitz#comments

BITKOM. (2010, January 13). *Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V.* Retrieved November 30, 2011 from IT- und Telekommunikations-Trends 2010: http://www.bitkom.org/62121_62116.aspx

Brabant, M. (2006, December 15). *BBC News*. Retrieved January 30, 2012 from Greek scandal sees Vodafone fined: http://news.bbc.co.uk/2/hi/business/6182647.stm

Bradshaw, T. (2011, November 14). *Financial Times - Technology*. Retrieved January 18, 2012 from WhatsApp users get the message: http://www.ft.com/intl/cms/s/2/30fd99a2-0c60-11e1-88c6-00144feabdc0.html#axzz1jvc63VKg

Breuer, G. (2011, October 7). Gordon Breuers's Blog about .Net-Development and the Windows Phone Platform. Retrieved February 2, 2012 from WP-Tipp #025 – Datenverbindungen: http://gordon-breuer.de/post/2011/10/07/WP-Tipp-025-%E2%80%93-Datenverbindungen.aspx

Brodkin, J. (2011, July 12). NetworkWorld. Retrieved September 15, 2011 from Microsoft Plans Big Skype/Lync Integration: http://www .Networkworld.com/news/2011/071211-microsoft-skype-lync.html?page=2

Brownlow, M. (2012, January 1). *Email Marketing Reports*. Retrieved January 15, 2012 from Email and webmail statistics: http://www.email-marketing-reports.com/metrics/email-statistics.htm

CallMagazin. (2001, April 4). *Telekom vor Bundesverwaltungsgericht gescheitert*. Retrieved January 12, 2012 from Letzte Meile: Telefon und Festnetz: http://www.call-magazin.de/telefon-festnetz/telefon-festnetz-nachrichten/telekom-vor-bundesverwaltungsgericht-gescheitert_6173.html

Caukin, J. (2011, September 6). *Skype*. Retrieved March 4, 2012 from A Day in the Life of Skype: http://blogs.skype.com/en/2011/09/a_day_in_the_life_of_skype_inf.html

Chip Online. (2011, November 14). *Chip Online: Kommunikation*. Retrieved January 10, 2012 from VideoMeet: Facetime, Skype, Google Talk vereint: http://business.chip.de/news/VideoMeet-Facetime-Skype-Google-Talk-vereint_52796327.html

Cloer, T. (2009, May 5). *Computerwoche*. Retrieved November 10, 2011 from VoIP wird für traditionelle Mobilfunk-Anbieter zum Problem: http://www.computerwoche.de/netzwerke/tk-netze/1894854/

Columbia. (n.d.). *Columbia University*. Retrieved March 3, 2012 from Resume of Henning Schulzrinne: http://www.cs.columbia.edu/~hgs/resume/bio_75.txt

Conneally, T. (2010, August 4). *BetaNews*. Retrieved November 23, 2011 from Vonage mobile app makes free VoIP calls to your Facebook friends over 3G, Wi-Fi: http://betanews.com/2010/08/04/vonage-mobile-app-makes-free-voip-calls-to-your-facebook-friends-over-3g-wi-fi/

DENIC. (2012, February 1). *DENIC Hintergrund*. Retrieved March 5, 2012 from ENUM-Domainstatistik: http://www.denic.de/hintergrund/statistiken/statistik-enum.html

Deutsche Telekom. (2012). *T-Mobile*. Retrieved March 14, 2012 from Netzabdeckung: http://www.t-mobile.de/netzabdeckung/0,21695,22950-_,00.html

Dinan, M. (2008, September 16). *TMCnews*. Retrieved January 3, 2012 from Skype: VoIP is Dead; IM Technology Is Key to Telecom's Future: http://voip-phone-systems.tmcnet.com/topics/voip-phone-systems/articles/40112-skype-voip-dead-im-technology- key-telecoms-future.htm

Drljača, S. Đ. (2010, January 13). *knol*. Retrieved October 10, 2011 from IMS Subsystem - NGN: Next Generation Networks: http://knol.google.com/k/ims-subsystem-ngn#

DSLTarife .Net. (2009, September 1). Infos, News und Tarife zum Thema Breitband-Internet. Retrieved October 10, 2011 from Auch T-Mobile erlaubt VoIP über Handys: http://www.dsltarife .Net/t-mobile-erlaubt-voip-nutzung-ueber-datentarife/news/6631.html

DutchNews. (2011, May 26). *DutchNews.nl*. Retrieved January 10, 2012 from KPN presses ahead with internet service extra fee plans: http://www.dutchnews.nl/news/archives/2011/05/kpn_presses_ahead_with_interne.php

EON. (2011, December 21). *Enhanced Online News*. Retrieved January 18, 2012 from Strategy Analytics: Smartphone Data Plan Adoption Key to Mobile Revenue Growth: http://eon.businesswire.com/news/eon/20111221005867/en/Strategy-Analytics/Blackberry-Messenger/WhatsApp

Facebook. (2012). *Newsroom*. Retrieved March 27, 2012 from Factsheet: http://newsroom.fb.com/content/default.aspx?NewsAreaId=22

Farlex. (2003). *The Free Dictionary*. (c.-H. D. Terms, Producer) Retrieved January 22, 2012 from Public Switched Telephone Network: http://encyclopedia2.thefreedictionary.com/Circuit-switched+telephone+network

FCC. (2012). *Federal Communiations Commission of the United States of America*. Retrieved March 1, 2012 from What We Do: http://www.fcc.gov/what-we-do

Finanzen. (2012, February 15). *Finanzen.ch: News & Analysen*. Retrieved February 20, 2012 from Swisscom erleidet Umsatzrückgang wegen Preiserosion (Zus): http://www.finanzen.ch/nachrichten/aktien/Swisscom-erleidet-Umsatzrueckgang-wegen-Preiserosion-Zus-78464

Frickel, C. (2011, July 7). *Online Focus*. Retrieved September 14, 2011 from Skype bei Facebook: Was Facebooks Videochat bringt: http://www.focus.de/digital/internet/facebook/skype-bei-facebook-was-facebooks-videochat-bringt_aid_643616.html

Gartner. (2003). *Media Relations*. Retrieved January 5, 2012 from Gartner Outlines Top 10 Trends to Watch in European Fixed Voice Telecom market: http://www.gartner.com/press_releases/pr9oct2003c.html

Gibson, M. (2010, November 19). *SignalNews*. Retrieved December 20, 2011 from Using 911 on a VoIP Phone: http://signalnews.com/911-service-from-voip-phone

Goodin, D. (2011, September 20). *The Register*. Retrieved October 15, 2011 from Skype for iPhone makes stealing address books a snap: http://www.theregister.co.uk/2011/09/20/skype_for_iphone_contact_theft/

GSMA. (2012). *Mobile Technology*. Retrieved January 18, 2012 from GSM: http://www.gsma.com/gsm/

Gurov, L. (2005, April 25). Netzwelt.de. Retrieved January 13, 2012 from DSL ohne Telefon: http://www .Netzwelt.de/news/70939_3-dsl-ohne-telefonanschluss-waers.html

Hines, M. (2004, July 24). *Cnet News*. Retrieved January 2012, 10 from Skype broadens its Net phone horizons: http://news.cnet.com/Skype-broadens-its-Net-phone-horizons/2100-7352_3-5281231.html

Huss, N., & & Kollrich, C. (2011, May 17). *Financial Times Deutschland*. Retrieved June 16, 2011 from Patente - Lizenz zum Weltverändern: http://www.ftd.de/wissen/technik/:patente-lizenz-zum-weltveraendern/60051974.html

Ihlenfeld, J. (2011, August 4). *Golem*. Retrieved October 27, 2011 from Skype stellt auf Googles VP8-Codec um : http://www.golem.de/1108/85467.html

Innovation Zen. (2006). *Innovation Zen*. Retrieved September 15, 2011 from Archive for the 'Innovation Theory' Category: http://innovationzen.com/blog/category/innovation-theory/

ITWissen. (2012, Feburary 5). *ILEC (Incumbent Local Exchange Carrier)*. Retrieved Feburary 5, 2012 from Das grosse Online-Lexikon für Informationstechnologie: http://www.itwissen.info/definition/lexikon/incubent-local-exchange-carrier-ILEC.html

Kadtke, J. (2012, April 5). *TechCast*. Retrieved April 5, 2012 from Smartphones -30% SB: Selectd Adoption & Forecast Data: http://www.techcast.org/BreakthroughAnalysis.aspx?ID=69

Kapustka, P. (2004, October 19). *CRN*. Retrieved June 16, 2011 from Powell Calls For 'Revolution' In Telecom Regulation: http://www.crn.com/news/networking/50500868/powell-calls-for-revolution-in-telecom-regulation.htm

Kewney, G. (2005, May 26). *The Register*. Retrieved November 30, 2011 from Skype makes empassioned 911 plea: http://www.theregister.co.uk/2005/05/26/skype_911/

Kheterpal, G. (2011, June 29). *The Telecom Blog*. Retrieved January 30, 2012 from Microsoft Patents ‘Legal Intercept’ Technology, Will Skype Have A Backdoor?: http://www.thetelecomblog.com/2011/06/29/microsoft-patents-legal-intercept-technology-will-skype-have-a-backdoor/

Kretowski, P. D. (2008, March 10). *VoIP-News*. Retrieved October 13, 2011 from State of the VoIP Market 2008: http://www.voip-news.com/feature/state-voip-market-2008-031008/

Lackes, R., & Siepermann, M. (2011). *OSI-Modell*. Retrieved January 1, 2012 from Witschaftslexikon Gabler: http://wirtschaftslexikon.gabler.de/Archiv/76651/osi-modell-v6.html

Landesanstalt für Medien Nordrhein-Westfalen (LfM). (2011, October 11). *LTE in NRW*. Retrieved November 15, 2011 from LTE-Tarife in Deutschland: http://www.lte-nrw.de/teedrei/Tarife.164.0.html

LTEmobile. (2012, January 10). *LTE Technik*. Retrieved February 12, 2012 from Optionen für die Sprachübermittlung in LTE Netzen: http://www.ltemobile.de/lte-technik/sprachuebertragung-im-lte-netz/

Microsoft Technet. (2012). *Microsoft Lync*. Retrieved March 13, 2012 from Unified Communications Open Interoperability Program – Lync Server: http://technet.microsoft.com/en-us/lync/gg131938.aspx

Mullins, R. (2011, November 10). *InformationWeek*. Retrieved December 20, 2011 from Blue Jeans Network Beats Microsoft To Lync, Skype Connection: http://www.informationweek.com/news/telecom/unified_communications/231902764

myVoIPProvider. (2009, March 9). *myVoIPProvider*. Retrieved June 22, 2011 from VoIP Graveyard - A collection of bankrupt and problematic VoIP providers: http://www.myvoipprovider.com/en/VoIP_Provider_Graveyard

NZZ. (2012, February 15). *NZZ Online*. Retrieved March 13, 2012 from Mit Pauschalangeboten gegen Gratis-Dienste: http://www.nzz.ch/nachrichten/wirtschaft/aktuell/telekomanbieter_spueren_die_preiserrosion_1.15075663.html

O'Brien, K. J. (2011a, October 7). *The New York Times*. Retrieved January 30, 2012 from Europe Approves Microsoft Purchase of Skype: http://www.nytimes.com/2011/10/08/technology/europe-approves-microsoft-purchase-of-skype.html

O'Brien, K. J. (2011b, June 22). *The New York Times*. Retrieved February 2, 2012 from Dutch Lawmakers Adopt Net Neutrality Law: http://www.nytimes.com/2011/06/23/technology/23neutral.html?pagewanted=all

Oiaga, M. (2010, February 10). *Softpedia*. Retrieved February 10, 2012 from Windows Live Messenger 300 Million Users, 1.5 Billion Conversations, 9 Billion Messages: http://news.softpedia.com/news/Windows-Live-Messenger-300-Million-Users-1-5-Billion-Conversations-9-Billion-Messages-134586.shtml

Oxford Dictionaries. (2010, April 1). *Oxford Dictionaries*. Retrieved October 25, 2011 from Diffusion: http://oxforddictionaries.com/definition/diffusion

Packetizer. (2011). *Packetizer*. Retrieved January 1, 2012 from H.323 versus SIP: A Comparison: http://www.packetizer.com/ipmc/h323_vs_sip/

Patel, N. (2011, June 9). *The Verge*. Retrieved January 9, 2012 from iMessage, Skype, Google Voice, and the death of the phone number: http://www.theverge.com/2011/06/09/google-voice-skype-imessage-and-the-death-of-the-phone-number/

Payne, T. (1999, December). *Techtarget*. Retrieved January 2, 2012 from Private Branch Exchange (PBX): http://searchunifiedcommunications.techtarget.com/definition/private-branch-exchange

Potter, E. (2009, September 15). *InStat*. Retrieved November 13, 2011 from Mobile VoIP Could Transform Mobile Landscape: http://www.instat.com/press.asp?ID=2618&sku=IN0904428MCM

Preuschat, A. (2011, July 11). *Total Telecom*. Retrieved February 3, 2012 from KPN hikes mobile data prices to battle sales slump: http://www.totaltele.com/view.aspx?ID=466356

Quincent. (2011, June 1). *Quincent Consulting*. Retrieved January 17, 2012 from Is BlackBerry Season Over?: http://www.quicentconsulting.com/blog_insight_quicent_consulting/is-blackberry-season-over/

Reuters. (2011, June 18). *The Economic Times*. Retrieved January 29, 2012 from Microsoft get antitrust approval to buy Skype: http://www.reuters.com/article/2011/06/17/us-skype-microsoft-idUSTRE75G65Q20110617

Rincón Hanna, D. (2011, July 20). *Brand New Start*. Retrieved March 2, 2012 from About innovation and how technology is changing the world: http://brandnewstart.posterous.com/

Sawall, A. (2012, January 13). *Golem*. Retrieved January 20, 2012 from Nokia Siemens Networks: "In Mobilfunknetzen einfach keine Kapazität mehr vorhanden": http://www.golem.de/1201/89061.html

SF. (2011, December 2011). *Tagesschau des Schweizer Fernsehens*. Retrieved February 15, 2012 from Grundversorgung: Internet wird schneller: http://www.tagesschau.sf.tv/Nachrichten/Archiv/2011/12/09/Schweiz/Grundversorgung-Internet-wird-schneller

Stölzel, T., Berke, J., Kuhn, T., & Wettach, S. (2009, April 9). *Wirtschaftswoche*. Retrieved December 10, 2011 from Mobilfunker wollen Skype in Funknetzen verbieten: http://www.wiwo.de/unternehmen/telekommunikation-mobilfunker-wollen-skype-in-funknetzen-verbieten/5154826.html

Swisscom. (2011a). *Über Swisscom*. Retrieved January 12, 2012 from Marktanteile der Wichtigsten Anbieter: http://www.swisscom.ch/de/ghq/portraet/markt-wettbewerber/marktanteile.html

Swisscom. (2011b). *Swisscom*. Retrieved November 10, 2011 from Markttrends: Eine Branche im Spannungsfeld zwischen Preiszerfall und Innovationsdruck: http://www.swisscom.ch/de/ghq/portraet/markt-wettbewerber/markttrends.html

Swisscom. (2011c). *Swisscom*. Retrieved March 10, 2012 from Das Unternehmen Swisscom: http://www.swisscom.ch/de/ghq/media/fragenundantworten/fragenzumunternehmen.html

TechTarget. (2007, June). *Definition Telecommunications*. Retrieved January 12, 2012 from SearchTelecom: http://searchtelecom.techtarget.com/definition/telecommunications

Torrieri, M. (2009, October 19). *TMCnet*. Retrieved January 15, 2012 from Report: Mobile VoIP Growth Will Impact Operator Voice download Revenue : http://www.tmcnet.com/channels/mobile-unified-communications/articles/66906-report-mobile-voip-growth-will- impact-operator-voice.htm

Unuth, N. (n.d.). *Voice over IP*. Retrieved February 10, 2012 from About.com: http://voip.about.com/od/voipbasics/f/telephony.htm

US FCC. (2012, January 4). *United States Federal Communications Comission*. Retrieved January 5, 2012 from VoIP and 911 Service: http://www.fcc.gov/guides/voip-and-911-service

Virgo Publishing. (2007, July). *Billing World*. Retrieved January 11, 2012 from VoIP Replacing the PSTN? A 10-Year Look: www.billingworld.com/articles/2006/07/voip-replacing-the-pstn.aspx

Vodafone. (2012). *Privatkunden*. Retrieved March 13, 2012 from Netzabdeckung: http://www.vodafone.de/privat/hilfe-support/netzabdeckung.html

von Bomhard, S. (2006, May 17). Space .Net. Retrieved January 12, 2012 from Anti-ENUM-Kartell verhindert kostenlose VoIP-Telefonate und Internet-Innovation!: http://www.space .Net/unternehmen/unser-pressebereich/detailansicht-pressemitteilungen/datum/2006/05/17/anti-enum-kartell-verhindert-kostenlose-voip-telefonate-und-internet-innovation/index.html

Warrelmann, O. (2002, June 16). *Alte Telefone*. Retrieved June 15, 2011 from Nicht Bell sondern Meucci hat das Telefon erfunden.: http://www.alte-telefone.de/seite9.htm

Zycko. (2007, January 16). *Internationaler Distributor Innovativer IT-Lösungen*. Retrieved February 10, 2012 from VoIP Revolution Threatens Telecom Firms: http://www.zycko.com/news/live-news/article/voip-revolution-threatens-telecom-firms/

A9. Declaration auf Authorship

I hereby declare

- that I have written this thesis without any help from others and without the use of documents and aids other than those stated above,
- that I have mentioned all used sources and that I have cited them correctly according to established academic citation rules.

Benjamin Harder