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SCENARIO ANALYSIS OF THE MOBILE VOICE MARKET

Thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science in Technology

Espoo, September 28th , 2007

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HELSINKI UNIVERSITY OF TECHNOLOGY

Abstract of the Master's Thesis

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Name of the Thesis:	Scenario Analysis of the Mobile Voice Market		
Date:	28.9.2007	**Number of pages:**	9+97
Department:	Department of Electrical and Communications Engineering		
Professorship:	S-38 Networking Technology		
Supervisor:	Prof. Heikki Hämmäinen		
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The development of mobile networks together with the growing popularity of Internet services is currently leading the mobile industry to converge with the Internet world. One of the most widely discussed Internet services is VoIP that has already become an important means of communication in the Internet. However, also the mobile industry has experienced some tentative launches of VoIP services (Nokia phones with SIP application, Fring, Three and Skype collaboration). In addition, the development of other mobile Internet services will only speed up the emergence of mobile VoIP. Mobile operators have recognized the threat of mobile VoIP and the consequences it may have on their voice revenue. On the other hand, some of the mobile operators may see the development as an opportunity to converge with the services industry.

This thesis consists of studies on the mobile packet switched networks and their applicability to be used with VoIP technology. Market dynamics of the VoIP offerings are studied to better understand the business dynamics of mobile VoIP services. The framework of *Five Forces* is used to combine the industry uncertainties from the previous technical and business studies. A set of important variables is then obtained from these uncertainties to describe the evolution of mobile voice market. A group of industry experts were interviewed in order to define the two most important variables (mobile market structure and access mode in multi-radio networks), which together structure the dimensions of the scenarios on mobile voice market.

This thesis introduces four industry scenarios that define the future market of mobile voice. The main outcome of this thesis is that the mobile industry is found to be on a verge of horizontalization. Mobile VoIP has a direct effect on the mobile operators' voice revenue, which especially emphasizes its effect on the market structural change. Besides, mobile VoIP has also synergies with all the diverged mobile services and together they will have an impact on the market structure if they break in to the mobile industry. In this evolution the alternative wireless technologies are seen as the main source of disruption. Also the regulation of mobile networks and services is found lagging the evolution and thus any act by the regulator will cause turbulence among the rising mobile VoIP market.

Keywords: mobile networks, voice over IP, business analysis

TEKNILLINEN KORKEAKOULU

Diplomityön tiivistelmä

Tekijä:	Kim Lindqvist		
Työn nimi:	Skenario analyysi mobiilipuhemarkkinasta		
Päivämäärä:	28.9.2007	**Sivumäärä:**	9+97
Osasto:	Sähkö- ja tietoliikennetekniikan osasto		
Professuuri:	S-38 Tietoverkkotekniikka		
Työn valvoja:	Prof. Heikki Hämmäinen		
Työn ohjaaja:	Tekn.lis. Hannu Verkasalo		

Mobiiliverkkojen kehitys yhdessä Internetpalveluiden kasvavan kysynnän kanssa on johtamassa mobiiliteollisuuden sekä Internet-maailman yhtymiseen. Yksi eniten keskustelua herättäneistä Internet palveluista on VoIP, joka on jo nyt kehittynyt tärkeäksi kommunikaatiotavaksi. Myös mobiiliteollisuus on jo saanut kokea muutamia alustavia mobiili-VoIP toteutuksia. (Nokian puhelinten SIP applikaatio, Fring, Three:n ja Skypen yhteistyö). Lisäksi myös muiden mobiili-Internet palveluiden kehitys tulee vauhdittamaan mobiili VoIPin nousua. Mobiilioperaattorit ovat huomanneet mobiili-VoIPin tuoman uhkan ja pelkäävät sen tuomia vaikutuksia puhepalveluidensa tuottoon. Toisaalta, jotkin mobiilioperaattorit ja Internetin palveluntarjoajat saattavat nähdä tämän kehityksen mahdollisuutena konvergoitua myös palveluliiketoimintaan.

Tämä diplomityö käsittelee langattomien pakettikytkentäisten tietoverkkojen soveltuvuutta VoIP-tekniikan käyttöön. Myös puhemarkkinoiden markkinadynamiikkaa on tutkittu, jotta VoIP-markkinoiden muuttumisen syitä voitaisiin paremmin ymmärtää. Näiden teknisten ja kaupallisten tutkimusten pohjalta on suoritettu kvalitatiivinen *Viiden Voiman* analyysi, jonka avulla mobiilimarkkinaan vaikuttavia epävarmuuksia on pyritty identifioimaan. Näistä epävarmuuksista on nostettu esiin joukko tärkeitä muuttujia, jotka parhaiten kuvaavat mobiilimarkkinan muutosta. Lopuksi joitakin teollisuuden asiantuntijoita haastateltiin ja näiden haastatteluiden avulla määritettiin kaksi tärkeintä muuttujaa (markkinarakenne mobiiliviestinnässä sekä yhteystapa multiradio-verkoissa), jotka yhdessä muodostavat skenaarioita tulevaisuuden mobiilipuhe-markkinasta.

Tämän työn tuloksena esitellään neljä tulevaisuuden skenaariota, jotka määrittelevät tulevaisuuden puhemarkkinan. Työn lopullisena päätelmänä on, että mobiiliteollisuus on horisontalisoitumisen partaalla. Mobiili-VoIPlla on suora vaikutus mobiili-operaattoreiden puhepalveluiden tuottavuuteen, mikä erityisesti korostaa VoIPn vaikutusta markkinarakenteeseen. Lisäksi mobiili-VoIPn vaikutus yhdessä lukuisien muiden mobiilipalveluiden kanssa tulee olemaan vielä aiempaakin huomattavampi. Tässä kehityksessä vaihtoehtoiset langattomat tekniikat nähdään tärkeimpinä disruption lähteitä. Myös mobiiliverkkojen sääntelyn todetaan olevan kehitystä jäljessä ja täten jokainen muutos sääntelyssä tulee aiheuttamaan muutoksia kehittyvässä mobiili-VoIP markkinassa.

Avainsanat: mobiiliverkot, IP-puhepalvelu, liiketoiminta-analyysi

Preface

This Master's Thesis has been written as a partial fulfillment for the Master of Science degree in Helsinki University of Technology. The work has been conducted as a deliverable for the COIN project in Networking Laboratory at the Department of Electrical and Communications Engineering.

First of all, I would like to thank Professor Heikki Hämmäinen for the opportunity to write this thesis at the Networking Laboratory, and for his valuable guidance throughout the project. I am also grateful to Hannu Verkasalo for his assistance during the course of my work.

I wish also to show my gratitude to all the persons who have contributed to my work. My co-workers; Tuukka Autio, Mikko Heikkinen, Bronwyn Howell, Annukka Kiiski, Antero Kivi, Teemu Kärkkäinen, Timo Nordlund, Timo Smura and Mathias Tallberg. I also owe thanks to Maija Vanhatalo for her valuable comments.

I would also like to thank all the interviewees and COIN-project partners for their comments and information provided for this thesis.

Finally, I would like to thank my family and all my friends for the support and care given during my studies.

Espoo, September 2007

Kim Lindqvist

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Abbreviations

2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
AMC	Adaptive Modulation and Coding
CD	Compact Disk
CDMA	Code Division Multiple Access
CS	Circuit witched
EDGE	Enhanced Data Rates for Global Evolution
ETSI	European Telecommunications Standards Institute
FCA	Finnish Competition Authority
FCC	Federal Communications Commission
FICORA	Finnish Communications Regulative Authority
GAN	Generic Access Network
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HS	Handset
HSDPA	High Speed Downlink Packet Access
HSOPA	High Speed OFDM Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IM	Instant Messaging
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISP	Internet Service Provider
ITU-T	International Telecommunication Union – Standardization Sector
LAN	Local Area Network
LTE	Long Term Evolution
MAC	Medium Access Control

MAN	Metropolitan Area Network
MIMO	Multiple Input Multiple Output
MNO	Mobile Network Operator
MOS	Mean Opinion Score
MSN	Microsoft Network
MVNO	Mobile Virtual Network Operator
OFDM	Orthogonal Frequency Division Multiplexing
PC	Personal Computer
PDA	Personal Digital Assistant
PHY	Physical layer
PLC	Packet Loss Concealment
PLMN	Public Land Mobile Network
PS	Packet Switched
PSTN	Public Service Telephone Network
QoS	Quality of Service
RTP	Real-time Transport Protocol
SDP	Session Description Protocol
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SMS	Short Message Service
ToS	Type of Service
UA	User Agent
UMA	Unlicensed Mobile Access
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over Internet Protocol
WAN	Wide Area Network
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide interoperability of Microwave Access
WLAN	Wireless Local Area Network
WML	Wireless Markup Language
XMPP	Extensible Messaging and Presence Protocol

1 Introduction

1.1 Background

Mobile communications, mainly mobile voice subscriptions, have gained their share of the markets over fixed public service telephone network (PSTN) subscriptions during the last decade. This evolution has mainly gained its growth on GSM and CDMA based networks and has made the fixed PSTN to decrease in amount of traffic as well as the amount of subscriptions. In November 2006 there were significantly more Finnish households where the only telephone was a mobile phone than households with only a fixed line telephone. What is more, there are even more households where the only phone is a cellular phone instead of having both the cellular- and the fixed line telephones. [1]

Mobile communications industry is predicted to experience a structural change as new ways of communication, such as instant messaging applications and voice over IP services, are gaining ground on the field of mobile communications. New emerging applications and services have set the development of network technologies to uplift with demand for greater bandwidth. This directs the mobile handset manufacturers as well as the mobile operators to focus on packetized traffic and on IP based solutions to bring the existing Internet services also to mobile phones. Along with this evolution, also the mobile VoIP services are enabled to reach the customers and thus set the mobile operators under a threat of substitute service. However, it is yet impossible to say how the change in mobile industry is going to affect the mobile telephony as besides the evolution of wireless bearer technologies there is also rivalry among the operators and service providers and all of these have their contribution to the emerging industry structural change. In addition, regulation of mobile communications has also vast effect on the development of the markets, and thus the whole mobile industry.

[1] http://www.tilastokeskus.fi/til/tvie/2005/ accessed 22.7.2007

In a technical sense the existing 3G network can already be used to implement mobile VoIP as it enables the IP traffic and thus also mobile VoIP service. However, this approach supports an operator-driven concept in which the operator owns and controls the access network and thus is also the player who charges and controls the use. Currently all the 3G handsets establish voice calls through the circuit switched domain and leave the packet switched domain for data applications, even though the packet switched domain could be used for VoIP and in that way shift the call expenses to data expenses. The packet data access also supports software VoIP applications which operate completely separated from the actual subscription of the mobile phone and only piggyback the established packet switched connection.

Another approach, totally separated from the whole 3G consensus, is to implement VoIP as a more generic voice service or voice application. In this case the role of network operator and the actual subscription would be also totally separated as the network connection for mobile handset could be provided by one or several different operators. Furthermore, the user could use a handset to connect the VoIP service provider to enter the operators VoIP gateway or establish a connection straight to the other peer only by piggybacking IP connections through any kind of wireless network. In this model the convergence of data access networks play a significant role.

Mobile operators know the threat of mobile VoIP and are currently either fighting against the disruptive forces that challenge their vertical business models or are taking a chance with the new opportunity. For example, German mobile operator T-Mobile first banned[2] mobile internet telephony from its 3G data service for mobile phones but then launched cellular voice call service with unlimited calling over WLAN[3]. With this T-Mobile clearly indicates that the company wants to pioneer on offering mobile VoIP services but lets no other player to operate on its own network. Other approach is made by the operator Three[4] which has contracted with a number of different Internet service providers, including VoIP

[2] http://www.t-mobile.co.uk/services/uk/fairuse/?WT.mc_id=fairuse access 22.7.2007
[3] http://t-mobile.com/company/PressReleases_Article.aspx?assetName=Prs_Prs_20070627 access 22.7.2007
[4] http://www.three.co.uk/x-series/ access 22.7.2007

company Skype. Three has completely different approach on the markets by acting only as a service aggregator and a network provider for its customers.

1.2 Problem Definition

Current mobile voice service can be delivered through numerous wireless IP-based networks which all differ in terms of user access, wireless coverage, bandwidth, roaming ability and handset interoperability. More factors can be listed, these being only examples. However, the relevant matter for the thesis is to study how the evolution of mobile VoIP will affect the cost structure of current operators and how the new challenger technologies will disrupt the business of operators who own the current cellular networks.

Open access to Internet via mobile networks leaves room for a number of potentially disruptive applications and services that may substitute the operator-controlled communication services. This sets the mobile operators on a situation where they confront a question of whether to face the Internet evolution or to stick on the old vertical business model. Thus the research question of this thesis is:

- To evaluate what kind of strategic disruption the emerging VoIP solutions will bring to the current market of mobile industries and …
- What kind of actions the mobile operators and other service providers are able to do in order to manage on the structural change of the markets.

1.3 Objectives and Scope

Regardless of the visions around the operator-driven and internet-based solutions, the aim of this thesis is not to set boundaries in which the development is assumed to happen, but rather to enlighten the different possible variables that might affect the business cases around mobile VoIP. When the factors of the business development of mobile VoIP are defined, their actual impact can be analyzed and further predict the different possible future scenarios. Presumably the development in this field is not going to happen among one

winning solution but rather among few different players who all are providing their keen solution.

The study is conducted in order to give strategic insights for the mobile operators and other voice service providers that are providing mobile voice subscriptions or comparable mobile voice services. Scope is mainly targeted to the consumer customer segment, although the technical studies would allow both the business and consumer segments.

The objectives of this thesis are:

- To model qualitative scenarios in the evolution of mobile voice service in regard to emergence of mobile VoIP.
- To recognize the strategies mobile operators can drive to both utilize the new opportunities and protect themselves against the risk of lost revenues.

A mobile handset is a term used to describe devices that are comparable to mobile phones and PDAs. The core idea in defining a mobile device is to find a comparable handheld device for mobile phone which must be as usable as a mobile phone but also to give support to new emerging wireless access techniques. In addition, these devices should communicate through IP-based wireless networks when implementing VoIP service. However, IP-trunking is not considered to be in scope of this thesis due to lacking wireless IP-based connection. Furthermore, the wireless propagation may be carried through any current or feasible wireless IP based media. The difference between mobile and nomadic wireless device is vague and because of this all such devices that are able to establish wireless IP connections are considered to be in scope of this thesis.

Scope of this thesis is limited up to 7 years from now. To be more specific, the constructed scenarios are expected to meet the consumer markets between years 2008-2015. However, as this thesis is to deliver scenarios of the future mobile voice markets the outcome is not that bound to time. But, on the other hand, the outcome that is closer to the present day is also expected to be more exact than the outcome that may confront the prevalent industry structure in year 2015. Predicting is not on the scope of this thesis so any kind of timing of the scenarios is also avoided.

1.4 Methodology

Three main methodologies are applied in this thesis. These are;

- Literature survey
- Expert interviews
- Analysis based on theoretical frameworks

Literature survey is used to study the technical and economical aspects around mobile VoIP industry. Applied approach is chosen to be qualitative analysis and the material that is explored to constitute an understanding of the current state of mobile VoIP industry include academic publications, technical books, management books, press releases, white papers, and newspaper articles.

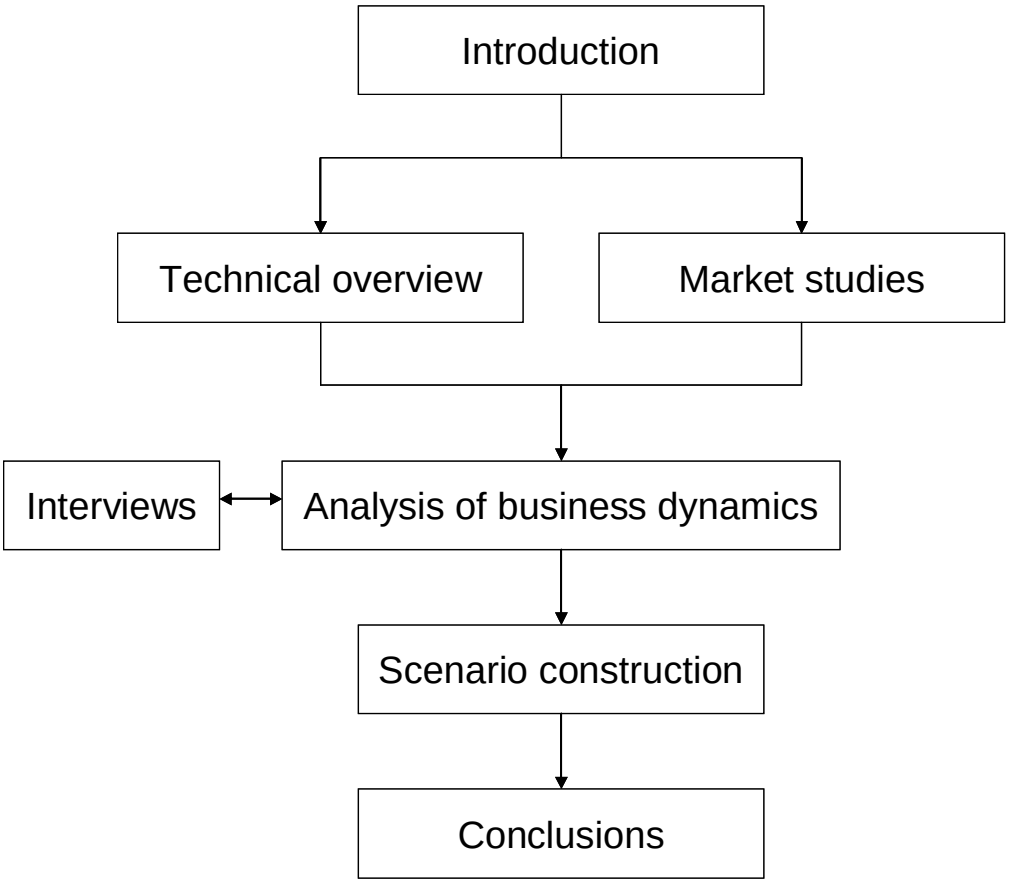
After constituting a solid base of knowledge on the mobile VoIP markets with the literature studies, few theoretical frameworks are applied together with the expert interviews. The adopted frameworks are mentioned along this thesis whenever they are applied. Interviews serve this thesis as a mean to broaden the insights that were previously derived from the literature survey. Interviews are also used to redirect the analysis part to meet the most important uncertainties that finally define the outcome of this thesis.

1.5 Structure

The structure of this thesis is depicted in the figure 1-1. After the introduction, this thesis continues with studies on the main technologies behind the mobile VoIP offerings. The main emphasize is laid on different wireless radio access technologies and also on VoIP protocols and their demand for network capacity.

Similarly as with the technical overview, market studies are conducted to better understand the market offerings and to distinguish the different players on the market. The previously introduced technical information is also partly used in this chapter as the different emerging mobile VoIP solutions partly determine the supply of different VoIP providers.

Figure 1-1 Structure of the work



After studying the technical perspectives of mobile VoIP (*chapter 2*.) and the market of mobile voice services and business models of wireless connection providers (*chapter 3*.) a level of abstraction needs to be created to draw strategic conclusions of the business on mobile voice services. An approach towards resolving the current business dynamics of mobile voice services is performed with scenario modeling (*chapter 4*.) and an analysis of achieved scenarios is further conducted to constitute a final set of strategies that is to serve as a final outcome of this thesis (*chapter 5*.). After the presentation of the final scenarios and their analysis, the final discussion and conclusions are presented on chapter 6.

2 Technical overview

To begin with, this chapter provides an overview of the wireless radio technologies that are the most relevant in mobile data connections and thus also in supporting the mobile VoIP. After getting familiar with the wireless access technologies, studies on different VoIP protocols are conducted to enlighten the current supply. Finally, after introducing the wireless carriers and the protocols behind VoIP services the adaptability of VoIP in the wireless networks and interoperability with the wireless bearers are examined.

2.1 Prevailing situation on wireless technologies

Mobility in IP-based voice transmission raises questions concerning the media in which the service can be carried out. Current operators can be roughly categorized into two different groups - *incumbent operators* being those who own the network infrastructure and *virtual operators* being those who might have some kind of network infrastructure but the main access network is outsourced from an incumbent operator. Thus the virtual operators are only providing the services and incumbent operators both the services and the network access.

Current cellular networks are based on circuit and packet switched technologies where the incumbent operators are the key players who own the infrastructure and thus are able to provide end-to-end services within their own network. A concept where the incumbent operator controls the network and thus decides which services are supported in the network is commonly referred with a name *Walled Garden*. This Walled Garden infrastructure is however crucial to VoIP operators and service providers who would desperately need the access to the handsets. By far the biggest Finnish incumbent operators haven't released any kind of solution for their consumer customers to use VoIP service in practice, despite the fact that some mobile phone manufacturers have already released UMA[5] compatible

[5] UMA refers to Unlicensed Mobile Access which is a seamless roaming technology providing roaming and handover between local area networks and Cellular network. UMA is also known as Generic Access Network which is the working name for the technology since 3GPP adopted it in 2005.

handsets[6] [7]. UMA with WLAN and 3G seems to be the strongest candidates for the incumbent operators to provide VoIP services in the short run.

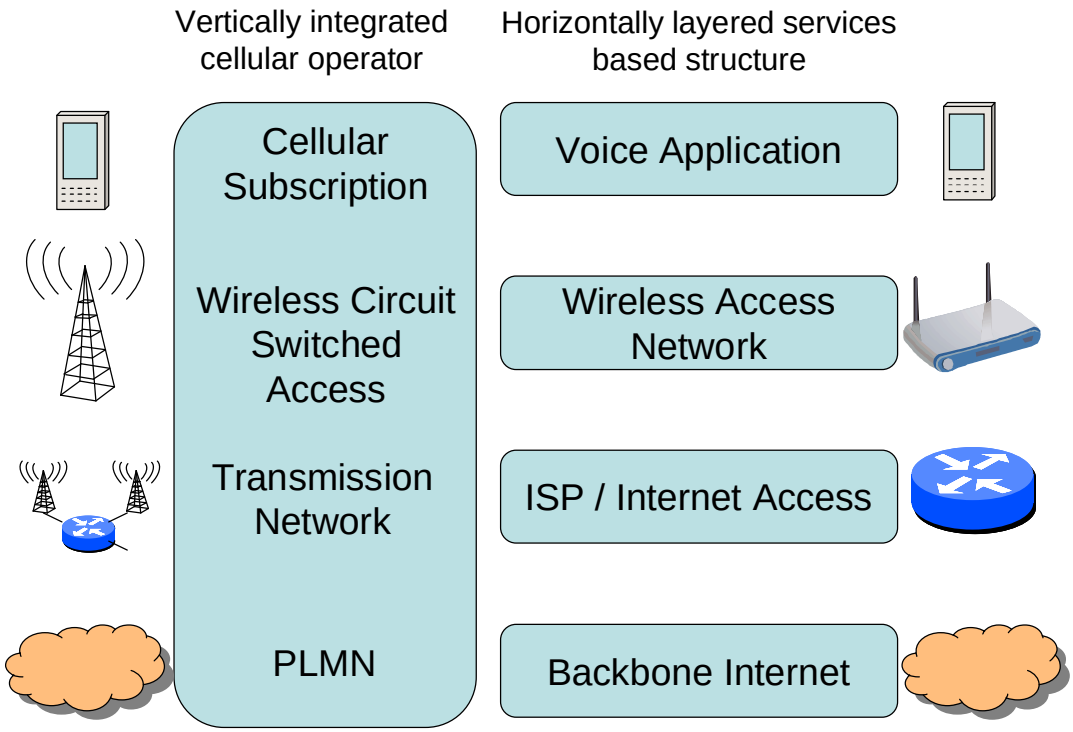
Some independent VoIP service providers[8] [9] have implemented VoIP services that are able to be accessed through any kind of broadband connection and thus are much further in giving boost to the mobile VoIP. The most relevant topic that rises around the mobility of these subscriptions is, nevertheless, the supporting wireless media that is deployed to seamlessly establish VoIP calls and enable network interoperability with active calls. In addition, even though IMS or UMA technology could enable seamless full feature VoIP roaming service, access to this network will anyhow stay within the network operators and VoIP service providers will be dependable of these network access providers. Furthermore it can be postulated that the evolution of roaming enabled full feature mobile VoIP is far limited by the incumbent operators and their willingness to shift towards open mobile broadband networks.

The potential of VoIP service providers is set along with the emergence of different wireless access networks. Prevailing situation in this field is far too immature in providing full feature wireless broadband access and thus it is unable to say which is going to be the dominant future technology. Nevertheless, guidelines to this evolution could be set between two abstract approaches; the first could be described as a vertically integrated development in 3G network in which the incumbent operators are able to provide full feature end to end voice service in addition with all the other kind of services. The other approach could be more layered structure where every network layer has its own service provider. Such a structure could be provided with WLAN or WiMAX technology or their interoperability with the 3G network. This type of approach is the most suitable for small virtual operators and for the proprietary solutions, especially if the access is not restricted by the access provider.

[6] http://www.samsung.com/PressCenter/PressRelease/PressRelease.asp?seq=20060718_0000273030 accessed 20.12.2007
[7] http://europe.nokia.com/6136/ accessed 20.12.2007
[8] http://www.ipon.fi accessed 25.8.2007
[9] http://www.vonage.com accessed 25.8.2007

On the figure 2-1 the two distinct approaches are introduced. On the left side of the figure 2-1 the incumbent operator administrates the whole network and thus is able to offer end-to-end service in its own network. This structure can be seen as a vertical integration over the network and the services and is close to the prevailing mobile networks. On the right side of the figure 2-1 the same structure is provided by a number of different operators all specified in their own service. This structure is more open towards rivalry and the barriers to enter the market are remarkably lower as each player can enter the market with only one end-service to offer.

Figure 2-1 Far end scenarios in mobile voice evolution



2.2 Bearer technologies for mobile VoIP

The second generation (2G) cellular GSM network is evidently becoming too narrowband in providing all the emerging services to mobile handsets. Due to this, the IP supportive mobile networks were introduced to tackle the problem. Wireless Application Protocol

(WAP) was introduced already in 2G phones but it needed special WML support from the web-pages that were intended to be viewed. Due to the lack of content supportive pages WAP became a niche solution and was supplanted by actual www content providing browsers in the handsets. This turning point can be seen as a starting point for developed packet switched communications. Since that, the evolution of cellular networks has evidently had a new bellwether from packet switched data capable technologies. Applications such as email, www and different data services on a mobile phone are growing the need for packet switched connections and thus mobile VoIP has become feasible service on mobile phones. What is more, there is progress in WLANs and other wireless broadband connections as well and this will undoubtedly narrow the gap between the mobile networks and the wireless broadband technologies.

Following chapters describe the relevant technologies concerning mobility and the current and future wireless carriers in mobile VoIP service.

2.2.1 Generic Packet Radio Service - GPRS and EDGE

Generic Packet Radio Service (GPRS) is the first true solution in offering email and www-content to the handsets. However, GPRS has become inadequate in providing enough bandwidth to all the emerging services among packet switched domain and thus Enhanced Datarate for Global Evolution, EDGE, has been introduced to improve the real-world data transfer speeds of GPRS. The main difference between GPRS and EDGE is in modulation and coding methods[10]. Compared to GPRS, EDGE gives the user at least a feel of the 3G user experience even though it cannot compete with the Wideband CDMA based true 3G solutions. Operators are, however, rolling out mobile broadband services under the name of 3G although the deployment of 3G, mainly WCDMA coverage, considers only a small fragment of the whole wireless coverage. In countries like Finland this is the only reasoned act as over half of the population lives on the biggest cities and the demography varies heavily between the urban and rural areas.

[10] http://www.3g-generation.com/gprs_and_edge.htm access 10.5.2007

GPRS provides user data rates up to 20kbps whereas with EDGE technology the corresponding figure is 59.2kbps [Halonen et al. 2002]. To compare this with the most common wideband codec G.711, which uses 64kbps coding, both the GPRS and EDGE become inadequate in providing mobile VoIP connections. However, if the voice coding is degraded to lower level, deploying e.g. G.729 coding which operates only with 8kbps, VoIP service would be feasible on these networks, although delay might become an issue. Main sources of delay on a GPRS network originate from packetization, buffering, propagation and queuing. Also processing delay in the handset and in the network equipment causes delay which is difficult to measure or even estimate. [Parantainen 1999] However, GPRS and EDGE are often found inadequate for mobile VoIP solutions when it comes to network delays. This is mostly due to the slowness of network infrastructure but also the processing power of handsets slows down the data-rate and causes delay on the overall throughput.

Even though GPRS and EDGE could be seen as past-time technologies and not suitable for mobile VoIP usage, they are yet quite relevant to this thesis as the prevailing coverage of those radio technologies is still dominating in many countries and the operators operating those networks also hold the customers' subscriptions.

2.2.2 3rd Generation mobile networks – 3G

Third Generation networks offer significant improvement to the mobile technologies with parallel voice and data access for customers - added with higher data rates on the urban areas. Current 3G / WCDMA networks allow transmission rates from 384/64kbps for mobile users [Kara et al. 2005]. However, the more efficient modulation schemes allow the 3G networks to reach higher throughputs. The lower throughput for mobile users is due to signal interference when the object is moving. Some 3G operators have however limited the maximum throughput to the lowest limit to ensure the capacity and sufficient channel bands for all users [UMTS Forum 2006]. What is more, the current 3G WCDMA band operates on 1.9-2.1MHz frequency but intentions to deploy the 900MHz band for the 3G WCDMA

use have been shown. This would help the operators to reach greater coverage with lower cost and thus speed up the spreading of the network.[11]

In 2006 there were over 50 operators in North America, Europe and Asia which were offering wireless access on mixed EDGE/WCDMA network. At the same time, over 30 European operators were providing complementary EDGE/WCDMA coverage in more than 20 countries. In total, more than 100 million WCDMA subscriptions had been exceeded worldwide in the end of 2006, and the population grows with over 3 million subscriptions every month. [UMTS Forum 2006]

The core Network of 3GPP is divided into two entities; circuit switched domain CS and packet switched domain PS. The Circuit Switched 3G core network is mainly built on the GSM core network having rather similar network entities with each other. The 3G packet switched domain in the core network is based on the GPRS network platform having the SGSN and GGSN nodes as operational elements in the network infrastructure. 3G core network is thus more similar with GPRS core network infrastructure [Chen et al. 2004].

VoIP applications are, of course, to be implemented on top of the packet switched domain, although the 3G already enables mobile voice calls on circuit switched domain. Thus it becomes relevant to evaluate the usability and the possible advantages of the mobile VoIP solution. Usefulness of this approach is far determined by the incumbent operators and by their decision on how stringent the classification of traffic and ToS contracts are to be. Also the pricing of packet switched data will have some contribution on the matter, as any ongoing call and even a location update will generate traffic on the link.

2.2.3 High Speed Packet Access - HSPA

High Speed Packet Access, HSPA, is a 3G mobile telephony protocol that currently consists of HSDPA and HSUPA standards. In short, the generic HSPA technology can be

[11] http://www.3g.co.uk/PR/Jan2006/2505.htm accessed 28.6.2007

seen as a similar upgrade to 3G (WCDMA) network than EDGE is for GPRS. To be more specific; HSDPA is a downlink protocol that specifies the downlink performance characteristics whereas HSUPA is an uplink protocol providing the specifications from the terminal to the network. HSPA refers to an implementation with both down- and uplink protocols.

Current HSDPA implementations are planned to give support for 1.8Mbit/s - 14.4 Mbit/s in downlink direction over a 5MHz bandwidth. The uplink speed with HSUPA standard is planned to reach 5.76Mbit/s.[12] What is more, with multiple input - multiple output (MIMO) technology the downlink speed can be extended to 20Mbps. [UMTS Forum 2006, Xiao et al 2005] VoIP traffic has, nevertheless, symmetric capacity demand and requires also high uplink performance from the network. What is more, also the handset must be capable of pushing the content upwards to the network with sufficient processing power.

One additional extension to HSPA technologies is AMC, Adaptive modulation and coding scheme which deploys dynamic link adaptation. In other words, it matches the modulation and coding to best fit the radio link conditions. [3GPP 2001] Utilization of a single connection can vary according to the connection parameters and thus it is possible to give the best available connection speed to the user terminal. Also Multiple-Input Multiple-Output technology is used in HSDPA to achieve higher downlink speeds. MIMO offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by utilizing several antennas on both sender and receiver and thus is able to benefit from higher spectral efficiency (more bits per second per Hertz of bandwidth). [Oestges et al. 2003, 3GPP 2001] MIMO also offers better link reliability and diversity and makes the use of the link more robust.

However, as the amount of HSDPA capable handsets is very scarce and only few models per mobile phone manufacturer have been introduced it is yet difficult to say how the HSPA evolution is going to take place on the markets. The most predictable scenario would be that the evolution follows the GPRS/EDGE/WCDMA path.

[12] http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=02XPgQ750882662622 accessed 2.5.2007

2.2.4 3G Long Term Evolution – 3G LTE

Future development project of HSPA is HSOPA - High Speed OFDM Packet Access which aims to provide 100Mbps downlink speeds based on OFDM modulation and 50Mbps uplink speeds based on single carrier frequency division multiple access modulation. This evolution path is better known under its working name 3G Long Term Evolution that is a path towards 4G networks but still deploying the 3G network infrastructure. With this evolutionary path the operators are able to utilize the existing network infrastructure longer. Also interoperability and handovers with the non-3GPP networks have been taken into account on 3G LTE network evolution path, which makes it an interesting future technology. However, as the evolution of the 3G LTE is yet on its early phase there is not much to say about the future prospects. Commercial launches have been estimated to take place in 2010 and 3G LTE is mainly competing against the mobile WiMAX on providing high-speed data access to users' mobile handsets.

2.2.5 Wireless local area network – WLAN

Wireless Local Area Networks (WLAN) are realizations of the IEEE 802.11x standards developed by the IEEE LAN/MAN Standards Committee 802. Common term to refer to all the standards in 802.11 standards' family is to use notation 802.11x. The 802.11x standards are designed to define the physical layer (PHY), Medium Access Control layer (MAC), network architectures and their interactions with the IP core network. More commonly known brand name for the 802.11x standards is Wi-Fi, Wireless Fidelity.

Public commercial WLANs have already been widely deployed to provide easy and cost-efficient access into the internet core services. WLAN hotspots[13] are emerging rapidly in city centers and similar public places. Today, WLAN access can be found for example from internet cafes, libraries, shopping malls, parks and public transportation stations. There are also WLAN concepts that are built to cover even larger areas, for example a city or certain district[14]. This eventually gives rise to the use of wireless access techniques and encourages

[13] Area of WLAN coverage.
[14] http://www.mastonet.fi , http://www.maxinetti.fi , http://www.fifi-wifi.fi/foo/ accessed 19.1.2007

to the use of mobile handsets also in public WLANs. Furthermore, the possible adoption of mobile VoIP services in these kinds of networks is merely a question of the cost of connection and compatibility of the handset.

The usefulness of the WLAN networks will be far determined by the possibility to establish seamless handover support and to perform roaming between different networks. Delays may also be generated into the WLAN connection as the user must associate with an access point every time a handoff takes place. Every handoff also demands an authorization procedure to grant the access which in turn causes delays in the handover procedure. When using Skype or MSN Messenger over WLAN connection with handovers taking place Lisha et Al. measured blank periods in voice conversation that lasted 3-7 seconds with Skype and respectively about 1 second when using the MSN Messenger. In both cases the caused delay was not crucial for the connection itself although some packets were lost during the blank period and conversation became discontinuous. Packet loss occurred as lost words or phrases during the conversation. [Lisha et Al. 2006] Even though these results apply only for these certain applications they still illustrate the problem with WLAN handovers. If the handover is performed between two different networking technologies the delay is expected to be even longer and thus degrade the quality of service. What is more, the situation between the handover is also crucial for VoIP as the signal to noise ratio (SNR) is lowering before the handover and eventually the call might be dropped before the handover takes place. [Arjona et Al. 2007]

2.2.6 Mobile WiMAX

Worldwide Interoperability for Microwave Access (WiMAX) is a Standards based wireless technology that provides high-throughput IP-based broadband connections over long distances. Similarly as with the IEEE 802.11 Wi-Fi standard, WiMAX is based on IEEE 802.16 standard. However, there is a difference between the spectrum allocations of WiMAX and WLAN as WiMAX uses licensed frequencies and thus the allowance to deploy a WiMAX technology must be granted from the regulator. Currently the WiMAX

product family consists of two main standards that are deployed in commercial networks. The first being the so called fixed WiMAX intended to be used as a last mile broadband connection to compete with fixed broadband. This standard is better known as IEEE 802.16-2004. The second WiMAX solution is called mobile WiMAX and is planned for mobile use, the IEEE standard for this is known as IEEE 802.16-2005e. Focus of this thesis meets only the mobile WiMAX deployments

WiMAX Forum is an industry-led organization, formed in 2001 to promote conformance and interoperability of the IEEE 802.16 standard. WiMAX Forum has its interest especially on the design of the WiMAX network, main emphasis being on the compatibility and interoperability of the end-to-end services. Even though the organization itself declares to be non-profit seeking, its main emphasis is to accelerate the introduction of WiMAX systems which on its behalf will leverage the companies providing WiMAX solutions. IEEE's role in developing WiMAX differ a bit as it concentrates more on the development of the radio interfaces[15].

Fixed WiMAX applications are expected to be able to obtain average capacity of 10/5Mbps up to a range of ten kilometers. Whereas mobile WiMAX network deployments fall a bit behind but are still able to receive 6/3Mbps connections in a range of up to three kilometers. [WimaxForum 2006] However, single VoIP applications are not considered as bandwidth consuming so the question of finding a suitable range with suitable bandwidth is most likely determined according to the commercial usefulness of both; the coverage range and the bandwidth[16]. One should also keep in mind that VoIP is not the only application that WiMAX is designed for, so the final bandwidth allocations and coverage ranges remain unrevealed. Some assumptions about the specifications of mobile WiMAX network were gathered from the WiMAX Forum's homepage[17] they are presented on the table 2-1.

[15] http://www.wimaxforum.org/about/ accessed 20.2.2007
[16] Besides bandwidth also delays and jitter affect the usefulness of WiMAX
[17] http.//www.wimaxforum.org accessed 15.7.2007

2.2.7 Flash OFDM @450

Last of the alternative wireless networks is smaller concept than any of the previously introduced wireless bearers. The flash OFDM, Fast Low-latency Access with Seamless Handoff Orthogonal Frequency Division Multiplexing, is a wireless wide area networking technology developed by Qualcomm Flarion Technologies. In Finland the regulator assigned the license for the 450MHz band with the right to deploy flash OFDM technology exclusively for Digita[18]. The contract however hold an article in which Digita itself is forbidden to offer any network services and to only act as a network provider for other end service providers.

Flash OFDM is mostly competing against fixed broadband technologies but due to its wireless connectivity it becomes relevant to study in the scope of this thesis. Handset support of flash OFDM is though another important question that also must meet the scope of this thesis as this technology is mainly intended for laptop use. However, at least one VoIP capable handset has been introduced for this band[19].

Up till now quite a little is publicly known of the flash OFDM 450 technology; however some technical information could be obtained from Qualcomm's homepages[20]. The most relevant of these are presented on the table 2-1 on the next chapter.

[18] http://www.450laajakaista.fi/ accessed 24.8.2007
[19] http://www.exoteq.com/ accessed 24.8.2007
[20] http://www.qualcomm.com/technology/flash-ofdm/index.html accessed 24.8.2007

2.2.8 Summary of wireless technologies

The technical specifications of the previously introduced wireless technologies are presented here in this chapter. The parameters on the table below are gathered from the previous analysis of wireless carriers.

Table 2-1 Summary of technical specifications of the wireless carriers

	WCDMA	HSPA	3G LTE	WLAN	Mobile WiMAX	Flash OFDM
Licenced freq	Yes	Yes	Yes	No	Yes	Yes
Spectrum	1.9-2.1 GHz	1.9-2.1 GHz	1.9–2.1 GHz	2.4 / 5 GHz	2.3–3.8 GHz	453 – 457 MHz 463 – 467 MHz
Status	Commercially available	Commercially Available	Estimated 2010	Commercially available	Estimated 2010	Commercially Available
Mobility	Mobile	Mobile	Mobile	Nomadic	Regional mobility	Regional mobility
Coverage	WAN	WAN	WAN	Indoors	MAN	WAN/MAN
Avg.Datarate	384 kbps / 128 kbps	2 / 1 Mbps	10 / 5 Mbps	~25 Mbps	6 / 3 Mbps	1 Mbps / 300 kbps
Est. RTT	250ms	100ms	20ms	low	low	30ms
Standard	3GPP	3GPP	3GPP	IEEE802.11	IEEE802.16e	Proprietary (Qualcomm)
Channel width	FDD 2 x 5MHz	FDD 2 x 5MHz	1.25-20 MHz	80 MHz	3.5 - 10 MHz	TDD 1.25 MHz
Available spectrum per operator	30MHz	30MHz	?	80 MHz	?	2 x 3.225 MHz

As this table indicates, the main evolutionary paths on wireless technologies are strongly following the guidelines set by either the 3rd Generation Partnership Project - 3GPP, or the frameworks published by the Institute of Electrical and Electronics Engineers - IEEE. However, also the flash OFDM based wireless technology is causing disruption on the mobile broadband market.

2.3 Signaling Protocols for mobile VoIP

In order to create a telephone call between two endpoints the underlying network needs a signaling protocol to be able to control the information to travel cohesively and to create synchronous connections between the participants.

2.3.1 Relevant signaling protocols for mobile VoIP

Internet Engineering Task Force (IETF) created the Session Initiation Protocol (SIP) for the signaling purpose. "It is an application-layer control (signaling) protocol for creating, modifying and terminating sessions with one or more participants. These sessions include Internet telephone calls, multimedia distribution and multimedia conferences" [Schulzrinne et al. 1999]. SIP has been widely adopted to be the main protocol in VoIP implementations over its corresponding competitor H.323. Furthermore SIP has been accepted to be the 3GPP/3GPP2 signaling protocol and it is also the core element in IMS infrastructure. Thus SIP can be seen more mobility specified and is more concentrated in this thesis instead of H.323.

Other signaling protocol that is used in VoIP communications is Extensible Messaging and Precense Protocol, XMPP. The core functionalities of XMPP are designed by the Jabber open source community in 1999 and the work was formalized by the IETF during 2002-2004. IETF has also released a set of RFCs to describe the functionalities of XMPP (RFC 3920-3923). Jabber is primarily designed to be an instant messaging protocol that gives support to presence service and to give support to extensions that can implement e.g. VoIP functionality on it. The functionality of Jabber/XMPP protocol is now extended through the standards process of XMPP standards foundation.[21] One of the most known applications using Jabber/XMPP protocol is probably GoogleTalk, which gives support for instant messaging, presence and VoIP. However, even Google has announced to give support also for SIP protocol which helps the future interconnection of different VoIP clients. [22]

[21] http://www.xmpp.org/xsf/ accessed 21.5.2007
[22] http://code.google.com/apis/talk/open_communications.html accessed 22.5.2007

Mobile IP would be also a keen solution to provide mobile connections in wireless networks but it is more of a generic network layer solution and therefore not yet the most suitable to be evaluated in the context of mobile VoIP. The architecture of mobile IP requires support from the home network as well as from the foreign network. The current problem with it lays in the fact that not all the foreign networks are mobile IP supportive and that restricts the use of it. When compared to SIP, mobile IP is rather complex structure to construct. Especially as the main elements of SIP-VoIP infrastructure stay within the operator and no additional modifications to user end networks need to be implemented. What is more, even mobile IP would be feasible in its entirety; it would still need help from some kind of signaling protocol. Therefore it is not necessary to evaluate the use of mobile IP in this thesis.

2.3.2 SIP protocol usage in VoIP applications

SIP protocol is designed by the IETF and is intended to be only a signaling protocol; the main task is only to set up and manage sessions between endpoints.[23] SIP uses the help of other supporting protocols such as Session Description protocol (SDP) for defining parameters for the session it is setting up. These parameters are, for example, the codec for audio or video stream. After the negotiations are carried out the actual data streaming and content sharing are provided by other protocols, typically Real-Time Transfer Protocol which handles the streaming of data. The four main components in the SIP architecture are:

SIP User Agent:

IP phone, PDA or similar internet endpoint device is a user agent UA. User agent can work either as a client or server depending whether it initiates requests or generates responses to queries.

[23] Use of SIP has spread vastly and currently many applications have their own modifications of the protocol.

SIP Proxy Server:

Proxy server takes control over the user agents and routes the SIP signaling between the source UA and destination UA. It handles the traffic between the endpoints of a conversation or may just help in setting up a connection.

SIP registrar:

Registrar server is the one that keeps track of the User Agents' locations. A client sends a register request to registrar server and informs its current location, registrar then maps SIP usernames to IP addresses. Registration and location update usually go hand in hand but the services could also be implemented as a separate components.

SIP redirect server:

Redirect is a location service to be used when User Agent has moved to other network or due to load balancing between several SIP servers. After the response the redirect server steps out of the messaging loop and the control is given back to the user agent. Redirect service is the least important of the four main components as the core of VoIP service can be run also without it.

From these components only user agent client is the one that operates as a mobile terminal. The other three are located in the operator's premises. What is more, all the server side implications can be united under one operational server that acts as a proxy server but takes also care of the registrations and possible redirects. As a result the architecture becomes even more simplified.

2.4 VoIP traffic's adaptability on wireless bands

VoIP traffic consists of a signaling protocol and of supportive protocols to describe the session parameters in addition to the actual payload. These parameters define also the voice codec[24] to be used on the conversation. Codec is a program (or device) whose function is to perform the encoding and decoding of digital data or signal. Encoded data is compressed

[24] Codec is an abbreviation derived from words coder/decoder

for the transportation and decompressed afterwards on the receiver. The actual voice-payload contains the compressed data and some additional information, such as timestamp, sequence number and synchronization identifier. Voice payload is mostly carried on Real-time Transport Protocol. For voice encoding there is a great number of different audio codecs to serve different encoding purposes and to fit the wide variety of broadband connections. The most narrowband audio codecs compress a normal human speech into less than ~10 kbps packet stream. In terms of channel bandwidth this packet stream would fit perfectly in almost any of the current wireless bands. However, there are also more issues besides the bandwidth that cripples the use of VoIP in certain bands.

The significance of compression can be notified when e.g. comparing the 10kbps audio stream with normal CD quality playback which is around 700kbps[25]. Human speech is, however, less informative in terms of frequency content and due to this the essential frequency scale can be limited between 300Hz – 3400Hz, whereas the CD playback is normally limited between 0-20kHz. In addition to narrowband audio codecs, there are also wideband audio codecs that consume more bandwidth than the narrowband codecs but respectively provide better audio quality.

2.4.1 VoIP Quality and Mean Opinion Score

Quality of a VoIP call can be defined either by measuring the quality of the connection or by measuring the quality of subjective user experience. The connection parameters are relatively easy to measure but the effect of data loss might not always correlate with the measured user experience as some codecs suffer more severe from packet loss or delays on the link. One special method for evaluating the user experience of speech quality is called Mean Opinion Score (MOS). Mean Opinion score is defined by the ITU-T organization and is tailored to be a tool for averaging the subjective user experience into commonly referred scale. When conducting speech quality measurements the MOS values can be used to rate

[25] 1,4Mbps in uncompressed stereo format. However, telephone speech is recorded as single channel (mono) format and thus it cannot be directly compared to dual-channel (stereo) format.

the estimated user experienced quality of speech into a scale of one(poor) to five(best) [ITU-T 1996].

2.4.2 Consequences of packet loss

Previously introduced wireless broadband carriers are all able to establish a connection with sufficient bandwidth. The most crucial factor in voice conversation is, however, packet loss as the lost packets can not be retrieved from the sender when needed. Any lost packet will cause silence on the receiver and thus make the conversation discontinuous. Some voice codecs are however able to fill in the missing payload by using the information gathered from previously received packets. This technique is called Packet Loss Concealment (PLC). A typical RTP packet contains 20ms of voice payload which can be somewhat recalculated in case of a single lost packet. Packet loss in wireless bands is however always quite bursty due to random signal interference [Bhagwat et al. 1996]. Even though a policy-based single packet dropping is also possible on the wireless links, the most crucial factor is the signal interference which might cause complete frames of packets to disappear. PLC algorithms can be used to improve the quality of speech but they usually help only with the single lost packets. In general, any packet loss in VoIP networks lead to worse result in MOS score. Even though the effect of packet loss can be fixed to some extent, the loss rate still shouldn't exceed 3% of total loss [James et al. 2004].

2.4.3 Effects of packet delay and delay variation

Packets also experience delay instead of being completely lost. Delay itself is not a crucial factor for conversation though it may be irritating for the persons participating on the conversation. Delay does not degrade the quality of the sound but it has an indirect effect on the conversation as it makes the information too old to play and thus the effect is the same as if the information is lost. In general, tolerable one-way end-to-end delay for VoIP

service is considered to be around 150ms[26] [27]. Thus the 2G solutions and even early 3G implementations become insufficient for robust VoIP use.

The delay originates from the packet queues in the routers (buffers) as routers tend to drop packets when congestion occurs, and as there is more delay there is also higher probability for a packet to be dropped. However, some other sources claim that delay up to 400ms is considered acceptable when using satellite systems, the schedulers, queuing algorithms and buffers must be adjusted to handle traffic with this special character[28]. However, these solutions are anyhow affecting directly the MOS score and thus lower the user experience on to a level that might not correspond to the quality that the user has accustomed with the circuit switched cellular subscriptions.

Delay variation is another issue that is topical to bring up when evaluating the quality of voice. The variation of delay (aka. jitter) happens mostly due to the simultaneous network traffic as besides the VoIP traffic there is also other background traffic on the common trunk networks. Even though VoIP traffic is quite predictable and does not generate bursts it must still share the resources with other traffic. Thus it becomes evident that the amount of traffic in a network is not constant but rather bursty by its nature. Solution to packet delays would be to introduce quality of service (QoS) algorithms on the networks. However, the problem with QoS implementations lies in its scalability and complexity as the users are expected to roam in different networks utilizing different interfaces and even different radio-technologies. Thus the question of unified QoS agreements becomes too complicated to be put in to practice.

All in all, any nonconforming traffic that travels on a link causes delays or jitter on the link, which by its nature is decreasing the throughput of the network and thus it has a direct effect on the grade of the audio quality. To solve this problem, a buffer of size much greater than one speech sample interval or a priority queue is needed at the receiver to remove the deteriorate effects of delay and jitter. [Zheng et al. 2001]

[26] http://www.netlab.tkk.fi/opetus/s383115/2006/kalvot/lecture3.pdf p.15 accessed 13.2.2007
[27] http://www.ciscopress.com/articles/article.asp?p=606583&rl=1 accessed 13.2.2007
[28] http://www.packetizer.com/voip/papers/understanding_voip/how_voip_works.html accessed 23.2.2007

2.5 Summary on mobile VoIP bearer technologies

Any of the previous access techniques represented in chapter 2.2 should not be considered as a standalone model but rather to consider them as complementary solutions for each other. Problem with the supportive wireless access techniques lays within the lack of ubiquitous mobile IP-based network access and in the interoperability of the existing bearer technologies. Even though VoIP can be run on top of the packet switched domain of 3G networks, it will remain in control of the mobile operator who owns the 3G network. GAN solution will bring some discussion on the matter but yet it will also hold the access partly in incumbent operator's network.

On the other hand, if VoIP is to be delivered through WLAN hotspots there is always the problem of limited coverage. VoIP with nomadic operability doesn't serve the idea of mobile telephony if the users cannot be sure whether their phone is on the coverage area or not. What is more, the problem in roaming between WLAN networks has not yet been completely solved. Roaming inside one domain is quite easy as the same IP address can be obtained inside the network but when hopping between different domains comes into play, a problem with IP reconfiguration arises. This problem could be solved with different solutions; nonetheless it is presumable that such inventions need further qualifying and accepting from different standardization organizations such as 3GPP and/or IEEE, etc. In addition, it is worth noting that even though such a protocol would be standardized the adoption of it is presumable to take a long time, during which alternative radio technologies are expected to tackle WLAN connections.

Conclusion for this chapter is that current 3G and HSDPA networks are still quite immature in providing sufficient service to implement a mobile VoIP service in terms of network delay and jitter. WLAN networks would be able to deal with the performance issues but lack sufficient coverage and thus the VoIP services on top of it can be called only nomadic. However, the future prospects are good as many techniques are evolving and as the amount of packet switched traffic is gaining ground on every network. What is more, there is no network where a packet switched connection would not have been implemented in some

extent and thus it is likely that the necessity of circuit switched connections need to be discussed, if not fully replaced by the packet switched connections.

3 Market of mobile VoIP

The aim of this chapter is to provide an overview of the companies currently providing VoIP services in Finland and worldwide. Fixed VoIP is left on secondary importance as it does not serve the focus of this thesis. However, as the amount of currently available fully mobile VoIP services are almost non-existing also nomadic VoIP is discussed in this chapter.

There are numerous different communication implementations where the term Voice over IP can be used. However, the term VoIP itself does not refer to any standardized protocol or practice but is more like a complementary service which has been defined by a number of different standards. Some proprietary programs for internet telephony and peer to peer clients have also been identified as VoIP clients and thus they have broadened the concept of VoIP. With VoIP client we refer to voice delivering interface comparable to cellular or PSTN subscription. VoIP client can be physical or software solution and its operational function is to connect a user with another user whose interface is either similar VoIP client or any other known telephone system. In short, VoIP client is referred to an interface comparable to mobile or fixed line subscription.

3.1 Proprietary VoIP solutions

Proprietary VoIP solutions are mainly proprietary software based VoIP clients. Term proprietary in this context denotes that the software is neither modifiable nor able to be studied in any way[29]. Users are, however, encouraged to share the software and in that way help to build a community of registered users. These users main advantage is to have a group of buddies[30] who all can be called freely with the proprietary software. Friends outside the community are either inaccessible with the proprietary solution or the calls are routed to other networks but some fees might be charged from the caller.

[29] GoogleTalk differs from the other competing solutions as it deploys open source Jabber/XMPP protocol
[30] Contacts using a proprietary software are common called buddies, and a list of buddies is often referred as a buddy list.

Four different proprietary VoIP solutions were studied in order to constitute an understanding of the current supply.

3.1.1 Skype

One of the fastest growing proprietary VoIP solutions is probably Skype, which announced in April 2006 to have exceeded 196 million registered users[31]. Even though these users are all mainly using Skype software on a wired platform, there are still a small percentage of users who also use Skype on a wireless platform. According to Skype, 5 million users have already downloaded Skype Pocket PC software[32] which can be run on PDAs, smart phones and pocket PCs. Skype's own software client is targeted to smart phones which operate on Microsoft's Windows Mobile operating system. Skype has not yet announced any software client which could be used on Symbian-based mobile phones even though there has been a wide discussion about the release date. The first promise about the release was targeted to take place on 2005[33] by Skype co-founder Niklas Zennström but the launch has been postponed often since that [Alkio 2006]. Interestingly there still has been an alliance with operator Three[34] to enable Skype calls on Symbian-phones. As this is not feasible service with all phones or networks it is assumable that both partners have modified their networks and services to enable the Skype service.

The reason for lack of operator-independent Skype-Symbian client might be immaturity of the current technology and unwillingness to release a client that is not fully operable with different operators' networks. Other reason might be that Skype has contracted with operators or phone manufacturers to postpone the release of the Skype-Symbian client. One reason for this might be that the current Symbian-phones are operating on cellular networks and thus the connection is mostly rated on per byte basis. Skype calls have been marketed to be free between any two Skype users. However, per-byte pricing might cause unwanted costs for the data transfer of the calls. Because of this a Skype-client suits better to the

[31] http://www.skypejournal.com/blog/2007/05/skype_developers_conference_20.html accessed 8.2.2007
[32] http://share.skype.com/sites/mobile/2006/11/5_million_downloads_and_counti.html accessed 8.2.2007
[33] http://www.tietokone.fi/uutta/uutinen.asp?news_id=23686&tyyppi=1 accessed 10.2.2007
[34] http://www.three.co.uk/xseries accessed 11.7.2007

WLAN capable mobile handsets and it might even be possible that Skype is waiting for the WLAN capable phones to become common among users. This is also seen with Nokia N800 Internet tablet which was given the Skype compatibility on July 2007[35].

Interestingly there is a software client called Fring[36], which is a proprietary software solution for Symbian-based phones which allow the user to use Skype-protocol even though the operating program is not actually Skype's own software client. The operability of Fring-client can be considered different from Skype's software as Fring has a separate VoIP gateway to forward point-to-point connection between two peers. The connection from gateway to a mobile phone is connected either through WLAN or through mobile packet data connection.

3.1.2 GoogleTalk

GoogleTalk utilizes an open protocol called XMPP, introduced already on chapter 2.4. Thus GoogleTalk is not actually a proprietary solution but rather standardized and open protocols based application with refined user interface. XMPP allows users of other XMPP clients to communicate with GoogleTalk users with the help of proxy servers that connect the users. VoIP in Google Talk is based on the Jingle protocol which is also open source software. The technology that is used within the server network of GoogleTalk is not though publicly known.

According to Google the main driver behind GoogleTalk is to provide interconnection between the systems and to make the communication services interoperable. However, currently neither Google nor any other VoIP service provider has unified their services to be interoperable directly with any other service provider. Reason for this lays simply in closed protocols that most proprietary clients are deploying.

[35] http://share.skype.com/sites/skypegear/2007/01/the_nokia_n800_skypeenabled_so.html accessed 23.7.2007
[36] http://www.fring.com accessed 15.2.2007

GoogleTalk comes pre-installed with Nokia's internet tablets N770[37] and N800[38], and with the BlackBerry handsets[39] and can be used as both a chat client and as a VoIP client. In addition, as GoogleTalk is based on open source software (Jingle protocol) it is also implemented in some other VoIP clients, such as previously mentioned Fring software client for Symbian S60 phones.

3.1.3 Microsoft Messenger

Microsoft Messenger is one of the most widespread instant messaging (IM) service having over 240 million active accounts in over 60 countries[40]. Microsoft however markets its messenger service to be used with two distinct interfaces called Microsoft Messenger and Microsoft Live Messenger. From these two the former becomes preinstalled on Microsoft XP operating system and the current edition also gives support to VoIP connections. The latter, Microsoft Live Messenger, is downloadable from Microsoft's homepage and it provides few supplementary features in addition to the ones introduced in Microsoft Messenger.

Microsoft has also implemented a special mobile service for the IM service users. However, this service is something totally different from what Google or Skype have done as even the IM chat client is based either on SMS messages or a web portal that doesn't give support to voice client of any kind. Thus Microsoft's own interest towards mobile VoIP can be seen really low. However, as the MSN protocol supports also VoIP connections and the previously introduced Fring software client also enables Microsoft messenger VoIP service with Symbian S60 phones, the MSN messenger can be seen among the future prospective mobile VoIP platforms.

[37] http://europe.nokia.com/A4144788 accessed 3.5.2007
[38] http://www.nokia.fi/A4359039 accessed 3.5.2007
[39] http://www.rim.com/news/press/2006/pr-12_01_2006-01.shtml accessed 3.5.2007
[40] http://www.microsoft.com/presspass/newsroom/msn/factsheet/WLMessengerFS.mspx access 16.5.2007

3.1.4 Yahoo!

Yahoo! Incorporated is a global Internet services based company whose main product is an Internet portal that provides a full range of products and services for the internet users. Yahoo claims to have world's largest customer base in email accounts and being the second on the internet search engine market, just after Google[41]. Thus the company can be seen as one of the most important proprietary software providing Internet companies in the world.

Company's Internet communication services are based on Yahoo! Messenger and Yahoo! Mail, of which the first is comparable to the previously introduced Skype, Microsoft and GoogleTalk messengers. Yahoo! Messenger is estimated to have approximately 78 million users[42]. However, Yahoo! Messenger's VoIP functionality is designed to work only between PC-to-PC connections and there is no current implementation of the voice client for e.g. Symbian-, BlackBerry or Windows Mobile based devices.

In addition, Yahoo! has a special concept for mobile users called Yahoo! Mobile[43]. However, the main services in this concept are email, instant messaging (excluding VoIP), and mobile blogging, mobile search engines and games. Thus, as Yahoo hasn't published any mobile messenger with VoIP capabilities or mobile VoIP client so far, Yahoo! Messenger does not fit to the scope of this thesis with its current implementations.

3.2 Open standards based VoIP

Open standards based VoIP is mainly a voice service that has a similar purpose of use with the traditional PSTN. The most distinctive solutions in this category are based on open signaling standards like SIP, XMPP and H.323 protocols. A call in this system is routed through an IP-based internet connection to a proxy-server which is also connected to the

[41] http://searchenginewatch.com/showPage.html?page=2156431 access 7.5.2007
[42] http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aurR77WLj6E4 access 8.5.2007
[43] http://mobile.yahoo.com access 7.5.2007

PSTN and/or to the PLMN. The voice traffic itself is like any other internet-traffic having its own specified protocols for the signaling and for carrying the voice-payload.

The most common open standards based VoIP provider is an ISP which adds value to its service by implementing also VoIP services into the service-mix. This is also called provider-branded VoIP and according to Sandvine Incorporated the service provider-branded VoIP already represents 51.2% of all VoIP minutes in Europe, while Skype follows closely behind with 45% of all VoIP minutes [Sandvine 2006]. There are also companies that have specified only in providing VoIP access on the internet. Main service of these companies is thus only the VoIP subscription. User equipment, software and piggybacked IP connection can be from any other provider. The following chapters introduce some of the open standards based operators relevant to this thesis.

3.2.1 Ipon Communications & Suomen Puhelin

The first virtual VoIP operator that was launched in Finland is Ipon Communications that started to operate in autumn 2003. Ipon Communications was however closely followed by Suomen puhelin, formerly Suomen Puhelinyhtiö. Both of these companies have targeted their service to both the consumer customers and corporate customers. All the Finnish VoIP-operators are, however, operating on the PSTN domain due to regulative issues and thus their general interest to bring the VoIP services also to mobile are assumable lower than concentrating on their core business on fixed lines. The main reason for this is most likely the lack of ubiquitous wireless packet based radio access that has made these companies to concentrate on the fixed domain services. Other issues rise with the high interconnection prices between PSTN and PLMN that prevents the customer adoption of VoIP subscriptions.

Interestingly Suomen Puhelin has started to collaborate closely with SparkNet wireless LAN service provider to offer VoIP in WLAN networks. SparkNet is an open WLAN network community that consists of consumer and corporate users that share their networks in order to benefit from the open connections of the other participants.

3.2.2 Vonage

One of the best known virtual VoIP operators in the world is probably Vonage which has over 2 million subscriber lines[44]. Vonage's customer base concentrates mostly on U.S, UK and Canada although their service is accessible all around the world. Reason why Vonage is pointed out in this thesis is that it is one of the pioneering companies in the VoIP branch, and as it is most likely the best known company that has taken the role of an operator even though the product is more of a telephone service and doesn't actually differ greatly from Skype or any other proprietary VoIP solution.

Besides subscriptions in U.S, UK and Canada Vonage also offers landlines in European countries which can be deployed by the foreign companies in order to decrease the interconnection prices of international calls. This implies that Vonage has also noticed the market opportunities to cut international roaming expenses with VoIP traffic. By doing so Vonage shows its interest towards European communications and can be considered as a potential VoIP service provider also in Europe.

3.3 Mobile operators' view of VoIP

Apart from the previously introduced VoIP approaches are the mobile operators who are already making business with widespread mobile voice service. For them the mobile VoIP can be seen as a threat or as an opportunity as it enables new kind of services but also poses new opportunities to all the rival companies that were previously incapable to establish connections to the handsets. Mobile operators are, however, dependable of the content providers and their value-adding services as those are attracting users to adopt new types of communication services more rapidly. By opening the Walled Gardens to other services operators also pose a risk for their voice service as any substitute voice communication application might utilize the IP-connection and steal a share of the total voice minutes of the cellular subscription. To make mobile VoIP attractive also for mobile operators the approach towards it must be performed in a manner that does not disrupt the current

[44] http://www.vonage.com accessed 12.12.2006

business strategy and follows the future guidelines of technological evolution. The strongest candidates for VoIP on packet networks are probably Generic Access Network (GAN) and IP multimedia subsystem (IMS) solutions as with these technologies the control of the subscription remains with the mobile operator. For the end user GAN and IMS provide only a shallow difference in the type of service as the control of the subscription will anyhow stay within the mobile operator. GAN and IMS are studied closer on the following chapters.

3.3.1 GAN – Generic Access Network

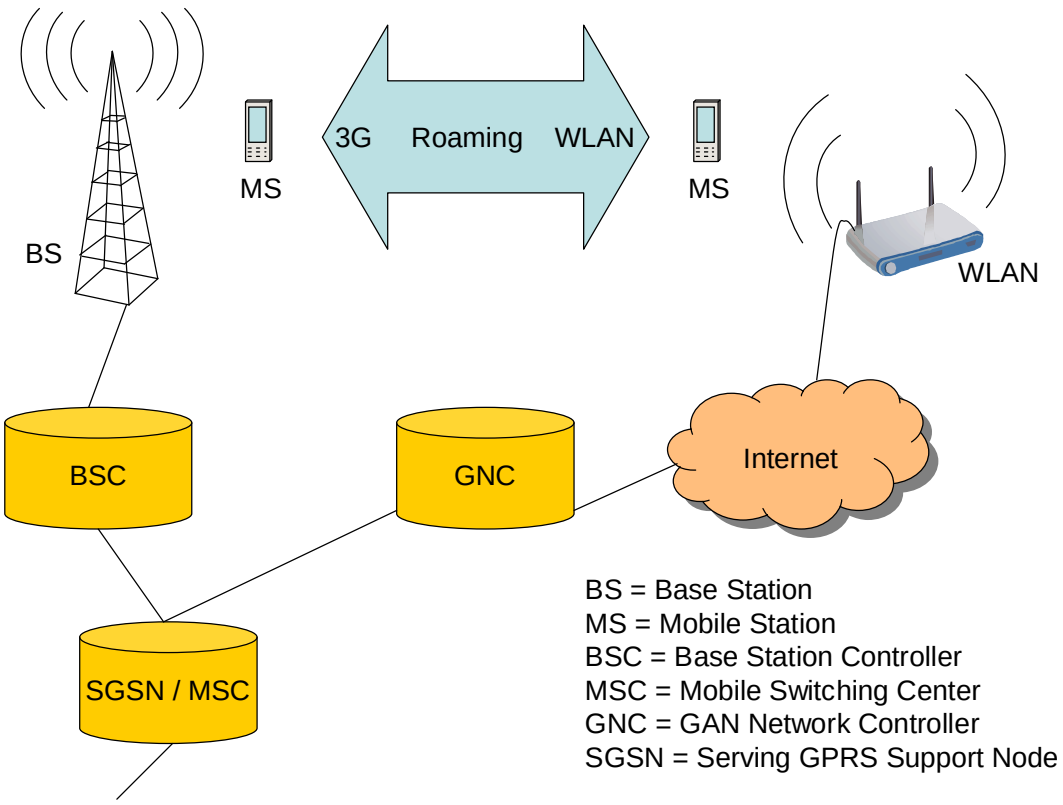
Generic Access Network - GAN is not that well known outside the 3GPP community, and the Unlicensed Mobile Access - UMA continues to be preferred as a marketing term. Regardless of the different working names for the concepts, they are both intended to give a solution to the same problem; to bring broadband access to mobile phones in places where user is mostly using a mobile phone. UMA was developed to be used within GPRS networks until the 3GPP adopted it in July 2005 and renamed the concept as GAN. Also the target network structure took a step forward and is currently 3G.

The core idea behind GAN network is that the existing cellular network remains unmodified and only an additional GAN Network Controller is introduced to act as a gateway between mobile operator's core network and the internet (or similar IP access network). [Greech et al. 2005] The user is thus able to connect to the mobile operator's core network through a wireless access point and is able to establish wireless connections with high-speed IP-based transmission channel. In this manner the user is not only able to receive calls through GAN access but also to exploit the usage for other Internet services. The main structure of GAN architecture is depicted in figure 3-1.

GAN solution has also many assets in terms of reusability of the core network infrastructure as it enables the use of existing architectures and therefore can be considered as a complementary add-on solution to 3G. GAN solution becomes particularly practical in areas where there is no 3G or any cellular coverage as the access may be implemented

through Wi-Fi. Another way to benefit from GAN is to implement it in places like offices and homes where people use the phone most often and thus it has direct effect on the cost of communication.

Figure 3-1 The structure of Generic Access Network



On the other hand, GAN solution will strengthen the role of incumbent operators in the same way as pure 3G solution would do. Besides the control of the core cellular network, the incumbent operator also holds the control of the actual cellular subscription, or simply put, the right to route calls with the certain phone number. This raises some issues concerning the routing of all the voice calls originated from a handset. The voice calls from a mobile phone are either connected through the circuit switched cellular core network or via the internet. When connected through the internet, it is assumable that when using some other separate or proprietary solution the call cannot be distinguished with the cellular phone number. Instead, it is closer to an independent VoIP connection and thus it can be

considered as a totally separated subscription, apart from cellular subscription. The main idea in GAN is, however, to use the WLAN connection to route the calls to mobile operator's backbone. Thus the voice service on GAN is fully based on the cellular subscription and the term VoIP might be misleading as the user might not even know whether one is using the cellular or WLAN connection.

The first UMA experiments in Finland were started in July 2006 by Nokia, city of Oulu and DNA/Finnet-Group. The employees of the city were given a Nokia 6136 mobile phone which is able to piggyback both the cellular and WLAN connections around the city. These experiments are carried through as a part of panOulu project which is targeted to provide free of charge wireless broadband connections for the citizens of Oulu.[45]

3.3.2 IMS – IP Multimedia Subsystem

IMS is a rather complicated platform on which the future multimedia networks are intended to be built. IMS platform is developed and specified by The Third Generation Partnership Project (3GPP) which is a collaboration agreement between regional telecommunication standardization organizations. European standards are represented by the European Telecommunication Standards Institute (ETSI). Also the Internet Engineering Task Force (IETF) has contributed heavily on the IMS structure by contributing to the development of the protocols behind the applications.

On a technical sense, IMS is not an access technology to provide mobile VoIP with but more like an infrastructure consisting of packet switched and circuit switched domains, having SIP as a signaling protocol and giving support to 3G, Wi-Fi, WiMAX and such technologies. The main motivation in IMS is to unify the mobile networks and evolved multimedia services together and take the concept of mobile services beyond current GSM standards. [3GPP 2007]

The technological structure of IMS is rather complicated and not worthwhile to be explored in this thesis. However, the main highlights in IMS structure are in its capabilities to

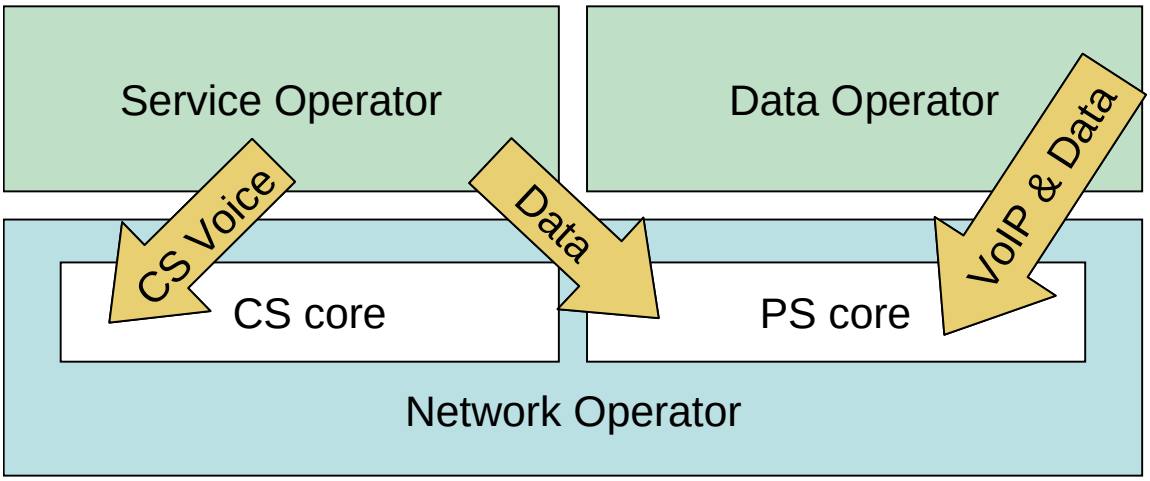
[45] http://press.nokia.fi/PR/200607/1066088_4.html accessed 1.2.2007

converge both the fixed and mobile domains and to generate one internally consistent infrastructure that would be completely access network independent platform [3GPP 2007]. In short, this would mean that the core functionalities of IMS technology can be accessed through any feasible IP connection [Nokia 2005]. Thus the previously introduced GAN network structure can be seen as a noteworthy technology also in IMS deployments. However, a recent research indicates that the deployment of IMS with GAN technology is expected to be more risky to current operators, but in addition it is also presumed to be more profitable than to introduce the IMS core functionalities without it [Heikkinen 2007].

3.3.3 Data Operator business model in cellular networks

One interesting concept in offering mobile packet switched connections would be to deploy the cellular, mainly 3G and beyond, networks to establish packet switched connection to the cellular core network and further to the internet. Mobile VoIP service would thus be enabled on top of the packet switched data connection and routed to some service provider's VoIP-gateway. In this case the horizontally layered business model of alternative wireless network providers is deployed to the current cellular networks and used as a base for modeling the synergies between the service and network operators.

Figure 3-2 Distinction of service operators and data operators



Data operators do not hold the right to route calls to CS core

The operational differences of data-operators and normal service operators are illustrated on the figure 3-2. In this model the service operators provide their customers circuit switched voice subscriptions and packet switched data services. However, the emerging model of data subscriptions would provide the customers only a data service on top of which the voice subscriptions would be implemented.

This model could be also advantageous for network operators who have unused capacity on their packet switched core network, although the data operator customers would still deploy the same frequencies that the service operator customers deploy.

3.4 Comparison of VoIP providers

Three major technical solutions rise when current and prospective VoIP solutions are evaluated. These are the previously mentioned proprietary solutions, open standards based VoIP providers and infrastructure based solutions such as GAN with IMS. To compare the market possibilities that these VoIP offerings have a simple swot-analysis[46] is conducted. Features are listed on the table 3-1.

Table 3-1 SWOT analysis on the different type of VoIP service providers

Proprietary solutions	**Open Standards based**	**Infrastructure based**
Strengths •Network effect •Lightweight organization •Modularity	Strengths •Interoperability •Interconncetivity •Standards based protocols •Simplicity	Strengths •Customer penetration •Market share •Wireless infrastructure
Weaknesses •Lack of access network •Reachability	Weaknesses •Lack of access network •Reachability	Weaknesses •Complexity •Slow technical change
Opportunities •Fast Ramp up •Penetration on PC world	Opportunities •Internet-led market •Penetration on fixed networks	Opportunities •Market dominance •Fixed network takeover
Threats •Profitability •Pricing of data access	Threats •Market share •Pricing of data access	Threats •Heavy investments •Challenger solutions •Alternative network technologies

[46] Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis is a strategic planning tool invented by Albert S. Humphrey at Stanford University.

3.5 Interconnection of the networks

Besides the technical limitations in the wireless networks and the restrictions in the business strategies that hinder spreading of mobile VoIP, there are also regulative forces that have their contribution to the matter. Fast development of VoIP subscriptions and especially the emerging use of mobile VoIP have made the charging of interconnection between the networks a widely debated topic. The actual problem with interconnection prices is that the cellular and fixed networks have different terminating fees which lead to unequal market prices and further sets the networks to unequal market positions.

Currently any virtual VoIP service provider that is operating in Finland must operate on PSTN as the only operators who either have their own mobile network infrastructure or are operating as a virtual mobile operator are allowed to route traffic from other networks to mobile network [Rantanen 2004]. For VoIP service provider this means that any VoIP call to mobile networks must be routed through an access operator which has the connection to mobile domain. This decision is introduced by Finnish Communications Regulative Authority and is reasoned with the fact that a so called GSM gateway initiates technical problems and malfunctions for the operational mobile network. Ficora justified its considerations with reference to requirements on the Communications Market Act, issued by Ministry of Transport and Communications Finland [Rantanen 2004, MINTC 2003]. Due to the fact that virtual VoIP operators or proprietary VoIP solution providers cannot route calls straight to mobile networks, the connection must be connected through a GSM gateway that lay on the network operator's premises and is connected to the cellular and PSTN network. Outcome of this regulation is that the VoIP operators are bound to use an intervening operator which can route the calls to mobile networks. This dependency forces the virtual VoIP operators to route their traffic through PSTN trunk operators to mobile networks, and thus the PSTN trunk operators are able to charge for these calls as an intervening party. To sum up; VoIP calls have been commonly free when called inside the internet domain, however, when the target network is a mobile network, the call is charged heavily as it is routed from the VoIP operator to PSTN access operator and further on to mobile network. This generates additional costs as also the intervening PSTN trunk

operator charges for the connection. To compare, a mobile to mobile phone call is a two party call and is routed inside the mobile network, thus the cost of connection is determined only between the caller party network and called party network.

The assessment principles for the pricing of mobile network interconnection published by Ficora, states that the Finnish mobile operators should all unify their mobile domain interconnection pricing so that the highest fee would be 4c/min and lowest 3.5c/min [Ficora 2006a]. In year 2006 the consumer market price for mobile calls was 7-8c/min [Juusela et Al. 2007a], whereas the 2007 consumer market price for fixed line calls was 1.95c/min [Juusela et Al. 2007b]. Ficora's guidelines for consumer market prices for 2008 and 2009 are respectively 2.20c/min and 2.35c/min [Juusela et Al. 2007b]. These pricing principles show that the prices of fixed and cellular calls are closing each other but sill the interconnection pricing levels have not yet experienced any changes. However, now that the mobile operators have agreed to set a limit for the interconnection prices inside the mobile domain it is also assumed that the prices of interconnection from fixed PSTN to mobile networks would decrease. This can be justified also with the fact that the fixed to mobile prices came down from 24-26c/min to 16-17c/min in 2005 due to similar regulative changes in the communications market act[47].

Outcome is that the current regulation is too slow to adapt to the current situation in providing mobile VoIP with competitive pricing. Mobile operators will be able to deploy mobile VoIP with mobile call pricing but the other VoIP providers still need to reside in fixed networks and suffer from the high fixed-to-mobile interconnection pricing. What is more, even though the mobile VoIP service would be implemented on top of an alternative wireless network connection or even on top of the packet switched side of 3G, only the mobile operators would still hold the right to route calls to mobile subscription without high interconnection pricing.

The problem in interconnection pricing is partly related to the numbering issues of different networks. Previously different prefixes on the numbers have defined the type of network in

[47] http://www.ficora.fi/index/viestintavirasto/lehdistotiedotteet/2005/matkapuhelut.html accessed 10.3.2007

which the call is to be terminated. Now, with the emergence of mobile VoIP this number identification scheme becomes problematic as the cellular networks can also be used to make VoIP calls that are under PSTN regulation. By far Ficora has only mentioned that VoIP in cellular networks could obtain the same numbering with the mobile subscriptions, but the right to VoIP calls with these numbers should be restricted only for the VoIP services on cellular networks [Ficora 2006b]. This statement sets the mobile operators and and VoIP service providers into unequal market positions.

On the other hand, according to Ministry of Transport and Communications Finland the number portability between fixed line network, cellular network and VoIP should be enabled [Kangas 2005]. This is nonetheless so far quite strange statement as it would implicate that the caller would never know whether the call is directed to mobile, fixed line or VoIP subscription. The prefix on the destination number is, however, identifying the destination network and thus the caller is able to distinguish whether he or she is calling to a fixed line or to a mobile network. Number portability between the networks would make the destination networks undistinguishable and result in unwanted call costs. Other result of this act would be the convergence of fixed and mobile domains under single network domain. This is better known with the term fixed-mobile convergence. However, the Ministry has not declared any public opinions of this kind of act, nor declared any public opinions about how to handle with the interconnection costs in such case.

The problem of high interconnection pricing from fixed network to cellular is seen problematic also with Skype as it holds the same market position with virtual VoIP operators. Any Skype-Out call that is intended to be terminated on mobile network must go through the same GSM gateway structure and thus it also faces the high pricing of interconnection. Skype has fought back to this problem by petitioning the FCC, Federal Communications Commission in the U.S. to open the mobile networks for open access [Goldberg 2007]. In short this means that Skype wants FCC to allow the customers to use devices and software of their choice on cellular networks. Motivation to this is clear, Skype has created software that is free to use in across the internet. Now Skype wants to the users to be able to use the software also on cellular networks.

Skype's petition for open networks is interesting change in the company's profile. Previously Skype has weighted that as it does not operate on the same basis as telecom operators and due to this it has no obligations to meet the telecom regulations. Skype CEO and co-founder Niklas Zennström put this into words in 2003 on CNET interview[48]. – "*Currently Skype is not subject to telecommunications regulation; therefore we do not have any legal obligation to provide any means for interception. This is software that's not any different from e-mail or chat.*" However, since that Skype has opened new services to call landlines (Skype-Out) and to take calls from the landlines (Skype-In). These services are regulated differently from the normal Skype peer-to-peer service and thus set the company also under the telecommunications regulation.

All these acts, statements and studies conducted by the regulative authorities, ministries and companies on the market well illustrate the magnitude of the numbering and interconnection issues have gained. This topic has been widely debated and evidently will continue to be analyzed by the authorities and companies on mobile VoIP branch.

[48] http://news.com.com/2008-7352-5112783.html access 13.3.2007

4 Analysis of Business Dynamics

After studying the technical perspectives of the wireless technologies and exploring the market dynamics of VoIP service providers, it becomes reasoned to direct this thesis towards an analysis on the mobile communication industry and analyze the synergies of technical and business factors on mobile VoIP.

Structure of this chapter is a construction of two frameworks that are used to construct future industry scenarios. The first method is introduced by Michael E. Porter and is known as a method of the Five Competitive Forces. The Five Forces analysis is used in this thesis to define the uncertain factors that affect the business opportunities of mobile VoIP services. Porter's (1980) method focuses mostly on defining the uncertain factors that are external to the company. However, besides the external factors affecting the company there are also internal factors and factors that can be presumed to be certain over a period of time. These factors are also absorbed to the study to further enlighten the mobile industry structure and to better define the initial condition of the industry. To find the most relevant certain factors that best define the future structure of the industry, a method introduced by Karlson (et al. 2003) was applied.

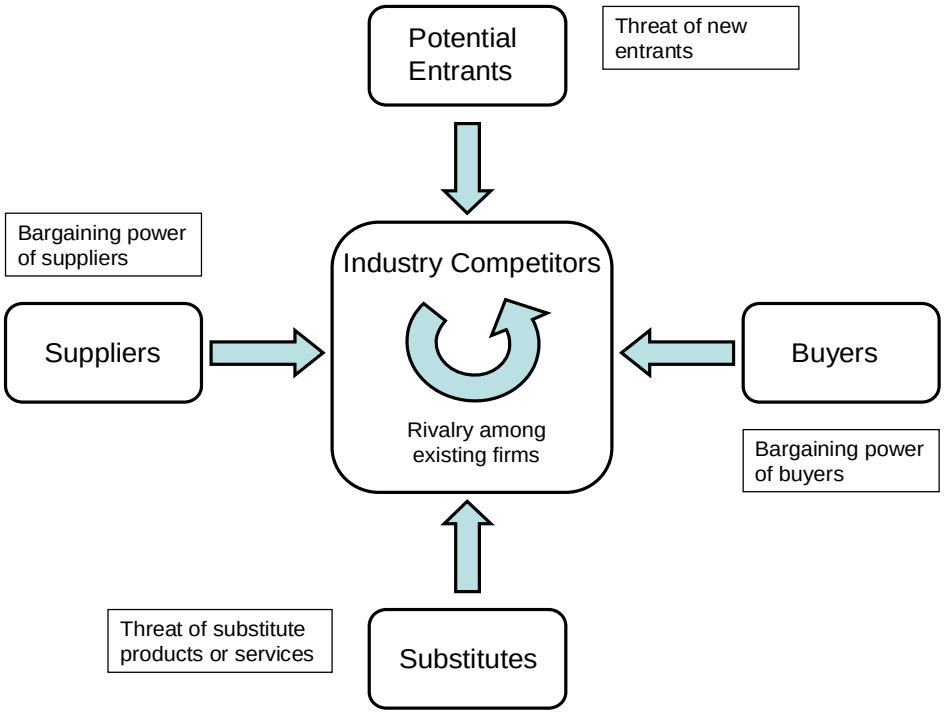
The process of finding the relevant uncertain factors on mobile VoIP industry was first conducted on the basis of five forces analysis with the help of findings from the method introduced by Karlson et al. These methods presented a list of 27 different uncertain elements of structure. On the next phase of the analysis a group of industry specialists were interviewed and they gave their contribution to this list of uncertainties and also validated the most important final uncertainties. In total six interviews were carried out in order to organize the list of uncertainties and to find the most important uncertainties that affect the development of mobile VoIP. Finally, after the interviews a set of six independent variables were gathered.

After the identification of the most important variables they were dimensioned to constitute a layout of the final scenarios. This chapter concludes with an early introduction of the scenarios, although the focus of this chapter is only to provide the variables that define the scenarios. More detailed analysis of the scenarios is presented on the chapter 5.

4.1 Five Forces Analysis

The framework of competitive strategy introduced by Michael E. Porter (1980) states that competition and profitability in an industry is dependent of five basic competitive forces. These forces are illustrated on the figure 4-1.

Figure 4-1 Competitive forces that affect an industry



The objective of competitive strategy is to find a position in the industry where the company can best defend itself against the competitive forces or can influence them in its favor [Porter 1980]. In this thesis the framework of five forces is used to define the most important uncertain elements of structure that affect the future industry structure of mobile

voice services, and especially the possibility of mobile VoIP service to overtake the business around mobile voice.

4.1.1 Threat of new entrants

Current regulatory framework for electronic communications and services by Finnish Competition Authority (FCA) emphasizes in providing harmonized, reliable and flexible approach to the regulation of electronic communication networks and services. According to FCA the focus of regulation in electronic communications has been under a change towards lighter regulatory intervention where markets are to become more competitive. However, FCA justifies that in order to justify the identification of communication markets with reference to ex ante regulation; the markets have to be subject to high and non-transitory entry barriers. [FCA 2006]

Porter (1980) states that a new entrant to an industry brings new capacity, grows the desire to gain market share, and substantial resources. However, the profitability on an industry is to reduce due to new entrants as the prices might be bid down or the incumbents' indirect costs might grow. The threat of an entry is dependable on barriers to enter the market, as well as the acts made by the existing players on the market. [Porter 1980] Besides emerging of new entrants, also an expansion or an acquisition into the mobile VoIP service branch can be seen as a threat of entry even though it is conducted by a mobile operator which already operates in the mobile industry. Thus the threat of start-up VoIP companies and proprietary VoIP solutions are evaluated equally with the threat of dominant mobile operators to overtake mobile voice market with a new solution or product.

According to Porter (1980) the significance of threat of new entrants is determined with the existence of **Barriers to Entry**. In the case of providing mobile VoIP services the most relevant sources of barriers to entry are:

Economies of scale in mobile voice business refer to the volume of the service. Unit costs in a production of services tend to decline when the absolute volume of the services increases. In short this means that in order to create a business around mobile VoIP service

the player is likely to face high unit costs per subscription if not entering the market of already high customer penetration. Economies of scale are exacerbating the entry of operators by either forcing them to accept the cost disadvantages of small entry or enter the market at large scale in order to benefit from the economies of scale but risk the new business with actions performed by the existing operators already on the mobile voice branch. Both strategies have undesirable features and risks that cannot be avoided. A company that could benefit from the economies of scale is an international mobile operator or international VoIP service provider.

As the main product in mobile VoIP is to be the mobile voice service carried over a wireless connection, the **product differentiation** is most likely to create a barrier to entry. This is due to the fact that the same kind of voice service is already implemented in cellular networks with huge customer penetration. In Finland the penetration of mobile phones is already over 100%[49] which implies that nearly every inhabitant carries 2G or 3G based mobile phone.[50] Customer loyalty and brand identification are thus presumed to form barriers to entry for VoIP services. Especially if the price of the substitute product is considered somewhat equal to the prior product, the challenger VoIP operators need to work aggressively to win customers from mobile operators. One interesting differentiation strategy is performed by operator Three[51] that bundles both the phone and the services into one extensive service, including not only a voice subscription but also Skype, Microsoft Messenger and Yahoo clients with unlimited data access.

One-time cost that faces the buyer of switching from one supplier to another is referred with **switching costs**. In the context of mobile VoIP the switching costs are evident when for example the user needs a new mobile phone to be able to utilize the VoIP service. On the other hand, as the existing operators have rolled out a VoIP service they have also faced switching costs from changing their technical infrastructure. Also employee retraining costs, license fees, marketing campaigns and such actions can be seen as switching costs for the service provider and all these kind of costs will in the end mirror to the final cost of the

[49] The number of cellular subscriptions exceeds the number of inhabitants. This is most likely due to some people having more than one mobile phone in use.
[50] http://www.tilastokeskus.fi/til/tvie/2005/ accessed 13.4.2007
[51] http://three.co.uk accessed 13.4.2007

service and thus set an uplift pressure on the price that an end user has to pay. The significance of switching costs are anyhow expected to reduce over time as packet switched connections become more common among user handsets and technical convergence of radio interfaces becomes more sophisticated.

Government policy and regulation can form huge barriers to enter the market by limiting or closing the entry into a market. One good example would be licensing of radio frequencies with WiMAX technology, especially the mobile WiMAX licenses that have not yet been dealt out in Finland. By dealing the licenses unevenly the market might become uninteresting and unable to compete against challenger technologies. What is more, delay of license allocations might also deter the technology to attain substantial penetration to compete against other technological solutions. Another issue that Finnish regulator has not yet committed is the interconnect pricing between cellular and PSTN networks. The current situation disgraces all PSTN traffic, and thus also VoIP calls which are currently under PSTN regulation. As an example using Skype-Out[52] service to connect other PSTN users the calls are charged with 2.9c/min whereas if the call terminates to cellular network it is charged 19c/min, difference being over six-fold.

As this thesis concentrates on mobile VoIP as a competitive service to cellular voice service there is no relevant need to evaluate the **access to distribution channels**. Mobile VoIP is a service, not a physical product and thus it can be offered through numerous distribution channels. To list such cases, a VoIP subscription could be delivered as preinstalled or downloadable software on a smartphone, a set of settings to preinstalled software client to a smartphone, or simply a separate VoIP capable mobile handset. Furthermore, with access to distribution channels Porter (1980) refers mainly to retail sales and spreading the product to old-fashion distribution channels. However, as mobile VoIP is considered as a service, the ability to actually use the service becomes more topical than the access to distribution channels of the product. In short, distribution of VoIP service is not considered to be a problem, compared to the diffusion and user adoption rate of the service.

[52] Referred prices checked from http://www.skype.com/intl/fi/products/skypeout/ access 6.6.2007

If the existing competitors on a mobile voice branch are expected to respond forcefully to make an entry of an entrant unpleasant, the entrant might find this as a threat. Assume that a VoIP operator would implement a mobile VoIP service that piggybacks the IP connections that the smart phone has, and assume that the price of this service would be set so low that an end user finds it cheaper to call through VoIP operator than traditional cellular subscription. In such a case mobile operator could rise to the challenge by lowering the price of its service below an **entry deterring price** and thus make the market unprofitable for the VoIP operator. Threat of such an act is referred with **threat of expected retaliation**.

4.1.2 Intensity of rivalry

Intensity of rivalry and competition on a certain branch are typically determined by the special features of the industry. The factors that determine the intensity and rivalry do change over time as the whole industry changes. Any industry has typically experienced declines on its growth rate after achieving a certain point of maturity. This results in intensified rivalry and profit declines. [Porter 1980]

As mentioned, rivalry among the existing competitors is evident on almost any branch but telecommunications is especially known to be extremely tough branch to compete. Price competition, advertising- and marketing campaigns not to mention rivalry in product introductions are giving the branch its hectic nature. Telecom operators are known to strive for customers and the situation has been especially bad in Finland. Strict competition made the prices to sink during the years 2003 and 2004 and showed the mobile operators the bottom price to run mobile services [Korvenmaa 2005]. This was due to escalation of strategic moves and countermoves which finally ended up leaving the whole branch worse off than before the rival competition. Now, a few years later the situation has reassured and competition has relented. Currently mobile VoIP can be seen as a new potentially disruptive phenomenon that might awake the mobile operators to tighten the current pricing of mobile calls to make them compete with VoIP calls. However, it is very unlikely that any of the current mobile operators would rush with implementing a VoIP service on their

network as it would mean that they challenge their competitors and end up fighting over the customers.

Unwillingness to implement VoIP service among the incumbent mobile operators is however opening a possibility for third party applications and proprietary software solutions to gain popularity among the smart phone users. As more and more smart phones are introduced with wireless broadband (e.g. WLAN) capabilities and with a possibility to install all kinds of applications to the mobile phones memory, it becomes also easier to install e.g. a proprietary VoIP client and use that in voice communications instead of the cellular subscription. Feasibility of this implementation is however far determined by the progress and usability of alternative wireless networks or the ability to use the high speed cellular packet data connection.

One possible rival group would be the international operators who can benefit the economies of scale. These companies are not believed to enter the Finnish market with their own cellular infrastructure due to the disgracing demography of Finland. Also the highly competed market might seem unattractive and not worth of investing. However, MVNO strategies are possible and in some extent even plausible, especially if the market structure moves towards horizontal structure. In such a case the international companies are attacking the service market and leaving the network provision for the current mobile operators.

4.1.3 Threat of substitute products or services

Identifying substitute products is a matter of searching for other products that can perform the same function as the concurrently analyzed product [Porter 1980]. In this thesis mobile VoIP serves not only as a substitutive functionality for the traditional mobile phone calls but also as a complementary service in addition to the mobile Internet services. However, Porter's theory of substitute products does not support the concept of complementary asset and therefore the complementary effect of mobile VoIP needs to be studied separately of Porter's theory. To hold the line, this chapter continues to identify mobile VoIP as a substitute service for mobile phone calls.

Substitute products for mobile voice calls could be categorized into two groups; to those which hold mobile voice calls as the main service but change the means to deliver it and to those which can be seen as new inventions in communication by substituting the whole idea of voice communications. However, as defined on the objectives of this thesis, the mobile voice service is expected to serve as the main communication channel and thus there is no need to evaluate the alternate messaging channels[53] as substitutes.

The main difference between current cellular calls and mobile VoIP is the wireless access channel. To be more accurate, the voice service stays the same and only the underlying technology changes from circuit switched to packet switched. In this sense the end user is not expected to compete over the solution. The connection can be either circuit switched or packet switched as long as the user gets the connection and is satisfied with the quality of the service.

4.1.4 Bargaining power of buyers

Not only are the substitute products or new entrants the main competitors for an industry, but also the consumers can be seen as a threat to the business if they have power to force down the prices of the products. Also bargaining for higher quality, more services and playing the service providers against each other can be seen as bargaining power of buyers. [Porter 1980] In telecommunications bargaining happens also on the subscription level as the consumers tend to switch to subscription with a pricing model that best correspond to their needs. This does not necessary involve a customer to switch the operator but only to switch to a cheaper service among the wide variety within the same operator. Porter (1980) refers to this with *consumer awareness*. The actual market prices, market demand and even supplier costs are also a base for buyer bargaining power, however these are not considered to be important when the charging of telephone service is considered. The truth behind consumer awareness of price levels lies supposedly in striking advertisement campaigns and price wars between the telecom operators that have woken the consumers to realize they can actually race their voice subscriptions. This boom was seen especially in years

[53] Substitute products could be for instance push-to-talk service or mobile instant messaging.

2004 and 2005 when over a million subscribers changed their operator on both years [Numpac 2007][54].

Allowance of bundling of 3G mobile phones with mobile subscriptions has also affected the customer base. In third quarter of year 2006 the Finnish market experienced 126000 new bundled subscriptions which corresponded 35% of all the subscriptions sold on that period. [Ficora 2006c] These bundled contracts bound the customers to fixed length contracts and thus any entrant to market faces difficulties in serving competitive VoIP services for these customers as demand is limited with the bundling contract. This phenomenon is known as Lock-In effect and it may have a huge impact on the future competition if the allowance is continued by the regulator. Some conclusions can be drawn from the fact that some of the biggest European mobile operators have disabled the VoIP capabilities from the bundled Nokia N95 handset as an act to defend their voice revenue[55]. On the other hand, handset bundling is also considered to decrease the architectural modularity of the mobile markets but on the other hand it may have positive effect when it comes to launching new services [Verkasalo 2007].

Low switching costs with rather standardized and undifferentiated service gives the consumers an asset to bargain. What is more, when consumers get into the habit of having internet content as a part of their every-day life, they will also demand this to be a part of their mobile usage.

One additional dimension that Porter (1980) also states is that the size of buyer overall costs should be small in relation to the price of the product in order for the consumer to be interested in bargaining for a lower price. In short, when the telecommunication costs make a significant amount of buyer's total costs, the buyer is more prone to bargain.

[54] Number Portability was allowed in June 2003. In year 2004 total amount of 1 212 857 numbers were ported, in year 2005 the same figure was 1 464 232.
[55] http://www.theregister.co.uk/2007/04/18/n95_crippled/ accessed 12.5.2007

Besides the mobile voice service, VoIP technology has also other advantages to differentiate itself from the cellular legacy voice service. Presence[56] service is one such surplus value that might turn the customers to choose VoIP applications instead of cellular voice. Another use for VoIP applications is to use VoIP connection as an alternative method for roaming, in the wildest estimations this kind of use is calculated to cut the roaming revenues of European telecom operators with 41% from 2005 to 2008 [Evalueserve 2005].

4.1.5 Bargaining power of suppliers

Supplier companies for a VoIP industry can be seen as a source of bargaining power as well as the buyers. Suppliers can use their bargaining power over participants by threatening to raise prices or by limiting the quality of a product or a service. By using these assets a powerful supplier can narrow down the profitability of an industry by collecting the profit increases instead of the company it is supplying to. The main suppliers for companies providing VoIP services can be categorized on different groups depending on how the service provider is implementing the VoIP service. If the evaluated VoIP service is built e.g. on the IMS platform, the main suppliers are the network infrastructure equipment (and software) providers.

VoIP industry and the services that VoIP companies offer are nevertheless dependable also from factors that are not directly originated from supplying companies but have similar cost dependencies with supplier companies. For example, VoIP service providers that want to route traffic to e.g. PSTN or PLMN networks need to pay an interconnection price due to termination of the call to a foreign network. In such a case the termination side network operator plays the role of a supplying company as it supplies the connection to other networks. Thus these companies are able to influence VoIP companies with bargaining power in terms of interconnection prices.

[56] Presence service can be implemented as a state of the corresponding subscription. E.g. the user could see the status of the called mobile phone

In general, conditions that make suppliers powerful are somewhat similar to the ones that make the buyer groups powerful. According to Porter (1980) the supplier group is powerful if the supplier group is dominated by a few companies and it is more concentrated than the industry it sells to. In VoIP business this doesn't hold as the players are numerous from network infrastructure vendors to handset manufacturers and different service providers. In addition, also the frequency licenses that are needed in order to operate on certain licensed bands (3G, WiMAX, etc.) play a significant role to the industry. Operators that want to utilize a certain frequency band must purchase a license for it.

4.2 Identifying uncertainties with impact on mobile voice communications

The method of categorizing industry uncertainties is the most challenging task in industry scenario construction. Each element of industry structure must be determined, examined and placed into one of three categories; *constant, predetermined* and *uncertain* [Porter 1985]. In this thesis some industry factors are considered constant and predetermined throughout the scope and time frame of this thesis. These constant and predetermined factors are a set of trends that motivate all the scenarios and define the industry's general conditions. In addition, these constant and predetermined factors do not differ between the scenarios but act as a guideline to define the certain parameters upon which the uncertain elements can be defined on. The constant and predetermined factors are listed in table 4-1 and they are chosen in a way that they help in dimensioning the future scenarios on the industry under examination, and furthermore assist on creating a solid base of information from which the actual uncertain elements can be drawn. In determining the constant and predetermined variables a method introduced in a book "Wireless Foresight; scenarios of the mobile world in 2015" by Karlson et al. (2003) was applied.

4.2.1 Constant and predetermined factors in mobile VoIP evolution

Karlson et al. study the field of mobile evolution from four different perspectives, these being; *Technological, Socioeconomic and Political, Business and Industry* and *Users, Values and Attitudes* perspectives. The following table 4-1 defines the constant and predetermined factors that apply throughout the study period of this thesis.

Table 4-1 Constant and predetermined certainties in mobile VoIP evolution

Technology Drivers

-Processing power of handheld devices will increase exponentially over time.

-Internet content will become general in handheld devices.

-Wireless connections will evolve in terms of coverage and throughput.

-Battery demand will increase but in a decreasing manner.

-Battery capacity will increase but not as rapidly as the demand.

-Standardization in radio technologies will increase.

-Proprietary solutions and IPR will become more eminent.

Socioeconomic and Political Drivers

-Globalization will increase.

-Democratization will increase.

-Market economy will prevail but also counter movements will continue.

-Social differences in regard to adoption of technology will continue.

-Amount of information and information channels will increase.

-Service and knowledge industry will continue to dominate industrial manufacturing industries.

Business and Industry Drivers

-Industries mature over time.

-Companies strive towards monopoly.

-Innovation will increase in attractive markets.

-Complementary products will emerge in an increasing manner.

-Value chains will increase in complexity and turn to value networks.

Users, Values and Attitudes Drivers

-Focus of mobile connections will become more international.

-Need for voice calls will not newer disappear.

-Need for mobility and overall communication will increase.

-Use of technology in everyday tasks will increase.

-Value of free time and experiences will increase.

-Explosion in social group formation in very large networks.

4.2.2 Interviews to determine the most important scenario variables

An interviewing process was intended to serve this thesis as a method to find the most important uncertain variables among all the uncertain elements of structure which were derived from the five forces analysis. However, the five forces method concentrates mostly on factors external to the company but do not consider relevant strategies for the companies with different initial conditions. The interviewees started to point out the internal factors which then were either absorbed to the final list of uncertainties or the existing uncertainties were modified so that they also respond to the internal interdependencies of the mobile industry. Thus the interviewees also helped in modifying the list of uncertain elements of structure (Table 4-3). So, although the uncertainties were mostly predetermined before the interviews, the final uncertainties in table 4-3 still experienced slight changes during the process, and finally saturated to their current form. However, these modifications were rather small and the main structure of the table 4-3 stayed the same through out all the interviews. The interviews were held in June 2007, except for a preliminary interview with Ficora in February 2007. List of interviewees is presented on table 4-2.

Table 4-2 List of interviewees

Name	Title	Company	Date
Klaus Nieminen	Senior Adviser	Ficora	20.2.2007
Jaakko Kuosmanen	Managing Director	ICT Turku	5.6.2007
Juha Korsimaa	Senior Development Officer	Fujitsu Services	12.6.2007
Tapani Nevanpää	Development Director	Teliasonera	19.6.2007
Mika Julkunen	Project Manager	Teliasonera	19.6.2007
Jarkko Utriainen	Head of Business Intelligence	DNA Finland	20.6.2007
Niklas Kolster	Chief Executive Officer	Ipon Communications	21.6.2007

4.2.3 Uncertain elements of structure

This chapter introduces the final uncertain elements of structure. The following uncertainties are collected from the five forces analysis and it holds all the uncertain elements of structure that affect the business around mobile VoIP. The following list is constituted in regards to the Finnish market with focus on the MNO's business strategies.

Table 4-3 Uncertain elements of structure in Finnish mobile voice business

Threat of new entrants

-Do the VoIP service providers pose a threat for the Finnish MNOs?

-Do international mobile operators pose a threat for the Finnish MNOs?

-How will the regulation deal with proprietary voice services?

-Is the regulation of interconnection pricing of PSTN and cellular going to change?

-What is the significance of positive network effect of Internet communities?

-Will flat rate pricing introduce new challengers on the service business?

-Does the mobile data access support all type of traffic?

Bargaining power of buyers

-How big is the consumer / corporate demand for mobile VoIP services?

-How does price sensitivity affect the rate of switching an operator or service?

-How do users adopt alternative roaming methods?

-Do the users deploy alternative mobile access technologies?

Intensity of rivalry

-How do the mobile operators' react with the Internet phenomenon?

-How are the license terms set for alternative wireless networks?

-Are the mobile operators going to deploy the alternative wireless technologies?

-Is the regulator going to continue the allowance of handset bundling?

-Does the MNO's value reside on the network infrastructure or on the customer population?

Threat of substitutes

-What is the level of software modularity in mobile phones?

-Will service bundling become popular with handset bundling?

-Do the alternative radio interfaces become popular on mobile phones?

-How do the Internet services affect the vertical mobile market?

-Do the instant messengers pose a threat to voice services?

-Do the switching costs have any significance on customer behavior?

-Is mobile VoIP able to replace or partially substitute CS voice?

-Are the mobile Internet businesses able to capitalize on the mobile market?

Bargaining power of suppliers

-Does the supplier group hold any potential entrants? E.g. HS manufacturers?

-Are the suppliers able to bypass the mobile operators in the value chain?

-Will the big suppliers support mobile VoIP on mobile handsets?

4.3 Causal factors driving the industry uncertainties

An industry scenario is an internally consistent view of an industry's future structure, which is based on the most important uncertainties that underlie the competitive advantage that the players on an industry are able to capture. In this thesis a set of future scenarios is used

as a method to deliver the final outcome. However, these scenarios are constructed based on the most essential factors that motivate all the possible scenarios; and these factors are derived from the uncertainties listed on the previous chapter. According to Porter (1985) identifying the uncertainties with the most relevant ramifications for the competition in an industry is the key factor in scenario construction and further in strategic planning. Yet, even though the most relevant uncertainties are sorted out they still need to be converted to independent and dependent variables that affect the future scenarios. [Porter 1985]

4.3.1 Independent and dependent uncertainties

Before being able to point out the uncertainties with the most relevant ramification on the mobile industry, the possible interdependencies between the variables need to be cut down. This is done by dividing the uncertainties into two categories.

- "*Independent uncertainties*. Those elements whose uncertainty is independent of other elements of structure. The sources of uncertainty may be inside or outside the industry." [Porter 1985]
- "*Dependent uncertainties*. Those elements of structure that will be largely or completely determined by the independent uncertainties." [Porter 1985]

Only Independent scenario variables can be used in scenario construction as they are not dependable on the other variables. Dependent variables are set after the assumptions about independent variables are resolved. Each of the dependent variables then becomes a part of the scenarios bringing each of them some special flavor. Independent scenario variables that were resolved from the table 4-3 according to the expert interviews are presented on next chapter.

4.3.2 Identifying the most important scenario variables

The most important scenario variables are derived from the list of uncertain elements of structure by combining the most important uncertainties into a set of independent variables. Most of the uncertain elements of structure have synergies with each other and thus they

need to be merged into consistent higher level variables. For example, the uncertain elements; *"How are the license terms set for alternative wireless networks"* and *"Do the network providers choose to compete or cooperate"* are partly dependable of each other and thus they need to be combined under one independent entity. Together with few other uncertainties these form an independent variable called *"What is the access mode in multi-radio networks"*. The six most important scenario variables that were formulated with this method are presented on the table 4-4.

Table 4-4 Independent scenario variables in mobile VoIP business

Most Important scenario variables

-What is going to be the dominating market structure?

-What is the access mode in multi-radio networks?

Less important scenario variables

-What is going to be the pricing structure of mobile communications?

-Is the market dominated by local or global service operators?

-What is the level of consumer demand for alternative communication methods?

-How is regulation of mobile telephony going to deal with the alternative mobile voice services?

The independent scenario variables are divided into groups of most important scenario variables and less important scenario variables with the help of specialist interviews. The most important scenario variables are chosen to be the dimensions upon which the final scenarios are to be constructed.

4.4 Identifying the causal factors behind the variables

The chosen scenario variables in future mobile VoIP business are here presented with the causal factors driving them. As the table 4-5 depicts, there are several causalities that

underlie both scenario variables, which is the case as the scenario variable were derived from the list of all the uncertain elements of structure.

Table 4-5 Causal factors determining the uncertainties in Finnish mobile voice market

Scenario Variable	Causal factors
Market structure of mobile industry?	- Do the international service providers or mobile operators enter the Finnish market? - Will the regulation support mobile voice service with the alternative wireless technologies? - What is the level of software modularity in mobile phones? - What is the level of significance of Internet communities and rich voice services? - Does the MNO's value reside on the network infrastructure or on the customer population?
Access mode in multi-radio networks?	- How are the license terms set for alternative wireless networks? - Do the network providers choose to compete or cooperate? - Do alternative wireless technologies ever become a success? - Are the mobile operators going to deploy alternative wireless technologies?

The scenario variables have now been determined and the causalities behind them are presented. Thus it becomes justified to introduce the actual scenarios of the future mobile VoIP markets. The dimensions of the scenario variables and the actual scenarios are presented in the chapter 4.5.

4.5 Dimensioning the scenario variables

After introducing the most important scenario variables the final scenarios begin to take form. Though before introducing the final scenarios some dimensioning of the variables

need to be conducted. Two most important scenario variables are both dimensioned in two distinct dimensions. Firstly, the uncertainty in dominating future market structure is dimensioned between *vertical market structure* and *horizontal market structure*. Secondly, uncertainty in development of alternative wireless radio technologies is dimensioned between *single-operator* access mode and *multi-operator* access mode in establishing a mobile voice call.

4.5.1 Market structure of mobile industry

Market structure of mobile communications is divided only into two dimensions, even though the complexity of the variable could have enabled a lot wider assessment. However, the current dimensioning was found essential in answering the question whether the dominating market structure is going to be horizontal or vertical. The mobile network operators can either produce the VoIP services in-house and act also as content providers or act only as mobile network providers and give the service management for external parties. According to Vesa (2005), vertical or horizontal market structure, together with the level of architecture modularity are the main dimensions that define the mobile market structure. In this thesis the definition of market structure is, however, presented fully based on the distinction between vertical and horizontal separation. Level of architectural modularity is seen as a part of the development of alternative wireless radio technologies.

Vertical market structure

Market convergence of the mobile industries is at its current stage rather poor giving the mobile operators' an asset to deploy mobile networks in all the means of mobile communications. In Finland the status quo is mainly group of mobile operators (Dna Finland, Elisa, Sonera) who control the mobile markets and thus characterize the vertical form of mobile market structure. However, as more divergent networking technologies emerge also the challenger players are given abilities to provide comparable voice services in the mobile domain and thus challenge the mobile operators in mobile voice business. On the other hand, mobile operators are expected to provide mobile VoIP in terms of GAN &

IMS technologies to maintain their market dominance and avoid the threat of opening the walled gardens.

Horizontal market structure

Convergence of mobile industries and mobile service providers is found significant when the synergy of alternative wireless communication channels and VoIP applications starts to put pressure on the mobile operator's dominance over mobile voice. However, mobile VoIP is not seen as the only solution to drive the markets towards horizontal structure as the horizontal market structure boosts also the concept of value networks and vice versa. Value networks, as presented by Shapiro et al. (1999) are also expected to leverage the adoption of advanced services. In this sense, this thesis observes not only emergence of mobile VoIP but also other internet content on mobile handsets.

Horizontal market structure of mobile communications would be actually continuation to the current broadband market in which the households are provided with fixed broadband connections of unlimited use with unrestricted content. This illustrates best the structure of horizontal markets and justifies also the expectations that the horizontal structure might become dominating also in mobile communications along with the emergence of mobile internet services.

4.5.2 Access mode in multi-radio networks

Access mode in multi-radio networks is defined as a dimension in which the mobile phone has several different radio techniques in use and it can utilize any of them in order to make a connection to the voice service. However, the uncertainty in this scenario variable is that whether the set of different radio technologies will be supported independently of each other or are they bundled together. Furthermore, the access mode variable holds also the uncertainty of whether the network selection is performed by the user or by the network itself. Thus the uncertainty in this scenario variable is divided into two dimensions; *single-operator* access mode and *multi-operator* access mode.

Single operator mode

Single operator access mode describes the relationship of a network operator and multiple network access technologies. In the single operator mode the mobile handset is able to access the network only through one predefined set of various access technologies. In short this means network technologies that mobile network operator can offer. Similarly, any network that is not managed by the network operator will not be accessible with the mobile phone.

In single operator mode the network interface of mobile handset is expected to be closed for any other network service than the one that is provided by the network operator. This kind of acts has already been seen by the mobile operators that use sim-lock on their bundled mobile handsets. In this mode the network is seen as a closed combination of different technologies and the decision of changing the network connection is made by the network itself. User may have some contribution to the selection as long as the selected network belongs to the predefined set of access networks.

In single operator mode the wireless networks are expected to operate cooperatively. Network based handovers are expected to be the key thing to support user satisfaction, and to find the most suitable network. Lowest cost access techniques are favored and the more expensive network utilized only when needed. Thus the utilization could be for example to favor WLAN over 3G and to utilize the latter only when user leaves the WLAN coverage.

Multi operator mode

Multi operator access mode is more complex assessment of the network connection than the single operator mode. With the multi operator mode the access networks and access network providers are seen in competitive context between each other. Furthermore, in the multi operator mode the network access selection is notably more open than in the single operator mode. Also the horizontal market structure becomes more anticipated in the multi operator mode as the voice service that supports multi operator mode is more likely horizontally layered than vertically integrated. However, it is also justified to say that the vertical market structure in mobile industries supports the multi operator access mode in

mobile handsets because of the strong emphasis of current vertical market structure. Also the Mobile Virtual Network Operator, MVNO, strategies support the multi operator mode with vertical market structure.

In addition, concept of national roaming might also become anticipated along the scenarios that meet the multi operator mode with vertical market structure. National roaming means that the mobile operators contract with each other in order to allow their customers to utilize competitors' networks. This concept is already implemented e.g. by Vodafone and Three in Ireland, where Three contracts for Vodafone's 2G network. In practice this means that Three has built 3G coverage over the main cities but has no network on rural areas.[57] National roaming contract allows thus Three's customers to utilize Vodafone's 2G network on those areas where Three has no network. If this same construction would be applied to the context of this thesis, it would imply e.g. mobile WiMAX operators to contract with 3G operators (or vice versa) to supply a nation wide coverage of mobile PS network. Given that the mobile WiMAX operator is not the same operator that have chosen to follow the 3G evolution path.

Difference between the multi operator mode and single operator mode is mostly difficult to determine as the techniques allow such a wide variety of different products and services. To determine whether the access mode is single operator allowed or multi operator supported a wide variety of factors were studied. Main factors were, open vs. closed access selection, competitive vs. cooperative access mode, and handset vs. network based network selection.

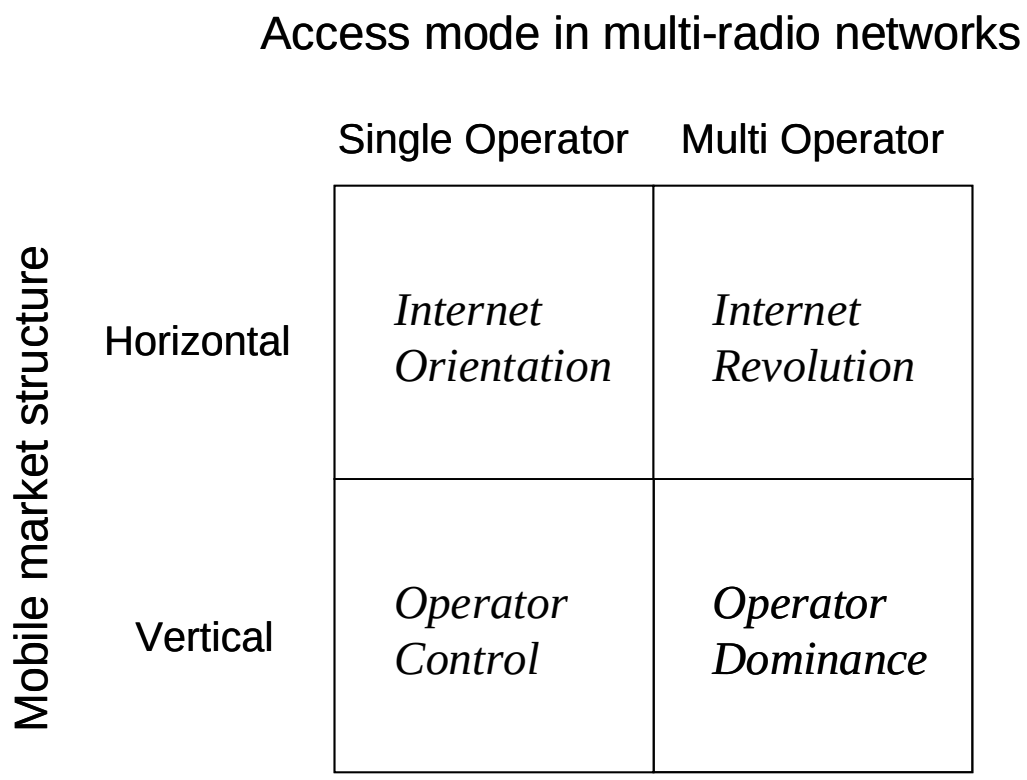
4.5.3 Constructing the scenarios

In order to construct the final scenarios the two most important scenario variables need to be combined into internally consistent scenarios. The following dimensioning, depicted in figure 4-2**,** describe the constructed scenarios in relation to these two most important scenario variables. Both dimensions of the access mode in multi-radio networks are

[57] http://www.3g.co.uk/PR/December2004/8818.htm access 26.8.2007

combined with assumptions of the corresponding market structure**.** Thus the final scenarios are presented as consistent combinations of the independent scenario variables.

Figure 4-2 Dimensioning of the final scenarios



As depicted in the figure above, four final scenarios were formulated. In the figure 4-2 the technical development rising alternative wireless carriers leads the scenarios rightwards towards divergent and interoperable wireless network technologies. Whereas the adoption of internet content into mobile communications push the evolution towards convergence of mobile industries and internet service providers and thus lead the markets towards horizontal structure.

5 Scenarios in the future mobile voice market

The main outcome of this thesis is to serve assistance in deliberation for the companies pondering in their strategic directions considering future prospects of mobile VoIP. Now that the scenarios have been formulated this thesis continues with deeper insights into these scenarios and broadens the conception of the mobile business in regard to sources of competitive advantage and the structural advantage of each scenario.

5.1 Current situation

The initial setting on the current mobile industry may also form a future scenario that has not been defined with the formal scenario construction process. This scenario is, however, only a prolongation of the current situation in terms of technological immaturity of mobile VoIP and thus also a continuation to the current vertical market structure. In the current situation the slowness of regulative decisions gives the mobile operators an asset to deploy their current business models and prepare for the future actions. Same time the VoIP service providers that still need to operate under PSTN regulation are suffering from the run down of fixed telephony. This happens in terms of vanishing customer population and high interconnection costs from PSTN to cellular.

In the current situation the high entry barriers keep the VoIP market unattractive for challenger VoIP service providers. However, a step towards new scenario might occur rapidly, either due to change of strategy by one of the dominating mobile operators or due to change of regulation considering the interconnection pricing. Regulator has probably the most difficult decisions to make in the current stage as either way it cannot favor both the mobile operators and VoIP service providers.

The current mobile industry holds the both scenario variables in an insufficient state considering mobile VoIP deployments. However, strategic planning considering the long-run mobile VoIP deployments is on key position. Future directions remain yet unknown

and the competing operators all face same questions; whether to stick to the current business models or to go over to the internet world and apply the horizontal structure on their business.

Table 5-1 Structural analysis of current markets in regard to mobile VoIP

Future Industry Structure	• Entry barriers remain high due to technical and regulative decisions. • Market convergence simmer on the shade of cellular operators' dominance. • Entry barriers sag slowly downwards along with the technical evolution and the converging markets.
Structural Attractiveness	• Progressive, currently favors big Telco's
Sources of Competitive Advantage	• Quality of Service • Economies of Scale • High market share
Competitor Behavior	Regulator is even bigger threat than the competitors on the branch. By opening the regulation or assigning new alternative wireless carriers the regulator will alter the market under high pressure of structural change.

5.2 Final Scenarios

The following chapters introduce the special characters of each of the scenarios constructed in the previous chapter. Main emphasis is laid on differing market prospects on each of these scenarios. Technical development is left on secondary importance as its function is to act more as an enabler for certain business methods than to take a role in describing the essential scenario dispositions.

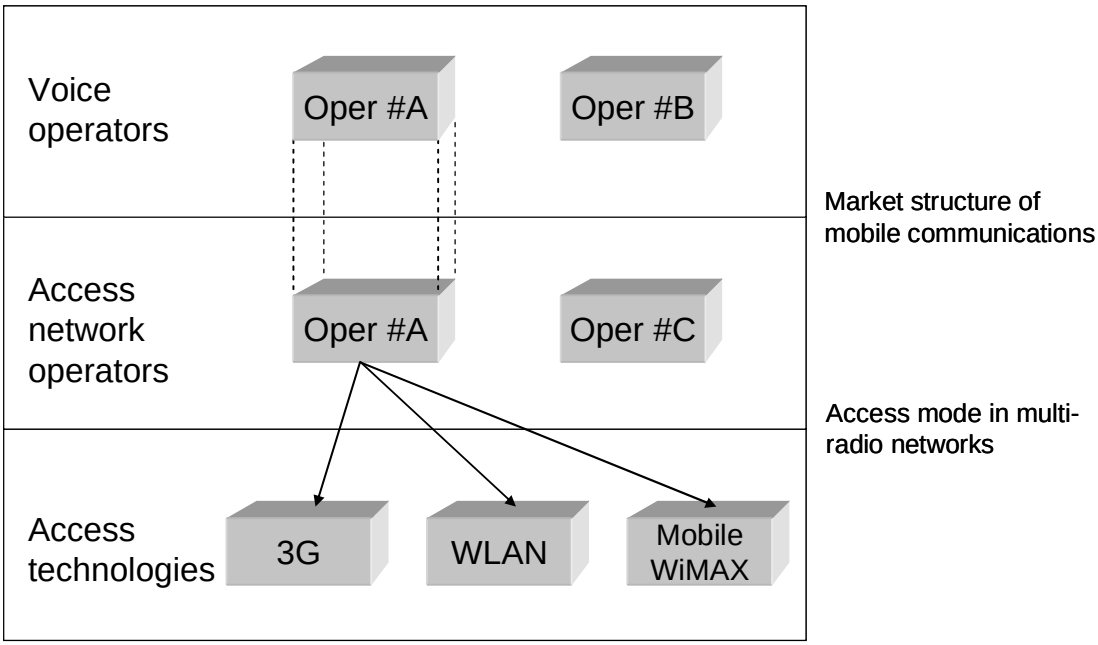
In total four scenarios were formulated to integrate the plausible future evolution paths into the scenarios that this thesis is to present. The following scenarios are not projected to be mutually exclusive but rather to coexist and show the correlating dynamics of the mobile industry structure. The scenario variables are presented in a way that they allow different markets, or even players on the same market with different initial competitive positions, to

face the scenarios differently. However, to meet the consistency these scenarios are expected to fulfill, the industry is still expected to behave cohesively, and in the end, fight over for the same customers.

5.2.1 Operator Control

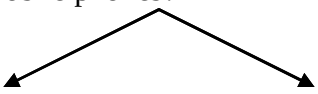
This first scenario continues partly from the current situation or is at least the one closest to the current situation. In this scenario the market structure of mobile industries is the same as now meaning that the mobile operators have maintained their vertically integrated value networks by offering both the voice service and the network connections. Customers also contract with the same means as they do currently, only difference being that the actual connection is able to deploy several different access network technologies. Furthermore, the wireless network operators might e.g. provide VoIP subscriptions alongside with their network subscriptions. This is phenomenon is already common in the fixed domain [Sandvine 2006].

Figure 5-1 Market structure and Access mode in scenario: Operator Control



In the figure 5-1 the operator A provides both, the voice service and the network access. Several wireless technologies are supported for the customer. As this scenario is closest to the current situation it is presumable that both the cellular subscriptions and VoIP subscriptions will coexist. Also, as the distinction between VoIP and cellular is vague, it is presumable that even a single subscription might be able to deploy both the CS voice and VoIP service in parallel, depending of the network supply. In addition, even though the scenario variable *Access mode in multi-radio networks* refers to multiple radio networks, the usage can, of course, be based also on single IP-based radio technology. Other issues considering the structure of this scenario are listed on the table 5-2.

Table 5-2 Structural analysis of scenario: Operator Control

Future Industry Structure	• Operators hold the access to mobile phones keeping the entry barriers high. • Market convergence simmer on the shade of cellular operators' dominance. • Emerging applications and technologies pose a threat that must be continuously monitored.
Structural Attractiveness	• Moderate, allows cellular operators to maintain their value chains.
Sources of Competitive Advantage	• Quality of Service • Service bundling
Competitor Behavior	Will the competitors find alternative channels to offer mobile VoIP services on mobile phones?  Yes No

In this scenario the mobile operators are the strongest candidates in providing mobile VoIP as they are currently only players who control the wide area wireless networks (3G). However, the technical development with alternative wireless carriers poses this scenario a threat of substitute service in which the alternative wireless access providers would be able to operate as a network access operator and as a VoIP operator and thus create a competing service for the mobile operators. Similarly, the alternative wireless network operators are a

threat when combined with an externally provided voice service. However, this setting leads the focus towards the scenario *Internet Orientation*.

Emergence of alternative radio technologies poses this scenario a risk to either allow the market to reach the horizontal structure or force the mobile operators to take part in the market convergence in order to maintain their share of the markets. Either way, the future direction from this scenario would be to follow the converging industries or try to catch the wave and manage the evolution by self taking a proactive role on the market. Proactive role would mean to strengthen the vertical value chain by self deploying competitive rich voice service[58] to tackle the advantages of VoIP service providers. In addition, an expansion or an upgrade of the supply of wireless network access is a method to compete against the alternative network solutions. Also the rich voice services might give the vertically integrated mobile operators better assets to compete against the rising Internet-led voice services. However, as the current mobile industry has a strong vertically integrated structure, the simmering structural change is not expected to happen rapidly. Thus the mobile operators will have good possibilities to organize their technologies and business models to better meet the future demand. In short this yields that whether the rising alternative wireless networks will be deployed by the new entrants or by the mobile operators will have a vast impact on the market structure. In Finland this poses the whole mobile market structure under a pressure of change as e.g. the mobile WiMAX licenses have not yet been auctioned and as the WLAN infrastructure is evidently horizontally managed. If the mobile WiMAX license auctions are won by the mobile operators the market is more likely to stay vertically integrated than if the license is won by a company that has not previously operated as a mobile operator.

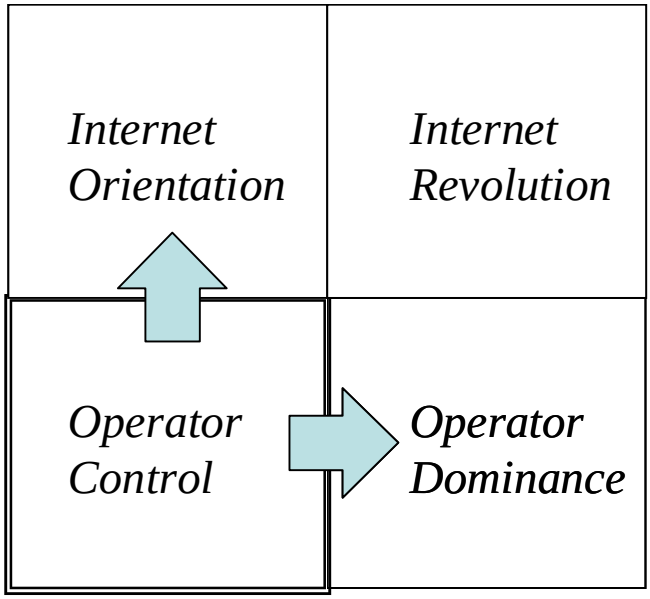
Timing plays also significant role in this scenario because the pressure from the converging markets is expected to push the market towards scenario *Internet Orientation*, whereas the mobile operators that have chosen to maintain their vertically integrated value chains strive towards the scenario *Operator Dominance*. Main importance lays in the question that are

[58] rich voice service refers to voice calling with additional features such as e.g presence and video calling.

the mobile operators able to fight against the structural change of market structure. If they succeed in this, the introduction of horizontal markets will be restrained or even forestalled.

Mobile operators that choose to step over to the Internet world and leave the voice service for some other company to provide will take a huge risk. Voice is definitely the biggest source of revenue for all the mobile operators and by assigning this service for some other company the operators actually give away their main source of revenue. However, it is not said that the structural change of market structure would force the mobile operators to ally with the service providers and to turn to bit-pipe operators. Even though, operators that have chosen not to take part on the market convergence might face difficulties in delivering services outside the company's core competence. Also the prevailing horizontal market structure of Internet services and the complexity of handling all the possible wireless network technologies might deter the mobile operators of moving towards scenario *Operator Dominance*. Thus the path towards scenario *Internet Orientation* becomes more anticipated.

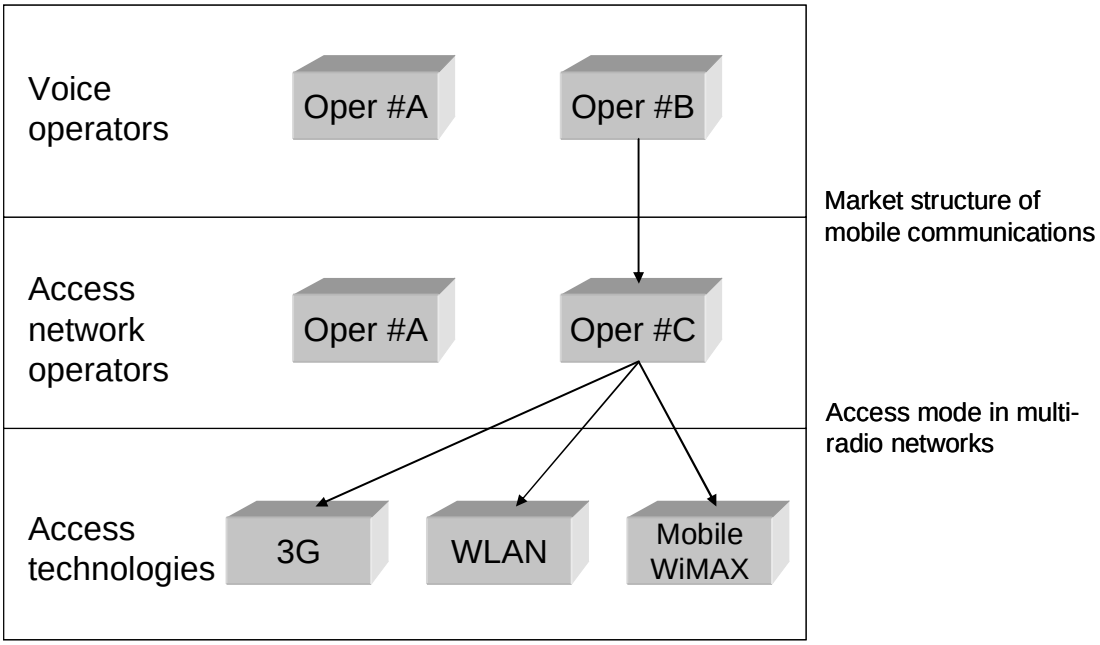
Figure 5-2 Possible development paths from scenario Operator Control



5.2.2 Internet Orientation

Growing popularity of Internet services is leading the mobile industries to converge with the Internet world. In this scenario the convergence of mobile industries and service providers has led the mobile market structure to attain a horizontal structure although the divergence and interoperability of wireless network technologies has not yet matured sufficiently to provide ubiquitous wireless Internet. In this scenario the mobile operators are expected to have recognized the future breakage of the action based pricing that reflects on the considerations of heading towards flat-rate pricing and ultimately also towards bit-pipe operator business model. Similarly as with the previous scenario, the character of this scenario is to be slightly fragmented between the old Telco world and new Internet world. However, in this scenario the role of service providers is emphasized even more than on the previous scenario as the amount of services and applications is not limited to only one service operator. This scenario supports also the distinction between network operators and service providers the way they are presented in the Communications Market Act[59].

Figure 5-3 Market structure and Access mode in scenario: Internet Orientation

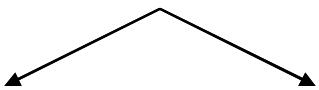


[59] [MINTC 2003]

The figure 5-3 illustrates the prevailing market dynamics that have been affected by the industry structural change. Operator B is a virtual operator providing VoIP service for its customers, whereas operator C has an exclusive right to provide the network access for the customers of operator B. More accurately, the Operator C manages all the connections to the mobile handset, either due to legacy business models in mobile communications or due to monopolistic control over the various network technologies.

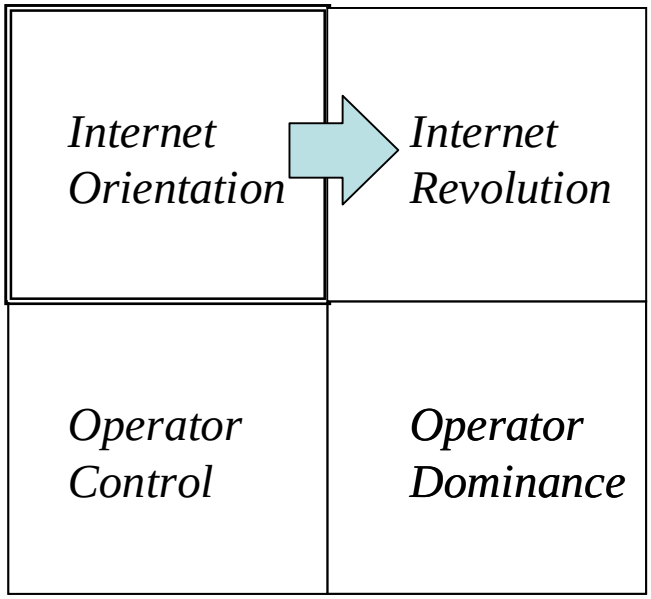
Compared to the current situation, the biggest difference in this scenario is the separation of services based industry and mobile network operators. In addition, the strongly tied customer relation between the legacy operator and the end customer is expected to be tied to the network access provider instead of the voice service provider. Other than voice based mobile Internet services providing companies are expected to find this scenario rather attractive as the huge penetration of mobile handsets will open completely new market for them. Further structural analysis of this scenario is presented on the Table 5-3.

Table 5-3 Structural analysis of scenario: Internet Orientation

Future Industry Structure	• Mobile operators move towards the model of bit-pipe operators. • Horizontal market structure is to stay • Network access and service providers separated • Various wireless network technologies have emerged • Mobile Internet services are growing
Structural Attractiveness	• Moderate, yet unknown pricing issues.
Sources of Competitive Advantage	• Converting value chains into value networks • Adopting the internet model into mobile world • Mobile VoIP seen also as a complementary service
Competitor Behavior	What will be the pricing level of bit-pipe operators and VoIP service providers?  Competitive Out of scale

If the horizontal market structure dominates the mobile industry, it would also imply that the future evolution would most probably lead towards scenario *Internet Revolution*. Horizontal business models are thus expected to maintain their position on the market, leading the mobile markets to the scenario Internet Revolution with multiple IP supportive wireless access technologies and with multiple operators providing the networks in a competitive environment.

Figure 5-4 Possible development paths from scenario: Internet Orientation

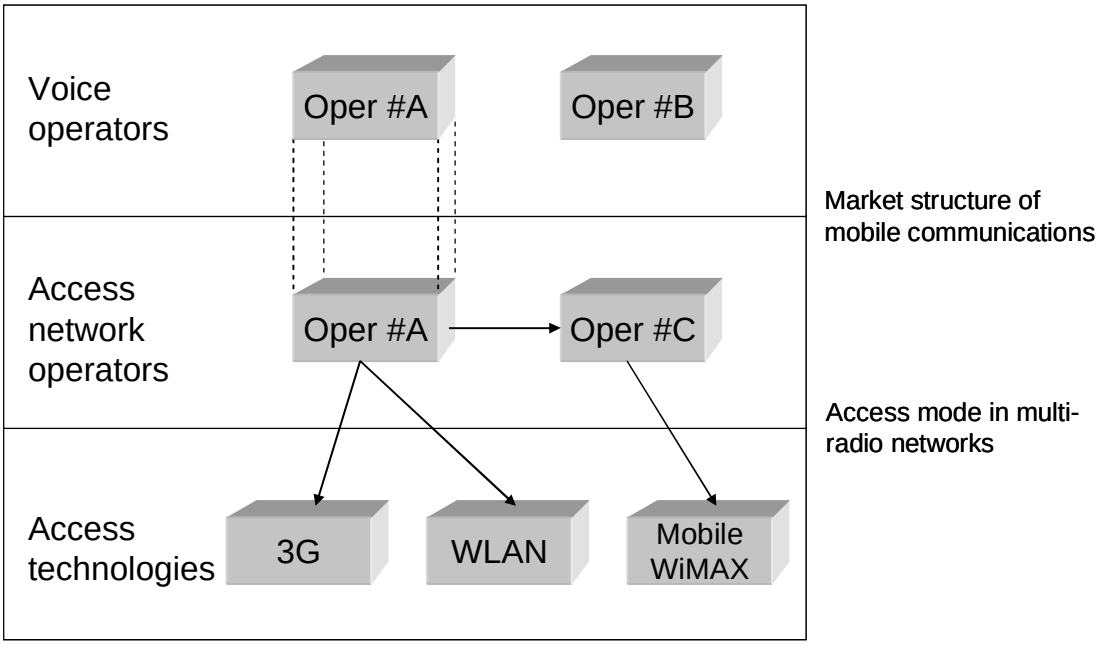


5.2.3 Operator Dominance

In this scenario the most relevant matter is the significant market power of mobile operators that is difficult to be overtaken by challenger actors. Mobile operators are considered vertically integrated in this scenario and a term master mobile operator is introduced to describe an operator that provides the voice service and the network access for its customers. Main characteristic of this scenario is however the relation in ownership and management of the alternative wireless technologies. Alternative networks that are not managed by the master mobile operator are seen either inaccessible with the mobile handset or access to these networks must granted by the mastering mobile operator. In short, this

would mean that if the user is willing to use a network that is not owned by the master mobile operator the network needs to have a roaming contract with the master mobile operator. Figure 5-5 illustrates the dynamics between the different operators in this scenario.

Figure 5-5 Market structure and Access mode in scenario: Operator Dominance

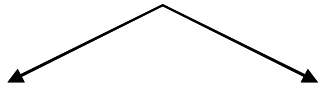


Operator A is seen as a master operator in this scenario. Operator C is an alternative network access provider with whom the Operator A has made a contract so that Operator A's customers are able to deploy Operator C's network in places where Operator A has no network coverage. The competitive network solutions are nevertheless acting in a cooperative mode in this scenario. True competition of the network access is thus left for the scenario with horizontal market structure. In an international level the cooperative contracting between network operators is better known as roaming agreements. However, on a national level the same concept is referred with a term national roaming.

Regulation of communication markets on its current form supports also this scenario. Pricing of interconnection and ability to route traffic to cellular networks are problems for current the VoIP service providers and the proprietary solutions. If the competitiveness of

these alternative services is hindered by the regulation it will also lead situation where the mobile industries and service providers will never converge and the horizontal Internet model will newer become dominating. Other structural analysis of this scenario is presented on the table 5-4.

Table 5-4 Structural analysis of scenario: Operator Dominance

Future Industry Structure	• Mobile evolution fully dominated by mobile operators • Substitutive products partly absorbed into mobile operators service packages • Subscriptions dominate over subscribers • Mobile operators manage the use of alternative networks
Structural Attractiveness	• High - Value chains stay the same
Sources of Competitive Advantage	• Economies of scale • Bundling of services into the subscription • Global interoperability and roaming
Competitor Behavior	What will be the significance of converging mobile industries and service providers?  Insignificant Significant

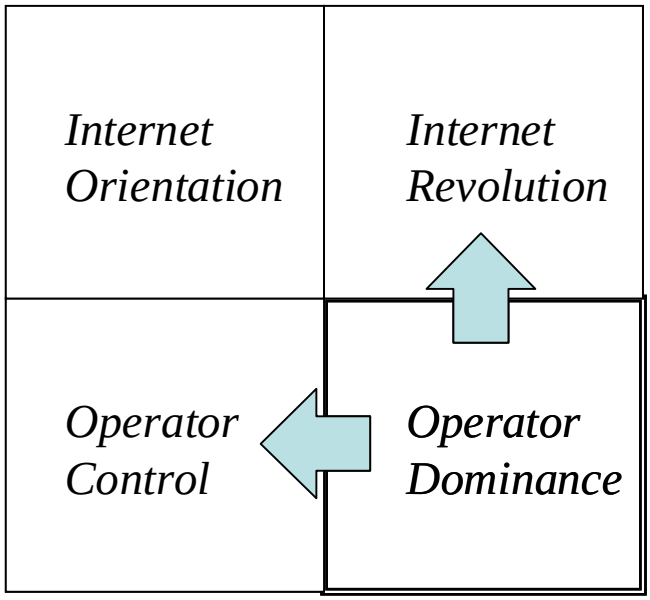
Those mobile operators that have already invested heavily on their network infrastructure and chosen the way to follow evolution of 3G and beyond will undoubtedly use their negotiation power over the regulator. Any huge investment on the network infrastructure introduces a risk that is posed by the alternative radio technologies and their possibilities to steal a share of the mobile markets. Thus the regulator must take into consideration both the long term investments made by the mobile operators and also try to regenerate the regulation in order to be able to introduce competition. Thus the regulation can be said to have the most significant power in this scenario.

The biggest uncertainty in this scenario is whether the companies should stick in the operator centric vertical business model or not. The Internet services will undoubtedly enter the mobile phones; the only question lays in the fact that is the service or application

provided by the operator instead of the specialized service provider. The penetration of Internet services will definitely unite the mobile industries with the Internet world but as long as the operators hold the actual voice subscription on their hands, the horizontal market structure will find it difficult to become prevailing. Also, as the centralized management of multiple access networks sets the mobile operators' value chains into vertical form, no other player is able to access the phone and thus charge for the connection. However, the horizontal market structure is also as possible as the vertical market structure because the mobile operators may face the pressure of horizontalization not only due to voice service but also from the other Internet services.

Outcome is that this scenario has two possible future directions; mobile operators may stick with the vertically integrated business model or open the voice service, turn to bit-pipe operators, and face the internet revolution. Some operators are also expected to e.g. hinder the market convergence with challenger buyouts or with using advantage of significant market power on contracting with the challenger companies.

Figure 5-6 Possible development paths from scenario: Operator Dominance



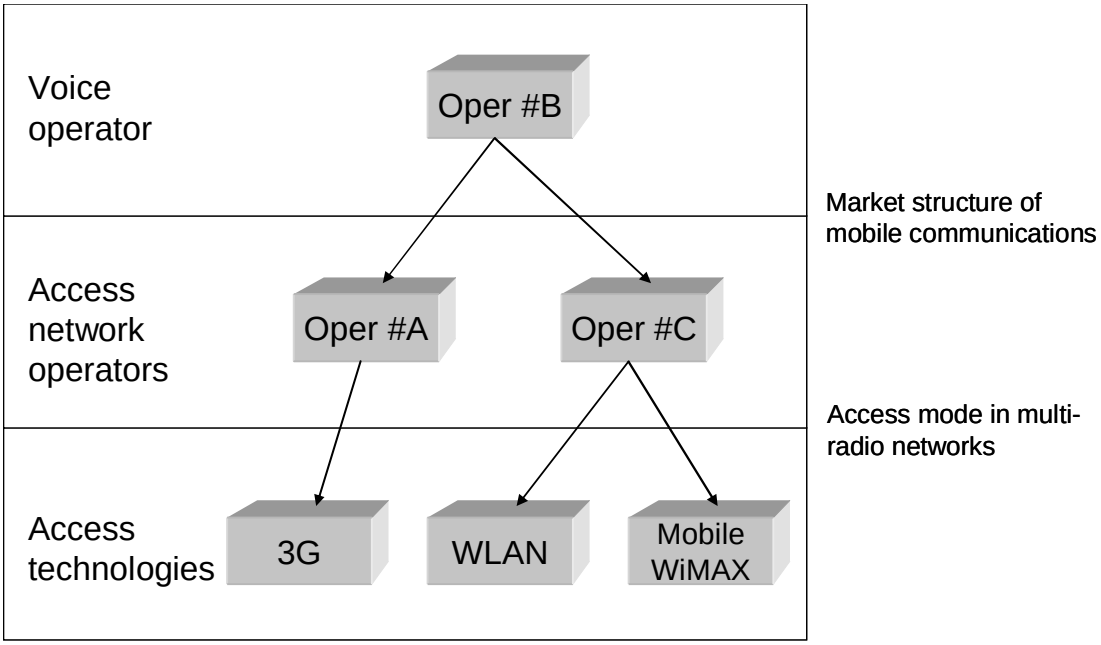
Arrow, on figure 5-6, that leads left towards scenario *Operator Control* illustrates that the concept of national roaming is not expected to hold this variable on stable state in the same

way as the horizontal breakage of the market structure is expected to do in the other scenarios. Thus, as this scenario is only a contractual setting of the access mode variable, the future prospect of this scenario might also lead towards scenario *Operator Control.*

5.2.4 Internet Revolution

This scenario constitutes the final product of the fully matured scenario variables. However, to present this scenario it is noteworthy that the evolutionary paths that lead to this scenario differ and also give this scenario slightly different characteristic. The possibilities to enter this scenario are either to adopt the early Internet model in which the user habits and usage will support the horizontal business models and thus ease the adoption of this model. Whereas, if the followed path goes through scenario *Operator Dominance* the users will become more prone to service bundles and ready made solutions. In the latter case the breakthrough of this scenario is expected to last longer than if the evolution would have been guided through the scenario *Internet Orientation*.

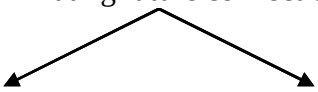
Figure 5-7 Market structure and Access mode in scenario: Internet Revolution



In this scenario the market structure is strongly horizontal and the distinction between services and network accesses is made clean cut. Thus the markets have many ways to provide the mobile VoIP service for the customer; the customer can either self manage both the VoIP service and the wireless network accesses or the services can be combined by an external service aggregator. Furthermore, in the latter case the service aggregation can also be driven by the voice service provider or by the network operator. For example the network operator may recommend certain VoIP services alongside with the mobile network subscription. Or the other way round, the service provider may recommend certain network operator. Main characteristic of this scenario is, however, that the user may use several wireless network operators to hold the mobile handset online.

Market dynamics of the operators and service providers, alongside with the utilization of wireless networks is illustrated on the figure 5-7 where the user uses operator B's voice service but accesses the service through network operators A and C. Thus the market has horizontal structure and the user utilizes several network operators to access the voice service.

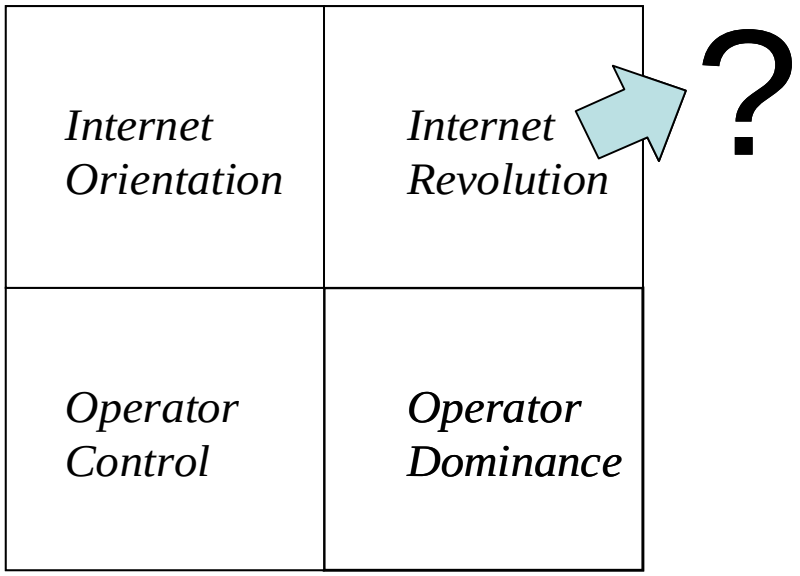
Table 5-5 Structural analysis of scenario: Internet Revolution

Future Industry Structure	• Service providers differentiated from network operators • Heavy divergence in access technologies • Bit-pipe operators dominate • Interoperability grows
Structural Attractiveness	• High for emerging service providers • Undefined for network operators
Sources of Competitive Advantage	• Differentiation strategies • Services based mobile industry • Subscribers instead of subscriptions
Competitor Behavior	What will be the dominating future connection to the Internet?  Fixed Wireless

Interoperability of the networks will probably set the highest demand for this scenario. Utilization of multiple access networks together with the support for seamless operability and mobile use will not be an easy task. Some sort of interoperability has been seen also in the previous scenarios as all the scenarios serve the idea of multiple radio interfaces. However, all the other scenarios more or less concentrate on providing the service within the same operator or within collaboration of the operators. This scenario introduces the access mode to be completely opened and that the networks are actually seen in competitive context between each other.

The future direction of this scenario is let wide open as any assumption about the future beyond this point becomes too unrealistic. On the other hand, to hold the scope and timeline of this thesis there is no need to go beyond this point as no groundbreaking technical or business launch is expected to become dominant in the scope of this thesis. Furthermore, as the figure 5-8 illustrates, the scenario variables are not considered to be backwards integrative in this scenario. This is due to already previously presented reasons of horizontal market structure staying horizontal once it has reached that state. Additionally, the multi operator access mode is not considered to be tied to single operator mode similarly as it was done in the scenario *Internet Orientation*. This is also expected to be due to the market power of VoIP service providers, since none of them is expected to be willing to bind the customers with restricted network access.

Figure 5-8 Possible development paths from scenario: Internet Revolution



A lot has changed if the industrial development leads all the way to meet the mobile Internet revolution. This scenario itself is rather vaguely defined as it is also the most distinct to current industry structure. Main issues rising in this scenario would be the question of wireless connections taking totally over the wired connections in terms of ubiquitous wireless internet access. Other issues would be the content independent communications which will ultimately lead to distinction of access providers and service providers and further to an issue of funding the services. Currently the VoIP telephony is riding on a crest of the wave by allowing free calls inside the VoIP domain. However, in future prospects this doesn't look promising and other earning principles need to be discovered. One such a principle would be to implement commercial funding, which is already implemented e.g. by the Blyk-operator[60].

This scenario is also justified with the insights that Anssi Vanjoki, Nokia Vice President and General Manager of Multimedia, have pointed out[61]. These are;

- Regulation needs to keep track of the changing world.
- There is only one digital industry.
- Internet model is to become dominating.

[60] http://about.blyk.com/ accessed 24.7.2007
[61] http://netlab/tutkimus/coin/COIN_seminar_2007/COIN_Seminar_2007_Vanjoki.pdf

5.3 Strategies to confront the scenarios

```
"Which one is the right path?"                        - asked Alice to the cat.
"That depends"                                        - said the cat.
"Of what?"                                            - asked Alice.
"Of where you want to go"                             - replied the cat moving his tail.
"It really doesn't matter"                            - said Alice raising her shoulders.
"Then it doesn't matter which path you choose..."     - said the cat.


--
       Levis Carroll
       Alice in the Wonderland, 1865
```

5.3.1 Strategic approaches to the scenarios

Now, after having introduced and analyzed the set of industry scenarios, the next rational step is to plan competitive strategies for the companies pondering in their strategic decisions considering the future mobile voice market. Porter (1985) introduces five fundamental approaches to dealing with uncertainty in strategy selection. These are especially of the essence when a company faces several plausible scenarios with differing strategic implications. Following approaches are the ones that companies should consider when planning their future directions. [Porter 1985]

Bet on the most probable scenario is probably the most common case in strategy formulation. Operators choosing their future directions might not even consider the other scenarios than the most probable one, thus the decision to follow the most probable scenario is often done implicitly with minor preparations for the other possible scenarios. However, this strategy might give the challenger VoIP solutions and new emerging applications a possibility to gain ground on the hidden and concealed markets.

One aspect that is noteworthy with this approach is that neither this thesis, nor the scenario method in general, predicts any probabilities of the scenarios. Thus the scenarios presented

in this thesis should be ranked with guidance from some other sources than only by this thesis.

Bet on the "Best" scenario is an approach in which the company managers select a strategy that the operator is expected to create the best competitive advantage. This approach differs from the previous one as the companies usually face different potentials on the future scenarios given their initial position and available resources. However, the operators choosing to follow this path must also face the risk that the "best" scenario might not occur and the chosen strategy becomes worthless. With respect to the previously introduced scenarios, the risk in betting on the best scenario would mean in most cases neglecting the power of converging mobile industries. In short, betting on the best scenario would imply a strategic choice of either trying to follow the operator centric path and hope that the market structure stays vertical. Or, in contrast, given that the mobile operator has already focused its business to head to the converging Internet markets, the best scenario would be one with the horizontal market structure. However, when betting on the best outcome, the operator's initial setting has a vast effect on the desired scenario.

Hedge. Opposite of betting on the "best" scenario is preparing against all the scenarios. Thus the outcome is usually a strategy that is not optimal for any scenario, though the risk is also lower as the company is prepared for all the possible scenarios. In regard to mobile VoIP, hedging would mean preparing for the horizontal service-led industry structure but also producing the VoIP services in-house. Similarly, it would mean preserving for all the alternative radio technologies, besides building up the 3G networks. Hedging would be good strategy for any virtual operator or smaller mobile operator in the short run, but really crucial for any operator in the long run. Especially the biggest incumbent operators rather monitor the markets than actually start to put effort on certain technologies. The amount of work and resources committed to a certain technology is then a part of company's internal policy and difficult to estimate from outside. In the end, hedging will demand lots of resources and work which will hinder the development of other technologies. An operator applying this strategy will finally end up lagging the operators with full commitment to only one scenario.

Preserve flexibility is an approach close to hedging. An operator following this strategy should try to maintain wide strategic insights in order to reduce the risk of early actions towards certain scenario. In telecom business, and especially related to current VoIP deployments this is well justified strategy to deal with the market uncertainties. Postponing any resource commitment that may lock the company into a particular strategy plays an important role in this strategy.

Influence is a strategy in which the mobile operator influences the market with its own resources to bring about the scenario it has the most competitive advantage. Simply put, the company may try to affect the causal factors behind the scenario variables in such a way that the favored scenario will occur. In the market of mobile VoIP this would mean to promote (or to discard) e.g. the alternative radio technologies or proprietary solutions.

Influence is one of the most challenging methods to follow a strategy as it is the only proactive method that a company can follow to make separation on the prevalent market structure. Some of the strategies could be implemented simultaneously giving the company a higher degree of diverged strategy.

5.3.2 Selecting the strategy

Final strategy that a company chooses to follow must meet the company's initial position on the market and also be in balance with the resources available for the company. Porter (1985) introduces five factors of how to come to a decision with the most suitable strategy.

First-mover Advantages are known to be important for a mobile operator that wants to gain early market share or gather widest variety of contractual advantage with e.g. the service providers. However, when mobile VoIP deployments are considered, the first-mover will not awake the customer masses as the market is saturated with high penetration of cellular subscriptions and the alternate solutions reside at the hands of 3rd party solution providers. Thus changing rapidly into mobile VoIP is not considered as a good first mover act. On the other hand, an operator that is able to contract with the 3rd party service providers and make service bundles might also be able to gain the biggest contractual

advantage of the converging mobile industries. Best scenario in this case would be to exclusively manage the convergence of mobile industries and service providers and thus leave the competitors outside of this market.
Sustained flexibility is most likely lost if an operator chooses to strive for the advantage of being the first-mover. However, if a company seeks for leadership on *the most probable scenario* or *bets on the best scenario* the first-mover advantage becomes important approach to overtake the markets.

Initial Competitive Position is a factor that the operators must assess carefully and find the relevant importance of the advantage the company can gain through it. Similarly as with *betting on the best scenario* the assessment of initial competitive position gives the operators narrow but well reasoned strategies which to follow. E.g. if an operator with its given initial resources faces two possible scenarios, from which the first turns out to be twice as profitable as the second one, but respectively the probabilities to meet these scenarios are 1/3rd vs. 2/3^{rds} the company finds the first scenario more tempting, even though the odds to meet this scenario are against. Thus *influencing the market* is often seen as a combined strategy when *betting on the best scenario*, due to strategic compatibilities of these both approaches.

An example of the given initial conditions meeting the industry structural change could be i.e. bit-pipe operational model applied by a mobile operator. In many cases the mobile operators have grown too massive on their customer support services and other auxiliary services. Therefore bit-pipe operating model can be difficult to achieve and it is feasible only for a small number of mobile operators. Thus it is worth noting that the initial condition of a company in many cases disables certain business strategies rather than enables them.

Cost or Resources required are, in general, factors that all the companies must assess in strategic future preparations as all the scenarios presented in this thesis demand some future actions. However, the given initial conditions set the companies on different initial positions and thus also the demand for costs and resources varies along the companies.

Companies that decide to follow *Hedging* or *Influence* strategies tend to require higher cost and resource demands than companies that choose to count only on one possible scenario. *Preserving flexibility* is also less demanding in the short run but will also turn costly to follow if the market does not indicate any movement towards certain scenario.

Competitors' expected choices are the ones every player on any industry wishes to identify in order to resolve the competitor acts and gain competitive advantage over the other companies. Any act performed by a company will reflect the decided strategy for its competitors and thus either preempt the competitors from certain strategies or open up other possibilities. By far, any of the Finnish mobile operators or VoIP service providers hasn't showed any kind of interest to launch commercial mobile VoIP, though IMS and GAN are studied for many years. Especially the utilization of Packet Switched domain with VoIP deployments is going to be an interesting future act, also if performed by virtual data operator.

Risk is a factor that is prevalent in any industry independent of its structure. Certain factors that characterize the risk can be defined according to the special characters of the analyzed strategic approaches. Porter (1985) defines four factors that generate the risk on all these approaches. A firm that seeks for strategic direction should analyze its activities in the light of:

- Timing of resource commitment
- The degree of inconsistency of strategies for alternate scenarios
- Relative probability of the scenarios
- The cost of changing strategies once the uncertainty is resolved

Hedging and *preserving flexibility* are the most expected strategies among the Finnish mobile operators as the risk of lost revenues and fear of cannibalization drive the operators to defend themselves. On the other hand, the mobile operators have also showed their negotiation power over the regulator, thus they are expected to use this wildcard also in the future. Furthermore, as mentioned before, the regulation is found to be one of the important

causal factors affecting the scenarios. Thus influencing the regulation would be one of the key attempts to deploy *the influencing method*, even though it is also one of the most difficult ones.

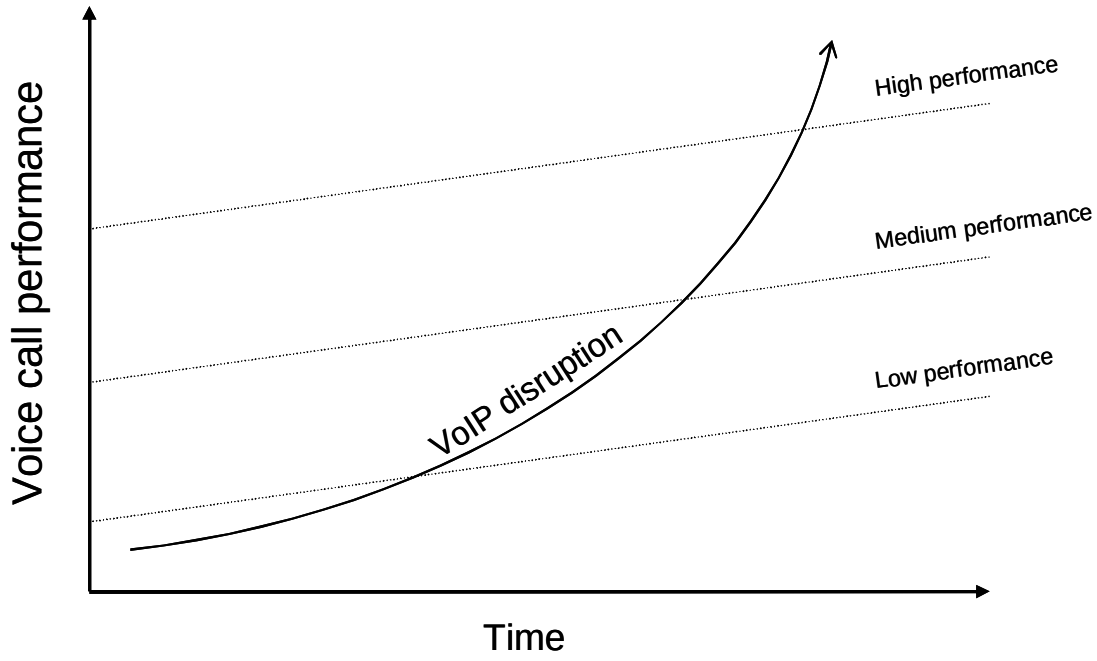
Scenario planning involves always risks and uncertainties which cannot be avoided as it gives the company guidelines of the future industry development. If the scenario planning process has not produced consistent scenarios the risk of distorted conception of the industry might lead the company into a situation where does not fully meet the actually realized industry structure. However, making conscious choices to follow one or more strategies to meet the future scenarios is a better way than inertia on management decisions. Also well planned and performed scenario analysis gives always better results than implicit strategic construction. What is more, the dynamics of the causal factors and variables that finally form the scenarios are a source of valuable knowledge that further correlates to the understanding of the business dynamics of the industry. Beyond this all lays also the contribution to the overall competitive advantage on the market

5.3.3 Final words

The final aspect that arises when VoIP technology's possibilities to overtake the mobile voice market are evaluated is that is the technology going to compete with the mass market or with high-end users. In the Internet domain the VoIP technology has been seen as a free service to speak throughout the world, similarly as email or chat-clients. In consequence, if VoIP service is to be targeted to mass markets in order to deliver cheaper solution to communicate, the prospects are good. Especially the proprietary solutions that have millions of registered users command vast amount of market potential. High end users are another side of the market but respectively VoIP can be targeted to meet the requirements of this segment as well. Demanding users could for example benefit from the presence information or other rich voice services or gain significant surplus value from the possibility to utilize the alternative wireless networks for voice calls. In this sense mobile VoIP solutions fit perfectly to meet the concept of disruptive innovation introduced by Clayton M. Christensen.

In the theory of disruptive technologies (or disruptive innovation) Christensen introduces "low-end disruption" that targets the user segment that is not profitably served by the incumbent. In telecommunications this has already happened with the fixed telephone network. Mobile networks have overtaken the PSTN networks and VoIP applications have started to become more general in home and office computers substituting the last remaining part of PSTN. Christensen theory continues with a statement that once a new innovative technology has gained foothold on the market it will seeks to improve its profit margin. Higher profit margins can be found from the target segments where the customer is willing to pay more for the product. To reach this target segment the mobile VoIP provider will need to innovate on how to reach the customers on this new target segment. What is more, the incumbent is not expected to fight vigorously for its least profitable customers, but rather to change is target segment higher to serve the more valuable customers. [Christensen 1997] The following figure 5-9 illustrates the market development with VoIP applications according to the Christensen's theory of disruption.

Figure 5-9 Progress of Voice over IP performance in voice call markets



According to Christensen theory the VoIP providers will gain foothold on the low performance markets but also seek for more profit on the higher markets. Thus, in the long

run, the technical evolution turns the VoIP solutions more efficient and they will capture the more demanding markets.

In the short run, VoIP technology can be seen as a substitutive service for circuit switched telephony. But on the other hand, if the concept of telephony is observed since Alexander Graham Bell invented the first analog telephone, the impact of VoIP as a new technology could be compared to digitalization of telephone systems. The old technology is actually only complemented with new features that the technical evolution brings along. Incremental development of new features and technologies has now come to the point when the old technology will not evolve sufficiently to be able to escape the new arrival.

6 Conclusions

This chapter summarizes the results of this thesis and discusses the consistency of the whole study process. Guidelines of the future research are also presented based on this study. This thesis presented an analysis of the development of future mobile VoIP markets and discussed the strategies mobile operators should follow in different future environments. The results were formed into five plausible future scenarios that should guide the discussion around the evolution of mobile VoIP.

6.1 Results

The main findings of this thesis are not only the scenarios that were constituted in order to deliver the final outcome of this study, but also the analysis of the business dynamics that affect the industry leading to these scenarios. Identifying the factors behind the industry structural change is supposedly even more valuable than the actual analysis since the analysis in this thesis is advisedly kept on an abstract level in order to be able to generalize the findings. More accurate analysis could be carried out with more exact viewpoint, e.g. to consider the scenarios with a differing initial setting and resources. Thus the scope could be bound on certain environment and the same study could be conducted to constitute company related micro-scenarios.

The constituted future scenarios on development of mobile voice communications describe the current market situation and mirror the future prospects of the evolving market. All the scenarios are based on the findings of the analysis of business dynamics. Final outcome of the analysis is that the future market structure depends on two independent variables; *Mobile market structure* and *Access mode in multi-radio networks*. These variables are dimensioned in two to form different aspects of the market. Four final scenarios were formulated based on these dimensions.

First of the Scenarios, *Operator Control*, continues closely from the current situation, the only difference being the expected emergence of mobile VoIP with support for multiple radio networks. In this scenario the voice is not a separate service from the network connection. Instead, a scenario called *Internet Orientation* is introduced to continue from the current situation with separation of the service providers and network access providers. In these two scenarios the biggest difference is whether the mobile operator controls voice calls or is the possibility of deploying VoIP open to rivalry.

The two latter scenarios are partly a continuation of the previous scenarios. Scenario *Operator Dominance* is probably most attractive for the mobile operators as it depicts the future to be fully controlled by the mobile operators, also in terms of controlling the VoIP usage. Whereas *Internet Revolution* is the opposite of *Operator Dominance*, stating the operators to be only bit-pipes and the actual content is to be determined by the users. In *Internet Revolution* the use of open access networks is emphasized, which is not believed to be possible in scenario *Operator Dominance*.

Main finding of all the scenarios is however the fact that in the long run the mobile industry is moving towards *Internet Revolution*. The only high scale uncertainty in this evolution is whether the evolution of mobile Internet will launch the industry structural change faster than the mobile operators can adapt to. If the revolution is to happen soon, the mobile operators need to take acts, as otherwise the challenging Internet solutions will have significant possibilities to rise and overtake the mobile service market.

A set of strategies is presented after the scenario construction to answer the fundamental question of selecting the right strategy. However, as there are numerous operators, there are also numerous different strategies to obtain. Therefore any certain strategy is not highlighted but the operators should consider the findings of this thesis with respect to their initial setting and resources. The main uncertainties in the strategy selection will inevitably be the question whether to seek for the alternative wireless technologies and what is the importance of Internet content on mobile phones.

6.2 Discussion

The purpose of this thesis is neither to set strict guidelines in which the development is assumed to happen nor to define the exact future facts about the evolution of mobile VoIP. The whole mobile VoIP industry is still in its infancy and the effect of the emerging industry structural change on mobile communications is still in both technical and economical sense. Thus the main outcome of this thesis is to illustrate the possible future prospects of the mobile industry, offer new insights for the interest groups of mobile industries and to raise discussion on the topics around the evolution of mobile VoIP.

The presented results best correspond to the development of the Finnish mobile VoIP industry, but as the study is conducted with a wide perspective taking into account also some European trends and phenomena the results become applicable for some other markets as well. In fact, as the mobile VoIP has not yet reached a significant position on any market, the analysis in this thesis considers all the markets of mobile communications where the Internet services are emerging to the mobile handsets.

This thesis is motivated with the author's interests in the mobile industries and thus reflects the author's subjective experience and interests on the mobile VoIP. However, the formal analysis of business dynamics is conducted according to the theoretical frameworks which gives this thesis structural plausibility. Furthermore, the critical factors that define the final scenarios were also grounded on specialist interviews which also add the objectivity of this thesis. In total six interviews were held to find the most important scenario variables. The interviewees were all specialists on mobile VoIP but represented different quarters of the mobile industry. With different selection of interviewees also different scenario variables might have been collected.

6.3 Future research

The purpose of this thesis was addressed to answer two questions: "What kind of disruption the mobile VoIP will bring to the current business of wireless communication industry?"

and "What kind of actions mobile operators and other service providers are able to take in order to outperform their competitors on the market?" However, now that the analysis has been performed and the results published the whole mobile industry can be seen in a totally new light. One of the unwritten findings of this thesis is that mobile VoIP, in its entirety, is still only side effect of a much bigger revolution – that is the Internet content overtaking the whole mobile world. Many studies on the market convergence and in technical details are yet to be performed in order to fully understand the significance this emerging industry structural change is about to inflict. Whether this change is good or bad is of course determined by the strategies that the individual companies choose to follow.

Other relevant directions for future research would be to apply quantitative analysis on the mobile voice markets in regards to emergence of mobile VoIP. Case analysis of certain mobile operators and their future prospects considering the deployment of VoIP technology might also help to understand the business dynamics of mobile operators. Also regulatory follow up is bound to the two previous issues, or it can be performed independently considering the alteration that VoIP needs in the current regulation.

Also other emerging Internet services that affect the concept of mobile communications should be studied to better understand the ongoing change in mobile industries. This thesis concluded with a finding that the mobile industry is actually on the verge of horizontalization but it was mostly found to be due to rising alternative solutions on mobile voice market. However, there are similar concepts and services rising also on other than voice market which will also push the market structure to take certain direction.

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