HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Electrical and Communications Engineering
Laboratory of Telecommunications Technology

Katja Koivu

DATA SERVICE DEVELOPMENT IN MOBILE NETWORKS

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Espoo, March 10, 2000

Supervisor Professor Ramin Baghaie

Instructors Olli Knuuttila, Master of Science
Mervi Ranta, Master of Science

HELSINKI UNIVERSITY OF TECHNOLOGY **ABSTRACT OF THE MASTER'S THESIS**

Author:	Katja Maaria Koivu	
Name of the Thesis:	Data Service Development in Mobile Networks	
Date:	March 10, 2000	**Number of Pages:** 96
Department:	Electrical and Communications Engineering	
Professorship:	S-38 Telecommunications Technology	
Supervisor:	Professor Ramin Baghaie	
Instructors:	Olli Knuuttila, M.Sc., Omnitele	
	Mervi Ranta, M.Sc., Helsinki University of Technology	

Fast developing and growing mobile telecommunications business puts pressure on fast service and product development. Services have to be as mobile as their users and fulfil various user needs. This thesis introduces a novel method for enhancing the customer-centred service development process, taking into account the rapidly changing mobile telecommunications technologies and their requirements.

The combination of user, business and technology aspects strongly affects the success of such services. All the aspects are needed in the service development process. However, the technology aspects set the most profound boundaries to the service implementation.

This thesis shows that the technology boundaries have to be taken into account when making decisions in different phases of the development process. The boundaries form criteria for proceeding in the process. Early service scenarios have to include enough information before they can be evaluated from the technological point of view. The evaluation gives insight into the opportunities the service scenarios contain and helps in selecting the best scenarios for forward development. After the evaluation, the scenarios can be converted into real concepts and prototyping can begin according to the ideas and criteria coming from the evaluation. However, what kind of criteria and how important the criteria are that the boundaries form depends highly on the company and intended service.

For this thesis, the Mediapoli wireless environment together with GO project facilities at Helsinki University of Technology offered excellent environment for simulating and testing mobile services as well as service development methods. The Wireless Local Area Network environment proved to be a suitable test bed for the future cellular services mainly because it does not set as strict bandwidth limits as the cellular technologies.

Keywords: Service Development, Mobile Networks

TEKNILLINEN KORKEAKOULU **DIPLOMITYÖN TIIVISTELMÄ**

Tekijä:	Katja Maaria Koivu		
Työn nimi:	Datapalvelujen kehitys matkapuhelinverkoissa		
Päivämäärä:	10.3.2000	**Sivumäärä:**	96
Osasto:	Sähkö- ja tietoliikennetekniikan osasto		
Professuuri:	S-38 Teletekniikka		
Työn valvoja:	Professori Ramin Baghaie		
Työn ohjaajat:	DI Olli Knuuttila, Omnitele		
	DI Mervi Ranta, Teknillinen Korkeakoulu		

Langattoman tietoliikenteen nopea kehitys ja kasvu edellyttävät nopeaa palvelu- ja tuotekehitystä. Palveluiden täytyy olla yhtä liikkuvia kuin niiden käyttäjätkin ja niiden tulee täyttää käyttäjien monenlaiset vaatimukset. Tämä diplomityö esittelee menetelmän, jota voidaan käyttää palvelukehitysprosessissa. Metodi ottaa huomioon nopeasti muuttuvat matkaviestinteknologiat ja niiden vaatimukset.

Palveluiden menestymiseen vaikuttavat useat tekijät käyttäjien, liiketoiminnan ja teknologian näkökulmista. Kaikkia näkökulmia ja tekijöitä tarvitaan palvelukehitysprosessissa, mutta teknologian asettamat kriteerit ovat ehdottomimpia palvelujen toteutuksen kannalta.

Tämä diplomityö osoittaa, että teknologian asettamat rajoitukset täytyy huomioida tehtäessä päätöksiä palvelukehitysprosessin eri vaiheissa. Rajoituksista muodostetaan kriteerejä, joiden perusteella prosessissa edetään. Varhaisten palveluskenaarioiden on sisällettävä riittävästi tietoa, jotta ne voidaan arvioida teknologian kannalta. Teknologiaevaluaation perusteella saadaan selville skenaarion mahdollisuudet ja samalla voidaan valita parhaimmat palveluideat jatkokehitykseen. Teknologiaevaluaation jälkeen voidaan skenaarioista muodostaa varsinaiset palvelukonseptit ja siirtyä prototypisointiin evaluaatiosta saatujen kriteerien ja ideoiden pohjalta. Yritys- ja palvelukohtaiset erot vaikuttavat kuitenkin suuresti kriteerien luonteeseen ja tärkeyteen.

Mediapolin langaton ympäristö Helsingin Teknillisessä Korkeakoulussa täydennettynä GO-projektin valmiuksilla tarjosi diplomityölle erinomaisen alustan langattomien palvelujen ja palvelukehitysmenetelmien simulointiin ja testaukseen. Langaton lähiverkkoympäristö (WLAN) osoittautui erittäin sopivaksi testialustaksi tulevaisuuden matkaviestinpalveluille: WLAN verkossa saavutetaan paljon suurempia datanopeuksia kuin matkapuhelinverkoissa.

Avainsanat: Palvelukehitys, Matkapuhelinverkot

Acknowledgements

I wish to thank my supervisor, Professor Ramin Baghaie, who has helped and guided me through the last steps of my master's degree.

I am grateful to my dear instructor Mervi Ranta for her enthusiasm and support. Her strength and confidence carried me through the times when I was in doubt. I would also like to thank the other members of the fantastic GO-PROD team for their cheerfulness and inspiring company. I would not have made it without them.

I am also thankful to the Omnitele staff, especially my other instructor Olli Knuuttila for his guidance and valuable comments. In addition, I would like to thank my colleague Jussi for his healthy criticism.

Finally, I wish to express my deepest gratitude to Janne and my dear parents Seija and Timo for their love and encouragement.

10th March, 2000 in Espoo, Finland

Katja Koivu

Table of Contents

ABSTRACT I

TIIVISTELMÄ II

ACKNOWLEDGEMENTS III

TABLE OF CONTENTS IV

LIST OF FIGURES VII

LIST OF TABLES VIII

LIST OF ABBREVIATIONS IX

1 INTRODUCTION 1

1.1 OBJECTIVES OF THE STUDY 1
1.2 SCOPE OF THE STUDY 2
1.3 METHODOLOGY AND STRUCTURE OF THE STUDY 3

2 MOBILE NETWORKS AND SERVICES 4

2.1 GSM PLATFORM EVOLUTION 4
2.1.1 High Speed Circuit Switched Data 5
2.1.2 General Packet Radio Service 6
2.1.3 EDGE 7
2.1.4 UMTS 8
2.2 GSM DATA SERVICES 11
2.2.1 Short Message Service 13
2.2.2 Wireless Access Protocol 13
2.3 CONVERGENCE OF THE INTERNET AND MOBILE TELECOMMUNICATIONS 15
2.3.1 Internet/IP Technology 16
2.3.2 Mobile IP 17

3 TELECOMMUNICATIONS BUSINESS 19

3.1 PLAYERS IN THE TELECOMMUNICATIONS BUSINESS 19
3.2 SMS SERVICE BUSINESS 23
3.3 REGULATORY ISSUES 24

4 FROM SERVICE IDEA TO IMPLEMENTATION....................................26

4.1 SERVICE DEVELOPMENT PROCESS..26

4.1.1 Business Strategy and New Service Strategy Development.................................28

4.1.2 Idea Generation...29

4.1.3 Service Concept Development and Evaluation...29

4.1.4 Business Analysis...31

4.1.5 Service Development, Testing and Prototyping...31

4.1.6 Market Testing...32

4.1.7 Commercialisation and Post Introduction Evaluation...33

4.2 TOWARDS AN EVALUATION AND VALIDATION FRAMEWORK.......................................33

4.2.1 Requirements for Technology Criteria and Design Framework.............................35

4.2.2 Creating the Framework..36

5 TECHNOLOGY BOUNDARIES IN MOBILE TELECOMMUNICATIONS .38

5.1 NETWORK ASPECTS..39

5.1.1 Capacity..39

5.1.2 Quality of Service...42

5.1.3 Coverage..46

5.1.4 Data Rate/Bandwidth..47

5.2 TERMINALS...48

5.3 SECURITY..49

5.4 INTEROPERABILITY, SCALABILITY, ADAPTABILITY..50

6 FRAMEWORK FOR SERVICE CONCEPT DEVELOPMENT AND EVALUATION...52

6.1 CONCEPT GENERATION...54

6.2 TECHNOLOGY EVALUATION..56

6.2.1 Guidelines..57

6.2.2 Evaluation Form..58

6.3 PROTOTYPING..59

7 CASE STUDY: MOBILE MUSIC...61

7.1 PROJECT INTRODUCTION...61

7.2 GO PLATFORM...64

7.2.1 Coverage and Capacity of the GO Platform...64

7.2.2 Data Rate of the GO Platform...65

7.2.3 Quality of Service of the GO Platform..65

7.2.4 Terminals in the GO project...65

7.3 SERVICE CONCEPT GENERATION..66

7.4 SERVICE DESIGN..66

7.4.1 *Streaming MP3 Player Service* *68*
7.5 SERVICE PROTOTYPE 69
7.5.1 *Criteria for a Prototype* *70*
7.5.2 *MP3 Player* *70*
7.5.3 *Features of Music in MP3 Format* *71*
7.6 PROTOTYPE IMPLEMENTATION IN THE MOBILE NETWORKS 71

8 CONCLUSIONS 73

8.1 FUTURE WORK 75

REFERENCES 76

APPENDIX A WIRELESS LAN FEATURES 82

APPENDIX B MOBILE MUSIC SCENARIOS AND TECHNOLOGY MODELS 84

APPENDIX C DESIGN RATIONALE 91

APPENDIX D EVALUATION GUIDELINES 93

APPENDIX E TECHNOLOGY EVALUATIONS FOR MUSIC SCENARIOS 94

List of Figures

FIGURE 2-1. EVOLUTION OF GSM TOWARDS THIRD GENERATION NETWORKS [REI99]..........................5
FIGURE 2-2. STRUCTURE OF GPRS NETWORK..6
FIGURE 2-3. UMTS ARCHITECTURE [ETS98A] 8
FIGURE 2-4. UMTS - GSM/GPRS NETWORK ARCHITECTURE [VES99] 10
FIGURE 2-5. ERICSSON R380 WAP PHONE [ERI99A] 14
FIGURE 2-6. TUNNELLING OPERATIONS IN MOBILE IP [PER98]..18
FIGURE 3-1. VALUE CHAIN IN MOBILE TELECOMMUNICATIONS BUSINESS [HEI99]................................19
FIGURE 3-2. BUSINESS MODEL FRAMEWORK [KAJ99] 21
FIGURE 3-3. POSITIONING OF PLAYERS IN THE MOBILE INTERNET [USK99]..22
FIGURE 3-4. SMS BUSINESS STRUCTURE [HAA99] 24
FIGURE 4-1. SERVICE DEVELOPMENT PROCESS [ZEI96] 27
FIGURE 4-2. BOUNDARIES AND IMPLEMENTATION FLOWS...34
FIGURE 4-3. FRAMEWORK ADAPTABILITY TO DIFFERENT NETWORKS...35
FIGURE 4-4. CRITERIA CLASSIFICATION 36
FIGURE 5-1. SERVICES FEATURES BY APPLICATIONS AND PLATFORMS 38
FIGURE 5-2. CALCULATION METHOD FOR UMTS SPECTRUM [UMT98C]...41
FIGURE 5-3. BANDWIDTH DEMAND OF SERVICES [SAA99A] 48
FIGURE 6-1. PROCESS AND BOUNDARIES 52
FIGURE 6-2. FRAMEWORK FOR SERVICE CONCEPT DEVELOPMENT AND EVALUATION 54
FIGURE 6-3. TECHNOLOGY MODEL 56
FIGURE 7-1. SERVICE DESIGN FRAMEWORK [RAN00B] 67
FIGURE 7-2. TECHNOLOGY MODEL FOR THE SERVICE PROTOTYPE 68
FIGURE 7-3. THE STREAMING MP3 SERVICE [MÄN00]...69

List of Tables

TABLE 2-1. WORLD-WIDE MOBILE MARKET FORECAST [UMT98A]....12
TABLE 2-2. THE MOST POPULAR WEB PAGES IN FINLAND, MAY 1999 [JUV99]....16
TABLE 4-1. ESTIMATED COST OF FINDING ONE SUCCESSFUL NEW PRODUCT [KOT97]....28
TABLE 5-1. QUALITY CODES IN GSM [NOK94]....43
TABLE 5-2. PROPOSED UMTS QOS CLASSES [3GP99]....44
TABLE 5-3. OPERATIONAL ENVIRONMENTS [UMT98C]....46
TABLE 5-4. DATA RATES IN DIFFERENT PLATFORMS....47
TABLE 6-1. EVALUATION GUIDELINES....57
TABLE 6-2. EVALUATION SHEET FOR TECHNOLOGY EXPERTS....59
TABLE 7-1. CRITERIA FOR PROTOTYPING....70
TABLE 7-2. TECHNOLOGY EVALUATION OF THE MUSIC SERVICE....72
TABLE 7-3. DOWNLOAD TIMES FOR 2MBYTES OF MUSIC....72

List of Abbreviations

AIUR	Air Interface User Rate
bps	bits per second
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Station
CBD	Central Business District
CDMA	Code Division Multiple Access
CN	Core Network
CPU	Central Processing Unit
CS	Circuit-Switched
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
D-AMPS	Digital Advanced Mobile Phone System
DCS	Digital Cellular System
DR	Design Rationale
DSSS	Direct Sequence Spread Spectrum
DST	Destination
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
EU	European Union
FA	Foreign Agent
FHSS	Frequency Hopping Spread Spectrum
FNUR	Fixed Network User Rate
FSK	Frequency Shift Keying
FTP	File Transfer Protocol
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HA	Home Agent
HIPERLAN	High Performance Local Area Network
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data

HTC	Helsinki Telephone Corporation
HTML	Hypertext Markup Language
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
IP	Internet Protocol
IPv4	Internet Protocol version 4
IS-95	Interim Standard –95 (CDMA)
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunications Union
LAN	Local Area Network
MH	Mobile Host
MM	Multimedia
MP3	MPEG-1 Audio Layer-3
MPEG	Moving Picture Experts Group
MS	Mobile Station
MSC	Mobile Switching Centre
NMT	Nordic Mobile Telephone
NSS	Network Subsystem
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
PKI	Public Key Infrastructure
PLMN	Public Land Mobile Network
PPP	Point-to-Point Protocol
PS	Packet-Switched
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RLAN	Radio Local Area Network
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RTS/CTS	Request to Send/Clear to Send
SGSN	Serving GPRS Support Node

SIM	Subscriber Identification Module
SMS	Short Message Services
SMSC	Short Message Service Centre
SRC	Source
TAC	Telecommunications Administration Centre
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS terrestrial radio access
UTRAN	UTRA network
W-CDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
VLR	Visitor Location Register

1 Introduction

The mobile telecommunications and the Internet world are converging. The number of subscribers in both areas has been increasing at a very high rate in the past few years and there is no reason to assume that this development would slow down. Operators and other parties of the telecommunications value chain will meet many challenges in developing and providing services for the more than ever moving and demanding users. Mobile services have to become as mobile as their users. They have to be extended to take advantage of the constantly changing context in which they are accessed.

With all the opportunities and possibilities available in mobile telecommunications the pressure to introduce new products and services on market is extremely hard. In addition, the service development process is usually long compared with the time a product or a service is on the market – lifecycles are short and the technology is fast moving forward. Realising services from idea to implementation and commercialisation requires thus practical processes and knowledge of technology. Service development also requires understanding of service implementation issues: what is possible and what is feasible.

1.1 Objectives of the Study

The research objective of this thesis is to create an analysis and validation framework for service development process. The framework helps service developers to clarify the suitability of services for different platforms and vice versa. This requires defining the service development process affected by technological issues in mobile telecommunications business.

The aim is to capture how the mobile environment requirements have to be taken into account while making development decisions. Furthermore, the aim is to clarify how the requirements are realised by the features and functions of the service. Such knowledge is a basis for suitable reuse of the experience in future development work.

To reach the goal it is important to understand features of services and the technologies behind them, both on the Internet and also in mobile telecommunications systems. One component in successfully understanding the mobile service implementation and where the boundaries for services come from is to define the parties of the value chain and their impact on the mobile telecommunications business.

One of the main questions is how to implement a specific service in various mobile telecommunications systems with different features. Thus, knowing what different types of services require from networks is essential.

Furthermore, a case study is done within the General Packet Radio Service (GPRS) in Otaniemi (GO) project [GO99]. The case study includes examining different stages of the development process and then studying a prototype of a service that emerges during the process. The GO project is a part of the MediaPoli-concept at Helsinki University of Technology in Otaniemi. It focuses on the issues of mobile Internet access and establishes a wireless service architecture. The key objectives of the GO project are to establish a wireless data communication network for research and educational purposes and to establish a platform for 3rd/4th-generation mobile and wireless Internet network research and development. Furthermore, mobile and wireless Internet networks' properties, special topics of the mobile environment, and service and end user issues are studied. In this thesis, the project platform is examined generally as a whole and then the study concentrates on the GO-PROD (Product concepts and user aspects) subproject.

1.2 Scope of the Study

The study is focused on data services implemented on Global System for Mobile Communication (GSM) and its evolution platforms in the European market. Furthermore, this study focuses on customer-centred design [Bey98]. The focus is on the technological aspects that have to be taken into account during the design process. Customer-centred service development is extremely important and interesting compared with purely technology-oriented development. It is hard to find continuous competitive advantage through only technology-oriented development in telecommunications [Rin99].

1.3 Methodology and Structure of the Study

The structure of the study is as follows. First, a literature survey is carried out to get a solid theory base for the thesis. The theoretical part is complemented with results of the empirical study, made by interviewing three experts working in the telecommunications business and with information from newspapers, telecommunications magazines and seminars.

The theoretical framework for the study consists of Chapters 2, 3 and 4. First, mobile technologies and mobile service concepts are handled in Chapter 2. An introduction of mobile telecommunications related business parties and other business issues follows. This includes introduction of the business criteria that belong to the later created framework. The service development process is introduced in Chapter 4.

The framework is developed during Chapters 4, 5 and 6. After the theoretical part, a synthesis is made at the end of Chapter 4. The synthesis includes definition of a preliminary framework for empirical studies. In Chapter 5, technological boundaries that affect services and service usage are defined. As a synthesis of the previous chapters, the actual framework and criteria list for concept development is presented in Chapter 6.

After the framework has been formed, a case study follows. The case study is carried out as a part of a larger project at Helsinki University of Technology. The GO project gives the necessary input to the case and through the case the synthesis emerged after theoretical and empirical part is proved. The case study and the GO project are introduced in Chapter 7. Conclusions will follow after the case study in Chapter 8.

2 Mobile Networks and Services

Mobile computing traditionally means terminal mobility. Terminal mobility is the ability of a terminal in motion to access telecommunications services from different locations, and the capability of the network to identify and locate that terminal. The term nomadic computing on the other hand refers to personal mobility [VTT98].

The mobile data trend is going towards personalised and diverse mobile services. Nomadic users already now use many IP based services. Businessmen loading e-mail with their laptops at airports is not a rare sight nowadays.

This chapter introduces the cellular technologies that enable usage of mobile services. Also, some of the services are introduced.

2.1 GSM Platform Evolution

Cellular radio networks are generally divided into three generations. The technologies handled in this thesis belong to the second and the third generations.

Analogue cellular systems, such as Nordic Mobile Telephone (NMT), are considered to be the first generation of cellular technologies. The second generation of cellular technology is the present digital network generation which includes systems like GSM, Digital Cellular System (DCS), Digital Advanced Mobile Phone System (D-AMPS), Interim Standard –95 (IS-95) plus enhancements to GSM (2G+): High Speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE) [Häg99].

According to International Telecommunications Union (ITU) specifications, the third generation cellular networks will offer data transmission speeds up to 2Mbps. Universal Mobile Telecommunications System (UMTS) is one of the third generation mobile communications systems being developed within the framework defined by the ITU and known as International Mobile Telecommunications IMT-2000.

The main difference between GSM and UMTS is the multiple access method. UMTS standard includes two different solutions: Wideband Code Division Multiple Access (W-CDMA) based solution and a hybrid of Time Division and Code Division Multiple Access (TD/CDMA), whereas enhanced GSM systems are based only on Time Division Multiple Access (TDMA). Commercially the W-CDMA UMTS will most probably be more noteworthy than the hybrid [Knu00].

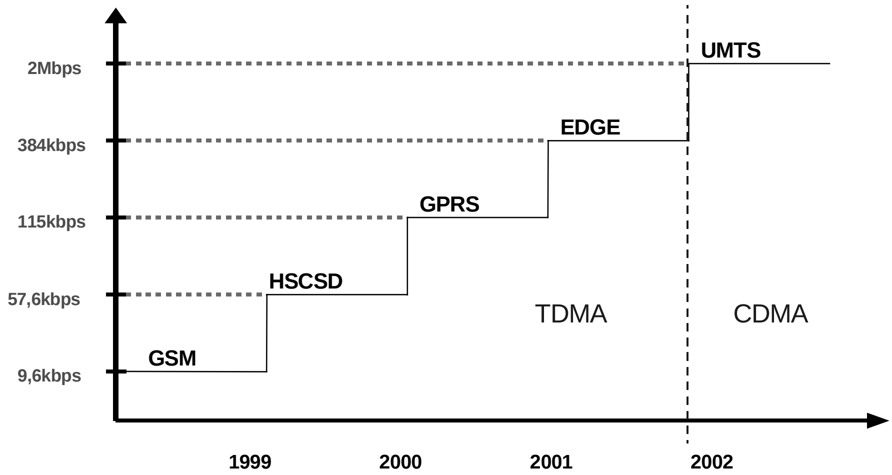


Figure 2-1. Evolution of GSM towards third generation networks [Rei99]

The GSM evolution path is shown in Figure 2-1. The data rates in the y-axis are the maximum data rates provided by different systems. In reality, maximum data rates are achieved only in very limited circumstances.

These different technologies are briefly presented in the following sections and in more detail later on in Chapter 6.

2.1.1 High Speed Circuit Switched Data

High Speed Circuit Switched Data (HSCSD) adds many improvements to the basic GSM [ETS99a]. The most substantial change is that multiple time slots can be allocated for one connection (1-8). In addition, the new channel coding increases the bit rate in one time slot from 9,6kbps to 14,4kbps.

Because of the circuit-switched nature of HSCSD, the access times to packet data networks, e.g., the Internet and intranets are relatively high (>30s) - it is the same situation as in fixed networks when using a modem.

The first HSCSD terminals are already on the market, but they do not support more than three timeslots downlink and one uplink. For example with Nokia Card Phone 2.0 the achieved data rate without data compression is at maximum 43,2 kbps [Nok99c].

2.1.2 General Packet Radio Service

The General Packet Radio Service (GPRS) [ETS98a] offers packet-switched data connections to cellular users. Because of the packet-switched nature of GPRS, it provides users with fast access times (<1s), fast data transmission and efficient use of radio resources. Depending on the used channel code and the amount of used timeslots, the maximum data rate offered by GPRS can reach 182kbps [Olo99].

GPRS can be implemented on the current GSM core network. However, GPRS adds two new network elements to the GSM system. These new nodes are The Serving GPRS Support Node (SGSN) and The Gateway GPRS Support Node (GGSN) (see Figure 2-2).

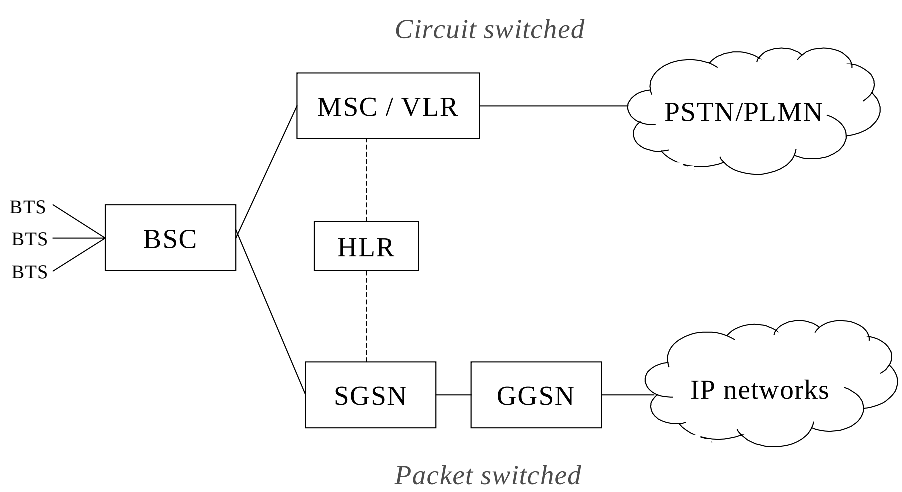


Figure 2-2. Structure of GPRS network

The SGSN concentrates on serving and tracking the mobile. It provides packet routing to and from a SGSN service area. The SGSN functions are authentication, session management, Short Message Services (SMS), mobility management and routing. Also, charging and security functions are performed.

The GGSN functions as an interface to and from external packet-switched networks. The GGSN is connected with SGSNs via an IP-based GPRS backbone network. The GGSN performs almost the same set of functions as the SGSN excluding SMS [Eri99b].

In addition to these hardware investments, some software updates are needed in the radio network and in the circuit-switched core network when GPRS is implemented. GPRS products and services will be launched on markets earliest in year 2000.

2.1.3 EDGE

Different second-generation systems have different evolution paths towards third generation IMT-2000 services [Buc97]. Network operators that are not granted UMTS licences can implement EDGE to offer IMT-2000 alike services. However, an operator with UMTS licence may still deploy EDGE to create a wireless data market before third generation CDMA systems are launched [Olo99].

EDGE offers improved data rate through optimised modulation (8-PSK) and it introduces a large number of channel coding schemes. The new modulation and the possibility to adapt the transmission rate to channel quality are the core of the EDGE concept. Introducing EDGE in a GSM network does not imply changes in the basic architecture. In any case, modifications of the Mobile Station (MS), Base Station (BTS) and Base Station Controller (BSC) are needed (see Figure 2-2), which means, among other things, software updates in circuit- and packet-switched parts of the network [Olo99].

EDGE offers both circuit- and packet-switched connections depending on the platform it is implemented in. The scope of the EDGE phase 1 standard is to increase GPRS bit rate, improve GPRS link quality control (EGPRS) and to offer high circuit-switched data rate with fewer timeslots and fast power control (ESCD) [Olo99]. With EDGE, the data rate offered by the original HSCSD or GPRS networks can triple.

The scope of the EDGE phase 2 (release 2000) includes supporting real-time services over EGPRS [Olo99]. The commercial deployment of EDGE is expected in 2001. Due to the unfinished standardisation, the actual features of EDGE are still slightly unclear [Saa99b].

2.1.4 UMTS

UMTS is a part of a global family of the third generation mobile communications systems created within the ITU's IMT-2000. UMTS uses a new frequency spectrum and a different multiple access method (CDMA) compared with GSM. UMTS offers fast access to various services, fast packet transmission and data rate on demand.

In January, 1998, the European Telecommunications Standards Institute (ETSI) agreed to a proposal concerning the radio access interface to be used for the future of global wireless communications, based on an evolved GSM platform. The frequency bands 1885-2025 MHz and 2110-2200 MHz are identified for future IMT-2000 systems, with the bands 1980-2010 MHz and 2170-2200 MHz intended for the satellite part of these future systems [Häg99].

UMTS Architecture

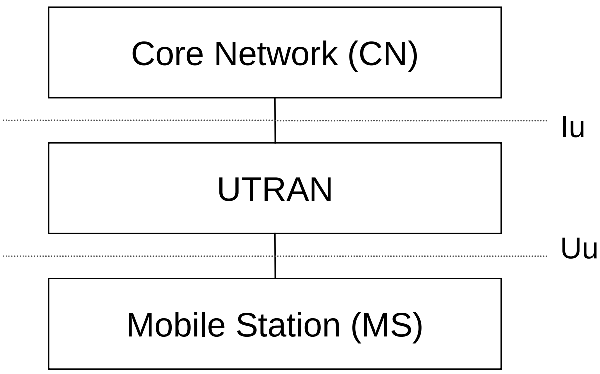


Figure 2-3. UMTS architecture [ETS98a]

Iu is the interconnection point, i.e., interface between The Core Network (CN) and the UMTS Terrestrial Radio Access Network (UTRAN), while Uu is the interconnection point between the user and the UTRAN (see Figure 2-3). The UTRAN supports two logically separate signalling flows via Iu to combined or separate network nodes of different types, e.g., MSC and SGSN [ETS98a][ETS99b].

UMTS offers both packet-switched and circuit-switched services. Logically, the Core Network (CN) contains two domains, a PSTN/ISDN, which is the circuit-switched (CS) service domain and an IP domain, which is the packet-switched (PS) service domain. It is possible to connect the UTRAN either to both of these CN domains or only to one CN domain. UMTS mobility management for the PSTN/ISDN domain is in principal identical to GSM mobility management [ETS99b].

Packet Access

Efficient packet access is a key feature of future mobile telecommunications systems. In the list below, UMTS packet data transfer over radio function is presented.

UMTS produces:

- Packet access control over radio channels
- Packet multiplexing over common physical radio channels
- Packet discrimination within the mobile terminal
- Error detection and correction
- Flow control procedures

These functions are located both in MS and in the UTRAN [ETS98a].

Because of the highly variable characteristics of packet data traffic in terms of packet size and packet intensity, a dual-mode packet transmission scheme has been chosen for the UMTS. Packet transmission can either take place on a common fixed-rate traffic channel or on a dedicated variable rate channel. The choice of mode depends on the packet data characteristics [Ves99].

Interoperability between UMTS and GSM

The extremely large footprint of GSM around the world makes the interoperability between UMTS and GSM networks offering world-wide coverage one of the main design criteria taken into account in UMTS standard development [ETS98a]. In order to utilise the interoperability, dual mode terminals are needed. These terminals most probably are GPRS class A terminals and UMTS terminals. Class A terminals make it possible to use both PS and CS services at the same time.

The UMTS-GSM network architecture is shown in Figure 2-4 [Ves99].

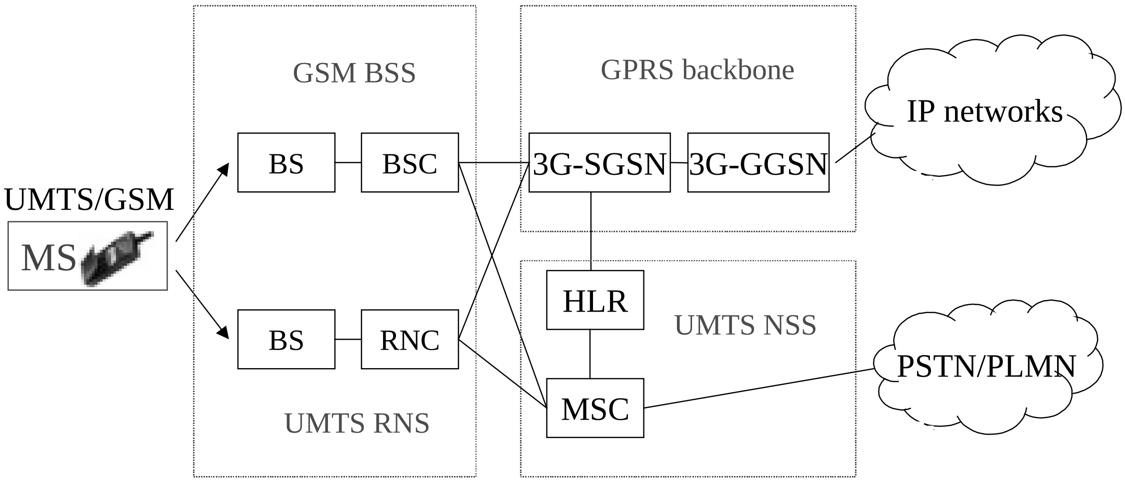


Figure 2-4. UMTS - GSM/GPRS network architecture [Ves99]

A dual mode terminal can execute a seamless handover between the UMTS and GSM base stations. Third generation SGSN and GGSN provide packet access both for GSM BSS and UMTS Radio Network Subsystem (RNS) [Ves99].

Mobile IP in UMTS

Mobile IP refers to a single generic mobility handling mechanism that allows roaming between all types of access networks. It provides high mobility for users and the possibility to move between fixed and mobile, and public and private networks. It is under consideration whether or not to include this specific mechanism to the UMTS standard [ETS99b]. Mobile IP is introduced more specifically in Section 2.3.2.

In UMTS, Mobile IP can be used to handle discrete mobility between access networks, whereas GSM/GPRS can be used for the handling of subscriber data, charging mechanisms, etc. Thus, Mobile IP handles roaming and possibly handover between UTRANs, whereas the GPRS SGSN node – enhanced to also include some IP functionality – is used for mechanisms such as authorisation and handling of encryption keys [ETS99b].

According to ETSI [ETS99b], deploying Mobile IP into UMTS has two main driving forces:

- Mobile IP as an overlay to the UMTS-GPRS would make it possible to offer easy roaming between different types of networks
- An integration of Mobile IP within the UMTS CN would additionally allow the operators to use standard IP technology to a larger extent and thus lower the costs for deployment and maintenance of networks

2.2 GSM Data Services

Voice services are still the most important services provided by mobile communications networks. However, the earlier presented incoming technologies bring new possibilities for various data services. At the same time, the importance of other than voice services grows rapidly.

Many surveys indicate that the market for mobile data services is expanding. According to Nokia's Telecommunications Magazine, it was estimated that wireless data is expected to reach 30 percent of all mobile traffic by 2001 [Nok99a].

The UMTS-forum has made a study of the world mobile market. Results of the study show clearly that market areas outside the European Union (EU) will dominate the world mobile market by 2005. Table 2-1 shows the world-wide market forecast for the physical users in millions of terrestrial mobile services, including multimedia [UMT98a].

Table 2-1. World-wide mobile market forecast [UMT98a]

	Year 2000	Year 2005	Year 2010
Europe, EU15	113	200	260
North America	127	190	220
Asia Pacific	149	400	850
Rest of the world	37	150	400
Total	426	940	1730

The majority of published estimations from different sources indicate quite extensive growth of the number of mobile data subscribers. For example, Arthur D. Little forecasts that the number of mobile data subscribers world-wide will reach 63 millions and Ovum forecasts an even higher number – 199 million by the year 2005 [Tiu99]. But, it has to be noticed that hopes for mobile data have been high for a long time and yet, in reality, the increase in number of data subscribers has been very modest.

The development of mobile data services follows the evolution path of cellular technologies. The first generation analogue cellular systems, e.g., NMT 900, offered extremely slow and unreliable data connections and identification methods were not well developed [Häg99][Hol98].

The second-generation digital cellular systems made an improvement to the data services and data rates. In addition, Subscriber Identification Module (SIM) cards in GSM phones improved security and enabled, for example, safe bank connections. Many companies co-operate in finding out ways how to use cellular phones for money transactions. Sonera SmartTrust together with many co-operation partners develop a paying method that uses the SIM card, Nokia and Visa on the other hand base their co-operation in developing a SIM independent solution.

The existing GSM networks offer high quality connections that pave the way for useful data applications. The Short Message Service (SMS) provides guaranteed delivery of small data packets even if the phone is switched off when the message is first sent. However, actual packet data services are not yet commercially available for GSM networks. Forthcoming second-generation services offer higher bit rates and packet-switched connections. The development path advances towards UMTS and third generation services that offer the ground for many high-speed services. In addition, wearable computers and totally computerised homes can be a part of everyday life after a few years. Wireless Local Area Network (WLAN) products and other possible wireless network applications can have a remarkable role in parallel with advanced cellular network services.

2.2.1 Short Message Service

Short Message Service (SMS) is included in GSM design to fulfil the customer need for speaking and paging from one single terminal [Mou92]. Short Message Service (SMS) can be seen as the first packet-oriented data transmission service implemented in cellular radio networks. According to ETSI standard, the actual SMS message can be up to 160 characters long and coded into 140 octets [Saa99b].

SMS messages are the fastest growing area of mobile telecommunications. Developed SMS services of today can be seen as a way for operators to get their customers used to other than voice services. In the year 1998 there was six times more SMS traffic in Radiolinja’s network than the year before, whereas speech traffic only doubled [Rad99].

The current SMS in GSM systems offers people the opportunity to send and receive simple pictures and messages and it also provides a possibility to access different information and entertainment sources such as weather reports, bus timetables and jokes. SMS transfer will be implemented also in GPRS and UMTS.

2.2.2 Wireless Access Protocol

The Wireless Application Protocol (WAP) is an advanced intelligent messaging service for mobile terminals. The WAP specification is published by WAP Forum. WAP Forum creates licence-free standards for the entire industry to use or develop products [WAP99].

WAP is most likely to do the same to the Mobile Internet as the Web did for the wired Internet: it hides the complexity of GSM on the application layer. The key to the success is to provide users with a compact and easy user interface [Afr99].

The Wireless Markup Language (WML), which complies with XML standards, is used in order to provide, for example, Web pages to the mobile devices. The language is designed to enable effective applications within the constraints of handheld devices. WML provides a smaller, telephony aware, set of markup tags. This capability makes it more appropriate to implement within handheld devices than Hypertext Markup Language (HTML) [WAP99]. This means that HTML coded pages have to be converted into WML code before they can be used in the WAP mode.

WAP terminals are characterised by a larger display screen than the antecedent cellular phones. Also, the menus are easier to handle. Compared with desktop computers, WAP terminals have less powerful Central Processing Units (CPU), less memory, restricted power consumption, smaller displays and different input devices, e.g., a phone keypad, voice input, etc. [WAP99]. The first WAP phones are already on the market. In Figure 2-5 is shown Ericsson's vision of the future WAP phone.

Figure 2-5. Ericsson R380 WAP phone [Eri99a]

With a WAP terminal, users will be able to send and receive e-mail, surf the Internet in text format and use all kinds of services from buying pizza to reserve opera tickets - not to mention all kinds of information services. Also, banking services will be available. The following press release is from Nokia [Nok99b]:

> *"(October 25, 1999) - The Woolwich is set to be the first British bank to offer its customers secure access to Internet banking services from their mobile phones,*

using the Wireless Application Protocol (WAP) server solution developed by Nokia, the world leader in mobile communications. Customers of the bank's personalised banking service, Open Plan, will be able to run their accounts, no matter which mobile phone network provider they use, by using their phones to dial-up their Internet service provider at their usual call rates. They can be confident of complete security as their transactions are transmitted from the WAP phone to Woolwich's exclusive WAP server."

The Wireless Application Protocol is not limited to any specific technology platform; it is extensible over time to new networks and transports. It is applicable to, for example, GSM 900/1900, DCS 1800, CDMA IS-95, TDMA IS-95, and third generation systems, e.g., IMT-2000, UMTS, and W-CDMA [Afr99].

Although WAP offers many possibilities and benefits that most users will not even have dreamt of, the role of WAP can easily be misunderstood. WAP does not allow access to the World Wide Web as we know it, and this leaves room for more capable solutions [Den98].

2.3 Convergence of the Internet and Mobile Telecommunications

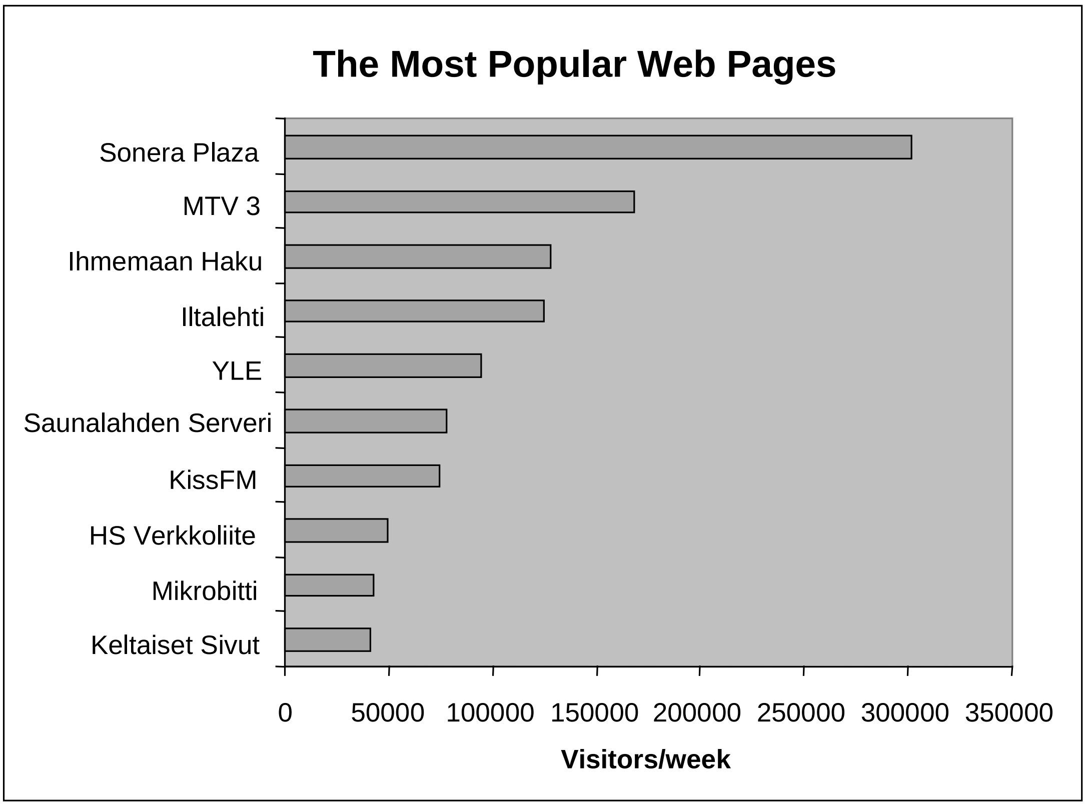
The key driver of wireless data is the access to the Internet. The mobile market is strongly correlated to the Internet, since 78 % of fixed Internet users also use mobile connections. Those users will potentially also use the same services with mobile devices [Hei99]. Already now, WAP provides Internet content for wireless users.

The most used Internet services are e-mail and surfing on the Web. Banking, shopping, entertainment, and news services are used all over the world via the Internet. Table 2-2 shows a list of Web pages that have the highest amounts of users per week in Finland. Most of these pages are Internet portals, e.g., Saunalahden Serveri. According to Steinbock [Ste99] a portal is

"…a Web site designed as a starting point for Web surfers. The business strategy depends on attracting a large number of users to the site, which

translates into higher advertising revenues and higher fees charged to other sites who want a prime link on the portal site."

Table 2-2. The most popular Web pages in Finland, May 1999 [Juv99]



The same trend can be seen in the mobile telecommunications area, since all of the WAP services in Finland are accessible only through some WAP portals.

2.3.1 Internet/IP Technology

Internet Protocol (IP) technology and IP networks are the base of the Internet. Internet Protocol connects networks that are part of today's Internet, and routes data packets to their destination according to IP addresses that are attached to the data packets. Data packets can be considered as a piece of e-mail or an image and they vary in size, from a few bytes to hundreds of bytes, depending on the network and applications [Per98][Pet96]. IP-networks are the most common packet-switched networks.

The current IP version 4 (IPv4) addresses of today are fixed locations, e.g., a computer that is connected to a company’s network. It is also possible to connect to the Internet from almost everywhere by a modem, but then too you first have to call to the ISP’s or company’s modem and, in that way, get an IP address from a specific address pool for one “Internet session”. It is the same thing with current ISDN connections, though access times are then faster. GPRS and Wireless Local Area Network (WLAN) are among the first technologies that offer direct packet data access without the need to call to an ISP.

2.3.2 Mobile IP

IP addresses are often figured as fixed connection points. Mobile IP will make a reversal to that and give more freedom and mobility to the users. Mobile IP is a proposed standard protocol that builds on the Internet Protocol (IP). It allows the mobile node to use two IP addresses simultaneously. A mobile node is any client device that changes its point of attachment from one sub-network to another. A mobile node has a fixed home address and a care-of address. The care-of address changes at each new point of attachment [Per98].

Mobile IP is so far used only in a LAN environment but will probably be implemented in the UMTS standard. Compared with mobility management in GPRS the difference is that every client device has its own permanent IP address. When a mobile changes its position in the same operator’s GPRS network, the IP address, given from the operator’s GGSN IP pool, remains. If the mobile changes the network while a session is still proceeding, the old operator routes packets from the former IP address to the new one given by the new operator. This means that the mobile reserves two IP addresses for a while. If the mobile is already outside the reach of its own operator when it begins an IP session, the mobile gets an address only from the foreign operator and uses the address as it uses its own operator’s IP addresses. That naturally requires roaming agreements between the two operators.

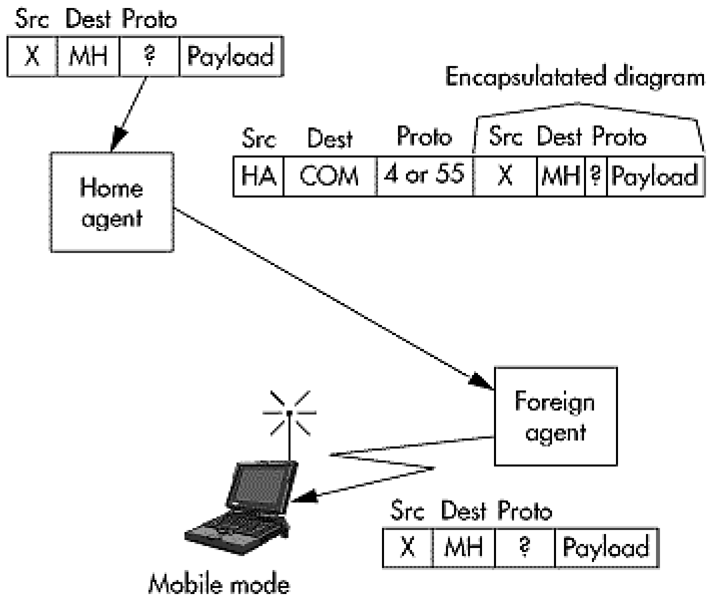


Figure 2-6. Tunnelling operations in Mobile IP [Per98]

Mobile IP uses a smart tunnelling protocol (Figure 2-6). When the mobile cannot reach its home agent the mobile tries to contact another agent. The default encapsulation mechanism is called IP-within-IP.

The home agent, i.e., the tunnel source, inserts a new IP header in front of any packet assigned to the mobile node's home address. Thereby the mobile node's care-of address is used as a destination address, i.e., a tunnel destination [Per98]. In Figure 2-6 the source X sends an IP-packet to the mobile host (MH). Because the mobile host, i.e., the mobile node, is situated out of the region of the home agent (HA), the HA routes the packet to the foreign agent (FA) and at the same time encapsulates the packet by adding a new header to the packet. The new header includes the address information of the FA. When the packet reaches the FA it is decapsulated and the mobile node receives the original packet.

3 Telecommunications Business

Telecommunications is a rapidly changing and growing business area. The business structure is changing as well as the technology and service oppotunities. A thorough understanding of users' needs and wants, the competitive situation, the company's own capabilities, and the nature of the market are essential elements of new service to success.

In this chapter, different telecommunications business aspects are introduced and clarified with service examples implemented on the SMS platform.

3.1 Players in the Telecommunications Business

In order to use different mobile services the user needs a terminal and also an access to services through a mobile network. This means, among other things, that the user has to be a subscriber to telecommunications services. Mobile operators offer the necessary infrastructure and subscription. They also take care of billing, customer care, etc. Infrastructure suppliers do business directly with operators. Often the infrastructure suppliers are also terminal suppliers, e.g., Nokia and Siemens. Furthermore, mobile operators have connections with various content providers, which usually are at the same time content bundlers. However, an operator can be a content provider and a bundler as well and thus has many roles in the value chain.

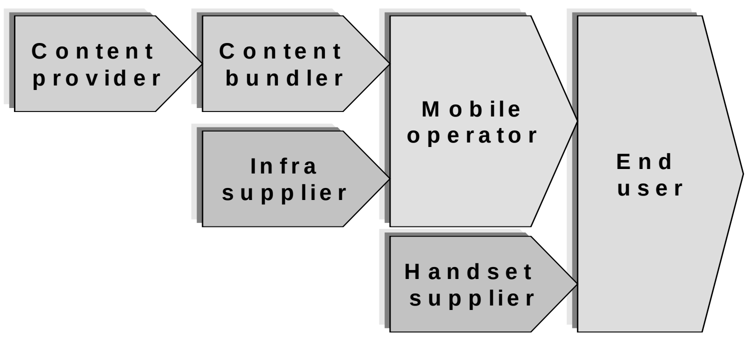


Figure 3-1. Value chain in mobile telecommunications business [Hei99]

The value chain described in the previous paragraph and in Figure 3-1 is a very simplified model introduced by Heilingbrunner [Hei99]. In practice there are more complicated interactions between the various parties. For example, a network operator, a bank, a handset and system supplier, and a software company can co-operate in piloting or commercialising a certain service. The end user of the service in that case can be a company who buys this service directly from the operator.

In addition, because the Mobile Internet business is still forming itself it is too early to say that how the value chain and the business model will actually look like. When packet data services are introduced to the cellular networks, traditional business models will change.

In [Usk99], a more complicated and complete business model, i.e., value chain for cellular packet data networks combining business models both in the Internet and in the cellular networks is proposed. The basic model is introduced in Figure 3-2 [Kaj99]. The arrows in the figure represent the flow of content or equipment towards the end users. Revenue flows are not marked in the figure.

Content and communication origination refers to content creation. Different content has to be collected and sorted for convenient consumption. *Content packaging* parties are the organisations that carry out the function of collecting and transforming content into a form appropriate for the delivery network [Win98].

Their success is dependent on the ability to pick up the right content and combine it with the right context [Usk99]. A great deal of information and services are relevant only in a limited context that which refers to the characteristics of the user's situation, e.g., current location, and its supporting environment, e.g., terminal capabilities [Cou98].

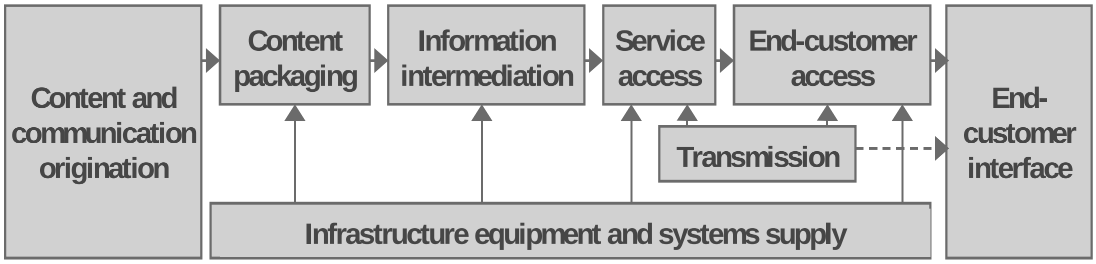


Figure 3-2. Business model framework [Kaj99]

Information intermediation is needed for managing the virtual link between content and the end user. The information intermediaries submit the right content to the right user without manipulating or producing the content. *Service access* on the other hand provides the link between the physical service network and a service offering [Win98]. The most common service access providers today are the Internet Service Providers (ISP).

Transmission means the way in which content is delivered to the end user. Transmission is usually invisible from the end user's viewpoint [Kaj97]. The transmission providers bundle the service with the end customer access providers or with the service access providers [Usk99].

End customer access is the part of the network where a physical connection between the end user and the transmission function. The physical end user device for communication is referred to as the *end customer interface* [Kaj97]. The main functions of a telecommunications operator typically are transmission and end customer access [Win98].

When packet data services are introduced to the cellular networks, players of both the Internet business and cellular business have to redefine their positions in the information value chain [Usk99].

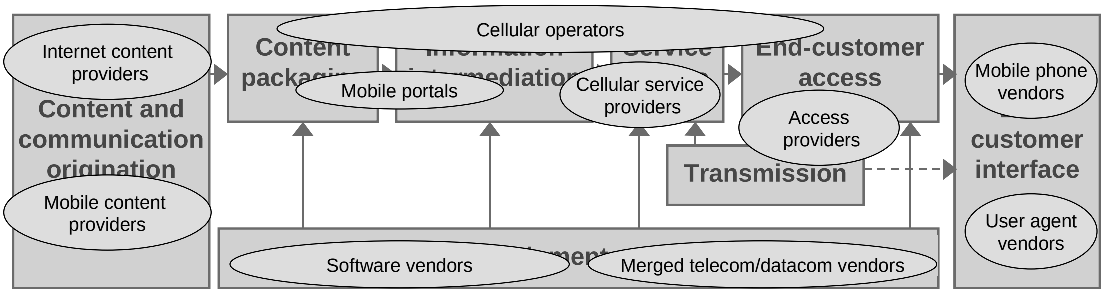


Figure 3-3. Positioning of players in the Mobile Internet [Usk99]

The information value chain of the Mobile Internet services can have two tendencies. First, there are Internet services that are accessed through mobile portals. Secondly, there are Mobile Internet services that are not accessible from the public Internet. Figure 3-3 illustrates one possible model for the Mobile Internet. The mobile phone vendors will maintain their grip on the user interface to some extent. However, also external user agent vendors will be able to provide client software to the terminals. The end customer access is provided by the operators, who have the required licenses. The operators may become access providers by selling radio resources to cellular service providers or they may choose to provide a full range of services, i.e., become cellular operators [Usk99].

If an ordinary teleoperator does not play as a service and content provider its role in the future can be seen as an invisible member in the value chain – the end user only notices the content and content provider together with the terminal vendor. In addition, consumers will demand access to the services they want from the companies they prefer. Network operators will not win the mobile portal war even though they own the pipes and airwaves that connect users to the Internet. In the end, carriers will only be able to promise partners preferred provider relationships, not exclusivity. Of course teleoperators are needed also as billing managers - at least in the beginning [Haa99] [Son99].

Seeing that there are so many players in the field, making services successful depends on a number of factors.

3.2 SMS Service Business

A differentiated service that delivers unique benefits and superior value to the customer is most likely to succeed. More precisely, a unique and superior service has unique features for the customer and meets customer needs better than competitors' services. The service has high relative quality and solves users' problems. It also reduces users' costs and is novel and innovative [Coo93].

SMS services can be used as an example of successful services in cellular networks. Kimmo Haapaniemi from Helsinki Telephone Corporation (HTC) highlighted some success factors in HTC's Cityphone services:

- SMS services are easy and inexpensive to integrate into existing cellular networks.
- Usage of content providers with a good brand gets people interested and it also gets them to use the services.
- Most of the services are aimed at mass market. Many times it is unprofitable to produce service only for a niche area. Mass market services that reach the general public or many of the business people are most likely to be profitable.

Today one ordinary SMS message costs less than one FIM. When we talk about SMS services that small amount of money is shared with many members of the value chain. As an example, there has been on the market Pepsi bottles that include instructions to a SMS message contest that offers over 4000 prizes. The service turned out to be a real success. Pepsi and Hartwall took their own share of the revenue. Almamedia, which represents Hartwall, took its share and the operator, the final link needed to produce the service, got the rest. Generally, the revenue proportions differ depending on the contract and occasion [Haa99].

In [Haa99], the most valuable and successful SMS services of today are bank services, HKL timetables, e-mail at the corporate level, and entertainment. For example, blond jokes were very attractive in the beginning for a while. Other successful entertainment services are games and sex. Such services have always been attractive to consumers, also in the traditional telephony business.

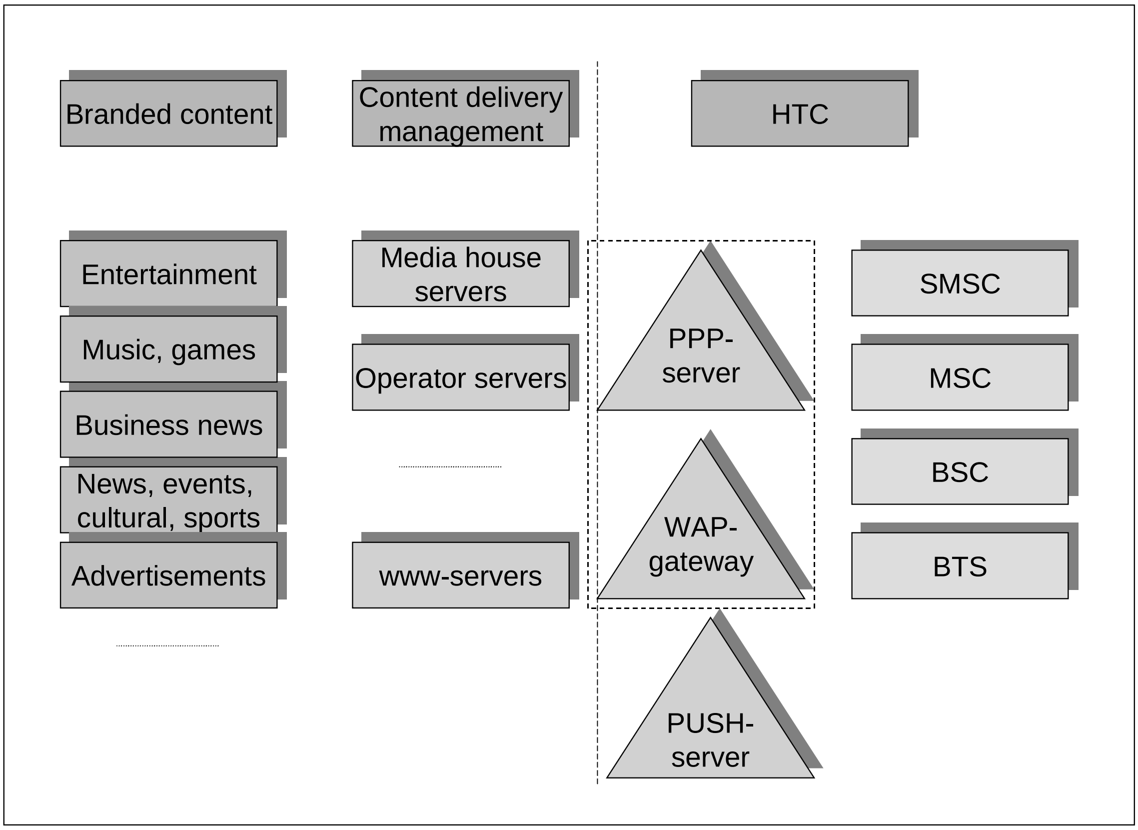


Figure 3-4. SMS business structure [Haa99]

Figure 3-4 shows business parties and the structure of HTC´s Cityphone SMS business [Haa99]. The servers in the figure can be either in possession of HPY or a company that handles the content delivery management.

In [Haa99], it is emphasised that marketing is extremely important in the whole service process. Most failures and successes come from marketing. In addition, product lifecycle issues are also important. It is difficult to move to the next phase of the cycle. Operators and other service providers have to be aware that there have always been innovators and early adapters that adapt new services very quickly and eagerly but this does not mean that the rest of the consumers will follow them [Haa99].

3.3 Regulatory Issues

The telecommunications business is regulated by many parties. Every country has its own regulation and laws, and in Europe there are many regulations, directives and decisions set by the EU. EU legislation has mainly only given directives concerning telecommunications. The directives control, for example, telecommunications activities and terminals [Hil99].

The national regulation in Finland includes laws such as the Telecommunications Market Act and the Radio Act. These laws are the basis of many decisions and commands given by the Ministry of Transport and Communications and Telecommunications Administration Centre (TAC). For example, the licences for cellular networks have to be applied from the Ministry of Transport and Communications. In addition, in year 1999 a new law, the Act on the Protection of Privacy and Data Security in Telecommunications, was ratified. For example, location based services address privacy policy issues: how much an operator is allowed to know about its customers and give the information further [TAC99]. In addition, encryption policies are different in different countries e.g. France does not allow strong coding. The Internet and copyright issues have caused many debates [Bra99].

However, the trend in telecommunications is deregulation. The Competition Office in Finland handles many telecommunications conflicts as any other conflicts in some other business areas [Hil99].

4 From Service Idea to Implementation

Strategic management processes are needed in every company for they address areas of critical importance to business. These processes typically involve large investments of capital, resources, and lots of analysis and planning. Product and service development is one of these processes [War98].

In [Zei96], a general service development process for all kinds of services is introduced. The process model consists of a number of careful steps and checkpoints designed to achieve successful services. Part of the reason for establishing distinct phases in the process is to define specific elements that must be present before allowing a development project to proceed to the next phase of the process.

Due to inherent characteristics of services, the development process for new services requires unique and complex adaptations [Zei96]. Since we are now dealing with telecommunications services, which have their own specific features, the model description is complemented and clarified with parts of other literature: [War98] and [Hei99], where the development process is studied from the telecommunications point of view.

Also, a real development process of a value added service for small companies is studied in order to give the reader a better understanding of the process in practice [Pel99][Rin99]. This project is referred as a '*case*' in the following sections.

4.1 Service Development Process

The service development model is shown in Figure 4-1 [Zei96]. This process is quite similar to the process for manufactured goods but the implementation of various steps is significantly different in telecommunications business. There are also significant differences between services: mobile telecommunications services have completely different features compared with for example restaurant services.

Figure 4-1. Service development process [Zei96]

New service ideas can be dropped at any stage of the process if the ideas do not fulfil the criteria for success at that particular stage. The checkpoints specify requirements that a new service must satisfy before it can proceed to the next stage of the development process. The checkpoints are coloured with blue in the figure above. Depending on the service and the company, some steps of the process can be executed simultaneously or even left out. The process in not to be understood as a totally top-down approach, but is more an iterative application of each of the stages from an abstract level down to a detailed specification and implementation.

The criteria should be measurable. The ensemble of criteria in each phase can include deliverables of many forms such as business cases, prototypes, commercial trials, etc. Companies ensure that the most valuable and potentially successful service ideas are elaborated further on the costly path of development by managing the project according to established criteria [War98]. Table 4-1 illustrates an example of estimated cost of finding one successful new product starting with 64 new ideas [Kot97].

Table 4-1. Estimated cost of finding one successful new product [Kot97]

Stage	Number of Ideas	Pass Ratio	Cost per Idea	Total Cost
Idea Screening	64	1:4	1 000	64 000
Concept Testing	16	1:2	20 000	320 000
Product Development	8	1:2	200 000	1 600 000
Test Marketing	4	1:2	500 000	2 000 000
National Launch	2	1:2	5 000 000	10 000 000
		$	5 721 000	13 984 000

The source of this example is a company that sells consumer packaged-goods. Therefore it is not directly applicable to the services business. However, it gives the reader an understanding of how expensive service or product development can be.

The development process follows customer-centred design. Another option would be technology-oriented design. It is hard to find continuous competitive advantage through technology-oriented development in telecommunications [Rin99]. However, we are used to considering service development mainly from technology point of view. The focus has to be on customers: what can we do for customers – not merely what technology can do for them.

The different steps of the service development process are introduced in the next seven sections.

4.1.1 Business Strategy and New Service Strategy Development

The new service strategy and ideas must fit into the larger strategic picture of the organisation. It is essential that an organisation knows its strategy and its desired image before developing new services. The types of appropriate new services will depend on the organisation's goals, internal capabilities and capabilities to support a certain service, and growth plans. Business strategy and service development in mobile telecommunications requires an understanding and knowledge of technology, a competitive environment, markets, customer requirements, and market requirements. A service strategy can be defined in terms of particular markets, market segments, types of services, time horizon for development, profit criteria or other relevant factors. The organisation will be in a better position to begin generating service ideas when the new service strategy is well defined [Hei99][War98][Zei96].

In the studied *case* [Rin99], a group of telecommunications operators join a common product development program. The general goal is to develop products and services for small and medium-sized companies and for consumer segments. The same operators also join a common platform development program.

4.1.2 Idea Generation

In an organisation there should be a formal mechanism for ensuring an ongoing stream of new service possibilities that fit into the organisation's strategies [Zei96]. Many methods are available, such as brainstorming, interviews, benchmarking in terms of learning from competitor's offerings, collecting ideas from employees and customers with suggestion boxes and feed-back forms, focus groups and user panels, etc. Front-line personnel, who actually interact with customers, can be especially good sources of ideas for complementary services and improvements to existing services.

In telecommunications, the technology-driven approach is usually taken instead of the customer-centred. Accordingly, in the studied *case*, the basic idea for the new development project came from the technology platform development program. It was discovered that the capacity and features offered by the platform were not fully taken advantage of. The major investments had already been made and there was capacity for new services. In the *case*, the new service was assumed to be good for the 'pacesetter image' of the operators even though the new service idea was based on an existing service. In order to find what kind of features should and could be added to the *case* service concept, a market research was commissioned by a consulting company.

4.1.3 Service Concept Development and Evaluation

Initial development begins when good ideas that fit the organisation strategies and business exist. The most attractive ideas that have potential to become successful, profitable and feasible are developed and clearly defined further so that eventually the organisation could produce a service description that introduces specific features and characteristics i.e. fundamentals of the planned service [Zei96]:

> *“The service design document would describe the problem addressed by the service, discuss the reasons for offering the new service, itemise the service process and its benefits, and provide a rationale for purchasing the service. The roles of customers and employees in the delivery process would also be described.”*

Itemising the service delivery process includes estimating the system requirements. Service description also defines the work associated with linking the network infrastructure, operational support systems and business process. This stage can include an early prototype for initial testing. Customers and employees should join this stage by considering whether they are favourable to the service concept [War98][Zei96]. The service concept should also be evaluated and validated in terms of technical feasibility and market effort. Also, a preliminary market potential estimate has to be made [Hei99].

In this phase of the *case* process the consulting company based the market research on mystery shopping. Mystery shopping is a method where companies hire outside research organisations to send people into service establishments and experience the service as if they were customers [Zei96]. In the *case,* also real customers were asked what kind of features they would like to have in the service. The consulting company reported the results including environment analysis and suggestions for actions. The report included initiative service concept and features, and an initial marketing strategy. In this phase the focus group was defined for small companies. After the research, the common development program decided to set the new project in motion. At this time, a process chart for new service development was finally completed and the decision criteria for different steps were settled.

4.1.4 Business Analysis

Feasibility and potential profit implications of the new service are determined after the service concept is favourably evaluated by customers and employees. Business analysis consists of demand analysis, revenue projections, cost analyses and operational feasibility assessment. As an outcome of the analysis, a business plan should be evaluated according to the organisation's profitability and feasibility objectives in order to determine whether the new service idea meets the minimum requirements [Zei96].

The first task of the new project in the *case* was to execute a feasibility study. The technological feasibility and commercial prerequisites were studied. At the end of the business analysis phase the *case* business plan was defined to its final form. The *case* service description was refined and the service concept was tested by the market research institute. The first mistake was made at this stage: the technological feasibility study was made only based on technological documents given by vendors. Too big a short cut was made, especially considering that the operators were using technologies from three different suppliers.

4.1.5 Service Development, Testing and Prototyping

Service development and testing stage involves all the people who have a stake in the service. During this stage, the service concept is refined to the point where a detailed service implementation plan can be produced. The plan most probably evolves over a series of iterations. It depicts the service events and processes in a flow chart, with the objective of recognising the potential service fail points. Thus, it defines, for example, the needed system, system capacity, and technical equipment. This stage also includes making a service prototype and a trial concept [Hei99][Kot97][Zei96].

The service development phase in the *case* was a long and painful one. It included forming a virtual project organisation and choosing a new project manager. The development was divided into two threads: technological and commercial development proceeded in parallel. In this phase, it was first discovered that the feasibility study concerning technology was conflicting with the reality. This delayed the project and the launch of the service by five months and made testing difficult. No prototypes were built, even though some features of the service were tested. In that way the ideal process was not followed. One reason was that the development environment was quite complicated. The joining operators were, for example, of different size and structure.

By the end of this stage, the organisation is ready to support commercial trials.

4.1.6 Market Testing

Market testing includes pilot projects and trials. The meaning of this phase is to ensure that the organisation does everything that is needed to support the service once it is introduced to the marketplace and to test the service to ensure it is working properly. The new service can be tested under varying circumstances with the organisation's own personnel or with a sample of customers. Another important reason for market testing is to determine marketplace acceptance of the service as well as pricing and other issues related to that service, i.e., other marketing-mix elements [Zei96] [War98].

The basic marketing-mix elements, i.e., four P's introduced by Kotler [Kot97] are price, place, promotion and product. Because services are very different from consumer products three elements are added to the four P's. These three new elements are people, physical evidence and process.

In the *case*, the market testing was made only with commercial aspects. The marketing-mix elements were tested such as the name of the service, visual expression and message. But neither trials nor pilots with actual service and technology were executed with customers. The other elements which were not tested were distribution, operational processes and internal processes. The problem was again the complicated development environment. The operational processes were defined in one environment but it was almost impossible to define a universally applicable process.

4.1.7 Commercialisation and Post Introduction Evaluation

The commercial launch is the point in the process where the service comes alive and it is introduced to the marketplace. Commercialisation in the *case* suffered from some problems. The service was first implemented in the participating operators' systems. Although the launch was already five months late, not all the technical details were clear at this point. Local sales failed in some sense and post introduction evaluation and also sales management were left to the local operators – not executed by the actual project team. The promotion went well though.

Monitoring all aspects of the service during introduction and through the complete service cycle is needed for post introduction evaluation. The gathered information should be reviewed and the service can be refined if needed. The necessary changes could be, for example, in the delivery process, content, staffing, or marketing-mix variables [Zei96]. Post introduction evaluation can also give new service ideas.

During a service development life cycle, testing is one of the critical processes to ensure the quality of the service before it is delivered to a customer [Chi94]. As a conclusion of the *case,* it can be said that the technological development process suffered a draw back because of the different platforms and insufficient testing. This draw back can be avoided in the future by doing more tests in the concept development phase, not relying only on suppliers' documentation, and carrying out real customer pilots on every platform.

Secondly, activating the operators to sell the service was hard even though they considered it a good one. This can be avoided with more interactions between the companies and the development project team during the whole process; there could, for example, be workshops already in the early phases of the process.

4.2 Towards an Evaluation and Validation Framework

Due to the highly increasing complexity of new telecommunications services and the requirement to come onto the market within a short time, new methods, techniques and tools covering the whole service development process are needed [Bor98]. The aim of the study is to create an analysis and validation framework for service development process in mobile telecommunications systems. This section explains the basis of the framework and how it could be taken advantage of.

In order to cope with the complexity of the service development, technology experts need guidelines and checklists to support them in taking into account all necessary constraints and possibilities during service design. Therefore, this thesis focuses on firstly studying the technology boundaries that lead to a list of technology criteria and secondly on showing how such criteria should be applied in improving the technology design of services. Notice that the service development must involve the expertise viewpoints of user requirements and business equally, however, the focus of this thesis is to gain in depth understanding from the technology viewpoint.

The technology boundaries are the most essential criteria in this thesis. With certain technology, different maximum values can be achieved only in ideal circumstances – but these circumstances may not be optimal for the operators, who build the networks and offer basic and value added services. In addition, the service provider can be some other party than the operator. In this case, the service provider has to know what kind of technologies and networks exist.

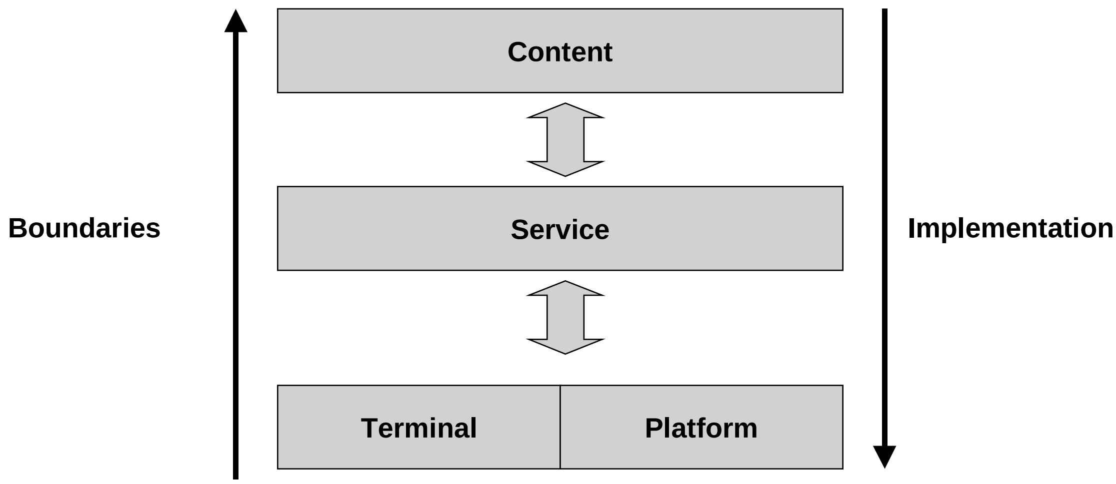


Figure 4-2. Boundaries and implementation flows

Figure 4-2 illustrates how boundaries and implementation are related to content, services, terminals and platforms, i.e., networks. From the figure it can be seen that terminals and platforms set the most profound restrictions for services and content. On the other hand, the customer-centred design of services begins from content and ends with implementation to a certain platform. The service ideas already answer to the user needs in some sense, hence the user restrictions can be seen to be less important in the process.

If we take advertisements as an example, the company that would like to advertise itself has many possibilities available. The company can decide to use mobile push services that run over the GSM platform. The advertisement has to be shaped so that it fits the terminals and platforms offered by operators and vendors.

4.2.1 Requirements for Technology Criteria and Design Framework

One condition the framework has to fulfil is that it has to be adaptable to different platforms (see Figure 4-3). It is not worthwhile to create a framework for one time use only. It is essential to find a list of technology boundaries from which the actual criteria for different platforms and services can be drawn. The list highlights what aspects have to be considered. The GO platform and cellular networks are studied with examples in Chapter 7.

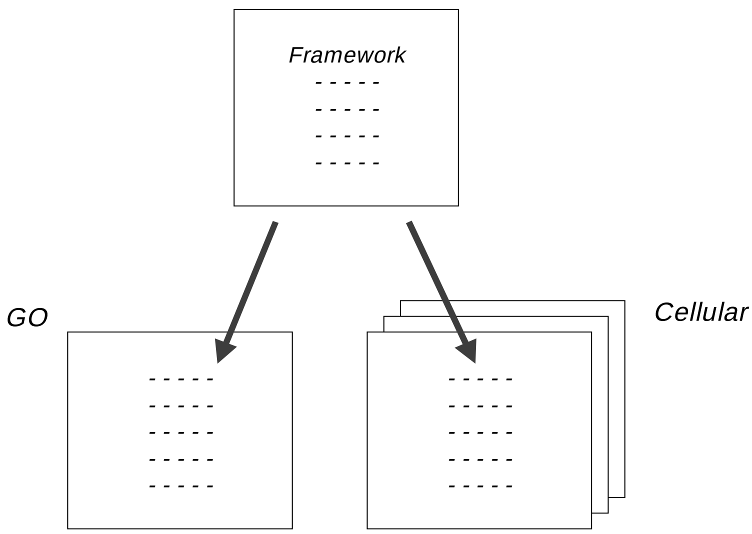


Figure 4-3. Framework adaptability to different networks

4.2.2 Creating the Framework

The information gained in the earlier chapters is now aggregated and assorted. By examining the development process and its features three distinct groups of criteria are found. Figure 4-4 presents a classification of criteria and also a few examples of the possible criteria sources.

The criteria come from technology, business and users. More specifically, the criteria are technological and other requirements and boundaries. Even though the criteria form three distinct groups the groups are related to each other in many ways. For example, prices depend on many factors. Technology has its own price, i.e., investments, users are willing to pay certain amount of money for services, and service providers want a profit from their share. Services have to fit all the criteria before they can be implemented in the networks and commercialised.

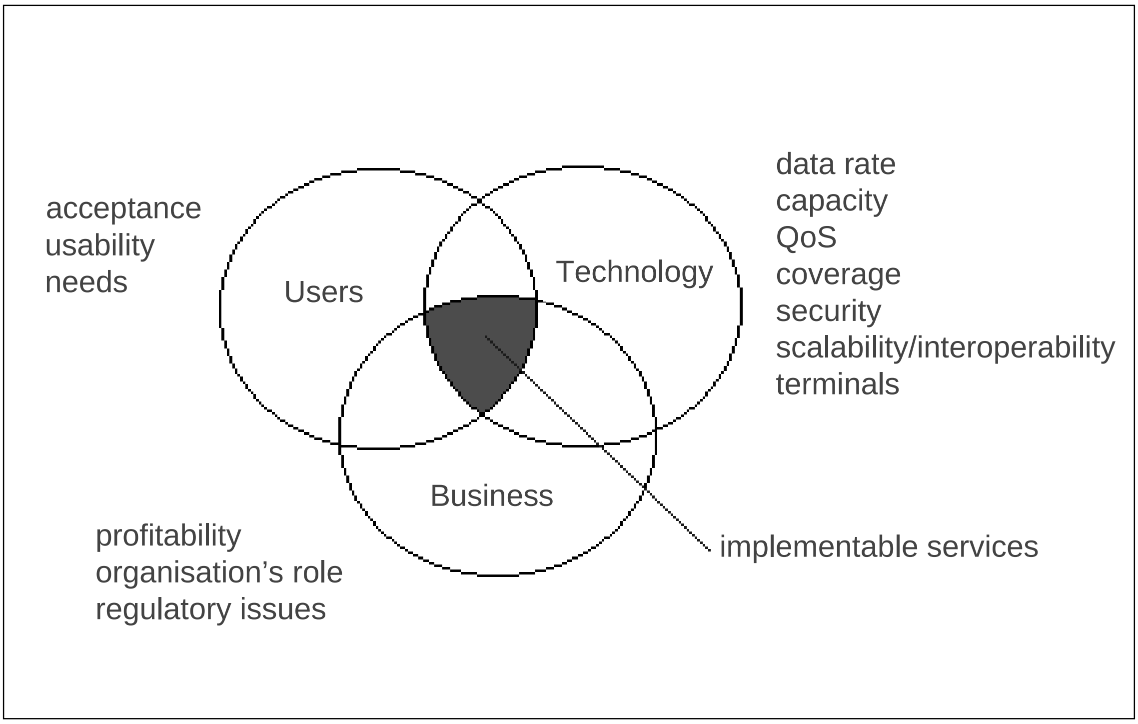


Figure 4-4. Criteria classification

The final framework defines the technology criteria more exactly. It includes information about when to use different criteria and how a certain criterion affects other criteria. The framework helps service developers and technology experts to use their knowledge efficiently in a formal way in service evaluation.

In the following list there are some technology-related issues and considerations that take place in different phases of the process:

Ideas and service strategy:

What do we know about technology and which technologies are we able to use?

Concept development and evaluation:

What kind of a technology is needed?

Define its limitations and possibilities.

Choose one or more presumably suitable technology for further consideration.

Business analysis:

How much does the technology cost?

Are the potential users willing to use such technology?

Service development and prototyping:

Set final technology decisions.

Test the technology details.

The final framework gives specific guidelines on how the considerations actually happen in the early phases of the process.

5 Technology Boundaries in Mobile Telecommunications

Networks themselves set boundaries for services. It does not matter how good your idea of a service is if the service can not be implemented by the current or incoming technology. The technologies introduced in the earlier chapters will be the basis for future mobile networks and thus also a future service platform.

Mobile and Internet services can be presented with a four-field model (see Figure 5-1). The model consists of two axes: the horizontal axis illustrates how high data rate is needed in order to perform the wished service at desired way and the vertical axis divides services by their nature of urgency.

The latter axis also indicates how strong the quality of service (QoS) requirements for different services are. The categorisation of services can be based on their tolerance to delays and losses in the network. Real-time services are often interactive by their nature and do not accept any delays or drops. On the contrary error tolerance is much higher with elastic services. Defining services to elastic and to real-time services is quite widely accepted categorisation [Saa99b]. Thus, the QoS follows real-time/elastic axis.

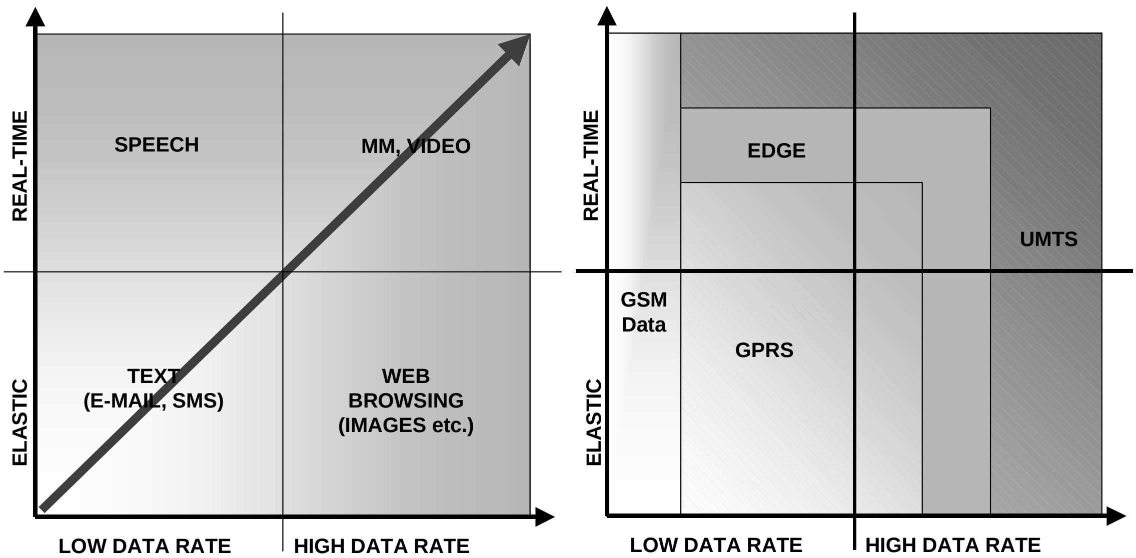


Figure 5-1. Services features by applications and platforms

The right-hand figure roughly illustrates what platforms are suitable for different services and vice versa. The figure is based on earlier in this thesis presented features of services and technologies. In addition, the colour of the model is shaded because it is not possible to draw a clear line between different cases. The next sections will handle these subjects more precisely.

5.1 Network Aspects

When it comes to the service implementation, some essential network planning issues have to be considered. New services may need more capacity, better QoS level or higher data rate. Network optimisation or building up a new network can be solutions for fulfilling these various needs.

Even though the service provider is not necessarily the network “owner” and can-not plan the network to be more suitable for certain services, it is likely that the operators and networks will answer the new needs arising from the growing number of mobile data subscribers.

5.1.1 Capacity

Network capacity is dependent on many factors. The required capacity is determined by an estimated customer base and average usage behaviour in different user groups. Usage behaviour refers to how often a user makes or receives a call, what the distribution of the call duration is and what is the average of transferred packet-switched data [Usk00].

Traffic in a network is usually dimensioned by estimating the traffic during the hour with most intense traffic known as the *busy hour*. The time of a busy hour is area, or even cell-specific. The average traffic per user is usually dimensioned lower in cellular than fixed network, due to higher service prices in mobile systems [Usk00].

Packet data dimensioning is more complex than dimensioning of circuit-switched speech, as packet transmission is not Poisson process. However, packet intensity varies in time [Usk00].

Data services bring traffic asymmetry from IP also to cellular networks. UMTS Forum [UMT98b] estimates the downlink-uplink traffic asymmetry to be around 40:1 in medium multimedia and around 200:1 in high multimedia. In reality, however, signalling data must also be transmitted to the uplink and this overhead reduces the asymmetry factor. When the signalling overhead is taken into account, the asymmetry is estimated to be 10:1 at its maximum. Nevertheless, recent researches have shown lower but significant asymmetries as packet transmission shows 5:1 asymmetries in the fixed network Internet usage, and the results are estimated to be quite similar in GPRS and UMTS [Usk00].

Service portfolios with numerous different services add a new perspective to traffic dimensioning. Different services add different requirements and loads to network and thus user behaviour pattern increases in importance. The introduction of new services have to be accounted for before their realisation, for new services may have notable impact on traffic distribution and load balance in the network [Usk00].

Figure 5-2 illustrates one method to calculate required capacity. The method goes only one step further; the end result is the spectrum requirement for UMTS/IMT-2000 based on the calculations for the needed capacity.

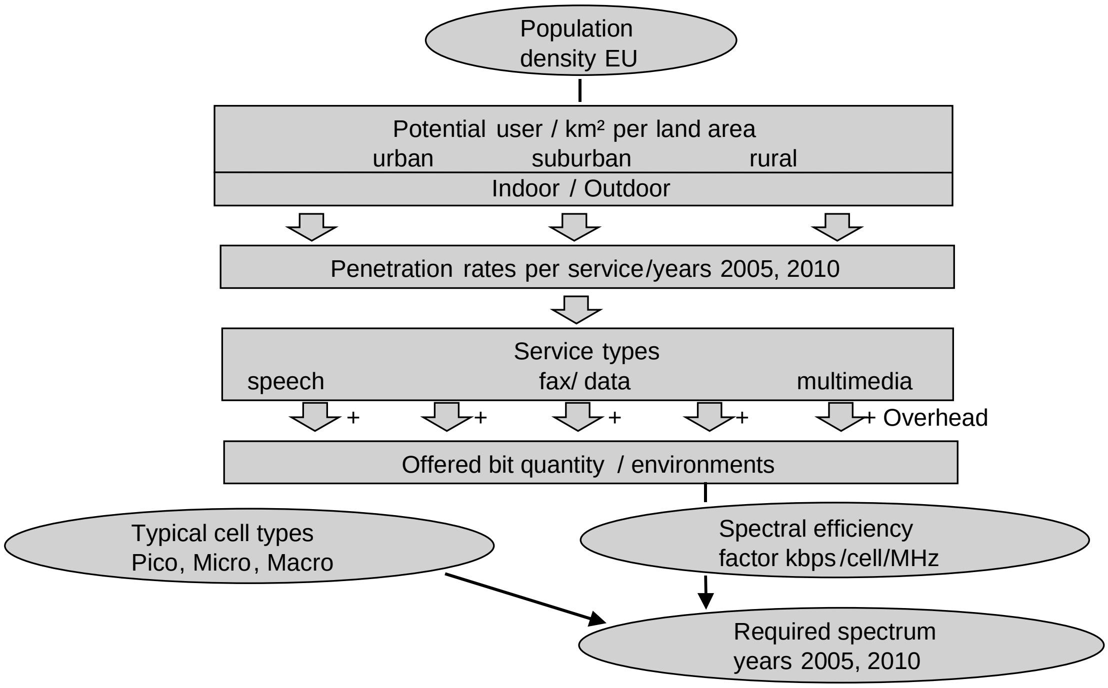


Figure 5-2. Calculation method for UMTS spectrum [UMT98c]

The requirement calculated for terrestrial UMTS/IMT2000 is based on several factors:

- Market forecast and penetration
- Potential user density
- Service and traffic characteristics
- Infrastructure and technical characteristics

The service types used in calculations are: speech, simple messaging, switched data, medium multimedia, high multimedia and high interactive multimedia. Spectrum requirements for each service type are considered in each of the six geographical operating environments: central business district (CBD), suburban, home, urban pedestrian, urban vehicular and rural. The spectrum requirement calculation takes place independently for each case, with a final summation giving the total spectrum requirement [UMT98c].

The first stage in the calculation is to derive the total amount of users per square kilometre for each of the six service classes. This can be derived from the population density and the service penetration. Each service in each environment generates a particular call rate (calls/hour) and particular call duration (s) and a particular bit rate (kbps). Further multiplication generates the bit requirement (kbit/hour/km^2). The bit requirement must be increased to take account of a coding factor, overheads for signalling and packet retries and blocking for circuit-switched. This gives the figure for the offered bit quantity (kbit/hour/km^2) [UMT98c].

5.1.2 Quality of Service

Quality of service (QoS) is a widely used term in many contexts. It is mostly used for describing the quality perceived by users according to different criteria. ITU-T E.800 defines QoS in the following way [Top99]:

> *"The collective effect of service performance, which determines the degree of satisfaction of a user of the service"*

Different standard institutes have defined various QoS indicators. Usually, in cellular and data networks, the indicators are a percentage of transmission parameters exceeding certain noise or loss parameters. QoS parameters are measurable factors that present a certain quality factor [Top99].

Most of the coming and current mobile data services are IP-based. Therefore, it is important to examine QoS aspects and parameters both in cellular networks and on the Internet. End-to-end QoS is a fundamental factor to, for example, mobile multimedia services.

Cellular Networks

Coding schemes in cellular networks affect data rates and at the same time the quality. If the signal is poorly coded, there is no protection for errors. The highest data rates can be achieved in an interference-free environment, whereas strong coding always decreases data rate.

Table 5-1. Quality codes in GSM [Nok94]

Quality	BER (%)
0	< 0.2
1	0.2 - 0.4
2	0.4 - 0.8
3	0.8 - 1.6
4	1.6 - 3.2
5	3.2 - 6.4
6	6.4 - 12.8
7	> 12.8

The quality level in a physical OSI layer can be measured in GSM systems. There are seven different bit error levels specified (see Table 5-1) [Nok94]. Bit error rate (BER) depends on adjacent and common channel interference (C/I) and noise.

The most common QoS parameters for cellular radio networks that can measured by operators are

- Downlink and uplink quality (BER) bit error ratio (%)
- Call attempt success rate (blocking) (%)
- Dropped call rate (%)
- Handover success rate (%)
- Downlink and uplink power level/field strength (dBm)

The mobile sensitivity according to GSM specifications is –102dBm for GSM900 and -100dBm for GSM1800.

HSCSD offers the same kind of quality as the current GSM systems. The difference between GSM and HSCSD, i.e., the amount of fixed channels per user, is taken care of in the call set up. Signalling parameters in the call set up define the desired data rate, Fixed Network User Rate (FNUR) and maximum possible Air Interface User Rate (AIUR), acceptable channel coding(s) for the call, and maximum number of time slots the mobile user can accept. The wanted AIUR is applicable only to non-transparent services. With transparent services, the user does not notice the possible change in data rate, caused by decrease in field strength and coding scheme [ETS99a].

A GPRS Quality of Service profile is defined by five different class values [ETS98c]. The classes are precedence, delay, reliability, peak throughput, and mean throughput. Different combinations of the attributes define many possible QoS profiles. The profiles are considered to be single parameters with multiple data transfer attributes. Therefore, only a limited subset of all the combinations can be supported in practice.

The first GPRS system releases support only the best effort. However, both Ericsson and Nokia have announced that their second GPRS releases in 2001 will include QoS definitions. The QoS in EDGE is based on the QoS in GPRS and HSCSD systems.

In the UMTS QoS proposal there are four different QoS classes, i.e., traffic classes: conversational, streaming, interactive and background class (see Table 5-2). Generally, the QoS mechanisms provided in the cellular network have to be robust and capable of providing reasonable QoS resolution. It is not reasonable to define complex mechanisms that do not take into account the restrictions and limitations of the air interface [3GP99].

Table 5-2. Proposed UMTS QoS classes [3GP99]

Traffic Class	Conversational Class	Streaming Class	Interactive Class	Background
Fundamental Characteristics	Preserve time relation (variation) between information entities of the stream. Conversational pattern (stringent and low delay)	Preserve time relation (variation) between information entities of the stream	Request response pattern Preserve payload content	Destination is not expecting the data within a certain time Preserve payload content
Application examples	voice	streaming video	web browsing	background download of e-mail

The main difference between UMTS QoS classes is how delay sensitive the traffic is: conversational class is meant for traffic which is very delay sensitive, while background class is the most delay insensitive traffic class. Conversational and streaming classes carry mainly real-time traffic flows. Conversational real-time services, like video telephony, are the most delay sensitive applications and those data streams should be carried in the conversational class. Interactive class and background class are mainly meant to be used by traditional Internet applications like WWW, Email, Telnet, FTP and News. Due to loose delay requirements, both provide better error rate than conversational and streaming classes. The better error rate is provided by means of channel coding and retransmission. Interactive class is mainly used by interactive applications, e.g. interactive e-mail or interactive Web browsing, while background class is meant for background traffic, e.g. background download of e-mails or background file downloading. Traffic in the interactive class has higher priority in scheduling than background class traffic, so background applications use transmission resources only when interactive applications do not need them. This is very important in a wireless environment where the bandwidth is low compared to fixed networks [3GP99].

Internet

The Internet today cannot offer consistently adequate performance. The basic protocols support only minimal transfer control, which is satisfactory for delivering packets, not for managing the quality of the delivery. The QoS in the Internet is based on the best effort. All the traffic gets whatever bandwidth is available because the best effort has no traffic contract. Congestion situation causes changes in delay and in packet loss rates for all packets equally. That makes delivering real-time or higher quality services unreliable. Mechanisms for ensuring quality in IP networks are needed [Top99].

However, improvements to the IP networks are coming. Several protocols have already been developed for advanced packet handling and traffic quality control. For example, The Differentiated Service (DiffServ) Working Group has solved how to mark IP data packets with both traffic class and traffic contract information. The IPv4 packet header has a largely unused 'type of service' field that could be used with minimal impact. The field can be redefined as DiffServ field and carry information analogous to QoS class and traffic contract compliance, defining acceptable packet delay and loss [Kau99]. With this new header information, packets that include real-time data can be prioritised and routed through the network more efficiently. DiffServ is targeted only to local use. It is not possible that the quality can be guaranteed through the whole Internet – not at least in the short run.

5.1.3 Coverage

Coverage is also a part of QoS perceived by users. If the network does not offer services in the area where a user wants to use them or the network coverage performance is low, the quality is deficient. Operators usually define adequate power levels for different types of areas according to what kind of a network they want to offer to their customers. These levels can be measured with appropriate equipment.

The coverage can be defined in many terms. We can talk about local and global coverage. Local coverage means that the network covers only a certain location. That location can be, for example, one country, one city, or even only one room. There is also a difference between network coverage and service coverage. Some services can be used via different networks and terminals. Some, on the other hand, require a special terminal and a special network.

UMTS-Forum divides coverage into six operational environment categories [UMT98c] (see Table 5-3). The table also gives rough estimations of the potential service user base and cell types in the different areas.

Table 5-3. Operational environments [UMT98c]

Operational environments	Density of potential users/km2	Cell Type
1.) CBD/Urban(in building)	180 000	Micro/pico
2.) Suburban (in building or on street)	7 200	Macro
3.) Home (in building)	380	Pico
4.) Urban (pedestrian)	108 000	Macro/micro
5.) Urban (vehicular)	2 780	Macro/micro
6.) Rural in- & outdoor	36	Macro

The categorising of coverage areas happens at three levels:

- Urban/Suburban/Rural,
- National/International or Local/Global
- Indoors/outdoors

5.1.4 Data Rate/Bandwidth

The cellular networks a variety of data rates in different operating environments. Table 5-4 shows estimated data rates offered by different platforms.

Table 5-4. Data rates in different platforms

Max data rate/ Environment	Outdoors - High Mobility	Outdoors	Indoors
GSM Data	14.4 kbps	14.4 kbps	14.4 kbps
HSCSD	57.6 kbps	57.6 kbps	57.6 kbps
GPRS	40 kbps	56 kbps	115 kbps
EDGE	144 kbps	144 kbps	384 kbps
UMTS	144 kbps	384 kbps	2 Mbps

In addition to the data rate, also connection set-up times differ from a network to another. It can be very frustrating to wait dozens of seconds before the service can be accessed. The data rate that users can gain depends on many factors. The offered data depend on the network capacity, coding and different network parameters.

It is probable that when users can use many time slots like in HSCSD and GPRS in order to gain higher bandwidth, voice is prioritised over data services.

For example, in EDGE, the mean data rate per user depends on the number of users. GPRS and GSM users can share the resources and that leads to difficult cellular planning for providing a consistent service.

There are many different types and categories of services. In Figure 5-3 the most common services according to their requirements for bandwidth are listed (see also Table D-2 in Appendix D).

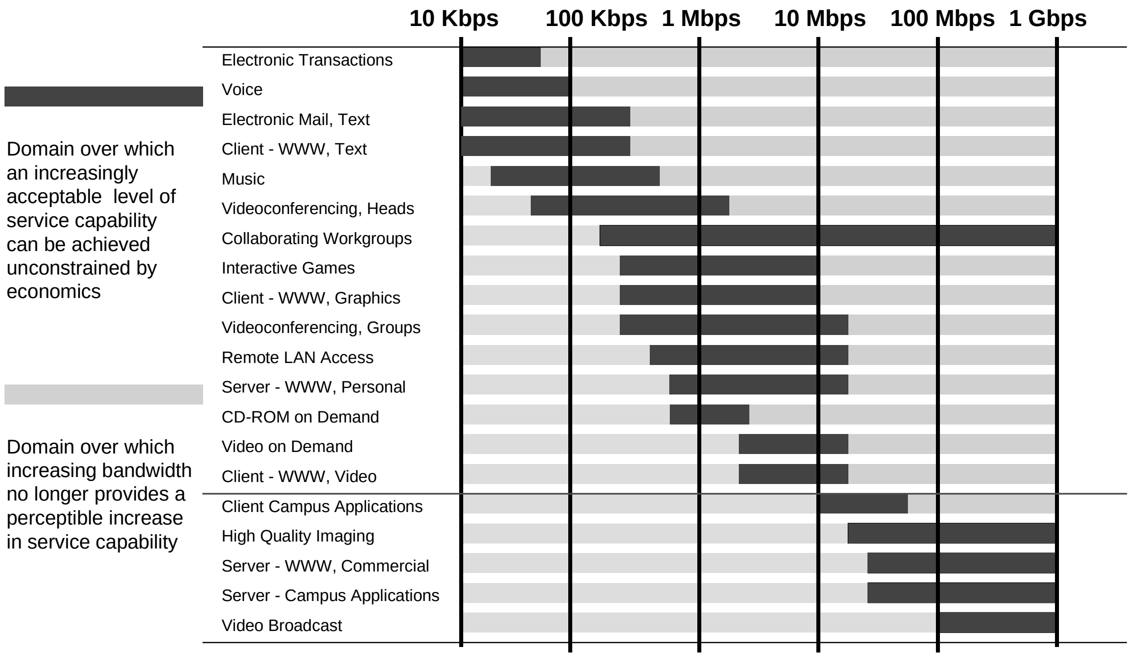


Figure 5-3. Bandwidth demand of services [Saa99a]

5.2 Terminals

As there are many different types of services, there are also various types of terminals. Mobile services of today can be used with ordinary cellular phones or with advanced cellular phones that have WAP-functionality. In addition, some of the cellular phones have a data connection interface, e.g., wire or infra-red link, and thus can be connected to a laptop or to an EPOC system. Also, Personal Digital Assistants (PDA) are popular. In addition, wearable computers are coming. IBM, for example, has chosen 100 test users for their ‘walkman alike’ wearable computer that includes earphones, ‘eye screen’, and CPU device on hips. The device is controlled with a pen, which functions as a mouse and a microphone [Lei99].

The trends with mobile terminals have been decrease in size and in weight, lower power consumption, i.e., longer battery lifetime, and having many features included in the phones. The wireless devices usually have restricted power consumption, less powerful CPUs, less memory, smaller and lower quality displays, and different input devices than fixed devices [Mar99]. The devices will also become very personal and they will be used under a wide range of operating conditions. Many terminals will be dual or even triple mode in the near future. There already now are GSM phones that function both in GSM900 and GSM1800 networks.

In consequence of the mobility, the following factors have to be taken into account when designing services for the wireless environment:

- The features of the display: limited size, resolution, and colours
- Data input and navigation is done with stylus and/or small amount of buttons instead of a mouse and a keyboard.
- The memory and CPU set restrictions on how much of the document processing can be done on the client device.

The size and resolution restrict the amount and size of elements that can be placed in one screen. The size of the documents and their processing have to be considered from the view of the whole architecture; how the actual information and styling related to it is described and handled [Mar99].

In addition, terminals support strictly defined data rates. In GPRS the uplink and downlink cases are handled separately. The combination of downlink and uplink time slot allocation will most probably be 4+1 or 4+2 at maximum, depending on the vendor. Therefore the first GPRS phones will support at the most 50 kbps data rates downlink – not the maximum values that the GPRS system can offer in optimal circumstances [Saa99c].

5.3 Security

The security-related functions of GSM and other mobile networks aim at two goals: protecting the network against unauthorised access and at the same time protecting the users from false impersonation; and protecting the privacy of the users [Mou92].

For example GPRS security function [ETS99c]:

- Guards against unauthorised GPRS service usage (authentication and service request validation).
- Provides user identity confidentiality (temporary identification and ciphering).

- Provides user data confidentiality (ciphering)

An increasing part of the data transfer will be secured using end-to-end encryption [Wal99]. However, in some countries, e.g., in France encryption is not allowed.

Security functions will be implemented on various protocol levels in the future, hence the complexity of security environment will increase. There will be two-way authentication procedures and Public Key Infrastructure (PKI) systems will be integrated into mobile stations. As a result of the convergence of wireless wide-area networks and the Internet, mobile users can easily be reached from the Internet. Mobile telecommunications operators have to protect their subscribers from attacks coming from the Internet. In addition, roaming creates a security risk if foreign network operators can not be trusted [Wal99].

The security issues are strongly related to the regulation issues introduced in Section 3.3.

5.4 Interoperability, Scalability, Adaptability

Mobile networks offer users services independent of time and place. The former presented boundaries set limits to ubiquitous service mobility.

As they move, users may experience considerable variations in their environment, in terms of latency, network bandwidth, available services around, etc. As a consequence, the level of service of the provided information may strongly depend on the context from which a user issues a query [Cou98].

There are different cases when scalability and interoperability are needed. If a person is having a videophone session with his cell phone and at the same time he walks from indoors to outdoors, and even worse, goes in to a car and starts driving, the service level most probably drops. For example, in UMTS systems the indoors data rate can be up to 2Mbps, but the outdoors data rate is expected to be under 400kbps. To handle such information, systems must be adaptive to change their behaviour, preferably without the user invention, depending on the current context of the user [Cou98]. The changes in the environment can be handled to some point by decreasing the picture resolution or by changing the colour scheme from colourful to black and white. It has to be considered whether the users willing to accept these variations in quality – and if they will, how far.

The other thing is the interoperability with totally different systems like GPRS and UMTS. At least some of the future terminals will be dual mode or even triple mode terminals. That means that the terminals can be used in different networks. One prerequisite for UMTS is that handovers between GSM/GPRS systems will work, because at least in the early phases of UMTS implementation the coverage offered by UMTS will be patched and it does not cover, for example, rural areas. In addition, there are differences between other terminal capabilities too.

The services should be designed so that they clearly fit some special environment or they should have some clever ways of managing different platforms and usage situations. The latter requires scalability. Adaptability, on the other hand, means that services have to be appropriate. Location based services, for example, offer the most accurate information.

6 Framework for Service Concept Development and Evaluation

The technology boundaries have to be taken into account when making decisions in different phases of the development process. The boundaries form criteria for proceeding in the process. If the criteria are not fulfilled, the development process has to be stopped as there exists no technology for realising the service. Of course it may be possible to return to some earlier design stages and check if the service definition can be changed to reach technological feasibility.

This section introduces one possible model for mobile service development and basic guidelines for evaluating the technology aspects. It also explains how the development process and technology boundaries can be combined (see Figure 6-1), i.e., how to use knowledge of technology for estimating and developing service ideas.

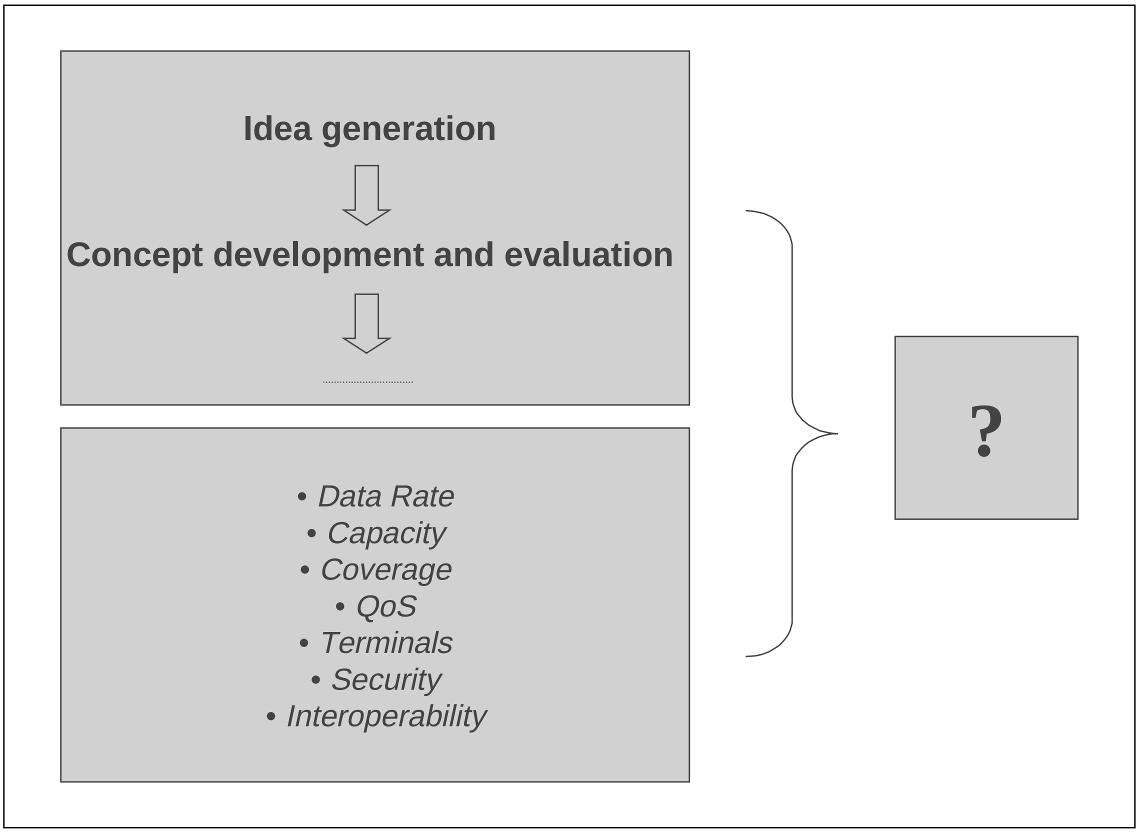


Figure 6-1. Process and boundaries

Here, the thesis focuses on the technological evaluation at the early stage where service concepts are to be evaluated and initial technology design starts. The focus was chosen as the most critical technology decisions are made at this stage. Furthermore, evaluation of vague service concepts is more challenging than evaluation of service prototypes with more possibility for concrete measurements. Evaluation of the technical feasibility of the service idea early is especially important when customer-oriented design methodology is applied. The ideas come from customer needs, not from the technology.

Moreover, service provision situation varies from company to another. Since there are many parties and roles in the mobile telecommunications value chain, service provision can be approached from two angles:

1) Service platform already chosen/owned. The company's (operator's) strategy could be to create services only to the GPRS platform → boundaries and limits of the network have to be checked, also improvement possibilities have to be known. An operator has the possibility to change and optimise its own network if needed - for example, if the data services become more successful than estimated [Don98].

2) Service provider operator and/or platform independent → the service provider company has to be aware of what kind of technologies and networks, i.e., different possibilities there are on the market and what their basic features and limits are. The same service could be implemented on a certain platform or on several platforms – the solution can also be totally platform independent.

Therefore, what kind of criteria and how important criteria the boundaries form depends highly on the company and the intended service.

The first stages of the service development process in [Zei96] are adjusted to the special mobile communications requirements handled in the thesis (see Figure 6-2).

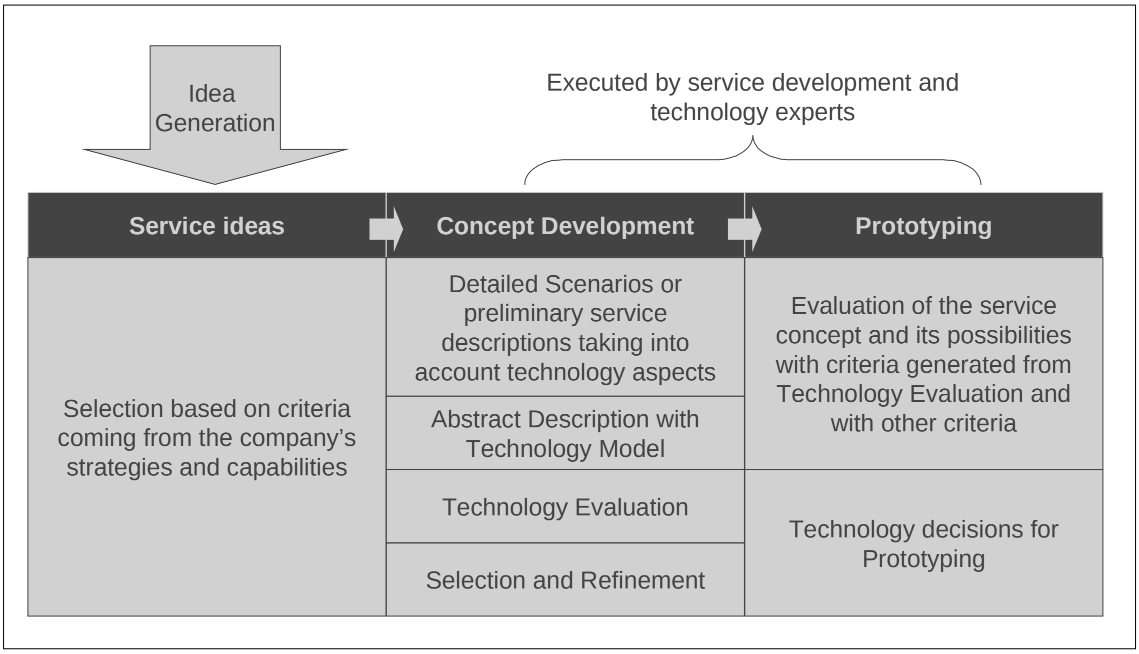


Figure 6-2. Framework for service concept development and evaluation

The contents of the framework are explained in the following three sections.

6.1 Concept Generation

Concept generation consists of idea generation and concept development. Carefully collected ideas have to be converted into detailed service scenarios that include all the information needed for a proper evaluation. Some of the service ideas can easily be dropped at this stage if they do not meet the company's overall strategies and capabilities. In the idea generation and selection phase, experts in computing, service design, or in telecommunications are not necessarily needed; idea generation is often carried out by people with skills in sales, marketing and other business functions [All93].

A service scenario in the framework is basically a small story about a fictional user that needs to use some services in a described situation and place. The incidents described in the story have a concrete character as they include details such as time and named existing places. Furthermore, service scenarios give basic profile information of the user and also define the main quality requirements of the service. Although the story is fictional, it always is backed up with real user data gathered during concept generation. For brevity, links to background data are not included in the scenario [Ran00b].

Scenarios should include the following information:

- Aim of the service (what user needs the service should fulfil)
- Data to be communicated
- Desired quality level
- Service/usage environment → mobility model and environment analysis

All additional information of estimated service user base, i.e., penetration, security needs, and, for example, of service usage duration is an advantage. When the service development process starts it is important to gather all the requirements for the possible service that are already clear in the beginning. These can come directly from the company's service strategy. If the customer segment has already been decided, how and where the customers move and use the service can easily be defined.

The actual concept development part of the process is the core of the technology evaluation. The concept development phase includes work contributions of technology, development and other possible experts, e.g. business experts.

The technology experts construct technology models out of the chosen scenarios. The technology experts study the scenarios and extract from them the involved parties, needed servers, transmission paths, changed data, etc. While doing this they discover alternatives on the technology solutions and express them as explicit models, i.e., technology models. Thus they achieve a description of the initial technological solution alternatives and are able to evaluate them. Without this extraction and modelling phase, the technology designers would have difficulty in recording the rationale for their evaluation and furthermore in communicating it to the other designers.

Technology models consist of the service architecture elements needed in implementing the service (see Figure 6-3). The elements form the basic architecture and are described in a few words and pictures in the model.

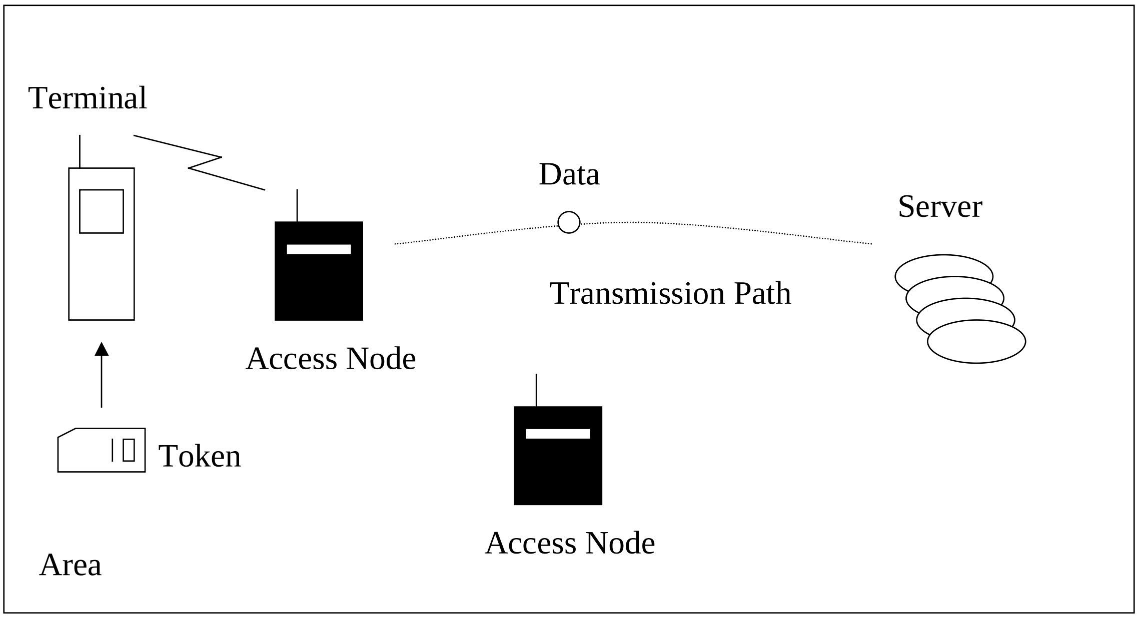


Figure 6-3. Technology model

These service architecture elements are:

- Terminals
- Data
- Interfaces (Access)
- Servers
- Other Relevant Factors, e.g., mediators

When the model introduced in Figure 6-3 is connected to some certain service scenario, the elements are named more specifically, e.g., area: urban, data: e-mail, etc. The elements can be a base for a computer application for service development. Technology evaluation is based on the scenarios and technology models.

6.2 Technology Evaluation

The aim of the technology evaluation is to find possible solutions for service implementation and to determine if they altogether exist. In addition, the critical technology related features of the service have to be discovered. Evaluation is done by a group of technology experts. Communication between the experts and also to the other experts from the user and business areas is extremely important. The results and improvement ideas coming from the evaluation have to be discussed with other members of the whole development team.

6.2.1 Guidelines

Instructions are needed in order that answers from different evaluators are comparable. The evaluators have to think through all the needed technology aspects. Logical order of the aspects is thus needed. Guidelines together with a well-prepared evaluation form give the basis for a successful evaluation of services according to the technology boundaries. The *evaluation guidelines* in Table 6-1 show how the different technology aspects should be considered.

Table 6-1. Evaluation guidelines

Technology aspect	Instructions	Needed information of the service
Data Rate	Data rate/bandwidth need is evaluated per one user. Please, check Table D-1 for help. Remember: data rate can depend on the needed quality level too!	Data to be communicated
Coverage	Evaluate the coverage need for the service: ▪ national/international ▪ rural, suburban, urban, local ▪ indoors/outdoors	Mobility model
Capacity	Capacity need consists of users and their usage in a limited area (Coverage). Usage means the combination of usage time and data rate. Capacity calculation can be based on environment analysis, which includes information of the population and service penetration in a certain area. Evaluate capacity aspects also considering terminals. The need depends highly on the data to be communicated.	Estimated user base in the service area. Environment analysis.
QoS	Evaluation of the needed level of quality. Is the level high, moderate or low? On what basis? What does that require in practise of the system?	Estimations and demands for quality of *content* and *network/system* User tolerance to: ▪ Blocking ▪ Dropping ▪ Noise ▪ Delays Real-time features
Security	Security requirements depend on the data to be communicated and for example on how the billing is executed.	Information of the needed security level, money transactions, etc.

Criteria that should be evaluated before proceeding to the next stage of the process are service requirements for data date, coverage, capacity, terminal capacity, quality of service, and security. In order to be able to better understand the need for quality of service the real-time features of the service should be considered too. Table D-1 referred in *evaluation guidelines* can be found in Appendix D.

6.2.2 Evaluation Form

A scenario and technology model evaluation form is prepared in order to get as good feedback and improvement ideas as possible from the evaluators.

Some requirements for the evaluation form are:

- Good and usable grading methodology
- Logical order of the aspects
- Reusability, storability

The form aimed at technology experts is based on the boundaries introduced in Chapter 5 and the instructions developed in Section 6.2.1. The evaluation contains considerations such as:

- What are the special requirements the service sets for networks and terminals?
- Which of the requirements are critical (bottle neck) and why?
- Can the service be implemented with current or incoming technologies?
- If not, what should be changed in the scenario in order to be able to implement the service?
- How could the service be put into practice?

First the evaluators have to consider the different technology aspects and their relation to the service scenario and the technology model. The technology aspects are then to be graded by their criticality, i.e., which of the aspects can become bottlenecks in the implementation of the service. When these aspects are analysed the experts should have a good understanding of what the service requires of the network. Therefore, answering the questions in the list above should be easy. The results of the evaluation are advantageous and fruitful when the evaluation is done in a consistent and proper way.

Table 6-2. Evaluation sheet for technology experts

SCENARIO EVALUATION FORM FOR TECHNOLOGY EXPERTS

Think the following questions considering the service described in the scenario:

1) What are the special requirements the service sets for **networks** and **terminals**? Which of the requirements are critical (bottle neck) and why?

Aspect	Criticalness	Reasons:
Data Rate		
Coverage		
Capacity		
QoS		
(Security)		
Terminal Capacity		

After evaluation the service by the features above think

2) Is the service implementable with current or incoming technologies?
Name the technologies and give the reasons why YES and why NOT.
You can also think what should be changed in the scenario in order to be able to implement the service?

Technology	Reasons:

Can you think of any possibilities how the service could be put in to practice?

The form is in electronical form (Excel sheet) so that the information can be stored, easily handled, and reused later on (see Table 6-2). Also, other electronical forms can be used.

After the experts have graded and evaluated the scenarios and the related technology models, the service concept reaches a more specific form. A detailed service description is made out of the scenarios. The service concept combines the best parts of the service scenarios. Prototyping is the next phase.

6.3 Prototyping

The prototyping phase includes the actual technology decisions. During this phase, the service concept is still forming itself to a more concrete form. Technology Evaluation gives the basic requirements of the service and possible implementation technologies as an input to the prototyping. The criteria found in the earlier phases can be more specific, i.e., actual values for the criteria can be given.

A design rationale approach can be applied in order to overcome the difficulty of change management and to ensure that all the requirements are taken into account during each service design decision. The aim of this approach is to store the background and reasons for design decisions so that the design process also produces the reasons for why, e.g., certain components or their features were selected along with the final component specifications. Thus, it is possible to go through the design decisions and check the needed modifications, when the requirements are changed or a new technology offers new alternatives for the implementation [Ran00a]. The design rationale approach is introduced in more detail in Appendix C.

This approach was tested at the GO-PROD seminar held in November 1999 and as a result the approach

> *"…was found easy to adapt and the participants were well motivated into its usage as they had their own experience in the difficulties of documenting design results properly in order to support the reuse (or even use) at later stages. Design rationale (DR) provides a systematic method for collaborative design and gives guidelines on judging the design decisions. When the groups presented their results to the seminar audience, DR turned out to provide means for an assessment meeting, since the transparent criteria and evaluation made it easy to comment and point possibilities for enhancements. In the example case contradictions in decisions and missing criteria were easily revealed by the DR."*[Ran00a]

7 Case study: Mobile Music

A case study is executed within the GO project. Section 7.1 introduces briefly the GO project and its key features to this thesis. The GO platform is introduced in Section 7.2. Development methods and results, e.g., a service prototype, are introduced in Sections 7.3, 7.4 and 7.5. Suitability of the prototype to cellular networks is considered in Section 7.6.

7.1 Project Introduction

This section is based on the GO project description [GO99]. The three-year GO project is carried out in Helsinki University of Technology and is funded by Tekes and seven companies from different aspects of telecommunications. The GO project offers an ideal environment for service development and testing. The project aims to research properties of wireless networks. That includes building up a network and implementing services in to it. The methodologies for implementation are also developed and tested.

The most interesting properties of wireless Internet networks and applications for the project are

- Mobility management, security issues, quality of service, performance, charging/billing, network management, configuration and operation
- Mobile-aware applications, location-aware applications, adaptive applications, application-network layer interaction
- Broadcast services, services in the future high capacity mobile Internet environment, impacts of mobility on services and applications
- How end users are willing to accept new services, how to use scenarios in visioning the future possibilities and challenges

The GO project is divided into seven subprojects. Most of the subprojects are quite independent of each other to allow parallel research and development in each of the subprojects. The project is divided into the following subprojects:

GO-CORE: Core network and mobility management project

GO-PROD: Product concepts and user aspects

GO-PERF: Performance engineering

GO-FORM: Formal methods for protocol evaluation and testing

GO-SEC: Security issues in mobile communication

GO-LAP: Large capacity wireless access point

GO-MM: Wireless multimedia services

The subproject GO-PROD is carried out by the Product Modelling and Realisation Group (PM&RG) in collaboration with the Usability Group of the Department of Computer Science and Engineering.

The PM&RG aims at providing novel information technology based tools for creating and deploying product data through the entire engineering process and the entire life-cycle of an industrial product. This covers both the new product development process and the customer order satisfaction process. PM&RG's current research interests include:

- allowing product development by distributed teams
- presenting product and process related knowledge in a reusable and transparent way
- capturing product development and background information already in during the early stages of conceptual design

The Usability Group is a research group interested in human-computer interaction and usability engineering. The work can be divided into three categories:

- usability testing and consulting
- usability research
- teaching human-computer interaction and usability engineering

GO-PROD focuses on service development and generates application concept prototypes that allow experimentation of mobile services and devices. The subproject will trace the product development process it applies and the applied product development information it makes use of as completely as possible by using appropriate modelling and documentation tools. The objective is to produce transparent and reusable documentation on the applied methods, rules, and software tools and on their evaluated capabilities for the various types of development tasks. In summary, the objective of GO-PROD is to show how the features of the concepts are reflected in the willingness of the people to use them in a mobile environment.

GO-PROD is divided into three threads that proceed in parallel in order to avoid waiting periods and to allow as much independent progress as possible. Furthermore, the concurrency was adopted to experience the product development management trend that keeps several parallel processes running and feeding each other for the sake of rapidity and agility.

The concept thread will define scenarios on who uses the product or service in what situation and how. The concept generation is based on studies on user groups such as researchers, students, aged people, editors, travelling businessmen, maintenance men, etc. The user studies apply a wide variety of user study methods for information gathering, analysis, idea generation, and validation. This process created a pool of well-founded and understood use scenarios that typically describe a service, its user(s), their mobility, and the locations. Moreover, rich background data was collected and stored along with the data created through designers' activities such as analysis and idea generation. The concept generation thread repeats the process quite autonomously on new user groups and thus generating an evolving pool of use scenarios for the usage of the product thread.

The product thread includes both the building of conceptual or demonstration prototypes for the concept thread and the building of illustrative cases of the GO project. The product thread carries out service and device design according to use scenarios that are selected from the results of the concept generation thread. The objective is to carry out design and realisation of rapid prototypes that can be used for assessment of the service ideas. For rapidity, the thread puts emphasis on modularization and reuse of the design knowledge as well as on allowing the collaborative design of interaction, technology and business experts. A new prototype will then be built each year based on the use scenario pool from the concept thread. Usability evaluation will be carried on the service and device prototypes. Furthermore the service architecture and the business chain will be evaluated in co-operation with the other subprojects and companies.

The methodology thread covers the methods, practices, and software tools that are needed to support the two other threads and puts an emphasis on making them as transparent as possible. Available documented methods and commercial tools are used and experimented with the most part; however, software development will also be carried out to propose novel approaches to overcome the difficulties of proper knowledge management and reuse.

7.2 GO Platform

The basis of the network used in the GO project is a core network called MediaPoli. The core network is located in Otaniemi area, having also some connection points in Tapiola in the Spektri building. The mobile network includes Nokia Wireless LAN base stations. There are several base stations both outdoors and indoors attached to the core network.

WLAN operates in 2,4 GHz frequency band. Ad-hoc principle and Direct Sequence Spread Spectrum data transmission are chosen for the GO project's network. An interested reader can turn to Appendix A for more information about WLAN technology.

7.2.1 Coverage and Capacity of the GO Platform

The main buildings in the area have indoor coverage but the coverage is still patched. The base stations aimed for outdoor coverage, function well in line-of-sight conditions (0,5km). Small obstacles in the way decrease the radius to 200m-300m and if there are, for example, stone buildings blocking the sight the signal from a base station can no longer be caught. Network capacity perceived by one user is highly dependent on the type of service and the amount of other users under the coverage of the same base station.

7.2.2 Data Rate of the GO Platform

The data rate provided by one base station is 2Mbps. The actual data rate for payload is smaller, depending on the transport protocol.

User Datagram Protocol (UDP) is a transport level protocol for unreliable connectionless delivery, while Transmission Control Protocol (TCP) offers a reliable stream transport service for IP traffic. Reliable TCP is used for most applications instead of UDP [Top99]. When using applications such as Web browsing and e-mail that run via TCP, the data rate is 1,4Mbps. The rate is decreased because of the overheads added to the packets and because TCP retransmits lost packets. With UDP the actual data rate is a bit higher, 1,6Mbps. UDP also adds overhead to the packets but does not support retransmission. This makes it unreliable compared with TCP. UDP protocol is mostly used for real-time services like video and audio [Mal99].

The data rate is divided between all the users connected to the BS. With Nokia WLAN base stations the number of users connected to one base station can technically reach 64. But the realistic estimations for the user amount is closer to the number 20 when referring to non real-time applications like e-mail and file transfer [Suv99].

7.2.3 Quality of Service of the GO Platform

With the GO platform, certain QoS levels are difficult or even impossible to maintain. When we take into account the delays and droppings caused by handovers, the quality drastically sinks. In Mobile IP mode, one handover causes 20ms delay and without Mobile IP (basic mode) handoffs fail.

7.2.4 Terminals in the GO project

The first phase terminals in the GO project are laptops that are equipped with Lucent 2Mbps WaveLAN network cards. Encryption is possible with these cards but is not used yet. Laptops with operating systems, such as Windows and Linux, need only the

Lucent card to operate in basic mode. The terminal has to be equipped with specific mobile node software before it can be used in Mobile IP mode.

7.3 Service Concept Generation

The service development process in the GO project begins with concept generation. Altogether, it follows the framework introduced in Chapter 6 to a large extent. Idea generation in GO-PROD includes many phases from information gathering to analysis based on user studies. As a result an idea of mobile music listening - among many other ideas - came up.

The mobile music case study included refinement and evaluation of three scenarios. The whole GO project includes many scenarios and therefore also selection among many scenarios has to be done in order to maintain and develop further the best ideas. The generated mobile music scenarios are presented in Appendix B.

7.4 Service Design

Scenarios have to include certain information before they can be evaluated, therefore all the technology aspects according to the evaluation form introduced in Chapter 6 were checked. Technology models were also drawn before actual technology evaluation and filling the evaluation forms (see Appendix B). The filled technology evaluation forms were stored in the GO-PROD’s database (see Appendix E).

During the process it became clear that it is important that business people too are present in evaluation. They should evaluate the scenarios according to the business criteria. Hence, business models are needed. Mäntylä and Ranta prepared three business and interaction models for music scenarios [Män00]. These models and the technology models were combined in order to get an actual service concept. The final concept combines the best parts of the scenarios. Figure 7-1 illustrates the service design framework used in GO-PROD.

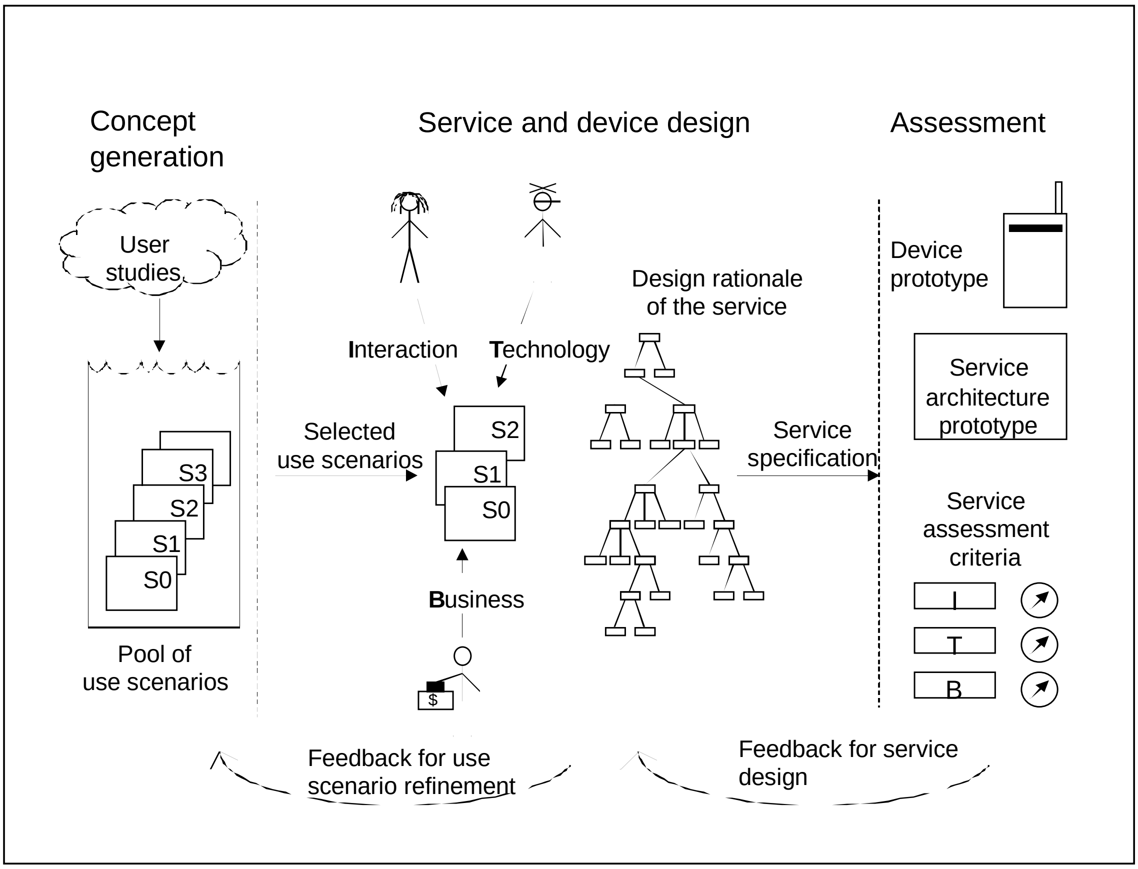


Figure 7-1. Service design framework [Ran00b]

The quality factors and service architecture chosen for the service concept were:

- CD quality music
- Server offering the music
- Music listening device for users on the move in Otaniemi area

These factors mainly came out of the scenario *Mobile Music in Otaniemi* (see Appendix B). Technology model for the service concept is shown in Figure 7-2.

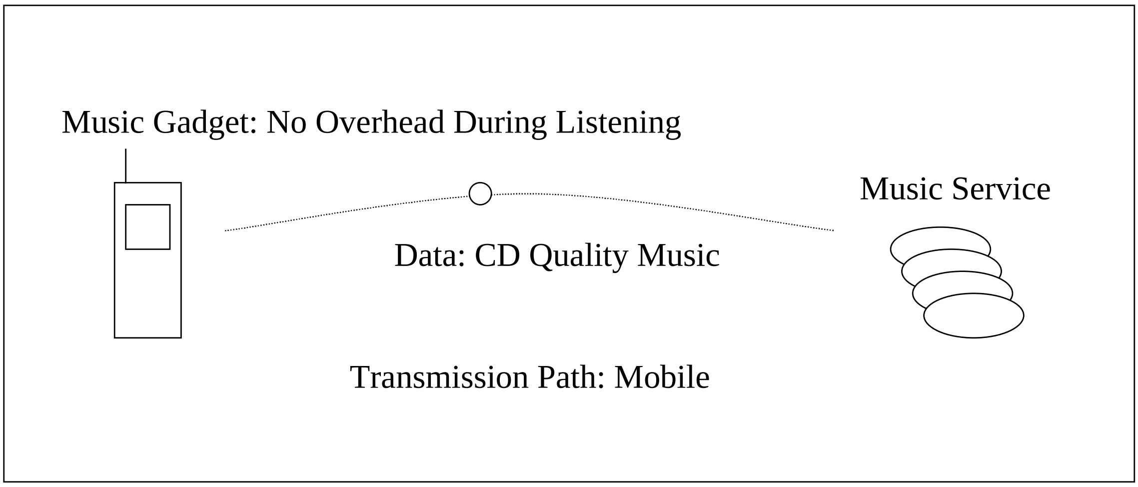


Figure 7-2. Technology model for the service prototype

These factors were easily combined with the *Streaming MP3 Player Service* interaction and business model.

7.4.1 Streaming MP3 Player Service

This *Streaming MP3 Player Service* description is adapted from the extended abstract of Mäntylä and Ranta [Män00]. The service being developed is based on a portable device that has the capability of accessing digital music stored in Moving Picture Experts Group (MPEG) -1 audio layer-3 (MP3) format on a server and playing it through earphones in a streaming mode. The actual prototyping effort aims at creating a hardware implementation of the device.

The total service includes, apart from the device, at least the following components that may or may not be controlled by a single service provider (see also Figure 7-3 for illustration):

- Access node that provides local wireless access to the portable device.
- Fixed network that provides wideband-networking capability between the access node and the server hosting MP3 data.
- The MP3 server that provides IP access to the MP3 music and may provide additional interfaces depending on the user interface metaphor chosen for the service.
- MP3 music providers that own the copyrights to the music must be paid when it is listened to.

- Potential other parties that may be present according to the user interface chosen. These may include a telecommunications service provider or a bank providing a micro payment service.

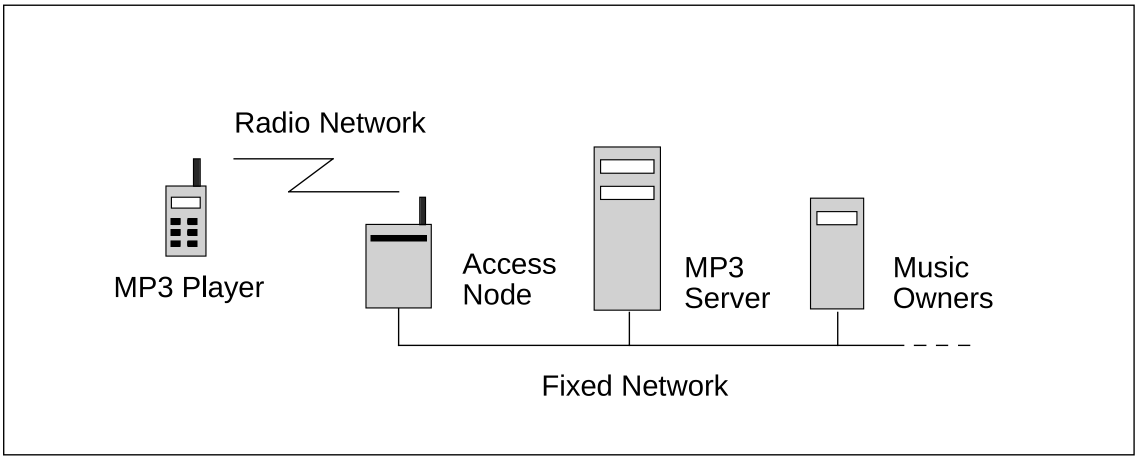


Figure 7-3. The streaming MP3 service [Män00]

The problem with the interaction model is that the device and the related service differ from the present commercial MP3 devices in the crucial aspect that music played is not pre-fetched and stored in the memory of the device. This means that, instead of 30 or so pieces of music, the device can access as many compositions as provided by the server. It also means that the user of the device does not necessarily need a computer to download the music to the device, as in present commercial devices. However, this also creates a challenge for the choice of the prime user interface metaphor of the device — that is, the choice of the interaction model of the service.

7.5 Service Prototype

Building a prototype of a service in GO-PROD strongly includes learning how to use a design rationale as a method for decision making and prototyping. Therefore, the research team is currently applying the DR approach in its own prototype development. The aim is to implement a computerised tool to support the storing, browsing, and editing of the DR and an initial data model has been programmed.

7.5.1 Criteria for a Prototype

This section presents all the criteria that were used for the design rationale for prototyping (see Table 7-1). The most important criteria are underlined in the list of criteria and the criteria that can be diminished are marked with a question mark. The list also includes criteria other than purely technology criteria. Some of the criteria were formed according to the technology evaluation and some were clear from the beginning. Also, some new ones came up.

Table 7-1. Criteria for prototyping

- Mobility:
  - Lightness of a terminal
  - Size
  - Ability to move
  - Area of usage
- Rapid prototyping:
  - Quick prototype
  - Rapid prototyping reuse
  - Gaining experience on prototype building
  - Technology experts available
- Usability:
  - Quick to use
  - Long playing time
  - Flexibility (variety of available music)
- Reasonable cost
- Quality music playing
- Reliability ?
- Innovativeness

7.5.2 MP3 Player

As a result of the design rationale and the earlier stages of the design process, MP3 format was chosen for the prototype. The first prototype, MP3 player, consists of a few standard components:

- PCI-bridge
- Sound card (Sound 100+)
- Mother board (ELAN 486/66, VGA display controller, 4 serial ports, keyboard connector)

The MP3 player does not restrict the radio access to one single technology. Both WLAN and GSM network cards can be attached to the player.

7.5.3 Features of Music in MP3 Format

MPEG-1 Audio Layer-3 (MP3) is a standard technology and format for compressing a sound sequence into a very small file (about one-twelfth the size of the original file) while preserving the original level of sound quality when it is played. It is normally used over IP. On-line listening of music in MP3 format requires more than 100 kbps data rate. Furthermore, in average ten pieces of music reserve about 35 Mbytes of memory [Asp99]. MP3 music is normally coded in 128kbps or 196kbps – that corresponds to CD quality music.

7.6 Prototype implementation in the Mobile Networks

This section answers how this prototype could be implemented in the HSCSD, GPRS, EDGE or UMTS network. Also, a WLAN solution is introduced. The section gives the explanations why the service succeeds or why it fails. The evaluation utilises the created framework. Results of the evaluation are shown in Table 7-2.

Because of the data rate limit the MP3 music sets to the networks, GSM data is too weak a platform for on-line listening. HSCSD could be more appropriate for that kind of a service but it takes over 30 seconds before one can start the listening because of the circuit-switched nature of HSCSD. In addition, HSCSD could offer at maximum less than 56kbps bandwidth, which is not enough for CD quality music.

GPRS, EDGE and UMTS on the other offer enough bandwidth for that kind of a service but they are not commercially available yet. Furthermore, GPRS quality classes may not be used in the first phases of the implementation; therefore the CD quality music (128 kbps or more) could be hard or even impossible to achieve.

Table 7-2. Technology evaluation of the music service

SCENARIO AND TECHNOLOGY MODEL EVALUATION FORM FOR TECHNOLOGY EXPERTS

Scenario:	1	*Mobile Music in Otaniemi*

Think the following questions considering the service described in the scenario:

1) What are the special requirements the service sets for **networks** and **terminals**? Which of the requirements are critical (bottle neck) and why?

Aspect	Criticalness	Reasons:
Data Rate	H	Music requires higher data rate that can be achieved with current cellular technologies
Coverage	M	Not a big problem to cover suburban areas (GSM already covers)
Capacity	M	Quite high data rate demand, but maybe not so many service users in the same area
QoS	H	CD Quality music that allows no delays, droppings, etc. - high quality requirements
(Security)	-	
Terminal Capacity	M/H	Terminals has to offer good quality music and enough data rate

H=High, M=Moderate, L=Low

2) Is the service implementable with current or incoming technologies?
Name the technologies and give the reasons why YES and why NOT.
You can also think what should be changed in the scenario in order to be able to implement the service?

Technology	Reasons:
GSM	not suitable because of the data rate limit
HSCSD	not suitable because of the data rate limit
GPRS	the first cell. technology that can offer needed data rates (music approx. 128kbps), technology not commercially available yet
EDGE	can offer needed data rates (music approx. 128kbps) - technology not commercially available yet
UMTS	can offer needed data rates (music approx. 128kbps) - technology not commercially available yet
WLAN	not suitable for covering the whole suburban area!

Can you think of any possibilities how the service could be put in to practice?
In the area there has to be a network/networks that offer enough bandwidth for moving users.
If there are many different networks (for example indoors WLAN, outdoors GPRS) users will have to have dual mode terminals.

Table 7-3 shows the approximate downloading times for 2 Mbytes of music when using different cellular platforms. However, the service idea includes on-line listening without any extra time for downloading.

Table 7-3. Download times for 2MBytes of music

Platform	Bandwidth	Time
GSM Data	9,6 kbps	30 min
HSCSD	40 kbps	7 min 30 s
GPRS	100 kbps	3 min
EDGE	200 kbps	90 s
UMTS	2 Mbps	9 s

8 Conclusions

The convergence of the Internet and mobile telecommunications creates a need and a market for effective and innovative mobile data services. Mobile telecommunications service providers need practical processes and knowledge about the technology, business and customers when they try to satisfy these new and more complex needs. Therefore, mobile telecommunications service development has to adapt to the rapidly changing environment.

This thesis focuses on how to take mobile telecommunications technologies into account during the service development process. The service development process demands from the beginning information about a company's own capabilities and goals, and also possibilities for technology choices on the market.

The combination of user, business and technology aspects strongly affects the success of services. All the aspects are needed in the service development process. However, the technology criteria set the most profound boundaries to the customer-centred service implementation. Therefore, they have to be considered already in the early phases of the whole development process.

The technology boundaries are taken into account when making decisions during the process. The boundaries form criteria for proceeding in the process. Early service scenarios have to include enough information before they can be evaluated from the technological point of view. The evaluation gives insight into the possibilities the service scenarios contain and helps in selecting the best scenarios for forward development. After the evaluation the scenarios can be converted into real concepts and prototyping can begin according to the ideas and criteria coming from the evaluation. However, what kind of criteria and how important criteria the boundaries form depends highly on the company and intended service.

The base for technology criteria forms a list that is adaptable to many different cases and technologies. The list contains the following aspects:

- Data Rate
- Coverage
- Capacity
- Quality of Service
- Security
- Terminal Capacity

The criticality of each aspect has to be evaluated in order to find the possible bottle necks of the service idea. Different technologies give their specific limit values to the decision making and evaluation process.

All the information gathered during the development process has to be stored for further use. If something in the service environment changes, it is easy to come back in the process and to find the new possibilities. As an example, some abandoned ideas can be more suitable after the change and worth of reconsideration and development.

The Mediapoli wireless environment together with GO facilities offers excellent possibilities to simulate and to test mobile services and service development methods. Wireless LAN is a suitable platform for testing future cellular services mainly because it has not as strict bandwidth limitations as the current cellular technologies. The fast cycle of mobile telecommunications business and rapidly changing environment enforce service developers to be efficient and fast in their moves. This emphasises the value of using different test environments.

The framework for technology evaluation and service design introduced in this thesis does not fully agree with the process in the GO project. In addition, the framework is only tested within the GO project. More cases and feedback are needed in order to prove the real value of the framework.

8.1 Future Work

This thesis defines only how the technology criteria can be applied based on the still vague service description of concept development. Studying how the criteria can be applied based on the more detailed service model resulting from prototyping could continue the study.

This study could be improved and continued by developing a coherent framework for the whole service development process. Also, business and user criteria have to be defined and combined with the methodology. The combination can be achieved by first clarifying what kind of links there are between different criteria groups and how those links should be considered.

Finally, the framework introduced in this thesis is tested only within the project environment in which it is created. Therefore, the framework has to be tested in different service development environments.

References

[3GP99] 3GPP, “3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; QoS Concept and Architecture,” *3G TS 23.107*, version 3.1.0, 1999.

[Afr99] African Cellular, “Wireless Application Protocol (WAP)”, *On-line Guide to Technology*, Available: http://www.cellular.co.za/. (Accessed: Sept. 10 1999)

[All93] J. Allen, “An environment for rapid service development (intelligent networks),” in *Fourth IEE Conference on Telecommunications*, Conf. Publ. No. 371, pp. 211-216, 1993.

[Bey98] H. Beyer and K. Holtzblatt, *Contextual design: Defining Customer-centered Systems.* Morgan Kaufmann, 1998.

[Bor98] M. Born and A. Hoffman, “An object-oriented design methodology for distributed services,” in *Proceedings of the Technology of Object-Oriented Languages and Systems, IEEE,* pp. 52-64, 1998.

[Bra99] N. Braithwaite, Bindman, and Partners, “Copyright I: Copyright, Civil Rights and the Internet”, in: *Liberating Cyberspace Civil Liberties, Human Rights & The Internet,* Liberty, Pluto Press in association with Liberty, pp. 125-139, 1999.

[Buc97] K. Buchanan, R. Fudge, D. McFarlane, T. Phillips, A. Sasaki, and H. Xia, “IMT-2000: service provider’s perspective,” in *IEEE Personal Communications*, vol. 4, issue: 4, pp. 8-13, Aug. 1997.

[Chi94] T. C. Chiang, “Product and service testing methodology and ISO 9000,” in *Proceedings of the IEEE International Conference on Industrial Technology*, pp. 852-855, 1994.

[Coo93] R. G. Cooper, *Winning at New Products*. Second Edition, Addison Wesley, 1993.

[Cou98] P. Couderc and A.-M. Kermarrec, “Improving level of service for mobile users using context-awareness,” in *Proceedings of the 18th IEEE Symposium on Reliable Distributed Systems*, pp. 24-33, 1998.

[Don98] G. Donatelli, C. Eynard, R. Rossi, and G. Strocchi, "Cellular network strategic planning methods in a service profitability analysis perspective," in *IEEE 1998 International Conference on Universal Personal Communications, ICUPC '98*, vol. 1, pp. 275-279, Oct. 1998.

[Eri99a] Ericsson, "Photo Library", *Corporate Press Room*, Available: http://www.ericsson.se/pressroom/. (Accessed: Dec. 20 1999)

[Eri99b] Ericsson, *GPRS Product Description*, Rev A, Mar. 31 1999.

[ETS98a] ETSI SMG2, "The ETSI UMTS Terrestrial Radio Access (UTRA) ITU-R RTT Candidate Submission," 1998.

[ETS98b] ETSI, "General Packet Radio Service (GPRS) Description," *GSM 03.60*, version 6.2.0, Oct. 1998.

[ETS98c] ETSI, "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Service Description; Stage 2," *GSM 03.60*, version 7.1.0, 1998.

[ETS99a] ETSI, Digital cellular telecommunications system (Phase 2+); High Speed Circuit Switched Data (HSCSD) – Stage 1, GSM 02.34, version 8.1.0, Release 1999, 1999-6, draft.

[ETS99b] ETSI, Evolution of the GSM platform towards UMTS, UMTS 23.20, version 1.5.0, SMG 12, 1999-00.

[GO99] *GPRS in Otaniemi (GO) Project description*, Helsinki University of Technology, Espoo, Finland, 1999.

[Hil99] M. Hilli, "Telealan säännöksiä," in *S-38.191 Televerkot yrityksissä*, Helsinki University of Technology, Espoo, Finland, Apr. 22 1999.

[Hei99] A. Heilingbrunner, "Application development towards UMTS," in *The 8th Summer School on Telecommunications seminar*, Lappeenranta, Finland, Aug. 9-13 1999.

[Hol98] K. Holley and T. Costello, "The evolution of GSM data towards UMTS," in *GSM World Congress*, Cannes, France, Feb. 1998.

[Häg99] S.-G. Häggman, *S-72.231 Matkaviestinjärjestelmät*, Course material, Helsinki University of Technology, Espoo: Otatieto, Spring 1999.

[Juv99] L. Juva, "Puolitoista miljoonaa suomalaista käyttää Internetiä viikottain," Aamulehti 10.6.1999, in: *Paikallisen teleoperaattorin internet-portaalistrategiat, Case: Finnet*, C. Löfberg, Master's Thesis, Tampere University of Technology, Tampere, Finland, 2000.

[Kaj97] M. Kajanto, Strategic Framework for the Interactive Information Network Industry, Doctoral Thesis, The Finnish Academy of Technology, Espoo, Finland, 1997.

[Kau99] D. H. Kaufman, "Delivering Quality of Service on the Internet," Available:http://www.telecoms-mag.com/issues/199902/tcs/kaufman.html. (Accessed: Oct. 8 1999)

[Kot97] P. Kotler, *Marketing Management, Analysis, Planning, Implementation, and Control.* Ninth Edition, International Edition, New Jersey: Prentice Hall International, Inc., 1997.

[Lei99] R. Leino, "Puettava tietokone tulee koekäyttöön," *Tekniikka&Talous*, p.15, Nov. 18 1999.

[Mar99] O. Marttila and P. Vuorimaa, "XML based mobile services," *in The 8th International Conference in Central Europe Computer Graphics, Visualization, and Interactive Digital Media'2000,"* WSCG'2000, Czech Republic, Feb. 2000.

[Mou92] M. Mouly and M. B. Pautet, *The GSM System for Mobile Communications*. France: published by the authors, 1992.

[Män00] M. Mäntylä and M. Ranta, *Interaction Models and Business Models of a Mobile Service*, Extended Abstract, Helsinki University of Technology, Laboratory of Information Processing Science, Espoo, Finland, 2000.

[Nis99] J. Nisula, S. Heijola, and P. Nihti, *Wireless LAN*, Loppuraportti, Omnitele Ltd., Helsinki, Finland, Dec. 1999.

[Nok94] Nokia Telecommunications, *Base Station Sub-system Parameters*, Course material, 1994.

[Nok99a] Nokia, "Solving the Wireless Puzzle with Nokia Total Connecticity," *Discovery - Nokia's Telecommunications Magazine*, vol. 49, pp. 12-14, Jun. 1999.

[Nok99b] Nokia, *Press Release October 26, 1999*, Available: http://www.nokia.com/press/index.html. (Accessed: Oct. 26 1999)

[Nok99c] Nokia, "Nokia Card Phone 2.0", *Matkapuhelimet*, Available: http://www.nokia.fi/matkapuhelimet/cardphone2_0.html. (Accessed: Nov. 11 1999)

[Olo99] H. Olofsson, "Introduction: What is EDGE, " *in EDGE Radio Access, Nordic Wireless Conference 1999,* Stockholm, Sweden, Oct. 1999.

[Pah97] K. Pahlavan, A. Zahedi, and P. Krishnamurthy, “Evolving Wireless LAN Industry – Products and Standards”, in: *Wireless Communications TDMA versus CDMA*, S. G. Glisic and P. A. Leppänen, Netherlands: Kluwer Academic Publishers, pp. 149-165, 1997.

[Per99] C. E. Perkins, “Tutorial: Mobile Networking Through Mobile IP”, Available: http://www.computer.org/internet/v2n1/perkins.htm/. (Accessed: Jun. 21 1999)

[Pet96] L. L. Peterson and B. S. Davie, *Computer Networks A Systems Approach*. San Francisco, California: Morgan Kaufman Publishers, 1996.

[Rad99] Radiolinja, “Radiolinja-konsernin tilinpäätöstiedote 1.3.1999”, *Lehdistötiedotteet*, Available: http://www.radiolinja.fi/rl_tietoa/pr_tiedotteet/tiedote.asp?id=275. (Accessed: Feb. 4 2000)

[Ran00a] M. Ranta, H. Asplund, K. Koivu, and M. Mäntylä, *Choosing Technology for a Ticket Buying Service*, Design Rationale groupwork at the GO-PROD seminar November 1999, Espoo, Finland, 2000.

[Ran00b] M. Ranta, K. Koivu, H. Asplund, M. Mäntylä, “Viewpoint Integration in Mobile Service Prototyping: A Case Study,” submitted to *The Sixth Annual International Conference on Mobile Computing and Networking (MobiCom 2000)*, Boston, MA, USA, Aug. 2000.

[Rei98] P. Reinisch, “Migration Strategies from GSM to UMTS," in *UMTS´99 Conference*, Monte Carlo, Monaco, 1999.

[Saa99a] M. Saarentaus and R. Riihimäki, presentation in Omnitele Ltd., 1999.

[Saa99b] A. Saarimäki, *Radio Network Aspects in GSM Data Evolution*, Master’s Thesis, Helsinki University of Technology, Espoo, Finland, 1999.

[Sai99] A. Saikanmäki, J. Valtonen, and J. Pentti, *Tulevaisuuden koti*, Loppuraportti, Omnitele Ltd., Tampere, Finland, Sep. 1999.

[Son99] P. Sondegger, J. L. Butt, L. Leyne, A. Aber, and T. Ritter, *Killer Apps On Non-PC Devices*, The Forrester Report, Forrester Research, July 1999.

[Ste99] D. Steinbock, *Kohti elektronista kauppaa*, Report, Department of Management and Organization, Helsinki school of Economics and business Administration, New Yourk City, Apr. 1999.

[TAC99] Telecommunications Administration Centre, “Telecommunications”, Available: http://www.thk.fi/englanti/tele/index.htm. (Accessed: Dec. 28 1999)

[Tiu99] R. Tiuraniemi, A. Saarimäki, J. Nisula, and E. Vesterinen, *Mobiili Data liiketoimintavertailu*, Report, Omnitele Ltd., 1999.

[Top99] P. Toppila, *Quality of Service in UMTS Based Internet Access*, Master’s thesis, Helsinki University of Technology, Espoo, Finland, 1999.

[UMT98a] UMTS Forum, *The Future Mobile Market: Global trends and developments with a focus on Western Europe*, Report 8, 1998.

[UMT98b] UMTS Forum, *Minimum Spectrum Demand per Public Terrestrial UMTS Operator in the Initial Phase*, Report 5, 1998.

[UMT98c] UMTS Forum, *UMTS/IMT-2000 Spectrum*, Report 6, 1998.

[Usk00] J. Uskola, *Strategic Network Planning Process in Transition from GSM to UMTS Technology*, Master’s thesis, Helsinki University of Technology, Espoo, Finland, 2000.

[Usk99] S. Uskela, *Services in cellular packet data networks*, Master’s thesis, Helsinki University of Technology, Espoo, Finland, 1999.

[Wal99] N. Wallenius, *Secure Communication Between Corporate Networks and Mobile Users Using GPRS Packet Radio Network*, Master’s thesis, Helsinki University of Technology, Espoo, Finland, 1999.

[WAP99] WAP-forum, “WAP white paper”, *Wireless Internet Today*, June 1999, http://www.wapforum.org/what/whitepapers.htm. (Accessed: Oct. 15 1999)

[War98] E. Ward, *World-Class Telecommunications Service Development*. Artech House, 1998.

[Ves99] E. Vesterinen, *Fundamentals of UMTS Radio Network Planning*, Master’s Thesis, Tampere University of Technology, Tampere, Finland, 1999.

[Win98] C. Winquist, *Organising and managing product and service development in networked telecommunications operators*, Master’s thesis, Helsinki University of Technology, Espoo, Finland, 1998.

[VTT98] VTT, “Mobile Multimedia White Paper”, Available: http://www.vtt.fi/tte/projects/mobmulti/. (Accessed: May 27 1999)

[Zei96] V. A. Zeithaml and M. J. Bitner, *Services Marketing*. McGraw-Hill, 1996.

Interviews

[Asp99] H. Asplund, GO-PROD, Nov. 26 1999.

[Haa99] K. Haapaniemi, Business Development Manager, Helsinki Telephone Corporation, Helsinki, Aug. 18 1999.

[Knu00] O. Knuuttila, Consultant, Omnitele, Jan. 12 2000.

[Pel99] P. Peltokangas and P. Rintasalo, Omnitele, Espoo, Nov. 19 1999.

[Rin99] P. Rintasalo, Consultant, Omnitele, Nov. 25 1999.

[Saa99c] A. Saarimäki, Consultant, Omnitele, Dec. 17 1999.

[Suv99] K. Suvanto, Product Marketing Manager, Nokia, Espoo, Sept. 9 1999.

[Mal99] J. Malinen, MART Project, Spektri, Espoo, Oct. 12 1999.

APPENDIX A Wireless LAN Features

This appendix provides an overview of Wireless LAN (WLAN) technology. Radio Local Area Network (RLAN) IEEE 802.11 standard was developed in year 1990. However, before year 1997 Wireless LAN technology was not mature enough for reliable data connections [Sai99]. WLAN operates in unlicensed frequency bands (IEEE 802.11: 2,4GHz) and offers currently data rates up to 11Mbps. The technology is adopted by the manufacturers and accepted by the users [Pah97]. WLAN technologies today are based on Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS) data transmission [Nis99]. ETSI’s RES-10 has defined an alternative wireless technology High Performance Local Area Network (HIPERLAN) I. HIPERLAN is more focused on the ad-hoc networking applications, supports higher data rates up to 23Mbps, and operates in 5.14-5.30 GHz frequency band [Pah97]. Table A-1 shows a comparison of these two WLAN technologies.

Table A-1. Comparison of WLAN standard technologies [Pah97]

	802.11 DS	**802.11 FH**	**HIPERLAN**
Frequency	2.4 GHz	2.4 GHz	5.15-5.30 GHz
Modulation	DBPSK, DQPSK	2GFSK, 4GFSK	FSK, GMSK
Access Method	Basic CSMA/CA, RTS/CTS, PCF with polling list, 20 frames	Basic CSMA/CA, RTS/CTS, PCF with polling list, 20 frames	Non-Preemptive Multiple Access (NPMA), 10 PDU
Topologies	Ad-hoc, Infrastructure	Ad-hoc, Infrastructure	Ad-hoc
MAC services	Authentication, Encryption, Power conservation, Time bounded services	Authentication, Encryption, Power conservation, Time bounded services	Encryption, Power conservation, Time bounded services, Routing and forwarding
QoS	No explicit support for QoS	No explicit support for QoS	Advanced user priority scheme and packet lifetime mechanism to support QoS

An ad-hoc network provides an environment to set up a temporary wireless network among a group of WLAN users [Pah97]. An ad-hoc network can consist of only computers with WLAN cards or computers with WLAN cards and temporary base stations installed for example for some conference.

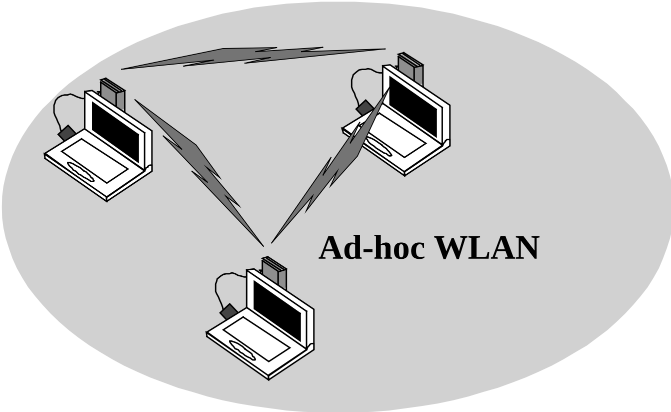


Figure A-1. Ad-hoc WLAN [Nis99]

In Figure A-1 computers equipped with WLAN cards can communicate with each others directly without specific base stations. The more ordinary and simple situation would be that for example a meeting room of a company is covered with WLAN and the employees can be connected to the company's network during meetings (see Figure A-2). WLAN Access points in this figure refer to base stations that are connected to the wired LAN infrastructure. WLAN can be used for all applications that are available via wired LAN. Applications can be for example e-mail and Web browsing. However, WLAN adds mobility and connectivity to the ordinary LAN. At the moment WLAN is often used at such places like museums, where a wired network is too expensive or even impossible to implement. WLAN is also used for extending the possibilities offered by the ordinary LAN. For example some public places, such as airports and exhibitions, open up tempting possibilities for serving customers better than ever before [Nis99].

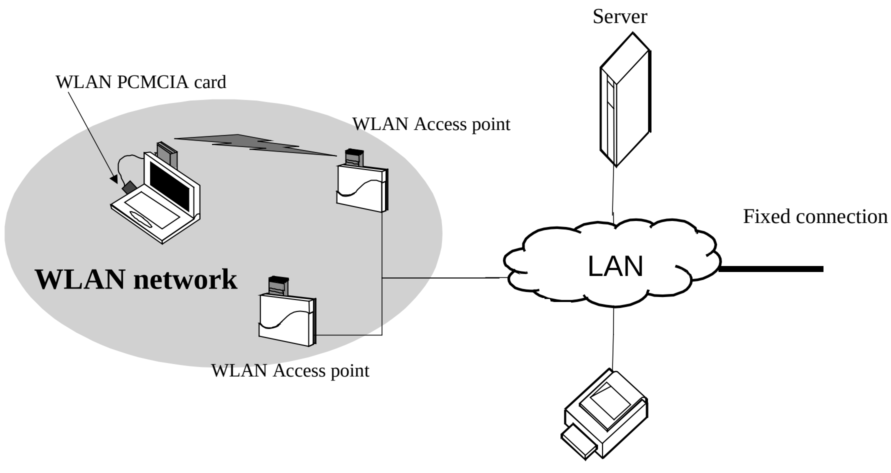


Figure A-2. Simple WLAN solution [Nis99]

Appendix B Mobile Music Scenarios and Technology Models

Scenario 1 Mobile music in Otaniemi

Participants: Tatu (Researcher), Anna (Tatu's friend)

Mobility Model: Exam supervision at the main building in Otaniemi (in lecture room), working at Tietotalo, and cycling between Otaniemi and Mäkkylä

Data to be communicated: Peppers' music, speech

Quality of content: Music: CD Quality, Speech: phone quality (GSM)

Tolerance to network/system quality:

Music:

Noise/Bit Errors	Small
Dropping	Not tolerated
Blocking	Temporarily allowed
Delays	Not tolerated (Real-time)

Speech:

Noise/Bit Errors	Tolerated
Dropping	Tolerated
Blocking	Tolerated
Delays	Not tolerated (Real-time)

Real-time features: Immediate response needed

Issues: Tatu wants to hear Red Hot Chili Peppers' new style before deciding whether to go for the concert or not. Anna and Tatu do not have time to meet before the decision has to be made, because Tatu is at work in Otaniemi the whole day.

Start: Tatu's friend Anna asks him to join her to Red Hot Chili Peppers' concert. Tatu does not know much about the band and its music nowadays because the band has a new guitarist.

Scene 1

At 9.00 Anna calls Tatu who is cycling to Otaniemi in order to supervise an exam at the main building. Anna asks Tatu to join her to Peppers' concert. Tickets have to be picked up latest in the evening. Tatu hesitates because he is not sure about their music now with the new guitarist. Anna has the new CD but Tatu has no time to get it. Then Anna remembers a new music service she had found from the Web and tells Tatu about it.

Scene 2

After Tatu has started supervising that the students will not cheat in the exam he connects with his Magic Mobile Device to the music service to hear Peppers' music and instantly starts hearing the music.

Scene 3

Tatu calls Anna after the exam is over and tells her that he is delighted to go to the concert.

Scene 4

He listens to the music again while cycling home to Mäkkylä because he found the new style very good indeed.

Basic requirements:

⇒ Music listening device

⇒ Server offering different types of music

⇒ Discussion device for negotiation

⇒ Music available in mobile way

⇒ No overhead of downloading

Technology model:

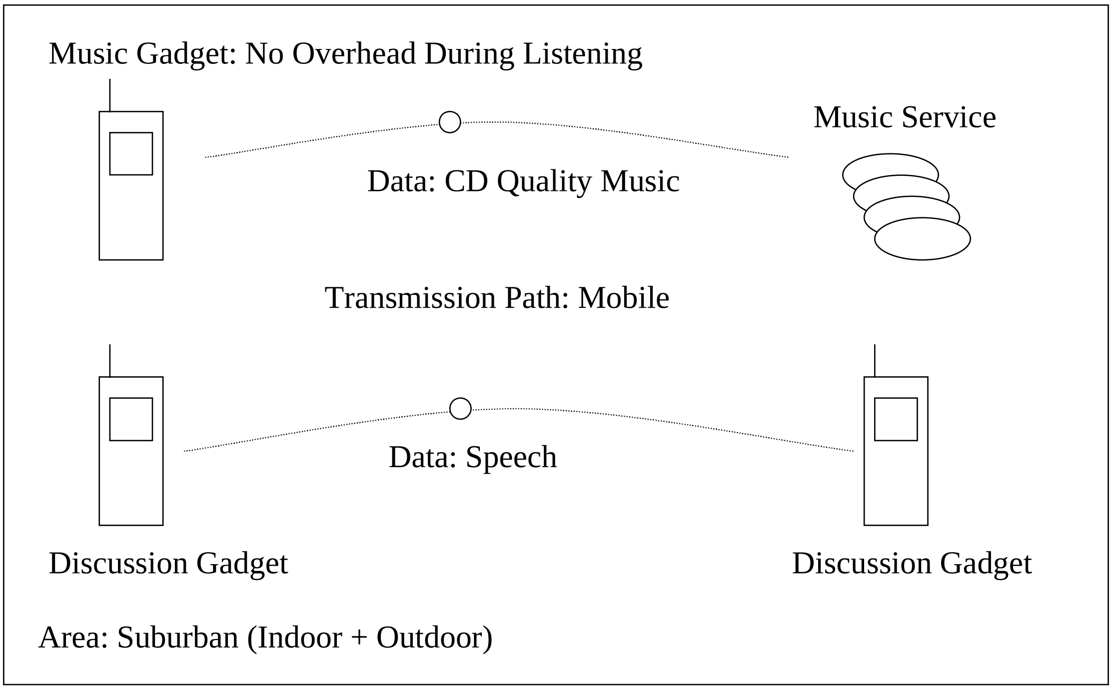


Figure B-1. Technology model 1

Scenario 2 Mobile music at the booking office

Participants: Booking office (selling tickets), Peter (going to opera)

Mobility model: Booking office

Data to be transferred: Concert/event music

Quality of content: Radio quality

Tolerance to network/system quality:

Noise/Bit Errors	Allowed reasonably
Dropping	Not allowed
Blocking	Not allowed
Delays	Not tolerated (Real-time)

Start: Peter is buying an opera ticket. The booking office has started a new wireless service.

Issues: Peter wants to go for an opera but he has to choose from two equally good choices. A booking office wants to offer for its customers a possibility to listen to and to get familiar with the forthcoming shows by different artist and bands. Unfortunately occasionally there are too few headphones and listening points for all the customers inside the booking office.

Scene 1

At 17.30 Peter arrives to the booking office. He wants to go for an opera but there are two equally good choices. He takes a queue number.

Scene 2

The queue number turns out to be at the same time a card that fits/can be attached to his Magic Mobile Device and offers him a possibility to listen to and get information about the operas.

Scene 3

Finally at 18.01 is Peter’s turn and he walks to the desk. He has had one half an hour time to make the decision about which opera to choose. He has made the decision and happily buys the ticket.

Basic requirements:

⇒ Local music offering

⇒ Token that allows customers to access music by own device

Technology model:

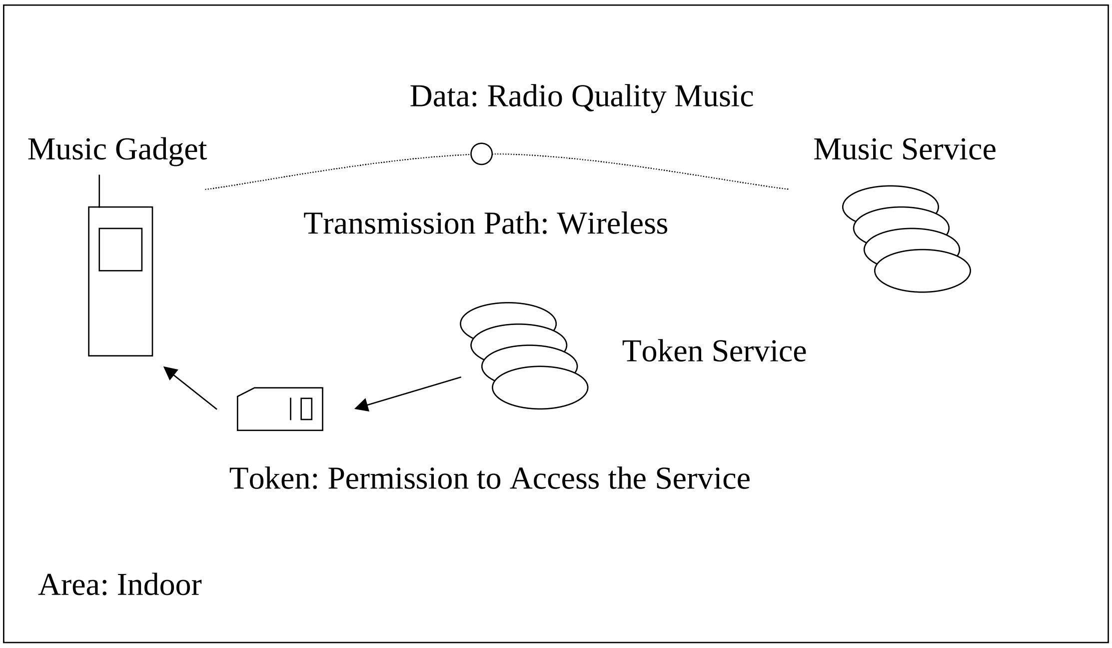


Figure B-2. Technology model 2

Scenario 3 Entertainment in the train

Participants: Lena (Researcher)

Mobility model: Home, train, Helsinki station, Tampere station, R-kiosk

Data to be transferred: Entertainment (text, audio, video, multimedia)

Quality of content: Music: CD Quality, Text: High quality (book), Multimedia: Presumable high

Tolerance to network/system quality:

Music:

Noise/Bit Errors	Small
Dropping	Not tolerated
Blocking	Not allowed (prepaid charge!)
Delays	Not tolerated (Real-time)

Text:

Noise/Bit Errors	Not tolerated
Dropping	Well tolerated
Blocking	Not allowed
Delays	Tolerated in some sense (not Real-time)

Multimedia:

Noise/Bit Errors	Small
Dropping	Not tolerated
Blocking	Not allowed
Delays	Not tolerated (Real-time)

Start: Lena has to visit a conference in Tampere

Issue: Lena wants entertainment (music, reading, etc.) during the long train trip.

Scene 1

Lena arrives at Helsinki station and visits R-Kiosk entertainment booth. She buys music for the trip.

Scene 2

While she is on the train Lena enjoys music.

Scene 3

Shortly before her final destination (Tampere) Lena gets a message to prepare disembarking the train.

Basic requirements:

⇒ Entertainment service available at different locations

⇒ Notification service of arrival at destination

⇒ Music selection service at railway station

⇒ Music listening service at train or

⇒ Entertainment while on move

Technology models:

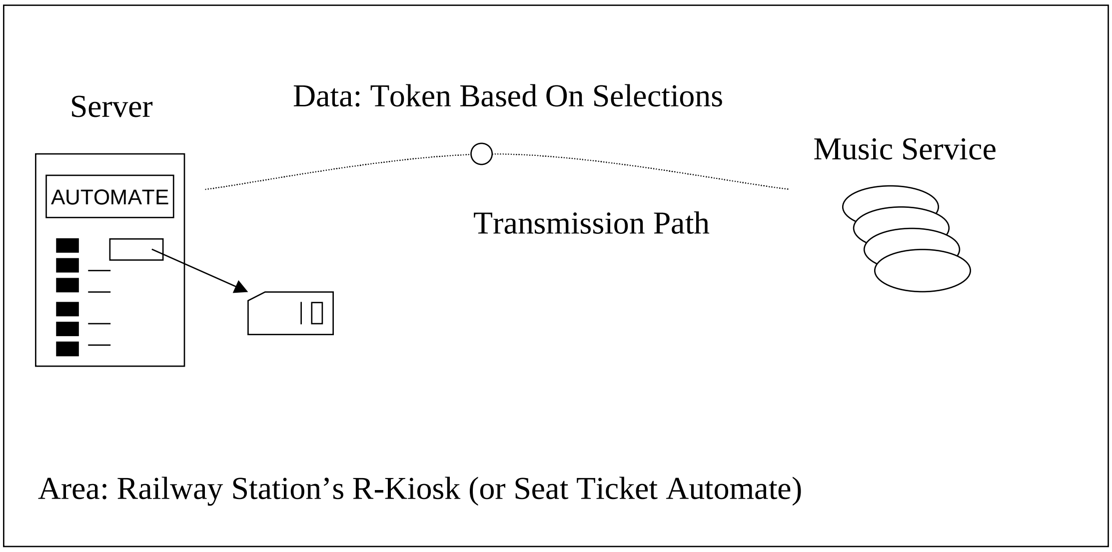


Figure B-3. Technology model for buying a token

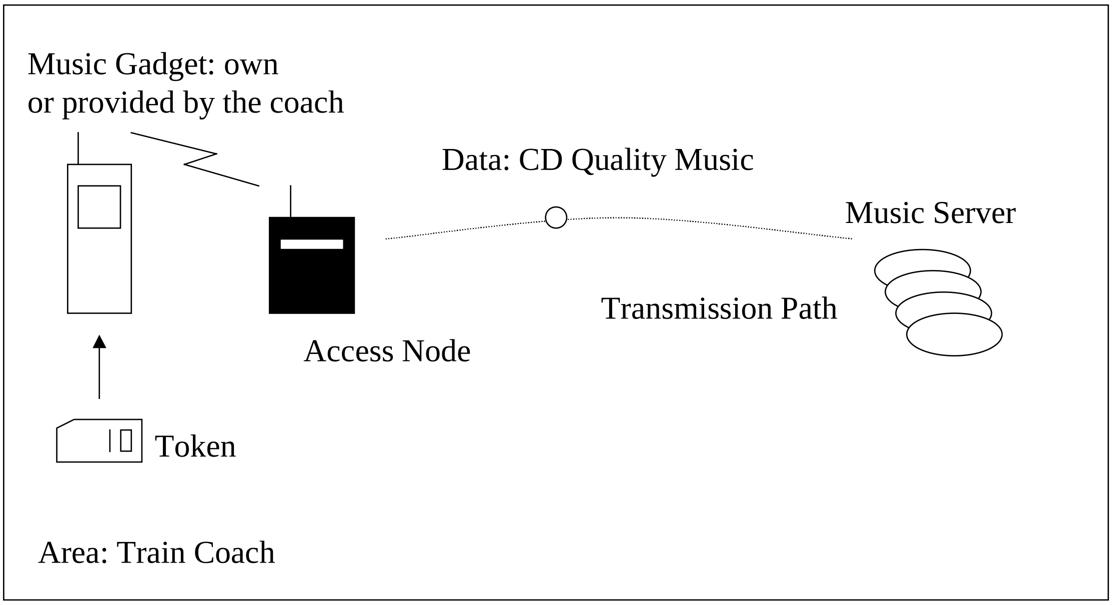


Figure B-4. Technology model for service usage - alternative 1

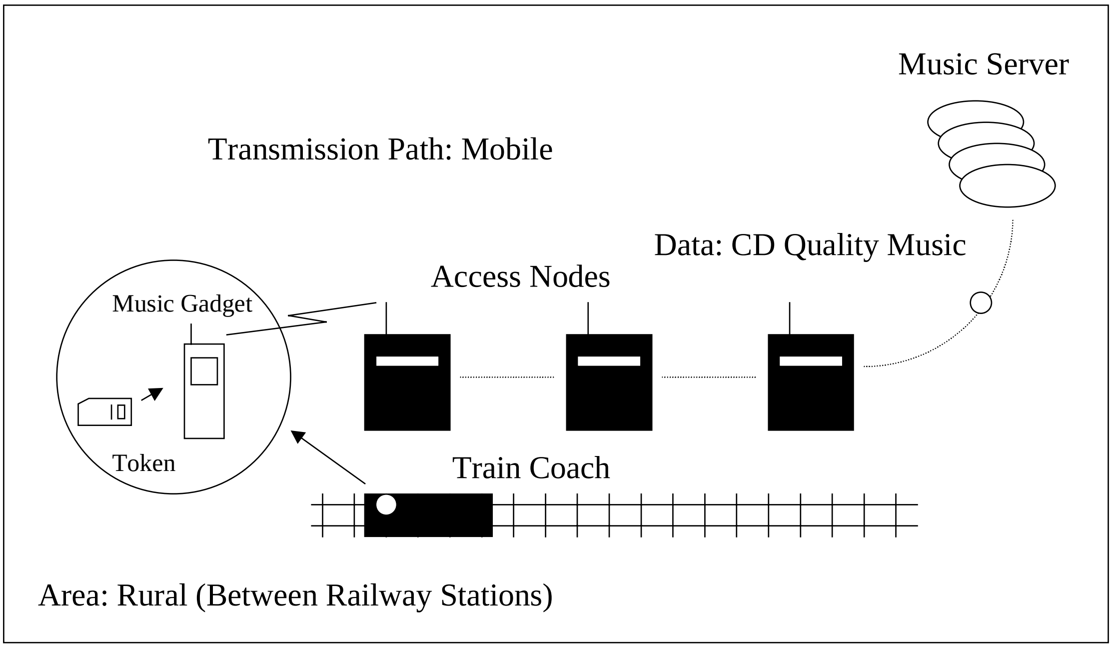


Figure B-5. Technology model for service usage - alternative 2

APPENDIX C Design Rationale

The basic concepts of the design rationale approach are copied from the report of Ranta et al [Ran00a].

The aim of the design rationale approach is to capture explicitly the alternatives, criteria, and validation principles related to each design issue in order to:

- allow other members of the design team or interest groups to view and comment the design decisions,
- make it easy to make changes to the design by going through the issues and evaluations again according to e.g. a changed criteria or an alternative,
- enhance the quality of the design by ensuring that all criteria are remembered at each issue and making it easy to check e.g. how many, alternatives were considered for each issue,
- motivate the implementation and manufacturing of the prototype by providing an access to the rationale behind the reached specifications,
- capture the design information in a reusable form that allows the designer to go through all the design issues while carrying out resembling design tasks instead of relying on the designer's ability to properly update all necessary changes to copied specifications.

Figure C-1 illustrates the concepts of design rationale that are briefly described in the following:

- Issue refers to a design task or design problem that is to be solved. Typically the first issues during a design process concern abstract decisions on the principles of the solution and gradually more and more concrete issues on the implementation and components follow.
- Alternative is a possible design solution for an issue. It is crucial that the DR documents also those alternatives that were not chosen, so that they can be addressed again if the criteria changes or if e.g. technology improvements change the characteristics of an alternative.
- Criterion defines the goals of the design, requirements to the solution and constraints according to the design strategy.

- Validation relates the criteria to the attributes of an alternative. Validation method depends on the type of criterion, however, the crucial thing is to record how or why a certain measure of criterion was determined for an alternative.
- Evaluation refers to the comparison of the validation results and on choosing the best one according to the scores of various criteria.
- Decision records the chosen alternative and reasons for it.
- Responsible records the information on the person who made the decision.

DR traces the design process as issues that follow each other and evolve into a the design solution on more and more detailed level. For each issue the previous decisions on design issues form a context in which the new issue and related alternatives are studied. Notice that the DR is typically not constructed as a log of series of decisions, but the designers may in advance define some issues or even alternatives to be processed later. Moreover, there is a regular need to return to earlier issues in order to add or refine a criterion that becomes better understood as the design process progresses.

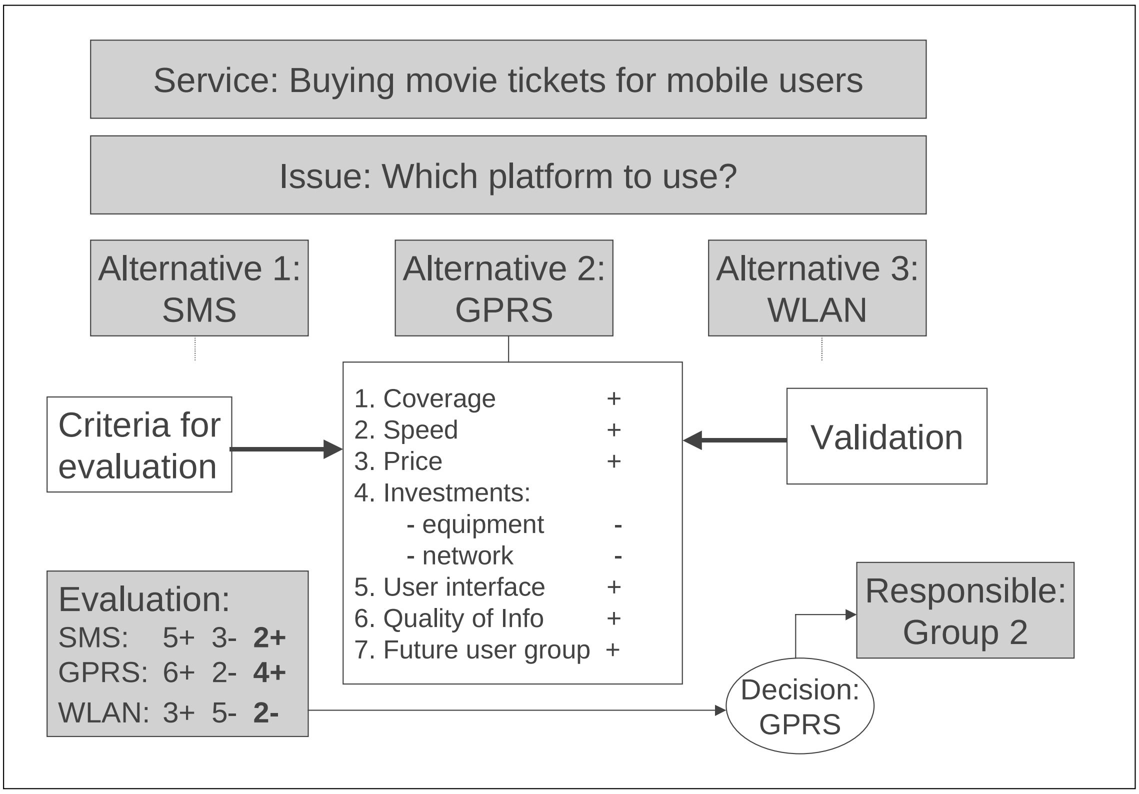


Figure C-1. Design rationale example [Ran00a]

APPENDIX D Evaluation Guidelines

Table D-1. Services and data rates [UMT98c][Häg99]

Service	Bit rate	Symmetry	Service	Bit rate	Symmetry
Voice/Speech			**Medium Multimedia**		
Teleconferencing	16	symmetric	LAN and Internet/Intranet access	384	asymmetric
Voicemail	16	symmetric	Application sharing (collaborating workgroups)	384	asymmetric
Speech telephony	8 - 32	symmetric	Interactive Games	384	asymmetric
			Lottery and betting services	384	asymmetric
Music/Audio			Sophisticated broadcast and public information messaging	384	asymmetric
Sound program	128	asymmetric	Simple on-line shopping and banking (e-commerce) services	384	asymmetric
High quality audio	940	asymmetric			
			High Multimedia		
Simple Messaging/Data			Fast LAN and Internet/Intranet access	2000	asymmetric
SMS	1,2 - 14	asymmetric	Video clips on demand	2000	asymmetric
Paging	1,2 - 14	asymmetric	Audio clips on demand	2000	asymmetric
E-mail	1,2 - 64	asymmetric	on-line shopping	2000	asymmetric
Broadcast and public information messaging	14	asymmetric			
Ordering/payment (simple e-commerce)	14	asymmetric	**High Interactive Multimedia**		
Low speed dial-up LAN access	14	symmetric	Video telephony	128	symmetric
Internet/Intranet access	14	symmetric	Video conferencing	128	symmetric
Fax	14 - 64	symmetric	Collaborative working and telepresence	128	symmetric

APPENDIX E Technology Evaluations for Music Scenarios

Table E-1. Technology evaluation for Mobile Music in Otaniemi

SCENARIO AND TECHNOLOGY MODEL EVALUATION FORM FOR TECHNOLOGY EXPERTS

Scenario:	1	*Mobile Music in Otaniemi*

Think the following questions considering the service described in the scenario:

1) What are the special requirements the service sets for **networks** and **terminals**?
Which of the requirements are critical (bottle neck) and why?

Aspect	Criticality	Reasons:
Data Rate	H	*Music requires higher data rate that can be achieved with current cellular technologies*
Coverage	M	*Not a big problem to cover suburban areas (GSM already covers)*
Capacity	M	*Quite high data rate demand, but maybe not so many service users in the same area*
QoS	H	*CD Quality music that allows no delays, droppings, etc. - high quality requirements*
(Security)	-	
Terminal Capacity	M/H	*Terminals has to offer good quality music and enough data rate*

H=High, M=Moderate, L=Low

2) Is the service implementable with current or incoming technologies?
Name the technologies and give the reasons why YES and why NOT.
You can also think what should be changed in the scenario in order to be able to implement the service?

Technology	Reasons:
GSM	*not suitable because of the data rate limit*
HSCSD	*not suitable because of the data rate limit*
GPRS	*the first cell. technology that can offer needed data rates (music approx. 128kbps), not commercially available yet*
EDGE	*can offer needed data rates (music approx. 128kbps) - technology not commercially available yet*
UMTS	*can offer needed data rates (music approx. 128kbps) - technology not commercially available yet*
WLAN	*not suitable for covering the whole suburban area!*

Can you think of any possibilities how the service could be put in to practice?
In the area there has to be a network/networks that offer enough bandwidth for moving users.
If there are many different networks (for example indoors WLAN, outdoors GPRS) users will have to have dual mode terminals.

Table E-2. Technology evaluation for Booking Office

SCENARIO AND TECHNOLOGY MODEL EVALUATION FORM FOR TECHNOLOGY EXPERTS

Scenario:	2	*Booking Office*

Think the following questions considering the service described in the scenario:

1) What are the special requirements the service sets for **networks** and **terminals**?
Which of the requirements are critical (bottle neck) and why?

Aspect	Criticality	Reasons:
Data Rate	M/H	*can be smaller than 128kbps (certainly more than 60), depends on coding etc. (only radio quality)*
Coverage	L	*Local indoor coverage*
Capacity	H	*In the same area many users that use quite high data rates!*
QoS	M	*Radio level music - some errors tolerated (but no blocking, dropping or delays)*
(Security)	-	
Terminal Capacity	M/H	*terminals have to be compatible with the token system and offer enough data rate and enough quality for audio*

H=High, M=Moderate, L=Low

2) Is the service implementable with current or incoming technologies?
Name the technologies and give the reasons why YES and why NOT.
You can also think what should be changed in the scenario in order to be able to implement the service?

Technology	Reasons:
GSM	*not enough bandwidth*
HSCSD	*not enough bandwidth*
GPRS	*possible but not available yet*
EDGE	*possible but not available yet*
UMTS	*possible but not available yet*
WLAN	*suits well for local indoor use when capacity and high data rates are needed - available already*

Can you think of any possibilities how the service could be put in to practice?
WLAN base stations located in the office. The office can have own server that offers music for customers in some proper format (for example MP3 or RealAudio)

Table E-3. Technology evaluation for Entertainment in the Train

SCENARIO AND TECHNOLOGY MODEL EVALUATION FORM FOR TECHNOLOGY EXPERTS

Scenario:	3	*Entertainment in the Train*

Think the following questions considering the service described in the scenario:

1) What are the special requirements the service sets for **networks** and **terminals**?
Which of the requirements are critical (bottle neck) and why?

Aspect	Criticality	Reasons:
Data Rate	H	*Music and multimedia require high data rate*
Coverage	L/H	*If only local service in the train, coverage need is low - otherwise high (rural coverage also needed)*
Capacity	M	*High data rate - not so many users?*
QoS	H	*Prepaid service, CD quality music for example. No tolerance to blocking or delays.*
(Security)	-	
Terminal Capacity	M/H	*Depends on the service; music needs data rate and quality capabilities. Can't be evaluated well with the given information.*

H=High, M=Moderate, L=Low

2) Is the service implementable with current or incoming technologies?
Name the technologies and give the reasons why YES and why NOT.
You can also think what should be changed in the scenario in order to be able to implement the service?

Technology	Reasons:
GSM	*not suitable because of the coverage and data rate requirements*
HSCSD	*not suitable because of the coverage and data rate requirements (hard to offer coverage inside the moving train)*
GPRS	*not suitable because of the coverage requirements, not available yet, data rate can be achieved though*
EDGE	*not suitable because of the coverage requirements, not available yet, data rate can be achieved though*
UMTS	*not suitable because of the coverage requirements, not available yet, data rate can be achieved though*
WLAN	*possible - enough capacity and bandwidth*

Can you think of any possibilities how the service could be put in to practice?
There could be a server inside the train that offers entertainment via WLAN base stations and terminals.
Token and terminal issues have to be considered carefully.