International Telecommunication Union

QUESTION 18/2

Strategy for migration of mobile networks to IMT-2000 and beyond

ITU-D STUDY GROUP 2 RAPPORTEUR FOR QUESTION 18/2

"Mid-Term Guidelines (MTG) on the smooth transition of existing mobile networks to IMT-2000 for developing countries"

International Telecommunication Union

THE STUDY GROUPS OF ITU-D

The ITU-D Study Groups were set up in accordance with Resolutions 2 of the World Telecommunication Development Conference (WTDC) held in Buenos Aires, Argentina, in 1994). For the period 2002-2006, Study Group 1 is entrusted with the study of seven Questions in the field of telecommunication development strategies and policies. Study Group 2 is entrusted with the study of eleven Questions in the field of development and management of telecommunication services and networks. For this period, in order to respond as quickly as possible to the concerns of developing countries, instead of being approved during the WTDC, the output of each Question is published as and when it is ready.

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International Telecommunication Union

Question 18/2
"Mid-Term Guidelines (MTG) on the smooth transition of existing mobile networks to IMT-2000 for developing countries"

Version 0.7.6

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

Page

Foreword

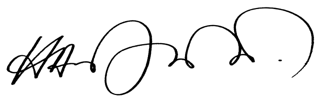
The World Telecommunication Development Conference held in 2002 (WTDC-02) in Istanbul, Turkey, adopted Question 18/2 dealing with "Strategy for migration of mobile networks to IMT-2000 and beyond".The main task entrusted to the Rapporteur's Group entitled to study the Question was to draft mid-term guidelines (MTG) for a smooth migration to IMT-2000, including interoperability among third-generation systems. However, given the complexity and the economic implications of the subject, the Rapporteur's Group dealing with Question 18/2 found it appropriate to focus on the stages involved in materializing IMT-2000 systems. For this reason, the process of IMT-2000 materialization is considered as a transition from pre-IMT-2000 systems that can be undertaken via a variety of scenarios. This first edition of the MTG is by itself a challenge. The purpose of the MTG is to provide telecommunication operators, policy-makers and regulators from developing countries with an understanding of viable transition paths – including economic aspects – to change smoothly their pre-IMT-2000 networks towards IMT-2000. The reflection induced by this MTG should help to perceive the pros and cons of the possible solutions towards IMT-2000 and to take adequate decisions.

With the upsurge of global wireless personal communications, these guidelines represent a complement to the ITU Handbook on the Deployment of IMT-2000 Systems where more detailed technical information can be found. The MTG is the result of the dedication of experienced and qualified experts from different Administrations, companies, industry groups and associations from developed and developing countries. The fruitful and outstanding cooperation with the ITU-R Sector, as well as with the ITU-T Sector, deserves special mention.

I would like to commend the Rapporteur, Ms Natasa Gospic, and the Editor, Mr Davide Grillo, for the important and useful results achieved, as well as special thanks are due to all those who have been volunteers in the preparation of the MTG.

ITU-D Study Group 2 has decided to streamline the MTG to a shorter and more typical Guidelines format within the coming year in readiness for the next WTDC to be held in Doha, Qatar in 2006.

In the meantime, it is my hope that the MTG will be a useful source of information for developing countries.



Hamadoun I. Touré
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Geneva/September 2004

SUMMARY

Introduction

In the last decade, large pre-IMT-2000 mobile telecommunications networks have been deployed all over the world. In some countries, the penetration of mobile users exceeds 75% and the mobile generated traffic is comparable to – if not greater than – the fixed traffic.

The following aspects, among others, characterize the current situation of mobile telecommunications:

- High penetration of mobile services in developed countries, with large investments in pre-IMT-2000 systems and materialized/planned deployment in the vast majority of them;
- Recognition that penetration of mobile services and increase of the customer base follows similar development trends in different developed countries, although with different factors of scale–setting the assumption that this may also be true for developing countries;
- Definition of a family of IMT-2000 systems in ITU (IMT-2000 family), with continued standardization work on the members of the family progressed via dedicated Standard Development Organizations;
- Identification and harmonization of spectrum usage on a global basis, with spectrum allocation policies following different rules in different countries;
- High potential for advanced and innovative IMT-2000 services if offered at attractive prices.

Operators have been very cautious in planning large-scale deployment of IMT-2000 networks and these will be implemented, more than ever, based on both short- and long-term strategic decisions, in-depth market analysis, and sensitivity analysis of key factors influencing service penetration and economic returns. More importantly, deployment of IMT-2000 networks will capitalize on investments already in place in pre-IMT-2000 infrastructure. This implies that the transition path from legacy, pre-IMT-2000 systems to IMT-2000 systems will be shaped by enhancements to existing equipment and/or replacement of equipment no longer capable of performing the desired functions. Movement of users and/or services delivery from an existing system to a new system may also belong to the materialization of a transition.

The possible mixture of enhancement and replacement actions depends on a variety of factors, including the target services to be offered, the capability of the legacy systems to adapt to changing requirements, the early or deferred decision about the target system that will eventually replace the legacy system. Whereas the above picture applies, in principle, to both developed and developing countries, the latter have specific requirements that impact to a substantial extent the transition path from pre-IMT-2000 to IMT-2000 systems. These requirements relate to operators, regulators and users.

Operator requirements

Minimization of infrastructure costs is a concern for operators in developed as well as developing countries. However, due to lower penetration rates and Average Revenue per User (ARPU) in developing countries this constraint is heavier in these countries. Thus, from the standpoint of the operators there is a need for a regulatory environment that minimizes implementation and roll-out costs (sustainable coverage obligations, low license fees, choice between alternative technologies allowing a cost efficient network deployment, possibility to use lower frequency bands, infrastructure sharing, etc.). Furthermore, since in most developing countries mobile networks provide a more extensive coverage than fixed networks, administrations in these countries may wish to support the usage of such networks for fixed/data applications.

Regulator requirements

Regulators in developing countries may wish in particular to set up a regulatory/legal framework that minimizes network deployment costs while facilitating the provision of an extensive network coverage and of specific "socially efficient" services and applications (e-health, e-education, etc.). There is also need for an education policy allowing the improvement of literacy rates and populations' ability to utilize IT services. Finally, since the usage of these services depends on the availability of computers and not only of telecommunications infrastructures, it may be desirable that a certain number of measures be taken in order to increase computer penetration rates.

User requirements

Due to lower income levels, users' ability to pay for telecommunications services is lower in developing countries than in developed ones. Thus, the availability of an affordable service offering and of reasonably priced handsets is a particularly important issue in these countries. The implementation by operators of technologies based on open international standards seems to be the best way for ensuring low network and terminal equipment costs thanks to competition between numerous manufacturers and economies of scale.

Objectives

These Guidelines are intended for use of telecom operators, policy-makers and regulators to facilitate development of their respective strategies for the transition from pre-IMT-2000 networks to IMT-2000. While it is desirable for pre-IMT-2000 systems to be able to evolve to IMT-2000, the decision whether or not to evolve is not within the scope of the ITU. In each case the decision, as a policy matter, must be made by those responsible for each particular system/service. These Guidelines intend to present an objective and neutral view of the issues to be addressed in the transition from existing mobile networks to IMT-2000.

The Guidelines are a natural complement to the ITU "Handbook on Deployment of IMT-2000 Systems", in which more detailed technical information can be found.

All IMT-2000 radio interfaces meet the ITU requirements for IMT-2000. The individual IMT-2000 radio interfaces have each been specified against these requirements to offer commercially attractive solutions for deployment of IMT-2000. The ITU does not therefore indicate preference for any one IMT-2000 radio interface over any other, and the mention of specific companies, products or migration scenarios in this document does not imply any endorsement or recommendation by the ITU. These Guidelines do not make any comparison between performance of different technologies nor do they promote any specific technologies.

Organization of the Guidelines

The Guidelines are organized as follows. Initially, in the introduction section the rationale for IMT-2000 systems is introduced and basic concepts on IMT-2000 are recalled. Aspects having great bearing on policies intended to guide the transition to IMT-2000 networks are then addressed (such as accommodating special needs of developing countries, spectrum requirements, interoperability with existing networks and among IMT-2000 technologies, spectrum licensing).

The section on policies for transition to IMT-2000 networks, considers a variety of situations in developing countries relating to the technology and the development of existing mobile networks to determine appropriate policies for the transition toward networks based on enhanced systems. The identification of a transition policy is based on the analysis of key aspects, that impact demand, investments and revenues. As already stated, although these aspects are common to all countries, their implications for developing countries deserve special treatment.

The section on transition starts with the recognition that today there are a number of pre-IMT-2000 systems (both analogue and digital) in operation, providing wireless voice and data services to end-users worldwide. These systems include, but are not limited to, AMPS, NMT, cdmaOne, TDMA, and GSM. Recommendations ITU-R M.622, M.1033 and M.1073 and Report ITU-R M.742 describe characteristics of pre-IMT-2000 systems.

Due to differences between the various pre-IMT-2000 systems, as well as differences between the IMT-2000 family systems, the possible transition paths for each pre-IMT-2000 system differ. However, in most cases, the transition requires the addition of IMT-2000 base station equipment and/or software, necessary modifications or additions of the Radio Access Networks (RAN), suitable upgrade/modification of the underlying "core network" along with the introduction of new terminals, which are typically dual-mode devices capable of operating both pre-IMT-2000 and IMT-2000 radio technologies.

Several factors should be considered in the selection of a transition path towards IMT-2000. One important factor is the availability and use of spectrum for both pre-IMT-2000 and IMT-2000 systems. Other issues that will have a major impact on how to materialize the transition include availability of equipment and service applications for the various technologies and their performance in the desired operating environment.

A key step in the process of finalizing a transition path toward IMT-2000 network deployment is the economic evaluation of the revenues expected from the investments over the economic life of the system, including the spectrum license acquisition costs – where appropriate. The section on economics of transition to IMT-2000 considers the cost of the possible options and also the assumptions about the evolution of demand and service penetration as well as tariff trends and policies. The methodology and practical aspects of transition to IMT-2000 are addressed.

In planning investments, a balance has to be struck between actions decided in the early stages of the network deployment – those that normally have long-lasting effects in terms of both shaping the network infrastructure and capital recovery – and actions which may be deferred – those that are normally taken in response to changing market trends and/or conditions, and whose economic profitability has to be measured within relatively short time frames. Whatever deployment policy is adopted, a significant margin of flexibility for adjusting the deployment plan has to be factored in from the outset.

A series of annexes complement the Guidelines, covering aspects such as evolution methodology and scenarios, operator migration paths, functional and service enhancements for pre-IMT-2000 operators. One of these annexes is a compilation of operator experience in transitioning to IMT-2000 systems. The transition is described in terms of existing systems, services envisaged to be offered, spectrum usage policy, investment plans, marketing strategies and socio-economic achievements. The consideration of the conditioning factors and the rationale underlying the choices shaping the transition path in the different cases is instructive for developing a sensitivity to key aspects to be addressed in other cases of transition.

Disclaim

Some sections of these Guidelines incorporate material from published ITU-R and ITU-T Recommendations in the form of “extracts”. To ensure correct reference to this material, relevant text is explicitly indicated by including it between “**{**” and “**}**” brackets and no editorial interventions has been operated on it to preserve integrity. As a result, minor misalignment in the use of names, acronyms and/or terms between this text and the rest of the Guidelines text may have occurred due to the different epochs in which the source material has been generated. In the few cases in which this may have occurred, either more recent names and/or acronyms should be retained or a “note to extract” indicates the suggested way to resume alignment.

Acknowledgements

These Guidelines have been prepared using information provided by a variety of administrations, companies, industry groups and associations, including examples of their products, systems, models and case studies.

The contribution and advice of ITU-R WP8A and WP8F, as well as ITU-T SSG, are gratefully acknowledged.

1 INTRODUCTION

{ [i] During the last few years, large pre-IMT-2000 mobile communication networks have been built up in many parts of the world. In some developed countries the penetration of mobile users has surpassed 75%, and in many countries there are more mobile subscribers than fixed-line telephone subscribers. The networks built up so far are mostly designed to provide coverage over the territory of a country, so these are large networks. The flexibility in using these networks and the high degree of mobility is a feature of pre-IMT-2000 systems. Mobility between networks is today an important aspect. Transparent roaming and handover between networks, including international cross-border roaming is a normal operation today.

Whereas it is desirable for pre-IMT-2000 systems to be able to evolve to IMT-2000, the decision whether or not to evolve is not within the scope of the ITU. In each particular case the decision, as a policy matter, must be made by those responsible for each particular system/service. However, the ITU can assist those parties making such decisions by providing background information such as contained in this document[1]. In developing radio Recommendations for IMT-2000, the ITU-R considered provisions that facilitate the evolution of pre-IMT-2000 systems towards IMT-2000 without compromising the capabilities, objective, and performance of IMT-2000. }

1.1 From existing mobile networks to IMT-2000

At the end of 2003, there were approximately 1.3 billion mobile phone users, with 227 million new digital subscribers added in 2003. With some 524 million customers, Asia Pacific boasts more mobile users than any other region, followed by Europe, North America, Latin America and Africa/Middle East.[2] While predictions vary, it is widely anticipated that the number of mobile users worldwide may double to more than 2 billion some time between 2007 and 2010 – representing a mobile phone for every third person on this planet.[3]

The transition from pre-IMT-2000 to IMT-2000 systems will happen over a period of time, thus allowing operators to fully exploit and capitalize on investments made in their pre-IMT-2000 infrastructure. Potentially, there are several transition scenarios for wireless operators to transition existing systems towards IMT-2000. Administrations and operators alike should consider what solutions are available at the time the transition is considered and conduct extensive financial and technical analyses before making decisions on the best approach.

Most mobile network operators in developed countries have already identified evolution paths to IMT-2000 Third Generation networks. By and large, operators of GSM, the Americas' TDMA and Japan's PDC (Personal Digital Cellular) networks have identified evolution paths to IMT-2000 CDMA Direct Spread (WCDMA) and IMT-2000 TDMA Single Carrier solutions. CdmaOne (IS-95) operators and some TDMA operators have identified evolution paths to IMT-2000 CDMA Multi-Carrier (CDMA2000) solutions. However, those operators are also evaluating all the options available for them to transition to IMT-2000.

As a matter of course, the possible transition paths reflect local situations and conditioning – including the competitive service provision environment, the service penetration policy, and the strategic and financial aspects. Before and during the transition process, it is required that operational and economic implications of the network deployment be assessed. By taking into considerations all these aspects, it is apparent that there is no single solution that is right for every operator.

These Guidelines do not make any comparison between performance of different technologies nor do they promote any specific technologies.

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1 NOTE TO EXTRACT – "this document" is Section 2.2 of ITU-R Handbook; Principles and approaches of evolution towards IMT-2000/FPLMTS (Volume 2 of the handbook on Land Mobile, including Wireless Access), not the MTG.

2 EMC World Cellular Database, December 2003.

3 ITU Database.

This document provides facts about the various mobile systems and technologies that might help to decide on the right transition path.

1.2 Driving forces for IMT-2000

{ [4] [i] Some of the key features and objectives of IMT-2000 as compared to pre-IMT-2000, are as follows:

Global system

- A global standard promoting a high degree of commonality of design world wide while incorporating a variety of systems.
- Use of a small pocket terminal world wide, but also the accommodation of a variety of other terminal types. Bigger marketplace leading to lower costs.
- Worldwide common frequency band[5].
- Worldwide roaming based on terminal mobility.
- Worldwide, off-the-shelf compatible equipment.

New services and capabilities

- Provision of capability, which enables new voice and data services which are significantly more advanced than pre-IMT-2000 technologies.
- Availability to mobile users of a range of voice and non-voice services, including packet data and multimedia services.
- Higher service quality, in particular voice.
- High quality and integrity, comparable to the fixed network.
- Significantly higher user bit rate capability.
- Flexible radio bearer.
- The capability to provide bandwidth on demand supporting a wide range of data rates, from simple low rate paging messages through voice to high rates associated with video or file transfer.
- Support for asymmetrical data capabilities which require high rates in one direction but much lower rates in the other.
- Improved security.
- Improved ease of operation.
- Intelligent network (IN) based service creation and service profile management based on ITU-T Q.1200-series of Recommendations.
- Coherent systems management based on ITU-T M.3000-series of Recommendations.

Evolution and migration

- Flexibility for evolution of systems, and migration of users, both from pre- IMT-2000 and evolution within IMT-2000[6].
- Compatibility of services within IMT-2000 and with the fixed telecommunications network (e.g., PSTN/ISDN).
- Provision of a framework for the continuing expansion of mobile network services and access to services and facilities of the fixed network.

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[4] NOTE TO EXTRACT – It is suggested that: a) the expression "A global standard …" be changed into "A global family of standards …"; b) the word "band" be changed into "bands".

[5] Although a worldwide common frequency band was the original objective of IMT-2000 (e.g. Rec. ITU-R M.1308), several frequency bands are now identified in the Radio Regulations as the result of decisions of WARC-92 and WRC-2000.

[6] "Evolution within IMT-2000" means the evolution of the individual IMT-2000 terrestrial radio interfaces.

- An open architecture which will permit easy introduction of advances in technology and of different applications.
- Ability to coexist and interwork with pre- IMT-2000.

Flexibility: multi-environment capabilities

- Accommodation of a maximum level of interworking between networks of different types to provide customers with greater coverage, seamless roaming and consistency of services.
- Integrated satellite/terrestrial networks.
- Provision of services by more than one network in any coverage area.
- Provision of these services over a wide range of user densities and coverage areas.
- Provision of services to both mobile and fixed users in urban, rural and remote regions.
- Wider range of operating environments, including aeronautical and maritime.
- A modular structure which will allow the system to start from as small and simple a configuration as possible and grow as needed, in size and complexity.
- Caters to needs of developing countries.
- Flexibility to utilize adaptive software downloadable terminals to support multiband and multi-environment capabilities.
- Key parameters of bandwidth, transmission quality and delay can be selected, negotiated, mixed and matched by the requirements of the service according to the instantaneous capability of the radio channel.
- Better (e.g., more efficient) use of the radio spectrum than pre- IMT-2000 consistent with providing services at acceptable costs, taking into account their differing demands for data rates, symmetry, channel quality, and delay. }

In developing countries, the task of bridging the digital divide has arrived at a juncture where most of the countries are still grappling with the problem of providing voice access. Large-scale computerization and growth of e-services require the availability of higher bandwidth on the access loop. In these countries, most of the access lines are likely to use wireless technology and, therefore, options such as xDSL or CATV or ISDN are not suitable for mass scale consideration. High-speed wireless data capability, using IMT-2000 would provide mobile wireless access technology giving IMT-2000 a unique opportunity in these markets.

In the developed countries the local copper loop has been unbundled to promote competition in broadband. It is not possible to carry out such unbundling in the wireless network. Consequently, interworking of different wireless technologies would be an alternative to provide competing broadband services.

1.3 IMT-2000 terrestrial technologies

The IMT-2000 standardization process was established by the ITU, which followed thorough and meticulous steps that considered the users' expectations, markets needs, market forces, technology evolution, transition of pre-IMT-2000 systems to IMT-2000, necessities of the developing countries, etc.

The process led to the concept of "IMT-2000 Family of Systems" in ITU-T and the issue of Recommendation ITU-R M.1457– Detailed specifications of the radio interfaces of International Mobile Telecommunications 2000 (IMT-2000), in the year 2000.

{ [ii] A terrestrial IMT-2000 system is built on two main parts, Radio Access Network and Core Network.

1.3.1 ITU IMT-2000 Family of Systems Concept

The IMT-2000 Family concept is used in ITU to realize a global service offering among IMT-2000 systems. See Figure 1.3.1.2.

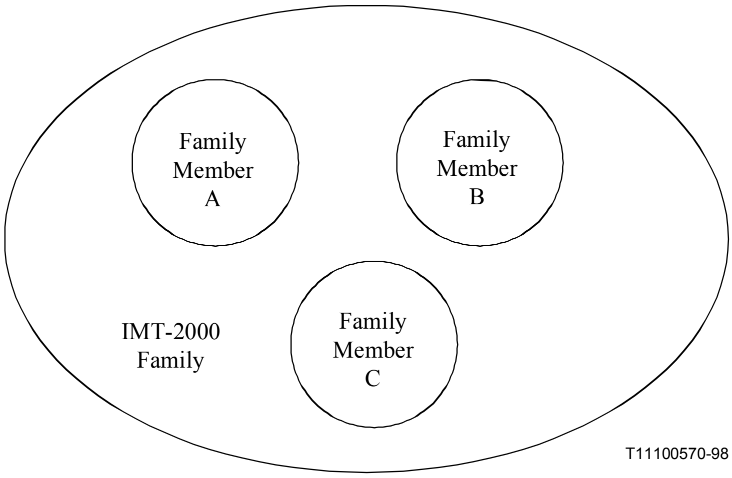
1.3.1.1 IMT-2000 Family

The IMT-2000 Family is a group of IMT-2000 Systems providing IMT-2000 capabilities to its users as identified in IMT-2000 Capability Sets. However, individual family members may have different intra-system specifications (e.g., functionalities in physical entities, signaling protocols, etc.)

1.3.1.2 An IMT-2000 Family Member

An IMT-2000 Family Member is an IMT-2000 System. A Family Member integrates and incorporates the IMT-2000 functions into physical entities and associated interfaces as necessary to provide IMT-2000 capabilities. The UIM, MT, RAN, and CN[7] functional subsystems may be specific to each Family Member along with the associated internal processes, internal interactions, and internal communication between functional entities. Support for IMT-2000 capabilities and interfaces will facilitate roaming between family members.

Figure 1.3.1.2: IMT-2000 Families



Operators have the option to selectively deploy only those capabilities and interfaces of IMT-2000 Family member networks which are needed to support the services they choose to offer. Individual Family Member systems are characterized by their support of service and network capabilities defined within the IMT-2000 Capability Sets.

A key feature of IMT-2000 family members is provisioning of a consistent set of application enablers based on the IMT-2000 capability sets and interfaces (given technical constraints and market needs). ITU has available a set of interface specifications to achieve this.

IMT-2000 consists of a number of Radio Access and Core Network systems which are described in the following section.

1.3.2 IMT-2000 Radio Access Networks and Standards[8]

The IMT-2000 terrestrial radio access technologies are based on various combinations of CDMA, TDMA, SDMA, single-carrier, multi-carrier, FDD, and TDD. None of the IMT-2000 technologies uses pure FDMA where a single radio channel is completely used to support a single user. A tutorial-like description of the relevant radio technologies is presented in the Handbook “Deployment of IMT-2000 Systems”.

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[7] NOTE TO EXTRACT – Write out the acronyms the first time.

[8] As used in this document, the term “standard” means a specification published by a Standard Development Organization, for example, ITU-R or ITU-T Recommendations.

1.3.2.1 IMT-2000 Terrestrial Radio Standards

The radio interfaces of IMT-2000 are specified in Recommendation ITU-R M.1457. The IMT-2000 radio interfaces and systems are described in more detail in the Handbook "Deployment of IMT-2000 Systems".

The IMT-2000 terrestrial radio access technologies are based on various combinations of CDMA, TDMA, SDMA, single-carrier, multi-carrier, FDD, and TDD.

IMT-2000 standards provide a highly flexible system, capable of supporting a wide range of services and applications. The standards accommodate five possible radio interfaces based on three different access techniques (FDMA, TDMA and CDMA):

Figure 1.3.2.1: IMT-2000 Terrestrial Radio Interfaces

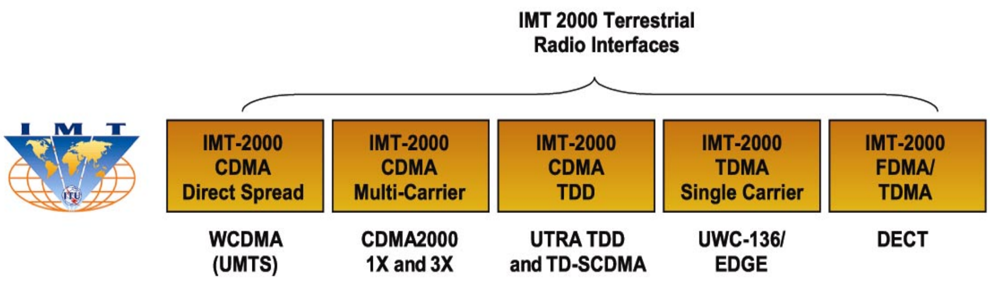

Table 1.3.2.1: IMT-2000 Terrestrial Radio Interfaces

Full Name	Common Names
IMT-2000 CDMA Direct Spread	UTRA FDD WCDMA UMTS
IMT-2000 CDMA Multi-Carrier	CDMA2000 1x and 3x CDMA2000 1xEV-DO CDMA2000 1xEV-DV
IMT-2000 CDMA TDD (time-code)	UTRA TDD 3.84 mcps high chip rate UTRA TDD 1.28 mcps low chip rate (TD-SCDMA) UMTS
IMT-2000 TDMA Single-Carrier	UWC-136 EDGE
IMT-2000 FDMA/TDMA (frequency-time)	DECT

1.3.2.2 Radio Network

A Radio Access Network consists of one or more Radio Network Systems. The Radio Network System (RNS) is the system of base station equipment (transceivers, controllers, etc.) which is viewed by the MSC as the entity responsible for communicating with Mobile Stations in a certain area. The radio equipment of an RNS may support one or more cells. An RNS may consist of one or more base stations. In the case of UTRA FDD and UTRA TDD both radio interfaces can be supported within a single radio access network.

Further details of the Radio Network System may be found in Recommendation ITU-R M.1457, with an overview included in the Handbook "Deployment of IMT-2000 Systems". }

1.3.3 IMT-2000 Core Networks

In addition to the Radio Network, the other essential component of the IMT-2000 terrestrial family is the Core Network. This section provides information on the core networks for the IMT-2000 Family members specified by each of the 3G Partnership Projects and transposed into standards by their respective partner Standard Development Organizations (SDOs). There are two such IMT-2000 Family Members and they are further described in sections 1.3.3.2 and 1.3.3.3 following an overview of core network standards in section 1.3.3.1. At the time of writing, harmonization of these core networks is a crucial topic for the ITU.

Within the ITU-T, the Special Study Group on "IMT-2000 and Beyond" has been addressing a number of aspects of harmonization of core networks. One area was investigation of the differences between the IP Multimedia Subsystems (IMS) of the two 3G Partnership Projects in Q.6/SSG. The current situation is that this work is converging well within the 3G Partnership Projects and it is anticipated that it will form the basis for a well-harmonized core network for systems beyond IMT-2000. The results of this work of Q.6/SSG are intended to be captured in the next edition of the Handbook on "IMT-2000 Deployment." Another essential area being investigated is harmonized mobility management for systems beyond IMT-2000 being addressed in Q.2/SSG. This work is also progressing well with a technical report on requirements targeted for completion in 2004.

1.3.3.1 IMT-2000 Network Standards

The two[9] IMT-2000 Core Network types recommended by ITU are shown in the following table:

Table 1.3.3.1: IMT-2000 Core Network Standards

Full Name	ITU-T Recommendations identifying this Core Network	IMT-2000 radio technologies supported by this CN
GSM evolved UMTS Core Network	Q.1741.1 (referring to 3GPP Release 99) Q.1741.2 (3GPP Release 4) Q.1741.3 (3GPP Release 5)	IMT-2000 CDMA Direct Spread IMT-2000 CDMA TDD IMT-2000 TDMA Single-Carrier
ANSI-41 evolved Core Network with cdma2000 Access Network	Q.1742.1 (3GPP2 specifications as of 17 July 2001) Q.1742.2 (3GPP2 specifications as of 11 July 2002) Q.1742.3 (3GPP2 specifications as of 30 June 2003)	IMT-2000 CDMA Multi-Carrier

{ The Core Network (CN) is logically divided into Circuit Switched (CS) domain and Packet Switched (PS) domain.

The CS domain refers to the set of all the CN entities offering "CS type of connection" for user traffic as well as all the entities supporting the related signaling. A "CS type of connection" is a connection for which network resources are allocated at the connection establishment and released at the connection release. The user is provided a "Quality of Service" reflecting guaranteed use of the full capacity of the CS type of connection for the full duration of the connection.

9 NOTE TO EXTRACT – The Handbook on Deployment of IMT-2000 identifies three core network standards. However within ITU-T only the first two have been formally defined as ITU Recommendations (Q.1741.x and Q.1742.x).

The packet switching (PS) domain refers to the set of all the CN entities offering "PS type of connection" for user traffic as well as all the entities supporting the related signaling. A "PS type of connection" transports the user information using a set of bits called packets: each such packet could be routed independently of the previous one. This technology supports potentially much more efficient use of network resources, dependent on the nature of the traffic offered. The user is provided a "Quality of Service" which may reflect competition for network resources involved in a PS type of connection.

It is noted that the user expects, for a given service, to experience the same level of quality in its delivery independent of whether CS or PS technology is used. }

Asynchronous Transfer Mode (ATM) and Internet Protocol (IP) are the two technologies and protocols of fundamental importance for the implementation of the IMT-2000 Core Networks. The Handbook "Deployment of IMT-2000 Systems" provides a description of these network transport technologies.

The two core network architectures of IMT-2000 are listed and briefly outlined below.

1.3.3.2 GSM evolved UMTS Core Network

This IMT-2000 Core Network type is defined in the series of ITU-T Recommendations Q.1741.x. In the following, the essential parts of Q.1741.3 (approved by ITU-T in August 2003, referring to 3GPP Release 5, featuring the IP Multimedia Subsystem, IMS) are extracted and presented for information.

Details are found in Annex A.

1.3.3.3 ANSI-41 evolved Core Network with cdma2000 Access Network

This IMT-2000 Core Network type is defined in the series of ITU-T Recommendations Q.1742.x. In the following, the essential parts of Q.1742.2 (approved by ITU-T in July 2003, referring to 3GPP2 references approved as of 11 July 2002) are extracted and presented for information.

Details are found in Annex B.

{ 1.4 IMT-2000 Standards Organizations

The ITU Recommendations for IMT-2000 have been developed taking into consideration the results achieved by the radio interface technology proponent organizations, global partnership projects and national and regional standards development organizations (SDOs). Each of the radio interfaces defined by an external organization shown in Table 1.4.

Table 1.4: IMT-2000 Terrestrial Radio Interfaces: External Organizations

Full Name	External Organizations
IMT-2000 CDMA Direct Spread	3GPP
IMT-2000 CDMA Multi-Carrier	3GPP2
IMT-2000 CDMA TDD (time-code)	3GPP
IMT-2000 TDMA Single-Carrier	T1 and TIA
IMT-2000 FDMA/TDMA (frequency-time)	ETSI

}

1.5 Demand for non-voice, high bit-rate services

Of the top 20 mobile second generation operators with leading world-wide data revenues expressed as a percentage of their total ARPU (Average Revenue per User), 19 of them are running GSM networks[10]. A key contributor to this success is the demand for non-voice services as evidenced by the explosive popularity of SMS, or text messaging, with over 1 billion SMS being sent daily. In the UK alone, more than 70% of mobile phone users now use their handsets for text messaging, and 16.8 billion chargeable person-to-person text messages were sent across the UK's four GSM networks in 2002. This figure is even higher in countries such as Germany and Ireland, and in general in all those countries where, effectively, text messaging complements or replaces voice calls in a number of social contexts.[11] <Source: Mobile Data Association>.

Other services, meanwhile, are steadily generating an increase in non-voice revenues for operators. Building on the enormous success of SMS, Mobile Multimedia Messaging Service (MMS) has so far attracted well over 1 million subscribers in Europe alone, allowing them to create, store, send and share their own audio-visual content. Already offered by more than 115 operators[12] – chiefly in Europe and Asia – MMS suggests which kinds of service opportunities can be offered by the increase in the available data speed, that is available with IMT-2000 technologies. Rapid progress is also being made to open up MMS interoperability – an indicator of the importance that operators are placing on the success of this data-driven market.

These elements underscore a demand for non-voice services, which in turn require the high-speed packet data services that only the IMT-2000 family of technologies can support.

1.6 Flexibility: Multi-environment capabilities

IMT-2000 has an important role to play in bridging the "digital divide" between regions and cultures.

Of this enormous market opportunity, it is anticipated that the largest revenue generators will be voice; personalized access to information and entertainment services ("infotainment"); mobile access to the Internet and corporate networks; and MMS. Other contributors to operators' revenues will include Location Based Services and "Rich Voice" – an extension of normal voice telecommunications that overlays the simultaneous transmission of photos, graphics, video, maps, documents and other forms of data.

New services and applications created by IMT-2000 will also exhibit distinct regional trends in terms of user take-up. An example of this is Asia Pacific, where The UMTS Forum an industry association predicts that annual revenues for all IMT-2000 technologies will reach USD 118 billion by 2010, with "customized infotainment" – personalized access to news, sports results, gaming and other forms of information and entertainment – representing 36% of all Asian IMT-2000 revenues, ahead of simple voice (28%), mobile access to the Internet and corporate networks (14%) and MMS (13%). In addition, at the 3G World Congress in Hong Kong June 2002, data was presented that showed that 3G operators were experiencing a 16% increase growth in ARPU (USD 35.4 to USD 41.8) between 2000 and 2002. Of this increase, 67% was directly attributed to users adopting and using packet data services.[13]

2 DEVELOPMENT OF POLICIES FOR TRANSITION OF EXISTING NETWORKS TO IMT-2000

The variety of situations in developing countries relating to the technology and the development of existing mobile networks implies the need for diverse and different transition policies toward networks based on enhanced systems. These Guidelines are therefore intended to address only those cases where the transition to IMT-2000 networks is expected to affect medium term investment plans.

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[10] Global Mobile Suppliers Association.

[11] Mobile Data Association.

[12] Global Mobile, EMC, GSMA, (www.gsmworld.com).

[13] 3G World Congress in Hong Kong June 2002 – "Mobile Services in Korea, 1X and Beyond", Wong Tong, President Samsung R&D Institute.

The identification of a transition policy is based on the analysis of key aspects, that impact demand, investments and revenues. As already stated, although these aspects are common to all countries, their implications for developing countries deserve special treatment.

Annex C to the guidelines contains a description of evolution methodology and scenarios.

2.1 Special needs of operators, regulators and users in developing countries

The number of mobile subscribers in developing countries is at low rates compared to developed ones, but the number of subscribers is increasing significantly. In fact, in many countries mobile penetration exceeds fixed-line penetration, therefore developing countries have a great potential when the penetration rates are concerned. But due to economic conditions, users in developing countries may be able to allocate very little of their income to telecommunications. With additional services like video conferencing and high speed mobile Internet, some usage fees of the IMT-2000 services are expected to be higher than those of current mobile services. Moreover, IMT-2000 infrastructure costs can cause increase in the usage fee. As a result, some of the pre-IMT-2000 subscribers in the developing countries may wish to continue to use the current systems. Therefore, determination of suitable methods of transition is an important issue for protecting the rights of present subscribers preferring not to migrate.

Costs will be another key decisional aspect for operators, as their investments in current pre-IMT-2000 mobile systems are great and returns may have not yet covered those costs. Operators must consider these costs in planning to deploy IMT-2000 systems, and actual deployment may be delayed. In order to capitalize on current mobile systems, IMT-2000 networks and terminals should be as compatible as possible with the current pre-IMT-2000 systems, and reuse of the existing pre-IMT-2000 infrastructure in the deployment of IMT-2000 systems, and infrastructure sharing, can reduce costs. Furthermore, there should be enough reasonably priced dual mode terminals that users in developing countries can afford them. This will help IMT-2000 to penetrate quickly.

Some typical needs of operators and users in developing countries are:

- Low licensing fees to reduce the entry cost for service providers.
- Ability to offer tariffs that are affordable to the end-users.
- { [i] Affordable pricing of mobile services, minimal initial investment and total network cost }
- { [i] Sufficient charging (billing) flexibility to adapt to different charging schemes and be capable of being configured for special conditions where mobility between cells, or even within a cell, is not required. }
- Roll out obligations that are in keeping with the business case of the operator and the user's interest.
- { [i] Solutions that enable coverage of rural areas (with varied terrain characteristics) with large cells. }
- Ability to share infrastructure to facilitate speedy and cost-effective deployment.
- Promotion of local development of applications and terminals.
- Hardware and software supporting open standards.
- Terminals that support local requirements, e.g. language and character sets.

In addition to these general needs it is also important to recognize that the needs of developing countries should not be just related to topographic and technical issues, but they should also be expressed in terms of commonly defined societal conditions.

2.1.1 Special needs of operators

Minimization of infrastructure costs is a concern for operators in developed as well as developing countries. However, due to lower penetration rates and ARPUs in developing countries, this constraint is heavier in these countries. Thus, from the standpoint of the operators there is a need for a regulatory environment that minimizes implementation and roll-out costs (such as sustainable coverage obligations, low license fees, choice between alternative technologies allowing a cost efficient network deployment, possibility to use lower frequency bands, infrastructure sharing). Furthermore, since in most developing countries mobile networks provide more extensive coverage than fixed networks, administrations in these countries may wish to support the usage of such networks for fixed/data applications.

Table 2.1.1: Special needs of operators

Item	Operator Needs and Rationale
Costs	Transition costs should be minimized as much as possible because vast majority of population has little discretionary budget for telecommunications/entertainment. Recovery of evolution/migration capital expenditure (CAPEX) and operating (OPEX) costs.
Fixed wireless access	Some operators may provide fixed wireless access for IMT-2000 services in urban areas.
Coverage and deployment obligations	Target coverage/service penetration and roll-out schedule set by regulators in some cases. The goal for coverage for IMT-2000 systems, which will be realized over time, should be co-terminus with existing pre-IMT-2000 systems. Roll-out obligations must be set keeping in view the business case of the operator and the user's interest.
Transition time	Time frame for transition from existing "mobile"/"fixed" towards IMT-2000. Operators should have maximum flexibility in determining and finalizing the transition.
Mass application	Applications such as tele-education, tele-medicine, e-government may require IMT-2000 technologies.
Government support	Role of government subsidy for infrastructure and/or advanced applications (not for infrastructure but for affordability of services by all including universal service obligations).
Value depreciation	Possible obsolescence of new infrastructure investments while waiting for IMT-2000 demand.
IMT-2000 bands	Access to appropriate frequency bands and adequate spectrum is required. Use of frequencies below 1GHz and allocation of future frequency bands as per WRC/WARC may be advantageous in providing cost-efficient coverage. Use of harmonized IMT-2000 bands decreases equipment costs and facilitates worldwide roaming.
Technical and administrative conditions	Conditions for use of spectrum (licensing/roaming/coverage/other operator obligations/).
Infrastructure sharing	Sharing of (radio/network) resources for rapid rollout and coverage (VNO, Virtual Network Operator) can be encouraged to facilitate speedy deployment of new technologies and lower the costs to operators.
Satellite component	Usage of satellite component of IMT-2000.
Market analysis and business cases	How to develop market analysis/business case? (population literacy, disposable income, etc.)
Services and applications	• Low entry fees would reduce the entry cost of service provider; • Use of IMT-2000 for access to education in remote villages, rural economic development, access to Internet at affordable price.
Availability of equipment from multiple vendors	• Existence of multiple vendors increases competition with positive price effects for operators; • Dependency of operators on vendors is reduced; • Multivendor systems require standardization by a broad community and leads to open standards.

2.1.2 Special needs of regulators

Regulators in developing countries may wish in particular to set up a regulatory/legal framework that minimizes network deployment costs while facilitating the provision of an extensive network coverage and of specific "socially efficient" services and applications (e.g., e-health, e-education). Education policies that improve literacy rates will increase the populations' ability to utilize IT (Information Technology) services.

Table 2.1.2: Special needs of regulators

Item	Regulator Needs and Rationale
License handling and allocation	Capitalize on experience of developed countries on • license awarding method, • license conditions, • license fees, • number of licenses.
Databases	Capitalize on experience of developed countries on • RFP (Request for Proposal) issued for awarding IMT-2000 licenses; • Rationale behind the preferred license awarding methods; • Information on the method of determination of Lowest Bid Rates; • Standard concession agreements – including provisions related to QoS numbering, interconnection, roaming, coverage, infrastructure sharing, etc. – that were signed with the IMT-2000 operators; • A list of rights and obligations of the IMT-2000 operators, including the rationale behind each.

2.1.3 Special needs of users

Due to lower income levels, the users' ability to pay for telecommunications services is lower in developing countries than in developed ones. Thus, the availability of an affordable service offering and of reasonably priced handsets is a particularly important issue in these countries.

Table 2.1.3: Special needs of users

Item	User Needs and Rationale
Costs	User affordability for services and terminals. • Tariffs should be affordable to the end-users.
Terminals	Ease of use and convenience of terminals. • The terminals should support local requirement in terms of language and must take into consideration the literacy level across the country.
Easy roaming	• Users want to use their usual terminals when traveling. • Roaming is facilitated by low prices and by the availability of compatible technologies/terminals in foreign countries.
Services and applications	• Use of IMT-2000 for education in remote villages, rural economic development, access to Internet at affordable price. Training of users on wireless data applications.

2.2 Strategies for smooth transition

2.2.1 Regulatory flexibility to allow transition

The adoption of flexible policies for the national allocation of the radio spectrum and for the choice of technologies provides market incentives for the development and deployment of advanced wireless services throughout the world. Regulators may wish to allow operators to transition their pre-IMT-2000 systems to IMT-2000 using their existing licensed spectrum, so that operators would not need to deploy these systems in new spectrum bands. This spectrum flexibility benefits operators by allowing them to spend capital resources on improving their system and can keep costs low. This can also be achieved by minimizing licensing costs for new spectrum.

The ITU recommends that IMT-2000 systems be deployed in any of the bands identified by the ITU for IMT-2000 in the Radio Regulations. ITU-R Recommendation M.1036 states that administrations may deploy IMT-2000 systems in bands other than those identified in the Radio Regulations.

Some countries have licensed IMT-2000 systems in bands not currently being used for pre-IMT-2000 systems, but identified in the Radio Regulations for IMT-2000. Moreover, in some countries (for example, the United States), system upgrades to IMT-2000 are taking place in the cellular bands (800 MHz and 900 MHz) and in the personal communications services (PCS) bands (1 800 MHz and 1 900 MHz). There are various possibilities to facilitate in-band transition. The regulators should evaluate these options carefully and select the one which best meets their needs.

One possibility to facilitate in-band migration consists of the following:

First, there are no regulatory limitations on which technologies can be used in the existing mobile bands. Regulations and/or license conditions specifying the use of a particular technology or standard in the bands would have to be eliminated.

Second, service definitions may also have to be modified to accommodate the new flexibility. This can be achieved in the regulations or license authorizing mobile services (e.g. cellular, PCS or IMT-2000), by keeping the definition broad and non-specific. For example, the use of a broad definition has allowed existing pre-IMT-2000 operators in various countries to pursue in-band transition to IMT-2000 using whatever technology they choose. In this case the operator makes the choice of technologies that best meets its business objectives. In addition, the operator is given the flexibility to introduce a new technology at any point in the license duration.

An alternative possibility to facilitate in-band migration is for the regulator to enhance the existing licenses and identify some preferred technologies in order to meet the demands of end users and operators. For example, these preferred technologies might be the IMT-2000 family. Spectrum management by the regulator may be simplified in this case because the properties (e.g. spectral emissions, transmit power, channel spacing etc.) of the technologies being deployed are known when issuing/enhancing the licenses. Given a choice from among the preferred technologies, the operators can still select the most appropriate technology from the set of technologies as well as the timing of the introduction of the new technology.

Harmful interference between licensees using pre-IMT-2000 and IMT-2000 systems may be addressed by specific technical rules that seek to avoid harmful interference between operators on adjacent channels in the same area. These technical rules include out-of-band emission limits, power flux density or field strength limits at the edge of the service areas or borders, guard-bands, and coordination requirements

2.3 Accommodating special needs for transitioning to IMT-2000

2.3.1 Solutions for low density areas

In rural, sparsely populated and/or low-traffic density areas, the coverage advantages of lower frequency ranges will be an important consideration for the deployment of wireless systems, including IMT-2000. Lower frequency radio waves propagate, or travel, farther than higher frequency waves. This variation in propagation as a function of frequency results in greater coverage per cell site in a cellular system operating in a lower frequency range as compared to one operating in higher frequency bands. Greater coverage per cell site results in the need for fewer cells to provide service for a geographic area. Additionally, there exists an inverse relationship between maximum achievable average data rate and maximum cell range.

For example, it is worth noting that operators in Brazil, Canada, Japan, Korea, New Zealand and the United States are currently utilizing the 800 and/or 1 900 MHz bands to offer IMT-2000 services by transitioning existing first and second generation systems to IMT-2000. Similarly, operators in Romania, Belarus, Russia, Uzbekistan and Sweden are upgrading existing systems in the 450 MHz band to IMT-2000.[14] It could be more costly to deploy IMT-2000 systems in non-harmonized frequency bands than in those that are harmonized and utilized by the majority of operators due to a lack of economies of scale. However there are many operators who are migrating in a cost-effective way their analog systems to IMT-2000 in existing bands.

Similarly, let us now consider the case of two technologies such as GERAN (GSM/EDGE Radio Access Network) and UTRAN (UMTS Terrestrial Radio Access Network). In terms of technology, both GERAN and UTRAN) can be used to realize large cell radii as required in sparsely populated areas. But due to the different frequency ranges where GERAN and UTRAN are envisaged to operate today, GERAN is more suitable for large cells. One reason for that is that GERAN is operated in 900 MHz, 800 MHz and that is specified for operation in 450 MHz. UTRAN can be used as complement to GERAN to enhance the traffic capacity and to offer significantly higher data rates.

2.3.2 Solutions for high density areas

Many developing countries have densely populated cities, which are growing so quickly that fixed lines cannot be installed fast enough to meet demand. In such situations, wireless systems, such as IMT-2000, may be a cost-effective and flexible solution.

A wireless system is likely to be less expensive and faster to deploy than a wireline network. In addition, wireless systems can be configured to handle both fixed and mobile traffic. This provides flexibility for operators to meet the demand for both types of services, which may vary over time. Wireless systems, such as IMT-2000, can also provide both basic voice, as well as low-to-high-speed data services. The capability to handle both basic and advanced services is another advantage for operators that want to expand their networks as demand for these services increases.

Finally, it is important to note that operators of wireless systems in lower frequency ranges, such as those below 1 GHz, can provide services in both rural and dense urban areas using the same network in terms of technology and frequency range. As explained above, operators in large countries with both rural/sparsely populated areas as well as densely populated areas (such as Brazil, Canada, and the United States) are able to meet demand for both voice and data services using IMT-2000 networks in bands below 1 GHz In high density areas, due to the significantly high traffic load, it may be necessary to deploy additional spectrum – preferably in the harmonized frequency bands.

IMT-2000 can be used to realize small cell radii as required in densely populated areas utilizing an inverse relationship that exists between maximum achievable average data rate and maximum cell range. In general, it can be engineered to balance between traffic capacity and higher data rates.

2.3.3 Universal service/access to basic and advanced services

In several developing countries around the world, the number of wireless users have overtaken the number of wireline subscribers. Increased competition is bringing down the price of wireless phone service, while simultaneously spurring higher levels of service quality. By encouraging investment in wireless systems, whether through allocation and assignment of suitable spectrum, or through the implementation of regulatory policies that provide incentives and flexibility to operators to meet user demands, administrations can leverage wireless technologies, such as IMT-2000, to address the lack of access to basic voice services.

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[14] The 450 MHz IMT-2000 system in Romania Belarus, Russia and Uzbekistan are commercial, whereas the system in Sweden is still in a trial stage.

In addition to improving access to basic voice services, developing countries are also looking to expand the definition of universal service/access to include data services, such as Internet access. Wireless systems, such as IMT-2000 have been designed to handle both basic voice as well as low-to-high speed data services. IMT-2000 technologies with their higher data rates can bring advanced services to a wider range of users, while meeting important social needs such as providing high speed connectivity to clinics, schools, libraries, governments, telecenters and other priority users.

In addition to Internet access, many other applications essential for developing countries, such as e-health/telemedicine, can be provided over wireless systems, including IMT-2000. Other applications include using IMT-2000 networks to monitor remote outpatients with specific health conditions.

2.3.4 Extension of IMT-2000 services to other accesses, including access via fixed networks

Wireless technologies, including IMT-2000, can be used for either mobile or fixed applications. Often, regulators decide to allocate spectrum for Fixed Wireless Access (FWA) systems to help increase teledensity, create competition and build out the local loop. Operators of FWA systems are able to charge different tariffs for fixed and mobile services, even though each service may be provided using the same equipment. Also, due to the high-speed data capabilities of IMT-2000 technologies, users may decide to utilize such technology for Internet access. In addition to accessing the Internet directly with wireless handsets or personal digital assistants, IMT-2000 handsets can be used as a modem connected to a laptop or desktop computer via Bluetooth or cables. Also available are IMT-2000-capable PCMCIA cards, which are wireless modem cards that plug into laptop or traditional desktop computers.

Requirements for the use of fixed networks in the role of fixed access networks are addressed in Q.1761[15].

2.4 IMT-2000 service offerings

Typical mobile and IMT-2000 service offerings include but are not limited to:

- Voice.
- Slow-scan video.
- Streamed video.
- Interactive multimedia.
- File and image transfer.
- Web browsing (internet and intranet access).
- E-mail.
- Information services:
  - Health
  - Education
  - Entertainment
  - Finance
  - Travel
  - Local Government
- Telemetry.
- SMS (person to person).
- SMS (Applications).
- MMS.
- Games.

[15] Recommendation Q.1761 “Principles and Requirements for Convergence of Fixed and Existing IMT-2000 Systems”, November 2003.

2.5 Spectrum requirements (including the possibility of using existing bands)

Specific concerns of developing countries include:

- Selection of spectrum band: WARC-92 identified the 1 885-2 025 and 2 110-2 200 MHz and WRC-2000 identified the 802-960 MHz, 1 710-1 885 MHz, and 2 500-2 690 MHz frequency bands for IMT-2000 systems. These frequency bands were accepted internationally. At WARC-03, Resolution 228 addressed the need to identify additional frequency bands for the future enhancements of IMT-2000 and systems beyond.
- Re-allocation of pre-IMT-2000 spectrum: The re-allocation of pre-IMT-2000 spectrum was also looked upon as a solution by many countries, to increase the spectrum available for IMT-2000. One of the problems faced was the fact that the IMT-2000 system would reside on frequency channels located between other channels used by the pre-IMT-2000 systems.

2.5.1 Current spectrum allocation for IMT-2000

{ [i] IMT-2000 will operate in the frequency bands identified in the Radio Regulations (RR) as intended for use on a worldwide basis by administrations wishing to implement IMT-2000, as follows[16]:

WARC-92 identified the bands:

- 1 885-2 025 MHz
- 2 110-2 200 MHz

and WRC-2000 identified the bands:

- 806-960 MHz[17]
- 1 710-1 885 MHz
- 2 500-2 690 MHz

for possible use by IMT-2000 systems, noting (in accordance with Radio Regulation 5.388) that identification of these bands does not establish priority in the Radio Regulations and does not preclude use of the bands for any other services to which these bands are allocated. Also, some administrations may deploy IMT-2000 systems in bands other than those identified in the RR.

In order to determine the principles and practical use of the spectrum for IMT-2000 systems it is considered:

a) that the RR identify the bands 806-960 MHz[18], 1 710-2 025 MHz, 2 110-2 200 MHz and 2 500-2 690 MHz as intended for use on a worldwide basis by administrations wishing to implement IMT-2000, as indicated in RR 5.388 (Rev.WRC-2000), 5.384A (WRC-2000), 5.317A (WRC-2000), Resolution 212 (Rev.WRC-97), Resolution 223 (WRC-2000), Resolution 224 (WRC-2000) and Resolution 225 (WRC-2000); by taking these footnotes and resolutions into account, flexibility should be afforded to administrations to decide on using these bands at the national level according to each administration's evolution/migration plan;

b) that in some countries, other services are in operation in the bands identified for IMT-2000 as indicated in Resolution 225, RR 5.389A, RR 5.389C, RR 5.389D, RR 5.389E and Recommendations ITU-R M.1073-1 and ITU-R M.1033-1;

c) that a minimized number of globally harmonized frequency arrangements in the bands identified for IMT-2000 by one or more Conferences will:
   - facilitate worldwide compatibility;
   - facilitate international roaming;
   - reduce the overall cost of IMT-2000 networks and terminals by providing economies of scale;

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[16] Some Administrations may deploy IMT-2000 systems in bands other than those identified here.

[17] The whole band 806-960 MHz is not identified on a global basis for IMT-2000 due to variation in the primary mobile service allocations and uses across the three ITU Regions.

[18] The whole band 806-960 MHz is not identified on a global basis for IMT-2000 due to variation in the primary mobile service allocations and uses across the three ITU Regions.

d) that when frequency arrangements cannot be harmonized globally, a common base and/or mobile transmit band would facilitate terminal equipment for global roaming. A common base transmit band, in particular, provides the possibility to broadcast to roaming users all information necessary to establish a call;

e) that when developing frequency arrangements possible technological constraints (e.g. cost efficiency, size and complexity of terminals, high speed/low power digital signal processing and the need for compact batteries) should be taken into account;

f) that some administrations may consider the use of the lower UHF land mobile bands, e.g. below 470 MHz, for the deployment of IMT-2000 systems in cases where it is desirable to evolve an existing first or second generation system to IMT-2000 and/or to take advantage of coverage benefits for rural, sparsely-populated or low-traffic density areas;

g) that some administrations are planning to use parts of the bands 698-806 MHz or 2 300-2 400 MHz for IMT-2000. }

2.5.2 Use of first and second-generation mobile spectrum for IMT-2000

Recognizing the advantages to be gained by the transition of existing systems to IMT-2000, WARC-92 and WRC-2000 identified the frequency ranges, including the 800 MHz, 900 MHz, 1800 MHz and 1900 MHz bands, in which most commercial first and second-generation wireless systems operate and encouraged administrations to facilitate transition from one generation to another on those bands.

Operators in Brazil, Canada, Chile, Japan, Korea, New Zealand, Romania and the United States, among others, are using first and second generation mobile spectrum for IMT-2000. Operators of analog systems in the 800 MHz and 450 MHz bands can upgrade their networks to IMT-2000 with commercial equipment that is available today. Similarly, second-generation operators of TDMA, cdmaOne and GSM are able to purchase commercially available IMT-2000 equipment to upgrade their systems. Given the significant initial capital expenditures necessary to deploy entirely new IMT-2000 systems, operators are finding that upgrading networks in existing spectrum is a more economically viable option.

2.6 Interoperability with existing networks and among IMT-2000 technologies

Inter-working between IMT-2000 systems and with legacy fixed and mobile systems is an important issue since, for the user, access to his/her services and applications globally (e.g. Virtual Home Environment) is important.

Inter-working (including with legacy systems) is important to provide coverage and global circulation of terminals. To this respect, it is important to note that specific multimode terminals will be available as commercial networks become a reality. SIM (Subscriber Identification Module) cards are another solution that can help overcome some of the interoperability issues between networks, but nevertheless require the use of multiple handsets to operate on different networks. In support of achieving this interoperability and roaming goals, the third generation partnership projects 3GPP and 3GPP2 have agreed to work to ensure:

- Interoperability between the 3GPP IMS mobiles and 3GPP2 IMS mobiles (a 3GPP IMS mobile can set up a session with a 3GPP2 IMS mobile and vice-versa).
- Application level inter-system IMS roaming (given that the mobile supports the visited network's access network and IP transport technology, a 3GPP IMS mobile should be able to roam into a 3GPP2 network and vice-versa).

Another interoperability issue that should be considered is the impact of the introduction of data services with IMT-2000. Given that IMT-2000 technologies are relatively new, interoperability of software and applications on IMT-2000 terminals and across borders will be increasingly important moving forward. One organization, the Open Mobile Alliance (www.openmobilealliance.org), was formed with the goal to deliver open standards for the mobile industry, helping to create interoperable services that work across countries, operators and mobile terminals and are driven by users' needs.

Other key issues to be considered in achieving this interoperability and roaming goals include:

- Access to emergency services.
- Location information.
- Lawful interception.
- Number portability.

2.7 Licensing aspects (Practices)

2.7.1 Licensing conditions

Licensing conditions are among the regulatory issues that are of importance to developing countries.

- Technology Requirements: It is worth considering whether policy-makers/regulators should follow a technology neutral approach or should mandate a particular technology and related transition path. A technology neutral approach could lead to benefits to end users in terms of a rapid technological evolution and lower prices.
- Financial requirements: They help to eliminate non-serious players and ensure a certain level of performance.
- Coverage: To prevent the development of information-rich and information-poor communities, the policy-makers/regulators of the various countries will need to ensure ubiquitous access to IMT-2000 services. However, from the service provider's point of view, it may not be viable to roll out expensive infrastructure in high-cost areas. It may be preferable to roll out network coverage in phases, based on demand and likely applications. Existing technologies and systems in place should have a scalable low cost transition path. Case studies have shown that operators can undertake gradual, phased upgrades to IMT-2000.
- Timing of IMT-2000 licenses: The timing for introduction of a new service is crucial and varies from country to country. It is necessary to judge the market potential and to deploy technologies that are proven and established. Developing countries can ill-afford to experiment with technology. However, the process of introducing wideband wireless services is time consuming and would require licensing and regulatory preparedness from an early period. It would be advisable that developing countries begin consultation right as early as possible.
- Number of operators: The limited availability of spectrum restricts the number of operators. In developed countries 3 to 5 operators have been preferred. Another issue is who should be eligible for this license: fixed operators, mobile operators, new operators, all or a combination of these. Japan, as an example, decided to exclude fixed operators from the licensing process.
- Infrastructure Sharing: Infrastructure sharing is particularly important for countries with widely dispersed populations and emerging mobile markets. It reduces the cost of network deployment and can improve penetration. It would also be necessary to identify the elements that can be shared, the amount of cost reduction that such sharing would bring about, for example, antenna masts, towers, and land building. Another issue for discussion is whether the regulator should play a pro-active role to encourage infrastructure sharing or should it be left entirely for operators.

For more information see Report ITU-R SM 2012-1 "Economic aspects for spetrum management" and chapter 3 "Licensing" of the ITU-R "National spetrum" handbook.

2.7.2 Methods of spectrum licensing

There are many methods of spectrum licensing that have been used both for first and second generation mobile licenses, as well as for IMT-2000 licenses. Most countries have required special licenses in order for operators to provide IMT-2000 services, while other countries have taken a more flexible licensing approach and allow operators to use current spectrum for IMT-2000 services and/or license spectrum use on a more generic basis, such as for "advanced wireless services". Some regulators allow the transition of first and second generation systems to IMT-2000 in their current bands and do not require further authorization to do so.

While not intended to be comprehensive or all-inclusive, a few of the more common methods of spectrum licensing are identified in this section, such as first-come, first-served, beauty contests, lotteries, and auctions. These guidelines do not endorse one methodology over any others, but gives some of the advantages and disadvantages of each methodology. Licensing is a national prerogative and each country must decide what methodology is appropriate for the conditions that exist within its legal, regulatory, and market framework.

For more information see Report ITU-R SM 2012-1 "Economic aspects for spetrum management" and chapter 6 "Economic aspects" of the ITU-R "National spectrum" handbook.

2.7.2.1 First Come, First Served

Originally, when spectrum was not scarce, regulators used a first-come, first-served approach to licensing spectrum. If there were fewer applicants than the number of licenses to award, then the assignment of spectrum was easy. For instance, if there were 10 licenses to give out and 8 applicants seeking authorization, the regulator could grant them all and have no problems. However, as spectrum has become more valuable, the regulator is unlikely to find an opportunity where it can assign frequencies on a first-come, first-served basis, except in the most remote areas.

Advantages and disadvantages of "First Come, First Served" spectrum licensing are summarized in Table 2.7.2.1.

Table 2.7.2.1: Advantages and disadvantages of "First Come, First Served" spectrum licensing

Advantages First Come, First Served	Disadvantages First Come, First Served
Speed	License may not end up in the hands of an entity that values it the most and can bring greatest value to the economy.
Inexpensive	The value of the license is not taken into account.

2.7.2.2 Beauty Contest

In a beauty contest (sometimes called a comparative hearing), the regulator or Ministry selects the winning applicant using comparative criteria that may be established either by precedent or by rule. In many countries, the first cellular licenses and broadcasting licenses were awarded through beauty contests. Beauty contests have also been used in some countries to issue licenses for IMT-2000. When beauty contests are undertaken, criteria to compare the prospective license applications are established and can include:

- The technical and financial stability of the applicants.
- The technical characteristics of the system being deployed.
- The coverage area being proposed.
- The schedule for build-out.

Advantages and disadvantages of "Beauty Contest" spectrum licensing are summarized in Table 2.7.2.2.

Table 2.7.2.2: Advantages and disadvantages of "Beauty Contest" spectrum licensing

Advantages Beauty Contests	**Disadvantages Beauty Contests**
Allows the regulator to determine the contender that will best serve the public interest.	Can be time consuming, particularly if the license is valuable. Applicants are often willing to exhaust all administration and litigation options.
Final costs for operators are more easily predicted than other options such as auctions.	Can get expensive for the applicants if they are willing to spend large sums of money to succeed in the beauty contest process.
Allows for equity considerations, such as minority ownership, small business ownership, etc.	Provides no method for deciding between two applicants that are essentially equal. The regulator may ultimately have to arbitrarily award the license.
	Government is responsible for choosing between alternative business plans stretching well into the future, and relating to new products and services that have not yet been developed.
	Need to be carefully structured to be fully transparent. Doubts over transparency of beauty contest process can lead to suspicions and dissatisfaction with the outcome.

2.7.2.3 Lotteries

Lotteries essentially decide among pre-qualified applicants by random selection. Applicants attend a drawing set at a specified date, time and location to draw numbers to decide who will get licenses.

Advantages and disadvantages of "Lottery" spectrum licensing are summarized in Table 2.7.2.3.

Table 2.7.2.3: Advantages and disadvantages of "Lottery" spectrum licensing

Advantages Lotteries	**Disadvantages Lotteries**
The process is quick.	The license may be awarded to an entity that is not qualified to build and operate the system. Any person may be able to participate in the lottery if no pre-qualification requirements are set. The regulator can establish criteria for participation in the lottery. However, this can be legally challenged and make the lottery process a lengthy one.
Provides a mechanism for selecting from substantially equal applications.	Speculators will participate in the lottery, with the purpose of reselling the license and reaping huge windfall profits. Reselling the license is known as "flipping it". So rather than the public getting the benefit of the revenues, the lottery winner will realize the revenues from the sale of licenses they got for minimal investment.
	If an unqualified party wins the lottery, the regulator has the challenge of deciding whether to let them sell it or not.

2.7.2.4 Auctions

Auctions award the licenses based upon the bidders' willingness to pay. Since the 1990s when spectrum auctions first began to be used for awarding spectrum licenses, billions of dollars have been raised in spectrum auctions and a fierce debate has arisen concerning the efficiency, competitive impact and social implications of this form of allocating spectrum. There are a variety of methodologies that have been used for spectrum auctions, including continuous, simultaneous multiple-round, and package.

Advantages and disadvantages of "Auction" spectrum licensing are summarized in Table 2.7.2.4.

Table 2.7.2.4: Advantages and disadvantages of "Auction" spectrum licensing

Advantages Auctions	Disadvantages Auctions
License can be issued quickly.	Auctions may lead to increased concentration in the industry. The regulator can consider placing spectrum caps to limit the amount of spectrum that one entity can hold, or limit eligibility to participate to non-incumbents. In addition, a nation can address monopoly concerns through its antitrust laws or competition policies.
Less resource intensive for both the government and the private sector when compared to beauty contests.	Auctions may ignore non-financial objectives that are in the public interest, such as equity considerations. The auction design can support those objectives by including strategies such as set-asides and providing bidding credits for certain groups that commit to addressing certain public interest factors.
License goes to the entity that values it the most. Auctions promote economic efficiency, one of the goals of spectrum management. Winning bids should come from the companies that can find ways of maximizing the stream of future benefits.	There may be some incentive for the government to act like any monopoly by restricting output and raising the price. In other words, if the government wanted to maximize the revenues to the treasury, it could withhold spectrum.
Spectrum is a public resource and therefore the profits benefit the citizens. The proceeds of the auction go to the government for national purposes.	Auctions may result in speculatively high bids for licenses for services that are not commercial at the time of the auction. Auctions can also be affected by hype and other non-economic forces.
Auctions can provide information about the economic value of spectrum. For instance, if applicants are willing to pay a high price to be able to provide one service, but will pay a very low price for a different service, then the regulator can determine which service has greater economic benefit and, therefore, can determine where it needs to focus its future spectrum management efforts.	Full information on IMT-2000 market characteristics is not always available, leaving some or all bidders without adequate information on market conditions, the regulatory environment, demand characteristics and the likely pricing structures.
	Likeliness of winner's curse that results in high prices for the license and leads to decreased investment capacity for operators and high end-user prices

2.7.2.5 Hybrid

A number of countries, including Austria, Italy, and Hong Kong, have adopted a "hybrid" approach to IMT-2000 license allocation. Tenderers have to pre-qualify in terms of criteria similar to those established for beauty contests to bid. Licenses are then allocated on the basis of an auction. Advantages and disadvantages of a hybrid approach are themselves a combination of the advantages and disadvantages of beauty contests and auctions.

Advantages and disadvantages of "Hybrid" spectrum licensing are summarized in Table 2.7.2.5.

Table 2.7.2.5: Advantages and disadvantages of "Hybrid" spectrum licensing

Advantages **Hybrid**	**Disadvantages** **Hybrid**
Ensures that contenders have appropriate resources and business plans to serve the public interest. Can require that licensees meet specific policy goals.	Auctions may lead to increased concentration in the industry. The regulator can consider placing spectrum caps to limit the amount of spectrum that one entity can hold. In addition, a nation can address monopoly concerns through its antitrust laws or competition policies.
License goes to the qualified entity that values it the most. Winning bids should come from the qualified companies that can find ways of maximizing the stream of future benefits.	Can be time consuming, particularly if the license is valuable. Applicants are often willing to exhaust all administration and litigation options.
Spectrum is a public resource and therefore the profits benefit the citizens. The proceeds of the auction go to the government for national purposes.	Beauty contest portion needs to be carefully structured to be fully transparent. Doubts over transparency of beauty contest process can lead to suspicions and dissatisfaction with the outcome.
Allows for equity considerations, such as minority ownership, small business ownership, etc.	Can get expensive for the applicants if they are willing to spend large sums of money to succeed in the beauty contest portion of the process.
	There may be some incentive for the government to act like any monopoly by restricting output and raising the price. In other words, if the government wanted to maximize the revenues to the treasury, it could withhold spectrum.
	Auctions may result in speculatively high bids for licenses for services that are not commercial at the time of the auction. Auctions can also be affected by hype and other non-economic forces.
	Full information on IMT-2000 market characteristics is not always available, leaving some or all bidders without adequate information on market conditions, the regulatory environment, demand characteristics and the likely pricing structures.
	Likeliness of winner's curse that results in high prices for the license and leads to decreased investment capacity for operators and high end-user prices

2.8 Lawful interception and common access to emergency services

The combination of IMT-2000 technology with position location capabilities, as well as with other dedicated systems, opens the door for the development of numerous public safety and law enforcement applications, including electronic citation, locating callers requesting emergency assistance, tracking of criminals on parole, enabling officials to access back-end data base without dispatcher assistance, and accessing real time information on land, air and water travel systems. In addition to security systems, IMT-2000 technologies can assist government officials with vehicular tracking and monitoring shipments en route to their destinations. Such services will be especially important for the shipment of high-risk hazardous materials such as explosives, radioactive materials, materials that are poisonous by inhalation as well as bulk shipments of flammable liquids and gases.

In addition to position location capabilities, IMT-2000 wireless networks use more elaborate authentication procedures than second generation wireless networks, deriving longer and more robust cryptographic keys (such as 128-bit secret keys) for added security.

There may be some merit in seeking to adopt common access mechanisms for emergency services, and standard interfaces for lawful interception and other security issues, in such a way that they are independent of the network technology. This could provide improved effectiveness of the emergency service (particularly for roaming users), and reduce operational costs in other areas. Studies on this subject are ongoing in ITU-T.

3 TRANSITION PATHS

There are a number of pre-IMT-2000 systems, both analog and digital, that are in operation today providing wireless voice and data services to end-users worldwide. These systems include, but are not limited to, AMPS, NMT, cdmaOne, TDMA, and GSM. Recommendations ITU-R M.622, M.1033 and M.1073 and Report ITU-R M.742 describe characteristics of pre-IMT-2000 systems.

Due to differences between the various pre-IMT-2000 systems, as well as differences between the IMT-2000 systems, the possible transition paths for each pre-IMT-2000 system differ. However, in most cases, the transition requires the addition of IMT-2000 base station equipment and/or software, necessary modifications or additions of the Radio Access Networks (RAN), suitable upgrade/modifications of the underlying "core network" along with the introduction of new terminals, which are typically dual-mode devices capable of operating both pre-IMT-2000 and IMT-2000 radio technologies.

Several factors should be considered in the selection of a transition path towards IMT-2000. One important factor is the availability and use of spectrum for both pre-IMT-2000 and IMT-2000 systems. Other issues that will have a major impact on the choice of transition include availability of equipment and service applications for the various technologies and their performance in the desired operating environment.

In terms of transition and upgrade paths, these Guidelines do not make any comparison between the performances of different technologies or promote specific technologies.

Typical operators' experiences of transition are provided in Annex G, for both developed and developing countries.

3.1 Introduction

Considered at the highest level, transition towards IMT-2000 is characterized by operator deployment of:

- A core network with links to the PSTN (Fixed Telephone Network), ISDN, the Internet/Intranets and external mobile and data networks.
- A radio Access Networks (RAN), eventually capable to work in several frequency bands and using complementary radio technologies (Radio Access Networks are based on radio interfaces. IMT-2000 radio interfaces are listed in section 1.3.2.1).
- Dual-mode or multi-mode terminals allowing subscribers to enjoy services on pre-IMT-2000 and IMT-2000 networks.

If an operator intends to upgrade its system, the operator has to evaluate the target system and he has to analyze which parts of the system have to be modified to which extent and which resources (e.g. spectrum) can be reused or have to be enhanced. The necessary modification of the system can be basically classified into evolution of components or transition of the entire system. As defined in ITU-R Recommendation M.1308:

- "evolution" is characterized as "A process of change and development toward enhanced capabilities", whereas
- "migration" is characterized as "Movement of users and/or service delivery from an existing system to a new system".

There exist basically two Core Network types:

- GSM (Evolved) Core Network; and
- IS-41 (Evolved) Core Network.

A movement of users and/or service delivery from a GSM Core Network to an IS-41 Core Network and vice versa is clearly a migration, since the Core Network equipment has to be replaced in both cases. But there are evolutions within both Core Network types. These evolutions are necessary to introduce new services and supplementary services and to support new capabilities of the Radio Access.

For the support of packet data services, GSM (Evolved) Core Networks have been complemented by IP based GPRS-backbone networks providing a specific fast Mobility Management to the packet data services, capable of handling fast handovers for real-time packet data services; whereas IS-41 Core Networks have been complemented by "classical/pure" IP networks and therefore uses generic IP-protocols for Mobility provision (i.e. Mobile IP).

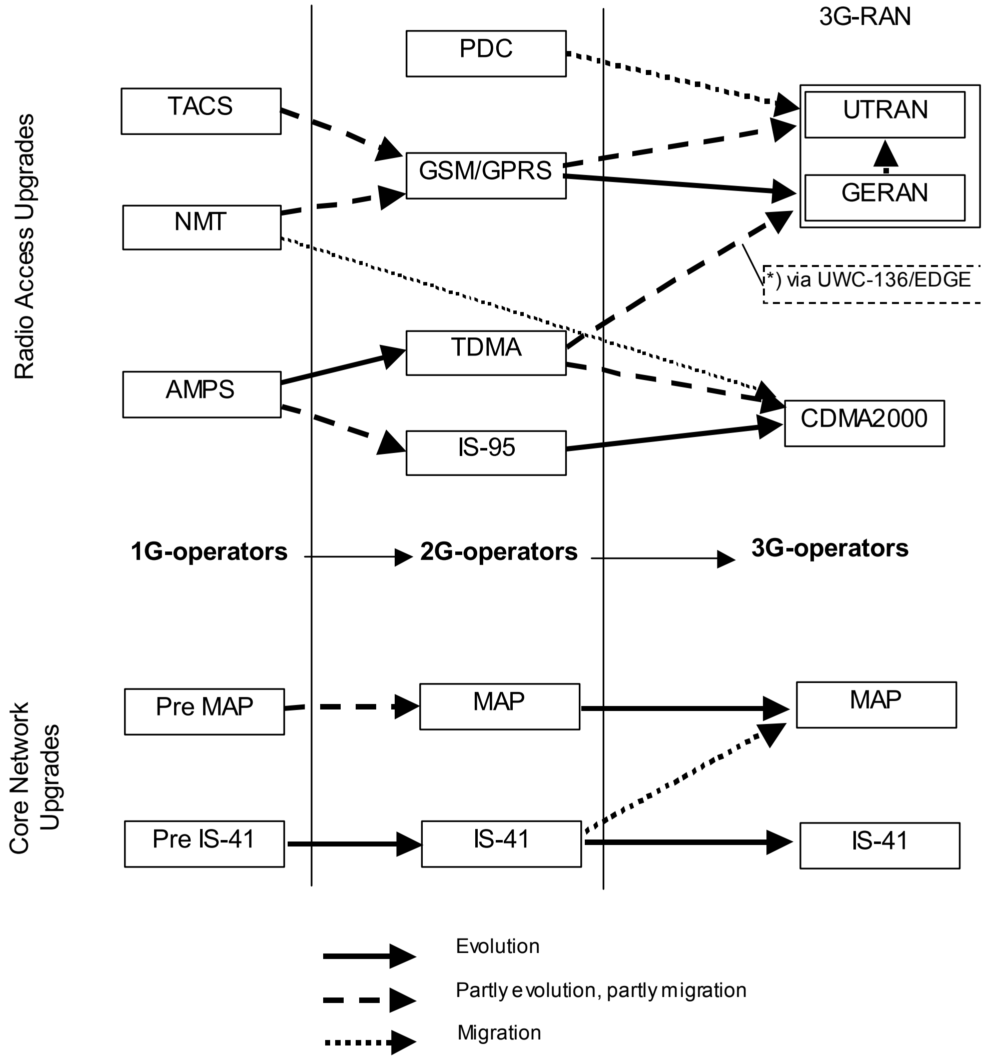
IMS (Internet Multimedia System) is an additional architecture which can be deployed on top of both the previous two core networks, and which provides specific packet data services (e.g. Voice over IP, Voice-over-IP-based conference calls, etc.). It has been adopted by both 3GPP and 3GPP2 for their Packet Core Network.

On the Radio Access Network (RAN) side in particular, the mobile industry has developed the essential specifications and continues to work in partnership, coordinated via 3GPP and 3GPP2 at the global level, to further evolve the technology in order to support future market needs. The step-by-step approach minimizes the need for large re-investments in IMT-2000 and yet provides significant improvements in the capability to deliver improved services at each step along the way. Updates of 3GPP and 3GPP2 standards provide backward compatibility, ensuring to the greatest extent possible a continuing service capability for existing operators and users.[19]

Analysis of the various transition scenarios, market analysis, and forecasts of future trends show that there existed and exist certain observed network upgrades of 1G- and 2G-operators towards 2G and 3G, as summarized in Figure 3.1. The figure shows these upgrades for both the Radio Access Network and the Core Network.

[19] See details of 3GPP Release Process in Annex E.

Figure 3.1: Observed network upgrades of operators



3.2 Considerations for transition

{ [20] [i] In planning the implementation of IMT-2000, the following objectives are desirable:

- to facilitate the deployment of IMT-2000, subject to market considerations and to facilitate the development and growth of IMT-2000;
- to minimize the impact on other systems and services within, and adjacent to, the bands identified for IMT-2000;
- to facilitate worldwide roaming of IMT-2000 terminals;
- to integrate efficiently the terrestrial and satellite components of IMT-2000;
- to optimize the efficiency of spectrum utilization within the bands identified for IMT-2000;
- to enable the possibility of competition;
- to facilitate the deployment and use of IMT-2000, including fixed and other special applications in developing countries and in sparsely populated areas;

[20] This taken from draft revision to ITU-R Recommendation M.1036.1.

- to accommodate various types of traffic and traffic mixes;
- to facilitate the continuing worldwide development of equipment standards;
- to facilitate access to services globally within the framework of IMT-2000;
- to minimize terminal costs, size and power consumption, where appropriate and consistent with other requirements;
- to facilitate the evolution of pre-IMT-2000 systems to any member of the IMT-2000 family as specified in Recommendation ITU-R M.1457. }

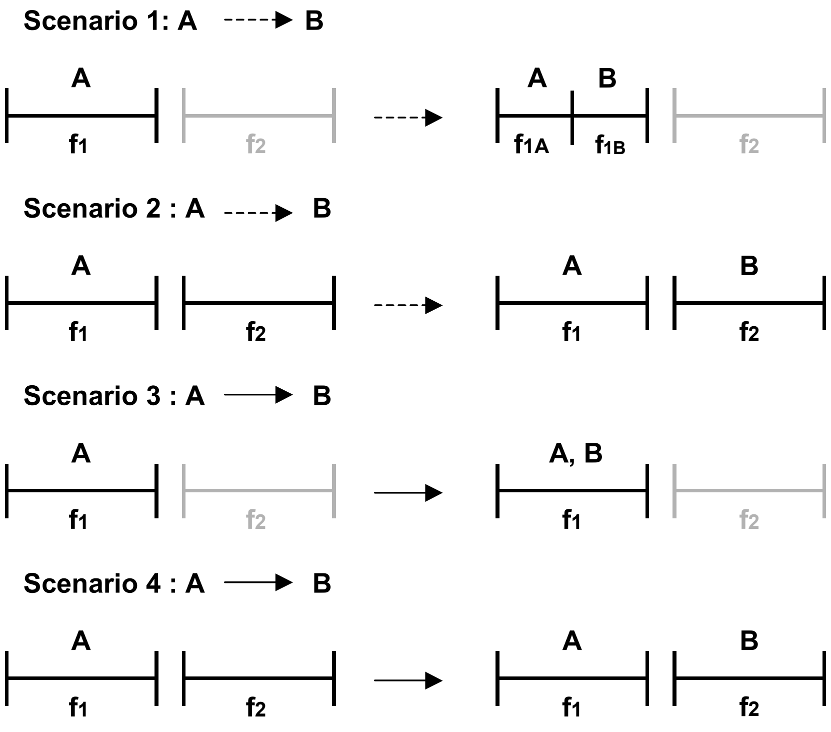
In case of transition of a system from one generation to the next one, major issues are spectrum usage and system configuration. When an operator transitions to an IMT-2000 system, coverage and capacity gains occur, therefore as users transition from the pre-IMT-2000 system the operator can gain spectrum efficiencies with the more advanced system. As for spectrum usage, four scenarios are possible, subject to regulatory conditions (see Figure 3.2-1 and Figure 3.2-2):

- Scenario 1: The IMT-2000 system (B) is deployed in the spectrum that is currently being used for the pre-IMT-2000 system (A). Obviously, the existing spectrum (f1) is split and some of the spectrum is allocated for the IMT-2000 system (f1b) and the rest remains in service for the pre-IMT-2000 system (f1a). New spectrum (f2) is not needed in this scenario. This allows operators to migrate users to new services utilizing the same spectrum, giving operators the opportunity to use the spectrum simultaneously for the pre-IMT-2000 and IMT-2000 systems.
- Scenario 2: The IMT-2000 system (B) is deployed in new spectrum. This allows the operator, for example, to migrate users to new services in new spectrum (f2) while evolving the capabilities of the pre-IMT-2000 system in the existing spectrum (f1).
- Scenario 3: The IMT-2000 system (B) is an evolved version of the pre-IMT-2000 system (A) deployed through a sequence of upgrades operated in the same spectrum. The IMT-2000 system (B) can fully interoperate with the pre-IMT-2000 system (A). Obviously, new spectrum f2 is not needed in this scenario.

Scenario 4: The IMT-2000 system (B) is an evolved version of the pre-IMT-2000 system (A). The IMT-2000 system (B) can therefore fully interoperate with the pre-IMT-2000 system (A). The IMT-2000 system (B) operates in new spectrum (f2), while the pre-IMT-2000 system (A) continues to operate in the existing spectrum. Scenario 4 is often combined with Scenario 3. Therefore, the IMT-2000 system (B) is in many cases also operated in the existing spectrum.

Figure 3.2-1: Transition scenarios in IMT-2000

(Actual examples of each Transition Scenario are available in Annex G “Operator experience in transitioning to IMT-2000 systems”).



KEY:
A: pre-IMT-2000 system; B: IMT-2000 system
A ----▶ B: A migrates to B; A ⟶ B: A evolves to B
f_1: operator’s current spectrum band
f_2: operator’s new spectrum band (different from f_1)

Figure 3.2-2: Key aspects of transition scenarios in IMT-2000

		Spectrum Bands	
		Same	Different
Backward Compatibility	Yes	Scenario 3	Scenario 4
	No	Scenario 1	Scenario 2

If the transition requires a migration of users and/or services, it has to be evaluated to which extent the network entities (e.g. Core Network and/or Access Network components) need to be replaced. This replacement does not necessarily affect the entire system. In general Core Networks evolve when Access Network components are changed out. In many cases and even in case of upgrade from a preceding generation of mobile systems to a new generation, there very often exist upgrade possibilities that affect only few entities of the system.

If the transition is from one generation to the next generation major functionalities (services, protocols, etc.) and properties (spectrum) of the old systems remain, to a large extent, available and unchanged within the new system. An evolution of system components provides a maximum of up- and downward compatibility, i.e. pre-IMT-2000 equipment does not have to be replaced but can be used together with new equipment, providing the full functionality of the pre-IMT-2000 system.

In general and not only for developing countries it can be concluded that evolutionary system upgrades are preferable from an operator and end-user point of view, because old investment can be retained to a large degree. However, in reality, pure system evolution is never possible, since even for the most flexible system design at least software updates or even hardware-updates (i.e. replacements) are necessary for some network components, if new features enhance the system. Moreover, experience shows that each technology will reach its limits concerning expandability, i.e. even evolutionary enhancements will eventually lead to an unacceptable system complexity. From that stage technology-jumps are necessary, which lead to the need of a new system, which is then incompatible to the old one and requires an appropriate migration and interoperability strategy.

These aspects should be taken into account when an operator determines his chosen transition path or paths towards IMT-2000.

{ [ix] There are likely to be four key elements to the decision by operators regarding the evolution of their particular pre-IMT-2000 systems:

1) *Feasibility of Evolution to IMT-2000* – ITU-R and ITU-T sectors have introduced the feasibility of evolution by providing sufficient flexibility within the scope of their IMT-2000 Recommendations for the broadest set of pre-IMT-2000 systems. Of course, providing for the evolution of pre-IMT-2000 systems does not undermine the achievement of the goals for IMT-2000.

2) *Cost-Effectiveness of Evolving to IMT-2000* – The benefits of evolving to IMT-2000 should be weighed against the cost incurred in executing this evolution option. This cost would also be incurred when evolving to any other more advanced non-IMT-2000 standard. The ITU took all the efforts to provide flexibility within the scope of their IMT-2000 Recommendations to help minimize the cost of evolution to IMT-2000.

3) *Attractiveness of Evolution to IMT-2000* – Evolution to IMT-2000 must be the most attractive approach among the various directions that can be taken in the advancement of today's mobile communications systems. As such, decision-makers would need to have a clear view of what IMT-2000 is, and how it is an improvement over the pre-IMT-2000 systems.

4) *Awareness of Evolution to IMT-2000* – An awareness of the advantages of the IMT-2000 evolution option is important for those who control or influence either the direction of pre-IMT-2000 standards and systems or the allocation and use of spectrum in the short and long term.

At first glance it might appear that there can be some degree of prioritization among these elements. Further consideration, however, shows that each one is important and must be present for the decision-makers to choose this path. Such awareness, along with the detailed information contained in this Report, should encourage the level of in-depth discussion needed for awareness and serious consideration of evolution to IMT-2000.

The other key elements, feasibility, cost effectiveness, and attractiveness of evolution should be used as measures for evaluating and resolving the issues associated with evolving pre-IMT-2000 systems toward IMT-2000. }

The following aspects are important, if an operator has to decide for a certain transition path:

a) Operation in worldwide harmonized frequency bands;

b) Existing/forecasted market share/market penetration of the target technology;

c) Probability that other operators adopt similar transition paths;

d) Ease of the transition from existing technology to the desired technology;

e) The system architecture of the target technology has to be future proof (i.e. capability to expand to cope with new requirements and new emerging services).

Status of the corresponding standard.

These aspects are important, because the past shows that the success of a certain mobile communication technology depends in particular on roaming capabilities (see points a to c above), on affordable equipment prices for terminals and also infrastructure (see points a to e above.), on ability to support new emerging services (see points e and f. above).

In considering transition paths from existing system to IMT-2000, it is important to recognize that both the start and end points are moving targets. The functions and capabilities of the network that is the starting point of the transition will themselves be evolving even as transition is taking place. Likewise, the target IMT-2000 technology or technologies are undergoing constant evolution and enhancement as time passes.

Development of specific transition paths must take due account of this.

3.2.1 Characteristics of IMT-2000 Radio Access and Core Networks technologies

ITU-R has produced a series of Recommendations for IMT-2000 Radio Access technologies. In particular the Recommendation M.1457 provides the state-of-the-art of IMT-2000 Radio Access technologies since it is periodically updated to reflect further evolutions of the technologies concerned. On the other hand, ITU-T has produced its Recommendations for the Core Networks: Q.1741.x series for GSM Evolved Core Network on per 3GPP Release basis (e.g. Rel-99, Rel-4, Rel-5 as specified in Q.1741.1, Q.1741.2, and Q.1741.3, respectively) and Q.1742.y for IS-41 based Evolved Core Network and its evolution based on the timeline defined by 3GPP2 (e.g. Q.1742.2 as "IMT-2000 References <approved as of 11 July 2002> to ANSI-41 evolved Core Network with cdma2000 Access Network").

In 3GPP, work on Release 6 is in progress.

3.2.1.1 IMT-2000 CDMA Direct Spread

ITU Name: IMT-2000 CDMA Direct Spread

Common Names: UTRA FDD
WCDMA
UMTS

IMT-2000 CDMA Direct Spread allocates different codes for different channels, whether for voice or data, and can adjust the amount of capacity, or code space, of each channel every 10 milliseconds. It creates high bandwidth traffic channels by reducing the amount of spreading (using a shorter code.) Packet data users can share the same codes and/or time slots as other users, or the network can assign to users dedicated channels and time slots. IMT-2000 CDMA Direct Spread is a spread-spectrum system based on direct sequence spread spectrum. It is spectrally efficient and its wideband nature provides the ability to translate the available spectrum into high data rates. This allows the flexibility to manage multiple traffic types, including voice, narrowband data, and wideband data. In IMT-2000 CDMA Direct Spread, data channels can support up to 2.4 Mbit/s of peak data throughput. Though exact throughput depends on what size channels the operator chooses to make available and the number of users active in the network, users can expect throughputs of up to 384 kbit/s.

HSDPA (High Speed Downlink Packet Access) is an enhancement to IMT-2000 CDMA Direct Spread that delivers peak data rates of about 10 Mbit/s. HSDPA is fully backwards compatible with IMT-2000 CDMA Direct Spread, and any application developed for the latter is planned to work with HSDPA. HSDPA is a feature of Release 5 of 3GPP specifications.

HSDPA achieves its high speeds through the addition of higher order modulation such as 16-QAM, variable error coding, and fast adaptation of the link to current radio conditions, adjusting modulation and coding as necessary. In addition, HSDPA uses an efficient scheduling mechanism to determine which user obtains resources. Finally, HSDPA shares its high-speed channels among users in the time domain.

3.2.1.2 IMT-2000 CDMA Multi-Carrier

ITU Name: IMT-2000 CDMA Multi-Carrier

Common Names: CDMA2000 1x and 3x
CDMA2000 1xEV-DO
CDMA2000 1xEV-DV

IMT-2000 CDMA Multi-Carrier is designed as a direct evolution of cdmaOne systems, with which it is backward compatible. It offers enhancements in voice capacity, speech quality and coverage, and is designed to provide high-speed packet data services. IMT-2000 CDMA Multi-Carrier operates in various frequency bands (450, 800, 900, 1 700, 1 800, 1 900 and 2 100 MHz).

IMT-2000 CDMA Multi-Carrier balances code assignments and power allocation to deliver voice and data services. The forward and reverse data channels of CDMA2000 can use either turbo or convolutional coding. For higher speeds, turbo coding provides an error correcting mechanism for data transmission that improves system performance and capacity. The packet data channels of CDMA2000 1X provide data rates up to 628 kbit/s. Other new features of IMT-2000 CDMA Multi-Carrier include the Quick Paging Channel Operation, variable transmission rates, and a channel structure that supports multiple services with various QoS. With the inclusion of Selectable Mode Vocoders (SMV) and antenna diversity techniques, CDMA2000 1X can provide a voice capacity of nearly three times that of cdmaOne systems[21].

[21] "Evolution of wireless data services: IS-95 to cdma2000". Knisely, D.N.; Kumar, S.; Laha, S.; Nanda, S. Communications Magazine, IEEE, Volume: 36 Issue: 10, Oct. 1998, Page(s): 140-149.

In case a network evolution is required based on demand for high data services, CDMA2000 1X and CDMA2000 1xEV-DO carriers can be deployed in any combination to provide a flexible mix of high-quality voice channels and high data rate services. For example, in 5 MHz of cleared spectrum, the operator can choose to launch two CDMA2000 1X carriers for voice and packet data, and one single CDMA2000 1xEV-DO carrier dedicated exclusively to high-speed packet data (up to 3.1 Mbit/s) or, alternatively, one single CDMA2000 1X and two CDMA2000 1xEV-DO carriers.

The CDMA2000 1xEV-DO option, primarily optimized for data services, is designed to interoperate with CDMA2000 1X networks. CDMA2000 1xEV-DO provides peak data rates of up to 3.1 Mbit/s in the forward link and 1.8 Mbit/s in the reverse link in a 1.25 MHz bandwidth. The high data capacity of 1xEV-DO is due to incorporation of higher order modulation schemes such as 16-QAM, dynamic link adaptation, adaptive modulation, incremental redundancy, multi-user diversity, receive diversity, turbo coding and other channel-controlling mechanisms[22].

CDMA2000 1xEV-DO incorporates a time division multiplexed (TDM) adaptive variable rate forward link that maximizes user data rates and sector throughput by allocating entire BTS power to one user at a time. Highly efficient implementation of channel sensitive scheduling and effective multi-user diversity achieves highest data rates at a given time. Also, Hybrid-ARQ schemes implementing incremental redundancy help deliver optimum efficiency which could otherwise be lost due to high mobility and variability of interference caused by varying traffic conditions.CDMA2000 1xEV-DV is an enhancement to IMT-2000 CDMA Multi-Carrier that combines the features of CDMA2000 1X and CDMA2000 1xEV-DO systems. Thus, it can provide either the voice capacity of CDMA2000 1X or the data capacity of CDMA2000 1xEV-DO, or provide a mix of voice and data capacity in one single carrier of 1.25 MHz.

3.2.1.3 IMT-2000 CDMA TDD (time-code)

ITU Name: IMT-2000 CDMA TDD

Common Names: UTRA TDD 3.84 mcps high chip rate

UTRA TDD 1.28 mcps low chip rate

(TD-SCDMA)

UMTS

In IMT-2000 CDMA-TDD, both uplink and downlink transmissions use the same carrier within the same frequency band. It combines CDMA with TDMA techniques to separate the various communication channels. Hence, a given radio resource element is characterized by both timeslot and CDMA code. Timeslots can be assigned to carry either downlink or uplink channels. In this way, the TDD technology can operate within an unpaired band; i.e. no duplex frequency band is necessary. Due to the TDMA structure and the joint detection algorithm, which significantly reduces the interference from the other CDMA signals present in the time slot, the system behaves more like a TDMA system. So, it neither suffers from cell breathing and from the necessity to maintain the operating margin to compensate for the uncertainty, nor requires a Soft Handoff capability. This is of particular value for hot spot scenarios implying heavy data load and for smallest cell sizes for indoor (pico environment) and outdoor (micro environment) solutions. Moreover, since timeslots for uplink and downlink can be assigned separately, IMT-2000 CDMA-TDD is particularly suited for asymmetric traffic. In the TDD mode the degree of asymmetry can be reassigned rapidly improving overall operating efficiency.

[22] CDMA/HDR: a bandwidth efficient high speed wireless data service for nomadic users. Bender, P.; Black, P.; Grob, M.; Padovani, R.; Sindhushyana, N.; Viterbi, S. Communications Magazine, IEEE, Volume: 38 Issue: 7, July 2000. Page(s): 70-77.

UTRA TDD (3.84 Mbit/s option) with a chip rate of 3.84 Mbit/s in a 5 MHz bandwidth channel, that is the same as the harmonized UTRA FDD radio signal, is cost-efficient for deployment as it can leverage the infrastructure of an FDD-only roll-out to offer scalable capacity for "hotspots" where combined voice and data traffic will be supported through a multi-tier architecture of macro, micro and pico cells. The minimum spectrum requirement is only half the bandwidth of WCDMA operating in the FDD mode, i.e. only one 5 MHz channel is needed when the TDD chip rate is operating at 3.84 Mbit/s.

TD-SCDMA is the Low Chip Rate version of IMT-2000 CDMA TDD, being therefore a radio transmission technology for IMT-2000 communication. TD-SCDMA combines two technologies – an advanced TDMA system with an adaptive CDMA component. TD-SCDMA is also called 1.28 Mbit/s TDD or LCR (low chip rate) TDD and uses a 1.6 MHz single band for each carrier. TD-SCDMA is designed to operate in TDD duplex mode with 5ms period for downlink and uplink transmissions. Within one period, the frame is divided into 7 traffic time slots, which can be flexibly assigned to either several users or to a single user who may require multiple time slots. TDD principles permit traffic to be uplink (from the mobile terminal to the base station) and downlink (from the base station to the mobile terminal) using the same frame and different time slots. The TD-SCDMA technology manages both symmetric circuit switched services, such as speech or video, as well as asymmetric packet switched services, such as mobile Internet data flows. For asymmetric services used with Internet access, a typical example shows that high data volumes are transmitted from the base station to the terminal, and more time slots are used for the downlink than the uplink. TD-SCDMA makes it possible to allocate the time slots according to the changes of the service module. TD-SCDMA is designed for high data rate data services – up to 2 Mbit/s. TD-SCDMA is able to use available frequency bands and has no need for paired bands, that means uplink and downlink transmissions use the same carrier with different time slot. With technologies such as Smart Antenna, Joint Detection, Uplink Synchronization and Baton Handover,., TD-SCDMA system can provide a low cost solution for implementation, operation and transition, with high system capacity and high efficiency of fragmented frequency resources. In addition TD-SCDMA can be implemented to support various radio scenarios: rural and dense urban areas coverage, pico/micro and macro cell deployments, and pedestrian to high speed moving environment. TD-SCDMA system is suitable to support high-speed circuit switched and packet switched data, as well as high voice quality

3.2.1.4 IMT-2000 TDMA Single-Carrier

IMT-2000 TDMA Single-Carrier

Common Names: UWC-136
EDGE
GERAN

Enhanced Data rates for Global Evolution (EDGE) was developed to enable TDMA, GSM, and GPRS operators to provide next-generation services. EDGE uses the same radio channels and time slots as GSM and GPRS, so it does not require additional spectral resources. EDGE provides a cost-effective solution for these operators to upgrade to IMT-2000, and enables significantly higher data rates and improved efficiency. It does so by enhancing the radio interface while re-using all the other network elements, including BSC, SGSN (Serving GPRS Support Node), GGSN (Gateway GPRS Support Node), and HLR. In fact, with newer GSM/GPRS deployments, EDGE[23] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. The same enhanced GPRS packet infrastructure supports both GPRS and EDGE, thus EDGE is fully backwards compatible with GPRS and any application developed for GPRS will work with EDGE. Once operators have deployed EDGE, they can enhance its applications capabilities by deploying the IP Multimedia Subsystem in their core networks, which will also support an IMT-2000 CDMA Direct Spread radio access network since both use a GSM (Evolved) UMTS core network.

[23] Assumes EDGE release 99.

Compared to GPRS, EDGE increases data rates by a factor of three and doubles data capacity. Though EDGE can theoretically provide 59.2 kbit/s in each of eight time slots, adding up to a peak network rate of 473.6 kbit/s in eight time slots, actual user data rates are typically in the 130 to 192 kbit/s (RLC payload) range with four time-slot devices. By sending more data in each time slot, EDGE also increases spectral efficiency by 150% relative to GPRS that uses coding schemes 1 and 2, and by 100% relative to GPRS that uses coding schemes 1 through 4.

3.2.1.5 IMT-2000 FDMA/TDMA (frequency-time)

ITU Name: IMT-2000 FDMA/TDMA

Common Names: DECT

The IMT-2000 radio interface specifications for FDMA/TDMA technology are defined by a set of ETSI standards. This radio interface is called Digital Enhanced Cordless Telecommunications (DECT). The individual layers are defined in different parts of the common interface (CI) standard. The standard specifies a TDMA radio interface with time-division duplex (TDD). The radio frequency bit rates for the specified modulation schemes are 1.152 Mbit/s, 2.304 Mbit/s and 3.456 Mbit/s. The standard supports symmetric and asymmetric connections, connection oriented and connection less data transport as well as variable bit rates up to 2.88 Mbit/s per carrier. The network layer contains the protocols for call control, supplementary services, connection oriented message service, connectionless message service and mobility management, including the security and confidentiality services.

In addition to the CI standard, access profile standards define minimum requirements for accessing specific networks and the interworking to these networks. For example, the Generic Access Profile (GAP) standard defines the requirements when using the speech service and the DECT Packet Radio Service (DPRS) standard defines the requirements for packet data transport.

A high level description of features and how the relevant ETSI standards interrelate to the different applications can be found in the ETSI Technical Report TR 101 178 "A high level guide to the DECT standardization".

This radio interface is a general radio access technology for wireless telecommunications. It is a high capacity digital technology, for wide cell radii ranging from a few meters to several kilometers, depending on application and environment. It provides telephony quality voice services, and a broad range of data services, including Integrated Services Digital Network (ISDN) and packet data. It can be effectively implemented in a range from simple residential cordless telephones up to large systems providing a wide range of telecommunications services, including Fixed Wireless Access.

This technology provides a comprehensive set of protocols, which provide the flexibility to interwork between numerous different applications and networks. Thus a local and/or public network is not part of the DECT specification.

3.2.2 Functional and service enhancements for users

Basic mobile telecommunications services – namely voice and text messaging – have proved to be a massive success for pre-IMT-2000 systems. While some initial steps have already been made into other areas such as mobile Internet Access, Enhanced Messaging Services and i-mode™, there are vast new opportunities that are now just starting to be exploited.

In particular, for the customer, ease of use and interoperability will continue to be of paramount importance. It is important to recognize that users are not interested in the IMT-2000 technology per se but the services and applications available to them. Different types of users have different needs and therefore it is important to consider the service platforms that will allow operators to differentiate their service offerings and allow smooth introduction of new services.

3.2.2.1 Services for users

According to a study commissioned by the UMTS Forum on the social shaping of IMT-2000[24], the handset has become an essential part of a process of intensifying personal social relations and users have a greater emotional relationship with their mobile phone than they do with any other device. An interesting result is that the small size, easy operation and personal nature of the mobile handset are essential ingredients of this, implying that it will remain the preferred form factor for IMT-2000 customers rather than a PDA or laptop. In turn, it means that IMT-2000 services must fit into this scenario in order to be successful.

Indications that such services can be successful are already emerging. Examples include pre-IMT-2000 i-mode information services that have proved enormously popular in Japan and are now being extended to Europe and the US. Graphic rich information is provided in a format that fits the screen and form factor of small mobile phones, while color displays and camera phones are promoting the spread of new applications.

Photo messaging, as part of a suite of Multimedia Messaging Services (MMS), which will also include e-postcards, audio clips, logos and text, will undoubtedly hit the mass market, and video clip messaging will evolve from transmission of still pictures. Information services to suit the consumer will include timetables, location information, local guides, news reports, movie, theatre guides, sports results (including video clips), music download, games download and multimedia broadcast. M-commerce will include payment and purchase, but mainly those items that are suited to the mobile form factor or immediate purchase rather than those that would require extensive browsing or complex transactions.

The social attractiveness using many IMT-2000 services will be greatly enhanced with the introduction of IP Multimedia Call Control. It gives the customer much better control and ease of use as well as opening the possibility for new telecommunications services.

3.2.2.2 Services for business

The mobile phone is a vital tool for business contact, and in many respects business customers use their handsets in a very similar way to users.

IMT-2000 allows handsets as well as larger-screen devices to have greater flexibility and capacity to access vital business data and applications. In addition, technologies such as Bluetooth may provide a link between handsets and other devices, increasing the flexibility of such devices for business use. While it is impossible to predict the future with absolute certainty, it is reasonably safe to assume that the wireless data capabilities of handsets, as well as PDAs and laptops, will continue to evolve, thereby influencing how each type of device is utilized by business users. As the devices and their applications evolve, business users will determine the optimal combination of devices to meet their specific needs.

3.2.2.3 Services in developing countries

It must not be forgotten that in many parts of the world the mobile phone is used as a substitute for fixed phones. This has arisen because of the relative ease, low cost and speed of deploying wireless access, compared with fixed copper or fiber. There are already hundreds of millions of subscribers who access basic telephony services in this way – a number that may soon increase to billions. In parallel with other more economically developed regions, mobile services for personal and business use will also evolve in these emerging markets. Adequate infrastructure is thus needed here in order to provide substitution for fixed access to the Internet. In developing regions, by being able to provide access to the Internet and the World Wide Web for the first time, IMT-2000 can play a major role in improving commercial opportunities for the people, health care and education.

3.2.3 Functional and service enhancements for operators

In order to support the introduction of new services, the underlying technology needs to evolve. There are no hard and fast rules – some new capabilities and services can be added to the existing network equipment through software upgrades.

[24] For further details see UMTS Forum Report number 26 at www.UMTS-Forum.org

Provision of a service depends on the bit rate needed for the service and the capacity of the network as well as any underlying technology to deliver the service. Many services can be introduced early on using existing technology, but then need the increased capability in order to be able to deliver it to the mass market. So, for example, Picture Messaging or Multimedia Messaging has already been introduced on various networks. However, as the mass market adopts these services there is likely to be demand for additional spectrum to meet capacity needs. On the other hand, some IMT-2000 services such as Video Telephony will need the bandwidth, capacity and spectrum of IMT-2000 from the outset to be viable. Some examples of such enhancements are described below. Additional details can be found in Annex F.

3.2.3.1 Pre-IMT-2000 service enhancements

A number of enhancements scenarios have already taken place within the context of pre-IMT2000 systems.

For example, ANSI-95A[25] systems, originally introduced in 1995, provided circuit switched data at 9.6 kbit/s in addition to voice services that were more advanced that existing first-generation systems. With the advent of ANSI-95 B systems in 1998, operators were then able to provide circuit switched data at 64 kbit/s. Though the ANSI-95 A/B systems (collectively known as cdmaOne systems) provided voice and data services, they were limited to low bit rate applications. CDMA2000 systems that are developed based on the requirements of the IMT-2000 mandate are a direct evolution of the ANSI-95 A/B networks[26].

Another example is provided by TDMA and GSM networks, deployed by operators in several countries in a combined fashion.. To maximize the efficiency and streamline the operation of these combined systems, TDMA/GSM operators and vendors have undertaken several major efforts to harmonize the TDMA and GSM radio access networks. Namely:

A data-only common packet based network enhancement for the two networks, GPRS, has been developed and deployed in at least one administration. In addition, interoperability between the circuit switched core networks (ANSI-41 and GSM-MAP) was developed. This effort, known as the GSM ANSI-41 Interworking Team (GAIT), has resulted in the introduction of new multi-mode TDMA/GSM/AMPS, multi-band GAIT phones.

Harmonization was also achieved in the area of voice/channel coding. A new concept of dynamically optimizing the voice/channel coding depending on radio conditions, known as Adaptive Multi-Rate (AMR) coding, has been developed that utilizes a suite of speech and channel coding schemes that maintain acceptable voice quality in poor radio environments and offer capacity gains in nominal radio environments.

As a result of these technology and harmonization/interoperability efforts, the economics of continued network build out and evolution have improved significantly. At the same time, competitive pressures to introduce enhanced voice and data services and global economies of scale have combined to make it more attractive to deploy GSM/GPRS, rather than to continue to build out using the 136+ radio and the ANSI-41 network. For the benefit of existing TDMA subscribers and because there are important potential roaming revenues from hundreds of millions of international GSM subscribers, some TDMA operators are deploying GSM/GPRS in their existing spectrum.

To support the migration to IMT-2000 of subscribers being served by GSM for voice services, a Data Voice (DV) version of the existing IMT-2000 TDMA Single-Carrier EDGE radio interface has been developed, and has been proposed as part of Revision 4 of ITU-R M.1457. As a result of the extensive harmonization already accomplished between TDMA and GSM systems, it is a relatively minor change to add a new logical channel to support additional signaling messages. Most notably, the EDGE radio interface is the same whether used within a GSM or ANSI-136 TDMA radio access network, which allows roaming between GSM and TDMA operators for EDGE data only services (EDGE-DO). It should be noted that GSM-MAP network signaling, which supports mobility management for the EDGE-DO subscribers, is already part of IMT-2000 TDMA Single-Carrier.

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[25] At the time of their introduction, these systems were known as IS-95A systems.

[26] "Evolution of wireless data services: IS-95 to cdma2000". Knisely, D.N.; Kumar, S.; Laha, S.; Nanda, S.; Communications Magazine, IEEE, Volume: 36 Issue: 10, Oct. 1998. Page(s): 140-149.

With the inclusion of this latest update into IMT-2000 TDMA Single-Carrier, operators will be able to offer common EDGE services to both their TDMA and GSM/GPRS customers. This will provide significant operational synergies that will allow greater efficiencies and simpler management of overall system resources. Such benefits are realizable by any TDMA operator considering IMT-2000 TDMA Single-Carrier as its evolution path.

3.2.3.2 IMT-2000 service enhancements

In addition to the enhancements to pre-IMT-2000 networks, it is expected that IMT-2000 standards, technologies and services will also further evolve. Following are several examples of such enhancements that are now being developed.

Further evolution of UMTS is already being considered. The UMTS radio access technology will be enhanced to support High Speed Downlink and Uplink Packet Access, enabling transmission at speeds of up to 14.2 Mbit/s. In the same way that EDGE increases spectral efficiency compared to GPRS, HSDPA increases spectral efficiency compared to IMT-2000 CDMA Direct Spread. The higher spectral efficiency and higher speeds not only enable new classes of applications, but also support a greater number of users accessing the network, with HSDPA providing over twice the capacity.

There will be other complementary technologies in order to provide really high data rates and very high user densities, such as would be found in conference centers, including Wireless Local Area Networks (W-LAN), which can complement UMTS in future, offering theoretical bit-rates up to 54 Mbit/s. Although public WLAN networks will also be deployed independently from the mobile networks, there are built-in advantages for the mobile operators that come from the ability to provide mobility management, subscriber management, high security and roaming.

Another enhancement is the IP Multimedia Subsystem (IMS). It enables real-time, person-to-person services, such as voice or video telephony, to be provided by means of packet switched technology in common with information and data services, by using IP multimedia Call Control. It allows the integration and interaction of telecommunications and information services as well as enabling telecommunications sessions to be established simultaneously between multiple users and devices.

Further evolutions of CDMA2000 are also considered. For example, with the inclusion of new Selectable Mode Vocoders (SMV) and antenna diversity techniques, CDMA2000 1X can provide a voice capacity nearly three times that of the IS-95 Systems[27].

CDMA2000 1xEV-DO is an enhancement to CDMA2000 that is primarily optimized for data services and enables data transmission at higher speeds. The CDMA2000 1xEV-DO air interface is designed to provide complete interoperability with CDMA2000 1X networks and provides peak data rates of up to 3.1 Mbit/s in the forward link and 1.8 Mbit/s in the reverse link in a frequency carrier bandwidth of 1.25 MHz. CDMA2000 1xEV-DO allows operators an economical option to deliver the wide range of IMT-2000 data services at affordable costs. The 1xEV-DO systems that are already commercially deployed[28] implement many advanced features of wireless telecommunication system design. CDMA2000 1xEV-DO incorporates a time division multiplexed (TDM) adaptive variable rate forward link that maximizes user data rates and sector throughput by allocating entire BTS power to one user at a time. Highly efficient implementation of channel sensitive scheduling and effective multi-user diversity achieves highest data rates at a given time. Also, Hybrid-ARQ schemes implementing incremental redundancy help deliver optimum efficiency, which could otherwise be lost due to high mobility and variability of interference caused by varying traffic conditions

CDMA2000 1xEV-DV is an enhancement to the IMT-2000 CDMA Multi-Carrier systems that combines the features of CDMA2000 1X and CDMA2000 1xEV-DO systems. Thus, it provides an option to provide either the higher voice capacity of CDMA2000 1X systems or the higher data capacity of CDMA2000 1xEV-DO systems or even provide a balanced mix of high capacity voice and data in one single carrier of 1.25 MHz.

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27 "SMV Capacity Increases", Andy Dejaco, Qualcomm Inc., CDG-C11-2000-1016010, October 16, 2000.

28 As of May 1st, 2003, these include operators in 3 continents such as: SK Telecom (S. Korea), KTF (S. Korea), Monet Mobile (USA), Giro (Brazil). Source: www.3gtoday.com

3.3 Transition from analogue (1G) systems (AMPS, NMT, TACS)

Currently, only 1.5% of the world's cellular subscribers (less than 20 million) are on analogue systems. Most of these utilize AMPS 800 MHz service in the Americas (approximately 18 million) with TACS and NMT accounting for just over one million each.[29] Few of the analogue NMT-450 systems are still in operation in the 450 MHz band in 24 countries. Most of them are in Eastern Europe and in particular in Russia (60 operators out of 82 operators). NMT900 and TACS systems are less prevalent, used only in a few countries.

Operators of analogue systems are able to migrate their systems to IMT-2000 either directly, or by first migrating to a digital pre-IMT-2000 technology and then to IMT-2000.

3.3.1 Transition to IMT-2000 CDMA Direct Spread

Where spectrum and resources are available, AMPS operators may migrate users and/or services directly to IMT-2000 CDMA Direct Spread.

For operators of AMPS systems preferring evolution, a natural path is the evolution to TDMA, then on to IMT-2000 since the AMPS and TDMA air interface both use 30 kHz RF channels which enable channel by channel changeover from AMPS to TDMA. Additionally, TDMA (ANSI-136) supports combinations of analogue and digital control channels and traffic channels easing the transition path.

Core Network evolution is possible because both AMPS and TDMA can be operated on ANSI-41 Core Networks.

Once the transition from AMPS to TDMA has been accomplished, then a strategy of GSM/GPRS overlay can be undertaken which provides a common packet data service for both TDMA and GSM subscribers, as many TDMA operators have already embraced, leading to the deployment of GSM MAP and setting the stage for transition to IMT-2000 CDMA Direct Spread. This path allows analogue operators to take advantage of the experience of many TDMA operators in their transition to IMT-2000 TDMA-SC and IMT-2000 CDMA Direct Spread. This strategy enables an existing analogue operator to undertake an orderly transition path using technologies such as GAIT, which allows roaming between GSM and TDMA networks, thus enabling transition in smaller incremental steps as resources are available.

All the NMT900 systems, the TACS systems and some of the NMT450 systems in Western Europe have already undertaken the transition to GSM. The transition from NMT required a new GSM-MAP core network, although the GSM-MAP Core Network is conceptually based on the NMT-Core Network architecture.

3.3.2 Transition to IMT-2000 CDMA Multi-Carrier

AMPS systems are based on ANSI-41 core network protocols, which are also the basis of IMT-2000 CDMA Multi-Carrier core networks. This facilitates smooth and easy transition for AMPS systems to IMT-2000 Multi-Carrier since most of the core network elements are reusable, resulting in lower deployment costs. In order to overlay IMT-2000 CDMA Multi-Carrier equipment on these analogue systems, operators need to add new base stations, base station controllers, and a packet data support node, and make software upgrades at the mobile switching center. Figure 3.3.2.1 shows the new components required for the transition from AMPS to CDMA2000. All CDMA handsets support AMPS and hence clearing the spectrum to add CDMA2000 RF carriers is practically seamless to subscribers.

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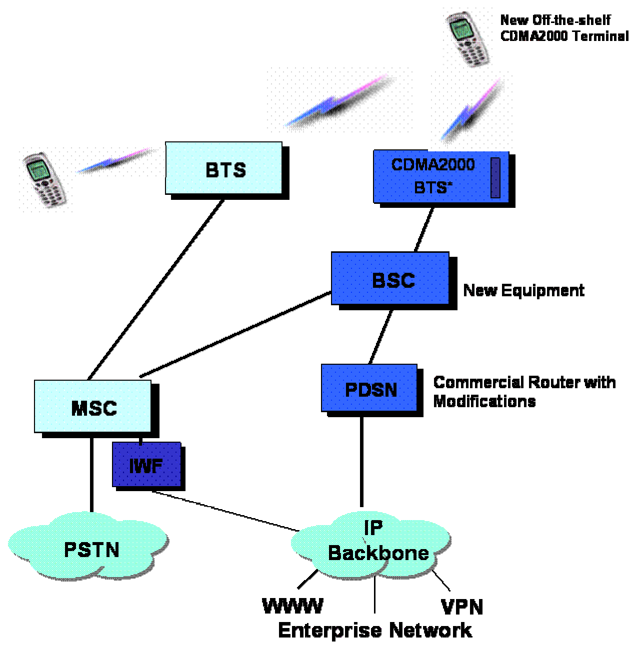
[29] EMC World Cellular Database, November 2003.

Figure 3.3.2: Migration path from AMPS to IMT-2000 CDMA Multi Carrier



Though NMT systems do not use the ANSI-41 core network protocol, several NMT operators have found it easy to make the transition to CDMA2000 within their NMT spectrum band, which is one of the IMT-2000 CDMA Multi-Carrier bands. A major advantage with an IMT-2000 CDMA Multi-Carrier radio base station operating in the NMT band is its extended coverage, which is better than the coverage of an analogue NMT-450 base station at the same frequency. Therefore an operator would need fewer base stations to provide the same coverage level. In addition, IMT-2000 CDMA Multi-Carrier base station transceivers (BTSs) may be co-located with analogue NMT BTSs, which will reduce network deployment costs significantly.

The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s in a single carrier of 1.25 MHz. Analogue pre-IMT-2000 operators have a choice to first make the transition to CDMA2000 1X and then choose to overlay CDMA2000 1x-EV-DO in multiple phases depending on network capacity evolution. The transition to CDMA2000 also offers analogue operators a transition path with flexibility to enable IMT-2000 services within their current spectrum, resulting in substantial cost savings as CDMA2000 systems can evolve using narrower 1.25 MHz channels, which facilitate deployment of three CDMA carriers in 5 MHz of bandwidth. CDMA networks are deployed with a frequency reuse of 1 instead of higher reuse factors such as 7/21 or 4/12 that are necessary for AMPS networks. This, in turn, will simplify network planning for the operator.

CDMA2000 also allows deployment of an IMT-2000 network in successive stages, depending on the frequency band available for an operator and the required network evolution based on demand for high-speed data services. In cases where there is a limited band available (i.e., generally about 2 X 5 MHz for NMT systems) the operator can deploy CDMA2000 services successively; that is, two CDMA2000 1X carriers for voice and packet data, or one CDMA2000 1X carrier for voice and data, and one single CDMA2000 1xEV-DO carrier dedicated exclusively to high-speed packet data (up to 3.1 Mbit/s). CDMA also enables easy coexistence of CDMA2000 carriers and NMT carriers with sufficient guardbands. This allows for smooth transition to IMT-2000 Multi-Carrier while providing enough flexibility to operate with existing carriers without any interference to either carrier during transition. The operator has an option to make the transition to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of high voice and data capacity in a single carrier.

With CDMA2000 1X deployments, analogue operators can increase the sector voice capacity 31-45 times[30] depending on the type of SMV[31]. Receiver diversity can further enhance these capacities to 59 times[32] when SMV1 is used. They can start offering data-rich applications supported by CDMA2000 systems such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to current CDMA2000 networks and handsets, thus enabling video conferencing with high-quality voice. Transition to CDMA2000 provides analogue operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.3.3 Transition to IMT-2000 TDMA Single-Carrier

For operators of AMPS systems wishing to deploy TDMA Single-Carrier, a natural path begins with the transition to TDMA, since the AMPS and TDMA air interface both use 30 kHz RF channels which enable channel by channel changeover from AMPS to TDMA. Additionally, TDMA (ANSI-136) supports combinations of analogue and digital control channels and traffic channels easing the transition path. TDMA digital traffic channels can be assigned from analogue control channels and analog voice channels can be assigned from digital control channels. Since AMPS and TDMA share the same 30 kHz RF channel, then a TRX by TRX replacement can be undertaken utilizing the same base stations.

Core Network evolution is possible since both AMPS and TDMA are operated on ANSI-41 Core Networks.

Once TDMA is deployed then a packet-based network component can be added using GPRS with the addition of 200 kHz radio channels. The same GPRS packet backbone can then be used for the evolution to IMT-2000 TDMA Single-Carrier. Optionally, a GSM overlay can be added to the TDMA system allowing GSM/GPRS/EDGE operation immediately in the same or different frequency bands insuring a smooth transition, and improving roaming opportunities for users.

3.4 Transition from TDMA/D-AMPS Systems

TDMA ANSI-136 is one of the dominant pre-IMT-2000 standards deployed throughout the Americas, and TDMA operators have various options for transition to IMT-2000, including the transition to UWC-136/IMT-2000 TDMA Single Carrier, IMT-2000 CDMA Multi-Carrier, or IMT-2000 CDMA Direct Spread.

3.4.1 Transition to IMT-2000 CDMA Direct Spread

Many of the major TDMA operators are deploying overlay GSM/GPRS/EDGE radio access and core networks. The GSM-based migration/transition[33] path offers TDMA operators the opportunity to deploy the combination of GPRS, EDGE and IMT-2000 CDMA Direct Spread that best meets their needs[34] thus facilitating simplified migration/transition to IMT-2000 CDMA Direct Spread as a future option, if not selected as an initial choice.

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30 "SMV Capacity Increases", Andy Dejaco, Qualcomm Inc., CDG-C11-2000-1016010, October 16, 2000.

31 The SMV algorithm selected by TIA and 3GPP2 for CDMA applications. Yang Gao; Shlomot, E.; Benyassine, A.; Thyssen, J.; Huan-yu Su; Murgia, C. Acoustics, Speech, and Signal Processing, 2001. Proceedings. (ICASSP '01). 2001 IEEE International Conference, Volume: 2, 7-11 May 2001. Page(s): 709-712 vol. 2.

32 "Future Capacity Improvements in CDMA Cellular Systems", Roberto Padovani, IEEE Proceedings, August 2001.

33 The expression "migration/transition" is used to indicate a change obtained through both evolution and migration.

34 For more technical information on these technologies, seePeter Rysavy, "Data Capabilities for GSM Evolution to UMTS," November 19, 2002, available at
http://www.3gamericas.org/English/technology_center/whitepapers/index.cfm
Much of the material in this section is taken from this paper.

This migration/transition to IMT-2000 CDMA Direct Spread from a GSM overlaid TDMA system involves a new radio access network, but several factors will ease deployment. First is that most IMT-2000 CDMA Direct Spread cell sites can be co-located in GSM cell sites. Second is that much of the GSM/GPRS core network can be used. While the SGSN needs to be upgraded, the mobile switching center needs only a simple upgrade and the GGSN stays the same.

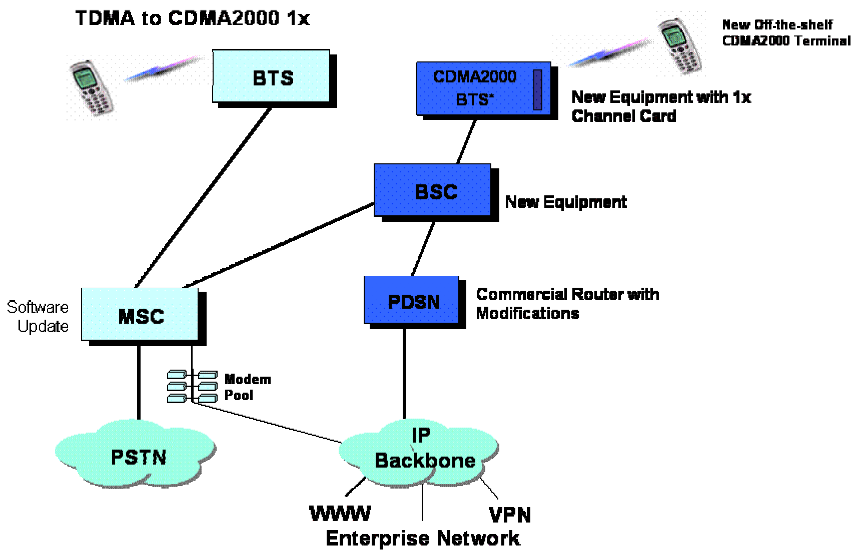
Another solution for TDMA is the migration/transition directly to IMT-2000 services via IMT-2000 CDMA Direct Spread and HSDPA. In this case an IMT-2000 CDMA Direct Spread overlay would be deployed analogous to the GSM overlay described above.

3.4.2 Transition to IMT-2000 CDMA Multi-Carrier

Operators of digital pre-IMT-2000 TDMA (ANSI-136, ANSI-54) systems have a smooth and easy migration/transition path to IMT-2000 Multi-Carrier. The digital TDMA systems are based on the ANSI-41 protocol, which is a common core network used by the CDMA2000 family that forms IMT-2000 CDMA Multi-Carrier. The common core network can be leveraged through a migration/transition to IMT-2000 CDMA Multi-Carrier which only requires operators to add CDMA2000 base stations, base station controllers (BSC), upgrade software at the mobile switching center (MSC), and add a packet data support node. In addition, IMT-2000 CDMA Multi-Carrier base station transceivers (BTSs) can be co-located with TDMA BTSs, which will reduce network deployment costs significantly. Figure 3.4.2.1 shows the new components required to make the migration/transition from TDMA to CDMA2000. CDMA2000 migration/transition also offers TDMA operators a wide selection of low-cost handsets, and mature technology with low infrastructure costs. Operators also gain from ease of network engineering as CDMA networks are deployed with a frequency reuse of 1 instead of higher reuse factors such as 7/21 or 4/12 that are necessary for TDMA networks. Also, CDMA handsets enable end users to roam from a partially built CDMA2000 1X network to the AMPS side of a TDMA-AMPS network. This in turn will simplify network planning for the operator.

The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s. TDMA operators can first make the transition to CDMA2000 1X and then choose to overlay CDMA2000 1xEV-DO in multiple phases depending on network capacity evolution. For the operators, this transition also offers the flexibility of enabling IMT-2000 services within their current spectrum resulting in substantial cost savings as these systems can evolve with narrower 1.25 MHz channels, which facilitate deployment of three CDMA carriers in a 5 MHz bandwidth.

Figure 3.4.2: Transition path from TDMA to IMT-2000 CDMA Multi Carrier



Transition to CDMA2000 also offers the choice of phased evolution, in which spectrum is cleared for migration/transition to CDMA2000 in multiple stages. This allows the operators to expand their IMT-2000 networks in successive stages, depending on the frequency band available for an operator and the required network evolution based on demand for high-speed data services. During the transition, CDMA carriers can easily coexist with TDMA carriers, providing a smooth migration/transition path. CDMA and TDMA have already coexisted for the past 8 years and many techniques have been developed to minimize the impact.

In case a network evolution is required based on demand for high data services, CDMA2000 1X and CDMA2000 1xEV-DO carriers can be deployed in any combination to provide a flexible mix of high-quality voice channels and high data rate services. Additional CDMA carriers can be added as the demand grows. This allows for smooth migration/transition to IMT-2000 Multi-Carrier while providing enough flexibility to operate with existing carriers without any interference to either carrier during transition. The operator has an option to make the transition to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of high voice and data capacity in a single carrier.

Through this migration/transition, TDMA operators can increase voice capacity manifold and start offering data-rich applications supported by CDMA2000 systems such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to current CDMA2000 1X networks and handsets, which enable video conferencing with high-quality voice. CDMA2000 migration/transition allows TDMA operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.4.3 Transition to IMT-2000 TDMA Single-Carrier

The TDMA community (as represented by 3G Americas and GSMNA) has decided to evolve to UWC-136/IMT-2000 TDMA Single Carrier. Many of the major operators are deploying overlay GSM/GPRS/EDGE radio access and core networks. The GSM-based transition path towards IMT-2000 TDMA Single-Carrier offers TDMA operators the opportunity to pick and deploy the combination of GPRS, EDGE and IMT-2000 CDMA Direct Spread and/or IMT-2000 CDMA TDD (time code) that best meets their needs[35] thus facilitating simplified migration/transition to the IMT-2000 CDMA Direct Spread and/or IMT-2000 CDMA TDD (time code) as a future options.

The transition from TDMA and GSM/overlaid TDMA systems to IMT-2000 TDMA Single Carrier incorporates constant enhancements in capability and efficiency. This progression can occur in multiple phases, first with the addition of GSM/GPRS, and then adding EDGE later; or can be accomplished by adding GSM/GPRS/EDGE in a single upgrade, as some carriers in North America have done. For further flexibility, an IMT-2000 CDMA Direct Spread radio access network can also be added later, followed by evolved capability enhancements such as HSDPA. For example, an operator might initially deploy GSM/GPRS/EDGE throughout its license area, but then implement IMT-2000 CDMA Direct Spread only in major cities, with customers handed to its EDGE or GPRS networks when they travel outside IMT-2000 CDMA Direct Spread coverage.

A TDMA operator is not required to shut down its network to begin the process of deploying GSM. TDMA operators who have chosen the GSM evolution path are deploying overlay networks that leverage existing cell-site facilities, networking transports, and central site resources. These operators have deployed GSM and GPRS simultaneously. Depending on its infrastructure vendor and the age of the equipment, it is possible for an operator to increase the capacity of the TDMA mobile switching centers (MSCs) enough to free up one or more MSCs, which then are upgraded with software to support GSM. In the radio network, the GSM base-station equipment often can share the TDMA antennas.

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[35] For more technical information on these technologies, see Peter Rysavy, “Data Capabilities for GSM Evolution to UMTS,” November 19, 2002, available at http://www.3gamericas.org/English/technology_center/whitepapers/index.cfm. Much of the material in this section is taken from this paper.

To deploy GPRS, a GSM operator adds a packet core infrastructure, which consists of two types of elements: GGSNs and serving GPRS support nodes (SGSNs). These elements are the foundation for future migration because they are re-used as the operator adds EDGE and IMT-2000 CDMA Direct Spread. At the cell site, the GSM base station equipment is upgraded with software and channel cards to support GPRS. In many GSM/GPRS networks, EDGE[36] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. Other operators might replace their equipment now to take advantage of new types of base stations that accommodate multiple combinations of GSM, GPRS, EDGE and IMT-2000 CDMA Direct Spread simultaneously, with the flexibility to devote more resources to a particular service as demand grows.

To provide additional high data rate applications beyond those supported by GPRS, operators can deploy Enhanced Data Rates for Global Evolution (EDGE). EDGE is part of the IMT-2000 TDMA Single Carrier radio interface, and further enhances this GSM/GPRS radio interface by adopting new modulation technology to achieve higher data rates using operators' existing radio spectrum. Standardization of the GERAN (GSM/EDGE Radio Access Network) within 3GPP includes advanced Quality of Service mechanisms, enabling EDGE to offer almost all 3G services although with limited data rate compared to IMT-2000 CDMA Direct Spread. As a further enhancement to EDGE, operators can deploy the IP Multimedia Subsystem in their core networks, which will also support an IMT-2000 CDMA Direct Spread radio access network. This gives operators the flexibility to deploy IMT-2000 CDMA Direct Spread as a complement to EDGE with service transparency. EDGE is one solution to provide IMT-2000 services in existing pre-IMT-2000 spectrum resources.

3.5 Transition from PDC

3.5.1 Transition to IMT-2000 CDMA Direct Spread

Most of Japanese mobile operators have been operating PDC (Personal Digital Cellular) system, which is Japanese standard using 800 MHz and 1.5GHz bands. The PDC standard is based on TDMA air-interface and Japan-specific core network for provisioning of voice and packet data service up to 28.8 kbit/s. Almost all the subscribers are using advanced terminals allowing a variety of mobile Internet services. 3G licenses were awarded to three operators in Japan, two of which, NTT DoCoMo and J-PHONE (Vodafone K.K. at present), selected IMT-2000 CDMA Direct Spread system and have already started the commercial service. Two independent networks of the PDC and IMT-2000 CDMA Direct Spread need to be deployed so that inter-working function was introduced.

On deployment of the IMT-2000 CDMA Direct Spread system, it was very difficult to build up independent cell-sites dedicated to the 3G systems, because operators already installed PDC antennas on many buildings for providing high quality services to huge number of subscribers (over 46 million as of 2000). Therefore, operators co-installed antennas for the 3G system onto the same sites with PDC, where a dual- or tri-band antenna and small-size base stations were developed for saving space and reducing weight.

3.5.2 Transition to IMT-2000 CDMA Multi-Carrier

Another PDC operator in Japan, KDDI, chose IMT-2000 CDMA Multi-Carrier system. Since PDC system and IMT-2000 CDMA Multi-Carrier system have different air-interfaces and core network protocols, transition from PDC to IMT-2000 CDMA Multi-Carrier took place in the way of intermediate system of 2.5G like cdmaOne (CDMA ANSI-95A/B). The PDC operator at first started new system in frequency bands different from or the same as those of the PDC, and then terminated transmission of carriers of the PDC service. The operator shared some of the equipments as base station shelter, power supply, antenna, RF equipment and etc for dual operation of two systems of the PDC and IMT-2000 CDMA Multi-Carrier. The transition process from cdmaOne to IMT-2000 CDMA Multi-Carrier is explained in section 3.6.1.

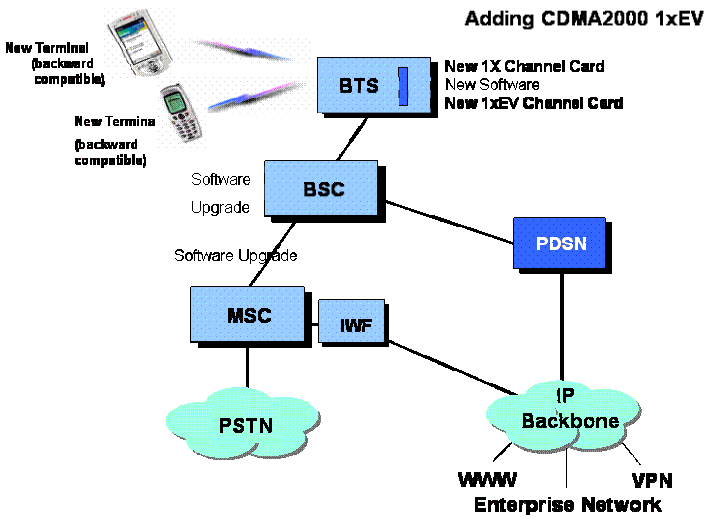
[36] Assumes EDGE release 99.

3.6 Transition from cdmaOne Systems

3.6.1 Transition to IMT-2000 CDMA Multi-Carrier

Operators of digital pre-IMT-2000 cdmaOne (CDMA ANSI-95A/B) systems can easily evolve to IMT-2000 CDMA Multi-Carrier directly. IMT-2000 CDMA Multi-Carrier was designed to be fully backward compatible with its predecessor, cdmaOne, so that the requirements of system evolution are simpler than that of other systems.

Figure 3.6.1: Evolution path from cdmaOne to IMT-2000 CDMA2000 Multi Carrier



The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s. Operators can overlay CDMA2000 1X, CDMA2000 1xEV-DO and CDMA2000 1xEV-DV in multiple phases depending on required network capacity evolution. Evolution to CDMA2000 offers cdmaOne operators the flexibility to enable IMT-2000 services within their current spectrum, resulting in substantial cost savings as these systems can evolve with narrower 1.25 MHz channels, which facilitates deployment of three CDMA carriers in 5 MHz of bandwidth. CDMA2000 enables a wide selection of handsets and infrastructure. Timely availability of advanced feature-rich multi-mode ASICs ensures continued support for low-cost mobile handsets and network infrastructure.

All air interface revisions of CDMA2000 provide full backward compatibility to cdmaOne. The CDMA2000 family of systems incorporates various innovations, such as selectable mode vocoders (SMV), quick paging channels, high-speed supplemental channels, reverse link power control and pilot gating, which enable these systems to deliver enhanced voice capacities and very high data rates while ensuring efficient sleep mode procedures that result in longer battery life for handsets. In order to overlay a CDMA2000 system onto a cdmaOne system, an operator needs to simply make software upgrades at the base station controller and the mobile switching center, add new channel cards and software at the base stations, and add a packet data support node. Figure 3.6.1 shows the evolution path for cdmaOne to CDMA2000.

Evolution from cdmaOne to CDMA2000 requires relatively small capital investment. The low POP cost, minimal spectrum requirements, and efficient and low-cost technology contributed to Moody’s favorable view of the upgrade path to IMT-2000 provided by CDMA technology. POP prices have decreased for cdmaOne carriers upgrading to CDMA2000 1X since 2001.

cdmaOne operators can nearly double the voice capacity of their network through evolution to CDMA2000 and provide high-quality speech using well proven selectable mode vocoders (SMV). Use of SMV at an average speech coding rate of 5.9 kbit/s and 4.5 kbit/s for mode 1 and mode 2, results in a voice capacity of 116 Erlangs and 133.9 Erlangs respectively in a bandwidth of 5 MHz[37]. In addition, dual antenna mobile receivers employing receiver diversity techniques, together with optimal diversity combining strategy, enhance the capacity gains further and improve the number of simultaneous voice connections supported as well as device battery life.

Overlaying CDMA2000 1xEV-DO provides an evolution path for very high data rates up to 3.1 Mbit/s supporting various multimedia messaging services (MMS), video gaming and other applications such as video conferencing. Evolution to CDMA2000 1xEV-DO provides a flexible framework for delivering QoS in data services through a wide range of data rates and packet types. The protocols are designed to provide seamless virtual handoffs in a service area for packet data services and also a seamless interoperation with the CDMA2000 1X air link. Provision of a quick paging channel improves stand by time significantly.

Further enhancements to CDMA2000 1xEV-DO include higher peak rates and data capacities both in forward and reverse link that provide a peak data rate of 3.1 Mbit/s on the forward link and 1.8 Mbit/s on the reverse link. Smooth rate transitions using finer rate quantization up to 1.8 Mbit/s is introduced in the reverse link with Hybrid-ARQ methods. These enhancements are expected to support even a wider range of physical layer packet types for smaller payloads to improve packing efficiencies as well as larger payloads to support higher data rates up to 3.1 Mbit/s. An additional equalizer in CDMA2000 1xEV-DO enhances faster Internet access and quicker downloads in low mobility environments, facilitating richer applications.

The CDMA2000 operator has an option to evolve to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of both high-quality voice as well as high-speed data sessions over a single carrier. CDMA2000 1xEV-DV mixes voice and data optimally thereby creating extra capacity to further enhance data rates. This is achieved by introducing a high rate packet data channel that uses dynamic modulation and coding based on channel conditions, fast and efficient retransmissions, and dynamic resource allocation mechanisms. CDMA2000 1xEV-DV is fully backward compatible with ANSI-95A/B and CDMA2000 1X. ANSI-95A/B or newer mobile stations can operate in a CDMA2000 1xEV-DV cell and CDMA2000 1xEV-DV capable mobiles can deliver data on older systems.

The family of CDMA2000 technologies thus provides for smooth evolution of cdmaOne systems to IMT-2000 Multi-Carrier ensuring higher voice capacity to support a greater number of end users and high packet data rates enabling richer and new classes of applications supporting the IMT-2000 service environment, such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to the current CDMA2000 1X networks and handsets that enable video conferencing with high-quality voice. CDMA2000 provides CDMA operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.7 Transition from GSM Systems

The GSM industry has charted an evolutionary path to IMT-2000 in a logical, structured and standardized way. This includes the possibility of making the transition to IMT-2000 through upgrades to GSM/GPRS/EDGE, or by introducing IMT-2000 CDMA Direct Spread, or by implementing both paths. This flexibility gives operators an exceptional set of alternative deployment strategies to precisely suit their situation with regard to their legacy networks, capacity needs, spectrum availability and speed of take-up of the new services in the market.

The original GSM system, designed to support basic voice and data services, consists of a circuit switched Core Network that provides the routing of calls to mobile subscribers, the Base Station Subsystem for radio access and the Mobile Station. One of the most important factors in GSM’s success is the Standard Open Interfaces that have enable any vendor to supply any elements of the network and for Operators worldwide, to deploy multi-vendor systems of their choice.

[37] “SMV Capacity Increases,” Andy Dejaco, Qualcomm Inc., CDG-C11-2000-1016010, October 16, 2000.

To improve the data capabilities of this original version of GSM, General Packet Radio Service (GPRS) can be added. This provides an “always on”, high-speed connection (up to 171 kbit/s) to packet data networks suited to the “bursty” traffic such as the Internet and World Wide Web, either directly or via Operators’ portals. With GPRS the core network is enhanced to embrace the packet switched domain, adding new IP-connected network elements. This extension of the core network lays the foundations of a common core network for both IMT-2000 TDMA Single Carrier and IMT-2000 CDMA Direct Spread.

3.7.1 Transition to IMT-2000 CDMA Direct Spread

GSM operators may choose to evolve their networks directly to IMT-2000 CDMA Direct Spread, as well as via EDGE. The pathway from GSM to IMT-2000 CDMA Direct Spread is clearly defined, starting with GPRS (and/or EDGE) and then on to CDMA Direct Spread. GPRS serves as a natural intermediate step, insofar as the Core Network is the same as is needed for CDMA Direct Spread. Operators with new spectrum for CDMA Direct Spread and who have an immediate need for additional capacity to deliver new services will most likely deploy WCDMA. The data rate performance of CDMA Direct Spread will be enhanced with High Speed Downlink Packet Access (HSDPA). They may also decide to upgrade their GSM/GPRS radio equipment with EDGE as a complementary technology in lower traffic areas.

For GSM operators who are the great majority of pre-IMT-2000-operators in developing countries, the best and most convenient, future proof path for them to IMT-2000 is the evolution to GERAN and the enhancement of the radio access by UTRAN. It has to be noted, that GERAN and UTRAN are aligned for service transparency. This allows seamless service provision, which is achieved by usage of the same Core Network, standardized Handover-procedures etc. The GSM to GERAN/UTRAN evolution includes the evolution of the MAP- and GPRS-Core Network.

IMT-2000 CDMA Direct Spread offers voice capacity advantages mainly through the benefits of interference averaging offered by its code division spread spectrum technology, combined with tight power control. One enhancement over GPRS is that the control channels that normally carry signaling data can also carry small amounts of packet data, which reduces setup time for data communications. CDMA Direct Spread will not necessarily replace GPRS or EDGE, but will in reality co-exist with them and may be built on one common core network.

GSM, due to its frequency hopping capability, can be considered as a spread-spectrum system based on Time Division Multiple Access (TDMA). IMT-2000 CDMA Direct Spread is a spread-spectrum system based on direct sequence spread spectrum. It is spectrally more efficient than GSM, and its wideband nature provides a further advantage — the ability to translate the available spectrum into high data rates. This results in flexibility to manage multiple traffic types, including voice, narrowband data, and wideband data. In IMT-2000 CDMA Direct Spread, data channels can support up to 2.4 Mbit/s of peak data throughput. Though exact throughput depends on what size channels size the operator chooses to make available and the number of users active in the network, users can expect throughputs of up to 384 kbit/s.

IMT-2000 CDMA Direct Spread introduces improved radio access technologies based on WCDMA, providing higher bit rates (up to 14.2 Mbit/s).

The benefits of these upgrades are summarized in Table 3.7.1.

Table 3.7.1: Benefits resulting from technology choices in the transition to IMT-2000 CDMA Direct Spread

Technology	Benefits
GSM/GPRS with coding schemes 1 to 2	IP packet data service delivers effective throughputs of up to 40 kbit/s for four-slot devices.
GSM/GPRS with coding schemes 1 to 4	Includes an option for operators to boost speeds of GPRS service by 33%.
GSM/GPRS/EDGE	Third-generation technology effectively triples GPRS data rates and doubles spectral efficiency.
IMT-2000 CDMA Direct Spread	Supports flexible, integrated voice/data services with peak rates of 2 Mbit/s.
HSDPA	An enhancement to IMT-2000 CDMA Direct Spread and fully backwards compatible. HSDPA will offer peak data rates of 10 Mbit/s.

3.7.2 Transition to IMT-2000 CDMA TDD (time-code)

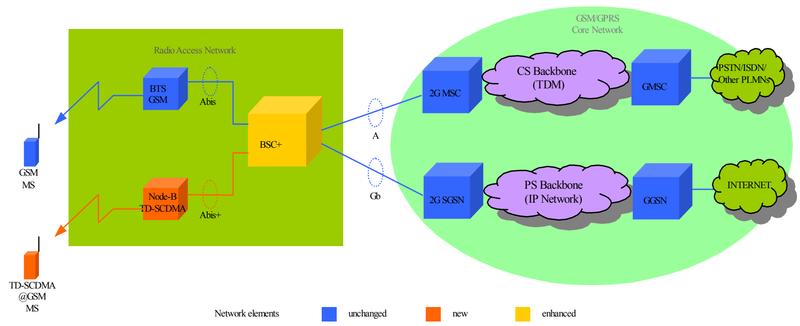
A possible transition path which re-uses an existing GSM network is via IMT-2000 CDMA TDD (time-code), i.e. TD-SCDMA. The process for this transition from GSM to TD-SCDMA can be divided into two gradually enhanced steps.

Step 1

TD-SCDMA provides a migration/transition alternative from the current existing GSM/GPRS network to IMT-2000 networks. A GSM/GPRS operator with large portions of TDD bands available (unpaired TDD bands) can introduce the TD-SCDMA Radio Access Network (RAN) while using the existing GSM/GPRS core network.

First the GSM/GPRS BSC is software upgraded to BSC+ to support TD-SCDMA radio subsystem. Then the new TD-SCDMA base stations (NodeBs) can be connected to the upgraded GSM/GPRS BSC to provide service based on GSM/GPRS network infrastructure. Correspondingly, the Abis interface is also upgraded to Abis+. No modification is needed for the existing A and Gb interfaces. This integration of an IMT-2000 air interface into existing and stable GSM/GPRS infrastructure results in a rapid availability of high system capacity without deployment of a completely new core network infrastructure.

Figure 3.7.2-1: Transition Step 1



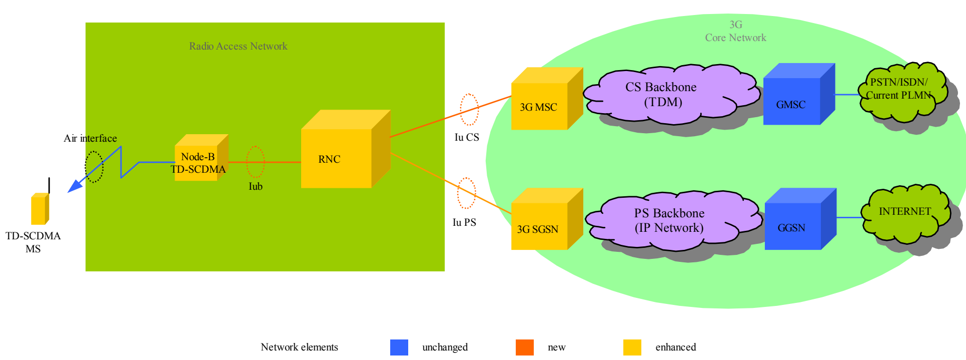
Step 2:

With the service development, IMT-2000 Core Networks are established and co-exist with the GSM/GPRS Core Networks. Then parts of TD-SCDMA equipments are upgraded to be able to connect with the IMT-2000 Core Networks.

The interface card of the Node B is upgraded to support Iub interface. The BSC+ is upgraded to RNC to support Iub and Iu interface, which consists of Iu CS, and Iu PS interfaces. The pre-IMT-2000 MSC is upgraded to IMT-2000 MSC to support Iu CS interface. The pre-IMT-2000 SGSN is upgraded to IMT-2000 SGSN to support Iu PS interface. For TD-SCDMA system, all the upgrading and migration paths related to Core Network is the same as WCDMA system.

After the upgrading, the system has made the transition to IMT-2000.

Figure 3.7.2-2: Transition Step 2



The benefits of these upgrades are summarized below:

Technology	Benefits
IMT-2000 CDMA TDD (time-code)	Enables reuse of the existing pre-IMT-2000 GSM /GPRS core network infrastructure. Enables implementation of IMT-2000 services in unpaired bands of minimum 1.6 MHz. Allows operators to plan a staged transition. Flexible, integrated voice/data services with peak rate of 2 Mbit/s supported.

3.7.3 Transition to IMT-2000 TDMA Single-Carrier

A straightforward way for GSM-operators to make the transition towards IMT-2000 is the evolution of the Radio Access Network from GSM to GERAN. GERAN deploys the EDGE radio interface and is therefore a Radio Access Network that belongs to the IMT-2000 radio technology of IMT-2000 TDMA Single Carrier. This is a smooth and fully backward compatible enhancement of the GSM radio access without any need of a change of the frequency spectrum. To go this evolution path, the operator will add GPRS and EDGE functionality within the Radio Access Network. The stepwise upgrade of GSM with GPRS and EDGE will evolve the pre-IMT-2000-GSM radio access to the 3G-GERAN.

EDGE is part of the IMT-2000 TDMA Single Carrier radio interface, and enhances the GSM/GPRS radio interface by adopting new modulation technology to achieve higher data rates using operators' existing GSM radio spectrum. Standardization of the GERAN (GSM/EDGE Radio Access Network) within 3GPP includes advanced Quality of Service mechanisms, enabling EDGE to offer almost all IMT-2000 services although with limited data rate compared to UMTS. EDGE is one solution to provide IMT-2000 services in existing pre-IMT-2000 spectrum resources.

The same enhanced GPRS packet infrastructure supports both GPRS and EDGE, thus EDGE is fully backwards compatible with GPRS and any application developed for GPRS will work with EDGE. It does so by re-using all the other network elements, including BSC, SGSN, GGSN, and HLR. In fact, with newer GSM/GPRS deployments, such as those being deployed in the Americas, EDGE[38] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. TDMA Single Carrier also uses the same radio channels and time slots as GSM/GPRS, so it does not require additional spectral resources. Thus, it provides a cost-effective solution for operators to upgrade to IMT-2000. Once operators have deployed EDGE, they can enhance its applications capabilities further by deploying the IP Multimedia Subsystem in their core networks, which will also support an IMT-2000 CDMA Direct Spread radio access network. In fact, as described in section 3.7.1, a big advantage deriving from the addition of IMT-2000 CDMA Direct Spread is that it can be operated together with the same Core Network as GSM/GERAN.

A further option that has already been chosen by many GSM-operators is the additional operation of the UMTS Terrestrial Radio Access Network (UTRAN). UTRAN is operated in a new frequency spectrum and enhances therefore the traffic capacity of existing GSM-operators. Especially in micro and pico cell environments, data rates of up to 10 Mbit/s can be reached by means of HSDPA. If the data rate and the load per cell are limited to smaller values, UTRAN (in particular the FDD-mode) can also be used to achieve coverage with very large cell-sizes. GSM operators who do not have new IMT-2000 spectrum can evolve to IMT-2000 by deploying EDGE as an upgrade to their GSM/GPRS networks.

38 Assumes EDGE release 99.

3.8 Capacity planning and system design

Once the high level specification for the network has been agreed, capacity planning can begin.

Capacity planning encompasses Core Network Planning and Radio Access Network Planning. A dimensioning exercise first establishes the key features of the required network topology, typically the nature and number of the required system modules.

Using the dimensioning model, the Core Network and Radio Access Network are then planned in detail.

Locations for the main elements of the core network are determined, and the required transmission capacity between each is identified.

Locations for the base stations are determined, typically based around the existing network's topography, with additional base station sites inserted where necessary to achieve the required coverage and capacity.

Coverage and capacity are the verified using a variety of radio planning tools. A Radio Network Plan is developed and the Radio Network Loading is verified. QoS, Soft Handover, and Cell Breathing are then checked.

3.8.1 Deployment aspects of UMTS

To expand capability and capacity further, operators can deploy UMTS, which is a complementary technology for EDGE, or an alternative. Worldwide, GSM and some new IMT-2000 operators are beginning UMTS deployments. Though UMTS involves a new radio access network, several factors will facilitate deployment. First is that most UMTS cell sites can be collocated in GSM cell sites, facilitated by multi-radio cabinets that can accommodate GSM/EDGE as well as UMTS equipment. Second is that much of the GSM/GPRS core network can be used. While the SGSN needs to be upgraded, the mobile switching center needs only a simple upgrade and the GGSN stays the same. Once deployed, operators will be able to minimize the costs of managing GSM and UMTS networks, as these networks share many of the same aspects, including:

- Packet-data architecture.
- Quality-of-service architecture.
- Mobility management.
- Subscriber account management.

Deployment of UMTS will occur in several stages, beginning first with a portion of the coverage area having UMTS, progressing through continuous UMTS coverage, and then reaching highly integrated, multi-radio operation. Table 3.8.1 shows this progression.

Table 3.8.1: Deployment progression of UMTS

Deployment Stage	Characteristics
Initial UMTS deployment	Only a portion of coverage area has UMTS. GSM provides continuous coverage. UMTS provides enhanced features and capacity relief for GSM.
Enhanced interworking of UMTS and GSM/EDGE	Continuous UMTS coverage. Higher loading in UMTS. Access network chosen based on service and load demands.
Full Multi-radio network capability	Dense deployment of UMTS, including micro cells. Integration of GERAN and UTRAN core equipment. Seamless quality-of-service integration. Addition of new radio technologies, such as WLANs.

3.8.2 Deployment aspects of CDMA2000

CDMA2000 offers significant spectral efficiency in terms of Erlangs/MHz and kbit/s/sector/MHz, representing several times the capacity of pre-IMT-2000 systems. Greater capacity helps minimize the frequency needed and number of base stations needed to deploy or evolve to IMT-2000 services. This simplifies the cost of deployment, while also allowing an operator who is evolving to IMT-2000 to maximize the investment they have in their existing network.

The availability of low-cost CDMA2000 terminals is made possible because CDMA2000 handsets use the same RF channelization components as cdmaOne handsets that were introduced in 1994. They make up a large portion of the more than 200 million commercial CDMA handsets being used worldwide. It is expected that this will continue to be true for all phases of the CDMA2000 evolutionary path, including the evolution to CDMA2000 1xEV-DO and 1xEV-DV devices and All-IP networks.

The enhancement of CDMA handsets is simple given that the same RF components are used throughout the evolution, thus helping reduce costs. This will also result in improved form factors and time-to-market. There are economies of scale for CDMA2000 handsets with a large selection of models (by [March 2004] there were [520] different models available commercially from [48] different manufacturers).

CDMA2000 equipment is commercially deployed in some countries in the following frequency bands (in MHz):

- 452.500-457.475; 462.500-467.475
- 824-849; 869-894
- 1 750-1 780; 1 840-1 870
- 1 850-1 910; 1 930-1 990
- 1 920-1 980; 2 110-2 170

For details see Annex D.

It is not necessary to acquire additional spectrum to deploy CDMA2000 as it can be deployed using existing spectrum, depending on capacity and regulatory constraints.

Once operators make the transition to CDMA2000 1X, they will have a complete IMT-2000 network capable of providing significantly higher voice capacity and packet data services up to 307 kbit/s (Rel 0) and 628 kbit/s (Rel A). For most operators, this will provide the beginning of their data service offerings.

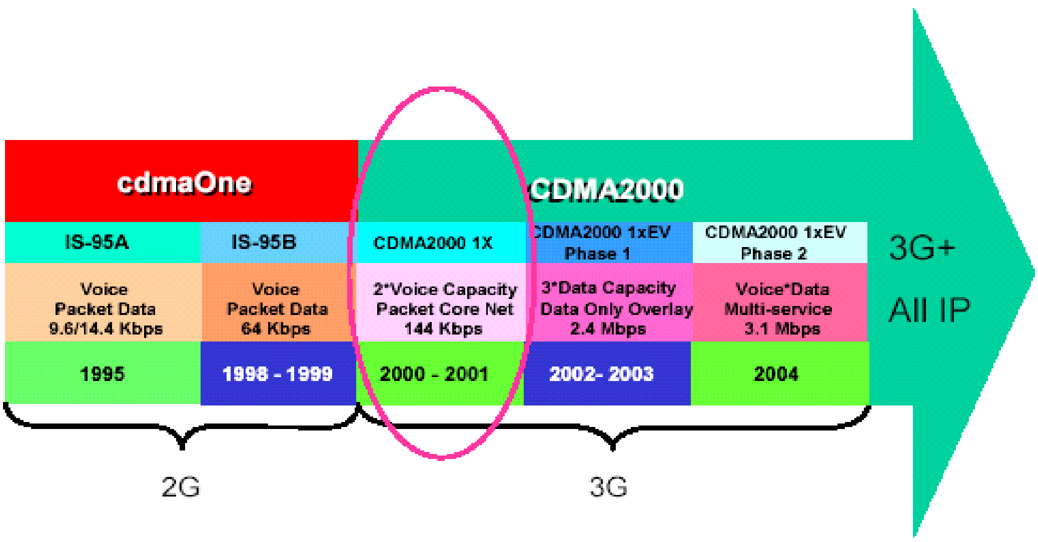
The next logical step for the operator is the introduction of CDMA2000 1xEV-DO (Rel 0), otherwise known on a commercial basis as High Data Rate (HDR), which utilizes the same bandwidth as CDMA2000 1X (1.25 MHz). CDMA2000 1xEV-DO (Rel 0) networks are capable of delivering packet data rates up to 2.4 Mbit/s. These carriers can be deployed in the same frequency band as CDMA2000 1X.

The drive for high-speed data throughput efficiency reaches its next phase with the introduction of CDMA2000 1xEV-DO (Rel A) and CDMA2000 1xEV-DV (Data and Voice) technologies. The Release A version of data-optimized CDMA2000 1xEV-DO technology will be able to deliver increased data rates up to 3.1 Mbit/s for downlink and up to 1.8 Mbit/s for the uplink. Like CDMA2000 1xEV-DO, CDMA2000 1xEV-DV will operate in a 1.25 MHz channel, thus providing a smooth transition to the next stage of the evolution process. Backward compatibility with CDMA2000 1X will be maintained for roaming, selective overlay opportunities, and protection of investment in handsets and infrastructure. CDMA2000 1xEV-DV will integrate voice and data on the same RF carrier while increasing peak data rates to 3.1 Mbit/s and maintaining the same voice capacity as CDMA2000 1X.

Operators can start with the first step of making the transition to CDMA2000 1X, then further evolving their networks to provide more efficient voice and data services, and eventually All-IP services.

The Mobile Internet and transition to All-IP networks are two of the key trends to be considered when planning for future wireless systems. 3GPP2 ensures that CDMA2000 networks have a step-wise path to multimedia services using IP transport. Backward compatibility to legacy networks and terminals is also one of 3GPP2's key priorities.

Figure 3.8.3.2: Deployment steps of CDMA2000



3.8.3 Deployment aspects of TDMA-SC

*<**Editor Note** – Additional text would be required.>*

It is not necessary to acquire additional spectrum to deploy EDGE as it can be deployed using existing spectrum, depending on capacity and regulatory constraints.

3.8.4 Modular system design

{ [i] Evolution strategies should consider using a modular approach. This would allow each independent module or subsystem to evolve at its own pace.

Any module or subsystem of a pre-IMT-2000 system can be considered as being taken into IMT-2000 operation when complying with IMT-2000 Recommendations and when connected to other subsystems also complying with IMT-2000 recommendations.

By comparing the states before and after the introduction of a module into IMT-2000, it can be maintained (no modification), enhanced (be modified) or changed (be replaced). There may be individual choices for discrete components within each module or subsystem.

The following scenario is an example of dividing a system into modules and an example of how this system may evolve into IMT-2000:

- *user data* (user id, subscription, etc.) – is likely to be maintained or enhanced;
- *terminal* – is likely to be enhanced or changed;
- *access subsystem* – is likely to be maintained, enhanced, or changed;
- *transport subsystem* – is likely to be maintained, enhanced or change;
- *service subsystem* – is likely to be enhanced or changed;
- *mobility subsystem* – is likely to be enhanced or changed;
- *security subsystem* – is likely to be enhanced or changed.

Some general guidelines can be drawn on how IMT-2000 can make use of specific pre- IMT-2000 modules. The actual path however, for any individual system in operation, has to be planned by the individual operator in each case. }

Manufacturers of IMT-2000 infrastructure equipment offerings are typically based on a modular system design. Following confirmation of the high level network specification (coverage, traffic, service offering, etc) the physical network implementation is dimensioned using the appropriate set of modules.

4 Economics of transition to imt-2000

A key step in the process of finalizing a transition path toward IMT-2000 network deployment is the economic evaluation of the revenues expected from the investments over the economic life of the system, including the spectrum license acquisition costs – where appropriate. This evaluation bases on the (cost of the) possible options and also on the assumptions about the evolution of demand and service penetration as well as tariff trends and policies.[39]

In planning investments, a balance has to be struck between actions decided in the early stages of the network deployment – those that normally have long-lasting effects in terms of both shaping the network infrastructure and capital recovery – and actions which may be deferred – those that are normally taken in response to changing market trends and/or conditions, and whose economic profitability has to be measured within relatively short time frames. Whatever deployment policy is adopted, a significant margin of flexibility for adjusting the deployment plan has to be factored in from the outset.

Numerical aspects for the various parameters characterizing the IMT-2000 network deployment are introduced in the following. It is to be noted that figures have only indicative value and that conclusions based on business analysis are critically dependent on the assumptions underlying the parameter choice.

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[39] A key metric in the evaluation is the NPV (Net Present Value) understood as the net present value of the network, i.e. cumulative discounted cashflow generated to date. On a less formal level, this metric is indicative of the profitability of a business, as appreciated at Year 0, over a span of N years – N ranging from 1 to the economic life of the system.

4.1 Market analysis and trends

<***Editor Note*** *– It is noted that this sub-section has to be adapted to better reflect developing countries' needs and scenarios.*>

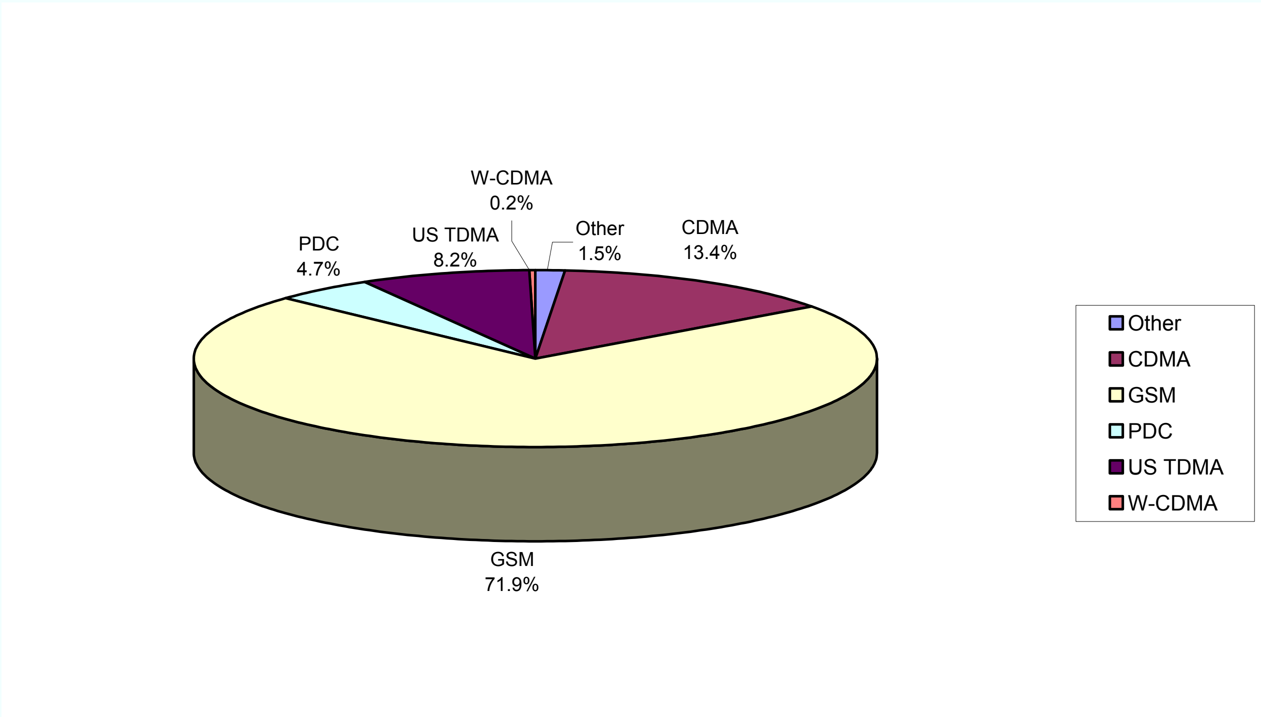
In general, there exist many different migration possibilities. Any decision concerning the most suitable solution for a certain operator requires a thorough analysis. Additionally, the overall market situation has to be taken into account, because mobile telecommunication systems are not isolated systems per country or per operator. In particular, worldwide interconnectivity, i.e. roaming, has to be provided to subscribers.

In this section, some examples of the market analysis for particular migration paths are provided. Information about operators following these paths is included in Annex F of these guidelines.

4.1.1 Market overview

There are currently 1.326 billion cellular subscribers in the world using a variety of technologies, both analogue and digital. The following charts give an overview of the current deployment of cellular technologies (as of November 2003).[40] Table 4.1.1 provides more detail on operators, subscribers, and mobile technologies used throughout the world.

Figure 4.1.1-1: World subscriber figures



[40] All data on operators, subscribers and technologies is sourced from the EMC World Cellular Database unless otherwise noted. Data is at November 2003.

Figure 4.1.1-2: Africa: 48 million subscribers

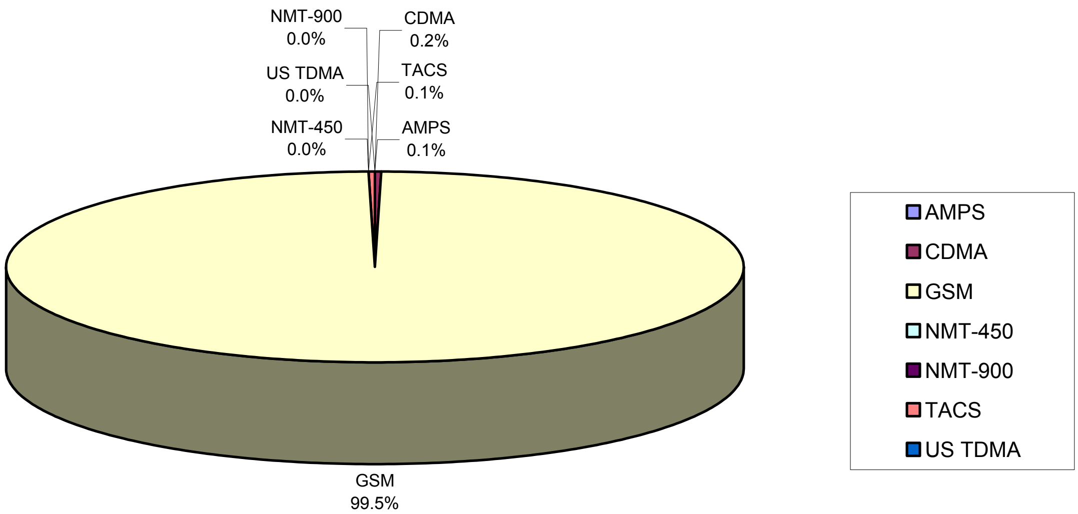


Figure 4.1.1-3: Americas: 120 million subscribers

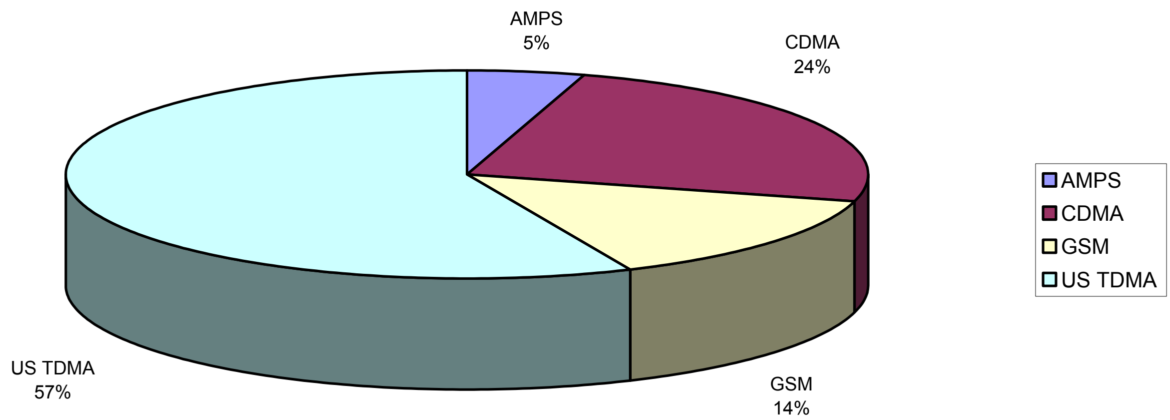


Figure 4.1.1-4: Middle East: 26 million subscribers

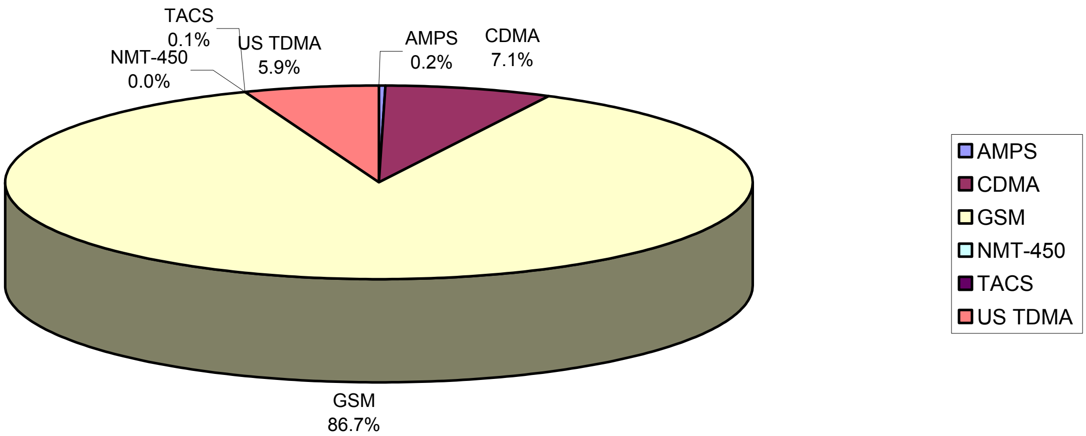


Figure 4.1.1-5: USA/Canada: 151 million subscribers

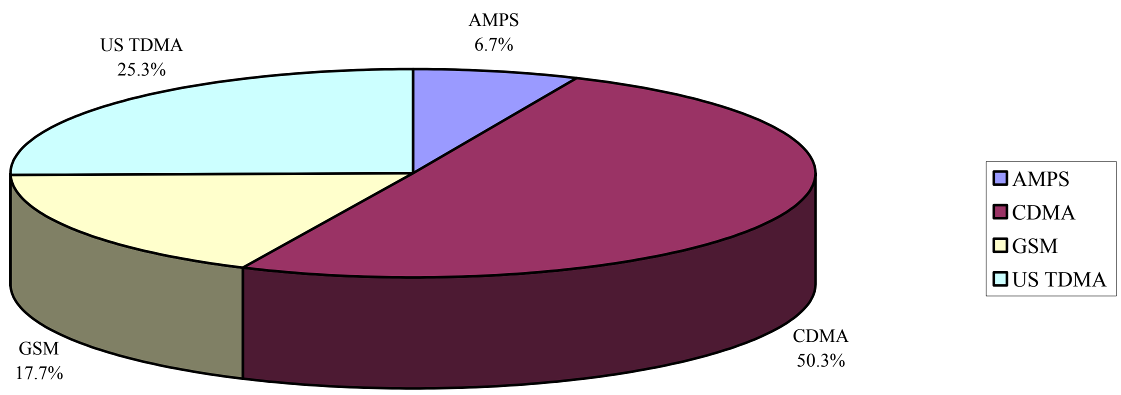


Figure 4.1.1-6: Eastern Europe: 105 million subscribers

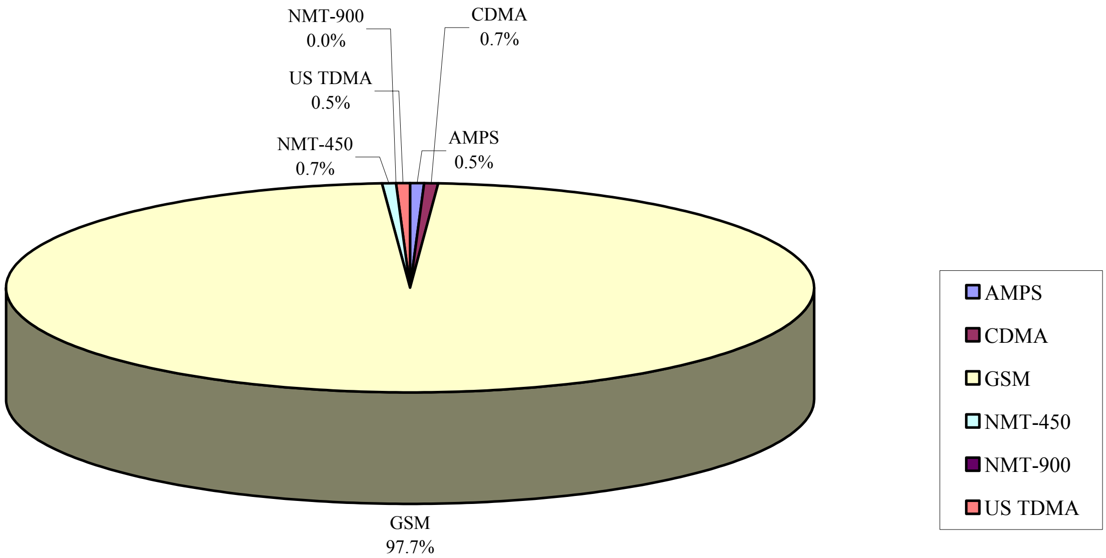


Figure 4.1.1-7: Western Europe: 352 million subscribers

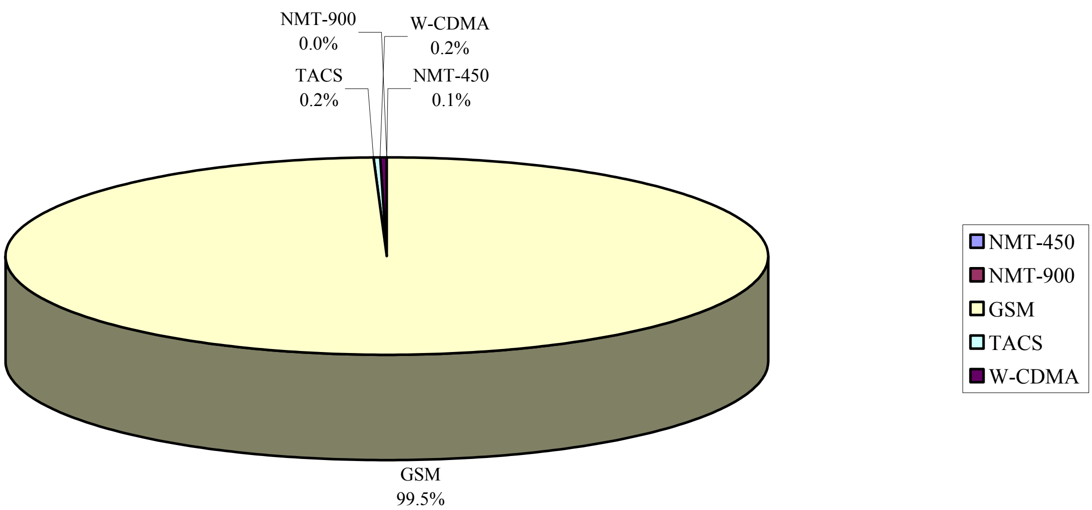


Figure 4.1.1-8: Asia Pacific: 524 million subscribers

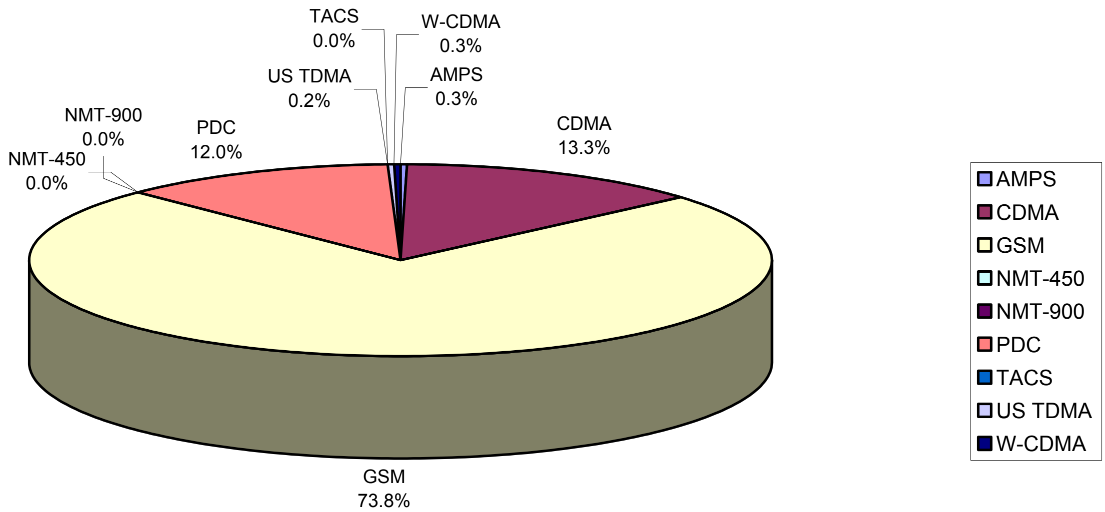


Table 4.1.1: Overview of mobile systems, number of operators and subscribers (nov. 2003 – jan. 2004)[41];

	Operators (also regional!)	Number of Countries	Subscribers worldwide (in million)
1G-systems	200	81	20
AMPS	118	52	17,95
NMT	73 (54 of them in Russia)	21	1
TACS	9	8	1,1
Pre-IMT-2000-systems	805	291	1 304
GSM	544	191	955
D-AMPS (TDMA)	127	56	109
CDMA (IS-95)	130	43	178
PDC	4	1	62
IMT-2000-systems	128	77	N/A
WCDMA	19	16	2,77
CDMA2000	88	44	75
EDGE	21	17	N/A

4.1.2 Market trends

The cellular market has seen dramatic change in the last decade. Four overall trends have emerged:

- Lower prices in airtime and terminals.
- Increased cellular penetration.
- Growing presence of developing countries.
- Growth in non-voice revenue.

Increased competition in the cellular market – both operators and infrastructure vendors – has led to significant decreases in price to the end user. One example of this trend is India, where airtime rates dropped by over 75% from 1996 to 2002.[42] Handset prices have also declined. Between 1994 and 2001, the average selling price of a handset went from USD 464 to USD 157. Prices are estimated to fall an additional 5.9% per year from 2001-2008, to an estimated price of just over USD 100.[43]

[41] 1G data from EMC World Cellular Database; November 2003; GSM data from GSM Association; TDMA data from EMC World Cellular Database; November 2003; CDMA (IS-95) data from CDG; WCDMA data provided by GSM Association; EDGE data provided by 3G Americas.

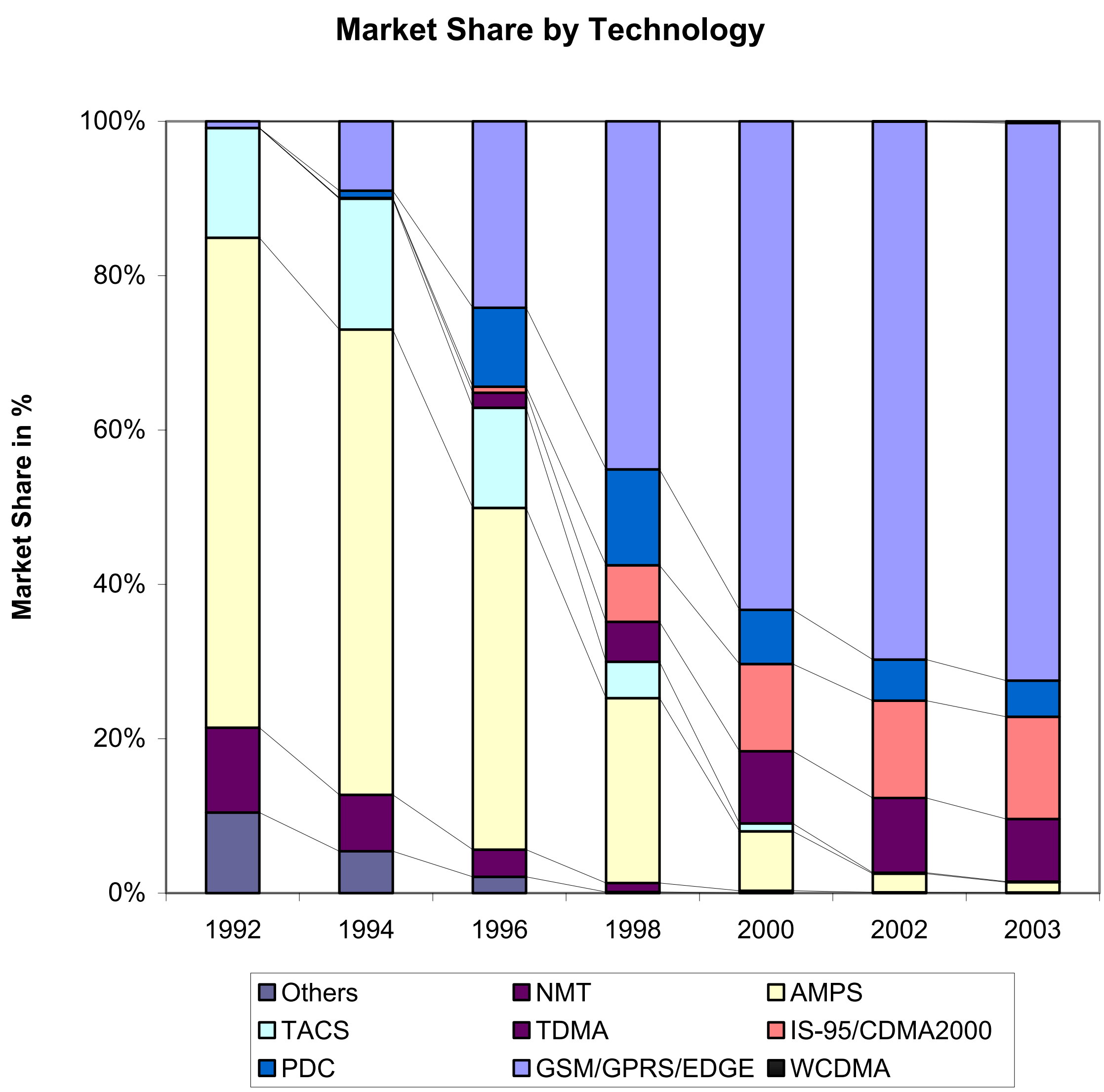
[42] Cellular Operators Association of India (COAI), September 2003.

[43] Deutsche Bank Securities, Inc, June 2003.

Falling prices have been a major driver of increased cellular penetration. GSM subscribers have increased twelve-fold since 1997. Similarly, the number of CDMA subscribers increased twenty-three-fold between 1997 and 2003.[44] The popularity of these two mobile technologies continues to grow. In 2003, GSM accounted for 182.9 million or 81% out of the 226.9 million new digital subscriptions. During the same period, CDMA accounted for 35.4 million or 16% of the new digital subscriptions. The shift towards GSM and CDMA2000 will be even more profound in Latin America over the next 3-4 years, as operators of TDMA and analogue networks begin to migrate to IMT-2000 technologies.

Figure 4.1.2-1 shows the trend in the number of subscribers per technology from 1992-2003.

Figure 4.1.2-1: Market shares by technology from 1992-200

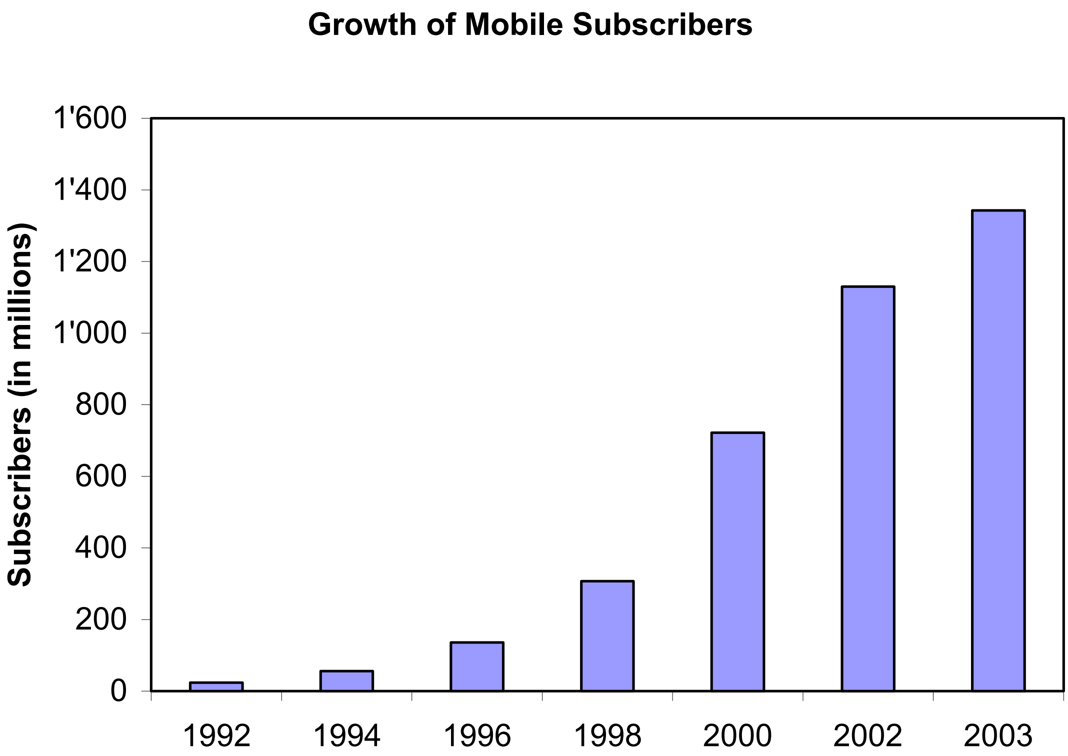


3[45]

44 EMC World Cellular Database, December 2003.

45 EMC World Cellular Database, December 2003.

Figure 4.1.2-2: Growth in number of mobile subscribers from 1992 – 2003[46]



For many developing nations, wireless technology has been identified as the best medium to get telecommunication services – both voice and data to the masses. In sub-Saharan Africa, for example, wireless lines already outnumber fixed. From 1995 to 2002, the number of mobile lines has grown by 75% in Africa, 30% in the Americas, 52% in Asia, 50% in Europe and 29% in Oceania.[47] Even though growth has been impressive, there is huge space for wireless growth in developing areas – India has over a billion people with no telecommunications line, China just under a billion and the vast majority of the developing world would count its connected population in single figure percentages. This increased penetration is forecast to continue. For example, penetration rates in Africa and the Middle East are estimated to grow to 11.4% by 2008, Similarly, penetration rates in China, India and developing Asia are forecast at 30%, 12% and 15% respectively.[48]

Developing countries have begun to increase their share of total cellular subscribers. At the end of 1996, Africa, the Americas (excluding the United States and Canada), Eastern Europe and the Middle East only represented a combined market share of 8%. By the end of 2002 this had jumped to 21%.[49] More developed markets are reaching their saturation point, which implies that future growth will be driven by the developing world. By 2008, it is estimated that 90% of new subscribers will be from developing countries.[50]

[46] EMC World Cellular Database, December 2003.

[47] ITU, 2002.

[48] Deutsche Bank Securities, Inc, June 2003.

[49] EMC World Cellular Database, September 2003.

[50] Deutsche Bank Securities, Inc, June 2003.

Wireless data is potentially a vast new market. IMT-2000 makes possible a wide variety of new services such as location-based services, multimedia, m-commerce, and messaging, many of which were not available with pre-IMT-2000 systems. Wireless Internet devices are rapidly becoming one of the most important and personal items people carry with them, and are increasingly combining the numerous functions of today's mobile phones, personal computers, TV, newspapers, cameras, library, personal diary and scheduler, wallet, and credit cards. Wireless Internet has the power to offer complete personalization of end user applications and services.

These services will be personalized by users to reflect their own lifestyles and the choices that they make. Many different kinds of services are necessary to suit the needs of the various market segments: from business users, to the diversity of user users (youth, users on the move, users on the road etc.), and also including the many vertical market applications that may need special adaptation.

It is difficult to identify with certainty wireless Internet's top services. Voice services are expected to remain a major revenue source for the operator. Even ten years from now, voice is expected to continue to dominate operators' ARPU, but this proportion will probably decline steadily as IMT-2000 systems enable the creation of an ever-wider range of data services. Revenues will increase steadily for the first few years of IMT-2000 deployment, accelerating more sharply some 4-5 years after first network launches.

One of the earliest indicators of the growth potential for non-voice services is the explosive popularity of SMS, or text messaging, with over 1 billion SMS being sent daily. Other services, meanwhile, are steadily generating an increase in non-voice revenues for operators. Building on the enormous success of SMS, Mobile Multimedia Messaging Service (MMS) has so far attracted well over 1 million subscribers in Europe alone, allowing them to create, send, store and share their own pictorial content. Already offered by more than 115 operators[51] – chiefly in Europe and Asia – MMS provides the market with an early glimpse of the service opportunities offered by higher speed data services. Location-based services could also become an important feature for the operator.

In the early days of wireless Internet, a significant share of revenue is expected to come from business users with Intranet/extranet access. Access to personalized, selected content will provide additional operator revenue as soon as the user market begins to take off. Applications and services will drive the new revenue models that seek to leverage the increased technical capabilities and bandwidth that IMT-2000 systems deliver, therefore IMT-2000 can important role to play in bridging the "digital divide" between regions and cultures. In addition, new services and applications created by IMT-2000 can be expected to exhibit distinct regional trends in terms of user take-up. An example of this is Asia Pacific, where the UMTS Forum predicts that annual IMT-2000 revenues will reach USD 118 billion by 2010, with "customized infotainment" – personalized access to news, sports results, gaming and other forms of information and entertainment – representing 36% of all Asian IMT-2000 revenues, ahead of simple voice (28%), mobile access to the Internet and corporate networks (14%) and MMS (13%).[52]

4.2 Costs and benefits of transition

The total costs of evolution/migration are the sum of a number of separate costs:

- Licensing costs (These include up-front and on-going license fees to the national regulator, and possible up-front and on-going royalty fees to equipment vendors).
- Marketing, advertising and promotion costs.
- Acquisition and retention of subscribers.
- Network infrastructure costs.
- Real estate costs.
- Operational costs, including salaries, training, network management and maintenance.
- Content and application development costs.

[51] Global Mobile, EMC, GSMA, (www.gsmworld.com).

[52] UMTS Forum Report #17.

The total benefits of evolution/migration are the sum of a number of separate benefits:

- Increased subscriber numbers.
- Increase in traffic per subscriber.
- Increase in market share.
- Increase in ARPU.
- Reduced operational costs.
- Reduced churn.

4.2.1 Costs of network transition

Comparing the costs of different network transition strategies is incredibly difficult, especially as the costs and benefits associated with transition involving new spectrum as opposed to evolution in the same spectrum band, are different. For example:

- The different IMT-2000 architectures employ different functional modules.
- The dimensioning rules will be different.
- The dimensioning assumptions and options will be different, even for the same nominal network specifications.
- The cost models for each will be different.

It is therefore even more difficult to develop a generic cost model.

4.2.1.1 Costs of the network transition for the operator

New technologies must be employed in such manner that the operators could keep their core technologies and investments in place, while enhancing their systems for the third generation.

The estimates of providing or upgrading pre-IMT-2000 networks to IMT-2000 (including license, network infrastructure, application and content development) vary widely.

Regulatory frameworks can have an important effect on the cost of migrating pre-IMT-2000 system to IMT-2000. For instance, a regulatory framework that allows an operator to migrate from pre-IMT-2000 systems to IMT-2000 in its current spectrum (in-band migration) and without having to pay for a new license or spectrum can have significant cost savings on the total migration.

4.2.1.1.1 Migration/transition from GSM to IMT-2000 CDMA Direct Spread

The migration/transition path from GSM to WCDMA is well understood and backed by global standards releases from 3GPP. The basic benefits of WCDMA are:

a) It was designed for effective deployment of IMT-2000 services.

b) It offers both FDD and TDD variants to offer operators the choice of how to deploy technology to make efficient use of the available spectrum in both paired and unpaired bands and for high and lower density areas.

c) WCDMA is already being deployed in many areas of the world. Of the operators that have made technology decisions for IMT-2000 so far, 85% of them have opted for WCDMA. This ensures a global market and brings the associated economies of scale that drive prices of infrastructure and handsets down and investment by vendors in R&D up.

d) WCDMA is designed to be technically backward compatible with 2G and 2.5G GSM-based systems and therefore leverage 2G investments.

e) WCDMA is operated at the same evolved GSM Core Network. Therefore it preserves valuable Core Network investments.

f) WCDMA is also backward compatible with services and business systems. It builds on the existing GSM community, which encourages developers and allows for the fast development of common approaches to data services to enable interoperability and roaming.

WCDMA provides additional capacity and quality-of-service mechanisms, and flexibility in managing resources between voice and data services. It is designed to be a complement to IMT-2000 TDMA Single Carrier.

4.2.1.1.2 Transition from GSM to IMT-2000 CDMA TDD

Migration/transition from GSM to TD–SCDMA does have advantages. It is a smooth and economical migration path to IMT-2000 and meets most of the needs for developing countries. The main advantages depicted below support this point of view:

a) TD-SCDMA is a member of IMT-2000 family standards, which is accepted by ITU as an innovative air interface technology, so it can be used in the global scope.

b) TD-SCDMA is a high spectral efficiency system. With the specific radio carrier characteristics of TD-SCDMA, it doesn't need pair of frequency bands and could make use of fragmentary frequency bands. As it just needs 1/3 the frequency bands of UTRA TDD (3.84 Mbit/s Option), it can save on the precious spectrum resources of the world. Most important thing for operators is that it makes them could save their money on buying frequency bands with achieving the same or much better services of IMT-2000.

c) One of the main objectives of introducing IMT-2000 systems is to satisfy the requirements for extensive capacity. Smart antennas, Joint Detection, Uplink Synchronization and Dynamic Channel Allocation technologies are all implemented in TD-SCDMA system to minimize radio interference to achieve high capacity. Thus TD-SCDMA is very suitable for highly dense populated areas.

d) Wireless data is potentially a vast new market for IMT-2000. With support of asymmetric traffic and adapt to the variety of uplink and downlink traffic rates through adjustment of timeslots, TD-SCDMA is suited for Internet services.

e) TD-SCDMA provides a smooth migration/transition path from pre-IMT-2000 to IMT-2000 (see above)

f) TD-SCDMA re-uses the current GSM/GPRS infrastructure that could reduce the transition cost and protect the existing investment. Operators can efficiently introduce the TD-SCDMA Radio Access Network (RAN) while using the existing GSM/GPRS core network.

g) TD-SCDMA mode can be implemented in all radio deployment scenarios: from rural to dense urban areas, from pico to micro and macro cells. In areas, where high communication capacity is needed, micro cell and pico cell system can be deployed. Small coverage per cell site results in the need of more cells for a geographic area as compared to macro cell, it means that more spectrum is needed.

4.2.1.1.3 Transition from GSM/TDMA to IMT-2000 TDMA Single-Carrier

IMT-2000 TDMA Single-Carrier (EDGE) provides an effective way of increasing capacity and throughput within existing spectrum for both GSM and TDMA operators. From GSM/GPRS, EDGE requires a relatively small investment to reach IMT-2000.

a) It was designed for effective deployment of IMT-2000 services.

b) Nearly all new GSM/GPRS base stations are EDGE-capable.

c) EDGE is a software-only upgrade from GSM/GPRS (there is a possibility that some hardware would be needed for additional processing capabilities if data usage is high but this is unlikely in the early stages of deployment).

d) EDGE is both backward compatible with GSM/GPRS and forward compatible with WCDMA.

The TDMA community, as represented by 3G Americas, has selected the migration/transition path for TDMA to GSM/GPRS and then to EDGE.[53] The transition path followed so far is justified as follows:

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[53] Per 3G Americas.

a) GSM has almost twice the capacity of TDMA – and with Adaptive Multi-Rate (AMR) codec software deployed, will quadruple TDMA capacity.[54]

b) Single Antenna Interference Cancellation, in development, will provide an additional 60-100 per cent increase in voice capacity.

c) EDGE software more than triples the data speeds of GPRS using the same spectrum and radio frequency.

4.2.1.1.4 Transition from cdmaOne to IMT-2000 CDMA Multi-Carrier

Transition from cdmaOne to CDMA2000 is eased by the fact that the latter is a direct evolution from the cdmaOne (IS-95) standard. The advantages can be summarized as follows.

a) CDMA2000 offers a doubling of voice capacity along with the introduction of packet data through 1X and delivering high-speed packet data through 1xEV-DO.

b) Since the CDMA2000 standard is so closely derived from the cdmaOne standard, many of the IS-95 components and equipment designs (both infrastructure and terminals) can be reutilized in CDMA2000. This evolution process has given CDMA2000 operators the benefit of product maturity leading to short time to market and economies of scale for the 1X and 1xEV-DO operators.

c) The operator evolving from cdmaOne to CDMA2000 has a cost effective upgrade path and is able to leverage much of the existing equipment already deployed in the IS-95 network.[55] In order to upgrade an IS-95 base station (BTS) to 1X capability a channel card upgrade is deployed. Operators can either replace existing IS-95 channel cards with 1X channel cards or add a new RF carrier with 1X channel elements. Since voice services are both forward and backward compatible between IS-95 and 1X the evolution process can be seamless.

d) Additionally, when the operator is ready to deploy high speed data services with 1xEV-DO again a channel card upgrade at the existing base station can be utilized. This upgrade path is possible because 1X and 1xEV-DO utilize many of the same radio components and designs as the IS-95 system.

e) At the BSC level the upgrades required are typically software related to add either 1X or 1xEV-DO to an IS-95 network. A packet data service node (PDSN) must be added for packet data functionality with the introduction of CDMA2000 into the network.

4.2.1.2 Degree of infrastructure sharing

Infrastructure sharing reduces the cost of network deployment. It is particularly important for countries with widely dispersed low-density populations and for newly emerging mobile markets.

Items that can be shared include antenna masts and towers, base site and other buildings, and radio access and transmission infrastructures.

An open question is whether the regulator should preclude infrastructure sharing, permit infrastructure sharing at the discretion of the operators, or play a pro-active role to encourage infrastructure sharing.

End user cost will be affected by the degree of infrastructure sharing permitted by the regulator and implemented by the operator. In countries or other areas where multiple IMT-2000 technologies are geographically co-located there may be reduced capability for infrastructure sharing.

4.2.2 Cost affordability for end users

In addition to the transition cost, there are other economic issues to consider.

- Regulatory issues (interconnection rate, luxury tax, etc.).

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[54] Rysavy Research, “Voice Capacity Enhancements for GSM Evolution to UMTS”, July 2002 (www.3gamericas.org/english/technology_Center/whitepapers

[55] “Evolution of wireless data services: IS-95 to cdma2000”. Knisely, D.N.; Kumar, S.; Laha, S.; Nanda, S. Communications Magazine, IEEE, Volume: 36 Issue: 10, Oct. 1998, Page(s): 140-149.

- Handset issues (availability, costs, potential need for subsidies, multi-band and/or multi-mode handsets, economies of scale).
- Competition of infrastructure vendors.

4.2.2.1 Handsets: Availability, affordability, and variety

Today, IMT-2000 handsets are commercially available for both CDMA2000 and WCDMA operators.[56]

The cost of handsets is a critical factor for any wireless operator's success in the market. In addition to offering high-speed, full-feature, multi-media phones, which will be more expensive initially, it will be necessary for IMT-2000 operators to sell low-cost terminals that support voice, SMS and circuit-data. The key driver of handset availability, affordability and variety – particularly at the low end of the market – is market size and the associated economies of scale. In order to keep the costs of IMT-2000 handsets as low as possible, CDMA2000 handset manufacturers can leverage the common manufacturing design and common components of cdmaOne handsets, making CDMA2000 handsets only marginally more expensive than cdmaOne handsets. In addition, the implementation of Zero Intermediate Frequency (ZIF), or direct conversion technology, will bring further cost savings in the production of IMT-2000 terminals. ZIF technology eliminates the need for an intermediate frequency and can reduce the cost of wireless devices by reducing the handset bill of materials, while also reducing the circuit board space needed by up to 50%.

Available today are a number of CDMA2000 handset chipsets designed to meet the needs of a wide range of users. As of March 2004, there were 520 CDMA2000 devices available from 48 manufacturers, including 58 CDMA2000 1xEV-DO devices, and new devices are continuously being introduced.[57] The economies of scale and the opportunity to leverage common design and components between generations of CDMA products have led to the continuing decrease of CDMA2000 handset prices. In addition, many existing cdmaOne and CDMA2000 handsets are dual-mode devices that also support analogue networks, an important concern for current cdmaOne and TDMA operators who still have significant analogue coverage.

As a direct transition from GSM/GPRS, WCDMA terminals are and will increasingly be developed by the same broad range of terminal manufacturers that service the GSM market that as of January 2004 offers some 700 different devices.[58] Dual-mode terminals (GSM/GPRS & WCDMA) are entering the marketplace, providing backward/forward compatibility. With the exception of the radios (and some chipset developers are even working to combine the radios into a single chip), many functions common to both can be shared in the handset chipsets to reduce space, power and processing requirements and ultimately cost. As of January 2003, several manufacturers collectively offered a total of 25 GSM 850/1900 terminals for use in the Americas[59] 12 EDGE devices are either available or will be available by Q2 2004, and most new GPRS devices will EDGE-enabled. Dual-mode EDGE/WCDMA terminals are expected in 2004.[60]

4.2.2.2 Service affordability

In addition to affordable handsets, service packages must also be within the price range of end-users, including the important pre-paid market that exists in many developing countries. Administrations' decisions on critical regulatory issues such as interconnection rates, tariffs and service flexibility play a determinant role in the ultimate rates charged to users. With the advent of always-on packet-data, wireless operators may have a more flexible option of charging flat rates for data services. Other options could be to charge for services based on volume, the number of times used (for data applications), or the traditional method measured by total time used.

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[56] A detailed listing of commercially available devices, including phones, Personal Digital Assistants (PDAs), laptops, PC cards, wristwatches and even sunglasses, can be found at www.3gtoday.com

[57] www.3gtoday.com

[58] GSM Association.

[59] Manufacturers' websites.

[60] Global Mobile Suppliers Association, December 2003.

4.2.3 Other considerations

4.2.3.1 Roaming

Thanks to the popularity of international travel for business and pleasure alike, roaming between mobile networks is an intrinsic part of today's customer experience. International roaming is becoming significantly easier with the introduction of phones that support multiple frequency bands and modes. The increasing prevalence of multi-band/multi-mode phones is important for two reasons. First, with expanded options, operators will be able to offer their customers nationwide, region wide or even worldwide coverage. Second, as multi-band/multi-mode phones become more common, operators will be able to attract additional roaming revenue since more users can roam onto their networks.

It is likely that tomorrow's IMT-2000 customer will not be aware of the radio or the network technology they are using in the "home" or "visiting" network. They will simply utilize their personal terminal device to access a portfolio of services and applications that are available to them at that instant via their user profile. This profile is governed by subscriber/user identity modules (SIM/UIM) in every digital mobile phone today.

Interoperability – the ability for services and applications to work seamlessly between networks and terminals – is likely to be a key issue in governing the uptake of IMT-2000 globally, and considerable industry resource is being invested in this area. The first fruits of this concerted effort include MMS interoperability.

It should be noted, however, that roaming requires more than merely multi-band/multi-mode handsets, which can operate in different environments. Essential prerequisites for roaming include, for instance:

- interoperable network-network interfaces between the "home" network and the "visiting" network to which the user is roaming to;
- handsets with appropriate radio and network protocol stacks so that the handset can communicate with the "visiting" network;
- an understanding of the contents of the subscriber/user identity modules (SIM/UIM) in the different network environments so that the user can be correctly identified; and
- commercial roaming and its associated service level agreements between different operators to permit the usage of respective networks by their subscribers.

4.2.3.1.1 GSM/EDGE/WCDMA roaming

WCDMA, EDGE, GPRS, GSM roaming capabilities are the result of careful development of the corresponding standards with the overall objective to assure a maximum of interoperability. For this purpose, these radio interfaces have been standardized to support handover between these radio technologies. Moreover these WCDMA, EDGE, GPRS and GSM access networks are connected to a common UMTS Core Network providing the possibility of seamless service usage.

Roaming has been one of the key drivers for the global success of GSM: out of a total market base approaching one billion, it is estimated that some 100 million of these are active "roamers"[61]. Mobile operators benefit from increasing growth in international roaming revenues, amounting in some instances to as much as 15% of their ARPUs (Average Revenue Per User).

While GSM has set the norm for automatic roaming, currently for voice, SMS and MMS, it is expected that this experience will be extended to include roaming and service portability for a growing range of advanced new voice and data services. Furthermore, with increasing commitment from the industry to offer interoperability between networks, terminals and services, the user experience continues to become richer and more appealing for all its customers.

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61 GSM roaming information is available at the GSM Association's website (www.gsmworld.com).

Because of its widespread deployment, GSM offers the most extensive roaming capabilities in the world. For GSM operators, and TDMA operators considering transition options, the revenue implications are considerable and an important component of the (post-transition) business case, i.e.[62]:

- At least 20,000 international roaming agreements are currently in place.
- GSM/GPRS provides roaming to over 100 countries.
- Roaming generated USD 12 billion in revenue in 1999.
- Roamers use 2 billion minutes each month.
- Roaming revenue can generate between 15% and 30% of an operator's annual revenue.

Intra-country roaming alone is a significant opportunity. In Latin America, for example, intra-country roaming revenue grew from USD 133 million in 1998 to USD 205 million in 2001. In-country roaming revenue is expected to grow to USD 391 million by 2007.[63]

Roaming from GSM/GPRS/EDGE to WCDMA and vice-versa is achieved by dual mode handsets, which may also need to operate in multiple frequency bands.

4.2.3.1.2 cdmaOne/IMT-2000 CDMA Multi-Carrier roaming

Regional and international roaming is supported on pre-IMT-2000 and IMT-2000 CDMA networks, with CDMA subscribers roaming in Asia, the Americas, Australia/New Zealand and Russia.[64]

Subscribers on cdmaOne (pre-IMT-2000) networks and CDMA2000 (IMT-2000) networks can roam on either network using their pre-IMT-2000 or IMT-2000 mobile phones. Since CDMA2000 1X systems are backward compatible to cdmaOne systems, voice roaming between pre-IMT-2000 and IMT-2000 CDMA networks is transparent from the user's perspective. For data roaming, an IMT-2000 subscriber will not be able to get advanced IMT-2000 data services when roaming on a pre-IMT-2000 system but will be able to receive services available on the pre-IMT-2000 system (usually a subset of the IMT-2000 services). This is similar to the experience a WCDMA or UMTS subscriber will have when roaming on a pre-IMT-2000 GSM/GPRS network.

A pre-IMT-2000 CDMA operator evolving to an IMT-2000 CDMA2000 system can do so without any impact on incoming and outgoing roamers, i.e., incoming and outgoing pre-IMT-2000 CDMA roamers can continue to roam as before but they do not acquire additional IMT-2000 service capabilities.

It is expected that the users of the two dominant IMT-2000 networks will also be able to roam using multi-mode, multi-band handsets that support CDMA2000, cdmaOne, GSM/GPRS, WCDMA and TD-SCDMA. Roaming agreements between CDMA and WCDMA operators, supported by the necessary subscription, open standard inter-core network interoperability and mobility management, open standard multi-mode multi-band handsets and unique mobile station identifier, would allow their subscribers to roam between the two dominant systems and their respective precursors using a single subscription and a single handset.

4.2.3.1.3 TDMA/AMPS to IMT-2000 CDMA MC/AMPS roaming

TDMA operators that have ANSI-41 based networks making the transition to an IMT-2000 CDMA ANSI-41 based network may offer their subscribers roaming using the analog air interface. This scenario is specifically relevant to operators who may have several TDMA properties in different countries making the transition to IMT-2000 but on different schedules. During the transition period, when an operator would have both CDMA and TDMA systems operational, its TDMA and CDMA subscribers could roam from one network to the other using the analogue mode available on their dual-mode (TDMA/AMPS, CDMA/AMPS) handsets.

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[62] GSM Association.

[63] Pyramid Research.

[64] CDMA roaming information is available at the CDMA Development Group's (CDG) website (www.cdg.org).

4.2.3.1.4 Network requirements for inter-system roaming

IMT-2000 radio interfaces rely on either of two existing core network types – ANSI-41 and GSM-Map (see section 1.3.3).

Inter-system roaming requires the standardization of network-to-network interface to allow the exchange of information such as subscriber profile, authentication keys, etc. As of January 2004, such interface is not standardized by ITU-T, hence there is no provision for inter-system roaming between the two core network types.

It is desirable to avoid the need for separate subscriptions for IS-41 networks (CDMA2000) and MAP networks (WCDMA, EDGE, TDD). Additionally, roaming agreements between IS-41 operators (CDMA2000) and MAP operators (WCDMA, EDGE, TDD) have to exist.

4.2.3.2 Terminal developments

Mirroring developments on the radio access, core network and services evolution side, mobile terminal devices are themselves evolving to become more diverse, powerful, flexible and feature-rich.

This evolution can already be seen with the proliferation of color screens and in-built digital cameras with email, browser and PDA-type functions as well as increasingly customizable user features on current phones. IMT-2000 phones are now capable of performing functions that have traditionally been limited to PCs and laptops. Powerful operating systems and execution environments are being incorporated into IMT-2000 devices to handle a wide variety of user entertainment and enterprise applications. They are also evolving to provide the end-users a more enjoyable experience through enhanced user interfaces, personalization and roaming capabilities. While previous generations of mobile phones have been essentially “hard wired” to perform a finite set of functions, network operators are now offering downloadable software applications – such as games or information services.

Similar to the introduction of multi-band phones that allowed users to roam between 800 MHz and 1 900 MHz AMPS/CDMA networks and other users to roam between 900 MHz, 1 800 MHz and 1 900 MHz GSM networks; phones are increasingly becoming multimode and multi-band devices capable of operating on different networks.

Today and in the near future, multi-mode and multi-band IMT-2000 phones will be available commercially to enable global usage in some or all of the 800 MHz, 900 MHz, 1 800 MHz, 1 900 MHz and 2 100 MHz bands:

- GSM/GPRS/EDGE/WCDMA.
- GSM/GPRS/EDGE/WCDMA/HSDPA.
- GSM/GPRS/CDMA2000 1X[65].
- GSM/GPRS/CDMA2000 1X and 1xEV-DO.
- WCDMA/CDMA2000 1X.
- GSM/ANSI-136[66]/GPRS/EDGE.

As mentioned above, the existence of multi-mode, multi-band terminals facilitates but is not sufficient to ensure roaming between operators’ networks.

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[65] Devices with CDMA2000 will support Assisted-Global Positioning (A-GPS) services using the 1 500 MHz band.

[66] GAIT devices.

4.3 Business plan and analysis

A key step in the process of finalizing a transition path toward IMT-2000 network deployment is evaluating the network economics. Specifically, operators should consider choosing the transition path that yields the most economic value, including revenues, spectrum license acquisition costs[67-68], where appropriate, capital expenditures (CAPEX), and operating expenditures (OPEX) over the economic life of the system. Economic evaluation may have to be based on assumptions about the evolution of demand and service penetration as well as tariff trends and policies.

To implement a financial model where all of the described aspects are properly taken into account, specially designed tools are normally used. This implies a sequence of steps to go through to associate values to the input parameters and to acquire the network engineering rules. Running the model generates the technical and financial outputs driven by geographical data and service demand. The implementation of a financial model is normally conceived so that further information on specific aspects may be obtained by increasing the level of detail in the description of the network infrastructure and/or network components.

4.3.1 The Business Plan process

A key metric in the evaluation is the NPV (Net Present Value) understood as the net present value of the network, i.e. cumulative discounted cash flow generated to date. On a less formal level, this metric is indicative of the profitability of a business, as appreciated at Year 0, over a span of N years – N ranging from 1 to the economic life of the system.

4.3.1.1 Business Plan outline

The economic evaluation comprises the following logical phases:

a) the year traffic demand[69] over the considered period is estimated. This, in turn, involves several steps, i.e.
   - estimation of the potential user population;
   - estimation of the service penetration considering dimensions such as: service class (i.e. bit rate of circuit switched and packet switched services), operation environment (i.e. dense urban, urban, suburban, rural), user age class, etc.;
   - estimation of the activity factor per service type and class;
   - estimation of OPEX (Operational Expenses including network and non-network related, handset subsidies, marketing and sales, etc.);

b) the Radio Access Network is planned on a year basis considering the increase in the traffic demand, point a) above, and the resulting need for incremental additions of network infrastructure (base stations and mobile switching centers) to meet capacity requirements. This stage considers that different operation environments are differently covered from a service point of view, both in time and as target coverage, with dense urban environments receiving priority;

c) the core network is also planned on a year basis considering the impact of traffic demand under points a) and b) above. As part of this planning, re-engineering of network components such as SGSN/GGSN or PCF/PDSN (Packet Controller Function/ Packet Data Serving Node) is also accounted for. This includes both HW and SW upgrading, i.e. processing power increase as well as architecture and functional enhancements due to implementation of successive IMT-2000 releases. This stage considers that packet switching equipment will, as a tendency, substitute circuit switching equipment;

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[67] The UMTS Third Generation Market – Structuring the Service Revenues opportunities. UMTS Forum Report #9. http://www.umts-forum.org/reports.html

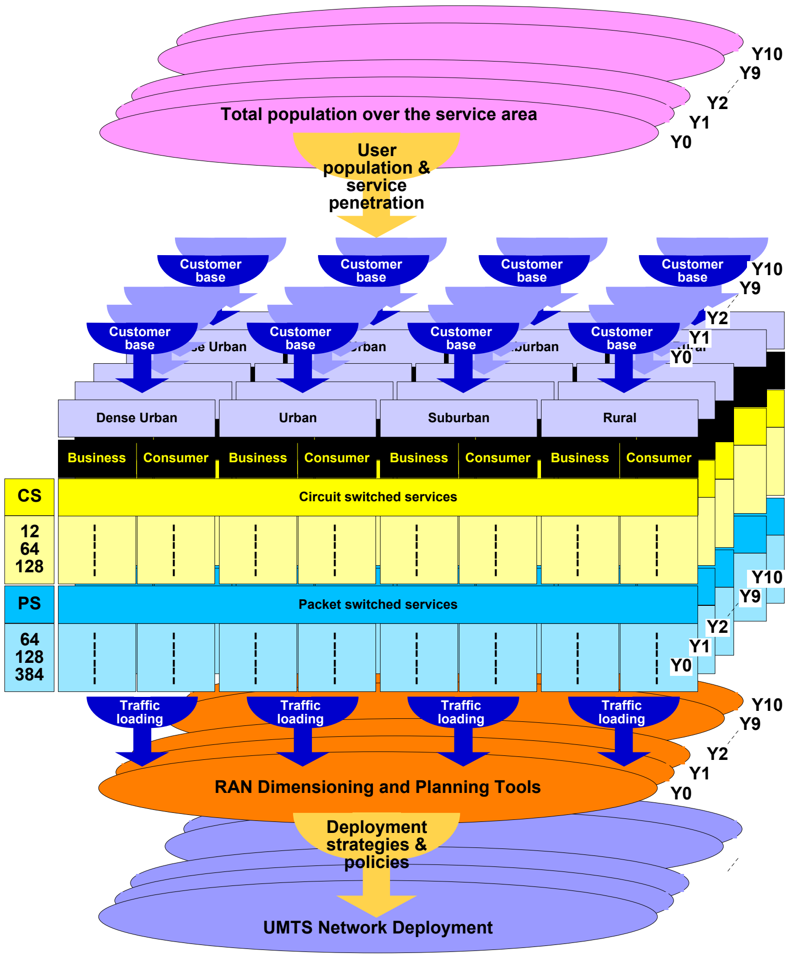
[68] The impact of license cost levels on the UMTS business case. UMTS Forum Report #3. http://www.umts-forum.org/reports.html

[69] As for capacity planning, the traffic demand results from the superposition of the demands related to the individual services. These may have different trends and, in general, different start-up times. In the following, unless stated otherwise, "demand" will indicate the superposition of the demands for the individual services.

d) a revenue structure for each service is assumed. This structure considers both the charges on the end-user and the balance between costs and revenues associated with possible agreements with third parties involved in the service support (e.g. content providers, brokers, etc). The service revenue is then subjected to a "price erosion" along the economic life of the system. This erosion depends mainly on the general trend of telecommunication service tariffs, and the operator's policy for attracting and/or preserving the customer base and face competition;

e) the NPV computation is carried out and, based on the analysis of the results, refinements of the IMT-2000 deployment strategy may be considered.

Figure 4.3.1.1: Radio Access Network planning and IMT-2000 deployment over the economic life of the system



The phases comprising the business plan are summarized in Fig. 4.3.1.1. Due to the many parameters on which the business plan may depend, a sensitivity analysis on the impact of critical parameters (such as demand estimation uncertainty ranges, slope in the service price erosion, etc), normally complements the business plan exercise[70].

70 In addition to accounting for uncertainty margins, the business plan may be made more sophisticated by including additional aspects having a bearing on costs and revenues, such as promotional actions and tariffs, co-location of 2G/3G radio infrastructure, risk and benefit sharing following agreements with service/content providers and/or brokers, and so on.

4.3.1.2 Service penetration and demand scenarios

The service demand and traffic scenarios are input to the dimensioning and planning process, and ultimately to the economic considerations of the business plan. The service and traffic scenarios are derived through a combination of data regarding, among others, demography, social aspects, service coverage areas, prospected acceptance of service offerings, traffic source activity and bit rate of offered services.

Processing the data, quite naturally, starts with identifying the service area and the overall population insisting on it (see Fig. 4.3.1.1). From the overall population, the potential customer population is identified as the one confined within specified age limits. Further, assuming a stated percentage for the population service coverage, the final customer base population is derived. From this, by assuming stated percentages of the service area for dense urban, urban, suburban and rural operation environment, and also assuming that the share of business and consumer customers are specific to each operation environment, the user population can be classified according to the joint criteria of operation environment and subscription type. Finally, assuming that the service penetration for circuit and packet switched services are also specific to the operation environment and subscription type, it is possible to derive the actual user population subscribed to IMT-2000 services. This population is now assumed evenly distributed over the service area for the purposes of estimating the offered traffic and, hence, carrying out the Radio Access Network planning. To this end, an activity factor specific to each service class is introduced and the overall traffic offered estimated (see Fig. 4.3.1.1).

To obtain the evolution of the Radio Access Network planning, the above exercise is repeated for each year along the economic life of the system, as indicated in Fig. 4.3.1.1. This involves updating of the overall population and adjusting all other input data having a dependence on time, such as the service penetration. Normally, the number and location of base stations and mobile switching centers for year N+1 correspond to those for year N plus the ones due to the increase in the customer base from year N to year N+1. In other words, no rearrangement of the radio network infrastructure in place at any time is normally considered.

4.3.1.3 Sensitivity analysis

As anticipated, several parameters having a bearing on the economic aspects of IMT-2000 deployment – and hence NPV – are either inherently affected by estimation inaccuracy or may vary depending on operator choices which, in turn, may vary in time in response to changing market and business conditions. Typical parameters considered in sensitivity analysis include:

– Traffic demand.

– Service penetration.

– Tariff erosion.

– Service offering.

4.3.2 The Business Plan exercise

4.3.2.1 Introduction

Many operators are challenged by debt burdens resulting from sometimes huge IMT-2000 license fees and large initial investments in infrastructure, existing and new operators find themselves largely dependent on the materialization of their business plans in order to create shareholder value and drive strategic go-/no-go-decisions (new entrants are additionally burdened by significant initial fixed costs of market entry).

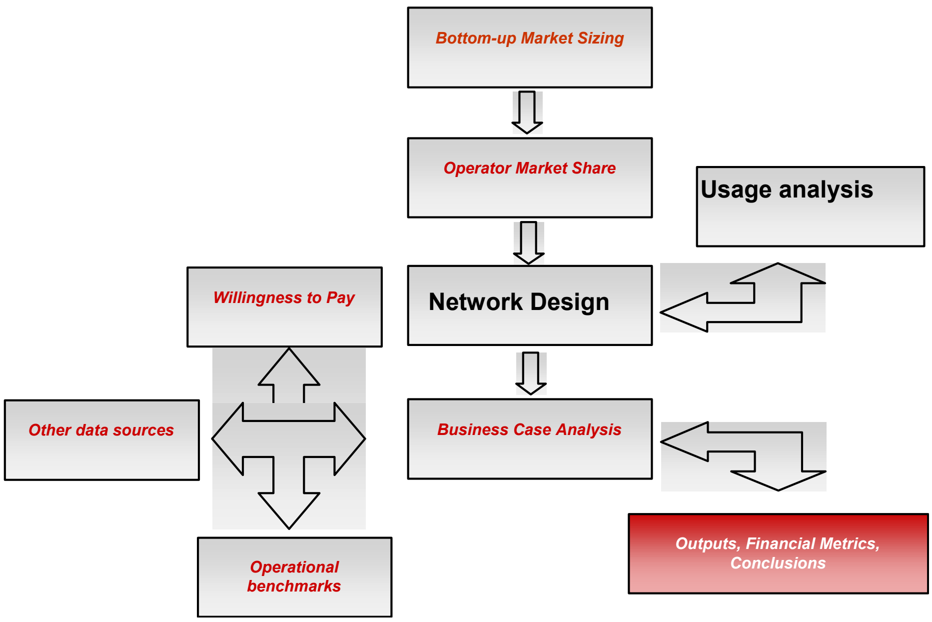
Considering the realities of increasingly saturated mobile subscriber markets and of declining voice ARPUs, the IMT-2000 vision shifts the focus from subscriber-driven growth to ARPU-driven growth. IMT-2000 business plans routinely factor in a large revenue portion originating from data applications: "IMT-2000 is fundamentally about applications". In order to make these projections come true, the subscriber making the transition from pre-IMT-2000 to IMT-2000 services, the take-up of the new services and the amount of usage of the single services must be actively driven by the operators. With this paradigm shift, introducing solid methodologies of subscriber churn simulation and revenue forecasting into the art of business planning, become crucial success factors.

This section highlights a structured approach towards IMT-2000 business plan development and real-life findings of an IMT-2000 business case, which is based on the representative, "real-life" example of a pre-IMT-2000 incumbent.

4.3.2.2 A modular approach to business planning

A possible business plan model is shown in Fig. 4.3.2.2.

Figure 4.3.2.2: Structure of the business plan model



The subscriber projections stand at the beginning and in the center of the business plan development process. Here, a forecast for the total mobile market in terms of penetration or subscribers is generated, then split into technologies (pre-IMT-2000, IMT-2000) and broken down to market share and subscriber projections for the individual operators. Finally, customer segmentation is introduced.

The revenue module uses different ways to forecast ARPU levels and ARPU trends. Budgetary and affordability approaches are top-down approaches usually used as "sanity checks": The budgetary approach is deployed for saturated or "quasi-saturated" markets (i.e. it is not economically attractive to the operators to increase penetration at the expense of price any further); the affordability or market ceiling approach applies to developing markets and does a reconciliation of penetration increase and ARPU decline (feasible penetration and ARPU level relative to GDP per capita are obviously correlated). The bottom-up approach goes the other way and consists of a per-segment and per-application model simulating pricing, take-up rates and usage of the services. Therefore it can be used to study the demand-driven dynamics of ARPU development and draw conclusions regarding the going-to-market strategy, e.g. optimal application calendars and application lifecycles.

The OPEX module uses a combination of multiples (driven by revenues, by subscriber numbers, by network topology, etc.), "brownfield" operator benchmarks (for the long-term margins after a "stable-state" is reached) and estimates for the initial "one-time" OPEX to generate an OPEX structure and development over the planning period.

CAPEX are usually determined using network component numbers resulting from an indicative or refined network planning along with pricing information to generate an investment plan. CAPEX are coverage-driven (usually in the first years) and capacity-driven (usually long-term). Outputs influence the cash flow (annual investments) and the profit and loss accounting (depreciation).

Accounting marks the final step in the business planning process: Here P&L and cash flow statements are generated as standard deliverables of a bankable business plan, and investor-side performance metrics – e.g. IRR (Internal Rate of Return) and NPV (Net Present Value) – as well as creditor-side metrics – e.g. DSCR (Debt Service Cover Ratio) and financial covenants – can be calculated.

4.3.2.3 Assumptions for a "real-life" business case

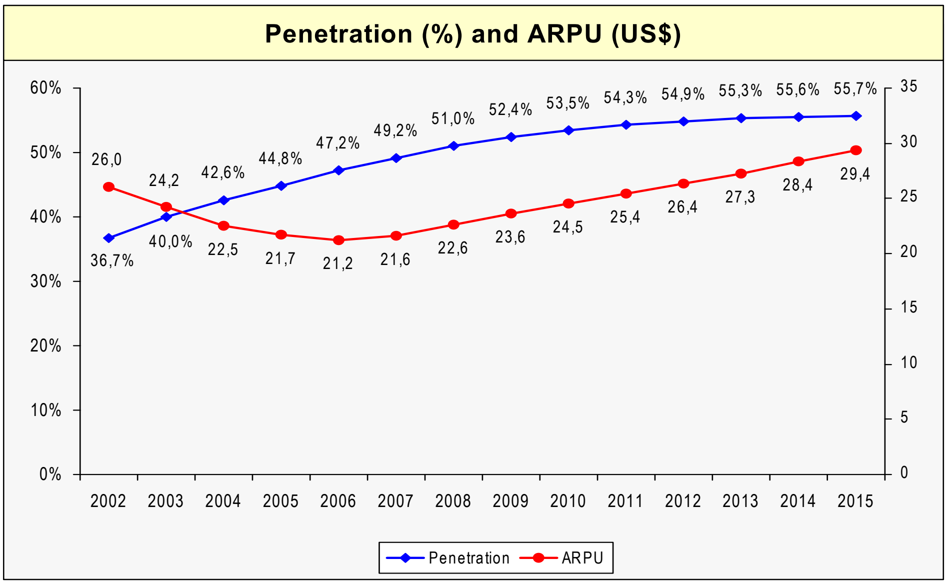
As anticipated, the business case is based on a pre-IMT-2000 operator with an IMT-2000 license and exercising its IMT-2000 business case in order to optimize investments and maximize returns and shareholder value. The market and competitive environment are as follows: The country has 24 million inhabitants and an annual GDP per capita of US$ 3.600, which is forecasted to grow by nearly 4% yearly during the next decade. After some consolidation has taken place, there will be three active mobile operators employing pre-IMT-2000 technology: "Champion", "Public", and "Mini". Champion and Public have recently been awarded additional IMT-2000 licenses, virtually free of charge (beauty contest), so that no significant CAPEX impact will originate from the license. Mini has been reluctant to engage in IMT-2000, and long-term perspectives for it are not yet clear. The planning period extends from 2002 to 2015. This example is a "worst case" business scenario where the operator has had to acquire new IMT-2000 spectrum – many operators worldwide will already have sufficient spectrum available and not have to acquire new spectrum.

4.3.2.4 Subscriber model

4.3.2.4.1 Total mobile market

The forecast for the development of the total mobile penetration is shown in Fig. 4.3.2.4.1.

Figure 4.3.2.4.1: Penetration forecast and "sanity" check



A “sanity check” employing an affordability-driven market ceiling model was done in order to reconcile the penetration assumptions with a top-down ARPU development estimate. This means that later, when the ARPU is modeled bottom-up, results may be produced up to that level without inhibiting the penetration projections. It is evident that in the current phase of a still strong market growth (from 36,7% in YE 2002 to 47,2% in 2006) ARPUs are set to fall, while later, when penetration approaches a level of 56% (considered a long-term “quasi-saturation” for this market). ARPUs may raise again following budgetary considerations, since for this country an annual GDP per capita growth of nearly 4% is assumed. Considering that voice prices are likely to decline and voice usage to remain flat, the gap in ARPU could be filled with revenues from data applications in the 2.5G, but especially in the IMT-2000 context.

4.3.2.4.2 Technology transition

Next, assumptions on the future technology split must be taken. For this business case, two distinct technology segments, pre-IMT-2000 and IMT-2000 are considered.

Note that an IMT-2000 subscriber is defined as a subscriber who has an IMT-2000 capable handset and uses a contract or prepaid package which allows him to use IMT-2000 services (the individual take-up and usage are assessed later in the revenue section). Like with a multitude of innovation adoption cycles observed in real-life, an S-curve type transition from pre-IMT-2000 to IMT-2000 seems fit for the purpose of describing the technology split. Pre-IMT-2000 and SMS adoption curves of the past provide a good benchmark for this qualitative behavior, with timing and slope of the S-curve remaining to be determined. To this end, separate assessment is performed of the acceptance of IMT-2000 in the “fresh market” (first time mobile users) and within the current pre-IMT-2000 subscribers, i.e. the “technology churners”.

Figure 4.3.2.4.2-1: Technology split

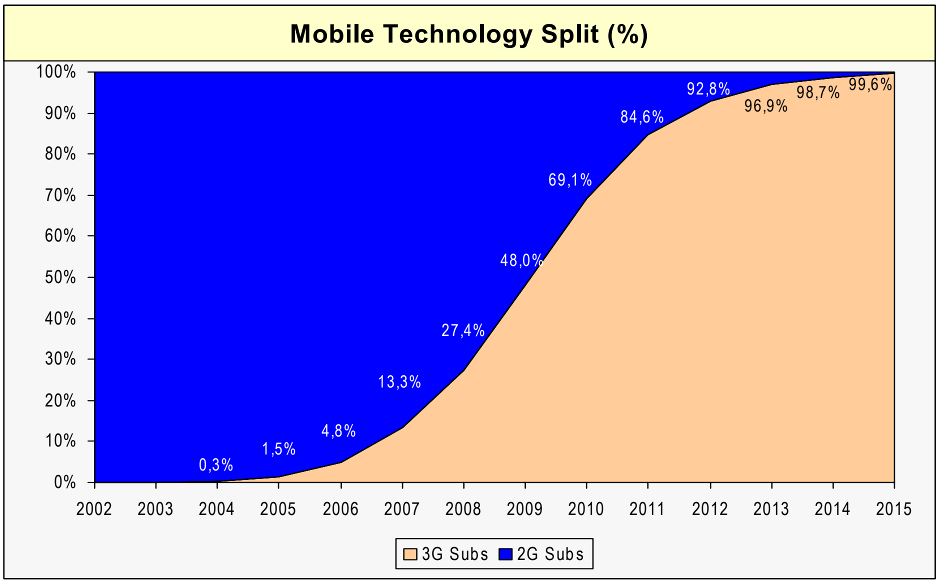
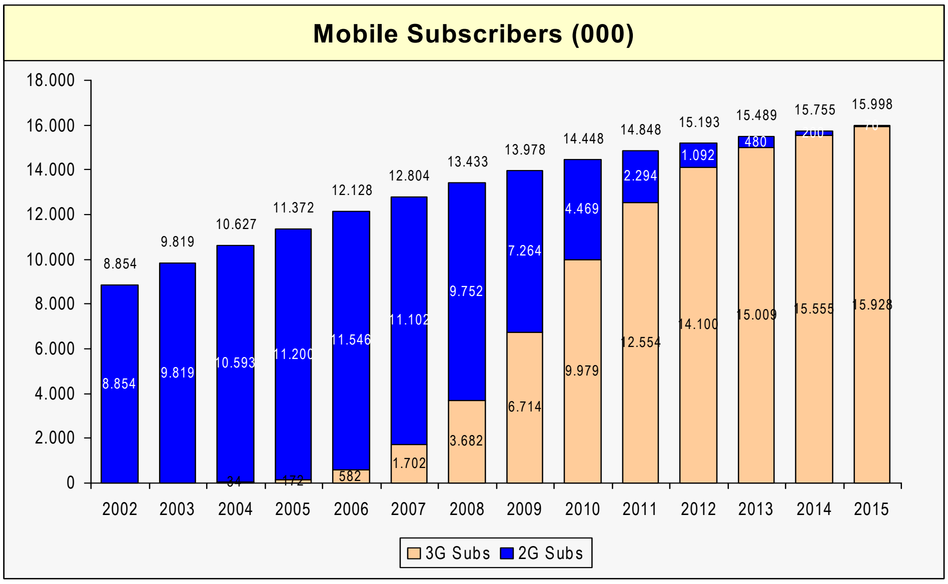


Figure 4.3.2.4.2-2: Subscriber base growth



As with the launch of any new technology, the initial IMT-2000 handsets will be priced at a premium and operators will have to decide whether to price the new data services as prestigious new offerings or low-cost services to attract new subscribers. In this exercise, it is assumed that high-end pre-IMT-2000 customers will be the first to become IMT-2000 subs, while the remaining lower-end and highly price-sensitive "fresh market" not yet using any mobile services will purchase basic services for a low price. On the other hand, a certain number of pre-IMT-2000 subscribers are also likely to be "inactive users" who are not really aware of innovations and rarely reassess their choice of product/service. The technology transition assumptions also have an impact on the differentiation of pre-IMT-2000 and IMT-2000 ARPU, which will be modeled later. Adding the different factors, the technology transition curve is as shown in Fig. 4.3.2.4.2-1. Combining penetration and technology split, the projections for the subscribers per technology are as shown in Fig. 4.3.2.4.2-2.

4.3.2.4.3 Market shares

Often-used methods of the business planning and analyst community to project market shares are "share of net adds" and "share of gross adds": The first method distributes the net additions according to certain percentages of the market between the operators; however, when the existing base is not negligible (as in every somehow developed market!), this method is inaccurate, since it ignores churn.

The second method distributes the gross additions between the operators, i.e. the yearly churn is added to the net additions defining a pool of subscribers which can be attracted by either operator; this is obviously better than the first method, but becomes inadequate when a large and some smaller operators coexist in a market, because the large operator will lose more churners in absolute numbers, given its large base, and these churners are subtracted from its addressable market, so that its share of churners will then be much smaller than its share of "fresh market". Furthermore, most analysts do not model different technologies as distinct sub-markets, so that the effect of some operators being active only in one technology, or having different launch schedules for the new technology cannot be distinguished.

These problems can be solved by modeling two distinct sub-markets, pre-IMT-2000 and IMT-2000, which are linked through the technology transition, and by defining different "churn pots" (i.e. addressable churners) for each operator. Technological churn (between the two sub-markets) is considered separate from competitive churn (within each sub-market). Key drivers are the "market attractiveness" of each operator, determined through a scoring model, the churn rates, and the "retention rates" of technology migrators, i.e. the percentage of those who stay with the same operator, provided that it also offers the new technology.

Figure 4.3.2.4.3-1: 2G subscribers per operator

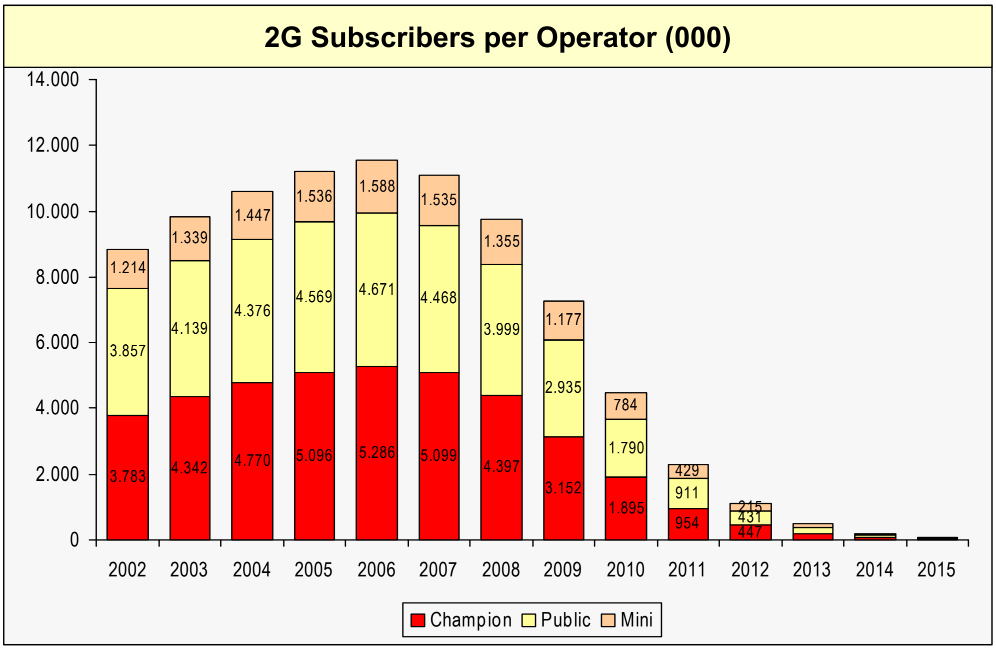


Figure 4.3.2.4.3-2: IMT-2000 subscribers per operator

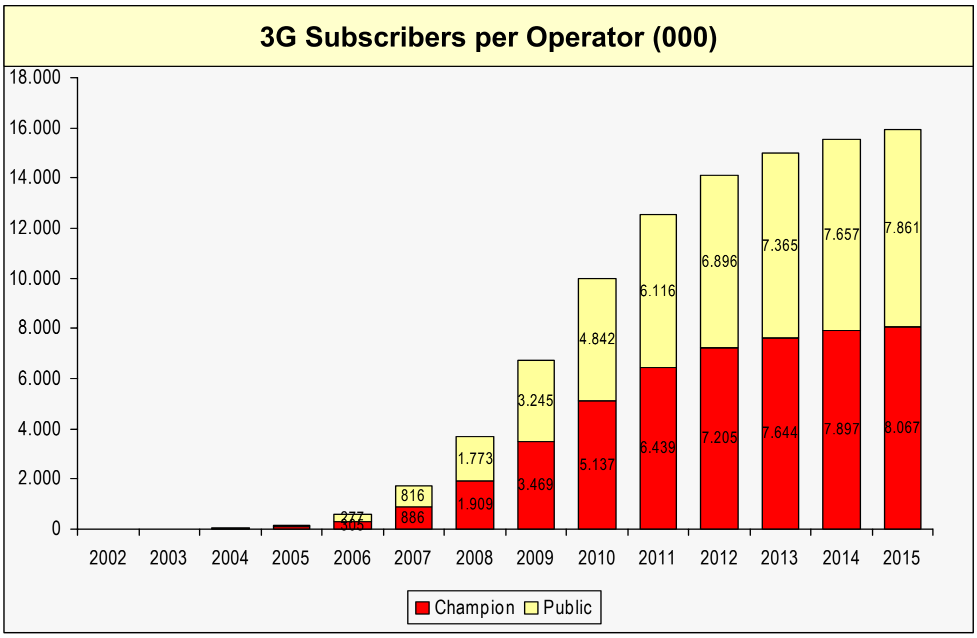


Figure 4.3.2.4.3-3: Total subscribers per operator

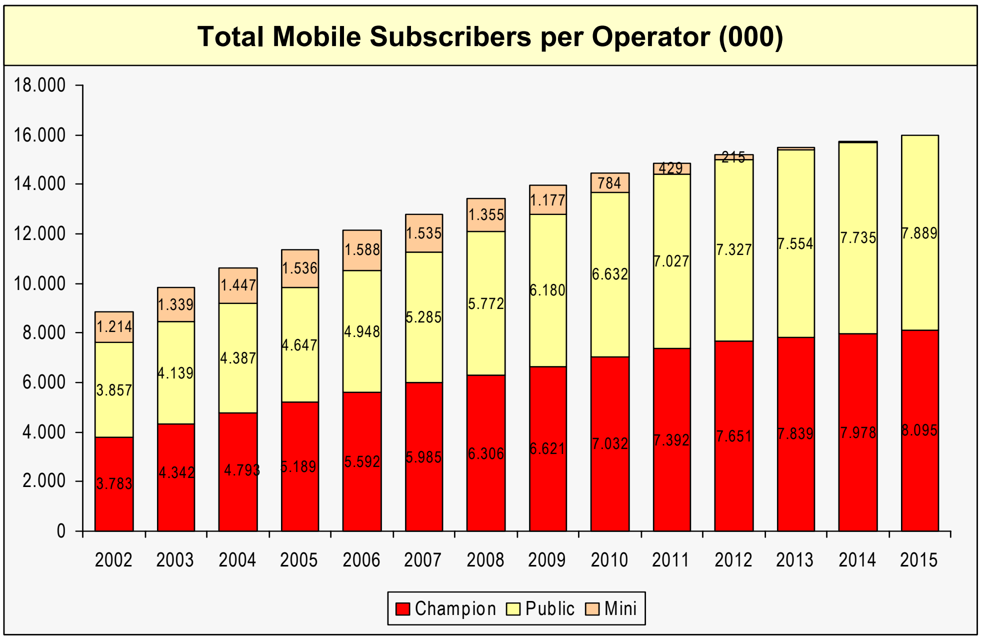
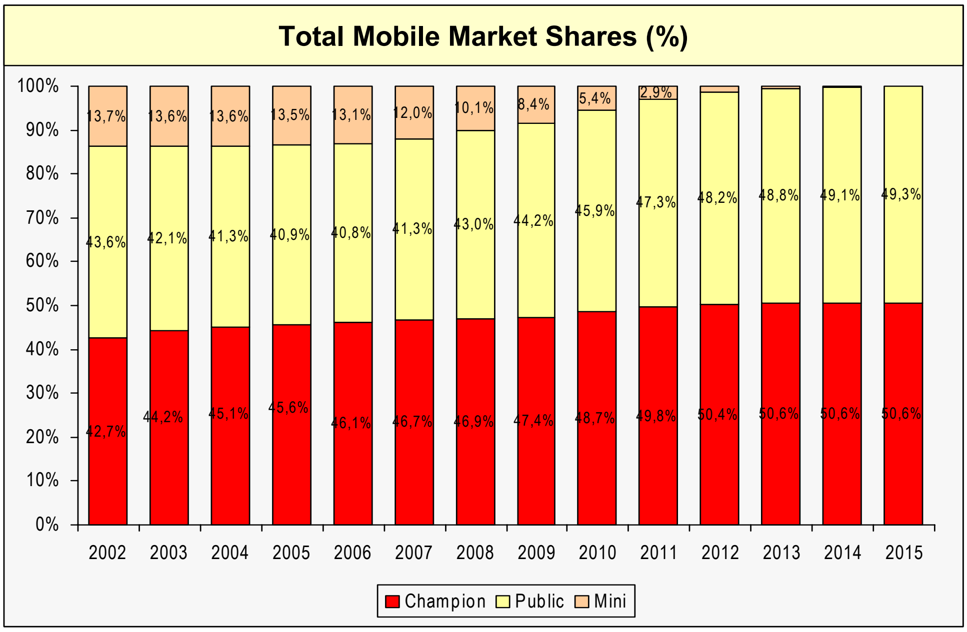
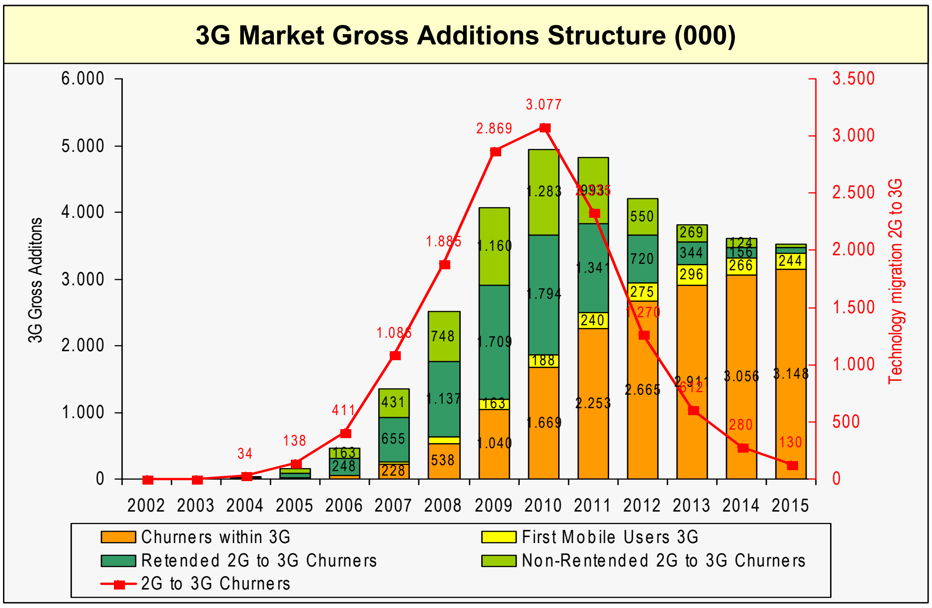


Figure 4.3.2.4.3-4: Total market shares per operator



The outcome of the market share and subscriber simulation is shown in Figs. 4.3.2.4.3-1 to 4.3.2.4.3-4, for the pre-IMT-2000, IMT-2000and total market respectively. The pre-IMT-2000 market should be shrinking after 2006. Champion is expected to perform strongly. However, only Mini may be able to achieve a significant change in market share, given its small existing base; the two incumbents are likely to stabilize their market shares at ~40%. With a decreasing pre-IMT-2000 market, this will give Mini only a modest benefit regarding subscribers in absolute terms, however. With IMT-2000 taking place, the incumbents' attention and competition will likely be shifted towards the IMT-2000 context in the later years. Mini is no player in that market, which would – if IMT-2000 transition will be complete – lead to Mini's extinction.

Figure 4.3.2.4.3-5: IMT-2000 market gross additions structure



Other options might include Mini introducing an MVNO (Mobile Virtual Network Operator) model with either Champion or Public as network partner. By counting the subscribers towards the "real" network operators, the "disappearance" of Mini as a IMT-2000 network operator will in any case open up the market for a split between Champion and Public, where a (small) advantage for Champion has been forecast.

Fig. 4.3.2.4.3-5 shows the structure of the gross additions to the IMT-2000 sub-market and gives some interesting information for a recommendable going-to-market strategy: Net additions to IMT-2000 come solely from retained and non-retained technology migrators from pre-IMT-2000, and from "fresh market" starting directly with IMT-2000. The latter is nearly negligible, and the incumbents will clearly focus on first retaining their technology migrators, second acquire technology churners from Mini, and third compete between themselves.

4.3.2.4.4 Segmentation

Champion's subscribers need to be segmented in order to hand over the data needed for the revenue calculation, since ARPU modeling will be done bottom-up per segment. The results are shown in Figs. 4.3.2.4.4-1 to 4.3.2.4.4-3. As can be seen, most of the growth is assumed to come from the residential prepaid segment, which long-term will account for 70% of the subscriber base (now: 60%), while residential postpaid will give 20% (now: 25%), corporate and business 10% (now: 15%). The quality of the subscriber mix in pre-IMT-2000 is set to deteriorate much quicker and more than overall, because higher-end subscribers will gradually make the transition towards IMT-2000, which in turn enjoys a very high-end subscriber base from the beginning (business and residential postpaid) and will converge towards the long-term total market ratios, as stated above.

Figure 4.3.2.4.4-1: Champion's year average subscribers

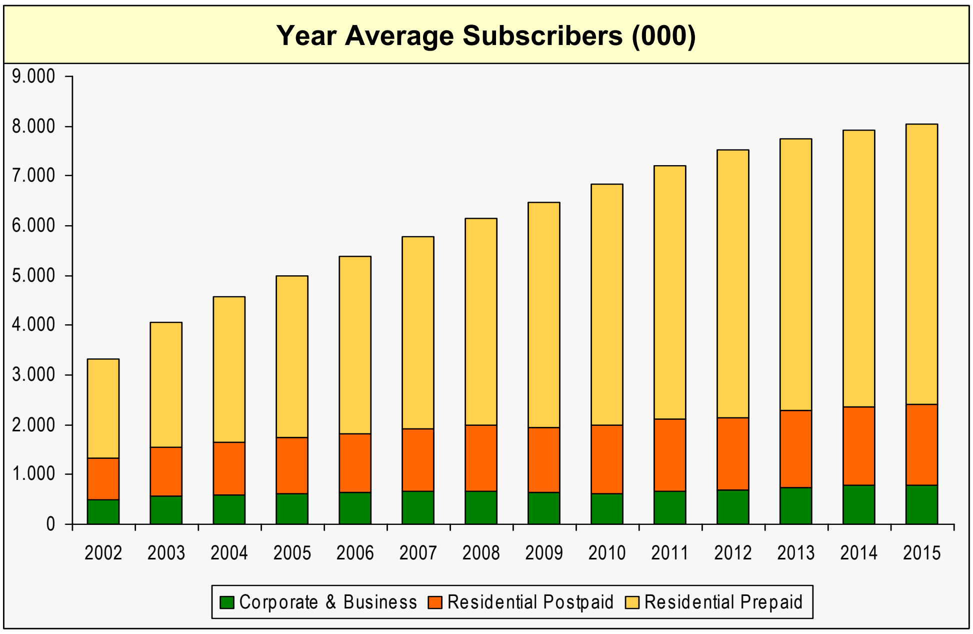


Figure 4.3.2.4.4-2: Pre-IMT-2000-subscriber segment split

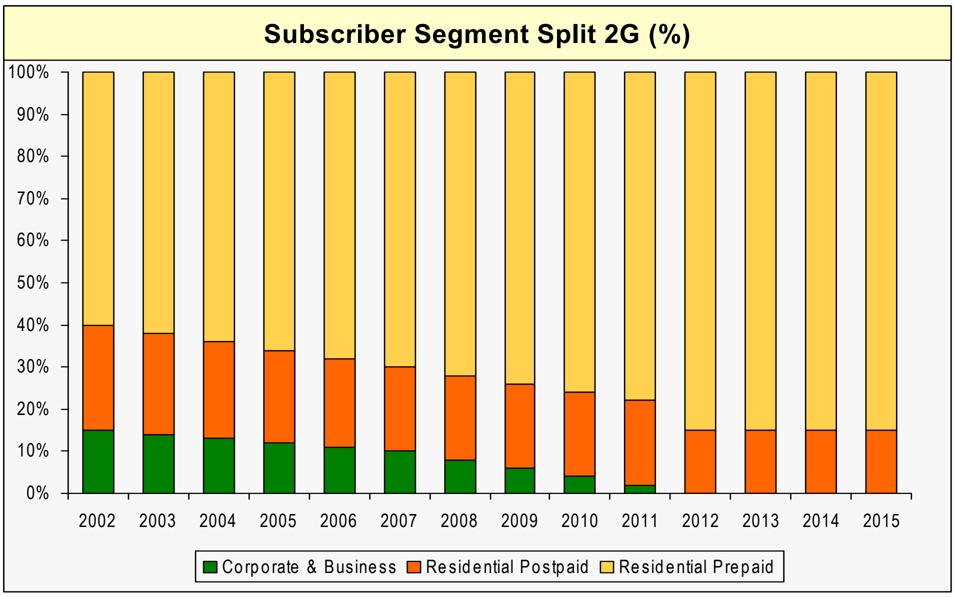
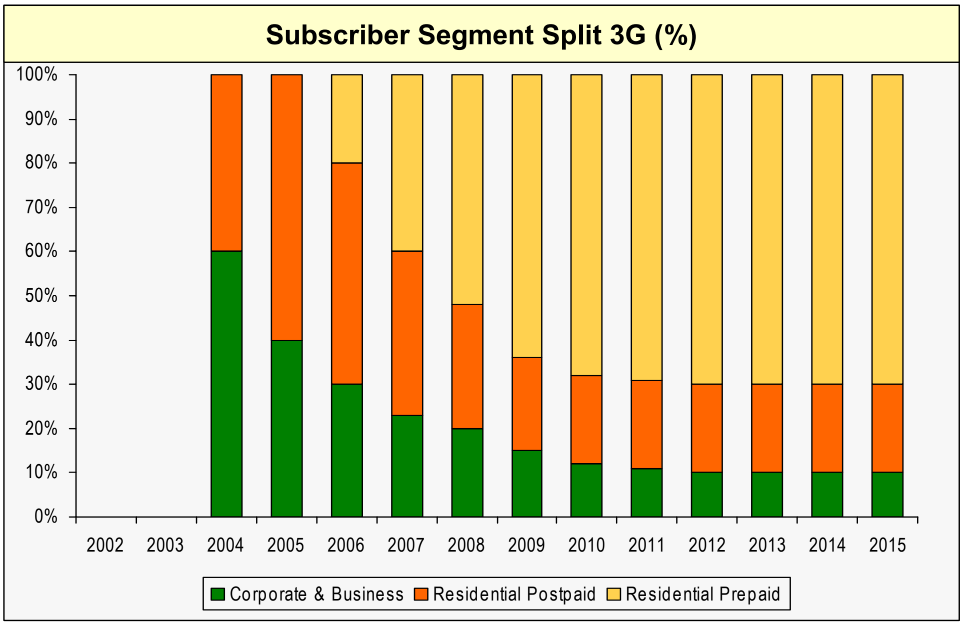


Figure 4.3.2.4.4-3: IMT-2000 subscriber segment split



4.3.2.5 Revenues

After having used top-down revenue modeling already to check the plausibility of the penetration projections, consideration can be given to bottom-up modeling of the revenues per technology (pre-IMT-2000, IMT-2000), per segment (corporate and business, residential postpaid, residential prepaid) and, regarding data revenues, per application, following the schematics of Fig. 4.3.2.5-1. Note that for data revenues, take-up rate (i.e. how many subscribers of a segment use a certain application) and usage (how much the active users use the application) are treated separately.

Figure 4.3.2.5-1: Revenue Calculation (per technology and segment)

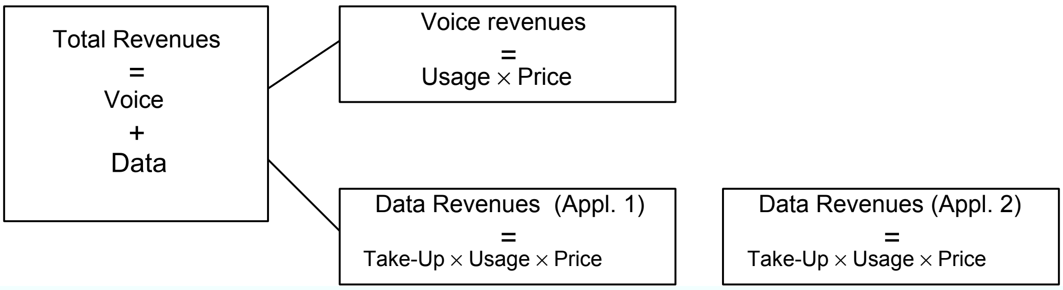


Fig. 4.3.2.5-2 illustrates the ARPU, Fig. 4.3.2.5-3 the revenue outcome of the business model. Because of the initially very high-end subscriber mix in IMT-2000, IMT-2000 ARPUs start at a much higher level than pre-IMT-2000 ARPUs. Data share of IMT-2000 ARPU (starting at 13%, growing to 32%) is obviously much higher than data share of pre-IMT-2000 ARPU (~3%) at all times. pre-IMT-2000 ARPU will decline fast not only due to decrease in voice ARPU, but also because pre-IMT-2000 subscribers will be gradually lower-end, while high-end subscribers will migrate towards IMT-2000 fast. However, with migration going on, also the IMT-2000 subscriber quality will converge towards market level, bringing falling IMT-2000

ARPUs. Taking all ARPU effects and subscriber migration effects together, blended monthly ARPU shows a decrease from USD 27,2 to USD 16,3 until 2006, and then a ramp-up again resulting from increasing IMT-2000 data revenues. The ARPU curve is also in line with the affordability and budgetary considerations discussed with the penetration projections.

In the revenues, the increase in subscribers until 2006 will overcompensate the decrease in ARPU. After 2007, the benefits of IMT-2000 begin to materialize, adding ~50% to the revenues until 2015. After 2007, revenues from IMT-2000 become a crucial factor in Champion's business.

Figure 4.3.2.5-2: ARPU

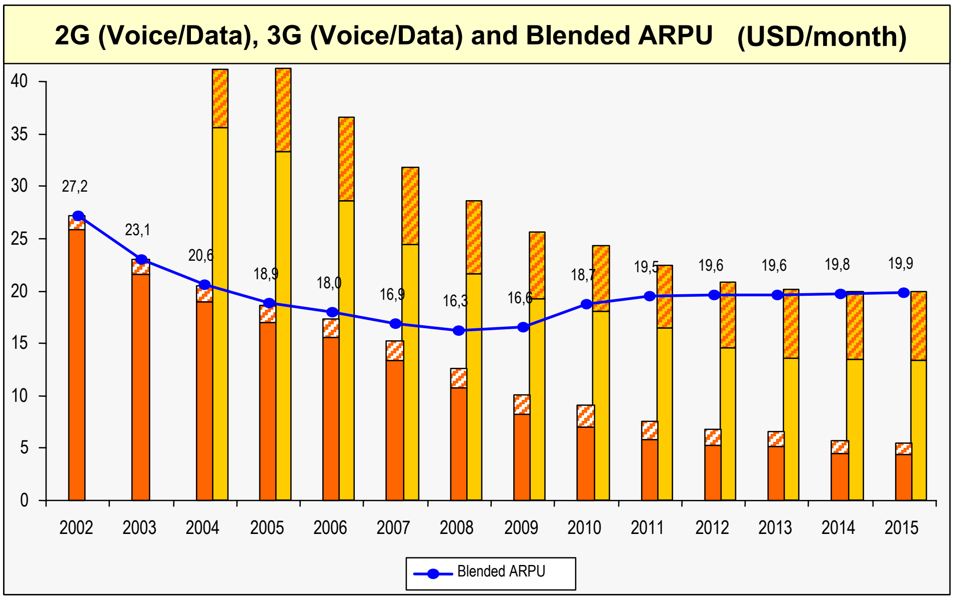


Figure 4.3.2.5-3: Revenues

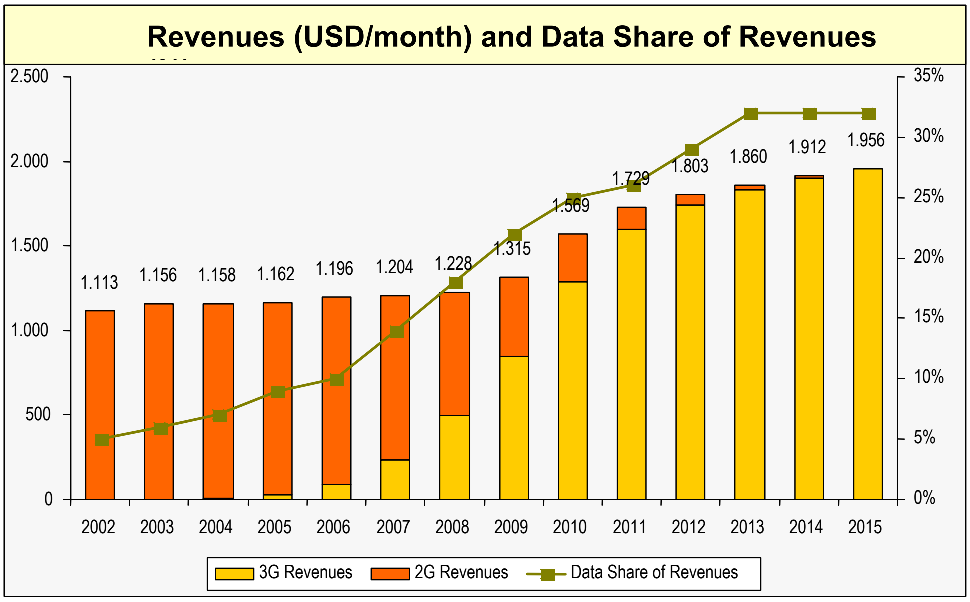
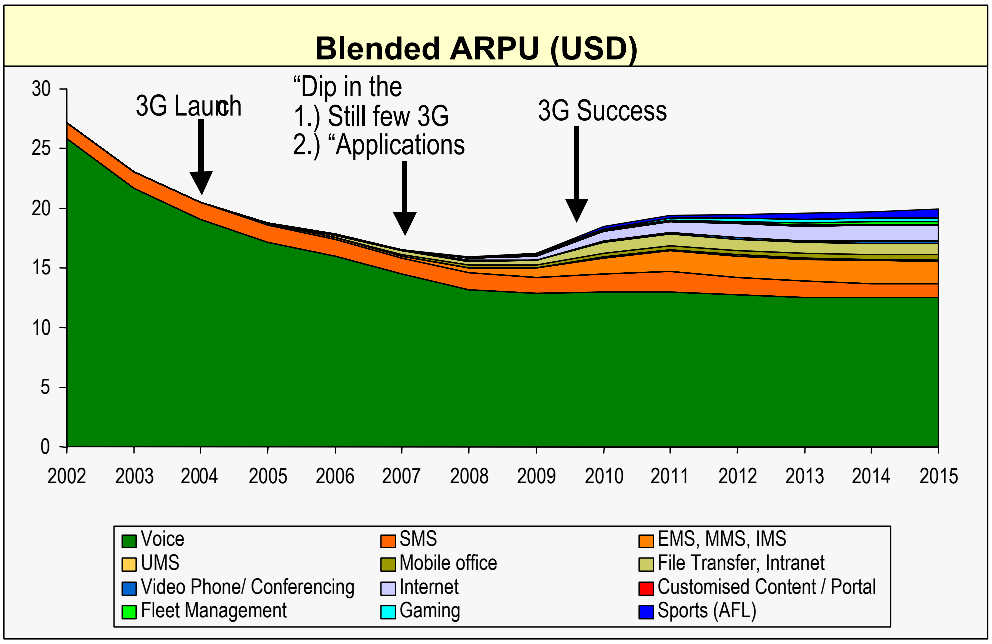


Fig. 4.3.2.5-4 details the blended ARPU structure. The contributions to the blended ARPU resulting from IMT-2000 data applications appear to become beneficial after 2007, when the "fan out" of applications starts to translate into money for the operator. Before that, most of data revenues are expected to originate still from SMS usage, at least in blended ARPU. In pure IMT-2000 ARPU, the situation is different, of course, since there will be a higher data share of ARPU right from the beginning, and even in the beginning the IMT-2000 application portfolio will comprise multiple applications.

Figure 4.3.2.5-4: Blended ARPU breakdown



There are two effects that lead to this "dip in the middle" in blended ARPU that is typical for a technological innovation situation such as IMT-2000 migration:

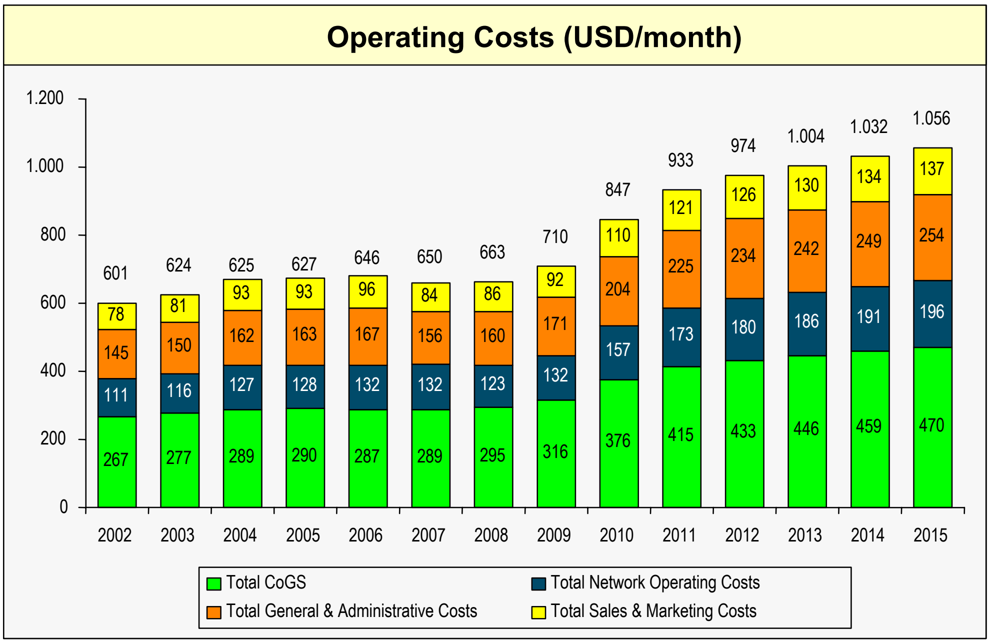
Firstly, in the beginning the subscriber base is still dominated by pre-IMT-2000 subscribers, so that the higher ARPU of the IMT-2000 subscriber only contributes little to the blended ARPU; secondly, even IMT-2000 ARPU may not culminate right at the start, because applications first have to get acceptance among the customers. The combination of these two factors results in a time lag between introduction of the new technology and the "cash out" phase for the operator. Actually, the two issues are linked by the fact that an attractive portfolio of applications will both trigger faster subscriber migration and higher IMT-2000 ARPUs (another facilitator to speed up subscriber migration would be to offer more heavily subsidized IMT-2000 handsets, however the resulting increase in OPEX could offset the short term gain when looking at the level of EBITDA, Earnings Before Interest and Taxes, Depreciation and Amortization). Of course, beyond these considerations there is also the strategic imperative to retain high-value customers who are likely to be first movers in any technology transition, and will give IMT-2000 a good customer mix right from the start, although at limited absolute numbers. The early adopter of IMT-2000 among the operators is likely to maintain this advantage in subscriber quality over the time.

4.3.2.6 OPEX

Champion operates its pre-IMT-2000 business efficiently and has therefore established a typical OPEX structure of a "brownfield" operator, meaning that the various OPEX categories represent stable percentages of revenue, there are no significant one-time costs, and EBITDA margins of 46%, EBIT (Earnings Before Interest and Taxes) margins of 33% have been established. The introduction of IMT-2000 means not only investment into assets and their depreciation, but also a certain volume of one-time and fixed costs, while IMT-2000 revenue has yet to rise, so that the business case of the incumbent is destined to "suffer" in the initial years, regarding operating results.

In this analysis, the EBITDA margin is estimated to fall to 42% in 2004 and 2005 and to reach back at a stable long-term level of 46% in 2007/2008. The OPEX breakdown is shown in Fig. 4.3.2.6.

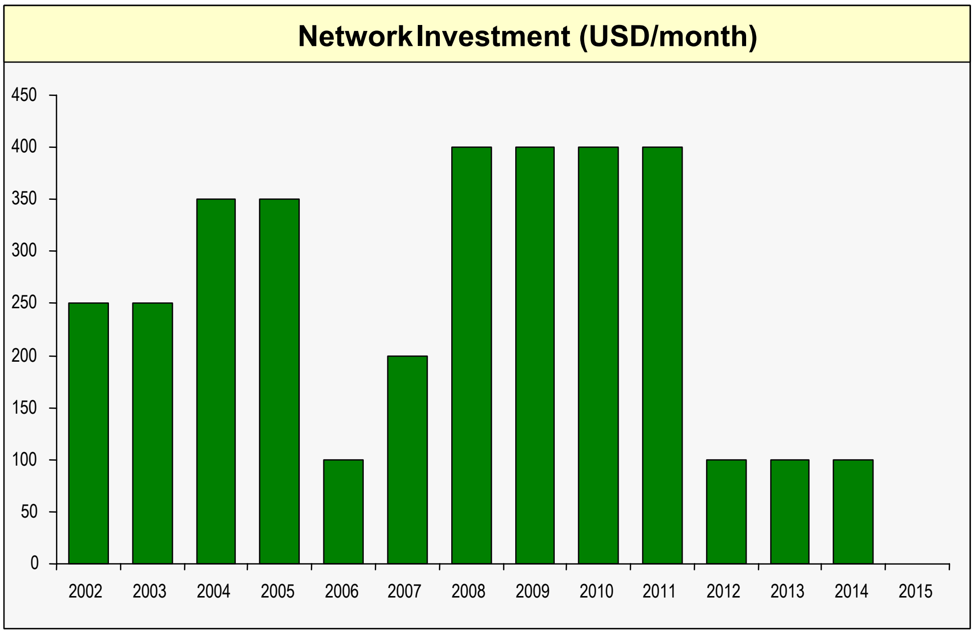
Figure 4.3.2.6: OPEX breakdown



4.3.2.7 CAPEX

Indicative CAPEX for Champion are shown in Fig. 4.3.2.7. Until 2005, strong pre-IMT-2000 subscriber growth implies that a large portion of the investment is still dedicated to the pre-IMT-2000 infrastructure. IMT-2000 investment starts in 2004 and is initially coverage driven; after 2007, further significant IMT-2000 CAPEX should be planned in order to increase capacity. After 2011, there should be little further CAPEX related to IMT-2000.

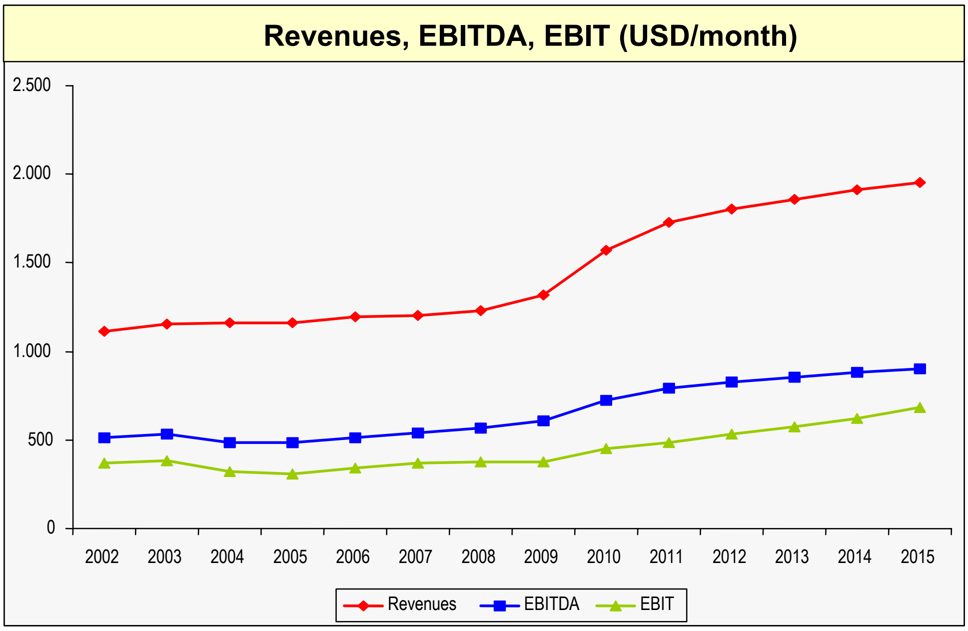
Figure 4.3.2.7: CAPEX



4.3.2.8 Accounting

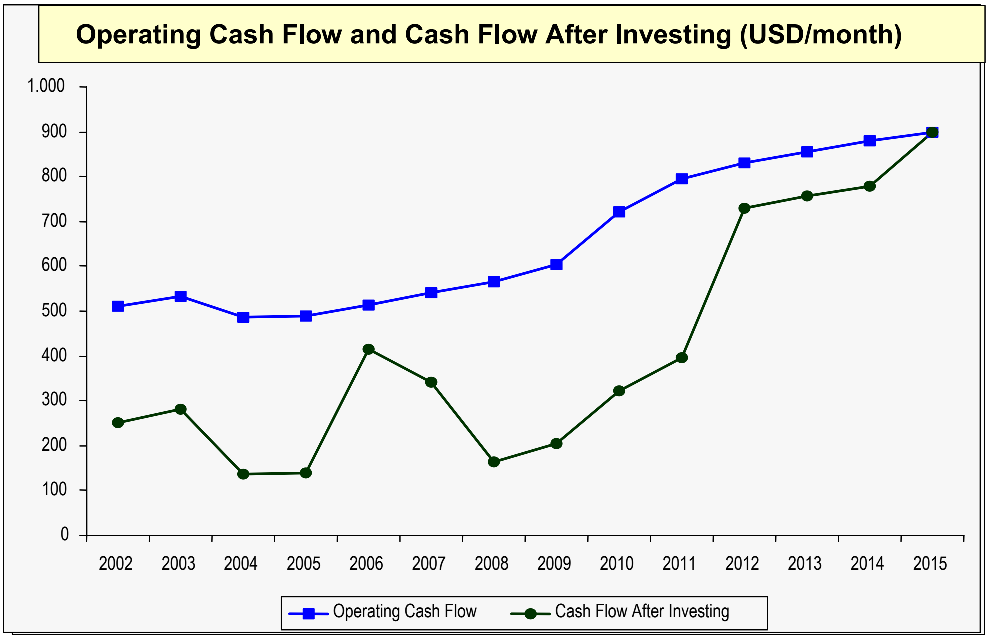
Revenues, EBITDA and EBIT are shown in Fig. 4.3.2.8-1. Revenues have already been discussed. EBITDA margin is 46% in the beginning, will decrease to 42% temporarily with the launch of IMT-2000, and reach back at 46% in 2007/2008. EBIT margin is 33% in the beginning, will decrease to 26,5% in 2005, and then slowly rise to 34,8% in 2015.

Figure 4.3.2.8-1: Revenues, EBITDA, EBIT



Cash flow projections are shown in Fig. 4.3.2.8-2. The two strong investment cycles (pre-IMT-2000-extension/IMT-2000-introduction and IMT-2000-extension) can be seen as large gaps between operating cash flow and cash flow after financing. The operating cash flow will double between 2002 and 2015, the cash flow after investing even grow three times.

Figure 4.3.2.8-2: Cash flow



4.3.2.9 What happens if "Champion" abandons IMT-2000?

If Champion abandoned its IMT-2000 plans, the following implications on the market and its own business would result (the results are shown in Figs. 4.3.2.9-1 to 4.3.2.9-4):

- In this market with two large and a smaller operator, the decision of the smaller operator not to introduce IMT-2000 was assumed not to have a big impact on the overall technology migration. The decision of the big players on IMT-2000 launch and respective timing, however, would have an impact on the general IMT-2000 migration. If Champion didn't start IMT-2000, IMT-2000 migration would be slower, and a larger "residual" 2G/2.5G base would most likely be carried forward within the planning period.
- Champion would obviously offer some 2.5G services to its clients. However, the high-end mobile users would still want to use IMT-2000, and therefore churn to the only IMT-2000 operator, Public.
- These both factors would give Champion a smaller addressable market in the future, less subscribers, and a lower-quality subscriber mix with lower ARPUs. Subscriber numbers in the pre-IMT-2000-only case should be roughly half than with IMT-2000 in the long term. ARPUs without IMT-2000 should also be about half than in the original case. Therefore, revenues without IMT-2000 should be ¼ of the originally projected revenues, i.e. with IMT-2000 revenues would double, without IMT-2000 revenues would half in the long term.
- On the OPEX side, there would be no one-time effects on EBITDA margins from a IMT-2000 launch, but on the other side the lower ARPU level would also drive down profitability (many OPEX are linear with subscriber number, not with revenues!), leading to a lower stable-state EBITDA margin that may well be only 40% in the long run.

- On the CAPEX side, the impact of not introducing IMT-2000 would mean that only some capacity-driven investments into 2G/GPRS equipment during the pre-IMT-2000 subscriber growth from 2002 to 2006 would have to be carried out (which is necessary in any case).
- EBIT would not be lowered by IMT-2000 assets depreciation, but the residual investment into pre-IMT-2000 extension would still have to be depreciated.
- Without IMT-2000, cash flow after investing would be higher between 2004 and 2010. In the long-term, however, it would decrease dramatically, in line with the falling revenues.

Figure 4.3.2.9-1 Subscriber comparison

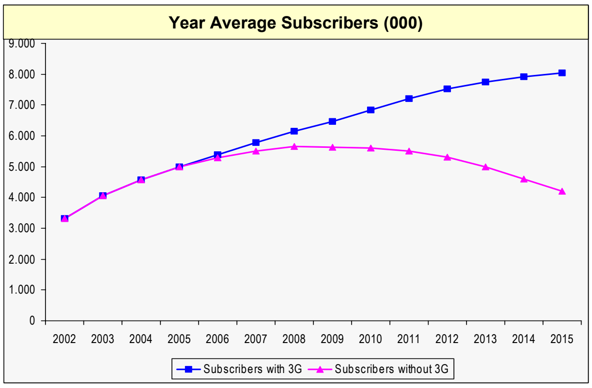


Figure 4.3.2.9-2 ARPU comparison

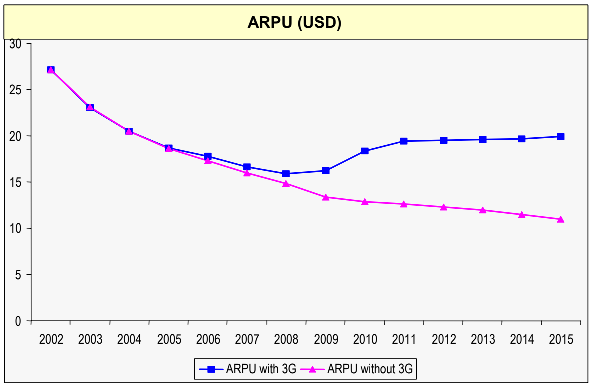


Figure 4.3.2.9-3 Cash flow comparison

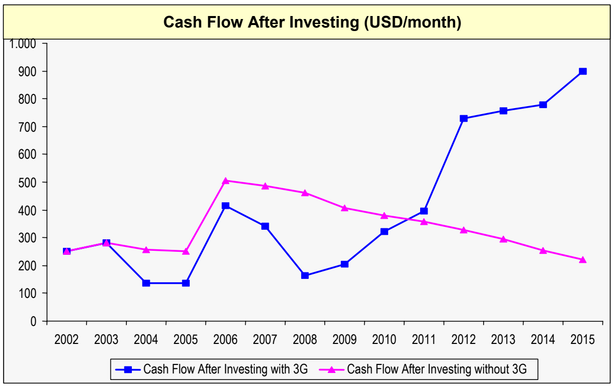
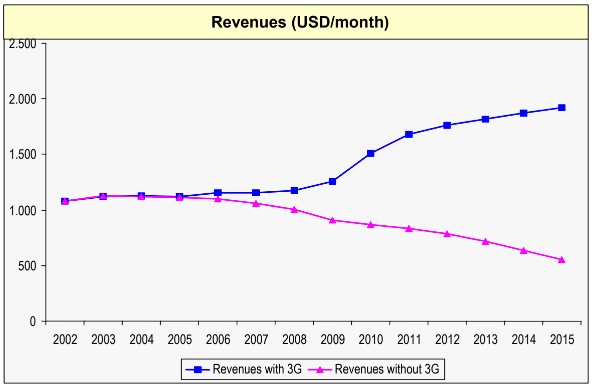


Figure 4.3.2.9-4 Revenue comparison



4.3.2.10 Conclusions

The findings of the business case suggest that Champion is well advised to take a "go" decision with respect to IMT-2000 deployment. In fact, the additional investment in infrastructure appears to have only limited impact on Champion's business case, both in terms of numbers and in terms of time frame. Champion will be able to double subscriber numbers, recover high ARPU levels, double revenues, reestablish good EBITDA and EBIT margins, get solid cash flows. On the other side, to abolish IMT-2000 seems to be a clear way out of business, in the long term: The addressable market shrinks, as users migrate to the new technology; market share decreases; technology migration offsets market growth, subscriber numbers decrease; the best customers leave first, ARPU declines; revenues fall dramatically; EBITDA margins become worse not better; falling operating cash flow pulls down cash flow after investing, even without investment.

5 CONCLUDING REMARKS

The net effect of the gradual substitution of pre-IMT-2000 systems with IMT-2000 systems worldwide will be the result of the combination of substitution processes in many countries where local conditions and investment policies will determine the actual transition path and, ultimately, the speed of the transition.

A range of requirements and expectations condition the transition from pre-IMT-2000 to IMT-2000 systems – with those associated with capitalizing on investments in infrastructure already in-place playing a key role. Although these motivations are generally common to different countries and different operators, it is their perceived relative importance, as well as the attitude towards transitioning, that determine the actual transition path in developed and developing countries. In particular, the former base their decisions on when and how to go for IMT-2000 systems on an investment-against-revenue trade-off, whereas the latter tend to consider the transition to IMT-2000 as a way of bridging the digital divide and solve the service delivery/distribution problem – provided that costs be affordable. In this respect, further important requirements for developing countries include low investments for entry networks and economic provision of service coverage in sparsely populated areas.

Evolution and migration are the phases through which a transition materializes, with the mix and sequence determined on the basis of economic and strategic decisions. In general, not only for developing countries, evolutionary system upgrades are preferable from the operator and user points of view, because earlier investment can be largely reused. However, in reality pure system evolution is never possible, since even for the most flexible system design at least software updates or even hardware-updates (i.e. replacements) are necessary for some network components, if new features enhance the system. Moreover, experience shows that in time every technology will reach its expansion limits (i.e. even evolutionary enhancements will eventually lead to unacceptable system complexity). At that stage, technology jumps are necessary, leading to the need for a new system, which is then incompatible with the old one and requires an appropriate migration and interoperability strategy.

6 DEFINITIONS

For the purposes of these Guidelines, the following definitions will apply.

Term	Source	Definition
Evolution	ITU Handbook	A process of change and development of a mobile radio system towards enhanced capabilities (Rec. ITU-R M.1308).
Evolution towards IMT-2000	ITU Handbook	A process of change and development of a mobile radio system towards the capabilities and functionalities of IMT-2000 (Rec. ITU-R M.1308).
Migration to IMT-2000	ITU Handbook	Movement of users and/or service delivery from existing telecommunication network to IMT-2000 (Rec. ITU-R M.1308).
Pre-IMT-2000	ITU Handbook	Mobile systems that are currently in service or will be introduced prior to IMT-2000 (Rec. ITU-R M.1308). Note – In the context of these guidelines the definition of "Pre-IMT-2000" applies to all deployments of systems conforming to pre-IMT-2000 standards, as covered in Recommendations ITU-R M.622, M.1033 and M.1073.
3GPP Release	3GPP TR 21.900 V5.0.1	Specifications are grouped into "Releases". A mobile system can be constructed based on the set of all specifications, which comprise a given Release. A Release differs from the previous Release by having added functionality introduced as a result of ongoing standardization work within the Groups. Specifications pertaining to a given Release shall be distinguished by the first field of the version number ("x" in x.y.z: he meaning of the three fields is defined in 3GPP TR 21.900 V5.0.1[71]). A given specification may simultaneously exist in several versions, each corresponding to a different Release. In principle, a Release of the specification can be identified as consisting of all those specifications with a "major" version field of a given value.

71 3GPP TR 21.900 V5.0.1 "… outlines the working methods to be used by the 3GPP Technical Specification Groups and their Working Groups and their Sub-Groups, and by the 3GPP Support Team in relation to document management, i.e. handling of specifications, updating procedures, change request procedures, version control mechanisms, specifications status information etc. It complements the rules and procedures defined for 3GPP. …"

For the purposes of fully clarifying 3GPP specification process and release concept, 3GPP TR 21.900 V5.0.1 is given in Annex E.

3GPP Specification	3GPP TR 21.900 V5.0.1	Generic term standing for Technical Specification and Technical Report. Each specification is associated with a "version number" in the form x.y.z which uniquely identifies the document. In general, a 3GPP Technical Specification (TS) is identified by: • the specification number, e.g. 3GPP TS <aa.bbb>; • the version number, e.g. V <x.y.z>; • the specification title; • the release number, e.g. for UMTS, Release 5. The significance of the fields <aa.bbb> and <x.y.z> is defined in 3GPP TR 21.900 V5.0.1. In particular, the range of the field "aa" depends on the type of system. For the UMTS system (Release 1999 onwards), the field "aa" ranges from 21 to 35, for identifying coverage of aspects related to: requirements specifications, service, technical realization, signaling protocols, radio access and core network, SIM/UIM, security, test specifications, etc.
3GPP Version	3GPP TR 21.900 V5.0.1	Unique identifier in the form x.y.z for a specification at a given point in time. Example: version 3.12.3.
3GPP2 Publication	3GPP2 S.R0097	Any document published by a 3GPP2 constituent body (Technical Specification Group, or Steering Committee). A publication must conform to the Publication Numbering Scheme, briefly defined as follows. A.Bcccc[-ddd]-X version y.z Where: A [A] identifies the publishing TSG/body [A, C, S, X or SC] B denotes project, report or specification [P, R, S] cccc is the 4-digit document number [0000-9999] ddd is the optional 3-digit part number for multi-part documents [000-999] X denotes revision [0, A-Z]: 0 is the initial release (0th revision), A is the first revision, and so on y is the "point release" number 0 is used when the document is first created, 1 number is incremented whenever the document is approved for publication (e.g., 1 is the first approval by the plenary for publication) z is an internal edit level 0 internal edit level z, always reset to 0 when the document is approved for publication, 1 internal edit level is incremented by the entity (e.g., working group) that is developing the document. The Publication Process completes the development life cycle of a new revision of a 3GPP2 specification (see definition of "3GPP2 Document Revision"). The development cycle is a three-stage process.

3GPP2 System Release	3GPP2 S.R0052	The System Release is a set of specifications and features defined in the System Release Guide (SRG). SRG for a System Release provides an overview for and reference of the 3GPP2 wireless telecommunication system (cdma2000) capabilities, features, and services. The features and capabilities provided by a cdma2000 System Release are listed and briefly outlined. References and specification numbers for the features are provided. Any given System Release includes only features and capabilities that are part of at-that-time-published 3GPP2 specifications.
3GPP2 Document Revision	3GPP2 S.R0099	Document revisions are indicated by the revision level designator X (see "3GPP2 Publication" definition above) and are used to identify significant technical changes or additions to a specification (which will typically be supported independently in product implementations). Revisions are not mutually exclusive, meaning that manufacturers may continue to build products in conformance with revision 0 of a specification even after revision A has been published.

7 ABBREVIATIONS/GLOSSARY

1G	First Generation
2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
A	
AAA	Authentication, Authorization and Accounting
ANSI	American National Standard Institute
ARPU	Average Revenue per User
ATM	Asynchronous Transfer Mode
B	
C	
CAPEX	Capital Expenditure
CDMA	Code Division Multiple Access
CEPT	European Conference of Postal and Telecommunications Administrations
CITEL	Comisión Interamericana de Telecomunicaciones (Inter-American Telecommunication Commission)
CN	Core Network
CS	Circuit Switching
CSCF	Call Session Control Function
D	
DECT	Digitally Enhanced Cordless Telecommunications
E	
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest and Taxes, Depreciation and Amortization
EDGE	Enhanced Data for GSM Evolution
EDGE DO	EDGE Data Only
ETSI	European Telecommunication Standards Institute
F	
FDD	Frequency Division Multiplexing
FDMA	Frequency Division Multiple Access
G	
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
H	
HA	Home Agent
HLR	Home Location Register
HSDPA	High Speed Downlink Packet Access
I	
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IMT-2000	International Mobile Telecommunications – 2000
IP	Internet Protocol

ISDN	Integrated Services Data Network
IT	Information Technology
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union – Development Sector
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Sector
J	
K	
L	
M	
MAP	Mobile Application Part
MGCF	Media Gateway Control Function
MMS	Multimedia Message Service
MSC	Mobile Switching Center
MT	Mobile Terminal
MVNO	Mobile Virtual Network Operator
N	
NPV	Net Present Value
O	
OPEX	Operational Expenditure
P	
PCF	Packet Controller Function
PCF	Packet Controller Function
PDC	Personal Digital Cellular
PDSN	Packet Data Serving Node
PDSN	Public Data Switched Network
PS	Packet Switching
PSTN	Public Switched Telephone Network
Q	
R	
RAN	Radio Access Network
RNS	Radio Network System
S	
SDMA	Space Division Multiple Access
SDO	Standard Development Organization
SGSN	Serving GPRS Support Node
SIM	Subscriber Identification Module
SMS	Short Message Service
SCDMA	Synchronous Code Division Multiple Access
T	
TD-CDMA	Time Division-Code Division Multiple Access
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TIA	Telecommunications Industry Association

U	
UIM	User Identity Module
UMTS	Universal Mobile Telecommunication System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
UWC	Universal Wireless Consortium (now, 3G Americas)
V	
VLR	Visitor Location Register
VNO	Virtual Network Operator
VoIP	Voice Over IP
W	
WCDMA	Wideband Code Division Multiple Access
Y	
Z	

ANNEX A

GSM evolved UMTS Core Network

{ Source: ITU-T Rec. Q.1741.3

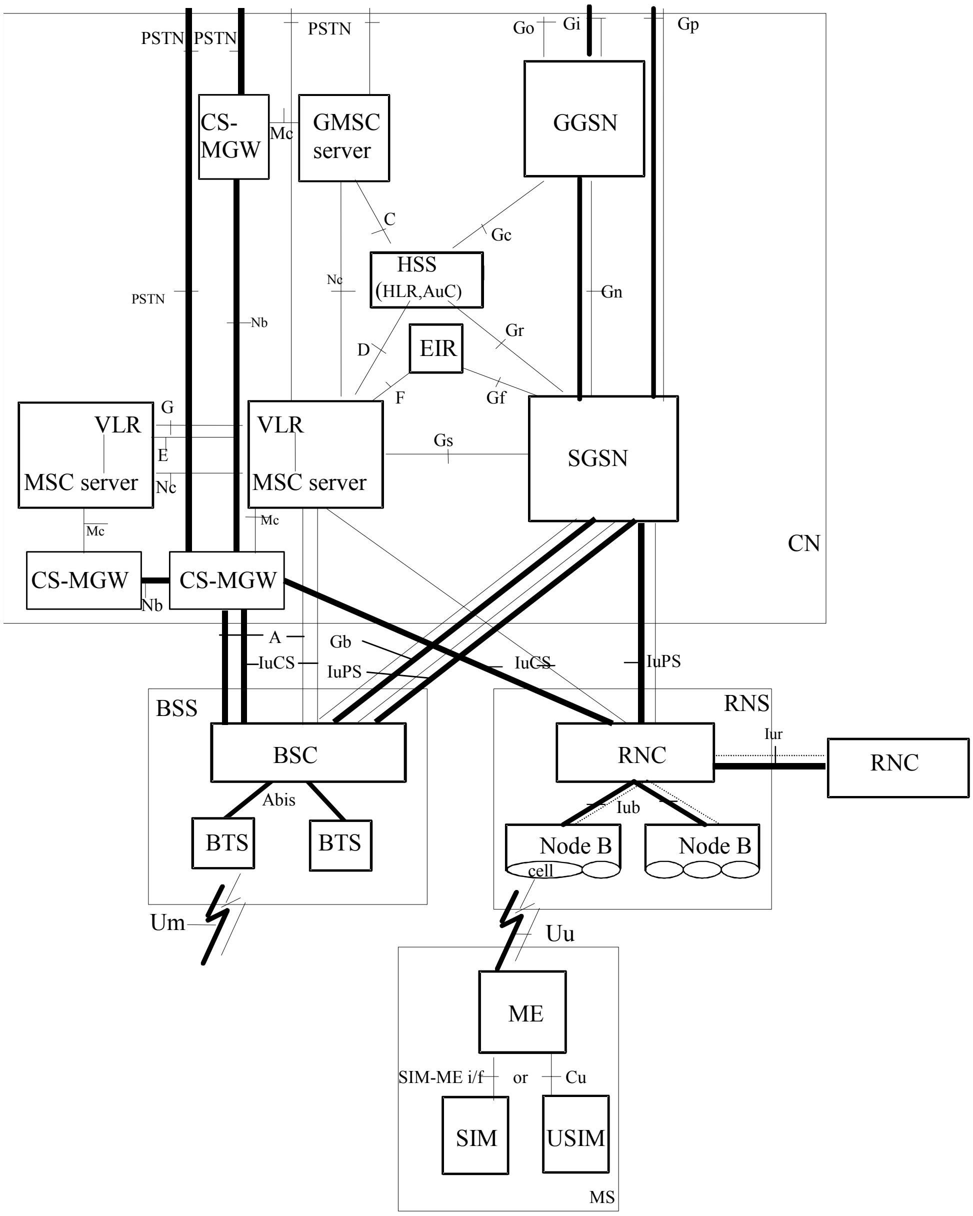
6 Basic architecture for the UMTS IMT-2000 family member

The basic configuration of a Public Land Mobile Network (PLMN) supporting GPRS and the interconnection to the PSTN/ISDN and PDN is presented in Figure 6-1/Q.1741.3. This configuration presents signalling and user traffic interfaces which can be found in a PLMN. Implementations may be different: some particular functions may be gathered in the same equipment and then some interfaces may become internal interfaces.

In the basic configuration presented in Figure 6-1/Q.1741.3, all the functions are considered implemented in different equipments. Therefore, all the interfaces within PLMN are external. This Recommendation will only describe the internal interfaces in the Core Network (CN) and the external interfaces to and from CN. Interfaces Iu, Iur and Iub are defined in the UMTS 25.4xx-series of Technical Specifications, which are outside the scope of this Recommendation. Interfaces A and Abis are defined in the UMTS 48-series of Technical Specifications, which are also outside the scope of this Recommendation. Interfaces C, D, E, F and G need the support of the Mobile Application Part of the signalling system No. 7 to exchange the data necessary to provide the mobile service. No protocols for the H-interface and for the I-interface are standardized. All the GPRS-specific interfaces (G- series) are defined in the UMTS 23-series and 24-series of Technical Specifications. Interfaces Mc, Nb, and Nc are defined in UMTS 23.205 and in the UMTS 29-series of technical specifications.

From this configuration, all the possible PLMN organisations can be deduced. In the case when some functions are contained in the same equipment, the relevant interfaces become internal to that equipment.

Figure 6-1/Q.1741.3: Basic Configuration of a PLMN supporting CS and PS services and interfaces



Legend:

Bold lines: interfaces supporting user traffic;

Dashed lines: interfaces supporting signalling.

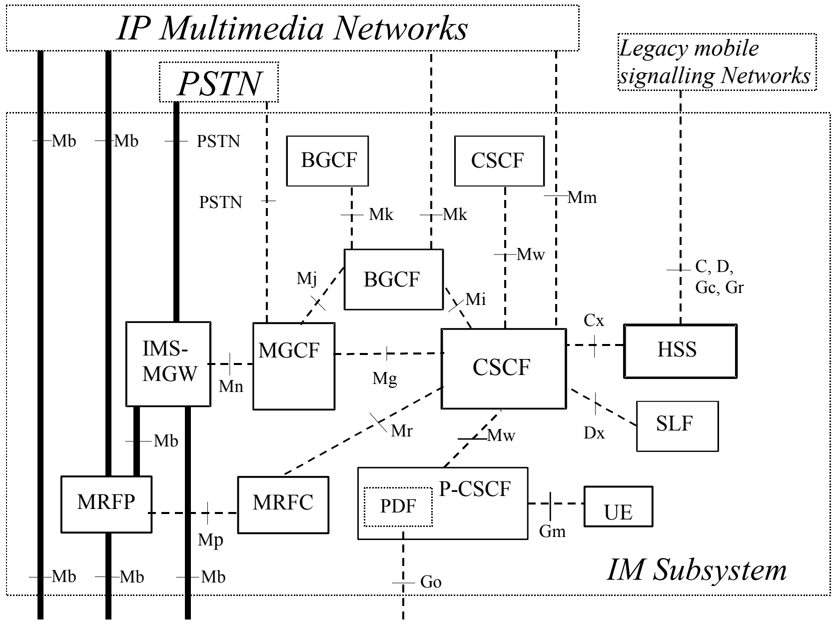
Note 1 – The figure shows direct interconnections between the entities. The actual links may be provided by an underlying network (e.g. SS7 or IP): this needs further studies.

Note 2 – This is a simplified architecture figure. Not all nodes and interfaces are indicated.

The configuration of IP Multimedia (IM) CN Subsystem entities is presented in Figure 6-6/Q.1741.3. In the figure, all the functions are considered implemented in different logical nodes. If two logical nodes are implemented in the same physical equipment, the relevant interfaces may become internal to that equipment.

Only the interfaces specifically linked to the IM subsystem are shown, i.e. all the SGSN, GGSN and HSS interfaces depicted in Figure 6-1/Q.1741.3 are still supported by these entities even if not shown.

Figure 6-6/Q.1741.3: Configuration of IM Subsystem entities



7 Network Entities

7.1 Gateway Mobile Switching Centre (GMSC)

The Mobile Switching Centre (MSC), which performs the routing function to the actual location of the Mobile Station (MS) is called the Gateway MSC (GMSC).

A GMSC Server and a CS-MGW make up the full functionality of a GMSC.

7.1.1 Gateway MSC Server (GMSC Server)

The GMSC server mainly comprises the call control and mobility control parts of a GMSC.

7.2 Mobile Switching Centre and Visitor Location Register MSC/VLR (MSC/VLR)

7.2.1 Mobile Switching Centre (MSC)

The Mobile-services Switching Centre (MSC) constitutes the interface between the radio system and the fixed networks. The MSC performs all necessary functions in order to handle the circuit switched services to and from the mobile stations.

In order to obtain radio coverage of a given geographical area, a number of BSS and/or RNSare normally required; i.e. each MSC would thus have to interface to one or more BSS(s) and/or RNS(s). In addition several MSCs may be required to cover a country.

7.2.2 Mobile Switching Centre Server (MSC Server)

The MSC Server mainly comprises the call control (CC) and mobility control parts of a MSC.

7.2.3 Visitor Location Register (VLR)

A mobile station roaming in an MSC area is controlled by the Visitor Location Register (VLR) in charge of this area. When a Mobile Station (MS) enters a new location area it starts a registration procedure. The MSC in charge of that area notices this registration and transfers to the Visitor Location Register the identity of the location area where the MS is situated. If this MS is no yet registered, the VLR and the HLR exchange information to allow the proper handling of calls involving the MS.

A VLR may be in charge of one or several MSC areas.

The VLR contains also the information needed to handle the calls set-up or received by the MSs registered in its database (for some supplementary services the VLR may have to obtain additional information from the HLR). The following elements are included:

– The International Mobile Subscriber Identity (IMSI);
– The Mobile Station International ISDN number (MSISDN);
– The Mobile Station Roaming Number (MSRN);
– The Temporary Mobile Station Identity (TMSI), if applicable;
– The Local Mobile Station Identity (LMSI), if used;
– The location area where the mobile station has been registered;
– The identity of the SGSN where the MS has been registered. Only applicable to PLMNs supporting GPRS and which have a Gs interface between MSC/VLR and SGSN;
– The last known location and the initial location of the MS.

The VLR also contains supplementary service parameters attached to the mobile subscriber and received from the HLR.

7.3 Home Subscriber Server (HSS)

The HSS is the master database for a given user. It is the entity containing the subscription-related information to support the network entities actually handling calls/sessions.

A Home Network may contain one or several HSSs: it depends on the number of mobile subscribers, on the capacity of the equipment and on the organisation of the network.

As an example, the HSS provides support to the call control servers in order to complete the routing/roaming procedures by solving authentication, authorisation, naming/addressing resolution, location dependencies, etc.

The HSS is responsible for holding the following user related information:

• User Identification, Numbering and addressing information.
• User Security information: Network access control information for authentication and authorization
• User Location information at inter-system level: the HSS supports the user registration, and stores inter-system location information, etc.
• User profile information.

The HSS also generates User Security information for mutual authentication, communication integrity check and ciphering.

The HSS may integrate heterogeneous information, and enable enhanced features in the core network to be offered to the application and services domain, at the same time hiding the heterogeneity.

The HSS consists of the following functionalities:

• IP multimedia functionality to provide support to control functions of the IM subsystem such as the CSCF. It is needed to enable subscriber usage of the IM CN subsystem services. This IP multimedia functionality is independent of the access network used to access the IM CN subsystem.
• The subset of the HLR/AUC functionality required by the PS Domain.
• The subset of the HLR/AUC functionality required by the CS Domain, if it is desired to enable subscriber access to the CS Domain or to support roaming to legacy GSM/UMTS CS Domain networks.

The organisation of the subscriber data is outlined in 3GP TS 23.008. It also indicates which numbers, addresses and identifiers specified in 3G TS 23.003 are stored in HSS.

7.3.1 Home Location Register (HLR)

The HLR can be considered a subset of the HSS that holds the following functionality:

- The functionality required to provide support to PS Domain entities such as the SGSN and GGSN, through the Gr and Gc interfaces. It is needed to enable subscriber access to the PS Domain services.
- The functionality required to provide support to CS Domain entities such as the MSC/MSC server and GMSC/GMSC server, through the C and D interfaces. It is needed to enable subscriber access to the CS Domain services and to support roaming to legacy GSM/UMTS CS Domain networks.

7.3.2 Authentication Centre (AuC)

The AuC can be considered a subset of the HSS that holds the following functionality for the CS Domain and PS Domain:

- The AuC is associated with an HLR and stores an identity key for each mobile subscriber registered with the associated HLR. This key is used to generate security data for each mobile subscriber:
  - data which are used for mutual authentication of the International Mobile Subscriber Identity (IMSI) and the network;
  - a key used to check the integrity of the communication over the radio path between the mobile station and the network;
  - a key used to cipher communication over the radio path between the mobile station and the network.
- The AuC communicates only with its associated HLR over a non-standardised interface denoted the H-interface. The HLR requests the data needed for authentication and ciphering from the AuC via the H-interface, stores them and delivers them to the VLR and SGSN which need them to perform the security functions for a mobile station.

7.3.3 HSS logical functions

This section provides a high level and not exhaustive description of HSS functionality.

- *Mobility Management*

  This function supports the user mobility through CS Domain, PS Domain and IM CN subsystem.
- *Call and/or session establishment support*

  The HSS supports the call and/or session establishment procedures in CS Domain, PS Domain and IM CN subsystem. For terminating traffic, it provides information on which call and/or session control entity currently hosts the user.
- *User security information generation*

  The HSS generates user authentication, integrity and ciphering data for the CS and PS Domains and for the IM CN subsystem.
- *User security support*

  The HSS supports the authentication procedures to access CS Domain, PS Domain and IM CN subsystem services by storing the generated data for authentication, integrity and ciphering and by providing these data to the appropriate entity in the CN (i.e. MSC/VLR, SGSN or CSCF).
- *User identification handling*

  The HSS provides the appropriate relations among all the identifiers uniquely determining the user in the system: CS Domain, PS Domain and IM CN subsystem (e.g. IMSI and MSISDNs for CS Domain; IMSI, MSISDNs and IP addresses for PS Domain, private identity and public identities for IM CN subsystem).

- *Access authorisation*

  The HSS authorises the user for mobile access when requested by the MSC/VLR, SGSN or CSCF, by checking that the user is allowed to roam to that visited network.

- *Service authorisation support*

  The HSS provides basic authorisation for MT call/session establishment and service invocation. Besides, the HSS updates the appropriate serving entities (i.e., MSC/VLR, SGSN, CSCF) with the relevant information related to the services to be provided to the user.

- *Service Provisioning Support*

  The HSS provides access to the service profile data for use within the CS Domain, PS Domain and/or IM CN subsystem.

- *Application Services and CAMEL Services Support*

  The HSS communicates with the SIP Application Server and the OSA-SCS to support Application Services in the IM CN subsystem. It communicates with the IM-SSF to support the CAMEL Services related to the IM CN subsystem. It communicates with the gsmSCF to support CAMEL Services in the CS Domain and PS Domain.

7.4 Equipment Identity Register (EIR)

The Equipment Identity Register (EIR) is the logical entity, which is responsible for storing in the network the International Mobile Equipment Identities (IMEIs), used.

The equipment is classified, as “white listed”, “grey listed”, “black listed” or it may be unknown.

This functional entity contains one or several databases which store(s) the IMEIs used.

The mobile equipment may be classified as “white listed”, “grey listed” and “black listed” and therefore may be stored in three separate lists.

An IMEI may also be unknown to the EIR.

An EIR shall as a minimum contain a “white list” (Equipment classified as “white listed”).

7.5 SMS Gateway MSC (SMS-GMSC)

7.6 SMS Interworking MSC

7.7 Gateway GPRS Support Node (GGSN)

The UMTS GPRS Support Nodes (GSN) is the Gateway GSN (GGSN) and the Serving GSN (SGSN). They constitute the interface between the radio system and the fixed networks for packet switched services. The GSN performs all necessary functions in order to handle the packet transmission to and from the mobile stations.

Gateway GPRS Support Node (GGSN): The location register function in the GGSN stores subscriber data received from the HLR and the SGSN. There are two types of subscriber data needed to handle originating and terminating packet data transfer:

– Subscription information:
  - the IMSI
  - zero or more PDP addresses.

– Location information:
  - the SGSN address for the SGSN where the MS is registered.

7.8 Serving GPRS Support Node (SGSN)

The UMTS GPRS Support Nodes (GSN) is the Gateway GSN (GGSN) and the Serving GSN (SGSN). They constitute the interface between the radio system and the fixed networks for packet switched services. The GSN performs all necessary functions in order to handle the packet transmission to and from the mobile stations.

Serving GPRS Support Node (SGSN): The location register function in the SGSN stores two types of subscriber data needed to handle originating and terminating packet data transfer:

– Subscription information:
  - the IMSI;
  - one or more temporary identities;
  - zero or more PDP addresses.
– Location information:
  - depending on the operating mode of the MS, the cell or the routeing area where the MS is registered;
  - the VLR number of the associated VLR (if the Gs interface is implemented);
  - the GGSN address of each GGSN for which an active PDP context exists.

7.9 Circuit Switched – Media Gateway Function (CS-MGW)

Note – In this document the term Media Gateway Function (MGW) is used when there is no need to differentiate between the CS domain entity and the IP Multimedia CN Subsystem entity. When referring specifically to the CS domain entity the term CS-MGW is used. When referring specifically to the IP Multimedia CN Subsystem entity, the term IM-MGW is used.

This component is PSTN/PLMN transport termination point for a defined network and interfaces UTRAN with the core network over Iu.

A CS-MGW may terminate bearer channels from a switched circuit network and media streams from a packet network (e.g., RTP streams in an IP network). Over Iu, the CS-MGW may support media conversion, bearer control and payload processing (e.g. codec, echo canceller, conference bridge) for support of different Iu options for CS services (AAL2/ATM based as well as RTP/UDP/IP based).

The CS-MGW:

– Interacts with MGCF, MSC server and GMSC server for resource control.

– Owns and handles resources such as echo cancellers etc.

– May need to have codecs.

The CS-MGW will be provisioned with the necessary resources for supporting UMTS/GSM transport media. Further tailoring (i.e. packages) of the H.248 [22] may be required to support additional codecs and framing protocols, etc.

The CS-MGW bearer control and payload processing capabilities will also need to support mobile specific functions such as SRNS relocation/handover and anchoring. It is expected that current H.248 [22] standard mechanisms can be applied to enable this.

7.10 IP Multimedia (IM) Core Network (CN) Subsystem entities

7.10.1 Call Session Control Function (CSCF)

The CSCF can act as Proxy CSCF (P-CSCF), Serving CSCF (S-CSCF) or Interrogating CSCF (I-CSCF). The P-CSCF is the first contact point for the UE within the IM subsystem (IMS); the S-CSCF actually handles the session states in the network; the I-CSCF is mainly the contact point within an operator's network for all IMS connections destined to a subscriber of that network operator, or a roaming subscriber currently located within that network operator's service area. Further definitions of the P-, S- and I-CSCF are provided in 3G TS 23.228.

7.10.2 Media Gateway Control Function (MGCF)

The MGCF:

– Controls the parts of the call state that pertain to connection control for media channels in an IMS-MGW.
– Communicates with CSCF.
– Selects the CSCF depending on the routing number for incoming calls from legacy networks.
– Performs protocol conversion between ISUP and the IM subsystem call control protocols.
– Out of band information assumed to be received in MGCF and may be forwarded to CSCF/IMS-MGW.

7.10.3 IP Multimedia Subsystem – Media Gateway Function (IMS-MGW)

A IMS-MGW may terminate bearer channels from a switched circuit network and media streams from a packet network (e.g., RTP streams in an IP network). The IMS-MGW may support media conversion, bearer control and payload processing (e.g. codec, echo canceller, conference bridge), it:

– Interacts with the MGCF for resource control.
– Owns and handles resources such as echo cancellers etc.
– May need to have codecs.

The IMS-MGW will be provisioned with the necessary resources for supporting UMTS/GSM transport media. Further tailoring (i.e. packages) of the H.248 [22] may be required to support additional codecs and framing protocols, etc.

7.10.4 Multimedia Resource Function Controller (MRFC)

The MRFC:

– Controls the media stream resources in the MRFP.
– Interprets information coming from an AS and S-CSCF (e.g session identifier) and control MRFP accordingly.
– Generates CDRs.

7.10.5 Multimedia Resource Function Processor (MRFP)

The MRFP:

– Controls bearers on the Mb reference point.
– Provides resources to be controlled by the MRFC.
– Mixes incoming media streams (e.g. for multiple parties).
– Sources media streams (for multimedia announcements).
– Processes media streams (e.g. audio transcoding, media analysis).

7.10.6 Subscription Locator Function (SLF)

The text in this clause is based on the text in references [2] – [6] clause 4a.7.5.

The SLF:

– Is queried by the I-CSCF during the Registration and Session Setup to get the name of the HSS containing the required subscriber specific data. Furthermore the SLF is also queried by the S-CSCF during the Registration.
– Is accessed via the Dx interface.

The SLF is not required in a single HSS environment. An example for a single HSS environment is a server farm architecture.

7.10.7 Breakout Gateway Control Function (BGCF)

The Breakout Gateway control function (BGCF) selects the network in which PSTN breakout is to occur and – within the network where the breakout is to occur – selects the MGCF.

7.10.8 Application Server (AS)

An Application Server (AS) i.e., SIP Application Server, OSA Application Server, or CAMEL IM-SSF, offers value added IM services and resides either in the user's home network or in a third party location. The third party could be a network or simply a stand-alone AS.

Note – The OSA Application Server does not directly interact with the IMS network entities but through the OSA Service Capability Servers (OSA SCS-s). Further information on OSA is provided in 3G TS 22.127.

The AS (SIP Application Server and/or the OSA Service Capability Server and/or IM-SSF) can communicate with the HSS. The Sh and Si interfaces are used for this purpose.

The Serving-CSCF to AS interface is used to provide services residing in an AS. Two cases were identified:

– Serving-CSCF to an AS in Home Network.

– Serving-CSCF to an AS in a trusted External Network (e.g., Third Party or Visited). The S-CSCF does not provide authentication and security functionality for secure direct third party access to the IM Subsystem. The OSA framework provides a standardized way for third party access to the IM Subsystem.

An Application Server may influence and impact the SIP session on behalf of the services supported by the operator’s network. An AS may host and execute services.

8 Interfaces and Reference points

8.1 C Interface (Gateway Mobile Switching Centre Server (GMSC Server) – Home Location Register (HLR))

The Gateway MSC server must interrogate the HLR of the required subscriber to obtain routing information for a call or a short message directed to that subscriber.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities.

For Customized Application for Mobile network Enhanced Logic (CAMEL) purposes, this interface is used e.g. at terminating calls to exchange routeing information, subscriber status, location information, subscription information, etc.

8.2 D Interface (Visitor Location Register (VLR) – Home Location Register (HLR))

This interface is used to exchange the data related to the location of the mobile station and to the management of the subscriber. The main service provided to the mobile subscriber is the capability to set up or to receive calls within the whole service area. To support this, the location registers have to exchange data. The VLR informs the HLR of the location of a mobile station managed by the latter and provides it (either at location updating or at call set-up) with the roaming number of that station. The HLR sends to the VLR all the data needed to support the service to the mobile subscriber. The HLR then instructs the previous VLR to cancel the location registration of this subscriber. Exchanges of data may occur when the mobile subscriber requires a particular service, when he wants to change some data attached to his subscription or when some parameters of the subscription are modified by administrative means.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities.

For Customized Application for Mobile network Enhanced Logic (CAMEL) purposes, this interface is used to send the CAMEL related subscriber data to the visited PLMN and for provision of Mobile Station Roaming Number (MSRN). The interface is also used for the other purposes e.g. to retrieve subscriber status and location information of the mobile subscriber or to indicate suppression of announcement for a CAMEL service.

8.3 E Interface (Mobile Switching Centre Server (MSC Server) – Mobile Switching Centre Server (MSC Server))

When a mobile station moves from one MSC area to another during a call, a handover procedure has to be performed in order to continue the communication. For that purpose the MSC servers have to exchange data to initiate and then to realise the operation.

After the handover operation has been completed, the MSC servers will exchange information to transfer A interface or Iu-interface signalling as defined in 3G TS 23.009.

When a short message is to be transferred between a Mobile Station and Short Message Service Centre (SC), in either direction, this interface is used to transfer the message between the MSC server serving the Mobile Station and the MSC server, which acts as the interface to the SC.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities (see 3G TS 29.002).

8.4 F Interface (Mobile Switching Centre Server (MSC Server) – Equipment Identity Register (EIR))

This interface is used between MSC server and EIR to exchange data, in order that the EIR can verify the status of the IMEI retrieved from the Mobile Station.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities.

8.5 G Interface (Visitor Location Register (VLR) – Visitor Location Register (VLR))

When a mobile subscriber moves from a VLR area to another Location Registration procedure will happen. This procedure may include the retrieval of the IMSI and authentication parameters from the old VLR.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities.

8.6 Gc Interface (Home Location Register (HLR) – Gateway GPRS Support Node (GGSN))

The text in this clause is base on the text in references [2] – [6] clause 6.4.2.3.

This optional signalling path may be used by the GGSN to retrieve information about the location and supported services for the mobile subscriber, to be able to activate a packet data network address.

There are two alternative ways to implement this signalling path:

– If an SS7 interface is implemented in the GGSN, signalling between the GGSN and the HLR uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities (TCAP);

– If there is no SS7 interface in the GGSN, any GSN in the same PLMN and which has an SS7 interface installed can be used as a GTP to MAP protocol converter, thus forming a signalling path between the GGSN and the HLR.

8.7 Gf Interface (Equipment Identity Register (EIR) – Serving GPRS Support Node (SGSN))

The text in this clause is based on the text in references [2] – [6] clause 6.4.2.4.

This interface is used between SGSN and EIR to exchange data, in order that the EIR can verify the status of the IMEI retrieved from the Mobile Station.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities (TCAP).

8.8 Reference point GGSN – packet data networks (Gi reference point)

The text in this clause is based on the text in references [2] – [6] clause 7.2.

This is the reference point between the GGSN and a packet data network. It may be an operator external public or private packet data network or an intra operator packet data network, e.g. for provision of IMS services.

8.9 GLa Interface (Gateway Location Register (GLR) – Home Location Register (HLR))

In circuit switched domain, this interface is the same as that between the VLR and the HLR. The HLR regards the GLR as the VLR via this interface. On the other hand, in packet switched domain, this interface is the same as that between the SGSN and the HLR. The HLR regards the GLR as the SGSN via this interface.

8.10 GLb Interface (Gateway Location Register (GLR) – Visitor Location Register (VLR))

This interface is the same as those between the VLR and the HLR. The VLR regards the GLR as the HLR via this interface.

8.11 GLc Interface (Gateway Location Register (GLR) – Serving GPRS Support Node (SGSN))

This interface is the same as those between the SGSN and the HLR. The SGSN regards the GLR as the HLR via this interface.

8.12 GLd Interface (Gateway Location Register (GLR) – Intermediate Mobile services Switching Centre (IM-MSC))

In the network with the GLR, when the IM_MSC receives a message, it interrogates the GLR for the routing information of the MSC. However, this interface is internal because GLR and IM-MSC are implemented in the same physical node and the protocol on this interface is not specified.

8.13 GLe Interface (Gateway Location Register (GLR) – Intermediate GPRS Serving Node (IM-GSN))

In the network with the GLR when the IM_GSN receiving a PDU notification from the GGSN, the IM_GSN relays the notification to the SGSN by interrogating via the interface the routing information to the GLR. The interrogation uses the same operation on the interface between the SGSN and the HLR.

8.14 GLf Interface (Gateway Location Register (GLR) – Short Message Service-Gateway Mobile Switching Centre (SMS-GMSC))

This interface is used to forward mobile-terminated short messages in the network with the GLR in case of SMS transfer over GPRS. Signalling on this interface uses the Mobile Application Part (MAP).

The SMS-GMSC regards the GLR as the SGSN via this interface.

8.15 GLg Interface (Intermediate Mobile-services Switching Centre (IM-MSC) – Short Message Service-Gateway Mobile Switching Centre (SMS-GMSC))

This interface is used to forward short messages in the network with the GLR in case of SMS transfer over non-GPRS. Signalling on this interface uses the Mobile Application Part (MAP).

The SMS-GMSC regards the IM_MSC as the MSC via this interface.

8.16 GLh Interface (Intermediate Mobile-services Switching Centre (IM-MSC) – Mobile Switching Centre (MSC))

This interface is used to forward short messages in the network with the GLR in case of SMS transfer over non-GPRS. Also this interface is used to exchange data needed by the MSC to perform subscriber authorization and allocate network resources. Signalling on this interface uses the Mobile Application Part (MAP).

8.17 GLi Interface (Intermediate Mobile-services Switching Centre (IM-MSC) – Gateway Mobile Location Centre (GMLC))

Also this interface is used to exchange data needed by the MSC to perform subscriber authorization and allocate network resources. Signalling on this interface uses the Mobile Application Part (MAP).

The GMLC regards the IM_MSC as the MSC via this interface.

8.18 GLj Interface (Intermediate GPRS Serving Node (IM-GSN) – Gateway GPRS Support Node (GGSN))

In the network with the GLR when receiving a PDP PDU from the external network the GGSN sends a notification to the IM_GSN by the routing information from the HLR. The GGSN regards the IM_GSN as the SGSN via this interface.

8.19 GLk Interface (Intermediate GPRS Serving Node (IM-GSN) – Serving GPRS Support Node (SGSN))

In the network with the GLR when receiving a PDP notification from the GGSN, the IM_GSN relays the notification to the SGSN by the routing information from the GLR. The SGSN regards the IM_GSN as the GGSN via this interface.

8.20 Gn Interface (Gateway GPRS Support Node (GGSN) – Serving GPRS Support Node (SGSN))

This interface is used to support mobility between the SGSN and GGSN. The Gn interface is used when GGSN and SGSN are located inside one PLMN. The Gn interface also includes a part which allows SGSNs to communicate subscriber and user data, when changing SGSN.

Signalling on this interface uses the User Datagram Protocol, UDP/IP.

8.21 Gp Interface (Serving GPRS Support Node (SGSN) – External Data Network)

The Gp-interface is used if GGSN and SGSN are located in different PLMNs. The Gp interface also includes a part that allows SGSNs to communicate subscriber and user data, when changing SGSN.

Signalling on this interface uses the User Datagram Protocol, UDP/IP.

8.22 Gr Interface (Home Location Register (HLR) – Serving GPRS Support Node (SGSN))

This interface is used to exchange the data related to the location of the mobile station and to the management of the subscriber. The main service provided to the mobile subscriber is the capability to transfer packet data within the whole service area. The SGSN informs the HLR of the location of a mobile station managed by the latter. The HLR sends to the SGSN all the data needed to support the service to the mobile subscriber. Exchanges of data may occur when the mobile subscriber requires a particular service, when he wants to change some data attached to his subscription or when some parameters of the subscription are modified by administrative means.

Signalling on this interface uses the Mobile Application Part (MAP), which in turn uses the services of Transaction Capabilities (TCAP).

8.23 Gs Interface (Mobile Switching Centre (MSC)/Visitor Location Register (VLR) – Serving GPRS Support Node (SGSN))

The SGSN may send location information to the MSC/VLR via the optional Gs interface. The SGSN may receive paging requests from the MSC/VLR via the Gs interface. The MSC/VLR may indicate to an SGSN, via the Gs interface, that an MS is engaged in a service handled by the MSC.

Signalling on this interface uses connectionless SCCP (without TCAP). SCCP Global Title (GT) is used for addressing.

8.24 gsmSCF – HLR Interface

8.25 gsmSCF – gsmSRF Interface

8.26 gsmSSF – gsmSCF Interface

8.27 gprsSSF – gsmSCF Interface

8.28 H Interface (Home Location Register (HLR) – Authentication Centre (AuC))

When an HLR receives a request for authentication and ciphering data for a Mobile Subscriber and it does not hold the requested data, the HLR requests the data from the AuC. The protocol used to transfer the data over this interface is not standardised.

8.29 IuBC Interface (Cell Broadcast Center (CBC) – Radio Network Subsystem (RNS))

The IuBC interface between the CBC and the RNS is specified in the 25.41x-series of 3G Technical Specifications.

The CBC-RNS interface is used to carry information concerning:

– the CBS messages itself; and

– CBS delivery parameter.

8.30 IuCS Interface (Mobile Switching Centre (MSC) – RNS or BSS)

The IuCS interface between the MSC and its RNS or BSS is specified in the 25.41x-series of UMTS Technical Specifications.

The RNS-MSC interface is used to carry information concerning:

– RNS management;

– call handling;

– mobility management.

8.31 IuPS Interface (Serving GPRS Support Node (SGSN) – RNS or BSS)

The IuPS interface between SGSN and RNS/BSS is used to carry information concerning:

– packet data transmission;

– mobility management.

The IuPS interface is defined in the 25.41x-series of 3G Technical Specifications.

8.32 A Interface (Mobile Switching Centre (MSC) – Base Station System (BSS))

The A interface between the MSC and its BSS is specified in the 48-series of Technical Specifications.

The BSS-MSC interface is used to carry information concerning:

– BSS management;
– call handling;
– mobility management.

8.33 Gb Interface (Serving GPRS Support Node (SGSN) – Base Station System (BSS)

The BSS-SGSN interface is used to carry information concerning:

– packet data transmission;
– mobility management.

The Gb interface is defined in 3G TS 48.014, 3G TS 48.016 and 3G TS 48.018.

8.34 Reference point GMLC – external LCS Client (Le reference point)

At this reference point external LCS Clients request services from the PLMN.

8.35 LCS interfaces using MAP

8.36 Mc Reference Point (Mobile Switching Centre Server (MSC Server) – Circuit Switched Media Gateway (CS-MGW))

The Mc reference point describes the interfaces between the MGCF and IMS-MGW, between the MSC Server and CS-MGW, and between the GMSC Server and CS-MGW. It has the following properties:

– Full compliance with the ITU-T H.248 [22] standard.
– Flexible connection handling that allows support of different call models and different media processing purposes not restricted to ITU-T H.323 [23] usage.
– Open architecture where extensions/Packages definition work on the interface may be carried out.
– Dynamic sharing of MGW physical node resources. A physical MGW can be partitioned into logically separate virtual MGWs/domains consisting of a set of statically allocated Terminations.
– Dynamic sharing of transmission resources between the domains as the MGW controls bearers and manage resources according to the ITU-T H.248 [22] protocols.

The functionality across the Mc reference point will need to support mobile specific functions such as SRNS relocation/handover and anchoring. It is expected that current H.248 [22]/IETF Megaco standard mechanisms can be applied to enable this.

8.37 Mobile Switching Centre (MSC) – gsmSCF Interface

8.38 Nb Reference Point (Circuit Switched Media Gateway (CS-MGW) – Circuit Switched Media Gateway (CS-MGW))

Over the Nb reference point the bearer control and transport are performed. The transport may be RTP/UDP/IP [69][70] or AAL2 (ITU-T I.363-2) [68] for transport of user data. In the R00 architecture different options for user data transport and bearer control shall be possible on Nb, for example: AAL2/Q.AAL2, STM/none, RTP/H.245 [21], IPBC.

8.39 Nc Reference Point (Mobile Switching Centre Server (MSC Server) – Gateway Mobile Switching Centre Server (GMSC Server))

Over the Nc reference point, the Network-Network based call control is performed. Examples of this are ISUP or an evolvement of ISUP for bearer independent call control (BICC). Different options for signalling transport on Nc shall be possible including IP.

8.40 Reference point fixed networks – MSC

The MSC is based on a normal ISDN exchange. It has, for call control, the same reference points as the fixed network exchanges. The signalling reference point considered in the Technical Specifications is related to the signalling system No. 7 User Parts TUP and ISUP associated to the circuits used for incoming and outgoing calls.

8.41 IM Subsystem Reference Points

8.41.1 Reference Point HSS – CSCF (Cx Reference Point)

The Cx reference point supports information transfer between CSCF and HSS.

The main procedures that require information transfer between CSCF and HSS are:

1) Procedures related to Serving CSCF assignment.
2) Procedures related to routing information retrieval from HSS to CSCF.
3) Procedures related to authorisation (e.g., checking of roaming agreement).
4) Procedures related to authentication: transfer of security parameters of the subscriber between HSS and CSCF.
5) Procedures related to filter control: transfer of filter parameters of the subscriber from HSS to CSCF.

Further information on the Cx reference point is provided in 3G TS 23.228.

8.41.2 Reference Point CSCF – UE (Gm Reference Point)

The Gm reference point supports the communication between UE and IM CN subsystem, e.g. related to registration and session control.

The protocol used for the Gm reference point is SIP (as defined by RFC 3261 [66], other relevant RFC’s, and additional enhancements introduced to support 3GPP´s needs).

8.41.3 Reference Point MGCF – IMS-MGW (Mn Reference Point)

The Mn reference point describes the interfaces between the MGCF and IMS-MGW in the IMS. It has the following properties:

– Full compliance with the H.248 [22] standard functions for IMS – PSTN/PLMN interworking.
– Flexible connection handling which allows support of different call models and different media processing purposes not restricted to H.323 [23] usage.
– Open architecture where extensions/Packages definition work on the interface may be carried out.
– Dynamic sharing of IMS-MGW physical node resources. A physical IMS-MGW can be partitioned into logically separate virtual MGWs/domains consisting of a set of statically allocated Terminations.
– Dynamic sharing of transmission resources between the domains as the IMS- MGW controls bearers and manage resources according to the H.248 [22] protocols and functions for IMS.

8.41.4 Reference Point MGCF – CSCF (Mg Reference Point)

The Mg reference point allows the MGCF to forward incoming session signalling (from the PSTN) to the CSCF for the purpose of interworking with PSTN networks.

The protocol used for the Mg reference point is SIP (as defined by RFC 3261 [66], other relevant RFC’s, and additional enhancements introduced to support 3GPP´s needs.)

8.41.5 Reference Point CSCF – MRFC (Mr Reference Point)

The Mr reference point allows interaction between an S-CSCF and an MRFC.

The protocol used for the Mr reference point is SIP (as defined by RFC 3261 [66], other relevant RFC's, and additional enhancements introduced to support 3GPP´s needs).

8.41.6 Reference Point MRFC – MRFP (Mp Reference Point)

The text in this clause is based on the text in references [2] – [6] clause 6a.7.6a

The Mp reference point has the following properties:

– Full compliance with the H.248 standard [22].

– Open architecture where extensions (packages) definition work on the interface may be carried out.

8.41.7 Reference Point CSCF – CSCF (Mw Reference Point)

The Mw reference point allows the communication and forwarding of signalling messaging between CSCFs, e.g. during registration and session control.

8.41.8 Reference Point GGSN –PDF (Go Reference Point)

This interface allows the Policy Decision Function (PDF) to apply policy to the bearer usage in the GGSN.

The Policy Decision Function (PDF) is a logical entity of the P-CSCF. If the PDF is implemented in a separate physical node, the interface between the PDF and the P-CSCF is not standardized.

8.41.9 Reference Point CSCF – BGCF (Mi reference point)

This reference point allows the Serving CSCF to forward the session signalling to the Breakout Gateway Control Function for the purpose of interworking to the PSTN networks.

The Mi reference point is based on external specifications i.e. SIP [66].

8.41.10 Reference Point BGCF – MGCF (Mj reference point)

This reference point allows the Breakout Gateway Control Function to forward the session signalling to the Media Gateway Control Function for the purpose of interworking to the PSTN networks.

The Mj reference point is based on external specifications i.e. SIP [66].

8.41.11 Reference Point BGCF – BGCF (Mk reference point)

This reference point allows the Breakout Gateway Control Function to forward the session signalling to another Breakout Gateway Control Function.

The Mk reference point is based on external specifications i.e. SIP [66].

8.41.12 Reference Point CSCF – SLF (Dx Reference Point)

This interface between CSCF and SLF is used to retrieve the address of the HSS which holds the subscription for a given user.

This interface is not required in a single HSS environment. An example for a single HSS environment is a server farm architecture.

Details are described in 3G TS 23.228, sub-clause 5.8.1.

8.41.13 Reference Point to IPv6 network services (Mb reference point)

Via the Mb reference point IPv6 network services are accessed. These IPv6 network services are used for user data transport. Note, that GPRS provides IPv6 network services to the UE, i.e. the GPRS Gi reference point and the IMS Mb reference point may be the same.

8.41.14 Reference Point CSCF – AS (ISC Reference Point)

This interface between CSCF and the Application Servers (i.e., SIP Application Server, OSA Service Capability Server, or CAMEL IM-SSF) is used to provide services for the IMS.

Details are described in 3G TS 23.228, sub-clause 4.2.4.

8.41.15 Reference Point HSS – SIP AS or OSA SCS (Sh Reference Point)

The Application Server (SIP Application Server and/or the OSA Service Capability Server) may communicate to the HSS. The Sh interface is used for this purpose. Details are described in 3G TS 23.228, sub-clause 4.2.4.

8.41.16 Reference Point HSS – CAMEL IM-SSF (Si Reference Point)

The CAMEL Application Server (IM-SSF) may communicate to the HSS. The Si interface is used for this purpose. Details are described in 3G TS 23.228, sub-clause 4.2.4.

8.42 Reference Point CSCF – Multimedia IP networks (Mm Reference Point)

This is an IP interface between CSCF and IP networks. This interface is used, for example, to receive a session request from another SIP server or terminal.

ITU-T Rec. Q.1741.3 }

ANNEX B

ANSI-41 evolved Core Network with cdma2000 Access Network

{ Source: ITU-T Rec. Q.1742.2:

6 Basic architecture for the ANSI-41 evolved Core Network with cdma2000 Access Network family member

The basic architecture for the ANSI-41 evolved Core Network with cdma2000 Access Network family member includes a circuit-based and packet based core network and an all-IP multimedia domain.

The following text is based on reference [12 a-d][72] section 2.1.

Figure 6-1/Q.1742.2 presents the network entities and associated reference points that comprise the ANSI-41 evolved Core Network with cdma2000 Access Network. The network entities are represented by squares, triangles and rounded corner rectangles; circles represent the reference points. The network reference model in this document is the compilation of several reference models currently in use.

- The network reference model is a functional block diagram.
- A network entity represents a group of functions, not a physical device. For example, a Mobile Switching Center (MSC) is a physical device; it comprises frames, shelves, circuit packs, etc. The physical device may comprise a single network entity such as the MSC, or it may comprise some combination such as the MSC, the Visitor Location Register (VLR), the Home Location Register (HLR), and the Authentication Center (AC). The physical realization is an implementation issue; a manufacturer may choose any physical implementation of network entities, either individually or in combination, as long as the implementation meets the functional requirements. Sometimes, for practical reasons, the functional network entity is a physical device. The Mobile Station (MS) is an excellent example.
- A reference point is a conceptual point that divides two groups of functions. It is not necessarily a physical interface. A reference point only becomes a physical interface when the network entities on either side of it are contained in different physical devices.
- A “Collective Entity” contains encompassed network entities that are an instance of the collective.
- A “Composite Entity” contains encompassed network entities that are part of the composite.

(The portion of the figure within the solid line is the Core Network)

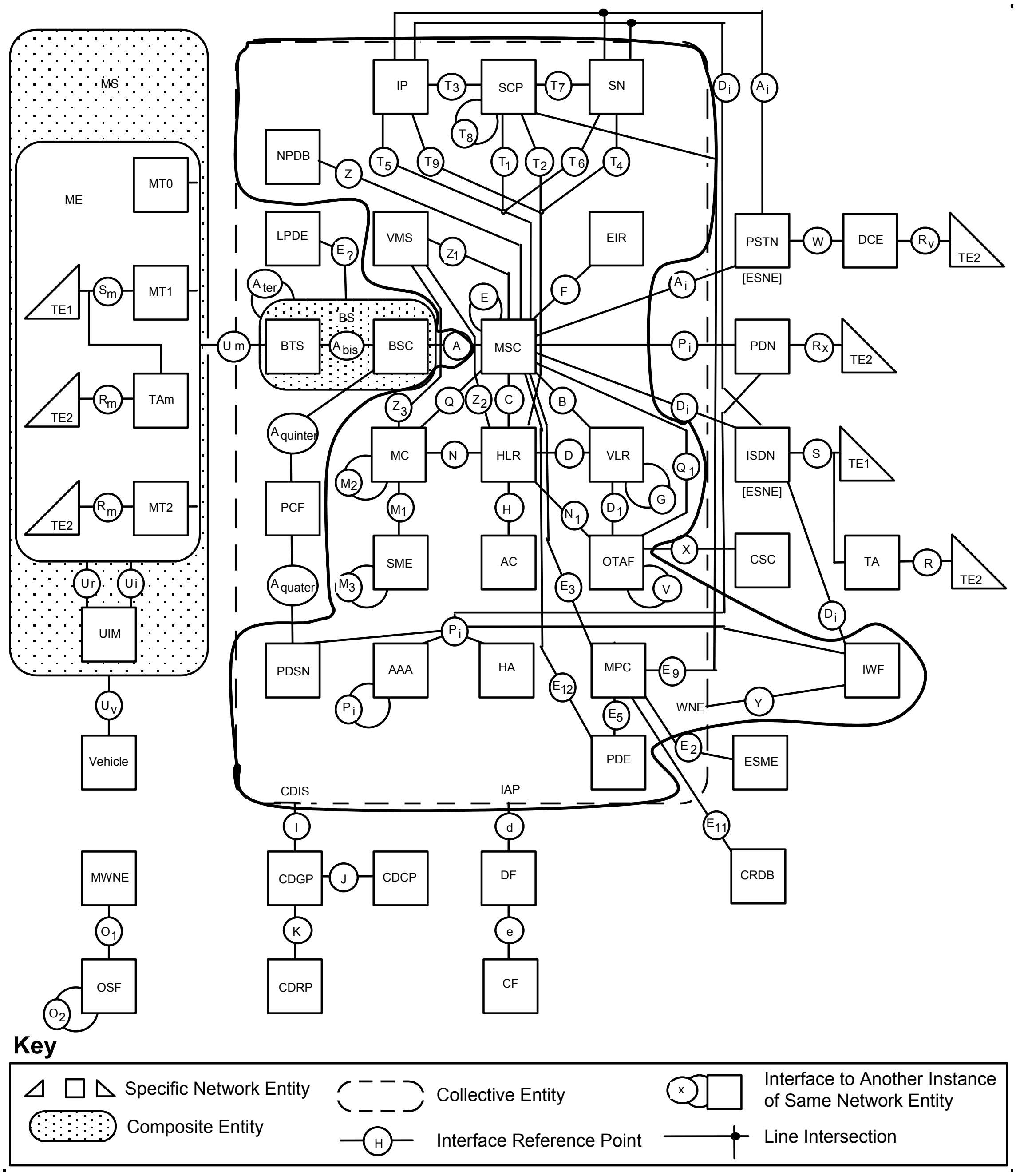
[72] [12a] CWTS; CWTS-MC-S.R0005-B (2002): Network Reference Model for cdma2000 Spread Spectrum Systems.

[12b] TIA; TSB100-A (2001): Wireless Network Reference Model.

[12c] TTA; TTAE.3G-S.R0005-B (2001): 3GPP2 Network Reference Model for cdma2000 Spread Spectrum Systems.

[12d] TTC; TS-3GB-S.R0005-Bv1.0 (2001): Network Reference Model for cdma2000 Spread Spectrum Systems.

Figure 6-1/Q.1742.2: ANSI-41 evolved Core Network with cdma2000 Access Network Reference Model

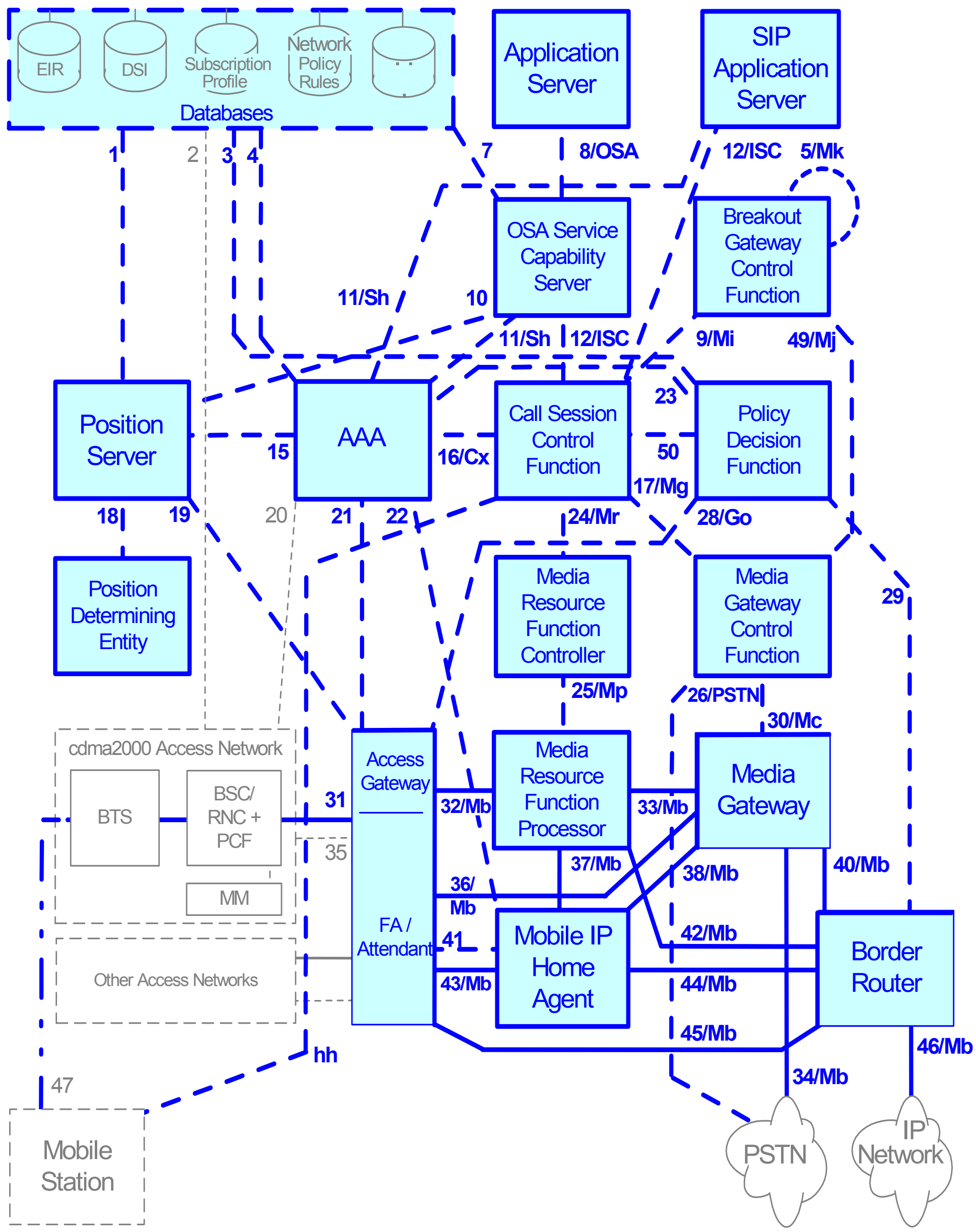


The basic architecture for the ANSI-41 evolved Core Network with cdma2000 Access Network family member also includes an all-IP multimedia domain.

All-IP MMD Core Network Architecture:

Figure 6-2/Q.1742.2 presents the core network entities and associated reference points that comprise the MMD (Multimedia Domain) of the wireless All-IP Network Architecture Model. The network entities are represented by squares and rectangles; the interfaces between network entities are reference points identified by numbers. Figure 6-2/Q.1742.2 includes several reference points that have dual labels. Either of these labels may be used in the specifications relating to these reference points. Note: in Figure 6-2/Q.1742.2 the network elements and reference points highlighted in "blue" identify the "IP MMD Core Network".

Figure 6-2/Q.1742.2: ANSI-41 evolved Core Network with cdma2000 Access Network IP MMD Core Network Architecture Model



The MMD of the All-IP Network offers both general packet data support and multi-media session capabilities. The multi-media session capabilities are built on top of the general packet data support capabilities. The general packet data capabilities may be deployed without the multi-media session capabilities. Some network entities are common to providing both capabilities.

Figure 6-3/Q.1742.2 shows the entities that comprise the general packet data support portion of the MMD core network. These are known collectively as the Packet Data Subsystem (PDS). Figure 6-3/Q.1742.2 includes several reference points that have dual labels. Either of these labels may be used in the specifications relating to these reference points. Note: in Figure 6-3/Q.1742.2 the network elements and reference points highlighted in "blue" identify the "Packet Data Subsystem".

Figure 6-3/Q.1742.2: ANSI-41 evolved Core Network with cdma2000 Access Network Packet Data Subsystem Core Network Architecture Model

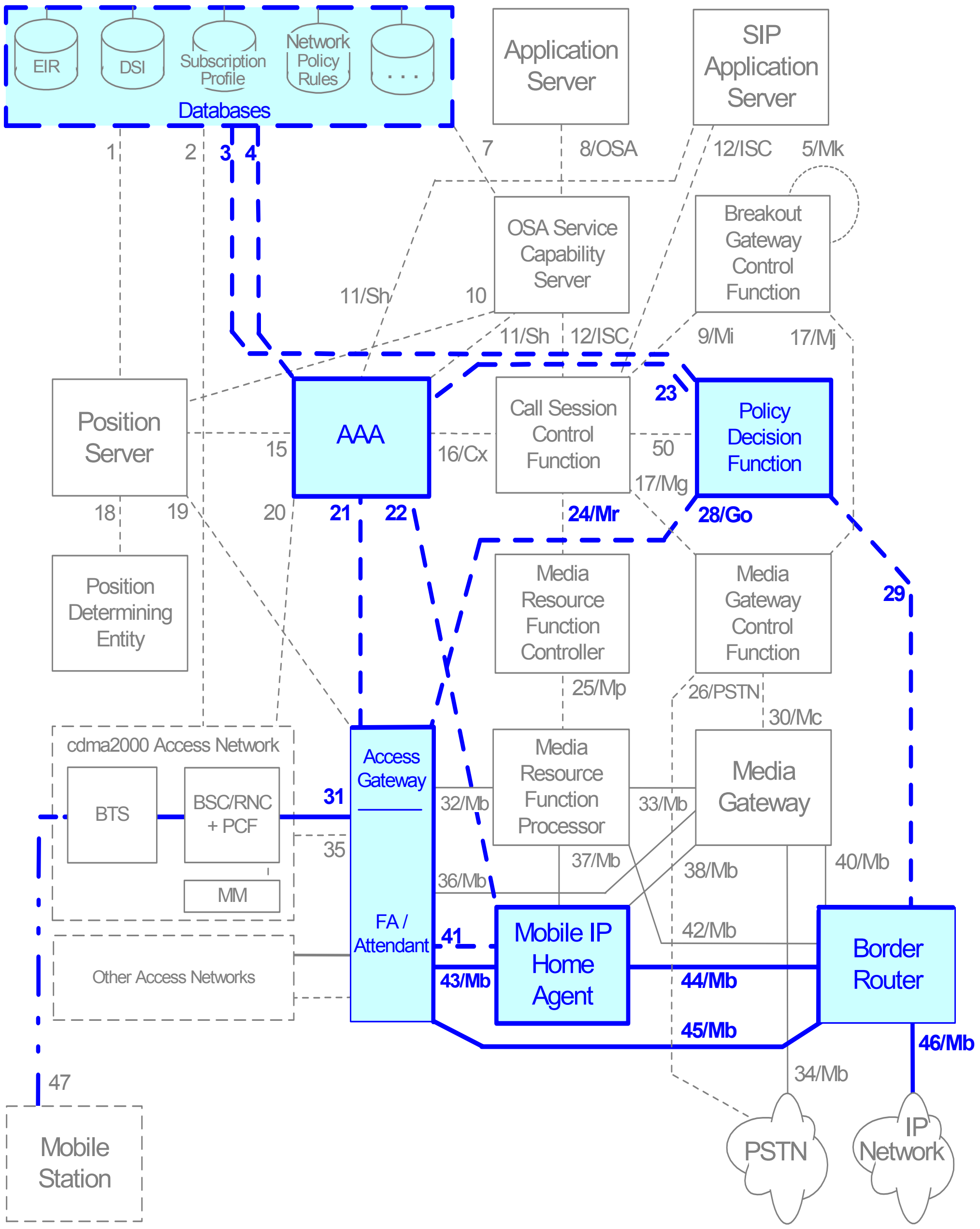
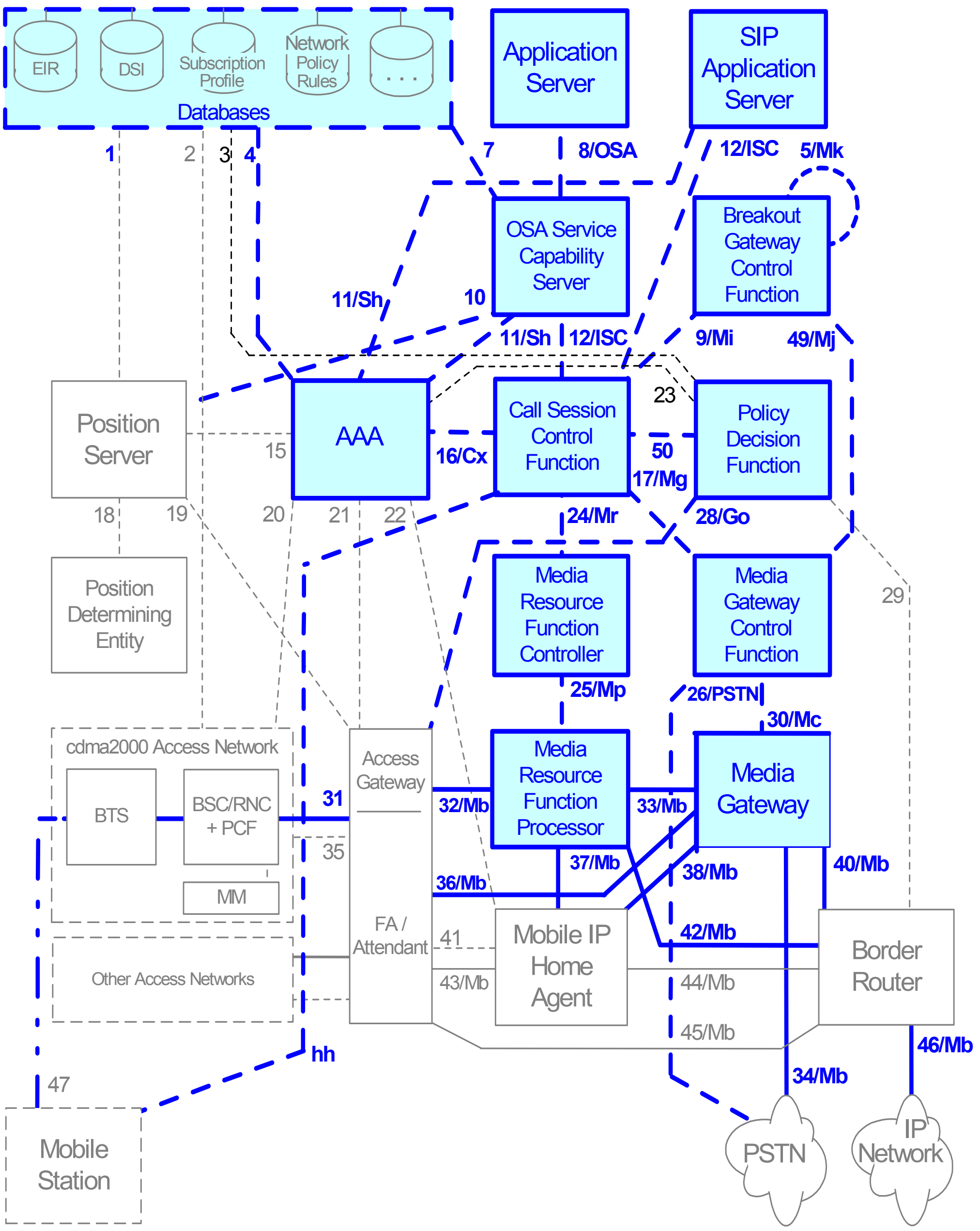


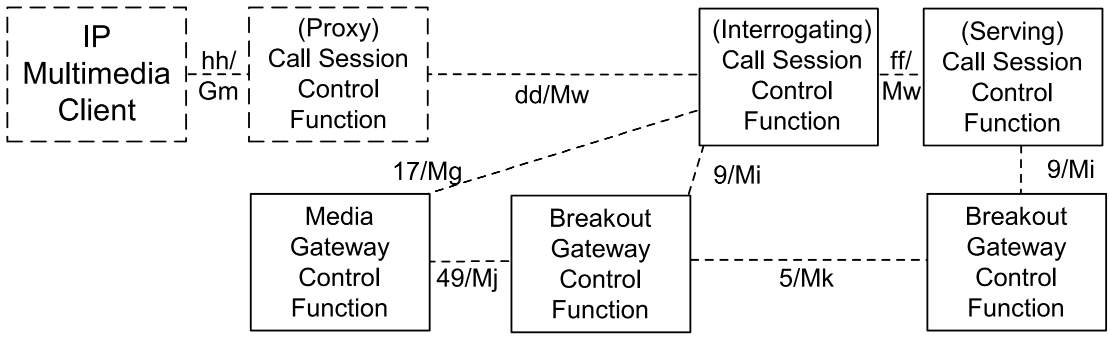
Figure 6-4/Q.1742.2 shows the entities that comprise the multimedia session capabilities of an All-IP network. These entities are known collectively as the IP Multimedia Session Subsystem (IMS). Figure 6-4/Q.1742.2 includes several reference points that have dual labels. Either of these labels may be used in the specifications relating to these reference points. Note: in Figure 6-4/Q.1742.2 the “IP Multimedia Session Subsystem” is identified by the network elements and reference points highlighted in “blue”.

Figure 6-4/Q.1742.2: ANSI-41 evolved Core Network with cdma2000 Access Network IP Multimedia Session Subsystem Core Network Architecture Model



The session control functions within the IMS are logically interconnected in various ways in the session scenarios. Figure 6-5/Q.1742.2 identifies the reference points within the IMS between these session control entities. In many cases there are dual labels for these reference points either of which may be used in the applicable specifications.

Figure 6-5/Q.1742.2: Session Control Reference Model



7 Network Entities

7.1 Authentication, Authorization and Accounting (AAA)

The AAA is an entity that provides IP based Authentication, authorization, and Accounting. The AAA maintains security associations with peer AAA entities to support intra- and/or inter-administrative domain AA A functions.

- The Authentication Function provides Authentication of users.
- The Authorization Function of AAA provides authorization of service requests based on subscriber profiles, and network policy. It also generates keys required for establishing security associations between PDSNs in access provider networks and HAs in home IP networks.

The Accounting Function gathers accounting data concerning the services used by individual subscribers.

7.2 Authentication Center (AC)

The AC is an entity that manages the authentication information related to the MS. The AC may, or may not be located within, and be indistinguishable from an HLR. An AC may serve more than one HLR.

7.3 Call Data Collection Point (CDCP)

The CDCP is the entity that collects the call detail information.

7.4 Call Data Generation Point (CDGP)

The CDGP is an entity which provides call detail information to the CDCP (in ANSI-124 format). This may be the entity that converts call detail information from a proprietary format into a standard format. All information from the CDGP to the CDCP must be in this standard format.

7.5 Call Data Information Source (CDIS)

The CDIS is an entity that can be the source of call detail information. This information may be in proprietary format. It is not required to be in the standard format.

7.6 Call Data Rating Point (CDRP)

The CDRP is the entity that takes the unrated call detail information and applies the applicable charge and tax related information. The charge and tax information is added using the standard format.

7.7 Collection Function (CF) – (Intercept)

The CF is an entity that is responsible for collecting intercepted communications for a lawfully authorized law enforcement agency.

The CFs typically include:

- the ability to receive and process call contents information for each intercept subject;
- the ability to receive information regarding each intercept subject (e.g., call associated or non-call associated) from the Delivery function and process it.

7.8 Coordinate Routing Data Base (CRDB)

The CRDB is an entity that stores information to translate a given position expressed as a latitude and longitude to a string of digits.

7.9 Customer Service Center (CSC)

The CSC is an entity where service provider representatives receive telephone calls from customers wishing to subscribe to initial wireless service or request a change in the customer's existing service. The CSC interfaces proprietarily with the OTAF to perform network and MS related changes necessary to complete the service provisioning request.

7.10 Delivery Function (DF) – (Intercept)

The DF is an entity that is responsible for delivering intercepted communications to one or more collection functions.

The DFs typically include:

- the ability to accept call contents for each intercept subject over one or more channels from each Access function;
- the ability to deliver call contents for each intercept subject over one or more channels to a Collection function as authorized for each law enforcement agency;
- the ability to accept information over one or more data channels and combine that information into a single data flow for each intercept subject;
- the ability to filter or select information on an intercept subject before delivery to a Collection function as authorized for a particular law enforcement agency;
- the optional ability to detect audio in-band DTMF digits for translation and delivery to a Collection function as authorized for a particular law enforcement agency;
- the ability to duplicate and deliver information on the intercept subject to one or more Collection functions as authorized for each law enforcement agency;
- the ability to provide security to restrict access.

7.11 Equipment Identity Register (EIR)

The EIR is an entity that is the register to which user equipment identity may be assigned for record purposes. The nature, purpose, and utilization of this information is an area for further study.

7.12 Home Agent (HA)

The HA is an entity that:

- authenticates Mobile IP registrations from the MS;
- redirects packets to the foreign agent component of the PDSN, and optionally receives and routes reverse packets from the foreign agent component of the PSDN;

- may establish, maintain and terminate secure communications to the PDSN;
- receives provisioning information from the AAA Function for users;
- may assign a dynamic home IP address.

7.13 Home Location Register (HLR)

The HLR is the location register to which a user identity is assigned for record purposes such as subscriber information (e.g. Electronic Serial Number (ESN), Mobile Directory Number (MDN), Profile Information, Current Location, Authorization Period).

7.14 Intelligent Peripheral (IP)

The IP[73] is an entity that performs specialized resource functions such as playing announcements, collecting digits, performing speech-to-text or text-to-speech conversion, recording and storing voice messages, facsimile services, data services, etc.

7.15 Intercept Access Point (IAP)

The IAP is an entity that provides access to the communications to, or from, the equipment, facilities, or services of an intercept subject.

7.16 Interworking Function (IWF)

The IWF is an entity that provides information conversion for one or more WNEs. An IWF may have an interface to a single WNE providing conversion services. An IWF may augment an identified interface between two WNEs, providing conversion services to both WNEs.

7.17 Local Position Determining Entity (LPDE)

The LPDE facilitates the determination of the position or geographical location of a wireless terminal. Each LPDE supports one or more position determining technologies. Multiple LPDEs using the same technology may serve the coverage area of a Mobile Position Center (MPC) and the multiple LPDEs each using a different technology may serve the same coverage area of an MPC. Local PDEs (LPDEs) reside at the Base Station (BS).

7.18 Managed Wireless Network Entity (MWNE)

A MWNE (within the Collective Entity) or any specific network entity having Operation System wireless management needs, including another Operations System.

7.19 Message Center (MC)

The MC is an entity that stores and forwards short messages. The MC may also provide supplementary services for Short Message Service (SMS).

7.20 Mobile Position Center (MPC)

The MPC selects a PDE to determine the position of a mobile station. The MPC may restrict access to position information (e.g. require that the MS be engaged in an emergency call or only release position information to authorized network entities).

7.21 Mobile Switching Center (MSC)

The MSC switches circuit mode MS originated or MS terminated traffic. An MSC is usually connected to at least one BS. It may connect to the other public networks (PSTN, ISDN, etc.), other MSCs in the same network, or MSCs in different networks. The MSC may store information to support these capabilities.

[73] IP, Intelligent Peripheral.

7.22 Number Portability DataBase (NPDB)

The NPDB is an entity which provides portability information for portable Directory Numbers.

7.23 Over-The-Air Service Provisioning Function (OTAF)

The OTAF is an entity that interfaces proprietarily to CSCs to support service provisioning activities. The OTAF interfaces with the MSC to send MS orders necessary to complete service provisioning requests.

7.24 Packet Data Network (PDN)

A PDN, such as the Internet, provides a packet data transport mechanism between processing network entities capable of using such services.

7.25 Packet Data Serving Node (PDSN)

The PDSN routes MS originated or MS terminated packet data traffic. The PDSN establishes, maintains, and terminates link layer sessions to MSs. The PDSN may interface to one or more MSs and may interface to one or more PDNs.

7.26 Position Determining Entity (PDE)

A PDE facilitates determination of the position or geographical location of a wireless terminal. Each PDE supports one or more position determining technologies. Multiple PDEs using the same technology may serve the coverage area of a Mobile Position Center (MPC) and the multiple PDEs each using a different technology may serve the same coverage area of an MPC.

7.27 Service Control Point (SCP)

The SCP is an entity that acts as a real-time database and transaction processing system that provides service control and service data functionality.

7.28 Service Node (SN)

The SN is an entity that provides service control, service data, specialized resources and call control functions to support bearer-related services.

7.29 Short Message Entity (SME)

The SME is an entity that composes and decomposes short messages. A SME may, or may not be located within, and be indistinguishable from, an HLR, MC, VLR, MS, or MSC.

7.30 Visitor Location Register (VLR)

The VLR is the location register other than the HLR used by an MSC to retrieve information for handling of calls to or from a visiting subscriber. The VLR may, or may not be located within, and be indistinguishable from an MSC. The VLR may serve more than one MSC.

7.31 Voice Message Center (VMS)

A VMS stores received voice messages, data messages e.g. email, or both message types and supports a method to retrieve previously stored messages. A VMS may also support (on a Directory Number basis) notification of the presence of stored messages and notification of a change in the number of voice messages, data messages, or both message types that are waiting retrieval.

7.32 Wireless Network Entity (WNE)

A Network Entity in the wireless Collective Entity.

7.33 Access Gateway (AGW)

The CDMA2000 AGW consists of the PDSN and other logical functions required to interface the core network to the CDMA2000 RAN.

- The PDSN routes MS originated or MS terminated packet data traffic. The PDSN establishes, maintains, and terminates link layer sessions to MSs. The PDSN may interface to one or more MSs and may interface to one or more PDNs.

7.34 Application Server

Application Servers provide value-added network-based services for wireless subscribers. These services may be accessed via the OSA Service Capability Server (OSA-SCS) or accessed directly from the user's mobile station via other network entities, by-passing the OSA-SCS.

7.35 Authentication, Authorization and Accounting (AAA)

The AAA is an entity that provides IP based Authentication, authorization, and Accounting. The AAA maintains security associations with peer AAA entities to support intra- and/or inter-administrative domain AA A functions.

- The Authentication Function is an entity that provides Authentication of terminal devices and subscribers.
- The Authorization Function of AAA provides authorization of requests for services and/or bandwidth, etc. and has access to the Policy Repository, the Directory Services, Subscriber Profiles, and the Device Register.
- The Accounting Function gathers data concerning the services, QoS, and multimedia resources requested and used by individual subscribers.

7.36 Border Router (BR)

The BR connects the Core Network with peer networks (e.g., other service providers, corporate networks, Internet). The BR performs IP packet routing, exterior gateway routing protocols, and policing of incoming and outgoing traffic, ensuring traffic complies with defined Service Level Agreements established with peer networks. The BR may intercept any QoS allocation request, and issue a request to the Policy Decision Function (PDF), which shall verify that the requested inbound and/or outbound QoS is available. A successful response from the PDF may cause the BR to forward the bandwidth allocation request to its final destination.

7.37 Breakout Gateway Control Function (BGCF)

The BGCF selects the network in which PSTN breakout is to occur and, within the network where the breakout is to occur, selects the MGCF.

7.38 Call Session Control Function (CSCF)

The CSCF establishes, monitors, supports, releases Multimedia sessions, and manages the user's service interactions.

7.39 Databases (DB)

The information in the core network DBs may include but is not limited to EIR, Dynamic Subscriber Information, Network Policy Rules and Subscriber Profile data.

7.40 IP Multimedia Client

The IP Multimedia Client communicates with Application Servers, P-CSCFs, and other IP Multimedia Clients. The IP Multimedia Client is an application that resides in the MS.

7.41 IP Network

The IP network corresponds to IP based packet data networks that provide a transport mechanism between the core network and external IP networks. IP Network represents packet networks connected to the core network including the public Internet, private IP backbone networks and private IP networks such as corporate Intranets.

7.42 Media Gateway (MGW)

The MGW provides an interface between the packet environment of the Core Network and the circuit switched environment of the PSTN for bearer traffic, when equipped with circuit capabilities. The MGW may provide vocoding and/or transcoding functions to the bearer traffic. The MGW may also provide modem functions to convert digital byte streams to and from audio modem tones placed on circuits, and may provide the capability to terminate PPP (Point-to-Point Protocol) connections. It also provides policy enforcement relative to its activities and resources.

7.43 Media Gateway Control Function (MGCF)

The MGCF provides the ability to control a Media Gateway through standardized interfaces. Such control includes allocation and deallocation of resources of the Media Gateway, as well as modification of the usage of those resources.

7.44 Media Resource Function Controller (MRFC)

The MRFC, in conjunction with the MRFP, provides a set of resources within the core network that are useful in supporting services to subscribers. The MRFC, in conjunction with the MRFP, provides multi-way conference bridges, announcement playback services, tone playback services, etc.

7.45 Media Resource Function Processor (MRFP)

The MRFP, in conjunction with the controlling entity, provides multi-way conference bridges, announcement playback services, tone playback services, etc.

7.46 Mobile IP Home Agent (HA)

The HA provides two major functions: registering the current point of attachment of the user, and forwarding of IP packets to and from the current point of attachment (IPv4 Care of Address (CoA) and/or IPv6 Co-located CoA) of the user. The HA accepts registration requests using the Mobile IP protocol and uses the information in those requests to update internal information about the current point of attachment of the user, i.e., the current IP address to be used to transmit and receive IP packets to and from that user. The HA interacts with the AAA to receive Mobile IP registration requests that have been authenticated, and to return Mobile IP registration responses. The HA also interacts with the Access Gateway to receive subsequent Mobile IP registration requests. The HA may interact with several network entities in performing its work of forwarding IP packets to the current point of attachment of the user.

7.47 Mobile Station (MS)

Note – Not part of the core network.

7.48 OSA Service Capability Server (OSA-SCS)

The OSA-SCS provides access to network resources needed during service application execution. The interface towards the Application Server uses application programming interfaces such as Open Service Architecture (OSA). The interfaces towards other network entities use the relevant protocols.

7.49 Policy Decision Function (PDF)

The PDF provides management of core network QoS resources within its own core network necessary to support services to network users. It communicates with the Access Gateway to provide authorization of resource allocations. The PDF makes policy decisions with regard to use of core network QoS resources within its own network, including consideration of Service Level Agreements (SLAs (Note, the maintenance of SLAs is for further study.)). QoS policy information for network resource utilization may be forwarded to and cached by the PDF.

7.50 Position Determining Entity (PDE)

The PDE communicates with the Position Server to determine the precise geographic position of the MS based on input data provided by the Position Server.

7.51 Position Server

The Position Server provides geographic position information to requesting entities.

7.52 Public Switched Telephone Network (PSTN)

The PSTN is defined in accordance with the appropriate applicable national and regional standards.

8 Reference Points

The following text is based on reference [12 a-d] section 2.1.2.

8.1 Reference Point B

Reference Point B is the interface between MSC and the VLR.

8.2 Reference Point C

Reference Point C is the interface between the MSC and the HLR.

8.3 Reference Point D

Reference Point D is the interface between the VLR and HLR.

8.4 Reference Point d

Reference Point d is the interface between an IAP and the DF.

8.5 Reference Point D_1

Reference Point D1 is the interface between the OTAF and the VLR.

8.6 Reference Point D_i

Reference Point D_i is the interface between:

- The IP and the ISDN.
- The IWF and the ISDN.
- The MSC and the ISDN (ESBE).
- The SN and the ISDN.

8.7 Reference Point E

Reference Point E is the interface between the MSC and MSC.

8.8 Reference Point E_3

Reference Point E3 is the interface between MPC and the MSC.

8.9 Reference Point E_5

Reference Point E5 is the interface between the MPC and the PDE.

8.10 Reference Point E_9

Reference Point E9 is the interface between the MPC and the SCP.

8.11 Reference Point E_{11}

Reference Point E_{11} is the interface between the CRDB and the MPC.

8.12 Reference Point E_{12}

Reference Point E12 is the interface between MSC and the PDE.

8.13 Reference Point e

Reference Point e is the interface between the CF and the DF.

8.14 Reference Point F

Reference Point F is the interface between the MSC and the EIR.

8.15 Reference Point G

Reference Point G is the interface between the VLR and the VLR.

8.16 Reference Point H

Reference Point H is the interface between the HLR and the AC.

8.17 Reference Point I

Reference Point I is the interface between the CDIS and the CDGP.

8.18 Reference Point J

Reference Point J is the interface between the CDGP and the CDCP.

8.19 Reference Point K

Reference Point K is the interface between the CDGP and the CDRP.

8.20 Reference Point L

Reserved.

8.21 Reference Point M_1

Reference Point M1 is the interface between the SME and the MC.

8.22 Reference Point M_2

Reference Point M2 is the MC to MC interface.

8.23 Reference Point M_3

Reference Point M3 is the SME to SME interface.

8.24 Reference Point N

Reference Point N is the interface between the HLR and the MC.

8.25 Reference Point N1

Reference Point N1 is the interface between the HLR and the OTAF.

8.26 Reference Point O_1

Reference Point O1 is the interface between an MWNE and the OSF.

8.27 Reference Point O_2

Reference Point O2 is the interface between an OSF and the OSF.

8.28 Reference Point P_i

Reference Point P_i is the interface between:

- The AAA and the AAA;
- The AAA and the PDN;
- The IWF and the PDN;
- The MSC and the PDN; plus
- The PDSN and the PDN.

8.29 Reference Point Q

Reference Point Q is the interface between the MC and the MSC.

8.30 Reference Point Q_1

Reference Point Q_1 is the interface between the MSC and the OTAF.

8.31 Reference Point T_1

Reference Point T_1 is the interface between the MSC and the SCP.

8.32 Reference Point T_2

Reference Point T_2 is the interface between the HLR and the SCP.

8.33 Reference Point T_3

Reference Point T_3 is the interface between the IP (Intelligent Peripheral) and the SCP.

8.34 Reference Point T_4

Reference Point T_4 is the interface between the HLR and the SN.

8.35 Reference Point T_5

Reference Point T_5 is the interface between the IP (Intelligent Peripheral) and the MSC.

8.36 Reference Point T_6

Reference Point T_6 is the interface between the MSC and the SN.

8.37 Reference Point T_7

Reference Point T_7 is the interface between the SCP and the SN.

8.38 Reference Point T_8

Reference Point T_8 is the interface between the SCP and the SCP.

8.39 Reference Point T_9

Reference Point T_9 is the interface between the HLR and the IP.

8.40 Reference Point V

Reference Point V is the interface between the OTAF and the OTAF.

8.41 Reference Point X

Reference Point X is the interface between the CSC and the OTAF.

8.42 Reference Point Y

Reference Point Y is the interface between a Wireless Network Entity (WNE) and the IWF.

8.43 Reference Point Z

Reference Point Z is the interface between the MSC and the NPDB.

8.44 Reference Point Z_1

Reference Point Z_1 is the interface between the MSC and the VMS.

8.45 Reference Point Z_2

(Not shown in section 6 figure.) Reference Point Z_2 is the interface between the HLR and the VMS.

8.46 Reference Point Z_3

Reference Point Z_3 is the interface between the MC and the VMS

An interface exists when two Network Entities are interconnected through exactly one signalling or bearer stream Reference Point. The Reference Points and their associated Network Entities are:

8.47 Reference Point 1

Reference Point 1 is the signaling interface between the Databases and the Position Server (Multimedia Domain only)

8.48 Reference Point 2

Reference Point 2 is the signaling interface between the Databases and the cdma2000 Access Network.

8.49 Reference Point 3

Reference Point 3 is the signaling interface between the Databases and the Policy Decision Function [Multimedia Domain only].

8.50 Reference Point 4

Reference Point 4 is the signaling interface between the Databases and the AAA.

8.51 Reference Point 5/Mk

Reference Point 5/Mk is the signaling interface between Breakout Gateway Control Functions [Multimedia Domain only].

8.52 Reference Point 6

Reference Point 6 is the signaling interface between the Databases and the Legacy MS Domain Support [Legacy MS Domain only].

8.53 Reference Point 7

Reference Point 7 is the signaling interface between the OSA Service Capability Server and the Databases.

8.54 Reference Point 8/OSA

Reference Point 8/OSA is the signaling interface between the OSA Application Server and the OSA Service Capability Server. Reference Point 8/OSA may employ interfacing techniques that support a wide spectrum of capabilities, ranging from secure (e.g., application programming interfaces such as Parlay, used for un-trusted parties) to non-secure (e.g., used for trusted parties).

8.55 Reference Point 9/Mi

Reference Point 9/Mi is the signaling interface between the Visited Network's BGCF and the Home Service Network's Serving-CSCF (Multimedia Domain only).

8.56 Reference Point 10

Reference Point 10 is the signaling interface between the Position Server and the OSA Service Capability Server (Multimedia Domain only).

8.57 Reference Point 11/Sh

Reference Point 11/Sh is the signaling interface between the SIP Application Server and the AAA and between the OSA Service Capability Server and the AAA for user's service authentication and/or authorization, and for retrieving information from the MMD database (Multimedia Domain only).

8.58 Reference Point 12/ISC

Reference Point 12/ISC is the signaling interface between the SIP Application Server and Call Session Control Function and between the OSA Service Capability Server and the Call Session Control Function for service control (Multimedia Domain only).

8.59 Reference Point 13

Reference Point 13 is the signaling interface between the Legacy MS Domain Support and the PSTN (Legacy MS Domain only).

8.60 Reference Point 14

Reference Point 14 is the signaling interface between the Legacy MS Domain Support and the MAP (TIA/EIA-41 & GSM) (Legacy MS Domain only).

8.61 Reference Point 15

Reference Point 15 is the signaling interface between the Position Server and AAA.

8.62 Reference Point 16/Cx

Reference Point 16/Cx is the signaling interface between the AAA and the Call Session Control Function (Multimedia Domain only).

8.63 Reference Point 17/(Mg)

Reference Point 17/(Mg) is the signaling interface between the Call Session Control Function and the Media Gateway Control Function (Multimedia Domain only).

8.64 Reference Point 18

Reference Point 18 is the signaling interface between the Position Server and the Position Determining Entity.

8.65 Reference Point 19

Reference Point 19 is the signaling interface between the Position Server and the Access Gateway (Multimedia Domain only).

8.66 Reference Point 20

Reference Point 20 is the signaling interface between the AAA and the cdma2000 Access Network (Multimedia Domain only).

8.67 Reference Point 21

Reference Point 21 is the signaling interface between the AAA and Access Gateway.

8.68 Reference Point 22

Reference Point 22 is the signaling interface between the AAA and the Mobile IP Home Agent.

8.69 Reference Point 23

Reference Point 23 is the signaling interface between the AAA and the Policy Decision Function (Multimedia Domain only).

8.70 Reference Point 24/Mr

Reference Point 24/Mr is the signaling interface between the Call Session Control Function and the Media Resource Function Controller (Multimedia Domain only).

8.71 Reference Point 25/Mp

Reference Point 25/Mp is the signaling interface between the Media Resource Function Controller and the Media Resource Function Processor.

8.72 Reference Point 26/PSTN

Reference Point 26/PSTN is the signaling interface between the Media Gateway Control Function and the PSTN (Multimedia Domain only).

8.73 Reference Point 27

Reference Point 27 is the bearer stream interface between the cdma2000 Access Network and the Media Gateway (Legacy MS Domain only).

8.74 Reference Point 28/Go

Reference Point 28/Go is the signaling interface between the Policy Decision Function and Access Gateway.

8.75 Reference Point 29

Reference Point 29 is the signaling interface between Policy Decision Function and the Border Router.

8.76 Reference Point 30/Mc

Reference Point 30/Mc is the signaling interface between the Media Gateway Control Function and the Media Gateway (Multimedia Domain only).

8.77 Reference Point 31

Reference Point 31 is the bearer stream interface between cdma2000 Access Network and the Access Gateway.

8.78 Reference Point 32/Mb

Reference Point 32/Mb is the bearer stream interface between the Access Gateway and the Media Resource Function Processor (Multimedia Domain only).

8.79 Reference Point 33/Mb

Reference Point 33/Mb is the bearer stream interface between the Media Resource Function Processor and the Media Gateway.

8.80 Reference Point 34/Mb

Reference Point 34/Mb is the bearer stream interface between the Media Gateway and the PSTN.

8.81 Reference Point 35

Reference Point 35 is the signaling interface between the cdma2000 Access Network and the Access Gateway.

8.82 Reference Point 36/Mb

Reference Point 36/Mb is the bearer stream interface between the Access Gateway and the Media Gateway (Multimedia Domain only).

8.83 Reference Point 37/Mb

Reference Point 37/Mb is the bearer stream interface between the Media Resource Function Processor and the Mobile IP Home Agent (Multimedia Domain only).

8.84 Reference Point 38/Mb

Reference Point 38/Mb is the bearer stream interface between the Media Gateway and the Mobile IP Home Agent (Multimedia Domain only).

8.85 Reference Point 39

Reference Point 39 is the signaling interface between the Media Gateway and the Legacy MS Domain Support (Legacy MS Domain only).

8.86 Reference Point 40/Mb

Reference Point 40/Mb is the bearer streams interface between the Media Gateway and the Border Router.

8.87 Reference Point 41

Reference Point 41 is the signaling interface between the Access Gateway and the Mobile IP Home Agent.

8.88 Reference Point 42/Mb

Reference Point 42/Mb is the bearer streams interface between the Media Resource Function Processor and the Border Router.

8.89 Reference Point 43/Mb

Reference Point 43/Mb is the bearer streams interface between the Access Gateway and the Mobile IP Home Agent.

8.90 Reference Point 44/Mb

Reference Point 44/Mb is the bearer stream interface between the Mobile IP Home Agent and the Border Router.

8.91 Reference Point 45/Mb

Reference Point 45/Mb is the bearer stream interface between the Access Gateway and the Border Router.

8.92 Reference Point 46/Mb

Reference Point 46/Mb is the bearer stream interface between the Border Router and the IP Network.

8.93 Reference Point 47

Reference Point 47 is the Radio Link (air interface) between the Mobile Station and the cdma2000 Access Network.

8.94 Reference Point 48

Reference Point 48 is the signaling interface between the cdma2000 Access Network and the Legacy MS Domain Support (Legacy MS Domain only).

8.95 Reference Point 49/(Mj)

Reference Point 49/(Mj) is the signaling interface between the Breakout Gateway Control Function and the Media Gateway Control Function (Multimedia Domain only).

8.96 Reference Point 50

Reference Point 50 is the signaling interface between the Policy Decision Function and the P-CSCF (Multimedia Domain only).

ITU-T Rec. Q.1742.2 }

ANNEX C[74]

Methodology for evolution

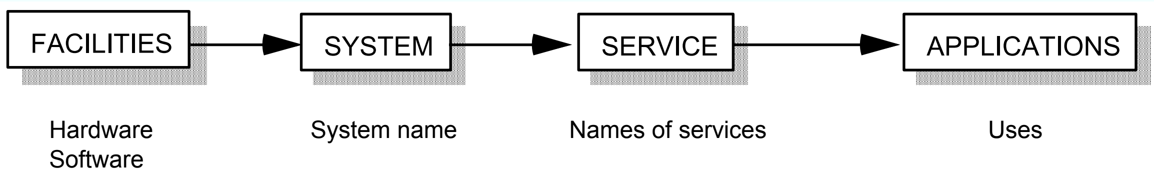
C.1 Evolution Methodology and Scenarios

{ [i] In this annex evolution approaches are presented, including a phased approach for the introduction of IMT-2000.

C1.1 IMT-2000 Evolution Framework

IMT-2000 evolution will likely occur in several dimensions or components; hence it is useful to consider a framework to facilitate the evolution studies. This section proposes such a framework, including definitions of the relevant terms. It is shown how the evolution of facilities, system and services can proceed more or less independently from each other.

In the telecommunications field, a combination of *facilities* or *components* (comprising hardware, software and network) constitutes a *system*, which gives rise to a set of *services*. The services may then be put to various *applications* by the user. Thus, to represent these ideas diagrammatically:



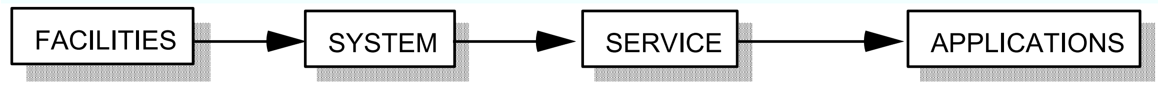
The addition of other facilities modifies the system to provide additional services and to permit new uses. Thus, an answering machine enables the caller to leave a message, obtain pre-recorded information, etc., as an adjunct to the telephone service.

The terms “system” and “service” often refer to two aspects of the same object. While “system” refers to the collection of facilities, “service” refers to a set of capabilities provided by the system. “Application” can refer to either the use of an independent “system” or a public “service”. Whenever the word “application” appears, a good test for its correct use is to try to answer the question: What is being applied? or What is it the application of?

74 NOTE TO EXTRACT – For the purposes of MTG, it is considered that sub-section A1.2.3 is the most relevant. Q.18/2 would like to have WP8A-8F opinion on the applicability of the remaining text in Appendix C given the state-of-the-art for the production of equipment intended for evolution to IMT-2000.

IMT-2000 Framework

Applying the above concepts to IMT-2000 would lead to:



FACILITIES	SYSTEM	SERVICE	APPLICATIONS
– terminals – base stations – controllers – databases – security software – transmission lines – switches	– IMT-2000	– IMT-2000 services (In the case of speech, a service which allows a user to communicate with another user from different locations and while in motion)	– voice conversation – mobility services – obtain quotations – etc.

Framework for Evolution to IMT-2000

In terms of the evolution to IMT-2000 aspects, this means that the evolution of facilities, systems, services, and applications can be considered separately and more conveniently. For example:

Facilities: The evolution of the facilities or system components may be made transparent to users in order to provide the same services more effectively from the point of view of the operator or service provider, or it may allow new services or better features in existing services.

System: As facilities evolve, a system will also evolve in terms of its capabilities, possibly to a point that, if enough changes are made, a new system may be considered to have been created. However, even if the component facilities do not change they could be combined in a different manner to form an evolved system or a new system.

Service: Even if the hardware components and system do not change, it is still possible to create new services through inherent flexibility built into the system or by means of software modifications.

Applications: As users become experienced with services, new applications of the same services will occur, which may eventually evolve into formal services when the service provider realises a new value-added service.

The conclusion of this analysis is that although changes may be occurring at one level, they may be invisible at other levels, and the overall evolution may be managed.

C.1.2 Phases for Evolution to IMT-2000

C.1.2.1 Network Aspects

Possible target public networks for integration[75] are:

- ISDN and other broad band telecommunication networks;
- mobile telecommunication networks.

These types of public networks describe the variety of public environments where a third generation mobile system has to operate. In addition to the integration in a public network environment a third generation mobile system needs to be integrated in different private environments as well.

In the early introduction phase second generation mobile networks and ISDN networks are likely to be the target networks for integration. However in the long-run broadband networks becoming state of the art network technology will also be the target networks for integration of third generation mobile systems.

[75] See also new Recommendation ITU-R M.1182: Integration of terrestrial and satellite mobile communication systems.

C.1.2.2 Radio Aspects

When IMT-2000 starts its commercial cycle, the dominant force will be a multitude of pre- IMT-2000 networks, spread out over a wide coverage area. During this phase the IMT-2000 service provider may have to supply a radio that can, in addition to meeting the IMT-2000 requirements, also "talk" to the pre-IMT-2000 network standards and provide connectivity with their methods of communication.

The implied requirement for the IMT-2000 terminal is for a substantial core radio operating both in IMT-2000 environment as well augmenting service availability by using pre- IMT-2000 systems.

This could be done by programming the radio for additional protocol capability, with the price being determined by the number of features the radio owner wants to have.

Pre- IMT-2000 systems will have to add suitable interfaces to their systems to provide service for IMT-2000 radios. }

C.1.2.3 Satellite Considerations

The satellite and terrestrial components of IMT-2000 in general complement each other by providing service coverage to areas which either alone may not economically serve. Each component has particular advantages and constraints. The satellite component will provide coverage to areas which may not be within the economic range of the terrestrial component; this applies additionally to rural and remote regions. Providing satellite coverage, in more densely populated areas could encourage later coverage by the terrestrial component. IMT-2000 satellite systems can also provide a multicast layer as a complement to the IMT-2000 terrestrial mobile networks.

There are currently six satellite systems defined as part of the IMT-2000 family through their radio interfaces (see Recommendations ITU-R M.1455-2 and ITU-R M.1457-3) and each can be expected to operate independently from one-another. All aim to provide coverage for regional, multiregional or global service areas and hence there may be several satellite systems, capable of providing service in any country.

The following points should be studied further by ITU-R Working Party 8D:

- The effect of the development of the IMT-2000 infrastructure of terrestrial-based components on the implementation and evolution of IMT-2000 mobile satellite systems.
- The impact and practicality of dual mode user terminals providing voice and data services, whichever the mobile network used (satellite or terrestrial).

{ C.1.2.4 A 3-Step Approach

Evolution and migration may come in three main steps between four levels for each system. These steps may occur at different times in different regions and at different times for different operators:

LEVEL 1: *Existing mobile systems*. Examples: GSM Phase 1 and Phase 2, D-AMPS, PDC, PHS, etc. – mid '90s technology.

STEP A: The *evolution* from level 1 to 2 for GSM. Change of technology for some (US-PCS).

LEVEL 2: *Enhanced mobile systems.* Examples: GSM Phase 2++, US-PCS, Advanced PDC/PHS. Brings new technology and services into existing mobile systems, to the edge of second generation technology limits (IN, higher bit rates, etc.). Old terminals may work in parts of the system, but cannot use new services.

STEP B: The *change* from level 2 to 3.

LEVEL 3: IMT-2000 during the introduction phase, limited capability sets, partly re-use pre- IMT-2000 technology. Possibly adds a new frequency band, a new air interface, a new integrated access and service concept to previous systems. Deployment of new services is cheaper and easier in the new frequency band. Pre- IMT-2000 terminals can still be used where pre- IMT-2000 exist, but may in due time be phased-out. New coverage and service areas introduced at this stage can not be used, except for those who invest in new terminals. A level 3 terminal may be a multi-mode terminal that can access service logic through a number of air interfaces, including IMT-2000, as well as pre- IMT-2000 radio interfaces.

STEP C: The *evolution* from level 3 to 4.

LEVEL 4: Target IMT-2000: no technical limitations or bottlenecks for a full implementation of IMT-2000. Market demands on high quality and high bit rate services will push the rapid deployment of IMT-2000. Interworking with previous generation systems is maintained.

New IMT-2000 technology introduced at level 3 (and fully operational at level 4) will comply with all IMT-2000 objectives/specifications and will facilitate access to services in visited network segments across regions. Also, the user mobility provided through UIM (User Identity Module) functionality will provide service accessibility in visited networks during the intermediate phases. **}**

ANNEX D

Information on operator transition paths

Note – Unless otherwise specified, data in Annex D relate to July 2004.

<**Editor Note** – WP 8F recognizes that the information in this annex is not presented in a common format at present.>

D.1 IMT-2000 CDMA Multi-Carrier Information

Table D.1: Commercial IMT-2000 CDMA Multi-Carrier Systems Transitioned from Pre-IMT-2000 Systems (chronological order of launch date)

Country	Operator	Date	Frequency Bands	Pre-IMT-2000 Technology
South Korea	SK Telecom	Oct. 1, 2000	800 MHz	cdmaOne
South Korea	LG Telecom	Oct. 1, 2000	1 700 MHz	cdmaOne
South Korea	KT Freetel	May 1, 2001	1 700 MHz	cdmaOne
USA	Western Wireless	July 1, 2001	800 MHz	TDMA, cdmaOne
USA	Monet Mobile Networks	Oct. 15, 2001	1 900 MHz	N/A
Romania	Zapp Mobile	Dec. 7, 2001	450 MHz	NMT450
Brazil	Vivo	Dec. 12, 2001	800 MHz	AMPS, cdmaOne, TDMA
USA	Leap Wireless	Dec. 10, 2001	1 900 MHz	cdmaOne
USA	Verizon Wireless	Jan. 28, 2002	800 and 1 900 MHz	AMPS, cdmaOne
Canada	Bell Mobility	Feb. 12, 2002	800 and 1 900 MHz	AMPS, TDMA, cdmaOne
USA	MetroPCS	Feb. 21, 2002	1 900 MHz	N/A
Japan	KDDI	Apr. 1, 2002	Japan 800 MHz	cdmaOne
Puerto Rico	Centennial de Puerto Rico	Apr. 4, 2002	1 900 MHz	cdmaOne
Canada	Telus Mobility	June 3, 2002	800 and 1 900 MHz	AMPS, cdmaOne, IDEN
New Zealand	Telecom Mobile Limited	July 22, 2002	800 MHz	AMPS, TDMA, cdmaOne
Chile	Smartcom PCS	July 26, 2002	1 900 MHz	cdmaOne
USA	Sprint	Aug. 11, 2002	1 900 MHz	cdmaOne
Puerto Rico	Sprint Puerto Rico	Aug. 11, 2002	1 900 MHz	cdmaOne
U.S. Virgin Islands	Sprint U.S. Virgin Islands	Aug. 11, 2002	1 900 MHz	cdmaOne
USA	Cellular South	Sept. 9, 2002	800 MHz	AMPS, TDMA

Israel	Pele-Phone	Sept. 30, 2002	800 MHz	cdmaOne
Moldova	JSC Interdnestrcom	Sept. 30, 2002	800 MHz	cdmaOne
USA	NTELOS	3Q 2002	1 900 MHz	cdmaOne
Venezuela	Telcel BellSouth	Nov. 13, 2002	800 MHz	cdmaOne
Colombia	EPM-Bogota	Oct. 2, 2002	1 900 MHz	cdmaOne
USA	U.S. Cellular	Oct. 6, 2002	800 and 1 900 MHz	AMPS, cdmaOne, TDMA
India	Tata Teleservices	Nov. 7, 2002	800 MHz	cdmaOne
USA	Kiwi PCS (Comscape)	Nov. 14, 2002	1 900 MHz	N/A
Venezuela	Movilnet	Nov. 20, 2002	850 MHz	TDMA
Canada	Aliant Mobility	Nov. 25, 2002	800 MHz	AMPS, cdmaOne
Canada	MTS Mobility	Nov. 27, 2002	1 900 MHz	cdmaOne
Poland	SFERIA	Nov. 2002	800 MHz	
Australia	Telstra	Dec. 2, 2002	800 MHz	cdmaOne
Ecuador	BellSouth Ecuador	Dec. 3, 2002	800 MHz	AMPS, TDMA
Panama	BellSouth Panama	Dec. 3, 2002	800 MHz	AMPS, TDMA
Indonesia	PT Telekomunikasi	Dec. 5, 2002	800 MHz	
Russia	Delta Telecom	Dec. 16, 2002	450 MHz	NMT450
India	Reliance Infocomm	May 1, 2003	800 MHz	N/A
Mexico	IUSACELL	Jan. 23, 2003	1 900 MHz	cdmaOne
USA	Illinois Valley Cellular	Jan. 2003	800 MHz	TDMA
Puerto Rico	Verizon Wireless Puerto Rico	Feb. 4, 2003	1 900 MHz	TDMA
Belarus	Belcel	Feb. 10, 2003	450 MHz	NMT450
Thailand	Hutchison CAT	Feb. 24, 2003	800 MHz	N/A
Nicaragua	BellSouth Nicaragua	Mar. 26, 2003	800 MHz	TDMA
Nigeria	Multi-Links	Mar. 26, 2003	1900 MHz	TDMA
Dominican Republic	Centennial Dominicana	Mar. 27, 2003	1 900 MHz	cdmaOne
China	China Unicom	Mar. 28, 2003	800 MHz	cdmaOne
USA	ALLTEL	Mar. 2003	800 and 1 900 MHz	cdmaOne, TDMA
Pakistan	TeleCard Limited	Mar. 2003	1 900 MHz	cdmaOne
Canada	SaskTel Mobility	Apr. 10, 2003	800 MHz	cdmaOne
Colombia	BellSouth Colombia	May 5, 2003	800 MHz	TDMA
Russia	SOTEL-Video	May 10, 2003	450 MHz	
India	Mahangar Telephone Nigam Ltd (MTNL)	May 19, 2003	800 MHz	cdmaOne
Guatemala	BellSouth Guatemala	May 20, 2003	1 900 MHz	cdmaOne
USA	Midwest Wireless	June 2, 2003	800 MHz	TDMA
Azerbaijan	Caspian American Telecom	June 15, 2003	800 MHz	

Jamaica	Oceanic Digital Jamaica	June 17, 2003	800 MHz	cdmaOne
Uzbekistan	JSC Uzbektelecom	1H 2003	450 MHz	
Vietnam	S Telecom	July 1, 2003	800 MHz	N/A
Guatemala	SERCOM	July 15, 2003	1 900 MHz	cdmaOne
Taiwan	Asia-Pacific Broadband Wireless Communications	July 29, 2003	800 MHz	N/A
Indonesia	PT Wireless Indonesia	July 29, 2003	1 900 MHz	N/A
Nigeria	Starcomms Limited	July 2003	1 900 MHz	cdmaOne
Chile	BellSouth Chile	Aug. 11, 2003	1 900 MHz	TDMA
Bermuda	Bermuda Digital Communications	Aug. 17, 2003	800 MHz	AMPS, TDMA
India	Shyam Telelink	Sept. 5, 2003	800 MHz	cdmaOne
Indonesia	PT Radio Telepon Indonesia	Sept. 12, 2003	800 MHz	
Kazakhstan	JSC ALTEL	Dec. 10, 2003	800 MHz	AMPS
Russia	Moscow Cellular Communications	Nov. 1, 2003	450 MHz	NMT450
Kyrgyzstan	AkTel LLC	Nov. 18, 2003	800 MHz	N/A
Peru	Telefonica Moviles Peru	Nov. 27, 2003	800 MHz	cdmaOne
Japan	KDDI	Nov. 28, 2003	2 100 MHz	
Ecuador	TELESCA	Dec. 1, 2003	1 900 MHz	N/A
Argentina	Movicom BellSouth Argentina	Dec. 1, 2003	1 900 MHz	cdmaOne
Dominican Republic	Verizon Dominicana (formerly CODETEL)	Dec. 3, 2003	1 900 MHz	cdmaOne
Peru	BellSouth Peru	Dec. 5, 2003	800 MHz	TDMA
Indonesia	PT Mobile-8 Indonesia	Dec. 8, 2003	800 MHz	
USA	Rural Cellular Corporation	Dec. 31, 2003	800/1 900 MHz	TDMA
Georgia	Iberiatel	4Q 2003	450 MHz	
USA	Sagebrush Cellular	Mar. 2004	800 MHz	AMPS

D.2 IMT-2000 CDMA Direct Spread and IMT-2000 CDMA TDD (time code) Information

Launched:

Table D.2-1

Country	Operator	Status
Australia	Hutchison 3G	In service
Austria	Connect Austria	In service
Austria	Hutchison 3G	In service
Austria	Mobilkom	In service
Austria	T-Mobile Austria	In service
Austria	tele.ring	In service
Bahrain	MTC Vodafone	In service
Denmark	HI3G Denmark	In service
Greece	STET Hellas	In service
Hong Kong	Hutchison	In service
Italy	H3G	In service
Japan	J-Phone	In Service
Japan	NTT DoCoMo	In Service
Korea	KT ICOM	In service
Korea	SK IMT	In service
Luxembourg	Tele2	In service
Sweden	HI3G	In service
UAE	Etisalat	In service
UK	Hutchison 3G	In service

In trial/planned:

Table D.2-2

Country	Operator	Status
Australia	Vodafone	Planned
Belgium	BASE (KPN Orange)	Planned
Canada	Rogers AT&T Wireless	Planned
Finland	TeliaSonera	In Trial
France	Orange France	In Trial
Germany	O2	In Trial
Germany	T-Mobile	Planned
Germany	Vodafone D2	In Trial
Hong Kong	SmarTone 3G	Planned
Ireland	Hutchison Whampoa	In Trial
Ireland	O2	In Trial
Ireland	Vodafone Ireland	In Trial
Isle of Man	Manx Telecom	In Trial
Israel	Partner Communications – Orange	Planned
Italy	TIM	Planned
Monaco	Monaco Telecom	In Trial
Netherlands	KPN Mobile	Planned
Netherlands	Vodafone Libertel	In Trial
Poland	Centertel	Planned
Portugal	Vodafone Telecel	In Trial
Russia – Moscow	Mobile TeleSystems	In Trial
Russia – Moscow	Megafone	In Trial
Russia – Moscow	VimpelCom	In Trial
Russia – St Petersburg	North-West GSM	In Trial
Singapore	MobileOne	In Trial
Singapore	Singapore Telecom	Planned
Slovenia	Mobitel	In Trial
Spain	Amena	Planned
Spain	Telefónica Móviles	In Trial
Spain	Vodafone España	Planned
Spain	Xfera	Planned
Sweden	Svenska UMTS-Nät	Planned
Switzerland	Orange	Planned
UK	Orange	Planned
UK	Vodafone	Planned
USA	AT&T Wireless Group	Planned

License awarded:

Table D.2-3

Country	Operator	Status
Australia	3G Investments	Licence Awarded
Australia	Optus	Licence Awarded
Australia	Telstra	Licence Awarded
Belgium	Belgacom Mobile	Licence Awarded
Belgium	Mobistar	Licence Awarded
Czech Republic	Eurotel Praha	Licence Awarded
Czech Republic	RadioMobil	Licence Awarded
Denmark	Orange Denmark	Licence Awarded
Denmark	TDC Mobil	Licence Awarded
Denmark	Telia Denmark	Licence Awarded
Finland	Finnish 3G	Licence Awarded
Finland	Radiolinja	Licence Awarded
Finland – Republic of Åland	Alands Mobiltelefon AB	Licence Awarded
Finland – Republic of Åland	Song Networks	Licence Awarded
France	Bouygues Telecom	Licence Awarded
France	SFR	Licence Awarded
Germany	E-Plus	Licence Awarded
Greece	Cosmote	Licence Awarded
Greece	Panafon SA	Licence Awarded
Greece	STET Hellas	Licence Awarded
Hong Kong	Hong Kong CSL	Licence Awarded
Hong Kong	Sunday	Licence Awarded
Israel	Cellcom Israel	Licence Awarded
Israel	Pelephone	Licence Awarded
Italy	Ipse 2000	Licence Awarded
Italy	Vodafone Omnitel	Licence Awarded
Italy	Wind	Licence Awarded
Latvia	LMT	Licence Awarded
Latvia	Tele2	Licence Awarded
Liechtenstein	Orange	Licence Awarded
Liechtenstein	Tele2	Licence Awarded
Luxembourg	Orange Communications	Licence Awarded
Luxembourg	P&T Luxembourg	Licence Awarded
Malaysia	Maxis Communications	Licence Awarded
Malaysia	Telekom Malaysia	Licence Awarded
Netherlands	3G Blue	Licence Awarded
Netherlands	Dutchtone	Licence Awarded
Netherlands	O2	Licence Awarded

New Zealand	Maori Spectrum Trust	Licence Awarded
New Zealand	Telecom New Zealand	Licence Awarded
New Zealand	TelstraClear	Licence Awarded
New Zealand	Vodafone New Zealand	Licence Awarded
Norway	Netcom	Licence Awarded
Norway	Tele2 Norway AS	Licence Awarded
Norway	Telenor Mobil	Licence Awarded
Poland	Centertel	Planned
Poland	Polkomtel SA	Licence Awarded
Poland	Polska Telefonia Cyfrowa	Licence Awarded
Portugal	OniWay	Licence Awarded
Portugal	Optimus	Licence Awarded
Portugal	TMN	Licence Awarded
Singapore	StarHub	Licence Awarded
Slovak Republic	EuroTel Bratislava	Licence Awarded
Slovak Republic	Orange	Licence Awarded
Sweden	Orange Sweden	Licence Awarded
Sweden	Vodafone Sweden	Licence Awarded
Switzerland	Swisscom Mobile	Licence Awarded
Switzerland	TDC dSpeed	Licence Awarded
Switzerland	Team 3G	Licence Awarded
Taiwan	Asia Pacific Broadband Wireless Communications	Licence Awarded
Taiwan	Chunghwa Telecom	Licence Awarded
Taiwan	FarEasTone	Licence Awarded
Taiwan	Taiwan Cellular Corporation	Licence Awarded
Taiwan	Taiwan PCS	Licence Awarded
Thailand	CAT/TOT	Licence Awarded
UK	O2	Licence Awarded
UK	T-Mobile	Licence Awarded

Source: EMC World Cellular Database, November 2003, GSM Association.

EDGE OPERATORS WORLDWIDE – Status of Deployments at January 2004

Source: 3G Americas, Global Mobile Suppliers Association, GSM Association

Launched:

Table D.2-4

Country	Operator	Status
Bahrain	MTC Vodafone	Launched
Bermuda	Telecom/AT&T Wireless	Launched
Brazil	Oi	In Trials
Canada	Rogers AT&T Wireless	Launched
Chile	Telefónica Móvil	Launched
Czech Republic	Eurotel	In Trial
Finland	TeliaSonera	Launched
Hong Kong	Hong Kong CSL	Launched
Hong Kong	Sunday	In Trial
Hong Kong	Peoples Telephone	In Trial
Hungary	Pannon GSM	Launched
Hungary	Westel	Launched
India	Bharti	In Trial
Lithuania	Bite GSM	Launched
Puerto Rico	AT&T Wireless	Launched
Romania	Orange Romania	In Trial
Serbia	Mobtel Srbija	Pilot network
Thailand	AIS	Launched
Thailand	DTAC	Commercial Field Testing
USA	AT&T Wireless Group	Launched
USA	Cingular Wireless	Launched

In deployment:

Table D.2-5

Country	Operator	Status
Brazil	Claro	In deployment
Brazil	TIM	In deplyment
Brazil	Sercomtel	In deployment
Brazil	Brasil Telecom	In deployment
Brunei	DST	Early 2004 launch
Chile	Entel PCS	Early 2004 launch
Colombia	Colombia Móvil	In deployment

Guatemala	Sercom SA	In deployment
Italy	TIM	Major cities by mid-2004
Kuwait	Wataniya Telecom (NMTC)	Q1 2004
Malaysia	DiGi	In deployment
Mexico	Telcel	In deployment
Peru	TIM Peru	Test phase from Q1 2004
Philippines	SMART Communications	In deployment
Philippines	Globe	In deployment
Slovenia	Si. Mobil – Vodafone	Launch by end March 2004
Thailand	TA Orange	Early 2004 launch
Ukraine	Kyivstar GSM	In deployment
USA	Dobson Communications	In deployment
USA	T-Mobile USA	In deployment
USA	Cincinnati Bell	In deployment
USA	WestLink (Kansas)	In deployment

Planned:

Table D.2-6

Country	Operator	Status
Argentina	Telecom Personal	Planned
Bahrain	Batelco	Planned
Bermuda	Bermuda Telephone Company	EDGE capable
Brazil	CTBC	Planned
Canada	Microcell	Planned
Caribbean: Anguilla	Cable & Wireless	Planned
Caribbean: Antigua and Barbuda	Cable & Wireless	Planned
Caribbean: Barbados	Cable & Wireless	Planned
Caribbean: Cayman Islands	Cable & Wireless	Planned
Caribbean: Dominica	Cable & Wireless	Planned
Caribbean: Grenada	Cable & Wireless	Planned
Caribbean: Jamaica	Cable & Wireless	Planned
Caribbean: Montserrat	Cable & Wireless	Planned
Caribbean: St Kitts and Nevis	Cable & Wireless	Planned
Caribbean: St Lucia	Cable & Wireless	Planned
Caribbean: St Vincent and The Grenadines	Cable & Wireless	Planned

Caribbean: Turks and Caicos Islands	Cable & Wireless	Planned
Colombia (East)	Comcel	Planned
Colombia (West)	Occel	Planned
Ecuador	Conecel	Planned
France	Bouygues Telecom	Planned 2004/5
Israel	Cellcom	Planned
Russia	Vimplecom	2004 launch planned
USA	Cellular One of NE Arizona	Planned
USA	EDGE Wireless (AWS affiliate)	Planned
USA	Viaero	Planned

ANNEX E

3GPP TR 21.900 V5.0.1, Technical Specification Group working methods (Release 5) – Extract

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

- 1 presented to TSG for information;
- 2 presented to TSG for approval;
- 3 or greater indicates TSG approved document under change control;

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.;

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

In order to ensure correctness and consistency of the specifications (i.e., technical specifications and technical reports) under responsibility of the Technical Specification Groups (TSG) of the 3rd Generation Partnership Project (3GPP), clear, manageable and efficient mechanisms are necessary to handle version control, change control, document updating, distribution and management.

Also, the fact that the specifications are/will be implemented by industry almost in parallel with the writing of them requires strict and fast procedures for handling of changes to the specifications.

It is very important that the changes that are brought into the standard, from the past, at present and in the future, are well documented and controlled, so that technical consistency and backwards tracing are ensured.

The 3GPP TSGs, and their sub-groups together with the Support Team are responsible for the technical content and consistency of the specifications whilst the Support Team alone is responsible for the proper management of the entire documentation, including specifications, meeting documents, administrative information and information exchange with other bodies.

E.1 Scope

This document outlines the working methods to be used by the 3GPP Technical Specification Groups and their Working Groups and their Sub-Groups, and by the 3GPP Support Team in relation to document management, i.e. handling of specifications, updating procedures, change request procedures, version control mechanisms, specifications status information etc. It complements the rules and procedures defined for 3GPP. This document does not stipulate the details of the internal working of the TSG Sub-Groups. From the Technical Specification Group point of view, a task and responsibility is given to a Working Group directly answering to the Technical Specification Group. In practice, the work/task may be carried out in a subgroup of that Working Group.

E.1A References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

3GPP TR 21.801 (v4): “3GPP drafting rules”.

3GPP TR 21.905: “3G vocabulary”.

3GPP TS 21.101 (v3): “3rd Generation mobile system Release 1999 Specifications”.

3GPP TS 21.102 (v4): “3rd Generation mobile system Release 4 Specifications”.

3GPP TS 41.102 (v4): “GSM Release 4 Specifications”.

ANNEX F

Functional and Service Enhancements for Pre-IMT-2000 Operators

F.1 Functional and service enhancements for GSM Operators

The primary benefit of IMT-2000 CDMA Direct Spread over GSM/GPRS/EDGE is its increased capacity for both voice and data, which enables much faster data services. IMT-2000 CDMA Direct Spread offers voice capacity advantages mainly through the benefits of interference averaging offered by its code division spread spectrum technology, combined tight power control.

Switch based service platforms

At the start of GSM, there was only a basic speech telephony service besides low speed data and a few supplementary services such as Call Forwarding. Later, GPRS was introduced to provide packet delivery of data. The service logic for these services was an integral part of the Mobile Switching Center (MSC) software and was heavily based on ISDN technology.

Specialized mobile platforms

The first really unique mobile services were the Short Message Services (SMS), which also includes the Cell Broadcast Message Service (CBS). These services are provided by special platforms: the SMS Message Center (SMSC) and the Cell Broadcast Center (CBC). Other service platforms fit into this category, notably those for Location Based Services (LBS) and Multimedia Messaging Services (MMS).

IN-based service platforms and CAMEL

In the European scenario, the introduction of Intelligent Network (IN) services in GSM brought many new supplementary services. Customized Applications for Mobile Enhanced Logic (CAMEL) provides a standard IN services creation platform with standardized interfaces into the switch platforms, registers and billing systems for the first time, allowing third parties to create IN services. Platforms of this type are also known as Wireless Intelligent Network (WIN). One notable success has been the introduction of Pre-paid services.

Virtual Home Environment

Moving towards IMT-2000, it was recognized that there would be an explosion of innovative and personalized services and that users would want the look and feel of their own personalized services to be identical whenever they roamed, including when in another operator’s network. In order to provide for this consistent look and feel for the roaming user, 3GPP (Third Generation Partnership Project (3GPP) has devised the concept of the Virtual Home Environment (VHE).

Content delivery via client/server service model

With the advent of the Internet, World Wide Web and now the mobile Internet we have arrived at a situation where virtually any qualified developer, anywhere can create mobile applications. Software applets in the terminal interact directly with software in a networked server using Internet Protocols (IP) as transport. The combination of Java download and simple standard Applications Servers in an IP enabled mobile data network means that an unlimited range of information, entertainment, location, and m-commerce applications can be developed quickly, at low cost by innovators to suit the personal needs of the users.

Portal platforms for content aggregation and delivery

Many industry players, including mobile operators, ISPs and phone retailers, have invested considerable sums in tailoring their portal offerings. Although superficially similar to the portals of today’s fixed Internet, IMT-2000 mobile portals exhibit significant differences in character due to the additional challenges resulting from the need to optimize the content for small form factor devices and the necessity for delivering that content to the mobile user. The UMTS Forum has provided guidance on technology choices, standards and service options in Report 16: 3G Portal Study – A Reference Handbook for Portal Operators, Developers and the Mobile Industry. Through the introduction of portal based services, the industry is successfully addressing issues that are critical to delivery, including billing, security, privacy, quality of service, interoperability and content formatting.

New service opportunities with IP

For UMTS, the whole of the mobile industry throughout the world has selected the Session Initiation Protocol (SIP) from the Internet Engineering Task Force (IETF) as a common IP Multimedia Call Processing standard. It represents a major step forward in terms of service provision as well as a change to more efficient network architecture – the IP Multimedia Subsystem or "IMS".

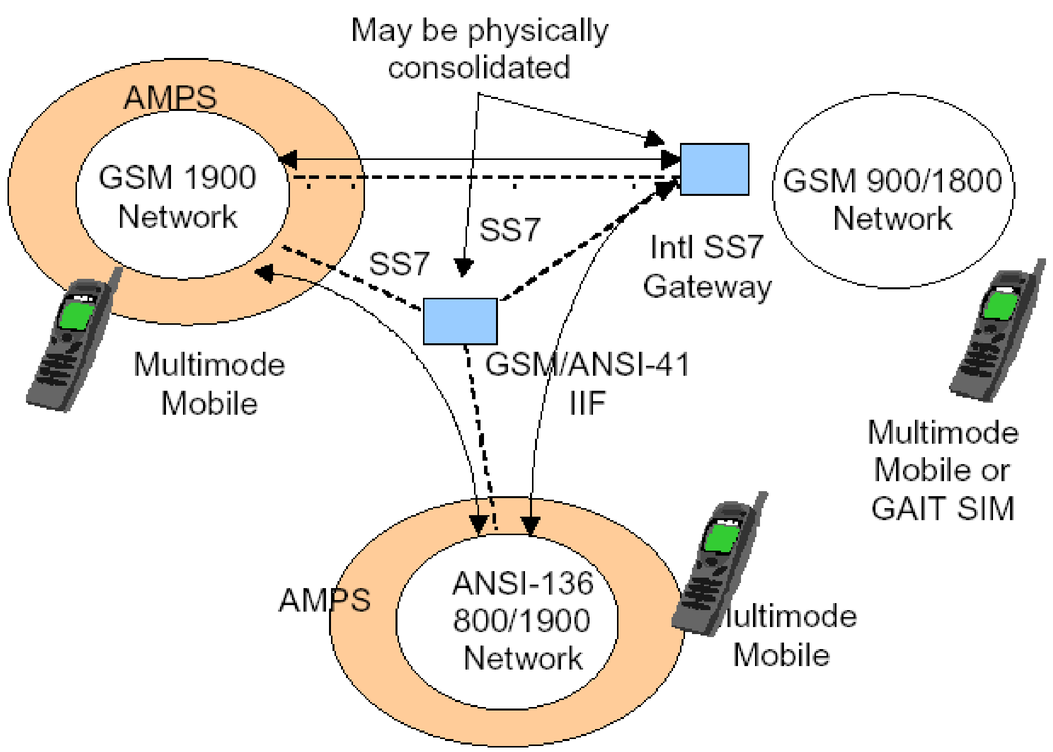
Like Client-Server, SIP can interact with applications in the mobile handset that can be downloaded to perform processes such as call set-up, call diversion and the modification of calls in progress. New mobile services such as "Push-to-Talk", Dispatch, Instant Messaging or Presence based services can be offered as software in Applications Servers, which again interwork with the SIP server and handset client.

F.2 Functional and service enhancements for TDMA operators

Operators have used a variety of business relationships (mergers, acquisitions, joint ventures, etc.) to acquire the coverage and capacity needed to achieve a 'national footprint'. As a result, some operators operate in both the 850 MHz and 1 900 MHz bands, and offer both TDMA and (since 2002) GSM/GPRS services.

The existing GSM/ANSI-41 Interworking function (IIF) allows interoperability between GSM-MAP and ANSI-41 (TIA/EIA-41) core networks, as is shown in Figure F.2-1 below.

Figure F.2-1: Interoperability between GSM-MAP and ANSI-41 (TIA/EIA-41) core networks.



On the radio interface front, further harmonization was accomplished for the IMT-2000 TDMA Single-Carrier 200 kHz Data-Only (DO) carrier known as EDGE. Most notably, the EDGE radio interface is the same whether used within a GSM or ANSI-136 TDMA radio access network, which allows roaming between GSM and TDMA operators for EDGE-DO services.

TDMA operators also have the option of making the transition to IMT-2000 CDMA Multi-Carrier (CDMA2000) in a direct (one-step) transition to IMT-2000 services. CDMA2000 core networks are based on the same ANSI-41 standards as TDMA systems. Consequently, TDMA operators willing to evolve their networks to CDMA2000 only have to deploy a CDMA2000 radio access network over their TDMA radio access network and, via the backhaul, interface directly into their existing ANSI-41 core network. CDMA2000 operates in the same frequency bands as TDMA (850 MHz and 1 900 MHz). Therefore there is no need for operators to acquire new spectrum to introduce IMT-2000.

CDMA2000 allows operators to provide coverage with fewer base stations than TDMA and to conserve existing TDMA and AMPS cell site locations (e.g. share antennas). However, several TDMA operators select a 1:1 overlay strategy.

Figure F.2-2: CDMA2000 1:1 overlay on TDMA network

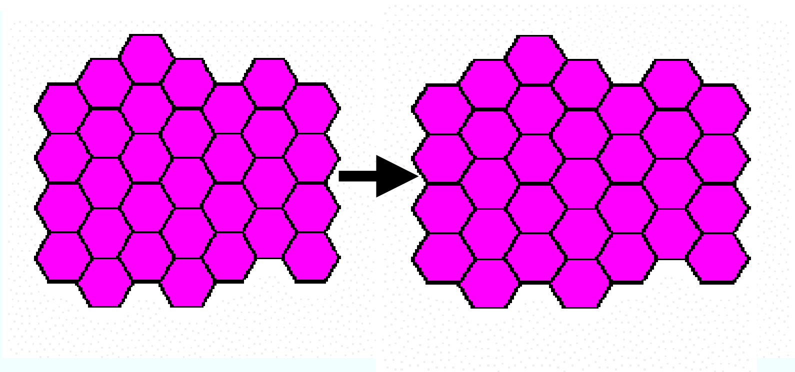
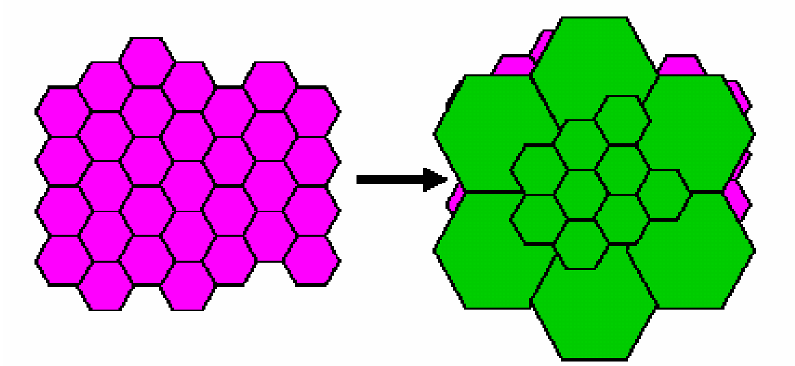


Figure F.2-3: CDMA2000 N:1 overlay on TDMA network



Most TDMA operators still operate an AMPS network to provide urban and rural coverage. Since all CDMA2000 phones support AMPS, the users of these terminals can roam onto the coverage area that is provided by the AMPS network.

CDMA2000 can be introduced with 1.8 MHz of spectrum (1.25 MHz carrier and 0.54 MHz guardband for the first carrier). Each subsequent carrier requires 1.25 MHz of spectrum. Higher-speed data services can then be provided with CDMA2000 1xEV-DO.For the first CDMA2000 carrier (1.8 MHz), the operator must clear out an equivalent amount of spectrum in the TDMA system. When a 7/21 reuse is practiced in the TDMA system, this means that in every sector three 30 kHz TDMA carriers must be cleared. For every additional CDMA2000 carrier (1.25 MHz), operators need to clear two TDMA carriers from each sector. The addition of CDMA2000 carriers can be done either across the whole network or only in selected geographical areas, depending on traffic requirements.

The addition of CDMA2000 increases the voice capacity of the TDMA network. This means that CDMA2000 will accommodate migrated TDMA subscribers as well as provide additional capacity that can be used to either add more voice subscribers, provide them with value-added services, or data-only subscribers. The table below[76] shows spectrum migration for a 15 MHz TDMA voice network in 7/21 reuse and the resulting impact on capacity. It is assumed that each subscriber generates 20mE of traffic.

Table F.2: Spectrum migration for 15 MHz TDMA voice network in 7/21 reuse

TDMA carriers per sector	TDMA calls per sector	TDMA Erlang per sector	Total TDMA Erlangs per cell	TDMA sub-scribers	CDMA carriers per sector	CDMA calls per sector	CDMA Erlang per sector	Total CDMA Erlangs per cell	CDMA sub-scribers	Total sub-scribers
23	69	58	174	8700	0	0	0	0	0	8 700
20	60	50	150	7500	1	36	28	84	4 200	11 700
18	54	44	132	6600	2	72	62	186	9 300	15 900
16	48	38	114	5700	3	108	96	288	14 400	20 100
14	42	33	99	4950	4	144	131	393	19 650	24 600
12	36	27	81	4050	5	180	167	501	25 050	29 100
10	30	22	66	3300	6	216	202	606	30 300	33 600
8	24	17	51	2550	7	252	238	714	35 700	38 250
6	18	11	33	1650	8	288	274	822	41 100	42 750
4	12	7	21	1050	9	324	310	930	46 500	47 550
2	6	2	6	300	10	360	346	1038	51 900	52 200
0	0	0	0	0	11	396	382	1146	57 300	57 300

[76] Source: Ericsson, "TDMA to CDMA2000 Migration", March 2003.

F.3 Increased Voice Capacity for TDMA and GSM Operators

As networks become more heavily used, operators must find ways to increase capacity, either by acquiring additional spectrum or by increasing the efficiency of their existing network. In a real-world environment, a GSM network can handle roughly more simultaneous calls than a comparable TDMA network and seven times more than an analog network. GSM also supports the harmonized Adaptive Multi-rate speech transcoding (AMR), a new voice-coding technology that boosts capacity to four times more than TDMA without AMR.

In a capacity-constrained situation, frequency optimization techniques such as AMR, frequency hopping, dynamic power control, discontinuous transmission, and dynamic frequency and channel allocation allow a TDMA operator with a saturated network to use a GSM/GPRS overlay to continue supporting its TDMA customer base while adding GSM's ability to offer revenue-generating, market-differentiating data services.

The example of a TDMA operator that deploys a GSM 850 MHz overlay illustrates the opportunity to sustain service to current TDMA customers while introducing GSM in the same frequency bands. To create channels for GSM service, one option is to switch the TDMA network's 7/21 frequency re-use pattern to a 5/15 pattern, which increases capacity by as much as 50%, or to a 4/12 pattern, which increases capacity by up to 90%. Those capacity gains allow the TDMA network to handle more calls while freeing up enough bandwidth to launch GSM in the existing spectrum.

Such capacity gains can reduce or even eliminate the need for additional spectrum. This is important where new spectrum is not available or where the cost of obtaining additional spectrum may be prohibitive.

F.4 Functional and service enhancements for cdmaOne operators

The operators who deployed IS-95 A and B systems are called cdmaOne operators. IS-95A systems were originally introduced in 1995 to operate in a carrier bandwidth of 1.25 MHz with significant enhancements to voice capacities compared to the 1st generation wireless systems. The IS-95 A/B systems were deployed in 800, 1 900 and 400 MHz bands as the frequency spectrum was made available by the regulators in different countries.

The IS-95A systems were also employed by some operators to provide circuit switched data at 9.6 kbit/s. With the advent of IS-95 B systems in 1998, some of the operators were able to provide circuit switched data at 64 kbit/s. Though the IS-95 A/B systems provided voice and data services, they were limited to low bit rate applications. CDMA2000 systems that are developed based on the requirements of the IMT-2000 mandate are a direct evolution of the well-tested and widely deployed 1S-95 A/B networks[77].

CDMA2000 is designed to offer significant enhancements in spectral efficiency for both voice and data[78]. CDMA2000 systems 1X and 1xEV-DO are designed to operate in the same carrier bandwidth and chip rate as the cdmaOne systems. Therefore, the RF infrastructure is largely common between CDMA2000 and cdmaOne systems thus allowing the cdmaOne operators to retain a significant cost of investment while enabling smooth transition to third generation wireless networks.

Importantly, CDMA2000 systems are designed to provide backward compatibility and cdmaOne systems are designed to provide forward compatibility with each other. This means that terminals designed for IS-95 A/B can operate in CDMA2000 networks and also a CDMA2000 handset can operate in IS-95 A/B system thus a smooth and gradual transition to CDMA2000 networks is possible for the cdmaOne operators. Based on the market requirements, the cdmaOne operators initially can selectively chose high density areas of the existing networks to deploy CDMA2000 systems and gradually propagate to the rest of their networks as necessary. The high-density spots for instance can be the urban centers with a need for higher data rates and enhanced voice capacities. The advantage with CDMA2000 is that it can seamlessly integrate with IS-95 A/B.

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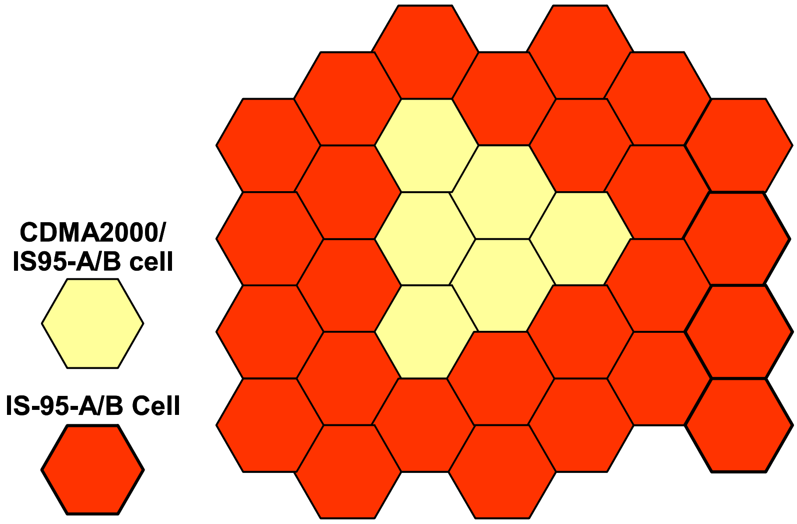
[77] "Evolution of wireless data services: IS-95 to cdma2000". Knisely, D.N.; Kumar, S.; Laha, S.; Nanda, S.; Communications Magazine, IEEE, Volume: 36 Issue: 10, Oct. 1998. Page(s): 140-149.

[78] "cdma2000 mobile radio access for IMT 2000". Rao, Y.S.; Kripalani, A.; Personal Wireless Communication, 1999 IEEE International Conference, 17-19 Feb. 1999. Page(s): 6-15.

Figure F.4: Example showing a selective overlay of CDMA2000 cells and seamless integration in a IS-95 A/B network



Due to the additional refinements in design of power control structure, coherent uplink architecture, coding and modulation procedures, CDMA2000 systems offer many enhancements for cdmaOne operators. CDMA2000 1X systems provide a voice capacity of approximately two times that of IS-95 systems. CDMA2000 1X systems promise a much higher speech quality with improved coverage compared to the cdmaOne systems. Taking into account the innovations with respect to new SMV (selectable mode vocoders) and antenna diversity techniques, CDMA2000 1X systems can provide about 3 times more voice capacity than cdmaOne systems. These enhancements in voice capacity are achievable with minor upgrades to the Base Station channel card hardware and software.

The CDMA2000 1X systems introduce packet data interface with higher capacity for data services. CDMA2000 1X offers "always on" wireless data with peak data rates up to 628 kbit/s. CDMA2000 1X provides simultaneous voice and data services. One of the key characteristics of CDMA2000 is that it has built-in signaling support to provide variety of multimedia applications with differing degrees of Quality of Service. It provides scheduling and prioritization among competing services including QoS control capabilities. Also, CDMA2000 1x systems reduce battery consumption in idle mode by about 50% through the use of the specifically designed Quick Paging Channel.

The CDMA2000 1X EV-DO option provides a high performance and cost effective solution for cdmaOne operators planning to expand the data services. The CDMA2000 1x EV-DO technology currently offers data rates up to 2.4 Mbit/s in a mobile environment in a 1.25 MHz carrier bandwidth[79]. Similar to 1X, 1x EV-DO preserves investment of existing cdmaOne investments by allowing reuse of CDMA RF carriers, network planning tools and other deployment resources. The CDMA2000 systems therefore provide a cost effective, evolutionary approach to deliver 3G services.

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[79] CDMA/HDR: a bandwidth efficient high speed wireless data service for nomadic users. Bender, P.; Black, P.; Grob, M.; Padovani, R.; Sindhushyana, N.; Viterbi, S. Communications Magazine, IEEE, Volume: 38 Issue: 7, July 2000. Page(s): 70-77.

ANNEX G

Operator experience in transitioning to IMT-2000 systems

This annex provides operator experiences in transitioning to IMT-2000 systems. Table G.1 cross-references these operator experiences with the transition scenarios listed in section 3.2.

Table G.1: Transition scenario of operator experiences

Scenario	Operator Experiences	Pre-IMT-2000 Network (Frequency)	IMT-2000 Network (Frequency)
Scenario 1	Russian Federation	NMT 450 (450 MHz)	CDMA2000 1x (450 MHz)
Scenario 2	Chile (Telefónica Móvil de Chile)	AMPS/TDMA (850 MHz)	GS+M/GPRS/EDGE (1 900 MHz)
Scenario 2	Japan (NTT DoCoMo)	PDC (800 MHz)	WCDMA (2 000 MHz)
Scenario 3	Hong Kong (Hong Kong CSL Ltd)	GSM/GPRS (900/1 800 MHz)	GSM/GPRS/EDGE (900/1 800 MHz)
Scenario 3	Japan (KDDI: au)	cdmaOne (800 MHz)	CDMA2000 1x (800 MHz)
Scenario 3	Thailand (Advanced Info Service Public Co. Ltd)	GSM/GPRS (900 MHz)	GSM/GPRS/EDGE (900 MHz)
Scenario 3	Venezuela	TDMA (800 MHz)	CDMA2000 1x (800 MHz)
Scenario 4	Hungary (Pannon GSM Telecommunications Ltd)	GSM (900 MHz)	GSM/GPRS/EDGE (1 800 MHz)

CHILE – Implementation of IMT-2000 technology (EDGE) and TDMA Migration in Chile

Source: Telefónica Móvil de Chile

1 Background

Telefónica Móvil de Chile has been providing wireless telecommunication solutions in Chile since 1989. Telefónica Móvil de Chile is part of the Telefónica group of companies present in 14 countries and covering a potential 514 million subscribers. Telefónica group companies in Latin America make up over half of the 50 million Telefónica subscribers worldwide.

Telefónica Móvil de Chile draws on the experience in design and implementation of networks provided by its parent and partners to ensure they provide a high quality of both voice and data services to its customers nationwide.

In the first quarter of 2003 Telefónica launched GSM/GPRS in the 1 900 MHz band and this launch was followed in October by the launch of EDGE.

2 Infrastructure Implementation

Telefónica's new GSM network was granted as part of Chile's last 30 MHz spectrum auction in the 1 900 MHz band. This process included a technical proposal where coverage and implementation times were evaluated. In order to obtain the necessary spectrum, Telefónica Móvil de Chile had to outline a fast nation wide roll out project.

Currently in the process of migrating from AMPS/TDMA mobile technology at the 850 MHz band, Telefónica Móvil de Chile selected the GSM/GPRS/EDGE family of technologies. The move was a decision that was based on global penetration, cost, services, and handsets considerations.

Telefonica's GSM network was set up in approximately four month's. All base stations were purchased new and a significant proportion were fitted with EDGE transceivers. Nationwide roll out was not affected by the later implementation of EDGE because as a radio feature EDGE can be activated per transceiver.

3 Spectrum Efficiency

EDGE provides a cost effective way to offer advanced services without increasing existing spectrum. All EDGE devices will support GSM/GPRS and work on multiple spectrum bands including variations of 800/900/1 800/1 900 MHz. EDGE is compatible with GPRS (Telefónica Móvil de Chile have nationwide GPRS coverage) so when customers move out of an EDGE enabled area GPRS packet data services will remain available. Telefónica Móvil de Chile has initially concentrated EDGE deployment in high demand data areas only.

Telefónica Móvil de Chile currently have commercially available class 2 multi-slot terminals (up to 2 TSL in downlink an 1 TSL in uplink), and have seen average rates of around 40 to 80 kbit/s for static applications with peaks of up to 100 kbit/s. Given the low cost and effort required to deploy EDGE these are pleasing results. Spectrum efficiency has also improved showing an increment of around 2.5 times compared with that of GPRS.

4 GSM Migration

With the addition in 2003 of GSM/GPRS/EDGE Telefónica Móvil de Chile now have a very robust network platform to compete in the Chilean mobile market. Providing to its customers a complete profile of advanced voice services, a wide range of terminals and enhanced mobile data services.

The service portfolio includes games download (MOVIL GAMES), ring-tones download (MOVIL MUSIC) and Multimedia Messaging (MOVIL IMAGES). In terms of Mobile Data Telefónica Móvil de Chile provide MOVIL INTERNET and have recently launched the VPN MOVIL that is very much enterprise oriented. These services allow customer's added mobility and a complete set of applications will become available in their own mobile office.

In general, Telefónica Móvil de Chile have found that the key is to concentrate the marketing of EDGE on giving mobility to data users and not to sell data mobility to voice users. Telefónica Móvil de Chile believe that EDGE will assist them to improve the users experience with mobile data and that this will in turn expand the market, and as a result increase revenues.

HONG KONG – Implementation of IMT-2000 technology (EDGE) in Hong Kong

Source: Hong Kong CSL Limited

1 Background

CSL launched its mobile services in 1983, and today operates a world-class GSM/Dual Band network through its mobile brands: 1O1O and One2Free. The Company also provides comprehensive pre-paid mobile services and international roaming services. It offers leading-edge mobile technology including WAP (Wireless Applications Protocol), HSCSD (High Speed Circuit Switched Service Data) and GPRS (General Packet Radio Service).

2 EDGE Services

In August 2003 CSL launched Hong Kong's first commercial EDGE network. Customers in Hong Kong can now enjoy data applications at a faster data transfer rate when using an EDGE capable device. Mr Hubert Ng, CSL's Chief Executive Officer says, "The adoption of EDGE is a natural evolution of the existing GPRS network. The EDGE deployment is also aimed at accelerating the adoption of mobile data services, and prepares the market when the next generation of mobile data gets widely accepted."

EDGE services offered include the GPRS suite of Multimedia Messaging Service, Java games, email and WAP browsing plus a new range of video downloads. Video downloads will work on video equipped GPRS terminals however the EDGE addition is geared towards the social premium segment of the market.

3 Evolution from 2GSM

Upgrading the existing HKCSL GPRS network was a relatively straightforward process, since in effect EDGE is an upgrade of GPRS. The upgrade became attractive due to the rapidly increasing demand for data transmission driven by the growing number of MMS and GPRS terminals attached to the network. Customers with these camera equipped colour screen handsets initially want to personalize them with their choice of polyphonic ringtone and colourful wallpaper. The more adventurous extend this use of data into uploads or downloads of MMS pictures and video clips of their favourite obsessions or download java games for offline time killing. The combination of the S curve growth in MMS terminals plus the larger file sizes for downloads of these features has driven a need for more capacity and quicker processing by the network.

The process of upgrade was relatively straightforward, much like a version upgrade of the network software, however it was accompanied by a revised radio plan in order to optimize the network performance for data. Remote sites were upgraded initially until the software and network performance was stable and then the major data traffic areas were progressively cut over to the EDGE. Since this was fully integrated with the current GPRS network, any slip-ups in the cut over of a particular base station were likely to affect the entire customer base, so the stakes were high. In practice the event ran smoothly without significant incidents.

4 Network Performance

Part of what makes EDGE so attractive is that the network has performed very closely to theoretical data rates, which are roughly three times that of GPRS, which gives plenty of headroom for expansion in both scope and scale of applications. This has enabled a range of video "channels" to be created for downloads, which then allows customers a richer experience in their use of mobiles.

5 EDGE Roaming

CSL then quickly implemented EDGE roaming with AIS, who was also in the process of upgrading to EDGE. The speed, with which this was completed utilizing the normal GPRS roaming process, was a graphic illustration of the ease of global rollout of new higher speed data services. Thailand is an important business and recreational roaming destination to CSL customers, who can now use all of their favorite data applications whilst abroad.

6 EDGE, Market Reality

Since the launch of EDGE in August subscriber growth to date has exceeded CSL's expectations. The Nokia 6220, the first EDGE terminal is currently the best selling handset in Hong Kong, in part because it offers the novelty of video on an affordable cool handset.

Data usage by the subscribers has been double that of normal MMS handset buyers, where package subscription is currently 50% for EDGE data transport package subscription has been near 100%. In effect this means that those currently buying this handset plan to use it on an ongoing basis for data services. This indicates that we have turned the corner in data service adoption for segment, although it is still an early adopter/fast follower phenomenon.

EDGE network topology has provided CSL a cost effective way of offering 3G like services and thus satisfying immediate customer demand. EDGE is paving the way to a full and harmonized 3G rollout and will allow CSL to deliver optimum performance, flexibility and coverage at the lowest possible cost.

HUNGARY – Implementation of IMT-2000 technology (EDGE) in Hungary

Source: Pannon GSM

1 Background

Pannon GSM Telecommunications Ltd launched its 900 MHz frequency in March 1994 and in 1999 they won the tender for the 1 800 MHz frequency in Hungary. In November of 2000 Pannon GSM rolled out its 1 800 MHz frequency in Budapest, this network was built at record speed. Pannon GSM then began to operate its 1 800 MHz band nationwide in 2001. In May 2003 Pannon made the first EDGE (IMT-2000) test call in Europe and since October 2003 the service is being tested in several parts of Budapest. With over 2.785 million subscribers on its GSM900/1800 network Pannon GSM holds a 36% share of the Hungarian mobile market.

Since first launching its mobile services in March 26, 1994, Pannon GSM have followed a continuous development process. Development has been aimed at ensuring coverage of the motorways, county seats and the Balaton area, followed by single-digit national highways. As a result of the ongoing, detailed network expansion efforts, as well as the expansion of the capacity of the existing network, 75% of the population had access to the digital services provided by Pannon GSM by the end of 1995. By the end of 1996, this number had reached 99%. Building on its existing voice and data capabilities Pannon GSM introduced WAP services in 2000 and in 2001 were the first to launch GPRS technology in Hungary. Pannon GSM also provides WLAN services in Ferihegy Airport, making a high-speed connection to a local computer network and thus to the Internet, WLAN provides extremely fast access to data stored on the network and the worldwide web.

While awaiting government decision on 3G licenses in Hungary Pannon GSM are continuing their evolutionary path to 3G by testing EDGE technology at several Budapest spots.

2 EDGE Services

EDGE is a significant enhancement to GPRS, offering traditional GPRS services at a higher data speed and ensuring better quality of service. EDGE is capable of data transfer faster than that of fixed lines and paves the way for a huge increase in the popularity of non-voice applications. Mobile based broadband applications such as mobile Internet access, MMS, television and video streaming, interactive games and the ability to remotely access workplace networks will become available. Hungarian users now require such services as increased data speeds for non-voice services and eventually total telecommunication mobility. EDGE implementation will allow Pannon GSM to bring users closer to these requirements.

3 Evolution Costs

EDGE technology utilizes existing GSM/GPRS infrastructure, enabling Pannon GSM to implement EDGE at only incremental cost. EDGE enabled terminals will continue to work on both GSM and GPRS enabled networks and will also work on WCDMA networks. The compatibility of the GSM family of technologies that includes GSM/GPRS/EDGE/WCDMA ensures that Pannon GSM can avail of economies of scale when implementing EDGE.

4 EDGE Implementation

Pannon GSM is currently performing EDGE trials before rolling out commercially. Trials began on the 20th October 2003 and a pre-selected group of users in Budapest are currently testing the new technology. To date tests have proven positive. Current tests that have taken place in Budapest's largest shopping mall have shown a significant increase in data rates to end users and improved mobile services usability. By upgrading existing GSM network elements to include EDGE capability, Pannon GSM will greatly enhance user experiences with mobile services, while leveraging the most from its current network investment. EDGE will allow Pannon GSM to provide its Hungarian operators 3G like services both immediately and cost efficiently.

JAPAN – Implementation of IMT-2000 technology (FOMA) in Japan

Source: NTT DoCoMo

1 Introduction

Japan's mobile telecommunications company, NTT DoCoMo, provides wireless voice and data telecommunications to more than 47 million customers. The company provides a wide variety of leading-edge mobile multimedia services. These include i-mode®, a very popular mobile Internet service, which provides e-mail and Internet access to over 40 million subscribers, and FOMA®, launched in 2001 as the world's first 3G mobile service based on WCDMA. At the heart of our operations is a commitment to providing customers with cutting-edge, cost-effective service and a belief that ongoing, focused research and development can help us to continually reinvent the concept of mobile telecommunications. In addition to wholly owned subsidiaries in Europe and North and South America, the company is expanding its global reach through strategic alliances with mobile and multimedia service providers in Asia-Pacific, Europe and North and South America.

2 FOMA Launch

In October 2001, NTT DoCoMo launched the world's first fully commercialized third-generation mobile telecommunications service under the brand name of "FOMA", which stands for "Freedom of Mobile multimedia Access". Using the WCDMA technology, one of the IMT-2000 global 3G standards, FOMA enables high-capacity, high-speed data transmissions and offers an exciting new range of services including videophone and video mail. Ever since the launch of FOMA, NTT DoCoMo has continued expand its network coverage at a rapid pace and released a number of new handsets equipped with advanced functionality. As a consequence, the total number of subscribers to the 3G FOMA service nationwide exceeded 1.6 million in November 2003, approximately two years after the commencement of the service.

3 FOMA Services

FOMA has made mobile video and high-speed data transmissions a reality. Since its fully commercialized service launch in October 2001, new handsets offering advanced features have been released one after another to satisfy the needs of ever-expanding number of subscribers. With the evolution of FOMA far from over, NTT DoCoMo is committed to move further ahead in its efforts to create a richer mobile telecommunications environment, in which users can access virtually any information they require, free from the constraints of time or location.

3.1 i-mode

Following the functional enhancements enabled by "i-appli", i-mode service has become even more advanced with the use of FOMA 3G technologies. FOMA's high-speed packet transmission speeds of up to 384 kbit/s makes i-mode service significantly faster and able to handle greater volumes of data such as e-mail messages of up to 10,000 characters, and to attach files of melodies and still images. The latest handset models also feature an enhanced data capacity, increasing the size of each "i-appli" content to as large as 200KB. The i-mode service has always offered enhanced convenience to its users, whereas FOMA's new capabilities realize entirely new potentials.

3.2 Visual Communications/Videophone

Mobile telecommunications became infinitely more expressive with the introduction of videophone capability on FOMA. The service, which allows subscribers to speak to each other face-to-face, is extremely useful for personal communications as well as in business situations, as it enables business users to provide an initial view of products to their clients and customers, and maintain closer contacts between office and field operations, or personal users to place a video call to a friend over a mobile phone.

3.3 High-speed data telecommunications

- High-speed packet transmission at rates of up to 384 kbit/s[80] allowing users to access to e-mail and web sites at faster speeds.
- 64K circuit-switched data transmission, an ideal solution for sending a large volume of data, such as video images, in real time.

3.4 Multi-access

FOMA's multi-access capability allows subscribers to simultaneously engage in multiple modes of telecommunications. For instance, in a business setting, this capability allows salespersons to talk to customers while accessing their corporate database, and for personal use, the service is convenient for chatting with friends while searching restaurants on i-mode. The latest handset models even enable subscribers to take still pictures and send them as e-mail attachments while talking on a phone.

3.5 i-motion

i-motion service allows subscribers to download exciting content combining audio and video data. The service is offered in three formats — video with sound, still picture frames with sound, and sound-only files. The number of compatible content sites has been increasing, providing subscribers with a greater variety of information services, such as movie previews, promotional music videos, and news and sport highlights, among others.

The "i-motion mail" video message service enables subscribers to send video, recorded by the mobile phone's built-in camera or downloaded from a web site, by attaching it to an email. The maximum file size has been dramatically extended from previously only 100KB to 300KB, and users are now able to play back videos of up to 30 seconds containing more expressive content and higher-definition images.

4 A Vision for Growth

Futuristic 3G telecommunications capabilities have long been anticipated worldwide, but they could not be realized until the advent of WCDMA technology. NTT DoCoMo launched its WCDMA-based 3G FOMA service ahead of the rest of the world and continues to progress by streamlining its operations to achieve greater business efficiency, enhancing the functionality of its state-of-the-art mobile handsets, supplementing its product line-up with advanced new offerings, and aggressively expanding the FOMA service area. With many high value-added functions superior to the second-generation PDC service, FOMA has proven itself capable of reliably meeting the most demanding business needs and is well on the way to becoming one of our mainstream mobile telecommunications service offerings.

In addition to introducing sophisticated new functions and further expanding the service area of FOMA, NTT DoCoMo's future plans include the reduction of handset weight to less than 100g and the extension of handset battery life to more than 300 hours. To accelerate the uptake of FOMA service in Japan, NTT DoCoMo aims to extend its nationwide population coverage to 99% by the end of March 2004. Meanwhile, indoor coverage will also be expanded in parallel to enable customers to use FOMA in buildings and underground shopping malls, etc.

5 3G Global

Through technical exchange and joint studies with leading operators abroad, NTT DoCoMo is stepping up its efforts to facilitate an early implementation of 3G mobile telecommunications services worldwide. Leveraging its extensive technical R&D capabilities, its expertise pertaining to the WCDMA technology, one of the global 3G standards for which the company played a primary role in the standardization activities, and its experience and know-how as a world pioneer in commercial 3G services, NTT DoCoMo aims to further proliferate 3G mobile telecommunications services on a global scale.

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[80] The uplink transmission of data is carried out at rates of up to 64 kbit/s. This is, however, provided on a best-effort basis, and the actual transmit speed varies depending on the propagation conditions and network traffic.

JAPAN – CDMA2000 1X Deployment and Associated Multimedia Services Launched in Japan[81]

Source: KDDI (JAPAN)

1 Wireless Market Outlook in Japan

The total number of wireless subscribers in Japan at the end July 2003 was 77,795,800. The total number of mobile Internet subscribers in Japan jumped up from 12,720,000 (as of end June 2000) to 65,174,100 (as of end July 2003) – an increase of 512% just in 37 months. KDDI attributes much of this dramatic growth to the launch of its commercial CDMA2000 1x service, known as "au".

2 CDMA2000 1x Launch by au

In July of 1998, au launched its second-generation cdmaOne system throughout Japan, offering new high-quality voice services to its existing TACS and PDC customers, while continuing to run those other networks. In April of 1999, au began offering its "Ezweb" service, which enabled the provision of Web-based applications to mobile devices. In April of 2000, au began offering international roaming with other cdmaOne operators, while in July of 2000, au launched IS-95B, the packet service upgrade to cdmaOne, which provides data rates of 64 kbit/s.

By November of 2001, only three years after deploying its cdmaOne network, au had reached a total of 10 million subscribers. In the same timeframe, au terminated its TACS operations and decided that to shut down its PDC operations by the end of March 2003.

In April of 2002, au upgraded its cdmaOne system to CDMA2000 1x, covering 54% of the Japanese population initially and expanding to cover 90% by December of 2002. Less than sixteen months after its initial commercial launch, there were 9 million CDMA2000 1x subscribers on the au network.

3 Secret of au's Success in CDMA2000 1x Launch

Due to CDMA2000 1x's inherent backward compatibility with cdmaOne, which enables cdmaOne terminals to operate on CDMA2000 systems and vice versa, service coverage for the CDMA2000 1x system was practically equivalent to the existing cdmaOne service coverage from day one. In addition, the straightforward upgrade path from cdmaOne enabled a rapid and low cost CDMA2000 1x roll-out. Moreover, the technology maturity inherited from cdmaOne, led to the development of CDMA2000IMT-2000 CDMA Multi Carrier handsets that were the same size or smaller than cdmaOne handsets, had the same battery life and operational stability, with a minimal increase in cost.

In deciding how to rollout its CDMA2000 1x network, au considered two different options:

1) an upgrade approach; or

2) an overlay approach.

In an upgrade approach, a cdmaOne operator upgrades all of its existing infrastructure equipment and software to CDMA2000 1x in one step. This approach has the advantage of requiring less capital expenditure for the upgrade to CDMA2000, but results in some disruption of services while the cdmaOne software was modified.

In the overlay approach, a cdmaOne operator deploys a CDMA2000 network alongside its existing cdmaOne network, migrates customers over to the new network, and then upgrades the cdmaOne network equipment. This approach has the advantage of not requiring an initial modification to the cdmaOne network, enabling ongoing, uninterrupted services. However, this approach requires more capital expenditures.

After weighing these options, KDDI adopted the "upgrade" approach in its rollout of CDMA2000 1x.

[81] More detailed information is available at the ITU-D IMT-2000 website (www.itu.int/ITU-D/imt-2000/documents/Case%20studies%20ITU-D%20Meetings/KDDI_Japan_Annex.pdf).

4 Mobile Multi-media Services by au

With its fully commercial CDMA2000 1x system in place, au has been offering a variety of multimedia services to its customers, including:

- Ezweb – WAP2.0-based Internet Access and Browsing Platform.
- EZweb@mail – IMAP4-based e-mail platform.
- Ezplus – Java^{TM} application services, with support of mobile agent function using HTTP, and automatic application update from servers.
- Eznavigation – Accurate position location-based services powered by gpsOne.
- Ezmovie – Video distribution available nationwide, using industry standards, i.e. MPEG-4 for video coding and MP4 for video file format.
- Photo-mail (including eznavigation associated with Photo-mail, which stores location information along with pictures to provide vivid memories for travellers, the ability to provide easy recommendations on locations, and a number of business applications).

5 Objectives and Goals for 3G Migration: au's Next Step

As au continues to expand its successful CDMA2000 1x services, it is looking down the road to determine what is driving customer demand. Based on its experience with IMT-2000 services, au has discovered, to no one's surprise, that customers want large-volume content with low prices. An obstacle to providing advanced applications with rich content is the cost per bit of data. Therefore, a low-cost infrastructure for data transactions is required. Reducing cost per bit is essential for the provision of content-rich services and applications.

In order to further reduce the cost per bit and offer its customers more content-rich applications, au plans to add CDMA2000 1x EV-DO later in 2003. CDMA2000 1x EV-DO is specifically tailored for asymmetric high data rate packet telecommunication with mobility. It uses the same carrier width that cdmaOne and CDMA2000 1x occupy (1.25 MHz), and has similar RF characteristics and link budgets, allowing collocation of CDMA2000 1xEV-DO carriers and base stations with those of CDMA2000 1x network. The forward link (base station to mobile) sector throughput of CDMA2000 1x EV-DO is 600 kbit/s or higher on average, with 2.4 Mbit/s as the peak, which performs very much higher (bps/Hz) than CDMA2000 1x or WCDMA.

RUSSIAN FEDERATION – Evolution and Migration of 1st Generation NMT450 Analogue Mobile Networks to IMT-2000

Source: Russian Federation

1 Background on NMT450 Evolution and Migration

NMT (Nordic Mobile Telephone)[82] is a first-generation analogue mobile cellular network standard that was first deployed in 1981 in Scandinavia in 450 and then in 900 MHz band, and later in 12 other Eastern European and CIS countries including Russian Federation in 450 MHz frequency band[83]. NMT450 was a first federal cellular standard deployed in Russia in 1991. Number of users of NMT450 in Russia once reached 1mln is now declining.

In 1998 a need for digital technology for future migration of NMT networks was identified at the NMT MoU Plenary. After studying three different technology options for digitization of the NMT systems, two technologies were selected in 1999 for future evolution of the NMT450 networks: GSM400 and CDMA450. After deployment of two trial GSM400 networks, this evolution path was abandoned by manufacturers who supported it. Between October of 2000 and December of 2002, trials of CDMA450 (also known as IMT-MC-450, or Band Class 5 of IMT-2000 CDMA Multi-Carrier[84]) were conducted by different NMT operators in Russia, Hungary, Romania, Sweden, Georgia and Belarus. Trials have led to successful commercial launches in Romania, Belarus and then in Russia.

2 IMT-MC-450 studies and trial networks

Russian Administration in support of requests from leading NMT450 operators has initiated a study on effective use of 450 MHz frequency band by digital technologies for s smooth migration of NMT450 networks. The studies included studies of NMT network evolution options and implications, EMC and sharing studies of CDMA technology. Studies were carried out by leading Russian scientific research institutes. Studies have shown that IMT-MC-450 is an effective solution for evolution of NMT450 networks in Russia.

In order to practically support the results of theoretical studies trial networks were deployed first in Moscow by Moscow Cellular Communications (December 2001) and then in St. Petersburg by DeltaTelecom. The trials were aimed at testing system coverage and capacity, high-speed packet data capabilities, electro-magnetic compatibility (EMC)/sharing with NMT450 network and other users of the band and adjacent bands, and roaming capability.

The following trial results were reported by operators:

- Single cell radio coverage of up to 50 km.
- Capacity claims proved.
- Approximately 100 kbit/s average packet data transfer rate (download and upload) achieved in urban environment, in movement.
- Excellent voice quality experienced.
- Roaming successfully tested.
- EMC: two networks, analogue and digital, may coexist in the band, if the guardbands are used at both sides of CDMA carrier.

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82 See Report ITU-R M.742-4, Annex 3 for general description of the NMT standard; See NMTA website http://www.nmtworld.org for more information on NMT450 operators.

83 Almost all of NMT450 networks operate in the 450-470 MHz frequency band.

84 See Recommendation ITU-R M.1457-3

Based on the studies results and trial network tests IMT-MC-450 was chosen by the Ministry of Telecommunications and Informatics of the Russian Federation as the technology evolution path for existing NMT450 networks in Russia. The IMT-MC-450 standard was adopted as a federal standard in the Russian Federation.

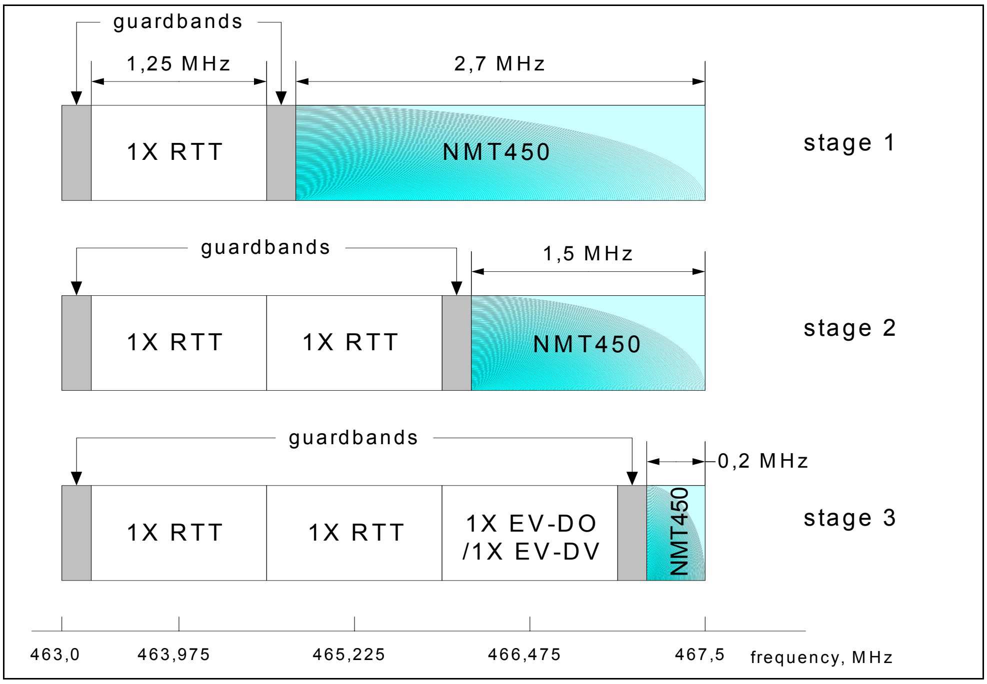
3 IMT-MC-450 Commercial Network Deployments

Following the trials and decision of Administration mentioned above, DeltaTelecom deployed a full scale commercial IMT-MC-450 network in Saint Petersburg, Leningradskaya Oblast (Region), and several other regions in north-west of Russia under trademark "SkyLink". Moscow Cellular Communications (MCC) is currently deploying an IMT-MC-450 network in Moscow and Moscow Region to provide services under SkyLink name starting this autumn. There are other NMT450 operators in Russia currently deploying IMT-MC-450 networks in other parts of the country.

A) Stages of IMT-MC-450 Network Deployment

Studies have shown that smooth migration to digital technology in the 450 MHz band may be performed in several stages, as illustrated in Figure G.1. In most cases, the NMT450 operators have limited bandwidth available (2x4.5 MHz on average), which allows usage of three IMT-MC-450 carriers (1,25 MHz each). The need to move from one stage to another may appear at different times in different parts of the network. Traffic demands may greatly vary across the covered territory. Thorough analysis and careful planning should be used to achieve high efficiency and quality.

Figure G.1: Spectrum usage (BS Tx band) in 3 stages of network evolution



1) *First stage: initial deployment*

First, a single IMT-MC 1X RTT carrier is introduced. This requires the NMT450 operator to clear 2x1,79 MHz of spectrum used by the analogue NMT system (2x1,25 MHz for the 1x RTT carrier, and 2x2x0,27 MHz for a guardbands between the IMT-MC and analogue narrowband carriers). At this time, the NMT analogue network is still operational and providing service to the customers in parallel with the new IMT-MC system.

2) *Second stage: network growth*

With growth of voice and data traffic in parts of the network, a second IMT-MC 1X RTT carrier can be introduced. This requires the operator to clear an additional 2x1,25 MHz of spectrum used by the analogue NMT system. No guardbands between the IMT-MC carriers is needed. Depending on traffic demand, one IMT-MC carrier can be used mainly for voice, while the second carrier can be used for voice and data. During this stage, NMT analogue subscribers are still being served by the network, but with limited quality due to restricted bandwidth of 1,5 MHz.

3) *Third stage: high demand for data services*

When the data traffic in the network increases substantially and higher bitrates are desirable by end users, a data-optimized carrier – (1xEV-DO) and furthermore 1xEV-DV can be introduced.[85]

B) Commercial IMT-MC-450 Services

When SkyLink began its IMT-MC-450 commercial operations, the cellular mobile radio telecommunications market in St. Petersburg was well developed with nearly 37% penetration and with three competing operators, Megafon and MTS (GSM), and Fora (analogue).

SkyLink's objectives for its IMT-MC-450 deployment were to 1) replicate coverage of its analogue NMT network and continue provision of high quality voice services, and 2) provide a variety of new data services to compete with the GPRS services offered by its competitors.

1) *Coverage*

SkyLink began offering commercial IMT-2000 services over its IMT-MC-450 network in December of 2002. Initially, the network deployment was limited to Saint Petersburg and its nearest suburbs. In order to cover the same geographic area as its analogue NMT system, SkyLink deployed IMT-MC-450 base stations (BTSs) on top of 60 of the 67 existing analogue NMT cell-sites. It was shown that the coverage quality of IMT-MC-450 network is significantly better than that of the analogue NMT system.

2) *Services*

In addition to providing high-quality voice services, SkyLink is offering the following advanced data services over its IMT-MC-450 network:

- High-speed access to Internet (with data rates up to 153 kbit/s) using computers, notebooks and PDAs.
- Access to specialized Web-portals using mobile terminals or PDAs[86].
- E-mail reception and transmission with SMTP/POP3 protocols using mobile terminals or computers.
- Mobile games and specialized applications, such as "Search of objects" with option to receive a city map with the found objects on PDA screen.

When it began providing these services, SkyLink decided to offer three different pricing plans, see Table G.2.

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[85] Assuming 2x 4,5 MHz, continued analogue NMT operation is not possible in areas where all three IMT-MC 450 carriers are in use.

[86] The SkyLink network is developed and constantly modified the Web-portal SkyMobile on which is collected the most important, operatively updated information on user's account, dealers, cash departments, news, exchange rates, weather, help phones, etc.

Table G.2

Pricing Plans (Tariffs)	Subscriber's number	Voice minutes included	MBytes of data included	Monthly fee
1	7-digit (local StP numbering area)	Unlimited	75	USD 72
2	7-digit (local StP numbering area)	Unlimited	30	USD 60
3	10-digit: (8-901+7-dig.)	Unlimited	30	USD 50

The duration of voice conversations was not limited, and the cost for data transmissions over the limit is USD/0,3 per MByte.

3) *Network and service offering expansion*

Once it completed its initial network deployment in the St. Petersburg region, SkyLink began to expand its IMT-MC-450 network and services to Leningrad Region. Wireless service penetration in the St Petersburg and Leningrad Region had increased to 45%, with four GSM operators (Megafon, MTS, BeeLine and Tele2), which were offering a variety of services using GPRS, including MMS.

Under these conditions, SkyLink decided to focus its IMT-MC-450 network deployment and service offering in Leningrad Region area where the majority of the population (more than 50%) lives, and to offer a wider variety of higher quality voice and data services.

The new pricing plans included: the Manager Tariff (USD 30 monthly fee, includes 300 minutes to public telephone network (PTN) numbers and an unlimited number of minutes to mobile phone numbers); and the Special Tariff (exclusively for analogue NMT subscribers that migrate to the IMT-MC-450 network).

The expanded list of data services included: protected access to Intranet (based on VPN); a significantly extended list of services through the Web portal; and preparation for introduction of special platforms of online access to wireless applications using BREW (Binary Runtime for Wireless).

C) Lessons Learned from Commercial IMT-MC-450 Operations

Based on its experience with a commercial IMT-MC-450, SkyLink has made the following observations:

1) Actual capacity and network throughput of the IMT-MC-450 network met declarations made by equipment manufacturers.

2) Electromagnetic compatibility between the analogue NMT and IMT-MC-450 systems was achieved when guardbands were implemented between the analogue and digital carriers.

3) No serious electromagnetic compatibility problems occurred between the IMT-MC-450 system and other wireless systems operating in adjacent frequency bands.

4) The adopted market entry strategy, including tariff plans, was justified:
   - Despite a high entrance fee (> USD 400) there is a steady demand for offered services.
   - More than half of subscribers use data services.
   - Average monthly data traffic volume is approximately 10 Mbytes per subscriber;
   - More than 5% of subscribers have monthly data traffic volumes significantly exceeding the amount included in the pricing plan (30 MBytes per month for pricing plan 1 and 2, see Table 1).
   - Average Revenue Per Subscriber (ARPU) of IMT-MC-450 network is eight times more than the ARPU of analogue NMT450 network.
   - Stable growth of subscriber base of IMT-MC-450 network.

5) The further reduction of analogue NMT subscriber base in 2004 will enable to enter the deployment of a second IMT-MC-450 carrier, that will double the network capacity.

4 Conclusion

The evolution path for the 1st generation NMT450 analogue mobile networks to IMT-2000 has been explored in Russia by studies and trial networks, and has proved successful by commercial launches in Russia and elsewhere in Eastern Europe.

The use of IMT-MC in the 450 MHz frequency band may serve as an efficient solution not only for NMT450 operators seeking to evolve their networks, but also for new operators interested in providing IMT-2000 services across vast territory with less investment. At the same time experience of rolling out of IMT-MC-450 network in St. Petersburg has shown that the system also allows operators to build IMT-2000 systems in the 450 MHz range in territories with high density of traffic.

The experiences of the NMT operators in the Russian Federation demonstrates that there is a demand for wireless data services and Internet access, particularly as subscribers get used to paying not for session duration, but for information volume. In addition, in the absence of advanced wireline infrastructure, IMT-MC-450 networks provide a unique opportunity to deliver high-speed data services (especially access to the Internet) to subscribers in both urban and rural areas.

In conclusion, the Russian Federation anticipates that the experience of its NMT450 operators in evolving their 1st generation analogue systems to IMT-2000 using IMT-MC-450 will be useful to other countries and operators as they investigate their options for IMT-2000 deployment.

THAILAND – Implementation of IMT-2000 technology (EDGE) in Thailand

Source: Advanced Info Service Public Company Limited

1 Introduction

Advanced Info Service Public Company Limited (AIS) started out in the information technology field as a computer service provider and today we have firmly established ourselves in the wireless telecommunications sector as an analog mobile phone service provider of cellular 900 and digital GSM systems.

With over 13 million subscribers AIS is not content with being Thailand's leading mobile phone service provider, AIS continues to integrate the latest in advanced technology and deliver more than just voice telecommunication into the hands of its subscribers. In return for their confidence and support, AIS is committed to exceeding customer expectations in all aspects of mobile phone technology provision and service.

2 EDGE

In October 2003 AIS began to roll out EDGE technology in Bangkok's financial district and Chonburi, other major cities will be upgraded by December or January 2004. The decision was made by AIS to deploy EDGE to satisfy customer demand. Current customer demand expects wireless data to provide the same data rates as wireline data does. WLAN technology is currently used in hotspots to ensure that these data rates were satisfied however it has been found that these rates were demanded in a wider area.

AIS see EDGE as the technology that is essential to cater for user demand and improve quality of service (e.g. faster FTP/MMS/e-mail). EDGE will provide AIS customers with mobile data and multimedia services such as video streaming, Internet browsing, email and corporate data access. The enhancements will enable customers in Thailand to access mobile multimedia services at higher speeds, and improve the quality of service such as Video Message, Multimedia Messaging Service, Java games, email and WAP browsing.

3 Marketing

The marketing of EDGE today is not different from that of marketing GPRS. AIS have been focusing on the marketing of services and applications rather than technologies behind the services. Customers are educated about how they can receive better QoS using bandwidth consuming services and applications if they switch to using an EDGE capable phone. The special marketing promotion will be advertising the bundle of EDGE/GPRS and WLAN package. This promotion is set up to give more benefit to heavy data users and convince them to switch to using EDGE capable phones.

4 Spectrum Efficiency

EDGE stimulates the growth of mobile data traffic, increasing throughput by up to three times that of GPRS. The increase in quality and speed means that user experience with data services will improve for both private user and business customers. High-speed access will become available to MMS, video and audio streaming, intranet/internet access and corporate email.

EDGE was first rolled out in the main centers of Thailand because of the high data traffic in that area. AIS expected that heavily consuming data users mostly would adopt new bandwidth consuming applications. Speed provided by GPRS may not be able to satisfy their QoS demand on those applications.

In that area, AIS dedicated 4 TS for EDGE/GPRS traffic channels. Assuming that a user with GPRS phone would like to download 120 kbyte video mail. With GPRS phone (1 Tx + 4 Rx), it takes around $(120 \times 8)/(4 \times 10) = 24$ seconds: but with EDGE phone (1 Tx + 2 Rx) it only takes around $(120 \times 8)/(2 \times 30) = 16$ seconds. In addition there are 2 TS left available for other EDGE/GPRS users to use also. So, QoS on data usage is better. The QoS on voice usage will be achieved only when all data users switch to use EDGE phone and remain downloading same data volume; then, some EDGE/GPRS TS can be freed up for voice calls.

5 3G Evolution/Compatibility

3G licenses have not yet been awarded to operators in Thailand so by implementing EDGE, AIS are able to provide 3G like services at a relatively low cost. Given that EDGE shares the same packet core network with WCDMA and that is it also backward compatible with GPRS, EDGE will enable AIS to provide a seamless and standardized migration to 3G in the future.

UGANDA – GSM networks bring health care to rural Uganda

Reprinted with permission, Cellular News – 23 September 2003

The launch of a nationwide, wireless network to improve Uganda's ability to treat patients and combat the spread of disease was announced yesterday. The network is built around the country's well- established cell phone network, inexpensive handheld computers, and innovative wireless servers called "Jacks". The technology allows health care workers to access and share critical information in remote facilities without fixed telephone lines or regular access to electricity.

The announcement was made by Canada's International Development Research Center (IDRC), WideRay, a wireless technology company based in San Francisco, and SATELLIFE, a non-profit organization focused on improving health in developing countries.

The Jack servers, which are about the size of a thick textbook and use long lasting industrial-grade batteries – a single charge lasts up to a year – are being installed in health care facilities across Uganda. Health workers can link to the device using the infrared port on their handheld computers to retrieve or submit information, and to access email.

"This is going to be a giant leap forward for Ugandan health care. It could save thousands of lives and have significant benefits in health outcomes for Uganda's citizens," said Holly Ladd, Executive Director of SATELLIFE.

This project will provide health practitioners in the field with tools that were previously unavailable or outdated. For example, users can now access the latest treatment guidelines for tuberculosis and malaria and learn of the most cost-effective approaches to fight HIV/AIDS, which infects one in 10 adults in Uganda. They can also read the latest medical journals and textbooks from around the world, in a digital form.

The technology should also improve health care administration by reducing the time taken to submit, analyze and respond to reports and requests for supplies.

Recognizing the potential of this technology for Uganda, Connectivity Africa, a Canadian government initiative managed by IDRC and funded from Canada's Fund for Africa, contributed USD 565,000 to the development of this information network.

"The convergence of new technologies low-cost handhelds, broad and reliable wireless coverage and WideRay's innovative use of it have made applications that once seemed impossible in Africa a reality," said Richard Fuchs, Director of IDRC's Information and Communication Technologies for Development (ICT4D) program area. "This project will be a powerful example to the rest of the world of what is possible with wireless technology."

VENEZUELA – Venezuelan Experience on the Implementation of CDMA 1xrtt Network by one Existing TDMA Operator in the 800 MHz Band (824-849 MHz/869-894 MHz)

Source: Venezuela

1 Background

By 2001, one Venezuelan mobile operator, completed studies on the feasibility and revision of the business case for deployment of a new technology in the 800 MHz band, with two options: GSM and CDMA, and several requirements, such as: substantial increase in network capacity, greater compatibility with existing infrastructure, better positioning to provide 3G services, and substantial reduction of future CAPEX and OPEX requirements.

In studies of the two options, six main aspects were taken into account by the operator:

- Availability of technologies in the 800 MHz band.
- Efficiency of frequency use (traffic handling capacity).
- Compatibility with existing infrastructure.
- Positioning to offer 3G services.
- International experiences.
- Availability of terminals.

2 Study of Options

2.1 Availability of technologies in the 800 MHz band

By 2001, only one digital technology could provide solutions that met the requirements considered by the operator: CDMA 1xRTT. Some manufacturers had announced their intent to provide a GSM solution for the 800 MHz band, but thus far, this had not materialized.

The operator had then to choose either the CDMA 1xRTT option, with successful experiences in other countries of the Americas, or GSM, without knowing whether that solution would be developed, and without previous experiences to draw upon. In addition to the infrastructure problem, there was major concern in connection with the GSM option regarding the availability of user terminals as, thus far, no manufacturer was offering GSM terminals in the 800 MHz band.

2.2 Efficiency of frequency use (traffic handling capacity)

To date, on this item, CDMA has shown itself to be the technology making the most efficient use of the spectrum and, therefore, providing greatest traffic handling capacity. Nonetheless, we must note another important problem that had to be resolved: radio frequency engineering.

Having to implement the new network in the very congested 800 MHz band, it was necessary to revise frequencies plan to provide for the coexistence of a new technology. This involved considerable effort to make room for the new technology in part of that band without affecting the quality of the existing TDMA system.

2.3 Compatibility with existing infrastructure

As GSM is a form of TDMA technology, some people had the impression that there was greater compatibility between these two technologies (GSM and TDMA) than between TDMA and CDMA. However, the fact that IS-136 and GSM are two forms of TDMA does not mean that they are at all compatible from either the user terminal or the operator network standpoint, while TDMA and CDMA networks share the same telecommunications protocol in the core network (ANSI-41).

Such a feature of compatibility enabled the operator to share the same TDMA applications and systems on a new CDMA 1x network. In concrete terms, it meant sharing such important platforms as HLRs, voice mail, SMS, WIN, prepaid, etc., enabling customers to migrate from the TDMA to the CDMA platform while retaining their telephone numbers and user profiles.

2.4 Positioning to provide 3G services

Careful study of a TDMA operator's options in migrating toward 3G shows that the GSM route requires additional spectrum (UMTS spectrum), as well as two additional platforms: the GSM network and the UMTS network. However, the CDMA2000 route does not require additional spectrum, as it can be implemented in the 800 MHz band on only one platform: the CDMA2000 network.

2.5 International experiences

By 2001, the European operators that had invested heavily to obtain licenses for use of the spectrum required to implement UMTS were in a critical situation since financial point of view. Many could not make payments while others were asking governments to relieve them of their payment obligations. Problems were aggravated by delays in the development of UMTS technology and none of the implementation commitments had been fulfilled. In fact, new delays were announced regularly.

On the other hand, Korean and Japanese experiences with the CDMA 1x platform had been very successful. The number of users was growing rapidly and new applications and terminals were appearing every day.

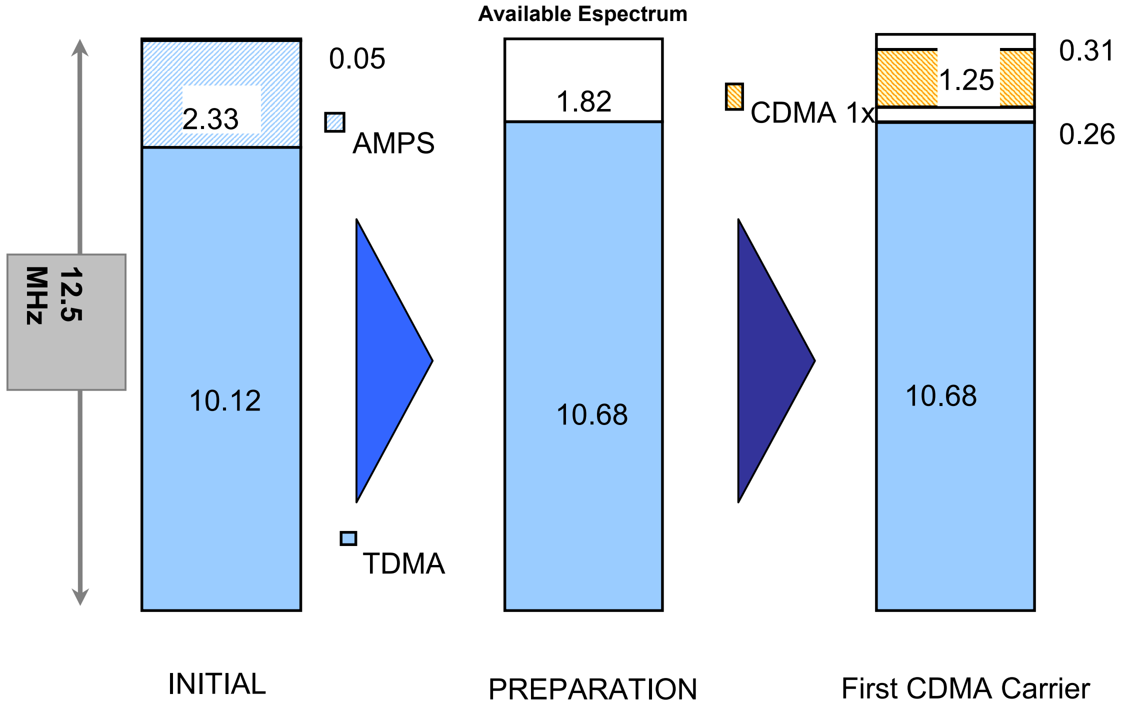
2.6 Availability of terminals

For purposes of the decision, the terminal issue was one of the more studied aspects. The operator had already learned from experience how advantageous it was to have a wide variety of terminals tailored to the different customer segments, as well as manufacturers willing to provide in the terminals the latest technological innovations in the technology used by the operator. Thus, the decision had to take into account the existence of a wide range of manufacturers, committed to delivering terminals tailored to the applications to be implemented and to market requirements, taking into account the Korean and Japanese experience, as well as the decision taken by one large North American operators, and one large Brazilian operator to implement the technology CDMA 1x, generated confidence that terminals would be available.

3 Network Construction and Commissioning

The project to install and bring into operation of the CDMA 1xRTT platform consisted, as mentioned above, of building a network parallel to the TDMA network (over 400 cells), retuning the entire existing network (AMPS and TDMA) to free the necessary spectrum to raise the CDMA 1xRTT carrier, adaptation of sites for installation of the new radio base stations and the MTX, interconnection, connecting platforms and common nodes to the AMPS, TDMA, and CDMA 1x, and adjustment of operating systems, billing, and administrative procedures.

Figure G.2 – Plan for Spectrum Migration to CDMA 1xRTT



One of the project's main challenges was to integrate the TDMA and CDMA 1x networks into the core network, operations support systems (OSS), and business support systems (BSS). The objective was to ensure number portability between networks, transparency of services, and compatibility of the two networks by reutilizing platforms providing basic and value added services, such as SMS (*Móviltexto*), voice mail (*Móvilmensaje*), HLRs, the other voice services, SCP, and Wireless Intelligent Network (WIN), both for the prepaid service collection platform and for calling records to bill for the new network's services. Processes and systems to support the new wireless data services also had to be designed.

At the time the project began, no platform existed enabling subscribers' profiles and locations to be stored (HLR) that was capable, for both networks simultaneously, of handling and managing subscribers to ensure the transparency of the process.

At the same time, an exhaustive study had to be made of the services associated with the WIN network and their current support procedures so as to be able to integrate them with the new network.

The possibility of coverage of 1x subscribers under the analogue network had to be evaluated, as several services required fundamental changes in treatment. Even basic services such as voice messaging required adjustments to call routing procedures owing to existing differences among providers.

Prepaid service had been operating over TDMA with manufacturers' proprietary protocols which, with introduction of the new network and a new provider, became an obstacle to integration with 1x. For this service, solutions were more sophisticated. Negotiations were conducted with providers and competitors to ensure deployment of a system based on the standard IS-826 telecommunications protocol for prepaid mobile telephony systems. This involved designing a new network architecture, in order to meet the objectives by the deadlines without affecting existing systems.

Within nine months – from January to October 2002 – all these efforts had met with success, with participation by all company units, while simultaneously satisfying the installation and operating requirements of the existing AMPS, TDMA, and CDPD networks.

4 Tests of Operation

The commercial certification process consisted of validating the network's commercial operation through the use of general testing protocols for calls, services, and systems supporting commercial operation and customer services. The certification process was conducted on the call and service different systems, that is, postpaid and prepaid on-line systems, agents' extranet, voice activation, on-line The operator, operational intranet (Switch-MTX and short message service, postpaid and prepaid calls and services, tests in outdoor locations; indoor tests in each region's most important structures; handoff: maintenance tests for calls when the receiving radio base station changes, for both digital and analogue radio base stations; IVR: card activation, data transmission.

Tests were divided into postpaid and prepaid categories, and a multidisciplinary certification team was formed. Its structure was: the fault repair group, responsible for monitoring and correcting problems on systems operated on The operator; the testing group, organized into regions by the regional managers; and a group of regional manager's office employees, responsible for call and service tests. The test protocol explained the objective, scope, and execution of each test, as well as the anticipated result. This tool was highly important in team coordination, for which a small group was required, which acted as liaison between the regions of each commercial area.

Information for Question 18/2 Rapporteur

Sources of extracts from other ITU documents:

i Section 2.2 of ITU-R Handbook; Principles and approaches of evolution towards IMT-2000/FPLMTS (Volume 2 of the handbook on Land Mobile, including Wireless Access).

ii Section 4 of Annex 1 of ITU-R M.1308.

iii Handbook on IMT-2000 deployment, sections 3.2 and 3.3.

iv CPM Report to WRC-03.

v ITU-R M.819.

vi CPM Report to WRC-03.

vii This taken from the draft revision to ITU-R Recommendation M.1036.1, which will be considered for adoption by the 2003 Radiocommunication Assembly.

viii This taken from the draft revision to ITU-R Recommendation M.1036.1, which will be considered for adoption by the 2003 Radiocommunication Assembly.

ix Section 2.2 of Handboook on IMT-2000 deployment.

x Section 9.1 of ITU-R Handbook; Principles and approaches of evolution towards IMT-2000/FPLMTS (Volume 2 of the handbook on Land Mobile, including Wireless Access).

xi Section 9.1 of ITU-R Handbook; Principles and approaches of evolution towards IMT-2000/FPLMTS (Volume 2 of the handbook on Land Mobile, including Wireless Access).