UMTS: 3G Mobile Communication System

Synthesis of 4 FITCE Belgium & SITEL **UMTS** Lunch Sessions

Prof. Dr. ir. Leo Van Biesen

Vrije Universiteit Brussel, Dept. ELEC
Pleinlaan 2, B-1050 Brussels, Belgium
e-mail: lvbiesen@vub.ac.be

Abstract- **The world of telecommunications is rapidly evolving, driven by the European success of GSM and a global phenomenon as Internet. The primary aim of third generation mobile communications systems, referred to in Europe as UMTS, is to achieve convergence between the mobile and the Internet environments by offering a broad range of high-quality and high-speed mobile multimedia services.**

Implementation of 3G systems represents a major challenge for the engineers, the manufacturers, the operators and service providers and the Governments and regulators.

During lunch sessions organised by FITCE & SITEL a unique opportunity in Belgium has been offered to familiarise with a broad range of concepts associated with these new emerging telecommunications systems.

In this paper, an attempt to deliver a summary of the 4 UMTS lunch session's presentations is presented. Major features are highlighted, views and opinions from the distinct speakers are bundled and questions from the audience grouped and analyzed.

I. INTRODUCTION

The world of telecommunications is rapidly evolving, driven by the European success of GSM and a global phenomenon as Internet. The primary aim of third generation mobile communications systems, referred to in Europe as UMTS, is to achieve convergence between the mobile and the Internet environments by offering a broad range of high-quality and high-speed mobile multimedia services. 3G mobile systems will form an important building block in the construction of the Information Society by ensuring the convergence of communications, information and entertainment content, consumer electronics and computing.

3G mobile networks will make an intensive use of modern technologies, such as spread spectrum techniques for the air interface, IP architecture for the core network and non-geostationary satellite constellations. Implementation of 3G systems represents a major challenge for the engineers, the manufacturers, the operators and service providers and the Governments and regulators.

The four lunch sessions of SITEL & FITCE have offered a unique opportunity in Belgium to familiarise with a broad range of concepts associated with these new emerging telecommunications systems, which undoubtedly will a have major impact on the society for the next ten to twenty years.

The lunch sessions have been held in Brussels on Wednesdays in November and December 2001 and February 2002. The Free University of Brussels, both the Dutch speaking VUB (Vrije Universiteit Brussel) and French speaking ULB (Université Libre de Bruxelles) acted as hosts.

The series of luncheon talks have been aimed by the organisers towards the group of technical and marketing people wanting to be kept informed about the latest evolution in the mobile telecommunications sector. In general, this goal has been reached, since most leading telecom companies, research institutes and official or authorities administrations active in Belgium were represented in the sessions. Furthermore, the registration rate of more than forty participants per lecture, do illustrate the global success of the FITCE and SITEL initiative. It is hoped, therefore, that in the future similar joint venture activities can be scheduled and will be organised.

II. SHORT OVERVIEW OF THE LECTURES

In the first lecture an accurate and well-balanced technical *'Introduction to UMTS'* was presented by ir. J-P Pirlot of the BIPT (Belgian Institute for Postal services and Telecommunications). He sketched the technical definitions and gave details on the implementation in the distinct technologies. Comparisons with the current GSM 900 and 1800, GPRS and EDGE were addressed. The speaker drew special attention on the regulatory aspects, rules and legislation. Some indications of the state of deployment in Belgium, Europe and world-wide, were also given. Many questions were asked by the audience with respect to license agreements in Belgium and about starting dates and possible delays for operations in Belgium.

During the second session, Mr. M. Recinella shared the views of an *'UMTS Integrator'*. From his experiences at Telindus, he addressed the successive steps in the resources

to build or to migrate to UMTS. The different problems to be tackled were analyzed; i.e. the radio planning problem, the business planning view and the network planning. It has been shown that planning requires an integrated approach between the Marketing, Engineering and Finance departments. Special attention was also given towards the site acquisition and site sharing problems and the current status in Belgium of the sites.

The third session undoubtedly was the meeting with the highest expectations from the attendees. During a Panel Discussion, the 3 licensed operators in Belgium had the opportunity to answer some general but also very specific questions about the current state of the deployment of the operations, their preferences or choices for hardware manufacturers and about their testing facilities and testing experiences. The Panel Discussion was preceded by keynote presentations by the representatives of the Belgian operators.

Ir. O. Vandenbulck represented Mobistar and addressed some views on changes, which will have their impact on all stakeholders when migrating from 2G or 2.5G towards 3G operations in Mobile Communications. He clearly addressed the problem of revenues and explained the difference in billing schemes between current services and UMTS.

Ir. L. Claus, director of Engineering & Operations at Proximus (Belgacom Mobile), gave a detailed and well-structured overview of GPRS. He clearly indicated how GPRS paves the way towards UMTS.

Finally, ir. E. Rijks, CTO at KPN Orange (now Base), discussed some operational issues for UMTS. He documented his contribution with some interesting data on the current testing of hardware in his company.

During the final lunch session the organizers aimed to receive some views of content and media contributors to stress some problems with respect of how to use UMTS as a new medium, to share some forecasts on new interactive media and to inform on copyright issues.

First, B. Tuyteleers, Key Account Manager Benelux for Tele Atlas, analyzed briefly how his company as a content provider is preparing the future. He gave a clear overview of Location Based Services and addressed (car) navigation facilities in particular.

Finally, ir. M. Lauwers gave an excellent presentation and slide show with movie animations on the views of Siemens on the 3G in Mobile Communications and Services. Some Mobile applications of Siemens were introduced; e.g. the Personal Information Management approach (Mobile Portal and Mobile Office) and Xpressions450.

III. ENHANCEMENTS IN 3G MOBILE SYSTEMS

The numbering of the generation(s) in Mobile Systems has one thing in common with the so-called Industrial Revolutions: one easily looses track or count! Obviously, real numbers are required to indicate the actual generation, since integers do not allow the description of the transition between the actual second and third generation to come.

The first generation in Mobile Networks based on Cells clearly addresses analogue voice communications. Common feature in the second generation is the digital way of communication, both for voice (as in the first generation) but also for data at low speed (9.6 kbit/s). Examples are the well-known and popular GSM (with some limited extra features such as SMS), the TDMA solution in IS-136, the CDMA solution in IS-95 or the Pacific/Japanese Digital Cellular.

The third generation groups the mobile services, which will allow multimedia applications and mobile Internet at relatively high speeds (2 Mbit/s).[1] UMTS (Universal Mobile Telecommunications System) and IMT-2000 (International Mobile Telecommunications) belong to the 3G. 5 different standards are foreseen. The UMTS in Europe will be implemented using UTRAN (UMTS Terrestrial Radio Access Network), which has 2 modes of operation (UTRA-FDD, which is compatible to IMT-DS (Direct Sequence) and UTRA-TDD, which is equal to IMT-TC (Time Code)).

However, in transition from 2G to 3G new enhancements to 2G have been made. Examples are the WAP (Wireless Access Protocol), short distances connectivity using Bluetooth (2.45 GHz spread spectrum link), CAMEL (Customized Application for Mobile Enhanced Logic), EDGE (Enhanced Date rates for GSM Evolution, allowing data rates up to 384 kbit/s), GPRS (General Packet Radio Services), etc.

The major enhancements to be expected from third generation mobile services are directly linked to the new kind of services, which will be offered:

i. *Communication services:* enhanced voice quality, fax, e-messaging;
ii. *Information services:* news, weather reports, sports information, lottery results, stock exchange, etc.;
iii. *Financial services:* on-line banking and shopping, ticketing, electronic payments;
iv. *Business services:* virtual office, corporate Internet, etc.;
v. *Entertainment services:* video and music on demand, electronic games;
vi. *Transport related services:* in-car real-time navigation (GPS), traffic info…

[1] Although 2 Mbit/s sounds impressive as future data rate with respect to mobile data traffic, it is worth to compare future expectations in local access networks too. xDSL based technologies, such as VDSL will theoretically allow up to 40 times faster networking!

Some examples of new to be offered services were given and have been demonstrated during the final lunch session.

IV. ARCHITECTURE AND PROTOCOLS OF UMTS

The evolution towards PS (Packet Switching), which already for considerable time periods have been noticed in switched networks, e.g. in TCP-IP (Transmission Control Protocol/Internet Protocol) or ATM (Asynchronous Transfer Mode), has also entered the realm of mobile cellular systems in the creation of packet switched GSM; i.e. GPRS. The GPRS network also uses IP routers with IP addresses and invokes statistical multiplexing by packet transmissions. The important revolution in mobile networks, therefore, should be considered to be the implementation of GPRS in GSM core networks, whereas UMTS or 3G are a straightforward evolution of GPRS!

The revolution of GPRS can be described by the fact that a user is constantly connected to the network (always on), which is very suitable, e.g., for e-mail services or web browsing. New also is the way of tariff charging per volume, instead of per connection or time duration of a connection (comparable to some ADSL providers who already do charge volumes). The noticeable increase in data rate compared to classical GSM is also appreciated by the customers, together with the fact that one remains reachable while surfing, as is the case with ISDN in the local access loop.

With UMTS the user will benefit all the advantages of GPRS; i.e. be always-on, pay for the data, which has been used, but at a still higher throughput (in theory up to 2 Mbit/s).

With respect to the implementation of 3G Mobile Networks, the worldwide differences relate to the preferred Radio Access technologies: BRAN (Radio Access Network), SRAN (Satellite Radio Access), GERAN (GPRS/EDGE Radio Access Network), CDMA 2000 (MultiCarrier) or UTRAN (UMTS Terrestrial Radio Network). Almost all European operators prefer the latter. The 3G implementation of the Radio Access technologies is depicted in Figure 1.

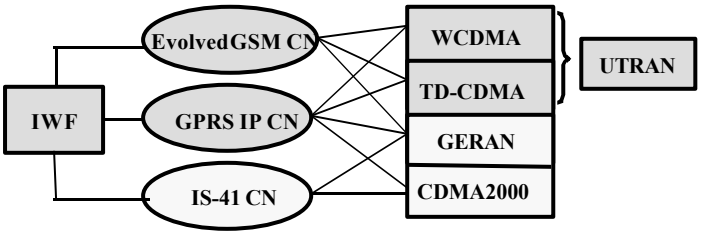

Figure 1: Implementation of 3G Mobile Networks.

The Inter Working Functions either use GSM Evolution as Core Network, either GPRS with Internet Protocol or, if no GSM-MAP messaging is foreseen such as for some providers in the US, the ANSI-41 Core Network.

In UTRAN, the preferred European Radio Network, the User Equipment will consist of the mobile unit (handset) in which a new USIM will have to be placed (Universal Subscriber Identity Module). This USIM will have double as much RAM as the SIM in GSM (64 kBytes), will be backwards compatible with SIM (the USIM will not work in GSM phones, but a GSM SIM card will operate in 3G/UMTS devices) and will allow global roaming and multiple network access (i.e. with a USIM SmartCard, the 3 future 3G UMTS providers in Belgium will be accessible).

The interconnectivity between the Core Network and the User Equipment is shown in Figure 2. The Radio Network Subsystem consists of Radio Network Controllers connected to Base Stations (Node B). When compared to the GSM Core Networks, one observes that in UTRAN the Base Station Controllers (BSC) have interfacing between each other too.

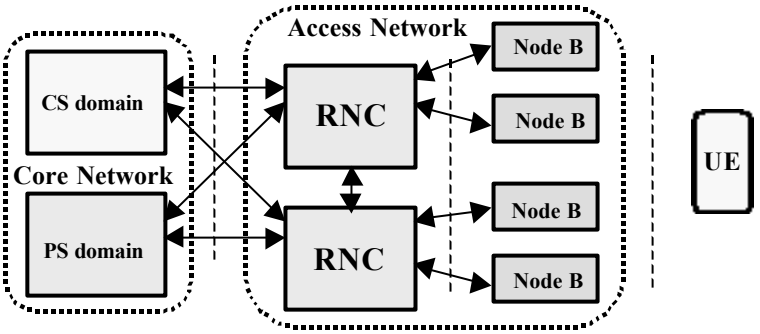

Figure 2: Interconnection scheme between the Core Network with either Circuit Switched (CS) or Packed Switched (PS) domains, the Access Network and the User Equipment (UE).

With respect to the protocols in UTRAN, reuse of GSM protocols (CS) and GPRS (PS) are envisaged. For the Radio Interface, specific protocols are foreseen (see Figure 3 level 2):

- MAC (Medium Access Control);
- RLC (Radio Link Control)
- RRC (Radio Resource Control)
- PDCP (Packet Data Convergence Protocol)

For the Core Network, UTRAN proposes specific protocols too (see Figure 3 level 3):

- RANAP in CS (Radio Access Network Application Part);
- GTP-U UMTS version of GPRS Tunneling Protocol or ATM (Asynchronous Transfer Mode) in PS.

GPRS has introduced two new network nodes in the GSM Public Land Mobile Network (PLMN): the Serving GPRS Support Node (SGSN), which is at the same hierarchical level as the mobile services switching center (MSC), keeps track of the location of the individual mobile stations (MSs) and performs security functions and access control. The SGSN is connected to the base-station system via Frame Relay. The Gateway GPRS Support Node (GGSN) provides

interworking with external packet-data networks and is connected with SGSNs via an IP-based GPRS backbone network. The structure of UTRAN packets in relation the OSI-layer model is described in Figure 3. Layer 3 consists of 2 parts, as is already the case in GPRS.

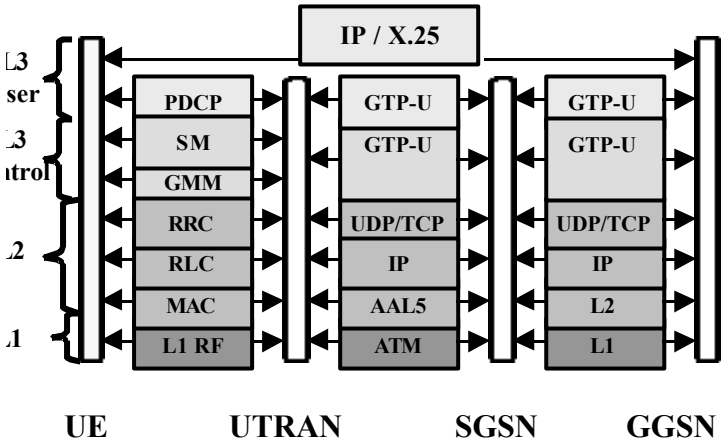

Figure 3: Structure of UTRAN Packets related to the OSI-model and the used protocols.

Important new features and technologies have been selected for the digital communication in UMTS too. A complete overview and description of the operation and details on advantages with respect to the actual used principles, however, go beyond the scope of this paper. An important key player undoubtedly is the Code Division Multiple Access (CDMA) and the application of the latter using Spread Spectrum techniques. It can be shown from theoretical studies that CDMA (as will be used in UMTS) has some important advantages when compared to Time Domain Multiple Access (TDMA, as is used in the actual GSM for each allocated frequency channel). Worth to notice are:

- The flexible services: bit rates, QoS (Quality of Service), delays, packets;
- The bandwidth on demand;
- The spectrum efficiency and frequency planning;
- The robustness against interference and an enhanced resistance against multipath reflections;
- The soft way of handover, due to basestation diversity, without the usage of interrupts as is the case in GSM.

Users in a cell occupy in UMTS both the entire allocated frequency and time domain. The distinction between the users is done through the use of unique codes. Codes of other users appear as noise that can be partly suppressed by the receiver at the base station. But not all interference can be suppressed, especially if high-data-rate users are located at the edge of a cell.

An important change in the radio link for UMTS, furthermore, is the spectral assignment of frequencies and bandwidth. The spectrum usage of UMTS, when compared to GSM is sketched in Figure 4.

The Primary GSM (P-GSM) in the 900 MHz band has been extended first with 50 extra channels to yield the Extended Global System for Mobile communications (E-GSM), whereas the 1800 MHz band, referred to as the dual band GSM in many locations worldwide occupies the radio spectrum just below a window allocated to some DECT (Digital Enhanced Cordless Telecommunications) applications. Note that the 1900 MHz band allocated to GSM in the U.S.A. (known as the third band, hence tri-band GSM) is not shown in Figure 4. MSS in Figure 4 indicate Mobile Satellite Services, TDD refers to the Time Division Duplex and FDD to Frequency Division Duplex, with an offset of 190 MHz.

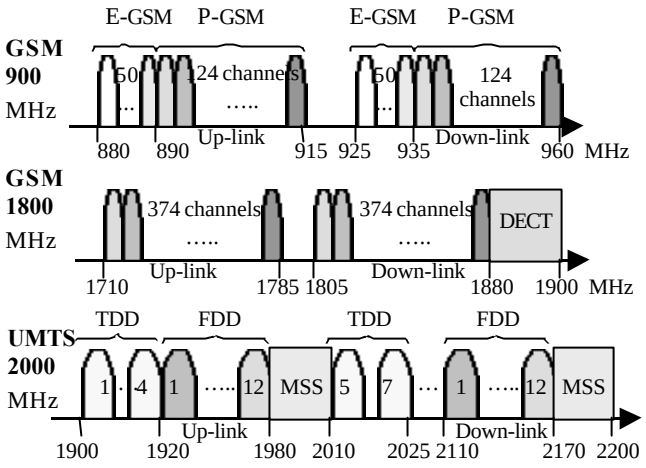

Figure 4: Spectral Management of UMTS compared to the European GSM-bands.

To conclude the short overview on the architecture, protocols and technologies used in UMTS, a comparison between GSM and the in Belgium to be deployed Wideband CDMA in UMTS is sketched in Table 1.

Characteristic	GSM	WCDMA
Multiple Access	TDMA	DS-CDMA
Duplexing	FDD	FDD or TDD
Modulation	GMSK	QPSK
Carrier spacing	200 kHz	5 MHz
Chip rate	not applicable	3.84 Mcps
Frequency bands	900 & 1800 MHz	2000 MHz
Frequency Diversity	Slow Frequency Hopping	Spread spectrum
Power control	2 Hz	1500 Hz
Frame duration	4.615 ms	10 ms
Time Slot	577 µs	666 µs
Voice coding decoding	RPE-LTP or EFR	ACELP
Packet data	GPRS	Load based

Table 1: Comparison between some characteristics in GSM and WCDMA

V. REGULATORY ASPECTS FOR UMTS IN BELGIUM

The regulatory and legal aspects of UMTS deployment do concern the following issues:

1. Spectrum licensing;
2. Telecom numbering;
3. Tariffs and Interconnection;
4. RollOut of Mobile Networks.

The Mobile Spectrum licensing in Belgium has been assigned to Belgacom Mobile (Proximus), Mobistar and KPN Orange (now Base) according to the following Royal Decrees (RD):

1. RD of 7-3-1995: GSM 900 for Belgacom Mobile and Mobistar;
2. RD of 24-10-1997: DCS 1800 + E-GSM for KPN Orange (now Base) and GSM 1800 for Belgacom Mobile and Mobistar;
3. RD of 18-1-2001: March 2001 auction of 3G (UMTS) licenses:
   - License A (150.2 million EURO): Belgacom Mobile;
   - License B (150 million EURO): KPN Mobile;
   - License D (150 million EURO): Mobistar.

The spectral occupancy of the licenses (license C is not attributed) in Belgium is depicted in Figure 5, whereas the 3G licensing in Europe is shown in Table 2 (fees are expressed in million EURO).

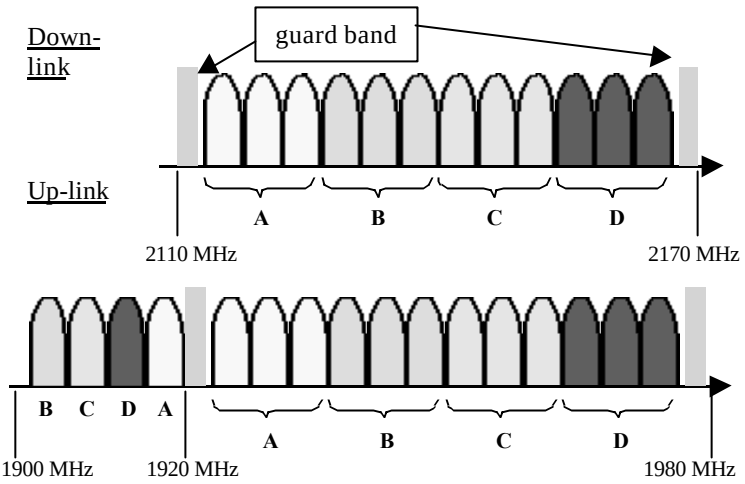

Figure 5: Spectral allocation for 3G services to the different licensees in Belgium.

Since telecom numbers do form scarce resources, some legal actions have been ordered in Belgium related to the numbering issues. The RD of 10-12-1997 has ruled a national numbering plan and attributed the prefix number 04XX to the mobile services. Next, Mobile Number Portability will be operational from 2002 on, which will allow to change from operator without having to change the number.

The RD of 18-1-2001 foresees the launch of commercial services within a period of 18 months, with coverage objectives of 30% in year 3, 40% the year after and 50% in year 5. However, in the lifetime of the UMTS lunch sessions, it became clear from the Belgian operators that some delays can be expected. Negotiations with the minister and the departments in charge are still in process.

Country	Procedure	Number	Fees
Austria	auction	6	832
Belgium	auction	3	450
Denmark	auction	4	510
Finland	beauty	4	-
France	beauty	2	9909
Germany	auction	6	50798
Greece	auction	3 (+3)	646
Italy	auction	5	11998
Netherlands	auction	5	2684
Portugal	beauty	4	399
Spain	beauty	4	517
Sweden	beauty	4	-
United Kingdom	auction	5	38473

Table 2: 3G licensing in Europe (status November 2001)

Finally, lots of questions and remarks have been formulated during the lunch sessions with respect to the site sharing obligations and the set-up of a common site database (see hereto also chapter VI).

Also aspects of radio wave impacts on environment and humans have been addressed. A fundamental question is to determine the responsibility and the authority in Belgium in the matter of radiation protection. Either the latter is regionalized, which then could put the responsible authority to the Regional Departments for the Environment. However, if the Federal Government should be competent in this matter, the Ministry of Health & Safety should be in charge. Recently, the highest court in Belgium (Council of State) has concluded that the limits in radiation should be regulated by Federal rules, and thus by the Ministry of Health & Safety.

In the RD of 29-4-2001, the safety margins for exposure to EM-fields (electromagnetic fields) have been set four times better (safety factor of 200) than those of the ICNIRP (International Commission on Non-Ionizing Radiation Protection) recommendations (safety factor of 50). Research on biological impact has yielded the critical value of 4 W/kg tissue and results in a radiation limit of $0.686\sqrt[2]{f}$ in V/m, where f equals the used frequency. For GSM 900 this rule results in a maximum field of about 20 V/m and 30 V/m for future UMTS.

Consider, however, that the level of exposures arising from the phones held near to the head or other parts of the body are substantially greater than whole-body exposures arising from base stations. Field measurements done on exposures arising from base stations in Belgium seem to be lower than the ICNIRP guidelines.

The usage of Adaptive Power Control (APC) means that the cellular phone continually adjusts the power it is transmitting to the minimum needed for the base station to receive a clear signal. This reduction can be less than the peak power by a factor of up to a 100 times if the phone is near a base station.

Telindus as an integrator states that given that more than 50% of the population now has a mobile phone, one could conclude that in making decisions about the siting of base stations, planning authorities should be encouraging their siting closer to, and not further from people.

The BIPT is preparing now a procedure on how to implement the radiation limits based on measurements before site acquisition and deployment, prognoses and practical measurements in operational phases.

VI. SOME COMMENTS ON COMMERCIAL ASPECTS OF 3G DEPLOYMENT IN BELGIUM

Depending on the sources, which have been consulted, some forecasts of the global revenues of mobile commerce have been cited. Taking the lowest figure of the available forecasts for 2003 into account, a world-wide revenue of 13 billion US$ is to be expected (Analysys). However, forecasts in Telecom matters are very difficult to make. WAP, e.g., has been forecasted and carefully planned, but did up-to-now not generate a serious breakthrough. SMS (Short Message Service), on the contrary, was not as such forecasted to yield success, but has gained an important market share due to the youngsters, who prefer this communication medium over voice. Proximus indicated recently (April 2002) that about 8% of their income are generated by the usage of SMS. For Mobistar a comparable figure was shown for 2001. The Belgian operators do expect to obtain about 25% of their income in mobile services from data revenues by 2005. This is needed, however, to compensate a loss of income due to the competition.

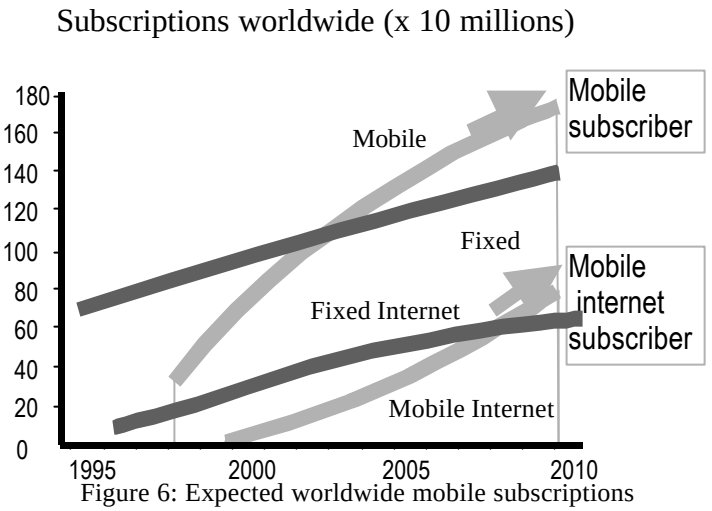

Figure 6: Expected worldwide mobile subscriptions

The worldwide expected number of mobile subscriptions (from the contribution of Siemens) is shown in Figure 6. Following this forecast, the number of fixed and mobile users will be equal from 2003 on, whereas after that the number of mobile users will grow faster than that of the fixed line users. With respect to Internet usage, the crossing of both curves is expected to take place in 2008. All mobile operators agree that the number of mobile clients will increase at a rate much higher than is the case for fixed users.

Planning in 3G, nevertheless, is totally different from the one in, e.g., 2G. Marketing, Engineering and Finance functions have now to work together in a closer way to result into an Integrated Planning. An important difference in the network planning for UMTS compared to GSM is the fact that geographical coverage and capacity (by cells) no longer can be regarded as being independent design parameters. This is due to the use of WCDMA, where all users in a cell share the same time and frequency resources and the same power amplifier with respect to the transmitter. The transmission range – and hence the size of a cell – of a Node B (equivalent to BSC in GSM, see Figure 2) depends on the loading of the cell, which is referred to as being *cell breathing*. This is

mainly due to the interuser-interference, which is typical for a CDMA system. This interference will increase with the number of simultaneous users. To maximize the capacity in a cell, and hence to maximize the reachable data transmission rate, the transmitted power should be reduced and minimized.

The planning of a network for UMTS deployment consists of 3 distinct steps, according to Telindus:

1. A static analysis considering the general outline;
2. A static (Monte Carlo based) analysis and dynamic simulations;
3. Time and space dynamic simulations.

The first step defines the definitions of the different types or classes of services in terms of the obtainable data rate, the unavoidable generated delay, the reachable BER (bit error rate) and the quality of service (QoS). With these the local distribution of the types of services in the region to be covered can be determined, and hence, budget calculations, e.g. considering 50% to 80% loading of the cells, can be linked. In this phase, the identification of the sites has to be performed; i.e. investigations will have to be made to see whether existing GSM sites can be used or if new ones have to be acquired.

In the second step simulations will have to be made to investigate the quality of different services at different locations, and this also as a function of time. Statistics on the performance will have to be generated; e.g. the effective data rate, information on dropouts, reachable coverage etc. In this step service availability and quality of service will have to be measured from field trials.

In the final phase, time dynamic simulations are proposed to investigate the performance of a population of moving mobiles over a period of time. Special attention has to be paid to investigate the handover parameters and the attained performance of the network. From these, physical site parameters can be derived, such as height, tilt, azimuth with respect to the site location and some radio frequency parameters (frequency and capacity planning, handover regions etc.).

At this moment the network planning in Belgium still resides in the first phase. During the lectures some attention has been paid to the need for increased outsourcing and the immediate benefits of the latter. Also the complex process of site acquisition has been treated in detail for the Belgian case.

The speakers have successfully removed some existing confusions and uncertainties within the audience and the public. For the site acquisition process, e.g., the questions on Building Permits (BP) have been answered in the following way. For existing masts no BP is required if the height of the antenna mast is not increased. However, this is only the case in Flanders. The Flemish Parliament: is considering forbidding sites located within a radius of 300m around houses. Some local authorities do not allow at all that sites are located in the center of their commune, so consequently sites do concentrate at the border of a commune. The end result is to yield more concentrated sites, and hence a rule in contradiction is generated versus what was wanted to be achieved (fewer masts). Finally the figure of no less than 2000 BP dossiers, which are untreated or awaiting decision, has been mentioned for Belgium!

Finally, the important issue of cost savings by site sharing or infrastructure or network sharing have been studied too. Figures on cost savings (up to 40% in global) from sharing have been analyzed. Actual examples from sharing in Europe have been presented and some regulatory perspectives were brought forward.

For Belgium the Program Law of 2-1-2002 has set-up the legal platform for site sharing. Operators are obliged to share their own sites with interested competitors. Compensation will be based on the real cost for the acquisition, the construction, and the maintenance added with a percentage to compensate for the invested capital. The operator requesting a BP for a site shall first verify whether other operators are also interested in that particular site; and if that is the case then, site sharing has to be foreseen in the design of the site. All operators shall develop a common database containing all existing sites and sites which are under development. The BIPT, again, shall act as arbitrage in all these matters.

Many questions were recorded and answered too regarding the necessary hardware. During the Panel Discussion, the 3 Belgian licensed operators for UMTS have explained their status with respect to the hardware selection, laboratory testing and other issues related to the future UMTS deployment.

VII. CONCLUSIONS AND ACKNOWLEDGEMENTS

The subject proposed by the FITCE Belgium board of directors together with the one of SITEL has shown great interest by the Belgian Telecom industry and sector. UMTS as medium and technology is a hot topic. Belgian operators are preparing the future and data content and multimedia providers are very busy with the development of new products ready for the customer market in evolution. The speakers have shown great expertise and mastership in the distinct subcomponents in the UMTS broad and multidisciplinary matters. Their open vision, mind and willingness to share their experiences have contributed largely to the success of the UMTS lunch sessions.

No reference to any literature is given, since the speakers have handed over hard copies of their well prepared PowerPoint presentations and since this paper has aimed to try to summarize the discussed subjects, rather than to prepare academic text-book like chapters on the proposed technology.

The author wishes, finally, to thank the organizers for the invitation to act as a moderator and host for the four lunch sessions. It has been a great experience, and the collegiality

between industrial competitors, academic researchers and regulators or administrative decision-makers has been particularly appreciated. It is hoped, therefore, that this kind of activities at affordable prices will be continued in the next future.

VIII. WEBPAGES OF ORGANISERS

The URL of the 2 organizers, FITCE Belgium and SITEL are printed below:

- FITCE Belgium:
  http://www.fitce.be
- SITEL:
  http://www.sitel.org