JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
1813–2235/2006/02–1–33–37
http://www.fspublishers.org

Implementation of Universal Mobile Telecommunication System

MEHWISH BASHIR[1] AND SALMAN AFSAR†
Institute of Horticultural Sciences and †Department of Computer Science, University of Agriculture, Faisalabad-38040, Pakistan
[1]Corresponding author's e-mail: mahwishbashir@yahoo.com

ABSTRACT

This research includes in depth study of Universal Mobile Telecommunication System (UMTS) that is envisioned as successor to Global System for Mobile Communications (GSM). It represents an evolution in terms of capacity, data speeds and new service capabilities from second generation mobile networks. UMTS uses W-CDMA as the underlying standard, is standardized by the 3 GPP. 3G Systems are intended to provide a global mobility with wide range of services including telephony, paging, messaging, Internet and broadband data. The UMTS is capable of providing multi-mobile services with multi-operators supporting a wide range of global mobile-communication standards.

Key Words: W-CDMA; HSCSD; MMS; Air interface; AMR; EFR; GRAN

INTRODUCTION

Universal Mobile Telecommunication System (UMTS) is one of the third generation (3G) mobile phone technologies. W-CDMA is the technology behind UMTS that is wideband spread-spectrum 3G mobile telecommunication air-interface that utilizes Code Division Multiple Access. UMTS handles a mixed range of traffic, using a mixed cell layout, which consists of macro-cells that are overlaid over micro and pico-cells shown in Fig. 1. Cell size is quite crucial in UMTS networks. For the probability of good signal reception, a fraction of the used area is integrated to obtain the average over the coverage area of a cell as follows:

$$U(n, \sigma, P_{edge}) = P_{edge} + Q(\sqrt{2}d)e^{d}$$

Where,

$$d = \frac{\sqrt{2}\,\sigma}{10\ n \log 10\ (e)} - \sqrt{2}\ \text{inv}\ Q\ (P_{edge})$$

U is the fractional area with radius r and propagation parameters—path loss exponent 'n' and standard deviation '**δ**'; P_{edge} is a good received signal at edge of cell; and Q is the probability function.

This network architecture helps in distributing data traffic. Local traffic operates in the micro-cells and pico-cells (for example, a local cellular subscriber, slow-moving subscribers, and users in dense population areas) while highly mobile traffic operates in the large macro-cells (such as a cellular subscriber traveling on a highway or by air). This greatly reduces the number of handoffs required for the fast-moving traffic. It uses W-CDMA as the underlying standard, is standardized by the 3 GPP. UMTS supports up to 1920 k bit/s data transfer rate, although at the moment users in the real networks can expect performance up to 384 k bit/s- in Japan up-grades to 3 M bit/s are in preparation. However, this is still much greater than the 14.4 K bit/s channels in HSCSD (High Speed Circuit Switched Data) and offers the first prospect of practical inexpensive access to the World Wide Web on a mobile device and general use of MMS.

- 3G/UMTS employ a 5 MHz channel carrier width to delver significantly higher data rates and increased capacity compared with second generation networks. This 5 MHz channel carrier provides optimum use of radio resources, especially for operators who have been granted large, contiguous blocks of spectrum typically ranging from 2 x 10 MHz up to 2 x 20 MHz to reduce the cost of deploying 3G networks.
- Simply put, UMTS is the combination of the W-CDMS air interface, Gem's Mobile Application Part (MAP) core and GSM family of speech codecs like AMR and EFR. Technically speaking, W-CDMA is merely the air interface, while UMTS is the complete stack of communication protocols designated for 3G global mobile telecommunications and as a direct successor to GSM. UMTS uses a pair of 5 MHz channels, one in the 1900 MHz range for up-link and one in the 2100 MHz range for down-link. The specific frequency bands originally defined by the UMTS standard are 1885-2025 MHz for up-link and 2200 MHz for down-link.
- A major difference of UMTS compared to GSM is the air interface forming Generic Radio Access Network (GRAN). It can be connected to various backbone networks like the Internet, ISDN, and GSM or to a UMTS network. GRAN includes the three lowest layers of OSI model. The network layer (OSI 3) protocols form the Radio Resource Management Protocol (RRM). They manage the bearer channels between the mobile terminal and the fixed network including the handovers.
- UMTS offers tele services (like speech & SMS) and

bearer services, which provide the capability for information transfer b/w access points. It is possible to negotiate and renegotiate the characteristics of a bearer service at session or connection establishment and during on-going session or connection. Both connections oriented and connectionless services are offered for Point-to-Point and Point-to-Multipoint communication.

MATERIALS AND METHODS

UMTS network services have different QoS classes for four types of traffic:

- Conversational class (voice, video telephony, video gaming)
- Streaming class (multimedia, video on demand, web cast)
- Interactive class (web browsing, network gaming, database access)
- Background class (e-mail, SMS, down-loading)

A UMTS network consists of three interacting domains, Core Network (CN), UMTS Terrestrial Radio Access Network (UTRAN) and User Equipment (UE). The core network consists of nodes (switches) with connecting lines. The main function of the core network is to provide switching, routing and transit for user traffic. Core network also contains the database and network management functions. The basic Core Network architecture for UMTS is bases on GSM network with GPRS. All equipment has to be modified for UMTS operation and services. The Core Network is divided in circuit switched and packet switched domains. Some of the circuit switched elements are Mobile services Switching Centre (MSC), Visitor location register (VLR) and Gateway MSC. Packet switched elements are Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). Some network elements, like EIR, HLR, VLR and AUC are shared by both domains.

Wide band CDMA technology was selected for UTRAN air interface. UMTS WCDMA is a Direct Sequence CDMA system where user data is multiplied with quasi-random bits derived from WCDMA Spreading codes. In UMTS, in addition to channelisation, Codes are used for synchronization and scrambling. WCDMA has two basic modes of operation: Frequency Division Duplex (FDD) and Time Division Duplex (TDD).

UMTS offer global radio coverage and world-wide roaming. For that purpose the URAN will be built in hierarchical way in layers of varying coverage as depicted in Fig. 2. A higher layer will cover a larger geographical area than a lower layer. In the highest layer there will be satellites covering the whole planet, the lower layers form the UMTS terrestrial radio access network UTRAN. They are divided in to macro, micro, pico-layer. Each layer is divided into cells. The lower the hierarchical level, smaller the cells. Smaller cells allow for a higher user-density. Therefore macro-cells are used for land-wide coverage; additional micro-cells are installed in areas with higher

Fig. 1. UMTS architecture

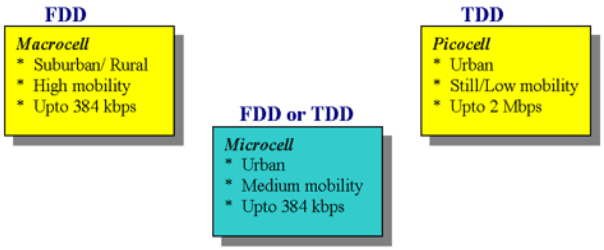


Fig. 2. Hierarchical cell structure of UMTS to offer global radio coverage

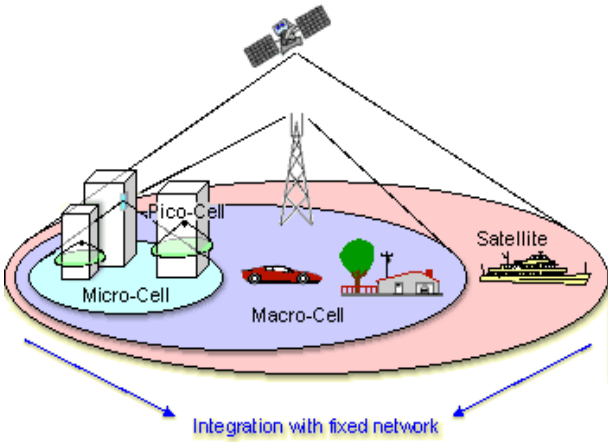
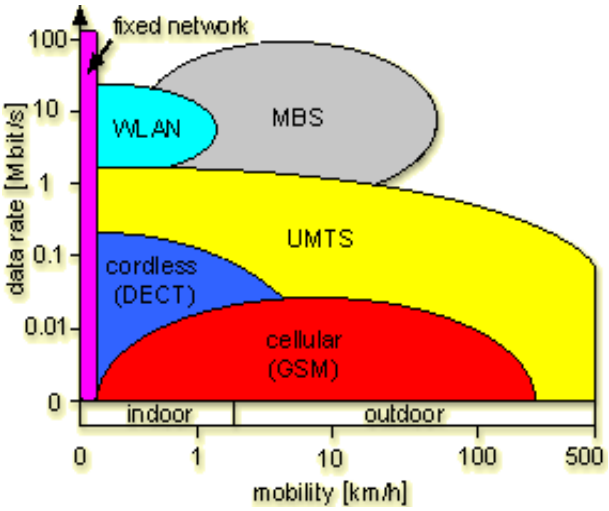


Fig. 3. Data rate versus mobility for UMTS in comparison with fixed network and other mobile communications systems (WLAN Wireless Local Area Network, MBS Mobile Broadband Systems)



population density and pico-cells in buildings and for so called "hot spots" (e.g. airports, railway stations).

The maximum data rate and the maximum speed of the user are different in each hierarchical layer. In the macrolayer at least 144 k bit/s with maximum speed of 500 km/h shall be possible. In the micro-layer 384 k bit/s with

maximum speed of 120 km/h shall be supported. The pico-layer offers up to 2 M bit/s with a maximum speed of 10 km/h. It shall be possible for the user to trade off bit error rate versus delay in certain limits. For real-time applications with constant delay (speech, video) the bit error rate can be in the range of 10^{-3} to 10^{-7}, the maximum delay can be in the range of 20 ms to 300 ms. For non-real-time applications (e-mail, SMS) with variable delay the bit error rate can be in the range of 10^{-5} and 10^{-8}. The maximum delay can be 150 ms and more.

Fig. 4 shows the spectrum for UMTS lies between 1900 MHz to 2025 MHz and 2110 MHz to 2200 MHz. For the satellite service an own sub-band in the UMTS spectrum is reserved (up-link 1980 MHz to 2010 MHz, down-link 2170 MHz to 2200 MHz). The remaining spectrum for terrestrial use is divided between two modes of operation. In the FDD (Frequency Division Duplex) mode there are two equal bands for the up-link (1920 MHz to 1980 MHz) and for the down-link (2110 MHz to 2170 MHz). In the operation mode TDD (Time Division Duplex) up-link and down-link are not divided by use of different frequency carriers but by using different time-slots on the same carrier. So there is no need for a symmetrical spectrum but the remaining un-paired spectrum can be used.

The UTRAN provides the air interface access method for User Equipment. Base Station Controller is referred as Node-B and control equipment for Node-B's is called Radio Network Controller (RNC).

The functions of Node-B are:

- Air interface Transmission/Reception
- Modulation/Demodulation
- CDMA Physical Channel Coding
- Micro Diversity
- Error Handing
- Closed Loop Power Control

The functions of RNC are:

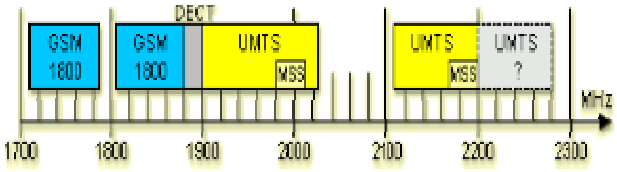
- Radio Resource Control
- Admission Control
- Channel Allocation
- Power Control Settings
- Handover Control
- Macro Diversity
- Ciphering
- Segmentation/Reassembly
- Broadcast Signaling
- Open Loop Power Control

It is necessary for a network to know the approximate location in order to be able to page user equipment. Here is the list of system areas from largest to smallest.

- UMTS systems (including satellite)
- Public Land Mobile Network (PLMN)
- MSC/VLR or SGSN
- Location Area
- Routing Area

Fig. 4. Spectrum for UMTS -

1920 MHz - 1980 MHz FDD Uplink
2110 MHz - 2170 MHz FDD Downlink
1900 MHz - 1920 MHz TDD
2010 MHz - 2025 MHz
1980 MHz - 2010 MHz MSS (Mobile Satellite Service) Uplink
2170 MHz - 2200 MHz MSS Downlink



- UTRAN Registration Area
- Cell
- Sub-Cell

The Asynchronous Transfer Mode (ATM) is defined for UMTS core transmission. ATM Adaptation Layer type 2 (AAL 2) handles circuit switched connection and packet connection protocol AAL 5 is designed for data delivery. The architecture of the Core Network may change when new services and features are introduced. Number Portability Data-base (NPDB) will be used to enable user to change the network while keeping their old phone number. Gateway Location Register (GLR) may be used to optimize the sub-scriber handling between network boundaries. MSC, VLR and SGSN can merge to become a UMTS MSC.

The UMTS standard does not restrict the functionality of the User Equipment in any way. Terminals work as an air interface counter part for Node-B and have many different types of identities. Most of these UMTS identity types are taken directly from GSM specifications.

- International Mobile Sub-scriber Identity (IMSI)
- Temporary Mobile Sub-scriber Identity (TMSI)
- Packet Temporary Mobile Sub-scriber Identity (P-TMSI)
- Temporary Logical Link Identity (TLLI)
- Mobile station ISDN (MSISDN)
- International Mobile Station Equipment Identity (IMEI)
- International Mobile Station Equipment Identity and Software Number (IMEISV).

UMTS mobile station can operate in one of three modes of operation:

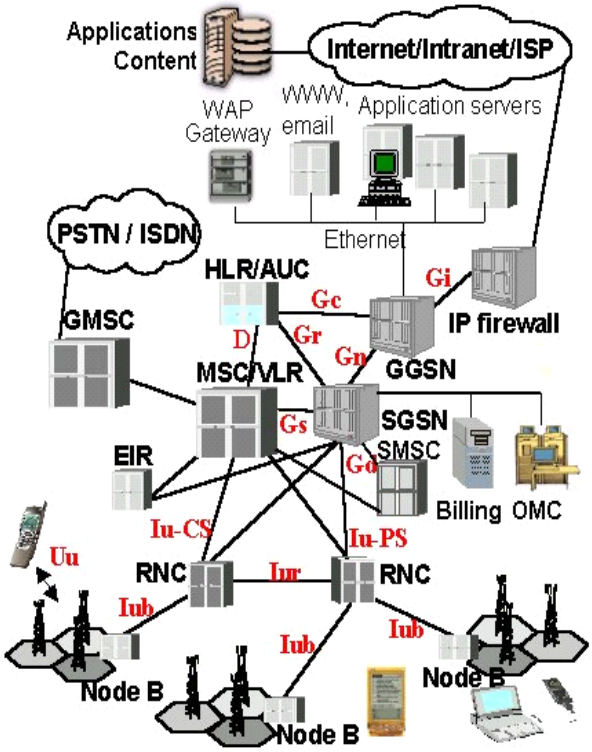
- PS/CS mode of operation: The MS is attached to both the PS domain and CS domain, and the MS is capable of simultaneously operating PS services and CS services.
- PS mode of operation: The MS is attached to the PS domain only and may only operate services of the PS domain. However, this does not prevent CS-like services to be offered over the PS domain (like VoIP).
- CS mode of operation: The MS is attached to the CS domain only and may only operate services of the CS domain. UMTS IC card has same physical characteristics as GSM SIM card. It has several functions:

- Support of one User Service Identity Module (USIM) application (optionally more that one)
- Support of one or more user profile on the USIM
- Up-date USIM specific information over the air
- Security functions
- User authentication
- Optional inclusion of payment methods
- Optional secure down-loading of new applications

RESULTS

- UMTS is one of the most significant advances in the evolution of telecommunications in to 3G networks. It allows many more applications to be introduced to a worldwide base of user and provides a vital link b/w today's multiple GSM systems and the ultimate single worldwide standard for all mobile telecommunications, International Mobile Telecommunications-2000 (IMT-2000)
- UMTS is above 2G mobile systems for its potential to support 2 M bit/s data rates from the outset. This capability, together with the inherent IP support, combines powerfully to deliver interactive multimedia services and new wide-band applications, such as video telephony and video conferencing.
- At the air interface level, UMTS itself is incompatible with GSM. UMTS/GSM dual-mode phones, hence they can also make and receive calls on regular GSM networks. If a UMTS customer travels to an area without UMTS coverage, a UMTS phone will automatically switch to GSM. If the customer travels outside of UMTS coverage during a call, the call will be transparently handed off to available GSM coverage.
- UMTS also features the additional benefits of automatic international roaming plus integral security and billing functions, allowing operators to migrate from 2G to 3G while retaining many of their existing back-office systems. Offering increased capacity and speed at lower incremental cost compares with second systems, UMTS gives operators the flexibility to introduce new multimedia services to business users and consumers while providing an enhanced user experience. This in turn provides the opportunity for operators to build on the brand-based relationships. UMTS will offer enterprise customers and consumers all the benefits of broad-band connectivity whilst on the move.
- Regular GSM phones cannot be used on the UMTS networks. All UMTS/GSM dual-mode phones should accept existing GSM SIM cards. Sometimes, you are allowed to roam on UMTS networks using GSM SIM cards from the same provider
- UMTS will also have a Virtual Home Environment (VHE). It is a concept for personal service environment portability across network boundaries and b/w terminals. Personal service environment means that users are consistently presented with the same personalized features,

Fig. 5. Shows how UMTS network could be build



user interface customization and services in whatever network or terminal, wherever the user may be located. UMTS also has improved network security and location based services.

- Satellite technology can readily provide global coverage and service and it is expected to play an important role for UMTS world-wide coverage. UMTS is being standardized to ensure an efficient and effective roaming and handover between satellite and terrestrial networks.

Problems and issues. Some of the rollout problems operators faced include:

- Over-weight handsets with poor battery life;
- For fully fledged UMTS incorporating Video on Demand features, on base station needs to be set up every 100 m. While this is economically feasible in urban areas, It is impossible in less populated suburban and rural areas;
- Competition for broad-band access from Wi-Fi;
- Lack of significant consumer demand for 3G.

CONCLUSIONS

- UMTS has been specified as an integrated solution for mobile voice and data with wide area coverage. Symmetry b/w up-link and down-link data rates when using paired (FDD) spectrum also means that UMTS is ideally suited for applications such as real-time video telephony- in contrast with other technologies such as ADSL where there is a pronounced asymmetry b/w up-link and down-link through-

put rates.

- For existing GSM operators, it is a simple but costly migration path to UMTS: most of the rest of their infrastructures may remain the same, but the cost of obtaining new spectrum licenses and overlaying UMTS at existing towers can be prohibitively expensive.
- UMTS is supposed to support real-time services including multimedia as well as packet data services. From the user point of view the main advantage of UMTS will be a broad offer of services. Speed, variety and user-friendliness of the services will be significantly improved as compared with GSM. For example the down-load of photo from the internet that take's one min in GSM with 9.6 k bit/s will last only half a second in UMTS with 2 M bit/s.
- UMTS integrates packet and circuit data transmission with the benefits of virtual connectivity to the network at all times

Alternative ways of billing (e.g. pay-per-bit, per session, flat rate, ul/dl asymmetric band-width) as demanded by many emerging data services.

REFERENCES

Aidarous, S., D.A. Prooudfoot and X.N. Dam, 1990. Service management in intelligent networks. *IEEE Network Magazine*, 4: 43–51

Aidarous, S. and T. Pleyak, 1994. *Telecommunications Network Management in to the 21st Century*. IEEE Press, New York

Canny, J.F., 1986. A Computational Approach to Edge Detaction. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 8: 679–98

Swanson, R.H., 1991. Emerging technologies for network management. *Business Communication Rev*., 53–8

Stevens, W.R., 1991. "TCP/IP Illustrated, The Protocols". Addison Wesley Longman, Inc

Skidmore, S. and B. Wore, 1992. *Introducing System Analysis*, pp. 127–45. NCC Blackwell Publications, U.K

Tranter, R.S., 1998. "TCP for High Performance in Hybrid Fiber Coaxial Broad-Band Access Networks", *IEEE/ACM Transactions on Networking*, 1

William, H.T., 2000. *Wireless Personal communication (Bluetooth & Other Technology)*: pp. 15–127. Kluwer Academic Publishers, USA

(Received 01 July 2005; Accepted 20 October 2005)