Chapter 7
UMTS: 3rd Generation Cellular Mobile Radio System

Péter Fazekas
Budapest University of Technology and Economics, Hungary

ABSTRACT
The aim of this chapter is to provide a brief yet comprehensive overview of the 3rd generation UMTS (Universal Mobile Telecommunication System) mobile network, with emphasis on its specific protocols. Therefore, in this chapter, the basic operation and protocol structure of UMTS network is described. The main architectural changes compared to GSM are shown, as well as the principles of the physical radio interface. The details of other relevant UMTS specific interfaces in the access network and their protocols are provided as well, along with the description of transport network solutions. The most relevant part of UMTS specifications, the radio interface protocols, are also presented.

INTRODUCTION
The worldwide success of the GSM network during the 90s set the base for further development of cellular mobile telephony systems. The need for supporting packet switched transmission and higher bitrate was recognized early, thus GPRS (General Packet Radio Service) and later EDGE (Enhanced Data-rates for GSM Evolution) services based on GSM networks were standardized and deployed by the end of 90’s. These allow higher bitrates than GSM, by means of allocating multiple timeslots to a single user’s transmission and applying higher order physical modulation scheme in case of EDGE. Although Internet access with GPRS/EDGE mobile devices is possible, the supported bitrates of these systems are far less than today’s requirements. The highest theoretical bitrate with...
GPRS is 160 kbps and 480 kbps with EDGE; however practically achievable useful rates are just around the third of these values. Moreover, although QoS (Quality of Service) classes and guarantees were introduced in GPRS, the allowed delay and delay jitter values are so high (and so are the practical delay values in existing systems) that real-time packet switched services cannot be used over this network.

Besides the mentioned shortcomings of GSM/GPRS/EDGE networks, the ever-increasing signal processing capability that can be integrated into a handheld terminal allowed for the definition of new radio interface that supports higher bitrates (note that the bottleneck in mobile communications is usually the radio interface, because of hardware limitations and available bandwidth). As it is known from Shannon’s law, the achievable bitrate is directly proportional to the used physical bandwidth; thus, it was inevitable to define a system that uses much wider frequency band (compared to the 200 kHz in GSM based networks) for transmission.

Although early discussions about the 3rd generation of mobile systems were already initiated in ITU (International Telecommunication Union) at the beginning of 90’s, 3G standardization speeded up in 1998, when ETSI (European Telecommunication Standardization Institute) decided that Wideband Code Division Multiple Access (WCDMA) would be the base of 3G radio interface and a new standardization body, 3GPP (3rd Generation Partnership Project) was formed with the aim of defining the global 3G standard. Currently 3GPP has 367 individual members (companies) form Europe, USA, Canada, Japan, China and the Republic of Korea.

The new 3G system was developed to fulfill initial requirements, originating from the existing deployment of cellular networks and the timely needs of mobile telecommunication services. The non-exhaustive list of requirements includes:

- interoperability with legacy GSM network, including the possibility of inter-system handover
- 3G system should inherit as much as possible from 2G systems (including existing infrastructure, equipment, protocols, etc.)
- up to 2 Mbps bitrate (indoor) for stationary customer, 144 kbps for outdoor user of pedestrian speed and 64 kbps for vehicular terminals
- definition and differentiation of different QoS classes according to typical communication services, with different delay and loss guarantees
- support of different and time-variable bitrates to different users, support of asymmetric upload and download traffic
- possibility of multiplexing different services (e.g. real-time video, voice and file transfer) over the same connection
- support of packet switched and circuit switched services, maximizing common networking functions serving both types of traffic.

According to the requirements above, the UMTS system features the following main properties, in comparison with GSM/GPRS/EDGE:

- 5 MHz wide channels instead of 200 kHz
- instead of Time Division Multiple Access (TDMA) Direct Sequence Code Division Multiple Access (DS-CDMA) based radio interface
- new radio access network to maintain the new radio interface
- shares core part of the network with GSM/GPRS
- support of four QoS classes
- DS-CDMA allows for a frequency reuse factor of 1 (the same frequency band can be used in neighboring cells)
- because of a reuse factor of 1, UMTS allows the so called “soft handover”: a ter-