3G Telecommunication Networks

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Abstract: 3G is the third generation of wireless technologies. This comes with enhancements over previous wireless technologies, as high-speed transmission, advanced multimedia access and. 3G is mostly used with mobile phones and handsets as a means to connect the phone to the Internet or other IP networks in order to make voice and video calls, download and upload data and to surf the net. 3G is the successor of 2G and 1G standards. The 3G networks handle the majority of all data transfers for cellular service providers.

Keywords: 3G, 4G, 5G, Radio Access Network, Telecommunication, Cellular Network.

I. Introduction

3G wireless technology is the convergence of various 2G wireless telecommunications systems into a single global system which includes both terrestrial and satellite components. 3G wireless technology has ability to unify existing cellular standards with CDMA, GSM, and TDMA. 3G has the following enhancements over 2.5G and previous networks: Higher data speed, Video-conferencing support, Enhanced audio and video streaming, Web and WAP browsing at higher speeds, IPTV (TV through the Internet) support transfer rate for 3G networks is between 128 and 144 kbps for devices that are moving fast and 384 kbps for slow ones. For fixed wireless LANs, the speed goes beyond 2mbps.

II. Back Ground

The first mobile telephone systems (car phone) were introduced in the late 1940s in the United States and in 1950s in Europe. Those early single cell systems were constrained by restricted mobility, limited service, low capacity, and poor speech quality. The equipments were heavy, expensive, bulky and susceptible to interference. Because of these limitations, less than one million subscribers were registered worldwide by 1980s.

A. First Generation (1G): Analog Cellular

Cellular systems are introduced in the late 1970s and early 1980s, represented a quantum leap in mobile communications system (mostly in capacity and mobility).Microprocessors and semiconductor technology made smaller, more sophisticated mobile systems and lighter weight a practical reality for many more users. 1G cellular system still transmits only analog voice information. The 1G systems are Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS). With the 1G introduction, the mobile market showed annual growth rates of 30 to 50 percent, rising to near about 20 million subscribers by 1990.

B. Second Generation (2G): Multiple Digital Systems

The development of 2G cellular system was driven by the need to improve transmission quality, coverage and system capacity. Further advances in microwave devices and semiconductor technology brought digital transmission to mobile communications. Speech transmissions are still dominates the airways, but the demands for short message, fax, and data transmissions are growing rapidly. Supplementary services as encrypting of user data and fraud prevention have become standard features which are comparable to those in fixed networks. 2G cellular systems that includes GSM, D-AMPS, CDMA and PDC.

C. 2G to 3G: GSM Evolution

Phase 1 of the standardization of GSM900 was completed by the European Telecommunications Standards Institute (ETSI) in 1990 and included all necessary definitions for the GSM network operations. Several bearer services and tele-services have been defined (include data transmission up to 9.6 kbps), but some very basic supplementary services were offered. As a result, GSM standard were enhanced in Phase 2 (1995) to incorporate a large variety of supplementary services which were comparable to digital fixed network integrated services digital network (ISDN) standards. In 1996, ETSI decided to further enhance GSM in annual Phase 2+ releases that incorporate 3G capabilities. GSM Phase 2+ releases have introduced important 3G features such as intelligent network (IN) services with customized application for mobile enhanced logic (CAMEL), enhanced full rate (EFR), enhanced speech compression/decompression (CODEC), adaptive multi-rate (AMR), high–data rate services and new transmission principles with high-speed circuit-switched

data (HSCSD), general packet radio service (GPRS), and enhanced data rates for GSM evolution (EDGE). UMTS is a 3G GSM successor standard that is downward-compatible with GSM, using the GSM Phase 2+ enhanced core networks.

III. Third Generation (3G) Wireless Networks

3G wireless networks consist of and a core network and a Radio Access Network (RAN). The core network consists of a packet-switched domain, which includes 3G GGSNs and SGSNs, which provide the same functionality as provide in a circuit-switched domain, and a GPRS system, which includes 3G MSC for Charging for services, switching of voice calls and access is done through the Charging Gateway Function (CGF), which is also part of the core network. RAN and core network functionality is different to each other. The access network provides a core network technology independent access for mobile terminals to different types of network services and core networks . Either core network domain can access any appropriate RAN service; e.g. it should be possible to access a "speech" radio access bearer from the packet switched domain.

The Radio Access Network consists of new network elements, called Node B and Radio Network Controllers (RNCs). Node B is comparable to the Base Transceiver Station in 2G wireless networks. RNC replaces the Base Station Controller. It provides handover control, the radio resource management, and support for the connections to packet-switched and circuit-switched domains. The interconnection of the network elements in RAN and between core network and RAN and is over Iub, Iur and Iu interfaces based on ATM as a layer 2 switching technology. Data services run from the terminal device over IP, which in turn uses ATM as a reliable transport with QoS. Voice is embedded into ATM from the edge of the network (Node B) and is transported over ATM out of the RNC. The Iu interface is split into 2 parts: packet-switched and circuit switched. The Iu interface is based on ATM with voice traffic embedded on virtual circuits using and IP-over-ATM and AAL2 technology for data traffic using AAL5 technology. These traffic types are switched independently to either 3G MSC for voice or 3G SGSN for data.

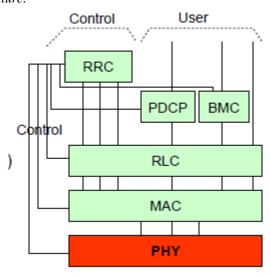*A. 3G wireless network architecture:*

Figure 1 shows the 3G wireless network architecture.

The following is a brief description of each protocol layer in a 3G wireless network architecture:

- Global Mobility Management (GMM): protocol that includes attach, security, detach and routing area update functionality.
- Node B Application Part (NBAP): provides procedures for paging distribution, broadcast system information, management of dedicated and logical resources.
- Packet Data Convergence Protocol (PDCP): PDCP provides protocol transparency for higher layer protocols. It also maps higher level characteristics onto the characteristics of the underlying radio-interface protocols..
- Radio Link Control (RLC): It provides a logical link control over the radio interface.
- Medium Access Control (MAC): This layer controls request and grant access signaling procedures for the radio channel.
- Radio resource Control (RRC): RRC layer main functions are connection establishment and release, Radio bearer establishment/reconfiguration and release, Broadcast of system information, RRC connection mobility procedures, Outer loop power control, Paging notification and release.
- Radio Access Network Application Protocol (RANAP): This protocol encapsulates higher layer signaling. Manages GTP connections and the signaling between RNC and 3G-SGSN, It also manage signaling and circuit-switched connections between 3G MSC and RNC.
- Radio Network Service Application Part (RNSAP): This protocol is used for providing communication between RNCs.

- GPRS Tunnel Protocol (GTP): GTP operates on top of TCP/UDP over IP.It tunnels the protocol data units through the IP backbone by adding routing information.
- Mobile Application Part (MAP): supports signaling between HLR/AuC/EIR and SGSN/GGSN.
- AAL2 Signaling (Q.2630.1, Q.2150.1, Q.2150.2, AAL2 CPS and AAL2 SSSAR): protocols suite used to transfer voice over ATM backbone using AAL2.

B. Architecture difference between 2G and 3G: Second generation GSM networks consist of BTS, BSC, HLR/AuC/EIR and MSC/VLR network elements. The interfaces between BTS, BSC and MSC/VLR elements are circuit-switched PCM. GPRS technology adds a parallel packet-switched core network. The 2G+ network consists of BSC with packet interfaces to GGSN, SGSN,HLR/AuC/EIR. The interfaces between SGSN network and BSC elements are either Frame Relay or ATM for providing reliable transport with Quality of Service (QoS).

3G wireless technology introduces new Radio Access Network (RAN) which consist Node B and RNC network elements. The 3G Core Network consists same entities as GPRS and GSM: 3G MSC/VLR, GMSC, HLR/AuC/EIR, 3G-SGSN, and GGSN. ATM technology is used to provide reliable transport with QoS and IP technology is used end-to-end for multimedia applications. The BSC can be evolved into an RNC by using add-on cards or additional hardware that is co-located. The carrier frequency (5Mhz) and frequency bands (2.5 to 5Ghz) are different for 3G wireless technology and 2G/2G+ wireless technology. Evolution of BSC to RNC requires support for new protocols such as RRC,PDCP, RANAP, RNSAP and NBAP.BTS evolution into Node B may prove to be difficult and may represent significant capital expenditure on the part of network operators.

IV. Future Scope

4G The Fourth Generation is available in many major metropolitan areas in the U.S., as companies continue to expand its service area. The 4G includes multiple technologies that are WiMAX and LTE. 4G LTE technology will have an average speed of download approximately 5 to 12 Mbps, according to Verizon Wireless. A download made using 4G WiMAX technology speed average will be between 3 and 6 Mbps. This is a significant upgrade over 3G networks; allow increased performance when multitasking, playing games or streaming video.

5G The fifth generation of mobile communication technology or 5G is in a developmental stage. Important characteristic of the new technology will be the ability of mobile devices to simultaneously send and receive information from cell towers, That things are not possible with older networks. There is no defined standard for 5G download speeds till date of publication.[1]

Additional Information

The International Telecommunications Union (ITU) is a special agency governed by the United Nations that determines global standards for mobile networks and the devices that connect to them. This allows anyone using a mobile device marketed to support a specific network to have a realistic expectation of the speed and connectivity of the device. Mobile networks, like 3G, 4G and 5G are primarily used by cellphones, broadband modems and tablets. Wireless technology is backward-compatible, as 4G devices will use 3G networks to transfer data, if 4G is unavailable.

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