EVOLUTION OF MOBILE CELLULAR NETWORKS

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1 Introduction

Mobile networks have been evolving over the decades and each evolution brings a significant improvement to the cellular technology. The cellular networks are known by generation number: 1G, 2G ,3G, 4G. This paper reviews the evolution of mobile networks and the factors behind the development of different generations. First, a brief overlook of mobile network architecture of each generation is presented followed by their limitations and features.

2 First-generation System (Analogue System)

First generation of mobile networks also known as 1G was all analog system. Different first-generation systems were developed by different countries. Nordic countries introduced their first-generation mobile system called NMTs (Nordic Mobile Telephones) while UK welcomed the use of Total Access Communication System (TACS) and japan launched its own 1G mobile network [1]. Advance Mobile Phone System (AMPS) was also another first-generation system adopted in the US. This caused the incompatibility of different mobile systems due to different frequencies being used. they offered mainly speech services and FDMA (Frequency Division Multiple Access) was their basic technology which assigns each channel to only one user to communicate with the base station hence, the network couldn't handle many subscribers at the same time.

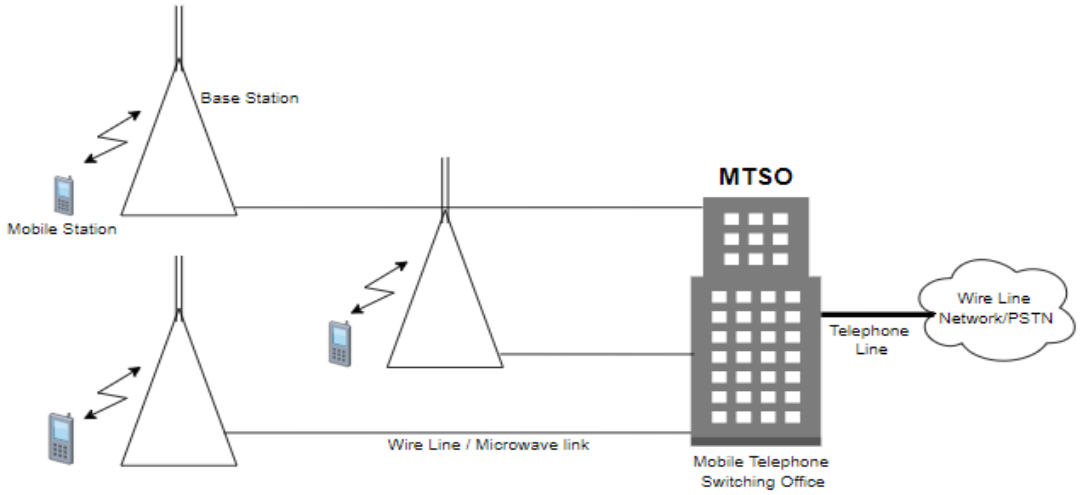

Figure 1: First generation AMPS network architecture

The architecture of 1G networks was relatively basic. The mobile stations transmit and receive signals from base stations through radio link, each base station serves only for one cell. Then the base station relays the signals to MTSO via land line or microwave link. MTSO's function is to connect between mobile stations by switching the signals to their destination path.

2.1 Limitations of 1G Sytems

- Analog system, no support for encoding and susceptible to air interference
- Inefficient use of frequency bands
- Incompatibility between different systems, no roaming
- Data rate of 2kbps and a bandwidth of 30KHz, poor speech quality

3 Second-generation System (Digital System)

The limitations and the problems of first-generation necessitated the development of a 2G mobile networks such as GSM and D-AMPS. GSM (Global System for Mobile Communication) was developed in Europe and become widely available around the world. However, in North America D-AMPS (Digital Advance Mobile Phone Services) which evolved from AMPS become the standard.

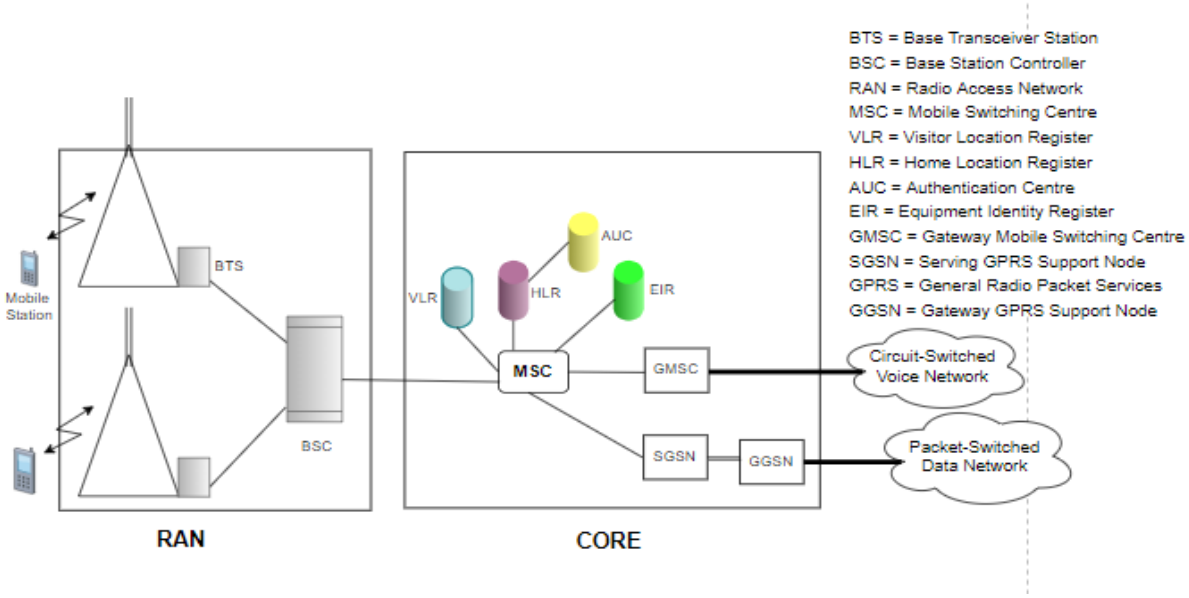

Figure 2: Second generation GSM network architecture

TDMA (time division multiple access) technology that allows many users to use the same channel as each frequency is divided into small time slots was implemented in 2G systems [2]. This enables the networks to support more voice and data traffic. The GSM underwent a lot of improvements over the years from 2G, 2.5G to 2.7G with features such as GPRS and EDGE. 2G offered 9.6kbps while GPRS and EDGE achieved a data rate of up to 170kbps and 380kbps respectively.

The GSM network consists of RAN and CORE. The BTS station comprises the antenna mounted on top of a tower, and relays transmitted and received signals to the radio equipment housed on the ground (BTS). The MSC is the repository of the database and control functions required to set up calls and establishes connections with the Mobile Users. It operates using data stored in the VLR, HLR, AUC and EIR. GMSC is typically used to provide a connection to other network services providers. Both the CORE and RAN is monitored by Network Operation Centre (NOC).

3.1 Limitations of GSM

- Different 2G networks design standards.
- Roaming to different countries was much improved but not globally.
- Unable to support complex data such as videos and online gaming

3.2 Features of GSM

- Digital transmission, encryption of traffic
- TDMA technology, supports more users than FDMA
- Voice Mail System, Short Message Service and intelligent services
- Higher data rates and bandwidth 300kbps and 25MHz respectively.
- Basic mobile internet with GPRS, email, web browsing etc.

4 Third-generation Networks (UMTS)

The third generation fulfill the globalization of mobile networks. The specification of its standards and protocols was developed by 3GPP2 association with the aim to make a global 3G mobile phone system. The UMTS promises a higher data rates supporting video calling, streaming contents and better voice quality. It utilized WCDMA (Wideband Code-Division Multiple Access) [3]. The main components are base stations or Node B, RNC (Radio Network Controller), SGSN and MSC.

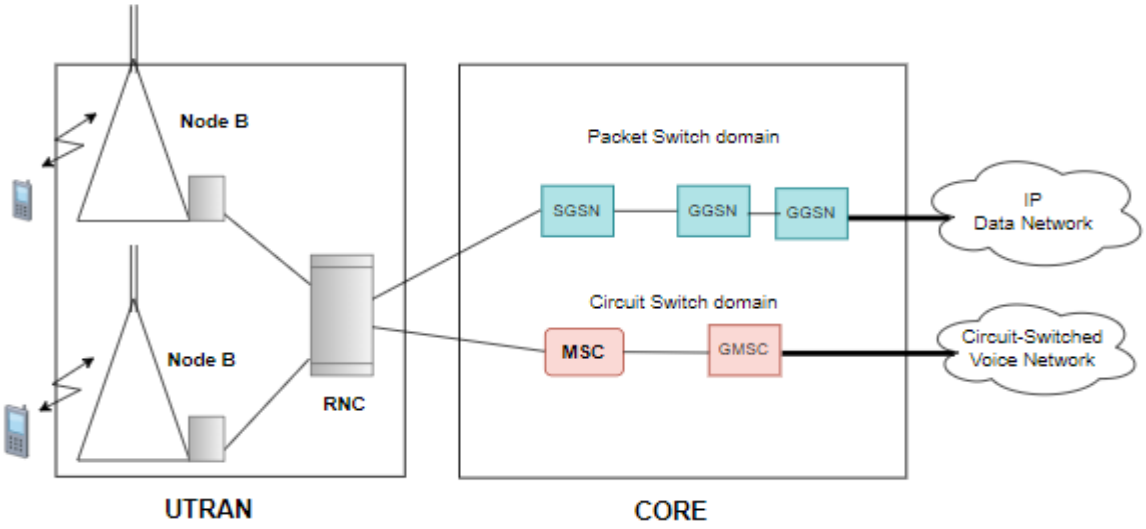

Figure 3: Third generation network architecture

The overall functioning of 3G network resembles the GSM network. Several base stations are managed by RNC which is responsible for the Handover decisions. The core network provides all the central processing management for the system. Packet switch domain handles packet data traffic by routing according to their destination.

4.1 Features of 3G

- Data rates and bandwidth of up to 2Mbps and 100MHz respectively.
- Digital broadband, increased speed.
- New radio spectrum to relieve overcrowding in existing systems.
- Security and reliability.

5 Fourth-generation Networks (LTE)

Initial goal of cellular communication was mobility and global connectivity, but as the technology evolved services started expanding not only restricted to voice and SMS only. The main aim of fourth-generation (Long Term Evolution) was to increase the speed and capacity while reducing latency of mobile networks. The mobile networks architecture become simple while moving towards ALL-IP system. MIMO (Multiple Input Multiple Output) antenna is a technique used in 4G to enable improved signal range, reduced bit errors, lower power consumption, reduced interference [4]. The transmission scheme of 4G is OFDMA (Orthogonal Frequency Division Multiple Access) it uses multiple carriers to support higher bit rates per user.

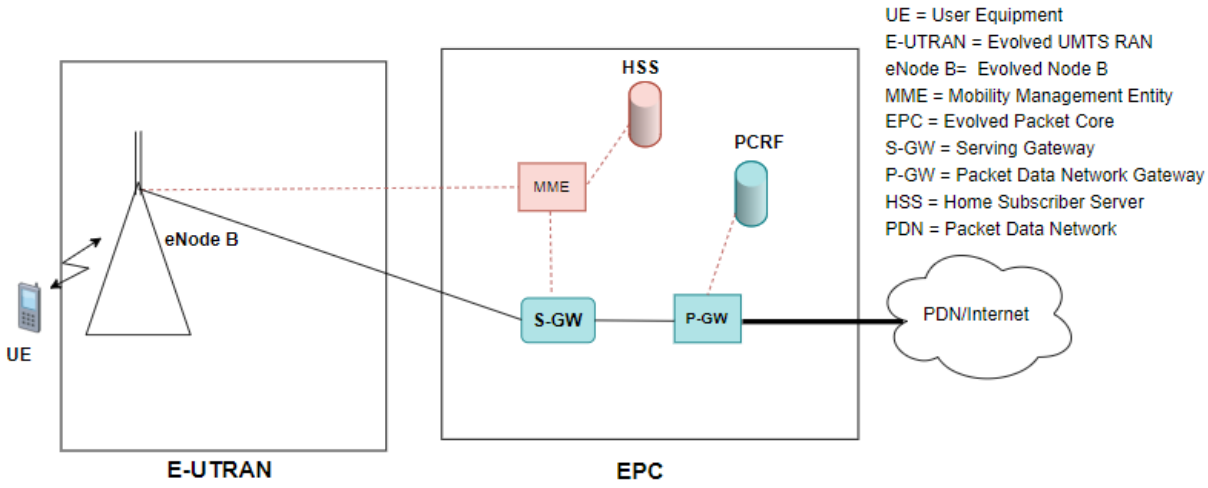

Figure 4: Fourth generation network architecture

eNode B manages the air interference by looking after dynamic scheduling, handover etc. Moving to the packet core, Serving Gateway is the anchor between EPC and E-UTRAN. Its function is routing and forwarding user data packets. P-GW is the connectivity between EPC and Packet Data Network. The main control node in LTE network is the MME which provides mobility sessions managements such as subscriber authentication, user tracking, roaming etc. HSS is a substitute to HLR and stores subscriber information.

5.1 Features of LTE

- Reduced delays and latency, higher bandwidth,
- Increased user data throughput.
- Simplified network architecture.
- Seamless mobility between different radio access technology.
- Easy roaming between different network operators.

Conclusion

This review paper presents the evolution of cellular mobile networks from 1G, 2G, 3G and 4G networks and their network architectures. The driving factors of this evolutions included the need for global standard mobile networks, efficient use of scarce frequency spectrum, ever increasing mobile users and mobile data broadband. As technology evolve so does the need of user expectations, this led the introduction of advanced mobile networks.

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