

Enhancement of 3G, 4G networks

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Abstract

The enhancement is required in every field. Day by day our world is getting modernized. We need to adapt new technology to survive in the world of competitors. So people try to introduce the new technology and outdate the previous one. Similarly in the case of networks we make enhanced versions of networks. 4G is faster than 3G network with less buffering, better audio quality, streaming services with reduced lag and improved gaming experience. The evolution of 5G networks will make our lives even more easier. 5G technology will work on sustainability, efficiency. It will be using space-saving approach. It will also help in minimising the energy requirements of web device and network infrastructure.

Keywords- 5G,CDMA,TDM,SMS.

1. Introduction

The third generation of mobile telecommunications technology is 3G. An information transfer rate of at least 200 kbit/s is provided by the services which are supported by 3G network. 3G Systems give us with mobile broadband access to smartphones, mobile modems. In early 1980s, the International Telecommunication Union (ITU) carried out the research & development work which resulted in the 3G technology. It took around fifteen years to develop the specifications & standards of 3G networks. IMT-2000 is the name given to the technical specifications of 3G. Then the allocation of communication spectrum between 400 MHz to 3 GHz for 3G was done. 3G standard was then approved by both the government & communications companies. In 1998, NTT DoCoMo in Japan launched the first pre-commercial 3G network, branded as FOMA. It was made available as a pre-release (test) of W-CDMA technology in May 2001. Again the efforts were made by NTT DoCoMo in launching the first pre-commercial 3G network on October 1, 2001. The UMTS was the first European pre-commercial network on the Isle of Man by Manx Telecom. Then in December 2001, the first commercial network was opened in Europe for business

Telenor. In January 2002, the first network CDMA-based 1xEV-Do technology went commercially live by SK Telecom in South Korea. The second South Korea 3G network was by KT on EV-Do in May 2002. It shows that the competition among 3G operators was first seen by South Koreans. Then, Monet Mobile network gave the first commercial United States 3G network on CDMA 2000 1xEV-Do technology. In February 2002, m.Net Corporation built the first pre-commercial demonstration network in the Southern Hemisphere in Adelaide , South Australia using UMTS on 2100 MHz . In July 2002, came the second 3G network operator in the USA , Verizon Wireless on CDMA2000 1xEV-Do.

The fourth generation of mobile telecommunication technology standards is 4G. It is basically a successor of third generation (3G) standards. The 4G system was visualized by the Defense Advanced Research Projects Agency (DARPA). The DARPA considered that every mobile device would be both a transceiver & a router for other devices in the network in peer-to-peer networking. This would eliminate the spoke-and-hub weakness of 2G & 3G systems. 4G systems provide mobile ultra-broadband Internet access, example, to smartphones & other mobile devices. A packet-switched network is provided in 4G systems instead of the circuit-switched infrastructure. It signifies that traditional voice calls are displaced by IP telephony in 4G. Technologies of 4G includes following key features:

- 1.1. Physical layer transmission techniques
 - 1.1.1.1. MIMO(multi-antenna and multi-user)
 - 1.1.1.2. Frequency-domain-equalization
 - 1.1.1.3. Frequency-domain statistical multiplexing
 - 1.1.1.4. Turbo principle error-correcting codes
- 1.2 Channel-dependent scheduling
- 1.3 Link adaption
- 1.4 Mobile IP utilized for mobility
- 1.5 IP femtocells

After the 3G and 4G networks, the next phase of mobile telecommunications standards may be the 5th generation mobile networks (5G). We can also say it as 5th generation wireless systems as termed in some research papers and projects. A new generation of 5G standards may be introduced approximately in the early 2020s. According to the researches till now, 5G networks may have the following objectives:

- Higher number of supported devices
- Lower battery consumption
- Lower outage probability (better coverage)
- Higher number of simultaneously connected devices
- Lower latencies
- Lower infrastructure deployment costs
- Higher versatility and scalability
- Higher system spectral efficiency
- High bit rates in larger portions of the coverage area

Federico Boccardiat Alcatel-Lucent's Bell Lab & a number of pals gave some interesting speculation. Their main focus was on the technologies that will have an unruly impact on the upcoming generation of communication. According to them, a possibility could arise that 5G networks will be dependent on different frequency bands which carry information at different rates and also, they have different propagation characteristics. So, there would be a rapid change in network according to a device's data demand. In addition to the currently used microwave transmission, there will be an involvement of another technology using millimetre wave transmissions. Since the microwave real estate comes at a huge premium, we have only 600MHz of it. So naturally, the longer wavelengths and higher frequencies of millimetre wave transmissions will come in way, which would be ranging from 3 to 300GHz. This process would not be wholly smooth. The propagation characteristics of these frequencies is the main problem because of the three main factors that block the signal:

1. Buildings
2. Heavy weather
3. People themselves as they move between the device and the transmitter.

By using advanced transmission technologies like directional antennas will help to cope up with these problems. The next would be the multiple input-multiple output (MIMO) technology. In this, multiple antennas would be there to pick up and transmit several signals at once which will improve the efficiency. The final unruly technology identified by these people is the device's ability to communicate with each other without using the network. Like there might be ten thousand devices in a sensor network to transmit temperature data. It will become easier if instead of sending through a single base station, they send it from one device to another.

In the design of 5G cellular networks these fundamental challenges will be reached with the help of new research directions.

2. Comparison

Now is the right time to start considering the evolution potential of 3G systems when the first commercial 3G services based on 3GPP specifications have been launched around the world. It is believed that content consumption related services will be the cause of the major traffic cause in the future mobile networks, which are realized with IP technologies. Thus, it is necessary to optimize the cellular networks for carrying IP traffic as efficiently as possible.

To understand the current architecture, it is necessary to have some historical background on 3GPP system. Because 3GPP network is a network of GSM network architecture, we need to start from 2G networks. To create a mobile telephony network that would provide equivalent services to ISDN was the main objective of the GSM network. The currently important short messaging service (SMS) was more like a side product of mobile telephony. Time-division multiplex (TDM)- based

transmission technology was predominant in fixed networks when GSM was designed. Thus, it was a natural choice to build GSM network architecture on top of TDM-based transmission.

2.1 The Current Trajectory

At this time, the mobile industry is still busily deploying 3G networks based on WCDMA or CDMA2000 technologies in different parts of the world. In particular the evolution based on High Speed Packet Access (HSPA) and CDMA2000 Evolution Data Optimized (EV-DO) promised to deliver high data rates up to a peak rate in the region in excess of 10 Mbps (in the downlink). Mobile operators around the world are generally committed to follow the main 3G evolution path and upgrade their 3G deployments, as equipment becomes available from infrastructure suppliers and handset vendors. In addition there are also network operators committed to deploy a new breed of technology based on the IEEE 802.16 family of standards. This technology is based on OFDMA and is probably the most advanced wireless technology for commercial use at present. New radio licenses for this technology are generally allocated at the 2.3 GHz band and above. Many of the successful "valued added services", such as ring-tone download or ring-back tone, are in fact based on the simple short message service (SMS). Some markets see some success in the use of 3G for DSL substitution. However, much of these are barely profitable for the operators, due to the flat rate pricing. So given the relatively slow uptake of 3G services, we may wonder why we need to develop a "beyond 3G" system so soon.

2.2 Evolution of the Sub-systems

When IP-based transport networks have become commonplace in fixed networks and have proven to provide robust solutions, it has become clear that benefits of the IP based networking technologies should also be utilized in cellular networks. Due to inherent any to any connectivity between hosts, IP networks enable more distributed functional architectures and more versatile network topologies than what is practical in TDM or ATM-based networks. In the following, we discuss how the strengths of IP-based transport can be leveraged in 3G networks.

2.2.1 RAN Evolution:

A new Radio Access Network architecture has been proposed to address the issues discussed above; RNC functionality of the conventional RAN architecture is distributed into smaller pieces.

2.2.2 CS CN Evolution

The coupling of the user and control plane handling within the CS CN have already been addressed in 3GPP Release. The MSC (and GMSC) functionality is divided into two network elements: MSC server and MGW. The former takes care of all the control plane functionality within the CS CN and terminates the control plane protocols of the Iu_cs interface. The latter handles user plane processing and switching, which includes termination of user plane protocols of the Iu_cs interface, speech codec processing, and switching between the circuits.

2.3 END Game

In the history of mobile technology evolution, standardization frequently focused on a subset of the functional aspects of a system needed to ensure interoperability across various network interfaces. The wide participation of the industry enabled fair review and deep scrutiny of technology solutions but also led to significant delay in product delivery, extensive compromise in design, support of numerous redundant options and many missed opportunities for interoperability. Against these considerations, the target architecture of the next generation mobile network should best be based around a homogeneous packet-switched core network, together with the support of a set of new but spectrally efficient radio access techniques, based on some form of evolved OFDMA technology. This architecture is intended to provide a smooth migration of existing 3G networks towards a fully IP (Internet Protocol) based network that is both cost efficient and has sufficient "broadband" access performance.

Third Generation (3G) wireless systems have been deployed on a broad scale all over the world. An evolution of the radio access technology has also been taken by the 3rd Generation Partnership Project (3GPP) through the introduction of High Speed Downlink Packet Access (HSDPA) and Enhanced Uplink (HSUPA). Even if these technologies provides 3GPP with a competitive radio access technology they do not take benefits from the potential gain of MIMO with high number of antennas or the inter-cell interference reduction techniques. On the other hand, users and operators requirements and expectations are continuously evolving and competing radio access technologies are emerging. Thus, researches on the Fourth Generation (4G) systems and beyond start considering the next steps in the mobile evolution, in order to ensure the communication requirements in the mid-term future. In 2011 the first version of the LTE-Advanced system, the evolution of LTE (Long Term Evolution), has been finished in the release 10 and proposes new features that aim to enhance the capacity and the spectral efficiency of LTE:

2.3.1 Carrier Aggregation: This feature permits the use of larger bandwidth and spectrum usage flexibility. It enables the operators to extend the operational bandwidth of LTE up to 100 MHz to meet the recommendations of International Mobile Telecommunications IMT-Advanced systems. The carrier aggregation could be also used for load balancing when one carrier is highly loaded. The standard allows inter-carrier and intra-carrier aggregations.

2.3.2 MIMO Enhancements: In LTE release 8, the maximum number of antennas at the base station and the user equipment is 4 and 2 respectively. In the LTE-Advanced, the number is increased to allow the use of 8x8 MIMO schemes in the downlink and 4x4 MIMO schemes in the uplink. Moreover, the LTE-Advanced and its futures releases will support the Multi-user MIMO schemes that lead to a capacity increase thanks to the resource reuse in space. This feature is expected to have a high impact on the system feedback, user scheduling, power control.

2.3.3 Enhanced inter-cell interference coordination(e-ICIC): With the use of heterogeneous networks (containing macro, pico and femto cells), the system capacity is expected to be increased. Indeed, femto and pico cells will focus on serving the indoor users or the high loaded public zones. However, users in the cell edge of these cells will highly suffer from interference from the other type neighboring cells. In release 10, some schemes for coordination based on the use of some specific resources (ABS subframes) to schedule cell edge users has been proposed. Moreover, the interference between the control channels of different cells could be reduced.

2.3.4 Coordinated Multipoint Transmission and Reception(cOMP): One way to reduce the inter-cell interference is to form a cluster of neighboring cells that are able to cooperate together in order to coordinate their transmission or reception. The CoMP techniques are based on a quick information exchange over the X2 interface between the different coordinated cells. Indeed, signal processing based techniques for coordination need updated knowledge of the transmission channel to be efficient. In general, there are two strategies for cooperation: Coordinated scheduling: It is based on scheduling users to serve in a way that minimizes the inter-cell interference. This can be also reached by using transmission beams that avoid collision. In this strategy, only one point transmits to the terminal.

- **Joint processing** : It is based on joint transmission from several points to serve one user. It requires a joint computation of the transmission pre-coding that minimizes the inter-cell interference. This strategy requires a high information exchange load over X2 interface.

In this article we discuss in detail the features, and the design and implementation challenges of FDD and TDD systems for 4G wireless systems. Frequency-division duplexing and time division duplexing are two common duplexing methods used in various wireless systems. However, there are advantages and technical issues associated with them.

1. The Frequency-Division Duplexing System FDD systems allocate different frequency bands for uplink (UL) and downlink (DL) transmissions. More users can be allocated into the spectrum by clustering their UL and DL channels on different bands. The frequency offset, WO, used to separate the pair of channels should be large enough for the user terminal to avoid self-interference among the links because both links are simultaneously active. In addition, a UL channel and a DL channel (which may belong to different users) have to be separated by no less than WG, the width of the guard band, for the base station (BS) to avoid self-interference. Generally, the minimum band separation between UL and DL can be smaller at the BS than at the mobile station (MS), because the BS has a more expensive but sharper RF filter.
2. The Time-Division Duplexing System In contrast to the FDD system, a TDD system does not require paired frequency channels or the guard band, as

illustrated in Fig. 1b. The UL and DL transmissions operate in the same band but alternate in the time domain. Hence, the spectrum can be allocated more flexibly. Figure 2 illustrates the typical structure of a frame, which consists of one UL subframe and one DL subframe, both of which contain a number of time slots that may be adapted according to the time-varying traffic asymmetry. There are guard intervals at downlink-to- uplink (DL-to-UL) and uplink-to-downlink (UL-to-DL) transitions, and they are known as transmit/receive transition gap (TTG) and receive/transmit transition gap (RTG), respectively. Both TTG and RTG should be large enough for the hardware at the terminal to switch to transmission and reception modes as well as to account for the propagation delay between the mobiles and the BS. For synchronous systems, the TTG is generally larger since UL transmissions of the users nearby the BS have to be postponed until the signals from users at the cell edge propagate back. This delay is proportional to the round-trip delay and hence the cell radius. On the other hand, RTG normally does not require such additional delay and is hence shorter.

The TDD system brings a number of advantages and flexibilities important to future-generation systems that the FDD system cannot offer. However, the TDD system also introduces many technical challenges. In the following, we shall first present the advantages of employing the TDD system, followed by its potential challenges in design and implementation.

3. Conclusions

The evolution of 3G and 4G networks made our lives more comfortable. The enhanced 5G network would bring more changes in the world of networks. It will arrive with new features and objectives most probably in the 2020s.

4. References

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