# Challenges in the implementation of Fourth Generation Wireless Systems

Gaurang Naik[1] ,Vignesh Aigal[2] ,Pulkit Sehgal[3],Jitesh Poojary[4]
Final Year, Electronics & Telecommunication Engineering, University of Mumbai

## Abstract

**The low cost and effectiveness of the second and third generation wireless communication systems prompted the development of 4G System. 4G refers to fourth generation wireless communication system and is a successor to 3G and 2G standards. In spite of its several advantages over the earlier standards, 4G has yet to conquer the world of wireless communications. In this paper, several key challenges faced in the global implementation of 4G System have been discussed briefly and possible solutions have been proposed.**

## 1. INTRODUCTION

Every second day, a new mobile device gets introduced in the market. The devices have become smaller and lighter day by day. Larger screens, high screen resolutions, HD Video Recordings, longer battery life etc. has been introduced in these new devices. Features like live video streaming, tele-video-conferencing, and Voice over Internet Protocol (VoIP) are no longer a distant reality today.

Second Generation Systems (2G) were extremely successful in the previous decade, providing wide range of services at relatively low cost and high efficiency. Then came the third generation of wireless system (3G). Mobile devices were then used for much more than mere telephony. Features like live video streaming and tele-video-conferencing turned from imagination to reality. However, the human hunger for speed and more features never ends. The outcome of this hunger was the Fourth Generation of wireless Communication Systems.

Some key features of 4G networks are stated as follows:

- High usability: anytime, anywhere, and with any technology
- Support for multimedia services at low transmission cost
- Personalization
- Integrated services

4G networks are designed to be heterogeneous networks, which allow users having integrated devices (e.g. Software Defined Radio) to access connectivity anywhere and everywhere.

Substantially large amount of capital has been invested in the development and maintenance of the existing 2G and 3G Systems. It would be economically unfeasible to replace these systems entirely by a new system. 4G Systems are, therefore, designed to interoperate with 2G and 3G Systems.

The essence of 4G Systems lies in the fact that the user can access any wireless network regardless of where he is. In order to ensure automatic, efficient, smooth and successful switching between different wireless networks, it is necessary to create a common protocol to access these networks. The main objectives of 4G Technology are as follows:

- A spectrally efficient system.
- High network capacity, i.e. more users per cell.
- A minimum data rate of 100Mbps when moving, and 1Gbps when stationary.
- Smooth vertical handoff over heterogeneous wireless networks.
- Interoperability with the existing wireless systems.
- High QoS for bandwidth hungry multimedia services.

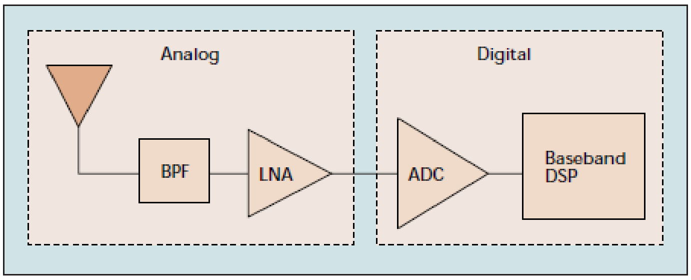
## 2. CHALLENGES

The first successful field trial for 4G was conducted in Tokyo, Japan on June 23$^{rd}$, 2005. NTT DoCoMo was successful in achieving 1Gbps real time packet transmission in the downlink at a moving speed of about 20kmph. Several such attempts have been made in the past by several companies in different parts of the world. However, a successful model of 4G that can be implemented on a global scale is still missing.

Multimode User Terminals, Wireless System Discovery, Wireless System Selection, Terminal Mobility, Network Infrastructure and QoS Support, Security and Privacy, Fault Tolerance and Survivability, Multiple Operators and Billing System, Personal Mobility are the basic key challenges in turning to 4G.

### 1. Multimode User Terminal

In order to use the large variety of services and wireless networks in 4G systems, multimode user terminals are essential as they can adapt to different wireless networks by reconfiguring themselves. This eliminates the need to use multiple terminals (or multiple hardware components in a terminal). The most promising way of implementing multimode user terminals is to adopt the software radio approach.



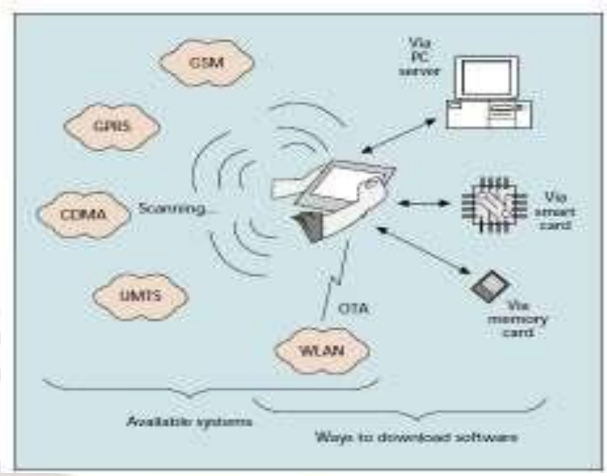

The analog part of the receiver consists of an antenna, a band pass filter (BPF), and a low noise amplifier (LNA). The received analog signal is digitize by the analog/digital converter (ADC) immediately after the analog processing. The processing in the next stage (usually still analog processing in conventional terminals) is then performed by a reprogrammable baseband digital signal processor (DSP). The DSP will process the digitized signal in accordance with the wireless environment. Unfortunately, the current software radio technology is not completely feasible for all the different wireless networks due to the following technological problems.

## II. Wireless System Discovery

To use 4G services, multimode user terminals should be able to select the target wireless systems. In current GSM systems, base stations periodically broadcast signalling messages for service subscription to mobile stations. However, this process becomes complicated in 4G heterogeneous systems because of the differences in wireless technologies and access protocols. One of the proposed solutions is to use software radio devices that can scan the available networks.

## III. Wireless System Selection

With the support of 4G user terminals, we can choose any available wireless network for each particular communication session. As every network has unique features, using a suitable network for a specific service may optimize system performance and resource usage. Furthermore, the right network selection can ensure the QoS required by each session. However, it is complicated to select a suitable network for each communication session since network availability changes from time to time. Moreover, adequate knowledge of each network is required before a selection is made. This includes precise understanding of the supported service types, system data rates, QoS requirements, communication costs, and user preferences. A multimode terminal attaches to the WLAN and scans the available systems.



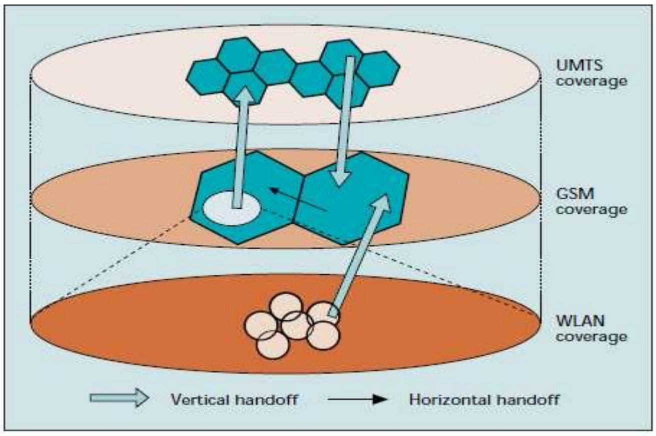

## IV. Terminal Mobility

In order to provide wireless services at anytime and anywhere, terminal mobility is a must in 4G infrastructure. Terminal mobility allows mobile clients to roam across geographic boundaries of wireless networks. There are two main issues in terminal mobility: location management and handoff management. With location management, the system tracks and locates a mobile terminal for possible connection. Location management involves handling all the information about the roaming terminals, such as original and current located cells, authentication information, and QoS capabilities. On the other hand, handoff management maintains ongoing communications when the terminal roams. Mobile IPv6 (MIPv6) is a standardized IP-based mobility protocol for IPv6 wireless systems. In this design, each terminal has an IPv6 home address. Whenever the terminal moves outside the local network, the home address becomes invalid, and the terminal obtains a new IPv6 address (called a care-of address) in the visited network. A binding between the terminal's home address and care-of address is updated to its home agent in order to support continuous communications. However, this handoff process causes an increase in system load, high handover latency, and packet losses. Although some enhanced Mobile IPv6 (MIPv6) schemes have been proposed to solve these problems, more needs to be done to satisfactorily overcome these problems.

## V. Network Infrastructure & QoS

Existing wireless systems can be classified into two types: non-IP-based and IP-based. Many non-IP-based systems are highly optimized for voice delivery (e.g., GSM, cdma2000, and UMTS). On the other hand, IP-based systems are usually optimized for data services (e.g., 802.11 WLAN and HiperLAN). In 4G wireless environments, the problem in integrating these two systems becomes apparent. Research challenges such as QoS guarantee for end-to-end services need to be addressed, although they are by no means easy to tackle, especially when time-sensitive or multimedia applications are considered. Current QoS designs are usually made with a particular wireless system in mind. For example, the 3G Partnership Project (3GPP) has proposed a comprehensive QoS architecture for UMTS. It realizes QoS in UMTS via the UMTS Bearer Service and its underlying bearer services There are clear definitions of characteristics and functionalities of each bearer service on a specific layer. These enable the provision of a contracted QoS in all aspects, including control signalling, radio interface transport, and QoS management functionality.

Vertical handoff and horizontal handoff of a mobile terminal.




## VI. Security & Privacy

The security challenge with IP networks is one of the most significant factors that slows down the further adoption of network technologies. Operators and enterprises recognize the clear productivity improvements and cost savings of converging their communication technologies on a single infrastructure and enabling universal connectivity for users.
However, they are hesitant to adopt technologies that may compromise their privacy, put their business at risk and potentially cause significant financial loss.
An end-to-end system approach to security is required in next-generation wireless networks, including:

- Platform hardening
- User/operator authentication, authorization and auditing
- Secure protocols, communication and data storage
- Software and configuration integrity
- Secure network management, control and signalling
- End-point compliance
- Network perimeter protection and interior protection
- Unsolicited traffic protection

## VII. Personal Mobility

In addition to terminal mobility, personal mobility is a concern in mobility management. Personal mobility concentrates on the movement of users instead of users' terminals, and involves the provision of personal communications and personalized operating environments. when there is a video message addressed to the mobile user, no matter where the user is located or what kind of terminal is being used, the message will be sent to the user correctly. A personalized operating environment, on the other hand, is a service that enables adaptable service presentations (in order to fit the capabilities of the terminals in use regardless of network types). Currently, there are several frameworks on personal mobility found in the literature. Mobile-agent-based infrastructure is one widely studied solution In this infrastructure, each user is usually assigned a unique identifier and served by some personal mobile agents (or specialized computer programs running on some servers). These agents act as intermediaries between the user and the Internet. A user also belongs to a home network that has servers with the updated user profile (including the current location of the user's agents, user's preferences, and currently used device descriptions). When the user moves from his/her home network to a visiting network, his/her agents will migrate to the new network.

## 3. CONCLUSION

The main objective of this paper is to review the various reasons why 4G has not been implemented on a large scale across the globe in spite of its popularity and the hype created around it. Though implementation of such a revolutionizing technology seems difficult, it is not impossible.

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