King Fahd University of Petroleum and Minerals

Electrical Engineering Department

EE400
Communication Networks

Project Report (Group5)

G4 Technology

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Table of Contents

List of Figure

Introduction

The mobile communication generations has traversed a long way through different phases of evolution since its beginning early in the 1970s. The steady global boom in the number of mobile users each year has improved the development of more and more technologies. Today various different generation technologies with their individual pros and cons are existing globally. The approaching 4G (fourth generation) mobile communication systems are projected to solve still-remaining problems of 3G (third generation) systems and to provide a wide variety of new services, from high-quality voice to high-definition video to high-data-rate wireless channels. The term 4G is used to include several types of broadband wireless access communication systems, not only cellular telephone systems. One of the terms used to describe 4G is available to use Mobile multimedia, anytime anywhere, Global mobility support, integrated wireless solution, and customized personal service. As a guarantee for the future, 4G systems that are cellular broadband wireless access systems have been attracting much interest in the mobile communication arena. The 4G systems not only will support the next generation of mobile service, but also will support the fixed wireless networks.

This report aims to focus upon the features expected to be provided in 4G systems and potential challenges, in order to give an in-depth view of the next-generation communication systems.

1.1 Reasons to Have 4G

It is being designed to allow communication between wireless devices across many different wireless standards. Fourth generation wireless will make it possible to seamlessly integrate many different standards, as well as integrate broadband communication wirelessly. 4G systems are expected to provide the communications for the following reasons:

- **Support interactive multimedia services: teleconferencing, wireless Internet, etc**

  4G systems will provide not only telecommunications services, but also data and multimedia services.

- **Wider bandwidths, higher bit rates.**
- **Global mobility and service portability.**

  It is available for use anytime and anywhere. These capabilities are also important for future mobile communications. When a new system is first introduced, it is generally difficult to provide such an extensive service area as the existing system

- **Low cost.**

  Users can exchange various kinds of information, it is necessary to lower charges dramatically to keep the cost at or below that of existing services.

- **Scalability of mobile networks**

1.2 Why not 3G!!!

3G still leaves some unsolved problems that it does not concern or concerns only partly. The limitations and difficulties of 3G include:

- The 3G never lived up to the promises.
- Instead of one standard worldwide, there are three incompatible systems in USA alone.
- Few 3G services.
- The data rates in 3G are very close to those available in 2G systems.

1.3 Evolution from 3G to 4G

	3G (including 2.5G)	**4G**
Speeds	384 Kbps to 2 Mbps	20 to 100 Mbps in mobile mode
Frequency Band	Dependent on country or continent (1800-2400 MHz)	Higher frequency bands (2-8 GHz)
Bandwidth	5-20 MHz	100 MHz (or more)
Switching Design Basis	Circuit and Packet	All digital with packetized voice
Access Technologies	W-CDMA, 1xRTT, Edge	OFDM and MC-CDMA (Multi Carrier CDMA)
IP	A number of air link protocols, including IP 5.0	All IP (IP6.0)

From: www.mobileinfo.com

2- 4G Systems Features

2.1 High usability: anytime, anywhere, and with any technology

Systems are expected to fulfill the anytime, anywhere, any technology requirement. In order to meet this challenge, 4G networks are expected to be heterogeneous and all-IP-based; which allow users to carrying an integrated terminal can use a wide range of applications provided by multiple wireless networks.

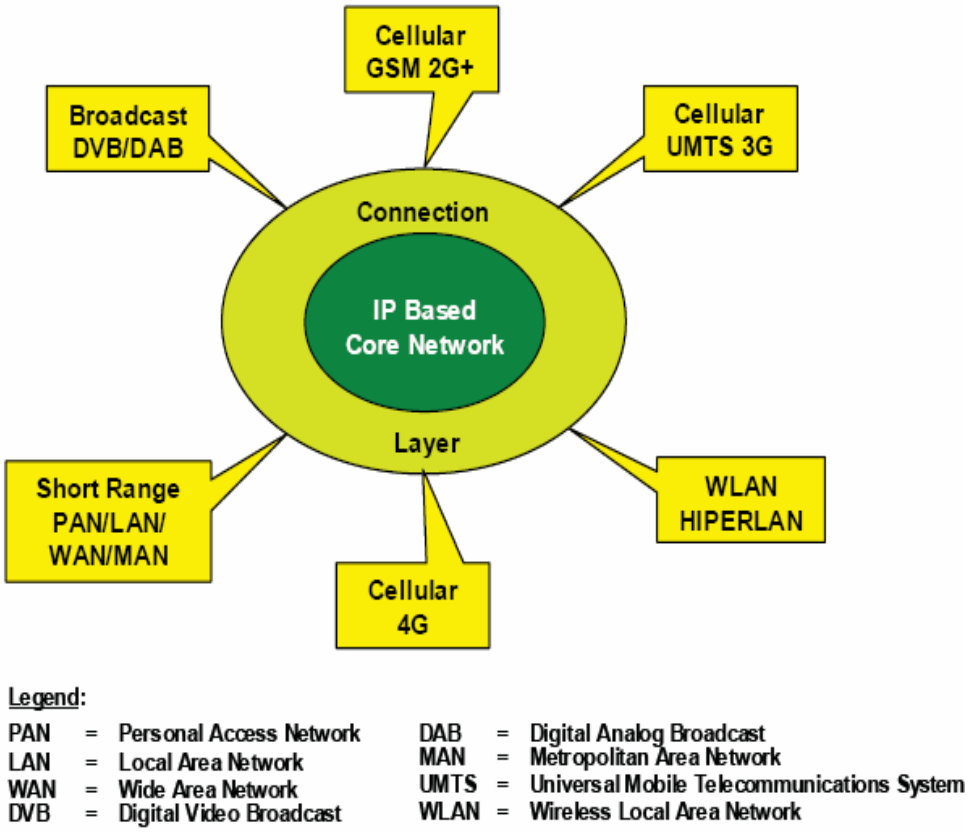

Figure1: Seamless Connections of Networks

2.2 Support for multimedia services at low transmission cost

4G systems will provide not only telecommunications services, but also data and multimedia services; thus, peak speeds of more than 100 Mbps in stationary mode with an average of 20 Mbps when traveling are expected. Also users are able to support fast speed and large volume data transmission at a lower cost than today at the same time.

2.3 Service personalization

In order to overcome the saturated mobile communications market, operators will seek new 4G users in widely different locations, occupations, and economic classes. In order to meet the demands of these diverse users, service providers should design personal and highly customized services for them.

2.4 Integrated services

Users can use multiple services from any service provider at the same time. For example, imagine a 4G mobile user who is looking for information shown in nearby shop. His mobile can simultaneously use

- Global Position System (GPS) (for tracking his current location)
- A wireless LAN (for receiving information in the nearby shop)
- CDMA (for making a telephone call)
- And so on…

In this example, the user is actually using multiple wireless services that differ in quality of service (QoS) levels, security policies, device setting, charging methods, and applications.

3- Research Challenges

To migrate current systems to 4G with the features mentioned previously, researchers are facing a number of challenges. It is convenient to discuss the challenges (and their proposed solutions) by grouping them into three different aspects: mobile station, system, and service. Each of these aspects leads to several important research areas. These challenges are grouped into the following different aspects:

- Mobile Station:
    1. Multimode User Terminal
    2. Wireless System Discovery
    3. Wireless System Selection
- System:
    1. Terminal Mobility
    2. Security and Privacy
- Services:
    1. Multiple Operators and Billing System
    2. Personal Mobility

3.1- 4G Systems Challenges in Mobile Station:

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 [1]. Figure 1 shows the design of an ideal software radio. The analog part of the receiver consists of an antenna, a bandpass filter (BPF), and a low noise amplifier (LNA). The received analog signal is digitized 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.

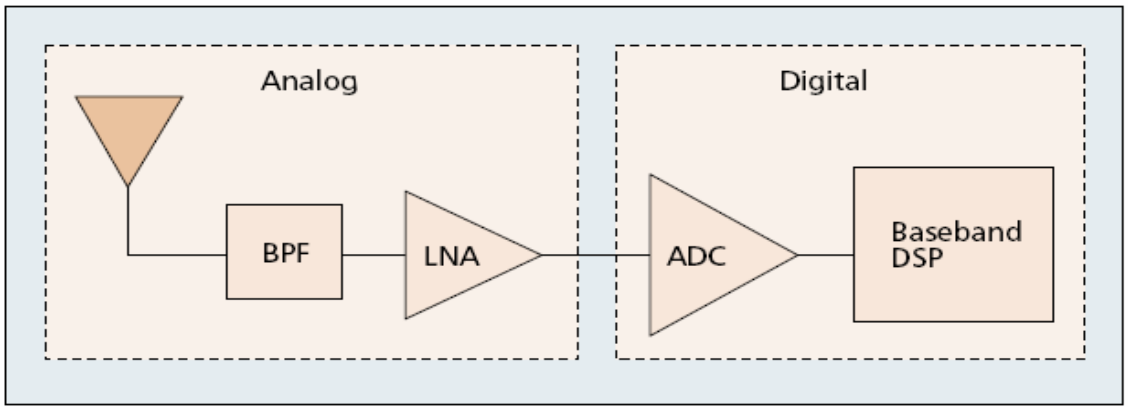

Figure2: An ideal software radio receiver.

2) Wireless System Discovery:

The multimode user terminals should be able to select the target wireless system in order to use the variety of 4G services. In current GSM systems, base stations periodically broadcast signaling 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. After scanning, they will load the required software and reconfigure themselves for the selected network. There are a number of ways to facilitate the downloading of software modules. For example, the download can be done via PC server, memory card, and smart card or over the air (OTA). Figure 3 shows an example of how a multimode terminal attached to a WLAN is scanning the available wireless networks. Once the terminal discovers the available system, it can download the suitable software to reconfigure the software radio. As shown, the software can be downloaded from media such as a PC server, smart card, or memory card, or over the air (OTA). Each downloading method has its own advantages and disadvantages with respect to speed, accuracy, resource usage, and convenience.

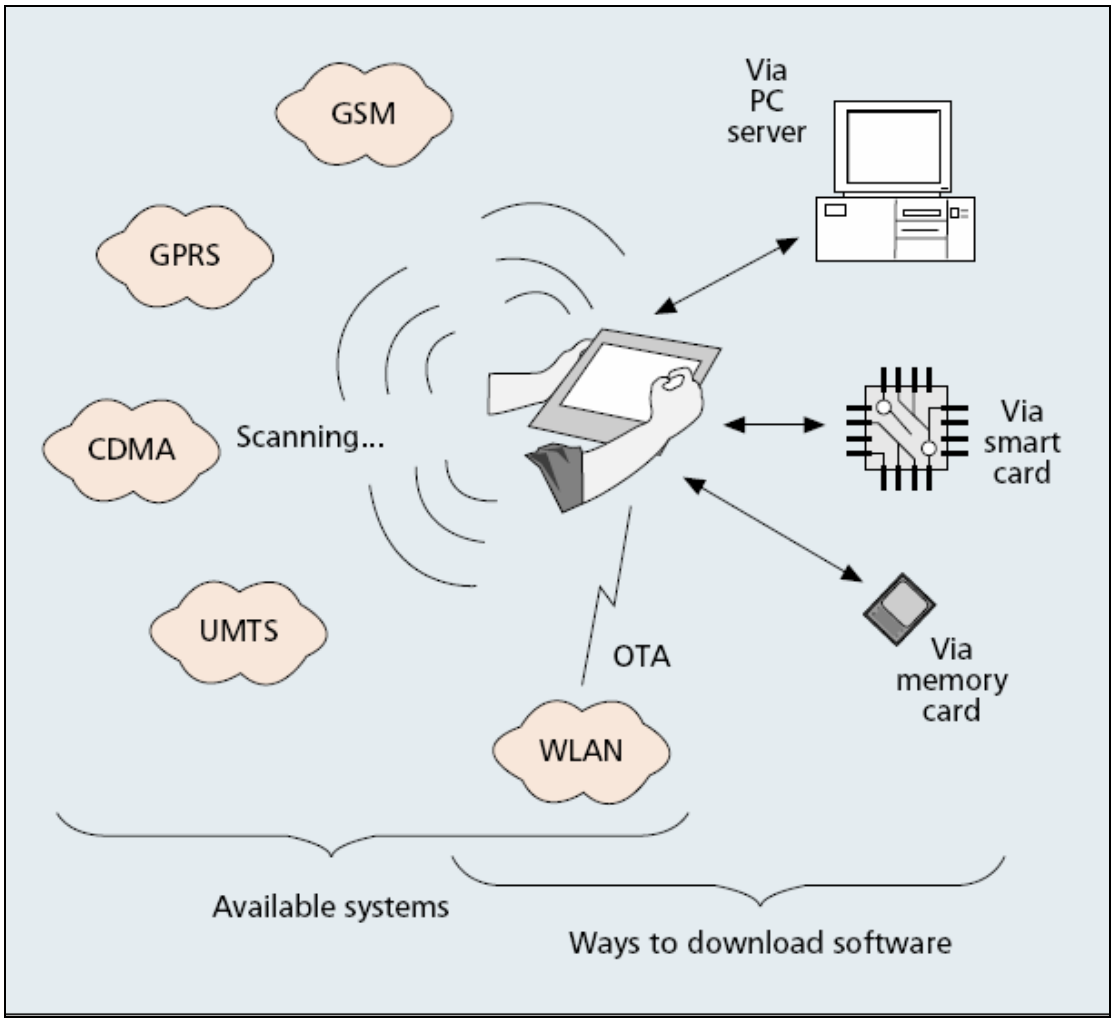

Figure 3: *A multimode terminal attaches to the WLAN and scans the available systems.*

3) 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.

3.2- 4G Challenges in the System:

1) 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.

2) Security and Privacy

Security requirements of 2G and 3G networks have been widely studied in the literature. Different standards implement their security for their unique security requirements. For example, GSM provides highly secured voice communications among users. However, the existing security schemes for wireless systems are inadequate for 4G networks. The key concern in security designs for 4G networks is flexibility. As the existing security schemes are mainly designed for specific services, such as voice service, they may not be applicable to 4G environments that will consist of many heterogeneous systems. Moreover, the key sizes and encryption and decryption algorithms of existing schemes are also fixed. They become inflexible when applied to different technologies and devices (with varied capabilities, processing powers, and security needs). To design flexible security systems, some researchers are starting to consider reconfigurable security mechanisms. As an example, Tiny SESAME is a lightweight reconfigurable security mechanism that provides security services for multimedia or IP-based applications in 4G networks.

3.3- 4G Challenges in the Services:

1) Multiple Operators and Billing System

In today's mobile market, an operator usually charges customers with a simple billing and accounting scheme. A flat rate based on subscribed services, call durations, and transferred data volume is usually enough in many situations. However, with the increase of service varieties in 4G systems, more comprehensive billing and accounting systems are needed. Customers may no longer belong to only one operator, but instead subscribe to many services from a number of service providers at the same time. It may be very inconvenient for a customer to deal with multiple service providers. Instead, a brokering service can be provided. Customers do not have to waste time handling all the financial transactions involved. To achieve this, operators need to design new business architecture, accounting processes, and accounting data maintenance. Moreover, equalization on different charging schemes is also needed. This is because different billing schemes may be used for different types of services (e.g., charging can be based on data, time, or information). It is challenging to formulate one single billing method that covers all the billing schemes involved. Furthermore, 4G networks support multimedia communications, which consists of different media components with possibly different charging units. This adds difficulty to the task of designing a good charging scheme for all customers .besides; the media components may have different QoS requirements. It is very complicated to decide a good tariff for all the possible components. In order to build a structural billing system for 4G networks, several frameworks have already been studied. The requirements on these frameworks include scalability, flexibility, stability, accuracy, and usability.

2) 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. Figure: 4 demonstrate the concept of personal communications using a personalized video message application. 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. 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 agents will migrate to the new network.

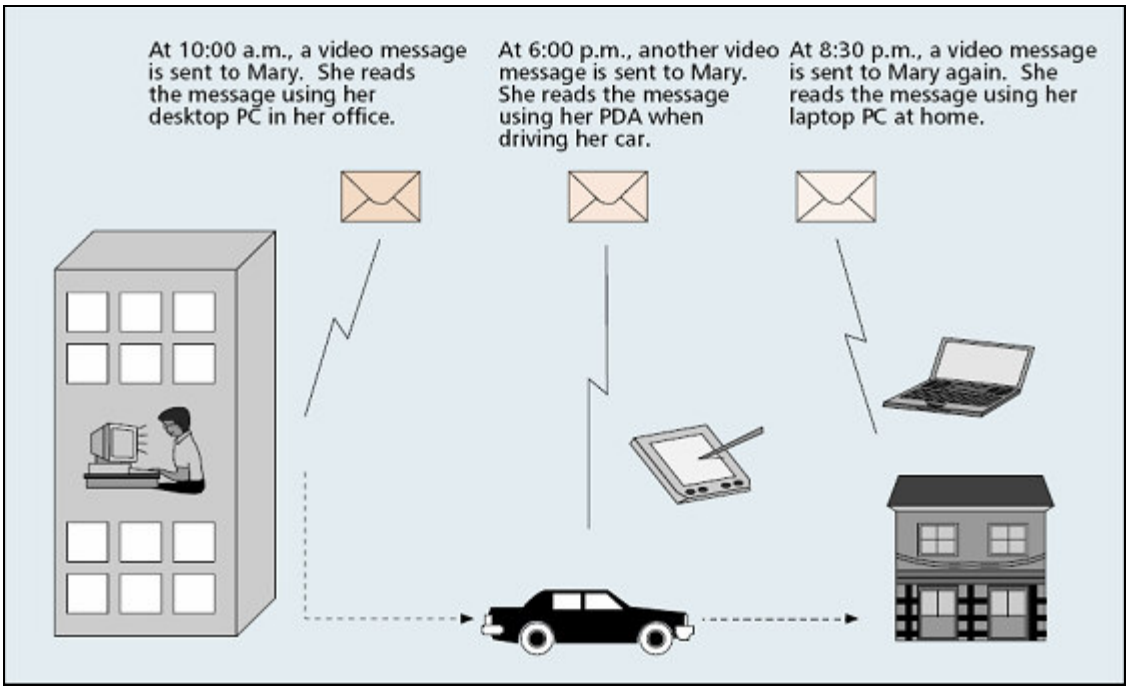

Figure: 4 an example of personal mobility

	Key challenges	Proposed solutions
Mobile station		
Multimode user terminals	To design a single user terminal that can operate in different wireless networks, and overcome the design problems such as limitations in device size, cost, power consumption, and backward compatibilities to systems.	A software radio approach can be used: the user terminal adapts itself to the wireless interfaces of the networks [1].
Wireless system discovery	To discover available wireless systems by processing the signals sent from different wireless systems (with different access protocols and incompatible with each other).	User- or system-initiated discoveries, with automatic download of software modules for different wireless systems [2].
Wireless system selection	Every wireless system has its unique characteristic and role. The proliferation of wireless technologies complicates the selection of the most suitable technology for a particular service at a particular time and place.	The wireless system can be selected according to the best possible fit of user QoS requirements, available network resources, or user preferences [3, 4].
System		
Terminal mobility	To locate and update the locations of the terminals in various systems. Also, to perform horizontal and vertical handoff as required with minimum handover latency and packet loss.	Signaling schemes and fast handoff mechanisms are proposed in [5].
Network infrastructure and QoS support	To integrate the existing non-IP-based and IP-based systems, and to provide QoS guarantee for end-to-end services that involves different systems.	A clear and comprehensive QoS scheme for UMTS system has been proposed [6]. This scheme also supports interworking with other common QoS technologies.
Security	The heterogeneity of wireless networks complicates the security issue. Dynamic reconfigurable, adaptive, and lightweight security mechanisms should be developed.	Modifications in existing security schemes may be applicable to heterogeneous systems. Security handoff support for application sessions is also proposed [4].
Fault tolerance and survivability	To minimize the failures and their potential impacts in any level of tree-like topology in wireless networks.	Fault-tolerant architectures for heterogeneous networks and failure recovery protocols are proposed in [7].
Service		
Multi-operators and billing system	To collect, manage, and store the customers' accounting information from multiple service providers. Also, to bill the customers with simple but detailed information.	Various billing and accounting frameworks are proposed in [8, 9].
Personal mobility	To provide seamless personal mobility to users without modifying the existing servers in heterogeneous systems.	Personal mobility frameworks are proposed. Most of them use mobile agents, but some do not [10, 11].

Table 1. *A summary of key challenges and their proposed solutions.*

CONCLUSION

The key concept behind 4G systems is integrating their capacities with all of the existing mobile technologies through advanced technologies. The challenges facing this system are grouped into three aspects: mobile station, system, and services. The discussion on these challenges not only shows that there is much work to be done in the migration to 4G systems, but also highlights that current systems must be implemented with a view to facilitate a seamless integration into 4G infrastructure. Without these infrastructures, 4G services will not be launched easily. Future wireless networks will need to support diverse IP multimedia applications to allow sharing of resources among multiple users. There must be a low complexity of implementation and an efficient means of negotiation between the end users and the wireless infrastructure.

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