Challenges and Proposed Solutions in the Migration to 4G Mobile

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ABSTRACT
Convergence of mobile communications, computing and Internet is on the way. This provides the driving force towards development of 4G technology. 4G mobile systems have the potential to provide flash high data rates over a wide area and roaming facility. 3G merely focus on developing new standard and hardware whereas 4G systems will support comprehensive and personalized services, providing stable system performance and quality of service (Qos). However, such technologies don't come without their challenge. In this paper these challenges are discussed as well as the proposed solutions to the research problems aspect have been presented.

Introduction
Mobility is one of the most compelling features in communication these days, having an enormous impact on computing. A lot of research on mobility in next generation network systems is being done, which promises or emerging omnipresent and ubiquitous communications. The standards for Fourth Generation (4G) networks systems are evolving. These networks systems require new level of mobility support as compared to traditional 2G systems such as GSM, IS-95, and cdma One were designed to carry speech and low-bit-rate success prompted the development of third-generation (3G) mobile systems. They were designed higher data-rate services. During the evolution from 2G to 3G, a range of wireless systems, including TMT-2000, Bluetooth, WLAN, and Hiper LAN, have been developed. All these systems we independently, targeting different service types, data rates, and users. In Figure 1 the shift is shown: while 2G was focused on full coverage for cellular systems offering only one technology, 3G provides its services only in dedicated areas and introduces the concept of vertical handover.

Figure 1. Evolution from 2G to 4G
Coupling with wireless local area network (WLAN) systems, 4G will be a convergence platform all the network layers. Researchers are trying to establish 4G systems that integrate existing and newly developed wireless and also developing frameworks for 4G networks. Different research programs, such as M MIRAI, QOS and Do Como, have their own visions on 4G features and implementations. The next generation (4G) is the futuristic approach and is envisioned as a convergence of different wireless access technologies providing the user with the best...
anywhere, anytime connection and better resource utilization.

**Personalization**

This new-generation network will provide personalized service. In order to meet the demands of diverse users, service providers should design personal and customized services.

**Integrated services**

4G systems also provide facilities for integrated services. Users can use multiple services from any service provider at the same time.

**Terminal Heterogeneity and Network Heterogeneity**

In order to be a step ahead of 3G, 4G just not only provide higher data rates but also a clear and tangible advantage in people's everyday life. Thus the success of 4G will consist of a combination of terminal heterogeneity and network heterogeneity. Terminal heterogeneity refers to the different types of terminals in terms of display size, energy consumption, portability, weight, complexity etc. Network heterogeneity is related to the increasing heterogeneity of wireless networks due to the proliferation in the number of access technologies available (e.g., WiMAX, Wi-Fi, and Bluetooth). These heterogeneous wireless access networks typically differ in terms of coverage, data rate, latency, and loss rate. Therefore, each of them is practically designed to support a different set of specific services and devices. 4G will encompass various types of terminals, which may have to provide common services independently of their capabilities.

**Challenges in Integrating Heterogeneous Systems**

It is convenient to discuss the challenges (and their proposed solutions) by grouping them into three different aspects namely Mobile station, System and Service. In this section each of the key research areas are explained.

**Mobile Station**

**Multimode User Terminals**

In order to use the large variety of services and wireless networks in 4G systems, multimode user terminals are essentials as they can adapt to different wireless networks by reconfiguring themselves. This eliminates the need to use multiple terminals. The most promising way of implementing multimode user terminals is to adopt the software radio approach. Figure 2 shows the design of an ideal software radio. 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 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 base band digital signal processor (DSP).

![Figure 2. An ideal Software Radio Receiver](image)
filtering, spreading and, dispersing, parallel DSPs have to be used. This also creates problems such as high circuit complexity and high power consumption and dissipation.

**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 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 reconfigure themselves for the selected network. Once the terminal discovers the available systems, it can download the suitable software to reconfigure the software radio. As 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. OTA downloading approach in which multimode user terminals constantly monitor a predefined broadcasting channel (global pilot and download channel, GPDCH) to check for available networks. Once they detect a new available network, they can decide whether or not a change should be made.

**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 a unique feature, using a suitable network for a specific service may optimize system performance and resource usage. 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 type, system data rates, QoS requirements, communication costs, and user preferences. Proposed selection scheme in which Session Initiation Protocol (SIP) messages, location information of the source mobile node, available networks of both mobile nodes, and user preferences are all taken into account in the form selection when a mobile node makes a call to another mobile node. Other researchers also suggest that network resources and minimum QoS requirements should be considered in network selection. Despite these research efforts, we believe that there are many issues to be resolved in selecting the appropriate wireless systems.

**Systems**

**Terminal Mobility**

In order to provide wireless services at any time 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
- 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 located and current located cells, authentication information, and QoS capabilities. 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.

![Figure3. Vertical handoff and Horizontal handoff of a mobile terminal](image)

However, this handoff process causes an increase in system load, high handover latency, and packet losses. It is difficult to solve these problems in 4G networks. The reason is that besides horizontal handoff, vertical handoff is also needed. Figure 3 shows an example of horizon handoff. Horizontal handoff is performed when the terminal moves from one cell to another, within the same wireless system.
Vertical handoff, however, handles the terminal movement between two different systems (e.g., from WLAN to GSM).

**Network Infrastructure and QoS Support**

Existing wireless systems can be classified into two types: namely 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 order to provide noiseless services for the streaming, the required bandwidth for the applications is fully supported in this system. In 4G and 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 because the lack of service bandwidth usually increases AV packet delays as well as packet loss rates. The bandwidth can be the most important QoS parameter among QoS parameters, 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. 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 signaling, radio interface transport, and QoS management functionality. Additionally, in order to support various services, the UMTS specification has defined QoS classes and their attributes for dealing with differentiated QoS requirements. However, providing QoS only in UMTS cannot guarantee end-to-end QoS because systems that are non-UMTS are involved. To address this problem, internetworking with most common QoS architectures is used now.

**Architecture of the QoS Negotiable Service Framework**

Since the home networks primarily uses Ethernet as a backbone network to interconnect legacy home network devices, delivering QoS for the multimedia home services is one of the key issues in home IP networks. We propose a QoS negotiable service framework (QNSF) to provide end-to-end QoS guaranteed services as well as priority based QoS services for the AV streams connected through subscriber networks.

![Figure 4. An Overview of the QNSF](Image)
the IP packet’s TOS field. Finally, the traffic cache module monitors the QoS guaranteed service traffics and regularly gathers its service status information. If abnormal service status occurs, the QoS manager deletes the abnormal service from QoS guaranteed service lists.

**QoS Provisioning Service in Home Networks**

We present functional interoperations among the QNSF component blocks and QoS negotiation flows in Figure 5. To provide QoS guaranteed services in the multi-room home networks, QoS client devices such as DTV devices and wireless PDAs require the capabilities of QoS negotiations using QoS client API modules.

![Figure 5 Interoperations among function blocks and QoS negotiation flows](image)

**A. QoS Negotiation Messages**

When QoS clients requests resource reservation to the QoS Manager, they exchange QoS negotiation messages until the negotiation completes. When a QoS client requests resource reservation, a negotiation message basically includes traffic identification information and required resources. The QNSF classifies the traffics with destination IP address, destination service port number, and protocols. Selectively, QoS negotiation messages contain the service profile information, such as service name, codec, and etc.

**B. QoS Negotiation Flows**

When application session setup begins, our QNSF negotiates a QoS service level for multimedia applications through QoS client APIs. When a QoS client requests service’s resource reservation to the QoS Proxy, the QoS manager checks whether the requested resource is available. If the resource is available, the QoS manager inserts application information on the QoS management tables and updates the resource usage of reserved paths, as well as replies to a QoS client that the request is approved. If the resource is not available for the request, the QoS manager informs a QoS client that the request is denied. If application services want to renegotiate QoS parameters, a QoS client module can perform any number of QoS negotiations before the service starts. If the QoS guaranteed service finished, a QoS client informs the QoS manager that the current QoS guaranteed service is ended. Then the QoS manager deletes the service information from a QoS management table and releases reserved resources.

**C. QoS Guaranteed Services and Best Effort Services**

The QNSF provides two QoS service categories: QoS guaranteed services and priority based best effort services. Initially, the QNSF decides the maximum guaranteed service bandwidths and the remaining portion of total link capacity assigns as the best effort service bandwidths. Normally, a QoS guaranteed service reserves required resources by QoS negotiations until the service finishes. In case of priority based best effort services, the QNSF provides its service priority based on the DSCP values of best effort service packets. The QNSF supports three kinds of best effort services which are high, medium, and low priority service. Class marker maps its service class with referencing the DSCP value of packets. We use a commercial Ethernet switch to provide the rate controls for QoS based traffics.

**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 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.
Fault Tolerance and Survivability

In the past, extensive work has been done to provide fault tolerance in wired networks and high speed data networks (e.g., public switched telephone networks and asynchronous transfer mode networks); These attempts have improved the reliability, availability, and survivability of the networks under study. A cellular wireless network is typically designed as a tree-like topology that has several levels, including device, cell, switch, and network levels. One major weakness of this topology is that when any level fails, all levels below will be affected. The situation becomes worse when multiple tree topology networks work together in 4G security systems. Their fault-tolerant designs should consider power consumption, user mobility, QoS management, security, system capacity, and link error rates of many different wireless networks. To simplify the survivability design, proposes three classes of strategies to improve network survivability in different layers namely prevention, network design and capacity allocation, traffic management and restoration. But the work is not for 4G networks, so it remains to be seen whether these strategies are applicable to 4G situations. There are two ways to achieve fault-tolerant architectures to support QoS in failures. The first is to use a hierarchical cellular network system. The second is to use collocated or overlapping heterogeneous wireless networks.

Services

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). Furthermore, 4G networks support multimedia communications, which consists of different media components with possibly different charging units. In order to build Structural billing systems for 4G networks, several frameworks have already been studied. The requirements on these frameworks include scalability, flexibility, stability, accuracy, and usability.

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.

Conclusion

In this paper research challenges in the migration to 4G networks are analyzed and their solution are discussed. The challenges are grouped into three aspects namely mobile station, system, and Multimode user terminals, wireless system discovery, terminal mobility, QoS support, security, failure and survivability are the main issues that we have addressed. Signaling schemes, fast handoff mechanism fault tolerant architectures for heterogeneous networks, failure recovery protocols, efficient billing and accounting systems are needed in 4G networks. The current systems must be implemented with a view to facilitate a Seamless integration into 4G infrastructure. There are many issues involved in seamless mobility within a heterogeneous environment, which are yet to be dealt with, the most critical are

1. security
2. End-to-End re-configurability,
3. QOS

FUTURE SCOPE

Further issues like mobile multimedia, handoff delay, adaptability and scalability and most importantly providing connectivity at vehicular speeds will play an important role in the design of efficient mobility Architecture.

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