Challenges in mobile multimedia: technologies and QoS requirements

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Abstract:- This paper seeks to provide challenges in mobile multimedia communication together with engineering perspective. It is known that advent of powerful hand-held devices and the desire for communication on the move are driving forces behind an engineering mobile technology. Quality of service (QoS) including the corresponding infrastructure presents the framework toward next-generation wireless networks. The goal is to analyze network mobility issues ad requirements in the context toward the fourth generation (4G) networks. In the first part of this article, we deal with key drivers in mobile multimedia including technologies overview. The second part gives quality of service requirements and challenges including the network infrastructure.

Key-words: mobile multimedia, technology, QoS, wireless network

1 Introduction

Over the last years, there has been a rapid growth of wireless communication technologies. Voice communication over wireless lines using cellular phones has matured and become a significant feature of over daily life. Alongside, portable computing devices have emerged. Electronic mail, short message service (SMS), and calendar/diary programs are being provided to mobile or roaming users. Observing this trend, it can be safely predicted that the next generation of traffic in high-speed networks will be mostly generated by personal multimedia applications including video-on-demand, news-on-demand, WWW browsing, games, travel information systems, etc. For multimedia traffic (voice, video, data) to be supported successfully it is necessary to provide quality of service (QoS) guarantees between the end-systems. Moreover, mobility beings a new dimension to problem solving in this domain, resulting in unpredictable resource requirements and mobility in the network [1].

Advances in wireless communication technology specifically the development of the IEEE 802.11 protocol family and the rapid deployment and growth of GSM networks have enabled a broadband spectrum of novel and breaking solutions for new applications and services. More and more people and companies are demanding fee mobile access to multimedia services. Mobile multimedia is the next application in mobile communications after the success of GSM and SMS. It enables the industry to create products and services to better meet the consumer needs. However, an innovation in itself does not guarantee success. It is necessary to be able to fulfill customer needs rather than wait for a demand pattern to surface [2].

To date, most of the development in the area of QoS support have occurred in the content of individual architecture components. Much less progress has been made in addressing the issue of an overall QoS architecture for multimedia communications. However, considerable progress has been made in the separate areas of distributed systems platforms, operating systems, transport systems and multimedia networking support for quality of service. In end systems, most of the progress has been made in areas of scheduling, flow synchronization and transport support [3]. Many current network architectures address QoS from a provider’s point of view and analyze network performance failing to address comprehensively the quality needs of applications. Research in mobile multimedia is typically focused on bridging the gap between the high resource demands of multimedia applications and the limited bandwidth and capabilities offered by state-of-the art networking technologies and mobile devices [4].

Starting from the key drivers in mobile multimedia, technologies overview, will be given. Than we will present mobile multimedia services characteristics. The classification of the services will be analyzed, too. The second part will provide quality of service requirements and challenges in the area of mobile multimedia.

2 Key drivers in mobile multimedia

Mobile multimedia is defined as a set of protocols and standards for multimedia information exchange over wireless networks. It enables information systems to process and transmit multimedia data to provide the end user with services from various information retrieval and context based services. Multimedia allows the user to enhance understanding of the provided combined information presented by more than one media type (text, pictures, graphics, sounds, animations, videos).

Mobility as on of the key drivers of mobile multimedia can be decomposed into user mobility, device mobility and service mobility. The user mobility is forced to move from one location to location during fulfilling his activities. The access to information and computing resources is necessary regardless the actual position. User activities require a device to fulfill the needs regardless of the location in a mobile environment (notebooks, cell-phones, personal digital assistant PDA,…). The service itself is mobile and can be used in different systems and more seamlessly among the systems (e.g., mobile agents).

The key feature of mobile multimedia is around the idea of reaching customers and partners regardless of their location and delivering multimedia content to the right place at the right time. Key drivers of this technology are technical and business drivers.

The miniaturization of devices and the coverage of audio networks are the key technical drivers in the field of mobile multimedia. Actual mobile devices with features fit into cases with minimal dimensions and can be or are carried with the user in every size for every application scenario. Nowadays public wireless wide area networks cover the bulk of areas especially in congestion areas. They key enable mast of time adequate quality of service. They allow location independent service provision and virtual private network access.

Market evolution and service evolution are the most important business drivers. The market for mobile devices changed in the last years. Shrinking services and falling operation (network) costs made mobile devices to a mass-consumer good available and affordable for everyone. As a result, we have a subscribe growth and therefore a new increasing market for mobile multimedia services. The permanent increasing market brought more and more sophisticated services, starting from poor quality speech communication to real-time video conferencing. Meanwhile mobile multimedia services provide reach media content and intelligent context based services.

The value chain of mobile multimedia services describes the players involved in the business with mobile multimedia. Every services in the field of mobile multimedia requires that their output and service fees must be divided to them considering interdependencies in the complete service life-cycle. For example, network operators provide the end-user with the infrastructure to access services mobile via wireless networks. Content providers and aggregations license content and prepare it for end-users. They collect information and services to provide customers with convenient service collection adapted for mobile use. Fixed internet companies create the multimedia content. They handle the computing infrastructure and content creation. Device manufacturers deliver hardware and software for mobile multimedia services and are not involved with any type of content creation and delivering.

3 Technologies overview

After the first-generation analog mobile systems, the second generation (2G) mobile digital systems were introduced around 1991 offering higher capacity and lower costs for network operators. For the users, they offered short messages and lo-rate data services added to speech services. People want to have continuous high quality services and, at the same time, are unaware of how they will get it and where they are going next. Hence, they need a functioning mobile infrastructure capable of handling high amounts of data. Second generation networks can be used to transfer data at very limited speed. An important evolution of the 2G systems, sometimes known as 2,5G is the ability to use packet-switched solution in General Packet Radio System (GPRS). The main investment for the operators lies in the new packet-switched core network, while the extensions in the radio access network mainly is software upgrades. For the users GPRS offers the possibility to always be on-line and only pay for the data actually transferred. Data rates of up to 20kbps per user time slot is offered. The next generation 3G, offers better data transfer capabilities, but its speed is still insufficient for many desired applications like videoconferencing. The ITU efforts through International Mobile Telecommunication IMT-2000 have led to a number of recommendations. These recommendation address the area such as user bandwidth, richness of service offerings (multimedia services) and flexibility (networks that can support smaller, or large numbers of subscribers). The recommendations also specify that IMT-2000 should operate in the 2GHz band. However, in general, the ITU recommendations are mainly a set of requirements and do not specify the detailed technical solutions to meet the requirements [5].

The step to be taken, in order to arrive to the goal of the fourth generation 4G is called beyond 3G (B3G). In other words B3G is also, known as heterogeneous systems and networks together, while 4G is a new air interface. Path to beyond 3G and 4G is shown in Figure 1, where transmission speed is shown in dependency of cellular environment.

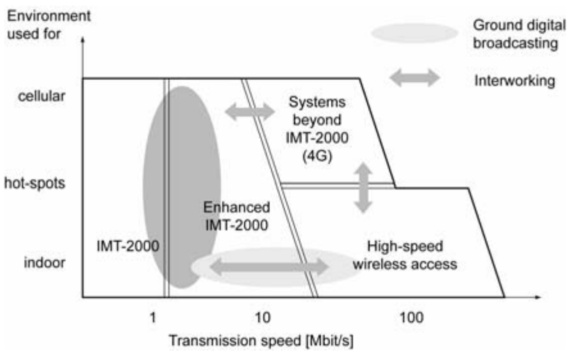

Figure 1. Step to B3G and 4G.

Within the rapid development wireless communication networks, it is expected that fourth generation mobile systems focus on seamlessly integrating the existing wireless technologies including GSM, wireless LAN and Bluetooth. This contrasts with 3G, which merely focuses on developing new standards and hardware. 4G systems will support comprehensive and personalized services, providing stable system performance and quality.

Different research programs have their own visions on 4G features and implementations. Some key features mainly from the users point if view of 4G networks are stated in follows:

- ✓ high usability: anytime, anywhere and with any technologies
- ✓ support for multimedia services at low transmission cost
- ✓ personalization
- ✓ integrated services.

First, 4G networks are all-IP based heterogeneous networks that allow users to use any system at any time anywhere. Users carrying an integrated terminal can use a wide range of applications provided by multiple wireless networks. Second, 4G systems provide not only telecommunications services, but also data and multimedia services. To support multimedia services high data rate services with good system reliability will be provided. At the same time, a low per-bit transmission cost will be maintained. Third, personalized service will be provided by this new generation network. It is expected that when 4G services are launched, users in widely different locations, occupations and economic classes will use the services. In order to meet the demands of these diverse users, service providers should design personal and customized for them. Finally, 4G systems also provide facilities for integrated services. Users can use multiple services from any service provider at the same time. To migrate current systems to 4G with the features mentioned above, we have to face a number of challenges.

Fourth generation (4G) wireless communication systems will be made up of different radio networks providing access to an Ipv6 based network layer. In densely populated area, 3G will augment ubiquitous 2,5G networks by providing higher bit rate access.

4 Mobile multimedia services

The concept of mobile multimedia services was first introduced in 1992, when the ITU realized that mobile communications was playing an increasingly important role. It began work on a project called Future Public Land Mobile Telecommunications Systems (FPLMTS). The aim was to unit the world under a single standard. Given the fact that this acronym is difficult to pronounce, it was subsequently renamed International Mobile Telecommunications-2000 (IMT-2000). It is a single family of compatible standards defined by a set of ITU-R Recommendations. The main objectives for IMT-2000 are [6]:

- high data rates, 144/384kbps for high mobility user with coverage and 2Mbps for low mobility users with limited coverage
- capability for multimedia application and all mobile applications
- high spectrum efficiency compared to existing systems
- high flexibility to introduce new services
- high degree of commonality of design worldwide use of a small pocket terminal with seamless global roaming.

Progress has been made in the development of some signal processing techniques and concepts for use in tomorrow's wireless systems. These include smart antennas and diversity techniques better receivers, and hand over and power control algorithms with higher performance [7].

Mobile multimedia services aims to combine the Internet, telephones and broadcast media into a single device. To achieve this, IMT-2000 systems have been designed with six broad classes of services. None of them are yet set in hardware, but they are useful for regulators planning coverage and capacity, and perhaps for people buying terminals when they finally become available. 3G devices, for example, will be rated according ot the types of service they can access, from a simple phone to a powerful computer. Three of the service classes (voice, messaging, switched data) are present on 2G networks, while three more (medium multimedia, high multimedia, interactive high multimedia) involve mobile multimedia.

Even in the age of high-speed data, voice is still regarded as the "killer app" for the mobile market. 3G will offer call quality at least as good as the fixed telephone network, possibly with higher quality available at extra cost. Voicemail will also be standard and integrated fully with email through computerized voice recognition and synthesis.

Messaging is an extension of paging, combined with Internet email. Unlike the text only messaging services built into same 2G systems, 3G allows email attachments. It can also be used for payment and electronic ticketing.

Switched data includes faxing and dial-up access to corporate networks or the Internet.

Medium multimedia is one of the most popular 3G service. Its downstream data rate is ideal for Web surfing. Other applications include collaborative waking, games, and location-based maps.

This can be used for very high speed Internet access, as well as for high definition video and CD quality audio on demand. Another application is online shopping for products that can be delivered over the oar (music program for a mobile computer).

Interactive high multimedia can be used for fairly high-quality videoconferencing, or videphones and for telepresence, a combination if video conference and collaborative networking.

Some services characterizes are shown in Table 1 [8]. They include user nominal bitrate, effective call duration, user net bit rate and service bandwidth.

According to the dependencies among the services, they are structured to three levels: basic level services, value added services (VAS) and high level applications. In the context of mobile multimedia, the basic level services (voice, messaging, data retrieval, video, etc.) refer to the collection, sharing and exchange of multimedia data. The VAS (wireless home networking, high density networks, Internet/Intranet access, video conferencing, telemetry, location based services, payments, etc.) level refers to the provision and distribution of the multimedia information. Finally, the high level applications, entertainment applications, telematics, construction, electronic healthcare, provision, e-government, e-learning, etc.) is concerned about usage and consumption of the data.

5 QoS requirements and challenges

Observing the growing demands of roaming users, it can be predicted that the next generation wireless networks will be burdened with bandwidth-intensive traffic generated by personal multimedia applications such as web browsing, traveler information systems, video and games. However, the available resources (e.g. bandwidth) for supporting such applications is extremely linked. Additionally, mobility of users poses a significant challenge due to the fact that the resource requirements in the network could be quite unpredictable. Therefore, proper management of bandwidth and hence efficient schemes for quality QoS provisioning between the end-systems are necessary to accommodate the envisaged high bandwidth multimedia services. Until new, research and the current day technology has only identified the bottlenecks to provide QoS in mobile multimedia. Although various frameworks for QoS provisioning there exists a plenty of challenges and issues that need to be tackled before the next generation wireless multimedia networks are widely used in practice. Today's research and prototyping efforts are mostly directed towards various components of mobile computing. A sample of areas being investigated includes research in wireless communications, networking technologies for integration of portable computers and devices into existing computer and communication networks, networking technologies to provide broadband access to mobile computers, and application design for mobile computers.

In particular, multimedia applications require high data rates, reliable connection, more memory, high revolution displays and high speed processing units. It is very difficult to incorporate all these features in the network and also in the hand-held terminal. Even if these features are included, the issues related to portability are not met. It is required that the handset should be small, light weight with more memory capacity and high speed processing unit.

As for multimedia traffic, it can be broadly classified as real-time and non-real-time. Real-time traffic (e.g., video and voice) is highly delay sensitive, whole non-real-time traffic (e.g., transmission, control protocol TCP packets and text data transfer) can tolerate large delays. Table 2 gives various applications and their traffic classes along with some typical parameters values like bandwidth, connection time, etc.

For multimedia traffic (voice, video and data) to be supported successfully, it is necessary to provide QoS guarantees between the end-systems. QoS provisioning means that the multimedia traffic should get predictable service from resources in the multimedia traffic should get predictable service from resources in the communication system. Typical resources are central processing unit (CPU) time (the communication software to execute) and network bandwidth. The communication software must also guarantee an acceptable end-to-end delay and maximum delay jitter, i.e., maximum allowed variances in the arrival of data at the destination. In most cases, QoS requirements are specified by bandwidth delay and reliability. Figure 2 shows the characterizes of traffic types in wireless networks in terms of the bandwidth usage and typical tolerable delay. Since the traffic varies significantly within a wide range of parameters, guaranteeing QoS becomes even more challenging. Multimedia traffic is also characterized by bushiness, stream-oriented nature and for keeping a long and continuous load on the network.

Mobile multimedia is expected to be a main application of 4G networks. However, multimedia streams can be sensitive to packet loss, which in turns can result in video artifact. Such packet loss can often occur when there is an interruption to a connection when a user is moving between networks that are autonomous.

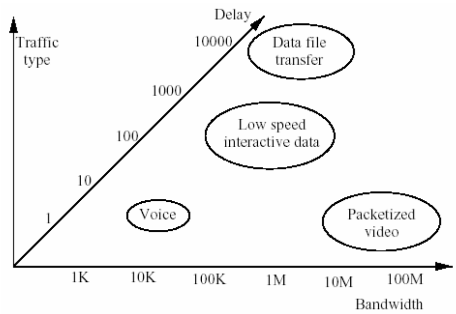

Figure 2. Characteristics of multimedia traffic types in wireless networks.

Quality of service mechanisms, including resource reservation (signaling), admission control and traffic control, allow multimedia applications to get certain quality guarantee e.g., on bandwidth and delay for its packets delivery. Providing QoS guaranties in 4G networks is a non trivial issue where both QoS signaling across different networks and service differentiation between mobile allows will have to be addressed. On the other hand, before providing network access and allocating resources for a mobile node (MN), the network needs to authenticate the mobile nodes (or mobile users) credential. Further more, a security association needs to be established between the mobile node and the network to ensure data integrity and encryption.

IP network element (such as a router) comprises of numerous functional components like mobility, QoS, and for authentication, authorization and accounting (AAA). We identify these components into two planes: the control plane and data plane functionalities as shown in Figure 3.

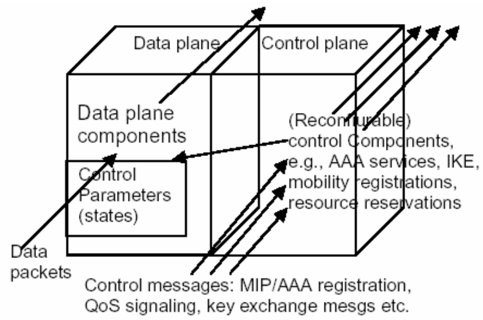

Figure 3. Control plane and data plane.

The control plane performs control related actions such as AAA, Mobile IP (MIP) registration. QoS signaling, installation (maintenance of traffic selectors and security associations, etc.). The data plane is responsible for data traffic behaviors (classification, scheduling and forwarding) for end-to-end traffic flows. Some components located in the control plane interact through installing and maintaining certain control states for data plane, with data plane components in some network elements such as access routers (ARs), IntSrv nodes or DiffServ edge routers. However, not all network elements. Also, not all network elements are involved with data plane functionalities.

QoS provisioning comprises data plane (mainly traffic control) and control plane (mainly admission control and QoS signaling) functions. We can identify the fundamental differences of QoS provisioning in all-IP 4G mobile networks from a traditional, wired or wireless IP networks. Where as its resource control mechanisms can be similar to the of traditional networks, changing a location during the life time of a data flow introduces changed data path and installing new resource control parameters and data plane. The control plane is mainly involved with path decoupled, end-to-end way of mobile registrations, while data plane concerns mobility-enabled routing for data flows into and from an MN while it moves between different locations. The data plane behavior is achieved by installing changing certain binding caches upon certain control plane information exchange.

6 Conclusion

Communication engineering approaches the problem of the limited bandwidth and capabilities offered by the start-of-the art networking technologies and mobile devices by considering not only characteristics if the networks and devices used, but also on the tasks and objectives the user is pursuing when applying/demanding mobile multimedia services and exploits this information to better adapt those services to the needs of the user.

The applications should be adaptive and network-aware. The network must provide application-aware services. Thus end-to-end QoS provisioning is no longer the sole responsibility of particular layer but also the layers combined. The performance of the complete system can be improved by the collaboration of the application with the network. The application should be capable of dynamically changing with the varying network conditions. At the same time, the network should be aware of the application and cater to the varying needs of the application.

Today mobile IP can be used for current purpose where the traffic is mostly non-realtime. For future systems one must solve the security problem based on study the requirements of various services being engaged for B3G and 4G as well as propose solutions which fulfill the security requirements and resolve the threats. The most important is developing optimized solutions to enable seamless mobility for mobile networks and mobile nodes.

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Services	User nominal bit-rate [kbit/s]	Effective call duration [s]	User net bit-rate [kbit/s]	Service bandwidth [kbith/s]
High interactive MM	128	144	128	256/256
High MM	2000	53	1509	15/3200
Medium MM	382	14	286	15/572
Switched data	14	156	14.4	43/43
Simple messaging	14	30	10.67	22/22
Speech	16	60	16	28/28

Table 1. Some service characteristics.

Traffic class	Bandwidth requirements	Average bandwidth	Connection duration	Average duration	Applications
Real time	30kbps (constant bit rate)		1-10mins	3mins	Voice service Audio-phone
Real time	256kbps (constant bit rate)		1-30mins	5mins	Video-phone Video-conference
Real time	1-6MBPS (avg) 2-9 Mbps (peak)	3Mbps	5mins to 5hrs	10mins	Interactive video Video on Demand
Non-real time	5-20Kbps	10Kbps	10-20sec	30sec	Email, paging, fax
Non-real time	64-512Kbps	256Kbps	30sec – 10hr	3mins	Remote login
Non-real time	1-10Mbps	5Mbps	30sec – 20mins	2mins	FTP Retrieval service

Table 2. Traffic classes and multimedia applications.