Trends in multimedia over wireless broadband networks

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Abstract:- Future wireless multimedia will mainly be characterized by a *horizontal* communication model, where different access technologies such as *cellular mobile, broadband wireless access, wireless LANs, short-range connectivity,* and *wired systems* will be combined on a common platform to complement each other in an optimum way for different service requirements and radio environments. The simplified battle between the *best* technologies does not make sense, since different technologies have their optimal usage in different places. The major vehicle toward the next phase of telecommunications networks is combination of Internet technologies and mobile communications. On the path toward 4G, evolutionary rather than revolutionary progress could be preferred, as a means of ensuring maximum reuse of service platforms and access infrastructures while evolving them. The trends in multimedia wireless networking toward 4G system is pointed out in this paper.

Key-words: multimedia communications, 4G service framework, hybrid QoS management

1 Introduction

Broadband wireless communications have gained increased interest during the last years. This has been fueled by a large demand on high-frequency utilization as well as a large number of users requiring simultaneous high-data-rate access for the applications of wireless mobile Internet and e-commerce. The convergence of wireless mobile and access will be the next storm in wireless communications, which will use a new network architecture to deliver broadband services in a more generic configuration to wireless customers, and support value-added services and emerging interactive multimedia communications. Large bandwidth, guaranteed quality of service, and ease of deployment coupled with recent advancements in semiconductor technologies make this converged wireless system a very attractive solution for broadband service delivery. Various existing emerging wireless technologies characteristics are shown in Table 1. [1, 2].

Wireless multimedia communications require medium to high bit rate channels (64 kbps to 2Mbps per user) [3]. Therefore, for these applications, it will be necessary to have broadband wireless networks that support bit rates in excess of 2 Mbps per radio channel, where each radio channel could be shared by multiple users or sessions. In addition, these services have to be provided with some quality of service (QoS) guarantees over their respective, error-prone wireless connections. In order to archive these goals, one has to address the following key issues:

- haw to increase the capacity of wireless channels,
- how to provide QoS in a cost-effective way,
- haw to combat the wireless channel impairments.

Most multimedia services tend to be real-time in nature, i.e., the data being transported need to get to the destination by a certain time in order to be useful. This implies the need to develop techniques for call admission, bandwidth allocation and the handling of real time variable rate streams.

Most of the wireless systems today also support mobility. The velocity associated with mobility has been one of the key parameters that affect system design. For this reason, many of the approaches to solving channel related problems associated with mobility have been developed for specific classes of mobile systems - pedestrian (velocity of a few m/sec), vehicular (velocities of about 100 m/sec), and high-speed (velocities of hundreds of km/sec). Mobility also affects routing and addressing, which have received a significant amount of attention.

The two major protocol-related problems in wireless multimedia concern medium access and quality of service. Wireless systems are inherently multiple medium access in nature and therefore need to have a reliable medium access control (MAC layer that also supports QoS).

Audio, video and graphics need to be compressed before transport over a bandwidth constrained wireless channel. The two video compression standards that are most relevant to these systems area MPEG-4 and H.264. Even with scalable and multiple description based source coding schemes, there will still be lost data on wireless systems. Error recovery and concealment at the receiver is therefore an important topic and has received some attention again primarily for video. These error concealment techniques rely to a large extent on knowing the underlying source compression technique and exploiting some of the tools that are used therein. Joint source-channel coding in which source and channel coders are optimized in tandem, has immense applicability in wireless multimedia communication systems [4].

2 Trends

During the last couple of years the combination of Internet technologies and mobile communications has been successfully considered the major vehicle toward the next phase of telecommunications networks. Especially in the case of cellular network integration, this is typically referred as *all-IP networking* [5].

Although the near-term research and development seems quite straightforward, economic and business environment uncertainties make it hard to predict any precise timing. It is clear that cellular networks will continue to improve in terms of capacity, services, and coverage. The most urgent development is enabling heterogeneous networking, including support for vertical handovers, seamless roaming, and micro-mobility with IP. A number of wireless quality of service (QoS), we are becoming more pragmatic. Some issues will be solved at the application layer, and we will have to accept inherent limits of unreliable wireless channels.

Software-defined radio (SDR) technology will become available, and reconfiguration time will not be an issue. There is a long research road ahead before this is a reality. Not only will wireless terminals and base stations become SDR-based; the core backbone network will also gain more adaptability and reconfigurability. The proportion of software in telecommunications systems will increase everywhere. Terminals, phones, routers, and other devices will be able to process and hold more and more programs.

WLANs have started to become more popular, not only within companies and homes, but also as a public hotspot technology. The reason for the popularity of IEEE802.11-based networks are simple: the technology is cheap; for upper layers and applications it performs just as "wireless Ethernet"; and as unlicensed radio technology it is easy to deploy. It is also the only widely available wireless technology to quickly build broadband wireless networks. The development of WLAN technology from early 1 and 2 Mbps models to present-day direct sequence spread spectrum (DSSS) and orthogonal frequency-division multiplexing (OFDM)-based systems up to 54 Mbps has been quite rapid, and work done toward future extensions on upper layers, QoS, and innovative new physical layer technologies is still going on.

There have occasionally been suggestion that third-generation (3G) cellular technology, which has been promising at first 384 kbps and later up to 2 Mbps connections to a user, is going to break through commercially because of the emergence of WLANs. However, it is early and drastic to predict that. It is clear that 3G has problems. It has not reached the quick and strong global success most of its ardent supporters claimed in would, and it is hard to predict its commercial progress; but 3G systems will emerge. There was perhaps unavoidable hype surrounding 3G, and we should not make the same mistake with WLAN hotspots. WLAN will be an inevitable and important part of the future wireless and mobile broadband infrastructure. However, we also need large-scale cellular networks to support high-velocity mobility and provide geographical coverage. One also should not overemphasize only raw radio bit rates, as it is well known that the actual application bit rates with WLANs are lower (e.g., with TCP the maximum data rate would be about 6.1 Mbps in 11 Mbps mode in ideal conditions); and of course, the capacity is shared between users. The overall aggregate capacity of cellular technologies is also high. The simplified battle between the *best technologies* does not make sense, since different technologies have their optimal usage in different places!

4G is a system of systems that brings in standardized capabilities and technologies to make composable and auto-configurable networks. However, although combination of networks is key, the actual deployed

4G networks will also include new radio technologies.

The core cellular technology will be based on 3G, including Unversal Mobile telecommunications System (UMTS) and code-division multiple access 2000 (CDMA2000); Global Systems for Communications (GSM) evolutions such as General Packet Service (GPRS) and Enhanced Data for GSM Evloution (EDGE) will play an important role. Even before full SDR capability, early versions of software radios can be used to provide multimode terminal technology for users; of course, multimode terminals are already available. The key issue is to use all different aspects and capabilities of networks to provide a good user experience.

In fact, cellular networks such as existing 2.5G and 3G networks have excellent global reach and good customer management (most notably billing and authentication) functionalities. Many key players in the field, among them Ericsson and Nokia, have lately demonstrated cooperation and vertical handover capabilities between WLAN, 3G, and 2G networks. The interworking architecture between WLAN and 3G/2G systems could provide fast deployment for global roaming and billing. Hence, the controversy between 3G against WLAN is partially already being tackled, and the 3G Partnership Project (3GPP) is working on interoperability.

There is still a need to provide better harmonization of WLAN and cellular network interfaces with operating systems and other higher-layer software. The present very heterogeneous situation is slowing down some interesting work from application developers who have no interest in developing different versions of the same software base for all different wireless access technologies.

Mesh networking combined with end user mobility is probably an important key ingredient to provide extensive and ubiquitous wireless broadband access for everyone. Especially in city areas, the wireless mesh network overlay structure can be used to feed information toward local ad hoc and peer to peer networks based.

3 Towards 4G

The grand challenge for the next decade toward the fourth generation (4G) is for the European research community to continue to the design and creation of new technologies while ensuring that their deployment will be realized with reduced capital and operational expenditures in order to maintain sustainable growth of the whole industry and society.

Cooperation of heterogeneous access networks (cellular and broadcast in particular) is an area that has been investigate for some time through a number of EU projects, with the aim of setting up technical foundations, developing specific services and architectures, and addressing network management aspects [6].

Most of the technical barriers have been identified, but need now to adapt to the current regulatory and business context characterized by openness of systems, diversification of system actors, and the search for productive investment. Network cooperation is probably one of the main clues for addressing the 4G technological landscape, but it needs to be driven by a number of requirements that are meaningful from the technological viewpoints as well as from the regulatory and business ones.

In recent years an excess of available technologies convincing killer applications have created profitability issues for many companies, hence leading to rethinking requirements not only on the technical side, but also from the business and end-to-end perspectives.

In parallel, there has been increasing interest in the *push* paradigm, in particular to groups of users supported by the spectrum efficiency of broadcast bearers, and the attractiveness of broadcast TV interactive services. The push toward an Information Society has motivated the development of new wireless access technologies, services, and applications. This happens in a continuous process:

- identifying future service needs,
- identifying potentially available spectrum matching the capacity need,
- agreeing on the technical specifications to enable access to new services.

This has lad to the emergence of wide range of wireless digital transmission technologies and service platforms to comply with new user needs requiring more capacity, support of multimedia traffic, extended support for mobility, and so on. This is why, for instance, GSM/GPRS/EDGE are available for wide area mobile communications, WLAN technologies were developed for local area wireless connectivity (e.g., in the enterprise and home), and DAB/DVB-T were created for audio and digital broadcast services. To capture the end-to-end dimension of the overall system, the delivery dimension is typically looked at, but not as much application provisioning and system operations as part of the system.

2G/3G and DVB infrastructures as well as service platforms are good starting points because of their established popularity and complementaries in terms of coverage, operations, services, and content. The objective is to provide a unified framework such that service providers can address both cellular and broadcast terminals with applications that have similar application logic. The advent of integrated broadcast/cellular terminals would then benefit from such an existing infrastructure.

3.1 Multimedia service framework conception

The main objective of this service framework is to be adapted to the peculiarities of 2G/3G and broadcast platforms (i.e., complying with legacy systems), while offering opportunities for enhanced and/or new types of services, or new access and delivery methods to services. In essence, it reuses known concepts but adapted to the coexistence of heterogeneous access networks with specific features. The service framework aims to combine the interest of the value chain members. Such value chain is articulated along the assets with which each provider markets its added value, as illustrated in Figure 1. At the very end of the chain, the end user is the driver for such a system [7].
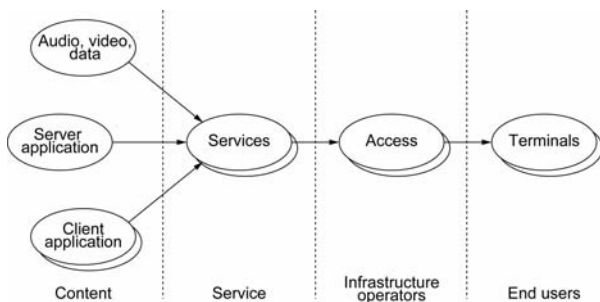

Figure 1. Value chain articulation.

Service are combinations of audio, video, and data, applications running on servers and applications to be downloaded into user terminals. Creators (i.e., content providers, application designers) of these components have to face the increasing diversification of targets (multiplicity of networks, terminals, and contexts) as well as the risk of seeing their creation misused.

Service providers combine these assets into attractive packages to be purchased by end users. This requires settings up authentication and billing mechanisms, and ensuring that the service is made available as expected by the creators in order to meet user expectations. Service provider's interest is to have the most appropriate service instances delivered to

the largest number terminals while optimizing the required bandwidth.

Finally, infrastructure operators have the role of ensuring proper service access and asset delivery to end users, more or less irrespective of the service type. Service access and delivery requirements are agreed and captured into a service level agreement (SLA) including quality of service (QoS), security and mobility support aspects, at an aggregated level and for specified geographical areas and time.

The client/server paradigm has proven to be very efficient to offer innovative services, based on the fact that the server application is upgradeable, and/or that client applications can be downloaded over the air. There are the features that are reused in this service framework and adapted to the case of hybrid cellular/broadcast networks.

The application running on the server and the related client applications are the assets that will enable further reuse of audio/video/data assets, and adaptation to multiple types of terminals, for users on multiple platforms to access proposed services. This is achieved by means of a number of interactions between the various assets.

Client applications can be generic into terminals (e.g., browser) or specific to a service. The nature of interactions between client and server applications deals with:

- Network profile – to determine terminal dynamic connectivity characteristics such as available networks and QoS classes.
- Terminal profile – to determine terminal application execution capabilities.
- User profile – to facilitate the personalization of the user experience, and discovery of new services.
- Authentication/billing – to support the controlled use of services, when required.

Profiles can be resident in either the network (e.g., 3G concepts for off-line personalization of services in support of the virtual home environment) or the terminal with motivation of preserving privacy or when a profile is likely to change fast (case of network profile). Both cases will coexist and the server application deals with both. Note that digital rights aspects can be involved in the interactions as a means to ensure proper use or reuse of the audio/video/data.

From the application provider point of view, the process is in the business-to-business domain in the sense that it must be aware of the application in the form of a service the service provider can advertise to

end users. Associated with the service, there can be an application to be downloaded to the terminal, in order to enable improved user experience.

The service descriptions and the client applications can be either pushed to the terminal in a typical client/server interaction. In case of a broadcast bearer, the objects are indexed with sufficient information for the terminals to filter out unwanted ones, and played out for instance cyclically for permanent availability over the air. Object organization into cycles is optimized to for instance minimize the access time to a given object.

3.2 Hybrid QoS management

Delivery over hybrid networks requires a framework for QoS such that guarantees can be given to service providers to ensure that content is made available to end users as expected at application design. Concretely, the service provider has to know in which form service must be *packaged* (in terms of QoS attributes) to adapt to network limitations. This typically deals with the setup of different instances of the same end-user service in order to comply with the network types or QoS classes and likely context in which users are connected to a given network [8].

In Figure 2. the process is built around the idea of making terminals discover services they can actually run or access through the network to which they are connected. This implies some preprocessing consisting of generating the network specific service descriptions under the constraints of the QoS the targeted networks can actually offer.

At service registration, a service description is available for determining how the service should be made known to end users, and what the QoS requirements are to properly run the service. Note that the service description must include if the service can be available under different forms (e.g., video, still picture formats, and bit rates selectable for various instances). Next, the network-specific service description are generated and made accessible to end users over the networks on which they are applicable.

When a service is mapped on a broadcast network, the service descriptions are pushed using an announcement protocol. Terminals filters out descriptions that do not match capabilities or use preferences.

Hybrid QoS management framework relies on a semi-distributed approach and builds on intrinsic transport and QoS control mechanisms. The added value of this framework resides in the signaling links defined between the entities that take part in the end-to-end content delivery, with help of the mediation entity. The pragmatic assumption is that the QoS bottlenecks are on the wireless access side. Since there is limited number of such access networks, there is no significant scalability issue expectable.

Support for this framework is in the form of signaling gateways available at each administrative domain (DVB networks, 2G/3F networks) and interconnected to exchange the necessary information. The signaling gateways also host measurement probes for reporting the information at the appropriate level.

QoS provisioning consists of provisionally reserving bandwidth for a given service, while QoS control aims to allocate resources so that the QoS requirements are met as long as the service session for a given user is active. SLA optimization can be admitted in a given domain. Support of a given of a QoS classes instance has a direct impact on the necessary bandwidth at a given location. Consequently, in some cases it is desirable to index the service to be deployed with some geographical information (cell identification, area and coordinates, etc.). The mediation entity can keep track of this information and link it to the service announcement process where the announced services will take into account the available resources in different areas.

4 Concluding remarks

Traditionally data-communications-driven Internet and voice-dominated mobile communications were *separate* disciplines, both enjoying exponential growth. If define this as first step of the convergence, we can argue that most of the basic technology building blocks already exist for it. The basic framework for wireless Internet is already reasonably well understood in both mobile radio (cellular) systems and more open wireless LANs (WLANs). However, the practical integration task between traditional (cellular) radio systems and TCP/IP-based architectures remains formidable with all its details and performance tuning. A lot of work is needed before transparent all-IP networking becomes reality.

As for fourth generation (4G), a number of different interpretations exist. Some people see it as a new radio interface in the traditional movement from 3G to a new *full* standard, which presumably would provide at least higher data rates and better adaptivity. Another often used interpretation refers to heterogeneous (integrated, IP-enabled) wireless

networks. Probably the truth is a combination of both, as the future hierarchical and heterogeneous overlay network infrastructure will also definitely require *new air interfaces* – and enhanced adaptivity – in order to provide better scalability, QoS, and wireless capabilities.

On the path toward 4G, evolutionary rather than revolutionary progress could be preferred, as a means of ensuring maximum reuse of service platforms and access infrastructures while evolving them. 4G has to be seen as the next-generation communications systems, which may include new wireless access technologies, but in any case will be able to provide a unified framework to both ends of the communications system. This leads to defining a service infrastructure able to provide an interworking framework between various actors in the multimedia value chain.

References:

[1] K.R.Rao, Z.S.Bojkovic, D.A.Milovanovic, *Introduction to multimedia communications: applications, middleware, networking*, Wiley 2005.

[2] K.R.Rao, Z.S.Bojkovic, D.A.Milovanovic, *Multimedia communication systems: techniques, standards and networks*, Prentice Hall 2002.

[3] Z.Bojković, D.Milovanović, Wireless multimedia coding and transport layers, *9th WSEAS* CSCC2005, Athens. *Invited paper.*

[4] D.Milovanović, Z.Bojković, Integration QoS and security technologies in 4G mobile networks, *9th WSEAS* CSCC2005, Athens.

[5] P.Mahonene et al., Hop-by-hop toward future mobile broadband IP, *IEEE Commun. Magazine*, vol.42, pp.138-146, March 2004.

[6] S.Y.Hui, K.H.Yeung, Challenges in the migration to 4G mobile systems, *IEEE Commun. Magazine*, vol.41, no.12, Dec. 2003, pp.54-59.

[7] O.Benali et al., A framework for an evolutionary path toward 4G by means of cooperation of networks, *IEEE Commun. Magazine*, vol.42, pp.82-88, May 2004.

[8] P.Demestichas et al., Wireless beyond 3G: managing services and network resources, *IEEE Commun. Magazine*, vol.40, pp.80-82, Aug. 2002.

Table 1. Various wireless technologies characteristics.

| Network	Standard	Radio basic rate	Frequency band	Mobility
WLAN	IEEE802.11b	1, 2, 5.5, 11 Mbps	ISM 2.4 GHz	Low
	IEEE802.11a	up to 54 Mbps	ISM/UNI 5 GHz	Low
	IEEE802.11g	up to 54 Mbps	ISM 2.4 GHz	Low
Bleutooth	IEEE802.15.1	1 Mbps	ISM 2.4 GHz	Low
WMAN	IEEE802.16	134 Mbps	10-66 GHz	N/A
	IEEE802.16a	70 Mbps	2-11 GHz	N/A
2G	GSM	9.6/57.6 kbps	900/1800/1900 MHz	High
	GPRS	115 kbps		High
	EDGE	384 kbps		High
3G	UMTS/WCDMA	up to 2 Mbps	1900-2025 MHz	High
Next generation WLANs		up to 1 Gbps (indoor) 150-250 Mbps (outdoor)		Low
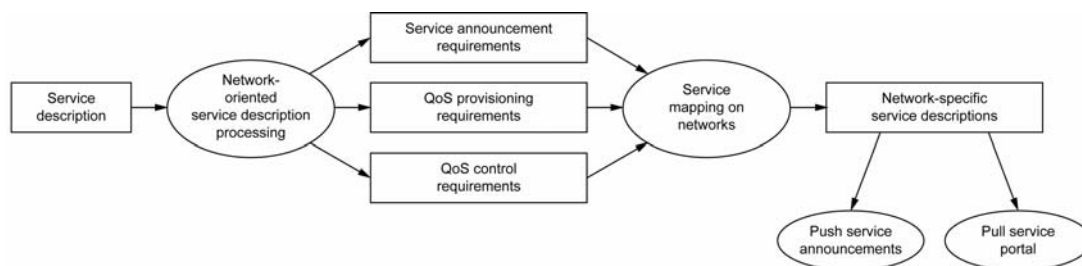
Figure 2. Service description based QoS management process [7].