Enhancement of existing network infrastructure with Media on Demand functionality

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***Abstract*--With the evolution of radio access technologies that provide higher data transmission rates, the mobile market will introduce content rich multimedia services over mobile networks at the user instant needs. Media on demand (MoD) refers to the system that provides clients access to media and plays it back with little or no delay. Therefore it has to face numerous challenges, such as providing mobile streaming over various access networks and mobile terminals simultaneously to millions of mobile users across broad geographic area. It is expected that this technology will merge the communications and media industry, allowing movie producers and TV companies to stream their content over mobile operator's infrastructure and service providers generating attractive killer applications. In this article is presented a case study of integrating end-to-end multimedia delivery solution into existing Ericsson Mobility World Croatia network infrastructure. The problems and benefits of including new network entities are explored and the planned solution for the year 2003 is proposed.**

***Index terms*-- Media on Demand, mobile streaming, multimedia services**

I. Introduction

The evolution of mobile networks started with the replacement of first generation mobile systems with the second. The 1G, commonly called NMT (Nordic Mobile Telephony) that appeared in early '80s was analog, circuit-switched and narrowband and was suitable only for voice communication. Due to its constraints and global diversity, it was soon replaced by 2G systems during the '90s. Currently, four 2G technologies coexist: GSM, cdmaOne, TDMA and PDC. The different evolution paths are shown in figure 1 [1]. As figure 1 shows, the generally accepted 3G migration path is to upgrade the GSM network to 2.5 General Packet Radio Service, and then the GSM/GPRS network will evolve into EDGE – Enhanced Data Rates for Global Evolution and finally into the Universal Mobile Telecommunication System (UMTS) with speeds up to the 2 Mbps. These technologies are briefly described in [2].

During the evolution of mobile networks, an evolution of mobile applications has been taking place. The figure 2 shows the gradual evolution of mobile services and

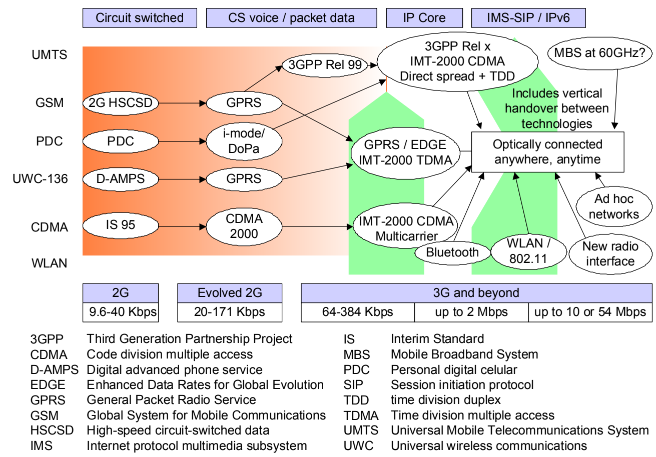

Fig.1 Mobile migration path

their requirements for data transmission rates [3], as follows:

- 10 - 100 kbps for voice
- 64 - 100 kbps for Internet access
- 144 kbps - 2 Mbps for video

Fulfilling most of these requirements today with data transmission rates up to the 53.6 kbps (171.2 kbps theoretically [4] when the coding scheme 4 is used), GPRS had an exception role in providing a variety of new services, such as online chat, m-commerce, location-based services, Internet access, etc. and contributing to the better acceptance of services among consumers. With the rapid growth of mobile market and Internet users, the need for offering users different sorts of content, that they used to download and access over Web, has been discovered. The content including text, images, animations, sounds and in the near future multimedia will have to be personalized (targeting specific user's needs) and delivered to mobile terminals with different processing and display capabilities.

In order to provide streaming of high quality multimedia content to mobile devices, third generation of mobile networks with higher data rates and greater bandwidth has to be introduced. In addition, most of mobile multimedia applications have a demand for asymmetric bandwidth, meaning that a greater bandwidth is needed for downlink, while the uplink is mainly used for control information, such as user's selections and commands. UMTS meets these and other requirements, needed to become a global mobile multimedia communication standard that will deliver high-speed Internet services and multimedia to the mobile users at their instant needs.

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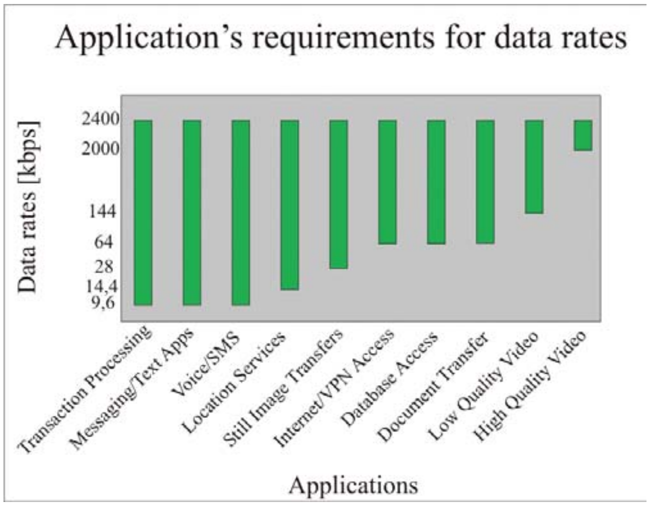

Fig.2 Evolution of mobile services and their requirements

By the definition, Media on Demand (MoD) refers to the system that provides clients access to media and plays it back with little or no delay [5]. The challenges these services will have to face include providing mobile streaming over various access networks and mobile terminals simultaneously to millions of users across broad geographic area, while in the same time adapting the stream to constantly changing characteristics of radio link.

This article gives an overview of Media on Demand functionality in the following section. In the section III some possible applications and services based on this technology are presented, while the section IV demonstrates a case study of integrating Media on Demand functionality into the existing network infrastructure on the example of Ericsson Mobility World Croatia. The problems and benefits of including new network entities are explored and the planned solution for the year 2003 is proposed. The section V discusses possible scenarios of introducing MoD solution into the operator's network, which for example wants to launch mobile streaming video service. In the last section related work considering improvements of streaming technology in the field of compression, intelligent routing and efficient delivery has been described. Finally the conclusion summarizes the work described in the article and gives references to the similar projects.

II. MEDIA ON DEMAND

Media on demand is, opposite to Multimedia Messaging Service [6] [7], needed in the interactive media applications when the access to media is required at the user instant needs, while the latter one delivers the media content asynchronously through the messaging service. The requirements that have been set in order to provide Media on Demand functionality include the increasing bandwidth in mobile environments, the increasing capability of mobile devices, and the better compression algorithms. While it wasn't possible to fulfill these requirements with the existing networks, 3GPP regards streaming services as the important building block of future 3G multimedia applications. Therefore it has defined 3GPP Packet-switched Streaming Services (PSS) as a framework for IP based streaming applications in 3G networks [8]. The problems needed to be solved were storing and processing the large amount of media data files that could potentially cause storage problems at the client side and the long start-up latency. Streaming service solves this issue by allowing streaming media to be consumed as it is received.

Applications that can be built on the top of streaming services can be classified in two categories: on demand (music, news on demand) and live information delivery applications (radio and television programs) [9].

General Service architecture is presented in figure 3. For its implementation at least streaming client and content server are required to be included. Other entities, such as: portals, profile servers and caching servers can be added to the architecture aiming to provide additional services and to improve their quality of service.

Portals are the common place from where multimedia streams can be run and controlled. Device profile servers store device profile descriptions that consist of terminal capabilities and/or user preferences. This information can be used to control the presentation of the streaming media content to a mobile user. The content itself is usually stored on content servers, located somewhere in the network.

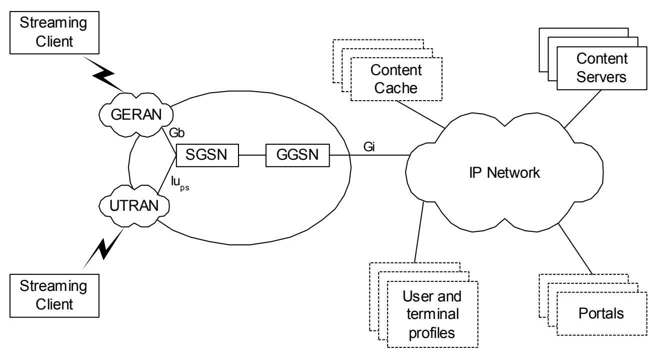

Fig. 3 PSS general architecture

The PSS include the following media codecs for video, still images, vector graphics, bitmap graphics, text, timed text, natural and synthetic audio, and speech:

- AMR narrow-band speech
- AMR wideband speech
- MPEG-4 AAC low complexity (AAC-LC) audio
- SP-MIDI (Scalable Polyphony MIDI)
- ITU-T H.263 video
- MPEG-4 visual simple profile video
- JPEG and GIF images
- XHTML-encoded formatted text

The protocol stack used in a PSS client is illustrated in figure 4. It includes protocols for session setup and control (Real Time Streaming Protocol (RTSP) and Session Description Protocol (SDP)), Hypertext Transfer Protocol (HTTP) for capability exchange, Synchronized Multimedia Integration Language (SMIL) for scene description, HTTP over TCP/IP for transporting of static data and RTP over UDP/IP for real time media transport.

Video Audio Speech	Capability exchange Scene description Presentation description Still images Bitmap Graphics Vector Graphics Text Timed text Audio	Capability exchange Presentation description
Payload Formats	HTTP	RTSP
RTP		
UDP	TCP	UDP
IP		

Fig.4 Protocol stack used in PSS client

When talking about multimedia, it is often thought of broadband multimedia. But there are also narrowband multimedia services. For example, multimedia presentation consists of different media types synchronized in time and on display. In addition, synchronization format is separated from a display format, which is done in SMIL [10]. Therefore data streams are encoded as separated objects, while SMIL just synchronizes them. It enables applications to describe temporal aspect of a presentation and display format on the screen, as well as to associate hyperlinks with media objects.

The problem of heterogeneity of different radio access networks and the varying of QoS and speed in the connection are addressed with the capability exchange mechanism. Capability exchange is one of the most important PSS functionalities, realized by the PSS server matching process of mobile terminals' requests with device capability profiles description in order to determine the best fit's multimedia stream for the user terminal. At the beginning, mobile terminal sends its identity with the list of URLs pointing at the device profiles locations and/or profile attributes to the PSS server. Device profile server stores the device profiles and provides them to the server on request. After completing the matching process, PSS server delivers the most appropriate media stream to the mobile user.

Second problem concerns efficient delivering of streaming media content across different radio access networks with constantly changing characteristics of radio links [11]. This issue can be solved with the proxies for content caching and optimization of data transmission over wireless links to mobile terminal. It means that, if in a connection bandwidth for multimedia stream falls below the limited value, proxies can be configured to present multimedia presentation to the user instead.

III. APPLICATIONS AND SERVICES

Many new applications with integrated streaming services are soon going to be introduced. Possible mobile services have been classified into four groups: Infotainment, Edutainment, Corporate and M-commerce [12]. There are some examples of them: downloading MP3 files to suitable devices, sending digital pictures over the air, videoconferencing, distance learning over video stream of teacher together with his voice or audio track, video and audio on demand (including TV, radio, etc.), multimedia information services (sports, news, stock quotes, traffic).

Another classification of applications can be in terms of bandwidth requirements (from low to high data rates) and the nature of communication (interactive, point-to-point, one-way, pull services, multipoint and broadcast). This classification is proposed by NTT DoCoMo [13], and can be seen on fig.5. The applications are also structured according to growth of data rates. Voice communication services are yellow colored and messaging services are presented in orange. They don't require high data rates, as for example, new video-based 3G applications do (e.g. video telephony), shown in blue, as well as applications involving the transport of large amounts of data (e.g. web and mail applications, MP3 music and file transfer), shown in green. Most of the 2.5G applications are already available, while others requiring greater capacity and higher data rates are waiting for 3G systems.

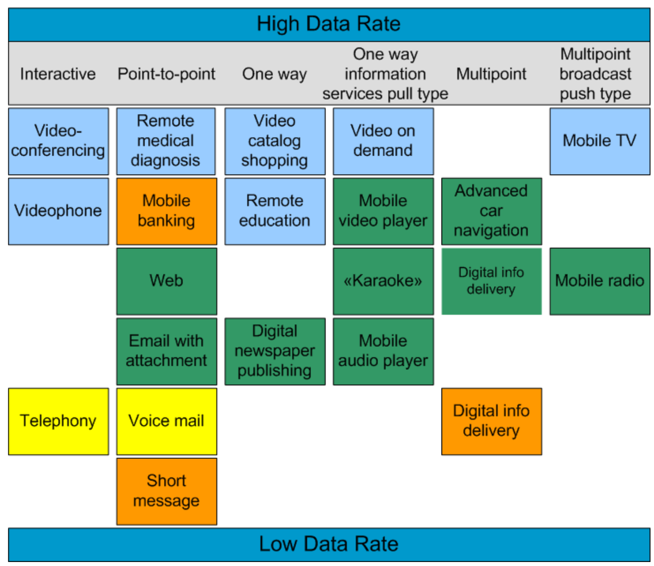

Fig.5. Classification of application proposed by NTT DoCoMo

IV. CASE STUDY

The Media on Demand (MoD) solution is planned to be integrated in the existing infrastructure of Ericsson Mobility World Croatia lab. The main purpose will be to experiment and test potential mobile multimedia applications and to demonstrate the capabilities of the platform for commercial use. It will enhance the portfolio of the lab with additional test cases and demonstration examples in order to provide a preview of future application types which will come with next generation networks (EDGE, UMTS).

The solution consists of different software and hardware components integrated into consistent and seamless system architecture, offering all the needed components for operators to deploy on demand multimedia services. This solution contains: content encoding tools, content streaming and download server(s), content delivery network, media player and bearer networks.

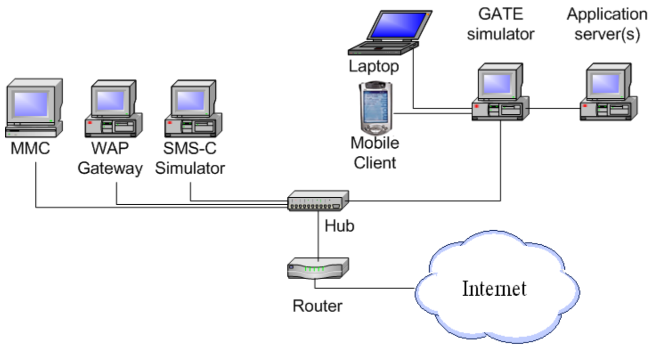

Fig.6. Current layout of Ericsson Mobility World Croatia lab

The architecture of Ericsson system incorporates and extends the architecture standardized in 3GPP PSS Release 4, and future versions will follow the 3GPP approach and standardization track to ensure interoperability with the upcoming 3G and potentially 2.5G terminals. Possible adaptation of the system can be achieved through deployment of a distributed software architecture with leading industry software technologies, which in addition allows flexible usage of software components on standard system hardware.

Specifically, the discussed system contains components having the following functionalities: they enable connection to multimedia requests, act as a proxy for HTTP requests and RTSP set-up and stream the content to destination terminals. Separate modules/components are responsible for connecting to external network using interfaces compliant to 3GPP specifications, making integration with the network easier. The O&M, authentication, billing and subscriber handling/database are also an integral part of the system.

In a demo system, which will be installed in the Ericsson Mobility World lab, most of functionalities will be presented in the form of software modules on a single server.

Current situation in the Ericsson Mobility World lab is shown in fig.6. The lab capabilities include MMS testing (comprising of MMC trial system and WAP gateway), SMS-C simulator (used to send notifications), and GATE simulator, used to simulate GPRS network conditions and monitor application behavior. Testing with GATE simulator is done through connecting client terminals via Ethernet/USB connection with GATE machine on one side and with content server(s) through Ethernet on other side. In this way, traffic (data packets) passes through GATE machine, where it can be monitored or influenced, using certain algorithms.

GATE simulator is a standard Ericsson Mobility World test system, aimed not only for streaming applications testing, but rather for any kind of applications targeted for wireless packet data networks. Additional application testing can be implemented in terms of load testing, which requires separate server.

In the proposed solution for the year 2003, as shown in fig.7, Instant Messaging and Presence Server (IMPS) and Load Testing Suite together with the MoD

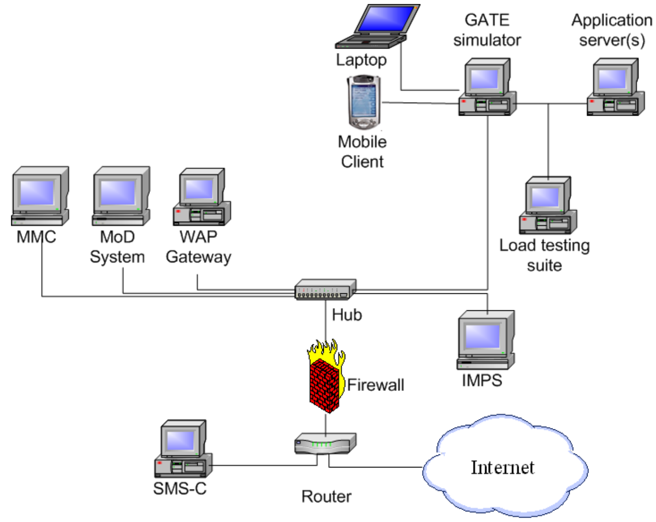

Fig.7. Proposed solution planned for the year 2003

solution are planned to be integrated. Further details regarding their functionalities are out of the scope of this article. The MoD system in the lab will be a trial version, enabling the functionality needed for testing and demonstration purposes. This includes all functionality to show how on-demand multimedia is created, delivered and presented on a mobile network environment.

In addition, demo terminals for this purpose will be Pocket PC and/or Symbian-based. There are two possible scenarios:

- PDA with PocketPC will be connected to a GPRS phone using Bluetooth, or
- GSM module will be plugged into the PDA to have a complete wireless experience.

The 3GPP SMIL player for Pocket PC [14] used on the destination terminal will be also supplied with the MoD solution, and will be able to support different download techniques and different audio/video content formats (MPEG-4, AMR-NB, H.263). Symbian devices are in the testing phase.

Media content creation platform will also be available, if a more sophisticated solution is going to be required. Content creation platform is based on Apple Macintosh system. In present situation, the aim will be to showcase and experiment with the MoD platform itself.

Regarding content transfer to destination terminal, there are several possible methods that can be chosen depending on the network bandwidth and desired/required QoS level:

- *Streaming* - delivers the content in the most efficient way, minimizing both user's waiting time for the content delivery and memory size used to hold a couple of seconds of multimedia, while imposing a more firm bandwidth limit to provide adequate QoS. Therefore it requires temporal buffering of content parts before playing it at the end user's terminal.

- *Download* - the content will be rendered at the user's side after completing its download from the web server, which takes more time and memory capacity than the previous method.
- *Progressive download* – user's player initiates requests for downloading parts of target file and upon finishing the current one, plays it while downloading the next one.
- *Resumed download* – during the creation or encoding of content, flags have been set on the blocks of content in order to safely resume a download at the point of interruption.

The Media on demand system will be implemented in the lab on a fast Ethernet LAN. It will be connected to the Internet through a firewall. In this network setup, it will be possible to use the MoD system as a source server for content feed to the terminals, through GATE testing platform. Thus it will be possible to monitor and measure traffic (simulate real GPRS network conditions).

In this testing case, operator network is not involved as the streaming is done directly through the GATE server machine, which is connected to MoD system through Ethernet interface, and to the terminal via USB port interface. As this is only a network simulation, different scenarios can be tested and (simulated) network conditions are completely under control of the tester (in contrast to real network). On the other hand, a real network will always give a complete real-life testing environment, but its traffic parameters are inherently stochastic and non-repeatable for testing purposes.

The system will also be capable to adapt to network condition changes (interruptions, bandwidth changes, etc.), that will apply if an operator network is used. Since there are no guaranteed dedicated data-only timeslots in the GSM network, the available bandwidth will be the main issue. The bandwidth can be dynamically checked prior to data transfer, and if it is too low, streaming will not commence, and the user will receive a notification.

V. INTRODUCING MOD SOLUTION INTO THE OPERATOR'S NETWORK

The MoD solution has been made to seamlessly integrate into the operator's various service network components. The operator deploys the MoD solution in his service network (intranet). Users can access media on demand services over GPRS or UMTS radio access network and the core network. Though targeted for wireless packet data networks, this MoD solution can be also run within circuit-switched networks, mainly GSM.

Operator has several options, when deciding about deployment of MoD services in his network, depending on the existing infrastructure and developed business model and revenue sharing with content provider. Concerning the fact whether or not he wants to be involved with content creation, encoding, maintaining and delivering it to end users, several scenarios can be implemented, ranging from simple employment of streaming server functionality, over providing only service charging functionality to content provider, to scenarios of operator hosting encoded content and/or applications that use this content. In the last case, operator is completely responsible for the content.

There are two ways of integrating MoD system into the operator's network:

- *Centralized architecture* – aimed for early service deployment, when multimedia enabled terminals are still not available to the mass market, and
- *Distributed architecture* – aimed for the later phase of service deployment, when the growing number of subscribers is going to use the multimedia on demand services.

Centralized architecture integrates MoD solution into the operator's entire service network already existing service components, with the billing interface and the interface to the operator's subscriber database enabling the operator to establish the appropriate business model of revenue sharing with content providers, application developers and media community. Scaling of the centralized architecture can be achieved by adding more supporting nodes, while still residing in one central site. Hence, at a certain point in time, depending of the operator's network topology, this approach will create a bottleneck in the IP backbone, affecting both the user's experience and streamed/downloaded data transfer across the IP backbone. When this happens, a migration path to distributed architecture is provided.

Distributed architecture is proposed as a solution for the increased number of users, solving the previous discussed problem with the deployment of edge routers across the IP backbone. The benefits of implementing this architecture are the following:

- content peering across the infrastructure, enabling the content stored closest to the user to be delivered, thus minimizing bandwidth usage and providing content to a great number of users
- load balancing traffic across servers
- optimizing the distribution of streaming video and static Web content
- personalizing wireless content for certain subscribers

Scaling of distributed architecture with supported and complementary nodes (such as encoding system, storage, etc.) enables not only the increasing number of multimedia services users, but also provides users with guaranteed QoS, compelling content, attractive applications and open access to Internet community, as well as content and applications providers with high quality secured content and billing mechanisms.

VI. RELATED WORK

In the research industry a lot of work has been done, and still companies are searching for ways to improve streaming technology. The keys of improvement streaming media quality lie in unused bandwidth, intelligent routing and better compression [15]. One way to accomplish this is to use unused transmission capacity to buffer additional data that could in the case of Internet congestion or dropping of connection help the system to display the stored data, thereby avoiding its interruptions. In another development [15], software with dynamic intelligent routing has been made to avoid packet loss and delays due to the Internet congestion. New data compression technique that divides and classifies video files based on actual images rather than on data blocks has been created, saving time and eliminating the need to encode and decode object descriptions, and what is most important, reducing the actual amount of data transmitted. The related articles [5] [11] [16] deal with the latest research of reliable transfer of media over Internet and new data compression methods, problems and challenges of streaming multimedia content in 3G mobile communication systems, and innovative strategies for improvements of storage capacities, while saving network bandwidth, respectively.

VII. CONCLUSION

This paper briefly described Media on Demand functionality together with problems concerning its implementation in 2.5G and 3G mobile communication systems as introduction to case study of integrating MoD solution into the existing Ericsson Mobility World Croatia lab network infrastructure. The trial version of MoD solution will be installed in the lab, enabling the functionality needed for testing and demonstration purposes. The main purpose of this trial version will be to experiment and test potential mobile multimedia applications and demonstrating capabilities of the platform for commercial use. Finally, the planned layout of the lab for the year 2003 has been proposed, as well as benefits and limits of implementing this solution. In other sections, scenarios of deployment of MoD solution at the operator's side have been discussed and finally related work with the latest research in this area has been presented.

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