The ADAMANTIUM Multimedia Content Management System for Real Time Cross-Layer Adaptation of IPTV and VoIP Services over IMS

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Abstract

IMS entails novel business opportunities for pioneering and emerging multimedia services, such as IPTV and VoIP video call applications. However, this strong commercial interest on this promising convergent IMS environment is balanced by the lack of efficient user/customer-centric network management mechanisms. ADAMANTIUM proposes an IMS-compatible Multimedia Content Management System (MCMS) focused on performing dynamic cross layer adaptations for optimization of the user experience in terms of perceptual quality for media services. This multimodal management system will be applied in an integrated and coherent way along all the network layers and delivery-chain nodes based on a user/customer-centric approach rather than a typical engineering one.

Keywords: IMS, PQoS, VoIP, IPTV, Video.

1. Introduction

Fixed/mobile convergence is a massive trend that requires adequate network and service infrastructures. One of the visions of this trend is that services will be sold in a consumer mass market based on the provision of content at a requested quality, exploiting the Perceived Quality of Service (PQoS) concept [1]. The evaluation of the PQoS for multimedia content that have variable bandwidth demands, will provide a user with a range of potential choices covering for example the possibilities of low, medium or high quality levels, indication of service availability and costs. However, the IMS infrastructure [2-3] –the most promising platform for the convergence- currently does not consider any Perceived QoS-aware management mechanism within its service provision management system, eliminating its traffic policies to the UMTS SBLP, which is a typical traffic differentiation mechanism that classifies the service bearers to different classes with specific QoS constraints.

In this brewing environment, ADAMANTIUM project, going beyond the current state-of-the-art and paving the way to the future interaction between Multimedia Services and IMS, proposes an extension of the IMS management capabilities through PQoS-aware mechanisms. More specifically, it is introduced the concept of PQoS awareness into the current IMS management system, towards which the whole traffic engineering is not performed abruptly, but with scope the PQoS optimization at the user terminal.

More specifically ADAMANTIUM proposes an IMS compatible PQoS-aware multimedia content management system, which in case of possible distorted playback of the multimedia service at the users terminal, will be able to dynamically and in real time adapt the various NQoS parameters across the layers (i.e. service, network and link) of the network delivery chain (i.e. service generation, delivery and consumption) with scope the optimization/maximization of the delivered PQoS level and as such not interfering with the end-user experience of the content being consumed [4]. Moreover, the proposed management system does not only improves abruptly the delivered PQoS level but it performs a sophisticated reallocation of the occupied resources in order to keep the total traffic of the bearer constant, indicating that the proposed management system uses more efficiently the already utilized resources, without requesting/spending more resources in order to perform the PQoS optimization.

Hence, the marketing perspectives of the ADMAANTIUM MCMS are multidimensional creating new and sustainable market opportunities based on converged business models between the telecom, the content and the consumer industries.

From the operator's aspect, ADAMANTIUM manages more efficiently the allocated resources to the adapted services without altering the total service/bearer bit rate, providing therefore an optimal trade-off between service quality provision and resource consumption.

From the customer's perspective, which pays for gaining access to a specific media service, ADAMANTIUM enhances and maximizes the user experience in terms of perceptual constraints without any extra cost or charge. Therefore, ADAMANTIUM adds value to the promotion of the emerging multimedia services over an error prone environment, reassuring a cost-effective and perceptually acceptable service reception.

Following this introductory section, the rest of the paper is organized as follows: Section II describes the ADAMANTIUM overall architecture, Section III presents the proposed Multimedia Content Management System (MCMS) and Section IV describes the encoder architecture of the proposed framework. Finally Section V concludes the paper.

2. ADAMANTIUM Overall Architecture

Figure 1 depicts the overall architecture of ADAMANTIUM project. It comprises of:

- The ADAMANTIUM Multimedia Content Management System (MCMS) Module, which is the main project entity and focuses on monitoring the network statistics (i.e. core, access, terminal), the service generation (i.e. Media Server Resource Function (MSRF), VoIP terminals) and the service perceptual level at the end-user terminal in order to define and apply an optimal cross layer adaptation action across the delivery network chain and media lifecycle (i.e. service generation node, core network, access network and end-user terminal) for maximizing the user satisfaction.

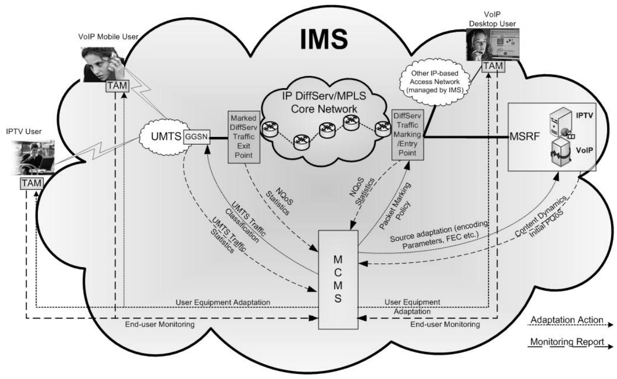

Figure 1. The overall architecture of ADAMANTIUM

- § The ADAMANTIUM Multimedia Server and Resource Function (MSRF), which is an IMS-based MRF module with an additional threefold responsibility:
  - The IPTV service generation, session management and service streaming.
  - The VoIP service session management and signaling.
  - The monitoring of the spatial and/or temporal content dynamics along with the selected encoding/streaming parameters
  - The adaptation, according to the MCMS commands, of the IPTV encoding parameters and/or the respective FEC value.
- § IP Core – DiffServ/MPLS Core Network

  ADAMANTIUM considers a DiffServ/MPLS-enabled core network for the delivery of the requested multimedia service. The MCMS will be equipped with compatible modules and interfaces for the packet marking and traffic monitoring at the edges of the DiffServ/MPLS traffic network, considering all the core network nodes (i.e. routers) as inter-cooperated and capable of treating appropriately marked traffic by the corresponding DiffServ/MPLS mechanisms, without being necessary any further configuration by the IMS/MCMS.
- § The UMTS Access Network

  At the access side a UMTS access network is considered, which provides service/bearer classification mechanisms for providing QoS constraints on the delivered service type (e.g. video, voice, data, etc). ADAMANTIUM project will exploit these classification mechanisms of the GGSN in its sophisticated PQoS-aware cross layer adaptation procedure with scope the perceptual optimization of the delivered service. Moreover, in order to support interactive multimedia services, the Multimedia Broadcast/Multicast Service (MBMS) infrastructure will be considered as an extension to the typical UMTS architecture, which provides an uplink channel for the provision of interactive and bidirectional applications.

§ The ADAMANTIUM Terminal Adaptation Module (TAM). At the PQoS-enabled user terminals (e.g. 3G mobile handset, SIP voice/video phone (hardphone or softphone), PDA) a TAM will be integrated, which enables the terminal's interaction with the appropriate interfaces/modules of the MCMS. ADAMANTIUM concept aims to be applicable to a mass market of mobile terminal devices and therefore the TAM technical requirements will be minimal in order to be straightforward applicable to future commercial mobile handsets.

There are two functions associated between the MCMS and the TAM of the PQoS-enabled user terminals:

- § Adaptation function: according to the control command/parameters received from the MCMS, the PQoS-enabled user terminal adapts on the fly its VoIP/Videocall codec, encoding bit rate or mode, packetization scheme (e.g. numbers of frames in a packet) and jitter buffer size (or buffer algorithm if required), aiming at end-to-end perceived quality improvement.
- § Monitoring function: reporting delivered PQoS (e.g. MOS score for voice and video) and relevant terminal parameters (e.g. codec type, bit rate, encoding mode, packetization parameters) to the MCMS module. These parameters are obtained by the TAM interface, which is implemented in the terminal device.

When the monitoring PQoS value at the mobile terminal remains for a specific temporal duration below a pre-defined perceptual threshold, a PQoS alarm will be triggered back to the MCMS, which will in turn initiate the sophisticated ADAMANTIUM cross layer adaptation procedure. This pre-defined perceptual threshold corresponds to the lowest acceptable perceived quality level and is dependent on the application/service type and the user profile

Towards minimizing false initiations of the adaptation procedure, combined PQoS and CNR statistics will be considered into triggering this PQoS feedback mechanism. Perceptual subjective studies will be exploited for defining the optimal theoretical and statistical trade-off between the monitored perceptual degradation, its temporal duration and the respective CNR (Carrier-to-Noise Ratio) value.

Finally, it is essential to stress on the inter-dependent dynamic cross layer nature of the proposed adaptation by the MCMS module, according to which the adaptation actions are performed without altering the total traffic of the service bearer. Towards this, considering an adaptation at the media server (e.g FEC change) in order to enhance the service robustness and subsequently the delivered PQoS level, then a respective adaptation of the encoding/streaming parameters must be also considered in order to retain constant the total service bit rate. Thus, the MCMS will dynamically and inter-dependently adapt all the relative QoS-related parameters at every step of the media lifecycle (i.e. from the service generation to content consuption), following a cross layer method (i.e. from the service to link layer), in order to maximize the delivered PQoS level with simultaneous maintenance of the total service/flow/bearer traffic. This action is essential for compatibility issues between the proposed MCMS and the current IMS infrastructure.

3. The Multimedia Content Management System

The ADAMANTIUM project is based on a Next Generation Network IMS infrastructure and aims at developing within this NGN environment an integrated PQoS-aware management system, which will be able to maximize in real time the end user satisfaction for the cases that PQoS degradation is noticed. This system is called Multimedia Content Management System (MCMS) and will perform dynamic and content dependent cross layer adaptation techniques across the multimedia network delivery chain.

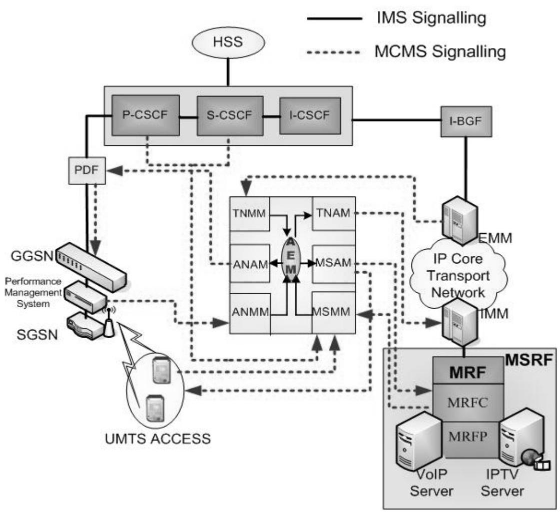

Figure 2. The ADAMANTIUM MCMS and NGN IMS architecture

The MCMS is the central entity of the proposed PQoS-aware and user-centric ADAMANTIUM IMS architecture that will seamlessly communicate with the already existing IMS modules and interfaces. Thus, MCMS will be fully IMS compliant, composed of modules based on IMS signaling (preferably SIP/SDP, although Diameter will be also considered) for communication, processing and interaction with the rest IMS modules and interfaces, although IMS Diameter will also be possible. Figure 2 depicts the overall architecture of the proposed MCMS within the IMS-native components, their signaling relations and interactions.

According to figure 2, the IMS Application Servers (AS) for IPTV and VoIP applications are hosted within the Media Resource Function (MRF), which executes IMS applications and services by manipulating SIP and SDP signaling for interfacing with other systems. ADAMANTIUM project considers that MRF and AS modules are combined into a single entity, which will be called as Media Server Resource Function (MSRF). The MSRF, besides being a media server, provides mechanisms for bearer-related services such as conferencing or bearer transcoding, through a controller (MRFC) and a processor (MRFP) in compliance with the MCMS decisions.

The HSS (Home Subscriber Server) is the master user database that supports the IMS network entities that are actually exploited by the CSCF modules for handling the calls/sessions. The HSS contains the subscription-related information (user profiles), performs authentication and authorization of the user, and can provide information about the physical location of user.

The control layer of the IMS infrastructure consists of nodes for managing call establishment, management and release, which are called Call Session Control Functions (CSCF). The CSCF inspects each SIP/SDP message and determines if the signaling should visit one or more application servers en route to its final destination. More specifically, the CSCF is a distributed entity comprised of three different components:

§ The Proxy CSCF (P-CSCF), which acts as the entry point for any service invocation within IMS and grants appropriate access rights after successful user authentication. The P-CSCF is tasked to relay session and media related info through Diameter protocol to the Policy Decision Function (PDF) when the operator wants to apply Service Based Local Policy (SBLP). Based on the received information the PDF is able to derive authorized NQoS information that will be passed to the GGSN when SBLP is applied.

§ The Interrogating CSCF (I-CSCF) acts as a topology-hiding gateway between the P-CSCF and the S-CSCF, by determining the S-CSCF or the AS to which an end-user should register. I-CSCF is a contact point within an operator's network for all connections destined to a subscriber of that network operator. The I-BGF (Interconnection Border Gateway Function) will be also used as gateway to IP networks, providing NAT and Firewall functions;

§ The Serving CSCF (S-CSCF) is responsible for key routing decisions as it receives all the User Equipment (UE)-originated and UE-terminated sessions and transactions. Therefore it is also responsible for handling registration processes, maintaining session states and storing the service profiles.

In this multimodal management environment the MCMS modules comes to enhance the current IMS management capabilities by adding real-time dynamic cross layer adaptation procedures for providing end-to-end perceptual optimization and therefore maximization of the user experience.

The MCMS architecture will be based on a central decision module, the Action Engine Module (AEM), responsible for taking optimal adaptation decisions based on the monitoring of network and perceptual statistics, gathered by IMS-based (preferably SIP/SDP-based) monitoring and adaptation modules. Afterwards, the AEM exploiting theoretical mapping frameworks between NQoS and PQoS will process all the selected statistics and define a perceptually optimal cross layer adaptation action.

More specifically, for monitoring purposes the following modules are considered:

- Multimedia Service Monitoring Module (MSMM)

The MSMM performs monitoring of the service session through the P-CSCF and S-CSCF modules of the IMS. This is the only module of the MCMS that is activated when a service is requested; whilst all the rest remain in idle mode until the active adaptation procedure starts. Then, the MSMM, except from simply informing the MCMS for the liability of the service, monitors the PQoS and CNR values at the end-user mobile terminal device, while at the service generation site, the content dynamics and the encoding parameters are also monitored through the TAM of the terminal device.

- Transport Network Monitoring Module (TNMM)

The TNMM module is used during the dynamic cross layer adaptation procedure for monitoring network statistics like packet loss, jitter, delay etc. at the DiffServ/MPLS core transport network. Towards this, the appropriate External Marking Modules (EMM) interface will be developed and integrated at the egress edge router of the core transport network for enabling interaction and communication with the TNMM of the MCMS.

- Access Network Monitoring Module (ANMM)

The ANMM module monitors the UMTS access network statistics, based on the exploitation of historical data, which are updated in near real time by the UMTS performance management system at frequent time periods.

For adaptation purposes, MCMS considers the following modules, through which the optimal adaptation actions for PQoS optimization are applied:

- Multimedia Service Adaptation Module (MSAM)

The MSAM performs adaptation actions at the end-user terminal device and at the service generation entity (i.e. the MSRF for IPTV services or the end-user terminal for VoIP applications) relative to the decoding (i.e. buffer scheme) and encoding (bit rate, packetization etc.) parameters, as well as FEC value adaptation towards enhancing the error resilience of the delivered service

- Transport Network Adaptation Module (TNAM)

The TNAM applies the adaptation actions to the DiffServ/MPLS-enabled core transport network through the Internal Marking Module (IMM), which will be developed and integrated at the ingress router of the core network. The IMM receives the adaptation actions from the TNAM and translate them to DiffServ/MPLS compatible commands, which are finally applied by marking appropriately the incoming traffic.

- Access Network Adaptation Module (ANAM)

The ANAM applies the adaptation actions, decided by the AEM of the MCMS, to the UMTS access network through the IMS PDF module. The PDF in turn applies them at the GGSN by performing service bearer classification in order to improve its QoS characteristics and therefore enhance the delivered PQoS level.

A. MCMS Interaction with Access Network Modules

At the access network, UMTS offers tele-services and bearer services by supporting both connection-oriented and connectionless services for Point-to-Point and Point-to-Multipoint communication. The proposed architecture will focus on the packet switched elements of UMTS, such as the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN).

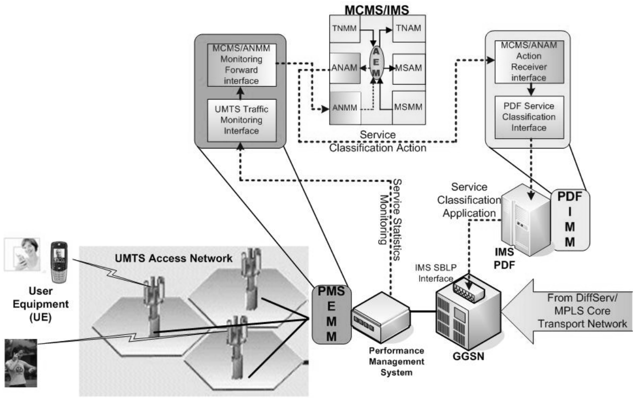

Figure 3. The ADAMANTIUM Access Network Architecture

Figure 3 depicts the proposed Access Network architecture, where monitoring and adaptation activities will be focused on extending the existing IMS Service Based Local Policy (SBLP) mechanisms at the access domain by specifying and developing the appropriate interfaces for communication between i) the ANAM/MCMS and the IMS/PDF ii) the ANMM/MCMS and the UMTS Performance Management System (PMS).

More specifically, for monitoring purposes it will be specified the UMTS External Monitoring Module (EMM), which will interact using IMS-based messages (e.g. SIP/SDP) with the UMTS PMS for providing near real time access network statistics to the ANMM/MCMS. Similarly, for adaptation purposes the PDF Internal Marking Module (IMM) will be developed for communication between the ANAM/MCMS and the IMS/PDF entity, through which the traffic/service classification will be applied to the GGSN, based on the existing IMS SBLP differentiation mechanisms.

B. MCMS Interaction with Core Network Modules

Similarly, it will be designed, developed and demonstrated a core network architecture, which mixes the capabilities of Differential Services and Multiprotocol Label Switching technologies with final scope the best efficiency of a network which carries IPTV and VoIP services. Towards this, the typical DiffServ/MPLS network architecture will be enhanced by integrating them with the MCMS/IMS adaptation procedures, which will enhance the policy decision mechanisms by considering PQoS-aware traffic classification.

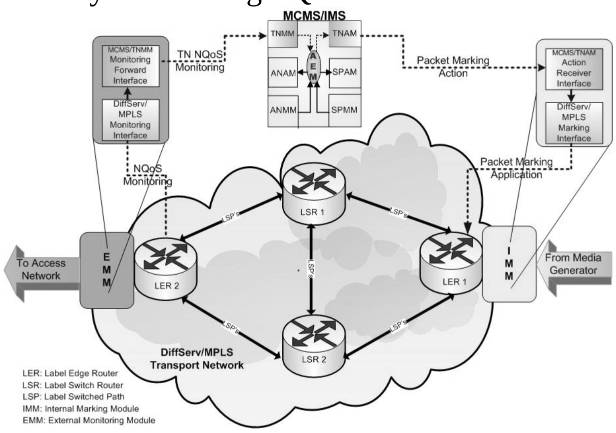

Figure 4. ADAMANTIUM DiffServ/MPLS Core Network Architecture

Figure 4 depicts the proposed DiffServ/MPLS transport network architecture where the DiffServ/MPLS Internal Marking Module (IMM) and DiffServ/MPLS External Monitoring

Module (EMM) modules will be developed for the interaction between the MCMS relative modules (i.e. TNMM and TNAM) and the DiffServ/MPLS ingress and egress routers.

Once the AEM of the MCMS has determined a specific adaptation action for improving/optimizing the delivered PQoS level, then regarding the DiffServ/MPLS transport network, the appropriate IMS-based (e.g. SIP/SDP-based) adaptation action is forwarded from the TNAM/MCMS module to the MCMS/TNAM Action Receiver interface of the Internal Marking Module (IMM), which initially translates the received adaptation action into standard DiffServ/MPLS classification commands. These translated actions are further forwarded to DiffServ/MPLS Marking interface of the IMM, which applies them into the ingress router (i.e. LER 1) of the transport network, where the actual packet marking and traffic classification is performed through the relative labels of the incoming traffic.

Then the marked/classified media flow is treated appropriately by the mechanisms of the DiffServ/MPLS-enabled Label Switch Routers (LSRs) across the transport network, minimizing –according to the characteristics of each traffic class- the effects of the network delay, packet loss etc. on the streaming flow of the IPTV/VoIP service.

At the other end, where the media flow exits the core-transport network through the egress router (i.e. LER 2), the External Monitoring Module (EMM) will calculate network -related statistics about the jitter, packet loss etc of each classified flow. These NQoS-related statistics will be calculated by the DiffServ/MPLS Monitoring Interface of the EMM and afterwards they will be forwarded to MCMS/TNMM Monitoring Forward Interface, which translates them into MCMS-compliant form and finally reports them into the TNMM module of the MCMS. According to the reported statistics from the TNMM, and taking under consideration the monitoring statistics from the MSMM and ANMM, the AEM/MCMS will decide the optimal adaptation action for improving the PQoS level of the delivered IPTV applications.

C. MCMS Interaction with MSRF and Terminals

The adaptation of the multimedia content according to the changing usage environments during the service delivery is becoming more and more important, because the characteristics of the environment (e.g., Quality of Reception) are varying during the consumption of the multimedia service. Thus, immediate actions are needed to be performed in order to enable a unique, worthwhile, and seamless multimedia experience during the entire session. These actions are usually referred as dynamic multimedia content adaptation.

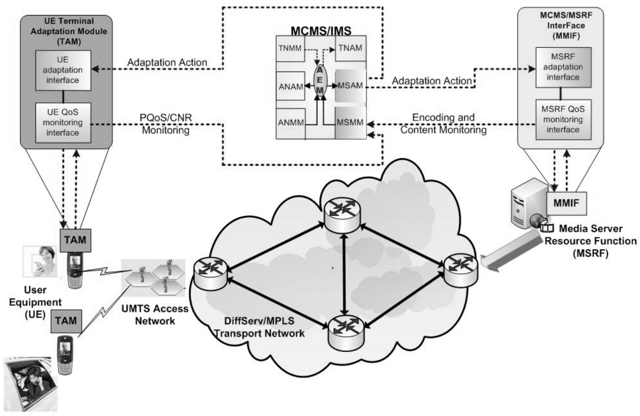

Figure 5. The Modules Interaction for IPTV Service Adaptation

To this end, for realizing these service adaptation tasks, the MCMS needs to interact with the two end-point entities: the MSRF and the Terminal Adaptation Module (TAM) of the

User Equipment, for adaptation actions and PQoS monitoring. Figure 5 depicts the overall interaction mechanism for the case of IPTV service adaptation. When the MCMS is running in active mode, specific sub-modules/interfaces of each entity are in charge of performing these tasks:

- At the MCMS side, the two sub-modules having a specific role for service adaptation are:
  - The MSMM (Multimedia Service Monitoring Module), which receives the MS PQoS, CNR, content dynamics and the encoding statistics monitoring information from both the MSRF and the TAM of the end user.
  - The MSAM (Multimedia Service Adaptation Module), which forwards the MS adaptation actions to be undertaken by the MSRF and/or TAM according to the AEM PQoS-aware adaptation decision.
- At the UE and at the Media Server sides, two different interfaces are introduced for interacting with the MCMS and acting accordingly for the service adaptation and monitoring:
  - The Terminal Adaptation Module at the User Equipment (UE/TAM)
  - The MSRF/MCMS InterFace (MMIF) located at the MSRF

The UE/TAM interface is a hybridic interface installed on the end-user mobile handset, performing either monitoring or adapting actions, where the monitoring includes the PQoS for the delivered video quality of IPTV and the CNR value, indicative of the quality signal reception at the physical layer and the adaptation is relative to the coding adaptation for VoIP services Towards performing this monitoring and adaptation actions both UE/TAM and MSRF/MMIF are similarly equipped with an adaptation and monitoring module/interface: The UE/MSRF Adaptation interface and the UE/MSRF PQoS Monitoring Interface respectively, as it is exactly depicted in figure 6. The communication internally between these modules and externally with the MCMS respective MSMM and MSAM modules is performed based on SIP/SDP messages, similarly as it is specified for the rest IMS interfaces/modules, providing compatibility and operability of the MCMS modules and interfaces with the existing IMS infrastructure.

4. Encoder/Decoder of the MSRF for IPTV and VoIP applications

For performing multimedia adaptation and monitoring actions within the multidiverse IMS environment, there is a need for designing, specifying and developing an enhanced IMS compatible encoder server, which will be act as part of the MSRF, and a decoder terminal. The ADAMANTIUM project will develop a complete architecture of encoder/server decoder/terminal, targeting towards the best multimedia (IPTV/VoIP) service adaptation according to the monitored PQoS constraints.

Figure 6 depicts the ADAMANTIUM Encoder/Server – Decoder/Terminal architecture along with the respective adaptation modules for both IPTV and VoIP applications. At the server side, according to the requested PQoS adaptation and the content dynamics, the optimal rate control and the packetization scheme is specified. In this respect the encoder module performs the encoding/compression alteration of the content. Respectively, the rate shaper receives the relative dynamics metadata in order to prepare the encoded bit stream for optimal packetization and streaming. Thus, ADAMANTIUM will take under consideration the content dynamics in the temporal and/or spatial domain of the requested service in order to specify the optimal adaptation actions. The quantification of the content dynamics will be performed according to the ITU P.910, 1999 document, which specifies the Spatial Information (SI) and Temporal Information (TI) metrics for determining the perceptual spatial and temporal dynamics of the content, along with other encoding related parameters such as INTRA-coded MacroBlocks per frame for encoded video signal.

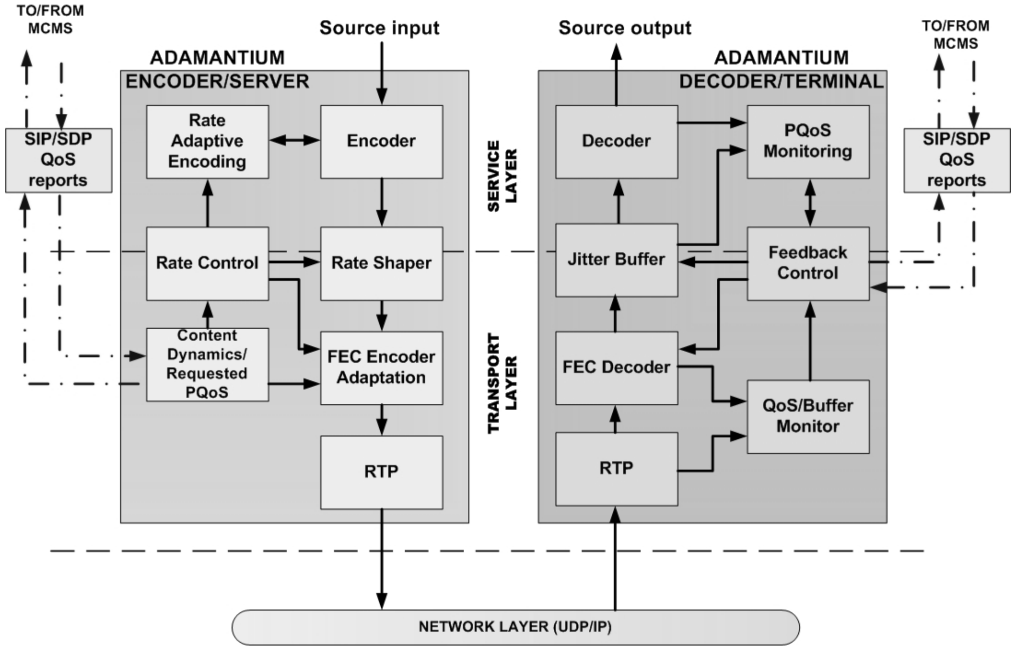

Figure 6: ADAMANTIUM encoder/decoder of the MSRF for IPTV and VoIP services.

According to the received IMS-based QoS reports (preferably SIP/SDP-based) with respect to the content dynamics and the requested PQoS level, a FEC encoder adaptation will be also performed before the packetization and the actual streaming of the service. This FEC adaptation will be performed in harmony to the rate control module, in order the total service bit rate to remain constant at the initial level.

At the client end-user side the de-packetization is performed at the transport layer in agreement with the QoS/Buffer status. Then, the received de-packetized encoded bit stream is driven to the FEC decoder, which reconstructs the received encoded video signal. A jitter buffer module is used in order to normalise the arrival rate of the stream and therefore to minimize the effects of the perceptual degradation caused by asynchronous packet reception. This module reports also to the PQoS monitoring module about the PQoS status of the received service, which in turn sends IMS-based QoS reports (preferably SDP and SIP based) back to the server, through the MCMS module.

ADAMANTIUM does not simply perform an abrupt adaptation of the aforementioned parameters, but ADAMANTUM adopts a sophisticated adaptation procedure, targeting the optimization of the delivered PQoS level and the maintenance of the total service bit rate constant.

A. IPTV/Video Services and Adaptation

IPTV (Internet Protocol Television) describes a system where a digital television service is delivered using the Internet protocol over a network infrastructure. For residential users, IPTV is often provided in conjunction with Video on Demand (VoD) and may be bundled with Internet services such as Web access and Voice over IP (VoIP).

There are two different types of IPTV services, as seen by the major actors in the domain:

- Live IPTV for mass distribution, which is multicasted to a large number of users;
- VoD IPTV for personal usage, unicasted to the proper user.

These two IPTV service categories have different contraints and their adaptation will be made differently in the context of the ADAMANTIUM project.

For VoD IPTV services, each user receives a dedicated stream, composed specifically for him. Therefore, an adaptation of the service can be established accordingly on-the-fly for each user, depending on the required action established by the AEM of the MCMS, e.g. spatial resolution, decoding capacities, etc. Towards this, at the service distribution side, at the MSRF, ADAMANTIUM will adjust the delivered video stream according to the required actions sent by the MSAM to the encoder/MSRF adaptation interface (i.e. '*Content Dynamics/Requested PQoS'* module in Figure 7). Consequently, for the VoD service delivered per user, the MCMS will be in charge of informing the MSRF how to adapt the content according to the retrieved user terminal PQoS. For each VOD stream requested, the MCMS will inform the MSRF of the adaptation to be processed.

For Multicast IPTV services, the situation is completely different since one stream is delivered to multiple users and it cannot be adapted to the requirements of only one/single user. Considering a multicast IPTV session, then a specific number of users is considered, who have joined the multicast session, will watch the specific service. Once the video streaming process has been taken place and it is transmitted, the users' mobile handsets measure in real time the delivered PQoS level and the respective signal quality reception at the physical layer (e.g. CNR). If for a specific duration the viewing conditions are degraded, then a PQoS alarm is reported from the TAM of each user terminal back to MCMS. Therefore the users of a multicast session may be conceptually classified to two groups: The one group experiences good perceptual quality and therefore PQoS alarm has not reported, while the other group contains users experiencing poor perceptual quality, who have already reported to the MCMS poor playback through the PQoS alarm.

The AEM MCMS, being in idle mode, passively monitors the multicast session and collects the received PQoS alarms. MCMS will switch to active mode for this multicast session when the number of the received PQoS alarms (disatisfied users) becomes more than a specific percentage (e.g. 20% of the total users), which will be researched and experimentally specified. Then, the dynamic cross layer adaptation procedure is triggered in order to improve the delivered end-to-end PQoS level for all the users, who watch the specific multicast session.

The IPTV services that will be deployed in the ADAMANTIUM project will demonstrate and evaluate both Live multicast IPTV and unicast VoD IPTV, as well as their corresponding adaptation mechanisms. A complete IPTV architecture will be deployed in the framework of the project, using IGMP and RTP in conjunction with SIP/SDP-based signalling for overall IMS compliance and operability. The ADAMANTIUM project will study the possibility to merge all the signalling functionalities into a global SIP/SDP framework examining the case of enhancing current SIP/SDP protocol by including ADAMANTIUM PQoS-related fields in their packet headers.

The video quality evaluation during the reception of an IPTV service will be based on a light assessment tool, which will be based on mapping NQoS-statistics collected from the mobile terminal (i.e. BER) to perceived quality. More specifically, partner Vodafone will significantly contribute into integrating this software-based assessment tool to commercial mobile phones running Symbian or Windows Mobile OS, helping towards the ADAMANTIUM vision for commercial exploitation of its results. Towards developing this tool, partner Vodafone will exploit the experience of its participation to the IST project MOTIVE, which examined –among others- similar issues about PQoS-evaluation tools at the mobile terminals.

All these initiatives break the strict limitation for exploitation of the ADAMANTIUM results by pushing forward adopting the ADAMANTIUM concept and techniques to the wide communication market.

B. VoIP Applications and Adaptation

VoIP (Voice over Internet Protocol) is a modern technology for delivering voice call over IP networks. The concept of VoIP has now been extended from voice to voice/video over IP. A voice/video call can be from a mobile handset (e.g. a 3G handset) to a SIP voice/video terminal (a softphone or a hardphone), or to a voice/video phone connected to a PSTN/ISDN network via a voice or multimedia gateway. In this project, we focus on voice/video call application between a mobile handset and a SIP voice/video terminal (a softphone or a hardphone) and we will demonstrate its application in PQoS-aware IMS-compatible MCMS system.

In VoIP applications, it is crucial for equipment providers, network operators and service providers to assess, predict, and possibly control the end-to-end perceived voice/video quality for commercial and technical reasons. The most widely used end-to-end perceived voice/video quality is the Mean Opinion Score (MOS) at a five-point scale ranging from 5 (excellent) to 1(bad). MOS score can be for one-way listen-only quality or for conversational quality which takes into account interactivity. For a listen-only MOS score, end-to-end delay can also be taken into account for interactivity consideration. Standardisation bodies such as ITU-T have standardised some objective voice quality measurement algorithms such as ITU-T P.862 Perceptual Evaluation of Speech Quality (PESQ) for measuring listening-only voice quality by comparing a reference speech with a degraded speech and ITU-T G.107 (E-model) for predicting conversational voice quality from a set of network and terminal parameters (e.g. codec type, packet loss rate, end-to-end delay).

The MOS score obtained from PESQ has been used widely in industry for assessing whether a terminal device (e.g. a mobile phone) or a network/link can deliver satisfactory voice quality (e.g. MOS score over 3.5 for a mobile terminal). As PESQ is an intrusive measurement which requires an injection of a test signal/speech into the tested system/network, it cannot be used for live network monitoring. E-model based methods such as VQMON will be used in ADAMANTIUM as a lightweight monitoring tool embedded in the end-user mobile terminal to predict in real-time the voice quality during a call. However, such kind of monitoring tool is only used to predict the quality for a VoIP application, it has not been used in any control scheme to adapt a terminal or network mechanisms/parameters to achieve optimum end-to-end voice/video quality. Current VoIP terminals (such as a 3G handset) can only set a fixed bit rate within a selected codec (e.g. a fixed 12.2 Kb/s AMR (Adaptive Multi-Rate) codec) without adaptation of codec type and bit rate.

In ADAMANTIUM, an E-model-based monitoring tool will be used to predict voice quality in a VoIP terminal. The terminal can adapt its codec type (e.g. AMR, iLBC, G.723.1, EVRC (Enhanced Variable Rate Codec)), bit rate (e.g. any bit rate within AMR's 8 bit rate modes from 4.75 Kb/s to 12.2 Kb/s), packet size (e.g. numbers of speech frames in a packet) at sender side, and jitter buffer size, buffer algorithms at receiver side, according to control command/parameters from the MCMS system. If voice priority marking is used (e.g. the beginning of a voiced segment is perceptually more important than other parts of the speech segment, thus it can be marked as high-priority frames), the length and number of high-priority frames will be also examined within ADAMANTIUM as a parameter for control. The adaptation of terminal parameters on-the-fly during a call should react promptly to performance degradation due to network congestion in order to achieve a satisfactory end-to-end perceived voice quality.

Similarly for video call applications, a V-model (similar as E-model for voice) will be used to predict video quality in a VoIP terminal. Video encoding parameters such as bit rate, frame rate and resolution can be adapted on-the-fly during a video call to control end-to-end video quality.

5. Conclusions

Being harmonized with market needs, ADAMANTIUM will create the conditions for a new generation of media technologies, providing significantly higher performances through PQoS-aware dynamic cross layer adaptation techniques in the IMS infrastructure. By enhancing the existing IMS purely engineering management techniques with intelligent and flexible cross layer adaptation methods, higher performance at the provision of a new generation of media services will be offered.

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