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QUALITY OF SERVICES IN INTEGRATED UMTS/IP NETWORKS

ABSTRACT

Fast development and implementation of new telecommunication services and Intelligent Transport Systems (ITS) have created new environment for the network telecom operators and service providers and logistic and transport enterprises. The crucial issue for successful business and other professional applications is the provision of the end-to-end quality of service in the inter-network operation of mobile and fixed networks. The problem was less expressed in the traditional networks oriented to telephony, but the issue of different QoS algorithms grows with the spreading of data transmission services and multimedia applications. The existence of different QoS algorithms and procedures in the IP-based networks (IP – Internet Protocol) also makes difficult the finding of a single solution for the implementation of QoS in the IP-based networks. In the indicated context this work systemically defines the problem of providing a single end-to-end QoS protocol in the connected UMTS/IP networks. The possibilities of its realization are presented on the example of two protocols. The work gives the basic characteristics of the two protocols that fulfil the criteria set in the realization of the new generation of mobile networks.

KEY WORDS

quality of service, mobile communication, IP protocol

1. INTRODUCTION

The problem of quality of services (QoS) in traditional mobile networks is mainly related to measurement parameters characteristic of voice communication: probability of call loss, probability of call blocking, propagation delay, etc. However, with the introduction of data transmission services and multimedia applications via mobile network, the problem of QoS provision becomes much more complex. In data transmission there is the requirement of satisfying additional criteria regarding reliability of transmission and possibilities of error-free transmission, etc. Various ITS applications set also additional requirements in accordance with the telecommunication architecture and selection of transmission media [1], [2].

The existence of various QoS algorithms and procedures in IP-based networks complicates the finding of a single solution for the implementation of QoS in connected UMTS/IP networks. This paper presents an overview of the problems and possibilities of insuring end-to-end quality of transmission in mobile telecommunication networks of the new generation based on IP. Special study is related to the solutions of the protocol which allow end-to-end quality of service in UMTS/IP networks [3], [4].

2. SYSTEMIC IDENTIFICATION OF PROBLEMS AND REQUIREMENTS OF THE GUARANTEED QoS INSURANCE

In accordance with the systemic identification of problem solving it is necessary for the identified problem to define the users' requirements and to develop systemic specifications on the basis of which new solutions will be developed or the existing ones combined in the area of technologically feasible solutions with adequate relations of prices and performances. The sequence and the methods of systemic analyses and syntheses are explained in the coursebooks and manuals of systemic engineering [1].

In the domain of solving the problem of insuring the guaranteed QoS in IP-based new generation mobile telecommunication networks five groups of problems may be identified:

1. The problems that refer to the physical layer, i. e. the linking possibilities. The restrictions in providing QoS on the transmission link (e. g. delay in establishing the connection) affect the end-to-end quality of service. If typical QoS parameters are analysed (delay, delay variation, magnitude of bit error, throughput volume) then the restrictions on the physical layer will affect an increase in overall end-to-end delay (which is always greater than the sum of delays on single links).
2. The problems in providing the transmission between adjacent cells. QoS parameters have to be within permitted limits in the handover period, so as to meet the requirements regarding end-to-end QoS.
3. The problems at the network level primarily refer to IP infrastructure and the need for stricter limitations regarding QoS, especially regarding requirements for real-time transmission and the related QoS guarantees.
4. The problems in management include the management of a connected UMTS/IP network, as well as the possibility of configuring the network core elements and interface elements in order to fulfil the desired QoS requirements regarding fast reconfiguration on demand, control of the network hierarchical structure, etc.
5. The problem of network administration includes issues of users registration, as well as services and spent resources pricing. The issue of handover is related to the price of the service of a certain QoS level. Network efficiency is a parameter that is analyzed in every QoS "cost model". The pricing models are based on updating of information on the users traffic.

Unlike the networks of fixed topology, the implementation of the quality of services in mobile networks is additionally made difficult by the fact that the infrastructure networks and the available resources are variable and the users mobile. Also, in integrated UMTS/IP networks it is necessary to connect different administrative domains, and each was assigned a different QoS models, i. e. protocols. Having in mind the previously mentioned problems, it may be concluded that it is necessary to establish a single "end-to-end" QoS protocol which will simplify the procedure of insuring the guarantees regarding quality of services in the connected networks.

Implementation of end-to-end QoS protocols depends to a great extent on the fulfilment of the following assumptions:

- **Mapping of QoS parameters at the network level**. Differentiation of services based on the set of traffic classes requires the establishment of an efficient and reliable QoS mapping mechanism.
- **Dynamic QoS management.** It is based on dynamic QoS control and management, which means adequate monitoring of the network in accordance with the users requirements as well as dynamic monitoring and modification of the available QoS.
- **Selection of control and management mechanisms.** The measure has to provide QoS management via a set of own management mechanisms. These mechanisms should allow the establishment, maintenance and break of network QoS procedures.

Insurance of the desired end-to-end service quality in heterogeneous network structures requires the analysis of several components out of which the following are the most important ones: reservation of network resources, agreement with the users - SLA (*Service Level Agreement*), network management, transmission safety and pricing. For the unification of functional characteristics of these components it is necessary to define the model of unique end-to-end QoS protocol.

There are several protocol models that treat these problems. In the continuation the basic characteristics of the two protocols that insure the end-to-end QoS support are presented

3. PROTOCOLS FOR INSURING END-TO-END QoS SUPPORT

3.1. End-to-end QoS management protocol – *E2ENP*

"*End-to-End Negotiation Protocol*" (E2ENP) is a protocol of multimedia applications/sessions management, which includes functions such as authentication and security [1]. For the transmission of control data E2ENP uses SIP (*Session Initiation Protocol*). The descriptive model of the E2ENP protocol, based on XML (*Extensible Markup Language*), has been implemented for the specification of the system characteristics and QoS parameters based on the improvements of the *Session Description Protocol new generation* - SDPng.

The basic characteristic of E2ENP protocol is the possibility of quality of service management in different network types. Defining of the reference protocol model allows separation of two important segments: package transmission and insurance of concrete service. This model is used for the analysis of different aspects of QoS management within the global network architecture, and represents also the basis for differentiation of relevant system QoS parameters. Various devices in the network (terminals, routers etc.) are grouped into two domains: service domain and transport domain – transmission (Fig. 1).

Transport domain is responsible for package routing with QoS guarantee and includes all the control functions which insure QoS for IP packages. An example are the resource reservations via RSVP [5], package marking and filtering in DiffServ domains [6], etc.

Service domain refers to the aspects of multimedia services such as descriptions of session negotiation and possibilities for session initiation; authentication, authorization; accounting, auditing, charging - (A4C) security service functions, etc.

In order to complete the picture about the QoS relevant system parameters the user domain is introduced.

Within a reference model, the description of the service for a certain application is insured by the end system resource, which has usually been implemented within the terminal operative system (OS) or middleware, and is marked as EQM (End-system QoS-Management). EQM provides data on available resources and possibilities for multimedia information processing (type of audio/video devices, multimedia codec, etc.) as well as for the network transmission control (type of network device, currently available access network, signal quality, etc.).

The application can be reconfigured depending on the available resources via monitoring which is carried out in NM (Network Management) node and the results are sent to EQM. NM nodes control also the network resources access in accordance with: agreement with the provider (that is defined in SM – Service Management component), results of network resources monitoring, package routing regulations, etc. Within the network, the SM component participates actively or passively in the information exchange with the end system when multimedia session is established or adapted.

The described model allows definition of several types of QoS parameters:

- **End-to-end QoS parameters.** This set of parameters corresponds to the user perception about the application performance. These parameters are processed within the user domain (Fig. 1) and forwarded to the user via graphical interface for QoS requirement definition.
- **Application QoS parameters** are used for the description of the application performances in accordance with software and hardware resources of end systems/services. The adjustment of application QoS parameters with agreement specifications is determined within the network at the service layer within the service domain (Fig. 1).
- **Transport QoS parameters.** These enable the description of end-to-end requirements in accordance with the network resources – throughput volume, delay, jittering, etc. Defining and development of transport QoS parameters are related to data monitoring procedures and with transport mechanisms provided by the transport domain.

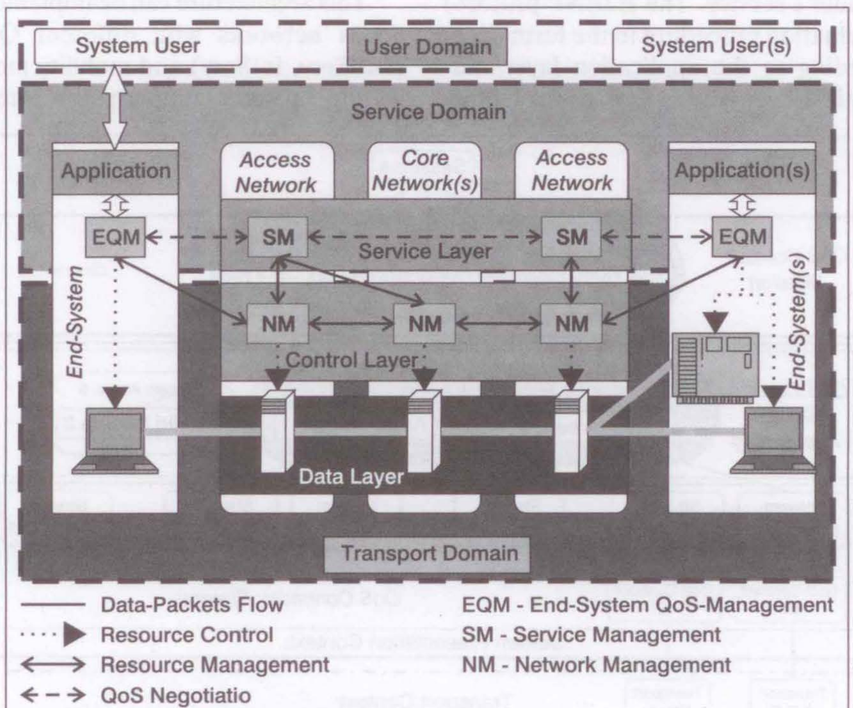

Figure 1 - Reference model of end-system QoS resources management [1]

These mechanisms are grouped into two functional layers – the data layer, responsible for package routing with respective QoS, design and classification of traffic, buffer management, and control layer, responsible for router access, reservation mechanisms and resources access control.

Mobile multimedia applications mean the control of various types of media (voice, video, data). Adequate traffic streams can be logically grouped on the basis of different dependencies and criteria, so that QoS specifications can be hierarchically modelled taking into consideration time synchronization, QoS correlation and resources.

The hierarchical model (Fig. 2) allows the design of alternative QoS specification, which is required by applications for automatic adaptation according to the available resources and user requirements. The E2ENP protocol model is represented in the form of a tree of QoS specifications. Parts of the tree represent respective alternatives in case of adaptation, called "QoS agreement". Here, the origin node defines the behaviour of a single stream in case of adaptation, whereas the next node ("QoS context") represents the description of the traffic streams group after adaptation.

The heterogeneous end systems exchange QoS data with the aim of determining the common set of parameters for the establishment and adaptation of a session. Each of these data that are used in the process of end-to-end QoS coordination has to be evaluated in relation to the user QoS requirements, end system resources and provider's service. The E2ENP protocol starts then the evaluation procedure in the form of requirements according to the application layer/middleware with the aim of generating QoS control information. Within this procedure, the application performs the mapping of application QoS parameters to the local system parameters, generating at the same time several alternative solutions which may be assigned to transmission QoS parameters. After that, the QoS configuration parameters are verified in relation to the service provider obligations. This verification can be performed in the local system or within the network as part of the QoS parameters exchange. Based on the previous activities, a set of valid QoS configuration data is obtained, which describe the complete set of systemic QoS parameters. These parameters can be adapted (depending on the choice of the access network and provider obligations) during the current session and thus it is possible to plan adequate activities in network management.

3.1. MARSP end-to-end QoS signalling protocol

Further, an overview of MARSP (Mobility-Aware Reservation Signaling Protocol) end-to-end QoS signalling protocol is given, which represents the architecture which provides the quality of service in the systems with different access networks, and integrates functions of resource management and network mobility, which is also one of the preconditions for fulfilling the requirements of the third generation networks [2].

It insures QoS in mobile IP-based networks with the following characteristics.

This architecture can be implemented in heterogeneous networks with different QoS requirements (DiffServ, IntServ) and mobility models [2]. The signalling protocol supports the integrated handover

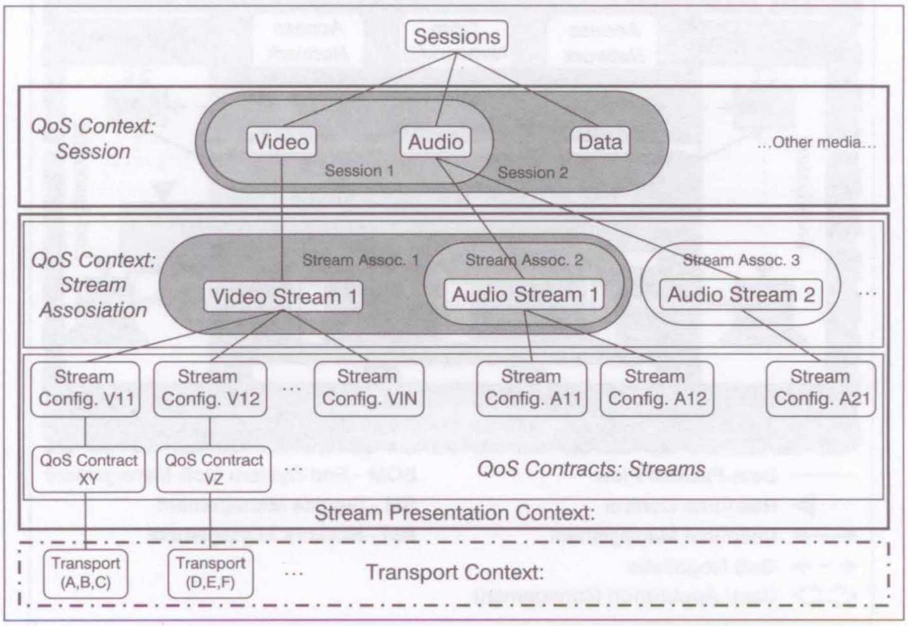

Figure 2 - Hierarchical model of QoS specification [1]

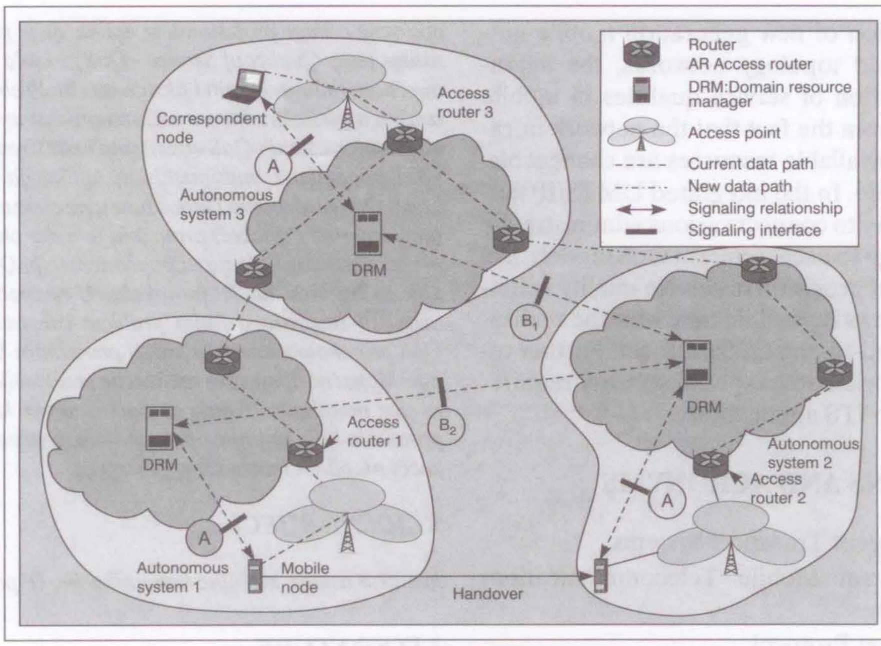

Figure 3 - QoS Signalling Architecture [2]

model which can be dynamically changed with the changes of conditions in the network.

At different locations different radio access networks (RANs) are used. Also, the represented architecture does not depend on the specific radio access technology.

In IP-based mobile networks, the access router (AR) insures IP connectivity to mobile nodes MN within domains, as presented in Figure 3. One AR can be connected to several access points (APs). These APs insure the connectivity of the connection layer with the radio transmitter and represent part of RAN. Every domain has a DRM (Domain Resource Manager) which controls all the resources at the IP level within the domain. This can be represented as a separate logical control entity. The actual implementation, of course, can use several distribution entities.

DRM determines the routing paths and reserves the resources for new access points within the observed domain or domains of one of the adjacent DRMs.

After having received the request for handover (Step 1), DRM looks for resources in the new domain (Step 2). After successful reservation (Steps 3a and 3b), the handover is realized.

If the node requires resources on the transmission path before being registered with the new AR, the packages will be transferred to the new path immediately upon receiving an appropriate QoS after handover.

The protocol architecture allows the separation into signalization for resource management and signalization for mobility management with the aim of achieving independence of different technologies. Resources management can be regarded as additional function which improves the traditional data transmission with "best effort".

As part of mobility-aware QoS architecture several logical interfaces are defined. Basically, the distinction is between signalization for resource management, mobility management and signalization at the application level. Direct signalization between applications can also be required with the aim of adapting the contents of their data stream to currently available resources. The exchange itself can follow due to handover, especially due to the connection of the wireless access technology (known as vertical handover).

During the QoS analysis, the decision on actual handover is made on the basis of two basic criteria:

- **Availability of signals.** In this case the parameters of radio transmission are analyzed such as e. g. signal-noise relation. Lower layers transmit information on the conditions and availability of radio-transmission to IP layer.
- **Availability of resources.** In the realization of handover, AR must insure resources that are sufficient to fulfil the mobile node QoS requirements

4. CONCLUSION

Using systemic analysis the work defines the problem and sets the requirements related to the provision of guaranteed QoS in the connected UMTS/IP networks. Five groups and requirements are identified for end-to-end QoS protocols. The basic characteristics of the two protocols that insure end-to-end QoS are described. These protocols fulfil the basic criteria set in the realization of new generation mobile networks. Unlike fixed topology networks, the aggravated implementation of service qualities in mobile networks results from the fact that the network infrastructure and the available resources are changeable, and the users mobile. In the integrated UMTS/IP networks it is necessary to connect various administrative domains, and assign to each different QoS models, i. e. protocols. Efficient provision of service quality in heterogeneous networks is possible only with the realization of a unique end-to-end QoS protocol. Further research should be oriented to special security requirements that refer to ITS applications.

ABBREVIATIONS AND ACRONYMS

ITS – Intelligent Transport Systems
UMTS – Universal Mobile Telecommunications System
IP – Internet Protocol
QoS – Quality of Service
SLA – Service Level Agreement
E2EN – End-to-End Negotiation Protocol
XML – Extensible Markup Language
SDPng – Session Description Protocol new generation
EQM – End-system QoS-Management
NM – Network Management
SM – Service Management
MARSP – Mobility-Aware Reservation Signaling Protocol
RAN – Radio Access Networks
DRM – Domain Resource Manager

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SAŽETAK

KVALITETA USLUGA U INTEGRIRANIM UMTS/IP MREŽAMA

Brzi razvoj i implementacija novih telekomunikacijskih usluga i Inteligentnih transportnih sustava (ITS) stvara novo okruženje za mrežne telekom operatore i davatelje usluga te logistička i transportna poduzeća. Ključno pitanje za uspješne poslovne i druge profesionalne aplikacije je pružanje kvalitete usluge (eng. Quality of Service - QoS) s kraja na kraj u međumrežnom radu mobilnih i fiksnih mreža. Problem je bio manje izražen u tradicionalnim mrežama orijentiranim na telefoniju, ali pitanje različitih QoS algoritama raste širenjem usluga prijenosa podataka i multimedijskih aplikacija. Postojanje različitih QoS algoritama i procedura u mrežama baziranim na IP (eng. Internet Protocol) protokolu također otežava pronalaženje jedinstvenog rješenja za implementaciju QoS-a u mrežama koje se baziraju na IP protokolu. U naznačenom kontekstu ovaj rad sustavno definira problem osiguranja jedinstvenog QoS protokola s kraja na kraj u povezanim UMTS/IP mrežama. Mogućnosti njegove realizacije predstavljeni su na primjeru dva protokola. U radu su date osnovne karakteristike dva protokola koja ispunjavaju kriterije koji se postavljaju u realizaciji mobilnih mreža nove generacije.

KLJUČNE RIJEČI

kvaliteta usluge, mobilne komunikacije, IP protokol

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