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QoS Requirements and Implementation for IMS Network

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***Abstract:** The issue of converged networks is to ensure the sufficient quality of services for entire duration of communication transmission. This issue is closely connected to real- time services, such as VoIP (Voice over Internet Protocol) and videoconferencing. These services require strict adherence to quality parameters, otherwise their function is not guaranteed. IMS (IP Multimedia Subsystem) resolves this problem in perticular, which concluded on the basis of user profiles can provide the required quality of service. In the latest specifications of the Universal Mobile Telecommunication System (UMTS) networks, the 3GPP defines the IMS technology. That is why the multimedia sessions in the IMS are processed by a set of network elements originally designed to support IP multimedia services in the UMTS. The QoS mapping between IMS services and IP transport is fundamental for maintaining a suitable quality. The differentiation of these two technologies can lead to unpredictable and unwanted behavior for services. The possibility of employing DiffServ and IntServ mechanisms into the IMS environment in order to achieve full QoS support for real time applications is the object of interest.*

***Keypads:** (Voice over Internet Protocol), (IP Multimedia Subsystem), (UMTS), QoS, Networks, IMS, IP, DiffServ and IntServ*

I. INTRODUCTION

While there is an ever increasing requirement for personalization, consumer's mobility and agile services necessitates for a better communication technology than what is presently available. Users are looking for easier and better ways of reaching out to each other over whatever terminal or access technologies available at present. Therefore, the setup of network infrastructure must provide sufficient network resources for high value services for better user experience. A natural way to make this new approach possible is the evolution towards an all IP environment which appears to be a strong trend. The IP Multimedia Subsystem (IMS) represents such an architecture providing multi access to required services and large scale interoperability.

The IMS technology originated from the Third Generation Partnership Project (3GPP) Release 5 specifications as a part of the core network evolution from circuit switching to packet switching architecture. The idea was to integrate traditional telecommunication services with the Internet Protocol.

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Therefore, this architecture uses two of the most successful representatives in communications, namely fixed/mobile networks and the Internet. The IMS refers to a functional architecture based on Session Initiation Protocol (SIP) specification, which allows voice, text and multimedia services to pass through all connected networks. IMS is a technological framework that allows the evolution of standardized person-to-person communication services from multi-access to interactive multimedia experiences in real time anywhere and at any time. IMS can provide a range of interesting services including video telephony, push-to-talk overcellular, instant messaging and combination of these services in one session. To provide end-to-end QoS, it is necessary to manage the QoS within each domain along the path. In the IP domain, there are some well-known mechanisms for QoS provisioning, such as Differentiated Services (DiffServ) and Integrated Services (IntServ). The end-to-end QoS in the IMS architecture introduces several challenges which have to be faced.

II. THE IP MULTIMEDIA SUBSYSTEM

2.1. Why IMS

Moving towards a common network infrastructure supporting all kind of services is a very attractive idea. An integrated network not only takes advantage of network resources but also reduces costs, especially when using the widely supported IP protocol with more and more applications and devices available each day.

2.2. 3G mobile networks evolution towards All-IP

Current trends towards All-IP environments can be noticed in the evolution of 3G mobile networks. An example is UMTS evolution. The first step is given in Release 4, (please see figure 1 below) specifying an architecture for the circuit switched domain that enables the transport of voice over packets. In case of choosing IP, the possibility of using a common backbone for both circuit and a packet domain is open, thus driving towards an All-IP core network.

Release	Functional Freeze	Main Radio Features of the Release
Rel-99	March 2000	UMTS 3.84 Mcps (W-CDMA FDD & TDD)
Rel-4	March 2001	1.28 Mcps TDD (aka TD-SCDMA)
Rel-5	June 2002	HSDPA
Rel-6	March 2005	HSUPA (E-DCH)
Rel-7	Dec 2007	HSPA+ (64QAM DL, MIMO, 16QAM UL), LTE & SAE feasibility study, EDGE Evolution
Rel-8	Dec 2008	LTE work item – OFDMA air interface, SAE work item, new IP core network, 3G femtocells, dual carrier HSDPA
Rel-9	Dec 2009	Multi-standard radio (MSR), dual cell HSUPA LTE-Advanced feasibility study, SON, LTE femtocells
Rel-10	March 2011	LTE-Advanced (4G) work item, CoMP study, four carrier HSDPA

Figure 1: UMTS Releases

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The introduction of the IMS subsystem in Release 5 allows users to access a new range of services through the packet switched domain: IP multimedia services, thus encouraging the use of IP for all type of services. Finally, following the works in Release 5, the logical step of supporting different IP access networks is also specified in Release 6, thus allowing the access to all the services through virtually any access network such as UTRAN (UMTS Radio Access Network) or WLAN (Wireless Local Area Network).

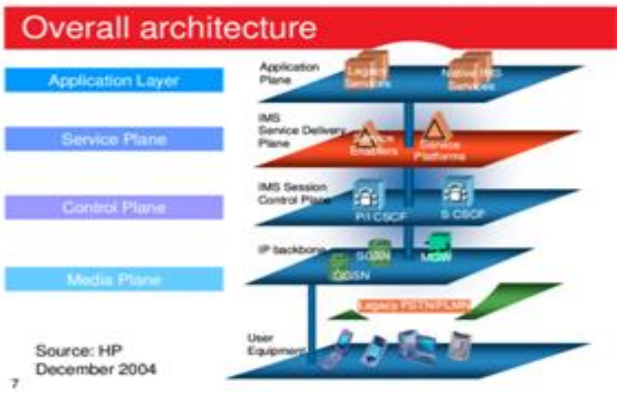

Figure 2: Overall architecture

2.3 IMS functional architecture

The most important element is the CSCF (Call State Control Function), which is basically the combination of a SIP registrar and a SIP proxy server. Actually, there are three types of CSCF (Proxy CSCF or P-CSCF, Interrogating CSCF or I-CSCF and Serving CSCF or S-CSCF) with well defined roles in the session establishment. P-CSCF is specialized in the direct dialog with the user terminal, while I-CSCF provides localization and authentication functions by querying the HSS 1 (Home Subscriber Server), which also stores users' profiles. Finally, S-CSCF is the key element to access to available services, since it registers the users, provides billing information to mediation systems and performs service triggering, providing access to separate application servers if necessary. The IMS also defines a set of elements to achieve interworking with conventional telephone networks. The MGCF (Media Gateway Control Function) uses MEGACO/H.248 commands to control the media gateways (MGW) that convert VoIP streams into voice streams over switched circuits of 64 kbit/s and vice versa. As signalling has to be converted too, the MGCF controls the Transport Signalling Gateway (TSGW) to do this task. The All-IP nature and support for conventional networks, IMS can be thought of as an appropriate enabler technology for network and services convergence.

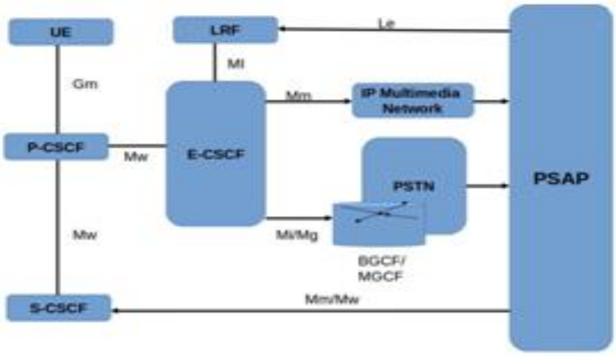

Figure 3: IMS core architecture

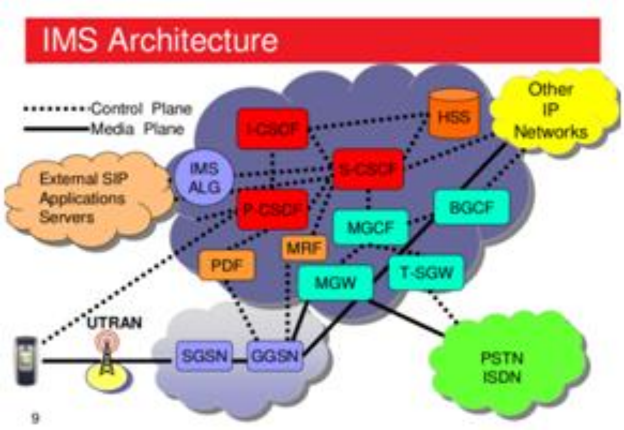

Figure 4: IMS Functional Architecture

III. QOS CONCEPTS AND CHALLENGES THEREOF

Quality of Service and Resource Allocation are critical. IMS requires the carrier to have greater control over their network resources.

3.1. Defining QoS

In the context of packet networks, **Quality of Service** (QoS) refers to the ability of the connection to meet certain specified service commitments. Different types of traffic and different services require different QoS levels due to their sensitivity to various transmission errors. The major impairments experienced on packet networks include:

(i) Dropped packets – routers may drop some packets when buffers are full.
(ii) Out-of-sequence packets – packets arrive out of order and must be re-sequenced.
(iii) Latency (delay) – packet transit time is delayed due to excessive retransmissions.
(iv) Jitter – signal variations that can introduce timing errors or bit errors.
(v) Bit errors – bit corruption that can accumulate and degrade message integrity.

The quality of certain services is much more susceptible to some types of errors than others. The real-time nature of voice communications over packet, including VoIP, makes the speech quality very susceptible to latency (delay) more so than to bit errors. Dropped packets may not affect some services, such as voice, but would ruin the integrity of a file transfer. Therefore, the network must identify the different types of traffic on the network and ensure that adequate resources are available to meet the different needs of the different types of traffic.

To control QoS, networks must establish a set of traffic classes for services based on the type of impairment that is most important to control. These traffic classes can then be prioritized across the network to ensure the required resources are devoted to the service to preserve the quality needed. In general, QoS traffic classes prioritize the following two types of services:

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3.1.1. *Time Sensitive Services*

Services such as Voice or Streaming Media which are very delay sensitive but are able to tolerate some packet loss and not lose their value.

3.1.2. *Content Sensitive Services*

Services such as file transfers and interactive services which are not as time sensitive but are very sensitive to bit errors and packet loss.

UMTS specifications define four traffic classes for the management of QoS:

(i) Conversational – VoIP, voice.
(ii) Streaming – Video and Multimedia Content.
(iii) Interactive – Web browsing.
(iv) Background – Email and file transfers.

The major distinguishing factor among these four classes is whether they are time-sensitive or content-sensitive.
Conversational and Streaming classes are real-time transfers of data and are most time sensitive while Interactive and Background must preserve the accuracy of the bearer channel payload content.
In the Internet, five traffic classes have been defined to control QoS characteristics of traffic compared with the four classes defined for UMTS:

(i) Premium Constant Bit Rate (PCBR) – VoIP, voice.
(ii) Premium Variable Bit Rate (PVBR) – Video and teleconferencing.
(iii) Premium Multimedia (PMM) – Audio/Video downloads, adaptive video
(iv) Premium Mission Critical (PMC) – Transactions, database queries.
(v) Best Effort (BE) – Email, all else.

3.2. IMS challenge

Though commercially available IMS services are not in their infancy, there is an enormous scope of service enhancement and providers are working on the implementation of IMS in both network's and user's side. QoS solutions are not enforced by the specification, although QoS requirements are well defined. As IMS enables the provision of commercial services by the operator and third parties, another challenge is defining billing schemes for charging services, as the value chain and impact on final services' price have to be determined.

3.3. IMS QoS architecture

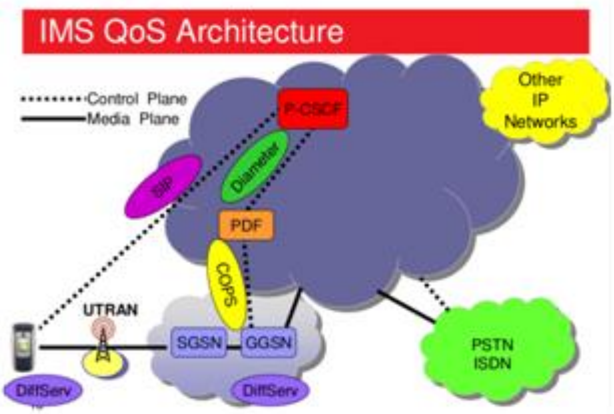

Figure 5: IMS QoS Architecture

3.4. QoS management functions and flow

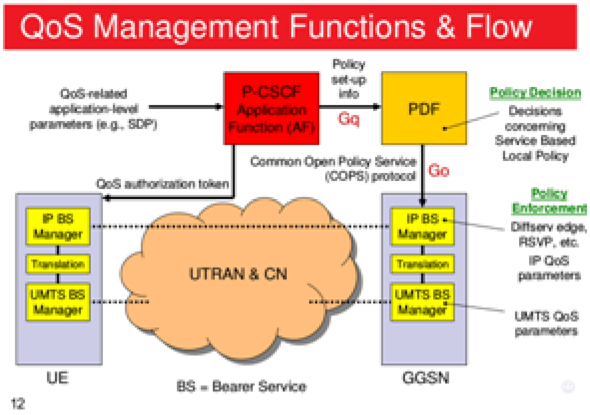

Figure 6: QoS Management Functions & Flow

3.5. Three QoS Models

3.5.1. *Best-effort model*

The best-effort model does not use QoS. If it is not important when or how packets arrive, the best-effort model is appropriate.

3.5.2. *Integrated services (IntServ)*

IntServ can provide very high QoS to IP packets. Essentially, IntServ defines a signaling process for applications to signal to the network that they require special QoS for a period and that bandwidth should be reserved. With IntServ, packet delivery is guaranteed. However, the use of IntServ can severely limit the scalability of a network.

3.5.3. *Differentiated services (DiffServ)*

DiffServ provides the greatest scalability and flexibility in implementing QoS in a network. Network devices recognize traffic classes and provide different levels of QoS to different traffic classes.

3.6. Integrated Services (IntServ)

IntServ is a framework developed by the IETF to provide individualized QoS guarantees to individual application sessions. IntServ provides services on a per flow basis where a flow is a packet stream with common source address, destination address and port number. Two key features lie at the heart of IntServ:
(i) *Reserved resources*: A router is supposed to know what amounts of its resources (buffers, link b/w) are already reserved for ongoing sessions.
(ii) *Call setup*: A session requiring QoS guarantees must first be able to reserve sufficient resources at each network router on its source-to-destination path to ensure that its end-to-end QoS requirement is met.

3.6.1. *Call Setup Process*

Traffic characterization and specification of the desired QoS:
(i) Tspec: Characterizes the traffic the sender will be sending into the network.
(ii) Rspec: Characterizes the QoS being requested by the connection.

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3.6.2. Signaling for Call Setup

A session's Tspec and Rspec must be carried to the intermediate routers: RSVP (The Resource ReSerVation Protocol allows applications to reserve bandwidth for their data flows. To implement RSVP, the RSVP software must be present on the receivers, senders and routers).

3.6.3. Per-element call admission

Once a router receives the Tspec and Rspec for a session, it determines whether or not it can admit the call.

3.6.4. Service Classes

The Intserv architecture defines two major service classes:
(i) *Guaranteed QoS*: Provides firm (mathematically provable) bounds on queuing delays that a packet will experience in a router.
(ii) *Controlled-load Network Service*: Provides a service closely approximating the QoS that same flow would receive from an unloaded network element.

3.7. Differentiated Services (DiffServ)

There are difficulties associated with IntServ model of per-flow reservation of resources as enumerated below:
(i) *Scalability*: Intermediate routers have to maintain per-flow state e.g., It was observed that a backbone router using OC-3 speed link sees approximately 256,000 source-destination pairs in one minute. Does not scale.
(ii) *Flexible service models*: Intserv provides small number of pre-specified service classes. Need for qualitative or relative definitions of service classes.
DiffServ provides the greatest scalability and flexibility in implementing QoS in a network. Network devices recognize traffic classes and provide different levels of QoS to different traffic classes. Differentiated services can be described associated with traffic classes, rather than traffic flows which performs complex traffic classification and conditioning at the network edge. It does not have per-flow state in the core. The goal of the DiffServ model is scalability and Interoperability with non-DiffServ-compliant nodes. Diffserv architecture has two sets of functional elements:
(i) *Edge functions*: Packet Classification and traffic conditioning.
(ii) *Core function*: Forwarding.

3.7.1. PHB (Per Hop Behaviour) Groups

There is a demand to provide assured forwarding of IP packets over the Internet. In a typical application, a company uses the Internet to interconnect its geographically distributed sites and wants an assurance that IP packets within this intranet are forwarded with high probability as long as the aggregate traffic from each site does not exceed the subscribed information rate (profile). It is desirable that a site may exceed the subscribed profile with the understanding that the excess traffic is not delivered with as high probability as the traffic that is within the profile. It is also important that the network does not reorder packets that belong to the same microflow, no matter if they are in or out of the profile.
(i) AF (Assured Forwarding) - Assured Forwarding (AF) PHB group is a means for a provider DS domain to offer different levels of forwarding assurances for IP packets received from a customer DS domain. Four AF classes are defined, where each AF class is in each DS node allocated a certain amount of forwarding resources (buffer space and bandwidth).
(ii) EF (Expedited Forwarding) – Expedited Forwarding (EF) requires that (at each node) the egress (outbound) rate exceed the ingress (inbound) rate for a conforming aggregate – highest class.
(iii) BE (Best Effort) – whatever bandwidth left.
(iv) Others...

3.8. Setting up end-to-end QoS

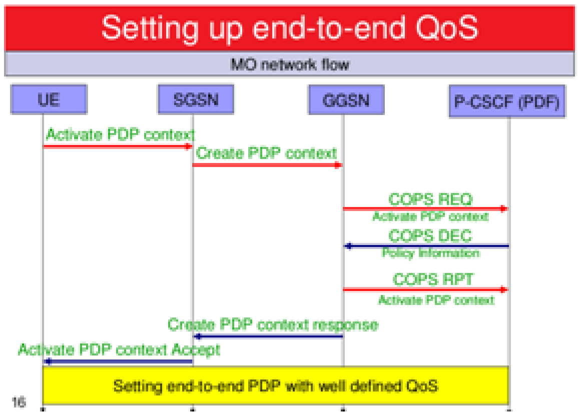

Figure 7: end-to-end QoS

The figure above provides a procedural look at establishing end-to-end connection ensuring QoS.

IV. CONCLUSION

It is very important to note that it is not enough to allocate resources to ensure that the bearer (data) channel can achieve the prescribed Quality of Service requirements. The control signals passing among the nodes in the Transport Plane and the Control Plane must also be QoS managed to ensure that the entire session quality is achieved.

There are two primary means for providing enough network resources to meet all the QoS needs present in the demand on the network. One way is through gross over-provisioning where large amounts of resources (queue size, bandwidth, diverse routes) are provided to ensure that the peak traffic experiences maximum quality. Obviously very uneconomic in large scale networks and requires forecasting of peak demand.

The other approach is to control quality and allocate resources through a reservation process by which the initiation of each session includes a request for the required resources needed based on the application of the session. Resource requests can then be accepted or rejected based on available resources at the time. The concept of *Differentiated Service* (DiffServ) for the internet is favoured as the means to regulate resources on a QoS basis. DiffServ routers would prioritize traffic based on QoS requirements and the available bandwidth of the network. At times of congestion, lower priority services would be dropped in favor of higher priority or premium services.

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An abundance of dropped or denied services due to inadequate resources is a clear sign that capacity growth is required in the network.

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