QoS-APCVS: An Enhanced EPS-IMS PCC Architecture Proposal to Improve Mobile Service Dependability

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Abstract

IP Multimedia Subsystem's (IMS) presents the framework architecture which can provide multimedia services for Evolved Packet System (EPS). In busy network, the main failures are service blocking, handover outage and non satisfying QoS criteria. So we aim to improve dependability of dedicated bearer establishment in EPS-IMS Network. In mobile access network, we consider service is available if it is admitted by base station and is reliable if it is still supported in handover position. In core network, we consider service as reliable if its QoS criteria are satisfied. So we propose a new Qos Provisioning solution. To provide new application or to support handover service in busy network, our approach preempts resources by utility factor instead of priority consideration in existing works. In addition to bandwidth reservation our solution allows core network reservation to improve the delay of real time service and minimize the loss rate of non-real time services.

Keywords

Dependability, QoS provisioning, EPS- IMS architecture, Control admission, Virtualization, Routing Algorithm, Congestion Control

1. Introduction

Mobile telecommunication networks offer multimedia applications with audio services, video and integrated data, in contrast to the circuit network switching limited to voice services. Today, mobile communication has become the backbone of the society [1]. In the mobile system all multimedia sessions go through the access network then by the switching packet in core network [2]. We consider the following main failures of mobiles services:

- Blocking and outage in access network
- Delay of real-time service and data loss in core network

We aim to improve dependability of dedicated bearer establishment in EPS-IMS Network. Dependability is the discipline that quantifies the reliance that can be placed on the service delivered by a system [3] and consists of two major aspects: availability and reliability [4]. In mobile access network, we consider service is available if it is admitted by base station and is reliable if it is still supported in handover position [5]. To reduce blocking and outage rate of services in access network, we propose in [5] a new Preemption Admission Control algorithm using preemption bandwidth from already connected applications according to a specified “utility” policy protocol. Experimentations give results [5] show an improvement of access availability and reliability with acceptable QoS. In core network, we consider telecommunication service as reliable if its QoS criteria are satisfied. In our paper [6] a Delay Utility Scheduling (DUS) is presented and discussed. According to experimental results, our proposition improves service times in different nodes. It defines also an Overlay Routing Algorithm (ORA) in which we propose to separate information in overlays and use OSPF according to two criteria such us propagation time and service time. Our solution ORA[6] gives the optimum path between source and destination.

In this work we proposes a Qos Provisioning solution supporting tree QoS parameters; Bandwidth, Delay and Packet loss. After having introduced our context, we present primary existing solutions related to EPS-IMS QoS Provisioning [7][8]. Then the paper is organized as follows; Section 3 defines ours motivations. In section 4 we propose a new PCC architecture; QoS Access Preemption and Core oriented Virtualization Solutions (QoS-APCVS). This one contains two news entities; Master eNodeB and Master GW. We present and discuss their contributions such as Preemption Control Admission (PCA), Overlay Routing Algorithm (ORA), and Avoid Packet Loss (APL) in Sections 5 and 6. Concluding remarks are made in Section 7.

2. EPS-IMS QOS PROVISIONING

IP Multimedia Subsystem’s total functioning is depends on the Session Initiation Protocol for signaling the messages from source to destination. Its functionality depends on Internet Protocol [9].

The PCC (Policy and Charging Control) provides end to end QoS control. Figure 1 shows a simplified model to establish dedicated bearer [8]. PCEF (Policy and charging Enforcement Function) interacts with PCRF (Policy and Charging Rules Function) to provide a service class requested by the subscriber. If user requests a class service, his UE (User Equipement) send request to P-CSCF (Proxy Call Session Control Function) of IMS subsystem. This request contains SDP (Session Description Protocol) which reflects the required QoS. So P-CSCF asks PCRF to reserve access resources. Then PCRF translates SDP description to QoS parameters and verifies SPR (Subscription Profile Repository). PCRF communicates request to PDN Gateway. This one transfers the demand to Serving Gateway. It relays request to MME (Mobility Management Entity). MME asks eNodeB if acess resources are available to provide QoS required. When successful eNodeB reserves access resources and notifies UE to activate dedicated bearer.

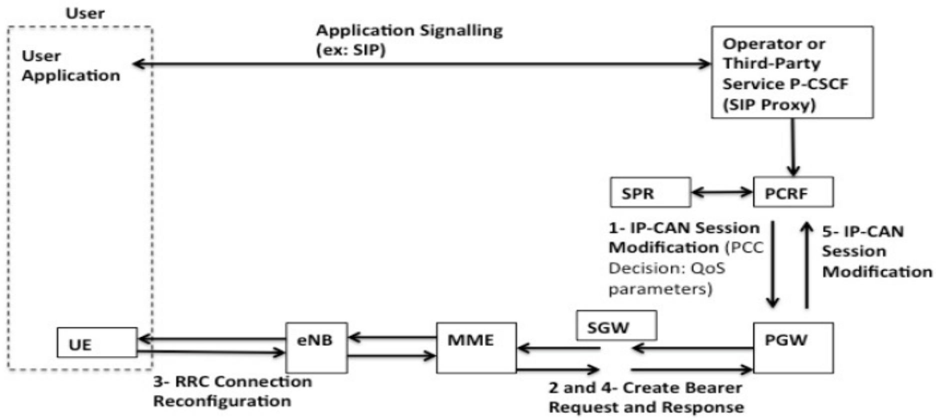

Figure 1: Dedicated Bearer establishment [8]

Qos-LRF detailed in [7] defines the session relocation as the possibility of reserving the required network resources on a different QoS level, and transferring the session to a different level in order to provide the service according to the QoS parameters specified for the new level. The main objective of this feature included in the QoS-LRF is to benefit the session with higher priority in each QoS level.

This solution applies the pre-emption functions specified with the PCC architecture. Information given by SBF (Service Flexibility Bit, priority level, the PEC (Pre-emption Capability) and PEV (Pre-emption Vulnerability) parameters, which give Qos-LRF the possibility to use other session's resources and reserve them for a different session with higher priority level. The introduction of the SFB gives the possibility of using the pre-emption functions in the other QoS levels before blocking the activation of a new session, or before canceling an active session with lower priority level [7].
Figure 2 shows the entity called QoS Level relocation Function (QoS-LRF), which is in charge of making decisions about session relocation in the QoS levels.

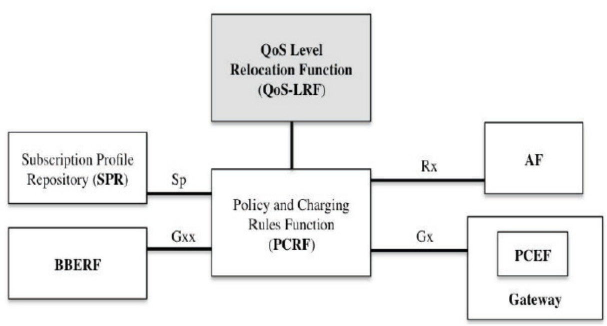

Figure 2. QoS-LRF PCC Architecture [7]

3. MOTIVATIONS

The PCRF reserves access resources. Dedicated bearer will not be established if access resources are not available. Authors in [7] propose an enhanced IMS QoS architecture to support efficient QoS providing for flexible services with dynamic QoS requirements. But they reduced the QoS level parameters to the Bandwidth (BW) requirement in order to reduce the problem complexity.

These work benifets higher priorities sessions. This paper proposes a Qos Provisioning solution supporting tree QoS parameters; Bandwidth, Delay and Packet loss. Ours contributions are:

- To provide new application or to support handover service in busy access network our approach preempts resources by utility factor instead of priority considered in existing works [7].
- In addition to access resources reservation that provides required bandwidth in LTE network, our solution allows core network resources reservation to improve the delay of real time service and minimize the loss rate of non-real time services

4. ENHANCED EPS-IMS PCC ARCHITECTURE

We propose a new EPS-IMS PCCC architecture named QoS Access Preemption and Core oriented Virtualization Solutions (QoS-APCVS). In our new model QoS-APCVS (Figure 3), we added two new entities to PCC architecture:

Master eNB entity; it communicates between eNB and MME and performs our Preemption Control Admission (PCA) [5] algorithm. This algorithm will be expressed in section 5 and it is detailed in our publication [5].

Master GW entity; it communicates between PCRF PCEF and S-GW to reserve core network resources. This entity performs ours algorithms Overlay Routing Algorithm (ORA) [6] and Avoid Packet Loss (APL). We briefly present ORA in section 6.1. It is detailed in [6]. The APL is a new congestion control solution oriented network virtualization. It will be presented in sub section 6.2. As shown in Figure 3 we consider two sub Master GW:

- **Master GW Inter-Domain** : to support IP Network connecting Serving GW to PDNGW
- **Master GW Extra-Domain** : to support IP Network connecting PDN GW to IMS

We detail alls Model transactions in Table I.

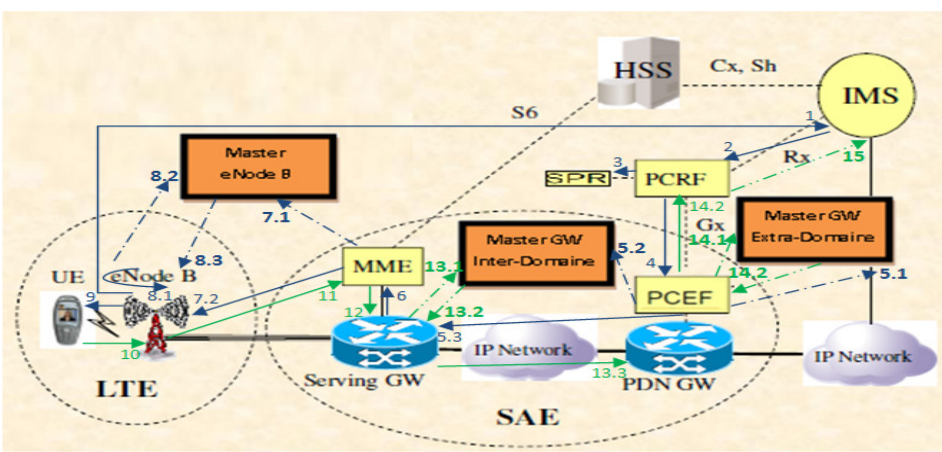

Figure 3. QoS-APCVS an enhanced PCC architecture

5. MASTER ENODEB CONTRIBUTION

According to estimation of increasing mobile application's consumers. We are interested in Long Term Evaluation (LTE) network. LTE dependability depends on availability and reliability of his evolved Nodes Bases stations (eNB/eNodeB). One eNB is available when it is able yet to admit a new media and to support connection. And it is reliable when it is able to support handover connection. In our paper [5], we propose ***Preemption Control Admission (PCA)*** [5] which is Admission Control algorithm using utility adaptation in UTRAN LTE.

Master eNodeB is a new entity of our enhanced EPS-IMS PCC architecture (
Figure 3). It communicates between eNB and MME and performs our ***PCA*** [5] algorithm.
In busy network, our ***PCA*** preempts resources by utility factor to provide new application or to support handover service. Our solution improves the accepted number of user's applications and customer's satisfaction value. Some existing work [10][11][12] considers a higher QoS with lower dependability (availability and reliability). ***PCA*** improves dependability with providing acceptable QoS.

Table 1. Description of Qos-APCVS Transactions.

Transaction Number		Description
1		UE send request to P-CSCF of IMS subsystem. This request contains SDP reflecting the required QoS
2		P-CSCF asks PCRF to reserve access and core resources
3		Then PCRF translates SDP description to QoS parameters (BW, Delay/Loss Rate) and verifies SPR
4		PCRF communicates request to PCEF on PDN Gateway
5	5.1	PCEF send rules (Delay/Loss Rate) to MaterGW Extra-Domain. It performs ours algorithms ORA (RT services) or APL (NRT services) to reserve resources between PDN GW and IMS.
	5.2	PCEF send rules (Delay/Loss Rate) to MaterGW Exter-Domain. It performs ours algorithms ORA (RT services) or APL (NRT services) to reserve resources between PDN GW and Serving GW.
	5.3	PCEF send rules (BW) to Serving GW.
6		Serving GW relays this rules to MME.
7	7.1	MME sending rules to Master eNodeB, where LTE is busy (failure of 8.1) Master eNodeB performs our PCA algorithm.
	7.2	MME requests to eNodeB the establishment of dedicated bearer.
8	8.1	eNodeB cheeks available resources providing required QoS (BW)
	8.2	eNodeB informs Master eNodeB about 8.1 failure
	8.3	Master eNodeB sends the results of our PCA to eNodeB
9		When successful eNodeB reserves access resources and notifies UE to activate dedicated bearer.
10		UE acknowledges eNodeB about Radio Bearer activation
11		eNodeB acknowledges MME about this activation
12		MME relays this acknowledgement to Serving GW
13	13.1	Serving GW asks Master GW Inter-Domain of path resulted according to 5.2 request
	13.2	Master GW send results of ORA/APL algorithm to Serving GW
	13.3	Serving GW acknowledges PDN about bear activation
14	14.1	PDN GW asks Master GW Extra-Domain of path resulted according 5.1 request
	14.2	Master GW send results of ORA/APL algorithm to PDN GW
	14.3	PDN GW informs PCRF about success of Qos policy
15		PCRF a acknowledges IMS of reserving Qos in access network , core network and IP network connecting PDN GW to IMS

6. MASTER GW CONTRIBUTIONS

In core network, we consider telecommunication service as reliable if its QoS criteria are satisfied. **Master GW** is a new entity of our enhanced EPS-IMS PCC architecture (
Figure 3). It communicates between PCRF PCEF and S-GW to reserve core network resources. This entity performs our algorithms ***Overlay Routing Algorithm (ORA)*** [6] *and* our new proposition ***Avoid Packet Loss (APL)***.

6.1 Overlay Routing Algorithm

In ***ORA*** [6] we have proposed to separate information in overlays. ***ORA*** uses OSPF according to two criteria such us propagation time and service time. And we consider improvement service time given by our proposition ***Delay Utility Scheduling (DUS)***. In ***DUS***, packets are stored by class in queues. Then a tourniquet alternates to serve packets from these queues according to their dynamic weight depending on a fixed weight, LF (Load Factor) and UDF (Utility Delay Factor).

6.2 Avoid Packet Loss (APL)

6.2.1 Network Virtualization

Fundamental changes in network architecture and service delivery model are required by the future Internet. However, the current IP-based Internet protocol along with the huge amount of investment in the Internet infrastructure make any disruptive innovation in the Internet architecture very difficult [13]. Network virtualization was used as evaluation tools [14]. Also the role of virtualization in network can be the separation of policy from mechanism [15]. Network virtualization consists on overlay that is a logical network built on top of one or more existing physical network [14].

6.2.2 Congestion Control Works

The loss rate depends on saturation capacity of the nodes and queue management scheme. To adress the congestion control mecanism we consider :

- Drop Tail [16][17] : if the buffer of node is saturated Drop Tail eliminates all arriving packets

- RED [16][17] : it rejects arriving packets before saturation of queue. When the average queue length exceeds a minimum threshold (minth), packets are dropped at random using a calculated probability. When the average queue length exceeds a minimum threshold (minth), all arring packets are eliminated.

- The Internet traffic suffers from heavy losses due to network congestion caused by limited capacity of queue in the routers. There exist control technique to repair these losses.

- ARQ [18] Automatic Repeat reQuest : it consists in retransmitting dropped packets upon the destination's request.

- FEC [17] Forward Error Correction : this technique sends redundant packets to the destination.

6.2.3 Congestion Control Oriented Network Virtualization

To not retransmitting dropped packets like in ARQ [17]. And to not overload network by transmitting redandancy of FEC [18]. We propose solution that avoids packets dropping. We denote threshold failed node (TFN). If load of node achieves TFN, this node does not receive packet until load will be less than (TFN/2). The value of this threshold is dynamically changed. It is depending to queue's capacity C_i. And C_i is dynamic and proportional to load rate of queue number i; remember that there are three queues in each node. So we do not have in the same node one queue empty and other queue full. We denote :

- NTotal = total capacity of all the node's buffer
- Ni= load of queue number i
- Ci= capacity of queue number i
- Ci is proportional to Ni rate
- Ci= [Ni /(N1 +N2 +N3)] * Ntotal
- TFNi=Ci/Ni

And we propose to use 3 overlaies network. Each overlay OL_i acording to packet group G_i. Our overlay OL_i does not contain failed node. And the failed node have $TFN_i >= 1$. And we apply OSPF routing algorithm depending on TFN_{min}

7. CONCLUSION

The paper's aim is to improve dependability of dedicated bearer establishment in EPS-IMS Network. We have presented primary existing solutions related to EPS-IMS QoS Provisioning which supporting only Bandwidth parameter. Then we have proposed a Qos Provisioning solution supporting tree QoS parameters; Bandwidth, Delay and Packet loss. This solution represents a new PCC architecture; ***QoS-APCVS***. We introduce two new entities; **Master eNodeB** and **Master GW**. We present their contributions such as ***PCA***, ***ORA***, and ***APL***. Additional work is needed to evaluate ***QoS-APCVS*** solution. We will try to make experimental simulations to justify ***QoS-APCVS*** impacts.

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