Agent Based QoS Provisioning for NGMN [LTE]

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Abstract
Quality of Experience is the most preferred parameter for all the end users, in mobile environment, and it matters more than Quality of service, because it is the individual’s own experience. User’s perception of QoS is an important consideration for service providers, network operators, and equipment manufacturers and also to the research community, to ensure customer satisfaction and business growth. In this paper we propose an agent based QoS provisioning mechanism for next generation mobile networks, especially the Long Term Evolution (LTE) network, to assess end user perceived experience. In our model the user interface agent present in the terminal device, monitors QoS parameters, periodically and assesses the user experience and forwards these inputs to the ‘On Demand Service Decision maker (OSDM)’, which in turn provides an optimal solution. Mobility of users at different velocities (5kph, 30kph, 60kph and 120kph has been simulated through NS2, with JADE platform. Performance analysis of NGMN in terms of QoS parameters such as packet loss, delay, jitter and throughput has been carried out with and without the QoS monitoring agents and the results demonstrate better performance with the application of agents.

Keywords: Quality of Experience, Quality of Service, Long Term Evolution, Next Generation Mobile Networks, On Demand Service Decision Maker, QoS Monitoring and JADE Platform.

I. INTRODUCTION
Next generation Mobile Networks evolution is driven by not only new hardware and software development but also the hectic day to day human activities even on the move, resulting in a total mobile community. They use smart phones for all personal communication needs and to maintain ubiquitous connections to corporate/enterprise networks at work, or to establish a wireless entertainment network at home. For meeting these diverse demands, the next-generation wireless network has to provide certain Quality-of-Services (QoS) to the users. Basic idea of providing QoS guarantees is to ensure that users’ requirements are satisfied throughout the service period. The most common QoS requirements include the maximum throughput, minimum delay bound or delay jitter, and packet loss rate. But the service with these QoS requirements calls for an integrated support from the content servers, the core network and the wireless access network, with each relying on different mechanisms for service differentiation, resource reservation or admission control. New modulation, coding or medium access schemes allow more efficient utilization of the radio resources and these improvements cannot keep pace with the explosive growth of bandwidth hungry applications. Hence the experience of unpredictable disconnection from the core network, while on the move, results in service disruption. Because of these two unique properties, providing absolute QoS guarantees in wireless/mobile networks need special tools and mechanisms.

II. LATEST TRENDS IN END-TO-END QoS IN HETEROGENEOUS MOBILE NETWORKS
In order to achieve the goal of providing high-quality services in next-generation wireless networks, it is necessary to implement new techniques that can guarantee Quality of Service when considering the limitations imposed, both by the end-users and the network. There have been many research approaches [1-8], trying to provide end-to-end QoS guarantees over heterogeneous networks. In Ref. [1], the main QoS challenges for the seamless support of different categories of hyper handover are summarized. The paper presents a QoS framework that includes a three-plane network infrastructure and a terminal-based hierarchical policy management system. A network manager and bandwidth broker based QoS framework is proposed to describe how the framework supports end-to-end QoS provision adaptively and seamlessly. In Ref. [2], QoS architecture in a heterogeneous radio access network is
presented. Authors argue that policy-based service negotiation is an important component of the bandwidth broker, in order to provide a flexible end-to-end QoS management in beyond 3G systems. Furthermore, they identify the following significant issues: the need for a policy decision point at the radio bearer service entity, along with the interaction of service negotiation and mobility management protocols. The Resource Brokerage scheme is discussed in Ref. [3] where the interfaces and modules of the RB process are presented. Authors in Ref. [4] present a novel end-to-end QoS architecture that enables seamless services over heterogeneous wireless access networks. They discuss the main architectural approaches and design issues of mobility-aware QoS signaling in IP networks. Then they introduce a QoS signalling architecture that integrates resource management with mobility management. In Ref. [5], a DiffServ resource allocation architecture is proposed for the evolving wireless mobile Internet, identifying two major challenges in establishing a wireless mobile Internet: support of fast handoff and provisioning of quality of service (QoS) over IP-based wireless access networks. The proposed registration-domain-based scheme supports fast handoff by significantly reducing mobility management signaling. Authors in Ref. [6] investigate the design of a wireless network architecture that exploits user profiles, such as the location, the velocity (both speed and direction), and the resource requirements of the mobile Device, to maximize network efficiency and provide better QoS to different classes of users. The key underlying primitive of the architecture is the use of both real-time and aggregate user profiles to perform advance resource reservation in the handoff target cells of the wireless cellular network. In Ref. [7], the authors consider the use of IP-level QoS signaling as a key component to support end-to-end QoS for various applications in the next generation of mobile systems. In Ref. [8], the authors propose a hierarchical architecture for both mobility and QoS support in IP-based wireless networks. The proposed architecture has several advantages and provides excellent solutions to the problems raised by mobility and by the wireless environment. In QoS provisioning, they enable end-to-end QoS guarantee by using the resource reservation protocol (RSVP) signaling. In particular, the RSVP aggregation technique is used to avoid the scalability problem.

III. CHALLENGES OF QoS IN NGMN

A layered structure for 4G is proposed. The five layers are the distributed, cellular, hot spot, personal network and fixed layer. The supported mobility and covered cell size increases from the fixed layer to the distributed layer. Interworking will be required between different access systems in terms of intra-system and inter-system handover as well as seamless services of mobility, security and quality of service. The 3G to 4G transition is towards a predominance of automated and autonomously initiated machine-to-machine interactions. 4G must be dynamic and adaptable with built-in intelligence. Key challenges will be personalization, seamless access, quality of service and intelligent billing, as noted by NGMN forum.

A. Personalization

The following requirements characterize "personalization architecture": support of personal context - user profiling, context awareness; seamless service provisioning - advanced signaling and session control, AAA (authentication, authorization, accounting); open third party access (e.g., web services); adaptability (on all levels) - content, communication (protocols), service logic; reconfigurable terminals - new strategies for pervasive/ubiquitous computing; programmable open platforms.

B. Seamless Access

Seamless access in 4G will go much beyond the roaming as we know it today and will be a much more sophisticated affair. Seamless Access in 4G will mean connectivity to the enduser across a wide range of access technologies and access networks with minimal input from the user. The following requirements characterize "seamless access": seamless network integration based on IP; terminal mobility, personal mobility, service mobility, session mobility; new 4G wireless technologies should be IP-centric; dynamic resource allocation at all network/system levels; adaptability/programmability of network components; secure but simple service agreements; SIM-card like universal authentication..

C. Intelligent Billing

User related requirements include: QoS dependent charging; billing support to diverse access; support to real time billing information; support to interworking of prepaid systems; support to “per-call” service situations. Operator related requirements include: billing support to IP traffic; flexibility of costs calculations (time, volume, QoS dependent, access dependent); distribution of revenue by value chain operators; customer relationship management; reliability of billing operations; instant fraud detection and cut-off.

D. Quality of Service

4G service quality will be the collective effect of the performance of all system elements in combination with
the user expectations, which determines the degree of satisfaction of the 4G customer. The operator’s perspective is characterized by the customer service requirements, the customer perception of QoS, the offered QoS, and the QoS actually delivered. QoS modeling and QoS signaling would be crucial factors for a future 4G system that integrates heterogeneous network types.

IV. QoS IN LTE NETWORKS

Since LTE and UMTS employ different QoS mechanisms, we need to be able to map between LTE’s QCI parameters for EPS bearers and the four QoS categories and associated parameters of Pre-Release 8 PDP Contexts. The 3GPP recommendations provide rules for mapping QoS definitions between the systems. The QoS parameter sets supported within the EPC concern themselves with how packets are handled as they enter traverse and leave a network. Adding more bandwidth at the edge of a network may resolve some capacity or congestion problems, but it does not resolve jitter, nor can it fix traffic prioritization problems.

A. LTE and QoS

Each bearer (user data) path in LTE is assigned a set of QoS criteria. In the case a user may have services requiring different QoS criteria; additional bearer paths may be added. LTE identifies a set of QoS criteria with QoS Class Identities (QCI s) as shown in Table 2. The critical QoS parameter for any EPS bearer is its QCI, which represents the QoS features an EPS bearer should be able to offer for a Service Data Flow (SDF). Each SDF is associated with exactly one QCI. Network operators may pre-configure all QCI characteristics in an eNB, for example, based on their actual characteristics. The parameters they choose to define these determine the allocation of bearer resources in the E-UTRAN.

<table>
<thead>
<tr>
<th>Table 1.LTE QOS-BASED DATA FLOW SPECIFICATIONS (QCI)</th>
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B. EPS bearers and SDFs

LTE sees any Service Data Flow (SDF) as belonging to one of nine QoS-based data flow specifications. Several 3GPP releases have moved toward a sophisticated multimedia-based policy-oriented environment. LTE offers the promise of policy-based, fixed-mobile convergence for new real-time applications such as VoIP, push-to-talk dispatch, messaging enhanced with video clips and even two-way video telephony.

V. GENERIC IMPACT OF QOS PARAMETERS ON QOE

The under mentioned diagram (Figure 1), depicts the important components that contribute for the assessment of Quality of Experience as perceived by the user in terms of the Quality of Service Parameters that are effective in the network at that instant of time. The Components namely: Quality of Media (QoM), Quality of Delivery (QoD), Quality of Presentation (QoP), Quality of user perception(QoUP) will impact the user experience. However the basic measurements pertaining to the standard QoS Parameters are the critical inputs that are monitored continuously and fed to the On Demand Service Decision maker for effective resource allocation and Management.
VI. AGENT BASED APPROACH

The use of an agent-based infrastructure for the management of QoS in a mobile communications environment is a good choice for implementing several adaptation strategies by which available resources need to be rearranged in such a way that the user is always satisfied. These strategies can be implemented by the exploitation of agents' cooperation abilities for optimization purposes [9]. On each server node in the network, a Service Agent is present which has to monitor whether the QoS parameters are managed. It keeps track of the users logged in and their occupied resources, in order to optimize the use of available resources. Support agents present in the base station will manage the mobiles within the cell. Further, it helps in customizing the different management policies concerning the processing of data flows as per QoS amongst mobile devices. Provisioning end to end QoS is of paramount importance to achieve user satisfaction for on demand applications support in NGMN. The mobility factor of the user and the resulting air interfaces behaviour cause fluctuations in the received signal, which in turn causes variable status of the service performance. Figure 2, indicates the presence of the mobile agents, located at critical network elements, monitor the QoS and co-coordinating among themselves for achieving the best possible QoS.

VII. PROPOSED QOS FRAMEWORK FOR NGMN (LTE)

The generic view of the frame work at the network level is depicted in Figure 3.
The main components of this architecture are the following: Service and Policy management control agent, User Interface Agent Manager, QoS Agent, Business Intelligent Agent, Security Service Agent and Charging and Accounting agent. All these interact with each other and offer an optimized service to the end customer. We focus on QoS Agent, whose functions are elaborated in the succeeding paragraphs.

A. Quality of Service Agent

Figure 4, explains the use case diagrams for the Quality of service agent. This module contains the different functions like mapping process, Levels of QoS and SLA, quality Of Experience, QoS Policies, QoS Negotiation, QoS Controller and Metrics, Customer QOS and SLA Management resource Reservation And Optimization Process;

Figure 4. Use Case Diagram for Quality Service Agent

The main functionalities including logic used to develop this module are depicted in the below given Figure 5 along with pseudo code.

Figure 5. Pseudo Code for Quality of Service Agent

B. QoE and UIAM

In order to satisfy the basic requirements of On Demand Service Management, an agent manager with couple of agents has been developed to provide the close interaction with the user for the detailed understanding of the service request and to provide suitable solutions. Agent manager through its service request agent, parses the request, analyzes the same and passes on to the corresponding service provisioning entity/server. It is the Agent Manger that invokes agents based on the user request for the fulfillment of the requested component like the level of quality of service, the degree of security and the required memory usage etc. The corresponding service agent positioned at the server identifies the needs, to map the request against the availability of the service and returns the responses to the AUIM through its counter parts. Agent manager offers the bundled services to the user in the form of a service and ensures user satisfaction through the local agents.

VIII. LTE NETWORK SIMULATION MODEL

In the laboratory, we have simulated a seven node network to prove the concept, understand and analyze the results, in order to validate the proposed model being suggested for managing the Next Generation Mobile
Networks [LTE World, 2011]. Simulation parameters are listed in Table 1 for information and ease of understanding with clarity. Simulated network diagram is shown below. Here we adhered to JADE (Java Development Environment) tool, because of its flexibility and support for dynamic mobility and interaction of the agents. Key classes and object parameters have been customized to cater for the limitations of the simulation environment. Quality of service (QoS) is the capability of the network to enforce different priorities of resource allocation for different application types, subscribers, or data sessions, guaranteeing a certain level of performance to all. QoS-enabled LTE networks provide differentiated access and reliable, real-time services such as voice. End-to-end QoS requires support at the edge of the network, in particular, the Radio Bearer between the mobile user and the LTE eNodeB. LTE is the game changer and defines QoS not only to guarantee the quality of a service but also to support different service levels for latency or bit-rate sensitive applications. Simulation diagram is given in Figure 6.

IX . QoS MONITORING AND RESULT ANALYSIS

Quality of service (QoS) is the capability of the network to enforce different priorities of resource allocation for different application types, subscribers, or data sessions, guaranteeing a certain level of performance to all. QoS-enabled LTE networks provide differentiated access and reliable, real-time services, such as voice. End-to-end QoS requires support at the edge of the network, in particular, the Radio Bearer between the mobile user and the LTE eNodeB.

Table 3: Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>ULINK:1920–100</td>
<td>Mbps</td>
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For Provisioning of attractive billing options, with a guaranteed service for the services of choice is a challenging task. The class of QoS and Guaranteed Bit Rate (GBR) are significantly dependent on the level of latency, jitter, and dropped packets experienced by the users. Without QoS implementation, subscribers will experience choppy videos, and echoes and also delays, resulting in poor quality. The class of QoS and Guaranteed Bit Rate (GBR) are significantly dependent on the level of latency (delays in packet transmission), jitter (variation in latency), and dropped packets experienced. Without QoS implementation, subscribers will experience choppy videos, and echoes and also delays, resulting in poor quality. As discussed earlier, the eNodeB, MAC Scheduler is responsible for providing Radio Bear QoS over the LTE air interface. A QoS-aware MAC Scheduler should support GBR and Non-GBR bearers, in both the downlink and uplink transmissions. Due to the non-standardization of scheduling algorithms in LTE Networks, implementation decision is left to the vendors to balance QoS, fairness and technical complexity. Latency, jitter and Packet loss are the critical parameters that play an important part in ensuring quality of services; we explain them in detail for clear understanding, in the succeeding paragraphs.

Figure 7. Class Diagram for QOS
The above class diagram Figure 7 explains the functionalities of the QoS and it has different Classes mentioned below:

- BandwidthAllocation
- EarliestDeadlineFirst
- Round Robin
- FirstInFirstOut
- QoSPacketQueue
- QoSQueue
- ServiceClass
- WeightedFairQueue
- Object

A. Bandwidth Allocation:
This bandwidth allocation class is used for allocating the bandwidth. This class contains the below methods BandwidthAllocation(), SetDISubChannels(), SetOperativeSubBand(), GetOperativeSubBand(), etc. facilitate for dynamic allocation for the requested services.

B. EarliestDeadlineFirst
This class is used in QoS for creating and using the deadline. This class mainly contains the following methods EarliestDeadlineFirst(), reprioritize(), pthread_serschedprio()…etc.

C. QoSQueue:
This class contains all the QoS parameters and main methods in this class are QoSQueue(), scheduleTask() and run().

D. QoS Packet Queue:
This class contains all the QoS Packet data in the QoSPacketQueue. This class contains the methods like QoSPacketQueue(), putMessage(), getMessage(), etc.

X. ONE WAY DELAY MEASUREMENT
To ensure the QoS of real-time applications such as VoIP, telepresence and transactional services, one way delay and delay variation (jitter) measurements are important as SLAs specify these parameters. Typical SLA specifications call for unidirectional jitter less than 1-5ms and latency in the 3-10 ms range, in both wire line and wireless networks for 4G (WiMAX / LTE). Service providers are opting for one-way measurements to assure their SLAs and monitor the services, since round trip delay metrics often fail to identify QoS issues in asymmetrical access networks. Since a round-trip delay measurement aggregates send and receive path delays, unidirectional issues can escape detection difficulties in troubleshooting. One-way measurements can quickly identify and quantify these QoS issues, but precision and accuracy of measurements is critical. One-way delay and jitter are calculated by sending precisely time-stamped test packets across the network under test.

To test the delay or jitter of a particular service, the test packet is tagged with the same frame attributes as the packets carrying the service along with time-stamping. In our setup, we have measured the jitter of a video streaming application from the server, being down loaded by the UEs attached to the eNodeB, each one getting activated at five seconds interval. Different file sizes and contents have been selected to study the jitter response in this setup. Figure gives the detailed measurement methodology for streaming video carried out in the laboratory environment.

Recording of radio traces for a longer period with increased number of UEs has become the challenge and is the limitation for collecting the relevant data. Figures 9 and 10 depict the information regarding the through put and the pattern of jitter respectively. Instead of trying to measure the exact values, we adapted the process of looking at the comparative response of our model to these important parameters with the QoS monitoring agent and without the agent. The clear indication in increased through put and better jitter management by the Agent based On Demand Service Management proposal substantiates the use of agent technology and its contribution to provide better services to the customers. This value addition derived is based on the
sensing of the experience of the customer through the QoS monitoring agent, positioned at the mobile device. Thus we conclude that the concept of customer experience management definitely adds to customer service management and to the business growth of the service provider.

Figure 9. Data rate VS Number of UEs

XI. SUMMARY AND CONCLUSION

In summary this paper proposes an adaptable service management framework that exploits mobile agent’s architecture to support on demand service management to the mobile user community. Our implementation, of the framework, through simulation and modeling processes in a controlled environment has given good results, which are shown in the form of graphs, there by confirming our model and the associated concepts that enhance the on demand service requirements. In Conclusion a fundamental milestone in the path towards next-generation mobile networks is the deployment of flexible, autonomic, and self-manageable solutions for efficient, scalable and robust user service provisioning. It is the optimal service decision function that interacts with various agents of the associated modules and facilitates to identify the best matching solution, based on the service request. All the agents of the modules interact with the network management functional tools and extract the best offerings to satisfy the customer needs, on real time basis and operate under the control of the Agent Manager of the proposed system. It is with this coordination and cooperation of all the agents and the effective functionality of the management functions. Sample measurements of Jitter, packet loss and throughput have been carried out, for streaming video application to confirm the value addition of our model, which demonstrates, considerable improvement, over the systems functioning without the agents. Thus our idea is a value addition for the mobile users and also to the service providers, for the enhancement of service quality and business growth.

Variations in packet delay cause network performance degradation and affect the user perceived quality, especially in case of real time services like video streaming and VOIP etc. Thus the QoE is drawing attention of the mobile communication industry and research community for quick solutions. For real time streaming applications, packet loss, delay and jitter result in degraded video quality and the users’ reaction to these changes is critical for the service providers. Our results regarding, one way delay measurements in respect of streaming application show that the network with QoS monitoring agent performs much better than the generic network.

REFERENCES


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Prof. D Jayaramaiah, an Alumnus of IIT-Delhi with thirty five years of experience in Telecom, Software, IT industry and R&D at Defence Labs has been actively involved with state of art technology management and application software development. Earlier he was Head R&D of L&T InfoTech, Bangalore Division. Currently he is heading Information Science and Engineering Department at The Oxford College of Engineering-Bangalore, affiliated to VTU. His research interests are Next Generation Mobile Networks, Mobile Agent Technology and Network Management Systems. He is a Fellow of the IETE and Senior Member CSI and senior member PMI-USA. He has presented Seventeen Research Papers at various International Conferences organized by IEEE, World Wireless Congress, 3GMF, 4GMF and IASTED.

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