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A Novel QoS Optimization Architecture for 4G Networks

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***Abstract*—**4G Communication Networks provide heterogeneous wireless technologies to mobile subscribers through IP based networks and users can avail high speed access while roaming across multiple wireless channels; possible by an organized way to manage the Quality of Service (QoS) functionalities in these networks. This paper proposes the idea of developing a novel QoS optimization architecture that will judge the user requirements and knowing peak times of services utilization can save the bandwidth/cost factors. The proposed architecture can be customized according to the network usage priorities so as to considerably improve a network's QoS performance.

***Keywords*—**QoS, Network Coverage Boundary, Services Archives Units (SAU), Cumulative Services Archives Units (CSAU).

I. Introduction

THE 4G mobile networks will replace the existing mobile phone networks in an IP based network. With arrival of IPv6, every device in the world can easily get a unique IP address. This allows full IP based communications through a mobile device. If 4G is deployed efficiently, it can solve many problems related to speedy connections, performance, connectivity, and end user performance. These networks are helpful in reducing the signal to noise ratio (SNR) at the reception side alongside achievement of scalability and higher data rates [5, 6]. The QoS is the ability to provide different priority to various applications, users, or data flows, or to guarantee a certain level of performance to a data flow [1, 3]. For example, a required bit rate, delay, jitter, packet dropping probability and/or bit error rate may be guaranteed. The QoS guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over IP, online games and IP Telephony, since these often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource as we observe in cellular data communication.

In the absence of network congestion, QoS mechanisms are however not required. The development process of many new mobile systems consist of developing the requirements, providing solutions which satisfy the requirements, showing evidences for each technology to satisfy the requirements, as well as building international consensus through the standardization activities [1]. In particular, the QoS is important in packet-switched telecommunication networks for traffic management and is meant to describe the ways of possible reservation of control mechanisms. QoS is vital in cases when network jitter and congestion increases as in case of digital media streaming applications, web TV, voice over IP etc [7]. Networks, where the traffic load is normal, QoS may not be that much necessary unless congestion state appears to effect services availability as we observe in cellular mobile communication networks. The design principle for QoS architecture is to have a structure which allows for a potentially scalable system that can maintain contracted levels of QoS. Especially if somehow we provide an equivalent to the Universal Telephone Service, it could possibly replace today's telecommunications networks.

Therefore, no specific network services should be presumed nor precluded, though the architecture should be optimized for a representative set of network services. Also, no special charging models should be imposed by the Authentication, Authorization, Accounting, and Charging Architecture system, and the overall architecture must be able to support very restrictive network resource usage. In terms of services, applications that use VoIP, video streaming, web, e-mail access and file transfer have completely different prerequisites, and the network should be able to differentiate their service. The scalability concerns favour a differentiated services approach. This approach is laid on the assumption to control the requests at the borders of the network, and that end-to-end QoS assurance is achieved by a concatenation of multiple managed entities. With such requirements, network resource control must be under the control of the network service provider. It has to be able to control every resource, and to grant or deny user and service access. This requirement calls for flexible and robust explicit connections admission control mechanisms at the network edge, able to take fast decisions on user requests.

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The proposed QoS architecture has been designed by taking into account the mobility, QoS, and other relevant issue i-e jitter, queuing and bandwidth issues. The next section describes the proposed design of the QoS Unit in the 4G network environment envisaged. The overall QoS architecture is considered, while we conceptually present the most relevant elements of this architecture. The details of the signaling flow of end-to-end QoS support in this architecture is also given in this section. Section 3 provides the discussion on the proposed design. Finally, the key conclusions are reported along with future directions.

II. Architecture of Proposed QoS Analysis Unit

The proposed architecture of the QoS unit comprises of mainly two components namely,

i. The Services Archives Unit denoted by SAU.

ii.The Cumulative Services Archives Unit denoted by CSAU.

The proposed architecture is shown in Fig.1.

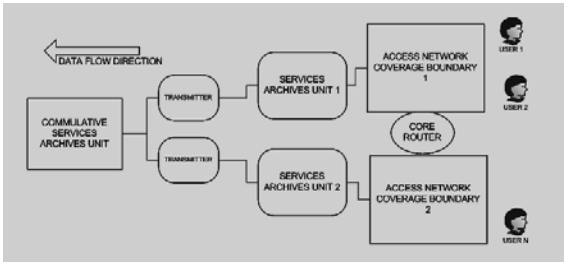


Fig. 1 4G QoS Analysis Architecture Overview

a. The Services Archives Unit (SAU)

The proposed SAU is a server machine with an IP based detailed database of user record and application program that covers a single access network. When a users gets connected to the network, it traces its network ID, matches it with the allocated IP address and with the help of the application program calculates the types of services (Voice, Multimedia, WAP etc) being used during the communication session. The SAU thus creates a log of the services made used by various customers. Later on this log of users may be transmitted to the central processing machine termed as CSAU by means of a transmitter as shown in fig. 1. The literature indicates that Mobile IP, has several drawbacks ranging from triangle routing, its effect on network overhead and end-to-end delays to poor performance during handover due to communication overhead with the home agent [2, 4, 6, 7, 8]. Several micro-mobility approaches attempt to modify some mechanisms in mobile IP to improve its performance.

The proposed architecture can be used to identify issues of performance tuning/ diagnosis through performance measurements of factors like jams, network jitter, network congestions etc.

b. The Cumulative Services Archives Unit (CSAU)

The CSAU is meant to receive the data from the SAU's through its receiver. After receiving, the CSAU generates a summary of services used in different access networks in form of a graph. This generated graph determines a summary of services used, services usage time slots, breaks, and re-logins, network jitter and congestion states.

On implementation, the proposed architecture will be vital in diagnosing QoS problems and hence optimizing the network accordingly. The data flow diagram of the proposed analysis unit based 4G network is shown in Fig. 2.

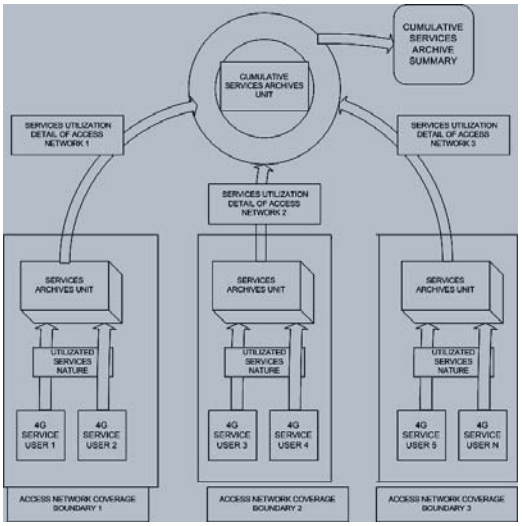


Fig. 2 Dataflow Diagram of Proposed 4G QoS Architecture

The proposed structure once embedded in the 4G network can easily derive calculations for QoS enhancement without disturbing the other concurrent processes. Moreover the architecture is least concerned with the resource utilization of the 4G communication infrastructure as the model describes to have its own hardware and software bases to perform its operations.

III. Discussion

As computer and telecommunication networks are in a state of merger, there is a dire need to improve the availability of uninterrupted high quality of services to the users. This requires architectures with huge capacities of handling data transfer and services provision. Such architectures must be flexible enough to handle multiple types of data acquisition requests. A network must keep a personalized intelligent profile of user requirements so as to facilitate them during network access. For this reason large scale research projects are under way [4, 5, 6, 7, 8].

In 4G network, user acquires services both in static and dynamic states. When ever the resources are limited, the priority assignment procedures are adopted. In areas with heavy loads of data traffics, these techniques help little and ultimately a user suffers [5, 7].

The terminology AAA referring Authentication, Authorization and Accounting mechanisms must be combined

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together in such systems so as to ensure the availability of QoS and user data/costing coordination [8].

The suggested architecture fulfills the requirement of not disturbing the Authentication, Authorization and Accounting mechanisms as it fetches the user data after connectivity for both static and dynamic users. In areas with heavy loads, the users and terminals of a 4G use the handover between any of the available technology without breaking their network connections and they maintain their QoS levels. The users can further roam between administrative domains keeping their contracted services across domains thus help for the architecture to consider breaking points in network loops in terms of QoS..

In order to keep a track record of user profile by the service provider, a user is approached both inside and outside his mother network.

In case the service providers are many in number, they all keep on exchanging information to keep track of the services being used by their customers [3].

In the proposed architecture all the network service discrepancies can be removed with uniqueness without directly affecting the 4G network user performance because the structure is working as an attached module and not affecting the already running components of the 4G system.

The proposed architecture is gaining information through the bandwidth utilization and user demand factors. The data acquired by the proposed architecture is purely related to QoS optimization. The main feature of the proposed QoS architecture is that it never asks for any information that is personal/ confidential. Hence the type of data received determines the nature of user requirements. This identifies the services being utilized by a user on an access network, e.g. the functionality of connection establishment time defines the time slots of services usage. All this information being vital for calculating the trend of user needs makes the network optimization easier for the professionals who can mould the network accordingly and derive a general trend of user specific requirements. The fig. 2 depicts the block diagram of the proposed architecture with its components as the source of information gathering and processing. A network optimized according to the derived values, will provide efficient performance to network users and reduces user complaints regarding congestion, service breaks and jitters. In short, once a measurement of user requirements is achieved through this architecture, we can direct our optimization in a right direction with out disturbing the user services, hence saving extra costs and efforts.

IV. Conclusion and Future Work

As 4G networks are gaining wide popularity, it is currently thought to be the next generation of mobile computing. Its usage and advantages make it distinguished from all other peer technologies and cellular networks. In order to keep its services available all the time, there is a dire need to improve its services provision efficiency. We introduce the statistical analysis unit based architecture capable of supporting such an idea in a multi-operator environment of 4G network. The theme the improvement in the structural performance by customizing it according to the network type needs thus saving extra bandwidth/ cost factors. The same can be used in helping the operators to judge the user requirements and knowing peak times of services utilization.

The proposed SAU architecture has the capability and flexibility to fit in an already functional 4G network. It can be customized according to the network usage priorities so as to considerably improve a network's QoS performance. The concept will be refined by a field trial with real users after an initial test phase in controlled environments in future.

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