A Priority Based Next Generation Network Simulation Study for Quality of Service Benefits: A Greek Case Study

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Abstract: - In recent years, the economic and technological developments, market liberalization, strong-demand multimedia services and the increased number of mobile networks users, indicate the necessity for convergence of the two network technologies, mobile telephony and Internet, in order to provide Internet services in the mobile communications environment. The above requirement has led to the creation of the Next Generation Network (NGN). This paper studies the functional architecture of NGN emphasising on the control functions, signalling architecture and functions of Quality of Service (QoS) issues service level. The network service layer architecture is described, along with the resource control functions, which are an important part of the architecture of NGN. Furthermore, an NGN network in Greek region is analysed, modeled and simulated using Riverbed simulation environment based on priorities levels. Finally, the simulation results are presented and analyzed.

Key-Words: - NGN, QoS, functional architecture, Greek region, Riverbed Modeler, simulation

1 Introduction

Next Generation Network (NGN) is a network based on package transport capable of providing telecommunication services and able to use multiple broadband and QoS transport technologies, in which the functions related to services are independent of the underlying technologies related to the transport. It offers unlimited user access to different service providers. It supports generalized traffic which allows continuous and global service provision to users.

In September 2003 the European Telecommunications Standards Institute (ETSI) [1] created the technical committee TISPAN (Telecoms and Internet Converged Services and Protocols for Advanced Network) aiming to standardize the NGN in agreement with the constitution of the International Telecommunication Union Telecommunication Standardization Sector ITU-T [2]. The TISPAN committee decided for the control level to adopt the IMS26 (IP Multimedia Subsystem) architecture, who initially had been developed for 3G mobile networks from the 3GPP (3rd Generation Partnership Project) [3] which belongs also to the ETSI. ETSI TISPAN architecture, is the most complete and standardized architecture for the growth and the concretization of the NGN. The following Fig.1 provides a comparative view of the existing vertical network infrastructure (conventional network) and a network in accordance with the New Generation Networks architecture [4], [5], and [6].

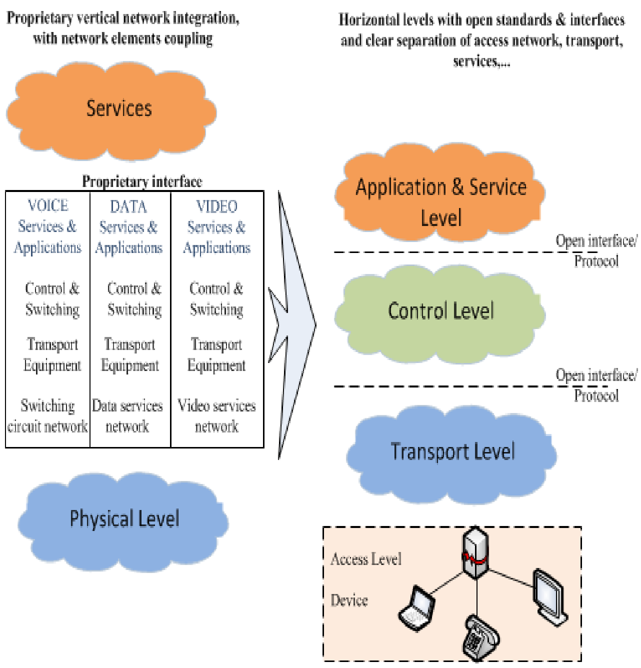

Fig. 1. New Generation Network: From vertical to layered architecture

1.1 General Features

The functional architecture of the NGNs integrates the following principles:

• **Multiple access technologies support:** the NGNs functional architecture is required to offer flexibility in the configuration necessary to support multiple access technologies.

• **Distributed control:** this shall enable the adaptability in the distributed nature of processing of packet-based networks and shall enable location transparency for distributed computing.

• **Open control:** the control environment of the network is open in order to support the creation, renewal of the service, as well as the integration of the service by third parties.

• **Independent service provision:** the procedure for the provision of the service is distinguished from the operation of the transport network using the above mechanisms of distributed and open control.

• **Support of services on a convergent network:** this functionality is necessary to provide easy to use multimedia services, drawing on the technology dynamics of the convergent wired – mobile functional architecture of NGNs.

• **Improved security and protection:** this is the core principle of an open architecture. The utmost need is to safeguard network infrastructure through the provision of mechanisms for the security and supervision of the related layers.

• **Functional characteristics of the module:** the functional modules integrate the following principles:

– The functional modules may not be distributed on multiple physical units but they may have multiple instances.

– The functional modules are not directly interconnected to the layered architecture. However, similar modules may be found on different logical levels.

The functions performed at the various levels of the network are depicted in the following Fig.2 [7]. The functional architecture of NGNs supports User - Network, Network-Network, Network Application and Network Service Interfaces (UNI, NNI, ANI, and SNI). The functions of the NGNs are distinguished in the service stratum functions and the transport stratum functions. The provision of the services/application to the end-users is materialized through the exploitation of the applications support functions and the services support functions with the respective control functions. The transport stratum provides IP interconnection services to the NGNs users, under the control of the transport control functions, including the network attachment control functions, the resources and inflow control functions and the mobile control functions.

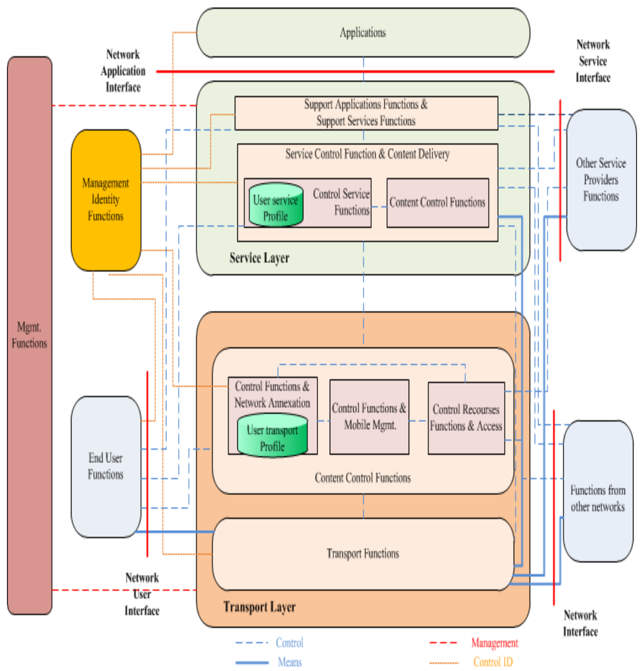

Fig. 2: Review of the New Generation Networks layers and Functional Components

2 Quality of Service

The term Quality of Service refers to the ability of the network to offer better services to its users, which services with a guaranteed transport rate, enhanced features for the minimization of data loss, low Jitter and controlled latency. QoS plays a very important part in all modern networks. On the part of the user, the network is required not only to serve the user, but serve him/her according to his/her personal requirements. QoS support is particularly important to the network administrator as well. An NGN network maximizes gain compared to other types of networks, because it is able to provide the QoS selected by the user. Although the deployment of such a network is much more expensive, the financial benefits from the provision of such services, which are distinguished on the basis of QoS, are more. Moreover, the provision of QoS is another way to depreciate network investment, as it allows optimum usage of resources. In addition, QoS provision allows the network to promote in the market numerous cost-effective packages so as to provide the users with customized services, attracting thus new customers, as they cover the needs of different users. In a few years, the concept of networks shall change, according to the specifications of NGN. As stated above, QoS is important for all networks, but the ultimate winner is the user, who is not interested in the intermediate technologies used but solely for his/her continuous connection with the network and the use of the desired services. This means that, if the network has guaranteed high transport rates and data integrity, then the user shall not be tolerant to low transport rates or information packets loss. The first and primary need of a user is to be able to connect to the network any time. In order to achieve this, the network must provide increased possibilities of successful connection, as well as fast access. Therefore, the connection possibility must exceed 90% and the waiting period for a connection must not exceed a few seconds.

A second requirement is for the network to be able to maintain the connection active, throughout the duration of the call and not to present communication failure phenomena. This requirement is met by all communication networks, but mobile telecommunications encounter many difficulties as this requires complete geographical coverage and large capacity per cell.

Call quality is another requirement of the user, as the latter wishes voice quality to be similar to actual quality. Thus, there must be usage of various compression algorithms that can minimize the volume of information without, however, deviating significantly from actual quality.

All the above requirements also apply to voice services. The most important requirement usually is very high speed, followed by the requirements for a small number of faults and non-loss of information. Of course, requirements vary depending on the service and thus, for example, file transfer requires data integrity, while video provision requires high transfer speed. In brief, there are 6 dimensions, which contribute to the perception of the QoS offered by the end-user [8], [9]; these are:

- Services availability
- Satisfactory Data Passage
- Delay
- Jitter
- Information loss rate
- Fault rate

3 Critical Parameters for QoS

The most important parameters affecting the user, who is the judge of the QoS offered, are the delay, jitter and information loss. These parameters, along with others, such as the guaranteed transmission rate, the maximum transmission rate, etc. are those that differentiate QoS classes and define the various QoS profiles offered by the networks. Below follows a short description of these parameters.

Delay: This is the time between a user action and its results. Low delay times imply high exchange speeds, while long delays mostly occur in data transfers, for which fast transport is not of interest.

Jitter: Describes the variable times of arrival of the packets to the recipient, which is particularly annoying for certain real time services and is dealt through the usage of buffering techniques, which eliminate this phenomenon.

Information loss: This is the rate of information not delivered, or delivered with errors. There are many algorithms that aim in the correction of information loss issues, but this is not always feasible. Applications such as file transfer require zero data loss, while others, such as video transfer are tolerable to information loss up to a certain degree.

In order for the network to be able to offer the required rate of performance, there must be usage of specific mechanisms within the network. Through these mechanisms there is control of the network services and the distribution of related performance data of the services, even in the case that network resources are claimed. The NGN must be able to support a broad range of QoS activity services. In order to offer these QoS services, it is necessary to identify the following:

A) Bearer Service QoS Classes
B) QoS control mechanisms
C) QoS control functions architecture
D) QoS control/signaling

A. QoS Classes

The current templates distinguish the remote services which are used on the terminals and networks and the bearer service that prevent entrance to the terminals (from UNI to UNI). In an open and liberated market, it is not always feasible to control the internal installation of the user. In an NGN environment, the performance of the networks at the bearer services level must be considered.

B. QoS Control Mechanisms

On an NGN network, there could be usage of various QoS control mechanisms [10],[11] respectively to the different technologies and the eventually different operational standards. These support mechanisms of the QoS have a strong impact on the architecture required for the generation of the requested service. In fact, there are various alternative solutions, which depend, for example, on the final capabilities of the users, or the needs of the services.

- Service Requested QoS
- User service requested QoS with prior authorization
- User service requested QoS without prior authorization

C. QoS control functions architecture

The architecture of the QoS control functions [12], [13] on an NGN network must be able to support the three scenarios of the QoS control mechanism.

D. QoS control/signaling

The control and signaling of the QoS on an NGN network uses RSVP and COPS protocols in order to satisfy the requirements of the QoS control functions architecture QoS in certain implementation scenarios.

4 QoS structural elements

The key of a proper framework architecture surrounding QoS is the existence of a set of special mechanisms in the network used for the control of the response of the network following a service request. Such response may focus on a certain element of the network, or the signaling between network data, or the control and management of traffic in a network.

As shown in Fig. 3 the structural elements that comprise QoS are classified in three planes:

Control Plane: This includes mechanisms that concern the methods of selection of the path through which traffic "travels". These mechanisms include input control, QoS routing and resources engagement.

Data Plane: This includes mechanisms that are directly related to the traffic generated by the user. These mechanisms include the management of the temporary data entry, congestion prevention, packets signaling, queuing and time scheduling, classification, supervision and configuration of traffic.

Management Plane: This includes mechanisms related to the function, management and administration of the network. These mechanisms include the Service Level Agreement (SLA), traffic restoration, measurement, recording and supervision of traffic.

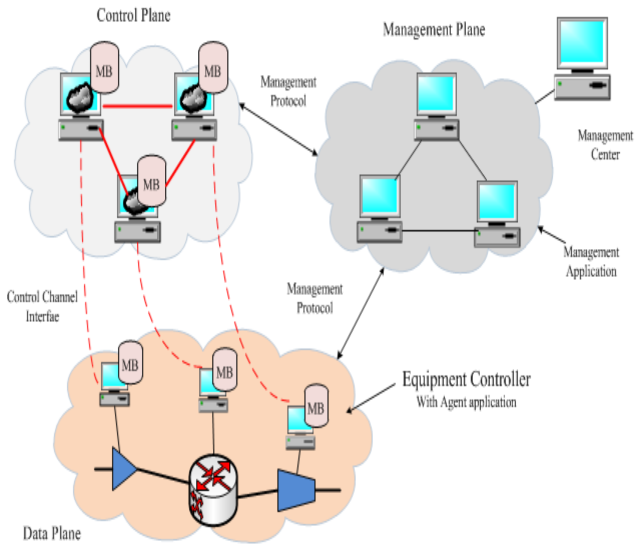

Fig. 3: Logical levels of Service Layer

Fig.4 [8] presents in detail the structural elements comprising the framework architecture around QoS.

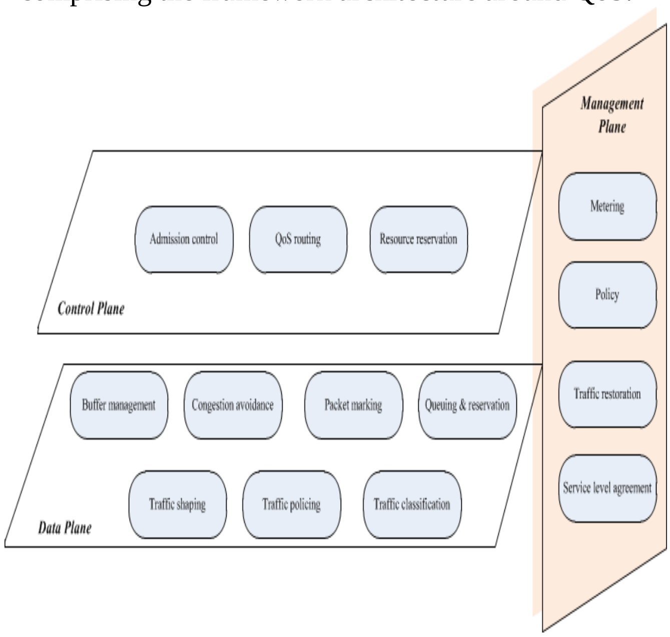

Fig. 4: Structural elements of QoS architecture

Signaling may be materialized on any of the three logical planes and can be considered as an interaction between such structural elements. In the case of signaling at the control or management plane, there is usage of a signaling protocol. It is important to note that QoS framework architecture is logical and does not impose restrictions in the method of realization of a structural element. For this reason the materialization of a structural element can be distributed, or centralized.

5 Simulation Analysis and Results

Networks architecture has become so complex that traditional analytics method cannot provide an accurate understanding of system behavior. Riverbed Modeler [14] is a commercial tool for the modeling, simulation and analysis of the communication networks, distributed systems, computer systems and computer applications. It allows the design and study of communications networks, devices, protocols and applications with great flexibility and scalability. It offers object-oriented approach to modeling and graphics editors whose combination allows monitoring the structure of real networks and network components. This tool supports all types of networks and technologies allowing thus the design and testing of various scenarios with a reasonable certainty concerning the output results, while the change of certain parameters enables direct study of the effect of such changes on the network. The areas of implementation include protocols and schemes of wireless and satellite communications, the design of networks and the analysis of their performance and their problems before actual implementation, the management of micro-component networks and fiber optics networks, the development and management of protocols, the assessment of routing algorithms for switching routers and other connection devices. Some of its features that render it such a powerful tool are the hierarchical network models, the object-oriented modeling (which allows nodes and protocols to be modeled as classes, with all features of object-oriented design), the ability of concurrent simulation and comparison of multiple scenarios, the ability to input traffic patterns in the modeling software, the capability of analysis using built-in graphics tools. Riverbed avails a very effective simulation engine further enhanced by the capability offered to the user to change memory utilization during simulation. Its core is in C++ programming language and it is compiled same as a C++ program. This fact provides the ability of particularly detailed control by the user, if the latter has a good level of comprehension of the language.

The main objective was the development and study of a Next Generation Communication Network [15] in which applications with different priorities are sent. The simulation analysis was based in the Asynchronous Transfer Mode (ATM) [16] protocols and architecture modified to next generation networks system needs.The packets are stored in several buffers in the network with different priorities. The NGN network is constituted by thirteen nodes which function as end users (clients) and one gateway through they pass all the data. The nodes are outspread in thirteen large cities in geographical area of Greece and the packets inside the network are sent with accidental priority from one to three – one the highest weight, factor and three the lowest as it is defined for NGN networks, in the control plane service layer with uniform distribution.

The priorities levels are analyzed below [17], [18], [19]:

- *Priority level 1:* This priority level has the higher acceptance indemnity in the network. This priority is addressed in emergency telecommunications over NGN. In this level data services will be examined.
- *Priority level 2:* This priority level has lower acceptance indemnity from level 1, but higher acceptance indemnity from the one that is granted in the level 3. As examples of level 2 priority would be, the real time services (VoIP, video), VPN and voice services. In this level voice applications will be studied.
- *Priority level 3:* This priority level has the smaller acceptance priority in the network. As examples are reported the “traditional” services of Internet Services Provider (ISP) (eg. email). In this level email applications will be studied.

In the case that a buffer does not have packets, getaway checks for data every 1 sec. Fig. 5 illustrates the topology used for the experiment located at different places in Greece: Alexandroupoli, Kavala, Serres, Thessaloniki, Ioannina, Trikala, Larissa, Lamia, Patra, Kalamata, Khania, Iraklion, and Rhodes. The nodes are interconnected through the Getaway node in Athens. The applications operation mode is assigned as Simultaneous, and start time is set to Constant (100). The simulation duration is set to End of Simulation. The application start time offset is set to uniform (0, 300), and duration is set to End of Simulation. The end hosts are changed according to scenario definition.

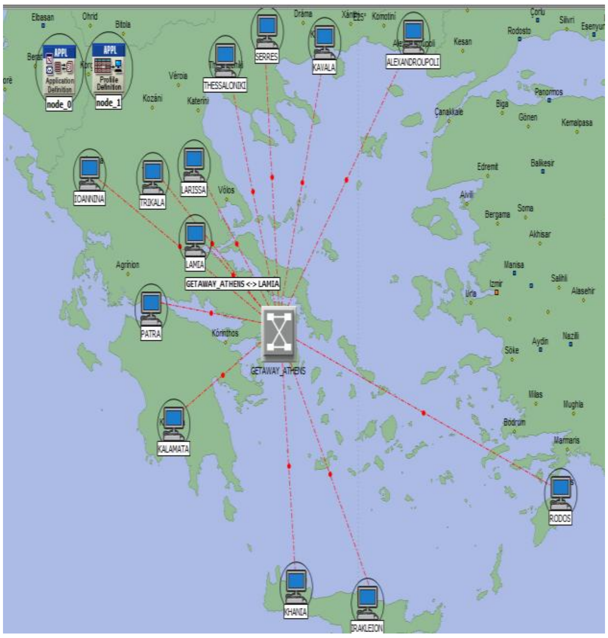

Fig. 5: Next generation network nodes location

The NGN is a network which has convergence of all technologies that are widely used while the node model is a simple model since the major operation is executed in the service layer. Furthermore all the nodes are been subjected in the same processing and modeling.

The assumptions that have been taking into account while developing the network was:

- 50% bandwidth it is occupied for data emergency applications
- 33% bandwidth it is occupied for voice applications
- 17% bandwidth it is occupied for email applications

Fig. 6 shows applications configuration in Riverbed Modeler environment.

There are two main types of statistics that we are interested in. The first type is the collection of values from individual nodes in the network (node statistics) and the second type is from the entire network (global statistics). Global statistics can be used when we are interested in an overall picture of the network performance. Global Statistics are collected for all nodes/links in the network. Node statistics provide information about individual node. The Global Statistics of the network, whose graphs will be examined, are listed and analyzed in the following:

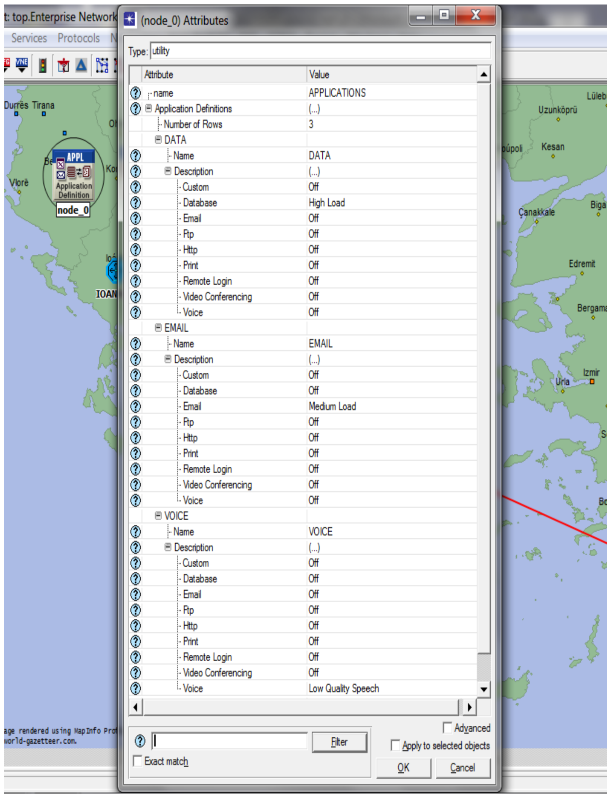

Fig. 6: Application configuration for the network assumptions

- **Delay variation:** Measures the variance among samples of end-to-end delay experienced by Packets traversing the network along all connections established network-wide.
- **Traffic Received (bits/sec)**: represents the application traffic received by the layer across the network.
- **Traffic Sent (bits/sec)**: represents the application traffic sent by the layer in bits/sec through the network.

The Node Statistics of the network are analyzed below:

- **Buffer usage (Bytes)** : represents buffer used in number of bytes for a specific queue. This statistic is updated on a cell enqueue and cell dequeue. This statistic does handle compounded cells. By default, a time-average of this statistic is plotted. Buffer used in number of bytes for a specific queue.
- **Client Traffic Received (bits/sec)**: Average bytes per second forwarded to the Database Application by the transport layer in this node.

The results and graphs are presented in the following Fig. 7-10. For different time moments it is observed that various nodes send messages with different priorities. The packets with priority level 1 are sent straight and correspond in calls of emergency. The packets with priority level 2 correspond in voice while the remaining packets with priority level 3 have smaller priority and correspond in email applications. The first graph (Fig. 7) depicts the delay variation in our simulation scenario. This graph is drawn between the time and number of bytes in the network, so those are represented in the X and Y axis's respectively. Time is calculated in the terms of minutes. For efficient networks delay variation must be very low value. The analysis indicates that our network has been developed in order to serve emergency priorities at first – approximately achieves 0.0000062 sec which is a very significant value for network delay variation.

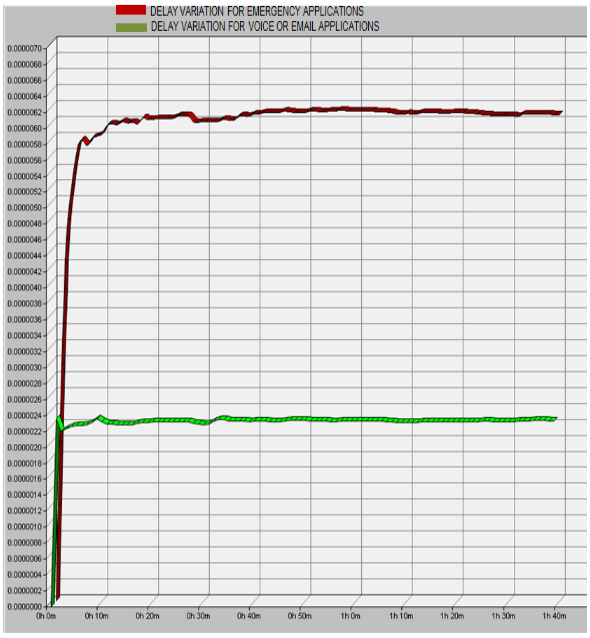

Fig. 7: Delay variation for emergency applications and voice applications

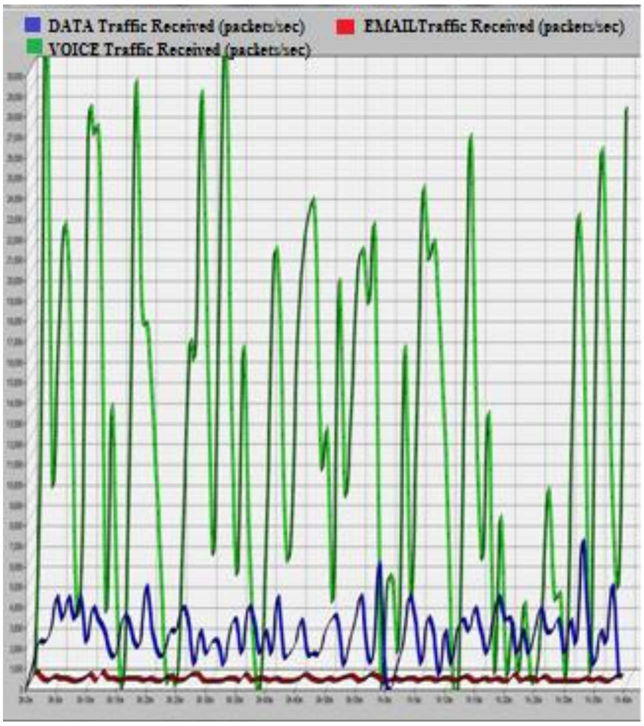

Fig. 8: NGN traffic received for the sum of applications

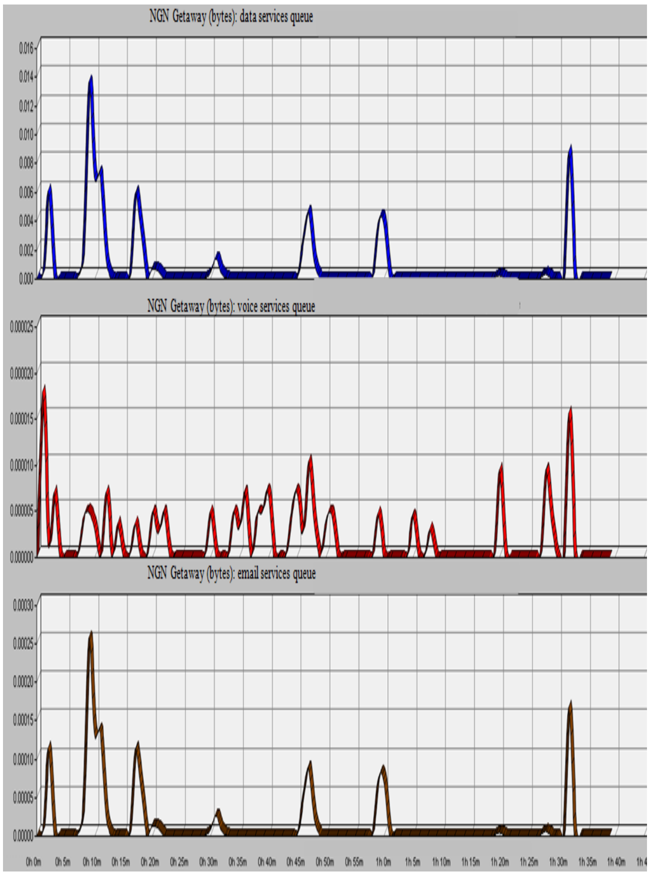

Fig. 9: Next generation network application services buffer usage queue

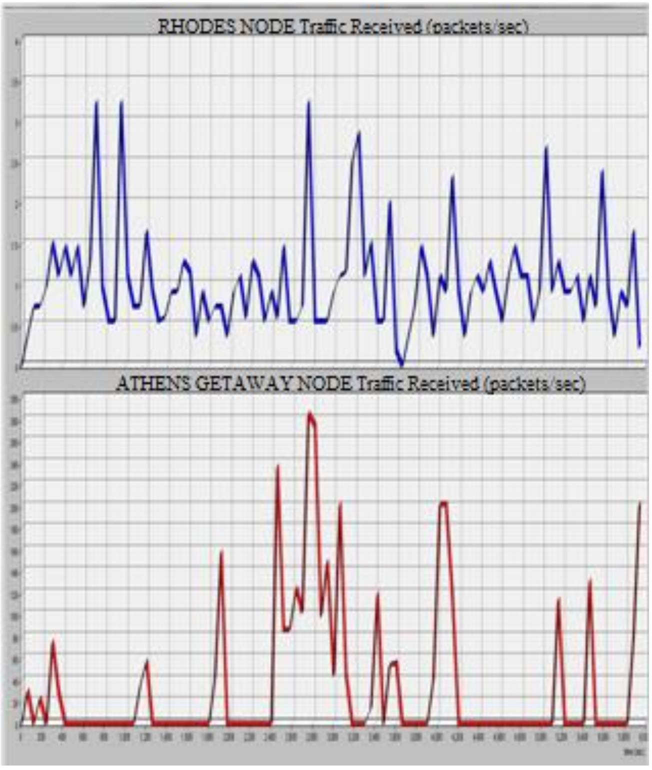

Fig. 10: Application traffic received two nodes comparison

Following is the graph (Fig. 8) of traffic received by the network in bytes per second. It can be seen that steady stream of traffic is sent without disruption and emergency application occupy half of the available bandwidth followed by other applications. Small spikes at the beginning of the simulation are indications of management the control traffic due to the presence of nodes. Following graphs in Fig. 9 shows the application services buffer usage queue in term of bytes versus time. This value must be low for any network and our network model achieves low values with promising results. These results shows that voice and email applications have more or less equivalent usage queue and emergency services presents higher traffic due to the fact that the channel is always busy with data transmission although with collisions avoidance. Finally, last figure (Fig. 10) shows the comparison of two nodes, Getaway node (Athens) and end user node (Rhodes) in terms of traffic received (packets/sec). It is obvious that Athens node getaway gathers all types of data and has increased values comparing with the other node (Rhodes) something which is normally expected.

6 Conclusions

In this paper, the functional architecture use of Next Generation Networks (NGNs) has been discussed and a detailed analysis of the most important parameters affecting QoS has been presented. The NGN must be able to support a broad range of QoS activity services. A simulation study in the geographical area of Greece was conducted in which applications with different priorities are sent. Data services email and voice applications are examined. As depicted in the paper, our network has been developed in order to serve emergency priorities at first and succeed excellent results. Conversely, in case of calls and packets that are sent with the same priority, further experiments shows, the network is perplexed, it does not know how to react and defines that the first packet with the smaller number will be served. In addition, Furthermore, it should be noted the assumptions made by the author that transmitted packages have the same size which is obviously not applicable in real time environmental conditions.

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