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Improving QoS and Service Level Agreement of Mobile Application at Transport Layer using Fuzzy Logic Mapping

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Abstract*—Mobile applications and mobile application environment of next generation networks require enhanced quality of service (QoS) to support user's service level agreement (SLA). This paper presents an adaptation technique at transport layer to minimize the impact of varying and adverse network condition along with security and priority to satisfy the SLA. The paper extends the transport layer functionalities to manage the SLA by selecting network layer parameters and application layer parameters. The given approach provides a performance based on the analysis of mapping network layer and application layer availability and security to network concerned parameters like security and priority by using fuzzy rules. Network parameters scrutinize at transport layer to get the information about speed, delay, jitter and loss. Application layer provides information such as priority, security to the extended functionalities of transport layer. The objective is preserving the QoS perceived as per SLA at an acceptable level.

***Keywords*— QoS, SLA, fuzzy rules, mobile applications, next generation networks**

I INTRODUCTION

Explosion of multimedia mobile devices and mobile applications are causing huge amount of data traffic over mobile networks [1]. As more and more mobile users running their mission critical application jobs like text, graphics and video in mobile environment, the efficient management of these types of applications are vital for the achievement of mobility. Quality of service (QoS) adaptability is important since certain important features of the integrated network require QoS adaptability [2]. The cost loss cause of the fall in time and/or deprived performance of the mobile application enhances gradually. Mobile applications work in a different way comparatively of client/server applications. In case of client/server model, client and server computer shares the software application components. In a mobile application environment, any application may be running on many more mobiles across an entire world.

The evolution of mobile and mobile network applications introduced new challenges in support of expected and consistent communication performance. Mobile networks are getting ubiquitous popularity as it permit for the setup of communications with no requirement of connecting cables. Such types of networks are distinctively categorized as per the resources of scarce (like power of battery, bandwidth, storage limitations and processing, etc.), requirement of any established infrastructure, huge rates of errors, and using a active topology as each of the vertex is capable to connect or disconnect the network in any time [3]. To get the guarantee of QoS for these types of applications onto the mobile networks and for the sustainability of QoS, it's required to incorporate a procedure to observe the QoS and presentation of each application to work with the existing network resources. In adding up, this process should be a continuous one to prove the assurance so that communication channels should satisfy the technical and commercial needs with the service delivery. The measurement of QoS parameter is basically used as the term in order to satisfy the hundred percent outputs when the mobile networks are used to transmit video, text, or graphics applications. Today, without considering the limitations of bandwidth, mobile applications are in great demand, QoS prerequisite in wireless multimedia network has become great importance [4]. Evolution of Wireless computer networks is required to serve the services dynamically. To ensure QoS assurance, it in sufficient to just place resources as QoS degradation is frequently obvious [5]. Because of this, the QoS evaluation and observations are necessary as they permit the network controller for the assurance that without scaling the present networks the mobile applications receive high quality of service and can utilize the available resources successfully. According to research [6], service providers may make use of a combination of different technologies access to offer users to select a wide variety of innovative services, characterized by the demand for different requirements of QoS.

The main objective of this proposed work is to invent a method to estimate the mobile network performance by taking into consideration the QoS requirements. This technique is used to measure the entire Quality of service in mobile networks by using fuzzy logic inference system. This technique is very much accepted which supports a method for management of nonlinearities and uncertainties which may be present in physical structure [5]. It uses a linguistic terms, natural description, of various problems that can be solved instead of using terminology of relationships between particular numerical values [7]. In [8], the author proved that fuzzy logic is for solving complex problems, less computation required than the Neural Networks. Fuzzy set is the generalization of crisp set.

Problem Definition

Mobile applications management insists on real time. The online observation of objects, middleware, network and the resources that includes working of applications. The technology for the organization of text, video and graphics applications has not kept back rapidity with the usage of large scale, heterogeneous, distributed applications. Thus, it introduces many more tests for the Application Service Providers and also for IT Sectors or large organization and:

- Based on QoS parameters, how does the mobile application mapping will be done with the consideration of different services?
- How to observe QoS at various layers with the required specification of QoS?
- How to resolve the problem of network layer parameters when service level agreement (SLA) is used and how to map these parameters as per the end-user service level agreement?

Even though there is a trivial growth in the field of measurement systems and platforms management and still there is a vast semantic space between the metrics proposed by the commercial platforms and measurement systems and the metrics that administrators need [9]. Efficient control of end-user service level agreement is not a separate method. The given layers decide the evaluation of mobile applications. An application below average performance or fault may have various causes across the different layers like application, network or transport layer. Research exposes that the problem occurs at application layer, 45% are because of network problems, 45% are because of application design problems/bugs, 10% are due to host/disk problems [10].

II RELATED WORK

QoS prerequisites are becoming day to day essential with the requirement of mobile communications and appearance of bandwidth-requirement multimedia applications [4]. Therefore, the QoS performance and measurement are essential. As there have been many more research on the user service level control and management with various forms for various applications. Some researches mention that there are many researchers working on the transport layer management and measurement with various models for kinds of applications. Few of those stated the significance of mapping of network to application layer and some of the researchers provided the method on how to develop the mapping. A new framework [11], which is called dynamic QoS-based bandwidth allocation (DQBA), to support heterogeneous traffic with different QoS requirements in WiMAX networks. This DQBA aims to maximize the system capacity by efficiently utilizing its resources in compliance with the IEEE 802.16 standard specifications. For the QoS measurement in communication networks have been the immense areas of research on the basis of active and passive measurement types [12]. An intelligent approach [13] has used a fuzzy logic evaluation and assessment system to estimate the QoS of an audio multimedia application. This study illustrated how the QoS parameters could be combined to give a single output QoS without the necessity for analytical, heavy calculations and mathematical models.

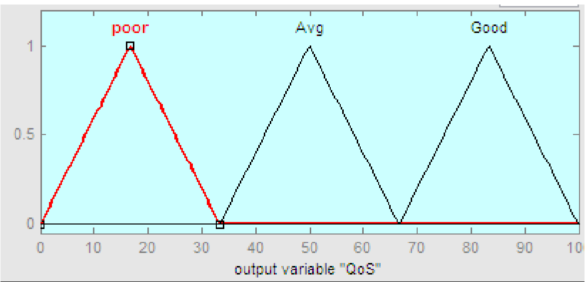
In [8], [14], [15][16][17], the author have worked on network analysis problem using fuzzy logic. The authors have worked on evaluating the QoS using fuzzy logic by [15], [16]. In this study, the author used a fuzzy logic method to get the performance of image transmission QoS over a network and then to meet the required quality of image was based on frame rate.

Tse-Au et al.[18] presented a methodology to graphically characterize the response time of an existing DB access application as a function of network “tunable latency” in a mobile environment. This paper is based on experimental data collection by using off-the-shelf technologies to set up the testing environment. In our paper, we use mapping approach. The author [19] presented a framework to be used to predict end-to-end QoS at the application layer based on mapping of QoS guarantees across layers in the protocol stack and concatenation of guarantees across multiple sub-networks.

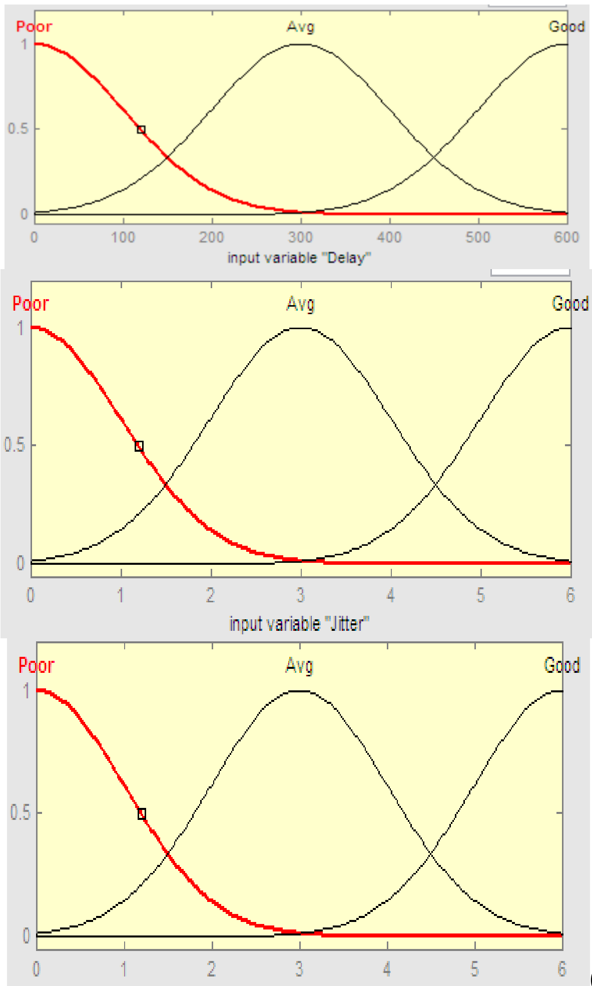
A per-packet differentiated queuing service (DQS) is developed in wired-wireless integrated networks, especially in terms of its support of QoS adaptability to mobility and to bursty real-time applications [2]. QoS-based dynamic adaptation techniques is developed for the flexible employment and smooth integration of headlight prefetching and dynamic chaining to continuously provide quality streaming services to mobile users [20].

III METHODOLOGY

A mobile application is an intellectual organize unit, consists of any type which runs in a mobile surroundings. It can be a single module like a database, a web page, an URL, a CORBA object, a UNIX process, an EJB or a Java class, etc. However in theory, a mobile application is a mixture of processes and objects with some dependent relationships that communicate with each other in order to supply a service to end users [21]. Mobile application fuzzy membership functions as inputs and outputs are shown in fig. 1.



(a)



(b)

Fig 1. Mobile application Fuzzy membership functions a) Output b) Inputs

Fuzzy logic system for network layer

Evaluation of QoS is to be calculated on the basis of fuzzy logic. Our system proposes a fuzzy inference system which includes fuzzy reasoning, fuzzy rules, fuzzy inputs and fuzzy outputs. As we have considered previously, jitter, delay and loss are the main QoS parameters of an audio application. Their performance will be evaluated and specified as input variables given to the fuzzy system. Three fuzzy sets were used as the fuzzy input variables to produce the input membership functions on the basis of QoS needs of as shown in Figure 1(a). The fuzzy linguistic variables used were Poor, Medium and High. All input parameters were mapped to these fuzzy sets as per its QoS value. We used a Gaussian membership functions which is most popular for computing simplicity, its smoothness and for representing fuzzy sets [7].

Membership Functions	**Delay**	
	Mean	**Std Deviation**
Poor MF	0	101.9
Average MF	300	101.9
Good MF	600	101.9

(a)

Membership Functions	**Jitter**	
	Mean	
Poor MF	0	Poor MF
Average MF	3	Average MF
Good MF	6	Good MF

(b)

Membership Functions	**Loss**	
	Mean	
Poor MF	0	Poor MF
Average MF	3	Average MF
Good MF	6	Good MF

(c)

Membership Functions	**QoS**	
	Mean	
Poor MF	0	Poor MF
Average MF	50	Average MF
Good MF	100	Good MF

(d)

Table 1. Mean and Standard deviation values of mobile applications input and output membership functions (a) Delay (b) Jitter (c) Loss (d) QoS

First of all the mean and SD (standard deviation) values have to be considered for mobile application as shown in Table 1. According to the QoS requirements, the mean and SD values were selected to offer logical outputs to reproduce usually QoS of the application. Here, QoS is the output which is the fuzzy output. Therefore, this output was assumed as the marker of how the network is dealing with the existing application. As shown in fig 2, these fuzzy output variables are split into three. The corresponding fuzzy linguistics variables were Poor (for poor QoS), Average (for average QoS) and Good (for good QoS).

Fuzzy Rules :-

(If delay is poor) and (Jitter is poor) and (Loss is poor) then (QoS is Good)

(If delay is poor) and (Jitter is poor) and (Loss is Medium) then (QoS is Good)

(If delay is poor) and (Jitter is Medium) and (Loss is poor) then (QoS is Good)

(If delay is Medium) and (Jitter is poor) and (Loss is poor) then (QoS is Good)

(If delay is poor) and (Jitter is Medium) and (Loss is Medium) then (QoS is Average)

(If delay is Medium) and (Jitter is poor) and (Loss is Medium) then (QoS is Average)

(If delay is Medium) and (Jitter is Medium) and (Loss is poor) then (QoS is Average)

(If delay is Medium) and (Jitter is Medium) and (Loss is Medium) then (QoS is Average)

(If delay is High) or (Jitter is High) or (Loss is High) then (QoS is Poor)

Fig 2 Fuzzy Rules at Network Layer.

Thus quality of service depends upon the delay, jitter and loss accordingly. The fuzzy rules are as shown in figure 2.

QoS mechanism at Application Layer

In our implementation working of application jobs will be measured in terms of response time priority and security. This information is carried in a special message packet called “QoS report”

SLA – Priority, security and Response time

Definition:
Priority = Response Time -Request Time
Priority=1(Low Priority)
Priority=2(Medium Priority)
Priority=3(High Priority)
Expected Service Level – Priority=1 = 99.5%
Expected Service Level − Response Time = 4 seconds
Minimum Service Level – Priority=3 = 98.5%
Minimum Service Level − Response Time = 6 seconds

Fig 3. *A Sample SLA for Mobile Application*

Fuzzy Rules :-

(If priority is low) and (security is low) then (QoS is poor)
(If priority is low) and (security is high) then (QoS is average)
(If priority is low) and (security is medium) then (QoS is poor)

(If priority is medium) and (security is low) then (QoS is average)
(If priority is medium) and (security is high) then (QoS is good)
(If priority is medium) and (security is medium) then (QoS is average)

(If priority is high) and (security is low) then (QoS is poor)
(If priority is high) and (security is high) then (QoS is good)
(If priority is high) and (security is medium) then (QoS is average)

Fig 4. Fuzzy rules at Application Layer

In the paper total numbers of rules are dependent on number of input variables from application layer and the number of fuzzy sets associated with each input variables. In this fuzzy system, two parameters priority and security are used to create nine rules as shown in fig 4, resulting from the combination of the three inputs (delay, jitter and packet losses) from network layer each having three fuzzy sets.

The specific fuzzy rules based on service level agreement used in the evaluation process are shown in Figure 3. From this Figure QoS, low or good is decided.

System Architecture and Analysis steps

In this paper, mapping of application layer parameters and network layer parameters are calculated at transport layer to fulfil service level agreement. Initially the system architecture consists of two inputs at Network layer and at Application layer respectively. First block contains three numbers of inputs like delay, jitter and loss of packets. Based on these factors QoS is being calculated. Simultaneously, second block contains two inputs as priority and security which then gives Evaluated QoS. The mapping of these outputs at Network layer and at Application layer QoS parameters will be evaluated and analysed by the User SLA selection. Then the final output will be produced at the site of User SLA as shown in figure.

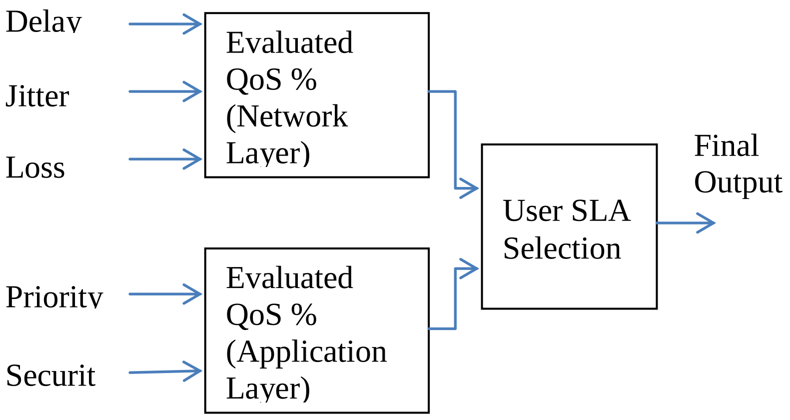


Fig 5. System Architecture

Based on network layer parameter the output QoS vector values are taken into consideration. As these parameter values were sorted out evenly into three regions poor, average and good to represent the QoS. The sorting is based on two thresholds 35% and 70%. These thresholds are used as follows:

- If the QoS value is less than or equal to 35% then the QoS will be in the poor region,
- If the QoS value is greater than 35% and less than or equal 70% then the QoS will be in the average region, and
- If the QoS value is greater than 70% then the QoS will be in the good region.

Table 2. Tested inputs QoS Parameters with their expected QoS (Network Layer)

Delay [msec]	Jitter [msec]	Loss [%]	Evaluated QoS [%]	QoS Level
20	0.45	0.99	80.3	Good
65	0.67	2.24	79	Good
45	3.2	0.89	76.8	Good
200	2.2	0.95	58	Average

70	3.2	3.2	50.8	Average
260	3	2.8	51.2	Average
300	1.1	1.1	73.8	Good
75	4	0.98	75.5	Good
510	1.1	2.1	66.7	Average
489	4.8	5.6	19.8	Poor
500	4.6	5.6	20.3	Poor
560	5.5	5.5	19.1	Poor

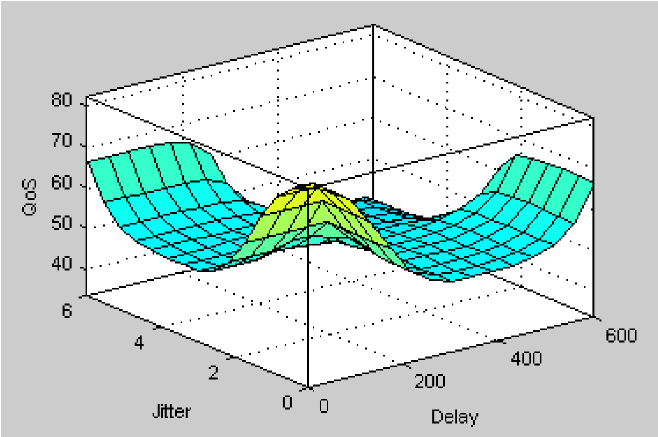


Fig 6. Inputs QoS Parameters with their expected QoS (Network Layer)

Table 3. Tested inputs QoS Parameters with their expected QoS (Application Layer)

Priority	**Security**	**Evaluated QoS [%]**	**QoS Level**
0.922	0.905	80.3	Good
0.839	0.877	76.2	Good
0.83	0.905	78.3	Good
0.5	0.5	50	Average
0.61	0.668	52.4	Average
0.711	0.786	63.9	Average
0.849	0.886	77.4	Good
0.757	0.832	66.1	Average
0.06	0.13	18.6	Poor
0.16	0.28	31.4	Poor
0.188	0.305	32.4	Poor

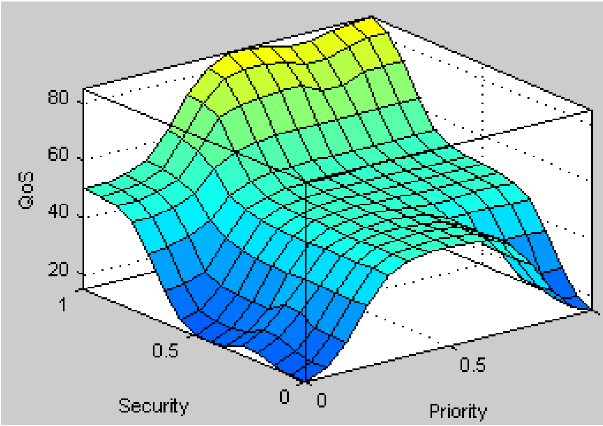


Fig 7. Inputs QoS Parameters with their expected QoS (Application Layer)

IV RESULTS AND DISCUSSION

In the proposed work, an evaluation of a mobile application was carried out. The parameters like jitter, delay and loss were evaluated. The outputs were given to the fuzzy inference system to construct the QoS of each stream. For testing various combinations of parameters value were chosen and given to the system. It has been observed that the output QoS was completely depends on the input parameters by using fuzzy rules, which are created on the basis of the mobile application requirement as illustrated in Table 2 and Table 3 using fuzzy evaluation method.

V CONCLUSION AND FUTURE WORK

This paper presents the management of Mobile application which involves accurate monitoring of end-user service level agreements, and processed them to the application layer, network layer, and transport layer parameters. Here, we provided a study on mapping application layer response time, availability to network parameters such as security and priority by using fuzzy rules. In order to get information about these parameters such as delay, loss and jitter the Network parameters are performed and Application layer parameters such as priority, security are measured in order to get the information The designed approach consists of evaluating the major QoS parameters and used them as inputs to the evaluation system according to the QoS parameters requirements of each network system. After this, they are combined with application layer parameters, the combined system produces an output that will be transmitted to transport layer to represents the instantaneous QoS as per the user requirement. We presented a method which directly maps the combined QoS at the application level and network parameters to the transport layer.
In this area, various challenges are still available. There are other application layer parameters such as packet loss, availability, etc., that we have not considered in this paper.

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