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# Generic modelling for IoT traffic management and ranking aims organized QoS using AI approach

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### ABSTRACT

The explosive growth of IoT devices and the diverse traffic patterns generated by these different devices have made traffic classification as one of the primary focuses for addressing challenges in IoT applications. High Quality of Services (QoS) must also be maintained while handling such different traffic types at the same time. In particular, machine-to-machine (machine type communication MTC) communication within IoT networks has grown significantly, and the competition between MTC and the existing human type communication (HTC) has become one of the main challenges that exhausts specific network resources. This paper has proposed a generic model to overcome the challenged related to the heterogeneity of network resources. The proposed system uses QoS parameters to enhance the IoT traffic flow by using two fuzzy logic inference system. The system works as a proactive machine to estimate the QoS condition and manage the traffic flow between MTC and HTC accordingly. The outcomes of this machine are maintaining the high level of QoS and dynamically managing the IoT resources and ranking using an AI approach.

## 1. Introduction and related work

The basic principle of the IoT is to give entities ('real' objects, those with sensors that bridge into the cyber world and actors, along with communication capabilities) to rely on each other for the gathering and exchanging of information in some form of collaboration. The IoT is simply this

formula: (Things + Intelligence + Network = IoT) [1]. The prosperous Internet of Things, a representative transformation of the traditional Internet has achieved significant societal progress, such as smart home services, intelligent city applications, smart health, intelligent grids and systems, and so on [2]. MTC (Machine Type

Communication) or M2M (Machine to Machine) communication is a means by which electronic devices, including—but not limited to—wired and wireless devices, exchange data with aforementioned specified central server(s), or send control signals without human intervention. It is the workhorse of the Internet of Things, tying together countless devices and software. MTC is motivated by the increasing prevalence of IoT applications, with use cases that are often satisfied through Wireless Sensor Networks (WSNs) for intelligent surveillance and control.

The QoS parameters (like: throughput, delay, link utilization, jitter and etc.) in IoT applications also play an explicit role when one wants to identify the performance of an application. Given the widespread adoption and popularity of IoT systems, we can expect that the number of users as well as IoT devices will begin to rapidly increase in the near future. Thus, enhancing QoS for IoT applications is vital as to enable them to achieve an increased adaptiveness [3].

The IoT is essentially integrated with the Internet, and their respective traffic leads to shared resources. Satisfying QoS requirements ensure that the services and applications are still offered. Traffic Classification is a key factor for infrastructure management to provide Quality of Service. There remains an array of opportunities to improve IoT's QoS by traffic classification methods [4].

Contemporary communication systems have been designed for human-type communication (HTC), which is downlink-heavy and bursty. In contrast, machine-type communication (MTC) traffic is performed between machines and has its own characteristics: it is uplink dominant, at times periodic, yet mostly continuous. With a growing number of connected devices, it becomes increasingly critical to specify the type of traffic. The worst-condition events happen in case of signalling congestion and network performance degradation, that not only impacts human type communication HTC, but also M2M application as well [5].

The following study offers a complete perspective with background on prior research in the field: Al-Shammari et al. 2018 [1], Mobile and Wireless Networking... 2013 [4], Wu et al. 2024[6], Beshley et al. 2024[7], Umoh et al. 2017[8], Mazhar et al. 2023[9], Hailan et al. 2024[10], Mohammed et al. 2025[11] and Tahaei et al. 2020[12].

The previously listed research did not share the effect of QoS features on the MTC and HTC

heterogeneity. The issue at hand is to satisfy QoS for HTC and MTC at the same time, as the IoT traffic characteristics may threaten the performance degradation. The first concern within an IoT network is the network resources shared between HTC, MTC and the procedure that must be taken to optimize and actively maintain the NQoS. The MTC traffic will supposedly grow dramatically in the next generation of wireless networks. MTC has opposing traffic characteristics when compared to human-style communication, and therefore requires new traffic models. MTC traffic is considered an essential element for the design and evolution of future networks and their QoS architectures, making it possible to support reliable M2M communication services while preserving traditional HTC services (voice, video, data). Our AI approach differs from existing fuzzy/machine learning-based QoS management schemes because the model reduces training dependency.

This paper gives the following aims and objectives to deal with these issues:

- a) Address the network resource challenges and proposed dynamic IoT traffic management system depending on the relationship between the NQoS parameters and the network resources shared between HTC and MTC.
- b) Suggest a proactive agent machine to classify the IoT traffic and rank the priority of resources between HTC and MTC in order to achieve a high score of NQoS.
- c) By performing the two previous contributions, the proposed model will maintain the QoE status at user satisfaction.

The main novelty of this paper is to perform a proactive traffic management model that reports the existence of (MTC) and (HTC) in IoT networks. By integrating QoS parameters with a dual fuzzy logic inference system, the model presents an intelligent mechanism for dynamic resource allocation and traffic prioritization. This work contributes to improving QoS maintenance and adaptive network resource sharing in heterogeneous IoT environments using AI, which is an important challenge in modern communication networks.

The paper sections are arranged as below: the upcoming section presents comparison between the present study and previous research. Section 3 present the study methodology and proposed model. Section 4 Present simulation set up and dynamic system design of the suggested generic

model. Results and Discussions are introduced in section 5 and section 6 presents the conclusion also puts front progress and proposal for future work.

## 2. Comparison between the Present Study and Previous Research

Table 1. shows the Comparison between the present study and the previous researches that includes area focus of the studies and major contribution in the related area.

**Table 1.** Comparison between the Present Study and Previous Research

Ref.	Year	Area Focus	Major Contribution
[13]	2015	Impact of M2M traffic on Human-type Communication users on the LTE Uplink Channel	Evaluated the impact of massive number of MTC devices on traditional HTC users in LTE network when using both dynamic and semi-persistent scheduling. Results showed that MTC advices negatively affects the performance of HTC users in LTE networks.
[1]	2018	IoT Traffic Management and Integration in the QoS Supported Network	Offers Fixed network resources share policy solution of Traffic flow management
[14]	2019	Slicing Cell Resources: The Case of HTC and MTC Coexistence	Proposed model that allows the investigation of the effect of the allocation of resources to slices on the radio interface of one cell, hence the correct setting of the slice parameters. The model observed the mutual effects of slice traffic between MTC and HTC.
[15]	2020	Uplink Performance	Proposes stochastic

[10]	2024	e of NOMA-Based Combined HTC and MTC in Ultra dense Networks Traffic Engineering Solution for Telecommunication Network Optimization	geometry has been proposed to solve the traffic sharing between MTC and HTC. Identify method for dynamic traffic management using ML/AI approaches.
The present study	2026	Generic modelling for IoT traffic management and ranking aims organized QoS using AI approach	Proposes a generic model to overcome the challenged related to the heterogeneity of network resources. The system works as a proactive machine to estimate the QoS condition and dynamically manage the traffic flow between MTC and HTC accordingly.

## 3. Methodology

In order to accommodate for the traffic of IoT network, and ensure that will not be critically affecting the performance of HTC traffic (Voice, Video, HTTP and FTP services); a particular QoS for MTCs applications traffic flows should be offered so that the QoE of real time application's user keep them satisfied. A new management policy for traffic flow is suggested in this proposal, for describing MTC traffic flows on the IoT network, in which managing the network and links via QoS approach specifically intended for different MTC traffic flows and isolation of standard HTC from MTC are proposed. The requirement of such a new policy arose out of the limitations of the current traffic flow management not having an ability to distinguish between MTC and HTC traffic flows in terms of sharing network resources. The available network resources shared (R) with the form of resource sharing between MTC resources share (S), and HTC resources share (T) in the network. A new method is proposed for addressing QoS degradation issue in an isolation manner via two

disjoint sets. The share size of the (S) and (T) shares is a percentage of an available amount of network resources (R), and can be dynamically modified in accordance with a situation where the traffic flows fluctuate [1]. Therefore, the previous proposal can be written as

$$R = S + T \quad (1)$$

and

$$S = \beta R \quad (2)$$

and

$$T = \alpha R \quad (3)$$

and

$$\beta + \alpha = 1 \quad (4)$$

and

$$\beta = 1 - \alpha \quad (5)$$

where,  $\alpha$  is the fraction of network resources allocated to the HTC traffic flows and remaining network resources that share MTC traffic flows is  $\beta$ .

In [16], the paper presented the important of QoS parameters and gave the relative priority of IoT services as:

$$P_{IoT_k} = \frac{\sum_{m=1}^m X_{km} Y_{km}}{\sum_{k=1}^k \sum_{m=1}^m X_{km} Y_{km}} \quad (6)$$

Where,  $P_{IoT_k}$  is the i-th IoT service priority;

K- Service traffic flow number;

m- Parameter of quality service number;

$X_{km}$ - priority of m for service k.

$Y_{km}$ -the important of m for service k.

From (6) we can represent the priority of the whole service resources (R) as

$$P_{R_k} = \frac{\sum_{m=1}^m X_{km} Y_{km}}{\sum_{k=1}^k \sum_{m=1}^m X_{km} Y_{km}} \quad (7)$$

Where,  $P_{R_k}$  is R relative priority.

From (2) and (7) we get

$$\alpha_k = \frac{P_{T_k}}{\sum_{j=1}^k P_{R_k}} \quad (8)$$

Where, j is network resource number and  $P_{T_k}$  is priority of HTC resource service.

And, from (3) and (7) we get

$$\beta_k = \frac{P_{S_k}}{\sum_{j=1}^k P_{R_k}} \quad (9)$$

Where,  $P_{S_k}$  is priority of MTC resource service.

Thus,

$$P_{R_k} = P_{T_k} + P_{S_k} \quad (10)$$

In order to obtain fair sharing for  $\alpha$  and  $\beta$  priorities,

It is possible to demonstrate  $\alpha$  and  $\beta$  as function of QoS [1] as

$$\alpha + \beta = f(QoS) \quad (11)$$

where, QoS is function of network QoS and application QoS [17] and QoE is a function of QoS [18] as

$$QoS = f(NQoS + AQoS) \quad (12)$$

and

$$QoE = f(QoS) \quad (13)$$

Therefore, from (6) & (8) let us written the following result as

$$QoE = \alpha + \beta \quad (14)$$

The QoE is directly correlated to the quality of service (QoS) and factor—which is an influencing factor on QoE—is very important, it seems important to introduce an objective relationship between the QoE and the QoS, so that we can maintain a satisfactory level for the user. Here there might be some correlation between QoE and QoS which can be made by the Weber-Fechner Law [19]. The law's formula can be expressed as

$$QoE = k \ln(QoS) \quad (15)$$

In (9), when QoS is multiplied by a constant value, QoE increases approximately in an additive manner by a constant number. For example, if QoS becomes 4 times stronger than its initial value then QoE will have 2 added. From (8) and (9), let us find the relationship between total network resource sharing ( $\alpha$  and  $\beta$ ) with QoS as

$$\alpha + \beta = k \ln(QoS) \quad (16)$$

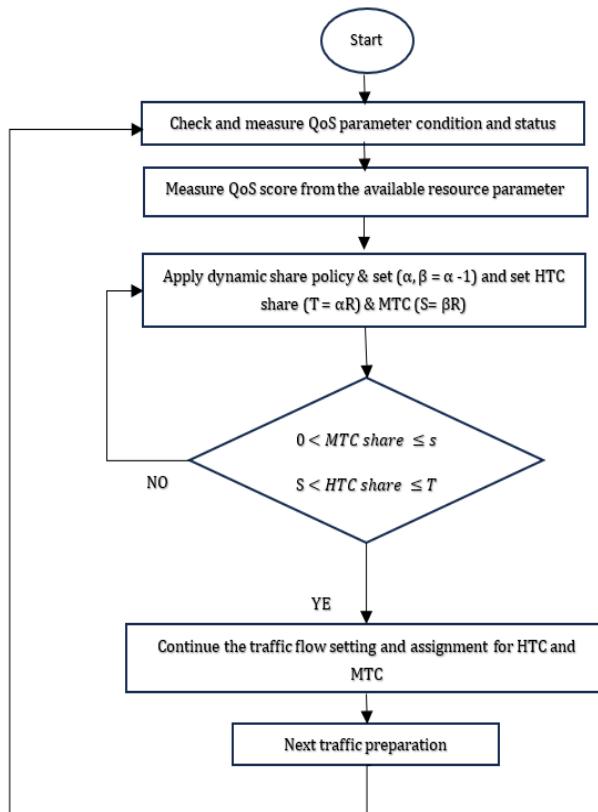
Now, it's possible to identify the share percentage of the two shares (S and T) from the feedback estimation of QoS score. The QoS score depending on the QoS parameter the measured from the IoT network. A simple estimate and set of synthetic values is given in Table 2, for  $\alpha$  and  $\beta$ , concerning to the traffic density pattern from productive practical network scenarios that suggested in [4],

[20]. In this study, we will rely on  $\alpha$  and  $\beta$  in Table 2.

**Table 2.** Suggested values of  $\alpha$ ,  $\beta$  and associated network resources share rate

Function	Percentage share of over whole network resources
$\alpha$	80%
$\beta$	20%

Figure 1 shows the flowchart of the proposed management policy for flow traffic to check the QoS parameter, then proceed to identify QoS score and then estimate the adaptive resource share of the network. The flowchart begins by examining the accessible QoS parameter and then obtains the QoS score.



**Figure 1.** Proposed dynamic network traffic flow management policy setting

#### 4. Simulation Setup

The proposed model performance has been studied through the utilization of a MATLAB-2021b simulator. We applied the Fuzzy logic (AI

approach) through MATLAB's fuzzy logic toolbox and analyzed the proposed model performance.

#### 4.1 Fuzzy Logic Approach

All Fuzzy Logic has the ability to handle imprecise & uncertain information; therefore, it's an effective method of detecting any abnormality within a network. A fuzzy rule-based system (FRBS) generally consists of three main parts: the processing in the first step (fuzzification) converts numerical data or connection duration to linguistic values, into three characterizations, low, medium and high. Then, the fuzzy inference system (FIS) interprets network behavior by using a pre-defined if-then rule set. Finally, the defuzzification operation transforms fuzzy outputs into crisp values which can be used for decision making such as to detect possible anomalies. The performance of FRBS is a result of its high adaptability and high efficiency since it does not use fixed threshold values, which minimizes the number of false positives, and also allows for fast adaptation in real time and varying network conditions [21], [22].

Membership functions specify how input variables are to be made fuzzy. The most popular membership function types are the triangular, trapezoidal and Gaussian functions. Sensitivity of system to anomalies is highly influenced by a membership function. The Mamdani and Sugeno models are most often used for inference. The Mamdani is intuitive and human-readable, the Sugeno model robust if computationally efficient and popular on line-time-systems. Rule-based inference methods are used, which employ operators such as AND (minimum), OR (maximum) and implication functions to decide the degree of occurrence of anomaly[22].

In this study, we used the Mamdani model for inference and the triangular member function (MF) with AND (minimum) operator.

Figure 2 Shows Fuzzy logic control model. The process starts by collecting QoS parameters from the network. The fuzzy control system uses these parameters to evaluate the respective QoS levels. After that the system sets QoS to obtain the resources share between HTC and MTC. It generates suitable report to traffic management centre through the IoT technologies based on this evaluation.

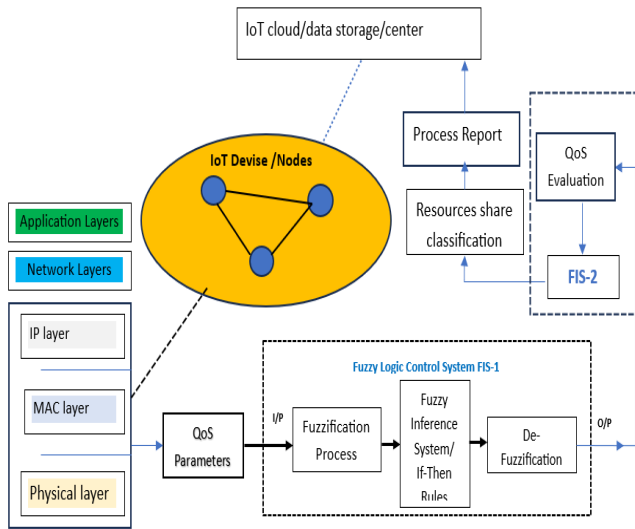


Figure 2. Fuzzy logic control model

### 4.2 Data collection and fuzzy inference system FIS

The network QoS parameter data is transmitted to the FL control system, and then FL is used to evaluate QoS and then select a proper resource sharing management policy for HTC and MTC. The proposed proactive agent machine studied by using two series FIS (FIS-1 & FIS-2) as shown in Figure 3.

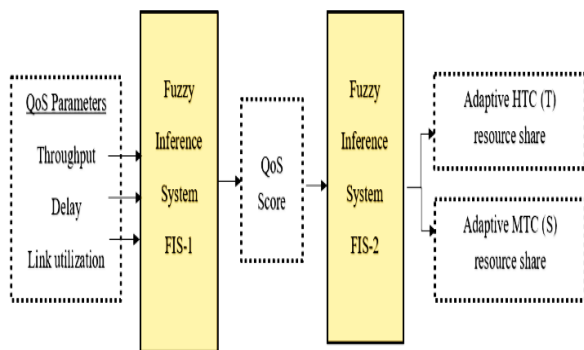


Figure 3. Dynamic proactive agent machine

In this approach, the collected input QoS parameter for fuzzifier in FIS-1 are Delay, link utilization and throughput. The illustration for the input parameter data collection shown as following:

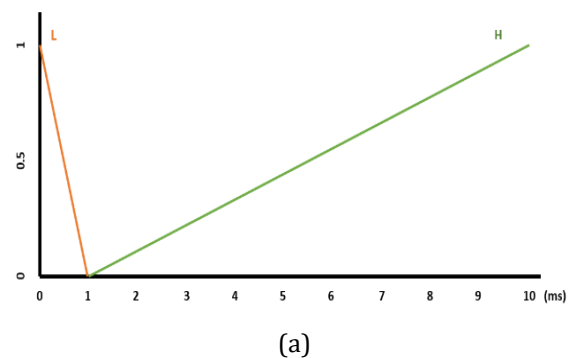
a) Delay (D) “is time taken for the packet to reach its destination, in seconds. Measured as the difference between the time a packet arrives at its destination and the creation time of the packet. This statistic is collected separately for

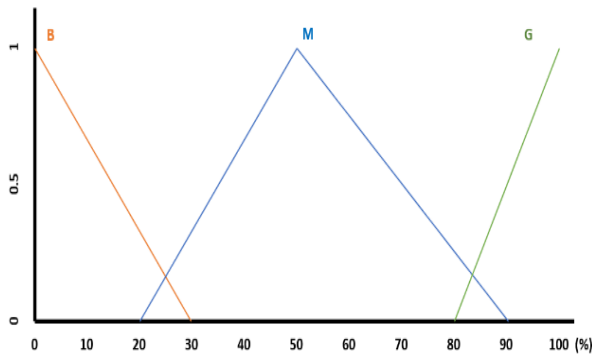
each source, destination pair” [1]. In this system, we select ultra-reliable and low-latency communications (URLLC) service, has 1 ms End-to-End (E2E) delay [23]. The member function MF of delay is shown in Figure 4 (a). Delay MF has two levels Low (L) MF when  $D < 1$  ms and high (H) MF when  $D > 1$  ms.

b) Throughput (T) “is the total number of successfully received packets at sink node per unit time (typically every second)” [24]. In this system, throughput ranges from 0% to 100% and the member function MF of Throughput is shown in Figure 4 (b) (Figure 4 (b) on the next page). Throughput MF has three levels: bad (B), Mid (M) and good (G).

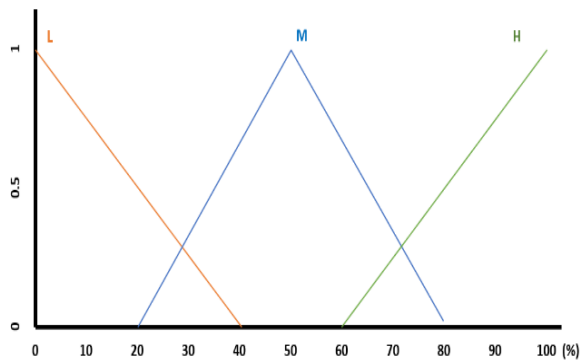
c) Link utilization (LU) describes the percentage of a network link that is being used. In this system, LU has range from 0% to 100% and the member function MF of LU is shown in Figure 4 (c) (Figure 4 (c) on the next page). Link utilization MF has three levels low (L), mid (M) and high (H).

The QoS parameter inputs are transferred through the fuzzification process to fuzzy values. Linguistic variables are generated by the inference engine according to the rule base. As presented in Table 3 (Table 3 on the next page), the inference engine gives 2 points for high throughput, 1 point for moderate throughput and 0 for low throughput. For delay, small delay is awarded 1 point and large delay is awarded 0 points. As for the utilization by links, scores 0 point for high (H), 1 point for moderate (M), and 2 points for low (L) utilization behaviors. Hence, QoS score ranges 0% to 100% and the member function MF of QoS is shown in Figure 5 QoS score MF has six levels (0, 1, 2, 3, 4, 5) (Figure 5 on the next page).





(b)



(c)

Figure 4. FIS-1 input MF: a) Delay MF, b) Throughput MF and c) Link utilization MF

Table 3. FIS-1 rule base

Input			Output
Throughput	Link utilization	Delay	QoS score
G	L	L	5
G	M	L	4
G	H	L	3
G	L	H	4
G	M	H	3
G	H	H	2
M	L	L	4
M	M	L	3
M	H	L	2
M	L	H	3
M	M	H	2
M	H	H	1
B	L	L	3
B	M	L	2
B	H	L	1
B	L	H	2
B	M	H	1
B	H	H	0

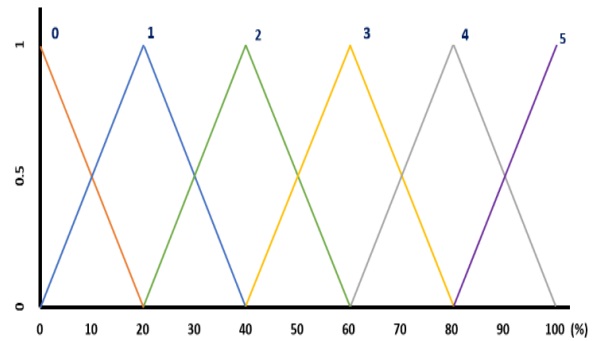
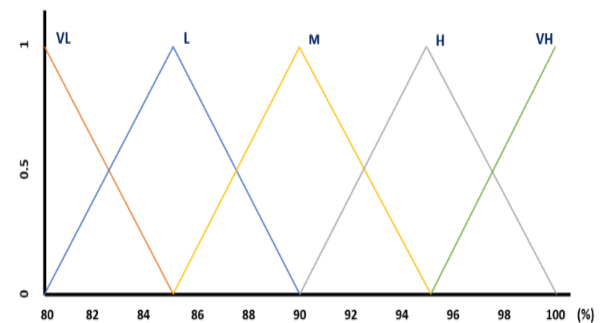


Figure 5. QoS score MF

In FIS-2, we applied the output crisp value of QoS score from FIS-1 as the input and the outputs are the dynamic resources share percentage of HTC (T) that is represented by alpha ( $\alpha$ ) and MTC (S) that is represented by beta ( $\beta$ ) as the following details:

- a) Alpha ( $\alpha$ ): Represent the HTC resource share percentage. The MF of alpha is shown in Figure 6 (a). Alpha MF has five levels: very low (VL), low (L), mid (M), high (H) and very high (VH). The range of alpha share resources is from 80 % to 100% as in Table 2.
- b) Beta ( $\beta$ ): Represent the MTC resource share percentage. The MF of beta is shown in Figure 6 (b) (Figure 6 (b) on the next page). Beta MF has five levels: very low (VL), low (L), mid (M), high (H) and very high (VH). The range of beta share resources is from 0 % to 20% as in Table 2.

The QoS score are converted through the fuzzification process to fuzzy values and the linguistic variables are estimated by the inference engine according to the rule base as presented in Table 4.



(a)

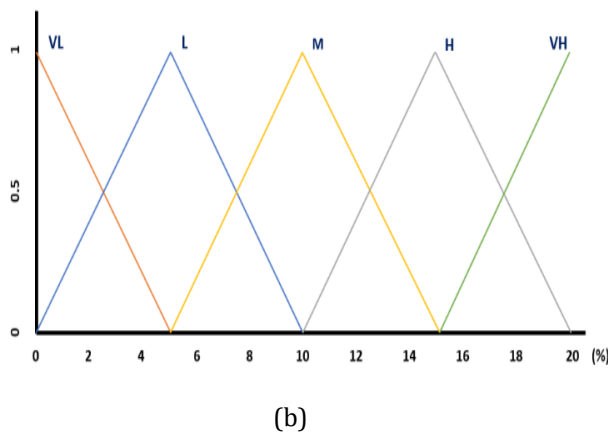


Figure 6. FIS-2 output MF: a) Alpha ( $\alpha$ ) MF, b) Beta ( $\beta$ ) MF

Table 4. FIS-2 rule base values of  $\alpha$ ,  $\beta$  and associated network resources share rate

Input QoS score	Output Alpha ( $\alpha$ )	Beta ( $\beta$ )
5	VL	VH
4	L	H
3	M	M
2	H	L
1	VH	VL
0	VH	VL

### 5. Results and Discussion

This study has been conducted using MATLAB 2021b by utilizing fuzzy Simulink tools. Two fuzzy inference systems (FIS-1 & FIS-2) has been used to both estimate and carry out the proposed model. FIS-1 output the Quality of Service scores and FIS-2 overcomes the proposed traffic flow percentage share of MTC and MTC resources from the whole network resources share. The generic model of dynamic traffic management for IoT network deliver the following points:

a) From FIS-1, the results of rules base that shown in figure 7 illustrate that when  $D = 0.728$  ms,  $T = 69.4$  % and  $LU = 84$  %, the QoS score = 40 %. That is mean the QoS score is 2. The QoS parameters (Throughput, delay and link utilization) — provided by IoT network — effect the value of QoS score. This score reaches 4 or 5 when the throughput rate is 100%; however, these scores decline when throughput is poor. Similarly, the impact on QoS scores was identified with respect to delay: network efficiency decreases when  $D > 1$  ms, and increases when the delay is lower. Moreover,

link utilization inversely affects network performance, meaning that the less time required to achieve network utilization, the higher the service quality scores of the network. See fig. 10 that shows the effect of throughput (T), delay (D) and link utilization (LU) on the QoS scores in Figure 8 (a, b & c respectively) (Figure 8 on the next page).

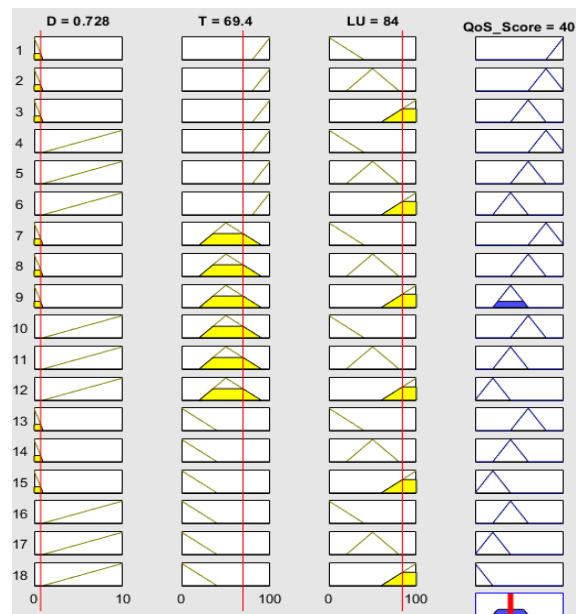
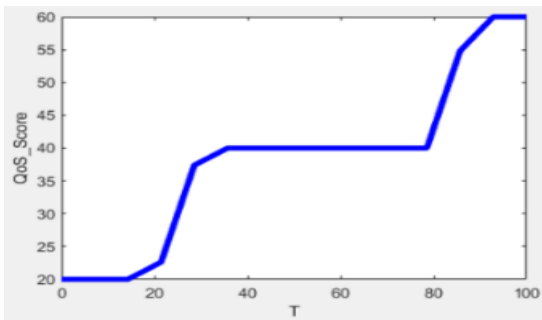


Figure 7. FIS-1 rules base results

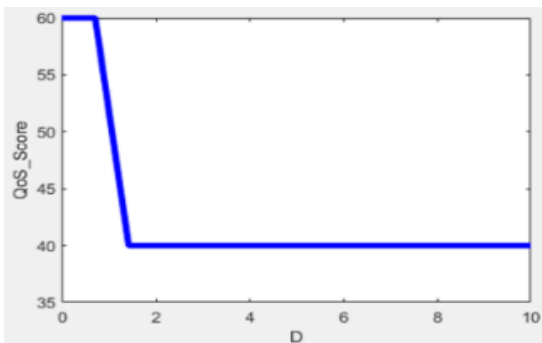
- b) From FIS-2, the results of rules base that shown in figure 9 (Figure 9 on the next page) present that when QoS level equal to 81.5 %, the HTC resources ( $\alpha$ ) are equal to 85 % while MTC resources share ( $\beta$ ) are equal to 15 %.  $\alpha$  inversely proportional with respect to QoS scores, while,  $\beta$  are directly proportional with respect to QoS score. Figure 10 (Figure 10 on the next page) shows the impact of QoS score on  $\alpha$  and  $\beta$ .
- c) See Figure 11(Figure 11 on the 10 page) that illustrates the HTC and MTC of network share resources of the whole rate/percentage in the network. The whole share percentage will dynamically be managed and distributed and the resources will be divided into HTC and MTC in order to achieve fair resource usage, by means of two disjoint sets. The resources sharing between HTC ( $\alpha = 80$  %) and MTC (20%) occurs when the score of QoS is very high. The model will dynamically adjust the network resources when the QoS scores diminish. At a very low QoS score, the HTC (T) retrieves the

very high percentage ( $\alpha$ ) of the available network adaptive resource (R) while the MTC (S) gets the very low rate ( $\beta$ ) from the collection of available resources in the network. Know, the range of  $\alpha$  resources will be managed between 80% and 100% and the range of  $\beta$  (1-  $\alpha$ ) resources from 0 % to 20%.

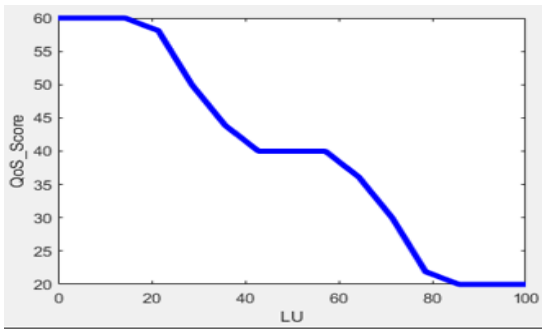
d) The resources share in FIS-2 depend on the variation of the Quality-of-Service parameters inputs in FIS-1. Thus, the two FIS work dynamically to adapt the resources in the IoT network.



(a)



(b)



(c)

Figure 8. a) Throughput; (b) Delay; (c) Link utilization

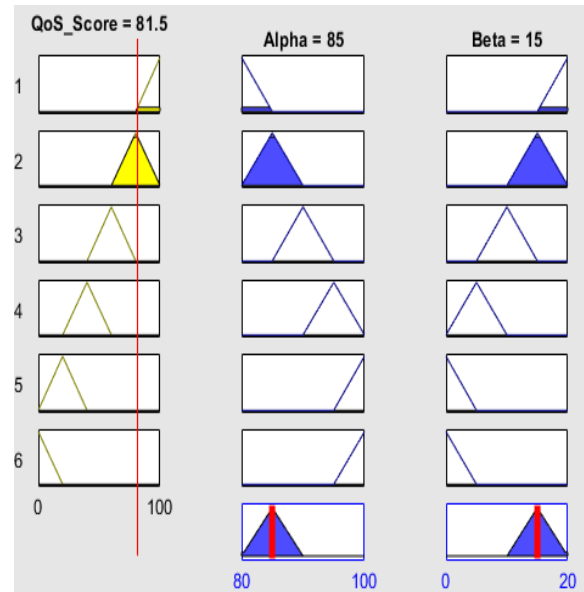
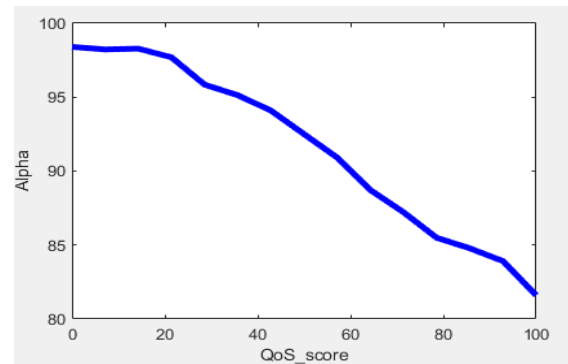
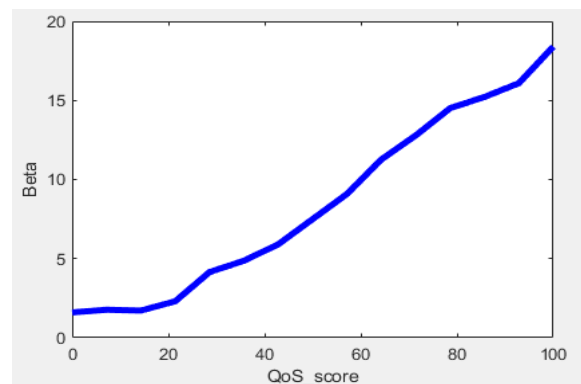


Figure 9. FIS-2 rules base results

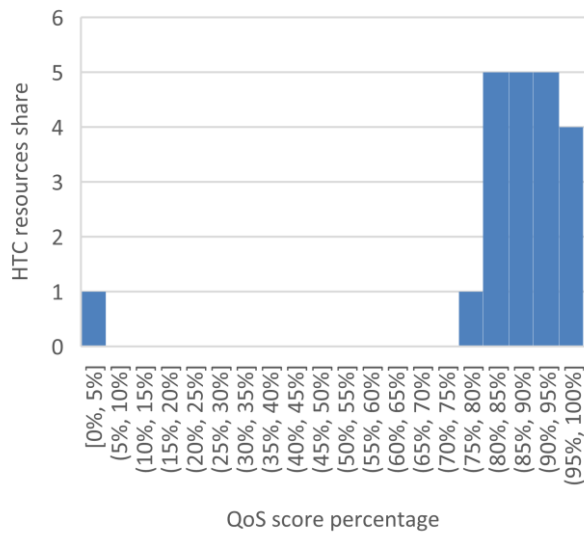


(a)

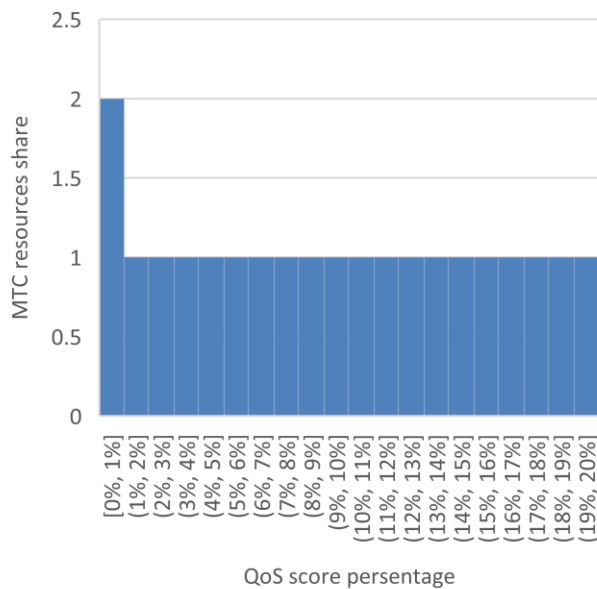


(b)

Figure 10. (a)  $\alpha$  with respect to QoS score; (b)  $\beta$  with respect to QoS score



(a)



(b)

**Figure 11.** (a) HTC resources share ( $\alpha$ ); (b) MTC resources share ( $\beta$ )

## 6. Conclusion

QoS is the network's ability to organize its traffic according to individual priority. Hence, the IoT traffic depends on the network QoS (NQoS) score. The concern of diversity in the combination of HTC

## Funding

"None".

and IoT traffic is addressed in this study. This work proposed generic modelling for IoT traffic management and ranking aims organized QoS in order to perform proactive agent machine. The fuzzy provides a reliable control system to perform the model. The presented model shows the dynamic management and distribution of the collective IoT network between MTC and HTC by maintain adaptive network resources sharing between  $\alpha$  and  $\beta$ .

The future proposal is to conduct the domain of our study with concern of next generation network NGN. This paper can be used to develop another proactive model depending on a new QoS parameter characteristic and IoT traffic classification in order to update traffic management, QoS optimization and QoE satisfaction.

## Nomenclature

AI	Artificial intelligent
AQoS	Application quality of service
E2E	End to end
FTP	File transfer protocol
FRBS	Fuzzy rule-based system
FIS	Fuzzy inference system
HTC	Human type communication
HTTP	Hypertext transfer protocol
IoT	Internet of things
LU	Link utilization
M2M	Machine to machine
MTC	Machine type communication
NQoS	Network quality of service
NGN	Next generation network
QoS	Quality of service
QoE	Quality of experience
URLLC	Ultra-reliable and low-latency communications
WSN	Wireless sensor network

## Greek symbols

$\alpha$	HTC traffic flows rate of whole network resources share
$\beta$	MTC traffic flows rate of whole network resources share

## Conflicts of Interest

The authors declare no conflict of interest.

## Author Contributions

All authors contributed equally to the preparation of this article.

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