The QoS Estimation for Physiological Monitoring Service in the M2M network

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Abstract: The Medical networks are one of the important Internet of Things applications. The International Telecommunication Union developing the standards cup for e-health with Machine-to-Machine (M2M) technology orientation. The QoS new classes and parameters should be standardized for e-health. The physiological monitoring service is one of the e-health applications. The bit rate, delay, and packet losses are considered as QoS parameters for physiological monitoring service now. The fuzzy logic using for estimation physiological monitoring service QoS proposed in this paper. The term set, rule base are determined. The Mamdani rule and gravity center method are used.

Keywords: Internet of Things, e-health, physiological monitoring, QoS, fuzzy logic.

1. Introduction

The Internet of Things (IoT) [1] is the most popular conceptual platform for future network today. There are many IoT concept applications. It could be Ubiquitous Sensor Networks (USN) [2], Vehicular Ad Hoc Networks (VANET) [3] and so on. One of the most important IoT applications is a Medical Network [4]. The Medical Network creates the information and technology base for e-health [5] implementation. The e-health system developing on the base of mobile healthcare, personalized medicine and interactive healthcare via social media and web 2.0 applications [5]. There are many standardized bodies which developing standards on the e-health area. They are International Standardization Organization (ISO) Technical Committee 215, European Committee for Standardization (CEN) Technical Committee 251, epSOS (european patients Smart Open Services), Health Level 7 (HL7) and so on. We will focus in this paper on the International Telecommunication Union (ITU) standard projects which developing on the machine-to-machine (M2M) technology [6] base for service layer. The e-health services promotion on the M2M networks base should be support not only technology but by QoS requirements too [7]. The IPTV services estimation [8], cluster head selection in the USN [9] are the well known examples fuzzy logic using in the telecommunication investigations. The fuzzy logic base method for physiological monitoring service on the M2M network for e-health system is proposed in this paper.

2. The QoS parameters set for physiological monitoring service

The special ITU-T Focus Group on the M2M Service Layer developing the standard projects on this area. One of standard project includes the requirements for QoS classes and parameters to e-health services. The following classes of services are considered at [7]: real-time critical applications (real-time physiological monitoring as example), real-time non-critical applications, mobile web-based medical consultations, remote control applications. The data rate, delay and packet loss are the parameters for above mentioned classes. There are some papers for e-health services QoS where delay, peak rate and average rate are considered as the QoS parameters [10, 11]. It's not insufficiently in our opinion because the losses should be considered too. The value parameters are the following: the data rate is from 10 kb/s up to 100 kb/s, the delay is not more than 300 ms and the losses should be less than 10^{-6}. The physiological monitoring service is a very important service for patient which depends both on the medical service quality and the network QoS. The integrated QoS estimation for the network side is needed for sharing of responsibility.

The fuzzy logic method proposed for integrated network QoS estimation. The table 1 consists the fuzzy logic controller (FLC) parameters. The input parameters include the data rates, delays and packet losses. The output parameter is the physiological monitoring QoS level.

Table 1. FLC parameters

(x) Input parameters	x_1	Parameter	Data Rate
		Term-fuzzy set	{Low, Average, High}
		Value limits	[10, 100] kb/s
	x_2	Parameter	Delay
		Term-fuzzy set	{Small, Average, Large}
		Value limits	[0, 300] ms
	x_3	Parameters	Packet Losses
		Term-fuzzy set	{Acceptable, Unacceptable}
		Value limits	$[10^{-10}, 10^{-1}] \Rightarrow [0, 0.1]$
(y) output parameter		Parameter	Physiological monitoring QoS
		Term-fuzzy set	{Very Low, Low, Average, High, Very High}
		Value Limits	[0, 100] %

3. The membership functions and fuzzy rules

The membership functions should be defined for all input and output parameters. The membership functions are shown on the fig.1 for data rate, delay, packet loss, physiological monitoring.

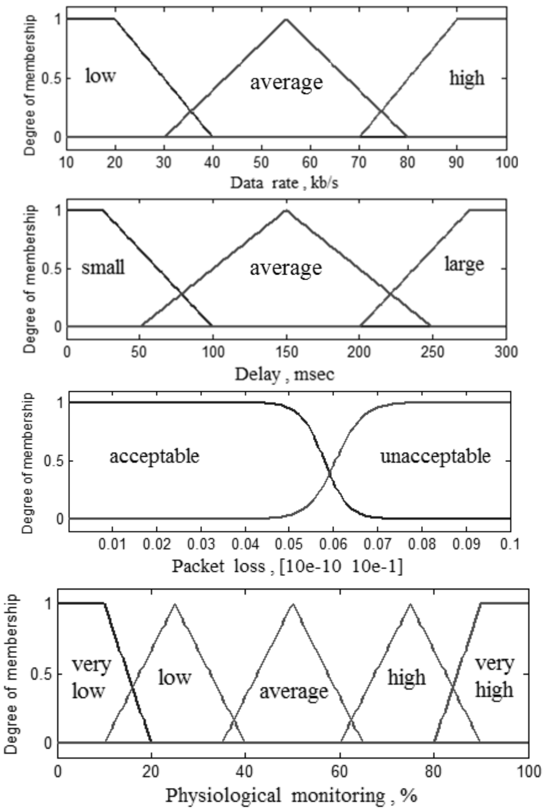

Fig. 1. Membership functions

We should be defined fuzzy rules further. The fuzzy rules are shown on the table 2.

The Mamdani FLC is used for fuzzy rule:

$$\boldsymbol{\mu_{A\rightarrow B}(x,y) = \mu_R(x,y) = \mu_A(x) \cap \mu_B(y) = min\,[\mu_A(x), \mu_B(y)]} \quad \textbf{(1)}$$

where A and B – fuzzy multitude $A \subseteq X, B \subseteq Y$, the ratio R is defined on the $X * Y$.
So:

$$\boldsymbol{\mu_{B'}(y) = max_{k=1\ldots N}\{min\left[\mu_{A_1^k}(\overline{x}_1), \mu_{A_2^k}(\overline{x}_2), \mu_{A_3^k}(\overline{x}_3), \mu_{B_1^k}(y)\right]\}} \quad \textbf{(2)}$$

where $\overline{x_1}$, $\overline{x_2}$ и $\overline{x_3}$ - input parameters (data rate, delays, losses), A_1^k, A_2^k и A_3^k - fuzzy multitudes for input parameters, $k = 1, \ldots, N$ – fuzzy rules, N – number of fuzzy rules (N = 3*3*2=18), y – output parameter (physiological monitoring QoS), B_1^k - multitude for output parameter.

Table 2. Fuzzy rules.

Rule number	Data rate	Delays	Packet losses	**Physiological monitoring QoS**
1	Low	Small	Acceptable	**Average**
2	Low	Small	Unacceptable	**Very Low**
3	Low	Average	Acceptable	**Average**
4	Low	Average	Unacceptable	**Very Low**
5	Low	Large	Acceptable	**Low**
6	Low	Large	Unacceptable	**Very Low**
7	Average	Small	Acceptable	**High**
8	Average	Small	Unacceptable	**Low**
9	Average	Average	Acceptable	**Average**
10	Average	Average	Unacceptable	**Low**
11	Average	Large	Acceptable	**Average**
12	Average	Large	Unacceptable	**Very Low**
13	High	Small	Acceptable	**Very High**
14	High	Small	Unacceptable	**Average**
15	High	Average	Acceptable	**High**
16	High	Average	Unacceptable	**Low**
17	High	Large	Acceptable	**Average**
18	High	Large	Unacceptable	**Very Low**

The centre of gravity method was used for defuzzification procedure. The calculations were made by MATLAB.

4. The fuzzy method surfaces

The fuzzy method surfaces are shown on the fig.2 – for data rate and delay parameters when packet losses in the range of [10^{-10}, 10^{-1}], on the fig.3 – for data rate and packet losses parameters when delay in the range of [0, 300] ms, on the fig.4 – for delay and packet losses parameters when data rate in the range of [10, 100] kb/s.

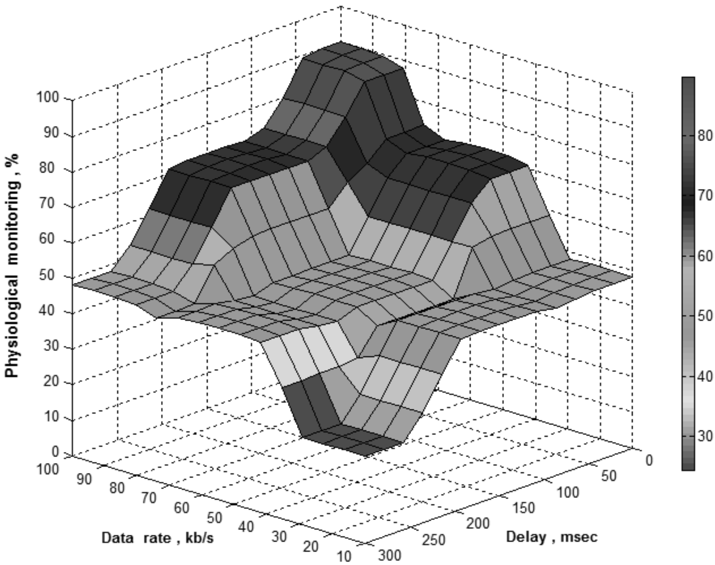

Fig.2. The surface for data rate and delay parameters

The surfaces could be used for physiological service estimation. For example, the fig.2 surface analyzing show that the network supporting the required QoS level for physiological monitoring service if the delay not more than 300 ms and data rate more than 80 kb/s or if the data rate more of 50 kb/s and delay not more than 100ms.

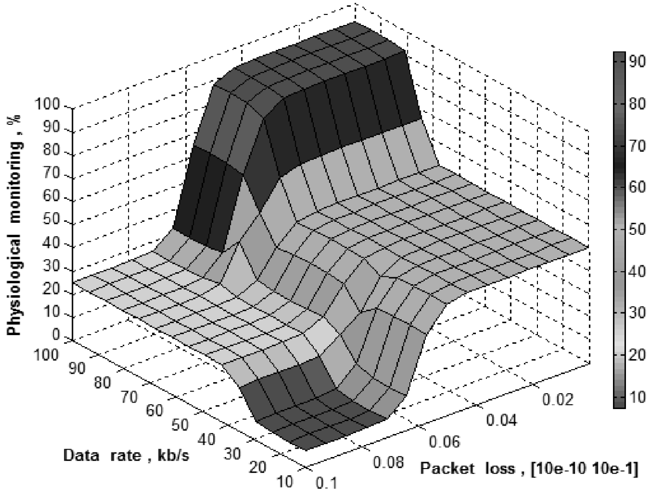

Fig. 3. The surface for data rate and packet losses parameters.

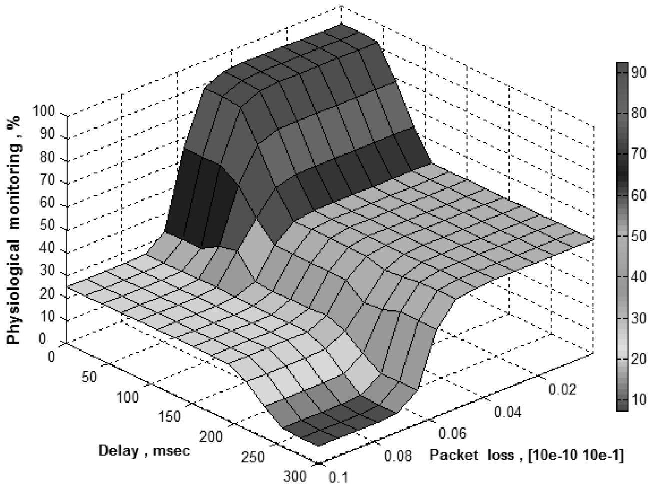

Fig.4. The surface for delay and packet losses parameters.

5. Conclusions

The fuzzy logic base method for QoS estimation for physiological monitoring service in the M2M network is proposed. The membership functions, rules set, different surfaces are defined. The proposed fuzzy logic method is the effective integrated QoS estimation for physiological monitoring service in the M2M network.

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