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Resource Management in Vehicular Ad Hoc Networks: Multi-parameter Fuzzy Optimization Scheme

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Abstract

Large amount of information like text, audio and video exists in vehicular ad hoc networks(VANETs). However, the highly dynamic network feature and the limited memory of the local server pose challenges to resource management, which not only leads to the failure of resource presentations to users, but the transmission of the invalid fragment data would also result in the significant waste of precious bandwidth and memory. To solve this problem, this paper improved the fuzzy logic resource management (FLRM)--multi-parameter fuzzy logic resource management (MP-FLRM). In the scheme, we first gather and record the request time, download time and upload time for each resource by the designed Vehicle to Infrastructure (V2I) communication mode. Then survival time can be reached after defuzzifier of the three kinds of parameters, which can update the resource list in real time. Simulation results show that MP-FLRM can improve system throughput. In this way system performance was enhanced.

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Keywords: Fuzzy logic； resource management； VANETs； MP-FLRM

1. Introduction

Vehicular ad hoc networks (VANETs) have raised increasing attention from both academic research and industrial aspects resulting from its important role in driving assistant system [1]. Applications also lead many problems. For

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instance, large number of resources exists in VANETs including information like text, audio and video. So how to efficiently manage these resources is a key point when we do research on VANETs.

However, VANETs are the type of network which features in high topology, intermittent connectivity, unstable links and local servers with limited memory[2]. These are meant to cause failure in resource delivery to users, as well as the transmission of large amounts of invalid fragment data, which absolutely wastes bandwidth and storage [3]. [4] proposed a resource reliability measurement algorithm (RRMA) to measure the reliability of each resource. "Reliability" refers to the functional and processing ability of each resource. Content allocation is a kind of local broadcasting service [5], where context storage is done in the form of large multimedia files and methods of storage differ in many kinds. In [6], the optimization–based resource management scheduling (RORMS) is based on the queuing theory, and compares the processing time of each resource. Then scheduler will allocate task to the resource which deals with the fast speed [7,8]. In [9], it proposes TLC (Trust point Load Balancing Method using Coalitional Game Theory) scheme to tackle the load balancing issue based on trust points. Based on the disadvantages of VANETs, such as the limited storage or low processing ability, [10] proposed a probabilistic key management algorithm for large-scale MANETs. [11]proposes a resource management scheme based on fuzzy logic. However, these papers all lose sight of the high speed of the vehicles and the large number of data existing in the networks. So it is necessary for us to propose a new resource management algorithm to stress these difficulties.

This paper improves the resource management scheme in [11], we call it multi-parameter fuzzy logic resource management scheme (MP-FLRM). This paper revises the FLRM. Sets of request time, download time and upload time are collected by V2I communication mode. Based on fuzzy logic, more time parameter is added in the system to make resource module in the local server.

2. Fuzzy logic resource management scheme

2.1. Definitions

Generally, the resource list includes the time tag, the source node ID, the resource ID and the resource information, which play an important role in resource management. In addition, request time, download time and upload time are added in the resource list, which we use set A, B and C to represent. The system will record the resource type in the process of communication between vehicles and the local server.

2.2. MP-FLRM scheme

This section is based on the fuzzy logic. According to the features of the vehicular networks, we developed the FLRM by adding a new time parameter—upload time, note set C. The modified scheme is designed for computing the survival time of every resource in the local server. Fig.1 shows the architecture of the fuzzy logic engine. It mainly includes three components: fuzzier, the fuzzy inference engine and defuzzifer. We will describe these 3 components in detail respectively.

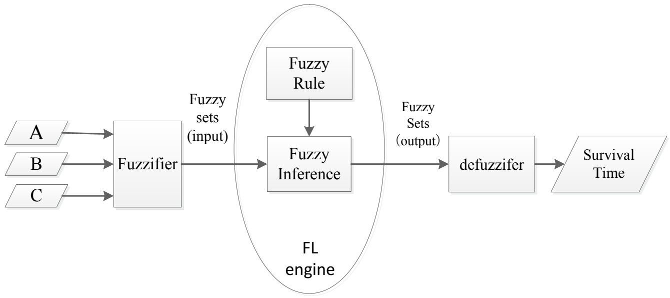

Fig. 1. Architecture of the fuzzy logic engine.

1) Fuzzier: The process of converting a numerical value to a fuzzy value using a fuzzy membership function is

called fuzzier. Normalization of data sets A, B and C is classified into "small", "medium" and "large". The normalized functions are shown as follows:

$$\sigma = \frac{\mu_i}{\mu_{\max}} \tag{1}$$

Where μ denotes the request time, download time or upload time of different resource in local server, μ_i denotes the element in data set A, B and C. Meanwhile, $\mu_{\max} = \max(\mu_1, \mu_2 ... \mu_n), \mu_i \in (\mu_1, \mu_2 ... \mu_n), \sigma \in [0,1]$.

$$\mu_{\min} = \min(\mu_1, \mu_2 ... \mu_n) \tag{2}$$

$$\mu_{ave} = \frac{\mu_1 + \mu_2 + ... + \mu_n}{n} \tag{3}$$

In this paper, the data sets A, B and C are all assumed to be finite. And we represent A, B and C by the numerical fuzzy unit vectors $A = (a_1, a_2 ... a_n), B = (b_1, b_2 ... b_n), C = (c_1, c_2 ... c_n)$. Now we take the specific resources within a local server for example. One number of requested resources a_1 is normalized as α_1 ($\alpha_1 \in [0,1]$). If α_1 is smaller than $\partial \times (\mu_{ave} + \mu_{\min})$, α_1 is called "small", meanwhile, we call α_1 "large" if α_1 is bigger than $\kappa \times (\mu_{ave} + \mu_{\max})$. Otherwise, we call it "medium", where ∂ and κ are harmonic coefficient in fuzzy logic. The same as α_1, download resource b_1 is normalized to β_1 ($\beta_1 \in [0,1]$). If β_1 is smaller than $\hbar \times (\mu_{ave} + \mu_{\min})$, it is denoted "small". If it is bigger than $\tau \times (\mu_{ave} + \mu_{\max})$, it is denoted "large". Also, $\hbar$ and τ are harmonic coefficient in fuzzy logic. The main idea is presented concisely in Formula (4), (5) and (6).

$$A_{LSR\_Req} = \begin{cases} REQ_{.SMALL}, (\alpha \le \partial \times (\mu_{ave} + \mu_{\min})) \\ REQ_{.LARGE}, (\alpha \ge \kappa \times (\mu_{ave} + \mu_{\max})). \\ REQ_{.MEDIUM}, Otherwise \end{cases} \tag{4}$$

$$B_{LSR\_Download} = \begin{cases} DOWN_{.SMALL}, (\beta \le \hbar \times (\mu_{ave} + \mu_{\min})) \\ DOWN_{.LARGE}, (\beta \ge \tau \times (\mu_{ave} + \mu_{\max})). \\ DOWN_{.MEDIUM}, Otherwise \end{cases} \tag{5}$$

$$C_{LSR\_Upload} = \begin{cases} UP_{.SMALL}, (\gamma \le \lambda \times (\mu_{ave} + \mu_{\min})) \\ UP_{.LARGE}, (\gamma \ge \delta \times (\mu_{ave} + \mu_{\max})). \\ UP_{.MEDIUM}, Otherwise \end{cases} \tag{6}$$

2) Fuzzy inference: when sets of specific variables A, B and C input, the system will divide the input into nine fuzzy groups. Based on the fuzzy rules, fuzzy output can be calculated using the nine group of information. So according to the resource management goal in the local server, Table 1 describes the reasonable prediction of survival time degree.

The survival is divided into five categories {shortest, shorter, short, medium, long, longer, longest} for blocking data processing. In addition, the shape of shortest and longest is different from others due to modular process.

Table 1 Reasonable prediction of survival time

RULE No.	IF(AND)			THEN SURVIVAL TIME
	A(LSR_RES)	B(LSR_DOWNLOAD)	C（LSR_UPLOAD）	
1	small	large	small	short
2	small	large	medium	medium
3	small	large	large	long

4	small	medium	small	shorter
5	small	medium	medium	short
6	small	medium	large	medium
7	small	small	small	shortest
8	small	small	medium	shorter
9	small	small	large	short
10	medium	large	small	medium
11	medium	large	medium	long
12	medium	large	large	Longer
13	medium	medium	small	short
14	medium	medium	medium	medium
15	medium	medium	large	long
16	medium	small	small	shorter
17	medium	small	medium	short
18	medium	small	long	medium
19	large	large	small	long
20	large	large	medium	Longer
21	large	large	large	Longest
22	large	medium	small	medium
23	large	medium	medium	long
24	large	medium	large	Longer
25	large	small	small	short
26	large	small	medium	medium
27	large	small	large	Long

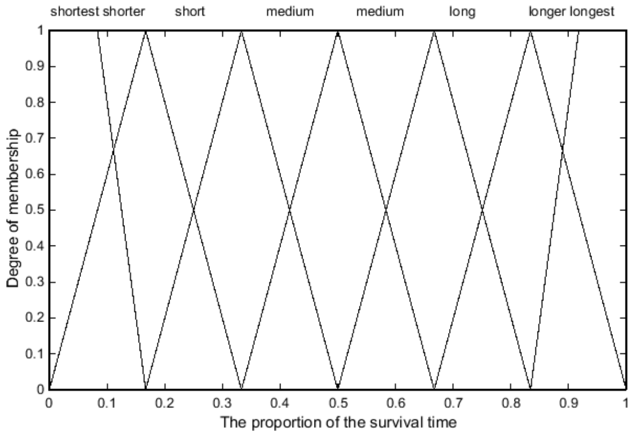

Fig. 2 The output membership function

3）Defuzzier: the process of producing a numerical result based on an output membership function and related membership degrees is called defuzzifier. Center of Gravity method is used in this paper to defuzzify the fuzzy result. If the numerical value of medium, long and longest have been reached, we will get a shape based on the function. Then fuzzy output can be calculated, as well as the survival time. Fig. 2 shows the output membership function.

3. Simulation

We compared RRMA, RORMS and FLRM with the proposed MP-FLRM using MATLAB. Firstly, group of vehicles with random locations is produced by mobility traces generator VanetMobiSim. Mobility model used in the simulation is IDM, which is a part of VanetMobiSim. It is used to simulate stop sign, traffic light and management within safety range. Vehicles can move at a specific speed along the road. For each scenario, throughput refers to the speed of resource produced successfully in the local server, which is measured in kilobits per second (kbps) and we use it to estimate the activity and performance of the system.

As is shown in Fig.4,5 and 6, performance of MP-FLRM is compared with FLRM, RORMS and RRMA. It is done mainly in three aspects: system performance is estimated by the throughput according to different arrival rate, time and the number of the stored resource. From the figures we know that FLRM does better in system performance than RORMS and RRMA, which indicates that survival time based on fuzzy logic is of great use to develop the stability of network connectivity. And the improved MP--FLRM improved FLRM resulting from more parameters taken into consideration in our scheme. Request time, download time, and upload time of resource are useful to module survival time so that system performance can be enhanced.

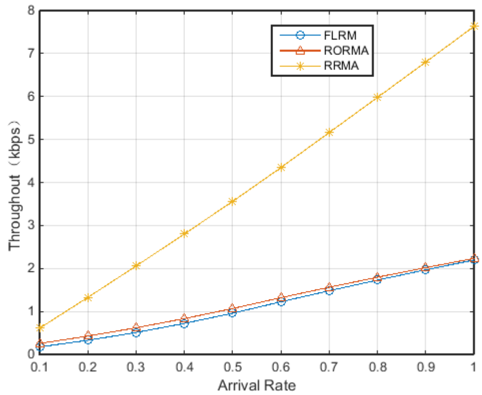

Fig.3 Throughput of different arrival rate

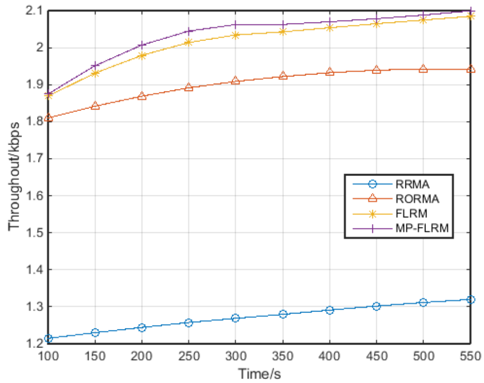

Fig.4 Throughput of different time

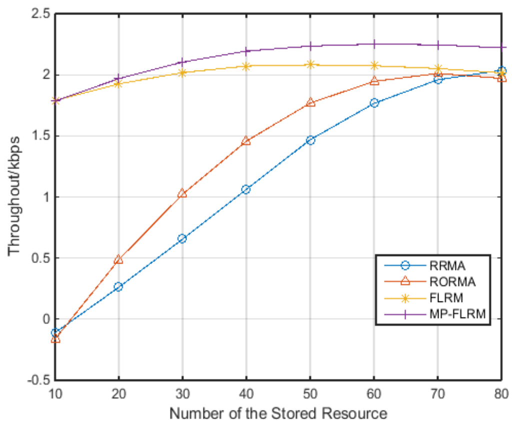

Fig.5 Throughput of different number of resource

4. Conclusion

This paper revises the FLRM. Sets of request time, download time and upload time are collected by V2I communication mode. Based on fuzzy logic, more time parameter is added in the system for resource module in the local server. Priority is given to every resource based on the survival time. System will delete the resource which survival time stays the shortest and keeps shorter all the time. By this way can the resource list be updated in time, and server storage balanced too. According to the comparison of the three schemes, it is estimated that the MP—

FLRM has better performance based on the throughput with different arrival rate, time and the number of the stored resource.

Acknowledgements

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