Fuzzy Approach for Load Balancing in Computer Networks

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Abstract

In computer networks, load balancing problem is very necessary. Imbalance load of traffic among nodes (or links) reduce the performance of the networks. In this paper, a system based on fuzzy logic is proposed for solving the load balancing problem in the computer networks. The fuzzy system located at each node of the computer network to make a load balancing of links by using two criteria which are link capacity and traffic density. The proposed system is applied for typical examples of computer networks and for two types of data traffic (low and high). Results of this fuzzy system assert its high achievement.

1. Introduction

Computer networks can provide full capacity for transferring the data. Imbalance workloads among nodes (or links) reduce the performance of the networks. As the configurations of today's computer networks are becoming more complicated, achieving high performance is becoming more challenging. Load balancing is crucial, since it ensures a good use of the network capacity, for that algorithms have been devised to improve the performance of the networks. Distributed algorithms usually use local information for transferring excessive loads in heavily loaded nodes to lightly loaded nodes. In conventional load balancing methods, fixed threshold levels are used to decide whether a node (or link) is heavily or lightly loaded (M. Huang, S. Hosseini and K. Vairavain 2001, J. Parent, K. Verbeek and J. Lemeire 2002).

The increase in traffic volume on the computer networks leads to a higher frequency of overloaded links in the network, causing a decrease in performance. When link loads approach link capacities, the network becomes congested with resulting packet loss. Balancing the traffic becomes important in order to redirect traffic from congested links to not congested links and achieve a more efficient utillisation of the network (M. Soderqvist 2005).

Considerable research has been devoted toward solving the load balancing problem in

the computer networks. A. Maji (2010) proposes a few enhancements to existing Head Clustering (HC) algorithm to remove the unbalanced distribution of nodes under the cluster heads of nodes and increase the active life of a node in ad hoc network. M. Tekaya, N.Tabbane and S.Tabbane (2010) present a new protocol to achieve better load balancing with respect to the end-to-end QoS requirement in ad hoc network. S. Nejad, S. Mortazavi and B. vahdat (2011) propose an intelligent algorithm based on fuzzy logic for load balancing in the centralized distributed system. M. Shahverdy, M. Behnami and M. Fathy (2011) propose an algorithm to detect bottleneck and remedies for load balancing in wireless mesh networks. S. Naaz, A. Alam and R. Biswas (2011) implement the fuzzy load balancing algorithm and compared the effect of using different defuzzification methods, reported in the literature. A. Alakeel (2012) proposes a new fuzzy dynamic load balancing algorithm for homogenous distributed systems. It dealing with inaccurate load information, making load distribution decisions, and maintaining overall system stability.

2. Load Balancing

In computer network, load balancing is a technique to spread work between two or more nodes (computers, printers, switching, …), links, CPUs, hard drives, or other resources, in order to get optimal resource utilization, throughput, or response time. Uising multiple components with load balancing, instead of a single component, may increase reliability through redundancy. Load balancing attempts to maximize network throughput by keeping all nodes or links busy, it is done that by migrating tasks from the overloaded nodes to other lightly loaded nodes to improve the overall network performance (A. Karimi, F. Zarafshan and A. jantan 2009).

There are two methods of load balancing are used generlly, that, static and dynamic. In static method, threshod levels are fixed and are not changed according to the current status of the computer network. Therefore, nodes in the network do not exchange state information for choosing new threshold levels. While, in dynamic method, threshod levels are changed according to the current status of the network. State information exchange is necessary when this method is used. Then, dynamic load balancing algorithms can respond better to network changes and result in better performance. Furthermore, load balancing is commonly classified into two categories, mulipath and gateway. The traffic load of multipath between a source node and a destination node, while of gateway is distributed amang a set of alternative paths in order to maximize throughput performance and minimize the impact of route failure (M. Huang, S. Hosseini and K. Vairavain 2001, V. Pham, E. Larsen , O. Kure and P. Engelstad 2009, I. Alocci 2010).

3. Proposed Method

A fuzzy system is designed for solving the load balancing problem in the computer networks. It has two input variables, they are link-capacity and traffic-density, and one output variable which is the load of link. This fuzzy system is located at each node of the computer network to make a load balancing of links by using two criteria which are link capacity and traffic density.

The linguistic values with trapezoidal or triangular membership functions of the fuzzy system variables are:

- (Zero, Small, Medium, Big) of link-capacity
- (Low, Medium, High, Very high) of traffic-density
- (Very lightly, Lightly, Medium, Heavey, Very heavey) of load.

The proposed fuzzy system at any node of computer network recieves capacity of link (Kbps) and density of traffic (Kbps or Mbps) of one link which is connected this node with one neighbor nodes. Then the fuzzy system find the load (Kbps) of that link. This process is repeated on all links for other neighbor nodes to finding the load of that links. Table (1) shows the rule base of fuzzy inference for this system and its membership functions are shown in Figure (1).

Table (1) the rule base of the fuzzy system

Link capacity / Traffic density	Zero	Small	Medium	Big
Low	Very heavey	Lightly	Very lightly	Very lightly
Medium	Very heavey	Medium	Medium	Lightly
High	Very heavey	Very heavey	Heavey	Medium
Very high	Very heavey	Very heavey	Very heavey	Heavey

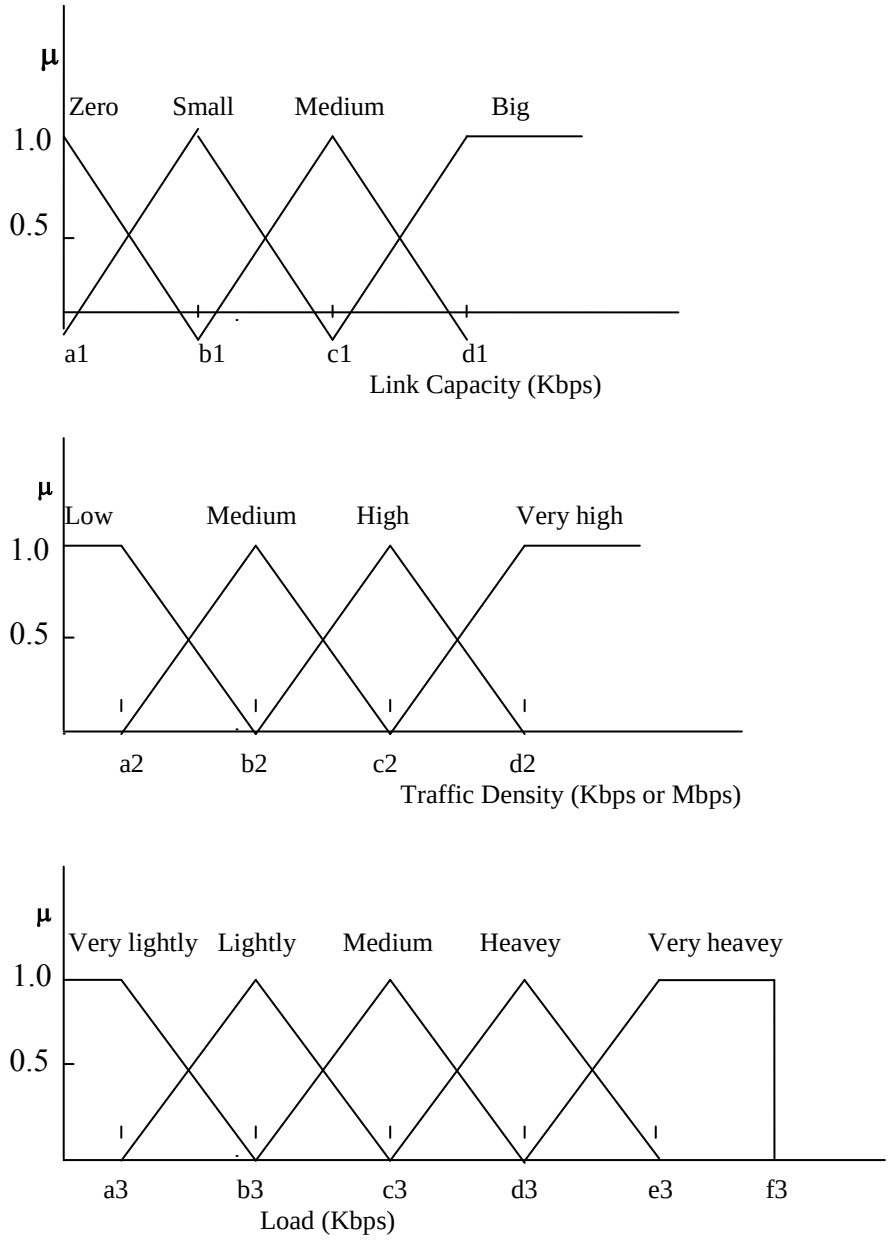

Figure (1) membership functions

4. Simulation Result

The simulation has been realized using C++ programming language, for evaluating the efficiency of the proposed method of using fuzzy system to solve the load balancing problem. Through that, it is applied for two examples of computer networks which are modeled as graphs, the first is a computer network (CN1) shown in Figure (2). While the second is a computer network (CN2) shown in Figure (3). The ranges of the membership functions of the fuzzy system are selected to cover the two computer networks (CN1, CN2). The centers of the membership functions corresponding with two types of data traffic (low and high) as described in Table (2)-(4). The rule base of this fuzzy system is of Mamdani type. The

Center of Gravity (CoG) method is used at defuzzification stage of the system. The crisp value of the output variable is the value of the center of gravity of the membership functions as given in the following equation.

$$\text{crisp value} = \sum_{i=1}^{n} c_i A_i \Big/ \sum_{i=1}^{n} A_i$$

where n is the number of activition rules, c_i is the center of membership function, A_i is the area of activition part of membership function.

Some of the results of the fuzzy system for the computer networks (CN1, CN2) and for two types of data traffic (low and high) are listed in Tables (5) and (6). In these Tables, the values of the inputs and outputs variables corresponding to the linguistic values of the membership functions of these variables are given in Figure (1).

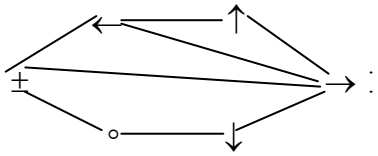

Figure (2) computer network (CN1)

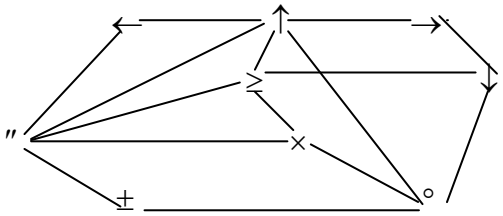

Figure (3) computer network (CN2)

Table (2) centers of link capacity membership function

Centers	CN1		CN2	
	High traffic	Low traffic	High traffic	Low traffic
a1	0	10	0	100
b1	1	50	2.75	250
c1	2	90	5.5	400
d1	3	130	8.25	550

Table (3) centers of traffic density membership function

Centers	CN1		CN2	
	High traffic	Low traffic	High traffic	Low traffic
a2	2	15	2	100
b2	2.75	95	6	400
c2	3.5	175	10	700
d2	4.25	255	14	1000

Table (4) centers of load membership function

Centers	CN1		CN2	
	High traffic	Low traffic	High traffic	Low traffic
a3	2	20	5	50
b3	6	60	15	150
c3	10	100	25	250
d3	14	140	35	350
e3	18	180	45	450
f3	22	220	55	550

Table (5) results of the fuzzy system for the computer network (CN1)

Traffic type	Link capacity	Traffic density	Load
Low traffic	20	34	141.13
	80	200	64.339
	130	240	129.581
High traffic	0.5	3.75	18
	1.25	3	12.6707
	2.75	3.5	11.2727

Table (6) results of the fuzzy system for the computer network (CN2)

Traffic type	Link capacity	Traffic density	Load
Low traffic	150	350	51.351
	500	400	188.462
	450	750	337.838
High traffic	8	13	3.4673
	7.5	10	28.3728
	0.2	9	43.3065

5. Conclusions

The proposed method which used fuzzy system to solve the load balancing problem of the computer networks is described in this paper. The fuzzy system at each node of network, to determine the load of links depending on two primary criteria that are link capacity and traffic density.

From the simulation results, the following points are noticed.

The structure of proposed fuzzy system is not related to the size of the computer network.

The input and the output of proposed fuzzy system are information about the one link of neighbor node in the computer network.

Results of the fuzzy system proof on its good performance for both computer networks (CN1, CN2) with two types of data traffic (low and high).

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نهج مضبب لموازنة حمل في شبكات حاسبات

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المستخلص

في شبكات الحاسبات، موازنة الحمل مسألة ضرورية جدا". الحمل غير الموزون للبيانات المارة بين النقاط (او الروابط) يخفض انجازية الشبكات. في هذا البحث، اقترح نظام يستند على المنطق المضبب لحل مسألة موازنة الحمل في شبكات الحاسبات. النظام المضبب يقع في كل نقطة لشبكة الحاسبات ليصنع موازنة حمل للروابط بأستخدام قياسين هما قابلية الرابط وكثافة البيانات المارة. النظام المقترح طبق لأمثلة نموذجية لشبكات الحاسبات والى نوعين من البيانات المارة (واطئة وعالية). نتائج هذا النظام المضبب اكدت على انجازيته العالية.