A Rate based Congestion Control Mechanism using Fuzzy Controller in MANETs

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Abstract: The traditional congestion control mechanism TCP, performs very poorly in MANETs Because there are a number of new challenges such as wireless link error, medium contention and frequent route failures in this kind of networks [1]. In this paper, we propose a fuzzy adhoc rate-based congestion control (FARCC) to enhance the efficiency of network in MANETs. In FARCC, we use a rate-based transmission scheme using two fuzzy controller of zero order Takagi Sugeno Kang (TSK) model to congestion detection and congestion control. The FARCC sender adjusts data rate by receiving a feedback packet from FARCC destination. NS2-based simulation results show that FARCC outperforms ITP and ATP to achieve, in terms of throughput and fair resource allocation in AdHoc networks under random topology.
Keywords: Rate control, congestion control, fuzzy controller, channel busyness ratio.

1 Introduction

Congestion control is a critical issue to achieve optimal network resource utilization and fairness among end-to-end flows.In MANET with shared resources, where multiple senders compete for link bandwidth, it is necessary to adjust the data rate used by each sender in order not to overload the network. Packets that arrive into router and cannot be forwarded are dropped, consequently an excessive amount of packets arriving at a network bottleneck leads to many packet drops.These dropped packets might already have travelled a long way in the network.Thus consumed significant resources. In recent years, the whole congestion control mechanism designed in manet, specify the number of packets that are droped lead to congestion.These approaches are divided into three categories: window-based, rate-based and a hybrid between a window-based and a rate-based approach. window-based congestion control is not appropriate for MANET to provide high throughput, short delay and stable performance with few packet collisions.
In this paper, we focus on the problems resulting from the medium contention and propose a novel Fuzzy Adhoc Rate based end-to-end Congestion Control scheme (FARCC).This is unlike TCP, a rate-based congestion control and tuning of rate is operated in destination node. Extensive simulations show that our scheme significantly outperforms ITP [2] and ATP [3] in terms of channel utilization, average delay, and fairness between different flows.

2 Fuzzy Adhoc Rate base Congestion Control (FARCC)

In this section, we will elaborate on the specific mechanisms used by FARCC. FARCC primarily consists of mechanisms at the sender to achieve effective congestion control and reliability. Each time the FARCC sender transmits a packet, it attaches a congestion header to the packet. The rate-stamp field in header is sender's current Rate. Which is filled in by the sender and

never modified in transit. The br-stamp field is channel busyness ratio that all the intermediate nodes along the path are calculated and may modify it to control the packet sending rate of the sources. The delay-stamp field is the average queuing delay that all the intermediate nodes along the path may modify it. The destination node is similar to a TCP receiver except that when it receives acknowledging a packet, it copies the congestion header from the data packet to its ACK. It also acts as a collator of the congestion information provided by the intermediate nodes in the network before the information is sent back to the sender. The destination node provides the reliability, flow control, and collated congestion control information through periodic messages. FARCC sender is responsible for the connection management and the startup rate. Estimation and controls the sending rate of each flow by the explicit feedback carried in the ACKs.

2.1 Intermediate node

Delay(q(t)) is queuing delay experienced by per packet traversing the intermediate node. The intermediate nodes maintain an average queuing delay as avg-delay(q(t)) irrespective of the specific flow. It is performed over all the packets traversing through them. Average queuing delay is impacted by the contention between different flows traversing the node. This value is maintained using exponential averaging according to (1). For every outgoing packet, an intermediate node updates its avg-delay(q(t)) and delay(q(t)) values.

$$ave - delay(q(t)) = \alpha * ave - delay(q(t)) + (1 - \alpha) * delay(q(t)) \tag{1}$$

Every packet consists of delay-stamp field. It refers to the maximum avg-delay(q(t)) value at the upstream nodes that packet has traversed through. When the packet is dequeued for transmission, the intermediate node updates the delay-stamp field in the packet with avg-delay(q(t)) value if delay-stamp field is smaller than avg-delay(q(t)) value. The Intermediate node runs an epoch timer of period E. This period E should be larger than the round trip time of a connection, but at the same time must be small enough to track the dynamics of the path characteristics. E is empirically chosen to be one second in our simulations. In addition, the intermediate node computes channel busyness ratio periodically For the whole channels communicating with it according to [4]. Intermediate nodes in the network maintain maximum channel busyness ratio periodically as br(t) values. Each packet consists of a br-stamp field that refers to br(t) value at the upstream nodes which packet traversed through. When the packet is dequeued for transmission, the intermediate node updates the br-stamp field in the packet with br(t) value, If it is smaller than br(t) value.

2.2 Destination node

The destination node provides periodic feedback to sender for the collates congestion information which are provided by the intermediate nodes (through the br-stamp and delay-stamp fields on the packets). When destination node receives a packet, delay-stamp and br-stamp fields in the packet refer to as maximum average queuing delay and maximum channel busyness ratio which are experienced by the packets traversed through intermediate nodes. For every incoming packet belonging to a flow, the destination node performs an exponential averaging of the Delay-stamp value. In addition it performs periodically an exponential averaging of the br-stamp value which is specified in the packet.

The destination nodes in the network maintain avg(br-stamp) and avg(delay-stamp) values. In order to send the feedback periodically, the destination node runs an epoch timer of period T. Note that the period T should be larger than the round-trip time of a connection, but at

the same time must be small enough to track the dynamics of the path characteristics. T is empirically chosen to be one second in simulations.

Congestion probability Estimation using Fuzzy Logic Controller

The destination node gets packets and passes them through both the fuzzy logic congesion detection system and fuzzy logic congestion control system. Then it calculates appropriate transmission rate and piggybacks new rate on packet to the sender node. The fuzzy logic congestion detection system will calculate the probability of congestion using congestion header of packets. In the following section, we will introduce how use the fuzzy logic controller to estimate congestion probability.The system model of FARCC is shown in Fig.1.
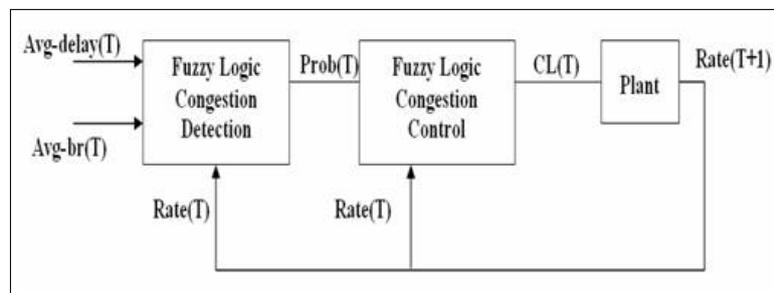

Figure 1: system controller to transmission rate

All inputs to fuzzy logic congestion probability system are considered as T, where T is the sampling period. The fuzzy congestion probability system consist of three inputs. The input avg-delay(T) is avg(delay-stamp) and The input avg-br(T) is avg(br-stamp) that are both calculated by destination node. The input rate(T) to primary system is current data rate in congestion header of packet. The fuzzy system in FARCC is zero order TSK-Fuzzy system. the fuzzy rules are determined based on a full combination of the input variables. Hence, there will be 36 (3*3*4) Fuzzy rules. If rth rule is denoted by R_r then the Fuzzy rule can be described generally as shown in the following equation:

R_r: IF avg-delay(T) is C AND avg-br(T) is D AND rate(T) is P THEN prob(T) is Z_r.

The output of fuzzy model as prob(T) is the probability of congestion, that is a value in the range [0,1] and how input variables are mapped to the probability of congestion detemined by simulation. Parameters Z_r (probability of congestion) are initialized using simulations and gathered experiences. Simulation is performed over 200 simulation runs in section 3. The goal of the proposed fuzzy controller is to determine the probability of congestion using current Network status and parameters except packet loss rate in the network.

Congestion control using fuzzy logic controller

In FARCC approache, There are three congestion levels low, medium and high. The destination node determines network congestion level using secondary fuzzy system at each sampling period according to Fig.1. The transmission rate tuned depends on specified congestion level through one of the three phases; multiplicative increase, additive increase and multiplicative decrease. two inputs of fuzzy logic congestion control system are considered at T, where T is the sampling period. The input prob(T) is congestion probability and output of primary Fuzzy system. The input rate(T) is current data rate in congestion header of packet. The zero order T-S fuzzy model has been selected for this system.

Plant modeling

Plant based on one of the congestion levels(low, medium and high) which is specified in output secondary fuzzy system performs one of three phases of multiplicative increase, additive increase and multiplicative decrease on current transmission rate respectively. If specified congestion level is low then it performs multiplicative increase phase according to (2) inorder the improvement of network throughput. [6]

$$new - rate = old - rate * (\frac{th - br}{avg(br - stamp)})$$ (2)

if congestion level is medium then it performs additive increase phase inorder the increases in transmission rate belong to average queuing delay of path nodes according to (3). [6]

$$new - rate = old - rate + (\frac{1}{avg(delay - stamp)})$$ (3)

If congestion level is high, then probability of congestion event is high. Therefore it performs multiplicative decrease and control send rate using average queuing delay and average channel busyness ratio, according to (4). [6]

$$new - rate = \frac{old - rate * avg(br - stamp)}{avg(delay - stamp) * th - br}$$ (4)

The destination node compares the new transmission rate with the current rate. If difference is greater than E then the new transmission rate is stamped on ACK packet and is sent to the sender, since increase in the number of feedbacks lead to an increase in congestion and network load.

2.3   Sender node

In connection initiation phase, the sender node sends a probe packet to receiver. The probe packet is piggybacked on the next data packet in sequence queued for transmission. When a new path is used, the connection is not aware of the available bandwidth on path. The probe packet perform bandwidth estimation once again allows the connection to operate at the true available bandwidth instead of either over utilizing or under utilizing the resources available along the new path.the sender node calculates time interval packets sending using send rate.

3   Simulation results

We used the NS2 simulator [7] to evaluate FARCC under random topology. the default parameter settings are as follows: the two-ray ground reflection model is used as the radio propagation model, IEEE 802.11 DCF as the MAC protocol, and AODV as the routing protocol. The parameters in FARCC are as follows: the initial values of the transmission rates are 110 kbps; The step sizes are appropriately tuned according to the scale of the network and the number of flows in network. In these topologies, each node is 200 meters away from its closest neighbors. The transmission range and the interference range are 250 m and 550 m, respectively. The data transmission rate is 2Mbps. The packets generated are of size 512 bytes in all the simulations. All the simulations are run for 100s and each data point on the figure is averaged over 10 simulation runs.

In this scenario the random topologies are generated for the simulations. The mobility model used for topology generation is the random waypoint model. All the simulations are performed

for a grid consisting of 50 nodes, distributed randomly over the two dimensional grid. The source destination pairs are randomly chosen from the set of 50 nodes in the network. Load on the network is 15 flows and FTP is the application that is used for all the flows in the network.
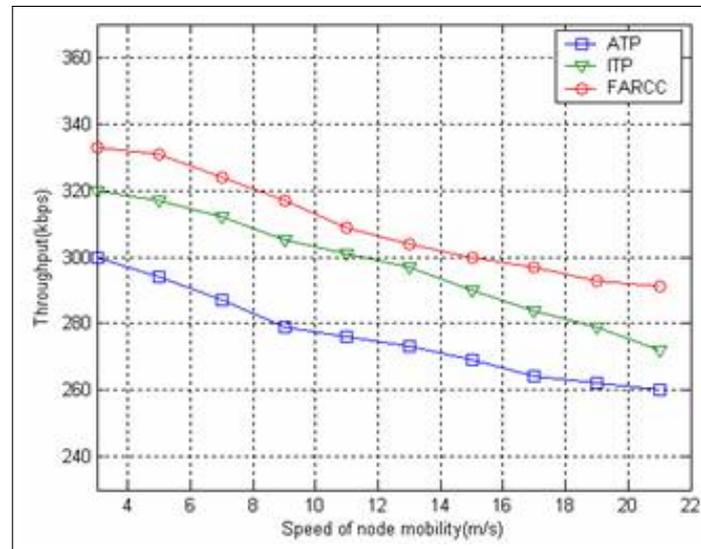

Figure 2: Throughput versus mobility in random topology

The first metric is the overall throughput shown in Fig.2 We observe with The larger speed of the node mobility, the aggregate throughput achieved by FARCC is able to provide an improvement of around 13.8%-48.4% over default ATP, and around 0.7%-23.6% over ITP.
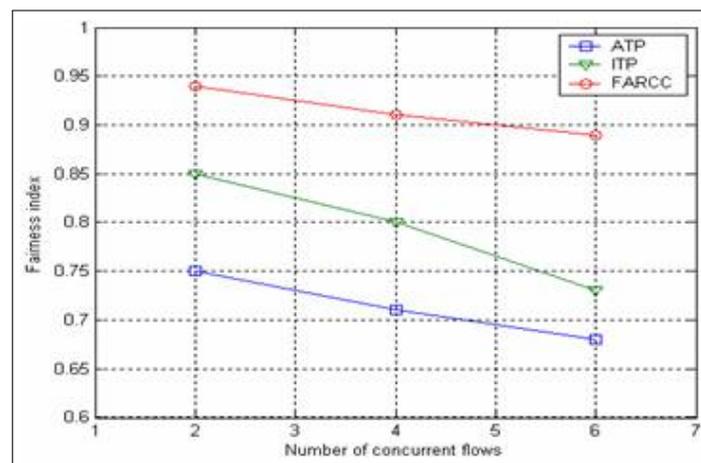

Figure 3: Fairness index in random topology

The result of the fairness index [8] is depicted in Fig.3 which shows a remarkable fairness of FARCC. The more concurrent flows, the better the improvement of FARCC over the congestion control algorithms and the mount of fairness index have an improvement of around 9 percent over ATP,and around 20 percent over ITP.

4   Conclusion

In this paper, we proposed an improved congestion control mechanism called FARCC in MANETs. The proposed scheme uses the fuzzy logic control mechanism to determine an appropriate data rate for sending packets. using the fuzzy logic congestion detection, probability of congestion is estimated. then fuzzy logic congestion control specifies network congestion level based on probability of congestion. The congestion level is used to tune the data Rate in plant. FARCC uses a feedback scheme to adjust data flow rate. Simulation results show that the proposed FARCC performs better than ITP and ATP for aggregate throughput. Consequently, our method supports higher fair resource allocation.

Bibliography

[1] Zhai, H.; Chen, X.; Fang, Y.; Rate-Based Transport Control for Mobile Ad Hoc Networks, *In Proceedings of the IEEE Wireless Communications and Networking Conference*, 4(1): 2264-2269, 2005.

[2] Wang1, N.; Huang2, Y.; Liu2, W.; A Fuzzy-Based Transport Protocol for Mobile Ad Hoc Networks, *In Proceedings of the IEEE International Conference on sensor network*, 2008.

[3] Sundaresan, K.; Anantharaman, V.; Hsieh, H. Y.; Sivakumar, R.; ATP: A Reliable Transport Protocol for Ad-hoc Networks, *In MobiHoc 03: Proc. of the 4th ACM International Symposium on Mobile Ad Hoc Networking & Computing*, 64-75, 2003.

[4] Kumar, S.; Raghavan, V.; Deng, J.; Medium Access Control Protocols for Ad Hoc Wireless Networks: a Survey, *Ad Hoc Networks*, 4(3): 326-358, 2004.

[5] Smitha, K.; Anand, H. U.; Mallapur, J. D., Fuzzy Based Congestion Control In Wireless Network, *International Journal of Computer Science and Communication*, 2(2):469-473, 2011.

[6] Zhai, H.; Chen, X.; Fang, Y.; A Call Admission and Rate Control Scheme for Multimedia Support over IEEE 802.11 Wireless LANs, *In Proc. First International Conference on Quality of Service in Heterogeneous Wired/Wireless Networks (QShine 04)*, 2004.

[7] The network simulator ns-2 website, available at : http://www.isi.edu/nsnam/ns.

[8] Wang, X.; Kar, K.; Cross-layer rate optimization for proportional fairness in multihop wireless networks with random access, *IEEE Journal on Selected Areas in Communications*, 24(8):1548-1559, 2006.