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Expert System for Handling Congestion in Opportunistic Network

Ahthasham Sajid[1], Khalid Hussain[2]

[1] Department of Computing Shaheed Zulfiqar Ali Bhutto Institute of Science and Technology Islamabad, Pakistan
[2] Department of Computer Science Lahore University Islamabad Campus, Pakistan
gullje2008@hotmail.com, khalid.hussain@cs.uol.edu.pk

Abstract

Opportunistic networks are one of the most popular categories of mobile Adhoc networks. These types of networks usually have to deal with intermittent disconnected path from source to the destination most of the time therefor suffers from numerous key challenges for successful custody transfer to be done between encounter nodes. There are numerous challenges faced due to such disconnectivity within the network but one of the key challenges is that which intermediate node will be selected as custody transfer and till how much time custodian node can carry messages as it will have storage constraints until a destination node is found. In this research study the same problem has been addressed via proposing a rule based expert system that will have better coordination among intermediate nodes for the transmission with less drop and better delivery ratio. Proposed technique has been tested and validated via ONE simulator and compared with MaxProp protocol.

Keywords: DTN, MANETs, ICN

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1. Introduction

Opportunistic networks belongs from the subclass of DTNs (Delay Tolerant Network) by this we means that opportunities for the communication to be successfully established b/w source and destination is discontinuous or irregular or dynamic. TCP protocol if used in opportunistic networks will break in this environment. Protocols over internet assumed to get quick return of acknowledgments so if long delays and variable queuing delays introduced in internet protocols it will fail to work. So one solution to resolve the issues is by exploiting node mobility and local forwarding mechanism and indeed used store and forward methods like during mobility data can be store at node level and when it gets suitable opportunity during mobility it should be forwarded [1]. Congestion can be cause in network due to various factors like topology, bandwidth, usage pattern or failure of hardware.

Congestion when it occurs can cause different effects on the performance like queuing delay, packet loss or the blocking of new connections. Traditional wired network in comparison with wireless networks will have low congestion control issues in them because wired network have fixed infrastructure and dedicated End to End communication links in particular. Scalability and mobility features of wireless networks indeed add chances for congestion to be caused in the network [3]. Network is said to be opportunistic when it is not sure about the future both in terms of its connectivity and also about its topology. Congestion in network is of two categories, link congestion and storage congestion. Second type of congestion is known as storage congestion is that when any nodes needs must have to store data by accessing its predefine storage limit till it can reach towards the destination; therefor opportunistic networks have to deal with this congestion rather than link congestion in general. In opportunistic networks limited contact period and unpredictability of contact events cause the long delays in Transfer of transmission not due to long propagation delays like in ICN [3]. Many of the modification have been made in TCP which is known as modified versions of TCP to support disconnection in wireless networks due to mobility of the nodes but the time assumed to be taken while suggesting those modifications were too short.

2. Related work

Different Techniques, Models, Protocols, Architectures presented by different researchers based on either (End-system flow control), (Network Congestion Control), (Network Based Congestion Avoidance) (Resource Allocation) which address congestion control issue in a Pro-Active manner to (Detect, Notify and then Avoid) both link and node level congestion to cope separately. This area is still an open research area as Bayesian networks were only sparingly used for congestion detection. Authors in research papers [5] [6] have only used Bayesian theory to handle the congestion issue in MANETs and DTN's. Techniques reviewed; specifically in [5] [6] have used Bayesian theory to deal with congestion issue after it has occurred in a network to found new route or overcome disconnection issue. Present routing techniques in opportunistic networks provide good results by use of context information but there are still many direction in integrated routing like which can be further investigated; like performance could be increased in terms of message delay, message delivery, network congestion and resource consumption etc. Research gaps identified in literature review in general and specially in the selected base research papers [6] [7] and [8]. Congestion issue has yet been handled by different authors in a proactive manner once it has occurred in the network. Traditional queue dropping mechanism like RED, FIFO, LIFO, Drop Tail, Drop front, History based drop have been used to replaced new packets at queue level in each node participating in the opportunistic networks. Artificial Intelligence technique has been used sparingly to detect congestion issue in opportunistic networks. Authors in the papers have [12] [13] only used so therefore there is a strong need of proposing a mechanism which enables each node to become self-intelligent using AI techniques. Estimation/ probability theory which could address congestion issue at node (Sender, Intermediate) level in a Pre-Active manner to detect congestion issue effectively before it is about to be rise. Bayesian theory is also being used in fault tolerance and in cooperative localization in yet in wireless networks domain like MANETs, DTN.

3. Proposed Methodology

3.1 Artificial Intelligence based Rule based Expert System:

Artificial intelligence based congestion detection framework has been proposed in figure 1 bellow which have three sub modules; Buffer Occupancy, Previous Contact History and custody transfer module. When node encounter with another node in the network firstly its buffer occupancy will be checked based on set threshold and node category will be assigned as less, average or high congested node that will be used as first input to the proposed rule based expert system. Secondly on encounter it will be check by a previous contact history module that either node have met before or not this information will be forwarded to the rule based expert system as input 2. Custody transfer module then at last will be call upon which will be responsible to make successful custody transfer of the packets based on the rules defines as illustrated in fig 5 bellow via a flowchart. The proposed artificial intelligence-based rule based expert system technique should be able to keep track of total packet sent at sending node and total packets received at destination node, sending and forwarding packet record at intermediate nodes and calculate packet loss for each node in the opportunistic network.

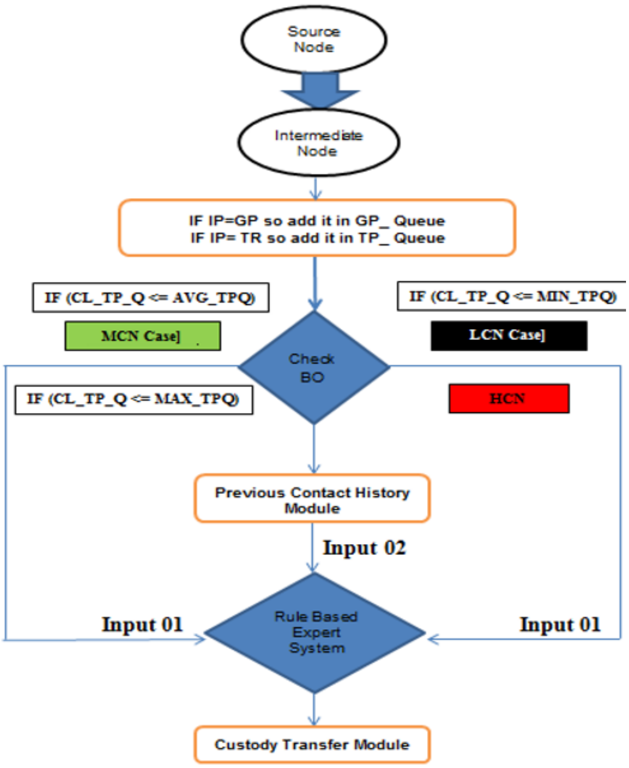

Fig 1: Artificial Intelligence Rule Based Expert System Model

3.1.1 Terminologies

IP (Incoming Packet)
GP (Generated Packet)
TP (Transit Packet)
IN (Intermediate Node)
BO (Buffer Occupancy)
CL (Current Length)
LCN (Least Congested Node)
MCN (Medium Congested Node)
HCN (High Congested Node)
MIN_TPQ
(Current length of Transit Packet Queue Limit b/w >=0% && <=25%)

AVG_TVQ
(Current length of Transit Packet Limit b/w >25% && <=70%)
MAX_TPQ
(Current length of Transit Packet Limit b/w >70% && <=100%)

Based on the model proposed in figure 1 above a forwarding schemed is proposed which uses two key parameters as threshold values illustrated in figure 2 bellow as per defined threshold over buffer and TTL at node level.; Calculated Buffer occupancy in terms of Less, Avg and High Congested Node and Sorting of Packets based on TTL value.

Fig 2: Node & TTL Thresholds:

3.1.2 Node Encounter Conditions

Possibilities of node encounters is illustrated by Fig 3 bellow that can be occurred in the network between the nodes based on their categories calculated over buffer occupancy parameter as less, average and high congested nodes.

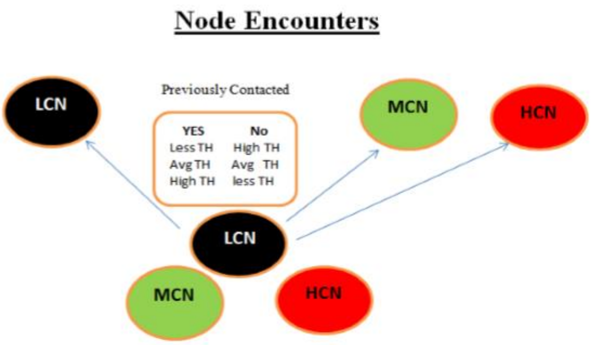

Fig 3: Contact Conditions

Fig 4 bellow illustrate that how a rule base will be used via using history as input to make an intelligent decision on the basis of which packets at queue over node level will be sorted down and a successfully custody transfer via illustrated flowchart in fig 5 further will be done.

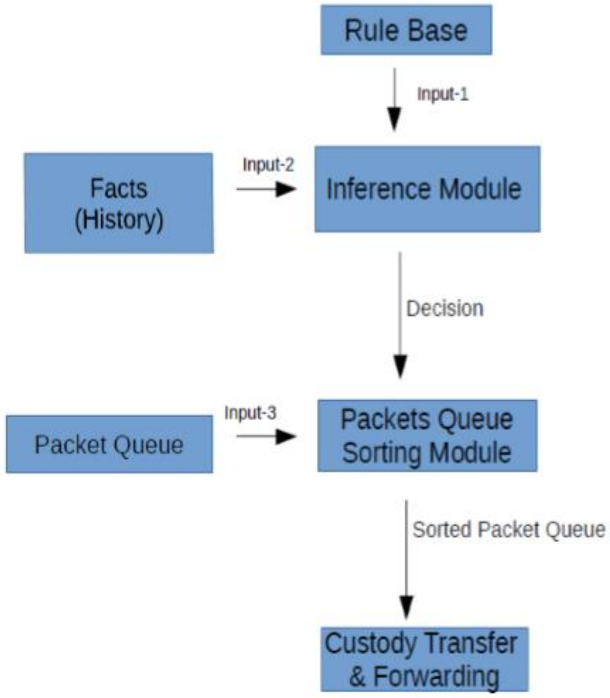

Fig 4: Rule Based Expert System

4. Model Validation & Simulation Setup

The simulation is conducted using ONE Simulator which is a discrete event java based simulation tool by varying buffer size from 3, 6, 9 and 12 MB. The list of other simulation parameters is listed in table 1 bellow.

Table: 1 Simulation Parameters

Parameters	Value
# of Nodes	100 to 500
Simulation Time	10000 to 50000 Sec
Channel Type	Bluetooth Interface
Routing Protocol	MaxProp
Buffer Size	3,6,9,12 MB
TTL	400 Sec
Simulator	ONE
Mobility Model	Map Route Movement

4.1 Results Analysis at Node Level:

Following 03 tests have been performed over 50000 simulation times with 10 MB buffer size upon proposed rule based expert system technique as illustrated in fig 4 in section 4 previously.

4.1.1 Buffer vs. Delivery Ratio Figure

5 bellow illustrates that initially at 3 MB MCN (Medium Congested Node) and HCN (High Congested Node) delivery ratio lies between 0.31 to 0.35 with increasing buffer size gradually at end over 12 MB buffer LCN (Less

Congested Node) & MCN (Medium Congested Node) get delivery ratio of 0.51 while HCN (High Congested Node) gets higher delivery ratio among all nodes; 0.61.

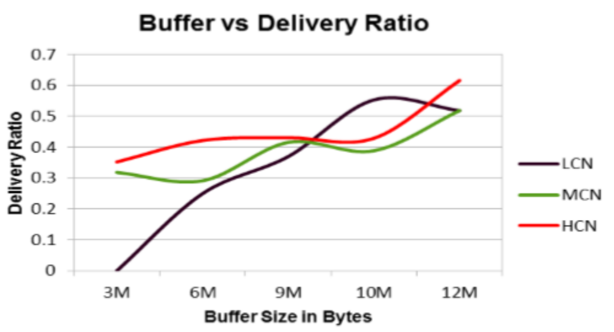

Fig 5: Buffer vs. Delivery Ratio

4.1.2 No of nodes vs. Delivery Ratio:

Figure 6 bellow illustrates that initially at 100 nodes delivery ratio lies between 0.45 to 0.56 with increasing no. of nodes delivery ratio of Less, Medium and High congested nodes tends to decrease as well; it starts at 0.46, 0.56 and 0.52 for LCN, MCN and HCN respectively over 100 nodes and its ends up with delivery ratio of 0.31 over 500 nodes for all types of nodes in the networks.

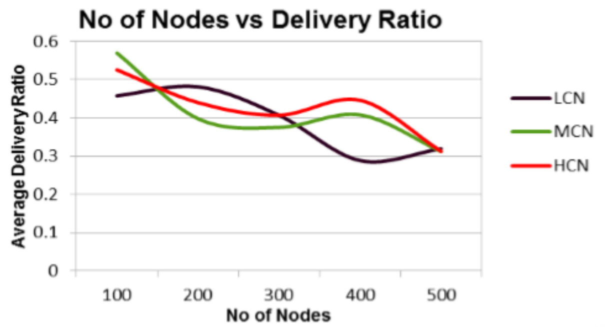

Fig 6: # of Nodes vs. Delivery Ratio

4.1.3 No of nodes vs. Packet Delivered

Figure 7 bellow illustrates that packet delivery has also increased with respect to the increase in no. of nodes in the network like at 100 node in start it lies between 187 to 214 while over 500 nodes packet send ratio ends up at 444 to 459.

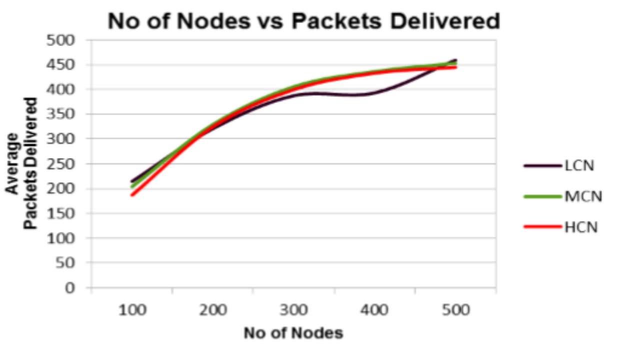

Fig 7: # of Nodes vs. Packet Delivered

4.2 Results Analysis at Network Level:

Following 03 tests have been performed over 25000 simulation times with 10 MB buffer size upon proposed rule based expert system technique as discussed in fig 5.in section 3 previously.

4.2.1 Buffer Size vs. Delivery Figure

8 bellow illustrates that how delivery ratio initially started at 16% but as the buffer size gets increases similarly delivery ratio for AIbCDM has increased between 3 to 6 % in comparison of the MaxProp.

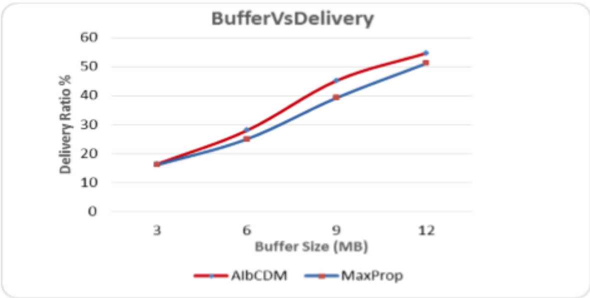

Fig 8 : Buffer Size vs. Delivery Ratio

4.2.2 Buffer Size vs. Overhead

Figure 9 bellow illustrates that how the overhead has decreased with increased in buffer size initially overhead started at 513 for MaxProp and 530 for AIbCDM but as soon as buffer size was increased from 3MB to 12 MB similarly overhead get decreases like over 12 MB buffer size; MaxProp and AIbCDM both have overhead of 300.

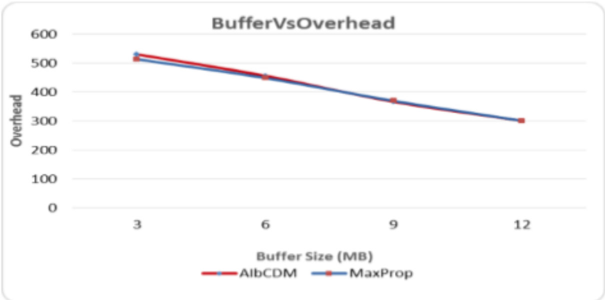

Fig 9: Buffer Size vs. Overhead (500 Nodes)

4.2.3 Buffer Size vs. Network Load:

Figure 10 bellow illustrates that how by increasing buffer size from 3MB to 12 MB network load get decreased like; at 3 MB it was 514 for MaxProp and 531 for AIbCDM but at 12 MB it ends up with 301 for AIbCDM and 302 for MaxProp.

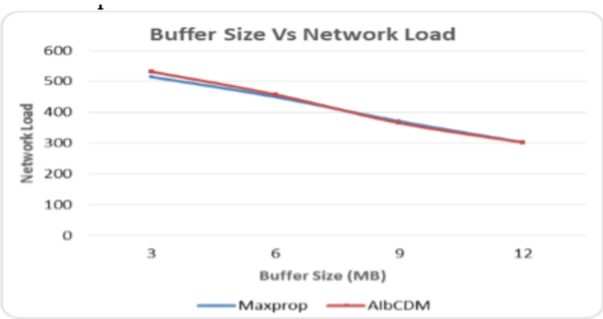

Fig 10: Buffer Size vs. Network Load

5 Result Discussion & Conclusion

Results for proposed new rule based expert system artificial Intelligence based technique is introduced as described in fig 4 in section 04 tested over 100 to 500 nodes with 3,6,9, 10 and 12 MB buffer Size. Buffer size vs. delivery for proposed Rule based expert system in fig 12 is analyzed and prove improvement is achieved as overall delivery ratio get increased from 1 to 6 % in comparison to the MaxProp protocol. Buffer size vs. overhead ratio for Rule based expert system in fig 10 is analyzed and prove improvement is further achieved even after increasing no. of nodes from 300 to 500 , overhead ratio get decreased as its starts at 500 initially and ends up at 300 over 12 MB in comparison to the MaxProp protocol. Tests have been performed and analyzed at node level in section 4.1 and network level in section 4.2 under section 04 previously, improvement for both node and network level in proposed rule based expert system technique is achieved overall in comparison to the MaxProp protocol results. In this research paper a new artificial intelligence based rule based expert system technique has been introduced and tested by using ONE simulator tool. Overall delivery ratio with less drop rate in comparison with the

MaxProp protocol both at Node and Network level as illustrated in section 4.1 and 4.2 respectively.

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