Design and Evaluation of an Efficient Congestion Adaptive Routing Protocol in MANET

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Abstract— Routing protocols for mobile ad hoc networks (MANETs) have been explored extensively in last few years. Routing may let a congestion happen which is detected by congestion control, but dealing with congestion in reactive manner results in longer delay, and unnecessary packet loss and requires significant overhead if a new route is needed. Adaptation to the congestion helps to increase both the effectiveness and efficiency of routing. These problems are solved by the congestion-aware routing protocols in certain degree. These protocols which are adaptive to congestion status of mobile ad-hoc network can greatly improve the network performance.This project work gives a proposal for a new algorithm, Efficient Congestion Adaptive Routing Protocol (ECARP) using cross layer design, which out-performs even during constrained situation. The project is simulated using the popular network simulator NS2 and the results are compared with the Ad hoc On-demand Distance Vector (AODV) routing protocol which is one of the dominate protocol design for MANET. Through simulation in NS- 2 that ECARP out-performs over AODV routing protocol in normal situation.

Key words: Ad hoc on-demand Distance Vector (AODV), Congestion, Mobile Adhoc Network (MANET), Network Simulator-2 (NS2)

I. INTRODUCTION

Mobile Ad Hoc Network (MANET) is a type of wireless network which are formed by a mobile nodes that work on the principle of cooperative agreement of mobile nodes. The characteristics of MANET are continuously changing infrastructures, no centralized network managers, no dedicated access points, no fixed base stations, not having a backbone network for controlling the network management functions, and there is a absence of designated routers for making routing decisions. All the nodes in MANETs are treated as equal in the environment and participate in the routing process by acting as routers for one another. During the transmission of data from one node to another, MANET requires several hops because of the limited wireless transmission range associated with the operation of the mobile nodes [1, 2, 3]. The above described characteristics of MANETs, particularly those listed due to the mobility of the nodes in MANET environment, and the continuously-changing of the network infrastructure, influences several challenges in to this research area. Due to the continuously changing infrastructure, the routes that were highlighted as “best” will no longer remain as the “best” at a later time. Therefore, it needs to re-compute the routes continuously, implying that in such networks, there is no permanent convergence to a fixed set of routes. For the reason, any routing protocol operating on MANET environments should consider these research issues and challenges during the design of a new protocol for the system. [1]. Designing routing protocols also include further challenges that one needs to design routing schemes in the presence of adversarial environments in MANET networks. Here, the primary focus is on fault-tolerant routing schemes that when the network contains malfunctioning nodes. As a motivation, we observe that most existing MANET protocols were assumed considering scenarios in which all the mobile nodes in the ad hoc network function properly and in an idealistic manner. The adversarial environments are common in MANET environments, and those nodes which will misbehave degrade the performance of these routing protocols. Thus, there is a need for fault-tolerant routing protocols which will identify to address routing in adversarial environments in presence of faulty nodes by exploring redundancies in the networks [4, 5]. Considering the above mentioned challenges we note a few applications of MANETs which them popular. One of the popular MANET application domains is communications in moving battlefields. Other applications are found in rural regions where building up fixed wired or wireless infrastructures can be costly and/or difficult.

Mobile Ad Hoc networks (MANETs) are marred due to its fundamental characteristics, such as open medium, dynamic topology, distributed operation, power constraints, constrained capability and unreliable connections.The neighbor selection schemes are all relatively static in nature. It is possible that the multi-hop router decides to change the assigned parent of a node (and conversely its depth in the network) but this is a rare event which becomes even rarer as the network routing tree settles into a steady state. While these algorithms are able to increase the reliability of the network substantially, the fact that they are static remains a serious flaw. The main conceptual reason for this is that if two nodes have the same depth, this does not mean they are necessarily geographically close. Consider the example, illustrated in Figure 16, where some node A wishes to send a message and has two neighbors, B and C, which have the same depth. The static algorithms would treat these nodes the same. However, it could be that node B is geographically close to node A and a good choice to route through while node C is far away, just barely in radio range, and hence has likely a less reliable radio link than node B. While it might be that node C is far enough away that node A almost never hears it and hence does not have it on the neighbor list very often, problems can arise if node A only hears one out of every ten messages from node C but has not removed it from the neighbor list.

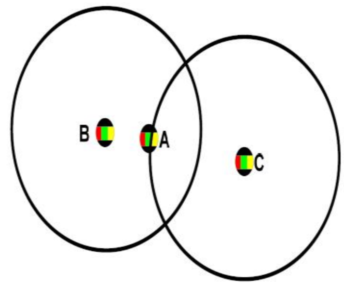

Figure 16: An example of a problem that can occur when nodes make decisions simply based on depth in the routing tree. The circles represent the radio range of node B and node C.

Fig. 1:

We cannot solve this problem by simply removing nodes from the neighbour list if we do not hear a lot of traffic from them because the node may be a very reliable link and just not have dad any data to send due to a lack of events in its sensor range. This means that even though node A does not hear from C very often, A does not know if this is because C is on a poor radio link or just does not have much to say. We wish to try and lessen the negative effect that this has on our network despite the lack of geographical information from the nodes.

II. Literature Survey

A. Routing in MANET:

A protocol that avoids congestion by reducing contentions that takes advantage of channel spatial reuse to reduce contention and is able to deliver more than 80% data packets even under heavy traffic load. Bluetooth devices forms the basis of Bluetooth routing protocol which considered the capabilities of the node within the network's range and protocol made decisions by taking signal strength, power constraints, memory and location into account. In MANET intermediate nodes are also called as redirectors elects to forward packets on behalf of source destination pairs thus reducing the aggregate transmission power consumed by wireless devices. This algorithm was compared in performance to MLSR and found that this algorithm consumed less power in order to find power efficient routes compared to MLSR due to its point-to-point on-demand design. For MANET a new agent based ad hoc routing protocol was also introduced and which achieves better performance under more dynamic conditions and shows improvement in terms of delay and number of received packets compared to DSDV. For MANET, AntHocNet hybrid algorithm for routing in mobile ad hoc networks based on the nature-inspired Ant Colony Optimization framework was introduced which was more scalable than AODV. A novel distributed routing protocol which guarantees security, anonymity and high reliability of the established route in a hostile environment, by encrypting routing packet header and abstaining from using unreliable intermediate node was described with its main features as non-source-based routing, flexible and reliable route selection, and resilience against path hijacking. Several routing algorithms that find near-optimal solutions for the joint optimization problem and the routing objective is to minimize communication cost, while maximizing information gain, differing from routing considerations for more general ad hoc networks and information-directed routing is a significant improvement over reported greedy algorithm.

For high node mobility and low traffic loads, simple changes like limiting replies by destination, one route per destination and preferring fresher routes over short ones improve the performance. In MANET for provision of asynchronous communication in partially-connected mobile ad hoc networks, based on the intelligent placement of messages, a new routing protocol can be designed. Results showed that it is possible for nodes to exploit context information in making local decisions that lead to good delivery ratios and latencies with small overheads. MANET routing protocols relies only on symmetric cryptographic techniques and dynamically discover the routes between nodes when needed and design is based on basic operation of DSR protocol. Ariadane performs better on some metrics than unoptimized DSR. Genetic Algorithms (GA) can be used for route discovery for QoS routing in MANETS based on reinforcement learning (RL) based on route discovery and GA based route expansion. RL techniques can play an important role in controlling flooding in route searching to improve performance of network in environments in which the route selection is only based on local network information. Biometrics and Genetic algorithm provide data security in MANET to strengthen the encryption algorithm and key. Genetic algorithms and dijkstra algorithm can be used to better the optimization problems in MANETs. The soft techniques like neural network, genetic algorithms and fuzzy logic based more routing techniques and to improve the routing mechanism in MANETs with genetic algorithms, buffer size, end to end delay and shortest path as the parameters for GA in route discovery can be used and alternative path or backup path to avoid reroute discovery in the case of link failure or node failure can be obtained. AOMDV protocol achieve best performance in high mobility case, whereas AODV Multipath performs better in case of low mobility and higher node density and total routing overhead gets lower. To ensure the complete data secrecy between communicating nodes in MANETs, three anonymity guarantee identity anonymity, route anonymity and location anonymity can be used and asymmetric key cryptographic schemes are practicable for wireless ad hoc networks. A newly developed MANET routing protocol AODVLRT decreased both of the routing message overhead and the average end to end delay than the well known AODV routing protocol and increased the throughput. This routing protocol enhances the network performance than the AODV routing for a network sizes ranging from 50 up to 300 nodes.To adapt to network topology variations Adaptive Backup Route technique can be used in MANETs named as AODV- ABL, it can solve the collision and congestion problems of packets in AODV-BR by choosing a backup route among many backup routes. Genetic algorithm can be used to find a very good path between source and destination in adhoc network nodes and can optimize the route in MANET.GA can reduce the number of clusters, cluster heads and loads among clusters can be evenly balanced. A fully localized algorithm that efficiently delivers multicast data messages to multiple destinations in which each node propagating a multicast data message needs to select a subset of its neighbours as relay nodes towards destinations was described which optimizes the cost over progress ratio where the cost is equal to the number of neighbours selected for relaying and the progress is the overall reduction of the remaining distances to destinations. The Zone Routing Protocol (ZRP) was the first hybrid routing protocol with both proactive and reactive routing components. ZRP defines a zone around each node consisting of its k-neighbourhood. Routing within a zone is performed using a proactive routing protocol and routing in different zones is performed by an on-demand routing protocol. ZRP performs efficient route discovery through border casting; route requests are spread by multicasting them directly to the nodes on the border of its zone. The size of the zone is dynamically determined based on network load. A flat mobile ad hoc network has an inherent scalability limitation in terms of achievable network capacity. It is observed that as the network size increases, per node throughput of an ad hoc network decreases. This is due to the fact that in large scale networks, flat structure of networks results in long hop paths which are prone to break because of route break or power depletion. A hybrid protocol in which the long hop paths are avoided by using backbone power capable nodes concept working as mobile backbone network. In HCR (Hybrid Cluster Routing) where nodes are organized into a hierarchical structure of multi-hop clusters using a stable distributed clustering algorithm. Simulation results show that HCR has better scalability, robustness and adaptability to large scale mobile ad hoc networks compared with some well-known routing protocols, e.g. AODV, DSR, and CBRP. AODV and OLSR are combined to form AOHR (AODV and OLSR hybrid routing) [4]. Here the characteristics of high data delivery fraction, low overheads, and short delay in AODV are combined with the characteristics of optimized routing length in OLSR, which means that AOHR is immune from topological structures.

B. Overview of Network Simulator (NS-2):

The proposed protocol evaluations are based on the simulation tool called the Network Simulator (NS2). An event driven network simulator NS2 is developed by the University of California at Berkeley. NS2 can be used to simulate a wide variety of network protocols, traffic sources. It also supports a wide variety of static and dynamic routing protocols. NS2 can also be used to implement multicast on demand routing protocols and it also supports the multipath routing protocols. NS2 is a part of the VINT (Virtual Inter Network test bed) project that developed the tools which are used for display of simulation results, analysis. In NS2 converters are used to convert the network topologies generated in to NS formats.

Network Simulator is an Object Oriented Tool command language (OTcl). It is a script interpreter which contains a simulation event scheduler and network component object libraries in addition to network setup (plumbing) module libraries. To arrange and run a simulation network, user must write an OTcl script that commences an event scheduler, which establishes the network topology using the network objects. In addition plumbing functions are available in the library and instructs the source to start and stop the broadcasting packets via the event scheduler. The reason of network plumbing is, plumbing of feasible data paths between the network objects by means of locating the neighbour pointer of an object towards the address of suitable object. While a user requests to create a new network object, it can be done by means of creating an object by writing a new object or by creating a composite object from the object library and also plumb the data path via the object.

The main component is the event scheduler. An event scheduler holds path of simulation time and fires each and every event in the event queue organized for the current time by means of invoking suitable network components. Timers use an event scheduler which is similar to that of delay. The difference is that timer computes a time value which is connected with a packet and performs a suitable action related to the packet. When a particular time expires it does not simulate a delay. Network Simulator (NS2) uses both OTcl and C++. NS disconnects the data path implementation from control path. To reduce the packet and event processing time NS2 uses the event scheduler. The basic network component objects inside the data path are written and compiled by using the C++. These compiled objects are available to the OTcl interpreter by means of an OTcl linkage that generates an identical OTcl object used for each of the C++ objects and also generates the control functions. The configurable variables identified by the C++ object which should be performed as member functions and also the member variables of the related OTcl object. Like this the controls of the C++ objects are distributed to OTcl. The objects in C++ does not require to be restricted in a simulation or internally used by means of another object which does not require to be linked to OTcl.

When a simulation run is completed, NS generates one or more text based output files which contains detailed simulation output data in the OTcl script. This data can be used for simulation analysis or input towards the graphical simulation display tool is called as Network AniMator (NAM). NAM consists of a graphical user interface and also a display speed controller and it is used to record various events. It can also present information such as throughput and the number of packet drops at each link graphically.

C. Congestion Control in MANETs:

Congestion takes place in MANETs with limited resources. In these networks, shared wireless channel and dynamic topology leads to interference and fading during packet transmission. Packet victims and bandwidth dilapidation are caused due to congestion, and thus, time and energy is wasted during its recovery. Congestion can be prevented using congestion-aware protocol through bypassing the affected links [16]. Severe throughput degradation and massive fairness problems are some of the identified congestion related problems. These problems are generated from MAC, and protocol routing and transport layers. Congestion control is the main problem in ad-hoc networks. Congestion control is associated to controlling traffic incoming into a telecommunication network. To avoid congestive crumple or link capabilities of the intermediate nodes and networks and to reduce the rate of sending packets congestion control is used extensively [17]. Congestion control and dependability mechanisms are combined by TCP to perform the congestion control without explicit feedback about the congestion position and without the intermediate nodes being directly intermittent [17]. Their principles include packet conservation, additive increase and multiplicative decrease in sending rate, stable network. End system flow control, network congestion control, network based congestion avoidance, and resource allotment includes the basic techniques for congestion control [18]. Packet failure in MANETs is primarily caused due to obstruction. Involving congestion control over a mobility and failure adaptive routing protocol at the network layer can condense the packet loss. The congestion non-adaptive routing protocols, leads to the following difficulties: Extensive delay: Most of the congestion control mechanism takes much time for detecting congestion. Sometimes the usage of new routes in some critical situations is advisable.The main problem is the delay stirring for route searching in on-demand routing protocol.

More Overhead: Congestion control mechanism takes effort for processing and communication in new routes for discovering it. It also takes effort in multipath routing for maintaining the multi-paths, though there is another protocol.

Heavy packet losses: Once the congestion is detected the packets may be lost. Congestion control solution is applied either by decreasing the sending rate at the sender, or dropping packets at the intermediate nodes or by both methods to decrease the traffic load. Due to high packet loss rate, small throughput may be occurred.

III. EXISTING SYSTEM

Most of the MANET routing protocols are not adaptive to congestion and cannot handles the heavy traffic loads while offering services to multimedia applications. It will find optimal paths for primary route and alternate route. Data will be delivered to its destination as quickly as possible, but it has no commitments in regards to QoS parameters, such as bandwidth or delay. Examples of best-effort services are Internet Protocol (IP), User Datagram Protocol (UDP), etc. Using protocols such as Transmission Control Protocol (TCP), the highest guarantee the network provides is just reliable data delivery. This is adequate for traditional data applications like ftp and telnet, but it is inadequate for those applications that require timeliness. For example, many multimedia applications need to communicate in real-time. They are sensitive to the delay and jitter, and cannot afford the unacceptable delay introduced by the retransmission of TCP.

In other words, different applications have different Quality of Service (QoS) requirements, such as delay, jitter, bandwidth and loss probability, which urges the Internet Service Providers (ISPs) to provide different treatment to different users. The notion of QoS is proposed to capture the performance contract between the service provider and the user applications. Basically, providing QoS requires cooperation of many network control mechanisms, such as routing, call admission, flow and congestion control. Much work has addressed routing schemes that try to achieve desired QoS objectives. On the other hand, QoS is really only noticed when the best-effort service encounters congestion. That is, when the network resource is unlimited and no any congestion happens, best-effort service will certainly satisfy the users' QoS demands. However, network resources are limited and congestion is unavoidable. Fluctuations of network conditions combined with the inability of handling congestion often affect the users' desired QoS. Thus, efficient end-to-end flow and congestion control is important and necessary to limit the input flows, to respond to the network conditions and to work with the routing scheme. Therefore, we propose an design of new efficient congestion adaptive routing protocol which is built in UDP to handle congestion while supporting the users' QoS.

IV. PROPOSED SYSTEM

This project work has the following contributions.

1) We introduce a method to estimate the forward packet loss ratio in real-time environment and we suggest an approach to construct composite goal functions which combine multiple QoS constraints, namely packet loss and delay, into a single goal function, which is used to complete QoS-based adaptive routing.
2) We experimentally implement the different goal functions based on different QoS goals and we investigate the performance of the adaptive routing scheme based on users' single and multiple QoS constraints.
3) We propose an efficient congestion adaptive routing protocol. It is an end-to-end flow and congestion control scheme for unicast applications.

V. SYSTEM ARCHITECTURE

The wireless ad hoc network shown in Figure 1 considers mobile nodes, which are not supported by an external device or control mechanism and have their communication range according to coverage area of the individual node. It may be seen that sending and destination nodes are connected using multihop communication and thus need congestion free path to achieve reliable communication.

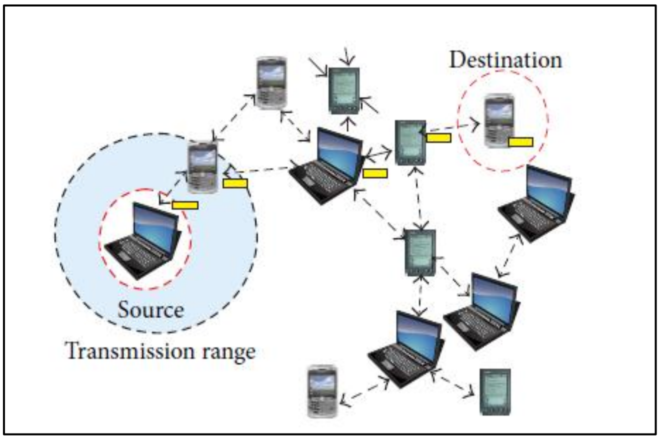

Fig. 2:

VI. ALGORITHM

Ecarp Congestion Control Algorithm This algorithm provides solution to improve routing protocols due to constrained environment.

1) Step1: check the occupancy of link layer buffer of node periodically, Let C be the congestion status estimated.

2) Step2: Compute Cs = Number of packet buffered in Buffer Buffer size ‘
3) Step 3: Set the status for Congestion. It can be indicated by three statues “Go”, “Careful” and “Stop” . [“Go” indicates there is no congestion with Cs ½ “careful” indicates the status likely to be congested with ½ Cs ¾ and “Stop” indicates the status likely to be congested ¾ Cs 1.]
4) Step4: Invoke congestion control routine when link failed event has occurred in data transfer with using active route or ¾ Cs 1.
5) Step 5: Assume that neighbor will have alternate route or noncongested route to the destination.
6) Step 6: Make Query to non-congested neighbors for route to destination.
7) Step 7: After obtaining the routes from the neighbors, select route with minimum hops.
8) Step 8: Once route is finalized start sending the data packets through non-congested rouTe.
9) Step 9: If there is no alternative route to destination then start splitting the traffic to the less congested route.
10) Step 10: Traffic splitting effectively reduces the congestion status at the next main node. In normal case AODV better then DSR using packet delivery ratio and average delay.

But in constraint situation of many CBR sources leading to same destination, DSR works better than AODV and DSDV was improved by using local corrective mechanisms which are quick reactive to local corrective mechanisms which are quick reactive to local route repairs to overcome the problem of congestion.

VII. Experimental Results

1) Simulation Setup. The simulations of network have been carried out using Qualnet 5.2.The simulation parameters are given in Table 1.
2) Performance Metrics. In this paper, the performance metrics such as packet delivery ratio, average end-to-end delay, and normalized routing overhead were calculated and evaluated for AODV, CRP, and ECARP.
3) Packet Delivery Ratio. Packet delivery ratio is the ratio of the number of data packets successfully received at the destinations to the number of data packets generated by the sources.
4) Average End-to-End Delay. The average end-to-end delay is a measure of average time taken to transmit each packet of data from the source to the destination.Higher end-to- end delay is an indication of network congestion.

Table 1

Parameters	Values
Node placement strategy	Random
Propagation model	Two-ray ground radio propagation model
Environment size	1500 m × 1500 m
Number of nodes	100
Transmitter range	250 m
Bandwidth	1 Mbps
Simulation time	300 s
Traffic type	Constant bit rate (CBR)
Number of CBR sources	20
Packet size	512 byte
Number of packets transmitted by sources	100
Maximum speed	20 m/s
Mobility model	Random way point model
Pause time	10 s
Packet rate	1, 5, 10, 20, 30, 40 packets/s

Table 1:

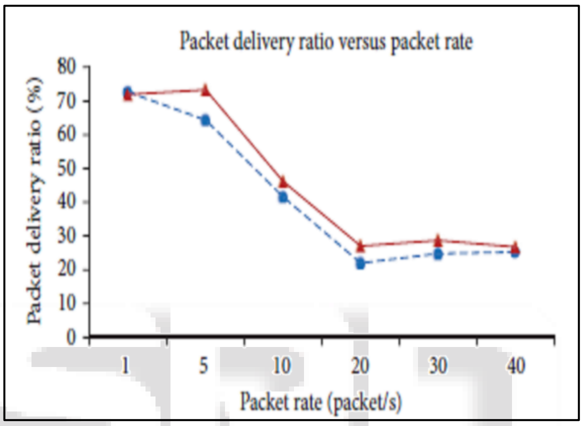

Fig. 3: Packet Delivery Ratio versus Packet Rate

– AODV
– ECARP

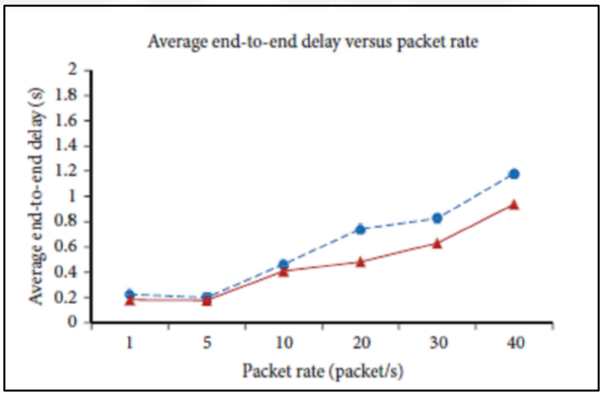

Fig. 4: Average end to end Delay Versus Packet Rate

– AODV
– ECARP

VIII. Conclusions

It is clear from the algorithms available for having adaptive solution for congestion in the network as due to vast payloads on network, which may be due to flooding of packets or may be due to repeat requests on the basis of error correction techniques. This is clear from the investigations that new set of solutions are needed to overcome the problem congestion in network. It is also clear that congestion is the problem associated with the network and has to be countered by having compromised solution rather than elimination.

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