A Simulation Study of Multi-Hop Wireless Network

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Abstract—Over a period of time there has been a massive revolution in wireless devices, ranging from centralized to infrastructureless ad hoc networks. The routing layer in an ad hoc network ties the network into a seamless entity and provide transparent services to higher layer protocols. We examined the performance of the various proposed Packet Routing Protocols and studied the effective network performance parameters with TCP regulated traffic. We studied the dependence of the performance on the transmission range of the mobile nodes with effective simulations in ns-2 simulator. We studied the performance of these routing protocols on the source application FTP and HTTP and on the choice of the ad-hoc routing protocol (AODV, DSR and DSDV). We conclude that persistent and non-persistent traffic behave quite differently in an ad-hoc network and choice of Routing Protocol has a major impact on the performance of the network.

1. INTRODUCTION

Ad hoc networks are multihop and infrastructureless networks. In an ad hoc network each node is as responsible as other and act as a router for other senders. Since some senders are out of the range of the receivers, the intermediate nodes have to act as forwards of the data/ack packets and maintain the same transparency as provided in wired networks. Ad-hoc routing protocols have been developed to provide the route discovery and network maintenance mechanisms for each mobile node in the network to communicate will all other nodes in the network. Thus mobile nodes in ad hoc network dynamically establish routing amongst themselves to form their own network on the fly.

Some of the situations where this kind of communication is deployed are: computers to participate in interactive lectures, persons communication in battlefield and other disaster situation where is impossible to setup an infrastructure.

Many different routing protocols have been proposed to successfully route the data packets, but none of them are defined as standards. Each has some benefits and drawbacks. Ad hoc routing protocols can be characterized in a number of ways as explained in RFC2501. First of all they should they should behave in distributed fashion and allow each of them of enter and leave the network on its own. The routing protocol should avoid data looping in the network and reduce the number of packet forwards. Nodes operate either in reactive or proactive mode. Similar to wired networks, proactive protocols are table driven and maintain routes for each node in the network. The nodes must be in continuous communication about the topology changes. For very dynamic topologies, proactive protocols can introduce a large overhead in bandwidth and energy consumption on the network. Reactive protocols trades off this overhead with lager delays. A route to destination is established only when it is needed on an initial discovery between source and destination.

Other issues are mainly concerned with channel access and MAC layer, so that contention can be made on a fair basis. Several proposals have been made to improve the efficacy of these protocols and few of them are standards for media access layer protocols. One of the prominent is IEEE802.11

In networks where nodes use the same physical channel, the transmission range of individual nodes is a key determinant of capacity, since it effectively determines the extent of spatial reuse possible. Capacity studies of multi-hop, ad-hoc wireless networks typically concentrate on the MAC layer, and investigate the effect of various parameters, such as the radio transmission range, the node density or the average distance between session end-points, on the maximal achievable throughput.

All these studies have, however, focused on the TCP throughput in static, multi-hop networks and do not consider the impact of mobility on the overall network capacity. In this paper, we endeavor to produce the consolidated view of the simulation and network behavior under different conditions and different routing protocols. Specifically:

(i) How variations in the average velocity of the nodes impact the goodput?

(ii) How the total goodput is affected by the traffic load (number of TCP connections) in the network?

(iii) How different traffic agents, persistent (FTP) and non-persistent (Telnet, HTTP) behave in ad-hoc scenario.

(iv) How our choice of the ad-hoc routing protocol (AODV, DSR or DSDV) affects the total goodput of the TCP sources, routing overhead and drop count?

(v) How does varying the transmission range effect the measurement parameters?

(vi) How does the fairness index depend under simulation parameters?

Our studies assume that all nodes are identical in the sense that they all use the same transmission range, the same buffer lengths B and follow the same mobility pattern. Our focus is thus on evaluating the right choice of if under different operating conditions. The common physical Channel is assumed to have a bandwidth C; for our studies with IEEE 802.11 LANs, we have used C = 2 Mbps.

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The rest of the paper is organized as follows. We enumerate the various simulation parameters that we have used in our studies in Section II. In Section III, we vary the number of FTP connections in the network and study how it affects the goodput. In Section IV, we study the effect of varying the number of sources under HTTP traffic sources. In Section V, we study the performance of these routing protocols under different mobility and transmission radius and question the existence of Optimal Range. Finally, Section VI has the conclusion.

II. SIMULATION PARAMETERS

The overall goal of our experiments is to measure the ability of the different routing protocols to react to the network topology change while continuing to successfully deliver data to their destinations. To measure this ability, our basic methodology was to apply to a simulated network a variety of workloads, in effect testing with each data packet originated by some sender whether the routing protocol can, at that time, route the packet to its destination. We are not attempting to measure the protocols performance on a practical workload taken from real life, but rather to measure the protocols performance under a range of conditions. Our protocol evaluations are based on these imitation of 40-50 wireless nodes forming an ad-hoc network moving within an area of 500m x 500m flat space for 600 seconds of simulation time. Total goodput is calculated by summing the TCP goodput of all the connections. Results are averaged over 10-20 runs. The physical radio characteristics of each node's network interface, such as antenna gain, transmit power and receiver sensitivity were chosen to approximate the Lucent WaveLAN direct spread spectrum radio.

In order to enable direct, fair comparisons between the protocols, it was critical to challenge the protocols with identical loads and environmental conditions. Each run of the simulator accepts as input a scene file that describes the exact motion of each node and a connection pattern (these are not taken from ns rather implemented on own) the exact sequence of packets originated by each node, together with the exact time at which each change in the motion of packet origination is to occur. We generated different scenario files with varying movement patterns and traffic loads and then ran various routing protocols against each of these scene files. Since each protocol was challenged in an identical fashion, we can directly compare the performance results of the various protocols. Our performance studies are carried out using simulations performed on the ns-2 simulator [10].

Traffic pattern is FTP with window size (w), equal to 32 packets, packet-size equals 512 bytes. All connections are initialized in first 20 sees of the simulation and the measurements are taken after 50 sees. This is done to avoid TCP Slow Start phase and get the results which are unaffected by the same. This also ensures that some statistics are not biased just because of initialization of some connection before others and therefore contribute to the results significantly.

The transmission range is 250m and speed of each node is 5m/s. Pause times are randomly chosen from 0 to 10 sees.

III. VARIATION WITH NUMBER OF TCP CONNECTIONS

We have varied the total number of TCP connection from 10 to 250 and measured the following three parameters.

(i) Total Goodput.
(ii) Routing overheads.
(iii) Packet Drop Count.

This study clearly reflects the maximum capacity of the ad hoc networks. We observe that with fewer TCP connections the performance is much higher but as the number of increases the performance start degrading, due to co-channel interference.

Amongst the different routing protocols we clearly observe that DSR and DSDV perform equally in terms of total data bytes received and on contrast AODV has least performance. The fair reason lies in the protocol implementation. As in DSR
the route is searched every time the sender has a packet to send. In DSDV, the routing tables are updated periodically. Also routing overheads are almost constant with number of connections. In AODV, each time there is a data packet to be sent the huge routing tables are sent over the network. This could be the reason for such low goodput.

In terms of packets drops, DSDV performs the worst and both on-demand protocols have near similar performance. The reason lies in the periodic nature of DSDV and packets sent within this duration, if have no fresh route will be buffered or lost.

In all DSR is most acceptable under the simulation conditions. But DSR implements the Route Request (RREQ) as flooding and to prevent infinite flooding the TTL has to be bounded, which questions the scalability of the protocol for large networks.

IV. HTTP TRAFFIC WITH NUMBER OF CONNECTIONS

HTTP is one of the prominent used TCP application used on a versatile basis. Presently wireline network has a complete holdover these applications, both in terms of working users and reliability of service.

HTTP is a protocol with the lightness and speed necessary for a distributed collaborative hypermedia information system. It is a generic object-oriented protocol which may be used for many similar tasks such as name servers etc. The essential features of this protocol are as described:

1. **Connection** The client makes a TCP-IP connection to the host using the domain name or the IP number and the port number given in the address.

2. **Request** The client sends the data to the server in the form of packets containing ASCII characters. After first request, the client waits for some time and then repeats the process.

3. **Response** The server responds to the request by sending the required pages. As a part of this service, the server responds with multiple connections at the same time. Each connection has a data stream to deliver with a variable/random packet size.

4. **Disconnection** The connection terminates by both the parties.

This protocol is implemented in ns using the definitions and functions. The simulation parameters are node mobility is 5m/s and transmission range is 250m. The mobility model is Random Way Point.

Here we observe that increasing the number of connection doesn't not saturate the network as in case of FTP since the file size is limited and packets are sent sparsely. A major portion of the bandwidth was used for maintaining the topology connectivity. We perceived that AODV should perform better in such case.

V. VARIATION WITH TRANSMISSION RANGE

We also attempt to analyze the network behavior with variation in transmission radius and different mobility speed. The source agents are FTP agents with default window size and packet size. The goodput vs transmission range figures are plotted for a 40 node network with 60 FTP connections and pause time of 5 secs. The speed of mobile nodes are uniformly distributed between 0 m/s and max. speed chosen for simulation.

As a matter of fact, at first sight it seems that the throughput of the network should increase as the transmission in increased, but as inferred from the above Figure it is seen that as the radius is increased the delivery fraction and goodput have rise till $R^*$ and later it start reducing.

At low radius the connectivity is less and the network has many long hop paths, delays are larger and hence the least throughput. As the range increases the connectivity is increased and hop count is reduced but after an optimal range $R^*$ the co-channel interference preclude the neighboring nodes to transmit simultaneously.

From these experiments it has been observed that at high
mobility DSDV, which is table driven performs better at low transmission range than DSR but as the mobility is reduced all protocols converge towards same value. AODV seems to unaffected by the transmission range and has the least performance in terms of total goodput.

VI. CONCLUSION

In this paper, we mainly focus on the different ad hoc routing protocols and their performance with respect to goodput, loss and overheads simulating under near similar conditions. Later we also try to compare these protocols with varying transmission range assuming all links share same physical channel.

Each of the protocol studied have some benefits and drawbacks. DSDV performs better at low mobility but fails to converge as the mobility increases. The performance of DSR was acceptable in all mobility and transmission range. Finally AODV in every case has shown least performance because of the heavy routing loads and updates.

Several avenues remain for future work. Specially the study at the MAC layer and scheduling policies. The simulation in this paper assume the famous Random WayPoint model. One could also verify the results over different mobility models or taking a sample realistic data motion.

REFERENCES