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"QOS ORIENTED RESERVATION BASED ROUTING MECHANISM FOR WIRELESS AD-HOC NETWORKS"

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Abstract: As wireless communication gains popularity, significant research has been devoted to supporting real–time transmission with stringent Quality of Service (QoS) requirements for wireless applications. At the same time, a wireless ad-hoc network that integrates a mobile ad-hoc network (MANETs) has been proven to be a better alternative for wireless communication. Due to bandwidth constraint and dynamic topology of the MANETs, supporting Quality of Service (QoS) is challenging task. This paper proposes a simple, yet effective, method for nodes in MANETs to compute their available bandwidth in a distributed way. Based on this value, a QoS reservation mechanism is introduced for MANETs, allowing bandwidth allocation on a per flow basis. This allows nodes to select the highest possible transmission rate for exchanging data, independently for each neighbor. Our mechanism not only guarantees certain QoS levels, but also naturally distributes the traffic more evenly among network nodes (i.e. load balancing). The paper analyzes the applicability of the proposed mechanism over both proactive and reactive routing protocols, and extensions to such protocols are proposed whenever needed in order to improve their performance on ad-hoc networks.

Keywords: Wireless Ad-hoc Networks, Reservation Mechanism, QoS, MANETs, CAC.

INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a collection of mobile nodes interconnected by wireless media. Several protocols have been proposed to manage multiple accesses to the shared wireless medium in MANETs, with the IEEE 802.11 being the most implemented protocol. There is the wireless "boom",

i.e., the development of mobile wireless devices that is more and more powerful and cheaper at the same time. The convergence between these two realities (new applications, mainly real-time multimedia applications and the wireless world) are the focus of many researchers. Differently from infrastructure wireless networks, where a fixed network access point is responsible for intermediating every communication that takes place in the network, an Ad-hoc Wireless Networks node should somehow dynamically discover to which nodes it is able to communicate directly (its neighbors) and how to reach nodes to which it cannot communicate directly (nodes that are not in its transmission range). Nodes in such a network should cooperate in order to allow communication to take place. They should act as hosts and routers at the same time, so that whenever a node is not able to directly reach another one, data flows through intermediate nodes until it reaches the destination. Thus-
"Ad-hoc wireless networks are self-creating, self organizing and self-administrating networks."

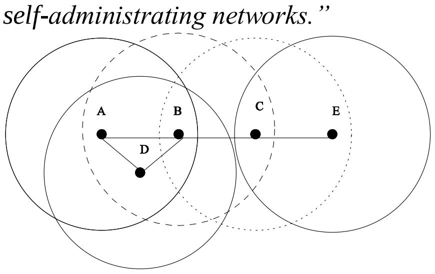

Figure: 1 A simple wireless ad-hoc network of five wireless mobile hosts

A few examples of its applications are:

a. A group of friends may establish a short duration network for exchanging data.
b. A team of firefighters may deploy a network for communicating to each other on an area that was completely destroyed (where no infrastructure was left).
c. Sensors may be spread by plane over a forest or a farm and they may spontaneously establish a network, so that measurements may be obtained from every sensor.
d. A military unit may deploy such a network in the battlefield, since they are not able to rely on the enemy's telecommunication infrastructure.
e. Space operations, undersea operations etc.

BACKGROUND

A Network is defined as the group of people or systems or organizations who tend to share their information collectively for their business purpose. In Computer terminology the definition for networks is similar as a group of computers logically connected for the sharing of information or services (like print services, multi-tasking, etc.). Initially Computer networks were started as a necessity for sharing files and printers but later this has moved from that particular job of file and printer sharing to application sharing and business logic sharing. Proceeding further Tanenbaum [1] defines computer networks as a system for communication between computers. These networks may be fixed (cabled, permanent) or temporary.
A Mobile Ad-Hoc Network (MANET) is an infrastructure less collection of mobile nodes that can arbitrarily change their geographic locations such that these networks have dynamic topologies which are composed of bandwidth constrained wireless links.

MANET nodes are equipped with wireless transmitters and receivers. At a given time depending on the nodes positions and their transmitter and receiver coverage patterns and transmission power levels, a wireless connectivity in the form of a random, multi hop graph or ad-hoc network exists between the nodes. This ad-hoc topology may change with time as the nodes move or change their transmission and reception parameters [2].

Routing is the act of moving information from a source to a destination in an internetwork. During this process, at least one intermediate node within the internetwork is encountered. This concept is not new to computer science since routing was used in the networks in early 1970's.

The routing concept basically involves, two activities: firstly, determining optimal routing paths and secondly, transferring the information groups (called packets) through an internetwork.
Routing is mainly classified into –

a. Static Routing
b. Dynamic Routing

Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator. The routing table doesn't depend on the state of the network status, i.e., whether the destination is active or not.

Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing mainly depends on the state of the network i.e., the routing table is affected by the activeness of the destination.
The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. MANETs are a kind of wireless ad-hoc network. There are two types of routing presents-

a. Reactive routing
b. Proactive routing

As the network topology is dynamic a routing protocol is needed to support the proper functionality of the network.
These protocols can be broadly classified as-

a) Proactive routing protocols such as DSDV, FSR, WRP, CGSR, GSR etc.
b) On-demand routing protocols such as DSR, AODV, TORA, ABR etc.

These routing protocols are necessary to enhance the QoS support capability of MANETs. QoS is the ability to provide different priority to different applications, users or data flows. A fundamental requirement of any QoS mechanism is a measurable performance metric.

Typical QoS metrics include available bandwidth, packet loss rate, estimated delay, packet jitter, hop count and path reliability.
To achieve the global efficiency of QoS requirements end to end bandwidth reservation is a challenging task.

Problem Statements:

Mobility: the possible random mobility of nodes with varying speeds and directions adds complexity to the majority of the common network problems such as addressing, routing and quality of service (QoS) support. Such types of Ad-hoc Wireless Network where nodes move are also known as Mobile Ad-hoc Networks (MANETs).

Dynamic Changing Topology: the fact that mobile nodes may move independently from each other makes the network topology to be in constant change. Node failures, poor channel conditions and interferences may also cause topology to be time-varying. A node can experience frequent topology changes during a session.

Bandwidth constrains: since channel conditions are very poor when compared to wired networks, congestion can take place very easily on such networks.

Energy constrains: many nodes that are part of such networks may rely on batteries, if this is the case; saving power is an important issue.

Scalability: solutions should not introduce too much overhead in order to maintain the scalability of the network. Mainly due to the constant change of network topology, the bandwidth and energy constraints, and this issue is more challenging on such networks [4] and [5] and [6] and [7] and [8].

LITERATURE SURVEY

Although many proposals have been published in the last few years, there are still lots of open issues related to QoS provisioning in Ad-hoc Wireless Networks. Different approaches have been proposed trying to enhance the reliability of such networks and, although Ad-hoc Wireless Networks differ from wired networks in many aspects as we see in our discussion.

Routing:

Wireless communications have been spread all over the world during the last years. The majority of the commercially available wireless devices are based on the IEEE 802.11 standards family. Most of them, such as 802.11b, 802.11a, 802.11g and, more recently, 802.11n allow the use of different transmission rates. The selection of which transmission rate should be used depends on the wireless medium conditions. The worse the channel quality, the stronger the code that should be used and, consequently, the lower the achieved transmission rate. Since channel quality is directly related to distance between nodes, we may say that usually, the closer two nodes are from each other, the higher the transmission rate used between them.

Auto Rate Fallback (ARF) Protocol:

The Auto Rate Fallback (ARF) protocol was the first to deal with this issue. Implemented on the Lucent Wave LAN-II wireless cards, the sender increases (or decreases) the transmission rate to be used in future transmissions based on the successes (or failures) in the previous ones.
In ARF

a. Source updates rate depending on ACKs received.
b. Drop transmission rate if ACKs are not received.
c. Increase transmission rate if timer expires of 10 consecutive ACKs are received

Advantage

The advantage of using ARF is that the radio capable of switching transmission rates can utilize this potential to combat adverse channel conditions.

Disadvantage:

a. If the channel conditions change very quickly, it can not adapt selectively.
b. If the channel conditions do not change at all, or change very slowly, it will try to use a higher rate every 10 successfully transmitted packets; this results in increased retransmission attempts and thus decreases the application throughput.

Receiver Based Auto Rate (RBAR) Protocol:

Receiver Based Auto Rate (RBAR) protocol, are based on Signal to Noise Ratio (SNR) measurements. The receiver measures the quality of the channel when it receives a Request To Send (RTS) message and selects the appropriate rate to be used under these conditions. It then informs the sender the rate to be used for data transmission through the Clear To Send (CTS) message.

a. Select rate using the RTS/CTS
    a) selected per packet
b. Selection made my destination
    a) Noise on receiver end determines ability to receive packet
    b) Receiver has more information then the sender
    c) Transmitting estimate data can be expensive
c. Implemented in 802.11 with minor modifications
    a) DCF
    RTS/CTS
    b) NAV
    c) Data packet header

Advantage:

a. Estimate is more accurate
    a) base on more complete information
    b) closer to actual transmission
b. Can be implemented into 802.11

Disadvantage:

a. The threshold mechanism used in each receiver to pick the best possible rate requires a calculation of the SNR thresholds based on an a priori channel model.
b. The algorithm assumes that the SNR of a given packet is available at the receiver, which is not generally true.
c. The RTS/CTS protocol is required even though no hidden nodes are present.
d. The interpretation of the RTS and CTS frames and the format of the data frames is not compatible with the 802.11 standard. Thus, RBAR cannot be deployed in existing 802.11 networks.

Traditional routing protocols, like the Ad-hoc On-demand Distance Vector (AODV) or the Optimized Link State Routing Protocol (OLSR), usually elect this kind of path, where the minimization in the number of hops causes the election of long range links over short range ones.

If short range links were elected, although the number of hops would increase, higher transmission rates could be used, and the overall performance of the network could be significantly improved [4] and [7] and [8].

In ***proactive routing*** protocols (like OLSR), the solution for this problem is quite straightforward. Since each node knows the (almost) entire network topology, information about link rates would be enough to choose an efficient path. The authors propose a routing metric that is able to maximize the achievable throughput on chosen paths. However they only implement it on a proactive protocol and no further comments on how to do so on reactive protocols are made.

Reactive protocols (like AODV) do not have any previous information about the network topology; they choose their routes by flooding the network with Route Request messages trying to reach the destination node [4] and [2] and [9].

It is observed that reactive routing can provide better response to the constant changes in the topology of a mobile ad-hoc network, while monitoring the 1-hop neighborhood may improve routing decisions and should not be a problem even when mobility is not so low.

Reservation-based approach:

Due to the shared media and multihop characteristics of AWNs, it is known that its capacity can be surprisingly low. Consequently, congestion may easily occur, provoking losses and high end-to-end delays. In order to avoid congestion, a reservation mechanism that works together with a Connection Admission Control (CAC) seems to be a reasonable solution. However, most of the QoS approaches found in literature for AWNs do not use reservations. One reason for that is the difficulty on determining the available bandwidth at a node. This is needed to decide whether there are enough resources to accommodate a new connection [4] and [6] and [8].

CAC is one of the most important functions in a computer network that provides guaranteed QoS. An important aspect of a practical CAC algorithm is that it must rely on the information that is available within the QoS framework of the computer network. It should be noted that this information is limited. The limitation is especially valid assuming that the DiffServ framework will most likely dominate the Internet in the near future [11].

Most of the previous research described how to integrate reservation scheme in the AODV and OLSR, ad-hoc routing protocols.

PROPOSED TECHNIQUES

In order to avoid an increase in the number of transmitted RREQs over the network, we propose that every node keeps track not only of their 1-hop neighborhood (what is already done by most of the existing ad-hoc routing protocols through the periodic exchange of HELLO messages), but also of the topology of these neighbors. That means that a node should know the links that exist between its neighbors. Once a node is aware of the topology of its 1-hop neighborhood, the RREQ/RREP procedure can take place with minor changes. Whenever a node receives and processes a RREQ, it may compute the best path (it terms of throughput) towards the node that sent him the RREQ message or towards any other node before in the path (if it is more efficient not to pass through the previous node). After computing this part of the path, the complete path information is updated in the RREQ message and it is re-broadcasted. When the first RREQ reaches the destination, a RREP is sent to the source following the path recorded in the request.

The route discovery procedure:

The route discovery procedure works as follows:

a. The source node broadcasts a RREQ message to its 1-hop neighbors.
b. Each node that receives the RREQ message computes the maximum throughput (minimum cost) path to the last node through which the RREQ passed.
c. The node includes the maximum throughput path it computed in the RREQ message by introducing the IP address of the nodes between the current node and the previous one together with the link cost to go from one node to another.
d. Finally, when the RREQ reaches the destination node, it replies with a RREP that should follow the path included in the RREQ, which represents the maximum throughput path from the source to the destination.

This procedure significantly reduce the number of RREQs in the network, avoiding even more the probability of collisions among copies of the same RREQ and, therefore, enhancing the overall performance of the system.

Reservation-based Mechanism:

Over the last years, Ad-hoc Wireless Networks (AWNs) have captured the attention of the research community. The flexibility and cost savings they provide, due to the fact that no infrastructure is needed to deploy a AWN, is one of the most attractive possibilities of this technology. However, along with the flexibility, lots of problems arise due to the bad quality of transmission media, the scarcity of resources, etc.

Since real-time communications will be common in AWNs, there has been an increasing motivation on the introduction of Quality of Service (QoS) in such networks. However, many characteristics of AWNs make QoS provisioning a difficult problem.

Goal of our Mechanism:

a. First reserving the network path that has sufficient resources to satisfy the QoS requirements.
b. Achieving global efficiency in resource utilization.

With the help of our mechanism we propose a simple, yet effective method to compute the available bandwidth at a node in AWNs. We use this method to propose a reservation based QoS mechanisms. Our proposal not only guarantees certain QoS levels, but also naturally distributes the traffic more evenly among network nodes (i.e. load balancing).

Available Bandwidth for Reservation:

The available bandwidth estimation is a fundamental operation for a QoS offer [12]. This operation is very difficult because of the approximate acknowledge of the network state and the random mobility of nodes. For AHNs, this mechanism is generally placed in the MAC layer to allow the source to estimate the available bandwidth quantities. This estimation must to take into account node's mobility, interferences caused by the different transmissions and the hidden stations problem. The available bandwidth quantities must be permanently up to date especially after congestion, establishment or a reception of a duplicate acquittement (DUPACK). Available bandwidth can be defined as the maximum throughput with which we can transmit (between two nodes) without interrupt flows transmitted on the Ad Hoc networks. This term must not to be confused with the 'link capacity' representing the maximum throughput which can attempt on this link, or with the 'unusable link capacity'. Knowledge of the available bandwidth quantity is required for admission control; QoS based routing, flow management and resources reservation [13].

Quantitatively, we define the available bandwidth in our mechanism, as:
Let assume that BW (in bps) is the total bandwidth quantity on a node. The maximum available bandwidth quantity on a node can be defined by this function (1):

MAB(i) = BW(i) – x(i) – SUM(j) € Ni x(j)…….(1)

Where: BW (i) = Total bandwidth on the node i,
x (i) = Used Bandwidth on the node i,
x (j) = Used Bandwidth by the node j neighbour of the node i,
Node j = neighbour of node i and
Ni = set of node i.

On a link (i, j), the available bandwidth is expressed by the following expression (2):

AB (i,j) = MIN { MAB(i), MAB(j)}…………….(2)

For a path p= (S, i, j…k, D), where S: Source, D: Destination and i, j…k the intermediate nodes; we have the Maximum Available Bandwidth guaranteed on the path is done by the formula (3):

MAB(p) = MIN { MAB(S.i), MAB(i,j), MAB(k,D)}….*(3)*

Due to the shared media and multihop characteristics of AWNs, it is known that its capacity can be surprisingly low. Consequently, congestion may easily occur, provoking losses and high end-to-end delays. In order to avoid congestion, a reservation mechanism that works together with a Connection Admission Control (CAC) seems to be a reasonable solution.

Connection Admission Control- "Set of connection taken by the network during the call-setup phase".
CAC is one of the most important functions in a computer network that provides a guaranteed QoS. The **goal of the CAC** is to decide whether an incoming connection should be accepted or rejected in a node of a network offering reservation based services in order to maintain the guaranteed QoS.In this paper we use Adapting Routing in the basis of node merit integrated with Connection Admission Control (CAC).We use this mechanism with the following reasons –

a. Used by almost all packet switching networks

b. Routing decisions change as conditions on the network change
   - Failure
   - Congestion
c. Requires info about network
d. Decisions more complex
e. Tradeoff between quality of network info and overhead
f. Reacting too quickly can cause oscillation
g. Too slowly to be relevant

Advantages of Adapting Routing:

a. Improved performance
b. Aid congestion control

Here we performed the simulation of the proposed scheme in OPNET Network Modeler 14.0 to prove practical efficiency of the scheme. The physical parameter considerations are same as taken in mathematical modeling. The steps of modeling in FSM (Finite State Machine) of Proposed Algorithm are as follows:

a. Initialize all nodes with the following specifications -
   Packet size = 1024 bits (exponential)
   Interarrival time = 1 sec (exponential)
   Number of node in network = 20
b. Generate random destination address after random delay.
c. Measure the Delay, Reliability,Bandwidth and Movability of node.
d. Add all measured parameters and define by new one "node merit".
e. Now for present packet and destination address- Calculate the route which must exist atleast for

duration t_{min}

$$t_{min} = \frac{Packetsize}{BW_{min}}$$

f. Reserve the route for [$t_{min} + t_{margin}$].
g. These calculations are added in the route list and assign it by node merit and set :
   a) Discard route value with 1 and 0.
   b) If value is 1 then discard the route else select the route for further process.
h. Repeat the process for 3600 sec and calculate overall average Delay, Traffic sent, Traffic Received.

PERFORMANCE EVALUATION

Once the proposed QoS oriented reservation based routing method's concepts have been completely defined, it becomes necessary to check their feasibility and evaluate their benefits. Simulation analysis is used here to evaluate the proposed scheme.

The goal of this section is to present the main aspects of the simulation model and its results.

Simulation Setup:

The simulation software is OPNET Modeler 14.0.
An OPNET simulation package includes three main graphic editors – network editor, node editor, and process editor. These three editors work together to provide various simulation environments. The development language is C. It provides a variety of toolbox to design, simulate and analyze a network topology. We use MANET Toolbox to simulate our hypothetical Ad hoc network. Moreover, we can also set parameters specific to routing algorithm [15].

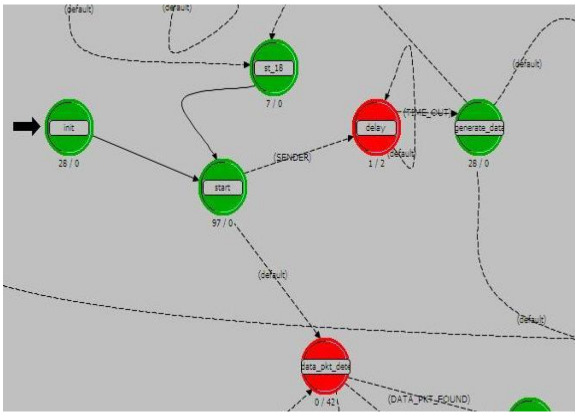

Figure 2: Part of complete process model showing only entering process & decesion making branchs for sender and receiver

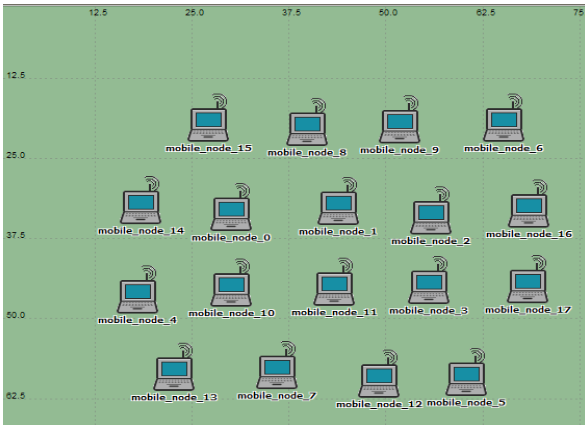

Figure 3 : Node Distributation

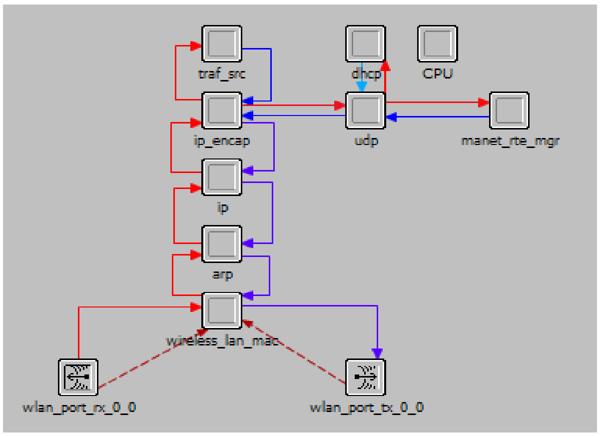

Figure 4 : Internal Architecture of Node

Two categories of parameters have been considered in our study: the input parameters and the output parameters. These parameters are as follows:
Input parameters: These include:

Table 1: Network Parameters

Parameter	Value	Description
Simulation time	120 Sec	Maximum execution time
Terrain Dimensions	1200 X 1200 Mt	Physical area in which the nodes are placed in meters
Number of Nodes	30-300	Nodes participating in the network
Traffic Model	CBR	Constant Bit Rate link used
Node Placement	Uniform	Node placement policy
Mobility	0-10 (m/s)	Speed of node
Routing Protocol	DSR, AODV, TORA	Routing protocol used

Output parameters:

Quality of Service (QoS) criteria:

Three important performance metrics we are evaluated:

Packet delivery ratio: the ratio of the data packets delivered to the destination to those generated by CBR or ftp sources.

Mean end-to-end delay: mean end-to-end delay related to data packets delivered to destination.

Routing load: gives the number of routing packets over the number of received data packets. Each routing packet sent or forwarded by a mobile is counted.

Throughput: It is the rate of successful message delivery over a communication channel. This data may be delivered over a physical or a wireless channel and it is usually measured in bits per second (bit/s or bps), and sometimes in data packets.

Packet Loss: The number of packets missed to reach the destination.

Simulation Results:

In this sub-section, we try to show that the performances provided by our reservation based routing mechanism, are always better than the previous research works.
Now we presents graph in the basis of comparison between DSR, AODV and Proposed Protocol.
Here we see -

a. We sent the same traffic in the protocols.
b. In our proposed protocol received traffic is greater than DSR and AODV.
c. In our proposed protocol delay is greater than DSR but reduced in AODV.

Comparison in terms of Delay:

End to End Delay: It refers to the data link's capacity (in bits per second) and its end-to-end delay (in seconds). The result, an amount of data measured in bits (or bytes), is equivalent to the amount of data "on the air" at any given time, i.e. data that have been transmitted but not yet received.

Figure 5 shows the average delay of existing protocol (DSR as red line and AODV as blue line) and proposed technique as green line. With increasing simulation time the average delay less than with compare with DSR and AODV protocol.

Since we apply reservation mechanism works together with CAC, so all the links are well established and capacity is excellent, for this reason delay is reduced and congestion will avoid.

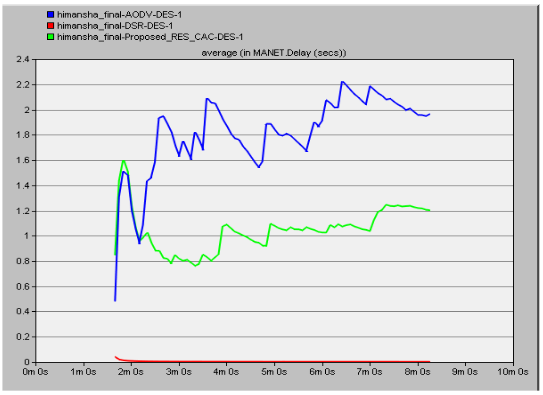

Figure 5: Average Delay per Route Comparison

Comparison in terms of traffic sent and received:

Figure 6 and 7 described the average packets sent and packets received of existing protocol (DSR as red line and AODV as blue line) and proposed technique as green line respectively. With increasing the simulation time packet transmission (sent) of proposed technique are same as DSR and AODV. But the packets received (at destination) of proposed technique are greater than as DSR and AODV.
Due to our mechanism total drop rate is reduced, so received traffic is increased and because of this throughput is also increased.

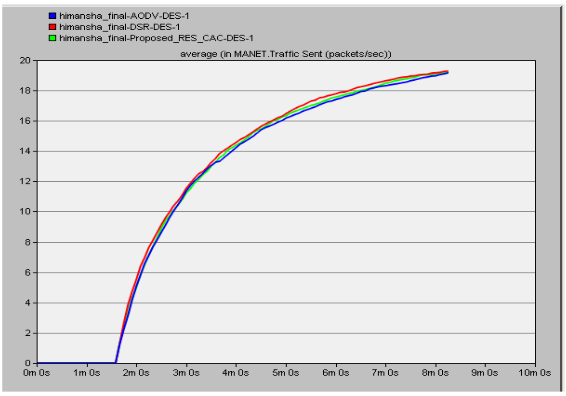

Figure 6: Average Traffic Sent per Route Comparison

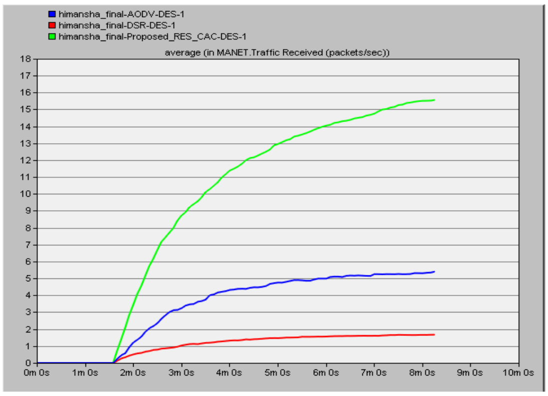

Figure 7: Average Traffic Received per Route Comparison

CONCLUSION & FUTURE PROSPECTIVES

The main contribution of the paper is the reactive routing mechanism for ad-hoc wireless networks. This mechanism provides a great enhancement on the overall performance of reactive routing mechanisms on ad-hoc networks. On such a network, traditional routing mechanisms usually minimize the number of hops, resulting on routes composed by long range, and consequently low throughput, links. Our reservation based mechanism provides a simple and very effective way of using the transmission rate as a routing metric without a significant increase of the signaling message overhead. Previous proposals were very inefficient, hugely increasing the number of signaling messages, what sometimes could even lead to a performance decrease when compared to traditional routing protocols. Although we used transmission rates as the routing metric, our mechanism could also work with many other metrics, such as mean delay, link stability, mobility or available bandwidth.

Future work is oriented to study a reservation recovery mechanism and a mechanism to free the existing reservation, when link is broken and set of connection loose.

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