Selfish Nodes in MANET: Impact on Security and QoS

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ABSTRACT
Most of the researches focus on the secure and reliable communications in Mobile ad hoc networks (MANETs) because of the presences of malicious nodes, unreliable wireless media, host mobility and lack of infrastructure. However the basic idea of forming an Ad Hoc network is utilizing the cooperation between nodes which becomes critical to maintain QOS. Nodes which are non-cooperative are called as selfish nodes. Not much work has been done to find the effect of selfish nodes in a MANET. In this paper, it is proposed to evaluate the performance of a network under the impact of selfish nodes. Simulations are conducted using Ad hoc On Demand Distance Vector (AODV) routing protocol to evaluate the performance degradation of MANET based on the degree of selfishness of the nodes.

General Terms
Mobile ad hoc networks (MANETs), Security, Quality of Service (QoS).

Keywords
Ad hoc On Demand Distance Vector (AODV), Selfish Nodes, Performance Degradation.

1. INTRODUCTION
Mobile Ad-hoc networks (MANETs) is an infrastructure less, autonomous mobile nodes communicate with each other by a wireless medium. Each node is a dynamically self-configurable node and has limited energy and computing resources. Each node acts as a host as well as a router. Normally routes between two nodes have multi-hops [2].

The total number of nodes and the density of nodes in the network depend on the application where MANETs are used. Some of the challenges in MANET [1] are,

1) No centralized administration control, so it is difficult to find the paths between nodes.

2) Unprotected wireless channel.

3) Different types of transmissions and receiving lead to asymmetric links.

4) Scalability is one of the issues in the deployment of nodes.

5) Selfish nodes degrade the performance [3].

Since MANETS do not have fixed infrastructure, there is no need of a base station or a dedicated router. Each node will act as a host and a router. So each node assists other nodes by sharing resources like battery power, bandwidth and CPU cycles to forward the packets on behalf of other nodes. But some of the nodes may not cooperate. They are called as selfish nodes. Selfish nodes affect the reliability and performance of the network [10].

There are three types of routing algorithms used in MANETs to forward the packets towards the destination. They are Proactive, Reactive and Hybrid routing protocols. Proactive algorithms are called as table driven methods; each node maintains the routing information about all of its reachable nodes. But the maintenance overhead is high. Reactive routing algorithms are on demand algorithms, route discovery operation is done whenever data is to be sent from the sender node to the receiver node. Reactive methods have minimum overhead. Some of the reactive algorithms are Ad-Hoc on demand distance vector routing (AODV) algorithm, Dynamic source routing (DSR) algorithm and Temporally Ordered Routing Algorithm (TORA). Both reactive and proactive methods are combined at various hierarchal levels in hybrid routing algorithms [6].

The goal of the routing in MANETs is to find an efficient route between nodes when the topology is changing dynamically. In AODV routing, Route Request (RREQ) messages are broadcasted from the source to all of its neighboring nodes, then neighboring nodes forward to their neighboring nodes. This forward ends when the destination node or the node that contains fresh route is found. Then the destination node sends Route Reply (RREP) message to the source node and creates routing table in the forward direction [7].

To maintain the route each node in the discovered route sends HELLO messages periodically to the neighboring nodes in the route. If any node fails to respond for three consecutive HELLO messages then that node is considered as failed node and RERR (Route Error) message is sent in the failed link. Then the new route discovery process should be originated from where failure is identified..

Advantages of AODV routing algorithms are 1) on-demand route discovery and sequence numbers usage at the destination maintains the recent route to the destination. 2) Delay for connection set up is less. Disadvantages of AODV are 1) multiple route discoveries lead to increased control overhead.2) sending periodic HELLO messages consumes more bandwidth. But when comparing to DSR, TORA routing methods AODV gives best performance. DSR is suitable only for low bandwidth and low power networks. TORA is suitable for densely populated MANETS [7, 8].

Selfish nodes are not malicious nodes; they do not perform dangerous activities like alteration of contents, fabrication, Denial of service (DOS) attacks and spoofing. But they refuse to share the resources and will not cooperate with other nodes in the network to save their battery power [3]. Some of the characteristics of selfish nodes are, not participating in the process of routing, not sending hello message and reply, dropping data packets and delaying Route Request (RREQ) packet [4].

Selfish nodes degrade the performance when compared to all the mobile nodes in the network. Performance can be evaluated by some of the Quality of Service (QoS) parameters such as throughput, cumulative sum of number of received packets and end to end delay [9].

2. RELATED WORKS

Dipali Koshti, Supriya Kamoji presented methods to find selfish nodes [11]. Reputation based techniques and Credit based techniques were applied in AODV and DSR routing algorithms to identify selfish nodes and the techniques were compared. In reputation based scheme when a suspicious node was identified by its neighbouring nodes, the information about selfish node was propagated to the entire network. In Credit based schemes each node was given a virtual currency. If any node performed faithful operation the incentives were given. Each node got payment whenever it provided a service to its neighbouring node. Three algorithms were implemented and compared. The reputation based approach using the 2ACK scheme detected and mitigated the effect of selfish nodes. The two hop acknowledgement was sent in opposite direction to the routing path. Routing overhead was reduced by sending acknowledgement only for a fraction of the received data packets. After detecting the selfish nodes, they were eliminated by choosing the alternate paths when transmitting the data. In Reputation based approach, the selfish nodes were punished, and the cooperating nodes were encouraged. When a node was identified and punished in first time, and during second chance if it changed its behaviour as a cooperative node it's cooperation coefficient was increased. Third method was based on an auction. Auction based AODV protocol for an ad hoc network used auctions to detect selfish nodes and enforced selfish nodes to cooperate with other nodes.

Harminder S. Bindra, Sunil K. Maakar and A. L. Sangal presented performance evaluation of reactive routing protocols such as AODV and DSR using Group Mobility Model and performances were compared [12]. These two protocols were on-demand protocols. But heir implementation mechanism was different. To evaluate the performance CBR and TCP flows were taken as load. Based on the variation in network load, mobility and type of traffic these protocols were analyzed. Using NS2 simulation and IMPORTANT (Impact of Mobility Patterns on Routing in Ad-hoc Network) tool a group Mobility model was generated. The metrics such as packet delivery fraction, average end-to-end delay, routing overhead and normalized routing load were considered for performance evaluation. Results showed that AODV gave best performance for Constant Bit rate traffic and DSR gave best performance for TCP traffic under bandwidth restricted option (not during heavy load or during high mobility). Average end to end delay was less in AODV routing protocol. So performance of AODV was good for CBR traffic than DSR.

Mohamed Amnai, Youssef Fakhri and Jaafar Abouchabaka presented QOS routing and performance evaluation for mobile ad hoc networks using Optimized Link State Routing Protocol (OLSR) [13]. The traffic types of multimedia such as Variable Bit Rate (VBR) and constant Bit rate (CBR) were taken to study the behaviour of routing protocol OLSR. Mobility models such as Random Way Point, Random Direction and Mobgen Steady State were chosen. CBR traffic showed that 1) the optimal delay was achieved in small density when using Random Way Point model and for heavy density optimal delay was achieved by Mobgen Steady State model. 2) The optimal throughput was achieved by Random Way Point. For the traffic VBR (MPEG-4), the optimal delay was achieved by means of Mobgen Steady State. But the optimal throughput was achieved by Random Way Point. The proactive nature of OLSR routing method and variability of VBR traffic were the reasons for the less packet delivery when using VBR traffic. Delay jitter and Packet delivery ratio could be considered for evaluating the performance more accurately in VBR.

Manijeh Keshtgary and Vahide Babaiyan presented Performance evaluation of reactive, proactive and hybrid routing protocols in MANET [14]. Due to the dynamic configuration and no centralized administration control in MANETS some of the challenges were faced by the protocol designers. The challenges were routing, service and frequently topology changes. Because of the limited power and bandwidth, the process of route discovery and maintenance of routing information were critical. Using simulation four MANET routing protocols AODV, OLSR, DSR and GRP were evaluated. Four different scenarios in OPNET modeler 14.0 were used. In each scenario, various routing protocols were used. Four evaluation metrics were used to compare the performance. Metrics were End-to-End delay, network load, throughput and media access delay. After evaluation it was concluded that AODV and OLSR perform better than the others. GRP was better than DSR in both throughput and delay, and not based on the network load. DSR was the worst choice for real time flows.

Naveen Kumar Gupta, Ashish Kumar Sharma, Abhishek Gupta presented a method for Selfish Behaviour Prevention and Detection in Mobile Ad-Hoc Network Using Intrusion Prevention System [15]. Some nodes in MANET that decided to save their memory, bandwidth, and power by dropping packets from the other nodes were called as selfish nodes. The efficiency, the reliability, and the fairness of MANET could be affected because of these selfish nodes. So finding selfish nodes was needed to improve the efficiency and reliability of MANETs. A model to increase the Selfish node detection rate and decrease the false detection rate was developed to increase the efficiency of the system. Some nodes were assigned in monitoring mode. Each monitoring node monitored both data and control packets that were send around within its receiving range. Each monitoring node kept a record for each of its neighboring node. Record had the following fields: 1) Last action, 2) Last request and 3) Status. The initial value for status was set to zero then every time it was updated by the monitoring node. For every action the first two fields were updated. Using the recent values of these three fields, selfish nodes were identified. The nodes refused to carry out networking tasks but used the services offered by other nodes were identified as selfish nodes. Sometimes selfish nodes also ignored packets destined to them to save resources. This was the low cost scheme to find selfish nodes.

3. MATERIALS AND METHODS

The goal of routing in MANET is to find the efficient routing between the source and destination even though topology is changing dynamically. It was already proved that Ad-hoc On-demand Distance vector routing is efficient for real time traffic.

To improve the routing protocols route caching concept can be used. Caching is one of the techniques used in computer science. Cache memory is a small, temporary memory used to store the recently accessed data values. In MANET cache memories are used for look up the routes that are taken recently. Route caching will decrease the flooding of network

and latency. Decrease the flooding in the network will decrease the overhead in route discovery process at every time. So Route caching will increase the performance of routing protocols.

Because of dynamic topology changes in the MANET each route has the field Time to live (TTL). At the time of storing in cache memory TTL will be assigned for each route. When TTL expire, the route entry in cache memory becomes invalid. In future searching route to the same destination, new route discovery process will be invoked.

4. RESULTS AND DISCUSSION

Simulations are performed in MANET designed with 15 nodes with 20 % of selfish nodes by transmitting the CBR traffic the performance of AODV routing protocol is evaluated in the presence of selfish node. The experiments setup is given in Table 1.

Table 1. Simulation Parameters

Simulation area	2 sq km
Number of nodes	15
% of nodes which are malicious	20
Bandwidth	2 Mbp
Traffic	Constant Bit Rate
Transmission power of node	0.005W

Figure 1 shows that, in MANET with the presence of selfish nodes, utilization of cache memory for route discovery process is less. So most of the times, route discovery process is done by flooding into the network.

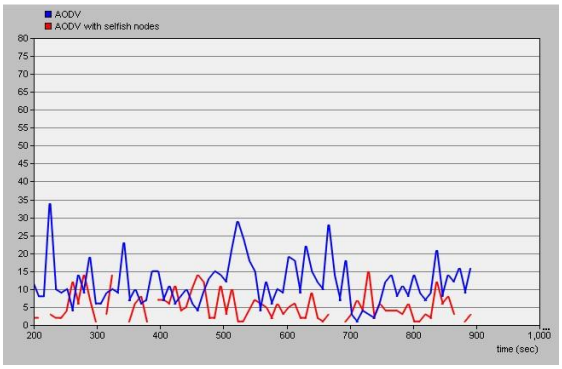

Fig 1: Cache replies used

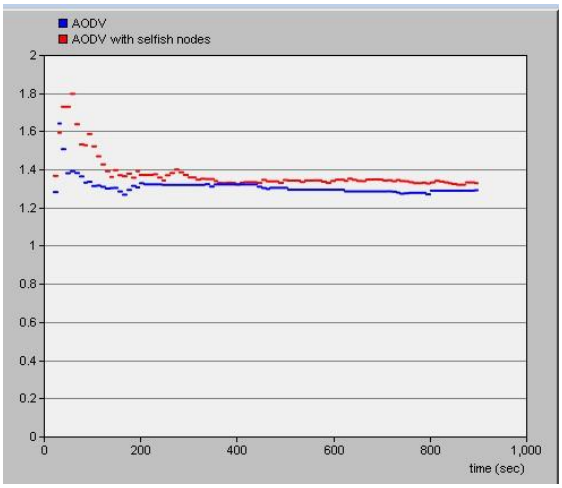

Fig 2: Number of Hops to the Destination

Figure 2 shows number of hops to be transmitted to send a data towards the destination. Blue colour line shows the number of hops when all nodes are cooperative. Red colour line shows the number of hops to be transmitted to reach the destination if some nodes are selfish. When comparing, the number of hops are increased if some nodes are non-cooperative. Number of hops to the destination increased from cooperative nodes routing around 25% when 20 % of the nodes are selfish nodes.

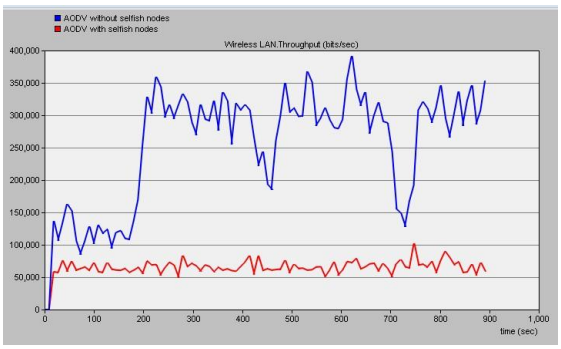

Fig 3: Throughput in bits per second

Figure 3 shows the throughput in bits per second. Without the presence of selfish nodes average throughput is around 2,50,000 bits per second . But in the presence of 20 % of the selfish nodes the throughput approximately reaches to 60,000 bits per second. Throughput is 4 times lower in the presence of 20% of selfish nodes.

5. CONCLUSION

The performance of a MANET network is evaluated under the impact of selfish nodes. Simulations are conducted using 15 nodes distributed within the distance of 2 square kilometres with 20 percentages of selfish nodes. For efficient routing of CBR traffic flows Adhoc On Demand Distance Vector (AODV) routing protocol is used. The performance is evaluated by comparing number of cache replies used in the process of route discovery, throughput and the number of hops to the destination. Result shows that the performance is degraded in MANET based on the degree of selfishness of the nodes.

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