An Evaluation of Ad-hoc Routing Protocols for Wireless Sensor Networks

Tanuja Khurana, Sukhvir Singh, Nitin Goyal

***Abstract*— Wireless mobile ad-hoc networks are characterized as network of nodes without any physical connections. In these types of networks there is no fixed topology due to the mobility of nodes, interference, multipath propagation, environmental conditions and path loss. The purpose of this master thesis is to study, understand, analyze and discuss three mobile ad-hoc routing protocols DSDV, AODV and DSR out of which the first one is proactive protocols, which depends on the routing tables which are maintained at each node. The other two are reactive protocols, which find a route to a destination on demand, whenever communication is needed. Considering the same parameters the DSR protocol transfers more data than both AODV and DSDV protocols, but due to the fact that changes in paths are avoided the losses in AODV is less as compared to DSR protocol. This work is to analyze the routing protocols for wireless networks based on their performance. This is done theoretically as well as through simulation. Basically what is to be done, to identify suitable routing protocols for use with WSN based on the limitations of the technology and propose an enhanced protocol for WSN.**

***Index Terms*— proactive protocols, reactive protocols.**

I. INTRODUCTION

Wireless sensor networks [1] [2] are promising unprecedented levels of access to information about the physical world, in real time. Many areas of human activity are starting to see the benefits of utilizing sensor networks. In almost all such cases, sensor networks are statically deployed.

One of the reasons for the sensors to be taken as stationary is that because the assumption facilitates the simplification of the clustering protocols, making them have a very low overhead. It also avoids having to manage the mobility patterns of the sensors and allows saving more energy, since the localization information that the network has to manage is non-existent.

The evolutionary step for sensor networks is to handle mobility in all its forms. Mobility in wireless sensor networks has attracted a lot of attention in the recent years and has introduced unique challenges in aspects like resource management, coverage, routing protocols, security, etc.

The major impacts the mobility makes in WSN are in the area of *Topology management* and *Energy management*. When nodes keep moving its position, topology management is responsible for the node connectivity and routing of nodes to the sink. The energy management on the other hand deals with the management of limited energy resource.

This project is mainly concerned with routing in mobile wireless sensor networks. The limited processing power, battery life and loss of packets of the motes present many challenges when it comes to routing in these networks. This work will look at several routing protocols to assess their suitability for use in mobile wireless sensor networks

II. PROBLEM DISCRIPTION

The aims and objectives of this project are as follows: Learn about the technologies and applications of wireless sensor network. Understanding limitations of sensor network in view of mobility & to evaluate protocols based on these limitations. Learn about the mobility impacts on routing. Analyze the routing protocols for wireless networks based on performance. This is done theoretically and through simulation. The thesis also includes the goal to generate a simulation environment that could be used as a platform for further studies within the area of wireless networks. This simulation environment is based on Network simulator 2.35. Identify suitable routing protocols for use with WSN based on the limitations of the technology.

III. WHY THIS PROBLEM IS CHOOSEN

Networking, in particular wireless networking has an interest of me. Due to this interest wireless networking was chosen as the base theme for the dissertation. Several variations of this general theme were developed and presented as possible projects. Two main themes are considered are routing and cluster head election in wireless networks. Both of them were considered in view of mobility, since mobility is one of the key challenging areas in WSN. After considering both these themes it was decided to look at routing. Mobile wireless sensor networks were eventually chosen as they have only been developed recently and the protocols for these networks have not yet been standardized.

Wireless computing is a rapidly emerging technology providing users with network connectivity without being gathered off of a wired network.

IV. ANALYZING ROUTING PROTOCOL PERFORMANCE

Our focus is given to study whether mobility affects protocol performance or not. We have evaluated the performance of DSR, AODV and DSDV across deferent set of mobility models and observed that the mobility models may drastically affect protocol performance. We have taken two scenarios to compare the performance of protocols. In the first scenario we taken an area of a size 900m over 900m and runs a single TCP connection over 4 nodes network. The second scenario runs a single TCP connection over a 10-node

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network over an area of a size 900m over 900m.When the sensor nodes are stationary, we compare the performance of protocols by taking 4 nodes and 10 nodes network and the result shows the performance degradation as the number of nodes increases.

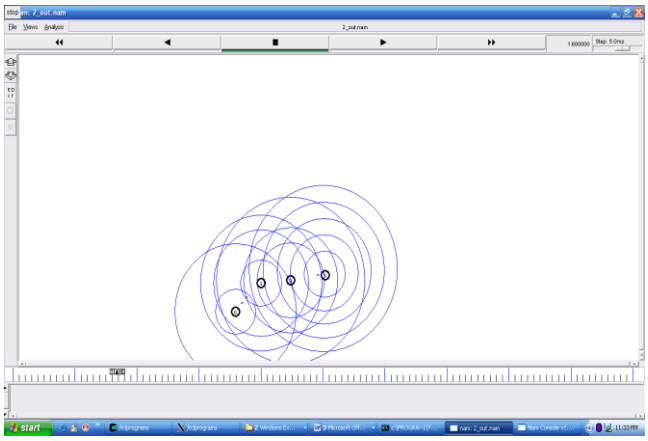

Fig. 1. TCP in a four node scenario with AODV routing protocol

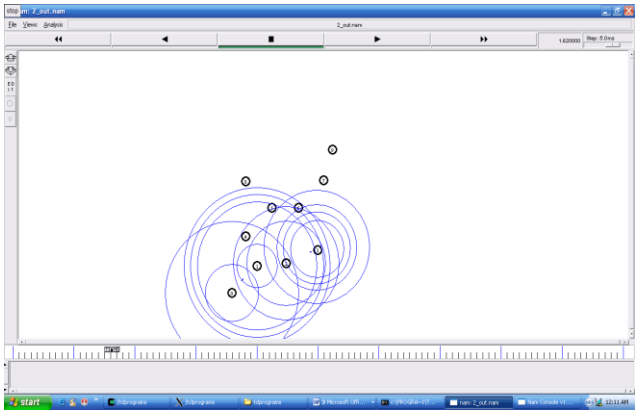

Fig. 2. TCP in a ten node scenario with AODV routing protocol

V. CHALLENGES DUE TO MOBILITY

The introduction of mobility in sensor networks introduces certain additional challenges. Some of them are detailed below.

Space and time are receiving renewed emphasis as defining parameters in the data collection scheme. The timely dissemination and processing of collected information becomes much more complex than a network resource optimization problem, as it has to take into account user and phenomenon mobility. On demand network reconfiguration now has to consider sensor repositioning over time, to best monitor an evolving event. There exists the expectation of higher levels of modeling within the network, so that it can respond in a timely manner to emerging situations and reconfiguring itself to meet the corresponding demands. Accordingly, efficient and versatile techniques to model spatiotemporal information are a necessity.

In particular, a successful mobile sensor networks will open new and intriguing venues for research in diverse topics such as:

- Scalable dynamic systems
- Routing
- Fault-Tolerance
- Data Management
- Efficiency, accuracy and precision
- Software support

But as it comes to the mobility most of the current routing algorithms are facing performance degradation. But the AODV has the less performance degradation and also the number of packets loss is less.

VI. RESULTS

We have compared the performance of AODV, DSDV, DSR routing protocols in which the performance of AODV is best suited. We have shown the performance of AODV routing Protocol with the help of X-Graph (The graph obtained by using NS-2 simulator) as below.

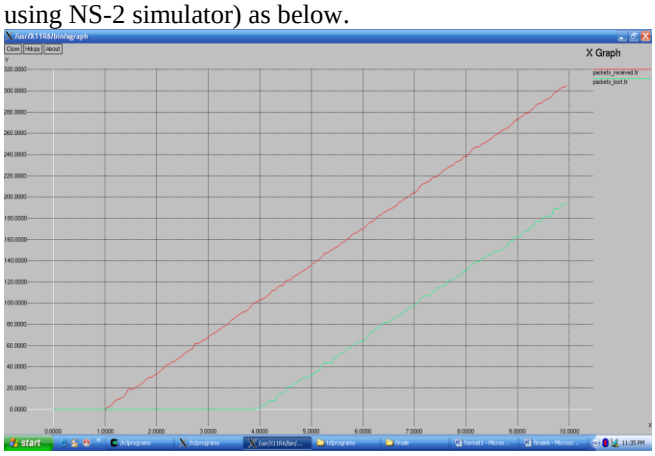

Fig 3. TCP packet received vs packet loss in a four node scenario with AODV routing protocol

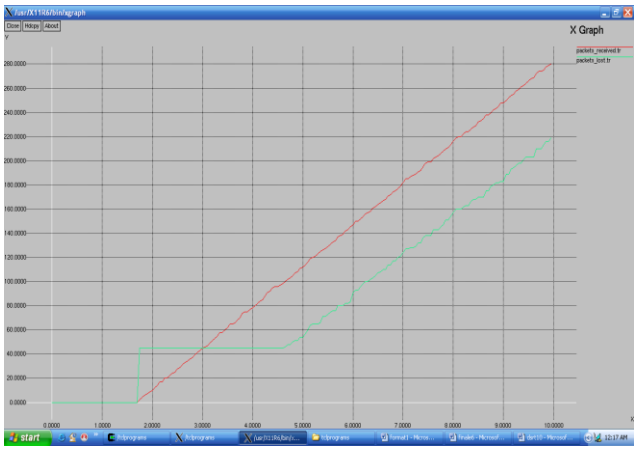

Fig. 4. TCP packet received vs packet loss in a ten node scenario with AODV routing protocol.

VII. CONCLUSION

In this work an extensive literature survey about the issues associated with mobility in wireless sensor network were conducted. The emphasis is given to routing issues, since it makes predominant impact in view of mobility. The entire work was done in two phases.

In the first phase, the performance evaluations of various routing protocols in mobile wireless sensor networks were done. The routing protocol considered were AODV, DSDV and DSR from MANET routing protocol category. All theses protocols were simulated and results were summarized and concluded with the help of xgraph that AODV having lowest packet losses in comparison to other protocols.
In the second phase, enhanced the cluster based energy efficient protocol for handling mobility. The protocols considered for this work were LEACH and LEACH-Mobile.

VIII. PROPOSED WORK

LEACH protocol is an elegant solution to power constrain problem, by forming enough number of clusters in a self-organized manner. LEACH basically rotate the cluster heads and achieves energy efficiency by a factor of 8. Although LEACH protocol has such advantages, it basically assumes that the nodes are fixed. As LEACH protocol does not consider the mobility of sensor nodes after the "Set-up Phase" of clusters within a round, LEACH protocol performs poorly with serious data loss in the environment of node mobility.

LEACH-M is an enhancement to LEACH to support mobility is introduced as LEACH-Mobile in short form named as "LEACH-M". The basic idea in LEACH-Mobile is to confirm whether a mobile sensor node is able to communicate with a specific cluster head, as it transmits a message, which requests for data transmission back to mobile sensor node from cluster head within a time slot allocated in TDMA schedule of a wireless sensor cluster. If the mobile sensor node does not receive the data transmission from cluster head within an allocated time slot according to TDMA schedule, it sending join-request message at next TDMA time slot allocated. Then it decides the cluster to which it will belong for this moment by receiving cluster join-ack messages back from specific cluster heads. The LEACH-M protocol achieves definite improvement in data transfer success rate as mobile nodes increase compared to the non-mobility centric LEACH protocol.

LEACH-M handles the node mobility well if the cluster heads are more of less stationary. But it is not true in all the cases as the cluster head election happens from the same set of mobile nodes. Also the cluster head rotation is purely on random manner plus the number of times the node was a cluster head in earlier rounds of TDMA, which is exactly the same way as in basic LEACH protocol. But as the cluster head keeps moving before the rotation comes, cluster itself get disturbed and the enormous amount of packet loss will occur until the next new cluster formation under a new head.

LEACH-ME suggests an improvement to the LEACH-M, which is suitable for mobile wireless sensor networks. The basic idea of LEACH-Mobile-Enhanced (LEACH-ME) is to make sure as much as possible that the cluster heads are from the group of mobile nodes having minimum node mobility or they are in group motion with the other cluster members (RPGM model [11]). By doing the modified election process to cluster head or modified rotation of duty of cluster head, the model make sure that the clusters are disturbed minimally in view of movement of cluster head .

Mobility factor through the Concept of Remoteness

Let $n_i(t)$, $i = 0,1,2,3,.....N - 1$, represents the location vector of node i at time t and $d_{ij}(t) = | n_j(t) - n_i(t) |$, the distance from node i to j at time t. Then the remoteness from node i to node j at time t is

$R_{ij}(t) = F(d_{ij}(t))$, Where F is the function of remoteness.

For a simple choice take F as identity function, then the remoteness is just the distance between the nodes.

As node moves relative to the other nodes remoteness remains the proportionate of its previous. But as it moves on a manner, in which its speed and angular deviation from the current state are not predictable, remoteness changes in time. Thus the definition of relative mobility measure of a node in terms of time with respect to its immediate neighbors

$$M(t) = \frac{1}{\mathbf{N}-1}\sum_{J=0}^{N-1}\left|d_{ij}(t)\right|$$

To reduce energy consumption during the other time slots that is not intended for a node, the node is put it in sleep mode. Therefore even though a node is in the radio range of its neighboring nodes, it can't hear the information send by its immediate neighbors.
In order to hear simultaneously, the cluster head gives an extra time slot as shown in fig. 5.

Slot 0	**Slot 1**	**Slot 2**	**…….**	**Slot N-1**	**Active**

Fig. 5.TDMA time slot for LEACH-Mobile-Enhanced

IX. FUTURE WORK

In future, this LEACH-ME can be simulated and the work can be extended to develop a non-cluster based routing protocol to handle mobility in WSN.

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