An Investigation on Mobility Influence on MAC Protocols of Wireless Sensor Networks

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***Abstract*— The collection of sensor nodes, which form a dynamic and arbitrary network by connecting on a wireless medium is called wireless sensor networks. This definition implicitly describes that links may appear or disappear at any time because of node mobility & other factors. The communication is completely dependent on the nodes (source and destination) of network. For a network to work efficiently various protocols for routing have been developed. These protocols provide the path among distant nodes via multi-hop links to improve network efficiency. The Protocols' performance affected by the various factors, such as mobility of nodes, varying network size, bandwidth and power consumption of node. This paper describes comparative analysis of protocols with reactive routing such as (AODV, DSR and DYMO) used in day-to-day scenario, under the Influence of different mobility models: like File, Group Mobility and Random-Way Point Model. The differentials of performance are investigated by altering the number of nodes and different mobility models, depending on the simulation results, how the efficiency of each protocol can be improved is also recommended. By using simulator we simulates throughput, average jitter packet delivery ratio and average end to end delay, in network layer hop count and RTS, CTS and ACK in MAC of protocols. For the above parameters simulation is performed with QualNet 5.0 simulator. The results show expressively noticeable Influence of mobility models on performance of routing protocols.**

***Keywords*— Wireless networks, AODV, CBR, DYMO, DSR**

I. INTRODUCTION

The usage of mobile devices like laptops and mobile phones in everyday life is heading to opportunities for unstructured and adhoc wireless communication. These devices have a fundamental ability to share information.

Access points are not needed as each node can act as a router as well as node at the same time [1]. These mobile nodes/routers can join and leave the network as per own wish. Each node finds route-by-route request. Routing protocol plays a significant role for sending data from the source to the destination that finds optimal path among two communication nodes.

Every protocol has its own rules to find the route or maintenance the route. There are many routing protocol proposed by researchers [2] [3]. Here routing protocol is also facing problems and various challenges for e.g. limited power-ability, Mobility models, transmission power limits, No central control authority, continuously maintains the information require properly route traffic. Mobility models are also a factor that affects the routing protocols' performance for great extent in mobility of nodes.

Due to the mobile nature, these nodes arbitrarily move randomly & organize themselves with in the network. This random nature affects the protocol performance. To improve the performance, many mobility models have been proposed. The performance of the reactive, hybrid and proactive routing protocols is dependent on mobility models used.

The comparative mobility ranking is also depending on the node speed as presence of the mobility model. This implies repeated failures on the link and different routing protocol reacts differently during the link failures. [4] [5].

A. Factors affecting performance of Wireless Sensor Networks

Bandwidth constraints and variable link capacity: Wireless link generally have lower capacity than cabled/wired link. Because of fading due to multi path, noise and interference, wireless link is not very stable. Environmental obstacles also affect the performance of the wireless link. Wireless links receive busty error compared to wired links which have flat bit error rates [5].

Dynamic topology: As the nodes are mobile they can join, leave or stay on the network. Thus network topology must be adaptable to the nodes current location. Depletion of battery capacity can also lead to node failure. New links are established and old likes are broken between nodes as these nodes dynamically adjust their power level. Thus the network topology must be created real-time depending on all these facts. Topology management is a hard issue [3] [6].

Mobility: The nodes mobility affects the average number of connected paths, which in turn Influences the routing algorithm's performance, node density and length of data paths. As the density is increased the throughput of the network increases, however after a certain stage if the density is raised the performance of some protocols are degraded [1] [10].

Energy constraints: The major affects energy because nodes are operated by battery and to minimize the node's total consumption of energy. Performance of the nodes increases when the total energy consumption is minimized as well as minimize the total number of collision [6].

Multi-hop communication: As the transmission power of a node is limited, a node communicates to the nodes beyond its transmission range via the intermediate nodes. So how to make routing effective is an interesting issue in such networks [9].

Limited physical security: Wireless network is less secure than wired network in natural. The lack of central authority, limited computation and power capacity in each node [6] [9].

B. Overview of Routing Protocols

Routing protocols [5] in Wireless sensor networks are stratified into three different categories based on their functionality and performance.

1. Reactive (On-demand) protocols
2. Proactive (Table driven) protocols
3. Hybrid protocols

Table Driven Routing Protocols: It is also termed as proactive routing protocols. In these protocols, the routing information is arranged in tabular form and is maintained by each node. These tables are updated regularly due to frequent change in the network topology. These protocols are implemented where there are frequent route requests [8] [13].

On Demand Routing Protocols: They are also called reactive protocols. They involve discovering routes to other nodes only when they are needed. It invokes the route discovery process when a node wants to communicate with another for which it has no route table entry. They are considered efficient protocol, where the frequency of route discovery is less. This makes them more suitable to the network with light traffic and low mobility [14].

Hybrid Routing Protocols: These protocols values the positives of the two routing protocols and combine them to obtain higher efficiency. These protocols divides the network into zones, to perform routing within the zone table driven routing is used otherwise on demand routing is preferable [10 11].

This paper measures the performance of reactive routing protocols under the influence of mobility. To understand the influence of Reactive routing protocols in different mobility model such as group, file and random waypoint mobility models are considered.

The remaining of this paper is organized in the following way: Section II discusses on brief introductions to various reactive routing protocols techniques. Section III discusses about the Simulation setup and platform used in this work. Section IV discusses on the results of the performance evaluation. Conclusion of paper given under section V.

II. ROUTING PROTOCOLS UNDER CONSIDERATION

The Adhoc routing protocols are mainly classified in three categories as discussed in section 1. This section discusses about the routing technique for the protocols used in the simulation.

A. Reactive Routing protocols

The simulation process uses the following reactive routing protocol:

1) Ad hoc On-Demand Distance Vector (AODV)

AODV [8] [9] routing protocol uses DSDV and DSR [7] algorithm. It implements the sequence numbering procedure and the periodic beaconing of DSDV and the route discovery procedure as used in DSR.

However, there are two significant differences between DSR and AODV. With DSR each packet carries full routing information, whereas in AODV the packets carry the destination address. This address and the sequence number.

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is meant for ad hoc network used by mobile nodes. It provides faster adjustment to implies that AODV has lesser routing overheads as compared to DSR. The other difference is that in DSR the route replies carry the address of every node with the route, while in AODV the route replies only carries the destination IP non-static link states, less processing and memory overhead, lower network utilization, and unicast route processing to destinations for the adhoc network.

The chief aim of the AODV protocol are the following:

1. To broadcast the discovery packets when required only.
2. To distinguish between local connectivity management (neighborhood discovery) and general topology maintenance.
3. To advertise information to the neighboring mobile nodes those need the information about the local connectivity changes.
4. AODV uses on demand route method for broadcast to decreases the overhead.

2) The Dynamic Source Routing protocol :

It is made of main two mechanisms route discovery and route maintenance.

Route Discovery: It is the method using which a source node that wants to send a packet to a destination node, learns a source route for the destination.

Route Maintenance: It is the method using which a node that wants to sends a packet to the destination can identify if there is any change in the network topology.

A route entry in DSR have information about the intermediate nodes all well and not only just the next hop information that is maintained in DSDV and AODV.

The source node adds the complete path for the route in the data packet, and sends the packet via the intermediate nodes specified for the path.

If the source node does not have a route towards the destination, it does a route discovery by flooding a route request (RREQ) packet in the network. A node that has a path to the destination in RREQ request will respond to the RREQ packet by replying with a route reply (RREP) packet.

The route recorded in the RREQ packet is used to send the reoly. To limit the route discovery, DSR allows nodes to operate within their network.

Preventing "Route reply Storms" is another optimization technique. As many RREP could be initiated at the same time, a delay time proportional to the hop's-distance can be used so that the closer node gets the higer priority.

Another method called "Packet Salvaging" is also used frequently in DSR. When an intermediate node which is forwarding a packet detects a broken route to the destination and if it has another route for the packet destination, it would use the alternate route to send the packet to the destination instead of discarding the packet.

3) Dynamic On-demand (DYMO):

The Dynamic On-demand (DYMO) [6] [13] routing protocol is a simple and fast routing protocol for networks with multihops. It does an on-demand discovery for the unicast routes through DYMO routers within the network and offers improved convergence in dynamic topologies. Digital signatures and hash chains are used for the accuracy of this protocol.

Route discovery and Route management are the primary operation of DYMO protocol. These mechanisms are explained in the following section:

1) Route Discovery:

When a source node needs to send some data to a destination node, it starts with the route discovery by sending an RREQ, which helps to discover a route to the particular destination.

After sending the RREQ, the source DYMO router waits for the route to be discovered.

If the route is not discovered within the RREQ wait time, the source node may retry to discover the route by sending another RREQ packet. To avoid congestion in a network due to repeated attempts for the route discovery for a particular target node destination an exponential backoff timer is used. While the node is waiting for the route discovery the data packets must be buffered by the source node's DYMO router.

The router's buffer is fixed and have limited space for the buffered data packets, in case the router buffer is full the older packets should be discarded first.Buffering of data packets while waiting for the route getting discovered can have both constuctive and destructive effect, and thus the buffer settings should be a configurable or intelligently controlled.

2) Route Maintenance:

When a data packet that has to be forwarded cannot be delivered to the next-hop router, as there is no route for the destination address; an RERR is generated. Depending on the condition, an ICMP Destination unreachable message must not be generated unless the router is responsible for the Destination IP Address and that Destination IP Address is known to be unreachable.

Moreover, an RERR should be generated after a broken link is detected for a forwarding route to quickly notify DYMO routers that a link issue has occurred and that certain routes are no longer available. If there are no recent traffic over the route with the broken link, the RERR should not get generated.

4) Mobility models in QualNet Simulator:

QualNet 5.0 [16] mobility model includes four mobility options: file, none, group, random waypoint. The file preference enables user to define a time order trace file to identify every node location. The none option fixes all nodes in place during the entire period of simulation. The group option divides the nodes as part of different mobility group surrounded by which every node follows the same random waypoint model. The random waypoint option specifies that every node selects a destination randomly within the physical environment.

III. SIMULATION SETUP

The simulation was conducted for different mobility models and different reactive routing protocols, while maintaining the constant traffic load. Each parameter observed and analyzed. We use a simulation model based on QualNet [16] for our analyzed evaluation.

QualNet is developed by Scalable networks as a discrete event simulator. It is extremely scalable, accommodating high fidelity models of ten of thousands of network nodes, that can model large scale network with mobility and traffic using computational resources. In this scenario, wireless connection in 30 nodes for Wireless Sensor Network is used to compare the performance of routing protocol (AODV, DSR, and DYMO) and data traffic with CBR between source and destination is applied over it. The nodes are distributed randomly over the region of 1500m x 1500m. This mobility model uses the file, Group and random waypoint in this experiment.

A. Snapshots

Figure.2 shows the snapshot of designed simulation scenario representing CBR between nodes of 1 to 30. Figure 3 shows the simulation scenario representing route discovery mechanism of 30 nodes for AODV routing protocol.

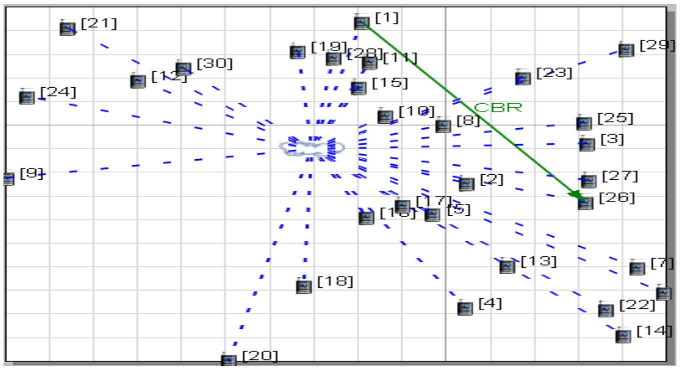

Figure 1. Snapshot of simulation scenario representing CBR between node 1 to node 26

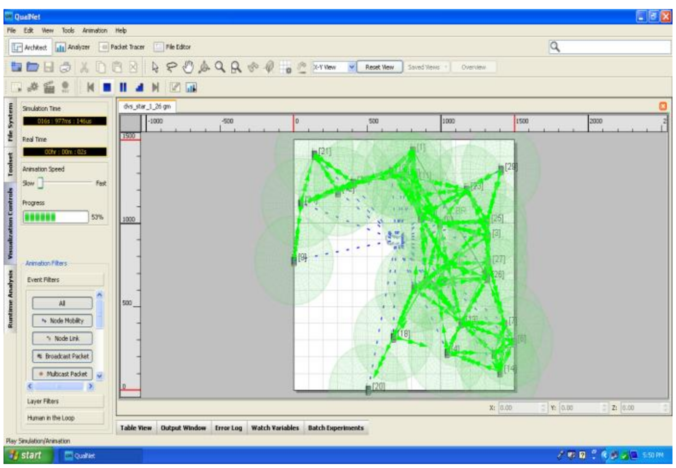

Figure 2. Snapshot of simulation scenario 30 nodes for AODV routing

B. Simulation Setup Parameters

Table I shows the various simulation parameters used in the simulation process.

TABLE I. SIMULATION SETUP PARAMETERS

Parameter	Value
Simulator	QUALNET 5.0
Routing Protocols	AODV, DSR, DYMO
Mac Type	IEEE 802.11
Number of Nodes	30
Transmission range	600m
Simulation Time	30s
Simulation Area	1500 X 1500
Mobility Model	File Mobility Group Mobility Random Waypoint Mobility
Energy Model	Mica-Motes
Traffic Type	Constant-Bit Rate
Node Placement Model	Random
Battery Model	Linear Model
Full Battery Capacity	1200 (mA,h)
Battery Charge Monitoring Interval	60 Sec.
Antenna Model	Omni direction
Total packet sent	24
Packet Size	12288 Bytes
Throughput	4274
Channel Frequency	2.4 GHz

IV. RESULT AND DISCUSSIONS

A. Influence on Average Jitter

Jitter: It occurs when in a transmission scenario different packets take different amount of time in reaching from the source to the destination. If a communication system has large amount of jitter then the signal quality is very poor.

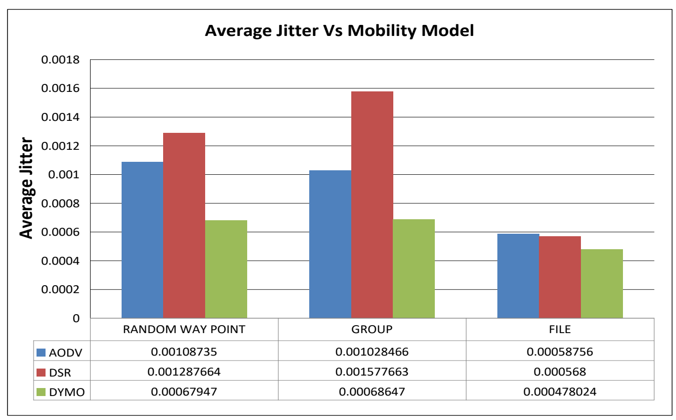

Figure 3. Represents Average Jitter vs Mobility Model

Fig. 4 shows how mobility Influences the Average Jitter taking routing protocol as parameter. Effects of inference can made:

- The DSR shows highest values of Average Jitter for group mobility.
- The DSR shows highest value of Average Jitter for Random Way Point Mobility.
- The DYMO shows least value of the average jitter for the three mobility models

B. *Influence on Average End to End Delay*

Average end-to-end Delay: It is defined as the time used to deliver a data packet from the application layer of the source to the corresponding layer of the destination.

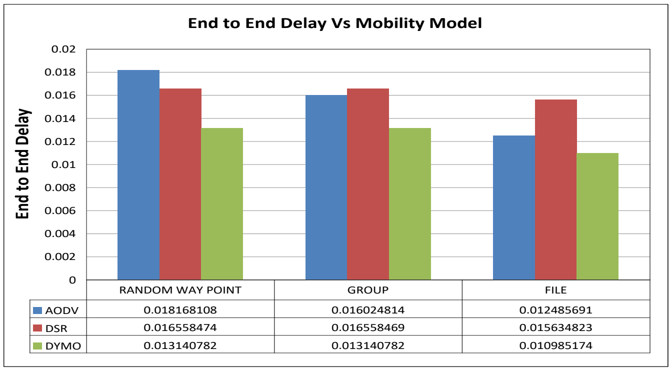

Figure 4. Represents Average End to End Delay vs Mobility Model

Fig. 5 shows the Average End to End Delayis Influenceed by mobiliy taking routing protocol as parameter. Following inference can made:

- The DSR protocol shows highest value for average end to end delay for file mobility.
- DSR shows highest value for average end-to-end delay on group mobility.
- AODV shows highest value in case of Random Way Point Mobility Model.

C. *Influence on Throughput*

Throughput: It is defined as the amount of data that can be successfully deliver over a communication channel over a given period of time. Typically, it measured in kbps, Mbps and Gbps.

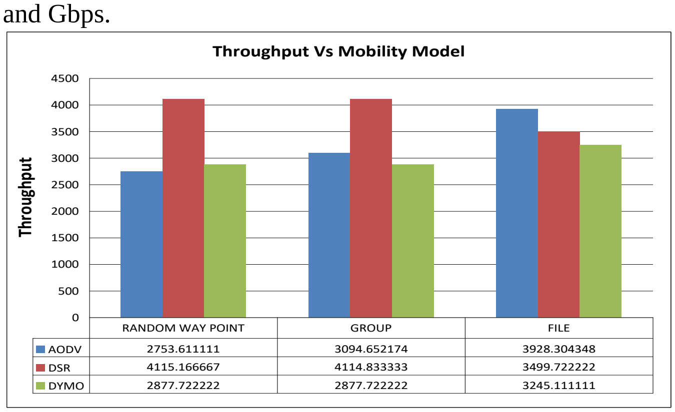

Figure 5. Represents Throughput vs Mobility Model

Fig. 6 shows the Influence of mobility on the throughput taking routing protocol as parameter. Following inference can be made:

- DSR shows highest value of throughput for the Random and Group Mobility followed AODV.
- DSR shows highest value for Random Way Point Mobility followed by AODV then DYMO.

D. *Influence on Hop Count*

Hop Count: It is defined as the total number of intermediate nodes hops to reach from a source to a destination node.

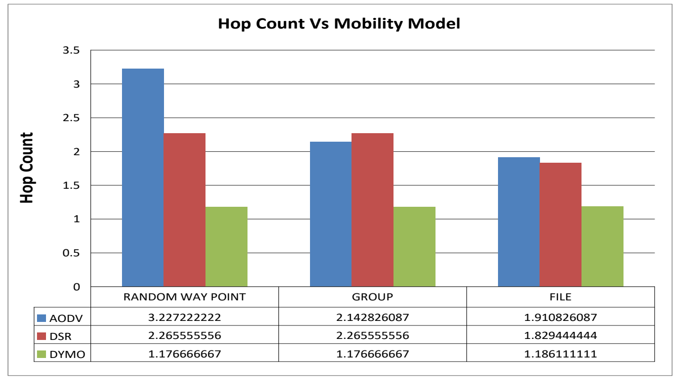

Figure 6. Represents Hop Count vs Mobility model

Fig. 7 shows how the Hop count is Influenceed by mobility taking routing protocol as parameter. Following effects of inference can be made:

- AODVshows highest value of the hop count for each mobility model followed by DSR.
- DYMO is having least value of the hop count for each mobility model.

E. *Influence on RTS Packet Sent*

RTS Packet Sent: RTS stands for Right to Send. Its a kind of message packet, which used in "Multiple access with collision avoidance" (MACA) solve the problems like "hidden terminal problem" and "Exposed terminal problem.

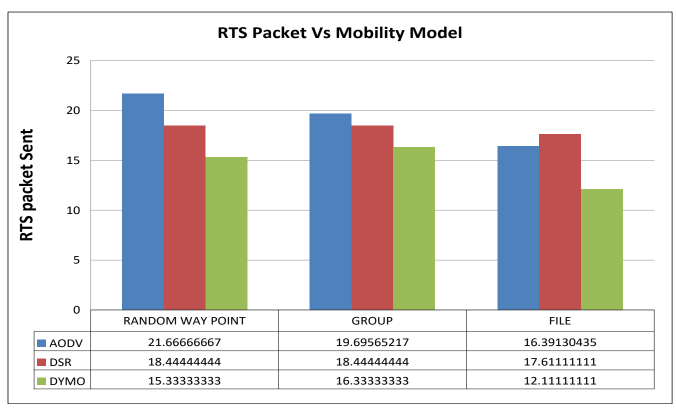

Figure 7. Represents RTS Packet Sent vs Mobility Model

Fig. 8 shows how the RTS packet sent are Influenceed by mobility taking routing protocol as parameter. Following inference can made:

- AODV shows highest value of RTS packet sent for each mobility model and is having highest value in Random way point and Group mobility.
- The DYMO having least value for Random Way Point mobility Model.

F. *Influence on CTS Packet Sent*

CTS Packet Sent: CTS is clear to send. It is also a message packet, which used in (MACA).

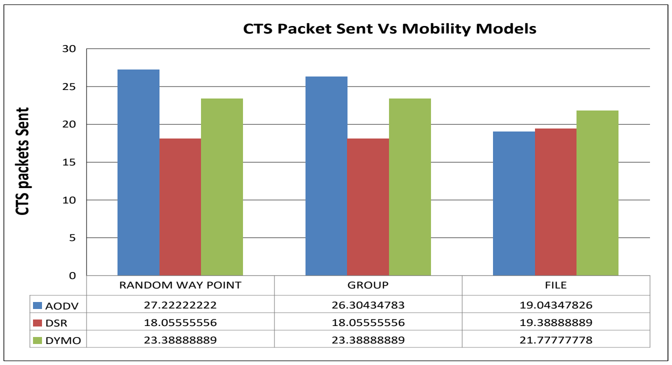

Figure 8. Represents CTS Packet Sent vs Mobility Model

Fig. 9 shows the CTS packet are Influenceed by mobility sent taking routing protocol as parameter. Following inference can made:

- AODV shows highest value of CTS packet sent for each mobility model followed by DYMO.
- DSR shows least value for each mobility model and moderate in case of random way point mobility model.

G. *Influence on ACK Packet Sent*

ACK Packet Send: Defined as an acknowledgement packet send by the receiver after receiving the correct data packet.

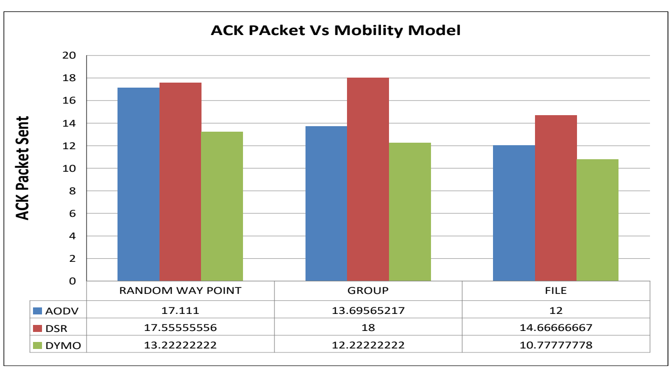

Figure 9. Represents ACK Packet Sent vs Mobility Model

Fig. 10 shows how the ACK packet sent is Influenceed by mobility taking routing protocol as parameter. Following inference can made:

- DSR shows highest value of ACK packet sent for the three mobility models followed by RIP.
- DYMO shows least value random way point each mobility model.

TABLE II. OVERALL COMPARISION OF THREE REACTIVE DEMAND ROUTING PROTOCOLS

Performance Metrics	AODV Routing Protocol	DSR Routing Protocol	DYMO Routing Protocol
Jitter	Efficient consistently low	Good	Worst Constantly Low
Average End to End Delay	Good	Average	Efficient consistently low
Throughput	Constantly Good	Good	Efficient Decreases At random way point
Hop Count	Average	Most efficient	Good
RTS Packet Sent	Average	Average	Good at random way point average at file & group mobility
CTS Packet Sent	Efficient	Good	Average
ACK Packet Sent	Good	Higher at RWP & group	Worst constantly high

V. CONCLUSION

The above result shows how the performance metric of reactive protocols are majorly Influenced by mobility. Simulation results have indicated that the comparative ranking of the different routing protocols may depend upon mobility model which have been used and analyzed performance shown in table II. The node speed also determines comparative ranking as the presence of the mobility involves multiple link failures and each routing protocol reacting differently during link failures. Table II shows the comparison of the three reactive routing protocols.

Researchers can take advantage of these results when designing a routing protocol for Wireless sensor networks.

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