Mobility in Mobile Communication System: A Preliminary Study

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ABSTRACT

This paper review previous models developed for mobile communication system. It outlines the mobility behaviors, communication algorithm, nodes movement model, routing protocols, and node localization technique used by such models. In this paper we present our study on the effect of the different communication parameters on the mobility behavior. Such parameters are capacity, delay, node power consumption, node localization accuracy, and fault tolerance. Based on the models investigated we propose a variant model that can increase flexibility and scalability, decrease node power consumption; achieve high transmission rate with lower delays, and achieve fault tolerance nodes. We report preliminary results of the simulation experiment we have conducted based on the model presented in this paper.

Keywords: *Mobile communication systems, Mobility, Fault tolerance.*

1. INTRODUCTION

In the last few years, a mobile node based communications systems and related technologies have emerged as a widely studied research. Many mobile nodes communication strategies were being built for research and testing purposes. This paper review the most important models developed for such environment. This paper outlines the mobility behaviors, communication algorithm, nodes movement model, routing protocols, and node localization technique used by these models. We also present our study on the effect of the different communication parameters on the mobility behavior. Such parameters are **c*apacity, delay***, ***node power consumption***, ***node localization accuracy***, *and* f***ault tolerance***. Capacity is important as it determines the maximum possible data transmission over the wireless link. Delay, the average time separating the data packets when sending it from source to destination [2], is important as it determines speeding up the transmission process. By node power consumption we mean the energy consumption for communication and movement at each node as stated in [8]. Each node in a wireless environment has limited energy as a battery, so it is very important to save energy and decrease battery life time. Fault tolerance, faults could occur at any time in mobile nodes, it is important to see how the mobile system deals with such faults. Node localization accuracy, known as the node ability to determine their location [6], is important to determine the movement direction of the node.

An environment with nodes mobility behavior is usually supported by wireless communication network. Such networks is the Ad-Hoc network that is defined in [7] as " a set of wireless mobile hosts/nodes forming a dynamic autonomous networks that communicate with each other without the intervention of a centralized access point or base station". Another definition for such networks is found in [2] as "a temporary infrastructureless network, formed dynamically by mobile devices without tuning to any existing centralized administration". Usually with Ad-Hoc mobility sending packets to remote nodes, involves asking other nodes to forward the packets.

The various models described in this paper deals with the high mobility environment in Ad-Hoc network. Based on the various existing models that were investigated we propose a variant model that can:

1. Increase flexibility and scalability.
2. Decrease node power consumption via node action scheduling as this can save time and energy, since it is important to increase node life time at the environment.
3. Achieve high transmission rate with low delay at the environment.
4. Achieve fault tolerance nodes.

The rest of the paper is organized as follows: in section 2 include a review of the related work, section 3 gives a review of the different mobility models that have been studied, in section 4 we outline the proposed model and its specification, and section 5 presents our simulation and the results.

2. BACKGROUND

The mobile node based communications systems area has a variety of researched models; each has its own view of parameters, environment structure, and work scenarios. For example in [3] discusses ways of allocating limited energy radio bandwidth to maximize the value of each node's contribution to the network. Their work is based on Self-Organizing Resource Allocation (SORA). This approach was used for tracking application such as tracking vehicles along a road or in an open area. SORA determines the set of local actions to be taken by each sensor node to meet some global goals of lifetime, latency, and accuracy for the data produced by the network as a whole. To achieve these aims each node can take a set of local actions, each with varying energy costs and differing contributions to the global task of the network. When used as a dynamic scheduling for the actions at each node, the energy cost could be decreased. The work done in [8], which is concerned with mobility environment, proposes a solution for mobile transaction commitment, and adopts a system model with a mobile host, that is a computer that can move while maintaining its network connection, through wireless links. The network includes fixed hosts and base stations. The base stations connects with the mobile host using wireless network while it connects with the fixed hosts through wired connection, each base station covers a geographical area called cell. The research done in [5] investigates the problem of planning paths for mobile robots in environments with dynamic network. Two different techniques for environment in which dynamic paths are destroyed and created were analyzed. It was shown that the one technique has very quick response, but at high communication cost, while the second approach showed that the same response speed can be obtained but with far fewer messages. A project based on the research done in [5] is concerned with bringing car to car communication into real world [1]. This work demonstrated the use of two scenarios in dynamic network . The first scenario, the high way scenario assumes no obstacles in the area, while the second one, the city scenario assumes where obstacles exists at the area. The experiment involves six smart cars. The cars are able to communicate by means of multi-hop communication among each other and with road side gate ways for internal access. The study done in [4] describes several localized algorithms that try to minimize the total energy per packet and lifetime for each node. Since there are a sets of control messages used to update positions for all nodes to maintains the routing algorithm efficiency. A new routing scheme "Global State Routing " based on the link state vector is proposed in [13]. The node maintains the global state knowledge of the network topology while optimizing their routing decision locally. According to this research it was found that as the routing error is decreased the transmission range increases. Next section the various models mentioned in this section are discussed while we describe our model, based on the above models in section 4.

3. MODELS SUMMARY

At this section we summarize three models that are concerned with mobility. We start with the model that is concerned with the capacity and delay model. Then we summarize the model that is concerned with both node localization, and energy consumption. The third one researches the effects of mobility over a set of communication protocols.

3.1 CAPACITY AND DELAY MODEL [10]

This model proposes a routing algorithm, which exploits the patterns to provide minimum delay. In the following section we outline the theoretical framework, assumptions, and algorithm steps of this model.

3.1.1 THE WORKING ENVIRONMENT

The environment is presented using two models, the network model and the mobility model.

I- The Network Model

It defines the structure of the nodes in the environment as shown in Fig. 1. The model is presented as a set of static nodes (**n**), and a set of mobile nodes (**m**). All are located in a disk of unit area (known area limitation to save node distance, direction, and transmission range). The static nodes are fixed and distributed uniformly at random over unit circular disk. The mobile nodes are randomly distributed in the disk initially at time ***t=0***. These mobile nodes change their positions and velocities according the mobility model which is described later.

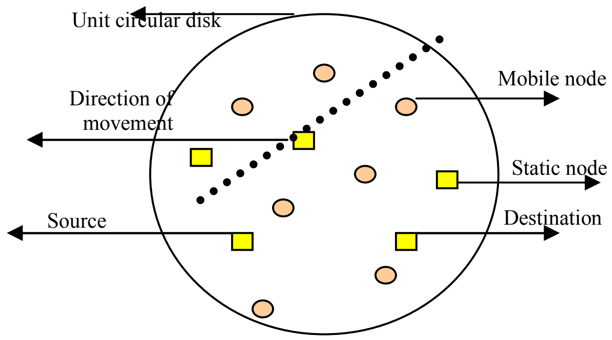

Fig. 1: Network model with node distribution

II- Mobility Model

It defines the mobility model of the nodes, such that it specifies both direction and speed of movement for each node. In this model each mobile node moves at speed ***V*** inside a unit circular disk. ***V*** is defined as a vector (x, y) that defines the direction of movement. At time ***t=0***, the position of these nodes are distributed uniformly at random inside the disk. Moreover, the directions of motion of mobile nodes are uniformly distributed in the disk. The node moves independently of each others, directly towards the next point at a certain velocity *V* in a convex domain denoted by ***A***. The node speed, position and direction are uniform distribution, the distance of node movement before changing its direction is exponentially distributed.

3.1.2 WORKING SCENARIO

This model concerns with a set of assumptions to ensure a bounded delay and good throughput, these are :

- The sources and destinations are static nodes, the mobile nodes are used as relays in order to achieve a good throughput.
- The number of mobile nodes (**m**) is between the square root of the number of static node or the same value. This is to obtain constant throughput per sender.
- The number of relays per packet should not be too large.
- A scheme is defined in order to decide which packets need to be handed off. This is to ensure that packet does not get strayed a long the path.

3.1.3 THE ALGORITHM

Based on the above assumptions and the network environment the following routing algorithm steps were introduced:

1) A static node chooses as a leader to be responsible for communicating all the messages of the static node in its region with the mobile nodes.
2) A static node that wants to transmit a packet will first send it to the leader at the region, and then the packet will be routed among the leader and the mobile nodes (static to mobile routing).
3) The mobile nodes relay the packets amongst themselves, such that it gets closer to the destination (mobile to mobile phase).
4) The carrying packets over a mobile node hands off to some leader node when it is close enough to the destination. Then the packet routed among the leader nodes to transmit the packet to the destination node (static to static phase).

3.1.4 MODEL PERFORMANCE

As reported in [10] this model guarantees $\Omega\left(Wm/\left(n\log_n^3\right)\right)$ throughput compared with $O(Wm/n)$ for other models, and $\Omega(m\lambda/n)$ throughput for each static node, where W represent the maximum available bandwidth, n the number of static nodes, m the number of mobile nodes, and λ is the available throughput of the leader. The relation between delay and mobile node speed is $delay\,\alpha\,\frac{1}{speed}$. It was assumed that the destination is fixed and does not move. The throughput is independent of velocity and it has final value $\lambda(n)$. This model showed that, the mobility behavior has a positive effect on delay in process of sending a packet between source and destination.

3.2 LOCALIZATION MODEL [MCL] [6]

This model is named "Monte Carlo Localization", it is concerned with location awareness, without using an expensive Global Positioning System (**GPS**) receiver in a sensor network node. The sensor nodes typically use small number of seed nodes that know their location and protocols, where by the other nodes estimate their location from the messages they receive. The coordinates of seeds are flooded throughout the network so each node calculates its position based on the received seed location. In this model they have proposed localization method for nodes considering mobile nodes and mobile seeds. It might be argued that mobility would make localization more difficult, but this model exploits mobility to improve the accuracy and precision of node localization.

3.2.1 THE WORKING ENVIRONMENT

The MCL approach does not require additional hardware on the nodes and works even when the movement of seeds and nodes are uncontrollable. The environment structure of this model is presented below.

I- Network Model

This model is composed of a set of mobile nodes and seeds with fixed transmission range , ***r***, for both mobile nodes and seeds. Both types of nodes initially distributed randomly. Each seed has radio range to announce; and only the node within this range will hear the location announcement from that seed. Time is divided into discrete time units, since a node may move away from its previous location, so localization process required at each time unit. Four types of seeds can be found in this model [6], these are listed below:

- Outsiders: seeds that were not heard in either the current or the previous time unit.
- Arrivers: seeds that were heard in the current time unit, but not in the previous one.
- Leavers: seeds were heard in the previous time unit, but not in during this one.
- Insiders: seeds were heard in both time units

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The mobile nodes and mobile seeds move randomly and independently at a square area as shown in Fig. 2.

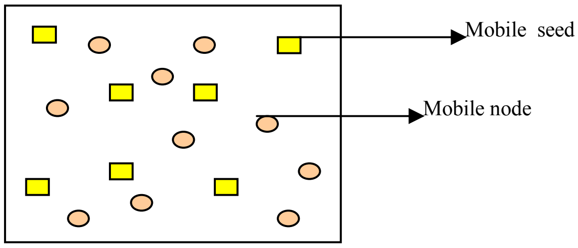

Fig. 2: Nodes Distribution

II- Mobility Model

The same mobility model is used for both nodes and seeds. The destination node, movement speed, and pause time after arriving at the destination are randomly chosen. The nodes are unaware of their velocity and direction, the nodes can vary their speed randomly during each movement, but the nodes have a known maximum velocity.

3.2.2 THE WORKING SCENARIO

The three scenarios that were investigated in this model are: Nodes are static, and the seeds are moving; Nodes are moving, and seeds are static; both nodes and seeds are moving. The last scenario is the most general situation; it applies to any application where the nodes and seeds are both deployed in an Ad-Hoc way.

3.2.3 ALGORITHM STEPS

The localization algorithm passes through the following three phases:

Phase 1: Initializing phase

At start the node has no knowledge about its position, so the initial samples of locations are selected randomly from all possible locations.

Phase 2 : Prediction phase

The mobility model is applied to each sample to get a new sample of locations. The node is unaware of its moving speed and direction, only aware of v_{max}.

Phase 3: Filtering phase
At this phase the node filters the impossible locations based on new observations. This phase is necessary to avoid network collisions and account for missed messages, where at time *t*, every node within radio range of a seed will hear a location announcement.

3.2.4 MODEL PERFORMANCE
This model studies range-free localization in the presence of mobility. It was found [6] that mobility can improve the accuracy and reduce the cost of localization. The technique (MCL) can provide accurate localization even when memory limits are present, the seed density is low, and network transmission is highly irregular. It was shown in [6] that applying the different localization techniques over time the accuracy MCL improve quickly.

3.3 ROUTING PROTOCOLS AND MOBILITY
This model as sescribed in [2] investigates the mobility effects on the performance of several mobile ad-hoc routing protocols based on a GlomoSim that is a library for parallel simulation of large scale wireless Network [14]. The various parameters that were investigated in this model were: ***consumed energy; data reception rate; over head*** ; ***delay***

3.3.1 THE SIMULATION ENVIRONMENT
The researcher simulated a number of nodes at specific area; and evaluated six protocols using GlomoSim simulator.

I- Network Model
The simulation done using 50 mobile nodes that were moving in 1600m*400m area for 15 minutes; each node has a power range of 250m.
II- Mobility Model
The random way point's model for node movement was used. In this model the node selects randomly a destination from the physical area then moves towards it, after reaching the destination the node stays there for a given time (pause time) to communicate. The pause time is fixed to 1 second during all simulation.

3.3.2 THE WORKING SCENARIO
A free space is chosen which supposes that no obstacles between the sender and the receiver. The IEEE 802.11 protocol was chosen for the MAC layer. Each node in the application layer generates one packet per second. For the transport layer this kind of application uses UDP.

3.3.3 THE TESTED PROTOCOLS
The tested protocols were:
1- WRP (Wireless Routing Protocol) is based on the vector distance algorithm, where it is introduced the shortest path predecessor node for each destination .
2- FSR (Fisheye State Routing) is based on the fisheye technique.
3- DSR (Dynamic Source Routing) based on the source route approach.
4- AODV (Ad-hoc On Demand Distance Vector) is based on a hop by hop routing .
5- ABR (Associativity Based Routing) is a routing protocol based on demand nodes associativity .
6- LAR (Location Aided Routing) is based on localization .

3.3.4 MODEL PERFORMANCE
It was found [2] that AODV and LAR are not much affected by the mobility. WRP and FSR lose a great amount of data packet. So, data reception rate decrease when the mobility increase. For delay ABR, AODV, and DSR have low transfer delays. So the delay at some protocols is steady on the average. The overhead generated by ABR, LAR, and AODV increase when the mobility increases. Because mobility rises implies route failure rise. The consumed energy for these tested protocols increases when the mobility increases. The study also shown that some set of protocols called reactive protocols such as (DSR, LAR) are more adaptive to mobile ad-hoc network.

3.4 MODELS MATRICES
The different parameters tested and their effects that were tested in the various model discussed in the previous sections are shown in Table 1.

TABLE 1
Table 1: Models Matrices

Model	Delay	Throughput	Energy Used	Set of control packet	Fault tolerance	Node location accuracy
1	Yes	Yes	__	__	__	__
2	__	__	Yes	__	__	Yes
3	No	No	No	No	__	__

Yes : a positive result. No :a negative result . __ : not investigated.

4. OUR MODEL
From the discussion presented above it is can be noted that there is a need for a fault tolerant mobility model in a mobile communication system and at the same time can also save ene rgy and minimize delays. Model 1(section 3.1) is found to have minimum delays and maximum throughput but does not take fault tolerance or energy conversation into consideration. For this reason we thought of adopting this model with the following changes that we think it makes the network fault tolerance and saves node energy.
1- Geographical area for mobile nodes with localization process instead of the static nodes, we believe this can increase mobility as the need for static nodes to relay the message is eliminated and bottlenecks on the nodes is reduced.
2- A set of mobile nodes work as a relay for the packet. In addition, it has the ability to route if there is a node failure. This improves fault tolerance. The number of mobile nodes per packet should not be too large, to decrease packet over head, and safe node energy. To ensure minimum energy consumption a set of action for each node then use dynamic action scheduling to investigate saving node power is used. Each node has a set of action but does not require power consumption for

these actions continually. We use action driven for power consumption as in [3].

3- Direction of motion for all nodes with fixed transmission range investigated via area division with limited distance transmission range.

4- Moreover, the node speed could be maximum which implies low delay.

4.1 NETWORK MODEL

In this model a set of mobile nodes distributed randomly over unit circular disk initially at time **t = 0**. Later the nodes change their position and velocities according the mobility model. We assume both the source and the destination are fixed at the transmit time (pause time to transmit). This is illustrated in Fig. 3.

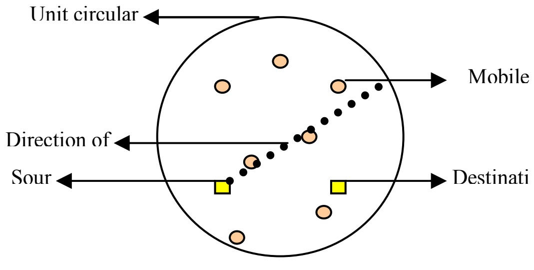

Fig. 3: Network model with node distribution

4.2 MOBILITY MODEL

We use the random way point mobility. In this model the node chooses its destination, its speed of movement, its pause time after arriving the destination randomly. The randomly behavior supports node mobility, but the nodes at our model are aware of their velocity and direction to safe delay and capacity and to avoid nodes collision (section 3.1). Random way point model is base on Poisson processes[11].

4.3 MODEL ASSUMPTIONS

We have adapted the assumptions made in the original model so that it fits with our mode. These assumptions are as follows:

1. Both the source and the destination are static for **time unit** during the transmission process to avoid delay, and to achieve a good throughput (section 3.1).The node at time **t** to be seed for its neighbors to support the node allocation.

2. In our model we use the node allocation process (section 3.2), the mobile nodes know the direction in which they are moving up to some degree of accuracy. This way in our model will investigate the node detection without additional hardware or centralized control. The node detection will use to determine the set of directions, such that the packet may pass through to the destination. This is illustrated in Figure 4.

3. The number of mobile nodes per packet should not be too large, to decrease packet over head, and safe node energy. Moreover, the node speed should be at maximum which implies low delay.

4. Dynamic scheduling for actions at each node, for example the node outside the transmission region at Fig. 4 should not perform listening action, then no power consumption for listening.

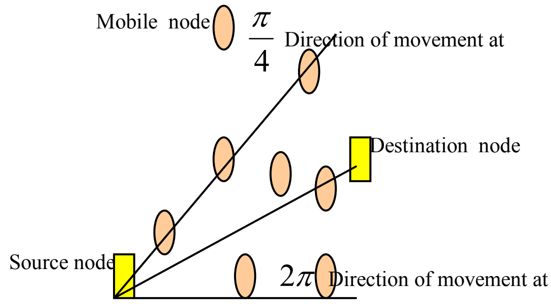

Fig. 4 : The transmission region

4.4 MODEL ALGORITHM

Based on the network and mobility models outlined above, taking the assumptions stated earlier, the steps taken to transmit messages are outlined below.

1. The area unit is divided into a hop transmission range.
2. A mobile node at a hop transmission range use one node as seed to be responsible for node allocation.
3. For the allocation process in the seed the algorithm of three phases in section 3.2.3. is used.
4. The mobile nodes relay the packets amongst themselves, such that it is closer to the destination.

5. PRELIMINARY SIMULATION RESULTS

NetLogo [9] is used to analyze and study the performance of our model. A snap shot of the simulator is shown in Fig. 5.

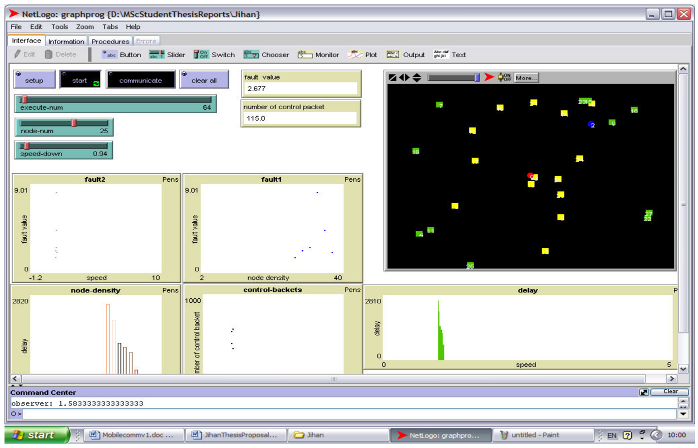

Figure 5 : A Snap shotof the the Simulator

During simulation the following assumptions were made:

1- Static source node and static destination node.
2- Exponential distribution for the distance of movement.
3- The mobile nodes have the same speed in movement.
4- The mobiles nodes are distributed and move randomly over the whole area.

5- During communication the source node prepare to send a message; this message passes through a set of mobile nodes to reach the destination.
6- Each mobile node may add packet on the message (control message).
7- The mobile nodes move randomly without specified direction.

The parameters that we intend to investigate during the simulation: delay value, and the number of control packets. We have so far investigated the effect on the delay of varying nodes density over the whole area while node speed remained constant. Also we have investigated the effect on the delay when varying nodes speed while nodes density over the whole area remains constant. The results are presented in Fig. 6 and Fig.7.

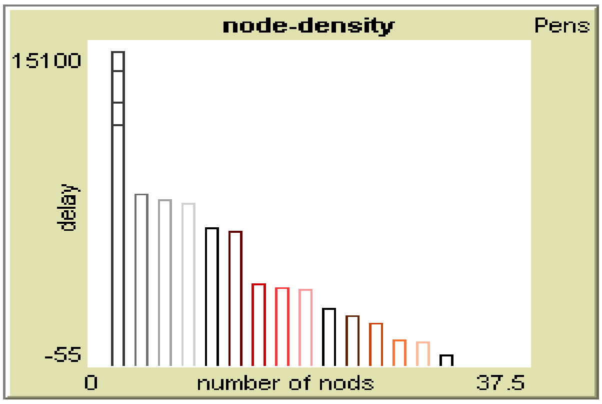

Fig. 6: Effect of varying nodes density on Delay

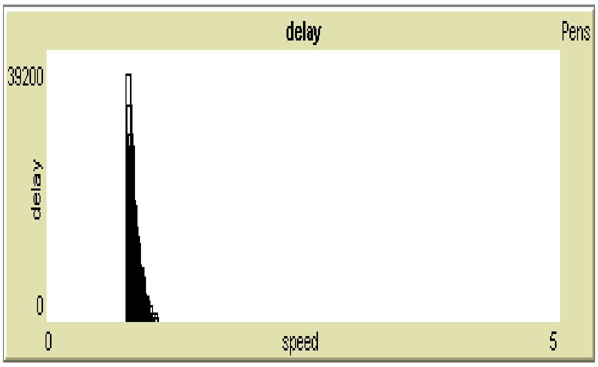

Fig.7: Effect of varying nodes density on Delay

As can be seen from the above graph; varying the nodes speed and increasing the density of mobile nodes have a positive effect of on the delay value. This result is the same as the one reported for model outlined in section 3.1, i.e. $delay\,\alpha\,\frac{1}{speed}$. In our model we have used only mobile nodes and dropped the need of static nodes that lead to simpler algorithms, compared with model 1. Eliminating the need for static nodes increases the fault tolerance of the system. We have done initial investigations that we hope to report our results in a future paper.

6. CONCLUSION

We have reviewed three previous models that were developed for mobile communication system. We have outlined the mobility behaviors, communication algorithm, nodes movement model, routing protocols, and node localization technique used by such models. We have presented the effect of the different communication parameters, capacity, delay, power consumption, node localization accuracy, and fault tolerance, on the mobility behavior for these models. Based on these three models we have outlined a propose variant model that we believe that can increase flexibility and scalability, decrease node power consumption, achieve high transmission rate with decreased delay times, and achieve fault tolerance nodes. We have so far investigated the effect on the delay of varying nodes density over the whole area while node speed remained constant using a simulator developed using Netlogo. In our model we have used only mobile nodes and dropped the need static nodes that lead to simpler algorithms and positive results with regard to transmission rates and delays. As on going research work we are conducting further simulation studies on the effect of the model developed in this paper on other parameters such as fault tolerance, energy consumption and number of control packets.

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