

Simulation Modeling of Mobile Communication
Environment – A comparative Study

By

Jihan Mohammad Hassan Al-Awawda

B.Sc.: Palestine Polytechnic University

Supervisor: Dr. Rashid Jayousi

A Thesis Submitted in Partial Fulfillment of Requirement
for the Degree of Master
Of Computer science

Computer Science Department
Al-Quds University

2008

Abstract

In the last few years, a mobile node based communication systems and related technologies have emerged as a widely studied research. Many mobile nodes communication strategies were being built for research and testing purposes. In this study the mobility behaviors, communication algorithm, nodes movement model, routing protocols, and node localization technique used by previous models developed for mobile communication system are outlined. In this thesis the effect of the different communication parameters such as the transmission angle, nodes speed, and number of mobile nodes, node localization, and fault tolerance probability on the message delay at environment with mobility behavior are evaluated. Based on the investigated models, 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 is proposed. The simulation results are reported; these results are conducted based on the proposed model.

خلاصة

في السنوات القليلة الماضية، ظهرت دراسة الاتصالات وتكنولوجيات نظام النقطة المتنقلة على نطاق واسع. الاتصالات المتنقلة عقد العديد من الاستراتيجيات التي يجري بناؤها لأغراض البحث والاختبار. في هذه الدراسة سلوك التنقل والاتصال والخوارزمية، والعقد النموذجي للحركة، بروتوكولات التوجيه، والتقنية المستخدمة من قبل النماذج السابقة لنظام الاتصالات المتنقلة. في هذه الفرضية أثر المعالم المختلفة مثل زاوية انتقال الاتصالات، سرعة الاتصال، عدد النقاط المتنقلة من الجوال، مدى الاتصال، واحتمال الخطأ في تأخير الرسالة نتيجة البيئة المحيطة. واستناداً إلى التحقق من النماذج المختلفة، والنموذج البديل التي يمكن أن يزيد تطويره من المرونة في الاتصال، والحد من استهلاك الطاقة، وتحقيق ارتفاع في معدل تدارك الأخطاء، في هذا البحث تقارير بنتائج المحاكاة على النموذج المقترح.

Deanship of Graduate studies
Al-Quds University

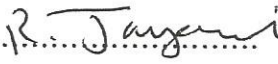


Simulation Modeling of Mobile Communication Environment – A comparative Study

Student Name: Jihan Mohammad Hassan Al-Awawda
Registration No: 20310282

Supervisor: Dr. Rashid Jayousi

Master thesis submitted and accepted, date: 21 / 7 / 2008

The name and signatures of the examining committee are as follows:

1- Dr. Rashid Jayousi	Head of Committee	Signature... 
2- Dr. Nedal kafri	Internal Examiner	Signature...  12/8/2008
3- Dr. Wasel Ghanem	External Examiner	Signature... 

DECLARATION

I certify that this thesis is submitted for the master degree in computer science as a result of my own research, I acknowledged that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed:  _____

Jihan Mohammad Hasan Al-awawda

Date: _____

1- Introduction

The communication networks as the mobile and the wireless communication grow fast. This can be seen in the explosive growth in mobile communications and the use of Bluetooth for short range wireless links.

The principal function of a network is to transfer information, so there is obviously a link between the effectiveness of the system on one side and the spatial distribution of network elements and the user demand on the other.

The communication networks infrastructure were classified into-

1- The Static Telephone Communication

This type of communication is just a circuit of switches, and it is a temporary communication path between the source and the destination point through switching the static links that exist in the network. By switching the local links, the central office can complete calls from the end-systems within its local zone and to be able to pass calls outside the local zones, the local central offices are connected to less numerous central offices of higher level, and so on. The basic architecture principles almost unchanged as illustrated in Figure 1.1.

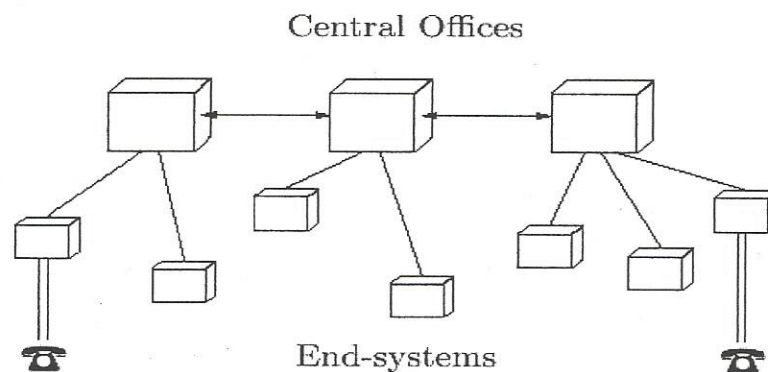
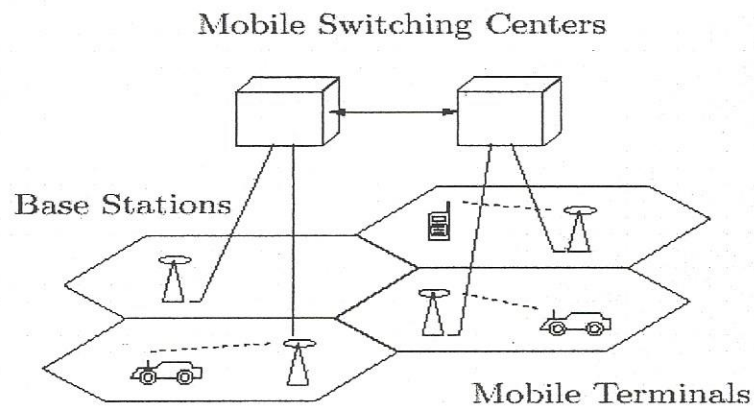


Figure 1.1: Public switch telephone network from (Konstantin, 1999)

2- Wireless Networks with Mobile Users

This type of networks is designed to serve voice and data connections between mobile users. The concept of the wireless systems is to deploy a number of low-power stations in the service area and let the mobile user communicate with the station providing the best quality of transmission. Its structure consists of mobile terminals, network subsystem, switching center, and base station with low power in the service area to provide best quality of transmission. The architecture of this network is represented in Figure 1.2.

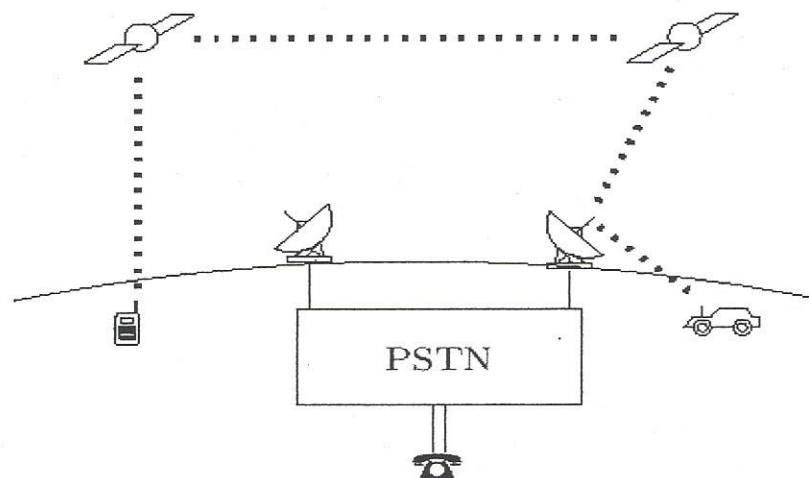


**Figure 1.2: Wireless telephone network
from (Konstantin, 1999)**

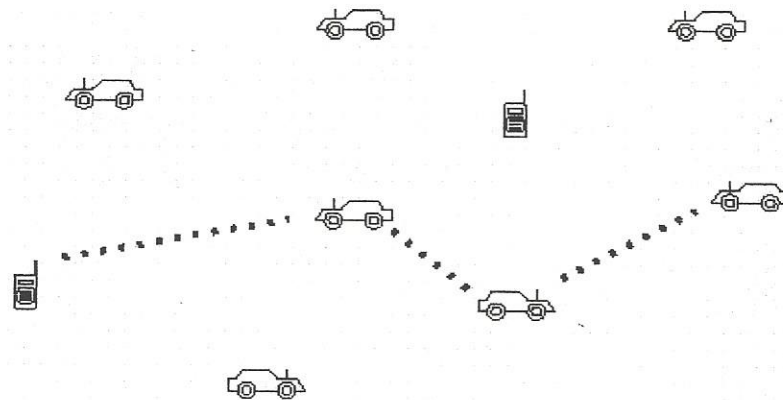
3- Mobile Wireless Networks

One type of mobile wireless network is the satellite networks, which were designed to serve both the wired and the wireless network. The satellite communication offers point-to-point voice connection, messaging and other low-rate data services. The second part of the wireless network is the ad-hoc, which is a set of mobile nodes, communicates over a wireless link without any centralized infrastructure. All the nodes communication evaluated through radio channel, so when the source and the destination are out of the radio range, then other mobile nodes participate in the transmission process by receiving and forwarding the bit of information one to another.

The two examples of the mobile wireless network are represented in Figures 1.3 and 1.4.



**Figure 1.3: Satellite communication network
from (Konstantin, 1999)**



**Figure 1.4: Ad-hoc network (Mobile Radio Network)
from (Konstantin, 1999)**

The communication structure methods shown in Figures 1.1 to 1.4 indicate that the ad-hoc network structure increase the successful message delivery probability leads to robust routing substrata even in very unstable network conditions. So, it is to this study, we shall address the mobile ad-hoc network in this study.

1.1 Research Problem Statement

The new generation of mobile communication is concerned with the rapid deployment of independent mobile user or information. The static communication is restricted with the power source, location, and too large number of stations when scaling the network. These restrictions imply additional hardware and high cost. In addition, it is not suitable for danger location or when any distortion done such as station failure via any emergency such as storm, an earthquake a crash or any technical failure. Also, the static network has static stations to pass the message. Moreover, this implies no flexibility in choosing process for the path of the message, besides high probability for the message to forward through long path, or use large number of static stations to offer the ability of shortening the path for the transmitted message.

We state our research problem statement as follow: the network communication is a very important process and the time taken to send a message from the source to the destination (represented in the literature as message delay) affects directly the network effectiveness and throughput. A certain application take requirement for safety process for human, message, or any user requires high calling response and low message delay. The static communication is not flexible enough to serve these goals, not available at an emergency situation such as a storm, an earthquake, a crash or any technical failure, not flexible in the replacement processes for the station, finally the static station hasn't movement ability at any direction or speed. Where, the mobile communication networks such the ad-hoc networks serve the previous goals. It is defined as "a wireless network that comes together when and where needed, as a collection of wireless nodes, without relying on any assistance from an existing network infrastructure" (Sobeih, 2002), this definition indicates network scalability, flexibility, and network assistances form mobile node available continuously. The node movement in the ad-hoc network provides positive

provide low message delay, high response and transmission availability in addition message fault-tolerance probability. After simulate our model that is represented later in chapter 3, it could be used in system to investigate minimum delay. Since, environment safety and time increased the probability of saving life when an accident occurs at far location as shown in the following graph. The following graph is taken from www.escop.info.

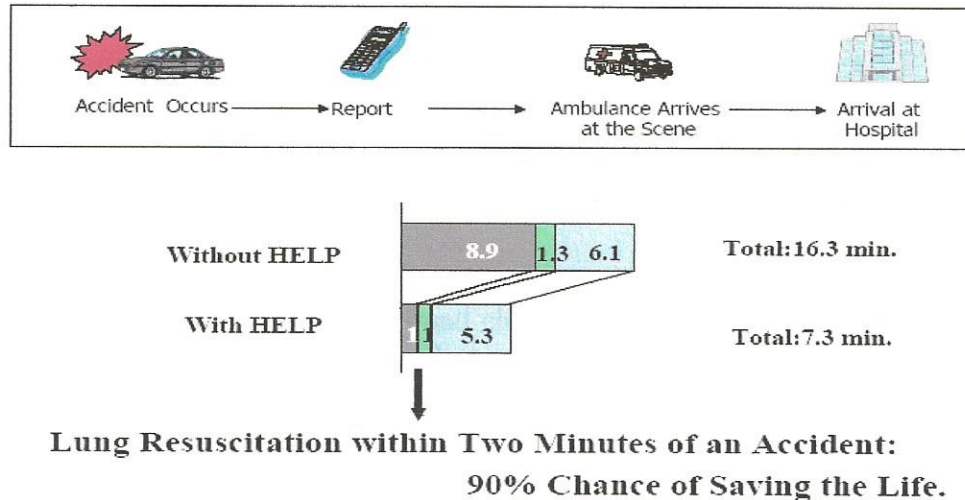


Figure 1.5: Saving life probability

In our research, we shall deal with this system in more details, instead of passing the message through the static cellular static station which may be out of service; it is passed through mobile node such as police cars or any taxi that provides the service. The following graph illustrates the help service steps. This graph is taken from www.gstforum.org.

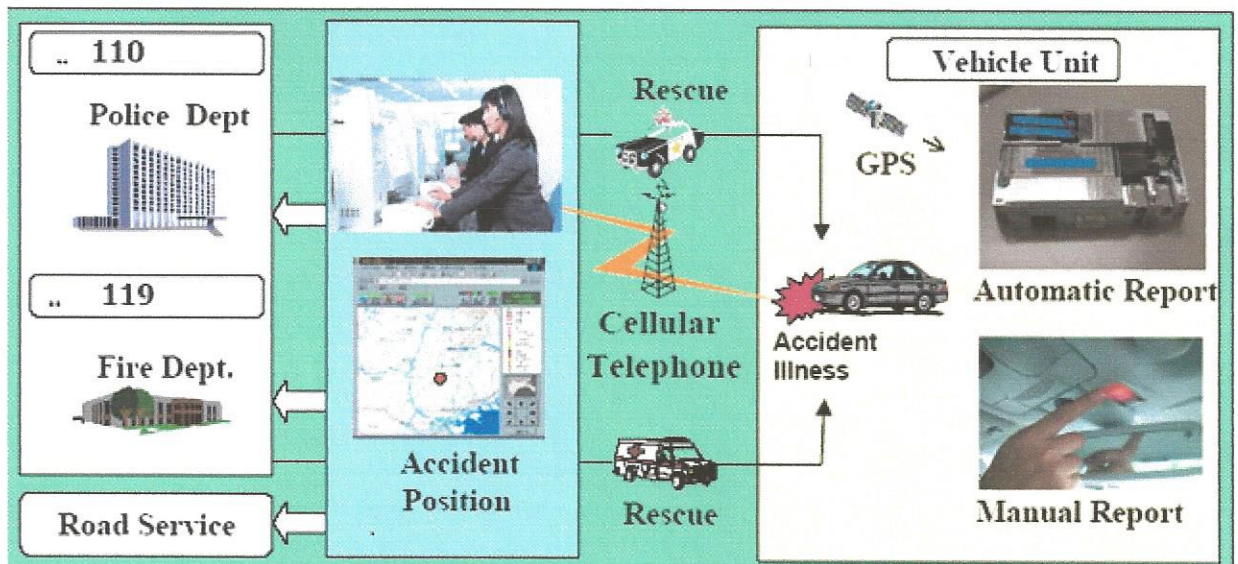


Figure 1.6: The help serves steps

1.2 Research Objectives

Our thesis objectives involve the model identifying, studying, and defining parameters to analysis. Therefore, our research objectives are as below:

1. To build a new model based on the capacity delay model (Nikhil and Zhen, 2003). Such change, reduces the static, increases the dynamic nodes to the model mobility for all nodes, and implements the new model with two static nodes representing the source and destination node, and a set of mobile nodes to relay the message. This means increasing the network mobility.
2. To study the nodes function (nodes behavior) of movement and message transmission in our model. Then define which parameters should be changed from static/mobile nodes environment to mobile nodes only environments to reach optimality as possible.
3. To simulate our new model and change some communication parameter such as transmission radius change, change angle of transmission, change the number of nodes, and change the speed of the mobiles nodes. Then study the effect of the environment through result analysis.
4. To analyze and study parameter testing results in our model, and concludes the general equations form our model. Then study the message transmission effect in different transmission angles.
5. To vary the model parameters to obtain, the best result and register the stat of parameters to investigate minimum delay of message transmission. Finally, study the fault-tolerance probability values of the message.

1.3 Research Questions

Our research asks sets of questions and answers them through out the research steps, results and analysis. In our thesis, the following are some of the questions that are examined in the area of mobile nodes based system:

- 1- What are the optimality degree and the environment complexity of various communication models with mobile nodes?
- 2- What are the mobile communication parameters that can be changed and optimized by the various founded mobile communication models?
- 3- What are the effective scenarios used for messages transmission?
- 4- What are the most effective changes in the communication parameters that made to investigate the best message delay values?
- 5- What are the best values of changed parameters in the mobile communication model that were collected in a state of communication, to achieve low message delay at the environment?
- 6- What is the percentage probability value of fault tolerance nodes, based on the number of mobile node that can receive the message from the sender node (founded in the transmission area)?

We expect to achieve the research objectives through building a mobility model with complex environment. The model and the research have the following assumptions:

- The source and destination nodes are static, the mobile nodes used as relays.
- The source and the destination nodes are static during the experiments.
- We have the possibility to send the message in a limited transmission angle to repair the message path continuously to the destination direction.
- We evaluate random selection for the receiver node from the transmission area.

1.4 Research contribution

This is an experimental research concerning several issues of mobile network communication, the effect of define model of mobility on the delay of message. Primarily the objectives that the study intends to achieve are the following.

- 1- Achieve low message delay between two stations, the source and the destination nodes. So, mobile nodes will distribute in the new model chapter 3 instead of

mobile/static nodes. Where, in (Nikhil and Zhen, 2003) this model guarantees best throughput compared with other models.

In addition, the relation between delay and mobile node speed is $delay \propto \frac{1}{speed}$

the delay values are reversed proportional to the mobile node speed. Where as showed the mobility behavior has a positive effect on delay in process of sending a packet between source and destination. The new model in chapter 3 indicates that, the mobility has a positive effect on message delay. More details are founded later in chapter 5.

- 2- Achieve low delay through repair process for the path of the message from the source to the destination. Moreover, message low delay will be achieved through nodes movement flexibility and through the transmission process controls. So instead of concerning the whole area around the sender of message identify an angle of transmission. The built model that is specified in chapter 3 investigates low delay value at transmission angle 90 degree.
- 3- Analyze a set of mobile node network parameters: the analysis process evaluated for the mobile nodes communication, the path of the message, the number of nodes and the speed of these mobile nodes. Therefore, we use the experimental method to analyze all the results of our model. The results produce two delay behaviors, quadratic and exponential behavior, more details in chapter 5.
- 4- Enhance a fault tolerance probability. Where, any node failure causes connection crashes at the fixed communication infrastructure; the failure may be a fire, an earthquake or disaster. Instead, at the mobile environment any node could be used to transmit data without relation with centralized situation (fault tolerance). In our model that specified in chapter 3 there is high probability to broadcast the message to a set of nodes, not only one.
- 5- Enhance the power consumption at each node to increase the node battery lifetime. This can be achieved through the dynamic actions scheduling at each node as (Geoffrey, David and Matt). Since each node has a set of actions to perform but not all at the same time. Our research explores this in a simple idea, where the nodes in the broadcast range listens and receives the message.

1.5 Organization of this Thesis

The rest of this thesis is organized as follows: Chapter 2 discusses the research and the study that are concerned with studying the mobile network communication parameters such as ad hoc networks, wireless communication, wireless network energy consumption, connectivity, capacity and delay. In Chapter 3, we present our model specifications such as network model, mobility model, algorithm and assumptions. In Chapter 4, we present the experimental design tool and our model simulator details. In Chapter 5 we identify and evaluate several experiments and present the results. Finally, Chapter 6 summarizes this thesis and suggests the future direction.

2-Background

2.1 Introduction

This chapter starts with an overview of ad-hoc networks description and mobile wireless communication criteria. Two major parameters of communication are considered, the mobile node communication delay and the mobile communication fault tolerance due to the number of nodes in the work environment, the angle of message transmission, and the distance between both source and destination. Then we summarize the research contributions. Finally we summarize the evaluation methodology used throughout this thesis.

2.1.1 Ad-hoc Networks and Mobile Wireless Communication

In the last few years, a mobile node based system communications and related technologies have emerged as a widely studied research. Many mobile nodes communication studies were being built for research and testing purpose. An environment with nodes mobility behavior, is usually supported by wireless communication networks, such one of these networks the Ad-hoc network that is defined in (EURECOM , 2004) as" a set of wireless mobile hosts/nodes forming a dynamic autonomous networks that communicate with each other without the intervention of centralized access point or base station". It is also called MANET (Mobile Ad-hoc Network) as in (www.antd.nist.gov) "A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time".

2.2 Wireless Network Energy Consumption

Researchers in the area of mobile node base communication systems proposed a number of models; each has its own view of parameters, environment structure, and work scenarios. For example in (Geoffrey, David and Matt, 2005) 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) which is a new approach for achieving efficient resource allocation in sensor networks. This approach was used for tracking application such as tracking vehicles along a road or in an open area and it provides controlling for aggregate behavior of sensors network. 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 various energy costs and different contributions to the global task of the network. When use a dynamic scheduling for the actions at each node, then the energy cost could be decreased (energy offering implies long life time for node).

The mobile node movement and communication consume energy. (Ivan, 2001) is a study that concern with describing several localized algorithms, that's algorithms try to minimize the total energy per packet and lifetime for each node. Since there are sets of control messages used to update positions for all nodes to maintain the routing algorithm efficiency, where the transmission power depends on the distance between nodes. The

result for this study shows that the communication over moving nodes depends on mobility rate without significant impact on the success rate or power savings of the routing task.

Moreover, at reference (Tsu-Wei, Mario, 1998) they propose a new routing scheme "Global State Routing" based on the link state vector. The node maintains the global state knowledge of the network topology then optimizing their routing decision locally. The result of this study shows that the introduced routing algorithm GSR is more desirable for a mobile environment compared with LS routing scheme (SL: Link State) where the mobility is high and the bandwidth is relatively low.

2.3 Wireless Network Connectivity

In a wireless network, the connectivity between nodes is very important for connection satisfaction. (Nadia, Habiba, Anne, 2006) in their research which is concern with mobility environment. They proposed a solution for mobile transaction commitment, and adopted a system model with:

- 1- Mobile hosts (MH), it is a computer that can move while maintaining its network connection through wireless links.
- 2- Fixed hosts (FH).
- 3- Base station (BS) it's responsible to connect MH through wireless with FH through wired connection, and each BS covers a geographical area called cell.

The use of static nodes and dynamic nodes adopted at model one at section 3.1. This paper studies a set of protocols to commit a transaction, and find out the best protocol in term of wireless message to commit a transaction in the UCM protocol (UCM: Unilateral Commit for Mobile) in away of making strong assumptions about the local concurrency and recovery mechanisms. The result of this study shows in regard for assumption that the needed information are transmitted from the MH to the BS as a part of registration process, then the handoff process do not increase the number of wireless messages. Else one additional wireless message needed, if MH does the transfer.

The researchers at this work design and experiment a commitment protocol that satisfies as the requirements of the mobile environment as much as possible (the research area is a data base processing). The idea here is similar to our work, but our area of research is the environment structure and communication.

To research in the message path at dynamic environment, the paper (Keith and Tucker, 2004) in their research checked an application of low cost, pervasively distributed network to plan paths for mobile robots in environments with dynamic network. They analyzed two different techniques for environment, where dynamic paths are destroyed and created. The result was, the first one has very quick respond, but at high communication cost, the second approach respond at the same speed, but with far fewer messages (concern with the currently resides messages a long the path). Reference (Keith and Tucker, 2004) a project that bringing car to car communication into real world.

(Andreas, Holger and Hannes and Amardeo, 2004) in their work they experiment two scenarios 1- high way scenario (no obstacles), 2- city scenario (with obstacles at the area), and they tested 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.

Related to communication connectivity the paper (Pasi, Esa and Henri, 2005) studies the connectivity properties of an ad-hoc network with n (n : number of nodes) mobile nodes. The mobile node is moving according to the random way point (RWP) mobility model. The RWP mobility model "the waypoint mobility model concentrates more nodes in the center of the area ". In this study approximated probability presented for network connection. The more we increase the number of nodes the more accurate the results will be in the network connectivity in both approximation and the simulated results. Moreover, this research compares the impact of node location distribution model on network connectivity; the results shows that the mobility induced by the RWP can either improve or degrade the connectivity probability depending on the number of nodes.

(Vegard, Mohamed-Slim and Geir and David, 2006) in their paper presented a feedback algorithm for wireless networks, where there is a signal transmitted through different channel between the base station and mobile users.

The algorithm called a multi-user diversity (MUD) and it can be used to enhance the wireless network capacity by opportunistic scheduling of users by giving priority for those users having good channel conditions. The study regards for different founded algorithms advantages in process of maximizing the average system spectral efficiency such as SMUD algorithm (SMUD: Selective Multi-user Diversity algorithm).

The introduced algorithm was tested at the environment with single cell in a wireless network with base station that exchanges information with a constant number N of mobile users, which have identically and independently distributed. They assume that the users always have data to send and these user data are robust with respect to delay.

The result for analysis of the scheduling algorithm with optimal spectral efficiency shows that the impact of scheduling delay and outdated channel estimates are analysis and numerically described. The introduced delay plots show that the system will be able to operate satisfactorily with consider to BER (BER: Bit Error Rate) when the normalized time delays are below certain critical values.

The network connectivity does not depend on the above idea, but it is related also with the nodes actions scheduling and the message transfer price vector as in (Geoffrey, David and Matt, 2005) .where, If the node is in a sleep action, then it can't send or listen the message (connectionless node).

The (Konstantin, 1999) is a thesis that investigated two problems in a network performance analysis when using methods from stochastic geometry.

The problems of the research are:

- 1- The evaluation of the effectiveness.
- 2- The analysis of the spatial distribution of services.

The work analyze the network type that can be constructed, then goes to search to find a path for delivering information from the source to the destination through simple algorithm corresponding to the individual stations of multi-level, hierarchically organized network. And they assumed that each level of stations is presented by a stationary point process. The result of this study shows a closed-form expression for the converge probability which may be evaluated for network that based on poisson-voronoi tessellations. But related with the ray-shoot algorithm, the result is the expression for the main length of the shortest path