Ministry of Education of the Republic of Belarus
Educational institution
Belarusian State University of
Informatics and Radioelectronics

Shakir
Mohammed Mozahim

Manet Technologies into Vehicular Communications

ABSTRACT

for a master's degree in engineering and technology
specialty 1 – 45 80 02 Telecommunication systems and computer networks

_____

Scientific Supervisor
Homenok M.
Ph.D., Associate Professor

_____

Minsk 2020

INTRODUCTION

Wireless ad-hoc network (WANET)is becoming one of the most animated and dynamic fields of communication and networks because of fame of movable device and wireless networks that has increased significantly in recent years. A mobile ad-hoc network is formed by collecting portable devices like laptops, smartphones, sensors, etc. that communicate through wireless links with one another. These devices collaborate with each other to offer the essential network functions in the nonappearance of immovable organization in a distributed manner. This type of network creates the way for various innovative and stimulating applications by functioning as an independent network or with multiple points of connection to cellular networks or the Internet see (figure 1).

Mobile Ad Hoc Network (MANET) is a temporary network that can be dynamically formed to exchange information by wireless nodes or routers which may be mobile. Network nodes may be a laptop, Personal Digital Assistant (PDA), mobile phones, MP3 players, digital cameras and so on. MANET does not use any existing network infrastructure or centralized administration. The routers are free to move randomly and organize themselves. So, the wireless topology of the network may change frequently and unpredictably. Such a network may operate in a stand-alone fashion or may be connected to the Internet. A MANET may be defined as a network that has many free or autonomous nodes often composed of mobile devices or other mobile pieces that can arrange themselves in various ways and operate without strict top-down network administration.

Many new applications are resulted from progress in the internet discipline because of wireless network technologies. For research and development of the wireless network, one of the most auspicious arenas is Mobile Ad- Hoc Network (MANET).

There are many important applications in MANET (Military field, PAN and Bluetooth, Business Sector, Sensor Networks ,VANET and FANET…. etc).

The mobile ad_hoc network (MANET) is closely related to WSNs. Wireless sensor network (WSN) plays a main role in the IoT system as its components include sensing, acquiring of data, heterogeneous connectivity, data processing, etc. The interaction between MANET and the Internet of Things opens new ways for the provision of services in smart environments and challenging issues in its networking aspects as well, the Internet of Things interfere with MANET and WSN then which makes The so-called (MANET-IoT) system.

The wide spread applications of MANETs has enabled sub categories of ad-hoc networking technologies, such as Vehicular Ad hoc Networks (VANETs) and Flying Ad hoc Networks (FANETs). Usually, these networks have high mobility with rapid topology changes as compared to a typical MANETs, because in both VANET and

FANET, most of the nodes are vehicles and UAVs (Unmanned Ariel Vehicles), respectively.

VANETs are the networks in which vehicle to vehicle (V2V) and vehicle to preinstalled infrastructure communication is supported. The main objectives of VANETs are to improve, traffic efficiency and traffic congestion, access to information and news to avoid accidents, and for entertainment purpose while driving.

Flying Ad-hoc Network (FANET) is a special type of MANET with support of very high mobility. In FANETs, the nodes are normally Unmanned Aerial Vehicles (UAVs) in Unmanned Ariel Systems (UASs) environment. These networks are aimed to construct self-organizing networks with flying aircrafts in the sky UAVs are involved in both military and civilian applications.

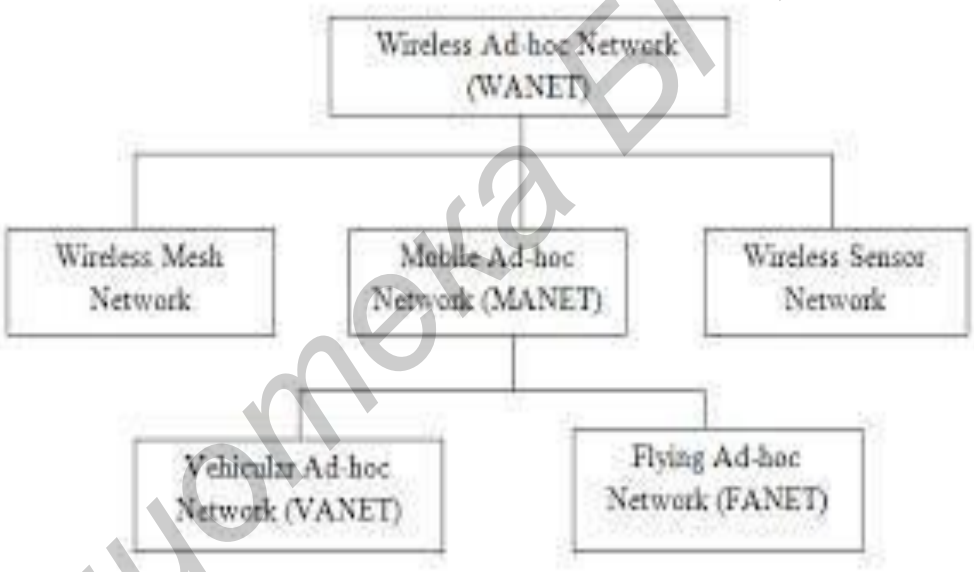

Figure 1 – Types of Networks

GENERAL DESCRIPTION OF WORK

The purpose of the Master's thesis is to study the features of using the basic model of MANET wireless mobile networks in VANET and FANET transport networks, as well as the development of a simulation network model by means of the NS-3 simulator, whose software encourages the development of simulation models that are realistic enough to allow the use of the NS-3 simulator as a real-time network emulator associated with the real environment.

One of the key roles in creating simulation models of self-organizing networks is played by the used model of moving mobile nodes. Researchers note the presence of significant differences in experimental results when using different models of movements of mobile devices. The mobility models in MANET technology is described to obtain an assessment of network effectiveness under various conditions (the number of nodes, the density of nodes and the nature of their movements) which are usually carried out using simulation modeling.

The task of modeling and testing new network structures and technologies for later implementation in everyday life is the most important task in the field of communications. Network modeling allows you to assess the main characteristics and scenarios of network usage on the ground, which contributes to creating or updating high-quality networks that meet all modern network requirements. The objectives of the study are to analyze and compare routing algorithms for wireless self-organizing networks, as well as typical mobility models for network nodes.

During the work, the network models were designed, and a series of experiments were conducted under different conditions of network performance, the impact of protocol-dependent and independent parameters of the protocol that affect the operation of the protocols and the efficiency of packet data transmission as a whole. Recommendations on the use of routing protocols in an environment with specific parameters are formed.

The first chapter discusses MANET technologies and their relationship with (the internet of things) that interfere with it by the presence of (Wireless Sensor Network) and MANET applications in vehicles (VANET) and drones (FANET)

The second chapter discusses various types of mobility models in MANET applications. Their classification by cases of implementation is presented, their main properties are described, and a classification is presented regarding their advantages and quality parameters and describe applications.

The third chapter discusses network simulators for modeling networks with dynamically changing topology. The installation process of the network simulator NS-3 is described in detail. The program's capabilities have also been demonstrated, including its additional FlowMonitor analyzer modules and NetAnim animator.

In the fourth chapter, based on the conducted studies, a network model is constructed in the NS-3 simulator. Selected models of the mobility of network nodes and a model of signal propagation, as well as other initial network conditions for analysis and comparison. The results are obtained and graphs of the dependence of the main parameters of the quality of service traffic on the operating conditions of the network and the selected routing protocol are constructed. Recommendations are made on choosing a suitable routing protocol depending on the network operating conditions.

SUMMARY OF WORK

Based on the current dynamics of the development of network infrastructure, self-organizing networks with dynamically changing topology are designed to solve a wide range of tasks

A mobile packet radio network without a fixed infrastructure is called a MANET network see (Figure 2).

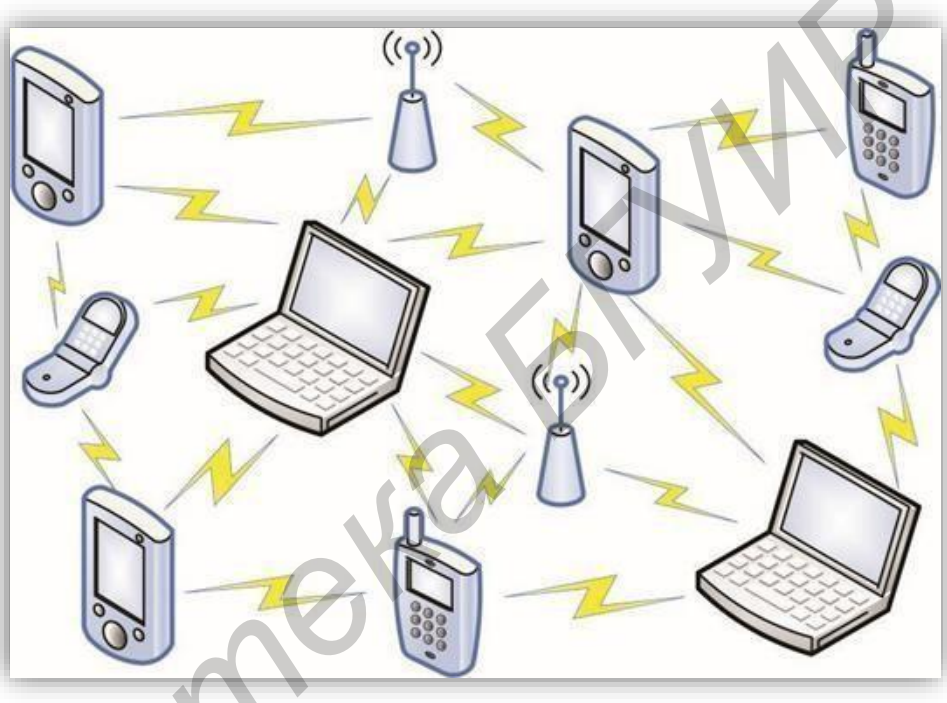

Figure 2 - Basic architecture of the MANET.

Such a network is self-organizing, since its nodes are not only terminal user terminals, but also are relay-routers, relaying packets of other subscribers and participating in finding routes to them, therefore, these networks are capable of selforganization. Such networks can consist of tens, hundreds and even thousands of nodes. Each such device can independently move in any direction and, as a result, often break and establish connections with neighbors. Client devices connect on the fly, forming a network. Each node in the network tries to forward data destined to other nodes. In this case, the determination of which node to send data to is dynamically done based on the connectivity of the network. This is different from wired networks and managed wireless networks, in which routers (in wired networks) or access points (in managed wireless networks) perform the task of managing data flows.

MANET self-organizing networks offer the following advantages over traditional wireless networks:

- The ability to transmit data over long distances without increasing the transmitter power;
- Resistance to changes in the network infrastructure, in the conditions of random dynamic topology;
- The ability to quickly reconfigure in adverse interference conditions; Simplicity and high speed of deployment.

Wireless networks built on the basis of mobile devices have a number of features:

1- Each device in such a network can independently move in any direction, and, as a result, often break and establish connections with neighbors due to interference or switching the node on / off.

2- Each node of the network is involved in the relay procedures of messages

of other subscribers and service information. In this case, the determination of which node to send data to is dynamically done based on the connectivity of the network.

3- The supply of power to mobile nodes can be limited, and therefore, when

designing hardware and protocols, it is also necessary to take into account energy consumption.

Currently, there are several classes of problems in MANET:

- The problem of ensuring noise immunity;
- The problem of ensuring the security of the transmitted data;
- The problem of overall network bandwidth;
- The problem of the effectiveness of the applied routing methods.

Intelligent transport communication networks are a subclass of MANET, where mobile nodes are vehicles, figure 3 .

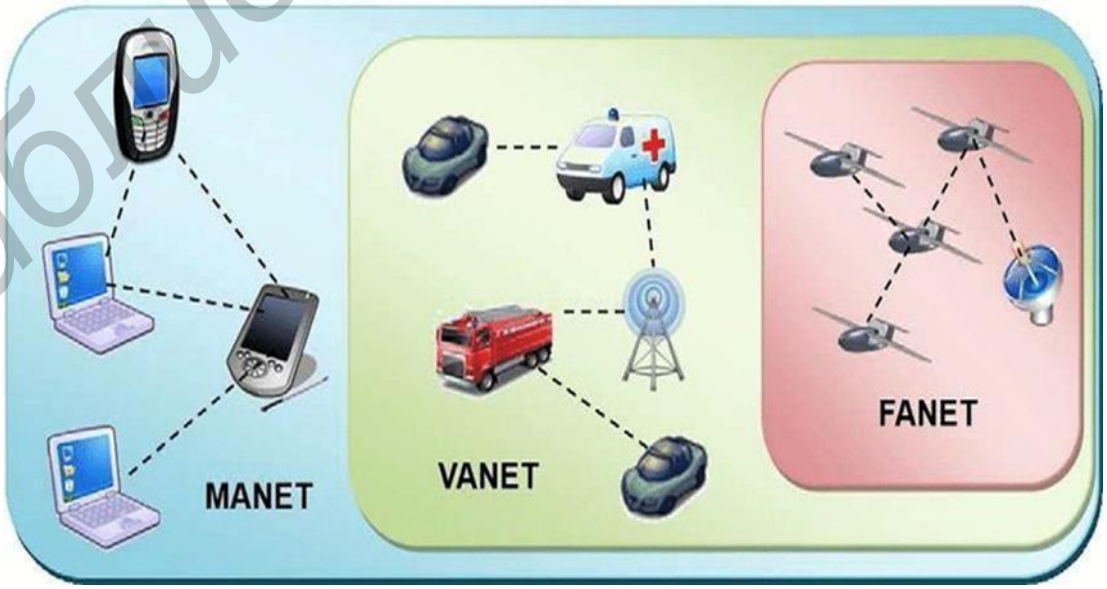

Figure 3 - Explanation of the between (MANET,VANET and FANET).

When developing such networks, the main problems are routing packets from the source node to the destination node, network scalability, maintaining connectivity in a variable topology environment.

Another important aspect in network modeling is the model of node mobility and signal propagation. These factors have a strong influence on the performance of mobile self-organizing networks, for example, the performance of routing protocols. A meaningful protocol evaluation and comparison with other similar protocols cannot be made without using a realistic mobility model. Although the movement of each node is random, there are several more influential points in their mobility models.

The development and selection of a realistic mobility model that truly portrays and predicts node mobility is the first step in mobility management. Based on the mobility model, protocols that take mobility into account at the design stage should be used. Therefore, these protocols, i.e. mobility management schemes can take full advantage of the positive effects of the mobility of network nodes. mobility management is still a relatively under-researched area.

Thus, in general, typical characteristics are characteristic of dynamic networks, which contribute to both a decrease in the quality parameters and an increase.

During the work, mobility models and routing protocols are presented. A brief overview of the popular network simulators used in the scientific community is given, they investigated the ability to support certain models of mobility of network nodes and various routing protocols of self-organizing networks, as a result, a network simulator with open code NS-3 was chosen as the most suitable for the conditions. For research, a mobility model based on the Gaussian-Markov law, random waypoints (Random Waypoint Mobility Model) and a mobility model of arbitrary direction (Random Direction Mobility Model) were selected. A series of experiments was conducted with various external factors: the number of network nodes, the speed of the nodes, as well as the speed and protocols of data transfer varied. Moreover, to assess the performance of the environment, depending on the density parameters of the network nodes, a model of the movement of nodes with their similar movement was used, the method and way of transmitting data and the number of receiving nodes. During the simulations, the main protocol-dependent parameters for evaluating the quality of service traffic (packet delivery coefficient (PDR), throughput (Delay), delayed data (Delay), and jitter values (Jitter)) were calculated.

The performance of the AODV reactive protocol is better in networks with static traffic, with a relatively small number of flows from source to destination. The protocol uses less resources than the proactive OLSR and DSDV protocols because the messages required to establish and maintain network routes use less bandwidth. But in situations in which communication lines break off quite often, the protocol uses a significantly larger bandwidth. In networks with low mobility, communication lines are not broken so often, control messages are minimal, so bandwidth and power consumption are

significantly reduced, making the AODV protocol more suitable for implementing a network with critical resources and bandwidth, critical situations.

Proactive protocols (OLSR, DSDV) are more effective when implemented in networks with high density and highly sporadic traffic. But the best situation for this type of protocol is an environment with a large number of nodes. Although, in turn, these protocols require a certain amount of bandwidth, to receive network topology update messages.

As for the delays in data transmission, for proactive protocols, the route establishment time is not a critical factor, these protocols support various routing tables containing information on the network topology, which allows routes to be found at any time without resorting to path search mechanisms, at that time how reactive protocols (AODVs) require starting the route finding process every time route information is needed, which takes a certain amount of time. The effect of delays in networks with reactive protocols is more noticeable with a low density of network nodes. The protocol sends several requests before finding the correct route.

Also, with increasing speed in the same network, the degree of packet delivery (PDR) decreases as the speed increases. At low speeds, communication links between nodes will be less likely to break, leading to high levels of packet delivery.

CONCLUSION

In the course of work the analysis of mobility patterns and routing protocols used in the ad-hoc network applications, a brief overview of the most popular network simulators used in the scientific community from the standpoint of their functionality to support certain mobility patterns of the network nodes and various routing protocols are designed and the procedure of installation and configuration of network simulator NS-3 for simulation of network applications.

Mobility models based on the Gauss-Markov mobility model (GMM), random waypoint mobility model (RWM) and random direction mobility model (RDM) and three types of routing protocols AODV, OLSR and DSDV were used for the research.

A series of experiments were carried out depending on the number of network nodes, the speed of movement of nodes, as well as the speed and protocols of data transmission. In addition, to assess the performance of the environment depending on the parameters of the density of network nodes, a model of the movement of nodes at their initial movement, the method and direction of data transmission and the number of receiving nodes was used. During the simulation, the main Protocol-dependent parameters of traffic service quality assessment: packet delivery factor (PDR), throughput (Throughput), data transmission delays (Delay), jitter values (Jitter) were calculated.

The complex analysis of parameters of quality of service concerning investigated protocols of routing, loading of a network, nodal density of a network and speed of movement of nodes is carried out. On the basis of the analysis, specific recommendations were developed for the application of the considered routing methods depending on the conditions of the network operation.

The developed simulation model based on the network simulator NS-3 and the results of test experiments show the possibility of its use in solving educational, scientific and engineering problems associated with the assessment of network performance for more complex network models and optimization of its functioning on various parameters of service quality on the territory with different degrees of coverage and connectivity of mobile nodes.

LIST OF PUBLISHED WORKS

1-M. Mozahim Shakir. Mobility models in mobile ad hoc networks/ M. Mozahim Shakir, Vladislav Belan, Nouri Zaid Ihsan Nauri , M.Y. Homenok - Ph.D., Associate Professor//54th scientific conference of graduate students, undergraduates, and students of BSUIR, 2018, Minsk.

2-M. Mozahim Shakir. Modeling of the MANET network in the simulator NS-3 / V.A. Belan, M. Mozahim Shakir, M.Y. Homenok // Telecommunications: networks and technologies (Minsk, May 2018) - Minsk: BSUIR, 2018.-- 20 c.

3-M. Mozahim Shakir. Simulation in the NS-3 simulator of the MANET network based on the AODV and DSDV routing protocols / V.A. Belan, M. Mozahim Shakir, M.Y. Homenok // Coding and digital signal processing in info communications (April 4, 2019, Minsk) - Minsk: BSUIR, 2019.-- 123 c.