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# Media Access Control Protocol Modelling for Mobile Sensor Network- Using OMNeT++ -MiXiM Network Simulator

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## *Abstract*

***Wireless Sensor Network (WSN) consist of large number of battery operated sensing and computing devices deployed randomly for monitoring applications. With the advent of new technologies WSNs are providing a new class of information to human beings. In most cases the networks were stationary but as a evolutionary step the WSNs have to consider mobility. This new class of sensor networks is Mobile Wireless Sensor Networks. Eg moving robots, surveillance aircrafts. Nodes share a single channel for communication. To share communication channel, establishment of a MAC protocol is required in the sensor nodes. The objective of the MAC protocol is to regulate access of the shared wireless medium, so that the performance requirements of the underlying application are satisfied. Energy efficiency and Mobility are big challenges for Medium Access Control protocol design to give a reliable communication. Paper describes a Mobility aware MAC protocol, implemented using OMNeT++ network simulator. OMNeT++ is open source discrete event simulator. Mixim is 'mixed simulator', developed for wireless and mobile simulations in OMNeT++.***

## 1 Introduction

A Wireless Sensor Network (WSN) is a special type of ad hoc network which consists of a large number of nodes equipped with different sensing devices. These nodes are deployed without careful planning. A Sensor node is a device which converts a sensed attribute into a user understandable form. Such device includes sensing module, a communication module, memory and a small battery. Various functions such as such as sensing, communication, and processing are included it. These networks are widely used in the fields of environmental monitoring, military etc. WSN applications have strong Constraints regarding power resources and computational capacity. There are four basic components in a sensor network:

- An assembly of distributed or localized sensors;
- An interconnecting network (usually, but not always, wireless-based);
- A central point of information clustering;
- A set of computing resources at the central point (or beyond) to handle data correlation, event trending, status querying, and data mining.

As the applications increased there was a need of new class of sensor networks, Which gave rise to Mobile wireless sensor networks (MSN[1]. Sensor networks are used in air (aircrafts), ocean monitoring, automobiles, robotics, environmental monitoring and many other. All these applications need some mechanisms to enable their motion in space. Since these are sensor networks they have constraints for energy and processing limitations. There are many classes of MSN.

- High mobility- in cars, airplanes devices move with high speed.
- Mostly static- Here moving velocity of devices is comparatively slow, like moving supervising cameras,
- Hybrid- It is the combination of both classes like aircraft which has sensors attached inside as well as outside.

The advantages of MSNs over WSNs are

- Coverage- since nodes are moving the coverage is dynamic.
- Data routing – failed nodes are replaced by moving nodes and all paths are operational.
- Data mulling – data can be collected from out of range stationary nodes.
- User access points.- devices which are out of range from the network can be accessed.
- Intermediate data is processed by conducting a processing of ad hoc network.

The conservation of energy and computation resources are the additional dimensions added to be included in protocol stack. The limited processing power, memory and battery life of the nodes introduces many challenges in design of MSN. The protocols needs to show the good performance and should be effective in stationary as well as mobile scenarios. The protocols is said to be working efficiently only when it is energy efficient in stationary scenario as well as it gives a satisfactory performance over mobile scenario.

The main objective of most MAC-layer protocols is to reduce energy waste. Energy is wasted due to collisions, idle listening, overhearing, and excessive overhead. These protocols can be divided into two main groups: schedule- and contention-based MAC-layer protocols. Schedule-based protocols come under the class of deterministic MAC-layer protocols. Here access to the channel is based on a schedule. Channel access is limited to one sensor node at a time. In this pre allocation of resources to individual sensor nodes is done. Contention-based MAC-layer protocols avoid pre allocation of resources to individual sensors. Single radio channel

is shared by all nodes and allocated on demand. To share communication channel the establishment of a MAC protocol is required in the sensor nodes. The objective of the MAC protocol is to regulate access of the shared wireless medium, so that the performance requirements of the underlying application are satisfied. Energy management is very important key design issue in sensor networks. The MAC protocol design is mainly focused on energy efficiency. Most protocols are designed with consideration that nodes are stationary. These protocols degrade in performance when they are applied in mobile environment.

### 1.1 Problems Due to Mobility

The mobility of nodes has introduced unique challenges in aspects like resource management, coverage, routing protocols, security. The mobility should be efficiently handled in all the layers of sensor network protocol stack.

The MSN has same stationary counter parts as that of WSNs. So they are having same constraints for energy and processing limitations. Additionally, it has to consider the mobility. The energy consumption is more in mobile nodes as compared to the stationary nodes.

As mobility is introduced in sensor networks it introduces certain issues[1]

- Space and time has to be considered while collecting data.
- Data processing has to take into account user and phenomenon mobility.
- On demand reconfiguration has to consider sensor positioning
- Effective and versatile positioning system is necessary.
- Multimodal and multi querying capacity has to present in the sensor network.

The major impacts the mobility makes in WSN are in the area of Topology management and Energy management. When nodes keep moving, topology management is responsible for the node connectivity and routing of nodes to the sink.

Implementation of Mobility aware MAC protocol is described in the paper.

The paper is organized as follows 2] General OMNeT++ and MiXiM framework. 3] Mobility aware MAC protocol. 4] Performance analysis of mobile sensor network.

## 2 OMNeT++ and MiXiM framework[2]

OMNeT++ is a discrete event simulator for studying protocols for wired and wireless networks. OMNeT++ is designed to model the communication network and distributed systems. The important part of OMNeT++ is the Eclipse based simulation IDE. Simulation IDE is customized eclipse instance. From IDE one can design simulation models. It has simulation configuration editor, C++ build support a simulation launcher which is capable of running simulation in batches. Results can be plotted and analysed by a analyser tool. Simulation results can be observed on sequence chart.

In OMNeT++ simulations the nodes communicate with each other by means of messages. The entities in OMNeT++ are implemented by means of components and these components can have the hierarchical structure[8]. The system is modelled by a Network Definition file NED file. NED file contains the description of network in terms of simple module and compound module. Simple module is the lowest level in hierarchy. The INI file is very important file where all the parameters of the network are defined. The OMNeT++ general hierarchy is as shown in the fig 1.

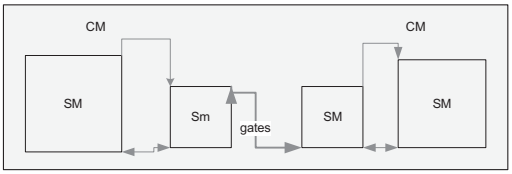


Fig.1 Module Hierarchy SM- simple module, CM- compound module.

The gates are input and output interfaces of the modules. The messages are sent through output gates and arrived at input gates. The series of connections from source to sink is called as routes.

B The wireless scenarios are bit complex since it requires in depth knowledge of networks and it is tedious to make the sound analysis. Mixim is 'mixed simulator' is developed for wireless and mobile simulations in OMNeT++. MiXiM supports wireless and mobile simulations. It provides detailed models of the wireless channel (fading), wireless connectivity, mobility models like constant speed, rectangular, circular mobility. Also it provides models for obstacles and many communication protocols mainly at the Medium Access Control (MAC) level. Furthermore, it provides a user-friendly graphical representation of wireless and mobile networks, support debugging. MiXiM has a powerful and feature rich tool box because of which the user can simulate and study the performance analysis of wireless networks. The specialty of MiXiM is such that is tries to hide the complexity of such simulations and user gets a clean and easy user interface.

Most of the simulators provide single frequency and single antenna systems, MiXiM has rich library of protocols and modules also it has supporting infrastructure. MiXiM can support simulation of networks consisting up to 1000 nodes.

Node module is as shown in the fig 2.

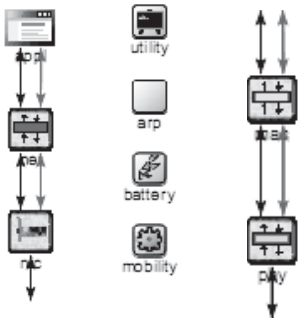


Fig 2 Node module

Node is compound module consisting of application layer, network layer, physical layer and MAC layer.The layers are connected via gates. 1st pair of gates is for passing up and down data messages and control messages between the nodes and 2nd pair is used to exchange control messages between nodes.It is important to note that the MAC and physical layer are grouped into NIC [ network interface card module)card. Node with IEEE 802.11 NIC is used for simulation.

# 3 Mobility Aware Mac Protocol

A MAC protocol design is a key issue in successful working of a Wireless network. The MAC protocol design for wireless sensor networks has many challenges, like constraint for energy resources, strict wireless bandwidth, channel utilization. Due to these issues the network topology and network scalability handling becomes a major problem. In wireless sensor networks, mobile or stationary; the nodes can fail or new nodes join the network. Also in mobile networks the nodes move from their locations due to motion of the medium or by electro mechanical mechanisms designed for their motion[3]. When nodes move the topology of the network changes so the protocol has to accommodate the topology changes. In following session some of the mobility issues are discussed.

## 3.1 A Mobility handling

MAC protocol for MSNs should take care of collisions, packet loss, resolution. Also it should give acceptable energy efficiency, throughput and robustness even when nodes are moving[8]. Some factors which are considered while designing MAC protocol[1].

- Moving nodes result in errors of synchronization and frame errors. MAC protocol needs to cope up these errors by adjusting frame time. The connections should be faster in the network.
- MAC protocol should be able to adapt the schedule according to Mobility conditions in the network.
- As mobility increases, probability of collisions increases which result in retransmission which in turn results in high energy consumption. MAC protocol should have means to use mobility information to avoid collisions.
- Mobility information of node and its neighbours should be periodically circulated. This increases overhead in the network in the form of control messages. To reduce this mobility information in the form of common control messages should be made common to all layers.
- Choice of mobility model should be such that it applies to real life.

## 3.2 Mobility Model:-

Mobility model used is constant speed mobility[2]. In this nodes move with constant speed and random direction from one location to another location[10]. The mobility module is responsible for the movement of the node or object. Mobility and connectivity handling is main task of MiXiM framework. Each entity has a mobility sub-module which is responsible for movement of the node. And base mobility module is responsible for giving the graphical representation of an entity. Due to motion of nodes the links are created or failed. Connection make or brake is handled by Connection Manager module.

# 4 Performance Analysis:-

The MSN was modelled with the help of OMNeT++. The set of experiments include 5nodes. The experiment is simulated on playground size 250m*250m. traffic is generated by sensor nodes. The simulation is run for 50 secs. The simulation parameters are as follows

Table 1 – Simulation Parameters

| No of nodes. | 5 |
|---|---|
| Node NIC | 802.11 |
| Connection manager Carrier frequency | 2.142e9Hz |
| P Max | 100mW |
| MAC header length | 272bits |
| MAC queue length | 14 |
| MAC bit rate | 2E+6bps |
| MAC tx power | 100mW |
| Mobility type | Constant speed |
| Node header length | 32bits |
| Thermal noise | -100dBM |

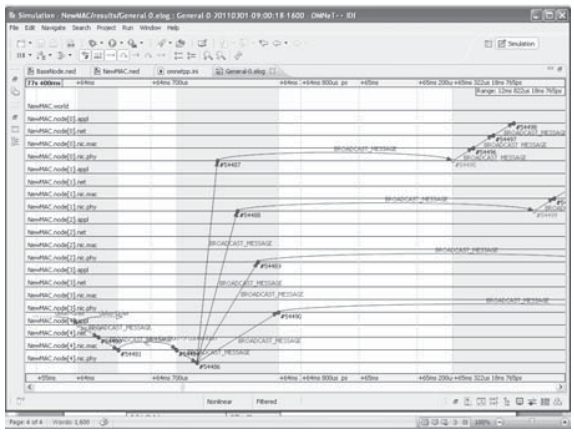

Fig 3 Transmission of Packet

Refer fig for layer wise transmission of packets. First broadcast packet is sent. Then nodes then sends RTS, CTS packet and data.

The contention period for each node is different, refer fig 4. After contention node gets access to channel and then it sends packet. Messages broadcasted, received and movement of node can be observed. 'Transmission over' is indicated after successful transfer of packet.. Event number s are indicated by #.

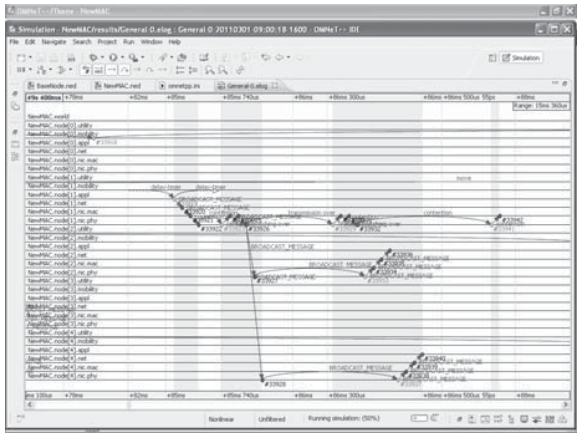

Fig 4. Contention and channel access.

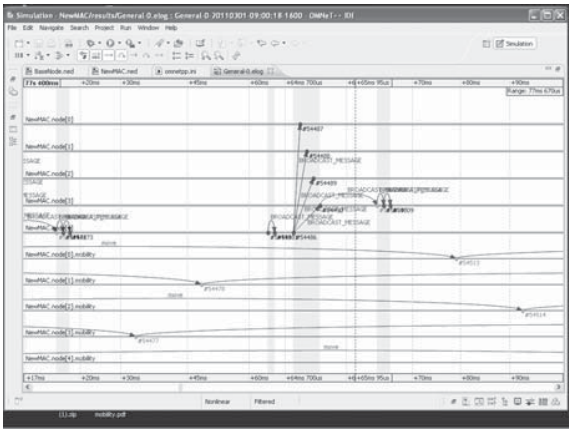

Fig. 5 MAC layer of node 3

The overall MAC layer performance of node3 is indicated in fig5. The contention, transmission and movement of node.

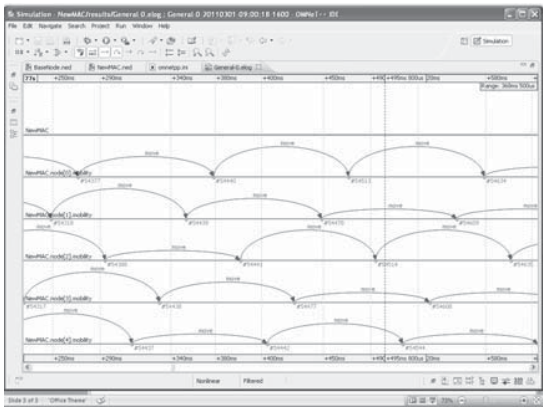

Fig. 6 Movement of nodes with constant speed mobility

Node movement is indicated as 'move' refer fig6. The nodes move with constant speed mobility which is similar to random waypoint mobility model[10]. From the simulation results we can see the data transfer of the messages. It is observed as mobility of the nodes increases the average packet delay increases.

When the nodes are moving it affects the overall energy consumption but the added advantage is it dynamically covers all the area under observation.

## 5 Conclusion

The advancement of WSNs lead to new class of WSNs called as Mobile sensor networks (MSNs). In MSN nodes are moving in order to cover the geographical area under observation. They are used in robotics, military, habitat monitoring and surveillance applications. Mobile sensor network, modelled using OMNeT++ network simulator and MiXiM framework. Energy consumption, efficient use of processing power were the considerations for MAC but now it has to consider the mobility. Few parameters of MSN are studied in the paper.

And it has been observed that the average energy consumption increases as mobility increases.

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