Evaluate the Effect of Mobility in Mobile Sensor Networks

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Abstract: ***Wireless Sensor Networks (WSNs) are emerging area of research. Improving routing mechanism is a fundamental challenge of WSNs. One possible solution consists in making use of mobility in WSNs. Routing in mobile WSNs becomes more difficult because of the frequent path failures and unpredictable topology changes, which may increase packet loss and packet delay. Mostly the existing comparative studies consider only one mobility model for evaluating routing protocols. One mobility model does not replicate the true behavior of a protocol; therefore in this paper we have evaluated the selected protocols with two different mobility models.***

Keywords: Wireless Sensor Networks, MWSNs, Mobility, Routing Protocol.

1. Introduction

WSN is a technology which has capability to change many of the Information Communication aspects in the upcoming era. From the last decade WSNs is gaining magnetic attention by the researchers, academician, industry, military and other ones due to large scope of research, technical growth and nature of applications etc. WSNs is a wireless network consisting of spatially distributed autonomous devices using wireless sensors [see in fig 1]to cooperatively monitoring and collecting data, assessing and evaluating the information, measuring the relevant quantities, formulating meaningful user interfaces, and performing decision-making and alarm functions. Sensors usually compose of four basic units: a processing unit with limited computational power and limited memory, a sensing unit/sensors (including specific conditioning circuitry), a communication unit (transceiver), and a power unit (battery) [1] [2].

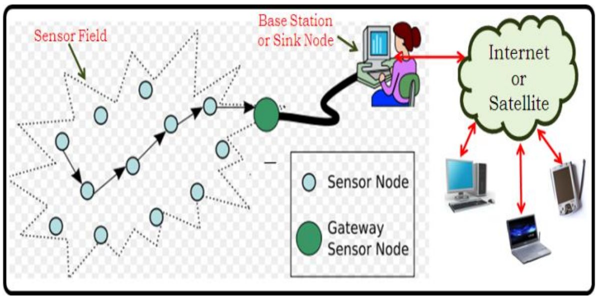

Figure 1: Network View of WSNs

The sensor networks can be used for various application areas relating to critical infrastructure protection and security, health care, the environment, energy, fire detection traffic monitoring, food safety, production processing, quality of life, home monitoring, object tracking etc.. For different application areas, there are different technical issues that researchers are currently resolving. Wireless sensor networks (WSNs) have become more and more prospective in human life during the past decade [3]. However, there are still some critical issues proved to be difficult to be achieved in static WSNs, e.g., long network lifetime and reliable network connectivity. With the help of mobility, mobile wireless sensor networks (MWSNs) have some natural advantages for overcoming these critical issues [4]. In addition, more and more exciting and complex applications require WSNs to be mobile rather than static, e.g., the smart transport system, security system, social interaction, miscellaneous scenarios [5].

Previous studies mostly consider evaluation based on static networks. There are various applications where nodes are mobile and needs due consideration [1-3]. The paper is organized in five sections. Section 2 presents the related work. Section 3 explains the MWSNs strategy. Section 4 presents the simulation results, and Section 5 concludes the paper.

2. Related Work

Mobility in Wireless Sensor Network is an emerging research area. In this section, we briefly survey the existing routing protocols that are designed to support mobility on WSNs. Different approaches towards application of mobile devices in WSNs have been explored in detail in [6]. In [7] author presents the mobility management for IP-based next generation mobile networks with their challenge and perspective. Classical and swarm intelligence based routing protocols for wireless sensor networks: A survey and comparison [8] . We focus on tools available for simulation of WSN and it is found that simulation of WSNs is discussed in several research contributions, such as [9] [10]. Authors of a research contribution [11] [12] present an exploratory study of existing experimental tools for WSNs. Here we explain some of the main applications of mobile sensor nodes and also mobility models to simulate the mobility patterns in WSN simulators CLARITY [13] Centre for Sensor Web Technology in Ireland is currently constructing a ubiquitous robotics testbed by integrating a collective of mobile robots with a WSN and a number of portable devices. Orbitlab [14] is short for Open-Access Research Testbed for Next-Generation Wireless Networks (including WSN also). It supports virtual mobility for mobile network protocol and application research. One of the central goals in WSNs is the design of energy-efficient protocols, optimized to maintain connectivity and maximize network lifetime. Usually, the connectivity condition is met by deploying a sufficient number of sensors or using specialized nodes with long-range capabilities to maintain a connected graph. Network lifetime is related to how long the power sources in network nodes will last [15].

Y.Y Shih et al. [16] 2013 proposed a scheme that exploits the regularity to improve the data delivery ratio in ZigBee wireless sensor networks. Qian Dong et al. [17] 2013 did a survey of mobility estimation and mobility supporting protocols in wireless sensor networks. They explored the difficulties caused by mobility at various layers, particularly, at the MAC layer. F. E. Moukaddem et al. [18] 2013 proposed a holistic approach to minimize the total energy consumed by both mobility of relays and wireless transmissions. J. Luo et al. [19] 2010 built a unified framework to analyze the maximizing network lifetime (MNL) problem in WSNs. Their investigation, based on a graph model, jointly considers sink mobility and routing for lifetime maximization.

In [20], authors have shown that mobility models can affect to performance matrices of routing protocol. Also to comprehensively simulate a newly proposed protocol for mobile sensor networks, it is recommended to check the performance of the protocol with multiple mobility models . In [21], authors highlighted the importance of underlying mobility models and simulated the results for different mobility models. In [22] authors investigated impact of mobility models on performance of specific network protocol or application and different routing protocols were evaluated under different mobility patterns. So ranking of routing protocols is dependent on the selection of the mobility pattern. In [23], the authors simulated same protocol for different mobility models and concluded that performance of protocol is not only affected by different mobility models but also by different parameters of same mobility model. Moreover, a routing protocol should be simulated for mobility model that closely resemblances its real world application. Hierarchical routing protocols are extensively tested for ad hoc networks [24-33].

Raghuvanshi and Tiwari [34] have used Qualnet for measuring performance of AODV and DYnamic MANET On-demand (DYMO) protocols over static WSN for parameters like throughput and delay. Q. Ren et al. [35] 2012 studied the problem of processing aggregation queries over a large scale MSN with the group mobility model. X.Li et al. [36] 2012 proposed a novel Deterministic Dynamic Beacon Mobility Scheduling (DREAMS) algorithm, without requiring any prior knowledge of the sensory field.

3. Mobile Wireless Sensor Networks (MWSNs)

In recent years, mobility has become an important area of research for the WSN community. A mobile wireless sensor network consists of sensor nodes that have the ability to move within the network [37]. Preliminary studies show that introducing mobility in wireless sensor network is advantageous [38, 39]. Mobility can be achieved by equipping the sensor nodes with mobilizers for changing their locations or the sensors can be made to self propel via springs [40] or wheels or they can be attached to transporters like vehicles, animals, robots etc. Sometimes the sensor nodes may move due to the environment (ocean or air) in which they are placed. The recent year researches prove that mobile wireless sensor networks outperform the static wireless sensor networks as they offer the following advantages:

- MWSN has a dynamic topology which reflects in the choice of other characteristic properties such as routing, MAC level protocols and physical characteristics.
- In static WSN, an initially connected network can turn into a set of disconnected subnet works due to hardware failure or energy depletion but in MWSN, the nodes can The lifetime of a sensor network can be increased using mobile sensor nodes .
- Mobile sensors can relocate after initial deployment to achieve the desired density requirement and to reduce the energy holes in the network.
- Mobility can reduce energy consumption during communication.
- MWSN has more channel capacity as compared to static WSN.
- Better targeting can be achieved using MWSN.
- Data fidelity can be achieved by MWSN by reducing the number of hops owing to which the probability of error decreases etc.

In WSNs mobility can appear in three main forms according to ref. [41].

• Node Mobility
Wireless sensors nodes are mobile in this context, the meaning of such mobility is highly application dependent. Node mobility implies that the network has to reorganize itself frequently, i.e., the logical topology of the network will change if just one of its members change its logical link due to a location change.

• Sink Mobility
Sink mobility refers to mobile information sinks, which can be considered as a special case of node mobility. The challenge is then the design choice for the appropriate protocol layers to support mobile sinks requesting data at a starting location and completing its interaction at a different location requiring the use of different network resources.

• Event Mobility
This is a quite uncommon form of mobility. Event mobility refers to applications where event detection is required, particularly in tracking applications.

3.1 Importance of Mobility

The main reason for which mobility was introduced in WSNs is to reduce the number of hops required to deliver data from sensor nodes to the base station. Thus, reducing the delay and prolonging the network lifetime by reducing the amount of energy required to send and receive messages. Therefore, it can be concluded that the routing protocol used when introducing mobility to WSNs has a great impact on the network performance [42, 43]. According to Reddy et. al. [42], two schemes must be considered when studying mobility in WSNs namely, location management and handoff management. Another issue to be considered when studying mobility is how to model the mobility pattern adopted by the network. According to [44], two schemes can be considered to model nodes mobility through simulation.

3.2 Mobility Management Issues

Mobility management involves functionality that aims at achieving continuous connectivity with maximum packet delivery, minimal packet loss and latency. The functions need to tackle the issues of routing, including route optimization in the access network, Fast handover with context transfer, Location (of dormant nodes), multi homing, Security – key management and (re)authentication, Auto configuration and addressing, cross-layer interactions (e.g., to support QoS or location-aware applications), and media access control. For nodes that do not participate in routing, mobility management needs to be considered as a primary function by itself [45].

3.3 Mobility Models

Mobility models consist of two different types of dependencies such as spatial and temporal dependency. Mobility of a node may be constrained and limited by the physical laws of acceleration, velocity and rate of change of direction. Spatial dependence is a measure of node mobility direction. Two nodes moving in same direction have high spatial dependency. The current velocity of a mobile node may depend on its previous velocity. The velocities of single node at different time slots are correlated. This mobility characteristic is called as the temporal dependency of velocity [46].

Frequently used mobility models includes Random waypoint, Manhattan, Gauss Markov, Reference point group mobility model (RPGM). We evaluate the performance of two popular mobility models i.e. Random Waypoint and Manhattan with PDR parameter using two different routing protocols.

3.4 Routing Protocols

Routing is a process of determining a path between source and destination upon request of data transmission. Routing is a very challenging task in WSNs due to several characteristics that distinguish them from other communication networks & wireless Ad-hoc networks. Performance of routing protocol closely related to architectural model [47,48].

- First, due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high.
- Second, in contrast to typical communication networks, almost all applications of sensor networks require the flow of sensed data from multiple sources to a particular BS.
- Third, sensor nodes are tightly constrained in terms of energy, processing, and storage capacities. Thus, they require careful resource management.
- Fourth, in most application scenarios, nodes in WSNs are generally stationary after deployment except for, may be, a few mobile nodes.
- Fifth, sensor networks are application specific, i.e., design requirements of a sensor network change with application.
- Sixth, position awareness of sensor nodes is important since data collection is normally based on the location.
- Finally, data collected by many sensors in WSNs is typically based on common phenomena; hence there is a high probability that this data has some redundancy.

Summary: We have used one proactive Destination-Sequenced Distance-Vector (DSDV) routing protocol and one reactive Ad Hoc On-Demand Distance Vector (AODV) routing protocol for implementation. With this study it is evident that there is a need for detailed assessment & investigation in the routing mechanism aspects of MWSNs in order to enhance the performance under various scenarios.

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4. Methodology, Experiments & Results

In this section we have used mixed method approach that includes both qualitative and quantitative as shown in fig 2

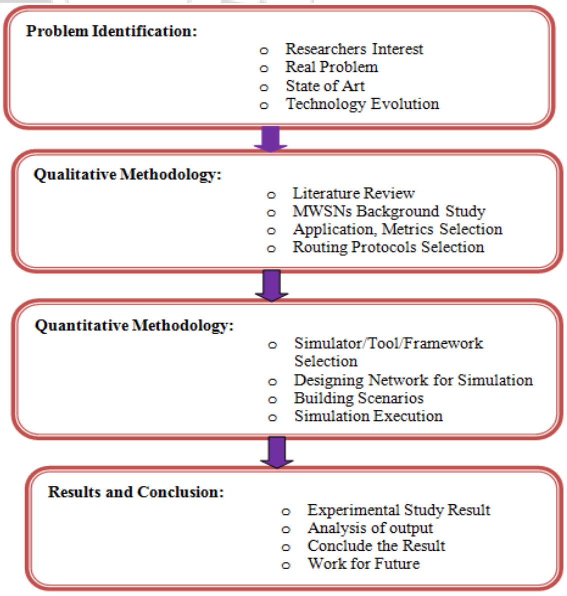

Figure 2: The Research Design Methodology

4.1 Simulation Environment

All the simulations are done in NS 2.34[47] on Fedora 17 Linux platform. The reason for using this simulator is that it is suitable for simulations of wireless sensor networks and moreover it supports various mobility models. In this environment a sensor network can be built with many of the same set of protocols and characteristics as those available in the real world. The mobile networking environment in NS-2 includes support for each of the paradigms and protocols.

4.1.1 Architectural View of NS

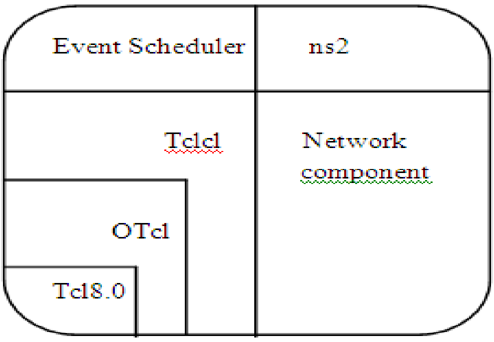

Figure 3: Architecture of Network Simulator

Figure 3 shows the general architecture of NS. In this figure a general user can be thought of standing at the left bottom corner, designing and running simulation in the TCL using the simulator object in the OTcl library. The event schedulers and the most of the network components are implemented in the C++ and available to OTcl through an OTcl linkage that is implemented using tclcl. The whole thing together makes NS, which is a OO extended TCL interpreter with network simulator libraries. [47]

4.1.2 Simulation Scenario

For simulations, using uniform distribution, 10, 20, 30, 40, 50 nodes were distributed randomly in the network field with 500m × 500m dimensions. Then two selected protocols are implemented with two different mobility models using packet delivery ratio (PDR) performance parameter.

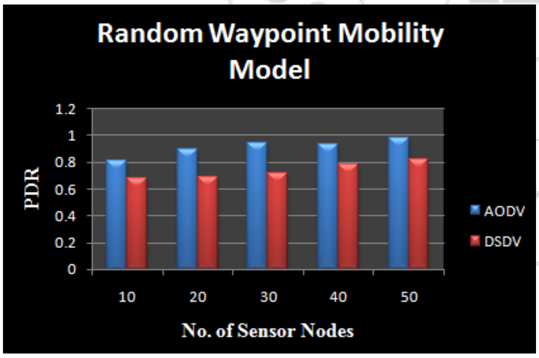

Figure 4: PDR with Random Waypoint Model

The figure 4 shows that the AODV protocol is giving high packet delivery ratio than DSDV with increasing node densities in Random Waypoint Model.

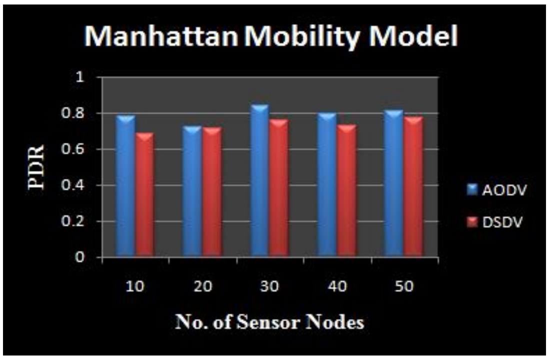

Figure 5: PDR with Manhattan Model

In figure 5 also the AODV protocol gives better performance than DSDV in Manhattan Model.

5. Conclusion

In this paper, we have evaluated the impotence of mobility on routing protocols with two different mobility model in WSNs.

We used two different protocols for the performance analysis and the impact of this method over the selected protocols. We analyzed the performance of the protocols on the basis of Packet Delivery Ratio. PDR of AODV is better than the DSDV. On the basis of performance results, we can conclude that impact of mobility depends upon the selection of routing protocol and nature of mobility models.

In future more wide research is necessary to further increase the life time of network, develop new routing algorithms, and the efficient usage of energy in sensor network using the mobility.

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