WIRELESS SENSOR NETWORKS

Technologies and Routing Protocols

Dr. Md. Zair Hussain
(*Associate Professor*)
Department of Information Technology, Maulana Azad National Urdu University, Hyderabad, Telangana, INDIA.

Dr. Md. Ashraf
(*Associate Professor*)
Department of Computer Science & Engineering, Maulana Azad National Urdu University, Hyderabad, Telangana, INDIA.

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PREFACE

The wireless sensor network (WSN) consists of a large number of sensor nodes, which are extremely small, low power, and low cost miniature devices built using semiconductor manufacturing techniques. They actually sense the physical phenomenon close to the point of their occurrence and enables increasing world instrumentation with increasing accuracy and without the mass of physical intrusion. The nodes communicate over wireless technology using radio frequency or laser approaches. The network collects environmental data which they then forward to an infrastructure processing node. The types of phenomenon that can be sensed include acoustics, light, humidity, temperature, imaging, seismic activity, any physical phenomenon that will cause a transducer to respond.

Wireless sensor networks may either monitor or control systems that may consist of thousands of nodes deployed in very high density. They could be located in homes and buildings, highways and cities, in infrastructures. WSN may be used for monitoring and warning of natural disasters and the affects including floods, winds and other natural phenomenon. They can be used for protecting the homeland in terms of security considerations. They could be used for conducting military surveillance. Military applications could be used for monitoring friendly forces, equipment, ammunition, battlefield surveillance, reconnaissance of opposing forces, and just terrain monitoring. They could be used

for battle damage assessment. They could be used for nuclear, biological and chemical attack detection and reconnaissance. Environmental applications include forest fire detection, bio-complexity mapping of the environment, flood detection, precision agriculture. Health applications include telemonitoring of human physiological data, tracking and monitoring of doctors and patients inside a hospital, and drug administration inside hospitals. Phone applications can include home automation, smart environment control, and home security. Other commercial applications can include environmental control of office buildings, interactive museums, detecting and monitoring of car thefts, managing inventory control, and vehicle tracking and detection.

Wireless sensor networks are constrained by available power resources, by processing speed, by storage capacity, by communication bandwidth, and by the harsh environment in which they function. In order to effectively use the limited energy available, computation costs which are much smaller than the communications cost, is utilized to minimize the amount of information that actually has to be sent. In-network processing is used to aggregate information from various sensors and to summarize that information before communicating and passing it on to the other nodes.vIt is important for wireless sensor networks to be robust because of the dynamic conditions under which they operate. It is important for the lifetime of the system to be maximized. Thus, the systems need to exploit redundancy. The designs for low duty cycle operation allow reconfiguration

so that as either sensors die or are damaged or if other sensors are added to the system, the system can reconfigure and self-configure to avail themselves of the newly active devices. Localized algorithms are used to prevent single points of failure. This is another consideration that is important because the scaling of the wireless sensor network may be either increased as additional sensors are added or decreased as sensors fail over time or are damaged. One of the major challenges for wireless sensor network is to prolong the lifetime of the network. It's important to have an effective hardware design for reliability of the system and for availability of the system. The power management effectiveness determines the endurance and the network operational time. These are very important considerations for the operational lifetime of these networks.

The network topology helps in optimizing communication cost. Clustering will help to reduce the communication cost. Clustering supports different communication patterns like one-to-one, one-to-all, one-to-any, one-to-many, and many-to-one. For the cluster based wireless sensor network, the cluster formation and leader election are the basic issues. The leader of cluster coordinates the communication among the cluster members and manages their data. The leader election problem originally appeared in the token ring networks (Distributed System) for managing the tokens. The leader election problem in both ad hoc networks, and wireless sensor networks is similar, but with the added complexities compared to the distributed systems. Designing the leader election algorithm for the wireless sensor network

is a challenging task due to following reasons:

- The failure rate of nodes is relatively high compared to static wired nodes.
- The transmission range and bandwidth of wireless channels is limited.
- Neighbour configuration is dynamic that is sensor nodes either may join or may leave a cluster during operation.
- Network topology is dynamic.

The leader election becomes even more complex in the wireless sensor network where thousands of sensor nodes are distributed in a region in uncontrolled and unorganized way.

There are many designs for WSNs on the basis of the routing paths established, network structure, the protocol operation and node types. Based on homogeneity and heterogeneity of sensor nodes in area of deployment, clustered and non-clustered routing protocols may be designed.

In homogeneous approach, all nodes are of identical types in the sense of size, shape, hardware configuration and the mode of energy supply. All nodes have the same transmission power (range), transmission data rate and processing capability, the same reliability and security. In heterogeneous approach nodes are of different types in the sense of size, shape, hardware configuration,

processing capability and the mode of energy supply.

A hierarchical multi hop routing protocol for wireless sensor network is dynamic in nature as it can handle the node failures due to power drainage and physical attack. It can also support random deployment of sensor nodes and scalability of the wireless sensor network. For a large wireless sensor network, it is not energy efficient for a one hop communication from the sensor nodes to the base station.

The clustering protocol divides the WSN into virtual groups called clusters. Each group has a cluster head and one or more member nodes. This supports in-network aggregation which increases the life span of WSNs. The clustering protocols have several advantages like scalable, energy efficient in finding routes and easy to manage.

In the non –clustered approach, there is no need to form a cluster of nodes. Each and every node is free to send data to the Base station on its own. Geographic routing is an approach for point-to-point routing in wireless sensor networks. With the recent advancement in design technologies, routing protocols based on virtual co-ordinate system is also one of the energy efficient approaches.

Hence, the research in this book uses the virtual co-ordinate system to develop a homogeneous cluster based multi-hop hierarchical routing protocol in order to

increase the network life.

The book is structured in the following way:

Chapter 1, titled Introduction, introduces wireless sensor networks, its applications and design issues. This chapter describes the This chapter compares geographic routing and routing based on virtual co-ordinate system. The proposed clustering protocol, Multiple Virtual Cord Protocol, considers the lifetime of the network.

Chapter 2 titled Background and Related Work presents an overview of various routing protocols with emphasis on data aggregationsupport for query and scalability of the network. It gives the issue of routing in WSNs and presents the design constraints for routing protocols in wireless sensor network. It also classifies routing protocols in WSN.

Chapter 3, titled Analysis of Existing Routing Protocols in Wireless Sensor Networks, analyzes seven different existing routing protocols namely, mLeach, pathdcs, BVR, ABVCap, PSVC, VCP and greedyHVP in wireless sensor networks on the basis of the lifetime of sensor networks.. It explains the simulation tool and simulation environment used in this dissertation work. The network simulator used is OMNET++. The results of simulation for the protocols are also analyzed.

Chapter 4, titled Multiple Virtual Cords Routing Protocol, presents a homogeneous cluster based multi-

hop hierarchical routing protocol. This routing protocol uses virtual coordinate system since the protocol based on virtual coordinate system shows less energy consumption in comparison with other protocols, which results in increase in the life time of WSNs.

✍ *Dr. Md. ZairHussain*

✍ *Dr. Mohd Ashraf*

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✍ *Dr. Md. ZairHussain*

✍ *Dr. Mohd Ashraf*

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