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WIRELESS SENSOR NETWORKS - FLAT BASED NETWORK STRUCTURE ROUTING PROTOCOLS

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Abstract: Wireless Sensor Networks (WSNs) is a collection of sensor nodes with capability of sensing various types of environmental and physical conditions. The network is composed with an individual number of nodes placed in a wide area and communicates through radio interface. The main object of the WSN is to collect the data from the environment So, different types of routing protocols have been designed to manage various types of routing, power management, data distribution and QoS for WSNs. Routing protocols in WSNs is responsible for maintaining the routes in the network and have to ensure the reliable single-hop or multi-hop communication under the conditions. In this paper, we focused Flat Based network structure routing protocols for WSN and compare their strengths and limitations.

Keywords: Nodes, QoS, Routing Protocols, Flat Based, Single-Hop, Multi-Hop

I. INTRODUCTION

In Twenty first century, a Wireless Sensor Networks is one of the important researches filed in the research community. These networks are composed with small sensor nodes that integrate sensing, wireless communication, and computation. Each sensor node has limited processing capability, storage capacity, and communication bandwidth. A Wireless Sensor Network (WSN) contains number of sensor nodes. These sensors have the ability to communicate either with each other or directly to base station (BS). All the sensor nodes are communicate with limited area through wireless medium (like radio interface) and collaborate to accomplish a common task, for example animal tracking, traffic control, military, environmental conditions[1].

Fig 1 shows a schematic diagram of Wireless Sensor Node components. It made up of four basic components: Sensing unit, Processing unit, Transceiver unit, Power unit and also based on application needs additional components are added such as a Area Finding System, a Power Generator and a Mobilizer. Sensing units are usually composed of two other subunits: Sensors and Analog to Digital Converters (ADCs).

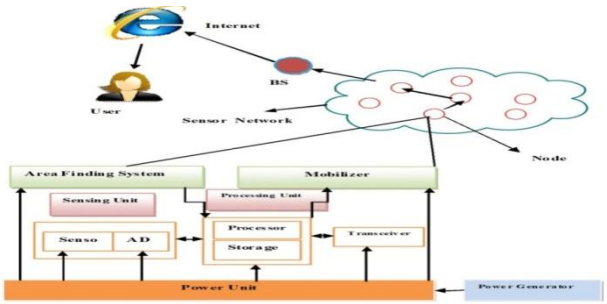


Figure 1: WSN Sensor Node Architecture

The analog signals produced by the sensors based on the observed events are converted to digital signals by the ADC, and then send to the processing unit. The Processing unit, which is generally associated with a small storage unit, manages the procedures that make the sensor node collaborate with the other nodes to carry out the sensing tasks. A Transceiver unit is connected with network. The most important components of a sensor node are the power generator unit. Power units may be supported by a power scavenging unit such as solar cells or environmental energy.

All the above subunits are may need to fit within a small box that is Matchbox-sized modules [2]. The required size of the box may be smaller than even a cubic centimeter [3] which is light enough to remain suspended in the air. Apart from the size, there are also some other constraints for sensor nodes. These nodes must [4]

- Low power consumption
- Operate in high volumetric densities
- Low cost and be dispensable
- Be autonomous and operate unattended
- Be adaptive to the entire environment.

Each sensor nodes communicate among themselves and collecting high quality data information from the physical environment. Each node takes own decision according to its knowledge of its computing, communication, energy resources and information. Each of these individual sensor nodes has the capability to collect and send the data directly to the base station or through other sensor nodes. A BS may be a fixed or mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data. The basic idea in Wireless Sensor Networks is that the capability of each and every node is limited, the aggregate power of the entire network is sufficient for the required mission.

A number of research activities have been carried out to explore and overcome the constraints of WSNs and solve design and application issues. In this paper various network structured routing protocols for wireless sensor network are discussed and compared. Section 2 of the paper listed out the WSN characteristics and design objectives. In Sections 3, the WSN design challenges and routing issues are described. In Section 4, Routing schemes in Wireless Sensor Networks. A

classification of Network Structure Routing Protocols is discussed in Section 5. In Section 6, Flat Based Routing Protocols and its representative protocols. We conclude with final remark in Section 7.

II. WSN CHARACTERISTICS AND DESIGN OBJECTIVES

The characteristics of Wireless Sensor Networks and application requirements have a decisive impact on the network design objectives in term of network capabilities and network performance [5].Wireless Sensor Networks contains the following unique characteristics and constraints [7].(i)Solid Sensor Node Deployment (ii) Battery-powered Sensor Nodes(iii)Severe Energy, Calculations, and Storage Capacity(iv)Self-configurable (v)Data Redundancy (vi) Application Specific and (vii)Frequent Topology Change.
Most of the sensor networks are application specific and have different application requirements. Thus, all or part of the following main design objectives is considered in the design of sensor networks: (i)Fault Tolerant (ii) Scalability (iii)Production Cost (iv)Hardware Constraints (v)Sensor Network Topology(vi)Environment (vii)Transmission Media (viii)Channel Utilization and (ix)Power Consumption.

III. WSN DESIGN CHALLENGES AND ROUTING ISSUES

The WSN routing protocol design is very challenging concept because of several network constraints. WSNs suffer from various limitations of several sensor network resources, for example, storage, power, bandwidth and central processing unit. The sensor networks design concept involves the following main aspects [7][8].

WSN Design Challenges

Node Deployment: Node deployment is based on the application. It deployed either fixed or randomized. Position awareness of sensor nodes is also important, since data collection is normally based on the location.

Limited Energy Consumption: Sensor nodes life is based on battery power. They have limited energy capacity. Energy poses a big challenge for network designers in hostile environments, so they require careful resource management.

***Data Gathering Method*:** The main objective of sensor node is to gather the data from the environment. It can be done in three ways:

- Time-Driven: when the collected data are transmitted based on periodic time in-travels.
- Event-Driven: when sensor nodes react immediately to the incident of a certain event.
- Query-Driven: when sensor nodes respond based on query executed by the BS or another node in the network.

Limited Hardware Resources: Every sensor nodes have limited energy, processing and storage capacities, and thus can perform only limited functionality. These hardware constraints present many challenges in software development and network protocol design for sensor networks.

Node/link Heterogeneity: All sensor nodes were assumed to be sane functionality that is homogeneous but, based on the application, a sensor node can have a different role or capability that is heterogeneous. Even data reading and reporting can be generated from these sensors at different rates, subject to diverse QoS constraints, and can follow multiple data reporting models.

Scalability: WSN network must be able to work with a large number of sensor nodes. So, sensor network routing protocols should be scalable and enough functionalities.

Network Dynamics: In many applications both base station and/or sensor nodes can be moveable. So, while constructing the routing protocol should able to manage the dynamic concept.

Transmission Media: Some common problems are associated with the channel (e.g. Error Rate, Power) may affect the operation of the sensor network. The required bandwidth of sensor data will be low(1–100 kb/s.) One approach to MAC design for sensor networks is to use time-division multiple access (TDMA)-based protocols because it saves more energy than contention-based protocols (like carrier sense multiple access and Bluetooth technology can also be used.

Coverage: WSN network cover only limited physical area of the environment. So, data range and accuracy is limited.

Data Aggregation: Sensor nodes are collecting the data from the physical environment and send it to the base station. Since sensor nodes may generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions is reduced. Data aggregation is the combination of data from sensor nodes according to a certain common aggregation function (e.g. duplicate suppression, minima, maxima and average). This technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols.

Quality of Service: In many applications, conservation of energy is considered relatively more important than the quality of data sent. Hence, as energy is depleted, the network may be required to reduce the quality of results in order to reduce energy dissipation in the nodes (energy-aware routing protocol).Consequently, routing, power management and data dissemination protocols for WSNs must be specifically designed.

IV. ROUTING SCHEMES IN WIRELESS SENSOR NETWORKS

Routing can be defined as a process [7] of finding a path between the source node and the sink or destination node to perform data transmission. In WSNs the network layer is oftenly used to implement the routing of the incoming data. In generally in multi - hop networks concept the source node cannot reach the sink node directly. So, in this time intermediate sensor nodes have to forward their packets to the target (designation) nodes. The formation of routing tables gives the solution. Routing table is the task of the routing algorithm along with the help of the routing protocol for their construction and maintenance.
According to the previous research work WSN Routing Protocols can be classified [9] into five, based on the way of establishing the routing paths, based on the network structure, based on the protocol operation, based on the initiator of communications, and based on how a protocol chooses a next

- hop on the route of the forwarded message?, as shown in Figure 2.

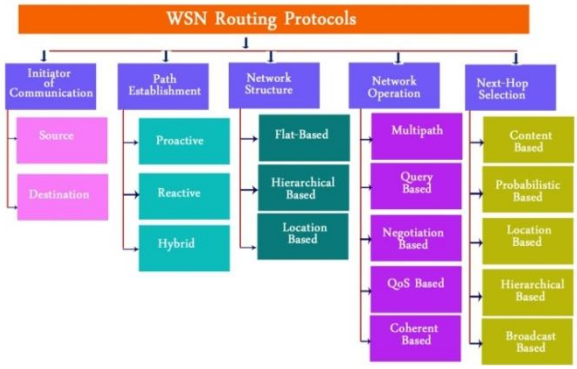


Figure2: WSN Routing Protocols

V. NETWORK STRUCTURE ROUTING PROTOCOLS

Classification of routing protocols in Wireless Sensor Networks is done in different levels based on either application or network structure. The Network structure routing protocols, which can be divided into two groups (i) Base Station Characteristics (ii) Sensor Node Characteristics. According to the characteristics the protocols classified in to three groups. Flat Based, Hierarchical based and Location based. Table 1 show all the major representative protocols which is used for network structure.

Table I: Routing Protocols for WSN (Under the Network Structure)

Category	Representative Protocols
Flat Based	SPIN, Directed Diffusion, Rumor Routing, GBR, MCFA, CADR, COUGAR, ACQUIRE, EAR
Hierarchical	LEACH, TEEN & APTEEN, PEGASIS, MECN & SMECN, HPAR, VGA, Sensor Aggregate, TTDD,
Location Based	GAF, GEAR, SPAN, MFR, GEDIR, GOAFR

VI. FLAT BASED ROUTING PROTOCOLS

These routing protocols are the multihop flat routing protocols. In flat networks, each node plays the same role and sensor nodes collaborate to perform the sensing task. Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This consideration has led to data centric routing, where the BS sends queries to certain regions and waits for data from the sensors located in the selected regions. Here we summarize these protocols and highlight their advantages and their performance issues.

SPIN (Sensor Protocols for Information via Negotiation): Heinzelman et.al. in 10] proposed a family of adaptive protocols called Sensor Protocols for Information via Negotiation (SPIN) that distribute all the information at each node to every node in the network that is each node in that network potentially acted as a base station. This enables a user to query any node and get the required information immediately. SPIN uses three types of messages, ADV, REQ and DATA. Fig 3 shows SPIN message communications.

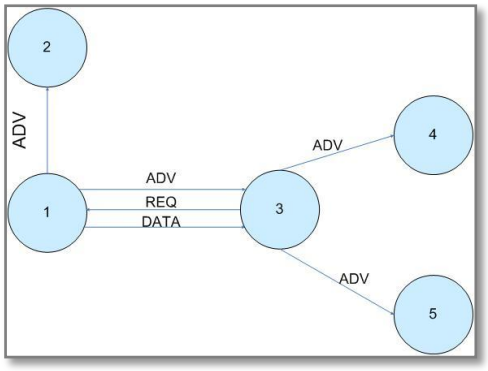
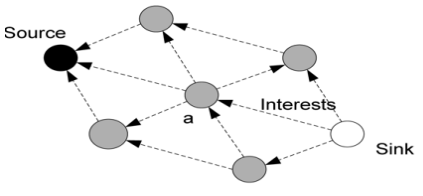


Figure3: SPIN Protocol

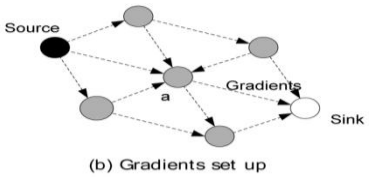
The ADV message is broadcasted by a node which has some data. This message will say about type of data contained by the advertising node. Interested nodes which got the ADV message send REQ message requesting for the data. The node having the data sends the data to the interested nodes. The nodes after receiving data send ADV message, and the process continues.

Directed Diffusion: In [11], C. Intanagonwiwat et. al. proposed a popular data aggregation model for WSNs, called directed diffusion. Directed diffusion is a data-centric (DC) in the sense sensor nodes are generated data based on the environment is named by attribute value pair. The idea of the DC protocol is to combine the data coming from diffusion sources enroute by removing redundancy data, minimizing the number of transmissions; thus saving network energy and prolonging its lifetime. DC routing finds routes from multiple sources to a single destination that allows in-network consolidation of redundant data.

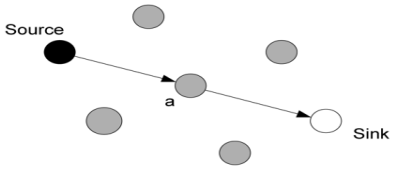
Figure4 shows an example of the working of directed diffusion ((a) sending interests, (b) building gradients, and (c) data dissemination). When interests fit gradients, paths of information flow are formed from multiple paths and then the best paths are reinforced so as to prevent further flooding according to a local rule. In order to reduce communication costs, data is aggregated on the way. The goal is to find a good aggregation tree which gets the data from source nodes to the BS. The Base Station frequently refreshes and re-sends the interest when it starts to receive data from the source(s).



(a) Interest propagation



(b) Gradients set up



(c) Data delivery along selected path

Figure4: An example of interest diffusion in sensor network

Rumor Routing[12]: The concept of rumor routing is to use agents to establish paths leading to each event when the event happens. The agents are actually long-lived messages traversing in the network. Later queries can be routed along these agent-generated paths. In order to join the path, the queries are first sent on a random walk in the network. See Fig 5.

Each node in the network maintains a list of its neighbors and an event table with forwarding information to all the events it knows of. When the network is initiated, the neighbor lists are generated by broadcasting each node's id and listening to the broadcasts. If the events are only needed for a certain amount of time or the size of the event table is limited, expiration timestamps can be added to the event table entries.

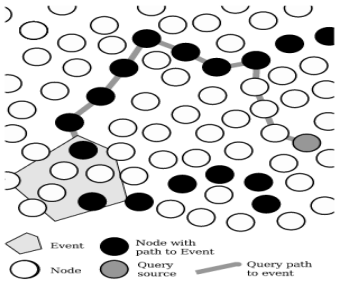


Figure5: Rumor Routing

GBR(Gradient-Based Routing): Schurgers et al. [13] proposed another protocol Gradient-Based Routing (GBR). The key idea in GBR is to memorize the number of hops when the interest is diffused through the whole network. As such, each node can calculate a parameter called the height of the node, which is the minimum number of hops to reach the BS. The main objective of these schemes is to obtain a balanced distribution of the traffic in the network, thus increasing the network lifetime

MCFA (Minimum Cost Forwarding Algorithm): The Sensor nodes of the MCFA algorithm [14] exploits the direction of routing is always fixed external base station. So, a sensor node need not have a unique ID nor maintain a routing table. Instead, each node maintains the least cost estimate from itself to the base-station. Each message to be forwarded by the sensor node is broadcast to its neighbors. When a node receives the message, it checks if it is on the least cost path between the source sensor node and the base-station. If this is the case, it re-broadcasts the message to its neighbors. This process repeats until the base-station is reached.

CADR Constrained Anisotropic Diffusion Routing (CADR) [15] is a protocol, which strives to be a general form of Directed Diffusion. Two techniques namely information-driven sensor querying (IDSQ) and constrained anisotropic diffusion routing (CADR) are proposed. The main objectives of the query sensors and route data in a network is to collect maximum data while minimize the latency and bandwidth. This can be done by activating only the sensors that are close to a particular event and dynamically adjusting data routes.

COUGAR: It is another data-centric protocol [16]. The main behind the idea is to use abstract query processing from the network layer functions such as selection of relevant sensors and so on. In-network data aggregation can also be used to save energy. The abstraction is supported through a new query layer between the network and application layers. Some disadvantages are introduction of additional query layer, requirement of synchronization between nodes and dynamic selection of leader nodes.

ACQUIRE[17]: A new data-centric method for querying sensor networks is ACtiveQUery forwarding In sensoRnEtworks(ACQUIRE). ACQUIRE protocol network as a distributed database where complex queries can be further divided into several sub queries. The querying mechanism works as follows: The BS node sends a query, which is then forwarded by each node receiving the query. Each node tries to respond partially by using its pre-cached information and forward it to another sensor. If the pre-cached information is not up-to-date, the nodes gather information from its neighbors within a look-ahead of *d* hops. Once the query is resolved completely, it is sent back through either the reverse or shortest-path to the base station.

EAR (Energy Aware Routing): The objective of energy-aware routing protocol [18] is to increase the network lifetime. It maintains a set of paths instead of maintaining or enforcing one optimal path at higher rates. These paths are maintained and chosen by means of a certain probability. The value of this probability based on how low the energy consumption of each path can be achieved. Network survivability is the main metric of this protocol. When compared to directed diffusion, this protocol provides an overall improvement of 21.5% energy saving and a 44% increase in network lifetime. However, the approach requires gathering the location information and setting up the addressing mechanism for the nodes, which complicate route setup compared to the directed diffusion.

The Table 2 shows how different Flat based routing protocols fit under different category according to different parameters.

Table II Comparison of Flat based routing protocols in WSNs

Protocol	Power Utilization	Data Aggregation	Scalability	Multi path	QoS	Query Based
SPIN	Limited	Yes	Limited	Yes	No	Yes
DD	Limited	Yes	Limited	Yes	No	Yes
RR	Low	Yes	Good	No	No	Yes
GBR	Low	Yes	Limited	No	No	Yes
MCFA	Low	No	Good	No	No	No
CADR	Limited	Yes	Limited	No	No	No
COUGAR	Limited	Yes	Limited	No	No	Yes
ACQUIRE	Low	Yes	Limited	No	No	Yes
EAR	Low	No	Limited	No	No	Yes

VII. CONCLUSION

Routing in sensor networks is a new area of research, with a limited, but rapidly growing set of research results. In this paper, we presented the concept of WSN node architecture and its functionality, design issues and challenges while constructing the WSN network, various types of routing schemes for WSN and comprehensive survey of representative routing protocols for Flat Based routing protocols under the wireless sensor Network.

VIII.REFERENCES

[1]. Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, Wireless sensor network survey, computer networks,ISSN: 1389-1286,Vol. 58,Page No.2292-2330,April 2008.

[2]. C. Intanagonwiwat, R. Govindan, D. Estrin, Directed diffusion: a scalable and robust communication paradigm for sensor networks, Proceedings of the ACM Mobi- Com'00, Boston, MA, 2000, pp. 56–67.

[3]. G.J. Pottie, W.J. Kaiser, Wireless integrated network sensors, Communications of the ACM 43 (5) (2000) 551– 558.

[4]. J.M. Kahn, R.H. Katz, K.S.J. Pister, Next century challenges: mobile networking for smart dust, Proceedings of the ACM MobiCom'99, Washington, USA, 1999, pp. 271–278.

[5]. Jun Zheng and Abbas Jamalipour, Wireless Sensor Networks: A Networking Perspective, a book published by A John & Sons, Inc, and IEEEE, 2009.

[6]. Sonali B. Patel, Prof. Rohit Srivastav2 A Review of Hierarchical Networks Routing Protocols In Wireless Sensor Networks, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 10, December- 2012 ISSN: 2278-0181

[7]. Kemal Akkaya and Mohamed Younis, A Survey on Routing Protocols for Wireless Sensor Networks, Ad hoc Networks, vol. 3, no. 3, May 2005, pp. 325-349.

[8]. J.N. Al-Karari, A.E. Kamal: Routing Techniques in Wireless Sensor Networks: A Survey, IEEE Wireless Communications, December 2004.

[9]. Akkaya, K. and Younis, M., A survey on routing protocols for wireless sensor networks, Ad Hoc Networks, Vol 3, Page No. 325–349,2005.

[10]. W. Heinzelman, J. Kulik, and H. Balakrishnan, Adaptive Protocols for Information Dissemination in Wireless Sensor Networks, Proc. 5th ACM/IEEE Mobicom Conference (MobiCom '99), Seattle, WA, August, 1999. pp. 174-85.

[11]. C. Intanagonwiwat, R. Govindan, and D. Estrin, Directed diffusion: a scalable and robust communication paradigm for sensor networks, Proceedings of ACM MobiCom '00, Boston, MA, 2000, pp. 56-67.

[12]. D. Braginsky and D. Estrin, Rumor Routing Algorithm for Sensor Networks, in the Proceedings of the First Workshop on Sensor Networks and Applications (WSNA), Atlanta, GA, October 2002.

[13]. C. Schurgers and M.B. Srivastava, Energy efficient routing in wireless sensor networks, in the MILCOM Proceedings on Communications for Network-Centric Operations: Creating the Information Force, McLean, VA, 2001.

[14]. F. Ye, A. Chen, S. Liu, L. Zhang, A scalable solution to minimum cost forwarding in large sensor networks, Proceedings of the tenth International Conference on Computer Communications and Networks (ICCCN), pp. 304-309, 2001.

[15]. M. Chu, H. Haussecker, and F. Zhao, "Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks," The International Journal of High Performance Computing Applications, Vol. 16, No. 3, August 2002.

[16]. Y. Yao and J. Gehrke, The cougar approach to in-network query processing in sensor networks", in SIGMOD Record, September 2002.

[17]. N. Sadagopan et al., The ACQUIRE mechanism for efficient querying in sensor networks, in the Proceedings of the First International Workshop on Sensor Network Protocol and Applications, Anchorage, Alaska, May 2003.

[18]. R. C. Shah and J. Rabaey,Energy Aware Routing for Low Energy Ad Hoc Sensor Networks", IEEE Wireless Communications and Networking Conference (WCNC), March 17-21, 2002, Orlando, FL.