Survey on Various Routing Protocols in Wireless Sensor Network

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Abstract—*Wireless sensor network is a one of the active research area now days and wireless sensor network routing protocol is the major issue because is depend on the application and network structure. Sensor nodes are communicate wirelessly and the routing protocols are responsible for maintaining route and reliable communication. In this paper i have discuss routing protocols for sensor networks and classification of them under three main categories which are data-centric, hierarchical and location-based protocols.*

Keywords: -Base Station, Wireless sensor network, Cluster Head.

I. Introduction

With advances in information technology, Wireless Sensor Network (WSN) is becoming a rapidly developing area in both research and application.WSN combines computing, communications and sensor technology together and has been applied in many different areas such as military, environmental monitoring, health care applications, etc. A sensor network is composed of hundreds or thousands of static or mobile sensors, which are scattered randomly in some regions. Its purpose is to acquire process and transmit data within the geographic area covered by the network and report the monitored situations to the users [11].

A sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. In addition, a power source supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment [12].

II. Routing In Wireless Sensor Network

Generally routing in sensor networks is very challenging due to several characteristics that differentiate them from existing communication and wireless ad hoc networks [3].

1. It is not possible to build a global addressing scheme for the deployment of thousands number of sensor nodes.
2. All applications of sensor networks require the flow of sensed data from multiple region to a sink(Base Station) .
3. Generated data has significant redundancy because multiple sensors may generate same data so this redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization.
4. Sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management.

Due to such differences the routing mechanisms have to consider the characteristics of sensor nodes along with the application and architecture requirements. Majority of the routing protocols can be classified as data-centric, hierarchical or location based routing. Data-centric protocols are query-based and depend on the naming of desired data, which helps in eliminating many redundant transmissions. Hierarchical protocols aim at clustering the nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. Location based protocols utilize the position information to relay the data to the desired regions rather than the whole network [3] [4].

III. Data –Centric Routing

In data-centric protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated data toward the sink. This process can result in energy savings because of less transmission required to send the data from the sources to the sink. In this section we discuss some of the data centric protocols.

A. Flooding and Gossiping

In flooding, each sensor receiving a data packet broadcasts it to all of its neighbours and this process continues until the packet arrives at the destination for the packet is reached. On the other hand, gossiping is an enhanced version of flooding where the receiving node sends the packet to a randomly selected neighbour, which picks another random neighbour to forward the packet to and so on. Flooding has several drawbacks like includes implosion, overlap and resource blindness by consuming large amount of energy. Gossiping avoids the problem of implosion by just selecting a random node to send the packet rather than broadcasting. However, this cause delays in propagation of data through the nodes [4].

B. Directed Diffusion

Directed diffusion is a data centric protocol. The main function is to combine the data from different sources by eliminating redundancy and minimizing the number of transmission which saves the energy and increases the network lifetime. Basically it measure events and creates gradients of information form neighbourhoods.

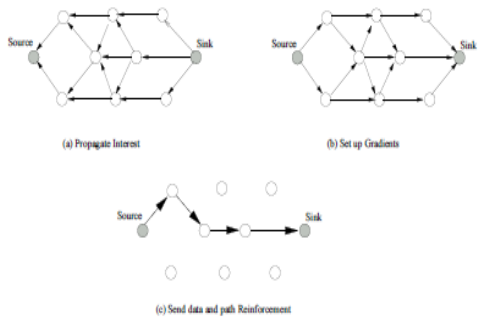

Fig. 1: shows an example of the working of directed diffusion (a) sending interests, (b) building gradients, and (c) data dissemination [3].

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 BS periodically refreshes and re-sends the interest when it starts to receive data from the source [3].

C. Rumour Routing

Rumour routing is consider to be a variation of directed diffusion it is based on the concept of *agent*, which is a long-lived packet that traverses a network and informs each sensor it encounters about the events that it has learned during its network traverse. An agent will travel the network for a certain number of hops and then die. Each sensor, including the agent, maintains an event list that has event-distance pairs, where every entry in the list contains the event and the actual distance in the number of hops to that event from the currently visited sensor. Therefore, when the agent encounters a sensor on its path, it synchronizes its event list with that of the sensor it has encountered. Also, the sensors that hear the agent update their event lists according to that of the agent in order to maintain the shortest paths to the events that occur in the network [3].

D. Sensor Protocols for Information via Negotiation (SPIN)

SPIN was designed to improve classic flooding protocols and overcome the problems like implosion and overlap. The idea behind SPIN is to name the data using meta-data. Before transmission, metadata are exchanged among sensors via a data advertisement mechanism, which is the key feature of SPIN. Each node upon receiving new data, advertises it to its neighbours and interested neighbours, i.e. those who do not have the data, retrieve the data by sending a request message. SPIN's meta-data negotiation solves the classic problems of flooding such as redundant information passing, overlapping of sensing areas and resource blindness thus, achieving a lot of energy efficiency. There are three messages defined in SPIN to exchange data between nodes. These are: ADV message to allow a sensor to advertise a particular meta-data, REQ message to request the specific data and DATA message that carry the actual data [4].

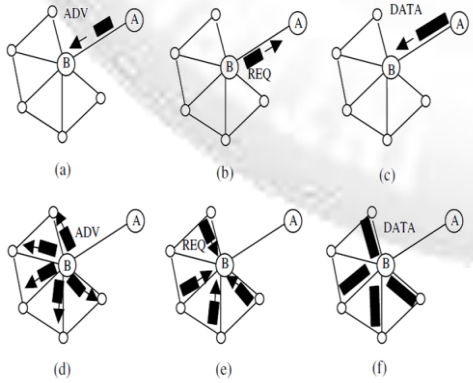

Fig. 2: Node A starts by advertising its data to node B (a). Node B responds by sending a request to node A (b). After receiving the requested data (c), node B then sends out advertisements to its neighbors (d), who in turn send requests back to B (e–f) [4].

The SPIN family includes many protocols. The main two protocols are called SPIN-1 and SPIN-2, which include negotiation before transmitting data in order to ensure that only useful information will be transferred and each node has its own resource manager which keeps track of resource consumption also it is polled by the nodes before data transmission. An extension to SPIN-1 is SPIN-2, which integrate threshold-based resource awareness mechanism in addition to negotiation. When energy in the nodes is plentiful, SPIN-2 communicates using the 3-stage protocol of SPIN-1. However, when the energy in a node starts approaching a low energy threshold, it reduces its participation in the protocol, i.e., it participates only when it believes that it can complete all the other stages of the protocol without going below the low-energy threshold. Other protocols of the SPIN family are SPIN-BC designed for broadcast channels. SPIN-PP is designed for a point to point communication, i.e., hop-by-hop routing. SPIN-EC works similar to SPIN-PP , but an energy heuristic added to it. When a channel is appears lossy, a protocol called SPIN-RL is used where adjustments are added to the SPIN-PP protocol to account for the lossy channel.

One of the advantages of SPIN is that topological changes are localized since each node needs to know only its single-hop neighbours. SPIN provides much energy savings than flooding and less redundant data. However, SPINs data advertisement mechanism cannot guarantee the delivery of data [4].

IV. HIERARCHICAL ROUTING

In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. This means that creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other layer is used for routing [3].

A. Low-energy adaptive clustering hierarchy

LEACH proposed by [9]. It protocol divides nodes in WSN into several clusters. Each cluster has a leader called cluster-head, other nodes called cluster-members. LEACH has a cyclical nature, and it proposes a concept named 'round', each round can be divided into two phases: cluster building phase and stable data transfer phase. The time and energy consumed in the latter phase is longer than that in the former.

In the cluster building phase, the sensor nodes generate a number between 0 and 1 randomly. Compared with T(n), the node will be selected as cluster-head if its generated number is less than the threshold. The cluster-head node broadcasts information to surrounding nodes, and the others choose the cluster to join according to the intension of the broadcasted information. Then, the cluster-head use the approach of TDMA to distribute the time slot of data transmission for members.

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

In the stable data transfer phase, the gathered data packages are delivered from members back to cluster-heads, and finally sent to sink node by cluster-heads. The sink node transfers the collected data to the monitoring centre for data processing. In this phase, tasks are tougher made by cluster-heads. The cluster-heads should process data fusion and communicate with sink node, which costs much energy of the cluster-heads. So, after certain time, the network should be rebuilt, and this procedure would be continuously circulated [11].

B. Power-efficient Gathering in Sensor Information Systems(PEGASIS)

It is an improvement of the LEACH protocol. Rather than forming multiple clusters, PEGASIS forms chains from sensor nodes so that each node transmits and receives from a neighbour and only one node is selected from that chain to transmit to the base station (sink). Gathered data moves from node to node, aggregated and eventually sent to the base station .

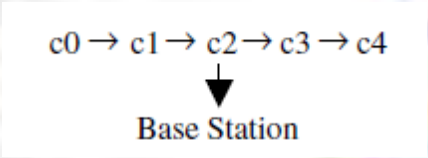

Fig. 3: Chaining in Pegasis [3].

To construct a chain, nodes employ the greedy algorithm starting with the farthest node from the BS. In each round, a node is chosen randomly to be a leader. This leader node initiates a control token to start data transmission from the ends of the chain. Each node *fuses*its neighbour's data packet with its own to generate a single packet of the same length and then transmits that to its other neighbour. This is repeated till all the sensed data are collected at the leader node, which then transmits one data packet to the BS throughdirect communication. If nodes can communicate only with neighbours, the leader node can starta multi-hop routing to the BS. PEGASIS assumes that nodes have location information about all other nodes. Observations shows that PEGASIS performs better than LEACH energy-wise by about 100 to 300%.

The main problem with PEGASIS is the long latency, which is at the order of N, where ***N*** is the number of nodes. This may he solved using multi-level chaining. Moreover, every node needs to have location information about all the nodes in the network. Also, a node may need to expend extra energy to find its closest neighbour [6].

C. Threshold sensitive Energy Efficient sensor Network protocol

TEEN is a hybrid of hierarchical clustering and data-centric protocols. The algorithm first goes through cluster formation. The CHs then broadcast two thresholds to the nodes in their clusters. Those are hard and soft thresholds for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head. Soft Threshold is the small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit. It stimulates the node to switch on its transmitter and report the sensed data. A node will report data only when the sensed value is beyond the HT or the change in the value is greater than the ST [7].

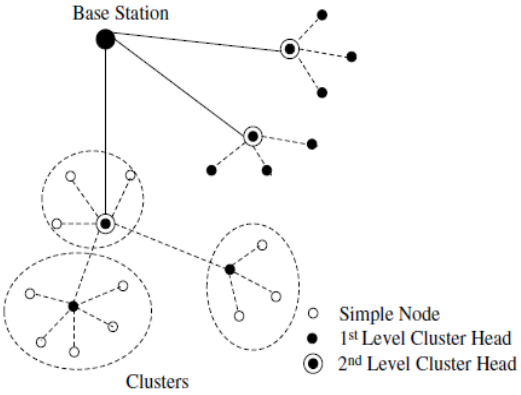

Fig. 4: Hierarchical clustering in TEEN and APTEEN [4].

D. Adaptive Threshold Sensitive Energy Efficient Network (APTEEN)

It was proposed by [5] is an extension to TEEN and aims at both capturing periodic data collections and reacting to time critical events. The architecture is same as in TEEN. APTEEN supports three different query types: historical, to analyze past data values, one-time, to take a snapshot view of the network; and persistent to monitor an event for a period of time.

V. Location Based Routing

In this kind of routing, sensor nodes are addressed by means of their locations. The distance between neighbouring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighbouring nodes can be obtained by exchanging such information between neighbours. Alternatively, the location of nodes may be available directly by communicating with a satellite, using GPS (Global Positioning System) [3].

A. Geographic Energy Aware Routing (GEAR)

The protocol, namely geographic and energy-aware routing (GEAR), uses energy aware and geographically informed neighbour selection heuristics to route a packet towards the target region. In GEAR, each node keeps an estimated cost and a learning cost of reaching the destination through its

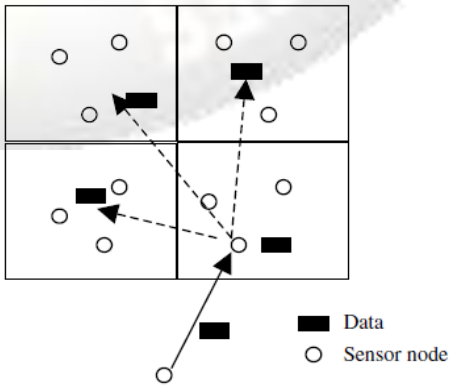

Fig. 5: Recursive geographic forwarding in GEAR [4].

neighbours. The estimated cost is a combination of residual energy and distance to destination. The learned cost is a refinement of the estimated cost that accounts for routing around holes in the network. A hole occurs when a node does not have any closer neighbour to the target region than itself. If there are no holes, the estimated cost is equal to the learned cost [4].

B. Geographic Adaptive Fidelity (GAF)

Geographic adaptive fidelity (GAF) is an energy-aware location-based routing algorithm. GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. Nodes change states from sleeping to active in turn so that the load is balanced. There are three states defined in GAF. These states are discovery, for determining the neighbours in the grid, active reflecting participation in routing and sleep when the radio is turned off [4].

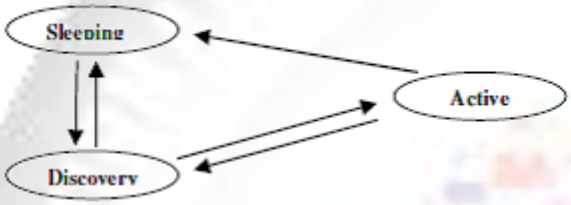

Fig. 6: state transmission in GAF

C. Minimum energy communication network (MECN)

Minimum energy communication network set up and maintains a minimum energy network for wireless networks by utilizing low power GPS. This protocol has two phases: 1. It takes the positions of a two dimensional plane and constructs a sparse graph, which consists of all the enclosures of each transmit node in the graph. The enclose graph contains globally optimal links in terms of energy consumption. 2. Finds optimal links on the enclosure graph. It uses distributed shortest path algorithm with power consumption as a cost metric. The small minimum energy communication network (SMECN) is an extension to MECN.In SMECN protocol; every sensor discovers its immediate neighbors by broadcasting a discovery message using some initial power that is updated incrementally [10].

VI. Conclusion

In this paper, i have discuss some of the routing protocols in wireless sensor network which are differ in terms of network structure and required by applications. Each of them is described under the appropriate category.

References

[1] Abbasi, Ameer Ahmed, and Mohamed Younis. "A survey on clustering algorithms for wireless sensor networks . " Computer communications 30.14, ELSEVIER (2007): 2826-2841.

[2] Akyildiz, Ian F., et al. "Wireless sensor networks: a survey." Computer networks 38.4 ELSEVIER (2002): 393-422.

[3] Al-Karaki, Jamal N., and Ahmed E. Kamal. "Routing techniques in wireless sensor networks: a survey." Wireless communications, IEEE 11.6 (2004): 6-28.

[4] Akkaya, Kemal, and Mohamed Younis. "A survey on routing protocols for wireless sensor networks." Ad hoc networks 3.3, ELSEVIER (2005): 325-349.

[5] Younis, Mohamed, and Kemal Akkaya. "Strategies and techniques for node placement in wireless sensor networks: A survey." Ad Hoc Networks 6.4, ELSEVIER (2008): 621-655.

[6] Ahmed, Ahmed A., Hongchi Shi, and Yi Shang. "A survey on network protocols for wireless sensor networks." Information Technology: Research and Education, 2003. Proceedings. ITRE2003. International Conference on. IEEE, 2003.

[7] Manjeshwar, Arati, and Dharma P. Agrawal. "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks." ipdps. Vol. 2. 2002.

[8] Singh, Shio Kumar, M. P. Singh, and D. K. Singh. "Routing protocols in wireless sensor networks–A survey." International Journal of Computer Science & Engineering Survey (IJCSES) Vol 1 (2010): 63-83.

[9] Heinzelman, Wendi Rabiner, Joanna Kulik, and Hari Balakrishnan. "Adaptive protocols for information dissemination in wireless sensor networks." Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking. ACM, 1999.

[10] Tyagi, Ms Parul, and Ms Surbhi Jain. "Comparative Study of Routing Protocols in Wireless Sensor Network." International Journal of Advanced Research in Computer Science and Software Engineering 2.9 (2012).

[11] Yan, Jian-Feng, and Yuan-Liu Liu. "Improved LEACH routing protocol for large scale wireless sensor networks routing." Electronics, Communications and Control (ICECC), 2011 International Conference on. IEEE, 2011.

[12] Anastasi, Giuseppe, et al. "Energy conservation in wireless sensor networks: A survey." Ad Hoc Networks 7.3 (2009): 537-568.