© 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

A Survey on Routing Protocols of Wireless Sensor Networks

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ABSTRACT

Research on remote sensor systems is the most well-known region for the exploration researchers. Remote systems are interfacing every single corner of the world and giving correspondence offices to different clients. Directing conventions are a standout amongst the most imperative components for any sort of correspondence. In this paper we will examine about the steering difficulties and configuration issues identified with remote sensor systems. This paper will exhibit a noteworthy investigation of different sorts of existing steering conventions for sensor system.
Keywords: Routing challenges and design issues in WSNs, Routing Protocols and their types

I. INTRODUCTION

In the universe of radio systems, it is difficult to overlook about the material science of wonders included when we endeavor to plan conventions. In this setting, we have immediately encountered the need to plan directing conventions to utilize solid data like piece blunder proportion, power levels and outer data that is rate of development or notwithstanding "driving" lower level parameters. This vision of things is an imperative lead for specially appointed environment change particularly directing [1]. This paper will give a critical investigation of directing conventions for sensor systems. Prerequisite of this study is to comprehend plan issues identified with remote sensor systems which can facilitate stretch out for an examination on the determination of specific conventions for particular applications.

Since the landing of impromptu systems, numerous proposition have been examined, mimicked and assessed. These proposition have prompted varieties, Specializations to given situations and enhancements. We will probably portray the real orders of steering calculations and in addition fruitful arrangements. A directing issue in a specially appointed system is the same as in a settled system [8]. A hub A from the impromptu system needs to communicate something specific m to another hub B of this same system; how can it decide the system hubs by which m will bit by bit be handed-off through the radio medium to achieve B?

II. CHARACTERISTICS OF ROUTING

ALGORITHMS

The characteristics in demand by most ad hoc routing algorithm developers are:

Simplicity: the protocols must generate as little surcharge of engagement data as possible and must be very simple to develop and deploy.

Self-Organization: no central control can be admitted in an ad hoc network and the structures necessary for routing management must be created in a distributed way and resist topology change as much as possible;

Scalability: protocols offered must adapt to different ad hoc network sizes and support different mobility and traffic models.

It is possible to add many more characteristics to the list, from the request for quality of service to energy conservation for each mobile device.

III. ROUTING PROTOCOLS

Ad hoc directing proposition can be characterized into two fundamental classifications: proactive and responsive steering. We can add other for the most part half and half proposition to these two families, for instance, the production of an inward system structure, or depending on the assumption that every system hub knows its position in an arrangement.

Proactive conventions are specifically roused by directing conventions conveyed in the Internet and are therefore adjustments of connection state steering and separation vector routings[2]. Their basic trademark is that every specially appointed system hub locally keeps up a directing table for sending information to any hub in the system. With these conventions, terminals occasionally trade data past their immediate neighborhood for all time looking after "tables" depicting the system, absolutely or somewhat, keeping in mind the end goal to choose courses to take amid message transmission; they are now and then called table-driven specially appointed steering.

Specially appointed responsive directing calculations minimize the utilization of control messages to a base to spare transfer speed. The data key to the figuring of a course between two system's hubs is just investigated when a solicitation for this course is communicated by the higher convention layers. The conventions of this class endeavor to keep the courses utilized and just those as up and coming as could reasonably be expected. The amount of transmission capacity utilized for control messages is especially delicate to the quantity of courses (execution and upkeep) and can be much lower than a proactive convention when this number is lower. The real disadvantage of this sort of convention is the imperative postponement fundamental between a solicitation for message transmission and the real transmission when the course has not yet been made.

Sensor nodes are constrained in energy supply and bandwidth. This Combined with a typical deployment of large number of sensors have posed many challenges to the design and management of the wireless sensor networks.

Efficient routing protocol on wireless sensor networks is one of the important challenges. Although there are some previous efforts on surveying the characteristics, applications, and communication protocols in WSNs,[3] the scope of this article is distinguished from these surveys in many aspects. In this paper, we present a thorough review of recent research of routing protocols for wireless sensor networks, including their advantages and drawbacks. Then we focused our attention on making a contrast between these protocols and highlight some future aspects of research.

IV. ROUTING CHALLENGES AND DESIGN ISSUES IN WSNS

Despite the innumerable applications of WSNs, these networks have several restrictions. The design of routing protocols in WSNs is influenced by many
Challenging factors which must be overcome before efficient communication is achieved in WSNs. Some of the routing challenges and design issues that affect routing process in WSNs

- Node deployment
- Energy consumption without losing accuracy
- Data Reporting Model
- Fault Tolerance
- Connectivity
- Quality of Service
- Operating Environment
- Production Costs

V. CLASSIFICATION OF ROUTING PROTOCOLS

There are many ways to classify the routing protocols. Almost all of the routing protocols can be classified as flat, hierarchical or location-based, according to the network structure. Furthermore, these protocols can also be classified into multipath-based, query-based, negotiation-based, quality of service (QoS)-based, or coherent-based depending on the protocol operation. In flat networks all nodes play the same role, while hierarchical protocols aim at routing techniques 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 Depending on how the sender of a message gains a route to the receiver, routing protocol can be classified into three categories, namely, proactive, reactive and hybrid protocols. In proactive protocols, all routes are computed before they are really needed, while in reactive protocols routes are computed on demand. Hybrid protocols use a combination of these two ideas.

Routing Protocols

A. Flooding

Flooding is an old technique that can also be used in the sensor network. In flooding, each node received a data and then sent them to the neighbors by broadcasting, unless a maximum number of hops for the packet are reached or the destination of the packet is arrived.

Gossiping protocol is the derivation of flooding. In this algorithm, nodes do not use broadcast but send the incoming packets to a randomly selected neighbor node. Once the neighbor node receives the data, it randomly selects another sensor node.

Flooding has several drawbacks. Such drawbacks include implosion caused by duplicated messages sent to same node, overlap when two nodes sensing the same region send similar packets to the same neighbor and resource blindness by consuming large amount of energy without consideration for the energy constraints[4]. 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.

B. SPIN (Sensor Protocols for Information via Negotiation)

SPIN is among the early work to pursue a data centric routing mechanism. The idea behind SPIN is to name the data using meta-data that highly describes the characteristics of the data, which is the key feature of SPIN.
SPIN has three types of messages, that is, ADV, REQ, and DATA.

- ADV-When a node has data to send, it advertises this message containing meta-data.
- REQ-A node sends this message when it wishes to receive some data..
- DATA - Data message contains the data with a meta-data header.

Conventional data dissemination approaches, e. g. classic flooding and gossiping, have three problems, namely, implosion, overlap, and resource blindness. SPIN solves these problems by using data negotiation and resource – adaptive algorithms.

SPIN's meta-data negotiation and resource adaptive solves the classic problems of flooding such as implosion, overlap and resource blindness, achieving a lot of energy efficiency. However, SPIN's[6] disadvantages are clear. First of all, it is not scalable. Secondly, the nodes around a sink could deplete their energy if the sink is interested in too many events. Finally, SPIN's data advertisement mechanism can't guarantee the delivery of data.

Directed diffusion is an important milestone in the data-centric routing protocols research in the wireless sensor networks. The algorithm aims at diffusing data through sensor nodes by using a naming scheme for the data. The main reason is to get rid of unnecessary operation of network layer routing in order to save energy.

C. LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH is a clustering-based protocol that utilizes randomized rotation of the cluster-heads to evenly distribute the energy load among the sensor nodes in the network. It is one of the most popular hierarchical routing algorithms for sensor networks. The idea is to form clusters of the sensor nodes. based on the received signal strength and use local cluster heads as router to the sink[7]. This will save energy since the transmission will only be done by cluster heads rather than all of the nodes.

The main energy saving of LEACH protocols comes from the combination of data compression and routing. It (i) employs localized coordination to
improve the scalability and robustness, (ii) uses data fusion to reduce the amount of information transmitted between the sensor nodes and a given sink, and (iii) uses dynamic cluster – heads mechanism to avoid the energy depletion of selected cluster – heads.

LEACH provided many good features to the sensor network, such as clustering architecture, .localized coordination and randomized rotation of cluster-heads; however, it suffers from the following problems:

- It cannot be applied 'to tirl!e critical applications.

- The nodes on the route from a hot spot to the sink might drain their energy quickly, which is known as "hot spot" problem.

D. PEGASIS (Power-Efficient Gathering in Sensor Information Systems)

PEGASIS is a chain-based power efficient protocol based on LEACH. Because each node has global knowledge of the network, the chain can be constructed easily by using a greedy algorithm. PEGASIS out performs LEACH by eliminating the overhead of dynamic cluster formation, minimizing the sum of distances that non-leader nodes must transmit, and limiting the number of transmissions.
It is near optimal protocol under the following assumption about the network.
• All nodes have location information about all other nodes and each of them has the capability of transmitting data to the base station directly.
• Sensor nodes are immobile.

E. Threshold sensitive energy efficient sensor network protocol (TEEN)

TEEN is a cluster based routing protocol based on LEACH.

TEEN works for some assumptions like: The network is composed of a base station and sensor nodes with the same initial energy and The base station has a constant power supply and can transmit with high power to all the nodes directly.

F. GEAR (Geographic and Energy Aware Routing)

GEAR uses energy aware and geographically informed neighbor 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 neighbors.

G. RSTP (Reliable Synchronous Transport Protocol)

RSTP is a novel transport protocol for wireless image sensor network. This protocol aims at the reliable and synchronous transmission of images from multiple sensor nodes to a sync point. RSTP protocol performs well in error- prone wireless channels even under high packet loss rates.

In the proposed protocol, the effort to synchronize the transmission of multiple images from different sensor nodes is implemented as part of the controlling facility at the receiver side. The synchronization mechanism takes advantage of the importance of different parts of the spectrum of an image. Only parts of the spectrum are synchronized instead of the whole image.

TCP is not suitable for transmission over wireless links. A WSN involves a large-scale employment of distributed sensors. Synchronization is vital for distributed applications, but it is not provided by any protocol. RSTP employs receiver-controlled reliability, a synchronization mechanism, progressive JPEG image transmission, and appropriate congestion control[9]. The design goals of RSTP’s synchronization control mechanism are composed of the following aspects: energy efficiency, synchronization of image transmission, and accuracy. In terms of energy efficiency, the algorithm should be simple, and require minimized computation by the energy-constrained sensor nodes. In RSTP, most of the synchronization control is processed by resource-sufficient sink nodes and sensor nodes are only involved by setting some flags in their headers.

H. Dynamic source routing (DSR)

As with all reactive protocols, the DSR protocol uses a process of route discovery between two network nodes when it is necessary for a specific communication. The main characteristic differentiating DSR from the other reactive protocols is the use of routing by the source: the transmitting node of a data packet must know the list of all intermediate nodes in order to reach its destination. This route is located in data packet headers, so much so that the intermediate nodes do not need a local routing function[8]. This mode exists in IPv4 as an optional protocol. It was initially developed to simplify network management but was abandoned for security reasons.

Routes that will be discovered on demand are kept for a certain period by a cache mechanism. As we will see later, different options are available to limit the necessity of route discovery by using these caches. In the DSR protocol, we find two reactive routing mechanisms: route discovery and route maintenance.

The DSR protocol works in an environment where radio connections can be unidirectional, since they consider routes between two network nodes in both "forward" and "reverse" ways as independent.

If a connection is discovered to be invalid, the node detecting it renders all routes in the cache using them invalid. Whether it has an alternate route or not, it generates a control message called route error (RERR). This RERR message is sent to the sources of the route which have become invalid.

I. Ad hoc on-demand distance vector (AODV)

AODV is a reactive routing protocol similar to DSR presented above. It uses the same route discovery mechanism (with the help of RREQ and RREP control messages) and route maintenance (with the help of the RERR control message). It also uses the concept of vector distance routing based on the distributed Bellman-Ford algorithm for calculating the shortest route. In the first place, the AODV[4] protocol uses HELLO control messages between direct neighbors. The objective of these messages is to verify the state of connections since AODV only manages symmetric connections. Contrary to DSR, it does not use source routing, and each network node maintains a routing table. This routing table will only be partial because, following the reactive routing principle, only actual route requests will enable network information.

The routing table memorized in each node is a table where each entry has the following information: destination node address, next hop node on the route to this destination, sequence number and time of expiration of this entry in the table. The algorithm retains the most recent route and, in the case of equality, the shortest one.

J. Optimized link state routing (OLSR)

The OLSR routing protocol can be considered as an adaptation to the ad hoc network world of the OSPF (open shortest path first) protocol deployed in wired Internet. Both are link state protocols, or a protocol where nodes periodically broadcast the state of connections perceived in their neighborhood to the whole network. The adaptation for ad hoc networks mainly consists of optimizing this global broadcast operation or flooding[10]. As we have seen in the section about flooding, OLSR will structure the network to avoid blind flooding: it is an information-based flooding method. The OLSR protocol defines the multipoint relay (MPR) concept to limit the number of message retransmissions during the necessary flooding operations.

Two types of control messages exist in OLSR: HELLO messages and TC (topology control) messages. HELLO messages serve an ad hoc network node to discover its close environment that OLSR defines as all its direct neighbors and their direct neighbors (or all the network nodes that we can reach with one retransmission).

TC messages transmitted by a node x contain partial information on the state of connection of x with its neighbors. Actually, to decrease the size of this information, a node x will indicate the state of connections that it has with all these neighbor nodes which have chosen it as MPR: they are MPR selectors. These TC messages are periodically transmitted to the whole network through a flooding process. It can locally rebuild a global topology view of the network and calculate the routes for each node with help from the Disjktra algorithm to obtain the shortest route.

K. Topology based on reverse-path forwarding (TBRPF)

The TBRPF[12] protocol, as with OLSR, is a proactive link state routing protocol. Neighborhood knowledge is maintained in each node by HELLO control message exchanges. On the other hand, TBRPF offers optimization consisting of only sending "differential" information, i.e. notifying neighbors only on neighborhood modifications since the last HELLO packet. In TBRPF, each network node will calculate a shortest route tree to the network.

On the other hand, to avoid overloading bandwidth, some strategies will make it possible for the nodes to propagate only a part of this tree in the network. The tree is locally calculated with the help of a variation of the Dijkstra algorithm (with a conflict resolution based on node identifier), but only the subtree called the reportable subtree (RT) will be transmitted to node neighbors. (12)

L. Zone-based hierarchical link state routing protocol (ZRP)

There is a debate between proactive and reactive routing protocols and we can conclude that each approach has a certain number of advantages and drawbacks. It would be natural to attempt to develop mixed methods, taking advantage of both techniques. That is what ZRP protocol is attempting, combining proactive and reactive mechanisms.

The proactive mechanism field, called IARP (intrazone routing protocol), is the direct neighborhood of a node. Each network terminal will choose a distance d corresponding to the number of hops (relays) authorized to reach direct neighbor terminals or routing zones. This distance d is not necessarily identical for each network terminal. Within this close field, a proactive routing mechanism is used, enabling the node to precisely know the topology of the subnet made up of close field nodes.

When a terminal wants to transmit a packet to a destination node not in its routing zone, it uses a reactive mechanism called IERP (interzone routing protocol). Following this reactive phase of the ZRP protocol, the terminal transmits its route search request to all peripheral nodes. If one of them has it in its local routing table (with the definition of close neighborhood that it has chosen), it can respond to that requesting node that it knows a route to the destination node. The nodes which do not have the target terminal in their routing table retransmit this request to their peripheral nodes and so on.

M. Location-aided routing (LAR)

In literature on this subject, several proposals have been introduced for the development of adhoc routing based on the use of network node coordinates. Network node coordinates are obtained from a system that is external to the routing protocol, with the use of a GPS (global positioning system) for example. This could be done in vehicle networks or simply in sensor networks where terminals are not mobile but where the network's dynamic comes from the disappearance of nodes which stop working or changes in the condition of wireless propagation.

In this section, we present the LAR[14] (location-aided routing) protocol, which uses knowledge of the sender and receiver node coordinates to optimize the flooding procedure. Each time a network node attempts to establish a route to a target terminal, it is supposed to know the target's coordinates.

N. NEAP (the Novel Energy Adaptive Protocol for heterogeneous wireless sensor networks)

The cluster-head is elected by a probability, based on threshold per round and cluster formation based on nodes current battery power and numbers of members currently under a cluster-head are taken, distance between cluster-heads and nods. At last, the simulation results show that NEAP achieves longer lifespan and reduce energy consumption in wireless sensor networks. Therefore, most of the current popular clustering algorithms are not fault tolerant, such as LEACH, PEGASIS and HEED. LEACH is the most popular clustering algorithm. Many of CH selection algorithms are based on LEACH's architecture it is proposed to elect the CHs according to the energy remaining in each node. Data of sensor nodes are correlated with their neighbor nodes, data aggregation can increase reliability of the measured parameter and decrease the amount of traffic to the base station. NEAP[6] uses this observation to increase the efficiency of the network. In order to develop the NEAP some assumptions are made about sensor nodes and the underlying network model. For sensor nodes it is assumed that all nodes are able to transmit with enough power to reach the BS if needed, that the nodes can adjust the amount of transmit power, and each node can support different Medium Access Control (MAC) protocols and perform signal processing functions. These assumptions are reasonable due to the technological advances in radio hardware and low-power computing.

NEAP, a novel energy adaptive and power aware protocol with hierarchical clustering for heterogeneous wireless sensor networks that distributes loads among more powerful nodes. Compared to the existing clustering protocols, NEAP has better performance in

CH election and forms adaptive power efficient and adaptive clustering hierarchy.

O. MAC Protocol

Medium Access Control protocols can be broadly classified as following categories. They are: (1) Scheduling based and (2) Contention based.

SMAC:

SMAC is a contention based MAC protocol. SMAC uses three novel techniques to reduce energy consumption and support self-configuration. SMAC[12] introduced a periodic sleep and wake up scheduling, which reduces energy consumption in listening to an idle channel. Neighboring nodes form virtual clusters to auto-synchronize on sleep schedules. SMAC also sets the radio to sleep during transmissions of other nodes.

EMAC:

In EMACS, time is divided into so called frames just like in TDMA but each frame is divided into timeslots and each slot contains three sections: communication request (CR), traffic control (TC), and data section. Each timeslot can be owned by only one network node. This network node decides what communication should take place in its timeslot.

TRAM

In this MAC protocol time is divided into number of slots as we do in TDMA. The network nodes switch in to idle mode or low power mode when they are not transmitting or receiving. A distribution election scheme is employed to determine which node to use a particular time slot.

Mobile TDMA

This protocol works by first splitting a given frame into control part and a data parts.

VI. CONCLUSION

In this paper, we have focused on routing, a basic function that any ad hoc network must provide. A brief study of existing routing protocols for wireless sensor networks is presented here in this paper.

In routing as in other aspects, ad hoc network solutions must face a number of challenges. We gave a short list of challenges, which are the subject of intense research. First, it will be important to control scaling: how does my solution handle itself if the number of mobile devices in my network increases? Quality of service control: how can I guarantee a level of performance for a given service? Power management control: in several scenarios, ad hoc network nodes are low energy capacity objects, a capacity that should not be wasted. Finally, there will be no important ad hoc network development without the study of specific security problems linked to these environments. Today networks are deployed and that ad hoc networks will undoubtedly become more important, even though many studies still remain to be done.

Here a significant study is presented on almost fifteen types of routing protocols and various design issues are studied in this paper.

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