

Multicast Routing Protocols in Wireless Sensor Network

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Abstract—Wireless sensor network is a multi-hop wireless networks with a group of sensor nodes formed by self-organization. However, the WSN with characteristic of self-organization, multi-hop, dynamic topology and limited energy resources, which make the network to prolong its lifetime, become extremely difficult. To prolong the life time of WSN with limited energy resources, Multicast can better met the requirements of network resources. It has an active significance for WSN to increase its performance in the near future.

Keywords- Multicast, Routing Protocols, WSN

I. INTRODUCTION

In telecommunication networks, technology has taken a new step towards sensing networks called Wireless Sensor Network (WSN). A large number of wireless nodes, according to demand of given geographical area, forms a WSN that enables their connectivity through radio antennas [2]. These are actually light-weight and low-volume nodes having constrained battery power, memory and processing ability. Every single node senses a physical parameter individually to gather information over a large scale from given geographical area. WSNs are most effectively considerable sensing networks in recent era, because they support various real-time applications such as environment monitoring, traffic surveillance, building structures monitoring, military sensing and information gathering and so on. However, the WSN with characteristic of self-organization, multi-hop, dynamic topology and limited energy resources, which make the network to prolong its lifetime, become extremely difficult [9]. Due to distinguish capabilities, it is highly demanding network for reliable monitoring and analysis of physical parameters over any geographical area. Designing of routing protocols faces many challenges due to limited resources of WSN nodes like short memory, limited energy and limited processing. To prolong the life time of WSN with limited energy resources, Multicast can better met the requirements of network resources. However, the widely use of multicast technology in Traditional wireless networks have too much difference with Wireless sensor network, such as MAODV, ODMRP multicast routing protocols which have been proposed by the mobile Ad hoc networks [9].

II. CURRENT RESEARCH ON MULTICAST ROUTING

According to the principle of multicast routing protocols, we can divide the WSN multicast routing protocols into five categories:

- Tree-based multicast routing protocols;
- Energy-based multicast routing protocols;

- Group location-based multicast routing protocols;
- All IP multicast routing protocols;
- Steiner-Based Secure Multicast Routing Protocol;

Further sections are organized as: description of Tree-based multicast routing protocols, Energy-based multicast routing protocols, Group location-based multicast routing protocols, all IP multicast routing protocols and Steiner-Based Secure Multicast Routing Protocol in section III, IV, V, VI and VII respectively. Finally a conclusion of the discussion is provided in last section.

III. TREE-BASED MULTICAST ROUTING PROTOCOL

The basic idea of tree based multicast routing protocol is to build up a multicast tree which was used to send data from the base station to any other WSN node [9]. So that the base station on the establishment of a tree, by broadcasting request packets discover the child nodes and these child nodes found their child nodes in the same way. In tree-based multicast protocols, there is only one path between a source-receiver pair.

Tree-based multicast protocols can be classified into two types:

- Source-tree-based multicast routing protocols
- Shared-tree-based multicast routing protocols

In a source-tree-based protocol, a single multicast tree is maintained per source, whereas in a shared-tree-based protocol, a single tree is shared by all the sources in the multicast group. Shared-tree-based multicast protocols are more scalable compared to source-tree-based multicast protocols. By scalability, we mean the ability of the protocol to work well without any degradation in performance when the number of sources in a multicast session or the number of multicast sessions is increased. In source-tree-based multicast routing protocols, an increase in the number of sources gives rise to a proportional increase in the number of source-trees. This results in a significant increase in bandwidth consumption in the already-bandwidth-constrained network. But in a shared-tree-based multicast protocol, this increase in bandwidth usage is not as high as in source-tree-based protocols. The main drawback of these protocols is that they are not robust enough to operate in highly mobile environments.

IV. ENERGY-BASED MULTICAST ROUTING PROTOCOL

As in Wireless Sensor network, sensor nodes have limited energy source and bandwidth; creatively considerable techniques are required to make them energy efficient that

would increase the life-time of a WSN. Such limitations become confronts for designing of WSNs and requires energy-awareness at all nodes deployed within the network. This paper has discussed three different multicast routing protocols for WSN that are energy efficient. These protocols are as:

- TEEN (Threshold Sensitive Energy Efficient Sensor Network)
- SPEED
- MMSPEED (Multipath Multi-SPEED)

A. Threshold Sensitive Energy Efficient Sensor Network

Threshold sensitive Energy Efficient sensor Network (TEEN) belongs to on-demand routing protocols category and mostly used for time crucial applications. In TEEN, nodes have two levels of cluster heads and also they follow hierarchical clustering design. After nodes have selected their cluster head, user needs to manually enter the attribute values, which will be broadcasted by cluster head in form of two parameters soft threshold and hard threshold. The sensor nodes will start transmitting data when minimum threshold value is greater than hard threshold. Another variable called sensed value is used for transmitted data. TEEN saves energy because it will only transmit data when the sensed value is higher than hard threshold, although it would sense data continuously. The soft threshold also saves energy by reducing the transmission, when there no or little change in the attribute value. Cluster head will consume more energy than a normal node because it needs to do extra processing. To maintain equal energy consumption among nodes, each node becomes a cluster head for fixed duration.

The biggest disadvantage of this protocol is that when hard threshold value is higher than sensed value there will be no transmission to clustered head from node, so the cluster head will have no updated information even if the node is no more in network. Figure1 shows operational flow diagram of TEEN protocol.

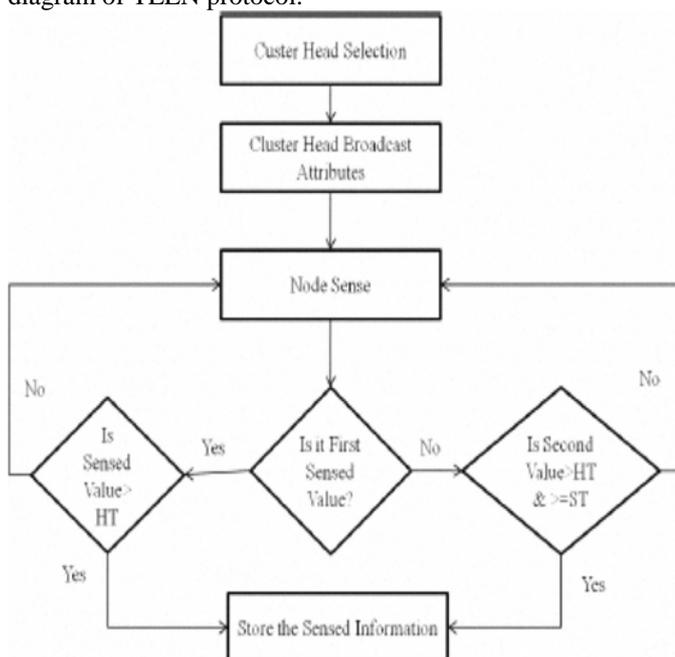


Fig.1. Operation Flow Chart of TEEN

B. SPEED

SPEED only stores the information of very next node. Stateless Non-deterministic Geographic Forwarding (SNGF) identifies next hop whenever source node transmit the data. SPEED uses Backpressure rerouting mechanism for congestion control/handling in the network [2]. Packets are given an alternative route to destination and normally no packets are dropped in Backpressure rerouting mechanism. Only when there is no alternative route to destination and network become very congested than the packets are dropped. It will consume less energy if there is no congestion in the network and also it will save energy by selecting shortest path to the destination but if there is congestion in the network, the energy consumption will be slightly higher. SPEED is a hybrid protocol because it combines the functionality of MAC and network layer to minimize the delay and to provide better response to congestion.

C. MMSPEED

MMSPEED is an extension of SPEED protocol [2]. The MMSPEED protocol aims to make routing decisions locally on the nodes and also to facilitate differentiated QOS in timeless and reliable domain. To make decisions locally without maintaining end-to-end routes, it uses geographic routing method. It assumes that main identifier for destination

is its geographic location rather than node ID. Periodic location update packets are used to instantly update the location information with neighbors, so that every node is aware of its very next neighbor within its range. Each node makes pre-packet decisions depending on the geographic location of the neighbor.

To achieve higher performance, MMSPEED needs MAC layer to support following function:

- To assign priority for accessing shared-medium depending upon the speed layer.
- Reliable packet delivery
- Average delay measurement
- Measurement of loss to individual neighbors

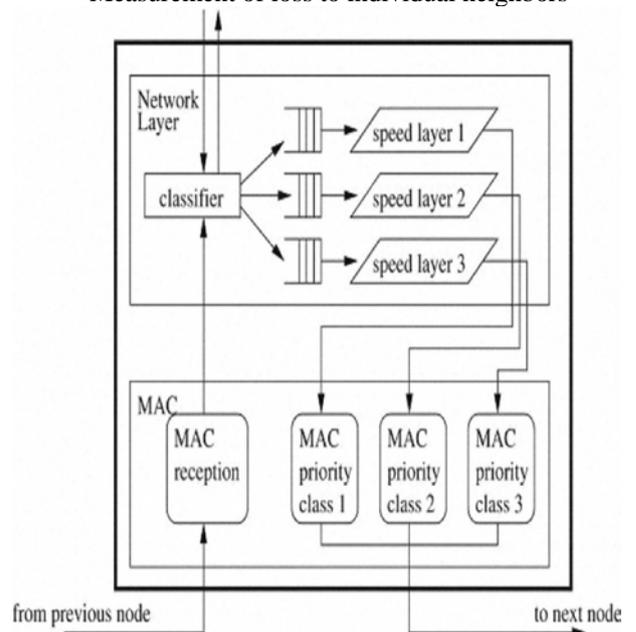


Fig. 2. MMSPEED Protocol

V. GROUP LOCATION BASED MULTICAST ROUTING PROTOCOL

In group location based multicast protocol we establish a multicast group with related sensor nodes in the scope of specific area. The basic idea of such an agreement is to divide sensor nodes into different regions based on demand.

We use different mode to communicate within a certain group and between groups. Region based multicast groups have Geo-Cast, Team Multicast and Mobile-cast and so on, we take Geo-Cast for example to discuss this protocol in detail [9].

Geo-Cast assumes that the multicast nodes have been in a particular multicast area already, multicast nodes within the region are known as location-based multicast group.

For this type of protocols there are two parts of the routing process, routing between nodes as one part, the other is the routing from source node to group area.

In Geo-Cast each sensor node is assumed to have a GPS device, with the help of which it can know about its own location.

Geo-Cast proposed two different location-based algorithms.

In the first location algorithm, transmission of multicast packets remains restricted in the Forwarding Zone regions. A forwarding zone is defined in the map, Forwarding nodes outside the region do not forward packet after receiving data, Multicast data can be forwarded after arriving in the multicast forwarding zone. Figure 3 explains the first location algorithm.

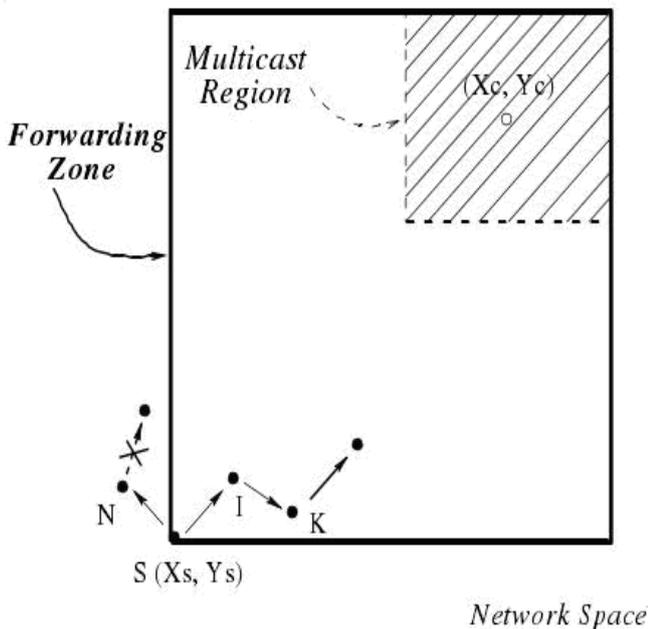


Fig.3. the first location algorithm

The second location algorithm is shown in Figure 4, in this each node has to find the other node which was more closer to multicast region to send data, Node need to compute the distance to the target zone is closer than its parent node or not, yes for forwarding data, no for abandoned data.

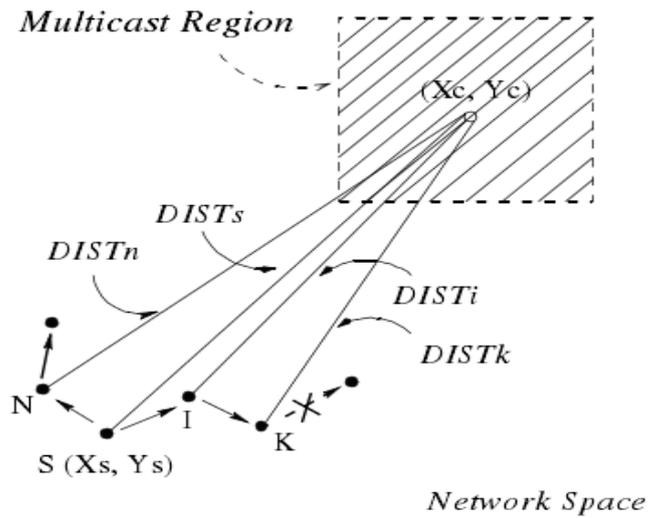


Fig. 4. the second location algorithm

VI. ALL IP MULTICAST ROUTING PROTOCOL

With the progress of technology it is possible to integrate WSN and Internet by existing infrastructure. Now a day, IPv6 technology has draw more and more attention owing to its excellent performance especially for almost inexhaustible address resources.

IPv6 network can be used to exchange data within WSN by access node with simple function. This simple mechanism of using IPv6 within WSN is known as all IP multicast routing protocols.

This protocol works as, there are 16 bytes of source address and 16-byte of destination address in IPv6 packet header, Destination address is set to multicast address, and Multicast group nodes with same addresses can receive the data[9].

VII. STEINER BASED SECURE MULTICAST ROUTING PROTOCOL

Several multicast protocols for WSNs have been discussed as yet. These protocols focus on how to deliver date packets, but none of them take the security into account. When WSN is working in the battle area or some hospital field, the security is one of the key questions in sensor networks [3]. In particular, the data transmitted between nodes should have three great characteristics: confidentiality, integrity and Authentication.

In order to satisfy security requirements and control of energy consumption, Steiner-based Hierarchical Secure Multicast Routing Protocol (SHSMRP) for wireless sensor network is presented here. The resulting protocol combines the idea of Steiner tree and cluster network topology, which is scalable and energy-efficient for large group communications in WSN. Furthermore, the proposed protocol adopts secure communication mechanism to ensure the data integrity, security and verifiability [3].

This protocol includes the following five phases:

- 1) Nodes information gathering phase
- 2) Steiner tree construction phase
- 3) Steiner sub-trees distribution phase
- 4) Data delivery phase
- 5) Steiner tree maintains phase

A. Nodes information gathering phase

In order to join the network, each node first gets location information by some location services, and then sends the join message to source node S including the location information. The source node should verify each node in order to prevent the malicious node to join in the network. The authentication of each node is checked by pre-shared key.

B. Steiner tree construction phase:

The source node S begins to construct Steiner tree as soon as nodes' information is obtained. Due to the limited number of receivers in one multicast packet, the Steiner tree should be partitioned into several sub-trees to meet the requirement of limitation of one multicast packet. Each Steiner sub-trees can be called as multicast group in this way.

C. Steiner sub-trees distribution phase:

After the Steiner tree divided into several sub-trees, source node S should broadcast topology structure of each sub-tree. And after each node receives the information of topology, it analysis the data packets of topology structure to obtain the role information about itself in WSN. For the security reasons, the sensor node should unicast the node-state information table before broadcasting the topology of Steiner sub-tree.

D. Data delivery phase:

When the source node wants to transmit any request, it should firstly determine the region of multicasting. Then the source node selects the related Steiner sub-trees which are in the geographical scope from local database. Taking a Steiner sub-tree as unit, the source node transmits multicast data using unicast technology. After the multicast packet reaches the root node of the sub-tree, CHs in the sub-tree forward the multicast packet in accordance with the order of CHs ' Height Value. Simultaneously, if the CH detects that it is the destination, it first validate the time stamp T and the value of $HMAC$ in the received message. Secondly, each CH who is the destination of multicasting broadcasts the content of multicast packet Each MN in the cluster also checks T and value of $HMAC$. If the inequality $Clock$ holds and computing result is equal to $HMAC$ in the received message, MNs accept the content of multicast packet.

E. Steiner tree maintains phase:

In this phase the maintenance of Steiner tree is done. The joining or leaving of new node in the tree is done. The main task of Steiner tree maintains is re-keying for each node in the network.

VIII. CONCLUSION

WSN routing protocols with purpose to find the path to save energy and establish reliable data transfer method, which made the network to maximize the life time. In this paper different types of multicast routing protocols for WSN has been discussed that are aimed to meet this purpose. Multicast routing algorithm can reduce energy consumption and transmission delay effectively and expand the applications of wireless sensor networks further more [1].

But, there are still too many problems need to be improved, such as how to build up an effective multicast tree in the case of reducing control packet cost effectively, Multicast routing protocols deserve further more groundbreaking research on wireless sensor networks.

ACKNOWLEDGMENT

The authors are grateful to prof. Rishi Kumar, Assistant Professor, Dept of Computer Science, Amity University, Noida for providing and giving his valuable advice to our research.

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