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Study of Routing Approaches in Wireless Sensor Network

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***Abstract*— Wireless Sensor Network is one special type of wireless networks without fixed infrastructure consisting of a collection of sensor nodes, and operating on limited amount of battery energy consumed mostly in transmission and reception. In the WSNs, every sensor node can sense, process data and communicate to base station (BS). In this paper, we throw the light on the strategies and methods used in routing protocols.**

***Index terms*- Energy efficient protocols, WSN, Adhoc Network.**

I. INTRODUCTION

Mobile environment differs from the stationary environment in many respects. Computers in stationary environments are usually very reliable and efficient during data transfer from one host to another host. A stationary environment can distribute an application's components and rely upon the use of high-bandwidth, small latency networks to provide excellent interactive application performance. The attribute of the typical stationary environment has guided the development of classified distributed computing techniques for building client-server application. These applications are usually unaware of the actual state of the environment so they assume implicit assumptions about type location and availability of resources. But mobile computers are quite fragile. A mobile computer may run out of battery power, be lost or damage or be stolen[1]. Mobile computer also interacts with surrounding environment, which may introduce noise, interruption blocking, disconnection, privacy breach, and risk of data loss due to remote access, low bandwidth and bandwidth variability. Relative to most stationary computers, a mobile computer has fewer computational resources available, which may change dynamically. So special precautions should be taken to enhance the reliability of data stored on mobile computers. In mobile computing, hosts move frequently. When a mobile host moves to new location it informs with nearby base station for further communication. This means frequent mobility of hosts leads an issue of location management for quick communication between mobile hosts for exchange of database.

Wireless enabled networks can be categorized in the following two types.

II. INFRASTRUCTURED NETWORKS

A. Infrastructure less networks

The flexibility, practicality and support for mobility of wireless communications overweigh the drawbacks discussed above. A wireless network connection is often a lot more convenient than a wired one. The wide scope of potential applications for wireless communications, especially in the context of Ad hoc networks, guarantees the added development and operating cost for advanced network management mechanisms[1].

III. ROUTING PROTOCOLS

The basic routing functionality for mobile ad hoc networks is as follows:

- Path generation Mechanism: which generates paths according to the assembled and distributed state information of the network and of the application; assembling and distributing network and user traffic state information,
- Path selection Mechanism: which selects appropriate paths based on network and application state information;
- Data Forwarding Mechanism: which forwards user traffic along the selected route forwarding user traffic along the selected route.
- Path Maintenance Mechanism: maintaining of the selected route.

There are more than 70 competing schemes for routing packets across mesh networks. Some of these include:

- AODV (Ad hoc On-Demand Distance Vector)
- B.A.T.M.A.N. (Better Approach To Mobile Adhoc Networking)
- Babel (protocol) (a distance-vector routing protocol for IPv6 and IPv4 with fast convergence properties)
- DNVR (Dynamic NIx-Vector Routing)
- DSDV (Destination-Sequenced Distance-Vector Routing)
- DSR (Dynamic Source Routing)
- HSLS (Hazy-Sighted Link State)
- HWMP (Hybrid Wireless Mesh Protocol)

IV. Properties of a proficient routing algorithm

Efficient packet routing is the key research issue in ad hoc networks. Several characteristics of the ad hoc networks make the routing problem very different than wired networks. First, dynamically changing network connectivity requires that routes be updated recurrently. Second, low bandwidth of wireless links necessitates that routing overhead be kept low, so that only a little fraction of network bandwidth is spent on transmitting routing packets (as opposed to data packets)[3]. Third, swift convergence of the routing protocol may be decisive even if the routes obtained may be sub-optimal. The reason for this is that spending a long time to obtain a high quality route (e.g., shortest path) may not be very productive, as routes may change by the time route discovery is complete. Therefore, there exists interesting trade-offs between the quality of the route, and time and overhead spent in determining that route. Fourth, the longevity of a node's battery becomes an issue since they will be using battery energy to sustain life within an ad hoc network. Routing protocols designed with energy conservation in mind may become important criteria that may need to be addressed In general; some common desirable properties that any routing protocol for an ad hoc network should possess are as follows[2]:

Qualitative Characteristics

Several qualitative properties for designing a routing protocol are desired for a mobile ad hoc network.

- Loop free: Presence of loops in the path from the source to the destination result in inefficient routing. In the worst-case situation, the packets may keep traversing the loop indefinitely and never reach their destination.
- Distributed control: In a centralized routing scheme, one node stores all the topological information and makes all routing decisions; therefore, it is neither robust, nor scalable. The central router can be a single point of failure; also, the network in the vicinity of the central router may get congested with routing queries and responses.
- Fast routing: The quicker the routing decisions are made, the sooner the packets can be routed towards the destination, as the probability that the packets take the chosen route before it gets disrupted because of node mobility is quite high.
- Localized reaction to topological changes: Topological changes in one part of the network should lead to minimal changes in routing strategy in other distant parts of the network. This will keep the routing update overheads in check and make the algorithm scalable.
- Multiplicity of routes: Even if node mobility results in disruption of some routes, other routes should be available for packet delivery.
- Power efficient: A routing protocol should be power efficient. That is the protocol should distribute the load otherwise shut-off nodes may cause partitioned topologies that may result in inaccessible routes.
- Secure: A routing protocol should be secure. We need authentication for communicating nodes, non-repudiation and encryption for private networking to avoid routing deceptions.
- QoS aware: A routing protocol should also be aware of Quality of Service. It should know about the delay and throughput for a source destination pair, and must be able to verify its longevity so that a real-time application may rely on it.

A. Quantitative Characteristics

There are several quantitative performance metrics that can be used to assess the performance of routing protocols within a mobile ad hoc network. First, throughput and end-to-end delay are typical performance measures that show a routing protocol's effectiveness in doing its job (i.e. delivering data packets)[4]. Second, for certain protocols that acquire routes on-demand the amount of time it takes to acquire a route or route discovery latency is also an important performance measure. This measurement more simply conforms to those protocols that are of a demand-base property and thus should be attained. Third, bandwidth utilization should be observed to notice, how effectual the protocol is if both routing packets and data packets share the same channel. One such measure would be to attain the number of bytes (or packets) of routing packets transmitted per number of bytes (or packets) of data packets delivered. Another such measurement may be the amount of data bits transmitted per data bit delivered to show the efficiency of data delivery throughout the network.

- IWMP (Infrastructure Wireless Mesh Protocol) for Infrastructure Mesh Networks by GRECO UFPB-Brazil
- MRP (Wireless mesh networks routing protocol) by Jangeun Jun and Mihail L. Sichitiu
- OLSR (Optimized Link State Routing protocol)
- OORP (OrderOne Routing Protocol) (OrderOne Networks Routing Protocol)
- OSPF (Open Shortest Path First Routing)
- PWRP (Predictive Wireless Routing Protocol)
- TORA (Temporally-Ordered Routing Algorithm)
- ZRP (Zone Routing Protocol)

The IEEE is developing a set of standards under the title 802.11s to define an architecture and protocol for ESS Mesh Networking.

V. Basis of routing strategy

One of the issues with routing in ad hoc networks concerns whether nodes should keep track of routes to all possible destinations, or as an alternative keep track of only those destinations that are of immediate interest. A node in an ad hoc network does not need a route to a destination until that destination is to be the recipient of packets sent by the node, either as the genuine source of the packet or as an intermediate node along a path from the source to the destination. On the basis of routing strategies used in mobile ad, hoc networks, routing protocols can be categorized in different classes: flooding, proactive, reactive, and hybrid[1].

A. Flooding

In flooding sender broadcasts data packets to all its neighbors. Then, each node receiving the data packets forwards these data packets to its neighbors. Thus, flooding provides potentially lower reliability of data delivery because flooding uses broadcasting which creates significantly high overhead cause network congestion. One of the advantages of flooding is to deliver packets to the destination on multiple paths, so from this point of view flooding is reliable. Also, flooding may be more proficient that other protocols when rate of information transmission is low enough that the overhead of explicit path generation/selection incurred by other protocol is relatively high (e.g. when nodes transmit small data packets relatively infrequently)[5].

B. Proactive or Table driven

In proactive routing algorithms, each node maintains a routing table containing the next hop information for every other node in the network, and hence a route between the source node and the destination node is always available making the approach proactive. Examples of proactive protocols include DSDV and the Fisheye State Routing (FSR). Protocols that keep track of routes for all destinations in the ad hoc have the advantage that communications with arbitrary destinations experience minimal initial delay from the point of view of the application. When the application begins, a route can be immediately selected from the routing table. Such protocols are called proactive because they store route information even before it is needed. They are also called table driven because routes are available as parts of a well-maintained table. Certain proactive routing protocols are Destination-Sequenced Distance Vector (DSDV), Wireless Routing Protocol (WRP), Global State Routing (GSR), Cluster head Gateway Switch Routing (CGSR). Proactive Protoco1s suffer the disadvantage of additional control traffic that is needed to continually update stale route entries. Since the network topology is dynamic, when a link goes down, all paths that utilize that link are broken and have to be repaired. If no applications are using these paths, then the effort gone in to repair may be considered wasted. This wasted effort can cause scarce bandwidth resources to be wasted and can cause further congestion at intermediate network points. Proactive protocols are scalable in the number of flows but are not scalable in the frequency of topology change. Proactive protocols are also scalable in the number of nodes[6].

1) Distance Vector

Distance vector algorithms are so called because each node maintains, for each destination, the distance to that destination from each of the node's neighbors. The neighbor with the shortest entry in this vector of distances is chosen to be the next hop to the destination. Choosing next hops in this fashion results in the shortest path to any destination. A node derives the information in its distance vector via periodically broadcast updates from its neighbors. This method, the Distributed Bellman-Ford (DBF) algorithm, is computationally efficient and straightforward to implement. However, the DBF algorithm is subject to both short- lived and long-lived routing loops because nodes choose their next hops in a distributed manner using information that may be out-of-date. Nevertheless, the simplicity of DBF has made it an attractive choice for implementation[7].

2) Link State

In a link state algorithm, each node monitors the status of its link with each of its neighbors. This information is shared periodically with the other nodes in the network. Thus each node acquires a complete description of the network topology, and can apply a shortest-path algorithm to choose its next hop for each destination. Due to propagation delays, the link state information at a particular node may be temporarily out-of-date, possibly resulting in loop formation. Such loops are short¬-lived, however, disappearing as routing updates traverse the network. Link state algorithms are more complex computationally and require more memory than distance vector algorithms, but they are not subject to the formation of long-lived loops[5].

C. Reactive or On demand

In reactive routing algorithms, a path discovery process determines the path to the destination only when the node has a packet to forward that is it reacts to a request to send data to a host. These types of routing algorithms are also referred to as on-demand routing protocols.

On-demand or reactive protocols have been designed to overcome the wasted work in maintaining unwanted routes. In these protocols, routing information is acquired only when it is actually needed. Reactive routing protocols save the overhead of maintaining unused routes at each node, but the latency for numerous applications will significantly enhance. Most applications are likely to suffer a long delay when they start because a route to the destination will have to be acquired before the communication can begin. Some reactive protocols are Cluster Based Routing Protocol (CBRP), Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR),Temporally Ordered Routing Algorithm (TORA), Associativity-Based Routing (ABR), Signal Stability Routing (SSR), Location Aided Routing (LAR). Reactive protocols may not be optimal in terms of bandwidth utilization because of flooding of the route detection request, but they remain scalable in the occurrence of topology change. Such protocols are not scalable in the number of nodes; however, they can be made scalable if a hierarchical architecture is used. Further reactive protocols are not scalable in the number of flows. Thus reactive strategies are suitable for networks with high mobility and relatively small number of flows.

A distinctive kind of on-demand routing is Source Routing.

1) Source Routing

In source routing, a node builds up a route by flooding a query to all nodes in the network for a given destination. The query packet stores the .information of the intermediate nodes in a path field. On identifying the target or any other node that has already learned the path to the destination, answers the query by sending a “source routed” response packet back to the sender. Since multiple answers may be formed, multiple paths may be computed and maintained. After the paths are computed, any link failure will trigger another query/response so the routing can always be kept up to date[7].

D. Hybrid

Hybrid routing protocols aggregates a set of nodes into zones in the network topology. Afterward, the network is divided into zones and proactive approach is used within each zone to preserve routing information. To route packets between diverse zones, the reactive approach is utilized. As a result, in hybrid schemes, a route to a target that is in the same zone is set up without hindrance, while a route discovery and a route maintenance procedure is required for destinations that are in other zones. The zone routing protocol (ZRP), zone-based hierarchical link state routing protocol (ZHLS), and: distributed dynamic routing algorithm (DDR) are hybrid routing approaches. The hybrid protocols can provide a better trade-off between communication overhead and interruption, however this trade-off is subjected to the size of a zone and the dynamics of a zone. Furthermore, hybrid approaches provide a compromise on scalability Issue in relation to the frequency of end-to-end connection, the entire number of nodes, and the frequency of topology change. Therefore, the hybrid approach is an appropriate candidate for routing in a large network[3].

Table driven routing approaches uses a connectionless approach of forwarding packets, without considering when and how frequently such routes are desired. It relies on an underlying routing table update mechanism that involves the constant propagation of routing information. In some typical scenario, table-driven approaches are found to have an edge over an on-demand approach due to the following:

- On-Demand routing protocols on the average create longer routes.
- On-Demand routing protocols are more sensitive to traffic load.
- On-Demand routing incurs higher average packet delay. This is due to latency caused by route discovery from new destinations and less optimal routes.
- In Table-Driven approach, routing• accuracy is less sensitive to topology changes and link failures.

Conclusion

A routing protocol is the mechanism by which user traffic is directed and transported through the network from the source node to the destination node. Objectives comprise maximizing network performance and minimizing the cost of network in accordance with its capacity. The network performance depends upon hop count, delay, throughput, loss rate, stability, cost, etc; and the network capacity is a function of available resources resides at each node and number of nodes in the network as well as its density, frequency of communication, frequency of change in topology. Routing in Ad hoc environment is diverse compared to normal wired networks. This paper elloborates the different strategies used for routing in WSN.

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