Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 3, March 2014, pg.665 – 670

RESEARCH ARTICLE

A Study on Routing Components and Routing Approaches in Sensor Network

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Abstract
A sensor network is an adhoc network defined under the energy constraints. As the communication is performed over the network, some amount of energy is lost by each participating nodes. One of the effective network operations is routing. Route optimization in sensor network depends on different routing elements. In this paper, these routing elements are discussed and explored. The paper has also discussed various challenges associated with network routing. In this paper, different routing approaches under different network architectures is presented and explored.

Keywords – LEACH, PEGASIS, ROUTING, CLUSTER, AGGREGATION

I. INTRODUCTION

A sensor network is composed of large number of sensor nodes defined under the energy specification in a limited area network. As the communication is performed over such network, some amount of energy is lost by each participating node. Each sensor network is involved in many communication and sensing activities such as sensing, transmission, location identification, monitoring etc. The criticality of network increases, when the network is a heterogeneous sensor network. In such network, achieving the energy effective and high communication under the physical boundaries is also a challenge. A sensor network is generally defined under the structured formation. One of such formation is the clustered network in which complete network is divided in small segments called clusters and each cluster is controlled by a cluster head. To achieve the effective communication over the network, effective deployment of nodes over the network is required. After the deployment process, the effectiveness is also required in all involved function to the communication. One of such network sensitive operation is the routing. Routing is about to identify the effective path over which the communication will be performed. There are number of constraints to identify such path [1][2][3]. Some of these constraints are shown in figure 1

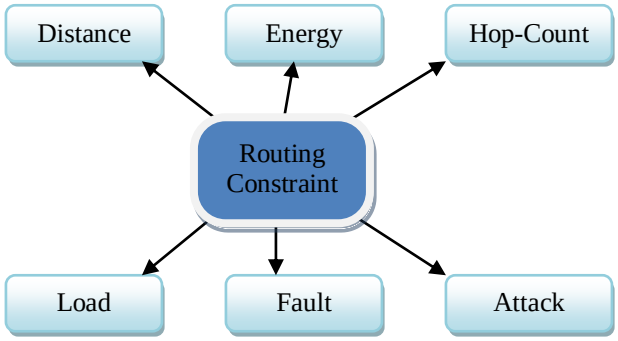

Figure 1: Routing Constraints

As shown in the figure, the routing constraints are defined and explored. One of the most known routing constraints is distance. Generally, the route optimization is performed from the shortest path. But this kind of route is also favorite to the attacker to attack the intermediate nodes. In sensor network, where with each communication some energy is lost, the shortest path nodes will lose their energy very quickly. Because of this, energy is one of the major decision vectors while performing the route selection. The routing in sensor network must be energy effective so that if the energy on some path nodes is lesser, other route will be identified. It will also improve the energy balanced communication over the network. Another important vector route selection over the network is hop-count[4][5][6]. As the communication is performed ver multiple nodes, each participating node release some amount of energy. To reduce the energy consumption over the route, the hop-count reduction based routing is also the energy effective criteria for route selection.

While performing the dynamic analysis over the route, some other factors that includes the monitoring of suspicious activity over the network. Generally some kind of activity monitoring is either done by some agent or the controller node. One of such vector is load or the congestion. As the multiple communications is being performed over the network, because of this some of the route nodes can suffer from extra load over the nodes. This can be either done in the form of DOS attack or some real overload communication. In such case, the load effective route identification is also performed to reduce the communication delay and to perform the reliable packet delivery. As the communication over the network is device or the component based, the network also suffer from different kind of node fault or the network faults. To provide the effective communication, the fault monitoring is also done. These faults can be in terms of some bad links or no link situation over the network. Another criterion for route identification over the network is attack identification. The attack can be some forwarding attack, man in middle attack, denial of sleep attack or the black hole attack. To generate the preventive route over these attacks, the attack specific parameters are considered to identify the effective route. The route identification is performed under high throughput analysis so that the effective route will be generated over the network[7][8].

In this paper, different routing approaches and the constraints related to the route optimization are discussed. The paper also covers the protocol oriented study under the route identification. In this section, the basic construction of sensor network as well as different constraints that affects the routing in sensor network is explored. In section II, the work done by the earlier researchers for route identification is discussed. In section III, different routing approaches adapted by different sensor network architecture will be discussed. In section IV, the conclusion obtained from the work is presented.

II. ROUTING CHALLENGES

In this section, different vectors or the challenges associated with route identification is been discussed. A sensor network is defined with lesser centralized control and lesser capabilities. Because of these restrictions, the routing in such network is always a challenge [9][10]. The factors that affect the route generation and identification are shown in figure 2.

A) Node Deployment

The node localization in a sensor network defines the physical parameter that affects the network performance. The deployment can be either randomized or the determistic. In case of determistic placement, the nodes are placed at specific locations under some defined architecture. The distribution of nodes under some specific order also improves the network

uniformity and the clustering so that the energy efficient processing will be performed over the network. The effective localization is defined under different vectors such as sensing range, bandwidth, type of network architecture etc.

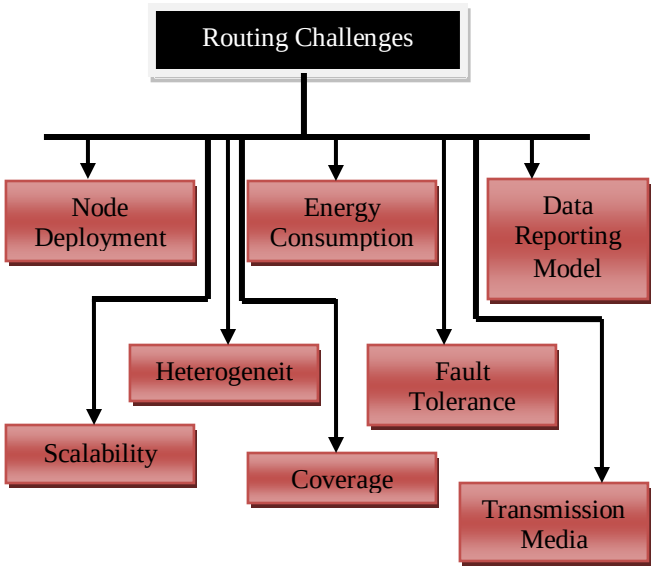

Figure 2 : Challenges Associated with Routing

B) Energy Consumption

Each node in sensor network is defined with limited energy. When some communication or the computation is performed over the network, each participating node loses some amount of energy. Because of this, the routing decision is performed under the energy awareness. It is required to generate a fault free communication, because re-routing or the reconstruction of network gives heavy energy loss. Another problem of network is the energy balancing. It means, the communication should be performed in such way, the energy consumption over the network will be performed in symmetric way otherwise, the unequal energy distribution over the network reduces the energy consumption and increases the criticality of energy challenges[11]

C) Data Reporting Model

The data reporting or the sensing is about to deliver the information periodically to the base station. This data reporting model can be event based, query based, time based or hybrid. The data diffusion approach is applied along with data reporting model to represent the type of information collection and the distribution. This kind of model also performs the monitoring to the network nodes and identifies the sudden changes so that more accurate and reliable communication will be performed[12].

D) Heterogeneity

When the network is constructed over the homogeneous nodes, the node replacement can be done easily. But when the capabilities of each node are defined, the criticality over the network is increased. In such case, a node cannot replace other node. The degree of heterogeneity affects the network capabilities. The special sensors are defined to perform specific operations so that the service oriented constraints are specified while performing the routing decision. The route identification becomes more specific in such network, so that the route optimization is required to perform under certain limits.

E) Fault Tolerance

In sensor network, a node can fail or block because of different reasons. The reason can be potential damage, some attack, lack of power or some environmental interference. While performing the route selection, the fault free participating nodes are selected so that the reliable communication will be performed. Some agents or the monitor nodes are placed over the network to identify the faulty nodes or links so that fault tolerance communication will be performed over the network.

F) Scalability

As the size of the network, the criticality of network communication and route identification also increases. The distance communication is performed using multi-hop routing and in such case, the identification of route with minimum number of intermediate nodes is also a challenge. As the number of intermediate nodes increases, the energy consumption over the route also increases. The scalability also need to identify the node state so that effective utilization of each node over the network will be performed.

G) Coverage

Coverage is defined as the sensing range that decides the communication reach of a node. Higher the range, more accurate the communication will be. The coverage is also limited to the physical area of the network. The sensing node also identifies the maximum connectivity over the network. Higher the connectivity level, more effective the routing decision will be.

H) Transmission Media

A sensor network performs the communication over the wireless channel under different vectors associated with communication channel. Some such vectors includes fading rate, error rate etc. Communication bandwidth, communication rate, MAC protocol design are also the integrated vectors with transmission media that affects the efficiency and reliability of communication over the sensor network.

III. ROUTING APPROACHES

In this section, different routing approaches adapted by sensor network are discussed. The routing approaches are divided in three main categories called flat based routing; hierarchical routing and location based routing. These routing approaches are adapted for any network based on the physical structure or the type of node deployment. To perform the routing, some routing protocols are also defined. In this section, these all approaches are explored in detail[13][14][15]

A) Flat Based Routing

This kind of routing is applied on a randomized homogeneous sensor network. In such network, all nodes are of same type and a multi-hop route identification is performed in such network. This routing approach is based on data centric routing where the queries is performed to the sender and based on the requested query; the data is transmitted to the receiver node. This routing approach includes the data diffusion to reduce the energy consumption and also remove the redundant information transmission. SPIN protocol defines such kind of routing. As the information query is requested by the receiver node, the similar query oriented data is collected by the protocol along with resource and data adaptive algorithms. The participating node converse lesser energy and perform the energy effective communication. While transferring the information, instead of performing the flooding, it performs the intelligent communication so that the redundancy of communicated data is reduced. The neighbor node selecting and the broadcasting is performed effectively.

B) Hierarchical Routing

This routing approach is called cluster based routing used in a specific network architecture called clustered architecture. In such kind of network, two level of communication is performed. One is the node to cluster head communication and other is cluster head to cluster head based communication. The hierarchical routing approach is again energy effective routing in which only low energy nodes can participate to generate the network path. As the network is divided in small area segments, the scalability over the network is also achieved. The cluster head based communication includes the aggregative

communication that performs the balanced energy consumption over the network. This kind of communication improves the network life. LEACH protocol is one of such hierarchical cluster approach. Hierarchical clustering uses the concept of data fusion along with aggregative communication that reduces the number of transmitted packets over the network so that the energy effective is achieved as well as the redundant information transformation is also reduced. In this routing type, the data is collected by a centralized node and this collection is done periodically. The routing protocol performs the continuous monitoring over the network nodes so that energy effective communication is performed over the network. Another improvement over the LEACH protocol is defined by PEGASIS protocol that performs the effective chain based routing. PEGASIS does not form any cluster, instead it creates a chain over the network nodes to perform the communication to the base station.

C) Location Based Routing

This routing approach is performed over the sensor node by tracking the node location. The distance analysis over the neighboring nodes is performed in this routing approach. The effectiveness of this kind of routing depends on the signal strength as the nodes are distance nodes. To identify the location of the node, the satellite communication is performed using GPS. The location demand is been performed to identify the communication activity over the network. In many networks such as vehicular area network comes under the location based or the geographic routing approach. GAF (Geographic Adaptive Fidelity) Protocol is one of such GPS based routing protocol. In this kind of routing, node election and the responsible node communication is been doing under the GPS monitoring and indication system so that the effective route will be generated for the communication. To improve the effectiveness of route optimization, this routing approach uses the concept of internal zoning so that the distance limit over the zone is applied and effective route identification is performed. As the nodes are mobile, the criticality of the routing approach is also increased because of node tracking. A zoning sensor is applied with each node to track the neighboring nodes so that the location tracking will be effective. This kind of protocol uses the aggregative routing along with data fusion so that the redundant information transmission will be reduced and the communication throughput will be improved.

IV. CONCLUSION

In this paper, a study of routing approaches is defined for sensor network. The paper has explored the concept of routing along with routing dependent elements. The challenges faced while performing the route selection is also discussed. The paper has also discussed different routing approaches under different network architectures.

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