A Survey on Cluster Based Routing Protocols for WSN and MANET

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Abstract

The advancements in wireless communication technologies enabled large scale wireless sensor networks (WSNs) deployment. The use of different wireless devices like cell phones, laptops GPS devices and other electronic devices have become penetrating, cheap and weighted in today's life. The demand for communication and networking among these various wireless devices has been increased for different applications. Wireless sensor networks from this point of view are the latest trend. Mobile Ad Hoc Networks (MANET) that are connected by wireless links are a self-configuring network of mobile nodes. The devices freely move in any direction and links among these devices are frequently changed. Collection of sensor nodes organised in a cooperative network is a wireless sensor network. Both of these networks fall into the category of infrastructure less wireless networks. In this paper we analyse and discuss some of the prominent cluster based routing protocols for Wireless sensor networks (WSN) and Mobile Ad Hoc networks (MANET) and compared them using various parameter metrics.

Keywords

Wireless sensor networks (WSN), Mobile Ad Hoc networks (MANET), Clustering, Routing protocols**..**

1. Introduction

Wireless sensor networks has come forth as a promising tool for utilizing self-organizing networks of battery-powered wireless sensors that can sense, communicate and process. Energy is a critical resource in sensor networks, while applications display a limited set of characteristics. Thus, there is a need and a chance to enhance the network architecture for the applications in order to minimize resource used. The limitations and requirements of wireless sensor networks make their architecture and protocols diverge and difficult from the needs of traditional Internet architecture.

A sensor network [7] is a network of many tiny disposable low power devices, called nodes, which are spatially distributed in order to perform an application-oriented global task. These nodes form a network by communicating with each other either directly or through other nodes. One or more nodes among them will serve as sink(s) that are capable of communicating with the user either directly or through the existing wired networks. The tiny sensor nodes, which consist of on board processor for data processing, sensing, and communicating components, influence the idea of sensor networks based on collaborative effort of a large number of nodes [2].

Mobile Ad hoc Networks [MANETs] communicate between various mobiles hosts which themselves act as routers and help in transmission of packets to the destination which lie inside the radio transmission range of each other through intermediate nodes. MANETs have a dynamic topology due to mobility of its nodes where links are broken and formed with time. These links can be bi-directional or unidirectional. Due to fast, reliable and energy efficient routing of data packets from the source to the destination it is an area of great concern for researches. Designing a protocol which helps to route data packets from source to destination with minimum battery power consumption and minimum possible hops of nodes is involved in MANETs routing.

The purpose of this document is to review various cluster based routing techniques and compare these techniques which have been presented by other researches. The rest of this paper is organized as follows. In second section we briefly discuss the different replication techniques provided by other researchers. In Section 3, provides further discussions, Section 4 shows some related work and Section 5 includes conclusions.

A. Clustering

The process of dividing the network into interconnected substructures is called clustering and the interconnected

substructures are called clusters [1].The cluster head (CH) of each cluster within the substructure acts as a coordinator. Each

CH within its cluster acts as a temporary base station. The main idea behind clustering is the grouping of network nodes into a number of overlapping clusters.

It also communicates with other CHs [2].of heterogeneous clusters. The main idea behind clustering is the grouping of network nodes into a number of overlapping clusters. Clustering make hierarchical routing possible in which paths are recorded between clusters instead of between nodes. It decreases the amount of routing control overhead, thus increasing the routes lifetime. The cluster activities inside the cluster is coordinated by the cluster head. The ordinary nodes in cluster have direct access only to cluster head and gateways. The nodes that can recognize two or more cluster heads are called gateways [3].

B. Advantages of clustering

Clustering routing protocols in WSN have a variety of advantages compared with flat routing protocols such as low energy consumption, lesser load, scalability and robustness. We summarize these advantages of WSN as follows:

Low energy consumption: In clustering routing scheme, data aggregation saves energy by reducing transmission data. While inter-clustering and intra-clustering communications allows low energy consumption for the entire network by reducing the number of sensor nodes performing the task of long distance communications. In clustering routing scheme only CHs performs the task of data transmission which lowers energy consumption.

Lesser load: Fusion has emerged as an important dogma and objective in WSNs. To combine data from different sources to eliminate redundant data transmissions and provide a rich and multi-dimensional view of the targets being monitored [1, 4] is the main idea of data aggregation or fusion. All cluster members send data only to the CHs, and fusion is performed at the CHs, which will drastically reduce transmission data and save energy. In addition, the routes are set up within the clusters which thus reduce the size of the routing table stored at the individual sensor nodes [1, 4].

Better robustness: The entire network is convenient and robust if only when the clustering routing scheme copes with the changes within individual clusters.

The advantages of clustering in Ad-Hoc are as follows:

- It Saves communication bandwidth and energy [3].
- Improves throughput, power consumption, scalability to allow better performance of the protocol for the Medium Access Control (MAC).
- Reduces the size of the routing tables to improve routing at network layer.
- Updates the routing tables after topological changes to decrease transmission overhead.

2. Related Work

In this section we present some of existing works on survey of cluster based routing in WSNs and MANETs

Roberto Carlos Hincapi´e, et al [4] have presented a survey on clustering techniques for MANET. Some preliminary concepts are introduced that form the basis for the development of clustering algorithms. Several clustering algorithms were explained and reviewed to MANET in a hierarchical manner. They also discussed various popular clustering techniques such as Weighted clustering algorithms (WCA), Distributed mobility-adaptive clustering (DMAC), Highest degree heuristic. They also discussed various clustering issues such as mobility algorithms, routing schemes and network topology.

Ratish Agarwal and Dr. Mahesh Motwani [5] have reviewed several clustering algorithms to organize mobile ad hoc networks in a hierarchical manner and presented their main characteristics. The survey examined cluster-based MANET issues, such as, the control overhead of cluster construction and maintenance, energy consumption of mobile nodes, stability of cluster structures and the load distribution in clusters.

Jiang *et al*. [2] discussed a total of three prominent advantages of clustering methods for WSNs, such as easy maintenance, more scalability, less overheads and then present a classification of WSN clustering schemes based on eight clustering Parameters. The authors also analyzed altogether six popular WSN clustering algorithms, such as, EECS, HEED, UCS, LEACH and *etc*., and compared these WSN clustering algorithms, including various Parameters.

A survey on clustering algorithms for WSNs was presented by Boyinbode *et al*. [4]. The main challenges for clustering algorithms were discussed and nine prominent clustering algorithms for WSNs were summarized in the survey such as LEACH, EECS, HEED, UCS, *etc*. They also compared these clustering algorithms based on metrics such as cluster size

uniformity of CH distribution, residual energy, delay, hop distance and cluster formation methodology.

3. Survey on Cluster-Based Routing Protocols For WSN

In this section, we present a survey on some prominent cluster-based routing protocols for WSN. We analyze four popular and prominent cluster-based routing protocols and highlight their advantages, disadvantages and characteristics.

A. Low-Energy Adaptive Clustering Hierarchy (LEACH)

Low-Energy Adaptive Clustering Hierarchy (LEACH), proposed by Heinzelman *et al.* [4], is one of the promising clustering routing approaches for WSNs. It has been an inspiration for many subsequent clustering routing protocols. The main objective of LEACH is to rotate CHs to select sensor nodes, so the high energy dissipation in communicating with the BS is spread to all sensor nodes in the network. LEACH is a distributive approach no global information of network is required. Several modifications are made to the LEACH protocol, which form LEACH family such as T-LEACH [4], TL-LEACH [4], E-LEACH [4], M-LEACH [4] etc.

B. Hybrid Energy Efficient Distributive Clustering (HEED)

Hybrid Energy-Efficient Distributed clustering (HEED) [4], introduced by Younis and Fahmy, which brings an energy-efficient clustering routing with explicit consideration of energy is a multi-hop WSN clustering algorithm. Multi-hop communication between CHs and the BS encourage scalability and more energy conservation. HEED does not select nodes as CHs randomly, different from LEACH in the manner of CH election. Cluster construction is performed based on hybrid combination of two parameters. One parameter is the intra-cluster communication cost, and the other parameter depends on the nodes residual energy. In HEED, elected CHs have relatively high average residual energy compared to MANETs. Moreover, one of the main goals of HEED is to get an equally-distributed CHs throughout the networks. Furthermore, the probability of prodigy that two nodes within each other's communication range become CHs together is very small in Hybrid energy efficient distributive clustering (HEED).

C. Unequal Clustering Size (UCS)

Unequal Clustering Size (UCS) model [2] was proposed by Soro and Heinzelman for network organization in order to increase the network lifetime by balancing energy consumption of CHs. It is the first unequal clustering model for WSN organization. In UCS it is assumed that the CHs positions are determined *a priori*, with all CHs arranged symmetrically in concentric circles around the BS which is located in the center of the network, thus it's easy to control the actual sizes of different clusters [wsn ppr].

D. Energy Efficient Clustering Schemes (EECS)

Energy Efficient Clustering Scheme (EECS), proposed by Ye *et al.* [2, 4], is a cluster-based algorithm which better suits the periodical data gathering applications. EECS is similar to LEACH scheme, where single-hop communication between the CH and the BS is performed and the network is partitioned into several clusters. In EECS, CH candidates compete for the capability to elevate to CH for a given round. This competition implicates candidates broadcasting their residual energy to neighboring candidates. If a given node fails to find a node with more residual energy, it becomes a CH. EECS is different from LEACH for cluster formation, It extends LEACH by dynamic sizing of clusters based on cluster distance from the BS.

4. Survey on Cluster-Based Routing Protocols For MANET

In this section, we present a survey on some prominent cluster-based routing protocols for MANET. We analyze four popular and prominent cluster-based routing protocols and highlight their advantages, disadvantages and characteristics.

A. Core Location-Aided Cluster-based routing protocol (CLACR)

In [1] Tzay-Farn Shih and Hsu Chun Yen have proposed a cluster-based routing protocol, Core Location-Aided Cluster-based Routing protocol (CLACR). In CLACR the entire network is partitioned into square clusters. The selection of cluster head is done by a cluster head election algorithm in each cluster. The number of nodes responsible for data transfer and routing is decreased considerably by the use of cluster mechanism. It also increases the route lifetime enormously and diminish the routing overhead. The path is computed using Dijkstra algorithm in a cluster-by-cluster basis by the CLACR [3].

B. Cluster Based Routing Protocol (CBRP)

In [1] M. Rezaee and M. Yaghmaee proposed a cluster based routing protocol (CBRP) for mobile ad hoc network. In CBRP weights are allocated to every node. The weights are divided in three groups in which each group gives the credit measures of node to become cluster head. The nodes send messages to the head and the node in the higher group which delivers messages to the neighbor nodes sooner is

chosen as the CH. Each node sent LIVE messages repeatedly to declare itself and to have knowledge of its neighbor nodes. It is used to calculate W (weight group). The weight of each node is repeatedly calculated using the parameters such the remaining battery lifetime, as the number of neighbors of the node, the transmission power and cumulative time.

C. Cluster Head Gateway Switching Protocol (CGSR)

Clusterhead gateway switch routing protocol (CGSR) proposed by Ching-Chuan Chiang et al. [1] relies on the same cluster-based approach as the CBRP. CGSR routes packets by just using cluster heads and gateway nodes as CBRP does. CGSR uses the destination sequenced distance-vector routing protocol (DSDV) for routing. To find out the next node on the way to the shortest destination cluster head every node stores a routing table and a cluster member table. The mobile nodes are grossed into clusters and a cluster-head is elected. A node that is in the communication range of two or more cluster-heads a gateway node. Cluster head scheme in a dynamic network can cause performance mortification due to frequent cluster-head elections, so CGSR uses a Least Cluster Change (LCC) algorithm. In LCC, cluster-head change occurs only if a change in network causes two cluster-heads to come into one cluster or one of the nodes moves out of the range of all the cluster-heads.

D. Efficient Cluster-Based Routing Protocol (ECBRP)

In [5] [1] Yi-Yu Su proposed an efficient cluster-based routing protocol which supports unidirectional network environments. In ECBRP, it updates the cluster information and then the node determines its own status by the exchanging the cluster information with its neighbor nodes. The cluster head manages the number of nodes and the degree of the node in the proposed clustering algorithm. It also considers the number of hanging node and unite it into the weight function. Nodes having more hanging nodes within its 2-hop neighbors have higher possibility to become a cluster head. Thus the clusterhead formed by the hanging nodes can be reduced. Hence this improves the efficiency of the cluster structure. The proposed weight function requires only degree of nodes and status.

5. Comparison of The Cluster-Based Routing Protocols

In this section, we will compare the above cluster-based protocols for WSN and MANET with various parameters. Table 1. Shows Cluster-based routing protocols for WSN i.e HEED, LEACH, UCS and EECS are compared based on different clustering parameters such as Energy efficiency, cluster stability, sizes of the clusters, cluster count, mobility of the cluster head, Role of the cluster head, convergence time of clustering. Also the advantages and disadvantages are shown in Table 1.

Table 2. Shows some of the popular cluster-based routing protocols for MANET are compared on the basis of various parameters such as the type of the protocol, routing overhead, the performance metrics of the protocol. Also the advantages and their limitations are shown in Table 2.

Table-1: Comparison of cluster-based routing protocol for WSN

Clustering Parameters	Cluster-based routing protocols			
	HEED	**LEACH**	**UCS**	**EECS**
Cluster count	Flexible	Flexible	Flexible	Flexible
Cluster sizes	Equal	Equal	Unequal	Unequal
Capabilities of cluster head	Same genetic structure	Same genetic structure	Same genetic structure	Same genetic structure
Mobility of cluster head	Fixed/Mobile	Fixed/Mobile	Fixed/Mobile	Fixed/Mobile
Role of cluster head	Relay aggregation	Relay aggregation	Relay aggregation	Relay aggregation
Control manners	Scattered	Scattered	Scattered	Scattered
Convergence time	Consistent	Consistent	Consistent	Consistent
Advantages	Extended network lifetime, Reduces energy load, Creates well distributed clusters	Low latency, Better energy utilization and system life time	Increases network lifetime ,Low energy consumption	Energy efficient, Increases network lifetime, control overhead complexity
Limitations	Higher communication overhead, Extra energy to rebuild cluster	Fault tolerance issues-nodes behave unexpected	Lacks universality[68]	Not suitable for long range networks

Table-1: COMPARISON OF CLUSTER-BASED ROUTING PROTOCOL FOR WSN

Parameters	Cluster-based protocol			
	CLACR	**CBRP**	**CGSR**	**ECBRP**
Type of protocol	Location based	Weighed based	Artificial intelligence based	Neighbor based
Routing overhead	✓	×	×	✓
Performance metrics	Routing life time, Delivery rate of data, Setup time for routing, Construction success ratio for routing	Average end to end delay, Packet delivery ratio	Mobility of the node, Distance of the node, Remaining energy of the node	Control overheads and wireless resources throughput, Failure ratio in routing
Advantages	i)It diminishes broadcast storm problem ii)Increases the routing life time iii)Reduces collision probability	i)Packet delivery ratio is increased ii)Packet delay is decreased iii)Network stability is increased iv)Routing control overhead is decreased	i)Network lifetime is increased	i)Unaffected to changes in network ii)Perceptible throughput iii)Control overheads are satisfactory

Yes	✓
No	×

6. Conclusion

We have presented a survey on different Cluster based routing protocols in WSN and MANET. All Protocols try to resolve the issues of their proposed aim. From our research we can say that there is no single protocol which addresses all issues in WSN and MANET simultaneously. A protocol may resolve one issue but completely ignore the second so as to get an optimal result for the first issue. We would like to conclude by mentioning that many such cluster based protocols are being presented for WSN and MANET. So researchers building new mechanisms can use the lessons learned from previous work.

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