

Cluster based Routing Schemes in Wireless Sensor Networks: A Comparative Study

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ABSTRACT

Recent improvements in the field of micro-electro-mechanical system, digital electronics and wireless communication technology are responsible for the development in applications of wireless sensor networks. Wireless sensor networks (WSNs) are consisting of large number of cheap and tiny devices known as sensor nodes. In WSNs, sensor nodes communicate to each other via the many communication approaches and these routing approaches are governed by routing protocols. These routing protocols are reliable for performance of wireless sensor networks. On the basis of these, this paper contains the survey on wireless sensor networks. Based on the network architecture, routing protocols in wireless sensor networks are categorized into three main types: data centric, cluster based or hierarchical routing and location based routing. Because of certain advantages clustering is becoming as an active root in routing technology. This paper cover the survey on cluster based routing in wireless sensor networks, summarize the merits and limitation of clustering protocols in wireless sensor networks, and suggest a classification of cluster based routing method. Finally conclude the paper.

Keywords

Clustering; Routing protocols; Wireless sensor networks; Cluster-based Routing, WSNs.

1. INTRODUCTION

The enhancement of wireless sensor network was formally motivated by military applications such as force protection, monitoring militant movement in remote area, battleground surveillance and opponent tracking. But these days, wireless sensor networks are used in many other application, including environmental observation, habitat monitoring, traffic control, home automation, and health application [1]. The WSN is collection of large number of the sensor nodes. The architecture diagram of sensor node is shown in figure 1. A node consists of mainly four units: a tiny sensor, a microprocessor, a power supply unit, a memory, and a radio receiver to communicate with the whole networks [2]. Because of the inherent limited energy resources, processing capacity and data transfer bandwidth, effective routing becomes a significant concern in wireless sensor networks. Routing schemes in WSNs are responsible for find out and preserving the energy efficient path. On the basis of network architecture, WSN schemes can be divided in to three categories: data centric cluster based or hierarchical and location based routing. Data-centric schemes are based on the query and naming of desirable data.

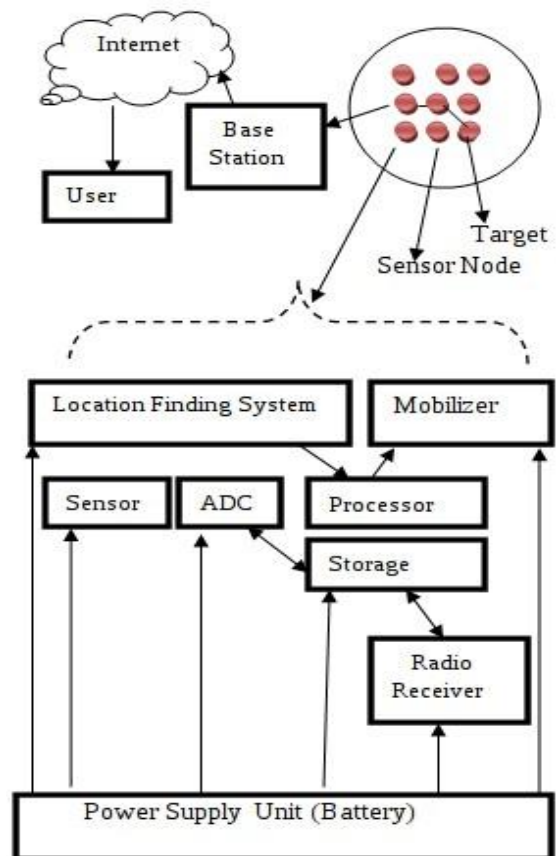


Fig.1. Architecture of sensor node in WSNs (source: [2])

Location-based schemes use the position information to transmit the data to the desirable regions instead the entire network. The routing procedures that are depend on network-flow framework, schemes that try for encounter some quality of service (QoS) requirements and routing function are categories as network flow, quality of service schemes. The main aim of cluster based schemes or hierarchical protocol is to make cluster of the sensor nodes that depend on the received signal strength. The transmission will only perform by such cluster heads than all sensor nodes, so this will save energy [3].

This paper provides a sufficient survey of several routing protocols proposed in recent years. The rest of paper is organized as follows. Section 2, explain the cluster based routing protocols. Section 3 compare the different routing protocols in cluster based routing. Sections 4 present the conclusion and future work.

2. CLUSTER BASED ROUTING PROTOCOLS IN WSNs

In wireless sensor network, collection of sensor nodes into a cluster is well-known as clustering. Every cluster contains a leader called cluster head. A cluster head may be selected by the group of cluster. A cluster head collects the information from the nodes within cluster and send this information to the base station (destination). The clustering procedure in WSNs is shown in figure 2. Clustering can be used as an energy-efficient communication protocol. The main aim of clustering is to minimize the total transmission power aggregated over the nodes in the selected path, and to balance the load between the nodes for extend the network lifetime. Cluster-based routing algorithms are growing to be an essential part of routing technology in wireless sensor networks on account of a form of advantages, such as larger scalability, less load, a smaller amount energy consumption and extra robustness [4].

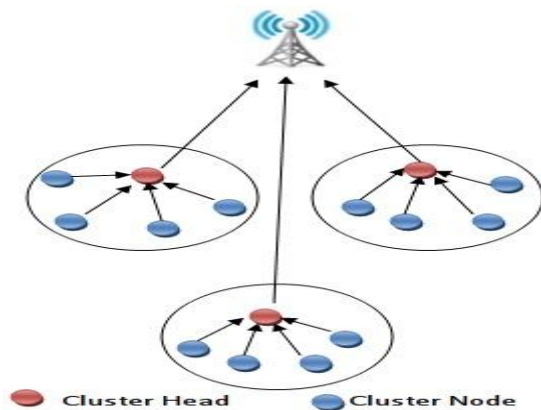


Fig.2. Clustering procedure in WSNs

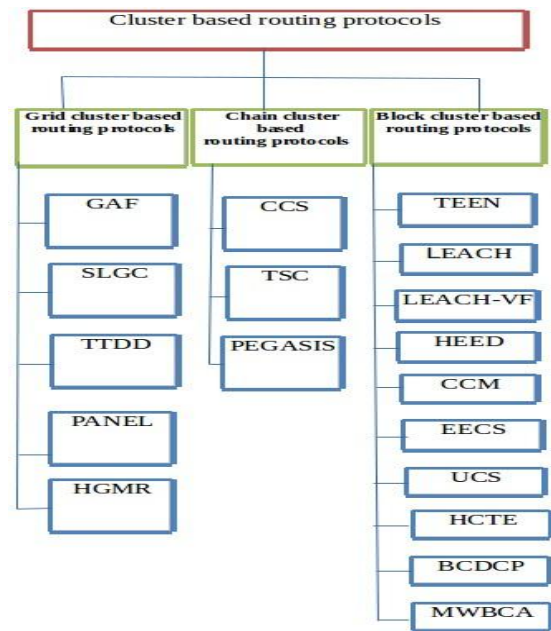


Fig.3. Classification of cluster based routing protocols in Wireless Sensor Networks

The cluster based routing protocol [2] are classified into three kinds: grid cluster based, chain cluster, and block cluster based routing protocols. The classification of cluster based routing protocols is shown in figure 3. The standard grid cluster based routing protocols are GAF, SLGC, TTDD, PANEL, HGMR etc. The standard chain cluster based routing protocols are CCS, TSC, PEGASIS. The popular block cluster based routing protocols are TEEN, LEACH, LEACH-VF, HEED, CCM, EECS, UCS, HCTE, BCDP, MWBCA etc. The advantages and drawbacks of the grid cluster based routing protocols, chain cluster based routing protocols, and block cluster based routing protocols are given in table1, table2 and table 3.

Table 1. Summary of advantages and drawbacks of grid cluster based routing protocols

Protocols	Advantages	Drawbacks
GAF [5]	<ul style="list-style-type: none"> ➤ GAF is totally localized and statics ➤ GAF can enhance the lifetime of the sensor network by saving energy 	<ul style="list-style-type: none"> ➤ GAF can inject the traffic, and the wait is not expected and bounded. This things create it inappropriate for real-time situation in WSNs
SLGC [6]	<ul style="list-style-type: none"> ➤ In SLGC schemes, energy utilization is minimum ➤ SLGC schemes has a better efficiency level 	<ul style="list-style-type: none"> ➤ SLGC can incur extra overhead in the situation of complex data communication
TTDD [7]	<ul style="list-style-type: none"> ➤ TTDD can determine and solve the multiple-mobile sinks and sink-moving difficulty in major-scale WSNs. ➤ TTDD is best applicable for event-detecting WSNs with uneven, instead of constant data traffic 	<ul style="list-style-type: none"> ➤ TTDD has more latency because the forwarding route is not the smallest route. ➤ Due to formation of grid structure and query flooding, TTDD have lower energy efficiency
PANEL [8]	<ul style="list-style-type: none"> ➤ PANEL maintains asynchronous applications ➤ It is an energy-efficient method that guarantees long network lifetime and load balancing because each node turn into a cluster head with equal probability 	<ul style="list-style-type: none"> ➤ In this scheme, clusters are pre-elected, which makes it unsuitable to WSNs. ➤ To find out geographic position information, unique conditions are needed, which are not forever available and which control the use of PANEL in WSNs.
HGMR [9]	<ul style="list-style-type: none"> ➤ Scalability problem does not occur in HGMR. ➤ It has very simple membership management ➤ It has energy efficient routing 	<ul style="list-style-type: none"> ➤ The simple network distribution may not get the most favorable routing paths. ➤ Energy utilization may be disturbed because all communication are to Access Points ➤ In this schemes, the efficiency of routing path is minimal

Table 2. Summary of advantages and drawbacks of chain cluster based routing protocols

Protocols	Advantages	Drawbacks
CCS [10]	<ul style="list-style-type: none"> ➤ In CCS, energy consumption is decreases because the length over which the message can be sending out to the base station from the cluster head is narrowed ➤ Conserves energy by separating the network into concentric group 	<ul style="list-style-type: none"> ➤ Nodes be in touch with their nearest neighbor by using small radio capacity, however the long chain is responsible for large delays
TSC [11]	<ul style="list-style-type: none"> ➤ TSC minimize the unessential data transmission in the sensor network 	<ul style="list-style-type: none"> ➤ TSC protocols may attains the unbalanced utilization of energy throughout the whole networks
PEGASIS [12]	<ul style="list-style-type: none"> ➤ PEGASIS minimize the overhead because of dynamic cluster formation ➤ Minimize the number of data transmissions because of the chain of data aggregation. ➤ In the PEGASIS, load of energy is distributed equivalently in the network 	<ul style="list-style-type: none"> ➤ PEGASIS is not right choice for networks with time-irregular topologies ➤ Communication has time-consuming delays, which can cause restricted access of node

Table 3. Summary of advantages and drawbacks of block cluster based routing protocols

Protocols	Advantages	Drawbacks
TEEN [13]	<ul style="list-style-type: none"> ➤ TEEN is well appropriate to time-critical applications ➤ It performs well in the situation like rapid changes in the sensed attributes such as temperature 	<ul style="list-style-type: none"> ➤ At any time if the thresholds are not encountered, the node will not communicate, and if the node dies, the network will not be capable to find it
LEACH [14]	<ul style="list-style-type: none"> ➤ LEACH keeps away from a lot of energy excess ➤ LEACH makes use of Time Division Multiple Access, it maintains cluster heads from unnecessary collisions 	<ul style="list-style-type: none"> ➤ It is not appropriate to networks deployed in large regions
LEACH-VF [15]	<ul style="list-style-type: none"> ➤ It solves the problem of areas by way of overlapped sensing coverage ➤ It solves the difficulty of sensing holes 	<ul style="list-style-type: none"> ➤ Energy efficiency in LEACH-VF is very poor
HEED [16]	<ul style="list-style-type: none"> ➤ HEED is a fully distributed cluster-based routing protocol ➤ HEED attains scalability and high energy efficiency by communicating in a multi-hop fashion 	<ul style="list-style-type: none"> ➤ Energy consumption is not balanced ➤ Huge overhead is formed because of multiple rounds.
CCM [1]	<ul style="list-style-type: none"> ➤ Cluster parts have minimum delay ➤ In CCM, Overhead on the network is low 	<ul style="list-style-type: none"> ➤ Cluster part preserves more energy ➤ CCM scheme uses only residual energy to select the cluster head
EECS [1]	<ul style="list-style-type: none"> ➤ EECS builds a more balanced network in conditions of communication load and energy consumption ➤ EECS uses dynamic sizing of clusters, to communicate with long distances with base station 	<ul style="list-style-type: none"> ➤ EECS is based on the use of global information for communication which causes a lot of overhead
UCS [1]	<ul style="list-style-type: none"> ➤ UCS schemes have minimum energy utilization 	<ul style="list-style-type: none"> ➤ UCS is still not sufficient for large-range networks
HCTE [17]	<ul style="list-style-type: none"> ➤ HCTE avoids unbalanced energy consumption. 	<ul style="list-style-type: none"> ➤ Energy efficiency in HCTE is very poor
BCDCP [18]	<ul style="list-style-type: none"> ➤ BCDCP saves energy and time ➤ Cluster-head distribution difficulty doesn't exist 	<ul style="list-style-type: none"> ➤ BCDCP is not appropriate for large networks and reactive networks
MWBCA [19]	<ul style="list-style-type: none"> ➤ Energy consumption in MWBCA is balanced 	<ul style="list-style-type: none"> ➤ Scalability of MWBCA is very poor

3. COMPARISON OF CLUSTERING PROTOCOLS

Table 4. Comparison of the presented clustering protocols

Protocols	Scalability	Load Balancing	Energy Efficiency	Algorithm Complexity	Cluster Stability	Delivery Delay
GAF	High	Moderate	Moderate	Moderate	Moderate	Poor
SLGC	Very poor	Moderate	Moderate	Moderate	Moderate	Very small
TTDD	Poor	Good	Very poor	Low	Very high	Very large
PANEL	Poor	Good	Moderate	High	Poor	Moderate
HGMR	Very high	Poor	Poor	Low	High	Moderate
CCS	Poor	Very poor	Poor	Moderate	Poor	Large
TSC	Moderate	Poor	Moderate	Moderate	Moderate	Moderate
PEGASIS	Moderate	Very poor	Poor	High	Poor	Very large
TEEN	Poor	Good	Very high	High	High	Small
LEACH	Very poor	Moderate	Very poor	Low	Moderate	Very small
LEACH-VF	Very poor	Moderate	Moderate	Moderate	High	Very small

HEED	Moderate	Moderate	Moderate	Moderate	High	Moderate
CCM	Very poor	Moderate	Very poor	Moderate	High	Small
EECS	Poor	Moderate	Moderate	Very high	High	Small
UCS	Poor	Poor	Very poor	Moderate	High	Small
HCTE	Very poor	High	Very poor	Moderate	Moderate	Very small
BCDCP	Very poor	Good	Very poor	Very high	High	Small
MWBCA	Very poor	High	Moderate	Moderate	Moderate	Very small

4. CONCLUSION AND FUTURE WORK

Wireless sensor networks (WSNs) have focused major attention over the previous few years. An emergent list of military and civil applications can provide work for WSNs for increased efficiency particularly in remote and hostile areas. Examples include disaster management, monitoring militant movement in remote area, enemy tracking, battleground observation, and border security. For these applications a large number of sensors are predictable. Formation of sensor nodes into clusters has been the good method for sustain scalability in WSNs. this paper survey the current position of the research and contains classification the different techniques. And also focus on the advantages and drawbacks of different cluster based routing protocols and signify them into tabular form. Based on comparison between different methods, it is clear that cluster based routing schemes are very efficient in performance growth of WSNs. This survey paper will be very helpful for researchers that are concerned about the improvement, modification or optimization of routing schemes for wireless sensor networks.

Energy consumption is one of the most important research areas of WSNs. It is requirement of WSNs to propose location based protocols which consume smallest amount of energy and provide high throughput. In future a protocol that has minimum energy consumptions can be proposed and implement. It is still an open problem that how to make cluster formation in heterogeneous sensor networks. Fault tolerance, security, cluster coverage, multi-hierarchy, and node placement are still open questions.

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