

Parametric Review of Various Routing Protocols and Effects of Clustering on them in WSN

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Abstract

With the recent advancement in technologies, a wireless sensor network comes into the light. It is used to monitor the environment conditions such as sound, temperature, etc. Military surveillance, weather forecast, bridge monitoring, under water movements and so on are the applications of Wireless Sensor Network. A Sensor node is deployed in an environment in such a manner that it forms a network comprising of several sensor nodes. Sensor nodes gathering information and transmit it to a requested party through an electrical signal and during transmission energy loss befall. To accomplish this task routing protocols are used described in this work. Routing protocols helps in transmitting information between nodes. Routing is performed with the help of clustering schemes. There are many promising routing protocols that try to forestall energy loss during transmission but lack some or the other manner.

Keywords: Wireless Sensor Network, Routing Protocols, Clustering Schemes

I. Introduction

Wireless Sensor network can be defined as a small radio range, self-organizing network. It has less cost and confined energy resources. Fig 1 shows a general architecture of a wireless network [1].

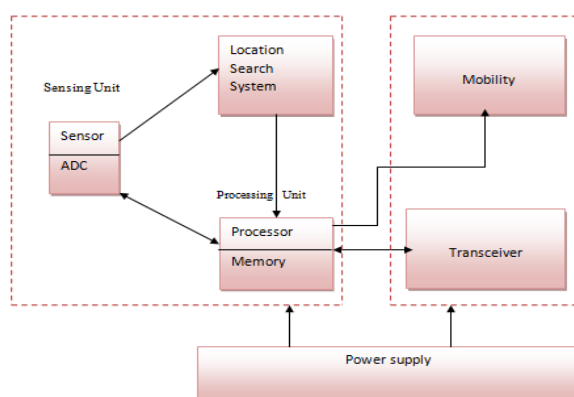


Fig1: Architecture of WSN

WSN can be of the structured and unstructured form. A Structured type network as shown in fig 2(a) consists of few and spaced distributed nodes that are deployed in a pre-planned way. Since they are few, therefore, it has Less network maintenance. While, in unstructured type, as presented by fig 2 (b), there is a dense collection of nodes that has ad-hoc deployment so it has difficult in network maintenance. There are certain issues in the architectural design of sensor nodes like energy efficiency, network topology, problems related to long distance communication, rise in traffic, reduction the node's lifespan. To overcome these issues different routing protocols are designed which work on different clustering schemes which are discussed in the following sections.

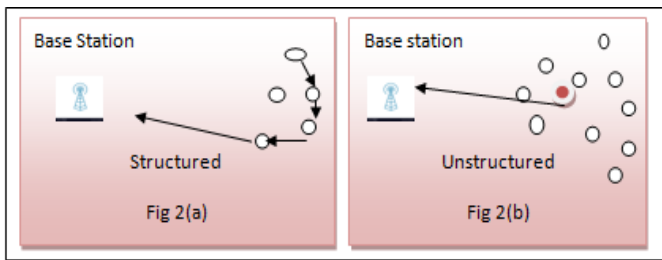


Fig 2: Structure and Unstructured

II. Routing Protocols

Routing protocols help in sending information from nodes to base station [2]. Fig 3 presents the different routing protocols. In this work, mainly network types are discussed. Different parameters that affect the working of routing protocol such as implementation cost that affects the designing of the protocol another is threshold value which plays an important role during transmission, some

protocol support and some not. The Battery depletion parameters also affect its working. Some protocols are restricted to its application areas. Protocols use residual energy after completing the routing process. Protocols can also detect uncommon events from their surroundings by using a Position Aware parameter. The problem of energy consumed by a sensor node is better understood by a parameter power supply. While transmitting data, protocols use negotiation parameters in which they reach to an agreement that which data should be transmitted to base station, later the leader node collects the data to be transmitted to base station that process is termed as data aggregation. A Protocol can spot the exact position of the sensor node utilizing the power of localization.

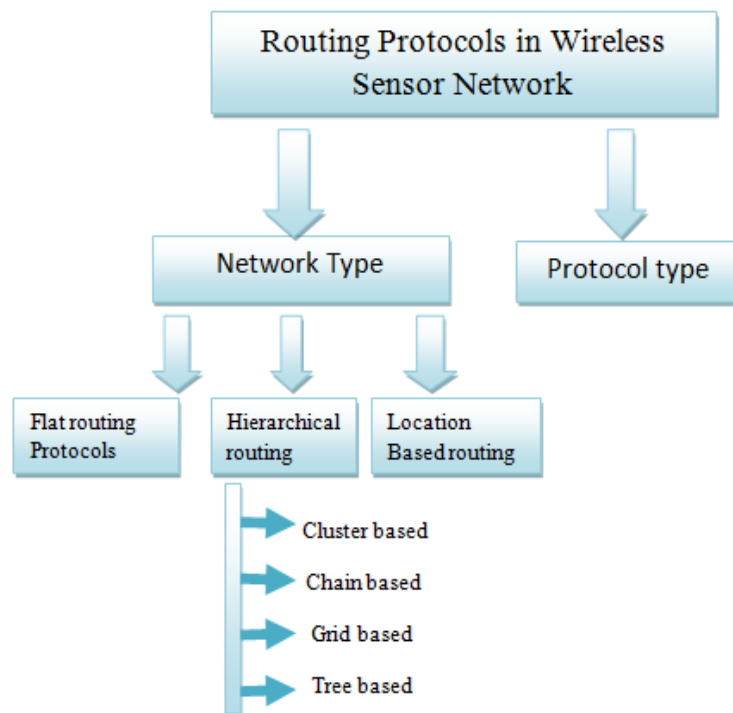


Fig3: The WSN Routing Protocols

For load balancing among sensor nodes protocols uses multipath. Some protocol also uses the neighborhood energy level for selecting CH, on the basis of the difference between node's residual energy and its single hop neighbor node's average

energy. Some protocols support the process of reconstructing the system by eliminating its incorrect results i.e. support failure recovery parameter.

2.1 Flat routing protocol

In flat routing protocol, sensor nodes create links without using synchronization. It also controls its sleep time by having variable duty cycle and context-based scheduling performed by the protocol. Their energy loss depends on traffic patterns. There are different flat routing protocols; in [4] author describes the protocol that uses handshakes ADV, REQ, DATA and it is applicable only in lossless networks; in [5] author suggest the purpose to design directed diffusion is for energy conservation and also illustrate its elements i.e. data propagation, reinforcement and interest. For handling node failure & energy efficiency rumor routing protocol is described by the author [6]. In [7] author states that GBR main aim is to produce balanced traffic distribution within the network. MCFA uses cost estimation rather using of unique id and routing table as suggested by the author in [8]. With the set of information CADR protocol diffuses the queries in [9]. In [10] author states that in Cougar sensor node selects the leader node which holds the responsibility of aggregating and transmitting data to sink node. Leader node generates query plans that describe the describe computations of data transmission of all queries and transferring it to associate node.

Author [11] elaborates that Acquire is an active query forwarding technique used in a distributed database that deals with one-shot queries for data. EAR is similar to direct diffusion; its goal is to increase network lifetime. The difference is it sets path instead of setting one optimal path [12] as suggested by the author. EAD protocol acts as a tree covering all sensor nodes from root to leaf. It considers residual energy instead of network topology [13]. Here table 1 describes flat protocols and parameters that affect them. The State complexity parameter is Less in all protocols. A Threshold value cannot be implemented in flat protocol and also applicable only for small scale applications. The Position Aware parameter does not apply to flat protocols.

2.2 Hierarchical routing protocol

In hierarchical based routing, the region is partitioned into a cluster; cluster head gather information passes to the base station. Collision is avoided. It requires global as well as local synchronization. Energy dissipation should be uniform as it is unavoidable. Hierarchical is further characterized by the for Lessing topologies.

2.2.1 A Cluster Based Topology:

In cluster-based topology more than one node is selected and assigned the responsibility of a cluster head (CHs) while remaining nodes are connected near to the CHs; the advantage of cluster-based is it is scalable, highly energy-efficient and disadvantage is it is application dependent, to an extent energy, to an extent abilities and network lifetime. There are different cluster-based protocols. LEACH is the very first protocol for energy efficiency which uses TDMA scheme explained by author in [14] which has certain drawbacks; these drawbacks are overcome by the HEED protocol which is an advanced version of LEACH as it selects CHs periodically by considering residual energy; node degree of each node for balancing power consumption within a network [15]. Author [16] gives a detailed study of a TEEN protocol is that it is best suited for reactive networks and also uses two sorts of threshold, namely soft threshold and hard threshold. APTEEN, an advance version of the TEEN author [17] describes that TEEN cannot be applied in regular time intervals therefore APTEEN is used for periodic data retrieval. Hence it supports the time-critical application. PEACH protocol minimizes the energy consumption and increase network lifetime by focusing on overhearing features in wireless communication to create clusters [18]. In EECS protocol author [19] describe that CH is elected based on residual energy, nodes having higher residual energy have greater probability of being elected as CH and also state that data aggregation increases overheads to all sensor nodes. EEUC protocol selects a node as

CH only if it is closer to base station. In this scheme, every node requires the access to global knowledge like location and distance to the sink node defined by the author in [20] while EEHC protocol uses randomized clustering algorithm in which CH collects and aggregated data from sensor node of different cluster and sends to base station [21]. In [22] author suggests that SLGC protocol in compare to LEACH has Less energy consumption but suffer from the overhead problem. TSC protocol reduces energy consumption for uniform as well as non-uniform networks by using tracks and sectors to create clusters [23]. SEP protocol prolongs the network life of few nodes assigned with higher energy [24]. In [25] author elaborates DEEC protocol, used in multilevel communication for heterogenous routing protocol. CH is selected based on the ratio of node's residual energy to the network's average energy. These hierarchical cluster-based protocols are explained in table 2 & are applicable for both small as well as large applications.

2.2.2 Chain Based Topology:

In chain-based topology, for transmission, usually multiple chains are created for connecting the sensor node [26]. A chain leader is elected which gathers information and transmits to base station. Its advantage is its simplicity and energy efficiency as node only transmit to nearest neighbor hence reduce energy consumption and disadvantage is it has large delay, imbalance energy consumption because a node which is nearest to leader suffers from traffic while gathering information. Also, it has Less robustness; if any node fails during the transmission then the whole transmission is terminated. PEGASIS protocol which is a chain-based approach uses a greedy algorithm. All sensor node acts as a leader in order to achieve load balancing described by the author in [27]. CCS increases the energy efficiency of PEGASIS, to do so base station location need to be known. The network is partitioned into concentric circular

paths [28]. In EBCRP protocol, a node delivers data by communicating other nodes that are at a short distance. An Author in [29] state that CHIRON protocol is helpful in small range networks. It consists of different phases i.e. construction of group, formation of chain, election of leader, and transmission of data. Hierarchical chain-based protocols are explained in table 3, they are Less in cost and uses data aggregation.

2.2.3 Grid Based Topology

In grid topology, with the help of a geographical approach network is divided into the grid which is also known as location-aware routing. Its major characteristic is that without routing table routing operation is performed. It has a simple structure and efficient data delivery with the limitation in load balancing and overload. A protocol like PANEL uses an algorithm for both time-critical application and non-time critical application. To some extent, load balancing can be achieved because allnodescan serve as an aggregator with sameprobability [30].

A TTDD protocol is best suited for the event-driven application instead of continuous traffic author [31] explains that a grid is formed by dividing a network into cells with dissemination nodes. This node helps in transferring queries to the source. HGMR protocol is a grid-based approach. Different nodesare assigned different responsibilities, using such data transfer strategy, energy efficiency can be achieved. It also reduces the scalability problem [32]. In GMCAR protocol author [33] describes that a network is partitioned into grids, where every grid contains a header node with multiple non-header nodes. Energy efficiency and network lifetime can be increased using two routing schemes high traffic and Less traffic. Hierarchical grid-based protocols not supporting parameters like failure recovery, residual energy.

2.2.4 Tree based topology

In Tree based topology, all sensor nodes construct logical tree in which data is delivered from a Less-level node to their corresponding higher

neighbor node until and unless data is received by root. The advantage of this topology is its simple structure along with less energy consumption and disadvantage is its less scalability. Author [34] illustrates that EADAT protocol with the help of energy aware and data-centric routing energy shortage problem can be solved. In these nodes having higher residual power will have lesser chances of becoming a leaf node. BATR protocol's aims at finding an optimal path within a balanced tree, where every node is expected to consume equal energy [35]. An author in [36] defines the objective of the PEDDA protocol that is to maximize network lifetime. For data transmission minimum cost tree is used. ETR protocol introduces a parameter i.e. network depth of a node. It decreases computation and storage cost [37]. Tree-based protocols can only be applicable for small scale applications as described in table 5.

2.3 Location Based routing protocol

In this category of routing protocol, addressing of a sensor node is done based on the locations, with the distance between neighbor sensing nodes is calculated with the incoming signal strength. Location-based protocols are: MECN protocol is a self-configured protocol and divides the network into sub-network, sub-network with a lesser number of nodes is chosen for data transmission as it consumes less energy [38]. In [39] author suggests an improved version of MECN i.e. SMECN that reduces power consumption number transmission hop is reduced. In GAF protocol author [40] describes that if in a grid there are sensor nodes that are not in used protocol put them in an idle mode which reduces energy as well as cost. In GEAR protocol every sensor knows its residual energy and relative distance to the base station [41]. In the SPAN protocol sensor node decide whether to sleep or to act as coordinator and transfer data to the base station explained by the author in [42]. Author illustrates

a TBF protocol in which data is routed through a predefined curve. It is used in network functions like discovery, flooding [43]. In BVGF a node transfers data if and only if its Euclidean distance is less to the target node among all other nodes. It has more battery depletion problems [44] GeRaF protocol consisting of geographical and sleep & awake mechanism illustrate by author in [45].

III. Clustering

Clustering is a process that divides the large area network into clusters; in these clusters, cluster head is elected which aggregate the information and passes to the base station. It is important to assure that cluster head node has balance energy dissipation. Many times, the network is organized into equal size of clusters, not necessary that cluster head has equal load. An Unequal clustering size (UCS) model is proposed to lead uniform energy dissipation among cluster head and increase the network lifetime [46].

Flat protocols uses different clustering schemes, among them cluster count, inter and intra cluster topology, roles are not used because the clustering process is not used in flat protocols [3], [47] shown in table 9. Location based protocols use clustering schemes but doesn't support the cluster head characteristics [2], [48], [51] in table 10. Hierarchical protocols use different clustering schemes [16]-[21], [49], [50] and [51] as shown in table 11.

IV. Discussions-

This section provides a detailed tabular comparison of various routing protocols, category-wise on the basis different parameters. Table 1 - 6 provides a brief parametric description of flat routing, hierarchical cluster-based, hierarchical Chain-based, hierarchical Grid-based, hierarchical tree-based and location-based routing protocols respectively. While Table 7 - 9 presents Clustering Scheme in flat, Location and Hierarchical Protocols respectively.

Table 1: Flat routing protocols

Protocols	Parameters													
	Implementa-tion	Threshold value	Battery Depletion	Applicabi-lity	Residual Energy	Position Aware	Power Usage	Negotiati-on	Data aggregati	Localizati-on	Multipath	Query based	State	Complexi-
SPIN	Less	Yes	More	SSA pp.	-	No	Less	Yes	Yes	No	Yes	Yes	Less	
DIRECTE D DIFFUSI ON	Less	-	Less	SS App.	-	No	-	Yes	Yes	Yes	Yes	Yes	Less	
GBR		Yes	Less	SS App.		No	-	No	Yes	No	No	Yes	Less	
MCFA	Less	-		SS App.		No	-	No	No	No	No	No	Less	
ACQUIR E	More	-	Less	SS App.	-	No	-	No	Yes	No	No	Yes	Less	
EAR	-	-	Less	SS App.		No	-	No	No	-	No	Yes	Less	

Table 2: Hierarchical cluster-based Routing protocols

Protocol s	Parameters														
	Cost	Failure Recovery	Threshold Value	Optimal Packet Size	Battery Depletion	Applicabilit y	Residual Energy	Position Aware	Position Consumpti	Negotiation based	Data aggregation	Localizatio	Multipath	Query based	
LEACH	Hig h	Yes	-	Yes	Less	NRTS	-	No	More	No	Yes	Y es	No	No	
HEED	Les s	-	-	Yes	Less	NRTS	Yes			No		-	No	No	
TEEN	Les s	-	Used	Yes		RTS	-	No	More	No	Yes	Y es	No	No	
APTEE N	Les s	-	Used	-		RTS	-	No	More	No	Yes	Y es	No	No	
PEACH	Les s	-	-	Yes	Less	RTS	-	Yes	Less	No	Yes	Y es	No	No	
SLGC		-	Used	-	Less	SSAp p.	-		-	No	Yes				
TSC	Hig h	Yes	-	-	Less	SSAp p.	-	No	Less	No	Yes	-	No	No-	
SEP	Hig h		Used	Yes		RTS	-			No					
DEEC	Hig h	Perio dic	Used	Yes		RTS	Yes			No					

Table 3: Hierarchical Chain-based Routing protocols

Protocols	Parameters														
	Cost	Threshold value	Failure Recovery	Optimal Packet	Battery Depletion	Applicability	Residual Energy	Position Aware	Position Consumpt	Negotiation based	Data aggregati	Localizati	Multipath	Query based	State complexit
PEGASIS	Less	-	Yes	Yes	Less	NRTS	No	No	more	No	Yes	Yes	No	No	Less
CCS	Less	-	Yes	Yes	More	SSA pp.	No	Yes	More	No	Yes	Yes	No	No	No
EBCRP	Less	-	Yes	-	Less	SSA pp.	Yes	No	Less	No	Yes	No	No	No	No
CHIRON	Less	-	No	-	More	Big app.	No	No	More	No	Yes	No	No	No	No

Table 4: Hierarchical Grid-based Routing protocols

Protocols	Parameters														
	Cost	Failure Recovery	Threshold Value	Optimal Packet	Battery Depletion	Applicability	Residual Energy	Position Aware	Position Consumpt	Negotiation based	Data aggregatio	Localizati	Multipath	Query based	State complexit
PANEL	High	No	-	Yes	More	Both	-	No	More	No	Yes	Yes	No	No	
TTDD	High	No	-	Yes	More	RTS	-	Yes	Less	No	No	No	Possible	Possible	Moderate
HGMR	Less	No	-	Yes	Less	MultiApp.	-	Yes	Less	No	No	Yes	No	No	
GMCA RE	High	No	-	Yes	Less	QoS n/w	-	No	More	No	No	Yes	No	No	

Table 5: Hierarchical Tree-based Routing protocols

Protocols	Parameter														
	Cost	Failure recovery	Threshold Value	Optimal Packet	Battery Depletion	Applicability	Residual Energy	Position Aware	Position Consumpt	Negotiation based	Data aggregati	Localizati	Multipath	Query based	
EADAT	Less	-	Yes	-	More	Small n/w	Yes	No	High	No	Yes	No	No	No	
BATR	Less	-	No	-	Less	Proactive networks	No	Yes	Less	No	Yes	Yes	No	No	
PEDAP	Less	-	No	-	Less	Small range networks	Yes	No	Less	No	Yes	No	No	No	
ETR	Less	-	No	-	Less	Small range networks	Yes	No	less	No	Yes	No	No	No	

Table 6: Location-based Routing protocols

Protocols	Parameters														
	Cost	Time & location	Threshold Value	Optimal Packet	Battery Depletion	Applicability	Residual Energy	Position Aware	Position Consumption	Negotiation based	Data aggregation	Localization	Multipath	Query	State complexity
MECN	High	Yes	-	-	More	Small Sale App.	-	No	More	no	no	no	no	No	Less
SMECN	Less	Yes	-	-	Less	Small Sale App.	-	No	More	No	No	No	No	No	Less
GAF	High	Yes	-	-	Less	Small Sale App.	-	No	To an extent	No	No	No	No	No	Less
GEAR		Yes	-	-	Less	Small Sale App.	Yes	No	To an extent	No	No	No	No	No	Less
Span		Yes	-	-	More	Small Sale App.	Yes	No	To an extent	Yes	Yes	No	No	No	Less
BVGF		Yes	-	-	More	Small Sale App.	-	No	To an extent	No	No	No	No	No	Less
GeRaF		Yes	-	-	More	Small Sale App.	-	No	Less	No	No	No	No	No	Less

Table 7: Clustering Scheme in flat protocols.

Protocol	Cluster Head Characteristics					Clustering Properties				Clustering Process		
	Count	Intra-cluster	Inter-cluster	Role	Mobility	Hops	Node type	Control Message	Overlapping	CH Selection	Energy efficiency	Scalability
SPIN	-	-	-	-	Possible	-	Resource rich	-	-	-	to an extent	To an extent
Direct diffusion	-	-	-	-	To an extent	-	Resource rich	-	-	-		To an extent
Rumor routing	-	-	-	-	Very To an extent	-	Resource rich	-	-	-		Good
GBR	-	-	-	-		-		-	-	-		
MCFA	-	-	-	-		-		-	-	-		
CADR	-	-	-	-		-		-	-	-		
Cougar	-	-	-	-	No	-	Resource rich	-	-	-	To an extent	To an extent

Table 8: Clustering scheme in Location Protocols

Protocol	Cluster Head Characteristics					Clustering Properties					Clustering Process			
	Count	Intra-cluster	Inter-cluster	Role	Mobility	Hops	Stability	Node type	Control	Overlap	CH Selection	Energy efficiency	Delivery delay	Scalability
MECN & SMECN	-	-	-	-	Less	Multi hop	-	Sensor	-	High	-			Less
GAF	-	-	-	-	To an extent	Multi hop	High	Sensor	-	Moderate	-	To an extent	Multi hop	High
GEAR	-	-	-	-	To an extent	Multi hop		Sensor	-	Moderate	-			To an extent
Span	-	-	-	-	Less				-	High	-			
TBF	-	-	-	-	Moderate				-	High	-			
BVGF	-	-	-	-	Less				-	High	-			

Table 9: Clustering schemes in Hierarchical Protocols.

Protocol	Cluster Head Characteristics					Clustering Properties		Clustering Process				
	Count	Intra-cluster topology	Inter-cluster topology	Role	Mobility	Hops	Stability	Energy efficiency	Delivery delay	Scalability	Algorithm Complexity	
LEACH	Variable	Fixed	Direct link	Agg. & relaying (AR)	Fixed to bs	k-hop	Medium	Very Less	v.small	Good	Less	
TEEN & APTEEN	variable			AR	Fixed to bs	1-hop	High	Very high	Small	Good	High	
PEGASIS	NA	NA	-	AR	Fixed to bs	1-hop	Less	Less	large	Good	High	
HEED	variable	Fixed	Direct link/multi hop	AR								
PANEL	variable	Adaptive					Less	Medium	Medium	Less	High	
SLGC							Medium	Medium	small	Very Less	Medium	
EECS	Constant	Fixed	Direct link	AR	possible	1-hop						
PEACH	Variable			AR	-	M-hop		Less				
EBCRP	-	-	-	AR	No	M-hop		Very Less	Large	Less	Moderate	

CHIRON	-	-	-	AR	No	M-hop		Moderate	Small	Less	Moderate
BATR	-	-	-		No	-		Less	Large	Less	Moderate
GMCA RE	-	-	-	AR	No	M-hop	Less	Moderate	Moderate	Moderate	High

V. Conclusion & Future Work

We have successfully reviewed the existing routing protocols and their parametric effect and also briefly provided the clustering schemes which affect their working. We are currently working on the comparison of these protocols based on different parameters to suggest which protocols are suited for a particular environment and application.

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