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A Review on Enhanced Dynamic Clustering in WSN

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***Abstract*—**Recent advancement in wireless internetworking has presented a number of dynamic routing protocols based on sensor networks. At present, a number of revisions are made based on their energy efficiency, lifetime and mobility. However, to the best of our knowledge no extensive survey of this special type has been prepared. At present, review is needed in this area where cluster-based structures for dynamic wireless networks are to be discussed. In this paper, we examine and compare several aspects and characteristics of some extensively explored hierarchical dynamic clustering protocols in wireless sensor networks. This document also presents a discussion on the future research topics and the challenges of dynamic hierarchical clustering in wireless sensor networks.

***Keywords*—**Dynamic cluster, Hierarchical clustering, Wireless sensor networks.

I. Introduction

THE Mobile Wireless sensor networks (MWSNs) comprise of small number of nodes that can be characterized by limited processing power and energy resources [1]. This network has sensing, computation and communication capabilities. The data collected by sensor nodes are transmitted to the Cluster Head (CH) then it forwarded to the Base Station (BS) via multi-hop routing. Basically WSN is deployed in a harsh area such as deep sea, war region, etc. It is almost difficult and expensive to change or replace the battery regularly. Hence increasing the network lifetime and energy conservation is the main objectives of WSN. One solution to fulfill this objective is to form clusters of nodes using clustering approach. In this approach, CH is selected from a group of sensor nodes and these CHs collects data from other nodes. Once data collection is completed CH send this data to the BS. Therefore, the application of the clustering-based approach has the advantage of reducing the amount of information that needs to be transmitted, as well as enhancing resource allocation and bandwidth reusability. Several dynamic protocols have been proposed in literature, with the objective of maximizing the sensor network lifetime by adopting cluster-based network architectures.

A typical WSN can be defined as a network of tiny devices, called sensor nodes, which are spatially distributed and work cooperatively to communicate information gathered from the monitored field through wireless links. The data gathered by the different nodes is sent to a BS which either uses the data locally or is connected to other networks, for example, the Internet (through a gateway). Fig. 1 illustrates a typical WSN.

Dynamic network topologies and harsh environment conditions may cause sensor-node failures and performance degradation. This requires WSN to support adaptive network operation including adaptive signal-processing algorithms and communication protocols to enable end-users to cope with dynamic wireless-channel conditions and varying connectivity. Energy consumption in networks can be effectively reduced by organizing the sensor nodes into clusters. So countless energy efficient routing protocols are proposed based on dynamic clustering to resolve the real time applications. Generally, sensor node energy level quickly exhausted from the network environment [4]. The scientific advance has brought the chances to expand and apply their sensor devices with very small scope and low power utilization and processing control. The clustering is anticipated since of its network scalability, power reduction and network topology. Also, the cluster schemes reduce their communication expenses between the sensor nodes. The Energy utilization in the network can be reduced by the way of organizing cluster structures and clusters effectively [2]. The advantages of clustering are,

1. To reduce energy consumption by improving bandwidth utilization.
2. To reduce wasteful energy consumption for avoiding overhead.
3. To increased connectivity and reduce network delay.
4. To achieve the load balancing.

The WSN is to being raise their many applications like ecological monitoring, mechanical manufacturing, security, agriculture, computerization and monitor, smart battlefield, healthcare, home automation, traffic control, animal tracking and forces observation [2]. Since the sensor nodes are powered by limited sequence assets, power good organization is individual of the major challenges in WSN.

Typically routing protocols on the scheme network structures are divided into two main groups: static and dynamic. The static clustering is not a well-organized method; which is considered as a prearranged way of network [41]. So several powers aware routing (dynamic) protocols are designed on the basis of the cluster configuration and CH selection. In dynamic clustering, nodes are portable; mobility is an important factor in the design of effective clustering algorithm for WSNs. In general, there are three different mobility models to consider: random, semi-deterministic and deterministic. In the random movement the mobility is totally unpredictable and each new movement can be completely independent of the previous movement [3]. In the semi-deterministic movement even though the individual nodes do

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not have a specified direction, it is possible to see a general pattern of a column evolving to it, in what is called a column model. In the deterministic movement the mobile nodes mostly move in the same direction only.

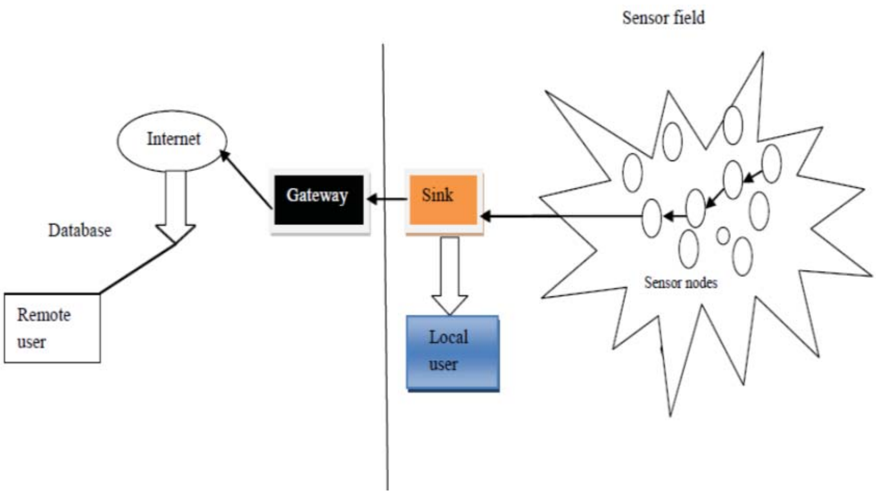

Fig. 1 Wireless Sensor Network

II. Routing Challenges

Routing in WSN is very challenging task due to its wireless nature. There are many reasons: a) WSNs have a large number of sensor nodes, it is not possible to apply a global addressing scheme for the high density sensor nodes as the overhead will be high to maintain the Ids of the sensor Network. b) Sensor nodes are strongly constrained in terms of energy consumption, processing, and storage capacity. So there is a need of some mechanism to manage the resources. There are many challenges and design issues that affect the dynamic routing process in Wireless Sensor Network [5].

A. Node Deployment

Node deployment in WSNs is manual or randomized which is based on the application. In manual deployment, the sensors are physically placed and information is routed through prearranged paths. In random node deployment the sensor nodes are deployed randomly, creating an ad-hoc routing infrastructure. If the resultant distribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy-efficient network operation. Inter sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

B. Fault Tolerance

Some sensor nodes may fail due to natural interferences, battery power, and any physical damage. One damaged sensor node can affect the overall performance of the entire network. So, we should frame a routing protocol that accommodates formation of new links and routes to the data collection BSs.

C. Quality of Service

In some applications, data should be delivered within a certain amount of time as soon as it is sensed, otherwise it will be useless. Therefore, delay, throughput and data delivery is considered as another condition for time-constrained applications.

D. Transmission Media

In wireless sensor network, communicating nodes are linked by a wireless medium. The conventional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the performance of the sensor network.

E. Scalability

The number of sensor nodes deployed in the sensing area may be on the order of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to events in the environment.

F. Heterogeneity

The sensors may be homogeneous or heterogeneous. The survival of a heterogeneous set of sensors raises many technical issues related to data routing and aggregation. For example, some applications might require a various combination of sensors for monitoring temperature, pressure, and humidity of the surrounding environment, detecting motion via acoustic signatures, and capturing images or video tracking of moving objects (animal tracking).

III. Issues in Cluster Based WSN Routing Protocols

The great extent examine effort has been carried out to solve the drawback of clustering techniques is to develop the individuality of cluster based routing methods but there are still a number of issue to be address for the well-organized use of cluster based routing techniques [25]-[28]. Some release issues to be addressed are:

A. Selection of Cluster Heads (CHs)

The performance and availability of CH is important factor for constructing the clusters. Consequently, rotation of CH role among the sensor nodes tries to distribute the energy consumption over all nodes in the network. Selection of CH for such rotation greatly affects the energy efficiency of the network. So it must be considered as the dominant factor.

B. Scalability

A scalable network system would be one that can start with just a few nodes but can easily expand to thousands of nodes. So careful observations are required to check the adaptability and scalability of clustering methods.

C. Network Topology

A topology is a usually schematic description of the arrangement of a network. So it is important to focus on the strength of clustering techniques.

D. Fault Tolerance

The ability of a system to respond gracefully to an unexpected hardware or software failure. So aiming for self-stabilization so that the system converges towards an error-free condition

E. Load Balancing

Load balancing is an essential consideration aiming at prolonging the network lifetime in WSNs. Even distribution of sensor nodes among the clusters is usually considered for cluster construction where CHs perform the task of data processing and intra-cluster management.

F. Maximizing of the Network Lifetime

Network lifetime is an inevitable consideration in WSNs, because sensor nodes are constrained in power supply, processing capability and transmission bandwidth, especially for applications of harsh environments. So, it is important parameter during cluster construction process.

IV. Mobility Models

A mobility model is a formal mathematical description generalizing the characteristics of mobility patterns. A mobility model falls into one of the two categories, namely, entity mobility models and group mobility models.

A. Entity/Individual Mobility Models

Mobile nodes' movements are independent of each other such as Random Waypoint, Random direction, Random Walk. In this model, the movement of a node travels from its origin location to a new location within a pre-defined time period or distance, by randomly choosing a path and speed. A node changes its direction and speed once the time expires or the maximum permitted distance is reached.

B. Group Mobility Models

Mobile nodes move dependent of one another like reference Point Group Mobility model, Column, Nomadic, Pursue, and Exponential Correlated. In this model, a set of mobile nodes collectively roam from one place to another according to the location of a reference node.

V. Related Works

A. LEACH

Low-Energy Adaptive Clustering Hierarchy (LEACH) is a primary hierarchical clustering protocol that suggests together distributed and centralized schemes [10]. The essential design of LEACH has been a support for several clustering routing protocols for past ten years. LEACH utilizes the randomized regular change of CHs to evenly allocate the energy delivery among the sensors in the network. The CHs have the responsibility of gathering data from their clusters, while also collect data from sensor nodes to be sent to the BS, which product in less energy dissipation, to extend the network lifetime. The operation of LEACH is broken up into lots of rounds, where each round is separated into two phases.

1. Set-up phase
2. Steady-state phase.

In the set-up phase, the clusters are structured; while in the steady-state phase, data is delivered to the BS. During the set-up phase, each node decides whether or not to become a CH for the current round. This decision is based on the suggested percentage of CHs for the network and the number of times the node has been a CH so far. This decision is made by the node choosing a random number between 0 and 1. The node becomes a CH for the current round if the number is less than the threshold. Initially, LEACH forms clusters based on the received signal strength and each node decides to become a CH at the specified interval based on the given threshold value [6], [7]. The threshold value calculated by where n is the given node, P is the priori probability of a node being elected as a CH, r is the current round number and G is the set of wireless nodes that have not been elected as CHs at the end of 1/P rounds. Every joint during the group beginning collection will produce a random number between 0 and 1. If this number is lower than the threshold (T (n)) the particular node will elect as a cluster head based on (1):

$$T(n) = \begin{cases} \frac{p}{1-p\left[r * \mathrm{mod}\left(\frac{1}{p}\right)\right]} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Merits

1. Accounting for adaptive clusters and rotates the cluster head periodically.
2. Periodic CH rotation among the nodes of the cluster in order to balance the load.
3. Increases the lifetime of the network.

Demerits

1. Uses single-hop routing within the cluster.
2. Leach randomly selects CH, which may result faster death of few nodes.
3. Elected CHs unevenly producing non uniform energy consumption
4. LEACH without considering the residual energy of nodes for CH selection

5. LEACH does not support movement of nodes.

B. LEACH-M

LEACH-M (LEACH-MOBILE) handles node mobility well, if the CHs are more or less stationary. The CH revolution is simply random and depends on the number of times the node was a group head in before rounds of TDMA, which is exactly the same way as in basic LEACH protocol [10]. Also, mobility factor considered into the account for CH selection [12]. The LEACH-M is based on their cluster head selection (2):

$$Mi(t) = \frac{1}{N-1}\sum_{j=0}^{N-1} |dij(t)| \quad (2)$$

In order to calculate d ij (t), from ith node to all its j th node or neighboring nodes, the broadcast medium may be used. These CH nodes convey their position to other sensors in the network. Each CH creates a TDMA schedule to all sensor nodes belongs to the cluster [15]. This allows the radio components of each non cluster- head node to be turned off at all times except for through its transmit time, thus minimizing the energy degenerate in the character sensors.

Merits

1. It supports mobility of CHs and member nodes in each round.
2. Residual energy and the number of nodes per cluster are also considered.

Demerits

1. Reconnection mechanism is not established properly when nodes are isolated due to mobility.
2. LEACH-M handles node mobility by assuming that the CHs are stationary.
3. LEACH-M has fixed time slot schedule; each node keep its allocated time slot even if it has no data to send or move out of the cluster.
4. It is not traffic and / or mobility adaptive protocol.
5. Packet loss is high.

C. LEACH-ME

In LEACH-ME (LEACH-Mobile Enhanced), the CH is selected based on the sufficient energy level and minimum mobility factor. Due to mobility, CH may move out of the cluster, causing the cluster to become headless. Each node should maintain certain additional information to make room for handling mobility [16]. Those are role, mobility factor, member lists, TDMA schedule.

Merits

1. Once a node becomes a nonmember in any of the cluster, it can join in any nearby cluster.
2. It is better than LEACH-M in successful data transmission.
3. It provides minimal data loss in case of nodes' mobility.

Demerits

1. The Cluster Head does not consider their overload. So, we cannot achieve load balancing.

D. CBR

Cluster Based Routing (CBR) Protocol is a Mobile-WSN protocol. The protocol collaborates with mobility and traffic adapted MAC layer to support sensor nodes' mobility and improve packet delivery ratio. The time-slots are scheduled for each sensor node with their respective cluster.

Two owners are created for each timeslot; original owner and alternative owner, such that CBR-Mobile can work adaptively to sensor nodes' mobility and traffic [14]. This protocol keeps the new mobile sensor nodes in the simple database tables and serves these nodes whenever free or unused timeslot is available. The sensor node does not need to wait for two repeated collapse frames from the CH to make the resolution they directly decide that it has moved out of its cluster after one frame [13]. The TDMA schedule due to their moment period is throwing significance to the open collect head to avoid the loss of message. [11]. The received signal strength is greater than the entry nodes; it will send the data back to CH using low transmission power.

Merits

1. The efficient bandwidth utilization is avoided by the unnecessary consumption of timeslots.
2. Data loss is avoided.
3. The sensor nodes are disjointed from the system for long time.
4. CHs are adaptively reassigning the timeslots according to sensor nodes mobility and traffic.

Demerits

1. CBR mobile WSN has higher average delay compared to LEACH-M.

E. ECBR

The ECBR is protocol for mobile nodes in wireless sensor network. ECBR-MWSN protocol selects the CHs using the parameters of highest residual energy, low mobility and least distance from the BS. The BS periodically runs the ECBR algorithm to select new CHs after a certain period of time. It is aimed to prolong the lifetime of the sensor networks by balancing the energy consumption of the nodes. The protocol results indicate that it gives better performance in terms of higher packet delivery ratio, throughput, energy consumption, routing overhead, and delay [21].

Merits

1. ECBR prolonging the network life time better than CBR.
2. The CH selection is more stable for their network.

Demerits

1. Fail to achieve the balanced energy consumption of nodes.
2. High delay and energy consumption.
3. Perform well in small zone sizes only.
4. Routing and mobility overhead is high.

F.CES

In CES, the CH selection mainly focused on the energy consumption of sensor nodes in the overall network and therefore obtains a longer network lifetime. In CES, each sensor calculates its weight based on k-density, residual energy and mobility and then broadcasts it to its 2-hop neighborhood. The sensor node with the greatest weight in its 2-hop neighborhood will become the cluster-head and its neighboring sensors will then join it. [17].

Merits

1. Packet delivery ratio is high compare to LEACH and LEACH-C.
2. CES uses 2-hop thresholds (Thresh Upper and Thresh Lower).
3. It provides good performance for coverage and broad casting in MWSNs.

Demerits

1. If node mobility is high cannot achieve the better throughput.

G. ZORO MSN

Zone-based Routing Protocol for Mobile Sensor Networks (Zoro MSN) considers design aspects such as mobility of sensors, zone with route protection, sequence update and communication between sensor nodes. [1]. Zoro MSN acts the same as a fusion map-reading protocol. In this protocol, ZH is placed at a one-hop distance from the sensor nodes [10], [11]. The communication among the ZHs as well as among ZHs and BS is through into a immediate method, based on a periodic timer that triggers the sending process on top of the ZH or based on the quantity of numbers the ZH have toward spread [9]. In Zoro MSN, only the ZHs act as routers for the network, which help keep away from the “transmit squall end product trouble” Zoro MSN uses a vicinity advertisement process that allows the ZHs to continue in sequence in relation to their near ZHs and helps identify which of those ZHs are closer to the BS than the recent ZH. The ZH uses this in sequence to select the best next hop to forward the accumulated data to the BS. The previous nodes forward their ZH facts packet toward the ZH and receive its acknowledgment for the reception of the packet.

Merits

1. Zone division is organized for improving efficiency.
2. The energy consumption and routing overhead is low.
3. Zoro MSN protocol is effective for smaller size zone.

Demerits

1. It is not effective for larger size zone.
2. Zoro MSN is not suitable for medium and high mobility nodes.

H. BCDCP

The Base-Station Controlled Dynamic Clustering Protocol (BCDCP) distributes the energy dissipation evenly among all sensor nodes to improve network lifetime and average energy savings [15], [16]. In BCDCP, nodes containing more residual energy have more chances to be selected as CH. In order to extend the lifetime of the whole sensor network, energy load must be evenly distributed among all sensor nodes so that the energy at a single sensor node or a small set of sensor nodes will not be drained out very soon. In BCDCP, we accomplish these tasks by means of an iterative cluster splitting algorithm. This simple algorithm first splits the network into two sub clusters, and proceeds further by splitting the sub clusters into smaller clusters. The BS repeats the cluster splitting process until the desired number of cluster is attained. The iterative cluster splitting algorithm ensures that the selected CHs are uniformly placed throughout the whole sensor field by maximizing the distance between CHs in each splitting step. Furthermore, in order to evenly distribute the load on all CHs, we utilize the balanced clustering technique where each cluster is split so that the resulting sub clusters have approximately the same number of sensor nodes [22], [23].

Merits

1. To produce load balanced cluster.
2. BCDCP distributes the burden of routing evenly among all CHs.
3. BCDCP protocol utilizes a time-division multiple access (TDMA) scheduling scheme to minimize collisions between sensor nodes.

Demerits

1. The overhead is high due to the BS control.
2. BCDCP is not suitable for large area of networks.

I.EEDBC-M

Energy Efficient Density Based Clustering for Mobile node (EEDBC-M) algorithm [24] is density based clustering where DBSCAN algorithm is used to form the balanced cluster that are significantly more effective in arbitrary shape of cluster formation. In EEDBC-M, the selection of CH is based on node residual energy, mobility factor and node density such as measuring node distance to its neighbors. It also achieves quite uniform CH allocation across the network. A careful selection of the CH selection parameters can balance load among CHs. The results demonstrate that EEDBC-Mobile algorithm outperforms than LEACH-Mobile in terms of the energy consumption, network life time, throughput, delay and data delivery ratio.

Merits

1. EEDBC-M provides organized and well-formed clusters.
2. The utilization of energy is high.

Demerits

1. Uniform CH nodes are not assigned in entire network
2. Cluster formation is difficult due to mobility.

J.MBC

Mobility based clustering protocol (MBC) [19] is well suited when sensor nodes are mobile. In MBC protocol, selection criterion of CH is different from the classical LEACH protocol; here CH is selected based upon the residual energy and mobility factor. The cluster is organized in steady-state phase and sensor node transmits its sensed data by TDMA timeslot in steady state phase. During CH formation, CH broadcasts a joint request message to create a new cluster and avoid packet loss when node or CH moves away from the current cluster. In this scheme, threshold of MBC is changed based on the residual energy and mobility factor in (3).

$$T(n)new = \frac{P}{1-p*[r \bmod (1/p)]} * \left(\frac{En\_current}{Emax}\right)\left(\frac{Vmax-Vn_{current}}{Vmax}\right), \forall\, n \in G \quad (3)$$

where En_current is the current energy, Emax is the initial energy, Vn_current is the current speed and Vmax maximum speed of the node. Key parameters of MBC were packet delivery rate, stable link connection, energy efficiency and lifetime of the network.

Merits

1. Low energy consumption.
2. Control overhead is less even in frequent membership change.
3. Increases the successful packet delivery rate
4. Provides reliability of a path depending upon the stability of every link.

Demerits

1. It is a proactive protocol only
2. It does not provide fault tolerance.

K. EPCR

EPCR presents two new routing protocols for MSNs. They are: Power-controlled routing (PCR) and enhanced version, i.e. Enhanced Power-Controlled Routing (EPCR) [20]. In both protocols, fixed transmission power is employed in the clustering phase but when ordinary nodes are about to send their data to their respective CHs, they change their transmission power according to their distance from their CH. While in PCR, the nodes are associated with the CH on the basis of weight, in EPCR, it is done on the basis of distance. In addition to the protocols, we suggest a packet loss recovery mechanism for the PCR and EPCR. Both protocols work well for both mobile and static networks and are designed to achieve high network lifetime, high packet delivery ratio, and high network throughput. These protocols are extensively simulated using mass mobility model, with different speeds and different number of nodes to evaluate their performance. Simulation results show that both PCR and EPCR are successful in achieving their objectives by using variable transmission powers and smart clustering.

Merits

1. Works for both mobile and static wireless sensor network.
2. Suggested a packet loss recovery mechanism for PCR and EPCR protocol.

Demerits

1. Supports homogenous networks only.
2. Does not provide load balancing.

L.FTCP-MWSN

Energy Efficient and Fault Tolerant Routing Protocol for Mobile Sensor Network (FTCP-MWSN) [18] does not require any extra timeslot for calculating the mobility of sensor nodes. During setup phase, the BS forms clusters based on the geographical locations of sensors and selects CHs based on the residual energy and position of the sensors. Since all nodes have the same initial energy CH is selected based on a random number (between 0 and 1) and CH probability, which is similar to the method used in the LEACH protocol [8].CH determines the number of frames at the beginning of each round based on the residual energy of network. Also events are subscribed to sensors and when these events occur sensor nodes send data packets; otherwise, sensors send small sized special packets, which consume much less energy as compared to large data packets. In the steady phase, CHs assign timeslots to the member nodes using TDMA scheme. Member nodes of a cluster transmit data, receive acknowledgements from the CH, and count their movements inside and outside of the cluster at their allocated time slot. In order to achieve reliability or detect the failure of nodes, CH sends the ID of SNs to BS, which has been moved out of the cluster and also the ID of the node which sends JOIN REQUEST packet. This protocol has an advantage of being fault tolerant and more energy efficient than LEACH-M [8], Leach-ME [16] and CBR-Mobile [14] protocols.

Merits

1. Provides reliability.
2. Provides fault tolerance.
3. Increases data delivery rate
4. Reduces the end to end transmission delay.
5. Each node updates information and calculates mobility factor at timeslot of the last round of steady phase.

Demerits

1. It does not provide load balancing.
2. Mobility overhead is high.

TABLE I
REVIEW OF DIFFERENT DYNAMIC ROUTING PROTOCOLS IN WSNS

Name of the Protocol	Network type			Sensor Mobility		Sensor Types		Clustering process		CH selection	
	Proactive	Reactive	Hybrid	Stationary	Mobile	Homogeneous	Heterogeneous	Static	Dynamic	Fixed	Random
LEACH	Yes	-	-	-	Partial	Yes	-	-	Yes	-	yes
LEACH-M	Yes	-	-	-	Complete	Yes	-	-	Yes	-	yes
LEACH-ME	Yes	-	-	-	Complete	Yes	-	-	Yes	-	yes
CBR	-	Yes	-	-	Complete	Yes	-	-	Yes	-	yes
CES	-	Yes	-	-	Complete	Yes	-	-	Yes	-	yes
ZORO MSN	-	-	Yes	-	Complete	Yes	-	-	Yes	-	Yes
BCDCP	Yes	-	-	Complete	-	Yes	-	-	Yes	-	Yes
EEDBC-M	-	Yes	Yes		Complete	Yes	-	-	Yes	-	Yes
MBC	-	Yes	-		Complete	Yes	-	-	Yes	-	Yes
EPCR	-	Yes	-	Complete	Complete	Yes	-	-	Yes	-	Yes
FTCP-MWSN	-	Yes	-	-	Complete	Yes	-	-	Yes	-	Yes

VI. APPLICATION DOMAIN AND DEPLOYMENTS

A WSN application can be of two types: Monitoring and tracking. The application domains of WSNs include military and crime prevention, environment, health (body area networks), industry and agriculture, and urbanization and infrastructure. Military operations involving force protection with unattended ground sensors formed into intelligent networks around forward operating bases are receiving much attention. Body Area Networks (BANs) integrated with soldier communication systems are also a key application, as vital health functions can be monitored when soldiers enter hazardous areas. In addition, the homeland security sector is showing great interest in WSNs for critical infrastructure monitoring (utilities, airports, etc.), border protection, incident detection and crisis management. In environmental applications, sensor networks are increasingly used to monitor nature. In environmental applications, sensor networks are increasingly used to monitor nature. Some examples of environmental monitoring applications include Great Duck Island; a sensor network deployment for habitat monitoring, biodiversity mapping, to observe wildlife, flood detection, forest fire detection, and precision agriculture. Furthermore, in the civil sector, WSNs have generated a lot of interest from their smart infrastructure applications, such as smart grids, smart energy metering, smart transport and traffic management, smart roads, etc. Structural health monitoring enables detecting the health status of structures using a network of accelerometers and strain gages.

The WSNs are one of the first real world examples of pervasive computing, the notion that little, neat, and economical sensing and computing devices will eventually permeate the environment. Though the technology is still in its early phase, it will enable a plethora of new services and applications [29].

A. Environmental Applications

Many initial WSNs have been deployed for environmental monitoring, which involves tracking the movements of small animals and monitoring environmental conditions that affect crops and livestock. In these applications, WSNs collect readings over time across a space large enough to exhibit significant internal variation. Other applications of WSNs are chemical and biological detection, precision agriculture, biological, forest fire detection, meteorological or geophysical research, flood detection and pollution study. The College of the Atlantic deployed a WSN consisting of 32 nodes on Great Duck Island, off the coast of Maine, to monitor Leach's Storm Petrel without human disturbance [30]. More recently, researchers from Australia, the Netherlands and the USA are developing a distributed environmental monitoring sensor network in Australia's Great Barrier Reef [31], which will provide valuable scientific information enabling a greater understanding of the environmental impact due to pollution, urban development and climate change [39].

B. Healthcare Applications

The wireless sensor networks could provide interfaces for disabled, integrated patient monitoring. It can monitor and detect elderly people's behavior, e.g., when a patient has fallen. These small sensor nodes allow patients a greater freedom of movement and allow doctors to identify pre-defined symptoms earlier on [32]. The small installed sensor can also enable tracking and monitoring of doctors and patients inside a hospital. Each patient has small and lightweight sensor nodes attached to them, which may be detecting the heart rate and blood pressure. Doctors may also carry a sensor node, which allows other doctors to locate them within the hospital. Mote Track [33] is the patient tracking system developed by Harvard University, which tracks the location of individual patient's devices indoors and outdoors, using radio signal information from the sensor attached to the patients [40].

C. Home Applications

With the advance of technology, the tiny sensor nodes can be embedded into furniture and appliances, such as vacuum cleaners, microwave ovens and refrigerators. They are able to communicate with each other and the room server to learn about the services they offer, e.g., printing, scanning and faxing. These room servers and sensor nodes can be integrated with existing embedded devices to become self-organizing, self-regulated and adaptive systems to form a smart environment. One example of a smart environment is the

Residential Laboratory at Georgia Institute of Technology [34].

D.Military Applications

The rapid deployment, self-organization and fault tolerance characteristics of sensor networks make them a very promising sensing technique for military applications. Military sensor networks could be used to detect and gain as much information as possible about enemy movements, explosions, and other phenomena of interest, such as battlefield surveillance, nuclear, biological and chemical attack detection and reconnaissance. As an example, sensors help to locate the source of incoming small arms fire so that counterattacks can be launched against snipers quickly and precisely [35]-[38].

E. Other Commercial Applications

The advance of wireless sensor networks leads to many agricultural, industrial and commercial applications. Some examples are herd monitoring, building virtual keyboards, managing inventory, monitoring product quality, interactive toys and transportation management.

VII. Conclusion

At the bottom of mobility in sensor nodes become gradually more useful in various applications. So in this paper, we have surveyed some of the existing 'dynamic clustering' routing protocols specifically with respect to their network lifetime and reliability requirements. In addition, we also provided a comparative study of 11 protocols reacting towards various networking parameters. As there is the infinite existence of dynamic routing protocols, we have considered only 11 samples of mobility based routing protocols to explicate the concept with individual Merits and Demerits. The factors affecting CH communication and cluster formation are highlighted and those challenges are pin pointed for future research directions in this regard.

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