Performance Analysis of Clustering Protocols for Wireless Sensor Network

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Abstract - *Wireless sensor networks (WSNs) are in large demand in recent years as a wide growth of wireless devices. WSNs consist of lots of tiny node & it is no longer useful when battery dies, so to avoid this issue many protocols were introduced. In this paper we analyses some clustering protocol like LEACH, DSC, FTEEC & MEFC protocol.*

1. INTRODUCTION

Wireless sensor network (WSN) consists of number of low power, low cost sensor nodes which are used in different applications such as environment monitoring, surveillance, remote sensing. Designing energy-efficient and reliable protocols is highly important in a resource-constrained wireless sensor network (WSN). Clustering protocols of WSNs are considered very energy efficient; Clustering implies dividing sensor nodes in group according to their nature and requirements. They can execute different function. This paper focusing on clustering protocol in WSNs. & give idea to build energy efficient and fault tolerant WSN. In this paper we get brief review of LEACH, DSC, FTEEC and MEFC protocol & show the performance by simulation & comparisons with each other.

2. LEACH Protocol

LEACH is the low energy adaptive hierarchy protocol which is TDMA bases MAC protocol. The concept of LEACH is to organize WSN in to clusters to improve the life of WSN & by decreasing the energy used to generate & maintain cluster heads. [2]

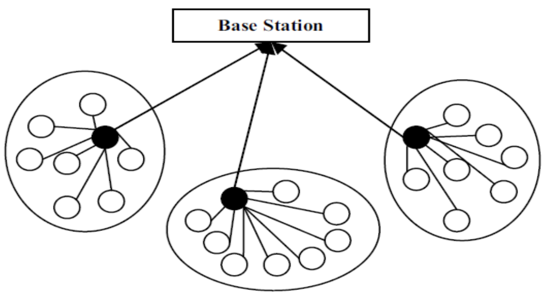

Fig. 1: Leach Structure [2]

The operation of leach protocol consists of two phases. Set up phases & steady state phase. In the set up phase each node decides whether or not to become cluster head for the current head. For the current round based on threshold,

$$T(i) = \begin{cases} \dfrac{p}{1 - p^*(r mod \frac{1}{p})} & if\ i \in G \\ 0 & otherwise \end{cases}$$

Where p is the cluster head probability, G is the set of nodes that have not been cluster heads in the last 1/p rounds and r is the current round. In LEACH each node becomes a cluster head only for a single time for r=$\frac{1}{p}$ rounds. In the beginning of each rounds every nodes belong to G. The node is selected as a cluster head for the current round if the random number is less than the T(i) otherwise the node is expected to join the nearest cluster head in its neighborhood. [1]

CH broadcasts a message to rest of nodes, depends of the signal strength of the message each node select CH. The CH creates a TDMA scheme & assigns each node a time slot .In the steady state phase cluster heads collect data from sensor nodes. Aggregate he data and send it to BS. [1]

3. DSC protocol

DSC stands for dynamic & static clustering. IN dynamic case DSC forms clusters for every round while in static, the clusters are fixed for 10 rounds & CH position rotates.
Dynamic clustering is divided in to rounds & each round consists two phases. Set up phase and Steady state phase. Set up phase work same as LEACH. In set up phase clusters are formed & CH selected, while in steady state phase, CHs collect the data and send it to the base station.

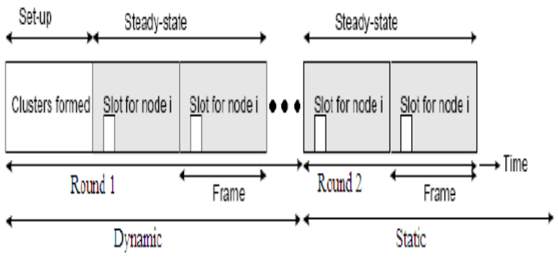

Fig. 2: DSC Structure [3]

In static clustering each round consists the steady state phase only. Nodes start sensing events & transmitting data to the cluster head as per TDMA. If round number less than 10 rounds, current CH select new CH with the enough energy for next round & inform the base station. If round number equal to 10 rounds then at the end of round all nodes send energy status & set up phase starts to form clusters.

4. FTEEC Protocol

FTEEC stands for fault tolerant & energy efficient clustering protocol. Fault tolerance is the mechanism that provides the continuous operation of the network by detecting the failure of nodes. In FTEEC we assume that all nodes have same initial energy. In set up phase, BS selects a number of nodes as CHs based on the following criteria: initially, BS selects a node A randomly as a CH. Then, BS selects another node **B** randomly as a CH if node B is not within the communication range of node A. Whenever a node is selected as a CH, BS notifies that node. Then, CHs broadcast their IDs to the network.

In the steady phase, a number of frames constitute a round, where each node has a time slot allocated to it in a frame using the TDMA scheme. In the steady phase, each active node A that is selected in the setup phase sends either the data that is sensed or a special packet to the CH in its allocation timeslot using the TDMA scheme. If the CH does not receive any data or a special packet from A, the CH will assume that A has failed. Then the CH will exclude the failure node from the allocated time slot.

At the end of a frame, if BS does not receive any data from a CH, the BS sets a timer and sends a 'hello' message to that CH. If the BS does not hear any 'ACK' message from the CH before the timer expires, the BS assumes that the CH has failed. Then the BS assigns the node with the most residual energy of the cluster as a new CH.

5. MEFC Protocol

Mobile centric energy efficient & fault tolerant clustering protocol is much similar to FTEEC. Main difference is FTEEC do not support mobility of sensor nodes & does not support mobile WSN applications. MEFC works in to four phases.

In network set up phase BS selects number of nodes as CHs which are one hop away from the BS, then selects some nodes as Alternative CH (ACH) & apply this procedure until all nodes of the network become CHs, ACHs and cluster members. The member node of cluster which is within communication range of maximum number of neighboring CHs will be selected as a gateway node.

In steady phase active nodes are assigned timeslot using TDMA scheme. Active nodes sense the data and send it to CHs. CHs aggregate all the data and send it to the BS.

In Fault tolerance phase, the BS sends "HELLO PACKET" to a CH at its allocated timeslots if the BS does not receive any data packet related to the event of interest. If the CH does not send any "ACK-HELLO" packet or data packet at the following timeslot the BS assumes that the CH has failed and selects an ACH to work as a CH.

In mobility management phase, redundant sensors are deployed such as in battle field surveillance where a group of nodes move together, alternative nodes can be kept in sleep mode and wake up at a certain interval to check the status of active nodes. Network coverage is also important for such applications. Where network coverage is not important but receiving data from each sensor is significant then all nodes are active. A number of nodes are selected as CHs and ACHs and the rest of the nodes are active members of a cluster. All members of a cluster work using TDMA scheme to send data to its CH. If a member node x of a cluster moves out of the cluster x sends a "JOIN CLUSTER REQUEST" message to the CH, y that is closest to the new location of x. If y has an available timeslot for x, y accepts x as new cluster member by sending an "ACCEPT JOIN" message and allocating the timeslot to x. Once the CH, y receives data from all member nodes y aggregates data and sends to the BS. If the BS does not receive data from y and reveals that y has not failed but moved outside of the cluster the BS selects the ACH with the most residual energy as a new CH. [4]

6. Simulation Results

We perform simulation to measure the performance of the all protocols in terms of network energy consumptions, network lifetime and number of message transmissions. We use randomly connected Unit Disk Graphs (UDGs) on an area of 100 meters X 100 meters as a network simulation model. The base station (BS) is placed at the central location of the network at co-ordinate (55 X 50) meter2. [4]

Table I: simulation parameters and their respective values.

Parameters	Value
Network Size	100 x 100 meter2
Number of Nodes	Maximum 200
Number of Clusters	4 – 12
Base Station Position	55 x50 meter
Transmission Energy Consumption (ε_{elec})	50 nJoule/bit
Energy Consumption in free space (ε_{fs})	0.01 nJoule/bit/m 2
Energy consumptions in sleep state	0.002 nJoule/sec
Initial Node Energy	3 Joule

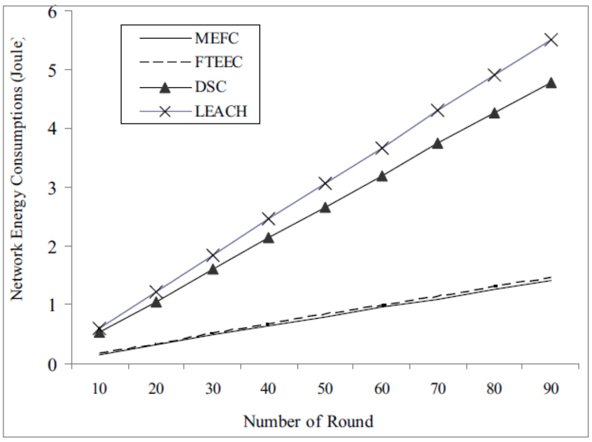

Fig. 3: Comparison of Network Energy Consumptions

We perform the simulation by varying the number of rounds between 10 and 90 by fixing the number of nodes at 100 and number of zones at 4 of an increment of 10, where a round comprises a cluster formation phase and a number of steady phases. Figure 3 illustrates that the network energy consumptions of the proposed MEFC protocol is much lower than the DSC and LEACH protocols but a very slightly lower than FTEEC protocol. FTEEC and MEFC have same performance in terms of network energy consumptions. This is because the MEFC protocol reduces the number of special packet transmissions as compared to the existing FTEEC protocol, Figure 4 demonstrates that the network lifetime of MEFC and FT-EEC protocols are almost the same though their lifetime are much higher than the existing DSC and LEACH protocols.

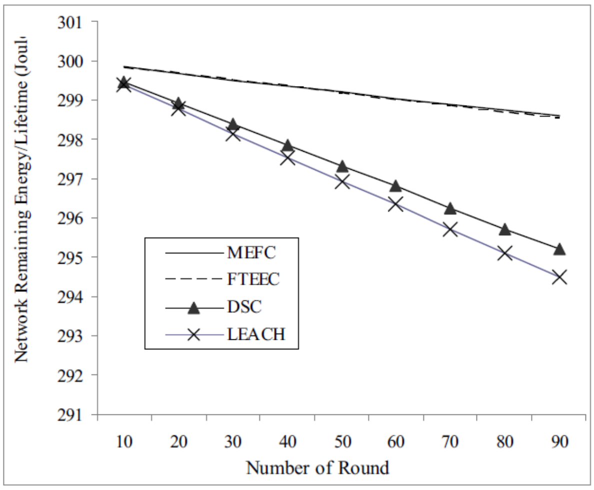

Fig. 4: Comparison of Network Lifetime

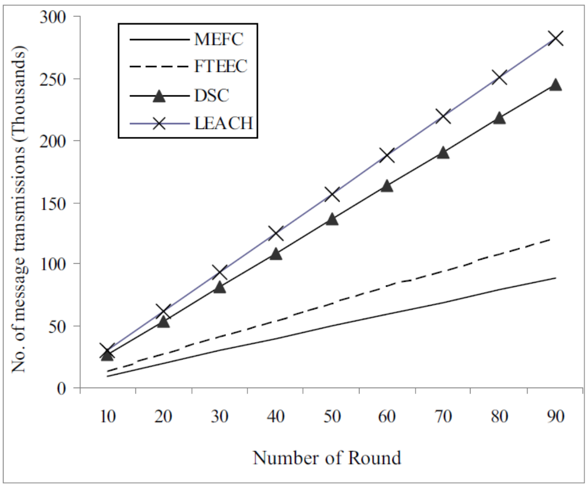

Fig. 5: comparison of number of message transmission

6. CONCLUSIONS

Theoretical analysis on energy consumptions shows that the MEFC protocol perform better than existing FTEEC, DSC and LEACH protocols in terms of network energy consumptions. Simulation results show that MEFC and FTEEC protocols have the similar performance but the MEFC protocol outperforms DSC and LEACH protocols in terms of network energy consumptions. This is because the reduction of the number of small-sized special packets transmissions in MEFC protocol does not reduces the overall network energy consumptions to a great extent.

LEACH	DSC	MEFC
All nodes can communicate with CH & CH communicates with BS	All nodes can communicate with CH & CH communicates with BS.	Only Active nodes communicate with cluster heads
CH selection is random process	CH selection based on energy status & current location of nodes.	Nodes that are one-hop away from the BS are becoming CHs
CHs are not uniformly distributed within the cluster that means CHs can be located at the edges of the cluster.	CH change in each round	CHs are uniformly distributed
No inter-cluster communication in the network because CHs directly communicate with BS.	No inter-cluster communication	Gateway-node available for inter-cluster communication

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