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A Review on Heterogeneous Protocols for Wireless Sensor Network

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Abstract: ***Wireless sensor networks are used in many important areas like military, vibration monitoring health monitoring, and industries etc. Because the sensor nodes has low power, small size, low cost and self-organizing behavior in harsh environments become the WSNs attractive in wide variety of applications. The important issue in the design of WSNs is energy usage. There are many routing protocols like: DEEC, DDEEC, EDEEC, TDEEC, BEENISH, heterogeneous routing, etc. that is used for energy efficiency. These protocols are used to increase the network lifetime of the wireless sensor networks and decrease the energy consumption of the nodes. In heterogeneity protocols clustering is used. Using clustering the whole sensing area is divided into groups. These groups are also known as clusters An Optimum clustering technique can low the energy consumption in WSN and increase the network lifetime. In WSN energy is main retainer during analyzing the routing protocols for WSN.***

Keywords: Wireless sensor networks, network lifetime, residual energy, CH, energy efficient routing protocols.

1. Introduction

A wireless sensor network (WSN) is typically composed of a large number of low-cost sensor nodes, which work collectively to carry out some real-time sensing and monitoring tasks within a specific area. [8].In wireless sensor network the sensor nodes are used that may sense the environment and gather the knowledge from the observance field and communicate through wireless links .The information collected is forwarded, via multiple hops relaying to a sink (also referred to as controller or monitor) that may use it domestically, or is connected to alternative networks [5].

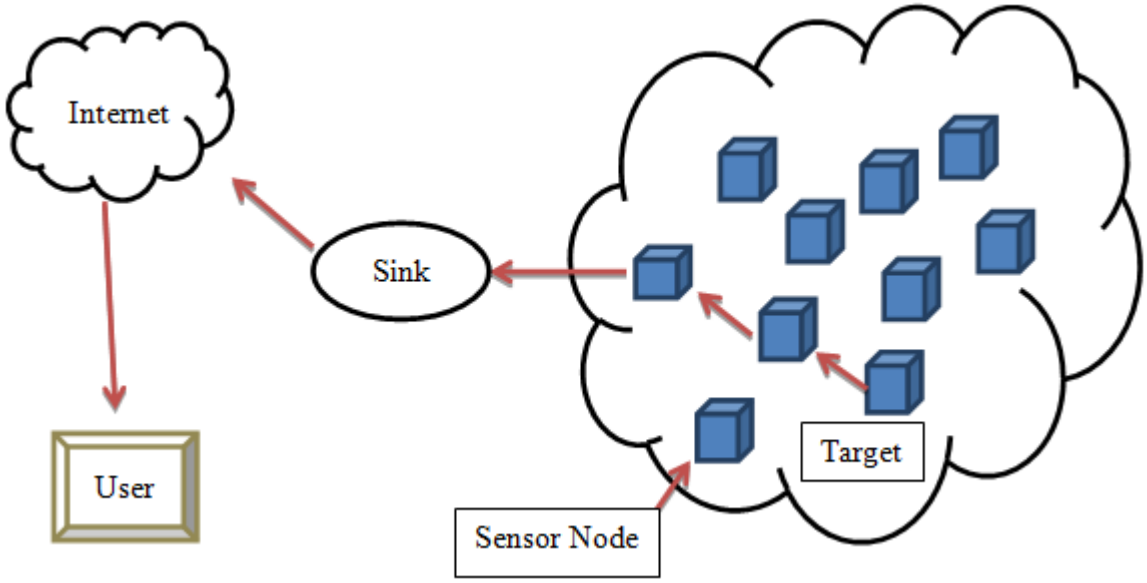

Figure 1: Architecture of Wireless sensor network

In WSN there is no physical connection between two sensor nodes, a virtual link is established between sensor nodes. The virtual link is capable for transmit and receiving the information from source to destination. The Fig:1 shows the architecture of Wireless Sensor Network (WSN). In this paper review various heterogeneous Protocols. Energy efficiency and reliability is one of the most important factors in WSNs. The objective of the routing protocols is to extend the lifetime of the sensor network and reduce the energy consumption of the nodes.

2. Literature Review

Aslam [2] Energy efficient routing protocol for Wireless Sensor Networks (WSNs) is one of the most challenging tasks for researcher. Hierarchical routing protocols have been proved more energy efficient routing protocols, as compare to flat and location based routing protocols. Heterogeneity of nodes with respect to their energy level, has also added extra lifespan for sensor network. In this paper, we propose a Centralized Energy Efficient Clustering (CEEC) routing protocol. We studied that the CEEC has maximum throughput and network lifetime in which nodes

with different energy level are deployed in separate regions. In CEEC, BS performs central clustering formation in network, with help of central control algorithm of CEEC. Advance central control algorithm considers four factors for selection of cluster-heads, initial energy of nodes, residual energy of nodes, and average energy of each region and location of nodes.

Divya et al [13] the sensor nodes are spread in a region which sense various types of information and then transmit this information from node to other nodes or to the final BS. These sensor nodes sense the various changes in the environment like temperature, pressure, etc. The data sensed by these nodes are then approved to the Base Station (BS) for estimation. Wireless sensor networks are used in various applications like military surveillances, habitat monitoring, forest fire detections, and landslide detections. This paper presents the new clustering algorithm called EE-SEP by modifying the SEP (Stable Election Protocol) for heterogeneous wireless sensor network. Energy Efficient - SEP protocol is used to increase the number of alive nodes and thereby increasing the energy efficiency, stability period and network lifetime and balancing the energy consumption. Simulation results show that proposed Energy Efficient SEP algorithm performs better as compared to SEP.

Kaur [5] The main requirements of wireless sensor network are to prolong the network lifetime and energy efficiency. In this paper, Heterogeneous - Hybrid Energy Efficient Distributed Protocol (H-HEED) for Wireless Sensor Network has been proposed to prolong the network lifetime. In H-HEED protocol the different level of heterogeneity is introduced: 2-level, 3-level and multi-level in terms of the node energy and also the three types of the node are used in H-HEED protocols for the selection of the cluster head (CH). In H-HEED protocol the significant improvement in the lifetime as compare with HEED protocol because number of rounds is maximum with multi-level H-HEED. Finally the simulation result shows that H-HEED achieves longer lifetime and more effective data packets in comparison with the HEED protocol.

Padmanabhan [7] Wireless Sensor Networks (WSNs) is a network of an inexpensive low coverage, sensing, and computation nodes. The difference between the WSN and the traditional wireless networks is that sensors are extremely sensitive to energy consumption. Energy saving is the main issue in designing the wireless sensor networks. Many researchers have focused only on developing energy efficient protocols for continuous-driven clustered sensor networks. In this paper, we propose a modified algorithm for Low Energy Adaptive Clustering Hierarchy (LEACH) protocol. Our modified protocol called "Energy-Efficient Adaptive Protocol for Clustered Wireless Sensor Networks (EEAP)" is aimed at prolonging the lifetime of the sensor networks by balancing the energy consumption of the nodes. EEAP makes the high residual energy node to become a cluster-head. The elector nodes are used to collect the energy information of the nearest sensor nodes and select the cluster-heads. We compare the performance of our EEAP algorithm with the LEACH protocol using simulations.

Rehman [9] Discussed in recent few years Wireless Sensor Networks (WSNs) have seen an increased interest in various applications like borderfield security, disaster management and medical applications. So large number of sensor nodes are deployed for suchapplications, which can work autonomously. Due to small power batteries in WSNs, efficient utilization of batterypower is an important factor. Clustering is an efficient technique to extend life time of sensor networks by reducingthe energy consumption. In this paper, we propose a new protocol; Energy Consumption Rate based Stable ElectionProtocol (ECRSEP). Our CH selection scheme is based on the weighted electionprobabilities of each node accordingto the Energy Consumption Rate (ECR) of each node. We compareresults of our proposed protocol with Low EnergyAdaptive Clustering Hierarchy (LEACH), Distributed Energy Efficient Clustering (DEEC), Stable Election Protocol(SEP), and Enhanced SEP(ESEP). Our simulation results showthat our proposed protocol, ECRSEP outperforms allthese protocols in terms of network stability and network lifetime.

Younis [11] Hybrid Energy Efficient Distributed Clustering (HEED) protocol is an extension of LEACH protocol, in this protocol the residual energy is used as primary parameter while other topology features like node degree, distances to neighbours are used as secondary parameter to attain power balancing in network. The clustering process is split into number of iterations, in every iteration nodes that are not covered by any cluster head and thus doubles their probability of becoming a cluster head. As these energy-efficient clustering protocols further enables each node to probabilistically and independently decide its role in the clustered network. Moreover they cannot guarantee optimal elected set of cluster heads [29].

3. Heterogeneous Protocols

The WSN contain various types of heterogeneous protocol like DEEC, DDEEC, EDEEC and BEENISH. These protocols are energy efficiency protocol. Using this protocol we can save the energy of the nodes and improve the network lifetime. In heterogeneous protocols the three types of model is used. These models are two levels, three levels and multilevel heterogeneous model. For two levels heterogeneous model following formula is used [3]:

$$E_{total} = N(1-m)E_o + Nm(1+a)E_o = N\,E_o(1-m+m+am) = N\,E_o(1+am) \quad (1)$$

E_o is the energy level of the normal nodes and $E_o(1+a)$ is the energy level of advanced nodes where a means more energy as compared to normal nodes. If N is the total number of nodes then Nm is the number of advanced nodes where m refers to the fraction of advanced nodes and $N(1-m)$ is the number of normal nodes [3].

For three levels heterogeneous model following formula is used[3]:

$$E_{total} = N(1-m)E_o + Nm(1-m_o)(1+a)E_o + Nm_oE_o(1+b) \quad (2)$$

$$E_{total} = NE_o(1+m(a+m_ob)) \quad (3)$$

In three levels heterogeneous model the super node is added.Super nodes of fraction $m_o$are having a factor of $b$times more energy than normal nodes so their energy is equal to $E_o(1+b)$. As $N$is the total number of nodes in the network, then $Nmm_o$is total number of super nodes and $Nm(1+m_{o)}$is total number of advanced nodes[3].

For Multilevel heterogeneous model following formula is used [3]:

$$E_{total} = \sum_{i=1}^{N} E_o\,(1+a_i) = E_o(N + \sum_{i-1}^{N} a_i) \quad (4)$$

$[E_o(1+a_i)]$ Where E_o is the lower bound and a_i means is the maximum energy i.e. more energy than the lower boundE_o[3].

3.1 DEEC (Distributed Energy Efficient Clustering)

DEEC protocol is proposed by L. Qing, Q. Zhu, and M. Wang et al. for energy efficiency. In this protocol the CH is selected based on probability of the ratio of residual energy. The twotypes energy level of nodes is used in DEEC protocol. Normal nodes and advanced nodes are used in DEEC. The DEEC is the two level heterogeneous WSNs model. In DEEC the advanced nodes is used for select the CH based on the residual energy of the nodes.The total initial energy of the network is the sum of energies of normal and advanced nodes[3].The two level heterogeneous WSNs contain (am)times moreenergy as compared to homogeneous WSNs. DEEC protocol can also perform efficiently for multilevel heterogeneous network. The DEEC used the following formula for the normal and advanced node [12].

$$p_i = \begin{cases} \dfrac{p_{opt}\,E_i(r)}{(1+am)\bar{E}(r)} & if\ S_i\ is\ the\ normal\ node \\ \dfrac{p_{opt}\,(1+a)E_i(r)}{(1+am)\bar{E}(r)} & if\ S_i\ is\ the\ advanced\ node \end{cases} \quad (5)$$

3.2 DDEEC (Developed Distributed Energy Efficient Clustering)

DDEEC protocol is proposed by BrahimElbhiri et al. This protocol is also used for energy efficiency. DDEEC is based on residual energy for CH selection to balance it over the entire network. DDEEC uses same method for estimation of average energy in the network and CH selection algorithm based on residual energy as implemented in DEEC. Difference between DDEEC and DEEC is centered in expression that defines probability for normal and advanced nodes to be a CH [10]. The advanced nodes have highest energy and the normal nodes have the lowest energy so the advanced nodes are used for selection CH as compared to normal nodes. In DEEC advanced nodes are continuously a CH and they die more quickly than normal nodes. To avoid this problem DDEEC protocol introduces threshold residual energy and change the equation 5.The following formula is given for threshold residual energy [3].

$$Th_{REV} = E_o\left(1 + \frac{aE_{dis}\,NN}{E_{dis}\,NN - E_{dis}\,AN}\right) \quad (6)$$

The average probability p_i for CH selection used in DDEEC is given below [3]:

$$p_i = \begin{cases} \dfrac{p_{opt}\,E_i(r)}{(1+am)\bar{E}(r)} & for\ Normal\ nodes, E_i(r) > ThREV \\ \dfrac{(1+a)p_{opt}\,E_i(r)}{(1+am)\bar{E}(r)} & for\ Advanced\ nodes, E_i(r) > ThREV \\ C\dfrac{(1+a)p_{opt}\,E_i(r)}{(1+am)\bar{E}(r)} & for\ Adv, Nml\ nodes, E_i(r) \le ThREV \end{cases} \quad (7)$$

3.3 EDEEC (Enhanced Distributed Energy Efficient Clustering)

This protocol is proposed by P. Saini*et al.* In EDEEC protocol the three level of energy level of nodes is used. This protocol is three level heterogeneous WSN model. Normal nodes, advanced nodes and super nodes are used in EDDEC. The super node is used for the selection of the CH because the super nodes have the highest energy as compare to normal and advanced nodes. Normal nodes contain energy of E_o, the advanced nodes of fraction (m) are having (a) times extra energy than normal nodes equal to E_o(1 + a) whereas, super nodes of fraction m_o are having a factor of (b) times more energy than normal nodes so their energy is equal to E_o(1 + b) [3]. EDEEC uses different p(opt) values for normal, advancedand super nodes, so, value of pi in EDEEC is as follows as:

$$p_i = \begin{cases} \dfrac{p_{opt}\,E_i(r)}{(1+m(a+m_ob))\bar{E}(r)} & if\ S_i\ is\ the\ normal\ node \\ \dfrac{p_{opt}\,(1+a)E_i(r)}{(1+m(a+m_ob))\bar{E}(r)} & if\ S_i\ is\ the\ advanced\ node \\ \dfrac{p_{opt}\,(1+b)E_i(r)}{(1+m(a+m_ob))\bar{E}(r)} & if\ S_i\ is\ the\ super\ node \end{cases} \quad (8)$$

Threshold for CH selection is given below:

$$T(S_i) = \begin{cases} \dfrac{p_i}{1-p_i.\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G' \\ \dfrac{p_i}{1-p_i.\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G'' \\ \dfrac{p_i}{1-p_i.\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G''' \\ 0 & \text{Otherwise} \end{cases}$$

3.4 BEENISH (Balanced Energy Efficient Network Integrated Super HeterogeneousProtocol)

BEENISH protocol is an energy efficient routing protocol used in wireless sensor network. This protocol is proposed by T. N. Qureshi, N. Javaid, A. H. Khan, A. Iqbal, E. Akhtar, M. Ishfaq. In BEENISH the cluster head (CH) is selected on the basis of residual energy of the nodes. The CH requires more energy as compare to member nodes. BEENISH is works like DEEC. In DEEC,two types of nodes are used: normal and the advanced nodes but in BEENISH the four types of nodes are used normal, advance, super and ultra-super nodes. The ultra-super nodes are selected for CH as compare to normal, advance and super nodes. Because the BEENISH uses the more energy level of nodes, so BEENISH provide the better result as compared to DEEC. Let $p_i = \frac{1}{ni}$is probability of node to become CH during epoch nirounds. When all the nodes have same every level at each epoch, selecting the average probability pi to be $p_{opt}\,N$can ensure that there are $p_{opt}\,N$CHs every round and approximately all nodes die at the same time. If nodes are having different energy then nodes with more energy have$p_i$larger than p_{opt} [1].

The average energy of rth round in BEENISH can be obtained as follows[1]:

$$\bar{E}(r) = \frac{1}{N} E_{total} \left(1 - \frac{r}{R}\right) \quad (10)$$

In real, WSN has more energy levels of nodes.CH is selected based on the probability for every energy level. The probability for normal, advance, super node and ultra-super nodes are given below [1]:

$$p_i = \begin{cases} \frac{p_{opt}\,E_i(r)}{(1+m(a+m_o(-a+b+m_1(-b+u))))E(r)} & if\ S_i\ is\ the\ normal\ node \\ \frac{p_{opt}\,(1+a)E_i(r)}{(1+m(a+m_o(-a+b+m_1(-b+u))))E(r)} & if\ S_i\ is\ the\ advanced\ node \\ \frac{p_{opt}\,(1+b)E_i(r)}{(1+m(a+m_o(-a+b+m_1(-b+u))))E(r)} & if\ S_i\ is\ the\ sper\ node \\ \frac{p_{opt}\,(1+u)E_i(r)}{(1+m(a+m_o(-a+b+m_1(-b+u))))E(r)} & if\ S_i is\ the\ ultra-super\ node \end{cases} \quad (11)$$

Threshold is calculated for CH selection of normal, advanced, super and ultra-super nodes by putting above values in equation below[1]:

$$T(S_i) = \begin{cases} \frac{p_i}{1-p_i(rmod\,\frac{1}{p_i})} & if\ S_i\ \in G \\ 0\ otherwise \end{cases} \quad (12)$$

In the equation of $T(S_i)$, we find that nodes with greater remaining energy $E_i(r)$ at round$r$are morepossibly to become CH as compare to low energy nodes. The aim of this mechanism is to efficiently dividethe energy consumption in the network and extend the stability period which is defined by first node die andnetwork lifetime defined by last node die from the start of WSN [1].

4. Conclusions

In this paper,the various heterogeneous protocols for the energy efficiency are discussed. The energy efficiency is the main issue for WSN. The WSN is used in many areas as discussed above. The requirement of each area is more the network lifetime and decreases the energy consumption. All these protocol overcome the problem of energy consumption. The BEENISH protocol is also used for energy efficiency purpose.Ultra super nodes is used for CH. CH consume more energy as compare with another nodes. In BEENISH become CH on the bases of residual energy level of nodes. The BEENISH protocol is the heterogeneous protocol and it perform better than the other exiting clustering protocols in heterogeneous environment of WSN. BEENISH is most efficient protocol in term of stability period, longer lifetime of network and send more effective message or packet to the BS than the other protocol.

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