Energy Harvesting for Lifetime Maximization of the Underground Sensor Networks via FFC in Underground Mining

P.Rama, S.Murugan

Abstract: ***Energy harvesting is the process by which energy is derived from external sources. Energy harvesting is one of the challenging problems in balancing energy within the limited bandwidth when compared to the surface of an area using sensor devices. To solve the above challenge, the aim of the work is to collecting and sharing the available energy source from sink node,to increase the life time of the sensor node and at the same time increases the lifetime of the sensor networks. Therefore, a Finer Force Care-up (FFC) method is proposed to shares the energy for underground mining. The FFC method is to estimate the quantity of available energy capacity for each sensor node in underground mining. To calculate the distance between the base station and itself the Monte-Carlo-Localization (MCL) method is used. Subsequently it derives the energy from overall sensor network into single node then calculates the energy loss of a particular packet transfer between one-sensor nodes to another node. Finally to shares the collective energy to overall sensors in the network in underground mining. This proposed work ensure the reliable packet delivery between the source and destination of sensor nodes; Simulation results shows the effective evaluation of the wireless sensor networks in underground mines to share the available power, reliable packet delivery, life time of the sensor networks and packet delivery ratio.***

Keywords: ***Fine Force Care-up, Life time, reliable packet delivery, Underground Mining, Energy loss, Packet delivery ratio, wireless sensor network***

I. INTRODUCTION

In wireless sensor networks underground communication system is a promising mode and having its application in coal mining, underground water mining, subway communication etc. The most common issue raised in wireless sensor networks is energy consumption.In underground mining, the main role-play in wireless sensor networks is saving energy.It is known that, each sensor node life time is based on the battery power.An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device.

When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit [1].Similarly in sensor networks, the future reading at a sensor is predicted, given the past reading history and the spatial and temporal knowledge of readings from surrounding sensors [2].Tracking the sensor nodes are categorised in many ways, they are, when tracking the node, the sensor node consumes more energy when compared to other process, and sensor nodes are normally force to use the power from battery only.Searching the shortest path when target the destination.

The microcontroller energy for consumption energy lost due to leakage.Power consumption of each bit transmission or receiving. Energy consumption, because of sensor node mobility. Power consumption in monitoring the sensor networks.In calculating the localization ratio, the energy consumption is taken major account in underground sensor networks.[19]In sensor networks, the energy can be saved in many ways. Putting the sensor node in sleep mode when the sensor, Object is not in their surrounding area in underground, Node is not in connectivity, Networks bandwidth level is fading[3].

The traditional cellular network communications like MANETs, WSN are having unique characteristics and constrains. The energy constrain in sensor networks is equipped with the embedded microprocessor and radio transceiver are taken into account The proposed approach is the usage of energy sharing from the sink node to its neighbour node, by using the power transceiver techniques is used to collect and share the reaming energy to increase the lifetime the sensor networks. Since the sensor network functions with battery power, it plays the critical role in wireless sensor networks.[4]Based on the functioning of sensor networks, sensor networks with low battery power may fail to reach hard by nodes by which leading to a break in some essential communications by disconnecting or disabling the entire network. Hence, without energy, the node will also fail to continue the environmental monitoring activities, which is more essential to the functional operation of the system.

To cope with these challenges in Underground sensor networks, a energy harvesting approach is proposed for lifetime maximization of sensor nodes with the aid of FFC methodology.

Revised Manuscript Received on May 04, 2019.

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Energy harvesting (EH) as a technology capable of providing self-sustainable operation of sensor networks.

The remaining section of this paper follows, Section 2 highlights the relevant related work in sharing the collective energy between the sensor nodes. Section 3 is system model and methodologies; Section 4 discusses the simulation results, Conclusion and future works conclude the paper in section 5.

II. RELATED WORKS

Haitao Zhang et al, proposed the cluster routing technology was using for load balancing sensor nodes. This method were improved the energy in each hotspot and reduce the consumption of sensor nodes in wireless sensor networks [5].Low –Energy adaptive clustering routing protocol was proposed by JiPeng et al which was periodically improve the communication quality and localization, also reduce the energy consumption. However, the problem is all the nodes cannot be fully utilize in the networks. It cannot be optimized in wide range [6].

Mark Perillo et al [7] described Energy Conservation method were improving the signal-to-noise ratio reduces the number of movement in wireless sensor networks. Blue noise model is used to reduce the noise of the signal on sensor networks. Hence, this model may not proceed in multi – hope networks.SAA-ERL Scheme for Node Localization was continuously acquire the sensor nodes with the assessment of anchor node. Using this method to save the energy, while nodes sleep the energy consumption was reducing. However, node localization in dynamic network is further research. SAA-ERL Scheme does not work properly in dynamic area[8]. Marc T. Kouakou et al investigates Cost-Efficient Sensor Deployment models focus on cost performance value and coverage of arbitrary position of mobile nodes in obstacles. In this model, deployment of environmental sensing process is more challenging and complex one[9].

Alwi M. Bamhdi et al, was proposed Dynamic-Power AODV routing protocol, this method were improve the density of coverage area and degrease packet delay in sensor networks, Hence further improvement of this method is performance of DP-ADOV and throughput[10]. Issa M. Khalil et al, is proposed ELMO: Energy Aware Local Monitoring scheme taken in account all the wake up nodes, does not taken in sleep node, to transfer information in secure manner, its main responsibility is monitoring the traffic of the sensor networks. Nevertheless, this monitoring method providing security in mobile ad-hoc networks [11].

Energy-Efficient Distributed Algorithm for Minimum-Latency Aggregation Scheduling were proposed by Yingshu Li et al, consume less energy 78 percentage [12]. Mostafa et al, Cluster-Based Energy-Aware localization Algorithm is consequently improves the life time and saves the energy in sensor networks. Simulation result maintains same localization accuracy. It does not implement in mobile sensor networks. Further, this method tries to implement in 3D space[13].Muhammad et al , proposed Novel Intelligent Localization Algorithm was transmit the power without any additional hardware resources and position sensor nodes within the range[14].

B. Rama Krishnan convenes the development of a package framework for data communication among the VANET nodes and the service discovery in a Highway VANET model where the vehicles are moving outside the city and he discussed a service discovery architecture and data communication [15]. Francisco J. Martinez1, Chai KeongToh, Juan-Carlos Cano, Carlos T. Calafate and Pietro Manzoni made a survey of several publicly available mobility generators, network simulators, and VANET simulators[23].Jing Zhao and Guohong Cao proposed several vehicles-assisted data delivery (VADD) protocols to forward the packet to the best road with the lowest data-delivery suspension and their practical conclusion display that the submitted VADD[16].

Rainer Baumann et al.proposed two new broadcast mechanisms that try to minimize the number of broadcasting messages and to get more stable [17]. The safety application requires low latency and delay in order to deliver the emergency messages and warnings in time to the destination region for all the vehicles in the surrounding of a hazard in a single hop or multihop communication.[18]Fang Deng et al, were proposed by Energy-Based Sound Source Localization for Low Power Consumption in Wireless Sensor Networks, Hence this method accurately determined path loss , and improve the localiza-tion accuracy. The energy based method also combine analyse localization error and energy consumption. Further, it can be improved and implemented in switching techniques [19]. R. Plate, et al describes the Energy-efficient Routing Protocol worked out taken into account physical distance between the nodes and determine the level of energy reside in nodes. However, fails for false detection in packet delivery [20].

III. PROPOSED METHODOLOGY

As per the literature review, a lot of energy efficient algorithms are used for prolonging network lifetime of WSN in underground mining. The Energy harvesting (EH) refers to collecting energy from surrounding (sun, wind) or other sources of energies (body heat, finger stroke, foot strikes) and converting these energies to electrical energy. Energies from external sources can be harvested to power the nodes to increase their lifetime and enabling new devices much more reliable. Here the Finer force Care-up based energy harvesting method is proposed to increase the lifetime of the networks with the aid of energy sharing .

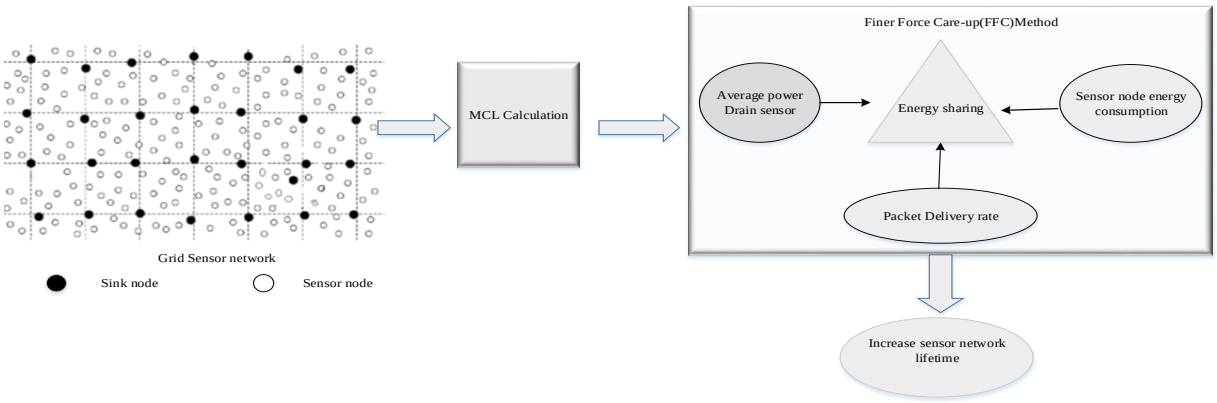

Fig. 1 Proposed methodology

Figure 1 gives details about FFC method flow of work, this figure starts with grid network to deploy in underground mining. The flow of work then moved to find distance between the sensor nodes with the help of MCL method. Next step to moving to FFC algorithm, this algorithm first calculate each packet much energy loosed for every packet data transfer. After that, next calculate the how much energy consumed each sensor node grid networks also calculate the packet delivery ratio. Finally collect the energy from the sensor node to sink node and based on need energy is shared and distributed to its neighbour sensor node. For this algorithm can be increase the lifetime of the sensor networks.

3.1 System Model

In the proposed architecture, Wireless Sensor Network is intended using grid network topology . The grid is constructed with respect to the diagonal line formed by the source node and the sink node.

Sink Node –Nodes are data collector all sensor nodes send data to the sink node.

Sensor nodes – Nodes are source information, they may also forward message in network.

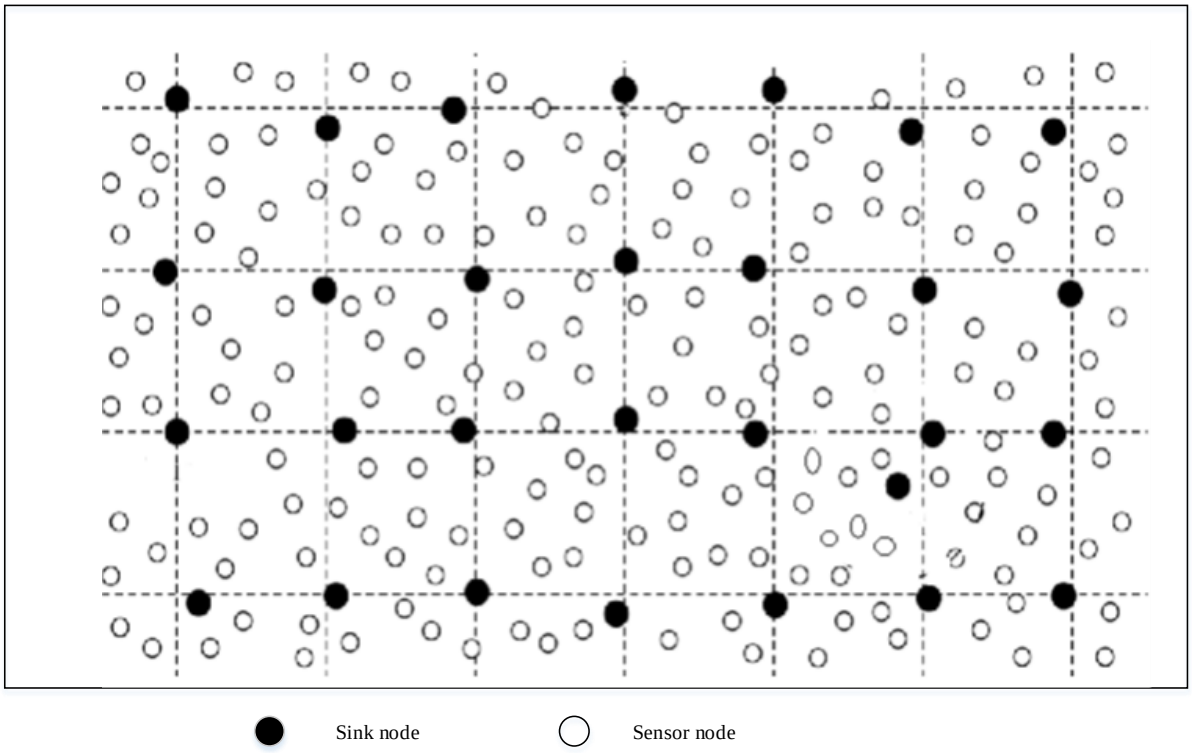

Fig . 2 Forming Grid networks in undergroundarea

The above figure 2 shows the deployment of set of sensor nodes in underground area like coil mining, subways and underground travelling with the help of grid network topologyIn deployment of sensor nodes, the node forms a Random Grid Topology and from that, one node acts as a sink node.

In Random Grid Topology, each node in the network can be able to connect its neighbour node with more dimensions. This Random Grid Topology is to achieve high reliability and performance i.e., the grid network is capable to handle any category of sensor nodes and it is easy to share the battery power using FFC method.

3.2 Distance Calculation

The Monte Carlo method is a kind of processing method hich is based on the probability theory, and it can be used to estimate the posterior probability distribution of nonlinear and discrete systems. Initially, in the FFC method, the MCL method is used to calculate the distance from the sink node to its neighbour nodes. Here, the sink node calculates the angle of received signal and the direction where the signal will be received using the Angle of Arrival(AOA) and Distance Difference of Arrival(DDOA)method. Based on the received signal information, distance will be calculated in each sensor node using equation (1).

$$D = sd^2 + nd^2 - 2 * sd * nd * \cos < GSN \quad (1)$$

Where,
D= Distance
Sd^2 =Sink node
Nd^2= Neighbor node

This MCL algorithm has high positioning accuracy and positioning efficiency compared with other mobile positioning algorithms. The MCL algorithm needs only to build the correct probability model and calculate the average value of a sample.

3.3 Finer Force Care-up (FFC) method

In last decades, WSNs have grown dramatically and made a great progress in many applications. But having limited life, batteries, as the power sources of wireless sensor nodes, have restricted the development and application of WSNs which often requires a very long lifespan for better performance.The proposed FFC method for energy harvesting technique in underground WSNs consists of fixed number of sensor nodes that improve the lifetime of networks. Energy Harvesting Wireless Sensor Networks are normal WSNs, where additional power sources assist the primary battery or entirely replaced by them. The main idea is to retrieve the power present in the nearby surroundings of a sensor node, transform it to a usable form using appropriate types of transducers and ultimately utilise it to power the sensor node themselves. If the power source used to stimulate the sensor network have enough energy level and always available then, EH supply a network with unlimited power and an approximately infinite lifetime.

Consider the following figure 3,the sink node monitors the physical layer of sensor network using their sensing technology, which gathers information about remaining battery level, time duration and sends the gathered information to sink node. By this information, we can collect the information about lifetime of a particular node and calculates the lifetime of sensor node from the equation (2).

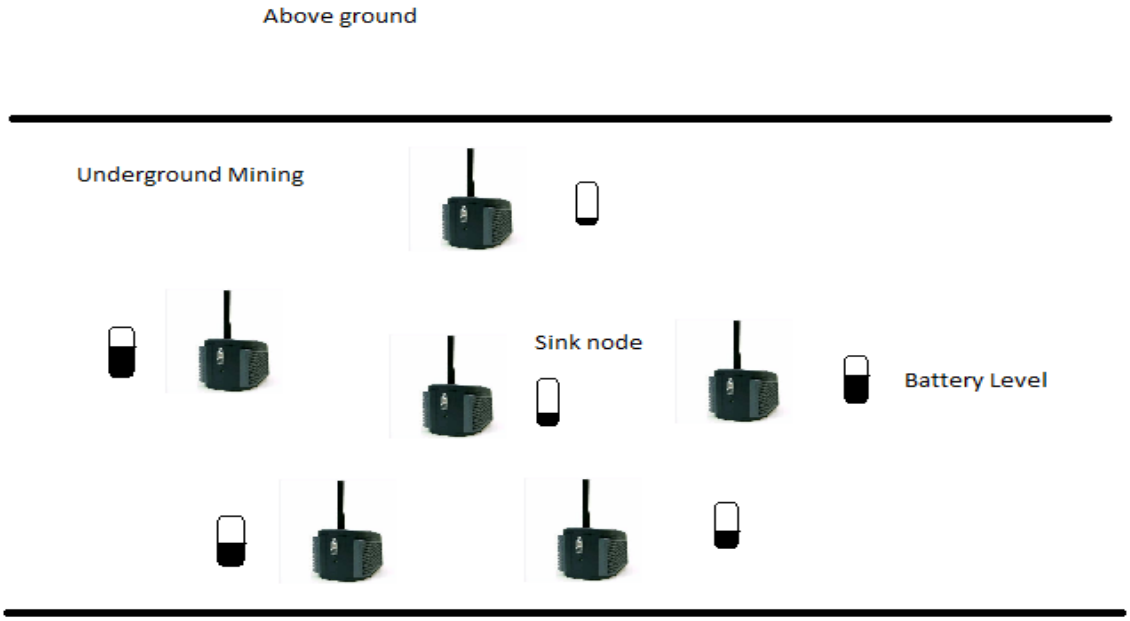

Fig 3 Underground sensor networks with battery deployment.

$$L = CN / APD \quad (2)$$

L = Lifetime of sensor networks
CN = Capacity of particular sensor node
APD = Average Power Drain sensor node

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In Figure 4, the sink node perceives battery power from the neighbour sensor nodes using wireless power transfer technology. There are many power transfer technologies which is used to wireless sensor networks. Thus, in this research work used Microwave power transmitter, it allows long distance power beaming with smaller wavelength radio frequency. Microwave communicates between the Base Station and Satellites, it emit's power 24GHz over sensor networks, which charges battery and temperature sensor using transmission ranges up to 20 feet.

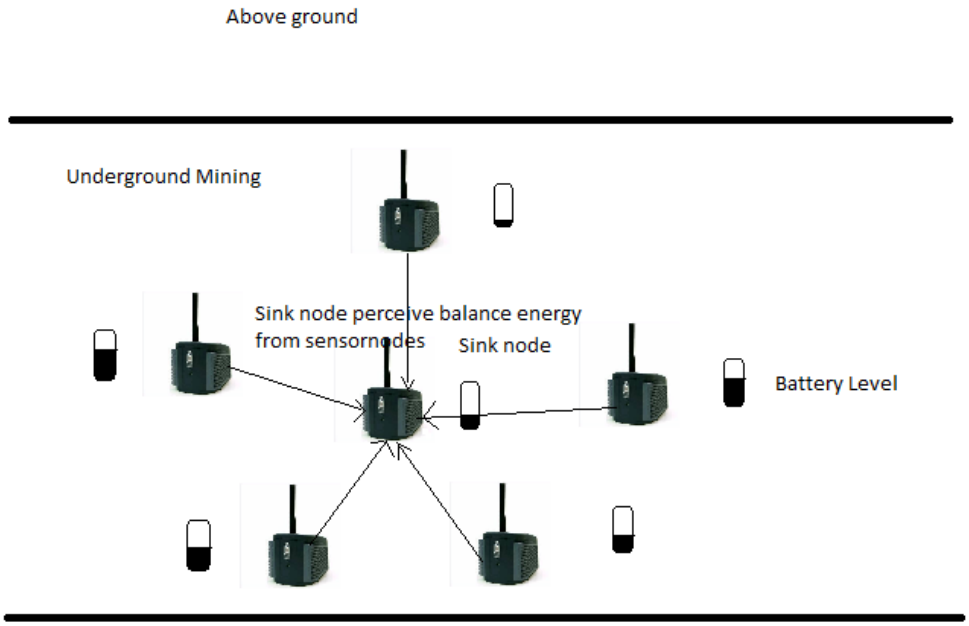

Fig . 4 Perceiving power from Neighbours node.

After perceiving the power from neighbour node to sink node as shown in Figure 5. The sink node calculates Average energy drain of each node for data transmission equation (3), Then compute the how much energy consumed for each transmission using equation (4).

$$APD = 0.1 * AS + 0.99 * SS \quad (3)$$

APD= Average power drain sensor node
AS= Active current sensor node
SS= Sleep current sensor node

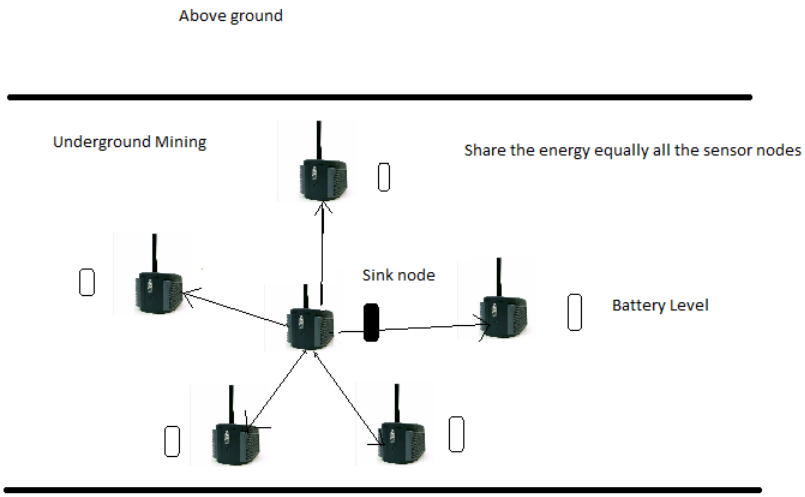

Fig .5 After perceive power from neighbours node to sink node

$$SensorNodeEnergyConsumption = \sum_{i=0}^{N}\left(\frac{Et_i + Er_i}{packetsize}\right) \quad (4)$$

Et= Energy transmitted
Er= Energy received
N= Number of sensor nodes

$$E = \sum_{i=0}^{N}\left(\frac{AE}{N}\right) \quad (5)$$

E= Energy
AE= Available energy in sink node
N= Number of neighbour nodes

Thus, the battery energy consumed whenever transmission part is turned ON. The power supply voltage is measure in two ways for each transmission, i.e., for current consumption and for another is previous transaction consumption. This measurement is using for finding difference of transaction and period, based on sensor node energy consumption and Average energy drain of each sensor node, the sink node is equally divides the available energy and sends to all the neighbour nodes by means of equation (5). The upcoming section demonstrates the experimental analysis of the proposed methodology and illustrates the efficiency of the methodology by comparative analysis.

IV. SIMULATION RESULTS

In this section, the discussion about the detail simulation of the proposed FFC method with packet delivery speeds and calculates the packet delivery ratio. The NS2 simulator is used to applying in FFC method to every sensor node for sharing its battery power level when sensor node deployed in underground area. In proposed method, simulation network area is 500 x 500 meter in underground wireless sensor networks, there is 50 sensor nodes are deployed randomly in grid sensor networks. The FFC method mainly considers the remaining energy of each sensor node. In each sensor node 10 J is charging via sharing the sink node to its grid topology neighbour nodes. The simulation parameters are tabulated in Table1, it considers only the remaining energy of sensor nodes of wireless underground sensor networks.

Table 1 .Simulation parameters

Simulation setting- parameters	
Parameter	Values
Network area size	500 X 500
Number of sensor nodes	50
Capacity of battery- transferred to sink per seconds	10J

4.1 Performance Metric

An evaluation metric is a measure, which helps to analyze how effectively the existing approaches are matched and to justify the proposed method. The results of Packet delivery ratio, Network lifetime and packet delivery speed are calculated to compute the efficiency. The parameters are illustrated in the following section.

4.1.1 Packet Delivery Ratio

Therefore, using FSFO method the sink node equally shares the power level, then the packet delivery ratio can be calculated for improving reliable packet delivery and increases the packet delivery speed. This method calculates the Packet Delivery Ratio between the number of successful packet transferred to the destination sensor node and number of packet transmitting by the source sensor nodes.

$PDR = Pr * 100/\sum_{i=n}^{n} Pg$ ---------- (6)

PDR = Packet Delivery Ratio
Pr= Total number of Packets received by sink sensor node
Pg= Total number of packets generated by source sensor node.
N= Number of sensor node deployed in grid networks
From equation (6), it calculates the packet delivery ratio to calculate the improvement of reliable packet delivery.

The Agent used for advertisement is TCP sink and the packet size is 1500 byte per/seconds. This Agent advertisement is used for getting information about its neighbour node location and the Application type used is FTP for file transferring, the channel type used is wireless.

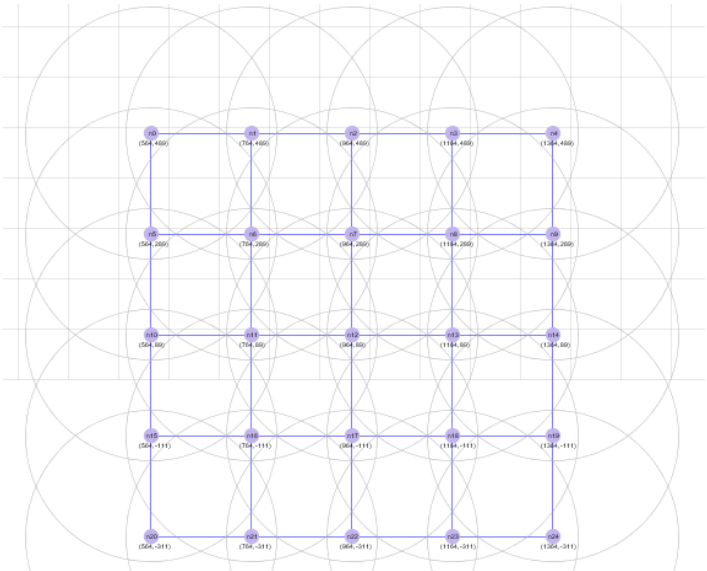

Fig . 6 Grid sensor network

4.2 Comparative analysis and discussion

In this experiment life time of the sensor networks and the

main goal of FFC method is carried out. To validate the proposed framework, we conducted extensive experiments and found that the proposed framework is superior to the models published previously such as

Mobile Charging Node (MCN), Heterogeneous Energy Efficient Mobile Clustering Protocol (HEEMCP) than Energy Efficient Hierarchical Clustering (EEHC) Protocol, Low-Energy Adaptive Clustering Hierarchy (LEACH) Protocols .The lifetime gain of the proposed model is significant when compared to other models. When energy is shared from sink node to its neighbour nodes then automatically it increases the lifetime of networks in underground area. In the proposed work, the lifetime 63 % is increased compared to other methods which is shown in figure 7.

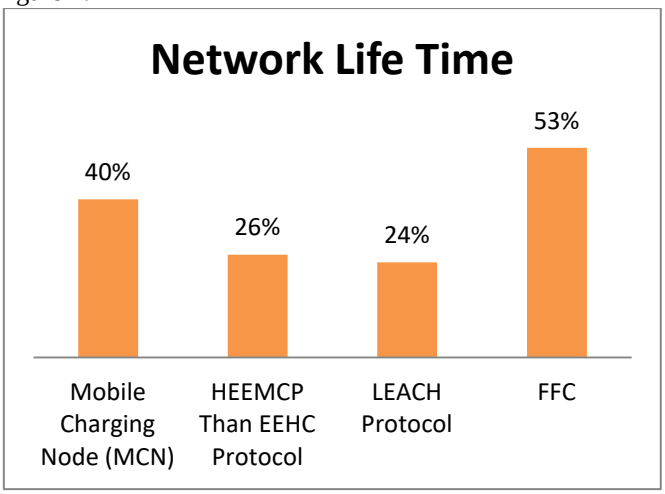

Fig.7 Comparison of proposed works and other existing works for Network Lifetime.

The following figure 8 shows results the packet delivery ratio of underground networks, and the proposed work improves the packet delivery ratio up to 53 % compared to existing works.

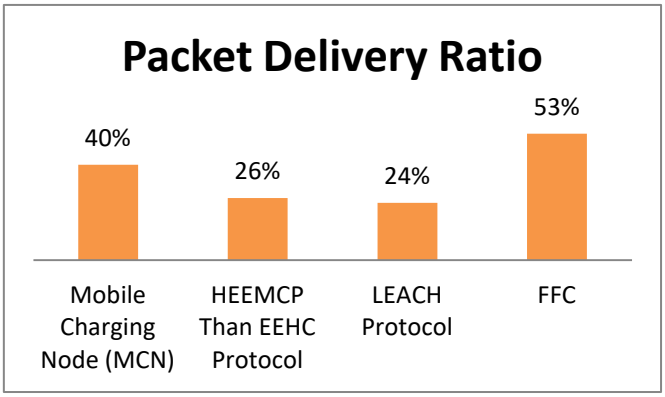

Fig .8 Comparison of proposed works and other existing works for Packet Delivery Ratio

Thus, the figure 9 gives the results of packet delivery speed of Mobile Charging Node (MCN) are 75 % HEEMCP than EEHC Protocol are 70 %, LEACH Protocol are 72% and the proposed work is to improve the speed of packet delivery 80 %.

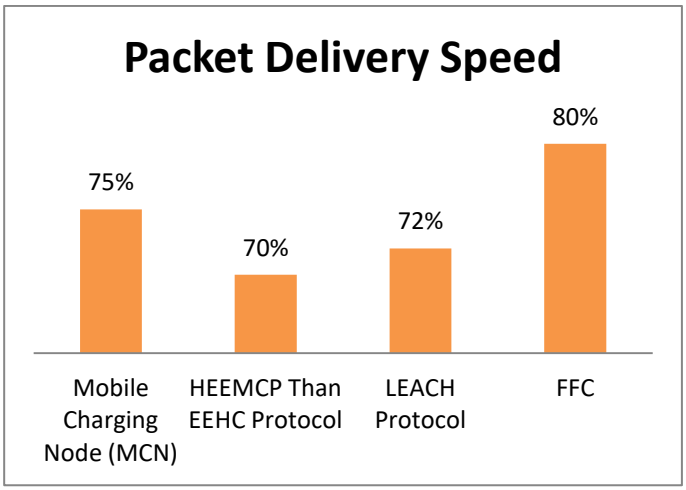

Fig .9 Comparison of proposed works and other existing works for Packet Delivery Speed

Ad-hoc Ondemand Distance Vector and Dynamic Source Routing protocols perform better at less packet size. Performance of all three protocols decrease as mobility of nodes increases [21]. The delay, throughput, control overhead and packet delivery ratio are the four measures used by Mohapatra et al. for the comparison of the performance of Ad-hoc Ondemand Distance Vector, Dynamic Source Routing , Optimized Link State Routing and Destination Sequenced Distance Vector protocols using matlab.

V. CONCLUSION

In existing system, there are many problems for handling energy perception between the sensor nodes to boost the energy. The proposed FFC method, shares the remaining energy between the sensor nodes using wireless underground sensor networks. In the underground area to form a grid network, in which a node acts as sink node. In this method, the distance is calculated between the sink nodes with the neighbour nodes used MCL method. The sink node collects the remaining energy from the neighbour nodes and calculates the energy draining of each packet transfer in the network. Also, calculates the transformation of packet delivery speed and ratio. Then, the sink node is to share the collective energy to its neighbour nodes using FFC method. In the proposed method, the FFC method concludes in improve the lifetime of the underground sensor networks, also increases the packet delivery ratio, speed, and shares the remaining energy without additional wired and wireless devices. Simulation results showed that effectively utilizes the remaining energy and increases the network lifetime in underground sensor networks. The future work, it can be able to apply in underground water sensor networks.

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