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Effect of Looping On the Lifetime Of A Multi-Sink Wireless Sensor Network Deployed For Healthcare Monitoring System

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Abstract: **This paper considers the application of Wireless Sensor Networks in healthcare monitoring systems. The KPS protocol with and without looping in Wireless Sensor Networks is also discussed. The KPS protocol is used for efficient delivery of messages of interest in the form of packets generated from different source nodes to multiple sink nodes within different geographic target regions. In the KPS protocol, forwarding potential is used along with the concept of Fermat point. This paper will focus on the lifetime of a Wireless Sensor Networks in healthcare monitoring systems. The lifetime of the network is considered in terms of the number of rounds, wherein each round is described by the complete transmission of the packet from the source node to the multiple sink nodes.**

***Keywords*—Wireless Sensor Networks; Fermat Point; Lifetime of Wireless Sensor Network; Healthcare Monitoring Systems; Grid deployment; KPS Protocol.**

I. INTRODUCTION

Sensor Networks have a wide range of application in mobile and wireless communication. A Wireless Sensor Network is the spatial deployment of sensor nodes over a particular region in order to monitor environmental or physical conditions and transmit the data gathered in the form of packets to single or multiple sink nodes via a well-established network. Many routing protocols were proposed in order to transmit data from source to multiple sink nodes. There are notable applications of WSN in the field of military, industry, space exploration, healthcare, etc. The lifetime enhancement of WSN through reduction in expenditure of energy is an interesting topic for researchers and is talked about for quite some time. The geometric concept of "Fermat Point" [1] plays a crucial role in lifetime enhancement of WSN.

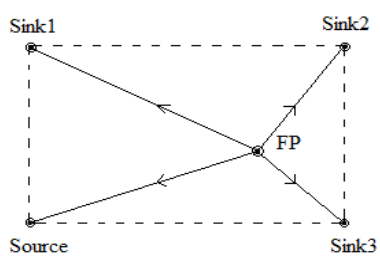

Fig. 1 Fermat Point of a polygon

The Fermat Point [2, 3] is a point within a polygon such that the sum of distances of from that point to all the vertices of the polygon is minimum. The packet transmission through Fermat point to multiple sink nodes uses a tree-like structure as shown in Fig.1. The concept of Fermat point is important for lifetime enhancement since it addresses the issues related to power consumption and delay incurred in the delivery of the packet. It also insures that the packet travels through an optimal path in order to reach the sink nodes.

Also, the Friis free space equation suggests

$$P_r = P_t * (G_t * G_r * \lambda^2)/(16 * \pi^2 * d^2 * L) \quad (1)$$

Where Pr, Pt, Gr and Gt are the power consumed for reception and transmission and gains of receiving and transmitting antennas respectively. So, according to equation (1), the Power of a sensor node is saved since the total distance travelled by the packet is reduced and henceforth the lifetime of the network will increase.

There are various applications of Wireless Sensor Networks in the field military, hostile environment monitoring systems [1], healthcare monitoring systems, etc. This paper deals with the lifetime enhancement of Wireless Sensor Network in healthcare monitoring system. It also addresses the effect of looping on the lifetime of an energy efficient routing protocol for multi-sink WSN deployed for healthcare monitoring systems. Moreover, the importance of WSN in healthcare monitoring system is also considered in this paper.

In Section 2 of this paper, the lifetime enhancement of a WSN is discussed along with the application of WSN in healthcare and its challenges. In Section 3, the KPS protocol for packet transmission is considered followed by discussion on the effect of looping on the lifetime of the Wireless Sensor Network. In Section 4 the results are discussed wherein there a comparison between Loop- Free KPS and the LEACH and TEEN protocols. The comparison between KPS and Loop- Free KPS is also done which is followed by Conclusion in Section 5 of the paper.

II. RELATED WORKS

A. Wireless Sensor Network for Healthcare Monitoring Systems

The prominent application of WSN in healthcare systems plays a vital role in improving the quality of living. The authors in [4] have discussed the WSN application for healthcare wherein five subsystems are used as shown in Fig.2.

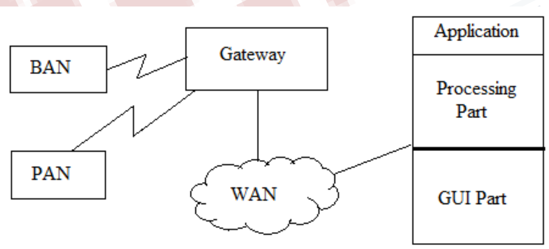

Fig. 2 Subsystems of Wireless Sensor Network for Healthcare Monitoring.

BODY AREA NETWORK SUBSYSTEM (BAN): It is an ad- hoc sensor network in which different tags like the Electrocardiogram [ECG] sensors or accelerometers are worn by the patients.

PERSONAL AREA NETWORK SUBSYSTEM (PAN): It includes the deployment of environmental sensors around the body of the patient which measures pressure, humidity, temperature, etc. and helps in providing contextual information of the patients.

GATEWAY TO THE WIDE AREA NETWORK: In order to connect Body Area Network subsystem and Personal Area Network subsystem with the wide area network, gateway is used. According to the authors of [4], gateway is the weakest point and that's why BAN and PAN must reduce the amount of data transferred in order to avoid congestion.

WIDE AREA NETWORK FOR HEALTHCARE: Wide area network is of utmost importance in order to remote monitor the patients. The gateway relays information to the wide area network which helps in extending the healthcare to a global scale as discussed by authors in [5].

END-USER APPLICATION: End user healthcare monitoring application is divided into two sub parts. The first one is the processing part which performs the reasoning and the second part is the Graphical User Interface (GUI) part which deals with real time monitoring and provides alerts in emergency situations. The end user healthcare monitoring application in a nutshell, collects the data, interprets it and triggers the necessary actions.

B. Lifetime Enhancement of Multi-Sink Wireless Network using Data Aggregation

Data Aggregation is another way to enhance the lifetime of a multi-sink wireless sensor network by efficiently reducing the energy expenditure during packet transmission. The authors in [6] have discussed how Fermat Point can be used as a point for data aggregation. The transmission of packets from source to multiple sinks is divided into two phases. In the first phase, the Fermat point receives the packet from different source nodes, and then the packets aggregation is done at the Fermat node wherein packets from multiple sources are collected and converted into a single packet. Henceforth, the second phase of the transmission starts wherein the aggregated packet is transmitted to multiple sink nodes as shown in Fig.3. The data aggregation reduces the number of transmissions as well as the number of bits to be transmitted and hence saves energy.

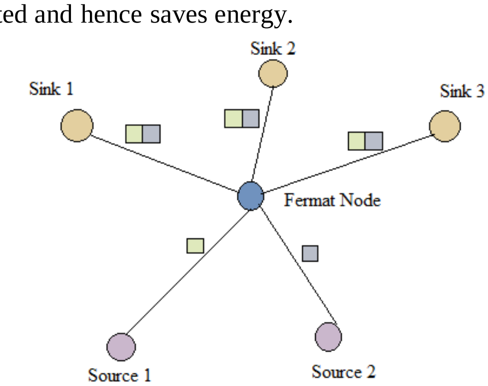

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Fig. 3 Data Aggregation at the Fermat Node, redrawn from [7].

The transmission and forwarding energy as discussed by the authors of [6] are directly proportional to the size of the packet nd the distance travelled. The equations of Energy transmission and forwarding are given below.

$$E_{TX} = m * 117 * 10^{-9} + m * 1.7 * 10^{-6} + D * m * \varepsilon * d^{n} \quad (2)$$

$$E_{forwarding} = D * (m * E + m * \varepsilon * d^{n}) \quad (3)$$

where, m is the packet size in number of bits, D is the duty cycle, d is the distance between two nodes, E is 50 nJ/bit and ε is 8.854 pJ/bit/sq. m. So, this scheme of data aggregation at the Fermat node enhances the lifetime of the Multi-Sink Wireless Sensor Network.

C. Wireless Sensor Network technology for Healthcare Monitoring and its challenges

Sensor networks are used extensively in the healthcare sectors. Some of the applications of Wireless Sensor Network in healthcare as discussed by authors in [8] include dense sampling of physical, psychological, cognitive and behavioral processes. The WSN technology in healthcare focuses on location tracking, medication, intake monitoring, movement detection, medical status monitoring, etc. according to the authors of [4].

The major challenges of application of WSN in healthcare include privacy, security, trustworthiness, resource limitation, delay in the information delivery, lifetime of the network, scalability, etc.

In order to ensure the quality of service, and enhanced lifetime of the WSN, it is necessary to eradicate the technical problems. Researchers are working hard in this field in order to provide solution to all the technical challenges. WSN application in healthcare has drastically improved the quality of care provided to the patients.

III. PROPOSED WORK

Before the discussion on the work, we need to understand the KPS protocol. The authors of [9] proposed the Fermat Point based KPS protocol for the efficient transmission from source to multiple sink nodes. In this protocol, the sensor nodes are deployed a grid fashion over a rectangular sensor field. The source is placed on one of the vertices of the rectangle and the sinks are placed on the remaining three vertices of the rectangle. The theoretical Fermat Point of the polygon so formed is calculated and the corresponding Fermat Node is determined. Once the Fermat Node is known, the source can start the transmission of the packets. The transmission is divided into two phases: (i) hop to hop transmission from source to the Fermat Node and (ii) hop to hop transmission from Fermat node to the multiple sink nodes. The node selects its next neighbor by calculating the forwarding potential (κ) for all its immediate neighbors. The forwarding potential is given as:

$$\kappa = res\_energy/dist \quad (4)$$

Where, res_energy is the residual energy of a node in milli Joules and dist is the distance of a node from the destination in meters.

As discussed in [9], the neighbor with the highest value of κ is selected as the next hop for packet forwarding. For each transmission of packet from one node to another some amount of energy is consumed. The radio model used in the KPS algorithm includes (i) sensing energy in order to sense the physical parameters, (ii) computation energy to convert sensed parameters into transmissible form, (iii) forwarding energy in order to transmit the packet to next hop and (iv) reception energy to receive a packet.

The Fermat Node has to perform some extra duties like computation and forwarding. The authors of [9] have also discussed the lifetime of the network. The network is declared dead as soon as any of the node's residual energy is less than or equal to zero. Also, in order to increase the lifetime of the network, the concept of threshold energy is taken into consideration. So, according to this concept, if the Fermat Node's residual energy is less than the threshold energy (τ), the second closest node to the Fermat Point is considered as the Fermat Node rather than the first one in order to increase the lifetime of the network. The second Fermat node may also transfer its charge to the third closest node once its energy goes down the threshold energy. This process continues until one of the node dies out in the network. As soon as one node dies, the entire network is declared dead.

The KPS protocol is an energy efficient protocol for packet transmission in multi-sink Wireless sensor network. But, one of the problems encountered in the KPS protocol is looping. This problem of looping is that the packet travels from one node to another and then back to the first node rather than routing towards the destination. The concept of looping can be understood by fig.4. Suppose node 5 has to send the packet to node 1. According to the KPS protocol, node 5 will find the forwarding potential of all its neighbors which are node 1, node 2, node 3, node 4, node 6, node 7, node 8 and node 9. The neighbor with the highest forwarding potential comes out. to be node 9. The packet is transmitted to node 9. Now, the same procedure is followed by node 9 and the packet is transmitted to node 8 which has the maximum value of the forwarding potential.

Now, node 8 finds that out of all its neighbors, node 5 has the maximum value of κ and hence it transmits the packet back to node 5. This is where the looping occurs. Once the looping occurs, the packet is transmitted by using the Greedy forwarding technique as discussed by authors of [12].

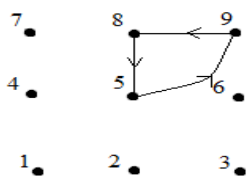

Fig.4 looping in the KPS protocol

In the proposed algorithm this looping is removed by using the concept of flag for each node. At the beginning of every transmission from source to sink, the flag for every node is initialized to zero. Once the transmission starts, the value of flag for the node which transmits the packet and acts as a relay node becomes one. In this process of packet transmission only those nodes will be selected for transmission whose flag value is zero. So, once a node has received and transmitted, it cannot receive the packet back since its flag is no longer zero. As shown in fig 5, now at node 8, the highest value of the forwarding potential is of node 5 but then its flag is zero. So, the second node with the highest value of κ which is node 4 is selected as the next hop for packet transmission and finally the packet reaches its destination node 1 without any looping.

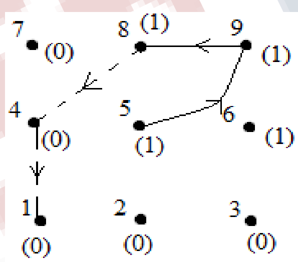

Fig.5 KPS protocol without looping with flag values in the brackets.

This improvised version of KPS which is free from looping can be now applied to healthcare monitoring systems in order to transmit the patient's data in the form of packet. As discussed by the authors of [5], one of the challenges of application of Wireless Sensor Network in healthcare include lifetime of the wireless sensor network. Applying this algorithm in healthcare will be helpful since it is an energy efficient scheme that uses the concept of Fermat Point for transmission of packets. Hence, the lifetime of the wireless sensor network is enhanced.

III. RESULTS

The simulation is done in MATLAB. This section deals with the performance of our proposed algorithm. It also includes the comparison of the KPS algorithm with the LEACH [10] and TEEN [11] algorithm. Towards the end of this section there are the results of KPS protocol with and without looping.

In the results the lifetime as per rounds is taken into consideration. One round indicates one complete transmission from source to sink nodes. Table I indicates the comparative study between KPS protocol, LEACH protocol and the TEEN protocol. The deployment of sensor nodes is in random fashion and the probability of a particular node getting selected as the cluster head is 0.8.

PROTOCOL	**LIFETIME (No. of rounds)**
KPS	657
LEACH	590
TEEN	1200

Table I. Comparison between KPS, LEACH and TEEN protocol.

The different parameters and their values taken into consideration for the healthcare monitoring system with and without looping are shown in Table II.

Parameters	**Values**
Nodes	100
Area	100 m ×100m
Number of sinks	3
Deployment Pattern	Grid
Transmission range	Variable
Packet size	4000 bits
Initial energy of nodes	1 Joules
Source selection mode	Round robin

Table II. Different network parameters and their values For KPS protocol with and without looping.

Fig. 6 indicates a region of 100×100 meters wherein the sensor nodes are deployed in a Grid Fashion 10 meters apart from each other. Hence, total 100 sensor nodes are deployed over a two dimensional Cartesian plane. The transmission range of the sensors are variable, in order to observe the performance of the KPS protocol with and without looping.

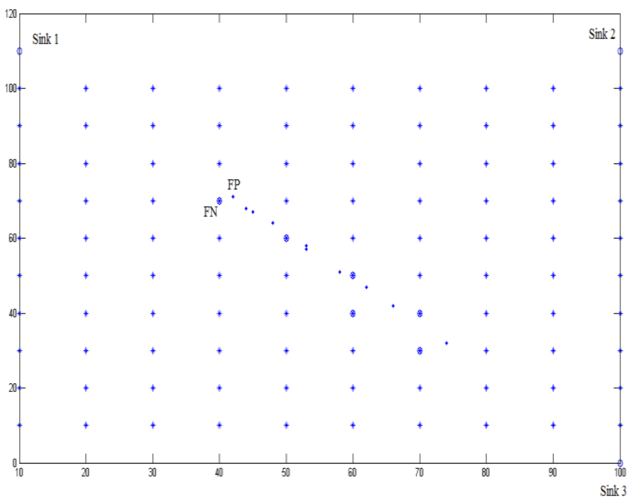

Fig.6 Deployment of sensors and sinks along with indication of Fermat

Points (FP) and Fermat Nodes (FN).

The Fig.7 indicates the lifetime of the Wireless Sensor Network in number of rounds for different transmission ranges. The two plots are for the KPS protocol without looping and with looping respectively for a multi sink wireless sensor network.

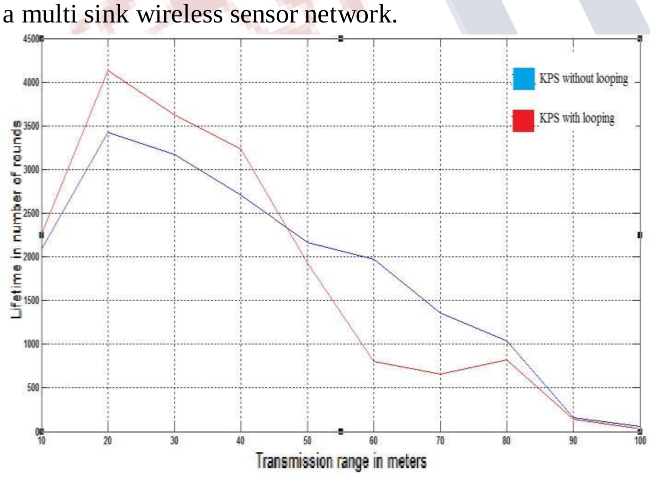

Fig.7 Lifetime of the KPS protocol with and without looping for different transmission ranges .

V. CONCLUSION

Lifetime of Wireless Sensor Network is a major challenge in the application of WSN in healthcare monitoring systems. Fig.7 shows that the implementation of KPS protocol without looping performs better as compared to KPS protocol with looping for higher transmission ranges. While for lower transmission ranges, KPS with looping gives better results. This is because more the transmission range, more the number of neighbors, lesser is the probability of getting all the neighbor flagged and hence, lesser is the chance of selecting greedy forwarding over KPS. Greedy forwarding performs less efficiently as compared to the KPS protocol. Thus, loop free KPS performs better at higher transmission ranges. KPS protocol also gives better results as compared to LEACH protocol. Hence, KPS is an energy efficient protocol for the transmission of packets from source to multiple sink nodes. Hence, it can be applied in healthcare monitoring systems.

References

[1] Young-Mi Song, Sung-Hee Lee, and Young-Bae Ko, "FERMA: An Efficient Geocasting Protocol for Wireless Sensor Netwroks with Multiple Target Regions", Embedded and Ubiquitous Computing-EUC2005 Workshops. Springler Berlin Heidelberg, 2005.

[2] The Fermat point and generalizations. [Online]:http://www.cut-the-knot.org/generalization/fermat_point.shtml

[3] Dan Pedoe, "Geometry, a comprehensive course", Dover Publications,1988.

[4] Alemdar, Hande, and Cem Ersoy. "Wireless sensor networks for healthcare: A survey." Computer Networks 54.15 (2010): 2688-2710.

[5] C. Gabriel, X. Huagang, G.A.O. Qiang, G. Esteban, R. Ricardo, E. Jose, A perspective of state-of-the-art wireless technologies for e-health applications, in: IEEE International Symposium on IT in Medicine Education, 2009.

[6] Kaushik Ghosh, Pradip K. Das, and Sarmishtha Neogy, "Effect of Source Selection, Deployment Pattern, and Data Forwarding Technique on Lifetime of Data Aggregating Multi-sink Wireless Sensor Network", Applied Computation and Security Systems, vol.1.

[7] Mahima Mehta, Kaushik Ghosh, "Validation of Global Minima Scheme in Wireless Sensor Networks", IJERT, Volume 4, Issue 09.

[8] Ko, J., Lu, C., Srivastava, M. B., Stankovic, J. A., Terzis, A., & Welsh, M. (2010). Wireless sensor networks for healthcare. Proceedings of the IEEE, 98(11), 1947-1960.

[9] Ghosh, Kaushik, Pradip K. Das, and Sarmistha Neogy. "KPS: A Fermat Point Based Energy Efficient Data Aggregating Routing Protocol for Multi-sink Wireless Sensor Networks." Advanced Computing and Systems for Security. Springer India, 2016. 203-221.

[10] Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan. "Energy-efficient communication protocol for wireless microsensor networks." System sciences, 2000. Proceedings of the 33rd annual Hawaii international conference on. IEEE, 2000.

[11] Goyal, Deepak, and Malay Ranjan Tripathy. "Routing protocols in wireless sensor networks: a survey." Advanced Computing & Communication Technologies (ACCT), 2012 Second International Conference on. IEEE, 2012.

[12] Kaushik Ghosh, Sarbani Roy, and Pradip K. Das, "An Alternative Approach to Find the Fermat Point of a Polygonal Geographic Region for Energy Efficient Geocast Routing Protocols: Global Minima Scheme,"In Networks and Communications, 2009. NETCOM'09. First International Conference on (pp.332-337). IEEE

[13] S.H. Lee and Y.B. Ko. "Geometry-driven Scheme for Geocast Routing in Mobile Adhoc Networks", IEEE, vol.2,06/ 2006.

[14] W.B. Heinzelman, A.P. Chandrakasan and H. Balakrishnana, "An application-specific protocol architecture for wireless micro sensor networks",IEEE Transactions on Wireless Communications, Vol.1, Issue4,October2002.