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AN OPTIMAL METHOD OF RELAY SELECTION IN WIRELESS BODY AREA NETWORK USING FIREFLY ALGORITHM

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Abstract

The emerging technology of wireless networking provides many applications for regular routines, saves the time and cost. One such application is wireless body area network (WBAN) which reduces the overall burden of people through caring aged people, prolonged diseases and so on. It provides a better quality of life and continuous support at home itself. WBAN is formed with low energy, power, and data rate devices and results better performance. There are several factors limits the performance of this network for e.g. distance between nodes, power, interference etc. So this paper aims to present a suitable method for energy aware relay selection algorithm using fire fly algorithm. Through this method, ideal relay nodes are selected based on residual energy.

Keywords: Relay selection, WBAN, MAC protocol, Energy, Fire fly algorithm

Introduction

Trending life style of current century over established countries and the requirement of quality life increasingly demands the advancement of various technologies preferred in day to day life. There are several factors that affect human life like air pollution, landslide, water quality, natural disaster, military, scientific, commercial applications and so on. But the traditional methods though it provides enough information its static, so it need lot and lots of improvement. Many researchers contributed towards the betterment of life. As a result of this many inventions have been added in day to day life of humans. One among the best inventions in the last century is networking which uses micro-electronics technology in an effective manner. Most of these technologies are embedded in our daily life. 98% of processors are in household appliances, vehicles, machines etc.[1].

Wireless sensor networks are broad class of micro-electro-mechanical systems (MEMS) technology. Wireless sensor network consists of tiny, low cost, self-configuring nodes connected together at various licensed free frequencies from 173MHz to 2.4GHz as shown in Fig. 1. Wireless sensor networks are geographically distributed remotely

expected to maintain, monitor or control various physical or environmental conditions. Since the sensor nodes are small in size, it can be embedded easily anywhere in the physical environment. This information is passed through the network to a server for taking further action as a result. Though it has many numbers of applications, the life time of sensor nodes are limited due to its processing power, memory, bandwidth and energy. But still due to its interesting characteristics like low power consumption, heterogeneous nature, ability to cope up with neighbour failures, positioning, nature of usage and flexible nature draws the contribution of many researchers.

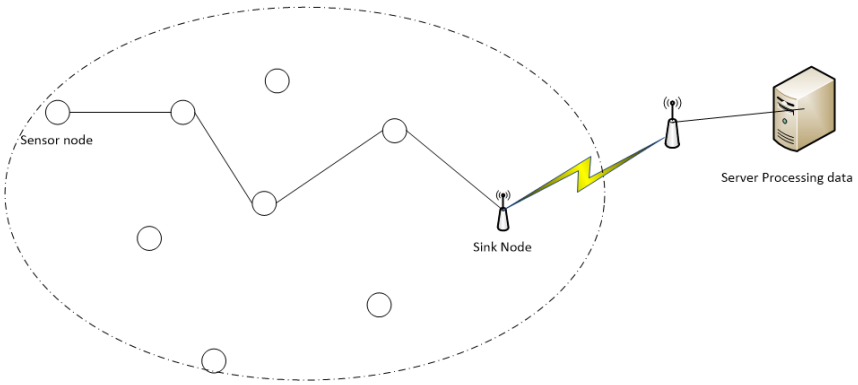

Figure 1: Wireless Sensor Network.

Managing the aged people and the health care is becoming a critical task in today's world due to the increasing economic factors. So it attracts many researchers towards the development of wireless body area network (WBAN), which involves the development of cost effective and intelligent sensors for various medical applications like monitoring ECG, blood pressure, insulin level, etc. A WBAN consist of sensor nodes deployed on the human body, accessories. They will be able to monitor sense and make simple process on to the collected data and communicate to the nearby nodes like laptop or phone. Now this information is streamed to remotely available personnel for diagnosis[2].

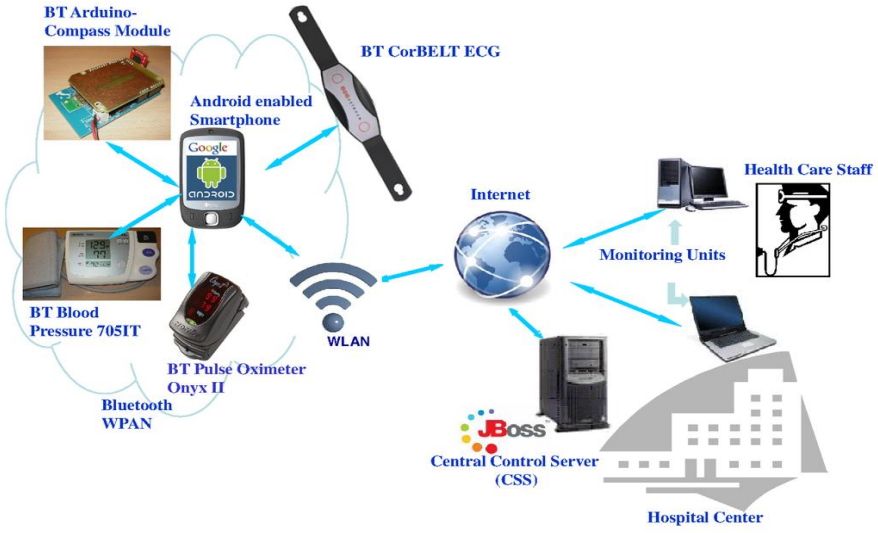

Figure 2: Wireless Body Area Sensor Network.

Basically BAN uses star topology based connection, where the nodes gather the information and communicate directly/intermediate nodes to the server[3]. The special interest group functions under IEEE 802.15.6 specification to enhance the solution for meeting various requirements. It provides a data rate from 10Kb/s to 10Mbp/s within 3 meters. In the entire protocol stack the prime layer considered for providing optimal service is Medium Access Control Layer. It helps for providing good Quality of Service according to the requirement. A good MAC protocol helps to reduce the collision rate, energy consumption and maximize reliability and throughput.There are various issues raised in dealing with the design of MAC for WBAN. Since sensor nodes are battery baked, one of the major constraints in MAC design is handling the energy requirement. According to the survey presented by Gopalan and Park (2010) depicts that when compared to CSMA based MAC TDMA based protocols consumes low energy. CSMA based protocols consumes more energy, varied latency and highly reliable. Though it supports scalability which is an important concern for WSN, it not efficient[4]. Since the existing QoS available for sensor networks are not applicable for body area network, due to its specific characteristics. So in the rest of the paper, section II discusses the various contributions of researchers in towards energy constrained relay selection in Body Area Network. Section III explains the method for mapping the proposed problem with optimization algorithms. Further, the performance of the MAC protocol is analysed with respect to the other protocols. Finally, this paper presents the scope for the future work in developing the MAC protocol with an exposure towards energy consumption.

Related work

As mentioned in Figure 1, the sensor nodes need to communicate the data to a server or medical personnel for taking suitable decisions. In wireless network, if the distance between sensor node and receiver (sink) node increases then the signal strength decreases. Therefore, an intermediate node should be chosen in order to support the communication. It not only used for increasing the signal strength, it may applied be applied to choose the interference free path to have a reliable data transfer. In order to improve the efficiency of the system, many researchers have contributed towards the improvement in MAC functionalities.

Elhawary and Haas (2011) proposed method for identifying relay node through clusters[5]. When the source node transmits data to the destination one of the relay node from the cluster is identified with high energy. This method effectively reduces overall transmission time, and the packet loss.

Ferrand et al. (2011) discuss the role of relay nodes[6]. They explored both cooperative and non-cooperative transmission modes. The various methods of identifying relay nodes are also discussed. They further recommend that the relay strategies suits well for this environment and results shows that good energy modules may be preferred

for efficient link setup. Yuan and Zhu (2013) proposed Enhanced MAC (EMAC), a relay selection by considering residual energy of the node using RSSI information[7]. But EMAC tries to modify the entire structure of superframe of IEEE 802.15.4. It allocates space specific to relay based transfer. Nadeem et al. (2013) also presents a solution for maintain good link capacity based on residual energy of the node using cost function[8].

Ayatollahitafti et al. (2016) combines various parameters for selecting a relay node like hop count, residual energy, link cost and queue length[9]. The proposed method reduces end to end delay, packet loss and overall energy consumption. Updatingthe existing structure may result changes in the entire architecture and overall complexity of the protocol. So an efficient design should not result major changes in the existing architecture. The objectives of this work are:

- Cluster based approach for relaying packets
- Packets are detected and forwarded
- Node selection is based on residual energy
- Uses firefly algorithm for optimization

Problem statement

IEEE 802.15.6 is a widely adopted personal area network (PAN) protocol for sensing and communicating health related information. When devices come into a close proximity, they form the network, since it prefers the star topology then hub or a single coordinator control the entire. Each and every network is identified by a dynamic identifier called BAN ID. The number of nodes participating in the network is limited to mMaxBANSize[10].

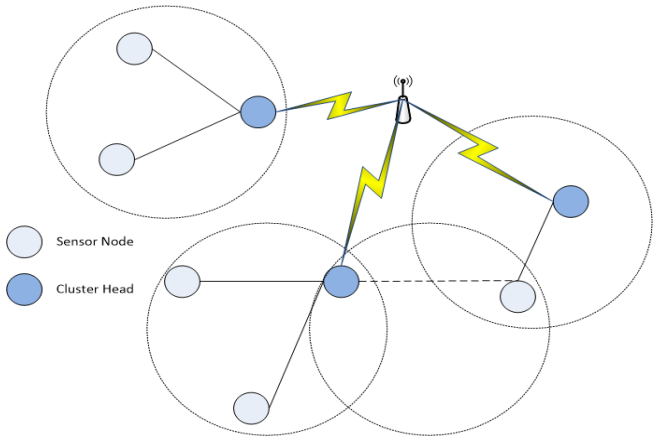

Figure 3: Cluster Head Selection for Relaying

To conserve energy mobile nodes need to be considered, whereas least contribution is provided towards the handling mobile nodes[11]. So in this work, relay selection procedure selects the cluster head close to nodes for efficient transfer of data.

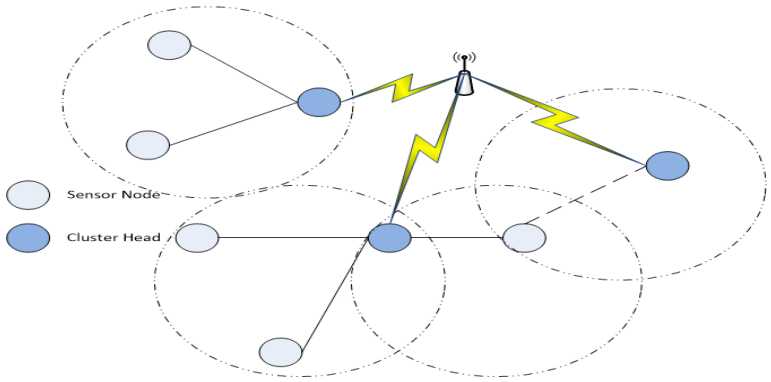

Figure 4: Change in Cluster Head Selection for Relaying.

Fire fly algorithm

The predominant feature of using Bio inspired works have been already demonstrated to address various issues like synchronization, self-organization etc. Firefly algorithm is one among the Bio inspired computing which can be applied to synchronization problems in wireless multihop networks[12,13,14]. It can be further applied to communication systems to provide monitoring, sensing and scheduling process. It's mainly applicable for homogeneous system which could signal the other flies and attract using the brightness. The attracting capacity of a fly is related to light intensity, more the brightness more the attracting capacity. The participating nodes are mapped to the fireflies.

The link qualities between the nodes are represented by the signal strength; hence the brightness factor is initialized to energy. This affects the node quality of service requirements with respect to the total energy spent for communication[9]. So the link quality between two nodes i and j are represented by $Link_{ij}$ were

$$Link_{ij} = (1-\gamma)Link_{ij} + \gamma\left(\frac{Tx_{suc,ij}}{Tx_{tot,ij}}\right)$$

in which $Tx_{suc,ij}$, $Tx_{tot,ij}$represents the total number of packets transmitted and retransmission attempts respectively. $\gamma$is the average weighting factor and assigned to 0.4.

Every node i is initialized with energy ($E_{ini,i}$)and for every transmission/reception of data packets it spend some energy($E_{cons,i}$).Therefore, the residual energy ($E_{res,i}$) left out after a packet transmit or receive is given by

$$E_{res,i} = E_{ini,i} - E_{con,i}$$

So after the mutation, it is assumed that the flies loose some energy and left with the residual energy. If the total number of packets transmitted by a node i is m and received is n then the energy consumed is given by

$$E_{con,i} = m * E_{tx} + n * E_{rx}$$

whereE_{tx} and E_{rx} are the energy consumed for a packet transmit and receive respectively. The attractiveness between the flies(nodes) are limited by the distance. Also, the energy consumption is influenced by the distance between two nodes i and j, let d represents the total distance between the two nodes. Hence,

$$E_{tx} = E_{tx_{erad}} + E_{amp} * d^2$$

$$E_{rx} = E_{rx_{erad}}$$

where$E_{tx_{erad}}$ and $E_{rx_{erad}}$ are the energy required by radio for transmit and receive, E_{amp} is the energy required for amplification. Every optimization algorithm has its objective function. So here the objective is to maximize the link cost between two nodes i and j is given by

$$Cost_{ij} = \frac{C_E * E_{res,j}}{E_{ini,j}} + \frac{C_Q * Q_{empty,j}}{Q_{tot,j}} + C_L * link_{ij}$$

where$Q_{empty,j}$ and $Q_{tot,j}$ are the current queue size and maximum capacity of the queue and C_E, C_Q and C_L are coefficients.

Table 1: Simulation Metrics,

Parameters	Values
Absorption Coefficient	1
Mutation Coefficient	2
Alpha	0.2
Initial Energy	2 Joules
C_E, C_Q, C_L	3, 2, 3
Tx Power	0.3 mW
MAC	IEEE 802.15.4

This model is implemented using MATLAB. The Simulation was carried out 100 iterations and metrics used are mentioned in Table I. The results are depicted in Fig. 5 for the increasing number of nodes. As discussed earlier, the increase in the number of nodes increases the energy consumption.

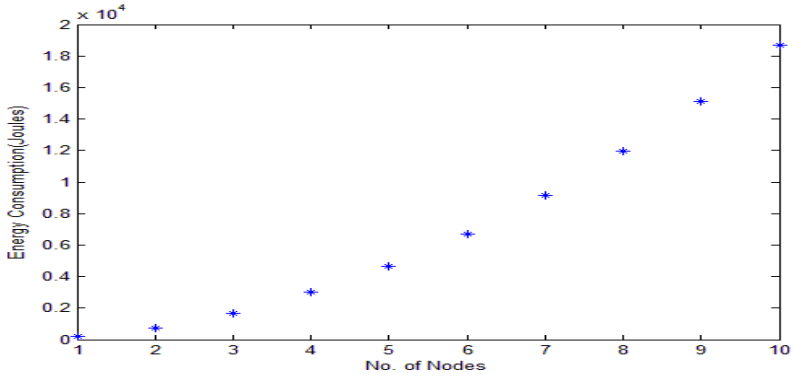

Figure 5: Impact of increasing Nodes in Power Consumption.

Conclusion

WBANs guarantee reasonable, inconspicuous, and unsupervised walking checking amid typical day by day exercises for delayed timeframes. To make this innovation pervasive and reasonable, various testing issues ought to be determined, for example, framework design, setup and customization, consistent integration, standardization, further use of normal off-the-rack parts, security and protection, and social issues. On account of the infeasibility/weakness to supplant the embedded device's batteries, ultra-low power utilization radios are basically required. So this paper addressed an efficient method of choosing relay in wireless body area network.

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