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An Energy Efficient Wireless Body Area Sensor Network using on Demand Sleep-Awake Algorithm

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ABSTRACT

A WBASN provides advantages compared to current electronic patient monitoring systems. Major Advantage of WBASN is Mobility support of patients due to use of portable monitoring devices. Another advantage is the location independent monitoring facility. Power management in a WBASN is a very important operational issue. Since sensor nodes are made up of small batteries with limited capacity, energy consumption must be minimized in order to increase the lifetime of a sensor node. This paper proposes sleep-awake concept for efficient power management in WBASN. In sleep mode nodes will be kept to sleep to save energy and to increase the network life time. In on-demand scheme of sleep-awake method, sensors should be awakened just when it receives a packet from neighbors. Since body parameters are dependent on one another, any one sensor might be in active state and all others can put to sleep state. To this end, our evaluation shows that with respect to an on-demand wake up scheme, forced wakeup method brings improvements along with a positive impact on the network lifetime.

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INTRODUCTION

In recent years wireless communications has emerged in variety of applications. In particular, wireless sensor network is developing in medical applications, placing sensor nodes in various parts of human body and communications between the nodes in and around the body is Wireless Body Area Sensor Networks (WBASN).

In WBASN sensor nodes are tiny and limited power. These nodes are capable of small storage and restricted processing. Reducing energy consumption and increasing the network life time of the network is the major issue in WBASN. However, energy consumption of the node should be reduced in order to increase the lifetime of the node and to increase the network longevity.

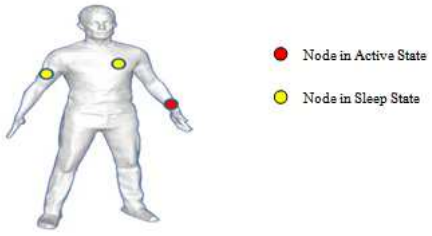

Fig. 1: Placement of sensor nodes on human body.

Lifetime of the sensor node can be increased either reducing the wastage of power or energy harvesting from some other resources like sunlight, vibration, etc. The fig1 shows that the sensor nodes are placed on various parts of the human body in order to monitor the human health. We used On-Demand Sleep Awake Algorithm to minimize the energy consumption.In this paper, we concentrated on how to reduce the wastage of energy. In general, the nodes are need more energy when it is active

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state while compare to the sleep state. We proposed to make all the nodes are sleep except Body Node Coordinator (BNC) node. Only on-demand all other nodes are awakened to sense the values. By using this On-Demand Sleep Awake (ODSA) Algorithm the energy of the nodes utilized effectively and the lifetime of the nodes and network will be increased.We have started with the introduction about WBASN in Chapter I and continuing Chapter II, in which we discussed about the previous papers that are related to the energy efficiency. The Sleep Awake concept will briefly described in Chapter III. The ODSA Algorithm for the proposed concept of On-Demand Sleep Awake will be explained in Chapter IV. We are discussing about our findings in Chapter V. Final Chapter VI consists of the conclusion and future direction of this paper.

II. Related Papers:

Even though minimizing energy consumption is significant problem in WBASN, we can use energy management techniques like reducing communication and increasing computation, power down certain components or the entire node, the coverage area of the node and renewable sources of energy. The energy will also affected by Routing Algorithms, Scheduling, Data Collection and Aggregation, etc (Amit Sharmer, 2011). Major concept that helps to reduce the wastage of energy is Duty-Cycling and Data Driven Approach. Duty Cycling means that the nodes that are awaken periodically changed and all other nodes are in power down lies sleep state. Data Driven Approach is the repetition of same data from different nodes will be avoided (Zahra Razaei, Shima Mobininejad, 2012).The various types of sensors like EMG, EEG, ECG, Temperature, Blood Pressure, Blood Glucose, Pulse Oximetry, etc used in WBASN. The placement of the sensor node on the body have three types, Implant Node (Inside the Tissues), Body Surface Node (Above the Tissues), and External Node (No contact between the node and Tissues) (Morassaghi, S., 2014).The technologies used for transmissions are ZigBee, Bluetooth, WiFi, Cellular Networks, etc. The major challenges that are facing by WBASN's are Postural Body Movements, Temperature Rise, Network Lifetime, Transmission Range, Limitation of Packet Hop Count, Limitation of Resources, etc Body Node Coordinator placement will play major role in WBASN. This BNC node can be placed by the Distance Aware BNC Placement Algorithm Iterative and Fixed, Position Aware BNC Placement Algorithm (Md.Tanvir Ishtaique Ul Huque, Abbas Jamalipour, 2015). The BNC node will act as a Cluster Head. Transmission will takes place only with the help of BNC node. Energy of node can be saved by avoiding the wastage of power consumption. We may avoid or reduce the wastage of energy by control the following Idle Listening, Collision, Over Hearing, Control Packet Overhead, and Over Emitting, etc (Zahra Razaei, Shima Mobininejad, 2012).When the data is transferred from the node, the energy needed for the transmission is depends on both the processor on the node and the technologies that are used for transmitting (Mark, A.,) Energy Harvesting helps to increase the energy level of the node. It can be done by either vibrations, sunlight, Temperature, Human Power, Airflow, Pressure Variation, etc (Mark, A.,)

III. Sleep-Awake Concept:

In General, Body Sensors that are in active state will consume more power. Every component in the sensor node might need the power to do any operation. Based on that operation all together the energy consumption of the particular node will be calculated. Since all the components of the node are in active state at a time, it may need more energy.

From the components and its power consumption of the sensor node is listed below.

Table 1: Energy Consumption of Components of Sensor.

Components	State	Values (Units)
Microprocessor	Active	6 mA
	Sleep	8 μA
Radio Transceiver	Active	20 mA
	Sleep	2 μA
Memory	Active	19 mA
	Sleep	2 μA
Sensor Board	Active	5 mA
	Sleep	2 μA

Sleeping possibility of the node is found out through the distance between the access point and sensor node (Huan-Chao Keh, 2011). The techniques of energy saving is based on the schedule of sleeping and awakening of sensor nodes, efficient routing path to access point, reduce the data overhead and adjust the range of sense (Huan-Chao Keh, 2011).There are two types of Sleep-Awake concept. Random Sleep Time and Periodic Sleep Time. For each duty cycle there will be two parts, Active Status and Sleep Status. In Active status Sensor nodes can be transmit the information with their neighbour nodes. But in Sleep status sensor nodes stops its transmission to save the power of the node.

In Random Sleep method the length of the active and Sleep status is irregular for every duty cycle. In periodic sleeping method the overhead of the node can be avoided. In general, every sensor node has following main components. (i) Sensing sub system which have sensors for data attainment and analog to

digital converter. (ii) Processing sub system consisting of memory and microcontroller for processing. (iii) Radio subsystem for transmission. (iv) Power supply unit. There are additional components like location finding system; a mobilizer can be added depends on the applications where they are used (Cdr Varghese Thattil (Rtd), W.G., 2010). Out of the above all sub systems; the transmission will consume more power. Therefore we propose to reduce the transmission between the nodes by making the nodes sleep state.We propose to introduce the On Demand Sleep Awake (ODSA) method in WBASN, only when there is a need for all the nodes to sense value, then the BNC node stimulate all other nodes to sense the value and to transmit the values to access point through BNC. So that energy consumption by the all other nodes will be reduced more.

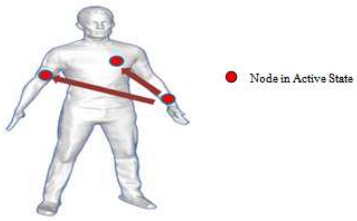

Fig. 2: Awakening the sleeping nodes.

IV. On-Demand Sleep Awake Algorithm:

Our method for solving the problem of reducing the power consumption is On Demand Sleep Awake Algorithm (ODSA). This ODSA Algorithm allows us to reduce the energy wastage in idle listening. The BNC node will sense the value on human body, when there is a demand, only then the other nodes being stimulated to sense the values. All other times the remaining nodes will be in sleep state. This BNC node can also selected periodically based on the energy level of the node.

Algorithm 1 : On-Demand Sleep Awake Algorithm:

Step1: Let us assume nodes are N_1, N_2, ... , N_k placed in different positions of human body.

$N=\{N_1, N_2, ... , N_k\}$

Step2 : Assign the Body Node Coordinator (BNC)

$BNC=N_i$ Where $N_i \in N$ [use BNC placement Algorithm]

Step3 : For i=1 to k

If N_i not equal to BNC, then

N_i = Sleep

Step4 : Sense the value using BNC

If (Sensed Value (BNC) != Acceptable Level), then

Goto Step5

Else

Transmit the data to access point

If (Energy Level (BNC) is Acceptable), then

Goto Step3

Else

Goto Step2

Step5 : For i=1 to k

N_i=Awake

Sense the value and send to access point through BNC

Step6 : Continue Step3

V. Findings And Discussions:

We have taken the following parameters for the simulation of Wireless Body Area Sensor Networks.

Transmission Range	:	10 Meters
Duty Cycle	:	On Demand
Sensor Node Sensing Power	:	30 mA
Initial Power of Node	:	2000 mAh
Frequency	:	402 to 405 MHz MICS band
Data Transfer Rate	:	< 1 mbps
No of Nodes	:	2 to 14

Best Case

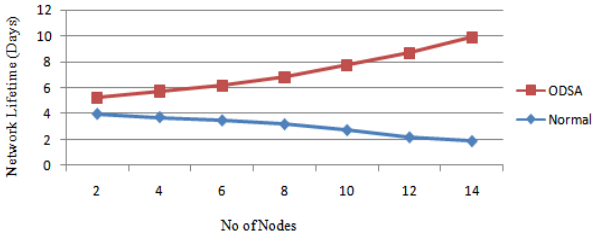

Fig. 3: Best case scenario of ODSA Algorithm.

Average Case:

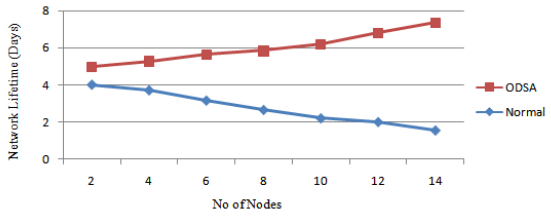

Fig. 4: Average case scenario of ODSA Algorithm.

Worst Case:

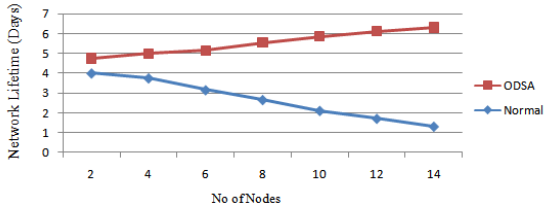

Fig. 5: Worst case scenario of ODSA Algorithm.

From the above findings when the number of nodes increased, the energy consumption by the ODSA will be predominantly less. Because the Body Node Coordinator changed periodically depends on energy level of the individual node. So the battery powers of all the nodes are remain higher. But unlikely energy consumption is largely higher in the normal setup.In Best case Scenario, the ODSA algorithm needed for less number of times. In average case scenario, the ODSA algorithm can be used normal. But in worst case scenario, ODSA algorithm will be used repeatedly. In best case scenario when the number of nodes increased, then they nodes can get time for the sleep state and alternatively uses the ODSA algorithm for sensing, so that the life time of the network dramatically increased. While considering the worst case scenario, the usage of ODSA algorithm increased rapidly, therefore the network life time will be reduced.It is clear that ODSA algorithm increases the lifetime of the network from the above simulation result. Even though the life time of the network varying in various scenario, the ODSA algorithm enhance the life time of the node while comparing with the normal method.

VI. Conclusion And Future Enhancement:

Reducing the Energy consumption of the node in WBASN is paying attention in the recent years. In this paper, we have analysed about the energy consumption and also we proposed one of the best methods ODSA for optimum utilisation of energy in Wireless Body Area Sensor Networks. The experimental result shows that the network life time has been increased greatly. Though we are using ODSA algorithm, further we can reduce the energy consumption of the node by conditional re-transmission method. By this conditional re-transmission method the energy consumption of the nodes will be reduced more. So the future work will be deliberated on conditional re-transmission for additional minimization of energy consumption.

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