***I.J. Wireless and Microwave Technologies*, 2015, 5, 56-62**
Published Online September 2015 in MECS(http://www.mecs-press.net)
DOI: 10.5815/ijwmt.2015.05.06

***Available online at* http://www.mecs-press.net/ijwmt**

An Energy Efficient Routing Algorithm for Wireless Body Area Network

Jyoti Kumari[a], Prachi[a]

[a] *The NorthCap University, Department of Computer Science and Engineering, Gurgaon, 122017, India*

Abstract

Wireless body area networks (WBANs) are emerging as one of the newest forms of Wireless Sensor Networks. In WBANs, sensor nodes accumulate human physiological data and transmit it to the sink node. However, transmission of physiological data to the sink node over a mobile route becomes a very daunting task for sensors due to their limited battery power. Moreover, replacement of critical sensor nodes is a major challenge in such scenarios. In order to increase network lifetime, some routing protocols have been proposed in the literature, but the majority of them are focused on coverage distance and residual energy of sensor nodes. In this work, we will propose an energy efficient routing algorithm for WBANs that will take into consideration two additional attributes (node criticality and communication count) along with the above stated attributes. These four parameters in the proposed algorithm will result in enhancement of working lifetime of the network via less energy consumption in comparison to existing routing protocols.

Index Terms: WBAN (Wireless Body Area Network), Coverage Distance, Node Criticality, Communication Count, BNC (Body Node Coordinator).

1. Introduction

Wireless Body Area Network (WBAN) is emerging as one of the most advanced communication networks. WBANs serve a variety of applications including healthcare, personal entertainment, advance sports training, live events, aviation, natural disasters, consumer electronic devices, etc. Sensors in WBANs measure physiological parameters of human body, such as sugar level, temperature, heartbeat, etc., and forward it to the concerned authorities using an intranet/internet facility. This kind of continuous monitoring is especially important in critical circumstances such as workers in coal mines and patients with serious medical conditions. The sensors in WBANs can be classified as implant nodes, body surface nodes and external nodes depending

* Corresponding author.
E-mail address: josahu98@gmail.com, prachiah1985@gmail.com

upon the position of sensor nodes with respect to the human body [1].

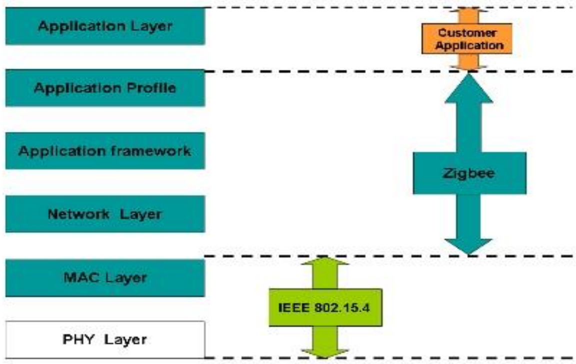

Fig.1. Layered Architecture for Wireless Body Area Network

According to IEEE 802.15.6 (WBAN) standard, the layered architecture of WBAN (Fig: 1) consists of Physical and Medium Access Control (MAC) layer which deal with communication. These layers help in establishing energy efficient, highly reliable, cheap and coherent wireless communication in the proximity of the human body. WBAN can be integrated with different wireless technologies like ZigBee, WSNs, Bluetooth, cellular networks, etc., which will allow expansion of advanced consumer electronics. However, rapid acceleration in the usage of wearable wireless sensor devices expedites the requirement of reliability, security, fault tolerance and quality of service aspect. However, there are certain factors like different bandwidth channel topological changes, time-varying wireless channel, variation in channel bandwidth which make WBANs less lucrative.

Our motive in this paper is to study existing routing algorithms for WBANs, present the shortcomings of each routing algorithm and to propose an algorithm which will overcome these shortcomings.

The remainder of this paper is organized as follows: Some existing routing algorithms are discussed in Section II. In section III, a new algorithm is proposed. Finally, section IV concludes the paper with future scope.

2. Existing Work

Routing is one of the major concerns in WBAN due to its unique features. Many WBAN routing protocols [2, 3, 4, 5, 6, 7 and 8] have been proposed in the literature. They have considered different parameters for different routing techniques. Some of existing routing approaches are presented in the following section.

In WBANs, three popular routing techniques exist, namely single hop, multi hop and cluster based. Some of the proposed routing approaches perform single hop communication while others perform multi hop and clustering, communication and few of them have implemented all of them [7] [8].

In multi hop routing, data between the source node and the destination node is transmitted via relay nodes. These relay nodes are called the next hops. Different algorithms take into account either the coverage distance or residual energy of a node as deciding parameter in the next hop selection. One of the existing multi hop routing protocols is [3] TICOSS (Time zone Coordinated Sleep Scheduling). In TICOSS, hop distance of all nodes to the coordinator node is calculated. On the basis of hop distance, network is partitioned into different time zones. In each time zone, nodes with same hop distance to the coordinator node are placed. When all time zones get constructed, a scheduling table is prepared which provides time slots to each time zone. Within one time slot, only the nodes of one time zone can participate in data transmission while all other nodes are put in sleep mode which saves a lot of energy. In TICOSS, network life time is increased, but delay occurs due to the formation of the time zones and scheduling table [9].

Another multi hop routing algorithm EER (Energy Efficient Routing) protocol [4] based on position information for mobile wireless body area sensor networks was proposed. This algorithm, minimizes the routing region to the intersection region of two circles that lie on the segment from the source node to the sink node. This reduced routing region results in decreased number of participating nodes in the routing and hence reduces energy consumption. The decreased participation of nodes leads to unicast style information transmission to the sink which saves energy but causes network delay. This algorithm gives better results as compared to flooding based and position information based routing algorithm.

In [5], an opportunistic forwarding algorithm was proposed which considered the relative distance of nodes to the sink node for routing purpose. This algorithm forwards data from the current node to the next hop nearer to the sink node. Due to this, the data transmission process causes less routing delay, but the negligence of energy level of a node creates a high burden on nodes nearer to the sink. These nodes die earlier than the nodes away from the sink.

Maskooki et al. found that during an activity, different postural movements lead to degradation in WBAN's network performance [6]. When there is no postural movement, source node can directly transmit data to the sink node. This type of communication is called LOS (Line Of Sight) communication. In case of postural movements, a disconnection may occur between the source node and the sink node and the source node cannot send data directly to the sink node. In this case, the source node is required to transmit data at high energy and this type of transmission is called NLOS (Non Line of sight) transmission. In NLOS, more energy gets wasted by the source node due to propagation loss of the human body. To avoid NLOS transmission, data is transmitted via relay nodes in LOS which have direct connection with the source as well as the sink node. In this algorithm, energy is saved by relay nodes, but the determination of appropriate positions for relay nodes is a daunting task.

Clustering routing is another popular routing technique in WBAN. The aim of clustering is to spread energy wastage equally on all the body nodes of the network. In clustering, nodes are grouped into different clusters. One node from each cluster is selected as cluster head based on some parameters. Only cluster heads of each cluster transmit data to the sink node. This leads to reduced transmissions and enhanced network lifetime. One clustering algorithm, Hybrid Indirect Transmission protocol [2] was proposed by J. Culpepper et al. in order to combine the positive points of LEACH [10] and PEGASIS [11] routing algorithms. Like LEACH, clusters are formed in order to minimize the numbers of transmissions from the source to the sink node. Similar to PEGASIS, energy wastage is further minimized when nodes within each cluster send data only to its next hop. Usage of TDMA allows parallel transmission of multiple cluster's data. In dense networks, large amount of energy is wasted in communication. However, this protocol does not take into consideration issues like reliability and heating of body tissue while making routing decisions. Another clustering algorithm SEA-BAN (Semi -Autonomous Adaptive Routing in Wireless Body Area Networks) [7] was proposed which combines the advantages of both single hop transmission and multi hop transmission. In this algorithm, data of all nodes are transmitted to the BNC (Body Node coordinator) which performs computations on this data. This leads to reduced computational burden on sensor nodes. All sensor nodes are assumed to be within coverage range of BNC. Node with highest residual energy is selected as the next hop among the neighboring nodes of the current node. This algorithm significantly improved the maximum network lifetime as compared to existing direct and multi hop transmission models. In [8], the author proposed an algorithm EAR-BAN (Energy Efficient Adaptive Routing in Wireless Body Area Networks) which is an extension and modification of SEA-BAN algorithm. EAR-BAN differs from SEA-BAN in a way that it considered the coverage distance along with remaining energy while performing routing. It is also a clustering algorithm, implementing direct and multi hop approaches depending upon the remaining energy and location information about each node. The Simulation results show that EAR-BAN has successfully enhanced the network working lifetime better than other existing WBAN routing protocols. But there are still some issues like BNC position, node criticality, communication count, body tissue heating etc. which need to be resolved.

EAR-BAN has proved to be the most energy efficient routing algorithm among the existing routing approaches. All of the above discussed algorithms performed routing in WBAN with a common goal of energy efficient communication. Some of them succeeded in achieving the same to some extent, but there is no single novel routing algorithm which works efficiently in different applications.

3. Proposed Work

Network working lifetime is a tedious task due to the low energy and to make such networks energy efficient, routing protocol is chosen very carefully. Such routing algorithm is proposed in this paper.

This section presents the proposed routing algorithm in which data of all nodes are transmitted to the destination. The destination node is assumed to be enriched with energy and do not have energy limitation. To transmit data to the destination node this algorithm adopts the most feasible routing approach depending upon the location and the residual energy information about each node. This algorithm has considered the communication count and node criticality along with the remaining energy and the coverage distance parameters for routing in WBAN. These two additional parameters will help in achieving maximum network lifetime among existing algorithms and will minimize energy consumption in the WBAN.

Considerations based on which algorithm is proposed are defined in the set up phase. The functionality and operations of the algorithm are defined in the operational phase.

i. Setup phase

The proposed algorithm is based on the following considerations:

- Two types of nodes, namely data nodes and video nodes are used.
- Type variable is defined for each node which denotes criticality of a node. It can have two values either info or video. If Type has info value, then the node has low criticality and if the value is video then the node is highly critical. Node with Type value as video is not selected as the next hop for other node's data transmission.
- Communication count defines how many node's data can be forwarded by a single node. It is denoted by the variable CommCount. A threshold is defined which sets an upper limit for the CommCount variable.

ii. Operational phase

At the beginning, all sensor nodes are deployed in fixed positions in WBAN. One among them is selected as the destination node to which data of all other nodes, accumulated by sensing within their coverage proximity are transmitted.

Nodes within coverage range of the destination transmit data using the single hop transmission technique. However, nodes which transmit outside the coverage range of the destination node adopt multi hop transmission technique.

In case of multi hop transmission, data from the source node to the destination node are transmitted via multiple next hops. To select a next hop, neighbor list of the current node is generated. The neighbor list provides the names of all nodes within the coverage range of the current node. One node among the nodes of the neighborlist is selected as next hop. The next hop selection is performed in two steps.

Step.1. The distance of next hop to the destination node must be lower than the current node's distance to the destination node. In addition to this, the energy level of the next hop must be greater than the threshold value.

Step.2. After step 1 conditions are fulfilled, four parameters, namely remaining energy of a node, coverage distance, communication count and node criticality are examined.

When all these conditions are satisfied, then this node is set as next hop and is added to the path from source sensor node to the destination is reached. However, if no such node is found, then in step two is performed for parameters excluding CommCount parameter. If an appropriate node is found, then it is set as the next hop, but if no such node is found, then step two is repeated for parameters excluding the residual energy parameter. This node is set as the next hop. Now, the energy value of this next hop is updated.

The pseudo code for the proposed algorithm is following:

```
Algorithm (N, Src, Dst)
/* Define a Network with N Nodes with Source and Destination*/
  1.  For i=1 to N
[Define N nodes with the Position and Energy Specification]
{
  2.  Nodes(i). Position=AreaPos(x, y)
      Nodes(i). Type = (Info or Video)
      Nodes(i). Energy=1J
      Nodes(i). CommCount=0;
}
  3.  Set CurNode=Src
[Set Source Node as Current Node]
  4.  While CurNode! =Dst
[Repeat Process Till Destination Node does not Occur]
{
  5.  Generate the Neighbor List for CurNode called NeighList
  6.  Set nexthop = NeighList (1)
  7.  For i=1 to NeighList. Length
{
  8.  If (Nodes(i).Energy>EThreshold And Distance(i,  Dest)<Distance(CurNode, Dest))
  9.  {
{
  10. Set nexthop=i;
}
  11. Else If (NeighList (i). Energy>Nodes (nexthop). Energy and NeighList (i). Type=Data and NeighList
      (i). Distance<Sensing Range)
{
  12. Set nexthop =i;
}
  13. Else If (NeighList (i). CommCount<Threshold and NeighList (i).Type=Data and NeighList (i).
      Distance<Sensing Range)
{
  14. Set nexthop =i;
}
}
  15. }
  16. Nodes (nexthop). Energy= Nodes (nexthop). Energy-ForwardingEnergy;
  17. Path. Add (next hop)
  18. Nodes (nexthop). CommCount= Nodes (nexthop). CommCount+1
  19. Set CurNode= nexthop
}
```

}

20. Nodes (Src). Energy= Nodes (Src). Energy-Transmission Energy;
21. Nodes (Dst). Energy= Nodes (Dst). Energy-Receiving Energy;

The energy value of the next hop is updated after every transmission. The value of CommCount variable is incremented by 1 after every transmission of the next hop. Now, this next hop node is set as the current node and this procedure is repeated till the destination node is reached. Finally, when the destination node is reached, energy values of the source node and the destination node are updated.

4. Conclusion

This paper has presented an algorithm which will perform routing more effectively than existing routing protocols in wireless body area networks (WBANs) with limited energy nodes. In this proposed algorithm, four attributes coverage distance, residual energy, communication count and node criticality are taken into account for energy efficient routing in WBAN. Node criticality and communication count parameters emphasize on reducing the burden on highly critical nodes and try to balance energy consumption evenly on all the nodes. This will largely lower the energy consumption and enhance the working lifetime of the network. The proposed algorithm appears to be a novel algorithm among existing algorithms. However, in the future, an some other critical parameters can be considered to optimize the routing in WBAN. The work is presented as a framework, in future it can be implemented in other applications.

References

[1] S. Movassaghi, M. Abolhasan, J. Lipman, D.Smith and A. Jamalipour, "Wireless Body Area Networks: A Survey", Communications Surveys & Tutorials, vol 16, Issue 3, pp. 1658-1686. 2014 IEEE.

[2] J. Culpepper, L. Dung, and M. Moh, “Hybrid Indirect Transmission (HIT) for data gathering in wireless micro sensor networks with biomedical applications,” Proc. 18th Annual Workshop on Computer Communications, 2003 IEEE.

[3] A. G. Ruzzelli, R. Jurdak, G. M. O Hare, and P. Van Der Stok, “Energy efficient multi-hop medical sensor networking,” Proc 1st ACMSIGMOBILE International Workshop on Systems and Networking Support for Healthcare and Assisted Living Environments, New York, USA, 2007.

[4] K. Kim, I. S. Lee, M. Yoon, J. Kim, H. Lee, and K. Han, “An efficient routing protocol based on position information on mobile wireless body area sensor networks,” Proc. 1st Int. Conf. on Networks and Communications, pp-396-399, IEEE 2009.

[5] M. Quwaider and S. Biswas, "On -body Packet Routing Algorithm for Body Sensor Networks", First International Conference on Network and Communications, pp. 171-177, IEEE 2009.

[6] A. Maskooki, C. B. Soh, E. Gunawan, K. S. Low, “Opportunistic routing for body area network,” Proc. IEEE Consumer Communications and Networking Conference, pp. 237-241, IEEE 2011.

[7] Md. Tanvir ul Huque et al., "SEA-BAN: Semi -Autonomous Adaptive Routing in Wireless Body Area Networks", 7th International Conference on Signal Processing and Communication Systems, pp. 1-7, IEEE 2013.

[8] Md. Tanvir ul Huque et al., "EAR-BAN: Energy Efficient Adaptive Routing in Wireless Body Area Networks", 7th International Conference on Signal Processing and Communication Systems, pp. 1-10, IEEE 2013.

[9] Christian H.W. Oey, Shelly Salim, and Sangman Moh, "Energy Aware Routing Protocols in Wireless Body Area Networks", 8th International Conference on Computing and Networking Technology (ICCNT), pp. 159-162, 2012 IEEE.

[10] Heinzelman et al., "Energy-Efficient Communication Protocol for Wireless Microsensor Networks",

Proceedings of the 33rd Annual Hawaii International Conference DOI: 10.1109/hicss.2000.926982, 2000 IEEE.

[11] Stephanie Lindsey, Cauligi S. Raghavendra, "PEGAIS: Power Efficient Gathering in Sensor Information Systems", Aerospace Conference Proceedings, vol.3, pp.1125-1130, 2002 IEEE.

Authors' Profiles

Jyoti Kumari is M.Tech holder in Computer Science from The NorthCap University of Gurgaon, India. Her current research interests include wireless Body Area Networks.

She received the B.Tech degree from B.P.S Women University Khanpurkalan of Haryana, India in 2013.

She is author of article "A Comprehensive Survey of Routing Protocols in Wireless Sensor Networks" IEEE indexed conference.

Prachi is Ph.D. holder in Computer Science from the Banasthali University of Rajasthan, India. Her current research interests include wireless sensor networks, key agreement in wireless peer-to-peer systems and security in underwater sensor networks. Prachi received the B.Tech. degree from M.D. University, Rohtak in 2007 and the M.Tech. degree with distinction in Computer Science from the Banasthali University at Rajasthan in 2009. She is author of 21 refereed articles in these areas, 9 in peer reviewed, reputed international journal indexed in international databases and 12 in IEEE and Springer indexed International Conferences.

How to cite this paper: Jyoti Kumari, Prachi,"An Energy Efficient Routing Algorithm for Wireless Body Area Network", IJWMT, vol.5, no.5, pp.56-62, 2015.DOI: 10.5815/ijwmt.2015.05.06