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Thermal and Delay Aware Protocol for Routing in Body Area Network

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Abstract—Body Area Networks is one of the emerging area in current research field. The nodes are used for transmission of the data to the physician sitting at the remote site. Routing of the data is a great concern as direct communication consumes more energy. Various algorithms are proposed for routing. This algorithm is proposed named Thermal and Delay Aware protocol (TDAP) which considers the temperature of the nodes and delay of information transfer as routing metric and is used for cost function calculation. TDAP considers the node's temperature, while routing the information from one node to another, the temperature of node rises threshold value that node is called hotspot node. As the hotspot node is found in the network an alternative and shortest path is searched using dijkstra's algorithm for transmitting information to the final node. TDAP algorithm will enhance the efficiency of routing and yield shorter path length for faster communication data.
Keywords—BAN; routing

I. INTRODUCTION

A Body Area Network (BAN) is defined as a ccommunication standard optimized for low power devices and operation on or around the human body to serve a large area of applications including medical, consumer electronics/personal entertainment and other, this is not only limited to humans. WBAN (Wireless Body Area Networks) came in 1995 by referring wireless personal area network (WPAN) technology as its backbone for communication. A wireless personal area network was later on named as Wireless Body Area Networks (WBAN). BAN technology focuses on communication of information related to human body. It is a network of nodes which senses any kind of vital changes occurring inside the human body and communicates with each other, then transfer the information to the control node in the network. This control node collects all the information from other nodes that are attached to the various parts of body and forward this information to the main server, which then transmit the information to the various medical centers.

With increasing population day by day and the costs of health care is also increasing. These factors have prompted the introduction of an innovative technology driven improvements towards the existing health-care technologies. The concept of Wireless Body Area Network (WBAN) came to exploit the benefits of wireless sensor technologies in e-health and e-medicine. The main advantage of using the BAN technology is that even if the patient is away from the direct observation of the physician, all the information related to the patient body will be transmitted to the doctor and in case of any kind of emergency quick action can be taken. The main function of these sensor nodes is to sample important signs and transfer the relevant data to a personal server through wireless personal network implemented using ZigBee (802.15.4) or Bluetooth (802.15.1) [10]. MBANs work in a defined frequency spectrum of 2360-2400MHZ [9].

According to World Health Organization (WHO), aging population and sedentary lifestyle are causing millions of people to suffer from obesity or chronic diseases everyday [7]. So, it is expected that this circumstance will decline the quality of health- care system [8].In this paper, we have to find an efficient algorithm for routing information among nodes, so that information can quickly be transmitted to the main server and then to the medical centers such that in case of emergency quick action can be taken by the doctors.

II. BACKGROUND

Routing protocols in WSNs have been studied during past years but the protocols do not meet the conditions for BANs as they do not meet the various constraints imposed by requirement in BAN [3].Several new routing protocols have been proposed in the past few decades. The routing protocols are classified with respect to the aims or according to the metric considered.

In this source node delivers its packets to the destination node, and buffers it till the destination. A simple model is used in this protocol. Sink node is wearied on wrist and moves forward and backward during activities like running and walking [11]. The lifetime of the network is increased by decreasing the energy consumption in both relay nodes and sensor nodes. In Randomized routing protocol, if a node with a data packet does not have a direct link with the destination, the node sends the data packet to a neighbour chosen at random. The packet is then forwarded in the similar way, until it is received by the actual destination. Another protocol proposed is utility based routing using link locality. In such protocol the packets are forwarded to the nodes with metric being calculated on the basis of the latest encounter with the destination. A utility value is assigned and the packet is forwarded by checking this value. The packet is then forwarded to the neighbouring node having highest utility value. It is usually implemented using the timer. One more classification of the routing protocols is based on the temperature. On the basis of temperature several protocols have been designed. They are designed to limit temperature rise as temperature can affect human tissue.

Thermal Aware Routing Algorithm (TARA) was proposed serving the objective to reduce the possibility of overheating of sensors. It any node has exceeded its temperature it is called as hotspot and then alternative path is found for the transmission of the packets. The nodes are considered again in later part of routing if the hot-spots are cooled down to a certain limit. But it only considers temperature as the routing metric so the delay is more and it is less reliable. Least Temperature Routing (LTR) is the routing protocol which makes the route by considering the neighboring node with the lowest temperature. For each packet a hop count is calculated. This routing does not ensure forwarding of packets in the direction of destination and the more bandwidth is wasted. Also, the end to end delay is more. Adaptive Least Temperature Routing (ALTR) is adaptive form of the above protocol LTR. In this a parameter MAX_HOP_ADAPTIVE has been introduced. If the value of hop count is lower than MAX_HOP_ADAPTIVE it is same as LTR but if it is greater instead of being dropped, the packet is routed using shortest hop algorithm [6]. Here the routing is not optimized in terms of delay and efficiency.

III. ROUTING CHALLENGES

BANs are used in various medical and non-medical applications including health-care, gaming, military and many more. As the BANs applications include different technological requirements, constraints and architectures, there are different challenges associated with BANs. This section covers the challenges associated.

Postural body movements-The link quality between nodes in BANs varies as a function of time due to postural body movements. [2] So the algorithm should be adaptive to the changes in the topology.

Limitation of sources- This is one of the important challenges as the nodes have limited energy and bandwidth. The protocol should be aware of the energy, quantity of the sources, memory available and network control otherwise the Quality of Service (QoS) may get affected.

High redundancy of data- Though redundancy of data in BAN helps in increasing reliability but the energy consumption may be more.

Dynamism of network- The degree of dynamism of network is increased due to certain factors such as environmental conditions, node mobility and destruction of communication. This increase of dynamism results in increased complexity of the network.

Energy consumption- To increase the network lifetime, energy consumption should be balanced so that no subset consumes higher energy. [4] Reliability on one route should not be there.

Heterogeneous environment- The nodes in BANs can be heterogeneous [3].Since the calculation for power, memory and power consumption vary for different nodes, it imposes great challenges on QoS.

MAC layer protocols-From the communication perspective, it is difficult to design such Medium access control protocols which ensure higher network capacity, energy efficiency and adequate quality of service [7].

IV. METHODOLOGY

Thermal and delay aware protocol is a routing protocol used to route packets within the human body to the sink node with a minimum amount of delay as well as taking into consideration the temperature tolerance of each sensor node. This protocol uses a combination of delay and temperature as a routing metric to provide the best shortest path to route the packet. Each node in the network is identified by a unique id. Distance Vector Routing is then used to route the packets within the body as the topology of the Body Sensor Network is fixed until a node fails to work and is known to each node. Since these are small networks with little number of nodes, loop node instabilities do not occur due to multicasting of only limited information and limiting the value of infinity to 16. Thus, the entire functioning of the protocol can be described in three steps shown in fig. 1:

- Creating of routing table
- Sharing of any amendments
- Updating the routing tables

Creation of routing tables involves calculation of various characteristics for the routing metric and using Dijkstra’s algorithm to find the shortest path. Each sensor node is itself capable of sensing the node temperature at time t. If the temperature of any node reaches the threshold value (44.c) that node is declared as a hotspot and it can no longer participate in routing until its temperature falls down. This information is passed to all the nodes so that they can update their routing tables.

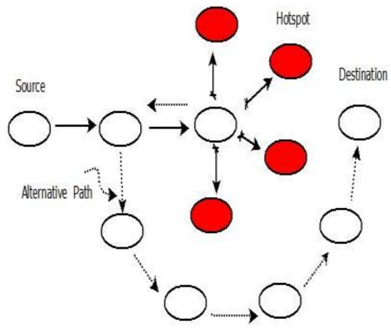

Fig.1 An example of Routing

The delay for every pair of sensor nodes is calculated during the initialization of the routing tables for each node. The delay usually ranges from 0-120 msec.

Various variables (such as low, medium, high) are used to describe the range of temperature and delay.

4.1 Creation of Routing Table

The calculation of TEMPERATURE AND DELAY is done using the following code:

```
temp=get_temperature(id,t);
If(temp>=0&&temp<=15)
set _templogic(id,low,t);
If(temp>=16&&temp<=30)
set _templogic(id,medium,t);
Elseif(temp>=31&&temp<=40)
set _templogic(id,high,t);
dely=get_delay(id,j,t);
If(dely>=0&&dely<=10)
set _delaylogic(id,j,t,low);
 If(dely>=11&&dely<=50)
set _delaylogic(id,j,t,medium);
Elseif(dely>=51&&dely<=120)
set _delaylogic(id,j,t,high);
```

Fuzzy logic is used to combine the temperature and delay characteristics for evaluation of the routing metric.

table I. CALCULATION OF ROUTING METRIC USING FUZZY LOGIC

Delay[I,j,t]/ Temp[j,t]	Low	Medium	High
Low	Low	Medium	Medium
Medium	Medium	Medium	High
High	High	High	High

Where Delay[i,j,t] describes the delay from node I to node j at time t and Temp[j,t] describes the the temperature of node I at time t'

```
For every pair of nodes[i,j]:
If (fuzzy_value==low)
set dist[i,j]=1;
else if (fuzzy_value==medium)
set dist[i,j]=8;
else if (fuzzy_value==high)
set dist[i,j]=16;
```

The logic variables are then assigned numeric values to be used as a routing metric. Since infinity is limited to 16 so logic variables are assigned values accordingly.

Each node then uses the Dijkstra's algorithm to calculate the shortest path to every other sensor node using the routing metric calculated above using fuzzy logic. The packet can then be routed along the shortest path. The shortest path was found out by using the Dijkstra's Algorithm as follows:

```
dist[s]←0  (distance to source vertex is zero )
For all v∈ v–{s}
do dist[v]←∞  (set all other distances to infinity)
S←∅  (S,the set of visited vertices is initially empty)
Q←V  (Q,the queue initially contains all vertices)
While Q≠∅   (while the queue is not empty)
Do u←mindistance(Q,dist)   (select the element of Q with the min distance)
S←S∪{u} (add u to list of visited vertices)
For all v ∈ neighbors[u]
Do if dist[v]>dist[u]+w(u,v) (if new shortest path found)
Then d[v]←d[u]+w(u,v)  (set new value of shortest path)
Return dist[id,j]
```

Tables were created using the following function:

Createtable(id,j,dist[id,j]); //j varies from 1 to n

where this function creates the routing table1 for node id to the destination node j and dist[id,j] indicates the routing metric along that path.

This then calls for the initialization of routing table of each node. However, to accommodate the amendments in the temperature of each node, each node senses its temperature every 30 sec. and in case a change from previous value is encountered, this information is multicast to other sensor nodes for updating. Also, as soon as the temperature of the hotspot node falls down it can again take part in routing and this information is multicast to every other node. This is known as the sharing process in Distance Vector Routing. On receiving the multicast information each node then updates its routing table and again the shortest path is found for all those nodes whose metrics have changed with time.

4.2 Sharing and Updating

```
For all nodes:
If(temp[id,t]>=threshold)
Set Hotspot[id]=Node[id];
multicastroute(Node[id]);
Set dist[id,j]=16;
For every hotspot node:
At every t+30 sec.:
If(temp[id,t]<=threshold)
deletehotspot(id);
recreate(id);
multicastroute(id);
For every other node:
At every t+30 sec.:
If(temp[id,t]!=temp[id,t-30])
recreate(id);
multicastroute(id);
```

where recreate(id)is a function used to reinitialise the routing table for node id and multicastroute(id) is a function to multicast information regarding the change in characteristics. This process is repeated each time the node characteristics change to allow efficient communication. Thus this protocol is an efficient protocol for routing of packets within the Body Sensor Networks that takes into account the delay and temperature characteristic of each node for delivery of packets thereby choosing the best shortest path for timely and quick communication.

V. CONCLUSION

WBAN based Health technologies have immense capabilities for continuous supervision of ambulatory settings, pre-occurrence detection of abnormal conditions, and monitored rehabilitation. They can provide patients with increased confidence and a better quality of life, and promote healthy behaviour and health awareness. Also, the promise of this technology should not be restricted to one area. Fitness and entertainment are taking new directions. Temperature Delay Aware Routing Algorithm (TDAP) for Body Area Networks based on the dentition of a cost function which considers the nodes temperature and delay of information transfer between nodes as metrics for calculation of the efficient route with minimum cost. Simulations results have shown the proposed protocol finds the shortest path for packet delivery between nodes. While transfer of packets between nodes, temperatures rise to minimum threshold value that node is called as hotspot node. The proposed algorithm determines the hotspot node. As the hotspot node is observed in the network while routing of information packet, the packet is send to the destination node by finding the alternative path along with ensuring the shortest path is detected using Dijkstra algorithm and minimum delay is there. TDAP algorithm will enhance the efficiency of routing and yield shorter path length for faster communication of urgent data.

VI. REFERENCES

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