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Priority Based Energy Efficient Data Transmission Using Cooperative Virtual MIMO Technique in Wireless Body Area Network

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ABSTRACT: Wireless Body Area Network (WBAN) is an exigent technology which is used to customarily monitor the patient's critical data. Initially, the sensor nodes have been placed on the human body which is configured with the wireless devices for transmitting the data. Sensor nodes are typically powered by batteries with a limited capacity. To some extent it is possible to prolong the life of the network by controlling the energy consumption of each sensor node. Energy consumption during the information transmission in WBAN remains one of the most significant research challenges. This paper imparts the proposed method called Cooperative Virtual Multiple-Input-Multiple-Output (PC-VMIMO) technique for Priority Based Energy Efficient Data Transmission, which is exclusively used to overcome the above challenges. In the same power transmission and lofty traffic overhead situations, this method can produce higher data rates and minimize the node transmitting time of the priority information, thereby reduce the energy consumption, latency, overhead and also improve the communication performance of the entire network. The simulation results demonstrate the effectiveness of the proposed method in various performance metrics, compared with the existing methods.

KEYWORDS: Wireless Body Area Network, Virtual MIMO, Priority based Cooperative Virtual MIMO.

1 INTRODUCTION

Wireless Body Area Network (WBAN) is an important wearable or implanted computing technology that is used to monitor the patient activities in various situations and reduces the health cost in many health care centers [1]. In recent years, virtual MIMO has engrossed a mounting interest because of its energy efficiency in the massive field of wireless networks. In traditional virtual MIMO network, multiple sensor nodes cooperate to transmit and receive the data [2]. However, direct application of MIMO techniques to WBAN is impractical due to the physical size and energy limitation of sensor node which typically can only support a single antenna to transmit and receive the data from various sensor nodes that may cause more traffic overhead, also it consumes more energy while forwarding various patient's critical data at the same time, and hence causes delay. Within a group, sensor nodes can communicate with relatively low power as compared to intergroup communication.

Many research works have been focused on the energy efficient data transmission in Wireless Sensor Networks using collaborative virtual MIMO technique, such as how to select collaboration nodes, how to transmit the data via cluster heads with less energy and delay , routing and so on [3]. In [4], a Cluster based Virtual MIMO (C-VMIMO) algorithm has been proposed by jointly considering a balanced energy load LEACH clustering algorithm with virtual MIMO technology. This algorithm is applied to all network nodes, and the energy is equally circulated to each sensor node by rotation election of cluster head nodes. Thus, the cluster head nodes can't drain rapidly and the network lifetime can be effectively optimized. To avoid network's energy imbalance, Dynamic Cooperative Virtual MIMO (DCVM) method has been proposed based on the node's residual energy. This virtual MIMO scheme is formed by choosing new cluster heads (CHs) dynamically and then make a certain number of nodes acting as virtual antennas with the near optimal selection technique [5].

Hence, instead of using multiple antennas attached to one node as in the traditional virtual MIMO model, Cooperative Virtual MIMO based communication presents the concept of several sensor nodes participating to transmit and/or receive the data. Most existing Cooperative MIMO methods have not considered priority based data transmission, and also focused only on collaborative data transmission among the nodes for large scale networks. When consider all these methods in WBAN, it may be possible to make use of the energy accumulation in the receiving nodes to improve the reliability of data transmission without any latency.

2 PC-VMIMO METHOD FOR WBAN

The priority based energy efficient data transmission using Cooperative Virtual MIMO model for Wireless Body Area Network is shown in Fig.1. In the proposed cooperative virtual MIMO framework, there are four types of nodes: Normal nodes (NNs), Accumulator nodes (ANs), Intermediate nodes (INs) and Receiver nodes (RNs). The normal nodes sense and collect the data from multiple patients. Accumulator nodes gather data from the normal nodes and use intermediate nodes to transmit their data to the receiver nodes of the neighboring ANs or send data directly to the Base Station (BS). Remedy Subscribed Base Station (RSBS) forwards the critical data to the BS when there is no accumulator node to transmit the data due to energy drain.

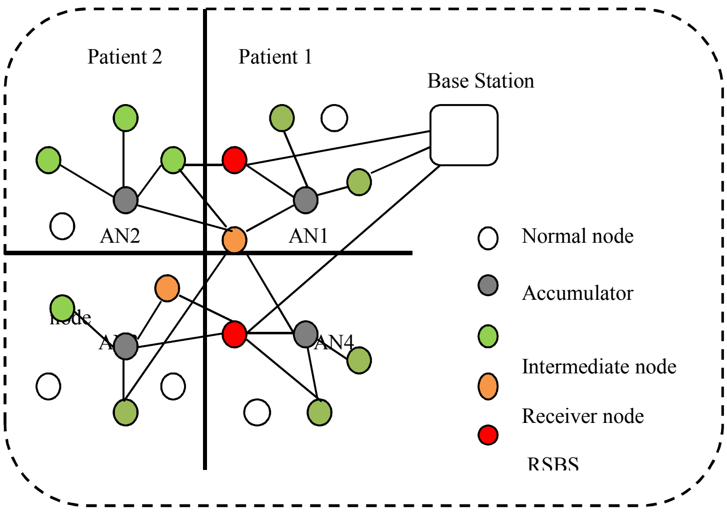

Fig. 1. Priority based Cooperative Virtual MIMO Model for WBAN

Fig.1 shows four accumulator nodes with different intermediate, receiver and RSBS nodes. For instance, AN1 has two intermediate nodes that directly communicate with the BS. AN2 has three INs that communicate with one receiver and RSBS node of AN1. In other words, there is multi hop communication from AN2 to AN1 and then from AN1 to BS. Similarly, the two intermediate nodes of AN4 communicate with two RNs of AN1 and AN3. It should be noted that the same receiver node of AN1 is used by INs of both AN2 and AN3. In other words, it is possible, that a RN is used by multiple intermediate nodes. AN3 has two options to reach to the BS via AN1 and AN4. During the data transmission the node facing several problems, namely, the accumulator node may be idle or busy, the receiving BS also unavailable in some cases. So, the proposed system overcomes the above difficulties in the following manner.

2.1 ACCUMULATOR NODE STATES

The data from the sensor node is stored in the accumulator node which is transmitted to the nearer RSBS. The accumulator node is one of the storage devices that used to store the patient information which can be ignored in three different cases. First, the Accumulator Node (AN) is out of the coverage, and then the sensor with least priority node is selected to transmit the data in order to avoid the routing overheads. Next, the Accumulator Node (AN) hears another route, in this case the priority data transmitted to the nearer possible accumulator nodes. If there is no Accumulator Node (AN) to transmit the data due to energy drain, the actuator node selects a RSBS to transmit the data to the BS with minimum hops. Finally, if the Accumulator Node (AN) is available for transmitting the data, the state of the accumulator node must be checked whether the accumulator node's energy value $E_s(AN)$ is the minimum of the energy strength value or not, The energy strength value is calculated as follows,

$$E_s(AN) = min_{i \in AN}(E_i) \quad (3)$$

The accumulator node's states are classified into two types:

2.1.1 IDLE STATE

Initially the accumulator device is idle, so the priority of the gathered data is calculated based on time and the importance which is measured as follows,

$$P_i = \frac{T_i}{G_i * S_i} \quad (4)$$

Where, P_i is the priority of the sensory data, T_i is the information class value, G_i is the generated rate in the human body, and S_i represents the size of the data. Based on the equation 4, the priority is estimated and transmitted to the nearest RSBS. The subscribed based station details are accessed by both the user and the receiver in the WBAN, which is used for further medical process.

2.1.2 BUSY STATE

The second state is busy state, in which the sensor node acts as the actuator node and chooses the route for transmitting the critical data to the nearest RSBS. Then, the routing will be done with the help of the Cooperative Virtual MIMO approach for transmitting the critical data. In the proposed method, the sensor node's data priority is calculated using the equation 4 and the BS is chosen according to their energy, minimum and maximum distance. The base station has been chosen as follows,

$$max_{node \in range} = \frac{E_{rem}(i)}{d_i} \quad (5)$$

Where, $E_{rem\,(i)}$ is the remaining energy in the node and d_i is the distance between the node and the BS. After choosing the BS, the sensory data is transmitted based on the proposed method. The energy consumption is calculated as follows,

$$E_{CV-MIMO} = \frac{N}{n} kr N_c \left(E_{ct} + I_{emp} E[d^4]\right) \quad (6)$$

Where I_{emp} is the base station parameter, N_C is the base station number, and d^4 is the distance with mathematical parameter.

3 SIMULATION RESULTS

The performance of the proposed model is evaluated by using the following performance metrics such as energy, latency and overhead. The simulations are carried out by NS2. The simulation parameter's information is listed in table 1. Then, the simulated experimental result has been discussed in detail.

Table 1. Simulation Parameters

Parameters	Values
Deployment area	400*400 m
Queue Limit	20
Placement	Random
Application type	Time driven
Packet size	32bytes
Traffic type	CBR
No of nodes	100
Simulation tool	NS2

3.1 ENERGY

In WBAN, the multiple patients' data should be transmitted with minimum amount of energy. If nothing is sensed, nodes are in idle mode for most of the time. Therefore, the large amount of energy is wasted during the data transmission. So, both sender and receiver nodes should be ready to act and schedule their mode while transmitting the data to avoid the energy consumption in the network. The overall network energy has been computed by using the equation 8.

$$E(R) = P_l t_l + P_{tx} * \left(t_{tone} + \frac{F}{R}\right) + P_{rx}\left(t_{tone} + \frac{F}{R}\right) \quad (8)$$

Where, P_l is the power consumed while state of listening, t_l is the time of listening state, t_t denotes the node's listening and sending time. P_{tx} is the consumed power in the state of transmitting data, and P_{rx} represents the consumed power in receiving state, F is frame size and R is the information bit rate. Thus, the performance of the proposed method energy metric is compared with the existing methods. From the Fig.2, it clearly shows that the proposed system consumes minimum energy while transmitting the multiple patients' vital data.

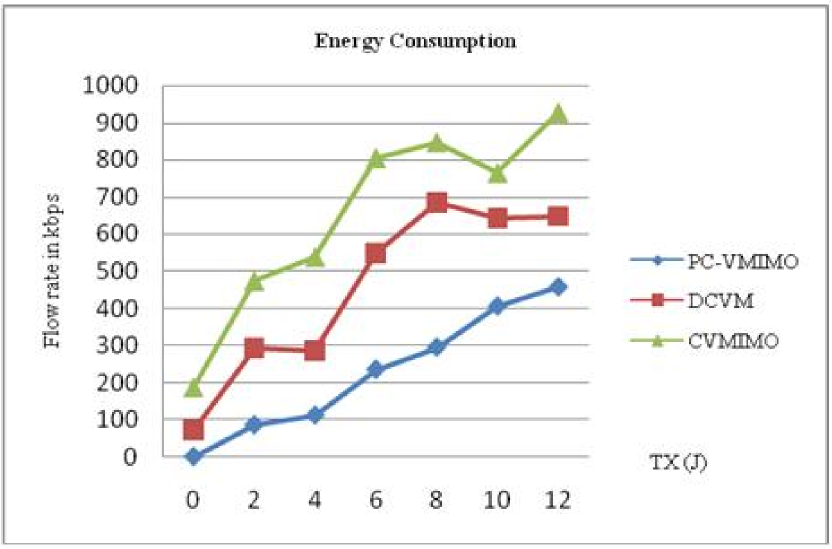

Fig 2: Energy consumption

3.2 LATENCY

The critical data should be transmitted before the deadline for real time observation in WBAN. The data is delivered successfully after the due time, and then the transmitted data should be futile. Therefore, the latency has been calculated using the following equation.

$$Latency = O_{waiting} + Tx_{time} = O_{waiting} + \frac{E}{R} \quad (9)$$

Where, O_{wait} is overall waiting time also considered as queuing latency, T_X is the information transmission time, F is the frame size and R is the data bit rate. Then, the latency metrics is presented in the below Fig.4 which shows that the proposed system consumes minimum latency while transmitting the maximum amount of information in the wireless body area network.

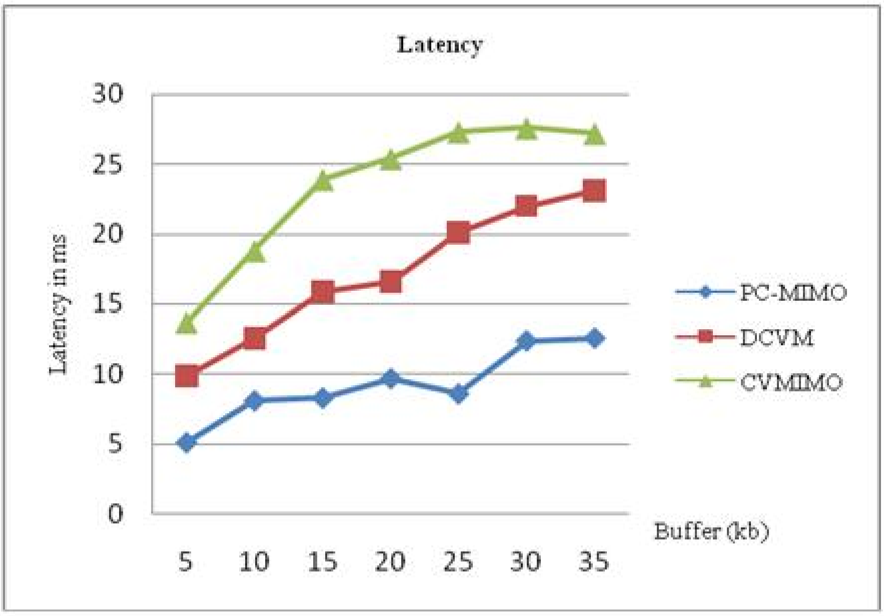

Fig 4: Latency

3.3 OVERHEAD

Overhead is also a significant measure while routing the data among the several nodes. The overhead for different amount of data has been evaluated. Thus, the proposed model provides minimum overhead as compared with existing methods which is depicted in the Fig.5.

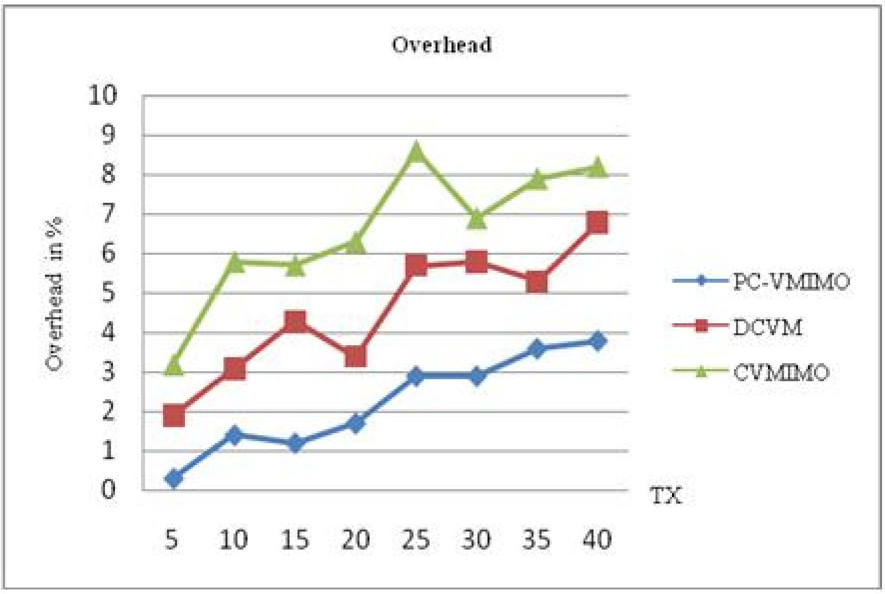

Fig 5: Overhead

4 CONCLUSION

In this paper, the Priority based Cooperative Virtual MIMO (PC-VMIMO) model for Wireless Body Area Network has been introduced to reduce the energy consumption and extend the network lifetime. This system transmits the patients' priority information to nearer RSBS or BS using different states of ANs with the help of Cooperative Virtual MIMO scheme. Hence, during the data transmission, the proposed system gives the way to transmit the multiple priority data without making any delay. Compared to existing methods, the simulation results show that the proposed method can provide the promising results such as minimizing energy, latency and overhead.

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