RESEARCH ARTICLE

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Throughput Analysis of AHTPC Algorithm for Wireless Body Area (WBAN) Network

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ABSTRACT

The low-power and long-term operations in WBAN can be achieved with efficient energy transmission which is consider as a key factor for WBAN. Many different techniques present in the literature deals with the Transmit Power Control (TPC) to transmit the data in WBANs by controlling its power. The technique of Transmit Power Control depends upon the condition of the channel and is categorized as reactive or proactive. The Proactive technique is susceptible to have error and delays of prediction type whereas the approach of reactive have more delays along with huge overhead. So, a hybrid technique is required that blends the benefits of both reactive and proactive approaches which is useful for any channel type. In this paper, an Adaptive Hybrid Transmit Power Control (AHTPC) algorithm is developed for WBAN. In this algorithm, a channel sample matrix is used to store the values of Packet Delivery Ratio (PDR) and Strength of received Signal, which are measured at the Base Station. If the Strength of received Signal and delivery ratio values falls outside the range of upper bound and some lower bound then execution of Reactive Transmission Power Control (RTPC) algorithm is done. The execution of Proactive Transmission Power Control algorithm (PTPC) is carried out when the channel is in fluctuating condition and consecutive RSSI samples difference become higher. The results achieved by the simulation shows that proposed technique achieves reduced packet drop with enhanced throughput compared to that of reactive and proactive techniques.

Keywords: Power Control; Hybrid; Channel condition; Packet Delivery Ratio; Adaptive; Wireless Body Area Networks.

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INTRODUCTION

Pervasive healthcare system consists of mini wearable sensor devices using wireless communication technologies. One of the major contributions in healthcare of pervasive systems is carried out by WBAN [1]. WBAN is a low power and miniaturized networking technology to trace and track essential physiological signals from in-body or on-body sensors. It satisfies the Quality of Service (QoS) that is required for the physiological signals that are obtained and operated in different environments [2]. Besides ubiquitous healthcare, WBAN can support applications such as entertainment, interactive gaming and military applications [3]. The WBAN is based on IEEE 802.15.6 standard, which has defined as wireless communication standard for short-range communication which is design to work in and around human body [4]. The Physical layers (PHYs) of 802.15.6 consist of Narrow Band (NB), ultra-wide band and Human Body Communications (HBCs).The new medical BAN is supported by NB PHY. The three modes of MAC layer is supported by all PHYs.

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First mode is beacon with super frame boundary, second mode is beacon without frame boundary and third mode is non-beacon. Energy-efficiency is

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an important concern for several medical applications in WBAN [5]. One of the main causes of energy wastage in WBANs is due to the interference between nearby WBANs. Interference causes Signal-to-Interference and Noise Ratio (SINR) to drop and hence the throughput is degraded. To avoid this kind of throughput degradation, a node has to increase its SINR by increasing its transmission power [6]. So, an energy efficient TPC is developed in this paper which can overcome issues of existing technique by using adaptive hybrid technique and it can be acceptable for any kind of channel condition.

The remaining part of this paper is arranged as follows: Reactive and Proactive Technique is dealt in Section 2. In Section 3, Adaptive hybrid TPC algorithm is discussed in detail. In Section 4, the simulation results are presented. Finally, the conclusion along with future work is drawn in Section 5.

REACTIVE AND PROACTIVE TPC TECHNIQUE

A TPC algorithm is utilized to dynamically change the Power Level of Transmission based on condition of channel in sensors [7]. Since, the sensors whose channel conditions changes rapidly owing to diverse characteristics like placement of sensor and movements of body. The condition of channel is considered to be good when the environment is static and stable. However, channel with bad condition and unstable is for dynamic environment because of non-line-of-sight propagation or frequent body movements. Both the environments are simultaneously considered for designing a practical WBAN [8].

Different researchers propose various reactive TPC approaches [4], [7], [8], [10], [11]. In all these works, the TPL is adjusted adaptively based on the measured RSSI values at the sink or AP. Later, researchers [9],[12] propose the proactive approaches. In these works, the channel condition is predicted using RSSI and channel gain measurements. The TP is then proactively adjusted based on these predicted values.

A hybrid TPC technique [13] contains both proactive and reactive approaches. The proactive approach uses the link quality estimator model based on Adaptive Neuro-Fuzzy Inference System. The reactive approach uses the RSSI measurements for TPL adjustment.

Both the proactive and reactive approaches have some drawbacks. The Proactive technique is susceptible to have error and delays of prediction type whereas the approach of reactive have more delays along with overhead. And also reactive approaches involve more feedback packets leading to huge TPC overhead in the networks which have fluctuating channel conditions,. If the channel condition is static and less volatile, predictive approaches cause unnecessary prediction overhead.

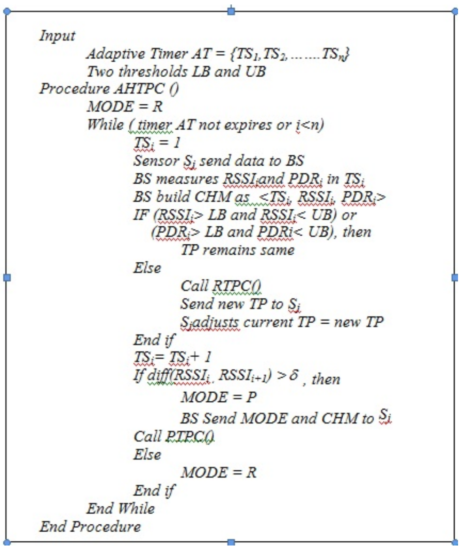
Hence, the main aim of this work is to design a hybrid technique that combines the advantages of both mechanisms, that is more suitable for all type of channel conditions. In order to meet this objective, an Adaptive Hybrid TPC (AHTPC) algorithm for IEEE 802.15.6 WBAN is proposed, which is discussed in this paper.

ADAPTIVE HYBRID TPC (AHTPC) TECHNIQUE FOR WBAN

In this work, an Adaptive Hybrid TPC (AHTPC) technique for WBAN is proposed. It adaptively selects either a conservative or an aggressive control mechanism depending on current channel conditions.

AHTPC Algorithm

The pseudocode of AHTPC technique is given in Figure 1.



```
Input
        Adaptive Timer AT = {$TS_1, TS_2, ……. TS_n$}
        Two thresholds LB and UB
Procedure AHTPC ()
        MODE = R
        While ( timer AT not expires or $i<n$)
                $TS_i = 1$
                Sensor $S_i$ send data to BS
                BS measures $RSSI_i$ and $PDR_i$ in $TS_i$
                BS build CHM as <$TS_i$, $RSSI_i$, $PDR_i$>
                IF ($RSSI_i$> LB and $RSSI_i$< UB) or
                   ($PDR_i$> LB and PDRi< UB), then
                        TP remains same
                Else
                        Call RTPC()
                        Send new TP to $S_i$
                        $S_i$ adjusts current TP = new TP
                End if
                $TS_i = TS_i + 1$
                If diff($RSSI_i$, $RSSI_{i+1}$) > $\delta$ , then
                        MODE = P
                        BS Send MODE and CHM to $S_i$
                Call PTPC()
                Else
                        MODE = R
                End if
        End While
End Procedure
```

Figure 1: Pseudo code of AHTPC Algorithm

In this algorithm, an adaptive timer is started. Initially, a MODE flag is set to R (reactive). Within this timer period, the AP measures the RSSI and PDR values and stores them in a channel sample matrix in the format <TSi, RSSIi, PDRi>, where TS represents time slots of the corresponding period. In AHTPC, two threshold values are maintained. They are Upper Bound (UB) and the Lower Bound (LB). In order to fix the LB and UB values, the samples of RSSI and PDR are collected at various time intervals with respect to different body positions.

The value of PDR corresponding to the lowest RSSI is taken as LB and the value of PDR corresponding to the highest RSSI is considered as UB. On the contrary, the RSSI value for which the minimum PDR is obtained from the farthest sensor is considered as LB and the RSSI value for which the maximum PDR is obtained from the shortest sensor is considered as UB.

The value of RSSI can be calculated by the following formula

$$RSSI[dbm] = “(10n \log10(d) “ A) \quad (1)$$

where n is a constant value, d is distance, and A is the offset.

If the values RSSIi and PDRi fall within the range of {LB,UB} , then the channel condition is considered as normal and no TPC technique is needed. On the contrary, the RTPC is executed. In this algorithm, the new TP is either increased or decreased based on the conditions and it is sent as a feedback packet to the sender. The sender then adjusts the TP based on this new value. If difference of RSSIi, RSSIi+1 is greater than another threshold δ, then the proactive mode is triggered by changing the MODE flag to P (proactive). The value of δ is determined by finding the exponential average of diff(RSSIi, RSSIi+1) over various time intervals and then the minimum among them is considered.

i.e., $\delta = Minimum\,(Eavg\,[diff(RSSIi\,, RSSIi+1)t_k],$ (2)

where t_k , k =1,2.....n is the time interval.

The AP then sends the feedback packet that consists of the MODE and the channel sample matrix. After that , PTPC is executed. At the end of the time interval, again difference ($RSSI_i$, $RSSI_{i+1}$) is checked. If it is less than ä, then the mode is again set to R.

SIMULATION RESULTS

The developed AHTPC algorithm is simulated by using NS-2. In the simulation, three scenarios are considered which are listed below

Scenario 1: The subject is static and sitting on a chair
Scenario 2: The subject sat on a chair and
(i) raised hands in upwards direction,
(ii) stretched the legs in two sides.
Scenario 3: The subject is slowly moving.

Simulation Parameters

The simulation parameters are given in Table 1.

Table 1 : Simulation Parameters

Number of Nodes	12
Size of topology	50 X 50m
MAC Protocol	IEEE 802.15.6
Simulation Time	10 to 50 sec
Traffic Source	CBR
Channel Model	CM3 and CM4
Propagation	Two Ray Ground
Antenna	Omni Antenna
Initial Energy	12 m Joules
Transmission Power	0.5 m watts
Receiving Power	0.3 m watts

Results & Analysis of Performance

The simulation results are presented in this section.

Scenario-1 Static Position

The simulation topology for scenario-1 is given in Fig. 2. In this scenario, 12 nodes are deployed during simulation process in which node 4 and node 11 are taken as base station.

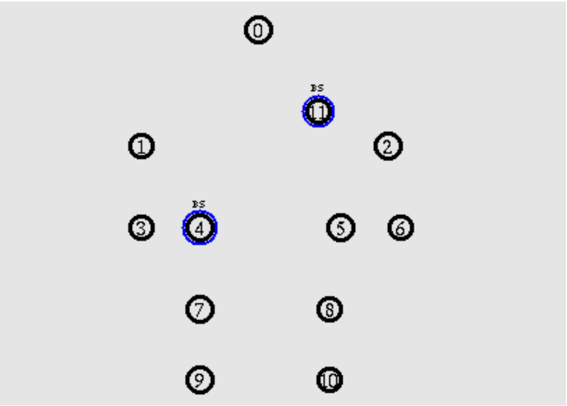


Figure 2: Simulation Topology

The throughput of AHTPC is analysed by varying simulation time and then it is compared with proactive and reactive techniques.

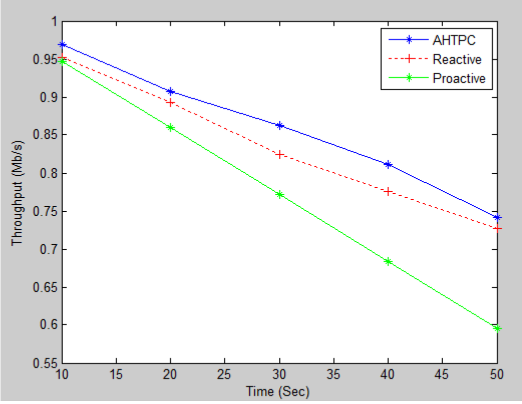


Figure 3: Throughput Vs Time (Static position)

Fig. 3 shows the throughput response of AHTPC, Reactive and Proactive by varying time. It is also inferred through the figure that, the throughput of AHTPC is 2.89% higher compared to that of Reactive and 11.48% higher when compared to Proactive. Since AHTPC checks both RSSI and PDR, it attains higher Throughput than the Proactive and Reactive techniques.

Scenrario-2 Static Position with Hands Raised and Legs Stretched

The simulation topology for scenario-2 is shown in Fig. 4. In this scenario, 12 nodes are deployed during simulation process in which node 11 and node 4 are taken as base station.

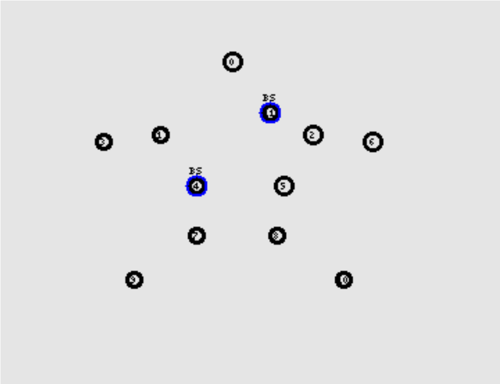


Figure 4: Simulation Topology

The throughput of AHTPC is determined and analysed by varying simulation time. Then it is compared with proactive and reactive techniques.

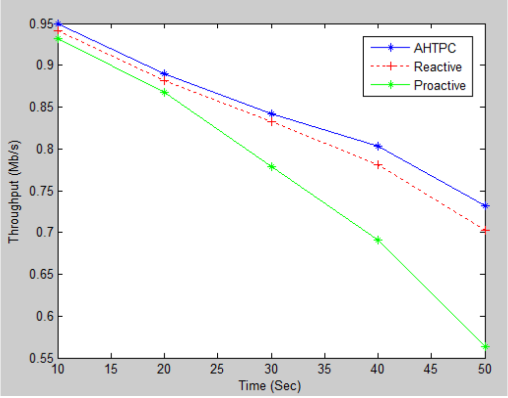


Figure 5: Throughput Vs Time (Static position with hands and legs stretched)

Fig. 5 shows the Throughput response of AHTPC, Reactive and Proactive by varying time. It is also inferred through the figure that, the Throughput of AHTPC is 1.96% higher compared to that of Reactive and 10.63% higher compared to that of Proactive. This is because the energy required to transmit data for longest path will consume more energy due to which nodes die at faster rate so as time increases throughput decreases.

Scenrario-3 Dynamic Position with Slow movement

The simulation topology for scenario-3 is shown in Fig. 6. In this scenario, 12 nodes are deployed during simulation process in which node 11 and node 4 are taken as base station.

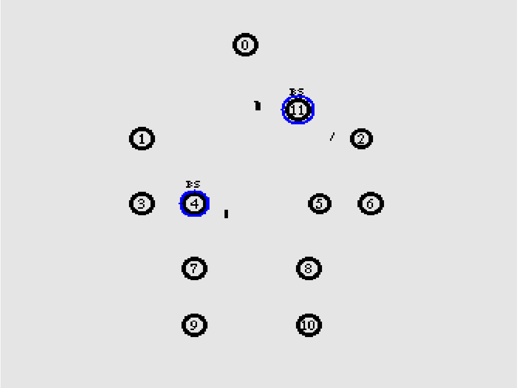


Figure 6: Simulation Topology for Scenario-3

The throughput of AHTPC is determined and analysed by varying simulation time. Then it is compared with proactive and reactive techniques.

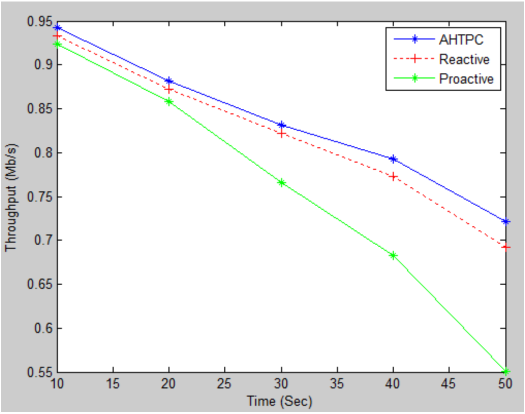


Figure 7: Throughput Vs Time (Dynamic position)

Figure 7 shows the throughput response of AHTPC, Reactive and Proactive by varying time. It is also inferred through the figure that, the throughput of AHTPC is 1.93% higher compared to that of reactive and 10.49% higher compared to that of Proactive. This is due to the involvement of more time in transmitting the packets from source to destination so that the multiples hops are required to transfer data in the network leads to decreased throughput.

CONCLUSION

In this paper, an Adaptive Hybrid TPC (AHTPC) algorithm for WBAN is proposed to control the power. In this algorithm, if strength of received signal and delivery ratio values falls outside the range of upper bound and some lower bound then execution of Reactive Transmission Power Control algorithm is done. Otherwise, the execution of Proactive Transmission Power Control algorithm (PTPC) is carried out when the channel is in fluctuating condition and consecutive RSSI samples difference become higher. Further more, the proposed AHTPC algorithm is compared with both reactive and proactive techniques. It is observed through the simulation that the proposed approach achieves less packet drop with enhanced throughput. Apart from channel condition and PDR, other parameters like duty cycle, data rate and the collision model will be considered in the future work for adaptive TPC in WBAN.

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