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Dual band Wireless Sensor Network with Reduced Routing Overhead

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***Abstract:*— Wireless sensor networks have been widely used in health care monitoring systems. With improved technologies in health care monitoring, the demand for high data rate transmission has also increased. Ultra wideband (UWB) is a short range wireless physical layer technology which is used to achieve high data rates in wireless sensor networks, without compromising the power consumption limits. The hardware implementation of UWB receivers is complex and also it consumes high power. This drawback can be overcome either by using a transmitter only method or by using a less complex narrow band wireless technology for receiver. The later method is proposed here with a narrow band feedback system, which increases the throughput. Second part of the paper deals with reducing the routing overhead of the network with a probability based method exploiting the neighbor coverage area. Simulation results show that the proposed methods improve bit error rate and throughput.**

***Key Wards:* AODV, routing, wireless sensor, ultra wide band.**

I. INTRODUCTION

Ultra wide band (UWB) technology does not use a carrier and data is transmitted in the form of short duration digital pulses [2]. Even though UWB technology meets the basic requirements of sensor networks, the hardware implementation is complex. As the sensor nodes are battery-powered, low power is required. As UWB transmitters consume low power and the data is transmitted in the form of short duration pulses, UWB receivers are complex in design. Recent researchers have found that his drawback of UWB can be overcome by using a "transmitter only" method. This method is efficient but reliability is a major challenge. Using narrow band at the receiver end instead of UWB, can reduce the receiver complexities and reduces the power consumption to a great extend [1].

The objectives of this paper are two-fold: Firstly, to improve the throughput by using the dual-band approach. Secondly, improve the end-to-end delay of the network by modifying the routing algorithm. Flooding is the simplest routing algorithm and is easy to implement, but it creates redundant copies of message. These duplicate messages increase the routing overhead and create a problem known as "Broadcast Storm" [3]. The Ad hoc On-Demand Distance Vector (AODV) [4] enables routing between mobile nodes wishing to maintain a network. Neighbor coverage rebroadcast protocol (NRBP) reduces the number of retransmissions of RREQ by collecting neighbor information and maintaining an uncovered neighbor set [5]. Each node calculates a rebroadcast delay [5], in order to find out which node should broadcast.

II. RELATED WORK

The authors in [6] proposed a multi-access scheme that is suitable for asynchronous transmit only UWB wireless sensor networks. Each sensor is assigned a unique number of UWB pulses per data bit. The number of UWB pulses assigned to the sensors is optimized to improve the bit error rate and system reliability [6]. Transmit-only scheme is not reliable as it does not send acknowledgements.

Haddady, Ribeirox, and Riedi [7] introduced a timer based scheme to reduce the broadcast storm problem. The analysis is done by assuming that there is no loss at the MAC layer. Two timer based schemes are introduced, Dynamic Reflector Broadcast (DRB) and Dynamic Connector-Connector Broadcast (DCCB) [7]. Abdulai, Khaoua, and Mackenzie [8] introduced a probabilistic location based scheme called Probabilistic Broadcast Protocol (PBP). In PBP, a rebroadcast probability is set based on the location of a node. Performance parameters like Throughput, End-to-End Delay also showed improvement. A major drawback of this scheme is that each node has to be equipped with a GPS. This increases the cost. Zhang and Wang [8], proposed Estimated Distance based Routing Protocol (EDRP) algorithm which extracts the distance information without using the Global Positioning Service

[8]. EDRP shows less routing control traffic than AODV. But, other performance parameters like Packet Delivery Ration and Latency are not improved, when compared to that of AODV. The Neighbor Coverage based Probabilistic Rebroadcast protocol (NCRP) is developed by Zhang Wang, Xia and Sung [5], to reduce routing overhead in Mobile Ad hoc networks. A parameter termed "rebroadcast delay" is set which determines the order of data forwarding. The node which has more common neighbors with previous node is said to have low delay. If this node rebroadcasts a packet, then it will reach more neighbors than a node with less common neighbors. Each node also maintains an "Uncovered Neighbor set" to exploit the neighbor knowledge [5].

III. PROPOSED SCHEME

A. Dual Band Approach

PPM (Pulse Position Modulation) based Impulse Radio UWB (IR-UWB) is used in this paper. IR-UWB transmits pulses of short duration and therefore, simple modulation schemes like PPM can be used. UWB transmitter consists of a binary source, code repetition coder, Time hopping and PPM shift and a pulse shaper. The channel used is IEEE 802.15, which is the modified version of Saleh-Valenzua Channel. The use of RAKE receivers in UWB increases its complexity. The use of SRAKE or PRAKE reduces complexity. A Selective RAKE (SRAKE) receiver selects the strongest multipath component and a Partial RAKE (PRAKE) receiver selects first few multipath components. The performance of both SRAKE and PRAKE is compared in MATLAB.

Each sensor node is a transceiver. In Dual band approach, the sensor nodes transmit data to a Coordinator node using Ultra wide band and the Coordinator node send back an acknowledgement to the sensors using Narrow band. It can be observed that the performance of Dual band sensors is better than that of sensors which use UWB for both uplink and downlink transmissions.

B. Neighbor Coverage Rebroadcast Protocol

For reducing the routing overhead between Coordinator nodes, Neighbor coverage Rebroadcast Protocol is proposed. Neighbor coverage rebroadcast protocol (NRBP) reduces the number of retransmissions of RREQ by collecting neighbor information and maintaining an uncovered neighbor set [2]. Each node calculates a rebroadcast delay [5], in order to find out which node should broadcast. A rebroadcast probability is also set depending on the coverage ratio and node density. When a node x sends an RREQ packet to its neighbor node y, node y can use the neighbor list in RREQ to determine how many of its neighbors have not been covered by the RREQ from node x. If node y has more neighbors uncovered by RREQ from node x, it means that if node y broadcasts the RREQ, the RREQ can reach more additional nodes.

IV. RESULTS AND OBSERVATIONS

A. Bit Error Rate of UWB RAKE Receivers

A binary source generates bits which are repeated N times to obtain a binary sequence. The sequence is encoded using Time Hopping spreading. This is done to shape the spectrum of transmitted signal. Figure 1 shows the transmitted signal with 3 Pulses per Bit.

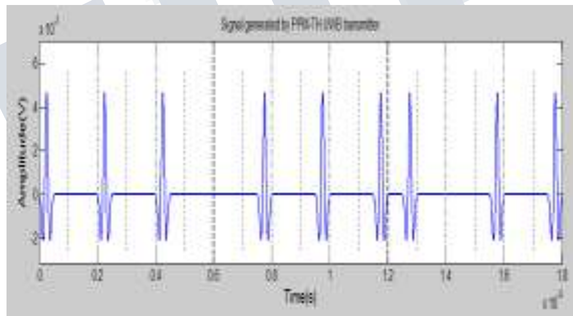

Fig 1: PPM UWB transmitted signal

The use of PRAKE or SRAKE reduces the number of correlate branches in an Ideal RAKE receiver. The Bit Error Rate performance of UWB network is simulated in Matlab and is shown in figure 2.

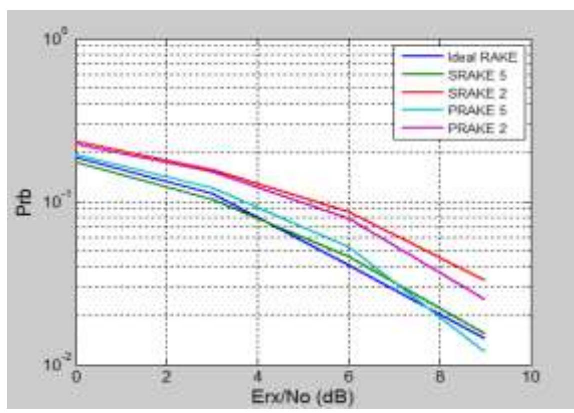

Fig 2: Bit Error Rate of SRAKE and PRAKE

The BER of SRAKE and PRAKE with five and two number of branches are simulated. Figure 3 shows the variation of BER with number of pulses per bit.

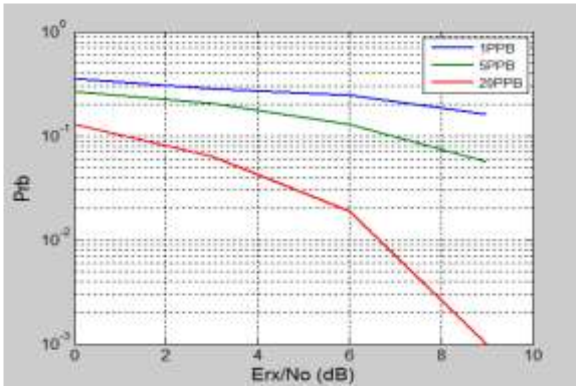

Fig 3: Bit Error Rate with varying Pulses per Bit

B. Dual band approach

The dual band approach is simulated in NS2 version 2.29. Three different topologies were created each for Dual band and also for UWB sensors. Routing algorithm used in this simulation was AODV. Throughput is a measure of packets received successfully at the Coordinator node. Throughput is obtained as shown in figure 4.

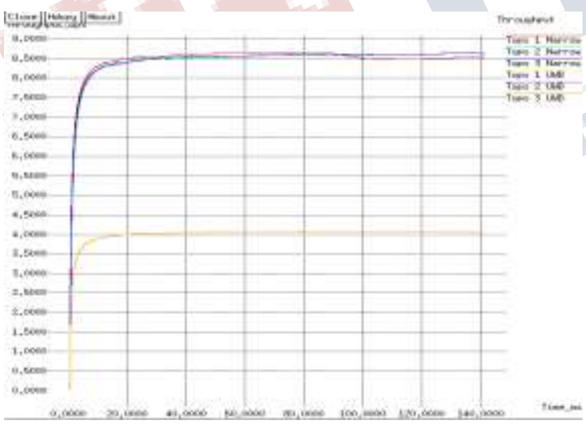

Fig 4: Throughput analysis

A higher throughput is observed for network which is using Dual band (Narrow band and UWB), when compared with network which uses UWB for both uplink and downlink transmission.

C. Neighbor coverage Rebroadcast Protocol

Two wireless networks with 17 coordinator nodes are setup in NS-2. NRBP is configured in one network and AODV is configured in the other. NRBP reduces the broadcasting nature of RREQs and therefore, the number of control packets send in NRBP is expected to be less when compared with that of AODV. Also, when the control packets are generated less, more number of data packets could be generated at the source. The comparison of Control packets generated is shown in figure 5

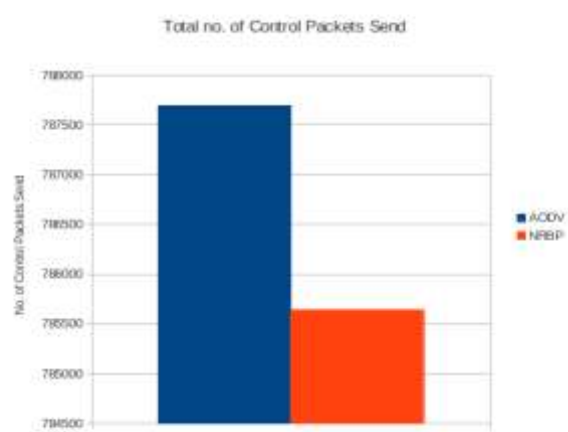

***Fig 5: Number of Control packets generated*.**

In NS-2, packets are continuously generated until the simulation ends. So, as the simulation time increases, more number of packets is generated from the source. Therefore, the number of received packets increases with time. This is shown in figure 6.The end-to-end delay comparison between AODV and NRBP is shown in figure 7. Since less number of RREQ is generated in NRBP, the delay in processing control packets will be less than that of AODV.

Thus, average end-to-end delay decreases in NRBP. Since the number of generated packets is more in NRBP, the number of received packets also increases. Less number of Control packets in NRBP reduces the chance of packet drop due to collision. Thus, the throughput of NRBP increases with time. The X graph output for throughput comparison is shown in figure 8.

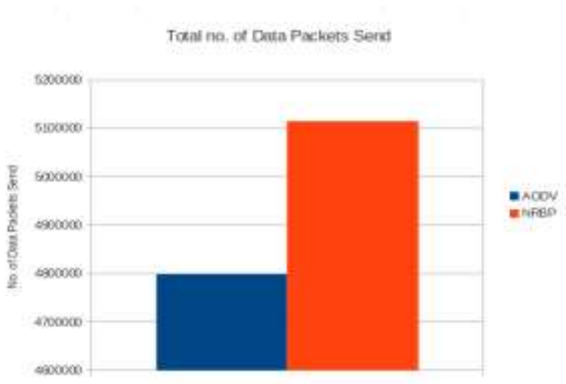

Fig 6: Number of data packets generated

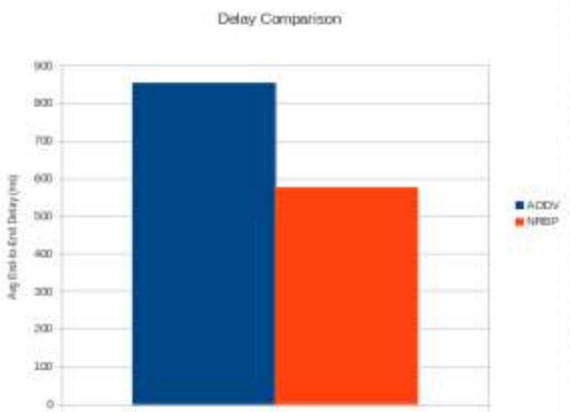

Fig 7: End-to-end delay

Fig 8: Throughput analysis

V. CONCLUSION

The performance of UWB system was studied. UWB receivers are generally complex and thus increase the power consumption. But UWB is widely used for achieving high data rate. Acknowledgements that are sent during communication in a network does not require high data rate and therefore it is send using narrow band transmission. Sensor data packets which require high data rate are sent using UWB. It is observed that throughput is improved in Dual band network. Simulation results show that NRBP protocol reduces the redundant rebroadcasts of control packets, so as to increase the network throughput and decrease the average end-to-end delay of the network.

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