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Network Coding Technique Based On Intelligent Hybrid MAC in Wireless Sensor Networks

Riyana M.
M. Tech. Student, AE & CS, ECE Department
Nehru College of Engineering and Research Centre, Pampady, Thrissur, India
Nithin Joe
Assistant Professor, ECE Department, NCERC Pampady, Thrissur, India

Abstract:
In existing method, IH-MAC based on QOS achieves energy efficiency and channel utilization during high traffic load. And also it uses the concept of parallel transmission to reduce delay but the information of the packet will lost during the parallel transmission and the data rate and speed slightly reduced in wireless sensor networks. Network coding technique is used in proposed system to improve energy efficiency, multicast capacity and to decrease packet delay and latency. Network coding enables the delivery of different packets to distinct neighbors in single transmission. It uses encoding and decoding techniques for better throughput and increase channel capacity. Network coding with intelligent hybrid MAC (IH-MAC) achieves high energy efficiency under wide range of traffic-load. It achieves high channel utilization during high traffic-load without compromising energy efficiency. And security is the important factor during parallel transmission in wireless sensor networks. So here secure routing based on random coding (SR-RC) is used, which utilizes two set of random numbers to ensure that the coverage nodes can decode the packets successfully. Random parameters without encryption and encrypted random parameters these are the two types of random numbers. First one which allows the relay nodes to estimate the dependency of coefficient vector and another one which protects data from eavesdropped. When compared to the existing system, proposed system gives better energy efficiency and channel utilization than the existing system.

Keywords: *network coding algorithm, IH-MAC protocol, secure routing based on random coding (SR-RC*

1. Introduction

Wireless sensor networks are the networks which consist of a large number of wireless sensor nodes that are deployed randomly. The sensor nodes are typically small, and equipped with low powered battery. Wireless networks, it is generally impractical to charge or replace the exhausted battery. The lifetime of the sensor nodes is very important; energy efficiency becomes the most important attribute for the design of MAC protocol of sensor networks. Idle listening is the major source of energy wastage for wireless sensor networks. Therefore, in sensor networks, nodes do not wake up all the time rather prefer energy preservation by going to sleep time.

After the sleep scheduling, nodes could operate in a low duty cycle which can significantly save energy and extend the network lifetime at the expense of increased communication latency and synchronization overhead. In different sleep scheduling schemes are analyzed and scheduling methods can decrease the end to end delay. But this method does not provide an interference free scheduling. The performance of broadcast scheduling is worse than link scheduling in WSNs, in terms of energy conservation. Hence, a hybrid MAC protocol for wireless sensor networks, called IH-MAC has used, which combines the strength of CSMA, link scheduling and broadcast scheduling. The IH-MAC which guarantees shorter latency for critical and delay sensitive packets and it reduces the energy consumption by suitably varying the transmit power. And it uses the concept of parallel transmission to reduce delay but there should be a possibility for data loss during the transmission and eavesdropping attack. So network coding algorithm is proposed, which will apply to IH-MAC protocol to increase network performance, and also it increases the end to end through put. Network coding is the technique where the relay nodes which mix up the incoming data's from the source in relay nodes and transmitted to the destination .it will increase the speed, channel utilization as well as each edge has maximum capacity in sensor networks. And security is the important factor during parallel transmission in wireless sensor networks so secure routing based on random coding (SR-RC) is used. which utilizes two set of random numbers to ensure that the coverage nodes can decode the packets successfully. In SR-RC, relay nodes allow to re-encoding the received data. Random parameters without encryption and encrypted random parameters these are the two types of random numbers. First one which allows the relay nodes to estimate the dependency of coefficient vector and another one which protects data from eavesdropped.

There are many applications of wireless sensor network where it is really needed to ensure the priority services for the critical data. One typical example can be a building equipped with a WSN where the sensor nodes monitor the power consumption of appliance in the building .another duty of the nodes is to work as a smoke detectors, and report alarms to fire monitoring hubs. So, in case of the communicating the later kind of data, it is desirable to ensure lowest possible latency. And also used in military applications.

2. Literature Review

For sensor network, S-MAC is one of the pioneering works in contention based MAC protocol. In S-MAC nodes operates in low duty cycle and energy efficiency is achieved by periodic sleeping. Nodes form virtual clusters, based on common sleep schedules, to reduce control overhead and enable traffic adaptive wake-up. T-MAC improves the energy efficiency of S-MAC by introducing adaptive duty cycle. T-MAC reduces the idle listening by transmitting all messages in burst of variable length and sleeping between bursts and it maintains an optimal active time under variable load by dynamically determining its length. TDMA has long been dismissed as an unfeasible solution for wireless ad hoc networks for its lack of scalability and adaptability to varying environments. However, it provides a good energy efficient and collision free communication. Recently several techniques have been proposed for TDMA in sensor networks. Nevertheless, these protocols still are unsuccessful to address the fundamental difficulties that stand-alone TDMA scheme face.

IH-MAC is completely different from Z-MAC and similar hybrid MAC protocol. Because in IH-MAC, each node calculates its own slot locally and independently, this is very flexible. IH-MAC is hybrid in the sense that it combines CSMA, the broadcast scheduling and link scheduling dynamically to improve the energy efficiency. Another important feature of IH-MAC is that it reduces energy consumption by suitably varying the transmit power and it reduces the latency by exploiting the concept of parallel transmission.

Network coding technique is used in the proposed system to improve energy efficiency, multicast capacity and to decrease packet delay and latency. Network coding enables the delivery of different packets to distinct neighbors in single transmission. It uses encoding and decoding techniques for better throughput and increase channel capacity. Network coding with intelligent hybrid MAC (IH-MAC) achieves high energy efficiency under wide range of traffic-load. It achieves high channel utilization during high traffic-load without compromising energy efficiency.

3. Intelligent Hybrid MAC Protocol Design

A Times- lot or Slot or a Frame is defined as the periodic interval, which consists of an active period and a sleep period. A duty cycle is the proportion or ratio of the active period to the entire cycle time (frame length). A rendezvous slot is defined as a time slot explicitly dedicated to a pair of nodes to communicate with each other. During rendezvous, a node forms a channel for transmission and reception with one of its neighbor. The term channel here refers to a time period or slot as opposed to frequency or code. IH-MAC classifies packets according to their importance (i.e. delay requirements) and stored the packets into the appropriate queue. The source node knows the degree of importance of the sensed data and accordingly the application layer sets the priority. Application layer does it by appending 1 extra bit at the end of the data packet. Fig. 1 shows the format of each data packet. The mechanism of IH-MAC is based on dividing the communication time into fixed length slots or frames. The contents of each slot are shown in Fig. 2. Each slot begins with a SYNC period. The purpose of the SYNC packet is to maintain synchronization between the nodes within the same virtual cluster. The next part of the active period of the frame is reservation slot which is used for the data slot reservation. And the last part is used for data and ACK transmission by sensor nodes.

Header	Data	Extra 1 bit (appending by app layer)

Figure 1: format of data packet

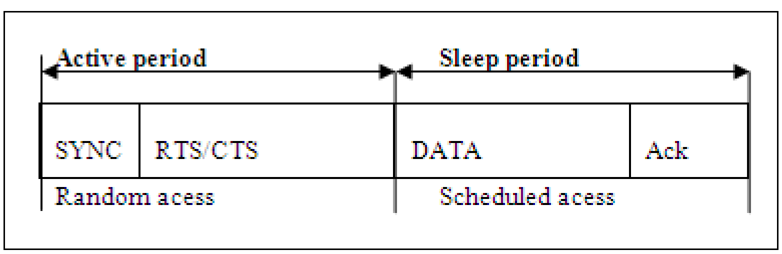

Figure 2: content of slot or frame for IH-MAC

3.1. Parallel Transmission

Let us consider that node A wants to send a message to node B. First of all A will send a RTS packet to the sensor node B. But node C will overhear the RTS packet because the node C is within the transmission range of node A. By overhearing the RTS the node C concludes with the decision that the transmission medium is busy.

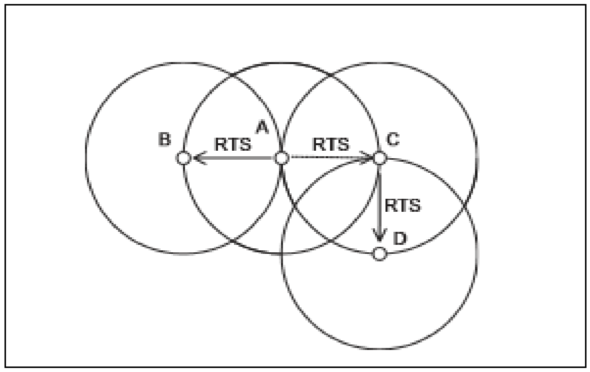

Figure 3: idea of parallel transmission using four nodes

Now let us consider at the same time node C has a data to send to D. In the conventional method, since node C knows that the transmission medium is busy it will not send any message to initiate any transmission. But we can see from the figure that the communication (RTS) from node C to node D will not affect the previous communication i.e., communication (RTS) from node A to node B. Since collision happens at the receiving end, and node B and node C are not within the same transmission range, transmission of C by no means will interfere with the reception of node B. Similarly if node B sends a RTS to node A, node A will reply with a CTS. This CTS will be overheard by C. But C need not to stop its transmission and it can send or receive during this time without any collision. It should be noted here that, when a node is within transmission range of a sender node, it can receive and correctly decode packets from the sender node. And when a node is within the carrier sensing range of a sender node, it can sense the sender's transmission. Carrier sensing range is typically larger than the transmission range; we use the carrier sensing range as two times larger than the transmission range. Again, the carrier sensing range and transmission range depend on the transmit power level. Now, if a node is outside the transmission range of a sender node but within the carrier sensing range then the node cannot perform any parallel transmission while that particular sender node is communicating. It is because, the node outside the transmission range and within the carrier sensing range can sense the packet but cannot successfully decode the packet. So, with the communication range and the sensing range, the reduction of delay (i.e., increased scope of parallel transmission) depends on the topology of the particular (deployment) sensor network.

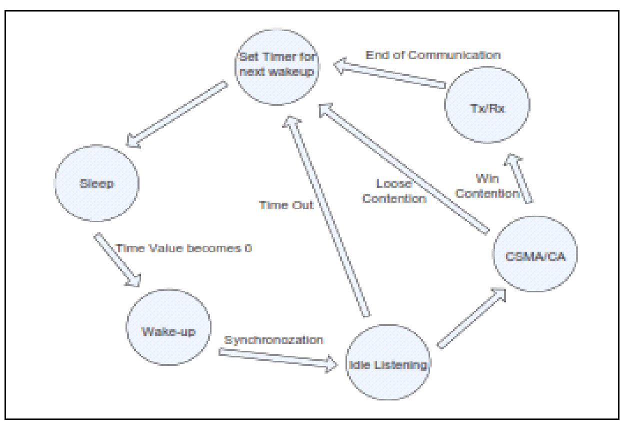

Figure 4: state machine of IH-MAC

During the sleep state the node turn off its radio and start a timer whose duration is predefined according to the duty cycle of the protocol with consideration of the existence of rendezvous communication between any pair of nodes. When the timer expires, the node goes to wake-up state. It turns on its radio and switches to listen to the data channel and its goes to idle listening state. If the node have any data to send or receive it goes in the CSMA/CA state otherwise after time out it goes to sleep state. If the sender node wins the contention both the sender and the intended receiver go to the *Tx/Rx* state and go to sleep state after successful communication. Nodes that fail contention go to sleep state.

4. Network Coding Algorithm

Network coding is the technique where the relay nodes, which mix up the incoming data's from the source in relay nodes and transmitted to the destination. It will increase the speed, channel utilization as well as each edge has maximum capacity in sensor networks. And security is the important factor during parallel transmission in wireless sensor networks so secure routing based on random coding (SR-RC) is used.

Network coding has been used as a method to increase the multicast capacity of wireless networks. In contrast to the store-and-forward paradigm of routing, network coding allows nodes to combine packets before forwarding them. In essence, network coding enables the delivery of different packets to distinct neighbors with a single transmission. Coded packets must be multicast for network coding to gain efficiency. Moreover, it is essential that uncoded packets be overheard by neighbors to enable inter flow coding i.e., uncoded packets may need to be multicast. . COPE requires nodes to overhear transmissions in their neighborhood. In addition, nodes in COPE need to know which packets have been received by their neighbors. This information is collected in one of the following ways asynchronous ACKs, packet reception reports, or probabilistic packet delivery information based on Expected Transmission Count (ETX) . Once a node is made aware of the packets available at its neighbors, it codes packets that can be decoded by all neighbors. Note that COPE scans only the 1-hop neighborhood of the transmitting node for opportunity to send coded packets. In addition, encoding and decoding is performed on a per-hop basis.

The broadcast nature of wireless networks is considered a challenge, as it creates interference between the links and produces unnecessary multiple copies of the same packet. However, if we allow the intermediate wireless nodes to code the packets, the broadcast nature becomes an opportunity. Consider the example, in Figure 5, where nodes s1 and s2 want to exchange their own packets, p1 and p2, respectively. Assuming that these nodes are out of range of each other, this communication incurs four transmissions; two transmissions for sending the packets to the relay node, and two transmissions for relaying the packets. However, the relay node can simply XOR the packets and send the coded packet p1⊕p2, which is shown in Fig:5. The nodes s1 and s2 can retrieve each others' packets by XOR-ing p1⊕p2 with their own packets, p1 and p2, respectively. As a result, the number of transmissions has been reduced to three by using binary network coding. Inter-session network coding solves the bottleneck problem and reduces the number of transmissions, by allowing packets from different sessions (sources) to be coded together. By reducing the number of required transmissions, network coding increases the throughput and decreases the interference between the links in wireless networks.

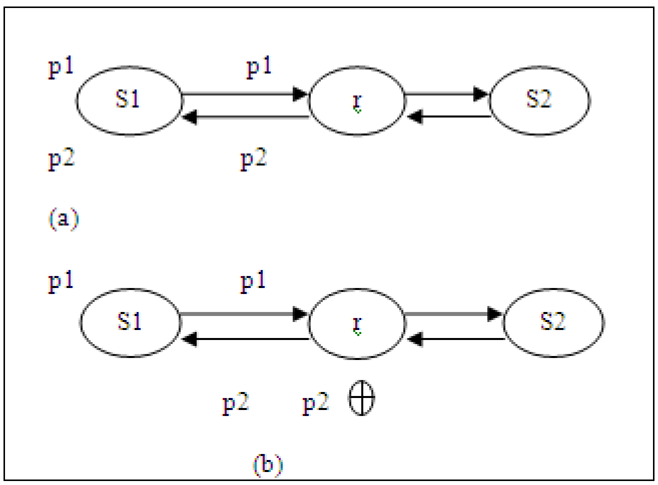

Figure 5: binary network coding

Another important application of network coding is to provide reliability in wireless networks. The traditional way to provide reliability for both wired and wireless networks is to use feedback messages to report the received (or lost) packets. By using feedback messages, the sender node will know which packets need to be sent again. However, these feedback messages consume bandwidth. Consider the example in Figure 5; the source node wants to deliver packets p1 and p2 to the node d. The reliability of the link s1 →d is equal to 2 3. In the case that the source node sends three coded packets, p1 + p2, p1 +2p2, and 2p1 + p2, on average, the destination

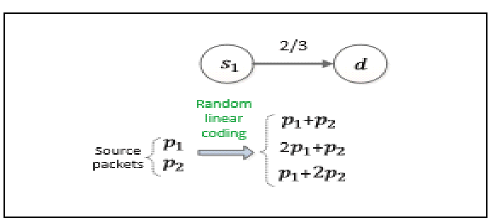

Figure 6: Application of network coding to provide reliability

node will receive two of the three coded packets. Therefore, the destination nodes will be able to retrieve the packets p1 and p2. However, without network coding, we need to use a feedback mechanism or else the source node needs to transmit each packet twice. As a result, communication schemes with network coding can provide reliability with a fewer transmissions than schemes without network coding. Coding the packets from the same session (source) is called intra-session network coding, which exploits the diversity of the links. In intra-session network coding, the packets from the same source are coded together (usually linearly), which makes the importance of the packets the same. Therefore, when k packets are coded together, a relay node does not need to know exactly which packets are received by the destination node; it is thereby enough to successfully deliver k coded packets out of the transmitted coded packets.

Network coding is the potential technology to decrease the communication traffic of wireless sensor networks. However ,it also suffers from the security threats such as eavesdropping or tempering.so secure routing based on random coding (SR-RC) is used for security in wireless sensor networks.

5. Secure Routing Based On Random Coding (Sr-Rc)

SR-RC utilizes two sets of random numbers to ensure that the converged nodes can decode the packets successfully. In SR- RC, relay nodes are allowed to re-encoding the received data. For example, an intermediate node receives the encoded data D1 and D2 , another intermediate node receives D3 and D4 . These two nodes will find the next hop node and forwards the data directly. If the intermediate nodes lost packets D2 and D4 in the forwarding process, whether the lost packets can be recover is very important. If the D1 and D3 are linear dependence, the sink code cannot successfully decoding the original data after receiving h copies due to the rank of coefficient vector matrix is less than h. If the relay node can re-encode the data from D1 , D2 to D1' , D2' which are linear independent, even if packets D2' and D4' was lost, the sink node can decode successfully. As a result, the decoding probability of the sink node is greatly increased. two types of random numbers: 1)random parameters without encryption. This type allows the relay nodes estimate the dependency of coefficient vector; 2)Encrypted random parameters. This type protects data from being eavesdropped. After generating a new encoded packet, the two random vectors are placed at the header of the packet and sent together with the coded data.

6. Evaluation and Performance

The proposed system approach is implemented in WSN with a particular dimension. The total number of sensor nodes used is 51. Over the sensing field the sensor nodes are randomly distributed. The sensor nodes are selected in between the dimension of 0 and 50. The average energy of the sensor nodes is set to be 100J. Packet loss rate is the equal in every node and the length of the original packet is set to 200 bytes. The performance of the proposed system is estimated by the key indicators energy consumption and network lifetime. Table 1 shows the simulation parameters used in wireless sensor networks.

Target monitoring area	100m*100m
Number of sensor nodes	51
Original packet length	200
The energy consumption of circuit nodes while Data transmission	48mw
Delivery ratio	99.82%
maximum end to end delay	20-40 ms
Duty cycle	15%

Table 1: simulation parameters

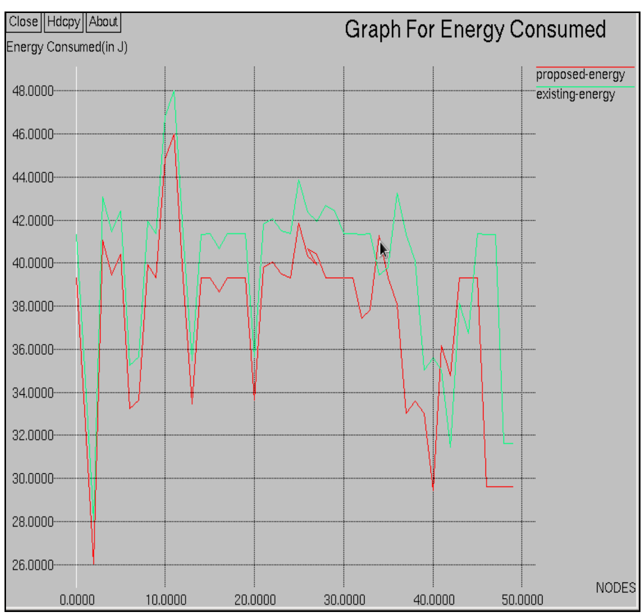

Figure 7:energy consumped by nodes

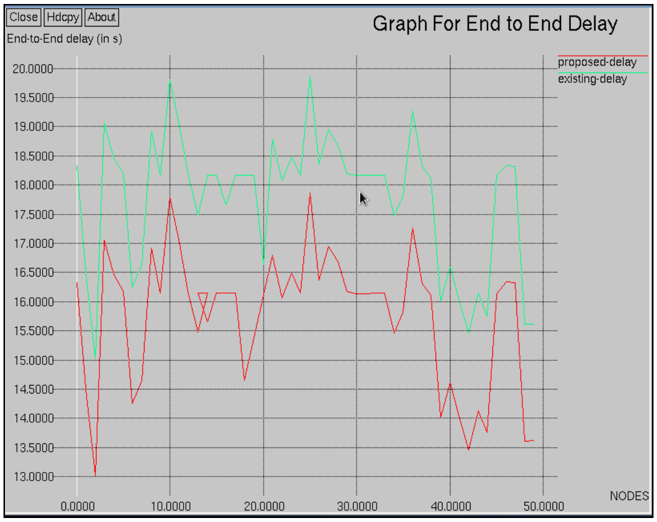

Figure 8: end- to end delay

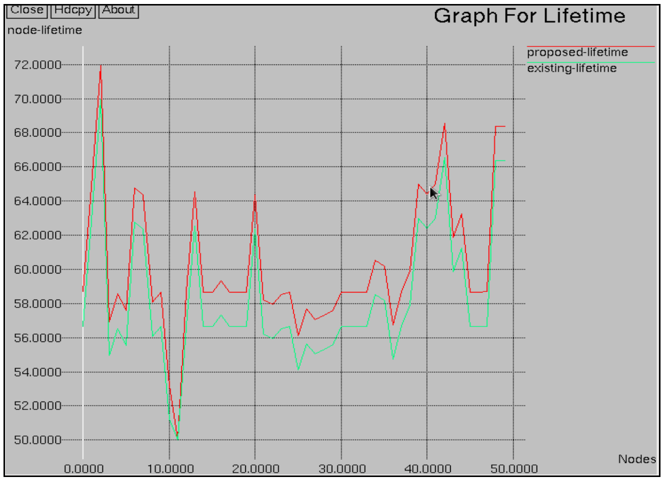

Figure 9: node life time

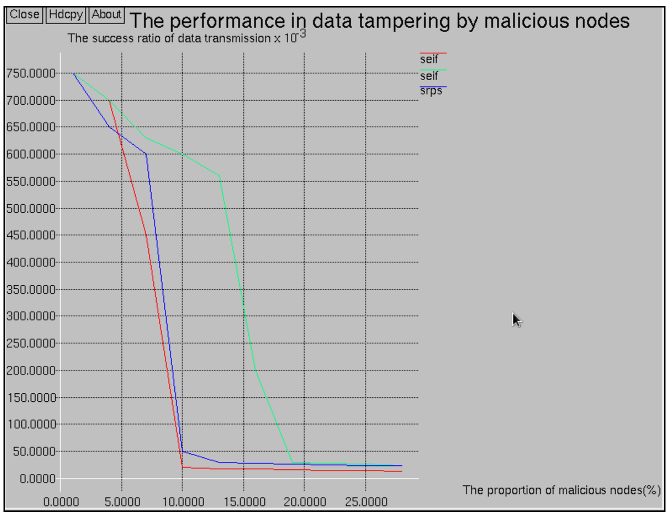

Figure 10 : performance in data tampering by malicious nodes

6. Conclusion

An network coding technique is used in proposed system to improve energy efficiency, multicast capacity and to decrease packet delay and latency. Network coding with intelligent hybrid MAC (IH-MAC) achieves parallel transmission by transmitting a signal with appropriate power. However network coding algorithm suffers from security threats such as eavesdropping attacks. So security is the important factor during parallel transmission in wireless sensor networks so secure routing based on random coding (SR-RC) is used. That utilizes two set of random numbers to ensure that the coverage nodes can decode the packets successfully. In SR-RC, relay nodes allow to re-encoding the received data. From simulation results we can see that it is effectively resist from eavesdropping attacks or tempering and Communication between sensor nodes is secured by using SR-RC algorithm. Finally simulated the proposed model and compared with the existing system. At end, performance of the proposed system is analyzed and evaluated with the existing work. Energy consumption and node life time is reduced and well balanced while compared to the existing system. In the future work, we intend to further improve the routing algorithm, by reforming network coding algorithm to reduce packet delay.

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