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Fairness Aware Probabilistic Algorithm with Rate Control and Congestion Avoidance in WSN

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Abstract: Designing a sensor network as per the customer needs is the challenging task. While designing, we have to maintain some parameters like network life time, throughput, packet drop, congestion control, fairness and node energy. Congestion leads to the main issues in the network at both sender side and also in the receiver side. Congestion occurs due to more sensors, packet drop, receiving more packets than transmitting and buffer queue size. Here, we propose a fairness aware scheme with MRCCAP that shares the resource allocation, channel bandwidth. FACC protocol controls the congestion at base station which provides the support for QoS. Intermediate nodes are placed nearer to source and sink nodes to determine the flow rate, arrival time and queue size. Congestion avoidance algorithm deals with the ratio of the number of upstream nodes to the number of downstream nodes. In connection with gained weight buffer management with a probabilistic algorithm, it will provide efficient fairness and better network performance. The simulation results show that the proposed model provides better throughput, packet loss and network lifetime compared to the previous technique.

Key words: FACC protocol, congestion avoidance, fairness and QoS, nodes, throughtput

INTRODUCTION

Wireless sensor networks is an emerging technology with vast applications like industrial, health care, object tracking, military purposes and environmental monitoring. All these applications mainly deal with the network layer and MAC layer. In these layers, the packets are transmitted from one node to another node in random motion. In designing a wireless sensor network, placing nodes at regular intervals of time is the main features for bandwidth utilization, path allocation and coverage area. If multiple packets are received by a same node from multiple paths, it leads to the traffic. It occurs when the received packet size exceeds the queue length. This traffic results in congestion over the network, reduces the system performance and network life time (Shih *et al*., 2001)

A congestion control technique relates the detection, notification and avoidance at either node or link. Here, we deal the fairness only with the congestion avoidance. When the queue occupancy is less than the congestion threshold, the congestion gets avoided in the buffer state. Packet collision in MAC layer is due to overhearing the data at the transmission side. In ESRT, the congestion is monitored and gets only notified at the packet header, thus packet drop is reduced (Sankarasubramaniam *et al*., 2003).

FACC protocol deals with flow state mechanism and fair rate at the source node and sink node. To distinguish between source nodes and sink node, a source ID is placed and it is set as 1 in source node. If it is set as 1, it is transmitting to the neighbor nodes and if it becomes 0, then it reaches the sink node. A queue is maintained at the source and sinks with a congestion threshold. If the queue is less than the threshold, it will be in accepted state and if the queue is greater than the threshold, it will go to rejected state. Compared to back pressure algorithms, it provides higher throughput and reduces the packet loss (He *et al*., 2003).

Literature review: Fair Media Access Control (FMAC) protocol is designed for connectivity between the sender and the receiver. The flow of packets and information is shared and it has three different modes, aggressive, restrictive and normal. In restrictive mode, the receiver collects the feedback and it slows the process from the transmitter side (Chen *et al*., 2007). If the sender acts as an aggressive mode, it gets feedback from the transmitter and it starts transmitting to the receiver node. In this shared medium the transmitter and receiver nodes do not get any feedback; then normal mode will take place. To achieve throughput in FMAC protocol, the size of the contention window is the essential factor.

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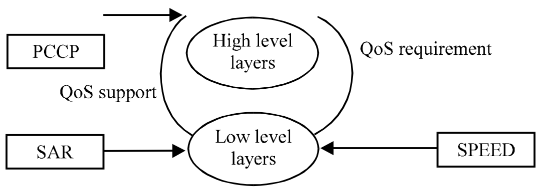

Fig. 1: QoS with opportunistic routing

ESRT is an event detection protocol which will transfer the information from node to node. It serves the congestion control techniques to improve the reliability and energy utilization. If the node energy is minimum, it is difficult to transmit the packets to another node. Here, self-configuration is established in ESRT for flexibility in the operation of network. The main thing in ESRT is minimum energy expenditure which the sink utilizes more energy then the source starts consuming the energy (Sankarasubramaniam *et al*., 2003). In sink node, there is a possibility of congestion results in unnecessary energy consumption. If congestion occurs, the information is passed to the sink node and notification is sent to other nodes within the radius.

QoS is a service provider which sensor transmits information towards sink node. QoS approaches the multipath routing with geographical area is termed as Efficient QoS Geographical Opportunistic Routing (EQGOR) and it is shown in Fig. 1. Although is a multipath, it takes very low time (Chen and Varshney, 2004).

COEQ protocol in which coding opportunities are selected in the optimal path. It leads to reduction in packet loss, delay and improvement in energy efficiency. The requirements of QoS in wireless sensor networks are energy consumption, throughput, delay and bandwidth (Meguerdichian *et al*., 2001). Sequential Routing algorithm is used for path selection and each sensor utilizes it. If congestion arises in the network, PCCP is used for better performance of QoS support. It is an upstream protocol where data packets have weighted fairness. With the support of QoS, PCCP will improve energy efficiency, throughput and packet loss ratio.

MATERIALS AND METHODS

Fairness and congestion avoidance metrics

Congestion avoidance: When the queue occupancy is less than the congestion threshold, congestion is avoided in the buffer state. The source should send the information to the neighbor nodes in which the alternate path is chosen, leads to congestion avoidance on the links and paths (Floyd and Jacobson, 1993). The congestion occurs due to packet collision and multipath traffic which reduces the energy efficiency and system performance of the network. To avoid congestion, packets are forwarded to every nodes and packet fairness in the sensor networks. Upstream and downstream nodes are used for queue monitoring to check the congestion level inside all the nodes (Tao and Ya, 2010) (Fig. 2).

The sensors are transmitting the packets to the network. If the node receives the packet, then the packet is checked for congestion. The checked congestion may be in the form of data rate, upstream/downstream, queue length, node delay, etc. If congestion is detected, congestion notification may send either implicit or explicit. Now, congestion is avoided by using AMID, rate control and traffic aware mechanism. The congestion avoided packet is now transmitted to the next node (Paek and Govindan, 2007).

Congestion avoidance by overhearing: In wireless sensor network, overhearing leads to an energy waste in the 2 nodes. It can act efficiently to reduce the redundant transmission in wireless sensor networks. The network uses MAC protocol like CSMA/CA in which the nodes have to listen to the medium for transmission using overhearing technique. Hence, the node has to consume more energy to overhear. In RCCAP protocol, sensor node utilizes the advantages of overhearing to know about the congestion in the neighboring nodes by estimating the correspondence nodes buffer occupancies. It estimates the number of message queued in the buffer and alters the routing path where the congestion is minimal. This leads to reduction in the packet drop as well as minimization of transmission delay.

In Fig. 3, source node tries to send some packets to the sink node. The packet reached node 1 from source node. The node 1 overhears that node 2 is congested and hence the node 1 directs the packet to node 3 to reach the sink node. Thus, it reduces packet drop and transmission delay of the network.

M-RCCAP protocol: Modified rate control congestion avoidance protocol is to determine the buffer length and rate control packets by considering each node will maintain the steady transmission rate and packet arrival time. The main thing to modify this protocol will improve the stability of the network. In PCCP it achieves, only 52% of throughput and fairness efficiency is low. Here, in our new proposed protocol is a hybrid topology were overhearing problem is also rectified. The sample period is measured for every time and by varying features, we measured the throughput for different time periods.

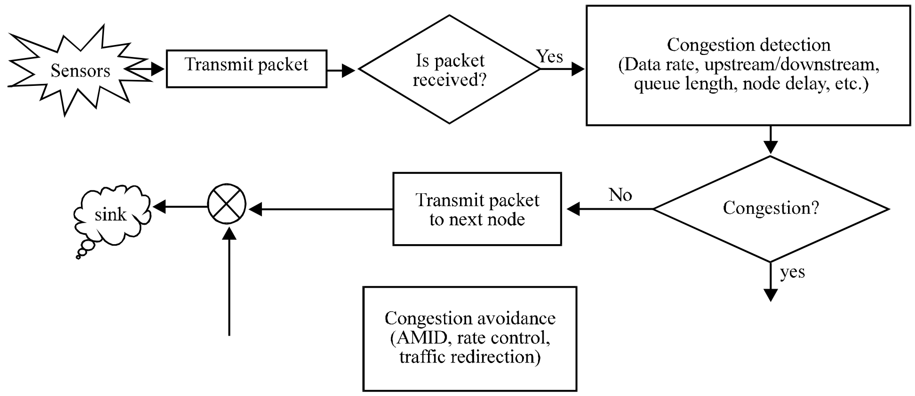

Fig. 2: Overview of congestion control protocols

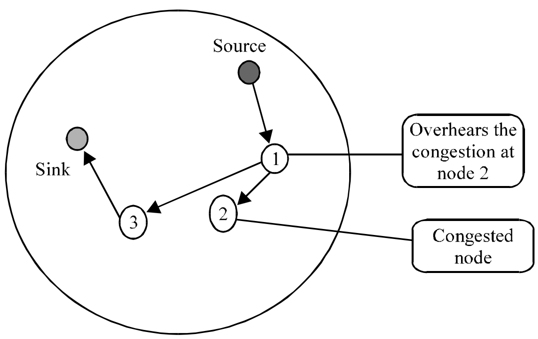

Fig. 3: Congestion avoidance by overhearing

A feedback control loop is designed to determine the total rate of control packets. The light-weight buffer technique will produce only 50% of throughput. To improve this, globalized probabilistic dropping packet's algorithm was designed. In this technique, the controller was designed and error message is sent to every node. If error is detected, it starts recovering the packets or data. This leads to improve in throughput and network performance.

Fairness aware congestion control scheme: In this scheme, the nodes are identified according to their placement from the sink. Nodes nearer to sink are called near sink nodes and the nodes which are far away from the sink are called near source nodes. Near the source, node will distribute the rate of every flow. If there will be the change in flow, light weight probabilistic dropping algorithm is used as per the occupancy of a queue (Sridharan and Krishnamachari, 2007). Near a sink node undergoes larger traffic than the near source node and it does not allocate a rate to flow limit. It gives warning message during packet drop and sends this information to near source node. Hence, near a source node will allocate, a light rate contributes to every flow.

The fairness aware scheme is used to control the congestion. In case of packet loss, nearer source node has to maintain flow state which further reduces the energy of the nearer source nodes. In case of energy consumption, it becomes unfairness which leads to the reduction of the network lifetime.

In Congestion Control and Fairness (CCF) algorithm according to the input and output traffic rates, it will increase or decrease the bandwidth to flow. It achieves high throughput and is independent of routing topology. In DCCA algorithm, the problem which occurs in multi hop wireless sensor network disturbing the sink is resolved. This algorithm is used for the MAC layer in which fair MAC protocol is implemented. Queue based congestion detection is to drop the packets or forwarding of packets is decided by the individual node (Wang *et al*., 2011).

RESULTS AND DISCUSSION

The implementation is done in Network simulator tool (Ns-2). Various parameters like packet drop, throughput, offered load, energy expenditure and fairness are measured. The nodes are placed at the hybrid terminal with random positions. In this simulation, we compare the new techniques with the existing techniques like no congestion control, fair MAC protocol and FACC protocol. The proposed model gives the better performance compared to existing model.

Packet drop comparison: Packet drop occurs due to Denial of Service (DoS). When malicious node or intruders enters into the network, packets gets dropped in every node. Figure 4 shows the comparison of packet drops between FMAC, FAAC and RCCAP techniques. If congestion is not controlled, there is a continuous flow

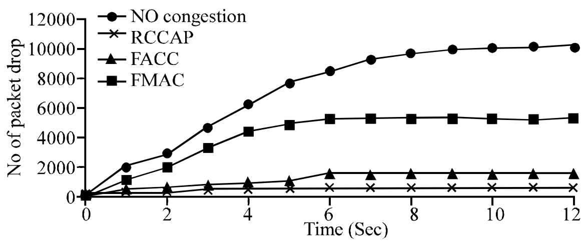

Fig. 4: Comparison of packet drop

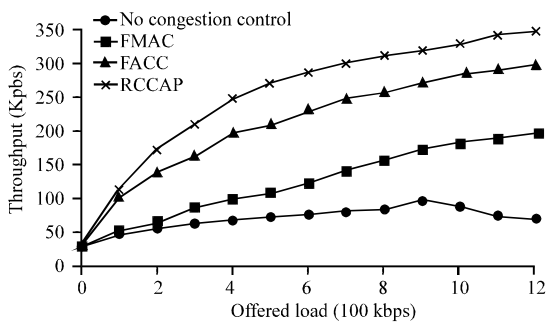

Fig. 5: Comparison of throughput

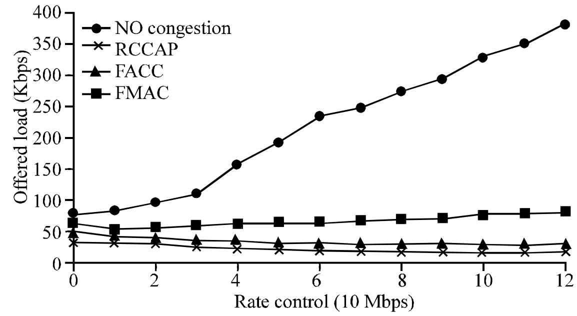

Fig. 6: Comparison of offered load

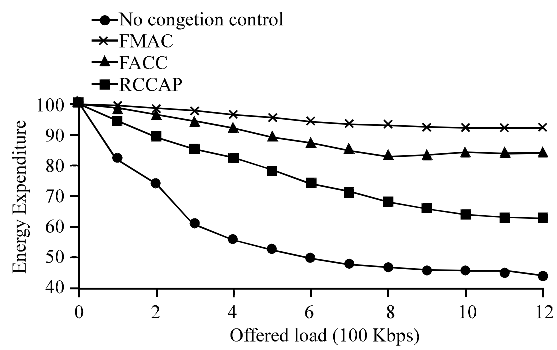

Fig. 7: Comparison of energy expenditure

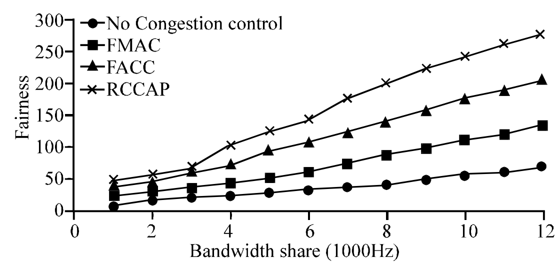

Fig. 8: Comparison of fairness metrics

packet drop until it reaches the destination node. It has the maximum loss of packets (Asoken *et al*., 1997). In FMAC, the Congestion is controlled in MAC layer but the ID response is low. It leads to loss of packets. In FACC protocol, the congestion gets avoided and back pressure is supplied to the nodes. It reduces the 21% packet loss compared to FMAC. In RCCAP protocol, the rate is controlled at every node and paths and sequence ID is formed for transmission. It results in few amounts of packet drop takes place. Compared to FACC, it provides better performance.

Throughput comparison: The number of successfully transmitted packets to the receiver is termed as throughput. To yield high system performance, we should maintain maximum throughput. Figure 5 shows the comparison of throughput with FMAC, FACC and RCCAP. From this, it provides a better performance than the other technique is clearly shown in Fig. 5. It improves 27% of throughput compared to previous techniques.

Offered load comparison: The offered load is mainly depended on queue traffic and it is used for balancing the network which extends the lifetime of the network. Secure load balancing will improve the network scalability and data accuracy. The offered load is maintained at stable conditions and provides better performance as shown in Fig. 6. If congestion is not controlled, the offered load will keep on increasing and other three protocols to maintain some steady output scenarios. Compared to previous techniques, RCCAP produces better performance.

Energy expenditure comparison: Energy expenditure is calculated as the ratio of number of transmissions to the throughput at the receiver. When the unwanted nodes are kept on idle state, the node is maintained at the same state (Akkaya and Younis, 2003). If a node becomes zero, the entire energy is lost. It leads to the link failure inside the network. Figure 7 shows the energy expenditure for different protocols. The energy expenditure is maintained at 92% in RCCAP whereas FMAC, FAAC has low energy expenditure.

Fairness comparison: Fairness means sharing of resource allocation and connectivity between the source and sink. After the avoidance of congestion, it provides better performance in fairness as shown in Fig. 8. If congestion is not avoided, it produces a minimum amount of fairness. FMAC and FAAC protocol maintains some improvement in fairness and RCCAP provides 33% fairness better than the FMAC and FAAC protocol.

CONCLUSION

This study deals with the weighted buffer probabilistic algorithm to avoid the congestion problem in wireless sensor networks. By using m-RCCAP, we can control the rate and also congestion problem due to overhearing. By sending and receiving RTS/CTS, we have rectified the congestion avoidance in overhearing. This protocol also shares the rate control, resource allocation, bandwidth utilization. By this, we have improved the parameters like throughput, fairness and reduced the packet loss, energy expenditure and offered load in the network. Here, we achieve 83% of improvement in network life time and system performance compared to existing techniques.

In future, it can be implemented on cognitive radio networks and wireless multimedia sensor networks for commercial and industrial purposes.

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