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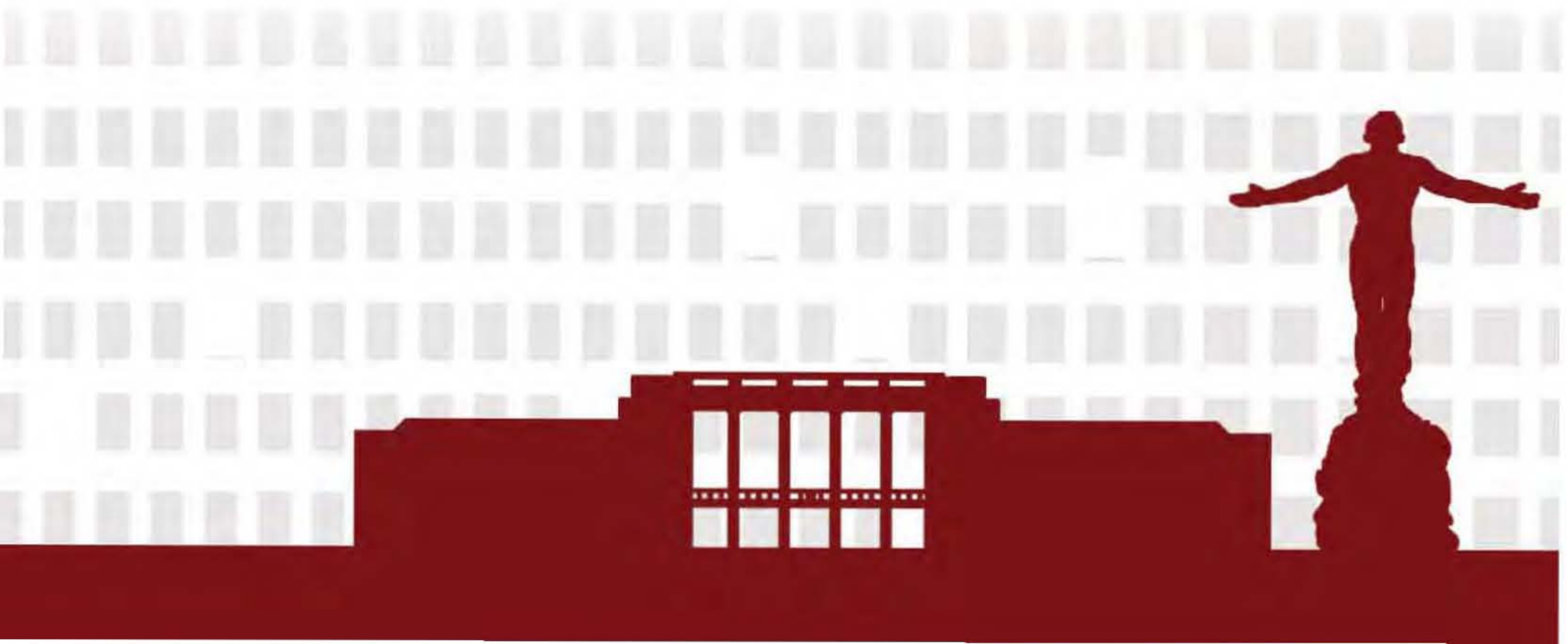

Proceedings of the 8th AUN/SEED-Net RCEEE 2015 and 11th ERDT Conference on Semiconductor and Electronics, Information and Communications Technology, and Energy

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A CROSS-LAYER ANALYTICAL MODEL OF COLLISION PROBABILITIES IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Currently, there are many research studies that focus on analyzing the collision in MAC layer of Wireless Sensor Networks (WSNs). However, the analysis only considered the behaviors of MAC protocols without considering the traffic types of higher layers, especially the cross-effect of routing layer while in the practical deployment of WSNs, the trade-off between the network adaptation and the data throughput should be considered. Several research works [1] [2] [3] advance the global time synchronization and a distributed TDMA in [4] is proposed to mitigate these drawbacks, making TDMA more practical for WSNs. CSMA approach is widely used in WSNs due to the simple nature of this approach. Contending nodes take a random backoff and at the end of this period, they sense the channel for activity and transmit the data if the channel is idle. Otherwise, these nodes repeat the process. CSMA protocol in MAC layer has many advantages such as simplicity, flexibility, and robustness; hence, nodes can join or leave the network without any extra operations. In the field of routing for WSNs, there are two kind of routing: proactive and reactive routing. The proactive routing protocols [5] [6] [7] [8] are more popular due to several advantages: adaptation to the node mobility and use of WSNs are usually many-to-one data collection applications. In this kind of routing, there are two traffic types generated in the WSNs: routing traffic and data traffic. So far, the analysis of MAC protocols has not considered the relationship between collision of routing traffic and data traffic. Hence, the networks using proactive routing are not usually optimized in configuration. This can lead to the problem of poor performance for data transmission.

In this paper, we present an analytical model of collision probabilities which can be used to evaluate the performance of WSNs using proactive routing protocols. Moreover, in this model collision probabilities of separated traffic types such as data traffic and routing traffic are also analyzed to show the mutual impact between them. To target the generalization of this proposed analytical model, several parameters which are usually used in practical implementation of WSNs are investigated such as routing information forwarding rate, acknowledgement, and data rate.

Figure 1 shows the simulation result and analysis of collision probability versus number of neighbor nodes, where the beacon period is 8 seconds and the data period is 2 seconds. It can be seen that when a node has more neighbor nodes, the collision probability is higher due to the higher contention of beacons and data packets. With the number of neighbor nodes fewer than 8, the collision probability is smaller than 0.065. This figure also shows that the analytical model fits well with the simulation results because it considers most of issues such as synchronous beacon forwarding, overlapped slots, and acknowledgements. This result also leads to a practical proposal that designing the sizing of multi-hop sensor networks can reduce the collisions.

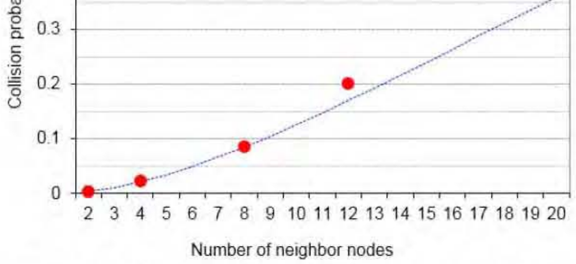

Figure 1: Collision probability versus number of neighbor nodes.

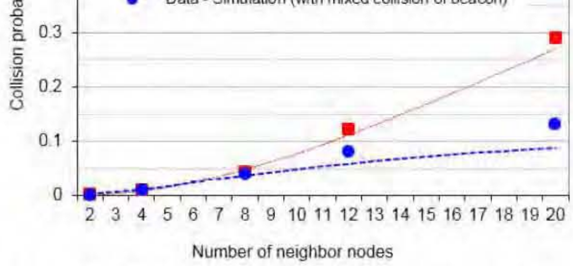

Figure 2: Separated collision probabilities of beacons and data packets.

Figure 2 shows the separated collision probabilities of beacon and data packets all nodes are set to stop their data transmission while they only run the routing protocol. It can be seen that the results from simulation and analysis is closely matched. When the number of contention nodes increases, both collision probabilities of beacon and data packet also increase. In case of high density of nodes, the total collision probability of routing (beacon) and data packet transmission is approximately 0.29 and 0.13 respectively if the number of neighbor nodes is 20. It can also be illustrated in the figure that the collision probability of beacon increases faster than the collision probability of data packets in both simulation and analysis. This is due to the synchronous beacon forwarding of the routing protocol. With the higher number of contention nodes, the collision probability in the simulation is slightly higher than that in the simulation due to the mixed collision and the number of retransmissions which are not considered in the analysis. Another reason which might cause the difference between simulation and analysis results is that the CCA is not considered in the analysis because it is too small (only 16 μs.

Keywords: Wireless Sensor Networks, MAC, proactive routing, collision probability.

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