Alleviating the Performance Degradation in Congested Sensor Networks using a Differentiated Routing Methodology

Saranya kandhasamy
Hindustan University
Chennai, India

TV Balasujitha
Hindustan University,
Chennai, India

J.Thangakumar
Hindustan University,
Chennai, India ,

Dr.M.Roberts Masillamani
Hindustan-University,
Chennai, India

ABSTRACT

The congestion in the sensor networks leads to the poor delivery of the data. This causes the heavy loss of data in the sensor network. In order to alleviate this problem, a combination of two algorithms is used in this paper. The algorithms are Active Congestion-less Routing (ACR) and Medium Access Control Enhanced Active Congestion-less Routing (MACR).Both these algorithms used a differentiated routing for High Precedence data and Low precedence data. ACR lessen the congestion by routing only the high precedence data, where as the MACR lessen the congestion in mobile network by routing High precedence data as well as Less precedence data. These algorithms perform this by the nodes in the network.

Keywords—
Sensor networks, congestion control, High precedence, Active Congestion-less Routing, Medium Access control Enhanced Active Congestion-less Routing.

- ## INTRODUCTION

Large numbers of nodes is included in sensor network deployment. Since deploying such large-scale networks has a high cost, it is increasingly likely that sensors will be shared by multiple applications and gather various types of data: temperature, the presence of lethal chemical gases, audio and/or video feeds, etc. Therefore, data generated in a sensor network may not all be equally important. With large deployment sizes, congestion becomes an important problem. Congestion may lead to indiscriminate dropping of data [7] (i.e., high-precedence packets may be dropped while Less-precedence packets are delivered). It also results in an increase in energy consumption to route packets that will be dropped downstream as links become saturated. As nodes along optimal routes are depleted of energy, only non-optimal routes remain, further compounding the problem. Toensure that data with high precedence is received in the presence of congestion due to less precedence packets, differentiated service must be provided. In this work, here the congestion that results from excessive competition for the wireless medium is proposed. Existing schemes detect congestion while considering all data to be equally important. Characterize congestion as the degradation of service to high precedence data due to competing the less precedence traffic. In this case, congestion detection is reduced to identifying competition for medium access between high precedence and less precedence traffic. Congestion becomes worse when a particular area is generating data at a high rate. This may occur in deployments in which sensors in one area of interest are requested to gather and transmit data at a higher rate than others (similar to bursty converge cast [5]). In this case, routing dynamics can lead to congestion on specific paths. These paths are usually close to each other, which lead to an entire zone in the network facing congestion. We refer to this zone, essentially an extended hotspot, as the congestion zone (Conzone).

In this paper, we examine data delivery issues in the presence of congestion. The use of data prioritization and a differentiated routing protocol and/or a prioritized medium access scheme to mitigate its effects on high precedence traffics proposed. The solution that accommodates both less precedence and high precedence traffic when the network is static or near static and enables fast recovery of less precedence traffic in networks with mobile high precedence data sources are obtained. This solution uses a differentiated routing approach to effectively separate high precedence traffic from less precedence traffic in the sensor network. High precedence traffic has exclusive use of nodes along its shortest path to the sink, whereas less precedence traffic is routed over un-congested nodes in the network but may traverse longer paths. Our contributions in this work are listed as follows :

II. TECHNIQUES AND ALGORITHMS USED

A. Active Congestion-less Routing

In the presence of sensor network ACR works solely. All the ACR data packets are classified into High precedence or less precedence by the data sources, and nodes within a congested zone only forward High Precedence data packets.

Less precedence traffic is routed out of and/or around the congested zone. ACR comprises three steps: high precedence network formation, conzone discovery, and differentiated routing. The combination of these functions segments the network into on-conzone and off-conzone nodes. Only high precedence traffic is routed by on-conzone nodes. Note that the protocol specifically accommodates less precedence traffic, albeit with less efficient routes than high precedence traffic. For the purposes of this discussion, we assume that there is one high precedence sink and a contiguous part of the network (critical area) that generates high precedence data in the presence of network wide background less precedence traffic. This paper assumes that nodes are location aware and densely deployed with uniform distribution. Since nodes in the scenario in Fig. 1 send all high precedence data to a single sink, tree-based routing, with the high precedence sink being the root, is most appropriate. However, Hull et al. show that tree-based routing schemes suffer from congestion, especially if the number of messages generated at the leaves is high. This problem becomes even worse when we have a mixture of less precedence and high precedence traffic traveling through the network.

Therefore, even when the rate of high precedence data is relatively low, the background noise created by less precedence traffic will create a conzone that spans the network from the critical area to the high precedence sink. Due to this congestion, service provided to high precedence data may degrade, and nodes within this area may die sooner than others, leading to only suboptimal paths being available for high precedence data, or a network partition may result, isolating the sink from the critical area. If a standard ad hoc routing scheme (e.g., AODV or DSR) is used to route the burst of high precedence data instead of the tree-based routing scheme, congestion occurs. There is one high precedence sink and two less precedence sinks, as shown in the figure. Only critical area nodes send high precedence data, while all other nodes in the network send less precedence data to either of the less precedence sinks. We now present the algorithms used by ACR to build high precedence routing networks, to perform dynamic conzone discovery, and to provide differentiated routing. This is followed by the description of two enhancements of the basic ACR.

a) High-Precedence Routing Network Formation

Once the nodes in the sensor network are deployed, the High Precedence data destination (the sink) starts building the high precedence routing network (IDPNet). This network covers all nodes, because at the time of deployment, the sink will usually have no information on the whereabouts of the critical area nodes. Also, based on the locations of events that can occur during the lifetime of the network, different nodes may constitute the critical area. Since all high precedence data is destined to a single sink, the IDPNet is based on a minimum distance spanning tree rooted at the sink. As with TAG [6], this structure ensures that all nodes have shortest path routes to the sink. However, instead of every node having a single parent, as in other tree-based schemes, we allow nodes to have multiple parents. A node that has multiple neighbors with depths (the number of hops to the sink) less than its own considers them all as parents (see Fig.1).

This property to support multipath forwarding, thus providing load balancing and making the routing network more resilient to failures is leveraged. Now consider the IDPNet formation process. Once the sink discovers its neighbors, it broadcasts a "Build IDPNet" [8] message (containing the ID and depth of the node) asking all nodes in the network to organize as a graph.

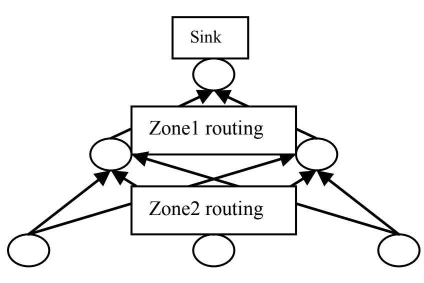


Figure1. Data routing in different zones

Once a neighboring node hears this message, it checks if it has already joined the IDPNet (i.e., if it knows its depth); if not, it sets its depth to one plus the depth in the message received and sets the source of the message as a parent. This node then rebroadcasts the Build IDPNet message, with its own ID and depth. If a node is already a member of the graph, it checks the depth in the message, and if that depth is one less than its own, then the source of the message is added as a parent. In this case, the message is not rebroadcast. If a node receives a Build IDPNet message with a depth value less than that of its parent's depth, it updates its own value to the received value, plus one. It then removes all current parents and adds the source of the message as a new parent. Finally, the Build IDPNet message is rebroadcast with the new depth value. In this fashion, the Build IDPNet message is sent down the network until all nodes become part of the graph. Similar to TAG [6], the Build IDPNet message can be periodically broadcast to maintain the topology and adapt to changes caused by the failure or addition of nodes.

b) Identification of congested zones and active routing

Nodes discover if they are on the conzone by using the conzone discovery mechanism [3]. After building the IDPNet, the next task is to dynamically discover the conzone. The conzone is formed when one area is generating high precedence data. We refer to this area as the critical area. This conzone discovery is done dynamically, because the critical area can change during the lifetime of the deployment and is triggered when an area starts generating high precedence data.

The conzone discovery algorithms allow nodes, in a distributed fashion, to determine if they are on a potentially congested path between the critical area and the sink. If they are, they mark themselves as "on conzone." The conzone discovery schemes are summarized in Fig. 2.

For brevity, we only present conzone discovery from the critical area to the sink in detail. In this case, critical area nodes detect an event that triggers discovery. A conzone must be then discovered from that neighborhood to the sink for the delivery of high precedence data. To do this, critical area nodes broadcast "discover conzone to sink" (ToSink) messages [8]. This message includes the ID of the source and its depth and is overheard by all neighbors. The depth is included here to ensure that nodes do not respond to the ToSink messages heard from their parents. When a node hears more than _ distinct ToSink messages coming from its children, it marks itself as on conzone and propagates a single ToSink message. This message is overheard by neighbors who mark this neighbor as being on the conzone in their neighborhood table. In our scheme, this threshold is a linear function of the neighborhood size (i.e., the number of nodes within the communication range) and of the depth of the node in the IDPNet, for node *x* with depth and neighborhood size

B. MAC-Enhanced Active Congestion-less Routing

a) Machine for MACR

The node state machine used by MACR [1] [2] to support differentiated routing based on 5 MAC-layer enhancements and the following approaches are used to establish the MACR mechanism.

1. Less Precedence approach In this approach, nodes forward less precedence data. All nodes in the network are initially in the less precedence approach. Upon receiving or overhearing a less precedence packet, nodes remain in the less precedence approach and, if appropriate, forward any data. If a node in the less precedence approach overhears a high precedence packet, it transitions to the shadow approach. Finally, upon receiving a high precedence event that needs to be forwarded (either because it sensed a high precedence event or because it was chosen as the next hop toward the sink), a node transitions to the high precedence approach.

2. High Precedence approach Nodes in the path of high precedence data are in the high precedence approach. Upon transitioning to this state, the node sets two timers: a received timer and an overhearing timer.

The values for these timers should be on the order of twice the expected inter-arrival delay of high precedence data. If a node in this approach receives a high precedence transmission, it begins channel contention by using our modified RTS/CTS protocol and forwards the data. It resets its received and overhearing timers and remains in the high precedence approach. Upon overhearing high precedence data, the node resets its overhearing timer only and stays in the high precedence approach. If a node in the high precedence approach overhears or receives a less precedence RTS, it sends a jamming high precedence CTS to clear the channel of less precedence data and to announce the existence of an high precedence path and stays in the high precedence approach. If the received timer expires, the node transitions to the shadow approach, maintaining the value of its overhearing timer. While this is the normal exit out of the high precedence approach, if both the received timer and overhearing timer expire at the same time, the node transitions back to the less precedence approach.

3. Suppression approach Nodes in this state are within the communication range of high precedence traffic but not on a forwarding path. Nodes in this state suppress less precedence traffic, thus preventing it from interfering with high precedence traffic in the network. Upon overhearing a high precedence packet, the node resets its overhearing timer and stays in this state. A node transitions to the high precedence approach upon receiving a high precedence packet itself. If a node in the suppression approach overhears a less precedence packet, it stays in the suppression approach and takes no action. If the node is the intended recipient of the less precedence data, it silently discards the packet and stays in the shadow approach. It should be pointed out that this is an aggressive action to maximize the service given to high precedence data. Finally, if the overhearing timer expires, the node transitions to the less precedence approach.

In this section, we present MACR, a combined MAC and routing scheme designed to support situations in which critical events may move or the sensors generating high precedence data may move. Though conzone discovery is dynamic in ACR, the overhead required to maintain the IDPNet in a dynamic environment may be prohibitive. As a result, we use a lightweight dynamic differentiated routing mechanism to accommodate mobile data sources. MACR is based on MAC-layer enhancements that enable the formation of a conzone on the fly with each burst of data. The trade-off is that it effectively preempts the flow of less precedence data, thereby seriously degrading its service.

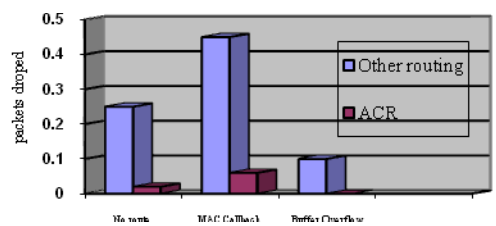
C. Advantages

- Provides very low jitter
- Increasing the delivery ratio of High precedence data
- Energy consumption is low.
-

D. Applications

ACR and MACR mainly released for High traffic sensor networks and Military Purposes to provide more importance to the high precedence data by degrading the performance of less precedence data.

E. Analysis on the Routing Methods



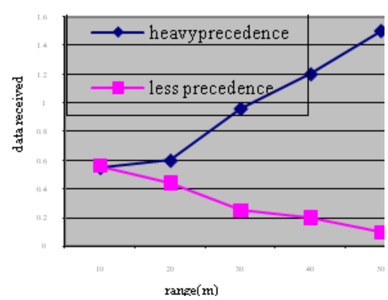


Figure2. Comparison of high precedence node
Figure3. Analysis of high precedence nodes dropping in
ACR & other routing techniques received ACR & MACR

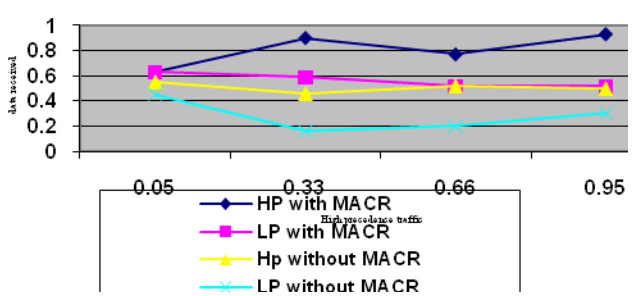


Figure4. Analysis of High precedence nodes received in high traffic

III. CONCLUSION

This paper addresses the active differentiated routing of data in wireless sensor network. ACR protocol assigns precedence and routes the data according to that precedence. Along with ACR medium access control enhanced ACR is used for the mobility and dynamics of the high precedence source. ACR increases the fraction of High Precedence data delivery and decrease delay and jitter for such delivery while using energy more uniformly in the deployment along with its variant. ACR also routes less precedence data in the presence of congestion. This additionally shows that MACR maintains high precedence data delivery rates in the presence of mobility. Both ACR and MACR support effective High Precedence data delivery in the presence of congestion. ACR is better suited for static networks with long-duration High Precedence data floods. For bursty high precedence traffic and/or mobile high precedence sources, MACR is a better fit. To ensure QoS [4] for video streams, reactive dropping methods could be combined into the routing protocol. This future work looks at the effectiveness of such techniques in sensor network environments. Also, while MACR merges multiple conzones naturally, we are now exploring the interactions of differentiated routing and multiple conzones, which may be overlapping or disjoint in ACR and its two enhancements. Finally, this will also explore the impact of different sizes and shapes of conzones on data delivery in the future.

REFERENCES

[1] Draft Supplement to Part 11: "Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS)", IEEE 802.11e/ D4.0.

[2] G.-S. Ahn, S.G. Hong, E. Miluzzo, A.T. Campbell, and F. Cuomo, "Funneling-MAC: A Localized, Sink-Oriented MAC for Boosting Fidelity in Sensor Networks," Proc. Fourth ACM Conf. Embe.

[3] D.B. Johnson and D.A. Maltz, "Dynamic Source Routing in Ad Hoc Wireless Networks," Mobile Computing, Kluwer Academic Publishers.

[4] E. Felemban, C.-G. Lee, and E. Ekici, "MMSPEED: Multipath Multi-SPEED Protocol for QoS Guarantee of Reliability and Timeliness in Wireless Sensor Networks," IEEE Trans. Mobile Computing, vol. 6, pp. 738-754, 2006.

[5] H. Zhang, A. Arora, Y. Choi, and M. Gouda, "Reliable BurstyConvergecast in Wireless Sensor Networks," Proc. ACM MobiHoc.

[6] S. Madden, M. Franklin, J. Hellerstein, and W. Hong, "Tag: A TinyAggregation Service for Ad-Hoc Sensor Networks," Proc.Fifth Symp. Operating System Design and Implementation (OSDI).

[7] B. Hull, K. Jamieson, and H. Balakrishnan, "Mitigating Congestion in Wireless Sensor Networks," Proc. Second ACM Conf. Embedded Networked Sensor Systems (SenSys).

[8] Raju Kumar, Riccardo Crepaldi, Hosam Rowaihy, Albert F. Harris III, Guohong Cao, Michele Zorzi, and Thomas F. La Porta, "Mitigating Performance Degradation in Congested Sensor Networks,", IEEE transactions on mobile computing, vol. 7, no. 6, pp 682-697, 2008.