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Improved Energy Efficient ADCC for Home Automation Networks in High Volume Sensed Data

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Abstract - A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location.There is a growing interest in the wireless sensor network technology in the home automation field, but as the number of sensor nodes in the home increases and as the data traffic generated by such nodes grows, the network becomes more congested. Due to resource constraints, a congestion control scheme for wireless sensor network is designed with simplicity and energy efficiently. In existing system, ADCC (Adaptive Duty-cycle Based Congestion Control), a lightweight congestion control scheme using duty-cycle adjustment for wireless sensor networks was used. This scheme uses both the resource control and traffic control approaches according to the amount of network traffic for the congestion avoidance. The proposed work improves energy efficiency with congestion control scheme implemented for Home Automation Network (HAN) with wireless sensor network (WSN). The Improvement is made on Adaptive Duty-cycle Based Congestion Control (ADCC) scheme. The deployment of Improved ADCC involves the aggregation of incoming traffic and node's channel capacity variation.

Keywords: *ADCC scheme, congestion control, Home Automation Network, Path Diversity Method, Wireless sensor network*

I. INTRODUCTION

With advances in processor and wireless communication technologies, sensor networks will be used everywhere in the future life. Home automation networks are one of the good environments that sensor networks and consumer electronics technologies will be merged. In the home automation networks, many sensors distributed in the house collect various physical data such as temperature, humidity, motion, and light to provide information to the HVAC (Heating, Ventilating, and Air Conditioning) control system. For example, the HVAC control system turns on the ventilator when the air is foul and controls the heating system according to the weather and the existence of people in the house.

A. Home Automation Networks

To realize these home automation networks, many sensor devices should detect events in the house and send them directly to the base station through the wireless channel. As sensor devices do not have sufficient computational ability and battery power, an energy-efficient sensor routing scheme is critical to send information to the base station. In the conventional sensor routing scheme, when each sensor node detects an event, it broadcasts the event to all sensor nodes within one hop range.

B. Data traffic generation

As the number of sensor nodes in the home increases and as the data traffic generated by such nodes grows, the network becomes more congested. The occurrence of congestion results in a drastic decrease in throughput and increase in per-packet energy consumption. Many congestion control schemes have been proposed in traditional networks such as AIMD (Additive Increase Multiplicative Decrease). The traditional congestion control schemes are not suitable for wireless sensor networks, however, because of their higher consumption of resources To design a congestion control scheme for a sensor network simply or with low complexity, it should be implemented at a lower layer such as the MAC (Medium Access Control) layer, rather than at an upper layer such as the transport layer.

C. Duty-Cycle Operation

As sensor nodes operate with limited power based on a battery that cannot be replaced easily, it is very important to reduce the energy consumption of each sensor node. One of the primary mechanisms for achieving low energy operation in energy constrained wireless sensor networks is duty-cycle operation. The existing congestion control protocols, however, do not consider the duty-cycle operation of the MAC layer. A low duty-cycle usually causes performance degradation in terms of latency and throughput. Especially, if the network becomes congested, the performance is degraded all the more.

D. Adaptive Duty-cycle Based Congestion Control

ADCC (Adaptive Duty-cycle Based Congestion Control) is an energy efficient and lightweight congestion control scheme with duty-cycle adjustment for wireless sensor networks. The ADCC scheme is implemented over a duty-cycle based MAC protocol. It uses both a resource control approach, by increasing the packet reception rate of the receiving node, and a traffic control approach, by decreasing the packet transmission rate of the sending node for congestion avoidance.

II. CONGESTION CONTROL FOR WIRELESS SENSOR NETWORKS

ESRT (Event-to-Sink Reliable Transport Protocol) is a transport solution developed to achieve reliable event detection and congestion control. In ESRT, the sink is required to periodically configure the source sending rate to avoid congestion. When congestion is detected, all the data flows are throttled to a lower rate. In adaptive traffic control scheme, the locally generated traffic and the route-through traffic are assigned bandwidths proportionally to provide fairness among the flows with different path lengths, which also prevents congestion.

It involves four modules,

- Data Traffic of Sensor Nodes in HAN Topology
- Identification of Congestion Points

- Adaptive traffic control scheme
- Measure of Congestion Reduction Rate

A. Data Traffic of Sensor Nodes in HAN Topology

The traffic control approach can alleviate network congestion by reducing the transmission demand. When congestion is detected, the traffic control approach notifies the source node of the congestion and triggers it to adjust the traffic according to the available resource. The two main criteria for traffic control approach are resource utilization and fairness. When two flows transmit traffic for the rate of T1 and T2, network congestion occurs if sum of T1 and T2 is larger than the available resource of a receiving node. The traffic control approach controls the traffic below the resource line and adjusts the traffic at the fairness line to guarantee fairness among the flows.

B. Identification of Congestion Points

As for congestion control, the first requirement is how to identify whether congestion occurs, and when and where it occurs. Congestion can be identified by monitoring the node buffer occupancy and the link load. In the traditional Internet, the methods that are employed to weaken congestion are packet dropping at the congestion point and rate decreasing in the source node. For wireless sensor networks, method to detect congestion and to overcome it should be carefully considered because most sensor nodes have limited resources. The congestion control protocols in wireless sensor networks must thus be simple and energy efficient In ADCC (fig 3.2), congestion is detected through the difference between the required service time and the duration of the active state in the duty-cycle. The required service time is calculated by monitoring the packet inter-arrival times of the child nodes.

The resource control approach adjusts the resource provisioning at the congested node for alleviating congestion. It is one of the resource control approaches that adjust the active time of the duty-cycle of a node. To alleviate the congestion, ADCC updates the duration of the active state by considering the calculated congestion degree. The new duration of the active state can be one of three cases. At first, ADCC checks if required service time exceeds maximum active time in the duty-cycle. In this case, the new duration of the active state is updated as maximum active time in the duty-cycle.

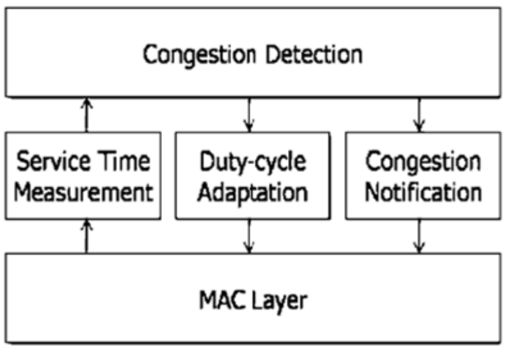

Figure 1: Operations of the ADCC Scheme

Then ADCC notifies the child nodes of the congestion so that the transmission rate of the child nodes can be reduced. Second, ADCC checks if required service time is between minimum active time in the duty-cycle and maximum active time in the duty-cycle. In the case that required service time is within the threshold, the ADCC updates active time in the duty-cycle as the calculated required service time, which means that ADCC performs resource control. Finally, if required service time is below minimum active time in the duty-cycle, active time in the duty-cycle is updated as minimum active time in the duty-cycle to guarantee the minimum energy consumption. The new duration of the active state is applied from the next duty-cycle to the next congestion control period.

The ADCC scheme adjusts the duration of the active time in the duty-cycle according to the required service time within thresholds. In other words, ADCC tightly controls the resources according to the incoming traffic. The energy consumption of a node is minimized when the node's effective channel capacity is equivalent to the aggregate incoming traffic.

C. Adaptive traffic control scheme

After detecting congestion, congestion control schemes need to propagate the congestion information from the congested node to the upstream sensor nodes that contribute to congestion. In the ADCC schemes, when the required service time exceeds maximum active time in the duty-cycle, ADCC notifies the child nodes of the congestion so that the transmission rate of the child nodes can be reduced. ADCC uses an explicit congestion notification method by broadcasting the congestion message to the child nodes.

The congestion control process of ADCC, including congestion detection, resource control, and traffic control, is repeated during the congestion control period. When congestion occurs, ADCC not only increases the packet reception rate of a receiving node but also decreases the packet transmission rate of the sending nodes. Therefore, ADCC can reduce the frequency of changing the transmission rate and the amount of control packets compared with the traffic control schemes.

D. Measure of Congestion Reduction Rate

In ADCC, when incoming traffic is low, the active time of the receiving node is reduced for low energy consumption. When the incoming traffic is high, however, the active time of the receiving node is increased up to the maximum threshold. In ADCC, when the incoming traffic is higher than the maximum threshold of the active time, the source nodes attempt traffic control.

In packet reception rate of the ADCC scheme, when node two nodes start transmission, the network becomes congested, and consequently, the packet reception rate of each scheme is decreased because of the use of limited resources for congestion control. Otherwise, the ADCC scheme increases the resources of node 1 by increasing the duration of the active time so that the node 1 can receive more packets. The packet reception rate of the ADCC scheme is no longer increased, because the duration of the active time has exceeded the maximum threshold. At this time, the ADCC scheme uses traffic control by decreasing the packet transmission rate of the sending node. The higher data rate decreases the duration of packet transmission, thereby reducing congestion and the probability of a packet collision.

III. IMPROVED ADCC

The proposed work presents ADCC (Adaptive Duty-cycle Based Congestion Control), an energy efficient and lightweight congestion control scheme with duty-cycle adjustment for wireless sensor networks. It uses both a resource control approach, by increasing the packet reception rate of the receiving node, and a traffic control approach, by decreasing the packet transmission rate of the sending node for congestion avoidance. ADCC reduces the frequency of changing transmission rate and control packet overhead. Congestion is detected with difference between required service time and duration of active state in duty-cycle. Required service time is calculated by monitoring packet inter-arrival times of child nodes. ADCC controls resources according to incoming traffic.

Energy consumption of a node is minimized by the equivalency of node's effective channel capacity and aggregated incoming traffic. ADCC improves reliability, prevent congestion and achieved higher throughput.

Proposed work involves four modules,

- Increase data volume streams
- Energy measure on congestion control
- Improved ADCC
- Performance Evaluation

A. Increase data volume streams

In improved ADCC, Data is generated by sensor nodes. A node requests data by sending interests for named data. Data matching the interest is then drawn down towards that node. Intermediate nodes can cache, or transform data, and may direct interests based on previously cached data. All nodes in a directed diffusion-based network are application-aware. This enables diffusion to achieve energy savings by selecting empirically good paths and by caching and processing data in-network.

The shared nature of the wireless medium causes a node to share the transmission channel not just with other nodes in the network, but also with external interference sources. Unlike wired networks, where throughput degradation on a network link is indicative of congestion, in wireless networks throughput degradation can occur due to a loss channel, increased packet collisions during congestion or external interference. In addition, throughput of a wireless link is also directly influenced by the rate adaptation algorithm through its choice of transmission data rate. Clearly, if a lower data rate is in use, the throughput for a given time interval will be lower than with a high data rate. In improved ADCC the incoming data streams is high i.e., the data rate is larger in use.

B. Energy measure on congestion control

A good congestion control scheme should not only be accurate, but it should be energy-efficient as well, especially because energy is the most constrained resource for a wireless device. In improved ADCC, the basic idea is that every node along the routing path should forward their congestion measurements to the destination so that the application at the

destination learns the degree of flow level congestion. However, if every node sends its measurement periodically, it will incur a considerable amount of traffic and energy consumption.
In this work, improved ADCC try to balance between energy consumption and accurate congestion control by the following two optimizations: (1) a node starts sending only when its congestion measurement is above a threshold by embedding its congestion level into the header of a data packet; and (2) as soon as a node receives a data packet with flow congestion level, it compares its current congestion measurement with the flow congestion level included in the packet header, and updates the flow congestion level in the packet header to its own congestion measurement only when its node congestion level is greater than the existing flow congestion level.

C. Improved ADCC

The improved ADCC involves the processes.

a. Aggregation of incoming traffic
b. Node's channel capacity variation

I. Aggregation of Incoming Traffic

In improved ADCC (fig 3.1), a novel approach for preventing traffic analysis in home automation network by combining the use of indirection and data aggregation is introduced. In our approach improved ADCC, the basic idea is that all sensed nodes will first send their readings to some designated non-sink node (referred to as a decoy sink node) that will aggregate these readings into summary messages that will then be forwarded to the real sink node. Since the traffic pattern towards the decoy sink node will increase and the traffic pattern towards the real sink will decrease (due to aggregation), improved ADCC able to protect the location of the real sink from adversaries performing traffic analysis. Improved ADCC have extended our basic idea of using a single decoy sink node to our final solution where multiple decoy sink nodes are used to further increase the randomness of traffic patterns and provide robustness should an adversary attack a decoy sink node mistakenly believed to be the real sink.

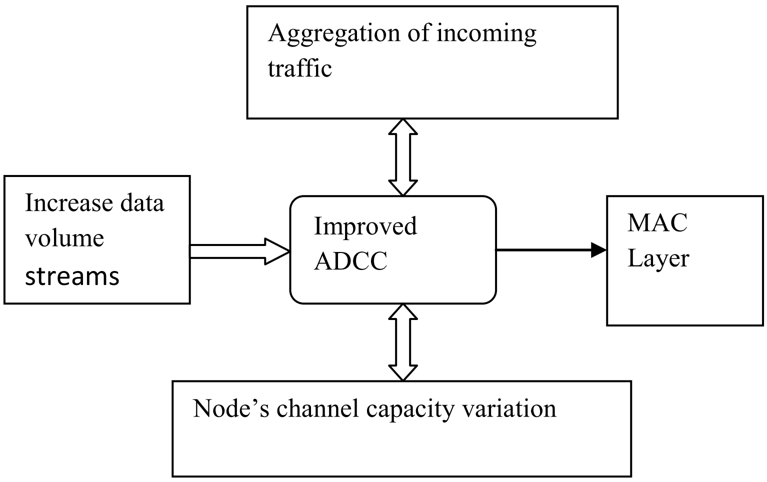

Figure 2: Improved ADCC

Sending a stream of readings to a decoy sink before forwarding them to the real sink creates a high traffic area near the decoy sink but it does not necessarily conceal the high traffic area near the real sink. To ensure that the amount of traffic near the real sink is reduced, we have the decoy sink perform remote aggregation on the readings before sending a stream of summarized data back to the real sink. Since the real sink is now receiving fewer messages from the decoy sink than it would otherwise receive directly from the sensors, the amount of traffic headed towards the real sink is significantly reduced.

b. Node's Channel Capacity Variation

Due to fading and outside interference, the wireless channel has a high packet loss rate and the capacity of the channel may change dramatically. In addition, today's wireless devices are able to adapt their coding rates according to channel quality, which may further increase variations in channel capacity. Such dynamics of the channel may compromise the protocols that depend on reliable message exchanges between nodes, as well as protocols that rely on explicit knowledge of channel bandwidth in improved ADCC. Therefore, all the components must be robust to packet losses and no assumptions about channel capacity should be made.

D. Performance Evaluation

The performance of improved ADCC on Home automation Network will be measured in terms of

- Energy Drain Rate of sensor nodes
- Data loss on congestion
- Data Traffic rate
- Resource utilization

Energy drain rate is measured by the amount of energy consumption and estimating the energy dissipation per second during transmission. The energy drain rate is measured in terms of joules per seconds. In improved ADCC, the energy drain rate is very low, because of the reduced energy dissipation. The improved ADCC scheme has low loss rates and data traffic rates due to their congestion control mechanism. Improved ADCC has the advantage of improving reliability and preventing congestion.

IV. CONCLUSION

Home automation networks are good environments for merging wireless sensor networks and consumer electronics technologies. In home automation networks, many sensors distributed in the house collect various physical data. As the number of sensor nodes in the home increases, however, and as the data traffic generated by such nodes grows, the network becomes congested. Due to limited resources of wireless sensor networks, traditional congestion control schemes are not suitable for them. This work proposes the improved ADCC scheme, a duty-cycle based congestion control scheme for wireless sensor networks. The improved ADCC scheme can reduce the frequency of changing the transmission rate and can reduce the control packet overhead by increasing the packet reception rate of the receiving node and decreasing the packet transmission rate of the sending node. Improved ADCC has the advantage of improving reliability and preventing congestion.

V. APPENDIX

Output Screen Shots

The congestion point is identified by the mechanism If the Demand > load

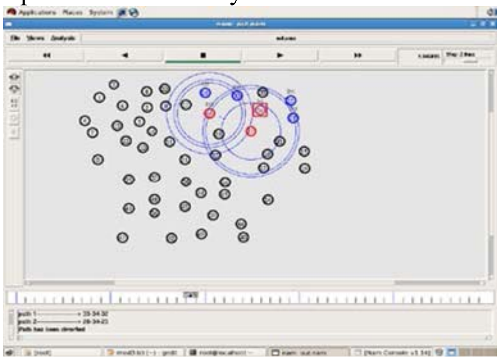

Figure 1: Adaptive Traffic Control Scheme

By identifying the congestion point the path is diverted by using adaptive traffic control scheme (fig 1). Hence the congestion is reduced.

Figure 2: Measure of Congestion Reduction Rate

Congestion reduction rate is measured in the terms of load and demand of data.

REFERENCES

1. Dam T and Langendoen K (2003) "An Adaptive Energy-Efficient MAC Procotol for Wireless Sensor Networks," Proc. of the 1st ACM International Conference on Embedded Networked Sensor Systems (SENSYS'03), pp. 171-180.
2. Dongho Lee and Kwangsue Chung (2010) “Adaptive Duty-cycle Based Congestion Control for Home Automation Networks”, IEEE Transactions on Consumer Electronics, Vol. 56, No. 1.
3. Du S, Saha A and Johnson D (2007) " RMAC: a Routing-Enhanced Duty- Cycle Mac Protocol for Wireless Sensor Networks," Proc. of the 26th IEEE International Conference on Computer Communications (INFOCOM’07), pp. 1478-1486.

4. Das S, He T, Lin C and Ren F (2008) "Alleviating Congestion Using Traffic-Aware Dynamic Routing in Wireless Sensor Networks," Proc. Of the 5th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON'08), pp. 233-241.
5. Kang J, Nath B and Zhang Y (2007)"TARA: Topology-Aware Resource Adaptation to Alleviate Congestion in Sensor Networks," IEEE Transaction on Parallel and Distributed Systems, vol. 18, no. 7, pp. 919-931.
6. Kim H, Lee S and Song J (2007) "Energy-Efficient Traffic Scheduling in IEEE 802.15.4 for Home Automation Networks," IEEE Transaction on Consumer Electronics, vol. 53, issue. 2, pp. 369-374.
7. Krishnamachari B, Lu G and Raghavendra C (2004) "An Adaptive Energy- Efficient and Low-Latency MAC for Data Gathering in Wireless Sensor Networks," Proc.of the 18th International Parallel&Distributed Processing Symposium (IPDPS'04), pp. 224-2.
8. Bahn H, Chae K and Oh H (2005) "An Energy-Efficient Sensor Routing Scheme for Home Automation Networks," IEEE Transaction on Consumer Electronics, vol. 51, issue. 3, pp. 836-839.
9. Hill J, Culler D and Polastre J (2004) "Versatile Low Power Media Access for Wireless Sensor Networks," Proc. of the 2nd ACM Conference on Embedded Networked Sensor Systems (SENSYS'04), pp. 95-107.

10. Culler D and Woo A (2001.)"A Transmission Control Schemes for Media Access in Sensor Networks," Proc. of the 7th Annual International Conference on Mobile Computing and Networking (MOBICOM'01), pp. 221-235.

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