International Journal of Electrical, Electronics and Computer Engineering 4(1): 120-124(2015)

ISSN No. (Online): 2277-2626

Congestion Control using Active agent in Wireless Sensor Network

Sheetal Meshram, Pallavi Chavan* and Supriya Jawale**

**Assistant Professor, Department of Electronics Engineering, PICE, Nagpur, (MS), INDIA*

(Corresponding author: Sheetal Meshram)

(Received 23 February, 2015 Accepted 28 March, 2015)

(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Wireless Sensor Networks (WSNs) represents a new category of ad hoc networks consisting of small nodes with three functions: sensing, computation, and wireless communications capabilities. A reliable protocol in wireless sensor network allows data transfer reliably from source to destination with reasonable packet loss. To improve the congestion control mechanism, for upstream congestion in wireless sensor networks the concept of agent task is applied. This paper presents Agent-based Congestion Control Protocol (ACCP) for wireless sensor networks. The traffic rate analysis on each node. It is based on the priority index and the congestion degree of the node. The parameter such as latency and throughput are investigated.

Keywords: Wireless Sensor Networks (WSNs), Congestion Control**,** traffic rate analysis, Congestion Control Protocol (ACCP)

I. INTRODUCTION

A sensor network is composed of a large number of sensor nodes, that are densely deployed inside the phenomenon or very close to it. The sensor nodes can sense the physical phenomenon, process the raw information, share the processed information with neighboring nodes and report the information to the sink node .There are mainly two types of traffic

(i) Downstream traffic
(ii) Upstream traffic.

The downstream traffic is one that is one to many multicast from sink to sensor nodes and upstream traffic is one that is many to one communication from sensor nodes to sink.
An upstream congestion control has single path routing and multipath routing .In single path routing, a child node can have single parent node .The traffic is forwarded from child node to parent node depending on certain policy as shown in Fig. 1.

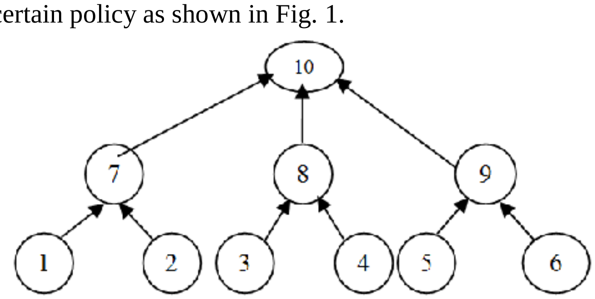


Fig. 1. Single path Routing.

In multipath routing, a child node can have a multiple parent node. Fig. 2 shows a multipath routing in which nodes 4 and 6 multiple parent nodes.

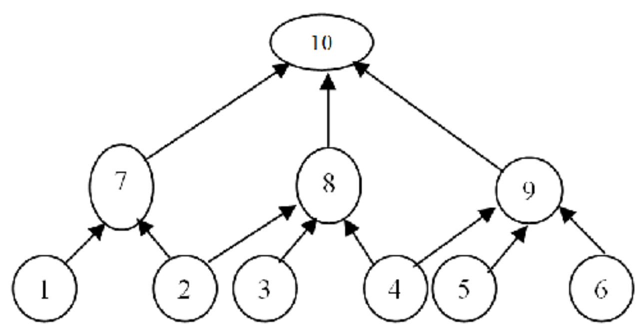
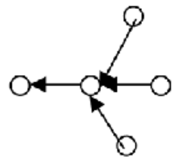


Fig. 2. Multipath path Routing.

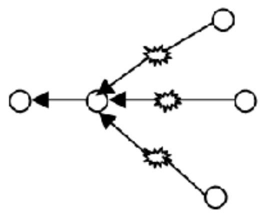
There are mainly two types of congestion that occur in WSNs.

(i) Node level
(ii) Link level

In first one the congestion is caused by buffer overflow in the node and can result in packet loss and increased queing delay as shown in Fig. 3a. Packet loss leads to retransmission and consumes additional energy .In second one the congestion occur when multiple active sensor nodes try to access the channel at same time as shown in Fig. 3b. Link level congestion increases packet service time, decreases both link utilization and overall throughput and wastes energy at sensor nodes. Both have direct impact on energy efficiency and QoS.



(a) Node level congestion (Buffer overflow)



(b) Link level congestion (Link collision)

Fig. 3. Congestion in wireless sensor networks.

There are two general approaches to control congestion.

(i) The first approach is network resource management that tries to increase network resource to mitigate congestion when it occurs.

(ii) The second approach is is traffic control that implies to control congestion by adjusting traffic rate at source nodes or intermediates nodes.

The rest of the paper is the review of different congestion control technique and various protocol to implement the same based on traffic control.

Performance of any transport layer protocol for WSN can be evaluated using congestion metric.

***Congestion Metric*>** Congestion degree, *d* is congestion detection metric that defined by:

$$d(i) = t_s^i / t_a^i \quad (2.1)$$

where t_s^i is the mean packet servicing time and t_a^i is the mean packet inter-arrival time of node *i*. Thus, the number of packet injected by the sensing nodes within a unit time and the number of the packet delivered to the base station is taking into account. Node efficiency or the average delivery ratio is calculated as:

$$\frac{\text{number of packets received by node } i}{\text{number of packets received by } i\text{'s parent}} \quad (2.2)$$

II. LITERATURE REPORTED

Congestion Control and Fairness (CCF) was proposed in [2] as a distributed and scalable algorithm that eliminates congestion within a sensor network. It ensures the fair delivery of packets to a sink node. CCF exists in the transport layer and is designed to work with any MAC protocol in the data-link layer.

In the CCF algorithm, each node measures the average rate *r* at which packets can be sent from the node, divide the rate r among the number of children nodes, adjust the rate if queues are overflowing or about to overflow and propagate the rate downstream. CCF uses packet service time to deduce the available service rate. Congestion information is implicitly reported. It controls congestion in a hop-by-hop manner and each node uses exact rate adjustment based on its available service rate and child node number. CCF has two major problems. The rate adjustment in CCF relies only on packet service time which could lead to low utilization when some sensor nodes do not have enough traffic or there is a significant packet error rate. Furthermore, it cannot effectively allocate the remaining capacity and as it uses work conservation scheduling algorithm, it has a low throughput in the case that some nodes do not have any packet to send.

The authors proposed Congestion Detection and Avoidance (CODA), that uses a combination of the present and past channel loading conditions, and the current buffer occupancy, to infer accurate detection of congestion at each receiver with low cost [2,3]. CODA uses a sampling scheme that activates local channel monitoring at the appropriate time to minimize cost while forming an accurate estimate. In CODA a node broadcasts backpressure messages as long as it detects congestion. When an upstream node (toward the source) receives a backpressure message it decides whether or not to further propagate the backpressure upstream, based on its own local network conditions. Nodes that receive backpressure signals can drop packets based on the local congestion policy (e.g., packet drop, AIMD (Additive increase multiplicative decrease), etc.).

An Adaptive Rate Control (ARC) mechanism was proposed which is most effective in achieving the goal of fairness, while being energy efficient for both low and high duty cycle of network traffic [11]. The ARC does not have any congestion detection or notification mechanisms. Each intermediate node increases its sending rate by a constant α if it overhears successful packet forwarding by its parent node. Otherwise, the intermediate node multiplies its sending rate by a factor β.

The proposed a new Priority- based Congestion Control Protocol. It employs packet based computation to optimize congestion control for a WSN. PCCP uses packet inter-arrival time and packet service time to produce a major of congestion.

In WSN sensor nodes have different priority due to their function or location and hence PCCP guarantees weighted fairness so that the sink can get different but in a weighted fair way, throughput from sensor nodes. PCCP is designed to work under both single path routing and multipath routing scenarios. PCCP results in lower buffer occupancy, achieves high link utilization and low packet utilization and low packet delay.

PCCP consist of intelligent congestion detection based on packet inter-arrival time and packet service time that has not been done been in the past. PCCP uses implicit congestion notification to avoid transmission of additional control messages and therefore helps improve energy efficiency. PCCP designs priority base algorithm employed in each sensor node for rate adjustment, in order to guarantee both flexible fairness and throughput called priority based rate adjustment (PRA).

III. AGENT BASED CONGESTION CONTROL ALGORITHM

At a particular node *i* Fig. 3 shows the queuing model having a single path routing. The transit traffic from the child node *i* = 1 is received by wireless sensor node i through its

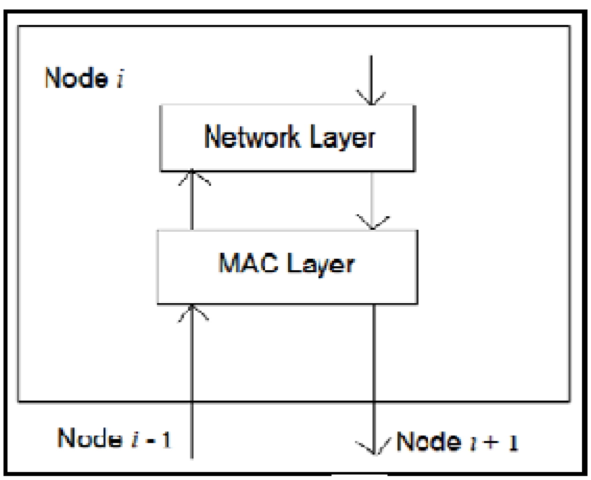


Fig. 4. WSN node.

MAC layer and denoted by r_t^i The source traffic at wireless sensor node i has rate r_s^i .Both the traffics get added at network layer before getting delivered to the node i+1 which is the parent node of wireless sensor node *i*.

The packet forwarding rate of the MAC layer is represented by r_f^i and depends on the MAC protocol alone. The total input traffic rate r_m^i at the wireless sensor node *is* given by

$$r_m^i = r_s^i + r_t^i \tag{4.1}$$

Let r_{in}^i be the packet input rate towards the wireless sensor node *i* from the wireless sensor node *i* – 1. *riout* be the packet output rate from the wireless sensor node *i* to the wireless sensor node *i* + 1.

If $r_{in}^i < r_f^i$, then $r_{out}^i = r_{in}^i$, and if $r_{in}^i > r_f^i$, then r_{out}^i is close to r_{in}^i. Hence the packet output rate at wireless sensor node *i* can be obtained from the following equation.

$$r_{out}^i = \min\,(r_{in}^i\,,\, r_f^i\,) \tag{4.2}$$

From equation 4.2 it is clear that the packet output rate at wireless sensor node *i* can be indirectly reduce through reducing the packet input rate to the wireless sensor node *i*.

Design goals. In this research work, a multi-agent system based intelligent upstream congestion control protocol has been developed. The design approach achieves the following goals.

Scalability. Scalability is achieved by significantly employing a multi-agent based system in each wireless sensor node for rate adjustment. The protocol aims to design an intelligent congestion control which minimizes the traffic rate involved in the sensor node, so that the proposed system avoids the transmission of additional control messages, there by improving the energy-efficiency.

QoS Awareness. Minimizing the overhead and maximizing the chance of efficiency, in terms of packet delivery ratio are contradictory goals. These two goals are balanced by the proposed congestion control protocol, to support the traditional QoS in terms of packet delivery, latency, throughput and packet loss ratio, which are needed for most of the real-time WSN applications *Fairness.* The upstream congestion control protocol uses guaranteed weighted fairness so that the sink can get different throughput from the wireless sensor node in a weighted fair way. The proposed protocol reduces the packet loss, while guaranteeing the weighted fairness, and supports multi-path routing with lower control overheads.

Efficiency. The protocol uses implicit congestion control notification to avoid transmission of additional control messages, which helps to improve the energy-efficiency.

Design architecture. A new multi-agent system based approach to control the traffic in the upstream congestion is used for single path routing. A Reusable Task-based System of Intelligent Networked Agents (RETSINA) is a multi-agent system that consists of three classes of agents: interface agents, task agents and information agents. Using RETSINA multi-agent an Agent-based Congestion Control Protocol (ACCP) for upstream congestion is proposed. ACCP consists of four components: Execution Monitor, Communicator, Planner and Scheduler. Based on the packet arrival time (*ta*) and packet service time (*ts*) at the Medium Access Control (MAC) layer the execution monitor detects the congestion. The packet service time (*ts*) is the time interval between arrival of packets at the MAC and its successful transmission whereas packet arrival time (*ta*) is the time interval between two subsequent packets arrived from any source. From this, a congestion index (Cx) is calculated at node *i* and is given by

$$Cx = ts/ta \qquad (4.3)$$

All the notifications at each wireless sensor node, in the packet header to be forwarded by the communicator module. From the congestion index the communicator module computes a global congestion priority index by adding source congestion priority index and the global congestion priority index of the lower level wireless sensor nodes. Through communication message packets the planner receives goals and finds ways to fulfill them. Planning component is reusable and capable of accepting different planning algorithms in an intelligent way. A list of all actions is scheduled by the scheduler and the action with the earliest deadline is chosen for execution. All modules are executed as separate threads and are able to execute concurrently. Thus almost all the packets are forwarded to the next wireless sensor node without any loses.

IV. SIMULATION RESULTS

In this section, we evaluate the performance of the ACCP protocol by simulating the scenario using wireless sensor nodes communicating via IEEE 802.11 MAC layer protocol model. The simulation environment is implemented in the NS-2, a network simulator that provides support for simulating wireless network for 60 and 80 nodes. The simulations are carried out using a sensor environment over a simulation area of 1500 meters × 1500 meters flat space. The buffer size is set to 100 packets. Performance has been analyzed below for the metrics latency and throughput.

Latency. Average latency is a measure of the average time between initiating a route discovery for a wireless sensor node to transmit and successfully setting up a route for the data transmission. Figure shows the analysis of latency on ACCP.

Protocol Overhead. Protocol packet overhead is the ratio of the number of protocol packets originated or forwarded, related to the route creation process that are received by a node per data delivery. This metric indicates the percentage of the total protocol messages transmitted for data forwarding. Figure shows the analysis of protocol overhead on ACCP under two different scenarios with wireless network environment.

V. CONCLUSIONS

The proposed upstream congestion control protocol can adjust the source rate based upon the current congestion status in the parent sensor nodes. The congestion control protocol in a wireless sensor network faces many challenges –the mobility of the nodes, the unreliable transmission medium, the lack of dedicated routers and infrastructure, the limited transmission range of the devices, and the available bandwidth. The simulation results demonstrate that the proposed approach and parameters provide an accurate and efficient method in realistic scenarios. This work can be extended to multi-path routing environment too. The ACCP reduces packet loss, which in turn, improves the energy-efficiency, and provides lower delay. This work can be extended to integrate data aggregation schemes to further reduce energy consumption, and to increase the battery life-time of the sensor node.

REFERENCES

[1]. Akyildiz I. F., Su W., Sankarasubramaniam Y., and Cayirci E.,"Wireless sensor networks: A survey", *Journal on Computer Networks*, Vol. **38**, pp. 393-422, 2002.

[2]. Cheng Tien, Ee Ruzena Bajcsy in "*Congestion Control and Fairness for Many to One Routing in Sensor Networks*" Electrical Engineering and Computer Science University of California, Berkeley.

[3]. Chieh Yih, Wan Shane, B. Eisenman, Andrew T. Campbell in "*CODA: Congestion Detection and Avoidance in Sensor Networks*" Dept. of Electrical Engineering Columbia University New York, NY 10027.

[4]. C. Wang , K. Sohraby, B. Li, Daneshmand, Y. Hu in "*Upstream Congestion Control in Wireless Sensor Networks Through Cross-Layer Optimization*", *IEEE, Senior Member*, Vol. **25**, NO. 4, MAY 2007.

[5]. V. Vijaya Raja *Research Scholar, St. Peter's University, Chennai, India,* R. Rani Hemamalini *Professor and Head, St. Peter's College of Engineering and Technology, Chennai, India,* and A. Jose Anand. *Assistant Professor, Jaya Engineering College, Chennai, India,* in "*Implementation of RETSINA-based Congestion Control Technique in Realistic WSN Scenarios" IJCSET* November 2011 Vol. **1**, Issue 10, 617-621.

[6]. Ing-Ray Chen, Anh Phan Speer, and Mohamed Eltoweissy, "Adaptive Fault-Tolerant QoS Control Algorithms for Maximizing System Lifetime of Query-based Wireless Sensor Networks", *IEEE Transactions on Dependable and Secure Computing,* Vol. **8**, No. 2, pp. 161-176, March-April 2011.

[7]. Jose Cecilio, Joao Costa, Pedro Martins, and Pedro Furtado, "Configuration Interface for Industrial Wireless Sensor Networks", *Workshops of International Conference on Advanced Information Networking and Applications", IEEE Computer Society,* pp. 447-452, *IEEE 2011*.

[8]. Paolucci M., D. Kalp, A. Pannu, O. Shehorg, and K. Sycara, "A planning Component for RETSINA Agents", Internet Draft.

[9]. Yu Yang, Yongjun Xu, Xiaowei Li, and Canfeng Chen, "A Loss Inference Algorithm for Wireless Sensor Networks to Improve Data Reliability of Digital Ecosystems", *IEEE Transactions on Industrial Electronics*, Vol. **58**, No. 6, pp. 2126- 2137, June 2011.

[10]. Yuanzhu Peter Chen, Arthur L. Liestman, and Jiangchuan Liu, "A Hierarchical Energy-Efficient Framework for Data Aggregation in Wireless Sensor Networks", IEEE Transactions on Vehicular Technology, Vol. **55**, No. 3, pp. 789-796, May 2006.

[11]. A. Woo and D. C. Culler, "A transmission control scheme for media access in sensor networks," *Proc. ACM Mobicom'01*, Rome, Italy, July 16–21, 2004.