

Location Based Multi-Queue Scheduler in Wireless Sensor Network

Eun-Mook Lee*, Ali Kashif*, Dong-Hyun Lee*, In-Tae Kim*, Myong-Soon Park*†

*Department of Computer and Radio Communications Engineering, Korea University, Seoul, 136-713, Korea
chizzv@ilab.korea.ac.kr, ali@ilab.korea.ac.kr, lunarcake@ilab.korea.ac.kr,
kimintai@ilab.korea.ac.kr, myongsp@ilab.korea.ac.kr

Abstract— Recent advances in technology realize small devices which have been enabled wireless communication among sensors. Wireless sensor network is used for monitoring such as environment, earthquake and disaster. In sensor network, real-time end-to-end data communication is very important. If we use traditional First Come First Serve(FCFS) scheduler, which needs a lot of time to send if a packet generated from leaf nodes which is the nodes in end of the network. To reduce the amount of exceeded deadline packet, intermediate node need to change delivery order among packets in its ready queue. In this paper, we propose Multi-Level-Queue scheduler scheme which use different number of queue according to location of node in the network. The simulation result shows that our proposed scheme reduces the Miss Ratio of packet.

Keywords—Wireless Sensor Network, WSN, Scheduler, Multi-Queue, Location based scheduler

I. INTRODUCTION

Recent advances in technology realize small devices which have sufficient power such as computation, memory, and efficient battery consumption. These technologies enable communication between small devices. As the results, wireless sensor network has developed[1].

Wireless sensor network is used for air traffic control, traffic surveillance, manufacturing automation, environment monitoring, disaster monitoring, and military sensing[2]. It is operated in non-infrastructure(e.g Access Point) area by communicating among nodes. Figure 1 simply represents sensor network architecture.

Most of research in wireless sensor network focus on energy efficiency by minimizing the communication overhead and data aggregation[3][4][5]. But all of wireless sensor network application collects some information and sends the information to Base Station or Sink. So, not only energy efficiency but also real-time data communication those are important factor in wireless sensor network.

Traditionally, First Come First Serve (FCFS) scheduler is used to support real-time communication on each node. But if most of nodes in network generate sensing data in a time, data packets which are generated far from Base Station need more time than data packets which are generated near from Base Station to be reached Base Station.

Therefore we should consider scheduling delivery order of data packet in immediate nodes within a deadline.

When each node in network schedule delivery order, the node has to decide which packet is urgent for real-time data communication. Basically, if a packet comes first, then the packet is processed firstly in common network. But if data delivery time is over a specific deadline, the data could be lost its meaning. And sensor network application usually considers large area, so the situation is occurred frequently. In other words, most of sensed data have to report BS in order to be used meaningfully within a deadline which is valid-time of sensed data meaning. Therefore most of wireless sensor network scheduler focus on maximize data transmission rate in a specific time.

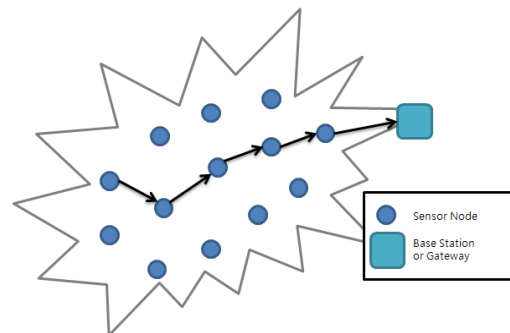


Figure 1 Simple Sensor Network Architecture

II. RELATED WORKS

[6] proposed priority based scheduler. If a packet has the longest distance from source to destination and short deadline, the packet has high priority than others. [6] calculates distance and deadline to get velocity of data packet.

† Corresponding Author: Myong-Soon Park; E-mail: myongsp@ilab.korea.ac.kr

$$V = \text{dis}(x_0, y_0, x_d, y_d)/d \quad (1)$$

$$V = \text{dis}(x_i, y_i, x_d, y_d)/(D-T_i) \quad (2)$$

[6] proposed (1) SVM(Static Velocity Monotonic) and (2) DVM(Dynamic Velocity Monotonic), SVM calculates a velocity once where the source node. DVM calculates a velocity where each intermediate node. And in [6] idea, if a packet's deadline is over, the packet is dropped in intermediate nodes to reduce meaningless works such as network traffic, data processing.

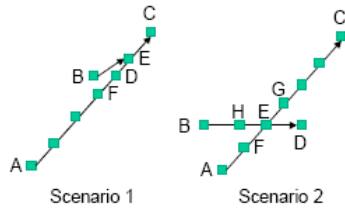


Figure 2 Scenarios of distance-aware scheduling

[6] assumes overload condition to generate explicit Miss Ratio.

In fact First Come First Serve(FCFS) could work better in other condition. But [6] use only its proposed scheduler for whole network. As the result of the meaningless works, it consumes resources such as memory, computation power and increases processing delay.

[7] is based on RAP[6], [7] considered transmission delay where intermediate nodes. As a result, [7] could provide more precise deadline aware solution. But as mentioned previous paragraph, [7] paper also use one scheduler scheme for whole network. It could be make meaningless wastes.

And There are other solutions using routing path[8][9]. [8] makes shortest routing path to BS, and channel reservation of the path(EPCR: Emergent Packet Channel Reservation) when emergent event is generated. If generic event is being in shortest path, the generic event is routed other route except critical path. And [9] proposed Back-Pressure Rerouting. It's also avoidance scheme for congested area by using re-routing.

As mentioned in here, there is some other scheme to provide real-time communication. But in this paper, we just consider packet scheduling only in intermediate node.

III. LOCATION BASED MULTI-QUEUE SCHEDULER

Figure 3 represent overall of general sensor network architecture. We select the color part in figure 3 because we think we don't need all of part of figure 3 to verify proposed idea. Figure 4 is shown the colour part as zoom-in. The color density in figure 4 represent load of each node.

A. Proposed Scheduler Scheme

When we use First Come First Serve(FCFS), a packet which is generated from node which located far from the BS(e.g 15-23 nodes in figure 4), needs a lot of time to be reached BS. So we need to change deliver order of packets in intermediate node.

To change the packet delivery order in intermediate nodes, we can consider two kind of method on each node.

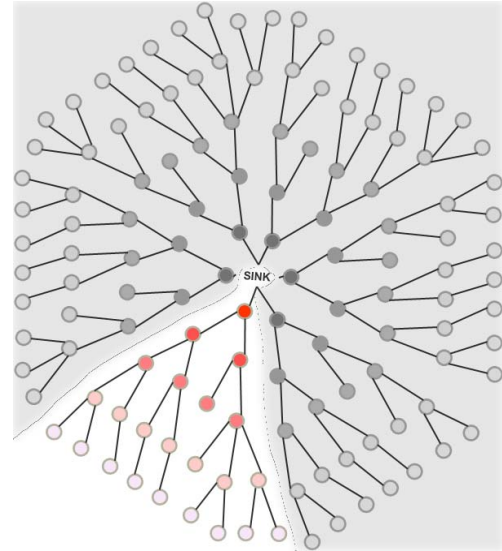


Figure 3 Architecture of sensor network

- ① SP(Simple Priority): when a node inserts a packet to the queue, the node finds the packet's location in a ready queue according to priority.
- ② Multi-FIFO-Queue: when a node inserts a packet, the node decides the packet's corresponding queue which corresponds to packet's priority.

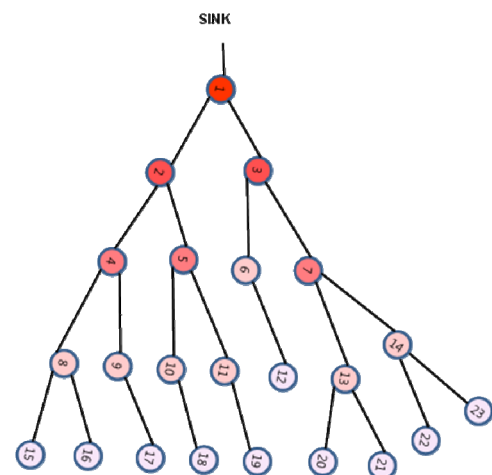


Figure 4 Node Deployment in our Proposed Scheme

We can think the first one method very easily. In most application, that method could be basic solution. But the first one method has high starvation probability. Starvation, in this paper, means low priority packet couldn't be sent in the ready queue, if a node continuously gets high priority packet. If we want to solve that problem, the node have to always check remaining deadline in order to sort again according to deadline among data packets in the ready queue. It is too heavy computation and that makes a lot of energy consumption.

Second one method use Multi-FIFO-Queue. Multi-FIFO-Queue is divided three multi queue or two multi queue according to location of node in network. Each queue has its priority such as high, mid, and low. When a node gets a packet, node decides the packet's priority according to hop count data field of packet. And the node give different opportunities to sent the packets in ready queue as high = 5, mid = 3, low = 2 like that. But, actually some nodes don't need multi queue scheduler. For example, leaf nodes(node number 15-23 in figure4) don't need multi queue because these nodes just have its own sensed data. That means leaf nodes don't need to separate queue.

Figure 5 flow chart simply represents scheduling operation after a node gets a packet.

In this paper, we restrict maximum number of multi queue size as three. Because if the queue size is over three, node need complex calculation to decide packet's priority for match with corresponding queue and give opportunities among queues to send.

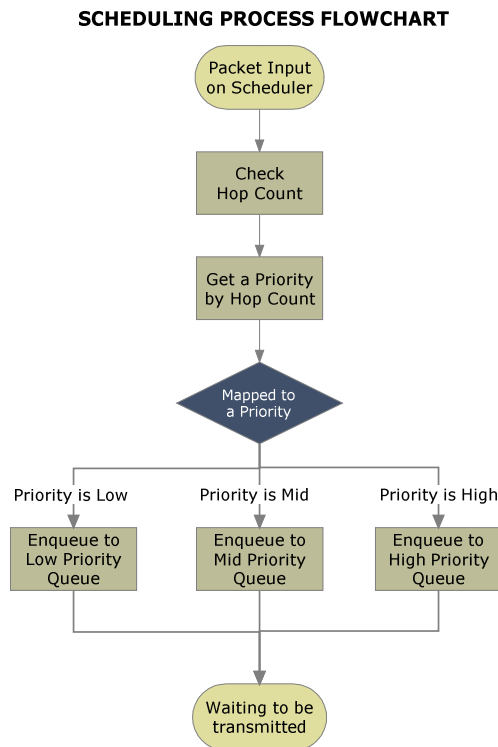


Figure 5 Scheduler Operation in Three Multi Queue

IV.SIMULATION

In this simulation, we compare traditional FCFS, Priority, RAP[4], and proposed Multi-Queue Scheduler.

At the first time, we want to try experiment on real sensor node. But we don't have enough number of sensor nodes to get proper result of test. So we simulate it with proper simulation parameter as possible as we can.

A. Simulation Environments

Figure 6 represents layer by layer Multi Queue applying and node deployment for simulation.

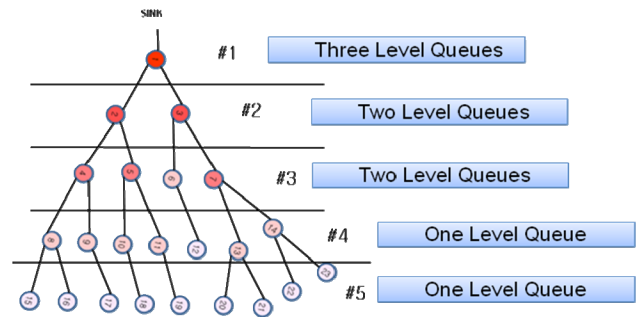


Figure 6 Layer by Layer Multi-Queue apply

Since nodes generate a packet in one second and the number of node is 23 for simulation, so that whole network generates 23 packets in one second. Generated packets are sent every 45 millisecond period on each node. One node could send 22.2 packets within one second. In this situation, we give deadline as 1000 millisecond. Therefore Missed packets must be occurred. These overload condition parameters make obvious result of simulation. The numbers in Multi-Queue Transmission Ratio of table 1 represent opportunities for sending. In other words, High Queue is given 5 times for transmission to next hop, Mid Queue is give 3 times, and Low Queue is given 2 times in three queue. Likewise, two queue are given the opportunities as high = 7 times, and low = 3 times.

And we impose the Time Cost of a Calculation as 3millisecond for each calculation. For example, SP(Simple Priority) scheduler has to check location of packet according to packet's priority. To get the location, SP has to compare new coming packet and others. Moreover, when Multi Queue inserts coming packet to corresponding priority queue, Multi Queue needs some calculation to know corresponding queue among some queues. So, simulator imposes the Time Cost of a Calculation.

Equation (3) shows spending time of calculation. The time is needed when a packet has come to a node for getting location of packet or getting corresponding priority queue.

$$\text{Spending Time} = 3_{ms} * \text{each comparison} \quad (3)$$

Table 1 contains simulation parameters as we mentioned.

Table 1 Simulation Parameters

Data Generation Period	1 packet / 1000 millisecond
Data Sending Period	1 forwarding message / 45 millisecond
Deadline	1000 millisecond
Multi-Queue	Three Queue(High, Medium, Low), Two Queue(High, Low), One Queue(Single Priority)
Multi-Queue Transmission Ratio	Three Queue(High = 5, Mid = 3, Low = 2), Two Queue(High = 7, Low = 3)
Number of Nodes	23
Time Cost of a Calculation	3 millisecond for each

Table 2 represents Data Packet structure in our simulation. We simply make data packet structure needed fields only in our simulation.

Table 2 A Structure of Data Packet

Field	Source ID	Data	Hop Count
Byte	4	8	1

B. Simulation Assumptions

- Every node knows its Hop Count from Base Station.
 - After node moving or deployment, every node get initial message(e.g hello message) by using initial message every node knows its Hop Count from BS.
- Node and Routing path are static.
 - In this simulation, we just focus on difference according to node location and scheduling. To simple our simulation, we don't consider mobility of node and dynamic routing path.
- If a packet is in excess of deadline, the packet is dropped.
 - Most of data have own timing constraints according to its application[2]. If a packet is delivered too late, the information would lost its meaning. So if packets are in excess of deadline, node drops the packets for saving resources.

C. Simulation Results

Figure 7 is a result of this simulation. The result represents the data amount of data exceeded deadline on BS.

The SP(Simple Priority) scheduler in that graph means sorting the queue by packet's priority(Hop count) as mentioned 3.1. RAP means whole network node use Three Queue (High, Medium, Low). Proposed Scheme means Multi Queue is applied layer by layer in network as shown in figure 6.

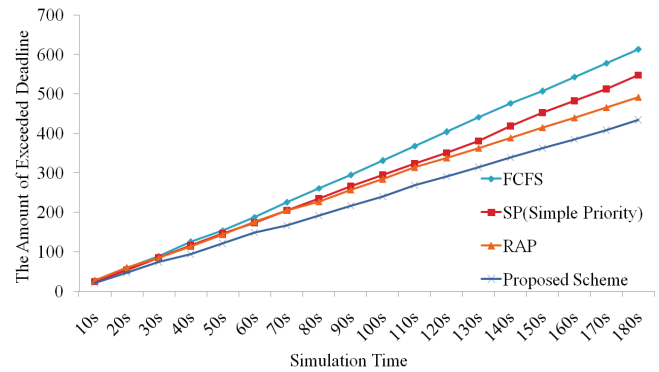


Figure 7 The Amount of Data Exceeded Deadline

As we mentioned in 5.1 Simulation Environments, missed packets must be occurred. In figure 7, FCFS generates lots of missed packets almost 600 packets at 180s simulation time. Relatively the Proposed Scheme is the best that generates only about 400 packets at 180s simulation time.

The performance difference between RAP and Proposed Scheme is whether the nodes consume meaningless processing(e.g. RAP calculates a packet's priority in order to insert its corresponding priority queue) or not. In case of SP(Simple Priority), sorting time in the queue consumes a lot of processing time. So that the result of SP method performance is lower than RAP and Proposed Scheme.

Figure 8 represents the amount of data arrived BS within the deadline. As we mentioned in SP(Simple Priority) description of III.A proposed scheduler scheme, SP scheduler has more starvation probability around #1 and #2 layer in figure 4 because the nodes generates low priority packets. On the contrary, FCFS occur starvation around leaf nodes. Because it needs too much time in order to deliver from leaf nodes to BS. According to the result, Proposed Scheme is the most similar as flat. That means this scheme provides fairness of network as well in perspective of sending opportunity.

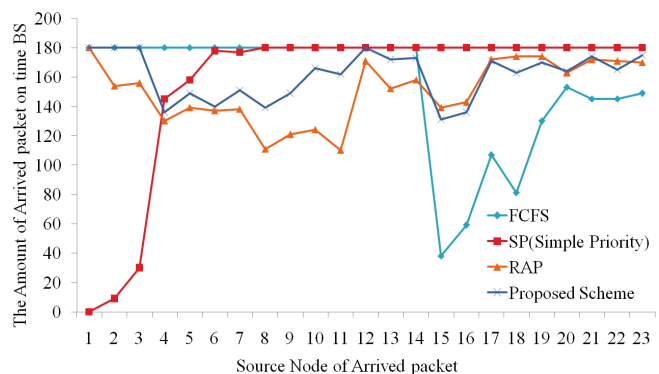


Figure 8 The Amount of Data arrived BS within the Deadline

Figure 9 represents the amount of total comparison in whole network for scheduling. As we expected, FCFS is the least comparison amount due to no instruction except inserting the packet into queue. Even though Proposed Scheme has more comparisons than FCFS, the comparison amount of Proposed Scheme is lesser than others. Moreover Proposed Scheme reduces the amount of data exceeded deadline and provides fairness of sending opportunity.

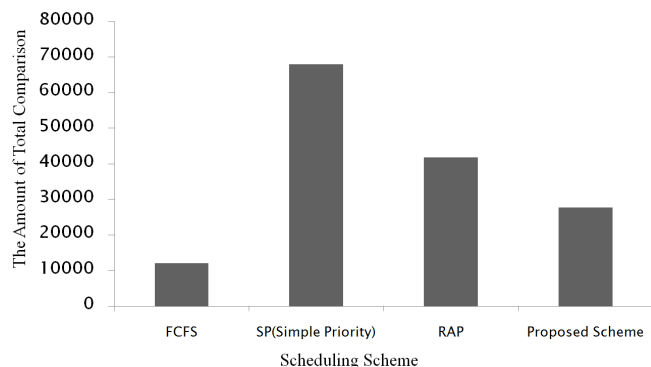


Figure 9 Total Comparison Amount

V. CONCLUSIONS

In this paper, we propose Multi Queue Scheduler scheme in wireless sensor network. Proposed scheme is applied layer by layer according to node location from in the network. As the result, that scheme reduces the amount of missed packets and provides fairness of data sending as shown in figure 7, and 8.

Moreover, proposed scheme has smaller comparison amount than SP(Simple Priority) and RAP. In sensor network, reducing computation means not only computation delay but also saving energy.

In future works, we will research about dividing threshold of network which is for applying proposed scheduling scheme in dynamic topology of sensor network.

REFERENCES

[1] Ian F. Akyldiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayici, 'A Survey on

Sensor Networks', *IEEE Communications Magazine.*, pp. 102-114, August. 2002

[2] CHEE-YEE CHONG, SRIKANTA P, KUMAR, "Sensor Networks: Evolution, Opportunities, and Challenges", *PROCEEDINGS OF THE IEEE.*, VOL. 91, NO. 8 pp. 1247-1256, AUGUST 2003

[3] Xiaohua Dai, Feng Xia, Zhi Wang, Liping Liu and Youxian Sun. "A Survey of Intelligent Information Processing in Wireless Sensor Networks", *International Conference on Mobile Ad-hoc and Sensor Networks(MSN)*, Lecture Notes on Computer Science, pp. 123-132, 2005

[4] Dong-sub Kim, Ali Kashif, Xue Ming, Jung-Hwan Kim, Myong-Soon Park, "Energy Efficient In-network Phase RFID Data Filtering Scheme", *Proceedings of the 5th international conference on Ubiquitous Intelligence and Computing*, LNCS 5061, pp. 311-322, June 23~25, 2008

[5] Kemal Akkaya, Murat Demirbas, and R. Savas Aygun, "The impact of data aggregation on the performance of wireless sensor networks", *Wireless Communications and Mobile Computing Journal*, Vol. 8, No. 2, pp. 171-193, 2008

[6] Chenyang Lu Brian M. Blum Tarek F. Abdelzaher John A. Stankovic Tian He, 'RAP: A Real-Time Communication Architecture for Large-Scale Wireless Sensor Networks', *Real-Time and Embedded Technology and Applications Symposium*, pp. 55, 2002

[7] Seong-Min Park, Guang-yao Jin, Won-il Choi and Myong-Soon Park, 'Scheduling Policy for Real-Time Communication in Wireless Sensor Networks', *The 8th International Conference on Electronics, Information, and Communication (ICEIC 2006)*, pp.79-82, Ulaanbaatar, 2006

[8] Shao-liang Peng, Shan-shan Li, Yu-xing Peng, Wen-sheng Tang, and Nong Xiao, 'Real-Time Data Delivery in Wireless Sensor Networks: A Data-Aggregated, Cluster-Based Adaptive Approach', *Ubiquitous Intelligence and Computing*, Volume 4611 pp. 514-523, 2007

[9] T. He et al., "SPEED: A stateless protocol for real-time communication in sensor networks", in *the Proceedings of International Conference on Distributed Computing Systems*, Providence, RI, May 2003