

COMPARATIVE STUDY ON THE PRIORITY BASED QOS AWARE MAC PROTOCOLS

Sikder Sunbeam Islam

Department of EEE
International Islamic University Chittagong
Chittagong, Bangladesh
sikder_islam@yahoo.co.uk

***Abstract-** In Wireless Sensor Network (WSN), QoS (Quality of Service) in sensor application plays a very important role especially where assured and timely data transfer is needed. QoS based routing is also required to ensure best use of nodes. Many QoS based routing and MAC protocols have been proposed but they can be grouped on the basis of problem they solve, like prioritization, timeliness, reliability etc. In this paper, we will study some priority based QoS protocols used in WSN and we will also make a comparison among them.*

Keywords: WSN, QoS, MAC Protocol

1. INTRODUCTION

WSN is a wireless network consisting of small sensing nodes which have computation and communication capabilities, operates in an unattended environment [1]. Node routes data back to Base Station (BS). Data transmission may from node to node or Multi hop towards the BS or gateway. WSNs can be deployed to support a wide variety of applications in many different situations, whether they are composed of stationary or mobile sensor nodes. Considering the dynamic nature of the network, several new protocols have been proposed that are more concern about QoS [2]. In WSN there are two types of protocols used to carry out the communication process between the nodes, they are Routing protocols and Medium Access Control (MAC) protocols. The basic communication types considered send periodic data or event-driven data to the base station or to the sink. The sensor node extracts data from a particular location and then multicast or broadcast of data is needed. Routing protocols needed to fill full these requirements along with energy conservation and QoS factors. The MAC protocol also plays an important role in accessing the channels using sensor nodes, and maintains energy saving, throughput, QoS and minimum delay. However, these protocols can be grouped on the basis of problem they solve, like Prioritization: Differentiate Services on the basis of definition of class of traffic, Timeliness: Guaranteed Delivery within a given time, Reliability: Ensure Probability of Delivery etc.[3]. Many MAC layer protocols have been proposed for WSN. Some of them are Contention Based like, T-MAC[4], S-MAC[5]; some are QoS based, Like, Q-MAC [6] as well as many QoS based routing protocol have been proposed like, SAR [7], SPEED [8] and also some comparative study has been done [17]. However, in

this paper we will only consider the priority based QoS MAC protocols for study and comparison.

The rest of the paper is organized as follows. We will briefly discuss on some Priority based QoS MAC protocols in section II and we will draw a comparison in Section III. Finally we will conclude the paper in Section IV.

2. PRIORITY BASED QOS MAC PROTOCOL

The main purpose of most MAC-layer protocols is to reduce energy waste caused by collisions, idle listening, overhearing, and excessive overhead. QoS provisioning in the MAC layer deals mainly with the scheduling of packets on the wireless channel subject to local limitations. They maintain access to the channel is based on a schedule. Channel access is limited to one sensor node at a time. Using Scheduling collision of packets during accessing the channel can be avoided. However, due to dynamic nature of WSN, providing certain quality of service (QoS) guarantees in a multi-hop wireless networks, where prioritizing data packets and providing different services based on application specifics is very important. Here, we are going to discuss on some priority based QoS MAC protocol briefly.

Q-MAC [6] is an energy-efficient; Priority based QoS-aware media access control (Q-MAC) protocol. Q-MAC tries to minimize energy consumption while providing QoS. Q-MAC uses the MACAW protocol as an under laying protocol to access the wireless channel. To satisfy QoS requirements for different traffic types, the Q-MAC introduces a queuing model where priority levels are set for different queues to reflect the criticality of data packets originating from different sensor nodes. Higher priority queues provide absolute preferential treatment over low priority queues.

The Q-MAC consists of intra-node and inter-node scheduling in WSN. The intra-node scheduling scheme adopts a multi-queue First-In First-Out (FIFO) based queuing style to classify data packets according to their application and MAC layer abstraction while the inter node scheduling handles channel access with the goal of minimizing energy consumption through reducing collision and idle listening.

For intra node scheduling in Q-MAC, five extra bits of information are added to every message, two for identification of the types of applications and three for the types of sensing data. Packets that have gone through more hops have a higher priority. In Q-MAC the queue architecture consists of five queues with one specified as an instant queue, meaning that any packet stored in this queue will be served instantly as showed in figure-1. After a packet is scheduled for transmission, the inter-node scheduling mechanism, Power Conservation MACAW (PC-MACAW) [9], is executed to achieve Loosely Prioritized Random Access (LPRA) between sensor nodes in which we use contention time of each node to maintain the order by which nodes access the channel.

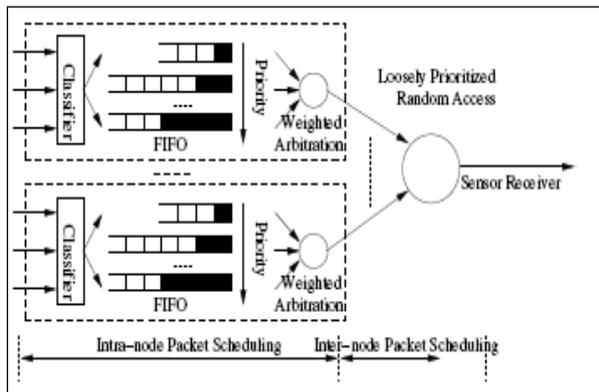


Figure 1. :Priority scheduling in QMAC[10]

PRIMA [11] is an energy efficient and QoS aware MAC protocol which has been designed for large wireless sensor networks. PRIMA protocol is composed of two components; a clustering algorithm for providing scalability and a channel access mechanism for providing multi-hop communications. The channel access is composed of a hybrid mode of TDMA and CSMA. CSMA mode is used to communicate control messages, while data messages are assigned TDMA slots. So, packet collisions and energy consumption can be minimized. PRIMA protocol minimizes the idle listening periods by forcing the nodes that have no data to send to go early into a sleep state to save energy, which is considered as a main source of the energy consumption in sensor networks. The PRIMA protocol provides QoS by employing a queuing model where traffics are classified depending on their importance into four different queues with different priorities such as, high (instant queue), medium, normal, or low,. Higher priority queues have absolute preferential action over low priority queues. For doing that PRIMA uses a sub protocol named C-MAC (Classifier MAC)-a modified version of Q-MAC.

The source node identifies the degree of importance of each data packet that it is sending which can be converted into predefined priority levels. By appending two extra bits at the end of each data packet, the application layer sets the required priority level for each data packet. The queuing architecture of the C-MAC is shown in Figure-2.

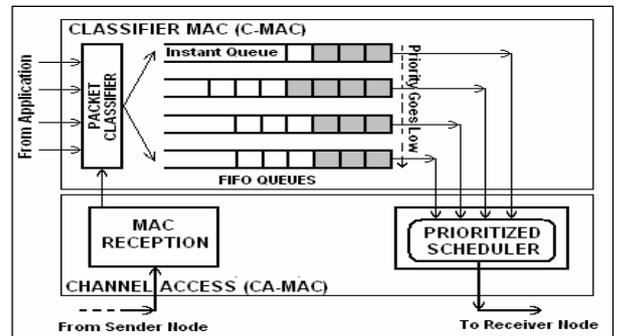


Figure 2. Priority scheduling in PRIMA [11]

DB-MAC (Bacco *et al.*, 2004) [12] is a contention-based MAC protocol designed for delay bounded applications upon hierarchical data gathering tree. Basically, a transmission close to the source is given a higher priority than a transmission close to the sink. Besides, nodes will overhear contention time slots from other to facilitate early data aggregation embedded. Therefore, a node if it is close to the source, will obtain medium access with a high probability. Meanwhile, it performs path aggregation as close as possible to the sources. When a source starts transmitting, the priority, Pr , is set to the maximum, Pr_{MAX} . Pr is then decreased by one at each hop. The receiving node decrements the priority by 1 and makes Pr_{MAX} to $Pr_{MAX} - 1$, and forwards the packet to the next node, which will contend for medium access with priority $Pr_{MAX} - 1$. The BI value is set between 0 and 1023 tics, depending on the value of the priority. Therefore, a node will obtain medium access with a high probability if it is close to the source. The priority access supported enables energy saving and decreases latency as compared to IEEE 802.11 scheme [12].

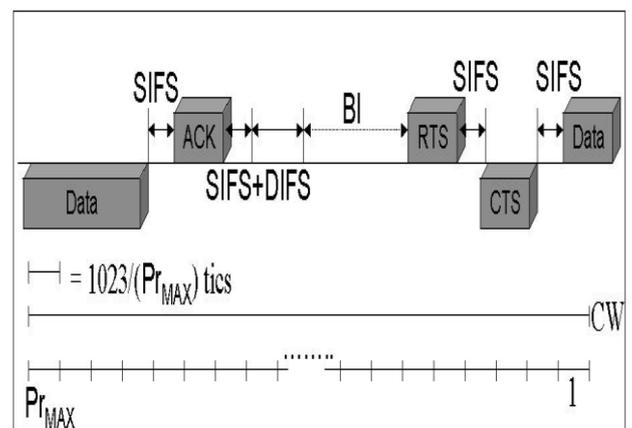


Figure 3. The contention mechanism in DB-MAC [12]

RAP [13] is a RT communication architecture designed for large-scale sensor networks. The architecture of RAP is shown in Figure-4. Control and Sensing applications interact with RAP through Query/Event service APIs.

The communication is supported by a scalable and efficient protocol stack, which integrates the geographic routing protocol (GF), transport-layer location-addressed protocol (LAP), velocity monotonic scheduling (VMS) policy, and contention-based MAC with packet prioritization. LAP is similar to UDP (connectionless) except that all messages are addressed by location instead of IP address. GF provides a greedy localized routing decision to forward a packet to a neighbor node. The keystone of RAP is the VMS policy, which is based on packet requested velocity that reflects both distance and timing constraints. Here, with higher requested velocity packet is assigned a higher priority. VMS reduces end-to-end deadline miss ratio by giving the packets with higher requested velocities, higher priority. Moreover, to implement packet priorities, two components of the standard IEEE 802.11 implementation have been modified. The initial waiting time after the channel becomes idle and the backs off window increase functions are modified to ensure that packets with high priority have high probability to get the channel in both contention avoidance phase and contention phase. Simulations demonstrate that RAP has effectively reduced the deadline miss ratio. The result shows that a multi-layer location-based communication stack with velocity based prioritization can improve the RT performance and QoS in WSNs.

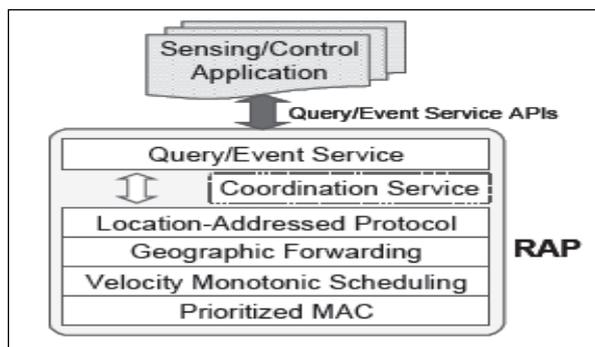


Figure 4. RAP Architecture [13]

For RT-WSNs, although IEEE 802.15.4 protocol has provided GTS (Guaranteed Time Slot) mechanism for time sensitive data, details of how to use it to maintain explicit QoS guarantees are still being developed. It is possible to let the PAN coordinator distribute GTSs corresponding to the deadline and bandwidth requirements of transmissions so as to support HRT guarantees (Francomme *et al.*, 2006) [16]. On the other hand, enhanced CSMA/CA MAC mechanisms may offer soft delay guarantees (Koubâa *et al.*, 2006). For example, priority toning strategy is used in (Kim and Choi, 2006) [14]. A tone signal will be sent by a node to the PAN coordinator to request it alerting other nodes to defer their contentions so as to support a fast delivery of high priority frames. In (Koubâa *et al.*, 2006) [15], traffics are categorized into high and low priority queues with different CSMA/CA settings. The result presents a heuristic solution to provide different QoS for messages of different priorities. Service differentiation of packets in MAC shows promising.

3. COMPARISON OF THE PROTOCOLS

Here the comparisons of the above MAC protocols have been given in details in the TABLE: 1.

4. CONCLUSOIN

In this paper, we tried to introduce all the priority based QoS aware MAC protocols. We also find their comparisons here which will help the researcher to find the idea of the priority based QoS aware MAC protocols at a glance.

5. REFERENCES

- [1] [1]. Jamal N, Al Kharaki, Ahmed E Kamal, 2004 "Routing Techniques in Wireless Sensor Network: A Survey" IEEE Wireless Communication
- [2] [2]. Akyildiz, I.F., W.Su, Y. Sankarasubramaniam and E. Cayirci, 2002, "A Survey on Wireless Sensor Network" IEEE Communication Magazine, 40(8): 102-116
- [3] [3]. Noor Zaman and Azween B Abdullah, 2011 "Different Techniques towards enhancing Wireless Sensor Network (WSN) routing Energy efficiency and Quality of Service" World Applied Sciences Journal 13(4): 798-805
- [4] [4]. T. V. Dam, K. Langendoen, "An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks," Proceedings fo the 1st ACM Conference on Embedded Networked Sensor Systems (SenSys'03), Los Angeles, Nov. 2003.
- [5] [5]. W. Ye, J. Heidemann, D. Estrin, "A Flexible and Reliable Radio Communication Stack on Motes," Technical Report ISI-TR-565, Information Sciences Institute, University of Southern California, Los Angeles, Sept. 2002.
- [6]. Y. Liu, I. Elhanany, and H. Qi. An energy-efficient QoS-aware media access control
- [7]. K. Sohrabi, J. Gao, V. Ailawadhi, and G. J. Pottie. "Protocols for self-organization of a wireless sensor network". *IEEE Personal Communications*, October 2000, pp. 16–27.
- [8]. T. He, J. A. Stankovic, C. Lu, and T. F. Abdelzaher. "SPEED: A stateless protocol for real-time communication in sensor networks". In *Proceedings of ICDCS*, 2003, pp. 46–58
- [9]. V. Bharghavan et.al , "Macaw: A media access protocol for wireless lans," Proc. ACM SIGCOMM, vol. 24, no. 4, 1994.
- [10]. Yang Liu, Elhanany, I.; Hairong Qi, " An energy-efficient QoS-aware media access control protocol for wireless sensor networks", Mobile Adhoc and Sensor Systems Conference, 2005
- [11]. Jalel Ben-Othman , Lynda Mokdad , Bashir Yahya "An Energy Efficient Priority-based QoS MAC Protocol for Wireless Sensor Networks" IEEE ICC 2011 proceedings
- [12]. Bacco, G.D., T. Melodia and F.Cuomo (2004). "A MAC protocol for delay bounded applications in wireless sensor networks" In: Proc. Med- Hoc-Net. pp. 208-220
- [13]. C. Lu, B. Blum, T. Abdelzaher, J. Stankovic, and T. He, "RAP: a real-time communication architecture for large-scale wireless sensor networks," in *Proc. IEEE RTAS*, pp. 55-66, September 2002.
- [14]. Kim, T.H. and S. Choi (2006). "Priority-based delay mitigation for event-monitoring IEEE 802.15.4 LR-WPANs" *IEEE Commun. Letters* 10(3), 213-215

- [15]. Koubâa, A., M. Alves, B. Nefzi and Y. Q. Song (2006), "Improving the IEEE 802.15.4 slotted CSMA/CA MAC for time-critical events in wireless sensor networks". In: *Proc. Workshop Real-Time Networks*. pp. 270-277
- [16]. Francomme, J., G. Mercier and T. Val (2006). "A simple method for guaranteed deadline of periodic messages in 802.15.4 cluster cells for control automation applications". In: *Proc. IEEE ETFA*. pp. 270-277.
- [17]. Luis Javier García Villalba , Ana Lucila Sandoval Orozco, Alicia Triviño Cabrera and Cláudia Jacy Barencó Abbas (2009), "Routing Protocols In Wireless Sensor Network" ISSN 1424-8220 www.mdpi.com/journal/sensors

TABLE-1: COMPARISONS OF THE PRIORITY BASED QOS MAC PROTOCOLS

Name	Packet Prioritization	Scheduling Scheme	Queue Type	Energy Awareness	QoS
QMAC	Packets go through more hop have more priority	Intra node and Inter node based Scheduling	Multi queue (five queues) FIFO type	High	High
PRIMA	Packets are prioritized depending on their importance	Packets are scheduled through hybrid approach (TDMA, CSMA).	four different queues (as High, medium, normal, low) FIFO type	High	High
DB-MAC	Packets from a node that Close to source get high priority	Contention based scheduling	N/A	High	High (Delay Bounded)
RAP	Here, with higher requested velocity packet is assigned a higher priority	Velocity Monotonic Scheduling	Multiple FIFO queues each corresponding to a fixed Priority level based on requested velocity.	N/A	High
GTS	Prioritization is done using a toning signal	N/A	High and low queue only, FIFO queue.	High	High