COMPARATIVE STUDY ON PRIORITY BASED QOS AWARE MAC PROTOCOLS FOR WSN

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ABSTRACT

In Wireless Sensor Network (WSN), QoS (Quality of Service) in sensor application plays a very important role. QoS based routing is required to ensure the best use of nodes in WSN. In this paper, a comparative study of QoS based routing in Media Access Control (MAC) protocols are presented based on the traits to solve problems like prioritization, timeliness, reliability etc. The study mainly focuses on some priority based QoS protocols used in WSN and a comparison among them. The study reveals that among the five mentioned protocols; QMAC, PRIMA, DB-MAC, RAP, GTS; PRIMA shows the best performance in the category of Packet Prioritization, Scheduling Scheme, Queue Type, Energy Awareness and QoS.

KEYWORDS

Network Protocols, Wireless Network, MAC Protocol, QoS.

1. INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network consisting of small sensing nodes, which have computation and communication capabilities, operates in an unattended environment [1]. WSN routes data back to Base Station (BS) based on the priority based service of the MAC protocols. Data transmission processes from node to node or Multi hop towards the BS or gateway. A wide variety of applications could be supported by deploying WSNs in many different situations, whether they are composed of mobile or stationary 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 Media Access Control (MAC) protocols. The basic communication type considers 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 fulfil 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 based on problems they solve, like Prioritization: Differentiate services based on definition of class of traffic, Timeliness: Guaranteed delivery within a given time, Reliability: Ensuring probability of delivery etc. [3].

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Many MAC layer protocols were proposed for WSN. Some of them are contention based like, T-MAC [4], S-MAC [5]; some are QoS based such as Q-MAC [6] and along with that, many QoS based routing protocol have been proposed like, SAR [7], SPEED [8] and also some comparative study has been done in article [9]. However, in this paper we only considered the priority based QoS MAC protocols for the analysis to develop a comparison. The rest of the paper is organized as follows: Priority based QoS MAC protocols in section 2 and Comparison of the protocols in section 3 and Conclusion in section 4.

2. PRIORITY BASED QOS MAC PROTOCOL

Reducing waste of energy caused by overhearing, collisions, excessive overhead, and idle listening is the main purpose of most MAC-layer protocols. QoS provisioning in the MAC layer deals mainly with the scheduling of packets on the wireless channel subject to local limitations. Access to the channel that is maintained by the protocols is based on a schedule. Channel access is fixed 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. Figure 1 shows the priority scheduling in Q-MAC. Q-MAC tries to minimize energy consumption while maintaining the 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 that is originating from different sensor nodes.

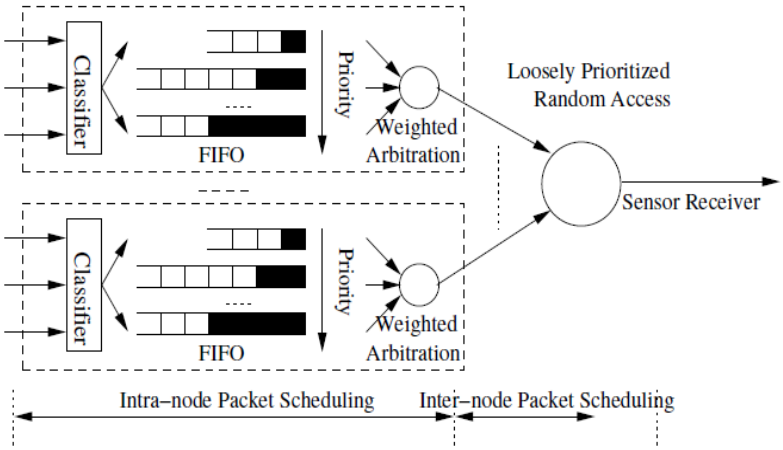

Figure 1. Priority scheduling in Q-MAC [6]

The Q-MAC consists of intra-node and inter-node scheduling in WSN. The intra-node scheduling scheme takes a multi-queue First-In First-Out (FIFO) based queuing style to classify data packets agreeing to their MAC layer abstraction and application 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. That means, 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.

PRIMA [10] is an energy efficient and QoS aware MAC protocol that 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 framed of a hybrid mode of CSMA and TDMA. To communicate control messages, CSMA mode is used while data messages are assigned in 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 to a sleeping state in order to save energy that is considered as a primary source of the energy consumption in sensor networks. PRIMA protocol provides QoS by employing a queuing model where traffics are classified depending on their importance in four different queues with different priorities such as, high (instant queue), medium, normal, or low. Queues with higher priority have absolute preferential action on top of 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.

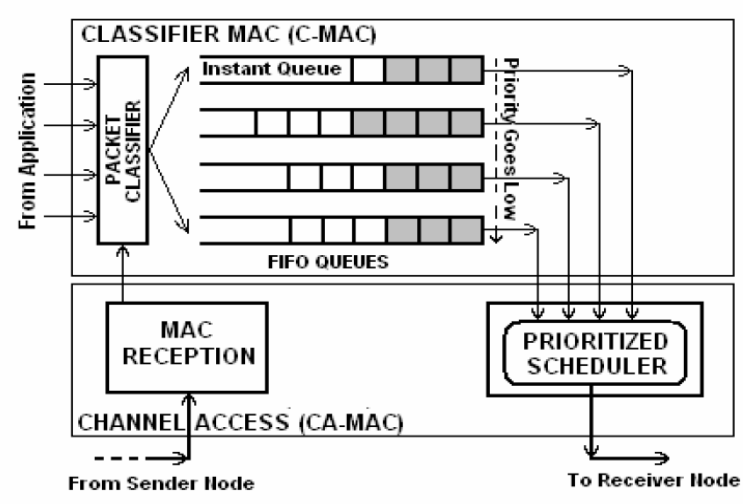

Figure 2. Priority Scheduling in PRIMA [10]

DB-MAC [11] in Figure 3 is a MAC protocol based on contention and it is designed for delay-bounded applications based on hierarchical data gathering tree. Actually, a transmission is given high priority when it is close to the source than a transmission that is close to the sink. Apart from this, nodes will overhear contention time slots from other in order to ease early data aggregation embedded. Therefore, a node will obtain medium access with a top probability if it is close to the source. Meanwhile, it performs path aggregation in such a way that it is maximum possible close to the sources. When a source starts transmitting, the priority Pr is set to the maximum PrMAX. Pr is then decreased by one at each hop. The receiving node decrements the priority by one and makes PrMAX to PrMAX -1, and forwards the packet to the next node, which will contend for

medium access with priority PrMAX - 1. The BI value is set between 0 and 1023 tics, depending on the value of the priority. If a node is close to the source, then it will take medium access with a high probability. The priority access enables decreasing latency and saving energy compared with IEEE 802.11 scheme [11].

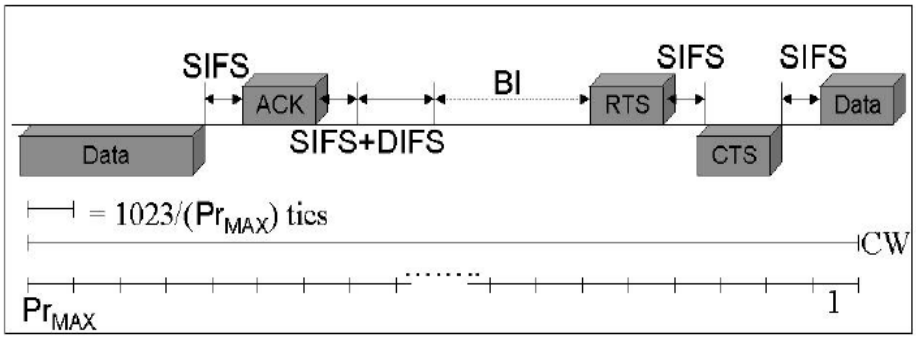

Figure 3. The contention mechanism in DB-MAC [11]

RAP [12] is a RT communication architecture designed for large-scale sensor networks. Figure 4 shows the architecture of RAP. Control and Sensing applications interact with RAP through Query/Event service APIs. The communication is sustained by an efficient and scalable protocol stack that integrates the transport-layer location-addressed protocol (LAP), geographic routing protocol (GF), contention-based MAC with packet prioritization and velocity monotonic scheduling (VMS) policy. LAP is almost same as UDP (connectionless). Only difference is that all messages are addressed by location rather than IP address. GF provides a greedy localized routing decision to forward packets into a neighbour node. VMS policy is the main key of RAP that is based on packet requested velocity that reflects both timing and distance and constraints. Here, packets are assigned a higher priority with higher requested velocity. End-to-end deadline miss ratio is reduced by VMS by giving the packets with higher priority and higher requested velocities. Moreover, to implement packet priorities, two components of the standard IEEE 802.11 implementation have been modified. The initial waiting time becomes idle after the channel and the back off window increase functions are modified to ensure that packets with top priority have high chance 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.

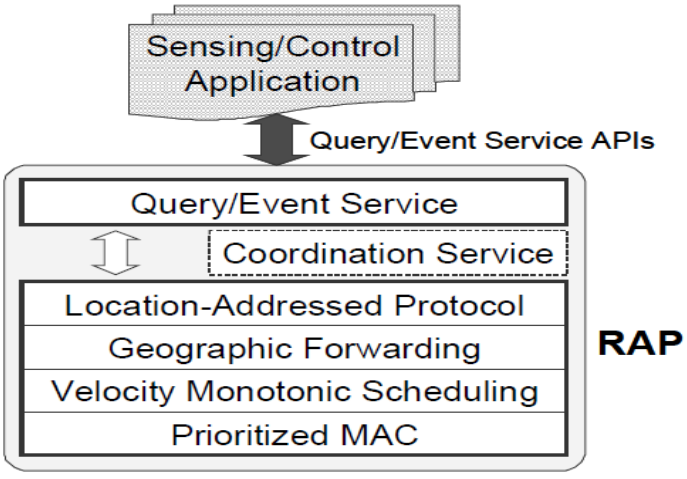

Figure 4. RAP Architecture [12]

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 to support HRT guarantees [13]. On the other hand, enhanced CSMA/CA MAC mechanisms may offer soft delay guarantees. For example, priority-toning strategy is used in [14]. A tone signal will be sent by a node to the PAN coordinator to request it alerting other nodes to defer their contentions to support a fast delivery of high priority frames. In [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 PROTOCOL

The comparisons of the above MAC protocols have been given below:

Table-1: Comparisons of the priority based QoS mac protocols

Name	Packet Prioritization	Scheduling Scheme	Queue Type	Energy Awareness	QoS
Q-MAC	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

3. CONCLUSION

In this paper, the priority based QoS aware MAC protocols have been introduced which are used in wireless sensor networks. The protocols are first discussed briefly and then their comparisons are done. In comparison, five categories are considered for marking the performance of the

protocols. However, it is seen from the above study among the five protocols the PRIMA shows the best performance in all the five mentioned categories. Although, the Q-MAC shows most likely the same performance of the PRIMA but in the case of packet prioritization the scheme of PRIMA is found better.

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