A Priority-based Parallel Schedule Polling MAC for Wireless Sensor Networks

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Abstract —MAC (medium access control) protocol plays an important role in Wireless Sensor Networks (WSNs) due to limited bandwidth and battery. MAC protocol that provides Priority-based quality of service (QoS) which satisfies various traffic transmission requirement will form the base of high-performance network application. This paper presents a new priority-based parallel schedule polling MAC protocol (PPSP-MAC) in WSNs, which combines polling orders with access policies including Gated and Exhaustive access policies to realize the priority-based scheme and reduces the overhead time through parallel schedule. Then the PPSP-MAC model is set up by method of imbedded Markov chain theory and generation function and the key system performance characteristics such as mean queue length, cycle time and throughput are explicitly analyzed. Theoretical and simulation results are identical and show that the new protocol achieves a better performance than the existing protocols such as IEEE802.11, IEEE802.15.4, S-MAC, PQ-MAC, etc.

Index Terms—WSN, polling, parallel scheduling, exhaustive access policy, gated access policy

I. INTRODUCTION

WSNs have been employed as an ideal solution in many applications such as industrial process monitoring and control, machine health monitoring, environment monitoring and so on[1]-[2]. Due to the limited resources of energy, computing and communication the MAC for WSN should be designed efficiently and simply. By the development of applications it's necessary for WSN to meet different traffic requirement such as real-time and reliability transmission. Many MAC protocols have been proposed for WSNs [3]-[5], including IEEE802.11 [6], IEEE802.15.4 [7], S-MAC [8], T-MAC [9], PQ-MAC [10], etc. IEEE802.11 as a traditional wireless MAC protocol uses two control modes contention-based DCF (distributed coordination function) and polling scheme PCF (point coordination function), but usually cannot differentiate priorities. IEEE802.15.4 adopts a hybrid mechanism of contention and schedule, which divides a supreme frame into contention and contention-free segments and is difficult to realize priority-based scheme. S-MAC is designed for WSNs based on IEEE802.11, in which nodes periodically detect channel or sleep to save energy and the nodes cannot be distinguished to serve. PQ-MAC provides priority-based scheme for various traffic requirement, which uses double protection for high priority traffic but decreases the network efficiency and throughput. It's difficult for these MAC protocols to differentiate priorities and reduce the overhead of switching between sensor nodes. MAC protocol that provides Priority-based QoS which satisfies various traffic transmissions in WSNs becoes a challenge.

In this paper we present PPSP-MAC, a Priority-based parallel polling scheme which uses different access policies to distinguish priorities and parallel schedule to reduce overhead. In WSN sensor nodes can be classified into different clusters and each cluster has a Cluster Header (CH) by a cluster algorithm such as LEACH (Low Energy Adaptive Clustering Hierarchy) [11], [12]. The CH transfers data from sensor nodes in the same cluster to the sink node. At first each node in one cluster sends a beacon to a coordinator to apply for joining the query-queue. After the query-queue being established the coordinator begins to poll every node in the queue and gives a chance to send data in order. The nodes which don't process the transmission in turn can keep sleeping status to save energy. For PPSP-MAC the node with higher priority traffic (h-node) such as key or real-time data initiates transmission by accessing the common channel through the gated access policy[13-14], in which upon receiving a polling message, a node is permitted to transmit all packets stored in its buffer. Other nodes with lower priority traffic (l-nodes) accesses the channel through the exhaustive access policy [13]-[15], in which the channel remains allocated to the station until its transmission is completed. When operating under the exhaustive access polling, upon the reception of a polling message the l-node is permitted to transmit all packets stored in its buffer as well as packets arriving during the transmission. When every l-node processing transmission it simultaneously switches to poll h-node, which parallels polling and transmission of data. So the PPSP-MAC efficiently differentiates priorities by always polling h-node at first under better fairness for l-nods through a simple way. Parallel schedule decreases the overhead.

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Then the PPSP-MAC model is set up by method of imbedded Markov chain theory and generation function and the key system performance characteristics such as mean queue length, cycle time and throughput are explicitly analyzed. Theoretical and simulation results are identical and show that the new protocol for WSNs guarantees differentiation of various traffic and fairness as well as low overhead.

The rest of the paper is organized as follows. Section 2 will describe the design of PPSP-MAC protocol model. Section 3 exactly analyzes the system characteristics including mean queue length, mean cycle time and system throughput. Section 4 presents the simulation and experimental results. Section 5 draws a conclusion.

II. PPSP-MAC Model Design

A. *Definition*

Consider a WSN cluster consisting of $N+1$ nodes including one key node h-node, with a higher priority and N l-nodes $1,2,K,N$ with lower priorities as shown in Fig. 1. The nodes are polled by the coordinator in designated order. The coordinator first polls h-node which proceeds to transmit using the gated discipline if it has information packets. Then the coordinator polls l-node i $\left(i=1,2,K,N\right)$ which transmits all of its packets if it has information packets in its queue to transmit. Synchronously the coordinator again polls the h-node to parallel transmission time and the time of walking and polling. The coordinator continues to poll all the l-nodes with the polling alternating between the l-nodes and the h-node.

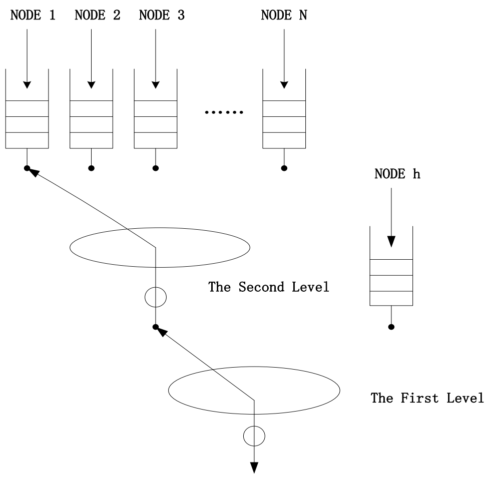

Fig. 1. A new PPSP-MAC model

B. *Work Conditions*

Assume that the AP polls station i at time t_n, switches to poll key station h at t_n^*, and then polls station $i+1$ at $t_{n+1}(t_n < t_n^* < t_{n+1})$. Further assume that each station has enough storage so that no information packets are lost under the first in first out rule.

The arrivals of the information packets waiting for transmission follow an independent *Poisson* distribution with generation function $A(z)$, mean value $\lambda = A'(1)$ for l-nodes and $A_h\left(z\right)$, $\lambda_h = A_h^{'}(1)$ for h-node.

The timing variables for each station to transmit information packets are independent of each other in the probability distribution which has a generation function $B(z)$, mean value $\beta = B^{'}(1)$ for l-nodes and $B_h(z_h)$, $\beta_h = B_h^{'}(1)$ for h-node.

The variable walking and polling times between l-nodes and h-node when the l-node has no information packets to transmit are independent of each other in the probability distribution which has a generation function $R(z)$, mean time $\gamma = R^{'}(1)$.

The function $F\left(z\right)$ represents the probability generation function for h-node to finish transmission of packets arriving during any slot time under the exhaustive access policy and $F\left(z\right) = A\Big(B\big(zF\left(z\right)\big)\Big)$.

It is not possible for information packets to get lost.

Each queue proceeds according to first in first out (FCFS).

C. *Generation Function*

The Markov chain reaches steady state under the condition $(N\rho+\rho_h)<1$ and the probability generation function for system status is defined as [8]:

$$\lim_{n\to\infty} p[\xi_i(n) = x_i; i = 1,2,3,\cdots,N,h]$$
$$= \pi_i(x_1, x_2, \cdots, x_i, \cdots, x_N, x_h)$$

$$G_i(z_1, z_2, \cdots, z_i, \cdots, z_N, z_h) = \sum_{x_1=0}^{\infty}\sum_{x_2=0}^{\infty}\cdots\sum_{x_i=0}^{\infty}\cdots$$
$$\sum_{x_N=0}^{\infty} \pi_i(x_1, x_2, \cdots, x_i, \cdots, x_N, x_h)\cdot z_1^{x1} z_2^{x_2}\cdots z_i^{x_i}\cdots z_N^{x_N} z_N^{x_h}$$
$$i = 1,2,3\cdots,N \tag{1}$$

At the time t_{n^*}, the generation function for system status is:

$$G_{ih}(z_1, z_2, \cdots, z_N, z_h) = \lim_{t\to\infty} E[\prod_{j=1}^{N} z_j^{\xi_j(n^*)}\cdot z_h^{\xi h(n^*)}]$$
$$= G_i(z_1, z_2, \cdots, z_{i-1}, B_i(\prod_{\substack{j=1\\j\neq i}}^{N} A_j(z_j)A_h(z_h)F_i(\prod_{\substack{j=1\\j\neq i}}^{N} A_j(z_j)A_h(z_h)))$$
$$, z_{i+1}, \cdots, z_N, z_h) - G_i(z_1, z_2, \cdots, z_{i-1}, 0, z_{i+1}, \cdots, z_N, z_h)$$
$$+R(\prod_{j=1}^{N} A_j(z_j)A_h(z_h))G_i(z_1, z_2, \cdots, z_{i-1}, 0, z_{i+1}, \cdots, z_N, z_h)$$
$$i = 1,2,\cdots,N \tag{2}$$

At the time t_{n+1}, the generation function for system status is:

$$G_{i+1}(z_1,z_2,\cdots,z_N,z_h)=\lim_{t\to\infty}E[\prod_{j=1}^{N}z_j^{\xi_j(n+1)}\cdot z_h^{\xi h(n+1)}]$$
$$=G_{ih}(z_1,z_2,\cdots,z_N,B_h(\prod_{j=1}^{N}A_j(z_j)A_h(z_h)))$$
$$i=1,2,\cdots,N \tag{3}$$

where $F(z)=A(B(zF(z)))$

$$F'(1)=\frac{1}{1-\rho} \tag{4}$$

III. System Characteristics

A. Mean Queue Length

Mean queue length is defined as the number of packets in queue j when queue i begins to be served at time t_{n^*}.

$$g_i(\mathrm{j})=\lim_{z_1,z_2,z_3,\cdots,z_N,z_h\to 1}\frac{\partial G_i(z_1,z_2,z_3,\cdots,z_N,z_h)}{\partial z_j}$$
$$i,j=1,2,3,\cdots,N,h \tag{5}$$

$$g_{ih}(\mathrm{j})=\lim_{z_1,z_2,z_3,\cdots,z_N,z_h\to 1}\frac{\partial G_{ih}(z_1,z_2,z_3,\cdots,z_N,z_h)}{\partial z_j}$$
$$i,j=1,2,3,\cdots,N,h \tag{6}$$

To obtain $g_i(i)$, the mean queue length of l-nodes, and $g_{ih}(h)$, the mean queue length of h-node, the first derivative of the generation function

$G_{ih}(z_1,z_2,\cdots,z_N,z_h)$ and $G_{i+1}(z_1,z_2,\cdots,z_N,z_h)$

at the point $z=1$ can be calculated as follows:

$$g_{i+1}(i)=g_{ih}(i)+\beta_h\lambda g_{ih}(h) \tag{7}$$

$$g_{i+1}(j)=g_{ih}(j)+\beta_h\lambda g_{ih}(h) \tag{8}$$

$$g_{i+1}(h)=\beta_h\lambda_h g_{ih}(h) \tag{9}$$

$$g_{ih}(i)=\gamma\lambda \tag{10}$$

$$g_{ih}(j)=g_i(j)+g_i(i)\beta\lambda[1+F'(1)]$$
$$-g_{i0}(j)+\gamma\lambda+g_{i0}(j) \tag{11}$$

$$g_{ih}(h)=g_i(i)\beta\lambda_h[1+F'(1)]+g_i(h)$$
$$-g_{i0}(h)+\gamma\lambda_h+g_{i0}(h) \tag{12}$$

Calculation of Eq. (7), Eq. (10) and Eq. (12) gives:

$$g_{i+1}(i)=\gamma\lambda+\beta_h\lambda\{g_i(i)\beta\lambda_h[1+F'(1)]$$
$$+g_i(h)+\gamma\lambda_h\} \tag{13}$$

Calculation of Eq. (8), Eq. (11) and Eq. (12) gives:

$$g_{i+1}(j)=\gamma\lambda+g_i(j)+g_i(i)\beta\lambda[1+F'(1)]$$
$$+\beta_h\lambda\{g_i(i)\beta\lambda_h[1+F'(1)]+g_i(h)+\gamma\lambda_h\} \tag{14}$$

Calculation of Eq. (9) and Eq. (12) gives:

$$g_{i+1}(h)=\beta_h\lambda_h\{g_i(i)\beta\lambda_h[1+F'(1)]+g_i(h)+\gamma\lambda_h\} \tag{15}$$

After all, calculating $\sum_{i=1}^{N}g_{i+1}(h)$ gives:

$$g_i(h)=\frac{(1-\rho)\rho_h\lambda_h\gamma+\rho_h\beta\lambda_h g_i(i)}{(1-\rho_h)(1-\rho)} \tag{16}$$

and Calculating $\sum_{i=1}^{N}g_{i+1}(j)$ gives

$$g_i(i)=\frac{(1-\rho)\sum_{i=1}^{N}(\gamma\lambda+\rho_h\lambda\gamma+\beta_h\lambda g_i(h))}{1-N\rho-N\rho_h\rho} \tag{17}$$

Calculating Eq. (16) and Eq. (17) gives the mean queue length for l-node as

$$g_i(i)=\frac{N\gamma\lambda(1-\rho)}{1-N\rho-\rho_h} \tag{18}$$

Calculation of Eq.(16) and Eq.(18) gives:

$$g_i(h)=\frac{\gamma\lambda_h\rho_h}{1-N\rho-\rho_h} \tag{19}$$

Calculating Eq. (12), Eq.(18) and Eq. (19) gives the mean queue length for h-node as

$$g_{ih}(h)=\frac{\gamma\lambda_h}{1-N\rho-\rho_h} \tag{20}$$

B. Mean Cycle Time

Mean cycle time is defined as the period between two polls for one queue. $E(\theta_h)$ stands for the mean cycle time of h-node, and $E(\theta_i)$ for the mean cycle time of l-nodes. It can be derived from Eq. (1) and Eq. (2) as follows:

$$E(\theta_h)=g_{ih}(h)\beta_h+\gamma$$
$$+\sum_{i=1}^{N}g_i(i)\beta+g_i(i)\beta\lambda\beta+g_i(i)\beta(\lambda\beta)^2+\cdots+$$
$$=\frac{\gamma\lambda_h}{1-N\rho-\rho_h}\beta_h+\frac{N\gamma\lambda(1-\rho)}{1-N\rho-\rho_h}\beta\frac{1}{1-\rho}+\gamma$$
$$=\frac{\gamma\rho_h+N\gamma\rho+\gamma-N\gamma\rho-\gamma\rho_h}{1-N\rho-\rho_h} \tag{21}$$

Simplifying Eq. (21) gives the mean cycle time for h-node as

$$E(\theta_h)=\frac{\gamma}{1-N\rho-\rho_h} \tag{22}$$

and similarly

$$E(\theta_i)=\sum_{i=1}^{N}[\gamma+g_i(i)\beta+g_i(i)\beta\lambda\beta$$
$$+g_i(i)\beta(\lambda\beta)^2+\cdots+g_{ih}(h)\beta_h]$$
$$=\sum_{i=1}^{N}[\gamma+g_i(i)\beta\frac{1}{1-\rho}+g_{ih}(h)\beta_h]$$
$$=\frac{N\gamma}{1-N\rho-\rho_h} \quad (23)$$

Simplifying Eq. (23) gives mean cycle time for l-node as

$$E(\theta)=\frac{N\gamma}{1-N\rho-\rho_h} \quad (24)$$

C. System Throughput

The System Throughput is defined as

$$E(\mathrm{T})=\frac{\textit{Total Serving Time}}{\textit{System Running Time}} \quad (25)$$

Total Serving Time (Transmision Time) can be expressed as

$$\sum_{i=1}^{N}[g_i(i)\beta+g_{ih}(h)\beta_h+g_{ih}(h)\beta_h\lambda_h\beta_h+$$
$$\cdots+g_{ih}(h)\beta_h(\lambda_h\beta_h)^n+\cdots]=\sum_{i=1}^{N}?\frac{\gamma(N\rho+\rho_h)}{1-N\rho-\rho_h} \quad (26)$$

System running Time can be expressed as

$$\sum_{i=1}^{N}[\gamma+g_i(i)\beta+g_{ih}(h)\beta_h+g_{ih}(h)\beta_h\lambda_h\beta_h$$
$$+\cdots+g_{ih}(h)\beta_h(\lambda_h\beta_h)^n+\cdots]=\sum_{i=1}^{N}?\frac{\gamma}{1-N\rho-\rho_h} \quad (27)$$

From Eq. (26) and Eq. (26) System Throughput can be given as

$$E(T)=N\rho+\rho_h \quad (28)$$

TABLE I: SYSTEM PARAMETERS

Names	Values	Names	Values
Switch Time	1ms	Slot	1ms
Frame	50bits	Rate	250kbps
γ	1ms	β	5ms
β_h	5ms		

IV. SIMULATION AND ANALYSES

According to the above model and system parameters in Table I, λ represents mean arrival rate of l-node and λ_h represents ones of h-node, β and β_h represents transmission time for l-node and h-node, γ represents switching time(walking and polling time). The theoretical calculations and simulated results are obtained as follows.

Furthermore, the comparisons between PPSP-MAC and IEEE802.11, IEEE802.15.4, S-MAC, PQ-MAC are also demonstrated.

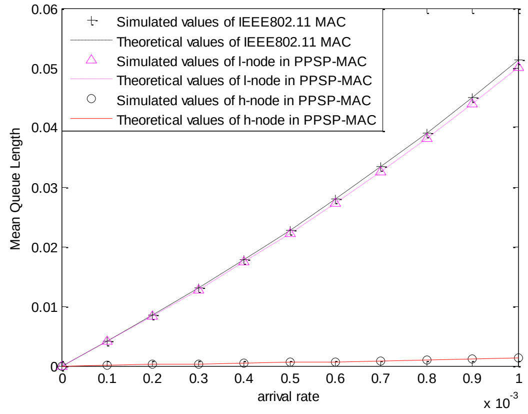

Fig. 2. Mean queue length changes with respect to arrival rate

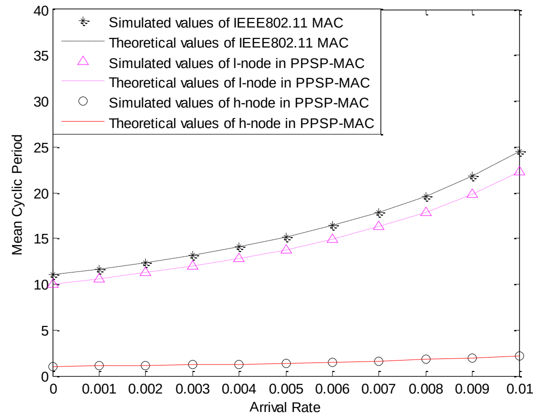

Fig. 3. Mean cycle time changes with respect to arrival rate

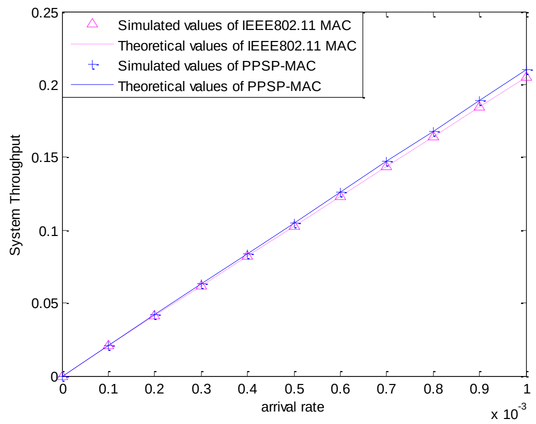

Fig. 4. System throughput changes with respect to arrival rate

Fig. 2-Fig. 6 show that the theoretical and simulated results are identical and the model performs well.

(1) Fig. 2 shows that the PPSP-MAC efficiently differentiates priorities between h-node and l-nodes from the mean queue length. As arrival rate of information packets increases, the mean queue length of h-node keeps to be shorter than the one of l-node. Compared with IEEE802.11 MAC both h-node and l-node have a better performance and the mean queue length of IEEE802.11 MAC is the longest.

(2) From the mean cycle time Fig. 3 also shows that the PPSP-MAC efficiently differentiates priorities well between h-node and l-nodes. As arrival rate increases, the mean circle time of h-node still keeps to be shorter than the one of l-node. Compared with IEEE802.11 MAC both h-node and l-node have a shorter mean cycle time than IEEE802.11 MAC.

(3) Fig. 4 shows that regarding the system throughput changes with the increase of arrival rate, the proposed system achieves consistent performance with no anomalies and compared with IEEE802.11 MAC the new system has a better performance than the IEEE802.11 MAC under $\lambda_h > \lambda$

(4) Fig. 5 shows the comparisons of S-MAC, PQ-MAC and PPSP-MAC on mean time delay with respect to the arrival rate. Mean time delay refers the time between arrival time and transmission time of one information packet. S-MAC has the longest mean time delay and cannot differentiate priorities. Even though both PQ-MAC and PPSP-MAC can provide priority-based scheme the h-node for PPSP-MAC has the shortest mean time delay and PPSP-MAC differentiates better. At the beginning l-node for PPSP-MAC has lower delay than one for PQ-MAC but it comes to be a little higher by the increment of arrival rate.

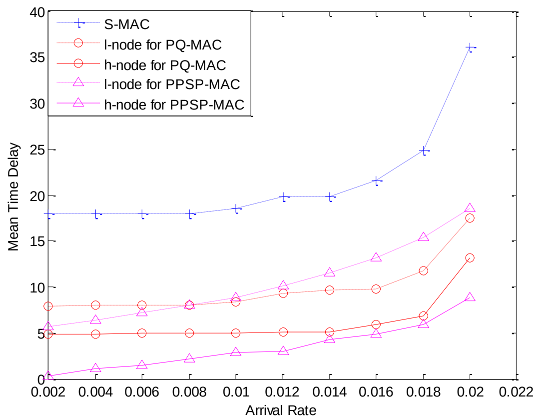

Fig. 5. Mean time delay changes with respect to arrival rate

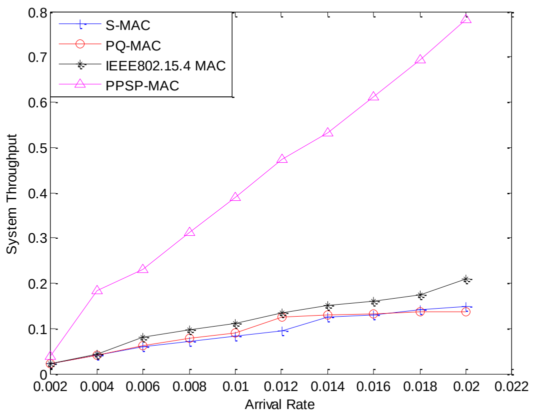

Fig. 6. System throughput changes with respect to arrival rate

(5) Fig. 6 shows the comparisons of S-MAC, PQ-MAC, IEEE802.15.4 and PPSP-MAC on system throughput with respect to the arrival rate. Obviously with the increase of the arrival rate PPSP-MAC has the biggest throughput and achieves a good performance. PQ-MAC accesses IEEE802.15.4 more. Usually the throughput of S-MAC is the lowest but it gradually accesses and even exceeds PQ-MAC's.

Overall from Fig. 2-Fig. 6 the proposed PPSP-MAC differentiates priorities well and outperforms current MAC protocols for WSN.

V. Conclusion

In this paper, we propose a new priority-based parallel schedule polling MAC protocol PPSP-MAC for WSN, which combines polling orders with access policies including Gated and Exhaustive access policies to realize the priority-based scheme and reduces the overhead time through parallel schedule. The new PPSP-MAC model was set up according to the method of the imbedded Markov chain theory and the generation function. Then the system characteristics including mean queue length, mean cycle time and throughput were analyzed. Theoretical calculations and simulation results are identical and show that the PPSP-MAC protocol differentiates priorities efficiently and compared with current WSN's MAC protocols such as IEEE802.11, IEEE802.15.4, S-MAC and PQ-MAC it achieves a better performance in a simple way.

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References

[1] W. Shi, H. Feng, and Y. Tang, "DESIGN and implement of wireless sensor network medium access control protocol," *Computer Science*, vol. 36, no. 7, pp. 60-67, 2009.

[2] M. Xia, Y. Dong, W. Xu, *et al*., "MC2: Multimode user-centric design of wireless sensor networks for long-term monitoring," *ACM Transactions on Sensor Networks*, vol. 10, no. 3, pp. 52:1-52:30, 2014.

[3] I. Demirkol, C. Ersoy, and F. Alagoz, "Mac protocols for wireless sensor networks: A survey," *IEEE Communications Magazine*, 2006, pp. 115-121.

[4] Q. Jian, Z. Gong, P. Zhu, and C. Gui, "Overview of MAC Protocols in Wireless Sensor Networks," *Journal of Software*, vol. 19, no. 2, pp. 389-403, 2008.

[5] V. Rajendran, K. Obraczka, and J. J. Garcia-Luna-Aceves, "Energy-Efficient, Collision-Free medium access control for wireless networks," in *Proc. ACM SenSys*, Los Angeles, California, 5-7 November 2003, pp. 181-192.

[6] Lan Man Standards Committee of the IEEE Computer Society, Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, IEEE Std 802.11-1997, New York, NY, USA, 1997.

[7] W. Sun, J. Wang, D. Mu, Z. Qian, and Q. Li, "Research of wireless sensor networks MAC protocol model based on Qos," *Journal of Electronic Measurement and Instrument*, vol. 27, no. 4, pp. 372-380, 2013.

[8] W. Ye, J. Heidemann, and D. Estrin, "An energy-efficient MAC protocol for wireless sensor networks," in *Proc. 21st Annual Joint Conference of the IEEE Computer and Communications Societies*, Jun. 2002, vol. 3, pp. 1567-1576.

[9] T. V. Dam and K. Langendoen, "An adaptive energy-efficient MAC protocol for wireless sensor networks," in *Proc. 1st International Conference on Embedded Networked Sensor Systems*, Nov. 2003, pp. 171-180.

[10] H. Kim and S. G. Min, "Priority-based QoS MAC protocol for wireless sensor networks," in *Proc. IEEE International Symposium on Parallel Distributed Processing*, New York: IEEE Press, 2009, pp. 1-8.

[11] K. A. Arisha, M. A. Yourself, M. F. Younis, "Energy-aware TDMA-based MAC for sensor networks," in *Proc IEEE Workshop on Integrated Management of Power Aware Communication, Computing and Networking*, New York, NY, May 2002.

[12] D. Yao, B. Zhang, and H. Liu, "Algorithms for detection latency guaranteed scheduling in wireless sensor networks," *Journal of Electronics and Information Technology*, vol. 32, no. 7, pp. 1591-1596, 2010.

[13] Z. Yang, H. Ding, and C. Chen, "Research on E(x) characteristics of two-class polling system of exhaustive-gated service," *Acta. Electronica Sinica*, vol. 42, no. 4, pp. 774-778, 2014.

[14] Z. Yang and H. Ding, "Characteristics of a two-class polling system model," *Tsinghua Science and Technology*, vol. 5, no. 19, pp. 516-520, Oct. 2014.

[15] Z. Guan, Z. Yang, W. Qian, and M. He, "On two-level state-dependent routing polling systems with mixed service," *Mathematical Problems in Engineering*, vol. 15, no. 9, pp. 10-19, 2015.

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