International Academic Institute for Science and Technology

International Academic Journal of Science and Engineering
Vol. 2, No. 1, 2015, pp. 112-119.
ISSN 2454-3896

International Academic Journal of Science and Engineering

www.iaiest.com

Knowing Effective Factors in Reducing Power Consumption in MAC Protocols' Listening For Wireless Sensor Networks

Majid Mozaffari[a], Alireza Pourbahram[b], Amir Falahati Marzdashti[c]

[a] *Master of software engineering from Islamic Azad University, Rasht Branch*.

[b] *Master of software engineering from Islamic Azad University, Rasht.*

[c] *Master of software engineering from Islamic Azad University, Rasht.*

Abstract

MAC protocols with low listening power are widely used in today's sensor networks (WSN). Reducing power consumption of separate parts without lowering the function of the whole network is one of the main challenges in wireless sensor networks. By technological development of WSN and its expansion, battery changing issues have been turned into greater ones. It must be noted that low power listening (LPL) is a common technique in MAC level to reduce energy consumption in WSN networks where nodes are periodically become active for observing communication channels.

Keywords: Wireless sensor networks, Neighbor Discovery, False Wake up

Introduction:

MAC is a control layer for accessing media transmission and holds the responsibility of preventing packet collisions. Energy consumption in nodes is one of the main challenges in WSN. Usually, highest energy

consumption is linked with radio part of a WSN. Standby and active periods in nodes are among the factors that increase energy consumption.

Comparison between MAC protocols:

S-MAC

S-MAC was designed in a way that its main goal was reducing energy consumption. Fine scalability and avoiding collision were among other goals it had. These secondary goals were obtained by hybrid scheduling and competition map. S-MAC was designed based on 802.11 protocols.

B-MAC

It was designed with the aim of increasing packets' delivery rate, throughput, and issues linked with delay and energy consumption when it is compared to S-MAC. B-MAC uses CCA and inspects returned packets in the channel. Reliability is achieved through the linkage layer and B-MAC uses a LPL that has a low communication capability. While S-MAC includes network and structures within the protocol, B-MAC does not take advantage of these capabilities (Kohvakka et al., 2009).

X-MAC

Unlike two other protocols that were discussed, X-MAC is primarily a protocol of link layer. By applying a shorter header, and a shorter sampling time, it gains a better lifetime. X-MAC is a versatile algorithm, which actively optimizes the work of cycles within receiving section in order to delay energy usage in every packet or to boost both of these parameters. X-MAC offers two ways for reducing energy consumption. First, it stores addressing data in the header in such a way that enables those receivers that do not need packet delivery to return to sleeping mode. The second way that X-MAC offers is using a stored header. This would allow a receiving node to force a delay to a sending node before header's period meets its end. The result would be reducing energy waste in sender and receiver sections. Most of modern MAC protocols use BOX-MAC.

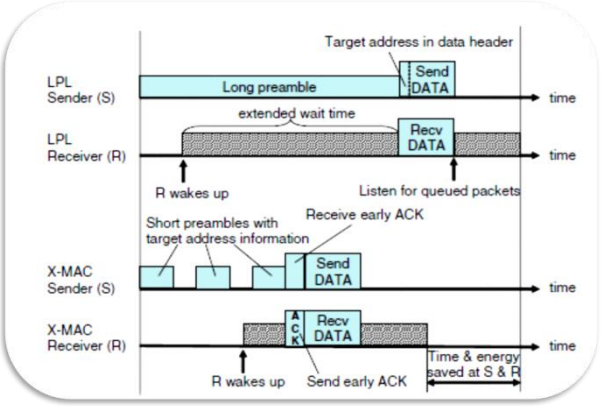


Figure 1: MAC Protocol Layers

BOX-MAC

It was developed out of B-MAC and X-MAC as an upgrade. BOX-MAC1 and BOX-MAC2 rely on the data of link and physical layer, while B-MAC and X-MAC relied on a single layer in order to reduce power consumption and achieve LPL goals. Usually, in BOX-MAC and BOX-MAC1 versions, there is one packed link layer that contains physical layer's data. BOX-MAC1 works as an upgraded version of B-MAC. Instead of B-MACs' headers, BOX-MAC1 transmits a unified data packet. This enables nodes to stay active for those packets that look meaningful to them and the result will be reduced power consumption. In contrast to X-MAC, BOX-MAC2 was developed to perform an initial inspection without checking whether enough power is available in the channel or not; rather than staying active for listening to a full packet. BOX-MAC2 shortens length of receive for four times, comparing to X-MAC. BOX-MAC1 has showed a higher performance when network's traffic is lower; and BOX-MAC2 has a better performance in high traffic networks. (see figure 1)

CCA

It is a basic mechanism in WSN protocols, which is used for evaluating channels' resolution and discovering activities in them (Vasudevan, 2005).

Applications of CCA

It is used in CSMA/CA protocols for preventing packet collision in shared networks. This mechanism has usage in LPL too, in a way that each node gets activated to perform CCA (Benjamin, 2013).

LPL

It is a MAC layer technique for lowering power consumption in wireless sensor networks. Sensor nodes get on/off either synchronously or nonsynchronously (Heidemann & Estrin, 2002; Polastre, Jason, & Culler, 2004; Galluzzi, & Herman, 2012).

Operation cycle of LPL

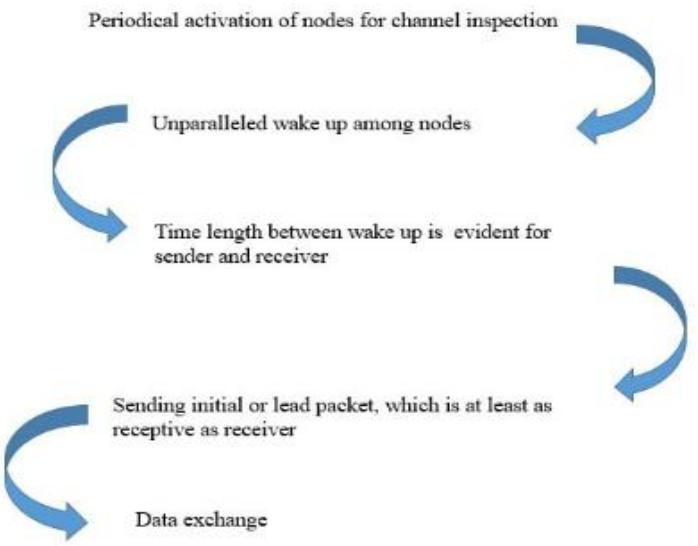


Figure 2: Operation cycle of LPL

Concerning LPL it should be noted that:

If threshold is set on too low amounts, node activates repeatedly and gets ready to receive nonexistent packets. If threshold is set on so high amounts, node will not wake up and sender will be forced to repeat transmission (Figure 2)

Neighbor discovery

Finding a group of neighbors for communicating with regions that are not within their range is a simple and common method for distributing periodical discovery signals (Kandhalu, Lakshmanan, & Rajkumar 2010; David & Levis, 2008).

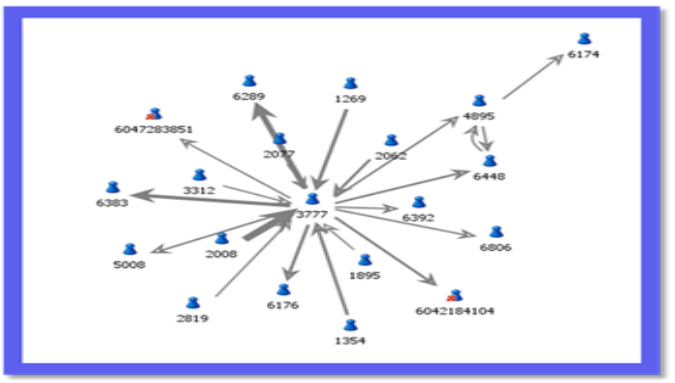


Figure 3: Neighbour Discovery

Each node attempts to discover and keep a group of its neighbors within network (observe figure 3) to use those nodes that are not within its range for communicating with other parts of the network that are not within transmission range of it (Herman, 2007).

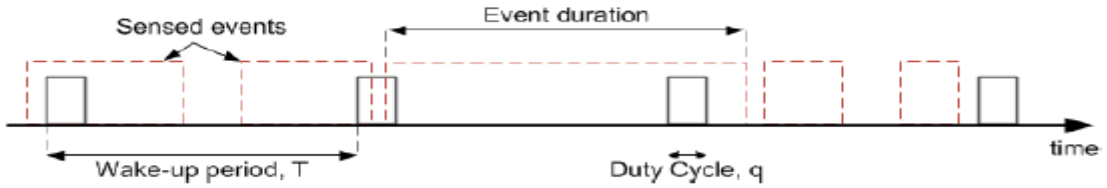
Sense probability function in neighbor discovery

We start analyzing the operation by the help of the following mathematical theorem.

First theorem

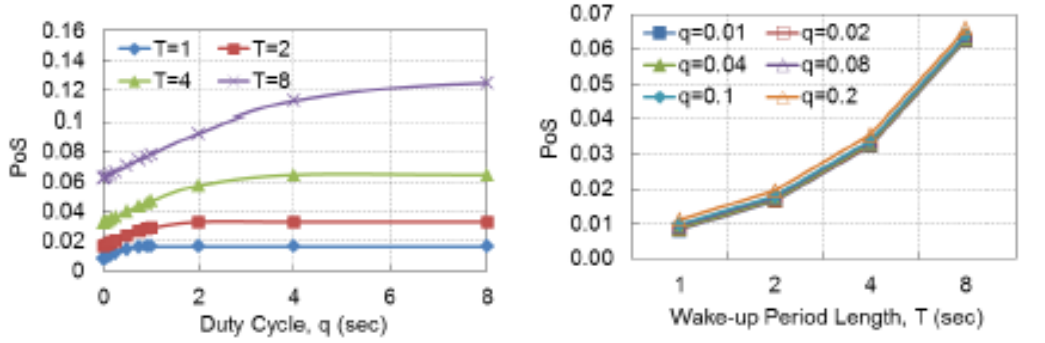
For an inactive sensor node with a work period that has a length equal to q within a sensor network that has a wake period equal to T and independent inputs (events) with an average rate equal to 1/π, sense probability function is obtained by the following formula:

$$PoS = (1 - e^{-\frac{q}{R}}) + (1 - e^{-\frac{T-q}{R}})(\frac{T+q}{2T})$$



PoSn indicates that there is a higher chance for receiving or sensing a transmission when there are more active senders around the listening nodes.

Increasing duration of wake up periods is followed by increased PoSn. But when PoS increases with T, extending operation cycle does not have a significant effect on it. (see stacked line chart 1)



(a) *PoS* against various duty cycles (q) (n=1, R=60s) (b) *PoS* against various wake-up period lengths (n=1, R=60s)

Chart 1: result pos chart

False wake up

Programs that are installed in noisy wireless areas are sensitive to false wake ups. A noise can be considered as a real activity, which can keep a node active, meanwhile no transmission takes place (see chart 2). False wake ups elevate power consumption and increase operation cycle to a great extent (David & Levis, 2008).

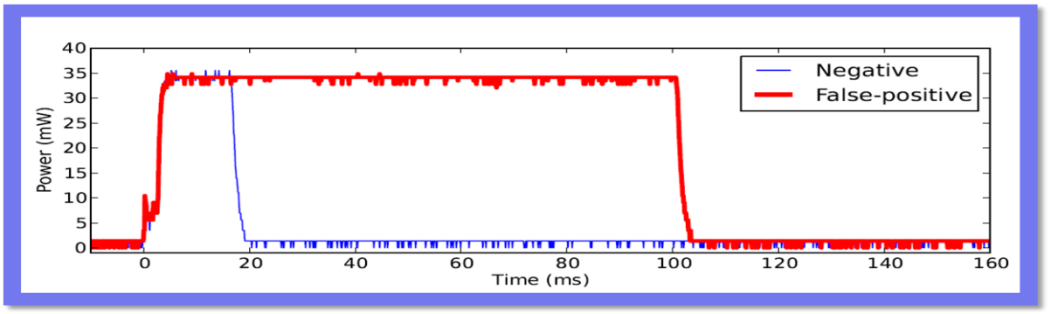


Chart 2: Sleep and waking chart

When channel is inactive radio component turns on for 19 milliseconds, and false wake up keeps radio turned on for 103 milliseconds till time out especially when the channel is busy.

Optimizing wake up threshold

For resolving the issue of false wake up in optimizing CCA, we should note that the best wake up threshold depends on some factors such as nodes that are neighbouring other nodes in the equipment. CCA threshold is a specific energy level, which is used to determine wake up time in nodes (802.15 4 standard). Further, applied design depends on the signal strength too (Hoiydi, & Aloha, 2002; Zeng, Li, & Arora, 2011).

AEDP

Energy detection protocol is adaptive. It has three variables as what follows: ETX, WR, and WR (L). AEDP has several key points in its design. First, based on trust level of network during operation (especially ETX) it begins to optimize energy discovery threshold. Secondly, as AEDP conducts required calculations by using available local values, it does not need any other information. Thirdly, AEDP is a light protocol, which only occupies one byte per sent packet (Krishnamachari, Estrin, & Wicker, 2002).

Four scenarios for AEDP

1. When ETX exceeds ETX's threshold, AEDP attempts to quickly reduce threshold's amount. This work proves the reality that limitations for trustworthiness of a network is more crucial than limitations in life period.

2. ETX is equal to its threshold, but WR exceeds its threshold. This case shows that current wake up threshold is lower than necessary limit to reach the ideal threshold. AEDP increases wake up threshold to a limited degree in order to reach to the desired level of program.

3. WR, ETX, and WR(L) possess their own suitable values. This state shows that present wake up threshold matches with the program limitations during its life period. AEDP looks for the lowest threshold that holds this condition.

4. AEDP will not counteract at all, when ETX and WR match with their limitation values but WR(L) does not have the same condition,. Wake up threshold remains at a high level for a required time length to match with wake up rate of program.

Conclusion

We suggested an analysis which is linked with MAC protocols of wireless sensor networks. We tried to convey that optimizing wake up threshold can prevent false wake ups, and reduce power consumption through it. In addition, we could show connection of nodes' within one physical location to the nodes that are out of their range via neighbour discovery. Further, we explained AEDP protocols and those protocols that are linked with it.

References:

A. El-Hoiydi. Aloha with preamble sampling for sporadic traffic in ad hoc wireless sensor networks. In Proceedings of IEEE International Conference on Communications, Apr. 2002

A. Kandhalu, K. Lakshmanan, and R. Rajkumar, Neighbor discovery inmobile sensor networks, 2010.

A. Kandhalu, K. Lakshmanan, and R. Rajkumar, U-connect: a low latency energy-efficient asynchronous neighbor discovery protocol, in Proceedings of the 9th International Conference on Information Processing in Sensor Networks (IPSN 10), pp. 350361, April 2010.

Benjamin D Parks. Analysis of the feasibility of utilizing wakeup radios to optimize energy and latency performance of wireless sensor networks. Master's thesis, University of Nebraska - Lincoln, 2013

Krishnamachari, L., Deborah Estrin, and Stephen Wicker. The impact of data aggregation in wireless sensor networks. Distributed Computing Systems Workshops, 2002. Proceedings. 22nd International Conference on. IEEE, 2002.

M. Kohvakka, J. Suhonen, M. Kuorilehto, V. Kaseva, M.Ha□annik□ainen,and T. D. H□am□al□ainen, Energy-efficient neighbor discovery protocol formobile wireless sensor networks, Ad Hoc Networks, vol. 7, no. 1, pp.2441, 2009.

Moss, David, and Philip Levis. Box-macs: Exploiting physical and link layer boundaries in low-power networking. Technical Report SING-08-00, Stanford University, 2008.

Polastre, Joseph, Jason Hill, and David Culler. Versatile low power media access for wireless sensor networks. Proceedings of the 2nd international conference on Embedded networked sensor systems. ACM, 2004.

S. Vasudevan, On neighbor discovery in wireless networks with directional antennas. INFOCOM 2005. 24th , 2005.

T.Herman, S.Pemmaraju, L. Pilard, and M. Mjelde, Temporal partition in sensor networks, in Stabilization, Safety, and Security of Distributed Systems (SSS 07), vol. 4838 of Springer Lecture Notes in Computer Science, 2007.

V. Galluzzi and T. Herman, Survey: Discovery in Wireless Sensor Networks, International Journal of Distributed Sensor Networks, vol.2012, pp. 112, 2012.

W. Ye, J. Heidemann, and D. Estrin. An energy-efficient MAC protocol for wireless sensor networks (SMAC). Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), 3:15671576, June 2002.

W. Zeng, J. Li, and A. Arora, Comparative Factor Analysis and Experimental Validation of Low Power MAC Performance, cse.ohiostate.edu, no. ii, 2011.