INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 5, Issue 5)
Available online at: www.ijariit.com

Performance evaluation of web server based upon IEEE 802.15.4

Ashok Kumar Yadav
ashok636@gmail.com
Bhagwant University, Ajmer, Rajasthan

Dr A. K. Solanki
solankibiet13@gmail.com
B. I. E. T. Jhasi, Uttar Pradesh

Dr. Sukhvinder Singh Bamber
ss.bamber@gmail.com
U. I. E. T. PUSSGRC, Hoshiarpur, Punjab

ABSTRACT

In the present era, a well-regulated web server comes with all new solutions to all new bulky heap of requests of daily users. As there is a rapid change in technology, the average number of requests on the webserver is increasing rapidly. Moreover, WSNs (Wireless Sensor Networks) has proved to be a revolutionary technology for monitoring the physical and environmental state of a machine. This manuscript targets to evaluate the performance of a web server based upon modern-day protocol IEEE 802.15.4 for WSNs using different scenarios (with GTS (Guaranteed Time Slot), Mixed GTS, & Without GTS). Depending upon the evaluation performed, it can be concluded that the performance of the wwebservercan is enhanced by trading-off in the use of the GTS mechanism in IEEE 802.15.4 for WSNs.

Keywords— *Web Server, IEEE 802.15.4 for WSNs, GTS*

1. INTRODUCTION

Web servers are defined as the program that employs HTTP which passes files that help in the creation of webpages to the users in the response of their requests, which are sent using the HTTP connection of their systems. Any device that shares the XML document with another device can be recognized as a web server. Moreover, it can also be defined as an Internet Server whose main aim is to respond back to the HTTP request and deliver the required content or services. Load on a Web Server may be defined as sending a large number of requests to the server for retrieving the required content using HTTP connection. Load on a Web Server definitely reduces the performance of the server i.e. slows down the response time of server for particular requests [1]. IEEE 802.15.4 protocol works to specify the MAC and physical sub-layer of LR-WPAN (Low Rate-Wireless Personal Area Network) [2]. Although this standard protocol was not initially developed for the usage in WSNs, it provides great flexibility which suits the requirements of WSNs by adjusting its parameters as per requirement. In fact, low-power consumption, low-cost and low-rate wireless networking are the key advantages of the IEEE 802.15.4 protocol [3], which helps to fulfills the basic requirements of WSNs. In this protocol, the physical layer is developed for low data-rates, energy efficiency, and robustness, whereas, MAC layer which contains the superframes structure, provides the flexibility to meet the requirements of the other applications.

IEEE 802.15.4 protocol has attracted researchers to work in this domain. Jurcik [4] evaluated the performance of IEEE 802.15.4 GTS (Guaranteed Time Slot) mechanism, and moreover, this research work aims at assessing IEEE 802.15.4/ZigBee protocol as a candidate technology within the ART-Wise framework. Koubaa [5] research work aims to build a path, dependent upon network calculus formalism, for performance evaluation of real-time applications using the GTS mechanism in one IEEE 802.15.4 cluster. Gholamzadeh [6] has discussed some techniques that result in decreasing the power consumption by WSNs.

This manuscript specifically targets to give a brief introduction to IEEE 802.15.4 used for the research and literature survey for the performance analysis/enhancements in IEEE 802.15.4 WSNs. Section 2 provides the detailed system description which is further moved on by evaluating the appropriate values for attribute settings in section 3. Section 4 describes the results and compares the three different scenarios: GTS, Without GTS and Mixed. Finally, section 5 concludes the manuscript.

2. SYSTEM DESCRIPTION

The simulation model administers the MAC and physical layer which defined in the IEEE 802.15.4 protocol and application layer which is defined in open-zb. Using OPNET® Modeler three different variants of 802.15.4 are developed i.e. With GTS–which contains all GTS enabled nodes, Without GTS-which, contains nodes that can handle unacknowledged non-GTS traffic, Mixed–which consists of With GTS and Without GTS nodes to handle both type of traffic [7].

2.1 Scenarios

Figure 1 shows the GTS scenario which contains one Web Server, one Router, one PAN Coordinator, one Analyzer and twelve end devices (all GTS enabled).

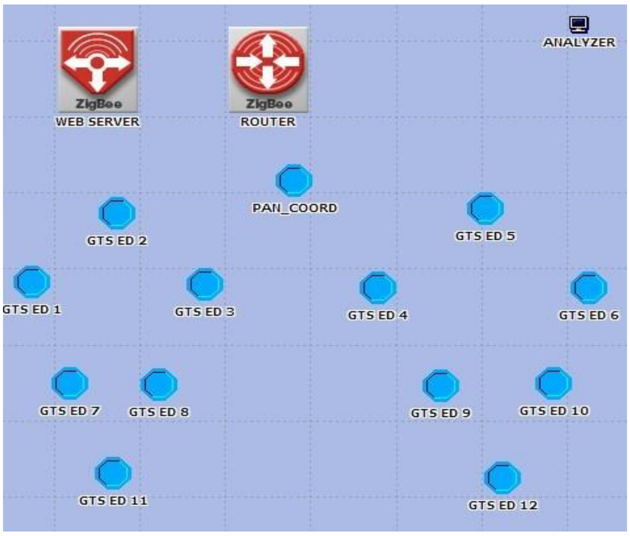

Fig. 1: Variant of 802.15.4 - With GTS

Figure 2 shows a Mixed scenario that contains one Web Server, one Router, one PAN Coordinator, one Analyzer and twelve end devices (six GTS enabled and six non-GTS).

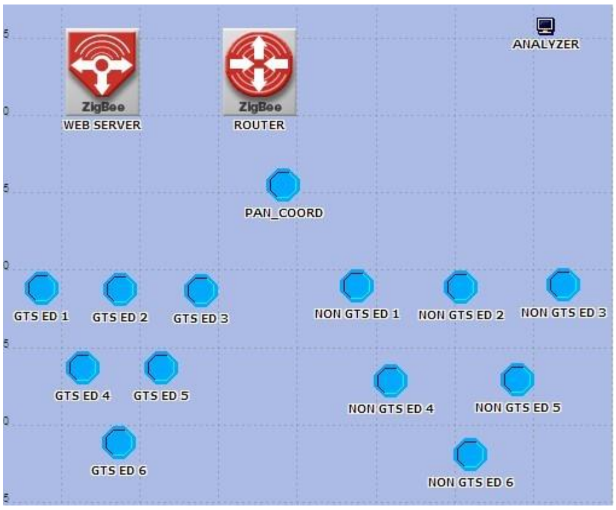

Fig. 2: Variant of 802.15.4 – With and Without GTS

Figure 3 shows the Without GTS scenario which contains one Web Server, one Router, one PAN Coordinator, one analyzer and twelve end devices (all non-GTS).

Fig. 3: Variant of 802.15.4 – Without GTS

2.2 The SuperFrame Structure

Superframe structure also known as beacon-enabled structure is defined as a structure which comprises of the time-intervals connecting two beacon frames, in which, one represents the beginning of the interval and the other represents the end[8]. PAN coordinator synchronizes the nodes and identifies its PAN by periodically dispatching the beacon [9]. The time instant between two successive beacon frames is called the Beacon Interval which includes the active period and, the inactive period. The active period, which also called superframe, is divided into 16 equally-sized time slots, and this is the time during which frame transmissions are allowed [10][11]. An inactive period is defined as, the period of time where all system nodes enter in sleep mode and save energy.

2.3 Attribute Settings

Web Server's Performance is based upon IEEE 802.15.4 for WSNs with an appropriate value to the attributes which belong to different types of devices, is relied on the suitable selection of a GTS mechanism. The attributes which can significantly affect the performance of protocol for WSNs are acknowledged traffic, unacknowledged traffic, GTS traffic, CSMA/CA, WPAN settings, etc.

3. RESULTS AND DISCUSSIONS

Simulation is carried out for three different scenarios of IEEE 802.15.4 standard protocol for WSNs i.e. With GTS Nodes, Mixed Nodes (With & without GTS nodes) and Without GTS Nodes. In this section, the results are presented and discussed for the performance at different layers of web server i.e. MAC layer, physical layer and application layer, based on IEEE 802.15.4 WSNs for different types of devices.

3.1 Physical Layer

The physical layer (PHY layer) is the lowest protocol layer in the IEEE 802.15.4. This layer is closest layer to hardware and directly controls and communicates with the radio transceiver. The PHY layer is responsible for activating the radio that transmits or receives packets.

3.1.1 Queue Size: Number of packets (bits) in a queue, waiting for the access to the channel at the transmitter of the web server so that they can be transmitted from the source to the destination. Figure 4 depicts that the queue size at the radio transmitter of a web server is: 0.990704, 0.942812 and 1.027836 packets respectively. It is clearly observable, that the queue size is maximum in the case of Non GTS scenario because all nodes can freely transmit the data or there is no waiting for the channel access, therefore lesser delays, minimum jitters, and minimum retransmission attempts, therefore 14 slots carrying all the data are busy with the transmissions / receptions from the different nodes. It is also observed that queue size is minimum in case of Mixed scenario because it is a combination of GTS and non GTS nodes, therefore, some superframe slots in case of GTS nodes have to be reserved for the time-sensitive data transmission, so depending upon the type of data whether GTS or Non GTS, it is immediately transmitted according to the relation $0 < CFP \leq GTSLength$. Therefore, it is concluded that if the queue size is to be taken into consideration at the radio transmitter of the webserver then combination of GTS and Non-GTS nodes should be preferred.

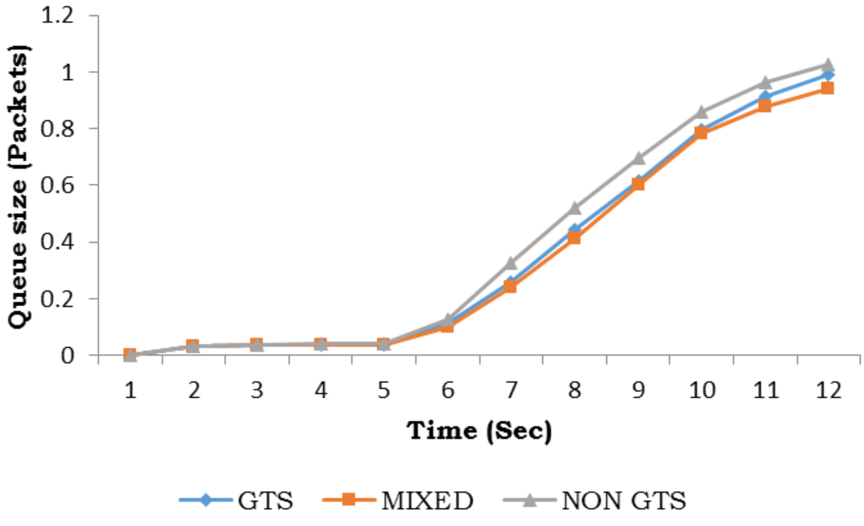

Fig. 4: Queue Size at Radio Transmitter of Web Server

3.1.2 Throughput: Average number of packets (bits) successfully transmitted by the transmitter of the webserver per second. Figure 5 depicts that the throughput in case of GTS, Mixed and Non GTS nodes is: 947, 892 and 972 packets / sec respectively. It is observed that Throughput is maximum in case of Non GTS because all the nodes are free to transmit the data as each node transmits data according to $CFP = 0$ and $0 < CAP \leq 14$ i.e. minimum or no waiting for the channel access, therefore lesser delays, minimum jitters and minimum retransmission attempts. Also, it has been observed that the throughput in minimum in case of Mixed Scenario as it is a combination of GTS and non GTS nodes therefore some superframe slots in case of GTS nodes have to be reserved for the time-sensitive data transmission which is transmitted according to the relation $0 < CFP \leq GTSLength$ and the non GTS devices transmit the data according to $14 – CFP$ which results in collisions, delays etc as a result of which the throughput is reduced. Therefore, it is concluded that if the throughput at the radio transmitter is to be focused upon then the nodes should be Non-GTS for the reason that all the 14 data-carrying time slots are free to transmit the data.

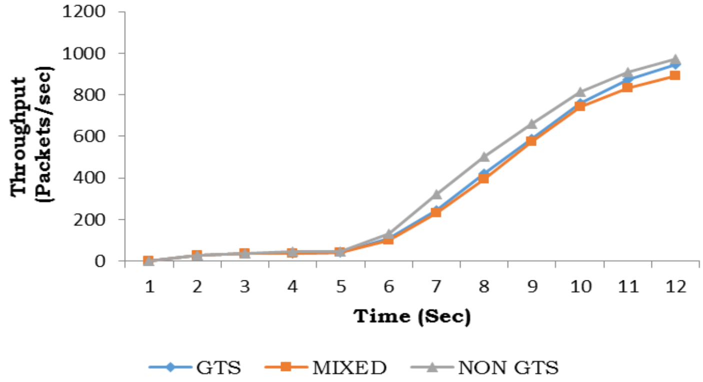

Fig. 5: Throughput at Radio Transmitter of Web Server

3.2 MAC Layer

Layer on the top of the physical layer is the MAC layer. It is responsible for accessing the medium for the transmitting the data from source to destination. Also, it is responsible for error detection and correction.

3.2.1 Queueing Delay: Amount of time spent in the queue at the MAC layer while trying to get access to the channel for transmission or reception. Figure 6 depicts that the queuing delay at the MAC layer of the webserver in case of GTS, MIXED and NON-GTS scenarios is: 0.075019371544, 0.092288731474 and 0.086080669394 sec respectively. It is observed that the Queuing delay is Maximum in case of mixed nodes because it is a combination of GTS and Non-GTS nodes because of which more collisions, delays, etc. Also, it is observed that queuing delay is minimum in case of all GTS nodes as all the required resources are reserved in advance as a result of which minimum delays, collisions, etc. Therefore, it is concluded that if the queuing delay at the MAC layer of the webserver is to be considered then all nodes connected to the webserver must be GTS enabled.

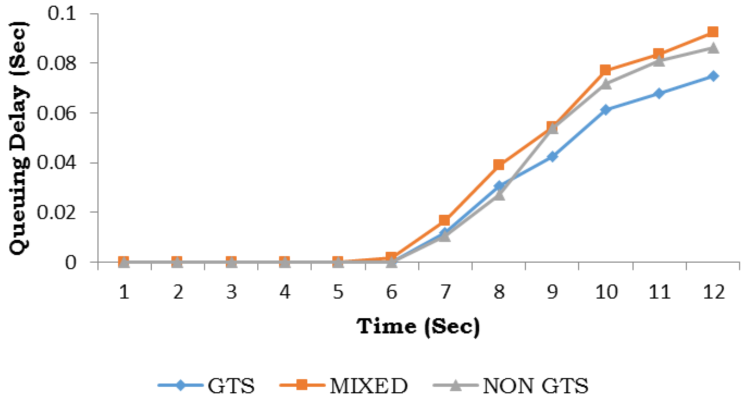

Fig. 6: Queuing Delay at MAC Layer of Web Server

3.2.2 Throughput: Average number of packets (bits) successfully transmitted/received from the MAC layer from the physical or network layer per unit time. Figure 7 shows that the throughput at the MAC layer of the webserver in case of GTS, MIXED and NON-GTS scenarios is: 46850, 43690 and 46456 bits/sec respectively. It is observed that the throughput is maximum in case of all GTS nodes as all the resources are reserved in advance. Also, it is observed that the throughput is minimum in case of combination of GTS and Non-GTS nodes because of the more collisions, delays, etc. Therefore, it is concluded that if the throughput at the MAC layer of the webserver is to be taken into consideration then all the nodes connected to the webserver should be GTS enabled.

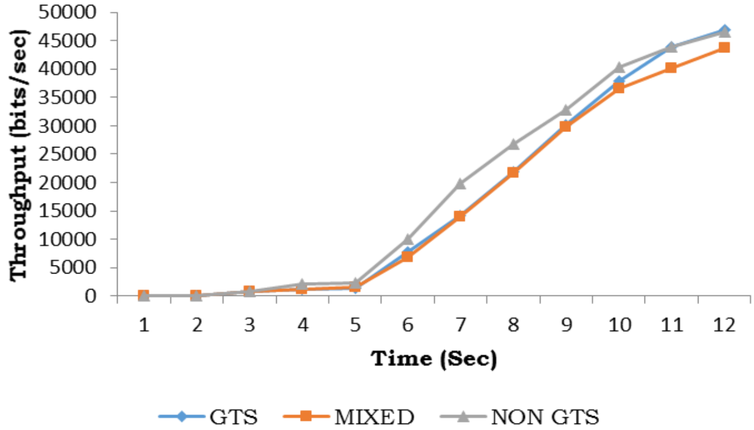

Fig. 7: Throughput at MAC Layer of Web Server

3.3 Application Layer

The topmost layer of the protocol stack which interacts with the client directly. It is responsible for inputs / outputs to / from lower layers.

3.3.1 Traffic Received: Data traffic received is the amount of actual data (data that is to be transmitted from the source to destination) received at the application layer either from the client or from the lower layer. Figure 8 depicts that the traffic received at the application layer of the webserver in case of GTS, MIXED and NON-GTS scenarios is: 39, 31 and 40 packets/sec respectively. It is observed that traffic received is maximum in the case of all Non-GTS nodes because all the data-carrying 14-time slots are free, none is reserved (Eqns. (4.5) & (4.6)). Also, it has been observed that the traffic received is minimum in case of mixed nodes because of combination of GTS and Non-GTS nodes because of which more collisions, delays, etc. occur (Eqns. (4.3), (4.4), (4.5) & (4.6)). Therefore, it is concluded that if the traffic received at the application layer of the webserver is to be focused upon then all the nodes connected to the webserver should be non-GTS.

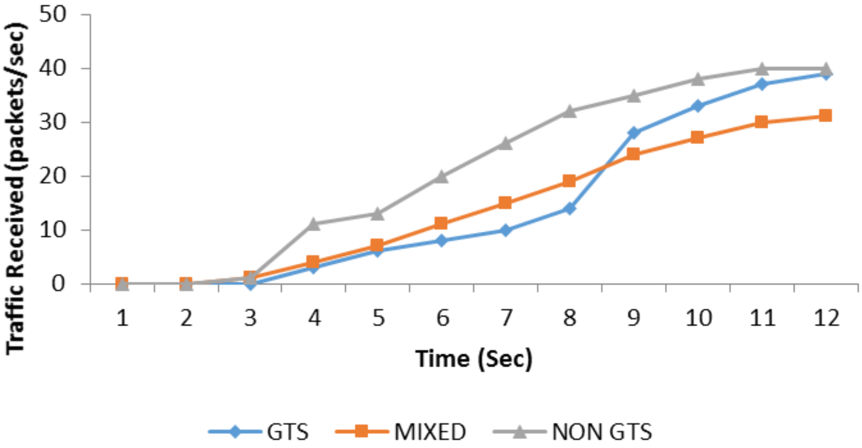

Fig. 8: Traffic Received at Application Layer of Web Server

3.3.2 Traffic Sent: Traffic sent is the amount of actual data (data that is to be transmitted from the source to destination) sent from the Application layer either to the client or to the lower layer. Figure 9 displays that the traffic sent from the application layer of the webserver in case of GTS, MIXED and NON-GTS scenarios is: 321, 303 and 317 packets/sec respectively. It is observed that the traffic sent is maximum in case of all GTS nodes connected to the webserver because all the required time slots are reserved in advance by each node. Also, it is observed that the traffic sent is minimum in case of mixed nodes as they are the combination of GTS and Non-GTS nodes because of which more collisions, delays, etc. occur. Therefore, it is concluded that if the traffic sent at the application layer of the webserver is to be taken into consideration then all nodes connected to the webserver must be GTS enabled.

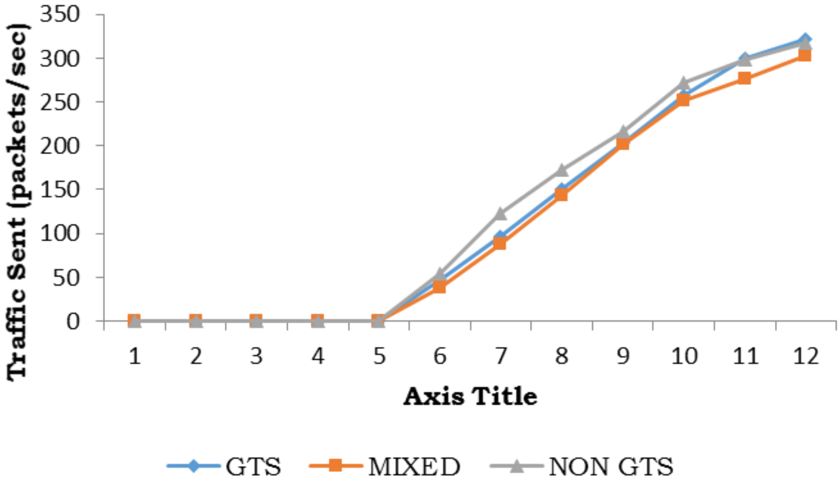

Fig. 9: Traffic Sent from Application Layer of Web Server

4. CONCLUSIONS

In this manuscript, there is research performed for evaluating the performance of a web server based upon the IEEE 802.15.4 protocol for WSNs. Depending upon the different scenarios (With GTS, Mixed & Without GTS), a particular type of system is employed. After the system selection, required attributes are selected on the bases of which the required graphs can be prepared. After that, graphs are prepared for the required attributes for making an easy comparison between the different scenarios. After interpreting the graphs quoted in the manuscript, it has been concluded that the GTS mechanism at the end devices in the network provides GoS to the data using the superframe structure but only at the cost of significant performance metrics at the webserver. Proving that, there is trade-off in the use of GTS mechanism in IEEE 802.15.4 for WSNs if the performance of the webserver is to be enhanced. Few significant conclusions have been reached (explained as follows):

- If the queue size is to be taken into consideration at the radio transmitter of the webserver then a combination of GTS and Non-GTS nodes should be preferred
- If the throughput at the radio transmitter is to be focused upon then the nodes should be Non-GTS for the reason that all the 14 data-carrying time slots are free to transmit the data.
- If the queuing delay at the MAC layer of the webserver is to be considered then all nodes connected to the webserver must be GTS enabled
- If the throughput at the MAC layer of the webserver is to be taken into consideration then all the nodes connected to the webserver should be GTS enabled
- If the traffic received at the application layer of the webserver is to be focused upon then all the nodes connected to the webserver should be non-GTS.
- If the traffic sent at the application layer of the webserver is to be taken into consideration then all nodes connected to the webserver must be GTS enabled.

5. REFERENCES

[1] Slothouber, Louis P. "A model of web server performance." Proceedings of the fifth international world wide web conference. 1996.
[2] Howitt, Ivan, and Jore A. Gutierrez. "IEEE 802.15. 4 low rate-wireless personal area network coexistence issues." 2003 IEEE Wireless Communications and Networking, 2003. WCNC 2003. Vol. 3. IEEE, 2003.
[3] Petrova, Marina, et al. "Performance study of IEEE 802.15. 4 using measurements and simulations." IEEE Wireless Communications and Networking Conference, 2006. WCNC 2006. Vol. 1. IEEE, 2006.
[4] JurcAk, P., et al. "A simulation model for the IEEE 802.15. 4 protocol: delay/throughput evaluation of the GTS mechanism." 2007 15th International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems. IEEE, 2007.
[5] Koubaa, Anis, Mário Alves, and Eduardo Tovar. "GTS allocation analysis in IEEE 802.15. 4 for real-time wireless sensor networks." Proceedings 20th IEEE International Parallel & Distributed Processing Symposium. IEEE, 2006.
[6] Gholamzadeh, Bahareh, and Hooman Nabovati. "Concepts for designing low power wireless sensor network." World Academy of Science, Engineering and Technology 45 (2008): 559-565.
[7] Lu, Zheng, and Hongji Yang. Unlocking the power of the OPNET modeler. Cambridge University Press, 2012.
[8] Wang, Jianfeng, Dave AT Cavalcanti, and Kiran S. Challapali. "Flexible MAC superframe structure and beaconing method." U.S. Patent No. 8,467,357. 18 Jun. 2013.
[9] Kim, Jungsook, et al. "RRMAC: A sensor network MAC for real-time and reliable packet transmission." 2008 IEEE International Symposium on Consumer Electronics. IEEE, 2008.
[10] Yoo, Seong-Eun, et al. "Guaranteeing real-time services for industrial wireless sensor networks with IEEE 802.15. 4." IEEE Transactions on Industrial Electronics 57.11 (2010): 3868-3876.
[11] Koubaa, Anis, Mário Alves, and Eduardo Tovar. "GTS allocation analysis in IEEE 802.15. 4 for real-time wireless sensor networks." Proceedings 20th IEEE International Parallel & Distributed Processing Symposium. IEEE, 2006.

