Impact of Link Quality Estimators and Garranted Time Slot in Wireless Sensor Network

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Abstract
The Link Quality Estimator and Quality of Service have a fundamental impact on the network performance in Wireless Sensor Networks (WSNs) and affects as well in the energy consumption of nodes. This paper will provide an implementation of Link Quality Estimator and the Garranted Time Slot in the Beacon Enabled, In this paper we develop a Collect Tree Protocol (CTP) and compare the performance of LQE and Quality of Service, and show their effect on the packet delivery ratio and throughput, covering the characteristics of low-power links, and their performance to the best of our knowledge.

Keywords
Link Quality Estimation (LQE), Collection Tree Protocol (CTP), Superframe Order (SO), Beacon Order (BO), Guaranteed Time Slot (GTS).

1. Introduction

The application in Wireless Sensor Network (WSN) needs many parameters like Quality of Service (QoS), Self-organization nodes. To ensure the best practice network it is necessary to try to solve the problem of QoS and the link between nodes. This paper it focus on the implementation of many parameters for the LQE and the manipulation of the two parameters BO and SO. It has been attracting a vast array of research works. The mechanism of allocation of GTS based on the model IEEE 802.15.4 use the Contention Access Period (CAP) and Contention Free Period (CFP). The route can be built by selecting the highest quality of link, the selection of route based on the link and QoS can maximize the lifetime of the network.

We implement the protocol CTP based on the slotted carrier sense multiple accesses with collision avoidance CSMA/CA and evaluate and analyse the performance of the throughput and packet delivery ratio.

To ensure the best performance of network it is necessary to try to solve the problems of unreliability of links. This paper has provided an implementation of CTP with Beacon Enabled mode. It has been attracting a vast array of research works. The route can be built by selecting the highest quality of link and join her with next beacon packet sent, the goal of this selecting is to maximize the lifetime of the sensor network. Avoiding successive retransmission of packet in order to reduce the energy consumption at each node to its task of routing in other words minimizing the route failed re-selection [1] [3].

This article opens with related work carried out on link quality estimation which shall be introduced in Section 2. Next section will present the most required parameter. Then, in section 4 an overview of the most Link Quality Estimator along with our implementations will be given. While Section 5 includes an overview of the proposed method, Section 6 shall discuss links performance. Last section concludes the paper.

2. Related Work

Many method of access to the canal is proposed in the literature for the wireless sensor networks but where is very few used in the real time applications.

There are some of WSN nodes available in market. The following paragraphs give the review of some routing protocols, which are based on the link quality and the energy for the real application and real world of WSN nodes.

A. RLQ: Resource Aware and Link Quality Based Routing Metric

The RLQ routing is based on the quality of the link and energy. In the RLQ if the both link quality and the residual energy are zero the routing based on the minimum hop counts. If one of there is not nul the routing based on their. For example the minimum total energy path is the shortest path.

B. SHRP (Simple Hierarchical Routing Protocol)

The SHRP routing is based on the energy and link quality. The selection of parent based on the information from the link layer. The SHRP route is based on the value of the RSSI and LQI; if the value of RSSI or LQI is lower from the threshold or the battery energy is lower than the fixed value the node eliminate from the neighbor table. The protocol chooses their route to the sink that has the minimum hop and maximum energy [7].

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C. LQER (Link Quality Estimation based Routing Protocol)

The LQER routing is based on the historical states of link quality after the minimum hop field is established. A dynamic window concept (m; k) is used to record the link historical information. The m is the number of successful transmission of k preview transmission [2].
The LQER protocol is based on the minimum hop field establishment algorithm to find the minimum hop neighbors and then each node will have the list of forwarding neighbors.

3. Overview of Link Quality Estimation and Quality of Service

In this section, we speak to the literature of the link quality estimators and the Garanteed Time Slot in WSNs, as well as their Overview evaluation. The most respected parameter in our test is the link quality estimator and the garanteed time slot.

A. Link Quality Metrics

Link quality metrics in wireless sensor networks can roughly be classified in two categories: physical and logical indicators.
The former are provided by the radio hardware and are based on the signal strength of a received packet, such as Received Signal Strength Indicator (RSSI), the Link Quality Indicator (LQI) and Signal to Noise Ratio (SNR) [3]. The logical indicators estimate the link quality by keeping track of message losses like Packet Received Rate (PRR) and Window Mean with Exponentially Weighted Moving Average (WMEWMA).

1) Packet Receive Rate (PRR)

The PRR is calculated from the ratio of the packet succesfully receiving by succefully sending between two neighbor nodes (1).

$$PRR = \frac{Number\ of\ Received\ Packet}{Number\ of\ Sent\ Packet} \qquad (1)$$

2) The Window Mean with Exponentially Weighted Moving Average (WMEWMA)

The WMEWMA based on the historical rate of it self and the current rate of the PRR to approximate the link quality at the time [4]. To measure the quality of the link the instantaneous reception rate was saved to use anather away. The PRR required for sending a packet through along the mentioned path equals the sum of all the send attempts per hop

$$WMEWMA = \alpha * WMEWMA + (1 - \alpha) * PRR \qquad (2)$$

B. Garanteed Time Slot

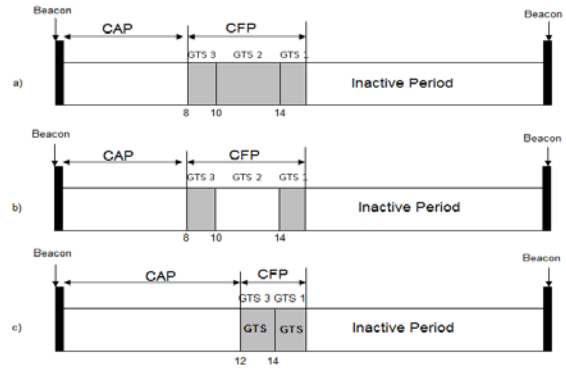

Fig. 1 Superframe structure with GTS reservation

The IEEE 802.15.4 can used in the beacon enabled or a non-beacon enabled mode. In the non beacon enabled the access to the channel based on the unslotted CSMA-CA mechanism. In the beacon-enabled the coordinator sends a periodic beacon containing information about the nodes [15]. A beacon contains also information on the nodes, when the node aims to send her data to communicate with the coordinator to synchronise with him. In the Fig. 1 the beacon interval composes with the active period and inactive period, the active period contain the CAP and CFP. During the active period the nodes can communicate with the Slotted CSMA/CA, and an inactive period during which devices may turn off in order to conserve energy. The active period is composed of three parts: a beacon, a contention access period CAP and a contention free period CFP.
The IEEE 802.15.4 specification defines four frame types: beacon frames, MAC control frames, data frames and acknowledgment frames. All frames must use a slotted CSMA/CA mechanism to access the channel except acknowledgment frames and any data frame that follows the acknowledgment of a data request command which are transmitted in the CAP.
In the CFP we can allocate the Slots for support the QoS. The nodes request the PAN coordinator to allocate GTS slots. The numbers maximum of slots can the coordinator allocate it are seven slots [16]. During the allocation the nodes can communicate with the destination. In the Fig. 1.c the reservation begins with the right to the left. If the node disallocate her reservation the left slots going to the right [17].

4. Experimental Setup

We use the open-source operating system Contiki. The system used for embedded systems and wireless sensor networks which are being developed by the Swedish Institute of Computer Science led by soft-ware engineer Adam Dunkels. It provides both full IP (Internet Protocol) networking and low-power radio communication mechanisms. Contiki is written in C [6].

TABLE I. Simulation Parameters

Parameter	Value	Unit
No of Node	12	Nodes
Dimension Space	250*250	Meters
Simulation Time	30	Minute
Deployment	Uniform	-
Update Interval	3	Second

The routing algorithm for protocol CTP

```
if(Packet=BeaconPacket)
    for NeighborTable[i]
        if(NeighborTable[i].nodeId= SenderAckNodeId)
            UpdateNeighborTable[i].rtmetric<-rtmetric
        end if
    end for
end if
if(Packet=DataPacket)
    rtmetric<-PRR
    sendAck(recievedPacket)
    reservationGTS(parentNode)
    forwardPacket(parentNode)
end if
if(Packet=AckPacket)
    for NeighborTable[i]
        if(NeighborTable[i].nodeId= SenderAckNodeId)
            UpdateNeighborTable[i].rtmetric<-rtmetric
        end if
    end for
    for NeighborTable[i]
        if(maxRtmetric<NeighborTable[i].rtmetric)
            maxRtmetric<-NeighborTable[i].rtmetric
            parentNode<-NeighborTable[i].nodeId
        end if
    end for
end if
```

5. Simulation Results

A. Throughput

The first experiment considers 12 nodes send her reservation to the next beacon and send a data packet after reservation to the current parent is consideres a coordinator. The aim is to study the throughput when different estimators are set up. The throughput is calculated from the ratio of total packets received divided by total time of simulation multiplied by the nodes number (3).

$$S = \frac{total\_received\_packet}{simulation\_time * number\_nodes} \quad (3)$$

In this section, we investigate the Link Quality Estimator with non Beacon Enabled and Link Quality Estimator with Beacon Enabled on the throughput. We compute the sum of Packet Receive Rate from the Link Quality Estimator, and then we compute the sum of Packet Receive Rate from the Link Quality Estimator with Beacon Enabled Fig. 2 and Fig. 3.

In the Fig. 2 the green curve with the Beacon Enabled has a throughput upper than the red curve, the packet in the Beacon Enabled can route to the destination with maximum of throughput than non Beacon Enabled, and the possibility of route with Beacon Enabled can make the route more flexible.

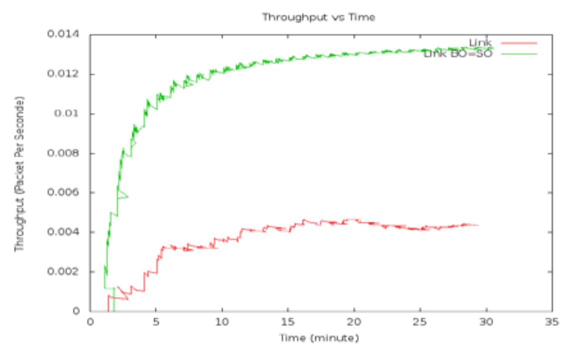

Fig. 2 Throughput of PRR

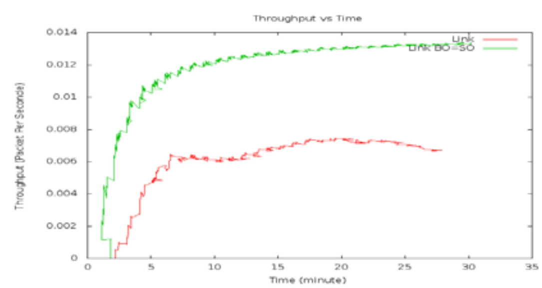

Fig. 3 Throughput of WMEWMA

The value of coefficient α equals 0,6 has an important effect in the curve of the two Link Quality Estimator in the Fig. 2 and Fig. 3. In the red curve of the Fig. 3 is based on the coefficient of α multiplied of the red curve of the Fig. 2 and the last value of the WMEWMA. The green curve is not changed because in the beacon Enabled is optimised and passed to the maximum throughput.

B. Packet Delivery Ratio

The second experiment evaluates the Packet Delivery Ratio which is defined by the ratio of packets successfully received divided by packets sent multiplied by 100 (4).

$$Pd = \frac{total\_received\_packet}{total\_sent\_packet} * 100 \quad (4)$$

Fig. 4 and Fig. 5 show the result of PDR for each node when they use PRR and WMEWMA as the routing Link. The DPR of the link with not beacon enabled mode as less than the beacon enabled mode, we fixed the Beacon Interval with the BO equals to SO, in our simulation the beacon enabled mode passed to the maximum PDR and passed the 50% of traffic.

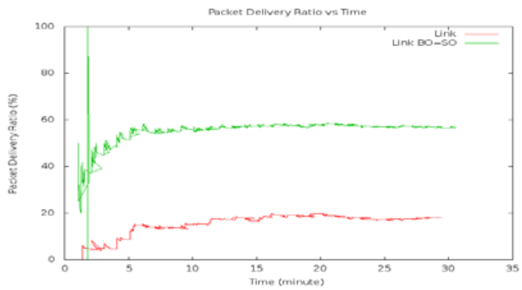

Fig. 4 PDR of PRR

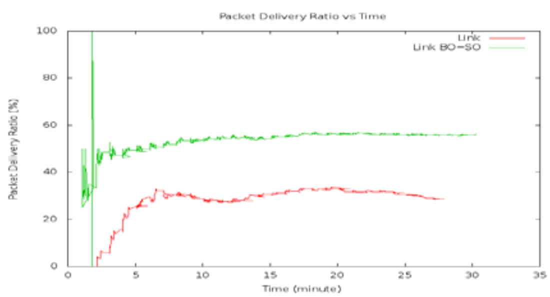

Fig. 5 PDR of WMEWMA

Like Throughput, the PDR increases in the event of use of the parameters BO and SO. Because the packets are distributed to the nodes according to the case and consequently the Packet Delivery Ratio increases i.e. the loss of the packets decreases in a remarkable way.

The analysis showed that results with 12 nodes, i.e., those with a high density, the PDR had a difference that reached 60% when compared a CTP with beacon enabled mode with non beacon enabled mode.

6. Conclusion

The performance of network can increase by many parameters like energy, quality of links, link indicator, Quality of Service. In this way we investigate our effor in link quality and Quality of Service and previous the impact of the Quality of Service in CTP protocole. The CTP has an important value to maximize the throughput and the packet delevery ratio. The life time of the network has increase by the Quality of Service. The route selected by the intermediate coordinator to the pan coordinator.

References

[1] Nouha, K. Anis, H. Youssef and A. Mario. Radio Link Quality Estimation in Wireless Sensor Networks: a Survey, IEEE/ACM Transactions on Sensor Networks (TOSN), vol. 8, pp. 113-122, 2012.
[2] J. Chen, R. Lin, Y. Li and Y. Sun, LQER: A Link Quality Estimation based Routing for Wireless Sensor Networks, Sensors, vol. 8, 2008.
[3] B. Nouha, K. Anis, H. Youssef and A. Mario. A Comparative Simulation Study of Link QualityEstimators in Wireless Sensor Networks, MASCOTS ’09. IEEE International Symposium, 2009.
[4] T. Liu, A. Kamthe, L. Jiang and A. Cerpa, Performance Evaluation ofLink Quality Estimation Metrics for Static Multihop Wireless Sensor Networks, IEEE SECON, pp. 1-9, 2009.
[5] S. Dawans, S. Duquennoy and O. Bonaventure, On Link Estimation in Dense RPL Deployments, (LCN Workshops), IEEE 37th Conference, pp. 952-955, 2012.
[6] S. Michael, L. Vincent and G. Domenico, BLITZ:Wireless Link Quality Estimation in the Dark, Wireless Sensor Networks Lecture Notes in Computer Science, vol. 7772, pp. 99-114, 2013.
[7] Sivagami, K. Pavai, D. Sridharan and S.A. V. Satya Murty, Energy and Link Quality Based Routing for Data Gathering Tree in Wireless Sensor Networks Under Tinyos-2.x, International Journal of Wireless and Mobile Networks, vol.2, 2010.
[8] G. Omprakash, F. Rodrigo, J. Kyle, M. David and L. Philip, Collection Tree Protocol, SenSys’09, 2009.
[9] Omprakash G., Rodrigo F., Kyle J., David M. and Philip L., Four-Bit Wireless Link Estimation, HotNets, 2007.
[10] Nouha, K. Anis, H. Youssef and A. Mario, B. J. Maissa, R. Denis and B. Leandro. F-LQE: A Fuzzy Link Quality Estimator for Wireless Sensor Networks, European conference on Wireless Sensor Networks 2010, Lecture Notes in Computer Science, vol. 5970, pp. 240-255, 2010.
[11] R. Nath, A TOSSIM Based Implementation and Analysis of Collection Tree Protocol in Wireless Sensor Networks, IEEE International conference on Communication and Signal Processing, 2013.
[12] V. Cagri G., Chellury S., Zhen S. and Ryan I. Resource-Aware and Link Quality Based Routing Metric for Wireless Sensor and Actor Networks, IEEE Communications Society subject matter experts for publication, ICC 2007.
[13] M. Kassio, R. Denis, C. Eduardo, A. F. L. Antonio, N. Augusto, J. Neuman de Souza, A Routing Protocol Based on Energy and Link Quality for Internet of Things Applications, sensors, vol. 13, pp. 1942-1964, 2013.
[14] Doina, I. Giovanni, S. Giovanni, T. Alberto. The impact of topology on energy consumption for collection tree protocols: An experimental assessment through evolutionarycomputation, Applied Soft Computing, pp. 2010-222, 2014.
[15] Z. Jianliang, J. L. Myung, Will IEEE 802.15.4 Make Ubiquitous Networking a Reality?: A Discussion on a Potential Low Power, Low Bit Rate Standard, IEEE Communications Magazine, vol. 42, pp. 140-146, 2004.
[16] N. P. Mahalik, Micromanufacturing and Nanotechnology, Sensor Networks and Configuration, Springer, pp. 31-49, 2007.
[17] ZigBee Alliance, ZigBee Specification, 17 Janvier 2008.