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Duty Cycle Research for Energy Consumption Efficiency under the IoT Wireless Environment

Eun-Ju Woo*, Yu-Sung Moon*, Ung-Se Choi**, Jung-Won Kim*★

Abstract

In this paper, we propose a method to reduce the amount of current through the Timing Control of the duty cycle and the Report Attribute Control at the MAC Layer in consideration of the Sleep Mode under the IoT wireless environment. The use of a duty cycle is an effective way to reduce energy consumption on wireless sensor networks where the node is placed in sleep mode periodically. In particular, we studied how to control power efficiency through duty rate in Short Transition Time and ACK Time processing while satisfying radio channel limitation criterion. When comparing before and after the improvement considering the delay time constraint, we validated the correlation of the electrical current reduction.

Key words: duty cycle, energy efficiency, IoT, wireless network, MAC, PHY

Ⅰ. Introduction

The new generation's IoT products will be eco-friendly products. It is expected to use Radio Frequency technology instead of space-constrained infrared technology to enable very low power consumption, high interactivity, and transmission and reception throughout the home. Under IoT wireless environment, power consumption should be minimized as much as possible. [1], [2]

Properly adjusting the duty cycle is efficient to energy reduction. Because application throughput is a dominant factor in determining the duty cycle in data transfer, it can be analyzed independently of other factors.

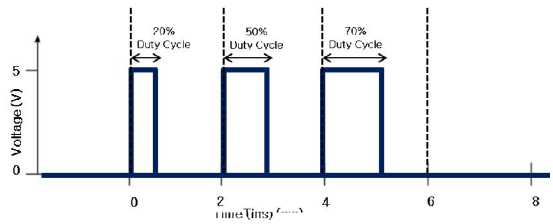

Fig. 1. Change in duty cycle for energy efficiency.

Fig. 1. shows the period change of the receiving node for Report Attribute Level optimization. For reach to the real time, when the method of supplying power only to the time when the actual sensor needs to be operated and cutting off the power for the remaining time is used, the power actually consumed reduces. [3]

The ZigBee device uses a duty cycle to provide stable low power communication in the

* JIANGXI HOLITECH KOREA BRANCH
** Dept. of Electronics Engineering, Korea Polytechnic University
★ Corresponding author
E-mail : passmiss@kpu.ac.kr, Tel : +82-2-783-8322
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wireless space. That is, the period has the same meaning as in Equation (1) below and 'Long Data Frame' means the sum of 'Preamble Time' and 'Time Packet'. The longer the packet data transmission and reception time, the greater the current loss is unavoidable.

Duty cycle changes occur during typical packet transmission and reception. [4]

$$Total\ \ time = \frac{Data\ (Long\ \ Data\ \ Frame)}{Duty\ \ cycle} \qquad (1)$$

For example, if Total Time is applied within a period of 100 ms, about 12 long data frames can be transmitted. Therefore, since the transmission data frame and the duty cycle are correlated as shown in Equation 1, the energy consumption of the battery can be reduced by changing the period.

II. Experiment

1. Network scenario for the experiment

The time of the Report Attribute optimizes the software protocol through current level control. And it has the same rules as the MAC transmission method, IEEE 802.15.4, which is the next step of the PHY procedure. [5], [6]

The scenario for the experiment calculates the energy for one of the device nodes of the network. Assume that there is only one important task when transmitting sensor data.

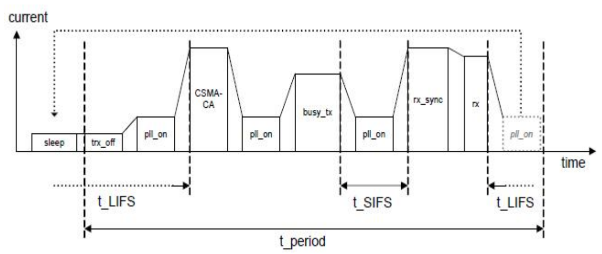

Fig. 2. Standard transmission scenario about MAC.

In Fig. 2, the duty cycle directly contributes time t_period. The maximum frame consists of Synchronization Header with 133 bytes and PHY Header, and they construct PHY Service Data Unit. [7]

Packet delay is applied to one node, and t_period includes Packet ACK and CSMA / CA processing transmission time. t_period is a processing time from the point of reception of the ACK to the time of resuming transmission / reception processing of another data frame. The ACK is a processing time from the point when the frame is received until the point when it is ready to transmit another data frame. [8]

2. Software design for the experiment

Fig. 3 shows the Report Attribute setting process related to the current consumption rate according to changing the duty cycle. [9]

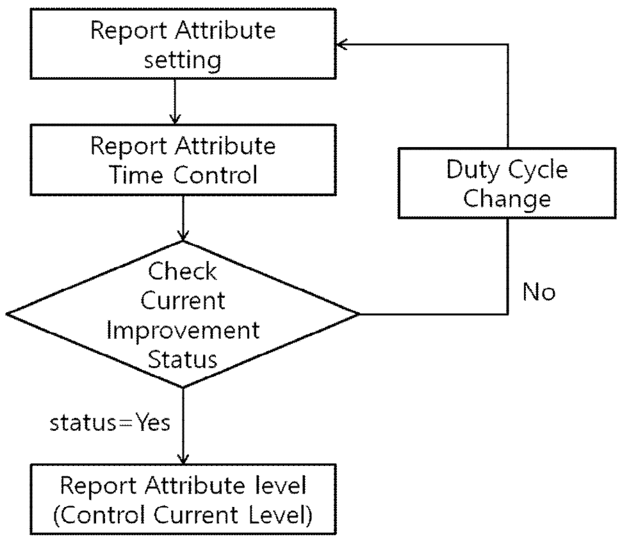

Fig. 3. Report Attribute setting process.

After the power is turned on, the algorithm of Report Attribute setting process is applied sequentially at the beginning. After transmitting the packet after the initial wake-up occurs and considering the waiting time for ACK reception, the duty cycle is expressed as Equation (2). [10]

$$Duty\ \ cycle = \frac{T_{period}}{T^2_{\max} + P_{\nabla ay} + \ CSMA/CA_{\nabla ay}\ p*100\%eriod} \qquad (2)$$

Also, according to FCC constraints, the duty cycle is calculated as the percentage of time for the radio is in TX mode per 100 ms cycle during the maximum continuous packet transmission.

3. Evaluation of energy efficiency following network transmission and reception

In the scenario shown in Fig. 2, sending and receiving commands of t_period sends a default response command with the maximum data size. The time lengths of the interval are different, and the duty cycle is applied differently depending on the delay time.

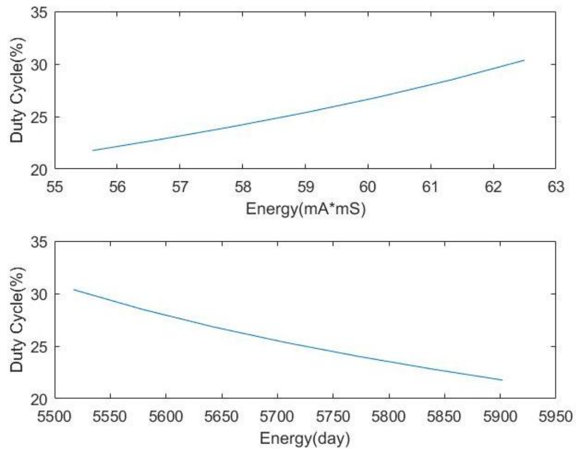

Fig. 4. Energy efficiency analysis through duty cycle application.

That is, when the maximum size of the unit operation description data is applied and the 2800 mAh battery is used, the system is turned on and off 10 times a day and the cycle is checked once every 5 seconds. The efficiency of that experiment is shown in Fig. 4.

III. Conclusion

This experiment was carried out using only a pair of nodes of the transmitter and the receiver. In the system, additional communication interference, routing packets, and data throughput were fixed to the maximum size. Considering low-speed communication, we studied energy consumption efficiency by applying packet delay time and period change. In addition, when 2,800 mAh is applied and the duty cycle is to be changed from about 31% to 21%, the energy consumption efficiency of the battery increases by about 7%. This means that the life of battery can be extended to 385 days. According to this result, we studied the necessity for reducing duty rate for improving Report Attribute Time and Report Attribute Level.

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