A study on wireless network mac cap considering efficiency of energy in ad-hoc network

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Abstract—The release of IEEE 802.15.4 PHY-MAC standard represents a milestone in developing of commercial wireless sensor network pursuing low power and low cost. In this paper, IEEE 802.15.4 Medium Access Control (MAC) protocol was analysed at the point of power consumption. This analysis measured the amount of the rest of power after transmitting data with beacon enabled mode and the power consumption of each node in the time period. ns-2 simulation is used to verify the analysis.

Index Terms— IEEE 802.15.4, zigbee, wpan, ad-hoc

I. INTRODUCTION

Ubiquitous computing connects every computer and this is invisible for everyone. This is based on the convergence with our routine which is permeated with our environment and matters. Ubiquitous network is information communication network which makes people possible to circulate the information contents anytime, anywhere without limitation of communication speed. With this realization, ubiquitous network gives us to use the information communication service freely as breaking away from the several restraint of traditional information network or service. Recently, the effort utilizing the ubiquitous computing and network and the development new services are progressing. Therefore the importance of related works and technology are dramatically increasing now. [5]

A plenty of developing Wireless sensor networks (WSNs) has focused on hardware industry as well as design of suitable networking protocols to meet the requirements of low cost and low power operation.[9] Despite the such an advance, the lack of a suitable WSNs standard and commercial products are come out. The release of IEEE 802.15.4 is much enough to make companies interested. The standard of IEEE 802.15.4 Low Rate Wireless Personal Area Network is the most suitable network for pursuing low rate, low cost and especially, low power which is needed to minimize in WSNs. At point of power consumption, the usefulness is very high putting light zigbee potocol stack[5] on PHY and MAC layer. Because of the battery life expectancy which is between months and years. It is easy to connect wireless network in Personal Operation Space (POS) having low complexity.

In this paper, after an overview of the network configura-tion and Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) mechanism, we measure the amount of the remaining power and compare the power consumption of each node.

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II. RELATED WORK

A. Network Topology

IEEE 802.15.4 standard supports peer-to-peer and one-hop star topology. In the star topology, after Full Function Device (FFD) is activated, it can make its own network and can be a PAN Coordinator. Every star network is operated independently. Therefore the neighbor networks must use different PAN ID. Once the PAN ID is firstly chosen, the PAN Coordinator can accommodate any kind of devices. But in the peer-to-peer topology, devices can communicate in the boundary of their propagation. The device under their channel which has started firstly transmitting becomes the PAN Coordinator. The other kind of topology can be constructed with using peer-to-peer topology.

B. CSMA/CA Mechanism

IEEE 802.15.4 LR-WPAN standard supports two kinds of channel access methods by the type of network configuration.

In the beacon enabled mode, slotted CSMA/CA channel access method is used. Every backoff slots for all devices are set to PAN Coordinator. Everytime a device wants to transmit date frame in the period of Contention Access Period (CAP), The device need to locate data frame at the border of next backoff slot, then wait for the number of backoff slot. If the channel is still busy after random backoff, the device waits for the number of another backoff slot before it attempts to access the channel. If the channel is idle, the device starts transmitting at the border of next backoff slot.

Successful reception and verification of Data frame or MAC command frame can be confirmed by ACK frame. However, IEEE 802.15.4 supports ACK frame as option. If a device which is receiving the data frame now can not process them with some reason, the message can not be confirmed. If the generator of the message can not receive an ACK in the certain period, it is regarded as failure and retransmitting the same message. If several retransmmittings are all failed, the message generator ends of connection or retransmission again.

In the non-beacon enabled mode, unslotted CSMA/CA channel access method is us-ed. Everytime a device tries to transmit data frame or MAC command frame, it needs to wait for random backoff time. If the channel is busy after backoff time, the device needs to wait for random backoff time before it accesses the channel again.

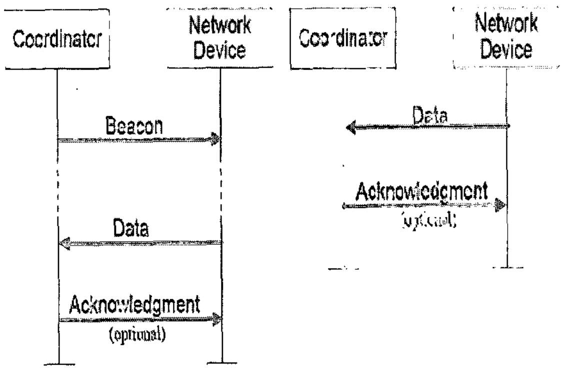

Fig. 1 Beacon and non-beacon communication.

In beacon enabled mode, if a device wants to transmit to Coordinator, the node which firstly listened beacon can transmit data. On the other hand, in the Non-beacon enabled mode, nodes spend their power asymmetrically. If a node makes traffic and spend its own power, most of the other nodes are sleeping.

C. IEEE 802.15.4 Superframe Structure

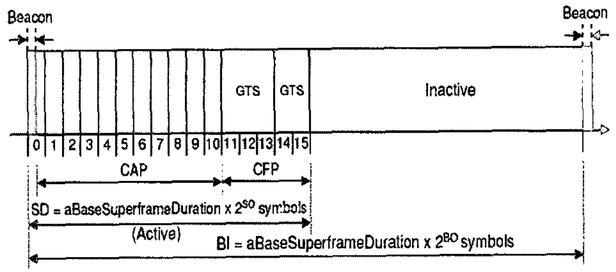

Fig. 2 IEEE 802.15.4 Beacon enabled mode superframe structure

In IEEE 802.15.4 LR-WPAN, superframe having the characters both of CSMA and TDMA are optionally used for superframe. [1] Superframe consists of CAP and Contention Free Period (CFP). Beacon Order (BO) value and Superframe Order (SO) values are used for superframe Duration (SD) and Beacon Interval (BI)

The length of SD and BI are defined followed:

SD = aBaseSuperframeDuration * 2SO
BI = aBaseSuperframeDuration * 2BO

During SD period, regardless of BI period, 16 slots are always allocated. This period is divided into CAP and CFP can be allocated up to 7 slots. BO and SO are macBeaconOrder and macSuperframeOrder respectably, which can have value from 0 to 15, saved in MAC Primitive Information Base (PIB). If the value is 15, non-beacon enabled PAN is operated and the PAN does not have superframe structure anymore.

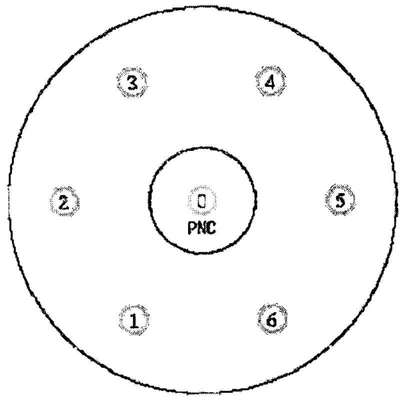

Fig. 3 Network topology of simulation

In a CAP, a node can transmit data using slotted CSMA/CA channel access method. If periodical transmitting is required, the node can require or the coordinator can allocate Guaranteed Time Slot (GTS) through the beacon frame.

D. Beacon Generation

Depending on the parameters of the MLME-START.request primitive, the FFD may either operate in a beaconless mode or may begin beacon transmissions either as the PAN coordinator or as a device on a previously established PAN. An FFD that is not the PAN coordinator will begin transmitting beacon frames only when it has successfully associated with a PAN. This primitive also includes macBeaconOrder and macSuperFrameOrder parameters that determine the duration of the beacon interval and the duration of the active and inactive portions. The time of the transmission of the most recent beacon will be recorded in macBeaconTxTime and will be computed so that its value is taken at the same symbol boundary in each beacon frame, the location of which is implementation specific.

E. Association and Disassociation

An FFD may indicate its presence on a PAN to other devices by transmitting beacon frames. This allows other devices to perform device discovery. An FFD that is not a PAN coordinator will begin transmitting beacon frames only when it has successfully associated with a PAN [2]. Association of a device starts after having completed either an active channel scan or a passive channel scan.

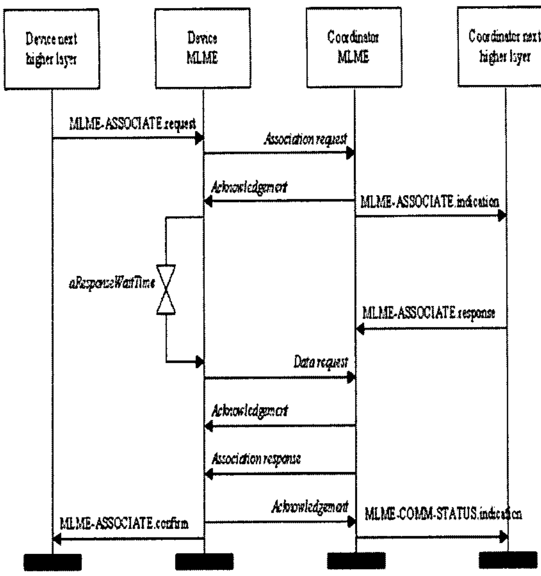

Fig. 4 Association message sequence

A PAN with which to associate, the next higher layers request that MLME configures the phyCurrent-Channel to the appropriate logical channel on which to associate, macPANId to the identifier of the PAN with which to associate and macCoordExtended-Address or macCoordShortAdd-ress to the address of the coordinator with which it associates. An unassociated device will initiate the association procedure by sending an associate request command to the coordinator of an existing PAN. If the association request command is received correctly, the coordinator will send an acknowledgement. This acknowledgement however does not mean that the device has associated. The coordinator needs time to determine whether the current sources available on a PAN are sufficient to allow another device to associate. This decision should be made within aResponseWaitTime symbols. If already associated, remove all information. If sufficient resources are available, the coordinator will allocate a short address to the device and generate an association response command containing the new address and a status indicating the successful association. If there are not enough resources, the coordinator will generate an association response command containing a status indicating failure. This response is sent to the device using indirect transmission.[11]

On the other side, the device, after getting the acknowledgement frame, waits for the response for aResponseWaitTime symbols. It either checks the beacons in the beacon-enabled network or extracts the association response command from the coordinator after aResponseWaitTime symbols. On reception of association response command, the device will send an acknowledgement. If the association is successful, store the addressed of the coordinator with which it has associated. The association procedure is shown in Fig4 on the coordinator side and in Fig4 on the device side. When a coordinator wants one of its associated devices to leave the PAN, it will send the disassociation notification command to the device using indirect transmission. Upon reception of the packet, the device should send the acknowledgement frame. Even if the ack is not received, the coordinator will consider the device disassociated.

If an associated device wants to leave the PAN, it will send a disassociation notification command to the coordinator. Upon reception, the coordinator sends ack. Even if the ack is not received, the device will consider itself disassociated. An associated device will disassociate itself by removing all references to the PAN. A coordinator will disassociate a device by removing all references to that device.

III. SIMULATION

A. IEEE 802.15.4 Superframe Structure

Experimental parameters are configured following Table1 configuration of simulation. The power consumptions for each node are measured by using energy consuming model of ns2. A PAN Coordinator and 6 devices are used to make the topology following Fig3 network topology of simulation. The distance among the nodes maintains around 10m and their propagation distance are configured 15m. When simulation starts, PNC makes beacon frame and then makes a new PAN. After that, the devices start to associate the PAN in order. When the simulation time goes at 7.0, 7.3, 7.5 seconds, PNC starts transmitting the data to the node number 1, 3, 5.

Table1 Configuration of simulation

Configuration Option	Value
channel type	WirelessChannel
propagation model	TwoRayGround
network interface	IEEE 802.15.4
MAC type	IEEE 802.15.4
number of queue	150
Size	50 x 50 m2
Area	15 m
Traffic	FTP
number of node	7
distance between nodes	10 m
beacon mode	Enabled
Duration	900 sec
initial energy	1
rx power	0.3
tx power	0.3
Time	100 sec

B. Experimental Results

In this experiment, we measured the power consumption of each node as time goes. When simulation starts, PNC makes beacon frame and makes a new PAN. After transmitting is being made at 7.0, the increasing of power consumptions is shown by Fig6 energy consumption for each node in the time period. The transmitting of node 0 and 1 makes more power consumption than the others. Because of the affect of the transmission, neighbor node 2 and 6 show more power consumption than node 3, 4 and 5. At 12.0, node 0 and 1, which are still transmitting data, are running out of battery. After that, the nodes which cannot find PAN Coordinator are just scanning. Because of transmission delay between node 0 and 1, the transmissions which had to be generated at 7.3, 7.5 are postponed after 12.0. But this is also disabled because of PNC's absence.

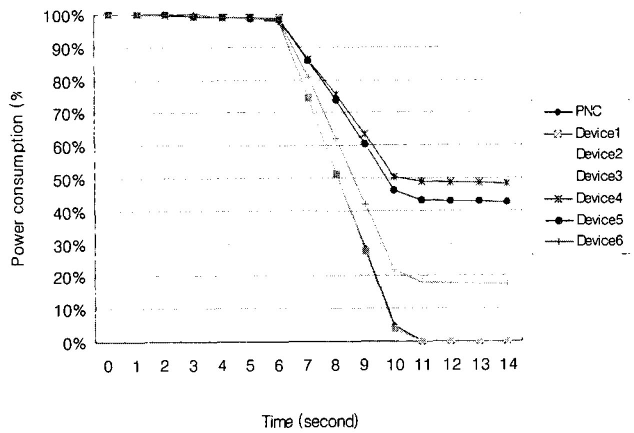

Fig. 5 remaining energy for each node

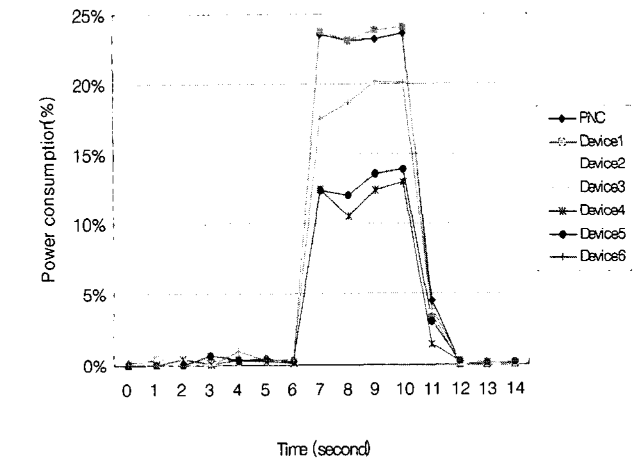

Fig. 6 energy consumption for each node in the time period

IV. CONCLUSIONS

In this paper, we measured power consumption of IEEE 802.15.4 LR-WPAN on the on-hop star topology. Nodes transmitting data spend the energy. Even the neighbor nodes spend some of their energy but the amount of consumption was different. Suppose there is no direct data transmission and the nodes are in the same POS, we need to consider of power consumption of each node in a PAN. We will analyze contention access period to reduce the power consumption.

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