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A Beacon Based Priority Routing Scheme for Solar Power Plants in WSNs

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***Abstract*—**Solar power plants(SPPs) have shown a lot of good outcomes in providing a various functions depending on industrial expectations by deploying ad-hoc networking with helps of light loaded and battery powered sensor nodes. In particular, it is strongly requested to develop an algorithm to deriver the sensing data from the end node of solar power plants to the sink node on time. In this paper, based on the above observation we have proposed an IEEE802.15.4 based self routing scheme for solar power plants. The proposed beacon based priority routing Algorithm (BPRA) scheme utilizes beacon periods in sending message with embedding the high priority data and thus provides high quality of service(QoS) in the given criteria. The performance measures are the packet Throughput, delivery, latency, total energy consumption. Simulation results under TinyOS Simulator(TOSSIM) have shown the proposed scheme outcome the conventional Ad hoc On-Demand Distance Vector(AODV) Routing in solar power plants.

***Keywords*—**Solar Power Plants(SPPs), Self routing, Quality of Service(QoS), WPANs, WSNs, TinyOS, TOSSIM, IEEE802.15.4

I. Introduction

In solar power plants(SPPs) and wireless sensor networks (WSNs) or wireless personal area networks(WPANs), we can prevent accidents using many sensor nodes to detect the status of the surrounding environments [1][3]. In particular, such as Figure 1, communication between multiple nodes in the process is inevitable collision course can increase the loss of important data because it is efficient data transfer needs[1][2].

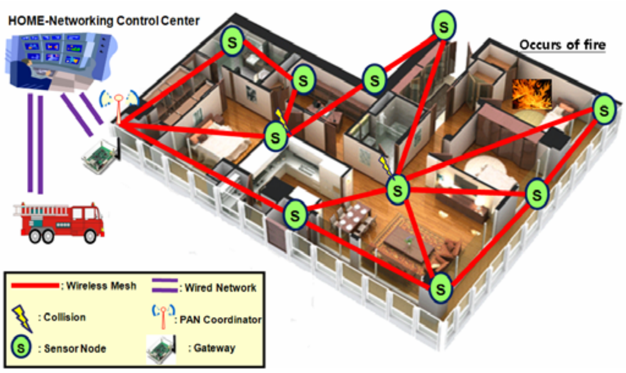

Fig. 1 Applications of SPPs and WSNs

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In SPPs and WSNs for efficient data transfer, many studies have been previous studies. First, WSNs based on standards threw out a complaint IEEE802.15.4 medium access control(MAC) layer using a super-frame structure[4][5]. There is IEEE802.15.4 standard of the proposed Carrier sense multiple access with collision avoidance(CSMA-CA) system back-off method to study[7],[8]. The another study, there exist the Back-off delay method about an emergency message at the contention area period(CAP) in super-frame[2]. And network administrators to send a beacon signal in the sensor node's back - off the frame representing the exponential decrease of a couple of breaks, the nodes of the back - off with exponential increase or decrease the back - off delay method[6].

Associated with the MAC layer back - off technique in addition to sending the network administrator using the beacon signal and network(NWK) layer using the efficient routing technique has been studied. IEEE802.15.4 standard is presented in the super-frame structure TDB (Time Division Beacon) Beacon, such as time-division method [9] and the super-frame structure having sections of the outgoing beacon which means BOP (Beacon-Only Period) divided in a way[10]. As an alternative, using the beacon signal between the beacon node with parent - child relationships through the routing path is to set[11]. This way when you set the routing path and the traffic distribution around the RSSI information to consider the cost of the optimal path is a way of reassessment.

Beacon routing techniques using multi - hop environment for more efficient data transfer and performance has shown. Conventional Ad hoc On-Demand Distance Vector(AODV) in Ad-hoc approach to user needs to configure the routing table is a technique by user[12]. But when the number of nodes increased ▪ response signal are requested, or when a new node to be added to the request signal unnecessary waste due to increased packet, it occurs disadvantages. And we apply the conventional method priority scheme for the MAC layer to prioritize. This method applies a simple packet priority for the industry because, in various environments such as homes and the difficulty seems to apply.

In this paper, a beacon-based routing scheme for SPPs uses a tree. Beacon-based routing tree for the network configuration seems to have an effective performance. But when you send data to multiple nodes, or urgent data transfer for a particular node of the first occupancy is lowered expectations for data transfer. In the paper, PHYsical(PHY) layer and MAC layer have been used to overcome these shortcomings through the WIBEEM[1] protocol based on Beacon. And in NWK layer, the priority about the emergency data and the node is selected. So data transmission using beacon packet and data packet is expected that takes place by occupy the priority from the important data and node. Also, after deciding the priority according to the beacon packet, back-off method of MAC layer is used to get more effective data preoccupancy and improved performance of the priority when data is transmitted. Thus, we solve the one-layer-dependence problem using cross-layer routing.

In this paper, the system has developed using TinyOS optimized wireless sensor networks provided by UC Berkeley. Most research are performed using the simulator, NS-2 to verify the performance of SPPs and WSNs, however, TinyOS has the advantage that the development of software(SW) and hardware(HW) are simultaneously conducted. And because TOSSIM is open source unlike other simulators, it has the great advantage to usability[13]. Also in terms of techniques, the priority scheme using beacon signal is valuable, because of that are studied at fewer areas for solar power plants.This paper is organized as follows: Section II explains the proposed algorithm. Section III examine performance of proposed algorithm using TOSSIM(TinyOS SIMulator). We conclude our paper and report our future research in Section VI.

II. Proposing algorithm of priority (BPRA)

In this paper, priority algorithm techniques using the beacon signal, priority techniques, and back-off techniques were applied.

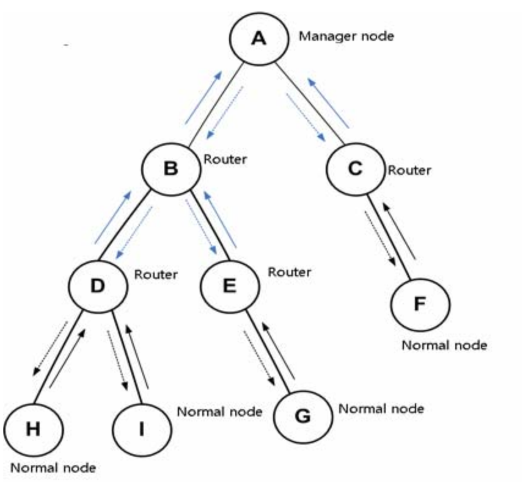

Fig. 2 Scenario of proposed algorithm for SPPs

The configuration of sensor node networks has parent-child structure as shown in Figure 2[17]. The configuration of sensor nodes is the normal node, the manager node which handles the network, and the router node that connects the manager node and the normal node. First, node ‘A’ is called Network manager. Second, node ‘B’, ‘C’, ‘D’, and ‘E’ are called router. Third, ‘F’, ‘G’, ‘H’ and ‘I’ are normal node. Manager node transmits the beacon signal for all over network. This signal can set synchronization in network, and it can be organized networks at standards into manager node. After organizing through the beacon signal, nodes form the parent-child structure using the RSSI signal. Because a RSSI signal is fluctuating with time, we should define Link Quality Indication (LQI) by low-pass filtering a given RSSI signal to formulate network topology. When the data transmission has started, the networks determine the order of priority. As time has passed, each node has different data transmission frequency. If the number of hops increases, the network has no capacity to transmit the data. Therefore, it is much harder to transmit data and the data transmission rate increases or decreases depending on the networks environment. There are four packets in IEEE802.15.4. They are the beacon packet which sends the sync. signal and network condition to whole network, data packet which sends the measured values of sensor nodes to network, command packet for management of each layer(PHY, MAC, NETWORK, USER) and data transmission, and acknowledgement packet to check the transmission of beacon and command packet We propose BPR method which uses only beacon and data packet. First of all, the beacon packet which is sent to network manager defines ‘NodePriorityBeaconFields’. In this process, manager node uses beacon to set the node priority for smooth and clear data transmission of high-prior nodes. The configuration of priority depends on the situation and circumstance. For instance, the priority could be determined according to the RSSI signal or the number of hops that the data transmitted. 'NodeSequenceNumber' is defined in the 'Reversed' part of data packets that we previously define within the standard, IEEE802.15.4. As each node transmits data, the 'NodeSequenceNumber' of the data packets increases.

$$\text{HighPriorityValue} = \text{NodeID\_NodeSequenceNumber} + \text{NodeSequenceNumber} \quad (1)$$

In this paper, the data transmission frequency of each node is chosen as the priority. 'NodeSequenceNumber' of the data packets is used to check the frequency of data transmission. Certain nodes get higher priority by considering node ID and transmission frequency. Zipf Distribution is used to consider the priority. Zipf shows the priority as slope degree which depends on the frequency of use[14, 18].

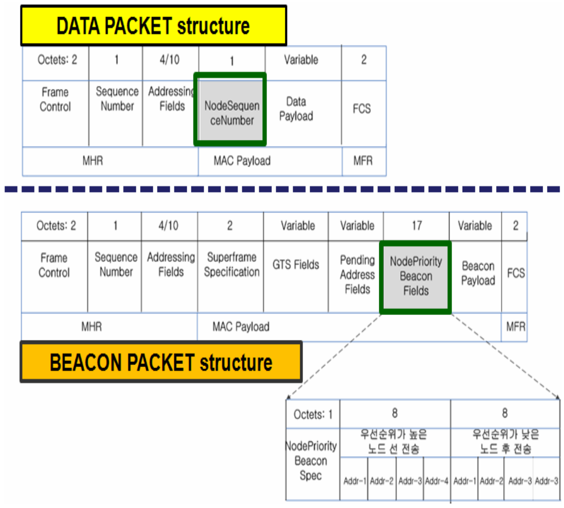

Fig. 3 Data packet and Beacon packet applied on proposed algorithm

Figure 3 shows the proposed BPR algorithm according to the suggested data and beacon packet of IEEE 802.15.4 standard. Basically, it uses a payload part of packet. 'NodeSuquenceNumber' which is 8 bits long is located in a frame of the data packet. 'NodePriorityBeaconField' which determines the priority of nodes is located in the beacon packet. The node which has 'HighPriorityValue' is considered as the highly prior node, loaded on the beacon packet, and transmitted to whole network. Nodes which receive it transmit the data using back-off timer and the other nodes do not transmit anything but wait.

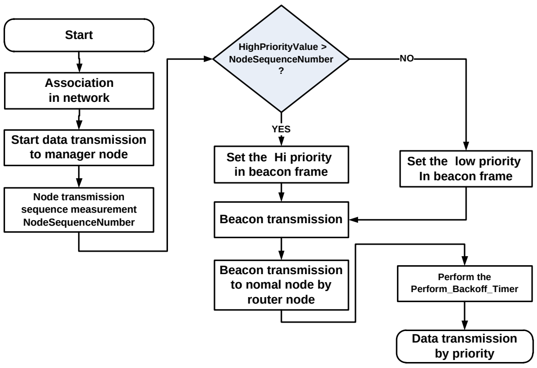

Fig. 4 The flow chart for proposed algorithm

Figure 4 shows the flow chart of beacon based priority routing Algorithm(BPRA) method. First, BPRA techniques have been applied in the association process state of nodes. When formed association-process after all nodes in the network received to a beacon signal sent by the manager-node, the data starts to be transmitted. Once the data transmission begins, nodes can receive the data during the certain time interval according to user's decision. Alternatively, according to the number of data sent by the data-packets can give priority to the wanting node ID. After giving priority using data and beacon packet, the data that has the information of prior node is loaded and sent to the nodes in whole network. Nodes receive the information of the beacon packet and transmit the data using back-off method.

III. Simulation

Simulation using TOSSIM(TinyOS SIMulator) is performed. TinyOS has the advantage that it can be used in both hardware and software part. Plus, it is suitable for Wireless sensor networks environment. This section is organized as follows: Section 3.1 was defined about simulation environment and performance verification parameters. In section 3.2, was shown simulation graph using TOSSIM, and represented performance improvement of proposed algorithm.

3.1 Simulation Environment and Performance Verification Parameters

The first step of simulation process is comparison between the AODV and BPRA method. The performance of AODV and BPRA on multi-hops is analyzed according to the topology in Figure 5. We focus on the node 6 and confirm the superiority of BPRA. Performance evaluation factors are as follows :

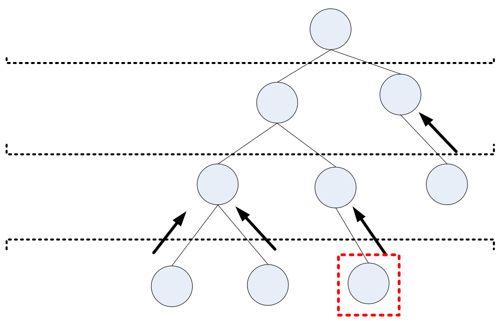

Fig. 5 Simulation Environment for SPPs

a. RX_Throughput (BPS): In simulation times, RX_Throughput signifies of received data at the node during a period. In this paper, RX_Throughput is defined that the number of the received packets of the node(NodeRxdata) divided by the period. It can be represented as PPS and bps.. PPS is Packet Per Second and bps is Bit Per Second. In this paper, the unit of RX_Throughput is byte. And a particular packet constant is 40 bytes. Therefore, value of bps can be obtained to multiply 8 by the value of PPS. RX_Throughput is represented by equation (2), NodeRxData is the number of received packets at the node, PKTByte is Packet-byte constant (40bytes), and T is total simulation times.

$$RX\_Throughput[bps] = \frac{NodeRxData}{T} \times PKTByte \times 8, \quad (2)$$

b. Delivery_Ratio(%): Delivery_ratio(%) was defined as all received packets per all transmission packets of the node. Represented by equation (3), NTXData is the number of transmitted packets, and NRXData is the number of received packets.

$$Delivery\_Ratio[\%] = \frac{NRXData}{NTXData} \times 100(\%), \quad (3)$$

c. Total_Energy(mW): Total_Energy is the consumed energy during the simulation according to the state of transmission, reception, and waiting. Total_Energy is represented by equation (4) ; TxEnergy = 0.02475mW, RxEnergy = 0.0135, SleepEnergy = 0.000015. TxNodeList is the number of data transmission nodes, RxNodeList is the number of data reception nodes, and SleepNodeList is the number of waiting nodes.

$$\begin{aligned} Total\_Energy &= Tx\_Energy + Rx\_Energy + Sleep\_Energy, \\ TxEnergy &= TxNodeList \times TxEnergy + RxNodeList \times RxEnergy \\ &\quad + SleepNodeList \times SleepEnergy, \end{aligned} \quad (4)$$

TABLE I
Simulation Parameter Setting.

Parameter	Value
Number of nodes	9
Number of node-hops	3
Maximum packet bytes	128bytes
Bit rate	250Kbps
Duty cycle	12.5 ~ 100% (8:4, 8:5, 8:6,
Maximum output power of radio frequency	1mW
Simulation time	100sec
Generation times of simulation packet	20 pps

3.2 *Performance Verification*

Table 1 is for parameter of simulation in figure 5. The number of nodes is 9, the number of node-hos is set from minimum of 1 hop to maximum of 3 hops. The selection of maximum packet size and bit rate is based on the standard, IEEE802.15.4. In this simulation, the number of super frame order is set from minimum of 4 to maximum of 8. The simulation is performed for 100 seconds. Even though the simulation lasts for only 100 seconds, it is still possible to get enough time to judge if the data is effectively transmitted because the beacon signal which is sent by network manager is generated every 3 seconds. The packet generated every second is set to 20 pps. The program of simulation is generally based on nesC language which TinyOS provides[15]. Some results are selected and represented as the graph to investigate the QoS(Quality of Service) of network. We try the simulation for 10 times in order to get 95% of confidence interval and find the expectation values[16]. The confidence intervals are so narrow that they don't show significant differences on graph.

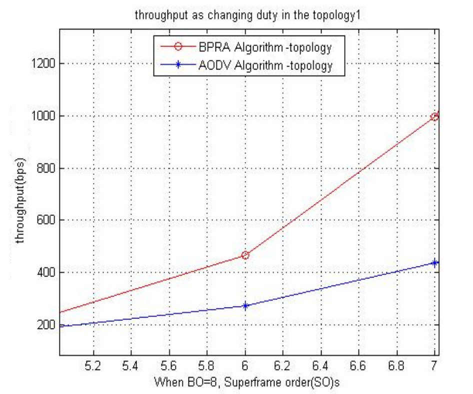

Fig. 6 Node6's the receiving throughput about period change of super frame [bps]

Figure 6 shows the received throughput of the packet at node 6. It is found that BPRA has better pps than the AODV one. In method of AODV, the SO(Superframe Order) value is 8, the received throughput is 550.5 bps of low value. At the same time, the received throughput in method of BPRA is 2.18kbps which is higher bps value than the one of AODV method. As the order of superframe gets larger, the throughput of those two algorithms increases. Especially, the throughput of BPRA algorithm has remarkable increase.

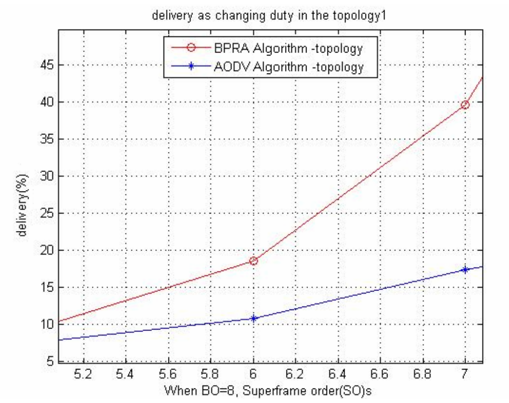

Fig. 7 Node6's the delivery ratio about period change of super frame [%]

Figure 7 shows the data transmission delivery at node 6 during the simulation. As superframe orders get larger, The delivery ratio gets higher. When the superframe period is set to 8, the delivery ratio is 21% of low value in AODV method. At the same time, the delivery ratio in method of BPRA is 87% that is higher delivery ratio than the one of AODV method. Consequently, BPRA is the effective algorithm rather than AODV.

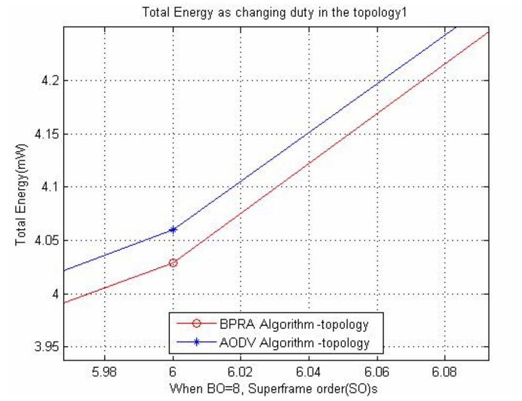

Figure 7 : Total power consumption about period change of super frame

The graph of figure 8 shows total power consumption according to the changes of superframe period during the simulation. As superframe orders get larger, total power consumption gets larger in proportion to the length of the packet transmitted. The total power consumption of ADOV method is higher than the one of BPRA method. When superframe order is set to 7, the power consumption of AODV method is 6.36mW and the one of BPRA method is 6.34mW. When superframe order is set to 6, the power consumption of AODV method is 4.06mW and the BPRA one is 4.029mW. In general, the larger superframe order means the increase of power consumption.

III. Conclusion

In order to remove unwanted consumption of signal in an existing AODV, we design the BPRA algorithm which uses the route request signal based on IEEE802.15.4 standard. It is node priority algorithm using the number of data frame sequences. The network QoS of BPRA algorithm has been verified using TOSSIM based on TinyOS. We can find TOSSIM has improved data throughput and the probability of packet reception in comparison with AODV in solar power plants. Also, we find the improved packet process time and overall energy consumption. In addition, depending on the topology configuration the proposed algorithm in environment at multi-hop was applied to the network. And increasing the number of hop-hop, the networks performance has degraded.

Because wireless sensor networks standard IEEE802.15.4 in solar power plants was provided standard about MAC and PHY layer, it is limited in the environment used many nodes, routers and network manager node. Therefore, limited Standard about upper layer is used existing routing algorithm(AODV). But in this paper, BPRA algorithm is used for efficient data transfer and overcome the shortcomings of unnecessary packet. Future studies are needed to additional studies about priority algorithm to consider environment and situations to attach the equity for priorities. Study should have a greater scalability through balanced perspective priorities and study for generalized.

References

[1] Ho-In Jeon, "WiBEEM: Optimal USN's architecture for U-City Core Services Implementation", The Institute of Electronics Engineers of Korea, 23(12), pp17-36, 2006.
[2] Dong-Sung Kim, Jung Il Lee, "Systematic Transmission Method of Industrial IEEE 802.15.4 for Real-time Mixed Traffic", The Institute of Electronics Engineers of Korea, 45(6), pp18-26,2008

[3] Hanback Electronics R&D Center INC., "Ubiquitous Sensor Network System: using Zigbex", Book Publishing ITC, p60-73, 2006.
[4] J.Zheng, M.Lee, " A Comprehensive performance study of IEEE802.15.4", Sensor Network Operations, IEEE Press, Wiley Interscience, Chapter 4, pp.218-237, 2006.
[5] P.Baronti, P.Pillai, V.Chook, S.Chessa, A.Gotta, Y.Hu, "Wireless sensor networks: A survey on the state of the art and the 802.15.4 and ZigBee standards", Computer Communications In Wired/Wireless Internet Communications, Vol.30, No.7, pp1655-1695, 2007.
[6] V.P.Rao, D.Marandin, "Adaptive Backoff Exponent Algorithm for Zigbee(IEEE802.15.4)", Lecture Notes in Computer Science, Vol4003, pp501-516, 2006.
[7] Myeong-Yu Kim, Ki-Hyung Kim, "CSMA-CA Backoff Algorithm for Consideration of traffic situation in IEEE 802.15.4", The Institute of Electronics Engineers of Korea, Summer Conference, pp1366-1367, 2009
[8] Woon-Geun Kwak, Jai-Yong Lee, " Cyclic Contention Free Access Scheme for IEEE802.15.4 WPAN ",The Institute of Electronics Engineers of Korea, Vol.32, No.7, p455-462,2007.
[9] ZigBee Alliance, ZigBee Specification, 2008.
[10] A.Koubaa, M.Alves, E.Tovar, "GTS Allocation Analysis in IEEE 802.15.4 for Real-Time Wireless Sensor Networks", IPP-Hurray Technical report TR-060404, 2006.
[11] W.Qiu, E.Skafidas, P.Hao, "Enhanced tree routing for wireless sensor networks", Ad Hoc Networks,No.7,p638-650,2009.
[12] C.Perkins, E.Royer, "Ad-hoc On-Demand Distance Vector Routing", Proceedings of Second IEEE Workshop Mobile Computing Systems and Applications, p90-100,1999.
[13] P.Levis, N.Lee, "TOSSIM: A Simulator for TinyOS Networks", 2003.
[14] J.Nielsen, "Zipf Curves and Website Popularity", http://www.useit.com/alertbox/zipf.html.
[15] D.Gay, P.Levis, R.Behren, M.Welsh, E.Brewer, and D.Culler, "The nesC Language: A Holistic Approach to Networked Embedded Systems", PLDI, 2003.
[16] H. Perros, "Computer Simulation Techniques: The definitive introduction!", North Carolina State University, http://www.csc.ncsu.edu/faculty/perros, 2003.
[17] Y.-M. Yang and S. Kim, "An improved self routing scheme by using parent-child relationship and beacon-only period for WSNs", IJICT, Vol. 2, pp. 279-301, 2010.
[18] Geoff Kirby, "Zipf's LAW", UK Journal of Naval Science, Vol. 10, No. 3 pp. 180-185, 1985