Energy Efficient and High Dissemination Rate Method Considering Extended Transmission Distances on a Wireless Sensor Network

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Abstract—**From the electric power consumed by sensor nodes comprising a wireless sensor network, a very large proportion is used to transmit and receive information wirelessly. Because most sensor nodes are battery-powered, long-term operation requires unnecessary wireless transmission to be minimized. There is currently insufficient research on cases involving increased wireless transmission distance and the accompanying increased power consumption. This paper proposes a new, effective method for information dissemination in situations with increased wireless transmission distances. The proposed method is able to minimize power consumption by not performing transmission if the message is considered already disseminated. Additionally, with increased wireless transmission distance, the number of instances of cancelled message transmission increases, further reducing the transmission and reception loads. Simulations demonstrated that the proposed method is effective at keeping power consumption increases to a minimum while greatly improving information dissemination rates, even in cases with increased transmission distances. Unlike the existing methods, the proposed method can improve dissemination rates without increasing power consumption in sensor networks, making it highly innovative and effective.**

Index Terms—**Energy efficiency, information dissemination, sensor network.**

I. INTRODUCTION

In recent years, advances in semiconductor technology have led to miniaturization of wireless terminals. Accordingly, there has also been increasing attention on wireless sensor networks. Generally, a wireless sensor network consists of a system of multiple nodes equipped with sensors that monitor their surroundings, which transmit the observed data to sink nodes that collect the data. These nodes form an autonomous network based on wireless transmission without the need for a fixed communication terminal such as a wireless LAN access point or mobile base station. Such technology, which allows for easy collection and dissemination of information with only small wireless nodes, is expected to be employed in a variety of fields, including the agriculture and manufacturing industries. This paper addresses some of the issues in information dissemination over wireless sensor networks.

Most nodes in wireless sensor networks are battery-powered. The power used by sensor nodes to transmit and receive messages comprises a large part of the total power used by the nodes, sometimes accounting for approximately half of the total power consumption [1]. It follows that the repeated sending and receiving of messages by each node results in battery depletion over a short period of time, which in turn leads to a reduced operating time for the wireless sensor network as a whole. It is therefore necessary to develop an information dissemination method that can suppress unnecessary message transmission in wireless sensor networks.

Generally, in wireless communication, when the wireless transmission distance is increased, the power required for transmission also increases considerably. With a battery-powered system such as a wireless sensor network, it is necessary to minimize the power consumption and battery consumption. Consequently, in a case such as that shown in Fig. 1, where Node 1 is transmitting a message to the long-distance Node 3 and the transmission power and distance are increased, the situation is often dealt with by having Node 1 communicate via an intermediary Node 2 rather than transmitting directly to the long-distance Node 3.
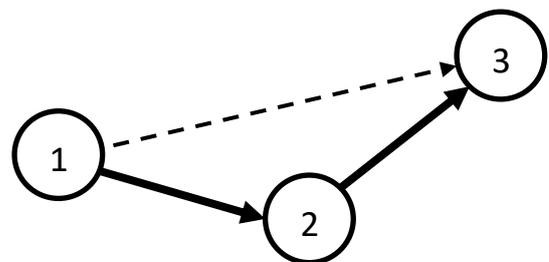

Fig. 1. Process of message dissemination to a long-distance node.

There has already been considerable research on sensor networks; however, cases with increased transmission power and extended wireless transmission range have not been considered so far, since networks with increased power and range are considered disadvantageous from a power consumption standpoint.

In this paper, we propose a wireless sensor network information dissemination method that minimizes increases in power consumption, while still allowing for a broadened communicable range. Our method suppresses transmission and reception of unnecessary messages by establishing an appropriate transmission probability according to the surroundings, thereby reducing the overall power consumption. The proposed method takes a message to be sent by a node and uses the number of instances of receiving the same message from adjacent nodes to determine whether

or not the message should be sent. If the same message has already been received a sufficient number of times, the message can be considered already disseminated to the surrounding nodes and is not sent. This judgment also applies to cases of retransmission, in which if the same message is found not to have been received a sufficient number of times, the message transmission to adjacent nodes is considered failed transmission and the message is retransmitted. In this way, high information dissemination rates can be achieved even in networks with high rejection rates.

When the wireless transmission distance increases, the number of nodes that can receive a message in a single transmission increase. Consequently, the number of opportunities for a node to receive the same message during information dissemination across the network increases as well. With our proposed method, if the same message has already been received more than a certain constant number of times, it is considered already sufficiently disseminated and its transmission is stopped. In this way, in a network with increased wireless transmission distance and thus increased possibility of the same message being received, the overall number of instances of message transmission can be reduced, which in turn reduces the number of instances of message reception. Generally, when the transmission distance is increased, the power consumption required for one instance of transmission also increases. However, with the proposed method, the numbers of instances of message transmission and reception are greatly reduced overall, resulting in lower power consumption across the entire network. As mentioned earlier, the existing methods fail to account for cases of increased transmission power and distance, making our proposed method valuable in its novelty.

The gossip method, for instance, has the issue of not considering the surrounding circumstances due to its use of a constant message transmission probability. In the proposed method, the transmission probability is determined by the number of message hops from the source node, further allowing for reduction of the number of transmissions.

Furthermore, performance evaluations conducted via simulations have shown that, although both the flooding and gossip methods can greatly increase the overall power consumption when performed on networks with extended wireless transmission distances, the proposed method barely increased the overall power consumption under the same conditions. In environments that employ sensor networks, the packet loss probability is relatively high. With the proposed method, both a high information dissemination rate and low power consumption rate can be achieved.

The remainder of this paper is organized as follows. Section II describes the existing research related to this problem. The proposed information dissemination method is presented in Section III. Section IV discusses the results of performance evaluation simulations and the effectiveness of the proposed method. Finally, Section V summarizes the main points of this paper and propose tasks for future research.

II. RELATED RESEARCH

Research has already been conducted on the gossip method. In [2], for example, the gossip method was expanded upon and it was demonstrated that with the probability of a broadcast from a node transmitting a message to another node at a certain distance set to 1, the method could achieve a high dissemination rate while reducing the number of messages. However, it was assumed that the method was operating in an environment with good network quality, and the dissemination rate can be expected to decrease in poorer quality network conditions. Additionally, the wireless transmission distance and power consumption were not studied.

A modified gossip protocol was also proposed and evaluated by performing simulations [3]. It was shown that the electric power consumption was lower when a sensor node transmitted information to a sync node, compared with when the conventional gossip method was used. However, this approach is intended for data collection and cannot be used for information dissemination. Moreover, the radio wave transmission distance was not investigated at all.

The Gossip Relay Protocol (GRP) and Temporarily Ordered Routing Algorithm (TORA) protocol were compared in [4]. It was shown that compared with the TORA, the GRP achieves high throughput, small delay, and small network load by simulation. However, the focus was only on collision avoidance in wireless communications, and the electric power consumption was not addressed at all.

An efficient heuristic method for data transfer from a sensor node to a sink node was also proposed for wireless sensor networks [5]. The results of simulations indicated that the electric power consumption was lower than that achievable using the existing methods. However, a simple model was employed in which the electric power was consumed in proportion to the number of nodes via which the data were transferred, which is not realistic.

In [6], a cluster-type hierarchical network was constructed for information dissemination, and an efficient message transfer method was proposed. However, messages were not considered in the construction and maintenance of the layered network architecture. Furthermore, as in [2], the wireless transmission distance and power consumption were not addressed.

Subsequently, a method of disseminating information to an entire wireless sensor network in which distributed processing is performed by each node was proposed [7]. The results of simulations indicated that information was disseminated more rapidly than when the existing methods were employed. However, the proposed model was only based on broadcasting and the characteristics of actual wireless communications were not accounted for. Therefore, the electric power consumption was not investigated.

An information dissemination method for a data center based on the gossip method was also proposed [8], and simulations revealed that this method could provide high throughput. However, since it was assumed that the network topology was known in advance and the topology did not change, it would be difficult to adapt this method to a sensor network. Moreover, the electric power consumption was not studied at all.

In [9], the authors proposed an method based on signal strength that relies on the fact that the further away a transmitting node is, the lower the power of the receiving node is. In this approach, messages are broadcasted faster the further away the receiving node is from the transmitting node.

This technique allows for information dissemination across an entire network with a small number of message transfers. However, a relatively low rejection rate was assumed. This method accounts for the states of the surrounding nodes when determining retransmission, which should allow for high information dissemination rates even in networks with high rejection rates. In addition, although there is some surplus of message transfers in retransmission, the overall network power consumption does not increase much as a result.

III. PROPOSED METHOD

In the proposed method, at the time of information dissemination, a node waits a certain amount of time before sending a message, rather than sending it immediately upon reception. During this period, if the same message as the message to be sent has been received a sufficient number of times by neighboring nodes besides the original source node, the message is considered already disseminated and its transmission is cancelled. Consequently, packet transmission is possible according to the message reception statuses of the adjacent nodes. In this way, if a message has already been disseminated to the adjacent nodes, unnecessary transmission can be minimized, which should allow the proposed method to reduce the power consumption at each node.

In the proposed method, a node that receives a message for the first time waits for a time T_1. During this waiting period, if a message identical to the one to be sent has been received α times, that message can be considered already disseminated and is not sent. Conversely, if the number of times the message has been received does not reach α within the time period, message transmission is executed. T_1 is given by the following equations.

$$B_1 = (2^{macMaxBE} - 1) \times aUnitBackoffPeriod$$
$$S_1 = SIFS + LIFS + B_1 + random(B_1) + CCA$$
$$T_1 = S_1 \times symboltime$$

Here, *SIFS, LIFS, CCA, macMaxBE, symboltime,* and *aUnitBackoffPeriod* are carrier-sense with multiple access collision avoidance (CSMA/CA)-defined parameters and $random(B_1)$ is a random value that satisfies the following inequality.

$$B_1 \geq random(B_1) \geq 0$$

It is necessary to set a sufficient time for T_1 until the dissemination status among the surrounding nodes is determined. Random numbers are used because collisions occur if nodes that receive messages from the same source node transmit simultaneously. To avoid such packet collisions, the waiting time is set between 1 and 2 times more than that which is prescribed by the IEEE 802.15.4 access control standard CSMA/CA.

When the transmission distance is increased, the number of adjacent nodes that can receive messages in a single instance of message transmission also increases. Based on the number of times the same message is received by the adjacent nodes, the method determines the execution of transmission and is able to reduce the number of instances of message transmission, consequently reducing the number of instances

of message reception among adjacent nodes. Although increasing the transmission power increases the power consumption required for one transmission, because the number of message transmissions and receptions is greatly reduced, low power consumption of the entire network can be expected.

After the message is first sent, the proposed method waits for a period of time T_2, during which it determines if a message has been sufficiently disseminated based on the number of times the same message has been received from the adjacent nodes. Because retransmission is executed when necessary, it is possible to increase the information dissemination rate. Although retransmission increases power consumption, increasing the dissemination rate is the most important factor in information dissemination. Additionally, since the proposed method performs retransmission only when necessary, the increase in power consumption is small.

Consider the relationship between T_1 and T_2. When $T_1 > T_2$, the transmitting node cannot receive the same message from the adjacent nodes β times, and retransmission is always executed. It follows that T_1 must be equal to or less than T_2. Specifically, T_2 is determined by the following equations.

$$BE = macMaxBE + 2$$
$$B_2 = (2^{BE} - 1) \times aUnitBackoffPeriod$$
$$T_2 = (SIFS + LIFS + B_2 + CCA) \times symboltime$$

The maximum T_1 was set to twice the maximum waiting time defined by CSMA/CA, whereas T_2 was set to 4 times the CSMA/CA-defined maximum. When receiving the same message as the transmitted one β times during T_2, the message is determined to have been successfully disseminated to the adjacent nodes, and the message is not retransmitted. On the other hand, if the same message as the transmitted one could not be received β times during T_2, the message is determined to have failed dissemination to the adjacent nodes. In this case, the transmitting node retransmits the message and waits for T_2.

Additionally, the number of instances of reception parameters α and β, used to determine transmission cancellation and retransmission, respectively, are set to satisfy the following condition.

$$\alpha \geq \beta$$

This condition is imposed because if β exceeds α, the number of nodes that never perform transmission increases, the β condition for determining retransmission becomes difficult to satisfy, and the number of retransmissions increases.

The proposed method allows for a message to be retransmitted a maximum of γ times. If a message identical to a retransmitted message is received β times during the waiting period, it is considered successfully disseminated to the adjacent nodes, and the transmitting node ceases to perform transmissions of the same message. However, if a message identical to a retransmitted message cannot be received β times during the waiting period, even if the retransmission is executed γ times, the transmitting node does not consider there to be any nodes in its vicinity and does not transmit the same message thereafter.
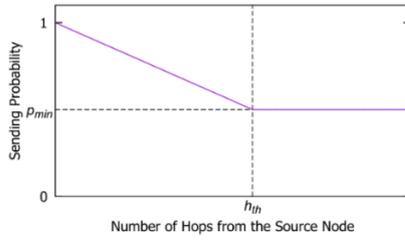
Fig. 2. Message broadcast probability.

In the proposed method, after receiving a message for the first time and performing the first transmission, the message is transmitted according to the probability p. In the existing gossip method, all nodes transmit messages with a constant probability. By cancelling transmissions with a constant probability at the time of transmission, the number of instances of transmission can be reduced. With the gossip method, the number of transmissions can be reduced in proportion to the transmission probability. However, if shortly after dissemination begins and the number of nodes that message already have is small and transmission is cancelled at the nodes, the information dissemination rate decreases considerably. At the same time, if the message broadcast probability is increased to prevent this situation, the number of cancelled transmissions would decrease even though the problem of decreasing information dissemination rate would be addressed, meaning that the overall number of transmissions would not be reduced.

Our proposed method determines the value of p based on the number of hops rather than using a constant value. By reducing the transmission rate after a message has been disseminated to a sufficient number of nodes, a high information dissemination rate can be expected to be maintained while reducing the overall number of transmissions.

Taking x as the number of hops from the source node, the probability $p(x)$ at which the method transmits messages is given by Equation (1) and shown in Fig. 2, where p_{min} is the minimum broadcast probability and h_{th} is the threshold of the number of hops.

$$p(x) = p_{min} + max\{\frac{(x-h_{th})\times(1-p_{min})}{1-h_{th}}, 0\} \quad (1)$$

If the number of hops exceeds h_{th}, the transmission rate must be p_{min}. When the number of hops from the source node is small, $p(x)$ increases. As the number of hops from the source node approaches h_{th}, $p(x)$ tends downward toward p_{min}. A summary of the definitions and symbols used in our method is provided in Table I.
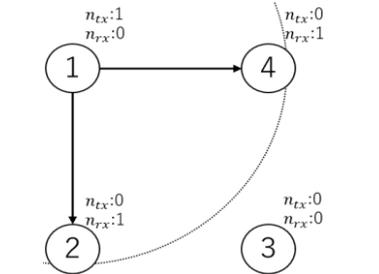
TABLE I: VARIABLE DEFINITIONS

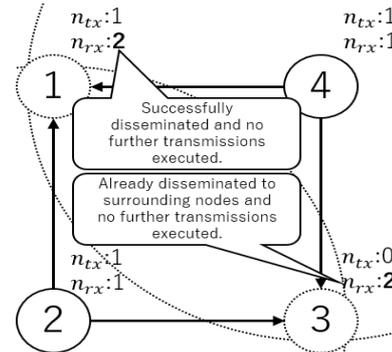|	
T_1	Transmission waiting period
T_2	Retransmission waiting period
α	Number of receptions for determining transmission cancellation
β	Number of receptions for determining retransmission
γ	Maximum number of retransmissions
p	Retransmission probability
p_{min}	Minimum broadcasting probability
h_{th}	Number of hops (from minimum broadcasting probability)

Finally, Fig. 3 shows an example of information

dissemination using the proposed method, wherein the solid circles represent nodes, each identified by a node number, n_{tx} represents the number of message transmissions per node, and n_{rx} represents the number of message receptions. The broken lines represent the communicable range, and the dotted circles indicate non-transmitting nodes. The proposed method parameters are set to $\alpha = 2$, $\beta = 2$, and $\gamma = 1$. For ease of explanation, $p(x)$ is assumed always to be 1.
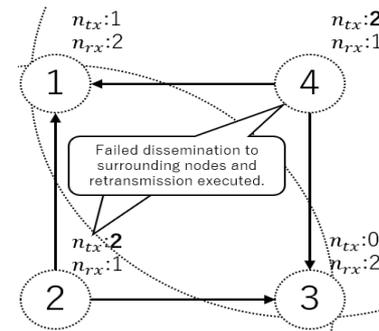
In Fig. 3(a), Node 1 transmits a message and then waits for T_1 only. The message sent by Node 1 arrives at Nodes 2 and 4 for the first time, so Nodes 2 and 4 wait for T_2 until transmission. In Fig. 3(b), Nodes 2 and 4 execute transmission, and the messages from Nodes 2 and 4 are sent to Nodes 1 and 3.

(a)   Step 1: Node 1 transmits a message.

(b)   Step 2: Node 2 and 4 transmit the message.

(c) Step 3: Node 2 and node 4 retransmit the message.

Fig. 3. Process of message dissemination in the proposed method.

Node 1 has received the message from the adjacent nodes twice, satisfying the value of β used to determine retransmission. Thus, the message is deemed successfully disseminated, and the node does not execute retransmission. Similarly, Node 3 has also received a message from the adjacent nodes twice, satisfying the value of α used to determine transmission cancellation. Thus, the message is deemed already disseminated to its surroundings, and Node 3 does not execute transmission thereafter.

In Fig. 3(c), Nodes 2 and 4, having received messages from

Node 1 as in Fig. 3(a), wait for T1 only. However, since Nodes 1 and 3 do not execute transmission, Nodes 2 and 4 are unable to satisfy the value of β used to determine retransmission. Therefore, after T1, the message is retransmitted.

IV. PERFORMANCE SIMULATIONS

This section describes the process and results of simulations conducted to evaluate the performance of the proposed method by analyzing the information dissemination rates and overall network power consumption.

A. Simulation Environment

The simulations were performed using a network model in which the nodes were arranged randomly on an area of 4000 m^2. The simulation nodes used the Mono Wireless TWELITE DIP [10], and a wireless frequency of 2.44 GHz, transmission rate of 250 kbps, and packet size of 127 B were assumed, as well as that a message fit entirely in one packet. The supply voltage was assumed to be 3.3 V, and the current when receiving messages was 14.7 mA.

The simulations supposed the usage of a Mono Wireless TWE-AN-P4208-10 antenna [11], a gain set at 2 dBi, and a minimum node receiving sensitivity of –96 dBm. Table II summarizes the sensor node parameters used for the simulations.

TABLE II: SENSOR NODE PARAMETERS

symboltime	16 ns
Frequency	2.44 GHz
Transmission rate	250 kbps
Antenna gain	2 dBi
Minimum receiving sensitivity	-96 dBm
Voltage	3.3 V
Size per packet	127 Byte

The wireless transmission distance was set to 200, 300, and 400 m. For each distance, the transmission power was set so that the reception sensitivity was –96 dBm, and the sensor node power consumption was obtained. It was assumed that there were no obstacles and reflectors between the nodes, and the attenuation of radio waves followed the free space loss model. In this case, the propagation loss $L_p(d)$ that occurs when a radio wave of wavelength λ arrives at a long-distance receiving node at a distance d from the transmitting node is given by Equation (2).

$$L_p(d) = (4\pi d/\lambda)^2 \tag{2}$$

Assuming that the gain of the transmitting antenna is G_t, the gain of the receiving antenna is G_r, and the minimum receiving sensitivity is P_{rm}, the required transmission power $P(d)$ is given by Equation (3).

$$P(d) = G_t + L_p(d) + G_r \tag{3}$$

Thus, the current at the time of transmission was obtained by taking the required power $P(d)$ at each distance. Since TWELITE DIP does not show the current at each transmission output, it was determined from the similar LSI

specifications [12]. Specifically, for the distances of 200, 300, and 400 m, the current was set to 8.24, 12.09, and 13.05 mA, respectively. Using the transfer rate r (bps), the power consumption J (J) is given by Equation (4) in terms of the current I (A), voltage V (V), packet size L (bit), and transfer speed r (bit/s) for one instance of transmission and reception.

$$J = I \times V \times \frac{L}{r} \tag{4}$$

A message to be disseminated was generated by a randomly selected node. The message was disseminated to the whole network using the flooding, gossip, and proposed methods, respectively. Note that the flooding and gossip methods did not execute retransmission. The broadcasting probability of the gossip method was set to 80%. In the proposed method, h_{th} was 50, informing p_{min}, which was set to 50%. In addition, α and β were each set to 2, and γ was set to 1.

TABLE III: TRANSMISSION DISTANCE AND POWER CONSUMPTION

Current at reception	14.7 mA
Current at transmission (200 m)	8.24 mA
Current at transmission (300 m)	12.09 mA
Current at transmission (400 m)	13.05 mA

TABLE IV: METHOD PARAMETERS

Wireless transmission distances	200, 300, 400 m
Rejection rates	0%, 10%, 20%, 30%, 40%, 50%
Number of trials	2500
Gossip method broadcasting probability	80%
p_{min}	50%
h_{th}	50
α	2
β	2
γ	1

With these settings, 2500 simulation trials were performed at distances of 200, 300, and 400 m, with rejection rates of 0%, 10%, 20%, 30%, 40%, and 50% using each method. The information dissemination rates and average power consumption values across the whole network were obtained from these trials. The power consumption varied depending on the transmission distance. The relationship between the transmission distance and power consumption is shown in Table III. Table IV summarizes the parameters of each method used in the simulation.

B. Simulation Results

Fig. 4(a-c) show the dissemination rates for the flooding, gossip, and proposed methods in cases in which the rejection rate was adjusted for a network of 1000 nodes at transmission distances of 200, 300, and 400 m.

From Fig. 4(a), it is evident that the information dissemination rate of the proposed method is lower than those of the flooding and gossip methods in areas with low rejection rates. This difference occurs because in the proposed method, when a message identical to the message to be transmitted is received from neighboring nodes a certain number of times, the message is considered already disseminated and the transmission is cancelled. In the proposed method, when there is a large number of nodes within the communicable range, the chance of receiving the same message increases,

the number of instances of transmission cancellation increases, and the information dissemination rate decreases. On the other hand, when the rejection rate increases, the information dissemination rate of the proposed method decreases more slowly than those of the flooding and gossip methods. This behavior occurs because in the proposed method, when the rejection rate increases and the chance of receiving the same message from the surrounding nodes decreases, the number of instances of transmission cancellation decreases, increasing the information dissemination rate.

(a) 1000 nodes at 300 m.

(b) 1000 nodes at 300 m
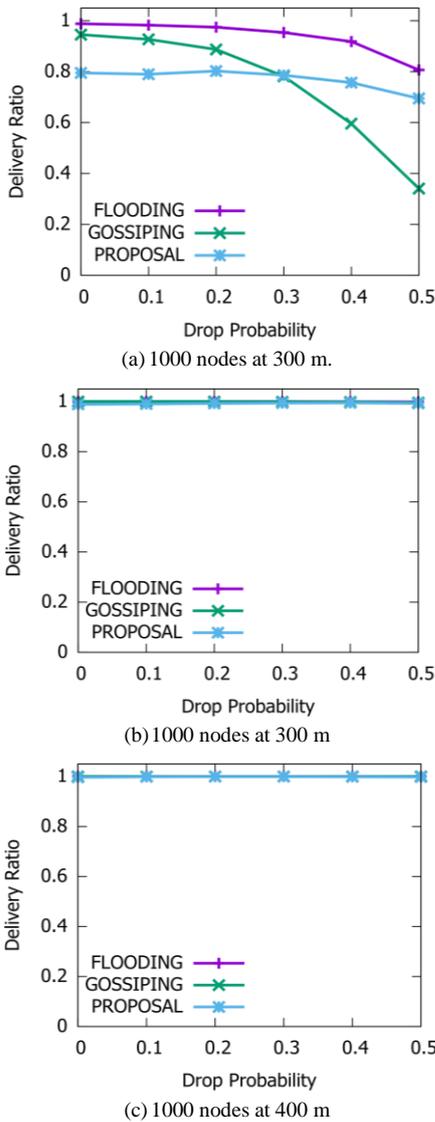

(c) 1000 nodes at 400 m

Fig. 4. Information delivery ratio with 1000 randomly located nodes.

In all methods, the information dissemination rate decreases as the rejection rate increases in areas in which the rejection rate is 0.3 or more, but the gossip method experiences a particularly sharp decrease in dissemination rate compared to the other methods. From this behavior, it can be understood that the performance of the gossip method decreases considerably with changes in the network environment. Conversely, when dissemination to adjacent nodes is considered to have failed, the proposed method executes retransmission. In this way, the chance of retransmission increases as rejection rate increases, making it more difficult for the information dissemination rate to decrease.

As can be seen from Fig. 4(b) and Fig. 4(c), in all methods, by increasing the wireless transmission distance, a high information dissemination rate can be maintained even in areas with high rejection rates. This tendency occurs because with increased distance, the number of nodes in the communicable range is also greater, sufficiently increasing the chances of receiving messages even when accounting for a high rejection rate.
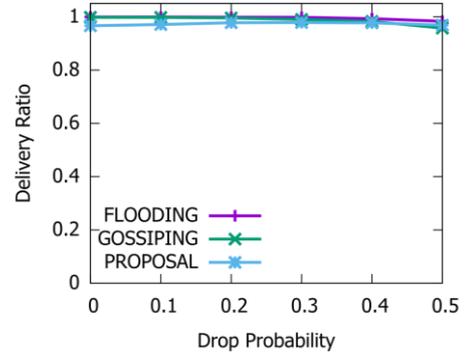

Fig. 5. Information delivery ratio with 1500 randomly located nodes.

Fig. 5 shows the information dissemination rates obtained when the number of nodes was increased to 1500 in environments otherwise identical to those used to obtain Fig. 4. It is evident that a high information dissemination rate can be maintained when the number of nodes and node density are increased, as in Fig. 4(b) and Fig. 4(c). This rate can be maintained because the number of nodes existing within the communicable range is sufficiently large; an effect similar to that of when the transmission distance is increased.
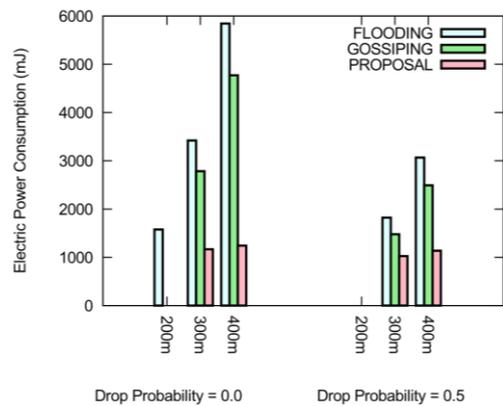

Fig. 6. Total electric power consumption with randomly located nodes.

Fig. 6 shows the power consumption across the whole network when the transmission distance was changed with 1000 node networks and the rejection rate was set to 0 and 0.5 for the flooding, gossip, and proposed methods where the dissemination rate was 0.95 or more. From this figure, it is evident that the power consumption of the proposed method across the whole network is less than those of the flooding and gossip methods for all transmission distances and rejection rates. In addition, in the proposed method, the fluctuations in power consumption with transmission distance are small, since the proposed method cancels transmission when a message has been determined to have already been disseminated. Although the power required to transmit one message increases depending on the transmission distance, since the number of instances of

transmission and reception decreases across the whole network, even though there may be an increase in the number of instances of transmission and reception by *retransmission*, the overall increase in power consumption can be minimized.

C. Summary of Simulation Results

In all methods, the information dissemination rate increased as transmission distance increased, regardless of a high rejection rate. In the flooding and gossip methods, the power consumption across the whole network greatly increased with increasing transmission distance. Conversely, in the proposed method, efficient information dissemination was made possible even accounting for the greater power consumption due to the increased transmission distance because an increased transmission distance introduced more chances for a single node to receive a message and thus decreased the number of transmissions. As a result, there was hardly any increase in overall power consumption. That is, unlike the existing methods, it is apparent that the proposed method is capable of achieving a high information dissemination rate with minimal increases in power consumption even in poor network conditions (i.e., with high rejection rates) where retransmissions occur.

V. CONCLUSION AND FUTURE CONSIDERATIONS

In this paper, we proposed a new method for information dissemination in wireless sensor networks, in which the transmission of a message in a node is determined by using the number of times the same message has been received by adjacent nodes. A similar process is performed for determining retransmission, allowing for improved information dissemination rates in environments with high rejection rates. Due to obvious increases in power consumption, networks with increased power have not been sufficiently investigated in previous research. In the proposed method, the overall number of instances of message transmission and reception can be reduced when the transmission distance is increased due to a concurrent increase in the number of nodes that can potentially receive the message during one instance of transmission. As such, the overall power consumption across the whole network can be kept low despite an increase in the amount of power necessary to perform one transmission.

Performance simulations revealed that, compared to the existing methods, the proposed method can achieve considerable improvements in information dissemination rates under network conditions with high packet rejection rates. Furthermore, the existing methods experience significant increases in overall power consumption when the transmission distance is increased, whereas in the proposed method, there was hardly any increase in power consumption under the same conditions. In this way, the proposed method can achieve both a high information dissemination rate and reduced power consumption in sensor network environments with relatively high packet rejection rates.

In future work, it will be important to investigate the control parameters, specifically, p_{min} and h_{th} for message sending probability and α and β for message retransmission. We will clarify the parameter region that yields appropriate operation by examining numerous network environments.

Moreover, it is important to evaluate the proposed method using actual sensor terminal systems and to demonstrate the validity of the proposed system.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

HH designed research; RK performed research; RK wrote the initial paper; HH reviewed and edited the paper; all authors had approved the final version.

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