A Study on the Efficient Routing Algorithm for Asset Management System

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ABSTRACT

Even though a lot of routing algorithms have been proposed, an omnipotent algorithm of routing technique, which has optimal efficiency, does not exist.

Therefore, A routing algorithm in a sensor network is an application oriented; the best effective routing algorithm depends on which application it is used to.

This paper's purpose is to make the routing algorithm used in asset management application to monitor indoor assets' movement. To do this, the paper supposes new multi-hop routing algorithm using RSS data.

The multi-hop routing algorithm using RSS data in this paper is superior to the routing algorithm based on DSDV because it enhance 27 % of routing time and 53% of RAM using capacity.

Keywords : Sensor Network, RSS, Routing Algorithm

1. Introduction

The words Wireless Sensor Network have been in wide usage at technology sessions of various societies and in various industrial sectors for many years. This shows a stronger demand than ever of the diverse contributions by sensor networks in preparing for the ubiquitous computing age coming soon.

Since this paper is a proposal on developing a routing algorithm for an efficient (reaction speed, resource usage quantity) management of asset management applications using the wireless sensor network, which is the core technology of ubiquitous computing, we will briefly examine wireless sensor network first.

The wireless sensor network sector is being led by the NEST(Network Embedded Systems Technology) project, which is led by the team of Professor Culler at U.C Berkeley. Wireless sensor network is literally a technology giving wireless networking function to existing sensors once used with a function limited to sensing, and has the purpose of appropriately processing environment data obtained through sensors, and then effectively transmitting it to the destination through wireless RF.

The study on wireless sensor network technology is in progress in various sectors including study on diverse forms of sensor node development, study on efficient MAC(Medium Access Control) in terms of energy, study on strong and efficient routing algorithm, study on effective storage and processing of obtained sensing data, study on security of data transmission, and study on applications that can be linked to sensor networks.

Among the diverse sensor network study areas, this paper is about developing a routing algorithm to improve sensing data transmission efficiency. That is, we're pursuing a new method of efficiently deciding the route for sending sensing data most quickly to the destination.

Although many routing algorithms are being proposed for wireless sensor network, there is no omnipotent routing algorithm offering the best effect in all situations. Thus, routing algorithm in wireless sensor network sector would be application oriented. Depending on the service or application used, the most efficient routing algorithm can be decided.

Also, we must keep in mind that wireless sensor network is essentially different from routing used in existing ad or network due to the limitation of operation with limited resources (memory, power, etc.) in limited space, with communication through low power RF.

The purpose of this paper is to develop a routing algorithm that may be used in asset management application for monitoring the movement of assets in an office. To this end, we developed a new multi-home routing algorithm using little resources but offering fast reaction speed by applying the RSS (Received Signal Strength) value once used in positioning of the sensor network to the routing algorithm.

It has been confirmed through experiment that the multi-home routing algorithm using RSS value propose in this paper offers an improvement of 27% in route completion speed and 53% in resource (RAM) usage compared to the DSDV-based routing algorithm known to have fast reaction speed in asset management application.

2. Main Body

2.1 TIP 30C

The sensor network platform used for this paper's experiment is the TIP 30C developed in 2004 by ‘Electronic Parts Research Institute'. As shown in Figure 1, TIP 30C adopted the Inverted F-Type ceramic antenna using 915MHz wireless RF band, and supports various sensor (light, temperature, humidity) functions. ATmega 128 was used for micro controller, along with 128KB flash memory and 4KB RAM for downloading programs. As for power, 2 1.5V AAA size batteries are connected in series, supplying 3V power.

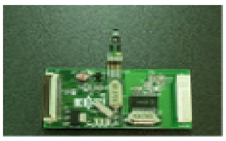

Figure 1 : Sensor node used (TIP 30C)

TIP 30C sensor network node adopts a low power RF transmission-reception module called CC 1000. CC 1000 RF module measures the RF strength, produces relevant signal with the RSSI (Received Signal Strength Indicator) output port, and receives input of this from ADC port of ATmega 128.

The output RSSI signal can be measured between 0V ~ 1.2V in the ATmega 128 A/D Converter, and the closer the distance between nodes, the closer the value to 0V. At this time, take caution that higher measured voltage means lower input signal, while ADC value scope is 0 ~ 341.

Since ATmega 128 operates at VDD 3V and samples analog signals using 10 bits, signal strength reading will be from 0 to 400. (The value measured by this paper's experiment does not exceed 200)

As described above, RSS value, which is the received signal strength, shows link performance in the network, and can be converted to be used in creating routing algorithm. In this paper, such new concept of routing algorithm using RSS value for sensor network is realized.

2.2 TinyOS

In this paper, the OS for sensor network node used TinyOS distributed by U.C Berkeley. TinyOS is a specially made OS for Network Embedded Systems like the sensor network. This was designed to create an ultra-mini capacity OS with small data memory with event-based application and mini core OS (about 400 byte code), and it only provides an event-based simple scheduler function.

As shown in Figure 2, TinyOS is an OS with limited functions, only supporting a scheduler function. TinyOS checks the existence of tasks to be handled in the task queue with FIFO structure, and processes them. When this process is done, it enters Sleep status, and when an event occurs, the event handler operates according to the interrupt vector based on the interrupt service routine (ISR). When this process is done, it returns to Sleep state.

As such, designed to be used in the sensor network, the time sleep state is maintained for TinyOS is over 99%, and since it is designed operate and maintain long-term continuous node time, it may be an ultra-mini OS appropriate for sensor network nodes with limitations in terms of resource.

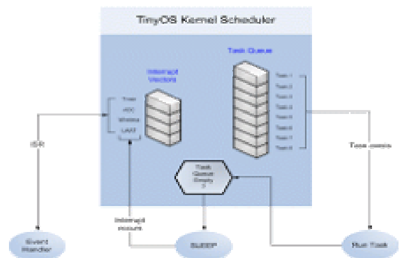

Figure 2 : TinyOS Kernel Scheduler

2.3 Algorithm

The ultimate goal of the routing algorithm this paper desires to develop is to find a method for efficiently identifying the best performing route to reach the destination node for transmitting sensing data. For this, routing algorithm using RSS consists of 4 key components as shown in Figure 3 below.

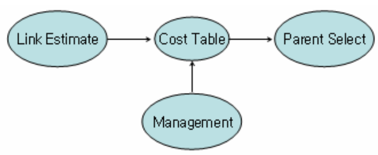

Figure 3 : Outline of the routing algorithm operation using RSS

The flowchart of overall routing operation using RSS for sensor network is as shown in Figure 4.

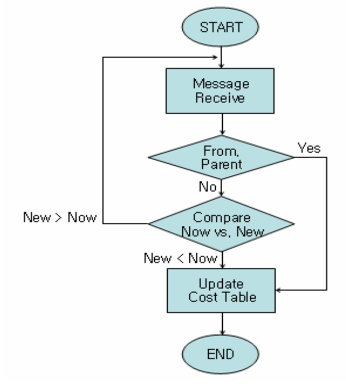

Figure 4 : Flowchart of overall routing operation using RSS

After continuously transmitting-receiving route messages to maintain wireless communication network connection, sensor network nodes judges RSS, which is the receiving signal strength, each time a route message is received and calculates the quality of links between sensor nodes. If the sensor node finds a better link, it updates the Cost table.

Thereafter, when forwarding a message, a new parent node is set to reach the destination address, and data is forwarded to this sensor node.

Thus, after obtaining the RSSI output value between sensor nodes at CC 1000 by hardware, the RSSI value is digitalized at the ADC of MCU(ATmega 128) and shared between sensor nodes, by which the parent with the best condition is chosen. This is a proposal to estimate that the physically closest node has the highest possibility of being the Parent.

2.4 Environment for experiment

Figure 5 is the environment for experiment to compare performances of the two routing algorithms. For nodes, a total of ten TIP 30C, one TIP30G, and laptop (SONY PCG-TR2: 1G CPU, 1GRAM) was prepared including the base node, and to make the sensor node height identical, sensor nodes were allocated on top of office partitions.

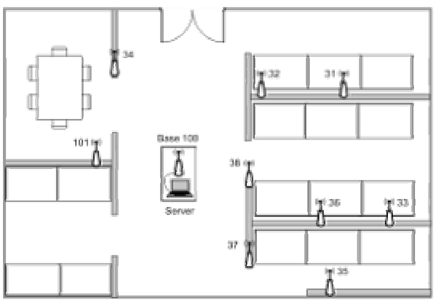

Figure 5 : Environment for experiment of routing algorithm reaction speed

By comparing the experiment results of DSDV (Destination Sequenced Distance Vector)-based routing algorithm that was designed in the past for sensor network by the Electronic Parts Research institute and the routing algorithm proposed by this paper, performances were verified.

The two types of routing algorithm fixed and measured the position of sensor nodes where the same network topology is formed when two routing algorithms are applied to obtain identical test conditions, and when measuring each routing algorithm's reaction speed, batteries were replace with new ones. In order to reduce the error rate due to operational variance during the experiment, the average of each value obtained by repeating measurement 100 times in identical conditions was obtained and used as result value.

To measure the reaction speed of routing algorithm for asset management using the sensor network, network topology display tool created with Java was used as shown in Figure 6. This Java tool can monitor the network topology forming status of all nodes in the sensor network, and can measure and store the time for forming a network based on hop count, making it an appropriate tool for measuring the reaction speed of routing algorithm.

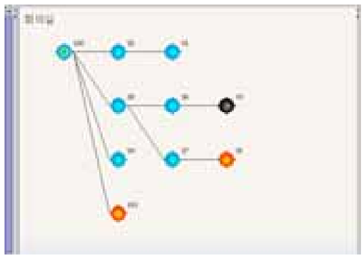

Figure 6 : Formed image of network topology

2.5 Experiment results

Figure 7 is a drawing that shows in graph form the time required to complete network topology based on the number of sensor nodes when applying two routing algorithms to identical network experiment conditions of Figure 5. The result shown in triangles on the graph is the result of testing DSDV-based routing algorithm, and the result in squares is the test result of routing algorithm using RSS value.

The resulting graph in Figure 7 has two focal points.

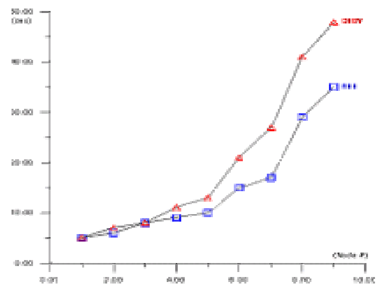

Figure 7 : Comparison of network topology completion speed

First, when DSDV-based routing and RSS value-based routing algorithms are each applied to the sensor node, it can be seen that the result of experiment using RSS value is better in terms of overall reaction speed.

Second, when there are less than 3 sensor nodes, it takes a similar amount of time to form network topology, but as the number of sensor nodes used increases from 4 to 9, the time gap required to form a network grows. Thus, in a network environment where the number of sensor nodes grows, it can be seen that the RSS-based routing algorithm offers faster reaction speed.

This paper compared the volume of RAM usage in sensor network nodes in the compiling process of two created routing algorithms, in order to prove the effect of quantitative resource improvement.

The result of this is shown in Figure 8. The volume of RAM usage of routing algorithm using RSS value is 0.912K bytes, which offers about a 53% savings effect compared to DSDV-based routing algorithm where just the RAM usage size is 1.928K bytes.

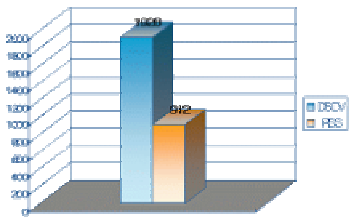

Figure 8 : RAM usage comparison

Table 1 is a table of summary after comparing and analyzing performance of DSDV-based and RSS value-based routing algorithm crated in this paper for sensor network. Resulting reaction speed was a value measured based on a case where there are 9 sensor nodes

Category	DSDV-based Routing	RSS-based Routing	Improvement (%)
Reaction speed	47 (sec)	34 (sec)	27
Quantity of RAM used	1928 (Byte)	912 (Byte)	53

Table 1 : Routing algorithm performance comparison

As can be seen through results of the experiment, the routing algorithm proposed by this paper shows that RSS-based routing algorithm achieved the effect of reducing about 27% of the time required to finish a network topology compared to the DSDV-based routing algorithm, when there are 9 nodes, in terms of reaction speed. Also, the volume of RAM usage of the routing algorithm using RSS value is 0.912K bytes, which is a savings of about 53% compared to 1.928K bytes, which is the volume of RAM usage for DSDV-based routing algorithm.

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3. Conclusion

This paper proposed a routing method using RSS value to create a routing algorithm that can satisfy the two requirements of fast reaction speed needed for asset management application and of reducing resource usage required by general sensor network technology, and then proved it through experiment.

In the environment for experiment of this paper, the routing algorithm using RSS value, compared to DSDV-based routing algorithm, proved superiority in terms of reaction speed and resource usage. However, if the routing algorithm proposed in this paper were tobe applied to asset management in a different environment, it would be difficult to ascertain its effect.

This does not only apply to routing algorithm proposed by this paper. Therefore, the routing algorithm for the sensor network will need work for optimizing it according to the requirements of the applied applications and the environment in which it is to be applied.

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