Ad hoc routing protocol by taking the communication quality into account between adjacent links

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Abstract— In an ad hoc network, communication distance is limited by the need to minimize the power consumption of the communication nodes. To deal with this, we usually employ multi-hop relaying functions that use the number of hops as a routing metric. But in an environment where traffic density is high, the same relaying node may be used by multiple sending nodes due to their spatial distribution. Data packets sent from such nodes may collide and cause packet loss at the relaying node, causing degradation of data transmission throughput.

To improve this situation, we propose ad hoc on-demand distance vector (AODV) using TCP with cache function and CM (Cross-layered Multipath)-AODV using SINR (Signal to Interference and Noise Ratio) to determine the next hop. However, in both methods the alternate path is determined based on AODV when the current path fails. It usually takes a long time to establish the new path, varying in proportion to the number of hops. So we need to invent a method that can realize high throughput even if communication failures are frequent. In this paper, we propose a method in which hello packets are used to generate the routing metric by monitoring the communication quality between adjacent links in AODV. We also describe the evaluation results of simulation experiments demonstrating the avoidance of throughput degradation when data traffic density is high.

Keywords— Ad hoc, Sensor network, AODV, OLSR, Routing

I. INTRODUCTION

Recently, R&D on sensor networks that use multi-hop functions has been examined [1], with special emphasis on applications for environmental monitoring to rapidly detect natural disasters [2], vital signs monitoring of human beings, and smart meters. The IEEE 802.15.4 standard will be applicable to these power-saving application services, since AODV and OLSR (Optimized Link State Routing) are typical communication protocols using IEEE802.15.4 [3,4]. These protocols usually use the number of hops as a routing metric.

A. Problem in the conventional protocols

In OLSR and AODV a relaying node may see multiple use depending on the sending nodes' geographical positions since only the number of hops is used in the routing metric. It is apparent that packet loss occurs frequently, resulting in a data transmission throughput decrease when a relay node is commonly used by multiple sending nodes. In addition, it takes quite a long time to switch to a new relay node when a failure is detected on a particular path.

B. Previous studies

For improving transmission throughput, common suggestions are AODV using TCP [5] with a cache function or CM-AODV [6] using SINR to determine the communication route. These can improve the throughput to some extent, but will not be applicable when the number of connections increases or relay node failure is frequent, since both methods are based on standard AODV, leading to extended recovery times.

II. PROPOSED NEW ROUTING METRIC

In this paper, we propose an improved AODV scheme. This scheme can switch rapidly to a new alternate routing path when a failure is detected.

The proposed scheme can solve the aforementioned problem by using a dynamic routing mechanism after establishing an initial communication path. The proposed scheme also has a cache to store the path selection. Our explanation of the method for sending and receiving hello packets and calculating the reception success rate of hello packets follows.

A. Route updating

After establishing a communication path, each node broadcasts hello packets at periodic intervals. Hello packets include a sequence number. When a node receives hello packets, it calculates their successful reception rate by evaluating their sequence numbers. After a certain time interval, each node calculates the number of successful receptions of hello packets from the next hop node candidates.
and selects the most appropriate node. The procedure for path route updating is shown in Fig.1.

![Fig.1. Path route updating procedure](image)

**B. Path route switching in case of link failure**

Since each node monitors the relayed packets from the next hop node with a directional antenna, it can easily register the next hop node’s successful transfer of the packet data. Therefore, the proposed scheme can achieve rapid path switching in the event of link failure. Whenever a failure is detected, the node selects the second-best node based on the list of successful reception rates, and removes the failure-node from the list.

### III. SIMULATION EXPERIMENTS

To verify the proposed dynamic routing’s effect, we designed experiments that compared it with AODV, and AODV using TCP with a cache. In the experiments, we assumed that ten nodes are randomly deployed and the maximum congestion window size is four. Fig.2 shows the results of this experiment after 100 repetitions.

![Fig.2 Confirmation experiment results](image)

We found that the proposed scheme is effective even when there are numerous link breaks.

### IV. CONDITIONS OF SIMULATION

We evaluated the throughput and power consumption of OLSR, AODV, and the proposed scheme, using QualNet [7] as a network simulator. Each node’s parameters were set with reference to XBee [8], which is based on IEEE802.15.4. Table.1 shows the parameters of the simulations. In simulation model 1, we separated 6 sub-areas and selected a sending node from each. We assumed a data packet transmission interval of 300 s in keeping with environment monitoring guidelines [2]. In simulation model 2, we assumed a data packet transmission interval of 10 s [9], since it takes 10 s to measure the vital signs information (pulse, perspiration, body temperature, etc.).

<table>
<thead>
<tr>
<th>Table.1 Simulation parameters</th>
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<tbody>
<tr>
<td><strong>Simulation model 1</strong></td>
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<tr>
<td>Monitoring type</td>
</tr>
<tr>
<td><strong>Simulation area</strong></td>
</tr>
<tr>
<td><strong>Number of nodes</strong></td>
</tr>
<tr>
<td>Deployment of Node</td>
</tr>
<tr>
<td>Movement rate</td>
</tr>
<tr>
<td>Number of connections</td>
</tr>
<tr>
<td>Utilization rate of node</td>
</tr>
<tr>
<td>Packet transmission interval</td>
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<tr>
<td>Data packet size</td>
</tr>
<tr>
<td>Hello packet transmission interval</td>
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<tr>
<td>Route updating interval</td>
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<td>Number of simulation</td>
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<td>Elapse time of simulation</td>
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### V. SIMULATION RESULTS

The throughput with respect to node utilization in simulation models 1 and 2 is shown Fig.3 and Fig.4. The number of connections per sub-area in models 1 and 2 was 20 and 40, respectively. Actual applied areas are shown in Fig.3 and Fig.4. Power consumption is shown in Fig.5.
VI. DISCUSSION

In simulation model 1, the proposed scheme’s throughput is almost double that of the existing protocol, independent of the node utilization rate. This is due to the proposed scheme’s maximal avoidance of packet loss and the protection of relay nodes against simultaneous use. Also, the proposed scheme can shorten the restoration time when relay node failure does occur. In simulation model 1, the restoration time is about 10 s. The proposed scheme can switch the path route immediately after the detection of a path failure.

In simulation model 2, in which each node moves at a speed of 1 m/s, the throughput of the proposed scheme is 2.5 times higher than with AODV [10]. Since the data packet transmission interval is shorter in simulation model 2, the restoration time will also become much shorter due to the node behavior.

As shown in Fig.5, the power consumption (7.1 mAh/day) of OLSR is the highest in simulation model 1. Second highest is the proposed scheme (6.9 mAh/day). AODV (6.7 mAh/day) showed the lowest power consumption of the three. This is why in the proposed scheme each node uses only hello packets. In OLSR each node also uses Topology Control (TC) packets in addition to hello packets.

Next we define the cost performance based on both the power consumption and the packet loss rate in order to totally verify the proposed scheme’s advantage.

Fig.6 and Fig.7 show the relative cost performance, comparing the existing protocols and the proposed one, where AODV’s cost performance = 1. The cost performance is formulated as follows.

\[
\text{Cost performance} = \frac{1}{\text{power consumption} \times \text{loss rate of packet}}
\]

In simulation model 1, the cost performance of the proposed scheme becomes higher than that of other protocols when the number of connections increases.

In simulation model 2, the cost performance of the proposed scheme is always higher than AODV.

VII. CONCLUSION

In this paper, we evaluated the effects of an improved dynamic routing architecture on throughput and cost performance. We found that the proposed routing scheme is more effective than the conventional ones when the number of connections increases, independent of the node utilization rate. Considering that in the existing protocols the throughput will decrease depending on the sending node’s geographical position and the number of connections, the proposed routing scheme offers a great advantage.

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