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Proposal and evaluation of information gathering methods that consider the MANET's load in a disaster

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Abstract: When a disaster occurs, victims must be rescued quickly and their safety confirmed. However, current information-gathering systems may become unusable if their infrastructures are destroyed. The Mobile Ad Hoc Network (MANET) is a rescue-support system. MANET typically uses the flooding strategy. In flooding, the source node broadcasts the Route Request Control Packet (RREQ) to discover a route to the destination. However, this generates a high number of redundant retransmissions, so flooding places a huge burden on the devices that compose MANET. In this paper, we propose a MANET system that uses location information and the current energy status of the node. By simulating a disaster, we demonstrate that our proposed system outperforms the existing systems in terms of the total number of RREQs and the average power consumption.

Keywords: Mobile Ad Hoc Network, Broadcast, Location Information, Energy Status

1 INTRODUCTION

Recently, growth of mobile devices and the Internet has spurred development of individual information communications. Information communication in disasters such as earthquakes, volcanic eruptions, floods, and terrorism has become more and more important because it is necessary to rescue the victims quickly and confirm their safety. Existing rescue-support systems for disasters use hazard maps and emergency call systems such as 119. Hazard maps anticipate damage and victims' responses. However, damage from disasters may be worse than expected. In this case, systems employing hazard maps would be useless. The emergency call system is regularly used by many people. In the event of a disaster, however, the system may be unusable due to destroyed infrastructure.

The Mobile Ad Hoc Network (MANET) is a current rescue-support system. MANET is a self-configured wireless network formed by a collection of wireless mobile nodes without a fixed infrastructure or a centralized administrator. A rescue-support system using MANET can gather information on victim safety dynamically in a disaster. MANET typically employs a flooding strategy. In flooding, the source node broadcasts the Route Request Control Packet (RREQ) to discover a route to the destination. MANET currently has two problems. The first is the increased number of devices composing MANET. The increase in the number of devices increases the total number of RREQs and degrades the availability of MANET. Second is the difficulty of ensuring electric power. If it is difficult to ensure electric power, the energy status of device must be considered. In this paper, we propose a MANET system that uses location information and the current energy status of the node.

The rest of this paper is organized as follows. Section 2 reviews related work on MANETs. Section 3 provides our proposed system. Section 4 presents the simulation setup and performance evaluation of our proposed system. Finally, section 5 concludes the paper and outlines future work.

2 MOTIVATION

Disseminating routing protocol control packets (e.g., RREQ packets) with blind flooding may entail a huge overhead as mentioned previously. Therefore, increased attention is focused on reducing the routing overhead associated with route discovery by increasing the effectiveness of broadcasting.

2.1 Route discovery using Location Information

In Iwasaki's Location Aided Routing middle (LAR-middle) algorithm [1], mobile nodes use location information obtained from global positioning system (GPS) receivers and transmit RREQ packets in a circle with a diameter of the distance between the source node and the destination node in order to determine the route. This approach effectively reduces the number of broadcast packets, but also reduces the number of communication paths to the destination node and decreases the fraction of packets delivered.

2.2 Route discovery using gossip

Haas et al. proposed an adaptive gossip-based protocol that employs a predefined probability p to forward an RREQ packet if there is the node more than a certain distance from the source ; otherwise it will gossip with probability 1 [2].

They conducted experiments to demonstate how simple gossiping uses up to 35% fewer packets than flooding for large networks and that the performance of AODV routing relying on a gossip-based search is improved even in a small network of 150 nodes.

2.3 Route discovery using directional gossip

Beradi exploited a directional gossip algorithm to improve the efficiency of route discovery. When a node receives a packet for the first time, it rebroadcasts with a higher gossip probability if the node is estimated to be closer to the destination than the sending node, otherwise it will forward the packet with a lower probability or discard it. However, the algorithm must under the assumptions that any two neighbor nodes can estimate the difference of their current distance from the destination and that such an estimation is done from the inside of the network by using periodic beacons [3].

2.4 Route discovery using energy-based gossip

Nitnaware and Verma introduced the Energy-Based Gossip (EBG) Routing Algorithm [4]. The intermediate nodes forward the RREQ packets with a probability based on the current energy status of that node. If the node 's remaining energy is 80% of the initial energy, then the probability will be set to 0.8, if it is 60% then the probability will be 0.6 and so on. The simulation demonstrates that energy consumption due to routing packets and routing overhead can be reduced 10% to 30%, but they do not consider the RREQ packets dying when the probability is too small.

3 PROPOSED SYSTEM

In our proposed system, RREQ packets are broadcast to the destination node based on the advanced LAR-middle algorithm and the advanced EBG algorithm.

3.1 Advanced LAR-middle algorithm

The Advanced LAR-middle algorithm is a route-discovery algorithm in which the source node receives more communication paths to the destination node than with the LAR-middle algorithm.

First, the source node transmits a RREQ packet to an intermediate node in a circle with a diameter of the distance between the source node and the destination node and in a circle in which the source node can transmit radio. The intermediate node receiving the RREQ packet also transmits the RREQ packet to the node in a circle with a diameter of the distance between the intermediate node and the destination node and in a circle in which the intermediate node can transmit radio. Thus, the source node receives more communication paths (paths through Node E or Node F in Fig.1) to the destination node than with the LAR-middle algorithm by flexibly changing the transfer range.

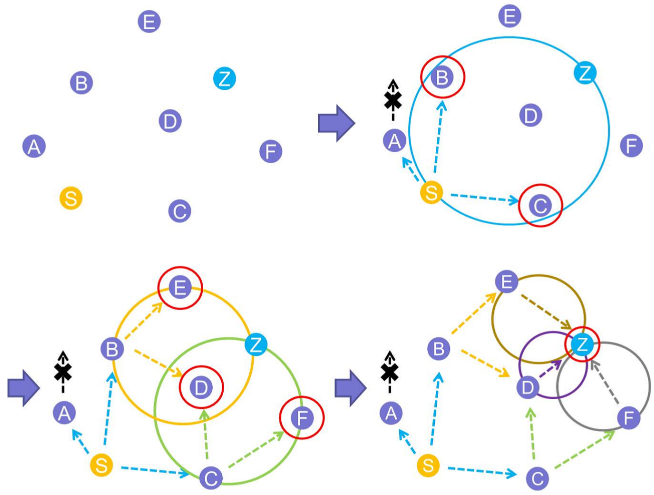

Fig. 1. Advanced LAR-middle algorithm

3.2 Advanced EBG algorithm

The advanced EBG algorithm is a route-discovery algorighm that reduces packet loss more than EBG.

When an intermediate node receives the RREQ packet broadcast from the source node, the intermediate node forwards the RREQ packet with the probability calculated based on the current energy status of that node. The probability of the node i is given by

$$P_i = (1 - \alpha) \times \varphi_i + \alpha$$

where α is the minimum relay probability and φ_i is the percentage of the residual energy of node i. This can prevent a node with little energy from consuming its battery and reduces packet loss more than EBG.

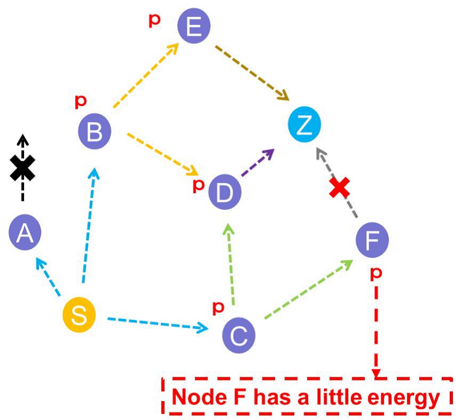

Fig. 2. Advanced EBG algorithm

3.3 Algorithm for Proposed System

The following is our algorithm for the proposed system.

Algorithm 1 Algorithm for Proposal System

Set the threshold k of the distance from the source node to the distance node;
while each RREQ received by the node **do**
  Set a random number r between 0.0 and 1.0;
  Obtain the distance h from the node to the distance node;
  if $h <= k$ **then**
    Calculate probability p using remaining energy;
    if $r < p$ **then**
      Broadcast RREQ;
      Update k to the value of h;
    else
      Drop RREQ;
    end if
  else
    Drop RREQ;
  end if
end while

4 PERFORMANCE EVALUATION

We conducted a simulation based on the supposition of a disaster and evaluated our proposed system.

4.1 Simulation Setup

We used network simulator ns-2 [7] to evaluate our proposed system. Network simulator ns-2 is an object-oriented, discrete event-driven network simulator developed at UC Berkeley and USC ISI as part of the VINT project. It is a very useful tool for conducting network simulations involving local and wide-area networks and wireless networks.

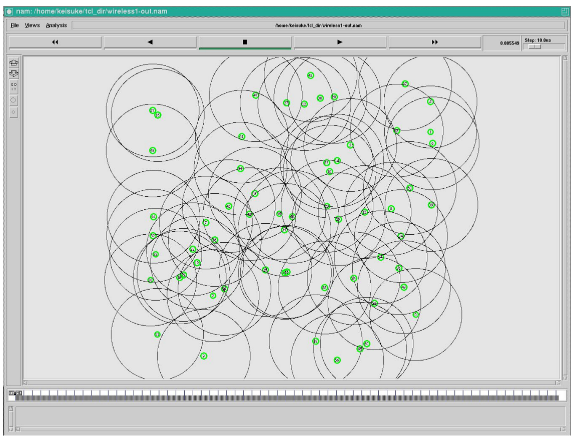

Fig. 3. The network simulator ns-2

This paper uses default radio propagation model ns-2 with a 2Mbps bit rate and transmission range of 250 meters. Our appliction uses the MAC layer protocol IEEE 802.11, and the mobility model is based on the random waypoint model [5] in 1000m $\times$ 1000m. We randomly placed many victim nodes, moving at randomly chosen speeds (uniformly chosen from 1 to 15 m/s) and a rescue node that collects the RREQ packet from victim nodes. Fifty victim nodes transmit the RREQ packet to the rescue node. We set the pause time to zero to achieve the dynamic topology and set the minimal speed to 1 to prevent mobility from going asymptotically to zero. The simulation time was set to 300s. Each data point represents an average of 10 different randomly generated mobility scenarios. Table 1 shows other simulation parameters from the experiment.

Table 1. SIMULATION PARAMETERS

Simulation Parameter	Value
Topology size	$1000m \times 1000m$
Transmitter range	250 meters
Number of nodes	50,60,$\cdots$,100
Simulation time	300 sec
max Speed	15 m/sec
Initial energy	1000 J
Energy consumption during reception	0.1 W
Energy consumption during sending	0.5 W

4.2 Performance Result

We compared our proposed system with existing systems (flooding, LAR-middle, gossip) in four broadcasts of the RREQ packet (the total number of RREQ packets, average energy consumption, packet delivery fraction, and delay time). Also, the minimum relay probability in our proposed system and the relay probability for gossiping are 50%.

Figure 4 depicts the total number of RREQ packets. The results demonstrate that our proposed system uses fewer RREQ packets than existing systems.

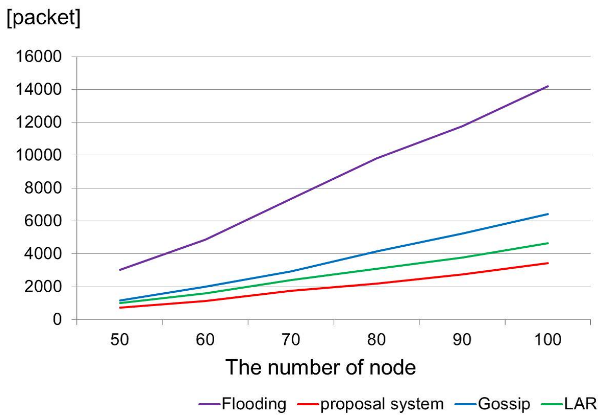

Fig. 4. The total number of RREQ packets

Figure 5 presents the average energy consumption. The results indicate that our proposed system has lower energy consumption than existing systems and fewer RREQ packets.

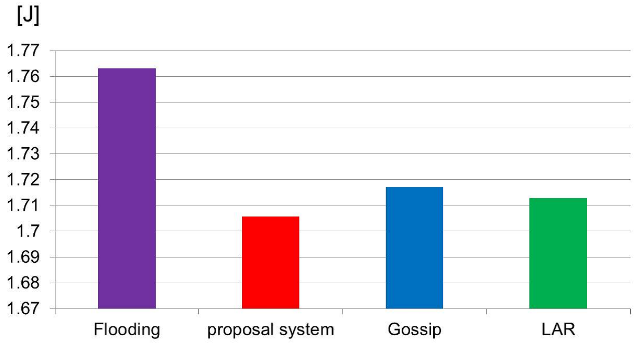

Fig. 5. Average energy consumption

Figure 6 plots the percentage of packet deliveries. Our proposed system delivers more packets than the gossip system but fewer packets than the two other systems.

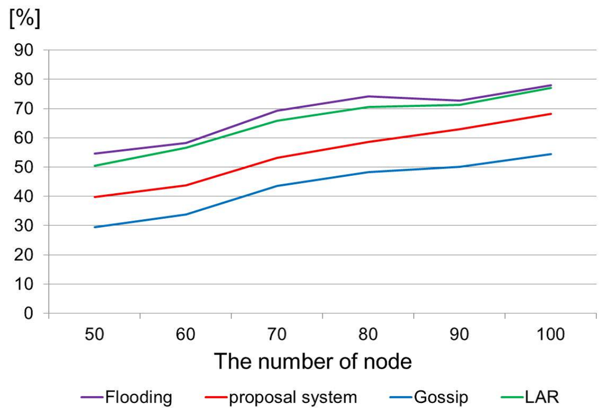

Fig. 6. Packet delivery fraction

Figure 7 plots the packet delay time. Our proposed system has less delay time than the gossip system but more delay time than the two other systems.

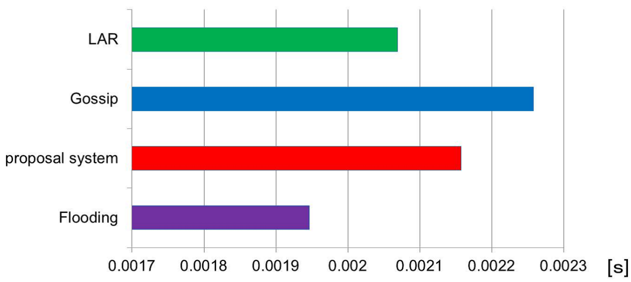

Fig. 7. Delay time

5 CONCLUSION

This paper proposes a MANET routing protocol using location information and current energy status of the node and evaluates the performance of broadcasting RREQ packets based on a supposed disaster. Experiment results proved that the proposed system is superior to the existing systems in the total number of RREQ packets and average energy consumption. However, experiment results also proved that the proposed system is inferior to flooding and LAR-middle algorithms in packet delivery fraction and delay time.

Future work will improve our proposed system's packet delivery fraction and delay time and add a new protocol for sending data to our proposed system to achieve this paper's purpose.

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