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A New Energy-Aware Routing Protocol for Improving Path Stability in Ad-hoc Networks

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Abstract

Since mobile ad-hoc network usually consists of battery-operated nodes, load balancing for balanced energy consumption is important. In this paper, we propose a new routing protocol to find the highest minimum node residual energy path among shortest paths for improving path stability in mobile ad-hoc networks. Using ns-3 simulation, we show that the proposed routing protocol provides more stable routing path than AODV and EA-AODV.

Keywords: MANET, Routing Protocol, Path Stability, AODV, EA-AODV

Introduction

Traditional ad-hoc routing protocols such as DSDV [1], DSR [2], and AODV [3] aim to find the shortest path from a source node to a destination node.

However, load balancing for balanced energy consumption is also important since mobile ad-hoc network usually consists of battery-operated nodes.

In this paper, we propose a new routing protocol to find the highest minimum node residual energy path among shortest paths. A path with higher residual energy is expected to have longer lifespan, so it can improve routing path stability. Using ns-3 simulation, we show that the proposed routing protocol provides more stable routing path than other protocols, AODV and EA-AODV.

Related Work

Many routing protocols have been proposed for ad-hoc networks. Traditional routing protocols aim to find the shortest path from a source node to a destination node. Proactive protocols such as DSDV maintain routes between all source-destination pairs regardless of the use of such routes. On the other hand, reactive protocols such as DSR and AODV, try to find routes on demand, that is, when a source node requests them.

Mobile ad-hoc network usually consists of battery-operated nodes. So, the energy efficiency is important in mobile ad-hoc networks. Power-aware protocols consider the node residual energy determining the routing path for energy efficiency and load balancing. Some nodes may transmit and/or relay more traffic than others. This unbalanced battery power consumption may cause an early battery exhaustion of a node and network partitioning as a result.

M. Tamilarasi and T. G. Palanivelu proposed an energy aware protocol, EA-AODV [4] which operates similarly to AODV but selects a route based on the minimum energy availability and the energy consumption per packet of the routes. A source node initiates a route discovery by broadcasting the RREQ (Route Request) packet. The destination node replies back to the source node using the RREP (Route Reply) packet. When an intermediate node forwards the RREP packet, it records its residual energy in the packet. Then the source node selects the path with the highest minimum node residual energy thought AODV select the shortest path.

New Routing Protocol for Improving Path Stability

Note that the RREQ packet is broadcasted but the RREP packet is unicasted to the source node. The RREP packet is forwarded through the path of the first RREQ packet received by the destination node in the reverse direction. Thus, the RREP forwarding path is determined by each node’s random delay before forwarding the RREQ packet.

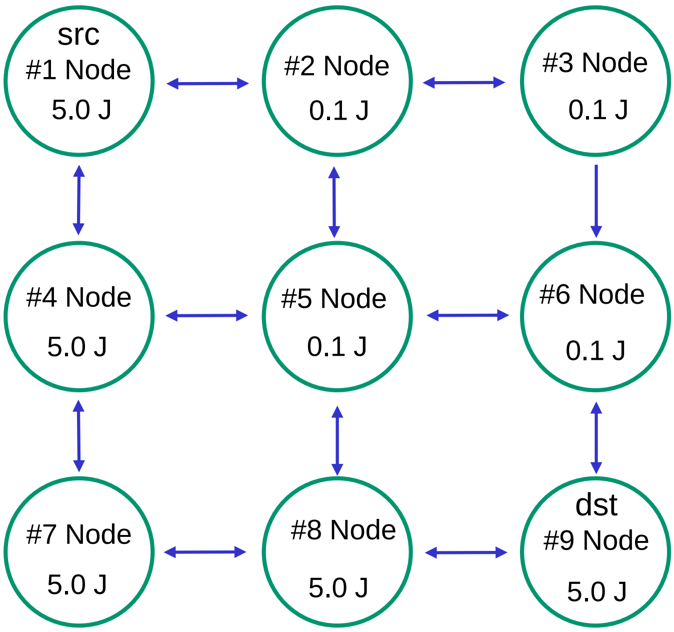

Figure 1. Example topology with node residual energy

Consider the simple topology in the Figure 1. The source node is node 1 and the destination node is node 9. Each node's residual energy is also given. There are 6 different shortest paths. Among them, the best routing path, that is, the path with the longest lifetime is 1 – 4 – 7 – 8 – 9 since the minimum node residual energy is the highest, 5.0J. However, EA-AODV may not find the best routing path. If node 8 received the RREQ from node 5 earlier than from node 7, node 8 will forward the replied RREP packet to node 5.

In this paper, we propose to record the node residual energy information in the RREQ packet instead of RREP packet. Figure 2 shows the flowchart of the relay nodes of the proposed protocol. When a node receives a RREQ packet, it determines whether the packet is broadcasted or discarded. First, the hop count in the RREQ packet is compared with the routing table entry. And then the minimum node residual energy is compared. Through this process, the routing path to the destination node is updated to the higher minimum node residual energy path, that is, the most stable path out of the shortest paths.

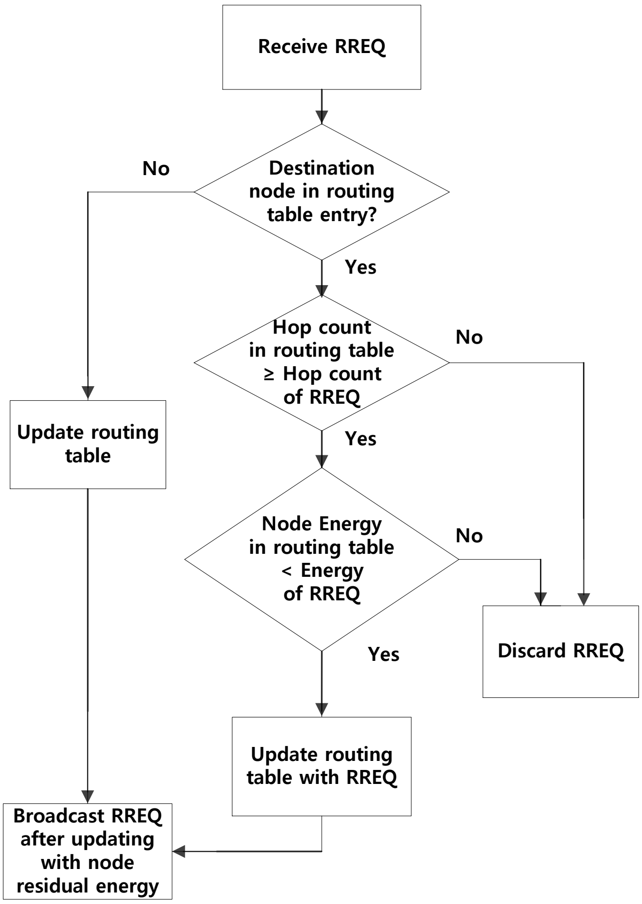

Figure 2. End-to-end delay

Performance Evaluation

We evaluate the performance of the proposed routing protocol using ns-3 simulator [5]. We compare AODV, EA-AODV, and the proposed routing protocol in Figure 1.

In first simulation, the source node generates UDP packet to the destination node every 1 second. The simulation time is 30 seconds. Figure 3 shows the simulation result. We can observe a few packets suffer huge end-to-end delay with AODV and EA-AODV. Those delays result from a battery exhaustion of a node on the routing path. As a result, it takes considerable time to find a new routing path.

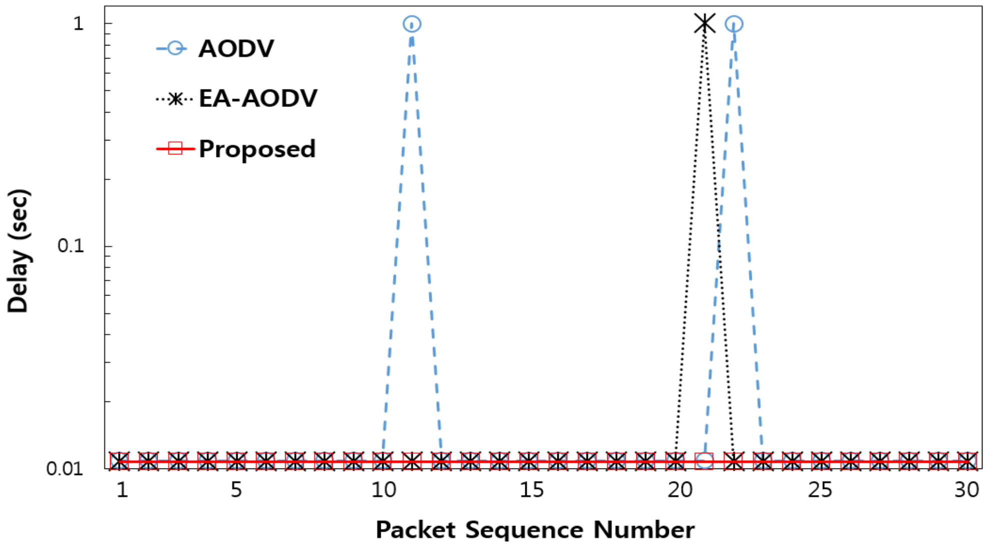

Figure 3. End-to-end delay of packet in 3x3 topology

In second simulation, we increase the nodes, 36, and simulate on 6x6 grid topology. We change packet generate rate 1 to 10 packet per sec and compare path's lifetime of each routing protocol. We change randomly the node's remain energy 0.1 to 0.5J at each simulation. The simulation time is 100 seconds.

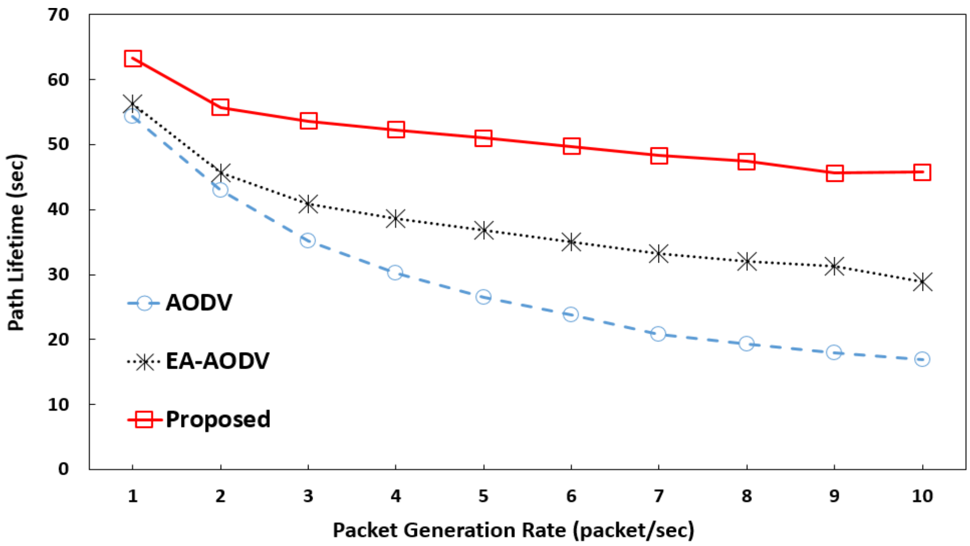

Figure 4. Path lifetime of each protocol

Figure 4 shows the simulation result. Proposed protocol shows best path life time more than AODV and EA-AODV. Proposed protocol can choice the best path to destination node, proposed protocol can ensure better stability path compared with AODV and EA-AODV.

Conclusion

In this paper, we propose a new routing protocol for improving path stability in mobile ad-hoc networks. RREQ packets convey the node's residual energy information and the routing path is determined with the highest minimum node residual energy path. From computer simulation, we showed the proposed routing protocol provides more stable routing path than AODV and EA-AODV.

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