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ICSSC 2013

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[2]COSTECH Lab EA2223, Université de Technologie de Compiègne, France
[3]FEMTO-ST Institute, Besançon, Université de Technologie de Belfort-Montbéliard, France
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[1]Cyber Physical System R&D Center, The Third Research Institute of Ministry of Public Security, Shanghai 201204, China;
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[2]Institute of Smart City, Shanghai University, Shanghai, 200072, China

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Introducing Coordination between Agents: One of the Sources of Urban Sustainability?

Arnaud Banos, Complex System Institute of Paris Ile-de-France (ISC-PIF), France

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WikiSensing: From Data Repository to Big Data Economy

Yike Guo, Imperial College, UK

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A Hong Kong - One of the Safest Cities and Most Stable Society in the World

Ir Jolly Wong, Hong Kong Police Force, Information Systems Wing, China

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Doan Hoang, University of Technology, Sydney (UTS), Australia

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[3]GuoDian Nanjing Automation CO., LTD, Nanjing, P.R.China

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[2]Department of Physics, Henan Institute of Education, Zhengzhou, China

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[2]College of Transport & Communications, Shanghai Maritime University, Shanghai, China
[3]School of Administrative Studies, York University, Toronto, Canada
[4]College of Engineering, Cornell University, New York, USA

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[2]Department of Physics, Henan Institute of Education, Zhengzhou, China

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[1]School of Communication and Information Engineering, Shanghai University, Shanghai, 200072, China
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[1,4]Dept. of Information and CommunicationEngineering, Yeungnam University, Korea
[2]Wireless Advanced Technology R&D Group, Samsung Electronics, Korea
[3]Dept. of Computer and Information Communication Engineering, Hongik University Korea

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[1]College of Information Science&Engineering, HeBei University of Science and Technology, shijiazhuang,China
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LINK QUALITY AWARE LOCAL REPAIR IN AODV-BASED AD-HOC NETWORKS

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Abstract

Route recovery process of Ad-hoc On-demand Distance Vector (AODV) protocol has been extensively studied. However, the recovery process still requires long delays and overheads. In this paper, we proposed a link quality aware local recovery protocol for AODV based Ad hoc networks. In the proposed method, when a link is broken, a node detecting a link-break asks to neighbor nodes who can be a substitute for a node causing the link– break. If there is such a node, then the recovery is quickly and locally completed. The proposed method does not increase overhead to find the substitute link comparing to the conventional AODV protocol. The results show that proposed protocol performs better than source repair and local repair in term of throughput. The simulation is done through Network Simulator (NS-2).

1 Introduction

In a past decade, wireless ad-hoc networks have been extensively researched because they have capabilities of self-configurable and self-healing, flexibility and scalability. As a result, applications based on wireless ad-hoc networks remarkably increase, for example, vehicular networks, Machine-to-Machine communications (M2M), internet of things, future tactical networks, public safety networks and so on [1, 2]. The wireless ad-hoc networks enable nodes to communicate over wireless multi-hop distances without any infrastructures. In order to implement this capability, the networks require Wireless Routing Protocols (WRPs) to find the optimal multi-hop path from the source to the destination. One of the well-known WRPs is Ad-hoc On-demand Distance Vector (AODV) routing protocol. While the protocol uses routing tables like routing protocols for wired networks, it searches the route only when it is needed, so that it reduce the overhead maintaining unnecessary route information [3]. Unlike conventional routing protocols used in the wired networks, WRPs are critical to the overheads and channel conditions. Since the channel conditions and network topologies in the wireless networks have time-varying nature, the built routes are frequently broken and recovered. Therefore, in WRPs, how fast to detect and to recover the broken links are essential research area for WRPs as shown in [4-10]. The link breaks in [4] are detected by a data transmission failure in Medium Access Control (MAC) layer. The method in [5] proposes the detection based on the quality of wireless channel measured from a physical layer. Unlike [4] and [5], the patent application in [6] proposes detection method by a node itself causing a link break. The method will be explained in detail in Section 2. The studies in [7-10] propose the enhanced local repairs. The enhanced repair methods will be introduced in detail in Section 2. This paper also proposes a way to quickly recover the broken link on the basis of link quality. In particular, we focus on the enhancement on the local repair which is one of route repair method defined in AODV protocol [3]. Some part of this paper has been presented in [11].
Section 2 illustrates not only the local repair of AODV protocol and a link-break detection method that is our previous work. In addition, prior arts on the local repair are introduced. In Section 3, after introducing motivation of this paper, the proposed method is described in detail. After the proposed method is simulation environments and results is provided in Section 4, finally, the conclusion is made in the last section.

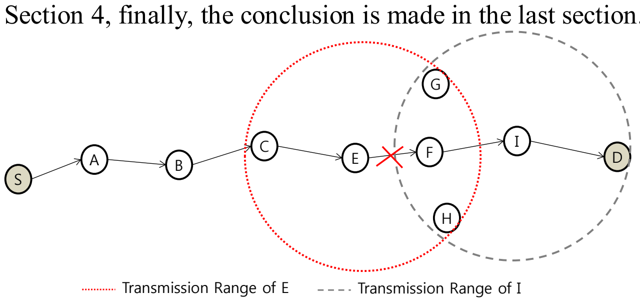

Figure 1. An example of a target network.

2 Local Repair Process and Self-Link-Breakage Detection

AODV protocol defines two types of route repair pro-cesses. One way is to find the whole new route from the source to destination, called source repair hereinafter. The other method, called Local Repair, is to find a new route from the upstream node of the broken link to the destination. For example, in the networks shown in Figure 1, the on-going route from a source, Node S, to a destination, Node D, is currently set to Node S->A->B->C->E->F->I->D as the arrow indicates in the figure. If a link between Node E and F is broken and the number of hops from Node E to the destination is shorter than that from Node E to the source, Node E broadcasts RREQ message to find a new route to Node I instead of sending Route ERROR (RERR) message to the source to initiate a new whole route discovery process. However, in certain cases, the local repair causes the performance degradations as described in our previous works [12]. If the local repair is not successfully completed, the source repair process needs to be started, so that the delay to recover the broken link increases more. In particular, when the route to be locally repaired is long, the performance degradation increases because other links in the upstream route can be broken during performing the local repair. Moreover, when Address Resolution Protocol (ARP) is operated with AODV protocol, the loss of ARP request packet causes the failure of the local repair described in [12].

As mentioned in Section 1, there are some studies on the local repairs as shown in [7-10]. In [7], Proximity Approach to Connection Healing (PATCH) has been proposed. PATCH replaces the broken one-hop link with two-hop link by finding a new node between the end nodes of the broken link. Enhanced Local Repair AODV (ELRAODV) proposed in [8] repairs the broken link by replacing the other new node. For example, in Figure 1, if the link between Node E and F is broken, ELRAODV makes new route following Node E->G->I or E->H->I. For this, ELRAODV uses a unicast RREQ message and all nodes need to exchange nodes' neighbor information. In [9], Over Hearing On-Demand (OHO) method is proposed. OHO recovers the broken link by finding the alternative node like ELRAODV. When a link is broken, OHO broadcasts Helper REQuest message (HREQ) message containing information of the broken node address (Node F in Figure 1), initiated recovery node address (Node E in Figure 1), destination address (Node D in Figure 1.) including destination sequence. When a node receives the HREQ message and its neighbors are upstream and downstream nodes of broken node, it will replace the broken node by sending Help REPly (HREP) message. The method in [10] is also similar to ELRAODV. It requires all nodes to periodically exchange their one-hop neighbor information and to maintain neighbor table. If a link is broken, a unicast message is forwarded based on the neighbor table and find new route.

To make quick detection on the link break, the study in [6] proposes a self-link breakage detection method. In the method, while most detection method is performed by the neighbor nodes around a node causing the link break, the paper proposes a way for a node causing the link break to declare the upcoming link break. To perform the proposed method, the system proposed in [6] utilizes sensors to detect any sudden environments changes, so that a node expects the communication disabilities of itself. When a node expects any upcoming communication disability, it broadcasts a built-in message to all one-hop neighbors so that the neighbors on the route start immediately route repair process. However, even though this method provides quick detection method on the link break, it also has the aforementioned issues on the repair process itself.

Bits:

0 1 2 3 4 5 6 7 8 9 1 0 1 2 3 4 5 6 7 8 9 2 0 1 2 3 4 5 6 7 8 9 3 0 1

Type	J	R	G	D	U	Reserved	Hope Count
RREQ ID							
Upstream Node IP Address							
Destination Sequence Number							
Downstream Node IP Address							
Originator Sequence Number							

Figure 2. Format of ANR message.

Neighbor IP address	Neighbor MAC address	Link State	Life Time
⋮			

Figure 3. Neighbor Table.

3 Proposed Protocol

We revisit Figure 1 for the better explanation. The proposed protocol operates when a link is broken, for example, Node F moves out over the radio range of Node E or Node F lost communication capability due to power extinction or hardware damage or so on. In the scenario, Node E and Node I are named as Upstream Node and Downstream Node, respectively. In the conventional AODV protocol, each node maintains routing table which has only one-hop away node information. However, in this proposed protocol, all participating nodes maintain two-hop away node information as well as one-hop away node information by overhearing transmissions of the next hop node. For example, Node G and H in Figure 1 have the IP and MAC addresses of Node E, F, and I. Node E also has the address information of Node F and I.

When a link is broken, the process with the proposed protocol is as follows:

— When a node detects a link break to the next hop node (hereinafter the node detecting the link-break is named as a detector) and a node causing the break (hereinafter the node is called a lost-node) or a node expects it causes a link-break described in [6], they broadcast Alternative Node Request (ANR) message. The format of ANR message is same as the format of RREQ shown in Figure 2. However, for representing ANR message, *Type* field is set to 5. Instead of *Destination IP Address*, and *Originator IP Address* fields used in the RREQ format, ANR message has *Upstream Node IP Address* and *Downstream Node IP Address* fields. In the example networks shown in Figure 1, *Upstream Node IP Address* and *Downstream Node IP Address* are Node E's and Node I's IP addresses, respectively. ANR message is not flooded over the networks. Therefore, when a node receives an ANR message, it does not forward the message to the next hop. Therefore, *Destination Sequence Number* and *Originator Sequence Number* fields in the message format are set to 0.

— A node receiving an ANR message check their neighbor table as shown in Figure 3. The table includes the MAC and IP addresses of neighbor nodes and link states. The node checks if it has neighbors whose addresses are the addresses of the detector and the next upstream nodes. If it has both addresses in the table, then it prepares to send the RREP to the detector.

— In the table, "Life Time" indicates how long the neighbor information is maintained. The life time is periodically checked so that if the value in Life Time is longer than certain threshold, the neighbor information is deleted. Whenever a node receives a packet from its neighbor, Life Time is reset to 0 and elapsed as time goes by.

— Even though ARP protocol is operating over wireless routing protocol, it may not operate in this method because the neighbor table has MAC address mapped with the target IP address. Therefore, RREP is sent right away without sending ARP request message unlike conventional systems.

— It is possible there are multiple nodes receiving the ANR message and having the information of the detector and the next upstream node. In this case, those try to send their RREP and it may cause the collisions. In addition, it is not guaranteed that the node having the best link reliabilities with the detector and the next upstream node sends its RREP earlier than others having the less reliability. To give the priority to the node that has the better link reliability, the candidates, that may send RREP message, uniformly choose their back off time slots between 0 and 2_n and sends RREP message after waiting the chosen time slots. The n is obtained as a function of Signal-to-Noise Ratios (SNRs) of the links of Upstream Node/Candidate and Downstream Node/Candidate as follows:

$$n = N - \left\lfloor \frac{r - SNR_{\min}}{STEP_{SNR}} \right\rfloor, if\ \ r > SNR_{\min'} \qquad (1)$$

where N is the maximum number of n, $STEP_{SNR}$ is $(SNR_{max}-SNR_{min})/N$, and SNR_{min} and SNR_{max} are the minimum and maximum $SNRs$ required in the system, respectively. γ is defined as $\gamma = \alpha \cdot SNR_{Up} + (1- \alpha)SNR_{Down}$ where α is system design parameter, SNR_{Up} and SNR_{Down} are SNRs of Upstream Node/Candidate and Downstream Node/Candidate, respectively.

— When the detector and the next upstream node receive the RREP, then they update their routing table. That is, the lost node's information is replaced by the information of the new node which sends RREP message successfully.

— If No RREP is not received within Feedback-Time period, the detector begins the conventional local or source recovery process.

If a conventional node receives the ANR message, it will just ignore the message because it does not understand a message setting Type field to 5 and the upstream node will start the conventional route recovery process.

Table 1. Simulation Parameters.

Simulation area	2000 m × 500 m
Antenna type	Omni directional
Radio Channel	802.11 a
Interface queue size	50 packets
Application layer Traffic	CBR
W_{min}	16
W_{max}	1024
SIF time	16 µsec
DIFS	34 µsec
Slot Time	9 µsec
MAC header	272 bits
PHY header	46 bits

4 Simulation

A. Simulation Environments

The summary of simulation parameters is shown in Table 1. Simulations are performed in Network Simulator 2 (NS2) version 2.35[13]. As example of target network is given in Figure 1. There are 10 nodes with one source (Node-S) and one receiver (Node-R). Traffic source is Constant Bit Rate (CBR) with varying data rate. Initially, node-G and node-H are not in the communication range of node-E. When source starts transmission, the route recovery process is initiated by the RREQ message by source node. Node-F must be the part of route. To simulate the link breakage node-F move to the out of communication range with very high speed. Before moving the node-F, node-G and node-H move with in communication range of node-E. During route repair process node-E can choose either node-G or node-H according to the link quality of the nodes. The packet size is 1000 bytes. IEEE 802.11-based protocol defined is used for the MAC layer protocol.

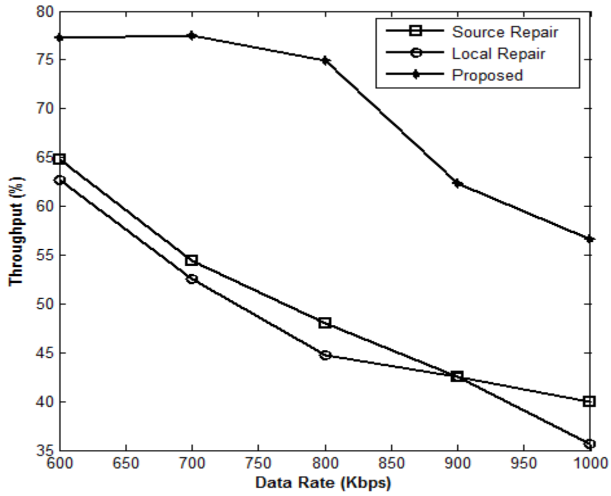

Figure 4. Throughput Comparison of Source Repair, Local Repair and Proposed Protocol.

B. Results and Analysis

The analysis is based on varying the data rate of the source from 600 Kbps to 1Mbps. The commonly used performance metric throughput is evaluated for different route repair methods. As shown in the Figure 4 the pro-posed protocol throughput is higher than source repair and local repair of AODV, because when a detector node de-tects a link breakage it sends a RREQ message. The neighbor node of detector with the better link quality transmits RREP to complete the route recovery process. The proposed protocol does not require any additional information exchanges between nodes before the link is broken, so that no overhead increases. The route recovery process of the proposed protocol is fast and reliable as compared to source recovery and local recovery.

In certain cases, local repair cases the performance degradation because if local repair is not successfully complet-ed, the source repair process needs to be started so that delay to recover the broken link increase more which can cause less throughput as compared to source repair.

5 Conclusion

The one of the representative ad-hoc routing protocols is AODV protocol. The protocol has been extensively re-searched, but there are still issues to be resolved. This paper also studies about one of well-known AODV issues which is the route recovery process. An enhanced method to resolve the issue is proposed in this paper which is based on link quality. When a node detects a link-break or expects an up-coming link–break caused by it itself, it broadcasts a message to one-hop neighbors that can sub-stitute the node causing the link-break. If there is such node, then the route will quickly be recovered with the substitute. For the method, nodes needs to overhear any packets transmitted by one hop neighbors and records their MAC address, IP address, and link status. The pro-posed method does not increase any overhead comparing the other methods and is backward compatible with the con-ventional systems. Simulation results show that pro-posed protocol provides higher throughput as compared to source repair and local repair process.

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