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Routing Approach with Immediate Awareness of Adaptive Path While Minimizing the Number of Hops and Maintaining Connectivity of Mobile Terminals Which Move from One to the Others

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Abstract—Wireless ad-hoc mesh network is a special kind of network, where all of the nodes move in time. The topology of the network changes as the nodes are in the proximity of each other. Ad-hoc networks are generally self-configuring no stable infrastructure takes a place. In this network, each node should help relaying packets of neighboring nodes using multi-hop routing mechanism. This mechanism is needed to reach far destination nodes to solve problem of dead communication. This multiple traffic “hops” within a wireless mesh network caused dilemma. Wireless mesh network that contain multiple hops become increasingly vulnerable to problems such as energy degradation and rapid increasing of overhead packets. In recent years, many routing protocols have been suggested to communicate between mobile nodes. One proposed routing approach is to use multiple paths and transmit identical copies of the packet on each path (i.e., path redundancy). Another more efficient routing protocol is to selective path redundancy from the multiple paths and sends packets on appropriate path. It can improve delivery efficiency and cut down network overhead, although it also increases processing delays on each layer. This paper provides a generic routing framework that immediately adapts the broken of established main route. The fresh generated route search process is taking place immediately if topology changing is initialized while data is being transmitted. This framework takes care of the route which is selected active next neighbor nodes to participate in the main route. At the time which the main route is broken, the data transmission starts immediately thus data is transmitted continuously through the new route and the broken route is recovered by the route maintenance process. We conduct extensive simulation studies to shows that proposed routing protocol provides the backup route at the time when the main route is loss and analyzed the behavior of packets transmission. Using the framework, the average of successfully generated data transmission at various hops is kept 4.5% higher than the other network without implemented it with about 22% of overhead packets increase. Related with average network speed, the proposed protocol has successfully improved the successful data transmission 10.94% higher (at average network speed between 10 and 40 km/h). In the future research, we will extend this framework in wide area of wireless network and compare it with other multipath routing protocols.

Index Terms—multi-hop, main route, connectivity, metric

I. INTRODUCTION

A Wireless (Ad-Hoc) Mesh Network consists of mobile nodes platforms which are free to move in the area. Node is referred to a mobile device which equipped with built-in wireless communications devices attached and has capability similar to autonomous router. The nodes can be located in or on airplanes, ships, cars, rooms, or on people as part of personal handheld devices, and there may be multiple hosts among them. The system may operate in isolation, or have gateways to a fixed network. Every node is autonomous. In the future operational mode, multiple coverage of the network is expected to operate as global “mobile network” connecting to legacy “fixed network”.

At each time and every node’s positions, a wireless connectivity in the form of a random, single-hop, multi-hop path may exist among nodes. This topology may change as the nodes move or adjust their parameters. Among networks, Wireless (Ad-Hoc) Mesh Network has several characteristics:

1) Dynamic topologies,
2) Bandwidth-constrained,
3) Energy-constrained operation, and
4) Limited physical security.

These characteristics create a set of underlying assumptions and performance considerations for protocol design which extend beyond static topology of the fixed network. The design should react efficiently to topological changes and traffic demands while maintain effective routing in a mobile networking context.

All nodes in Wireless (Ad-Hoc) Mesh Network rely on batteries or other exhaustible energy modules for their energy. As a result of energy conservation or some other needs, nodes may stop transmitting and/or receiving for
arbitrary time periods. A routing protocol should be able to accommodate such sleep periods without overly adverse consequences. Therefore, routing protocols for ad hoc network consider node mobility, stability and the reliability of data transmission.

Routing schemes differ in their delivery semantics: (a) unicast delivers a message to a single specified node; (b) broadcast delivers a message to all nodes in the network; (c) multicast delivers a message to a group of nodes that have expressed interest in receiving the message; and (d) anycast delivers a message to any one out of a group of nodes, typically the one nearest to the source. Broadcast is the dominant form of message delivery on the wireless network. Most of AODV protocol and its extensions use overhearing of broadcasted RREQ and RREP packets for discovering routes.

In this paper, we provide a framework that immediately adapts the loss of established main route. The main route can be losses because of either death nodes or metric calculation requirements. The network should capable to generate backup route search process immediately if topology changing is initialized while data is being transmitted. This framework takes care of the updated broken route which is selected active neighbor nodes to participate in the main route. At the time which the main route is broken, the broken route is recovered by the topology maintenance process then the data transmission starts immediately through the new route. It is expected to reduce the packet transmission delay by establishing the backup route while data is transmitted. We conduct extensive simulation studies to show that proposed routing protocol provides the backup route at the time when the main route is broken off and analyzed the behavior of packets transmission. A comparison between similar network of Link State Routing and the generic framework is also conducted. Simulation results show that modified algorithms under different formation conditions are more efficient than the network without deployed that framework. The remainder of this paper is organized as follows: Section 2 gives preliminaries and our system model. Section 3 discusses the detail design of the simulation model, its notations, and assumptions. Simulation algorithm that suits mobile environment is presented in Section 4. A performance evaluation of generic algorithm and comparison to a similar network of Link State Routing are presented in Section 5. Section 6 concludes the paper.

II. RELATED WORK

Wireless network is generally set up with a centralized access point for provide high level of connectivity in certain area. The access point has knowledge of all devices in its area and routing to nodes is done in a table driven manner [1][2][3]. The Nemoto[2] introduced a technical review of wireless mesh network products that implemented IEEE802.11 standard through installation of fixed wireless mesh network nodes. In terms of review the network performance at this stage, it will be represented as the view of use and evaluation of outdoors Muni-WiFi devices in accordance to applying the legacy LAN technology inside the corporate network. Performance of network access layer, i.e. performance of voice and TCP data transmission in terms of throughput, response time between mesh nodes, and communication delay in multi-hop transmission are presented.

However, Nemoto[2] intended to operate in static topology network. With recent performance in computer and wireless communications technologies, advanced wireless mobile device is expected to see increasingly widespread use and application. The vision of future mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality such that networks are capable to be dynamic, rapidly-changing with random, multi-hop topologies which are likely composed of relatively bandwidth-constrained wireless links. Supporting this form of host mobility requires address management, protocol interoperability enhancements and the like.

In this dynamic network, broadcasting plays a critical role especially in vehicular communication where a large number of nodes are moving and at the same time sending a large size of packet. In wireless network where nodes communicate with each other using broadcast messages, the broadcast environment works as receivers collect information from all transmitting nodes within its coverage neighborhood, and then allowing receivers to aware of immediate surrounding respond before re-transmitting packet. Several transmissions may be redundant (overhead) during broadcast mechanism. These redundant causes the broadcast storm problem [8], in which redundant packets cause contention, collision, and consume a significant percentage of the available energy resources. Thus, routing protocols should be capable to respond these changes using minimum signaling and taking into account the energy as a parameter distributed in network.

Routing is one of the key network protocols in telecommunication networks. It selects the paths for traffic to flow from all the sources to their final destinations. Between sources and final destinations, there are nodes, areas, and active traffic. There are proposals to allow flexible multipath routing in the Internet and single-path routing primarily uses where one user (source-final destination pair) uses only one selected path from the source to the destination, with the exception that traffic may split evenly among equal cost paths e.g., the current routing protocol within an AS, Open Shortest Path First (OSPF) protocol.

In single-path routing protocols, route maintenance can be performed in concurrent with data transmission and take its role whenever routes fail or broken off. Therefore, data transmission will be stopped while the new route is established, causing data transmission delay. On the other hand, multipath routing protocols perform the route maintenance process even if only one route fails among the multiple routes. To perform the route maintenance process before all routes fail, the network must always maintain multiple routes. This can reduce data transmission delays caused by link failure. However,
routing maintenance can lead to higher traffic of overhead. Several implementations of routing are based on AODV; typical examples are AOMDV, AODVM and AODV-BR protocols. The AODV-BR [10] protocol maintains the main route rules when it is broken by using the neighbor nodes around the routes to bypass the main route. At this protocol, neighbor nodes overhear the RREP packets for establishing and maintaining the backup routes during the route initiation process. If part of the main route is broken, nodes broadcast RRER packets to neighbor nodes. When neighbor nodes receive this packet, they establish an alternate route using information contained in overhead RREP packets previously.

The AOMDV [7] protocol establishes link-disjoint paths in the network. When nodes receive the RREQ packet from the sender node, AOMDV protocol stores all RREQ packets. So, each node maintains a list of neighboring hops where RREQ packet contains information about neighbor node of the sender nodes. If first hop of received RREQ packet is duplicated from its own first hop, the RREQ packet is discarded. At the final destination, RREP packets are sent from each received RREQ packet. The multiple routes are made by RREP packets that follow the reverse routes to source node that have been set up already in intermediate nodes.

For the AODVM [9] protocol, the intermediate nodes record all received RREQ packets in routing table. They do not discard the duplicate RREQ packets. The final destination node sends an RREP for all the received RREQ packets. An intermediate node forwards a received RREP packet to the neighbor in the routing table to reach source node. Each node cannot participate in more than one route.

III. SIMULATION MODEL, NOTATIONS, AND ASSUMPTIONS

In this paper, we propose framework of adaptive route protocol based on the AODV protocol and broadcast mechanism. AODV protocol is configured in the network with topology changed randomly because of the freely moving mobile nodes. In this circumstance, node failure occurs frequently. Therefore, AODV should capable to sense the path for nodes involved between source and final destination to prevent path breach caused by node failure. This framework generates route search process immediately after the established main route is broken. It uses RREQ and RREP packets which are broadcasted to active neighbor nodes in order to incorporate in the main route on behalf of source-destination path. Such this adaptive single hop routing may consume a lesser amount of energy in comparison to multi hop routing. In addition, this framework gets its advantage in the case transmission of larger packets where the fragmented packets should reach the final destination with higher successful transmission. The proposed framework assumes that nodes are capable of dynamically adjusting their relay nodes on per move step base. This behavior is almost similar to MANET routing protocols (e.g., AODV, DSR and TORA). One common property of these routing protocols is that they discover routes using broadcast flooding protocols whose value of distance metric in order to minimize the number of relay nodes between any source and final destination pair.

A. The Model

Simulation cover a single area of homogeneous nodes that communicate with each other using the broadcast services of IEEE 802.11. There are nodes with different roles simulated in this simulation, namely initiator node/source node, receiver node, sender node, destination node, and final destination node. Initiator node/source node is node that initiates transmission of packet. Packet can be either route discovery or data transmission. Like other nodes, initiator is always moving with random direction, speed, and distance. At the time it is moving, initiator node is always sensing its neighbor to maintain connectivity. Receiver node is node that can be reached by source/sender node. Nodes are defined as neighbors if it located within its distance radius range. At initial time, node senses its neighbors before packet data is required to be transmitted. Coverage neighbor nodes always receive packets that are broadcasted from sender. Destination node is selected receiver node in multi hop transmission that should relay packets to the next receiver node. Final destination node is node that became the end destination of packets.

Wireless link channel is assumed to have no physical noise; i.e., the errors in packet reception due to fading and other external interferences are not considered as a serious problem. Packets from sender to receiver will be transmitted as long as the bandwidth capacity is sufficient and the received signal to noise ratio (SNR) is above a certain minimum value. Thus every packet successfully received is acknowledged at the link layer and des-encapsulate at the higher layer. Each node is capable of measuring the received SNR by analyzing overhead packet. A constant bit error rate (BER) is defined for the whole network. Whenever a packet is going to be sent, a random number is generated and compared to the packet’s CRC. If the random number is greater, the message is received, otherwise it is lost. The default value for the BER is 0, which means there is no packet loss due to physical link error.

The layered concept of networking was developed to accommodate changes in local layer protocol mechanism. Each layer is responsible for a different function of the network. It will pass information up and down to the next subsequent layer as data is processed. Among the seven layers in the OSI model, we select the link layer, network layer, and transport layer are 3 main layers of network. The framework is configured in those layers. Genuine packets are initiated at Protocol layer, and then delivered sequentially to next layer as assumed that fragmented packets to be randomly distributed. Simulation models each layer owned with finite buffers. Limited buffer makes packets are queued up according to the drop tail queuing principle. When a node has packets to transmit, they are queued up providing the queue contains less than K elements (K ≥ 1). To increase the randomization of the simulation process, simulation introduces some delay on
some common processes in the network, like message transmission delay, processing delay, time out, etc. This behavior will result that at each instance of a simulation would produce different results. The packets exchanged between sender and receiver is of a fixed rate transmission $\lambda$ based on a Poisson distribution. Nodes that have packet queued are able to transmit it out using in each available bi-directional link channel.

Energy is power kept in each node. The energy consumption required to transmit a packet between nodes A and B is similar to that energy required between nodes B and A if only if the distance and the size of packet are same. The coverage distance range of the nodes is a perfect symmetric unit disk (omni-directional). If $d_{x,y} \leq r_x \rightarrow x$ and $y$ can see each other. This assumption may be acceptable in the condition that interference in both directions is similar in space and time; which is not always the case. Usually interference-free Media Access Control (MAC) protocol such as Channel Sense Multiple Access (CSMA) may exist. Heinzelman et al. assumed that the radio dissipates $E_{\text{elec}} = 50 \text{ nJ/bit}$ to run the transmitter or receiver circuitry and $E_{\text{amp}} = 100 \text{ pJ/bit/m}^2$ for the transmit amplifier [6]. Thus, to transmit a k-bit message a distance d using this radio model, the radio expends:

$$E_{\text{TXBS}}(k,d) = E_{\text{elec}} \cdot k + E_{\text{amp}} \cdot k \cdot d^2$$

(1)

and to receive this message, the radio expends:

$$E_{\text{RXBS}}(k) = E_{\text{elec}} \cdot k$$

(2)

The energy model included in simulation was based on the following formulas, taken from [35]:

$$E_{\text{TXBR}} = E_{\text{elec}} \cdot (E_{\text{amp}} \cdot m^2)$$

(3)

$$E_{\text{RXBR}} = E_{\text{elec}}$$

(4)

The energy behaviors of node are defined as follow:

- **During the idle time, a node does not spend energy.** Even though this assumption has been proven untrue because being idle might be as costly as receiving data, this is still an assumption that can be done in most experiments, since the most important factor is the overhead in terms of message exchange and its associated cost.

- **The nodes are assumed to have one radio for general messages.** The main radio is used in all operations when the node is in active mode, and to send and receive control packets. When this radio is turned off, then no messages will be received and no energy will be used.

- **Energy distribution among nodes can either be constant value, normally distributed, Poissonly distributed, or uniformly distributed.**

Simulation describes that antenna module installed in each node is capable of dynamically adjusting the transmission energy used to communicate with other nodes. Industrial standard of antenna module supports a management for controlling this energy consumption.

### B. Immediate Awareness Routing Algorithm

The core algorithm is developed from static mode (e.g., sensor networks). The enhancement algorithm for serving mobility then detailed in support of topology building, topology maintenance, and routing maintenance. We show our methodology on a tree network. The tree topology decomposes the paths between source and final destination into several route paths. The algorithm underestimates the interference among the route paths. The algorithm starts to operate with building the network topology. The role of the topology maintenance algorithm is to make sure that a minimum flow of packets is transmitted in order to maintain the route when there are no data packets available to send at the transmitter. The routing maintenance is responsible to sense the broken off the main route path during data transmission.

Network topology is initiated using broadcast mechanism and propagated through node-to-node based on routing metrics approach. During propagation, it takes into account all topology development, route discovery, and data transmission. Each source injects single big packet which fragmented into multiple packets in the network, which traverse through the network until reach the final destination. Packets, which are waited for an opportunity to be transmitted, are queued at each node in its path. This model is not only applicable in direct communication (one hop transmission) but it can also work in multi-hop transmission. In this situation, when the source and final destination nodes are located outside the maximum transmission range, source node is capable to discover multiple hops routing while keep the data being transmitted.

Network topology must be initiated before data transmission takes place. Topology development is proactive, it uses Topology Control (TC) messages to discover and disseminate link state information. It involves transmit and receives of HELLO packets, REPLY packets, CONFIRM packets, and so on; mostly redundant. These packets which successfully received by link layer, will update an entry in the neighbor table which cache information about surrounding nodes exists. HELLO packets and corresponding REPLYs have contents of [ID, hop, energy, time, throughput, direction], where ID is a unique neighbor node (IP address), hop is a number which increment each time packet reach at relay node, energy is current available energy level needed to ensure the communication with the neighbor node, time is current time at which this event is executed, throughput is total of hits that can be pushed through this available link having bandwidth and latency, and direction is the way node will move to reach its distance.

The topology maintenance algorithm is responsible for performing the route optimization operation that leads to the discovery of routes changes. The algorithm performs two basic operations: initiate broadcast maintenance packets, which computes whether a route optimization between two nodes is needed and sets up broadcast mechanism; and executes maintenance packets, which determines when to transmit routing maintenance packets. The framework optimizes routes through sequence of steps to converge to an optimum route. The
network will converge as fast as the transmission speed of data transmitted by node.

When a node first starts, it only knows of its immediate neighbors, and the direct cost involved in reaching them. (This information, the list of destinations, the total cost to each, and the next hop to send data to get there, makes up the routing table, or distance table.) Each node, on a regular basis, sends broadcast packets to neighbors to get all costs of destinations. The neighboring node(s) examine this information, and compare it to what they already 'know'; which represents an improvement on what they already have, thus update their own routing table(s). Over time, all the nodes in the network will discover the best next hop for all destinations, and the best total cost. When one of the nodes involved are changed, those nodes which used it as their next hop for certain destinations discard those entries, and create new routing-table information. They then pass this information to all adjacent nodes, which then repeat the process. Eventually all the nodes in the network receive the updated information, and will then discover new paths to all the destinations which they can still "reach".

During this sequence, relay node is determined by relevant information gathered from neighbor nodes. After omitted redundant packets and based on calculation metric value, relay node is set (i.e., a small set of nodes that potentially forward the broadcast packet) to achieve high delivery ratio with certain metric consideration. It means that only selected neighbors able to forward the packet to the next neighbors. The selected neighbor or new relays added to a route during iteration are very much dependent on the relay found in the previous iteration. This set can be selected dynamically (based on both topology and broadcast state information). In order to simulate this proposed routing, the relay node set forms a connected dominating set (CDS) and achieves full coverage of connected network. It is possible that the first iteration, which seemed as most optimum value of metric value is not the route achieving the optimum topology with optimum delay path.

Several relay nodes may exist between source and final destination, thus source node must choose the one providing a highest metric value in the path lead to final destination. Multiple packets are sent to that single (next) relay node. Transmission of multiple route-redirect packets will waste bandwidth and network resources (overhead packets increased). For sparsely populated networks, this may not be a problem. However, this is an issue in the case of densely populated networks where several potential nodes can be chosen. These situations are in contrast with the created environment in simulation. Densely populated nodes are desired to make alternate routing possible.

Routing maintenance is part of the framework that addresses this immediate awareness path change by giving priority for the execution of an update routing maintenance packet to the potential neighbor node that computes highest route metric energy-distance values first. After receiving an update routing maintenance packet, a node modifies its routing table, putting the source of the received packet as the next hop node for the specific sender-destination route path. To execute preferential event in sequentially distributed events, we used a simple approach that consists of applying a different time-event execution after the triggering event takes place. The lower and upper bound of the queuing interval are set such that they do not interfere with predefined timers used by the other events for layers and modification events.

The proposed scheme for maintaining the routes is as follows. First, when main route failure is detected, the RouteERROR packet sent back to a source and nodes participating in the path to allow detecting the disconnection of the main route. When the node receives the RouteERROR packet it checks the level flag in the routing table and determines whether it belongs to stay near or far from first relay of the main route. After received RouteERROR packet, the closest node reinitiates the route discovery process for the main route, and at the same time keeps the packets (already) received and reconfigures its path configuration. The dying node (i.e., node caused breakthrough) stops to receive new packets. It has responsibility to transmit packets (already) received to destination node before steady silent (and OFF). Immediately after the breakthrough path is successfully re-connected, the closest node starts data transmission through the backup route.

In AOMDV and AODVM, data transmission is started after the path is found. It cause overhead at the first route discovery and delay the first data transmission. The proposed framework solved these problems by starting a data transmission immediately after route discovery process starts at some interval of initial Time. To establish a main route, a source node broadcasts a HELLO packet with the level value of zero to neighbor nodes. When intermediate nodes receive the packet, they store the level value and information about the source node in the neighbor table. Neighbor nodes transmit the corresponding REPLY packet, which is sent back to the source node along with information owned through the reverse path. Intermediate nodes that receive the REPLY packet increment the level value in the neighboring table. By incrementing the level value, the protocol ensures that a node will be used as (considerably) the selected route path. When a source node receives the REPLY packet, the main route is established. Source node then broadcast confirmation packets about this selection to neighbor nodes again. Each source node does broadcasts HELLO packets with the certain level value to surrounding nodes. Consequently, nodes belonging to the main route keep different level values. Nodes belonging to the main route always have a level value one higher if located under several relays from source node. A value of zero for level flag indicates the source node of main route, and a value of one indicates the next relay in the main route.

After two hops iterations, the source node starts data transmission. When receiver receives a packet data from other nodes, it de-encapsulates the packet, check packet's destination, and searches the routing table to see if a route toward the destination node may exist. If this is not the
case, the node searches the neighbor table to see if information regarding the destination node is available. If this is not the case, the node will give up and makes information about this to its gateway. Otherwise, the node will process the received packet. The iteration will follows as described previously. When nodes are mobile and no data packets are available for transmission, a source node required to transmit explicit signaling packets to maintain a topology.

![Diagram](image)

Figure 1. Route maintenance steps. (a) At the time path is broken off. (b) The re-paired path (backup route) is established.

Figure 1 shows the way that the route is maintained when a new source node SC performs the route discovery process to the destination node FD as the final destination node of source node SC (a route is already established between source node SC and final destination node FD). A main route (SC → 1 → 2 → 3 → 4 → FD) between SC and FD is disconnected by the recently, then the backup route is established (SC → 1 → a → b → 3 → 4 → FD) between SC and FD.

We built a JAVA network simulator to evaluate this framework. The simulator supports physical, link and network layers for single/multi hop ad-hoc networks. We assume that IEEE 802.11 Distributed Coordination Function (DCF) or MAC protocol which uses Channel Sense Multiple Access with Collision Avoidance (CSMA/CA) already deployed. Successfully received packet by receiver’s interface is packet whose SNR is above a certain minimum value otherwise the packet cannot be distinguished from background noise/interference. Packets are transmitting through physical layer in accordance with Poisson distribution. Communication between two nodes in IEEE 802.11 uses RTS-CTS signaling before the actual data transmission takes place. Simulation simulates this with random hearing to link’s condition. The simulator uses two-steps propagation model to simulate interactive propagation in the operation of the protocol in dynamic environment. The two-steps propagation model is appropriate for outdoor environments where a line of sight communication existed between the transmitter and receiver nodes and when the antennas are omnidirectional.

Real data transmission is triggered by source node which injects one packet into the protocol layer. The packets either fragmented or not, flow through layers at every time-slot. The length of the active periods (denoted by random variable) is distributed randomly according to Mersenne Twister algorithm. The mean of transmission rate and arrival rate of packets can be controlled by changing the value of “p” (a Poisson distribution value). The arrival process is defined as the arrival packets stream at each node is a series of active and idle periods. The received packet is then processed by the layering module with the result that one of the following actions is taken: (i) the packet is passed to the higher layers if both MAC and IP addresses match; (ii) the packet is dropped if neither MAC nor IP addresses match; or (iii) the packet is forwarded to another node when only the MAC address matches. In the latter case, it searches the routing table to find the next route node with the higher metric calculation to react next destination node.

IV. PERFORMANCE EVALUATION

Our simulation modeled a network of 50 nodes placed randomly with a uniform distribution within a 300 X 300 meter area. Each node randomly selects a new position and moves towards that location with a certain speed. The average network speed is selected from value between 5 and 50m/s respectively. Once nodes reach the position, they become stationary for a predefined pause time and then select another position after a delay. This process continues until the end of simulation. The sources were determined, while final destination nodes were selected randomly over the network. Traffic was modeled using CBR (constant-bit-rate) sources with 1500-byte data packets and a traffic rate of Poisson distribution value at five packets per second is selected. We compared with the simulation results of similar Link State Routing (LSR). Scenarios for simulation are batched with variables of number initiators/sources and speed. The similar LSR network is selected because it is simple to deploy and can be used for analyzing a large scale of packets processes using known network topology. We compare the framework and similar LSR network to best understand the various tradeoffs and limitations of the algorithm.

A similar (LSR) network would generate full routing tables in advance where, all nodes in the network would be aware of distance level and routes to all other nodes in the network. This network can compute the optimum metric with shortest distance to a next relay node by listening replies of topology construction and topology.
maintenance packets transmitted by the neighbors. This network operation requires each node in the network to broadcast a routing packet. The broadcast packets contain information about the distance metric of all known destinations. Each node floods the network with information about what other nodes it can connect to, and the received packets may require to be forwarded by other nodes to propagate the entire network. After collecting packets from all nodes of the network, any node should be capable of computing optimum routes to any other node in the network. Each node then independently constructs this information into a tree. Using this tree, each node then independently determines the least-cost path from itself to every other node using a standard shortest paths (distance) algorithm. The iteration of propagation events to be entirely flooded mainly depends on the density of nodes in the network. The result is a tree rooted at the source node such that the path through the tree from the root to any other node is the least-cost path to that node. This tree then serves to construct the routing table, which specifies the best next hop to get from the current node to any other node.

Measurements of the experiment comprise the successful data transmission rate from source to destination nodes and the control packet overhead for route discovery and route maintenance. The graphs represent the results of experiments for various pause times.

![Graph of successful packet transmission rates.](image)

**Figure 2.** The successful packet transmission rates.

Successful packet transmission rates indicate that the destination node received all packets sent from the source node. Using the framework, there is improvement of successful data transmission about 4.5% higher than the network without implement it. The successful packet transmission rate is shown in Figure 2.

The proposed protocol provides higher data transmission rates than AODV protocols. When the route fails in the AODV protocol, the protocol performs the route discovery process again from the source node. In this research, recovery routes are repaired from intermediate nodes (connected to the failed link) which participating in the path leads to the destination node. The proposed protocol has a higher packet transmission rate than AODV protocol (because the proposed protocol can reduce the packet loss rate that occurs during the route research process) and need to wait at short delay for the route to be reinitiated.

![Graph of successful data transmission at different network speed.](image)

**Figure 3.** Establishment of backup route in data transmission at different network speed.

Figure 3 shows the comparison of the successful data transmission at different speed when the main route is broken between the networks with implement the framework and the other without implemented it. As a result, proposed protocol has successfully improved the successful data transmission (or backup the main route) 10.94% higher.

When the main route in network is broken off, the proposed protocol finds the new route by starting a route discovery process at the closest victim node and delays data transmission for a while. At this time, it causes the routing overhead of main route and backup route discovery processes. Control packets are packets used for establishing routes. In addition, data packets indicate the actual packets used for data transmission. Routing overheads is shown in Figure 4. About 22% increase of overhead packets at the network which implement the routing framework.

![Graph of routing packet overhead.](image)

**Figure 4.** Routing packet overhead.

**V. CONCLUSION AND FUTURE WORK**

In this paper, we proposed a routing protocol that establishes routes which is capable to adapt the broken off path between source and final destination nodes based on the AODV protocol for MANETs. The new protocol has not too high overhead to conventional AODV protocol. Also this protocol sends the data immediately after the main route is successfully recovered to reduce data transmission delay. During execution, besides discovering the backup routes when the main route is broken off, the framework always maintains the route
using the topology maintenance process. The main difficulty however is in identifying the bottlenecks in the network. The result obtained in this simulation is compared against the similar LSR network with AODV protocol. It is interesting to note that the routing policy, which was designed primarily for achieving higher successful data transmission in the single wireless network area, can also be engineered to achieve good delay performance in multiple wireless network area. In the future research, we will simulate this framework in wide area of wireless network and compare it with other multipath routing protocols such as AOMDV and AODVM.

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REFERENCES


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