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OPTIMALLY CONFIGURED ZONE ROUTING PROTOCOL FOR BLENDING VARIOUS NETWORK WITH MOBILE ADHOC NETWORKS

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ABSTRACT
This work presents a routing protocol that utilizes the characteristics of Short range technology for Short range-based mobile ad hoc networks. The routing tables are maintained in the gateway devices, and the routing zone radius for each table is adjusted dynamically via a fuzzy inference system. Given that some useless routing packets exist which increase the network loads in the existing ad hoc routing protocols, this work selectively employs multiple unicasts or a single broadcast when the destination device moves beyond the routing zone radius coverage of the routing table. The simulation results demonstrate that the dynamic adjustment of the routing table size in each gateway device results in considerably faster routing request reply time, as well as fewer request packets and useless packets compared with two representative protocols, Zone Routing Protocol (ZRP) and Dynamic Source Routing.

KEYWORDS: Short range scatter net; Zone routing protocol; Reactive routing; Proactive routing

INTRODUCTION
A Mobile Ad Hoc Network (MANET) lacks a fixed infrastructure. All devices in a MANET must participate in routing and forwarding since a MANET contains no Access Point (AP), base station, or router. When a source device wishes to communicate with a destination device, it must establish a routing path between the source and destination. Node mobility, available bandwidth and transmission power influence the design of the ad hoc network routing protocol.
Short range is primarily perceived as an affordable technology enabling peer-to-peer communication between with a central terminal and peripheral devices. The characterstic of low-power consumption and high security make Short range a good choice for MANET deployment. However, Short range-based MANETs do differ from traditional ad hoc networks in some important ways. First, the connection range is smaller in a Short rangeMANET owing to the low power of Short range devices. Second, the number of neighboring nodes for a Short range device is limited since the piconet scenario in a Short range-based ad hoc network comprises one gateway device and up to seven node devices. Third, a large routing table is inappropriate in most Short range devices due to limited storage space. Fourth, it is common for a moving Short range device with various network to be out of connection with the joined piconet owing to the short communication range in a Short range MANET.
To address these challenges, this work presents a zone routing protocol (ZRP) for Short rangescatternets. The proposed algorithm establishes a limited routing table in every gateway device, while keeping the size of the routing table adjustable depending on the computational result of a zone radius. The simulation results demonstrate that the ZRP requires less routing request reply time, and generates fewer request packets and useless packets than other representative routing protocols used in ad hoc networks. The remainder of the paper is organized as follows. Section 2 gives a brief description of the Short range technology and the related routing protocols, such as Dynamic Source Routing Protocol (DSR) and Zone Routing Protocol (ZRP). Section 3 shows the details of ZRP. Section 4 reviews the simulation results and comparisons. Conclusions are made in Section 5.

BACKGROUND AND RELATED WORK
Short range is a radio interface for short-range and connections between various network [1–4] uses a frequency-hopping scheme in the unlicensed, scientific, and medical band at 2.4 GHz. The normal range is10 m, but can be increased to 100 m. A frequency-hopping transceiver is used for reacting to interference and fading. Frequency-hopping spread spectrum (FHSS) possesses various properties that make it a good choice for an ad hoc radio system. There are several equally spaced channels exist, each wireless MANET is a collection of self-configuring wireless mobile hosts forming a temporary network without any centralized administration and fixed infrastructure. A routing protocol is required because there is no interface and two hosts that wish to exchange

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packets may not be able to communicate directly. A good routing protocol can not only determine the shortest routing path, but also is suitable for the mobility characteristics of ad hoc networks.

The routing protocols in MANET may be primarily classified as proactive and reactive. Proactive routing protocols require that all mobile devices have complete network knowledge. Unfortunately, most mobile devices have limited space for storing the routing information. Moreover, devices do not maintain routing tables in reactive routing protocols. Reactive routing protocols involve two main functions, route discovery and route maintenance. A source uses the route discovery function, generally implemented via some form of flooding, to establish a routing path to the destination. Route maintenance is responsible for avoiding routing along an unavailable path in situations involving topological changes.

Numerous ad hoc routing protocols have been presented in the literature [5]. The following briefly introduces two representative protocols, Dynamic Source Routing Protocol (DSR) [6] and ZRP [7–8]. DSR is a reactive routing protocol based on source routing, and each packet determines a routing path to the destination itself. In Route Discovery, the source device broadcasts a ROUTE REQUEST packet that is flooded through the network in a controlled manner and answered by a ROUTE REPLY packet from the destination device. Additionally, the routing fields of the ROUTE REQUEST record the traversed devices from the source to the destination. Route Maintenance is performed when a packet cannot be successfully forwarded to the next-hop device. In this situation the next link of the source route is declared broken. The source device then is informed of this broken link.

ZRP is a hybrid reactive/proactive routing protocol. On the one hand, ZRP limits the scope of the proactive Procedure to the local neighbors of the node. On the other hand, network searching is performed when a device cannot find the destination through proactive routing. The ZRP comprises two procedures, the IntrAzone Routing Protocol (IARP) and the IntErzone Routing Protocol (IERP). The IARP is used within the routing zone, while IERP is used when the distance between the source and destination exceeds the radius of the routing zone. Each device must maintain the routing information of all devices in its routing zone, and updates the information in the case of topological change. When the distance to the destination is less than the zone radius, the destination can be located by IARP based on the routing information in each device. However, if the destination is located outside its zone, the IERP will broadcast a route request to identify the destination. Each device that receives the route request will repeat the above procedure until the destination is found. Using a mixture of reactive and proactive routing, ZRP can control routing information storage space and number of broadcasts.Thongpook and Thumthawatworn [9] further developed an adaptive ZRP by using fuzzy rule-base to permit dynamic adjustment of the zone radius of the routing table for the IARP to react appropriately to network configuration change. Although numerous ad hoc routing protocols were proposed or reviewed in Refs. [5,9], they are not well suited for Short rangescatternets before being adapted to the specifics of Short range. Recently, Prabhu and Chockalingam [10] presented a routing protocol for increasing gain in network life time, but this protocol still did not address the issues of reducing routing request reply time and request packets and reducing useless packet path length. Kapoor and Gerla [11] also established a routing scheme for Short rangescatternets based on the ZRP, but failed to resolve the issue of allowing individual nodes to identify and react to changes in network behavior by adjusting the routing zone radius. To address the above challenges, this work proposes a novel routing protocol for a Short range MANET that can adapt ZRP to the characteristics of Short range technology. Notably, the proposed routing scheme uses a fuzzy inference system to tune the radius of the routing zone such that the collaboration of the proactive and reactive protocols can promptly accommodate the topological change in Short rangescatternets.

ZONEROUTING PROTOCOL (ZRP)

After observing the Short range-based ad hoc networks, we find several characteristics which are different from traditional ad hoc networks.

The number of neighboring devices is limited and small. For other ad hoc networks, the neighboring network may be large. However, in Short range-based ad hoc networks, a gateway device connects up to seven node devices, and a node also connects to limited gateway devices.

For a gateway device A in a Short range MANET, if there are other gateway devices within the same network, there exists at least one gateway device whose distance to device A is no more than two hops. Fig. 1 shows two possible conditions for the distance between two gateways. It is two hops if a node, said B, is connected to the gateways of two piconets and it is one hop if the device B is a node in one piconet Based on the above observations, we draw some conclusions as follows.

1. If routing tables are built in all gateway devices, all devices of ad hoc networks can be covered. It is not necessary to have routing tables in node devices.

2. When the routing table in a gateway device covers devices within two hops, the gateway can use this routing table to find other nearby gateway devices.

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3. The size of a routing table in the gateway is smaller than traditional ad hoc networks in general because there are at most seven active nodes within a piconet. The gateways have more room to adjust the routing zone radius following the change of network and node behavior.
4. If we can reduce the number of broadcasts, we can also diminish the number of nodes involved in unnecessary transmissions that may considerably interfere with the reply of establishing a connection. Meanwhile, we can reduce the time in finding a path to the destination which in turn alleviates the effects of topology changes due to node mobility.

Gateway device

Fig. 1 illustrates an example of a Short range network. The example displayed includes three piconets, whose gateways are respectively. The routing table of gateway E can be built similarly. The first node in each ID–Type pair records those devices which are separated from the gateway for one hop. The second node of the ID– Type pair identifies devices recorded in the first node as either gateways or nodes. Then in the third and the fourth nodes, devices with a distance to the gateway of two hops are recorded, and are identified as gateways or nodes, respectively. Furthermore, if node is connected to multiple gateways, the fifth and sixth nodes are used for the second gateway, the seventh and the eighth nodes for the third gateway, and so on.
The source routing approach is used in ZRP. The ROUTE REQUEST and ROUTE REPLY packets both have a type field and several routing fields which record the routing path from the source to the current nodes, as illustrated in Fig. 2 and Fig. 3. When a gateway device receives a ROUTE REQUEST packet, it first checks whether the destination is itself or instead is a device contained in its routing table. If the destination is itself, it sends the ROUTE REPLY packet to the source. The destination device reverses the routing path in the routing fields of the ROUTE REQUEST to switch the roles of the destination and the source before including them in the routing fields of ROUTE REPLY. The destination forwards the ROUTE REPLY to the neighboring device depending on routing fields.
If the destination is in its routing table, the device will add its ID following the last routing field in the ROUTE REQUEST, and then send the ROUTE REQUEST to the destination or a device neighboring the destination. If the destination is not contained in the routing table, the gateway device will append its unique ID to the last routing field and forward the ROUTE REQUEST to its neighboring devices via multiple unicasts or a broadcast, depending on the number of neighboring devices. If the number of neighboring devices, which are either gateways themselves or connected to gateway devices, exceeds a certain threshold, broadcast is used to forward the ROUTE REQUEST, otherwise the ROUTE REQUESTs is forwarded via multiple unicasts to avoid sending redundant ROUTE REQUESTs to numerous nodes. However, neighboring devices receive the ROUTE REQUEST only if they satisfy either of the following two conditions: (a) the neighboring device acts as gateway in another piconet or (b) the neighboring device of the gateway has one connection to a remote gateway not contained in the routing fields, and the gateway has not previously sent or forwarded this ROUTE REQUEST.
Each node except the source receiving the ROUTE REPLY in the network must seek routing fields and then send the ROUTE REPLY to the next specific device in ROUTE RECORD. The routing operation is complete when the source device, located at the final position in the ROUTE RECORD of ROUTE REPLY receives the ROUTE REPLY.

Neighborhood network

The node do not build the routing table and simply broadcast the ROUTE REQUEST. On receiving a ROUTE REQUEST, a network will first check whether the destination is itself. If this is the case, the node device will send the ROUTE REPLY to the source device. Meanwhile, if the destination is a neighboring device, the node device will add its own unique ID after the last routing field of the ROUTE REQUEST, and send the ROUTE REQUEST to the destination via unicast. Moreover, if the destination is neither itself nor a neighbor, the node device will add its own unique ID following the last routing field of the ROUTE REQUEST, and then unicast the ROUTE REQUEST to all its neighboring devices individually. The node device which receives a ROUTE REPLY also must forward it to the next specific device in the ROUTE RECORD.
The network sharing logic has been used to solve several routing protocols and handover problems efficiently in wireless networks in the literature [12–14]. There are lots of solutions on VLSI chips which allow fuzzy inferences to be hardware-computed, and high-speed low cost fuzzy chips have been introduced recently, the implementation of fuzzy logic by hardware thus becomes feasible nowadays [15–17]. In our scheme, a ZRP logic approach is attempted to offer the self-tuning capability in the routing zone radius estimation mechanism. The proposed ZRP routing zone radius estimator is encompassed in the dotted frame as shown in Fig. 1. The new network and node conditions inter zone method is employed to compute weighted average of the aggregated output of the inferential rules due to its simplicity in computation. Fig 1 and 2. Illustrate the mapping of inputs of the interzone into some appropriate linguistic or membership values, which are expressed by the values within the range of0 and 1. The set of membership functions for the node velocity, the node density, and the route query rate, are presented in

respectively. All the inputs v, n and r are mapped into three linguistic term sets, ‘low’, ‘medium’ and ‘high’. The output parameter of the inference engine, Rz, is defined as the routing zone radius control action of our scheme. The fuzzy linguistic variables for the output are‘low’, ‘medium’ and ‘high’, which are represented by the membership

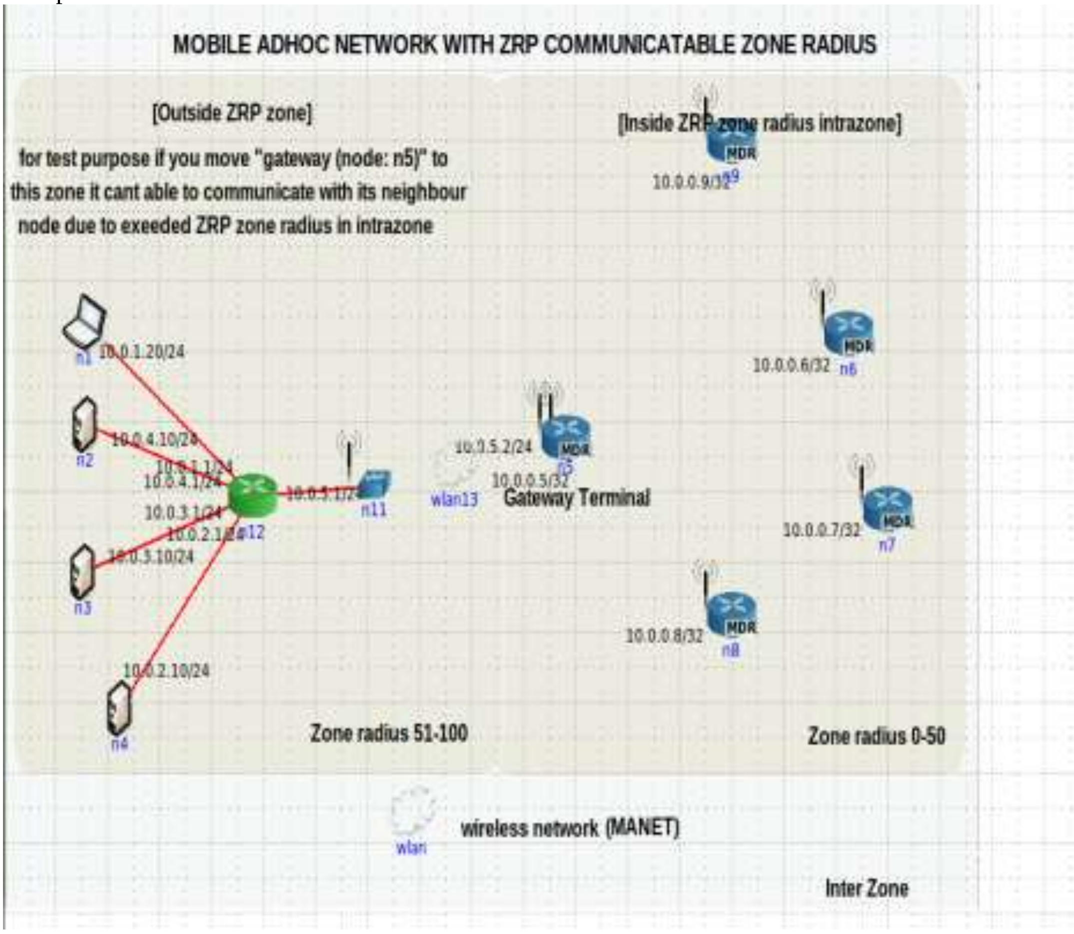

Fig 1

IF network reconfiguration rate is ‘low’, AND the node density is ‘low’, AND the route query rate is ‘low’, THEN the weighting factor of the routing zone radius for the routing table is ‘low’. Which the antecedent part of each ZRP rule constructed by the connective AND as shown in the above example is satisfied.
ZRP is found to have three advantages compared with the traditional ad hoc routing protocol.

1. Less number of broadcasting. In most ad hoc routing protocols, devices broadcast route requests if they do not know the locations of destinations. Broadcast messages then are continually delivered until the final destination is reached. Meanwhile, a gateway device in ZRP uses multiple unicasts or a broadcast if the destination lies outside of the routing zone radius and otherwise uses the selected unicast. This approach can significantly reducenetwork load since it reduces the total number of broadcasts. For example, this work assumes that the where Rz,i denotes the output of each rule induced by the firing strength wi. Notably, wi represents the degree to device n1 is the source, and that device n4 is the destination, as shown in Fig. 2. In ZRP, node n1 unicasts a ROUTE REQUEST to gateway n11. After receiving the ROUTE REQUEST, gateway n11 checks to see whether n4 is in its routing table. Because the distance between n11 and n4 is two hops, the position of n4 is recorded in the routing table of device n11. Therefore, device n11 unicasts ROUTE REQUEST to n5, and n5 forwards it to destination n4. On the other hand, in most reactive ad hoc routing protocols, for example, DSR, device n11 is unaware of the path to destination n7. Thus device n11 broadcasts the ROUTE REQUEST, and both devices n2 and n3 receive it. Unfortunately, device n3 does not know the position of destination n7, and thus also broadcasts the ROUTE REQUEST. Finally, the ROUTE REQUEST is passed to device n4, n5, which adds more traffic in the network and is clearly useless.

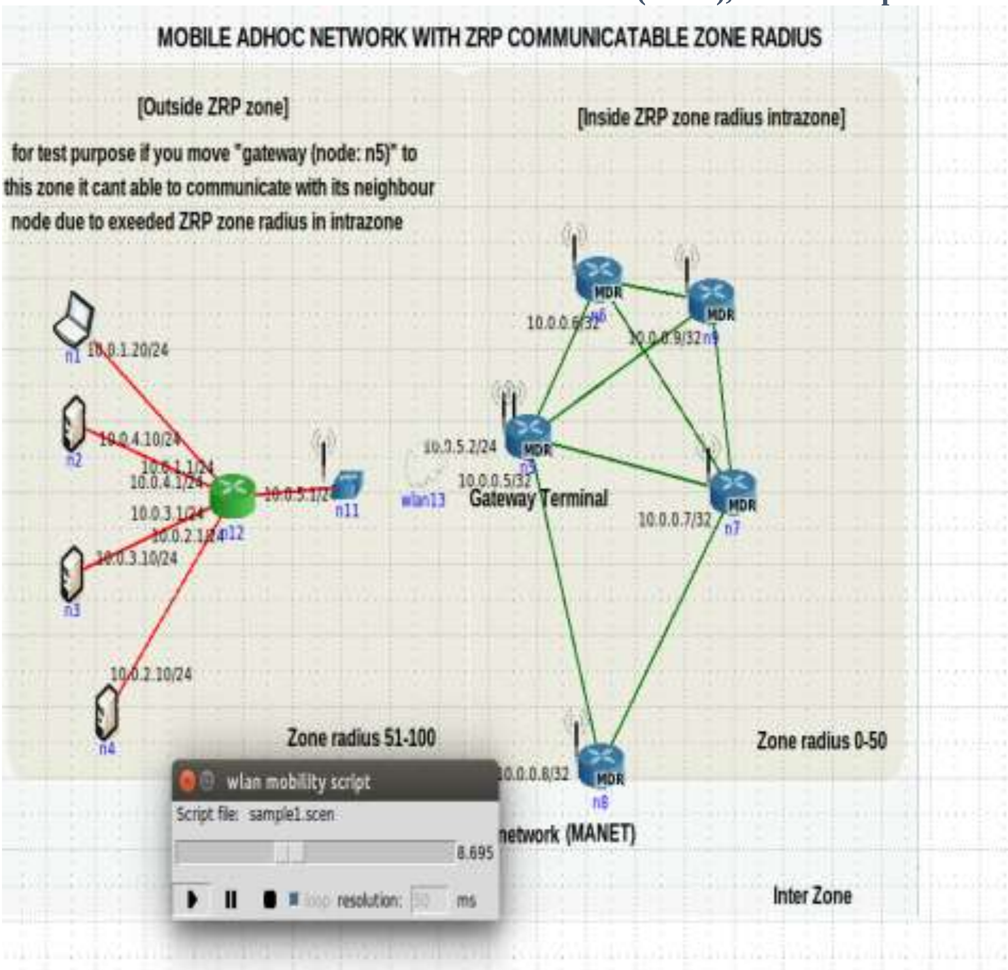

Fig 2

2. Lower storage spaces. Most proactive routing protocols require each network device to build a routing table. This requirement is extremely costly for all devices in MANETs. However, ZRP requires less storage space than traditional proactive routing protocols. ZRP controls routing table size via the routing zone radius. However, each device still must establish a routing table in the ZRP. In the ZRP, only gateway devices need to build routing tables, and each gateway connects up to seven nodes. The gateway devices thus can lengthen the routing zone radius for the routing table if necessary.

3. Shorter time for reply to route requests. In an ad hoc mobile network, the longer a source takes to receive a ROUTE REPLY, the more likely the transmitted path is likely to be changed. The ZRP has shorter reply time than the ZRP since the ZRP broadcasts more ROUTE REQUEST packets, which might interfere with the ROUTE REPLY and delay the arrival of the ROUTE REPLY at the source.

SIMULATION RESULTS

This work randomly generates Short range devices in a 5625 m2 area. Node positions and speeds are also produced randomly. The speed of each Short range deviceranges from 3 to 30 m/s, and the connection range of each device is 10 m. A gateway device can connect up to seven node devices, and a node device can join up to 10 piconets. ACL links are established. Following network construction, the network devices are randomly selected as the connection source and destination points. The maximum number of connections is limited to one third of the node counts in the network and each connection begins at a random time. The source device must send the ROUTE REQUEST to a destination and receive the ROUTE REPLY from a destination for building a routing path.
Clearly, the reply time in the ZRP scheme is significantly less. We believe that this is primarily because the DSR and ZRP both broadcast ROUTE REQUEST when devices are unaware of the destination positions. The packets will clearly be delayed when the network is congested with numerous ROUTE REQUEST broadcast messages since the number of connection sessions is up to one third of the number of network nodes. Although the ZRP also broadcast when the destination is not within its zone radius coverage, the capability of self-adaptation on the routing zone radius results in the spread of markedly fewer broadcasts. The ratio of broadcast to unicast for the four schemes accountsthe control packets that include the IARP and the IERP packets for broadcast and unicast

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traffic since this work focuses on the routing scheme. The number of ZRP schemes appear significantly lower than for the other schemes, while the number of unicast packets for ZRP schemes is slightly higher than for the other schemes. ZRP selectively uses either multiple unicasts or one broadcast depending on the situation of neighboring devices when the destination is out of the routing zone radius of the gateway. The figure further explains that the ZRP has the shortest reply time because the network nodes receive fewer messages and can reply ROUTE REPLY to the source faster than other protocols.

The routing path is identified when a source device receives a ROUTE REPLY from the destination device. However, some ROUTE REQUESTs may still be being sent via the network at this time. These ROUTE REQUEST packets do not give any help in building the routing path. The reason these packets remain alive is that some devices do not know that the routing path has been found, and consequently still forward the ROUTE REQUESTs to neighboring devices. ZRP has considerably fewer useless ROUTE REQUESTs than other schemes. Additionally, the success ratio or routing request for each node with different mobility is also better for the ZRP scheme.

CONCLUSION

This work takes use of some characteristics of network sharing technology to design an efficient protocol called the ZRP for Short range-based MANETs. In ZRP, routing table is built in each gateway device to reduce the space cost. In order to reduce the flooding of broadcast, the ZRP uses the unicast in gateway devices to replace the broadcast. ZRP also checks if the neighboring device needs to receive the ROUTE REQUEST packet. Simulation results demonstrate that the ZRP has less reply time of routing request, smaller broadcast to unicasts ratio, fewer request and reply packets, and lower useless packet ratio,. Notably, the vector of Routing Vector Method (RVM) can be incorporated into our scheme to replace the Short range

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