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Zone Routing Protocol

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ABSTRACT:

In this article, Introduce a routing protocol for a special class of ad-hoc networks, termed by us the Reconfigurable Wireless Networks (RWNs). The main features of RWNs are: increased mobility of the network nodes, larger number of nodes, and a large network span. To argue that the current routing protocols do not provide a satisfactory solution for routing in this type of an environment. To propose a scheme, called the Zone Routing Protocol (ZRP), which dynamically adjusts itself to the operational conditions by sizing a single network parameter – the Zone Radius. More specifically, ZRP reduces the cost of frequent updates of the constantly changing network topology by limiting the scope of the updates to the immediate neighborhood of the change. To study the performance of the scheme, evaluating the average number of control messages required to discover a route within the network.

Key Words: Hybrid Routing, Proactive Routing, Query Control, Reactive Routing, Routing Protocol and Routing Zone.

I. INTRODUCTION:

1.1 THE NOTION OF THE AD HOC WIRELESS NETWORKS:

An ad hoc network is defined as "An autonomous system of routers (and associated hosts) connected by wireless links the union of which forms an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet operating as a hybrid fixed/ad hoc network." The areas of application range from school classes over well-known services like chartrooms to online shopping, but they are also used in places that do not come to mind immediately, like in the military. Furthermore, it is not even necessary to have a human interaction factor: ad hoc networks can also be used to link together research computers or moving vehicles that exchange information "on the road", unbeknownst to the driver.

II.RECONFIGURABLE WIRELESS NETWORKS (RWNS):

RWN is a type of ad hoc network with rapidly changing topology. These networks typically have a large span and connect hundreds to thousands of nodes that can be rapidly deployed without infrastructure and where the nodes are highly portable. Thus rapidly changing the node constellation and the presence or absence of links. In this article, I concentrate on routing in large RWN networks with high mobility.

2.1 EXAMPLES OF THE USE OF THE RWN'S ARE:

- Tactical Operation - for fast establishment of military communication during the deployment of forces in unknown and hostile terrain;
- Rescue Missions - for communication in areas without adequate wireless coverage;
- National Security - for communication in times of national crisis, where the existing communication infrastructure is non-operational due to a natural disaster or a global war;

2.2 COMMUNICATION ENVIRONMENT AND THE RWN MODEL:

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The main challenges in the design and operation of the RWNs, compared to more traditional wireless networks, stem from the lack of a centralized entity, the potential for rapid node movement, and the fact that all communication is carried over the wire-less medium. In standard cellular wireless networks, there are a number of centralized entities. In ad-hoc networks, there is no preexisting infrastructure, and these centralized entities do not exist. The centralized entities in the cellular networks perform the function of coordination. The lack of these entities in the RWNs requires distributed algorithms to perform these functions. In particular, the traditional algorithms for mobility management, which rely on a centralized HLR/VLR, and the medium access control schemes, which rely on the base-station/MSC support, become inappropriate.

The following are a number of assumptions about the communication parameters, the network architecture, and the network traffic in a RWN.

- Nodes are equipped with portable communication devices. These may be powered by lightweight batteries. Limited battery life can impose restrictions on the transmission range, communication activity (both transmitting and receiving) and computational power of these devices.
- Connectivity between nodes is not a transitive relation; i.e., if node A can communicate directly with node B and node B can communicate directly with node C, then node A may not, necessarily, be able to communicate directly with node C. This leads to as the hidden terminal problem.
- A hierarchy in the network routing and mobility management procedures could improve network performance measures, such as the latency in locating a mobile. However, a physical hierarchy may lead to areas of congestion and is very vulnerable to frequent topological reconfigurations.
- Assume that nodes are identified by fixed IDs (based on IP addresses, for example).
- All the network nodes have equal capabilities. This means that all nodes are equipped with identical communication devices and are capable of performing functions from a common set of networking services. However, all nodes do not necessarily perform the same functions at the same time. In particular, nodes may be assigned specific functions in the network, and these roles may change over time.
- Although the network should allow communication between any two nodes, it is envisioned that a large portion of the traffic will be between geographically close nodes. This assumption is clearly justified in a hierarchical organization. For example, it is much more likely that communication will take place between two vehicles in the same unit, rather than between two vehicles in two different zones.

2.3 FEATURES FOR THE RWNS:

- Robust routing and mobility management algorithms to increase the network's reliability and availability; e.g., to reduce the chances that any network component is isolated from the rest of the network.
- Adaptive algorithms and protocols to adjust to frequently changing radio propagation, network, and traffic conditions
- Low-overhead algorithms and protocols to preserve the radio communication resource multiple (distinct) routes between a source and a destination - to reduce congestion in the vicinity of certain nodes, and to increase reliability and survivability.

III. PROACTIVE VS REACTIVE PROTOCOLS:

The protocols used in Ad Hoc networks generally are categorized into two groups: pro-active and reactive protocols. Pro-active protocols follow an approach similar to the one used in wired routing protocols. By continuously evaluating the known and attempting to discover new routes, they try to maintain the most up-to-date map of the network. This allows them to efficiently forward packets, as the route is known at the time when the packet arrives at the node. Pro-active or table-driven protocols, in order to maintain the constantly changing network graph due to new

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moving or failing nodes, require continuous updates, which may consume large amounts of bandwidth clearly a disadvantage in the wireless world, where bandwidth is often sparse. Even worse so, much of the accumulated routing information is never used, since routes may exist only for very limited periods of time. In contrast, reactive protocols determine the proper route only when required, that is, when a packet needs to be for-warded. In this instance, the node floods the network with a route request and builds the route on demand from the responses it receives. This technique does not require constant broadcasts and discovery, but on the other hand causes delays since the routes are not already available. Additionally, the flooding of the network may lead to additional control traffic, again putting strain on the limited bandwidth.

3.1. ZONE ROUTING PROTOCOL:

ZRP is a framework by using it we can take advantage of both proactive and on reactive protocol according to the application. In this separation of nodes, local neighborhood from the global topology of the entire network allows for applying different approaches and thus taking advantage of each technique's features for a given situation. These local neighborhoods are called zones (hence the name) each node may be within multiple overlapping zones, and each zone may be of a different size. The "size" of a zone is not determined by geographical measurement, as one might expect, but is given by a radius of length P where P is the number of hops to the perimeter of the zone.

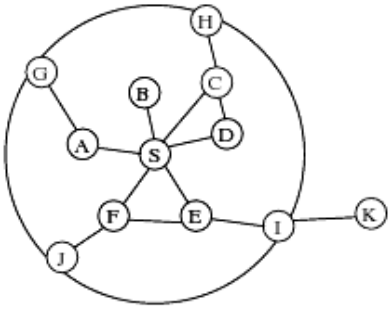

Figure 3 1.1: Example Routing Zone with P=2

In the above diagram ZRP, protocol having Zone radius 2 in this inside the zone communication done in proactive way and outside it between such zones in reactive way. A, E, F, H, J, C are interior node and D, G, I, k are border nodes communication between B and K is done through proactive way and L is located outside the zone.ZRP consist of three parts IARP proactive art, IERP reactive part of it and BRP used with IERP to reduce the query traffic.

3.2 ARCHITECTURE:

The Zone Routing Protocol, as its name implies, is based on the concept of zones. A routing zone is defined for each node separately, and the zones of neighboring nodes overlap. The routing zone has a radius ρ expressed in hops. The zone thus includes the nodes, whose distance from the node in question is at most ρ hops. An example routing zone is shown in Figure 1, where the routing zone of S includes the nodes A–I, but not K. In the illustrations, the radius is marked as a circle around the node in question. It should however be noted that the zone is defined in hops, not as a physical distance. The nodes of a zone are divided into peripheral nodes and interior nodes. Peripheral nodes are nodes whose mini-mum distance to the central node is exactly equal to the zone radius ρ. The nodes whose minimum distance is less than ρ are interior nodes. In Figure 1, the nodes A–F are interior nodes; the nodes G–J are peripheral nodes and the node K is outside the routing zone. Note that node H can be reached by two paths, one with length 2 and one with length 3 hops. The node is however within the zone, since the shortest path is less than or equal to the zone radius.

The number of nodes in the routing zone can be regulated by adjusting the transmission power of the nodes. Lowering the power reduces the number of nodes within direct reach and vice versa. The number of neighboring nodes should be sufficient to provide adequate reach ability and redundancy. On the other hand, a too large coverage results in many zone members and the update traffic becomes excessive. Further, large transmission coverage adds to the probability of local contention.

3.3 ZRP IMPLEMENTS IARP, IERP AND BRP:

ZRP refers to the locally proactive routing component as the Intra-zone Routing Protocol (IARP). The globally reactive routing component is named Inter-zone Routing Protocol (IERP). IERP and IARP are not specific routing protocols. Instead, IARP is a family of limited-depth, proactive link-state routing protocols. IARP

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maintains routing information for nodes that are within the routing zone of the node. Correspondingly, IERP is a family of reactive routing protocols that offer enhanced route discovery and route maintenance services based on local connectivity monitored by IARP.

The fact that the topology of the local zone of each node is known can be used to reduce traffic when global route discovery is needed. Instead of broadcasting packets, ZRP uses a concept called border casting. Border casting utilizes the topology information provided by IARP to direct query request to the border of the zone. The border cast packet delivery service is provided by the Border-cast Resolution Protocol (BRP). BRP uses a map of an extended routing zone to construct border-cast trees for the query packets. lternatively, it uses source routing based on the normal routing zone. By employing query control mechanisms, route requests can be directed away from areas of the network that already have been covered.

In order to detect new neighbor nodes and link failures, the ZRP relies on a Neighbor Discovery Protocol (NDP) provided by the Media Access Control (MAC) layer.NDP transmits “HELLO” beacons at regular intervals. Upon receiving a beacon, the neighbor table is updated. Neighbors, for which no beacon has been received within a specified time, are removed from the table. If the MAC layer does not include a NDP, the functionality must be provided by IARP.

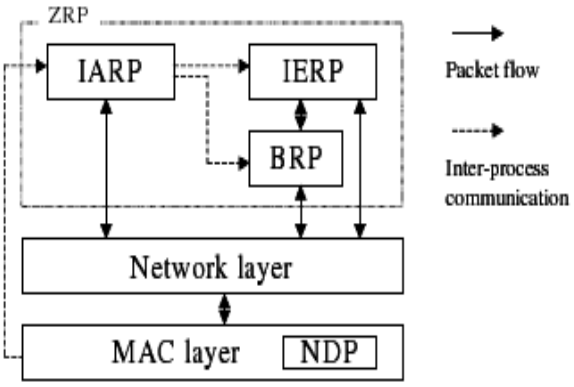

Figure 3.3.1: ZRP Architecture

The relationship between the components is illustrated in Figure 3.3.1. Route updates are triggered by NDP, which notifies IARP when the neighbor table is updated. IERP uses the routing table of IARP to respond to route queries. IERP forwards queries with BRP. BRP uses the routing table of IARP to guide route queries away from the query source.

IV. PERFORMANCE:

In order to maximize performance of the RNW’s, we need to minimize the amount of control traffic that is sent. Thus, we wish to maintain an overview of the networks topology that is as accurate as possible (at any given time thus minimizing delays caused by route discovery requests), while at the same time requiring sending as little packages as possible. Given the hybrid nature of the RNW’s , the goal can be reduced to finding the correct - i.e. optimal size of the routing zone radius ρ for the given network which may vary from case to case, depending on the circumstances.

The cost of maintaining the ever-changing local routes in RNW’s is too high, particularly since most of the routes are so short-lived that they are never used. Instead, a zone radius of $\rho \leq 3$ would be beneficial, to ensure that the zones overlap enough to allow for route redundancy. Note, however, that reducing $\rho \rightarrow 0$ effectively turns the ZRP into a completely reactive protocol, obsoleting the advantages gained from its hybrid nature: all routing is done on-demand (using IERP), as no node is able to contact another node using IARP.

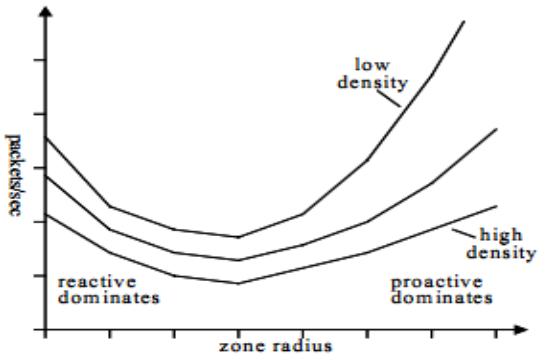

Figure 4.1: ZRP Traffic per Node (Schematic)

The results of shows that the IARP traffic grows with the number of nodes in a given zone, while increased mobility of a nodes increases IERP traffic: as nodes move, the routes between zones break and need to be ``re-discovered". Increasing the number N of nodes in the global network has only limited effect on the amount of pro-active traffic, since pro-active IARP updates are local to a zone. In

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general, it can be stated that ``larger zones provide more efficient queries, which compensates for the IARP maintenance cost".

4.1 PERFORMANCE GAIN ON THE EXAMPLE OF BORDERCASTING:

In this section, we will show how BRP can minimize the number of broadcasts significantly. First let us consider a network as shown in Figure 4.1.1.The first 8 nodes connected to the node in the middle should be seen as that node's peripheral nodes (that is, interior nodes are not shown in this example), the 8 nodes on the outside as the peripheral nodes of the extended zone. As we can see, the total number of queries if no BRP would be used would sum up to be 40!

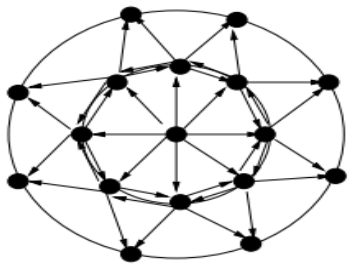

Figure 4.1.1: Query Flooding

Now we introduce selective border-casting. A large number of broadcasts can be avoided, since many of the zones overlap and peripheral nodes connect to the same nodes in the extended zone. As Figure 5 shows, the number has been brought down to 16, a decrease of over 50%!

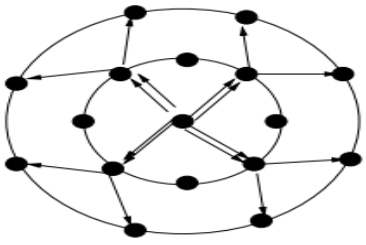

Figure 4.1.2: Selective Border Casting

The tremendous advantage of using Selective Broadcasting in the IERP is visualized in Figure 4.1.2, as adopted from other research papers.

It is important to note that all of the components of the ZRP provide the necessary flexibility optimal for nodes in a MANET:

- Each node may choose a different zone radius, according to its signal strength, transmission power, velocity etc.
- ZRP provides support for unidirectional links, which frequently occur in MANETs
- Local neighbors are detected using NDP, which can be implemented on the link-layer. Even though this requires periodic messages to maintain an accurate overview of the interior nodes, there is not much of an overhead since this is performed within the (comparably) small local zone. since only link-layer uncast are presumed to be reliable and in sequence, these properties are no requirements for other traffic

- The protocols that make up the ZRP are implementation specific. That is, one RNW with certain requirements may adjust AOD for use as the IERP and OLSR as the IARP, while in another situation it might be favorable to use TBRPF as the IARP and DSR as the IERP.
- By basing all components on the IP, ZRP can provide all the services customers are used to from wired networks. Another advantage is the possibility of implementing security aspects on the IP layer (for example through the use of IPSec), thus removing costly overhead from the wireless protocol vast performance gain through the use of link-optimization, selective border casting, Query Detection (1 and 2), Early Termination and Loopback Termination (see Figure 4.1.1)
- The ZRP can determine the appropriate zone radius dynamically on-demand ; propagation of the new routing zone is conceivable but would need to be implemented)

V. CONCLUSION:

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The Zone Routing Protocol (ZRP) provides a hybrid routing framework, in which each node maintains local routes within its zone in a pro-active manner, while inter-zone communication is performed in a reactive manner. In order to improve performance of the reactive IERP and avoid having to rely on flooding all neighboring nodes, thus risking exhaust-ting the available bandwidth, it makes use of a border casting protocol.

In contrast to other MANET routing protocols, RNW's, as mentioned above, provides a hybrid approach, a framework of protocols. Thus, it does not directly conflict or compete with any of the classical protocols, but is able to take advantage of each of those protocols strengths, depending on the situation, requirements and implementation. Also, ZRP is more suitable than other protocols for large networks spanning diverse mobility patterns by providing the benefits of both reactive and pro-active routing in a flat network that takes advantage of a near hierarchical approach and its components IARP, IERP and BRP

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