A SURVEY TO THE EXISTING ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK

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Abstract:
In this article, we present a survey to the existing routing protocols in mobile ad-hoc network. There are varies of such technologies existing nowadays. We will provide an overview of these technologies by presenting their characteristics and functionality, and then provide a comparison and discussion of their respective merits and drawbacks.

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Contents

1 Introduction

Since their emergence in the 1970s, wireless networks have become increasingly popular in the computing industry. This is particularly true within the past decade which has seen wireless networks being adapted to enable mobility.

There are two variations of mobile wireless networks. The first is known as infrastructured networks, i.e., those networks with fixed and wired gateways. The bridges for these networks are known as base stations. A mobile unit within these networks connects to, and communicates with, the nearest base station that is within its communication radius.

The second type of mobile wireless network is the infrastructureless mobile network, commonly known as an ad-hoc network. Infrastructureless networks have no fixed routers; all nodes are capable of movement and can be connected dynamically in an arbitrary manner. Nodes of these networks function as routers which discover and maintain routes to other nodes in the network. Example applications of ad-hoc networks are emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrains.

Since the service discovery in the first type of mobile wireless network is simple, we will focus on the second type of mobile wireless network, especially the ad-hoc network. An ad-hoc mobile network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. During the service finding process in ad hoc network, it needs many ad hoc routing protocols; the table driven type protocols and the source-initiated on-demand driven type protocols. And we will discuss them respectively.

2 Problem description

Ad hoc networks enable spontaneous connectivity among wireless devices, without requiring any particular infrastructure. In addition, ad hoc routing protocols increase connectivity by offering multi-hop communication, while supporting a continuously changing topology, leading to the automatic configuration of infrastructure-less Mobile Ad hoc Networks (MANETs). However, effective exploitation of networked services within a MANET requires enabling the delivery of services that best match the application's requirements, still taking into account the MANET's dynamics. [1]

3 Background (Review of literature)

Since we are supposed to do a survey to the existing technology about how to find new services in mobile distributed system, firstly we should know what the distributed system is. "A distributed system is a collection of independent computers that appears to its users as a single coherent system."[2] And as we mentioned before, we'll focus on the routing protocols in ad-hoc since we think that it can represent finding new services in distribute system.

3.1 Distributed Systems:

The definition above has two aspects. The first one deal with hardware: the machines are autonomous. The second one deal with software: the users think they are dealing with a single system. [2] Both are essential and have same goal: to connect users and resources in a transparent, open, and scalable way. [3]

3.2 Moblie Ad-hoc Network

A mobile ad-hoc network (MANET) is based on a self-organizing and rapidly deployed network. MANET applications include supporting battlefield communications, emergency relief scenarios, law enforcement, public meeting, virtual class room, and other security-sensitive computing environments. The ad-hoc networking technology has stimulated substantial research activities in the past 10 years. Many scholars were attracted to investigate this domain for further research and learning. Numerous problems and challenges exist in this field because of the frequent and unpredictable MANET topology changes. [4]

Accompany with the development of the mobile networks, today MANET is widely used in various mobile environments. As a result, there are many routing protocols designed adapted for MANET. These routing protocols can generally be categorized as: (a) Proactive protocols which is every node maintains one or more tables representing the entire topology of the network. These tables are updated regularly in order to maintain up-to-date routing information from each node to every other node. (b) Reactive protocols, which seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. (c). Hybrid protocols, which can be regards as a combination of proactive protocols and reactive protocols and try and exploit their strengths. One approach is to divide the network into zones, and use one protocol within the zone, and another between them. The Figure 3-1 below shows what we just narration.

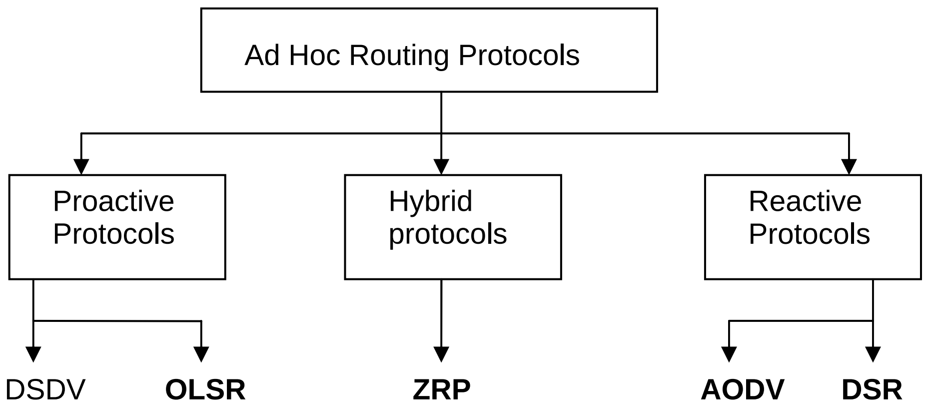

Figure 3-1 Categorization of Ad Hoc Routing Protocols

In the following sections, we will discuss most protocols in bold words we enumerate above, except one of the proactive protocols which are Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV).

3.3 Reactive protocols

Reactive protocols, invoke a route determination procedure on demand only. Thus, when a route is needed, some sort of global search procedure is employed. The family of classical flooding algorithms belongs to the reactive group. Some other examples of reactive (also called on-demand) ad hoc network routing protocols are Dynamic Source Routing (DSR), Ad-hoc On demand Distance Vector Routing (AODV) and the Temporally Ordered Routing Algorithm (TORA).

3.3.1 Dynamic Source Routing protocol

Dynamic source routing protocol (DSR) is a reactive routing protocol which is able to manage a MANET without using periodic table-update messages like table-driven routing protocols do. DSR was specifically designed for use in multi-hop wireless ad hoc networks.

For restricting the bandwidth, the process to find a path is only executed when a path is required by a node. In DSR the sender (source, initiator) determines the whole path from the source to the destination node and deposits the addresses of the intermediate nodes of the route in the packets. DSR was developed for MANETs with a small diameter between 5 and 10 hops and the nodes should only move around at a moderate speed.

DSR is based on the Link-State-Algorithms which mean that each node is capable to save the best way to a destination. Also if a change appears in the network topology, then the whole network will get this information by flooding. [5]

There are two major phase in DSR:

- Route Discovery (find a path)
- Route Maintenance (maintain a path)

Route discovery
For example, suppose a node A is attempting to discover a route to node E. The Route Discovery initiated by node A in this example would proceed as Figure 3-2 depicts:

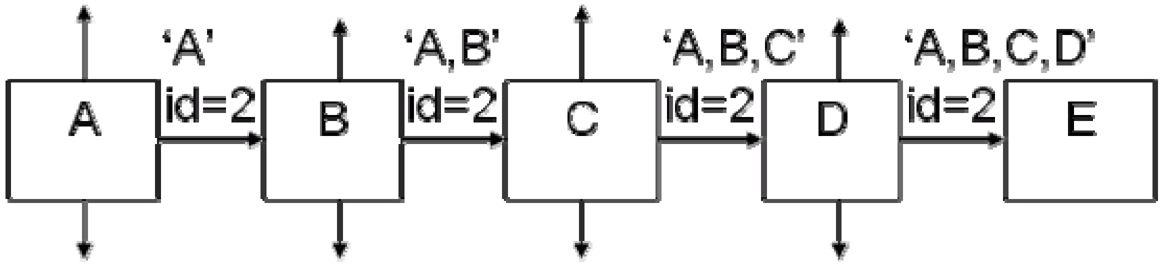

Figure 3-2

To initiate the Route Discovery, node A transmits a "Route Request" as a single local broadcast packet, which is received by (approximately) all nodes currently within wireless transmission range of A, including node B in this example. Each Route Request identifies the initiator and target of the Route Discovery, and also co determined by the initiator of the Request. Each Route Request also contains a record listing the address of each intermediate node through which this particular copy of the Route Request has been forwarded. This route record is initialized to an empty list by the initiator of the Route Discovery. In this example, the route record initially lists only node A. [6]

Route Maintenance
For example, in the situation shown in Figure 3-3 below, node A has originated a packet for node E using a source route through intermediate nodes B, C, and D:

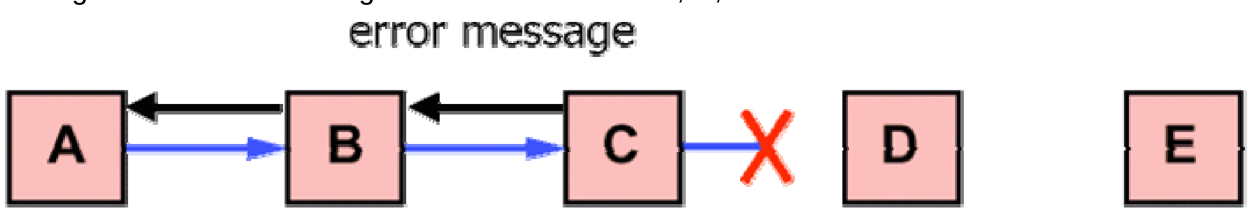

Figure 3-3

In this case, node A is responsible for the link from A to B, node B is responsible for the link from B to C, node C is responsible for the link from C to D, node D is responsible for the link from D to E. if node C find there is a broken link between C and D, C will send a Error message to node A, which will easer this route and then, find another one in its route cache or just initial a new route discovery.

3.3.2 Ad hoc On-Demand Distance Vector

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad hoc network. It uses destination sequence numbers to ensure loop freedom at all times (even in the face of anomalous delivery of routing control messages), avoiding problems (such as "counting to infinity") associated with classical distance vector protocols.

The Ad hoc On-Demand Distance Vector (AODV) algorithm enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. [7]

Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs) are the message types defined by AODV. In general, figure 3-4 illustrates an AODV route lookup session. Node A wishes to initiate traffic to node J, but since there is no route, Node A broadcasts a RREQ to all nodes in the network. When this request is forwarded to J from H, J generates a RREP. This RREP is then unicasted back to A using the cached entries in nodes H, G and D. [8]

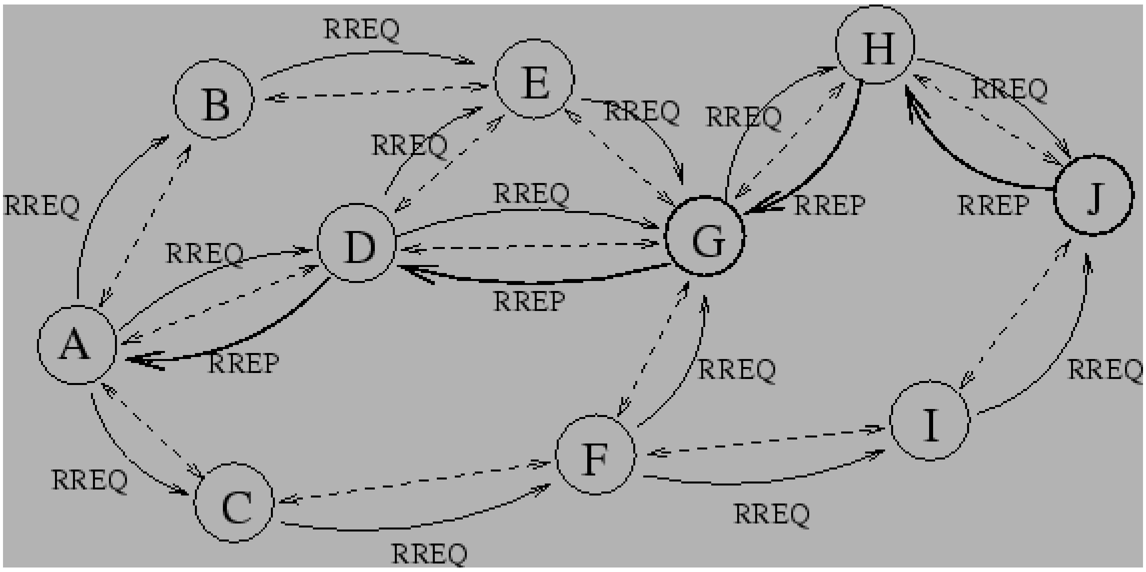

Figure 3-4: possible path for a route reply if Node A wishes to find a route to J.

3.4 Proactive 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 and can be immediately used at the time when the packet arrives at the node. The family of Distance-Vector protocols is an example of a proactive scheme. Examples of proactive routing protocols include the Wireless Routing Protocol (WRP) and Destination-Sequenced Distance-Vector (DSDV) routing.

3.4.1 The Optimized Link State Routing protocol

The Optimized Link State Routing (OLSR) protocol is an optimization of the classical link state algorithm tailored to the requirements of a mobile wireless LAN. The key concept used in the protocol is that of multipoint relays (MPRs). MPRs are selected nodes which forward broadcast messages during the flooding process. This technique substantially reduces the message overhead as compared to a classical flooding mechanism, where every node retransmits each message when it receives the first copy of the message. In OLSR, link state information is generated only by nodes elected as MPRs. Thus, a second optimization is achieved by minimizing the number of control messages flooded in the network. As a third optimization, an MPR node may chose to report only links between itself and its MPR selectors. Hence, as contrary to the classic link state algorithm, partial link state information is distributed in the network. [9]

In terms of the [10], the OLSR protocol has several outstanding characteristics

1. It is well suited to large and dense mobile networks, as the optimization achieved using the MPRs. The larger and more dense a network, the more optimization can be achieved.
2. It is suit for the networks, where the traffic is random between a large set of nodes rather than being almost exclusively between a small specific set of nodes.
3. OLSR is also suitable for scenarios where the communicating pairs change over time.

Multipoint Relays (MPRs)
The idea of multipoint relays is to minimize the overhead of flooding messages in the network by reducing redundant retransmissions in the same region. Each node in the network selects a set of nodes in its symmetric 1-hop neighborhood which may retransmit its messages. This set of selected neighbor nodes is called the "Multipoint Relay" (MPR) set of that node. Figure 3-5 describes MPRs.

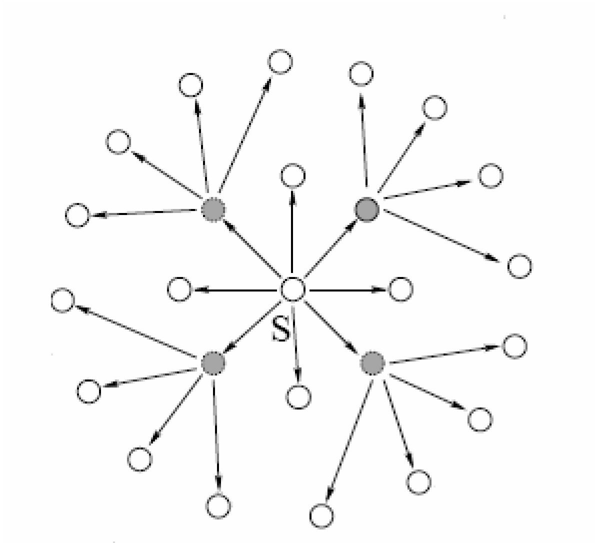

Figure 3-5: Diffusion of broadcast message using multipoint relays

The concept of multipoint relaying is to reduce the number of duplicate retransmissions while forwarding a broadcast packet. This technique restricts the set of nodes retransmitting a packet from all nodes, to a subset of all nodes. The size of this subset depends on the topology of the network.

Multipoint relaying technique works in a distributed way, keeping in view the mobile and dispersed nature of the network nodes. Each node calculates its own set of multipoint relays, which is completely independent of other nodes' selection of their MPRs. Each node reacts when its neighborhood nodes change and accordingly modifies its MPR set to cover its two-hop neighbors.

This is achieved by selecting neighbors as Multipoint relays (MPRs). Every node calculates its own set of MPRs as a subset of its symmetric neighbor nodes chosen so that all 2 hop neighbors can be reached through a MPR. This means that for every node in the network that can be reached from the local node by at minimum two symmetric hops, there must exist a MPR so that has a symmetric link to and is a symmetric neighbor of the local node.

3.5 Hybrid protocols - Zone Routing Protocol

The Zone Routing Protocol (ZRP) was introduced in 1997 by Haas and Pearlman. It is a hybrid of the proactive routing protocol (AODV) and the reactive routing protocol (OLSR). It takes the advantage of pro-active discovery within a node's local neighbourhood (Intrazone Routing Protocol (IARP)), and using a reactive protocol for communication between these neighbourhoods (Interzone Routing Protocol (IERP)). “Intra-zone routing is done by a proactive protocol since these protocols keep an up to date view of the zone topology, which results in no initial delay when communicating with nodes within the zone. Inter-zone routing is done by a reactive protocol. This eliminates the need for nodes to keep a proactive fresh state of the entire network." [11] And the Bordercast Resolution Protocol (BRP) is responsible for the forwarding of a route request.

3.5.1 An overview of the zone routing framework

In the Zone Routing framework, a proactive routing protocol provides a detailed and fresh view of each node's surrounding local topology (routing zone) at the local level. The knowledge of local topology is used to support services such as proactive route maintenance, unidirectional link discovery and guided message distribution. One particular message distribution service, called bordercasting, directs queries throughout the network across overlapping routing zones. Bordercasting is used in place of traditional broadcasting to improve the efficiency of a global reactive routing protocol.

3.5.2 The routing zone

More precisely, a node's routing zone is defined as a collection of nodes whose minimum distance in hops from the node in question is no greater than a parameter referred to as the zone radius as Figure 3-6 shows.

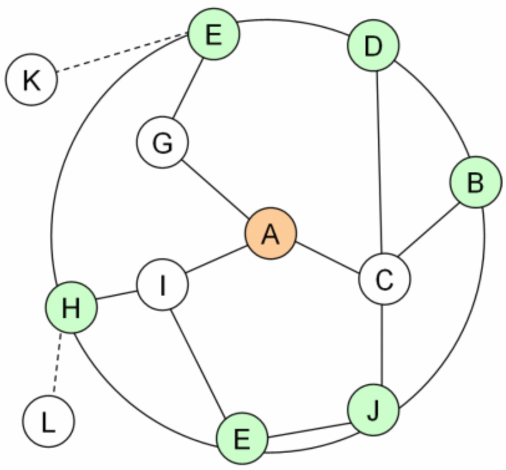

Figure 3-6 Node A's zone, radius=2 [12]

The construction of a routing zone requires a node to first know who its neighbours are. A neighbour is defined as a node with who direct (point-to-point) communication can be established and is, thus, one hop away. Identification of a node's neighbours may be provided directly by the media access control (MAC) protocols, as in the case of polling-based protocols. In other cases, neighbour discovery may be implemented through a separate Neighbour Discovery Protocol (NDP). Such a protocol typically operates through the periodic broadcasting of "hello" beacons. The reception (or quality of reception) of a "hello" beacon can be used to indicate the status of a connection to the beaconing neighbour.

Route discovery in the Zone Routing framework is distinguished from standard broadcast-based route discovery through a message distribution service known as the Bordercast Resolution Protocol (BRP), which is used to control traffic between zones. If a node has no route to a destination provided by the proactive inter-zone routing, BRP is used to spread the reactive route request.

3.5.3 The architecture of Zone Routing Protocols

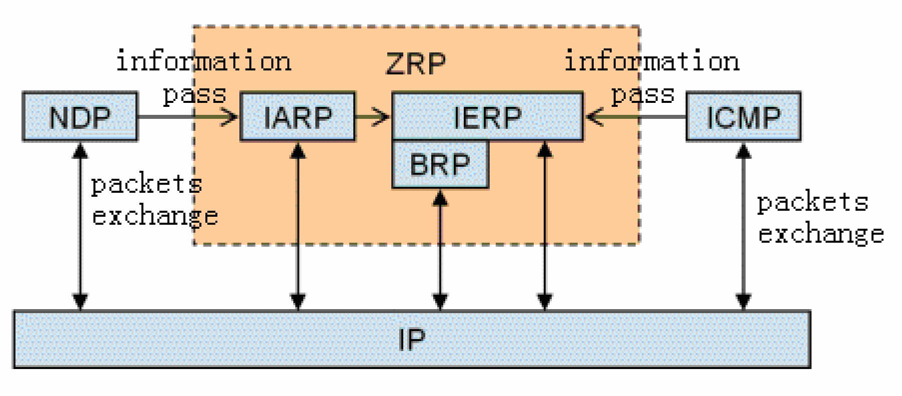

Figure 3-7 ZRP architecture [12]

The architecture of the hybrid Zone Routing framework shown in Figure 3-7 is modular, so that a link state routing protocol can be used as an IARP and an on-demand routing protocol can be used as an IERP. As an example, consider TBRPF or OLSR as an IARP and AODV or DSR as an IERP.

3.5.4 Zone Routing Protocols is a flat routing protocol

In actuality, the ZRP is a flat routing protocol. Each node maintains its own routing zone, which heavily overlaps with the routing zones of neighbouring nodes. Because there is a one-to-one correspondence between nodes and routing zones, the routing zones, unlike hierarchical clusters, do not serve to hide the details of local network topology. As a result, the network-wide interzone routing protocol (IERP) actually determines routes between individual nodes, rather than just between higher level network entities.

4 Discussion

4.1 Reactive protocols

Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route.

4.1.1 Dynamic Source Routing protocol

We start with the advantages of the reactive protocols. Reactive routing protocols have no need to periodically flood the network for updating the routing tables like table-driven routing protocols do. Intermediate nodes are able to utilize the Route Cache information efficiently to reduce the control overhead. The initiator only tries to find a route (path) if actually no route is known (in cache). Compared to other reactive routing protocols like ABR or SSA, DSR is beacon-less which means that there are no hello-messages used between the nodes to notify their neighbours about her presence .Therefore current and bandwidth will be saved. Other advantages of the DSR protocol include easily guaranteed loop-free routing, operation in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change.

There are also disadvantages. The Route Maintenance protocol does not locally repair a broken link. The broken link is only communicated to the initiator. The DSR protocol is only efficient in MANETs with less then 200 nodes. Problems appear by fast moving of more hosts, so that the nodes can only move around in this case with a moderate speed. Flooding the network can cause collusions between the packets. Also there is always a small time delay at the beginning of a new connection because the initiator must first find the route to the target.

4.1.2 Ad hoc On-Demand Distance Vector

The basic overview of AODV has been present in section 3.3.2. But there are several points which should be noticed since they are the characteristics of AODV which leads both of its advantages and disadvantages which we will discuss later. Let's first have a look at the characteristics:

(a) RREQ: All of the RREQ messages, which is 'routing request', contains the same information in each router discovery process. It says: Do you know how to reach [destination node]? And in this example, it's node J. When the next hop receives the RREQ message, it will check itself: Am I the [destination node] or do I know how to get [destination node]? If neither, it will save the [precursor node] in its cache. Therefore, when it find a route to [destination node], it can unicast this route information to those who asked for it.

(b) RREP: All of the RREP messages, which are routing reply, are mostly different. The only same information in those messages is the destination. It says: You can go to [destination node] via [next hop], and there is [hops amount] in total.

(c) Sequence number. Each route has a sequence number which can solve the "count to infinite" problem. As specified in [13], there are two rules for it: on the one hand, immediately before a node originates a route discovery, it MUST increment its own sequence number. This prevents conflicts with previously established reverse routes towards the originator of a RREQ. On the other hand, immediately before a destination node originates a RREP in response to a RREQ, it MUST update its own sequence number to the maximum of its current sequence number and the destination sequence number in the RREQ packet.

(d) RERR/link breakage: Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, a RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keeps a "precursor list", containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination. As RFC3561 [7] specified, there are four steps for a node handling the link breakage: firstly, invalidating existing routes. Secondly, listing affected destinations. Thirdly, determining which, if any, neighbors may be affected. Finally, delivering an appropriate RERR to such neighbors.

The advantages contain three aspects. The first one is Loop free routing: For example, when node A initials a route discovery process, it will create a route table entry with sequence number, for example, 001_J. "J" indicates the destination of this route is node J. So do other intermedia nodes. When the node J send RREP replies, since the sequence number in node H and the sequence number within J's RREP message are same, no action will be execute. But, if some other node initial a route discovery process for the destination node J, and the RREQ message will first through node H and then G, the J's RREP for that one will then, for example, have a later sequence number which is 002_J. in that case, when this RREP message comes to node H, H will use this one instead of the old one, 001_J. This mechanism can guarantee all loops are free. The second one is Local repair: For example, when node X detects there is a broken link to node Y and if the nodes have a route in their routing table with this link, the route will be erased. Node Source sends once again a route request to his neighbour nodes. Or a node on the way to the destination can try to find a route to D. That mechanism is called: Local Route Repair. The last is Low overhead and smaller routing tables in light load networks: Like all re-active protocols, it doesn't need to maintain a large routing table, so there will be a light load.

It's also notice the disadvantages. One portion is Delay caused by route discovery process. Since the only routing load will be appeared when a routing discovery initiate, at that period, the time delay compare with normal time will be considerable huge. And because the initiator has to wait for destination's replay, it has nothing to do at that time. The other is Bidirectional connection needed in order to detect a unidirectional link.

4.1.3 Distance Source Routing protocol vs. Ad hoc On-Demand Distance Vector

The Distance Source Routing Protocol and the Ad Hoc On-Demand Routing protocol are two dynamic routing protocols that initiate routing activities for ad hoc networks on an on demand basis. These protocols were designed for reducing the routing loading in ad hoc networks. The routing mechanism in DSR uses source routing, while AODV uses a table driven routing framework and destination sequence numbers. AODV relies on certain timer-based activities while DSR does not rely on such options. AODV uses traditional routing tables, one entry per destination for maintaining routing information. DSR on the other hand maintains multiple route cache entries for each destination.

AODV can gather only limited amount of routing information. DSR uses route caching aggressively by replying to all requests reaching a destination from a single request cycle. [14]

In the performance, the DSR protocol according to [15] has poor delay and throughput. This is mainly because of the aggressive strategy of using caching and lack of any mechanism to the expired or stale routes or to determine the freshness of routes when there are multiple available routes choices in cache. The author of [15] believed that the reason why DSR has low loads and also keeps its routing load down is the Aggressive caching. Hence, the mechanisms to expired routes and/or determine freshness of routes will benefit DSR’s performance significantly. On the other hand, if AODV’s using source routing on the request and reply packets in the route discovery process, the routing loads can be reduced considerably. Since AODV keeps track of actively used routes, multiple actively used destinations also can be searched using a single route discovery flood to control routing load. In general, it was observed that both protocols could benefit from using congestion-related metrics (such as queue lengths) to evaluate routes instead of emphasizing the hop-wise shortest routes, and by removing “aged” packets from the network. The aged packets are not critical for the upper layer. They will probably be retransmitted. But they contribute to the load in the routing layer. [15]

4.2 Proactive protocols

Since we have introduced some aspects of OLSR, and now we will on the one hand concentrate on the advantages of the protocol and on the other hand discuss the disadvantages.

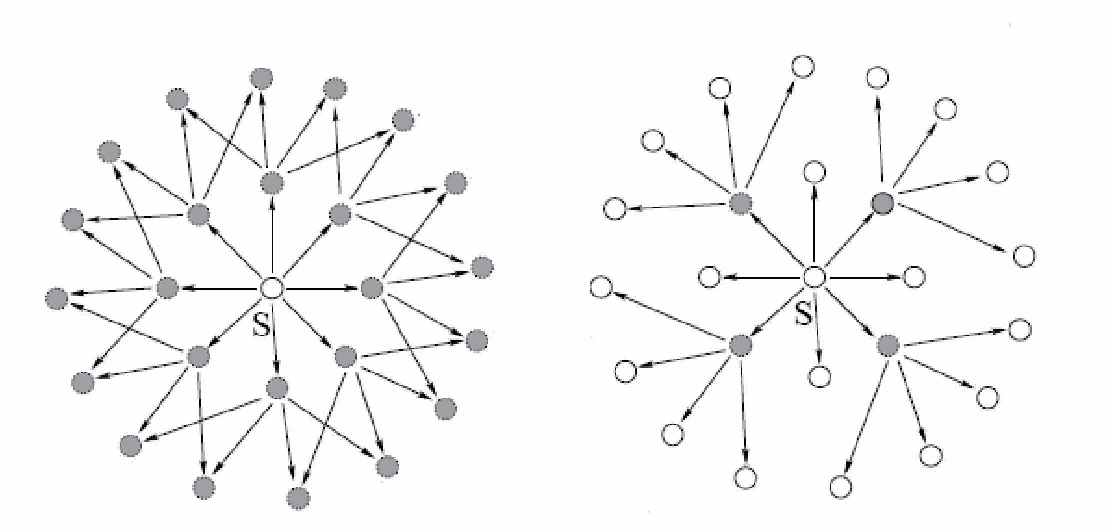

Figure 4-1

There are several merits of OLSR. Firstly, OLSR minimizes the overhead from flooding of control traffic by using only selected nodes, called MPRs, to retransmit control messages. We know that in a mobile network, we need to up-to-date the information. As a result, broadcast becomes an essential requirement. Let’s first look the Figure 4-1 above, the one on the left hand is just broadcasting message using pure flooding. And the right one broadcasts message using multipoint relays. It’s clear that when using pure flooding to broadcast message there may be lead to huge traffic, but in using multipoint relays to transmit message will sharply decrease the overhead.

Secondly, OLSR is ideal in high density and large networks. As we describe in the previous section, this protocol is especially for the network which situation are large and dense. OLSR uses hop-by-hop routing, each node uses its local information to route packets. The larger and more dense a network, the more optimized link state routing is achieved.

Thirdly, OLSR achieves more efficiency than classic LS algorithms when networks are dense. In classic LS algorithms, there are not any node can have the properties of the multipoint relays had, so once the network become dense gradually, the overhead from flooding of control traffic will be terrible. Then, OLSR avoids the extra work of "finding" the destination by retaining a routing entry for each destination all the time, thus providing low single-packet transmission latency, and OLSR can easily be extended to QoS monitoring by including bandwidth and channel quality information in link state entries. Thus, the quality of the path (e.g., bandwidth, delay) is known prior to call setup. An important issue in mobile network is the quality of service. Nodes in such a network usually act both as clients and service providers, making, contrary to most networks, the boundary between network and host less clear. OLSR provide a nice solution.

Finally, Route immediately available. As we mentioned before, ORSL is a kind of proactive protocols, one of the evident advantage of proactive protocols is that immediately provide the required routes when needed. As a member of these protocols, ORSL also can provide route in a short time interval.

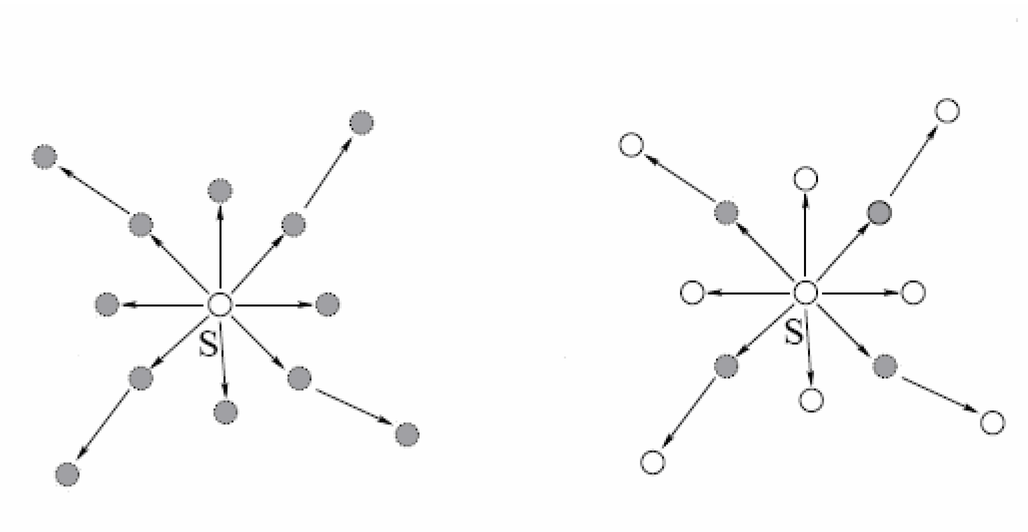

Figure 4-2

Though OLSR has many advantages, we also need to notice these negative aspects. In the beginning, when the network is sparse, every neighbor of a node becomes a multipoint relay. The OLSR then reduces to a pure LS protocol. This drawback is more or less the same once chose all the 1 hop nodes to be the MPRs. When the nodes are few, then OLSR will change to pure LS protocol. The left one in the Figure 4-2 above show that when all the 1 hop nodes regard as MPRs, and Figure 4-2 shows when we only have a few nodes. From the Figure 4-2 we hardly tell what the different of these two pictures. However, in this case, it will not influence transmit messages. After that, High control overhead (reduced by MPR usage) and storage is another barrier. Because information about the entire network need to be maintained at all times, OLSR require relatively much storage complexity and usage. Hence, there is a greater demand for storage capacity of nodes in such networks. Also, the control overhead adds to the necessary processing in each node, hence increasing the battery depletion time. Another downside to OLSR is that it must maintain information about routes that may never be used, hence wasting possibly scarce resources.

Then, the higher computation will be time consuming. In the mobile network, the change of the nodes is considerable frequent. Once when a change of neighborhood happened (neighbor failed or add new neighbor) or a change of the 2 hop neighbor set, we then have to re-calculate the MPRs. This situation may happen now and then, so the bad thing is it will take you always computation. At last the implementation is complexity. Firstly, OLSR is designed for large and dense network, and the larger and the denser the better. Secondly, to get 1 hop MPRs and calculate the 2 hop neighbors might be a troublesome job. [16]

4.3 Hybrid protocols

4.3.1 Proactive vs. Reactive protocol

In general, the existing routing protocols for mobile ad-hoc network can be classified either as proactive or as reactive.

The advantage of the proactive schemes is that, once a route is needed, there is little delay until the route is determined. However, pure proactive schemes are likewise not appropriate for the ad hoc networking environment, as they continuously use a large portion of the network capacity to keep the routing information current. Since nodes in an ad hoc network move quite fast, and as the changes may be more frequent than the route requests, most of this routing information is never even used! This results in a further waste of the wireless network capacity.

In reactive protocols, route information may not be available until a packet needs to be forwarded. 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 broadcast and discovery, but the delay to determine a route can be quite significant. Furthermore, the global flood-search procedure of the reactive protocols requires additional control traffic, again putting strain on the limited bandwidth. Because of this long delay and excessive control traffic, pure reactive routing protocols may not be applicable to real-time communication.

4.3.2 ZRP is a hybrid of the proactive and reactive routing protocol

What is needed is a protocol that, on one hand, initiates the route determination procedure on-demand, but at limited search cost. The protocol termed the "Zone Routing Protocol (ZRP)" is an example of such a hybrid proactive/ reactive scheme.

The benefits provided by routing zones, compared with the overhead of proactively tracking routing zone topology, determine the optimal framework configuration. As network conditions change, the framework can be dynamically reconfigured through adjustment of each node's routing zone

“The hybrid Zone Routing Protocol (ZRP) framework can adapt to a wide variety of network scenarios by adjusting the range of the nodes’ proactively maintained routing zones. Large routing zones are preferred when demand for routes is high and/or the network consists of many slowly moving nodes. In the extreme case of a network with fixed topology, the ideal routing zone radius would be infinitely large. (Consider the purely proactive routing protocols used on the fixed Internet). On the other hand, smaller routing zones are appropriate in situations where route demand is low and/or the network consists of a small number of nodes that move fast relative to one another. In the "worst case", a routing zone radius of one hop is best, and the ZRP defaults to a traditional reactive flooding protocol. However, in most cases, the ZRP protocol’s performance is better than both proactive and reactive protocols.” [16]

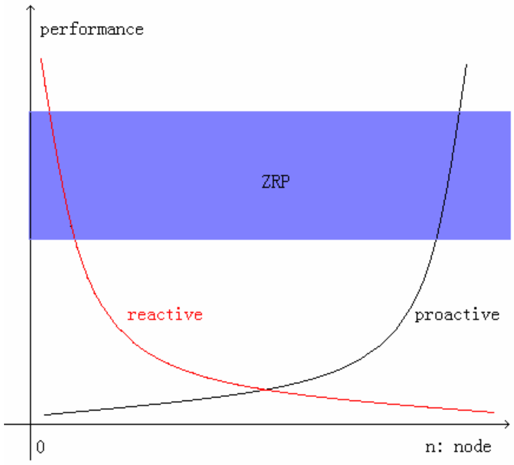

Figure 4-3 the performance of reactive, proactive and ZRP protocols

Figure 4-3 shows that the reactive protocol has better performance when there are a few nodes, while the proactive protocol has better performance when there are a lot of nodes. And the ZRP protocol has better performance than both of the former two protocols in most of cases.

4.3.3 ZRP performance

In order to maximize performance of the ZRP, 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 ZRP, this goal can be reduced to finding the correct - i.e. optimal - size of the routing zone radius r for the given network - which may vary from case to case, depending on the circumstances.

For example, in a stationary network, it would be possible to increase r to a larger number, without too much of a penalty: in this situation, the position or the number of available nodes changes infrequently, so that, given a larger routing zone radius, the nodes could take advantage of the comparably static and immediately available, since pro-actively maintained, routes.

On the other hand, mobile nodes without a stationary fixpoint would not benefit from large zones: the cost of maintaining the ever-changing local routes is too high, particularly since most of the routes are so short-lived that they are never used. Instead, a zone radius of r <= 3 would be beneficial, to ensure that the zones overlap enough to allow for route-redundancy.

The ZRP has a good scalability and a better performance in large zones. “The IARP traffic grows with the number of nodes in a given zone, while increased mobility of the 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 general, it can be stated that ``larger zones provide more efficient queries, which compensates for the IARP maintenance cost”. [17]

5 Conclusion

To summarize our whole task, we mainly discuss several different kinds of mobile ad hoc networks both the advantages and the disadvantages. All of these routing protocols are suited for different mobile environments. The IETF MANET Working Group has researched and developed a number of protocols for mobile ad-hoc networks, which we have described previously. These protocols can generally be categorized into two groups: proactive and reactive protocols.

In reactive protocols, DSR is more suitable in the MANET with small size, while AODV can handle much more but still restricted by the reactive protocols' characteristic. When comes to the large scale, proactive protocols will fit well. Compare with reactive protocols, proactive protocols is better in providing required route immediately. And OLSR is used in large and dense mobile environments.

A protocol which combines the two kinds of protocols is zone routing protocol. For routing operation inside the local zone, any proactive routing scheme can be applied. For interzone routing on demand (reactive) routing is used. The advantage of zone routing is its scalability, as global routing table overhead is limited by zone size. Yet, the benefits of global routing are preserved within each zone.

Appendix

A1 Glossary & abbreviations

- ABR
  Associativity-Based Routing
- AODV
  Ad hoc On-Demand Distance Vector
- BRP
  Bordercast Resolution Protocol
- DSDV
  Destination-Sequenced Distance-Vector Routing
- DSR
  Dynamic source routing protocol
- IARP
  Intrazone Routing Protocol
- ICMP
  Internet Control Message Protocol
- IERP
  Interzone Routing Protocol
- LAN
  Local Area Networks
- LS
  Link State
- MAC
  Media access control
- MANET
  Mobile Ad-hoc Networks
- MPR
  Multipoint Relay
- NDP
  Neighbour Discovery Protocol
- OLSR
  Optimized Link State Routing
- QoS
  Quality of Service
- RREQ
  Route Requests
- RREP
  Route Replies
- RERR
  Route Errors
- SSA
  Signal Stability based adaptive routing
- TORA
  Temporally Ordered Routing Algorithm
- WRP
  Wireless Routing Protocol
- ZRP
  Zone Routing Protocol

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