A STUDY ON MOBILE AD HOC NETWORK ROUTINGS

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Abstract: Mobile Ad hoc Networks (MANETs) has gained an important part of the interest of researchers and become very popular in last few years. MANETs can operate without fixed infrastructure and can survive rapid changes in the network topology. In this paper will introduce an overview about ad hoc networks, different definitions, different classifications, properties and different applications. Researchers are designing new MANETs routing protocols, comparing and improving existing MANETs routing protocols before any routing protocols are standardized. In this paper we have discussed routing fundamentals in MANET.

Keywords: Mobile ad hoc network, routing, reactive, proactive, Multi Hop

I.INTRODUCTION

Mobile Ad hoc Networks (MANETs) has a dynamic nature, which makes it ideal for different applications. This kind of network is more suitable in emergencies such as natural disasters due to quick deployment and minimal configuration. MANET is becoming more popular in the advance technology deployment devices such as mobile phones, MP3 players, and Wi-Fi capable laptops etc [1][2]. A special form of routing protocols is necessary in case of ad hoc networks, since two hosts wishing to exchange packets may not be within wireless transmission range of each other (i.e. not be able to communicate directly), but could communicate if other mobile nodes between them are also participating in the ad hoc network and are willing to forward packets for them [2][3]. For example, Figure 1 illustrates a mobile ad hoc network with three wireless mobile hosts. Node 3 is not within the range of node 1's wireless transmitter (indicated by the circle around node 1) and vice versa. If node 1 and node 3 wish to exchange packets, they must enlist the services of node 2 to forward packets for them, since node 2 is within the range overlap between node 1 and node 3.

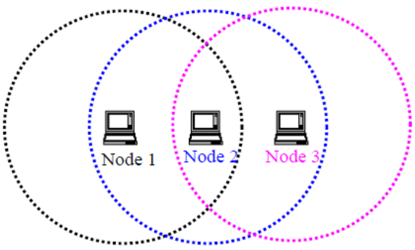

Figure 1: Exchange packets in a three mobile nodes ad hoc network

Each time a packet is transmitted to a neighboring node, it is said to have made a *hop*. In the above example, when node 1 sends a packet to node 3, the packet makes two hops: first from node 1 to node 2, and second from node 2 to node 3.

The situation in Figure 1 becomes more complicated with the addition of more nodes. The addition of just one node, as illustrated in Figure 3-20, results in multiple paths existing between nodes 1 and 3; packets may travel the path 1 - 2 - 3, 1 - 4 - 3, or even 1 - 4 - 2 - 3. An ad hoc routing protocol must be able to decide on a single "best" path between any two nodes.

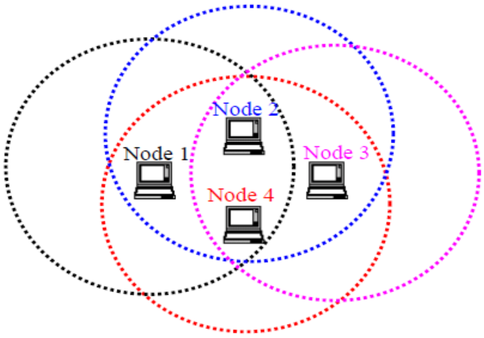

Figure 2: Exchange packets in a four mobile nodes ad hoc network

Sometimes in a network of mobile nodes, parts of the network may become isolated and separate[4]. This effect is called network *partitioning* and is illustrated in Figure 2. When network partitioning occurs, nodes can continue to exchange information within the same partition, but it is impossible for information to flow between separated partitions.

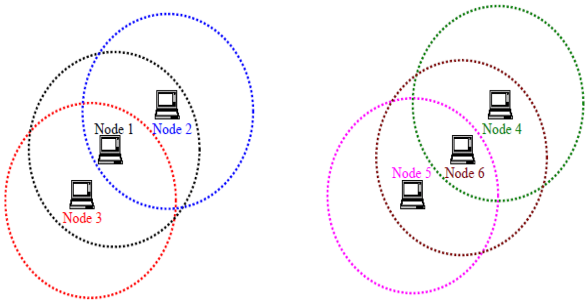

Figure 3: Ad hoc network partitioned into two separate networks

Another unique situation of wireless networks is illustrated in Figure 3. In this example, node 1 has a large enough range to transmit packets directly to node 3. However, node 3 has a much smaller range and must enlist the help of node 2 in order to return packets to node 1. This makes the link between node 1 and node 3 appears as a one-way or unidirectional link. Most conventional routing protocols require bi-directional links.

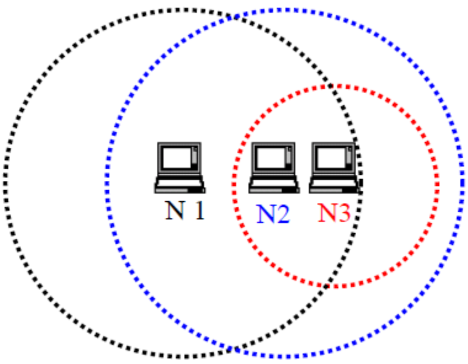

Figure 4: Ad hoc network with a one-way link

In summary, routing protocols for ad hoc networks face several challenges. Ad hoc networks require multi-hop forwarding to facilitate information exchange. Wireless links are nonuniform and can cause unidirectional links. By their nature, mobile nodes tend to "wander around", changing their network location and link status on a regular basis, sometimes partitioning the network. Furthermore, new nodes may unexpectedly join the network or existing nodes may leave or be turned off. It is the goal of ad hoc routing protocols to provide network connectivity despite these challenges.

Ad hoc routing protocols must minimize the time required to converge after these topology changes. A low convergence time is more critical in ad hoc networks because temporary routing loops can result in transmitting packets in circles, further consuming valuable bandwidth.

II.PROPERTIES OF MOBILE AD HOC NETWORKS

MANETs have the following special features that should be considered in designing solutions for this kind of networks [5].

- **Dynamic Topology:** Due to the node mobility, the topology of mobile multi-hop ad hoc networks changes continuously and unpredictably. The link connectivity among the terminals of the network dynamically varies in an arbitrary manner and is based on the proximity of one node to another node. It is also subjected to frequent disconnection during node's mobility. MANET should adapt to the traffic and propagation conditions as well as to the mobility patterns of the mobile network nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly. Moreover, a user in the MANET may not only operate within the ad hoc network, but may require access to a public fixed network.

- **Bandwidth:** MANETs have significantly lower bandwidth capacity in comparison with fixed networks. The used air interface has higher bit error rates, which aggravates the expected link quality. Current technologies suitable for the realization of MANETs are IEEE 802.11(b,a) with bandwidth up to 54Mbps and Bluetooth providing bandwidth of 1Mbps. The nature of high bit-error rates of wireless connection might be more profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subjected to noise, fading and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the links themselves can be heterogeneous.
- **Energy:** All mobile devices will get their energy from batteries, which is a scarce resource. Therefore the energy conservation plays an important role in MANETs. This important resource has to be used very efficiently. One of the most important system design criteria for optimization may be energy conservation.
- **Security:** The nodes and the information in MANETs are exposed to the same threats like in other networks. Additionally to these classical threats, in MANETs there are special threats, e.g. denial of service attacks. Also mobility implies higher security risks than static operation because portable devices may be stolen or their traffic may insecurely cross wireless links. Eavesdropping, spoofing and denial of service attacks should be considered.
- **Autonomous:** No centralized administration entity is required to manage the operation of the different mobile nodes. In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router. So usually endpoints and switches are indistinguishable in MANET.
- **Distributed Operation:** Since there is no background network for the central control of the network operations, the control and management of the network is distributed among the terminals. The nodes involved in a MANET should collaborate among themselves and each node acts as a relay as needed, to implement functions e.g. security and routing.
- **Multi-hop Routing:** Basic types of ad hoc routing algorithms can be single-hop and multi-hop, based on different link layer attributes and routing protocols. Single-hop MANET is simple in comparison with multi-hop MANET in terms of structures and implementation. When delivering data packets from a source to its destination out of the direct wireless transmission range, the packets should be forwarded via one or more intermediate nodes.
- **Light-Weight Terminals:** In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size and low power storage.
- **Infrastructureless and Self Operated:** A mobile ad hoc network includes several advantages over traditional wireless networks, including: ease of deployment, speed of deployment and decreased dependence on a fixed

infrastructure. MANET is attractive because it provides an instant network formation without the presence of fixed base stations and system administrators.

III. CHALLENGES IN MOBILE AD HOC NETWORK ROUTING

Some of the important factors that make routing in mobile ad hoc networks with wireless links challenging are[6]:

a) Frequent Topology Changes

All nodes in a MANET are mobile; this means that the topology is dynamic and routes that existed may not exist some time later due to the movement of the intermediate nodes. To alleviate this problem, the protocol should be resilient to topology changes. Reactive protocols that try to mend disconnected paths incur large control overhead and yet packets are lost during the reconstruction phase. Proactive protocols constantly update their routes but the constant overhead generated proves to be expensive in cases where the movement among the nodes is limited.

b) Frequent and Unpredictable Connectivity Changes

MANETs are expected to be used in hostile environments such as battlefields and emergency operations. As such, any routing protocol should not only be able to deal with frequent topology changes but also with unpredictable connectivity changes for instance due to changing weather patterns or varied geographies. Wireless links behave unpredictably in these situations.

c) Bandwidth Constrained and Variable Capacity Links

MANETs use wireless links that offer limited bandwidth for transmission. Further, these links may be of variable capacity. This presents one of the most important challenges to any routing protocol - keeping the bandwidth usage to a minimum even while responding reactively to changes in topology or proactively maintaining routes. Further, this also presents challenges in terms of the optimization of network routes in the MANET environment.

IV. REQUIREMENT OF NEW ROUTING PROTOCOLS:

In ad hoc networks, we need new routing protocols because of the following reasons[7]:

- Nodes in ad hoc networks are mobile and the topology of interconnections between them may be quite dynamic.
- Existing protocols exhibit least desirable behavior when presented with a highly dynamic interconnection topology.
- Existing routing protocols place a too heavy computational burden on each mobile computer in terms of the memory-size, processing power and power consumption.
- Existing routing protocols are not designed for dynamic and self-starting behavior as required by users wishing to utilize ad hoc networks.
- Existing routing protocols like the Distance Vector Protocol take a lot of time for convergence upon the failure of a link, which is very frequent in ad hoc networks.
- Existing routing protocols suffer from looping problems either short lived or long lived.
- Methods adopted to solve looping problems in traditional routing protocols may not be applicable to ad hoc networks.

V. FEATURES REQUIREMENTS FOR A ROUTING PROTOCOL IN AD HOC NETWORKS

The protocols to be used in the ad hoc networks should have the following features[8]:

- The protocol should adapt quickly to topology changes.
- The protocol should provide loop free routing.
- The protocol should provide multiple routes from the source to destination and this will solve the problems of congestion to some extent.
- The protocol should have minimum control message overhead due to exchange of routing information when topology changes occur.
- The protocol should allow quick establishment of routes so that they can be used before they become invalid.

VI. ROUTING PROTOCOL RESEARCH ISSUES

a) Table Driven Routing Protocols (Proactive)

In proactive or table-driven routing protocols, each node continuously maintains up-to-date routes to every other node in the network. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency. Thus, if a route has already existed before traffic arrives, transmission occurs without delay. Otherwise, traffic packets should wait in queue until the node receives routing information corresponding to its destination. However, for highly dynamic network topology, the proactive schemes require a significant amount of resources to keep routing information up-to-date and reliable. Proactive protocols suffer the disadvantage of additional control traffic that is needed to continually update stale route entries. Since the network topology is dynamic, when a link goes down, all paths that use that link are broken and have to be repaired. If no application is using these paths, then the effort gone in to repair may be considered wasted. This wasted effort can cause scarce bandwidth resources to be wasted and can cause further congestion at intermediate network points. Proactive protocols are scalable in the number of flows and the number of nodes but are not scalable in the frequency of topology change. Thus, this strategy is appropriate for a network with low mobility[9].

Certain proactive routing protocols are Destination-Sequenced Distance Vector (DSDV), Wireless Routing Protocol (WRP), Global State Routing (GSR) and Clusterhead Gateway Switch Routing (CGSR).

b) On-Demand Routing Protocols (Reactive)

In contrast to proactive approach, in reactive or on demand protocols, a node initiates a route discovery throughout the network, only when it wants to send packets to its destination. For this purpose, a node initiates a *route discovery* process through the network. This process is completed once a route is determined or all possible permutations have been examined. Once a route has been established, it is maintained by a *route maintenance* process until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. In reactive schemes, nodes maintain the routes to active destinations. A route search is needed for every unknown destination. Therefore, theoretically the communication overhead is reduced at expense of delay due to route research. Furthermore, the rapidly changing topology may break an active route and cause subsequent route searches [10]. Reactive protocols may not be optimal in terms of bandwidth utilization because of flooding of the route discovery request, but they remain scalable in the frequency of topology change. Such protocols are not scalable in the number of nodes, however, they can be made scalable if a hierarchical architecture is used. Further reactive protocols are not scalable in the number of flows. Thus, reactive strategies are suitable for networks with high mobility and relatively small number of flows.

Some reactive protocols are Cluster Based Routing Protocol (CBRP), Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), Associativity-Based Routing (ABR), Signal Stability Routing (SSR) and Location Aided Routing (LAR).

c) Hybrid Protocols

Finally in hybrid protocols, each node maintains both the topology information within its zone and the information regarding neighboring zones that means proactive behavior within a zone and reactive behavior among zones. Thus, a route to each destination within a zone is established without delay, while a route discovery and a route maintenance procedure is required for destinations that are in other zones[11].

The zone routing protocol (ZRP), zone-based hierarchical link state (ZHLS) routing protocol and distributed dynamic routing algorithm (DDR) are three hybrid routing approaches. The hybrid protocols can provide a better trade-off between communication overhead and delay, but this trade-off is subjected to the size of a zone and the dynamics of a zone. Furthermore, hybrid approaches provide a compromise on scalability issue in relation to the frequency of end-to-end connection, the total number of nodes and the frequency of topology change. Thus, the hybrid approach is an appropriate candidate for routing in a large network.

VII.ROUTING ARCHITECTURE

a) Flat Architecture

In flat architecture, all nodes carry the same responsibility. Flat architectures do not optimize bandwidth resource utilization in large networks because control messages have to be transmitted globally throughout the network, but they are appropriate for highly dynamic network topology. The scalability decreases when the number of nodes increases significantly.

b) Hierarchical Architecture

On the contrary, in hierarchical architecture, aggregated nodes into clusters and clusters into super-clusters conceal the details of the network topology. Some nodes, such as cluster heads and gateway nodes have a higher computation communication load than other nodes. Hence, the mobility management becomes complex. The network reliability may also be affected due to single points of failure associated with the defined critical nodes. However, control messages may only have to be propagated within a cluster. Thus, the multilevel hierarchy reduces the storage requirement and the communication overhead of large wireless networks by providing a mechanism for localizing each node. In addition, hierarchical architectures are more suitable for low mobility case. Although flat architectures are more flexible and simpler than hierarchical one, hierarchical architectures provide more scalable approach[12].

c) Aggregate Architecture

Finally, aggregate architecture aggregates a set of nodes into zones. Therefore, the network is partitioned into a set of zones. Each node belongs to two levels topology: low level (node level) topology and high level (zone level) topology. Also, each node is characterized by two ID numbers: node ID number and zone ID number. Normally, aggregate architecture is related to the notion of zone. In aggregate architecture, we find both intra-zone and inter-zone architectures which in turn can either support flat or hierarchical architecture.

VIII. CLASSIFICATION OF ROUTING ALGORITHMS

Routing algorithms are classified as follows [13]:

- Centralized versus Distributed
- Static versus Dynamic.
- Proactive versus Reactive
- Unicast versus Multicast

In *centralized* routing algorithms, a main controller is responsible for updating all the nodes' routing tables and/or to make every routing decision. Centralized algorithms can be used only in particular cases and for small networks. In *distributed* routing algorithms, the computation of routes is shared among the network nodes, which exchange the necessary information. The distributed paradigm is currently used in the majority of network systems.

In *static* routing systems, the path taken by a packet is determined only on the basis of its source and destination, without regard to the current network state. This path is usually chosen as the shortest one according to cost criterion. In *dynamic* routing systems, the routing policy can adapt to time and varying traffic conditions. As a drawback, they can cause oscillations in selected paths. This fact can cause circular paths, as well as large fluctuations in measured performance.

In a *proactive* routing protocol, all the routes to each destination are kept in an up-to-date table. Changes in the network topology are continually updated as they occur. The differences between the protocols are in how the changes are spread through the network and how many tables each node maintains. In the *reactive* approach, a connection between two nodes is only created when it is asked for by a source. When a route is found, it is kept by a route maintenance procedure until the destination no longer exists or is not needed anymore.

In case of *multicast* routing, a single packet is sent simultaneously to multiple recipients, but in *unicast* routing, a single packet is only sent to one recipient every transmission. Thus, the multicast method is a very efficient and useful way to support group communication when bandwidth is limited and energy is constrained.

IX.CONCLUSION

Mobile Ad hoc Networks (MANETs) have received increasing research attention in recent years. There are many active research projects concerned with MANETs. Mobile ad hoc networks are wireless networks that use multi-hop routing instead of static networks infrastructure to provide network connectivity. Routing in MANETs is a hard work and actually it is an interesting research area that has been growing in recent years. Its difficulty is mainly generated because of the continuous changes in the network. There exist some traditional solutions such as *proactive* protocols and *reactive* protocols, each one with its advantages and disadvantages. In this paper we studied about routing and MANET Basics.

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