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Abstract - Mobile Ad hoc networks (MANET) are considered as promising communication networks in situations where rapid deployment and self-configuration is essential. In ad hoc networks, nodes are allowed to communicate with each other without any existing infrastructure. Typically every node should also play the role of a router. This kind of networking can be applied to scenarios like conference room, disaster management, battle field communication and places where deployment of infrastructure is either difficult or costly. Many routing protocols exist to enable communication in ad hoc networks like, DSR [2], AODV [1], DSDV [3], etc. All these protocols assume that the source and destination nodes can reach each other using a single or multi-hop path. But, there exist situations when connectivity between source and destination cannot be guaranteed always. DSR [2] delivers data in a MANET with the assumption that the network is connected. DSR, fails when the network is partially connected, source and destination are in different partitions. Connectivity in the network is very low for less number of nodes in the network. As the density of nodes increases, connectivity improves.

In this Paper we mainly focus on these kinds of networks. We discuss the challenges in Mobile ad hoc network and more topology related details and the applicability of one of the existing routing schemes (DSR) on these networks in the forthcoming sections. In this paper we proposed SDRS(Smart DSR protocol) which deliver data in a partially connected ad hoc network.

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Proposed Smart DSR(S-DSR) Protocol for Ad Hoc Network

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Abstract - Mobile Ad hoc networks (MANET) are considered as promising communication networks in situations where rapid deployment and self-configuration is essential. In ad hoc networks, nodes are allowed to communicate with each other without any existing infrastructure. Typically every node should also play the role of a router. This kind of networking can be applied to scenarios like conference room, disaster management, battlefield communication and places where deployment of infrastructure is either difficult or costly. Many routing protocols exist to enable communication in ad hoc networks like, DSR [2], AODV [1], DSDV [3], etc. All these protocols assume that the source and destination nodes can reach each other using a single or multi-hop path. But, there exist situations when connectivity between source and destination cannot be guaranteed always. DSR [2] delivers data in a MANET with the assumption that the network is connected DSR, fails when the network is partially connected, source and destination are in different partitions. Connectivity in the network is very low for less number of nodes in the network. As the density of nodes increases, connectivity improves.

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I. INTRODUCTION

An ad hoc network can be defined as an assembly of communication nodes willing to communicate with one another over a wireless medium. There is no fixed infrastructure in an ad hoc network, unlike in the cellular networks. Such devices can communicate with another node that is immediately within their radio range (peer-to-peer communication) or one that is outside their radio range (remote-to-remote communication) using intermediate node(s) to relay or forward the packet from the source (sender) toward the destination (receiver) [6]. Power consumption is a serious issue in an ad hoc networks, since it rely on forwarding data packets sent by other nodes.

Ad hoc networks are self-creating, self-organizing and self-administering. That is to say that a formed network can be deformed while on transit without the need for any system administration. Ad hoc network is mostly used in conditions where there is non-

availability of infrastructure, unreliable or entrusted networks especially under emergency conditions.

Example of such communication capacity of an ad hoc networking can be applied in military war fighters in the battlefield, conferencing, sensor networks, home networking, embedded computing and personal area networking.

Due to lack of wired infrastructures and power control, there is always a problem of constant changes in the connectivity and link characteristics in ad hoc networks. In an ad hoc networking, multi-layer problem is always the case. Here, the physical layer should adapt to the constant changes in the link characteristics. It is important that ad hoc network applications should be design in such a way that it will handle connectivity problems. Packet delay and lost problems as well, have to be put into consideration when designing the network.

II. CHALLENGES IN MANET

Two main challenges in MANETs (when traditional routing protocols fail) are Intermittent Connectivity and Network Partition.

Intermittent connectivity:

- When nodes are in motion, links can be obstructed by intervening objects.
- When nodes conserve power, links are shutdown periodically Network partition:
- When no path exists between source and destination, it is perfectly possible that two nodes may never be part of the same connected portion of the network.

III. ISSUES IN CONVENTIONAL MANET ROUTING PROTOCOL

Intermittently Connected Mobile ad hoc network with long disconnection time creates network partition. In this context, conventional routing schemes fail, because they try to establish complete end-to-end path between sources to destination before any data is sent. Existing Routing protocols [1],[2] simply discard the packets if the packet is not delivered within a small amount of time. These routing protocols fail in Intermittently Connected Mobile Ad hoc networks because of the following characteristics of Network:

- Intermittent network contacts

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- End-to-end path between the source and the destination may have never existed
- Disconnection and reconnection is common highly variable link performance

IV. PARTIALLY CONNECTED AD HOC NETWORK

Intermittently connected Mobile Ad hoc networks are mobile wireless networks where most of the time there does not exist a complete path from a source to a destination, or such a path is highly unstable and may change or break soon after it has been discovered. This is due to Node mobility, limited radio range, physical obstacles, severe weather, wide deployment area or other physical factors. Most ad hoc network routing algorithms are designed for networks that are always connected. While it is certainly desirable to maintain a connected network, various conditions may cause a mobile ad hoc network to become partitioned, meaning that there is no single-hop or multiple-hop route between some (or all) source/destination node pairs. Might prevent some nodes from communicating with others and result in a partitioned network. The existence of network partitioning requires a new routing approach other than the traditional "store-and forward" routing paradigm used in most current ad hoc routing algorithms, in which messages are dropped if no route is found to reach a destination within a small amount of time.

V. ROUTING CONSIDERATIONS IN PARTIALLY CONNECTED AD HOC NETWORK

There are many characteristics DTN protocols, including routing, must take into consideration. A first consideration is if information about future contacts is readily available. For example, in interplanetary communications, many times a planet or moon is the cause of contact disruption, and large distance is the cause of communication delay. However, due to the laws of physics, it is possible to predict the future in terms of the times contacts will be available, and how long they will last. These types of contacts are known as scheduled or predictable contact [7]. On the contrary, in disaster recovery networks the future location of communicating entities, such as emergency responders, may not be known. These types of contacts are known as intermittent or opportunistic contacts.

A second consideration is if mobility can be exploited and, if so, which nodes are mobile. There are three major cases, classifying the level of mobility in the network. First, it is possible that there are no mobile entities. In this case, contacts appear and disappear based solely on the quality of the communication channel between them. For instance, in interplanetary

networks, large objects in space, such as planets, can block communicating nodes for a set period of time. Second, it is possible that some, but not all, nodes in the network are mobile. These nodes, sometimes referred to as Data Mule [8][9], are exploited for their mobility. Since they are the primary source of transitive communication between two non-neighboring nodes in the network, an important routing question is how to properly distribute data among these nodes. Third, it is possible that the vast majority, if not all, nodes in the network are mobile. In this case, a routing protocol will most likely have more options available during contact opportunities, and may not have to utilize each one[11][13][14]. An example of this type of network is a disaster recovery network where all nodes (generally people and vehicles) are mobile [15]. A second example is a vehicular network where mobile cars, trucks, and buses act as communicating entities [6].

A third consideration is the availability of network resources. Many nodes, such as mobile phones, are limited in terms of storage space, transmission rate, and battery life. Others, such as buses on the road, may not be as limited. Routing protocols can utilize this information to best determine how messages should be transmitted and stored to not over-burden limited resources. As of April 2008, only recently has the scientific community started taking resource management into consideration, and this is still an active area of research

VI. RELATED WORK

A number of projects attempt to enable message delivery in a partially connected Ad Hoc Network **Data MULE project** uses mobile nodes to collect data from sensors which is then delivered to a base station. The Data MULEs are assumed to have sufficient buffer space to hold all data until they pass a base station. The approach is similar to the technique used in [25]. These projects study opportunistic forwarding of information from mobile nodes to a fixed destination. However, they do not consider opportunistic forwarding between the mobile nodes. Li [22] explore message delivery in disconnected MANETs where nodes can be instructed to move in order to transmit messages in the most efficient manner.

Epidemic Routing [32] provides message delivery in disconnected environments where no assumptions are made in regards to control over node movements or knowledge of the network's future topology. Each host maintains a buffer containing messages. Upon meeting, the two nodes exchange summary vectors to determine which messages held by the other have not been seen before. They then initiate a transfer of new messages. In this way, messages are propagated throughout the network. This method guarantees delivery if a route is available but is

expensive in terms of resources since the network is essentially flooded. Attempts to reduce the number of copies of the message are explored in [25] and [26]. Ni et al. [25] take a simple approach to reduce the overhead of flooding by only forwarding a copy with some probability $p < 1$, which is essentially randomized flooding.

The **Spray-and-Wait** solution presented by Spyropoulos [26] assigns a replication number to a message and distributes message copies to a number carrying nodes and then waits until a carrying node meets the destination. A number of solutions employ some form of 'probability to deliver' metric in order to further reduce the overhead associated with Epidemic Routing by preferentially routing to nodes deemed most likely to deliver. These metrics are based on contact history, location information or utility metrics.

The **message ferrying project** [23] proposes proactively changing the motion of nodes to help deliver data. They investigate both 'node initiated' mobility, where the nodes move to meet a known message ferry trajectory, or 'ferry initiated' mobility, where the nodes signal communication requests via a long range radio, and the message ferry moves to meet them. Both assume control over node movements and in the case of message ferries, knowledge of the paths to be taken by these message ferry nodes. Other work utilizes a time-dependent network graph in order to efficiently route messages.

Replace message ferrying approach [33] state that in message ferrying approach ferry node is a central point of failure for the system. New approaches have been proposed which focus on the reliability of the systems. One of the solutions to this problem is replacement of ferry as proposed in. They proposed two protocols - either change the ferry node when the current ferry node fails, or change the ferry node periodically. The first method is centralized approach where successor ferry is always decided by the present ferry. Later is a distributed way of choosing the ferry node. Here each node declares its willingness to become ferry and on the basis of vote, one node will be chosen as ferry node information only.

Musolesi. [27] Introduce a generic method that uses Kalman filters to combine and evaluate the multiple dimensions of a node's context in order to make routing decisions. The context is created from measurements that nodes perform periodically, which can be related to connectivity. The approach only uses a single copy of a message, which is passed from one node to a node with a higher 'delivery metric'.

Jain [21] assume knowledge of connectivity patterns where exact timing information of contacts is known, and then modifies Dijkstra's algorithm to compute the cost edges and routes accordingly.

Merugu likewise make the assumption of detailed knowledge of node future movements.

Handorean [31] take a similar approach with knowledge of connectivity. However, they do relax this assumption where only partial information is known. This information is time-dependent and routes are computed over the time-varying paths available. However, if nodes do not move in a predictable manner, or are delayed, then the path is broken. Additionally, if a path to the destination is not available using the time-dependent graph, the message is flooded.

PROPHET Routing [30] is also probability-based, using past encounters to predict the probability of meeting a node again, nodes that are encountered frequently have an increased probability whereas older contacts are degraded over time. Additionally, the transitive nature of encounters is exploited where nodes exchange encounter probabilities and the probability of indirectly encountering the destination node is evaluated. Similarly [25] and [29] define probability based on node encounters in order to calculate the cost of the route. [27] And [28] use the so-called 'time elapsed since last encounter' or the 'last encounter age' to route messages to destinations. In order to route a message to a destination, the message is forwarded to the neighbor who encountered the destination more recently than the source and other neighbors.

Spyropoulos [20] use a combination of random walk and utility-based forwarding. Random walk is used until a node with a sufficiently high utility metric is found after which the utility metric is used to route to the destination node.

Leguay [24] present a virtual coordinate system where the node coordinates are composed of a set of probabilities, each representing the chance that a node will be found in a specific location. This information is then used to compute the best available route.

Lebrun [28] propose a location-based delay-tolerant routing scheme that uses the trajectories of mobile nodes to predict their future distance to the destination and passes messages to nodes that are moving in the direction of the destination.

Border node Based Routing (BBR)[35] protocol for partially connected VANETs state that considers the characteristics of partially connected VANETs while at the same time takes into account the limitations of existing routing approaches for partially connected ad hoc networks. The BBR protocol is specifically designed to accommodate for the effects of node mobility on data delivery. The BBR protocol has two basic functional units: a neighbor discovery algorithm, and a border node selection algorithm. The neighbor discovery process is responsible for collection of current one-hop neighbor information. This step requires periodic beaconing of "hello" messages. The border node selection process is responsible for selection of the right candidate/candidates for packet forwarding based on

the one hop neighbor information collected in the neighbor discovery process.

Random and Encounter Time Based Forwarding mechanism[4] state that based on the analysis of the existing utility-based forwarding mechanisms, for the inefficient forwarding of history encounter time based forwarding mechanism in the initial phase of the node movement, a Random and Encounter Time Based algorithm named RET is proposed in this paper. RET divides the nodes moving into two phases-random forwarding phase (initial phase) and utility-based forwarding phase. In random forwarding phase, random algorithm is used to forward packets. And in utility-based forwarding phase, the packets are forwarded by using utility value. The results of simulation experiment show that the RET algorithm can reduce the delivery delay under low node density.

VII. WORKING OF DSR

DSR contains 2 phases

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

Route Discovery and Route Maintenance only response on a request.

a) Route Discovery

If node A has in his Route Cache a route to the destination E, this route is immediately used. If not, the Route Discovery protocol is started:

- Node A (initiator) Sends a Route Request packet by flooding the network as shown in Fig1, each route request packet contains
 - Route record
 - Initiator Address
 - Request ID

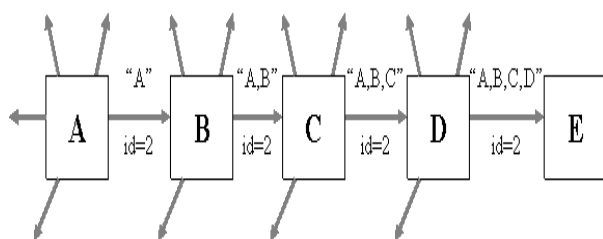


Fig. 1: Route Discovery example: Node A is the initiator, and node E is the target

- If the route discovery is successful the initiating host receives a route reply packet.
- When any host receives a route request packet, it processes the request accounting to the following steps.
 - If $< \text{initiator address, request id} >$ is found in this host then discards the route request packet.
 - If this host's address is already listed in the route record Discard the route request packet.

- If the target of the request matches this host's address return a copy of this route in a route reply packet to the initiator.
- Otherwise, append this host's address to the route record, and re-broadcast the request.

After getting the route reply the sender send the data to the destination.

b) Route Maintenance

In DSR every node is responsible for confirming that the next hop in the Source Route receives the packet. Also each packet is only forwarded once by a node (hop-by-hop routing). If a packet can't be received by a node, it is retransmitted up to some maximum number of times until a confirmation is received from the next hop. Only if retransmission results in a failure, a Route Error message is sent to the initiator that can remove that Source Route from its Route Cache. So the initiator can check his Route Cache for another route to the target. If there is no route in the cache, a Route Request packet is broadcasted.

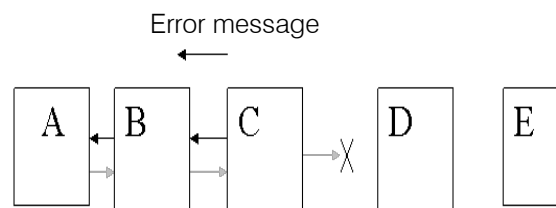


Fig. 2:

- If node C does not receive an acknowledgement from node D after some number of requests, it returns a Route Error to the initiator A.
- As soon as node receives the Route Error message, it deletes the broken-link-route from its cache. If A has another route to E, it sends the packet immediately using this new route.
- Otherwise the initiator A is starting the Route Discovery process again.

VIII. DSR OVER PARTIALLY CONNECTED AD HOC NETWORKS

DSR [2] delivers data in a MANET with the assumption that the network is connected DSR, fails when the network is partially connected, source and destination are in different partitions. Connectivity in the network is very low for less number of nodes in the network. As the density of nodes increases, connectivity improves. When the source node and destination node are connected then DSR work well but when the source node and destination node are not connected mean there is no path between source node and the destination node then DSR does not deliver data due to no path between source and destination.

IX. SMART DSR PROTOCOL

Smart DSR Protocol is an extension of DSR Protocol which can deliver data from a source to a destination even there is no path between source and destination. This protocol will work as normal DSR if the network is fully connected and when the network is not fully connected then also this protocol will make it ensure that data will be delivered from a source to a destination.

a) Design Issues

The following design issues have been identified that need to be addressed while Designing the proposed protocol.

- Which node will become a smart node?
- How will a source choose among the more than one smart replies?
- When will a node decide that it is in a new locality?

b) Smart Node Parameter

Which node will become the smart node there may be following parameter for that

- A node can be a smart node on behalf of the number of neighbors seen by node per unit time. If a node seen maximum number of neighbors it will indicate that mobility of node is high and there is a chance that the node will come near to the destination frequently.
- A node can be the smart node if the routing table of node is big which indicate that node is well connected to the network.

c) Selection of Smart Replies

As more than one node can send the smart reply to the source so selection of one reply out of many is also an issue to be consider. The source node can use the same parameter as we mentioned above to sort out this issue. A node which sends a smart reply will send the smart parameter to the source and source node can select best smart node on behalf of these parameters

d) Proposed Smart DSR Protocol

The proposed smart protocol will go for RREQ/RREP, RREQ/SRREP and SRREQ/SRREP cycle. We use the following symbolic notation for the proposed smart DSR protocol.

RREQ	Route Request
RREP	Route Reply
SRREQ	Smart Route Request
SRREP	Smart Route Reply

The proposed Smart DSR protocol will work according to the following steps.

Step 1 - A Source node need a route to destination it broadcast a RREQ packet across the Network.

Step 2 - Any node receiving this packet update their information for the source node and Will do following.

2.1 - If <Source address, Req id> is found in this node then discard the Route Request packet.

2.2 - If the node address listed in the Route Record. Discard the Route Request Packet.

2.3 - If the target of the Request node match this host address return a copy of this route in a Route replies Packet to the source node and goes to **Step 3**

2.4 - Otherwise append this host address to the route record, and rebroadcast this Request.

2.5 - If this is the last RREQ retry, the node checks its eligibility to become a Smart node and send a SRREP to the source if it satisfies all the criteria and goes to **Step4**

Step-3 If the source node gets the reply from the destination then after establish the path the source node send data to the destination,

Step-4 If Source node receives SRREP then it store the smart route reply and wait for more reply. After the expiry the timer the source will select some of the Smart reply and send data to only those smart nodes.

Step-5 After getting data from the original source the Smart node will do following

5.1 - After receiving the data from the source, smart node will store the data and permanently checks for new locality.

5.2 - When a smart node detect that it is in a new locality it send a SRREQ to destination on behalf of the source.

5.3 - If a smart node will receive a Route Reply from the destination then it deliver its data to the destination .After delivering the data to the actual destination the smart node will send an acknowledgement to the actual source so that the source node will aware of this fact that its data is sent to the destination.

5.4 - If Smart node will not get a route Reply from the destination it indicate that the destination is not connected with the smart node so smart node will select some another smart node to keep the data on behalf of the previous smart node and when then new smart node will move near to the destination it deliver data to the destination on behalf of the previous smart node.

5.5 - After delivery of data the new smart node will send acknowledgement to the previous smart node and when previous smart node move near to the original source node then it send an acknowledgement to the source node so that the original source node will be aware that data is deliver to the destination

e) States of Node

During the Smart DSR protocol node can be in various state those are explain below

Node has Data to Send:

This event is explained by the following algorithm1. A node initiates a RREQ message if it is the original source of this message, or it initiates a SRREQ message if it is storing data on behalf of other node.

Algorithm1:-

If node has data **Then** Node send a RREQ
If node receives a RREP **then** Protocol will use DSR
Else
If node receives SRREP **then** wait for RREP
 If there is no RREP then node will select Smart node and node sends data to the Smart node.

Node Receives a SRREQ:

This event is explained by the following algorithm 2. When a node receives a SRREQ it checks whether, it is the destination for this request.

Algorithm2:-

If a node A receive SRREQ **Then**
If A = Destination **Then** Protocol will use DSR
Else
if A is a Smart Node **Then**
 A store SRREQ in database.
 A send SRREP to source and broadcast SRREQ.
 A wait for data if data is available then A store data.

If it is the destination then the node sends a back RREP otherwise this node is not the original destination for this request then this node makes calculation for proxy selection parameters, if the parameter values are above some defined threshold then, the node sends a SRREP. At the end it simply forwards the SRREQ.

When a Node Receives a SRREP This situation is also Explain in Algorithm2. When a proxy/original source gets a original reply from a node. It simply sends data to destination.

If node gets a proxy reply then it will store this reply in a data structure and wait for route retries time out and then used some functions to evaluate the proxy route replies to choose some nodes to become proxy.

A Node Senses a New locality:

When a node realizes that it is in a new locality then it checks for locally stored data. If it finds some data then it initiates a Smart route request for that data.

X. CONCLUSION

The Smart DSR protocol designed in the work behave like a normal DSR protocol if the source and the destination are connected and however there is no path between source and destination then the Smart DSR protocol will be used to send the data between source and destination therefore using of the above protocol shall enhance the DSR Routing in partially connected network as well.

The proposed protocol seems to be effective when the network is partially connected additionally the proposed protocol will work when the network is connected mean there is a path between source and destination. We can enhance the efficiency of the protocol by changing the parameter for selection of a proxy node.

There is a trade off between "Load on Network" and "Message Delivery efficiency". If we impose less restriction on proxy selection, then the probability of message delivery increases But at the same time load on network and nodes increases. If we impose strict restrictions on proxy selection criteria, then message delivery probability decreases. In future we will modified the above mentioned protocol w.r.t the route maintaince as here the SDRS will use the same route maintaince as DSR. We also implement the above protocol on simulation and compare the result in future.

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