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Improving Qos in Disconnected Mobile Ad Hoc Network

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Abstract: A Mobile Ad Hoc Network (MANET) is a collection of mobile nodes that can communicate with each other using Multihop wireless links without using any fixed infrastructure and centralized controller. Communication links are susceptible to frequent failures due to intervening objects, which can cause intermittent connectivity i.e., there is no end-to-end path exists between source and destination all the time. Existing ad hoc routing protocols unable to deliver packets in the presence of a network partition between source and destination since they are robust to rapidly changing network topology. Flooding based schemes and Message Ferrying schemes are proposed by many researchers to overcome network partitions in intermittently connected ad hoc network. Flooding scheme is not suitable if partitions last for a long duration of time. Message Ferry distributes messages between nodes which are located in different partitions which may be disconnected. Ferry moves around a fixed path for providing regular connectivity in a disconnected network. But this scheme needs huge buffer space and also online collaboration between Ferry and other nodes in the network. With this in mind, a new routing scheme with two types of Ferries has been proposed. This scheme improves delivery rate and delay and it does not need any online collaboration between ferry and mobile nodes, it needs only online collaboration between local and global ferries.

Key words: Disconnected, message ferry, epidemic routing, delivery rate, latency

INTRODUCTION

The sharing of the information is necessary for many tasks and the urgent information can be disseminated the sooner or better a task can be completed. With the development of cheap wireless technologies like GSM and Wi-Fi, information is often available anytime and anywhere. The limitation of these technologies is that they require an infrastructure i.e., base stations for their functioning. In environments such as disaster areas or during wartime this type of infrastructure is generally not available, but information exchange is still desired. An option to communicate in these environments is to use long range radios that enable point-to-point communication. The problems with these are that they are often expensive, bulky and only provide low bandwidth communication. Hence, multihop wireless ad hoc network is used. In a multihop wireless ad hoc network, mobile nodes cooperate to form a network without using any infrastructure such as access points or base stations. Instead, the mobile nodes forward packets for each other, allowing communication among nodes outside wireless transmission range.

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. Node mobility, limited radio range, physical obstacles, severe weather, wide deployment area or other physical factors, 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 (Abolhasan *et al*., 2004).

The kind of communication networks addressed in this research are only viable for applications that can tolerate long delays and are able to deal with extended periods of being disconnected. In military war-time scenarios and disaster recovery situations, soldiers or rescue personnel often are in hostile environments where no infrastructure can be assumed to be present. Furthermore, the units may be sparsely distributed and mobile so connectivity between them is intermittent and infrequent (Davis *et al*., 2001). In any large scale ad hoc

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network, intermittent connectivity is likely to be the normal and thus research in this area is likely to have payoff in practical systems.

Issues in traditional Ad Hoc routing protocol: Existing Routing protocols (Corson and Macker, 1999) in mobile ad hoc network simply discard the packets if the packet is not delivered within a small amount of time. These routing protocols fail in Intermittently Connected Ad hoc networks because of the following characteristics of Network (Zhanq, 2006):

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

RELATED WORK

More number of works has been done on designing routing protocols in Mobile Ad hoc Networks. These routing protocols are all based on the assumption that the network is connected (Musolesi *et al*., 2005). In reality, the network could be highly-partitioned due to the various reasons specified earlier. These networks are known as Delay-Tolerant Networks (DTNs) and also disruption-tolerant networks (Zhanq, 2006). Several models based on mobility assisted scheme have been proposed to deal routing in this type of network: the existing movement-assisted routing methods can be classified into 2 categories based on the mobility control. The 1st category uses the random mobility of nodes to transmit messages. The 2nd category is controlled movement model, where nodes may change their original routes to collect and deliver messages.

One of the best existing random movement schemes is epidemic routing (Zhang *et al*., 2007). Assumption for this algorithm is nodes are all mobile and have infinite buffers. It is a flooding-based algorithm it means whenever a node has a message to send; it propagates the message to all nodes it meets and the nodes which receive continue to propagate the message. Sooner or later, the data is delivered to the destination with a high probability. This approach can achieve high delivery ratios and operates without knowledge of the network topology or communication pattern. It is well-suited for networks where the contacts between nodes are unpredictable. Animal tracking networks such as SWIN and ZebraNet uses random node mobility and flooding-based relaying (Li and Rus, 2003). Due to the considerable number of transmissions involved, these techniques suffer from high contention and may potentially lead to network congestion. To increase the network capacity, the spreading radius of a message is typically limited by imposing a maximum number of relay hops to each message, or even by limiting the total number of message copies present in the network at the same time (Spyropoulos *et al*., 2005, 2008). When no relaying is further allowed, a node can only send the message directly to destination when in case met.

Message ferrying (Zhao *et al*., 2004) is a mobility-assisted proactive routing algorithm that incorporates message ferries that allow communication among disconnected nodes. Ferries travel in a specified route, collecting data from sources and delivering data to the appropriate destinations. These message ferries allow nodes to communicate when the network is disconnected and when nodes do not have global knowledge of the network. It is a proactive routing algorithm created to address network partitions in intermittently connected ad hoc networks by establishing non-randomness in node movement. There are two types of nodes in MF scheme: Message ferries and regular nodes. This classification is based on their roles in communication. Ferries are mobile devices which take responsibility of carrying messages among other nodes, while regular nodes are devices without such responsibility. Several MF extensions could be carried out by installing multiple ferries (Zhao *et al*., 2005) in a set of subregions through partitioning. This idea can be used in remote village communications and remote area connectivity projects for providing Internet access. MF scheme provides regular connectivity in a disconnected network and also improves data delivery performance without global knowledge of each node's location. The main difficulty in designing ferry routes for arbitrarily moving nodes is that we cannot correctly predict the location of the nodes and hence it may not be possible to correctly position the ferry to contact the nodes for huge deployed area. In our research, we address the above issue with certain system requirements like message delivery latency and buffer space.

NETWORK MODEL

In this study, we focus on the application of Message Ferrying system in disconnected mobile Ad hoc networks. Regular nodes are assumed to move within the deployed area and perform the assigned tasks. It has limited in resources such as battery power, memory and computational power. Regular nodes are geographically distributed such that most of the time they cannot directly communicate with one another. Such a scenario is common in remote village communications. Remote village communication means communication between disconnected villages. Ferries are special mobile nodes which have more resources than regular nodes. For example, buses shuttle between remote villages which are equipped with memory (i.e., hard disks) and wireless interfaces can act as Ferries to collect and carry data among disconnected areas. One or more message ferry periodically visits each cluster/village to collect/deliver messages between disconnected nodes. In remote village communication, meeting point is an important place in the village where most of the people meets often regularly like bus stand, market places etc. In the meeting point, the ferry has the longest contact time with the visited nodes for exchanging message. In the regular/ferry, nodes messages will be dropped when buffer overflows or timeout expires. Timeout value depends on the delay requirement of the applications. Message ferrying is suitable for the application, which can tolerate long delay like file transfer, email and other non-real time applications.

In this proposed system, deployed area is divided into number of clusters. This system uses multiple message ferries to make connectivity between nodes. Here 2 types of ferries are used: global ferry and local ferry. Assumption here is that each Global Message Ferry (GMF) follows a fixed regular route and makes certain number of meeting points in its route. For each cluster there will be one Local Message Ferry (LMF) which receives/deliver messages from/to GMF/Regular nodes. Within each cluster there will be one or more meeting points to exchange messages. LMF route is only within its cluster. LMF's route is decided based on the location of the regular nodes in the cluster. Location of the nodes is found using global positioning system. Path is calculated such that it should cover more number of nodes. Path length should be the same/less all the time so that it can have regular contact with the global ferry. Path length of LMF is calculated based on the arrival time of the GMF.

GMF carries messages between clusters. LMF carries messages between nodes within the cluster or exchange message with GMF. Whenever source has a packet to send, it checks for a route to destination. If route found then deliver it, otherwise deliver the packet to LMF. LMF periodically checks any route to destination is found for the packet stored in its buffer. If LMF finds the route then it delivers the packet to destination. Whenever connectivity occurs between Local Ferry and Global Ferry then it exchanges the undelivered packets otherwise LMF buffers the packet. Within each cluster, regular nodes use AODV protocol for traffic within the cluster (intra-cluster traffic). We choose AODV protocol because nodes are mobile and topology changes very often.

Pseudo code

Node operation: If node has a packet to send then perform the following:

- If route to destination exists then deliver the packet to destination and remove this packet from its buffer
- If route to LMF exists then Deliver the packet to LMF
    - Else buffer the packet and wait for LMF's arrival

Local message ferry's operation:

- LMF maintains list of nodes which are located in its cluster using GPS and update this information before calculating the route.
- Before taking each trip, route is calculated such that it covers more number of nodes in its route.
- If route exist for the buffered packet then deliver the packet
    - Else wait for the Global ferry's arrival
- If GMF arrives within the communication range of LMF then
    - Exchange messages with the GMF

Global message ferry's operation:

- If route exist for the buffered packet then
- Deliver the packet to destination
- Remove the delivered packet from its buffer
- Else if connectivity exists with the LMF and Destination node is present in the LMF's cluster then Deliver the packet to LMF

RESULTS AND DISCUSSION

Simulation setup: The MANET network simulations are implemented using NS-2 simulator. The simulation period for each scenario is 1000 sec and the simulated mobility network area is 1500×1500 m rectangle. Network area is divided into 4 equal 750×750 m rectangle clusters. In each simulation scenario, atleast any one of the cluster is disconnected from the other. Nodes can move anywhere in the deployed area. GMF is assigned a particular trajectory which follows the meeting points of all the clusters. Route of the LMF is found using the location information of nodes which are located in the Local Ferry's cluster. Route is designed such that it covers more number of nodes in the cluster to improve delivery rate. There is a need of online collaboration between Local ferry and Global ferry, hence route length should be less than or equal to some fixed value which is based on the arrival time of the Global Ferry. If the length is less than the fixed value then Local Ferry should wait for some time at the Meeting Point for Global Ferry's arrival. Simulation runs are made with the number of nodes varying from 10-100. The transmission range is 250 m. Buffer size is specified as number of messages stored in the buffer. Buffer space of the nodes ranges from 10-50 and assume unlimited buffer space for message ferries.

Performance metrics: We consider data delivery rate, buffer space, node density and message delay metrics for evaluating the performance. Data delivery rate is defined as the ratio of number of successfully delivered messages to the total number messages generated. The average end-to-end delay is defined as the average delay time between the time a message is generated at the source and the time the message is received at the destination. These metrics reflect how efficiently the data is delivered. In epidemic routing, multiple copies may be delivered to the destination. Hence, delay is computed based on the time the first copy is delivered.

Analysis of results: In this study, we analyse the results of our simulations, comparing the performance of our protocol with epidemic routing protocol. We will discuss the performance metrics-delivery ratio and delay with number of hosts and buffer space for both the protocols.

In Fig. 1 there is a comparison between the delivery ratio of epidemic routing protocol in each of ten different node densities with 10, 20, 30,... 100 hosts. In all the cases, buffer size is unconstrained. Message ferry achieves an improvement in performance than that of epidemic routing protocol. Epidemic suffers from the inability to deliver messages to recipients that are in other disconnected cluster. In this protocol, message is propagated only to the accessible hosts until the TTL of the message expires. When TTL of the message expires message will be dropped. One reason for message dropping is that the recipient remains in the same disconnected cluster for long duration of time which is longer than TTL of the message. In our new scheme, message is carried by GMF and creates regular connectivity between clusters. Message delivery within each cluster is performed by LMF. LMF creates connectivity between most of the nodes in the cluster. This will increase the probability of delivering the packet.

Figure 2 shows the comparison of buffer space with delivery ratio for 50 hosts scenario. When the buffer size is small, probability of message dropping will be high and number of messages exchanged also will be low. At the other end, as buffer size increases, number of message drop will be reduced due to overflow. This will improve delivery ratio. In general, as the buffer space increases, the data delivery ratio increases. On the other hand, with limited buffer space, new packets may replace the old undelivered one. This results in packet drops and low delivery ratio. Epidemic routing protocol propagates the packet to all the accessible hosts. All the hosts in the network required to exchange message for all the remaining nodes in the network. Hence all the nodes need more buffer space. If number of nodes is increased then nodes need to have more buffer space. In the new protocol, regular nodes deliver messages to destination or Local Message Ferry and also receive messages which are intended for it. Hence, regular nodes does not require more buffer space and buffer space of regular nodes does not affect delivery rate. Local Message Ferry also does not require huge buffer space because it carries messages for the nodes which are located in its cluster. Global Message Ferry carries messages between cluster hence, it needs more buffer space than local message ferry. Hence, nodes in the new scheme may require very small amount of buffer space than epidemic routing protocol.

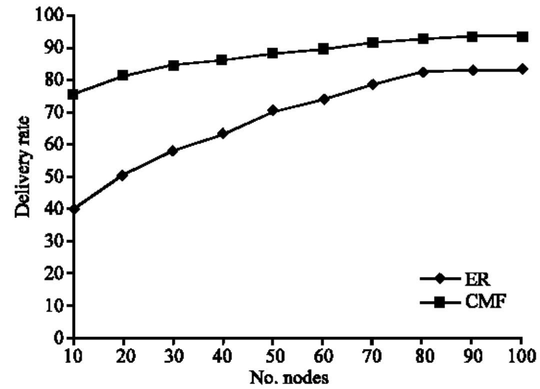

Fig. 1: Delivery rate and number of nodes

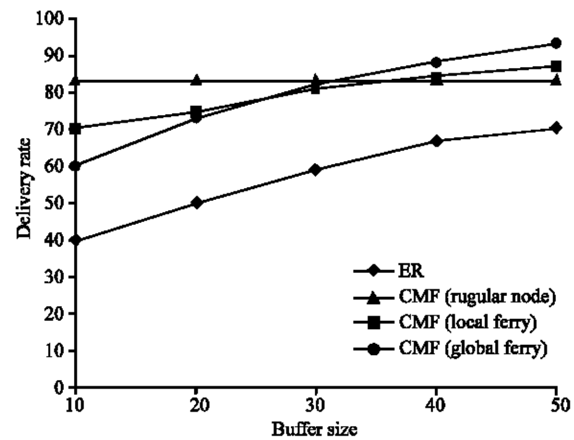

Fig. 2: Buffer size and delivery rate (number of nodes = 50)

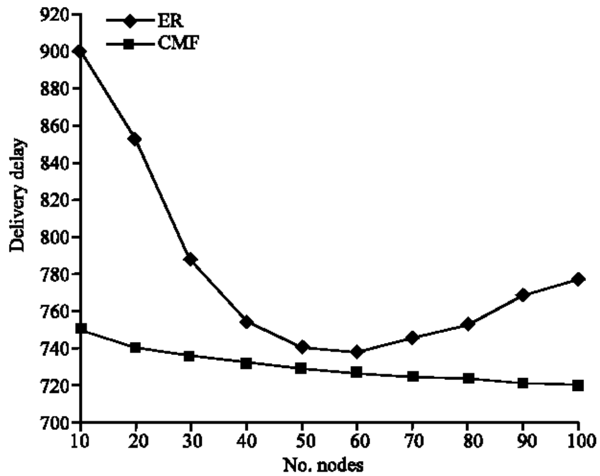

Fig. 3: Number of nodes and delivery delay

Figure 3 shows distribution of the number of nodes with respect to delivery delay for the buffer space of 50 messages. In epidemic routing protocol, number of nodes increases the connectivity between nodes and thus reduces the delay; this improvement is only up to certain limit because more number of nodes increases the congestion. If the destination is in the same cluster as the source or route exists between source and destination then the message is delivered more or less immediately in both the protocols. Consider, the situation that the destination is in other cluster which is disconnected from the source cluster. In this situation whenever connectivity occurs due to mobility of the node before the lifetime of the packet expires is only delivered in epidemic routing protocol. If delivery is important than any other metric, node has to wait for connectivity. This increases delay time. But in the new scheme, Global Ferry makes connectivity between clusters periodically and also Local Ferry makes connectivity among disconnected nodes within the cluster. This will reduce delivery delay.

CONCLUSION

In this study, we develop a technique which allows a message delivery in the situation where a connected path from source to destination never exists in mobile ad hoc networks.

There are number of applications like disaster recovery scenarios, remote village communications where nodes are disconnected. Existing ad hoc routing protocols unable to deliver packets in the presence of a network partition between source and destination since they are robust to rapidly changing network topology. For delivering packets in such scenarios, numbers of protocols were developed such as Epidemic routing protocol, Message ferrying protocol etc. Epidemic routing protocol delivers a packet only when connectivity occurs between destination node and any one of the node which carries the source packet. Message Ferry needs more buffer space to carry the messages between nodes. If Message Ferry needs to cover huge area and nodes are mobile then probability of delivering the packet is less and also takes more time to deliver the packets. To increase the above metrics more number of ferries can be used.

The goal of the new scheme is to maximize message delivery rate and to minimize message latency while also minimizing the total resources (e.g., memory and network bandwidth) consumed. In this scheme, nodes are grouped into clusters to reduce communication overhead. To reduce the communication delay, Local ferries are employed in each cluster to deliver messages within the cluster. Using GPS, node locations are identified and the location information is used for LMF's route calculation which is used to connect most of the nodes to improve the delivery rate. In this reaserch, we calculate packet delivery ratio, end-to-end delay to evaluate the performance of a routing protocol. The results illustrates that the performance of a routing protocol varies depending on node density and buffer space used. We observe that this new scheme produces highest throughput than Epidemic Routing protocol and also with single Ferry in long lived disconnected partitioned networks. Both schemes produce the same result when the network is connected or disconnected partitions with very less disconnection time. Future enhancement is to remove the online collaboration between ferries also.

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