AN IMPROVED NODE-INITIATED MESSAGE FERRYING APPROACH FOR DATA DISSEMINATION IN DISCONNECTED MOBILE AD HOC NETWORKS

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ABSTRACT

Message Ferrying is a new approach developed to assist communication in Mobile ad-hoc networks. Mobile ad-hoc networks are typically deployed with limited infrastructure. In addition, due to various conditions like limited radio range, physical obstacles or inclement weather, some nodes in the network might not be able to communicate with others. This could result in a disconnected network. In such situations, a typical network protocol might not yield good results. Message Ferrying is an approach which works around such problems. The message ferrying technique makes use of mobile nodes, called “ferries”, which are able to collect and transport data from one node to another. There are two approaches to deliver a message, Node-Initiated Message Ferrying (NIMF) and Ferry-Initiated Message Ferrying (FIMF). In NIMF approach a node will move towards known route of ferry if it has data to transmit or receive. The node comes close so that ferry will be in normal range of node. In FIME approach the ferry broadcast its location periodically. When a node wants to send or receive messages via the ferry, it sends a service request message to the ferry using its long range radio. This message contains the information of node location. According to this information ferry will adjust their trajectory to meet the node. After finishing the data transfer ferry will return to its default route.

This paper propose an improved version of NIMF, called Improved NIMF where the source/receiver nodes makes no movement towards the ferry, instead they select other nodes in their connected network which are nearer to the ferry with enough buffer space to send or receive their data to/from that node. Then that particular node transmits/receives the data to/from the ferry and receive/pass from/to actual sender/receiver. Through simulation experiments it is proved that the proposed approach works better than the NIMF.

Keywords: MANETs, message ferrying, disconnected network, ferries, improved NIMF.
1. INTRODUCTION

Mobile Ad hoc Networks (MANETs) are networks in which wireless mobile nodes cooperate to establish network connectivity and perform routing functions in the absence of infrastructure using self-organization [1, 2]. Since these networks do not require existing infrastructure and a priori planning, they can be rapidly deployed and have applications in a number of critical areas, such as, disaster relief, battle fields, and wide-area sensor networks.

Disconnected Mobile Ad hoc Networks are a class of Ad hoc networks where the node deployment is sparse, and the contacts between the nodes in the network do not occur very frequently. As a result, the network can remain partitioned for extended periods of time. Network partitioning happens due to limited transmission range, node failure, and topology changes.

Previous researchers in MANET have concentrated on routing algorithms which are designed for fully connected networks. In this case, the usual way to deal with disconnected network is to wait for network reconnection passively, which may lead to unacceptable transmission delay. One of the research challenges in MANET is the potentially frequent network partitioning which leads to no end-to-end connectivity. In literature [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14] we find a number of possible solutions for this problem. The Store-Carry-Forward paradigm or Message Ferrying (MF) is one of the solutions that the researchers have suggested.

Message Ferrying (MF) [15] is a proactive mobility assisted approach which utilizes a set of special mobile nodes called message ferries (or ferries for short) to provide communication services for nodes in the network. Message ferries move around the deployment area and take responsibility for carrying data between nodes. Message ferrying can be used effectively in a variety of applications including battlefields, disaster relief, wide area sensing, non-interactive internet access and anonymous communication. For example, in the earthquake disaster scenario, unmanned aerial vehicles or ground vehicles that are equipped with large storage and short range radios can be used as message ferries to gather and carry data among disconnected areas. This enables rescue participants and victims to use available devices such as cell phones, PDAs or smart tags for communication.

There are two variations of MF schemes, depending on whether ferries or nodes initiate non-random proactive movement. In the Node-Initiated MF (NIMF) scheme, ferries move around the deployed area according to known routes and communicate with other nodes they meet. With knowledge of ferry routes, nodes periodically move close to a ferry and communicate with the ferry.

Fig.1. An example of message delivery in the node-initiated MF scheme (taken from [15]).
In the Ferry-Initiated MF (FIMF) scheme, ferries move proactively to meet nodes. When a node wants to send packets to other nodes or receive packets, it generates a service request and transmits it to a chosen ferry using a long range radio. Upon reception of a service request, the ferry will adjust its trajectory to meet up with the node and exchange packets using short range radios. In both schemes, nodes can communicate with distant nodes that are out of range by using ferries as relays, so that routing is efficient without the energy cost and the network load burden involved in other mobility-assisted schemes that use flooding.

A key problem under the Node-Initiated Message Ferrying model is that, sender/receiver nodes has to periodically move close to a ferry to communicate with the ferry. This is a difficult problem. The difficulty in this context arises from the fact that the sender/receiver nodes has to move close to the ferry to deliver/receive the message i.e. they have to move purposely towards the ferry and the entire data dissemination is a synchronous type of mechanism. They have to synchronize with the ferry to deliver/receive the data to/from the ferry which may detain the other processing in those nodes. Such collaboration may disrupt the actual node mobility and processing and may not always be feasible or desirable.

To overcome this difficulty, this paper propose an Improved Node-Initiated Message Ferrying Approach (I-NIMF), where the nodes cooperate each other to deliver/receive the message to/from the ferry and the node which want to deliver/receive the data to/from the ferry makes no movement towards the ferry and there is no need to synchronize with the ferry.

2. IMPROVED NODE-INITIATED MESSAGE FERRYING APPROACH (I-NIMF)

In the proposed Improved Node-Initiated MF (I-NIMF) scheme, the ferry moves according to a specific route. The ferry route is known by nodes, e.g., periodically broadcast by the ferry or conveyed by other out-of-band means. Node which wants to deliver/receive the data to/from the ferry finds a node in their connected network which are nearer to the ferry with enough buffer space and forwards/receives their data to/from that node. Then that particular node transmits/receives the data to/from the ferry. Fig. 2 shows an example of how I-NIMF operates. In Fig. 2(a), the ferry F moves on a known route, part of which is illustrated. As the sending node S wants to deliver the data to the ferry, approaches a node which is nearer to the ferry with enough buffer space and forwards its messages to that node and that node will be responsible for delivery to the ferry. In Fig. 2(b), the receiving node R finds a node which is nearer the ferry and assigns the job of receiving data from ferry and delivering data to it. By using the intermediate nodes and ferry as a relay, S can send messages to R and R receives messages from S even there is no end-to-end path between them.
The following sections describe the operations of I-NIMF and how nodes cooperate to transmit/receive data to/from the ferry.

2.1. I-NIMF OPERATIONS (SOURCE TO FERRY)

1. Ferry F moves on a known route and sends out Hello messages periodically using a short range radio, and nodes simply listen to the channel to detect the ferry.

2. Node S (sender) receives Hello message from the ferry, finds an intermediate node I nearer to the ferry with enough buffer space.

3. Sender S forwards data to node I.

4. Now node I by hearing Hello message from ferry replies with an echo message.

5. After identifying each other, the node I and the ferry F initiate a message exchange conversation.

6. The node I will transmit all its buffered messages to the ferry F, which will be responsible for delivery.

2.2. I-NIMF OPERATIONS (FERRY TO RECEIVER)

1. Ferry F moves on a known route and sends out Hello messages periodically using a short range radio, and nodes simply listen to the channel to detect the ferry.

2. Node R (receiver) receives Hello message from the ferry, finds an intermediate node J nearer to the ferry with enough buffer space and assigns the job of receiving data from ferry.

3. Now node J by hearing Hello message from ferry replies with an echo message.
4. After identifying each other, the node J and the ferry F initiate a message exchange conversation.

5. The ferry F will then deliver to the node J the messages buffered at the ferry which are destined to R.

6. The node J then transmits all its buffered messages to the receiver R.

2.3. HANDLING BUFFER

Nodes are having limited buffer to store messages. Epidemic scheme [16] is a flooding scheme due to this sometimes nodes memory will be exhausted. To deal with this kind of situation, authors of "Wearable computers as packet transport mechanisms in highly-partitioned ad-hoc networks" [17] proposed to drop the message whenever there is shortage of memory. They talk about four different kinds of dropping strategies. They are:

- **Drop-Random (DRA)**: The packet to be dropped is chosen at random.

- **Drop-least-Recently-Received (DLR)**: The packet that has been in the host buffer for longest time duration is dropped.

- **Drop-oldest (DOA)**: The packet that has been in the network for longest duration is dropped.

- **Drop-Least-Encountered (DLE)**: The packet is dropped on the basis of the likelihood of delivery.

3. PERFORMANCE EVALUATION

This section evaluates the performance of the Message Ferrying schemes through *ns* simulations. The setup is with small number of nodes based on the premise that the node deployment is sparse. Please note that this framework can easily accommodate more number of nodes. Assume that there is a single ferry in the system. The main objective has been to evaluate *message delay*, which is defined as the average delay between the time a message is generated and the time the message is received at the destination.

The following default settings are used in simulation. Each simulation run has 40 nodes on a 5000m×5000m area. 25 nodes are randomly chosen as sources which send messages to randomly chosen destinations every 20 seconds. Messages are of size 500 bytes and the timeout value is 8000sec. Nodes move in the area according to the random waypoint model [18] with a maximum speed 5m/s and pause time 50sec. The node buffer size is 400 messages and the ferry speed is 15m/s. The default ferry route follows a rectangle with (1250, 1250) and (3750, 3750) as diagonal points. The WTP threshold controls how much time a node is allowed for proactive movement.
As can be seen from Fig. 3, the message delay is decreased through the proposed I-NIMF. This is because in I-NIMF, there is no need for the node to move to the ferry, which delays the delivery of message, instead it routes/receives the messages to/from the node nearer to the ferry.

4. RELATED WORK

In 2004, Zhao et al. [19] studied the problem of efficient data delivery in sparse mobile ad hoc networks; they develop two variations of the MF schemes, depending on whether ferries or nodes initiate non-random movement. In the Node-Initiated MF (NIMF) scheme, ferries move around the deployed area according to known routes and communicate with other node they meet. With knowledge of ferry routes, nodes periodically move close to a ferry and communicate with the ferry. In the Ferry-Initiated MF (FIMF) scheme, ferries move proactively to meet nodes. When a node wants to send packets to other nodes or receive packets, it generates a service request and transmits it to a chosen ferry using a long range radio. Upon reception of a service request, the ferry will adjust its trajectory to meet up with the node and exchange packets using short range radios. In both schemes, nodes can communicate with distant nodes that are out of range by using ferries as relays. They also adopted their algorithms from TSP, but here the TSP is used to optimize the expected message drops instead of optimizing the length of the route.

Also, [20] proposes a combination of high-power ground nodes called gateways and high altitude aircraft or satellites to provide communication for partitioned networks—messages are first routed within a connected component to the gateway, and then relayed via the aircraft or satellite to other components.

5. CONCLUSION

Message ferrying is a key routing technology for disconnected mobile ad-hoc networks. MF is a mobility-assisted approach which utilizes a set of special mobile nodes called message ferries to provide communication service for nodes in the area. There are two approaches to deliver a message, Node-Initiated Message Ferrying (NIMF) and Ferry-Initiated Message Ferrying (FIMF) approach. This paper described a new framework for
NIMF known as Improved NIMF (I-NIMF). In this scheme mobile nodes cooperate each other to deliver/receive data to/from the ferry. Extensive simulations proved that the proposed scheme performs significantly better than NIMF. This process provides a valuable insight regarding how the message delay can be overcome by using I-NIMF.

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REFERENCES


