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Survey on Latest Routing Algorithms in Opportunistic Networks

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Abstract: ***In the past wireless LANS and Cellular networks were used for communication. But there were some problems with these networks, in terms of coverage and capacity. In case of cellular networks the coverage is unlimited but capacity is small and in wireless networks coverage is limited and capacity is unlimited. In case of wireless networks if the nodes are mobile then Manets (mobile ad-hoc networks) can be used for communication. But this is only possible when distance between the nodes is small, if the distance increases then it is not possible to communicate so to remove this limitation opportunistic networks were developed. With this network nodes can communicate irrespective of the distance and the type of node Opportunistic networking tries to remove the assumption of physical end-to-end connectivity while providing connectivity opportunities to pervasive devices when no direct access to the Internet is available. Pervasive devices, can opportunistically exploit their mobility and contacts for data delivery. In this kind of network if a node moves towards another node then this is also taken as advantage in transmitting data. In this paper various routing schemes used in these kinds of networks are briefly explained. The routing schemes are classified based on their routing behavior and we will also present comparison among them.***

Keywords: Opportunistic network, routing algorithms, flooding, prediction, context.

1. Introduction

Opportunistic network is a kind of network where data is routed with tolerant delay from source to destination. This type of network is used for emergency applications. This network consists of mobile as well as fixed nodes. The main difference between opportunistic network and the traditional network is that in traditional network, nodes are deployed together and end to end path exist for data forwarding. But in opportunistic network path is not fixed in advance between source and the destination due to mobile nodes. In this network, first seed oppnet is deployed .Then it detects foreign devices for completing the emergency applications with tolerant delay. The detected devices are evaluated for their usability and resource availability. If it is satisfied the device is integrate into the oppnet as a helper. This helper integration process is continued until enough devices are found for completing the task. Once the integration process is completed, routing will be done with the help of helper nodes. Helper nodes are used as intermediate nodes for forwarding data from source to destination. Different nodes make association to exchange data from source to destination.

Message is delivered node to node closer to the destination. In an opportunistic network, routes are determined at each node when packets traverse through different nodes. Each node is equipped with local knowledge of the best nodes around it and it uses this knowledge to determine the best path to send out the message to the destination. In the absence of any such nodes, the node currently holding the message simply stores the message and waits for an opportunity.

Recently researchers have developed some routing schemes for opportunistic network .These schemes are shortly discussed and comparison is presented in the following section.

2. Related Work

In the past, several routing algorithms have been proposed to improve the routing performance in opportunistic networks. Here, we divide the opportunistic routing protocols into four categories [1]: Direct Transmission, Flooding based, Prediction based, Content based and Coding based Schemes.

In direct transmission routing, the source node generates message and food it in its buffer until it meets the destination directly. In this transmission source node forwards a message to destination when it directly meets that node. This system has a boundless deliverance delay, but has the advantage of performing only a single transmission per message.

In flooding based routing, the source node generates numerous copies of the message and injects those into the network. This injection of replicated message is sustained until destination receives the message.
In prediction based routing the overhead carried by flooding based routing schemes is further abridged by predicting the activities of the neighbor nodes for taking a few forwarding decisions. Probabilistic Routing scheme [2] calculates the delivery predictability from a node to a exacting destination node based on the observed contact history. It forwards a message to its neighbor node if and only if that neighbor node has a higher delivery predictability value.

In context based routing prediction based approach is additionally polished by utilizing context information because Predictions botched in some cases and delivery proportion is also less in this. Chiara Boldrini et al [3] have proposed History based routing (HiBOp) that uses up to date context information for data forwarding decisions. It creates and handles the context of a user. Throughout context creation for every node Identity table (IT) is created to grasp the context information. This IT is used to exclusively identify the node in the network. Then it maintains a history table to document the quality information of the nodes to utilize similarities between encountered nodes and destination.

In coding based routing schemes, a message is altered into a new format prior to transmission. The design principle of coding based schemes is to implant additional information within the coded blocks such that the original message can be fruitfully reconstructed with only a assured number of the coded blocks.

3. Some Recently Discovered Routing Schemes In Opportunistic Network

3.1 Community-Based Routing Algorithm

Recently, some researchers have productively used social network-based forwarding schemes in opportunistic routing protocols. In [5], Pan Hui et al. suggest a forwarding algorithm based on social network, BUBBLE, it uses (k-clique) a community detection algorithm to segregate dissimilar traces into a number of communities. Then forwarding procedure is performed according to the node global centrality or local centrality. If a node has higher centrality it means it is more accepted node in the network and also it will have larger probability of encountering with other nodes. But this algorithm does not take into account the characteristics of links, such as connection time or connection frequency.

SimBetTS Routing protocol is proposed in [3], which unite three metrics, betweenness utility, similarity utility and tie strength utility. Protocol performance evaluations were also conducted and results show that it enhanced overall delivery performance; the load on central nodes is reduced and better distributed across the network.

In this scheme first tie strength between nodes is calculated. Multidimensional Scaling (MDS) also known as structure analysis is used for this purpose. MDS illustrates the similarity of two nodes by analyzing the distance data, which is also be called dissimilarity data. Then community is detected using algorithms after that routing is done. For routing in community local centrality is calculated and for routing between communities global centrality is calculated.

Simulation results from [4] show that this protocol has higher delivery ratio than Epidemic, Bubble PROPHET and similar latency with Bubble Rap.

3.2 Contact Graph based Routing Algorithm

As we know SimBet uses social network analysis techniques to assist their forwarding decisions. It supposes that contact events between nodes imitate social structures such as communities. One method to spot communities involves representing contact events between nodes as a summative contact graph. The vertices of this graph match up to the nodes in the network and weighted edges program information about pair-wise node encounters. Communities can be found in these graphs using one of the many community detection algorithms for graphs.

This algorithm [6] uses community and neighborhood information from contact graphs to allocate priority to messages when forwarding them. This algorithm is based on a weighted contact graph, in which the weight of an edge corresponds to the information exchange capability between the connected nodes and their probability of encountering each other habitually. It places more importance on the neighborhood of a node rather than global connectivity metrics such as degree centrality.

In this first a contact graph is formed from the historical encounters within the network. Total contact duration among each pair of nodes over a fixed historical period provides an appropriate metric. Once the summative contact graph has been prepared, the next step is to discriminate nodes based on their relative importance for information distribution.

This information is then used to supply every node in the network with the identities of all its neighbors and the members of its community. There are basically four types of messages that this algorithm deals with i.e. immediately deliverable, immediately-deliverable (These are the messages with encountering nodes as their destinations), intra-community (These have a destination that belongs to the same community as the encountering nodes), inter community (messages that belong to the other's community) and third community messages (messages destined for nodes that do not belong to either of their communities). The nodes that are in communication range first deals with immediately deliverable messages and then intra and inter community messages and at last they exchange third community messages.

This algorithm in [6] was also compared with other algorithms like Epidemic, Prophet, SimBet and Bubble and the result shows that information obtained by suitable representation of node as a weighted graph can improve delivery performance while reducing other communication overheads. Contact Graph based routing delivers the most messages. It delivers approximately 87% more messages than SimBet and 375% more messages than Prophet. Contact Graph based routing also achieves the lowest overhead ratio. The performance was measured using the following metrics:

- **Delivery Ratio**: The fraction of all generated messages that is successfully delivered before the simulation stops.
- **Delivery Overhead Ratio**: The number of message transmissions divided by the number of delivered messages.
- **Average Hop Count for Delivered Messages**: The average number of nodes that messages traverse before reaching their destination.
- **Buffer Occupancy (in number of messages):** The number of messages (including duplicates) present in the buffer of a node on average over the entire duration of the simulation.

3.3 A Location Based routing algorithms

This algorithm aims at forwarding messages to a destination location/area, instead of forwarding to specific nodes. It is termed as LOOP[7] for Location based routing for Opportunistic networks. It makes use of the promptness rooted in human moving pattern. As human movements have a high degree of duplication including regular visits to certain places and regular contacts during daily activities, we can forecast a mobile node's upcoming locations based on its mobility trace with high assurance. These predicted future values can be used to forward message to the destination.

The design of algorithm focuses on two challenges
1) How to extract the movement history to expect the future location of the device.
2) How to choose nodes for message relay given the pattern towards the destination.

It consists of formulating the movement pattern mining as a multi-label classification problem and constructs a Bayes predictive model to discover the mobility history and gain knowledge of the movement pattern. This pattern will then be used to forecast the node's future movement. Based on the prediction, the capability of the node to transport a message to the destination is calculated through defined metrics. These metrics will help in determining proper relaying nodes.

This algorithm has several advantages as compared to existing approaches. First, in this no information, including location information, needs to be exchanged among nodes and hence privacy can be sealed. Second, it achieves total distributed control. Each node calculates its own metrics and fix on if it is a proper relay in the direction of the destination. Each node, based on its own state, can decide its individual forwarding policy without involving network broad changes. The simulation results from[7] indicate that this scheme is able to deliver messages at a high ratio, significantly decrease network load and nodes' buffer occupation, especially when more messages are involved in the network.

3.4 Node Density-based Adaptive Spray and Focus Routing

As we know routing algorithms in opportunistic networks can be categorized as forwarding -based routing and replication-based routing. In forwarding-based routing algorithms, only one copy of each exclusive message exists in the network. When the nodes come within communication range the carrier node forwards message to the encountered node and will not keep the copy of the message in its buffer. Although is has lowest overhead, it cannot achieve high successful delivery ratio. In contrast, replication-based routing algorithms produce numerous copies of a single message into the network to improve the successful delivery probability. But replication based routing cannot settle on how many message copies will be spread and will acquire much more network overhead.

Most of the copy-limited routing algorithms pay attention on how to assign the current number of message copies between two encountered nodes. But they did not consider the efficiency of message distribution. If the node density is high, a large number of message copies may be spread into the small local area and thus the delivery speed and ratio are limited. This system proposed that the practice of allocating message copies should be separated into two phases. In the first phase, message carrier node should decide how many message copies should be used to allocate according to the current node density extreme broadcasting of a large number of message copies in a local area will not improve the entire network performance. In the second phase, the message carrier node should decide how to allocate message copies between encountered nodes. The node that is more active will get more message copies. In this way this method can improve the network performance in terms of delivery ratio and delay.

In the paper [8], they present a copy-limited routing scheme DASF in opportunistic networks. DASF routing algorithm estimates node density according to the exchanged information between encountered nodes. It guarantees the balanced number of message copies that are used to allocate between encountered node pairs in current environment. DASF allocates message copies according to the activity of nodes. Using simulations they show that the proposed scheme outperforms the other evaluated schemes with delivery ratio and has lower average latency when node density is relatively high.

4. Conclusion

Opportunistic network is formed by devices that have very short range communication interfaces. Routing in such network is a big problem in order to increase delivery ratio and to reduce overhead in the network. Some existing routing algorithms in opportunistic network are briefly discussed in this paper and also some latest algorithms developed by some researchers recently are also discussed briefly in this paper.

Routing algorithms are classified based on their routing behavior. As introduction some algorithms that were developed in the past are discussed briefly which includes Direct Transmission, Flooding based, Prediction based, Content based and Coding based algorithms. In direct transmission routing, the source node generates message and stores it in its buffer until it meets the destination directly. In flooding based routing, the source node generates multiple copies of the message and injects those into the network. In prediction based routing the behavior of the neighbor nodes is predicted for taking some forwarding decisions. In context based routing prediction it uses the context information about the node to take the forwarding decisions. In coding based routing schemes, a message is transformed into another format prior to transmission. And in the other section we have discussed some algorithms recently developed such as SimBet, which combines three metrics, betweenness utility, similarity utility and tie strength utility to make decisions regarding message forwarding, LOOP that aims at forwarding messages to a destination location/area, instead of forwarding to specific node, DASF routing algorithm that estimates node density according to the exchanged information between encountered nodes. And we can conclude that each algorithm has its own advantages and disadvantages and according to some given environment we can use different algorithm that can help in better message forwarding in that particular environment. There is still a need to develop such an algorithm that can outperform all these algorithms and can give efficient message delivery.

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