A Review of Routing Algorithm in DTNs

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In this section, we briefly review routing algorithm in DTNs.

In 2004, Sushant Jain, Kevin Fall [1] first investigated the routing issues in DTNs, where messages are to be moved end-to-end across a connectivity graph that is time-varying. Further, they figured out dynamics of DTNs may be known in advance.

For we focus on the routing performance influenced by topology partitioning, we categorize routing algorithms into flat or hierarchical routing algorithms.

Flat routing algorithms employ only one routing approach globally, while all nodes involved play similar roles. Vahdat [2] proposed the Epidemic Routing, which is a flooding routing algorithm with zero knowledge. Compared with single copy routing, such as Direct Delivery [3], Randomized Routing (RR) [4], Epidemic Routing greatly improved delivery rate. However, Data replicating without control lead to resource waste, even network congestion. In order to reduce the waste of resource, Spray and Wait routing [5] was proposed, which configure the amount of message copy in the Spray phrase. Nevertheless, node will wait until contacting with the target node in the wait phrase. Thus, in large scale networks, routing performance cannot be guaranteed. Besides flooding based schemes [2] [6] [7], another very important DTN routing category is the contact information based routing, where a smarter relay node selection is made. Anders Lindgren [8] proposed a probability based routing algorithm, PRoPHET. Each node maintains the encounter history with other nodes, and the routing decision is made based on the encounter probability. Afterwards, MaxProp [9] was presented. It records neighbor nodes and their contact times with target node, therefore, a contact probability can be adopted as rule to choose next hop. By introducing knowledge oracles, this kind of routing can reduce resource consumption, and improve delivery rate as well. But with the node scale expanding, routes should cost more storage and computation resource to maintain the global historical information. Hence, the scalability and performance of flat routing are limited, when the network scale increases and topology varies all the time. In this scenario, flat routing cannot ensure low delay and high delivery rate. Besides, the resource cost for requiring global knowledge will be significantly increased.

Some researchers suggested using hierarchical routing in DTNs. Restricted by the dynamic topology and frequently interruption, hierarchical routing in DTNs is still in its early stages.

Literature [10] discussed that route can be divided into inter-and intra-cluster routing based on network clustering. For nodes in cluster have higher connectivity probability, intra-cluster routing adopt directly delivery approach so that a node will not delivery message until contacting with the destination node in same cluster. As to the intra-cluster routing, a relay mechanism similar with MaxProp is conducted. In [11], a kind of DTNs hierarchical routing algorithm was designed based on a mobility model where all nodes move according to strict and repetitive patterns. The algorithm is effective for a specific mobility model. However, it is difficult to recognize a mobility pattern and adapt to new network environment. Shabbir Ahmed et al, [12] adopt encounter frequencies of public transport networks to classify nodes. Based on clusters, nodes only relay messages to neighbor nodes which are in same cluster of the target node. Besides, Epidemic routing is conducted inside clusters. The scalability is improved by these algorithms, but the resource consumption of historical information remains high. The authors of [13] introduced a Hybrid DTN-MANET routing (HYMAD) protocol, which aimed at the high node density and mobility in complex network. HYMAD builds temporary disjoint groups of connected nodes as groups, by periodically scanning for network topology changes. Then, it uses DTN approach between disjoint groups of nodes while using MANET routing within these groups [13]. This method is decentralized and only makes use of topological information exchanges between the nodes, thus control the storage and information exchange cost. However, the update cycle of the topology need to be further discussed. Because if the cycle is too short, updating and maintaining the topology may be difficult, while the update cycle is too long, intra-cluster routing using MANET way may be invalid.

To sum up, the key point of hierarchical routing algorithm is the clustering method, especially in large scale DTNs. Efficient clustering method can form stable network blocks, in which nodes are similar with each other, then, corresponding intra- and inter-cluster routing algorithms are designed. Thus, hierarchical routing can improve the scalability and routing efficiency.

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