Message Forwarding in Mission-Oriented Delay-Tolerant Networks

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A mission-oriented robotic network is a network dedicated to multiple missions, each with different requirements. To accomplish these missions while satisfying various requirements, robots are typically distributed in a large geographical area and move to locations dictated by missions. For example, some robots designated for tracking a mobile target may follow the path of the target; while other robots may be designed to follow pre-specified routes to maintain communication. In this network, the connectivity is time-varying, and there might be a long time of disconnection between different parts of the network. This kind of network is considered as a mission-oriented delay-tolerant network (DTN), where nodes are distributed according to their missions, and can share information irrespective of temporary network disconnections.

We aim at design a message forwarding technique to effectively share information among robots in mission-oriented DTNs. Our foremost goal is to minimize message delivery time, while obtaining a high message delivery ratio. This presents several interesting challenges. First, we cannot predetermine or predict which mission a robot will execute at a given time, so we cannot determine the movement of the robots or design the contact points for them either. Second, to fully exploit the network utilization, the robots should be dedicated to their missions as much as possible, avoiding unnecessary overhead.

Existing message forwarding protocols for DTNs fall into two categories based on the mobility models: deterministic mobility and stochastic mobility. Most existing work using deterministic mobility models assumes either deterministic or semi-deterministic routing on certain special nodes such as ferries [1], where spatial-temporal approaches with designated contact points are used for relaying. In the case of stochastic mobility, naive epidemic forwarding, opportunistic forwarding, and prediction based forwarding techniques [2] have been studied. All the existing approaches are trajectory centric, i.e., they either focus on finding routes or forward messages using certain routes between specific endpoints.

Since maintaining routing tables in a time-varying network could entail significant overhead, we will design an on-demand message forwarding technique that uses ferries to deliver messages. Instead of employing extra ferry nodes with planned trajectories as exiting work does, we use intrinsic message ferrying by choosing a subset of robots on-demand that have lower priority missions to work as ferries in order to maximize the robot utilization. We divide the network into geographic units based on the communication range of robots; then use per-contact routing based on one-hop information, and predict the mobility of the robot in the next hop to control the mobility of the ferry robot for contacting. In this way, message forwarding can be achieved using two steps, i.e., inter-unit delivery and intra-unit delivery. There are three significant advantages of this approach. First, it is easy to calculate the next hop unit based on the geographical locations. Second, intra-unit delivery can be achieved by broadcasting, thus the inter-unit delivery can be simplified to delivering to any robot in the destination unit. Third, per unit data aggregation can be applied to messages that have the same destination units.

References

[1] M. Tariq, M. Ammar, and E. Zegura. Message ferry route design for sparse ad hoc networks with mobile nodes. MobiHoc, 2006.
[2] Q. Yuan, L. cardei, and J. Wu. Predict and relay: An efficient routing in disruption-tolerant networks. MobiHoc, 2009.