

# Dynamic Carrier-Assisted Routing in Mobile Networks

## (Project Summary)

Two schools exist in terms of handling node mobility in various mobile networks. The traditional connection-based (such as TCP/IP) model is built on the premise that the underlying network is connected and views node mobility as undesirable. Several counter measures have been proposed to remove (through recovery schemes) or mask (through tolerant schemes) the effect of mobility. The mobility-assisted model considers mobility as a desirable feature, where routing is based on the store-carry-forward paradigm with random or controlled movement of mobile nodes. Mobility as a means to improve system performance has been studied recently, specifically with respect to routing capability, location information dissemination, network capacity, and security.

We propose to use node mobility to enhance routing capability in a mobile network. A *dual control planes* model is presented, which includes the traditional S(stationary)-plane for routing among stationary nodes using connection-based message routing. In addition, we introduce a new control plane, M(mobile)-plane, for trajectory control of mobile nodes. Routing consists of a sequence of control plane switches, alternating between store-and-forward in the S-plane and store-carry-forward in the M-plane. Intra-plane and inter-plane communications are performed through contacts. In the M-plane, unlike existing works that focus on two extremes of spectrums: random movement and tightly controlled movement, we focus on *loosely controlled movement* of mobile nodes to assist routing in a store-carry-forward paradigm. The challenge lies in adapting the level of control to support a certain degree of flexibility, such as using dynamic node trajectory to maximize route sharing to minimize the number of carriers (special mobile nodes), while ensuring desirable global properties, such as short average moving distance with respect to the Euclidian distance between the source and destination and a small number of relays to increase network capacity.

The goals of the proposed research are the following: (1) Propose a generic framework for routing in dual control planes. (2) Offer flexibility in terms of trajectory control of mobile nodes to balance several global objectives. (3) Study the role change between stationary and mobile nodes in dual control planes to facilitate the routing process. (4) Explore the use of unicasting as a basic building block to support collective communication, including multicast, broadcast, anycast, gather (all-to-one), and gossip (all-to-all). (5) Extend the current model in the 2-D Euclidian space to the high-dimensional and non-Euclidian space. (6) Integrate different components in dual control planes and fine tune the system through an empirical study based on a set of well-defined quantitative performance metrics.

**Intellectual Merits.** The proposed framework is the first to integrate two schools of handling node mobility. As a result of previous studies on efficient routing, we believe that the proposed framework offers a very promising and unique combination of conflicting models. The proposed work advocates the importance of the schedule of carriers as well as the traditional message routing, and shows how to integrate these two processes. The proposed work also considers various trade-offs through well-defined mechanisms for carrier trajectory planning and sharing. In addition, the framework enriches the theory of routing in a mobile network. On the other hand, our work compliments the significant effort done in the DTN community as a viable new routing model. The proposed research has great potential to be extended to include routing in other high-dimensional and non-Euclidian space.

**Broader Impact.** We envision that the insights and results from this research will provide guidelines for efficient routing in a wide range of applications. This research will also exploit and contribute to theoretical studies in routing in a mobile network. We believe that the results obtained from this project will be useful in various applications of mobile networks, including MANETs, WSNs, and DTNs and the proposed study will contribute to making these networks more practical. Finally, the research results can be used as a stepping stone for searching for a new routing model in the GENI project.