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Architecting Protocols to Enable Mobile Applications in Diverse Wireless Networks

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Abstract

The goal of this thesis is to architect robust protocols that overcome disruptions and enable applications in diverse mobile networks. Mobile users operate in diverse environments, starting from mostly connected cellular networks to mostly disconnected delay tolerant networks (DTNs). Each of these networks are prone to frequent disruptions due to mobility, coverage holes, poor channel conditions, and other factors. Designing protocols to tolerate such disruptions is challenging because of the extreme uncertainty in mobile wireless environments. In this thesis, I focus on four networks that span the diverse connectivity spectrum and answer the following questions for each network: (1) What are the disruption characteristics in the network and what are the opportunities that can be exploited in the network?; and (2) What protocol design best exploits the opportunities to overcome disruptions and enable the specific application? In this thesis, the key insight used to tolerate disruptions is opportunistic resource usage. Opportunistic mechanisms use resources as they become available and are therefore naturally resilient to uncertainty. Specifically, I present four protocols that overcome disruptions and enable applications in diverse networks: 1) RAPID, which uses opportunistic replication to enable bulk transfer in mostly disconnected networks; 2) Thedu, which uses opportunistic prefetching to enable web search in intermittently connected networks; 3) ViFi, which uses opportunistic forwarding to enable Voice over IP (VoIP) in mostly connected mesh networks; and 4) Wiffler, which uses opportunistic augmentation to improve application performance in mostly connected cellular networks. The naive use of opportunism can waste resources and hurt performance. I show how, in most cases, utility-driven protocols can be used to implement opportunism in resource-constrained wireless environments. Finally, I present a detailed evaluation of the protocols using implementation and deployment experiments on two large scale vehicular testbeds. Deployment on a real testbed shows that the protocols are practical and can be implemented in realistic usage environments. The evaluations show that the protocols significantly improve performance of applications compared to the state-of-the-art, in their respective environments.

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