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Fatemeh Safari

A novel QoS-aware cross-layer framework for adaptive routing in MANETs

Chair: Dr. Stacey Scott
Advisor: Dr. Daniel Gillis
Co-Advisor: Dr. Herb Kunze [Math and Stats]
Non-Advisory: Dr. Hassan Khan
External Examiner: Dr. Xavier Fernando [Toronto Metropolitan University]

Abstract:

Mobile Ad hoc Networks (MANETs) have emerged as a prominent solution for providing communication, especially in scenarios where infrastructure-based networks are absent or impractical. With advances in mobile and wireless communication technology and their potential applications, infrastructure-less wireless networks and ad-hoc networks have attracted much attention from the research community and industry. Mobile ad hoc networks are formed by an autonomous group of mobile devices such as smartphones, laptops, and tablets that communicate with each other through wireless links (such as Wi-Fi or Bluetooth) without the use of any pre-installed infrastructure. That is, this infrastructure-less network type is designed to be both self-organized and self-configured, and without any central administration. This means that they do not impose any initial cost for setting up base stations or maintenance costs compared to standard networks that have both. However, the dynamic nature of MANETs, characterized by node mobility and varying network topologies, poses significant challenges to efficient and reliable routing that can affect the quality of service (QoS) negatively.

This thesis presents a novel QoS-aware cross-layer framework that addresses the broadcasting problem and path selection challenge in MANETs by employing fuzzy logic and Q-learning, with a specific focus on the Ad hoc On-Demand Distance Vector (AODV) and Ad hoc On-Demand Multipath Distance Vector (AOMDV) routing protocols (two of the most popular reactive routing protocols for mobile ad hoc networks). Specifically, the proposed framework leverages fuzzy logic to dynamically select a subset of nodes for message forwarding based on network conditions (i.e. available bandwidth, signal strength, queue congestion, MAC layer collision, node's remaining energy, and local network density) to overcome a variety of routing challenges while improving QoS parameters. By using fuzzy logic, the framework improves coverage area while minimizing redundancy, resulting in efficient and reliable information dissemination across the network. The proposed framework also incorporates a Q-learning-based technique into the AOMDV routing protocols to evaluate path quality, which are used to dynamically adjust routing decisions based on network conditions and traffic load. This enables effective congestion mitigation, ensuring reliable data transmission and meeting QoS objectives.

Simulations and performance evaluations were conducted to validate the effectiveness of the proposed approaches. The results demonstrate that the proposed methods outperform traditional approaches in terms of broadcasting efficiency, network throughput, end-to-end delay, and packet loss.