Abstract

This thesis introduces evaluation techniques for wireless multi-hop networks, bridging the gap between simplifying simulation approaches and expensive real-world experiments. Opposed to cellular and WLAN architectures, data traffic in wireless multi-hop networks is forwarded wirelessly over multiple hops. On the one hand, wireless multi-hop networks provide significant increased radio coverage compared to WLAN architectures. On the other hand, with their high physical layer data rates, wireless multi-hop networks appear to be a powerful supplement to cellular architectures. However, the design of efficient protocols and applications for mesh networks posses some unique challenges. Especially, interference experienced in wireless multi-hop networks is a challenging aspect, as there is no central instance for coordination. To fully exploit the advantages of wireless multi-hop networks, appropriate evaluation methodology is therefore indispensable.

The contributions of this thesis are threefold: As a first contribution, the scalable wireless mesh testbed architecture (ScaleMesh) is introduced. Opposed to previous work, ScaleMesh is distinguished by its unique combination of variable attenuation units and dual-radio communication. ScaleMesh can emulate large-scale wireless mesh networks on a small experimentation area in laboratory environment, while keeping the radio signal characteristics close to the real-world environment. Using ScaleMesh, a comprehensive performance study is performed, characterizing the delivery probability at link-level and analyzing the performance gain of dual-radio communication.

As a second contribution, an analytical model is introduced to characterize the effective throughput for multi-hop paths in IEEE 802.11n based wireless mesh networks. Opposed to previous work, this analytical model accounts for the novel frame aggregation and block ACK scheme of the IEEE 802.11n standard. Based on an acyclic discrete time Markov chain, the model captures the number of retransmission attempts at MAC-layer by estimating the amount of subframes to be retransmitted under a given channel model. The proposed model is validated in a set of comprehensive testbed experiments.

As a third contribution, an analytically tractable mathematical approach for accurately modeling the distribution of inter-contact times between mobile devices carried by users is presented. Opposed to previous work, a Markov-modulated Poisson process (MMPP) is employed for characterizing long-term dependencies in the mobility behavior. To illustrate the effectiveness of the approach, a validation with mobility patterns measured in a real-world environment is conducted. The presented quantitative results show that the modeling approach closely approximates the dichotomy of the distribution of human inter-contact times observed in recent studies of real-world trace data.