Effective Data Dissemination over Multi-hop Gigabit Wireless Networks

Sascha Gübner

Zusammenfassung

This thesis explores the effects of frame aggregation on the performance of the routing, transport, and application layer in multi-hop wireless networks. Frame aggregation is a crucial feature, first introduced in IEEE 802.11n and also present in IEEE 802.11ac, to harness the huge physical data rates available in these standards. With frame aggregation, several subframes can be aggregated to a single larger frame, resulting in a heavily decreased overhead for medium access. The contributions of this thesis can be summarized as follows.

As first contribution, the impact of frame aggregation on network performance is explored, both through analytical modeling and through a comprehensive measurement study. With the analytical model the achievable throughput in wireless chain topologies can be derived dependent only of the physical data rate, the error rate of the channel, the maximum allowed aggregate size, and the multi-hop path length. Furthermore, the technical obstacles in building a multi-hop capable real-world testbed are shown and a comprehensive measurement study is conducted therein. Characteristics of IEEE 802.11n on multi-hop paths, like throughput, mean aggregate size, and utilized MIMO features, are examined in depth. Furthermore, video streaming relevant characteristics, like delay, video quality, and mean aggregate size, are analyzed in the presence of frame aggregation in two multi-hop scenarios. It is shown, that limiting the possibility to aggregate frames severely impacts both the delay and video quality.

As second contribution, the findings of the measurement study are used to design an analytical framework to optimize routing decisions in general multi-hop networks with frame aggregation. A graph-based model is developed, that captures the interplay between frame aggregation and routing and transformed into an optimization problem defined by an integer linear program. Employing a heuristic solving approach, the model is then extended to a practical decentralized aggregation-aware routing scheme. The new routing approach is evaluated in simulations, where it could drastically reduce the average end-to-end delay and end-to-loss compared to standard routing protocols.

As last contribution, an analytical approach for accurately modeling the distribution of inter-contact times between mobile users is proposed. The model is extended by a graph-based clustering approach and is validated using two comprehensive data sets. It is shown, that the proposed approach closely approximates the distribution of human inter-contact times observed in recent studies of real-world trace data.