School of Electrical, Computer and Energy Engineering

PhD Final Oral Defense
On Asynchronous Communication Systems:
Capacity Bounds and Relaying Schemes

by
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Abstract
Practical communication systems are subject to errors due to imperfect time alignment among the communicating nodes. Imperfect time alignment can occur in different forms depending on the underlying communication scenario. In this doctoral study, we consider two different class of asynchronous communication systems; point to point (P2P) communication systems with synchronization errors and asynchronous cooperative communication systems. In particular, we study the information theoretic aspects of P2P systems with synchronization errors and develop new signaling solutions for asynchronous cooperative systems.

In the first part of the dissertation, we derive several upper and lower bounds on the capacity of the P2P systems with synchronization errors. First, we consider binary insertion and deletion channels and compute lower bounds on the mutual information between the input and output sequences for independent uniformly distributed (i.u.d.) input sequences. Then, we consider binary input symmetric output channels with
synchronization errors which also suffer from other type of impairments such as substitutions, erasures and additive white Gaussian noise (AWGN). We show that the capacity of any channel which can be decomposed into a cascade of a synchronization error only channel and a memoryless channel can be lower bounded in terms of the synchronization error-only channel capacity and the parameters of the memoryless channel. Then, to better characterize the deletion channel capacity, we relate the capacity of the three independent deletion channels with different deletion probabilities through an inequality relation enabling us to derive the tightest upper bound on the deletion channel capacity for deletion probabilities larger than 0.65. Furthermore, we provide the first non-trivial upper bound on the $2^K$-ary input deletion channel capacity. To do so, we first relate the $2^K$-ary deletion channel capacity with the binary deletion channel capacity, both with the same deletion probability, through an inequality relation which provides an upper bound on the $2^K$-ary deletion channel capacity in terms of the best existing upper bounds on the binary deletion channel capacity.

In the second part of the dissertation, we focus on developing new relaying schemes to solve asynchronism issues in cooperative communication systems. To this end, we propose two new relaying schemes for amplify and forward (AF) relay systems with two asynchronous relays. The first scheme is based on an orthogonal frequency division multiplexing (OFDM) approach useful for asynchronous cooperative systems experiencing excessive relative delays among the relay nodes under frequency selective channel conditions to achieve delay diversity structure at the receiver and as a result extract spatial diversity out of the system. The second one is a single carrier (SC) transmission based scheme providing spectrally efficient Alamouti code structure at the
receiver under flat fading channel conditions with the objective of reducing the overhead needed to overcome the aynchronism and to obtain spatial diversity.