



## Concurrent Multi-Path Connections in Coded Packet Networks

### Motivation

In this thesis you will evaluate networks which offer multiple transport resources, i.e. redundant paths of different quality. This type of network is common for P2P applications or *overlay networks*. In such networks, sources usually have multiple virtual connections to neighboring nodes participating in the overlay. Establishing a single communication path to a target is therefore not optimal. One approach is to divide a data block into multiple stripes which are sent to different neighbors. Since each neighbor makes forwarding decisions independently of each other, the stripes might take different paths to the sink. Thus, one cannot expect that stripes arrive in-order because the paths have different and possibly time-dependent characteristics, i.e. delay, jitter, and packet loss rates. Consequently, the sink must re-sequence the data stream before passing it to the receiving application. Unfortunately, it is very hard to predict whether adding an additional link improves the overall performance. For instance, individual packets might be delayed or entirely lost which prevents re-sequencing at the sink. If the sink requests retransmission of missing packets, additional delay is induced. This poses a problem for time critical data streams like voice or video.

A promising approach to cope with this problem is the usage of *random linear network codes*. Essentially, network coding is an extension of routing since it does not restrict a node to forward incoming traffic. Instead, outgoing traffic can be a linear combination of incoming packets. It can be used to proactively send redundant information enabling the sink to recover delayed or lost messages. Given suitable network topologies it also allows a more efficient usage of bandwidth.

### Assignment

- Investigate the implications of concurrent multi-path connections in routed networks
- Make yourself familiar with network coding and its applications
- Implement random linear network coding on top of UDP
- Evaluate the implementation and compare it to routing
- Study the behavior of your implementation with respect to link parameters (e.g. delay, bandwidth, and erasure probabilities)
- Eventually deploy your code in a real-world scenario, e.g. Planetlab

### Requirements

- Good programming skills in C and/or C++
- Very good knowledge in networking basics
- Basic knowledge in linear algebra, numerics, and statistics
- Experience in network programming is very useful

### Key words

Concurrent Multi-Path, Network Coding, Overlay

