This thesis presents novel methods that are able to perform real-time estimation of the available bandwidth of a network path. In networks such as the Internet, knowledge of bandwidth characteristics is of great significance in, e.g., network monitoring, admission control, and audio/video streaming.

The term bandwidth describes the amount of information a network can deliver per unit of time. For network end users, it is only feasible to obtain bandwidth properties of a path by actively probing the network with probe packets, and to perform estimation based on received measurements. In this thesis, two active-probing based methods for real-time available-bandwidth estimation are presented and evaluated.

The first method, BART (Bandwidth Available in Real-Time), uses Kalman filtering for the analysis of received probe packets. BART is examined analytically and through experiments which are carried out in wired and wireless laboratory networks as well as over the Internet and commercial mobile broadband networks. The opportunity of tuning the Kalman filter and enhancing the performance by introducing change detection are investigated in more detail. Generally, the results show accurate estimation with only modest computational efforts and minor injections of probe packets.

However, it is possible to identify weaknesses of BART, and a summary of these as well as general problems and challenges in the field of available-bandwidth estimation are laid out in the thesis. The second method, E-MAP (Expectation-Maximization Active Probing), is designed to overcome some of these issues. E-MAP modifies the active-probing scheme of BART and utilizes the expectation-maximization algorithm before filtering is used to generate a bandwidth estimate.

Overall, this thesis shows that in many cases it is achievable to obtain efficient and reliable real-time estimation of available bandwidth by using light-weight analysis techniques and negligible probe-traffic overhead. Hence, this opens up exciting new possibilities for a range of applications and services in communication networks.
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