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Doctoral Thesis by
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ABSTRACT

In this thesis a step towards the development of a "complete" model for a communication service and its implementation on a MIMO wireless communication system is developed. This model includes besides the physical wireless multipath channel medium, the necessary signal processing and channel coding, the media access control, the data transport mechanisms and the service application itself. Consistent models for these different parts of the communication system are developed.

Both concrete and more abstract measures of performance of a MIMO communication system are developed which have been missing in the research field. Coded packet error probability is derived on information theoretic grounds using mutual information, channel capacity and cutoff rate. Abstract performance measures, such as multiplexing gain, diversity gain and antenna gain are proposed, which measure three fundamentally different gains that can be achieved by a MIMO system. Those gain definitions allow insight and better understanding of the capabilities of a MIMO system.

Based on these performance measures, a so-called cross layer optimization method is proposed, the purpose of which is to make optimum use of the degrees of freedom in several functional blocks or layers of the communication system. The principle tasks involved in cross-layer optimization are developed. The notion of operating points and operating modes is defined which are subject to the proposed inter- and intra-layer optimization. The operating modes are private parameters of each layer and not visible or alterable by other layers. They take part in cross layer optimization by means of the intra-layer (inside the layer) optimization. The operating points on the other hand are public parameters which take part in inter-layer (between the layers) optimization.

Two fundamentally different approaches, the so-called top-down and bottom-up approaches, to cross layer optimization are proposed. In the top-down approach, operating points and modes are found such that a given quality of service of a communication application (e.g. streaming video) is implemented with minimum costs (e.g. transmit power). In the bottom-up approach, the cost is fixed and all possible operating points and modes that lead to the given cost (but not less cost) are computed. From all these so-called cost-efficient operating points, that one is selected which gives the highest possible quality of service. The terms "top-down" and "bottom-up" refer to the direction of basic information flow between the layers.

A formal, set-based mathematical description of the optimization process of both the top-down and the bottom-up approaches is developed. The concept of intra- and inter-layer optimization and of its set-based formalism is then demonstrated in two examples. In the first example, a top-down approach is applied to a file transfer application in a single user scenario. The second example demonstrates the steps involved in a bottom-up approach using video streaming for multiple users as the service application.