

M8 : Mathematical Modelling of Communication Protocols

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Course description:

This course is intended for graduate students with a background in dynamical systems or control - but with only a rudimentary exposition to communication protocols. In the course we will not develop the different communication protocols from a computer science point of view. So implementation issues will for all intents and purposes not be discussed. Rather we focus on the dynamical behaviour induced by communication protocols and the effects for the user of a communication channel. To this end the basic specifications of certain protocols will have to be introduced. Questions of how to determine whether a protocol induces a stable behaviour, whether there is fair access to the available capacity and whether the available capacity is used efficiently can be answered by analyzing appropriate models and we will discuss these issues in detail.

The three main areas which will be treated will be congestion control for the internet as it is implemented in TCP (transmission control protocol) and more modern variants thereof. Secondly, we will discuss media access control (MAC) which is a predominant feature of wireless communication channels. Finally, routing in a network will be discussed.

The different models available vary in the degree of refinement and include continuous and hybrid models. While the first class is more amenable to analytic tools to derive general properties, the modelling close to the packet level also has advantages. We will show how analytic tools can be used to understand properties of the communication channel given certain protocols.

The course will assume a working knowledge of basic stability theory, in particular stability of linear systems, linearization based theory and Lyapunov's second method. To prepare for the course it would also be helpful to read up on the Perron-Frobenius theory on (componentwise) nonnegative matrices. A brief and sufficient introduction to this topic is to be found in the later chapters of P. Lancaster, M. Tismenetsky. The theory of matrices. 2nd ed or in the standard book by Berman and Plemmons.



Fabian Wirth received his PhD in mathematics with the Institute for Dynamical Systems at the University of Bremen in 1995. He has since been working in the areas of stability theory and robust stability of linear time-varying, nonlinear and hybrid systems.

Since September 2007 he is Professor for Mathematics at the University of Würzburg. Previously he has held positions in Bremen, Frankfurt and at the Hamilton Institute in Maynooth, Ireland. In the latter position he has started working in the area of congestion control and on the modelling of TCP. His current interests include mathematical modelling of the dynamics given by a communication protocol, modelling of logistic networks and control over communication channels.

Fabian Wirth is associate editor of Systems and Control Letters and the SIAM Journal on Control and Optimization.