

# THE BEHAVIORAL APPROACH TO SYSTEMS AND CONTROL

Jan Willems - University of Leuven

The aim of this presentation is to present some of the main ingredients of a new mathematical language for discussing dynamical models of systems. The central object in this approach is the behavior of a system. The main feature of the behavioral approach is that it treats all system variables on an equal footing. This in contrast to the classical input/output view, where a system is regarded as being driven by inputs and generating outputs.

The behavioral approach is strongly motivated by practical modelling issues. Therefore, we start, by way of motivation, with a brief discussion of a couple of physical (electrical and mechanical) examples, where we will argue that the input/output approach is awkward and unnatural. However, these examples will bring to the foreground another feature of first principles models, namely the universal presence of auxiliary variables. This leads to the main objects of our mathematical language: the behavior, behavioral equations, and manifest and latent variables.

The place where the virtues of our viewpoint are most evident is in considering interconnections of systems. We will argue that interconnection leads to sharing of common variables. This in contrast to input selection and, perhaps, feedback, the usual way that interconnection is thought of.

We then turn to the class of systems for which a rather complete theory has been developed: linear time-invariant differential systems. While we are mainly interested in dynamical systems, we find it convenient to incorporate here distributed systems described by PDE's into the discussion. We set up three central results, theorems:

1. The existence of a one-to-one relation between linear time-invariant systems and polynomial modules.
2. The elimination of latent variables: the class of linear time-invariant systems is closed under projection.
3. Controllable systems are precisely those that admit image representations.

We end with a couple of thoughts on the way control is incorporated in this framework.