Dissipation in Networks of Process Systems

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Abstract:

"the field equivocally covered by the word communication permits itself to be reduced massively by the limits of what is called the context". *Jacques Derrida*

I will describe a research program which aims to develop a new approach for modeling and control of complex, networked systems. We use the thermodynamic entropy as a Lyapunov like function to derive sufficient conditions for dissipation. The current presentation focuses on consequences of an important toplogical result for networks called the Tellegen theorem. The Tellegen theorem is similar to the Gibbs-Duhem equation. It expresses orthogonality amongst primal and dual variables - in our context the forces and the fluxes. Forces are defined as gradients of the intensive variables whereas the fluxes are flows. One interesting aspect of the Tellegen result is that it is independent of constitutive equations. These can be nonlinear, discrete, passive or active.

The Tellegen theorem allows us to develop a theory for self-organization of complex, distributed networks of chemical process systems. We establish conditions under which the complex network is isomorphic to a gradient system with a Riemannian structure. We furthermore show that paths of such systems are optimal in a very precise manner since they can be defined using variational principles. For example, the network solves quadratic programs if the constitutive equations are linear. If they are discrete then the network solves mixed integer programs. In the general we solve mixed integer nonlinear programs to local optimality.