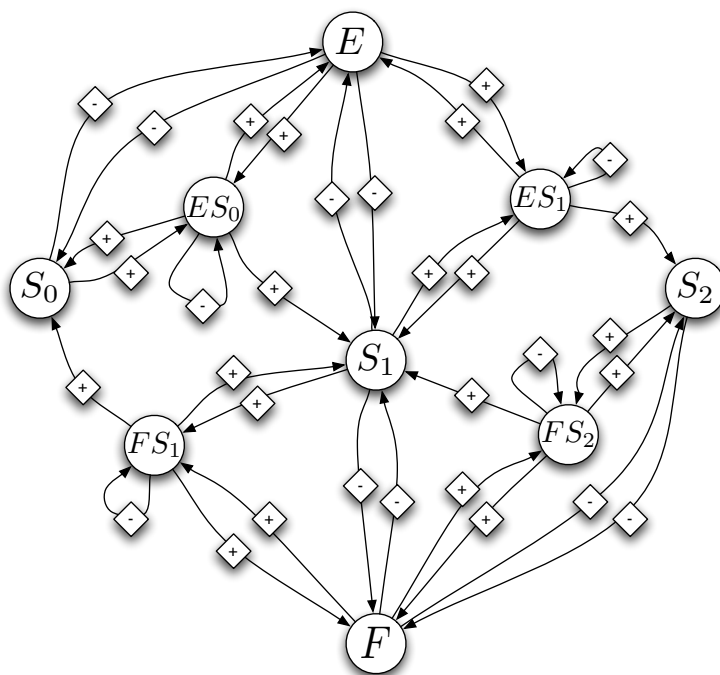


Project Complexity DTC  
**A Project in Dynamical Network Theory**

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Network theories are the most dominant tools in complex systems research at the moment. There are uncountable different variants, and applications to biology, economics, social sciences, actually nearly every branch of science. One reason is surely that network models are intuitive, they relate a number of components with each other. This is indeed very close to our common sense understanding of the world. To study network models is therefore essential for understanding the current trends in complex systems research.

In this project we study one of the most frequently asked questions in *dynamical network theory*: **What is the relation between the network topology and the qualitative behaviour of the network?**



To understand the problem we will study first some theorems related to the **interaction graph** which is closely related to the feedback loops governing a dynamical system, see the figure above. Clearly feedbacks can be positive or negative at every instance of time, explaining the positive and negative weights attached to the arrows. The dynamics can for example be obtained from chemical reaction systems, but the concept of the interaction graph is much more general. We will need to understand different assumptions related to the interaction graph. Important are for example so-called quasi-monotone systems which are characterised by the fact that the signs associated to the interaction graph will never change. In the project we will also learn that different networks (i.e.

graphs) can be attached to a dynamical system giving rise to different approaches to answer our fundamental question about the relationship of the network topology and its dynamics.

The project will incorporate an overview to existing network approaches in complex systems theory to put the interaction graph and its variants into perspective.

#### References:

M. Kirkilionis, "Reaction systems, graph theory and dynamical networks", pp. 131-150. in: R. Gauges et al (eds.) 5<sup>th</sup> Workshop on Computation of Biochemical Pathways and Genetic Networks, Logos-Verlag, 2008.

Domijan, M. & Kirkilionis, M. (2008). Bistability and Oscillations in Chemical Reaction Networks. *Journal of Mathematical Biology*, in press.

Sbano, Luca, and Kirkilionis, Markus. "Multiscale Analysis of Reaction Networks." *Theory in Biosciences*, 127(2), pp. 1431-7613, Springer Verlag (2008).

Domijan, M., and Kirkilionis, M. "Graph Theory and Qualitative Analysis of Reaction Networks." *Networks and Heterogeneous Media*, 3(2), (2008): 295-322.

M. Kirkilionis, U. Kummer, I. Stoleriu (Eds.): 2nd UniNet Workshop: Data, Networks and Dynamics. Logos-Verlag Berlin, 2006.

Kirkilionis, M., S. Walcher, *On comparison systems for ordinary differential equations*. *Journal of Mathematical Analysis and Applications*, 2004. 229(1): p. 157-173.