



The DFG Priority Programme 1305 "Control Theory of Digitally Networked Dynamical Systems"

Dipl.-Ing. René Schuh
 schuh@atp.rub.de

1 Introduction

Modern means of communication lay the foundations to connect different elements of control systems like sensors, actuators or even whole subsystems over a digital network [1–3]. By the implementation of wireless connections over a wide area, new control methods can be realized that would have been much more difficult or even impossible to set up in a wired network (see e.g. Figure 2). Furthermore, measured variables and control variables can now be transmitted to the controller from nearly every position of a technological plant.

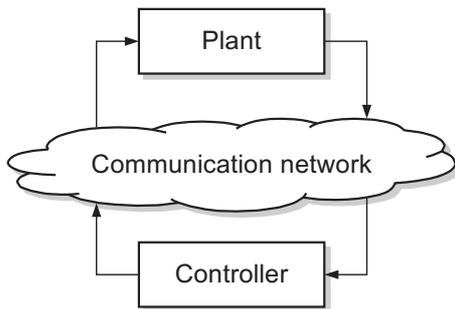


Figure 1: Basic structure of a networked control system

Such control structures cannot be handled with traditional methods for two reasons. On the one hand, the event-driven mode of operation of digital communication networks violates the assumption that data is processed and transmitted with a constant sampling rate. On the other hand, the structure of the network is persistently changing since the data network adjusts itself to the needs and the technical constraints.

Furthermore, the use of digital communication networks

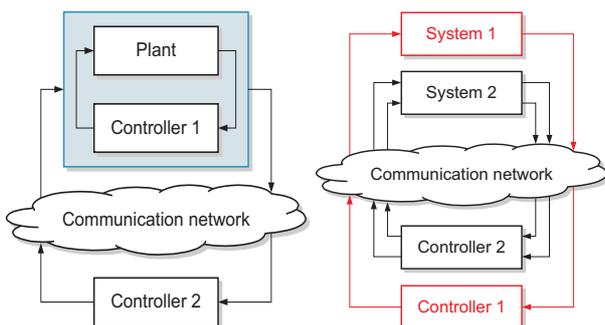


Figure 2: Innovative networked control concepts

causes some restrictions that can appear individually or in combination:

- Web-structures may be restricted and variable in time.
- The transfer rates are variable in time.
- Packets may get lost or irreparably damaged.
- Information is transmitted only with a bounded accuracy.

The networking of the control tasks can be advantageous in terms of lower system costs due to installation and maintenance costs. Other important reasons for their usage is their flexibility in matters of appearing or disappearing information channels as well as the fact that even mobile subsystems can be controlled over wireless networks.

2 Goal of the Priority Programme

The German Research Foundation has stated in 2007 a Priority Programme that includes 13 projects, aiming at the development of a control theory for the modelling, analysis and design of future digitally networked dynamical systems. In 2010 the second and last funding period started in which 11 projects are focussed on large-scale networked systems. The programme concentrates on the following three workpackages:

2.1 Modelling, analysis and development of asynchronously working control systems

By transmitting information over a non-deterministic network the basic digital control theoretic assumption of a constant sampling rate is violated and the systems become asynchronous and event-driven instead. New theoretic methods for the description, analysis and design of such systems shall be developed.

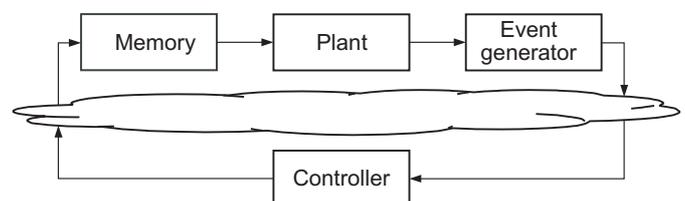


Figure 3: Structure of an event-driven control system

2.2 Performance of networked control systems

Methods for evaluating the performance of networked systems that consist of physical subsystems, communication units and control units have to be elaborated. Besides planned couplings the application of modern means of communication leads to unrequested interactions between the involved closed-loop systems. The methods for analysing and designing that are to be developed have to yield statements about which couplings of information are beneficial for the complete system, how to diminish unrequested couplings and which connection between the performance of the networked control system and the single closed-loop systems exist.

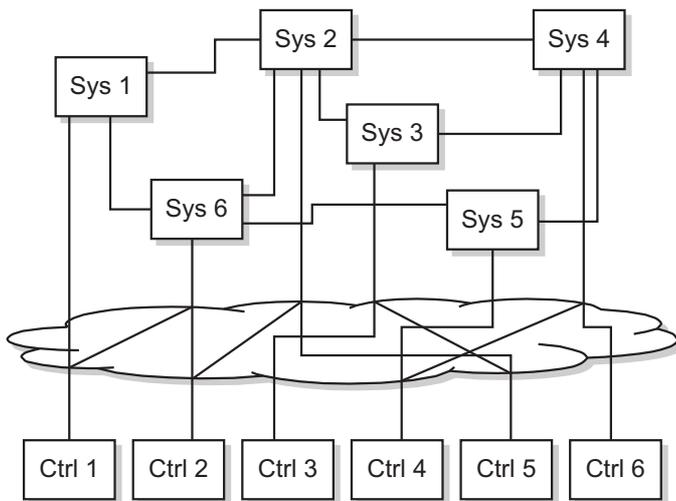


Figure 4: Structure of a system with multiple closed-loop systems

2.3 Development of innovative control concepts

The Priority Programme will also concentrate on the question which novel structures and methods of closed-loop control will be feasible by the use of digital networks. This aim requires the investigation of event-driven control, where the activity of the controller is restricted to the times in which disturbances have to be compensated or changes of the set point have to be realized. These investigations shall include control structures whose control task is solved by an attached controller and a persistently or from time to time connected remote controller. Further more, control structures have to be examined where the complete system - divided in (spatially) distributed subsystems - is controlled by distributed controllers.

3 Activities of the Priority Programme

Within the scope of the Priority Programme several activities in order to coordinate the projects and to achieve a national and international perception are planned.

- An **internet presence** which includes information about all participating projects, publications and workshops is available under

<http://spp-1305.atp.rub.de/>.

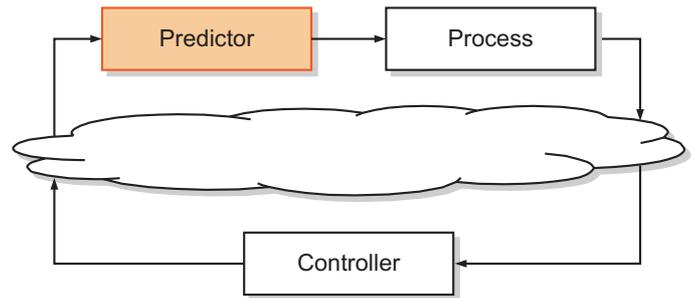


Figure 5: Structure of a predicted networked control system

This website also contains the bibliography DynaBIB about networked control systems (NCS) that comprises all relevant articles dealing with the subject of NCS.

- Two **PhD schools** have taken place during the six year run-time of this Priority Programme in October 2008 and September 2011. These schools, where experts in the field of digitally networked control systems were lecturing, could be attended by every national and international PhD student.
- Ten **issue-oriented workshops** were held in the first funding period. On these meetings, methods and solutions to the problems of the defined workpackages are discussed.
- Three **demonstration and benchmark processes** have been defined so that the control methods that are going to be developed during the Priority Programme can be compared and tested in a practical environment.
- The Priority Programme organizes a **guest programme** where foreign scientists can spend a long-term visit at one of the participating institutes. These scientists will also take part in the PhD schools and the workshops.
- Results of the Priority Programme are going to be presented on **international conferences** like the *European Control Conference (ECC)*, the *International Symposium on Mathematical Theory of Networks and Systems (MTNS)*, the *IEEE Conference on Decision and Control (CDC)* and the *IFAC World Congress*.
- Towards the end of the second funding period, a **symposium with international attendance** will be organized, where the main results of the programme will be presented.

References

- [1] at-Automatisierungstechnik 1/2008: *Digital vernetzte Regelungssysteme I*. Oldenbourg-Verlag, München, 2008.
- [2] at-Automatisierungstechnik 4/2010: *Digital vernetzte Regelungssysteme II*. Oldenbourg-Verlag, München, 2010.
- [3] it-Information Technology 4/2010: *DFG Priority Programme 1305: Control Theory of Digitally Networked Dynamical Systems*. Oldenbourg-Verlag, München, 2010.