Distributed Estimation and Control

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For interconnected systems, the state estimation and control algorithms associated with the subsystems can communicate over the network to improve their performance. This chapter describes methods for structuring the overall control system including the communication network and shows how to use the communicated information for estimation and control if the network induces transmission delays and packet loss.

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3.1 Estimation and Control Architectures

3.1.1 Distribution of Control Tasks

The availability of powerful communication networks leads to new architectures for the control of interconnected systems. The current hierarchical structure shown in the left part of Fig. 1.14 on p. 23 is replaced by distributed structures depicted in the right part of the figure. The grey boxes represent physical systems and the white boxes estimation and control algorithms. This idea is explained in more detail in this chapter.

The architecture of a control system describes which components of the plant, the state estimator and the controller work together and which information is exchanged among these components. Which architecture should be used depends upon different practical aspects like the availability of computer resources, the properties of the plant and the software used for the implementation of the estimation and control algorithms.

Classical control theory has concentrated on an embedded systems approach where all components of the controller are placed on a single computer board and connected to the overall plant. Hence, all information delivered by sensors of the plant are communicated to a single entity that is responsible for the estimation of the overall state and the generation of the overall system input. In control theory, this structure is called a centralized control loop and the controller a centralized controller.

There are several reasons why centralized control should be extended to more involved architectures:

- The plant may be large and geographically distributed. Then the centralized control architecture is no longer applicable because it is impossible to send all sensor information to a common controller, to provide the necessary computing power in one centralized entity, or to set up the overall plant model. Then it is necessary to distribute the estimation and control tasks over the subsystems and, possibly, a coordinator.

- The plant consists of independent subsystems that have their own control equipment and have to fulfill a common control goal. Then the natural way is to associate the control algorithms with the local computing resources.

- If the structure of the plant changes, for example due to the appearance and the disappearance of subsystems during operation, it is reasonable to simultaneously change the structure of the controller. Architectures have to be used that provide the corresponding flexibility.

Figure 3.1 illustrates several options of how to extend the centralized control architecture. The following explanations refer to the control problem but similar investigations can be made for state estimation and other control