PURDUE UNIVERSITY

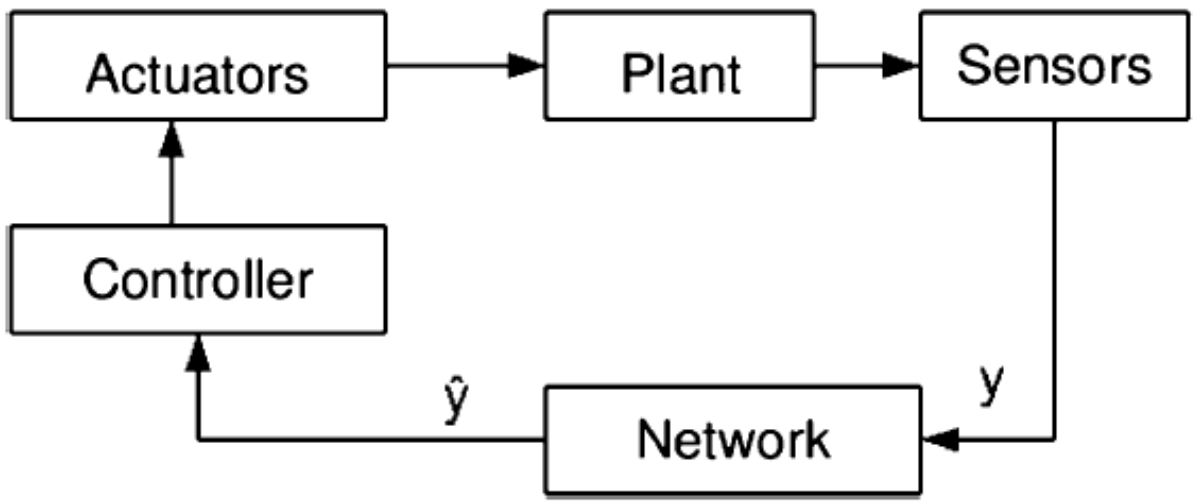
ECE 68000: MODERN AUTOMATIC CONTROL

Professor Stan Żak

Cyber-physical and Networked Control Systems

Network Control System (NCS)—What Is It?

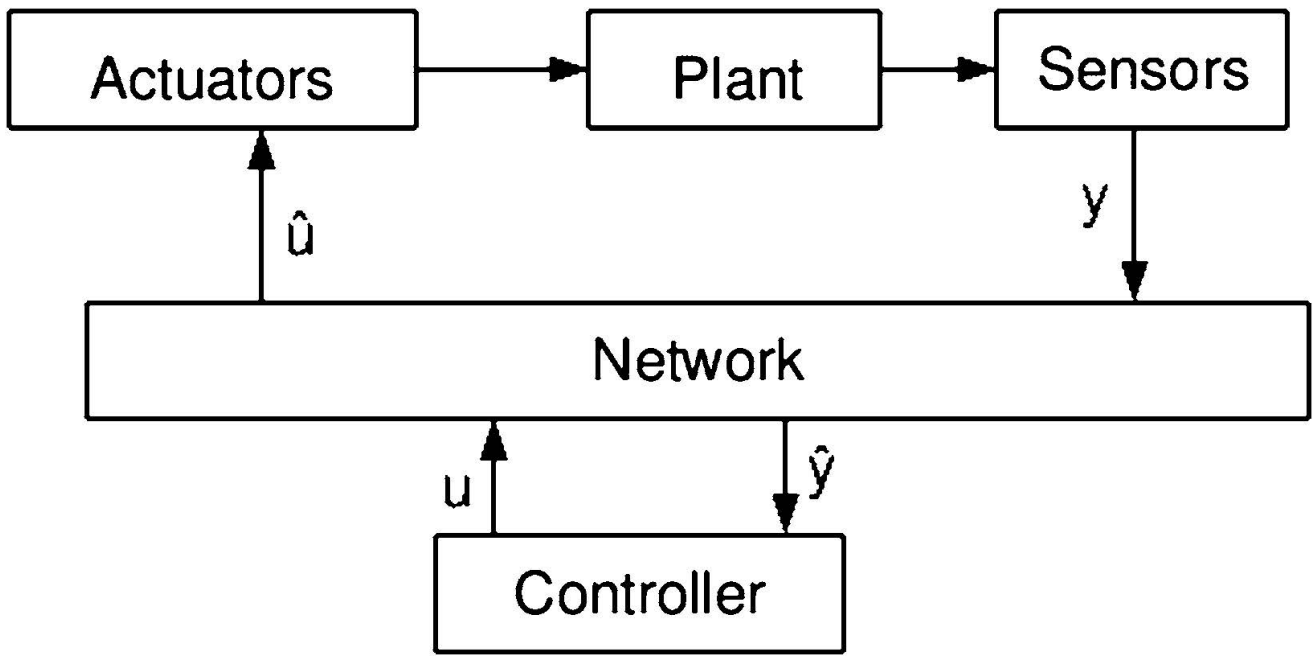
- When a feedback control system is closed via a communication channel, which may be shared with other nodes outside the control system, then the control system is called a NCS. A NCS can also be described as a feedback control system where the control loops are closed through a real-time communication network.



L. Bushnell and H. Ye, *Networked Control Systems: Architecture and Stability Issues*, in Encyclopedia of Systems and Control, Springer-Verlag London 2014

Another Look at a Network Control System (NCS)

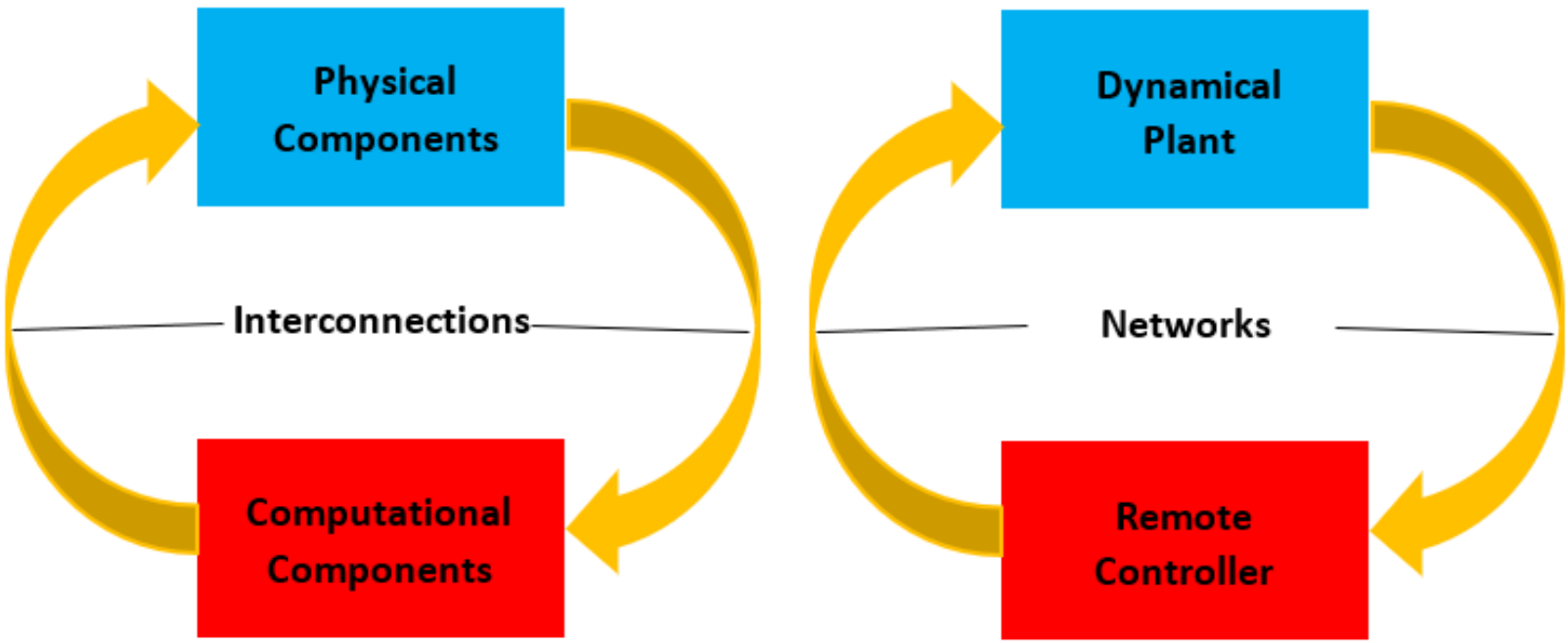
- A Networked Control System is a control system where the control loops are closed through a communication network. In a NCS feedback signals are exchanged among the system's components in the form of information packages through a network.



Cyber-Physical Systems

Definition

Cyber-Physical Systems combine cyber and physical components, that is, they are combinations of the physical world with the virtual world of information processing



More on the Term Cyber-Physical System

Definition

Cyber-Physical System (CPS)—a combination of virtual and physical components

- The term "cyber-physical system" (CPS)—first proposed in 2006 by Helen Gill of the US National Science Foundation

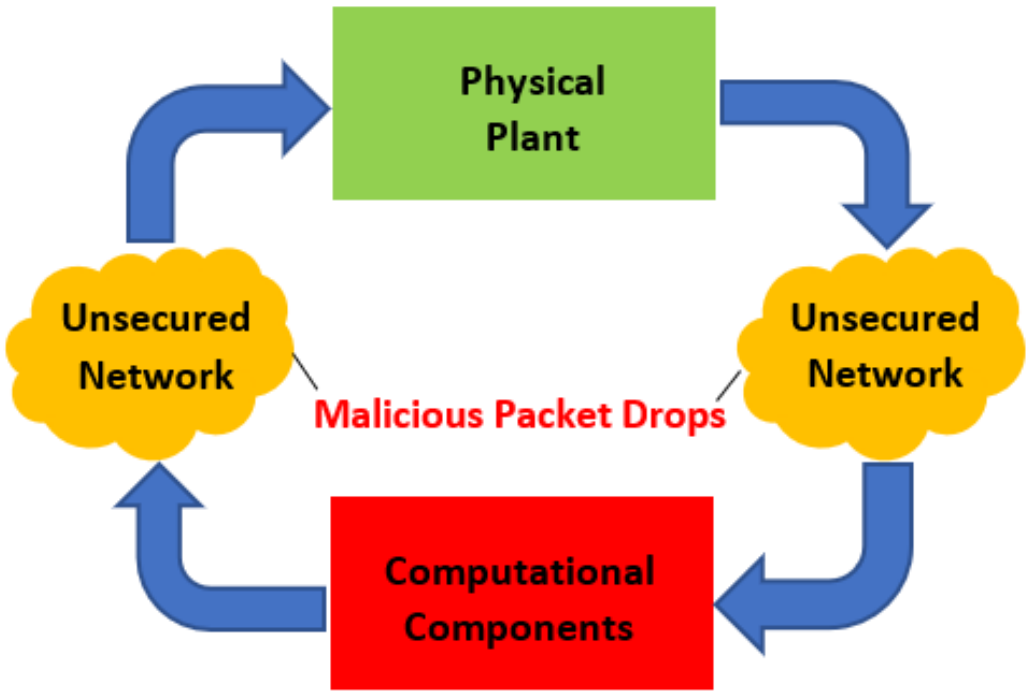
NCS versus CPS

- The CPS and "Networked System" Venn diagrams intersect, but neither is contained within the other.
  You could have CPS that are not necessarily networked in a graph (pacemaker, etc.) You could have networked systems that have no cyber component (human contact network, genetic networks) You could have systems that are both networked and CPS (power grid).

Shreyas Sundaram—private communication

Challenges in NCS

- Major challenge in the NCS design—security
- For example, malicious packet drop attacks in the communication networks



Need for the System State Estimate

- Many controllers call for the complete availability of the state vector of the controlled system
- It is frequently impossible to directly measure all the elements of the system state vector
- To retain the many useful properties of the state feedback control, one needs to overcome the problem of incomplete state vector information
- How to obtain good state estimate in the presence of modeling uncertainties and disturbances?
- What about system security operation?