Industrial Process Controllers and Simulators

Topic 2

Architecture of a Computer Control Systems

Definition

"Industrial Control System is any sort of device/system which includes a programmable computer but mostly it is not intended to be recognized as a computer."

Operates in safety-critical environments.

Mostly involves the use of Real-Time Operating System.

Principles of operation

Industrial Control Systems

Controller-object interaction

Controller-Object Interaction

1. **Signal exchange**
   - type of signals
   - hardware I/O systems
   - time-driven & event driven exchange
2. **Interaction with the object**

Controller-Object Interaction

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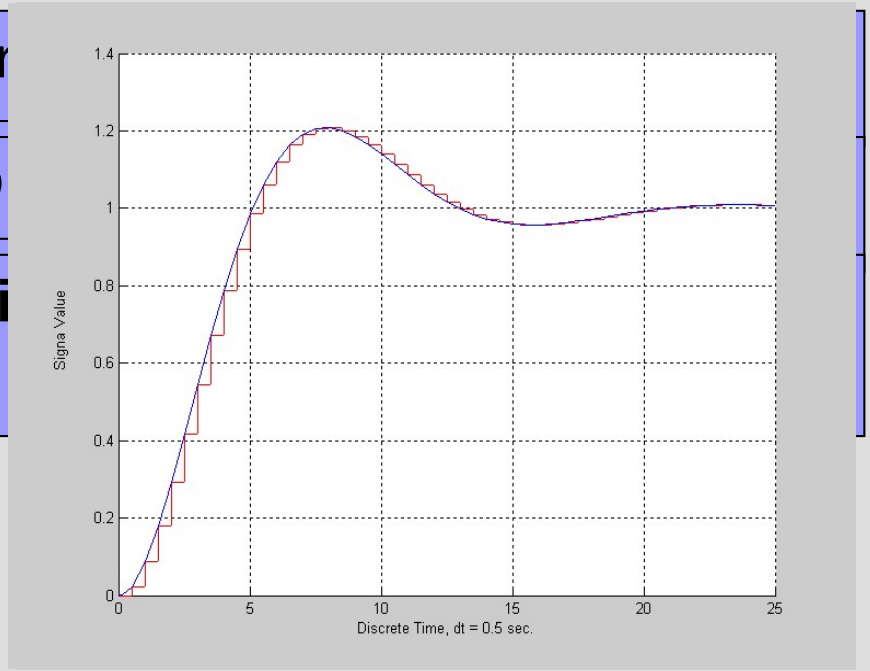
Signal Exchange

Types of signals:

- Analogous
- Discrete
- Pulse



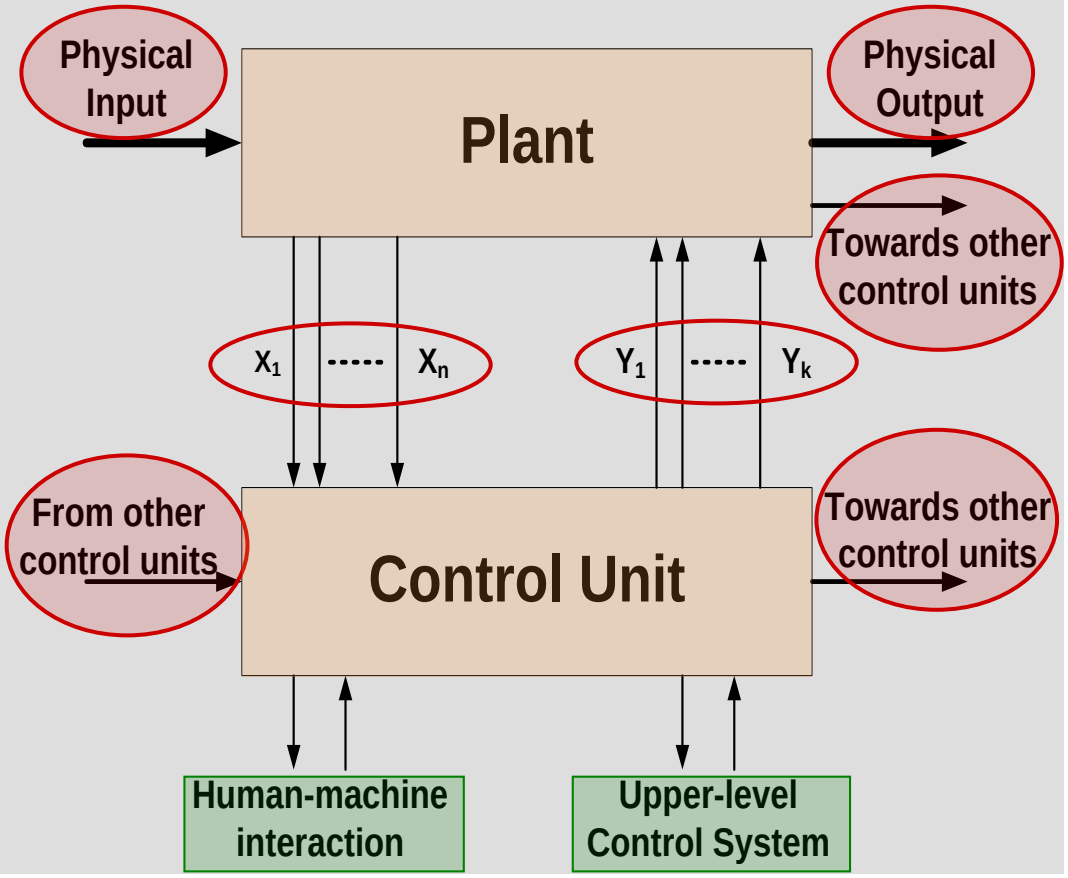
Signal Exchange

Two forms :

- Time-Driven — **The interaction takes place at predefined moments of time**
- Event-Driven — **The interaction takes place when a certain event occurs**

Industrial Control Systems

Physical organization



Industrial Control Systems

Main types :

- Continuous — Continuous interaction signals – they need conversion in both interaction
- Discrete — Discrete signals in both directions
- Hybrid — The plant operates in a mixed mode

Industrial Control Systems

Main types :

- Continuous
- Discrete
- Hybrid

Industrial Control Systems

Main types :

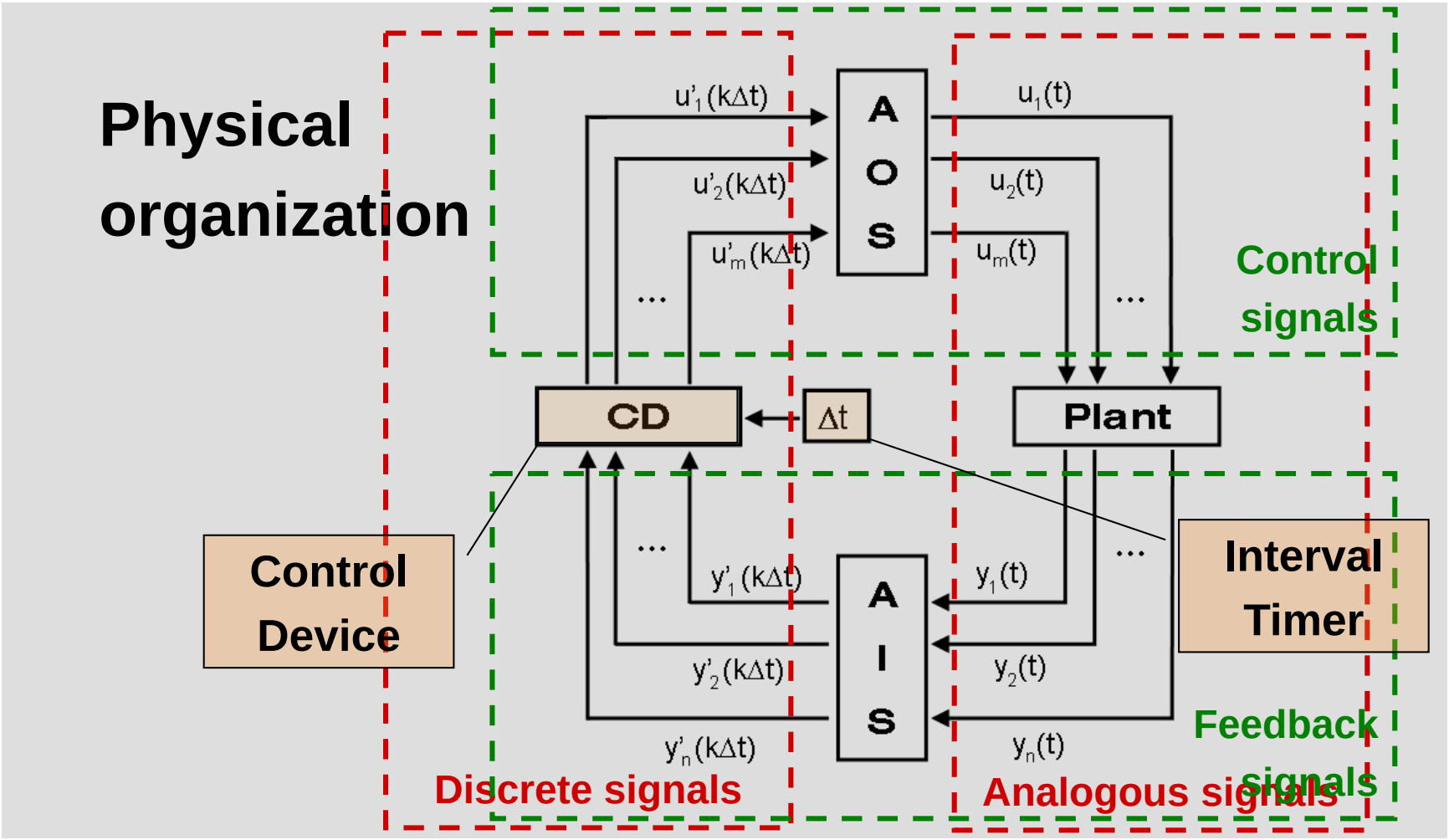
- Continuous
- Discrete
- Hybrid

Continuous Objects

Interaction :

- The controller is a discontinuous machine.
- Both incoming to and outgoing from the controller signals are continuous.
- Requires analogous I/O subsystems
- Two types of signal quantifying
  - By level
  - By time

Continuous Objects

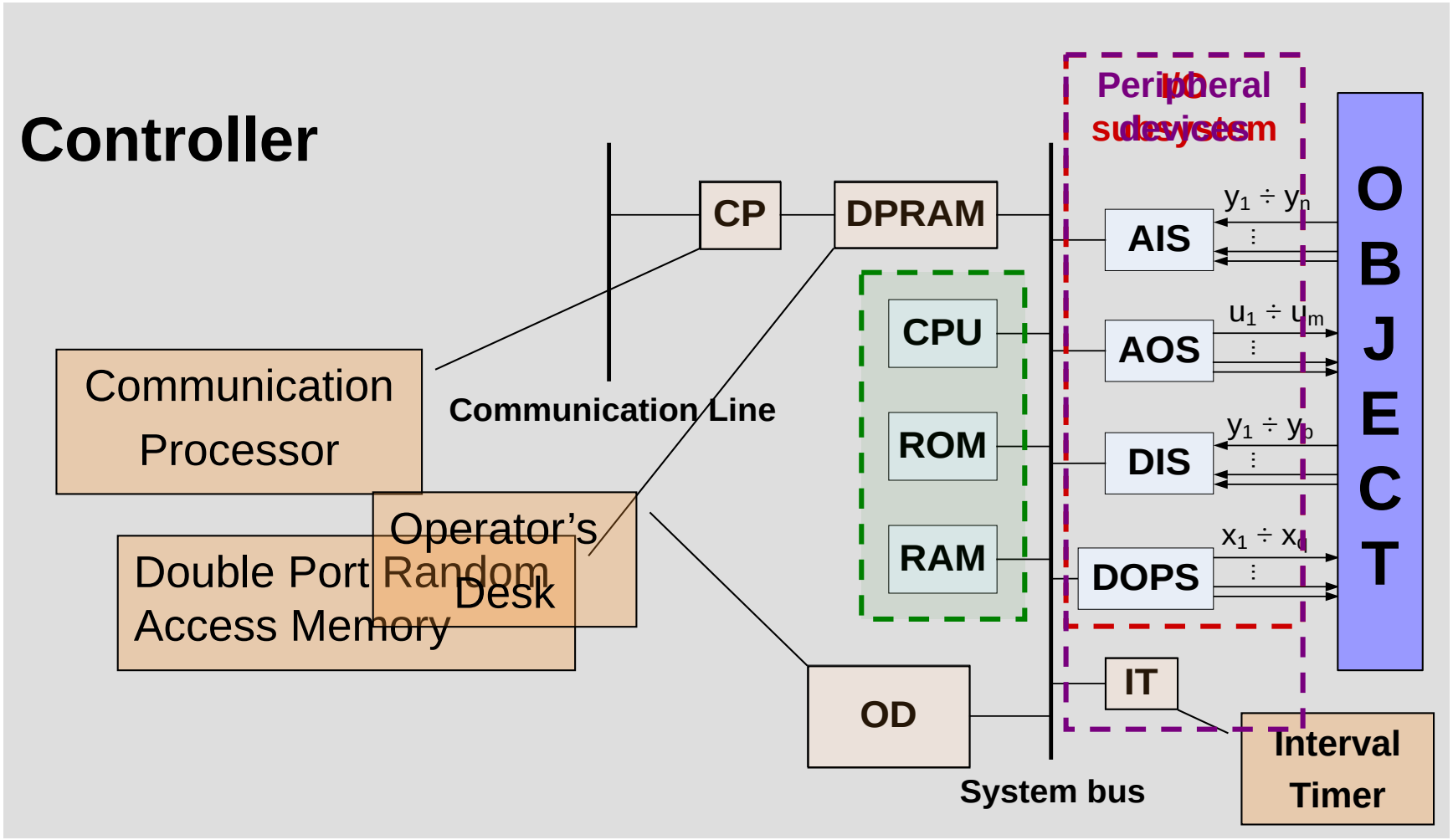


Continuous Objects

Signal Conversions :

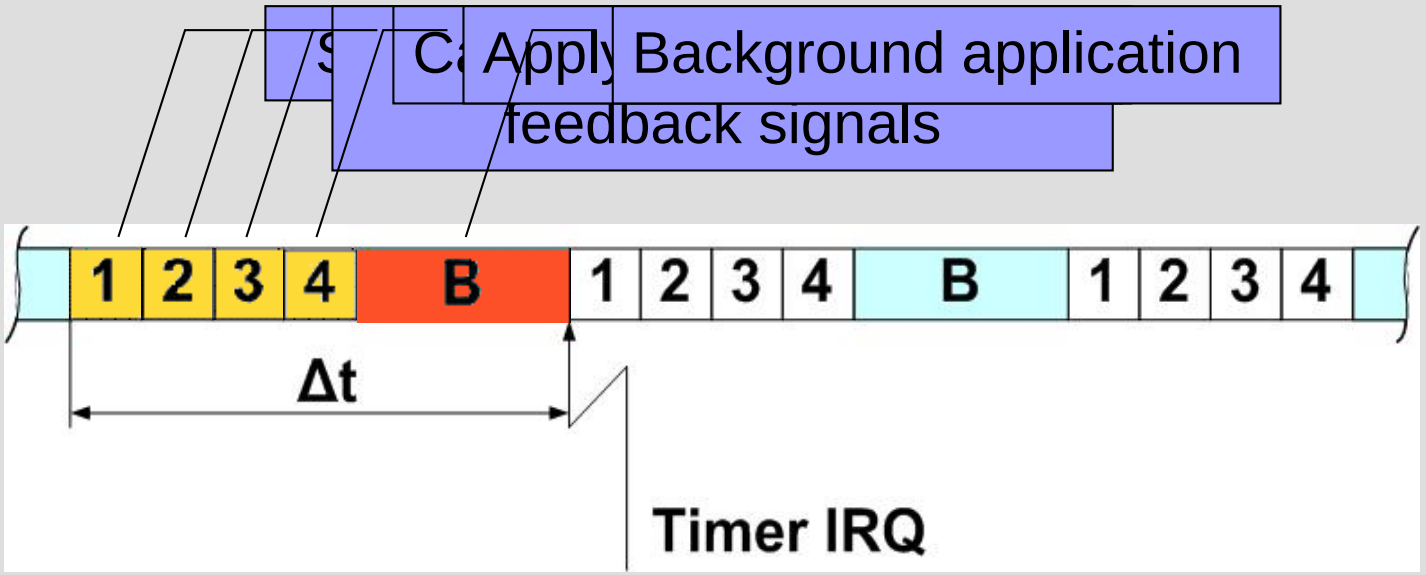
- Quantifying by level — **Performed by the ADC**
- Quantifying by time — **Performed by timers**
- Discrete-to-analogous — **Performed by the DAC**

Continuous Objects



Continuous Objects

Analogous ICS -> time chart of operation



Continuous Objects

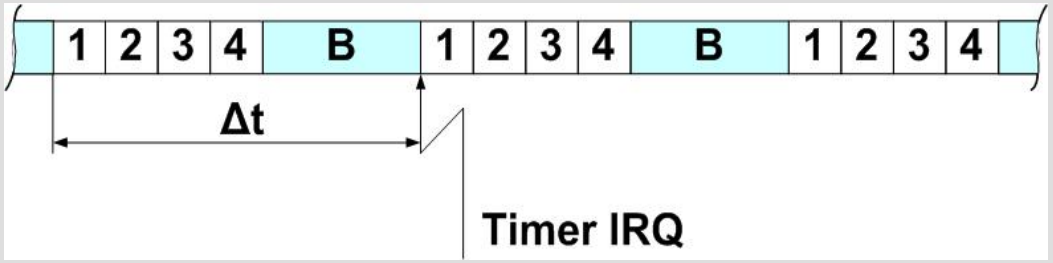
Analogous ICS -> how does it works

- Control device periodically executes a specific control task
- Period depends on the plant dynamics
- Period is based on interrupt requests
- Fluctuations of the moment for execution of phase 4 may occur

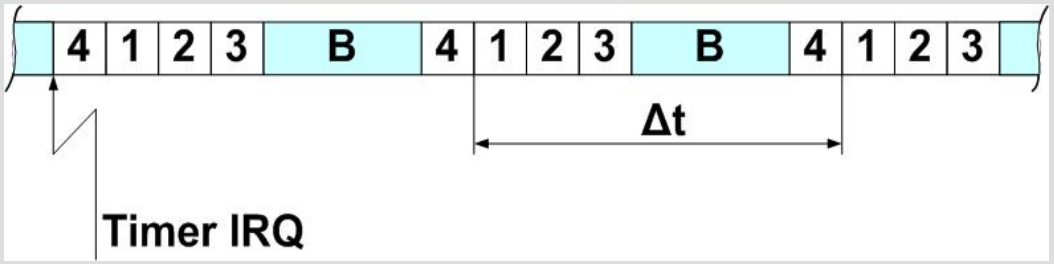
Continuous Objects

Analogous ICS -> avoiding output jitter

Old time chart

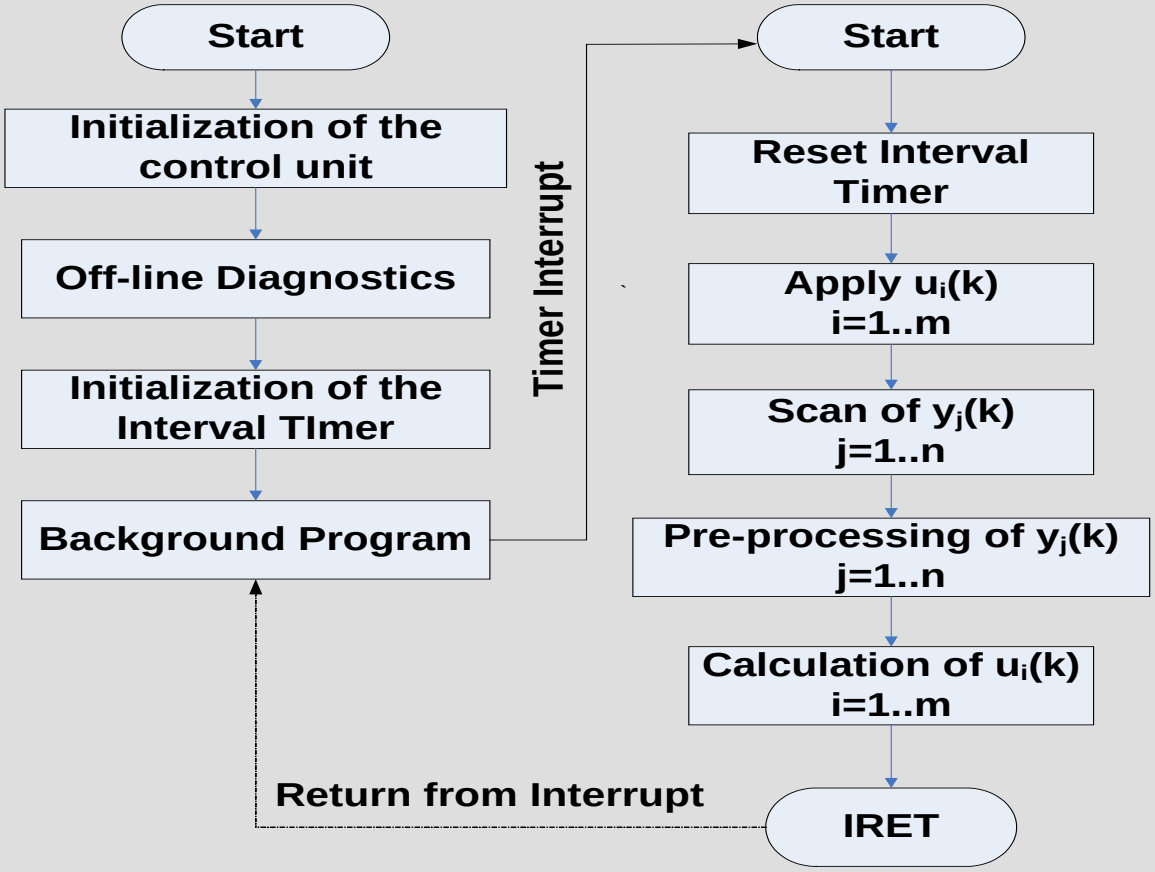


New time chart



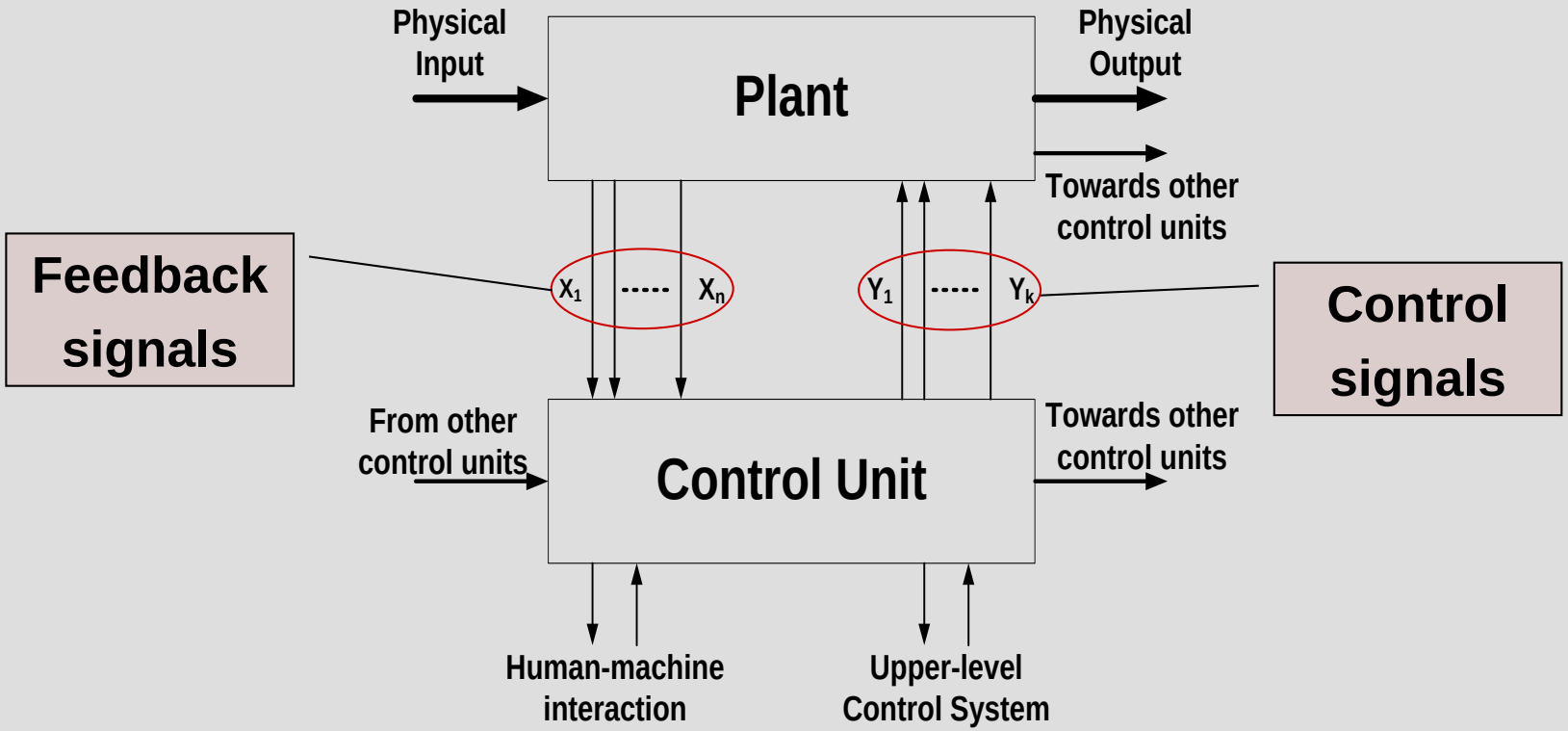
Continuous Objects

Algorithm essentials



Discrete Objects

Interaction:



Discrete Objects

Basics of the interaction :

- Typical for the machinery construction industry and the transport industry.
- Both the plant and the control unit function discretely
- Exchanged signals are usually discrete
- Analogous signals used to create additional control conditions

Discrete Objects

Discrete Industrial Control Systems (DICS)

Evolution:

- Relay Schemes
- Digital Electronic Circuits
- Programmable Controllers
  - Programmable Logic Controllers
  - State Logic Controllers
- Synchronous vs. Asynchronous DICS

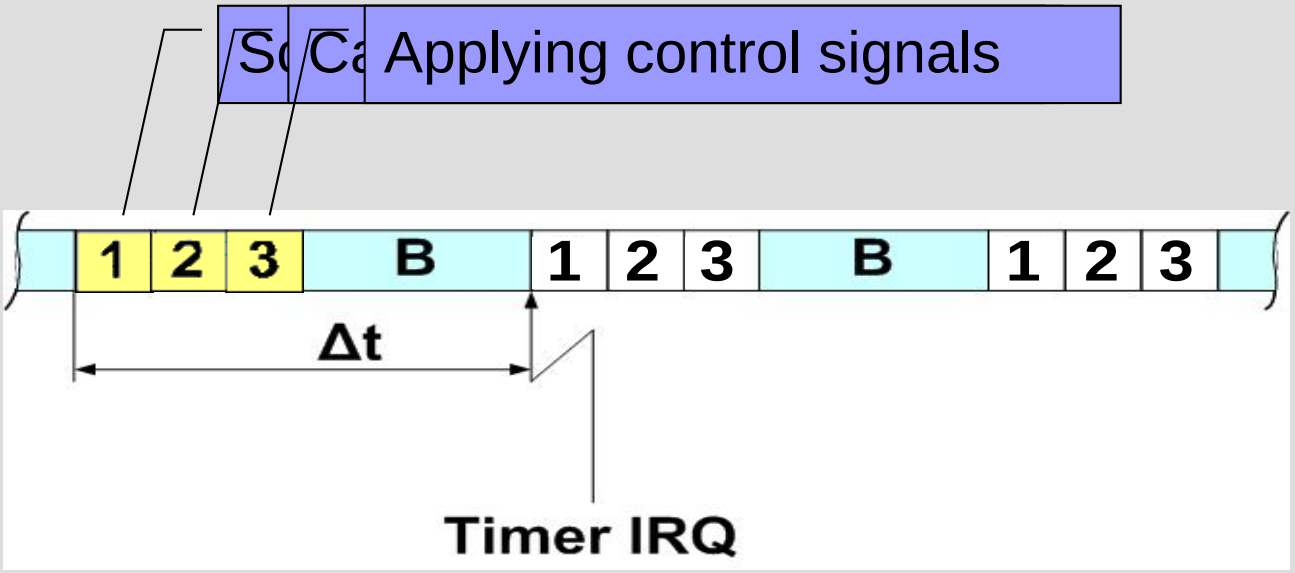
Discrete Objects

Plant and control device modeling and design

- Automata models
- Operational and control automaton
- Abstract synthesis of control automaton
  - Mealy Automata
  - Moore Automata
  - Petri Nets
  - etc.
- Structural synthesis of control automata

Discrete Objects

Programmable controller -> time chart



Discrete Objects

DICS programming

1. Different approaches for SLC and PLC
   - Abstract Synthesis for SLC
   - Structural Synthesis for PLC
2. Languages -> specialized languages exist for both controllers types
   - PLC – IEC 61131 Standards
   - SLC – Petri Nets, FSM, or other visual language

The END