Industrial Process Controllers and Simulators

Topic 8

Simulators – practical aspects

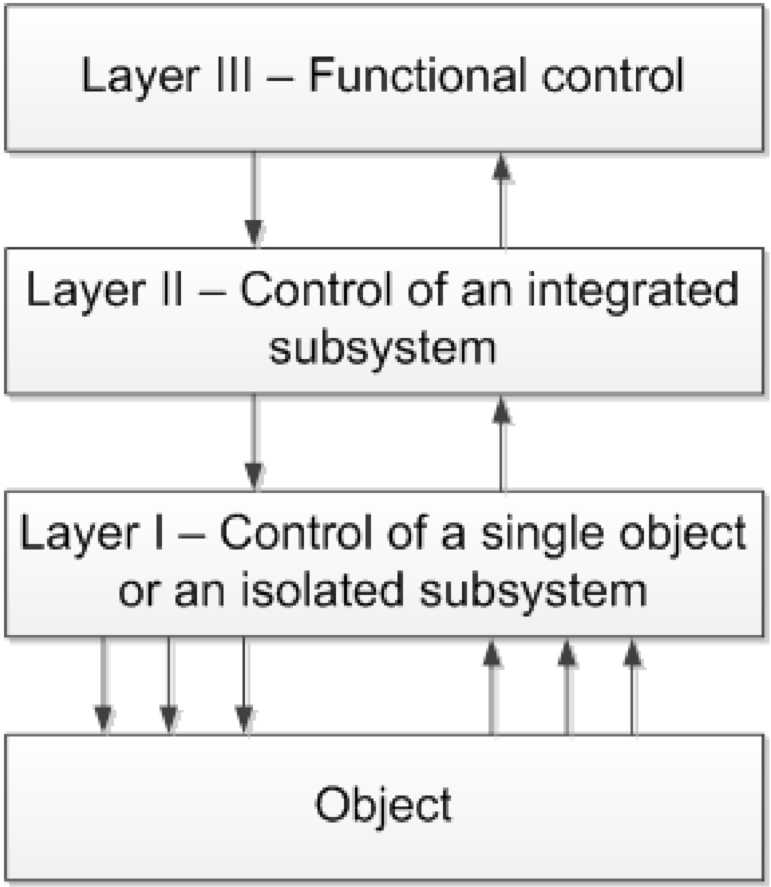
Problem Statement

Requirements

- Complex (incl. distributed) objects simulation
- Both H-I-L and S-I-L support
- Program generation for both simulator and controller
- Real-/Nonreal Time simulator operation
- Coordination between the simulator and the controller

Background of
the presented approach

System structure



General structure of a multi-layered control system

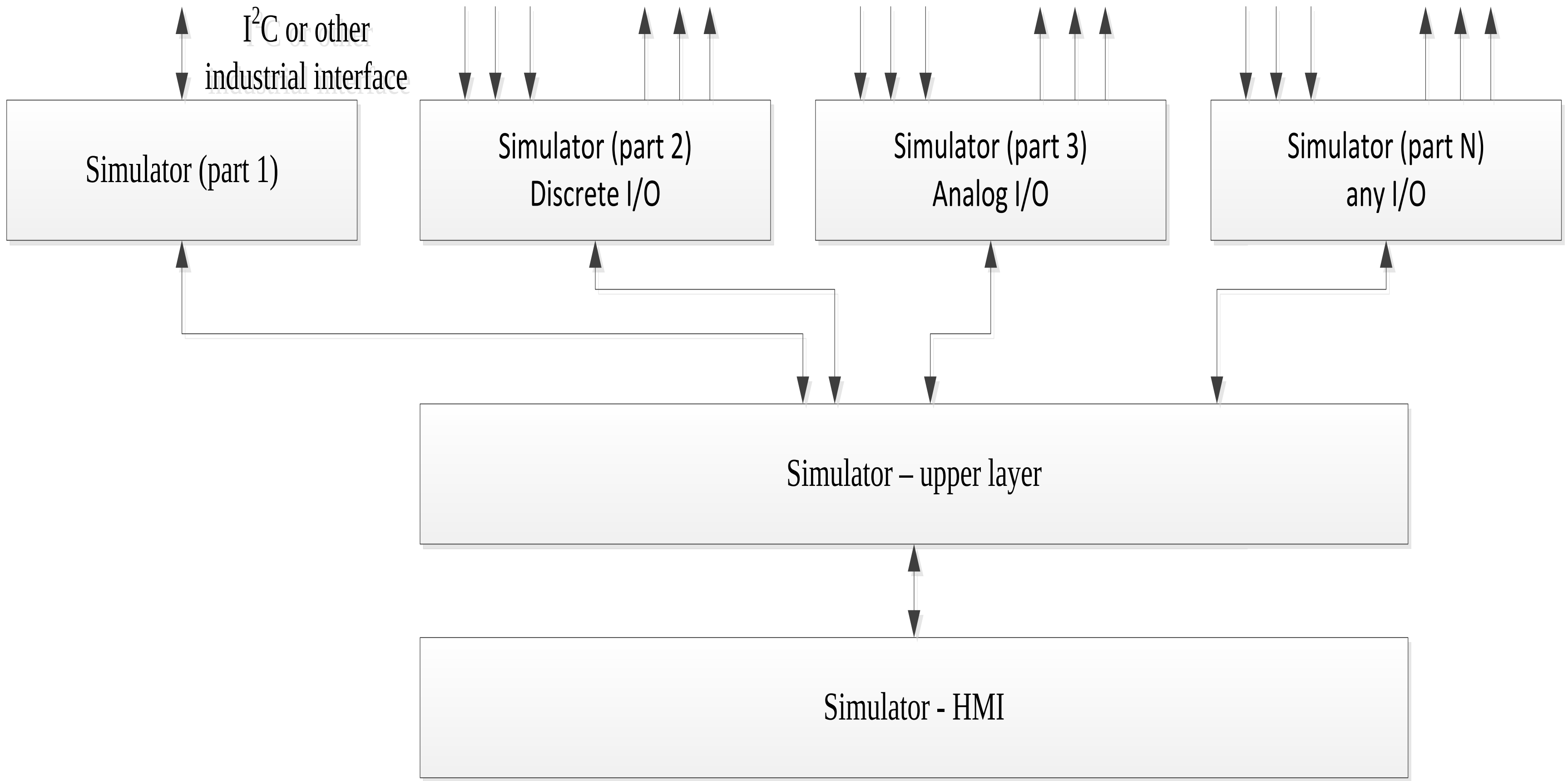
Ways to simulate the object

- Full simulation using a physical interface of the same type as the real object (and possibly including parts of hardware from the object);

- Partial simulation using a physical interface, emulating the real interface;

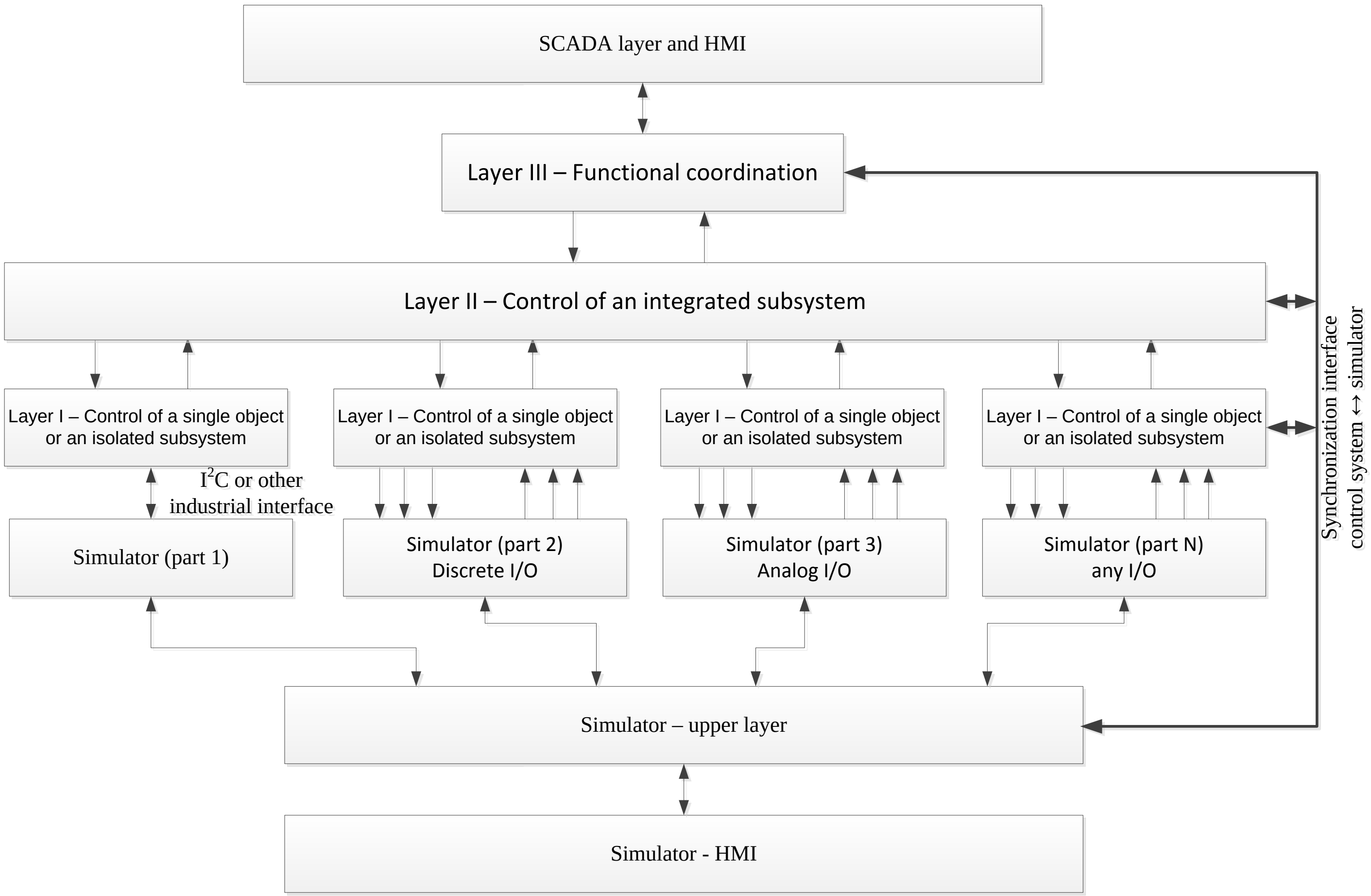
- Partial simulation using signal exchange based on a type of networking.

System structure



General structure of a multi-layered semi-natural simulator

System structure



Combined structure “control system ↔ simulator”

Special elements to be simulated

- Human-machine interface – “as is”
- Distributiveness of the object – parametric, geographical;
- Any type of networking.

The program generator

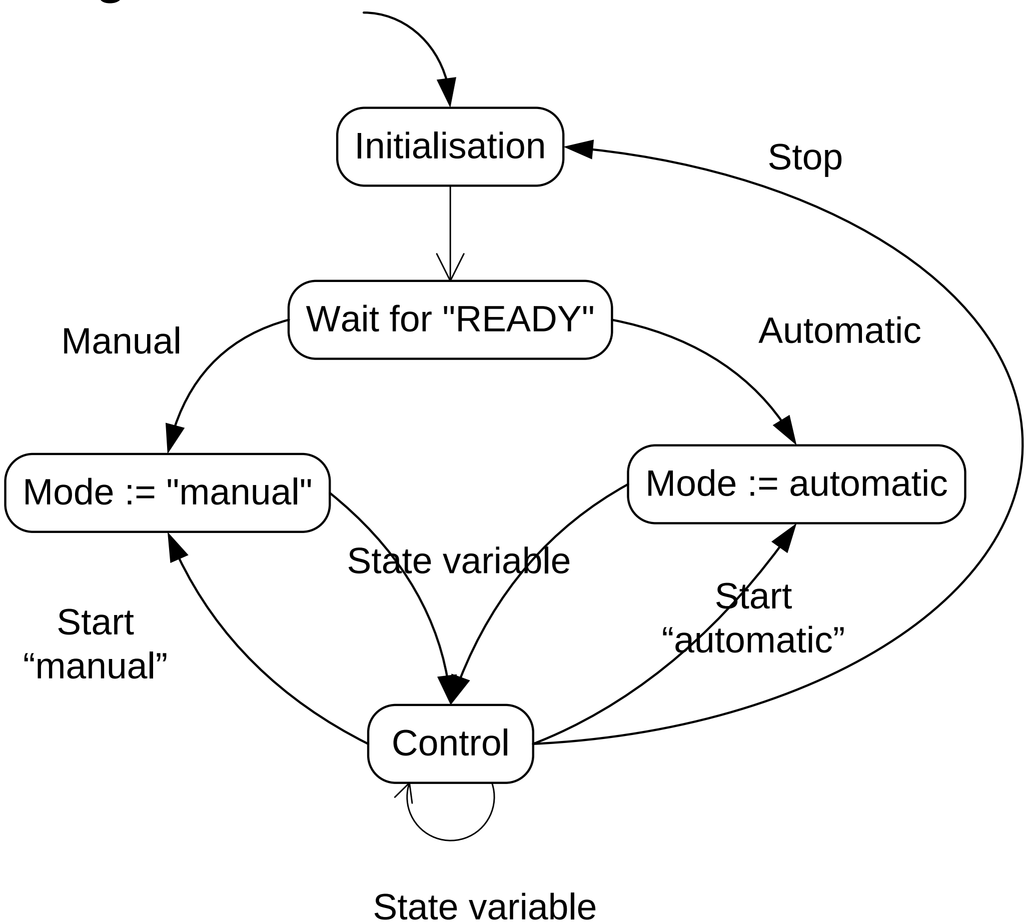
PRGEN

Program generator information inputs

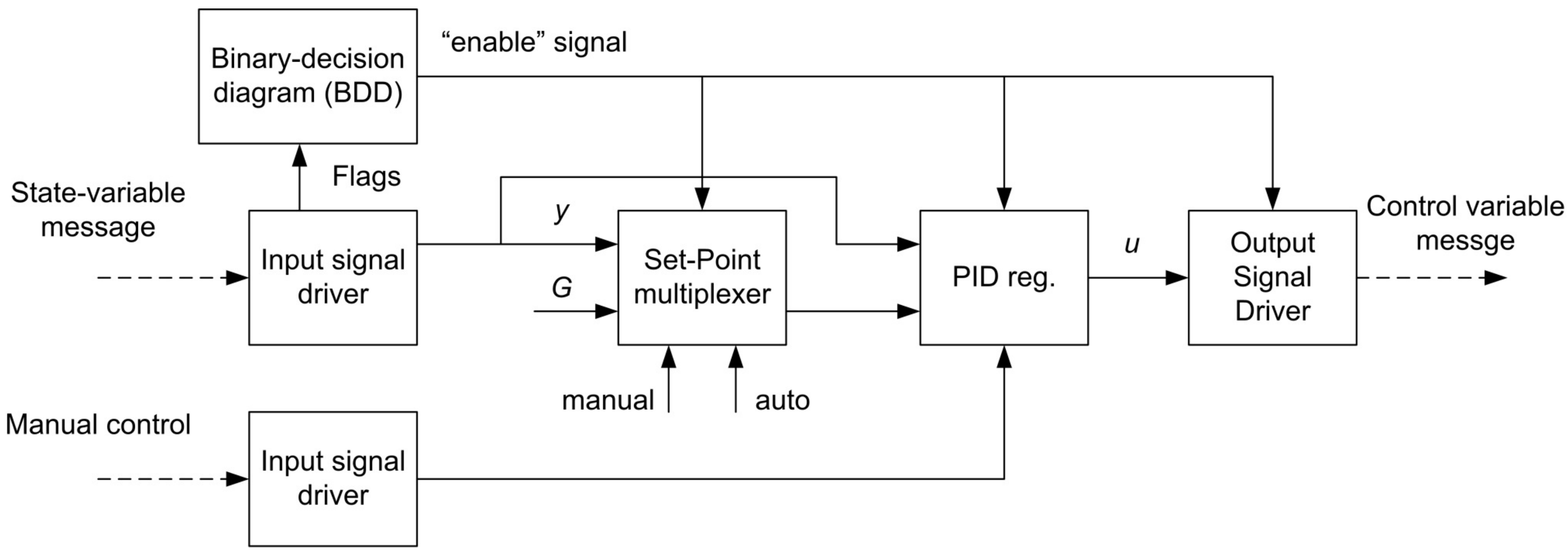
1. The Design Patterns (the template to which the code will be produced)
2. The Domain Meta-Data (the topology that should be modelled in the code, usually augmented with extra data provided by the developer)
3. The Domain Rules (the rules that dictate the structure and behaviour of the domain meta-data. This area is normally encapsulated in the generator program itself)

PrGen – program architecture

State-transition diagram



PrGen – program architecture



Signal-flow graph

Simulator projects

Tank farm control system and simulator

Tank farm control system and simulator

1. Multi-tank environment
2. An industrial OPC-based control system based on PROFIBUS network and devices

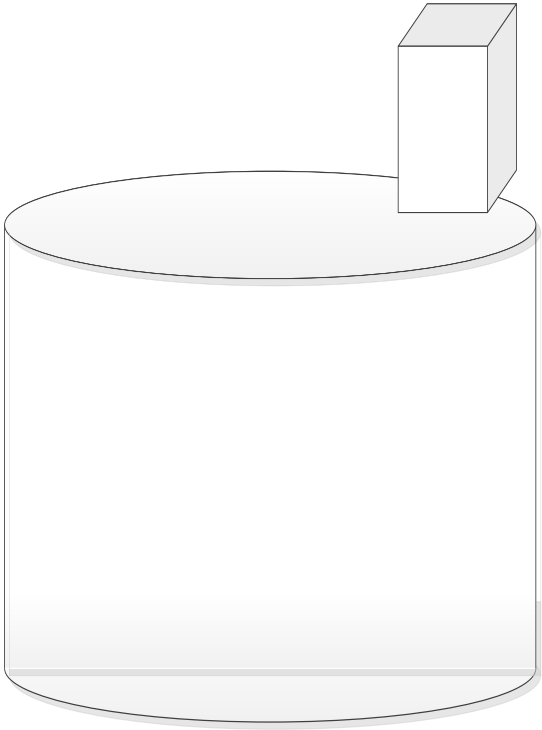
Tank farm control system and simulator

1. Multi-tank environment
2. An industrial OPC-based control system based on PROFIBUS network and devices

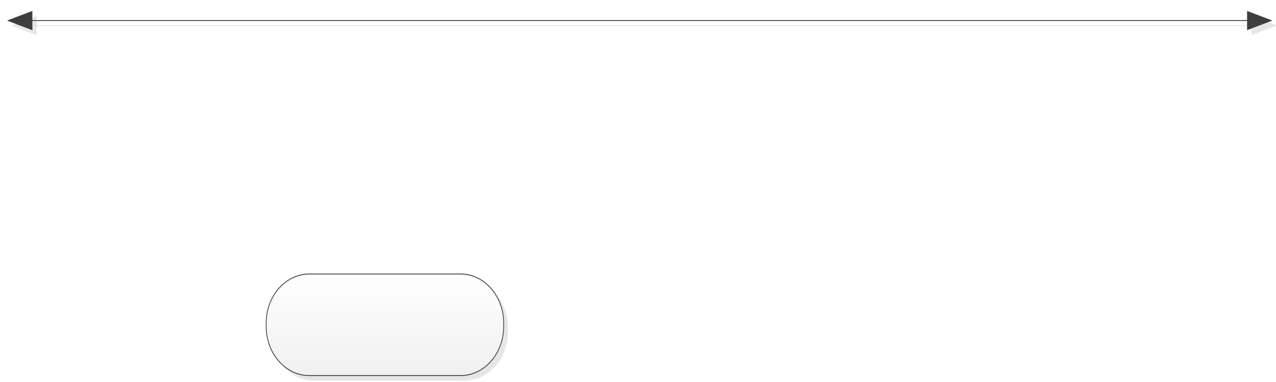
Requirements

1. Control functions test and tuning (control system tests, tuning and development);
2. Operators education/training;
3. Abnormal situations analyses.

Tank farm control system and simulator



Tank farm control system and simulator



Fuel tank – simulator structure

Tank farm control system and simulator

Problems

1. The PROFIBUS network;
2. The number of objects and support elements to be simulated;
3. Abnormal situations injection methods.

Tank farm control system and simulator

Solutions

1. The PROFIBUS network – simulated by
   SW time-diagram simulation and RS422 Master-Slave protocol emulator;
2. The number of objects and support elements to be simulated;
3. Abnormal situations injection methods.

Tank farm control system and simulator

Solutions

1. The PROFIBUS network;
2. The number of objects and support elements to be simulated – the component approach is applied. Every type of tank, valve, pipe and communication line has a template. Every real object was instantiated and parameterized. SBC were used to simulate “concentrated” elements and to run the corresponding part of the simulator ;
3. Abnormal situations injection methods.

Tank farm control system and simulator

Solutions

1. The PROFIBUS network;
2. The number of objects and support elements to be simulated;
3. Abnormal situations injection methods – an interface to the upper level of the simulator and the built-in possibility to control the graph execution and parameters of every module gives the possibility to simulate many abnormal situations – from leaks to communication loss.

Business building simulator

Business building simulator

1. Business building with many offices, stores, restaurants and other objects
2. Many utility companies are operating simultaneously – electricity, water, heating & air conditioning, security.
3. Experiments with the real equipment were impossible

Business building simulator

Requirements

1. Control functions test and tuning (control system tests, tuning and development);
2. Different scenarios of exploitation tests and experimentation;
3. Operators education/training;
4. Full time system logs;
5. Abnormal situations analyses.

Business building simulator

Characteristics

1. To cover over 3000 blocks for 7 computational and 3 logical low-level configurations.
2. Human streams simulation;
3. Behavioral scenarios;
4. Abnormal situations injectors.

Business building simulator

The system structure

Business building simulator

Problems

1. The MODBUS network;
2. The extremely huge number of objects and support elements to be simulated;
3. Abnormal situations injection methods.

Food industry machine simulator

Food industry machine simulator

Specifics

1. A non-linear object with a statistical behaviour
2. Experiments are unrepeatable

Conclusion

The presented simulator generation approach was implemented successfully for many different objects. Its internal structure answers requirements for building discrete, analogue and heterogeneous controllers and simulators, and the appropriate networks.

The possibility to connect both the real machine and the simulator to the controller and to compare real objects data and simulated behaviour enabled to tune the simulator to represent the objects very exactly.

The END