DESIGN OF EMBEDDED CONTROL SYSTEMS USING HYBRID PETRI NETS

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Outline

1. **Motivation**

2. **Hybrid Object Petri Nets**

3. **Modeling of an Embedded Control System**

4. **Conclusions and Perspectives**

Motivation

Embedded systems

➢ **Complex hard and software systems**

➢ **Often consists of components with different time and signal concepts described by different formalisms**

- **analog: continuous time model**
- **digital: discrete event model**
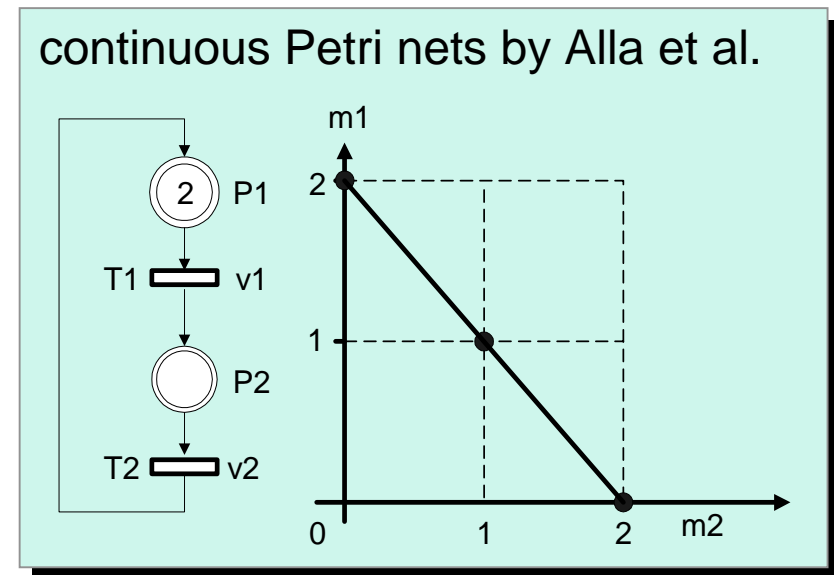- **mixed: both analog and digital behavior**

Modeling Formalism

✓ **high abstraction level**

✓ **mixed time concepts**

✓ **support for controlling of the system complexity**

Hybrid Petri Net

- **Modeling of discrete event and continuous systems with one description formalism**
- **Graphical constructs**
- **Formal analysis possibility**

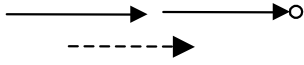Time Place-Transitions-Nets

continuous Petri nets by Alla et al.
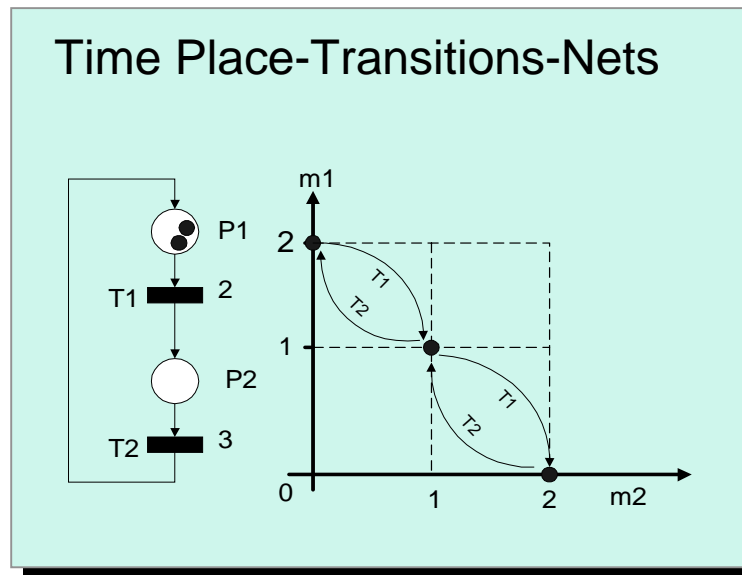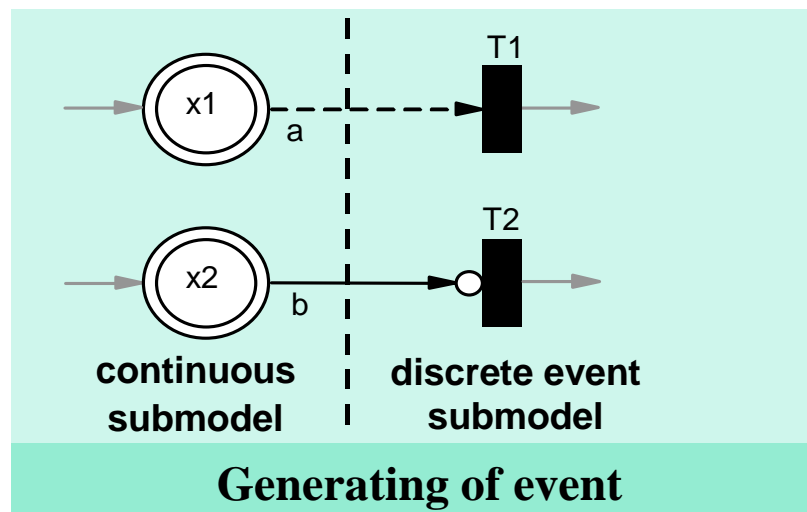
discrete event behavior   continuous behavior

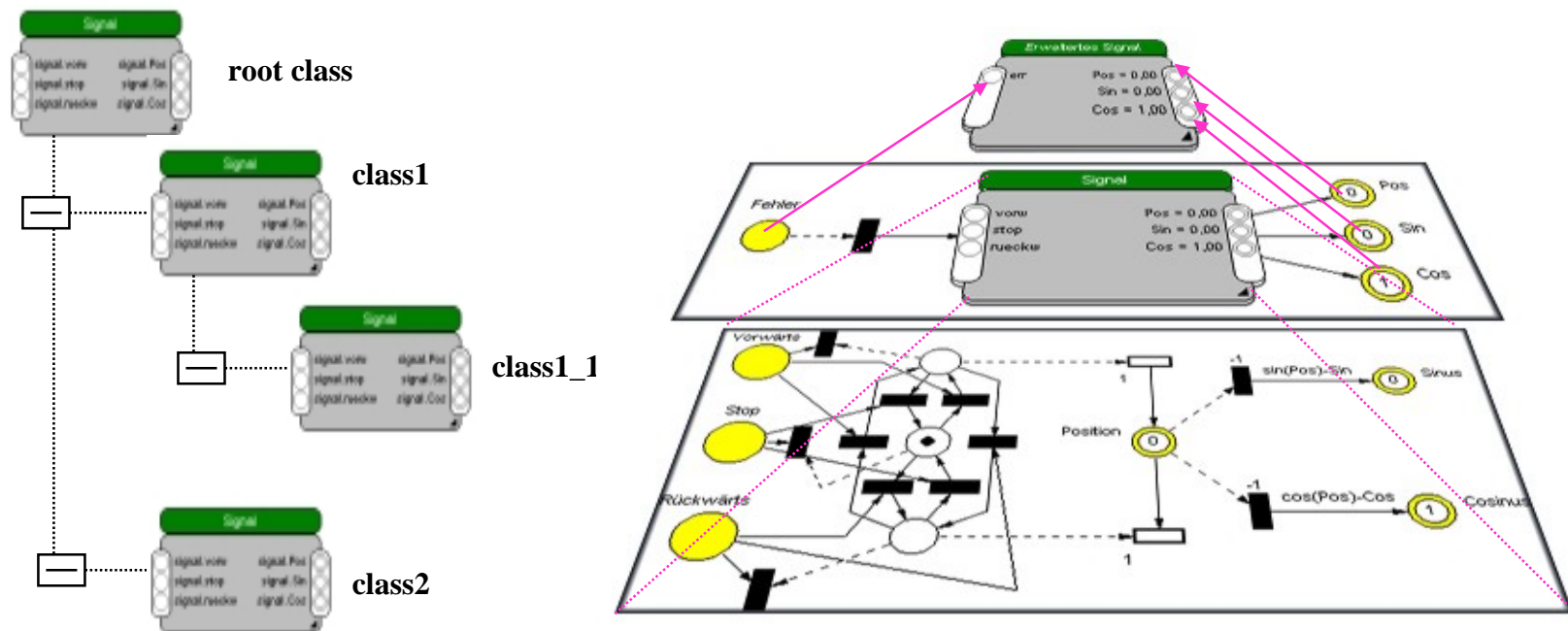# Hybrid Petri Nets

Hybrid Petri Net – Basic Design Patterns

TD	PD	TC	PC	
■	(m1)	▯	(m2)	→ ──→o ----→
discrete transition	**discrete place**	**continuous transition**	**continuous place**	**arc (normal, inhibitor and test)**

discrete event submodel   P3

continuous submodel   P1   T1   P2
u   v   y

Controlling of continuous process

discrete event submodel   T2

continuous submodel   P1   T1   P2
u   v   y

Generating of step function

x1
a   T1

x2
b   T2

continuous submodel   **discrete event submodel**
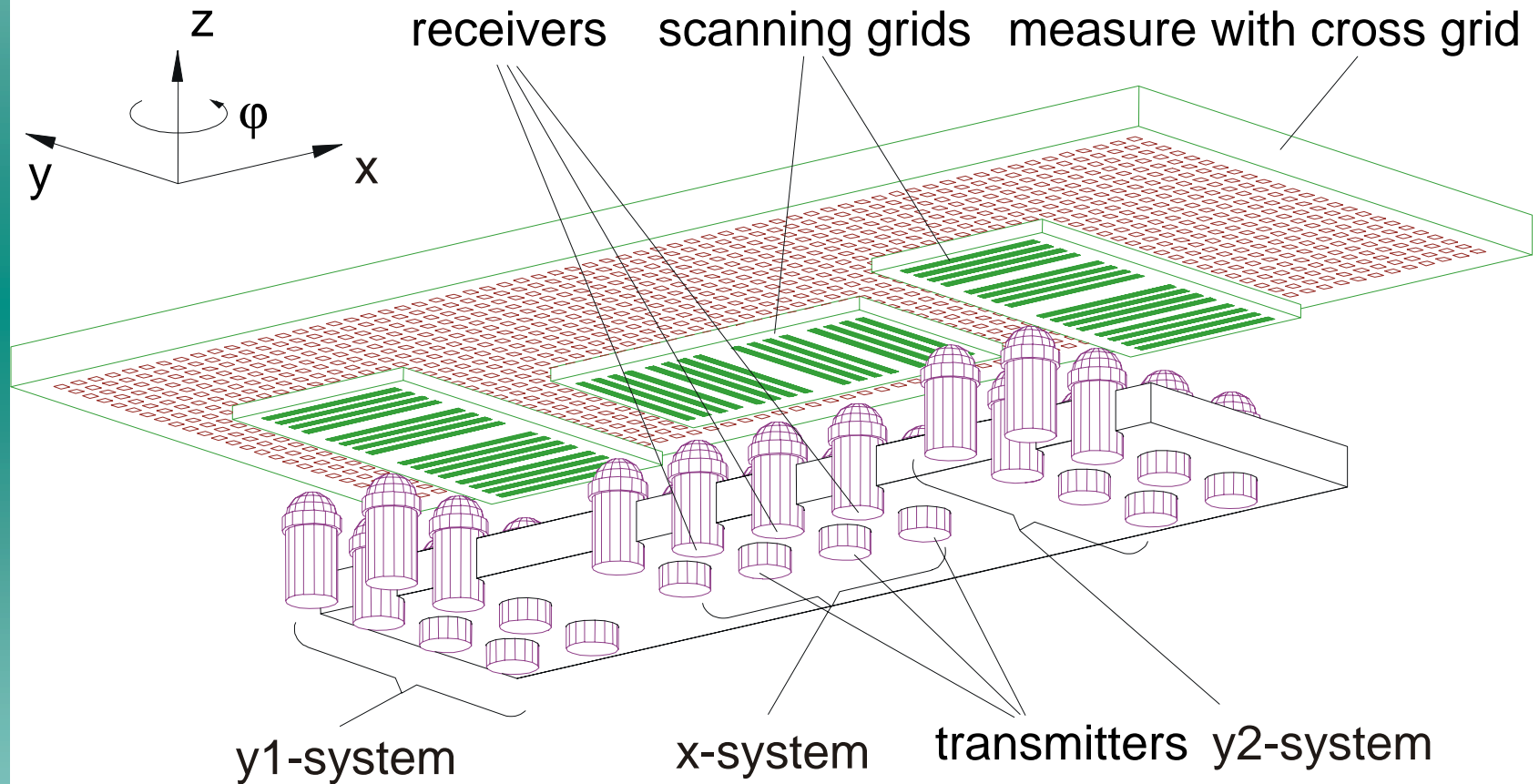
Generating of event
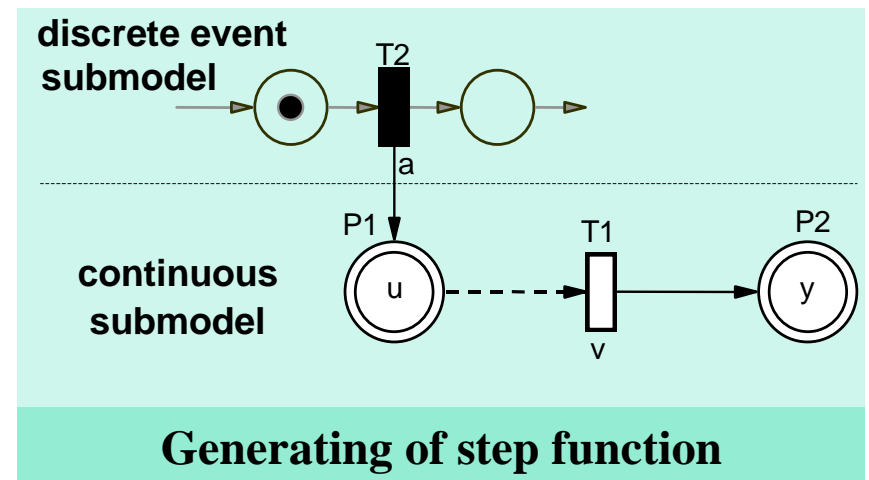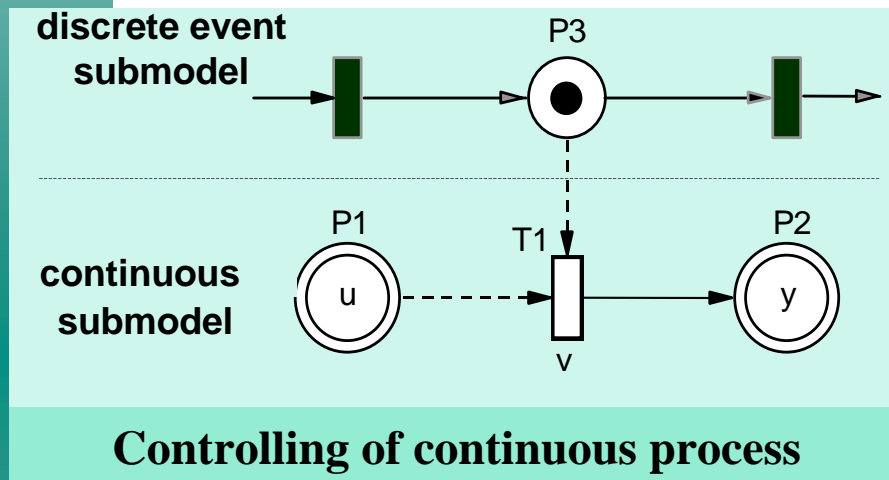
Hybrid Object Petri Nets (HOPN) (by Drath)

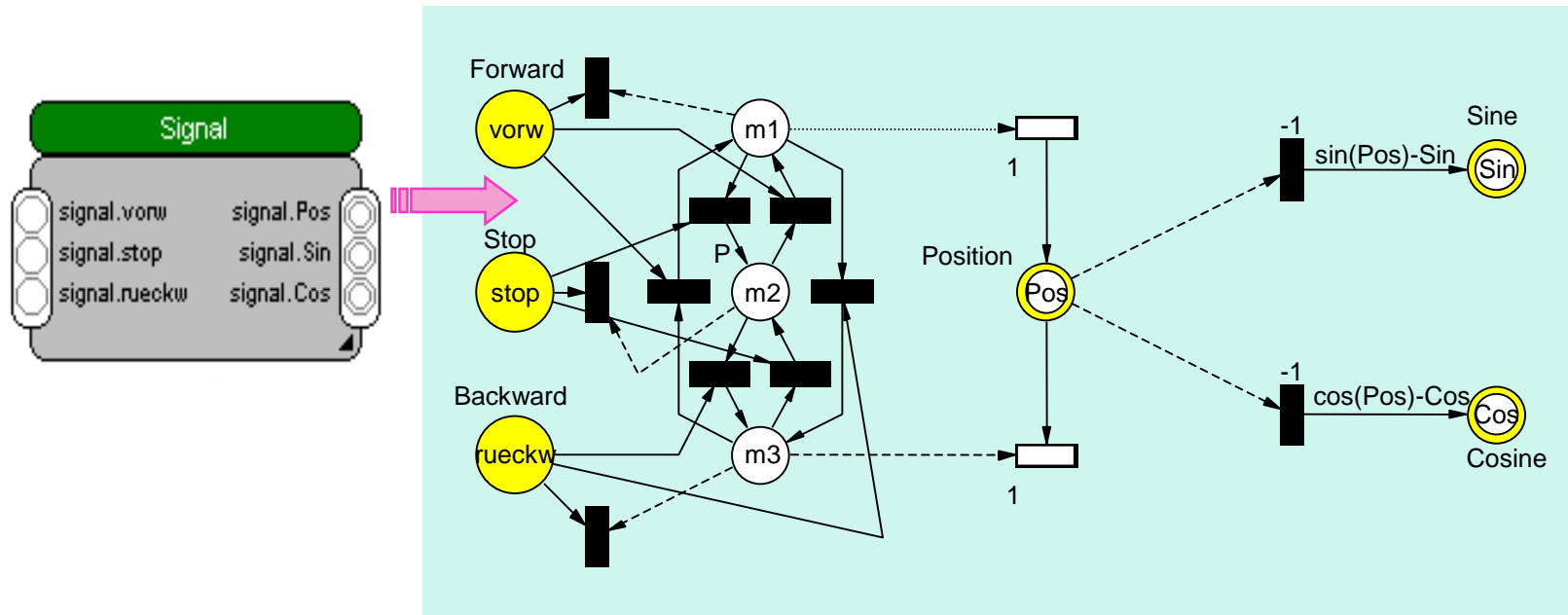**Object-oriented structure concepts of HPN**

➤ **Modeling of subsystems and abstraction into classes without influence of the semantics of the nets**

➤ **Clear graphic presentation (hierarchical and module composition)**

➤ **Reuse of HOPN objects (inheritance, static polymorphism)**

root class

class1

class1_1

class2

Multi-Coordinate Measuring System

receivers   scanning grids   measure with cross grid

z

φ

y   x
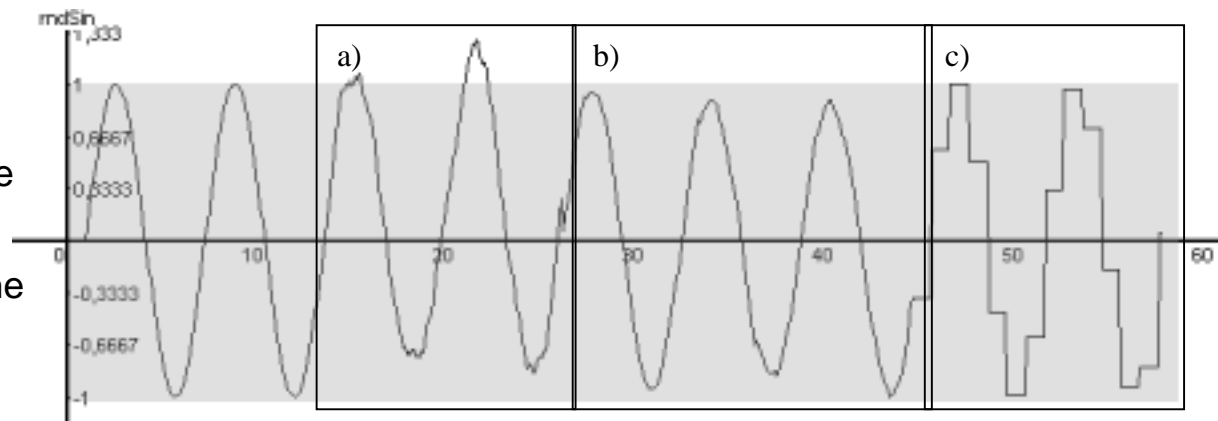
y1-system   x-system   transmitters y2-system

Multi-Coordinate Measuring System – Object Environment

Disturbance Types

a)   Disturbance of the offset values

b)   Disturbance of the amplitude

c)   Time delay

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Multi-Coordinate Measuring System – Position Calculation of One Axis

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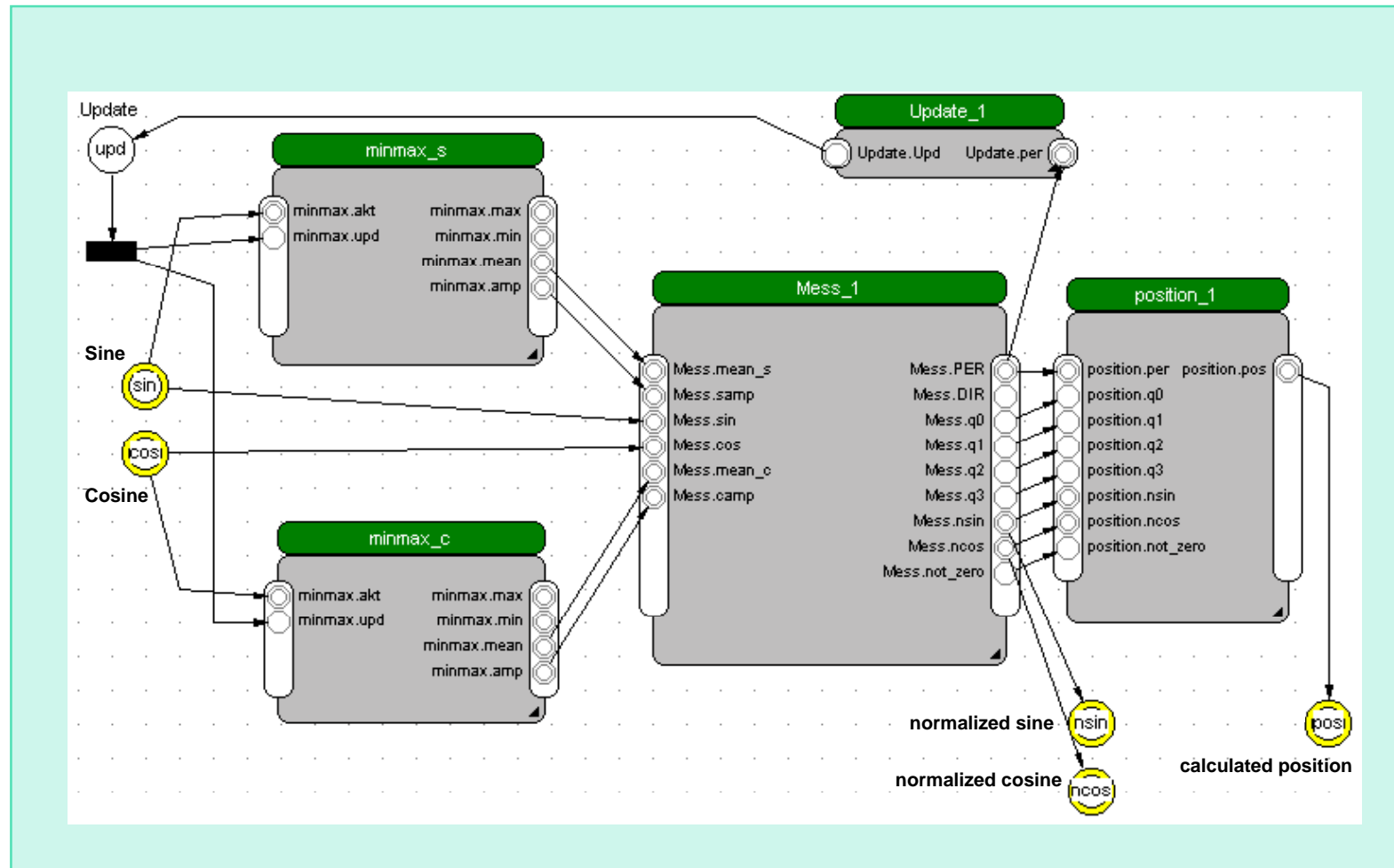
Multi-Coordinate Measuring System – Calculation of the Period
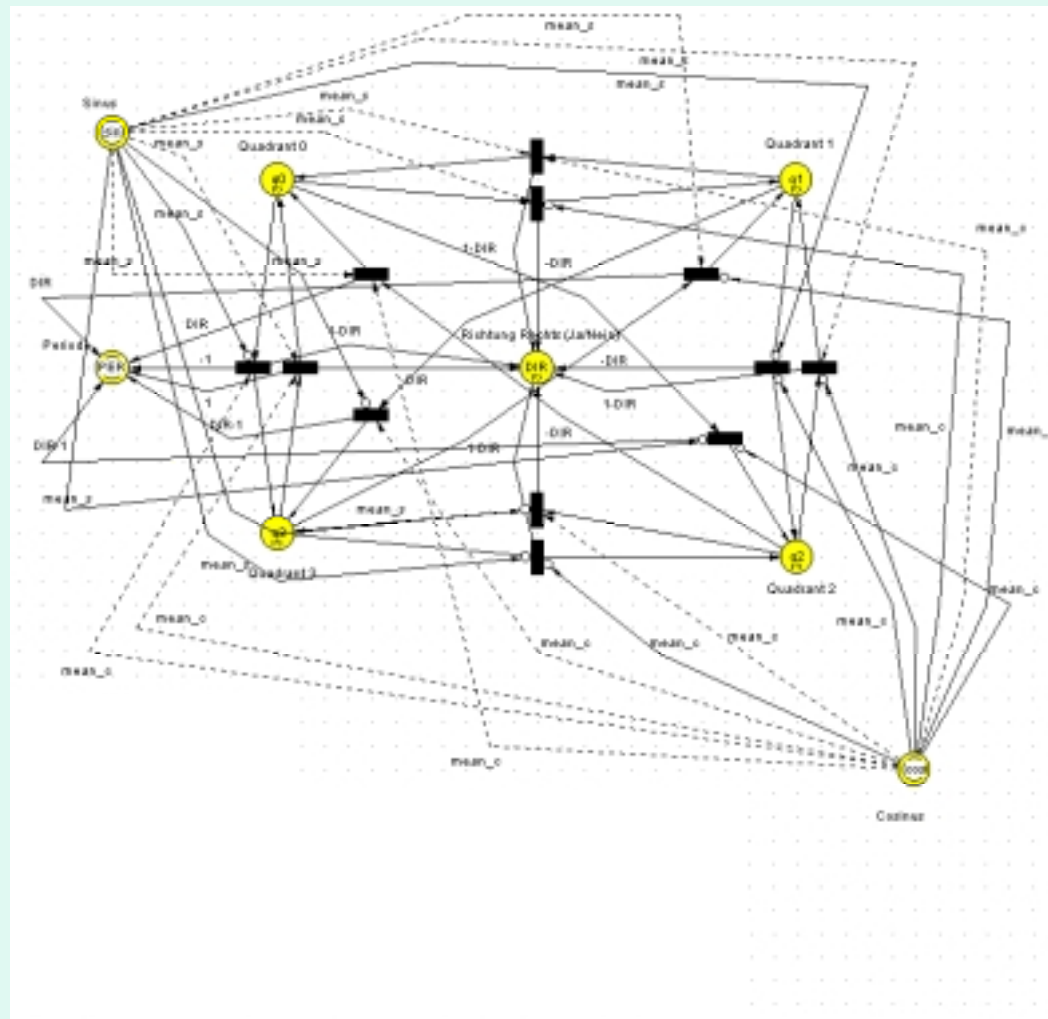
Multi-Coordinate Measuring System – Simulation Results
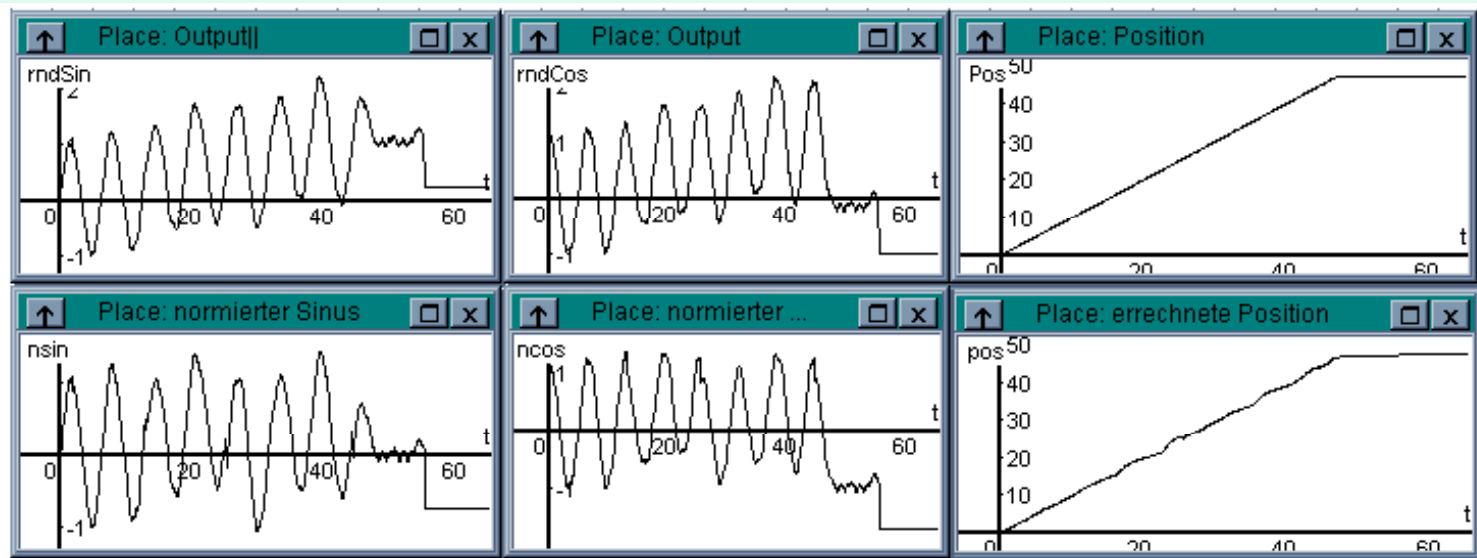
Conclusions and Perspectives

Hybrid Object Petri Nets

✓ modeling of heterogeneous/hybrid control systems

✓ well suitable for large and complex systems

✓ easy understandable graphical formalism

Future Research

✓ integration of the method in the design flow of the embedded control system

✓ connection on systems for hardware/software partition

✓ formal analysis of the nets (evolution graph)