Symbolic Timing Analysis for Systems

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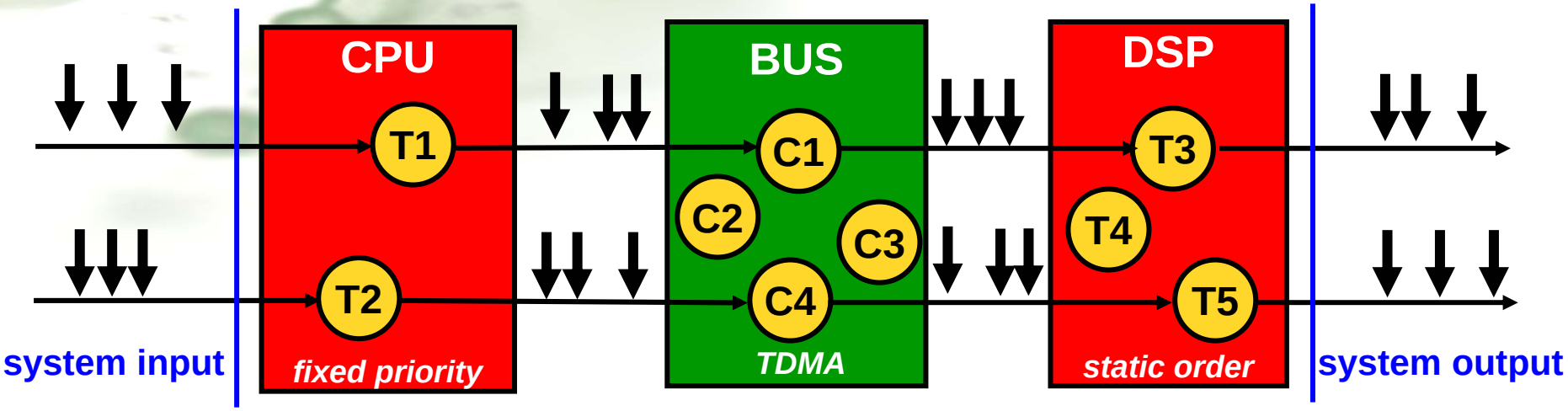
SymTA/S Approach

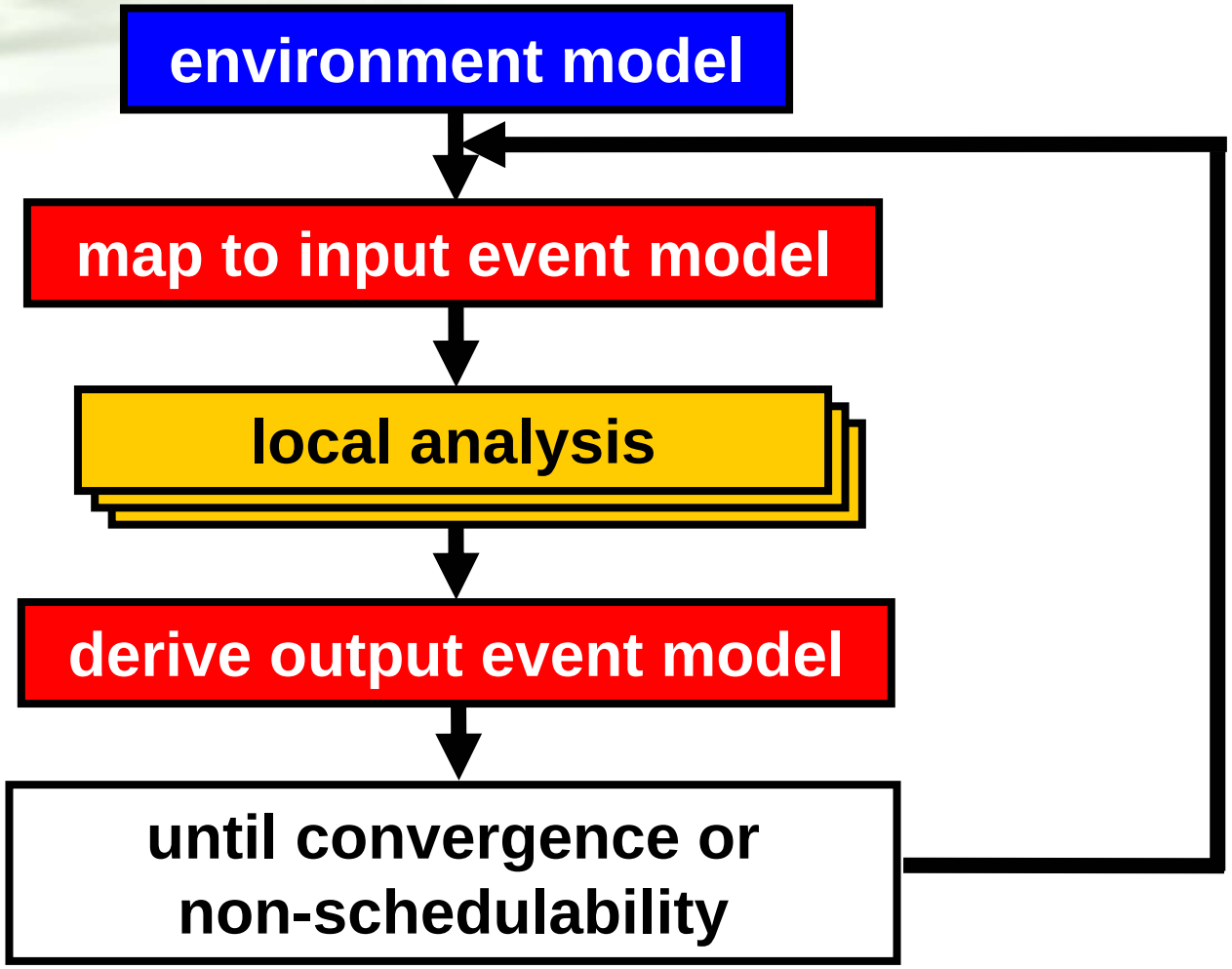
- Compositional analysis
- Relies on local timing analysis methods for components
- Component I/O timing described by event models
- System-level composition by event stream propagation and event model interfacing between components
- Iterative solution of event stream propagation
- Considers buffering influences on system timing
- Scalable and flexible, including heterogeneous systems

Compositional Approach



- Tasks are coupled by data flows (task inter-communication)
- Interpreted as activating events (event models)
- Composition by means of event stream propagation
  - Apply local scheduling techniques at resource level
  - Determine the behavior of the output stream
  - Propagate to the next component

System Analysis Loop

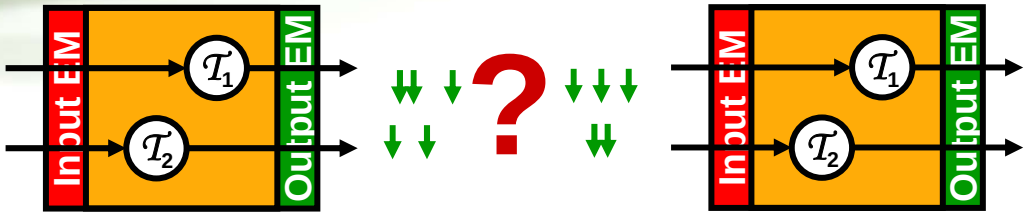


Standard Event Models

- Six-class event models using the same set of parameters
  - strictly periodic — T
  - periodic with jitter — T, J < T
  - periodic with bursts — T, J ≥ T, d
  - sporadic — t
  - sporadic with jitter — t, J < t
  - sporadic with bursts — t, J ≥ t, d
- Automatic Model Transformations
  - Event Model Interfaces
  - Event Adaptation Functions, incl. Shaping/Buffering

Event Model Transformations

- components may require different event models



needs interfaces

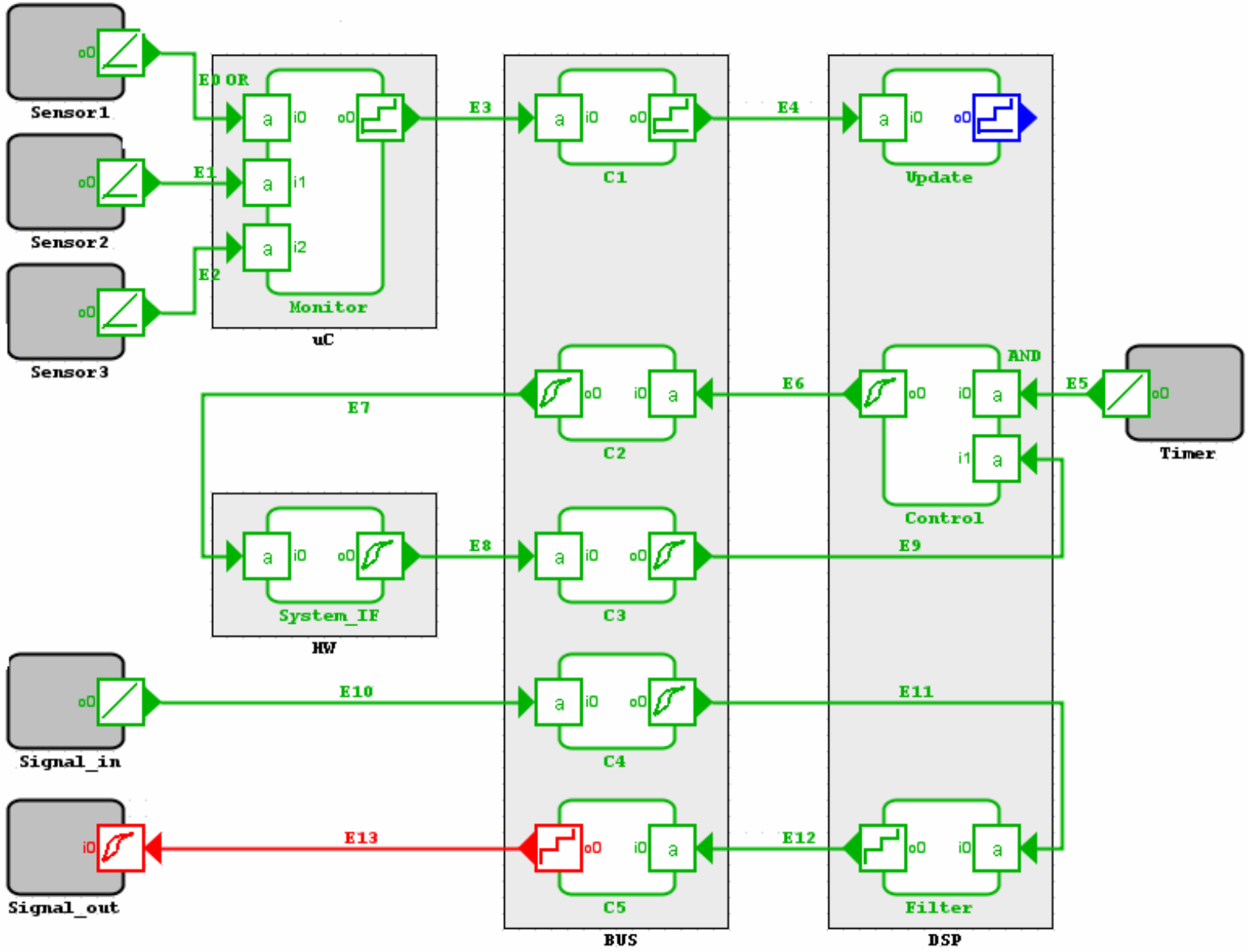
Important because

- Output timing usually more irregular than input timing
- Input models more constrained
  - Re-use of local analysis techniques (RMS)
  - Implementation dependent (e.g. black box)

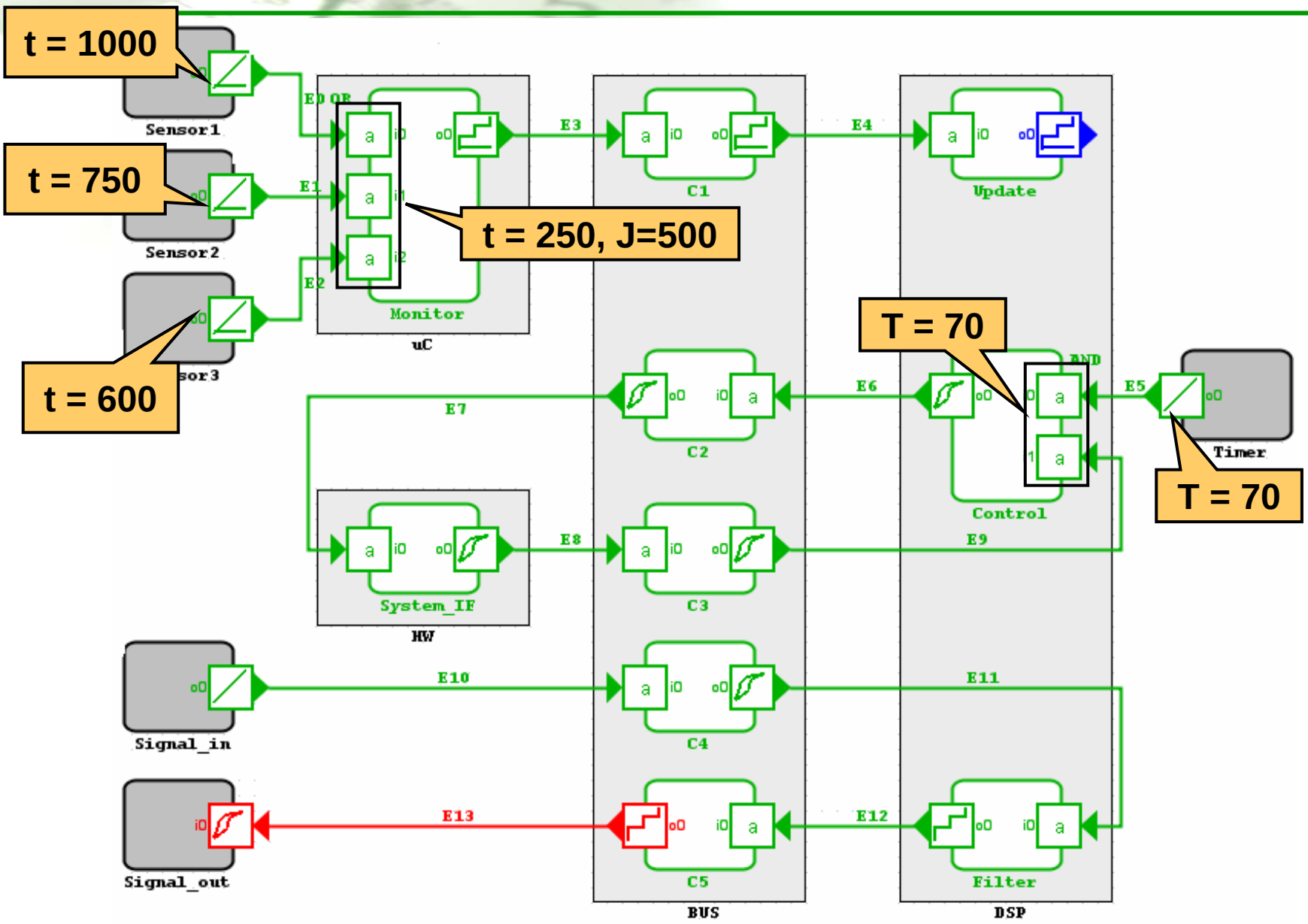
Resource Level Analysis

- Local scheduling techniques
  - Static Priority Preemptive incl. RMS and DMS
  - TDMA
  - EDF
  - Round Robin
  - Static Execution Order
- Industry related (including non-preemptiveness)
  - OSEK flavours
  - CAN, including error models

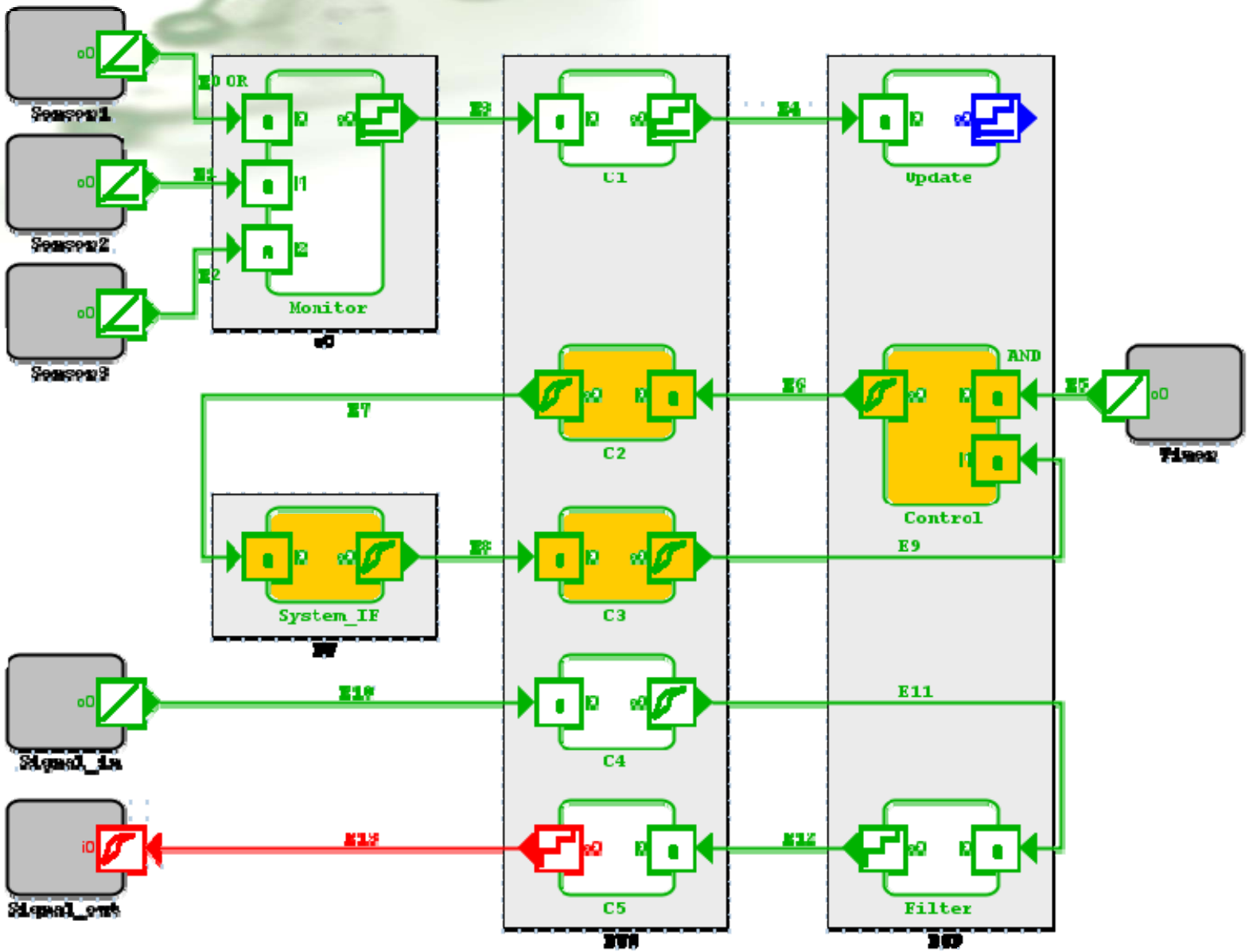
System Example



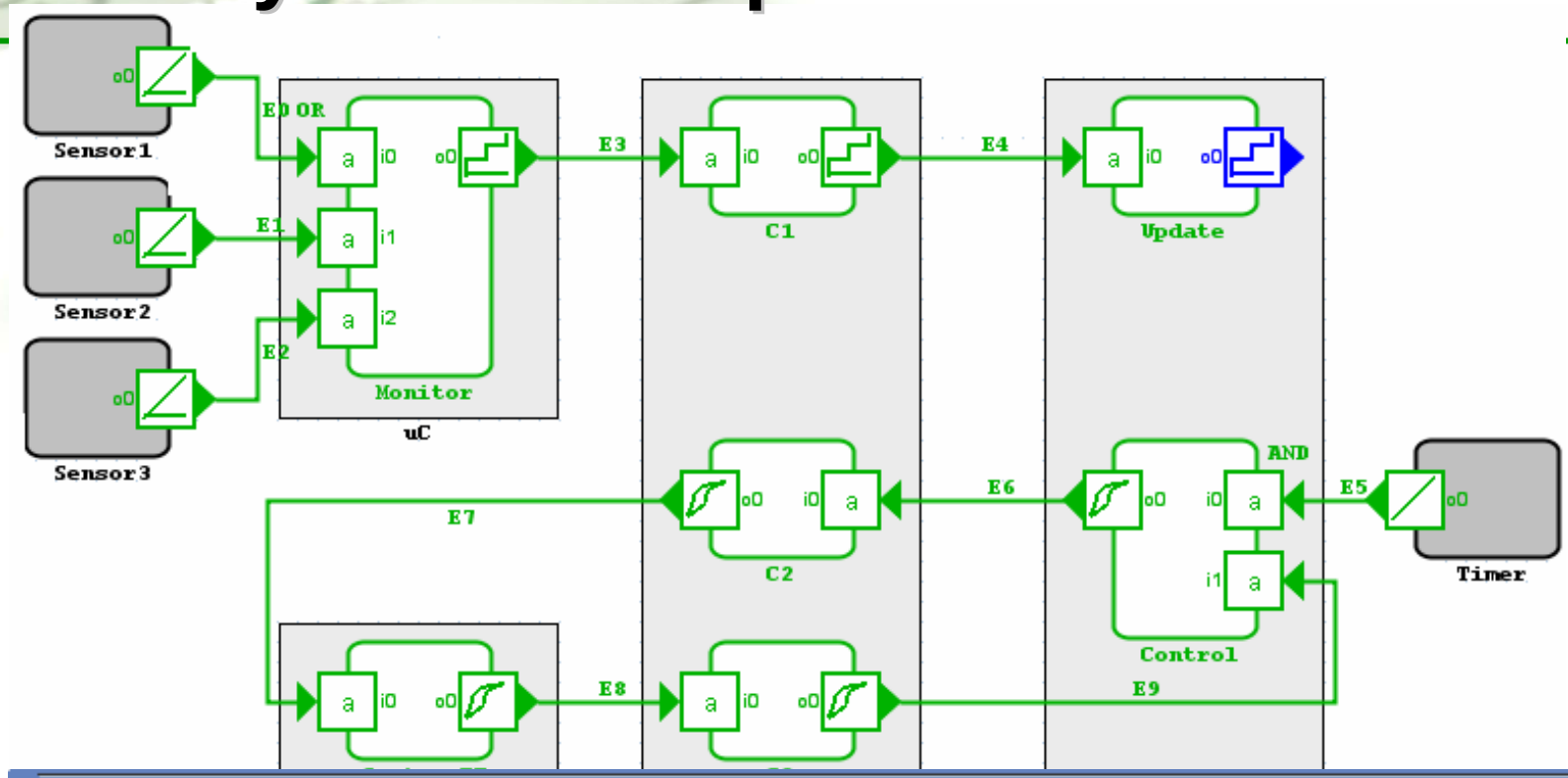
System Example: Multi-input Tasks



System Example: Functional Cycle



System Example: Constraints



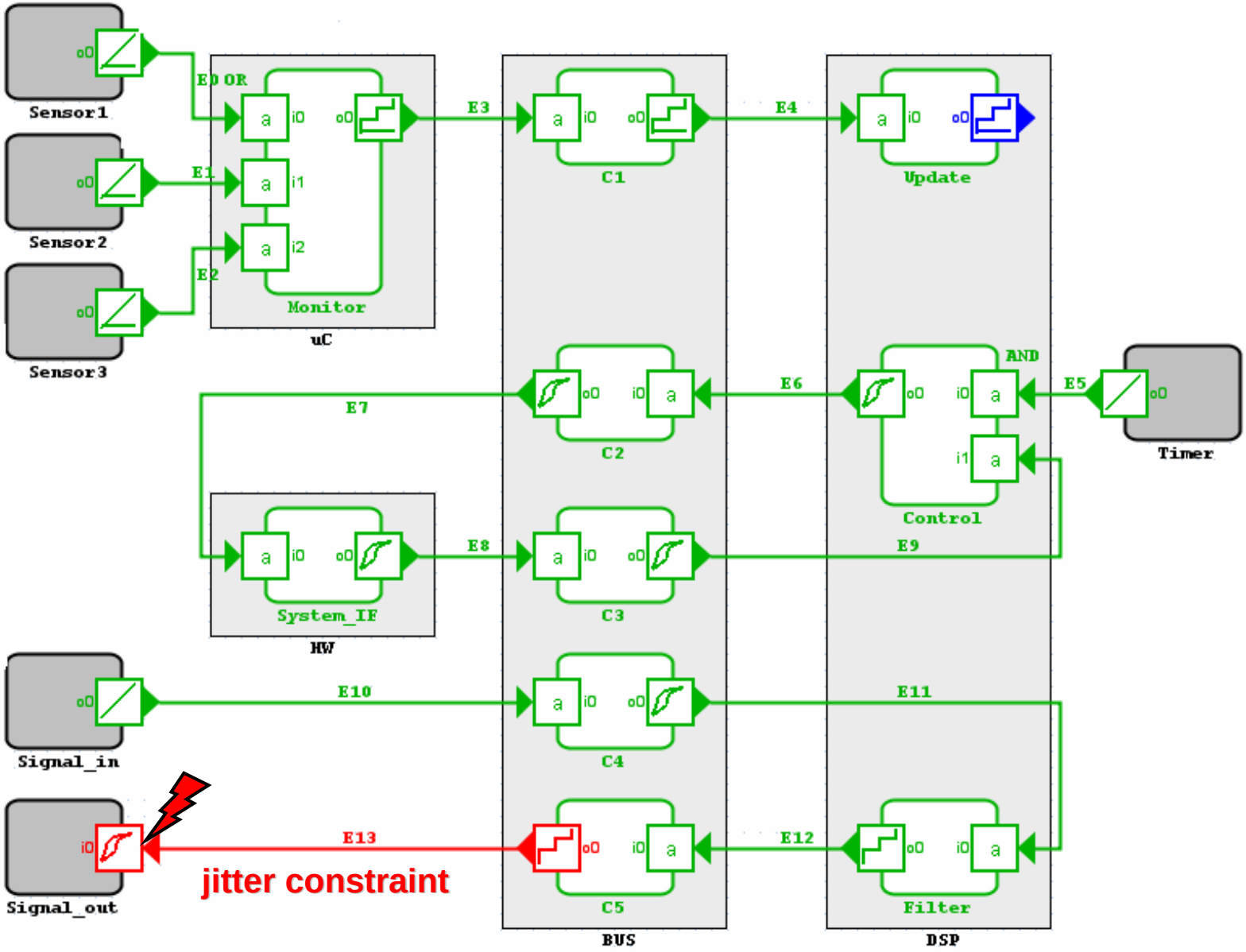
Path Observer

Start: End:

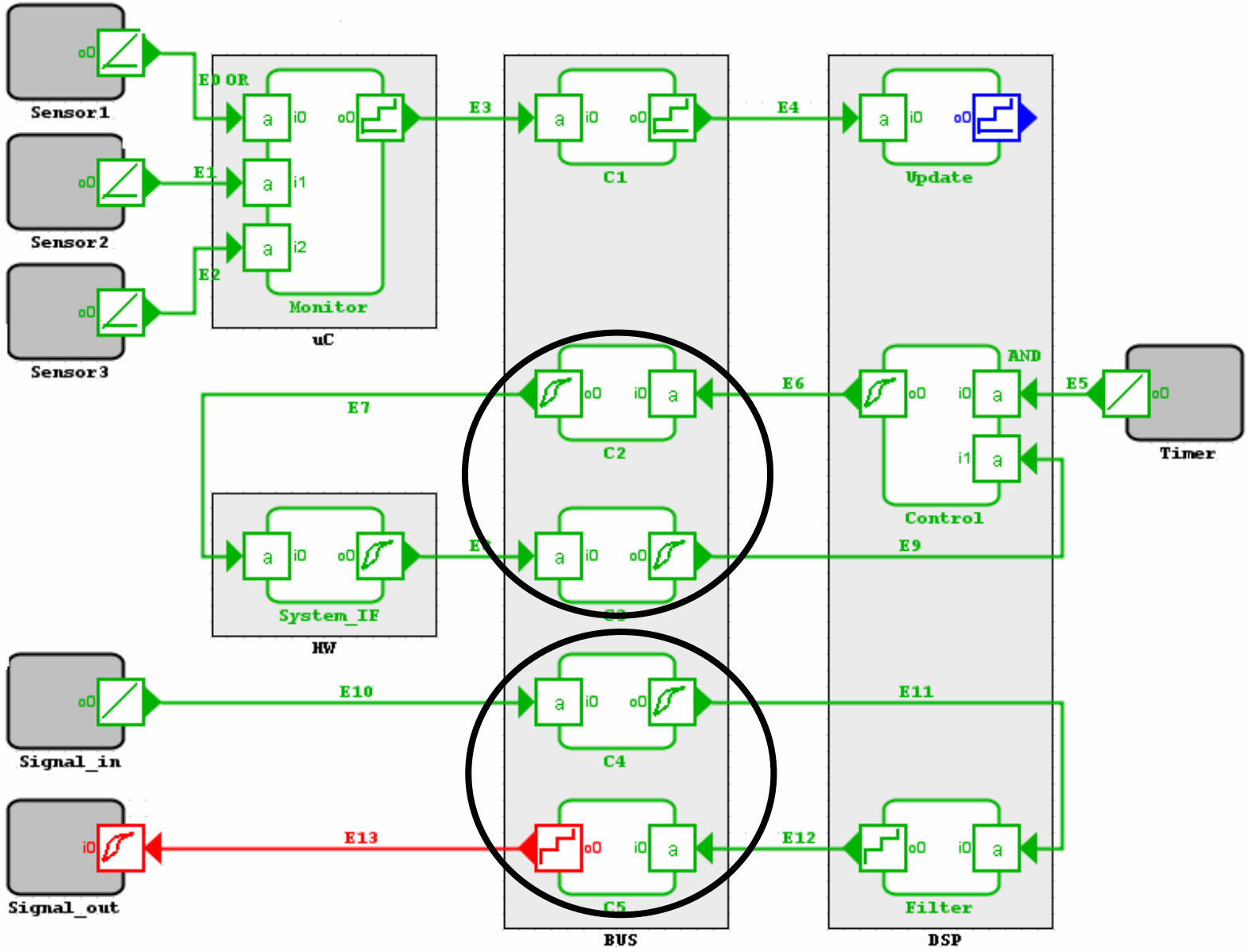
Name	Latency	Constraint	Buffer	Status
Paths				
Sensor1 → Update	[19,45]	70	5	
Sensor2 → Update	[19,45]	70	5	
Sensor3 → Update	[19,45]	70	5	
Signal_in → Signal_out	?	60	?	

Name	Latency	Token Con...	Laten...	Req. Tokens	Buffer	Status
Cycles						
✓ Control→E6→C2→E7→System_IF→E8→C3→E9→Control	[43,76]	2	140	2	5	

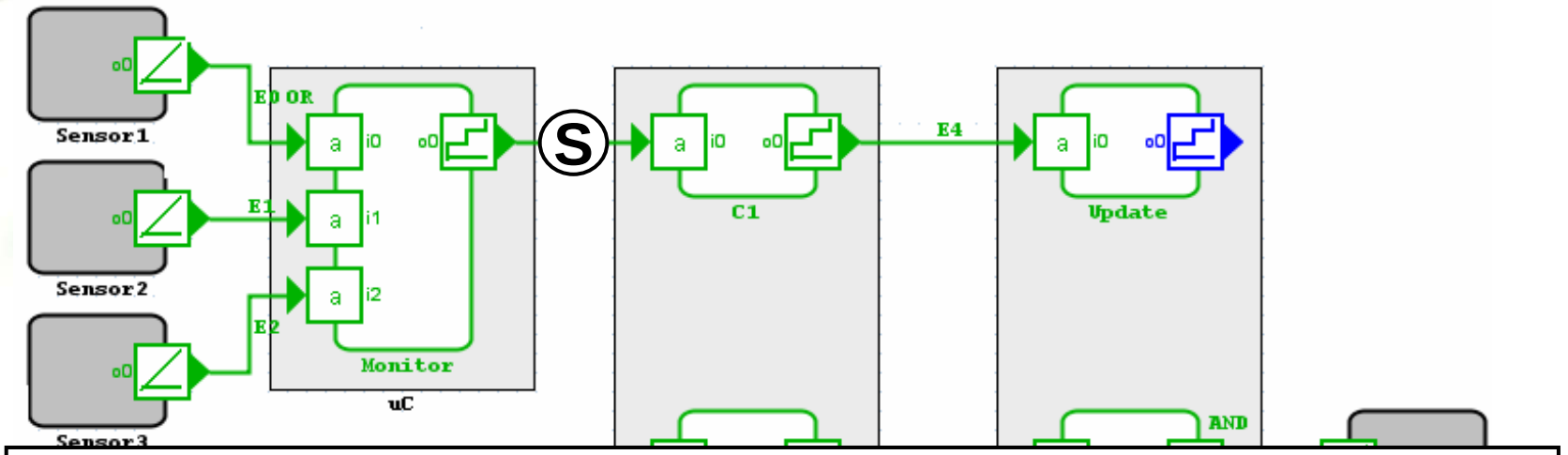
System Example: Constraints



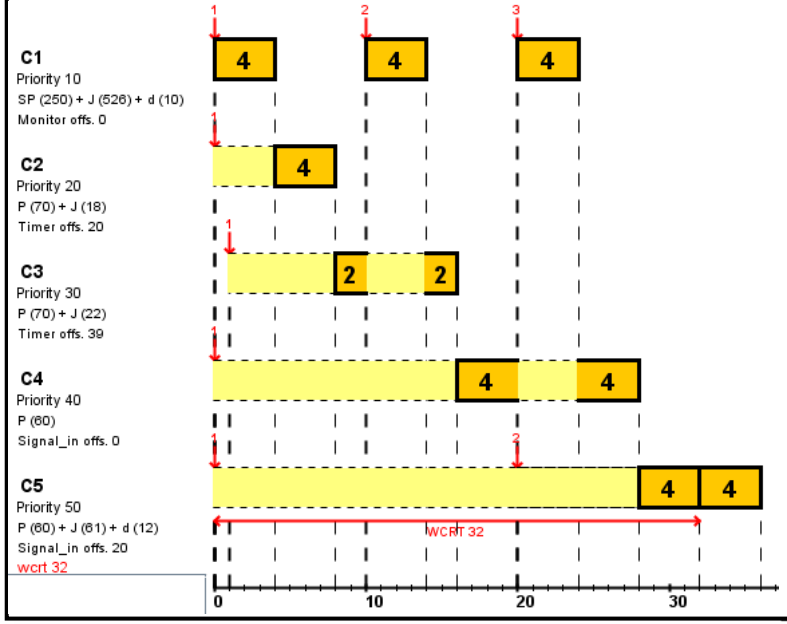
System Example: Precedence Relations



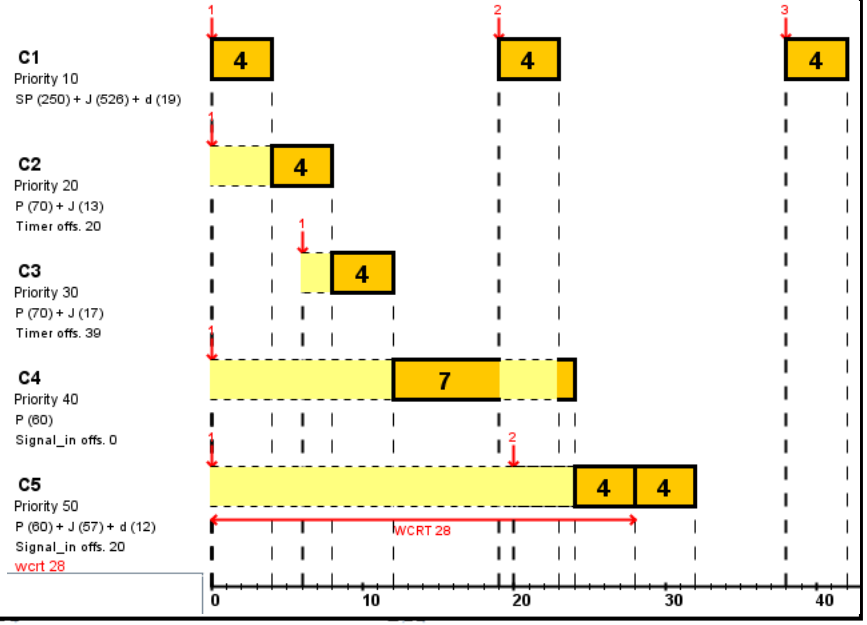
System Example: Traffing Shaping



Without Shaping



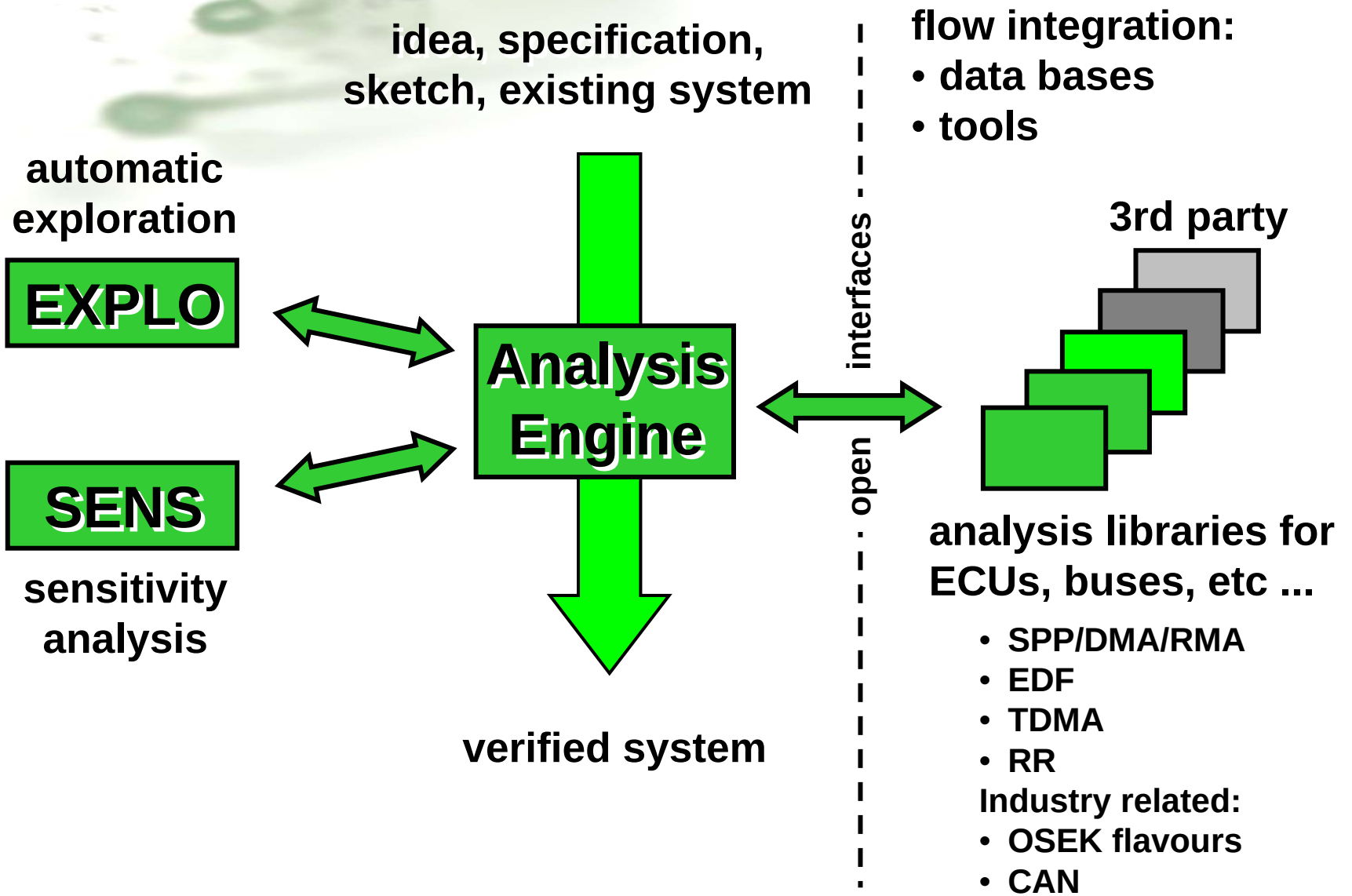
With Shaping



Key features

- Heterogeneous architectures with local scheduling strategies
- Complex applications
  - Multi-input tasks with AND and OR-activation
  - Tasks with different execution modes & context propagation
  - Functional and non-functional cycles
- System-level analysis
  - Local and global phase (offset) information between events and event streams, task precedence relations
  - End-to-end deadlines
- Traffic Shaping
  - Buffer sizes
  - Control interaction of connected components

SymTA/S Tool Suite



Current Limitations and Possible Extensions

- FIFO communication and activation
- Local analysis focus vs. holistic consideration
  - Pay bursts only once
- Few "holistic ideas" can be extracted and used in the compositional approach
  - Pseudo-holistic algorithm to compute path latencies
- Other event models