MAST:
A Timing Behavior Model for Embedded Systems Design Processes

By:

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1. Introduction: Background

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Many real-time systems are now distributed

- Cyclic executives being replaced by run-time schedulers
- Fixed priority and EDF scheduling are most popular among the run-time scheduling policies

Schedulability analysis techniques have evolved a lot in the last decade

- Originally RM and DM priority assignment techniques, together with response-time analysis
- Extended to distributed systems (holistic analysis, HOPA)
- Offset-based analysis introduced (FP and EDF)
- Multiple-event synchronization handled

Motivation

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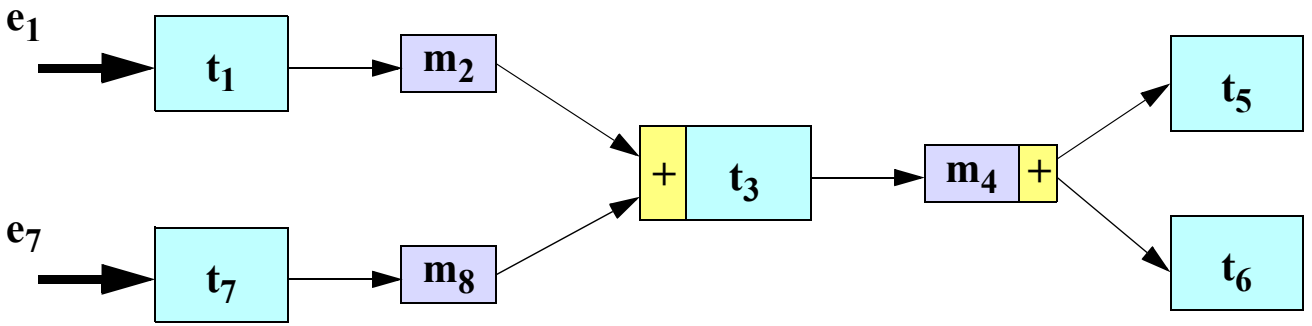
The latest schedulability analysis techniques are difficult to apply by hand

Need for a rich and flexible model of the real-time system:

- distributed, multiprocessor, or single processor
- composable software modules
- separation of architecture, platform, and software modules
- rich set of event-driven patterns; e.g.:



Objectives

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- Develop a *model* for describing the timing behavior of event-driven distributed real-time systems
- *Open model* that may evolve to include new characteristics or points of view of the system
- Develop a set of *tools* for analyzing the timing behavior of the application:
  - Schedulability analysis (hard real-time requirements)
  - Synchronization blocking calculation
  - Discrete-event simulation (soft real-time)
  - Priority assignment
  - Sensitivity analysis

MAST: A timing behavior model

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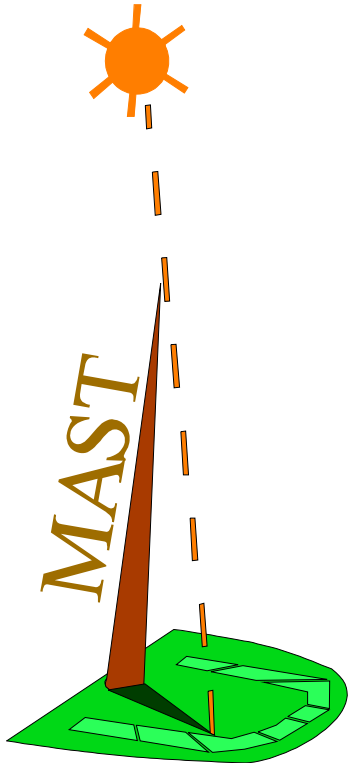
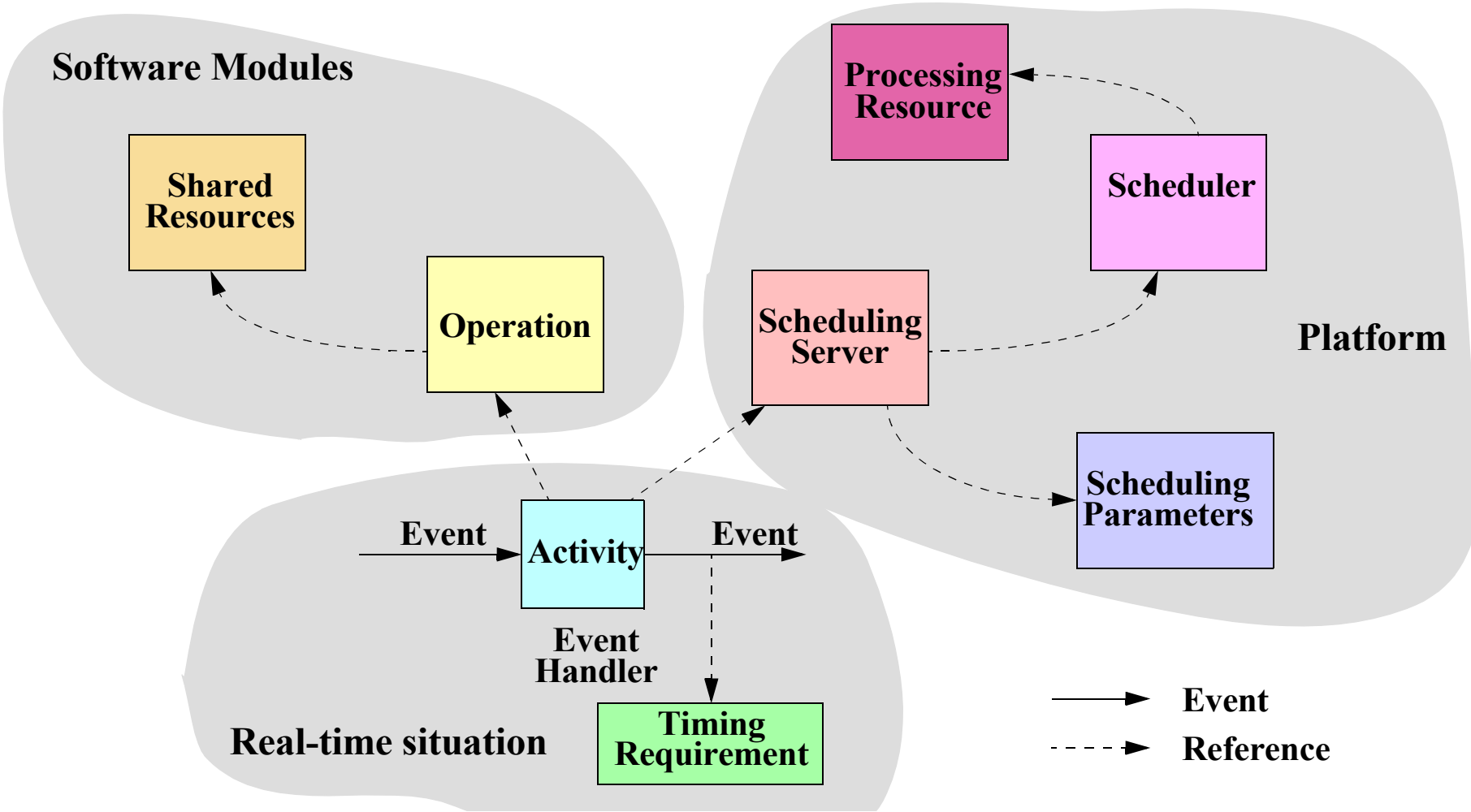
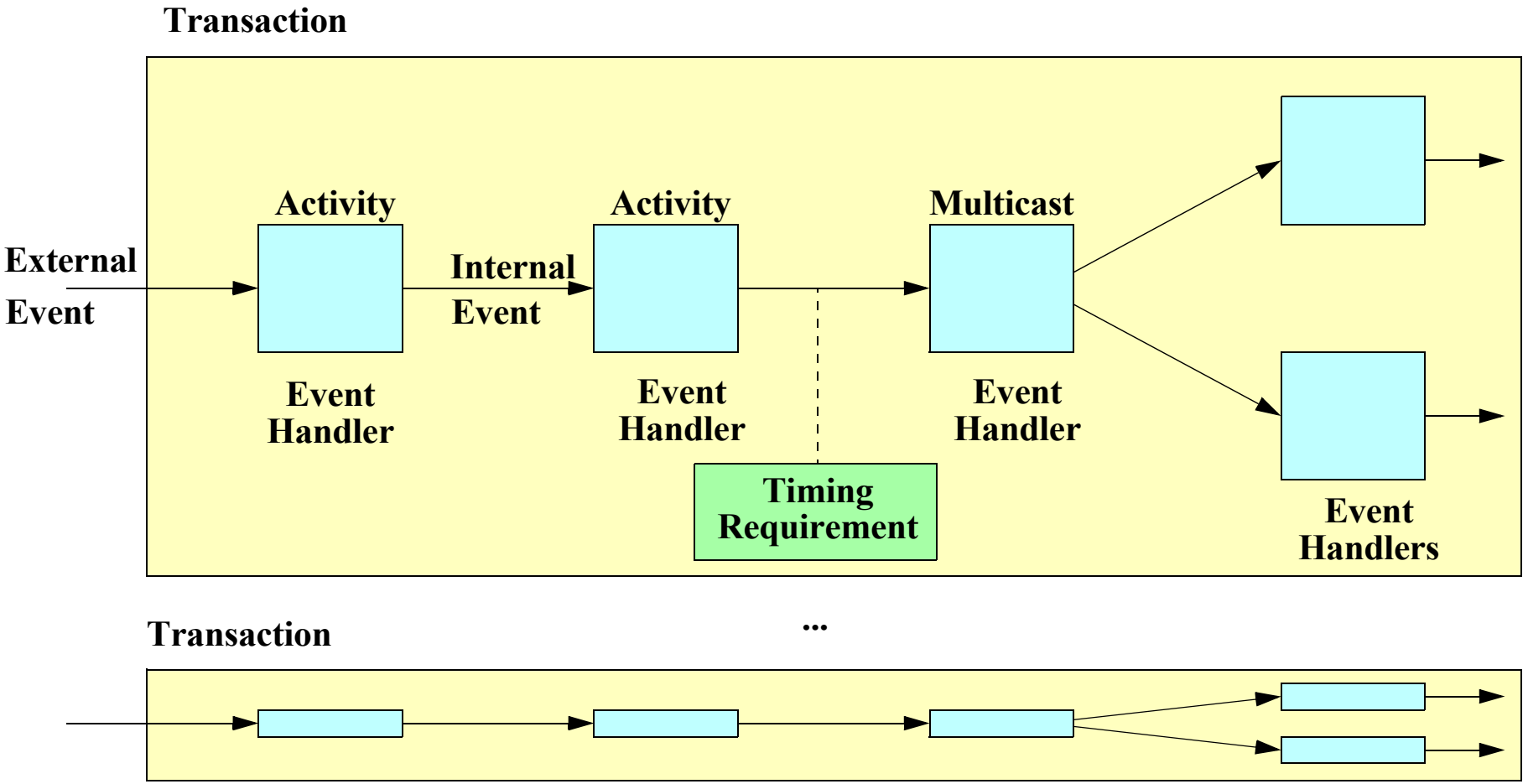
1. Introduction: Background, Motivation and Objectives
2. *Overview of the Real-Time Model*
3. Elements of the MAST Model
4. Integration into design processes
5. The MAST tool suite
6. Conclusions and Future Work



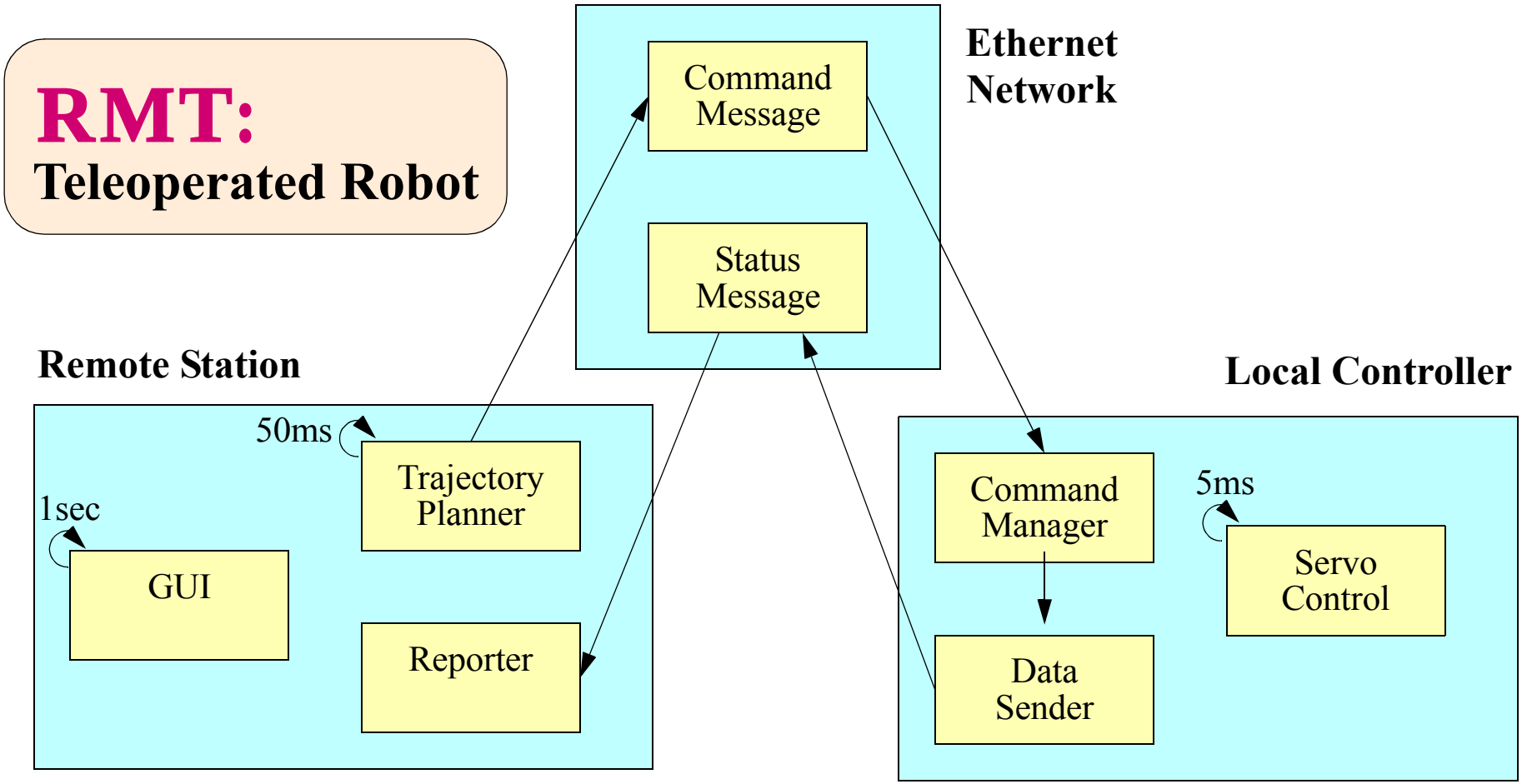
2. Real-Time Model: Overview



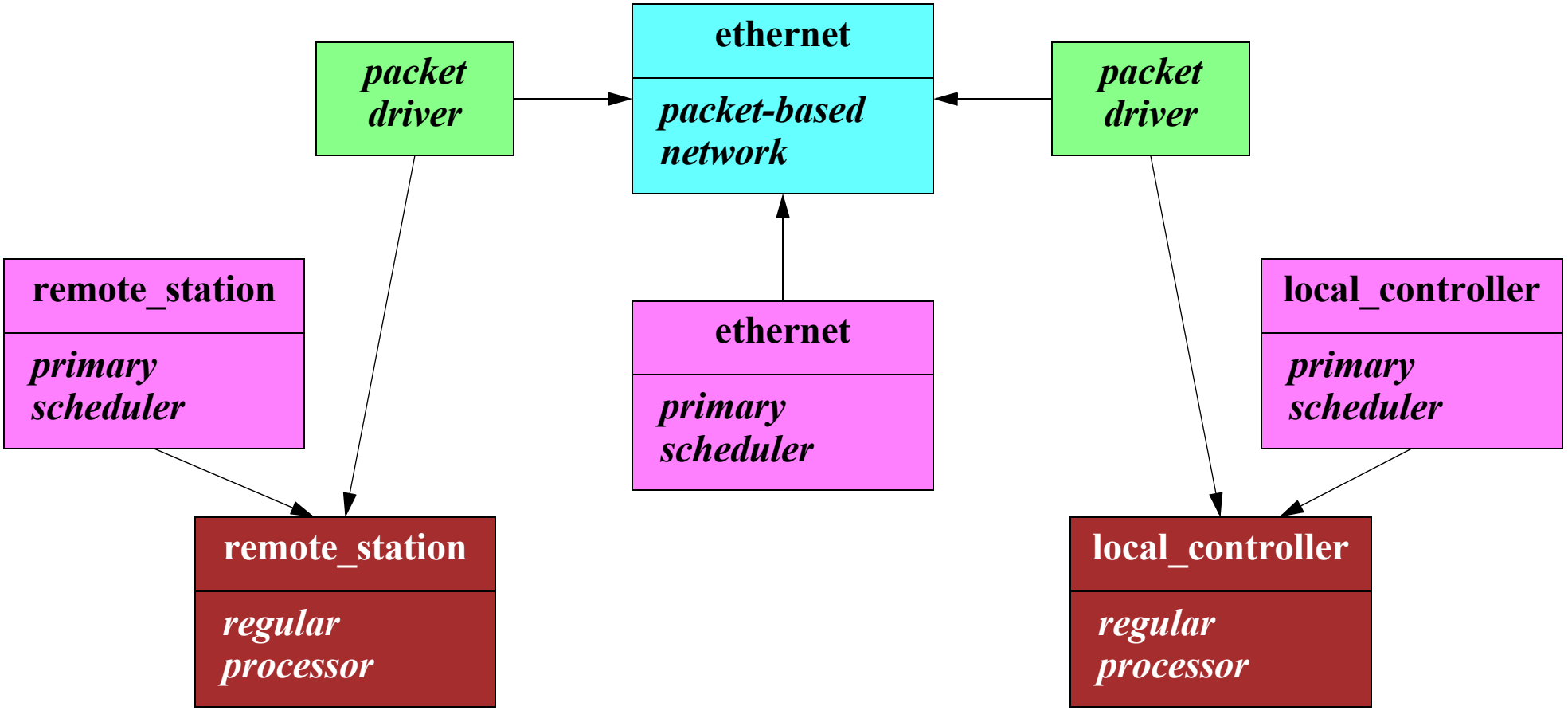
Real-Time Situation



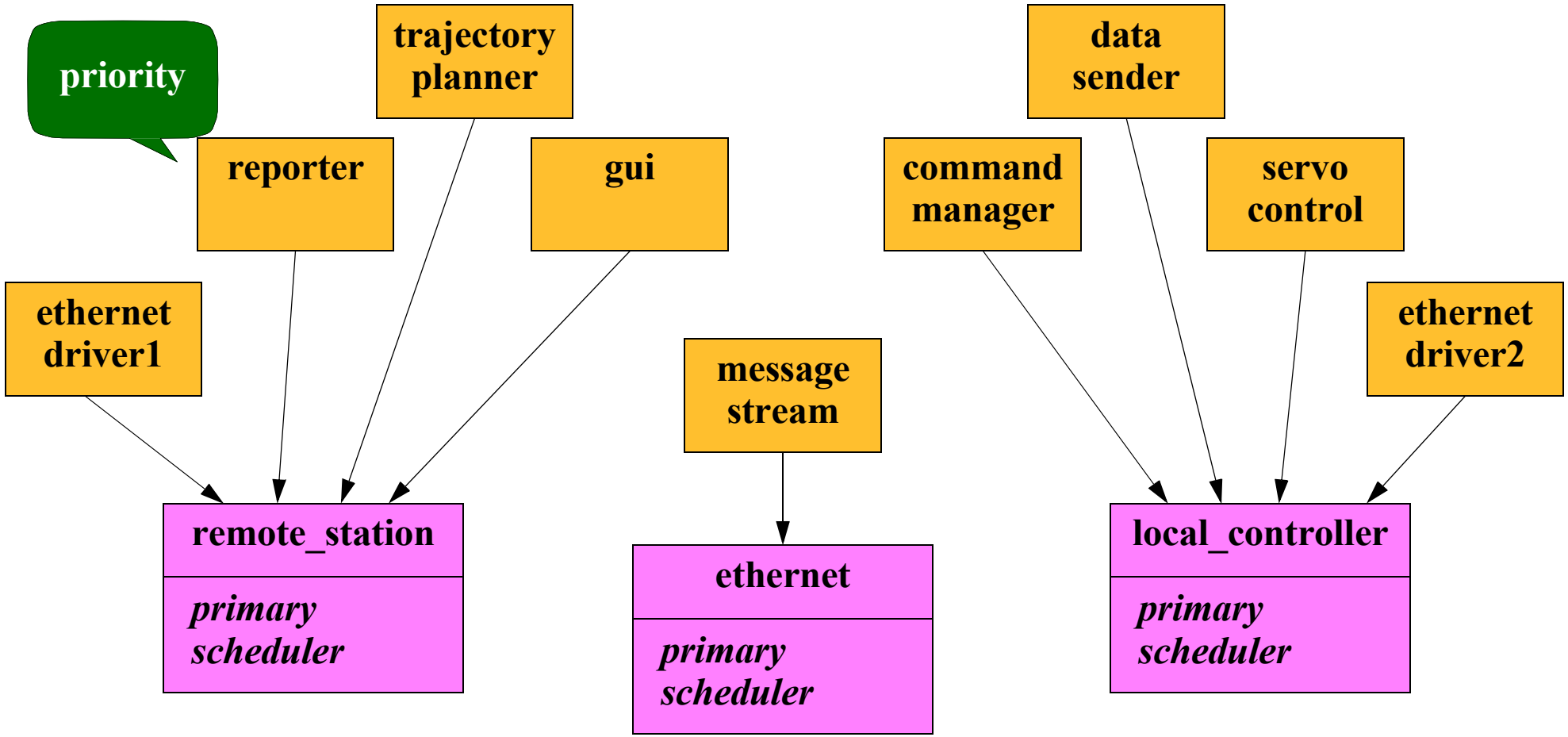
3. Elements of the MAST model: Example



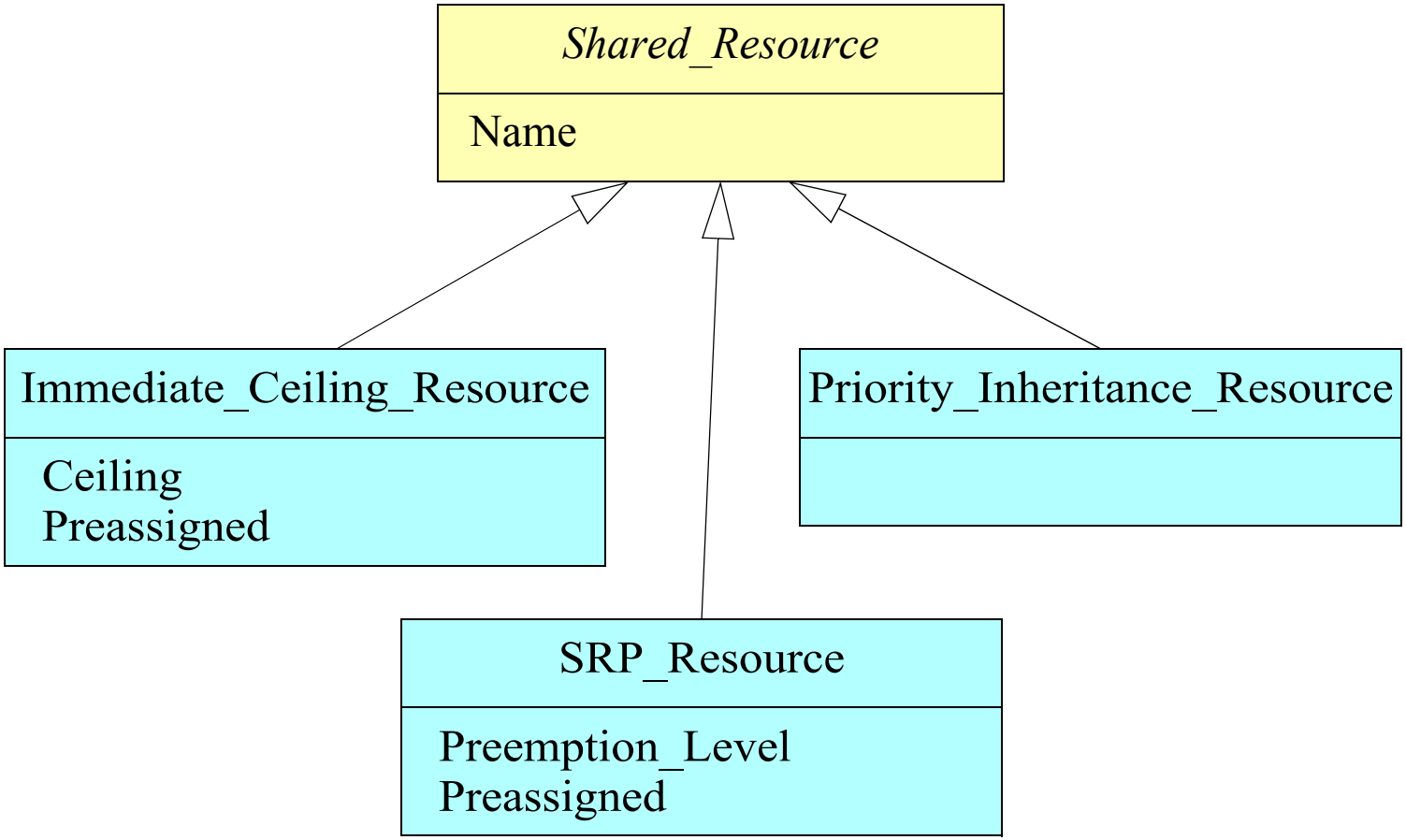
Processing resources, schedulers, drivers, and timers



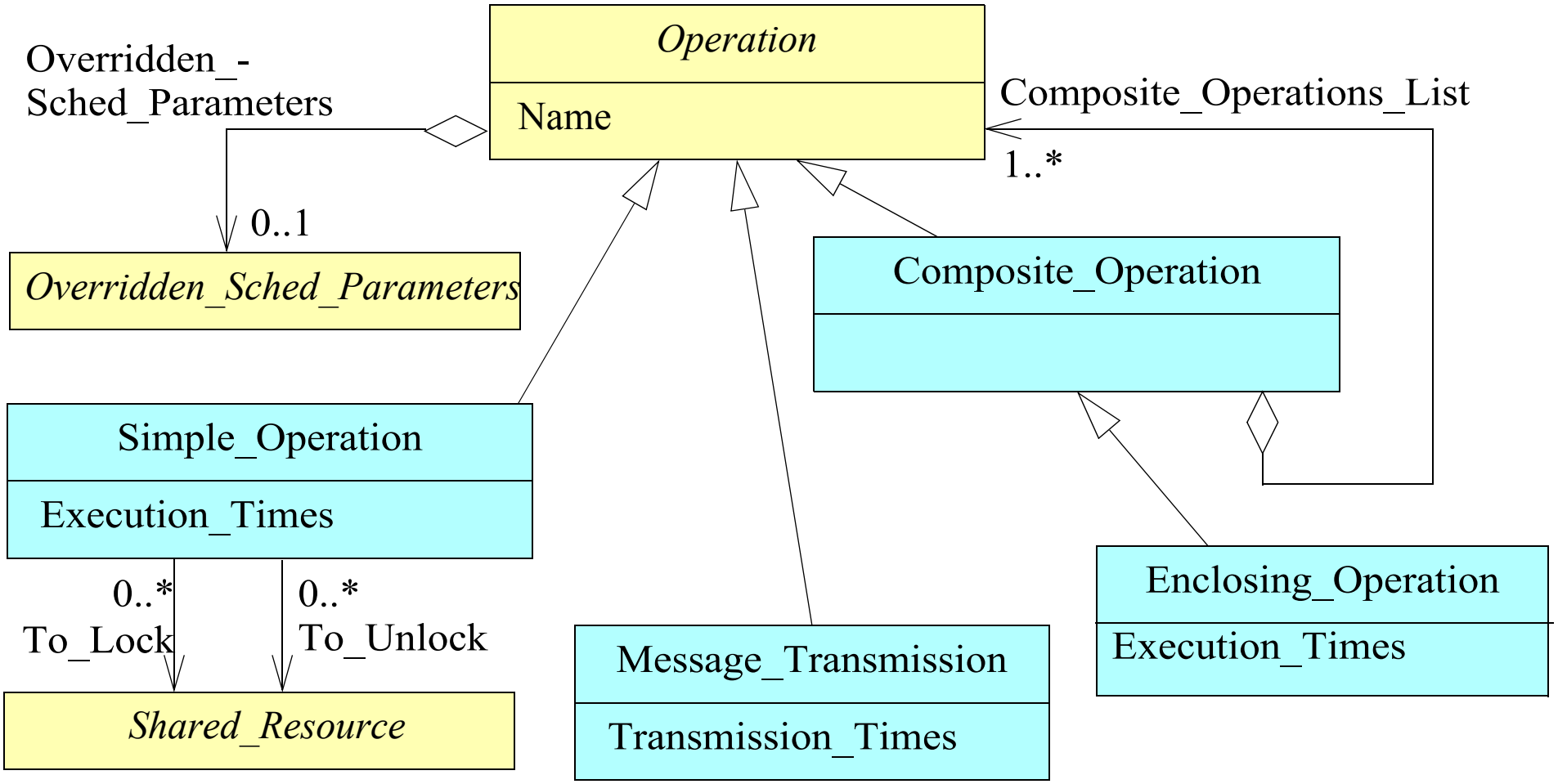
Scheduling servers



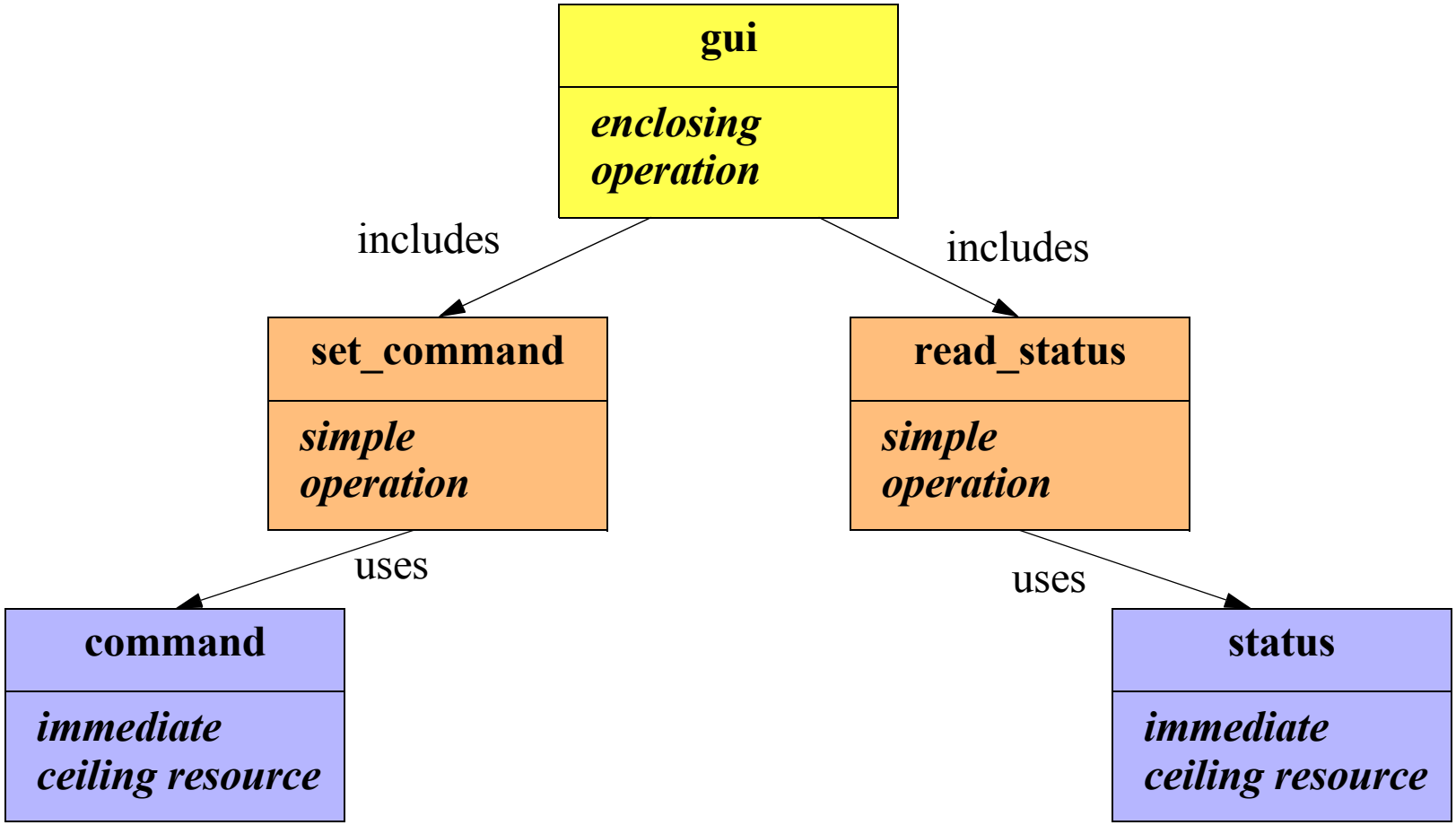
Shared resources



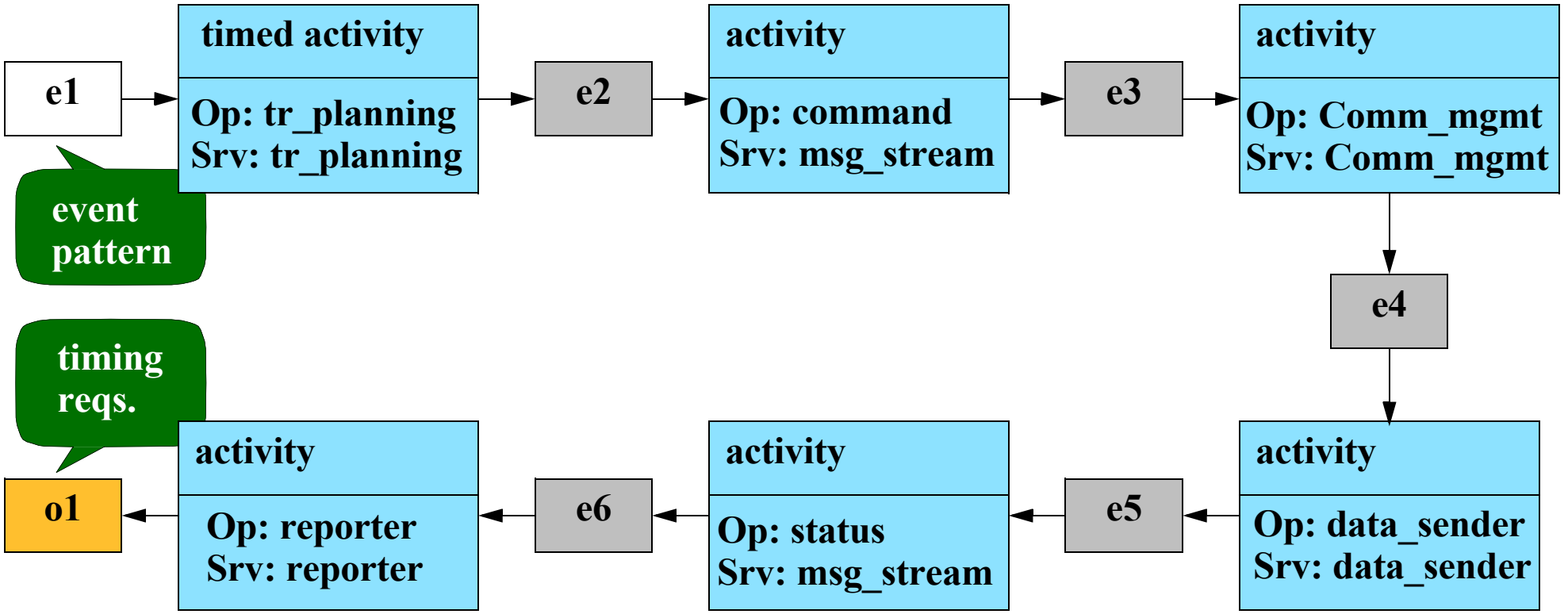
Logical Operations Model



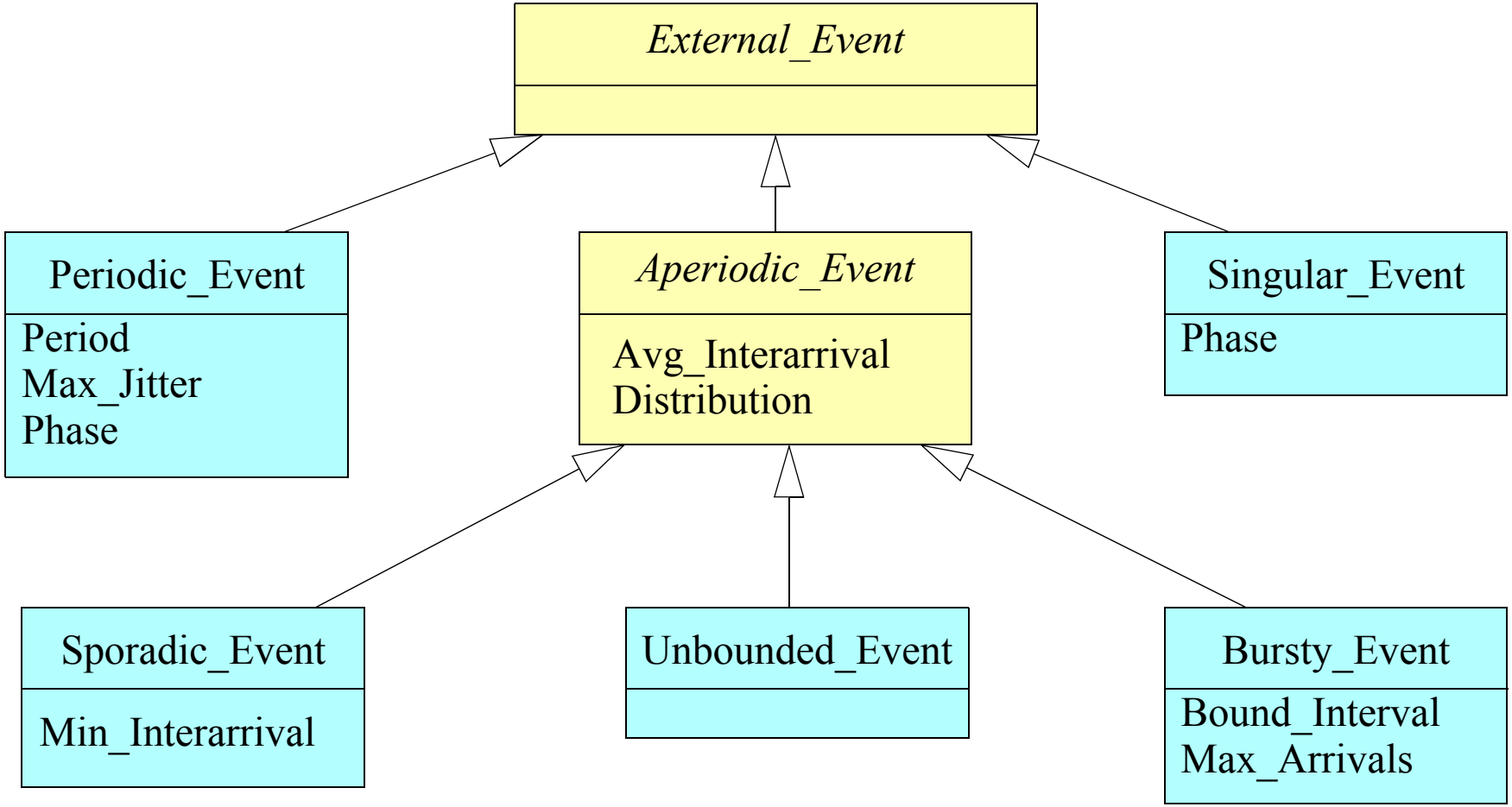
GUI operation in the example



Transactions: Distributed transaction in the example



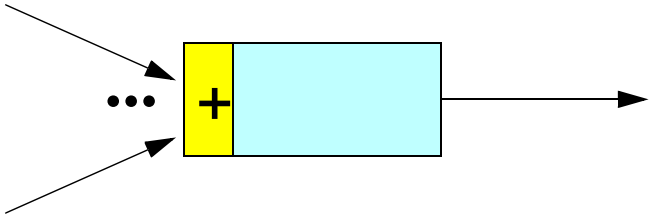
External Events



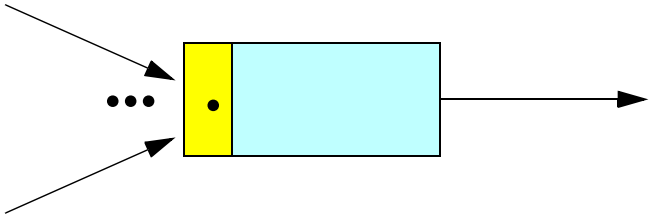
Event Handlers

Activity / Rate Divisor / Delay / Offset

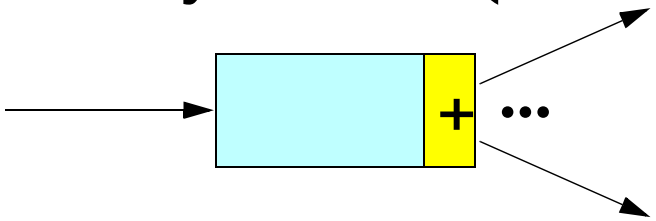
Concentrator (Merge)



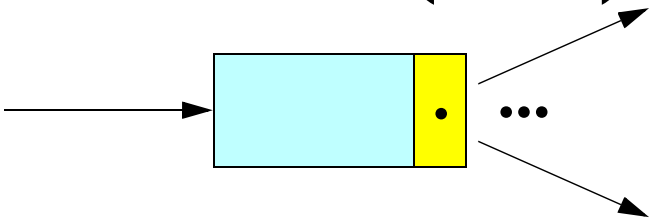
Barrier (Join)



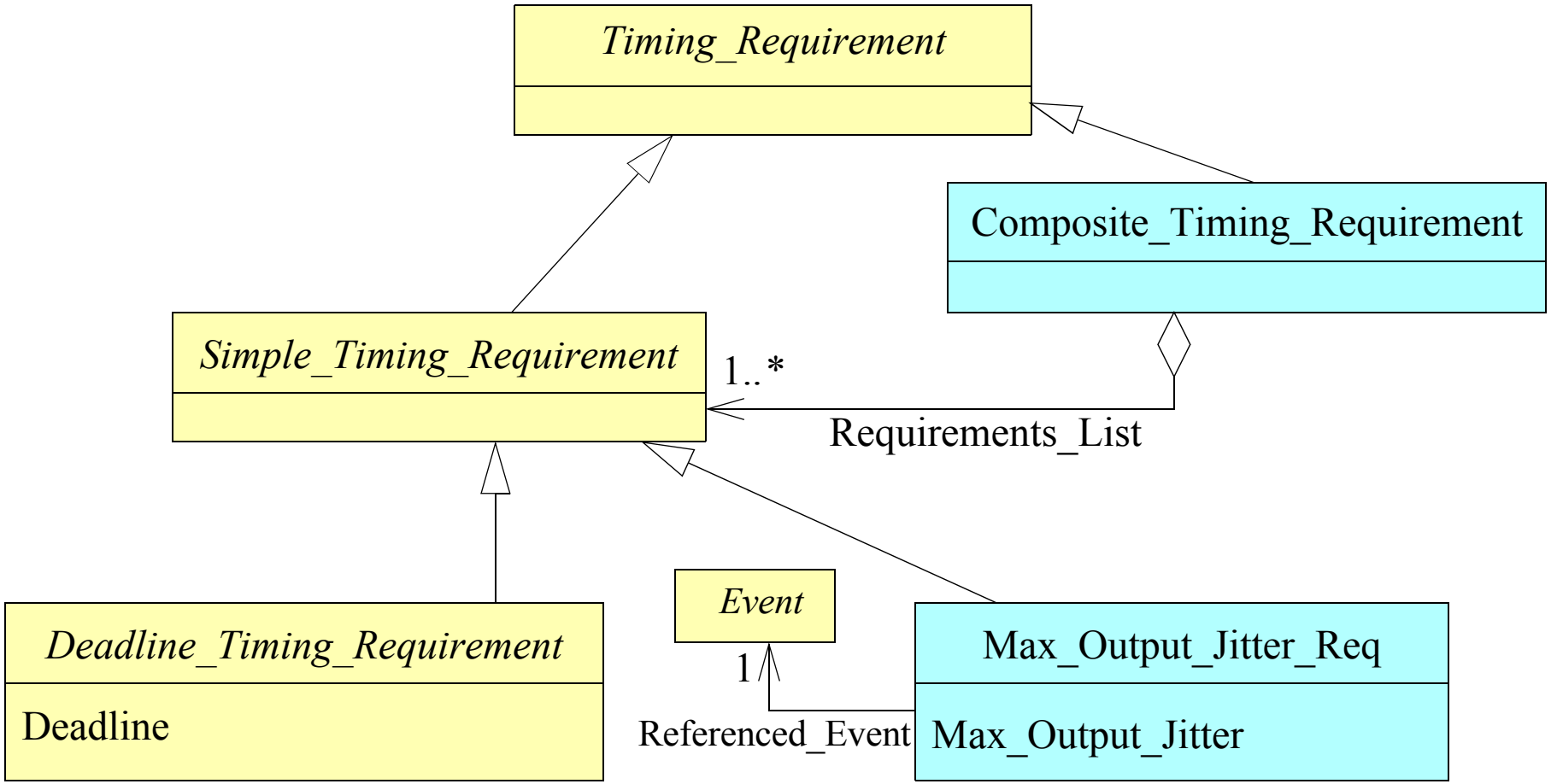
Delivery Server (Branch)



Multicast (Fork)



Timing requirements



4. Integration into the design process

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Components built with their own timing behavior model

- passive components: operations and shared resources
- active components: single or multithreaded, distributed, ...

The model is parameterized

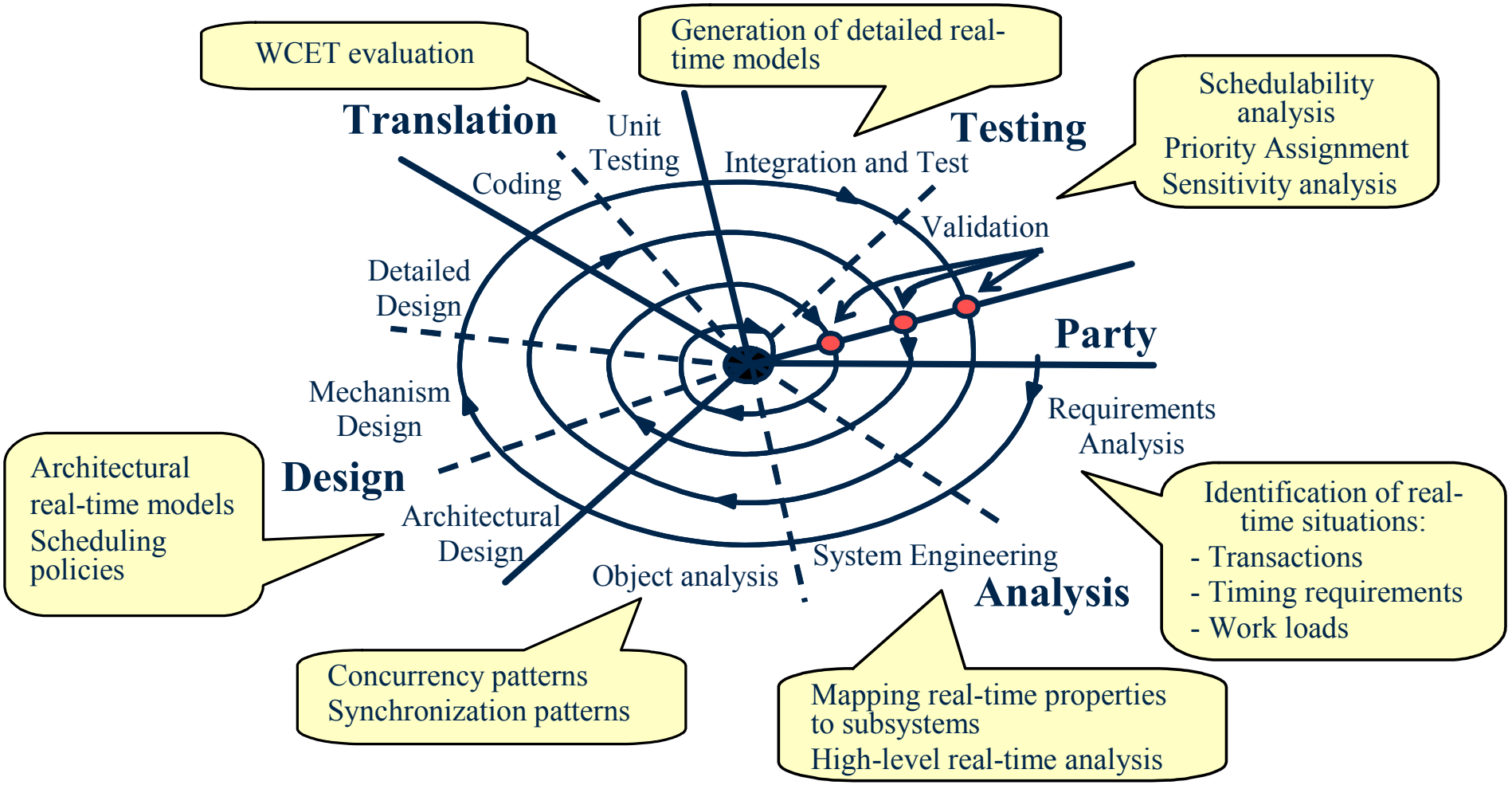
- i.e., actual data for WCETS

Deployment tool

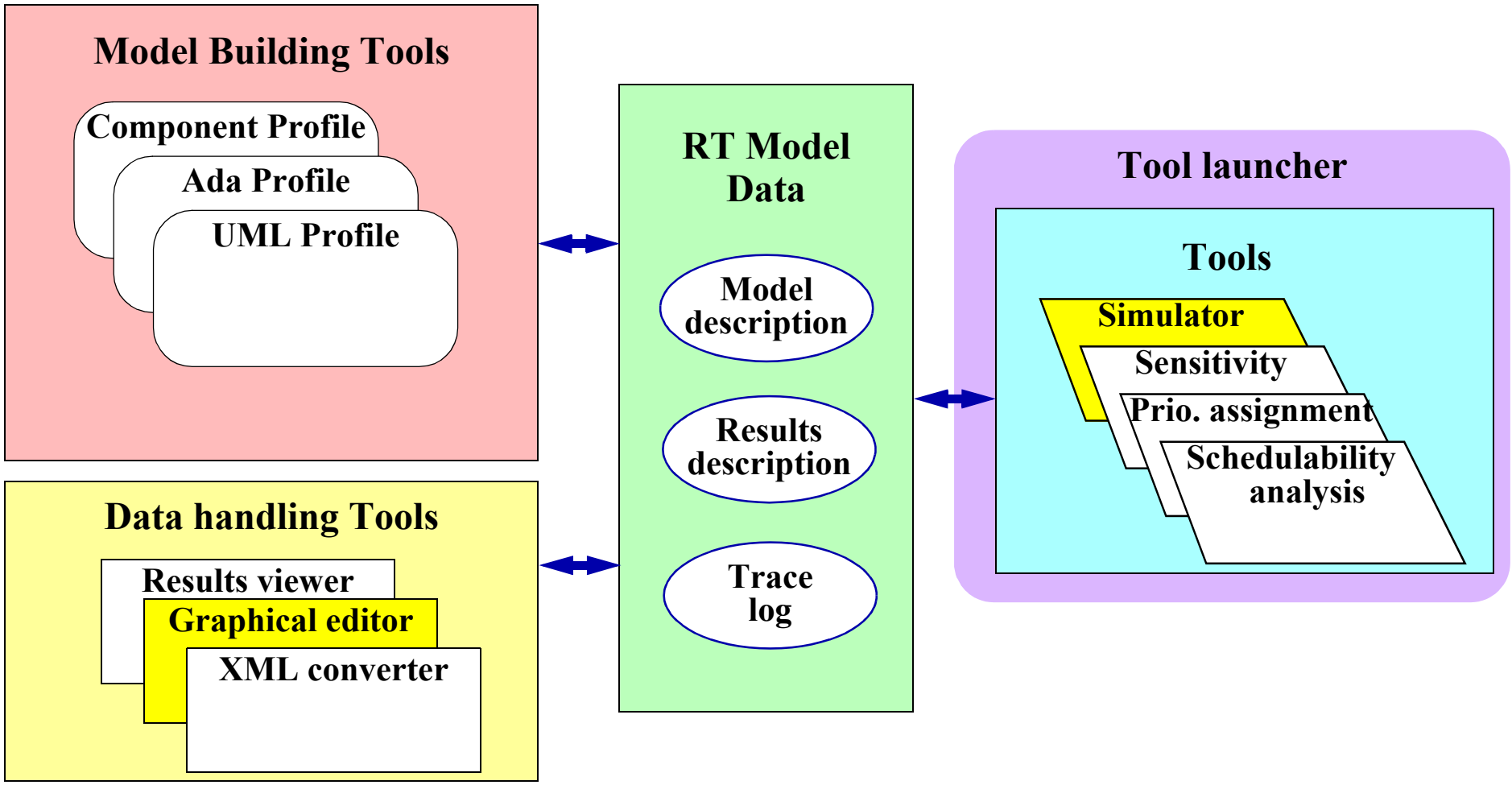
- instantiates the parameterized component models
- provides the platform model
- integrates them with the real time situation model

Automatic schedulability analysis is then made

Integration into the design process



5. The MAST Environment



6. Conclusions

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MAST defines a model for describing real-time systems

- distributed and multiprocessor
- complex synchronization and event-driven schemes
- composable software modules
- independence of architecture, platform and modules

MAST provides an open set of tools

- hard and soft real-time analysis
- automatic blocking times, priority assignment, sensitivity analysis...

XML specification language allows easy integration with other tools (i.e., UML tools)

Future Work

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Finish current tools:

- graphical editor
- integrate simulator

Implement missing tools:

- Multiple-Event Analysis
- Full support for EDF

Speed up the response time analysis

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