
INTEGRATING OPERATIONAL SPECIFICATION AND PERFORMANCE MODELING

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Abstract

There are two important early stages in the design of complex systems, modeling of the system (operational) specification and modeling of the system performance. In this paper, we propose a link between operational specification and performance modeling via VHDL. We show by an example, how the models can be made to interact, yielding a synergy leading to design efficiency and improved modeling accuracy. While this paper does not provide concrete rules to solve the general problem of linking these two models, it justifies the usefulness of such a link through an example. The paper also presents some typical performance study scenarios to illustrate the use of the methodology. We hope that the work presented in the paper fuels further research in the area of linking operational specifications and performance modeling. Providing a link between Operational Specification and Performance Modeling will bridge the hitherto existing gap between these two stages of the design process.

Integrating Operational Specification with Performance Modeling

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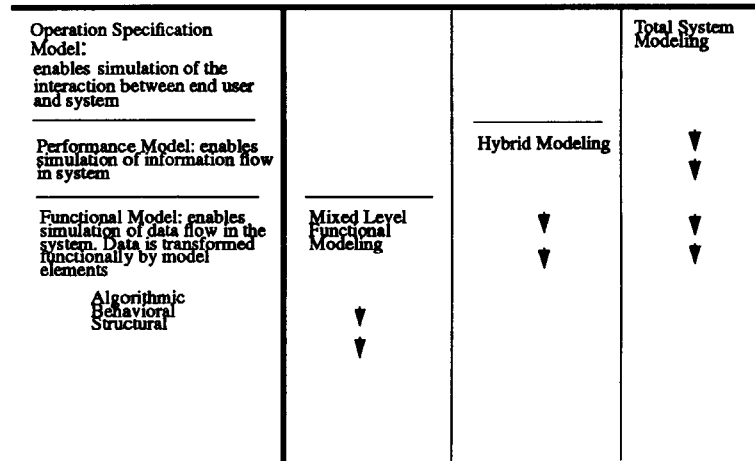
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Motivation

● Overall Design Process



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Motivation

Two important stages

- **Operational Specification**
 - ⇒ Simulatable description of system as seen by end user
 - ⇒ State machine view of system
- **Performance Model**
 - ⇒ Prediction and evaluation of system performance
 - ⇒ Model of actual hardware/software at arbitrary levels of abstraction
- **Hard to study system behavior from performance model because of lack of direct mapping between specification and implementation**
- **Hard to study performance issues from an operation specification**

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Motivation

Problems

- Current tools use different 'languages' for system description for different design phase
- Design process gets fragmented across languages and tools
- Makes the process very cumbersome and error-prone
- Need an integrated design tool that allows complete design (specification to final product) under a single umbrella

Solution

- Use VHDL as the language of description
- **Link Operation Specification with Performance Modeling**
- Hybrid Modeling

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Why link Op Spec with Performance Models

- Provide continuity in the design process
- Op Spec provides an efficient and graphical method for specifying algorithms
- Performance models accurately depict the system hardware/software
- Model algorithms (control structure) via Statecharts while modeling hardware/software (data flow) via the Uninterpreted Modeling methodology

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Why link Op Spec with Performance Models

Advantages

- Designer not forced to work with complex performance models early in the design process
- Flexibility in changing and studying algorithms through a medium that is easy to use (graphical)
- Algorithms are more naturally expressed and viewed as finite state machines.

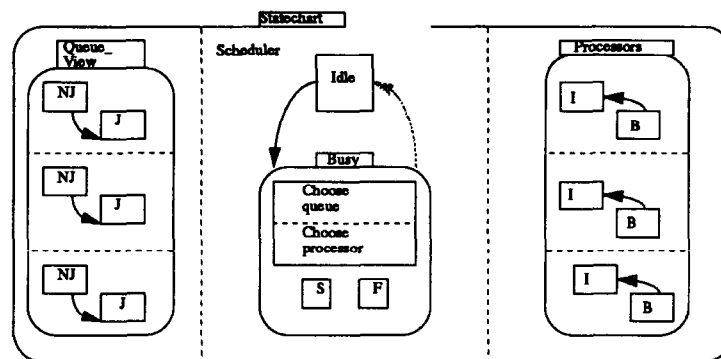
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Experiment

- Model a scheduling system
- Scheduling algorithm modeled as an Op Spec
- Hardware, Queues and Processors, modeled at the performance level
- Priority scheduling
- No preemption
- Multiple Qs, single server
- Op Spec via Statecharts; Performance model via Uninterpreted Modeling

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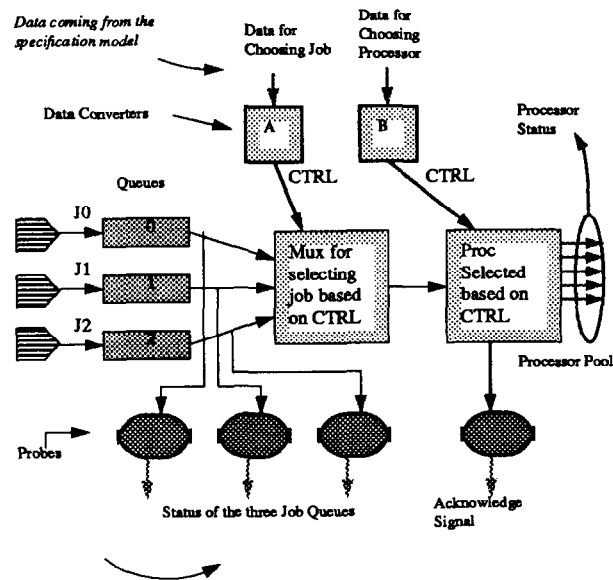
Operation Specification Model of Total System



NJ: No job in Queue, J: Job in queue
I: Processor Idle, B: Processor Busy
S: Success F: Fail

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Performance Model of Total System



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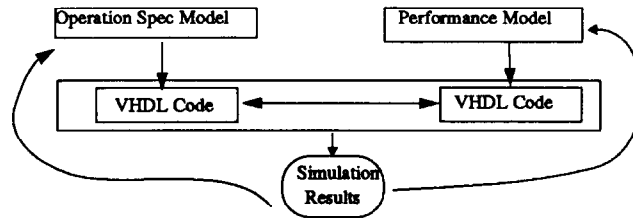
Link Points

- Op Spec to Performance Model (PM)
 - ⇒ Job selection
 - ⇒ Processor selection
 - ⇒ Data Converters

- PM to Op Spec
 - ⇒ Processor status
 - ⇒ Handshake signal
 - ⇒ Probes

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Link Schematic

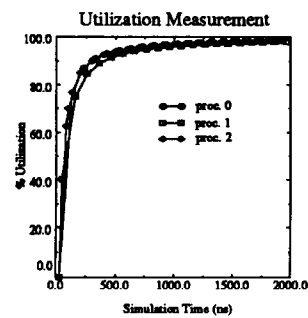
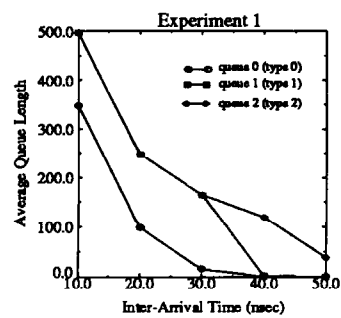


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Results

Experiment I

- Job processing time fixed: 100ns, 20ns and 50ns
- Vary Inter-arrival time
- Infinite Queue size
- For utilization measurement: Arrival time 30ns

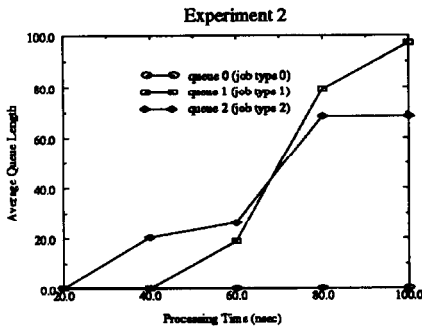


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Results

Experiment II

- Inter-arrival time fixed at 50ns, 20ns and 35ns
- Vary job processing time (for all job types)
- Infinite Queue sizes



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Conclusions

Operation Specification Model:
enables simulation of the interaction between end user and system

Performance Model: enables simulation of information flow in system

Functional Model: enables simulation of data flow in the system. Data is transformed functionally by model elements

Algorithmic Behavioral Structural



Mixed Level Functional Modeling

Hybrid Modeling



Total System Modeling



- Methodology is useful in incremental design which includes the Operation Specification level of abstraction.

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Future Work

- Test more complex examples
- Formalize the methods/techniques for the linking methodology and for link point identification
- Automate or semi-automate the link process

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