

Performance Trade-off in Distributed Simulation



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Distributed Simulation and Real Time Application, 10-13 Oct 2002

Previous work

- **Event orderings formalization using Partial Order Set**
- **Space performance analysis**

Objectives

- **Extend to time performance analysis**
- **Space and time trade-off**

Outline

- Performance Analysis in PDES
- Space Performance Analysis
- Time Performance Analysis
- Experiments
- Conclusions and future works

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Performance Analysis

Performance Analysis in PDES

- **Analytical**
 - stochastic processes (markov chain), queueing theory, operational law, etc
- **Simulation based**
 - Simulate the PDES protocol
- **Critical Path Analysis**
 - Derive the critical path

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Event Ordering based analysis

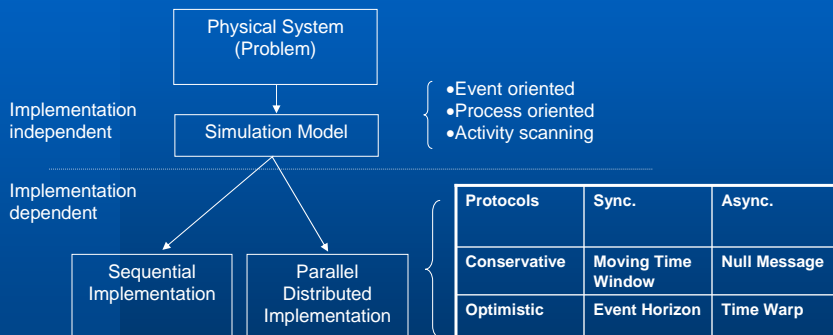
- **Simulation protocol implement a certain event ordering**
- **Variation in the implementation does not affect the event ordering**
- **Combination between simulation based and critical path analysis**

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Space Performance Analysis

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Simulation Modeling Process



Space Analysis

- **Memory requirement**
- **Classification:**
 - M_{prob} : characteristic of the real world system
 - M_{ord} : characteristics of the event ordering
 - M_{sync} : implementation overhead

FOR MORE INFO...

Effect of Event Ordering on Memory Requirement in Parallel Simulation (MASCOTS01) & Conservative Simulation Using Distributed Shared Memory (PADS02)

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Time Performance Analysis

Time Analysis

- **Event parallelism**
- **Classification:**
 - Π_{prob} : parallelism in real world system
 - Π_{ord} : parallelism due to event ordering
 - Π_{sync} : parallelism after implementation

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Inherent Event Parallelism

- **Definition: the existing parallelism in the physical system**
- **Factors:**
 - size
 - traffic intensity

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Event Ordering Parallelism

- **Definition:** parallelism that can be exploited by applying a certain event ordering
- **Factors:**
 - Characteristics of the physical system
 - Strictness of event ordering

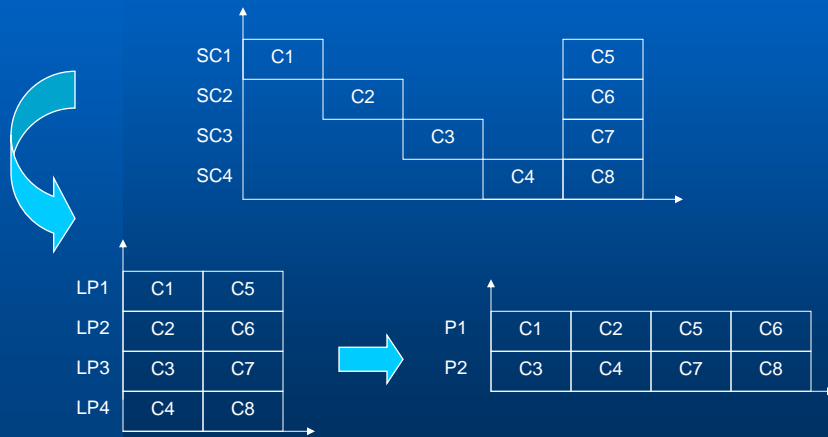
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Effective Event Parallelism

- **Definition:** parallelism obtained after running the simulation program on the real machines
- **Factors:**
 - Characteristics of the physical system
 - Strictness of event ordering
 - Implementation algorithm
 - execution platform (processor, network, operating system, etc)

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Event Parallelism Example



Experiments

Experiment

- **Focus on event orderings**
- **Apply four existing event orderings**
 - Total event ordering
 - Timestamp event ordering
 - Time-interval event ordering
 - Partial event ordering
- **TSA library**
 - order the set of events according to a certain event ordering, measure parallelism & memory

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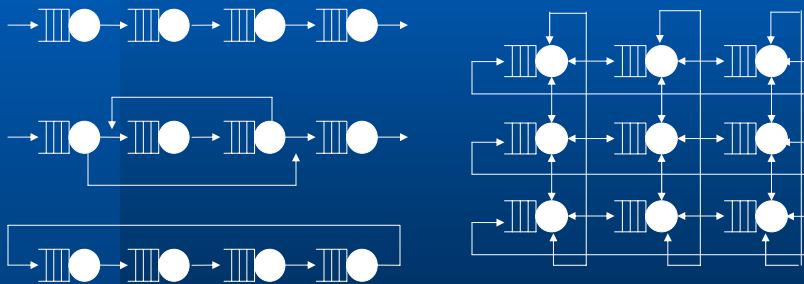
TSA Library

```
While (simulation is in progress) {
    remove event e with the smallest time
    stamped from event list
    simulation_clock = ts(e)
    execute event_handler(e)
    TSA(e)
}
TSA_report()
```

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Synthetic Benchmarks

- **Four queuing network topologies**



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Design Experiment

- **Factors**

- **Characteristics of real world system**

- Size (the number of service centers)
- Traffic intensity (open system), jobs population (closed system)
- Topology: four benchmarks

- **Four event orderings**

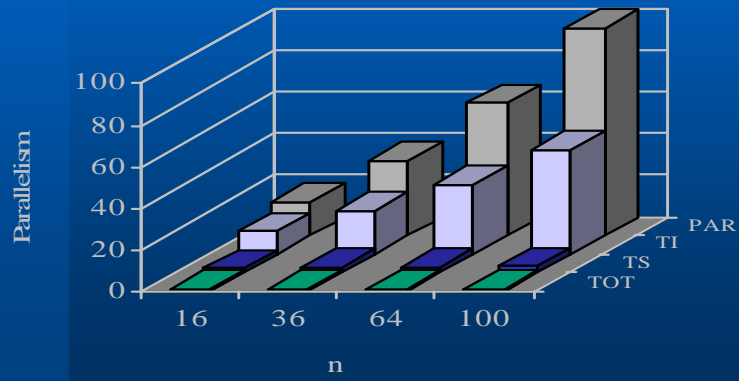
- **Output**

- **Event ordering parallelism**
- **Memory requirement**

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Effect of Event Ordering (cont)

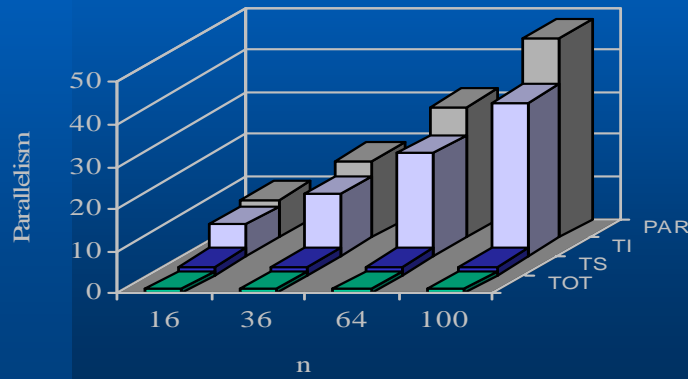
PIPE (n, 0.6)



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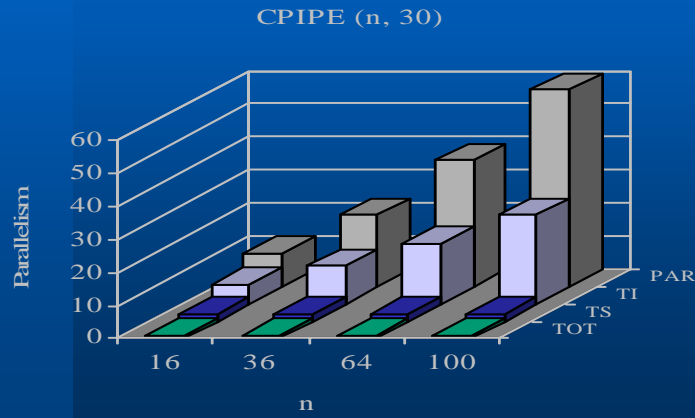
Effect of Event Ordering (cont)

PIPEFB (n, 0.6)



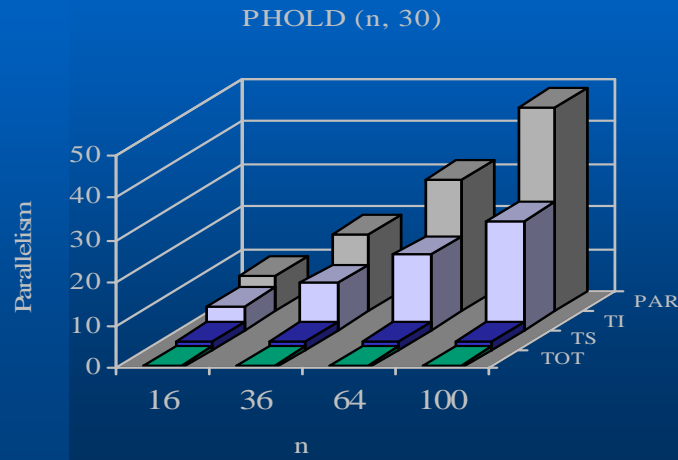
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Effect of Event Ordering (cont)



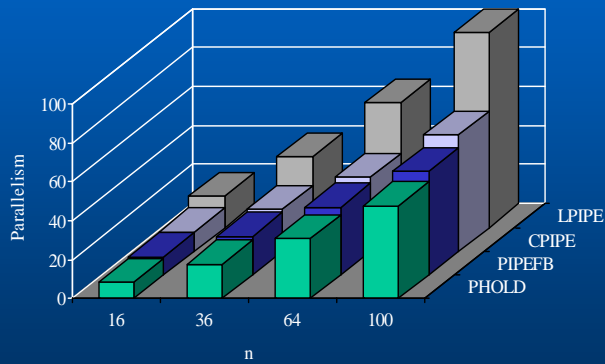
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Effect of Event Ordering (cont)



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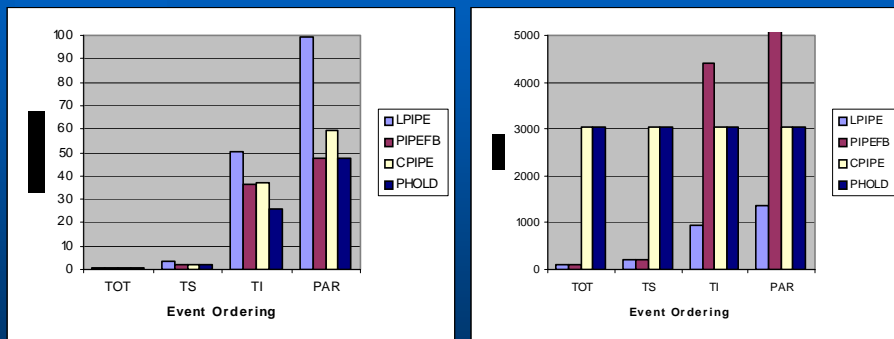
Effect of Topology



For the same average number of jobs in the system

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Time & space trade off



For the same size and average number of jobs in the system

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Conclusion & Future Works

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Conclusion

- **Event ordering based performance analysis for PDES**
- **Definition & classification of memory requirement in simulation**
- **Definition & classification of event parallelism in simulation**
- **The effect of size, traffic intensity, topology and event ordering on time and space performance**

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Future Works

- Find out the event ordering of the existing simulation protocols
- Experiment on M_{sync} and Π_{sync} on selected protocols (too many)
- Theory:
 - event ordering strictness
 - analytical model for each memory component and event parallelism level

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Thank you

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