Adaptive Scheduling of Data Paths using Uppaal Tiga

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Outline

1. Introduction
2. Océ Case Study
3. Uppaal Tiga
4. Model
5. Results
6. Conclusions & Future Work

Outline

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   - Scheduling Problems
   - Uncertainty
   - Goal of this Research
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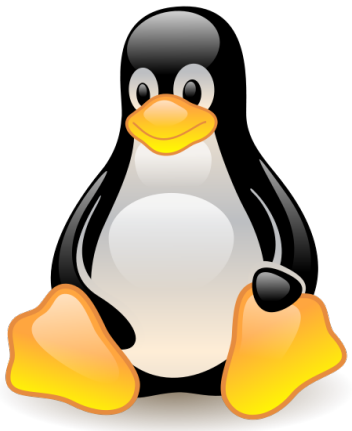
Scheduling Problems

- allocation of resources to activities over time
- in order to achieve some goals
- many different domains



Uncertainty

- existing literature
  - a function of known, perfect inputs
- scheduling processes in practice: driven by uncertainty
  - machine breakdown
  - unexpected arrival of new jobs
  - modification of existing jobs
  - uncertainty of task durations
  - ...

Goal of this Research

- industrial case study: Océ printer/copier
- address problem of uncertain job arrival times
- use Uppaal Tiga

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- Overview
- Data-Paths
- Schedule

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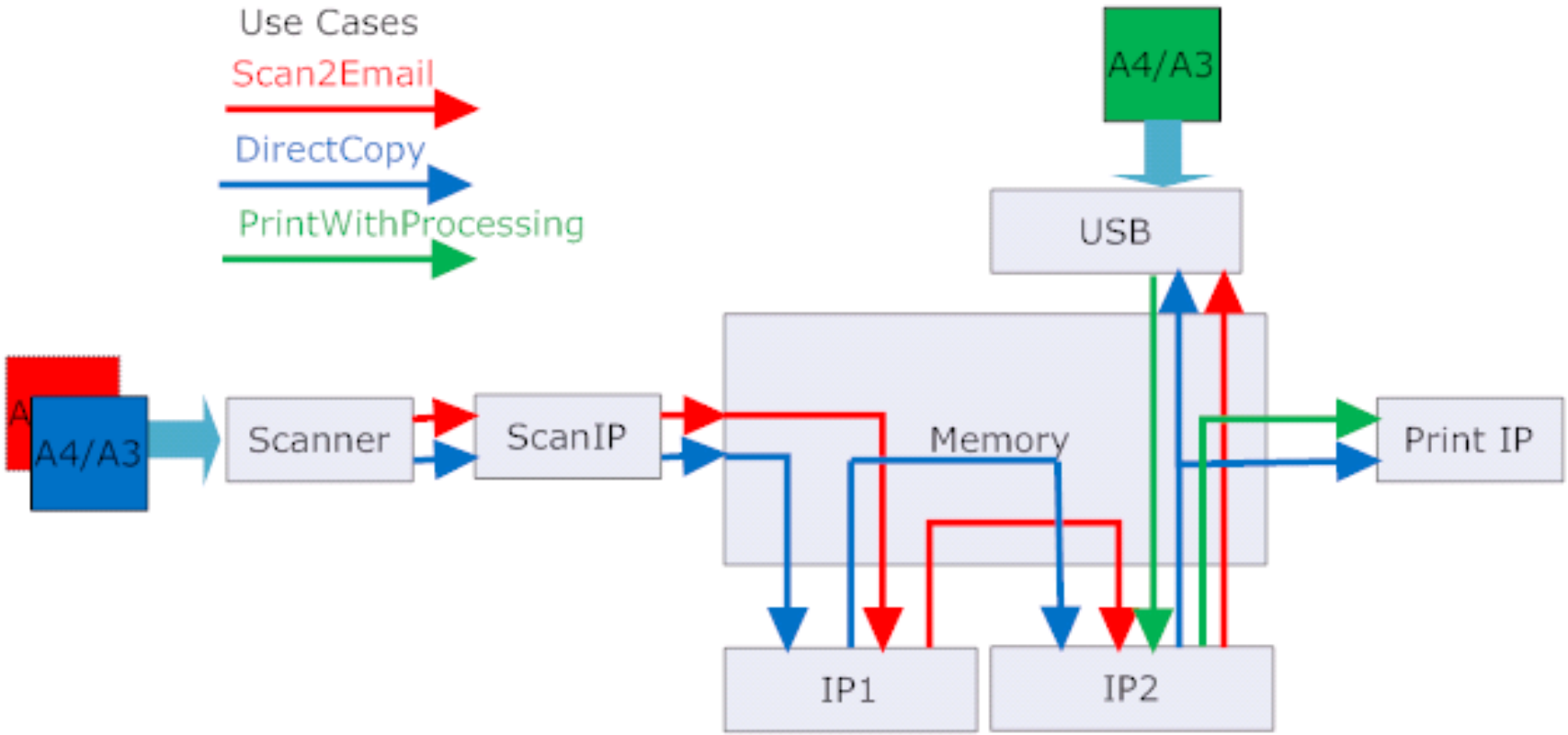
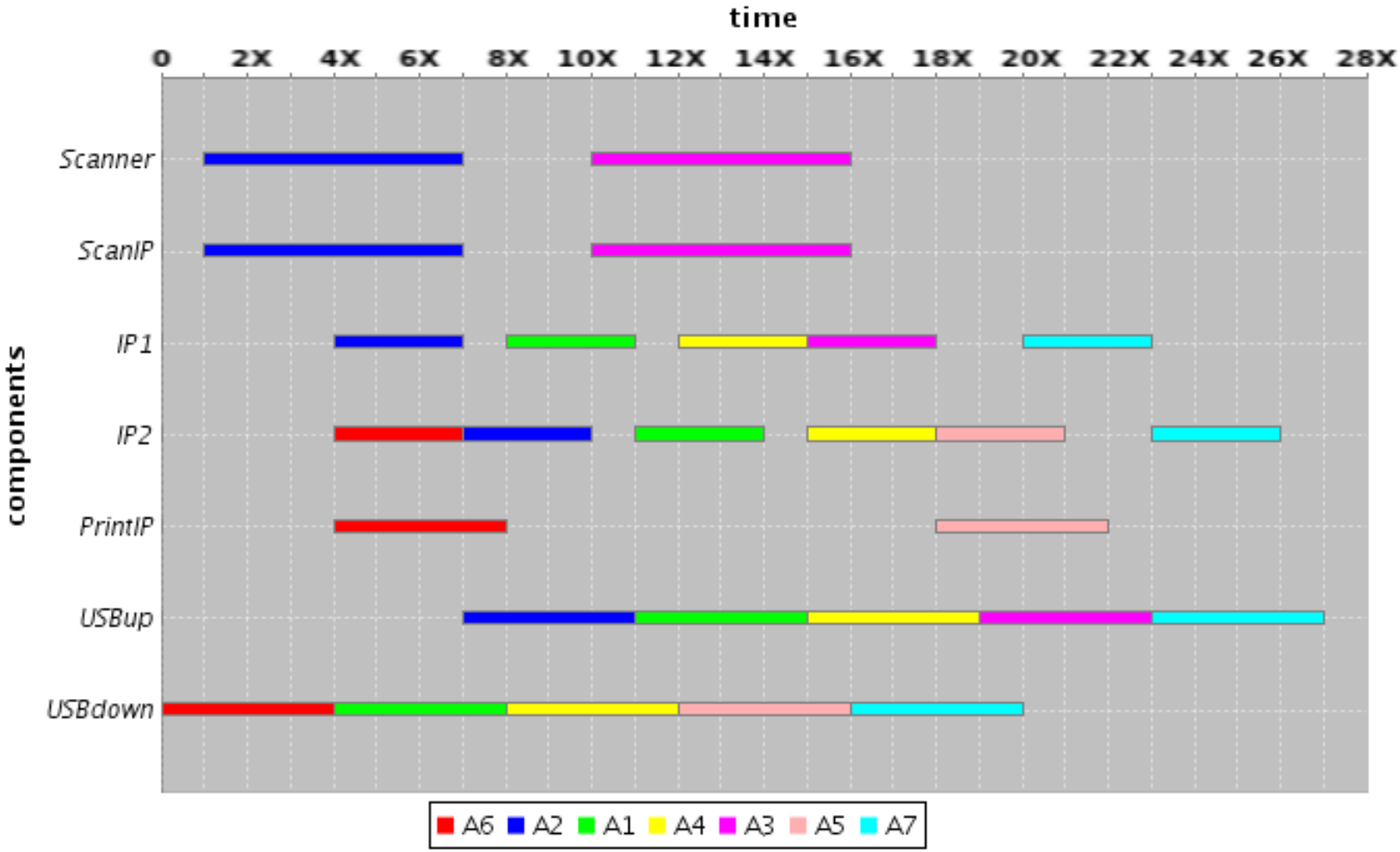
Océ Copy/Printer Overview

Océ Copy/Printer Data-Paths



Schedule of print/copy jobs



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- Controller vs Environment
- Printer vs User

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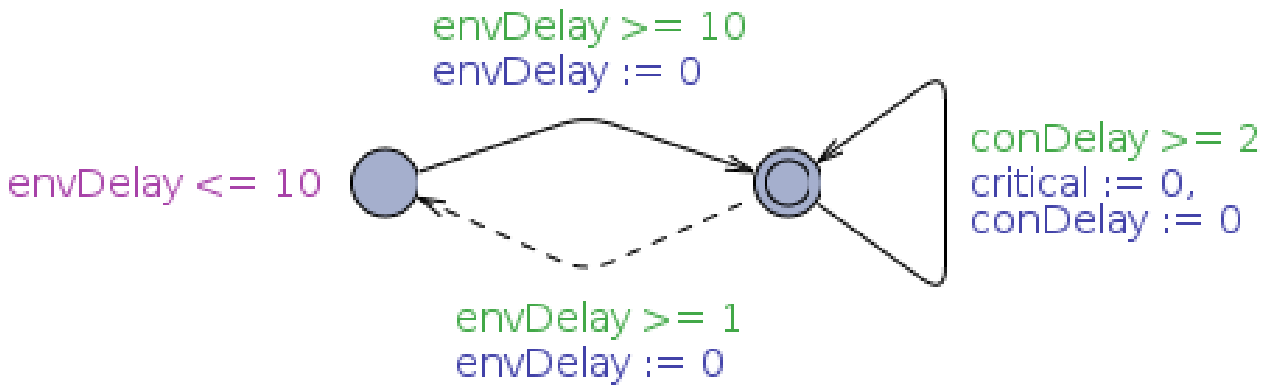
Controller vs Environment




```
control: A[] a0.critical <= 11
```

not satisfied

```
control: A[] a0.critical <= 12
```

satisfied

Printer vs User

- Printer
  - process jobs
  - meet timing constraints
- User
  - add jobs
  - moment is unforeseeable

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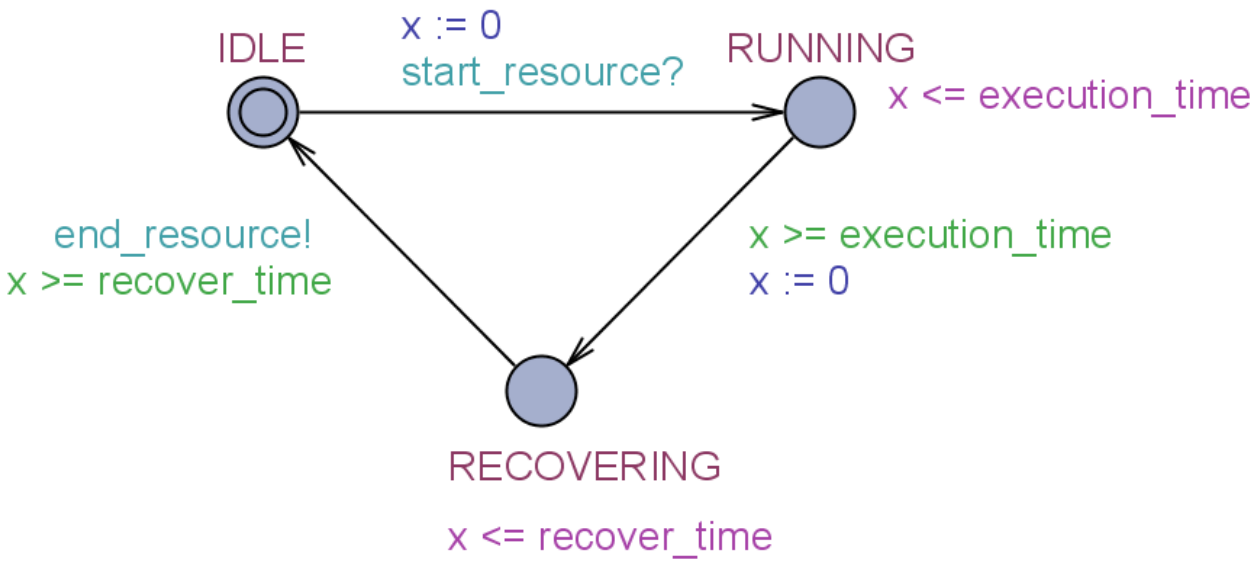
- Resources
- Copy Jobs
- Print Job
- Winning Condition

5 Results

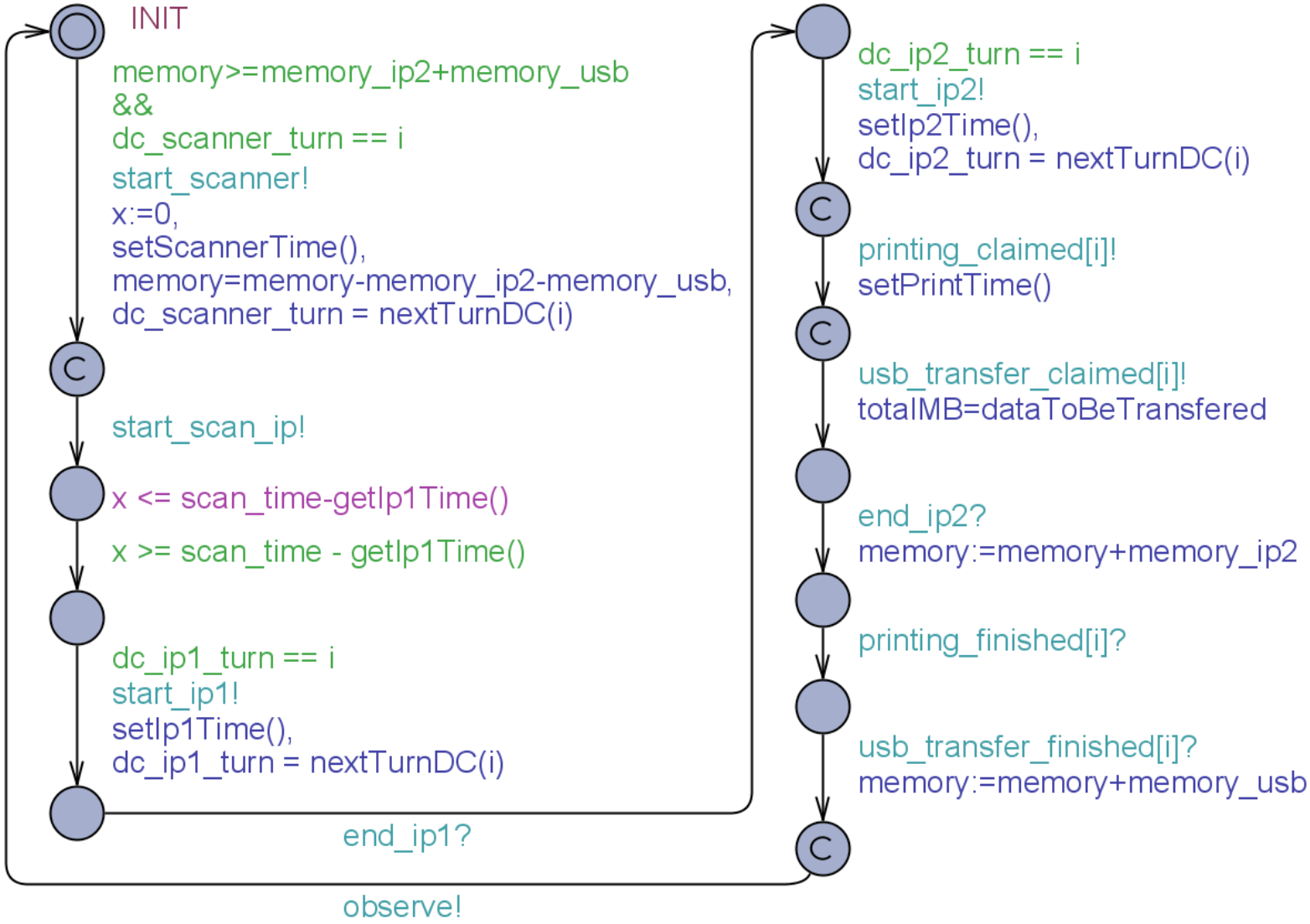
Uppaal Model Overview

- based on model by Igna et al. [FORMATS'08]
- network of timed game automata
- each use case & resource described by automaton
- restriction to simple scenario
  - continuous stream of copies
  - uncontrollable print job
- observer for finished copies

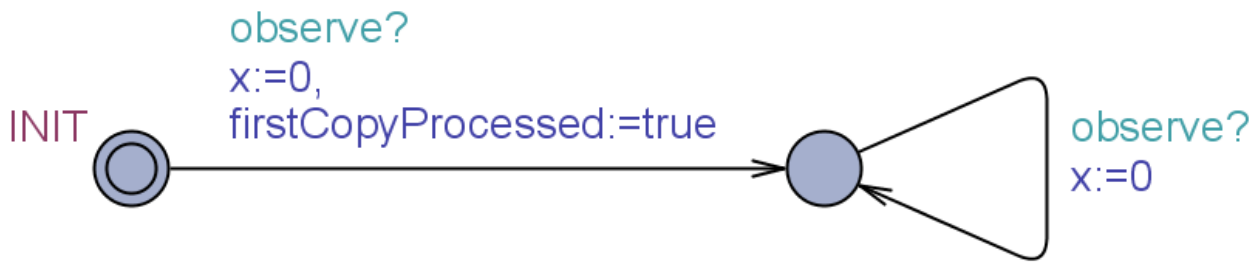
Resource Template



Copy Jobs

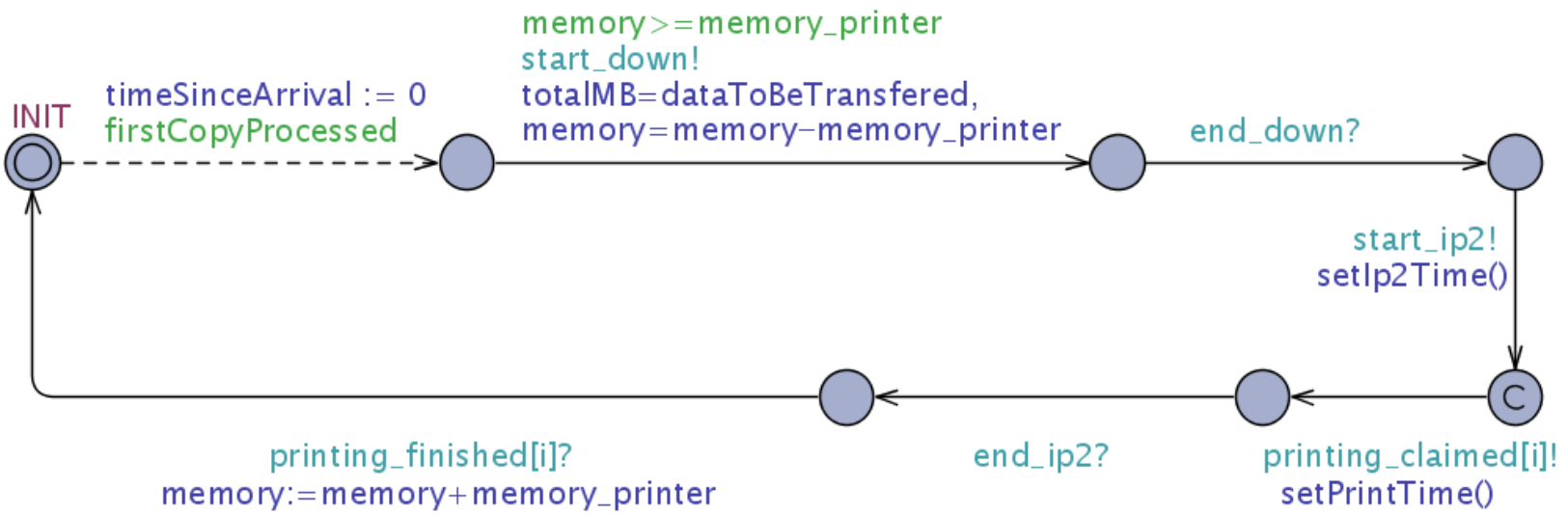

INIT
memory>=memory_ip2+memory_usb
&&
dc_scanner_turn == i
start_scanner!
x:=0,
setScannerTime(),
memory=memory-memory_ip2-memory_usb,
dc_scanner_turn = nextTurnDC(i)
C
start_scan_ip!
x <= scan_time-getIp1Time()
x >= scan_time - getIp1Time()
dc_ip1_turn == i
start_ip1!
setIp1Time(),
dc_ip1_turn = nextTurnDC(i)
end_ip1?
observe!
dc_ip2_turn == i
start_ip2!
setIp2Time(),
dc_ip2_turn = nextTurnDC(i)
C
printing_claimed[i]!
setPrintTime()
C
usb_transfer_claimed[i]!
totalMB=dataToBeTransfered
end_ip2?
memory:=memory+memory_ip2
printing_finished[i]?
usb_transfer_finished[i]?
memory:=memory+memory_usb
C

Observer




```
control: A[]
  (DC_OBSERVER.INIT imply DC_OBSERVER.x <= FIRST_DC_TIME)
 &&
  (!DC_OBSERVER.INIT imply DC_OBSERVER.x <= DC_TIME)
```

Print Job




```
control: A[]
  (!DPO.INIT imply DPO.timeSinceArrival <= DP_TIME)
```

Winning Condition

```
control: A[]
  (DC_OBSERVER.INIT imply DC_OBSERVER.x <= FIRST_DC_TIME)
 &&
  (!DC_OBSERVER.INIT imply DC_OBSERVER.x <= DC_TIME)
 &&
  (!DP0.INIT imply DP0.timeSinceArrival <= DP_TIME)
```

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- Extracting Strategies
- Comparison With Fixed Strategies

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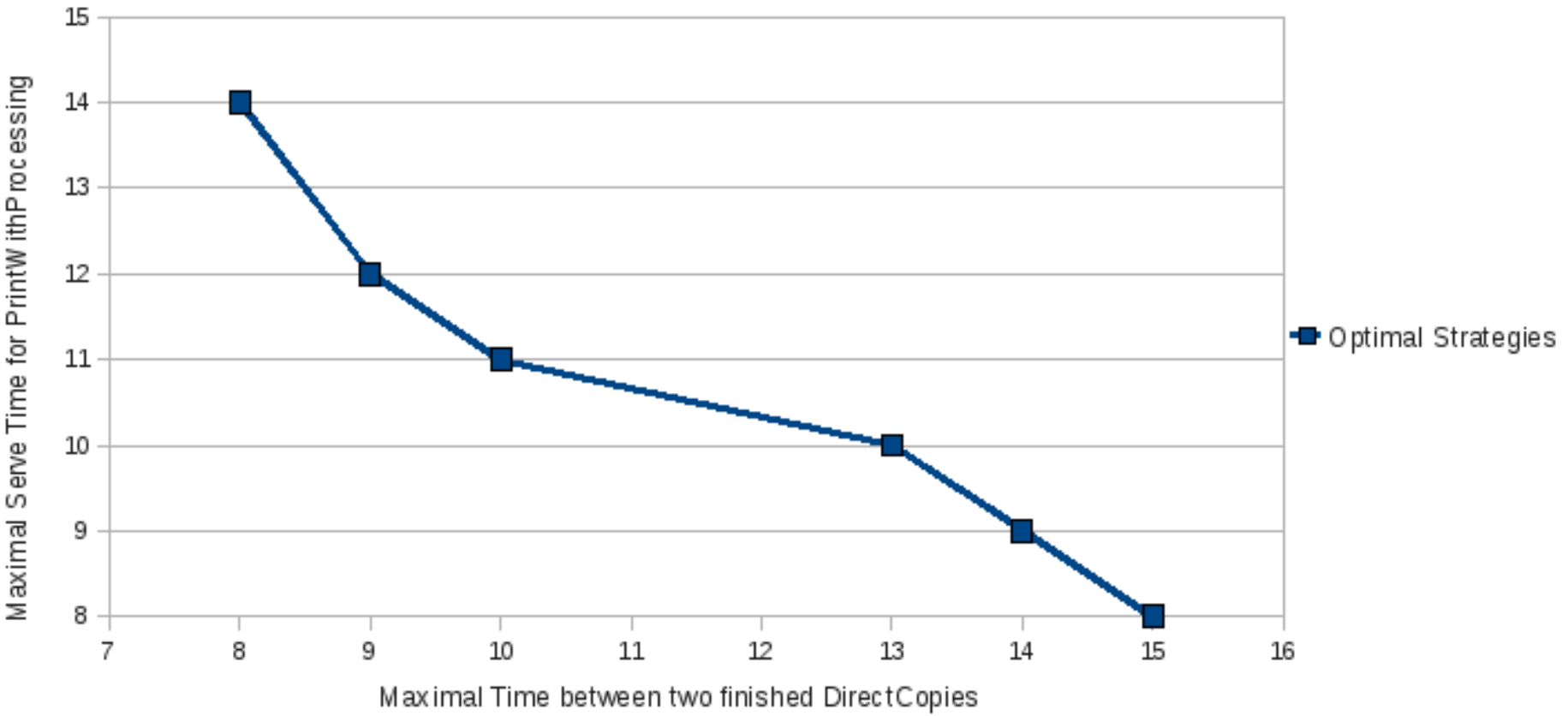
Optimal Strategies



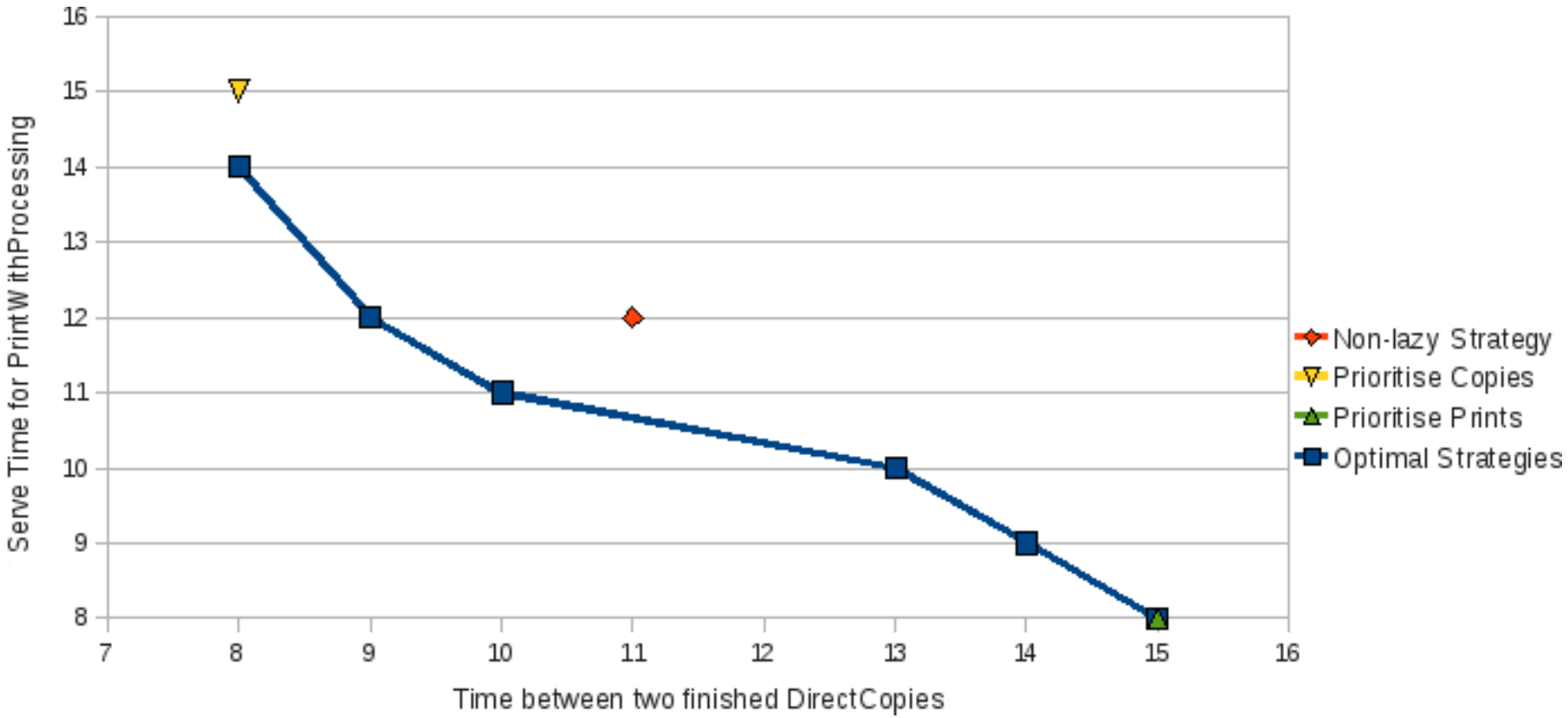
Extracting Strategies

- Tiga can generate strategies as set of rules
- not usable for real printer controller
  - very large size
  - include parts of model not existing in real world
  - does not abstract from number of jobs

Comparison With Fixed Strategies

- in practice: strategy should not be too complex
- comparing optimal strategies with simple ones can be helpful
- can also give hints how to improve existing strategies
- we built three simple strategies into our model

Comparison With Fixed Strategies



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- Future Work
- Questions

Conclusions

- application of timed automata to industrial scheduling problem
- limited to simplified model/scenario
- Tiga close to the point being helpful for actual design
  - indication of how close implemented rules are from optimum
  - finding bottlenecks
  - may help to find out and test better rules

Future Work

- improve efficiency of algorithm used by Tiga
  - more realistic model
  - more complex scenarios
- reduce size of generated strategy
- abstract also from number of jobs

Questions?