SFB 637
Autonomous Logistics

Autonomously Controlled Adaptation of Formal Decision Models

Comparison of Generic Approaches

- VRPTW with Uncertain Demand
- Planning System Layout
- Generic Optimization Model Adaptation Rules
- Computational Experiments & Numerical Results

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The Challenge

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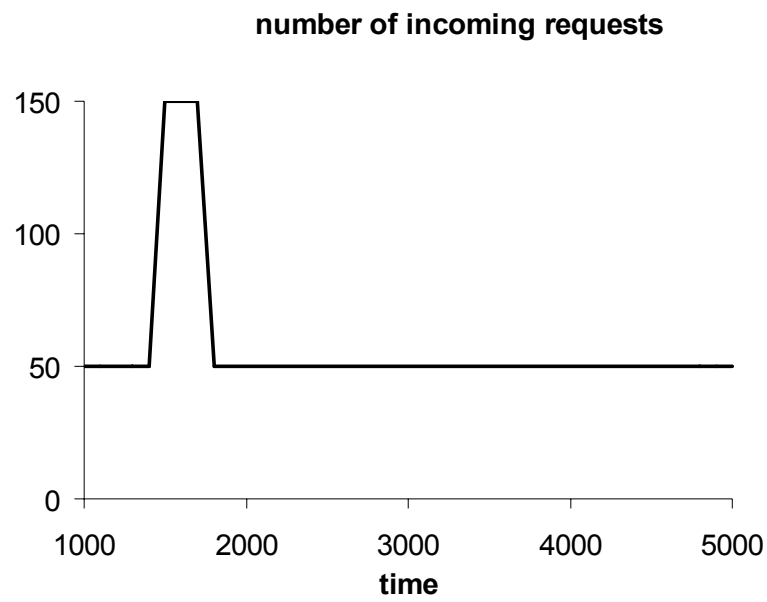
Vehicle Routing Problem with Time Windows

Three extensions

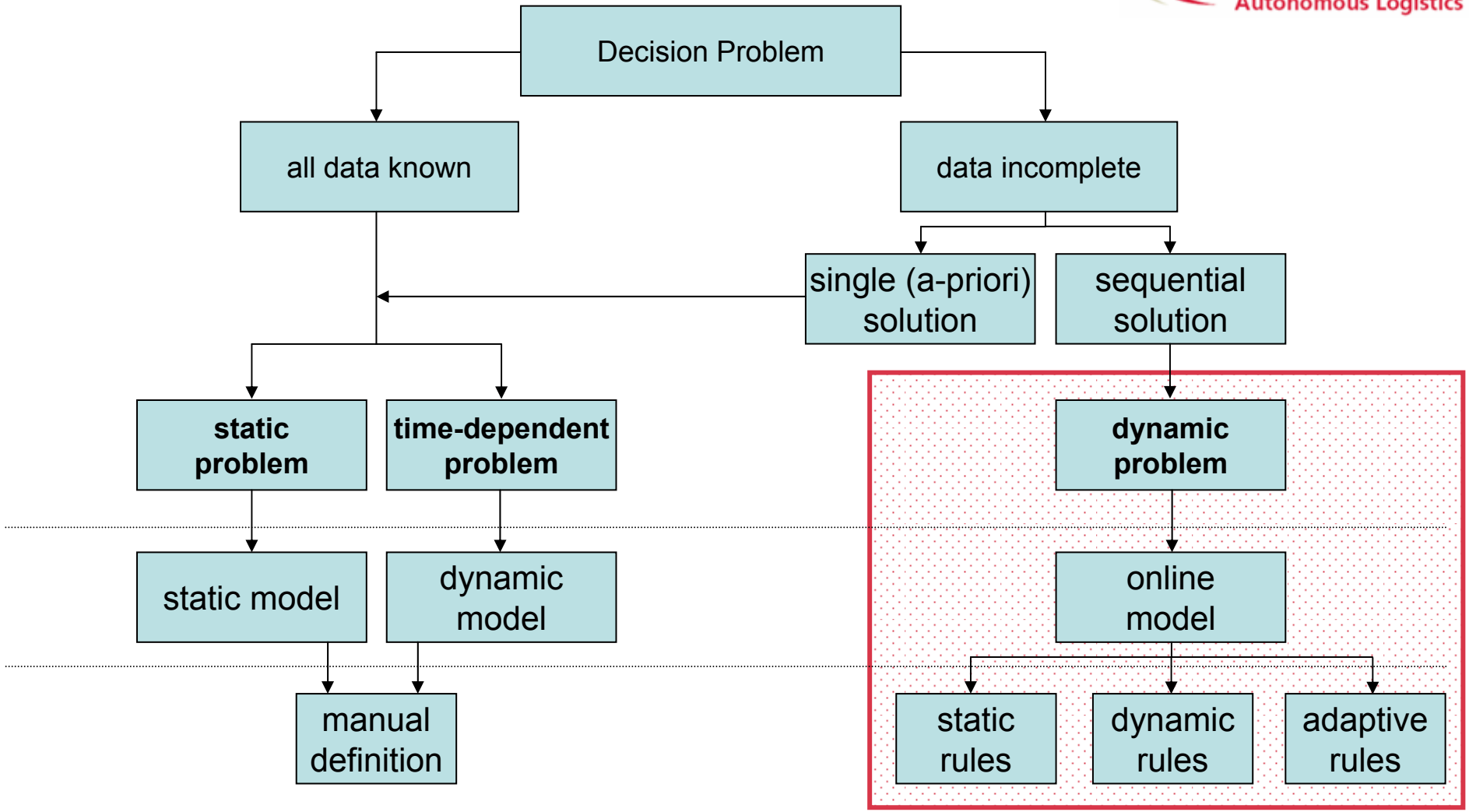
- soft time windows (penalties!)
- two fulfilment modes
  - self-fulfilment: cheap but sometimes delayed
  - subcontracting: expensive but always in time
- (re-)planning with incomplete data



Goals

- least cost transportation plan
- least punctuality rate p_t: 80%

Classification and Related Work



Online Optimization Model

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Sequence of "complete" decision problems

(sequence of instances)

Requirements expressed in an instance

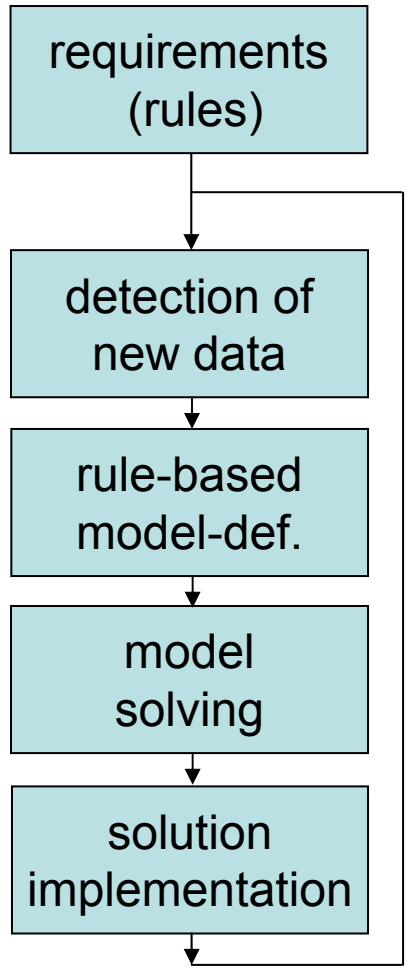
(1) $f^{self} \cdot (C^{self} + C^{pen}) + f^{sub} \cdot C^{sub} \rightarrow min.$

(2) one (empty) route for each vehicle

(3) each request is served

(4) subcontracted requests remain subcontracted

(5) started requests cannot re-assigned



Punctuality Requirement: Static Modelling Rules

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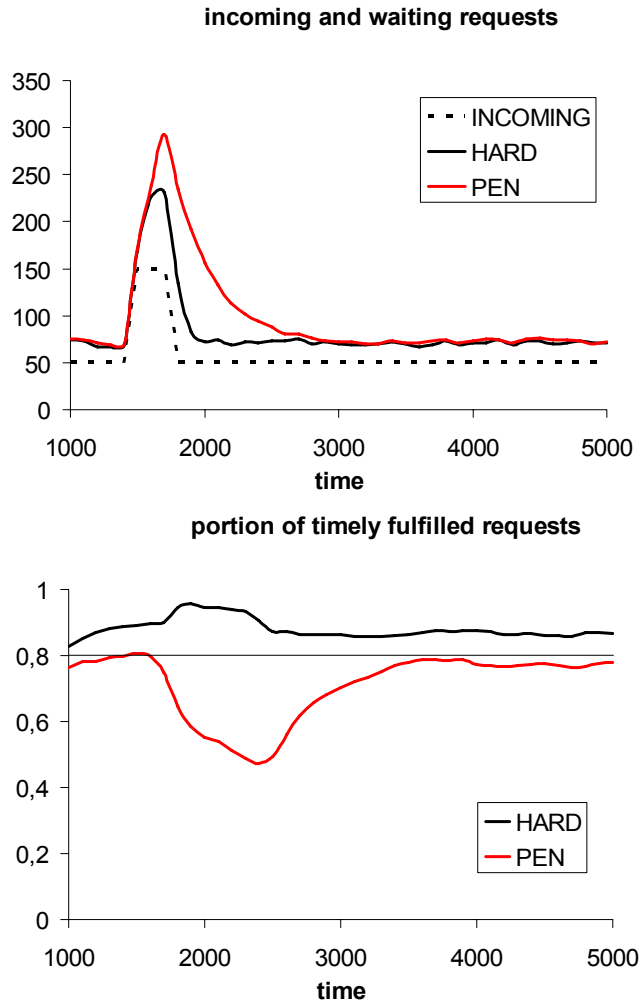
HARD

- constraint $p_t \geq 0.8$ for each replanning step
- constraint is strictly considered

PEN

- delays depreciate objective function value
- penalty increases proportionally with delay
- different fulfilment mode costs bias mode selection ($C_{sub}/C_{self} \approx 3$)

PEN and HARD: state-of-the-art



Adaptive Model Definition Rules

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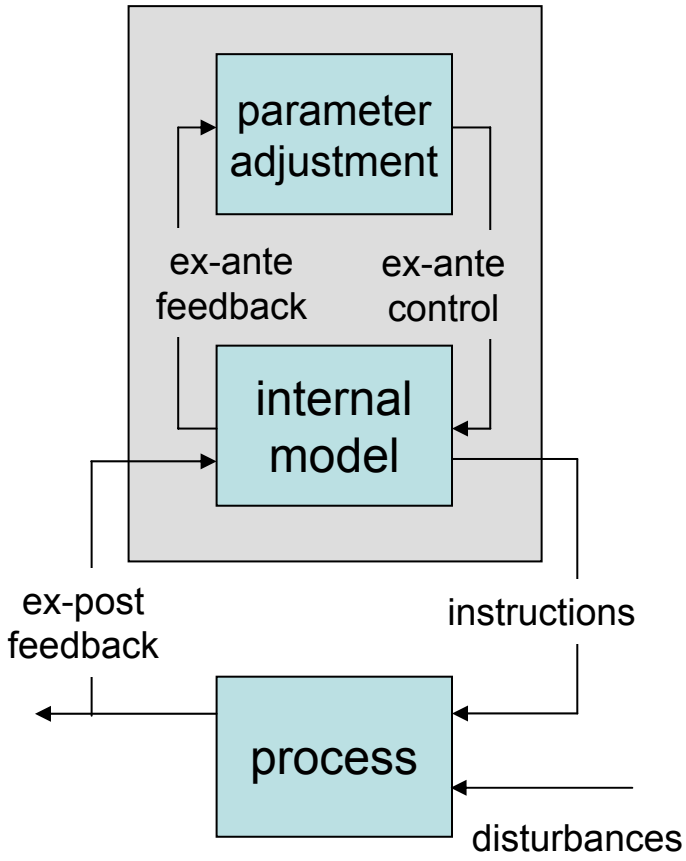
Deficiencies of static rules

- hard coding (constraints) ⇒ infeasibilities
- static penalty (objective function) ⇒ bad performance but prevention of infeasibilities

Reflection of problem severeness variation

- detecting current process performance
- automatic problem image modification
- re-definition of search direction and constraint set



Incorporating Adaptive Model Definition Rules

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Fetch current system performance

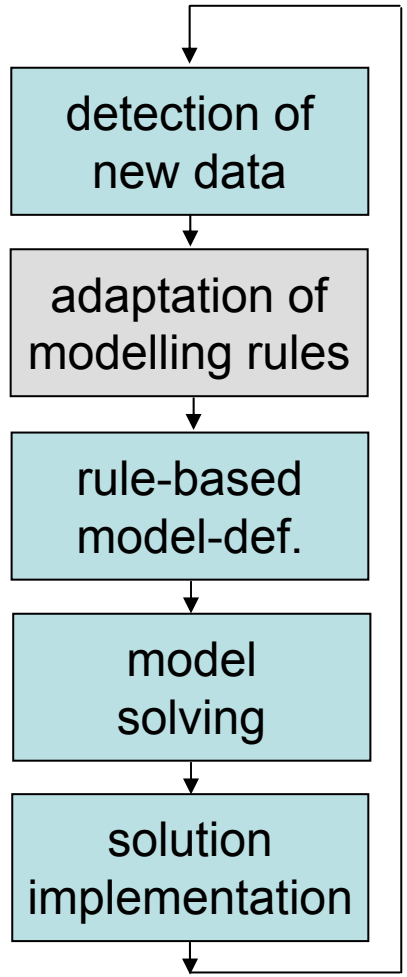
Analyse system performance

Constraint Set ADaptation (CSAD)

- adjust set of available solution proposals
- add or drop constraints
- sharp or relax existing constraints

Search Direction ADaptation (SDAD)

- adjust the evaluation of solution proposals
- manipulate the objective function
- re-weight the components (redefine coefficients)



Constraint Set ADaptation

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Restrict mode selection of new requests

Calculation of current punctuality rate p_t

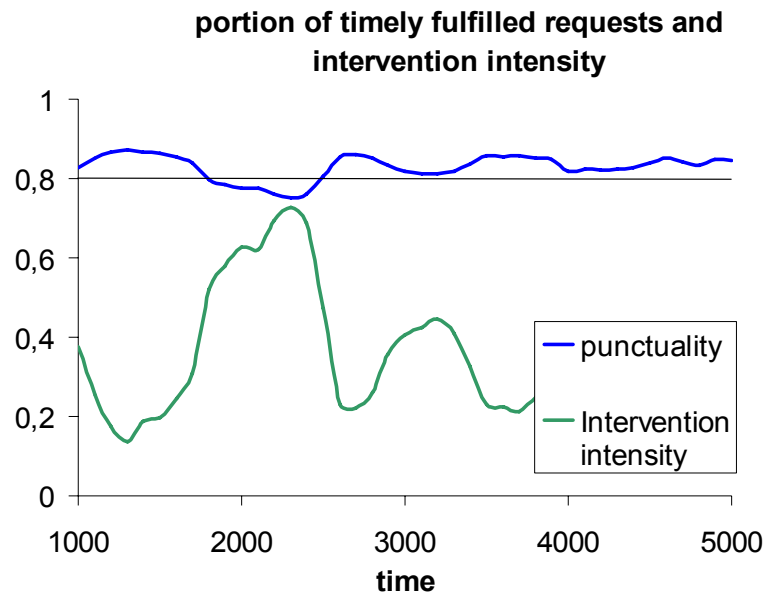
$G(p_t)$ percent of subsequently arriving requests will be subcontracted

Control function $G(p_t)$

- $p_t \leq 0{,}7 \Rightarrow G(p_t)=100\%$ (full intervention)
- $p_t \geq 0{,}9 \Rightarrow G(p_t)=0\%$ (no intervention)
- $0{,}7 < p_t < 0{,}9 \Rightarrow G(p_t)$ decreases from 1 to 0

No subsequent revision possible

$G(p_t)$ re-calculated before every update



Search Direction ADaptation

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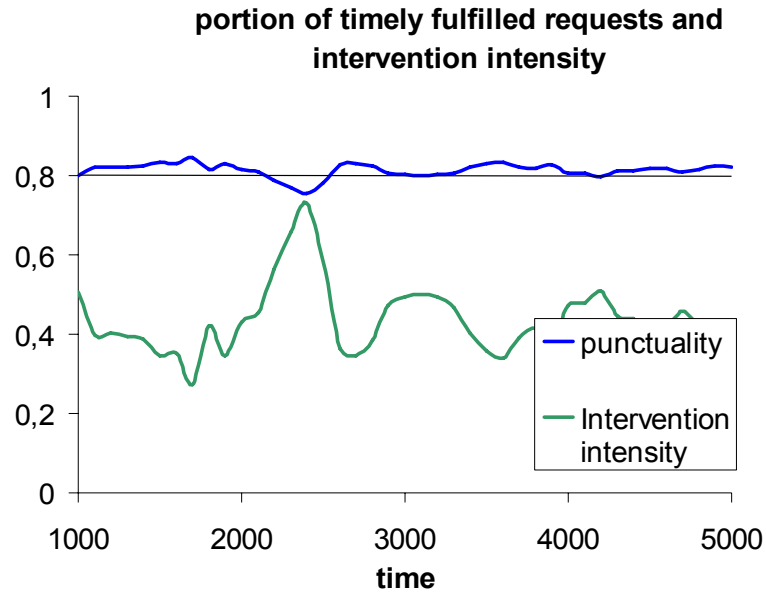
Re-weighting of costs of the two fulfilment modes

$Z = h(t,p_t) \cdot (C^{self} + C^{pen}) + 1 \cdot C^{sub} \rightarrow min$

- $h(0,p_0) = 1$
- $h(t,p_t) = 1 + (C^{sub} / (C^{self} + C^{pen})) \cdot G(p_t),\ t>0$

$h(t,p_t)$ re-calculated prior to solver call



Results – Good News

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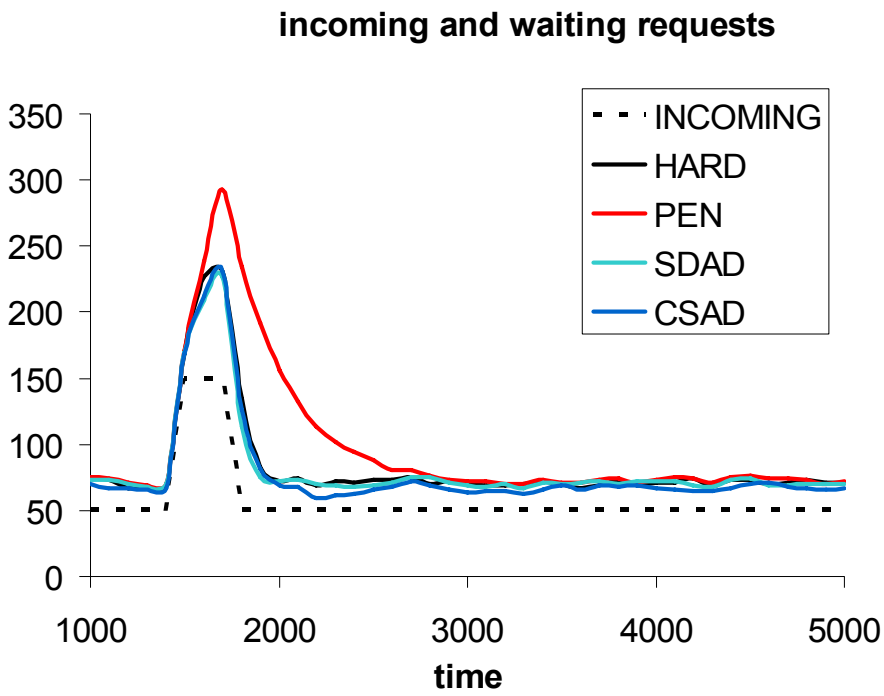

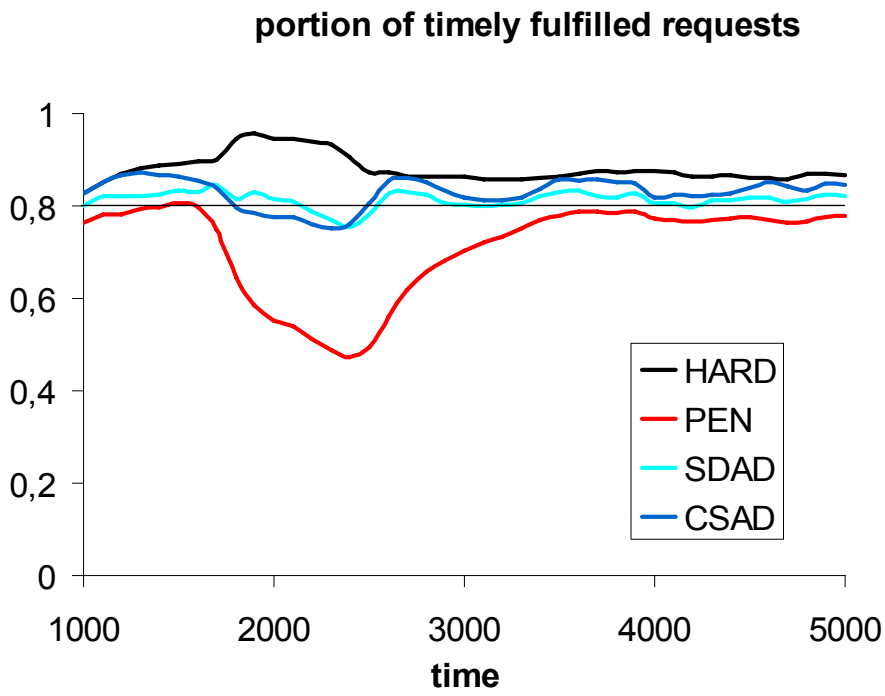

Subcontracting costs of a request: 3-times higher than self-entry costs

Results - Drawbacks

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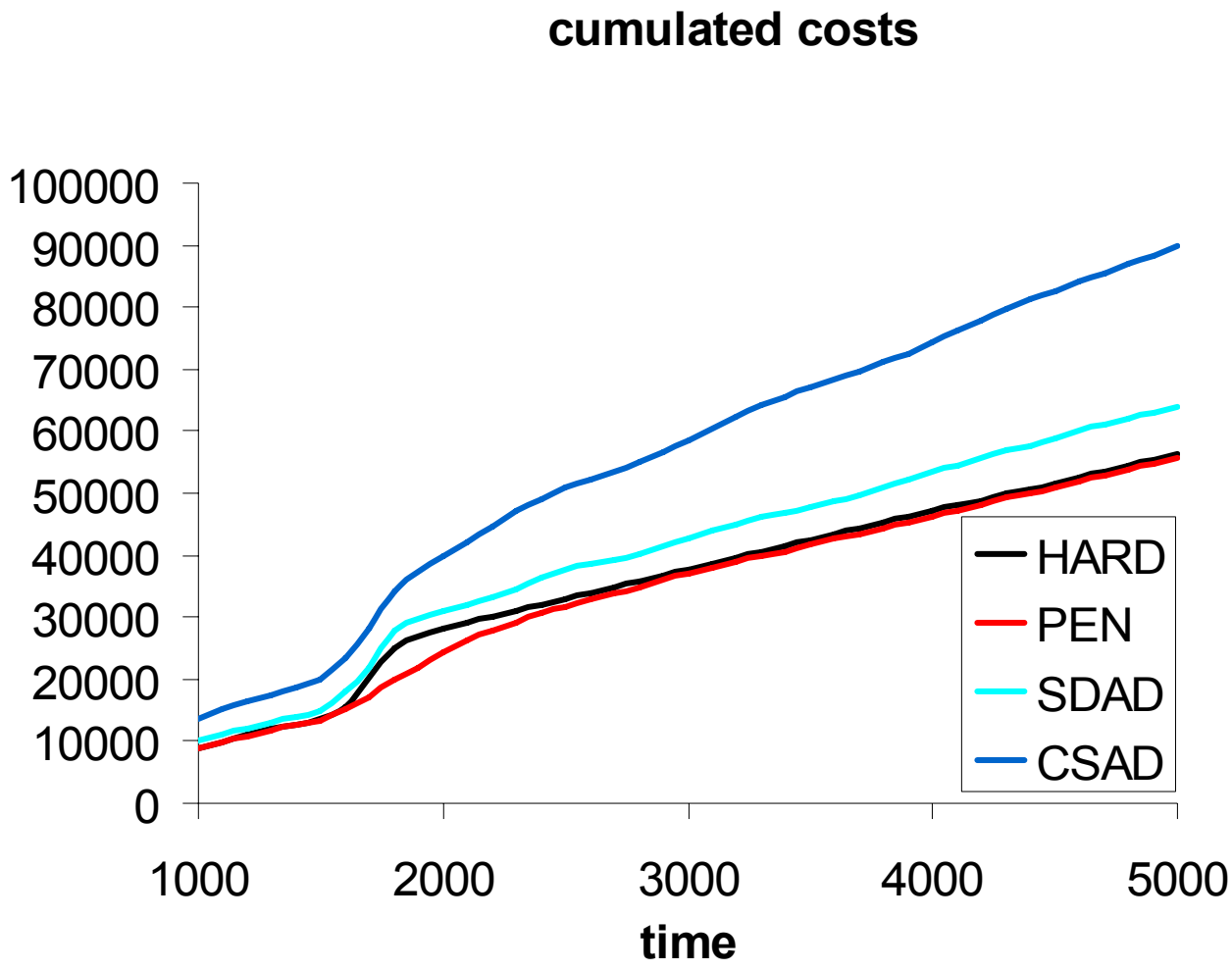

Conclusions and Future Research

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Findings

- adaptive model definition is reasonable
- deviation from strict cost-based decisions: additional costs!
- if constraints are “dangerous”: suitable alternative
- sufficient performance

Open Questions

- impacts of penalty values
- combination of static and adaptive rules
- managerial impacts