A dynamic service mechanic problem for a housing corporation

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Outline

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Introduction

Housing corporation

- Maintenance of houses: known well-ahead
- Emergency incidents: unforeseen

Same mechanics used to serve both types of jobs

Subcontractors also available

Decision: which jobs to serve with own mechanics,
which ones to subcontract

Problem description 1

Service mechanics problem:

Decision to take today, for the entire planning period:

which maintenance activities to assign to own mechanics and which ones to subcontractors

Decision criterion: expected costs of serving all jobs

Problem description 2

Characteristics

- Jobs: maintenance activities and emergency incidents
- Mechanics: handymen and experts
- Subcontractors
- Activities: start and end time, number and type of mech.
- Incidents: arrival and due time, duration, number and type of mechanics
- Costs: only for subcontracting, today less expensive than during planning period, and experts jobs more expensive

Problem description 3

Two versions of problem: with and without overtime

Overtime: only if remaining duration of job at most 4 hours

Moreover: maximum on the number of available overtime hours and cost involved, less expensive than subcontracting

Two-stage recourse model 1

First stage

Only activities explicitly

Probabilistic information on incidents

Decision: for each activity whether or not to subcontract

Subcontracted activities not reconsidered in second stage

Objective: total expected costs (first and second stage)

Two-stage recourse model 2

Second stage

Dynamic problem, incidents arrive one-by-one

Decisions: start time of each incident
assignment of all jobs to mechanics

First decision immediately after arrival, second one as late as possible

Two-stage recourse model 3

Notice:

1st stage: today probabilistic information is assumed
(stochastic programming)

2nd stage: during planning period no knowledge on incidents
(online optimization)

Online strategies

Four online strategies to make second-stage decisions

Two for problem without overtime:

- Simple
- Search

Two for problem with overtime:

- Simple with Overtime
- Search with Overtime

Simple

1. Activities are permanently assigned to own mechanics
2. After arrival of incident:
   - Start time = arrival time
   - Assign incident to mechanics:

     Own mechanics attempted first, otherwise subcontractors

Search 1

Activities tentatively assigned to own mechanics

After arrival of incident, search for start time:

Earliest time when enough own mechanics are available

If successful, incident tentative assigned to own mechanics

If not, at least one job needs to be subcontracted ⟹ assignment heuristic

Tentatively assignments become permanent when job starts

Search 2

Assignment heuristic (greedy)

Consider all tentatively assigned jobs

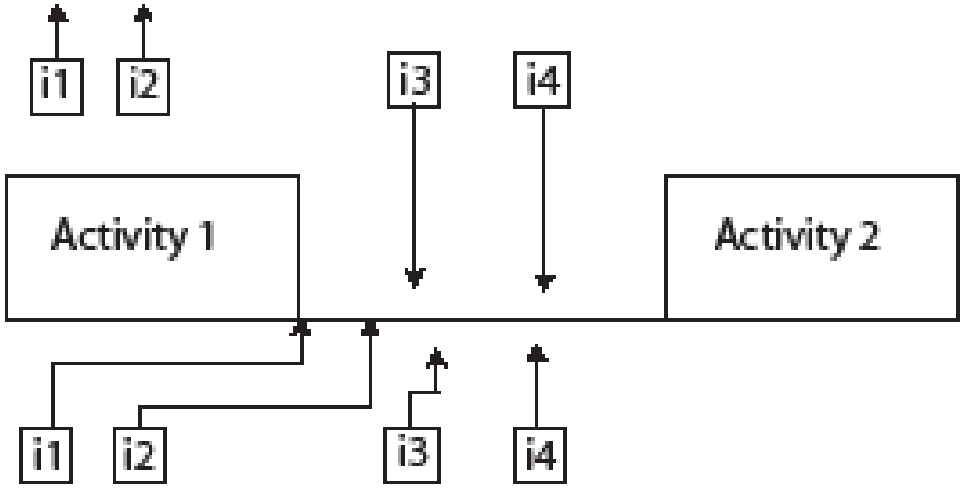
Order: decreasing costs for subcontracting

Assign jobs one-by-one to own mechanics or subcontractors

Subcontracting is permanent decision

Difference Simple - Search

Simple



Search

Simple with Overtime

Same as strategy Simple

But, order of assigning incidents:

- own mechanics regular hours,
- own mechanics overtime hours,
- subcontractors

Search with Overtime

Same as strategy Search

Implementation of overtime as in strategy Simple with Overtime

Genetic Algorithm

To calculate expected costs of a solution,
a sample of realizations of the incidents is drawn

Numerical experiments

Data

- Length planning period: 2 weeks
- 10 activities: duration 1 – 5 days, 2 – 4 mechanics
- 50 incidents (average): duration 1 – 8 hours (85%) or 2 – 3 days (15%), 1 – 2 mechanics
- Sample: 250 realizations
- Each online strategy: 15 instances

CPU time: less than 7 minutes

Results

1

For all strategies:

Compare original model to myopic model

Both solutions evaluated with ‘true’ objective

Online strategy	Increase in estimated costs (in %)
Simple	3 – 22
Search	3 – 28
Simple with Overtime	1 – 15
Search with Overtime	1 – 21.5

Results 2

Simple strategies more expensive than Search strategies

⇒ feasible region Search bigger

Strategies with Overtime less expensive than those without

⇒ overtime less expensive than subcontracting

Summary and conclusion

- ‘New’ problem, two versions: with and without overtime
- Model: dynamic, combination of stochastic programming and online optimization
- Four online strategies

- Our model better than myopic model
- Search strategies give lower estimated costs
- Strategies with overtime less expensive
- CPU time small

Thank you for your attention