DM204 (5 ECTS - 4th Quarter)

Scheduling, Timetabling and Routing

Skedulering, Skemalægning og Ruteplanlægning

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Scheduling

Allocation of scarce resources to tasks over time with the goal of optimizing some objectives

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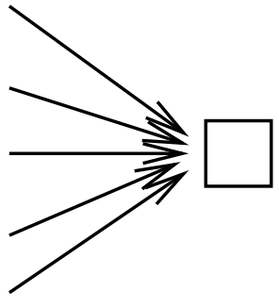
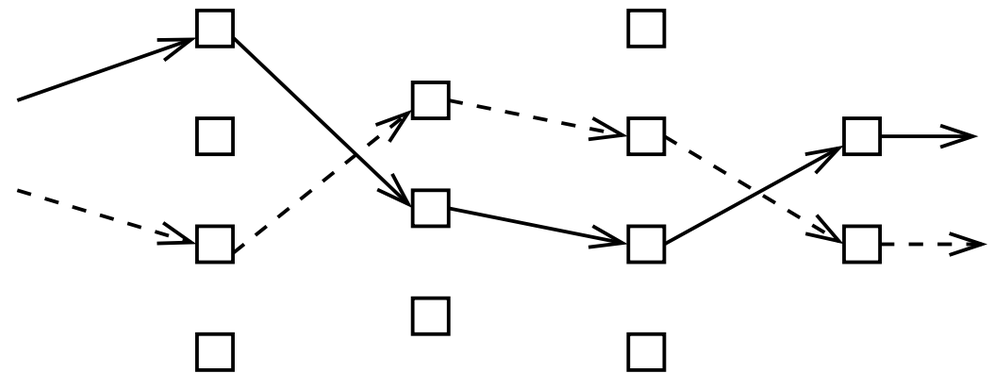
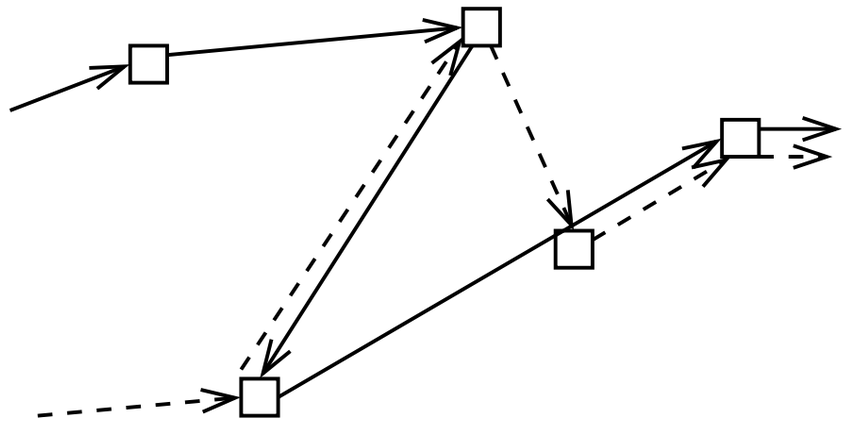
Single machine



Flow shop and
flexible flow shop

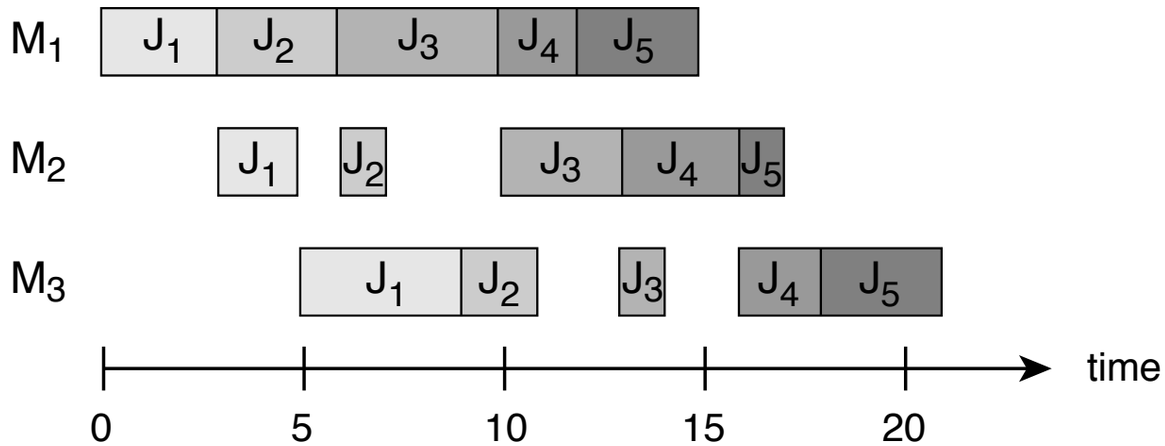


Job shop,
Open shop

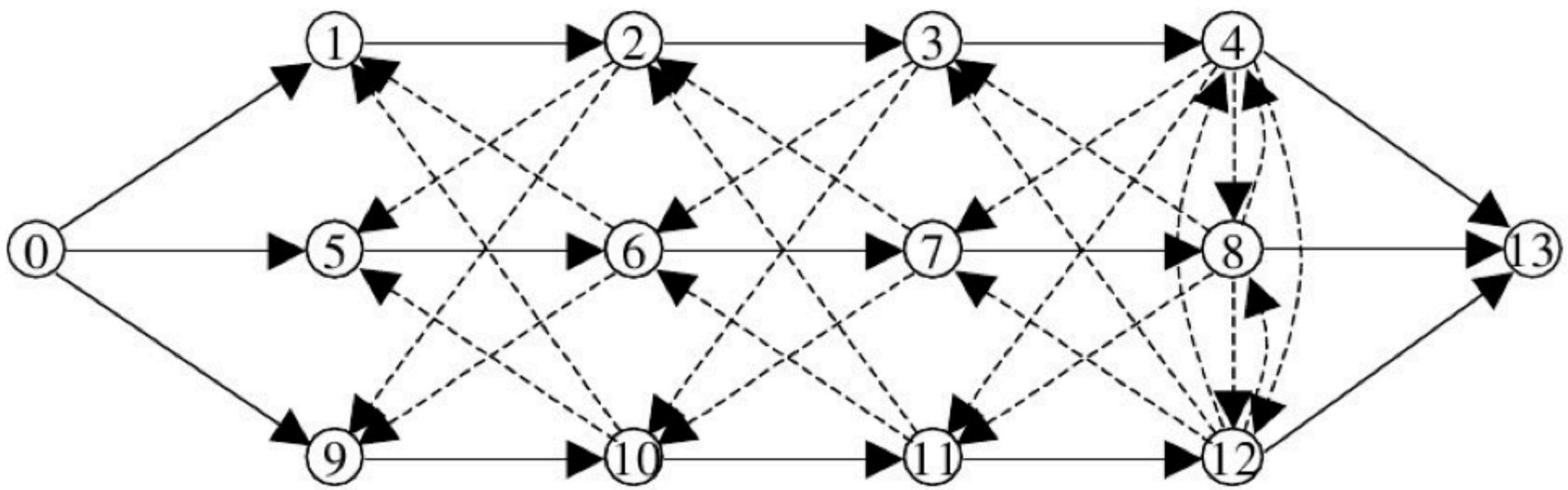


Scheduling

Gantt chart



Graph models



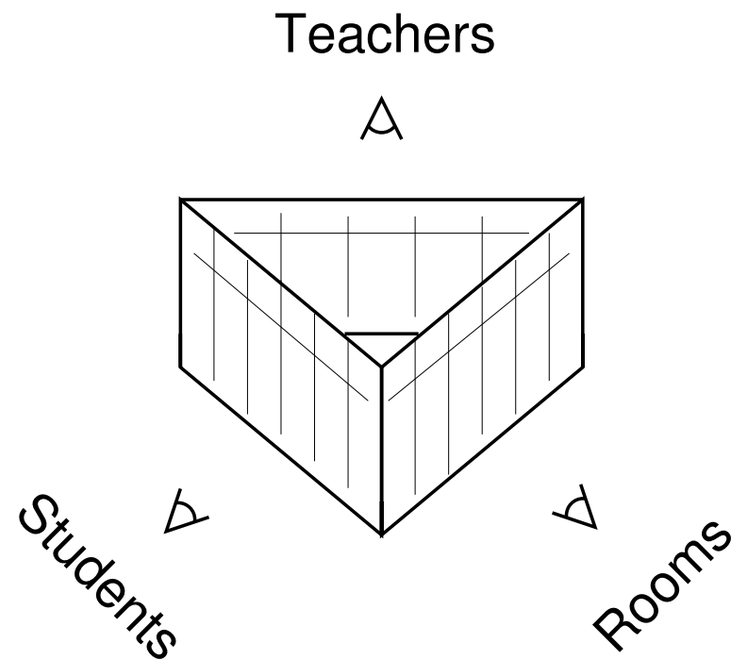
Timetabling

University course timetabling

Elective Courses at IMADA -- First Quarter -- Seminarrum					
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
8:00-10:00	DM818 *(Daniel Merkle)*	DM811 *(Marco Chiarandini)*	DM819 *(Kim Skak Larsen)*		
10:00-12:00	DM207 *(Rolf Fagerberg)*	DM819 *(Kim Skak Larsen)*	DM811 *(Marco Chiarandini)*	DM207 *(Rolf Fagerberg)*	
12:00-14:00	MM802 *(Niels Jørgen Nielsen)*		MM802 *(Niels Jørgen Nielsen)*		
14:00-16:00		COLLOQUIUM		COLLOQUIUM	MM804 *(Martin Svensson)*
16:00-18:00	MM804 *(Martin Svensson)*		MM804 *(Martin Svensson)*	DM818 *(Daniel Merkle)*	

Timetabling

University course timetabling



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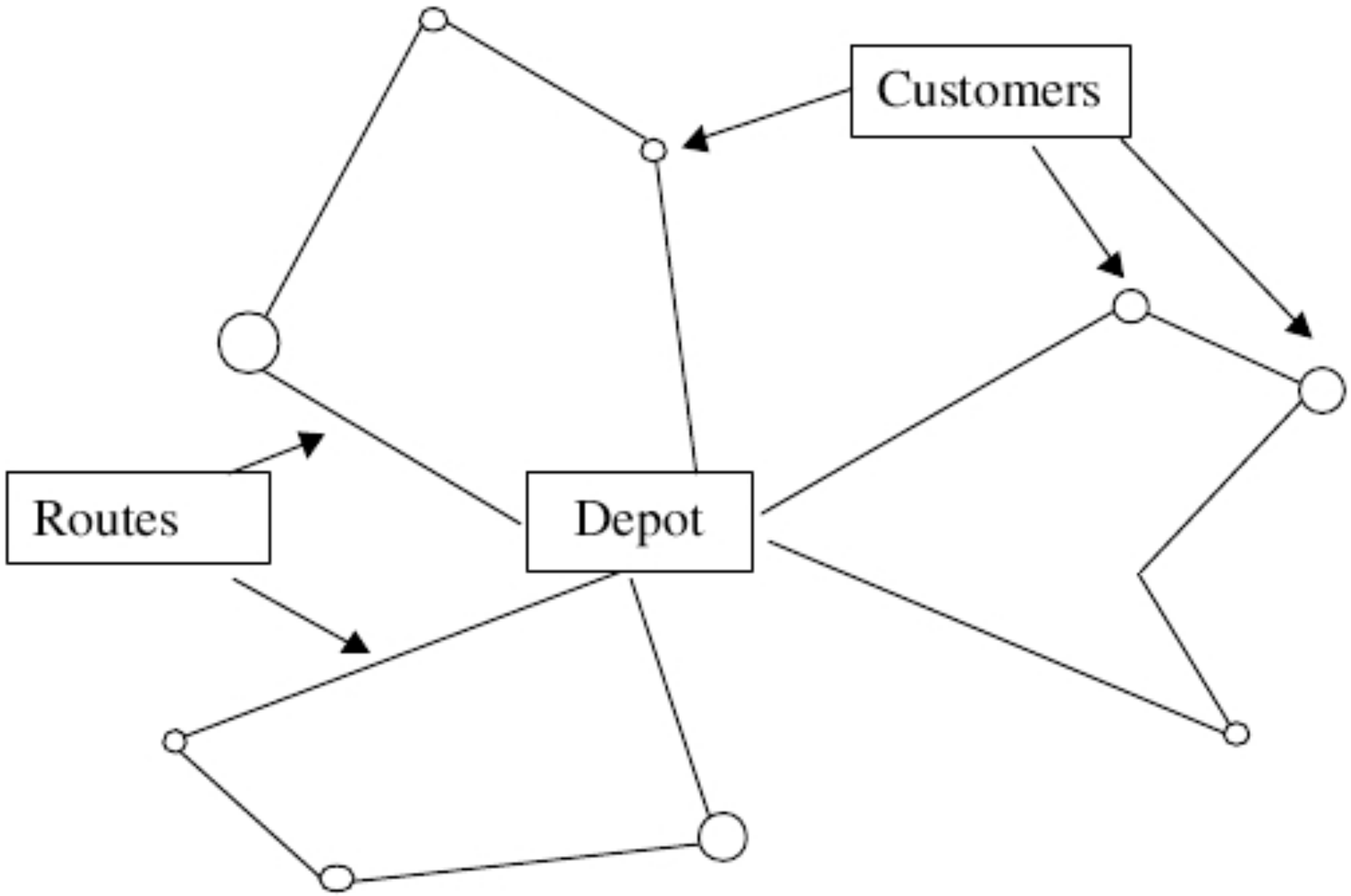
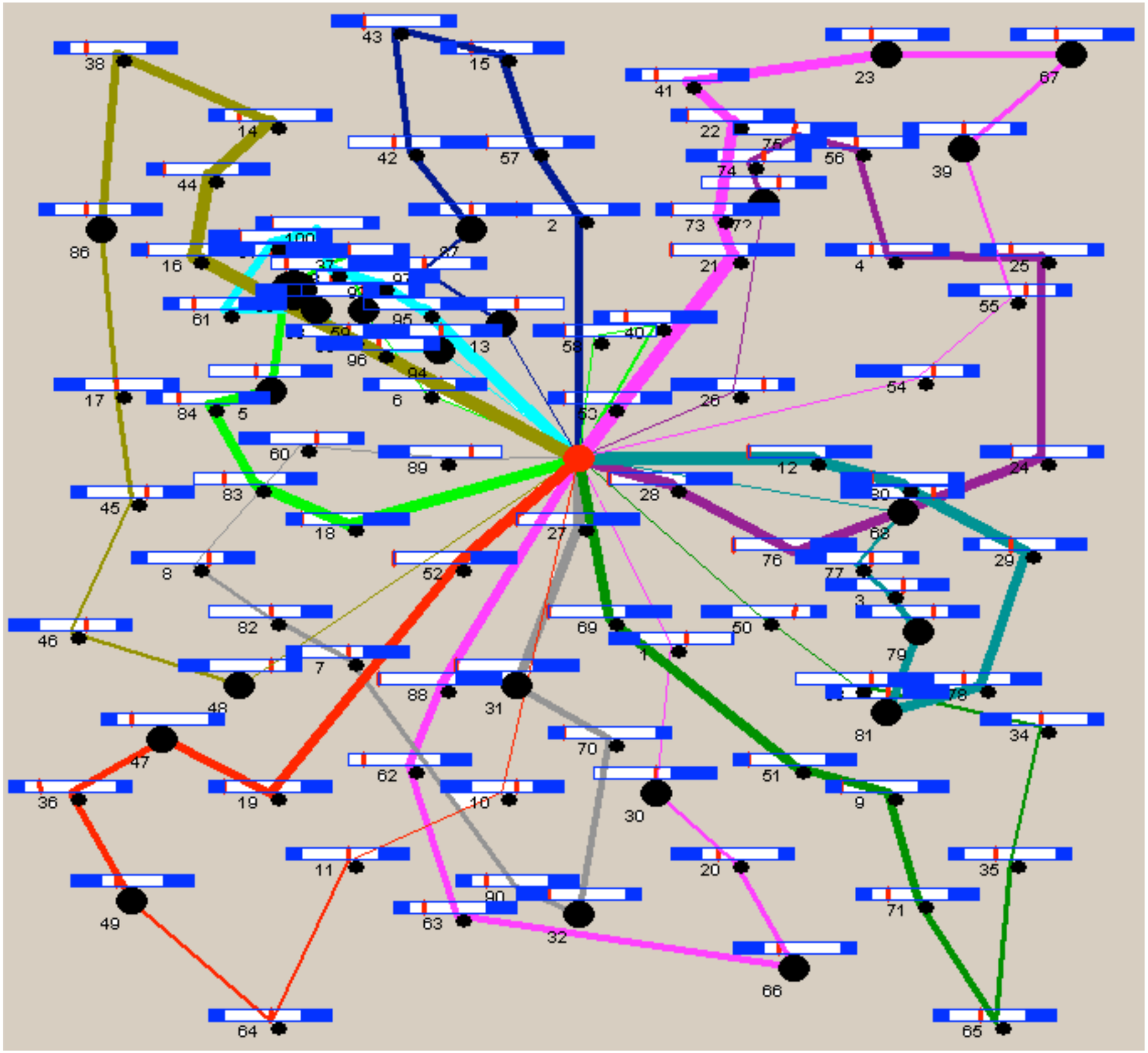
Vehicle Routing



Vehicle Routing



Methodology

- Graph Models and Algorithms
- Mathematical Programming
- Constraint Programming
- Heuristics

Mixed Integer Programming for Routing

$$\min \sum_{k\in\mathcal{V}} \sum_{i\in\mathcal{N}} \sum_{j\in\mathcal{N}} c_{ij} x_{ijk} \;\; s.t., \tag{3.1}$$

$$\sum_{k\in\mathcal{V}} \sum_{j\in\mathcal{N}} x_{ijk} = 1 \quad \forall i \in C, \tag{3.2}$$

$$\sum_{i\in C} d_i \sum_{j\in\mathcal{N}} x_{ijk} \leq q \quad \forall k \in \mathcal{V}, \tag{3.3}$$

$$\sum_{j\in\mathcal{N}} x_{0jk} = 1 \quad \forall k \in \mathcal{V}, \tag{3.4}$$

$$\sum_{i\in\mathcal{N}} x_{ihk} - \sum_{j\in\mathcal{N}} x_{hjk} = 0 \quad \forall h \in C, \; \forall k \in \mathcal{V}, \tag{3.5}$$

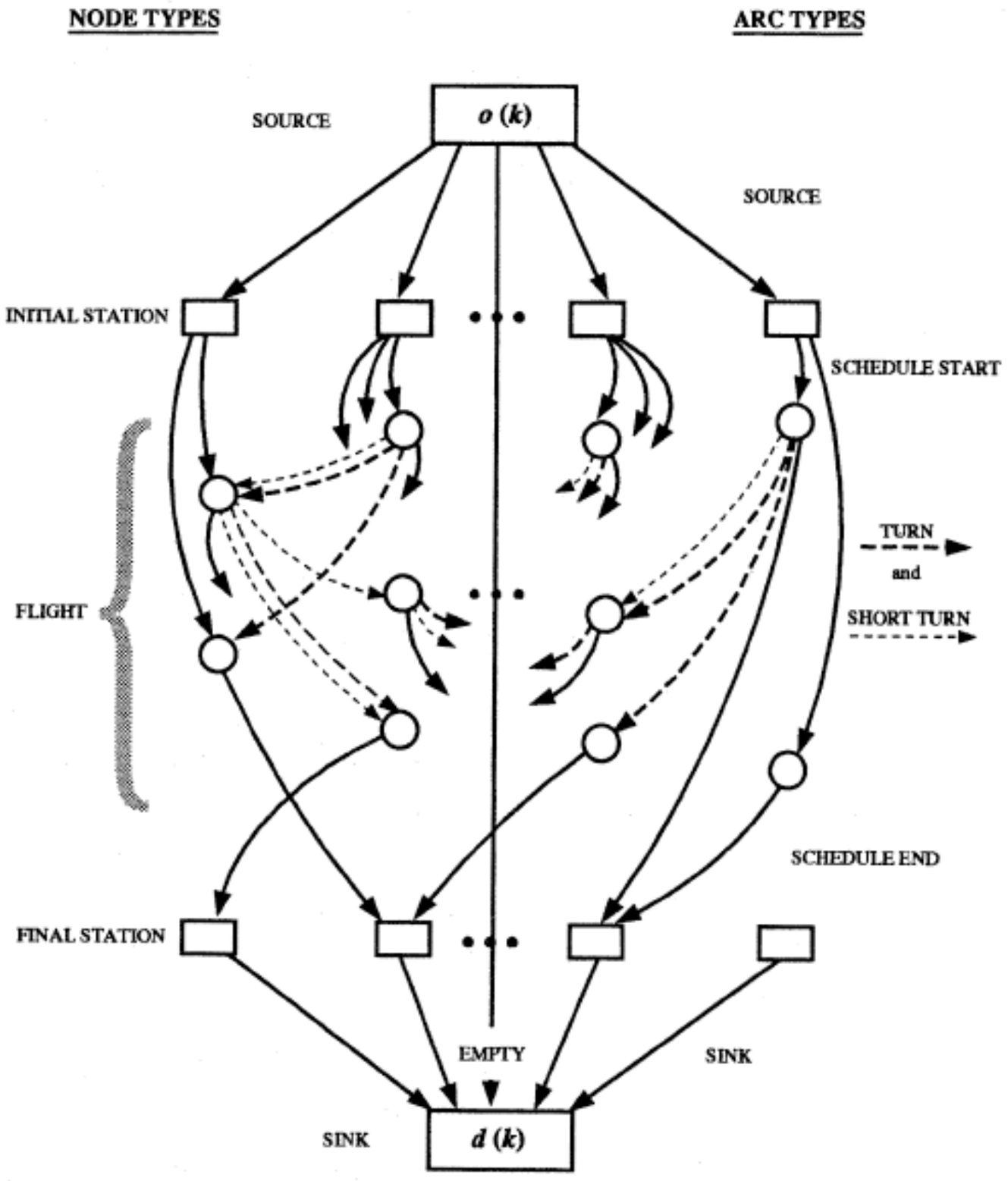
$$\sum_{i\in\mathcal{N}} x_{i,n+1,k} = 1 \quad \forall k \in \mathcal{V}, \tag{3.6}$$

$$x_{ijk}(s_{ik} + t_{ij} - s_{jk}) \leq 0 \quad \forall i, j \in \mathcal{N}, \; \forall k \in \mathcal{V}, \tag{3.7}$$

$$a_i \leq s_{ik} \leq b_i \quad \forall i \in \mathcal{N}, \; \forall k \in \mathcal{V}, \tag{3.8}$$

$$x_{ijk} \in \{0, 1\} \quad \forall i, \; j \in \mathcal{N}, \; \forall k \in \mathcal{V}. \tag{3.9}$$

Graph Algorithms



Constraint Programming for Scheduling

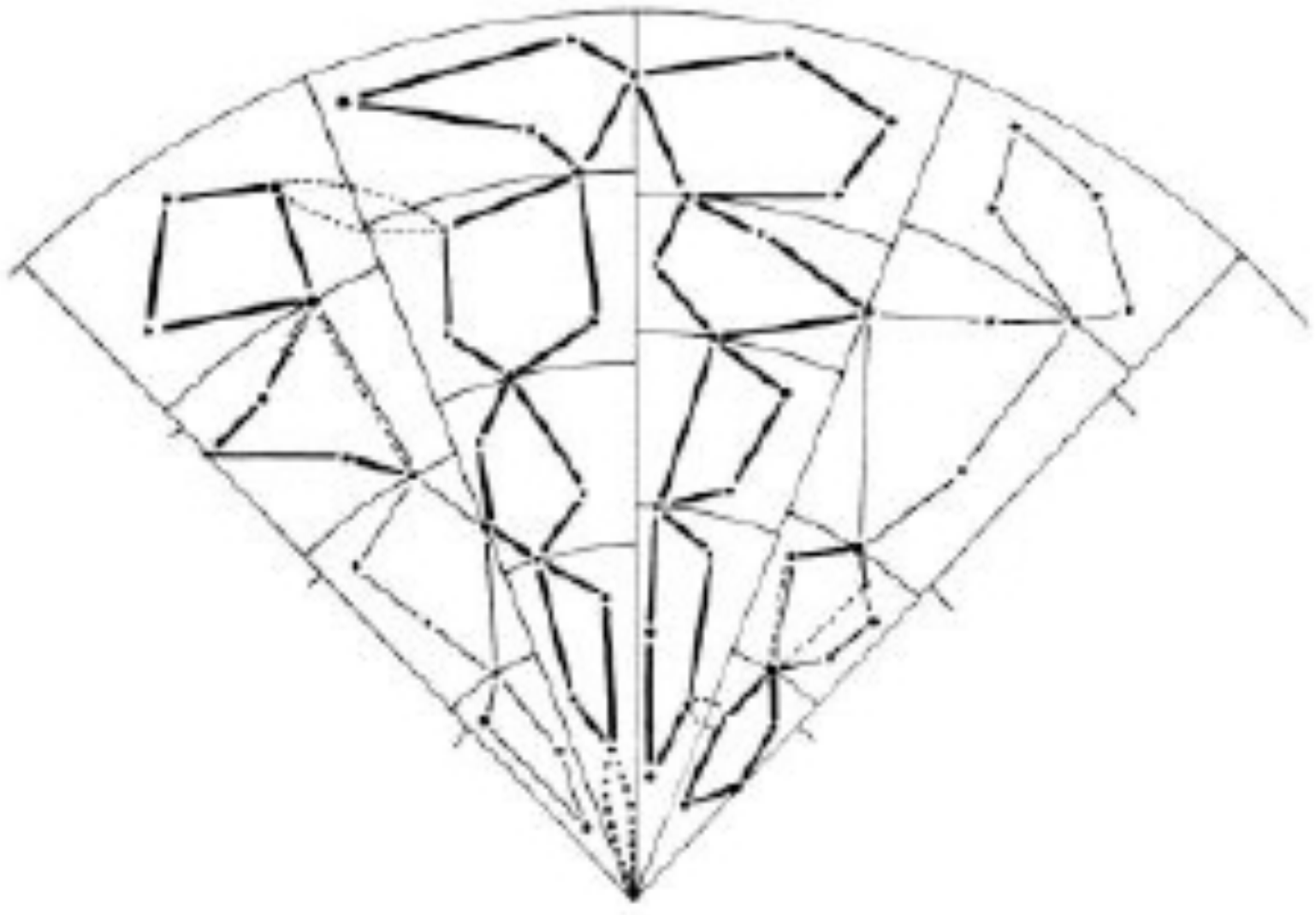
```
range Cars = 1..100;
range Configs = 1..18;
range Options = 1..5;
int lb[Options] = [1,2,1,2,1];
int ub[Options] = [2,3,3,5,5];
int demand[Configs] = [5,3,7,1,10,2,11,5,4,6,12,1,1,5,9,5,12,1];
int requires[Configs,Options] = [[1,1,0,0,1],[1,1,0,1,0],...,[0,0,1,0,0]];
set{int} options[o in Options] = filter(c in Configs)(requires[c,o]==1);

import cotfd;
Solver<CP> cp();
var<CP>{int} line[Cars](cp,Configs);
solve<cp> {
  forall(o in Options)
    cp.post(sequence(line,demand,lb[o],ub[o],options[o]));
} using {
  labelFF(line);
}
cout << "#choices = " << cp.getNChoice() << endl;
cout << "#fail   = " << cp.getNFail() << endl;
```

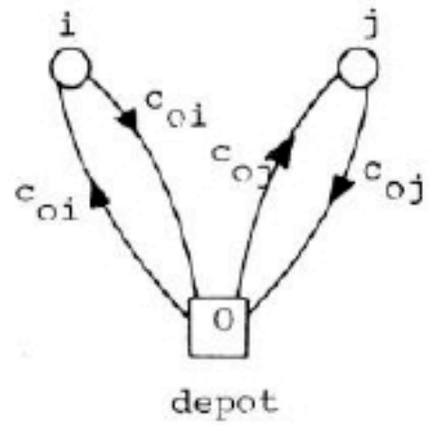
Statement 11.4: COMET model for the car sequencing problem (implemented in `carsequencing-cp.co`)

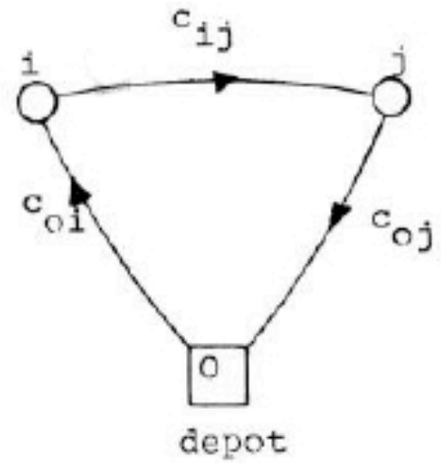
Heuristics for Routing

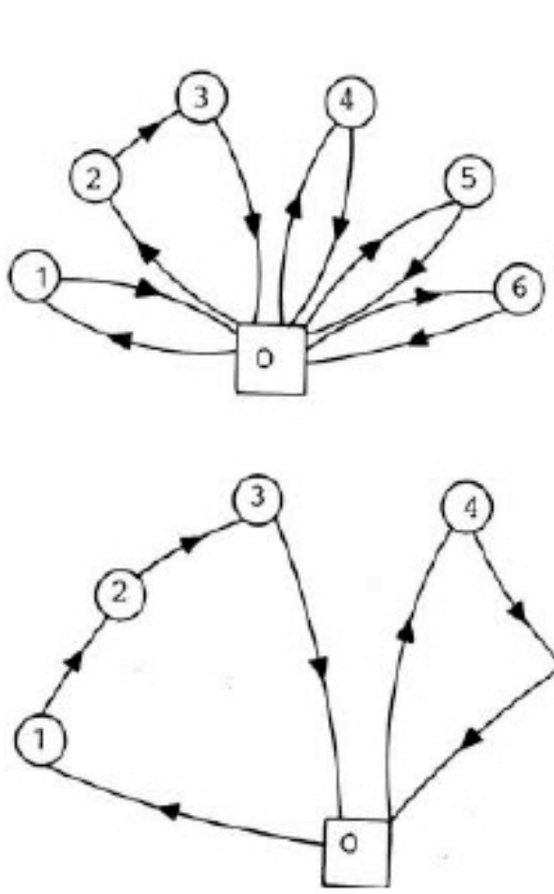
Sweeping heuristic

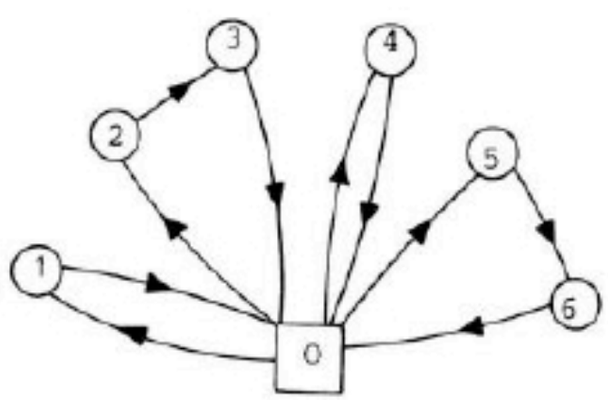


Heuristics for Routing









(Fiala 1978)

Aims of the course

You will learn to:

- recognize abstract models from real-life applications
- assess which solution method is most appropriate
- implement the solution methods
- analyze empirically the results produced
- describe with appropriate language

Prerequisites

- A bachelor in CS, Math or Mat-Øk (possibly)
- DM515: Introduction to Linear and Integer Programming (would be nice having)
- DM826: Modelling and Solving Constrained Problems (content should be known)

Course Work Load

- 14 lectures, 4 exercise sessions

Final Assessment (10 ECTS)

- Oral exam with external examiner.
  Duration: 30 min.
  Grade in 7 mark scale.

Course Material

- Text books
  - Pinedo, M. *Planning and Scheduling in Manufacturing and Services* Springer Verlag, 2005
  - Pinedo, M. *Scheduling: Theory, Algorithms, and Systems* Springer New York, 2008
  - Toth, P. & Vigo, D. (ed.) *The Vehicle Routing Problem* SIAM Monographs on Discrete Mathematics and Applications, 2002
- Literature (articles, photocopies)
- Slides
- Source code and data sets
- www.imada.sdu.dk/~marco/DM204