Intelligent Decision Support in Scheduling and Optimization

Dr Rong Qu

Automated **S**cheduling, Optimization **A**nd **P**lanning **Group**
School of Computer Science
The University of Nottingham

rxq@cs.nott.ac.uk
http://www.cs.nott.ac.uk/~rxq

ASAP Group, The University of Nottingham

Research Interests

- Intelligent Decision Support methodologies for real world Scheduling and Optimization
  - Nurse rostering, Educational timetabling
  - Multicast communication network routing
  - Portfolio optimization, Capital budgeting
  - 3D bin packing

- GCM at 3T
  - Case based reasoning
  - Data mining?

Nurse Rostering Problems

▸ Schedule a number of shifts to nurses in rosters, satisfying a set of constraints / requirements
  ◦ Hard constraint
    • enough number of shifts (of different types) coverage on each day during the scheduling period
  ◦ Side constraints
    • working/resting hours limit, complete weekends, skill levels, personal preferences, etc
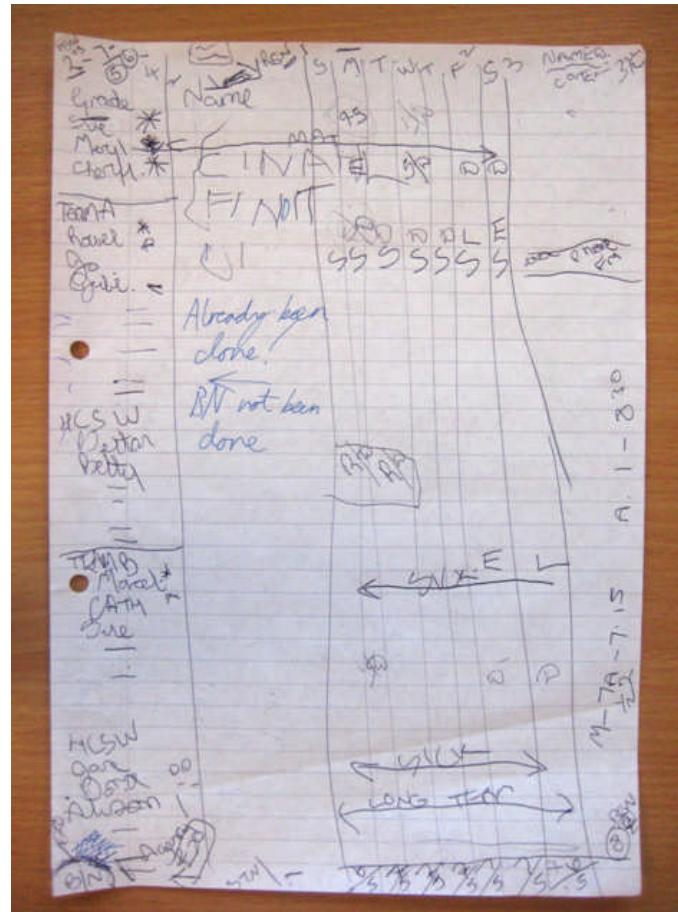
Nurse Rostering Problems

▸ Automated nurse rostering

- ◦ Can ensure legal requirements are not broken
- ◦ Lower costs e.g. hire less agency nurses to fill gaps in rosters
- ◦ Distribute rosters via email and web
- ◦ Generate management reports and statistics, connect to payroll systems, less paperwork, etc

Nurse Rostering Problems

Nurse Rostering Problems

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Total Penalty 176
Unassigned Shifts 0

Minimum Cover

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Nurse Rostering web site at http://www.asap.cs.nott.ac.uk/projects/nmhpr/data

Nurse Rostering Problems

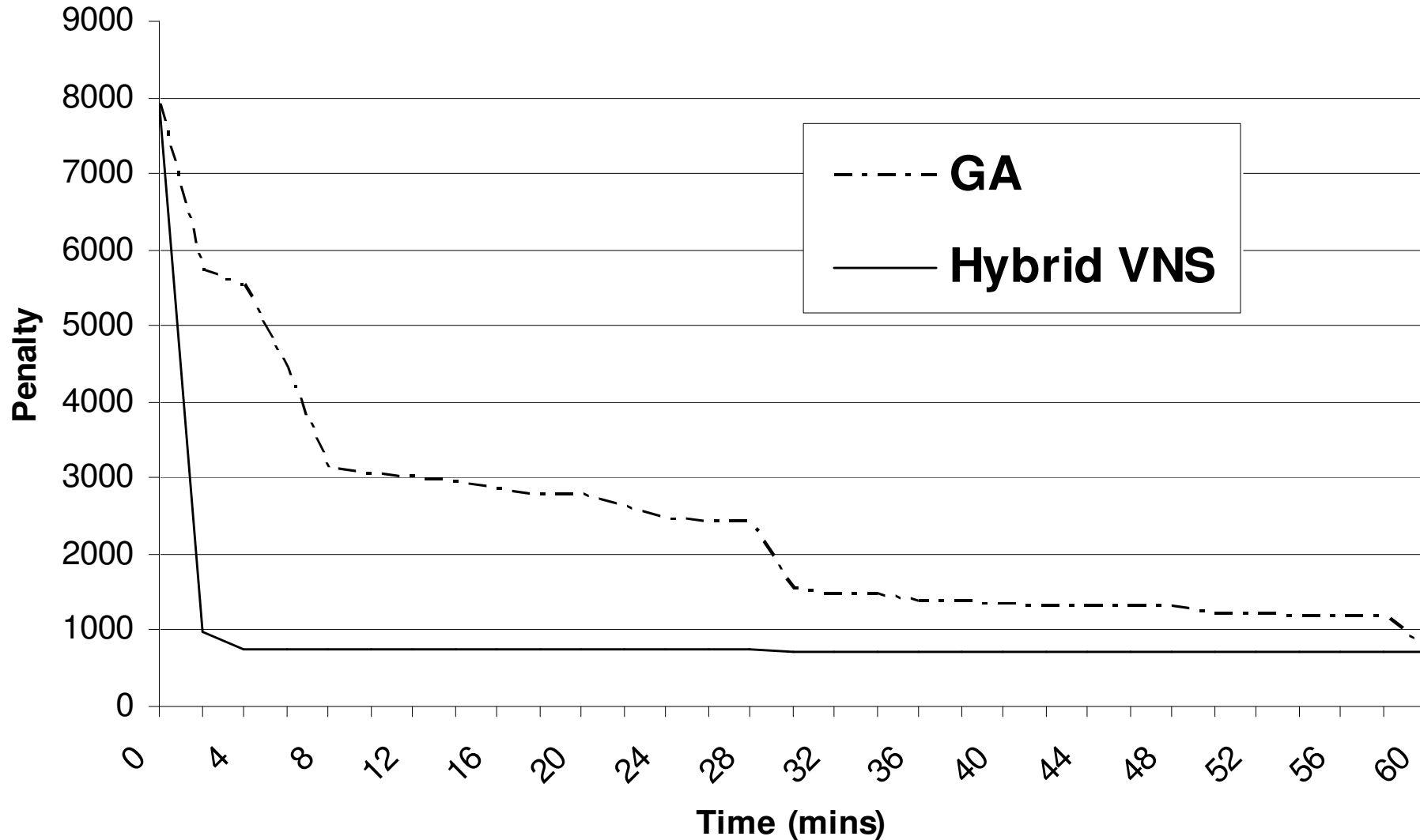Nurse Rostering web site at http://www.asap.cs.nott.ac.uk/projects/nmhpr/data

Nurse Rostering Problems

- HARMONY™
  - Automated workforce management software
  - Developed by ORTEC, The Netherlands, an international consultancy company on planning, scheduling, optimisation and decision support

- This work improved the algorithm in HARMONY™

Nurse Rostering Problems

Timetabling Problems

- Assigning a set of events (exams, courses, meetings) into limited timeslots satisfying a set of constraints
  - Students cannot sit two events at the same time
  - Students would like to have enough revision time between events
  - Lectures prefer to have large events scheduled earlier
  - …

- Important activities in all universities

Timetabling Problems

- Advanced search algorithms
  - Intelligent AI algorithms provide good solutions quickly
  - Genetic algorithms, Tabu search, etc

- Knowledge based systems
  - Intelligent decision support based on past experience
  - Case based reasoning, knowledge discovery

Timetabling Problems

Multicast Routing

▶ Multicast routing in telecommunications
- ◦ a communication service that simultaneously transfers information from a source to a group of destinations in communication networks
- ◦ distance learning, E-commerce and video/audio conferencing, etc, multimedia telecommunications
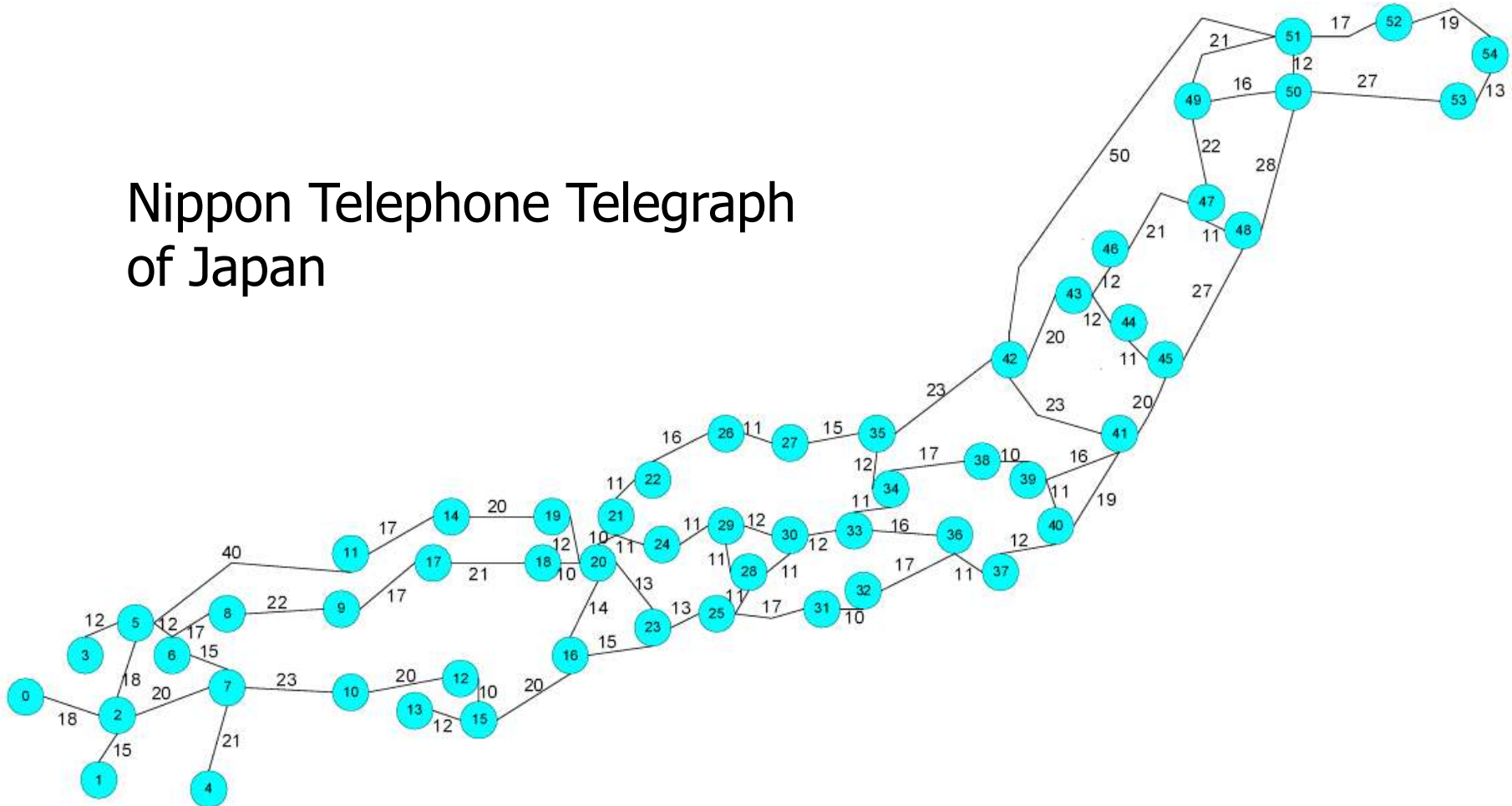
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Multicast Routing

▸ QoS Multicast routing
- ◦ Quality of Service (QoS) parameters (constraints and objectives)
- ◦ bounded end-to-end delay, messages must be transmitted from the source to destinations within a certain amount of time
- ◦ minimizing the cost of transfer via the multicast tree
- ◦ …

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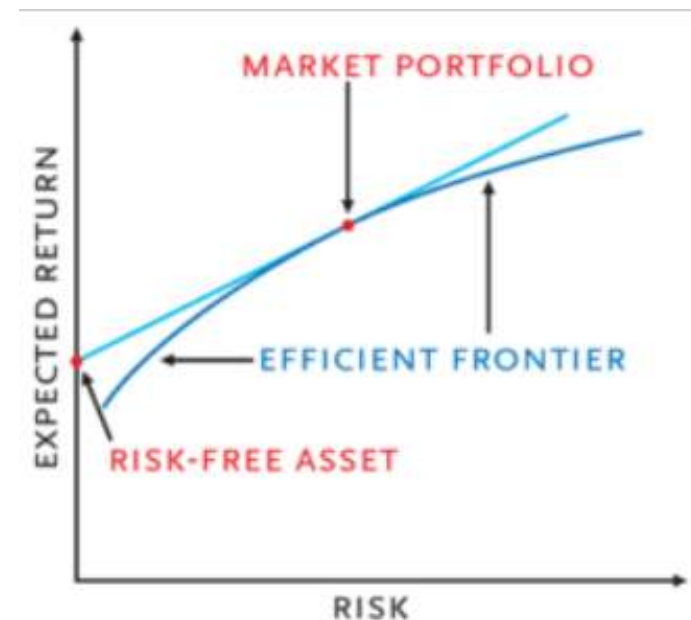& planning

Multicast Routing

Nippon Telephone Telegraph
of Japan

Financial Optimizations

- Portfolio optimization
  - Decision making on financial investment
  - To maximize the expected return and minimize the risk by carefully choosing different assets
  - Additional constraints
    - Cardinality
    - Transaction costs
    - Multiple objectives
    - ...

Financial Optimizations

- Capital budgeting
  - Corporate long term investments of different initial costs and different NPV
  - To maximize the expected NPV
  - Constraints / objectives
    - Annual budget
    - Interdependent investments
    - Multiple objectives
    - Uncertainties
    - ...

3T Analytical Tool in GCM

- **The Problem**
  - The existing large amount of data in GCM
  - Provide shipments, routes and costs
  - Plan freight to assess savings potential

- **Issues**
  - To set up the raw shipment data: 4-5 days
  - No exact match of the current operations to the existing ones
 - Spreadsheet simulations: 2-3 days
  - …

Analytical Tool in GCM at 3T

- ▸ **Data mining**
  - ▸ Knowledge acquisition of rules, patterns, etc
  - ▸ Transform data into useful information
  - ▸ Challenging tasks for complex and ill-structured applications

- ▸ **Case Based Reasoning**
  - ▸ Knowledge based systems
  - ▸ Learn to provide solutions to the new problem by adapting old solutions for similar problems
  - ▸ Using past knowledge/experience to solve similar problems

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Case Based Reasoning

- Excellent tool of problem solving based on experience / knowledge
  - Law legal court cases, help desk, configuration, etc.
  - Assumption: similar problems, similar solutions
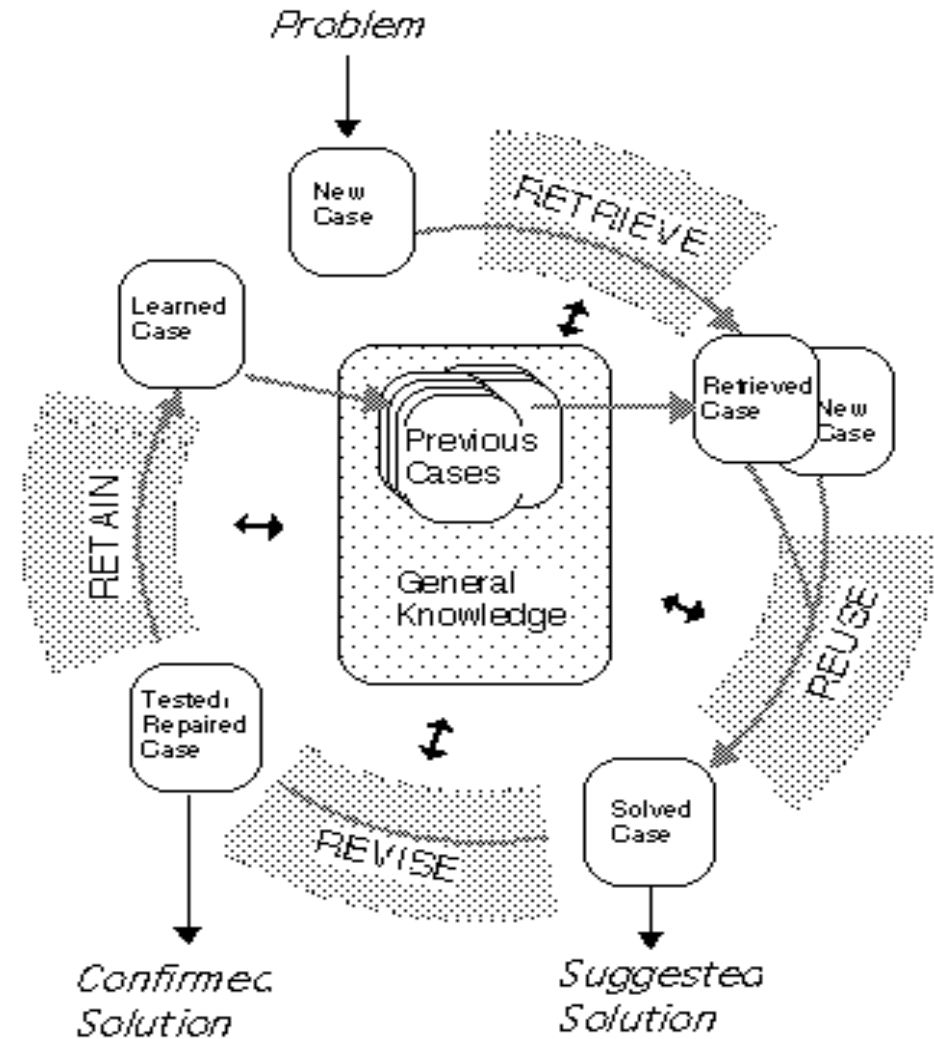
Case Based Reasoning

▸ In a CBR system
- Cases: the problem description and solutions
- Case base: a collection of previously solved representative problems
- Similarity measure: calculates how **similar** two cases are
- Retrieval: finds from the case base the most similar case
- Adaptation: utilises the retrieved solution for the new problem

Case Based Reasoning

- Model/extract/record the knowledge of problem solving without necessarily extracting specific rules / exact patterns
- Unlike in expert systems, no need to have exact matches in the database!
- More than one alternative solutions (or at least the closest solution) to support decision making
- System evolves to learn new experiences (cases) through its life cycle
- Interactive with users

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