



The University of
Nottingham

asap
automated
scheduling
optimisation
& planning
research

Intelligent Decision Support in Scheduling and Optimization

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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



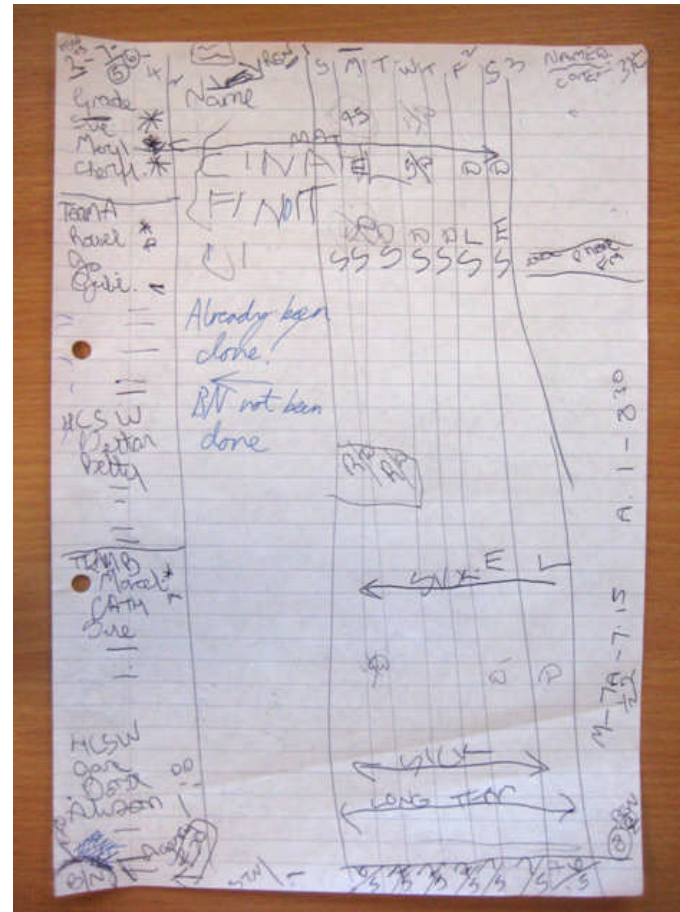
Nurse Rostering Problems

▶ 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

December	1						2						3						4										
	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		28	29	30	31
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	
1A	D	E	E	E	L			E	E	E	E		D	D	D	N	N	N				L	L	L	L				51
A	DH	DH	DH	DH	DH			DH	DH	DH		DH	DH	DH	DH		DH	DH				DH	DH	DH	DH	DH	DH		20
B	N	N	N	N				D	D	L	L	L				L	L	L				E	E	E	D	D			0
C	D	D	D	D	D				N	N	N		L	L	L				L	L	L		E	E	E	L			25
D				L	N	N	N	N			DH	D				E	E	E	DH	E	E		N	N			E	E	13
E					D	DH	DH	D					E	E		DH	E	E	E	DH	DH		D	D	E	E	DH	DH	21
F	L	L	L			L	L	L	L			N	N	N	N			D	D			D				D	D	D	10
G				E	E	E	E			D	D	D			E	E			D	D	D	D			N	N	N	N	10
H	E	E	E			D	D		E	E	E	E			D	D	D		N	N	N	N					L	L	26

Total Penalty 176
 Unassigned Shifts 0

Minimum Cover

E	1	2	2	2	1	1	1	1	2	2	2	1	1	1	1	2	2	2	1	1	1	1	2	2	2	1	1	1
D	2	1	1	1	2	1	1	2	1	1	1	2	1	1	2	1	1	1	2	1	1	2	1	1	1	2	1	1
DH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

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



Nurse Rostering Problems

	1					2					3					4																
December	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S				
1A	D	E	E	E	L			E	E	E	E		D	D	D	N	N	N					L	L	L	L				51		
A	DH	DH	DH	DH	DH			DH	DH	DH		DH	DH	DH	DH			DH	DH					DH	DH	DH	DH	DH				20
B	N	N	N	N				D	D	L	L	L				L	L	L					E	E	E	D	D				0	
C	D	D	D	D	D			N	N	N		L	L	L				L	L	L				E	E	E	L				25	
D				L	N	N	N	N				DH	D			E	E	E	DH	E	E		N	N			E	E	13			
E					D	DH	DH	D				E	E			DH	E	E	E	DH	DH		D	D	E	E	DH	DH	21			
F	L	L	L			L	L	L	L			N	N	N	N				D	D							D	D	D	10		
G				E	E	E	E			D	D	D		E	E				D	D	D	D			N	N	N	N	10			
H	E	E	E			D	D			E	E	E	E		D	D	D			N	N	N	N			L	L	26				

Too few resting time (10)

Too few consecutive late shifts (5)

Too few consecutive night shifts (5)

Total Penalty 176
Unassigned Shifts 0

Minimum Cover

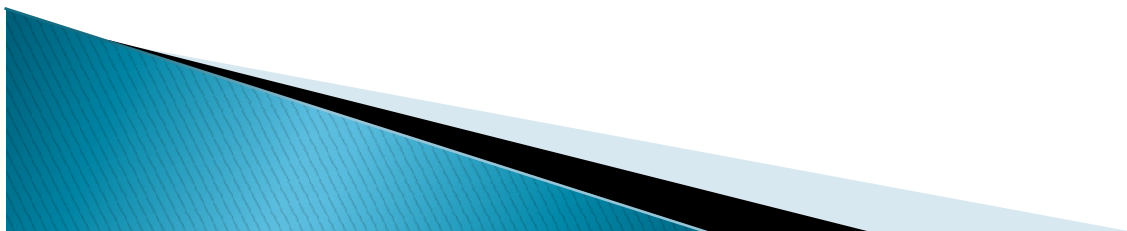
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DH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

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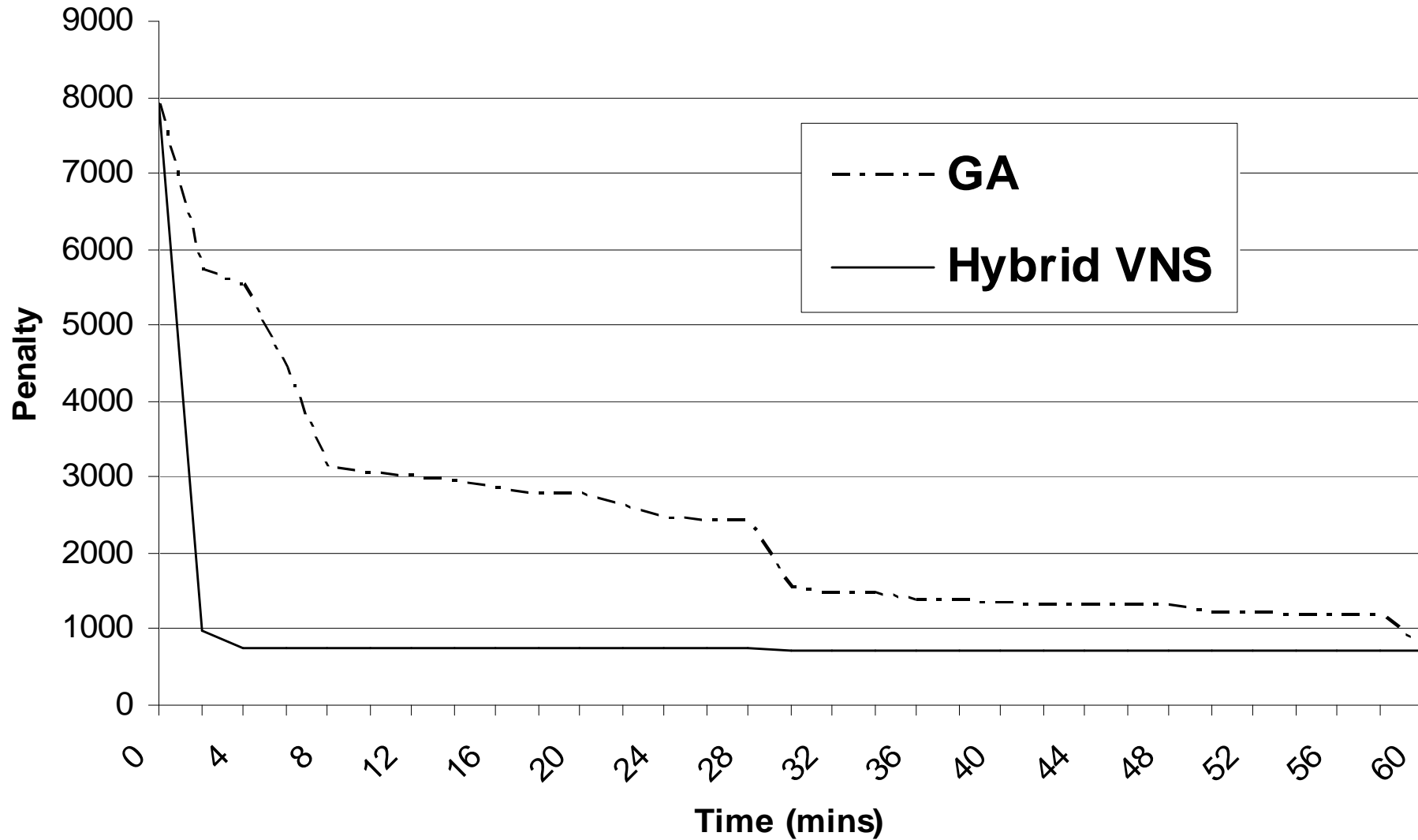
Nurse Rostering Problems

- ▶ 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



PATAT 2010

8th International Conference on the Practice and Theory of Automated Timetabling
Queen's University Belfast, Northern Ireland, 10th - 13th August 2010



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



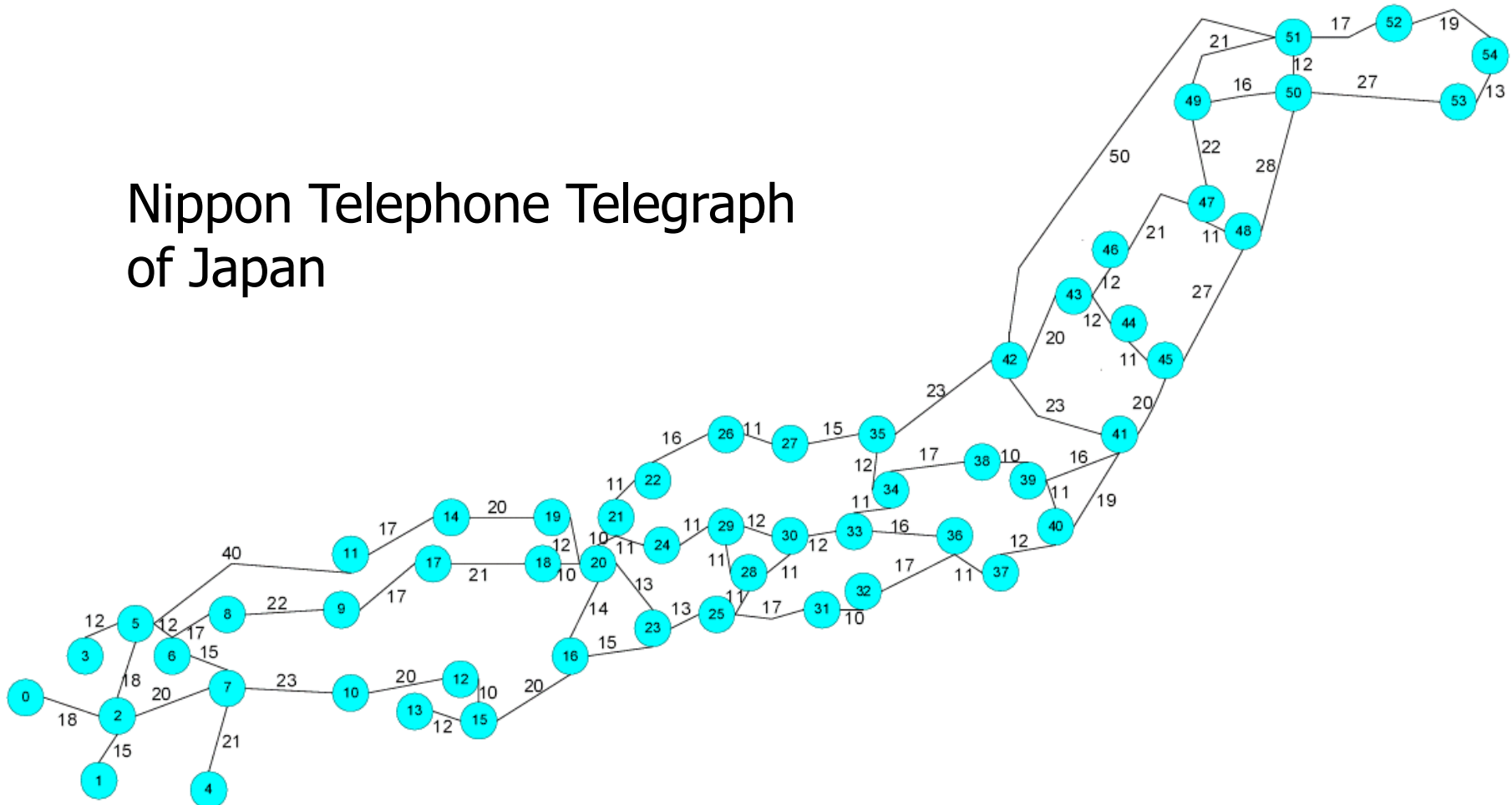
Multicast Routing

- ▶ 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
 - ...



Multicast Routing

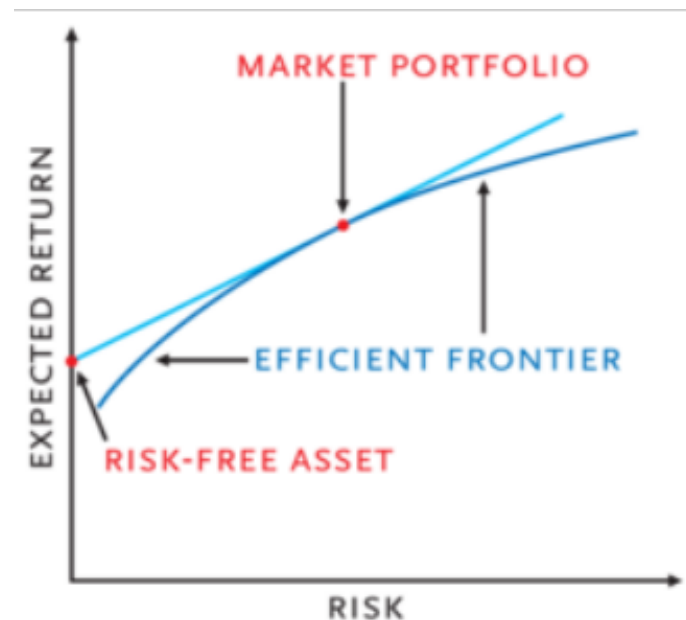
Nippon Telephone Telegraph
of Japan





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
- ...



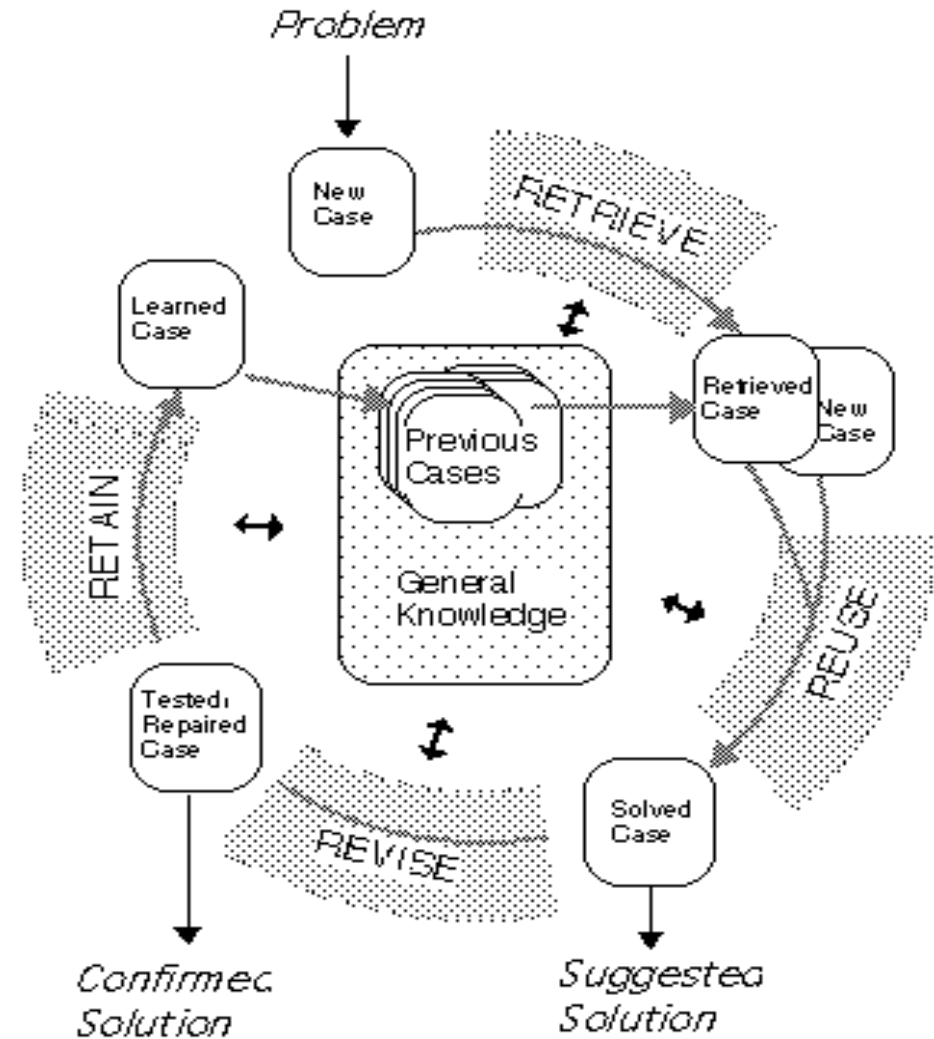
Analytical Tool in GCM at 3T

- ▶ 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



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



References

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