A Work Domain Analysis for the Vehicle Routing Problem

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Outline

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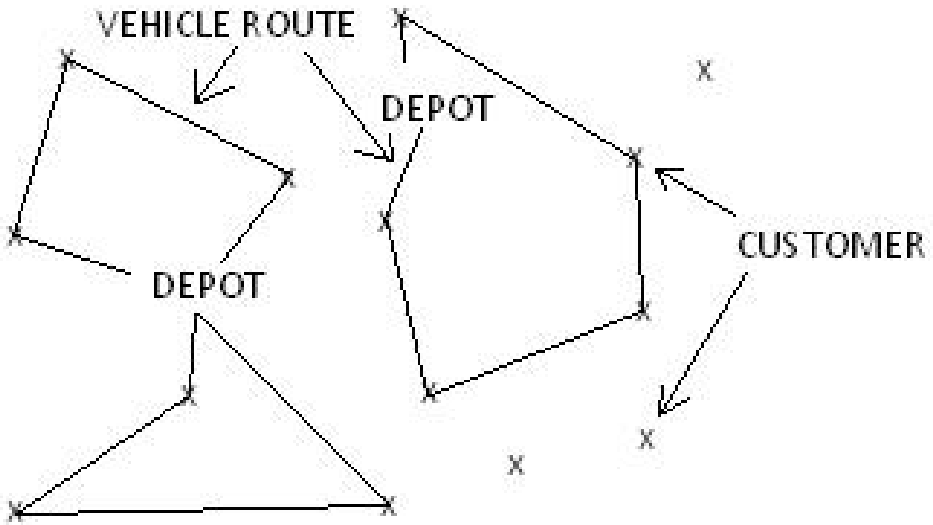
Introduction

- Agressive competition $\longrightarrow$ reactivity to customer demands (minimum quality of service)
- Vehicle Routing Problems (VRPs) optimisation
- VRP : Determine the routes to be performed by a fleet of vehicles to serve a given set of customers



Problem statement

- Take into account the real-world routing environment constraints : capacity, time windows,...
- OR : methods to efficiently solve the variants of VRPs [Toth and Vigo, 2002]
- Two important limitations :
  - Human factors are not much considered in the modelling phase of the problem
  - Models and solving systems are not ready to deal with the rapid changing situations

Problem statement

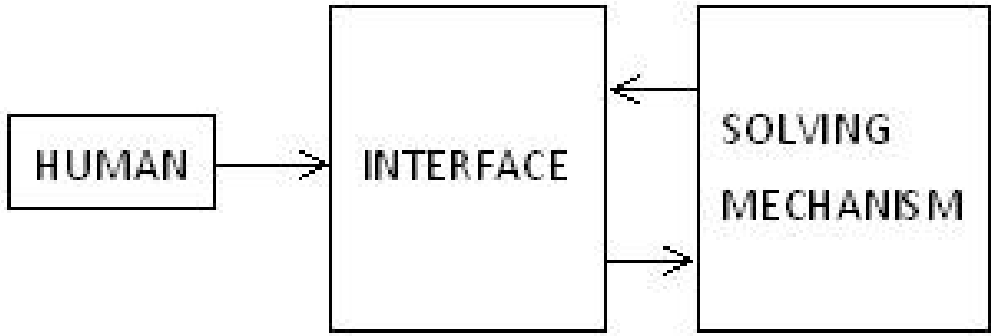
Goals for the VRP Decision Support System (DSS)

- The resulting solving tool and the human have to share a common view of the field (objects)
- The resulting solving tool has :
  - to deal with the unexpected
  - to resist the long-term changes of the situation
- The human could act between the real problem and the solving mechanism

Outline

Decision Support System

- We propose an interdisciplinary approach for the DSS
- Two different components :
  - Solving Mechanism based on Operational Research techniques
  - Human Interface based on Work Domain Analysis and where the human aspects are considered

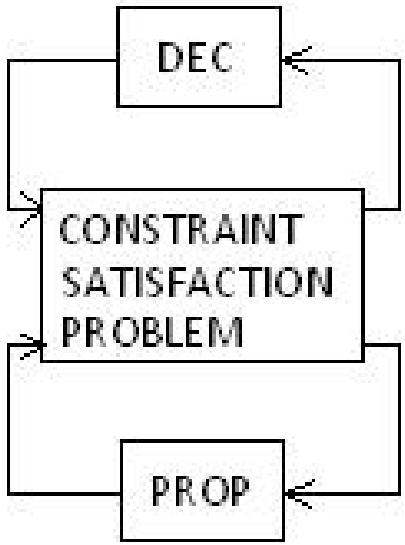


Solving mechanism

Solving Mechanism : based on Constraint Programming (CP) and other solving technics *[Desrochers et al., 1998]*

Properties of CP :

- Analysis and solving mechanisms can be separately considered
- Each type of constraint can be particularly processed
- We may take into account side constraints and user's preferences $\longrightarrow$ incrementally adding new constraints



Work Domain Analysis

Human Interface : based on the Abstraction Hierarchy (AH) *[Vicente, 1999 ; Rasmussen et al., 1994]*

Properties of AH :

- All the work constraints are stressed $\longrightarrow$ the system is ready to deal with the unexpected
- Tasks are not related to specific actors $\longrightarrow$ do not limit the scope
- An Ecological Interface design is derived from the AH

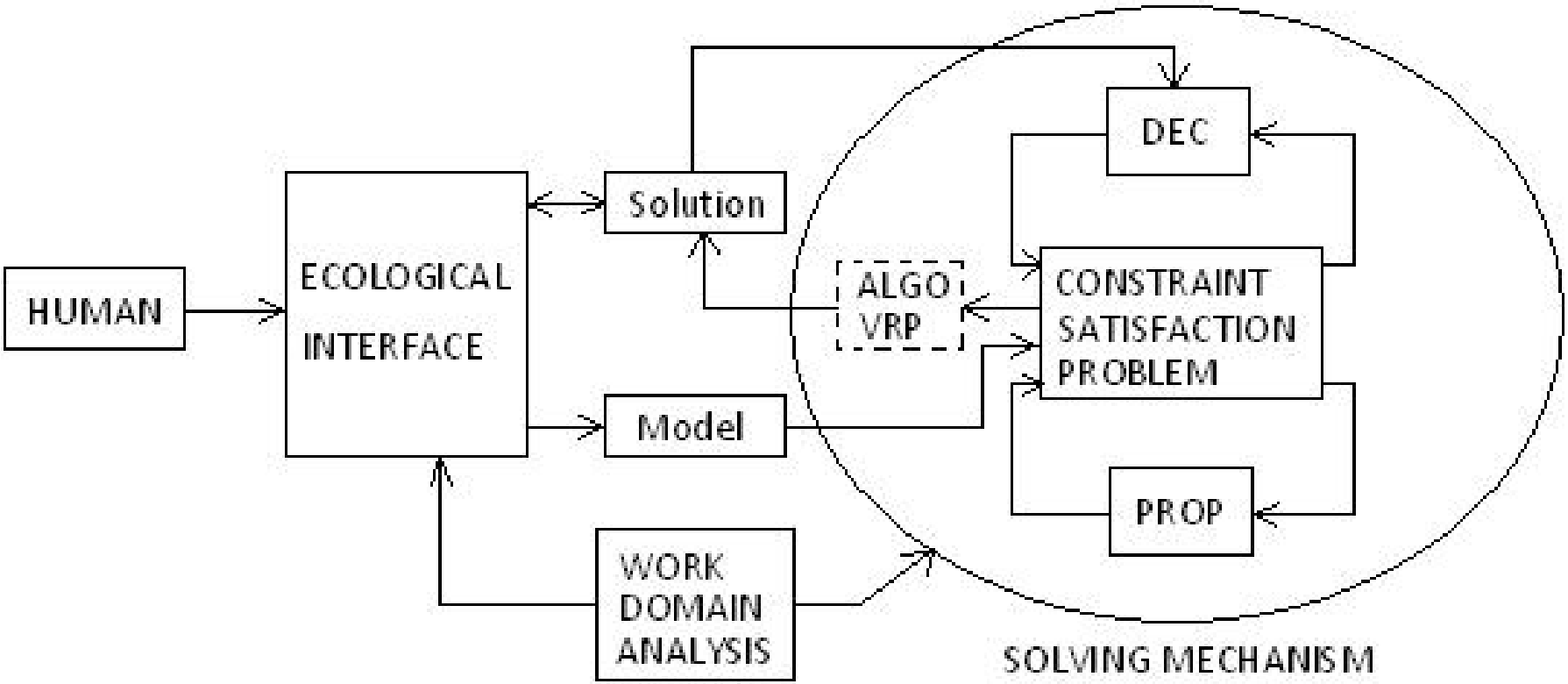
AH for the VRP

Tasks allocation

Tasks allocation :

- Solving Mechanism :
  - Select the algorithms to be useful
  - Propose and evaluate a set of feasible solutions
  - Re-evaluate the modified solutions
- Human tasks
  - Restrictions of the problem $\rightarrow$ select which constraints are activated
  - Choose the solving strategy
  - Modify all problem data
  - Modify the proposed solutions

Decision Support System



Outline

Scenario

Example

- 4 customers (C_i ; d_i), 2 vehicles (V_i ; $Q = 7$), 1 depot, 2 drivers (D_i)
- Set of constraints

Customers

	TW	d_i
1	[4,8]	2
2	[5,10]	3
3	[0,2] U [10,12]	2
4	[8,12]	5

Drivers

	TW
D1	[0,4] U [8,12]
D2	[0,8]

Allocation vehicle−customer $4 \rightarrow V2$

User preferences: All customers have to be served

AH for the example $\longrightarrow$ Model of the problem

Scenario

Solving Mechanism

	Customers	
	TW	d_i
1	[4,8]	2
2	[5,10]	3
3	[0,2] U [10,12]	2
4	[8,12]	5

	Drivers
	TW
D1	[0,4] U [8,12]
D2	[0,8]

Allocation vehicle−customer $4 \rightarrow V2$
User preferences: All customers have to be served

- Constraint Propagation :
  - C_4 is allocated to $V_2 \longrightarrow D_1$ is assigned to V_2 (TW)
  - C_1 can not be served by D_1 (V_2) because of TW constraints
  - Capacity (7) $\longrightarrow$ V_1 :$\{1, 2, 3\}$, V_2 : $\{4\}$ or V_1 :$\{1, 2\}$, V_2 : $\{3, 4\}$

Scenario

Customers	TW	d_i
1	[4,8]	2
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4	[8,12]	5

Drivers	TW
D1	[0,4] U [8,12]
D2	[0,8]

Allocation vehicle−customer $4 \rightarrow V2$

User preferences: All customers have to be served

- 2 options : V_1 :$\{1, 2, 3\}$, V_2 : $\{4\}$ or V_1 :$\{1, 2\}$, V_2 : $\{3, 4\}$
- Decisions :
  - D_2 rings before the start : "he is late" $\rightarrow$ User analysis : D_2 could have problems to serve C_3
  - The user decide to allocate C_3 to D_1 (V_2)

  AH Decision
- Constraint Propagation :
  - One option $\rightarrow$ V_1 :$\{1, 2\}$, V_2 : $\{3, 4\}$
- The DSS propose and evaluate the set of solutions (4 solutions)

Outline

Summary

- We propose an architecture for a VRP Decision Support System
- Interdisciplinary approach : Human factors and Operational Research techniques are considered for the DSS design
- We have presented the WDA (Abstraction Hierarchy) for the VRP

Further work

- Design the ecological interface architecture for a real-world case study
- Improve the solving mechanism
- Evaluate this approach against two other similar methods :
  - Cognitive Work Analysis for industrial scheduling *[Higgins, 1999]*
  - Mixed-initiative for scheduling *[Smith and Lassila, 1994]*