An interdisciplinary method for a generic vehicle routing problem decision support system

B. GACIAS[1], P. LOPEZ[1], J. CEGARRA[2]

[1]LAAS-CNRS; Université de Toulouse, France

[2] CLLE; Université de Toulouse, France

{bgacias,lopez}@laas.fr, julien.cegarra@univ-jfc.fr

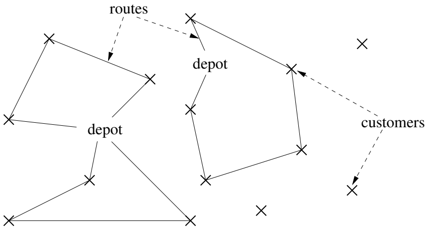
IESM 2009

Outline

Outline

Introduction

- Agressive competition → 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

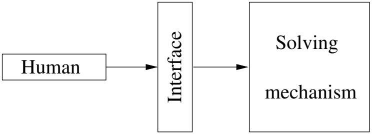
Goals for the VRP Decision Support System (DSS)

- 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

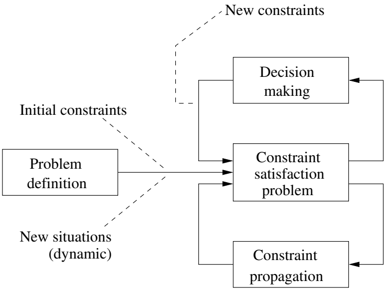


Solving mechanism

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



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

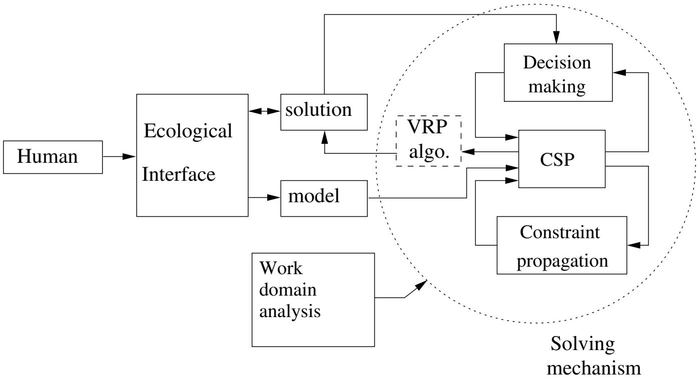
AH for the VRP

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	di
C1	[4, 8]	2
C2	[5, 10]	3
C3	[0, 2] U [10, 12]	2
C4	[8, 12]	5

Drivers

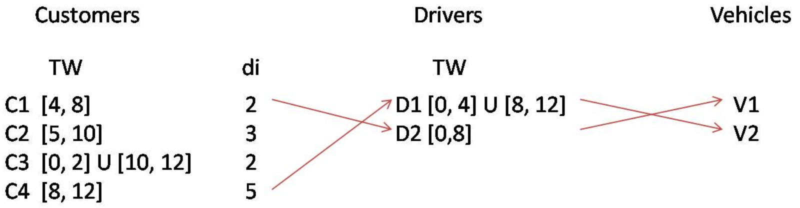
	TW
D1	[0, 4] U [8, 12]
D2	[0,8]

Allocation constraint Vehicle-Customer (V2-C4)
User preference: All customers have to be served

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

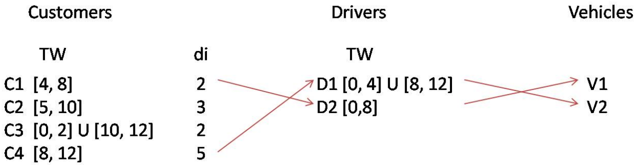
Scenario

Solving Mechanism



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

Scenario

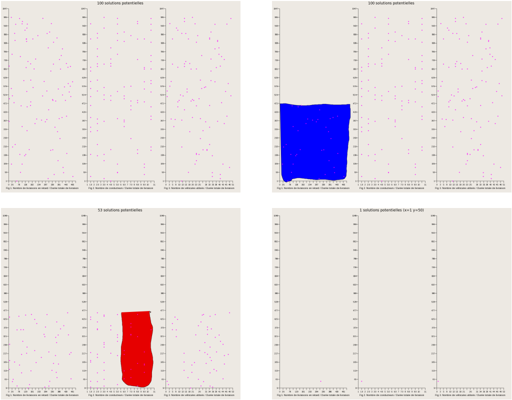


- 2 options : V_1 :$\{1,2,3\}$, V_2 : $\{4\}$ or V_1 :$\{1,2\}$, V_2 : $\{3,4\}$
- Decisions :
  - D_2 rings before the start : "he is late" $\rightarrow$ User analysis : D_2 could have problems to serve C_3
  - The user decides to allocate C_3 to D_1 (V_2)

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

Ecological Interface

- Selection of solution support tool
- Graphical tool with user preferences to guide the solution space search



Outline

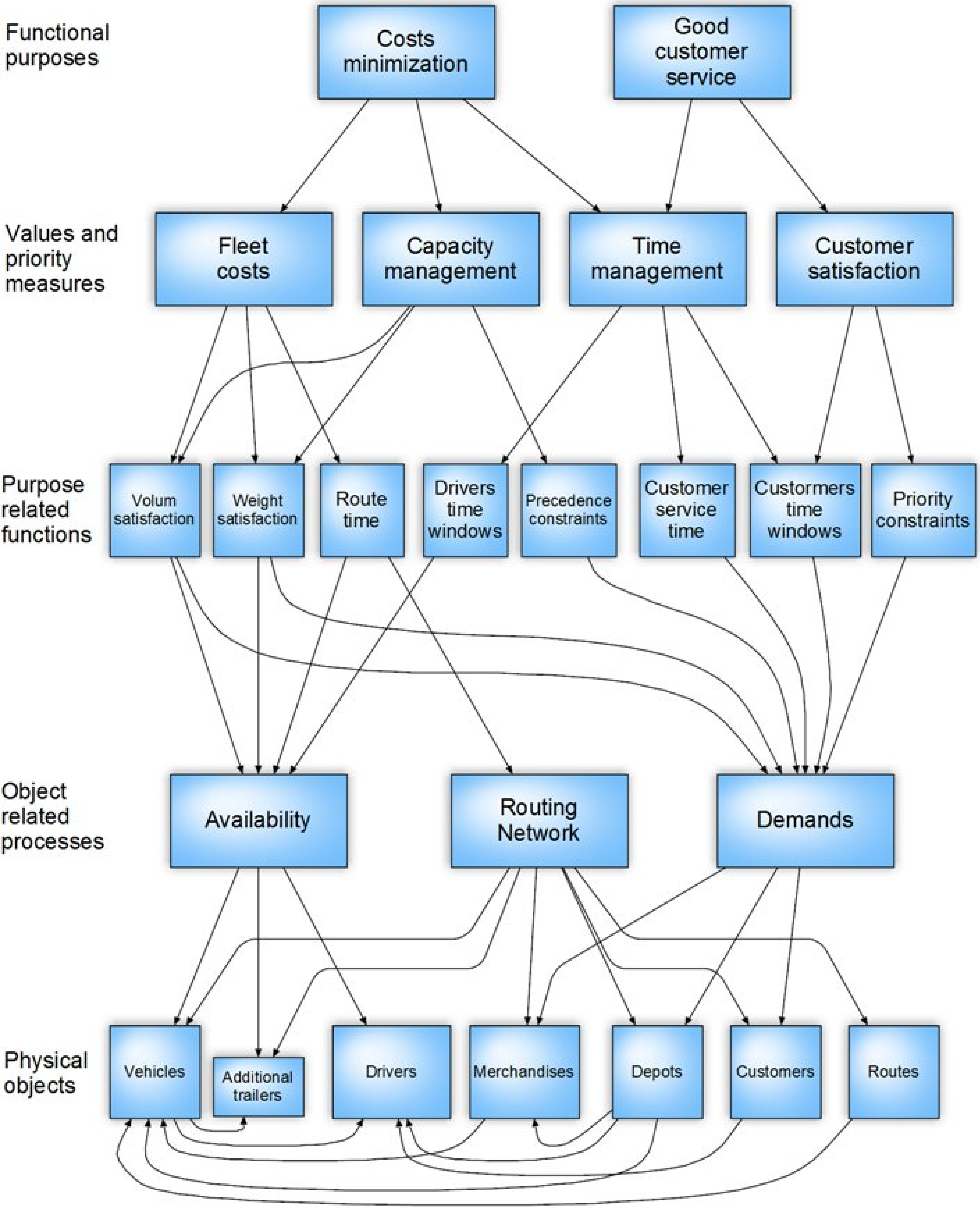
Summary

- We propose an architecture for a VRP Decision Support System
- Interdisciplinary approach : Human factors and Operations 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 : optimisation methods, model inversion,. . .

WORK DOMAIN ANALYSIS FOR THE VEHICLE ROUTING PROBLEM



WORK DOMAIN ANALYSIS FOR THE VEHICLE ROUTING PROBLEM