Efficient Local Search for Large Scale Combinatorial Problems

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June 27 2013
Overview

Thesis Info

Introduction

Local Search

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What is done
Title: *Efficient Local Search for Large Scale Combinatorial Problems*

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Start date: *December 1st 2012*

Contrat: Ecole des Mines d’Ales
Combinatorial problems - finding values for discrete variables such that:

- certain conditions are satisfied and
- objective function is optimized (minimized or maximized)

**The aim of the thesis**

Develop an efficient local search algorithms for few large scale combinatorial optimization problems

**Problems:**

1. Real World Vehicle Routing Problems (VRP) - the main problem
2. Machine Reassignment Problem (MRP)
3. Generalized Assignment Problem (GAP)
4. Bin Packing Problem (BPP)
5. Large Scale Energy Management Problem (LSEM)
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Local Search

Local search – iterative heuristic

- move from solution to solution in the space of candidate solutions (the search space) by applying local changes, until a solution deemed optimal is found or a time bound is elapsed.

**Algorithm 1** Local Search

1. Select an initial state $s_0 \in S$
2. while stopping criteria do
3. Select, by some heuristic, $s \in N(s_0)$ such that $f(s) < f(s_0)$
4. Replace $s_0$ by $s$
5. end while

- $S$ – the set of possible states (solutions)
- $N(s)$ – neighborhood, the set of states that can be reached from $s$ in one step
- $f(s)$ – objective function, a value that represents the quality of the state $s$
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Vehicle Routing Problem (VRP)

- distribution of goods between depots and final users

- Standard objective - minimizing the total travel distance

- Various constraints

- Every customer must be visited exactly once by a vehicle
Real world vehicle routing problems

- many constraints (drivers regulations, traffic constraints, heterogeneous fleet, hired drivers or vehicles,...)
- usually a hierarchical objective function (travel distance, travel time, waiting time, ...)

The main problem to be solved is provided by Geoconcept company
- large scale problem with up to tens of thousands customers
- huge number of different (hard and soft) constraints

The solution approach:
- constraint programming - for constraints satisfaction
- local search - for optimizing the solution
VRP cont.

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Google Machine Reassignment Problem (GMRP)

- challenging and novel optimization problem
- maximizing the usage of a set of machines
- assign processes on machines
- resource constraints
- up to 50,000 processes and 5,000 machines
- ROADEF/EURO Challenge 2012
Generalized Assignment Problem - GAP

- maximizing the usage of a set of machines
- assign jobs to agents (processes to machines)
- the agents have a resource capacity which is consumed by job processing
- each job is assigned to exactly one agent
- find a minimum cost assignment of jobs to agents
- Multi-Resource Generalized Assignment Problem (MRGAP)
- MRP is a generalization of MRGAP
Bin Packing Problem - BPP

- minimize the number of bins to pack the objects
- each object has the size
- identical bins (identical capacities)
- each object is assigned to exactly one bin
- Multi-Capacity Bin Packing (MCBPP)
- MRP is a generalization of MCBPP

Solving: Reduce BPP to MRP
Electricité de France (EDF)

60 nuclear power plants

- outages and production planning
- planning problem is very hard to solve
- ROADEF/EURO Challenge 2010
- 120 production scenarios
- time horizon: 1-5 years
- large number of constraints
• bibliography on VRP variants

• CVRP – Capacitated Vehicle Routing Problem
  • implementing basic classes in C++
  • implementing classical constructive heuristics (Savings - Clark-Wright, Insertion, ...)
  • constructive heuristic using matching
  • simple improvement procedures : 2-opt, 3-opt, insertion, swap, ...

• RVRP – Rich Vehicle Routing Problems
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GRASP approach for Set Covering (combined with Tabu Search)

- satisfiable results

GRASP - greedy + local search

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