Applied Mathematical Modelling 39 (2015) 3410–3433

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

Mathematical modeling of multiple tour multiple traveling salesman problem using evolutionary programming

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ARTICLE INFO

Article history:
Received 8 November 2011
Received in revised form 21 October 2014
Accepted 24 November 2014
Available online 5 December 2014

Keywords:
Evolutionary programming
Heuristics
Logistics
Maintenance networks

ABSTRACT

This study describes a single phase algorithm for the fixed destination multi-depot multiple traveling salesman problem with multiple tours (mdmTSP). This problem widely appears in the field of logistics mostly in connection with maintenance networks. The general model of the technical inspection and maintenance systems is shown in the first part, where the solution of this problem is an important question. A mathematical model of the system's object expert assignment is proposed with the constraints typical of the system, like experts' capacity minimum and maximum and constraints on maximum and daily tours of the experts. In the second part, the developed evolutionary programming algorithm is described which solves the assignment, regarding the constraints introducing penalty functions in the algorithm. In the last part of the paper, the convergence of the algorithm and the run times and some examination of the parallelization are presented.

1. Introduction

Nowadays in the field of globalized production and service industry the significance of the tightly integrated logistic systems is increasing. In the beginning mostly the production industry gets globalized, but now there are more and more multinational companies which offer even worldwide service solutions.

The operation of these systems requires periodic technical inspections and maintenance. The inspection generally requires specialized knowledge, sometimes it even requires special certificate. At elevators, which inspection and maintenance are very important from the aspect of life protection, there are governmental regulations available [1].

There have been many papers published dealing with multiple traveling salesman problem like [2] where the application of Google maps introduce a novel dimension into the application, but in out paper we treated the more complicated multiple route multiple traveling salesman problem.

There are devices which require periodic inspection and maintenance, for example, the safety and control devices of the electricity, gas, heat, water supply networks, monitoring devices, critical network control devices which require on site supervision and maintenance [3].

The main problem in this type of systems is to assign the experts to the objects what they inspect and control the experts on everyday route. The experts have to inspect the objects and to return to his home location at the end of the day. The optimal number of expert reduces the costs. This paper presents a heuristic optimization of this problem, even usable in large scale systems.

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http://dx.doi.org/10.1016/j.apm.2014.11.043
0307-904X/

2. Model of the network like inspection and maintenance systems

In these systems the maintenance tasks are ensured by one or more raw material and tool warehouses and repair facilities scattered over a large area.

The task of this logistic system is to provide the reliable operation and ensure the availability of resources – experts, raw materials, tools.

The optimal operation of the system has to be ensured by a virtual logistic center [4] due to the scattered resources and system elements, where the material and information flow is monitored and controlled.

These type of systems are often controlled by a virtual logistic center (Fig. 1), but in smaller scale – regional or countrywide systems – the controller facility, the core of the system, could be a conventional logistic center where not just the information processing but the material flow are also present.

The virtual logistics center controls the system using optimization processes, which requires complex mathematical models regarding constraints like operational requirements, government regulations and many other conditions.

3. Mathematical model of the technical inspection and maintenance systems

The pure multiple traveling salesman problem has a very extensive literature, but optimizing such a large systems with a lot of input parameters and boundary conditions cannot be found. In the literature, one can find researches with multiphase optimizations [5], like clustering or partitioning first and apply different multiple traveling salesman (MTSP) methods [6,7]. The clustering [8,9] and the partitioning [10] are widely used thanks to the speed of the algorithm but these methods are less suitable to found the global optimum due to the nature of the multiphase optimizations. The method presented here can optimize large systems with one phase algorithm. Above all, it handles the special constraints of the technical maintenance systems which we encountered in industrial projects.

In this article, only part of the complex model of maintenance system is shown because the optimization covers only the object – expert assignment.

In real logistic system inspection, maintenance and examination tasks are different, some require and some not require spare parts to build in.

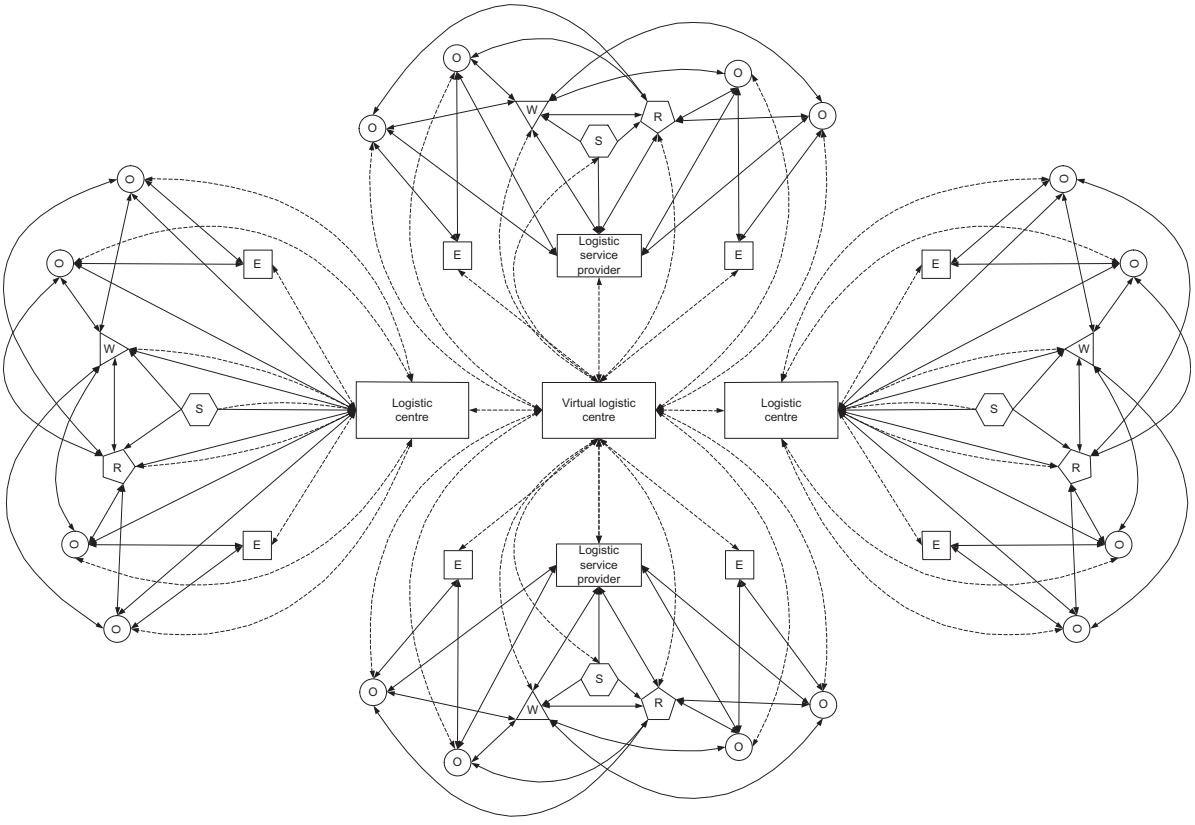

Fig. 1. General structure of a technical inspection and maintenance system Legend dashed lines: information flow, continuous line: material flow, E: expert, S: supplier, O: object, R: repair facility, W: warehouse.