

New Tabu Search Heuristic in Scheduling Earth Observation Satellites

Arezo Sarkheyli
Computer Engineering Department
M.S. Student of Payam Noor University
Tehran, Iran
arezo_sarkheyli@yahoo.com

Bahman Ghorbani Vaghei
Railway Engineering Department
Iran University of Science & Technology
Tehran, Iran
bahman_gh@iust.ac.ir

Alireza Bagheri
Computer Engineering Department
Amirkabir University of Technology
Tehran, Iran
ar_bagheri@aut.ac.ir

Abstract—Scheduling system of low earth orbit (LEO) satellite operations is one of the important tasks performed in satellites. Satellite specific constraints, satellite priorities, priorities of certain payload and special operations, as well as visibility conflicts are taken into consideration while generating the operations schedules in an optimum way. This paper proposes a tabu search heuristic for earth observation satellite scheduling problem, where as earth observing operations have to be scheduled on several resources while respecting time constraint and taking the priorities of the operations into account with the objective of scheduling as many operations as possible within its time window. The computational results indicate that this approach is typically effective to generate a near optimal and feasible schedule for imaging operations of the satellite.

Keywords- Earth Observation Satellite, Tabu Search, Heuristic, Scheduling Problem, Move Operation

I. INTRODUCTION

The mission of an earth observation satellite is taking photographs of specific areas to perform the user's requests. Currently, science activities on different satellites or even different instruments on the same satellite are scheduled independently of one another. As a given request can sometimes be satisfied by several satellites, the problem is not separable by satellites. Instead, planning must be performed simultaneously by all satellites, to help to improve the utility of the expensive resources, such as satellites.

The problem consists of selecting and scheduling a subset of requests yielding the maximal sum of priority subject to temporal constraints and resource constraints.

There has been plenty of research devoted to planning and scheduling a satellite by a variety of optimization techniques. Globus et.al. present initial results of a comparison of several evolutionary and other optimization techniques such as simulated annealing, genetic algorithm and so on. They found that simulated annealing is the best search technique [1]. Frank et.al. present a constraint-based approach to solve the earth observing satellite and proposes a stochastic heuristic search method for solving it [2]. Wolfe and Sorensen indicate the genetic algorithm is a lot slower

but appears to create near-optimal schedules [3]. Agness et.al. show that this is a large and difficult combinatorial optimization problem which could be viewed as an instance of the valued constraint satisfaction problem framework [4]. Barbulescu et.al. in [5] compare local search methods against a genetic algorithm using data from the U.S Air Force Satellite Control Network, and show the genetic algorithm yields the best overall performance on larger , more difficult problems. Lin et.al. in [6] formulate the scheduling problem as an integer-programming problem and indicate that the approach is very effective to generate a near-optimal , feasible schedule for the imaging operations of the satellite. Wang group propose a hybrid ant colony optimization algorithm [7]. Zhang et.al present an ant colony optimization approach for the satellite control resource scheduling problem and indicate that their approach possesses strong competitive advantages in exploring the best global solution [8].

This paper considers the problem of scheduling resources of earth observation satellites as a graph coloring problem which could be solved by a new heuristic tabu search approach.

II. PROBLEM DEFINITION

Consider a set of satellites and a collection of jobs which should be done by the satellites with a predefined duration in a period of time in a day. The main purpose of the jobs in the observation satellites is taking images form specific areas. Each job of observation is a collection of tasks supporting the job. We define a task to be a basic operation of image acquisition over an area of the earth and each job contains only the basic task of imaging.

Each imaging task has a priority specified by a user request and shows its emergency. All the tasks have an opportunity window that the observation could be done.

Predicting the visibility times of each satellite on requested area according to the satellite's orbit specifications is possible and necessary for scheduling process. When a low earth orbit satellite passes over a requested area, the area could be available just for a short period of time, so each satellite has a certain time window to process the task (to take an image).