Solving the Aircraft Engine Maintenance Scheduling Problem Using a Multi-objective Evolutionary Algorithm

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Abstract. This paper investigates the use of a multi-objective genetic algorithm, MOEA, to solve the scheduling problem for aircraft engine maintenance. The problem is a combination of a modified job shop problem and a flow shop problem. The goal is to minimize the time needed to return engines to mission capable status and to minimize the associated cost by limiting the number of times an engine has to be taken from the active inventory for maintenance. Our preliminary results show that the chosen MOEA called GENMOP effectively converges toward better scheduling solutions and our innovative chromosome design effectively handles the maintenance prioritization of engines.

Keywords: Multi-objective Evolutionary Algorithms, Scheduling Problem, Aircraft Engine Scheduling, Variable-length chromosome.

1 Introduction

Scheduling problems are a very common research topic. This is because, for efficiency reasons, our world relies heavily on schedules and deadlines. Aircraft engine maintenance is no exception. The United States Air Force has many planes that it must keep up and running. But with the downsizing that has occurred in recent years, the number of planes that are operational has become more critical. This means that every effort needs to be made to ensure that not only are the engines repaired in an efficient manner, but that their component's scheduled maintenance cycles are in sync so that the engine has fewer trips to the logistics maintenance center.

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Section 2 looks briefly at the types of scheduling problems that are researched and describes how each one behaves. Section 3 describes specifically the aircraft scheduling problem. It states why this problem is important, shows the maintenance flow, and gives the particulars as to how a system was implemented to solve the problem. Section 4 describes the algorithm used to implement the problem. Section 5 discusses our design of experiments and tells what metrics we used and why. Section 6 show the results of our experiments and looks at them analytically in an effort to discern any trends. Finally, the paper concludes with Section 7 where we summarize our findings and describe the future work we are doing on this problem.

2 Scheduling Problems

Scheduling problems can be formulated in many different ways. They are commonly abstracted into three different classes of problems: open shop, flow shop, and job shop. The definitions for these problems are described in [1].

2.1 Flow Shop

The flow shop scheduling problem consists of m machines and n jobs. All m machines are situated in a defined series. All n jobs have to be processed on each machine. All the jobs must follow the same routing along the series of machines. Once a job is completed on one machine, it is placed into the queue of the next machine in the series. Normally, jobs are removed from the queue on a *first in first out* (FIFO) basis, but this can be modified to fit the needs of the problem, such as higher priority jobs could be bumped to the front of the queue.

2.2 Job Shop

For the job shop problem, unlike the flow shop problem, each job has its own route to follow. With job shop problems, they can be modelled by having jobs visit any machine at most one time, or they can be created to allow for multiple visits to machines [1].

3 Aircraft Scheduling Problem

The U.S. Air Force has many aircraft in its arsenal. Its fleet is aging and it appears that plans are for the aircraft to be around for a while longer. But many of these engines are beyond their design life. In fact, 97% of all F100 engines and 84% of all F110 engines will be past their design life by the year 2010 [2]. One essential thing that the Air Force relies upon is a dependable fleet. If the Air Force does not have reliable aircraft, then they must procure redundant systems in order to ensure the success of any mission with a high degree of certainty. To achieve this type of dependability, the old "fix it when it breaks" mentality or