Home assignment number 2, 2012, in SF2863 Systems Engineering.

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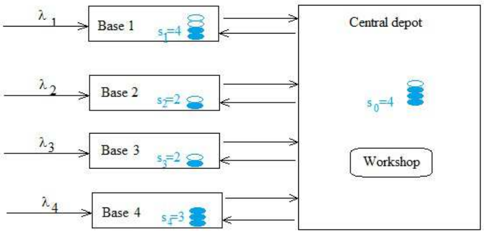
In this home assignment it is allowed to cooperate in groups of at most three persons each. Limited cooperation with other groups is also allowed, but should be refered to in the report.
One report per group is to be handed in, and you should describe in your own words how the problem was solved. It is not allowed to copy parts of another groups report or computer code! The answers to the questions in the assignment should be given in the main report. (Not in your computer printouts.) Relevant print-outs and plots should be included in the report. Computer code should be held available on request.
State your name, personal number and email adress on the front of the report.

A written report (printed out on paper) should be handed in to the instructor before 13.15, Thursday, November 29. Note that this deadline is sharp. Directly after there will be oral presentations. Some students will be randomly selected for oral presentation of the assignment at the beginning of the exercise session, so it is necessary to attend that session to get all the bonus points. (Note that the assignment is completely voluntary, but that a correct report that is handed in in time will grant you bonus points at the final exam.) A correct solution and participation in the presentation will grant four bonus points on the exam.

The purpose of this home assignment is to stimulate the understanding of how the METRIC model can be used for spare parts optimization on several levels.

Problem statement

We will consider a supply system on two organizational levels for a very expensive replaceable unit, here called “airplane engine”. The system consists of 4 bases, called North, South, East and West, each with a local spare parts inventory, and a central depot with both a workshop and a central inventory.
To each basis there is a (random) arrival of airplanes with an engine in need of repair. To the North basis a malfunctioning engine arrives on average every 6:th day, to the south every 8:th day, to the East every 9:th day and to the West every 12:th day on average.
When a malfunctioning engine arrives to a base it is replaced immediately with a functioning engine from the local inventory, as long as it is not empty. If there is no functioning engine in the local inventory to replace the malfunctioning engine with, then there will be a local inventory queue, a backorder is issued and the aircraft is grounded and has to wait for a functioning engine to arrive.
The malfunctioning engine is directly sent to the central workshop. At the same time a functioning engine is sent from the central inventory, unless it is empty, to the local inventory. If there is no functioning engine in the central inventory to send to the local inventory then a central inventory queue is formed. The transport time for a malfunctioning engine from a base to the depot as well as the transport time for a functioning engine from the depot to a base is 48 hours. The repair time for a malfunctioning engine at the central workshop is on average 72 hours.



Today there are no spare engines, and as a consequence it happens regularly that planes are grounded. This is now going to change, and you should implement the process.

Assignments

1. Assume that 11 spare engines have been ordered. They will be delivered one at a time with some weeks in between, but they should be ready for use as soon as they arrive. When a new spare engine arrives, use the METRIC model (Model 3) to determine the optimal location for the current number of spare engines. When you find the optimal location, the old spare engines are allowed to be replaced.

Determine how the expected number of grounded airplanes decrease when adding each new spare engine. Plot the efficient curve and determine in a table the efficient solutions.

Let s_k = the number of spare engines nominally kept in inventory k, where $k = 0$ for the central inventory, $k = 1$ for the North, $k = 2$ for the South, $k = 3$ for the East and $k = 4$ for the West inventory.

2. Let S be the set of all configurations $(s_0, s_1, s_2, s_3, s_4)$ such that $0 \leq s_k \leq 4$ for $k = 0, 1, 2, 3, 4$. Determine $EBO(s_0, s_1, s_2, s_3, s_4)$ for all points in S.

Plot all these points in a coordinate system with $s_0 + s_1 + s_2 + s_3 + s_4$ = the total number of spare engines on the horisontal axis and $EBO(s_0, s_1, s_2, s_3, s_4)$ = the average number of grounded aircrafts on the vertical axis, in the same figure as the efficient curve from assignment 1 above.

Note that you can use the result in 2 to verify your results in 1, but you should not use the result in 2 to determine the solution in 1. For larger problems the approach used here in 2 is not computationally feasible

3. Assume that the average repair time could be decreased from 72 hours to T_1 hours and/or that the transport time could be reduced from 48 hours to T_2 hours by investing a lot of money in the workshop or the transportation system. Determine how much each of these three alternatives would be worth, in terms of decreased need of spare engines. Is the optimal placement of the spare engines affected by these changes? Try different values of T_1 and T_2 of your own choice and comment on the consequences of changing them.

4. Assume that it is not possible to keep local inventories, so that all spare engines have to be located in the central inventory.

Plot the efficient curve for this situation and compare with the efficient curve from assignment 1 above. Comment on the result.

Good luck!