Home assignment number 2, 2013, in SF2863 Systems Engineering.

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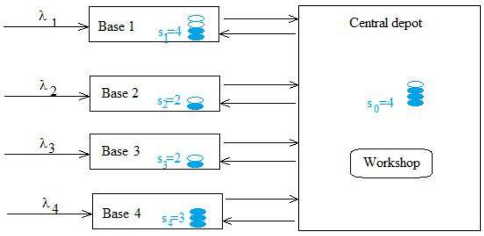
In this home assignment it is allowed to cooperate in groups of at most four persons each. Limited cooperation with other groups is also allowed, but should be refered to in the report.
One report per group is to be handed in, and you should describe in your own words how the problem was solved. Make the description rich enough so that it is totally clear how you define your states and modelled the problem and describe how you implemented the algorithms. 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, Friday, December 13. Note that this deadline is sharp. (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 clear report 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 "LRU unit". 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 LRU unit in need of repair. To the North basis a malfunctioning LRU unit arrives with intensity λ_1, to the South with intensity λ_2, to the East with intensity λ_3, and to the West with intensity λ_4.
When a malfunctioning LRU unit arrives to a base it is replaced immediately with a functioning LRU unit from the local inventory, as long as it is not empty. If there is no functioning LRU unit in the local inventory to replace the malfunctioning LRU unit 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 LRU unit to arrive.
The malfunctioning LRU unit is directly sent to the central workshop. At the same time a functioning LRU unit is sent from the central inventory, unless it is empty, to the local inventory. If there is no functioning LRU unit in the central inventory to send to the local inventory then a central inventory queue is formed. The transport time for a malfunctioning LRU unit from a base to the depot as well as the transport time for a functioning LRU unit from the depot to a base is 48 hours. The repair time for a malfunctioning LRU unit at the central workshop is on average T_{rep} hours.



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

Assignments

Divide your group into two subgroups.
One subgroup will consider the case that the LRU is the aircraft engine. Assume that each spare engine costs 3 million dollars. Aircrafts with malfunctioning engines arrive to the North base on average every 5:th day, to the South every 8:th day, to the East every 10:th day and to the West every 12:th day on average. Assume that the average repair time for the engines T_{rep} is 96 hours.

The other subgroup will consider the case that the LRU is the landing gear system. Assume that each spare landing gear system costs 2 million dollars. Aircrafts with malfunctioning landing gears arrive to the North base on average every 10:th day, to the South every 14:th day, to the East every 12:th day and to the West every 16:th day on average. Assume that the average repair time for the landing gear systems T_{rep} is 48 hours.

Each subgroup should solve the following

1. Determine how the expected number of grounded airplanes decrease when adding each new spare LRU unit. Plot the efficient curve and determine in a table the efficient solutions, and the marginal increase in expected downtime for each new million dollar spent on the LRU spare units.

Let s_k = the number of spare LRU units 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 LRU units 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 the initial value to T_1 hours and/or that the transport time could be reduced from the initial value 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 LRU units. Is the optimal placement of the spare LRU units 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.

Together the two subgroups should now solve the problem with both spare engines and landing gear systems.
Assume that the failures of the two LRU are independent and that both of them never fail simultaneously.
Start with zero spare parts and use Marginal allocation to decide the 10 first efficient (in EBO and cost of spares) configurations of spare parts, which type of spares should be kept and where should they be located. Use the results determined previously to determine the marginal increase in EBO by investing the money in spares.

Good luck!