Norges Teknisk-Naturvitenskapelige Universitet

TPK4186 - Advanced Tools for Performance Engineering
Spring 2020

Assignment 2

Prepared by Antoine Rauzy

Contents

1 Introduction

1.1 Objective of the Assignment

The objective of this assignment is to review all modeling formalisms we have seen this semester and therefore to prepare you to the final examination.

1.2 Requirements

Here follows a number of requirements.

1. You must provide your model together with a document explaining these models and reporting experiments you have performed with it.
2. You must make explicit all of your hypotheses. It is not a problem to make some restrictive hypothesis, but it is a problem if you do not mention it and do not justify it.
3. Assuming your name is Jack Sparrow, all of the above files must be included in a zip archive named:

   `TPK5120 - 2020 - Assignment2 - Sparrow Jack.zip`

   The deliverable of the assignment is this zip archive.
4. The assignment must be made individually.

5. You must design your models in an object-oriented style.
6. Recall that the quality of a model can be evaluated along three criteria: its completness, its correctness and its maintainability:
   - A model is complete if it describes all functionalities of the system under study. Some functionalities are however more important than other. You must first concentrate on the main functionalities, then develop the "nice-to-have" ones.
   - A model is correct if it is bug free. To ensure that your model is correct, test it, extensively.
   - A model is maintainable if it is well presented, if the identifiers are significant, and so on.

2 Tasks

Here follows the series of tasks that you are asked to complete.

2.1 Constraint Satisfaction Problem

Consider the problem of tiling a $m \times n$ checkerboard, i.e. completely and exactly covering it, with non overlapping dominoes, i.e. 2×1 rectangles.

Question 1. Propose a general formulation as a constraint satisfaction problem.

Question 2. Apply it to a 5×4 checkerboard. Find solutions with the algorithms implemented in Sherlock.

2.2 Combinatorial Optimization Problem

In a computer, 6 components must be connected by wires, i.e. the first component must be connected to the second, which must be connected to the third as so on. The distance in millimeters between each pair of components is given in the table below. The objective is to determine which pairs of components to connect so to minimize the total length of wire between components.

	1	2	3	4	5	6
1		6.7	5.2	2.8	5.6	3.6
2	6.7		5.7	7.3	5.1	3.2
3	5.2	5.7		3.4	8.4	4.0
4	2.8	7.3	3.4		8.0	4.4
5	5.6	5.1	8.4	8.0		4.6
6	3.6	3.2	4.0	4.4	4.6	

Question 3. Propose a formulation as a combinatorial optimization problem.

Question 4. Solve this problem using Sherlock.

2.3 System Architecture

Figure 1 shows the electric circuit of the Airbus A320 (slightly simplified).

Some equipment's of the aircraft work with direct current (DC), some other with alternate current (AC). Electric buses shown on the figure are in charge of distributing the current to these different equipment's.

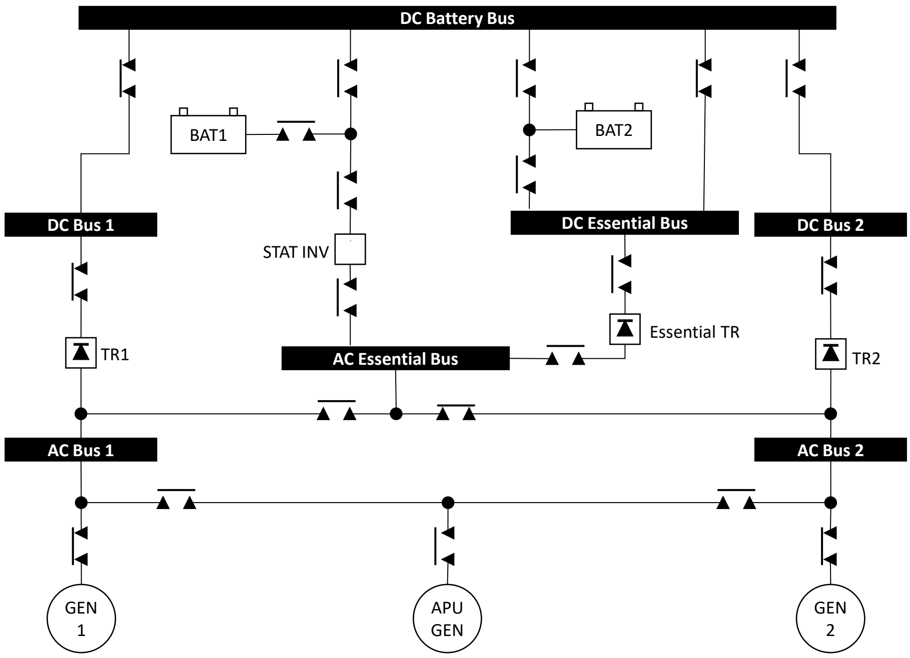

Figure 1: Electric Circuit of Airbus A320

Normally, the power supply is provided by the two generators GEN 1 and GEN 2, each of them being coupled with one of the two engines of the aircraft (not shown on the figure). One of these two generators is sufficient to cover the needs of the major functions of the aircraft. They both provide alternate current. So does the auxiliary power unit (APU) that is a backup in case both generators are failed.

The alternate current is transformed into direct current by means of transformer rectifiers TR's. The reverse transformation, from direct current to electric current is also possible via the static inverter.

The essential equipment's of the aircraft are powered via two essential buses, one for the direct current, one for the alternated current.

A number of circuit breakers are used to reconfigure the power supply in case of loss of sources. Indeed, these circuit breakers may fail as well.

You are asked to make an architectural study of this system.

Question 5. Design an operational view of the system. This study should include at least:

- A life-cycle analysis (restricted to flight modes).
- Some scenarios supporting your life-cycle analysis.

Question 6. Design a functional of the system.

Question 7. Design a physical view of the system.

Question 8. Connect the functional and physical views.

Note that many documents, including videos, are available on internet that explain how the electric circuit of the A320 works, in case you need further explanations.

2.4 Simulation

We want now to be able to simulate different scenarios of evolution of the A320 electric system. We shall indeed use the functional and physical views already designed (and simulated) to do so.

Question 9. Design a Janos model that makes it possible to animate the functional and physical views of your architectural study.

2.5 Safety Analysis

We want to complete our study by a safety analysis. The objective is, as usual, to determine the scenarios of failure and their probabilities, as well as the probability to lose the aircraft due to a failure of the power supply.

Question 10. Design a Cassis model to implement your safety study.

Question 11. Extract minimal cutsets from this model.

Probability of failure of components can be chosen arbitrarily. It is however very important to consider the failure modes of components.

2.6 Maximum Flow Problem

Due to a major natural catastrophe, a clinic receives 169 patients in need of emergency treatment. Each of the 169 patients requires a transfusion of one unit of whole blood. The clinic has supplies of 170 units of whole blood. The number of units of blood available in each of the four major blood groups and the distribution of patients among the groups is summarized in the table below.

Blood type	A	B	O	AB
Supply	46	34	45	45
Demand	39	38	42	50

The constraints are as follows.

- Type A patients can only receive type A or O;
- Type B patients can receive only type B or O;
- Type O patients can receive only type O; and
- Type AB patients can receive any of the four types.

Question 12. Propose a formulation as a maximum problem. Draw the directed graph and put the edge capacity above each edge.

Question 13. Solve this problem using Edgser.