EECE 513 – Design of Fault Tolerant Digital Systems
Assignment 2: SAN Modeling

In this assignment, you will create a Stochastic Activity Network (SAN) model using the Möbius modeling software [1]. You will then solve the model analytically to compute its reliability. **If you haven't yet done so, please download and install the Mobius software package from the class webpage now.**

We have a fault-tolerant computer system composed of 2 computers, at least one of which is required for the system to be functional.

Each computer has the following parts, stated along with the requirements for the computer to be operational:

- 3 CPUs, of which at least 2 are required to be functional
- 3 memory chips, of which at least 2 are required to be functional
- 2 I/O ports, of which at least one is required to be functional

For example, if both the CPUs in a computer have failed, then the computer has failed.

The time to failure of each component follows an exponential distribution with failure rates as follows:

- CPU: 1 failure every 5×10^4 hours
- Memory: 1 failure every 2×10^4 hours
- I/O port: 1 failure every 1×10^4 hours

Each component also has an associated *coverage*. Coverage is a probability measure. 1-coverage is the probability that the overall computing element will fail if the component fails, even though sufficient redundancy still exists. For example, in the table below, with the memory chip, if the chip fails, then there is a 0.005 chance that the computer will fail, even if sufficient redundancy exists.

We also have the possibility of catastrophic failure. The probability of catastrophic failure is the probability that the failure of the component will cause the entire computer system to fail, even if sufficient redundancy exists.

Redundant Component	*Fault Coverage Probability*	*Catastrophic Failure Probability*
CPU	0.9975	1×10^{-5}
Memory	0.995	1×10^{-5}
I/O	0.99	5×10^{-5}

Steps: Make any reasonable assumption that is needed. State the assumptions clearly in your report.

1. Create a SAN model for the computer system. In creating this model, you may want to use Replicate and Join nodes.
2. Solve the model, using analytical methods, to determine the reliability of the system from its inception to 5 years. Plot the reliability of the system R(t).
3. If you could make only one of the following changes to your system, which would you do to increase the reliability of the system at 5 years (provide the reliability plots for each of the choices below)
    a. Increase the number of computers in the system to 3 and run the system in TMR mode.
    b. Halve the failure rate of every component
    c. Double the number of memory chips
    d. Double the number of processors

Deliverables: Submit a report with the following parts in it (see below for formatting instructions).

a. A description of the model: code fragments of input/output gates and distribution parameters
b. Plot of the reliability of the system and insights from the plot
c. Answer to question 3 above and intuitive reason for it (along with the plots of the 4 choices)

Homework submission: You must hand in a printed copy of your report with your name and student number, in class on **Nov 3rd**. The report must be single-spaced, single column and written in 12 point font with reasonable margins, and **should have no more than 5 pages including all figures and appendices.**

[1] G. Clark, T. Courtney, D. Daly, D. Deavours, S. Derisavi, J. M. Doyle, W. H. Sanders, and P. Webster., *The Möbius Modeling Tool.*, Proceedings of the 9th International Workshop on Petri Nets and Performance Models, Aachen, Germany, September 11-14, 2001, pp. 241-250.