# CAS 781 Assignment 2

1. We wish to evaluate the reliability of a data centre's water supply system (for the cooling units). The system consists of the following three subsystems, all of which must be working for the overall system to be working:

   (a) The power supply, which is failed with probability $8 \times 10^{-6}$.

   (b) Four pumps, each of which is failed with probability $6 \times 10^{-4}$. At least two pumps must be operational to ensure operation of this subsystem.

   (c) A control valve, which is failed with probability $2 \times 10^{-4}$. If the control valve is failed, then reliable operation of this subsystem is still assured if a controller and a bypass valve are both working. These are failed with probabilities $3 \times 10^{-4}$ and $4 \times 10{-}4$, respectively.

   Calculate the probability that the system is failed. To reduce the failure probability, which subsystem should be improved?

2. This problem is another angle on data centre reliability. It is somewhat of a toy problem, but can scale. Consider a rack with eight (identical) servers. There is also a PDU in the rack (whether this is redundant PDUs or not is not important here). Individual servers fail at rate 0.004 and are repaired at rate 1. The PDU fails at rate $2 \times 10^{-6}$ and is repaired at rate 0.02. When the PDU is failed, all of the servers are offline.

   (a) Calculate the availability of an individual server (without considering the PDU) and the availability of the PDU. Enumerate all of the events that lead to less than six servers working. Using these events and the availabilities of the individual components, calculate the probability that at least six servers are working.

   (b) Using a CTMC approach, calculate the same probability as in the previous part.

   (c) Starting from a system where all components are working, calculate the expected time until less than six servers are working.

3. For this question we reconsider the TACOMA and Zapater et al. papers. For the cooling systems considered in both papers, discuss the reliability considerations that should be taken into account (for the cooling system only) - both what kind of failures may be an issue and how the system could cope with them. In particular, discuss how the algorithms provided could be adapted to take into account cooling system failures.