Assignment 08

This assignment consists of 6 problems. Problems 6, 7 and 9 are from 436, 437 page. Problem 3 of 451 page and problems 5, 6 of 475 page.

Problem #6:
[FULL 1975] Consider a variation of the cyclic queuing network model of Example 8.8, in which the I/O device uses the SLTF (shortest latency time first) scheduling discipline. The I/O service rate, λ_k, is a function of the number of requests in its queue and is given by

$$\frac{1}{\lambda_k} = \frac{\tau}{k+1} + \frac{1}{r} = \frac{r\tau + k + 1}{r(k+1)},$$

where $1/r$ is the mean record transmission time and τ is the rotation time of the device. Obtain an expression for the CPU utilization and the average system throughput, assuming $q_0 = 0.05$, $r\tau = \frac{1}{3}$, and $\tau = 10$ ms. Plot the average system throghput as a function of the CPU service rate μ (ranging from $0.1r$ to $10r$) for various values of the degree of multiprogramming $n = 1, 2, 5, 10$. For $\mu = r$, compare the throughputs obtained by the SLTF scheduling and the FCFS scheduling algorithm (for the latter case, the average I/O service time is constant at $1/\lambda_1$).

Problem #7:
Consider an application of the cyclic queuing model (CPU, paging device) to demonstrate a phenomenon called "thrashing" that could occur in paged virtual memory systems. Assume a fixed number, M, of main-memory page frames, equally divided among n active programs. Increasing n implies a smaller page allotment per program, which in turn implies increased paging activity – that is an increased value of μ. Often it is assumed that

$$\mu(n) = \frac{1}{a}\left(\frac{M}{n}\right)^{-b}$$

Assuming $\lambda = 0.0001$, $a = 0.2$, $b = 2.00$, and $M = 100$, plot the average system throughput as a function of the degree of multiprogramming. [Note that

q_0 and q_1 are functions of n and that when $n = 1$, a job is assumed to have all the memory it needs, requiring only initial paging, so that, $q_0(1) = 0.9$]. Unlike the model of nonpaged systems, the average throughput here will not increase monotonically, but after a critical value of n, it will drop sharply. This is the phenomenon of thrashing [NUTT 1997].

Problem #9:
Show that the number of nines in the steady-state availability A is given by $-log_{10}(1 - A)$.

Problem #3:
Write the mean-value function of a finite failure NHPP software reliability growth model as

$$m(t) = aF(t)$$

so that $F(t)$ has properties of a distribution function. Now derive equation (8.81) so that $h(t)$ is the hazard rate of $F(t)$. Plot $h(t)$ and $\lambda(t)$ vs. t for the Goel-Okumoto, generalized Goel-Okumoto, and log-logistic models.

Problem #5:
For the parallel redundant system with non-zero detection delay (Example 8.21), compute and plot the percentage of downtime contributed by state $1D$ as function of $1/\delta$ for several different values of $t_{th} \geq 0$. Assume that state $1D$ is a down state. Also separate out two components of the equivalent vailure rate λ_{eq} in the same way.

Problem #6:
For the WFS example, plot the steady-state , instantaneous, and interval availabilities as functions of time.