# EXAM–1 Fault Tolerant Systems 03/11/2002

## READ CAREFULLY BEFORE BEGINNING

1. This exam comprises 25% (400 level) or 20% (500 level) of your total grade. Points are indicated for each question/section.
2. This is an **closed book, closed notes** exam.
3. On-campus: You have **50** minutes to finish.
4. Video: You have **55** minutes to finish.
5. Make sure your copy has **7** questions.
6. Read each question completely before answering. Be sure you understand all assumptions and constraints. **Show all work and state all assumptions**. Partial credit can not be given for work not shown. Use the back of the page, if necessary.

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|---|---|
| REG MAXIMUM | 100 |
| DEDUCTIONS | − |
| **TOTAL SCORE** | |

PRINTED NAME _____

1. (15 pts) Definitions and terms:

   (a) (3 pts) Define *Reliability* $Q(t)$.

   (b) (3 pts) Define *Fault*

   (c) (3 pts) Define *Error*

   (d) (3 pts) Define *Failure*

   (e) (3 pts) What is the difference between a *transient* fault and and *intermittent* fault?

2. (15 pts) Redundancy

(a) What is the difference between *passive* redundancy and *active* redundancy?

(b) Assume we have a TMR and want to combine the results.

i. Show how a Flux Summer works. (Assume we are controlling a motor).

ii. Give the circuit of a 1 bit majority voter using only AND and OR gates.

3. (20 pts) This question relates to cyclic codes.

   (a) Given message $M$, and generator $G$ of degree $n$, describe mathematically, how cyclic codes work. Remember, that on both sides, the transmitter and receiver, the operations involves dividing by the generator. Denote the transmitted messages together with the frame check sequence with $T$, just as we did in the class notes.

   Start out with $(2^n M)/G =$ and look only at the error-free case, i.e. the case when there is no remainder.

   (b) Assume $G(X)$ has at least 3 terms. List at least three kinds of errors that can be detected.

   (c) If the degree of $G(X)$ is $n$, and all error patterns are likely, what is the probability that a long burst error is not detected?

(d) Assume a 3-bit FCS using the generator $G(X) = X^3 + X + 1$.

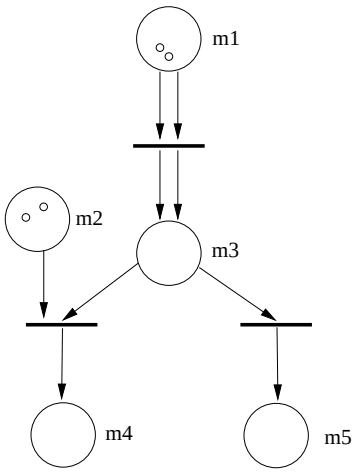
i. (6 pts) Draw the shift register circuit.

ii. (5 pts) Calculate the FCS for message 10101.

4. (10 pts) This question deals with Petri Nets:

   (a) A Petri Net is defined by a 5-tuple $\{P, T, A, W, M_0\}$. Define $P$, $T$, $A$, $W$, and $M_0$.

   (b) Given the following Petri Net, show the reachability graph.



5. (15 pts) A control system has 3 processors of type A and 4 processors of type B. The minimal allowable system configuration requires a single processor of each type.

   (a) Draw the Reliability Block Diagram for this system.

   (b) Draw the Fault Tree for this system.

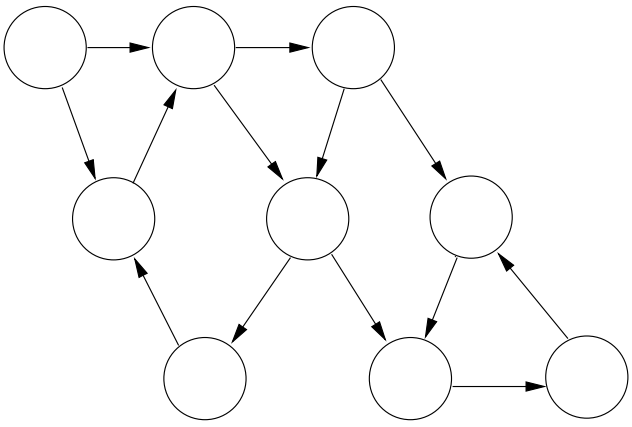
   (c) Draw a Petri Net that represents this system. Use descriptive pace names and clearly indicate your initial marking! (If this net gets big, you made a mistake). The fail rate for both types of processors is $\lambda_A$ and $\lambda_B$ respectively.

6. (15 pts) Markov model questions:

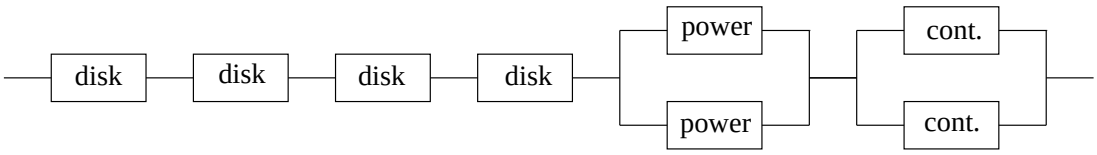
   (a) Assume a 2-of-4 processor system. Processors can either fail with $\lambda_{error}$ producing an error, or they can fail benign with $\lambda_{stop}$. Draw the Markov chain considering the two failure model. Clearly indicating fail rates and fail states.

   (b) Define *recurrent state* of a Markov chain.

   (c) In the following Markov chain, indicate recurrent and non-recurrent states by writing $R$ and $N$ in the states respectively.



7. (10 pts) A RAID system (Redundant Array of Inexpensive Disks) consisting of 4 disks, 2 controllers and 2 power supplies. All 4 disks, at least 1 controller, and at least 1 power supply are needed for the system to function. The RGB is shown below.




Assuming that all 8 components (disks, controllers, power) have the same fail rate $\lambda = 10^{-5}$. Derive $R(t)$ and then the MTTF. Show your derivation and give the numeric result!
(Hint: take advantage of the fact that $R_{controller}(t) = R_{power}(t)$).

# Extra Workspace