National Taiwan University

Department of Electrical Engineering

Fault Tolerant Computing

Midterm Exam, Nov. 19, 2018

This is an open book exam. Feel free to consult any book, article, or notes. However, you cannot give or receive help from others during this examination period. All forms of calculating devices are permissible, so use them as you see fit. Please sign below, indicating that you agree with these terms. Return this signed page with your completed answers. Solve all problems. Show your work and clearly mark your final answer.

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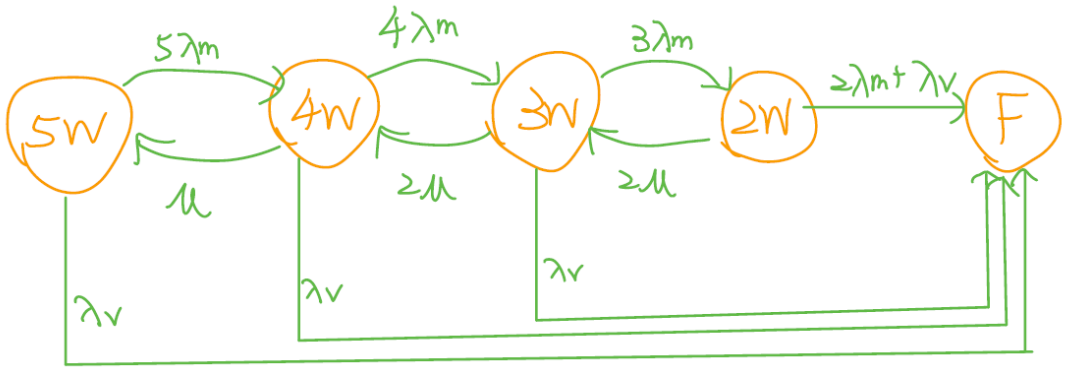
Signature:_____吳辰鋐_____

1. path may be
   HDEF HDI AGF ABDEF ACDEF ABDI ACDI

   Assume each module of reliability is R
   $R_{system} <= 1-(1-R_HR_DR_E R_F)(1-R_HR_DR_I)(1-R_AR_GR_G)(1-R_AR_BR_DR_ER_F)(1-R_AR_CR_DR_ER_F)(1-R_AR_BR_DR_I)(1-R_AR_CR_DR_I)$
   $= 1-(1-R^4)\,(1-R^3)\,(1-R^3)\,(1-R^5)\,(1-R^5)\,(1-R^4)\,(1-R^4)$
   $= 1-(1-R^5)^2\,(1-R^4)^3(1-R^3)^2$

2.



3. (a)2 因為五個投票決定，最多可以容忍兩個錯誤的結果而仍然投票正確
   (b)4 一次僅運作一個，若壞掉再進行替換，所以最多可壞掉 4 個
   (c)3 一次運作兩個，若壞掉再進行替換，所以最多可壞掉 3 個

4.

(1) $e^{-\lambda \times 3} = 0.73 \Rightarrow \lambda = 0.1049035$

(2) $1/0.1049 = 9.532$ (year)

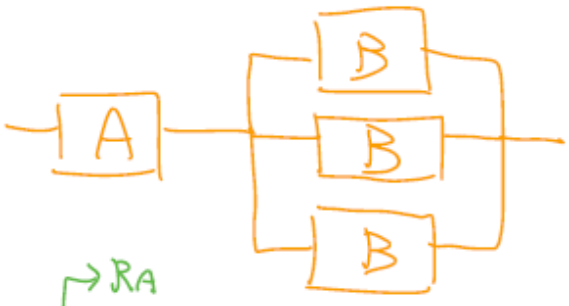
(3) MTTR + MTTF = MTBF $= 9.532 + (2/365) = 9.537$ (year)

(4) $R(1) = e^{-\lambda} = e^{-0.1049035} = 0.900411334611$

$1 - (1 - R(1))(1 - R(1)) = 0.990082$

$1 - 0.990082 = 0.9917\%$ #

5.

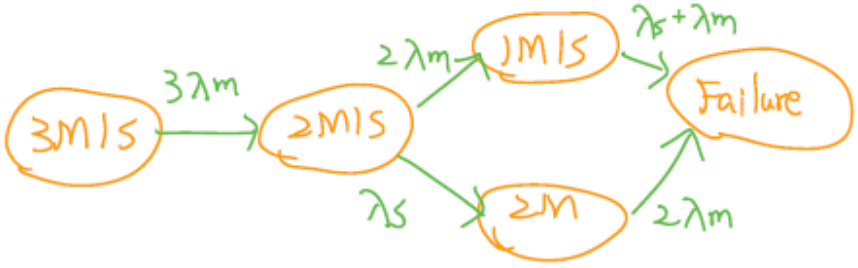


R_A

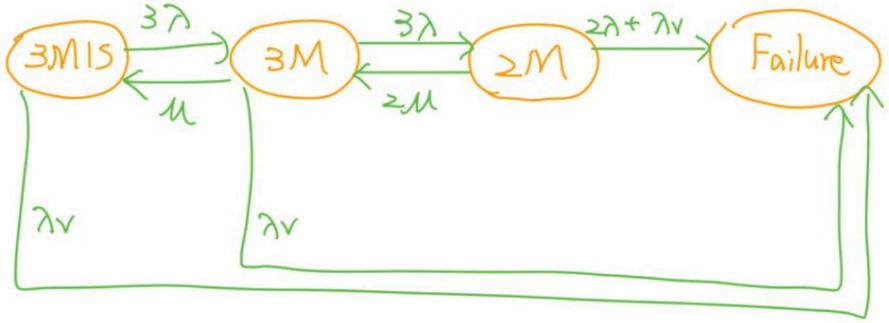
$0.99 \times [1 - (1-0.85)(1-0.85)(1-0.85)] = 0.986 > 0.98$

6.

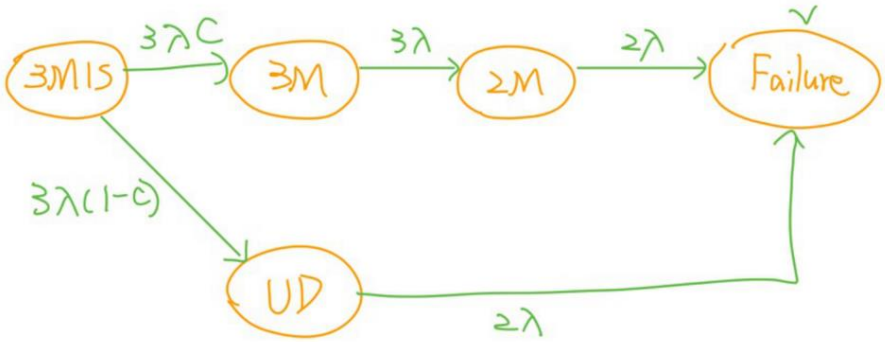
(a)



(b)



(c)



7.

8.

a	b	c	f(a.b.c)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

都是 0，不是 self-dual

9.

(a) $1-(1-e^{-\lambda})^3 = 1-\left[1-e^{-3\lambda}+3e^{-2\lambda}-3e^{-\lambda}\right]$

$= e^{-3\lambda} - 3e^{-2\lambda} + 3e^{-\lambda}$

(b) Exponential distribution ∵ constant failure rate
(module 3 P79)

(c) Poisson distribution ∵ failure rate is λt
(module 3 P77)

10.

(a) -> Ans.(3)

第一項表示四個 module 都正常，第二項表壞掉一個，第三項表壞掉兩個，但並不是任意壞掉兩個皆能正常運作，必須扣除壞掉 2,3 的情況，其餘皆仍可正常運作

(b)

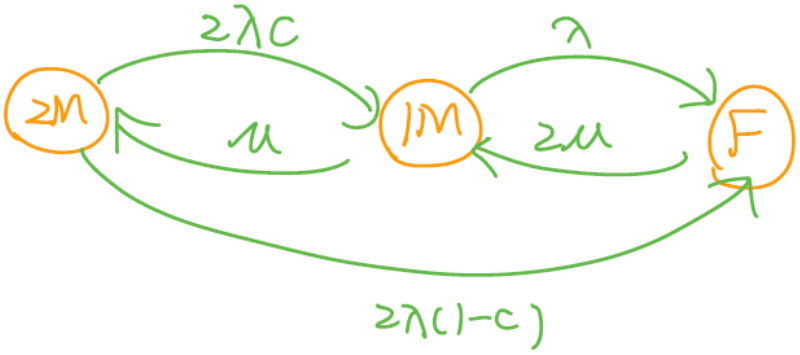
$R^4 + (1-R)R^3 \times 4 + (1-R)^2R^2 \times C \times 4 + (1-R)^2R^2$

a2、a3、12、13　　a1

$= 4cR^4 - 8cR^3 + 4cR^2 - 2R^4 + 2R^3 + R^2$

11.

(a)



(b)

$$\begin{cases} 2\lambda P_2 = \mu P_1 & -- (1) \\ 2\lambda(1-C)P_2 + \lambda P_1 = 2\mu P_F & -- (2) \\ P_2 + P_1 + P_F = 1 & -- (3) \end{cases}$$

(1) $\because \lambda/\mu = 0.5 \quad \therefore P_1 = P_2$

$\rightarrow$ (2) $\dfrac{P_1(\lambda + 2\lambda(1-C))}{2\mu} = P_F = \dfrac{P_1 + 2(1-C)P_1}{4}$

$\rightarrow$ (3) $\dfrac{P_1(9 + 2(1-C))}{4} = 1 \Rightarrow P_1 = \dfrac{4}{9+2(1-C)}$

$\rightarrow P_1 + P_2 = \dfrac{8}{11-2C}$ #

12.

(a)圖中黑箭頭表 message

橘箭頭表 ack/RSN

綠箭頭表 ack

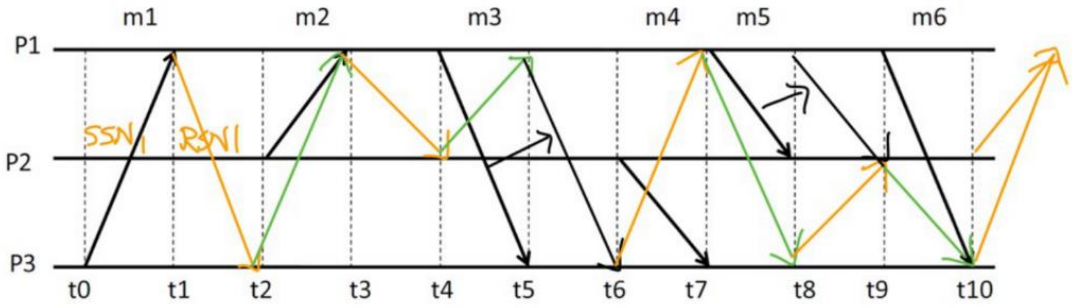


Figure 1: Process communication diagram

PS. Log 會由左至右不斷累積，但版面問題只寫出與該段時間有關係的部分

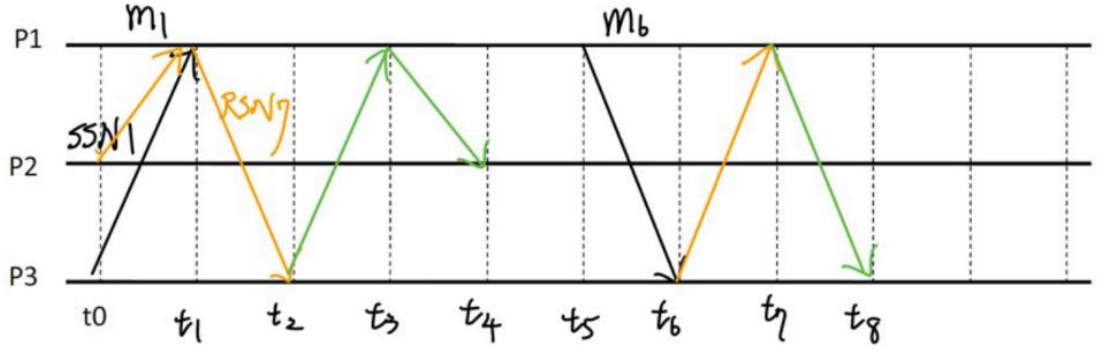
(a)

P_1	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
SSN	1	2	2	3	3	3	4	5	5	6	7	7
RSN	1	1	2	2	3	3	3	4	4	5	5	7
T_i'	ϕ	1	1	2	2	2	2	2	2	2	2	2
T_i''	ϕ	ϕ	1	1	2	2	2	2	2	2	2	2
log	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	(m_3, P_3, SSN_3)	(m_3, P_1, SSN_3)		(m_5, P_2, SSN_5)	(m_6, P_3, SSN_6)	(m_5, P_1, SSN_5) (m_6, P_1, SSN_6)

P_2	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
SSN	1	2	2	3	3	3	4	5	5	6	7	7
RSN	1	1	2	2	3	3	3	4	4	5	5	7
T_i'	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	5	5	5
T_i''	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	5
log	ϕ	ϕ	ϕ	(m_2, P_1, SSN_2)	(m_2, P_2, SSN_2)			(m_4, P_3, SSN_4)		(m_4, P_2, SSN_4)		

P_3	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
SSN	1	2	2	3	3	3	4	5	5	6	7	7
RSN	1	1	2	2	3	3	3	4	4	5	5	7
T_i'	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	3	4	4	4	6	6
T_i''	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	3	3	4	4	6
log	ϕ	(m_1, P_1, SSN_1)	(m_1, P_3, SSN_1)									

(b)



t0:Reset P3
t1:P2 根據在(a)t9 收到的 m5 發出 RSN_5 給 P1，而同時 P3 檢查 log 發現有一組完整的訊息(m1,P1,SSN1)(m1,P3,SSN1)，因此馬上開始進行補送 m1、SSN1 到 P1
t2:P1 收到 m1 後根據現在 RSN 為 7，因此回傳 RSN7 和 ack 到 P3(此時 RSN+1=8)，並改變 m1 的 T''為 7，而 RSN6 則進入 queue 中
t3:P3 回傳 ack 到 P1
t4:P1 可以再傳出訊息了，因此將在 queue 內 RSN6 的 ack 回傳至 P2
t6:P1 剛在(a)t9 傳的 m6 一直沒收到回饋，因此隔 5 秒後再傳一次 m6，T3'改為 6
t7:P3 收到 m6，T3''改為 8，回傳 RSN8
t8:P1 回傳 ack 至 t8