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**CSCI586 Fault Tolerant Computing**

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**Homework 1**

1. Why does the fault tolerance issue become more and more important in the high performance computing field?

In order to accommodate the ever increasing requirement for faster and more capable high performance computing (HPC) environments, there are two general approaches to increase computing power. First, simply use faster and more capable machines. Second, include more modules - cores, memory, controllers, etc - to split the tasks among.

This second approach presents the challenge that the failure of any module in a classical computing environment causes the system as a whole to fail. When there are relatively few modules in a system this is acceptable, but as the size of the system grows the average time it takes for any one module in the system to fail shrinks. Building systems able to gracefully handle faults in component modules is required for the very large systems of the present and will be even more important in the future.

Creating a dependable HPC environment requires a system to avoid faults before they happen and recognize them when they do, but then mask the faults when appropriate and tolerate as many errors as possible. Creating a fault tolerant computing system will ensure the system can fulfill the task it is attempting to perform.

2. MTTF calculations

(a) **MTTFTMR = MTTF 2/3 system = ?**  
Eq 1: MTTF =   
Eq 2: RTMR(t) = Odds TMR is functioning at time t

RTMR(t) = P(None have failed) + P(Only A failed) + P(Only B failed) + P(Only C failed)

RTMR(t) = RA(t)RB(t)RC(t) + [1-RA(t)]RB(t)RC(t) + RA(t)[1-RB(t)]RC(t) + RA(t)RB(t)[1-RC(t)]

Since in our TMR system each component is similar, RA(t) = RB(t) **=** RC(t)

RTMR(t) =

RTMR(t) =

RTMR(t) =

Eq 3: Eq1, Eq2 => MTTFTMR=   
Eq 4: R(t) =   
Since our modules follow the exponential failure law  
Eq 5: Eq3, Eq4 => MTTFTMR=   
MTTFTMR= |

MTTFTMR=

MTTFTMR=  
 **MTTFTMR=**

This result means that a TMR system will have a system MTTF 1/6 less than a single component by itself, assuming all individual modules have the same failure rate.

**(b) MTTF 1/3 system = ?**  
Eq 1: MTTF =   
Eq 2: R1/3(t) = Odds TMR is functioning at time t

R1/3(t) = 1 - [Odds TMR has stopped functioning at time t]

R1/3(t) = 1 - P(All have failed)

R1/3(t) = 1 - [1-RA(t)][1-RB(t)][1-RC(t)]

Since in our TMR system each component is similar, RA(t) = RB(t) **=** RC(t)

R1/3(t) =

R1/3(t) =

Eq 3: Eq1, Eq2 => MTTFTMR=   
Eq 4: R(t) =   
Since our modules follow the exponential failure law  
Eq 5: Eq3, Eq4 => MTTFTMR=   
MTTFTMR= |

MTTFTMR=

MTTFTMR=  
 **MTTFTMR=**

This result means that a 3 module parallel system will have a system MTTF 5/6 more than a single component by itself, assuming all individual modules have the same failure rate.

**(c) Using = hours**

(i) MTTF 1 of 1 system = = 10000 hours

(ii) MTTF 1 of 3 system = = 18333.33 hours

(i) MTTF 2 of 3 system = = 8333.33 hours