Test #2 (open books/notes)

I pledge that this test has been completed in compliance with the Graduate Honor Code and that I have neither given nor received any aid on this test.

Student Name: _________________________________________________________

Multiple – Choice Problems. Select one correct answer in each problem. Problems #1-#10 are each worth 6 points. Problems #11-#15 are each worth 8 points.

1. Which one of the following statements is false regarding Stochastic Petri net (SPN) modeling?
   (a) the reachability graph of an SPN may contain a vanishing marking
   (b) SPNP cannot solve a SPN model with an infinite number of states
   (c) an input place to only timed transitions definitely will have a corresponding component in the state representation in the underlying Markov chain
   (d) an input place to only immediate transitions definitely will not have a corresponding component in the state representation in the underlying Markov chain
   (e) it is possible that the reachability graph is exactly the same as the underlying Markov chain

2. Which of the following cannot be solved by SPNP to obtain its performance measures?
   (a) M/M/b/m
   (b) M/M/1/m
   (c) M/M/1
   (d) a closed product-form queueing network model with exponential service times and inter-arrival times
   (e) a k-out-of-n system with exponential failure and repair times per component

3. Consider the SPN model below corresponding to the underlying Markov model to the right of it. State OP means that the system is up, state FU means that the system fails unsafely
and thus is down permanently, and state \textbf{FS} means that the system is down only temporarily since it fails safely and can be reconfigured to be operational again in state \textbf{OP} after repair. Initially there is a token in place \textbf{OP}. How many markings will be generated in the reachability graph from this SPN?

(a) 3  
(b) 4  
(c) 5  
(d) 6  
(e) 7

4. Continued from the last problem, Which performance measure can be calculated with the following reward assignment?

\begin{verbatim}
if (mark("OP")) return 0;
else return 1;
\end{verbatim}

(a) availability  
(b) unavailability  
(c) safety  
(d) unsafety  
(e) unreliability

5. For case study \#2, “Dynamic quota-based admission control with subrating in multimedia servers,” suppose that the following reward function is defined based on the SPN model for dynamic with subrating (Figure 2 on slide \#199).

\begin{verbatim}
reward_type unknown()
{
  if (mark("RL") == 0 && mark("RS") == 0) return (1.0);
  else return(0.0);
}
\end{verbatim}

What performance measure are we getting when \texttt{expected(unknown)} is called in an SPNP program?

(a) reward rate due to departing low-priority clients with low QoS  
(b) reward rate due to departing low-priority clients with high QoS  
(c) rejection probability of arriving high-priority clients  
(d) rejection probability of arriving low-priority clients  
(e) rejection rate of arriving low-priority clients
6. For case study #3, “Analysis of replicated data with repair dependency,” which of the following is not true?
   (a) The underlying Markov chain does not contain any vanishing marking.
   (b) Under the frequent update assumption, a failure will trigger an update event.
   (c) Under the frequent update assumption, a repair will trigger an update event.
   (d) Figure 1 implies that the local status-update actions taken by each site will take zero time.
   (e) For all dependent repairman models, the Petri net model developed allows only one repair transition to be enabled at a time in order to control the repair order.

7. For paper [P1] entitled “On Survivability of Mobile Cyber Physical Systems with Intrusion Detection,” which of the following is not true regarding the SPN model shown in Figure 2?
   (a) when place energy does not have a token, the system enters an absorbing failure state.
   (b) when the number of tokens in place Nb is greater than or equal to 1/3 of the total number of tokens in place Ng and place Nb, the system enters an absorbing failure state.
   (c) in the initial state at t = 0 the only transitions that are enabled are TCP and TFP.
   (d) the transition rate of TFP depends on the number of detectors m.
   (e) the transition rate of TIDS depends on the number of detectors m.

8. For paper [P2] entitled “Reliability of Autonomous IoT Systems with Intrusion Detection Attack-Defense Game Design,” Figure 1 shows the SPN model for the case in which $\beta = 1$ such that a single mismatch of the vote cast by a node during IDS voting against the auditing vote outcome will drain the life quota of the node and evict it from the system. Suppose you assign a reward of 1 to states in which the number of tokens in place $N_1^b$ is at least 1/3 of the total number of tokens in places $N_1^b$ and $N_g$, and a reward of 0 otherwise. What would be the physical meaning of the expected reward at time $t$?
   (a) unreliability for Byzantine failure at time $t$
   (b) reliability for Byzantine failure at time $t$
   (c) unavailability for Byzantine failure at time $t$
   (d) availability for Byzantine failure at time $t$
   (e) mean time to Byzantine failure

9. For paper [P3] entitled “Lightweight Misbehavior Detection Management of Embedded IoT Devices in Medical Cyber Physical Systems,” the authors compare MedIoT with SVM and KNN in terms of effectiveness and efficiency performance metrics. Which of the following is not an effectiveness performance metric?
   (a) false positive probability
   (b) false negative probability
10. For paper [P4] entitled “Modeling and Analysis of Attacks and Counter Defense Mechanisms for Cyber Physical Systems,” for the SPN model shown in Fig. 2, which of the following is the correct reward assignment for calculating the reliability of the system $R(t)$ as the expected reward at time $t$?

(a) if (mark("PATRIT") == 1) return 0; else return 1;
(b) if (mark("PATRIT") == 1) return 1; else return 0;
(c) if (enabled("TATTRIT") || enabled("TATTRITA") || enabled("TPERVADEC") || enabled("TPERVADEA") || enabled("TLEAKC") || enabled("TLEAKS")) return 1; else return 0;
(d) if (mark("PATRIT") == 0 && mark("PLEAK") == 0 && mark("PPERVADE") == 0) return 1; else return 0;
(e) if (mark("PATRIT") == 1 || mark("PLEAK") == 1 || mark("PPERVADE") == 1) return 1; else return 0;
11. The SPN model above contains 4 places and 7 transitions. Note the following: (a) only \( t_7 \) is an immediate transition; (b) the transition rates of \( t_1, t_2 \) and \( t_6 \) are fixed (rates are given in the figure), while the transitions rates of \( t_3, t_4, \) and \( t_5 \) are marking-dependent (also specified in the figure); (c) only transition \( t_6 \) is associated with an enabling function; and (d) the arc multiplicity, if not equal to 1, is shown explicitly in the figure.

Suppose the initial state is \((P_1, P_2, P_3, P_4) = (4, 0, 0, 0)\). What is the set of states in the underlying Markov model?

(a) \((4,0,0,0),(2,0,2,0),(0,0,4,0),(2,2,0,0),(0,4,0,0)\)
(b) \((4,0,0,0),(2,0,2,0),(0,0,4,0),(2,2,0,0),(0,2,2,0),(0,4,0,0)\)
(c) \((4,0,0,0),(2,0,2,0),(0,0,4,0),(2,2,0,0),(0,2,2,0),(0,2,0,2),(0,4,0,0)\)
(d) \((4,0,0,0),(2,0,2,0),(0,0,4,0),(2,2,0,0),(0,2,2,0),(0,2,0,2),(1,2,0,1),(0,4,0,0)\)
(e) \((4,0,0,0),(2,0,2,0),(0,0,4,0),(2,2,0,0),(0,2,2,0),(0,2,0,2),(1,2,0,1),(0,4,0,0),(0,0,0,4)\)
12. Consider the SPN model above with the initial state being \((P_1, P_2, P_3) = (4, 0, 1)\). What is the set of states in the underlying Markov model?

(a) \((4,0,1), (0,0,2), (6,0,0)\)
(b) \((4,0,1), (2,0,2), (6,0,0)\)
(c) \((4,0,1), (2,0,2), (7,0,0)\)
(d) \((4,0,1), (2,0,2), (0,0,3), (7,0,0)\)
(e) \((4,0,1), (2,0,2), (0,0,3), (6,0,0)\)
reward_type unknown()
{
    if (mark("buf")<3) return (mark("buf")*mu);
    else return (3*mu);
}

13. Refer to the M/M/3/8 SPN model for HW #3, problem #1 as posted on the class website. If we assign rewards to markings of the SPN model based on the above reward function (where $\mu$ is the per-server service rate and $buf$ is the place that holds the number of customers), the expected cumulative reward over $[0,t]$, i.e., $\text{cum\_expected(unknown)}$, under this reward assignment is equal to:
   (a) expected throughput at time $t$
   (b) expected number of customers completed over $[0,t]$
   (c) reliability at time $t$
   (d) mean time to failure
   (e) expected system up time during $[0,t]$
14. Refer to the SPN model for HW #3, problem #2(a) where each component (CPU or MM) has an independent repair facility, as posted on the class website. Suppose you want to use the same SPN model for availability analysis. Assume a component (CPU or MM) can still fail when the system is down. What is the change you need to make to the SPN model in order to report availability at time $t$, i.e., $A(t)$, using the `expected()` function call?

(a) remove all enabling functions
(b) remove the enabling functions associated with CPU repair and failure transitions
(c) remove the enabling functions associated with MM repair and failure transitions
(d) remove the enabling function associated with the CPU repair transition
(e) remove the enabling function associated with the MM repair transition
reward_type unknown()
{
    if (!enabled("T6") && mark("RS") == 0) return (1.0);
    else return (0.0);
}

15. Refer to the SPN model for HW #3, problem #3 as posted on the class website. If we assign rewards to markings of the SPN model based on the above reward function (where T6 is the transition from SL to SLL and RS is a place holding free slots with 2 tokens representing one slot), the expected reward at steady state, expected(unknown), under this reward assignment is equal to:

(a) the average number of low-priority, high-QoS clients
(b) the average number of low-priority, low-QoS clients
(c) the average number of high-priority clients
(d) the rejection probability of low-priority clients
(e) the rejection probability of high-priority clients