5. Laboratory 6 – generalized stochastic Petri nets (GSPN)

5.1. Theoretical introduction

5.1.1 Definition of GSPN

The formal definition of Generalized Stochastic Petri Nets (GSPN) is as follows:

Definition 10. Generalized is 7-tuple:

$N = <P, T, F, H, \Pi, W, M_0>$

where:

P - a set of place,

T - a set of transitions; let us assume also that T_i – a sub set of immediate transitions, T_t – a sub set of timed transitions,

$F \subseteq (P \times T) \cup (T \times P)$ - a set of arcs,

$H \subseteq (T \times P)$ - a set of inhibitor arcs,

Π: $T \rightarrow N$ – priority function (N – natural number); for timed transition Π *(timed transition) =0* (lowest priority), for immediate one Π *(immediate transition)* ≥ 1,

$W: T \rightarrow R$ – is a function that associate R (real value) to the transition:

- for timed transitions: a (possible marking dependent) rate of negative exponential distribution specifying the firing delay,
- for immediate transition: a (possible marking dependent) firing weight,

$M_0: P \rightarrow N$ - an initial marking function.

The main differences between definitions 1. and 10. are:

- definition of the weight function for arcs is omitted in def. 10. (it is assumed that it is equal to 1),
- definition of the place capacity function is omitted in def. 10. (no restrictions on capacity of places),
- the priority function and W function are defined for transition in def. 10.

More information can be found in the lecture or in [BLP07].

5.1.2 Control task

5.1. A Petri net tool Pipe 2.5 is described in [BLP07]. Please compare the 10th definition with the definition given in [BLP07] (see Figure 5.1) and explain the differences. Are the definitions congruent?

$$GSPN = (S, T, \Pi, I, O, H, M_0, W)$$

where

- S is a set of places
- T is a set of transitions, $S \cap T = \emptyset$
- $I, O, H : T \to N$ $(N = S \cup T)$, are the input, output and inhibition functions
- $M_0 : S \longrightarrow \mathbb{N}$ is the initial marking
- $\Pi : T \longrightarrow \mathbb{N}$ is the priority function that associates the lower priorities to timed transitions and higher priorities to immediate transitions. Immediate transitions therefore always have priority over timed ones.
- $W : T \to R$ is a function that associates a real value to the transitions. $w(t)$ is:
  - a (possibly marking dependent) rate of a negative exponential distribution specifying the firing delay, when transition t is a timed transition (represented by a hollow rectangle).
  - a (possibly marking dependent) firing weight, when transition t is immediate (represented by a filled rectangle).

Fig.5.1. GSPN definition, source [BD91]

5.2. Let us assume, that t1 $\in$ T_i and t2 $\in$ T_t are enable. Which one of them will be fired? Explain your answer.

5.3. Please discuss the GSPN shown in Figure 5.2. (explain the meaning of the symbols, indicate the timed transition, etc.).

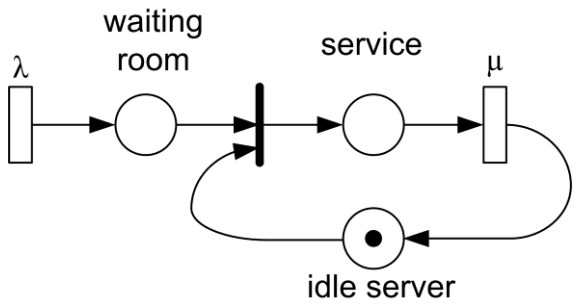

Fig.5.2. GSPN definition, source [M]

5.4. Explain the main differences between timed transitions in GSPN and TPN.

5.5. Explain: „M/M/1 queue".

5.2 Laboratory part

T5.1. GSPN model for handling of requests to the web server

We have one WWW Server and one backup server. Two ways to requests handling is shown in Fig. 5.3.:

a) handling by the primary server,

b) handling by the primary and backup server (as hot spare).

Service of requests shall be in accordance with the model of M/M/1 queue.

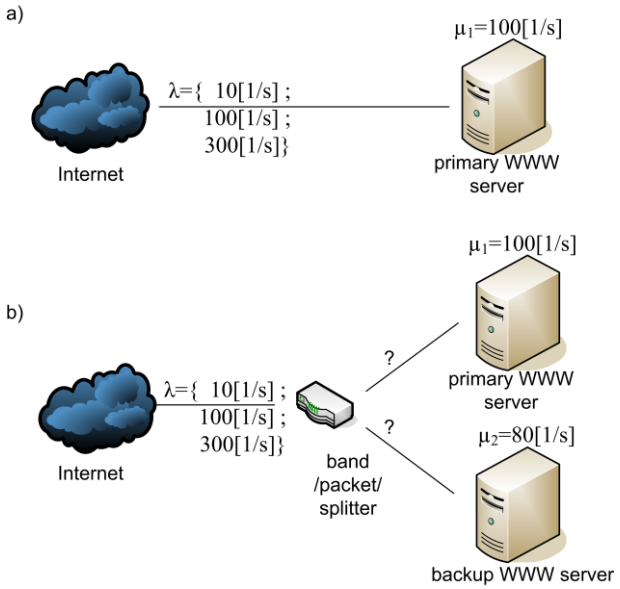

Fig.5.3. Request handling by a) one WWW server, b) two WWW servers

Basic tasks:

a) prepare GSPN model for system given in Fig. 5.1 a),

b) make an analysis of GSPN for given λ and explain results.

Additional tasks:

c) prepare GSPN model for system given in Fig. 5.1 b)

d) specify optimal rules for band splitter (based on GPSN simulations results).

T5.2. GSPN model for a cooling system of warp-speed generator

Let us assume, that spaceship „Enterprise" („Star Trek" series) uses two independent cooling subsystems for warp-speed generator. For each subsystem, the time to failure is described by exponential random variable with parameter λ=0,0001. Repair time is described by exponential random variable with parameter μ=0,001. Only one subsystem can be repaired at a time.

Prepare GSPN modeling cooling system, knowing that the spaceship is out of warp-speed due to two cooling subsystems failure. Make analysis and explain result .

6. References

[1] http://en.wikipedia.org/wiki/Bipartite_graph

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[BD91] B. Berthomieu and M. Diaz, *Modeling and Verification of Time Dependent Systems Using Time Petri Nets*, IEEE Transaction of Software Engineering, vol. 17, no. 3, march 1991

[MS06] J. Magott, P. Skrobanek, Partially automatic generation of fault trees with time dependencies, in: Proc. Dependability of Computer Systems, DepCoS-RELCOMEX '06, Szklarska Poręba, Poland, IEEE Computer Society Press, 2006, 43-50

[BLP07] Bonet P., Lladó C. M., Puigjaner R., Knottenbelt W., PIPE v. 2.5: a Petri Net Tool for Performance Modeling, Palma de Mallorca, Universitat de les Illes Balears, Spain, 2007; http://www.doc.ic.ac.uk/~wjk/publications/bonet-llado-knottenbelt-puijaner-clei-2007.pdf

[M] Marsan M. A., Stochastic Petri Nets: An Elementary Introduction, Universitá di Milano, Italy; http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.110.2081&rep=rep1&type=pdf

More information is given in references to the lecture.