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Procedia Technology 22 (2016) 623 – 628

Procedia Technology

9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania

Fault Tolerant Control Multiprocessor Systems Modelling Using Advanced Stochastic Petri Nets

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Abstract

Power systems need a safe management and power control. This means they are fault tolerant systems and specially need a strong safety of the processors, which have one of the most important tasks of the control. The paper presents how a processor can be modeled, what types of failures can appear in the functional state and the availability advanced modeling using discreet stochastic events models. The advanced Stochastic Petri Nets model proposed and used in this paper has a strong modeling power and this will be proved in comparison with classical availability models.

Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering

Keywords: Distributed power systems; Control; Stochastic Petri Nets; Processor Availability; Dependability.

1. Introduction

Renewable systems power management and control is an application requiring high availability. These types of systems need modelling and computing of the various dependability measures, so many model types have been developed.

Is well known dependability is a measure of quality, correctness and continuity of service delivered by a system. Dependability encompasses measures such as reliability, availability and risk. The dependability models are different from one another taking in account their modelling power. Modelling power is very much determined by the types of dependencies within subsystems that can be computed. For instance, if various components of a system

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Peer-review under responsibility of the "Petru Maior" University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2016.01.129

share a repair dependency among components, than Stochastic Petri Nets (SPN) can easily model such a repair dependency [1,2,3].

The usual dependability model types, according with Malhotra and Trivedi [4], Puliafito et al. [5], are the following: reliability block diagrams (RBD); fault trees without repeated events (FT); fault trees with repeated events (FTRE); reliability graphs (RG); continuous-time Markov chains (CTMC); generalized stochastic Petri nets (GSPN) and the proposed simplified SPN model, Logical Explicit Stochastic Petri Nets (LESPN).

Malhotra and Trivedi [4] has been shown that a RBD is equivalent to a FT. In Trivedi [3] has been presented the algorithm to convert the RBD model type into FT model type and the counter-assertion. The FTRE possesses higher modelling power than FT or RBD because any RBD or FT model can also be modelled by a FTRE. Any FT can be converted to a RG. In the paper Malhotra and Trivedi [4] is presented this conversion algorithm, but also that not every RG can be converted to an equivalent FT. Since FT is equivalent to RBD, this also proves that not every RG can be converted to an equivalent RBD. Any RG can be converted to an equivalent FTRE, so in Malhotra and Trivedi [4] is presented the converting algorithm, but also that the FTRE to RG converse is not true.

Markov models can handle some dependencies in a system, which combinatorial models cannot, according with Fricks and Trivedi [6], Murata [7]. Repair-dependency cannot be modeled by any combinatorial model type, but a CTMC and a GSPN model can easily model such dependency. Trivedi [3] has been shown that CTMC model is equivalent to GSPN model. For every GSPN model, an equivalent CTMC exists and vice-versa. Malhotra and Trivedi [4] present the GSPN to CTMC conversion algorithm and also the CTMC-GSPN conversion algorithm. The overall hierarchy of dependability model types is shown in Fig. 1.

Section 2 presents the fault-tolerant multiprocessor system (FTMS) and its GSPN dependability-model type. In section 3 we present the algorithm to develop the model -Logical Explicit Stochastic Petri Nets (LESPN)- for the FTMS. Section 4 presents the comparative study of the LESPN model and GSPN model for FTMS.

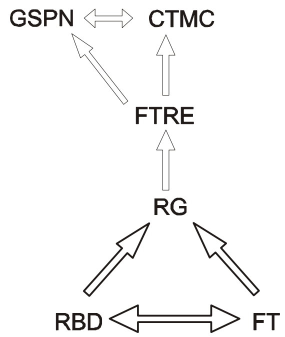

Fig. 1. Power hierarchy among the dependability model types.

2. GSPN modeling FTMS dependability

Fig. 2 shows the fault-tolerant analyzed multiprocessor system (FTMS) having a shared memory M3. The multiprocessor construction has two processors P1 and P2, each with a private memory M1 and M2 respectively. A processing unit consists of a processor and its memory and both processing units are connected to a mirrored-disk system. They are connected via an interconnection network N.

The proposed system is functional while N is functional and at least one of the processing subsystems is functional too. For a processing subsystem to be functional, the processor, the memory module and at least one of the two disks must be functional.

In the fault tolerant systems dependability modelling, have to be represented random variables as functional time, repair time. A SPN is able to associate a time random variable to the timed transition and also an exponential low for the random variable „time of the transition execution”. In Malhotra and Trivedi [4] for availability computing of the multiprocessor has been proposed the generalized stochastic Petri net model, which allows using timed stochastic transitions and also immediate transitions (no-timed). According with Puliafito et al [5], GSPN has two types of