1 Introduction

TimeNET is a software tool for the modeling and analysis of stochastic Petri nets with non-exponentially distributed firing times. It provides a graphical user interfaces to create various kinds of Petri nets models including GSPNs, eDSPNs, stochastic colored Petri nets, and Markov chains. The models can be evaluated for their performance and reliability with numerical analysis methods as well as simulation.

The goal of this report is an annotated bibliography of TimeNET-related papers. It does not cover publications by the group of contributors and authors of TimeNET, which can be found in the TimeNET web page as well as the individual home pages. This document should serve as an overview of examples and areas in which users have published successful applications of the tool, or in which the tool is compared with others or its modules are being used as part of other tools. The document is based on a literature search covering mainly IEEE Xplore and the ACM Digital Library, after which a classification scheme for topics has been set up. Each section lists papers for a certain area with a reference and some notes on the contents.

If there are missing papers or newer related publications that have not yet been included at the time of writing, please contact Armin Zimmermann at armin.zimmermann@tu-ilmenau.de for future updates of this document.

2 Application Areas

The bibliography uses the following topics as sorting criterion, although it should be noted that for many papers there is no clear characterization possible: Quantitative Evaluation of Systems, Parallel and distributed Systems, Robotics and Automation, Discrete-Event Systems, Security, Reliability and Dependability, Software and Systems Engineering, Communication System and Networks, Computer Performance, and Manufacturing.
2.1 Quantitative Evaluation of Systems

This section lists the papers that belong to Quantitative Evaluation of Systems.


**Aim:** This paper describes an automated approach for applying rare event simulation to stochastic Petri net (SPN) models of highly reliable systems. A formal algorithm is presented that obtains the required information from the high-level SPN description, without generating the full state space.


**Aim:** This paper presents a demo tool that introduces the new DSPN solver that was developed, and which has been inserted in GreatSPN. With the occasion also a new GSPN solver has been added, which allows for more flexibility in the net definition, and an easier integration with other tools.


**Aim:** The paper focuses on a reliable statistical analysis and the application of variance reduction techniques in a parallel, distributed simulation framework. It examines the application of variance reduction with control variates and shows an approach for their automatic selection in Petri net models.

Aim: In this paper, the theory of stochastic classes is extended which provides a close form calculus for the derivation of the state density function under the assumption that all transitions have an expolynomial distribution.


Aim: This paper presents the simulator CINSim. It was developed to investigate interconnection network architectures for a wide application range, like networks-on-chip or parallel computers. CINSim allows the simulation of arbitrary network topologies, various traffic distributions in time and space as well as dynamic reconfiguration of the network under investigation.

2.2 Parallel and distributed Systems

This section lists the papers that belong to Parallel and distributed Systems.


Aim: This paper develops a detailed probabilistic model based on Petri nets to evaluate the energy consumption of a wireless sensor node. The model factors critical components of a sensor node, including processors with emerging energy-saving features, wireless communication components, and an open or closed workload generator.


Aim: An algorithm is presented to calculate the destination distribution in all network stages for arbitrary destination patterns of incoming uniform packet traffic. Thus, the automatic generation of timed Petri net models is possible for arbitrary destination patterns of the packets.

**Aim:** Stochastic Petri nets have been extended for the modeling of hybrid systems by adding fluid places, that are filled and emptied continuously at a random (normally distributed) rate. The flow rates as well as the discrete transition rates may depend on the content a fluid place holds.


**Aim:** This paper describes a modeling project which was established to support the design of a distributed controller system. An anthropomorphic robot hand is the target system. Stochastic Petri net models for different communication schemes were developed in order to predict the performance of the considered systems.


**Aim:** This paper presents a general framework for optimal task reallocation in heterogeneous distributed-computing systems and offers a rigorous analytical model for the stochastic execution time of a workload.


**Aim:** The paper describes a fast simulation approach for rare events implemented in a Petri net tool. The technique is based on the recently developed RESTART method, which is applicable for rare events in a wide range of simulation models and has the potential to drastically reduce the simulation overhead. The paper presents selection and refinement techniques for thresholds, which are the most important input parameters of RESTART.
2.3 Robotics and Automation

This section lists the papers that belong to Robotics and Automation


**Aim:** This paper introduces Petri net (PN) based models of co-operative robotic tasks, namely those involving the coordination of two or more robots, thus requiring the exchange of synchronization messages, either using explicit (e.g., wire-less) or implicit (e.g., vision-based observation of teammates) communication.


**Aim:** This paper proposes a selection framework of multiple navigation primitives for a service robot using Generalized Stochastic Petri Nets (GSPNs). By adopting probabilistic approach, our framework helps the robot to select the most desirable navigation primitive in run time through the performance estimation according to environmental conditions.


**Aim:** In this paper, Petri Net Plans (PNPs) are presented, a language based on Petri Nets (PNs), which allows for intuitive and effective robot and multi-robot behavior design.


**Aim:** In this paper, a novel analysis approach, based on phase-type approximation, is proposed to provide transient and steady-state probabilities and determine performance measures of these non-Markovian SPN.
2.4 Discrete Event Systems

This section lists the papers that belong to Discrete Event Systems.


**Aim:** This paper addresses the general class of bounded Petri nets with stopwatches (SwPNs), which is an extension of T-time Petri nets (TPNs) where time is associated with transitions. Stopwatches can be reset, stopped and started.


**Aim:** In this paper, SimGine is introduced, a multi-formalism simulation engine for stochastic discrete-event systems based on SDES, which is a unified abstract description for stochastic discrete-event systems.


**Aim:** In this paper, an approach for the automatic transformation of UML-DAM models into Deterministic and Stochastic Petri nets and the subsequent dependability analysis is proposed.


**Aim:** This paper describes the design and the implementation of a new modeling tool for the analysis of non-Markovian stochastic Petri nets (SPN). This tool, called WebSPN, provides a discrete time approximation of the stochastic behaviour of the marking process which results in the possibility to analyze a wider class of PN models with prd, prs and pri concurrently enabled generally distributed transitions.

**Aim:** The objective of this effort is to develop a computer tool for drawing, editing and simulating timed Petri nets using object oriented programming (OOP). The developed C++ based Timed Petri Net Simulation Tool, TiPNet, simulates discrete systems with both deterministic and stochastic transitions and immediate transitions.

### 2.5 Security, Reliability and Dependability

This section lists the papers that belong to the area Security and Reliability.


**Aim:** This paper discusses a method that automates the availability analysis of middleware managed services based on the standard behaviour of the middleware, while taking into consideration the various system dependencies. TimeNET tool is used to interpret and determine the availability.


**Aim:** This paper describes the modeling methodology and the solution procedure implemented in DEEM, a dependability modeling and evaluation tool specifically tailored for Multiple Phased Systems. DEEM relies upon Deterministic and Stochastic Petri Nets as the modeling formalism, and on Markov Regenerative Processes for the model solution.

Aim: This paper proposes high level models for fault-tolerant mechanisms, in special TMR and recovery block, based on deterministic and stochastic Petri net (DSPN). By means of the proposed models it is possible to perform preliminary reliability analysis and the obtained results might be considered in a co-design methodology.


Aim: This paper addresses the dynamic modeling of Test Facility of a safety critical system used in Nuclear Power plant. Special attention has been paid to the modeling part of a communication module of this system in between the two computer based subsystems that are running on different platform, VxWorks and Linux, using a mathematical formalism, Petri Net. This paper also describes the use of TimeNET tool.


Aim: This paper presents OpenMADS, an open source tool for modeling and analysis of distributed systems. OpenMADS generates comprehensive availability models by using the input of SysML specifications and MARTE annotations, which are automatically translated into deterministic and stochastic Petri nets.


Aim: This paper presents the effort to model the computer system security using Stochastic Activity Network (SAN). SAN is a flexible and highly adaptable branch of Stochastic Petri Nets and has a well-developed software tool, Möbius.

Aim: This paper provides a realistic reliability model for complex services; the model can be used to study the asset allocation problem in degradable complex services. This paper uses a simple model to describe the failure characteristics of the system parts.

[40] Gallasch, G. E., and Billington, J. A study of the convergence of steady state probabilities in a closed fork-join network. In Automated technology for verification and analysis. 8th International Symposium, ATVA 2010 (Singapore, 2010), Berlin: Springer

Aim: The study presented in this paper is motivated by the need to calculate performance measures for computer controlled (agile) manufacturing systems. TimeNET is used to calculate the stationary token distribution of the GSPN for a wide range of the rates as N increases.


Aim: Based on Stochastic Petri Net (SPN) theory, a formalized model of vehicular 1553B bus system is constructed. The performance indices of the vehicular 1553B bus system are obtained through simulation experiment.


Aim: In this paper, a queueing model for service availability formulated as a Petri net is presented. A metric for service availability is defined and show how it can be estimated from the model. Assuming that a failure avoidance mechanism is present, the distribution of time-to-failure is analyzed.


Aim: The Experiment Schema Extension (Ex-SE) provides a means of specifying performance studies (model runs and output).
PN-Ex is an extended instantiation of the Ex-SE for Petri nets. This paper presents an experimental framework for PIPE2. A case study demonstrates the use of the Experimenter.


- **Aim:** This paper presents a case study on the combined use of different tools and techniques for the validation and evaluation, from the early stages of the design, of a fault tolerant software mechanism named distributed synchronization. The quantitative analysis has been performed using the SWN solvers of the Great-SPN tool.


**Aim:** This paper explores a model checking algorithm for CSLTA based on the translation into a Deterministic and Stochastic Petri Net (DSPN).


**Aim:** This paper presents a comprehensive availability model to evaluate the utilization of the live migration mechanism to enable VMM rejuvenation with minimum service interruption. Live migrations are performed observing a time-based trigger.


**Aim:** This paper briefly reviews the progress that has been made in the development of performance/dependability evaluation tools, and argues that the next important step is the creation of modeling frameworks and software environments that
support multi-level, multi-formalism modeling and multiple solution methods within a single integrated framework.


**Aim:** The paper presents a framework to evaluate dependability of PROFIBUS-DP networks. A hierarchical modeling approach is proposed, which considers both the effects of permanent and transient faults. Stochastic Petri nets are used as the modelling technique to obtain dependability models, with emphasis in the use of analytical/numerical methods to provide model’s solutions. In scenarios where its difficult to apply this approach, compact simulation models are derived.


**Aim:** This paper provides a simple importance function that can be useful for RESTART simulation of models of many highly dependable systems. Some examples from the literature illustrate the application of this importance function.

### 2.6 Software and Systems Engineering

This section lists the papers that belong to Software and Systems Engineering.


**Aim:** In this paper, an application example is being presented of one of the activities performed in the European ESPRIT project HIDE, aiming at the creation of an integrated environment where design toolsets based on UML are augmented with modeling and analysis tools for the automatic validation of the system under design. An automatic transformation from UML diagrams to Timed Petri Nets for model based dependability evaluation is applied.
Aim: This paper investigates the effect of three time-triggered system rejuvenation policies on service availability using a queuing model. The model is formulated as an extended stochastic Petri net using a variety of distributions for times between state changes.

Aim: This paper summarises and evaluates the results and experiences obtained from a verification, simulation and test suite for a fault-tolerant computer system designed and developed by DaimlerChrysler Aerospace for the International Space Station ISS. Generalised Stochastic Petri Nets (GSPN) have been used with the tools DSPN-Express and TimeNet to perform a statistical throughput analysis by means of simulation.

Aim: This paper describes an on-going effort in constructing a platform for developing distributed, embedded, real-time control systems which have high dependability and scalability requirements.

Aim: This paper describes an algorithmic approach for fast simulation of rare events applied in a Petri net modeling environment. The technique is based on the RESTART method, which is applicable for rare events in a wide range of simulation models, and has the potential to reduce the simulation overhead extremely.

**Aim:** This paper presents an efficient and numerically reliable method for the transient analysis of DSPNs. An analysis algorithm based on the method of supplementary variables is redesigned in order to improve its efficiency (with respect to both CPU-time and memory space) and its numerical quality (control of numerical errors) and to remove earlier restrictions (concerning the initial enabling of deterministic transitions).


**Aim:** Stochastic Petri Nets (GSPN) are used to model this system where $N$ is the initial marking of a control place. TimeNET is used to calculate the stationary token distribution of the GSPN as $N$ increases, revealing convergence of the steady state probabilities.

**Aim:** This paper aims at a discussion in the direction of identifying possible advanced approaches to the validation of dependable systems.


**Aim:** Performance model interchange formats (PMIFs) support the portability of models and sharing of solutions amongst different tools. XML-based interchange formats have been defined for the interchange of queueing network and Petri net models, amongst others, but there is still scope to extend their application to multiple formalisms, in particular beyond queueing networks.


**Aim:** A new reachability algorithm for general Petri nets is proposed. Given a Petri net with an initial and a target markings, a
so called complemented Petri net is created first that consists of the given Petri net and an additional, complementary transition.


**Aim:** In this paper, an approach is developed for representing temporal systems under uncertainty called state and event time net. The state and event time net can be used to recognize the significance of events and state variables with respect to current plant conditions and predict the hitter propagation of disturbances.


**Aim:** This paper proposes a modeling and verification method based on UML and colored Petri net. On the basis of analysis of advantages and disadvantages of UML modeling, colored Petri net is used as formal specification of UML modeling, which improves scalability of formal method and make up for the deficiency of UML, as lack of analysis of model and verification method.


**Aim:** The paper explores a hierarchy of SPN classes where modeling power is reduced in exchange for an increasingly efficient solution. Generalized stochastic Petri nets (GSPN’s), deterministic and stochastic Petri nets (DSPN’s), semi-Markovian stochastic Petri nets (SM-SPN’s), timed Petri nets (TPN’s), and generalized timed Petri nets (GTPN’s) are particular entries in our hierarchy.

Aim: In this paper, it is considered, in particular, the class of stochastic Petri nets whose marking process can be mapped into a Markov regenerative process.


Aim: A modeling notation is introduced which extends time Petri nets with an additional mechanism of resource assignment making the progress of timed transitions be dependent on the availability of a set of preemptable resources.


Aim: In this paper a new approach is presented for the automatic verification and performance analysis of SysML activity diagrams. A mapping procedure of SysML activity diagrams to their corresponding DTMC is described, and use PRISM model checker for the assessment and evaluation of performance characteristics.


Aim: This paper is an extension of our previous work where only continuous Petri nets have been considered. In the current extension infinite server semantics is considered for the continuous part and exponential and/or deterministic firing delays for the discrete part.


Aim: The paper aims at developing the model of data transmission in a single node with Deterministic and Stochastic Petri Nets (DSPN).

**Aim:** The paper presents research on a modelling of design measuring systems (MS) with time limited dataflow. A new method of describing MS model based on Petri nets and CPN tools environment is proposed in the article. The article provides an overall description of informal and formal methods, which can be used while designing systems.


**Aim:** This paper focuses on safety model of embedded system architecture using AADL (Architecture Analysis and Design Language). It achieves both the foundation of fault model annex to specify safety requirements and the transformation from AADL safety model to DSPN (Deterministic Stochastic Petri Net) model.


**Aim:** This work investigates the influence of different instruction fetch algorithms on the performance of an SMT processor by modeling it with Petri nets. Over the intrinsic results of a detailed processor simulation, our approach offers a generic evaluation.

### 2.7 Communication Systems and Networks

This section lists the papers that belong to Communication Systems and Networks.


**Aim:** This work exploits recent advances in this field, e.g., the Reversed Compound Agent Theorem, to efficiently evaluate the performance of systems with unreliable wireless links. Simulations have been performed with TimeNET.

**Aim:** This paper presents an analytical model developed using the stochastic reward net (SRN) modeling technique for the TCP flow behavior in WLANs. The purpose of developing an analytical model is the evaluation of stationary TCP flow behavior. The paper focuses on the TCP variant called TCP Reno which is implemented by most operating systems.


**Aim:** This paper analyses periodic maintenance strategies for managing replicated objects in mobile wireless environments. It develops a performance model based on Petri nets that considers the missing-read cost, write-propagation cost and the periodic maintenance cost with the objective to identify optimal periodic maintenance intervals to minimise the overall cost.


**Aim:** The paper describes how the completion time distribution for short TCP connections can be computed using Deterministic Stochastic Petri Net (DSPN) models of TCP protocol.


**Aim:** The paper presents a performance evaluation and resource management of hierarchical MACRO-/MICRO cellular networks using the new Modeling and Evaluation Language (MOSEL-2). MOSEL-2 with new constructs has the ability to find the performance and reliability modeling and evaluation of systems with exponential and non-exponential distributions. A MACRO/MICRO cell structure is solved numerically and mathematically in this paper to handle the handoff calls.
Aim: CINSim is a simulator for modeling a great variety of interconnection networks that are composed of switches, buffers, sources, and destinations. This includes regular networks as well as irregular ones. Steady-state simulation can be applied as well as terminating simulation to observe transient behavior of interconnection networks.

Aim: High availability is a key ingredient in the design of mission critical and revenue generating software applications. With the release of the Service Availability Forum specifications, the availability of these applications can be managed by standardized middleware. An approach to approximate from the system configuration the availability of the services provided by a middleware-managed application is presented.

Aim: The approach investigated in this paper was to apply the RESTART/Splitting technique to the well-known open source simulator Network Simulator 2 (NS2), which is capable of dealing with the required network operation and management issues.

Aim: This paper proposes the Stochastic Petri Nets (SPN) formalism to model IP networks loaded with traffic resulting from a set of ON-OFF finite TCP-Reno connections.
Aim: This paper contributes to the general theory of optimised handoff and addresses the need for a formal model that can characterise a mobility event and the associated mobility optimisation methodologies. It provides a systematic and formal approach to analysing a mobility event.

Aim: The decomposition methodology presented in this paper is based on Markovian arrival processes (MAPs), whose correlation structure is determined from the busy-period behavior of the upstream queues. The resulting compact MAPs in connection with sophisticated moment-matching techniques allow an efficient decomposition of large queueing networks.

Aim: The article covers how capturing complex, multi-granular preferences for personalizing database queries and in studying their impact on query results.

Aim: This paper aims to explore through a case study some of the main concerns of web services performance at the middleware layer. The acquired background is meant to start to develop a methodology, based on the SPE principles, useful to analyze web services performance.
Aim: The paper investigates the potential effects of software issues on the safety, reliability and availability of complex embedded autonomous systems. One of the key aspects of the research concerns the mapping of functional descriptions in form of integrated behavior-based control networks to State-Event Fault Tree models.


Aim: The paper sketches the fundamental properties and features of Snoopy, a tool to model and execute (animate, simulate) hierarchical graph-based system descriptions. The tool comes along with several pre-fabricated graph classes, especially some kind of Petri nets and other related graphs, and facilitates a comfortable integration of further graph classes due to its generic design.


Aim: Presented in this paper is an equivalent network theory for linear shift-invariant discrete-time networks having simple poles. Expressions are given for the network transmittance matrices in terms of a decomposition of the network’s rational system function matrix $H(z)$, and a set of arbitrary parameter matrices.


Aim: This paper presents a formal approach to model the traffic operational processes on a Maglev train example based on Stochastic Petri nets.

Aim: This paper deals with the integration of agent technology in the emerging field of vehicular networks.


Aim: This paper analyzes mobile service management schemes based on location-aware proxies with the objective to reduce the network signaling and communication cost in future personal communication systems (PCS). It is demonstrated via Petri net models that the proposed proxy-based mobile service management schemes outperform non-proxy-based schemes over a wide range of identified conditions.


Aim: The approach resorts to an imprecise analysis that extends distributions over the tightest DBM zones enclosing polyhedral domains, and approximates them with Bernstein Polynomials to obtain a global (non-piecewise) analytic representation.


Aim: This paper presents an intelligent, dynamic power conservation scheme for sensor networks in which the sensor network operation is adaptive to both changes in the objects under measurement and the network itself.
Aim: The paper offers a short overview of historical evolution of the field with an emphasis on popular performance modeling techniques such as queuing networks and Petri nets.

Aim: This paper aims at giving an efficient way for IEEE-1394b isochronous data transfer performance evaluation. The proposed model was evaluated by simulation with TimeNet 4.0. The influences of several system parameters are illustrated.

Aim: This paper describes the transient analysis component for deterministic and stochastic Petri nets which has recently been added to the software package TimeNET.

Aim: This paper presents an approach utilizing deterministic and stochastic Petri nets (DSPN) to analyze on-chip communication.
Aim: A new analysis method for continuous time Markov chains is introduced. The method combines, in some sense, simulation and numerical techniques for the analysis of large Markov chains. The basis of the new method is the description of a continuous-time Markov chain as a set of communicating processes.


Aim: This paper proposes the use of predefined Petri nets components to model and evaluate this activity. Aiming supporting a modeling process based on library’s components, a modeling tool was implemented. This tool was integrated with TimeNET, a well known Petri net tool, aiming computing model’s metrics.


Aim: The paper builds and analyzes a Petri net model of admission control in OFDMA system. The simulation results demonstrate our theoretical analysis and indicate that the PN model is effectively to analyze the process of admission in OFDMA system.


Aim: This paper documents the results of experimental simulations designed to compare the performance of multilayer perceptron (MLP) and radial basis function (RBF) based sensor signal change detection systems. The results of these experiments quantitatively show the advantages and disadvantages of Radial Basis neural activation for both the function prediction and function correlation neural networks tested.

Aim: The paper shows how controlled behavior of QoS-aware systems can be developed based on stochastic Petri Nets. Afterwards, it is shown how to obtain, using such an interpreted formal model, powerful numerical analysis for the management of the network QoS.


Aim: To research the call admission control in mobile communication system, a suitable stochastic service model is essential. This paper builds and analyzes the Petri net models of call admission control in multi-service OFDMA system.


Aim: This paper examines the performance of the wireless cell level of the USAIA architecture with means of a Petri net model.


Aim: This paper presents the simulator CINSim. It was particularly developed to investigate network behavior during a dynamic reconfiguration.


Aim: The Experiment Schema Extension (Ex-SE) provides a means of specifying performance studies (model runs and output). PN-Ex is an extended instantiation of the Ex-SE for Petri nets. This paper presents an experimental framework for PIPE2. A case study demonstrates the use of the Experimenter.
Aim: The paper develops intelligent protocols, enhancing efficiency, reliability and security based on detection of sensor signal changes, and describes their possible implementation on the lower level in sensor networks.

Aim: The versatile Modeling, Specification and Evaluation Language is the core element of the MOSEL-2 tool. The description languages is implemented in form of an evaluation environment that comprises translators to the modeling languages of several third-party performance evaluation tools that evaluate the specified model.

Aim: The paper describes a design and implementation of a novel intelligent sensor network protocol enhancing reliability and security by detecting a change in sensor signals.

Aim: The paper proposes a global model involving both rail and road traffic in the LC area. The TimeNET tool is used as a simulator that allows the monitoring of risky situations.

Aim: The paper proposes a global model involving both rail and road traffic in the LC area. The TimeNET tool is used as a simulator that allows the monitoring of risky situations.
**Aim:** This paper presents how to model and carry out the performance analysis of message-oriented middleware (MOM) using generalised stochastic Petri Net (GSPN) models. The results obtained from the Petri net analysis are compared against ones measured in a commercial MOM.


**Aim:** Our work aims to provide system performance and dependability models for supporting infrastructure optimization aiming at business oriented metrics. Stochastic Petri Net are used as an enabling modeling approach for analytical evaluation of complex scenarios.


**Aim:** The paper investigates the dependability modeling of computer networks with redundancy mechanism. It uses Stochastic Petri Net as an enabling modeling approach for analytical evaluation of complex scenarios.


**Aim:** The focus of this paper is the IEEE 802.11e MAC layer modeling under slow time varying Rayleigh fading channel via both layered and multi-layered design approaches and through non Markovian Stochastic Petri Nets (NMSPN). The paper presents extensions to SPN IEEE 802.11 compact model reported.


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Aim: This paper reviews the key concepts that are introduced by the error annex, and compares it to the existing safety evaluation techniques regarding its ability in providing modeling, process and tool support.


Aim: This paper provides an availability and energy consumption study using hierarchical heterogeneous modeling.


• Aim: This paper introduces a model of the handover process that identifies the intrinsic operations of a handover event and allows to predict performance for both an un-optimized handover and for specific optimization methodologies under resource constraints.


Aim: In this paper, a general method to adapt the transition parameters of timed Petri nets that show a cyclic behavior is presented. The cyclic time intervals can be of constant length or differ.


Aim: This paper proposes the use of cooperative game models to arbitrate bandwidth constraints in bandwidth constraint models. This work adopts cooperative games as a mathematical tool for arbitrating bandwidth constraints, considering differentiated service classes and network load information.
Ming, W., Chunxi, Z., and Xiaosu, Y. Performance evaluation of IEEE 1394b serial bus with Deterministic and Stochastic Petri Nets. Communications, China 10, 2 (Feb 2013), 121–133

Aim: IEEE 1394b is a high-speed data bus that is widely used in local area networks and consumer electronics. To best utilize this data bus, its performance must be understood. To evaluate its performance for both isochronous and asynchronous data transfers, model the IEEE 1394b bus is modeled using Deterministic and Stochastic Petri Nets (DSPNs), and simulations are conducted using TimeNET.

2.8 Computer Performance

This section lists the papers that belong to Computer Performance.


Aim: This paper discusses software reusability strategies for performance and reliability modeling tools.


Aim: In this paper a hierarchical method is proposed for constructing a large class of Petri nets, which preserves efficient product-form solutions when they exist. This scalable approach greatly improves the efficiency of finding steady state probabilities in a wide range of SPNs, making much larger SPNs feasible.

Aim: This paper presents an extension of the GreatSPN tool for Generalized stochastic Petri nets (GSPN) and Stochastic well-formed nets (SWN) solution that allows a check of state space properties.


Aim: This paper presents an efficient solution technique for the steady-state analysis of the second-order stochastic fluid model underlying a second-order fluid stochastic Petri net (FSPN) with constant flow and transition rates, and a single bounded fluid place.


Aim: This paper progresses one step further on enumerating reachable (forbidden, live, and deadlock) states for middle even k-th order systems (one non-sharing resource place in the middle position of the right-side process) with a formula depending on parameter k for a subclass of nets with k sharing resources.


Aim: This paper studies the performance of an adaptive video-on-demand (VOD) system. VOD system is modelled using stochastic Petri nets and use discrete event simulation to determine the performance of the system, i.e. the number of requests accepted by the video server compared to the number of requests offered.


Aim: The objective of this paper is to provide a first analysis of the effectiveness of simple server replication vs. failure prevention in non-high-availability applications.

**Aim:** This paper progresses one step further on enumerating reachable (forbidden, live, and deadlock) states for Middle-Left k-th order systems (one non-sharing resource place in the middle position of the left-side process) with a formula depending on parameter k for a subclass of nets with k sharing resources.


**Aim:** This paper introduces ArgoSPE, a tool for the performance evaluation of software systems in the first stages of the life-cycle. ArgoSPE implements a performance evaluation process that builds on the principles of the software performance engineering (SPE).


**Aim:** This paper shows that the behavior of a SOA system can be modeled by Petri Nets and, from the model, QoS levels (performance and availability) can be estimated. In this way, the analysis can be conducted without necessarily implementing the real system, which tends to be valuable in the design phase of SOA.


**Aim:** The paper describes the application of evaluation methods to (both fluid and discrete) Petri nets, their implementation in SPNP and gives some illustrations of the speed-up. The RESTART technique has already been applied in TimeNET, while
here both RESTART and splitting are implemented, and applied them to a general class of Petri nets including fluid ones.


**Aim:** This paper summarizes in a semiformal and illustrative way our proposal for a suitable software performance engineering process.


**Aim:** The main results of this paper are on the one hand the relationship between Algebraic High Level Nets and a restricted class of Algebraic Higher Order Nets given by folding and unfolding and on the other hand the concept of run time modification, which allows to modify existing models of flexible business processes in a formal way.


**Aim:** Stochastic Petri nets (SPNs) with general firing time distributions are considered. A stationary analysis method covering all possible combinations is presented by means of supplementary variables. The method is implemented in a prototype tool SPNica which is based on Mathematica. The use of the general execution policies is illustrated by a WWW server model.


**Aim:** This work presents and compares two different approaches for the transient solution of Markov regenerative stochastic Petri
Nets: the method based on Markov regenerative theory and the method of supplementary variables. In both cases the equations that govern the marking process of the non-Markovian stochastic Petri net are presented and then solved either in time-domain or using a Laplace-Stieltjes transformation.


**Aim:** In this paper an aggregation technique for generalised stochastic Petri nets (GSPNs) possessing synchronised parallel structures is presented.


**Aim:** This paper presents Pea brain, a collection of PIPE tool-compliant modules for performance estimation and resource optimisation based on bounds computation for Stochastic Petri Nets.


**Aim:** In this paper, a shifting framework is presented, study its properties and develop a Petri net model for a shifting algorithm. The model is analyzed in order to identify situations where shifting of priorities is beneficial.


**Aim:** In this paper, a new algorithm is suggested which avoids computing these matrices explicitly. The algorithm is formulated in terms of stochastic Petri nets.

Aim: This paper progresses one step further on enumerating reachable (forbidden, live and deadlock) states for top k-th order systems (one non-sharing resource place in the bottom position of the left-side process, below denoted as Bottom-Left ) with a formula depending on parameter k for a subclass of nets with k sharing resources.


Aim: This paper progresses one step further on enumerating reachable (forbidden, live and deadlock) states for top k-th order systems (one non-sharing resource place in the top position of the left-side process, below denoted as Top-Left ) with a formula depending on parameter k for a subclass of nets with k sharing resources.


Aim: This paper analyses a coloured stochastic Petri net model of a redundant fault-tolerant system. As the measure of interest a dependability metric, i.e., service availability, is evaluated. Service availability is defined as the number of successfully completed jobs relative to the total number of arrived jobs.

Aim: To illustrate general aspects of the security-performance tradeoff the paper sets up a simple Generalised Stochastic Petri Net (GSPN) model that allows to study both, performance and security and especially the tradeoff between both. Metrics such as cost and an abstract combined performance and security measure are formulated that explicitly express the tradeoff and it is shown that system parameters can be found that optimise those metrics. These parameters are optimal for neither performance nor security, but for the combination of both.


Aim: This document presents a case study in performance engineering. The case study consists of a Software Retrieval System based on agents. The system is modelled in a pragmatic way using the Unified Modeling Language and in a formal way using stochastic Petri Nets.


Aim: Based on the analysis of the Data Link layer of CAN bus protocol, a deterministic stochastic Petri nets model of MAC sub-layer in CAN bus protocol is built, aiming at the real-time performance analysis.


Aim: The main contribution of this work is the addition of Gaussian noise in order to obtain a better (but stochastic) approximation when synchronizations are important.

Aim: This paper applies SPE techniques to model and analysis how a mobile agent tracking approach addresses the highly dynamic movement problem in a distributed computing environment.


Aim: This paper presents a specific, extended instantiation of the Ex-SE for Petri nets (PN-Ex). The viability of the approach is demonstrated with a case study carried out using PIPE2 (Platform Independent Petri net Editor 2) with an experimental framework.

2.9 Manufacturing

This section lists the papers in the area of manufacturing.


Aim: The CodeSign object-oriented, temporal Petri net formalism with its associated tool is a modeling and simulation environment to meet those requirements. A case study conducted in an industrial setting is described that demonstrates the applicability of the CodeSign approach to the modeling of semiconductor manufacturing equipment with step-wise refinement.


Aim: In order to improve the performance evaluation of such systems, this paper proposes a GSPN with energy consumption and human resources allocation annotations.

Aim: This paper reports on a case study in the quantitative analysis of safety-critical systems. Our approach is to create a generalized stochastic Petri net (GSPN) model of the system and use it for the analysis of the system.


Aim: This paper focuses on the safety analysis of a train control supervisor for ATO using timed Petri nets as the modelling approach.


Aim: This paper proposes an approach based on generalized stochastic Petri nets (GSPNs). On the basis of this evaluation, it is observed that the newly proposed approach provides results that are at least as good as those from the most accepted alternatives and holds a number of additional advantages, such as modeling simplicity, improved precision, and model reuse for qualitative analyses.


Aim: This paper proposes a simulation modeling approach based on stochastic Petri nets to estimate the performance of SOA-applications. Using the proposed model is possible to predict resource consumption and service levels degradation in scenarios with different compositions and workloads, even before developing the application.

**Aim:** In this paper, an innovative approach to SCPM is presented, based on a new type of high level Petri nets, so called XML-nets. With the proposed XML-nets, the capabilities of SCPM can be significantly enhanced in comparison to existing methods.


**Aim:** In this paper an investigate the performance and dependability modeling of voice and data services in computer networks. Stochastic Petri Nets are used as an enabling modeling approach for analytical evaluation of complex scenarios.


**Aim:** This paper describes the interval generalized stochastic Petri net (IGSPN) as an interval extension to the GSPN model.


**Aim:** This paper progresses one step further on enumerating reachable (forbidden, live, and deadlock) states for top k-th order systems (one non-sharing resource place in the top position of the right-side process) with a formula depending on parameter k for a subclass of nets with k sharing resources.


**Aim:** To address the need for evaluation techniques for complex business processes, also known as workflows, this paper proposes an approach based on generalized stochastic Petri nets (GSPNs).
Aim: In this paper, a reliable mechanism is presented to help improve evaluation robustness when significant uncertainties exist.

Aim: Our work aims to provide system performance and dependability models for supporting optimization of infrastructure design aiming at business oriented metrics. In addition, a methodology is also adopted to support both the modeling and the evaluation process.

Aim: This study focuses on the specification and evaluation of parameterized generalized and stochastic Petri net (GSPN) models for reliability and safety estimates of embedded systems. The embedded system to be modeled is specified using the extended dependability block diagram (EDBD), a high-level system specification model, which is composed of several and diverse blocks: functional, decision, standby spare, multiple and subsystem.

References


