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Editorial

Performance and dependability techniques and tools

Welcome to this special issue of *Performance Evaluation, presenting selected papers of the recent 11th International Conference on Modelling Tools and Techniques for Computer Performance Evaluation* (TOOLS 2000) and the *Fourth IEEE International Performance and Dependability Symposium* (IPDS 2000), which were both hosted by Motorola in their Galvin Center in Schaumburg, a suburb of Chicago, 27–30 March 2000.

For TOOLS 2000, the aim was to further develop the theory and technology for tool-based performance and dependability evaluation of computer and communication systems. At IPDS 2000, academic and industrial researchers and practitioners met to address applied and theoretical aspects of computer performance and dependability analysis.

TOOLS 2000 enjoyed 49 regular submissions, of which 21 were selected as regular papers. IPDS 2000 received 37 regular submission, of which 17 where selected for the conference. In addition to these regular papers, two invited papers and 14 short papers addressing new tools for performance and/or dependability evaluation were presented. The proceedings of TOOLS 2000, including the 14 short tool descriptions, have been published as *Lecture Notes in Computer Science*, Vol. 1786 (B.R. Haverkort, H.C. Bohnenkamp, C.U. Smith (Eds.)) with Springer, whereas the IPDS 2000 proceedings have been published by the IEEE Computer Society Press.

In the current special issue, a selection of five papers from TOOLS 2000 and six papers from IPDS 2000 are presented. These papers have been selected by the respective program committees, and have been extended and considerably improved by their authors. An extra review procedure was invoked in the summer of 2000, and in the fall of 2000 the final papers were delivered.

In the first paper selected from TOOLS 2000, *Decomposition of General Tandem Queueing Networks with MMPP Input*, Armin Heindl (TU Berlin) presents a novel approach to decompose tandem queuing networks with generally distributed service times, subject to Markov modulated Poisson traffic; this type of queuing network model especially finds its application in the area of high-speed networking. The inter-queue traffic is described by means of semi-Markov processes and Markov modulated Poisson processes, instead of by renewal processes (as is the case in most decomposition approaches). Thus, the correlations in the traffic streams, which considerably impact the queue performance, can be accounted for. Comparisons with simulations show the accuracy of the new approach.

The evaluation of high-speed networks is also the application area aimed at by José Incera (ENST Bretagne), Raymond Marie, David Ros and Gerardo Rubino (all at IRISA in Rennes) in their paper *FluidSim: A Tool to Simulate Fluid Models of High-speed Networks*. When evaluating high-speed networks, it is computationally often very unattractive to simulate every packet individually. Instead, an approach can

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be followed in which streams of packets are represented as continuous flows. In doing so, the number of events to be handled by the simulator can be reduced considerable in many cases. The paper describes a general fluid model for communication systems, describes how to simulate such a model, and addresses the implementation of a tool for performing such simulations. Various application examples show the feasibility and advantages of the approach.

In the paper *Iterative Analysis of Markov Regenerative Models*, Reinhard German (Friedrich-Alexander Universität Erlangen-Nürnberg) addresses a new computational technique for the steady-state analysis of a class of stochastic Petri nets (SPNs) in which some transitions have generally distributed firing times. It is well-known that conventional algorithms for this class of SPNs suffer from the fact that the matrices **P** and **C** describing the embedded Markov chain (that needs to be computed) are non-sparse, and hence result in high memory requirements. German proposes a way to avoid the explicit computation of the matrices **P** and **C** altogether, thus reducing the space complexity of the algorithm considerably. Depending on the type of model at hand, the space complexity reduction comes at the cost of an increase in the time complexity. Experimental results are provided, thereby using the implementation of the new algorithm in the SPNica package, giving a feel for this trade-off.

The paper *Integrating Synchronisation with Priority into a Kronecker Representation* by Susanna Donatelli (University of Torino) and Peter Kemper (University of Dortmund) addresses the use of Kronecker algebra to overcome the state space explosion problem in generalised stochastic Petri nets (GSPNs). In particular, they develop a new, general framework for the decomposition of large GSPNs into smaller ones that synchronize over either timed or prioritized immediate transitions. The authors present in detail the required data structures to generate the Kronecker representation of the underlying Markov chain and to realize the numerical solution of the underlying Markov chain in an efficient way (using the Jacobi and Gauss–Seidel iteration scheme). The developed algorithms have been implemented in the APNN Toolbox; a comparison of their efficiency is provided.

The paper *A Method for Calculating Successive Approximate Solutions for a Class of Block Banded M/G/1 Type Markovian Models* by Michela Meo, Marco Ajmone Marsan (Politecnico Torino) and Edmundo de Souza e Silva (Federal University of Rio de Janeiro) addresses a new efficient method to compute the steady-state probabilities in Markov chains of block-banded M/G/1 type, based on Krylov subspaces. An attractive feature of the approach is that it computes successive approximations for the exact solution along the way. Many models arising in telecommunications fall within the class of models that can be handled with this new approach.

The papers from IPDS 2000 begin with *Correlational and Distributional Effects in Network Traffic Models* by Robert Geist and James Westall of Clemson University. In this paper, the authors show that synthetic traffic models that capture only the distributional or the correlational characteristics of real workloads can yield substantially optimistic predictions of queue lengths and drop rate in network traffic models. To address this problem, they propose and evaluate a new technique for generating synthetic arrival streams that better mimic real workloads. They then demonstrate that these synthetic traffic streams have sample autocorrelation functions that are consistent with the long-range dependence observed in real workloads, and allow one to produce better performance estimates than distribution-based and fractional Gaussian noise-based techniques.

Continuing with the network analysis theme, the next paper from Armin Heindl and Reinhard German of the TU Berlin is entitled *Performance Modeling of IEEE 802.11 Wireless LANs with Stochastic Petri Nets*. This analysis is the first to fully incorporate the effects of the IEEE 802.11 standard, notably the extended interframe spaces (EIFS) and the timing synchronization function (TSF). The analytical results suggest that EIFS tends to slightly reduce system throughput and prolong mean waiting times, for wireless LANs consisting of up to 10 stations. The paper also contains an excellent introduction to the IEEE 802.11 Distributed Coordination Function, which is the complex protocol that controls access to the wireless LAN and determines many of its performance characteristics.

In their paper *On Markov Reward Modeling with FSPNs*, Katinka Wolter and Andrea Zisowsky of the TU Berlin continue the exciting development of Fluid Stochastic Petri Nets by using them to model reward in performability models. Two variations of a known performability model are used to demonstrate the ability of FSPNs to model accumulated rate reward as well as accumulated impulse reward, the latter represented by the Dirac Delta function. A numerical discretization algorithm is used to solve the differential equations that embody the models. The accuracy of this discretization scheme as a function of space and time step size is discussed, and the difficult issue of boundary condition specification is explored.

Next, Peter Buchholz of the TU Dresden presents *Hybrid Analysis of SGSPNs with Time-dependent Transition Rates*. In this paper, Peter Buchholz presents a new analysis algorithm which combines the ideas of transient numerical analysis via uniformization and discrete event simulation. Simulation is used to determine the firing times of synchronized transitions describing interactions between components of a Superposed Generalized Stochastic Petri Net, and numerical analysis is used to compute the distribution of states between firing times of synchronized transitions. This approach avoids handling vectors of the size of the state space, and can therefore be used for models with a huge state space which cannot be analyzed with previous numerical analysis techniques.

Exemplifying the applied work that characterizes IPDS, the next paper *On The Effectiveness of a Message-driven Confidence-driven Protocol for Guarded Software Upgrading*, written by Ann Tai and Kam Tso (IA Tech), Leon Alkalai and Savio Chau (JPL), and William Sanders (University of Illinois), describes a new algorithm for solving the tricky problem of online upgrading the software of an operational spacecraft. They model their algorithm using a stochastic activity network (SAN), and manage their model's complexity by avoiding explicit representation of the algorithmic details of the upgrading process that have no impact on the reliability measure. Using this modeling technique they are able to show that a dynamic confidence-driven approach to bringing newly upgraded software online is superior to static approaches, and is the key to the attainment of cost effectiveness in this application.

In the final IPDS paper, entitled *Measure-adaptive State-space Construction*, Douglas Obal of Hewlett-Packard and William Sanders of the University of Illinois describe a new reward variable specification technique which, when combined with recently developed state-space construction techniques, allow the implementation of tools that will automatically adapt the size of the state space to constraints derived from the system model and the user-specified reward variables. In effect, the techniques presented in this paper allow one to construct a tool that can automate the type of manual complexity management that was described in the previous paper. Further, reward variables are extended to include path-based reward variables described in earlier work. This work is an important step forward not only in automated complexity management, but in separating the specification of the detailed system model from the specification of the performance, dependability, or performability measures of interest.

To conclude, we would like to thank all who contributed to the success of both conferences. Special thanks go to Haim Levendel and his staff at Motorola for hosting both conferences. We would like to thank the editor-in-chief of *Performance Evaluation* for giving us the opportunity to prepare this special issue, as well as Jan Kastelein at Elsevier for handling the editorial and production process. Furthermore, we would like to thank the reviewers (see the listing below) for their careful and timely reports.

It has been a privilege for us to compile this special issue. We hope you enjoy the selected papers as much as we did.

List of reviewers: A. Bell, A. Bobbio, P. Buchholz, P. Chimento, G. Ciardo, J. Dugan, A. Durresi, R. El Abdouni, S. Garg, M. Gribaudo, R. Harper, P. Harrison, G. Haßlinger, B. Haverkort, H. Hermanns, J. Hillston, S. Hunter, R. Jain, Z. Kalbarczyk, J. Knight, G. Kotsis, L.M. Le Ny, C. Lindemann, C. Llado, R. Marie, A. Miner, R. Muntz, M. Nelte, D. Nicol, A. Ost, B. Plateau, A. Riska, G. Rubino, R. Sadre, W. Sanders, M. Scarpa, M. Segal, D. Siewiorek, E. Smirni, A. Somani, E. de Souza e Silva, W. Stewart, A. Tai, H. Takagi, P. Taylor, J. Tomasik, K. Trivedi, K. Vaidyanathan, W. Xie and J. Zinchuk.

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