EDITORIAL

ADVANCES IN ANALYTICAL AND STOCHASTIC MODELLING

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Recent years are witnessing a tremendous technological breakthrough in all areas of life. In particular, the new advances in wireless and mobile communications are certainly changing the way we work and even the way we live. The life of a new technology from being an idea to the design, implementation and upgrade has become much shorter. Just to think on how long traditional telephony needed to reach its current development stage compared to the short life of wireless and mobile telephony. This shorter life cycle of technology puts greater pressure on the developers to shorten every stage of the development life cycle of new technology or product.

Performance modelling and evaluation has been an important part of the design, maintenance and development process of complex systems for the last decades. There have been a huge amount of published performance studies applied for wide range of applications in computer, communications, manufacturing, transportation and many other areas.

In these performance studies, wide range of methodologies has been used. However, most of these published studies are based on simulation modelling. Due to system complexity, analytical models received less attention in practice although many studies were published using mainly Markov modelling based on queueing network or matrix geometric solutions for different systems and scenarios but in much smaller volume.

Simulation is an efficient tool for studying detailed system behaviour but it becomes costly in manpower in developing the software and/or in computing time if high accuracy results are required. This is typical for systems with events happening at different time scales. Another typical problem with simulation is the long time to develop a simulation system. Markov models on the other hand provide more flexibility in producing numerical results for many interesting performance measures. Nevertheless, the numerical solution of Markov models may suffer from several drawbacks, such as state space explosion limiting the analysis to only small systems and restrictive assumptions of independent Poisson arrival processes for all types of homogeneous and uniformly distributed traffic types with exponentially distributed service times.

Analytical models, if they exist, provide a powerful tool for performance modelling and evaluation. Their power stems from their capability to provide fast and accurate solutions given that a set of appropriate assumptions are made. Additionally, they require shorter time to develop and amend which brings them again to focal point in todays technologies' development cycle.

As the range and the complexity of investigated systems increases, new advances on these methodologies become imminent. These advances should cover all aspects of analytical and stochastic methodologies including the exact or approximate, transient or steady state, but also the analytical or numerical solutions.

This special issue is a third of series of special issues [1, 2] of the International Journal on Simulation; Science, Systems, and Technology devoted to present novel articles on advances in many of the above listed directions.

Most the papers in this issue are extended versions of a set of selected papers presented at the 11th International Conference on Analytical and Stochastic Modelling Techniques and Applications (ASMTA'04) that took place in Magdeburg, Ger-

many in June 2004 as part of the European Simulation Multiconference (ESM'04). The ASMTA conference has attracted a large number of high quality papers this year in all areas of analytical, numerical and stochastic modelling.

The first paper in this issue by Ana Da Silva Soares and Guy Latouche was selected as the best paper in the ASMTA'04 and in the whole of ESM'04. This excellent paper deals with fluid queues with feedback control. Fluid queues consist of a buffer or reservoir controlled by a continuous-time Markov process evolving in the background. The content of the fluid buffer is a nonnegative real number, usually called the *level*, and the state of the underlying Markov process is called the *phase*. The renewal approach to fluid queues, originally developed by Ramaswami [3], is very efficient in that it allows for the analysis of different systems by a common set of tools. This is illustrated here with feedback fluid queues, that is, systems for which the rules of evolution of the phase process change when the buffer is either empty or full.

The second paper by A.N. Dudin, A.A. Shaban, and V. I. Klimanok presents novel advances in queueing theory. In this paper, a single server queue with a finite buffer is analyzed. Input is described by the BMAP (Batch Markovian Arrival Process). The disciplines of complete admission and complete rejection are dealt with. The stationary queue length distribution at service completion and arbitrary epochs is calculated. The loss probability is found and its dependence on the discipline of admission, correlation and variation of the BMAP, service time variation, buffer capacity and the load of the system is illustrated by means of numerical examples.

The paper by M. Scheidegger, F. Baumgartner, and T. Braun brings together the analysis and simulation. In their paper, the authors argue that discrete-event simulation of computer networks has significant scalability issues, which makes simulating large-scale networks problematic. They propose a high-level abstraction modeling network domains, interdomain links and traffic with highly scalable analytical models, which is much more efficient but slightly less accurate than node-by-node models. Thus, simulation scenarios containing several ISP networks become feasible. They also propose a way to combine this modeling approach with traditional packet-based simulators and present some preliminary evaluation results of the concept.

The next paper by L. Assafi and G. Bolch shows how time dependent priorities can be applied to providing service assurance in a call center. The main contribution of this paper is the transfer of several results derived in the field on Proportional Differentiated Services (Internet Quality of Service) to application in the research field of Call Center technology. Furthermore, it addresses some specific aspects of application to call centers. After presentation of general concepts of call centers and priority mechanisms, service level functions in call centers are introduced and the the suitability of time dependent priorities is discussed.

The paper by J. Rozsik and J. Sztrik investigates a multiserver infinite-source retrial queueing system for the performance modeling of cellular mobile communication networks. The objective is to demonstrate how the performance tool MOSEL (Modeling, Specification and Evaluation Language) [4] can be efficiently used in the modeling of cell based networks. In our analysis the blocked and dropped users are treated separately, that is they redial with different probabilities and different rates, with reducing the state space by maximizing the number of redialing customers with appropriately large values (i. e. when the ignored probability mass can be neglected). The guard channel scheme is included in the model, too. The novelty of the analysis is that not only the active but also both types of redialing customers are allowed to depart to other cells, which was not the case in the previous works.

The paper by L. Guan, M. Woodward, and I. Awan presents a new analytical framework for the congestion control of Internet traffic using a queue threshold scheme. This framework includes two discrete-time analytical models for the performance evaluation of a threshold based congestion control mechanism and compares performance measurements through typical numerical results. To satisfy the low delay along with high throughput, model-I incorporates one threshold while Model-II incorporates two thresholds. In both performance models, the mean packet delay, probability of packet loss and throughput have been found as functions of the thresholds and maximum drop probability. The performance comparison results for the two models have also been made through typical numerical results. The results clearly demonstrate how different load settings can provide different tradeoffs between throughput, loss probability and delay to suit different service requirements.

According to M. A. Azgomi and A. Movaghar, Stochastic activity networks (SANs) are a powerful and flexible extension of Petri nets. These models can be used for the modelling and analysis of various kinds and different aspects of distributed real-time systems. Similar to other classical extensions of Petri nets, SANs have some limitations for modelling complex and large-scale systems. In order to remove some of these limitations and provide high-level mod-

elling constructs, the authors defined a new extension for SANs, called hierarchical stochastic activity networks (HSANs). HSAN models provide a construct for composing a hierarchy of SAN submodels that is called macro activity. HSANs encapsulate hierarchies and a key benefit of these models is the possibility of automatic selection and usage of techniques for model construction with reduced state spaces by their modelling tools. In this paper, They present the informal and formal definitions, behaviour and state process of HSANs and introduce methods for the solution of HSAN models by state space analysis and discrete-event simulation techniques.
In the last paper of this issue, new modelling and analysis tools are explored. The strength of Artificial Neural Networks (ANNs) derives from their perceived capability to infer complex, non-linear, underlying relationships without any a priori knowledge of the model. However, in reality, the fuller the priori knowledge the better the end result is likely to be. In this paper, S.E.Kemp, I.D. Wilson and J.A. Ware show how to implement the Gamma test. This is a non-linear modelling and analysis tool, which allows the examination of the input/output relationship in a numerical data-set. Since its conception in 1997 there has been a wealth of publications on Gamma test theory and its applications. The principle aim of this paper is to show the reader how to turn the Gamma test theory into a practical implementation through worked examples and a explicit discussion of all the required algorithms. Furthermore, it shows how to implement additional analytical tools and articulate how to use them in conjunction with the non-linear modelling technique employed.

References

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Biography

Khalid Al-Begain is Professor of Mobile Networking and Head of the Mobile Computing, Communications and Networking Research Centre at the School of Computing of the University of Glamorgan in Cardiff/Wales/UK. He received his High Diploma (1986), the Specialisation Diploma of Communication Engineering (1988) and his Ph.D. degree in Communication Engineering (1989) from the Technical University of Budapest in Hungary. From 1990 to 1996 he held the position of a Assistant Professor at the Department of Computer Science of the Mu'tah University in Jordan. Then he became an Associate Professor at the same university. In 1997 he moved to the Department of Computer Science at the University of Erlangen-Nuremberg in Germany as Alexander von Humboldt research fellow. Later, he spent one year as Guest Professor at the Chair of Telecommunications, Dresden University of Technology, Germany. From 2000-2003, he has been Senior Lecturer and Director of Postgraduate Research in the Department of Computing of the University of Bradford, UK before moving to Glamorgan. He co-authored the book "Practical Performance Modelling" published by Kluwer Academic Publishers in Boston and more than 100 journal and conferences papers. He is senior member of the IEEE and many other scientific organisations. He also served as Guest Editor for two previous special issues of this Journal on Analytical and Stochastic Modelling Techniques. Since 2003, he became the Conference Chair for the annual ASMTA (Analytical and Stochastic Modelling Techniques and Applications) Conference (ASMTA'03 in Nottingham,UK and ASMTA'04 in Magdeburg, Germany). He also manages several research projects funded by the EPSRC and EU.
His research interests are performance modelling and analysis of computer and communication systems, analytical modelling and design of wireless mobile networks and multicast routing in mobile IP networks. He is also interested in Mobile Computing research.