

# Special Issue for Erol Gelenbe's 70th Birthday

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## Abstract

We introduce this special issue which is a collection of papers written in honour of Professor Erol Gelenbe in relation to his 70th birthday celebrations at Imperial College (see <http://san.ee.ic.ac.uk/Gelenbe2015>). These papers are all centred on probability models related to computer systems and networks, an area where Erol plays a pioneering role. We first briefly review Erol's work in this and related areas, and then discuss the papers that appear here.

## I. THIS SPECIAL ISSUE

This special issue is a collection of papers that have been presented during the celebration honouring Erol Gelenbe at Imperial College London, on the occasion of his 70th birthday. The celebration took place on September 20th to 24th at Imperial College and at some other venues in London.

Erol's work in probability modelling of computations and computer systems and networks started with his PhD Thesis at the Polytechnic Institute of New York in Brooklyn, better known as Brooklyn Poly, under the supervision of Professor Edward J. Smith Jr., and has continued at the University of Michigan, Ann Arbor, and then at the University of Liège, at INRIA, and throughout his career.

His early work included the mathematical properties of finite state automata with probabilistic transitions [1], and the types of formal languages that they would recognise [2], [3], showing that not only the probabilistic transitions themselves but also the probability that is used as a threshold for word recognition can have a powerful effect on the family of formal languages that are recognised.

Then, under the influence of the hot topic of the day, which was the design of virtual memory computer time-sharing systems, he turned his attention to the optimisation of memory management systems [4], [5], [6], [7], the overall real-time management of time-sharing systems [8] as well as the analysis of page replacement algorithms [9].

Driven by the need to understand how the performance of computation could be characterised, he has continued over the years with a unified variety of topics including the performance of parallel numerical algorithms [10], the intrinsic mathematical properties of secondary memory systems and their latency [11], the end-to-end delay of important protocols such as Voice-over-IP that is used in Skype [12], the performance of search algorithms in unknown and dangerous environments [13], the behaviour of interacting real and virtual agents within a simulation [14], the performance of gene regulatory networks [15], and the energy consumed in packet routing [16] or in communicating with spins [17].

Several papers in this special issue are directly related to various epochs of Erol's research. Thus the first paper by Ufuk Çağlayan limits its review to Erol's relatively recent work over the last ten to fifteen years.

The second paper by Guy Fayolle and Paul Muhlethaler on "A Markovian Analysis of IEEE 802.11 Broadcast Transmission Networks with Buffering" proposes two models for a CSMA protocol close to IEEE 802.11. This links directly to some of Erol's and Guy Fayolle's early work from the 1970's, and to Erol's early work on Carrier Sense Multiple Access (CSMA) [18], [19], [20]. The authors of this paper compute the station transmission rate, the stability conditions, and the average packet delay for protocols that yield stable behaviour without external control, in contrast to systems such as ALOHA and CSMA. The authors' numerical results also match well the performance of the standard IEEE 802.11 broadcast protocol.

The paper by Andrea Marin on "Product-form in G-networks" reviews the well known, and less known, results on Erol's famous Gelenbe or G-Networks [21], [22]. Erol invented these models to characterise systems where customers or users have the ability to influence the behaviour of others, such as re-routing them towards different resources than the ones they have originally requested, or removing them altogether from the system either singly or in batches. These behaviours result in unusual non-linear traffic equations, and Erol had shown that they have a separable and computationally efficient product form solution [23]. Dr. Marin's paper discusses the equational characteristics which lead to the product form.

Similarly, the paper by Jean-Michel Fourneau on "G-networks of unreliable nodes" shows an interesting generalisation where individual nodes may be subject to breakdowns, but the important aspect is that they are provoked by arrivals of some specific customers which are the breakdowns. The paper introduces this model and establishes the product form solution.

Stelios Timotheou in his paper "Fast Non-negative Least Squares Learning in the Random Neural Network" discusses a fast learning algorithm for the random neural network (RNN) [24], introduced in the late 1980's and the 1990's [25], [26], [27],

[28], [29]. It has had applications in image processing [30], [31], [32] and network routing [33]. The model's capability to approximate arbitrary continuous and bounded functions [34] is the theoretical justification for the use of learning algorithms that store complex functional relationships within these models. Similarly, Khaled Hussain and Ghada Moussa apply the RNN to a vehicle classification problem from visual and linguistic representation based on RNN learning [35], [36].

On the other hand, the work by Tuğrul Dayar and M. Can Orhana on "Cartesian product partitioning of multi-dimensional reachable state spaces" studies Markov chains that are composed of interacting subsystems, so that they can be constructed from a multi-dimensional model with each subsystem corresponding to a different dimension. This topic is related to Erol's PhD work from the 1960's and 70's [37], [38], [39], [40] on the study of state-space partitions for stochastic and deterministic system decomposition. The authors establish that the partitioning of the reachable state space of a three or higher dimensional system with a minimum number of partitions into Cartesian products of subsets of state spaces is NP-complete, and discuss both a merge based and a refinement based algorithm that yield possibly non-optimal partitions, and then they provide some experiments using these algorithms.

When dealing with multiple agents that have to take local decisions cooperatively based on limited interaction with their peers, the issue of determining whether they behave in an overall optimal fashion is an old and well known problem that is encountered in many diverse and unusual applications such as the control of multiple updates to a distributed database [41], the access of several processes to common data [42], defense against Distributed Denial of Service attacks [43], search by multiple agents [44], [45], auctions of different buyers within a shared economy [46], or emergency management where many evacuees have to exit a common area [47], [48], [49]. In the paper by Bruno Gaujal and Panayotis Mertikopoulos, "A Distributed Stochastic Approximation Algorithm for Stochastic Semi-definite Programming", a distributed stochastic approximation algorithm is presented, motivated by communications between multiple agents using common resources, such as shared wireless environments with Multiple-Input-Multiple-Output. The authors establish that their approach converges to the optimum under fairly general conditions and illustrate this with numerical examples.

The following paper by Yingdong Lu, Mayank Sharma, Mark S Squillante and Bo Zhang on "Stochastic Optimal Dynamic Control of  $G I_m / G I_m / 1_n$  Queues with Time-Varying Workloads" addresses one of the many issues that are coming to the forefront of the control of computer systems, including energy issues [16]. Efrat Perel and Uri Yechiali in their paper "Finite Two Layered Queueing Systems" study matrix geometric analytical techniques for large state-space systems. The twelfth paper is authored by Omer H. Abdelrahman and discusses "Detecting Network-Unfriendly Mobiles With the Random Neural Network". It links two areas in which Erol Gelenbe is active: network anomaly and attack detection techniques [50] and random neural networks [51]. It exploits the random neural network's capability to learn from examples so as to classify the attack patterns that are observed in mobile networks, so as to detect such attacks. Finally the last paper by HuiBo Bi and Omer H. Abdelrahman, discusses energy aware navigation of vehicles. It develops an energy optimisation framework akin to the work in [16], [52], which also includes specific energy consumption data related to motor vehicles. Then the paper applies this approach to a specific instance and evaluates it by simulations using the building evacuation simulator DBES [48], [53].

## II. ABOUT THE AUTHOR

Nihal Pekergin was born in Sivas, Turkey, and received her Engineering Degree in Electronics and Telecommunications from the Istanbul Technical University in 1983. She received a Master of Science degree in Computer Science from the same university in 1986. In 1987 she was awarded a Research Master's degree (DEA) in Modeling of Computer Systems from the Université Paris-Sud in 1987, and in 1991 she was awarded a PhD on "New performance models of parallel systems" under the supervision of Erol Gelenbe at the Université de Paris V.

Professor Pekergin started her academic career at the Istanbul Technical University where she served as an Assistant from 1986 to 1986. From 1988 to 1989 she was a Visiting Assistant at the Université de Paris-Sud, and then a Temporary Lecturer at the same university till 1991. In 1991 she was appointed to a Maître de Conférences position at the Sorbonne (Université de Paris I) where she remained until 2007.

In the meanwhile, she passed her Habilitation degree in 2001 at the University of Versailles-St-Quentin on "Performance Bounds for Networks and Systems", and joined the Université Paris-Est Créteil Val de Marne in September 2007. There, she served as Head of the Computer Science Department in the Faculty of Sciences and Technology (2008-2014). She has published several refereed international conference and journal papers, and is active in the formal aspects of the field of performance evaluation and quantitative verification.

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