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Capsule Reviews

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The Capsule Reviews are intended to provide a short succinct review of each paper in the issue in order to bring it to a wider readership. The Capsule Reviews were compiled by Fairouz Kamareddine. Professor Kamareddine is an Associate Editor of *The Computer Journal* and is based in the Department of Mathematical and Computer Sciences at Heriot-Watt University, Edinburgh, UK.

Neural Memories and Oscillatory Operation. PETER WHITTLE

The first aim of the article is to show that 'recognition' can be realized by an artificial neural net (ANN), and that the structures thus generated can be in close analogy to those observed in nature. To do so, the author introduces the McCulloch-Pitts ANN and then discusses recognition and memory, which involve the testing of statistical hypothesis and signal processing. Here, it is explained how 'observations' must be retained in the system and how this involves the passage to a continuous time operation which is a dynamic form of the Hamming net. The resulting 'probability maximizing algorithm' is then discussed with respect to a number of block versions. Finally, the Freeman model is explained to illustrate that the absolute signal levels are almost meaningless in biological contexts and that, for such contexts, the current state of a system is revealed by dynamic rather than static behaviour.

Chaotic Evolution via Generalized Probabilistic Automata (Probabilistic Arrays). AZARIA PAZ AND JACK CARLYLE

This paper puts forward the thesis that polynomially non-linear interaction, as modelled by a finite-state probabilistic array, can exhibit chaotic behaviour, except for small numbers of states and low degree. First, two-state systems are introduced and the authors ask the two questions: (1) are there chaotic mappings realizable by an $(n = 2, d = 2)$-array? (2) if d is more than 2, are there chaotic two-state probabilistic array-realizable systems? The paper sets out to answer these questions. After a number of remarks on chaos, a two-state chaotic system is introduced that answers the second question. Thereafter, the authors show that if $n = 2$ and $d = 2$, chaos cannot occur under some operations. This answers question (1) negatively.

A Stochastic Geometry Model for Cognitive Radio Networks. TIEN VIET NGUYEN AND FRANCOIS BACCELLI

Cognitive radio aims at exploiting voids in time and space in order to accommodate extra radio devices [or secondary users (SUs)] in a network whose first function is to serve a population of primary users (PUs). The key requirement is that the PUs ought to be as little affected as possible by the presence of SUs. The present paper concentrates on exploiting voids in space by considering cognitive radio in a wireless network with users distributed in the Euclidean plane. The main contribution is a new probabilistic framework based on stochastic geometry for analysing the performance of Medium Access Control protocols within a large wireless network with randomly located users sharing the medium with carrier-sensing multiple access. After an introduction to the stochastic geometry framework by analysing the single PU model of a cognitive radio network model with a single PU and a population of SUs, a cognitive radio network model featuring a multicast PU (which extends the single PU model) is investigated. Thereafter, the authors focus on a model featuring two mobile ad hoc networks: a primary and a secondary one where carrier sensors (CSs) are used to control the interference level. This results in the cognitive-CSMA protocol, in which if a user in a network (either primary or secondary) wants to transmit, it has to use CS to detect the presence of other users in the network. If this user senses no other user nearby, it is then allowed to transmit. Otherwise, it has to wait before transmitting. Both active and passive modes are studied.

Scheduling Service in a Queuing System with Impatience and Set-up Costs. EMMANUEL HYON AND ALAIN JEAN-MARIE

This paper deals with the optimal control of a queuing system with customers with deadlines (impatient customers) while minimizing the costs. According to this paper, serving customers has a cost, as do missing deadlines and holding customers. Furthermore, impatience destroys the structural properties commonly used for proving optimality. However, the authors show that it is possible to adapt the framework of structural analysis of Markov decision processes (MDPs) to establish structural properties for optimality. First, the optimal control problem is formulated in the framework of MDPs in a discrete time model where the slot is the time unit and where customers are stored in an infinite buffer waiting for the

controller to admit them for service. During a slot, customers can get impatient and leave, incurring losses. Each customer has a constant probability of leaving in each slot. Stochastic operators are used to count the number of lost customers and of the remaining customers. The evolution of the state from a slot to its successor is given by a dynamic operator and its recurrence equation. Properties of the stochastic operators are introduced and then the transition probabilities that characterize the dynamics of the controlled process are given. The costs or rewards associated with decisions and transitions are then introduced along with decision policies and their value functions (their total expected discounted cost). The optimal policy is defined in terms of a solution (fixed point) of a dynamic programming equation. Thereafter, structural properties of value functions are studied in order to get qualitative results on the optimal policy. First, structured properties are defined with their structured value functions, and then submodularity is defined. Then the structural properties of the dynamic programming operator are established for the system and they include submodularity (when the value function is monotone and convex). Thereafter, threshold policies are given and it is shown that the optimal policy is a threshold policy. Finally, the threshold of the optimal policy values is computed. There is also a discussion of the results and of possible extensions.

Bounding Aggregations for Transient and Stationary Performance Analysis of Subnetworks. H. CASTEL-TALEB, I. ISMAEL-AOULED AND N. PEKERGIN

If there are no product-form solutions for the steady-state distribution for large queuing networks, the computation of the stationary probability distribution is very hard or intractable due to state space explosion. For this reason, the paper uses the stochastic comparison of Markov chains through state functions and maps the original, large CTMC model into a reduced-size bounding model from which bounds on performability measures are computed without any computation on the original model. After an introduction to the stochastic comparisons of Markov chains, the queuing network that will be analysed is given and the proposed approach is described by some intuitive ideas on the construction of subnetwork bounds. Next, the upper/lower bounding systems are formally defined through the coupling of the original chain and its image on the considered subnetwork state space. The queuing network is studied with five queues which produces numerical results related to the impact of the parameters on the precision of the bounds.

An Optimal Inherently Stabilizing 2-Neighbourhood Crash-Resilient Protocol for Secure and Reliable Routing in Hypercube Networks. MEHMET HAKAN KARAATA, OZGUR SINANOGLU AND BADER ALBDAIWI

A stabilizing protocol guarantees that, regardless of the current configuration, the protocol reaches a legal configuration in a bounded number of steps and the configuration remains legal thereafter. An inherently stabilizing protocol is one where transient faults affecting the variables of the processes and their arbitrary initialization have no effect on its execution. In an earlier paper, the authors gave a stabilizing and inherently stabilizing algorithm, where n different messages are routed over all node-disjoint paths simultaneously from n arbitrary source nodes to n arbitrary destination nodes in a hypercube network in every interval of $n + 1$ rounds. This algorithm, however, was incapable of tolerating failure of processes and links. This paper addresses this shortcoming and enhances the algorithm to tolerate a large number of process and link failures. First, the authors present the definitions needed including the definition of an n-dimensional hypercube, and then give the input, output, message buffers and actions in each process in their earlier node-disjoint path algorithm which is stabilizing and inherently stabilizing. Thereafter, the authors describe the difference between the paths traversed by this earlier algorithm and constructed by the scheme proposed by Saad and Shultz. Next, the authors present their newly proposed algorithm in two steps. First, they explain message routing in the fault-free case and then they present the routing algorithm in the presence of node/link failures. A number of lemmas and theorems are established for this new algorithm, including the proof that it is stabilizing and inherently stabilizing, and delivers n messages originating from source process s through shortest all-node-disjoint paths to destination process d in an n-dimensional hypercube in the presence of up to a certain number of processes with crash failures in the hypercube (under some conditions).

Analyzer: A Complex System for Data Analysis. JAKUB STARKA, MARTIN SVOBODA, JAN SOCHNA, JIRI SCHEJBAL, IRENA MLYNKOVA AND DAVID BEDNAREK

Processing techniques for managing XML data suffer from various bottlenecks, which worsen their time/space efficiency. According to the authors, this is caused by either the generality of the techniques in that they take into account all possible features of input XML data, or by the restrictiveness of the techniques which restrict features of the given input XML data. This paper asks whether it is necessary to take into account the features that will be used minimally or will not be used at all, and if so, what are these features? Furthermore, working with real-world data is not simple, since data can change and may not be precise. The authors introduce a complex extensible framework called 'Analyzer' for performing statistical analyses of real-world documents. The system is built to address four problems: Data crawling, Processing of incorrect data, Structural analysis and Query analysis. First, the authors introduce the motivation for the exploitation of the knowledge of real-world data and give several examples where the knowledge of real-world data has been successfully exploited. Then the architecture of the Analyzer is given with its proposed analytical model and its basic implementation aspects.

Here, the models of documents, collections and plugins are given. The authors configured two simple analyses with four methods for generating the performance results. Afterwards, the authors move onto data crawling which they state to be entangled within performance bottlenecks and surrounded by ethics and copyright rules. The authors adapt and extend an existing HTML-oriented crawler. Then the paper concentrates on the processing of incorrect data focusing on the problem of structural invalidity of XML documents. The basic ideas of a correction model and proposed algorithms for finding structural repairs of invalid XML documents are given. Having crawled and corrected the XML data and/or schemas, the authors move to their structural analysis using several metrics. Next the authors concentrate on the analysis of queries over XML data and describe the XQAnalyzer tool which supports studies that include the analysis of a collection of XQuery programs. The paper ends with a discussion of the related works, the open problems and conclusion.

Design Techniques Targeting Low-Area-Power-Delay Product in Hyperbolic CORDIC Algorithm. SUPRIYA AGGARWAL AND KAVITA KHARE

The COordinate Rotation DIgital Computer (CORDIC) algorithm is a simple computation technique for realizing (at low computation complexity) various mathematical functions. However, the CORDIC algorithm suffers from various disadvantages: its sequential nature adds to its latency (and hence one needs intelligent identification of micro-rotations to minimize the number of iterations), it needs optimization of micro-rotations and a scale-factor compensation network, and its range of convergence (RoC) can be compromised. Furthermore, most optimization efforts have been targeted at the circular CORDIC algorithm and little done for the hyperbolic CORDIC algorithm. This paper proposes a novel scale-free design of the CORDIC algorithm in the hyperbolic mode, which avoids the above-mentioned disadvantages. After an overview of the underlying principles of CORDIC computations, of the iterative formulation of CORDIC equations and of the circular Scaling-Free CORDIC, the authors propose their scaling-free hyperbolic CORDIC algorithm. In their proposal, scale-freeness is derived from the Taylor series expansion of hyperbolic terms which realize the CORDIC iterations. Furthermore, the micro-rotations are identified by the most-significant-one location in the radix-2 representation of the rotation angle. An algorithm is given for the intelligent identification of micro-rotations and to minimize the number of iterations. Then the number of iterations used for realizing rotations is determined to limit its latency and mathematical identities used for extending the RoC. The (eight-staged) pipelined architecture of the proposed CORDIC processor is given, where the first stage is the pre-processing unit while the next seven stages perform CORDIC iterations. Errors in hyperbolic and exponent values are calculated using MATLAB inbuilt functions and their effect on existing systems is explained. The proposed hyperbolic CORDIC processor is tested on two benchmark circuits in neural networks: the XOR-problem and the 3-bit Parity problem. Finally, the field-programmable gate array implementation and complexity of the proposed CORDIC are discussed.