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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.

Self-optimized Cognitive Network of Networks. A. MANZALINI, P.H. DEUSSEN, S. NECHIFOR, M. MAMEI, R. MINERVA, C. MOISO, A. SALDEN, T. WAUTERS AND F. ZAMBONELLI

The paper argues for the need of an integrated cognitive networking approach aimed at simplifying management and control while being abstract, general and economical and proposes an approach for introducing cognitive capabilities in future networks. In particular, this approach would be based on a highly decentralized cyber environment of dynamically interconnected resources. The authors present their vision of this new decentralized cognitive plane (DCP) whose purpose is to enable future networks to self-optimize, self-manage and self-control in a reactive–proactive manner. Key issues related to the realization of the DCP idea include, amongst other things, implementation (on a rich variety of networks and devices) and information security.

Dynamic Multi-path Allocation in Ad Hoc Networks. YOSI BEN-ASHER, SHARONI FELDMAN AND MORAN FELDMAN

This paper argues that an ad hoc network creates a ubiquitous network that overcomes the no line of sight limitations by using mediators between communicating peers, but that wireless transmission channels are expensive and vulnerable. For this reason, the authors propose a dynamic allocation of multiple paths and present the metrical routing multi-path algorithm (MRMA) which randomly selects the shortest path out of a current group of 'short paths' in order to bypass a congested edge. MRMA is an extension of MRA, an earlier algorithm proposed by the authors, and generalizes the use of a single tree to a set of independent trees during the creation of session paths between nodes. The properties of the proposed algorithm are studied and simulation and experimental results are carried out.

A Hybrid Adaptive Protocol for Reliable Data Delivery in WSNs with Multiple Mobile Sinks. GIUSEPPE ANASTASI, ELEONORA BORGIA, MARCO CONTI AND ENRICO GREGORI

In sparse wireless sensor networks, the distance between neighbouring nodes is larger than their transmission range, and data are collected through special mobile nodes that move in the environment to gather information when they are within the transmission range. Such mobile nodes are called mobile sinks (MSs). Since the contact duration depends on the path followed by the MS and on its speed, and since it affects the data delivery process, the authors state the need for a reliable and efficient broadcast communication protocol that can transmit large amounts of data in a short time and with minimal costs, and that can efficiently manage a parallel delivery process with different MSs. And, this is what the authors set out to do through their energy-efficient hybrid interleaved (HI) data delivery protocol. After an introduction to related work, the design principles are introduced which include producing enough redundancy in advance and sending codes on demand depending on the feedback of the MSs. Data bundles of limited size are sent to one or more MSs that happen to be within the contact area of the sensor node. The operations required to transfer the bundle to an MS are given. The transmitted data are encoded and both the sensor and the MS are aware of the encoding parameters. The HI protocol is implemented in an event-driven simulator and this is used to evaluate the HI protocol and also to compare it with an implementation by the authors of the selective repeat protocol. For comparison purposes, a number of metrics (including energy and latency, amongst others) is used and three mobility scenarios (high level, low level and heterogeneous) characterized by different speeds for MSs are introduced. Finally, the protocol is validated with real sensor nodes.

Controlled Multi-path Routing in Sensor Networks Using Bezier Curves. OLIVIU GHICA, GOCE TRAJCEVSKI, PETER SCHEUERMANN, NIKOLAY VALTCHANOV AND ZACHARY BISCHOF

This paper aims at extending the lifetime of wireless sensor networks while ensuring timely delivery of data packets. The lifetime of a network can be defined in a number of ways. For example, it could be defined as the interval of time (a) until

a certain percentage of the network's nodes fail or (b) during which the network maintains connectivity. It is known that lifetime maximization and energy consumption are correlated problems. The authors argue that when long-running queries are executed, the nodes in the proximity of a designated route maintain higher energy reserves than the ones servicing that route and hence these dormant nodes should be used for routing purposes. This will reduce the variance of energy and will avoid adding significant delays to packet delivery. Hence, the approach of the paper is to use multi-path routing for load-balancing for prolonging the lifetime of the network and for minimizing the energy-level discrepancies among neighbouring nodes while at the same time guaranteeing timely delivery of data packets. To achieve their goals, the authors construct alternating multi-path routing of data packets based on Bezier curves which are highly flexible in the construction of their shapes and in the exploitation of the nodes in the vicinity of the source/sink. First, the preliminaries (including Bezier curves and a discrete approximation of them) are presented. Since a Bezier curve only allows the use of a small subset of nodes between the source and the sink nodes, the authors propose to use a family of curves between the source and the sink and they set out to build a multi-path routing model based on these families of Bezier curves. It is shown how to forward data packets along an individual trajectory from a given family of Bezier curves and how to load-balance the proposed stream pipes. The authors then move their attention to real-time aspects that will further prolong the lifetime of the network, decrease the energy expenditure of the nodes and ensure the timely delivery of the packets. Focusing on these real-time aspects, the authors review their proposed method and algorithms and propose changes to the ß policies and implementation. Experimental evaluation is carried out to demonstrate the advantages of the proposed method and to compare it with others.

The Edge-Fault-Tolerant Bipancyclicity of the Even *k*-ary *n*-cube. JYWE-FEI FANG

Paths and cycles are popular interconnection networks. A graph is pancyclic if it enables cycles of all lengths from 3 to N, where N is the order of the graph. Bipancyclicity is the restriction of pancyclicity to bipartite graphs. This paper considers the k-ary n-cube interconnection network $Q(k, n)$ which satisfies attractive properties like regularity and vertex/edge transitivity, and studies its fault-tolerant bipancyclic properties. First, the author introduces the preliminaries and background and defines the ladder-wounded cycle-of-ladders graph (a cycle-of-ladders with only faulty rungs, except the bottom and the top rungs). The main result of the paper is that when k is even, then $Q(k, n)$ is $(2n - 2)$-edge-fault-tolerant bipancyclic for $n \geq 2$.

Multiple Class Symmetric G-networks with Phase-Type Service Times. THU-HA DAO-THI, JEAN-MICHEL FOURNEAU AND MINH-ANH TRAN

The authors state that most generalized networks of queues have product form solutions such that the service times follow exponential distributions. This paper studies G-networks with phase-type service time and introduces a new type of signal which results in a new extension of G-networks that still has a product form for its stationary regime. First, the preliminaries are introduced, especially the definition of quasi-reversibility of Chao, Miyazawa and Pinedo which is used to accommodate a G-network with signals. In a network of N queues, each queue is quasi-reversible with signals. Furthermore, assuming quasi-reversibility for each queue in isolation, the stationary distribution of the network process has a product form. The authors present the model of one queue with results related to the stationary distribution and quasi-reversibility. From these results related to the model with one queue, the authors move on to connect the queues to form a network. This new network model is described along with its traffic equations and product form theorem which states that if the traffic equations satisfy a certain equation, then the network is stable and has a product form.

MS-DFA: Multiple-Stride Pattern Matching for Scalable Deep Packet Inspection. LUCAS VESPA, NING WENG AND RAMASWAMY RAMASWAMY

Deterministic finite automata (DFA) implement multiple patterns matching, however, their speed and efficiency are affected by the problems of maximizing the throughput and increasing the stride while minimizing memory. This paper aims at designing a fast and memory-efficient pattern-matching architecture, where DFA-matching operations are speeded up by increasing the stride while still maintaining a small memory, and where the throughput is still good with little memory. The authors achieve this through a block-based approach where states/transitions are grouped into coarse-grained and variable size blocks. Three blocks are used in the paper leading to a multi-stride DFA (MS-DFA) high-throughput low-memory pattern-matching engine with its prototype implementation and memory and performance analysis. After reviewing the related work, the authors explain the MS-DFA and the design and operation of an MS-DFA. Since MS-DFA consists of three blocks, the paper introduces each block separately. Then, the authors give an analytical model which allows the analysis of the performance and memory of the MS-DFA. Experimental results related to the analysis of performance and memory are given, and the MS-DFA is compared with another architecture (the VS-DFA).