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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 the content 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.

On the Behavioral Equivalence between *k*-Data Structures. M. MARTINS

Object Oriented (OO) systems constitute a challenge for traditional algebraic methods due to the fact that data is split into two categories: visible data and hidden data. This paper concentrates on the behavioral equivalence relation between hidden data elements. This behavioral equivalence relation is influenced by abstract algebraic logic (AAL) and behavioral equivalence is given as a kind of generalized Leibniz congruence considering the distinctive characteristics of the OO paradigm. The author defines a *k*-data structure to be a collection of data items of different sorts (lists, Booleans, etc.) and operations on these items, together with a set of *k*-tuples of elements called a filter. These *k*-data structures play an important role in the algebraic specification of OO programs. First, the preliminaries are given where the notions of sorted algebra, *k*-data structures and Leibniz congruence are detailed. Since Leibniz congruence is a generalization of the Nerode equivalence in automata theory, and since it is preserved under inverse images of surjective homomorphisms, the author introduces homomorphisms and products and shows that the homomorphism theorem can be generalized to *k*-data structures and that furthermore, global behavioral equivalence of *k*-data structures may be seen as a generalization of the equivalence of finite-state machines. The main theorem of the paper states that two *k*-data structures have the same behavior if and only if their quotients under the respective Leibniz congruences are isomorphic.

On Distributed Rating Systems for Peer-to-Peer Networks. Y. TIAN, D. WU AND K.-W. NG

A peer-to-peer (P2P) network consists of a large number of autonomous peers any of which could behave deceptively. A well-designed P2P should be resilient to malicious peers. This paper develops a stochastic model for understanding P2P rating systems and studies two representative system designs: the unstructured self-managing rating (UMR) system and the structured supervising rating (SSR) system. Furthermore, the paper proposes a loosely supervising rating (LSR) system for P2P which can be viewed as a generalization of a system in which both UMR and SSR are present. After introducing P2P rating systems and the critical factors for its performance, an analytical modeling framework which incorporates the various design and factor components is used to understand P2P rating systems. Particular attention is given to evaluating the rating management and the distribution mechanism during the study of how the designs of the UMR-like and the SSR-like systems behave under different environments and attacks. Performance analysis is carried out under a number of conditions (the ideal condition, whitewashing attacks, network dynamics and false rating attacks). The UMR and SSR performance rating systems are numerically studied under different adversary attacks and network environments and the model soundness and accuracy is analyzed. Next, a section is devoted to the proposed LSR system where the model is given and its performance analysis and evaluation are carried out. Related works are discussed in detail.

Reducing Power Consumption in Wireless Sensor Networks Using a Novel Approach to Data Aggregation. S. CROCE, F. MARCELLONI AND M. VECCHIO

Data communication is very expensive in terms of energy consumption whereas data processing consumes much less energy. For this reason, energy conservation schemes extend the lifetime of a wireless sensor network (WSN) by minimizing the energy consumption of the communication unit. One approach for doing so is the use of duty cycling schemes which are accompanied by in-network processing techniques like compression and aggregation. Aggregation allows limiting transmission/reception of messages to aggregates rather than to all the data measured at single nodes. This paper presents a distributed approach based on fuzzy numbers and weighted average operators to perform energy efficient aggregation in WSNs. First, the paper presents the four types of data aggregation techniques for sensor networks used in the literature. Then, the approach of the authors is presented by giving the proposed

Aggregation module which is based on each node having an estimate $E = (e, es)$ of the global aggregated function. E is a fuzzy number and the sensor also measures the values received as fuzzy numbers $V = (v, vs)$. The Aggregation module compares the relevant fuzzy numbers and produces a new estimate. A Table of Estimates is created dynamically and is used by a Decision module to decide whether the new estimate computed by the Aggregation module should be sent. There is also a Message Analyser module which analyses the message received and decides whether the information should be forwarded to the Aggregation and Decision procedures or simply stored in the Table of Estimates. The paper also has a process in place for the case when estimates become stale. Furthermore, the paper illustrates how the WSN life time can be estimated. The paper's proposal of handling power consumption is illustrated in two ways. First, through simulation examples where the maximum temperature in the network is measured and the results are compared to those obtained from executing the same simulations in another approach of the literature. Second, through a real example to monitor the maximum temperature in a 200 square meter flat. The results show that the algorithm is able to reduce the number of received and sent messages without affecting the quality of the aggregate estimation.

Similarity of XML-Schema elements: a structural and information content approach. A. FORMICA

Similarity measures for XML-Schema elements can support a number of useful activities. This paper gives a method for determining semantic similarity of XML-Schema elements where XML-Schema type hierarchies are addressed. The paper's approach is based on 1) an extension of an ontology management system known as SymOntos where the information content of type declaration components plays a crucial role and 2) a formalization of a similarity measure. First, the paper introduces related work where similarity measures have been proposed for dealing with hierarchically related concepts and numerical feature vectors. Then, the paper presents the XML-Schema data model focussing on a subset of the W3C XML-Schema specification and on type hierarchies involving complexTypes. Examples of complexTypes are given and their legality is referred to [Formica]. The formal background to the XML-Schema and type hierarchy is given. Since type expansion (see [Formica]) is a preliminary step for determining element similarity, the paper introduces the expanded form of an XML-Schema and moves to defining the notion of weighted type hierarchy. The method for determining similarity of XML-Schema elements is then introduced by giving its two building notions: information content similarity and type structural similarity and then combining them into the combined similarity notion (CombSim) for XML-Schema elements. A running example is used throughout to illustrate the various notions. This example is also used to determine similarity according to other approaches in the literature and to compare the results with the similarity results obtained from the proposal of the paper.

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Bi-Directional Synthesis of 4-Bit Reversible Circuits. Y. SONG, HUNG AND PERKOWSKI

Research efforts on the synthesis of reversible circuits lack in results concerning 4-bit circuits. This paper addresses this problem and presents a bi-directional synthesis approach which outperforms existing methods by eight steps (in contrast to existing methods which only perform four steps) for the Controlled-Not, Not and Peres gates (CNP) library. The paper first lays the background with permutation group theory and binary reversible logic. Then, the paper gives a bi-directional search algorithm which is enhanced using a simple strategy in such a way that the memory needed in the enhanced version remains the same as the memory needed in the bi-directional search. The bi-directional algorithm and its enhanced version minimize the number of binary reversible gates. The paper proposes a further algorithm which an enhances the bi-directional search algorithm by reducing quantum cost. Some experiments on 4-bit synthesis using CNP are carried out establishing the efficiency of the proposed bi-directional synthesis approach. A section is devoted to the synthesis of any n-bit non-reversible circuit and to even n-bit reversible circuits.

Accurate and Efficient Cache Warmup for Sampled Processor Simulation through NSL-BLRL. E. HELLEBAUT AND EECKHOUT

The paper starts from the observation that detailed simulation of full benchmark executions during design space exploration is infeasible. Proposed solutions to this problem in the literature include sampled simulation where a number of execution intervals (samples) are selected to be simulated. The unknown hardware state at the beginning of each sample (known as the cold-start problem) is solved by a warmup of large hardware structures and can be long. The paper argues for the need of efficient and accurate warmup strategies. The paper considers two earlier warmup proposals: the no-state-loss (NSL) and the boundary line reuse latency (BLRL) and combines them into an efficient warmup strategy called NSL-BLRL. First, sampled processor simulation is detailed and a number of existing warmup strategies are reviewed. Then, the paper proposes its warmup strategy which combines NSL and BLRL which is then extensively evaluated through experiments

that assess a number of criteria including accuracy, the warmup simulation instructions that need to be processed, the overall simulation time speedup, the storage requirement and the cache replacement policies. Through the experiments, the NSL-BLRL warmup strategy is compared to other warmup strategies and is shown to have a number of advantages.

Average-Case Performance Analysis of Online Non-Clairvoyant Scheduling of Parallel tasks with Precedence Constraints. K. LI

This paper addresses the problem of finding a non-preemptive schedule where parallel tasks run without interruption until completed such that the total execution time is minimised. The tasks have precedence constraints and the problem can be regarded as a parallel task scheduling problem. This paper concentrates on non-clairvoyant scheduling of precedence constrained parallel tasks where only the sizes of the tasks and the precedence constraints are known. In particular, the paper considers the problem where the scheduling algorithm is online. In that case, the online non-clairvoyant scheduling algorithm receives tasks at different times without prior knowledge of the future tasks and of the execution times on uncompleted tasks. The author extends the so-called SIMPLE algorithm which is an earlier non-clairvoyant scheduling algorithm of independent parallel tasks. The extension accommodates level by level (LL) scheduling of tasks where tasks are divided into different levels and where tasks on the same level are scheduled by algorithm SIMPLE. The algorithm LL-SIMPLE is given and followed by two other algorithms: the online non-clairvoyant scheduling algorithm LL-GREEDY (where GREEDY is an improved version of SIMPLE) and the well known online non-clairvoyant LS algorithm where boundaries between levels are broken. Extensive simulation results were carried out enabling a comparison between the three algorithms.

Information-Dynamics-Conscious Development of Routing Software: A Case of Routing Software That Improves Link-State Routing Based on Future Link-Delay-Information Estimation. H. EOM

As the title proposes, this paper considers the change or dynamics of information to be an important part of any analysis of information in software systems. This is justified by the fact that not only information is important, but its dynamic plays a crucial role in our software. The paper demonstrates the usefulness of its proposed information-dynamics-conscious software design and development approach through a networking problem. The networking problem considered is that of a link-state routing where each node collects information on the state of its outgoing links and shares it with all other nodes in the network in order to determine the best path from itself to any other node of the network. Since in a link-state routing each node creates a delay estimate for an outgoing link and sends it to all nodes, changes of the delay information should be considered in the design of the routing software. This paper studies in detail the information-dynamics-conscious-design issue. It discusses current link-state routing design approaches, argues that they are mostly static, and shows that the proposed dynamic conscious approach improves these approaches with respect to routing traffic and data performance. For example, in the usual link-state routing approaches, each node floods its link-cost estimates without any considerations as to whether such estimates are necessary for determining the path. However, in the proposed dynamic conscious approach, a node disseminates link-cost information only when this information is necessary for estimating the delay. After formulating the problem, the paper presents the routing-software design based on estimates of encountered delays (known as InfoDyn routing). A small example is given where InfoDyn routing improves routing performance compared with link-state routing. Then, the paper uses simulation (through the Maryland Routing Simulator MaRS) to compare a routing scheme based on the proposed approach with the shortest path first (SPF) link-state routing technique. Two simulation studies phases where introduced, each showing positive results and improvements gained by the use of InfoDyn. Finally, the paper reviews related works and concludes.