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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.

Design of Traffic Light Control Systems Using Statecharts. Y.-S. HUANG

In traffic signal control research, two issues are studied:

(i) Determining what signal-indication sequences to follow in order to optimize the performance.
(ii) How to implement the signal control.

The paper concentrates on the implementation of the signal control logic using the so-called statecharts model where dynamic properties are verified through the states method. The paper illustrates how some physical traffic lights control systems can be described with statecharts and how various components needed to make up the control systems become more evident. For example, statecharts enable better description of hierarchies, concurrency and timing specifications. The traffic lights control systems discussed include the eight-phase, six-phase and two-phase traffic light systems. The paper represents and analyzes using statecharts, an urban traffic network controller where nine intersections are considered. Since it is hard to represent all concurrent states together, the paper proposes concurrent state graphs where all concurrent states are modeled in complex statecharts. The concurrent state graph generates 17 nodes where each node consists of 9 elements corresponding to the 9 intersections of the urban traffic network. The urban traffic lights controller is then implemented. Concurrent state graphs are a convenient method to simultaneously represent all concurrent states in a complex system.

Solving Rummikub Problems by Integer Linear Programming. D. DEN HERTOG AND P. B. HULSHOF

Integer linear programming (ILP) has often been used for solving different kinds of puzzles and games on the computer. Rummikub is a game for two to four people where the winner is the one who eliminates all the tiles from his rack by forming them into sets of runs and groups. Players try to table the greatest amount of tiles by rearranging or adding them to sets already on the table. The Rummikub problem consists of finding the maximal number or value of the tiles that can be placed from your rack onto the table. This number can be very high and hence trying all the possibilities is impossible. This paper uses ILP techniques to solve combinatorial problems arising in Rummikub. The paper uses embedded XA-solver to solve the ILP problems associated with examples of Rummikub problems. These examples show that the execution time can be less than a second. Two such examples are shown in detail.

Persistent Semi-Dynamic Ordered Partition Index. A. THOMASIAN AND L. ZHANG

Similarity search is a popular search method in a number of database applications. This paper is concerned with similarity search in multimedia and image databases, where content-based image retrieval is implemented via range or k-Nearest Neighbor (k-NN) queries. Each such method has its disadvantages. The paper concentrates on k-NN queries with indexing and/or clustering which speed up such queries. The paper starts from point indexing methods where indices are categorized into main memory (which aim at reducing CPU time but are affected by the volatility and size of the main memory) and disk resident indices (where the number of disk pages accessed influences the query processing cost). As a matter of fact, some main memory resident indices have been designed for processing k-NN queries and outperform disk resident indices in reducing CPU time. Moreover, indices which work well with low and medium dimensional data are inefficient in high-dimensional space since the Minimum Bounding Rectangles of R-tree-like indices become highly overlapped in high dimensions incurring high partitioning time in each data transfer. To avoid such problems, this paper extends the static main memory ordered partition index (OP-tree) to make it semi-dynamic and persistent. Four methods are proposed to modify the original OP-tree to allow the insertion of new points. Three of the four proposed methods are implemented. The paper discusses the insertion methods and shows that amongst the three implemented methods, the add-level point insertion method works best. The paper also discusses scalability and applies clustering to partition the dataset into clusters so that the resulting partitions can fit into main memory.

Development, Analysis and Evaluation of Performance Models for Mobile Multi-Agent Networks. S. M. KORIEM
In order to better understand distributed systems design using the mobile agent paradigm, the paper proposes a new mobile agent performance model using the generalized stochastic Petri net (GPSN) modeling technique. Current GPSN modeling techniques allow a good balance between the modeling power and expressibility on the one hand, and the analysis power and efficient implementation on the other. In fact, GPSN are used to model real networks as well as describe the dynamic behavior (e.g. agent migration, interaction amongst the nodes, etc.) of the mobile agent network. With this in mind, the proposed model is further amended with new mobile agent behaviors (which describe the dynamic behavior of mobile agent networks with parallel agents) and uses a number of agent communication techniques (e.g. local, direct, indirect and parallel). In addition to all this, the proposed model allows for extra processes which describe the creation process of new agents during the agent migration process from node to node, and facilitates the analysis of the developed GPSN model when it incorporates requests from many users and a large number of mobile agents. The model allows for a large number of network nodes and a large number of users (which can also be parallel agents). To facilitate the analysis of the model when the system incorporates many users' requests and a large number of mobile agents, the paper proposes a reduction modeling technique to reduce the original GPSN model to a simpler one and discusses the verification of the correctness of the reduced net. Four performance studies are carried out which investigate the effect on the network performance of hop number, agent communication time, mobile agent size and mobile agent number.

Verifying an ATM Protocol Using a Combination of Formal Techniques. V. RUSU
The paper's starting points are as follows: (i) most industrial systems are out of reach of current state-of-the-art model checkers and theorem provers and (ii) attempts at overcoming this problem have been advocated by the combination of model checking and theorem proving through abstraction and compositionality. Compositionality allows each component to be abstracted and verified independently of any other component. The paper proposes another way of overcoming this problem and illustrates the proposed method on the medium sized Service Specific Connection Oriented Protocol (SSCOP). The method proposed is itself also compositional and is based on mechanized compositional and deductive reasoning where the proof assistant PVS is used for verifying invariants. SSOP is standardized in a document which includes a formal specification in SDL (Specification and Description Language). The main property verified concerns the secure data transfer service which consists of sending, detecting and resubmitting lost, protocol data units (PDU). The model of an extended automata is first presented together with a PVS implementation for proving invariance properties of the extended automata. The author shows next how a contiguous sequence of transitions can be collapsed into one transition resulting in an equivalent automata which is easier to verify. Since many systems consist of a number of communicating entities which are best modeled using parallel composition of extended automata, the author presents the composition of extended automata. The author defines two parallel composition operations: the interleaved and the atomic and shows that for the so-called class of stable predicates, if the two automata are mutually independent then verification on the interleaved parallel composition is equivalent to that on the atomic parallel composition. Since the abstract atomic parallel composition is more practical for verification, the author gives a compositional rule for verifying invariants at the abstract level and shows that the collapse operation (where a contiguous sequence of transitions can be collapsed into one transition) distributes over the parallel composition. This means that the composition rule together with the collapse operation enable the author to reduce the number of proof obligations. The rest of the paper is then devoted to the verification of the SSCOP protocol together with the concluding remarks and a discussion of related works. The proofs are all gathered in an appendix.

Static Task Scheduling with a Unified Objective on Time and Resource Domains. B. DEMIROZ AND H. R. TOPCUOGLU
Efficient scheduling tasks on an application on available processors is a critical issue for achieving high performance in parallel and distributed systems. For static scheduling, an application is represented by a weighted directed acyclic graph where the nodes represent the application tasks and the edges represent inter-task data dependencies. The task scheduling problem is NP-complete in its general case and there a only a few known polynomial-time scheduling algorithms. The width of a task graph is the maximum number of tasks that can be executed concurrently. The performance of any heuristic on a given graph is measured in terms of the schedule length (or makespan) of the overall completion time. There is a tradeoff between the minimization of the makespan and the minimization of the number of processes. The first (schedule length minimization) is for application utilization whereas the second (number of processes minimization) is for resource utilization. This paper unifies both objectives of schedule length (time) and process usage (resource) minimization with a weighting scheme that includes the normalized schedule length and the normalized process usage. Then, the paper formulates the general task scheduling problem using a genetic algorithm (GA). Performance studies are then carried out with five task scheduling heuristics for various graph characteristics. Comparison with related work is carried out concluding that the proposed method outperforms other heuristics.

Modeling the Input History of Programs for Improved Instruction-Memory Performance. C. A. G. ASSIS, E. S. T. FERNANDES AND V. C. BARBOSA

Since only a small fraction of the instructions of a program is responsible for most of its running time, and since there is a gap between memory and processor performance, the past few years have seen an ongoing interest in code-layout techniques which optimize memory use. This research is guided by the fact that the first basic blocks of a program to be loaded into memory should be precisely those most likely to be executed. This paper studies the construction of a dynamic probabilistic model of the inputs to a program which can be used to update the program's code-layout and to improve the usage of the instruction memory. The use of heuristic/probabilistic techniques is due to the fact that the optimality of a code layout cannot in general be decided. The paper starts by building the model which records, for a particular program P, a trace of the execution as it goes through the basic blocks of P and uses that trace to construct a Bayesian network. This Bayesian network together with another Bayesian network which represents the history of all previous executions of P lead to prediction capabilities which allow more efficient executions. The paper describes how the Bayesian network Bi which models the execution of a program P on input Ii is constructed. Then, the paper describes how to incorporate the probabilistic knowledge that Bi represents about the ith execution of P into $H(i-1)$, the history model of the first $i-1$ executions, to lead to a new Bayesian network which represents the first i executions. Then, the paper uses these constructions to formally predict efficient executions. The paper reports on numerous experiments using the proposed method.