

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 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.

Reachability Analysis of Augmented Marked Graphs via Integer Linear programming. CHIEN-LIANG CHEN, SHAO-CHI CHIN AND HSU-CHUN YEN

When studying the dynamics of Petri nets, one needs to analyse the reachability problem concerned with determining whether a specific marking can be reached as a result of a required functional behaviour. Such analysis involves solving systems of linear inequalities and constraints. However, reachability is not equivalent to solving such an equation. In other words:

1. If the initial marking of a Petri net P is μ_0 , then marking μ is reachable from μ_0 in P only if the state equation $\mu = \mu_0 + Ax$ is solvable for x in an m product of natural numbers where A is the adjacency matrix of P and m is the number of transitions of P .
2. For general Petri nets P , the solvability of the state equation does not imply reachability.

Nonetheless, the above equivalence holds for a subclass of Petri nets called marked graphs. This paper concentrates on the so-called “augmented” marked graphs (AMGs), a useful subclass of marked graphs. The paper introduces the so-called decomposable AMGs and shows that the reachability problem for decomposable AMGs is equivalent to solving a set of linear inequalities and constraints. The paper then extends its study of reachability to the model checking of decomposable AMGs with respect to a class of branching time temporal logic. In this respect, the paper gives a model checking algorithm and analyses its complexity.

General Tree k -Coterie to Reduce the Degradation of Quorums. YU-CHEN KUO

The k -mutual exclusion problem deals with a k -units shared resource in a distributed system where each resource can be accessed by only one node at a time. Hence, a solution to the distributed k -mutual exclusion problem guarantees that at most k -concurrent nodes can access simultaneously k units of the shared resource. Of the algorithms proposed in the literature to solve the k -mutual exclusion problem, the quorum based algorithm uses the quorum concept (a set of some nodes)

to achieve k -mutual exclusion. A k -coterie is a collection of quorums where among any $k + 1$ quorums, there are two with a non empty intersection. This intersection property of k -coteries guarantees the k -mutual exclusion. Important measurements to evaluate the fault-tolerance capability of a k -cotery include complementalness which implies nondomination. Earlier work proposed the basic tree k -coteries, a basic tree structure to construct k -coteries (BT k -coteries). This paper proposes the general tree structure to construct general tree 1-coteries (GT 1-coteries) and uses the coterie root-join operation to construct GT k -coteries at a common root. The paper shows that GT k -coteries could be complemental and hence are resilient when the network is 2-partitioned. The proposed general tree structure is suitable for any system with an odd number of nodes when depth = 2. Furthermore, GT k -coteries have a number of advantages over BT k -coteries and moreover, the degradation of quorums and the quorum size could be simultaneously reduced.

Modeling DNA/RNA Strings Using Resistor-Capacitor (RC) Ladder Networks. R. MARSHALL

This paper proposes to model DNA/RNA strings using electrical circuits comprised of resistors (R) and capacitors (C) forming a resistor-capacitor (RC) ladder network. Electrical circuits have been used in the literature to model biological concepts but have not been applied to DNA/RNA before. The paper first introduces the generic electrical model for a single-based and a two-based DNA string and then the specific model for a nucleotide. In developing the circuit models, only the chemical-structural aspects of nucleotides have been taken into account. This is suitable since the modeling is for DNA strings and not for amino-acids. This study reveals that numerous correspondances may be established between the behaviour of the proposed circuits and the biological/chemical properties of DNA/RNA strings.

Loopless Generation of Non-regular Trees with a Prescribed Branching Sequence. RO-YU WU, JOU-MING CHANG AND YUE-LI WANG

This paper starts from ordered trees (where the relative order of the subtrees is fixed) which are non-regular (i.e. the number

of subtrees in internal nodes vary). An integer sequence $s = (s_1, s_2, \dots, s_n)$ is a branching sequence of an ordered non-regular tree T (with internal nodes numbered 1 to n in the preorder list) if the node with number i has s_i subtrees for $1 \leq i \leq n$. As the title expresses, this paper studies the loopless generation of non-regular trees with a given branching sequence. A loopless generation algorithm is an algorithm where the amount of computations needed to change one object into the next takes a constant time. The paper presents a loopless algorithm that generates Gray-codes on non-regular trees. First, a structural representation of non-regular trees is given using the right-distance sequence (RD-sequence). The latter does not make sense without the branching sequence. Then, the authors rearrange the non-regular coding tree so that a Gray-code order enumeration can be obtained. The main theorem of this paper states that all non-regular trees with respect to a branching sequence can be generated in Gray-code order in O -time and that the generation of each RD-sequence takes constant time. Generating Gray-codes of k -ary trees can also be achieved by the algorithm.

The Bipancycle-Connectivity and the m -Pancycle-Connectivity of the k -ary n -cube. JYWE-FEI FANG

Interconnectivity is crucial for a massively parallel system and affects its performance, cost, efficiency and fault-tolerance capabilities. Various interconnection networks have been proposed in the literature. A path and a cycle are popular and there has been numerous interests in embedding them into various interconnection networks. In order to efficiently execute a parallel program, both the order of the allocated path and the size of the allocated cycle must correlate with the problem size of the program. This paper deals with panconnectivity where a graph G is panconnected if every disjoint vertices x and y of G are joined by a path of every length ranging from $\text{Dist}(x, y)$ to $N - 1$ where N is the order of the network and $\text{Dist}(x, y)$ is the distance between x and y . A graph G is m -panconnected if each pair of vertices x and y are joined by a path of each length ranging from m to $N - 1$. A graph G is bipartite if the vertex set of G can be partitioned into 2 partite sets V_1 and V_2 such that each edge of G joins one vertex in V_1 and the other in V_2 . Bipanconnectivity is the restriction of panconnectivity to bipartite graphs. Similarly, the paper defines the notions related to cycles where for example, a graph is pancyclic if it embeds a cycle of every length ranging from 3 to N and a graph is m -pancyclic if it embeds a cycle of every length ranging from m to N where $3 \leq m \leq N$. Other definitions of bipancycle-connectivity and m -pancycle-connectivity are defined similarly. The interconnection network considered in this paper is the k -ary n -cube, $Q(k, n)$ where the paper studies the bipancycle-connectivity and the m -pancycle-connectivity of the $Q(k, n)$. The paper shows that the k -ary n -cube is bipancycle-connected for k even and that the k -ary n -cube is strictly m -pancycle-connected for k odd, $n \geq 2$ and $m = nk - n$.

An Abstract Interpretation Approach for Enhancing the Java Bytecode Verifier. ROBERTO BARBUTI, NICOLETTA DE FRANCESCO AND LUCA TESEI

The language of the Java Virtual Machine (JVM) is called Java bytecode or JVMIL. A Java bytecode verifier performs a set of checks on JVMIL programs before their execution. However, this bytecode verifier may reject Java programs that were correctly compiled into bytecode programs. The problem arises in the presence of subroutines used to compile the Java try-finally construct. Existing solutions to this problem are unsatisfactory. This paper gives a formal abstract interpretation framework to reason about the bytecode verification and defines the verification process as a formal abstract semantics of JVMIL. In this context, the paper proposes an enhanced verifier of the try-finally construct by using bytecode routines. This enhanced verifier is based on the same algorithm as the standard one but uses a richer domain of types and is formalised in the abstract interpretation framework. This enhanced verifier is shown to accept some of the correctly compiled into bytecode programs that were rejected by the standard verifier. Hence, this enhanced verifier accepts a larger set of type-safe bytecode programs than the standard one.

On the Usefulness of Fibonacci Compression Codes. SHMUEL T. KLEIN AND MIRI KOPEL BEN-NISSAN

This paper concentrates on very large textual databases such as large information retrieval systems. In these systems, millions of words should be compressed allowing very fast decoding and search ability directly in the compressed text. Recent literature advocates the use of variable length codes where each codeword consists of a number of bytes in compression applications. This paper shows that similar properties can be derived by using higher order Fibonacci codes and moreover, new properties can be obtained related to the compression performance, robustness against errors, fast decoding techniques and support of compressed matching.

Fine-Grain Register Allocation and Instruction Scheduling in a Reference Flow. DAE-HWAN KIM AND HYUK-JAE LEE

Register allocation is a compiler technique that determines whether a variable is to be stored in a register or in memory. The graph-coloring approach to register allocation abstracts each variable as a single node in an interference graph. This however degrades the efficiency of register allocation. In order to avoid this disadvantage, numerous approaches have been proposed in the literature. Of these approaches, the fine-grain approach which decides register allocation for a variable multiple times at every reference of the variable, also has its limitations. This paper proposes a new register allocation which combines the advantages of both the graph-coloring and the fine-grain approaches while avoiding their drawbacks. A mathematical model for the simple estimation of an approximated cost is

derived and a heuristic with a reasonable amount of computation is developed. Also, the complexity of the proposed register allocation is studied and experimental results are given.

Hierarchical Radiosity for Multiresolution Systems Bases on Normal Tests. EMILIO J. PADRÓN, MARGARITA AMOR, MONTSERRAT BÓO AND RAMÓN DOALLO

The hierarchical radiosity algorithm is a global illumination model that enables realistic illumination results in the rendering of complex scenes with highly detailed models. Radiosity computation is attached to a specific level of detail (LOD) and hence cannot accurately treat multiresolution models. In some solutions to this shortcoming, the quality of illumination faces problems, in others, radiosity values are recomputed in terms of the selected resolution of objects. This paper proposes another approach where the hierarchical radiosity is precomputed only once and the fixed values are applied to a multiresolution scene. This approach is based on the analysis of the normal vectors of the multiresolution mesh and the selection of a representative set of normals. First, the paper reviews the hierarchical radiosity algorithm and then outlines its proposed radiosity algorithm for multiresolution systems. This algorithm is then built in 3 stages. The first stage deals with the normal analysis of computation. The second stage deals with illumination computation and colour encoding. The third stage deals with the rendering application (surface subdivision and colour application). The performance of the proposed algorithm of hierarchical radiosity in multiresolution systems is discussed using tests such as Teatime, Chesstime and Livingroom.

NIPSOM: Parallel Architecture and implementation of a Growing SOM. IREN VALOVA, DEREK BEATON, DAN MACLEAN AND JOHN HAMMOND

The self-organizing map (SOM) algorithm is sequential but has been parallelized in different variations although most of these variations remain primarily sequential. This paper focuses on a network implemented in a parallel SOM (NIPSOM) presenting an extension of a parallel growing SOM algorithm. The NIPSOM algorithm is implemented in a parallel environment and it is compared to other growing architectures.

Multi-criteria Scheduling of Precedence Task Graphs on Heterogeneous Platforms. ANNE BENOIT, MOURAD HAKEM AND YVES ROBERT

The efficient execution of applications with diverse and intensive computation needs requires effective scheduling strategies in order to minimize latency, to maximize reliability and to improve fault-tolerance. There are tradeoffs of these important requirements in a heterogeneous distributed system. Both heterogeneous scheduling and fault tolerance are difficult in their own but solving them together is even harder.

The aim of this paper is to propose a Fault Tolerant Scheduling Algorithm (FTSA) which tolerates multiple fail-silent and fail-stop processor failures without sacrificing latency. The FTSA is a greedy scheduling heuristic based on task criticalness. The properties of the FTSA are given along with its time complexity. Then, FTSA is extended to MC-FTSA which minimizes communication overhead. Thereafter the algorithm is modified with a greedy heuristic to improve its reliability resulting in RFTSA. The performance of FTSA, MC-FTSA and RFTSA is studied as well as the reliability of RFTSA and there is a comparison with the earlier system FTBAR.

A Weighted Voting-Based Associative Classification Algorithm. XIAOYAN ZHU, QINBAO SONG AND ZIHAN JIA

Numerous techniques exist for building classifiers. One such technique integrates associative rule mining with classification and is known as associative classification. To achieve high accuracy, a classifier may need to handle a large number of rules. It is a challenge to store, prune, retrieve and sort a large number of rules efficiently for classification. To overcome this challenge, this paper proposes the associative classification technique based on weighted voting (ACWV) which considers both the quality and number of rules. After building ACWV, the paper carries out extensive performance studies which evaluate the accuracy, runtime and main memory usage of ACWV.

Resampling Halftone Images Using Interpolation and Error-Diffusion. JEN-BANG FENG, IUON-CHANG LIN, YEN-PING CHU AND SHYH-CHANG TSAUR

A halftone image is a binary image aimed to preserve the picture quality of a continuous-tone image under human vision. Every printer is installed with halftoning transformations. There exist numerous halftoning schemes and inverse halftoning schemes. In the development of halftone images, there is a lack of basic processing tools like resampling, blurring and sharpening. This paper proposes a halftone image resampling scheme which preserves the original characteristics of the halftone image. The scheme uses interpolation and error diffusion. Moreover, halftone images can be magnified and shrunk to any desired scale. There is an evaluation criterion L1 which helps show the preservation of information before and after the resampling.

Accelerating Multiple Sequence Alignment with the Cell BE Processor. HANS VANDIERENDONCK, SEAN RUL AND KOEN DE BOSSCHERE

Computer architectures are moving from single-core processors to multi-core ones. The Cell Broadband Engine (BE) Architecture is a heterogeneous multi-core architecture targeted at compute-intensive workloads. This paper investigates the potential of the Cell BE processor by means of a case study

of implementing a bio-informatics program on the Cell BE. To do so, the paper starts by an overview of Cell BE and the bio-informatics program Clustal W which is a program for the simultaneous alignment of many nucleotide or amino acid sequences. Thereafter, the porting methodology into Cell BE is given. Next, the authors implement Clustal W on Cell BE and evaluate the benefits of porting into Cell BE.

Area-Feature Boundary Labeling. MICHAEL A. BEKOS, MICHAEL KAUFMANN, KATERINA POTIKA AND ANTONIOS SYMVONIS

It is NP-hard to obtain label placements on a drawing in such a way that the label is close to the feature it describes and does not overlap with any other label. Boundary labeling has been suggested in the literature for medical and technical drawings. This paper focusses on the boundary labeling problem where features can float within a region. That is, instead of electing a point to represent each region, regions are associated with areas so that any feature inside the area represents the region. This paper involves extensions and adaptation of existing algorithms in order to achieve the desired minimisation results. First, the paper defines the boundary labeling problem to be studied and introduces sites, leaders, labels and most importantly, the optimisation criteria which include the minimisation of 1) the total leader length, 2) the total number of leader bends and 3)

the length of the longest leader. After a discussion of previous work and after setting out the notation and terminology, the authors study the minimisation of the total leader length for two types of leaders. An efficient algorithm is given for the shortest leader computation.

A Case Study Using a Methodological Approach to Developing User Interfaces for Elderly and Disabled People. RICH PICKING, ALEXIA ROBINET, VIC GROUT, JOHN MCGINN, ARMANDO ROY, SIMON ELLIS, AND DENISE ORAM

This paper is concerned with enabling elderly people to live independently for longer. Technology can assist older people in their homes making them feel safe and easing the burden on the carers. Computer systems are powerful aids in this area and to be successful, they need to have adaptive interfaces. However, a right balance needs to be found between assistance versus nuisance and moreover, assistive technology may have negative consequences. This paper presents a case study on the development of interfaces for the elderly and disabled placing particular importance to ethical issues. The authors have developed affordable user interfaces that are integrated in home artefacts. These artefacts are connected remotely to a home network called the e-servant. The e-servant modifies the users' profiles according to their behaviour and adapts to the environment.