doi:10.1093/comjnl/bxm010

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.

Quantum Programming Languages: An Introductory Overview. R. RÜDIGER

During the first quarter of the 20th century, much research which was later to form the foundations of computer science has been laid down. Quantum theory, being the theory of physical processes at an atomic and subatomic scale, was one of the subjects that was also studied then. However, the influence of quantum concepts in the actual development and application of computer science remained less visible than any other concepts. This was to change in the past two decades were a number of applications which used quantum concepts were developed.

For instance, quantum cryptography became a commercial product and quantum systems were shown to speed some computational tasks. This led to the question of whether conventional programming models and languages can be sufficient for programming quantum systems. This paper reviews the research that has been carried out in the field of quantum programming languages (QPLs). First, the paper gives a summary of the terminology and notation of quantum theory. Then, the paper discusses briefly the interpretation of quantum theory and in particular the 'superposition principle' which states that 'at any given time, a quantum system can be in more than one state' and the consequences of the linearity of quantum mechanics. The author concludes that it is an open question whether a proper refinement of quantum theory exists but that nonetheless, attempts which reformulate quantum theory are very interesting. Thereafter, the author moves to the design issues of QPLs listing a number of desiderata targeted within the general goals of designing QPLS and some literature which relates to these desiderata. Possible directions towards designing QPLs are then named; these include high-level structures, quantum lambda-calculus and functional programming. Section 5 reviews some of the approaches in the literature that deals with the goals and the design of QPLs. In particular:

- notions such as the pseudocode for quantum computing, the QRAM (quantum random access machine) model, etc. are reviewed.
- The first real quantum programming language QCL is reviewed.
- A second quantum programming language, the Qlanguage, is then reviewed and compared to QCL.
- Then the author discusses a paper on software architecture and further reviews the current research directions in the area of QPLs. The QPLs discussed in the text are then summarized in a table together with a number of comments.

Locating Maximal Multirepeats in Multiple Strings Under Various Constraints. A. BAKALIS, C. S. ILLIOPOULOS, C. MAKRIS, S. SIOUTAS, E. THEODORIDIS, A. TSAKALIDIS AND K. TSICHLAS

A tandem repeat is a string ss where s is non-empty. A number of algorithms have been given for finding many kinds of repeats: tandem repeats, perfect repeats, maximal repeats, perfect tandem repeats, approximate tandem repeats, etc. Pairs are a generalization of tandem repeats. A maximal pair is a substring that occurs twice in a string.

This paper studies a generalization of pairs called multirepeats. In particular, the paper proposes an algorithm which finds all repeats that occur at least m times in a given set of strings. First, the paper defines the machinery needed and the two problems that will be studied. Then, the paper gives the algorithms which identify the maximal multirepeats according to the stated problems. The space and time complexity of the algorithms is studied.

A Novel Framework for Self-Organizing Lists in Environments with Locality of Reference: Lists-on-Lists. A. AMER AND B. J. OOMMEN

Retrieving data from a list of n elements using linear search has time complexity $O(n)$. The search cost can be reduced if the list is made self-organizing. A self-organizing search list runs a reorganization heuristic in order to optimize the linear search cost. Much research on such heuristic algorithms has been carried out [1]. Dependent access refers to the situation when during a given time interval only a subset of the query set is predominantly accessed on the list and this subset

changes with time. List reorganization for dependent access is far from trivial. This paper introduces a novel list organization framework called Lists-on-Lists (LOL) where a list is treated as a list of sublists where the sublists capture the information of the contexts of the individual elements.

Contexts are learned with the use of stochastic learning. First, the paper defines the so-called models of dependence where the Markovian and the periodic query generators are used. Then, the paper proposes how a self-organizing list of n elements can be divided into k sublists and then manipulates these sublists and captures the dependence between the access queries using a Learning Automaton (LA) partitioning scheme using either the Object Migration Automaton or the Modified Linear Reward-Penalty scheme. These proposed LOL algorithms are tested by changing many variables (dependence degree, partitioning algorithm, reorganization algorithm, access probability distribution within a context).

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Self-Stabilizing Local Routing in Ad Hoc Networks.
D. BEIN, A. K. DATTA AND V. VILLAIN

Many requirements need to be obeyed in wireless mobile ad hoc networks. Since such networks have no fixed network infrastructure but boast nodes with unique IDs, it is essential that routing protocols ensure that the network is fully self-organising and self-configuring and therefore, the routing tables of nodes need to be updated dynamically. The authors have provided a number of stabilizing algorithms and methods which improve networking technologies [1]. This paper presents a self-stabilizing optimal local routing algorithm (SOLR) for wireless mobile ad hoc networks which is able to automatically recover normal behaviour in case of failure and to allow each node to build a correct routing table. Such a system is guaranteed to arrive at a legitimate state in a finite (optimal) number of steps regrdless of its initial state. The optimal routing is done within the t-neighborhood of each node where the value of t represents the maximum number of destinations to which a node needs to maintain shortest paths. The paper starts by setting out the preliminaries needed, the model considered and the self-stabilization concept. Then, the paper presents the Self-Stabilizing Local Optimal Routing Algorithm which can cope with arbitrary initialization, frequent topology changes, possible non-existent global IDs, optimal routing and fast access to the routing tables. The paper then proves the correctness of the proposed algorithm and analyses its time complexity showing that if d is the diameter of the network, then the algorithm takes $O(d)$ time units to stabilize.

REFERENCE

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A Scheduling-Based Medium Access Control Protocol for Supporting Multi-Class Services in Wireless Networks
S.-T. CHENG AND M.-H. TAO

The larger the volume of traffic over a wireless network is, the more important it becomes to have an efficient and robust quality of service (QoS) technology. This paper focuses on multi-class services in wireless networks and proposes a prioritized scheduling-based medium access control (MAC) protocol based on centralized access schemes. The proposed MAC protocol is composed of:

(a) A weighted scheduling algorithm which maintains the weights of various types of services and fairly schedules the time slots in the transmission period for these services. This weighted scheduling algorithm can adapt to extreme cases.
(b) A QoS enhanced admission control algorithm (based on the exponential bounded burtiness (EBB) model) which manages resources and guarantees QoS requirements.

The paper analyses the setting of the protocol's four parameters (length of superframe, maximum allowable service rate in the transmission period, maximum allowable requests in the request period and the system throughput) in fully scheduling mode. Experiments are carried out which demonstrate the performance of the protocol in throughput, delay and collision.

Analysis of Rebuild Processing in RAID5 Disk Arrays.
A. THOMASIAN, G. FU AND S. W. NG

Rebuild is a systematic reconstruction of the contents of a failed disk on a spare disk. Rebuild is immediately initiated after a disk failure and should be completed as soon as possible to avoid data loss. The Rebuild Unit (RU) size is the minimum amount of data transferred per rebuild read. RU size should be small and large enough so that neither disk response time nor the efficiency of rebuild processing are affected. Given that disk loads are balanced due to striping, rebuild time can be approximated by the time to read the contents of any of the surviving disks. Earlier studies [1] showed that the read load of surviving disks is doubled. There has been a number of analysis of rebuild. This paper improves on earlier analysis of rebuild and takes explicitly into account the effect of disk zoning on read redirection during rebuild processing. Two heuristic methods to compute rebuild time are given as well as validation results against a detailed simulation study which shows the accuracy of the proposed analysis in estimating rebuild time.

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Are there new models of computation? Reply to Wegner and Eberbach. P. COCKSHOTT AND G. MICHAELSON

In 2004, Wegner and Eberbach published a somewhat controversial paper [1] in which it was claimed that Turing machines (TMs) fail to describe or capture a number of computational systems including the internet, and then argued that what is needed is the concept of superTuring computations (sTCs). In addition, Wegner and Eberbach claimed that interaction machines, the Pi-calculus and the $-calculus are systems capable of carrying out sTCs. This paper attempts to challenge Wegner and Eberbach's claims. To do so, the paper reviews the notion of computability especially as it was viewed by Turing, Church and Kleene. The basic argument of the paper centres around expressive power and effective computation. More specifically, the paper argues that many of the claims made by Wegner and Eberbach depend on the expressive power of the system but that such expressiveness does not entail meaningfulness of effective calculability. The paper notes that a TM tape is unbounded rather than infinite, that TMs' ability of self-encoding indicates that TMs capture a most general sense of computation and that to overthrow the Church–Turing thesis that all notions of computability are equivalent, one needs to find a new notion of computability which is more powerful than known ones including TMs and effective computability. The paper argues that any notion of computability must reject any physically implausible techniques especially computation by infinite means, and that Wegner and Eberbach's proposal for sTCs depends on the infinite.

The paper defends its position of remaining within physical limits by resorting to a number of established results which either confirm this position or are controversial. This position is the basic challenge to Wegner and Eberbach's claims and the paper goes on to illustrate that interaction machines are not a new class of computer, that the computational power of physically realisable systems programmed in the Pi-calculus is equivalent to TMs, and that either the $-calculus is a Church–Thesis system or it is not clear how the meaning of its programs can be formalized.

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