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S. Arun-Kumar
Naveen Garg (Eds.)

FSTTCS 2006: Foundations of Software Technology and Theoretical Computer Science

26th International Conference
Kolkata, India, December 2006
Proceedings

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Volume Editors

S. Arun-Kumar
Department of Computer Science and Engineering
Indian Institute of Technology Delhi
New Delhi 110016, India
E-mail: sak@cse.iitd.ac.in

Naveen Garg
Department of Computer Science and Engineering
Indian Institute of Technology Delhi
New Delhi 110016, India
E-mail: naveen@cse.iitd.ac.in

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Preface

Welcome to the proceedings of the 26th annual conference on the Foundations of Software Technology and Theoretical Computer Science (FSTTCS). FSTTCS is organized by the Indian Association for Research in Computer Science (IARCS) which it helped create by bringing together academic computer scientists from various parts of India. Over the years several changes have taken place in the conference, beginning with the first Springer LNCS edition in 1984. The first three proceedings were printed and published in India by the Tata Institute of Fundamental Research. Since then other changes, such as an international Programme Committee and pre-conference and post-conference workshops, have helped nurture and enhance the status of this conference among computer scientists interested in foundational research.

Along with these changes there are quite a few invariant properties this conference enjoys. It has always been held in India, and always in the second or third week of December, which is a good time to travel to and within the country. It is also the most convenient time to meet Indian researchers, most of whom would be temporarily free of teaching and administrative commitments.

This year for the first time in its history, FSTTCS was held in the historic city of Kolkata (formerly Calcutta) at the Indian Statistical Institute (ISI). FSTTCS is one of the events to commemorate the Platinum jubilee year of ISI and we are happy to be part of this celebration. Subhas C. Nandy of ISI Kolkata took full responsibility as chairman of the Organizing Committee.

The conference attracted 155 submissions with authors from 29 countries. We thank the authors for their interest in this conference. The reputation of a conference is effectively determined by its Programme Committee, the refereeing process and the Invited talks. This year, as in the past, we were able to get highly respected researchers to serve on our Programme Committee. The refereeing process too has been of a very high quality. The Programme Committee deliberated on each of the submitted papers and the accompanying referee reports and finally decided to select 34 submissions as being worthy of publication.

The invited speakers this year were Gordon Plotkin of the University of Edinburgh, UK, Emo Welzl of ETH Zurich, Switzerland, Gérard Boudol of INRIA, Sophia Antipolis, France, David Shmoys of Cornell University, USA and Eugene Asarin of Université Paris 7, France.

In keeping with what has now become tradition, two workshops on recent advances in areas of current interest to the community were also organized. The themes this year were *Timed Systems* (organized by Deepak D'Souza and Supratik Chakraborty) and *Approximation Algorithms* (organized by Anupam Gupta and Amit Kumar).

We would like to thank the authors who submitted papers and the Programme Committee for helping us maintain the standard of this conference. We especially thank the authors of the selected papers which form the bulk of this volume. We would like to thank Springer for agreeing to publish these proceedings in their prestigious *Lecture Notes in Computer Science* series, which has in no small way contributed to the status of this conference in academic circles.

We would also like to thank ISI Kolkata and Subhas Nandy's team for hosting FSTTCS, IIT Delhi and MPI-Informatik for providing support and of course, IARCS, the parent organization that FSTTCS gave birth to!

December 2006

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Contributed Papers – Track A

Contributed Papers – Track B

Shared-Variable Concurrency: A Proposal
(Abstract)

Gérard Boudol

INRIA Sophia Antipolis

In this talk I discuss the semantics of shared-variable concurrency, aka multi-threading. There are two well-known ways of managing concurrent threads: one either uses a *preemptive* or a *cooperative* scheduling discipline. In the former, a program, or more precisely its executable version, can be interrupted at any time during its execution by an external device, the scheduler, and the resources needed for execution are then given to another concurrent component for a while. This is perfect for executing concurrent *processes*, which do not share memory. In this case, the programmer does not have to care about the relative performance of the various processes in the system: this is the task of the scheduler. Unfortunately, it is very difficult to program multi-threaded applications with this model. The main difficulty is with *data races*, that is conflicting concurrent accesses to the memory. Although it is very easy to provide a formal "interleaving" semantics for preemptive multi-threading, this semantics usually does not coincide with what is actually implemented. In particular, the grain of atomicity is generally not preserved by the implementation, and a program may be time-sliced at some points of its execution which make no sense at the user level, and the consequence is that there is no clear semantics for the race conditions (see [14] for instance). It is therefore necessary to complement preemptive multi-threading with elaborate synchronization techniques, that require a real expertise from the programmer to be used (see [3]), and to design methods to analyze concurrent programs in order to make them "thread safe", avoiding or detecting race conditions [1,6,11]. We shall not follow the preemptive approach in our proposal for shared-memory concurrency semantics.

In the *cooperative* programming model, a thread decides, by means of specific instructions (like yield for instance), when to leave its turn to another concurrent thread, and the scheduling is therefore distributed among the components. This model, in which there is no data race, has been advocated as a better model than the preemptive one for programming some modern, massively concurrent applications. However, this model also has its drawbacks, the main one being that if the active thread runs into an error, or raises an uncaught exception, or diverges, then the model is broken, in the sense that no other component will have a chance to execute. In particular, in cooperative programming, we have to avoid divergence in some way. Still, we need to be able to program non-terminating applications. Any server for instance should conceptually have an infinite life duration, and should not be programmed to stop after a while. Such a

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server should not enter into an infinite loop however, it should rather be infinitely often waiting for a new request. In other words, in cooperative programming, programs *must be cooperative*, or *fair*, that is, they should be guaranteed to either terminate or suspend themselves infinitely often. Since we would also like to be able to reuse sequential code in a multi-threaded context, a challenge is: can we design a concurrency semantics that would be basically cooperative, in order to avoid data races, but where any thread – and in particular purely sequential code – is guaranteed to be fair?

Dealing with a higher-order imperative programming model à la ML for sequential code (some other choices are obviously possible), our proposal to solve the above mentioned challenge is to introduce a touch of preemptive scheduling into the cooperative model. The idea is very simple: it is to consider that every *recursive call* to a function should be regarded as a *suspensive* operation, that yields the scheduler for a while. We think that this is a natural and intuitive idea, since recursion appears to be the source of non-termination. Moreover, this does not introduce any data race. However, we then have to face a technical problem, which is that recursion, or more accurately non-termination, may occur in indirect ways in a ML-like, or, for that matter, a SCHEME-like language. Indeed, it is well-known that, on the one hand, recursion can be encoded in the pure λ-calculus, and, on the other hand, that recursion can also be encoded using circular reference (this is indeed the way it is implemented), as shown by Landin long ago [8]. The well-known method to recover from the first difficulty is to use a *type system*. In this talk I show that we can use a type and *effect* system [9] for dealing with the second difficulty.

To preclude circular references, we stratify the memory into *regions*, in such a way that functional values stored in a given region may only have a latent effect, such as reading a reference, in strictly "lower" regions. This allows us to define, by induction on the stratification, a *realizability interpretation* of the types and effects, for which the type and effect system is sound. From this we conclude that typable expressions can only diverge if they perform an infinite number of recursive calls, that is, if they suspend infinitely often, in our mixed cooperative/preemptive model. This termination argument is quite classical and general (see [2,5]): it was first used by Tait in [15], under the name of "convertibility", and then by Girard (see [5]) with his "candidats de réductibilité", and by Tait again [16] who called it the "realizability" technique, since it relies on an interpretation of types closely related to Kleene's original recursive realizability interpretation [7]. The realizability interpretation is also a special case of a "logical relation" [10,13]. As far as I can see, this technique has not been previously used for higher-order imperative languages: the work that is technically the closest to ours, and which was our main source of inspiration, is the one by Pitts and Stark [12], but their logical relation (intended to provide a means to prove observational equivalence of programs, not to prove termination) is restricted to a language where the memory can only contain values of basic types. In the talk I mention another application of typing termination, namely in typing "termination leaks" in information flow control (see [4]).

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