FIT 2009
Novi Sad, Serbia, June 14-27, 2009

Research topics on Concurrent and Global Computing

Concurrent and Global Computing:
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Assignment 1

Bisimilarity equivalences in CCS are used to establish the correctness of a system w.r.t. its specification. However, in this way, we are forced to specify the overall behavior of the system. Often we are interested in proving only specific properties, notably *liveness properties* ("eventually a certain condition will happen", e.g. "a process which has requested a resource will eventually acquire it"), and *safety properties* ("a certain situation will never arise", e.g. "two processes will never access a given data at the same time").
Hennessy-Milner Logic (1985) is a language for expressing such properties.

Illustrate this approach, providing a range of examples of properties on CCS processes that can be expressed using Hennessy-Milner Logic, and investigating the relationships between this Logic and bisimilarity notions.

Reference:
Chapters 5,6 of the book by L. Aceto et al., *Reactive Systems*, Cambridge University Press.

Assignment 2

Many modern reactive systems are *real-time time*, that is their correct behavior depends not only on the logical order in which events are performed, but also on their timing. Examples of such systems are embedded systems such as air bags, cruise-control systems, mobile phones, etc.
Two models of real-time reactive systems are *CCS with time delays* and *timed automata*.

Describe these models, illustrating usefulness, differences and similarities.

Reference:
Chapters 9-11 of the book by L. Aceto et al., *Reactive Systems*, Cambridge University Press.

Assignment 3

Once we have a notion of *bisimilarity* on a process language, we immediately have a *Coinduction Principle* stating that, in order to prove that two processes are bisimilar, it is sufficient to exhibit a *bisimulation* relating them.

Coinduction is a quite common and useful principle, however, practically, it is often convenient to consider refinements and variants of it, usually referred to as *Coinduction Principles up-to*. The idea is to replace the notion of bisimulation with that of *bisimulation up-to*: any bisimulation is a bisimulation up-to, but, in general, there are many more bisimulations up-to, so as applying the Coinduction Principle up-to is easier.

Describe the approach of Coindution up-to, and its practical usefulness for CCS and pi-calculus in particular, as it is illustrated in the following paper by D. Sangiorgi.

Reference:
D. Sangiorgi, *On the bisimulation proof method*, Mathematical Structure in Computer Science, 1998.

Assignment 4

In the literature there are some works which explicitly address the problem of formally reasoning about *security* and *fault handling* issues (which are common events in "real-life" distributed systems).

Reading the following paper, try to isolate the major criticisms moved against "classical" processes algebras by the author and the alternatives proposed.

Reference:
The Kell Calculus: A Family of Higher-Order Distributed Process Calculi. Alan Schmitt and Jean-Bernard Stefani. In LNCS volume of the post-proceedings of the Global Computing 2004 workshop, Venice, Italy, 2004. (34 pages)

Assignment 5

AJAX (*Asynchronous Javascript and XML*) is a new promising technology allowing web programmers to develop more user friendly and interactive applications.

Describe its architecture and how it can be used effectively to improve web applications based upon server-side technologies.

Assignment 6 (*)

The operational semantics of mobile ambients was originally given via a (unlabelled) *reduction system,* and a notion of observational equivalence between processes was defined as a *contextual equivalence,* see L. Cardelli, A. Gordon, *Mobile Ambients*, FoSSaCS'98, LNCS 1378, 1998.

More recently *labeled transitions systems* and *bisimilarities* equivalences have been proposed also for mobile ambients.

Illustrate at least one of the two following approaches to labeled transition systems and bisimilarities for mobile ambients, and the connections with the original reduction semantics.

References:
- M. Merro, F. Zappa Nardelli, *Behavioral theory for mobile ambients*, Journal of the ACM 52(6), 2005.
- J. Rathke, P. Sobocinski, *Deriving structural labeled transitions for mobile ambients,* LNCS 5201, 2008.

(*) This assignment is more difficult.