Timeout Interaction and Migration in Distributed Systems

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The complexity of distributed systems is increasing, and so they require appropriate formalisms and techniques for their specificatio and verification Since these distributed systems grow more complex and more powerful, it is important to fin scaling formal methods for both specificatio and verifi cation. Successful formalisms for specificatio and verificatio of certain distributed systems are given by networks of timed automata and by Petri nets; however, these formalisms are not easily scalable, a reason why we look for compositional specificatio and verificatio techniques. In terms of specification a process calculus would solve the compositional issue. Moreover, in distributed systems coordination is given by time scheduling, access to resources, and interaction among processes. When modelling distributed systems it is useful to have an explicit notion of location, local clocks, explicit migration and resource management.

We have introduced in Ciobanu and Koutny (2008) a rather simple and expressive formalism called TiMo as a simplifie version of timed distributed π-calculus Ciobanu and Prisacariu (2006) which is an extension of distributed π-calculus Hennessy (2007). TiMo is a process calculus with explicit migration allowing the use of timers for controlling process mobility and interaction. Migration involves several explicit locations. Each location has a local clock, modelling distributed systems in a more accurate way. Timing constraints for migration allow to specify a temporal timeout after which a process must move to another location. Two processes may communicate only if they are present at the same location. A timer denoted by $\Delta 3$ associated to a migration action go$^{\Delta 3} work$ indicates that the process moves to location $work$ after at most 3 time units. It is also possible to indicate a deadline for a communication over a channel; if a communication action does not happen before this deadline, the process gives up and switches its operation to an alternative process. E.g., a timer $\Delta 5$ associated to an output action $a^{\Delta 5}!\langle v \rangle$ makes the channel available for communication only for a period of 5 time units. Considering suitable data sets including a set *Loc* of locations, a set *Chan* of communication channels and a set *Id* of process identifier , the syntax of TiMo is presented in Table 1.

Using TiMo , we can specify and analyse complex timing systems in a new and intuitive way. Aiming to bridge the gap between the existing theoretical approach of process calculi and forthcoming realistic programming languages for distributed systems, TiMo represents in several aspects a prototyping language for multi-agent systems featuring mobility and local interaction. Starting with a firs version proposed in Ciobanu and Koutny (2008), several variants were developed during the last years. We mention here the access permissions given by a type system in perTiMo Ciobanu and Koutny (2011a), as well as a probabilistic extension pTiMo Ciobanu and Rotaru (2013). Inspired by TiMo , a fl xible software platform was introduced in Ciobanu and Juravle (2009, 2012) to support the specificatio of agents allowing timed migration in a distributed environment.

In terms of verification interesting properties described by TiMo regarding could be analysed and checked. The properties of distributed systems described by TiMo refer to process migration, time constraints, bounded liveness and optimal reachability Aman et. all (2012); Ciobanu and Koutny (2011b). A verificatio tool called TiMo@PAT Ciobanu and Zheng (2013) was developed by using Process Analysis Toolkit (PAT), an extensible platform for model checkers. A formal relationship between

P	$::=$	$a^{\Delta lt}!\langle\vec{v}\rangle$ then P else $P' \mid$	(output)
		$a^{\Delta lt}?(\vec{u}{:}\vec{X})$ then P else $P' \mid$	(input)
		go$^{\Delta lt}$ l then $P \mid$	(move)
		$P \mid P' \mid$	(parallel)
		0 $\mid$	(termination)
		$id(\vec{v})$	(definition
		ⓈP	(stalling)
L	$::=$	$l[\![P]\!]$	Located Processes
N	$::=$	$L \mid L \mid N$	Networks

Table 1: TiMo *Syntax.*

rTiMo and timed automata presented in Aman and Ciobanu (2013) allows the use of model checking capabilities provided by the well-known verificatio tool UPPAAL. A probabilistic temporal logic called PLTM was introduced in Ciobanu and Rotaru (2013) to verify complex probabilistic properties making explicit reference to specifi locations, temporal constraints over local clocks and multisets of actions.

Acknowledgements. The work was supported by a grant of the Romanian National Authority for Scientifi Research, project PN-II-ID-PCE-2011-3-0919.

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