

COST

Domain Committee "Information & Communication Technologies"

COST Action IC1202

Start Date: March 1, 2013

Timing Analysis on Code-Level

MONITORING PROGRESS REPORT

Reporting Period: from 1st March 2013 to 30th April 2013

This Report is presented to the relevant Domain Committee.
It contains three parts:

- I. Management Report** prepared by the COST Office/Grant Holder
- II. Scientific Report** prepared by the Chair of the Management Committee of the Action
- III. Previous versions of the Scientific Report;** i.e., part II of past reporting periods

The report is a "cumulative" report, i.e. it is updated annually and covers the entire period of the Action.

Confidentiality: the documents will be made available to the public via the COST Action web page except for chapter *II.D. Self evaluation*.

Based on the monitoring results, the COST Office will decide on the following year's budget allocation.

Executive summary (max.250 words):

The Action was launched March 2013. The activity that has taken place so far is the first joint WG and MC meeting, in Barcelona March 25-26, where all participating groups presented their current activities and areas of interest in the Action. Furthermore, Working Group-wise discussions took place planning ahead for the work in the Action towards meeting the objectives for Year 1.

The plans for Year 1 include two focussed meetings, targeting junior researchers, two more joint WG and MC meetings, and a workshop on code-level timing analysis that is currently being organized and will take place in Paris in July 2013. Ten STSMs are planned for Year 1. Dissemination activities include the setup of a web site, and a planned special session at the HiPEAC Fall Meeting in September 2013. Two special sessions were already held before the Action started, at ESWEEK in Tampere October 2012 and at the HiPEAC conference in Berlin, January 2013.

I. Management Report prepared by the COST Office/Grant Holder



I.A. COST Action Fact Sheet

- **COST Action** IC1202 - *Timing Analysis on Code-Level*
- **Domain** ICT
- **Action details:**

CSO Approval:(07/06/2012)

End date: (06/11/2016)

Entry into force: (07/11/2012)

Extension: -

- **Objectives:** *The main objective of the Action is to develop industrial strength code-level timing analysis techniques for future generation embedded systems.*

Embedded systems increasingly permeate our daily lives. Many of those systems are business- or safety-critical, with strict timing requirements. Code-level timing analysis (used to analyse software running on some given hardware w.r.t. its timing properties) is an indispensable technique for ascertaining whether or not these requirements are met. However, recent developments in hardware, especially multi-core processors, and in software organisation render analysis increasingly more difficult, thus challenging the evolution of timing analysis techniques. New principles for building "timing-composable" embedded systems are needed in order to make timing analysis tractable in the future. This requires improved contacts within the timing analysis community, as well as with related communities dealing with other forms of analysis such as model-checking and type-inference, and with computer architectures and compilers. The goal of this COST Action is to gather these forces in order to develop industrial-strength code-level timing analysis techniques for future-generation embedded systems.

Keywords: real-time systems, WCET analysis, code generation, time-predictable computer architecture, safety-critical embedded systems

- **Parties:**

Austria (23/10/2012)	Greece (09/10/2012)	Poland (date)
Belgium (date)	Hungary (date)	Portugal (21/08/2012)
Bulgaria (date)	Iceland (date)	Romania (date)
Croatia (date)	Ireland (26/11/2012)	Serbia (date)
Cyprus (date)	Israel (date)	Slovakia (date)
Czech Rep. (date)	Italy (25/07/2012)	Slovenia (date)
Denmark (04/07/2012)	Latvia (date)	Spain (18/06/2012)
Estonia (date)	Lithuania (03/10/2012)	Sweden (12/09/2012)
Finland (30/07/2012)	Luxembourg (date)	Switzerland (date)
FYR of Macedonia (05/02/2013)	Malta (date)	Turkey (date)
France (25/07/2012)	Netherlands (date)	United Kingdom (19/06/2012)
Germany (05/07/2012)	Norway (29/11/2012)	

- **Intentions to accept:** none

- **Other participants:** none

Chair:

Professor Björn Lisper

*Mälardalen University
School of Innovation, Design, and*

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- **Action Web site:** <http://www.tacle.eu>
- **Grant Holder Representative:** Prof. Björn Lisper, bjorn.lisper@mdh.se
- **Working Groups**

WG1: Timing models for multi-cores and timing composability

Christine Rochange, IRIT Toulouse (WG leader)
Peter Puschner, TU Vienna
Martin Schoeberl, TU Denmark
Juha Plosila, Univ. Turku
Damien Hardy, IRISA Rennes
Claire Maiza, IMAG
Isabelle Puaut, IRISA Rennes
Heiko Falk, Univ. Ulm
Michel Schellekens, National Univ. of Ireland, Cork
Enrico Mezzetti, Univ. Padua
Tullio Vardanega, Univ. Padua
Gintautas Daurys, Siauliai University
Zamir Dika, South East European University
Sverre Hendseth, Norwegian University of Science and Technology
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Stefan Petters, Polytechnic Institute of Porto
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Francisco Cazorla, Barcelona Supercomputing Center
Andreas Gustavsson, Mälardalen Univ.
Björn Lisper, Mälardalen Univ.
Zhonghai Lu, Royal Inst. of Technology
Raimund Kirner, Univ. Hertfordshire

WG2: Tooling aspects

Martin Schoeberl, TU Denmark (WG leader)
Peter Puschner, TU Vienna
Vesa Hirvisalo, Aalto Univ.
Damien Hardy, IRISA Rennes
Claire Maiza, IMAG
Isabelle Puaut, IRISA Rennes
Heiko Falk, Univ. Ulm
Enrico Mezzetti, Univ. Padua
Tullio Vardanega, Univ. Padua
Björn Lisper, Mälardalen Univ.
Raimund Kirner, Univ. Hertfordshire

WG3: Early-stage timing analysis

Tullio Vardanega, Univ. Padua (WG leader)
Juha Plosila, Univ. Turku
Enrico Mezzetti, Univ. Padua
Stefan Petters, Polytechnic Institute of Porto
Björn Lisper, Mälardalen Univ.
Raimund Kirner, Univ. Hertfordshire
Michael Zolda, Univ. Hertfordshire

WG4: Resources other than time

Stefan Petters, Polytechnic Institute of Porto (WG leader)
Peter Puschner, TU Vienna
Vesa Hirvisalo, Aalto Univ.
Juha Plosila, Univ. Turku
Heiko Falk, Univ. Ulm
Nicolas Sklavos, Technological Educational Institute of Patras
Michel Schellekens, National Univ. of Ireland, Cork
Gintautas Daurys, Siauliai University
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Amund Skavhaug, Norwegian University of Science and Technology

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Others

FSAC	0

Action Total : 0

Note: as of April 30, 2013, no cost claims had yet been processed. Therefore, the cost for the joint meeting in Barcelona March 25-26 appears as zero. No other funded activities took place before April 30.

II. Scientific Report

II.A. Innovative networking

Innovative knowledge resulting from COST networking through the Action

The Scientific work in the Action that has taken place so far has been mainly to identify the competences and research interests of the participating research groups, as well as topics for future collaboration within the Working Groups. There is a great interest especially in WG1 "Timing models for multi-cores and timing composability", but also the other WGs gather interest. A concrete achievement is that an initial inventory of benchmarks for evaluating code-level timing analysis methods has been done. This addresses one of the objectives in the Work Plan for Year 1.

Significant scientific breakthroughs as part of the COST Action

As the Action is still in its startup phase, it is too early to expect significant scientific breakthroughs as part of the Action.

Tangible medium term socio-economic impacts achieved or expected

Code-level timing analysis is an important component when analyzing the real-time properties of embedded systems. Time-critical embedded systems are found in many areas of great importance for Europe, such as automotive, avionics, and process control. These embedded systems increasingly use new technology, with multi- and many-core processors. As an important mission of the Action is to develop timing models, and analysis methods, for these kinds of processors, it can be thus expected to have quite some socio-economic impact in particular in areas like the aforementioned ones.

The Action has an Industrial Advisory Board (IAB), which currently has four members from end-users of timing analysis in areas like automotive and avionics. The task of the IAB is to provide feedback to the Action on its activities and its coordinated research, from an industrial, end-user perspective. The IAB thus provides a mechanism to ensure the industrial relevance of the Action, and thus increase its socio-economic impacts.

Spin off of new EC RTD Framework Programme, or National Programme proposals/projects

As the Action had only been active for two months until April 30, there was too little time for new project proposals to emerge. However there are a number of existing joint projects (see Appendix B), and we expect the increased interaction brought by the Action to help increase this number significantly.

II.B. Inter-disciplinary networking

Additional knowledge obtained from working with other disciplines within the COST framework

An explicit goal of the Action, and an objective for Year 1, is to foster interdisciplinary contacts. Therefore the Action has members that belong to neighboring areas, such as model-checking, high-level models for resource consumption, and computer architecture. The combination of techniques and knowledge from these areas with code-level timing analysis has a large potential scientific impact. For instance, there is an interest in the research community to combine code-level timing analysis via abstract interpretation with model-checking as the model-checking may help obtaining better precision. Type systems for resource analysis from high-level languages may evolve into means to perform fast, composable, approximate timing analysis. High performance computing systems are becoming increasingly used in time-critical embedded systems: thus, detailed knowledge of their architectures is paramount for successful timing analysis of these embedded systems.

Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide scientific and/or socio-economic impacts

As the Action is still in its startup phase it is too early to assess the scientific and socio-economic impact of its inter-disciplinary networking, but as exemplified above we believe that it has a large potential.

The Action held two special sessions already before the Grant Agreement was in place: at ESWEEK in Tampere, Oct. 2012 and at the HiPEAC conference in Berlin, Jan. 2013. Both these special sessions were outreach activities containing technical talks on topics of the Action, and promotion of the Action. The session at ESWEEK targeted the general embedded systems research community, whereas the session at HiPEAC targeted researchers in high performance computer architecture. Both these research areas are highly relevant to code-level timing analysis.

II.C. New networking

The original COST Action proposal was prepared by 23 researchers from ten different COST countries. Since then, five more COST countries have joined the Action: Greece, Ireland, Lithuania, Norway, and Former Yugoslavian Republic of Macedonia. 53 researchers were participating in the Action as of April 30, whereof 3 were female (6%) and 7 were Early Stage Researchers (13%). We expect the number of Early Stage Researchers to grow rapidly as activities targeting this category are taking place. The Action also actively seeks to recruit female researchers in the field.

Involvement of Early Stage Researchers in the Action

The Action has formed an STSM committee that will promote STSMs among the participating research groups, and evaluate applications for STSMs. Ten STSMs are budgeted for Year 1. As the Grant Agreement only was effective for two months for the reporting period, no STSMs were carried out during this period.

The Action plans two "focused meetings" during Year 1. These are events targeting Early Stage Researchers, where a group of such researchers and a set of selected experts spend a day with intense discussions on a selected topic. An important idea is to give the Early Stage Researchers the opportunity to get close access to the experts. To our knowledge, this meeting format has not been tried before.

Involvement of researchers from outside of COST Countries

National University of Singapore is in the process of joining the Action as a non-COST member. As of April 30, the status of the application was "JAF Approval". As Singapore does not have a reciprocal agreement with COST, the participants will have to bear their own costs.

Advancement and promotion of scientific knowledge

Due to the short time the Action has been active, no publications resulting from COST networking have yet appeared. However, during the reporting period, 7 publications have been submitted that have been jointly authored by members of different groups participating in the Action. See Appendix A for the list of these publications.

Besides the two special sessions mentioned in II.B one more special session is planned, at the HiPEAC fall meeting in Tallinn, Estonia.

The Action will arrange the annual WCET workshop, which will take place July 9 in Paris. This workshop is the main event in the code-level timing analysis area. This year, the workshop has attracted 17 submissions which are currently under reviewing.

The Action is currently launching a website: the current temporary address is www.knossosnet.gr/tacle/, which will be changed to www.tacle.eu. This website will contain up-to-date information about the action, including participants, past and upcoming meetings, links to download of tools created by Action members, etc.

For internal use the Action has a repository at a subversion (svn) server. This server provides version control, and allows Action members to share documents in a safe way. The version control is especially useful when documents are co-authored.

Activities and projects with COST network colleagues

A list of projects with partnership from different COST Action members is given in Appendix B.

The capacity of the Action members to raise research funds

The participants of the Action are in general well supplied by external grants, both nationally and internationally. Some examples of grants held by Action members, of relevance to the Action, are given in Appendix C.

II.D. Self evaluation***III. Previous scientific report(s)***

As the Action has just started, there are no previous scientific reports.

Appendix A: Joint Publications

The following list contains publications that have been submitted, or accepted for publication, while the Action has been active during the reporting period, and are jointly authored by members of different research groups participating in the Action.

F.J. Cazorla, T. Vardanega, E. Quiñones, J. Abella. Upper-bounding Program Execution Time with Extreme Value Theory. Submitted to WCET Workshop 2013.

L. Kosmidis, T. Vardanega, J. Abella, E. Quiñones, F.J. Cazorla. Applying Measurement-Based Probabilistic Timing Analysis to Buffer Resources. Submitted to WCET Workshop 2013.

Sudipta Chattopadhyay, Lee Kee Chong, Abhik Roychoudhury, Timon Kelter, Peter Marwedel and Heiko Falk. A Unified WCET Analysis Framework for Multi-core Platforms. In *ACM Transactions on Embedded Computing Systems (TECS)*, accepted for publication, ACM, 2013.

Philip Axer, Rolf Ernst, Heiko Falk, Alain Girault, Daniel Grund, Nan Guan, Bengt Jonsson, Peter Marwedel, Jan Reineke, Christine Rochange, Maurice Sebastian, Reinhard von Hanxleden, Reinhard Wilhelm and Wang Yi. Building Timing Predictable Embedded Systems. In *ACM Transactions on Embedded Computing Systems (TECS)*, accepted for publication, ACM, 2013.

Peter Puschner, Daniel Prokesch, Benedikt Huber, Jens Knoop, Stefan Hepp, and Gernot Gebhard. The T-CREST Approach of Compiler and WCET-Analysis Integration. *Proc. 9th Workshop on Software Technologies for Future Embedded and Ubiquitous Systems*, 2013, accepted for publication.

J. C. Kleinsorge, P. Marwedel, H. Falk. Simple Analysis of Partial Worst-case Execution Paths on General Control Flow Graphs. Submitted to EMSOFT 2013.

T. Kelter, T. Harde, P. Marwedel, H. Falk. Evaluation of resource arbitration methods for multi-core real-time systems. Submitted to WCET Workshop 2013.

Appendix B: Projects with Partnership from Different COST Action Members

W-SEPT: ANR (French national funding), Verimag, INRIA/IRISA, Univ. Toulouse

APARTS: FP7 Marie Curie IAPP, Mälardalen Univ., Tidorum Ltd

PROARTIS: FP7 ICT, Univ. Padua, Barcelona Supercomputing Center

PROXIMA: FP7 ICT IP (under negotiation), Univ. Padua, Barcelona Supercomputing Center, Univ. York

T-CREST: FP7 ICT, TU Denmark, AbsInt GmbH, TU Vienna, Univ. York

CERTAINTY: FP7 ICT, Uppsala Univ., AbsInt GmbH

CRAFTERS: ARTEMIS, Univ. Hertfordshire, Univ. Aalborg

parMERASA: FP7 ICT, Barcelona Supercomputing Center, Univ. Toulouse, TU Dortmund

Appendix C: Examples of Grants Held by Action Members

This is a list containing a few examples of external (individual) grants held by Action members. It complements Appendix B with some additional examples indicating the capacity of Action members to raise research funds.

ARAMiS: Bundesministerium für Bildung und Forschung (German national funding), AbsInt GmbH

E=Mp2: DFG (German national funding), Univ. Ulm

RALF3: SSF (Swedish national funding), Mälardalen Univ.

Contesse: VR (Swedish national funding), Mälardalen Univ.

FCT (Portuguese national funding), Instituto Superior de Engenharia do Porto

RTEMP (National Danish funding), TU Denmark

Formal QoS Analysis and Control for Network-on-Chip Communication (Intel Corporation), KTH Royal Institute of Technology