European Commission

PROXIMA

Towards a European Strategy for Cyber-Physical Systems

Concentration Workshop on Mixed-Criticality Systems and Multicore

PROXIMA

Francisco J. Cazorla
Barcelona Supercomputing Center (BSC)

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement number 611085, PROXIMA

SEVENTH FRAMEWORK PROGRAMME

Project General Information

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***Pro**babilistic real-time control of mi**x**ed-cri**t**icality **m**ulticore and m**a**nycore systems (**PROXIMA**)*

Coordinator: Francisco J. Cazorla (BSC)

Oct 2013 – Sep 2016

Integrated Project (IP), budget total: 6,793,991 Euro

Barcelona Supercomputing Center
Rapita Systems Limited
Sysgo S.A.S
Universita Degli Studi Di Padova
INRIA
Aeroflex Gaisler Ab
Airbus Operations SAS
University of York
ASTRIUM SAS
IKERLAN S.COOP
Infineon Technologies UK Ltd

PROXIMA Consortium

Challenge/Opportunity/Threat

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- Challenge:
  - EU industries developing Critical Real-Time Embedded Systems (CRTES) will face a once-in-a-life-time challenge caused by the transition to multi/many-cores
- Opportunity:
  - Integrating multiple applications onto the same hardware platform → advantages in performance, production costs, and reliability
- Threat:
  - Software performance becomes **unpredictable** and **unanalysable**
    - "Prove that all temporal constraints will be satisfied during operation" in a critical system

PROXIMA Thesis

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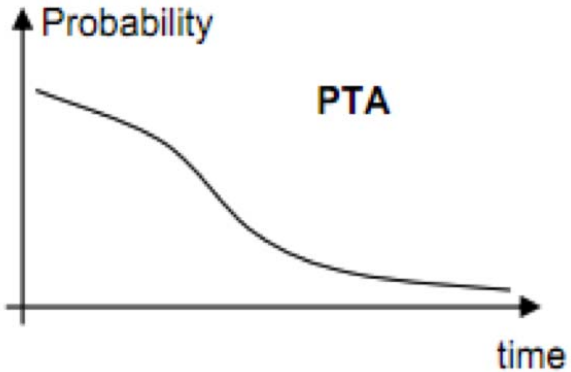
- Temporal behaviour (software timing) of CRTES on multi/manycore can be analysed with probabilistic timing analysis (**PTA**) techniques



- PROXIMA will deliver:
  - Hardware and OS-level software
    - That supports time randomisation transparently to the application
  - Probabilistic analysis techniques
  - Integration into commercial development and verification tools
  - Arguments to sustain certification

Main Outcome and Results

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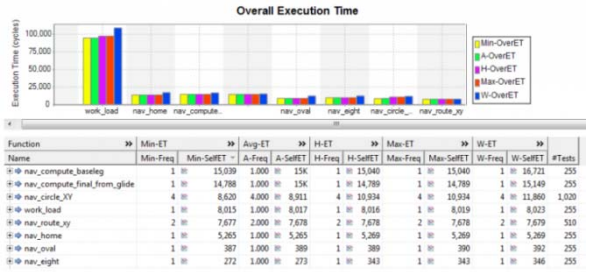
- Benefits:
  - Enables EU industry to <u>use high performance processors</u> in critical systems
    - Reinforce its technological and market leadership
  - Use <u>different criticality levels</u> on <u>multi/manycore</u> platform
  - <u>Streamlines the SW development</u> process
    - Reducing time, effort and costs of integration, verification, validation & activities



Function	Min-ET		Avg-ET		H-ET		Max-ET		W-ET		
Name	Min-Freq	Min-SelfET	A-Freq	A-SelfET	H-Freq	H-SelfET	Max-Freq	Max-SelfET	W-Freq	W-SelfET	#Tests
nav_compute_baseleg	1	15,039	1.000	15K	1	15,040	1	15,040	1	16,721	255
nav_compute_final_from_glide	1	14,788	1.000	15K	1	14,789	1	14,789	1	15,149	255
nav_circle_XY	4	8,620	4.000	8,911	4	10,934	4	10,934	4	11,860	1,020
work_load	1	8,015	1.000	8,017	1	8,016	1	8,019	1	8,023	255
nav_route_xy	2	7,677	2.000	7,678	2	7,678	2	7,678	2	7,679	510
nav_home	1	5,265	1.000	5,265	1	5,269	1	5,269	1	5,269	255
nav_oval	1	387	1.000	389	1	389	1	390	1	392	255
nav_eight	1	272	1.000	273	1	343	1	343	1	346	255

- Impact on R&D
  - A complete shift from traditional thinking

Exploitation Results

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From PROARTIS to commercial use

- **Tool Support**: RapiTime Analysis Tool → Operating Systems → Compiler
- **Safety argument**: DO-178B/C → Other Domains
- **Hardware Support**: Randomized timing hardware → COTS
- **Proof of product**: Industrial case studies

Aerospace

Automotive

Space

Rail

- Impact
  - Fast adoption of high performance technology
  - Reduction in verification cost of critical systems

Slide 6

FJC1 Francisco J. Cazorla; 15.10.2013

Research Trends for H2020

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- Impact on future R&D in MC multicore systems
  - Enabling PTA on time randomised HW and SW reduces integration, verification, validation and certification costs
    - By increasing the composability of the timing behaviour of individual parts

- Technology paths
  - Deterministic systems: serious limitations in modeling the causal dependence in the timing behaviour of the used HW and SW resources
    - Too many events happening concurrently in manycore systems to be tracked
  - <u>Move away from time deterministic designs into designs that facilitate PTA, e.g. time randomised design</u>

Research Trends for H2020

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- Maturity of the PTA technology
  - PROARTIS: defined the foundations that enable PTA
    - Main focus on singlecore. Partial coverage of multicore
    - Defined PTA-compliant HW and SW platforms
  - PROXIMA:
    - Extends PTA to end-to-end timing in multi/manycore
    - Works on COTS multicores with SW randomisation
    - Industrializes HW solutions (FPGA) and implements SW solutions in commercial tools
- Needs and future research projects
  - Provable Real-Time performance on manycore systems
  - Design of high-performance randomized HW features
  - Benefits of time randomised hardware in other domains

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