Research and Innovation on Advanced Computing & Control Systems - a European Perspective -

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Technology Trends and Research Challenges
- Motivation, Visions, and Opportunities
- Strategic Recommendations from Expert Groups

European Research
- Ongoing European R&I projects – an overview
- Opportunities in 2012 and 2013
  - FP7 Work Programme 2013
  - ARTEMIS Joint Undertaking
- Towards the new R&I Programme Horizon 2020

Conclusions
Fast paced evolution or disruption?

- Computing infrastructures rely on COTS more and more coming from the mobile & embedded world
- System SW increasingly becoming open source
- Energy efficiency as important as processing power
- Advanced computing resources accessible for new actors
  - Broad deployment of broadband
  - New business models, e.g. Cloud/pay-per-use based
- Knowledge mining is becoming a key enabler for industry
  - Applications becoming increasingly data-centric
  - Server farms, HPC, embedded computing converging

*Key challenge:* We need to master the complexity - concurrency, heterogeneity, hierarchies, cost, energy consumption!
Convergence of application worlds

The engineering world
- engineering
- creative design
- compute-intensive
- performance

The management services world
- RRP (res requ plan)
- logistics
- data-centric
- database transactions

The physical world
- embedded systems
- sensor networks / IoT
- real-time
- dependable & reliable

The Future - Converging Worlds
- forecasting/decision support
- from db/appl/web servers to “emergence of services”
- data centric, storage unlimited
- all-in-memory
- computing continuum
- systems of systems
- real-time,
  dependable, reliable
- accessibility anywhere anytime
- energy efficiency

Finances
Life Science

HPC
Cloud server farms

Embedded comp

Social Networks
Crowd Sourcing
Several autonomous systems function as an integrated system to satisfy broader needs

- From design to engineering of systems and SoS
- Embedded world meets the Internet
- Take a holistic view of SoS with emergent behaviour
- Follow a generic approach across different SoS
- Beyond “best effort”: satisfy non-functional properties
- Find the balance between co-operation and autonomy
Towards Smart Spaces: Example Automotive

**Future: Autonomous Driving Smart Space**
- System of systems with emergent behaviour
- Mixed criticalities – priority to safety and time-criticalities
- Cognitive control – learning, simulation capabilities
- Data provided by wireless sensor networks and the IoT
- Powered by a computing continuum

**Todays Reality: Independent Systems**
- GENESYS
- INDEXYS
- GENVI

**Under Preparation:**
- Systems with mixed criticalities powered by networked many-core systems
  - More computing performance
  - System Properties: Cost, Energy, Weight
  - System Functionality: New functions, New services

**Potential scenario/vision for HORIZON 2020**

Intended to be supported by WP2013 and ARTEMIS
HiPEAC Vision 2011/12

Computing systems: Research challenges ahead

Data Deluge
Energy Wall, Connected, Real world data
Turning point for Moore’s law

Efficiency System Complexity Dependability

Global optimization

Heterogeneous Computing Locality & Communication Cost-effective Software Cross Component Optimization Next Generation Computing Architecture for Data Deluge Reliable Ubiquitous Systems

Technology and new devices
Technology-scalable data centers

Report from a group of EU industrial & research experts

Medium term R&I challenges:

- Mobile platform efficiency in server nodes
- Taming the data deluge
- Holistic integration
- Federated data centers

cordis.europa.eu/fp7/ict/computing/
Major challenges in industrial HPC

- Energy efficiency
- Master manycore, heterogeneity, data locality
- Robust and reliable real-time HPC
- Break dependence on dual expertise
- Simulation exploiting massive parallelism
- HPC applications integrated in workflows
- Increased data-intensity
- Access & business models for SMEs
Systems and Control Science and Technology

Need for advanced control of systems

- with increasing scale and complexity
  - Distributed networked control
  - Autonomy, cognition and control
  - Model-based system engineering
  - Human-machine interaction

- with increasing demands
  - Time-criticality management
  - Control Algorithms
  - Data handling and processing
Identified Challenges - Workshop January 2012

- Ever increasing demand for computing
- Mobile world meets Internet world
- Holistic architecture integration
- Data management in shared memory
- Decentralised and distributed control
Embedded System Design Strategy 2020

- **Key Drivers:**
  - More real time awareness and sensor data
  - A world of data analytics
  - System interactions driven by societal needs

- **Main Challenges**
  - New scalable approaches based on SoS
  - Embedded meets the mobile world
  - Multi-core and virtualization become predictable
  - Support the development of platforms
- **ARM**
  - ARM processor used in 95% of the world’s mobile handsets
  - Early beneficiary of OMI (OMI-MAP)
  - Participation in 30 projects in 20 years
  - From 162 employees in 1996 to 1900 in 2009
  - Energy-efficiency trend positions ARM broadly on computing market

- **CAPS**
  - Leading global provider in compiler technologies & engineering services for parallel hybrid computing
  - Participation in EU project Milepost crucial for success of building a market leader product
  - Triplcation of staff in 4 years

- **TTTech**
  - Market leader in time-triggered safety critical real-time networks
  - Supported by 9 EU projects
  - From spin-off to 200 employees in 12 years
Data centre servers
ICT-Challenge 3
- Eurocloud
- IOLANES
- RELEASE
- ...

Green Data Centres
ICT Challenge 6
- FI4Green
- GAMES
- ...

Cloud Computing
ICT-Challenge 1
- Reservoir
- CONTRAIL
- 4CAAST
- ...

Towards Exa-scale HPC
ICT-Challenge 9 - FET
- MontBlanc
- DEEP
- CRESTA
- ...
FP7: 75 projects - 150 M€
Advanced Computing & Control Systems

- Next generation of energy efficient servers
- New platforms addressing mixed criticalities: embedded systems meet the Internet
- Exploit synergies between computing disciplines
- Cases studies for systems of systems
- Stimulate industrial take-up of novel computing tools
- Constituency building, roadmapping

Factory of the Future PPP

- Pilot on HPC-Cloud-based simulation services for SMEs

Tentative, subject to approval
Europe strong on relevant technologies:
- Next generation of energy-efficient servers
- Build on strengths in mobile & embedded computing
- Energy-efficiency, dependability, time-criticality, ...

Should Europe increase ambitions?
- R&I for data centres powering the cloud
- Address complete European datacenter eco-system
  - processor, chip, board, rack, storage
  - network, system software, applications
- Target 100x improvement in cost-/energy-efficiency
- Small-scale fully functional data-centre prototypes

Tentative - subject to approval of content and budget by the EC
- Management of critical and non-critical functional properties with focus on data management, energy efficiency and system integrity
- Integrated approach addressing safety & time-criticality
- Systems sharing computing resources respecting diversity, redundancy and performance
- Master distributed heterogeneous many-core systems
- Cross cutting research demonstrated across application

Tentative, subject to approval
Synergies across computing disciplines

- Energy efficiency
- Dependability
- Time-criticality
- Parallelisation – manycore, GPUs
- HW/SW co-design
- Customisation - heterogeneity
- Virtualisation
- Reconfigurability
- Multi-stacking / optical interconnect

Stimulate silo-like constituencies to network and build on each others strengths

Tentative, subject to approval
Tentative plans for ARTEMIS Call 2012

- ARTEMIS Sub-programmes on embedded systems research
- ARTEMIS Innovation Pilot Programmes:
  - AIPP1: Critical Systems Engineering Factories
  - AIPP2: Innovative Integrated Care Cycles
  - AIPP3: Smart environments - the Neural System for Society
  - AIPP4: Production and Energy Systems Automation
  - AIPP5: Computing platforms for embedded systems
  - AIPP6: “Intelligent-Built” environment and urban infrastructure for cities
- Closing: Late summer - 1-step submission procedure

Two complementary programmes - FP7 and ARTEMIS JTI:

FP7: targeting new paradigms, foundational research, cutting across applications with mid- to long term horizon.
ARTEMIS: closer to market targets, application focus, reference architectures, pilot demonstrations, migration pathways for legacy
Horizon 2020
What’s new?

- Part of Europe 2020, Innovation Union & EU Research Area
- Commission proposal for R&I funding programme (2014-20)
  - €80 billion in constant 2011 prices
  - For decision by European Council, Parliament by end of 2013
- A single programme bringing together three separate programmes/initiatives (FP7, CIP, EIT)
- More innovation, from research to retail, all forms of innovation
- Focus on societal challenges facing EU society, e.g. health, clean energy and transport
- Simplified access, for all companies, universities, institutes in all EU countries and beyond.
Objectives and structure

Europe 2020 priorities

Tackling Societal Challenges
- Health, demographic change and wellbeing
- Food security and the bio-based economy
- Secure, clean and efficient energy
- Smart, green and integrated transport
- Supply of raw materials
- Resource efficiency and climate action
- Inclusive, innovative and secure societies

EIT and JRC will contribute to addressing these challenges

Creating Industrial Leadership and Competitive Frameworks
- Leadership in enabling and industrial technologies
- Access to risk finance
- Innovation in SMEs

Excellence in the Science Base
- Frontier research (ERC)
- Future and Emerging Technologies (FET)
- Skills and career development (Marie Curie)
- Research infrastructures

Shared objectives and principles

Common rules, toolkit of funding schemes

Simplified access

International cooperation

Coherent with other EU and MS actions

European Research Area

Horizon 2020

tentative - current status of discussion
Leadership in enabling and industrial technologies

- Strategic, technology focused approach
  - With potential applications in many sectors/ challenges

- Differentiated from:
  - *Societal challenges*: demand led, combining different technologies/ solutions
  - *European Research Council*: Bottom up

- A new generation of components and systems: engineering of advanced and smart embedded components and systems
- Next generation computing: advanced computing systems and technologies
- Future Internet: infrastructures, technologies and services
- Content technologies & information management: ICT for digital content and creativity
- Advanced interfaces and robots: robotics and smart spaces
- Micro- and nanoelectronics and photonics
Conclusions

- ICT theme of “Leadership in enabling and industrial technologies” in H2020 mentions
  - Smart embedded systems
  - Control, SoS and complex system engineering
  - Advanced computing
- Innovation measures bridging between research and the market key under H2020
- EC is preparing FP7 WP 2013
  - Tentative WP publication: July 2012
  - Two Calls considered: closing early 2013
  - Including transition measures
- Consultations with experts for H2020 continue

More information:
- cordis.europa.eu/fp7/ict/computing
- cordis.europa.eu/fp7/ict/embedded-systems-engineering
- www.artemis-ju.eu
- www.ec.europa.eu/research/horizon2020