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The HiPEAC Vision

The HiPEAC Vision Document is a deliverable of the coordination and support action on **High Performance and Embedded Architecture and Compilation** that gathers over 450 leading European academic and industrial computing system researchers from nearly 320 institutions in one virtual center of excellence of 1700 researchers.

January 2017 version is available at:
http://hipeac.net/vision
Cyber physical entanglement

• The entanglement between the physical and virtual world
• Virtual reality, augmented reality and cyber-physical systems blending together
• Many computers with any shape or size and new interactions with surrounding people
Human and machine collaborating

• Entering the Centaur\(^1\) era
• Cobots
• BCI (Brain Computer Interface)
• Intelligent Personal Assistant (Siri, Cortana, Google now, Alexa...)

\(^1\) In Advanced Chess, a "Centaur" is a man/machine team. Advanced Chess (sometimes called cyborg chess or centaur chess) was first introduced by grandmaster Garry Kasparov, with the objective of a human player and a computer chess program playing as a team against other such pairs.

(from Wikipedia)
(Narrow) Artificial Intelligence everywhere

- **Artificial Intelligence** is changing the man-machine interaction – natural interfaces, "intelligent" behavior

- The new systems should make intelligent and **trustable decisions**
Key ingredients for trustable systems

- Security
- Privacy
- Safety

Mixed-criticality
IoT: the Internet of Threats

Today security / privacy issues make the newspaper headlines. Massive adoption of IoT by citizens relies on confidence in terms of security and privacy.

Massive adoption of IoT by citizens relies on confidence in terms of security and privacy.
Trust is key for critical applications

• Beyond predictability by design and beyond worst-case execution time (WCET)
• Capability to build trustable systems from untrusted components
• Mastering trustability for complex distributed systems, composed of black or grey boxes
Smart Computing Distribution

New services

Processing, Abstracting Understanding as early as possible

Cyber Physical Entanglement

Internet of Things

Cloud / HPC

Big Data

Data Analytics / Cognitive computing

Fog computing
Edge computing
Stream analytics
Fast data...
by real-time micro-servers
and even Nano-servers
(concentrator, fusion of several sensors)

Transforming data into information as early as possible
Embedded intelligence needs local high-end computing

System should be autonomous to make good decisions in all conditions

Safety will impose that basic autonomous functions should not rely on “always connected” or “always available”

Cloud and HPC cannot support many cyber-physical applications.
Embedded intelligence needs local high-end computing

Example: detecting elderly people falling in their home

*Privacy* will impose that some *processing* should be done locally and not be sent to the cloud.
Embedded intelligence needs local high-end computing

Dumb sensors

Smart sensors: Streaming and distributed data analytics

*Bandwidth* will require more *local processing*
"People who are really serious about software should make their own hardware"  
Alan Kay

- With doubling hardware performance, the value was in the software
- With stagnating hardware performance, the value is in the co-design of hardware and software
- In the embedded systems market, almost 90% of the market is on hardware (from global market insight).
- We need to retain European capacity to design hardware

PC-era: Intel  
Mobile era: ARM  
CPS-era: ?
• Computers should not waste energy on tasks that have no added value
• Trade-off energy/precision/response time
• Approximate systems because the world is not only 1 and 0
• Need new programming concepts for energy efficiency
• The myriad of IoT devices will have a large worldwide energy impact
Growing complexity of software and hardware

- ARM® Dual Cortex™-A15 Microprocessor Subsystem
  - Up to 1.5 GHz
- NEON™ SIMD coprocessor and VFPv4
- 2 MiB Unified L2 Cache Memory
- 6 Power Domains
- IVA-HD Hardware Accelerator Subsystem
- ARM Dual Cortex™-M4 Image Processing Unit (IPU)
  - Dual-core, 200 MHz per Core
- On-Chip Debug with 14-pin JTAG and CTools Technologies
- Display Subsystem
  - Display Controller with DMA Engine
  - Support for 3 LCD Outputs and 1 TV
  - 3 Video, 1 GFX, and 1 Write-back Pipeline
  - HDMI Encoder: HDMI 1.4a, HDCP 1.4, and DVI 1.0 Compliant
- Dual-Core PowerVR® SGX544™ 3D GPU
- 2D Graphics Accelerator (BB2D) Subsystem
  - Vivante™ GC320 Core
- Imaging Subsystem (ISS), Consisting of Image Signal Processor (ISP) and Still Image Coprocessor (SIMCOP) Block
- Face Detection Interface (FDIF)
- Power-Independent Audio Back-End (ABE) Subsystem
- Level 3 (L3) and Level 4 (L4) Interconnects
- DDR3/DDR3L Memory Interface (EMIF) Module
  - Up to 4 GiB of SDRAM per EMIF (2 GiB per Chip Select)
- General-Purpose Memory Controller (GPMC)
- System Direct Memory Access (DMA) Controller
- Five High-Speed Inter-Integrated Circuit (I²C) Ports
- HDQ™/1-Wire® Interface
- 5 Configurable UART/IrDA/CIR Modules
- 4 Multichannel Serial Peripheral Interfaces (MCSPIs)
- Multichannel Buffered Serial Port (MCBSP)
- Multichannel Pulse Density Modulation (MCPDM)
- Multichannel Audio Serial Port (MCASP)
- 6-Path Digital Microphone (DMIC) Module
- MIPI® High-Speed Synchronous Serial Interface (HSI)
- High-Speed (HS) Multiport USB Host Subsystem
- SATA Host Controller and Physical Layer (PHY)
- MMC/SDIO Host Controller
- SuperSpeed (SS) USB OTG Subsystem and USB3 PHY
- Up to 256 General-Purpose I/O (GPIO) Pins
- 11 General-Purpose Timers
- 2 Watchdog Timers
- 32-kHz Synchronized Timer
- Power, Reset, and Clock Management
  - Multiple Independent Core Power Domains
  - Multiple Independent Core Voltage Domains
  - Module-Level Clock Management for Dynamic Reduction of Consumption
  - Available TI Clock Tree Tool (CTT) for Interactive Clock Tree Configuration
- Package
  - 754 Device Pins
  - Ball Grid Array (BGA)
  - 0.5-mm Ball Pitch

Functional diagram OMAP 5432 Multimedia Device
There is a need for a holistic approach for systems development.
Managing complexity

- Interoperability and composability
- Cognitive solutions for computing systems:
  - AI for computing systems
  - Similar to *Generative design* for mechanical engineering

“And that’s why we need a computer.”
Generative design approach

The user *only states desired goals and constraints*

Motorcycle swingarm: the piece that hinges the rear wheel to the bike’s frame
Time to revisit the basic concepts

The US wants to “reboot computing”...

We propose to re-invent computing, typically by challenging basic assumptions...
- Interrupts, layered of memory, binary coding, ...
Highlights of HiPEAC vision 2017...

Cyber physical entanglement

Artificial intelligence

Human and machine collaboration
Holistic view

- Guaranteeing trust
- Improving performance and energy efficiency
- Mastering complexity

- Security, safety, privacy
- Mastering parallelism and heterogeneity
- Beyond predictability by design

- Increasing ICT workforce
- Reinventing computing

Local Computing
- Entangled
- Customized hardware
- Compute intensive
- Composability
- Cognitival

HiPEAC Compilation Architecture
HiPEAC vision 2017 in a nutshell
Download the new HiPEAC Vision at:

http://hipeac.net/vision

Give us your comments at:
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