CERBERO
Cross-layer modEl-based fRamework for multi-oBjective dEsign of Reconfigurable systems in unceRtain hybRid envirOnments

presented by Michael Masin (IBM Research - Haifa, michaelm@il.ibm.com)

joint work with
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• CERBERO consortium in a glance
• Background on Cyber Physical Systems (CPS) and Cognitive CPS
• CERBERO goal (WHAT)
• CERBERO use cases (WHY)
• CERBERO tool chain (HOW)
• Summary of CERBERO approach
• Next steps
Consortium: 12 partners from 7 countries

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Started: January 1, 2017
Duration: 36 months
To build Cognitive Cyber Physical Systems

Components and Technology Providers

Started: January 1, 2017
Duration: 36 months

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and evaluate by 3 use cases

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Cyber Physical Systems (CPS)

- **Autonomous cyber** systems communicating with **physical** environment
- **Examples**
  - embedded controllers
  - home appliances and cars communicated with cloud
  - industrial controllers, SCADA
- Usually **small** System of Systems (SoS) or **star** topology of similar devices connected to cloud
- **Main challenge:** Combine Cyber and Physical Models for design, analysis and operation
- **Established** technologies for design and operation
• **Reconfigurable** CPS that understand operational context in real time, especially with **humans** or **teams** of machines and humans

• **Examples**
  - mars rover
  - autonomous vehicles
  - autonomous vessel fleets
  - self healing appliance
  - self adaptive manufacturing

• Usually **large** SoS and **fog** topology between hybrid devices

• **Main challenge:** Reconfigurable “Smart” Cyber Systems in Uncertain Hybrid Environments

• **Emerging** design and operation methodologies
• Integrated model-based framework for multi-objective design, fast prototyping and continuous DevOps of Cognitive Cyber Physical Systems

  • From (User Requirements)
  • SoS and System level
  • Application / Service level
  • Real Time Manager level
  • To Real Time Software and Hardware implementation
CERBERO Expected Impact

• Collection of partially integrated toolchains and methodologies for CPS that
  • collect data usage
  • apply predefined control
  • find shortest path navigation

• Integrated modelling and design environment for Cognitive CPS with
  • self adaptation and self healing capabilities
  • adaptive control based on global objectives
  • congestion, accident (and other risks) avoidance

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CERBERO Drivers

- CROSS-LAYER
- KEY PERFORMANCE INDICATORS MANAGEMENT
- FAST DSE
- RAPID PROTOTYPING

- MODULARITY & RE-USE
- MODEL-BASED
- INTEGRATED CHAIN

- MODULARITY & RE-USE
- OPEN SOURCE TOOLS
- STANDARDISATION ACTIONS

PERFORMANCE

LONGEVITY

ACCESSIBLE

STANDARD

INTEROPERABILITY

CERBERO

ADAPTIVITY
INCREMENTAL DESIGN: SYSTEM IN THE LOOP
MANTAINANCE

OPEN SOURCE
OPEN ACCESS
PATENT
SOCIETAL IMPACT

R&D: SysML and FMI, MPEG
APPLICATION: ECSS & ESA
CERBERO Use Cases

**Self-Healing System for Planetary Exploration:**
- Self-healing and self-adaptive embedded CPS processing systems capable of operating in such a critical environment
- Adaptive **System of Systems** for planetary exploration mission
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Ocean Monitoring:
• Smart video-sensing unmanned vehicles with immersive environmental monitoring capabilities
• Individual and fleet self-operation, power management and navigation
• Data analysis and information fusion to enable smart adaptation strategies to address rapidly changing environment conditions in order to obtain or maintain positions on sea and other missions objectives
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**Smart Travelling for Electric Vehicle:**
- Highly networked scenario composed of heterogeneous concurrent subsystems
  - Electric Vehicle, Person possessing a only partially observable personal agenda, the Smart Energy Grid and the Smart Mobility that provides mobility-aware functionality (e.g. parking places, charge points, smart home, smart office, etc.)
- High degree of autonomy and support for adaptability, plus modelling and managing the distributed communication layers.
- Virtual Reality simulated environment

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CERBERO Toolchain v0.1

User Requirements and technical specifications (Excel)

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- VT
- AOW
- DYNAA
- PREESM
- ORCC
- PAPI
- SPIDER
- JADE
- LLVM
- C++
- ARTICO3
- MDC
- LLVM Compiler
- Multi Core Compiler

Semantic layer

= existing interface
= planned integration

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BEYOND SEPARATION OF CONCERNS:

- Modeling, optimization and analysis of hybrid systems with continuous physical and human behavior and discrete cyber models of computation and communication
- Many layers of abstraction with unique models and tools
CERBERO Approach

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**BEYOND REQUIREMENTS ANALYSIS:**
- High level functional and non-functional (i.e. security, sustainability, usability) requirements analysis and continuous verification
- Generalization of requirements by means of common Key Performance Indicators
CERBERO Approach

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• **BEYOND SCENARIO AWARENESS:**
  • Methodology for designing *cognitive* system architectures
  • Autonomous and sensor-based *hardware/software reconfiguration*
  • *Multi-layer runtime adaptation* approach by means of a high-level self-adaptation engine
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- **BEYOND TOOL INTEGRATION:**
  - Semantic integration of different design automation components
  - Incremental prototyping and verification, with system-in-the-loop co-simulation capabilities
Current status and next steps

• Elaboration of use cases
• Requirements for the tools and integration platform
• Initial methodology, framework, and toolchains
• Building CERBERO users community
  • CERBERO Summer School – Alghero (Italy), September 25-30, 2017
    http://www.cerbero-h2020.eu/summer-school
• Iteration cycles based on feedback from use case providers and users community
Thank you for your attention! Any questions?

http://www.cerbero-h2020.eu/
Designing Cyber-Physical Systems

From concepts to implementation

Multi-objective Methodologies and Tools for Self-healing and Adaptive Systems

http://www.cerbero-h2020.eu/summer-school

Cyber-physical systems (CPS) are complex and autonomous ensembles of different components that interact to offer smart and adaptive functionalities. These systems are increasingly used in a variety of applications with a growing market, potentially bringing about significant social benefits. However, there is no such thing as a free lunch, and there are several new challenges and trade-offs to face when designing CPS, especially since they should be able to adapt to the changing environments, or heal themselves. Uncertain operation environments and interactions with humans as users and/or as operators complicate the scenarios of these ever increasingly pervasive systems.

The CPS summer school is targeted at students, research scientists, and R&D experts from academia and industry, who want to learn about CPS engineering and applications. The program is composed of both lectures and practical sessions, covering all the design phases of CPS (i.e., from concept to the definition of the final system and the discussion of the key challenges).

Topics:
- Market trends for cyber-physical systems
- Applications of CPS, including wearable, biomedical, Industry 4.0, cognitive, and automotive systems
- Hardware/software co-design, adaptivity and multi-view modeling
- Low power design of heterogeneous systems
- Tools for dataflow design, high-level synthesis, hardware/software co-design, and coarse/fine reconfiguration
- Security in adaptive and interconnected systems

Confirmed speakers:
- Alberto Sangiovanni-Vincentelli, University of California, Berkeley
- Hironori Kasahara, Waseda University and IEEE Computer Society
- Armando Tacchella, Università di Genova
- Eduardo de la Torre, Universidad Politécnica de Madrid
- Muhammad Shafique, Vienna University of Technology

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**Self-Healing System for Planetary Exploration:** The objective of this use case is twofold. On one side it focusses on a single unique embedded CPS; while, on the other, it focusses on its integration with other systems of a planetary exploration mission. CERBERO is mainly conceived to define self-healing and self-adaptive processing systems capable of operating in such a critical environment.
**CERBERO Use Cases**

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*Ocean Monitoring:* Smart video-sensing unmanned vehicles with immersive environmental monitoring capabilities and capable of individual and fleet self-operation and navigation. CERBERO will define algorithms for data analysis and information fusion to enable smart adaptation strategies to address rapidly changing environment conditions in order to obtain or maintain positions on sea.
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