Self-adaptation of Cyber-Physical Systems

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CERBERO IN A NUTSHELL

Cyber Physical Systems (CPS) are embedded computational collaborating devices, capable of controlling physical elements and responding to humans. CERBERO aims at developing a CPS design environment based on two pillars: a cross-layer model based approach to describe, optimize, and analyze the system and all its different views concurrently; and an advanced adaptivity support based on a multi-layer autonomous engine.

CERBERO effectiveness is assessed in challenging and diverse scenarios: planetary explorations, ocean monitoring and a smart travelling for electric vehicle.

CONSORTIUM & PROJECT OVERVIEW

Self Healing for Planetary Explorations

This use case focuses on a single unique embedded CPS. CERBERO technologies are going to be adopted to define self-healing and self-adaptive processing systems capable of operating in such a critical environment.

Ocean Monitoring

Smart video-sensing unmanned vehicles with immersive environmental monitoring capabilities. CERBERO will define algorithms for data analysis and information fusion to enable smart (self-) adaptation strategies to address rapidly changing environment and system conditions.

Smart Travelling for Electric Vehicle

Highly networked. Heterogeneous concurrent subsystems: Electric Vehicle, Person (partially observable personal agenda), Smart Mobility (parking, charge points, etc.), etc. CERBERO will support adaptability, plus modelling and managing the distributed communication layers.

- MECA: decision support for user of a CPS
- VT: quantitative requirements verification to provide correct-by-construction design.
- AO: multi-objective multi-view cross-level optimization.
- DynAA: system analysis and design tool, combines features from system and network simulators.
- PREESM: dataflow to core mapping with static optimization capabilities (i.e. latency and load balancing).
- PAPI: runtime monitoring.
- SPIDER: runtime manager.
- JADE: Just-in-time compilation.
- MDC, ARTICO²: hardware acceleration and support for adaptivity.

Self-Adaptivity in CERBERO H2020

In CERBERO, tackling the development of self-adaptive CPS and CPS of Systems, we provided a generic definition of a self-adaptive system: the adaptation loop.

Support @Design-Time

To handle partitioning of applications over heterogeneous adaptive system PREESM is going to be used. PREESM was originally meant to handle actors partitioning over homogenous multi-core infrastructure, but we are now integrating within it MDC-compliant and ARTICO accelerators models. The HW accelerators are going to be instrumented with HW Performance Monitoring Counters (handled with PAPI) to monitor their internal status.

Support @Run-Time

“PAPI-fication of the hw layer” for continuous monitoring of accelerators, from standard ARTICO3 slots to Coarse-Grained Reconfigurable (CGR) ones.

Support @Design-Time

PREESM - N:N

SD-SoC - N:N

PAPI

MDC - N:1

Monitoring

Partitioning

HW Generation

SPIDER

PAPI-compatible extension of SPIDER for runtime management of hw-sw resources.

SRAM-Based FPGA

Extremely flexible behaviours: surfing among working points that can be user commanded or self-determined (i.e. low battery level).

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Michael Masin, Francesca Palumbo, et al.
Cross-layer design of reconfigurable cyber-physical systems

DATE 2017 - Design, Automation & Test in Europe Conference