Let’s get physical - EDA Tools for Mobility

Frank Oppenheimer
OFFIS – Institute for Information Technology
OFFIS at a glance

Application-Know-How
concentrated in R&D-Divisions

ICT-Know-How
concentrated in interdisciplinary Technology Clusters

- Ambient Health Technologies
- Analytical Information Systems
- Dependable Systems
- Embedded System Design Automation
- Human Machine Interaction
- ICT for Smart Grids

Energie
Energy

Gesundheit
Health

Verkehr
Transportation
3 Socio-economic drivers for embedded systems of the future

Mega cities ➔ Industry 4.0 || Smart grid || Smart mobility || …

System of cyber physical systems (CPS)

CPS || … || CPS

… || Computing platform || …

… || Embedded system || …

Source: http://www.dailydealmedia.com/?p=28742

ERIC2013 October, 23th 2013
4 Vision: Technologies for Smarter Mobility

Information on current situation is used by road users in real-time for safe, efficient, environmentally sound and comfortable mobility.

Application examples:
- Autonomous driving
- Multi-modal mobility
- “The car that cares”
- Adaptive routing up to 4D harmonization

Requirements for real-time information processing and control increase.

Requirements on computing density (no. applications/computing platform) increases significantly.

Physical properties of computing platforms need to become analyzable and predictable to guarantee real-time, power, and reliability requirements of the applications.
5 The Importance of Extra-functional Properties

Influence on the development of systems
6 Challenge I: Communication - Mobile and Green

Overview

Smart mobility
Communication - Mobile and Green

Ever increasing demand for (computational) power

Extra-functional properties limit the power of modern communication equipment and infrastructure.

Source: Jan M. Rabaey
8 HW/SW power & timing estimation with back-annotation

Executable task model

Architecture/resource model

Task mapping

Mapped & annotated task model

Estimation & back-annotation

Power and Timing Estimation tools with back-annotation

- SW estimation
- IP estimation
- HW estimation

Communication graph

- Number of cycles
- Switched capacitance

Control Data Flow Graph

Extra-functional Timing & Power model

- Communication
- Computation
- Basic Block
- Branch
Extra-functional properties such as
- energy consumption, battery life
- cooling
- reliability
- availability

limit the capabilities of modern communications equipment and infrastructure.

New system design methodologies must be able to support **extra-functional property closure** through
- a formal representation of **extra-functional constraints** (promise and assumption),
- representing **extra-functional properties** in executable or analytical prototypes and
- to enable a **formal match of the constraints against implementation properties**.
10 Challenge II: Aging and Reliability

Overview

Smart mobility

Function, timing & energy demand under variation and aging

Communication and energy
What drives Technology and what’s next?

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Reliability by design

State-of-the-art design:

(Over-)Designed System

System Requirements

System Requirements

Overdesign

Production

System Requirements

PTV Variations

(Over-)Designed System

System Requirements

Aging

Degraded System

System Requirements

With PTV + aging prediction, regarding adaptive techniques (as DVFS) and redundancies:

System Requirements

Overdesign

Adaptive design

Designed System

System Requirements

Production

Worst-Case PTV

System Requirements

Aging

System Requirements

Production

System Requirements

Aging
Optimize longterm reliability needs understanding degradation effects:

• combine multiple extra-functional model for aging prediction
• introduce adaptive techniques already at design entry to reduce overdesign cost
• Use fast aging prediction to pick the best solution
Challenge III: Integrated Mobility - Smart and Safe

Overview

Smart mobility

Source: http://www.openpr.de/images/articles/l/6/l62112789_g.jpg
15 Autonomous mobility
Then and now

Source: Universität der Bundeswehr, Munich

Source: Team Victor Tango (Virginia Tech and TORC Technologies)
State-of-the-art in mixed-critical system design

Fully distributed with dedicated HW/SW platforms for different criticalities

(Safety-critical) Embedded Application
- Hard deadline $d_{2>3}$
- Soft power constraints
- Soft temperature constraints

Mobile Multimedia Application
- Soft deadline $d_{4>5}$
- Hard power constraints
- Hard temperature constraints
Segregation on shared computation platforms

Guarantee extra-functional properties per application on shared platform resources

(Safety-critical) Embedded Application

Mobile Multimedia Application

CPU 1 | CPU 2 | Memory | HW IP

Multi-core architecture

Eric2013
Segregation on shared computation platforms
Guarantee extra-functional properties per application on shared platform resources

Source: http://rtcmagazine.com/articles/view/102791
Goal: Compositional analysis of power and temperature in mixed-critical systems

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Necessary increase in the function density (= more functions in less ECUs) due to
- limited space
- weight requirements
- energy efficiency
- cost
- availability
promotes the use of multi-core processors.

Management of multi-core's shared resources to guarantee temporal and spatial segregation of safety-critical applications. But at the same time enabling compositional power and temperature analysis and management.
Driving Challenges

Summary

I) Communication - Mobile and Green:
- 10+ billion mobile communication devices
- Power consumption/heat of infrastructure limits bandwidth and QoS
- Power consumption of mobile devices limits service usability, functionality and availability (-> battery lifetime)

II) Aging and reliability:
- Shrinking feature size increase variation and degradation
- Aging and reliability become the next limiting extra-functional property.

III) Mobility - Smart and Safe:
- Combination of mobile, multimedia and (safety-critical) embedded services on the same device.
- Multi-cores enable higher functional density but cost predictability
Y-chart 2.0
An EDA coordinate system for extra-functional properties
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