Design of embedded mixed-criticality CONTROl systems under consideration of EXtra-functional properties

Kim Grüttner (OFFIS)

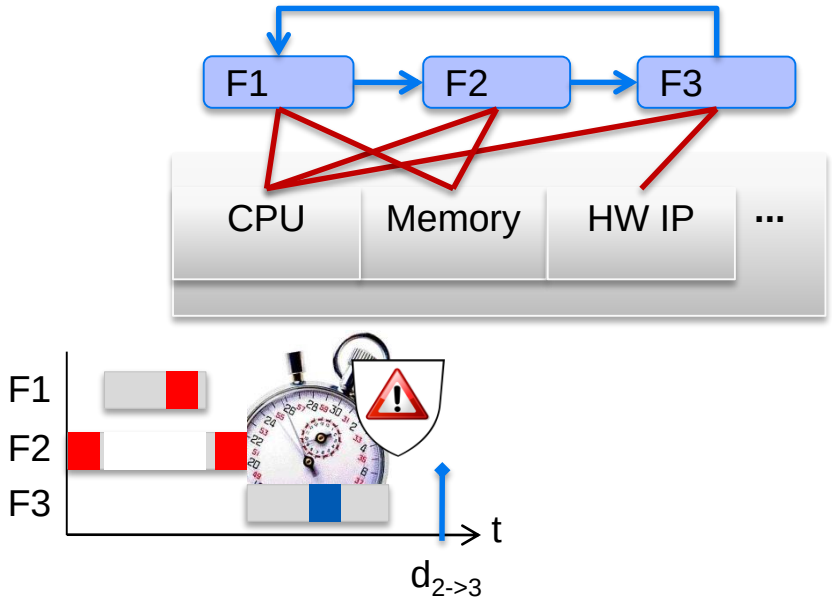
The CONTREX consortium

Funded by the EC under

Grant Agreement 611146

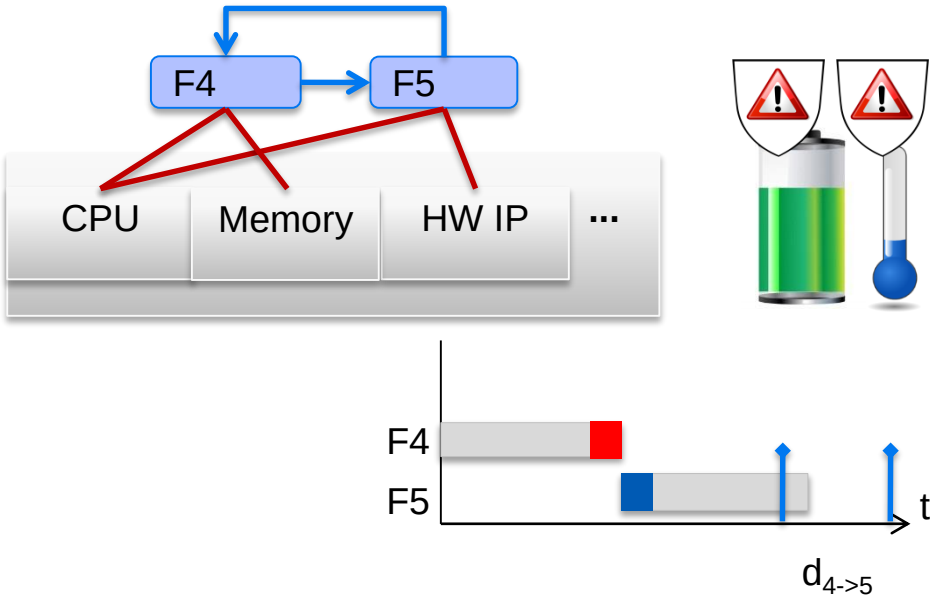
2 Motivation: State-of-the-art

Safety relevant system



Safety critical tasks
- Hard deadlines (e.g. $d_{2->3}$)
- Static schedule based on BCET/WCET analysis
- No power constraints
- No temperature constraints

Non-Safety, performance (QoS) critical system



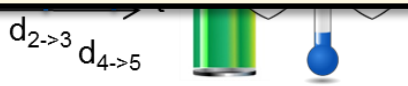
Mission critical tasks
- Soft deadlines (e.g. $d_{4->5}$) based on QoS metrics
- Dynamic schedule
- Hard power constraints (e.g. battery limited)
- Hard temperature constraints

Motivation: Integration on a single chip!?

We aim at:

- **consideration of extra-functional requirements and constraints (timing, power, temperature) at design entry**
- **representation of extra-functional properties**
  - timing
  - power
  - temperature

  in executable prototypes and
- **analysis of these properties**
  - under different application deployments and mappings and
  - scheduling, power and thermal management decisions.



Outline

- Introduction and Motivation
- Project Overview
- CONTREX Methodology Overview
- Modeling of EFPs and Criticalities
- EFP Modeling, Simulation, and Monitoring
- Runtime Management
- Summary

5 Project Overview and Consortium

PARTICIPANT NO.	PARTICIPANT ORGANISATION NAME	PART. SHORT NAME	COUNTRY
1 (Coordinator)	OFFIS e.V.	OFFIS	Germany
2	STMicroelectronics srl	STM	Italy
3	GMV Aerospace and Defence SA	GMV	Spain
4	Cobra Telematics SA	Cobra	Switzerland
5	EuroTech S.p.A.	EUTH	Italy
6	Intecs S.p.A.	INTECS	Italy
7	iXtronics GmbH	iX	Germany
8	EDALab srl	EDALab	Italy
9	Docea Power	Docea	France
10	Politecnico di Milano	PoliMi	Italy
11	Politecnico di Torino	PoliTo	Italy
12	Universidad de Cantabria	UC	Spain
13	Kungliga Tekniska Högskolan	KTH	Sweden
14	Electronic Chips & Systems design Initiative	ECSI	France
15	ST-POLITO Societa' consortile a r.l.	ST-PoliTo	Italy
16	Intel Corporation SAS	Intel	France

Starting date: 01/10/2013
Duration in month: 36
Call identifier: FP7-ICT-2013-10
Website: http://contrex.offis.de

Universities and Research Institutes
Industry
Small and Medium Size Enterprises
Other

6 CONTREX Reference Architecture

Starting point

System Models
(e.g. from 3rd party model-driven design flow)

Legacy HW/SW
(e.g. existing C-Code, VHDL, Verilog, …)

Model capturing and (timing) analysis

CONTREX UML/MARTE Model

Generic Task Model

Generic HW Model

ForSyDe Model

Analytical DSE for timing

Functional and extra-functional analysis

Virtual Platform

User SW

MiddleWare (e.g. Kura)

OS with RT and Resource manager

Hardware Model

Off-Chip Network Model

Timing Monitor | Power Monitor | Battery Monitor | Temp. Monitor

Timing Model | Power Model | Battery Model | Temp. Model

Environment Model (functional & extra-functional)

Simulative DSE for power and temp.

Design validation

Actual HW
(e.g. Xilinx Zynq, ST iNemo, ST SeCSoC)

Tech. data: package desc., floorplan, technology, …

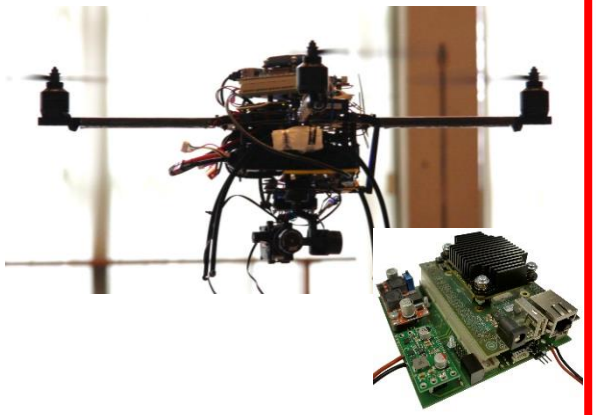
HW in-the-loop facilities

Timing Measurement

Power Measurement

(Temperature Measurement)

Avionics



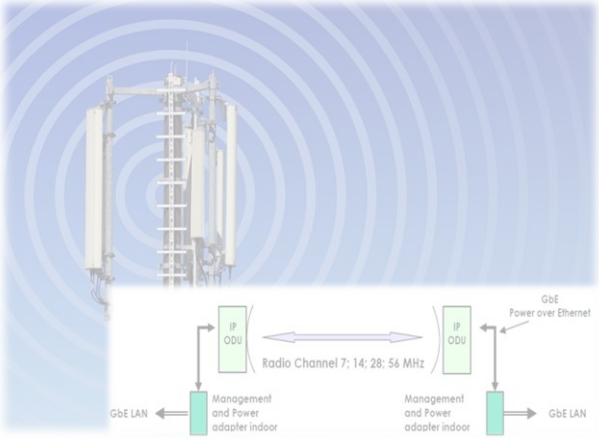
Flight Control Computer for a Remotely Piloted Aircraft

Goal: *Executes safety-, mission- and non-critical applications on the same multi-core execution platform.*

Criticalities: *safety- and mission-critical*

Extra-functional properties: *hard real-time, power, temperature, reliability*

Telecommunication



Ethernet over Radio System

Goal: *Optimization of performance/cost characteristics of a Gbit Ethernet over radio system.*

Criticalities: *safety-, mission-, non-critical.*

Extra-functional properties: *real-time, power, temperature, reliability*

Automotive Telematics

Automotive Telematics Box

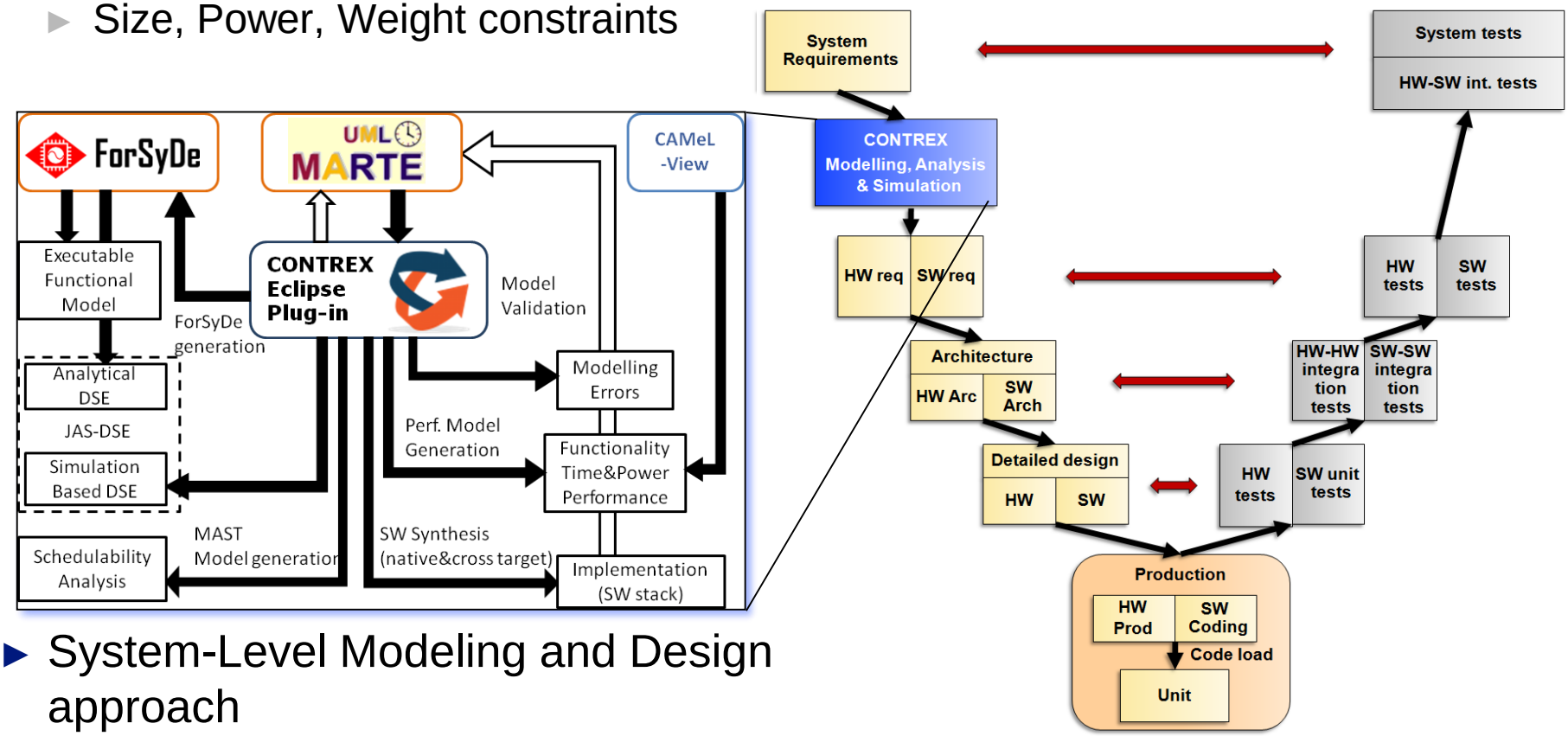
Goal: *Move processing from local (on-board) devices into the cloud.*

Criticalities: *mission- and non-critical.*

Extra-functional properties: *performance, power, security, reliability*

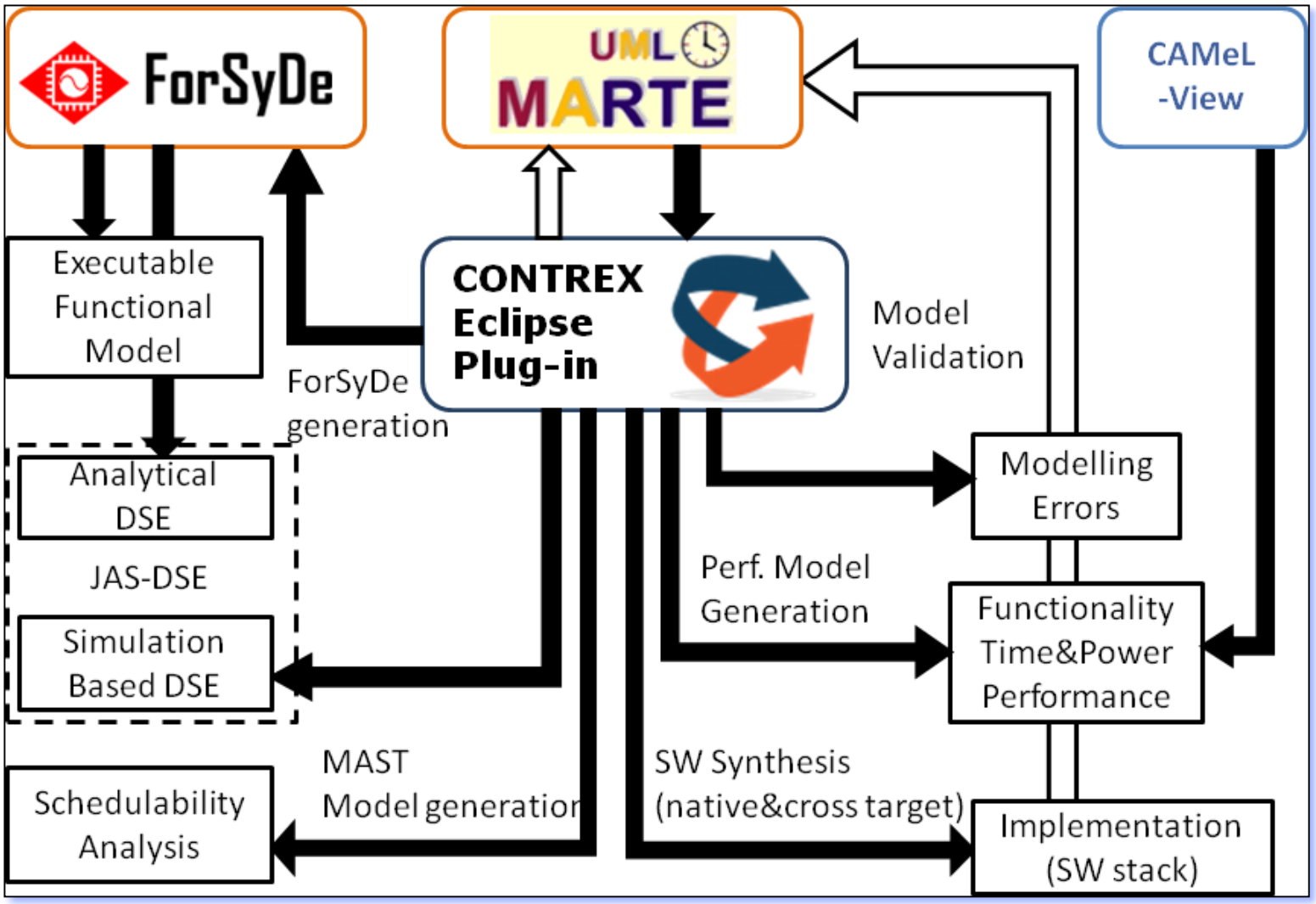
8 Early Modeling of EFPs and Criticalities: Avionics Motivation & CONTREX answer

- Design of Remote Piloted Aircraft (RPA) equipment:
  - Partitioning in early phases, based on design expertise
  - Resource oversizing (avoid late integration issues)
  - Adaption to new contexts difficult
  - Size, Power, Weight constraints



- System-Level Modeling and Design approach

9 CONTREX Eclipse Plugin

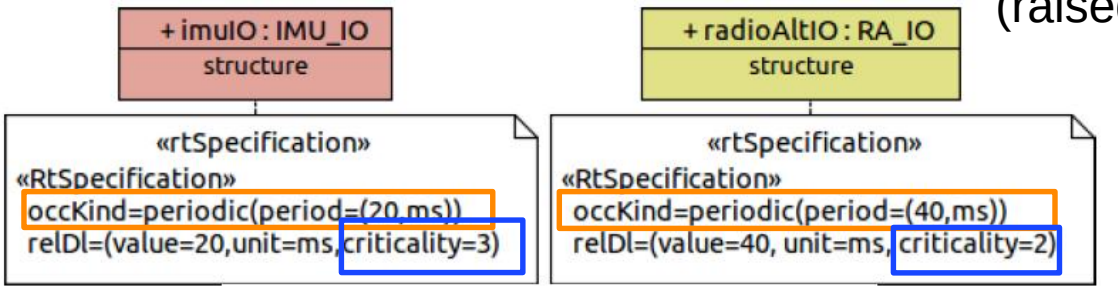


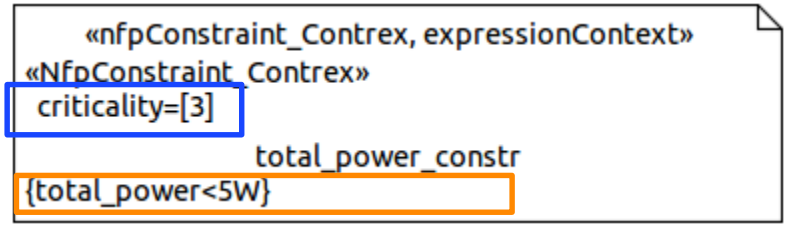
Modelling of EFPs and Criticalities

- **EFPs and Criticalities:** Fundamental and Necessary information for DSE and for efficient design of Mixed-Critical Systems
- Captured in UML/MARTE

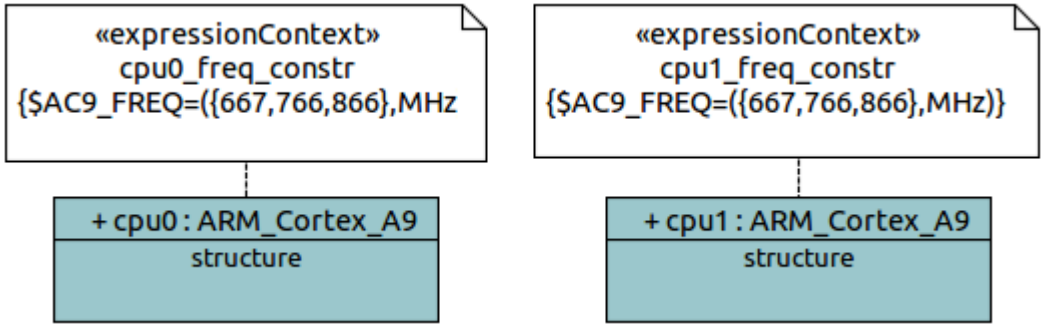
- EFPs:
  - At System Inputs and Outputs
  - At Application, Platform & System Level

- Criticalities:
  - Associated to Components and to EFPs and Performance requirements
  - Novel & Minor extension of MARTE (raised to OMG)

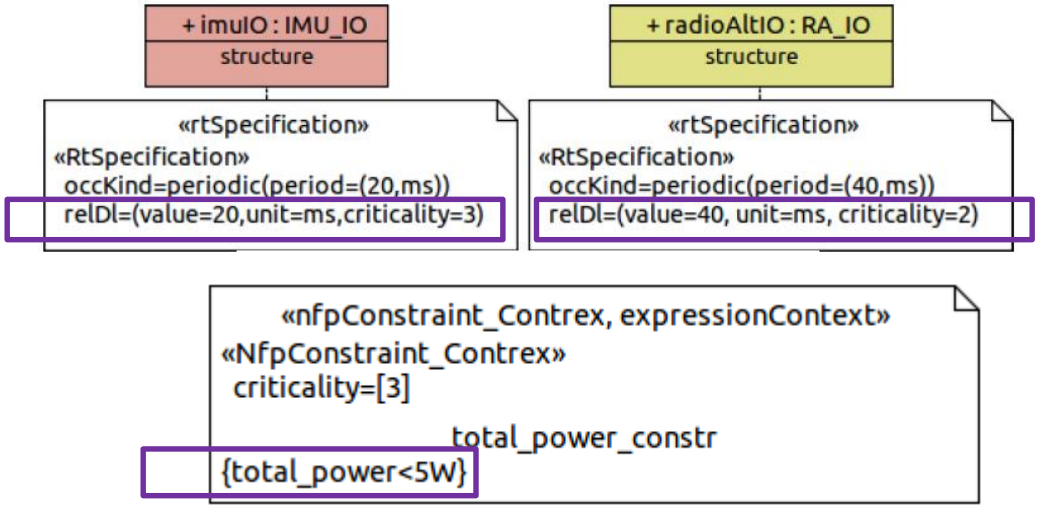




- DSE parameters: Define Design Space

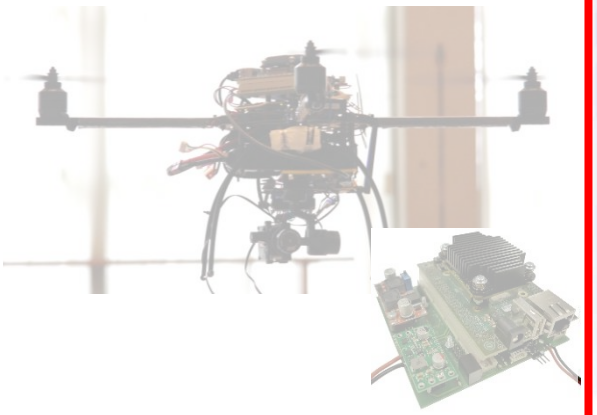


- Design Space Exploration for
  - Application parameters (e.g. task periods)
  - Platform parameters (e.g. working frequency)
- Performance Requirements



12 Use-Cases and Demonstrators

Avionics



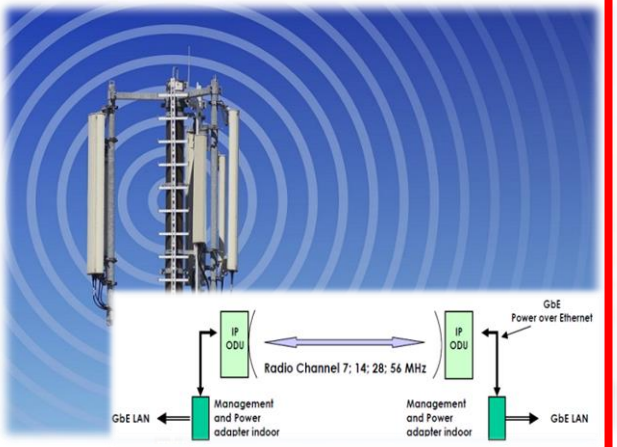
Flight Control Computer for a Remotely Piloted Aircraft

Goal: *Executes safety-, mission- and non-critical applications on the same multi-core execution platform.*

Criticalities: *safety- and mission-critical*

Extra-functional properties: *hard real-time, power, temperature, reliability*

Telecommunication



Ethernet over Radio System

Goal: *Optimization of performance/cost characteristics of a Gbit Ethernet over radio system.*

Criticalities: *safety-, mission-, non-critical.*

Extra-functional properties: *real-time, power, temperature, reliability*

Automotive Telematics

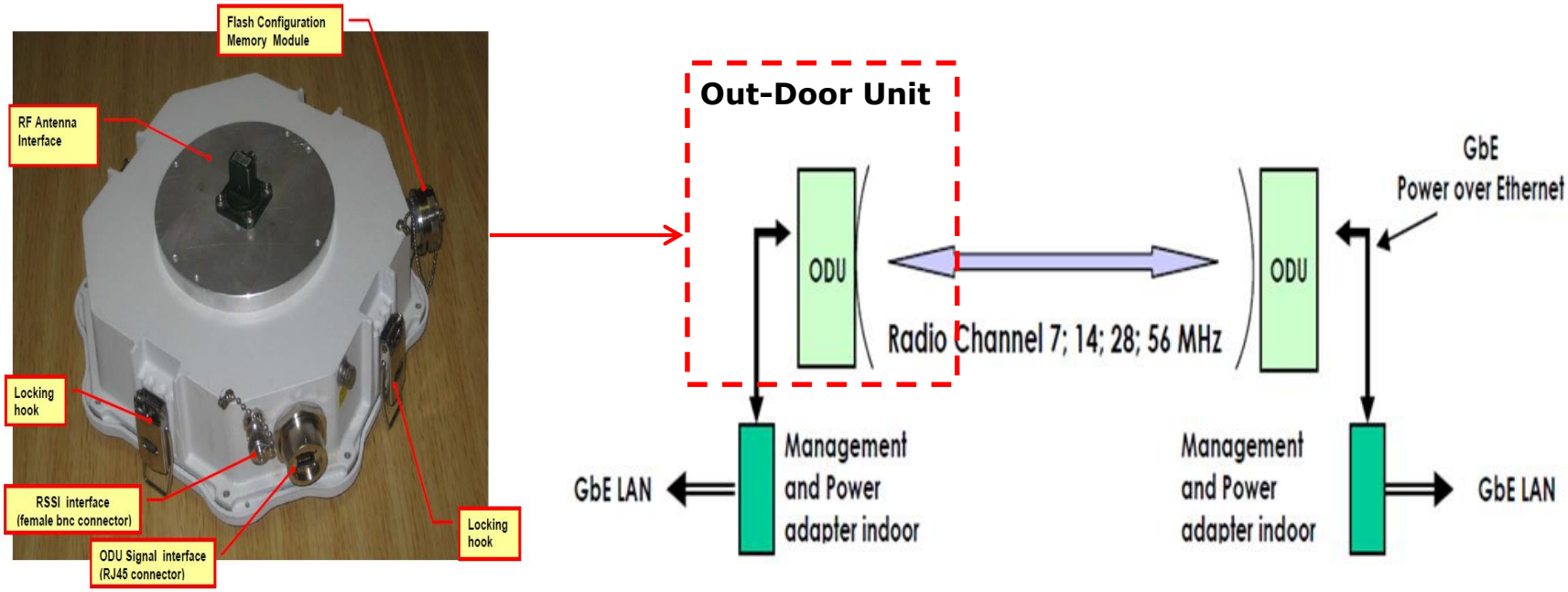
Automotive Telematics Box

Goal: *Move processing from local (on-board) devices into the cloud.*

Criticalities: *mission- and non-critical.*

Extra-functional properties: *performance, power, security, reliability*

The Telecom Demonstrator is based on the Point-to-Point (P2P) Ethernet over Radio Microwave Wireless System



- Software components developed within Intecs (except for L2Switch + Modem - FPGA)
- High reliability
- Automatic Transmit Power Control (ATPC)
- Timing guarantees
- Power, temperature, weight, and size constraints

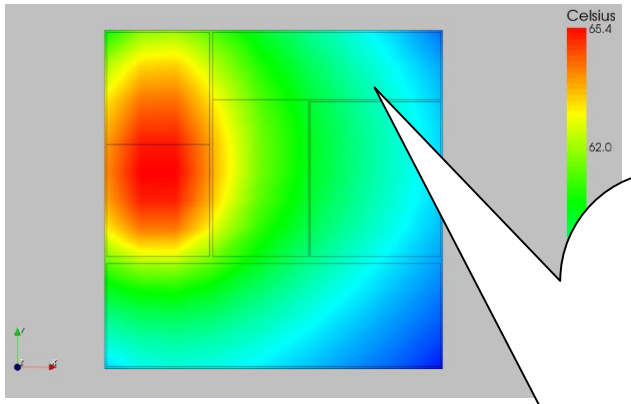
VP-based EFP Modelling and Simulation

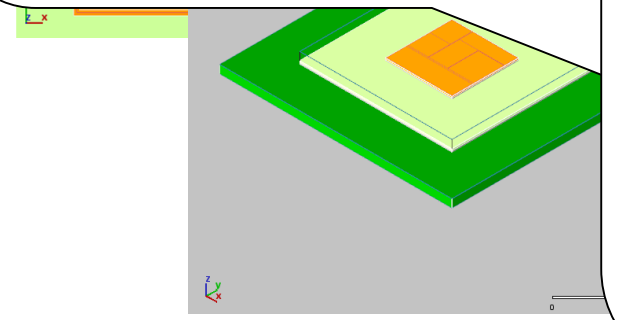
Application

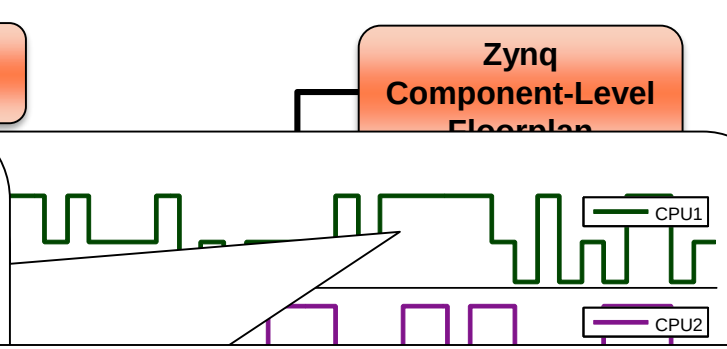
Zynq power model (PSM)

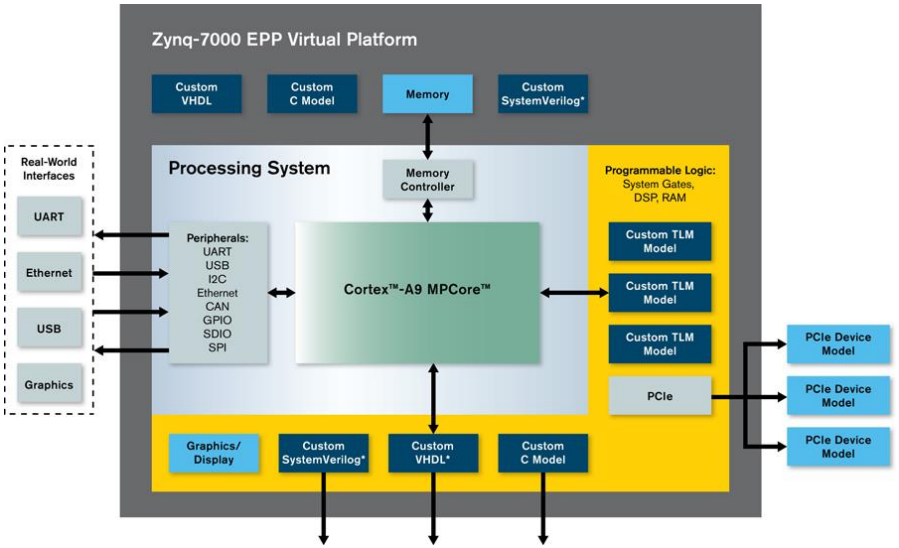
Zynq platform model

Zynq Component-Level Floorplan



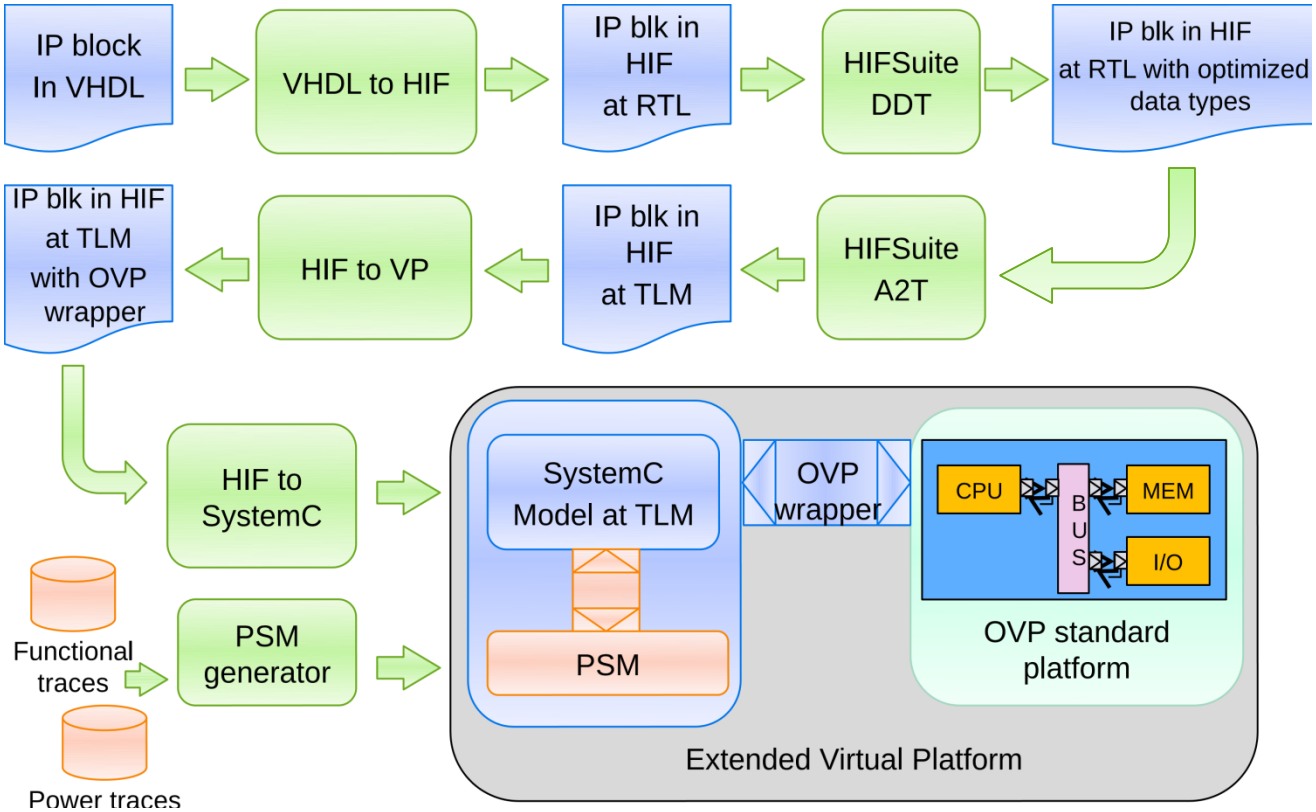






Source: Cadence

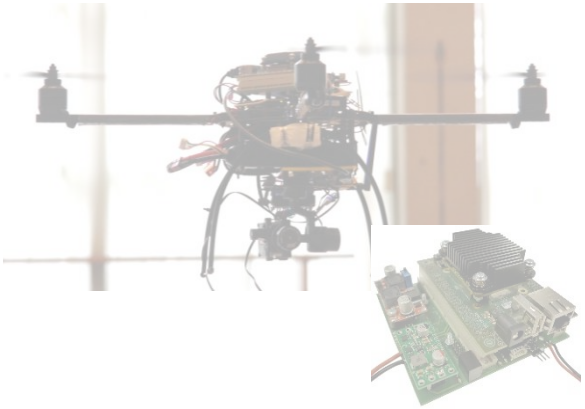
Automatic IP Integration



- Automatic abstraction to TLM
- Automatic PSM generation from power traces
- Automatic generation of VP component with power model

Use-Cases and Demonstrators

Avionics



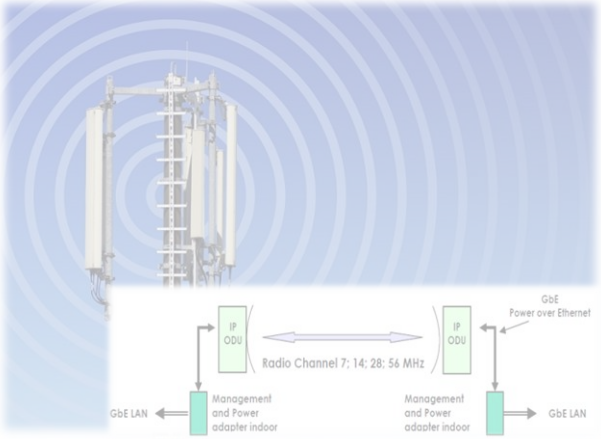
Flight Control Computer for a Remotely Piloted Aircraft

Goal: *Executes safety-, mission- and non-critical applications on the same multi-core execution platform.*

Criticalities: *safety- and mission-critical*

Extra-functional properties: *hard real-time, power, temperature, reliability*

Telecommunication



Ethernet over Radio System

Goal: *Optimization of performance/cost characteristics of a Gbit Ethernet over radio system.*

Criticalities: *safety-, mission-, non-critical.*

Extra-functional properties: *real-time, power, temperature, reliability*

Automotive Telematics

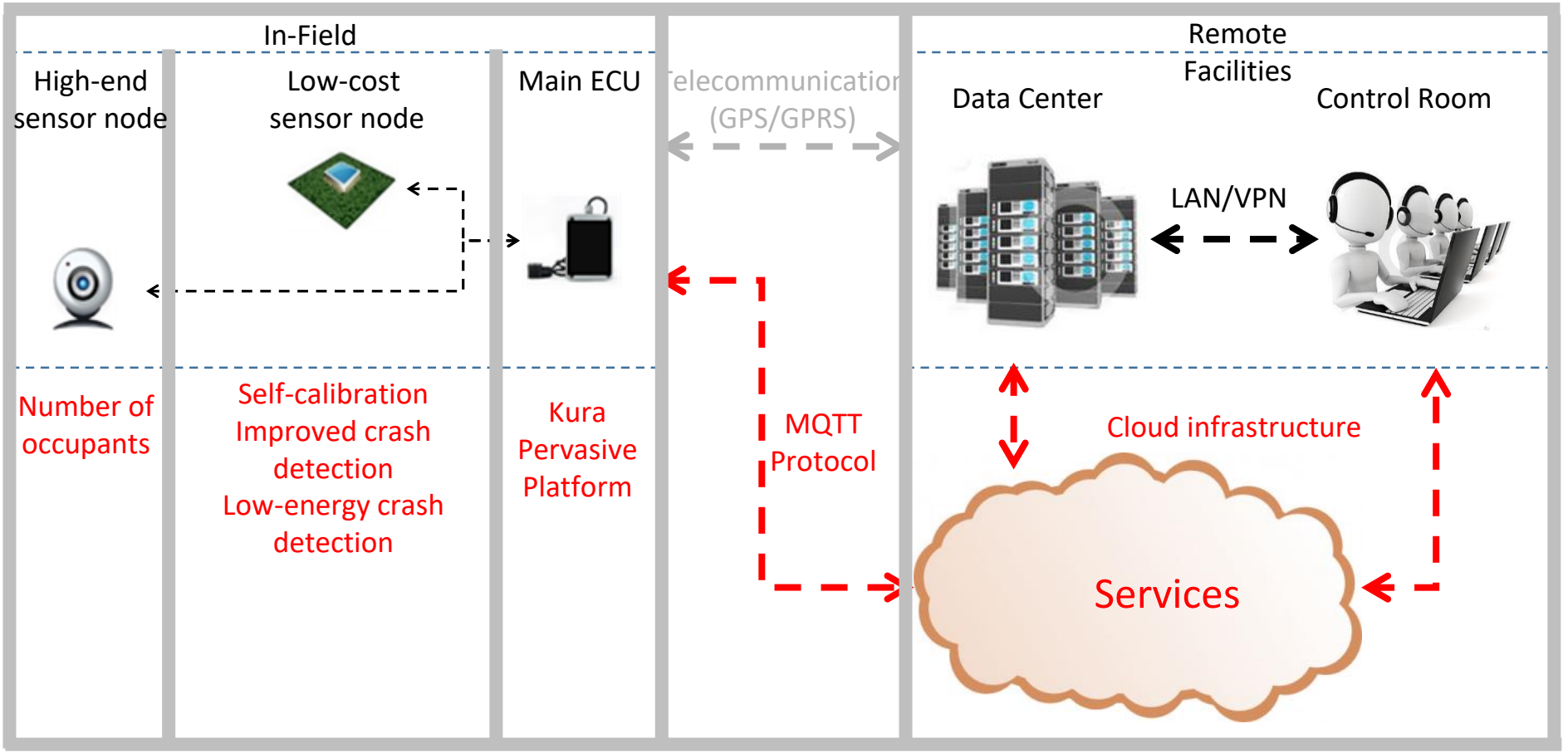
Automotive Telematics Box

Goal: *Move processing from local (on-board) devices into the cloud.*

Criticalities: *mission- and non-critical.*

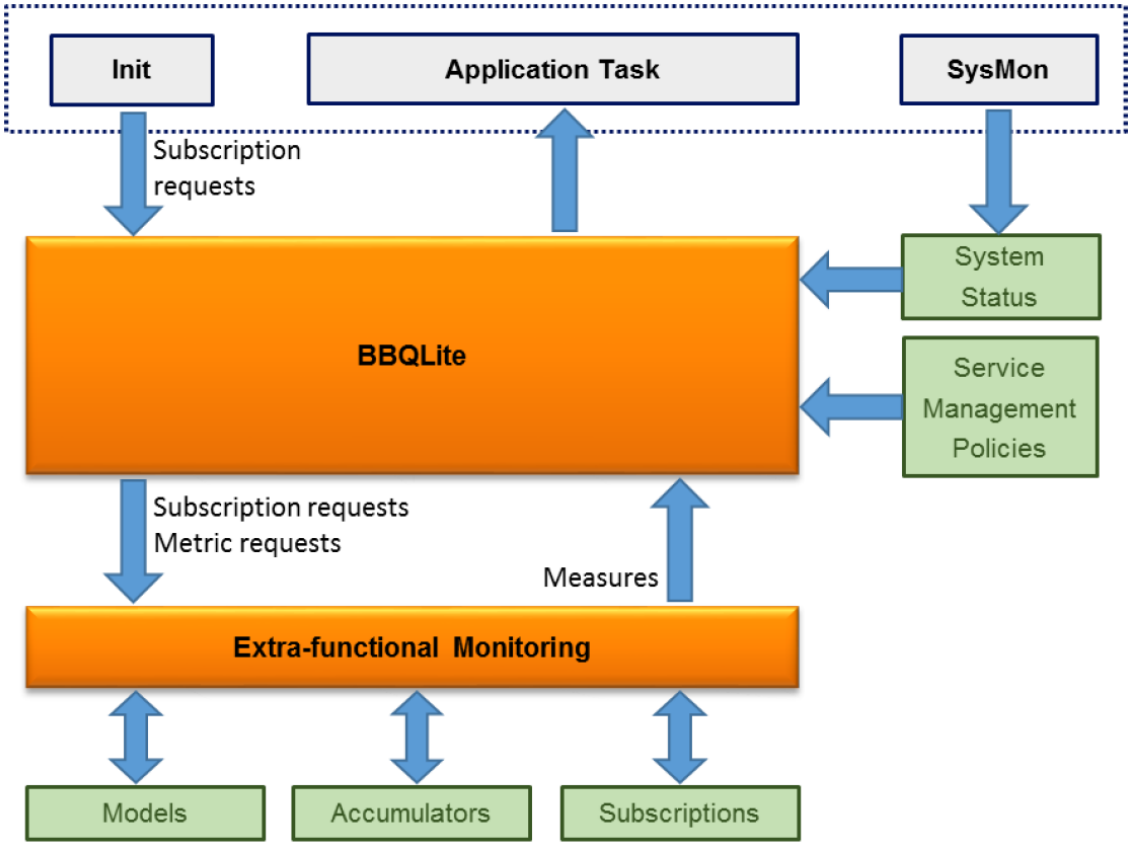
Extra-functional properties: *performance, power, security, reliability*

Automotive Telematics Demonstrator



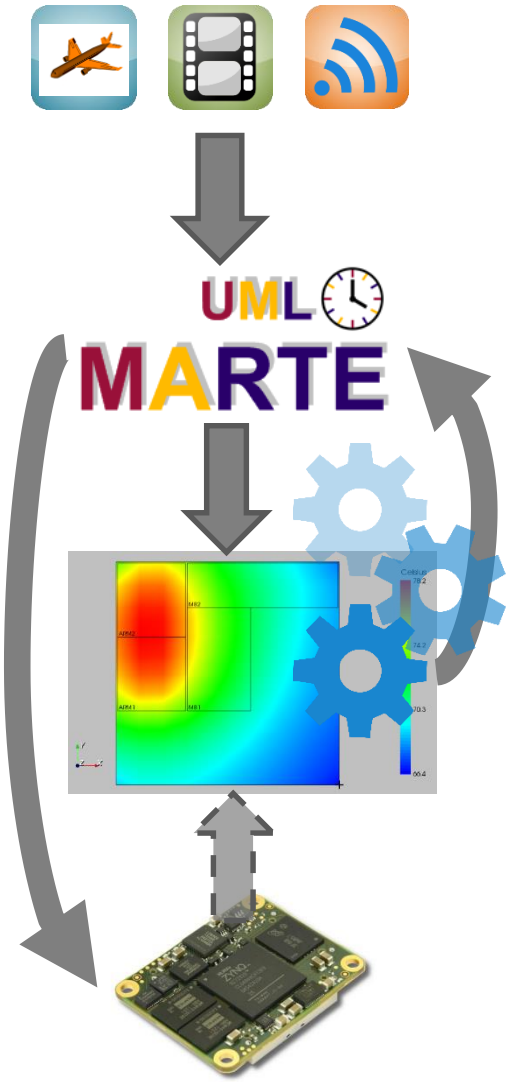
Runtime Resource Management with EFP

- Operating condition profiles derived at design-time
- Decision based on three types of information
  - Functional status
    - Operating mode (e.g. car motion status, key on/off, …)
  - Extra-functional status
    - Metrics exposed by extra-functiona monitoring infrastructure
    - Power sensor, temperature sensor, battery status, …
  - Design-time configurations
    - Based on developer knowledge and simulation results
    - System characterisation framework for hardware and software
- Battery models for easy integration in EFP monitoring framework
  - Based on SystemC and SystemC AMS



Summary and Conclusion

- Tools for power and temperature specification, analysis and management in combined multi-core real-time and high-performance embedded systems
  - UML/MARTE modelling and analysis framework for extra-functional properties
  - Power and temperature aware simulation / virtual platform
  - Run-Time resource manager
- Enables energy efficient and cost-effective design of highly integrated systems



Source: Trenz Electronics

Thank you very much for your attention!

Find more information at:

http://contrex.offis.de

Funded by the EC under
Grant Agreement 611146