MARTE extensions and modeling
Mixed-Criticalities

A synthesis of modeling needs of the Contrex Project and the solutions proposed using minor extensions to MARTE
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2 Contrex Modeling objectives

► A holistic approach for the specification, modelling, analysis and validation of mixed-critical distributed control systems

► Based on a meta-model for mixed-critical and distributed control systems, providing the required semantics support to the design methodologies used in Contrex

► Providing a comprehensive framework to manage extra-functional properties at node level in a mixed-critical scenario
  ► time, power/energy, performance, temperature, reliability and QoS
3 Preliminaries

A language:
- vocabulary, grammar, syntax, & cultural heritage + spellers, word processors.

Modeling language
- Ontology/Meta-models, a modeling methodology, tools and modeling patterns
4 Goals for the meta-model

- A UML Meta-Model able to capture all the relevant concepts for Contrex, taken from:
  - Architectures
  - Components
  - Networks
  - Functional and extra-functional properties and constraints
  - Models of computation
  - Validation

- Relevant Contrex system characteristics
  - Heterogeneity
  - Distributed
  - Control systems
  - Mixed-criticality
5 Requirements

- To cover all the **essential** concepts
- Organized to be generic in the essential concepts and extended/extensible to the specific domains in CONTREX
- To facilitate links/mappings to all relevant formalisms and design flows of interest in CONTREX
- To handle different levels of abstraction
- To be capable of addressing all the relevant stages in the development processes used by our industrial partners
6 Our approach

► Starting point: UML+MARTE Profile
  ► Covering real-time, embedded systems, DSE

► What is already covered
  ► RT: schedulability, performance, nfp, clocks, timing.

► Relevant concerns for Contrex
  ► Architectures
  ► Components
  ► Models of computation
  ► Functional and extra-functional properties and constraints
    ► Of those are relevant: Timing, Energy, Memory

► Relevant for Contrex system characteristics
  ► Hierarchical scheduling
  ► Control systems oriented (Hw & Sw)
7 UML/MARTE Domain view

- MARTE Profile (normative)
- NFP subprofile
- GRM subprofile
- GQAM subprofile

- MARTE meta-model (non-normative)
- NFP domain
- GRM domain
- GQAM domain

MARTE standard
8 Required extensions
9  Required extensions to MARTE

- Specific modeling elements for mixed criticality, and general purpose distribution technologies and networks
  - MC - Annotation of multiple non-functional properties for mixed-criticality systems
  - NW - Expressing complex overhead models and topologies of general purpose Networks
Hierarchical scheduling in MARTE
The extensions to the normative library of MARTE implies in practice tooling support for the mechanism to manage the annotation of values in VSL expressions.

A deep review of safety standards have been made to support this activity (IEC 61508, IEC 26262, DO-178, IMA –[RTCA DO-297]).

```
«dataType»
«nfpType»
{exprAttrib= expr}
NFP_CommonType

expr: VSL_Expression
source: SourceKind
statQ: StatisticalQualifierKind
dir: DirectionKind
mode: string [*]
criticality: Integer [*]
```

```
NFP_Constraint

kind: ConstraintKind [0..1]
criticality: Integer [*]
```
NW – Topological extensions

- Network Interface
- Abstract Channel
Communication Requirements

Communicating Task

Data Flow

CommunicationStep

msgSize: NFP_DataSize

CommunicationRequirements

maxErrorRate: NFP_Percentage
maxThroughput: NFP_Frequency
maxDelay: NFP_Duration

RtUint

isDynamic: Boolean
isMain: Boolean
memorySize: NFP_DataSize
srcPoolPolicy: PoolMgtPolicy
srcPoolWaitingTime: NFP_Duration

CommunicationChannel

msgSize: NFP_DataSize
utilization: NFP_Real

DataFlow

communicationRequirements: CommunicationRequirements [*]
taskSource: Task [*]
taskDestination: Task [*]

CommunicatingTask

requiresMobility: Boolean
isPeriodic: Boolean
14 Methodological aspects

► As a validation of the conceptual proposals an initial profile has been produced as an extension of the MARTE profile.

► Contract based design
  ► The foundational concepts for a library of NFP constraints has been developed

► Modelling configurations: the “mode” attribute
  ► Stages in the development process: Refinement and abstraction
  ► Perspectives viewpoints and views
  ► Management of V&V for specific extra-functional properties

► Links to other formalisms
  ► Synchronous Data Flow has been studied and initial models for the exploitation of MARTE have been proposed
References

► F. Herrera, P. Peñil, E. Villar
"UML/MARTE Modelling for Design Space Exploration of Mixed-Criticality Systems on top of Time-Predictable HW/SW Platforms“. Jornadas de Computación Empotrada (JCE15). 2015-09

► F.Herrera, P. Peñil, E. Villar


► Fernando Herrera, Pablo Peñil, Eugenio Villar
"A model-based, single-source approach to design-space exploration and synthesis of mixed-criticality systems“. 18th International Workshop on Software and Compilers for Embedded Systems, SCoPES 2015, ACM. 2015-06


► CONTREX website: https://contrex.offis.de/home/