Timing Constraints in EAST-ADL and MARTE

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Introduction

Real-Time Embedded Systems (RTESs) are soft or hard, based on how strict their timing constraints are. Safety-critical RTESs are systems whose failure would lead to the loss of human lives or environmental disaster.

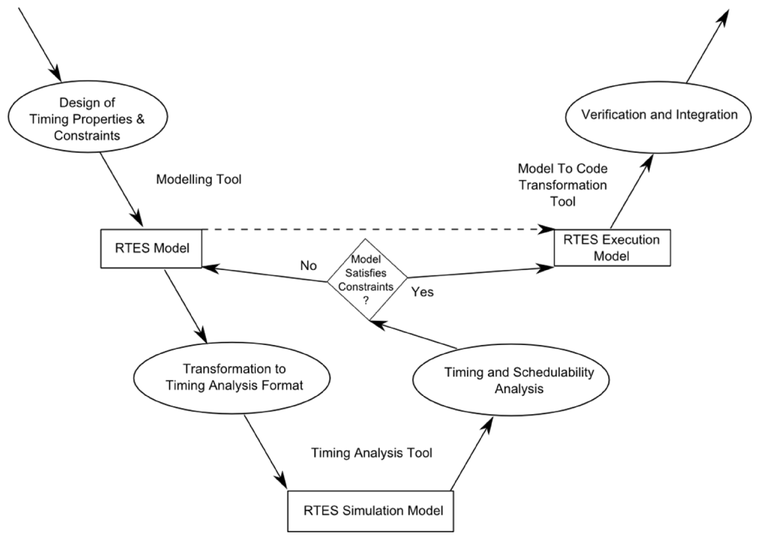

Figure 1. Model-based development

Performance and timing analysis, the key features of RTES development, can be done in the early development stages using model-based engineering (Figure 1).

Objectives

1) Review of state-of-the-art modelling languages for RTESs (Table 1).

	Timing in	First release	Latest release	Developed by	Inspired by
UML	SimpleTime	UML 1.0 (1997)	UML 2.4.1 (2011)	OMG	Booch, OMT/OOD[1]
SPT	Time Domain Model	SPT 1.0 (2003)	SPT 1.1 (2005)	OMG	UML
MARTE	Time Package	MARTE 1.0 (2009)	MARTE 1.1 (2011)	OMG	SPT
SysML	-	SysML 1.0a (2005)	SysML v1.3 (2012)	INCOSE, OMG	UML
AADL	Timing Properties	AADL v1.0 (2004)	AADL v2.1 (2012)	SAE	MetaH
AUTOSAR	Timing Extensions	AUTOSAR (2003)	AUTOSAR 4.1 (2013)	AUTOSAR Partnership	-
EAST-ADL	TADL Concepts	EAST-ADL1.0 (2004)	EAST-ADL 2.1 (2010)	FP7 EAST-EEA	AUTOSAR

[1] UML originated from the Booch method, Object-Modeling Technique (OMT), and Object-Oriented Design (OOD)

Table 1. Summary of the modelling languages that have been reviewed

2) Case study: Analysis of TIMMO-2-USE's validator of a Brake-By-Wire (BBW) system in a vehicle modelled in EAST-ADL.

EAST-ADL is a high level abstraction of AUTOSAR. Its introduces 4 abstraction levels:

Vehicle Level: Technical Feature Model
Analysis Level: Functional Analysis Architecture
Design Level: Functional and Hardware Design Architecture
Implementation Level: AUTOSAR compliant code

The BBW model by TIMMO-2-USE includes multiform timing constraints: *The vehicle shall start to brake within 5 meters after the brake pedal is pressed.*

3) Design of a model of a BBW system in MARTE

MARTE is a UML profile for RTESs. We used custom Clocks, the TimedConstraint stereotype and non-functional properties from MARTE, Requirements from SysML, and OCL (Figure 2).

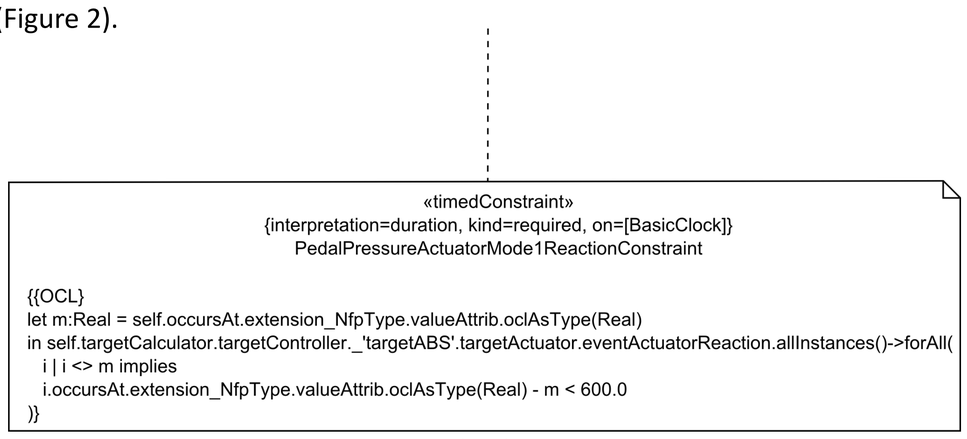

Figure 2. A MARTE class diagram constraint

Conclusions

Timing constraints can be specified using different mechanisms in all of the state-of-the-art modelling languages for RTESs.

TIMMO-2-USE's BBW system modelled in EAST-ADL shows how EAST-ADL (and TADL) can be used in a model-based development of an RTES. A large number of tools can be used for modelling, implementation, and timing analysis but it is difficult to use a single tool-chain.

Our BBW model shows how MARTE (using elements from SysML and OCL) can be used in a model-based development of an RTES from the automotive industry.

Table 2. shows a comparison of the different timing constraints in EAST-ADL and MARTE. Although MARTE has shortcomings compared to EAST-ADL, the possibility of using the tools:

- *Acceleo* for code-generation
- *Cheddar* for timing analysis

directly on a MARTE model promise a simple single tool-chain approach to modelling, implementation and timing analysis.

EAST-ADL Timing Constraint (value)	MARTE Timing Constraint (value)
Reaction (upper)	TimedConstraint («nfp» class property:TimeUnit)
Execution (upper)	TimedConstraint (class property:Real)
Periodic (period)	TimedConstraint (class property:Real)
InputSynchronization (upper)	TimedConstraint («nfp» class property:TimeUnit)
OutputSynchronization (upper)	TimedConstraint («nfp» class property:TimeUnit)

Table 2. Comparison of EAST-ADL and MARTE timing constraints

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