GLIWA
embedded systems

OT1 – An open timing information exchange format

Contents

- Introduction
- Overview of features, concept
- Use cases and Implementation
- Examples

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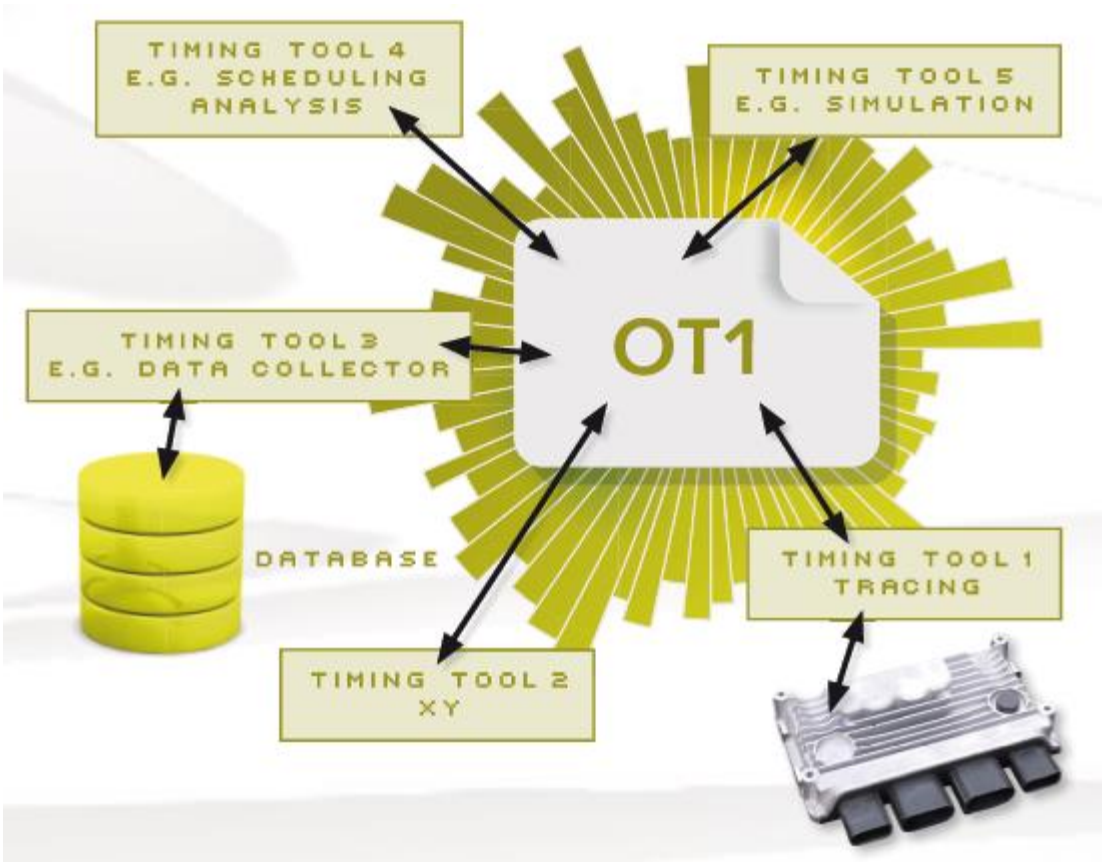
OT1 - The Timing Cloud

Goal: a unified data exchange format which is used by all kinds of timing/tracing related tools



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OT1 - Key features

- **Data exchange format for**
  - System configuration (tasks, priorities, runnables, etc. or buses, messages, etc.)
  - Traces (log of e.g. scheduling related events)
  - Timing information (core execution time, response times, etc.), also referred to as “timing guarantees”
  - Timing requirements (e.g. max. allowed response times)
- **Any tool can provide/retrieve information**
- **XML based**
- **Open format**
  - free of charge
  - As originally planned, some of the OT1 ideas have been integrated into AUTOSAR, namely into ARTI, the **A**UTOSAR **R**un-**T**ime **I**nterface.
  - Other OT1 concepts will probably become part of ASAM in 2019 (this is the status as of November 2018).
- **Proven** (used for years in several automotive projects)

OT1 – Documents overview

The following documents/files are available in SVN (only most important listed)

File	Description
OT1.xsd	Format definition (XML schema)
*.xml	Examples
OT1.xsd.html	Schema documentation (automatically generated)
OT1.uml	UML class diagram and use-cases for StarUML (see staruml.sourceforge.net for free download)
OT1.jpg	StarUML screen-shot of class diagram
OT1 Introduction.ppt	This presentation

OT1 - License

“This specification is intended to define a data exchange format for timing and tracing related information.

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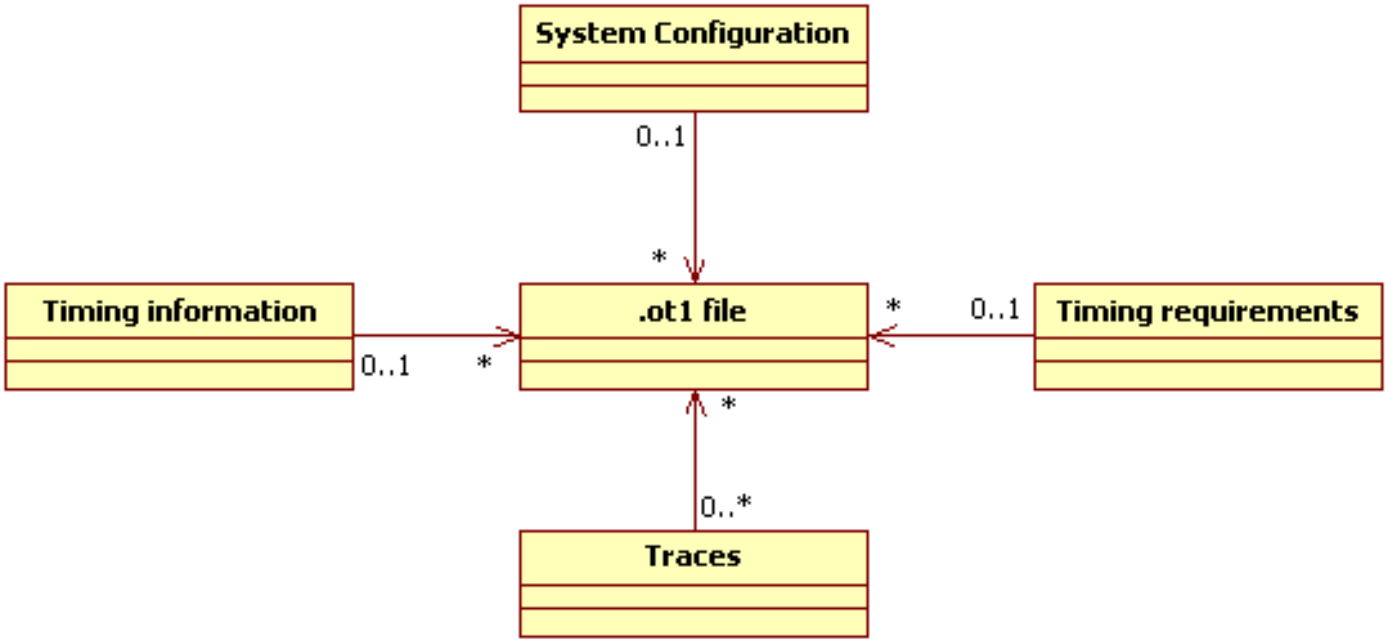
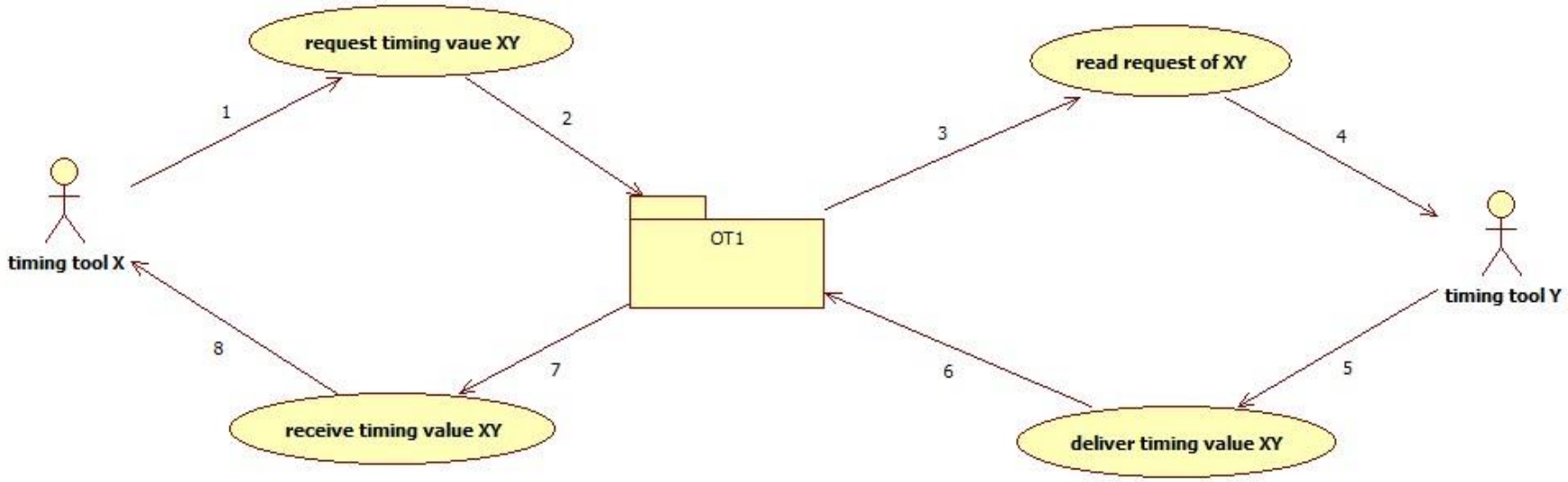
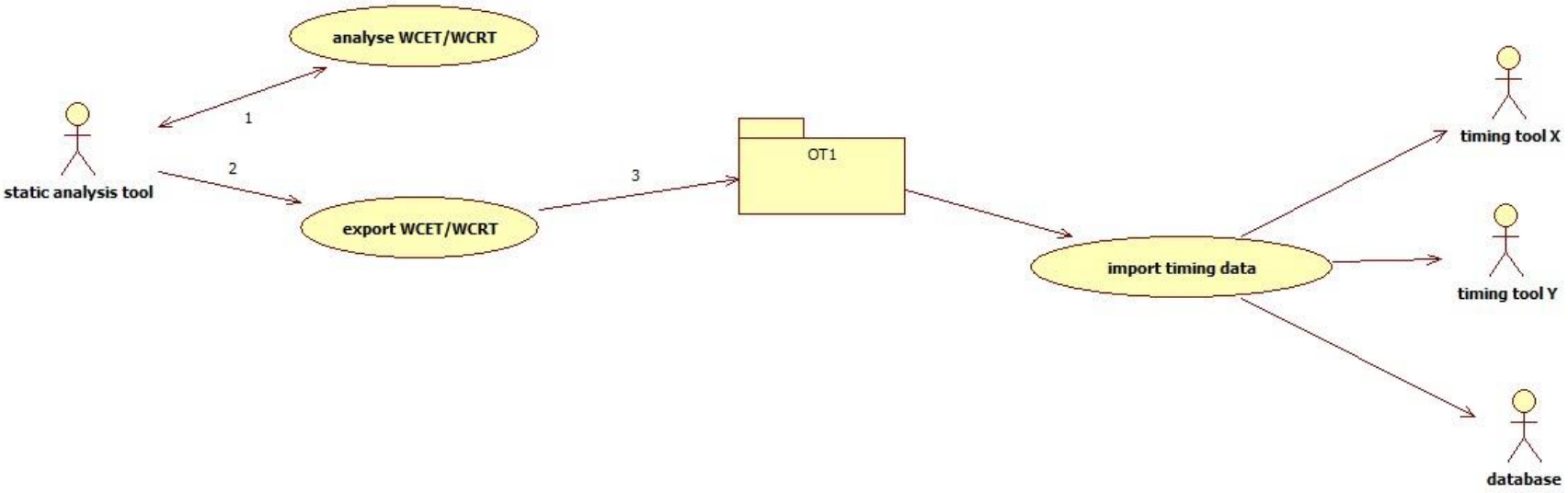
4 possible contents of an .ot1 file



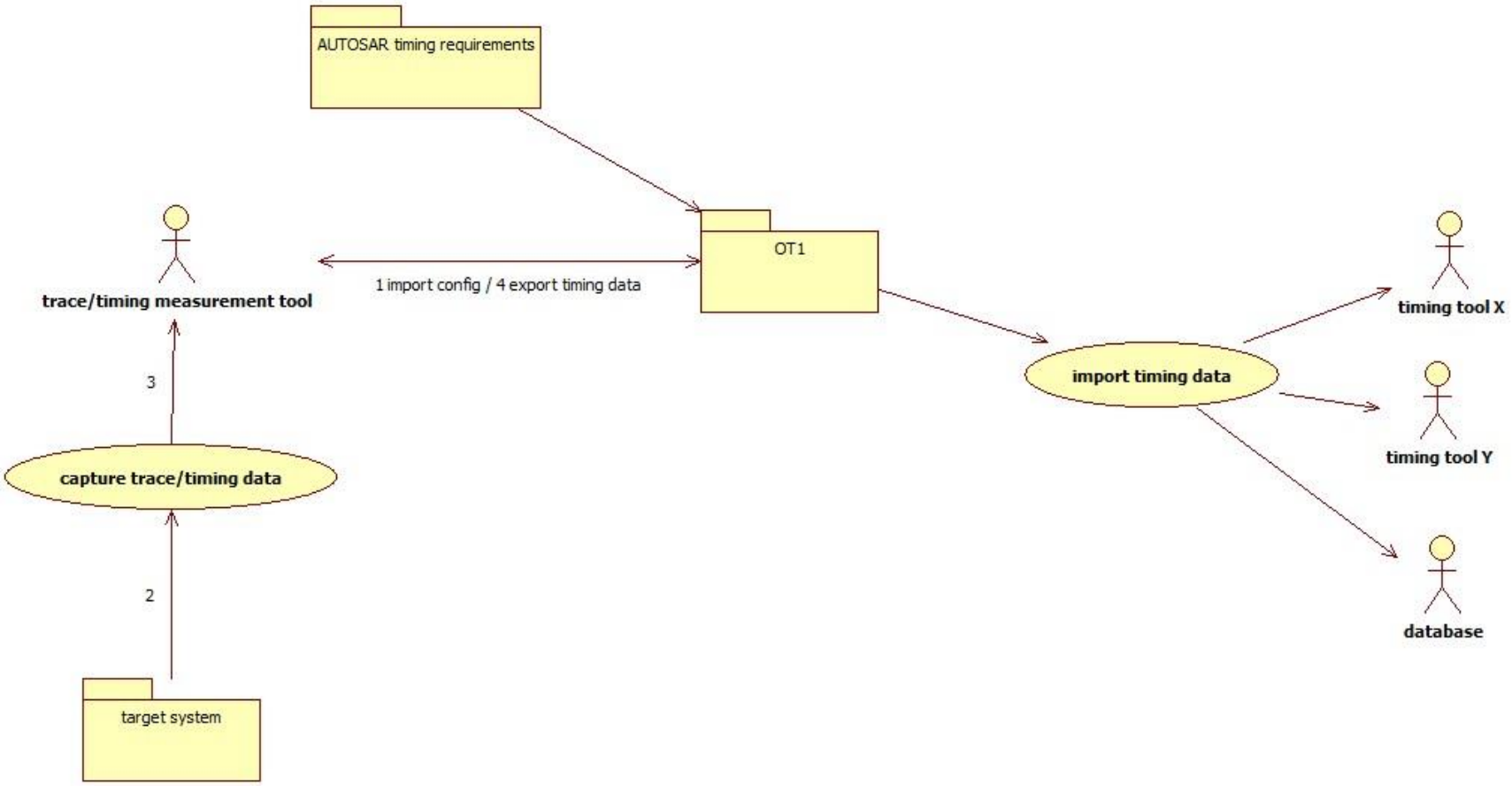
Use case „request – response“



Use case „static analysis“



Use case „tracing“

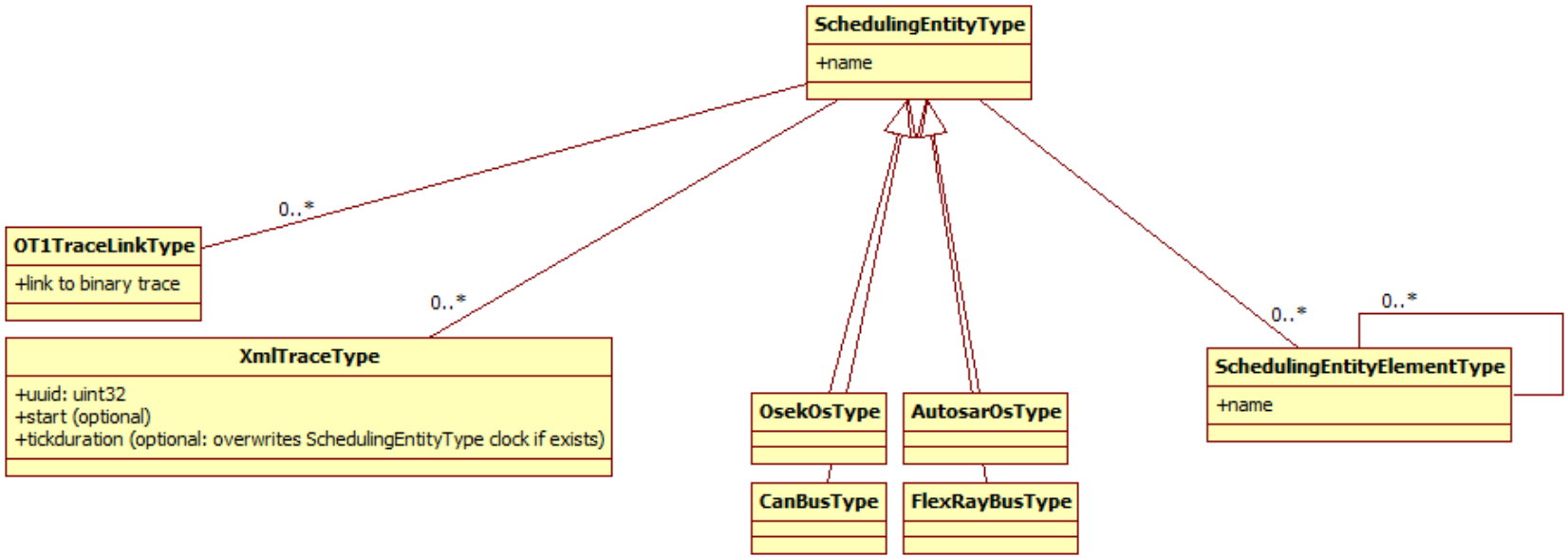


Further use cases

Many more use cases are supported (previous examples form an incomplete list only)

Scheduling Entity

- A Scheduling Entity
  - Is unique
  - Can be of type AutosarOsType, OsekOsType, CanBusType, FlexRayBusType...
  - Acts as a Base Element for all Child-Elements (Tasks, Interrupts ...) and Traces



Scheduling Entity Element

- 3 kinds of Element types that describe the system
  - Application Elements
  - Communication Elements
  - Virtual Elements
- Application Elements are executing Code, e.g.
  - Tasks, Interrupts, Runnables...
- Communication Elements are transporting Data
  - Frames, PDUs...
- Virtual Elements are
  - Simple Time-Stamp-Elements/User-Events
  - Event-Chains, needed for the AUTOSAR Timing Constraints

Scheduling Entity Element

- Each Element may have an number of
  - Timing Values/Information
  - Timing Constraints (including AUTOSAR Timing Constraints)
- Each Element can have Child-Elements (System-Tree-View)

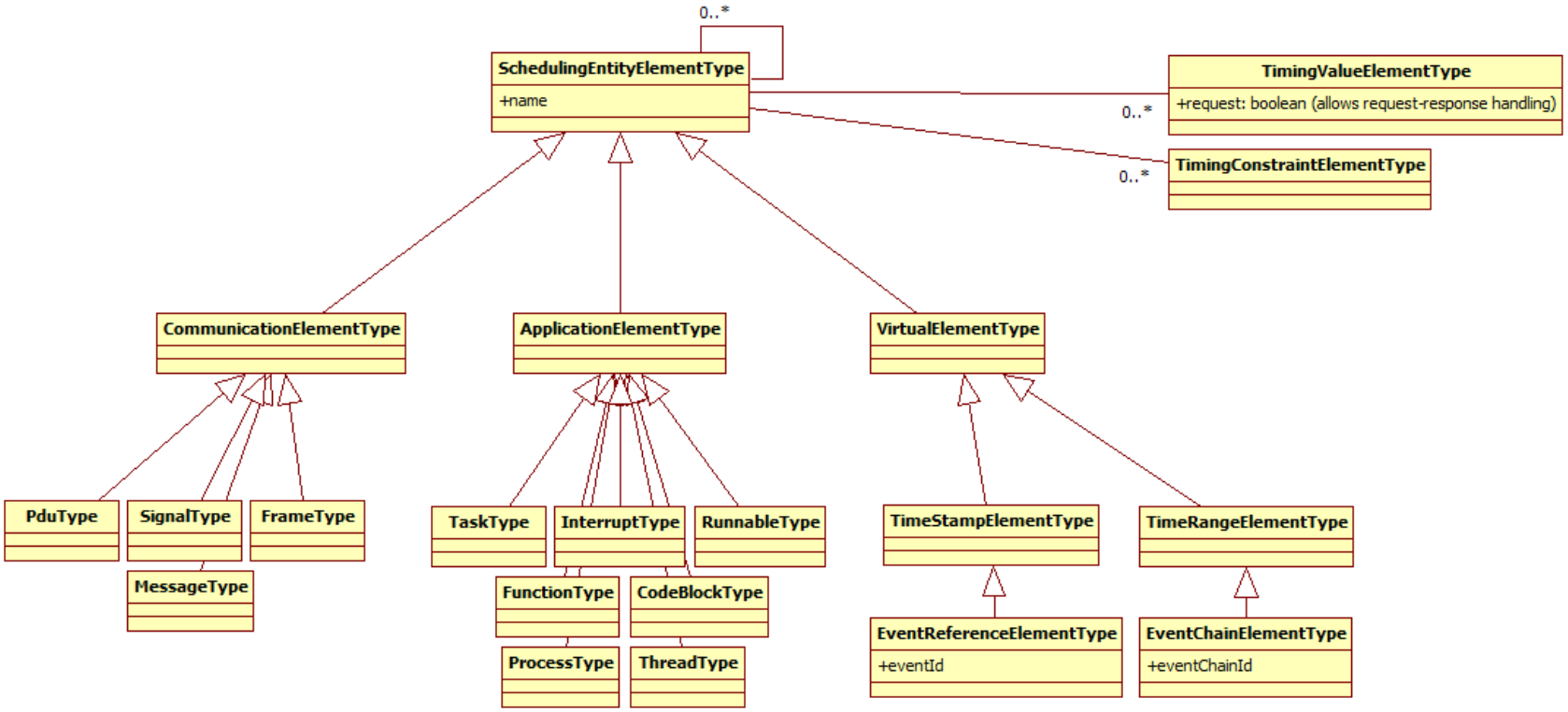
→Task

→Runnable

→ Function

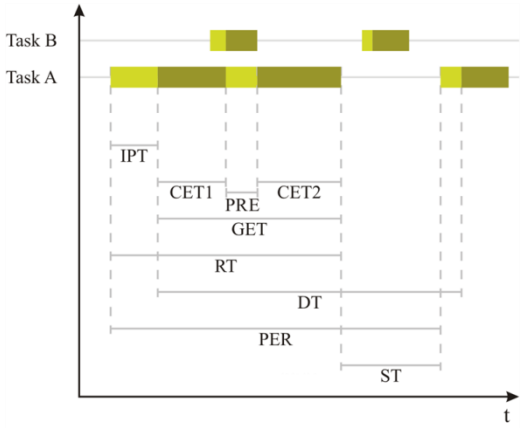
→ Code Block

Scheduling Entity Element



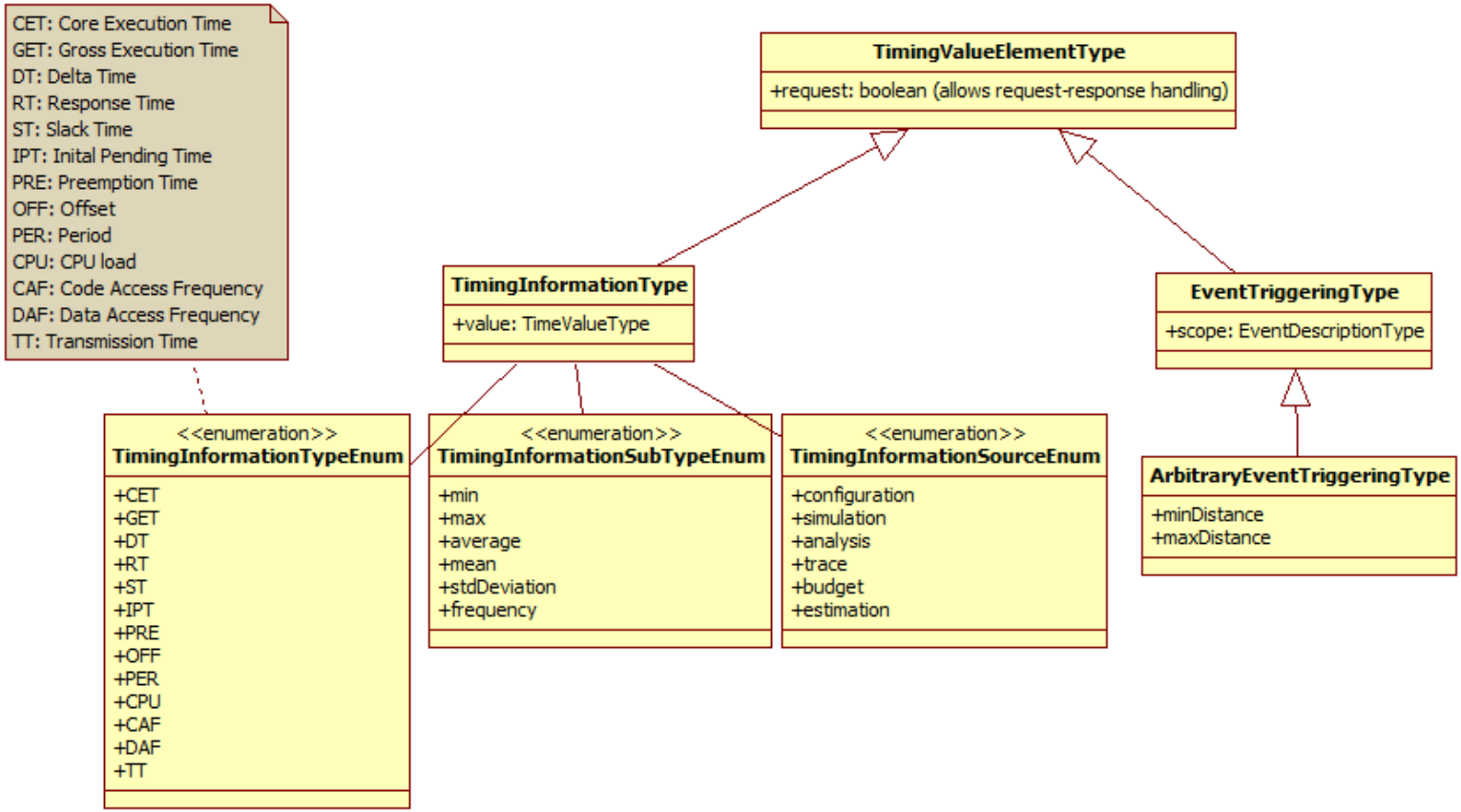
Timing Values/Information

- All important Timing values can be stored in ***OT1***
  - CET, GET, RT ...



- Also Arbitrary Triggering can be stored to provide an occurrence model for non periodical tasks/interrupts
  - Min occurrences of n instances
  - Max occurrences of n instances

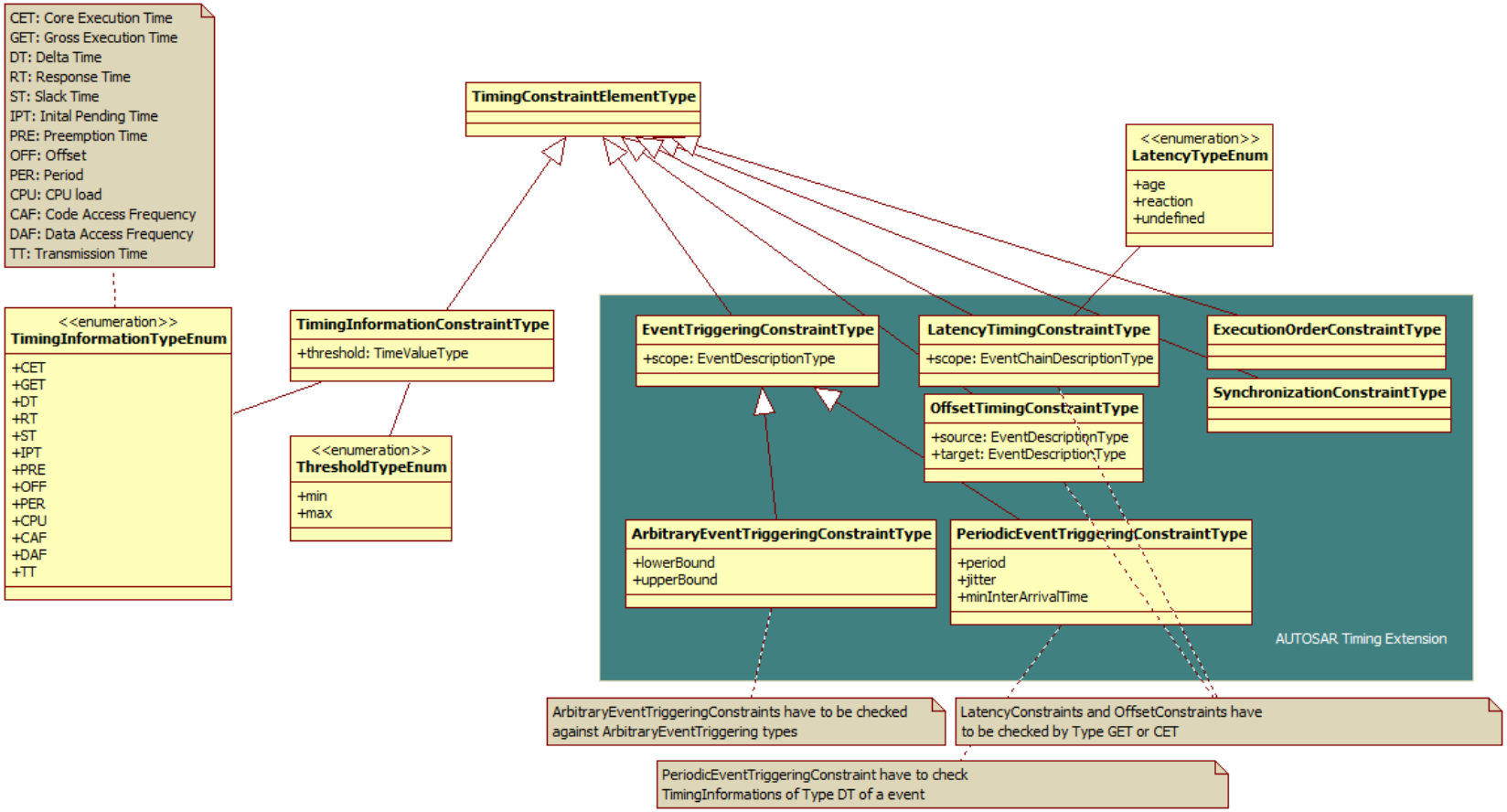
Timing Values/Information



Timing Constraints

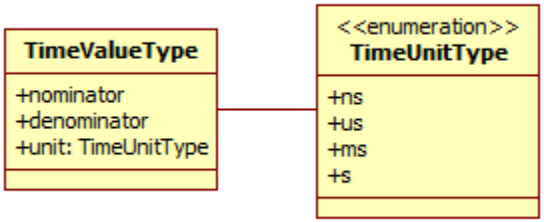
- All important Timing values can be constrained in ***OT1***
  - Min and max threshold for all Timing Information
- ***OT1*** support the AUTOSAR Timing Constraints, defined in the AUTOSAR Timing Extension of release 4.0

Timing Constraints



Time Values

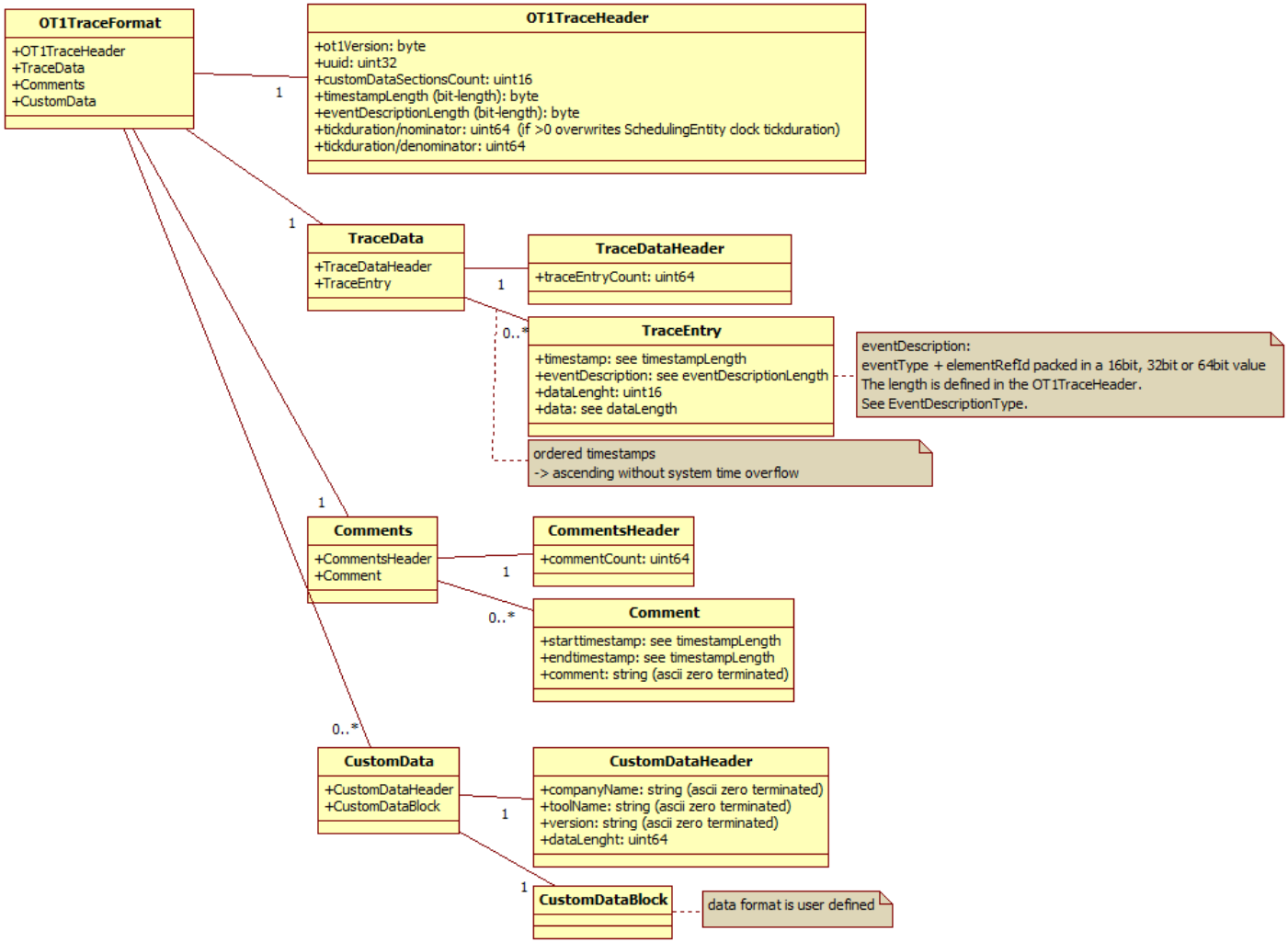
- All time values have the same format
  - Nominator
  - Denominator
  - Unit



OT1-Trace-Format

- The ***OT1***-Trace-Format is a binary format to unify trace data
- The format contains
  - OT1TraceHeader
  - TraceData
    - Trace Data Header followed by Trace Entries (Events)
  - Comments
    - 3 kinds of comments (time stamp comments, time range comments and trace comments)
  - CustomData
    - Each user/company/tool is able to extend the trace with custom binary data

OT1-Trace-Format



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Examples

Simple AUTOSAR OS (2 Tasks/1 Interrupt)

```
<?xml version="1.0" encoding="utf-8"?>
<OT1 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="..\OT1.xsd" version="0.1">
  <SchedulingEntity xsi:type="AutosarOsType" name="AutosarSystem" uuid="4028503229">
    <Clock tickduration="1000" maxAbsTime="65535" />
    <EventDescriptionContainer vendor="string" tool="string" version="string">
      <Event elementRefId="1" eventType="start" value="1" id="10" />
      <Event elementRefId="1" eventType="stop" value="2" id="11" />
      <Event elementRefId="2" eventType="activation" value="3" id="12" />
      <Event elementRefId="2" eventType="start" value="4" id="13" />
      <Event elementRefId="2" eventType="stop" value="5" id="14" />
      <Event elementRefId="3" eventType="activation" value="6" id="15" />
      <Event elementRefId="3" eventType="start" value="7" id="16" />
      <Event elementRefId="3" eventType="stop" value="8"  id="17" />
      <Event elementRefId="100" eventType="user" value="1000" description="this is user event 1" id="101" />
    </EventDescriptionContainer>
    <Element xsi:type="InterruptType" name="Interrupt1" id="1" type="category_2" priority="255" />
    <Element xsi:type="TaskType" name="Task1" id="2" type="preemptive" priority="20" />
    <Element xsi:type="TaskType" name="Task2" id="3" type="nonPreemptive" priority="20" />
    <Element xsi:type="TimeStampElementType" name="UserEvent1" id="100" />
    <Traces>
      <OT1TraceLink vendor="Company XYZ" tool="Tool XYZ">
        <link>..\Traces\OT1trace.ot1</link>
      </OT1TraceLink>
    </Traces>
  </SchedulingEntity>
</OT1>
```

Scheduling Entity

Elements

Link to a binary OT1-Trace

Examples

A Task with Timing Values and Timing Constraints

Timing Values

Timing Constraint

```
<Element xsi:type="TaskType" name="Task1" id="2" type="preemptive" priority="20">
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="max" source="trace">
    <Value nominator="100" denominator="1" unit="us" />
  </TimingValue>
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="min" source="trace">
    <Value nominator="75" denominator="1" unit="us" />
  </TimingValue>
  <TimingConstraint xsi:type="TimingInformationConstraintType" timingValueType="CET" thresholdType="max">
    <Threshold nominator="95" denominator="1" unit="us" />
  </TimingConstraint>
</Element>
```

Examples

A Task with Runnables

Runnables

```
<Element xsi:type="TaskType" name="Task1" id="2" type="preemptive" priority="20">
  <Element xsi:type="RunnableType" name="Runnable1" id="201" />
  <Element xsi:type="RunnableType" name="Runnable2" id="202" />
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="max" source="trace">
    <Value nominator="100" denominator="1" unit="us" />
  </TimingValue>
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="min" source="trace">
    <Value nominator="75" denominator="1" unit="us" />
  </TimingValue>
  <TimingConstraint xsi:type="TimingInformationConstraintType" timingValueType="CET" thresholdType="max">
    <Threshold nominator="95" denominator="1" unit="us" />
  </TimingConstraint>
</Element>
```

Examples

A Task with an AUTOSAR Offset Constraint

```
<Event elementRefId="201" eventType="start" value="101" id="18" />
<Event elementRefId="201" eventType="stop" value="102"  id="19" />
<Event elementRefId="202" eventType="start" value="103" id="20" />
```

Start of „Runnable1“

Start of „Runnable2“

```
...
<Element xsi:type="TaskType" name="Task1" id="2" type="preemptive" priority="20">
  <Element xsi:type="RunnableType" name="Runnable1" id="201" />
  <Element xsi:type="RunnableType" name="Runnable2" id="202" />
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="max" source="trace">
    <Value nominator="100" denominator="1" unit="us" />
  </TimingValue>
  <TimingValue xsi:type="TimingInformationElementType" type="CET" subType="min" source="trace">
    <Value nominator="75" denominator="1" unit="us" />
  </TimingValue>
  <TimingConstraint xsi:type="TimingInformationConstraintType" timingValueType="CET" thresholdType="max">
    <Threshold nominator="95" denominator="1" unit="us" />
  </TimingConstraint>
  <TimingConstraint xsi:type="OffsetTimingConstraintType" sourceEventId="18" targetEventId="20">
    <Minimum nominator="20" denominator="1" unit="us" />
    <Maximum nominator="60" denominator="1" unit="us" />
  </TimingConstraint>
</Element>
```

Offset Constraint

min, max threshold