Kap. 7: Entwicklung von Anwendungen (b) Modellierung

7. Entwicklung von Anwendungen

Konzentration auf

- Sicherheitskritische Anwendungen
- Echtzeitanwendungen

Gliederung

(a)

1. Einführung
2. IEC EN 61508
3. Programmiersprachen (MISRA C/C++, Ada)

(b)

4. Modellierung (SysML, UML MARTE, …)

(c)

5. Validierung
6. Systematisches Testen

7.4 Modellierung

Gliederung

7.4.1 Einführung

7.4.2 SysML

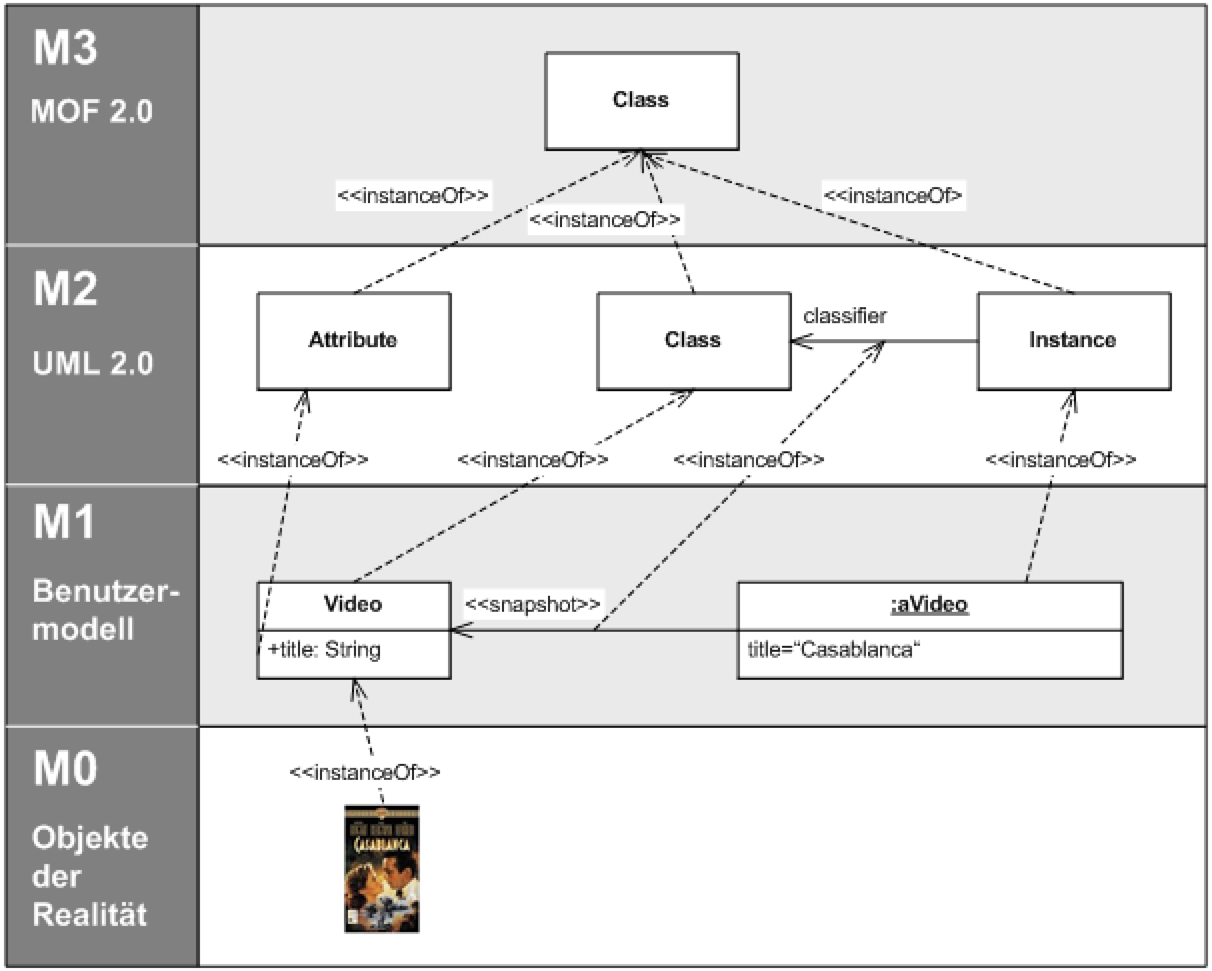
7.4.3 MARTE

7.4.1 Einführung

- OMG Object Management Group
- UML und ihre Verwandten - Standards zu Modellierung
  - Bisher primär UML (Unified Modeling Language) kennengelernt (vgl. LV Softwaretechnik)
  - Katalog: http://www.omg.org/technology/documents/ modeling_spec_catalog.htm#MOF
  - hier nur Ausschnitt
  - SysML (Systems Modeling Language, für komplexe Systeme)
  - MOF Meta Object Facility (extensible model driven integration framework, u.a. Modellierung von UML)
  - OCL Object Constraint Language (Festlegung von Prädikaten/Restriktionen für UML-Modelle und Metamodelle
  - XMI XML Metadata Interchange Specification
    OMG MOF 2 XMI Mapping Specification
    (MOF → XML Mapping, Exportieren/Importieren von Modellen aus/in Modellierungswerkzeugen)

MOF Meta Modeling

- MOF: OMG Meta Object Facility
- M3 hat sich selbst als Metamodell



http://upload.wikimedia.org/wikipedia/commons/9/93/M0-m3.png

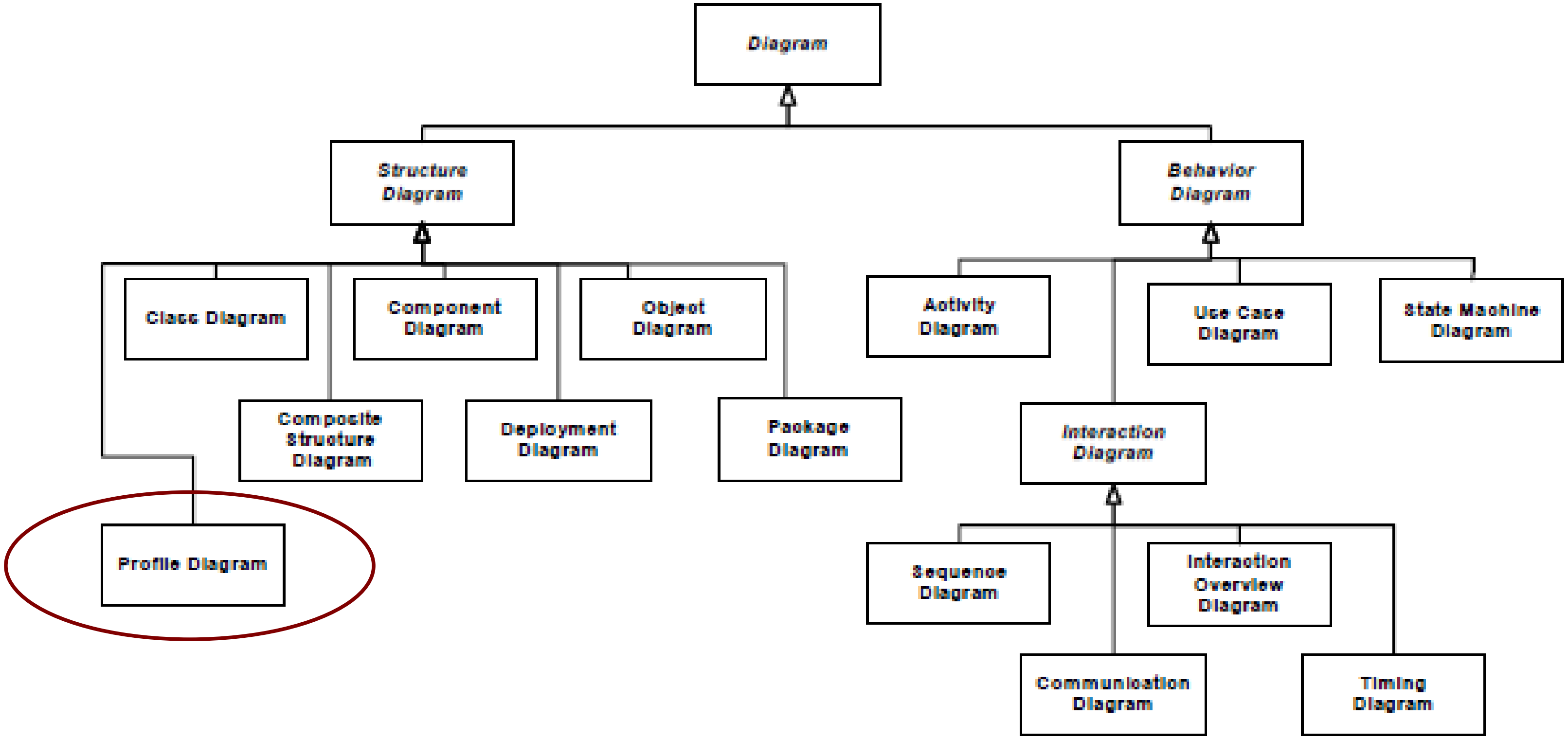
UML 2 Profil

- Erweiterung des UML 2 Metamodells durch einen leichtgewichtigen Erweiterungsmechanismus
- „A profile defines limited extensionsto a reference metamodel with the purpose of adapting the metamodel to a specific platform or domain“ (OMG 10-05-05)
- UML Metamodell bleibt unverändert
- Profile Diagram als neuer Diagrammtyp für die Anwendungvon Profilen
- Erweiterung basiert auf
  - Stereotypes mit Tagged Values
  - Constraints (Kommentare oder in formaler OMG Object Constraint Language (OCL))
- Analogie zu Einschränkungen auf Quellcode-Ebene wie z.B. in MISRA C

Stereotypes: Modification to original element semantics

UML Diagrammtypen

- **UML 2.3**



UML 2.3 OMG 10-05-05.pdf

UML Profil (Definition der OMG)

- **A UML profile is a specification that does one or more of the following:**
  - **Identifies a subset of the UML metamodel.**
  - **Specifies “well-formedness rules” beyond those specified by the identified subset of the UML metamodel.**
  - **“Well-formedness rule” is a term used in the normative UML metamodel specification to describe a set of constraints written in UML’s Object Constraint Language (OCL) that contributes to the definition of a metamodel element.**
  - **Specifies “standard elements” beyond those specified by the identified subset of the UML metamodel.**
  - **“Standard element” is a term used in the UML metamodel specification to describe a standard instance of a UML stereotype, tagged value or constraint.**
  - **Specifies semantics, expressed in natural language, beyond those specified by the identified subset of the UML metamodel.**
  - **Specifies common model elements, expressed in terms of the profile.**

Profile-Notationen

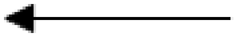


Figure 18.5 - The notation for an Extension

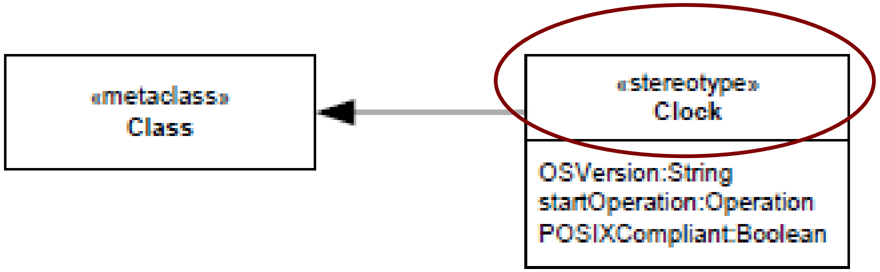


Figure 18.13 - Defining a stereotype

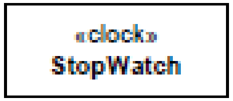


Figure 18.17 - Using a stereotype

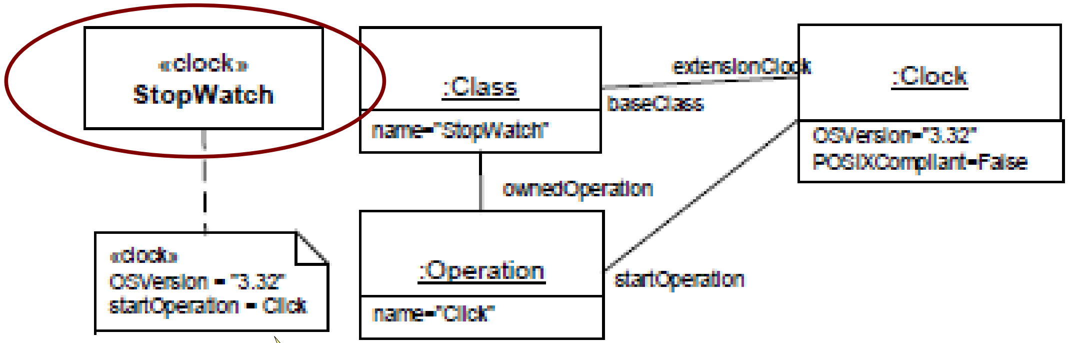
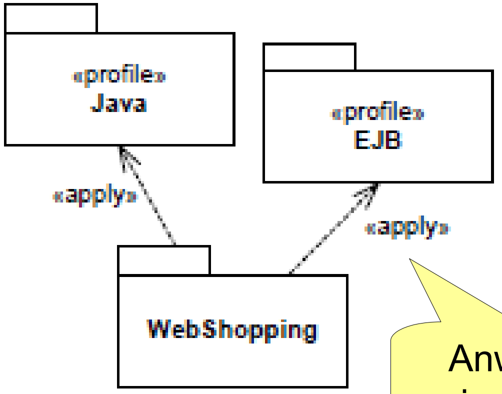


Figure 18.18 - Showing values of stereotypes and a simple instance specification

Constraints
als Kommentar



Anwenden
eines Profils

UML 2.3 OMG 10-05-05.pdf

Figure 18.12 - Profiles applied to a package

7.4.2 SysML

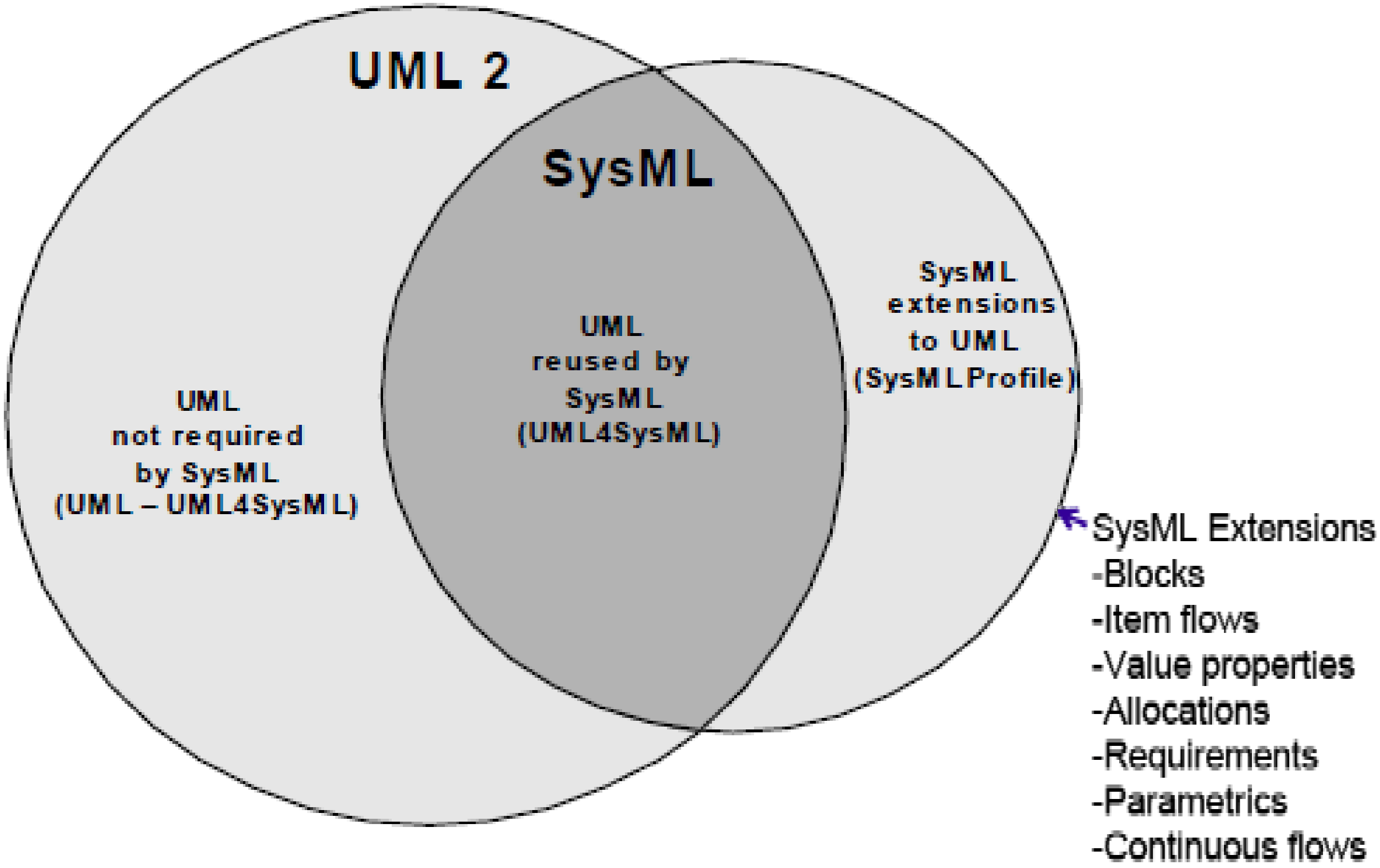
- **OMG SysML: Systems Modeling Language**
- **UML 2 Profil für Systems Engineering**
- **OMG Standard formal/2012-06-01 (Version 1.3 beta)**
- **The OMG Systems Modeling Language (OMG SysML™) is a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities. In particular, the language provides graphical representations with a semantic foundation for modeling system requirements, behavior, structure, and parametrics, which is used to integrate with other engineering analysis models. SysML represents a subset of UML 2.0 with extensions needed to satisfy the requirements of the UML™ for Systems Engineering RFP. SysML uses the OMG XML Metadata Interchange (XMI®) to exchange modeling data between tools.**
- **Erweiterung durch UML Stereotypes, UML Diagramm-Erweiterungen, Modell-Bibliotheken**
- **Engineering-Prozess: Von Dokumenten zu Modellen**

SysML Tools

- Basieren i.w. auf UMl-Modellierungswerkzeugen
- Kommerziell
  - Artisan (Studio)
  - EmbeddedPlus (SysML Toolkit)
  - No Magic (Magic Draw)
  - SparxSystems (Enterprise Architect)
  - IBM / Telelogic (Tau and Rhapsody)
- Open Source basierend auf Eclipse
  - TopCased
  - Papyrus

SysML ↔ UML 2 7.4.2

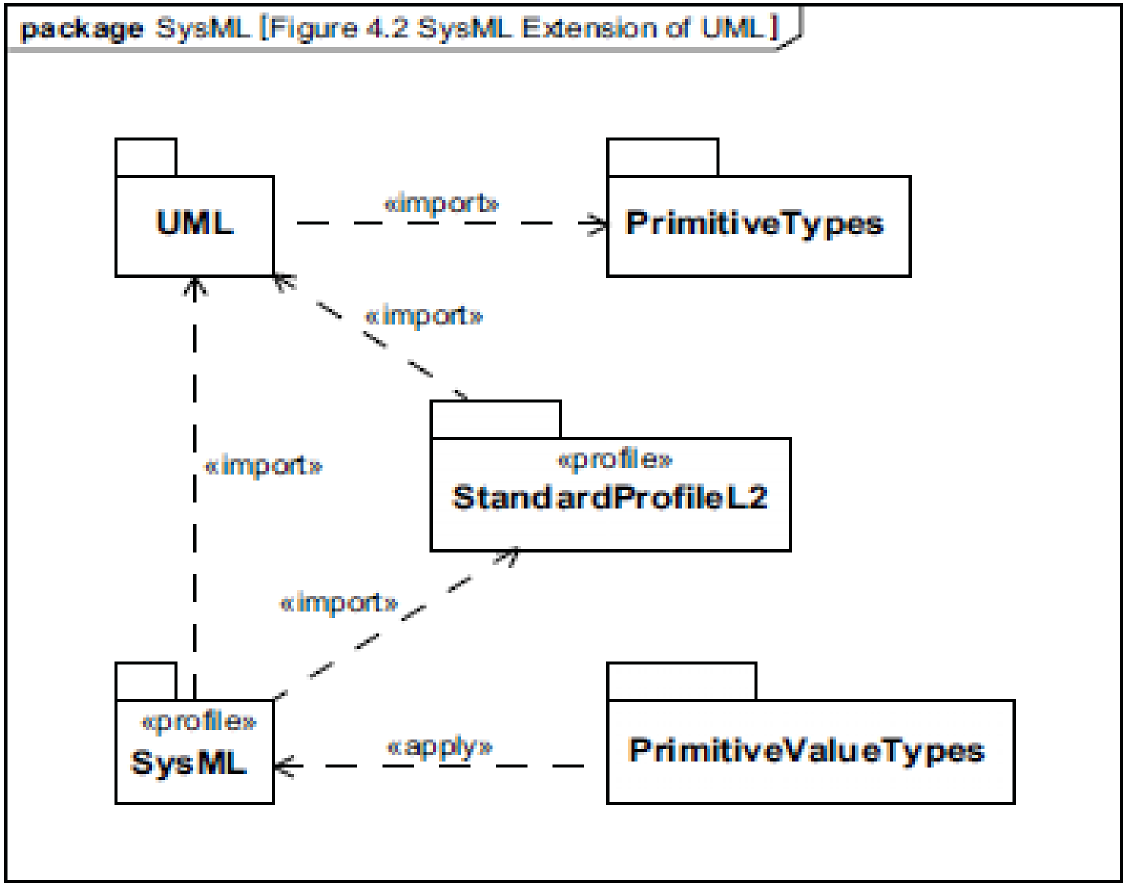
- Überblick zum Zusammenhang



SysML 1.3 OMG 12-06-01.pdf

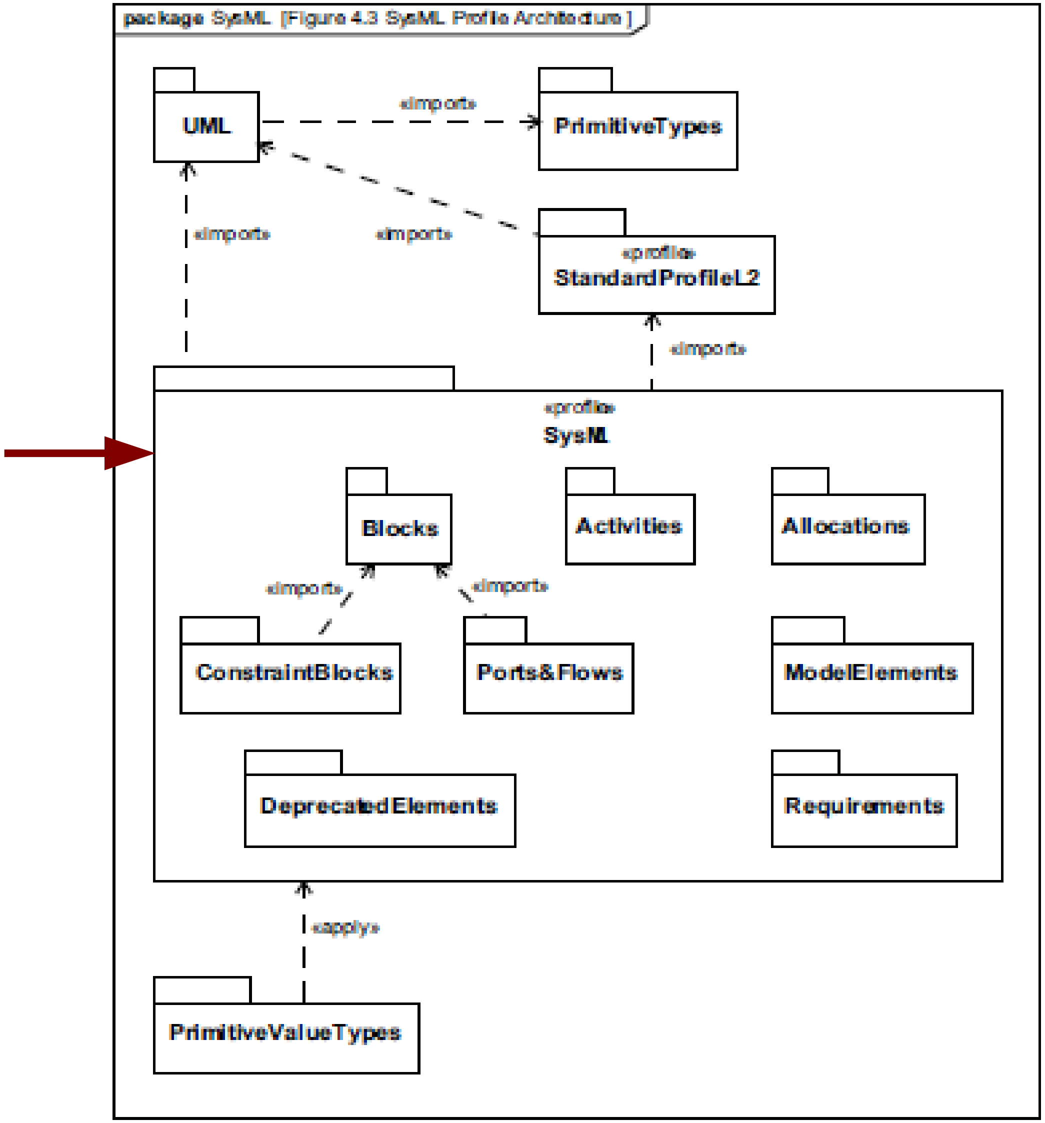
SysML ↔ UML 2

- Erweiterungen



SysML 1.3 OMG 12-06-01.pdf

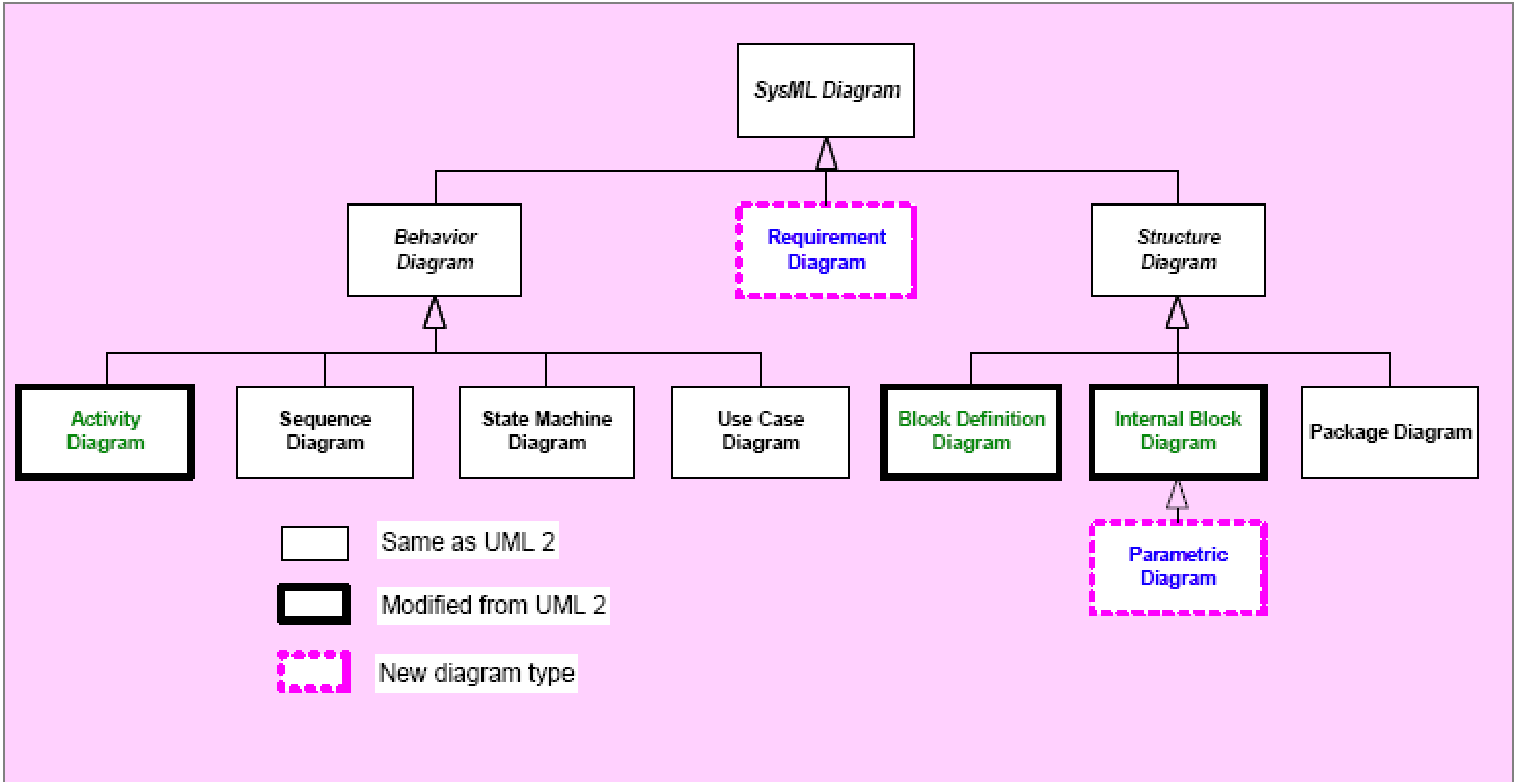
SysML Paketstruktur



SysML 1.3 OMG 12-06-01.pdf

SysML-Diagrammtypen

Überblick

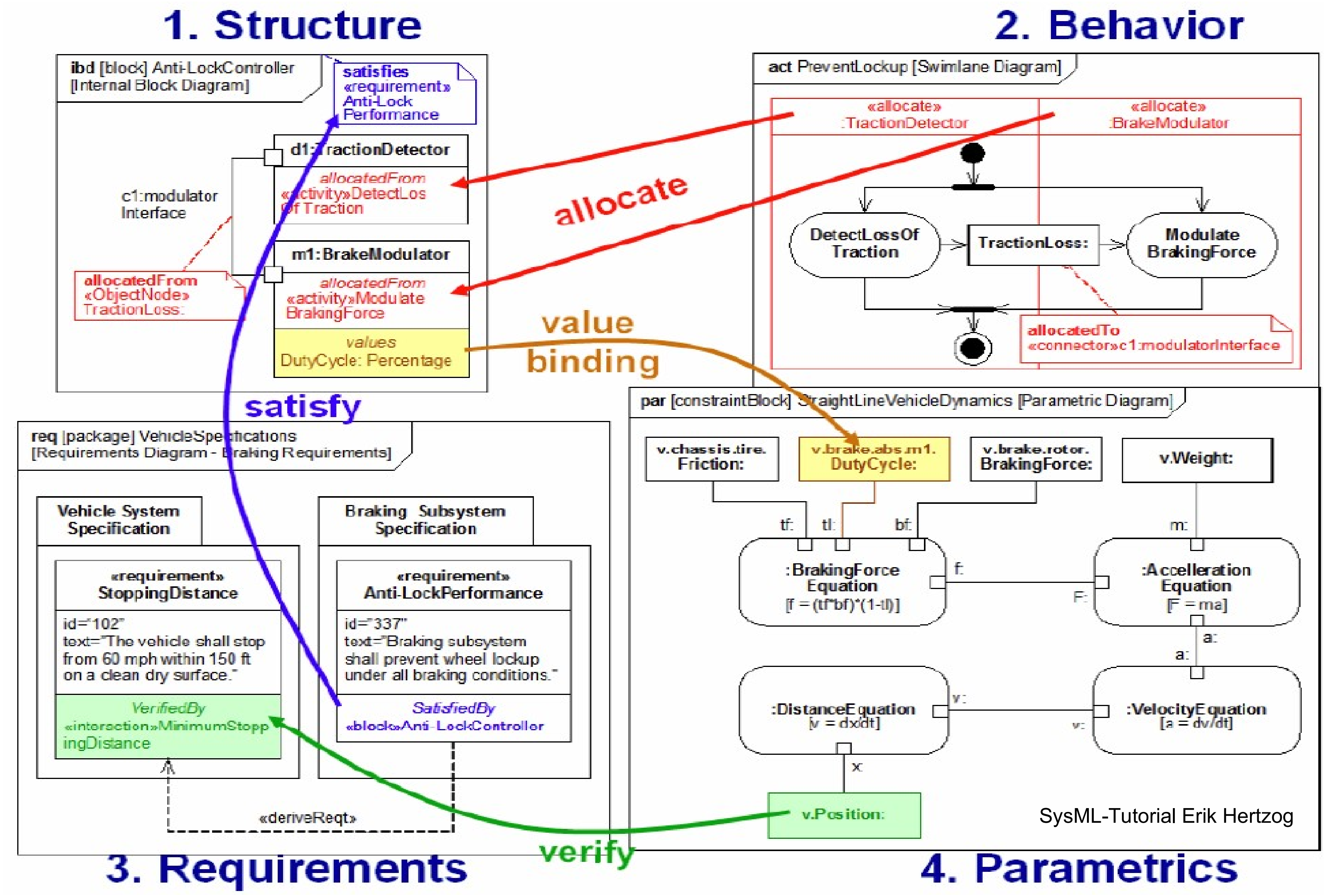


SysML-Tutorial Erik Hertzog

SysML-Erweiterungen

- **The SysML packages extend UML as follows:**
  - **SysML::Model Elements refactors and extends the UML kernel portion of UML classes.**
  - **SysML::Blocks reuses structured classes from composite structures.**
  - **SysML::ConstraintBlocks extends Blocks to support parametric modeling.**
  - **SysML::Ports and Flows extends UML ports, UML information flows, and SysML Blocks.**
  - **SysML::Activities extends UML activities.**
  - **SysML::Allocations extends UML dependencies.**
  - **SysML::Requirements extends UML classes and dependencies.**
  - **SysML::DeprecatedElements extends UML ports, UML interfaces, and SysML Item Flows.**

SysML-Säulen



1. Structure

2. Behavior

3. Requirements

4. Parametrics

ibd [block] Anti-LockController [Internal Block Diagram]
satisfies «requirement» Anti-Lock Performance
d1:TractionDetector
allocatedFrom «activity»DetectLossOfTraction
c1:modulator Interface
allocatedFrom «ObjectNode» TractionLoss:
m1:BrakeModulator
allocatedFrom «activity»Modulate BrakingForce
values DutyCycle: Percentage
allocate
value binding
satisfy
act PreventLockup [Swimlane Diagram]
«allocate» :TractionDetector
«allocate» :BrakeModulator
DetectLossOf Traction
TractionLoss:
Modulate BrakingForce
allocatedTo «connector»c1:modulatorInterface
req [package] VehicleSpecifications [Requirements Diagram - Braking Requirements]
Vehicle System Specification
«requirement» StoppingDistance
id="102"
text="The vehicle shall stop from 60 mph within 150 ft on a clean dry surface."
VerifiedBy «interaction»MinimumStoppingDistance
Braking Subsystem Specification
«requirement» Anti-LockPerformance
id="337"
text="Braking subsystem shall prevent wheel lockup under all braking conditions."
SatisfiedBy «block»Anti-LockController
«deriveReqt»
par [constraintBlock] StraightLineVehicleDynamics [Parametric Diagram]
v.chassis.tire. Friction:
v.brake.abs.m1. DutyCycle:
v.brake.rotor. BrakingForce:
v.Weight:
tf:
tl:
bf:
m:
:BrakingForce Equation [f = (tf*bf)*(1-tl)]
f:
F:
:Accelleration Equation [F = ma]
a:
a:
:DistanceEquation [v = dx/dt]
v:
v:
:VelocityEquation [a = dv/dt]
x:
v.Position:
verify
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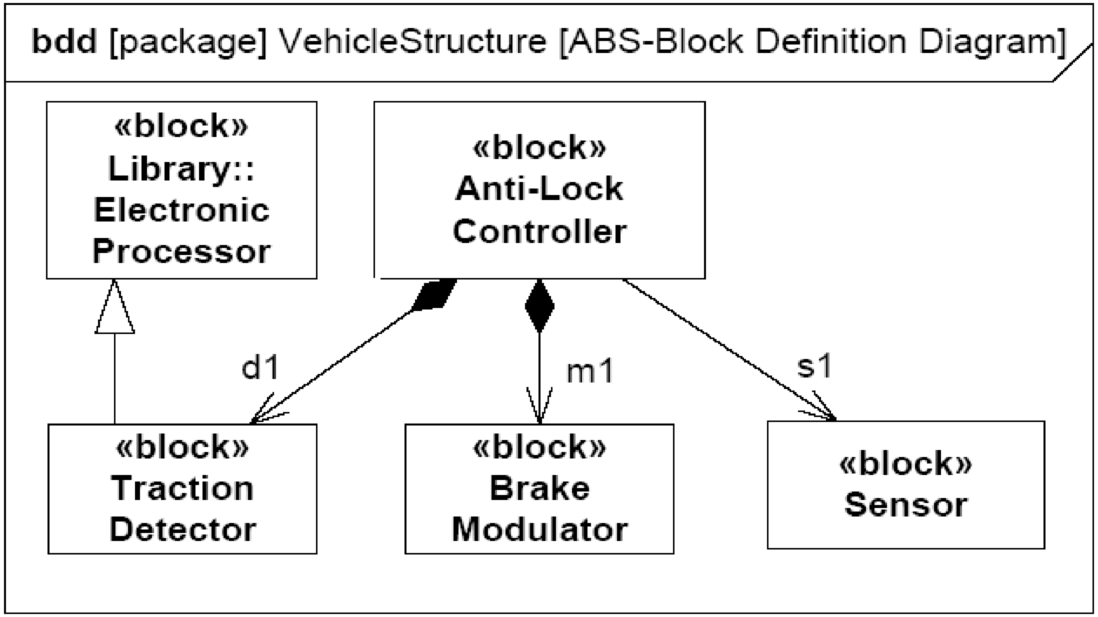
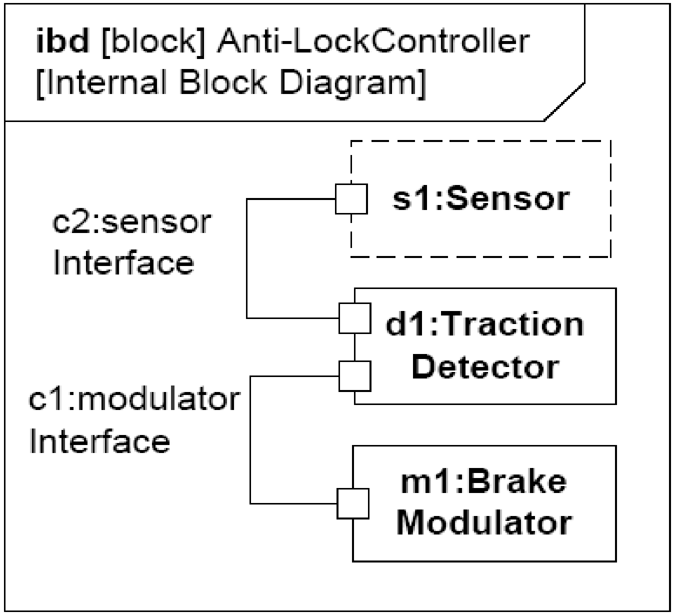
Blockdiagramme

Block Definition Diagram


bdd [package] VehicleStructure [ABS-Block Definition Diagram]
«block» Library:: Electronic Processor
«block» Anti-Lock Controller
d1
m1
s1
«block» Traction Detector
«block» Brake Modulator
«block» Sensor

Internal Block Diagram



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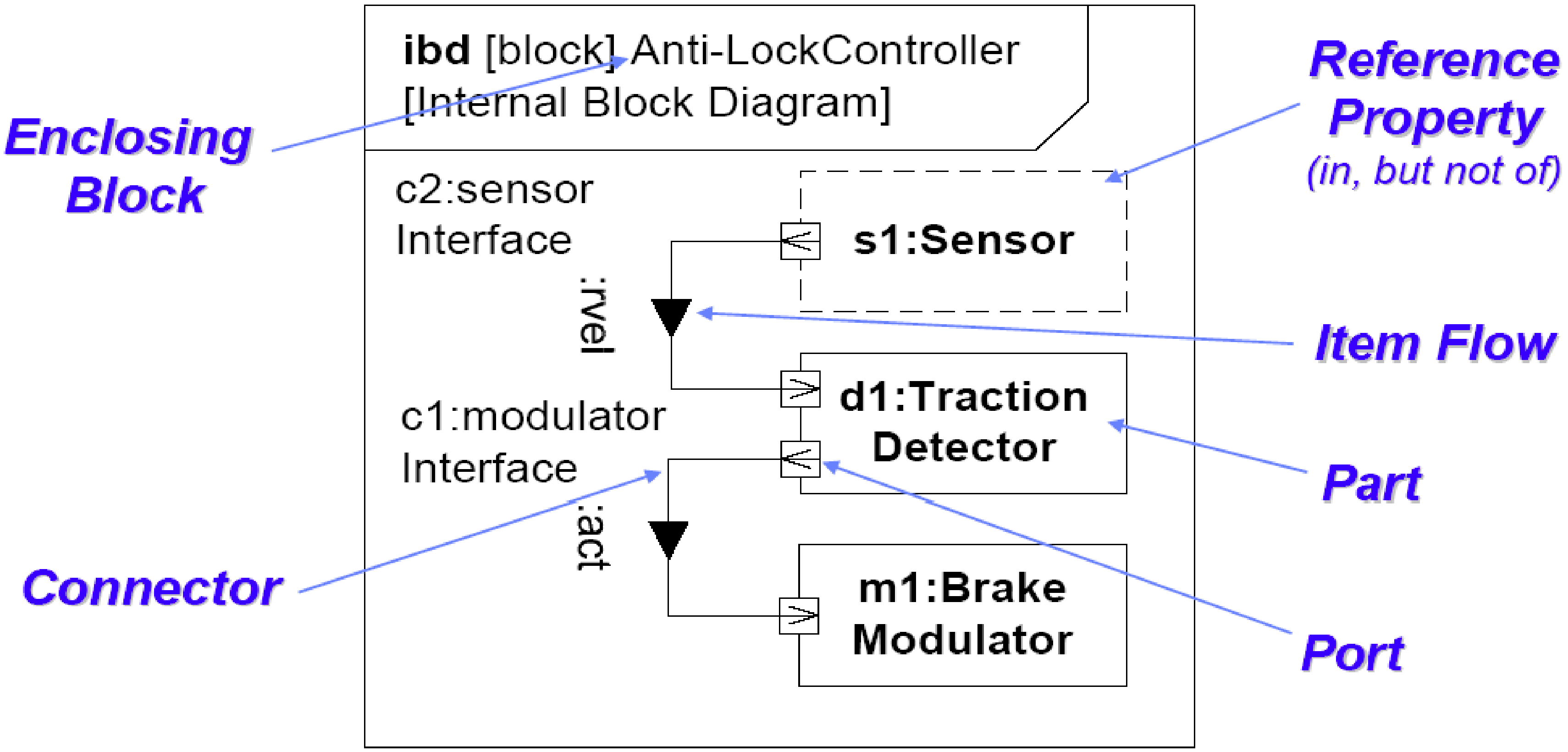
- Definition von Bausteinen
- Festlegung von Eigenschaften
- Beziehungen zwischen Blöcken („part“ = Benutzung eines Blocks)
- Sichtbare Schnittstellen

Blocks, Parts, Ports, Connectors, Flows 7.4.2



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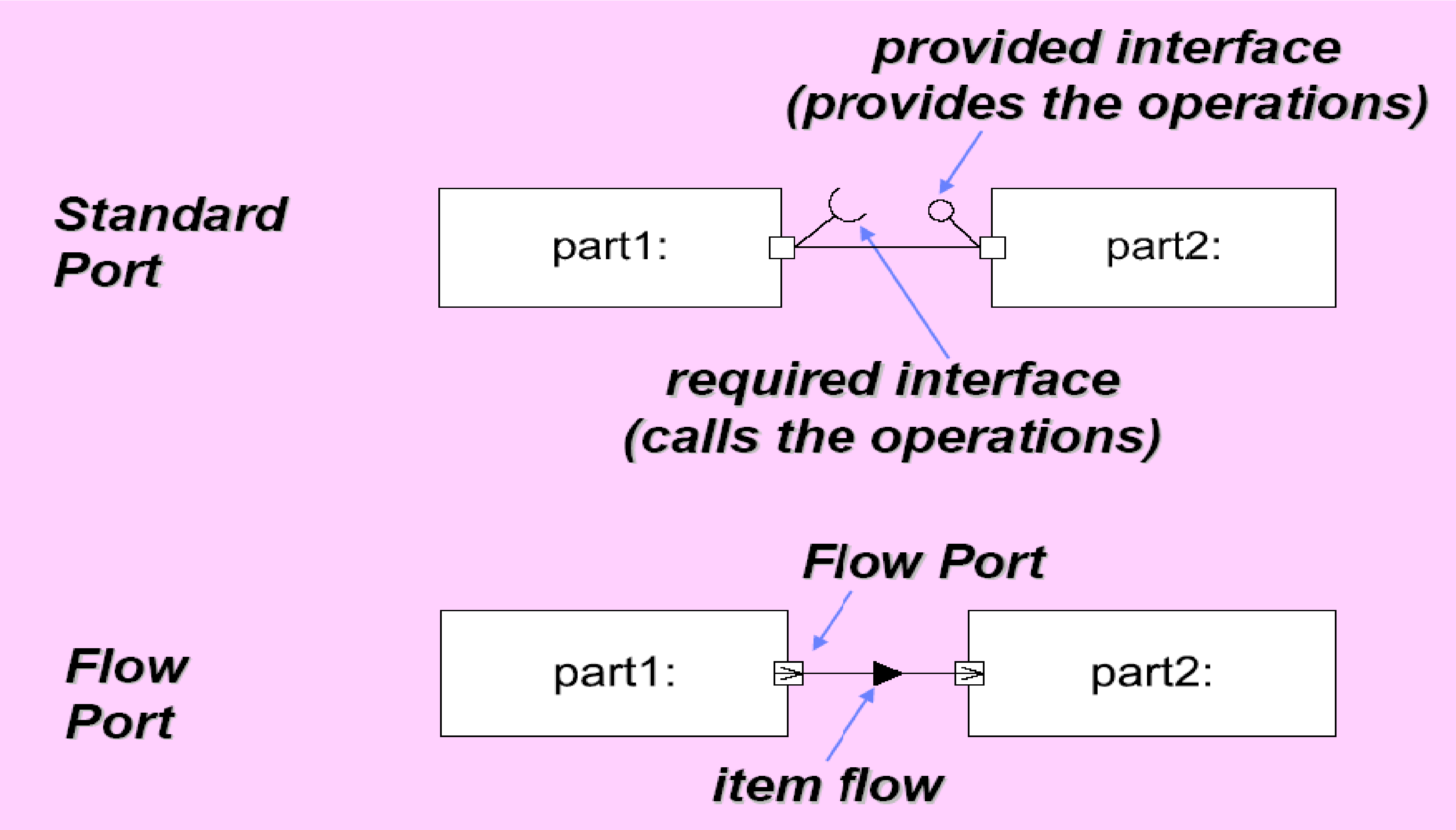
Port-Typen

- **Standard (UML) port**
  - The port indicate the existence of a service interface which external blocks may call (as in software)
  - Interaction is as defined for the individual operation made available through the interface
- **Flow ports**
  - Specifies what can flow in or out of a component
  - Has a specified direction and content
  - May be bi-directional

Port-Typen (2)



Standard Port

provided interface (provides the operations)

required interface (calls the operations)

Flow Port

Flow Port

item flow

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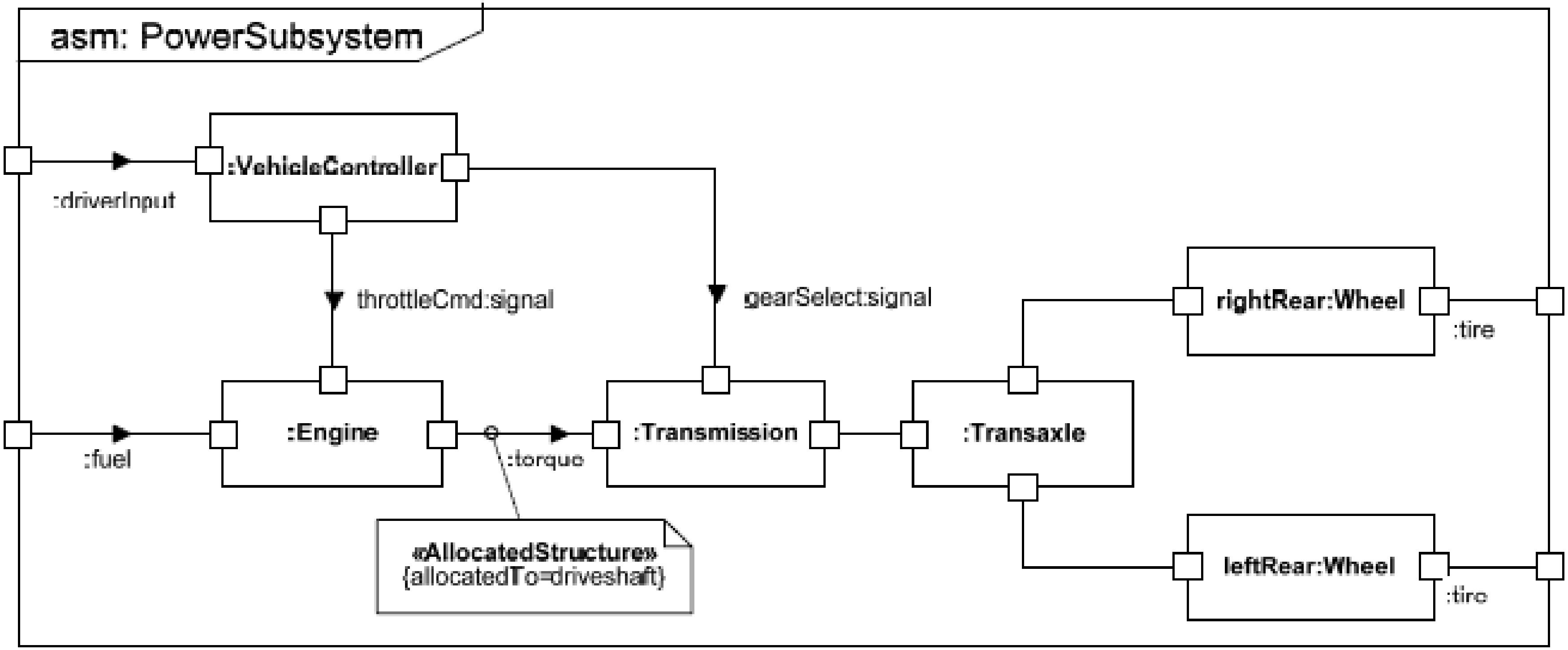
Beispiel Internes Blockdiagramm

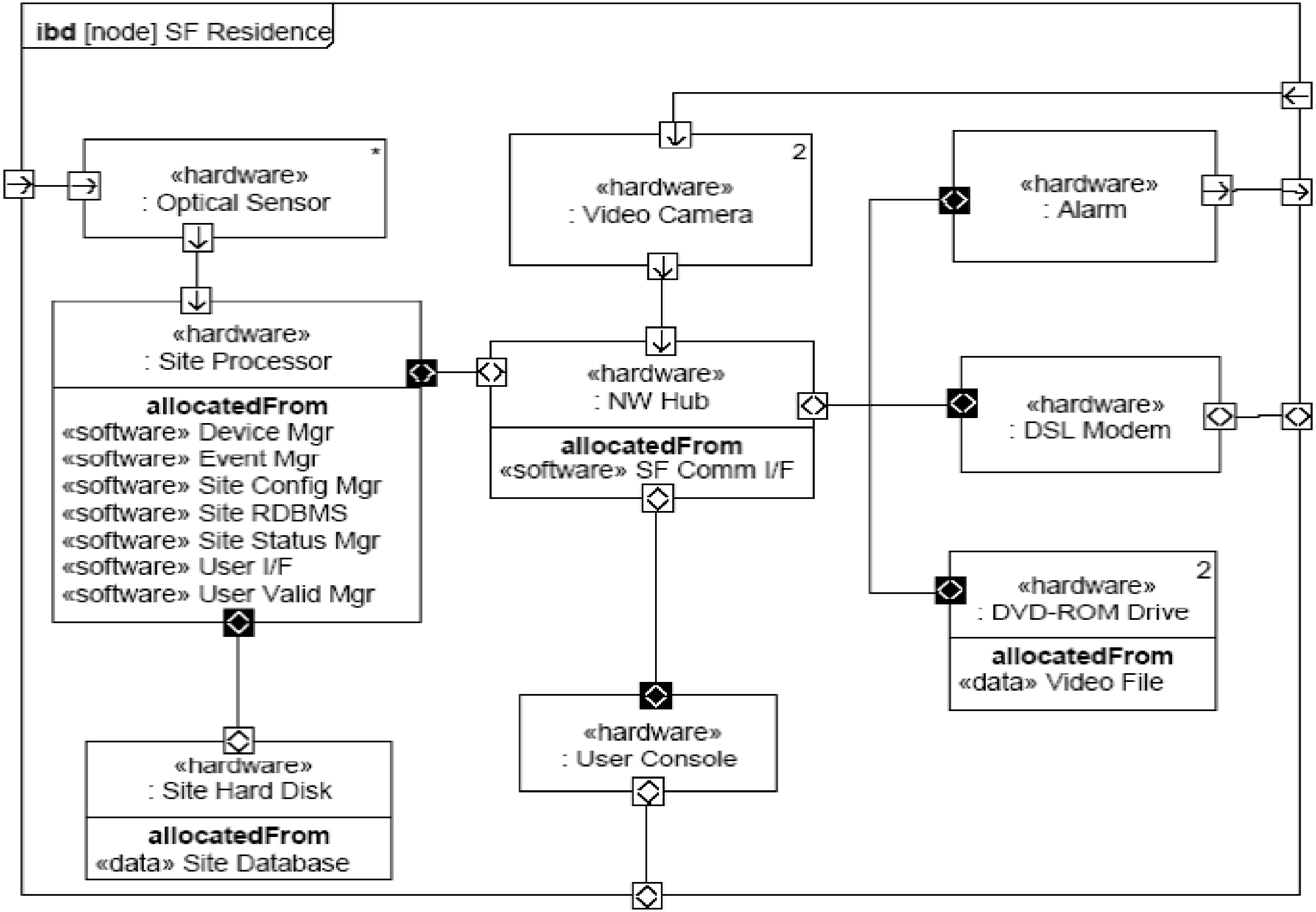


SysML 1.3 OMG 12-06-01.pdf

Allocation

- SysML provides 3 mechanisms for representing the allocation of functional or physical elements to other physical elements
  - Via Swimlanes in activity diagrams
    - Elegant
  - Via the addition of a separate compartment in the block structure
  - Via relationships directly on diagrams

Beispiel Allocation



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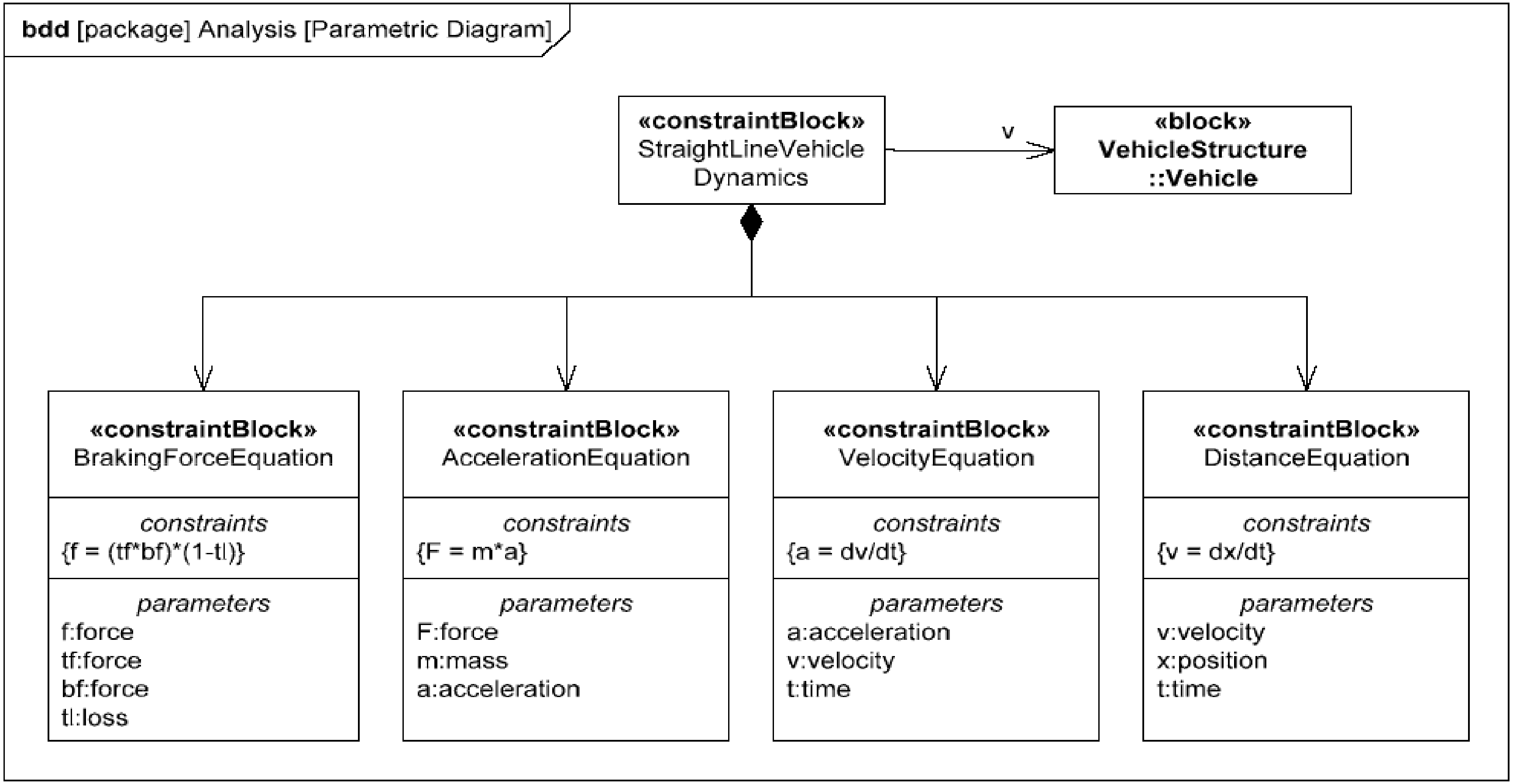
Parametrische Constraints

- Genutzt für Constraints zwischen quantifizierbaren Eigenschaften
- Definiert als Stereotype
  - Expression = Text String
  - Sprache für Expressions offen (informell, OCL, MathML)
  - Auswertung durch externe Tools (nicht durch SysML)

Beispiel Parametrische Constraints



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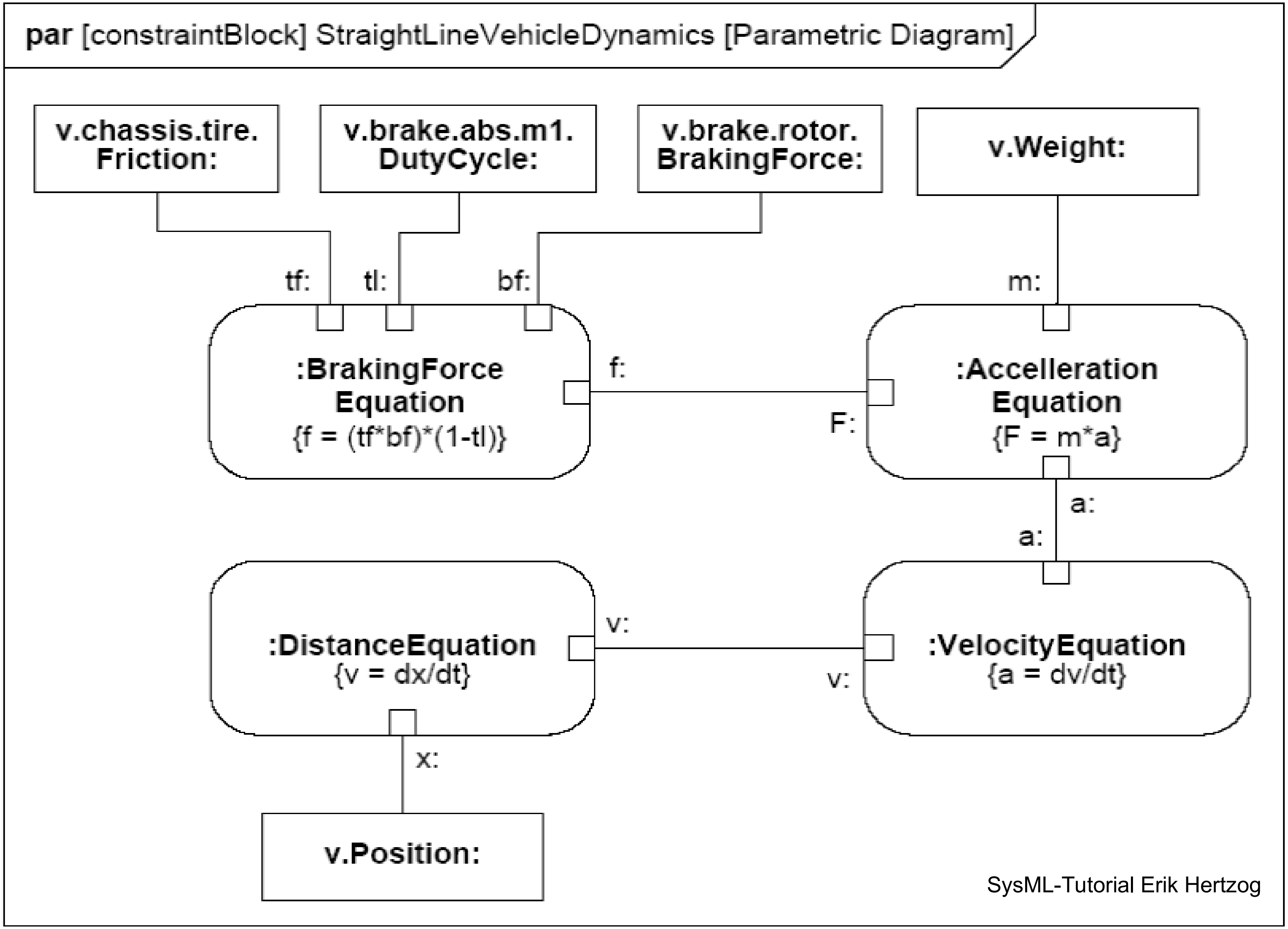
Beispiel Variablen-Bindung



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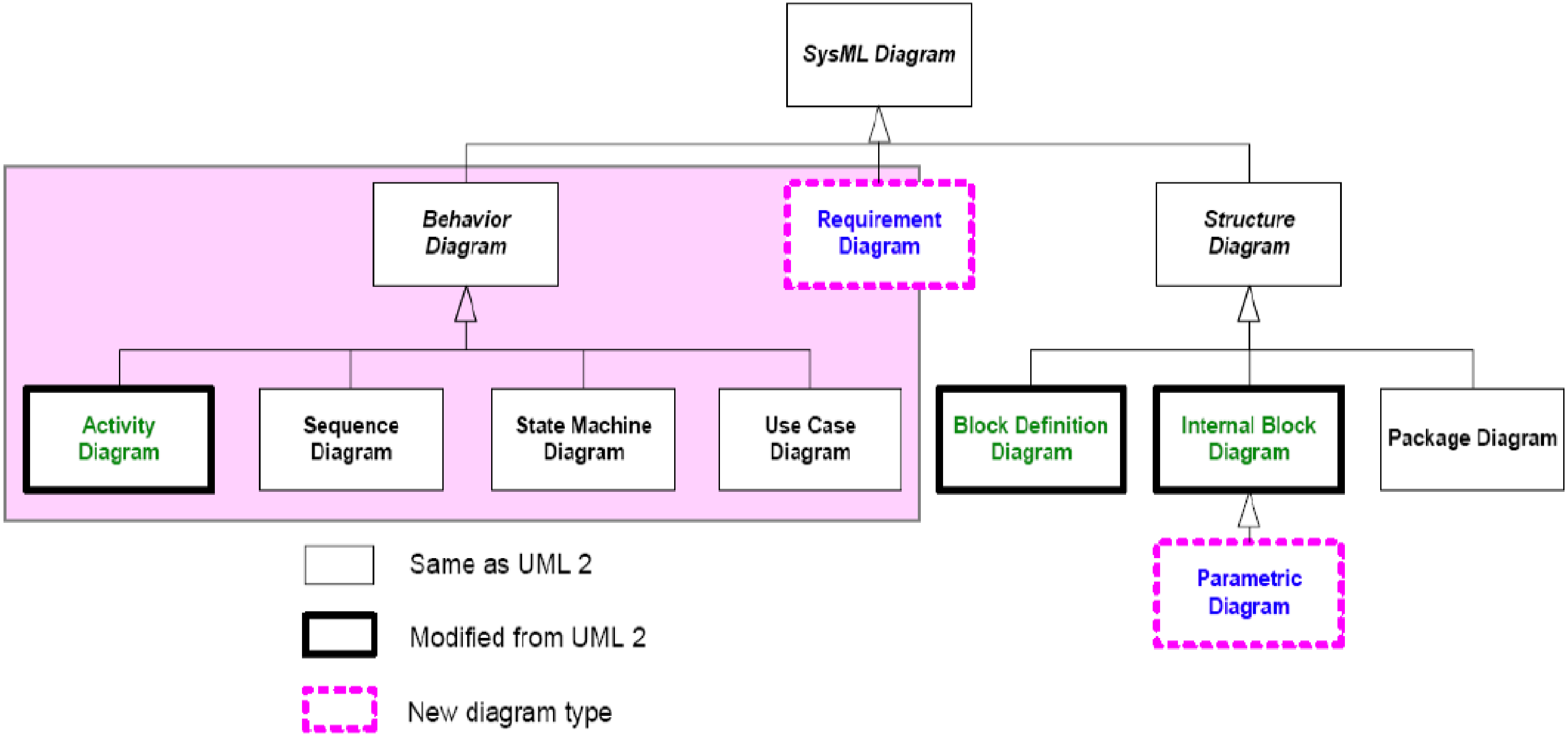
SysML Verhaltensdiagramme



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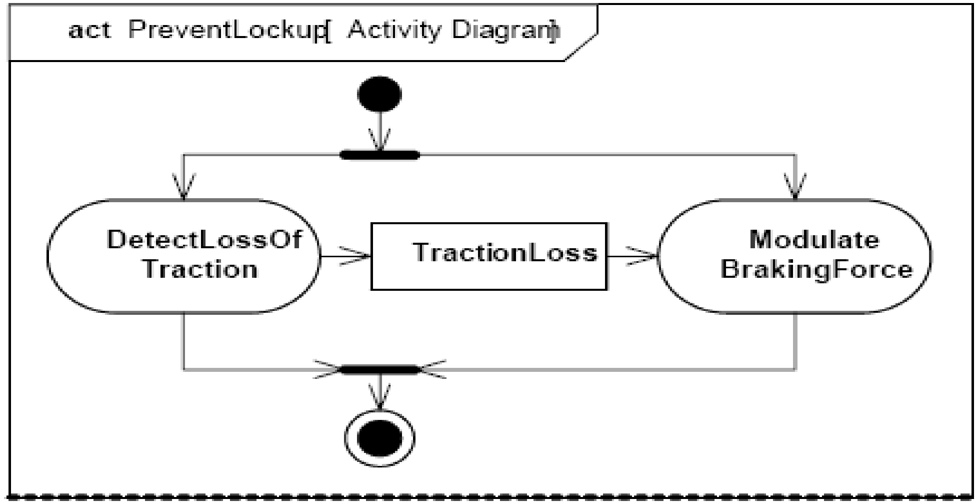
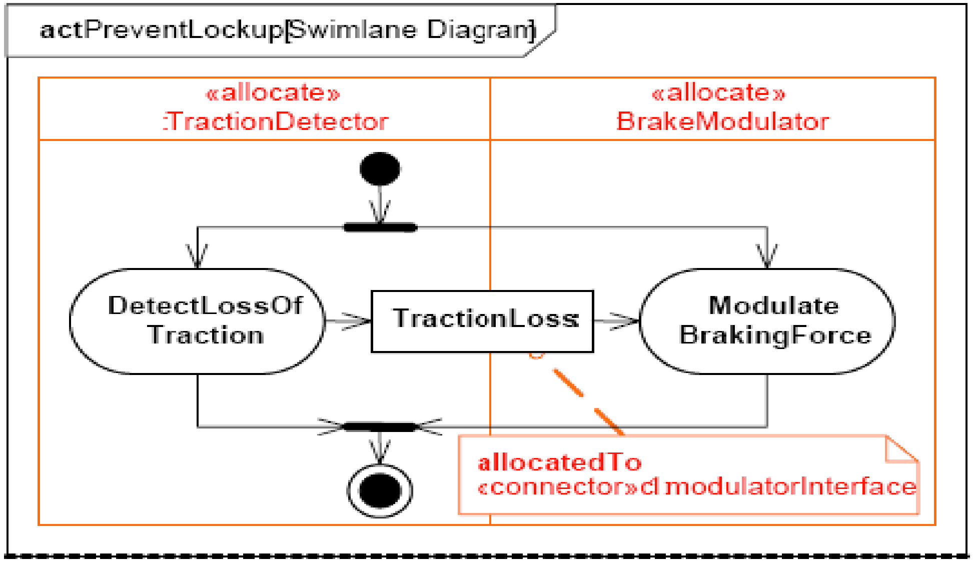
Aktivitätsdiagramme




actPreventLockup[Swimlane Diagram]
«allocate» :TractionDetector
«allocate» BrakeModulator
DetectLossOf Traction
TractionLoss
Modulate BrakingForce
allocatedTo
«connector»c1 modulatorInterface

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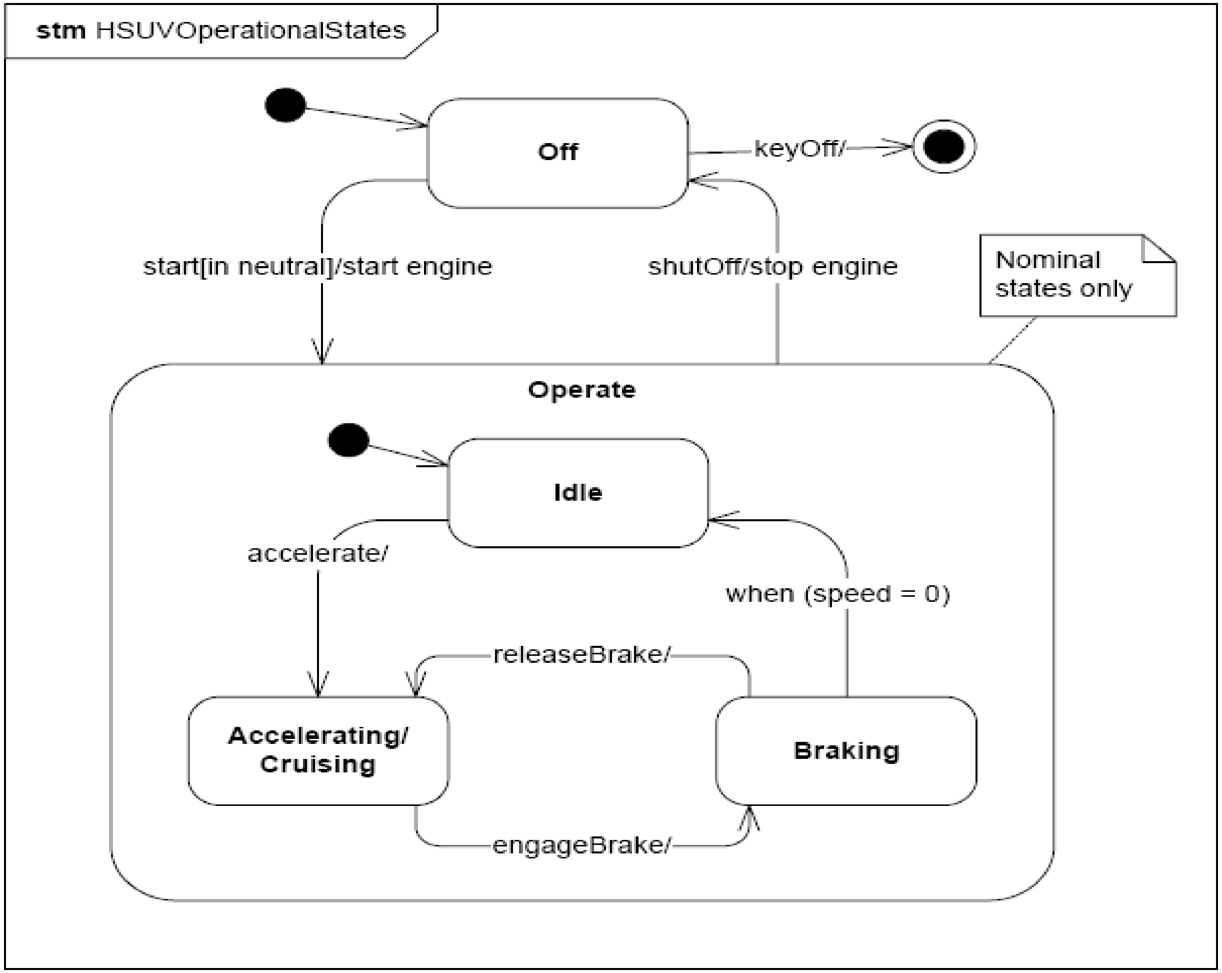
State Machines

- **Beispiel**



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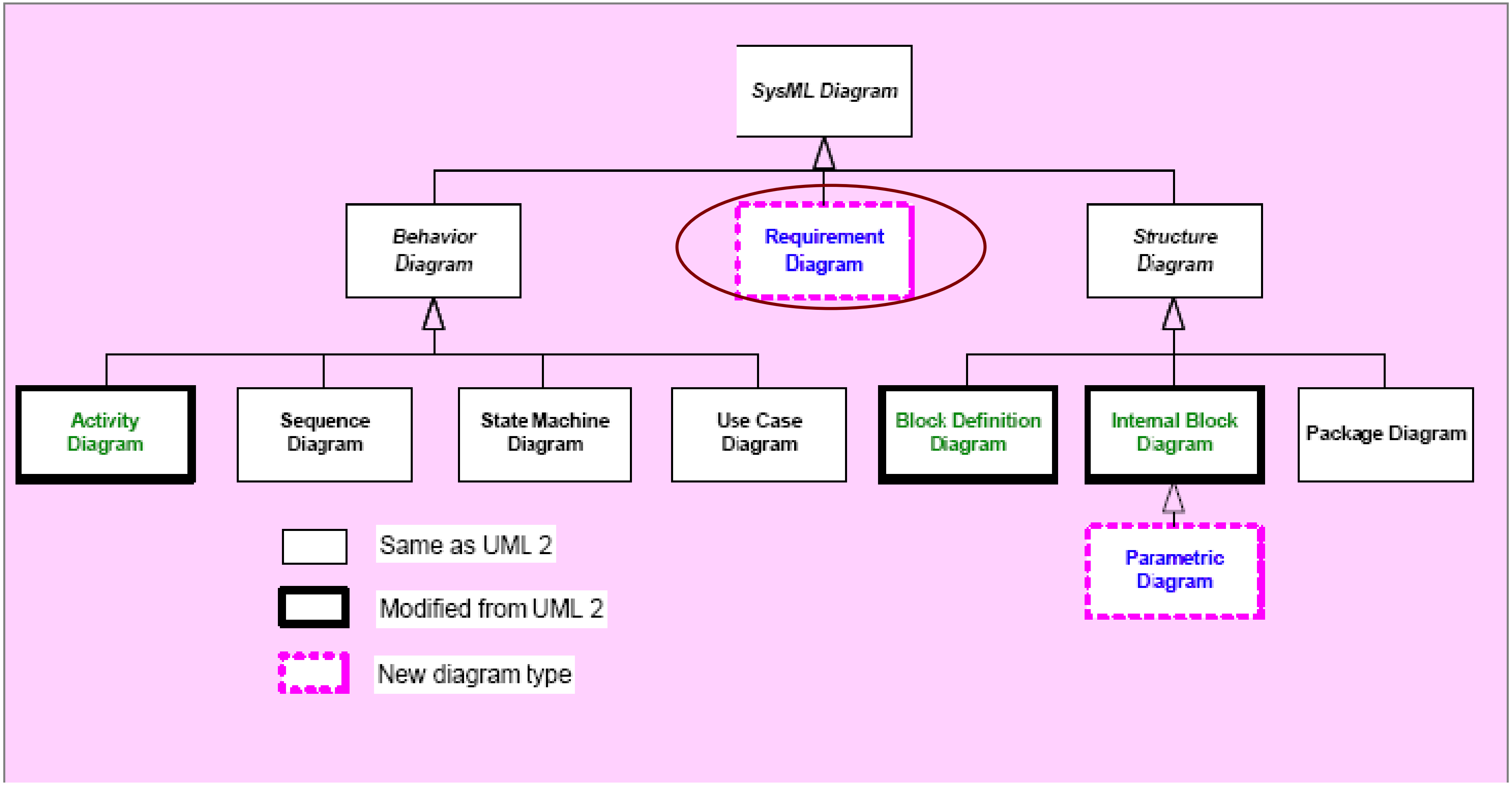
Requirements-Diagramm



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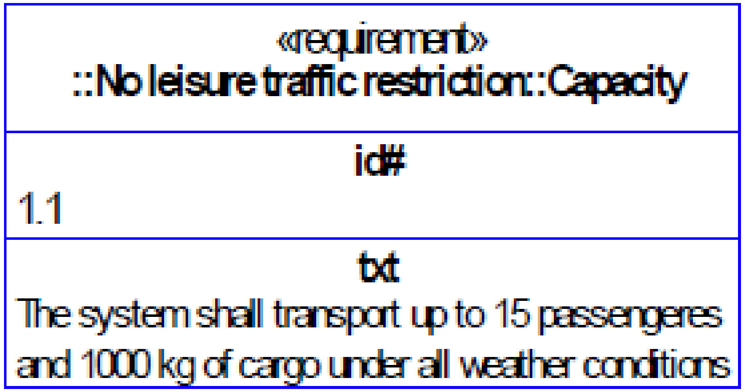
Requirement

- In SysML ist Requirement eine Zeichenkette (String)
- Keine Annahmen darüber, wann Requirement Elemente im Entwurfsprozess zu verwenden sind
- Notation:



«requirement»
::No leisure traffic restriction::Capacity

id#
1.1

txt
The system shall transport up to 15 passengeres and 1000 kg of cargo under all weather conditions

Zusammenfassung Requirements

- **SysML provides the following features**
  - Representation of requirements
    - Representation of individual *requirements*
    - Requirement *composition*
    - Requirements can be sub-classed using specialization
  - Requirement relationships
    - *derive* relationship between derived and source requirements
    - *satisfy* relationship between design models and requirements
    - *verify* relationship between requirements and test cases
    - generalized *trace* relationship between requirements and other model elements
    - *rationale* for requirements traceability, satisfaction, etc
  - Alternative graphical, tabular and tree representations
    - Supported by the standard, but currently not implemented in any tools

Stereotypes

- **Überblick**

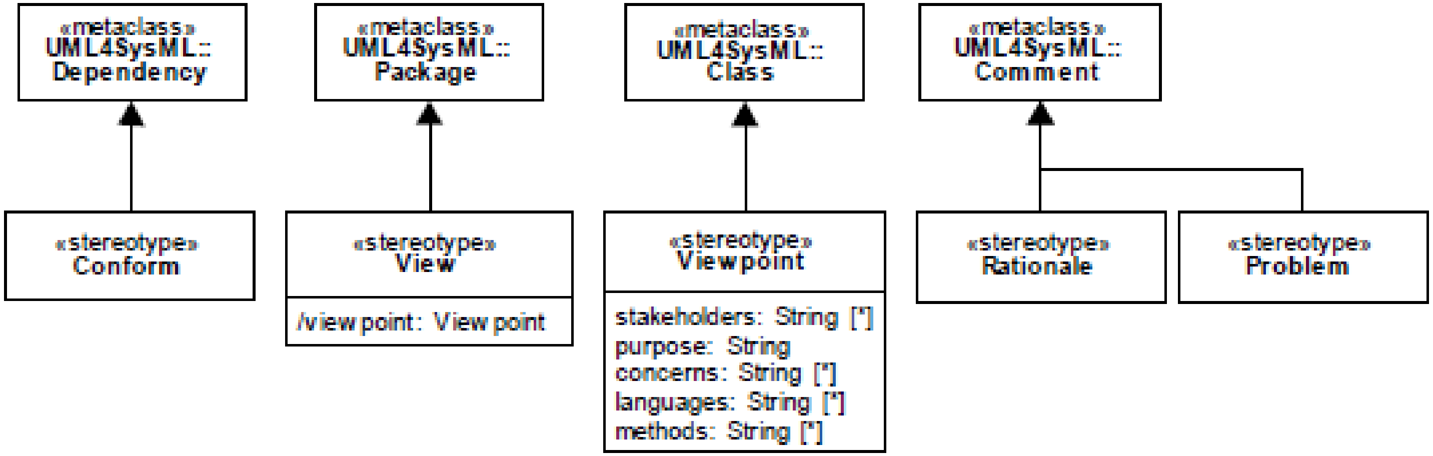


Figure 7.1 - Stereotypes defined in package ModelElements

SysML 1.3 OMG 12-06-01.pdf

Beispiel

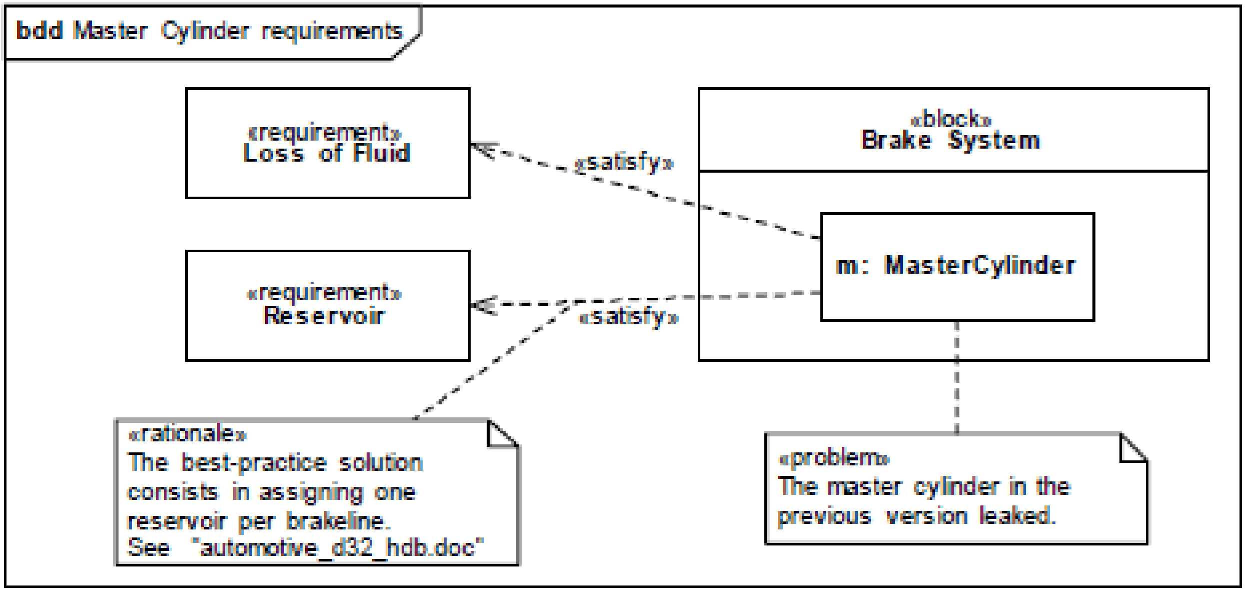

bdd Master Cylinder requirements
«requirement»
Loss of Fluid
«requirement»
Reservoir
«satisfy»
«satisfy»
«block»
Brake System
m: MasterCylinder
«rationale»
The best-practice solution consists in assigning one reservoir per brakeline.
See "automotive_d32_hdb.doc"
«problem»
The master cylinder in the previous version leaked.

Figure 7.2 - Rationale and Problem examples

SysML 1.3 OMG 12-06-01.pdf

7.4.3 MARTE

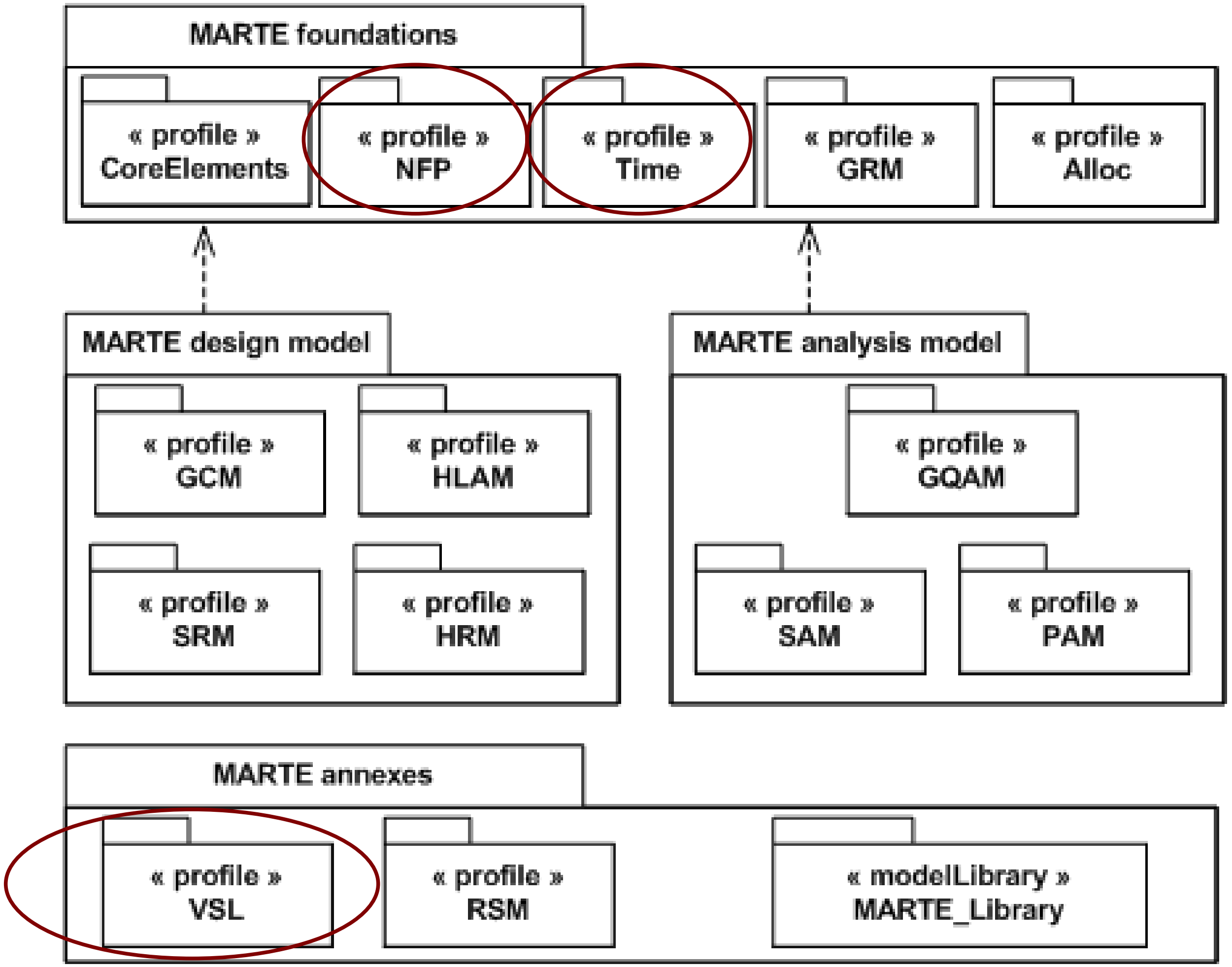
- MARTE: Modeling and Analysis of Real Time and Embedded systems
- OMG Standard formal/2011-06-02 (Version 1.1)
- UML 2 Profil
- Unterstützung für Modellierung, Simulation und statische Analyse
- Zahlreiche MARTE Modell-Bibliotheken
  - Primitive Typen
  - Erweiterte Datentypen
  - Maßeinheiten
  - Vordefinierte NFP-Typen
  - Time
  - Echtzeitbetriebssysteme (OSEK/VDX, Arinc-653 (Avionik))
  - ...

MARTE Hauptkomponenten

- Core Framework zur Definition der Basiskonzepte
  - Core Elements
  - Non-Functional Properties (NFP) Modeling
  - Time Modeling (Time)
  - Generic Resource Modeling (GRM)
  - Allocation Modelling (Alloc)
- Refinement 1: Reine Applikationsmodellierung (z.B. Hardware and Software Plattform Modellierung)
- Refinement 2: Unterstützung für quantitative Analyse of UML2-Modellen, insb. Schedulability und Performance-Analyse
- Anhänge
  - insb. Value Specification Language (VSL)
  - Sprache zum Zusammenfügen der Modellbibliotheken

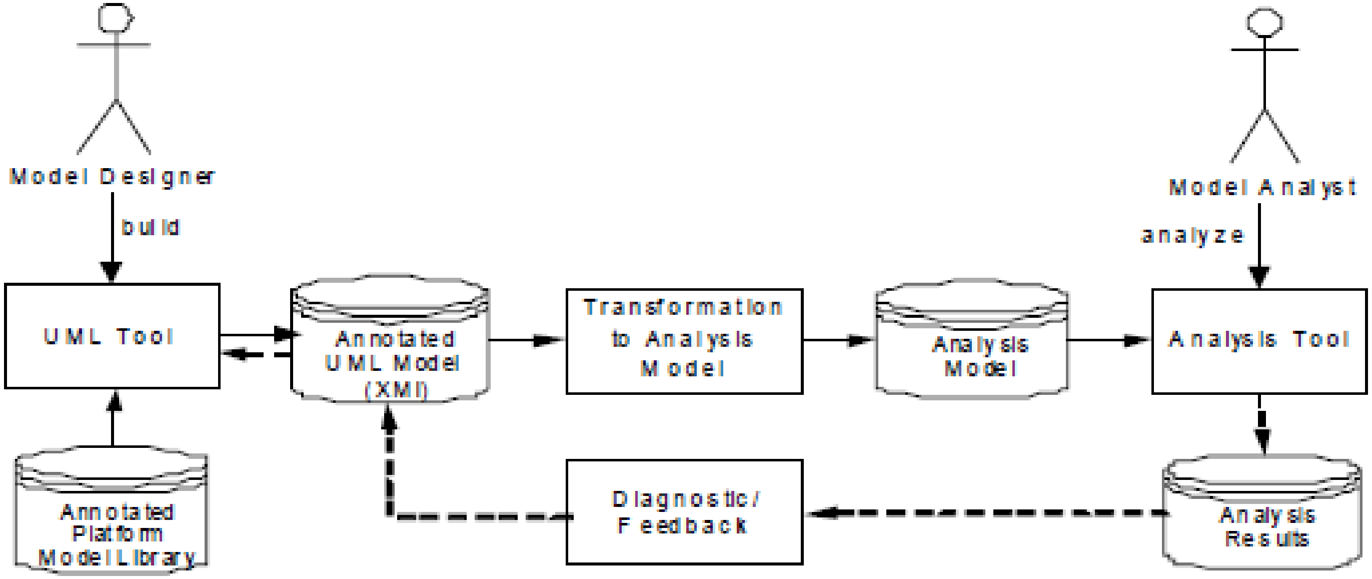
MARTE Paketstruktur

Überblick



UML MARTE OMG 11-06-02.pdf

MARTE Toolchain für Modellanalyse



UML MARTE OMG 11-06-02.pdf

Value Specification Language Framework

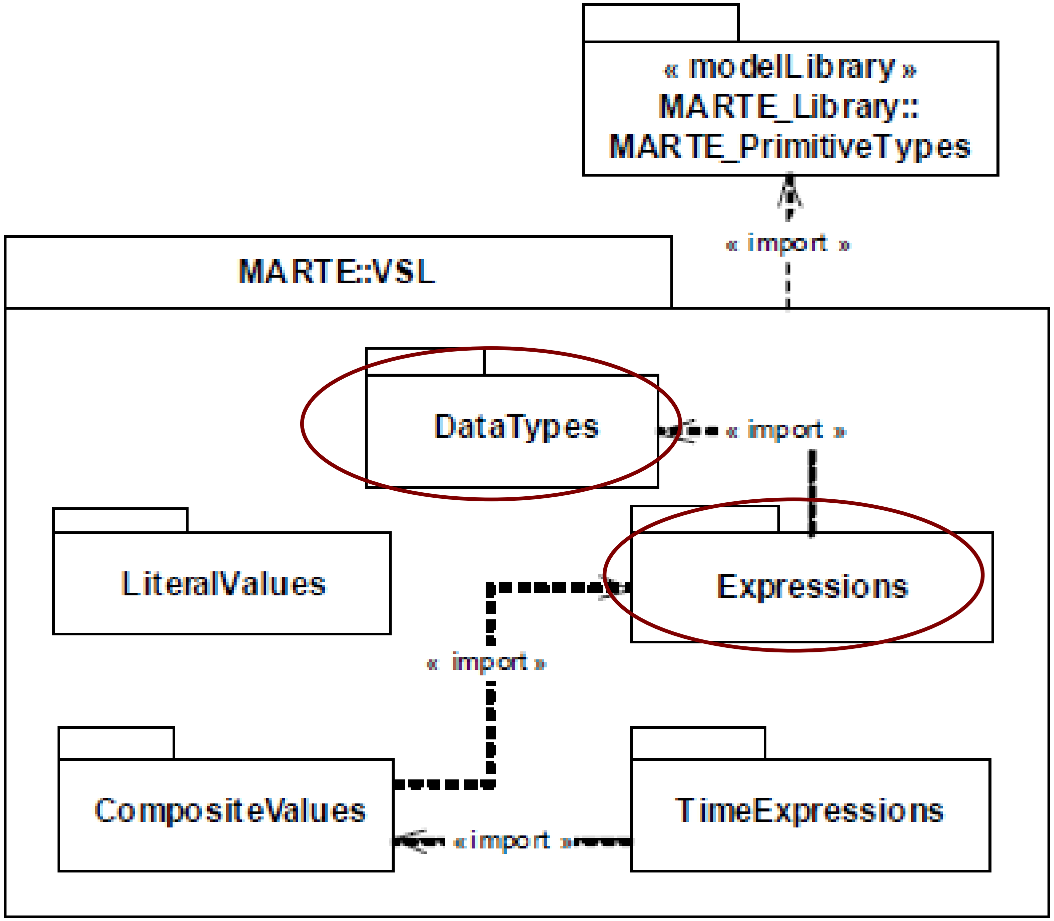


Figure B.1 - Structure of the VSL framework

UML MARTE OMG 11-06-02.pdf

VSL-Datentypen

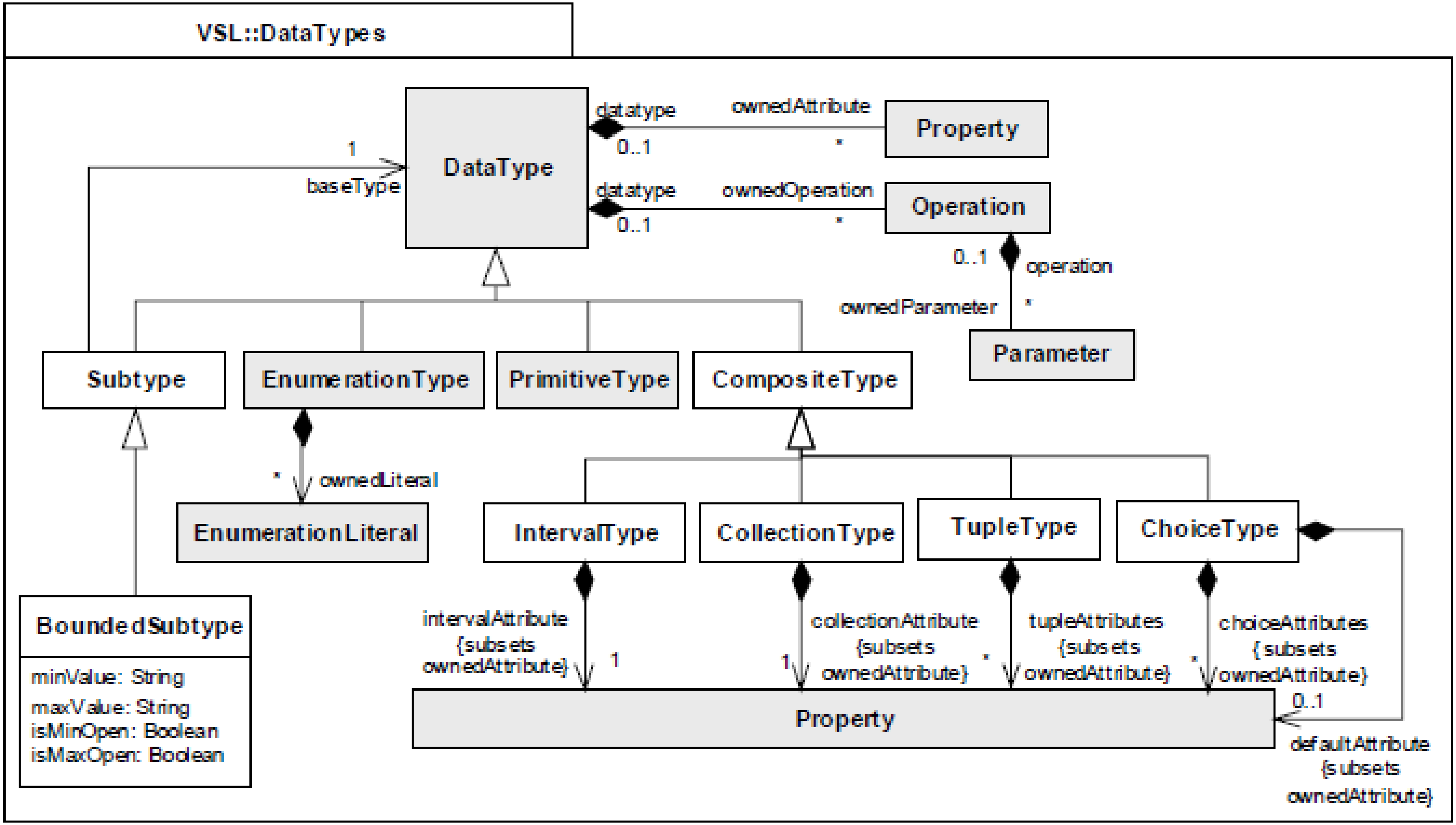


Figure B.2 - VSL::DataTypes package

UML MARTE OMG 11-06-02.pdf

VSL-Ausdrücke

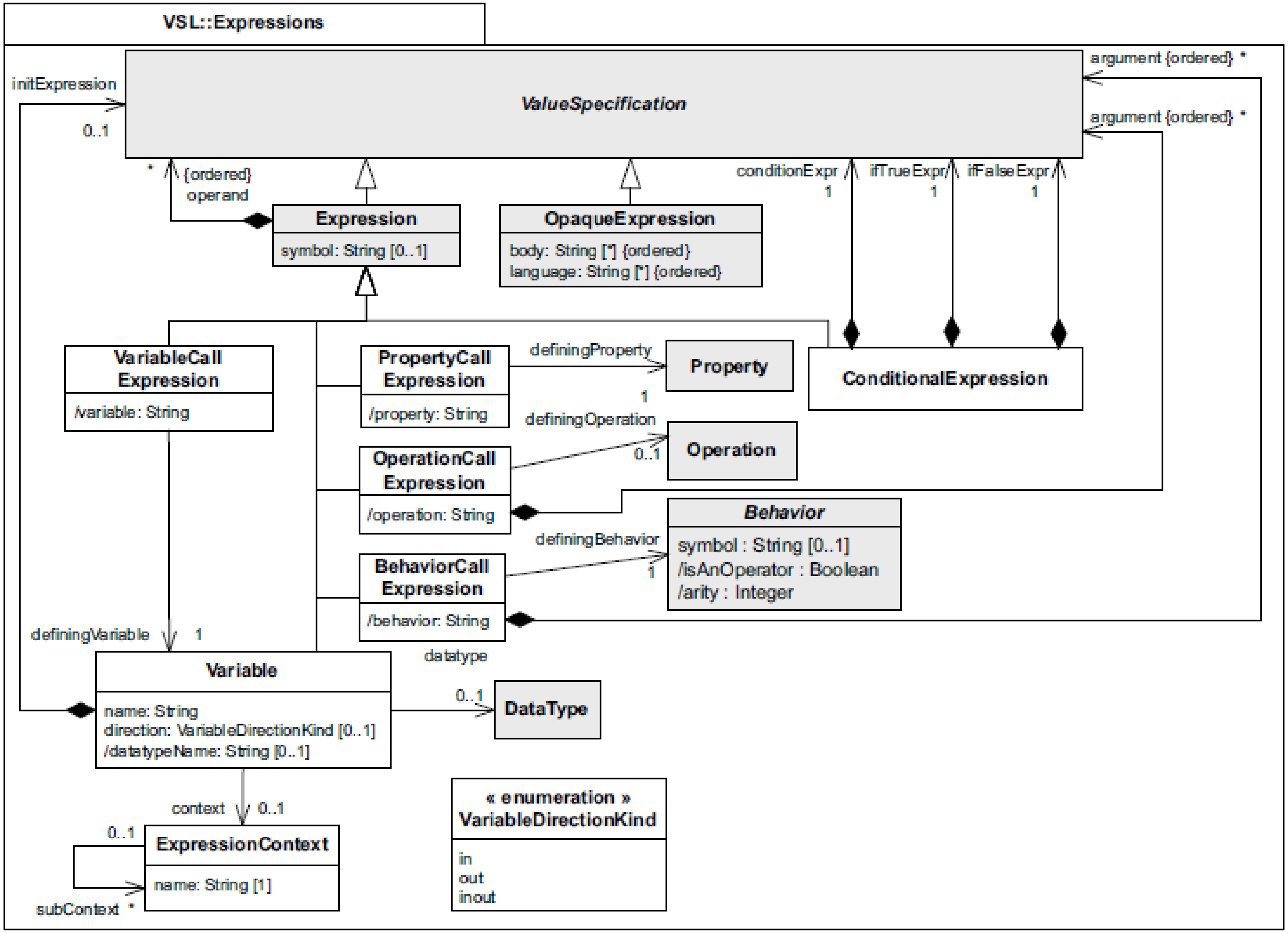


Figure B.4 - VSL::Expressions package

Non-Functional Properties (NFC) Modelling

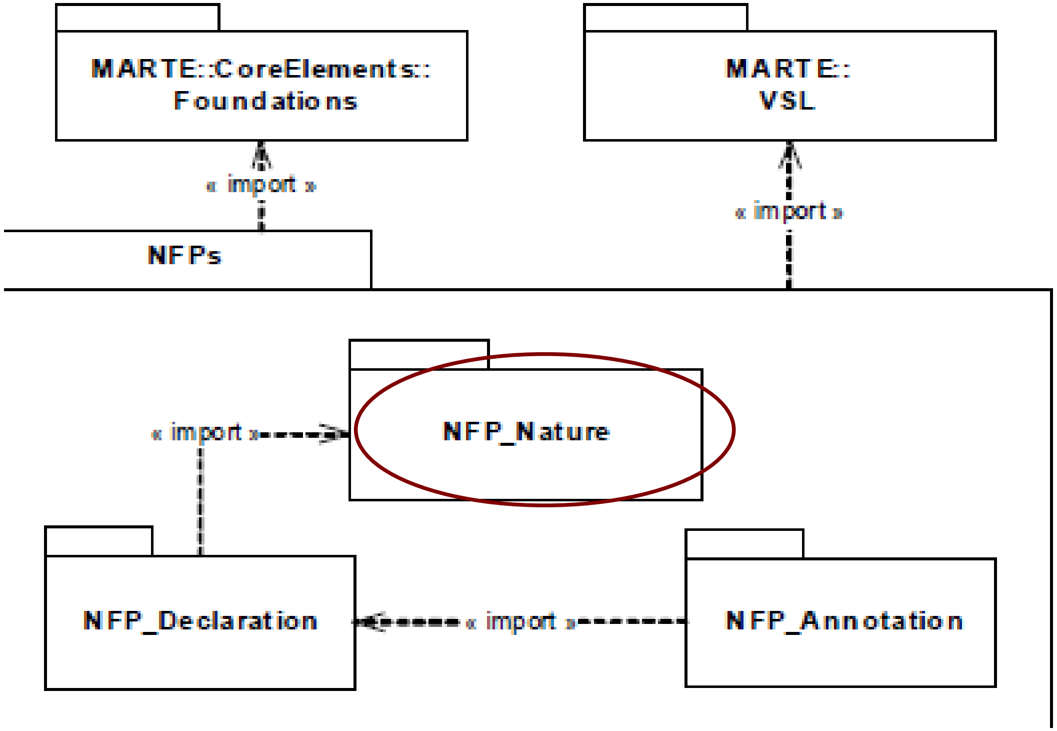


Figure 8.1 - Structure and dependencies of the NFPs modeling package

UML MARTE OMG 11-06-02.pdf

Non-Functional Properties (NFC) Modelling (2) 7.4.3

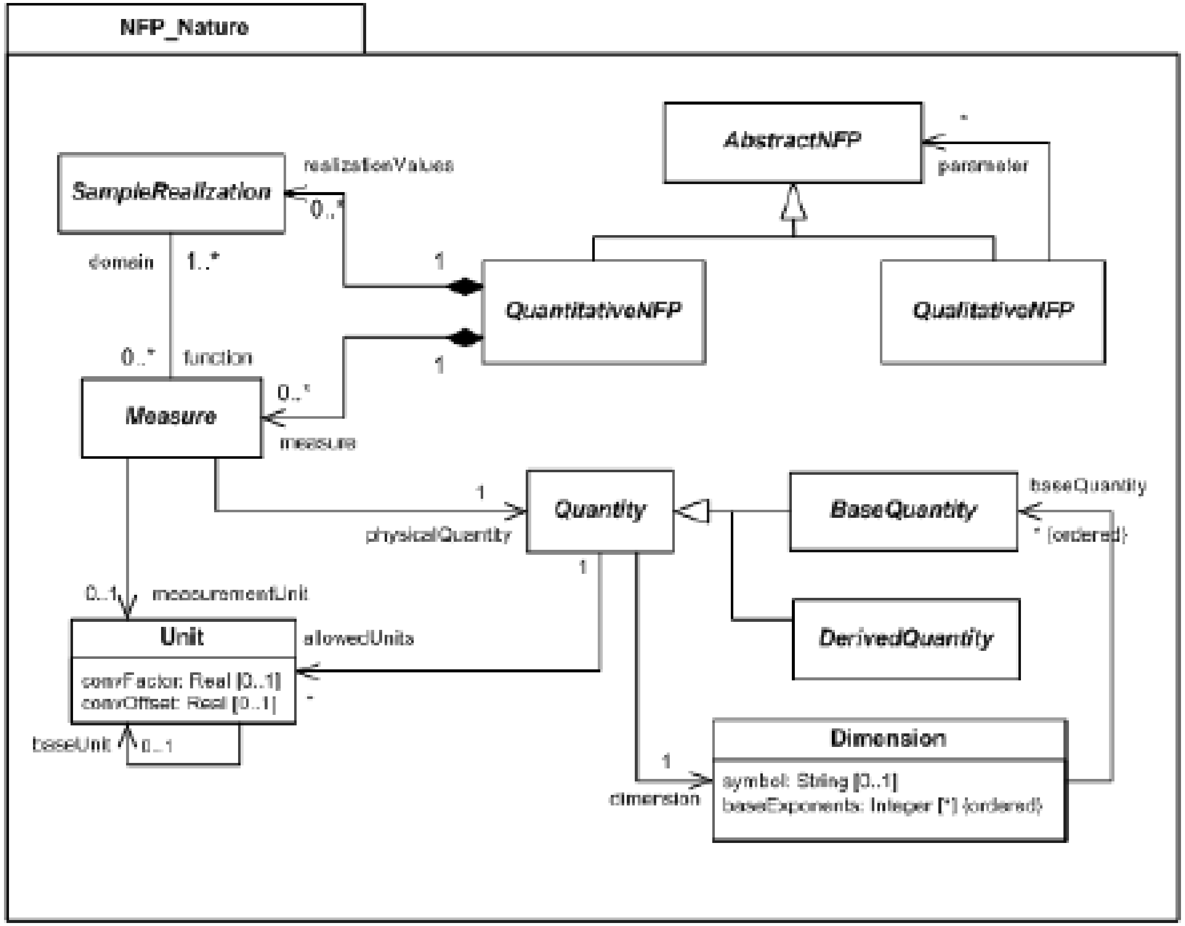


Figure 8.2 - Domain Model for NFP Nature

UML MARTE OMG 11-06-02.pdf

Zeitmodell (Time)

- **Überblick**

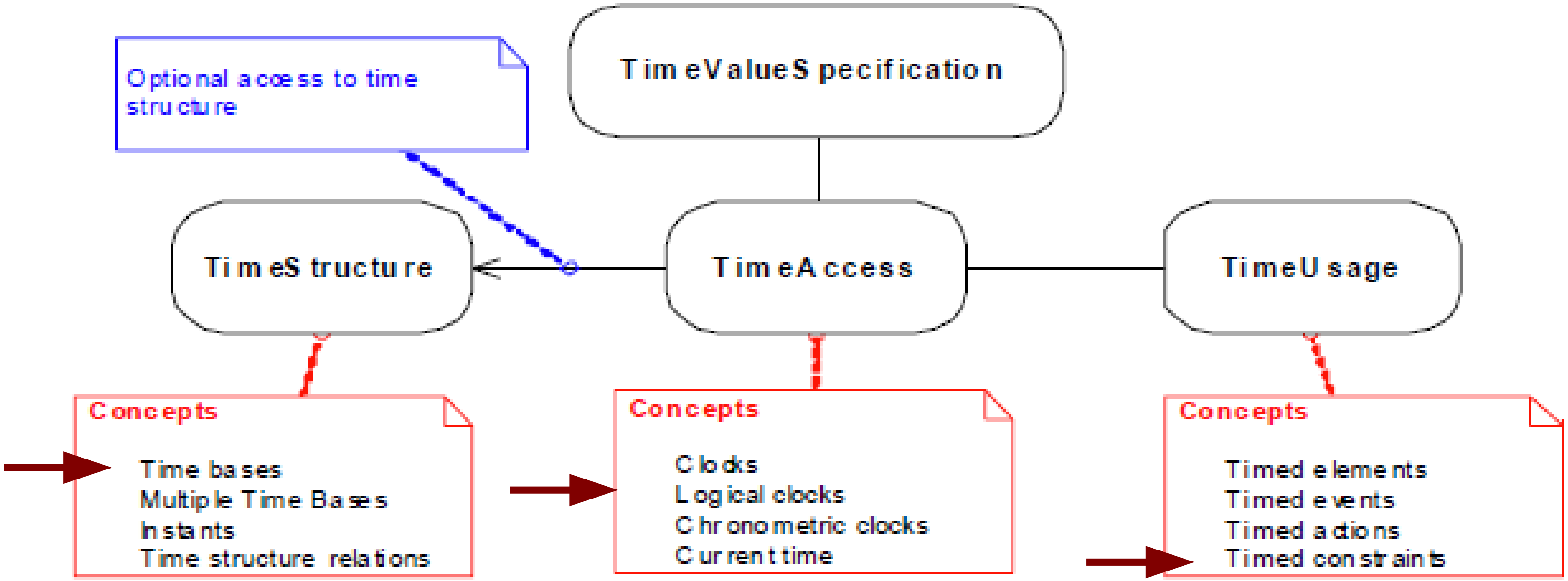


Figure 9.1 - Overview of the time model concerns

UML MARTE OMG 11-06-02.pdf

Basic Time Models

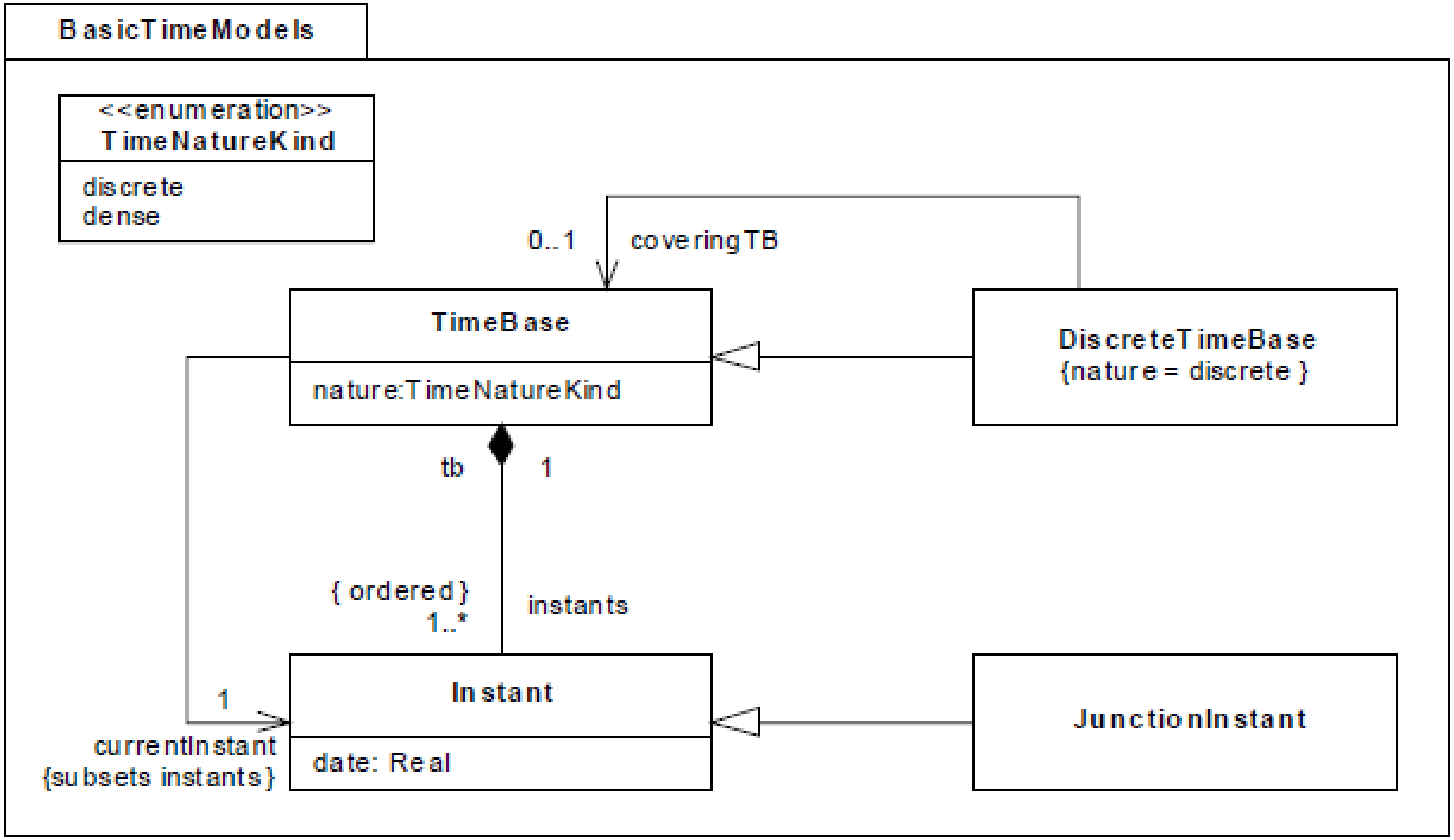


Figure 9.3 - Basic time diagram of the time model

UML MARTE OMG 11-06-02.pdf

Uhren (Clocks)

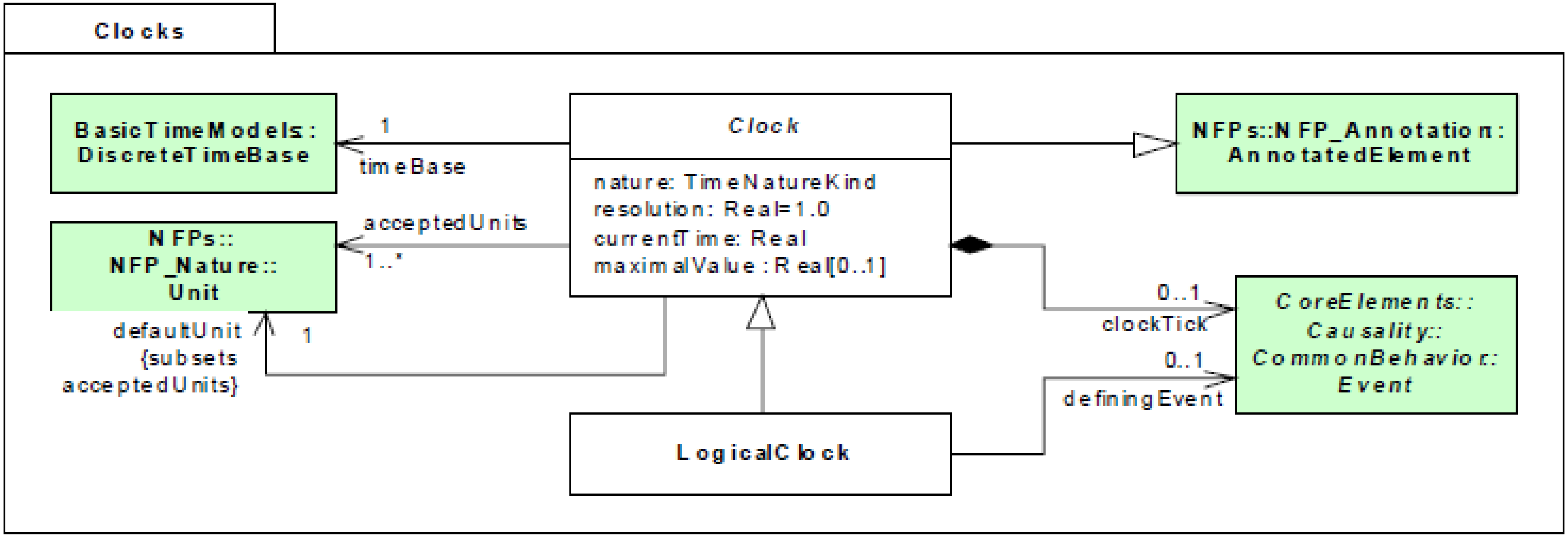


Figure 9.9 - Clocks diagram of the time model

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Uhren (Clocks) (2)

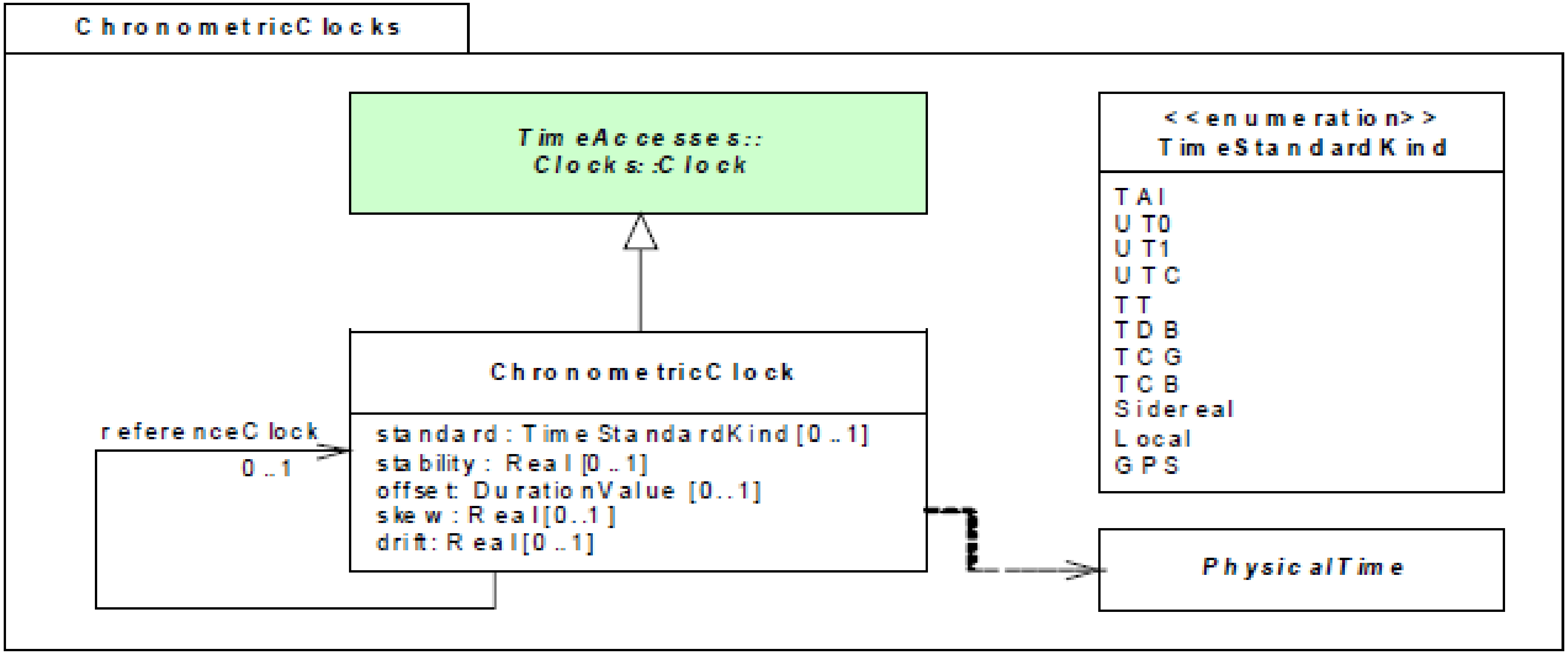

Figure 9.12 - ChronometricClocks diagram of the time model

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Uhren (Clocks) (3)

- **Beispiel**

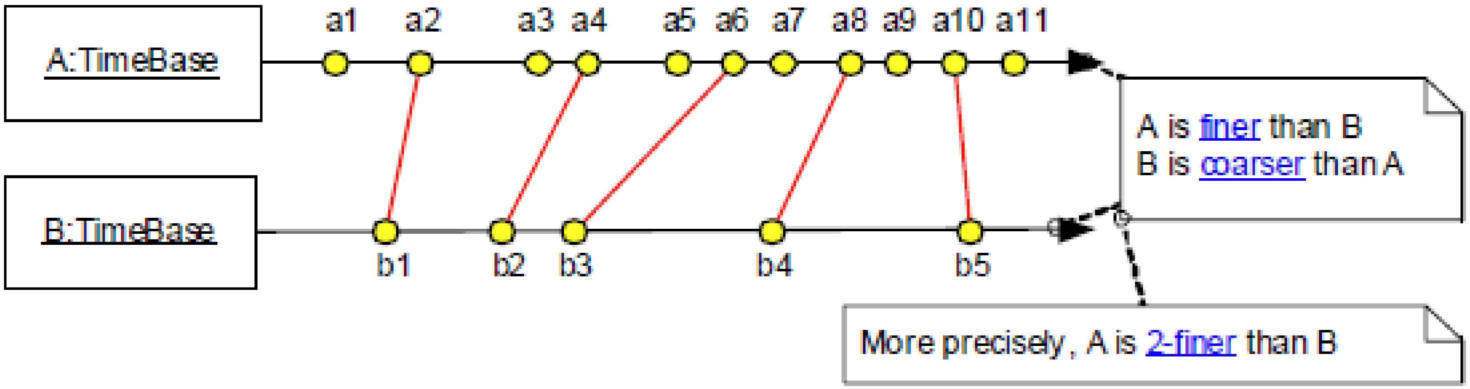

Figure 9.7 - Example of time relations between two time bases

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Timed Constraints

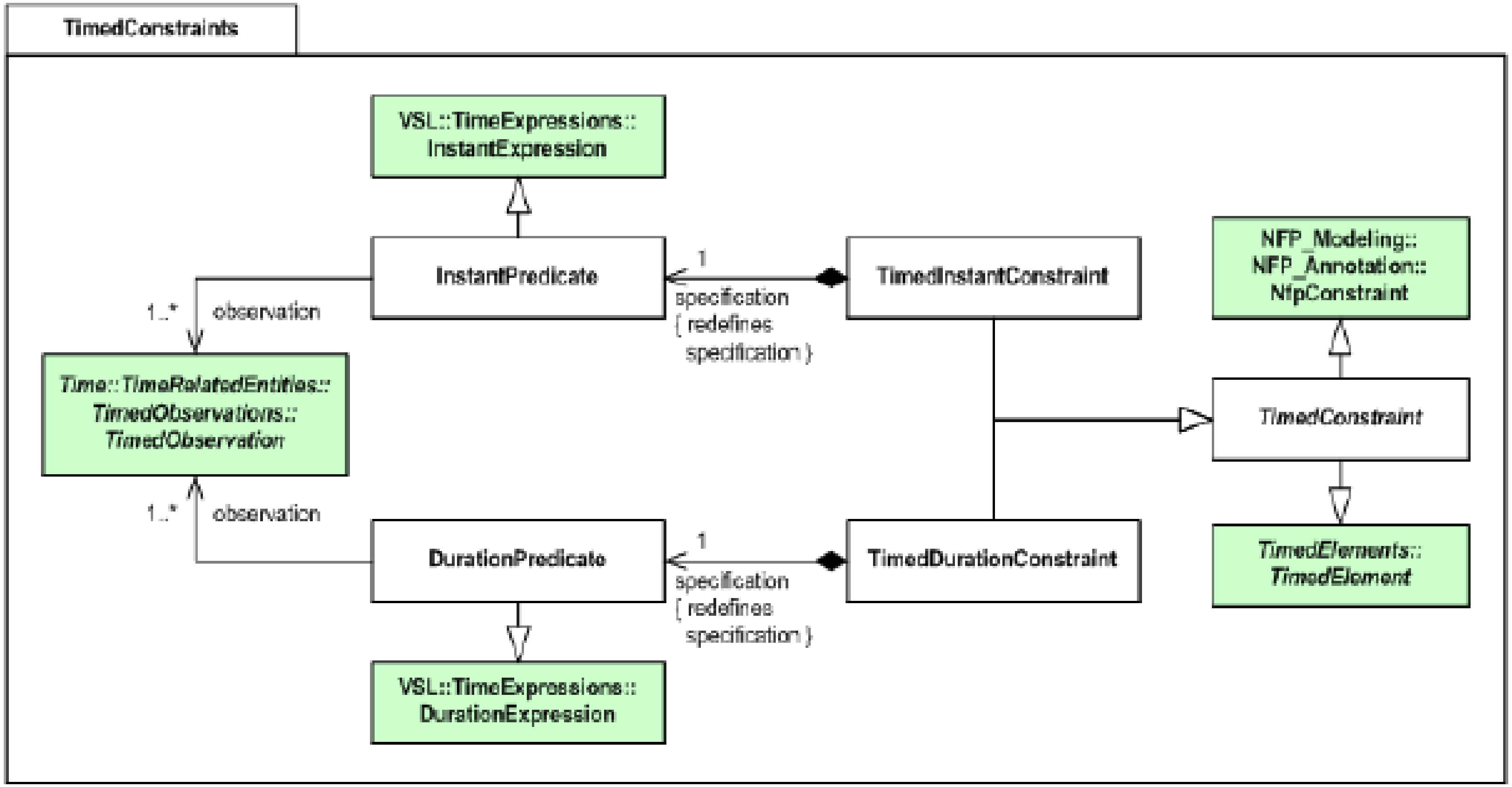

Figure 9.18 - TimedConstraints diagram of the time model

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Timed Constraints (Beispiel) 7.4.3

- **Zusammenfassendes Beispiel**

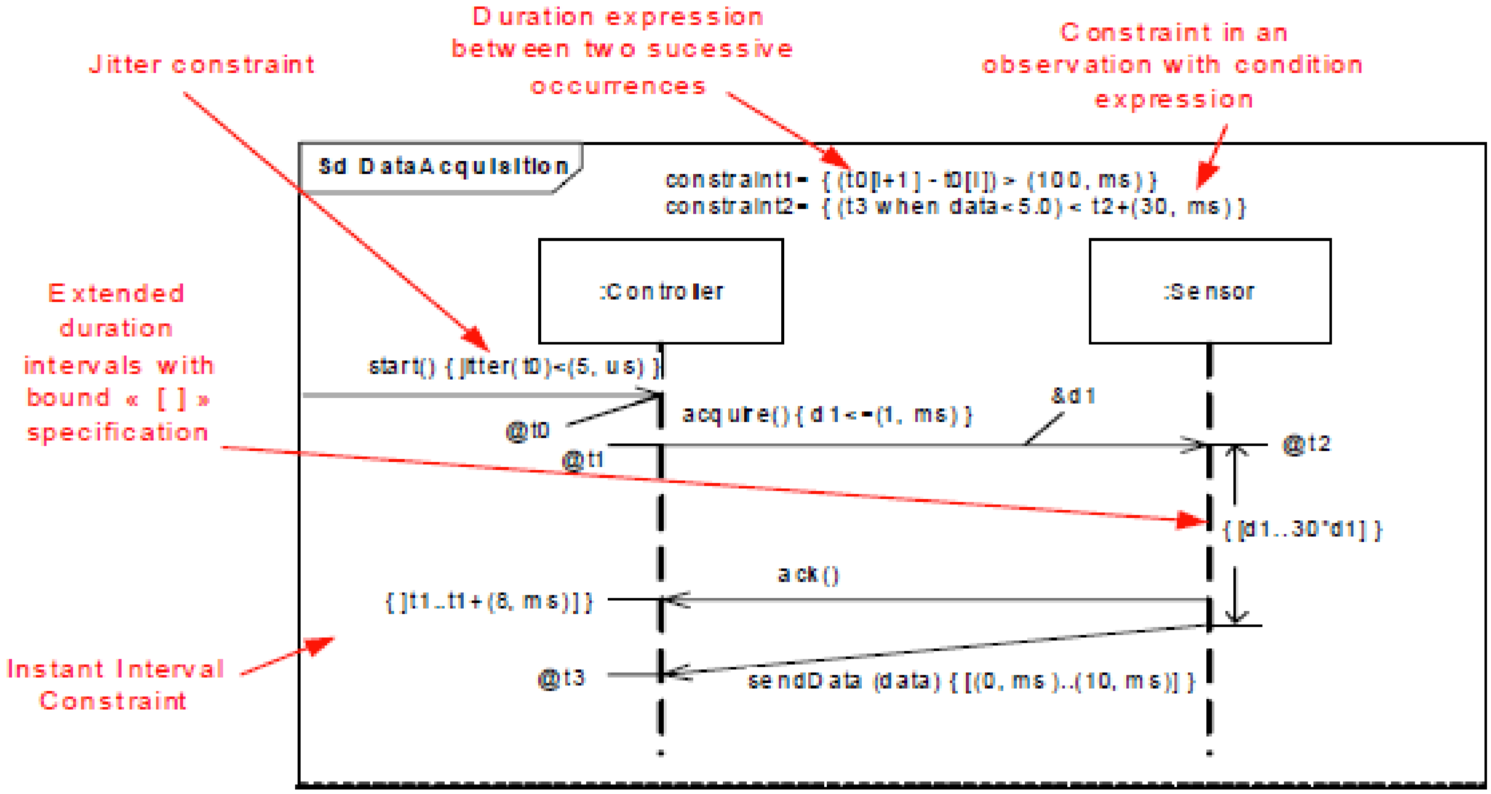
Jitter constraint
Duration expression between two sucessive occurrences
Constraint in an observation with condition expression
sd DataAcquisition
constraint1= { (t0[i+1] - t0[i]) > (100, ms) }
constraint2= { (t3 when data<5.0) < t2+(30, ms) }
:Controler
:Sensor
Extended duration intervals with bound « [ ] » specification
start() { jitter(t0)<(5, us) }
@t0
@t1
acquire() { d1<=(1, ms) }
&d1
@t2
{ [d1..30*d1] }
ack()
{]t1..t1+(8, ms)] }
Instant Interval Constraint
@t3
sendData (data) { [(0, ms)..(10, ms)] }

Figure B.14 - Time Expressions and Constraints in Sequence Diagrams with VSL

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