Introduction to modeling

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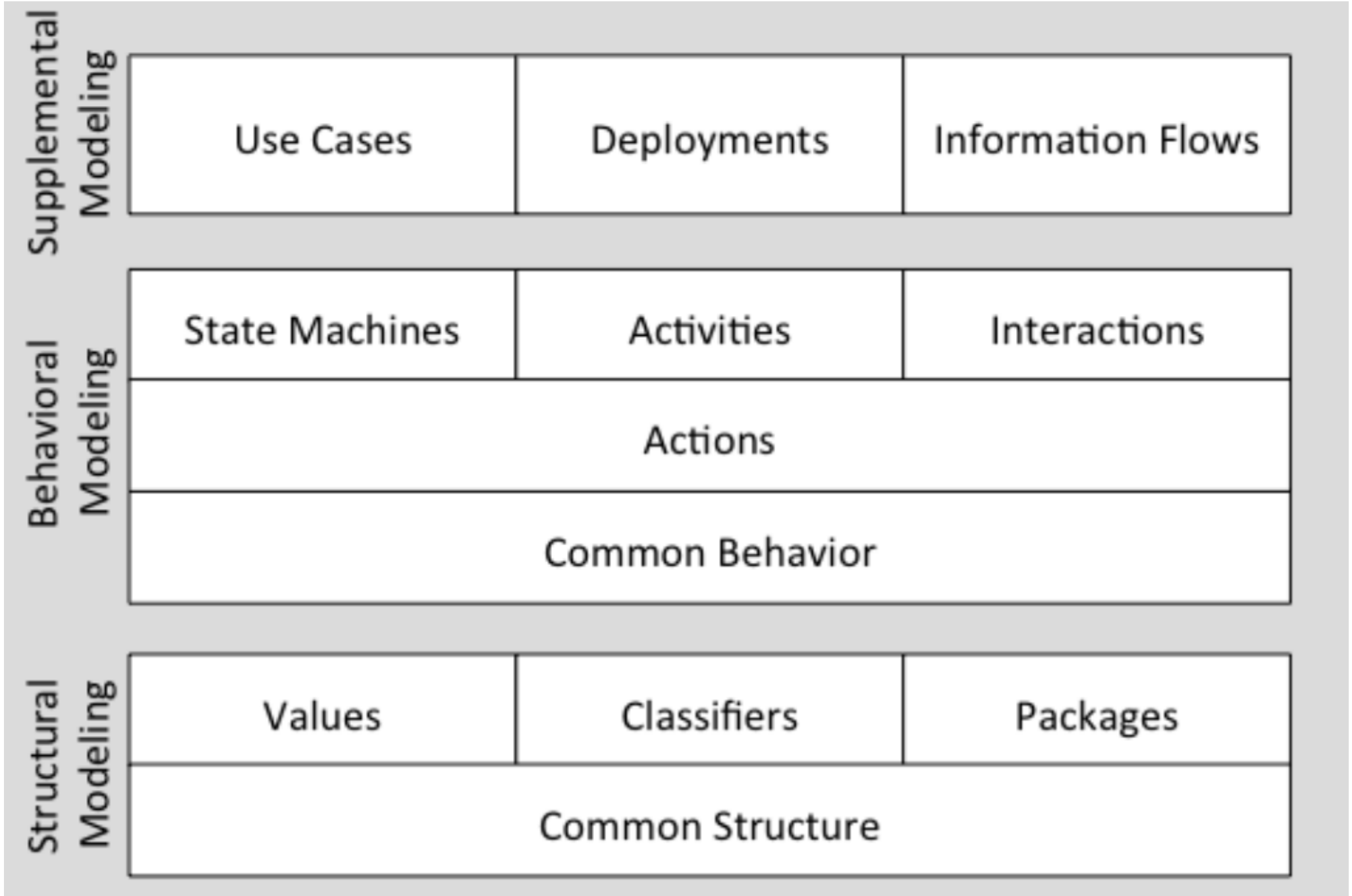
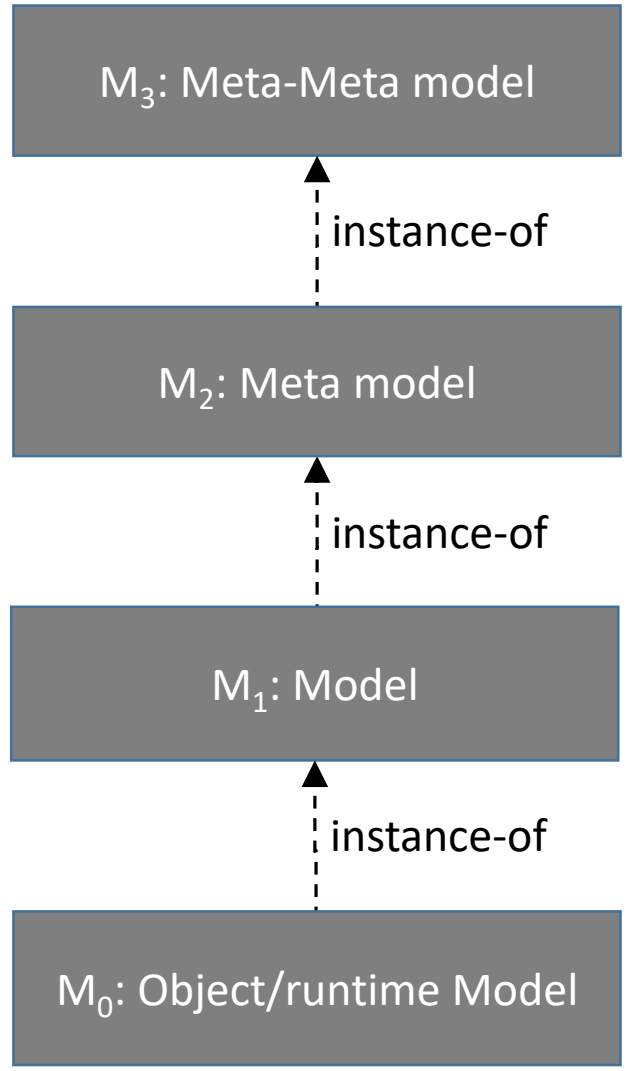

Supplemental Modeling
Use Cases
Deployments
Information Flows
Behavioral Modeling
State Machines
Activities
Interactions
Actions
Common Behavior
Structural Modeling
Values
Classifiers
Packages
Common Structure

UML, now with semantics!

- For a long period of time
  - UML was considered as “semantic free” (considered as a major flaw)
    - Until UML 2.4 its semantics was only described in prose
    - This assertion does not hold at all for UML 2.5
- Semantics of UML
  - Defined using an operational approach
  - Two normative documents
    - fUML defining the semantics of classes and activities
    - PSCS defining the semantics of composite structures
    - PSSM defining the semantics of behavior state-machines
  - Models build using classes, activities, composite structures and state-machines are by construction executables

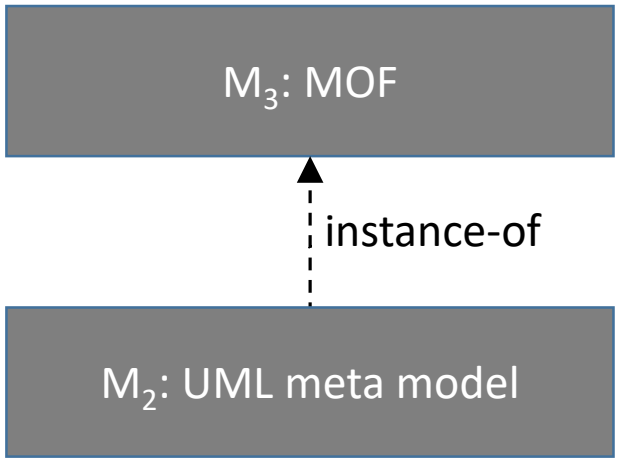
Meta-models and languages

- The elements of a model are defined in a meta-model, e.g. a Class in case of UML
- A model at M_n is instance of a M_{n+1} model
- Typical (design) models = M_1 models



UML Meta-models and languages

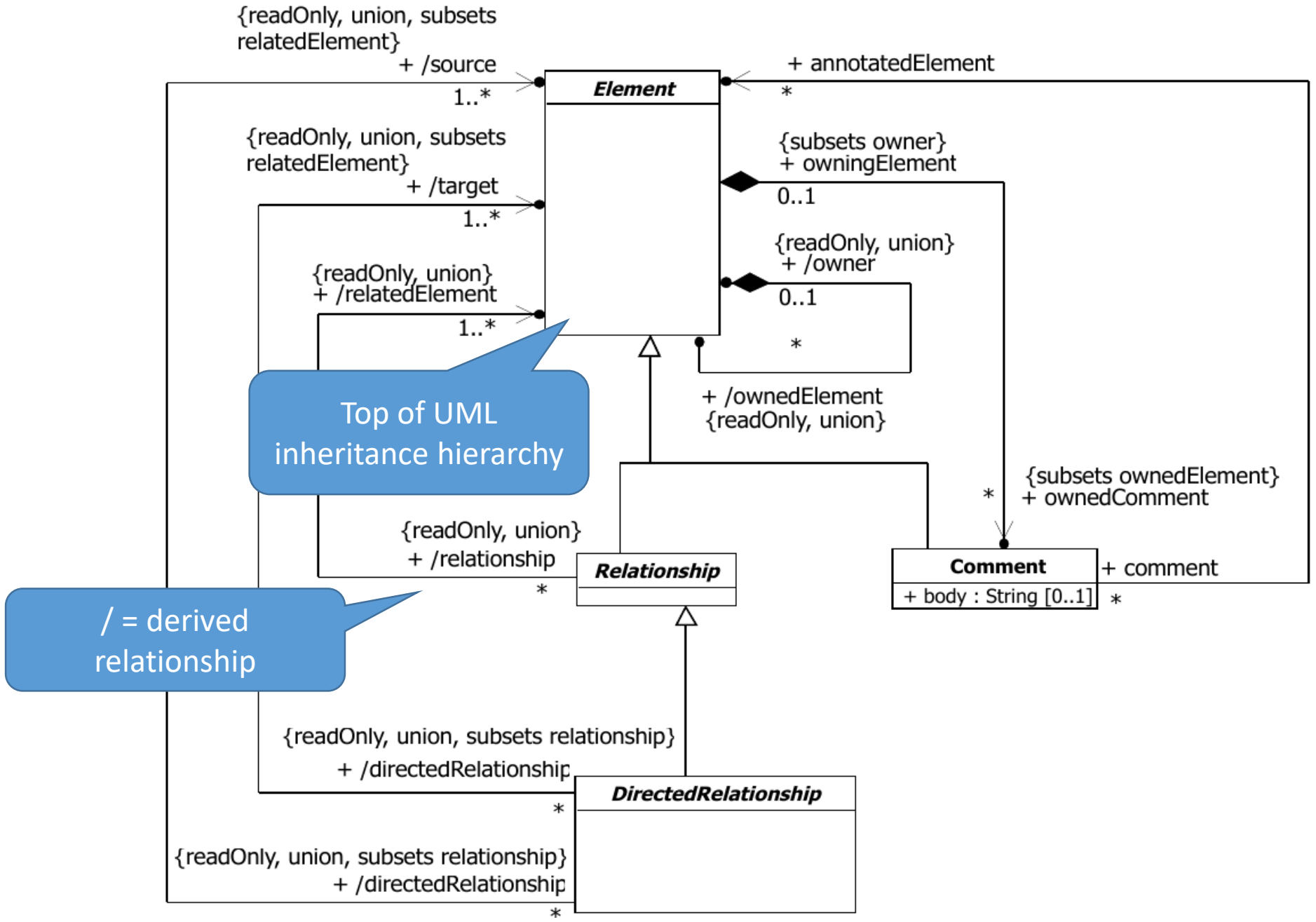
- Meta-Object facility (MOF, OMG standard)
  - Imports basic MM concepts from UML (Class, Property, Association, Generalization)
  - Specification becomes kind of recursive



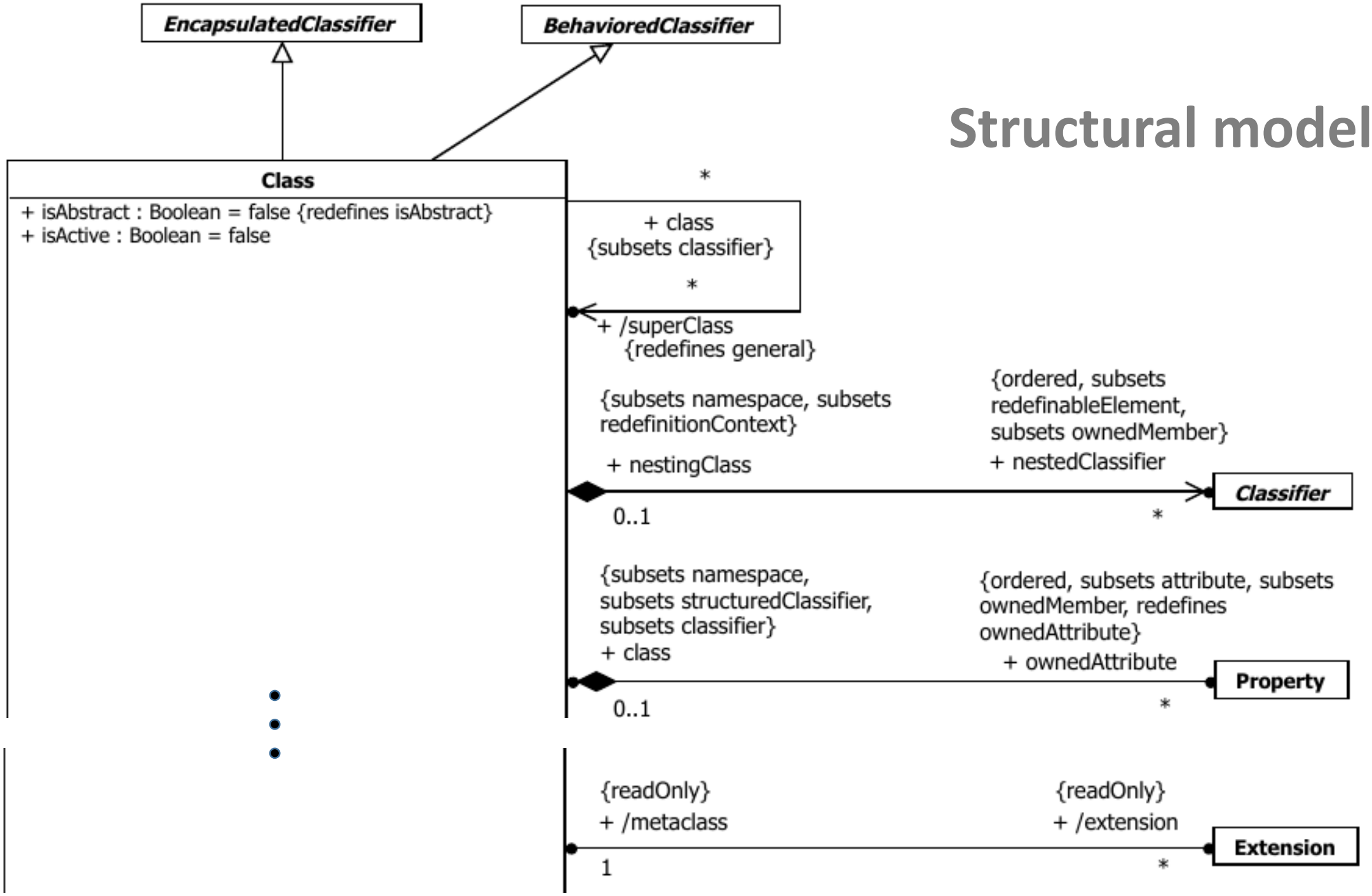
- UML-Meta-Model, 3 main parts
  - Common infrastructure
  - Structural modeling
  - Behavioral modeling

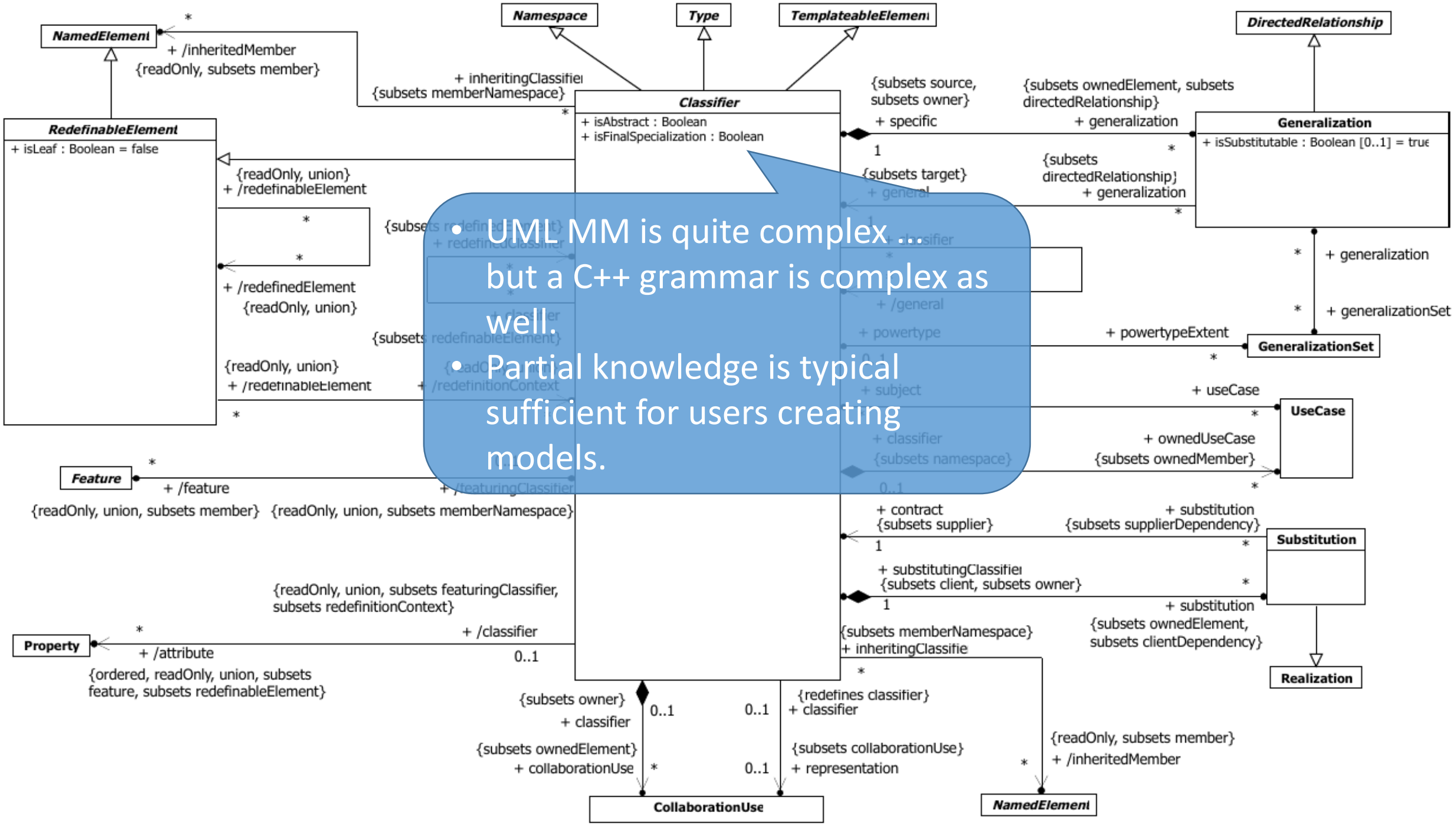
- Additional (OCL) constraints limit what can be “legally” modeled

Common structure



Structural modeling





- UML MM is quite complex ...
  but a C++ grammar is complex as well.
- Partial knowledge is typical sufficient for users creating models.

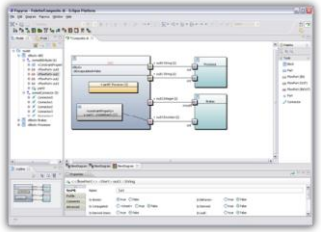
Meta-model implementations - Ecore

- Part of Eclipse Modeling Framework (EMF)
- Meta model for describing models and runtime support
  - Change notification,
  - Persistence support with default XMI serialization
  - A reflective API for manipulating generic EMF objects
- Ecore tools: Sirius (graphical tool)

Agenda

1. Modeling languages, motivation
2. UML, the software modeling language
3. Formalize models, meta-modeling
4. **Papyrus UML modeler (+ class and state-machine diagram)**
5. Model transformation, principles
6. Model transformation, languages

Papyrus UML modeler



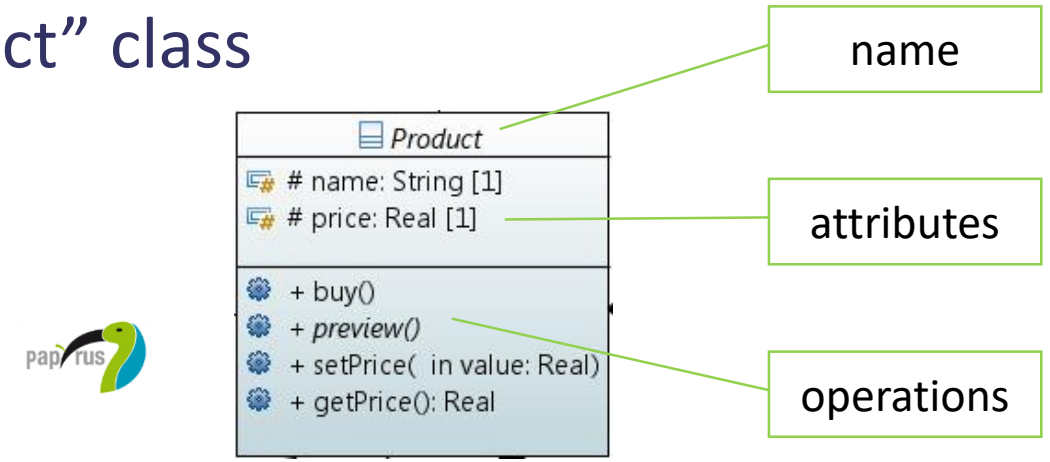
- Papyrus in a nutshell
  - Industrial-grade **open source** Model-Based Engineering tool
  - Part of the Eclipse release train
  - **Standard based** (OMG UML, MARTE, …)
  - Customizable to address domain-specific concerns
  - Multiple extensions exist (some shown later)

- Get started: https://www.eclipse.org/papyrus/

Classes and class diagrams

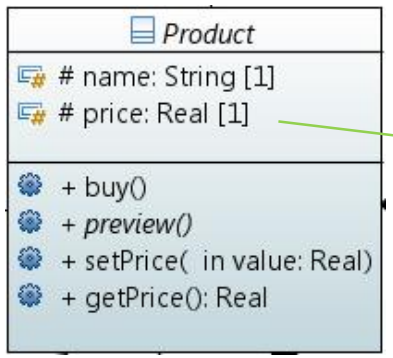
Overview

- Description of a set of objects with common semantics, features, and constraints
- Among features, a class has attributes and methods
- In UML, features are gathered within compartments: a class has a name, a compartment of attributes, and a compartment of operations
- Example: a “Product” class



Classes and class diagrams – attributes

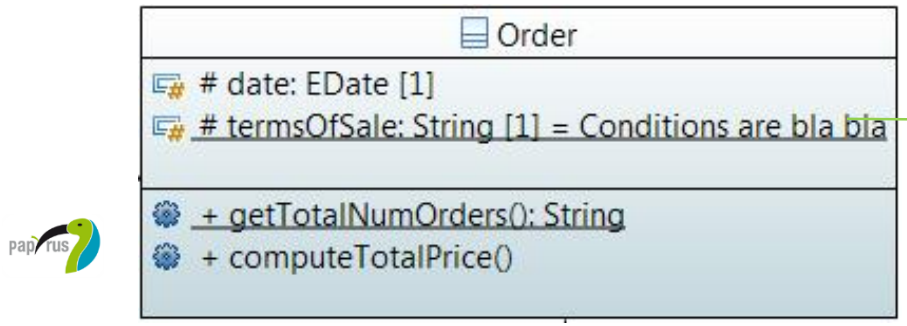
- An attribute describes data of the class when instantiated as an object
- Specification of an attribute
  - Visibility: constraint on the access of the attribute (more on this later)
  - Name
  - Type: class that the attribute instantiates at runtime
  - Multiplicity: cardinality, i.e. number of elements
    - Syntax: [lower..upper] (* means several, n..n is also noted n, 0..* is also noted *)
  - Default value
- In UML, an attribute is modeled with a Property element
- Example:



Visibility = protected
Name = price
Type = Real
Multiplicity = [1..1] ➔ [1]

Classes and class diagrams – static attributes

- An attribute takes value when the class is instantiated as an object…
- …unless the attribute is static
- A static attribute can be accessed without instantiating the class
- A static attribute has a visibility, multiplicity and type as well
- Example: “termsOfSale” is a static attribute since we want to access it without having to instantiate any “Order”

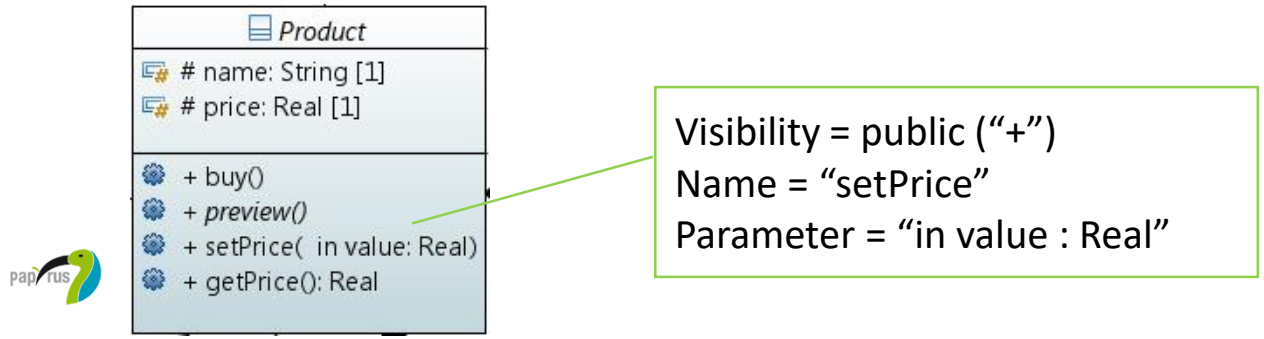


Static attribute with default string value (underlined)

Classes and class diagrams – operations

- A class has methods with signature and body
- In UML, an operation is the specification of a method, i.e. the method signature, independently of its implementation
- In UML, the word “method” is used to designate an implementation of an operation, i.e. the body of a method in a class
- Specification of an operation
  - Visibility
  - Name
  - Parameters: name, direction (in, out, inout, return), type, multiplicity, default value
- Example

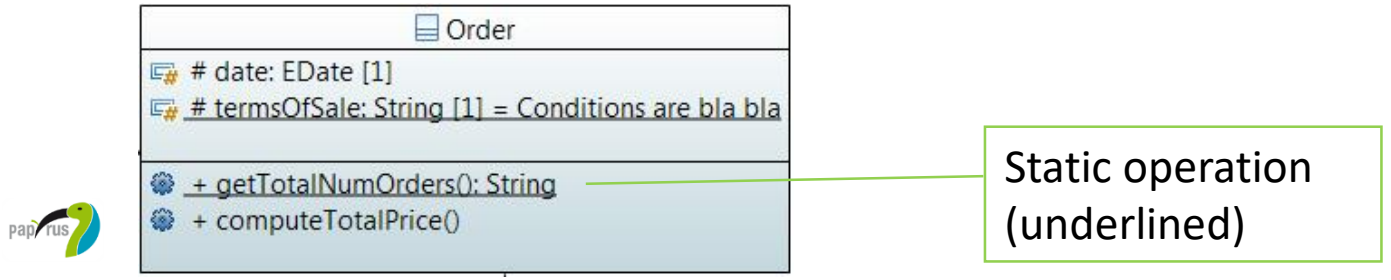
Careful, the same “method” word in UML and OOP do not designate the same things. Yes this can be confusing…



Visibility = public (“+”)
Name = “setPrice”
Parameter = “in value : Real”

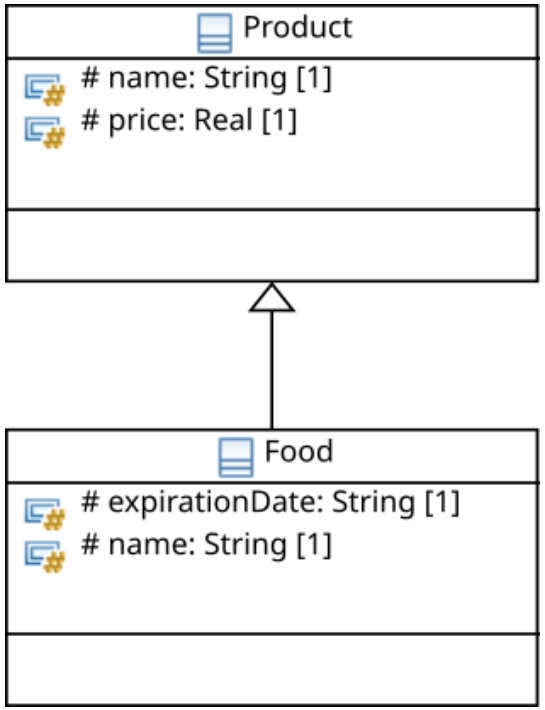
Classes and class diagrams – static operations

- Usually an operation is accessed from the object instantiating the class…
- … unless the operation is static
- A static operation can be accessed without instantiating the class
- Example: “getTotalNumOrders” is a static operation since we want to access the total number of orders without instantiating an “Order”



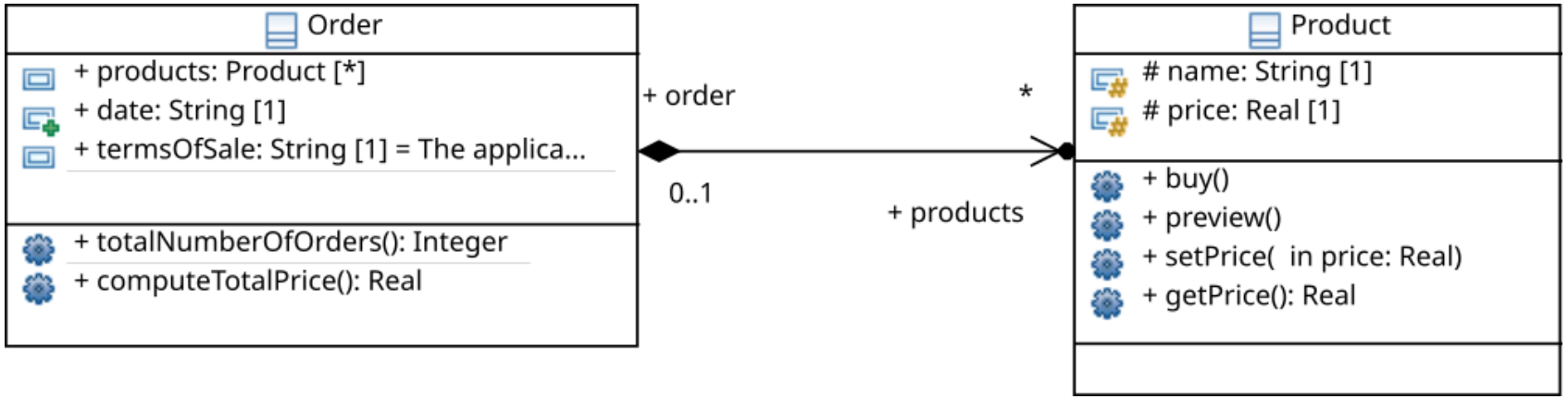
Inheritance / Generalization

- A class might inherit from another
- Notation uses hollow arrow
- **Optionally** show inherited features (Feature is a superclass of Operation and Property in the UML MM)



Association

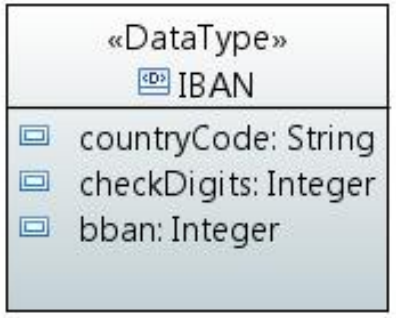
- Link between two classes
- Two ends, can be directed, multiplicity as for properties
- Aggregation kind: none, shared and composition



Data Types

Overview

- A class can type attributes, i.e. the attribute is an instance of the class at runtime
- DataType is similar to a class; it is typically used to represent value types of a certain domain, or primitives, or structured types
- Instances of a data type are identified by the values of the attributes
- Example: “IBAN” is a structured type, defined by a country code, check digits, and a BBAN



Data Types

PrimitiveType

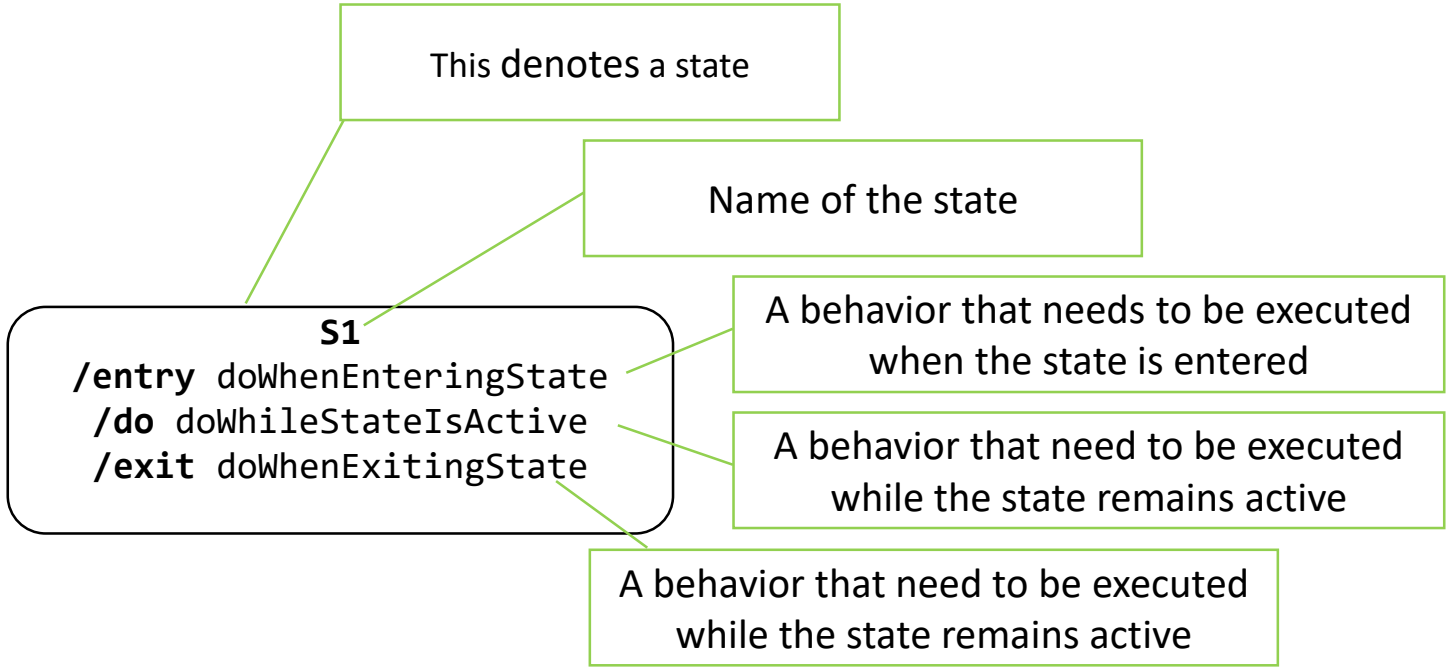
- An atomic data type, i.e. without structure
- UML primitive types: Boolean, Integer, UnlimitedNatural, String, Real
- Example:

Enumeration

- Data type whose values are enumerated as user-defined enumeration literals
- Example:

State – Simple state

- "A state models a situation during which some invariant condition holds"

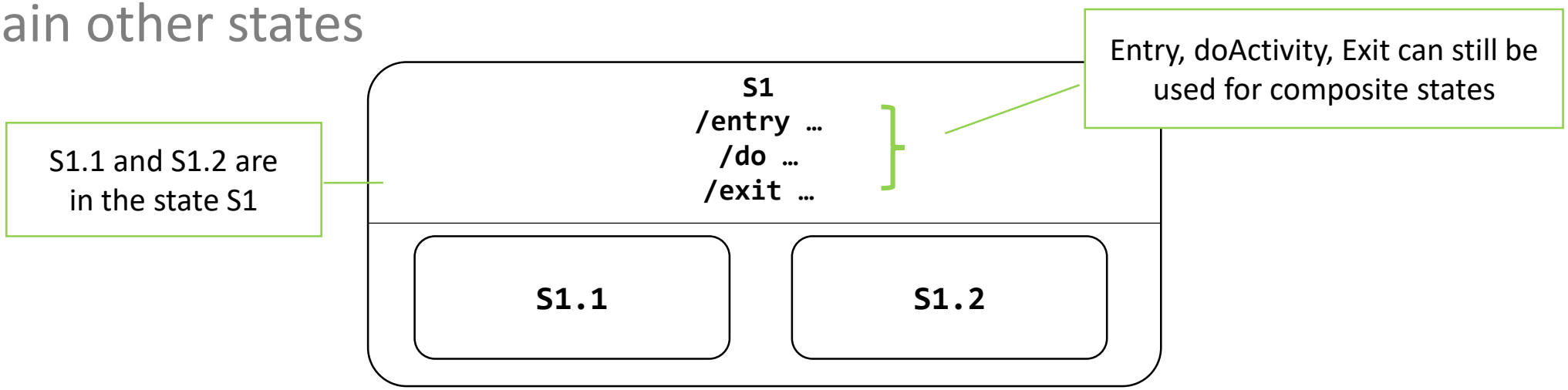


- Example: an order can be Payed, Confirmed, Packed, Cancelled,…

Payment was done and confirmation of the order was sent to the client

State – Composite state

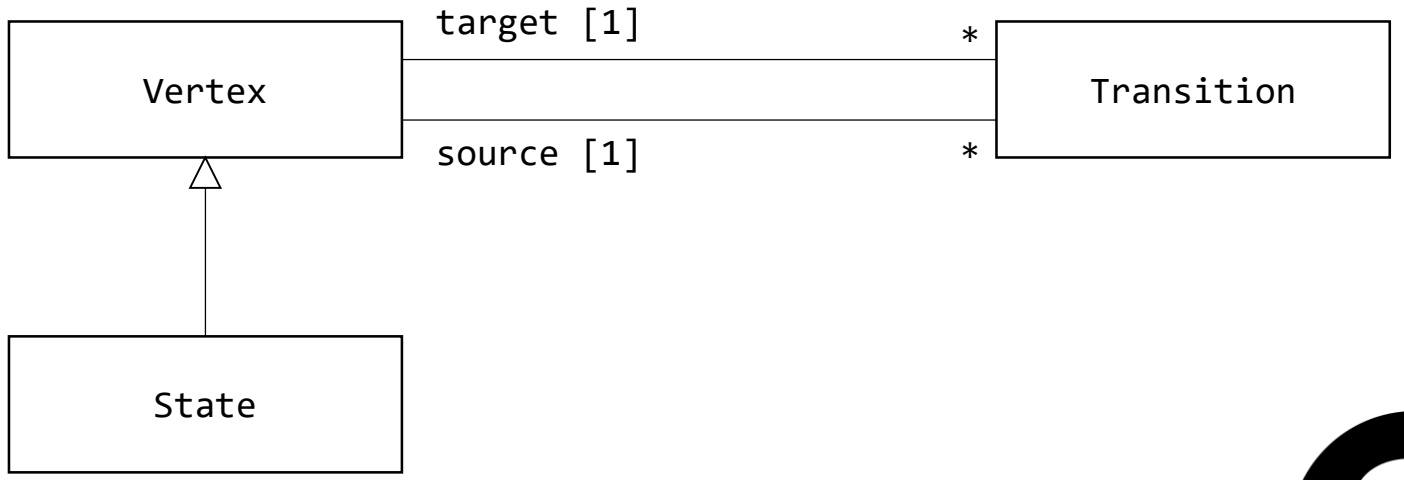
- In addition to what is possible with a simple state, a composite state can contain other states



- If S1 is active that means one of the states included in S1 is also active (e.g., situation where S1 is active as well as S1.1).
- Example: An order can be in the process of being Finalized. This process usually includes the payment and the sending of a confirmation of the order. Therefore Finalized can contain both Payed and Confirmed.

Until now

- We talked about states (simple and composite)
- What is missing here to complete simple state-machines?
  - How do we move from a source state to a target state ?



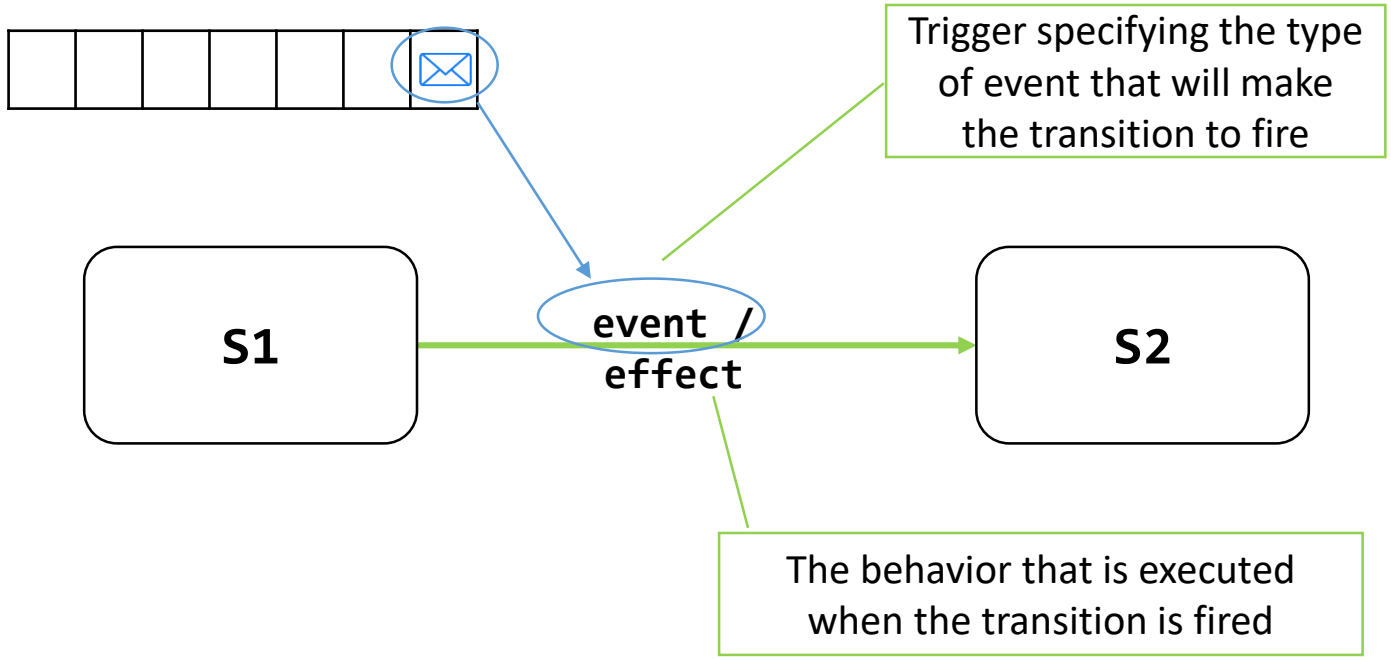
Transition – Completion transition

- A transition is an edge between one source vertex and one target vertex
  - Note: both source and target can be the same
- It denotes part of a path that can be followed during the execution of step of a state-machine.

- Completion transition: There is no constraint(s) to fire this transition. It can be fired immediately after S1 was exited.

Transition – Triggers and Effects

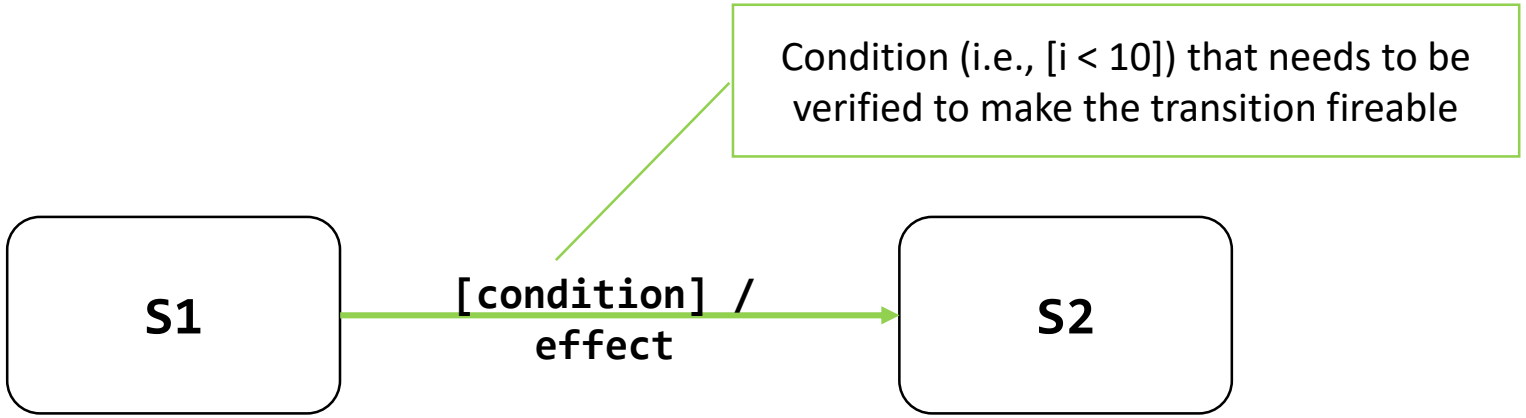
- Can be triggered
  - Fires when a specific event is available (Time, Signal, Call)



- Note: A single transition can specify multiple triggers (i.e. it can fire upon the arrival of many different events)

Transition – Guarded Transition

- Can be guarded
  - Fires when a the condition placed on the guard is verified

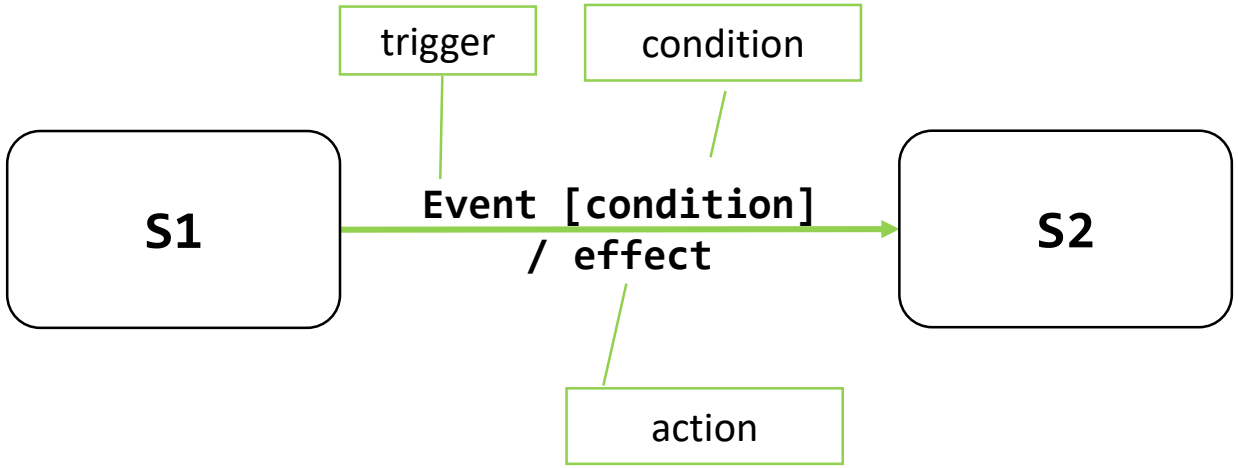


- Note: guards are specified using UML constraints which in turn contain an expression
  - Makes specification unnecessary complex, could directly use expression

Transition – Guarded and Triggered transition

Transition

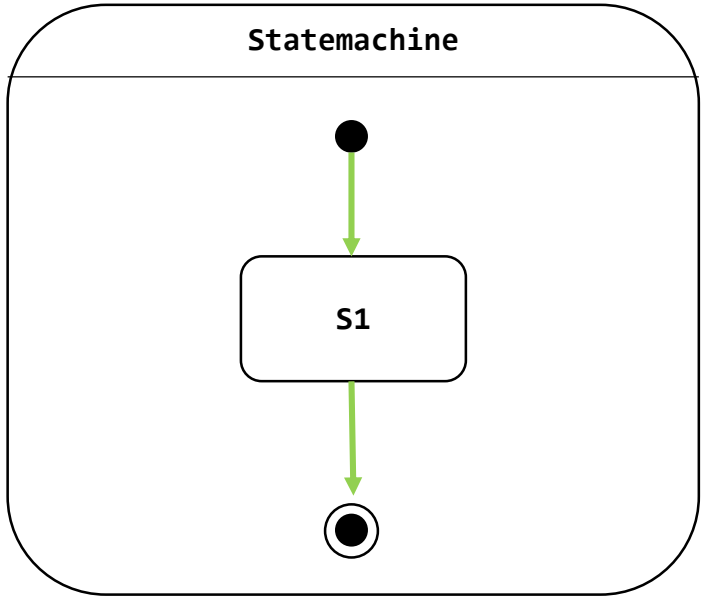
- Can be guarded and triggered
  - Fires when a specific event is available and the condition specified holds

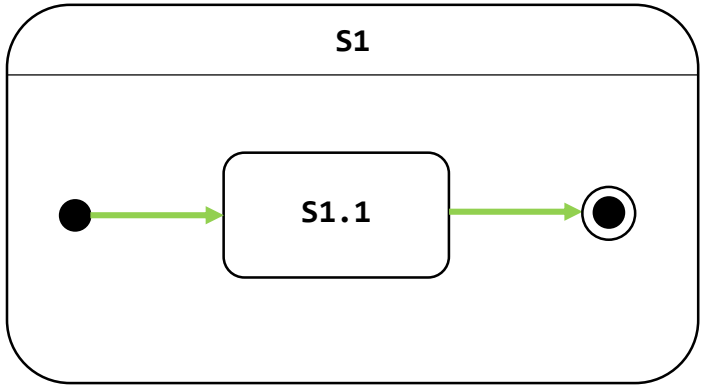


Initial and final pseudo state

- Initial state ●
  - Define the starting point of a state-machine
  - Define the starting point of a behavior owned by a composite state

- Final state ◉
  - Specialization of a state
  - Define the end point of a state-machine
  - Define the end point of a set of states owned by a composite state





Example State-machine diagram