

AMSS Lecture 9: The UML Meta-Model & Profile Diagrams

Traian-Florin Șerbănuță

2025

Agenda

Goal

Understand the UML meta-model and how **Profiles** extend/customize it.

The UML Meta-Model

- ▶ UML Meta-Model Basics
- ▶ Meta-Model Architecture (MOF layers)
- ▶ How UML Constructs Are Defined

Profile Diagrams

- ▶ Profiles as Meta-Model Customization

The UML Meta-Model

1. What Is a Meta-Model?

- ▶ A *model* represents a real-world system.
- ▶ A *meta-model* defines the **rules for building models**.
- ▶ UML itself is not just a set of diagrams — it is a **modeling language** defined by a meta-model.

Key idea

The UML meta-model defines:

- ▶ What a *Class*, *Attribute*, *Operation*, *Association* are
- ▶ How they relate
- ▶ What diagrams can contain

Model-Driven Architecture (MDA)

MDA is a software development approach defined by the Object Management Group (OMG)

- ▶ Focuses on creating and transforming models rather than writing code directly
- ▶ Separates business logic from platform-specific implementation
- ▶ Supports automation:
models → transformations → generated code

Key MDA Model Types

- CIM** Computation-Independent Model
(business/domain understanding)
- PIM** Platform-Independent Model
(logic without tech details)
- PSM** Platform-Specific Model
(technology-bound design)

Examples of MDA Languages / Modeling Standards

UML Unified Modeling Language
(primary MDA modeling language)

MOF Meta-Object Facility
(meta-modeling framework)

QVT Query/View/Transformation
(model transformation language)

OCL Object Constraint Language
(add constraints to models)

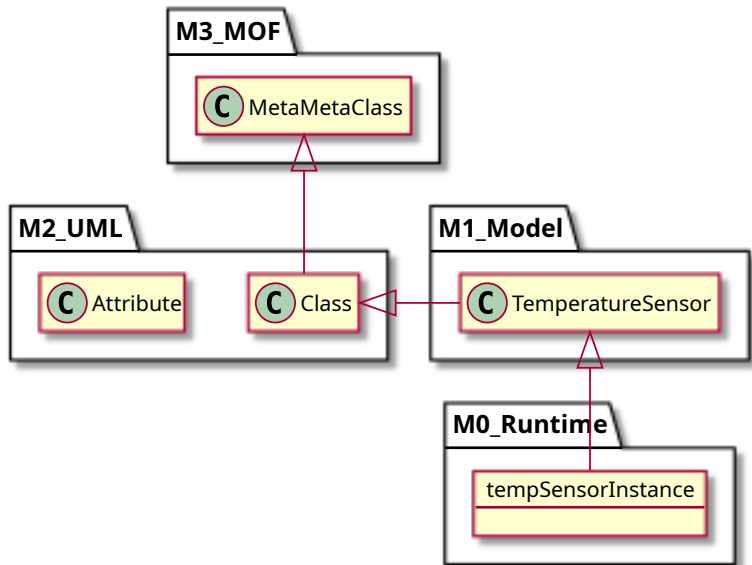
XMI XML Metadata Interchange
(model serialization/exchange format)

2. The Meta-Object Facility (MOF) Architecture

UML is defined using a 4-layer meta-model architecture:

Layer	Meaning	Example
M3	Meta-meta-model	MOF defining UML's structure
M2	Meta-model	UML specification (classes, states, components...)
M1	Model	Your diagrams (class diagrams, state diagrams...)
M0	Runtime	Real objects in the running system

MOF Visualization (as a Package Diagram)



Meta-Object Facility (MOF) in More Detail

- ▶ MOF is an Object Management Group (OMG) standard
- ▶ Defines how meta-models are built
- ▶ UML, SysML, BPMN meta-models are all built using MOF
- ▶ Enables interoperability between modeling tools

Key MOF Concepts

Classes Meta-classes used to define modeling concepts (e.g., UML Class)

Properties Define attributes and relationships in the meta-model

Packages Group meta-model elements

Associations Link meta-classes together

MOF Variants

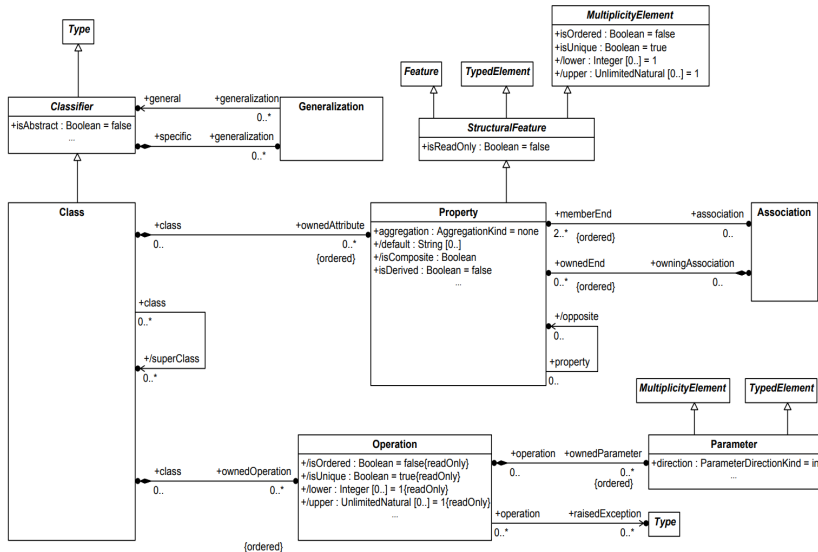
Essential MOF (EMOF)

- ▶ A simplified subset of MOF
- ▶ Used for simple DSLs, transformation systems
 - ▶ Many DSLs (Domain-Specific Languages) use EMOF for simplicity

Complete MOF (CMOF)

- ▶ Offers the full expressive power of MOF
 - ▶ UML is defined in CMOF

3. Essential MOF (EMOF) classes



Profiles and Profile diagrams

4. Profiles and Stereotypes (10 minutes)

Profiles are **lightweight extensions** to the UML meta-model

- ▶ Add domain-specific concepts
- ▶ Add constraints
- ▶ Specialize existing UML meta-model elements
 - ▶ without modifying UML itself

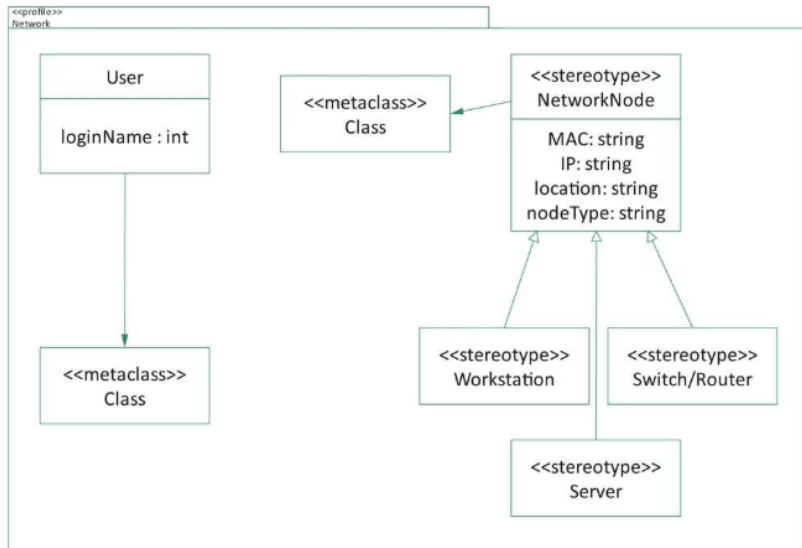
Stereotypes extend UML elements

- ▶ Add tagged values
- ▶ Add constraints
- ▶ Add semantics

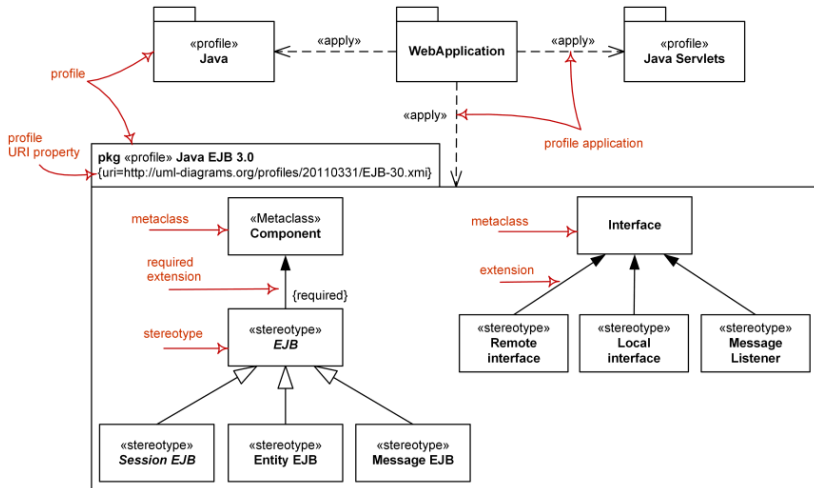
5. Profile Diagrams

Define UML *extensions* for domain-specific modeling.

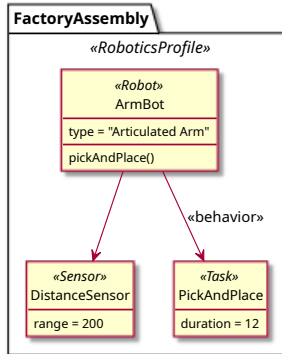
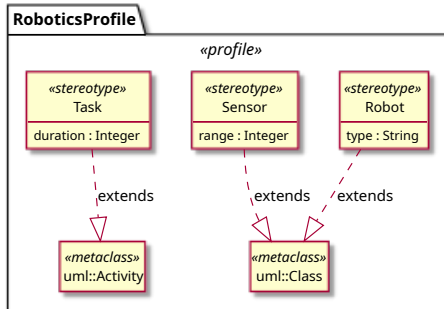
- custom stereotypes, tagged values, and constraints.



5. Profile Diagram example



A profile diagram and a DSL model using it



Why Profiles instead of modifying the UML meta-model?

- ▶ Profiles keep UML standard-compliant
- ▶ Tool-friendly
- ▶ Tailored for specific domains (IoT, automotive, medical, cloud, finance)

Examples:

- ▶ SysML = UML Profile
- ▶ MARTE (real-time systems) = UML Profile

Interactive exercise (Secure Web Services profile)

Create a UML Profile Diagram that extends UML to better describe security characteristics of web-service components.

Tasks

1. Create a WebSecurity profile
2. Add stereotypes
 - a. SecureComponent extends Component with encryption and CA tags
 - b. SensitiveData extends Class with a dataCategory tag
 - c. AuthRequired extends Operation with authLevel tag
3. Add at least one constraint
 - ▶ e.g., SensitiveData must have at least one private attribute

Summary

- ▶ UML is defined by a **meta-model** (M2 layer) using MOF (M3 layer)
- ▶ Your diagrams are **models** (M1), representing real objects (M0)
- ▶ Profiles customize UML **without altering the meta-model**
- ▶ Stereotypes add domain semantics and constraints
- ▶ Profiles are essential for domain-specific modeling (e.g., SysML)