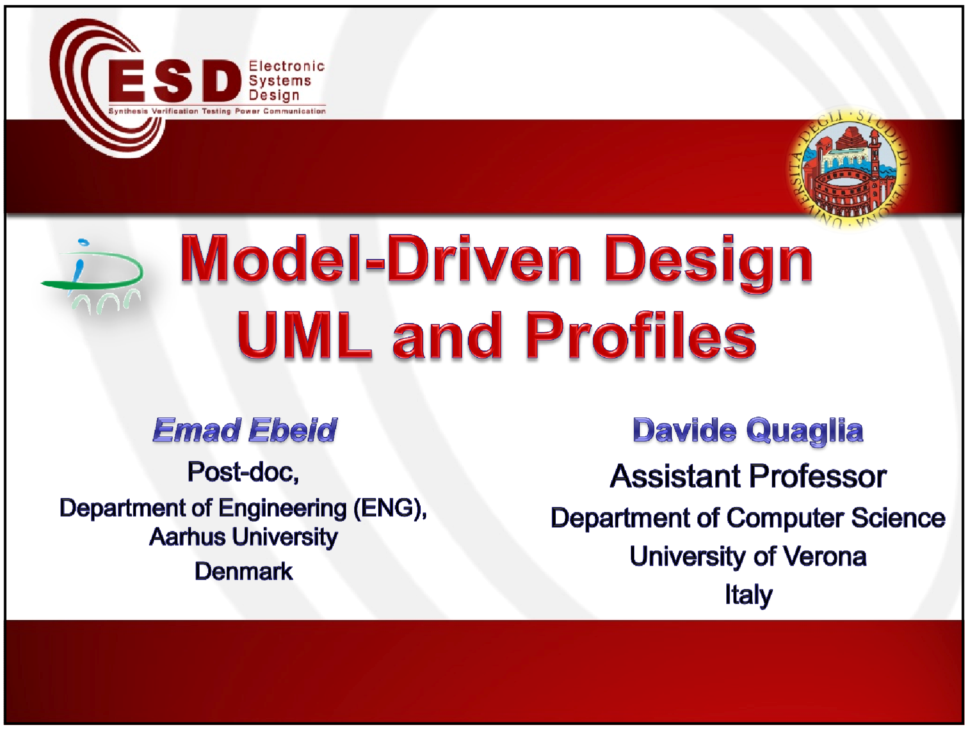

Model-Driven Design UML and Profiles

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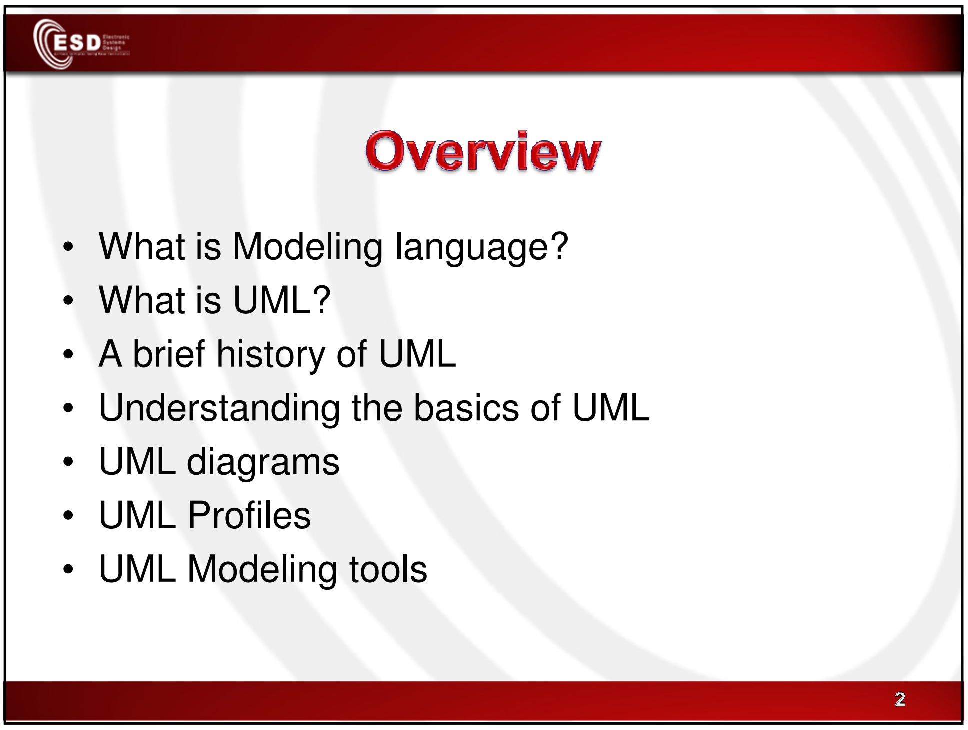
Department of Computer Science
University of Verona
Italy



Overview

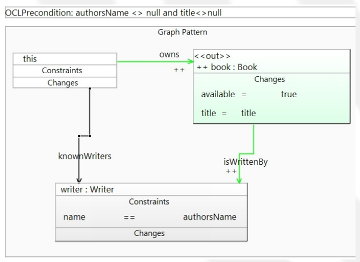
- What is Modeling language?
- What is UML?
- A brief history of UML
- Understanding the basics of UML
- UML diagrams
- UML Profiles
- UML Modeling tools

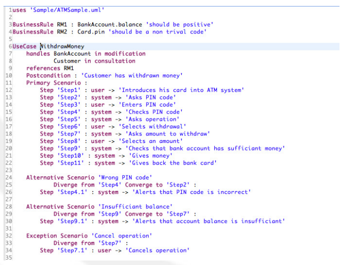
2

What is Modeling language?

A modeling language is any artificial language that can be used to express *information*, *knowledge* or *systems* in a structure that is defined by a consistent set of rules. The rules are used for the understanding of the meaning of components in the structure

- A modeling language can be graphical or textual



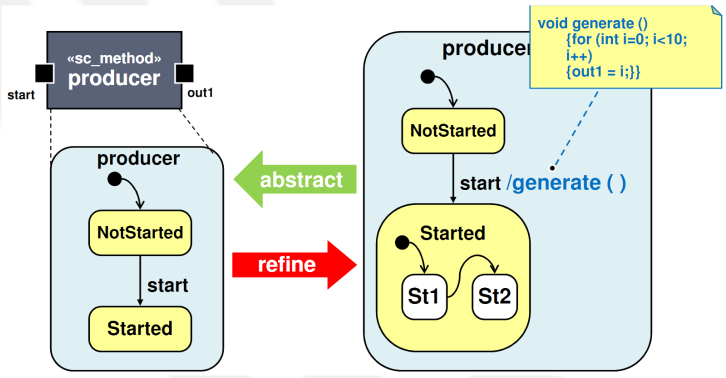


```
uses 'Sample/ATMSample.uml'

BusinessRule RM1 : BankAccount.balance 'should be positive'
BusinessRule RM2 : Card.pin 'should be a non trival code'

UseCase WithdrawMoney
    handles BankAccount in modification
            Customer in consultation
    references RM1
    Postcondition : 'Customer has withdrawn money'
    Primary Scenario :
        Step 'Step1' : user -> 'Introduces his card into ATM system'
        Step 'Step2' : system -> 'Asks PIN code'
        Step 'Step3' : user -> 'Enters PIN code'
        Step 'Step4' : system -> 'Checks PIN code'
        Step 'Step5' : system -> 'Asks operation'
        Step 'Step6' : user -> 'Selects withdrawal'
        Step 'Step7' : system -> 'Asks amount to withdraw'
        Step 'Step8' : user -> 'Selects an amount'
        Step 'Step9' : system -> 'Checks that bank account has sufficiant money'
        Step 'Step10' : system -> 'Gives money'
        Step 'Step11' : system -> 'Gives back the bank card'

    Alternative Scenario 'Wrong PIN code'
            Diverge from 'Step4' Converge to 'Step2' :
        Step 'Step4.1' : system -> 'Alerts that PIN code is incorrect'

    Alternative Scenario 'Insufficiant balance'
            Diverge from 'Step9' Converge to 'Step7' :
        Step 'Step9.1' : system -> 'Alerts that account balance is insufficiant'

    Exception Scenario 'Cancel operation'
            Diverge from 'Step7' :
        Step 'Step7.1' : user -> 'Cancels operation'
```

3

Model-Driven Design

- Models can be refined continuously until the application is fully specified



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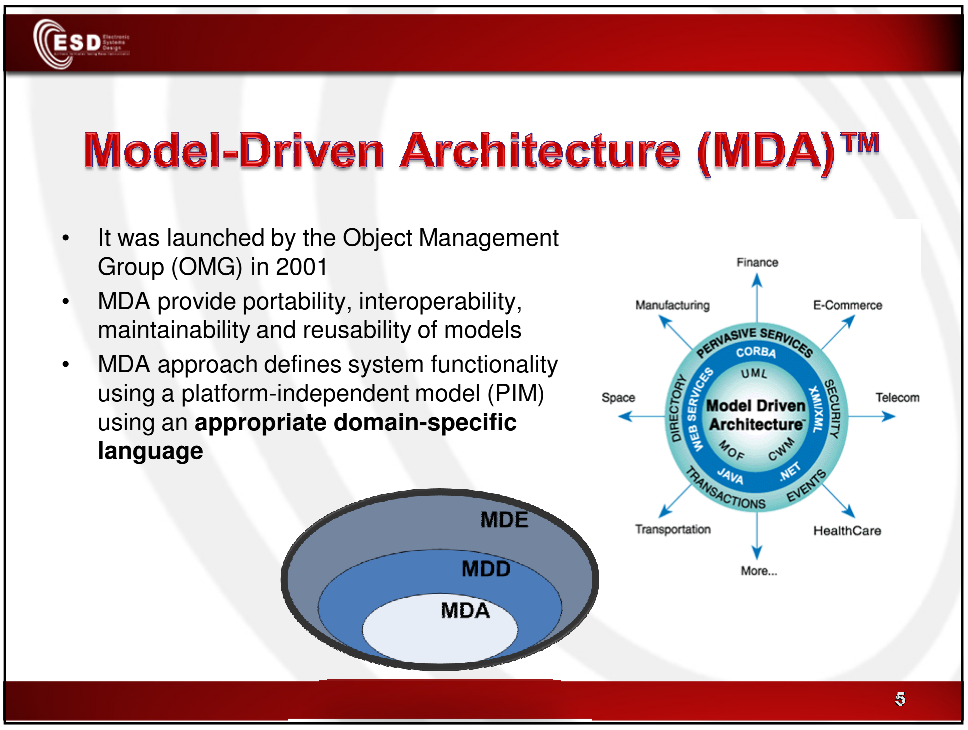
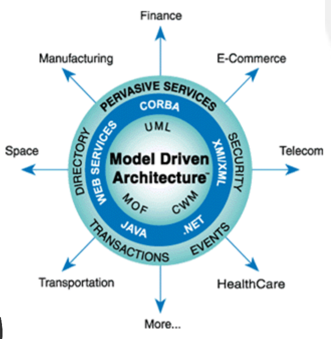
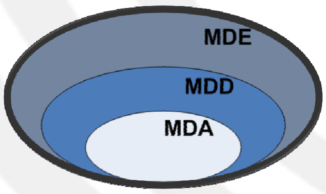


Model-Driven Architecture (MDA)™

- It was launched by the Object Management Group (OMG) in 2001
- MDA provide portability, interoperability, maintainability and reusability of models
- MDA approach defines system functionality using a platform-independent model (PIM) using an **appropriate domain-specific language**





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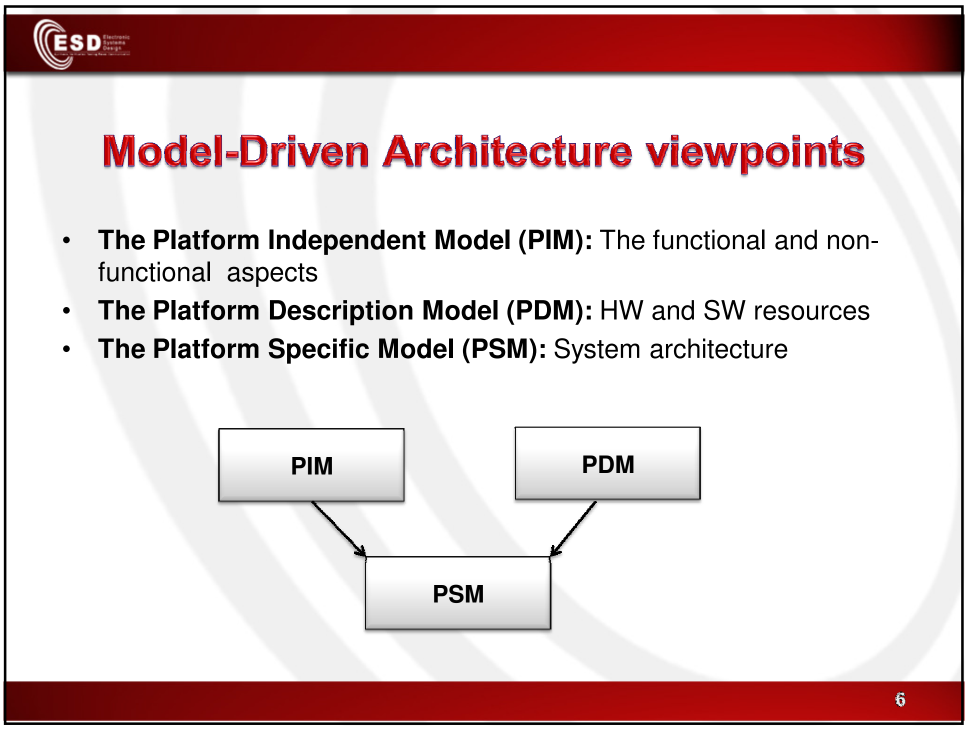
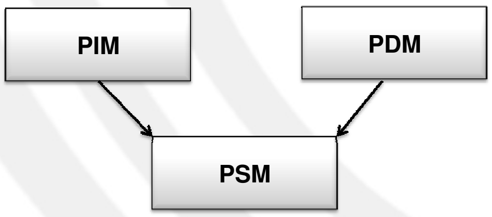


Model-Driven Architecture viewpoints

- **The Platform Independent Model (PIM):** The functional and non-functional aspects
- **The Platform Description Model (PDM):** HW and SW resources
- **The Platform Specific Model (PSM):** System architecture



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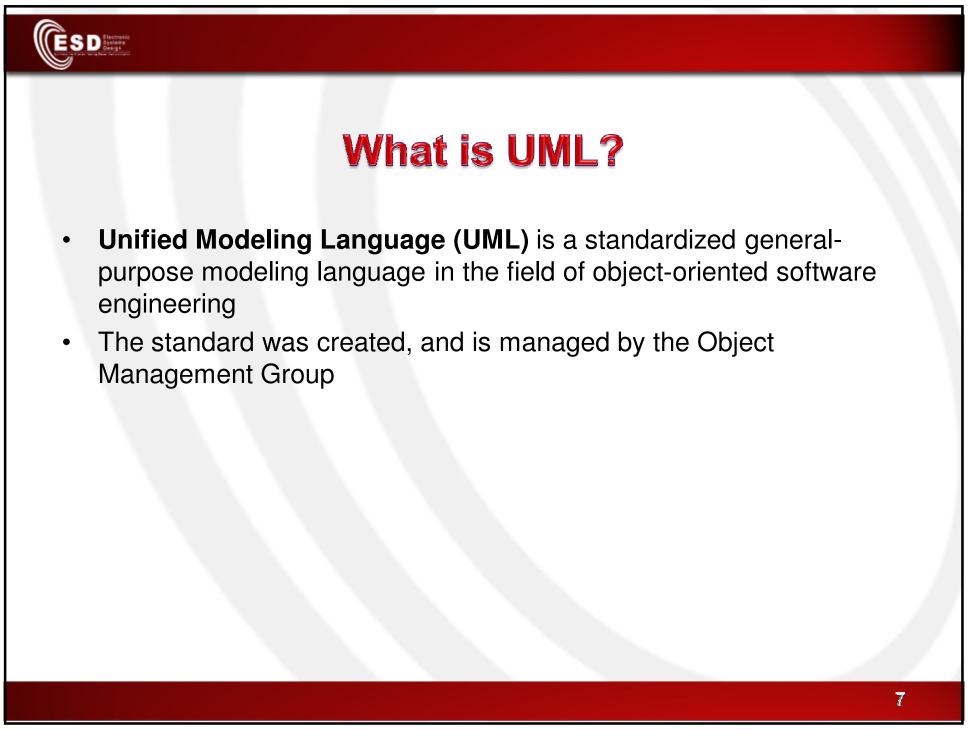
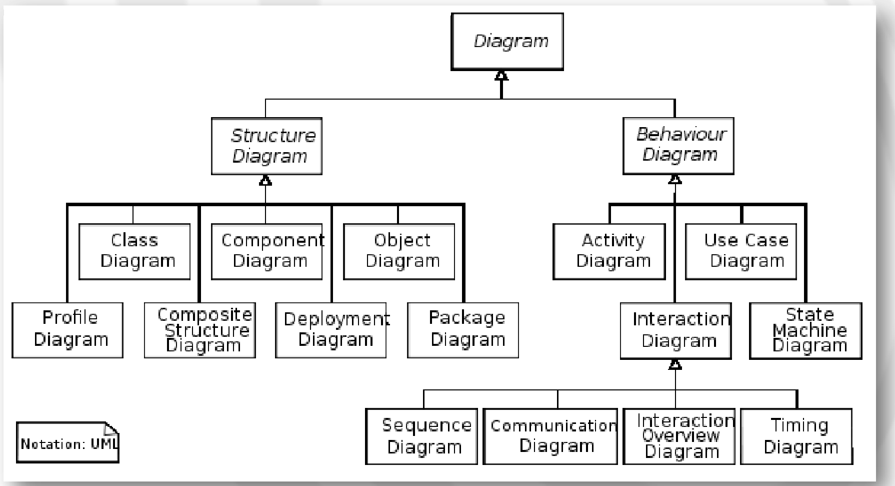


What is UML?

- **Unified Modeling Language (UML)** is a standardized general-purpose modeling language in the field of object-oriented software engineering
- The standard was created, and is managed by the Object Management Group

7

UML diagrams



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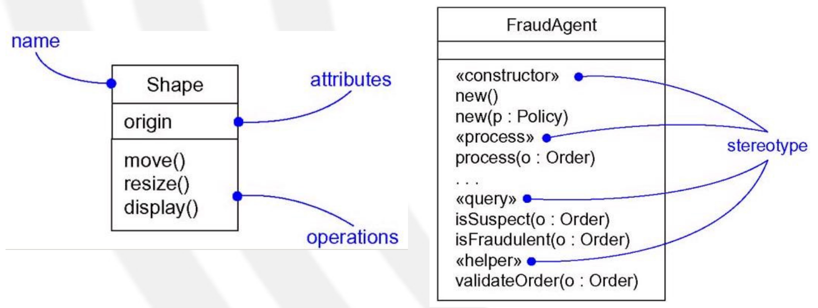
Why UML for Modeling

- Use graphical notation to communicate more clearly than natural language (imprecise) and code(too detailed)
- Help acquire an overall view of a system
- UML is *not* dependent on any one language or technology
- UML moves us from fragmentation to standardization

9

Class Diagram



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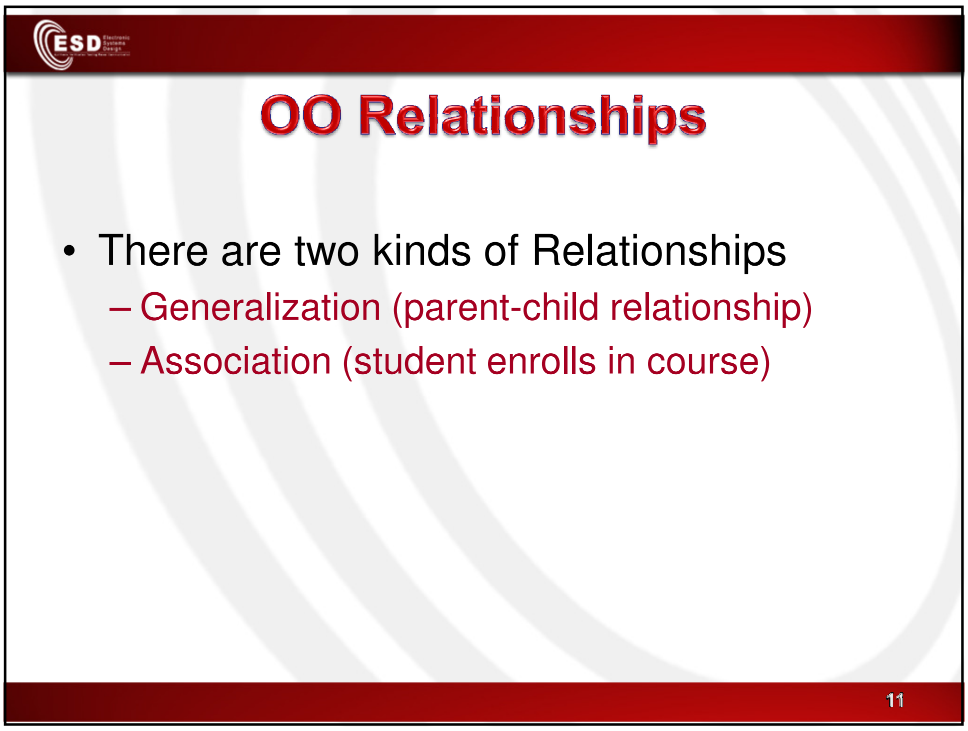
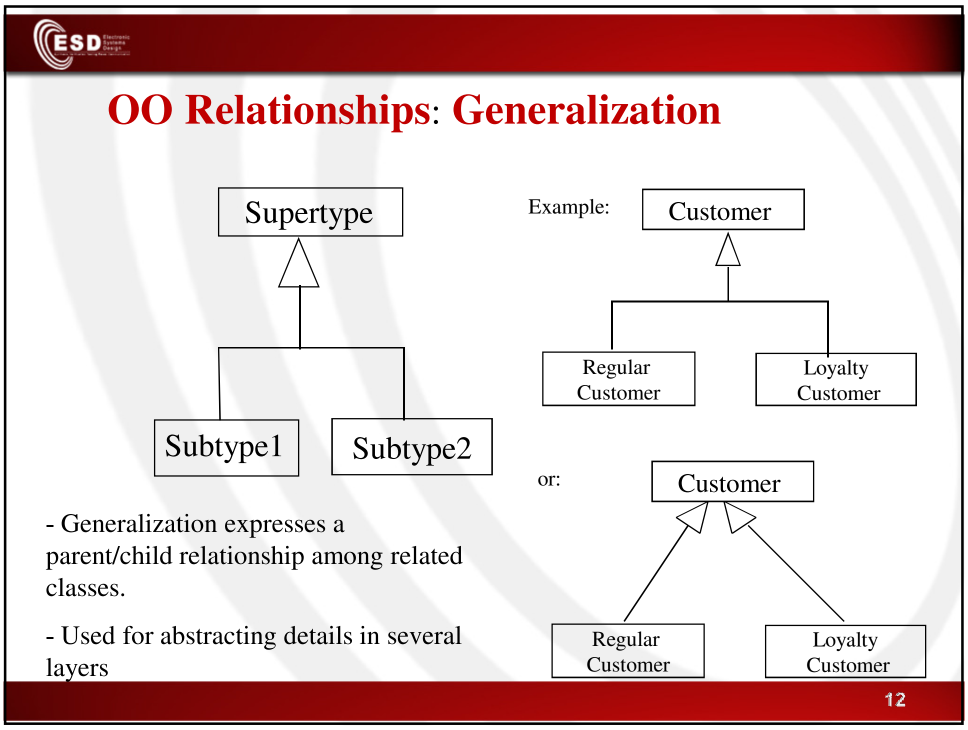


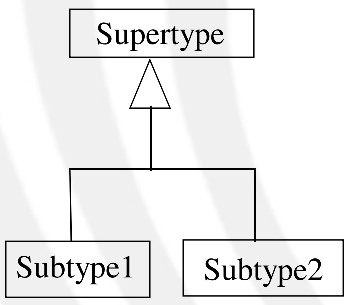
OO Relationships

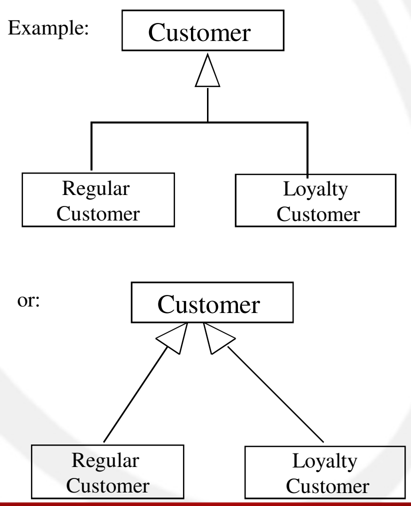
- There are two kinds of Relationships
  - Generalization (parent-child relationship)
  - Association (student enrolls in course)

11



OO Relationships: Generalization

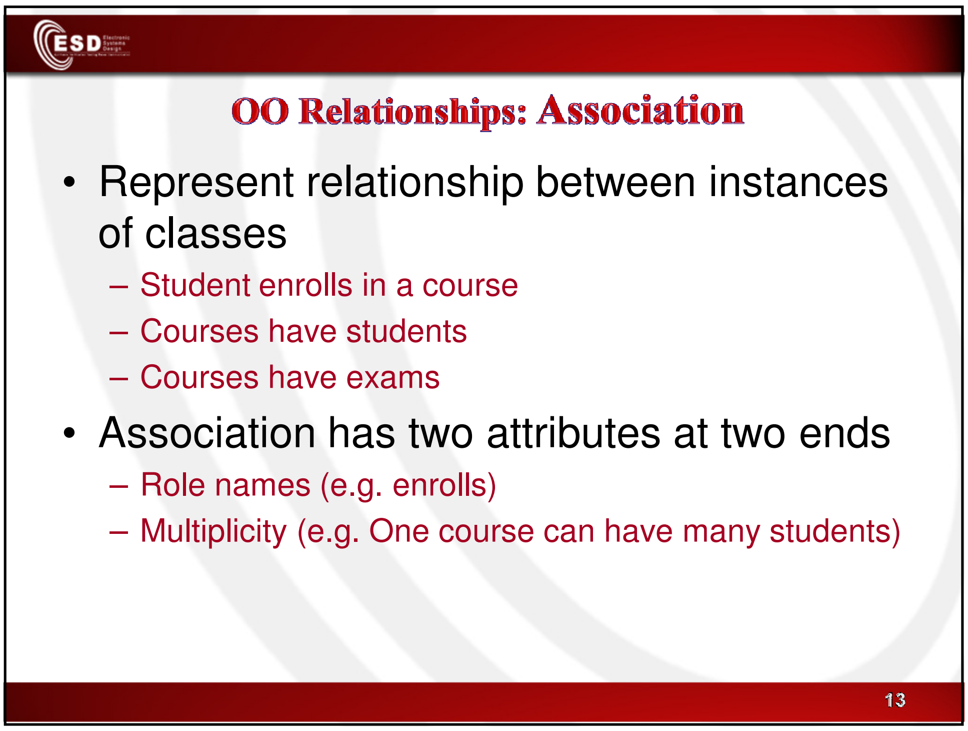




- Generalization expresses a parent/child relationship among related classes.

- Used for abstracting details in several layers

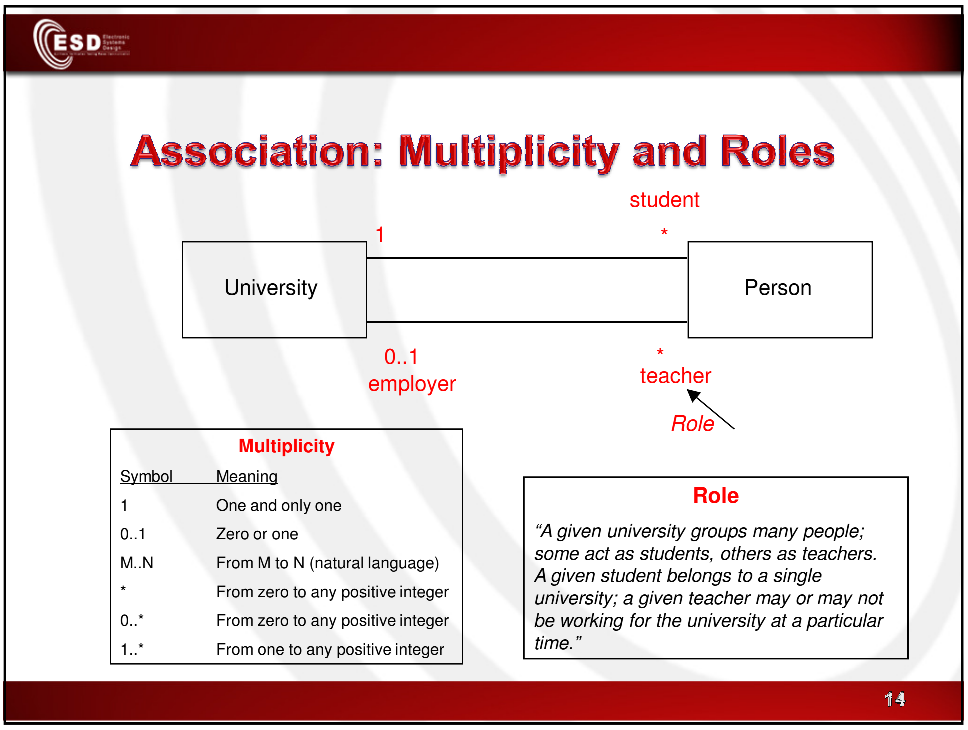
12



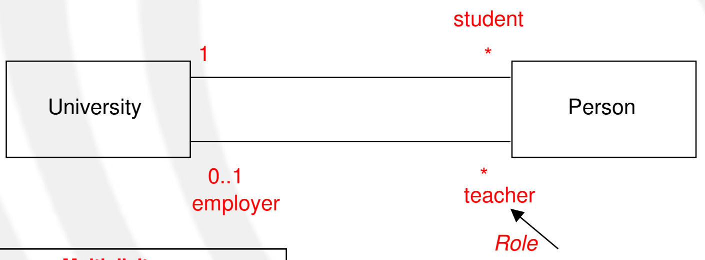
OO Relationships: Association

- Represent relationship between instances of classes
  - Student enrolls in a course
  - Courses have students
  - Courses have exams
- Association has two attributes at two ends
  - Role names (e.g. enrolls)
  - Multiplicity (e.g. One course can have many students)

13



Association: Multiplicity and Roles



Multiplicity

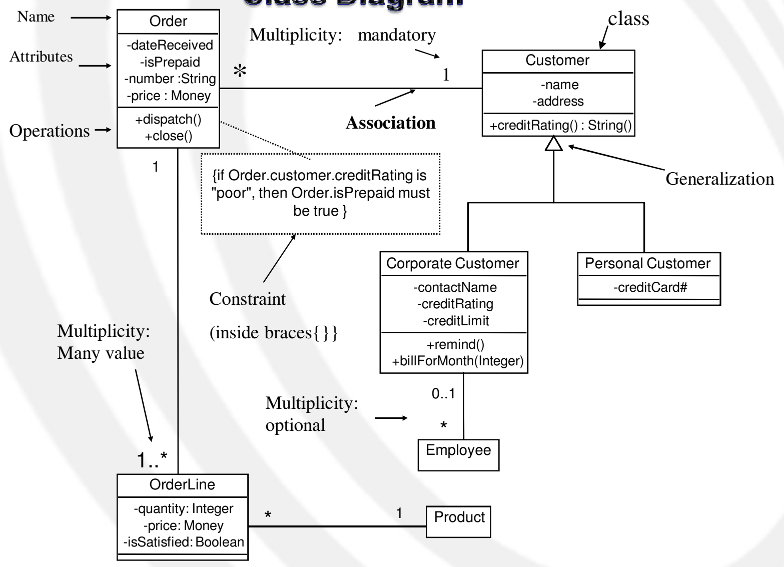
Symbol	Meaning
1	One and only one
0..1	Zero or one
M..N	From M to N (natural language)
*	From zero to any positive integer
0..*	From zero to any positive integer
1..*	From one to any positive integer

Role

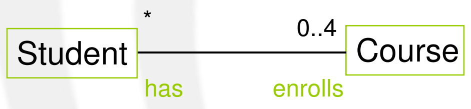
"A given university groups many people; some act as students, others as teachers. A given student belongs to a single university; a given teacher may or may not be working for the university at a particular time."

14

Class Diagram

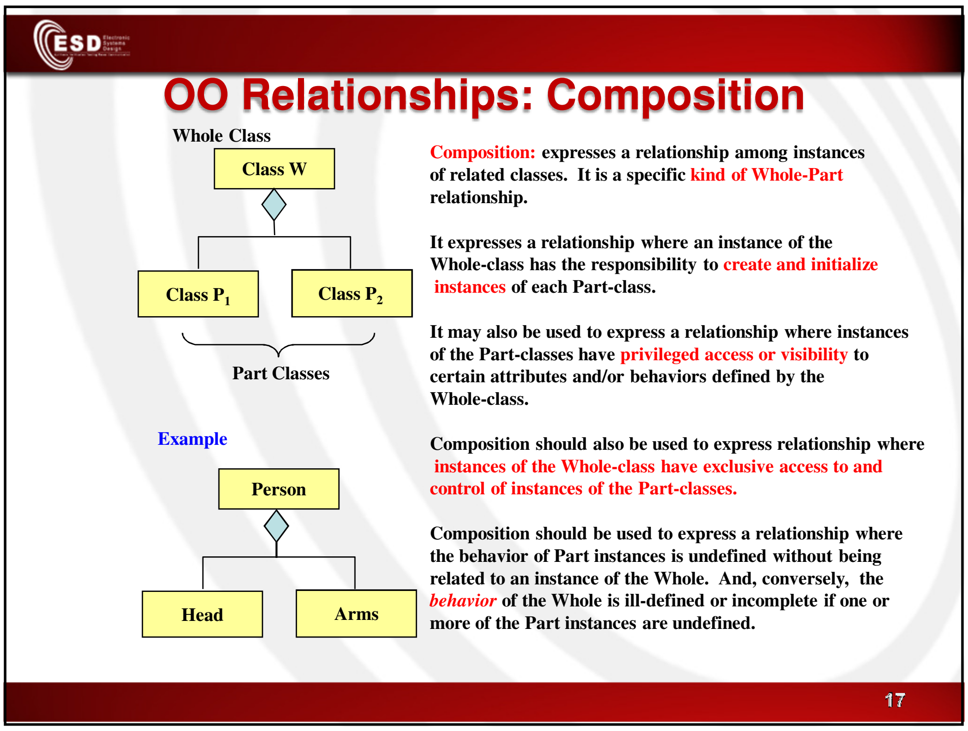


Association: Model to Implementation

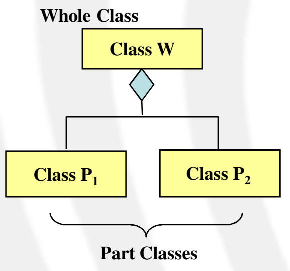


```
Class Student {
    Course enrolls[4];
}

Class Course {
    Student has[];
}
```



OO Relationships: Composition

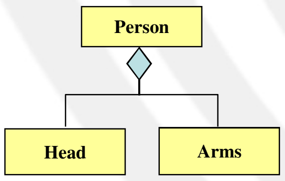


Composition: expresses a relationship among instances of related classes. It is a specific kind of Whole-Part relationship.

It expresses a relationship where an instance of the Whole-class has the responsibility to create and initialize instances of each Part-class.

It may also be used to express a relationship where instances of the Part-classes have privileged access or visibility to certain attributes and/or behaviors defined by the Whole-class.

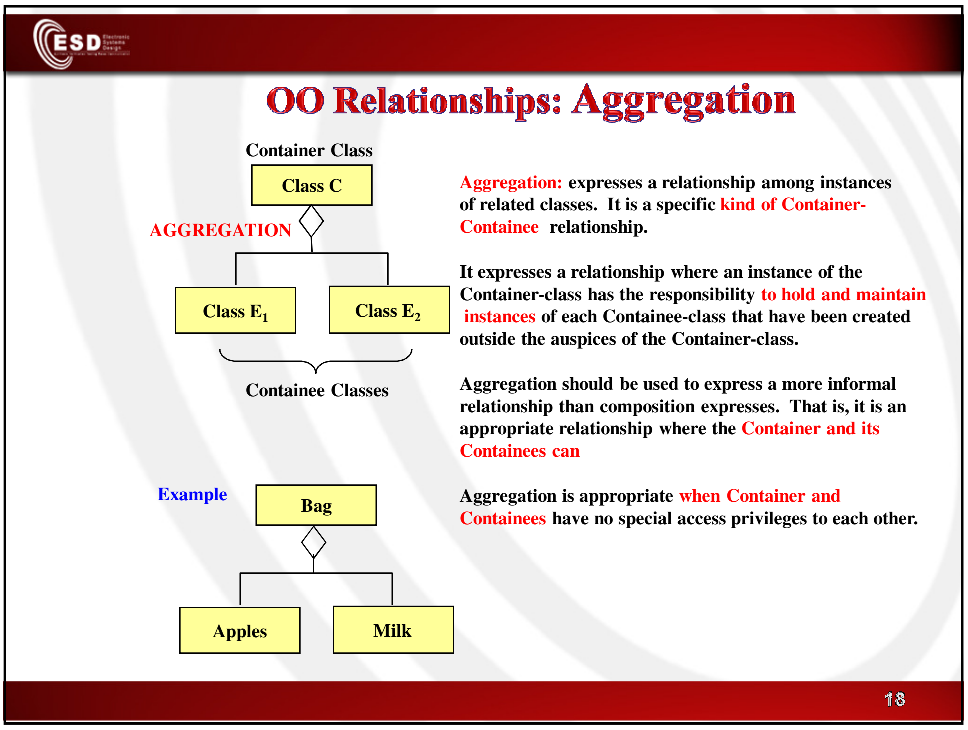
Example



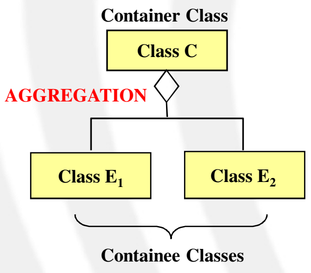
Composition should also be used to express relationship where instances of the Whole-class have exclusive access to and control of instances of the Part-classes.

Composition should be used to express a relationship where the behavior of Part instances is undefined without being related to an instance of the Whole. And, conversely, the *behavior* of the Whole is ill-defined or incomplete if one or more of the Part instances are undefined.

17



OO Relationships: Aggregation

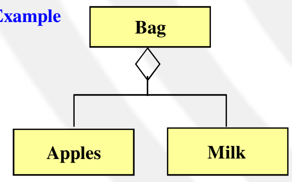


Aggregation: expresses a relationship among instances of related classes. It is a specific kind of Container-Containee relationship.

It expresses a relationship where an instance of the Container-class has the responsibility to hold and maintain instances of each Containee-class that have been created outside the auspices of the Container-class.

Aggregation should be used to express a more informal relationship than composition expresses. That is, it is an appropriate relationship where the Container and its Containees can

Example



Aggregation is appropriate when Container and Containees have no special access privileges to each other.

18

Aggregation vs. Composition

Composition is really a strong form of aggregation

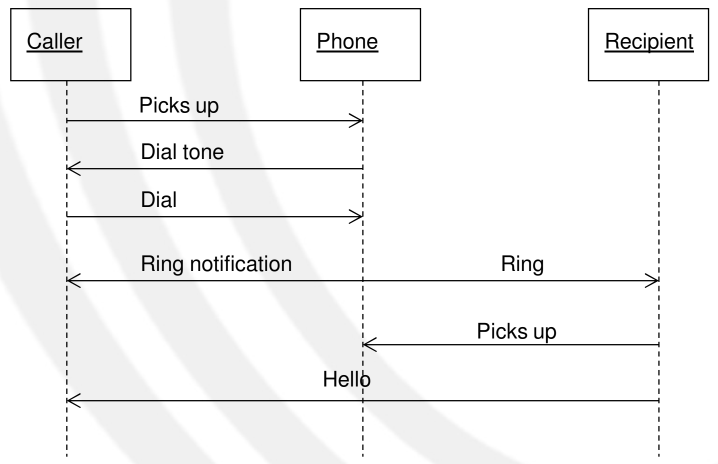
- components have only one owner
- components cannot exist independent of their owner
- components live or die with their owner (e.g. Each person has a head that can not be shared with other people).

Aggregations may form "part of" the aggregate, but may not be essential to it. They may also exist independent of the aggregate.

e.g. Apples may exist independent of the bag.

19

Sequence Diagram(make a phone call)

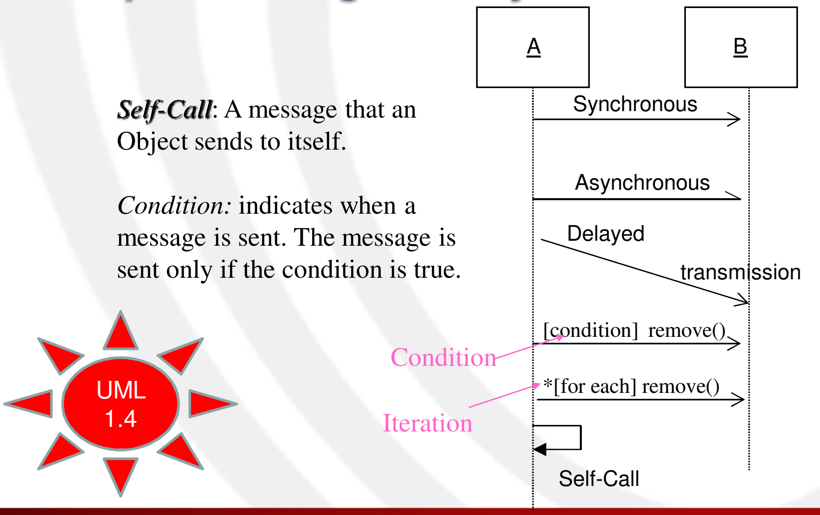


20

Sequence Diagram:Object interaction

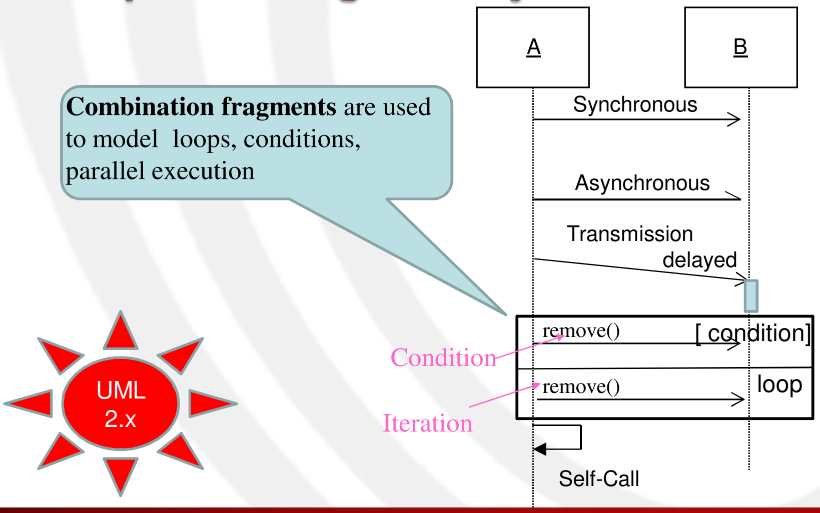
Self-Call: A message that an Object sends to itself.

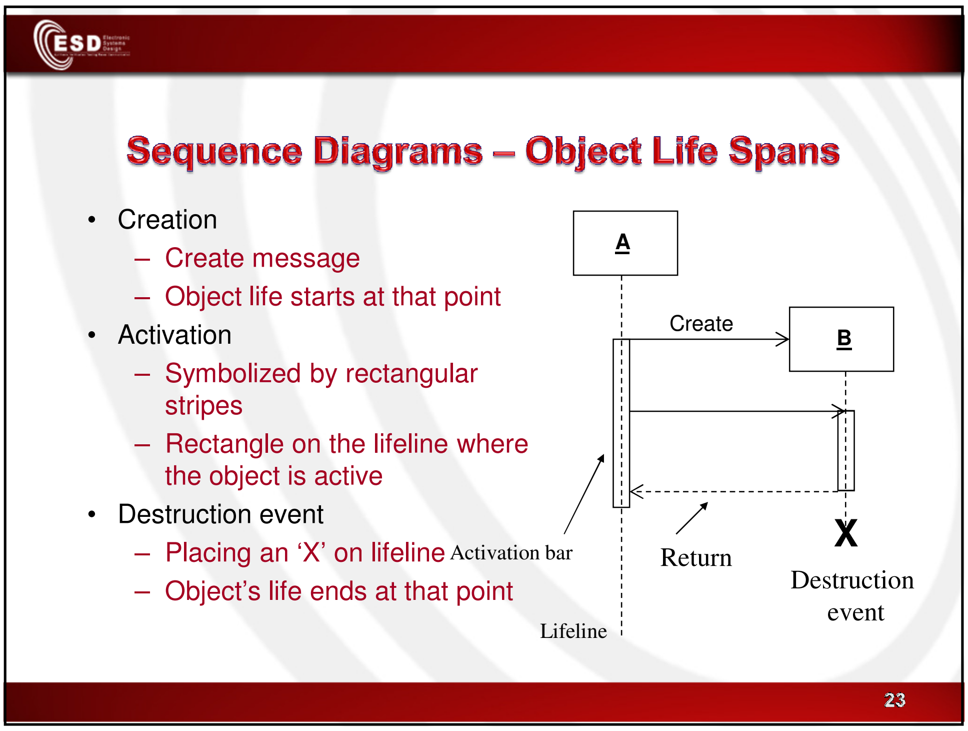
Condition: indicates when a message is sent. The message is sent only if the condition is true.



Sequence Diagram:Object interaction

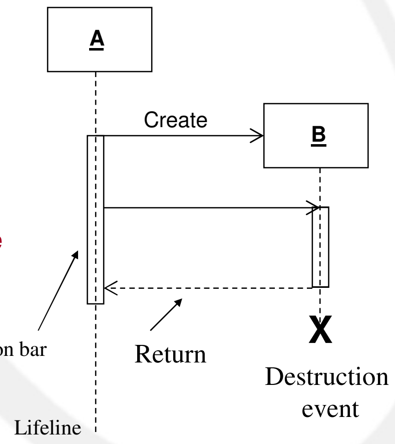
Combination fragments are used to model loops, conditions, parallel execution





Sequence Diagrams – Object Life Spans

- Creation
  - Create message
  - Object life starts at that point
- Activation
  - Symbolized by rectangular stripes
  - Rectangle on the lineline where the object is active
- Destruction event
  - Placing an ‘X’ on lifeline
  - Object’s life ends at that point



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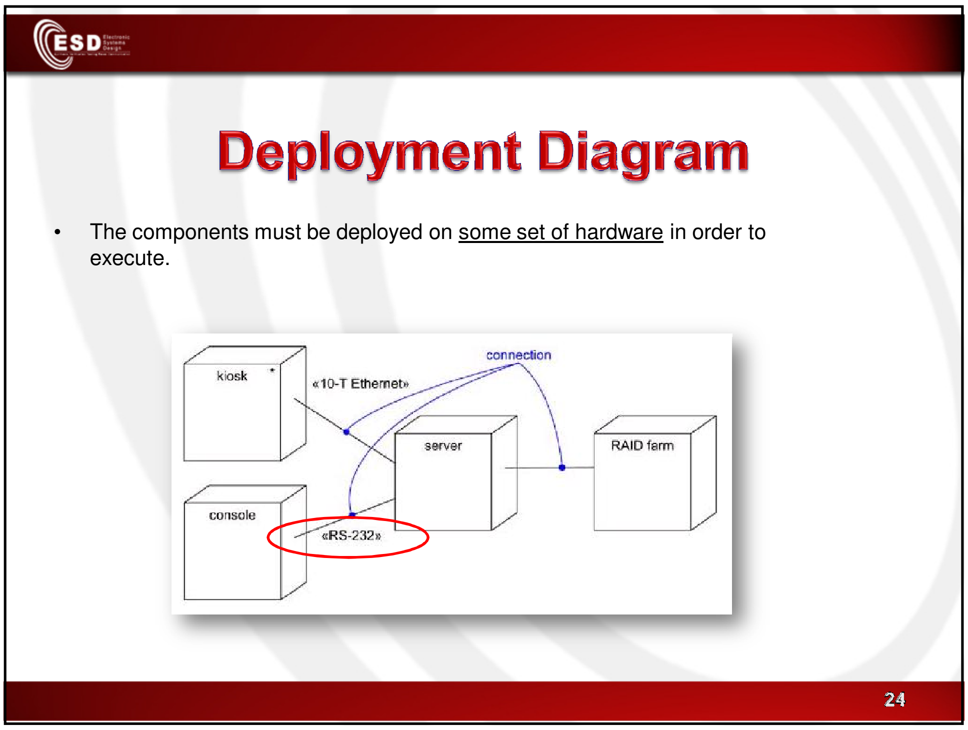
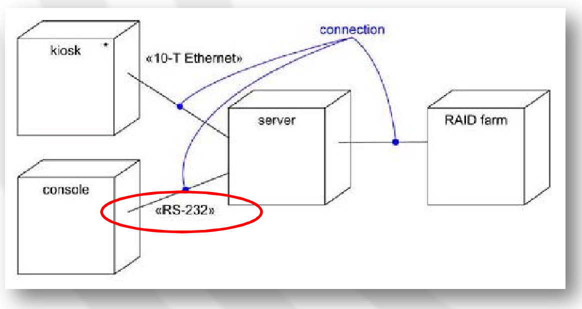


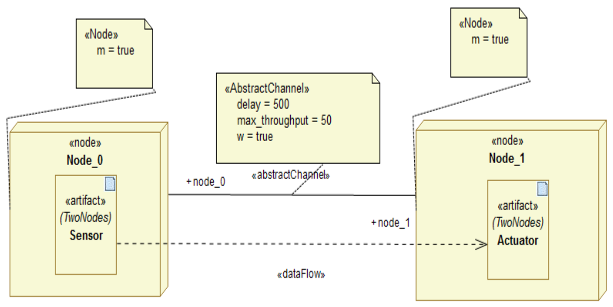
Deployment Diagram

- The components must be deployed on <u>some set of hardware</u> in order to execute.



24

Deployment Diagram (2)

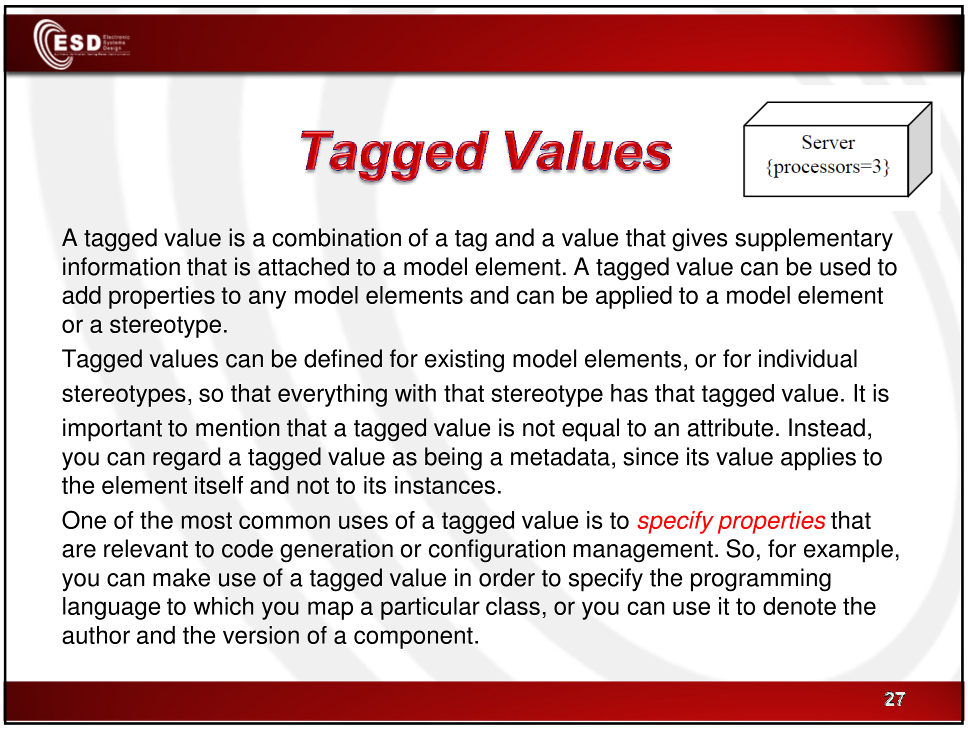


UML Profiles

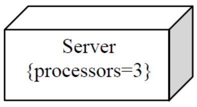
- **Profile**: Provides a generic extension mechanism for customizing UML models for particular domains and platforms. Extension mechanisms allow refining standard semantics in strictly additive manner

- Profiles are defined using stereotypes, tag definitions, and constraints that are applied to specific model elements, such as Classes, Attributes, Operations, and Activities

- A Profile is a collection of such extensions that collectively customize UML for a particular domain (e.g., aerospace, healthcare, financial) or platform (J2EE, .NET)



Tagged Values

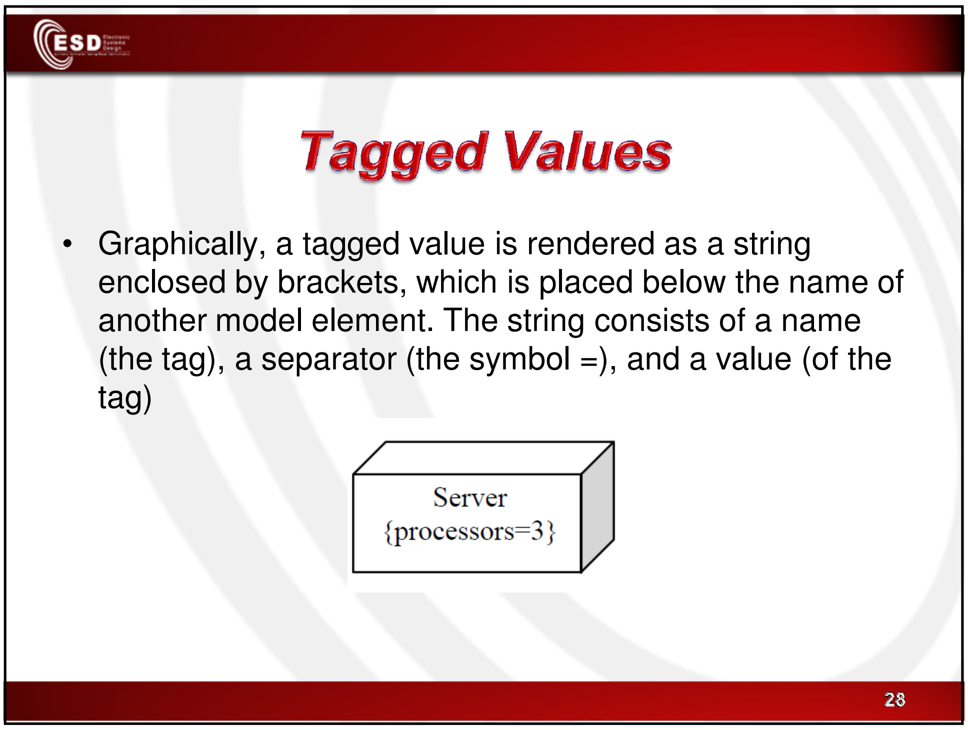


A tagged value is a combination of a tag and a value that gives supplementary information that is attached to a model element. A tagged value can be used to add properties to any model elements and can be applied to a model element or a stereotype.

Tagged values can be defined for existing model elements, or for individual stereotypes, so that everything with that stereotype has that tagged value. It is important to mention that a tagged value is not equal to an attribute. Instead, you can regard a tagged value as being a metadata, since its value applies to the element itself and not to its instances.

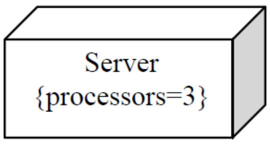
One of the most common uses of a tagged value is to *specify properties* that are relevant to code generation or configuration management. So, for example, you can make use of a tagged value in order to specify the programming language to which you map a particular class, or you can use it to denote the author and the version of a component.

27



Tagged Values

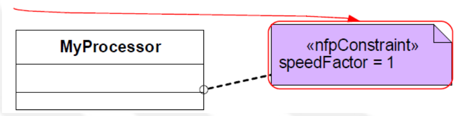
- Graphically, a tagged value is rendered as a string enclosed by brackets, which is placed below the name of another model element. The string consists of a name (the tag), a separator (the symbol =), and a value (of the tag)



28

Constraints

- Constraints are properties for specifying semantics and/or conditions that must be held true at all times for the elements of a model. They allow you to extend the semantics of a UML building block by adding new rules, or modifying existing ones.
- For example, when modeling hard real time systems it could be useful to annotate the models with some additional information, such as time budgets and deadlines. By making use of constraints these timing requirements can easily be captured.

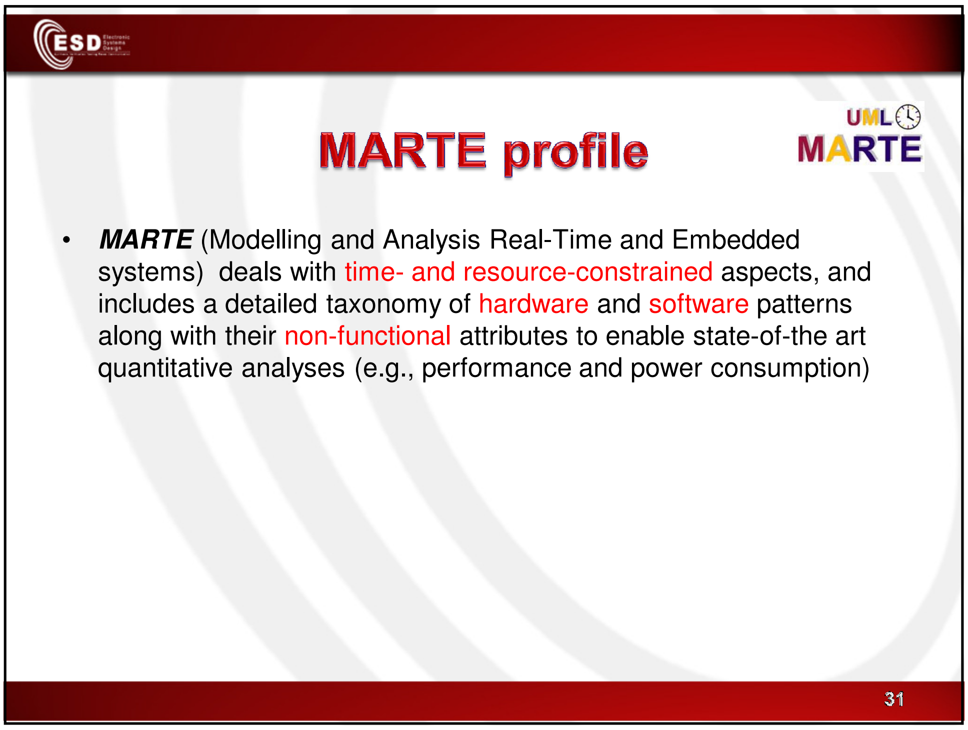


29

Catalog of Adopted OMG Profiles

- UML Profile for CORBA
- UML Profile for Enterprise Application Integration (EAI)
- UML Profile for Enterprise Distributed Object Computing (EDOC)
- UML Profile for Modeling QoS and Fault Tolerance Characteristics and Mechanisms
- UML Profile for Schedulability, Performance, and Time
- UML Profile for System on a Chip (SoC)
- UML Profile for Modeling and Analysis of Real-Time and Embedded Systems (MARTE)
- UML Testing Profile
- UML Profile for Systems Engineering (SysML)
- UML Profile for DoDAF/MoDAF (UPDM)

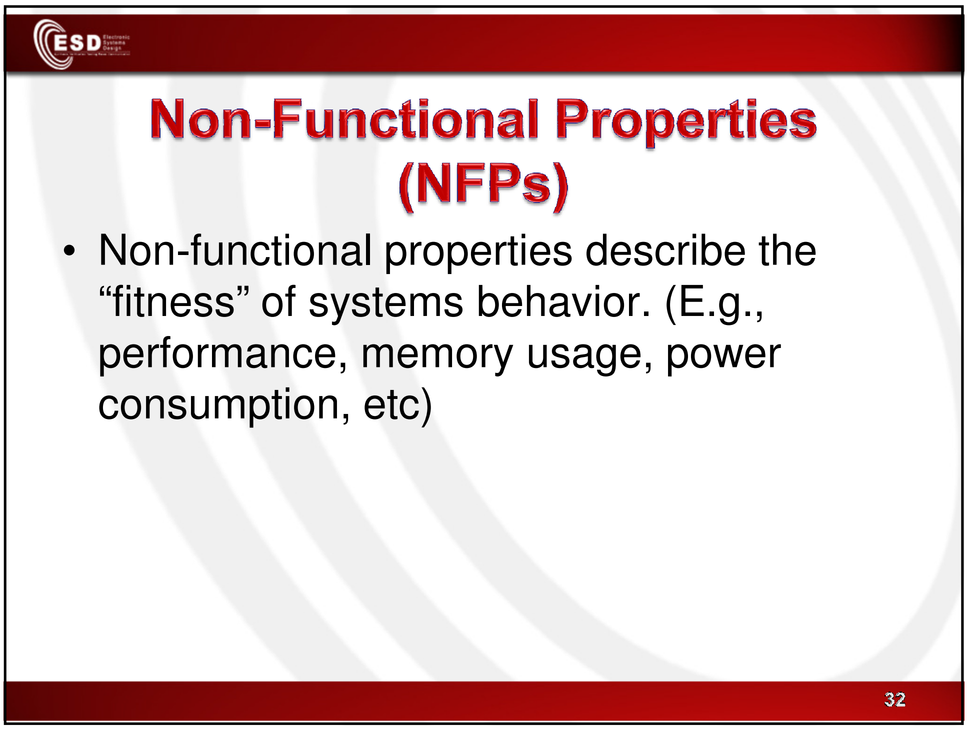
30



MARTE profile

- ***MARTE*** (Modelling and Analysis Real-Time and Embedded systems) deals with time- and resource-constrained aspects, and includes a detailed taxonomy of hardware and software patterns along with their non-functional attributes to enable state-of-the art quantitative analyses (e.g., performance and power consumption)

31



Non-Functional Properties (NFPs)

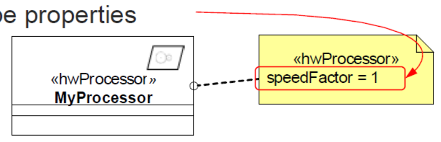
- Non-functional properties describe the “fitness” of systems behavior. (E.g., performance, memory usage, power consumption, etc)

32

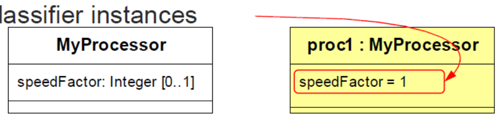
NFP subprofile

Three mechanisms to annotate UML models:

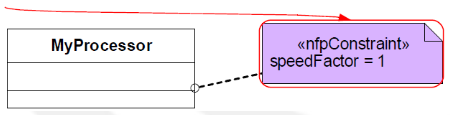
- Values of stereotype properties



- Slot values of classifier instances

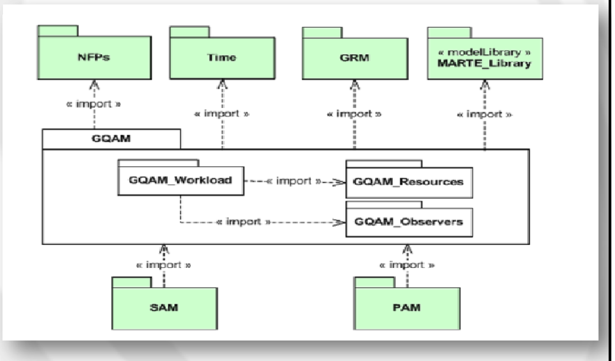


- Constraints



Generic Quantitative Analysis Modeling (GQAM)

The generic analysis domain includes specialized domains in which the analysis is based on the software behavior, such as performance and schedulability and also power, memory, reliability, availability, and security.



GaExecHost

- It denotes a processor that executes Steps
- In performance modeling, an GaExecHost can be any device which executes behavior, including storage and peripheral devices.

node

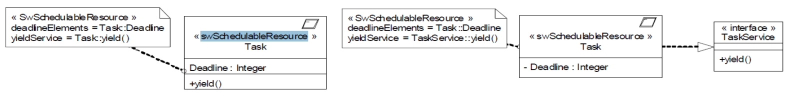
Task

SwSchedulableResource

- **Semantics** SchedulableResources are resources, which execute concurrently to other concurrent resources. The competition for execution among the set of schedulable resources is supervised by a scheduler. In fact, a scheduler interleaves their execution based on a scheduling algorithm. Common SchedulableResources are POSIX Thread, ARINC-653 Process, and OSEK/VDX Task. By default, schedulableResources share the same address space but preserve their own contexts (program counter, registers, signal mask, stack, etc.).

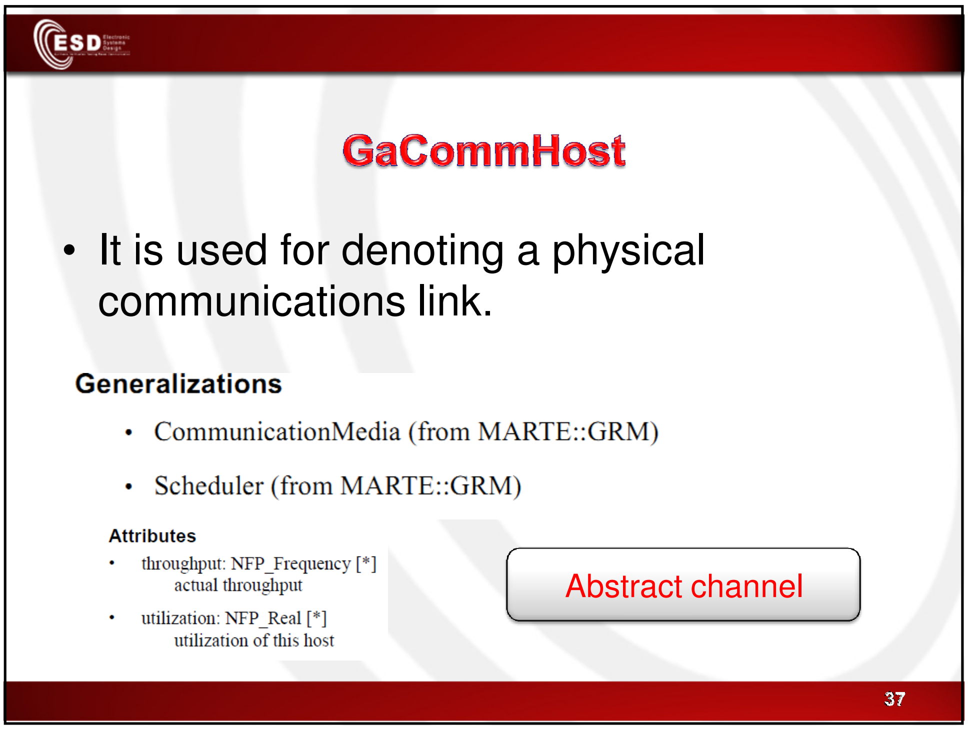
Applying SwResource stereotypes on classifiers

All stereotypes of the SRM sub-profile extend the UML::Classes::Kernel::Classifier metaclass. Thus, any UML Classifier sub-metaclass may be extended by those stereotypes (e.g., Class, Interface, Component, and AssociationClass). Figure 14.40 and Figure 14.41 illustrate UML Class and UML Component extension.


« SwSchedulableResource »
deadlineElements = Task:Deadline
yieldService = Task:yield()
« swSchedulableResource »
Task
Deadline : Integer
+yield()
« SwSchedulableResource »
deadlineElements = Task::Deadline
yieldService = TaskService::yield()
« swSchedulableResource »
Task
- Deadline : Integer
« interface »
TaskService
+yield()

(i) Class (ii) Class and Interface

Figure 14.39 - Class extension example



GaCommHost

- It is used for denoting a physical communications link.

Generalizations

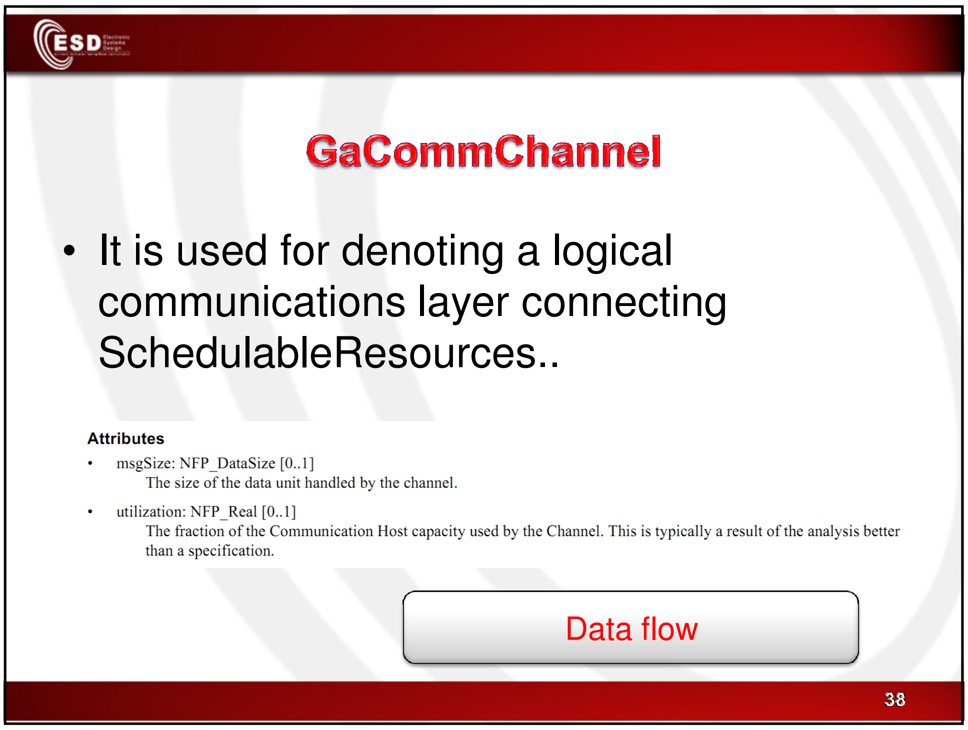
- CommunicationMedia (from MARTE::GRM)
- Scheduler (from MARTE::GRM)

Attributes

- throughput: NFP_Frequency [*]
  actual throughput
- utilization: NFP_Real [*]
  utilization of this host

Abstract channel

37



GaCommChannel

- It is used for denoting a logical communications layer connecting SchedulableResources..

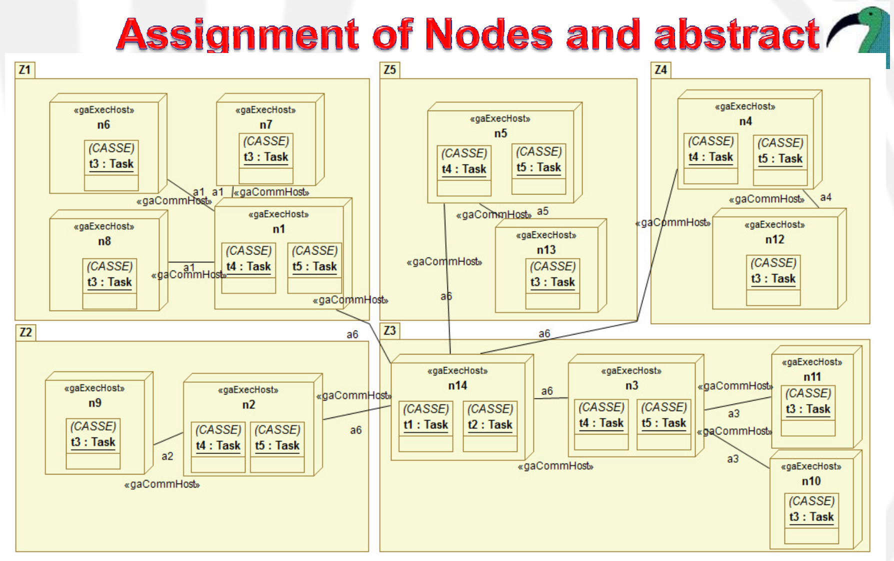
Attributes

- msgSize: NFP_DataSize [0..1]
  The size of the data unit handled by the channel.
- utilization: NFP_Real [0..1]
  The fraction of the Communication Host capacity used by the Channel. This is typically a result of the analysis better than a specification.

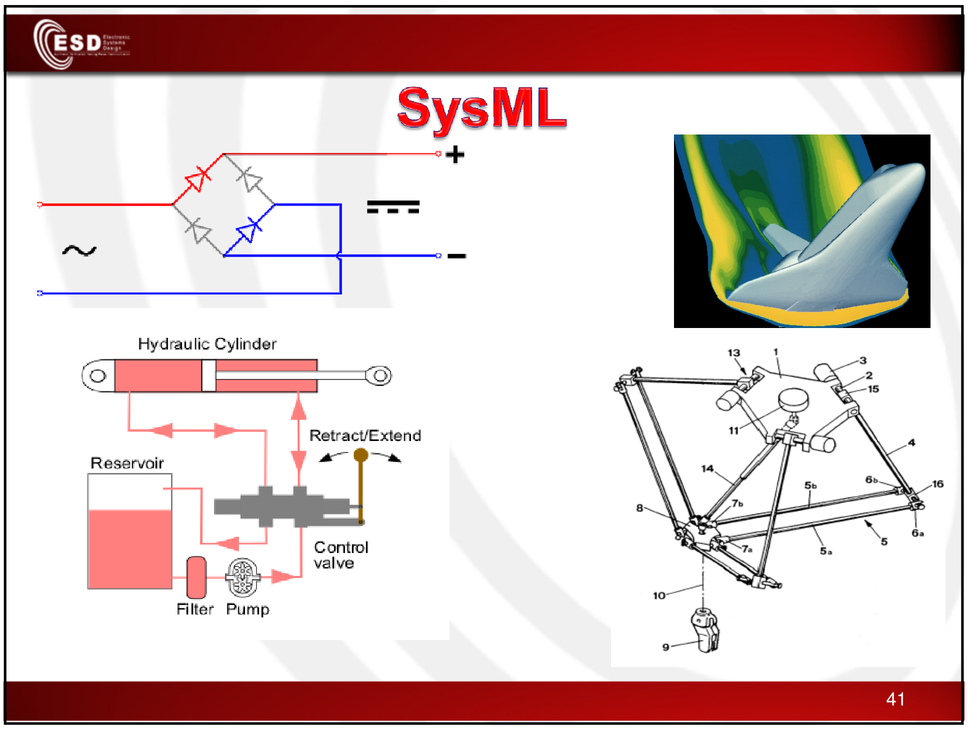
Data flow

38

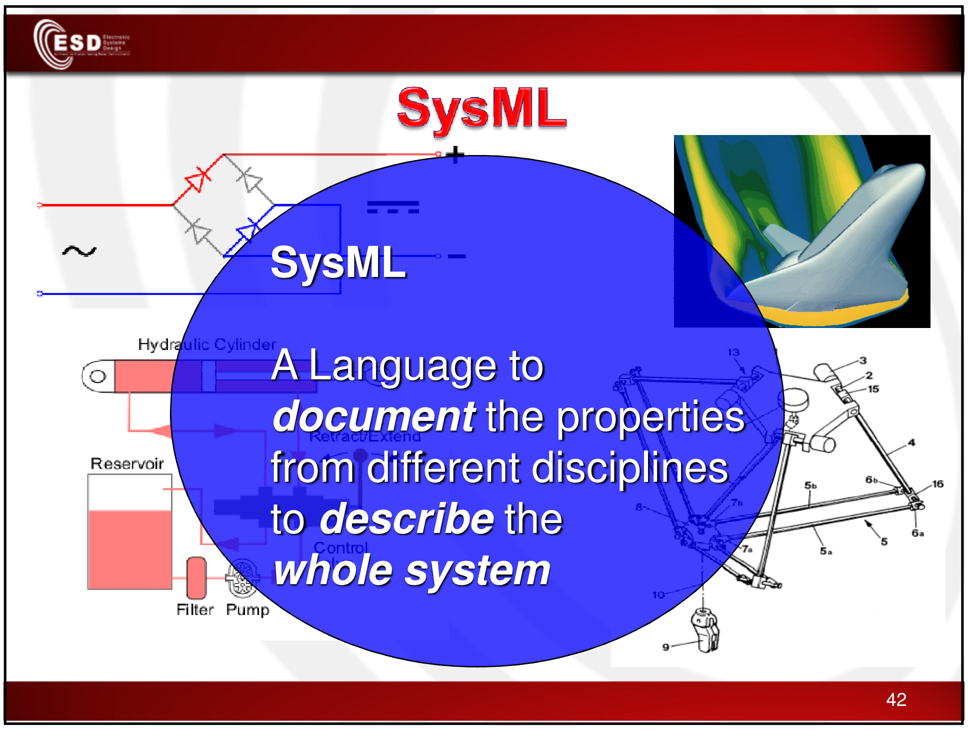
Assignment of Nodes and abstract


Z1
«gaExecHost» n6 (CASSE) t3 : Task
«gaExecHost» n7 (CASSE) t3 : Task
«gaExecHost» n8 (CASSE) t3 : Task
«gaExecHost» n1 (CASSE) t4 : Task (CASSE) t5 : Task
«gaCommHost»
a1
Z5
«gaExecHost» n5 (CASSE) t4 : Task (CASSE) t5 : Task
«gaExecHost» n13 (CASSE) t3 : Task
a5
a6
Z4
«gaExecHost» n4 (CASSE) t4 : Task (CASSE) t5 : Task
«gaExecHost» n12 (CASSE) t3 : Task
a4
Z2
«gaExecHost» n9 (CASSE) t3 : Task
«gaExecHost» n2 (CASSE) t4 : Task (CASSE) t5 : Task
a2
Z3
«gaExecHost» n14 (CASSE) t1 : Task (CASSE) t2 : Task
«gaExecHost» n3 (CASSE) t4 : Task (CASSE) t5 : Task
«gaExecHost» n11 (CASSE) t3 : Task
«gaExecHost» n10 (CASSE) t3 : Task
a3

SysML



SysML

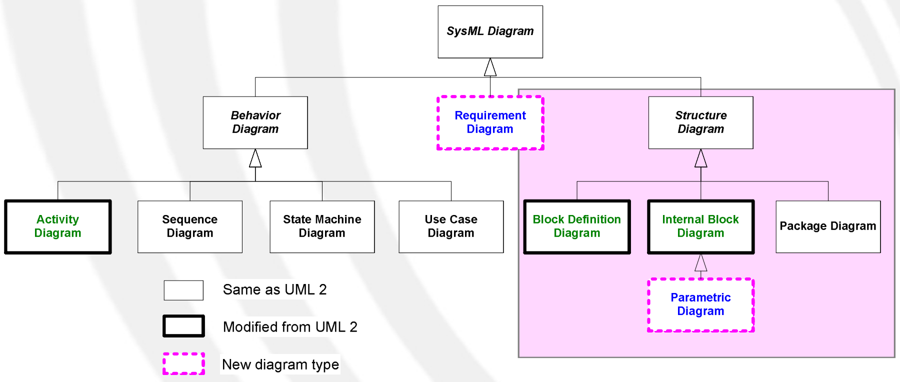


SysML

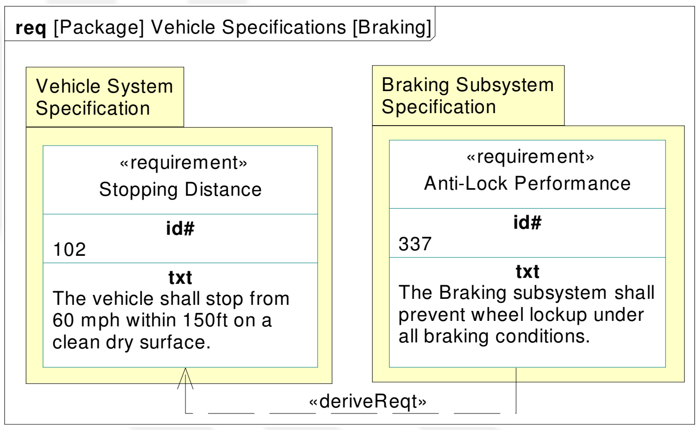
SysML

A Language to ***document*** the properties from different disciplines to ***describe*** the ***whole system***

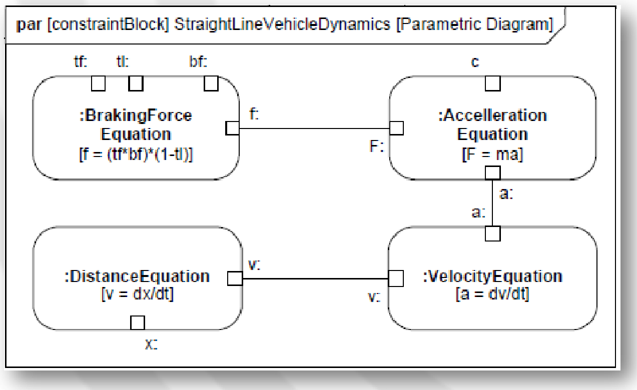
Structural Diagrams



Requirement diagram

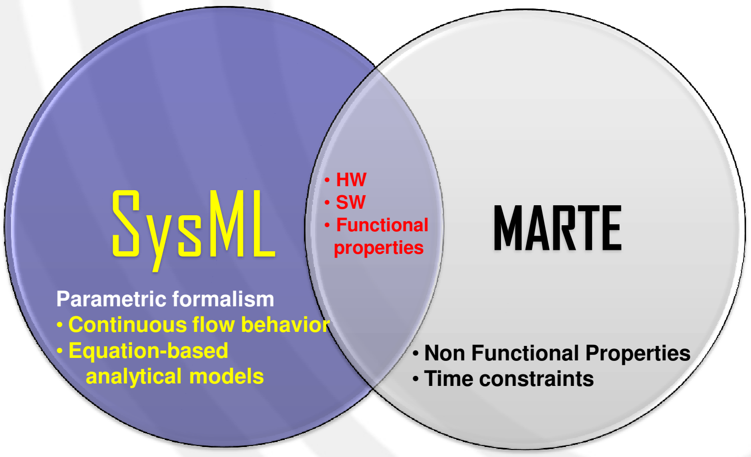

req [Package] Vehicle Specifications [Braking]
Vehicle System Specification
«requirement»
Stopping Distance
id#
102
txt
The vehicle shall stop from 60 mph within 150ft on a clean dry surface.
Braking Subsystem Specification
«requirement»
Anti-Lock Performance
id#
337
txt
The Braking subsystem shall prevent wheel lockup under all braking conditions.
«deriveReqt»

Parametric diagram



45

SysML vs MARTE

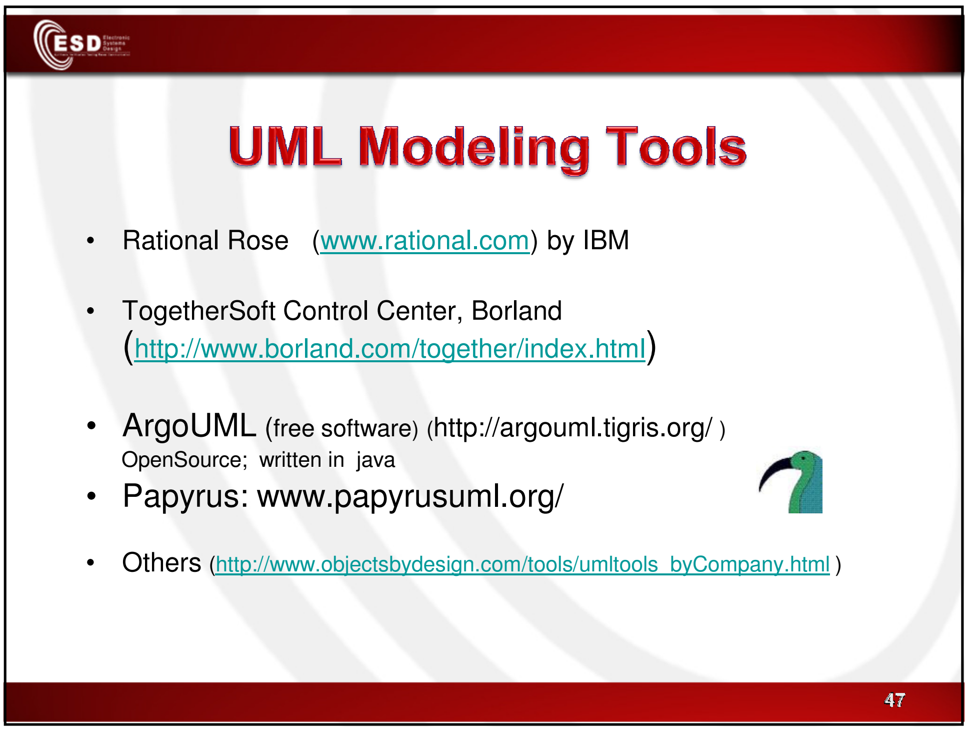


Parametric formalism
- Continuous flow behavior
- Equation-based analytical models

- HW
- SW
- Functional properties

- Non Functional Properties
- Time constraints

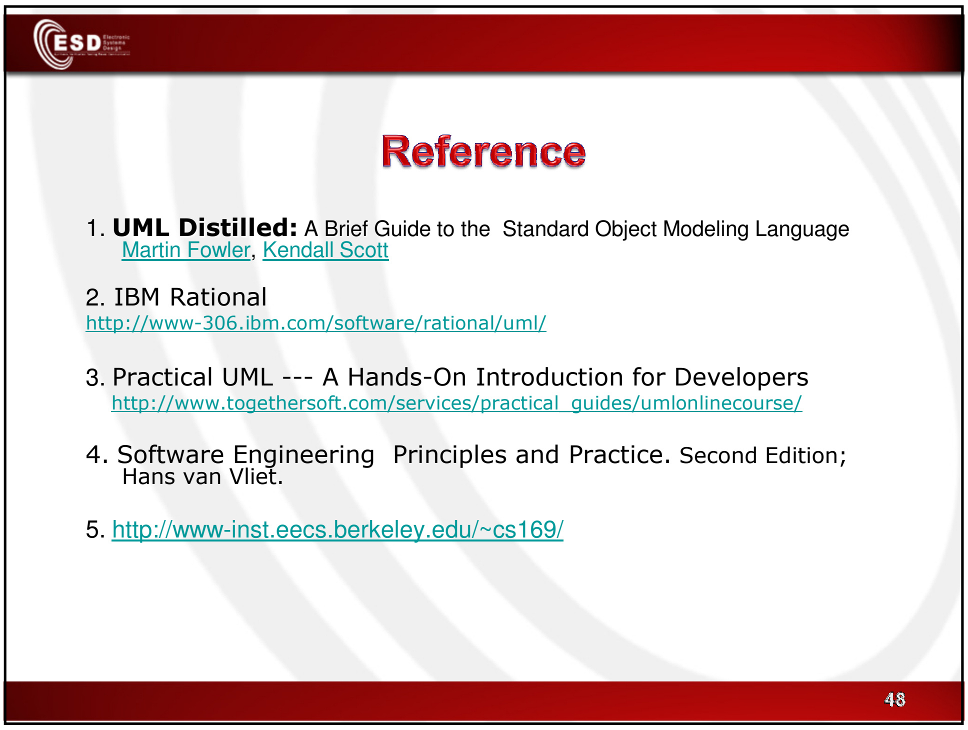
46



UML Modeling Tools

- Rational Rose (www.rational.com) by IBM
- TogetherSoft Control Center, Borland (http://www.borland.com/together/index.html)
- ArgoUML (free software) (http://argouml.tigris.org/)
  OpenSource; written in java
- Papyrus: www.papyrusuml.org/
- Others (http://www.objectsbydesign.com/tools/umltools_byCompany.html)

47



Reference

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2. IBM Rational
   http://www-306.ibm.com/software/rational/uml/
3. Practical UML --- A Hands-On Introduction for Developers
   http://www.togethersoft.com/services/practical_guides/umlonlinecourse/
4. Software Engineering Principles and Practice. Second Edition; Hans van Vliet.
5. http://www-inst.eecs.berkeley.edu/~cs169/

48