Problem frames and UML description development

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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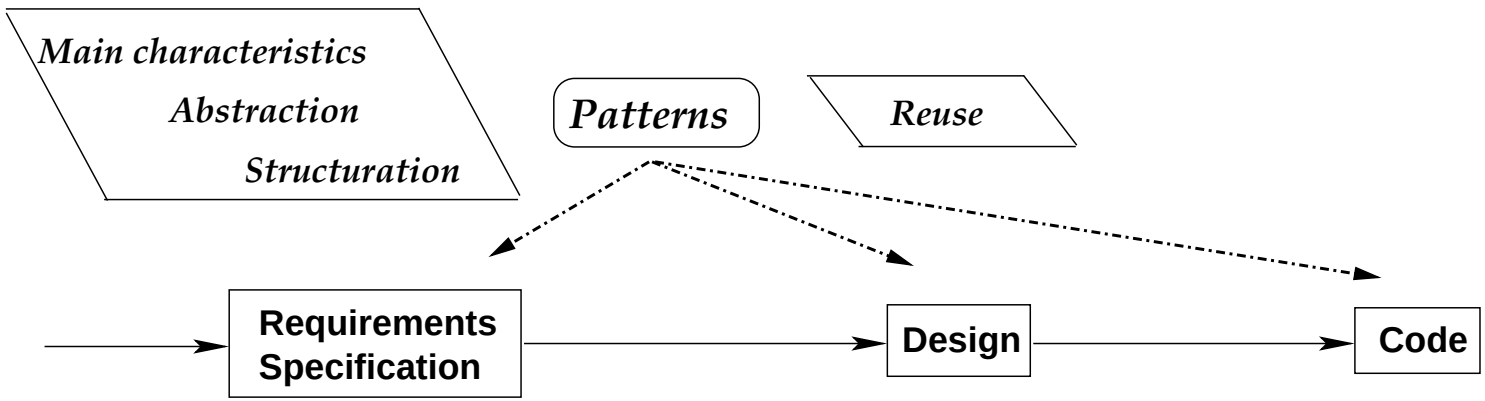

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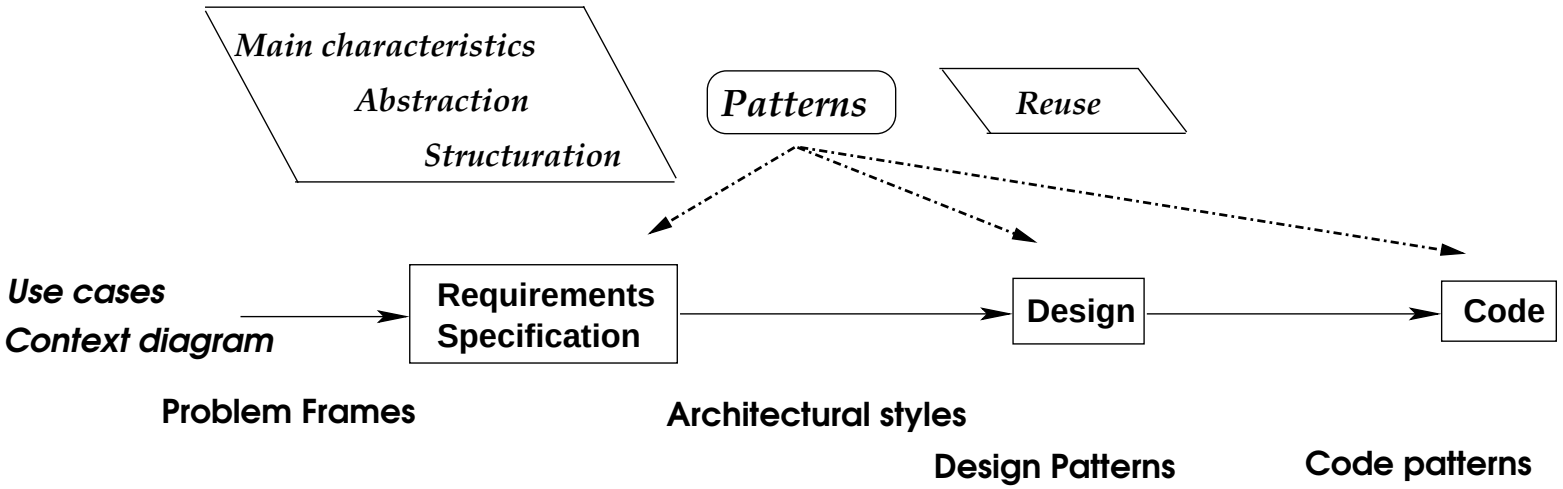

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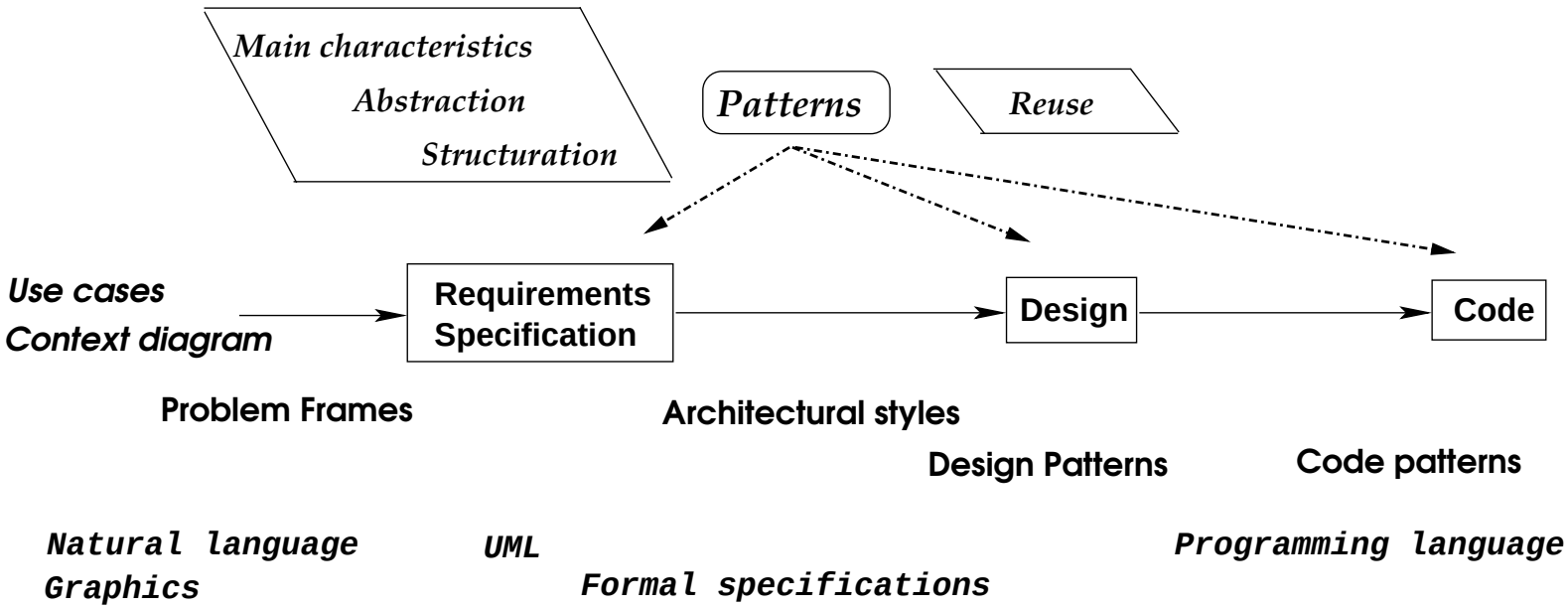

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Patterns

- a promising approach to software development, a means to reuse software development knowledge on different levels of abstraction, classify sets of software development problems or solutions that share the same structure

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Gianna Reggio (DISI, Università di Genova, Italy)
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- a promising approach to software development, a means to reuse software development knowledge on different levels of abstraction, classify sets of software development problems or solutions that share the same structure
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  Design Patterns for finer-grained software design,
  frameworks less abstract, more specialised.
  idioms/"code patterns" : low-level patterns related to specific programming languages

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  Design Patterns for finer-grained software design,
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  idioms/"code patterns" : low-level patterns related to specific programming languages
- construct software in a systematic way, body of accumulated knowledge, not starting from scratch

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- a software development method

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Gianna Reggio (DISI, Università di Genova, Italy)
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- a software development method
  combines
  - the use of the structural concepts provided by problem frames

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  1. Match the problem with a problem frame
  2. Develop the UML description

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  predefined schemas or skeletons for their contents

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- model the domain, the requirements capture and specification, and their relationships, model the design

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Problem Frames (M. Jackson)

- problem frames concept : present, classify, understand software development problems

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Gianna Reggio (DISI, Università di Genova, Italy)
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- diagram : involved domains, requirements, design, interfaces

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- diagram : involved domains, requirements, design, interfaces
- five basic problem frames, variants

We propose associated development methods

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/∼choppy

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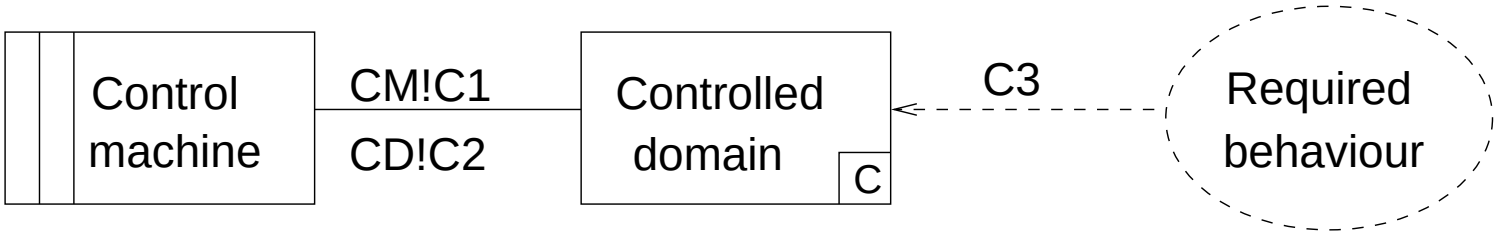
A basic problem frame : required behaviour



There is some part of the physical world whose behaviour is to be controlled so that it satisfies certain conditions. The problem is to build a machine that will impose that control.

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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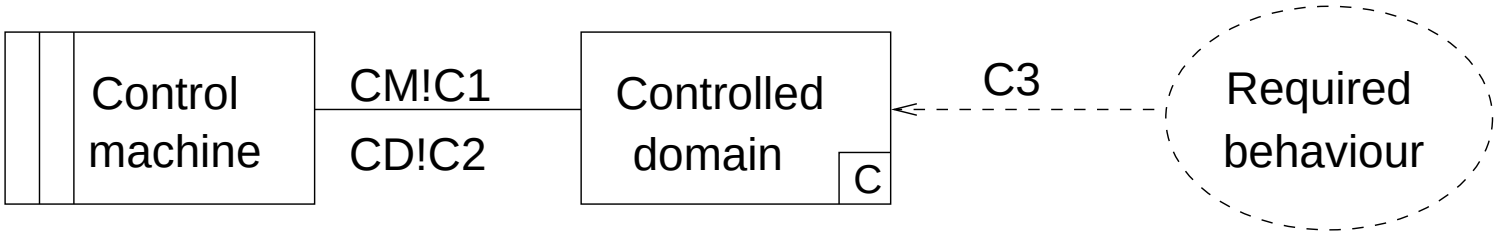
A basic problem frame : required behaviour



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- embedded systems
- sensors (C2) and actuators (C1)

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Gianna Reggio (DISI, Università di Genova, Italy)
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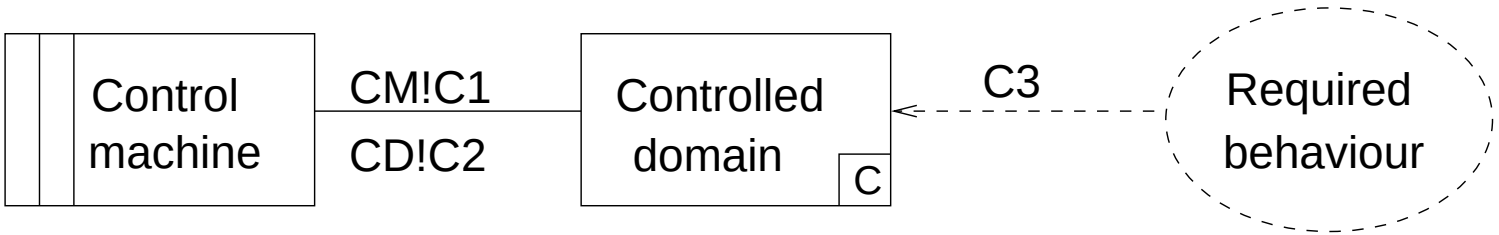

- embedded systems
- sensors (C2) and actuators (C1)

Example : A machine that keeps the temperature of some liquid between given bounds. Then, the temperature of the liquid would be a shared phenomenon controlled by the environment. The corresponding sensor would be a thermometer. Another shared phenomenon would be the state of a burner. That state would be controlled by the machine, i.e., the machine is able to switch the burner on or off.

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Gianna Reggio (DISI, Università di Genova, Italy)
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Problem Frame notation

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Gianna Reggio (DISI, Università di Genova, Italy)
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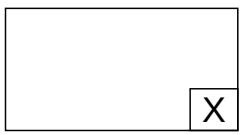
Problem Frame notation

Machine domain

Designed domain

Given domain



Lexical domain

Biddable domain

Causal domain

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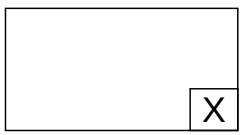

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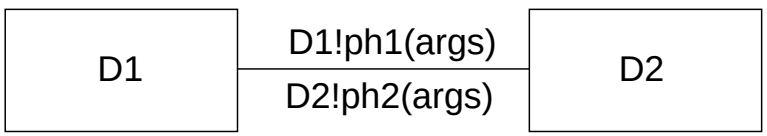

Interface and shared phenomena

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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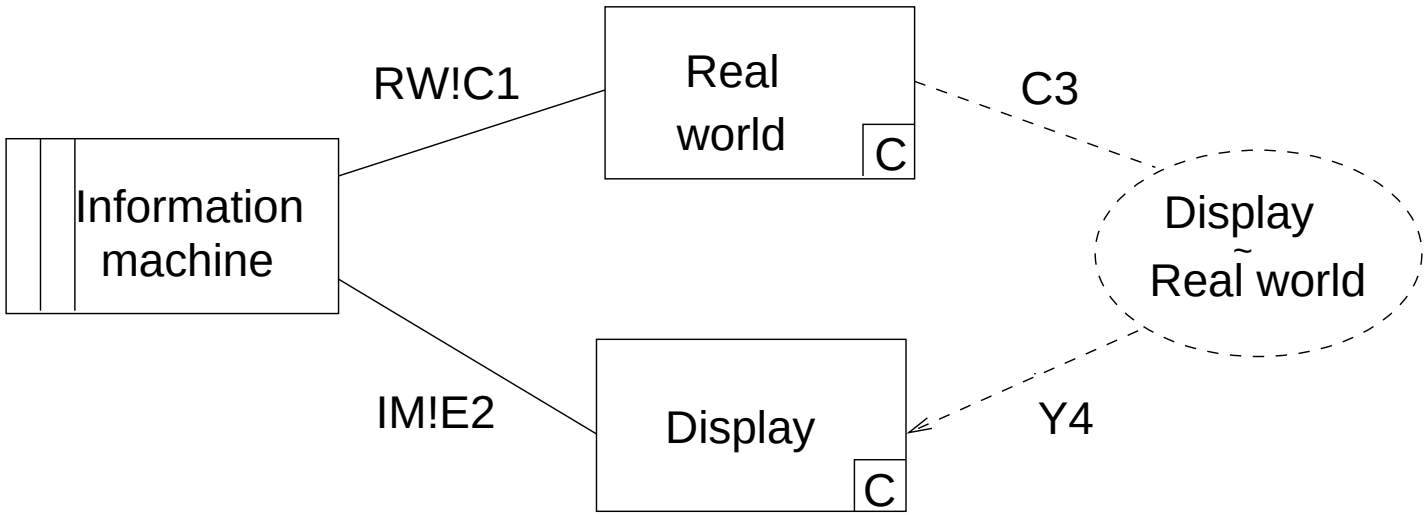
A basic problem frame : information display



There is some part of the physical world about whose states and behaviour information is continually needed. The problem is to build a machine that will obtain this information from the world and present it at the required place in the required form.

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Gianna Reggio (DISI, Università di Genova, Italy)
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UML description

Following Astesiano-Reggio : a Domain Model, a Requirement Specification, and a Design Specification

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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Diagram skeletons for the basic problem frames (or some variant) illustrated on examples/case studies

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/∼choppy

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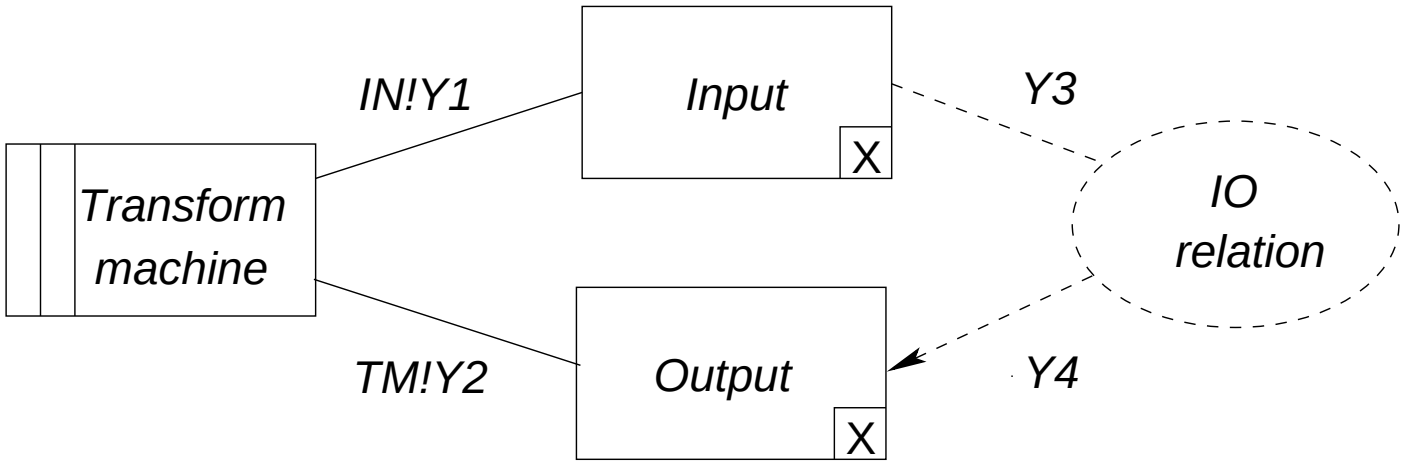
A basic problem frame : transformation



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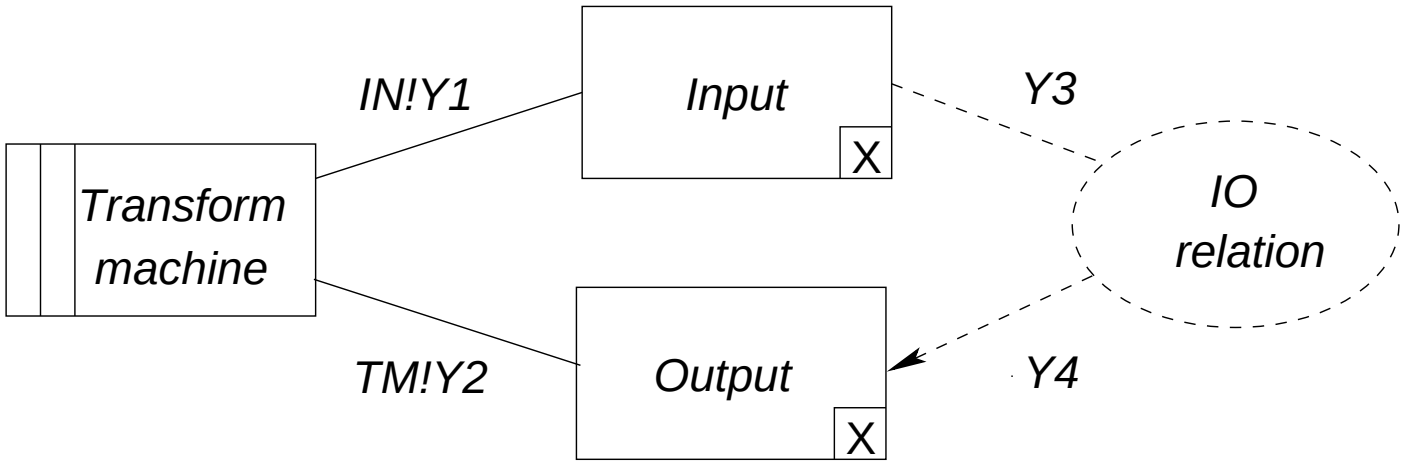

There are some computer-readable input files whose data must be transformed to give certain required output files. The output data must be in a particular format, and it must be derived from the input data according to certain rules. The problem is to build a machine that will produce the required outputs from the inputs.

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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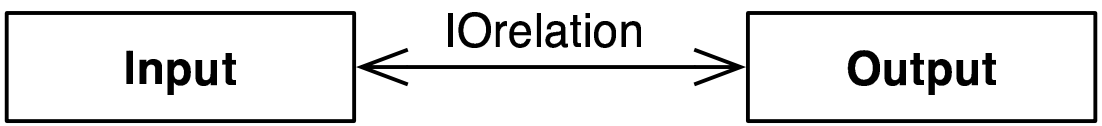
Transformation Frame : Domain Model and Requirement Specification



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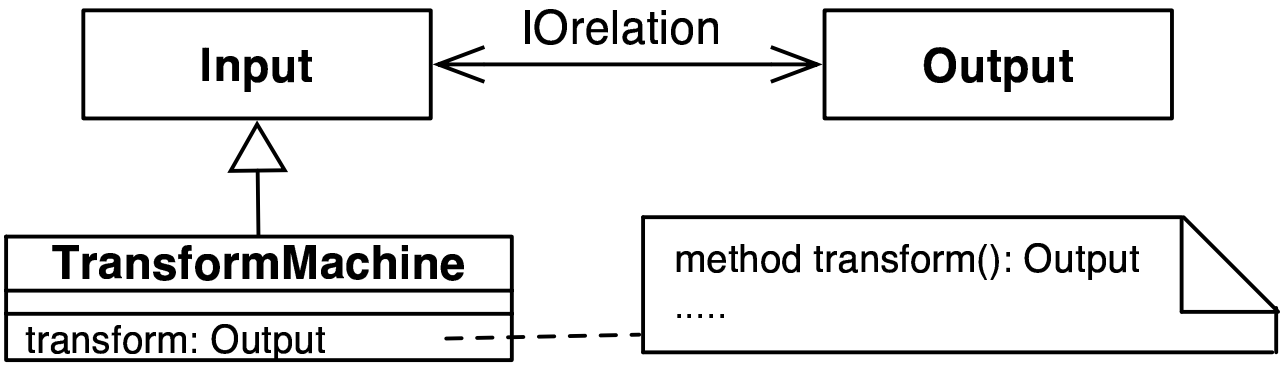
Transformation Frame : Design Specification



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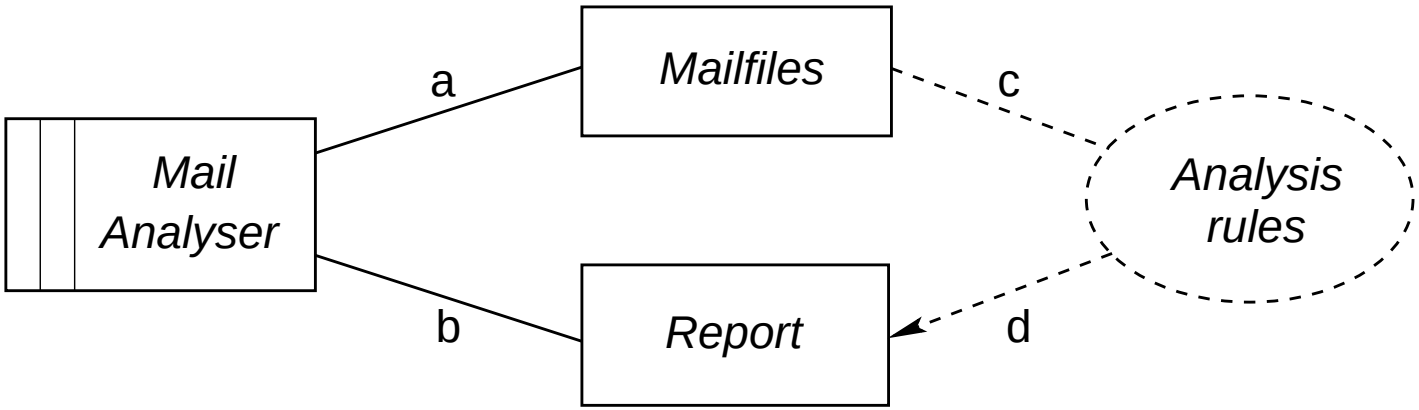
Mailfiles Analysis Case Study (Jackson)



a: MF!{Mail, File, From, To, Length}

b: MA! {ReportLine}

c: {Mail, From, To, Length}

d: {ReportLine}

The goal is to analyse mailfiles, and build a report providing for each correspondent, the number of messages received, their maximum and average lengths, and the same information for the messages sent by the user of this facility

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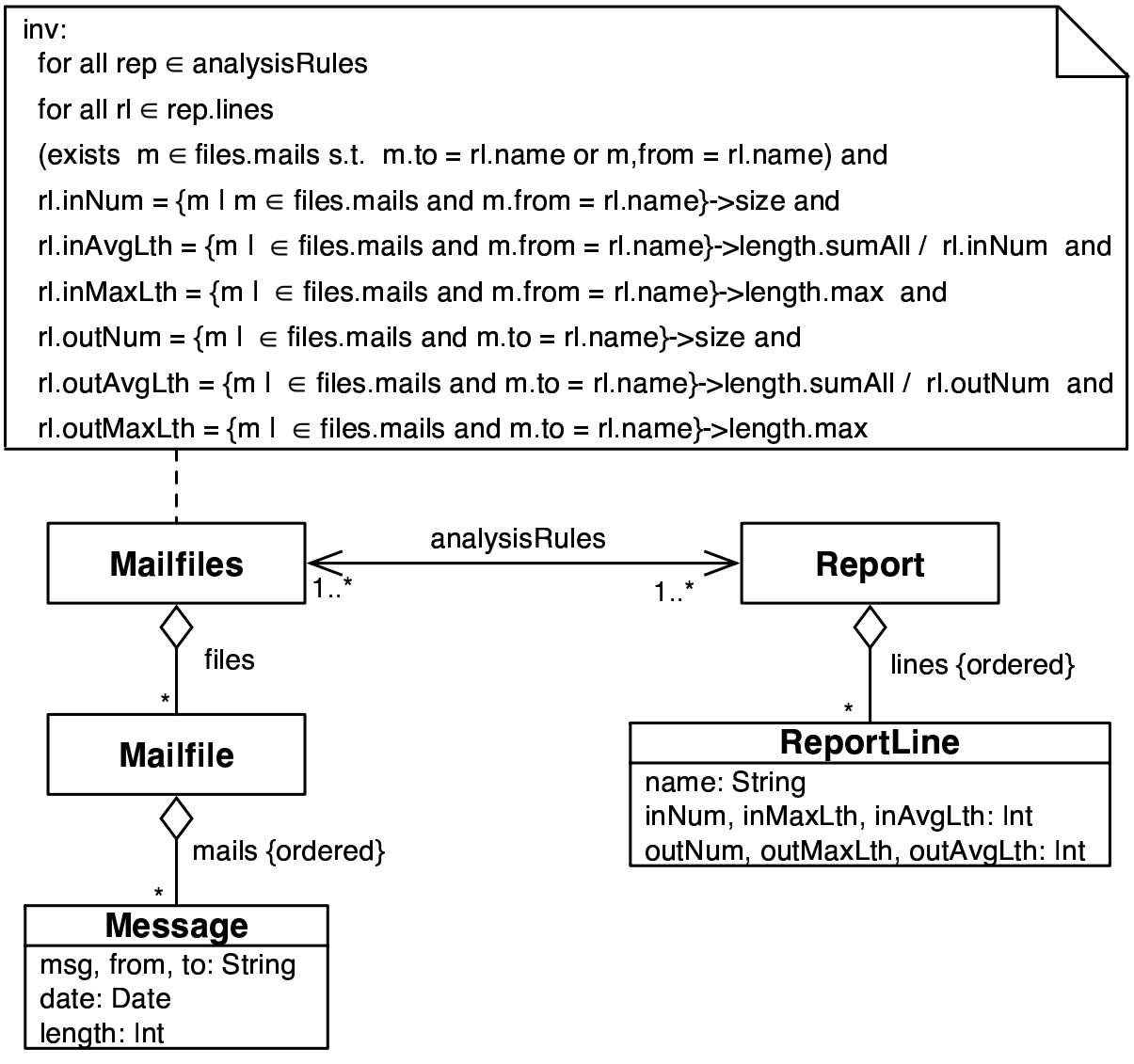
Mailfiles Analysis : Domain Model and Requirement Specification



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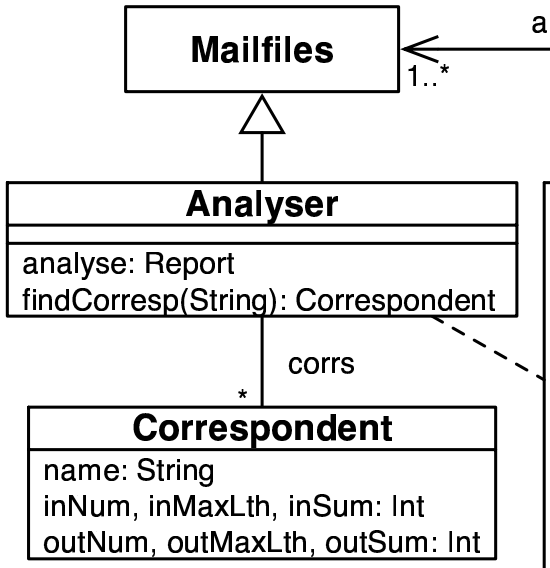


```
method analyse(): Report
%%collecting the data about the correspondents
self.corrs = {}
for all m ∈ self.files.mails do
 if m.to = "myself" then
  { c = findCorresp(m.from);
    c.inNum = c.inNum+1;
    c.inSum = c.inSum+m.length;
    if m.length > c.inMaxLth then c.inMaxLth = m.length; }
 else
  { c = findCorresp(m.to);
    c.outNum = c.outNum+1;
    c.outSum = c.ioutSum+m.length;
    if m.length > c.outMaxLth then c.outMaxLth = m.length; }
%%creating the report
r = create(Report);
r.lines = {};
for c ∈ self.corrs do
 { rl = create(ReportLine);
   rl.name = c.name;
   rl.inNun = c.inNum;
   rl.inMaxLth = c. inMaxLth;
   rl.inAvgLth = c. inSum / c.inNum;
   rl.outNun = c.outNum;
   rl.outMaxLth = c. outMaxLth;
   rl.outAvgLth = c. outSum / c.outNum;
   r.lines = r.lines U {rl} ; }
method findCorresp(n:String): Correspondent
if n ∈ corrs.name then
 return cors->select(name=n)
```


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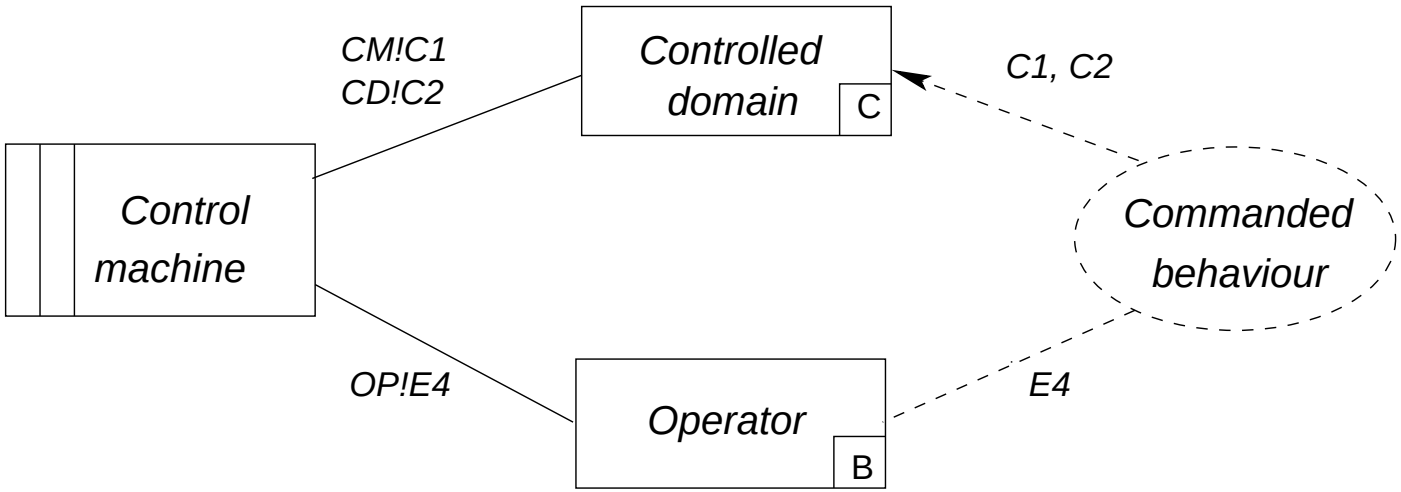

E4 are operator commands, *C1 are Pulses and C2 are Sensors*

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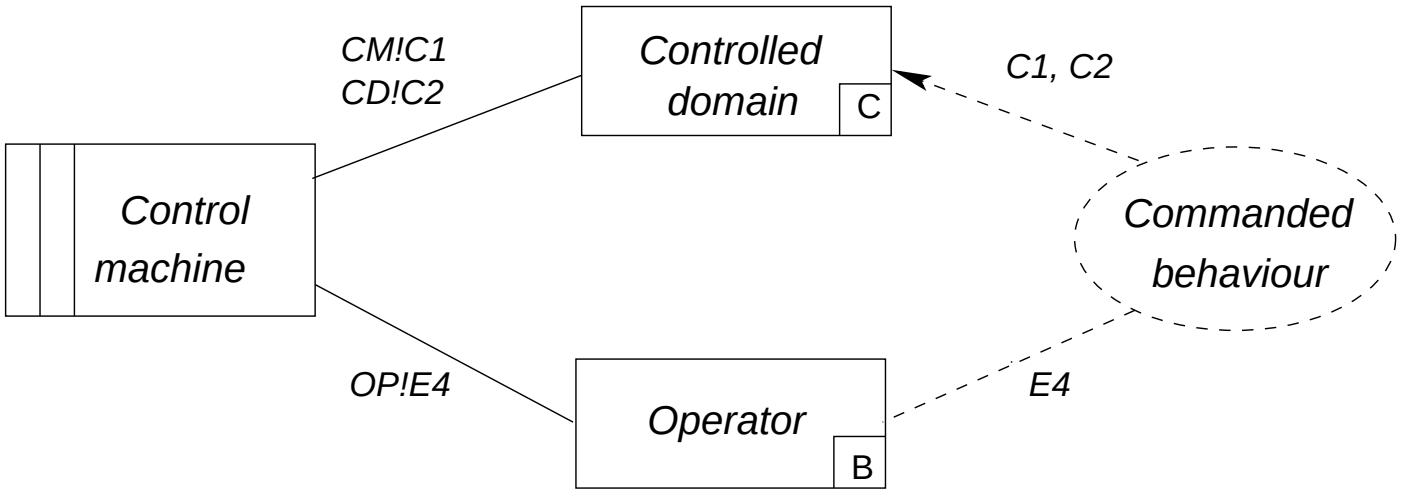

E4 are operator commands, *C1 are Pulses and C2 are Sensors*

There is some part of the physical world whose behaviour is to be controlled in accordance with commands issued by an operator. The problem is to build a machine that will accept the operator's commands and impose the control accordingly.

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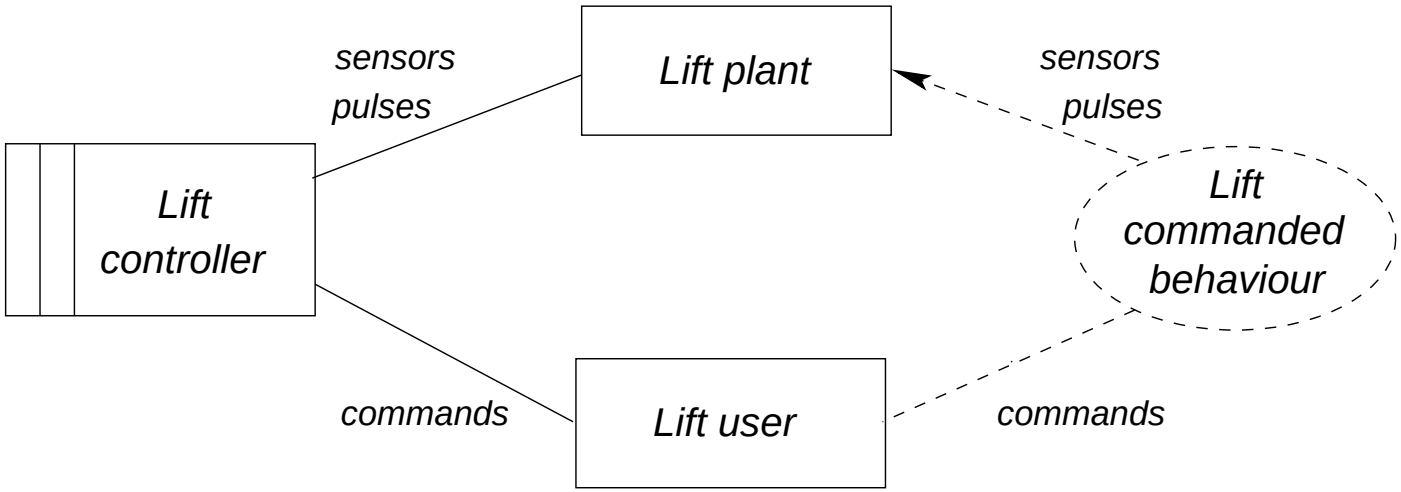
Lift System Case Study



A lift system consists of a lift plant (that is the cabin, the motor moving it and the doors at the various floors), some software automatically controlling the lift functioning (the controller), and the people using it (the users). The controller monitors the lift plant by means of sensors, which communicate the status of its various components (e.g., there is a sensor detecting the position of the cabin), and directs its behaviour by means of orders (e.g., it can order to open/close the doors).

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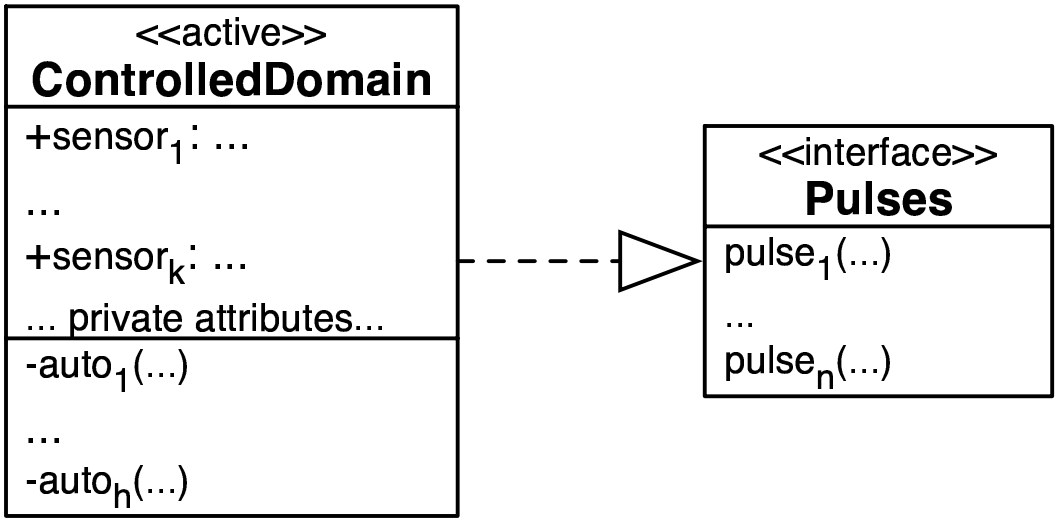

The *Controlled domain*

- is equipped with some sensors

$\longrightarrow$ public attributes sensor$_1$, . . . , sensor$_k$

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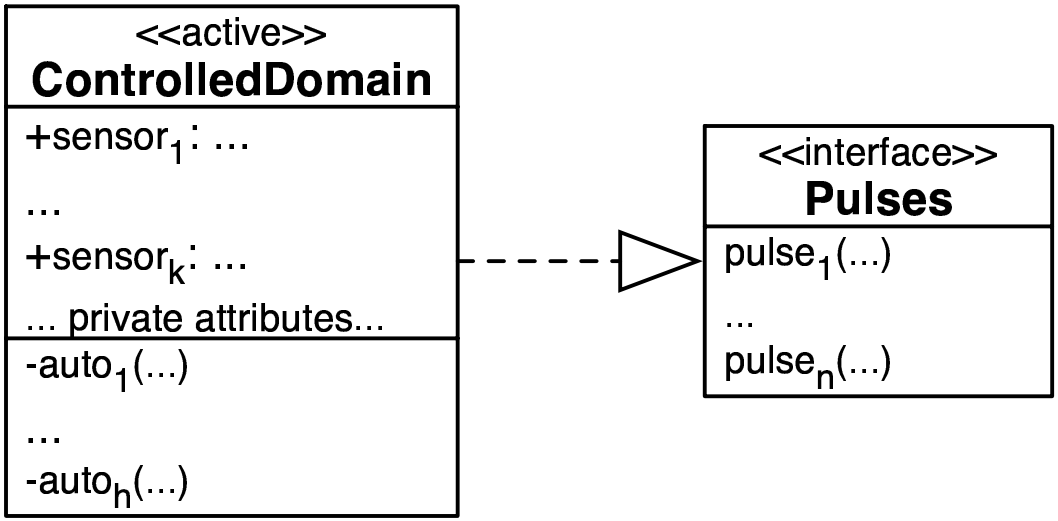

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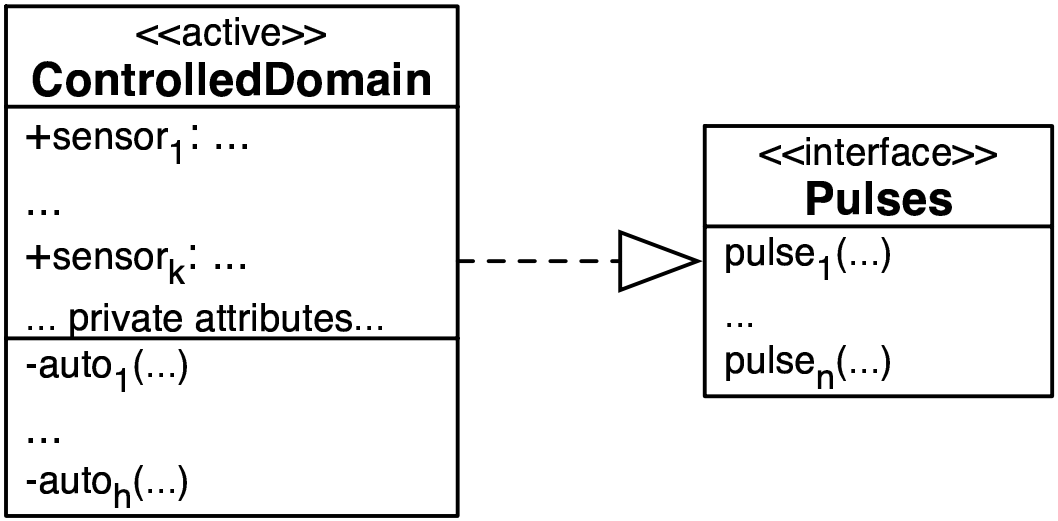

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- may change its state and functioning,

"autonomous" activities $\longrightarrow$ $\text{auto}_1, \ldots, \text{auto}_h$

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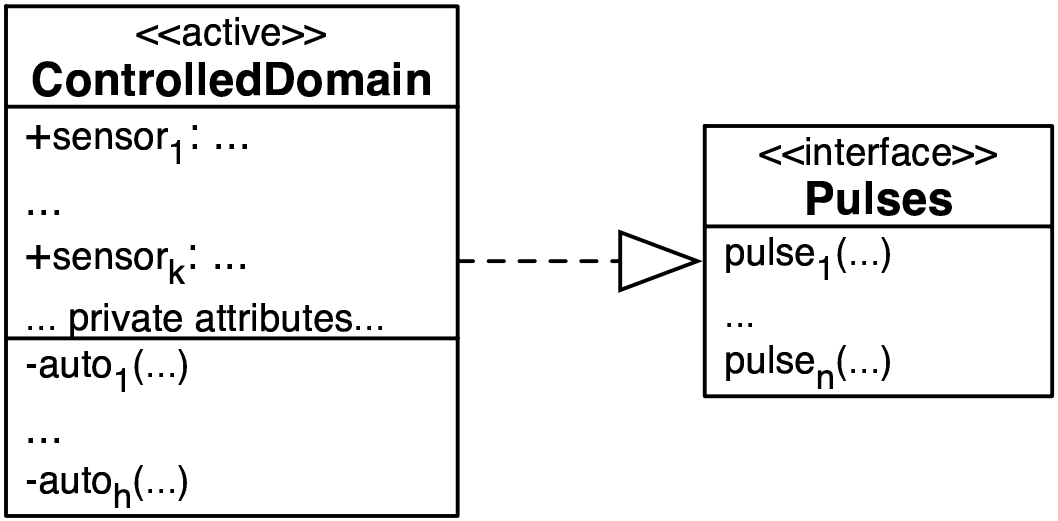

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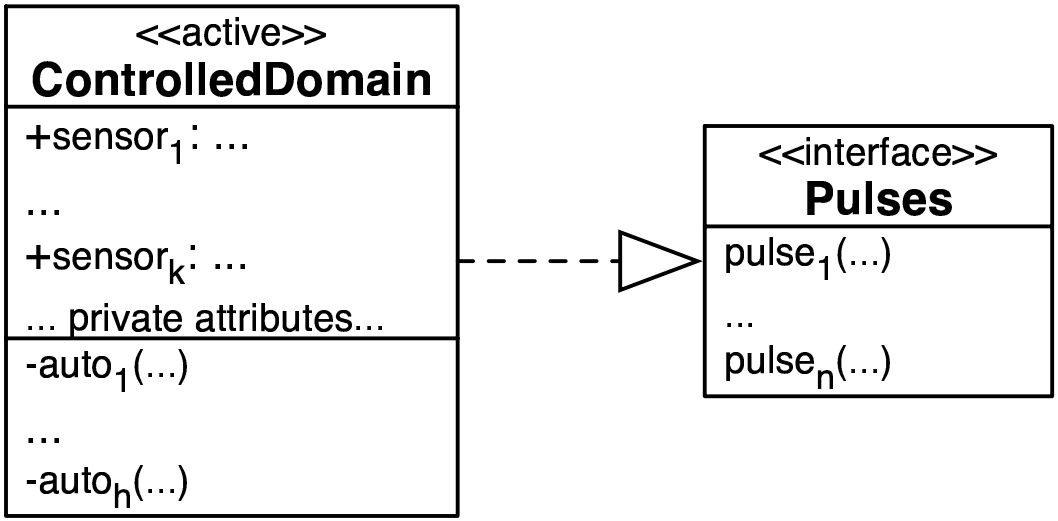

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- if a value signalled by sensors is derived from attributes, invariant constraints

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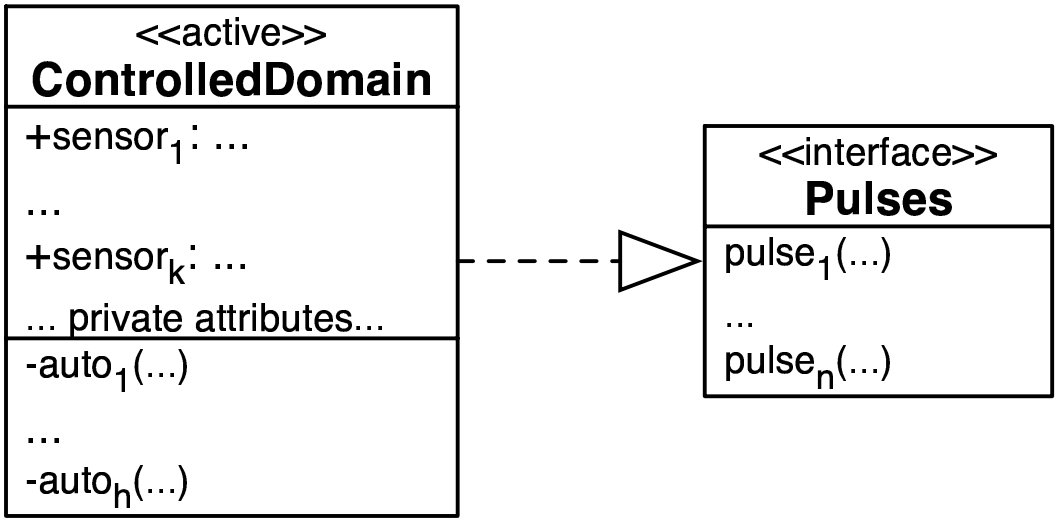

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- other private attributes may be used to describe its state
- if a value signalled by sensors is derived from attributes, invariant constraints
- behaviour : statechart, events (pulse$_i$ auto$_j$), attributes und

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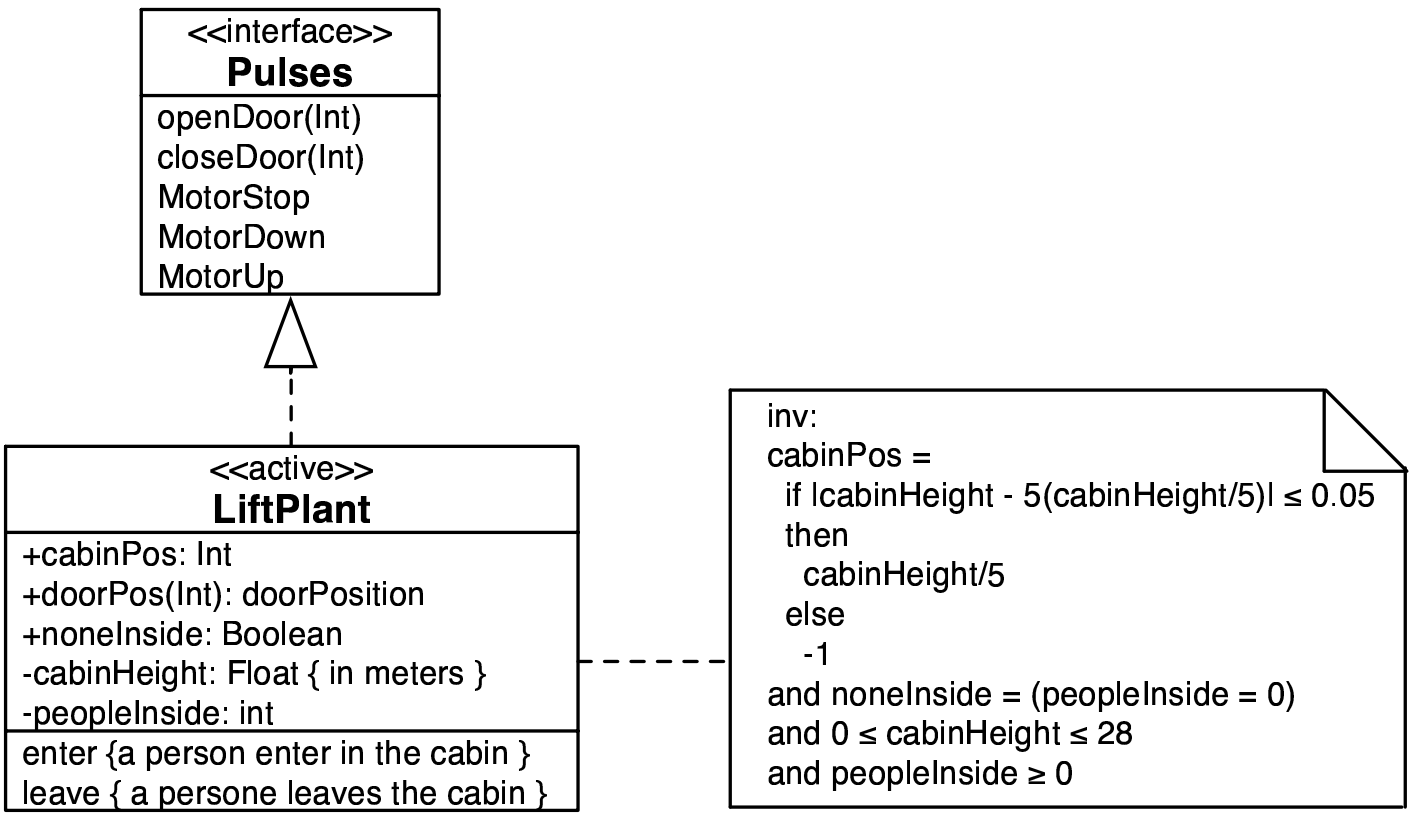
Lift Case Study : Domain Model - Class Diagram



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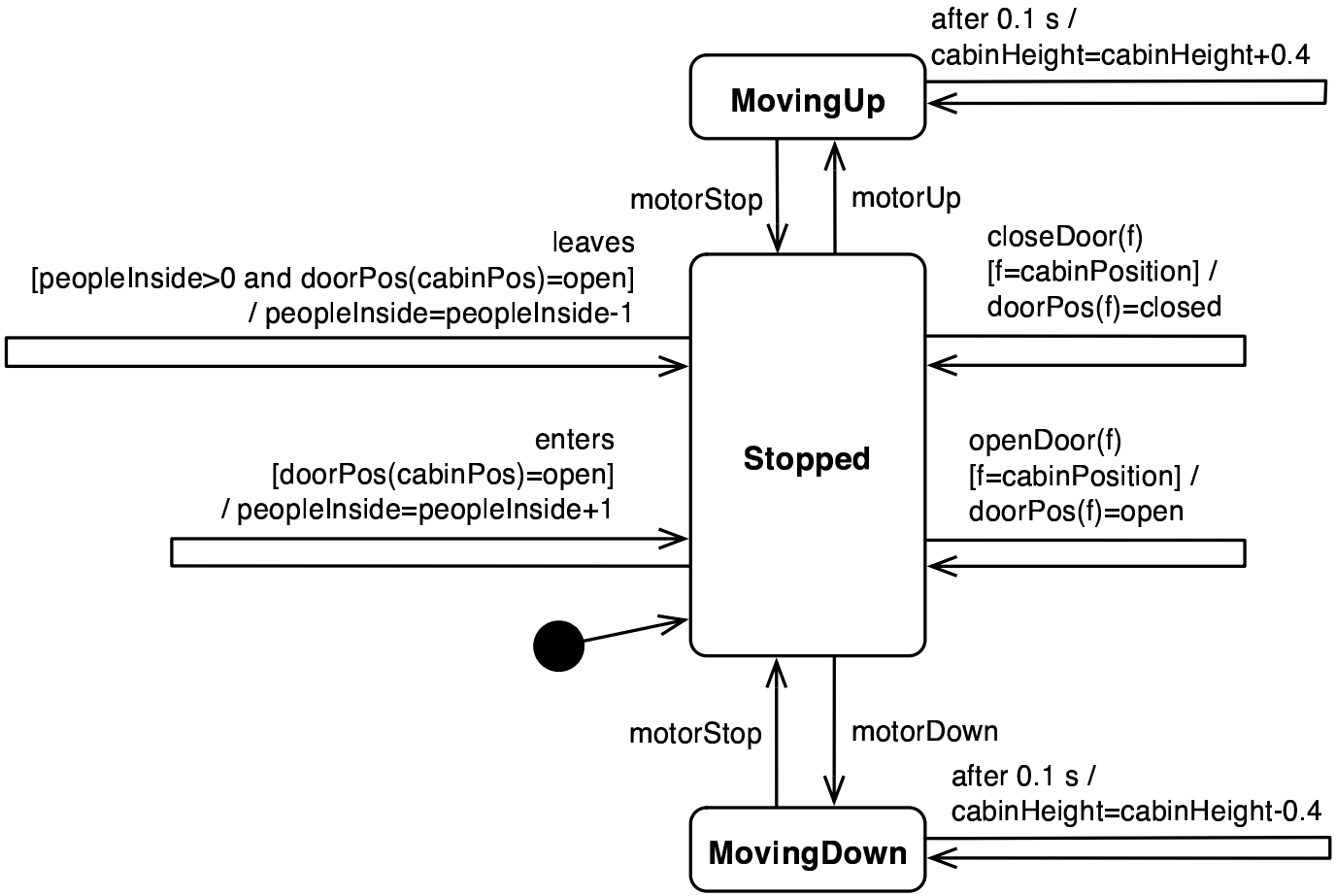
Lift Case Study : Domain Model - Behaviour of LiftPlant



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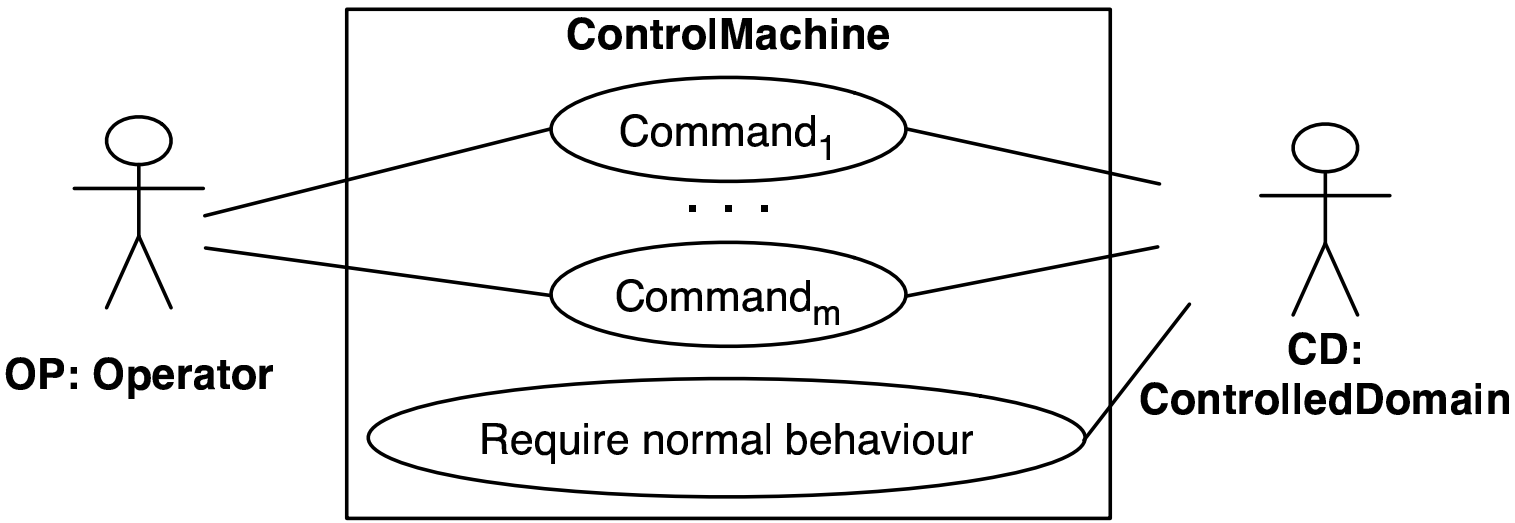
Commanded Behaviour : Requirement Specification - Use case Diagram



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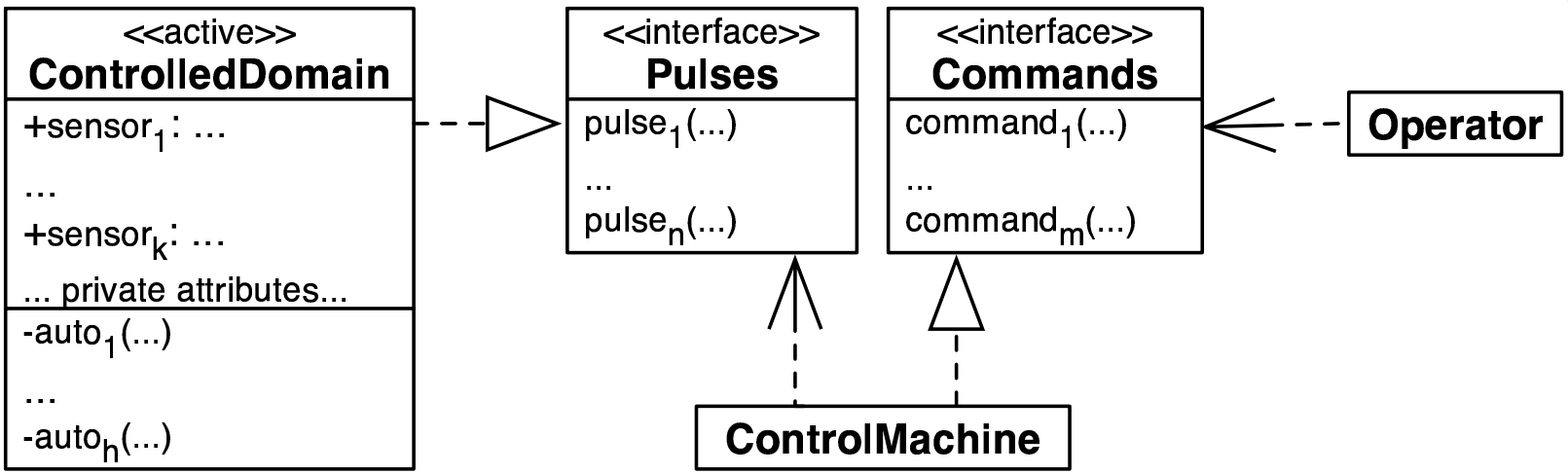
Commanded Behaviour : Requirement Specification - Class Diagram



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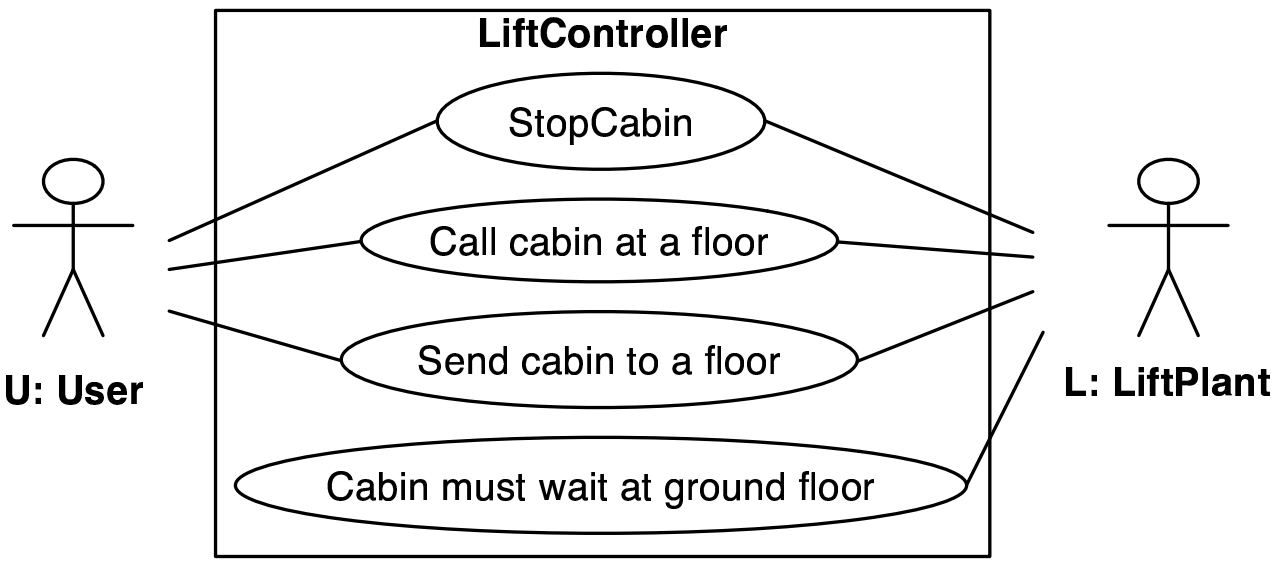
Lift Case Study : Requirement Specification - Use Case Diagram



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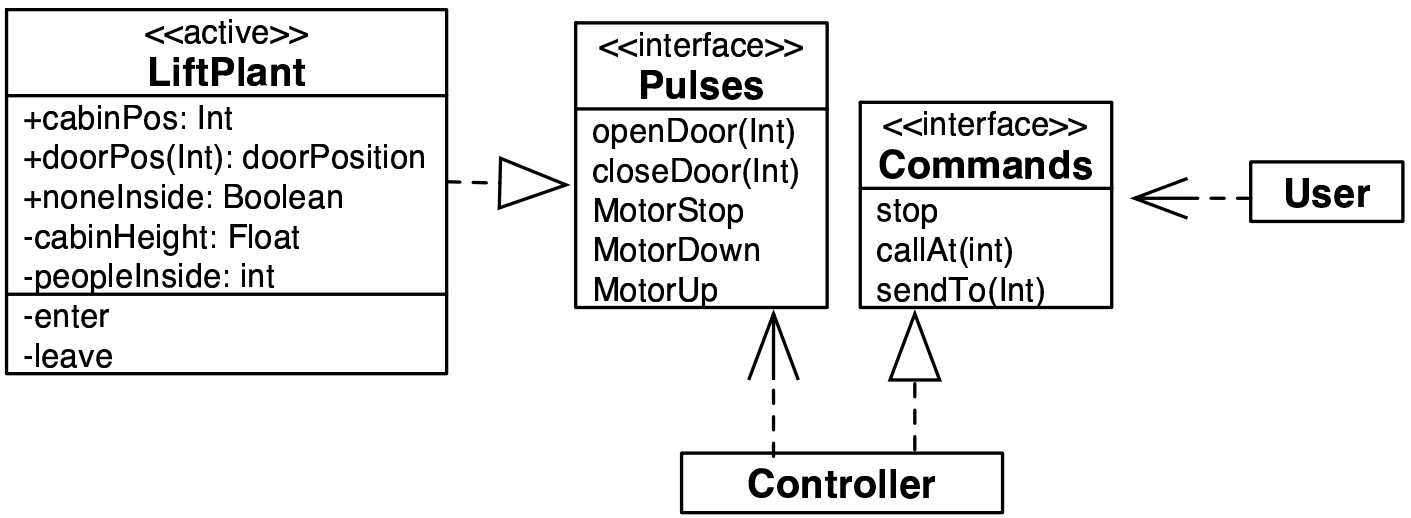

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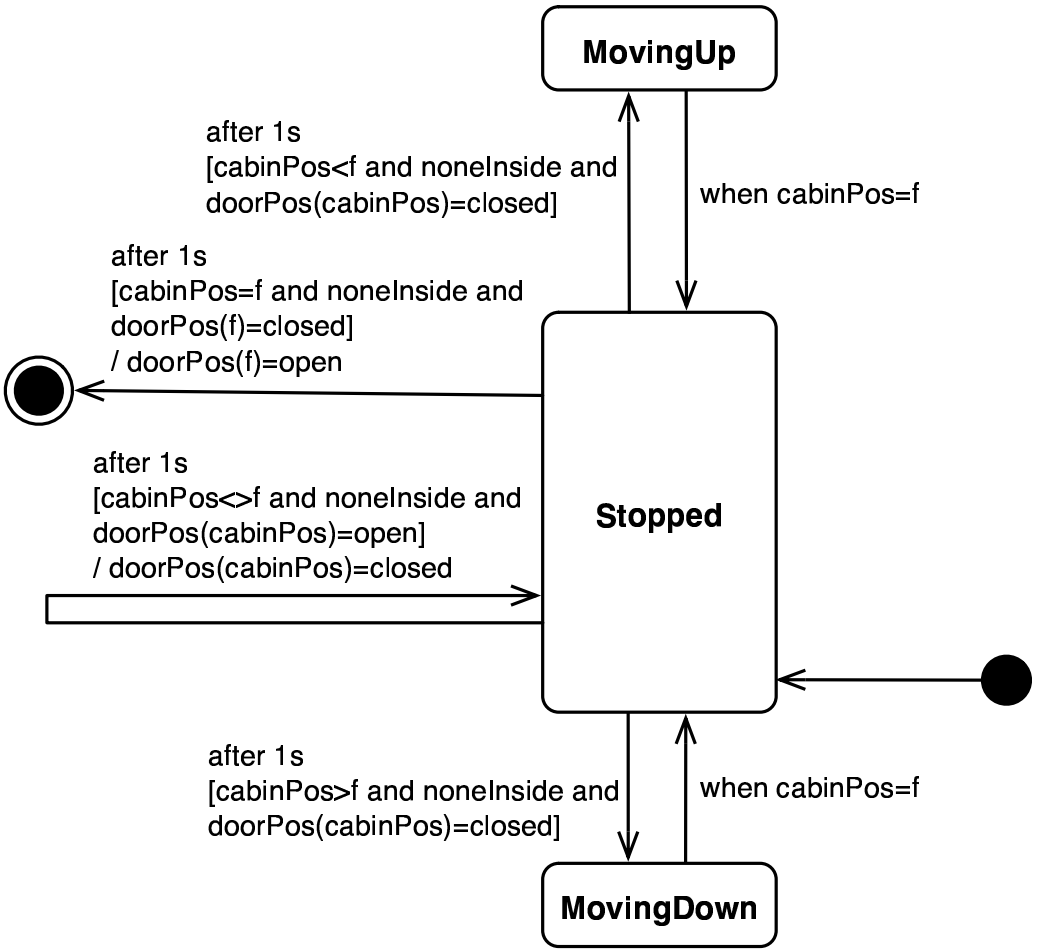
Use Case Description : Call the cabin at floor f



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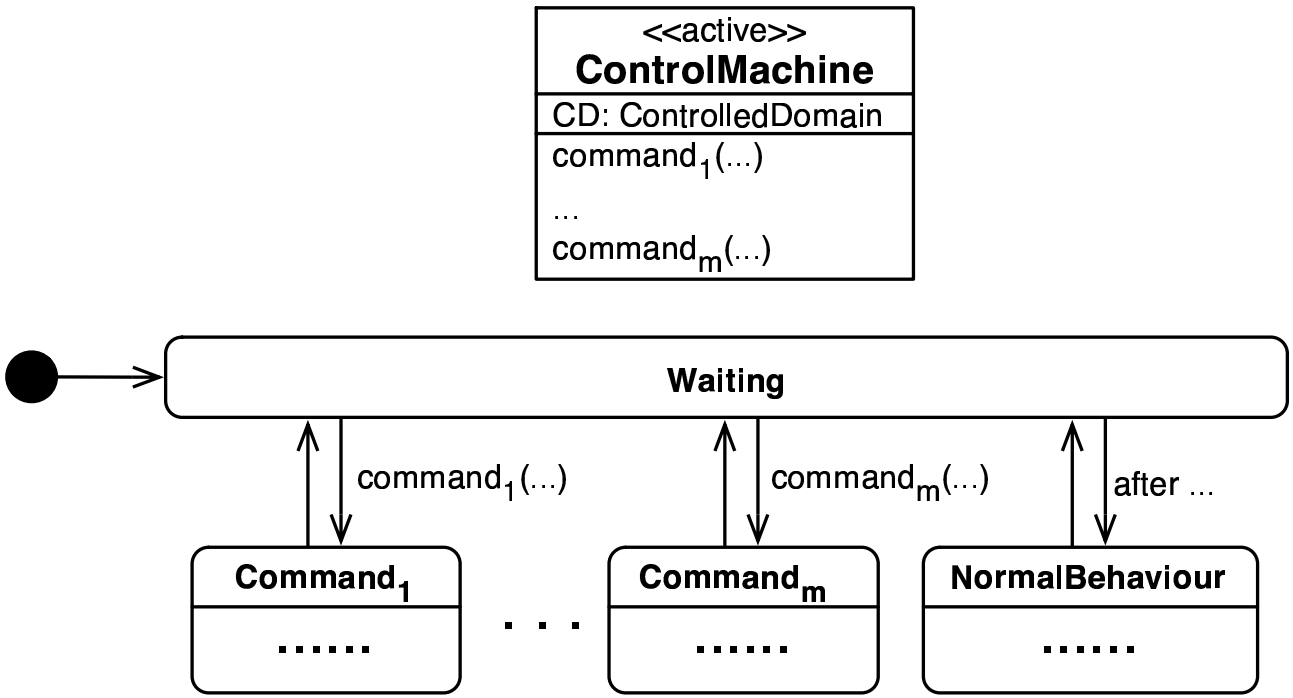
Commanded Behaviour Frame : Design Specification



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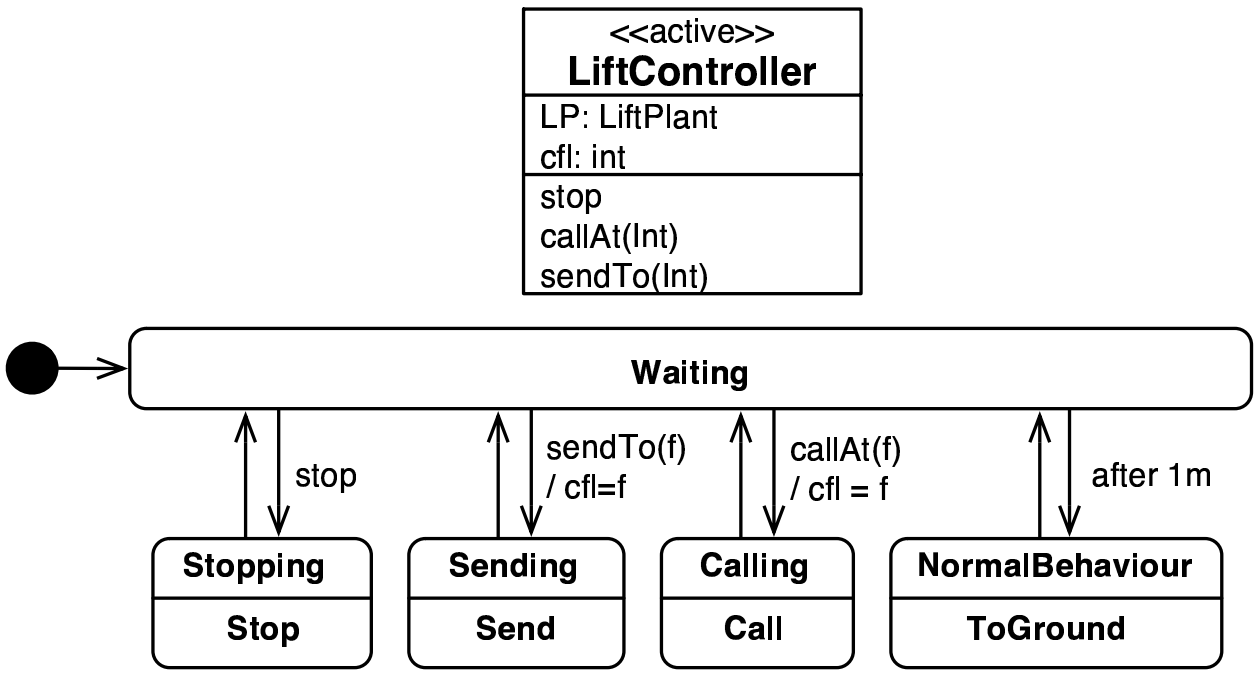

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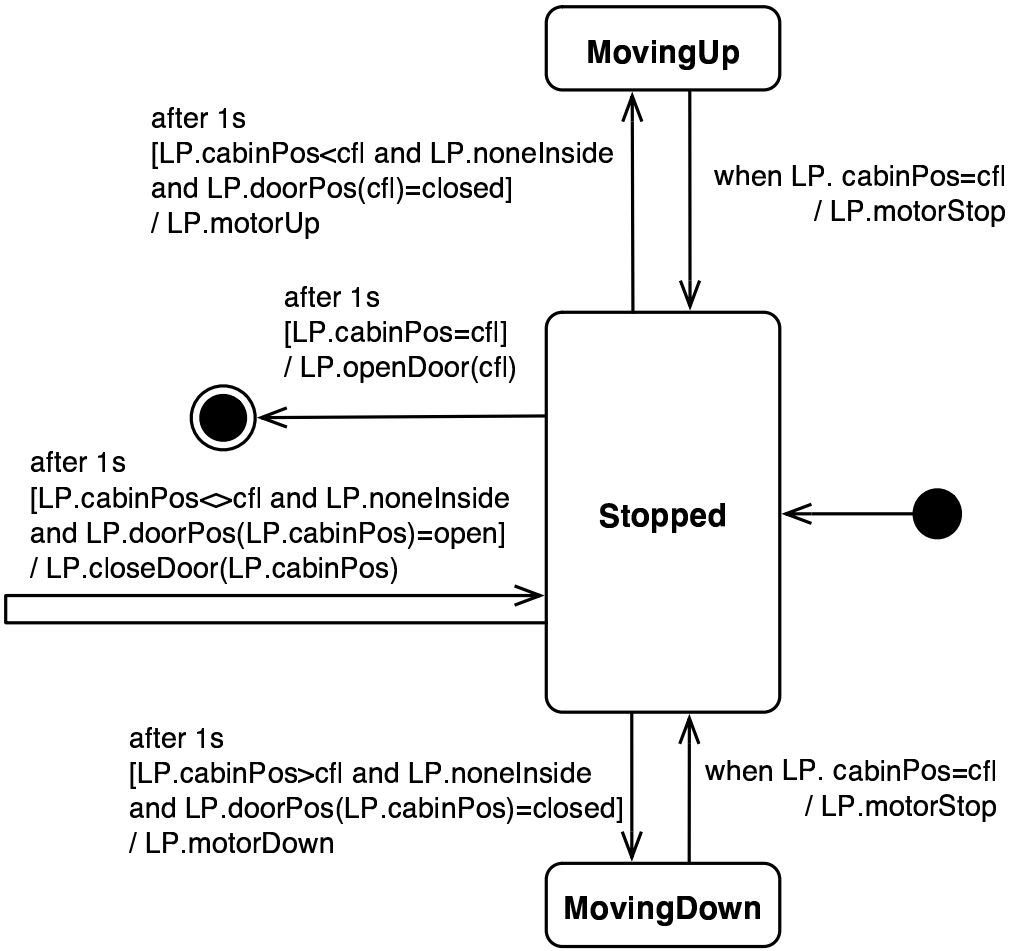

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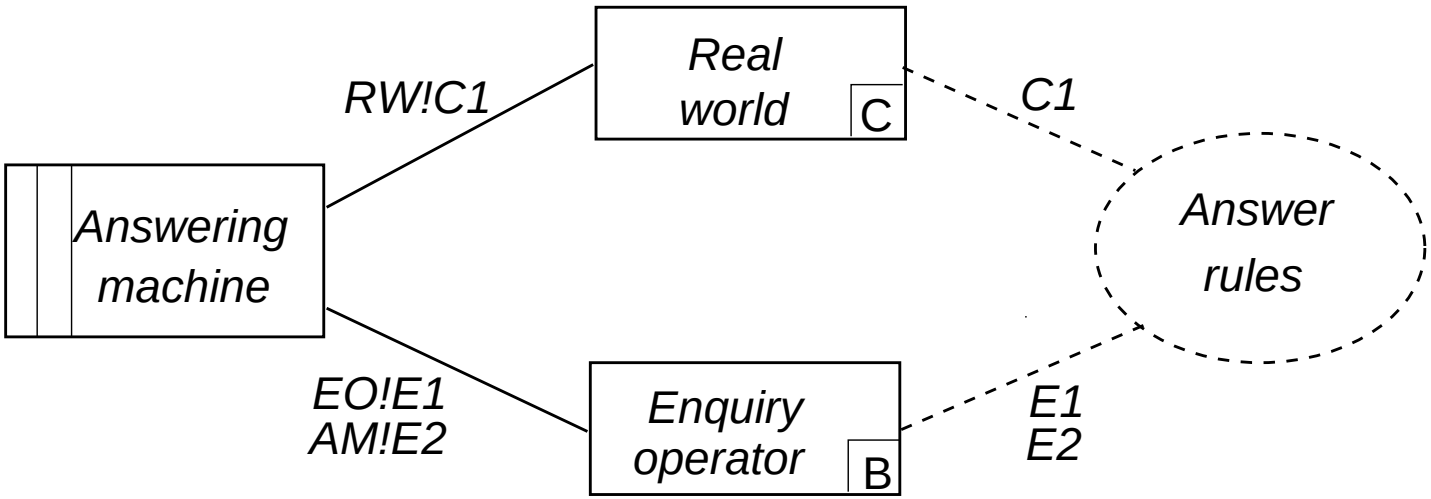

C1 phenomena are referred to later as Events issued by the Real world

E1 are Enquiries from the Enquiry operator

E2 are Display Acts and Error Messages displayed by the Answering Machine to the Enquiry Operator

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Gianna Reggio (DISI, Università di Genova, Italy)
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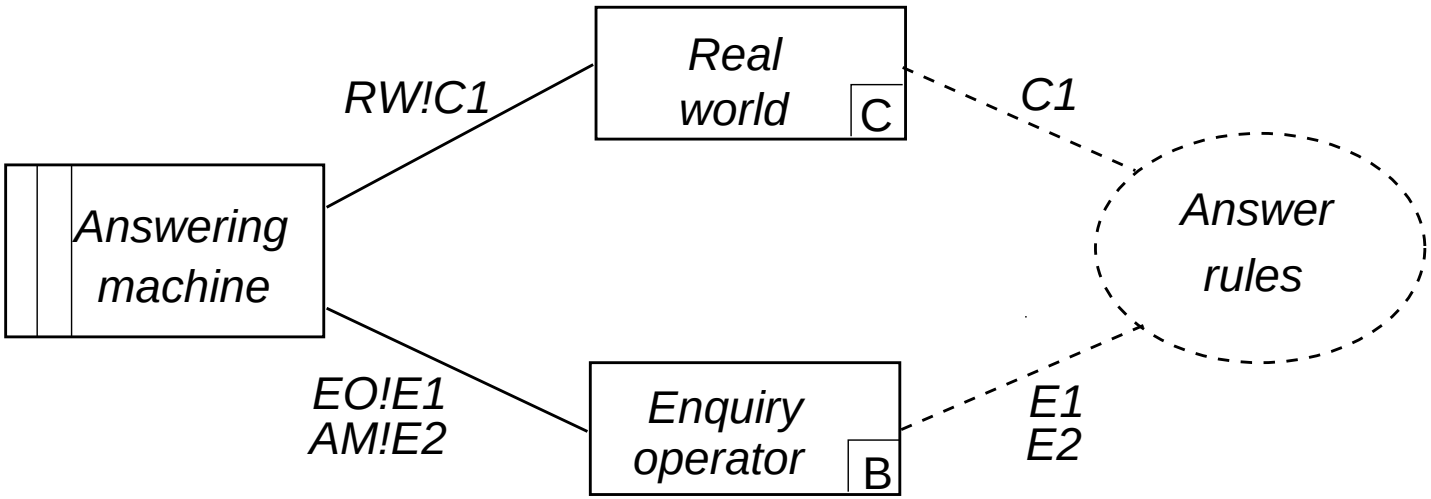

C1 phenomena are referred to later as Events issued by the Real world

E1 are Enquiries from the Enquiry operator

E2 are Display Acts and Error Messages displayed by the Answering Machine to the Enquiry Operator

> *There is some part of the physical world about whose states and behaviour information is needed upon requests from the operator. The problem is to build a machine that will obtain this information from the world and present it at the required place in the required form.*

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/∼choppy

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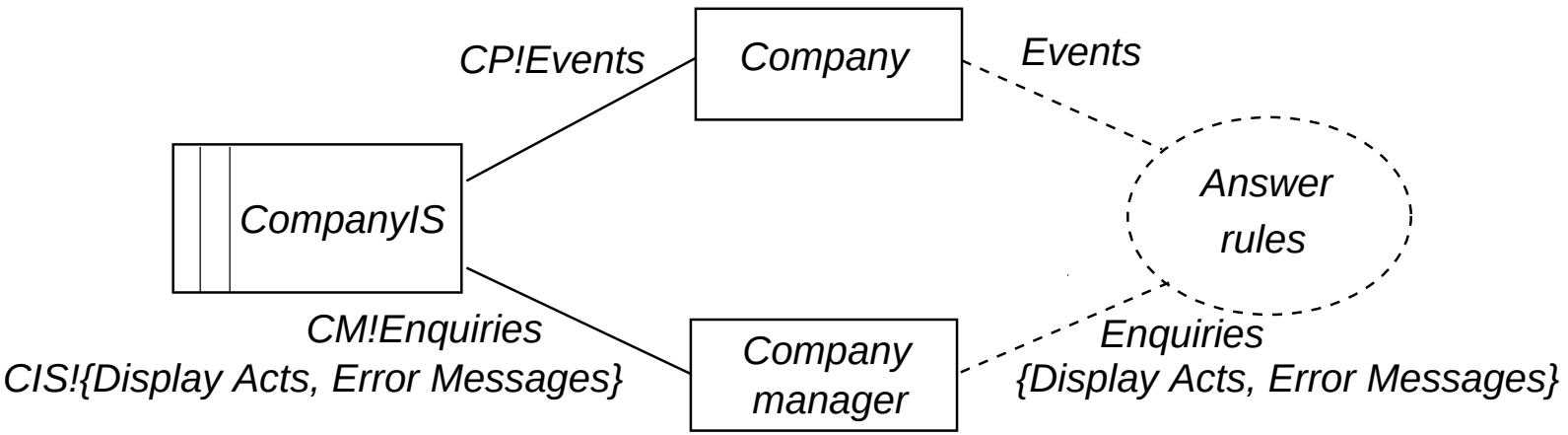
Case Study : Company Information System



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Company Information System : Domain Model (Real World)

Christine Choppy (LIPN, Université Paris XIII, France)
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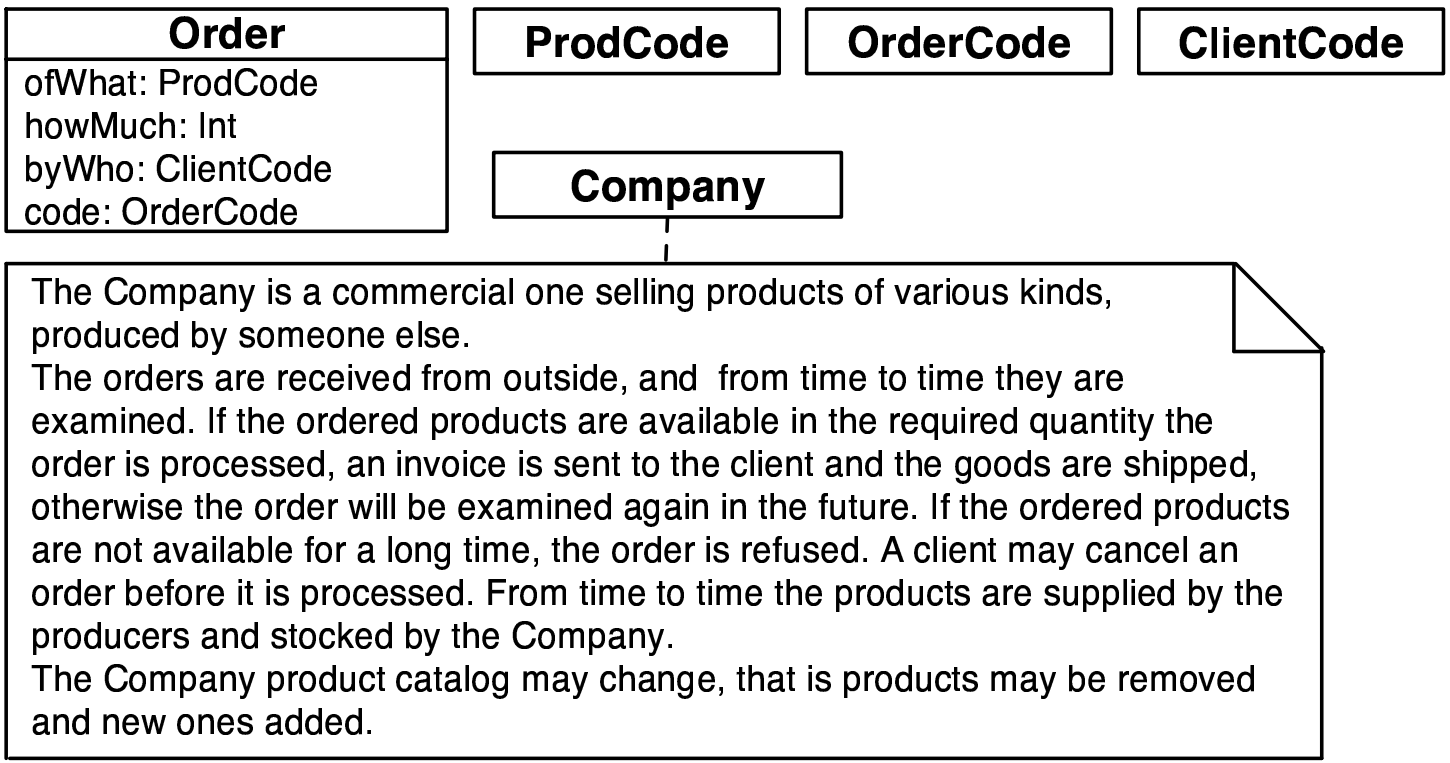
notation



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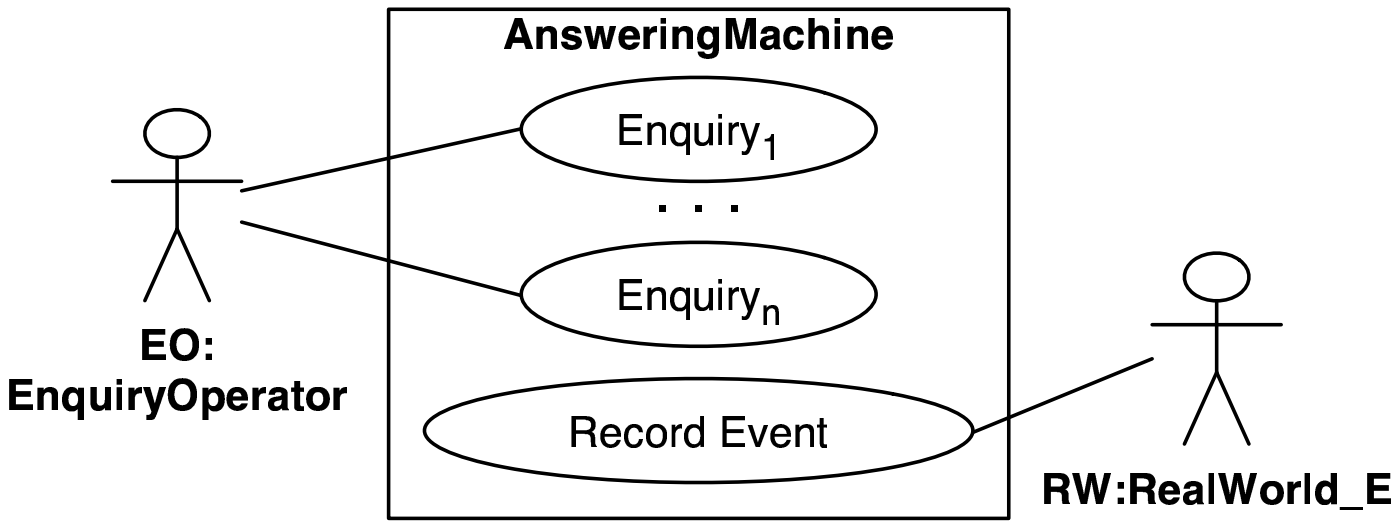
Commanded Information : Requirement Specification - Use Case Diagram



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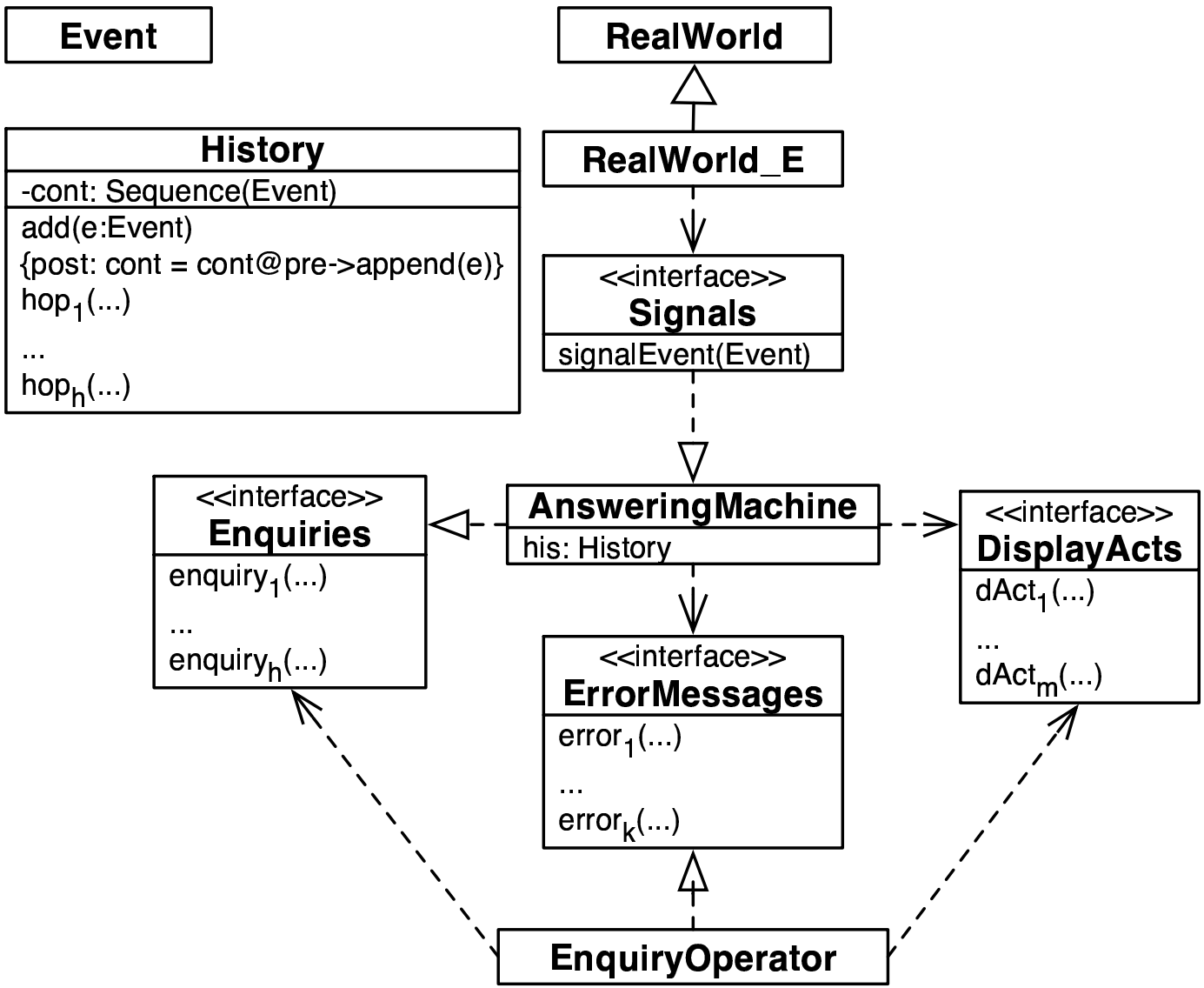
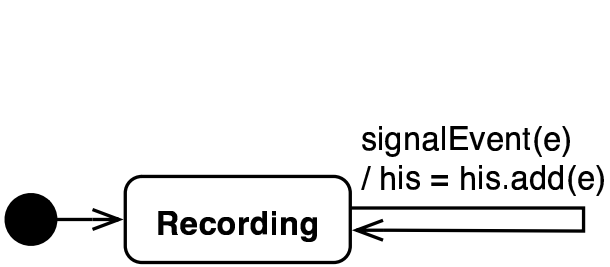
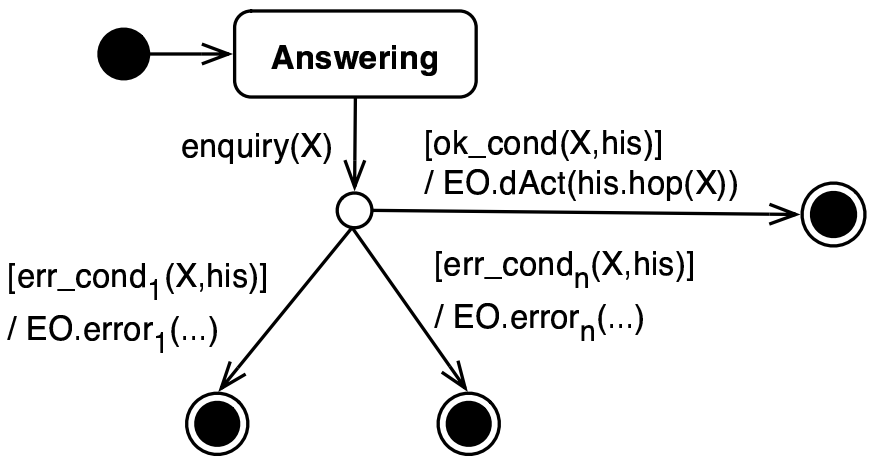
Commanded Information : Requirement Specification - Class Diagram



Commanded Information : Requirement Specification - Use Case Descriptions



Use case Record Event



Generic use case Enquiry

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/∼choppy

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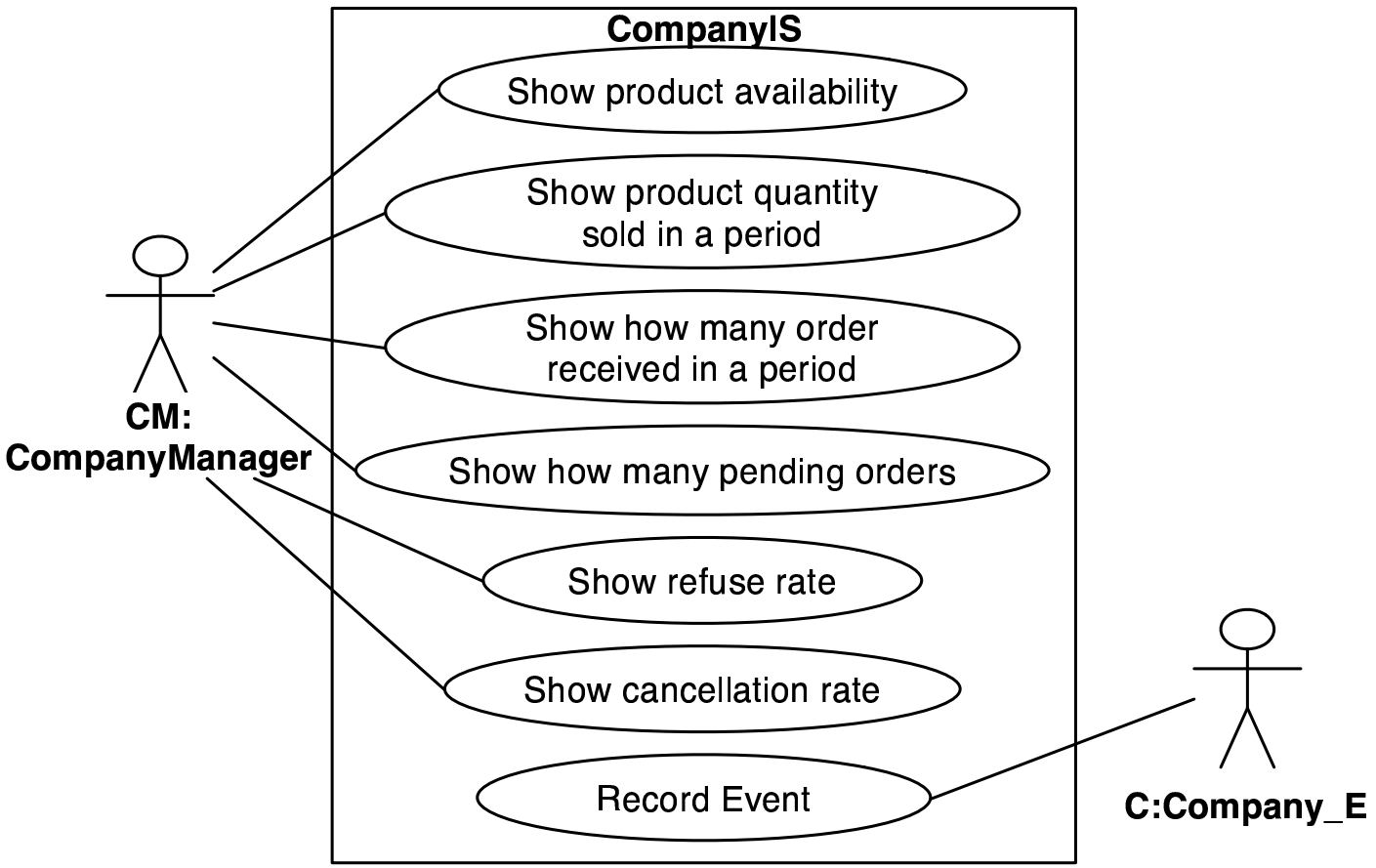
Company Information System : Requirement Specification - Use case diagram



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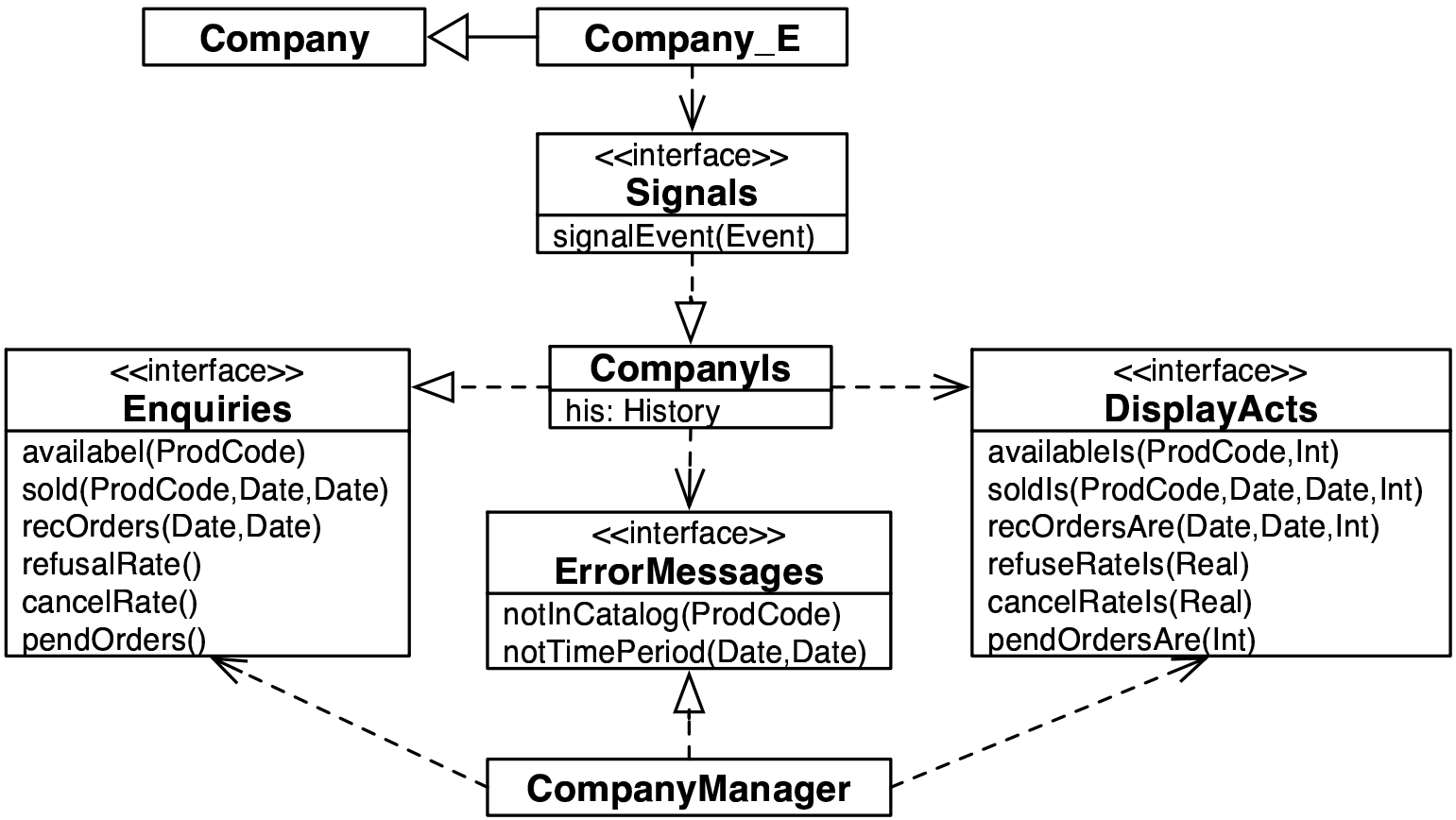
Company Information System Requirement Specification - Class Diagram



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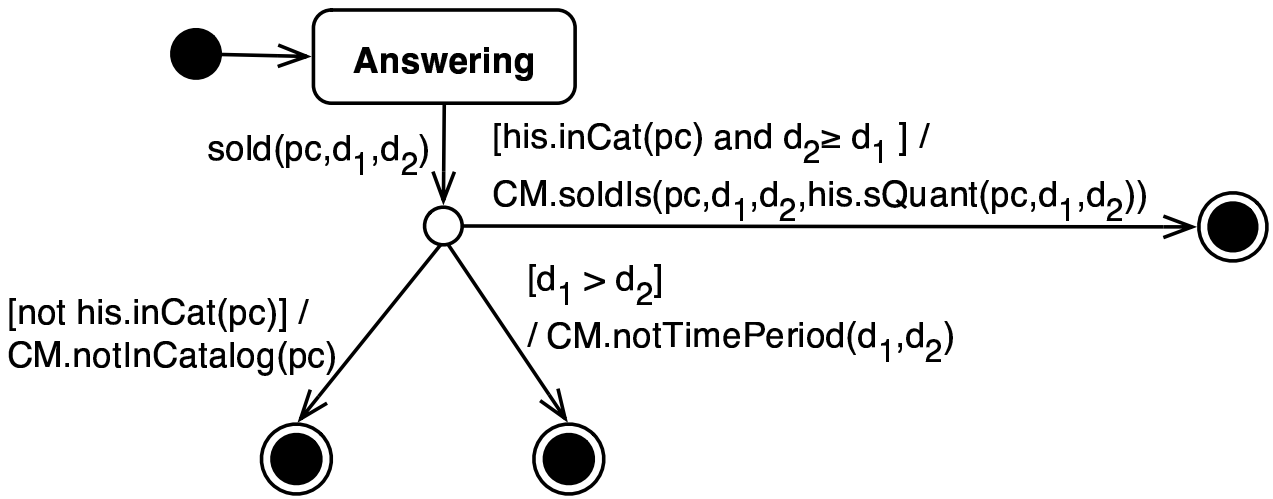
Show product quantity sold in a period



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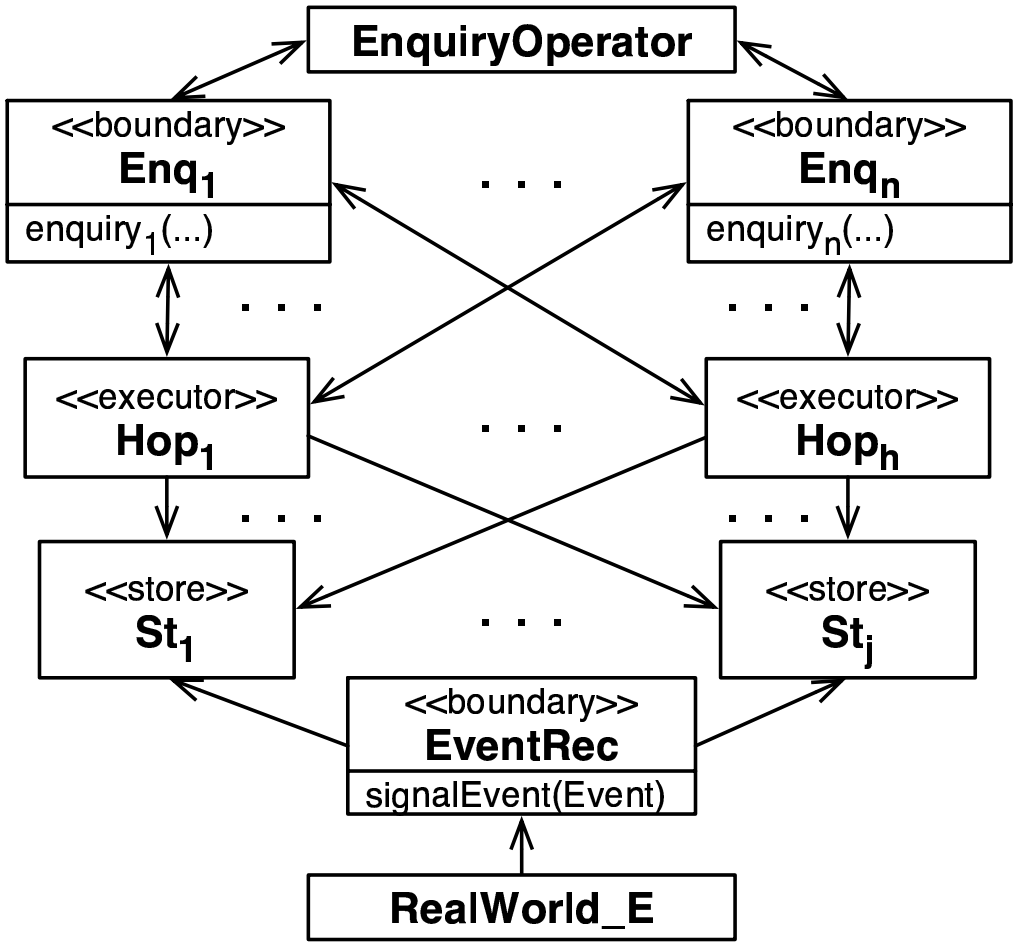
Commanded Information : Design Specification - Static View



and behaviour diagrams ...

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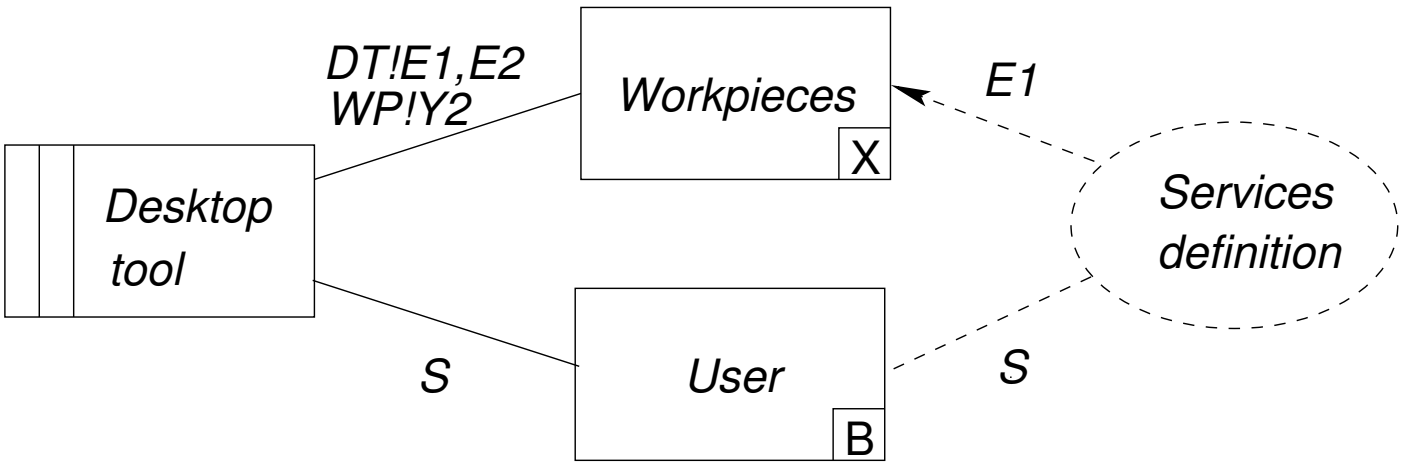

E1,E2 are resp. LOOKS and OPERATIONS *Y2 are MESSAGES*

S (SERVICES) are U!COMMANDS–S, DT!MESSAGES–S, DT!SHOWS

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Gianna Reggio (DISI, Università di Genova, Italy)
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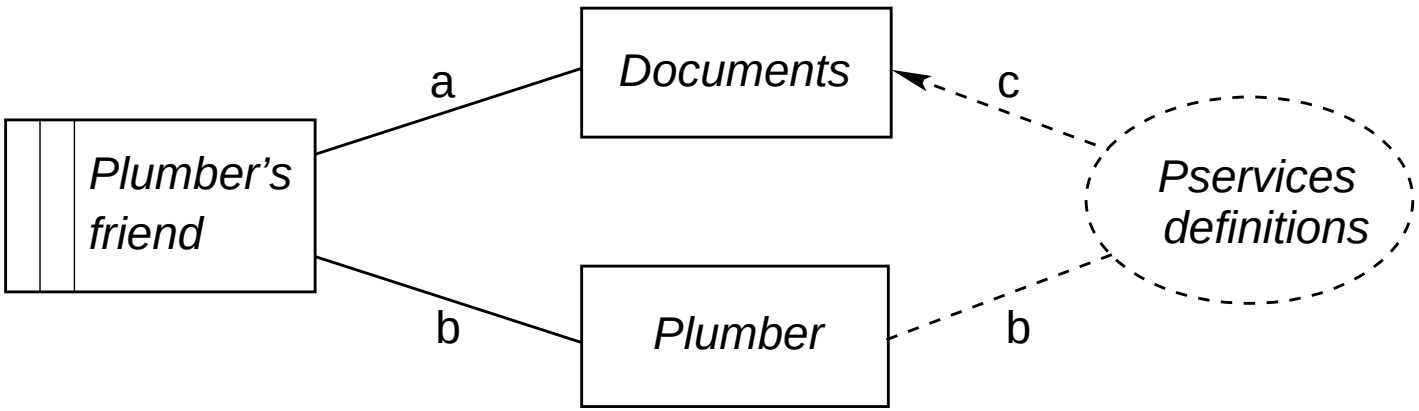
Plumber's Friend Case Study



a: PF![{SQLSelect}, {SQLInsert, SQLUpdate}] c: {SQLSelect}

b: PSERVICES = {AddClient, AddPart, CreateInvoice, ComputeBudget, ChangeClientAddress, ChangePartPrice, UpdateInvoice}

support a plumber in handling documents invoices to present to the clients (initially to approve a job and at the end to require the payment), records about the clients, parts used (tubes, faucets, ...), All these documents are stored in an already existing relational database

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/~choppy

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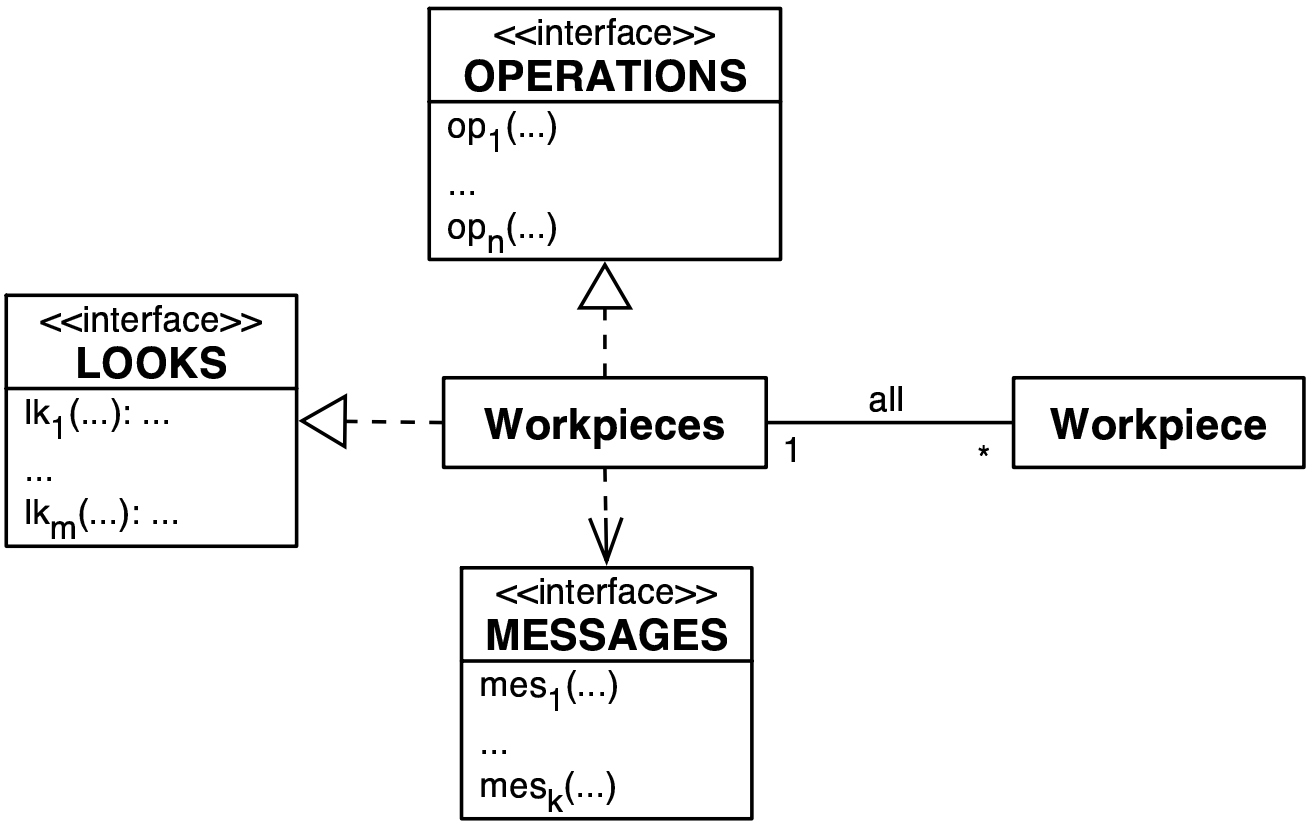
Rich Workpieces Frame : Domain Model



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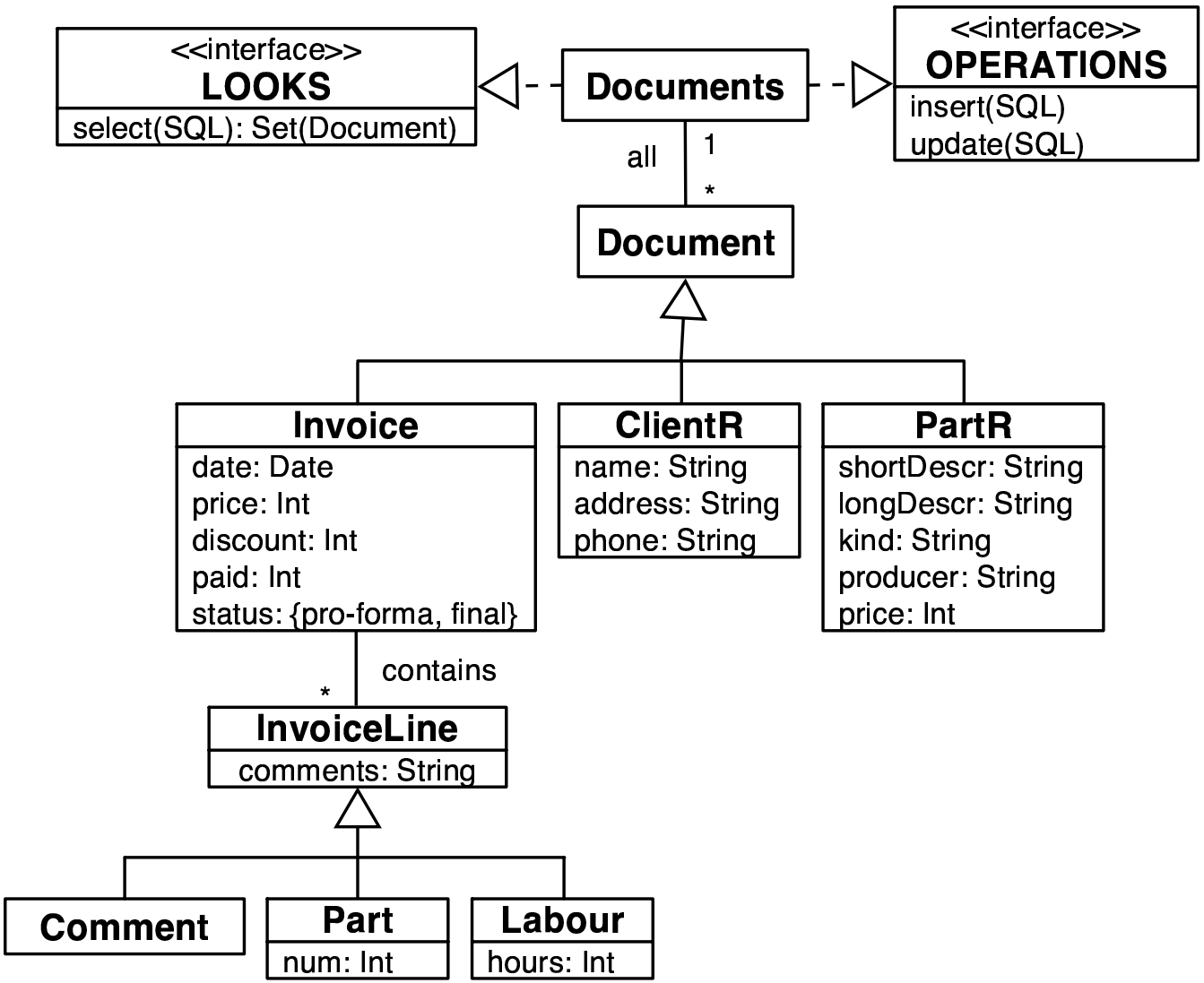

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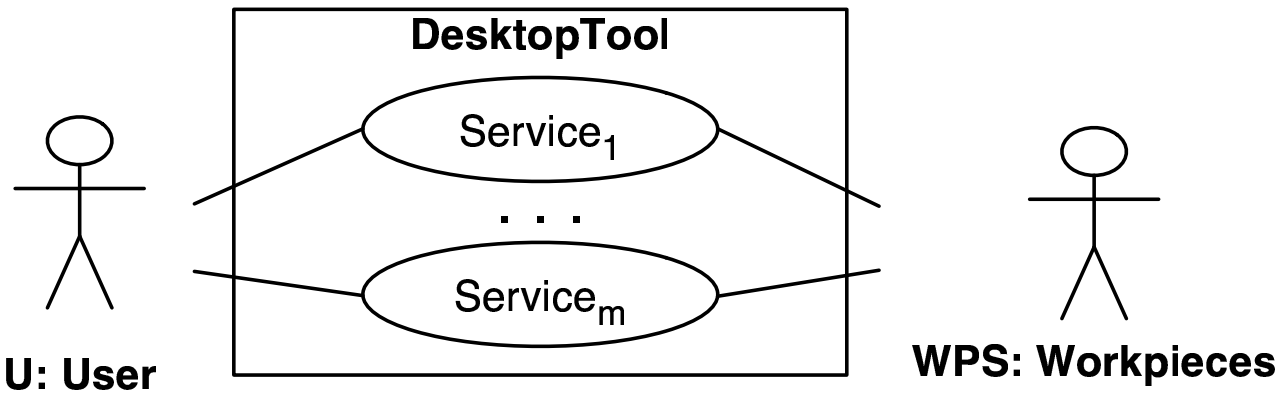
Rich Workpieces Frame : Requirement Specification - Use Case Diagram



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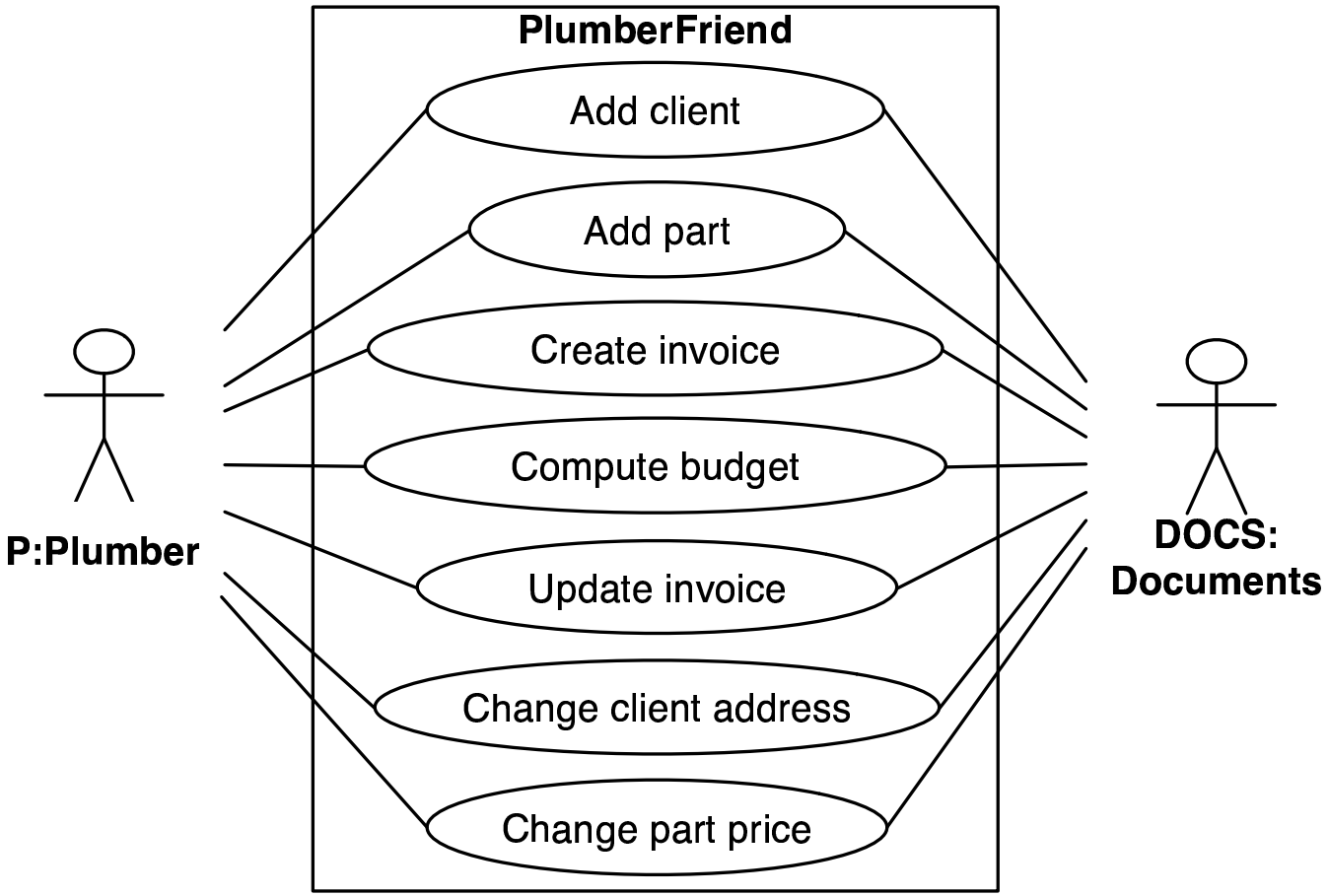

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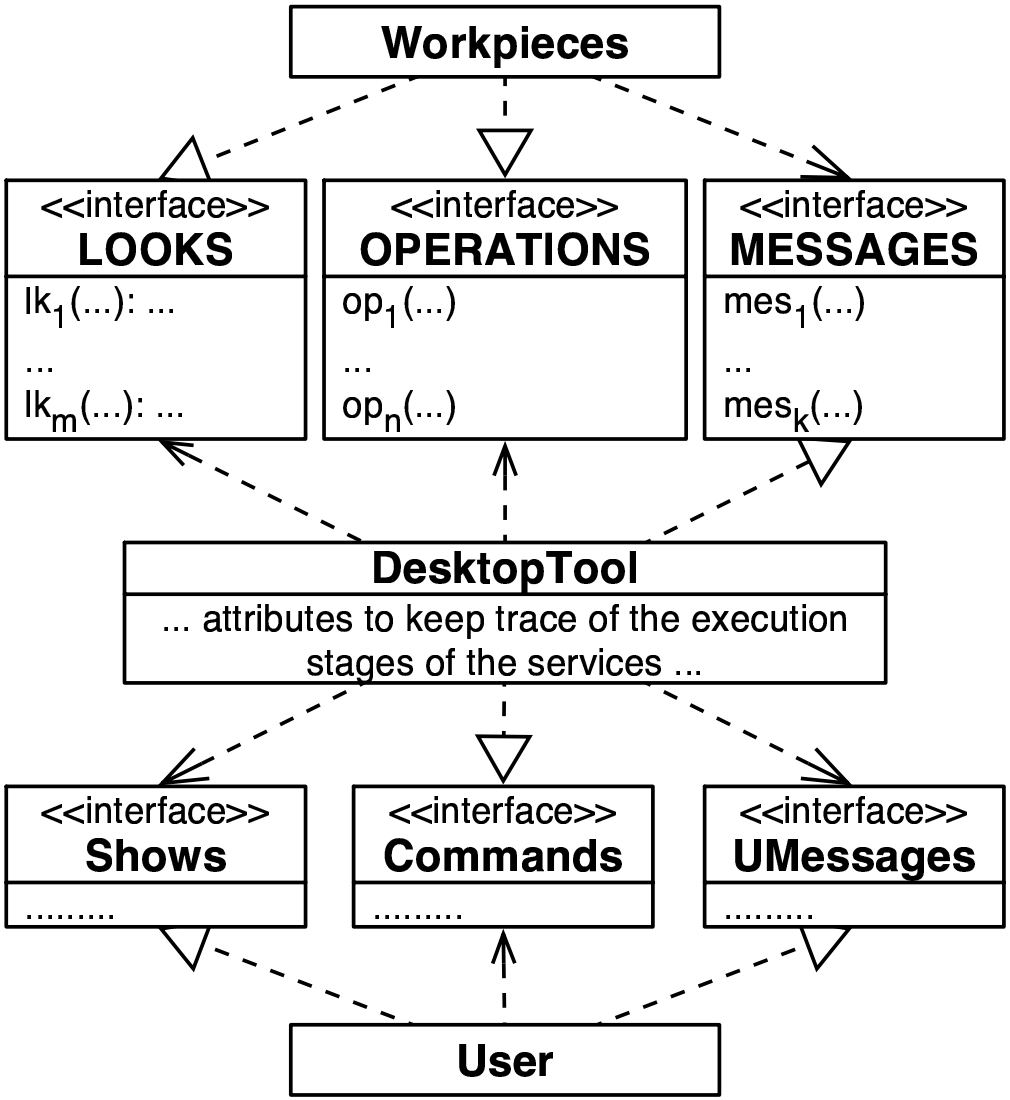
Rich Workpieces Frame : Requirement Specification - Class Diagram



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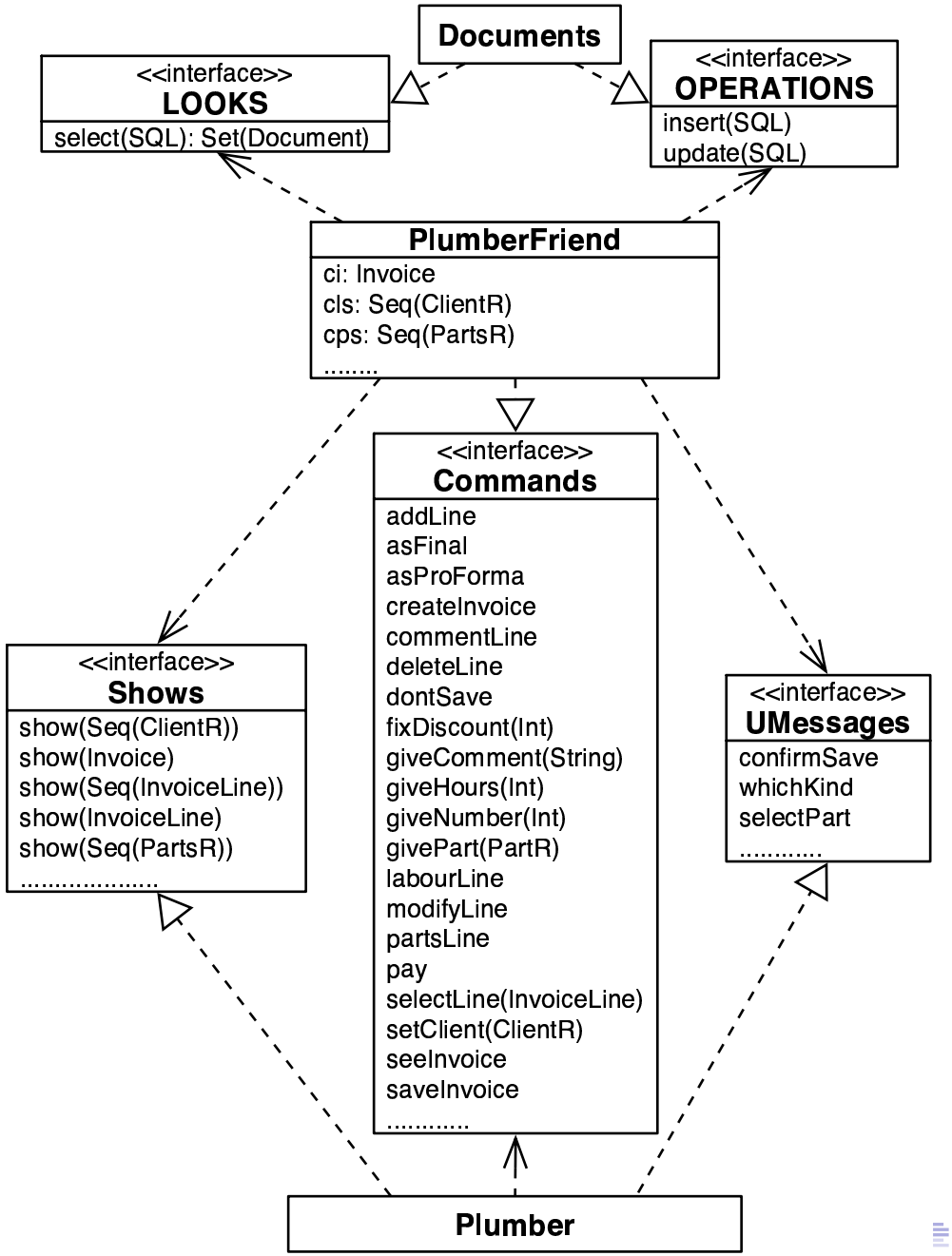
Use Case (Service) Create invoice



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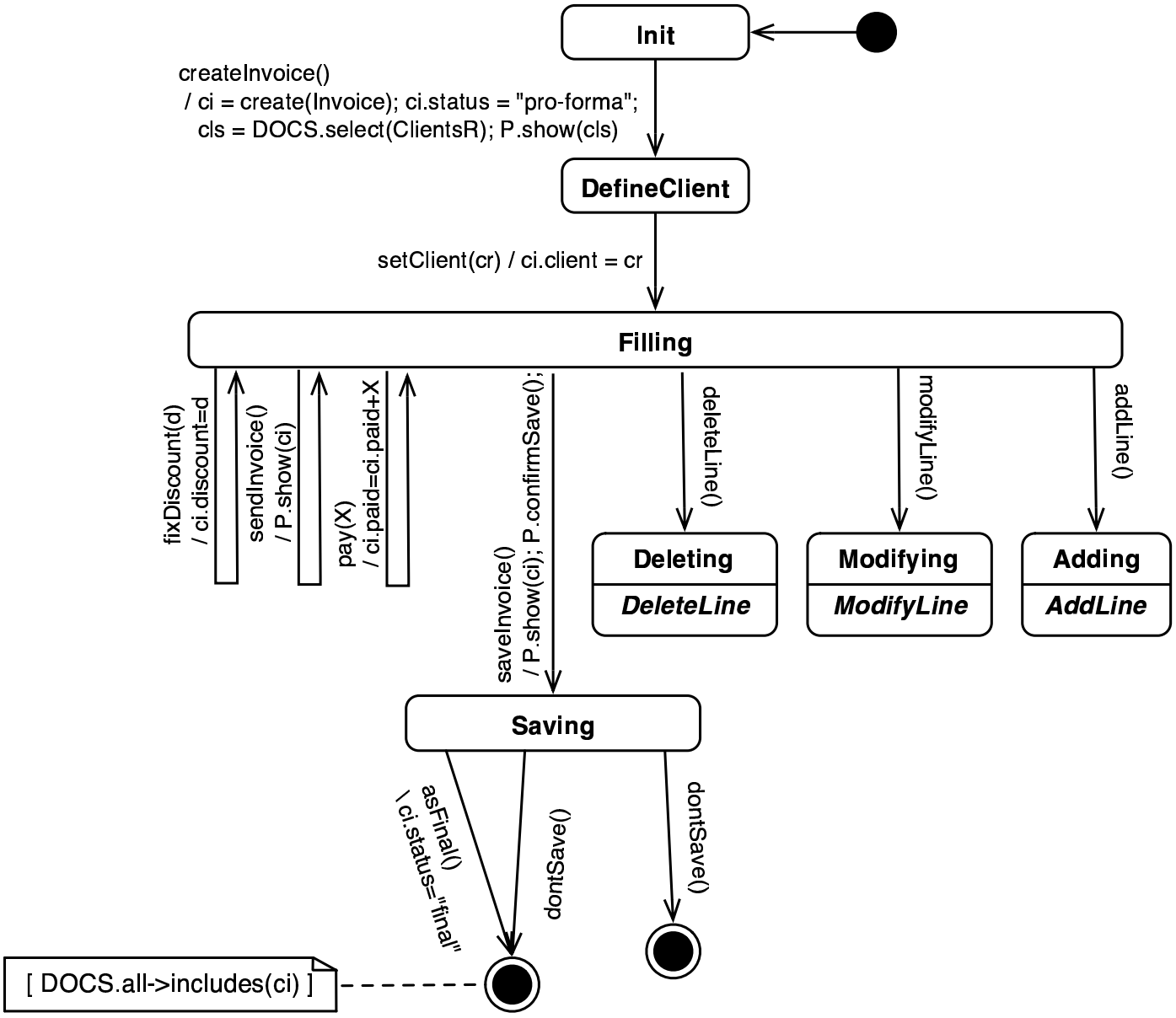
Use Case Create invoice - statechart



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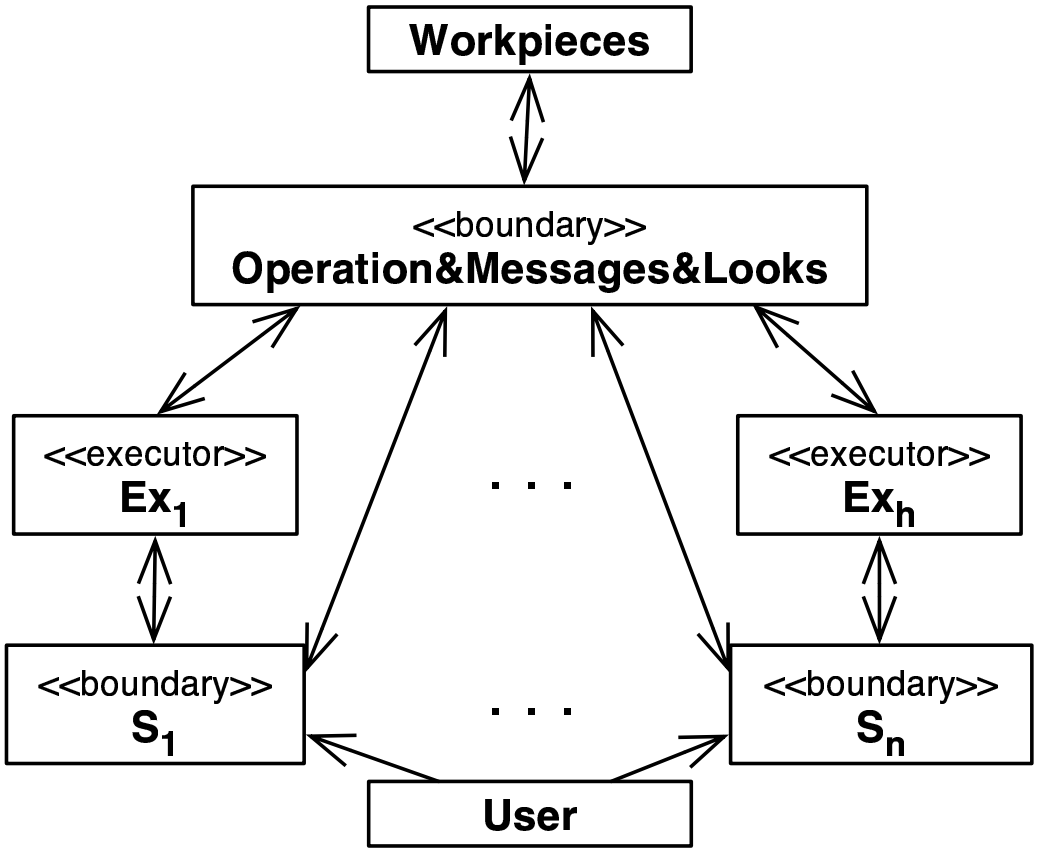
Rich Workpieces Frame : Design Specification



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- a software development approach
  1. match with a (basic or variant) problem frame (check IST paper for the Required behaviour frame)
  2. model the various frames parts following the proposed UML diagrams

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- a software development approach
  1. match with a (basic or variant) problem frame (check IST paper for the Required behaviour frame)
  2. model the various frames parts following the proposed UML diagrams
- problem frames are very good at providing a first requirement structure that is invaluable to start the analysis of a problem and understand its nature.
  A means to reuse experience helpful to start a complex problem analysis with some structuring concepts in mind.

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- problem frames are very good at providing a first requirement structure that is invaluable to start the analysis of a problem and understand its nature.
  A means to reuse experience helpful to start a complex problem analysis with some structuring concepts in mind.
- reduce time spent to decide which UML constructs to use and how to model the domain and the requirements

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
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Conclusions (follwd)

- a more direct path to the UML models, improved models quality (relevant issues are addressed, a uniform style is offered)

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Conclusions (follwd)

- a more direct path to the UML models, improved models quality (relevant issues are addressed, a uniform style is offered)
- essence : use and combination of the relevant underlying concepts, possible different notations (e.g. a graphical language for a different level of abstraction, UML, formal specification language, etc) and different target languages.

Christine Choppy (LIPN, Université Paris XIII, France)
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- how to match a complex problem with a basic pbf ?

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Gianna Reggio (DISI, Università di Genova, Italy)
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- how to match a complex problem with a basic pbf ?
  either devise a more complex problem frame (still covering a range of applications)
  quite some work done in this area (by others) ...
  Enterprise Applications frame (ASWEC)

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  associate/embody architectural styles ...
  (Jon Hall, Lucia Rapanotti et al., Christine Choppy, Maritta Heisel and Denis Hatebur)

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  (Jon Hall, Lucia Rapanotti et al., Christine Choppy, Maritta Heisel and Denis Hatebur)
- how to validate this approach ?

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- how to move from the problem frame to the design ?
  associate/embody architectural styles ...
  (Jon Hall, Lucia Rapanotti et al., Christine Choppy, Maritta Heisel and Denis Hatebur)
- how to validate this approach ?
  integrate with other development methods (Agile, KAOS, ...)

Christine Choppy (LIPN, Université Paris XIII, France)
Gianna Reggio (DISI, Università di Genova, Italy)
http://www-lipn.univ-paris13.fr/∼choppy

Issues
Motivation
Problem Frames
The transformation frame
The Commanded Behaviour frame
The Commanded Information frame
The Rich Workpieces frame
Conclusions and perspectives