

Modeling and Execution of Software User Interfaces



Marco Brambilla

 @marcobrambi





System Modeling

The context

The need

The missing part



The UI Modeling Problem





UI Modeling Problem

**User interface and interaction development
is a painful phase of software process**

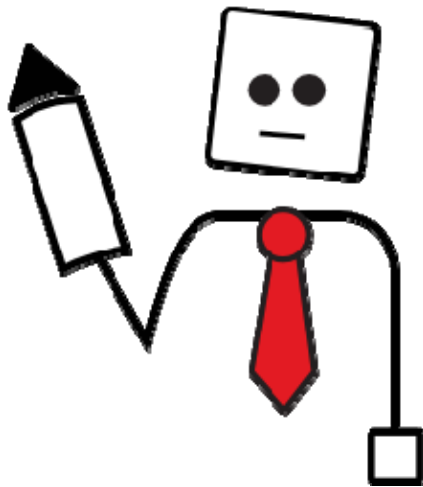
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The UI Design Problem

Costly and
Inefficient process



Complexity of
user interfaces (UIs)



Ineffective
tools



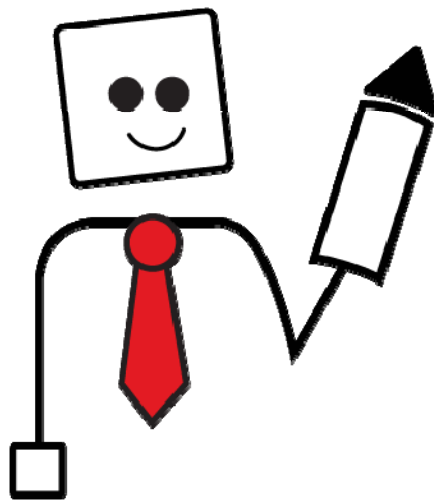
Manual
development



No MDE
technology



The UI Design solution: IFML



Platform independent
description of UIs



Focused on user
interactions



No definition of
graphics and styles



Reference external
models



Standardization gap

- User interaction has been overlooked in software engineering standards
- Hence **the Interaction Flow Modeling Language (IFML)**



- In less than 2 years (a record in OMG!), we obtained approval of the beta IFML standard
- Version 1.0 due to come out in these weeks



The Interaction Flow Modeling Language





IFML Objectives



Content

Navigation Path

Event

Binding to
Business Logic

Binding to Persistence Layer



IFML Objectives: Content

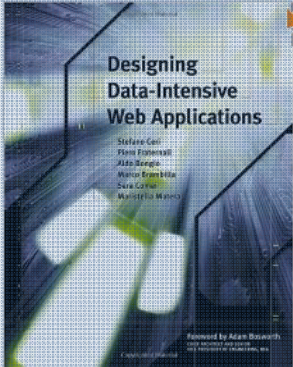
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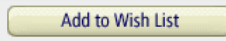
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– Sara Nelson, Amazon Editorial Director

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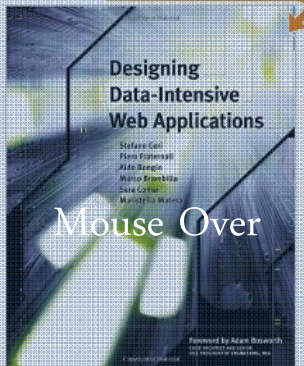
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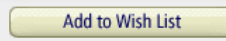
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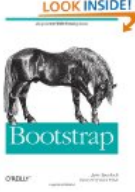
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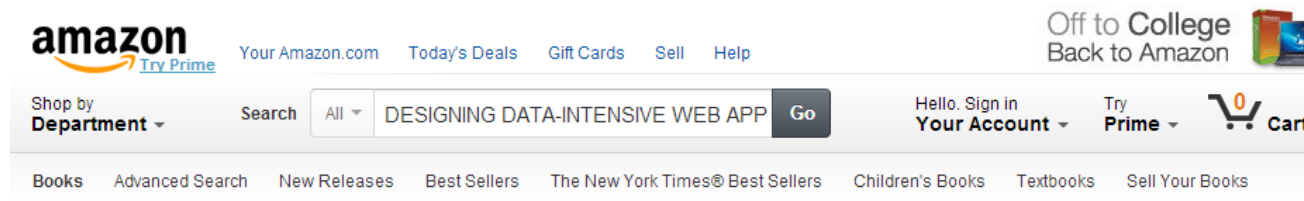
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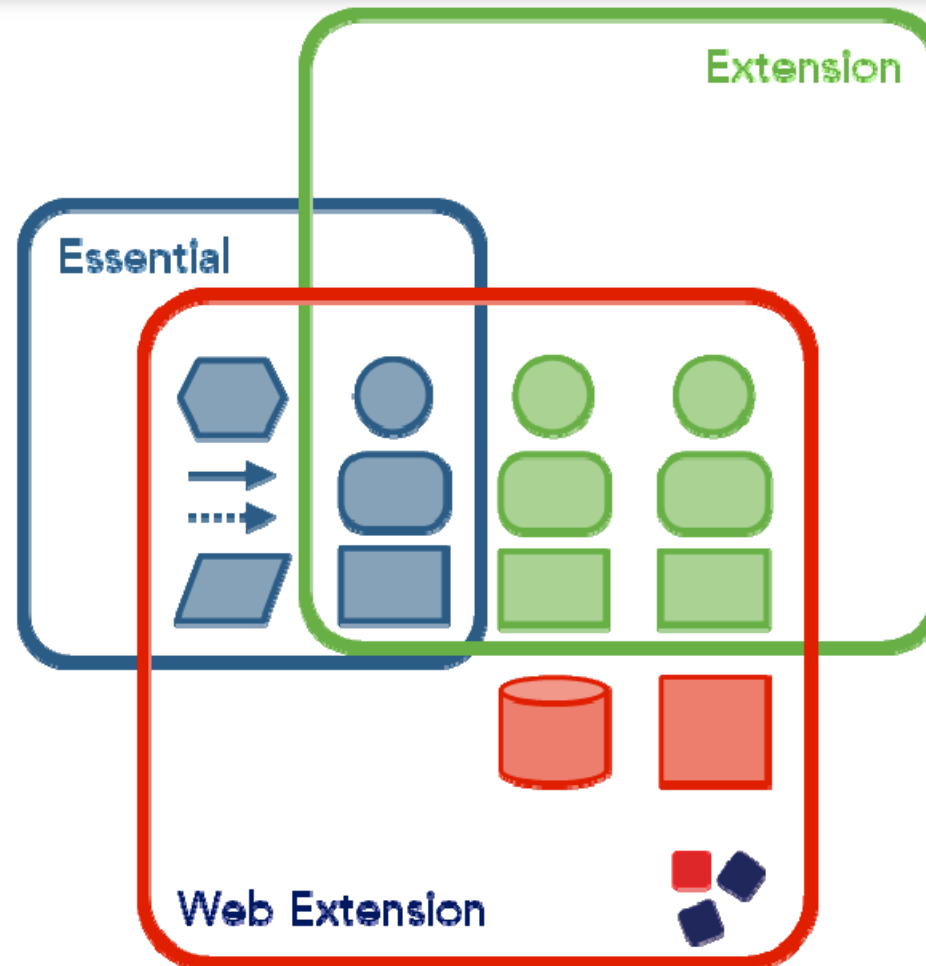
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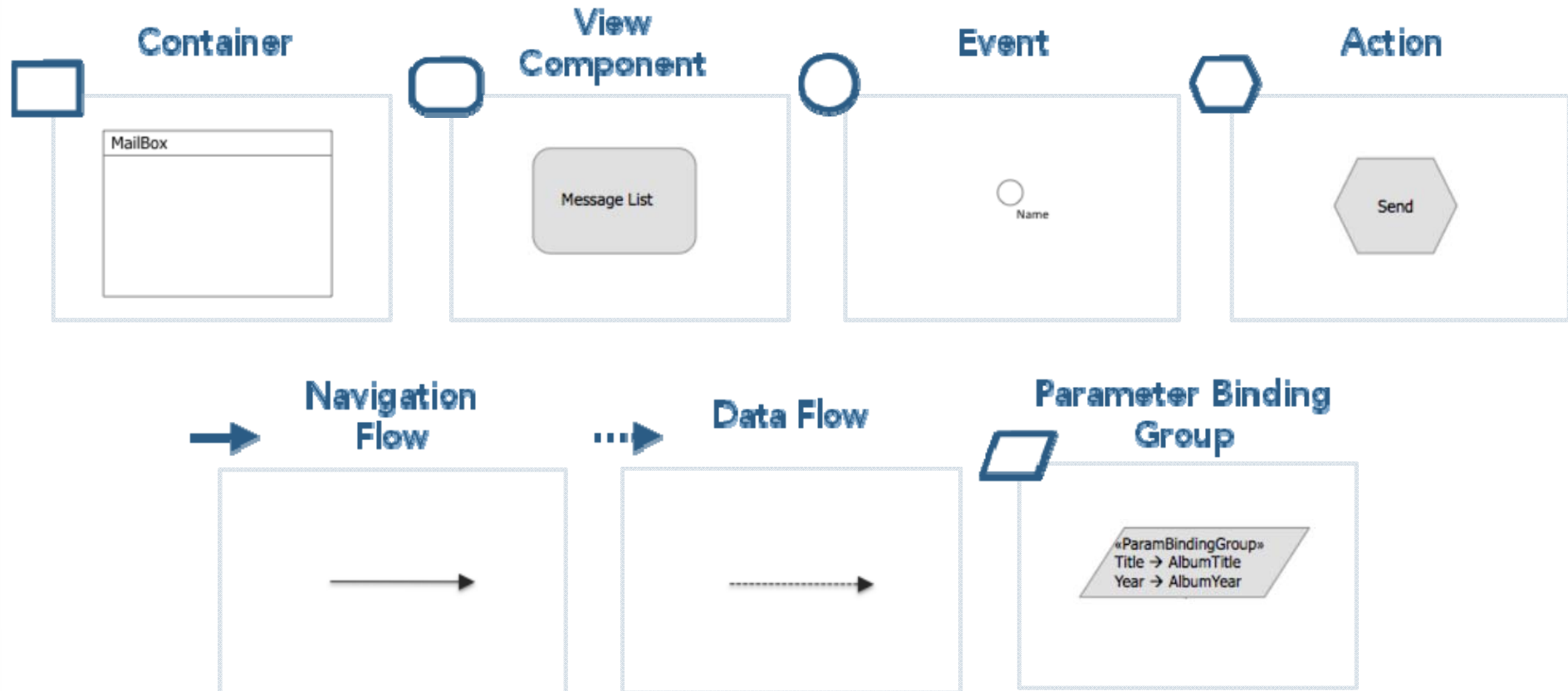


IFML Overview





IFML Essentials



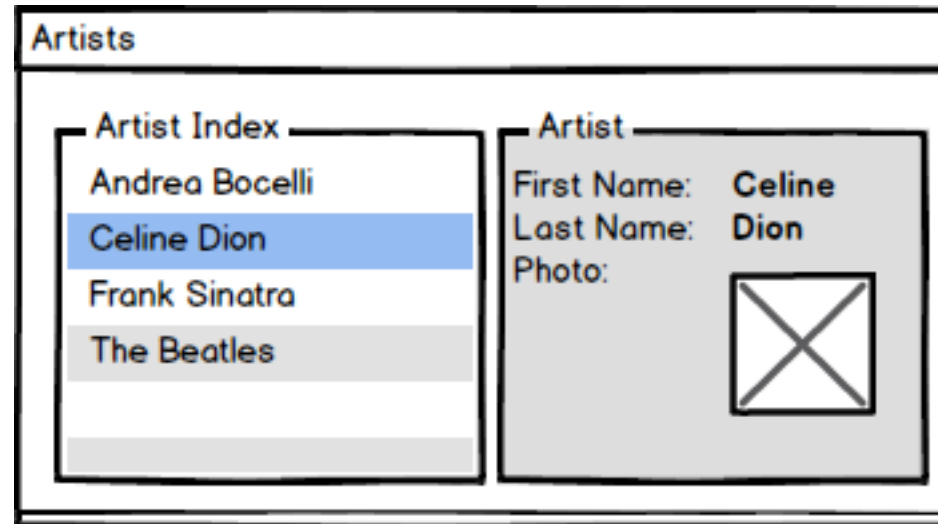


Covered aspects

- **Multiple views** for the same application
- **Mobile and multi-device** applications
- Visualization and input of data, and production of **events**
- **Components** independent of concrete widgets and presentation
- **Interaction flow**, initiated by the user or by external events
- **User context**: the user status in the current instant of the interaction (position, history, machine, platform,...)
- **Modularization** of the model (design-time containers for reuse purpose)
- User input **validation and constraints**, according to OCL or other existing constraint languages



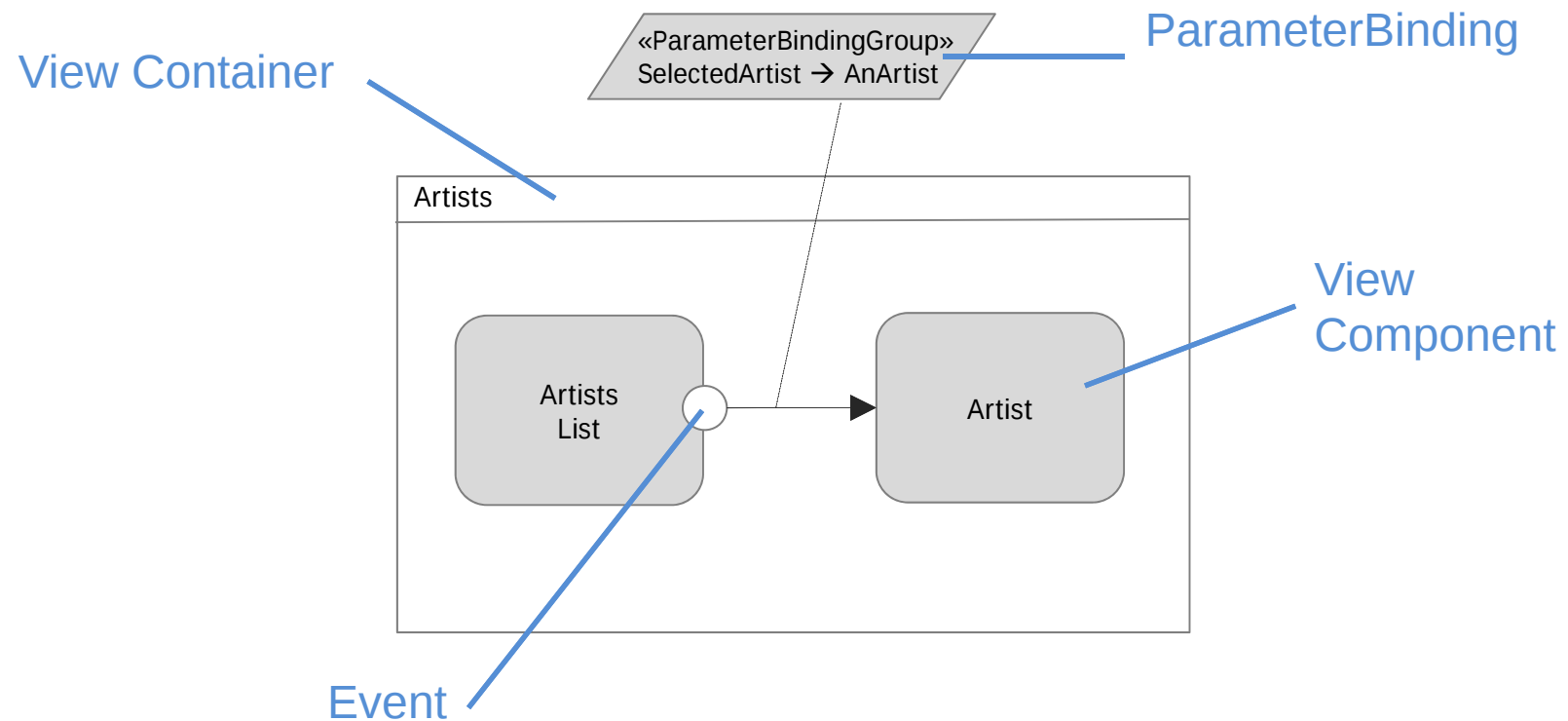
IFML by example



Basic navigation flow between ViewComponents



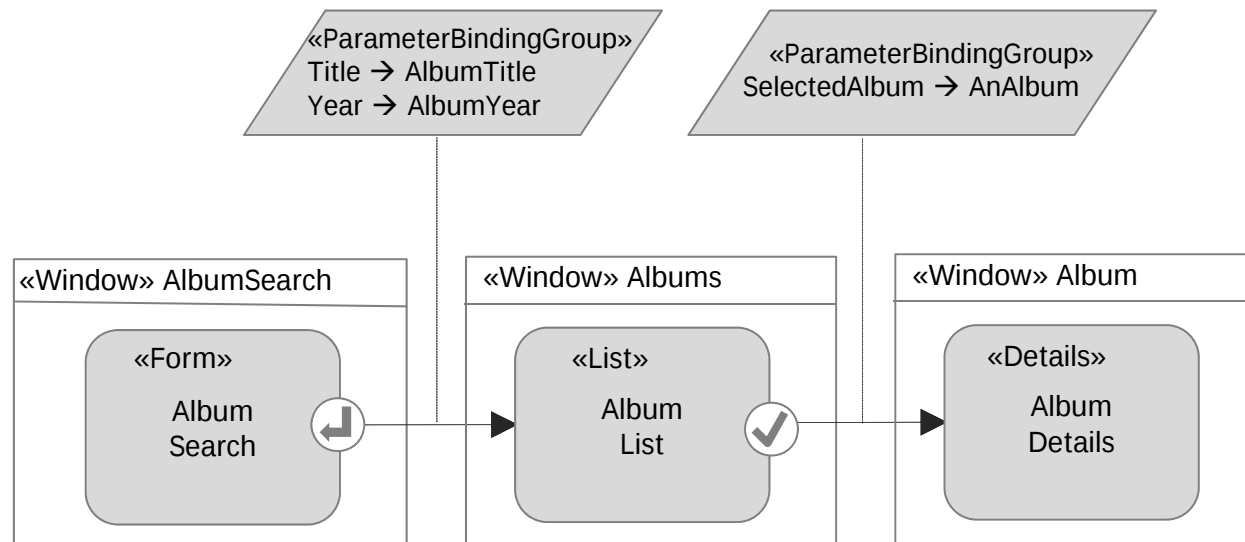
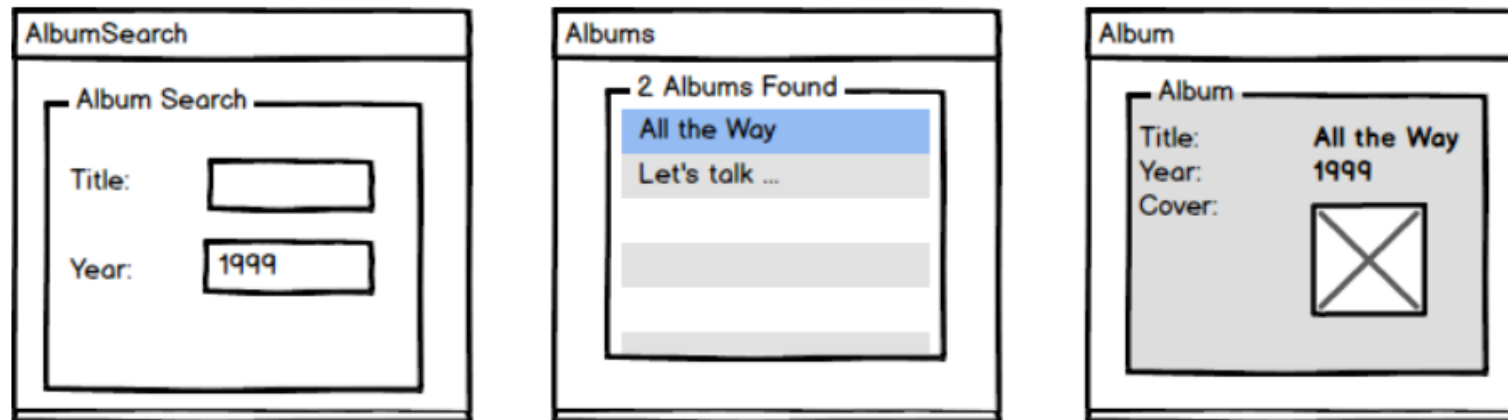
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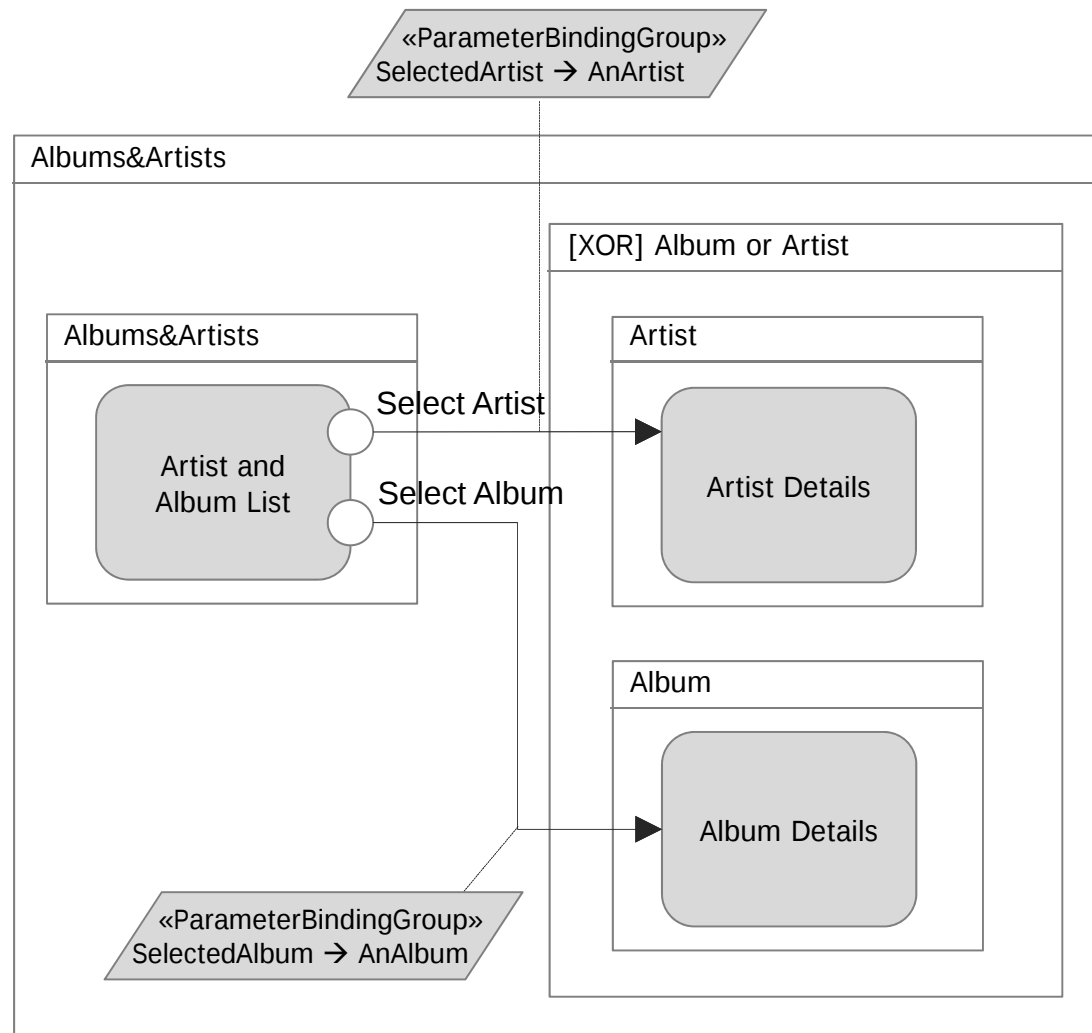


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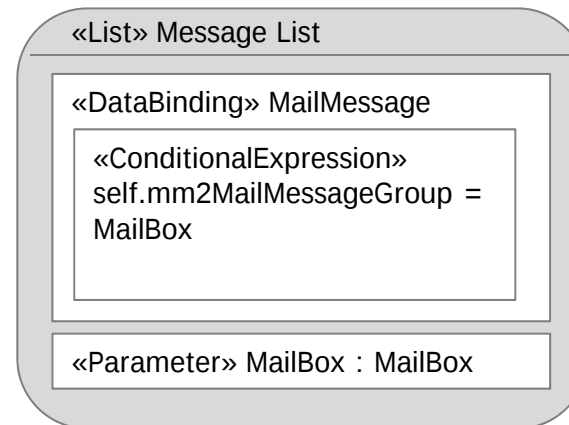
IFML by example



Nesting of ViewContainers
Tagged ViewContainers (XOR)



IFML – adding details to ViewComponents



ViewComponentParts:

- Data binding
- Parameters

Types of ViewComponents (<<List>>)

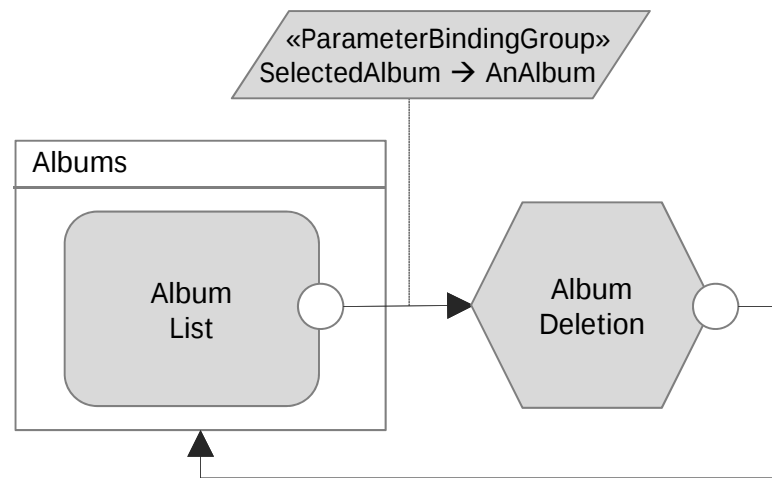


Data binding

- Joint use of IFML and other modeling languages:
 - DataBinding to classes and attributes of UML Class Diagrams
 - Also with other content models, such as: Entity-Relationship, Ontologies, ...



IFML by example



Actions

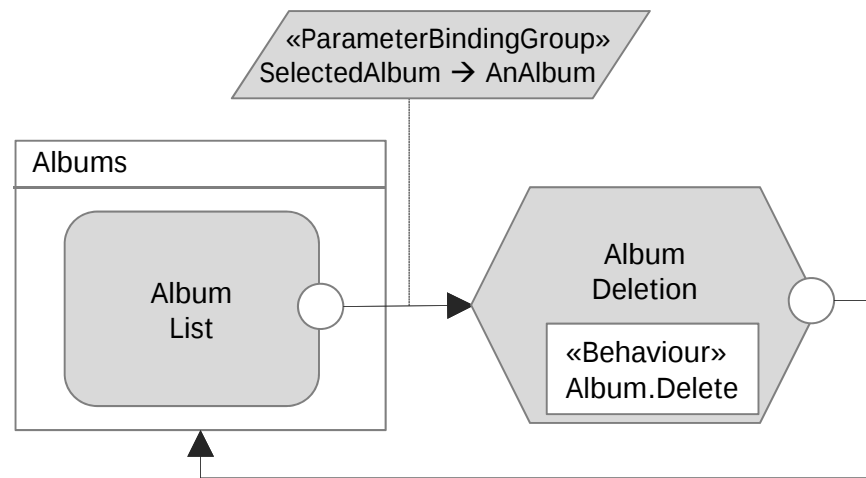


Dynamic Behaviour

- Joint use of IFML and other modeling languages
- Connection of Actions to back-end business logic as
 - UML methods of classes
 - whole UML dynamic diagrams
 - activity diagram, sequence diagram, state chart diagram, ...



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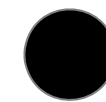


Actions



IFML – subtyping events

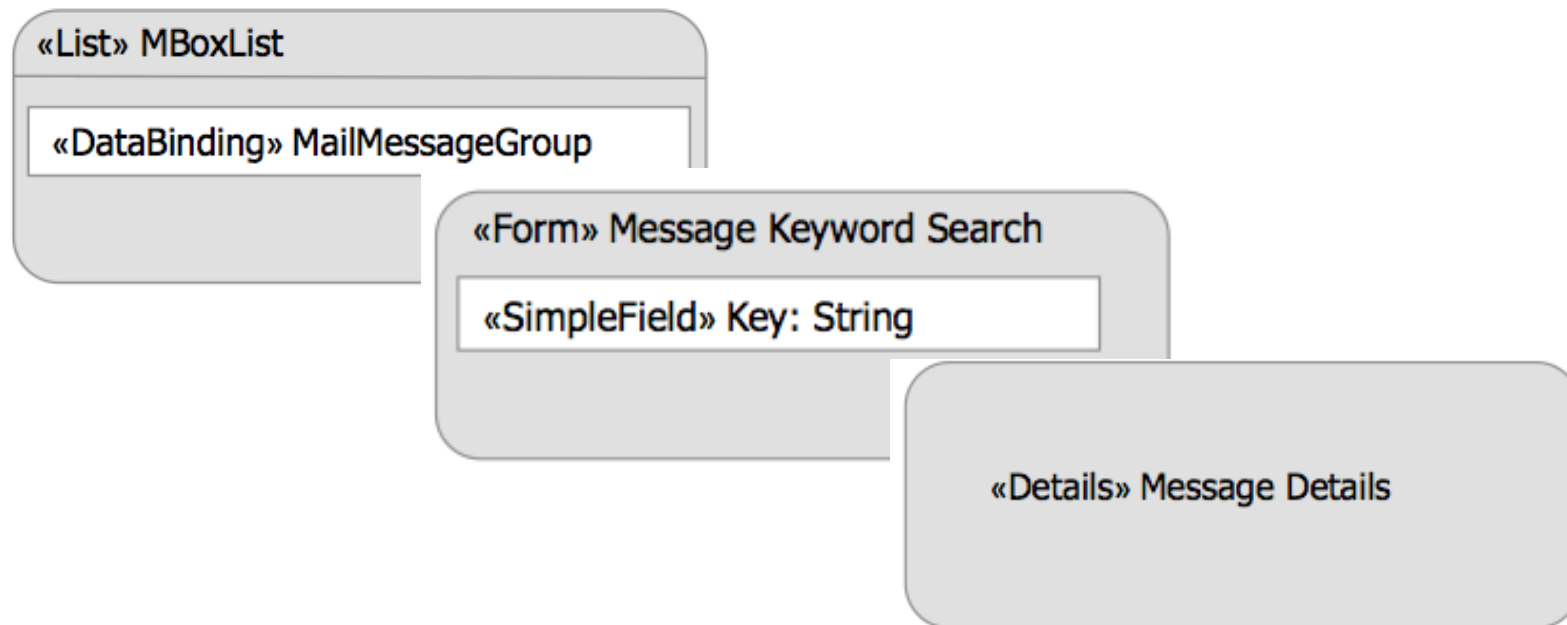
✓ OnSelect event
↩ OnSubmit event } Catching events



Throwing events



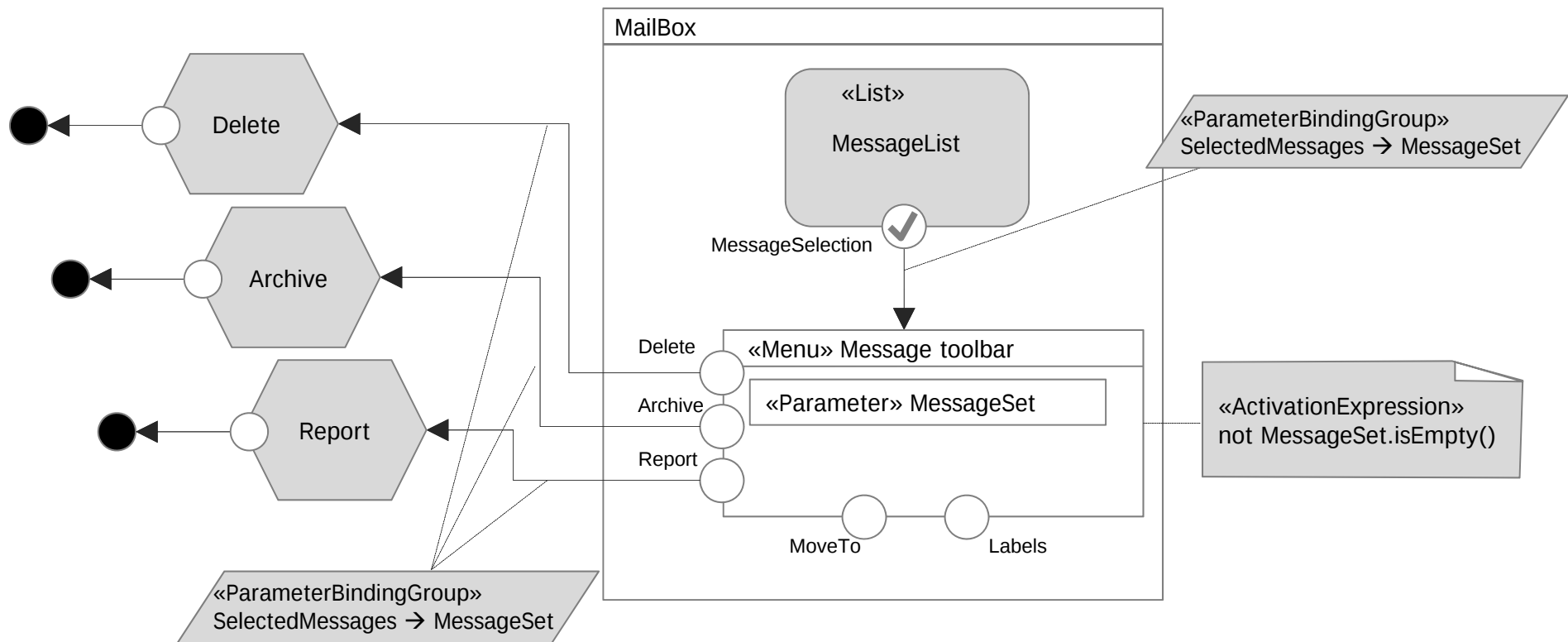
IFML – subtyping components



.. And as many others as you want!



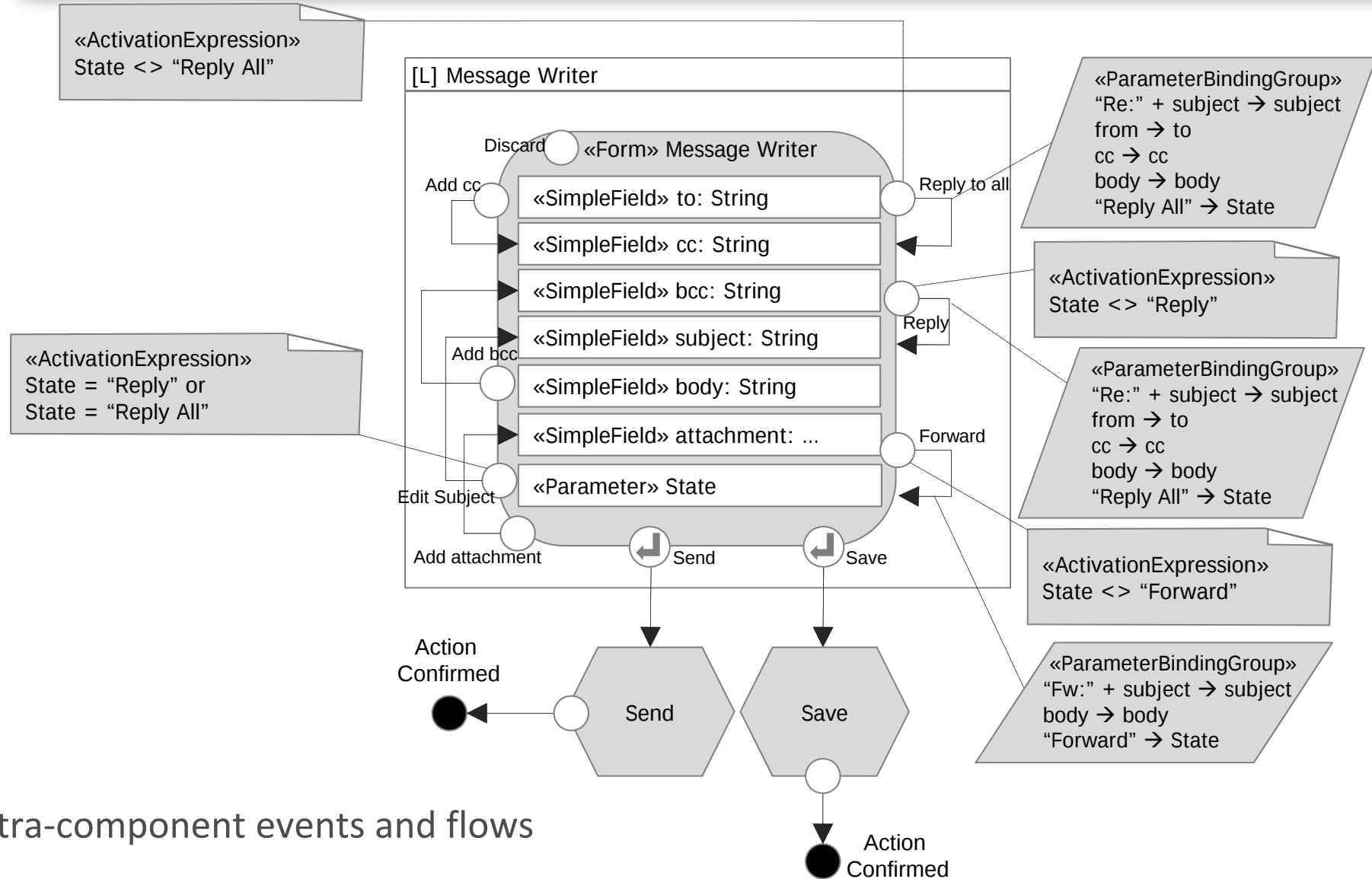
IFML by example



ActivationExpression, SubmitEvent, Event generation



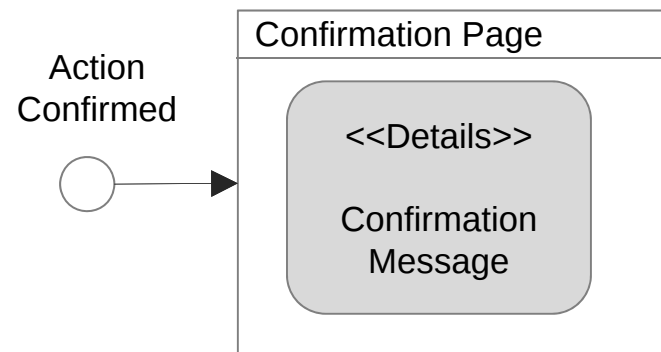
IFML concrete syntax by example



intra-component events and flows



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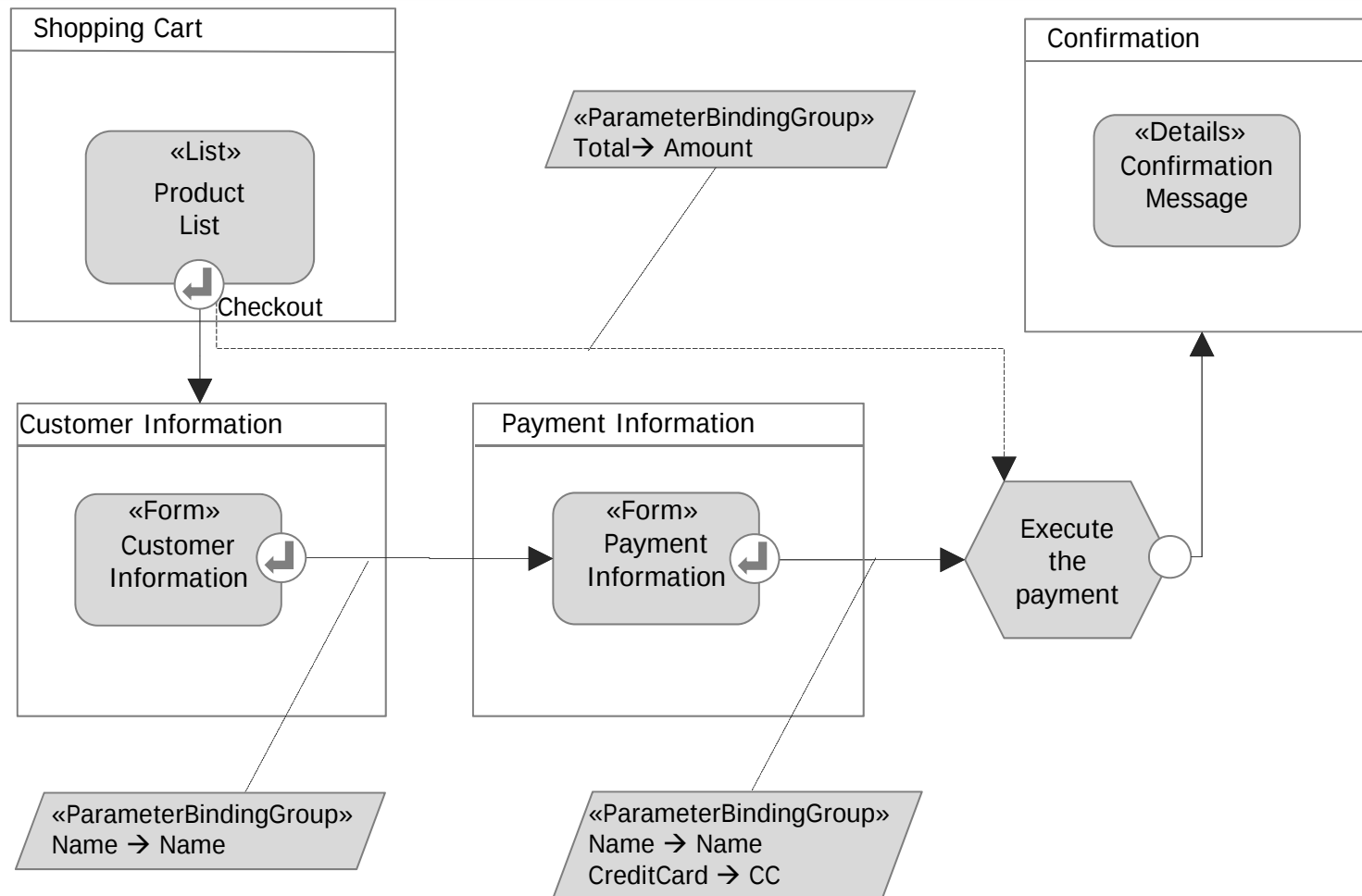


Capturing of custom events

Note: typical problem of event-based systems (termination, ...)

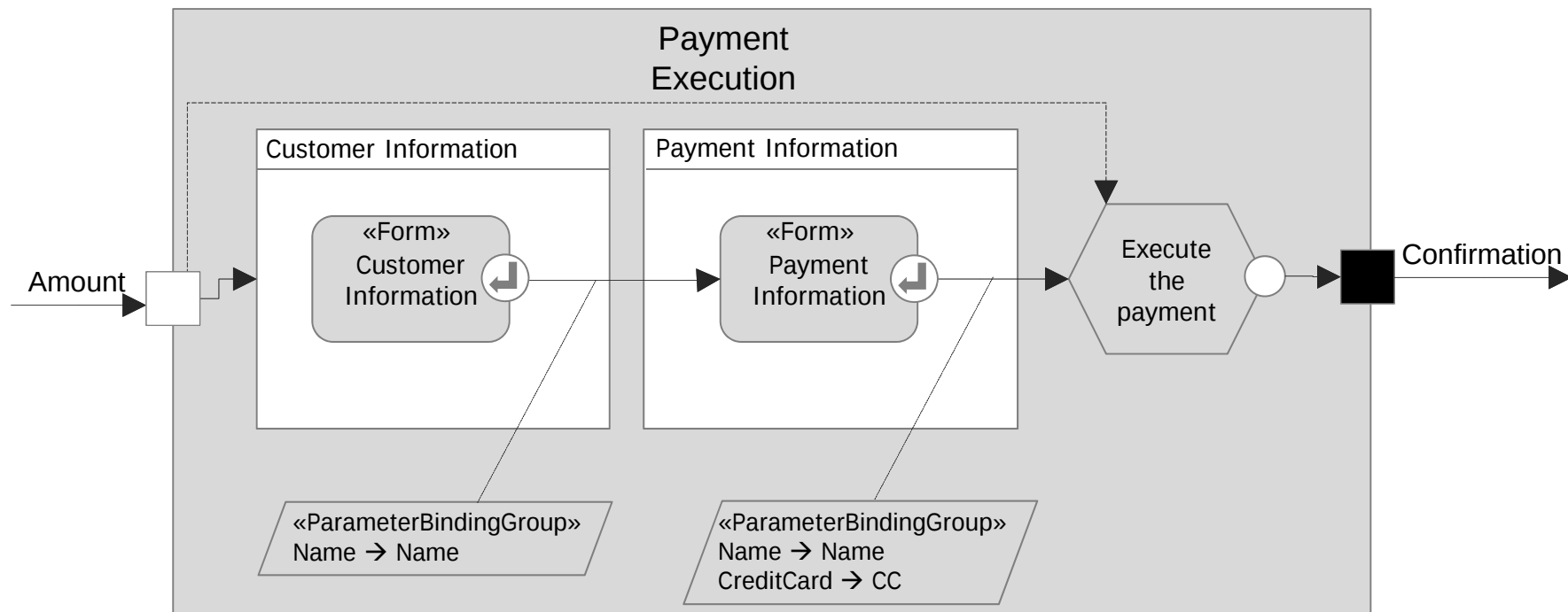


IFML example – online payment





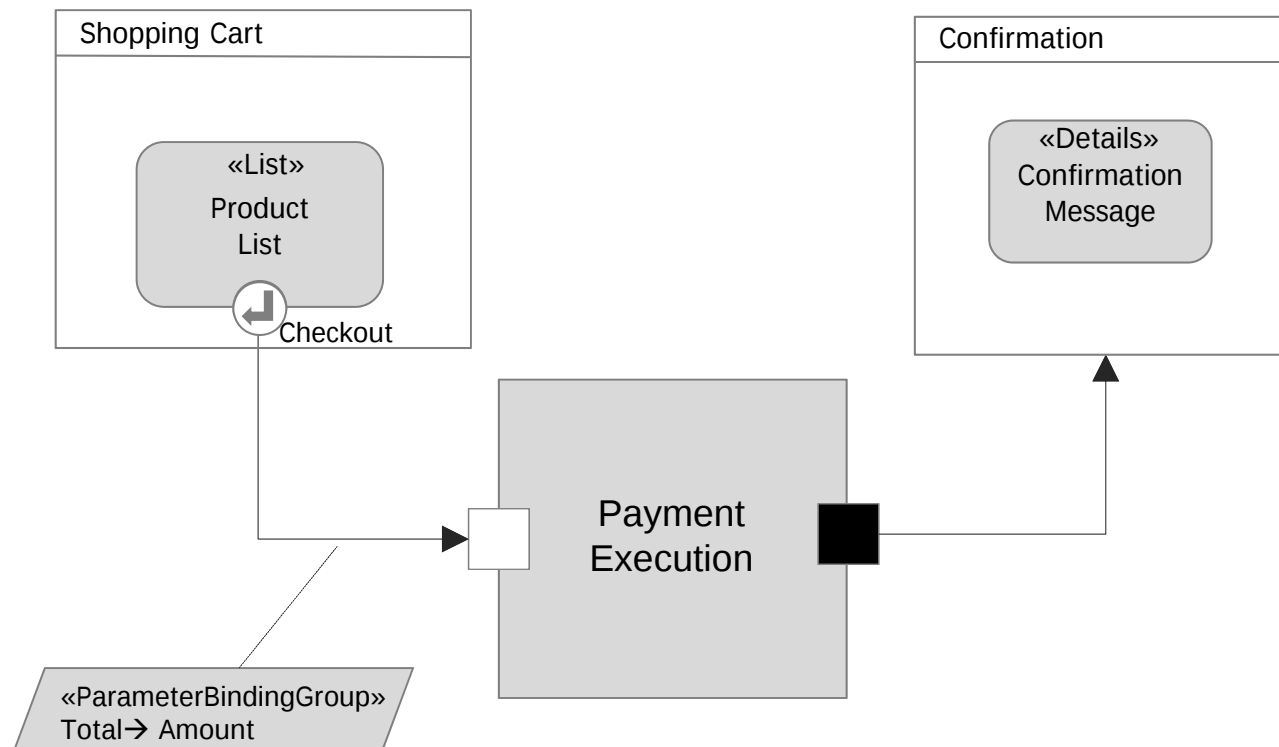
IFML concrete syntax – modules



IFML Modules - definition



IFML concrete syntax – modules



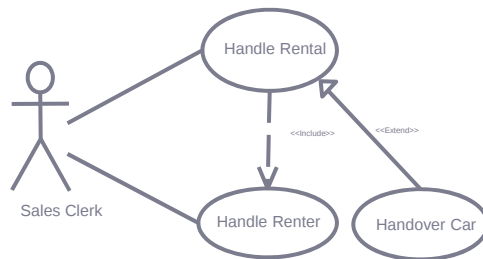
IFML Modules - usage



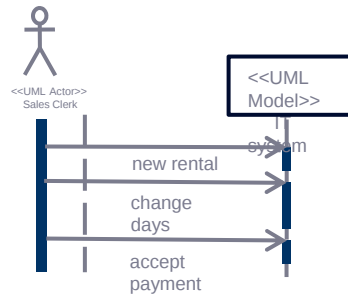
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(business and requirements)

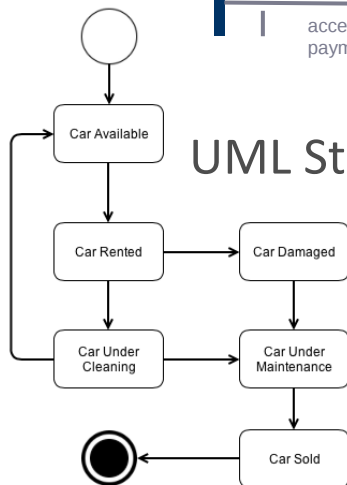
UML Use Case



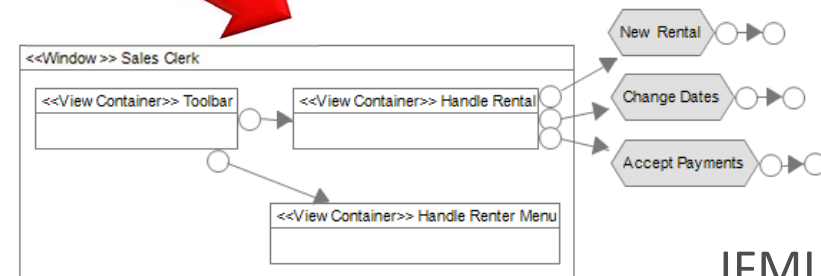
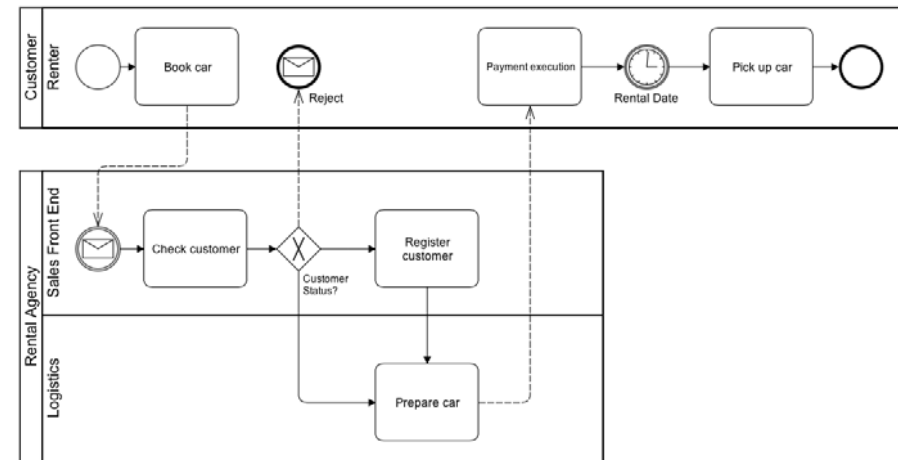
UML Sequence



UML Statechart



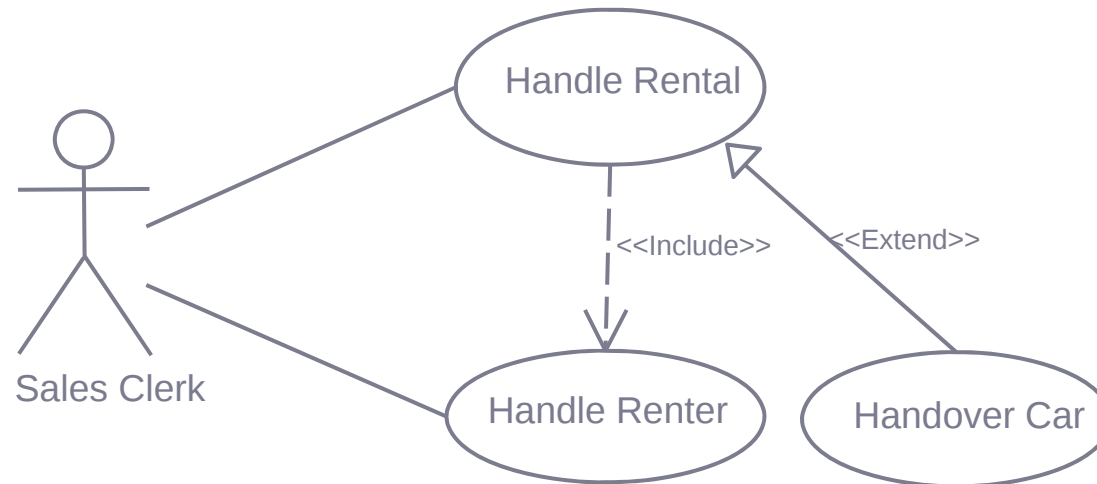
BPMN process



IFML



Integration with UML Use Cases

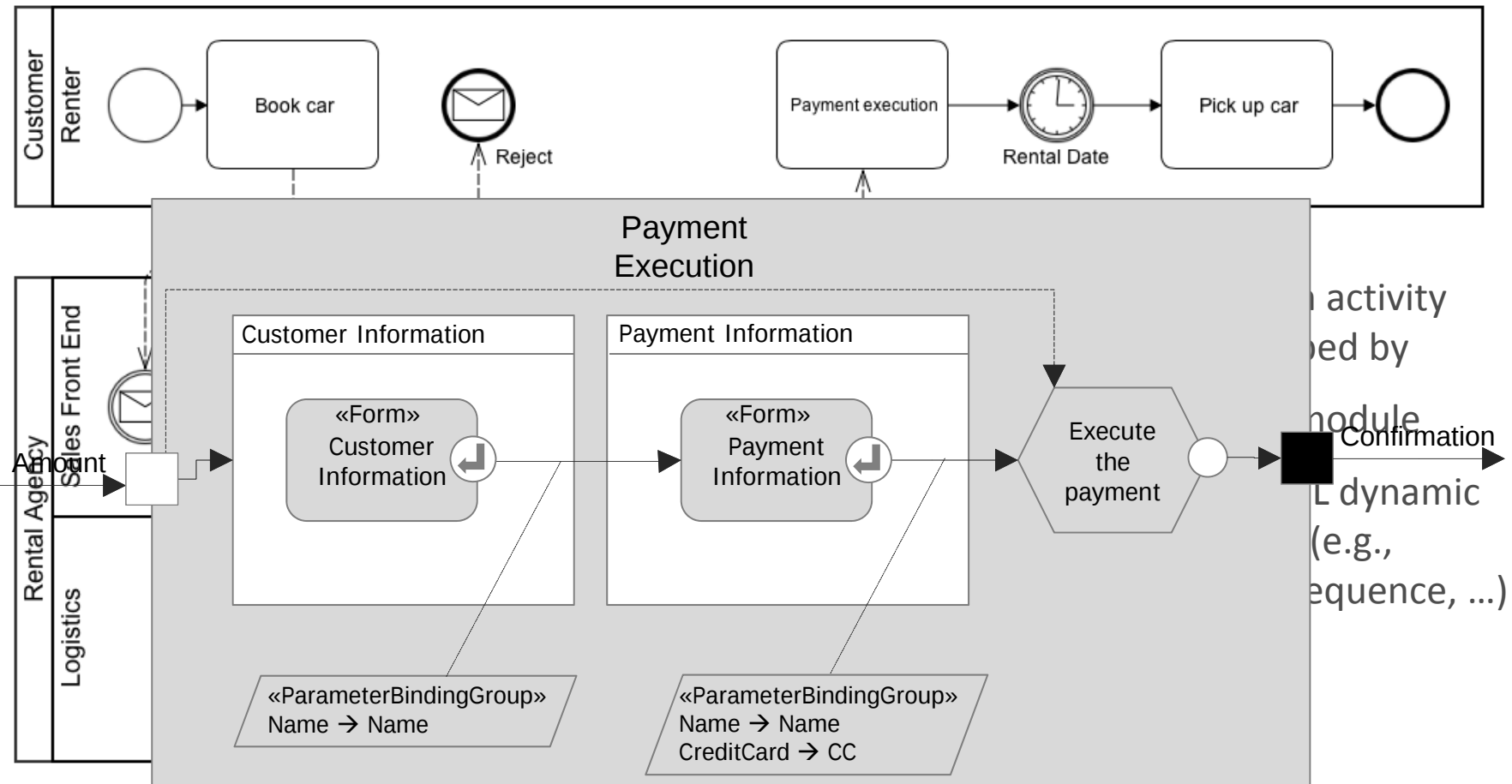


Each use case can be described by

- A business process
- A plain UI description in IFML
- Some UML dynamic diagrams (e.g., activity, sequence, ...)

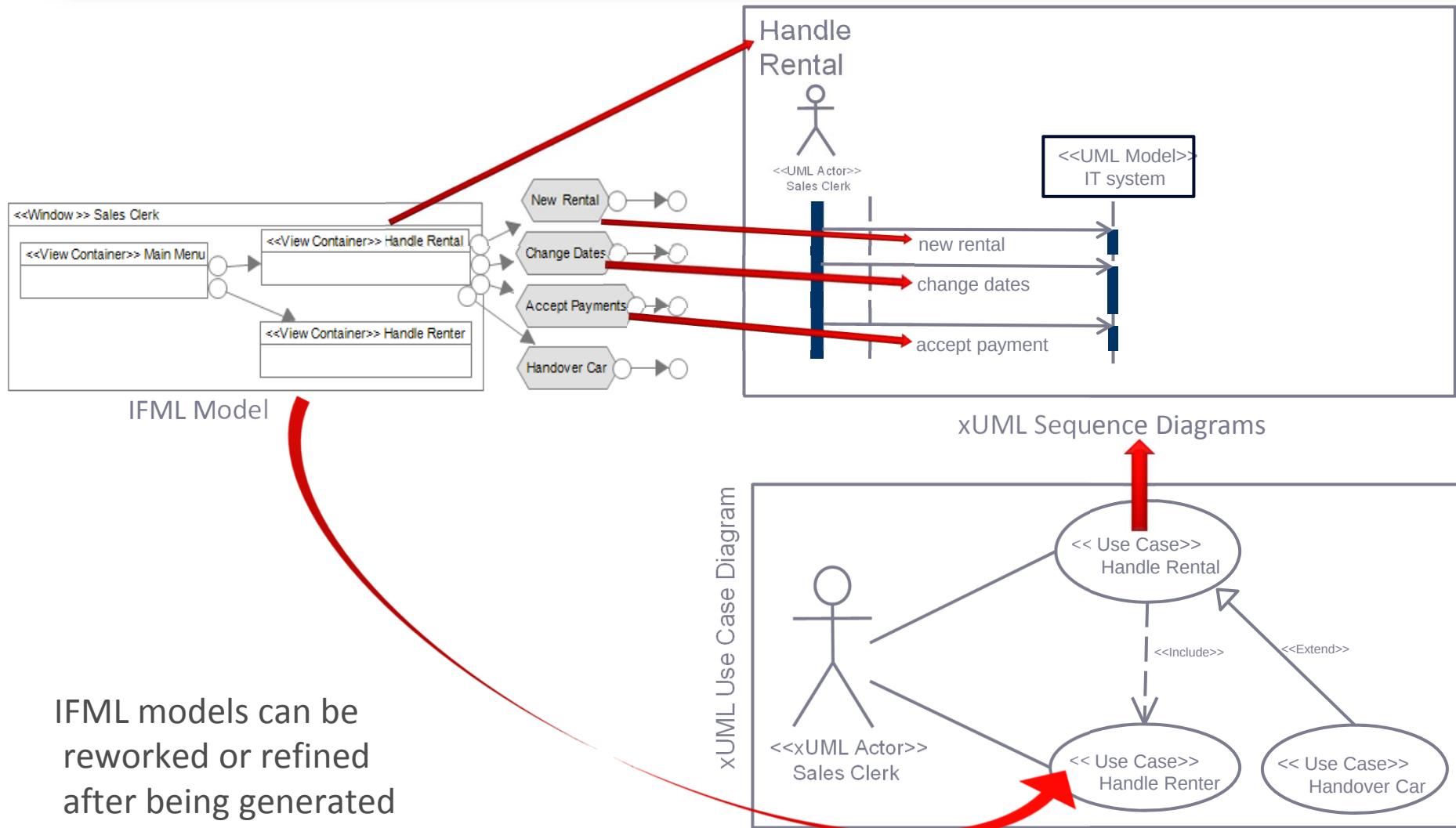


Integration with BPMN





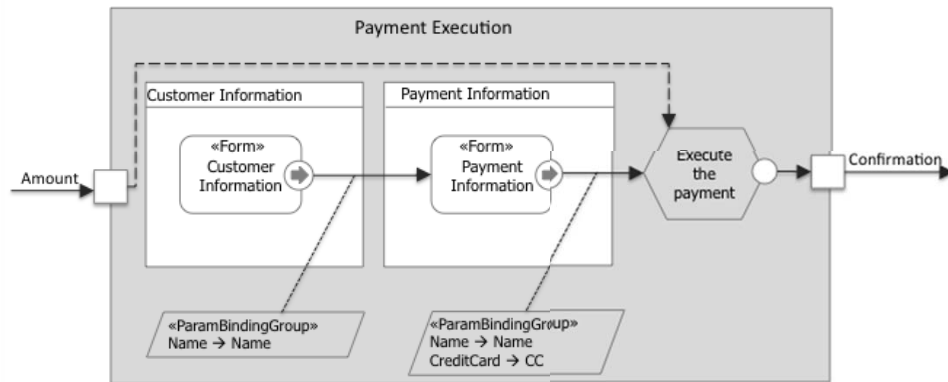
Example of UML - IFML mapping



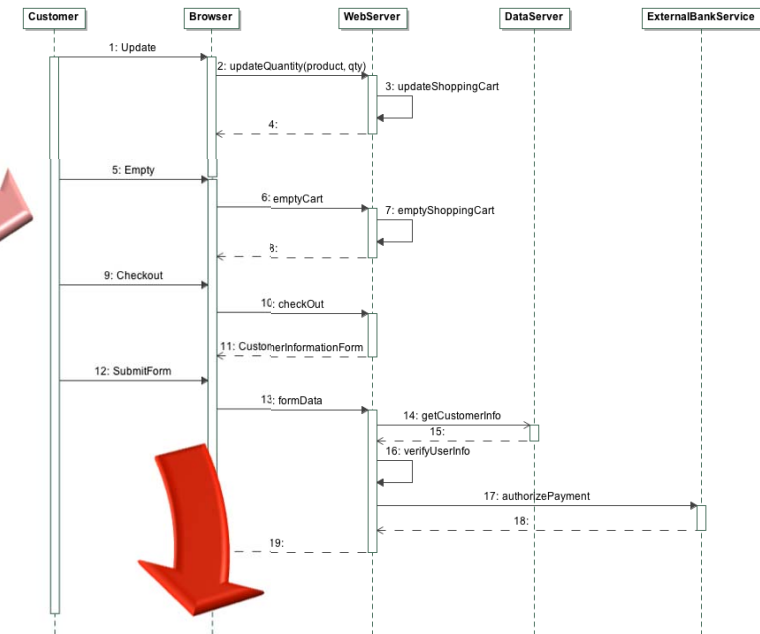


Multiple aspects modeling – 2 (implementation and architecture)

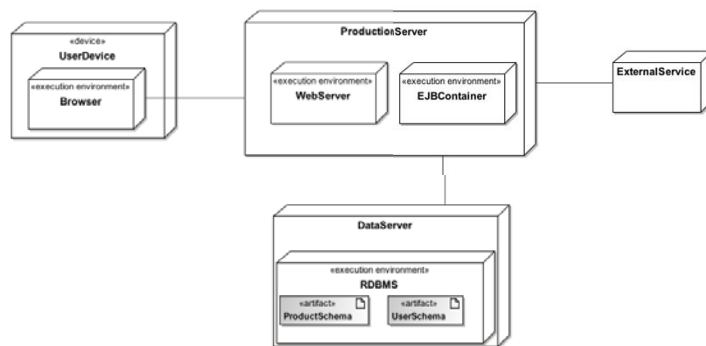
IFML



UML Sequence



UML Deployment



UI Mockup models

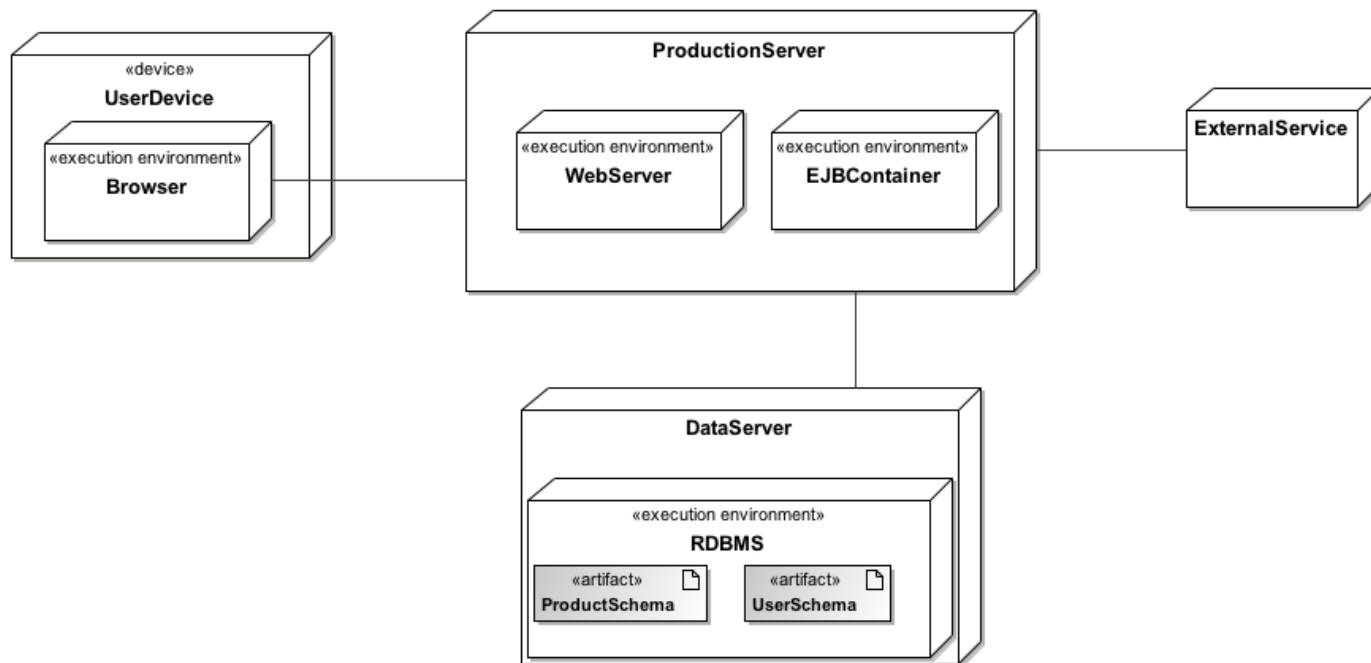




Integration with UML

Description of deployment architecture

- UI is just one facet of system design
- Often need to position it in a broader architectural vision

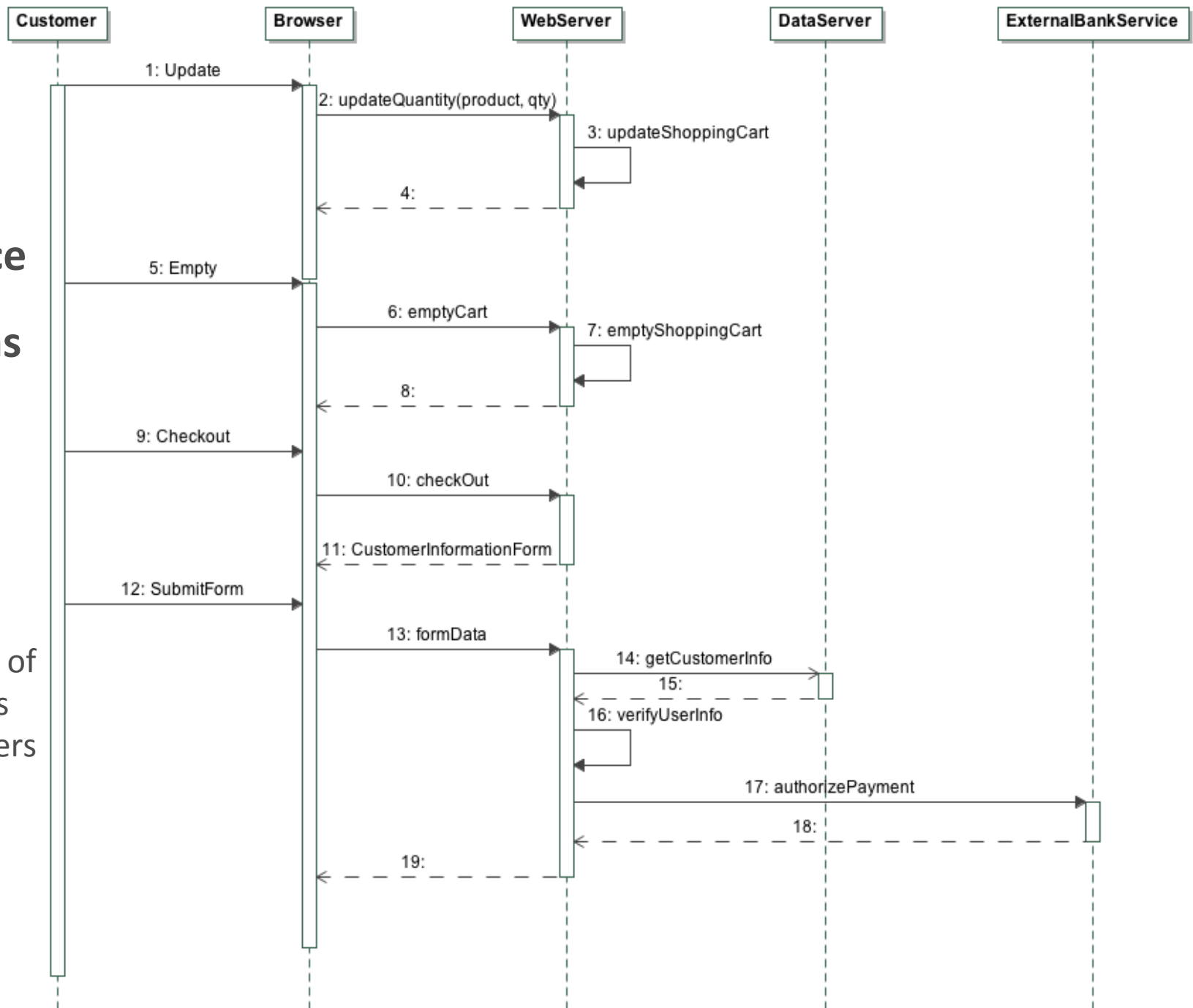


- UML deployment diagram

UML Sequence Diagrams

Tiers and calls

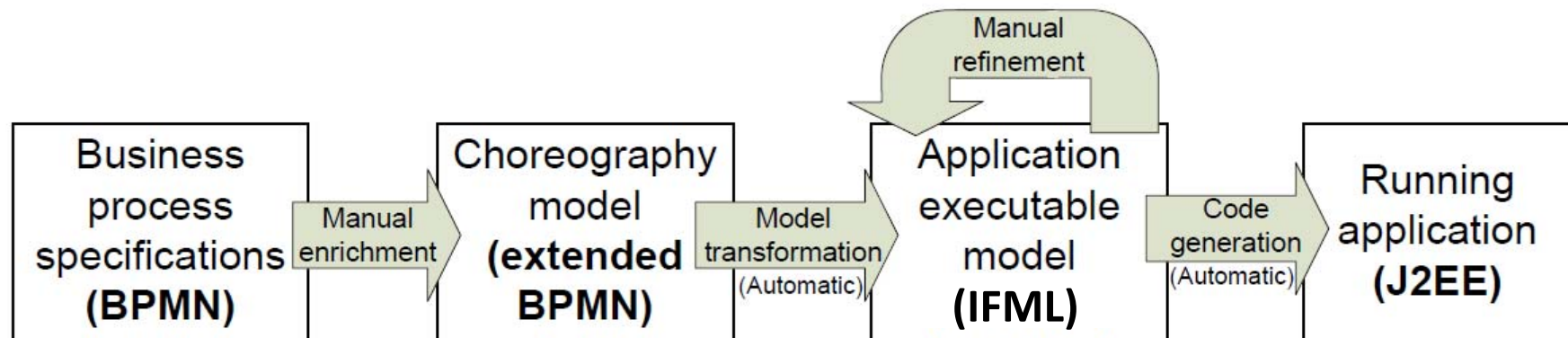
Explicit
description of
interactions
between tiers





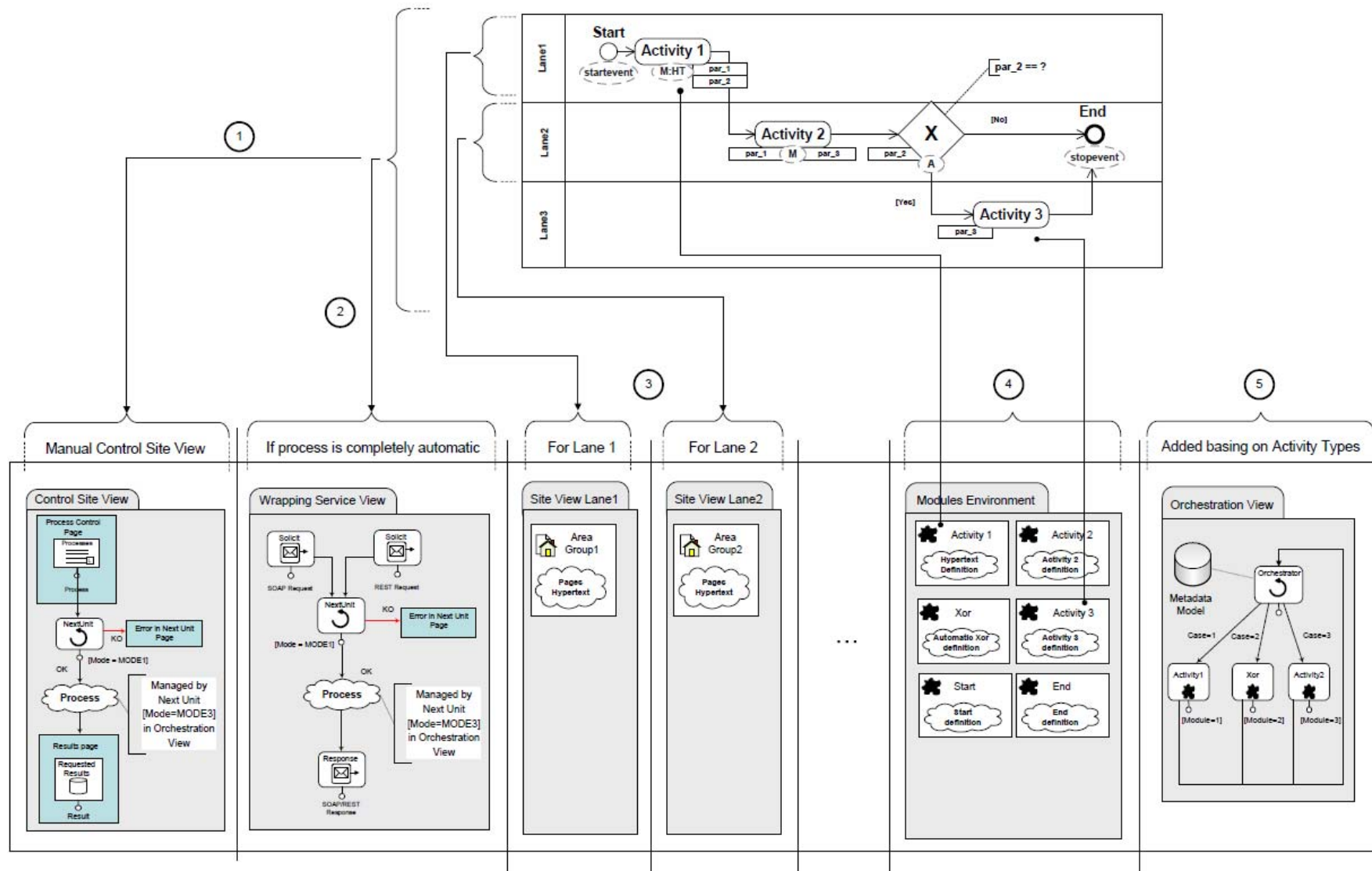
Model-driven Development Process

- Manual specification of BPMN process model
- Automatic transformation of BPMN to WebML
- Possible manual refinement of WebML models
- Automatic running code generation on J2EE platform
- Virtuous development cycle





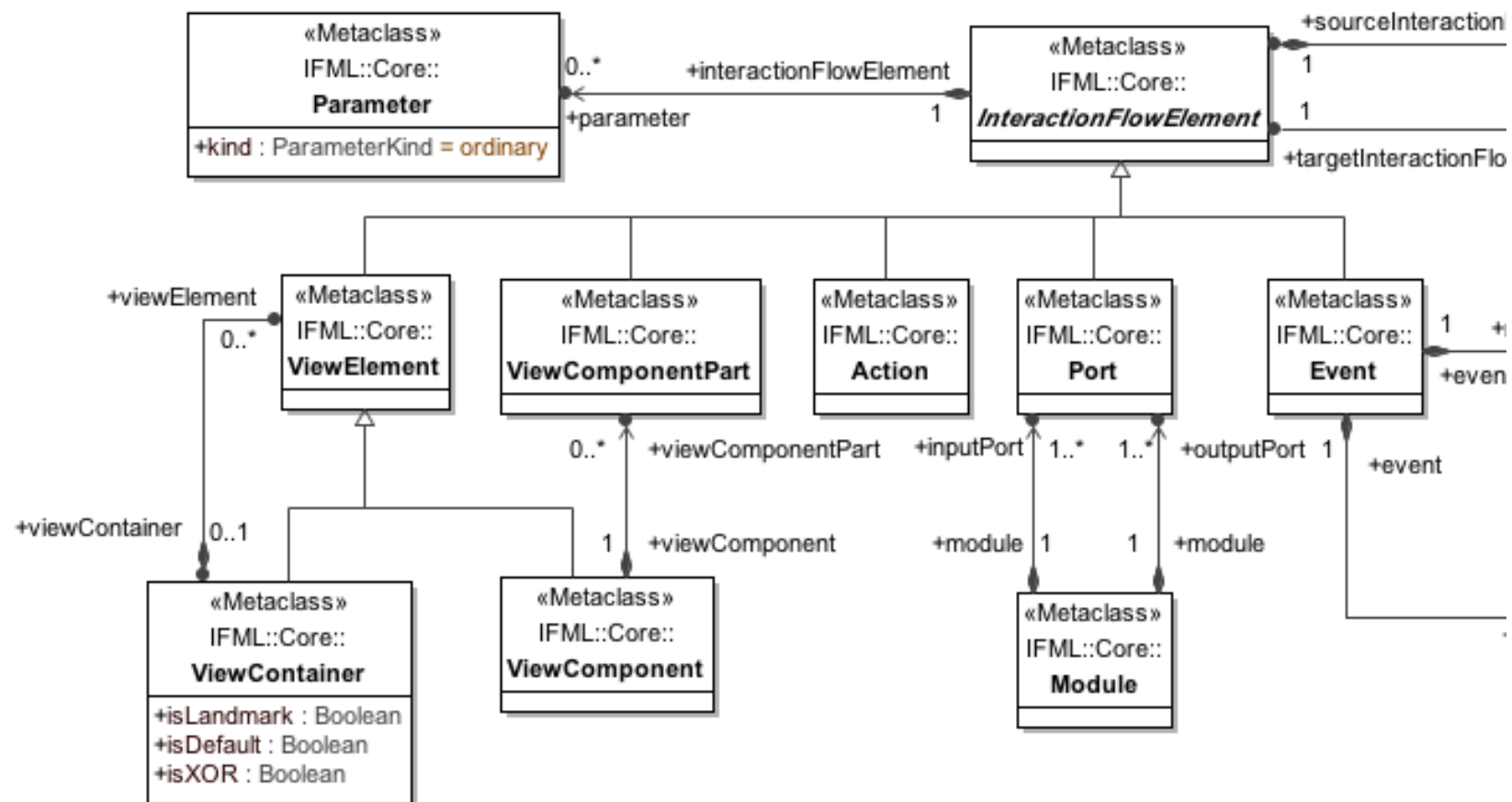
The generated model artifacts





How does it work? IFML metamodel (1)

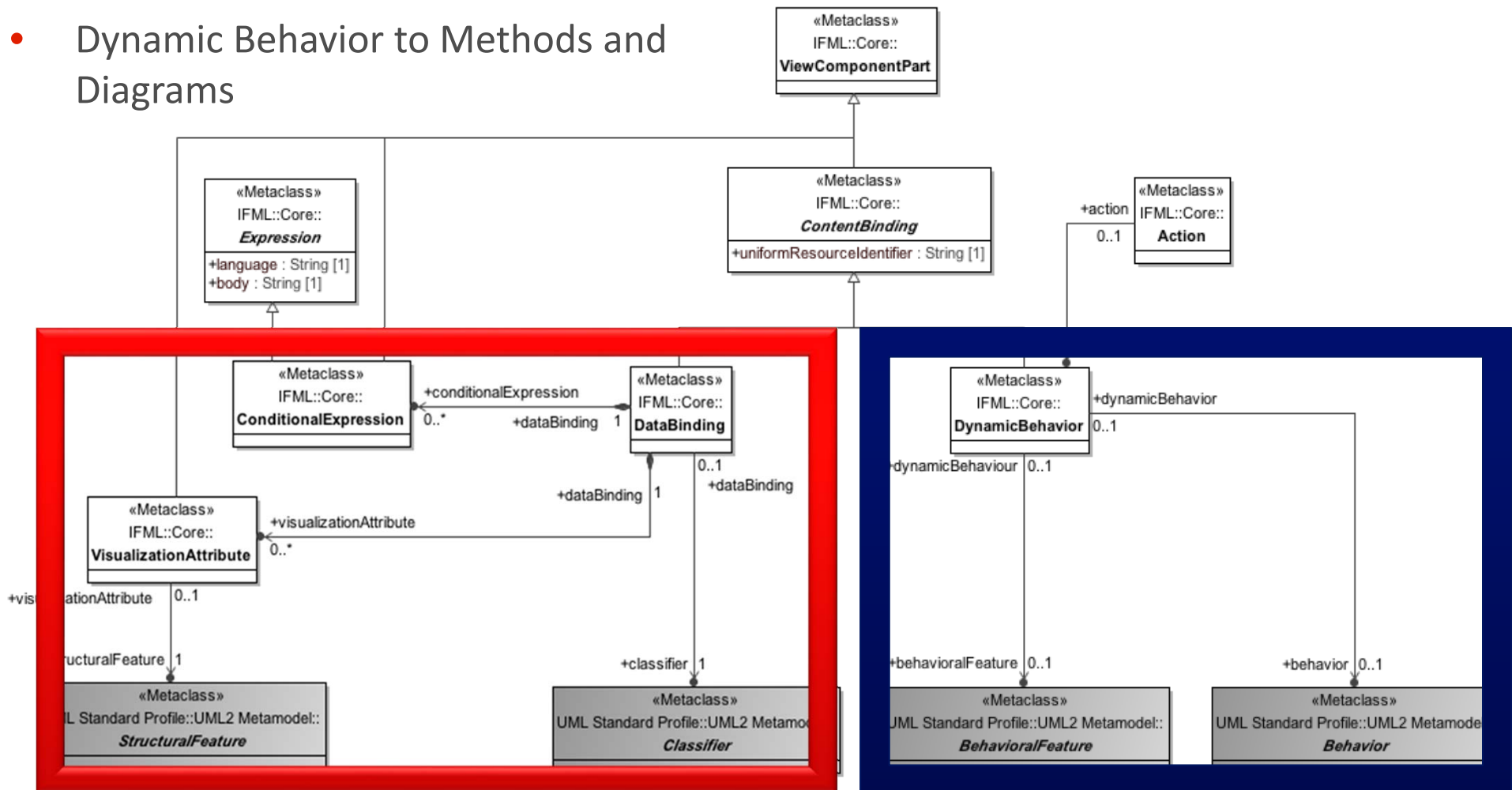
IFML is defined through a metamodel





IFML metamodel (2): Content Binding

- Data binding to Classes and Attributes
- Dynamic Behavior to Methods and Diagrams





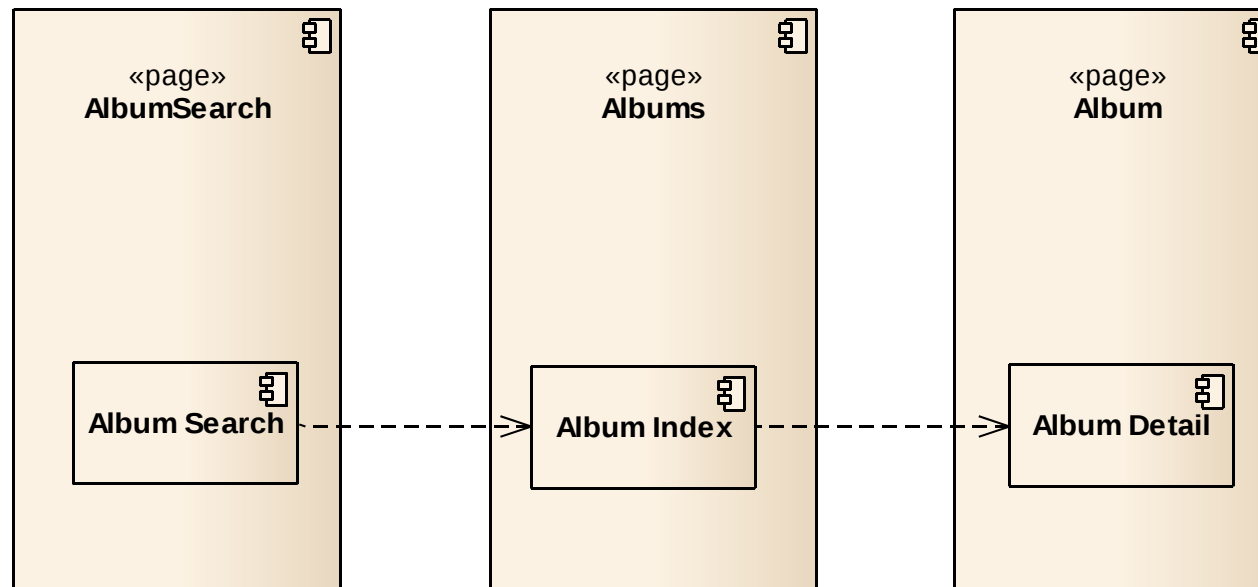
Practical results of having a standard

- An official **metamodel of the language** which describes the semantics of and relations between the modeling constructs
- A **graphical concrete syntax for the interaction flow notation** which provides an intuitive representation of the user interface composition, interaction and control logic for the front-end designer
- A **UML Profile** consistent to the metamodel
- An **interchange format** between tools using XMI
- All this, specified through standard notations themselves



Also: interchange with profile-based diagrams. The UML Profile for IFML

Static aspects



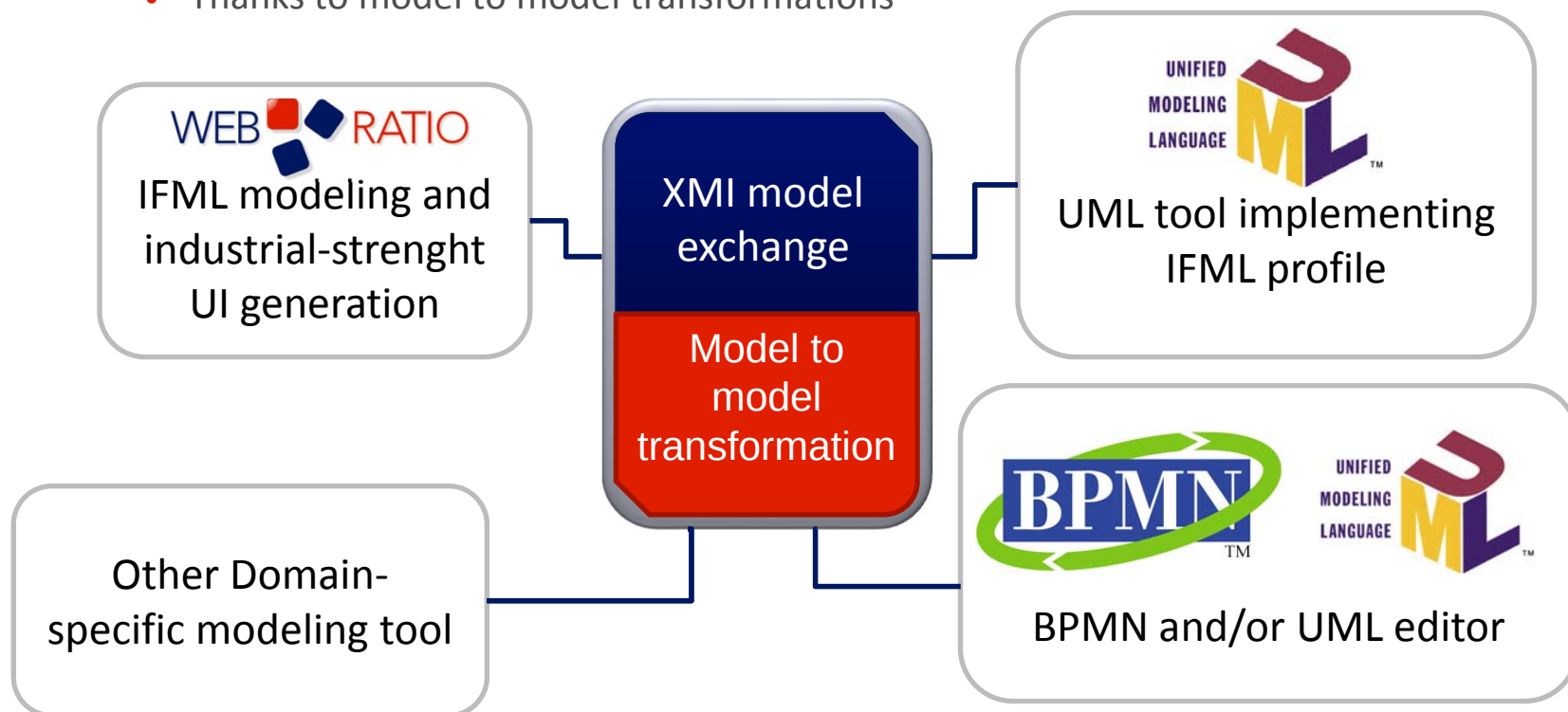
Dynamic aspects





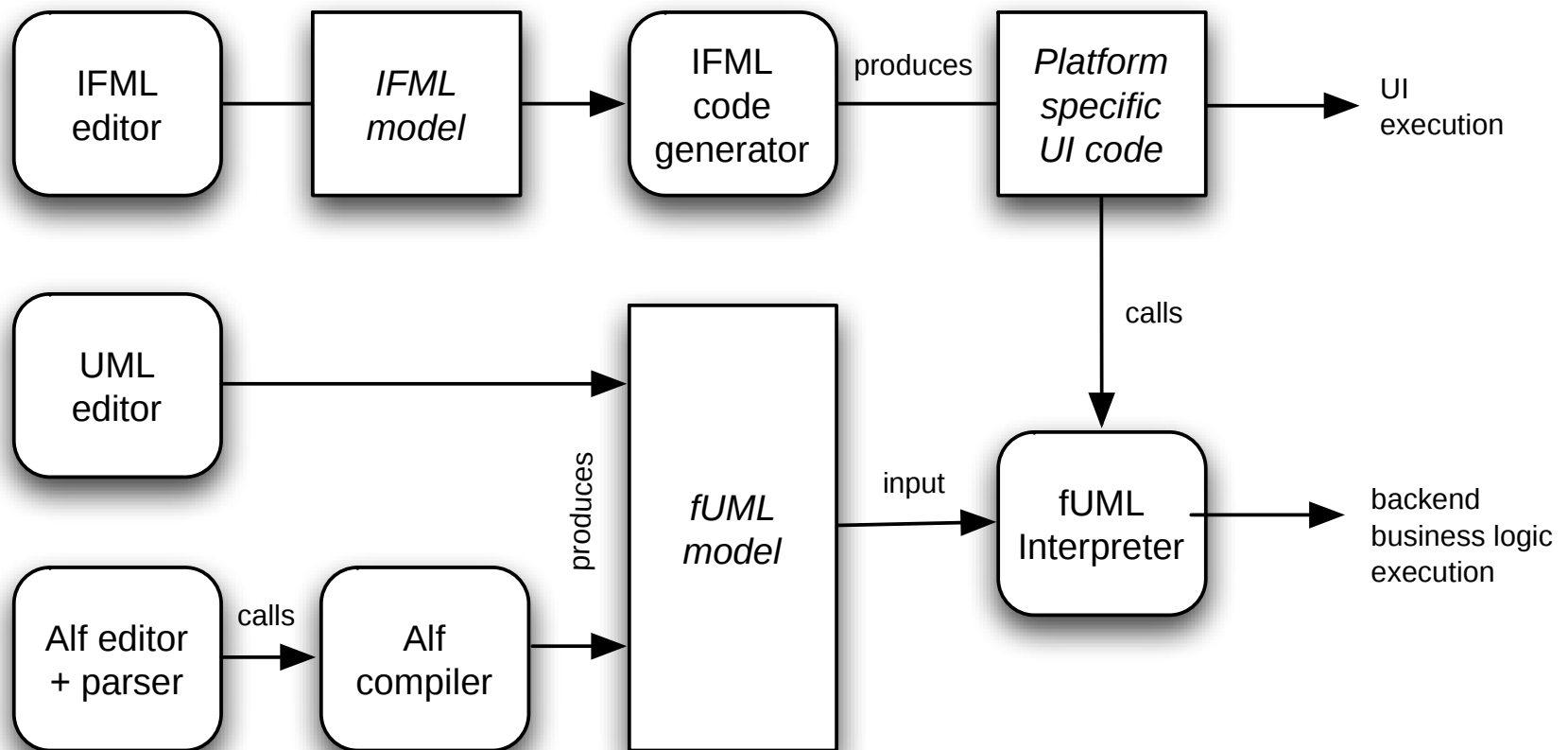
Model integration and interchange

- Tight and seamless integration between different modeling tools
 - Thanks to XMI interchange format, UML profiles, vendor-specific notation implementations
 - Thanks to model to model transformations





Executability experiment within OMG





Broader, enterprise-wide system modeling

- Joint usage of IFML with other MDA languages can be devised:
 - SysML
 - SoaML
 - ...
- ... and also with other frameworks (e.g., Model Driven Enterprise Engineering)



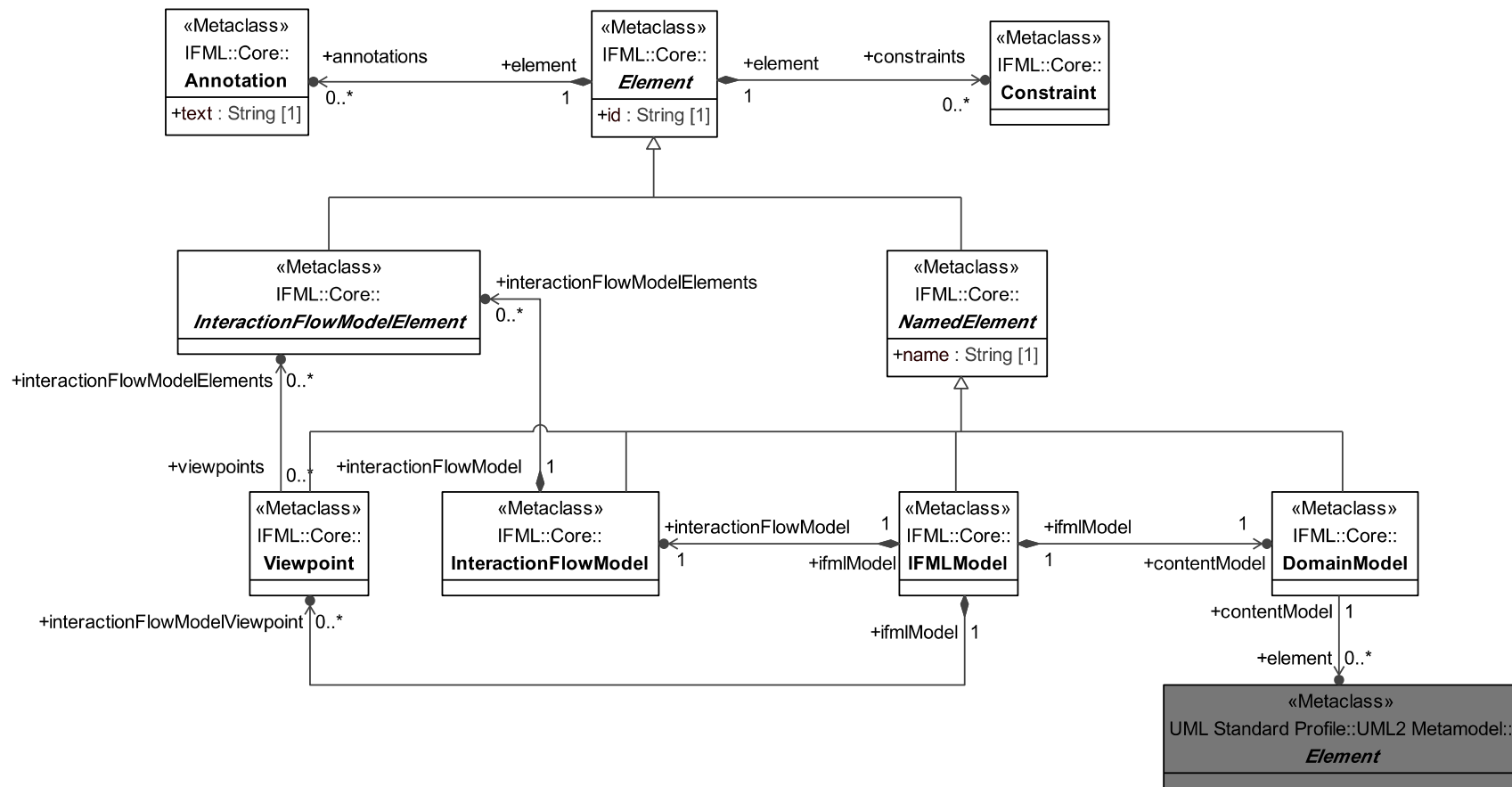
The Metamodel

-- excerpts --



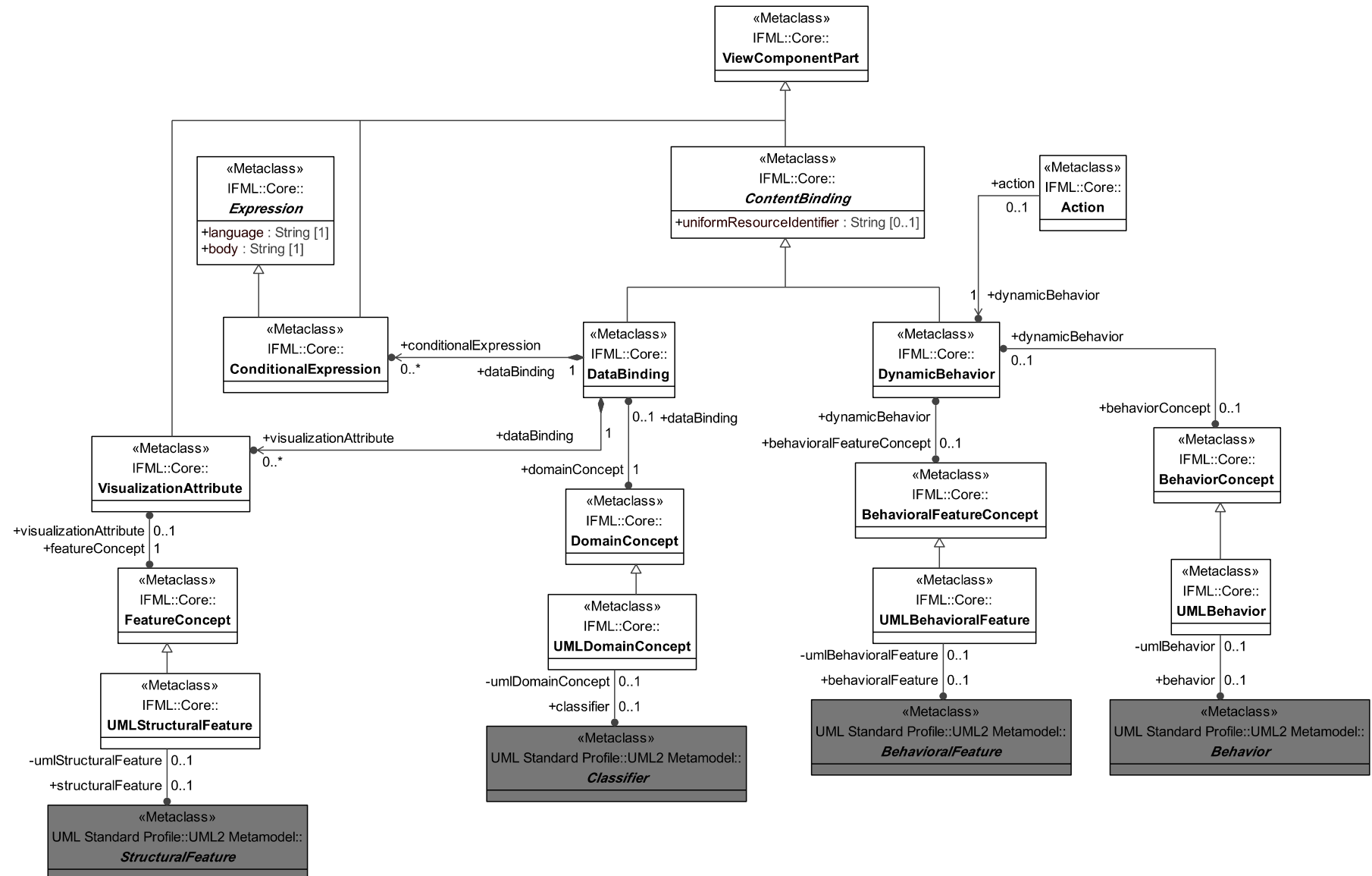


IFML Model



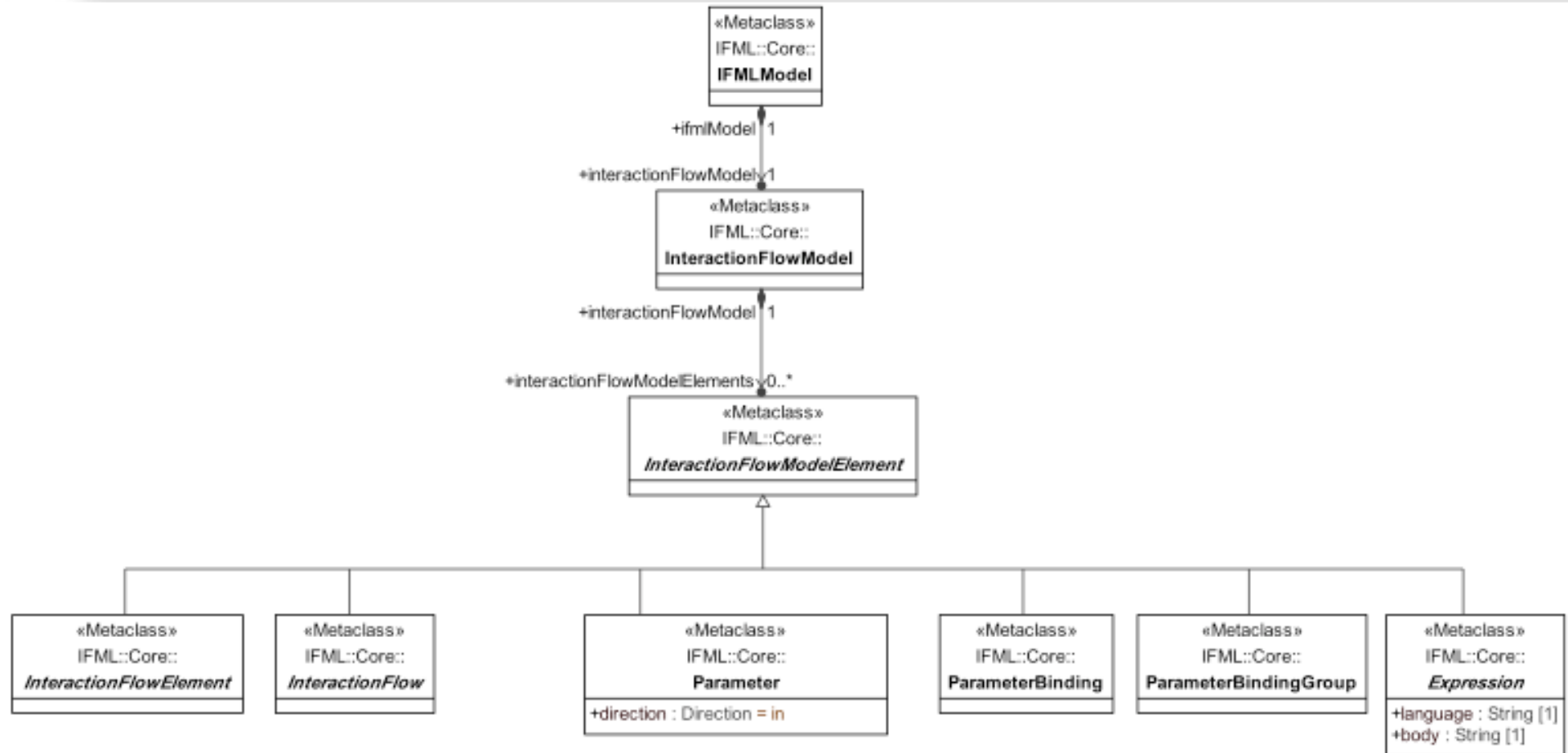


Content



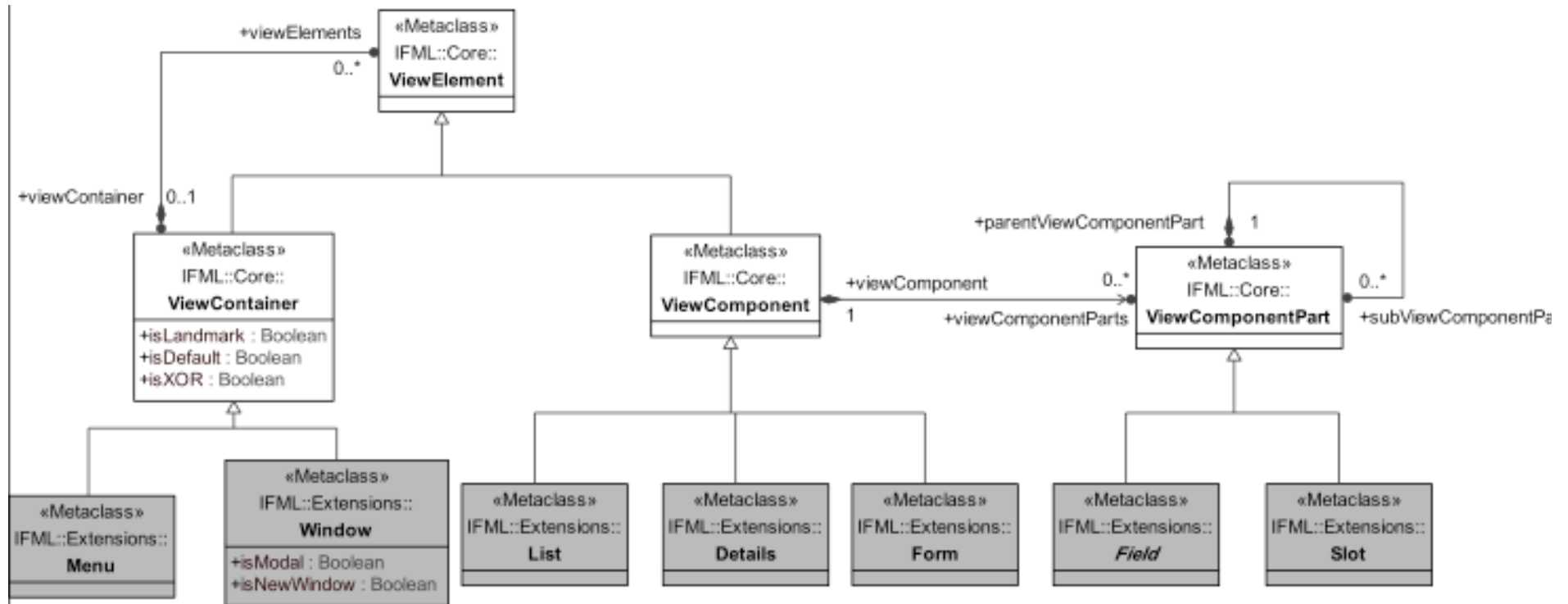


InteractionFlowModel



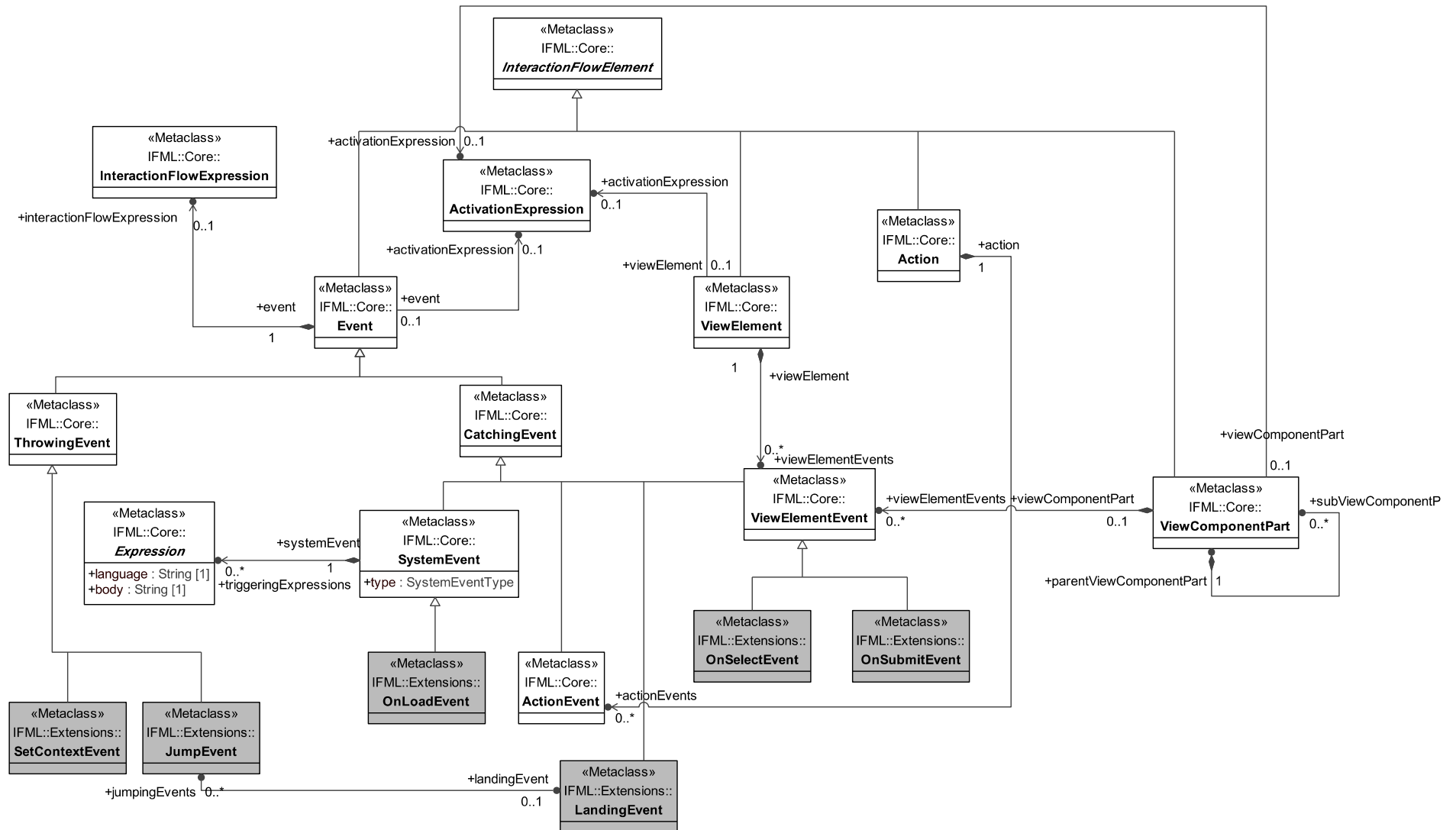


ViewElements



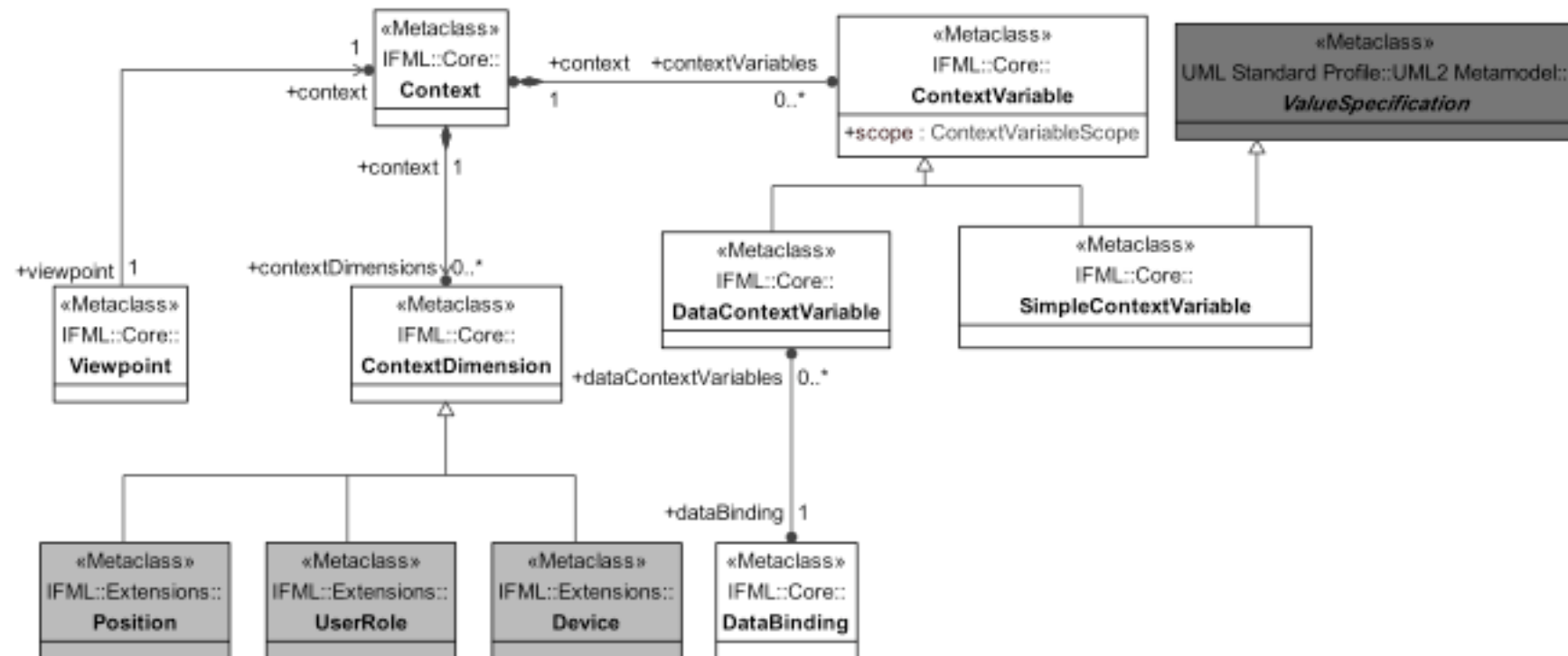


Events





Context



Examples





Example 1: online mailer (e.g., Gmail)

Typical email interface

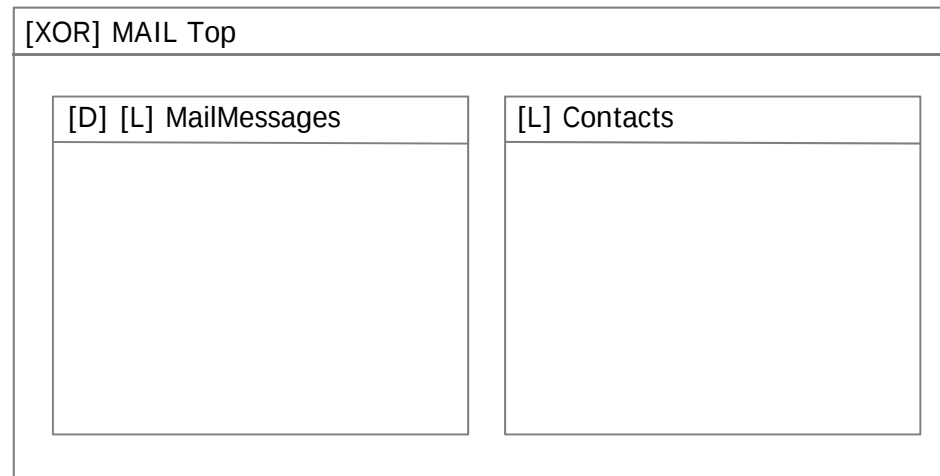
Usability

Friendliness

Complex interaction flows



Top down design from containers





«Window» [XOR] MAIL Top

[D] [L] Messages

«List»

MailBoxList



[XOR] MessageSearch

[XOR] MessageManagement

MailBox

«List»

Message List

[L] Settings

[L] MessageWriter

...



«Window» [XOR] MAIL Top

[D] [L] Messages



[XOR] MessageSearch

[XOR] MessageManagement

MailBox

[L] Settings

«List»
Message List

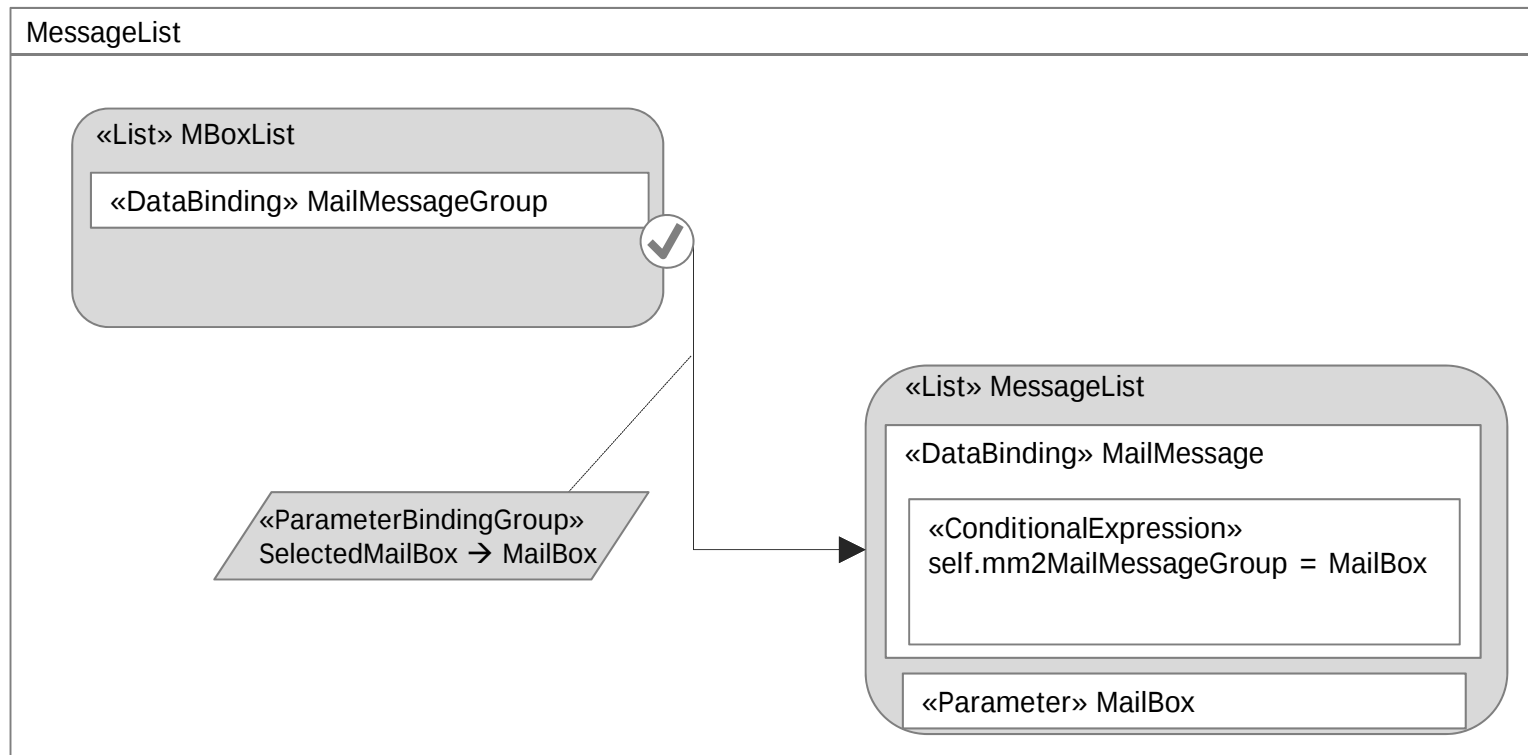
[L] MessageWriter

«ParameterBindingGroup»
SelectedMailBox → MailBox

...

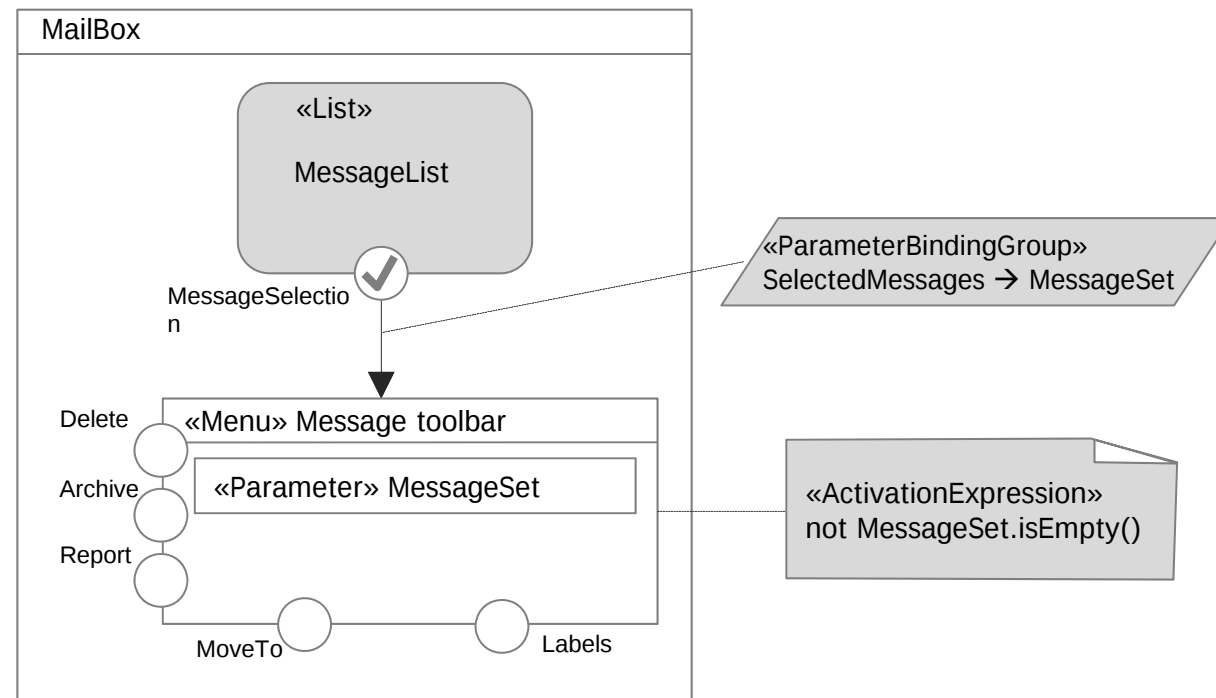


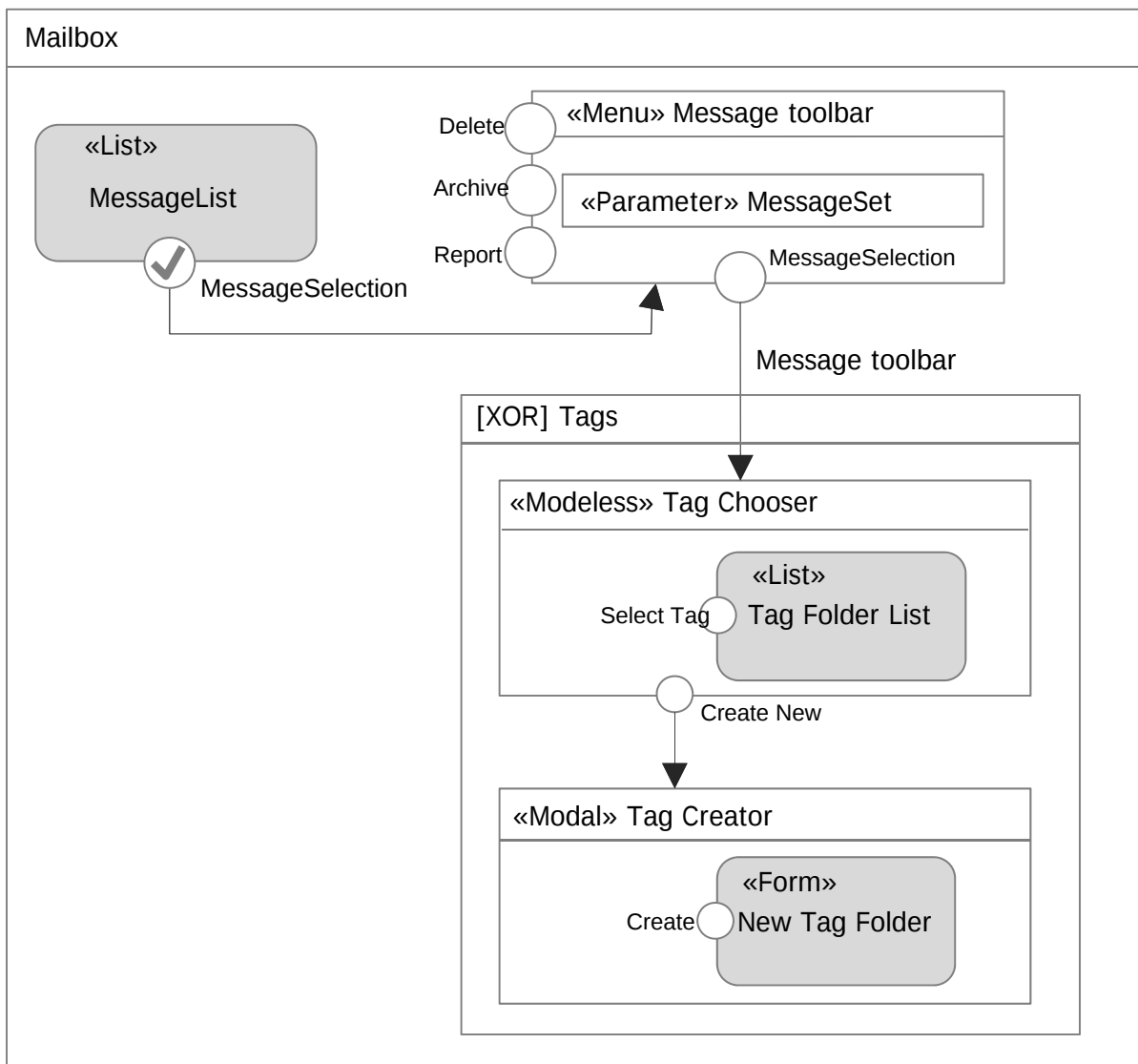
Parameters and Conditions

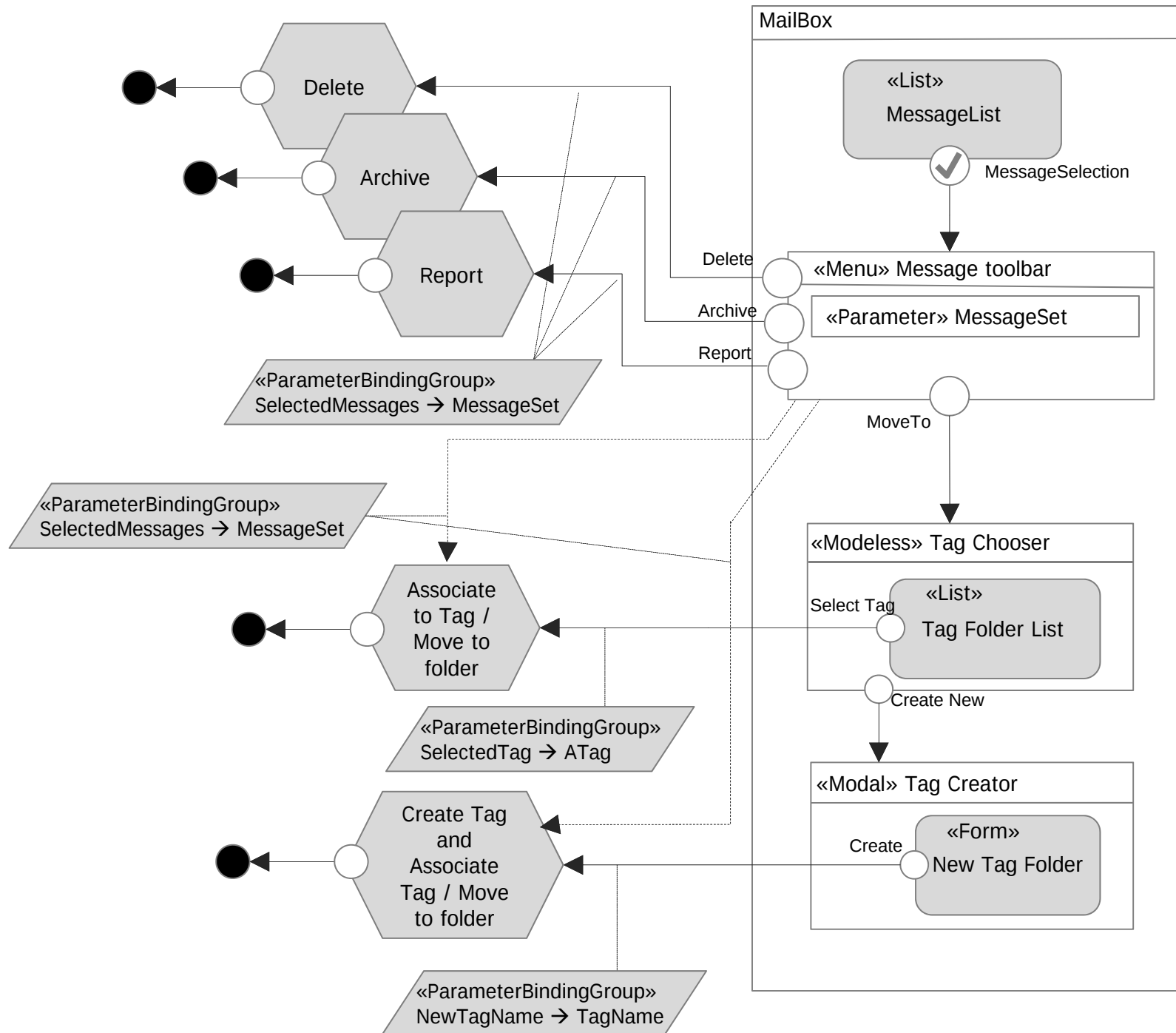




Activation expressions

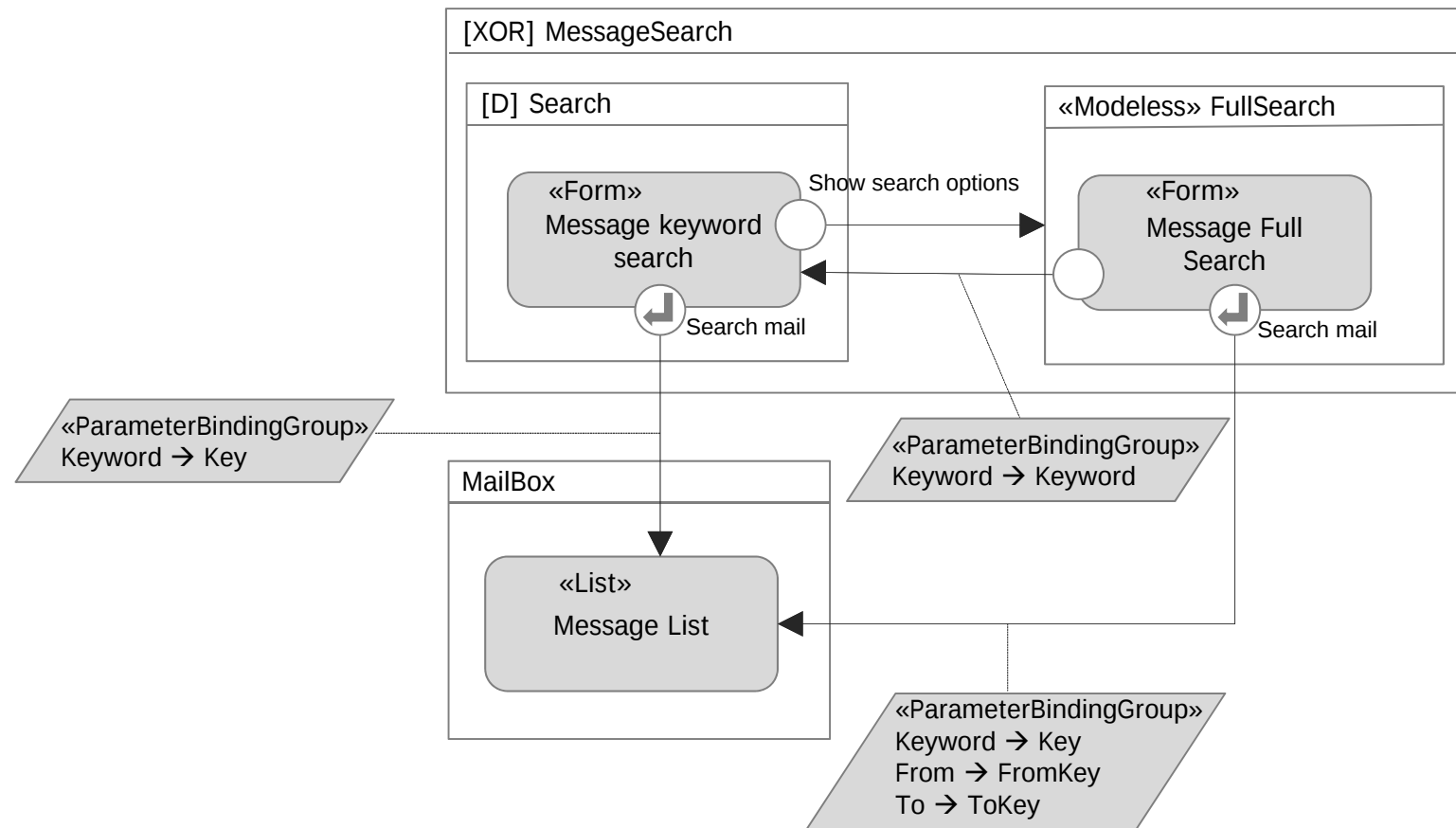






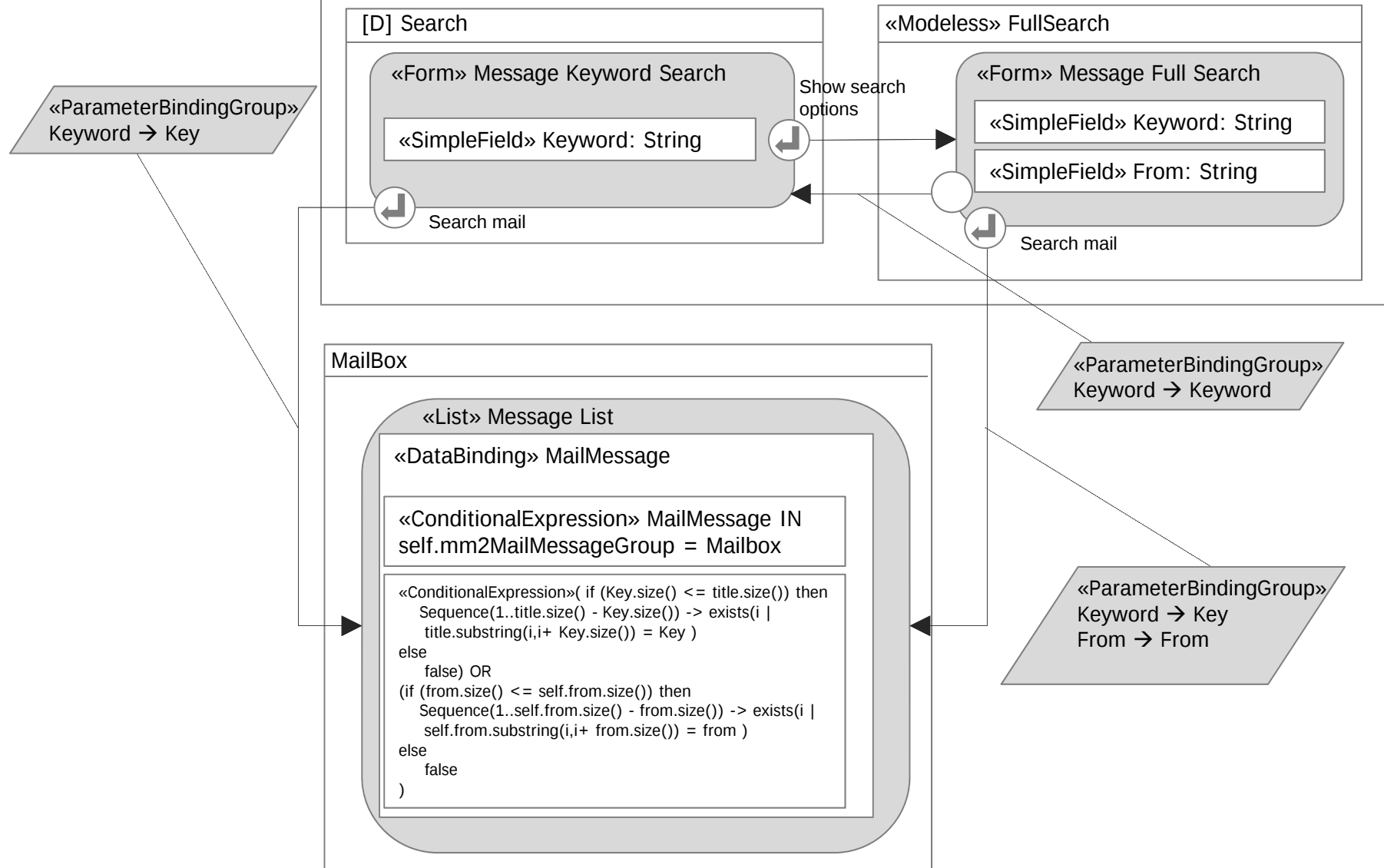


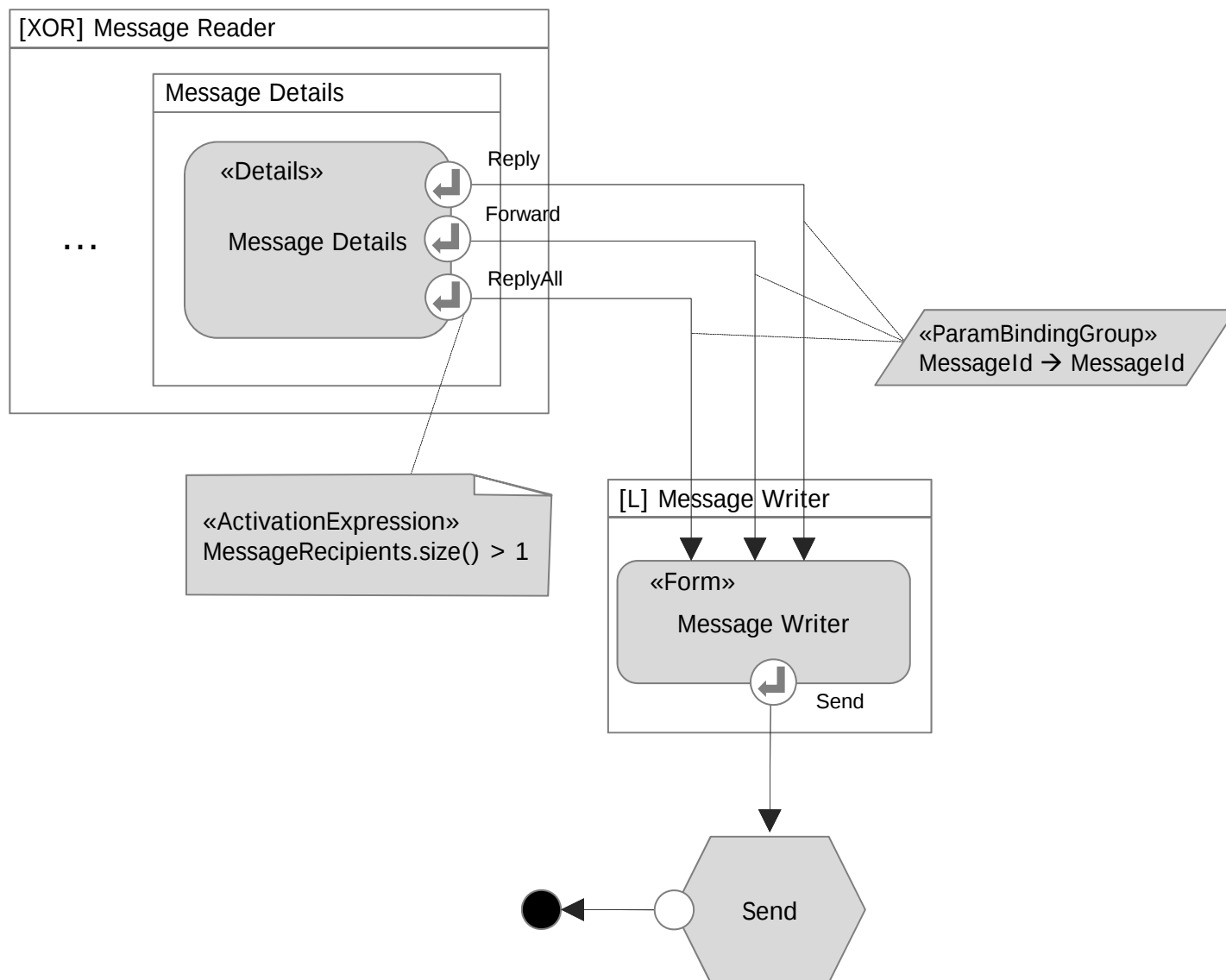
Search forms





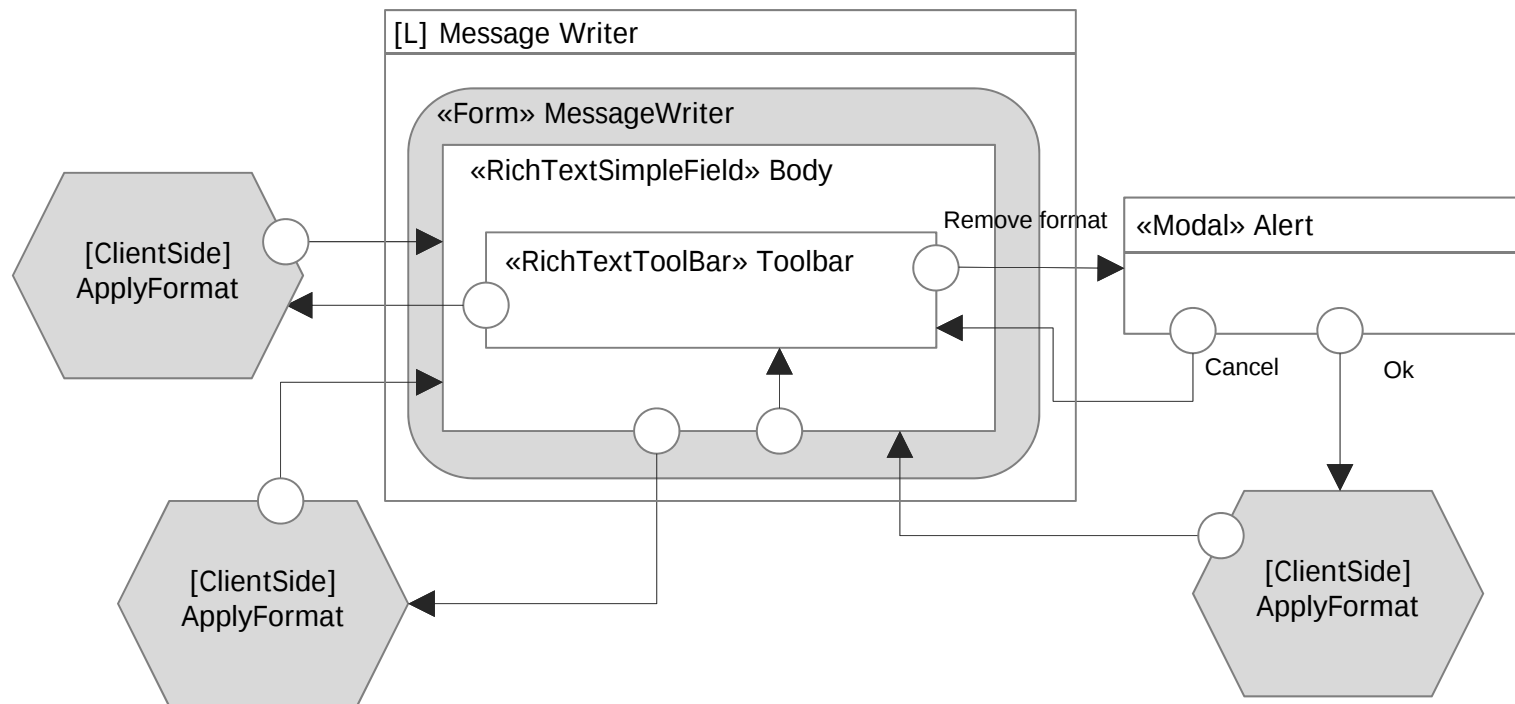
[XOR] MessageSearch







Client Side





Example 2: Instagram

Typical mobile UI

Simple app

Complex interaction

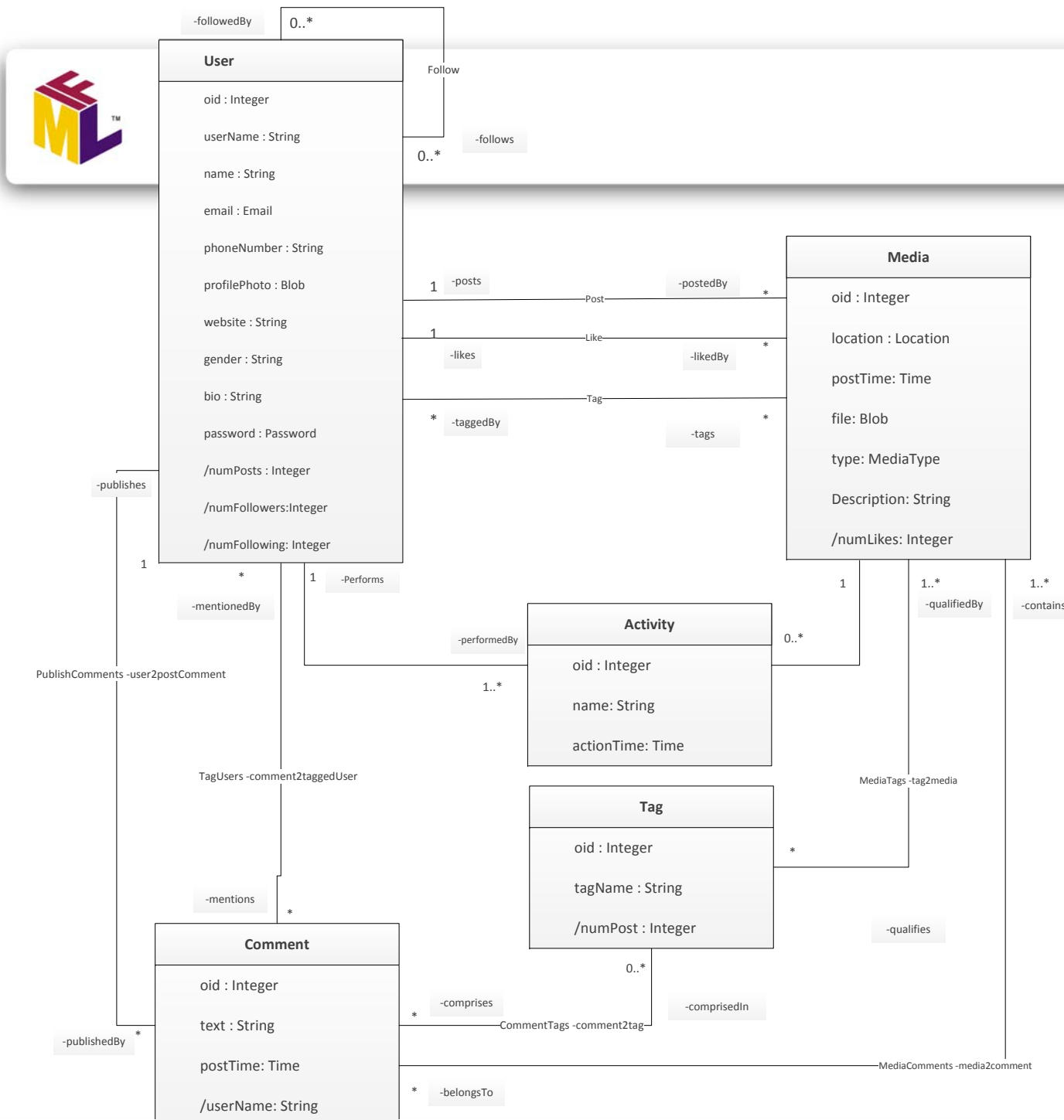




Fig 9.3

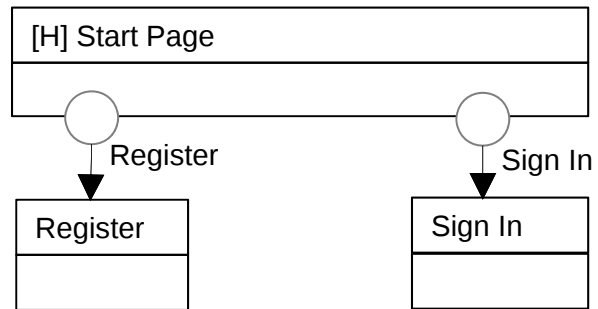




Fig 9.4

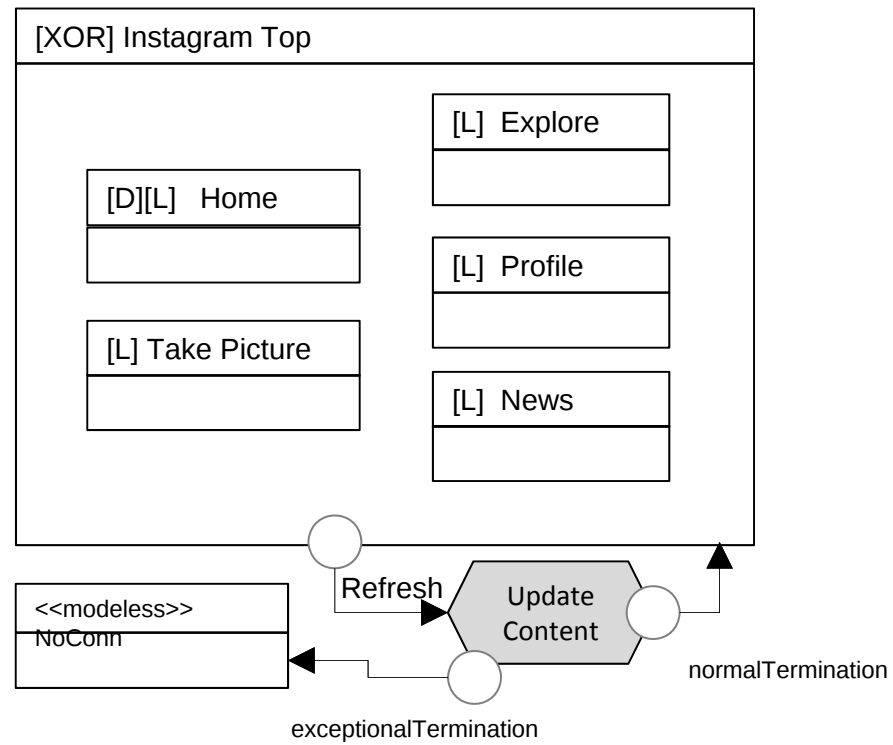




Fig 9.5

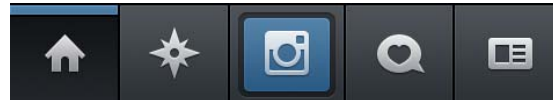




Fig 9.6-B

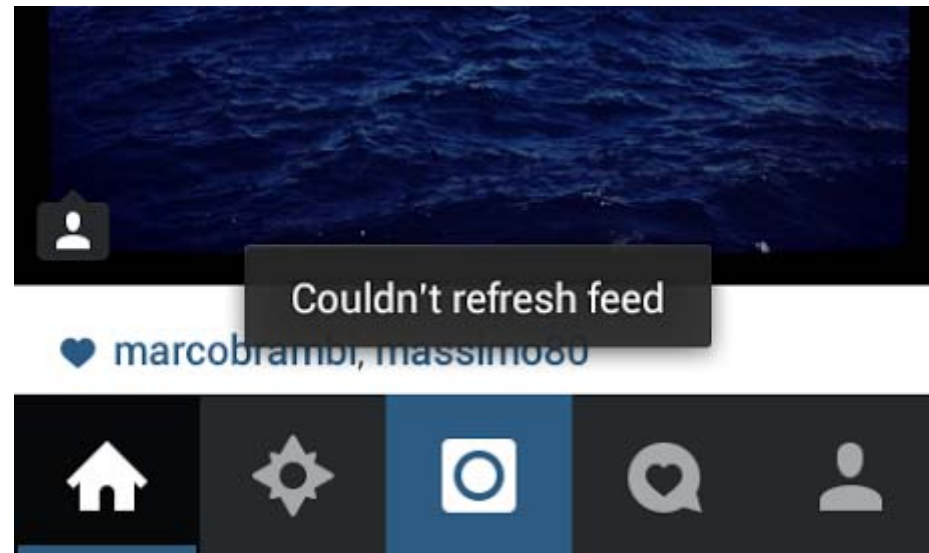




Fig 9.7

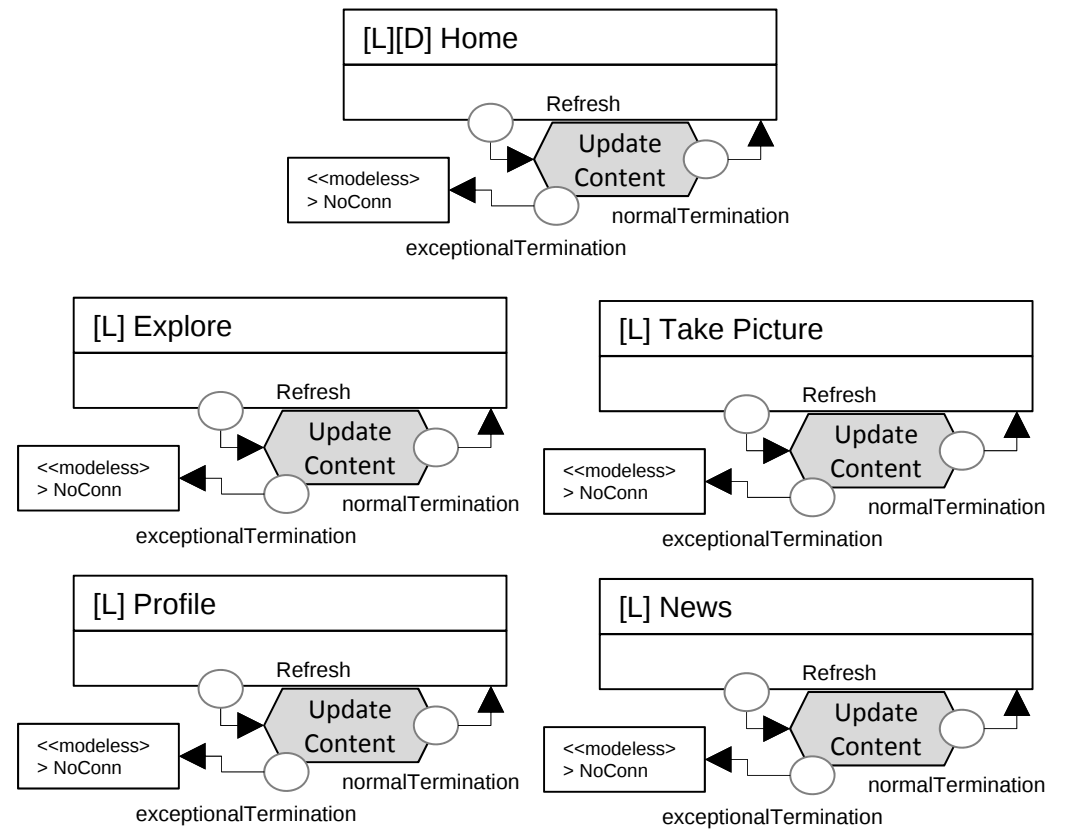
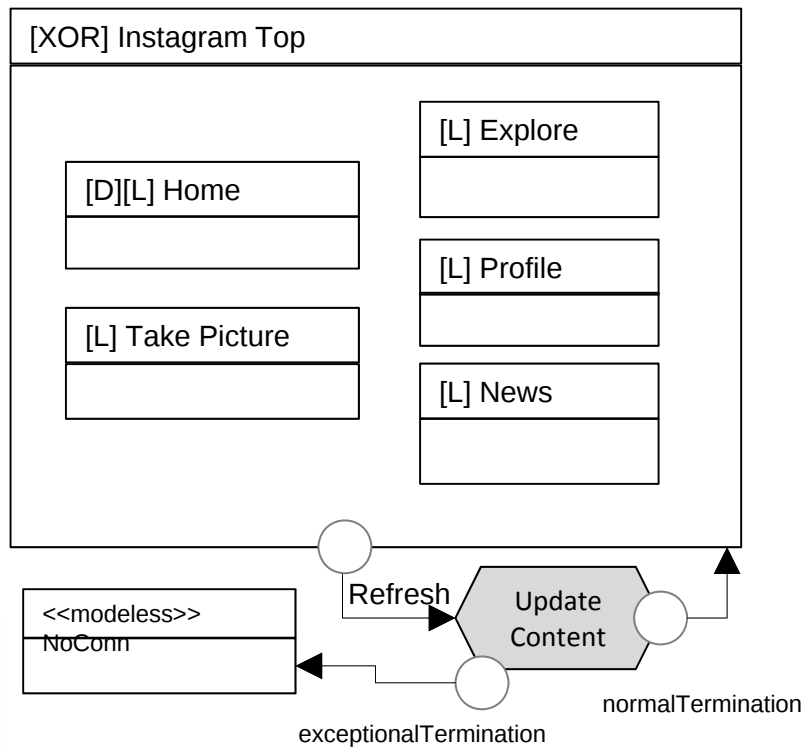




Figure 9.8

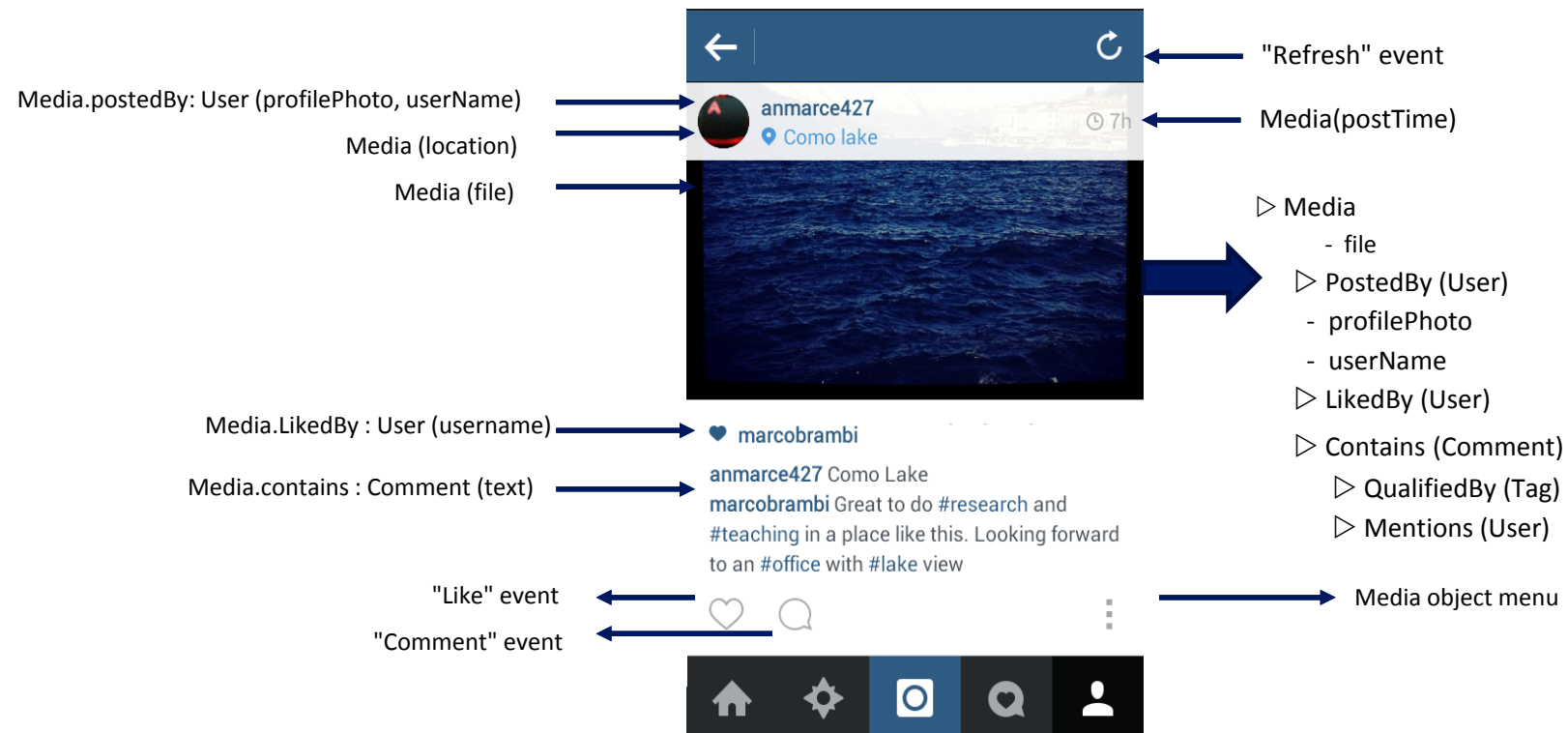




Figure 9.9

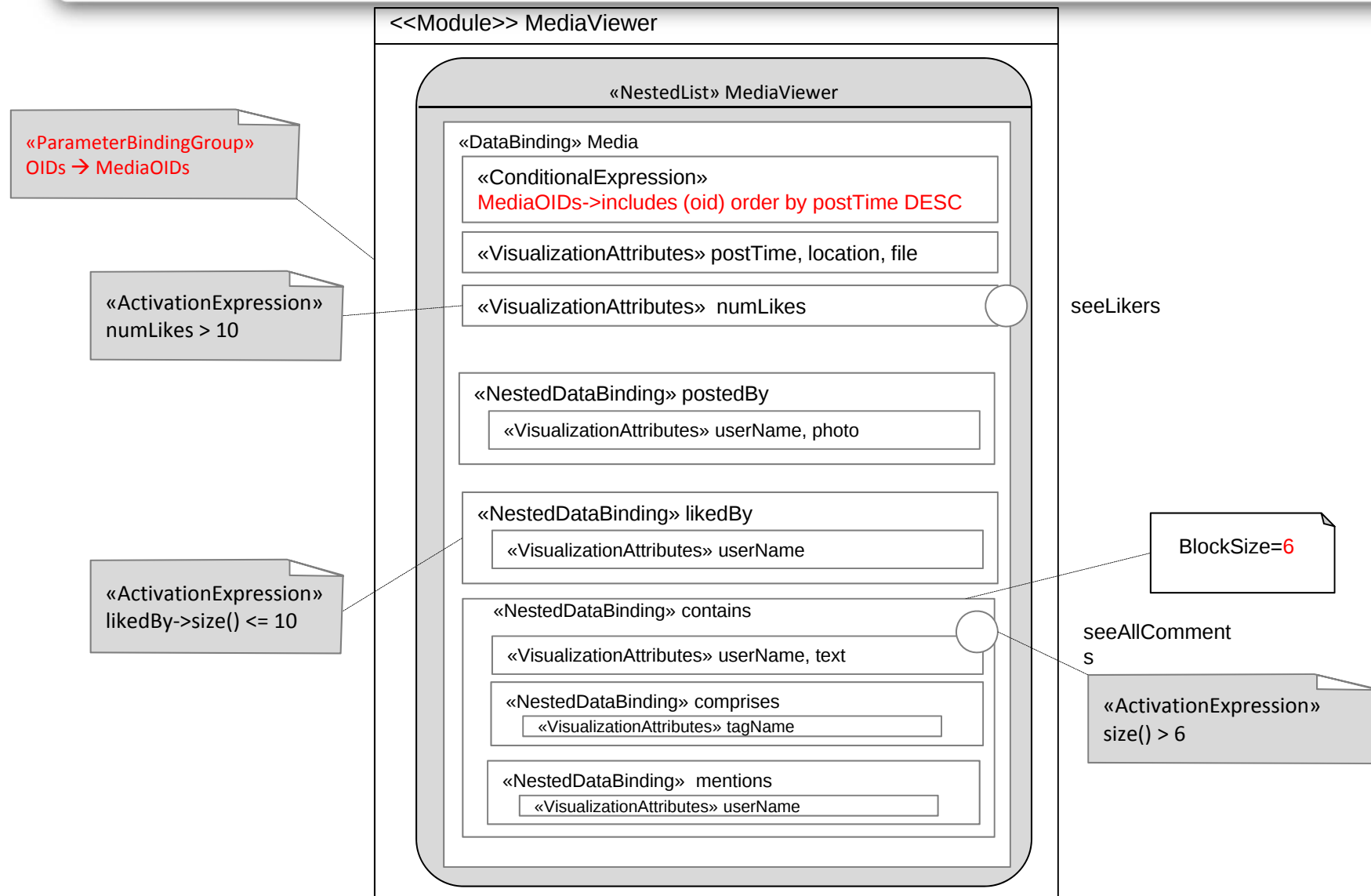




Figure 9.10

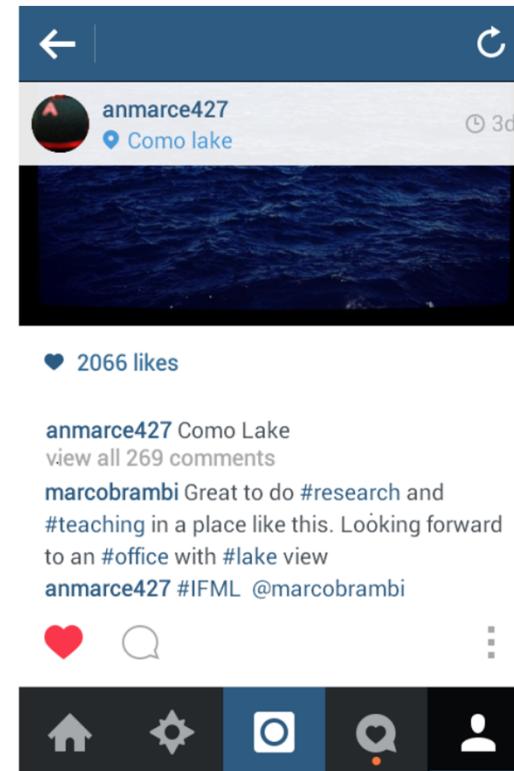
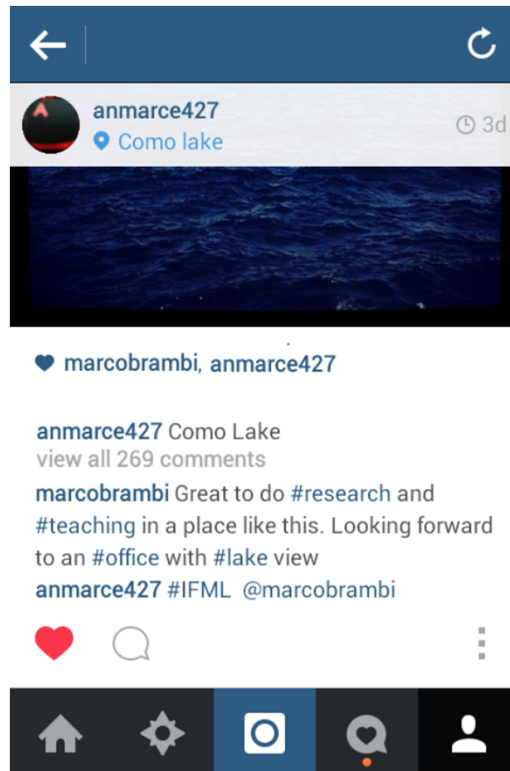




Figure 9.11

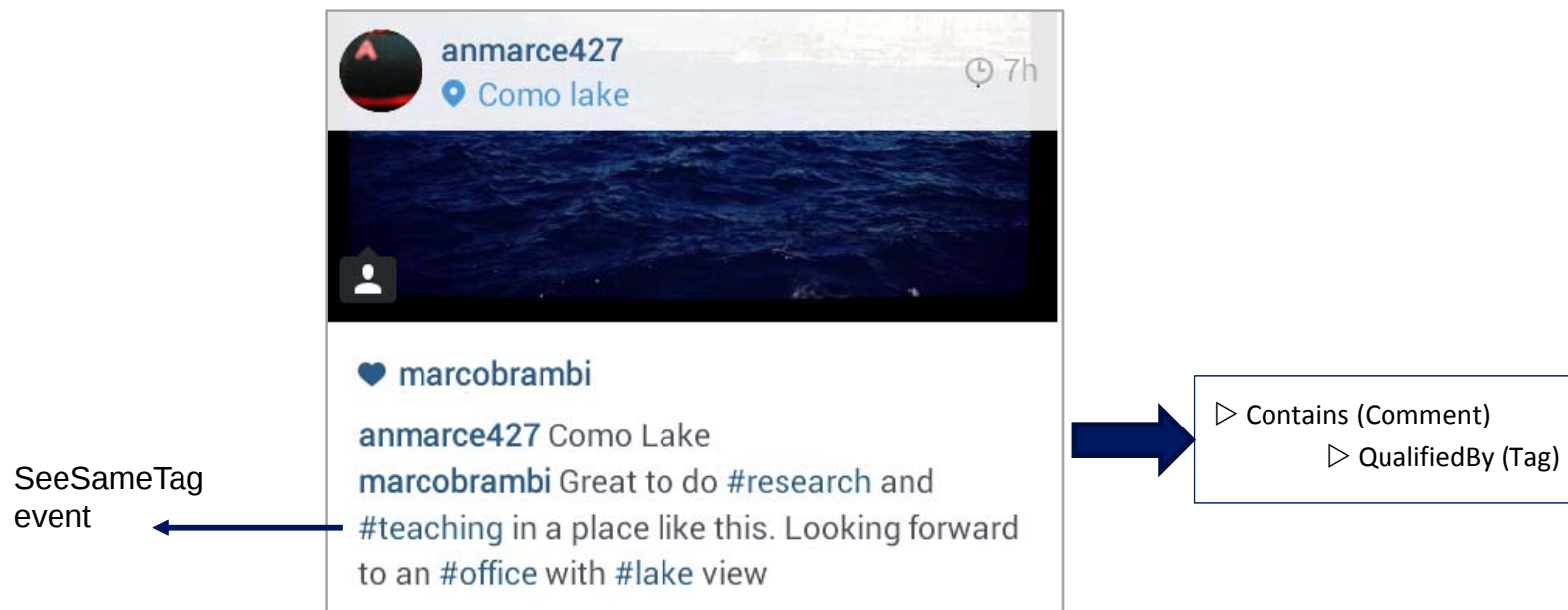


Fig 9.12

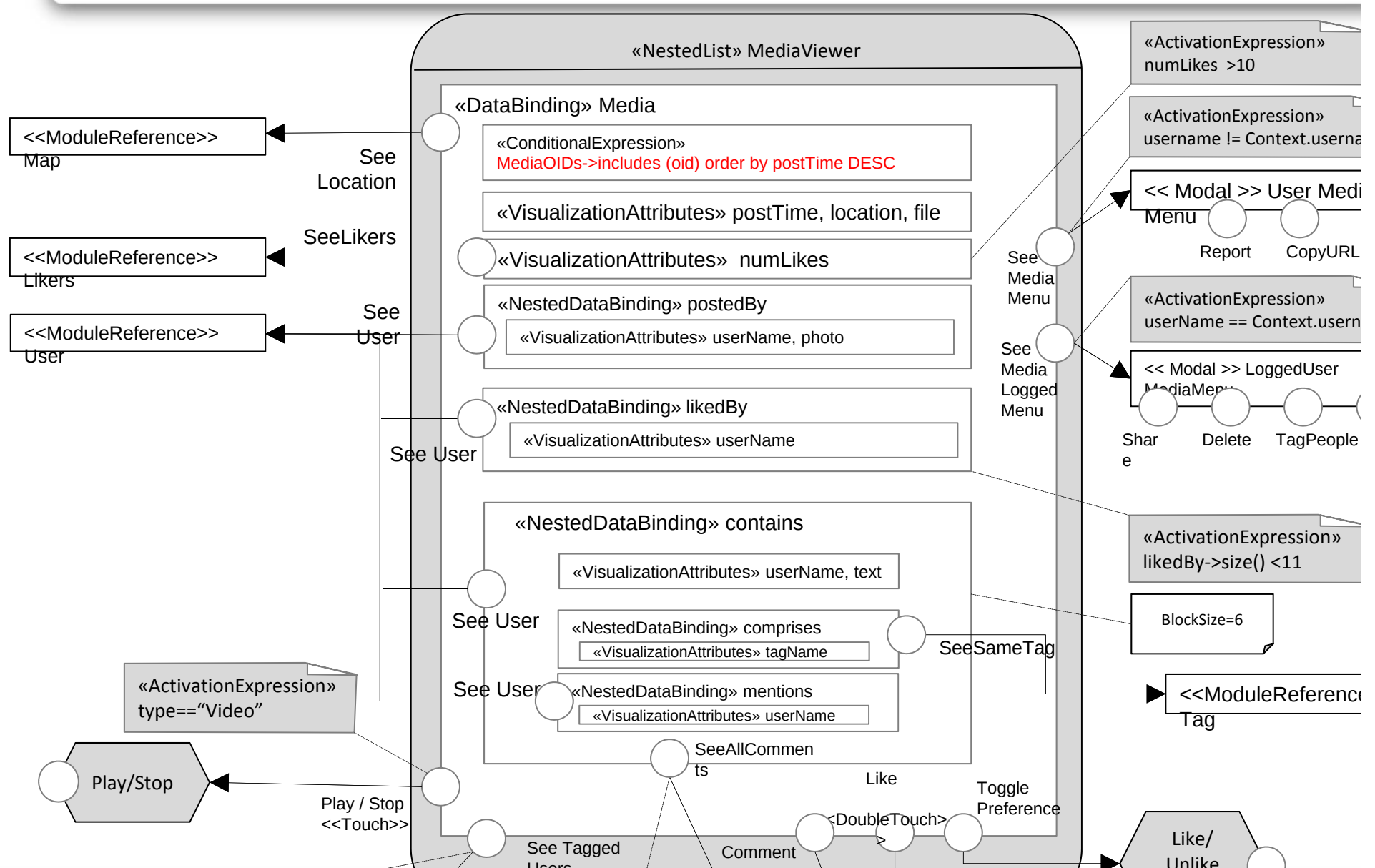




Fig 9.13





Fig 9.14



COMMENTS



anmarce427 Como Lake
6 days ago



marcobrambi Great to do #research
and #teaching in a place like this.
Looking forward to an #office with
#lake view
6 days ago



anmarce427 #IFML @marcobrambi
3 days ago

Add a comment



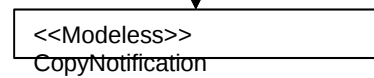




Fig 9.16

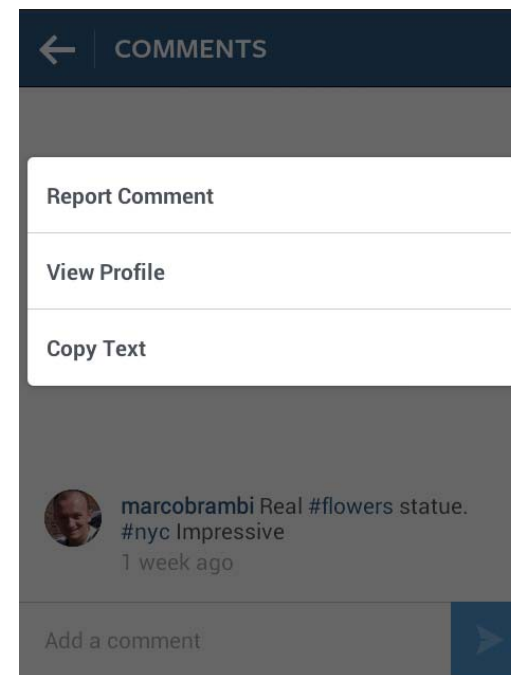
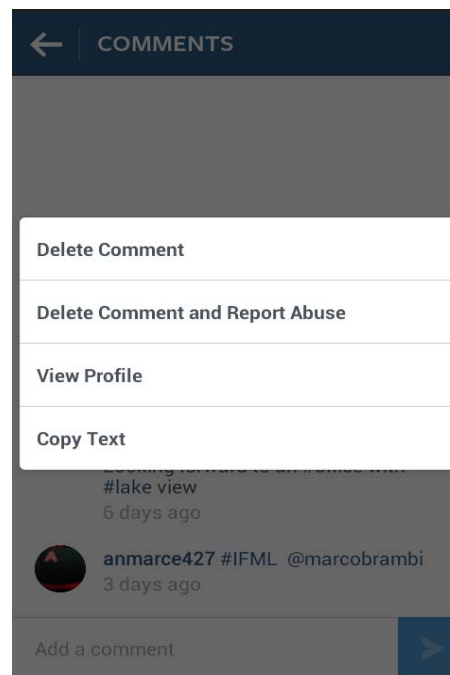
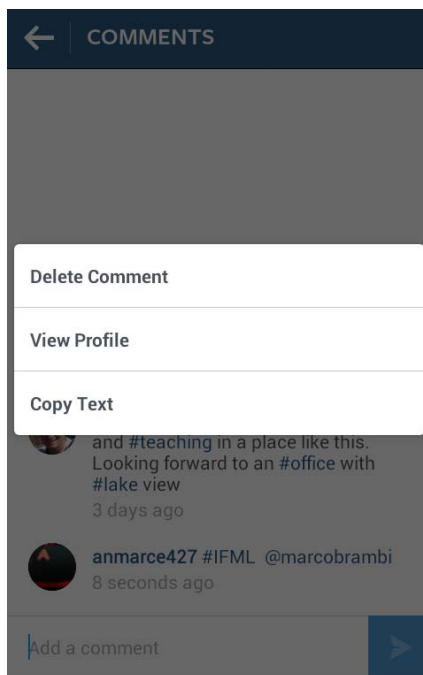




Fig 9.17



COMMENTS



anmarce427 Como Lake
3 days ago



marcobrambi Great to do #research
and #teaching in a place like this.
Looking forward to an #office with
#lake view
3 days ago



anmarce427 @marcobrambi
41 seconds ago

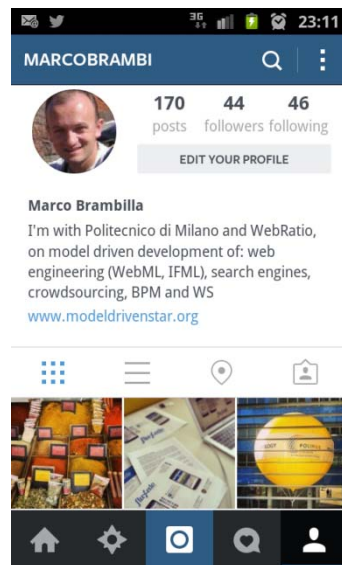
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9.18



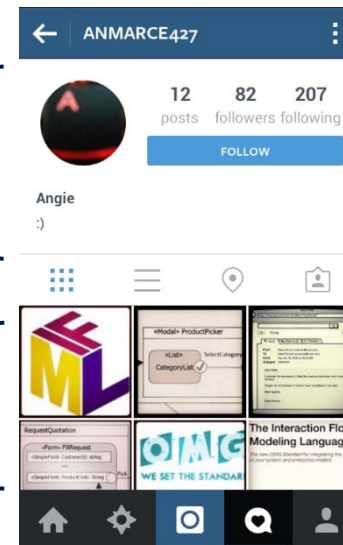
ProfileData

Profile menu

Upper section

Commands

Lower section



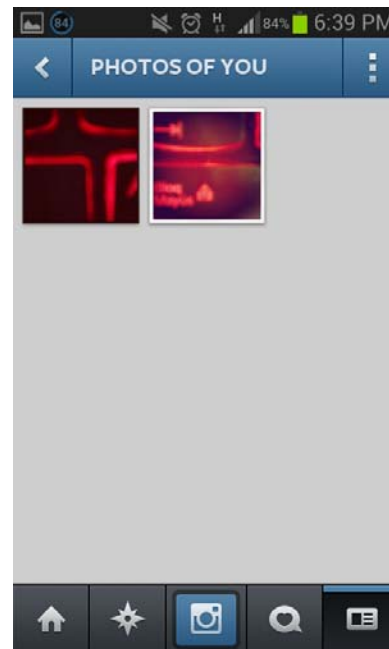
ProfileData



Fig 9.19



MediaMap



PhotosOfUser

Fig 9.20

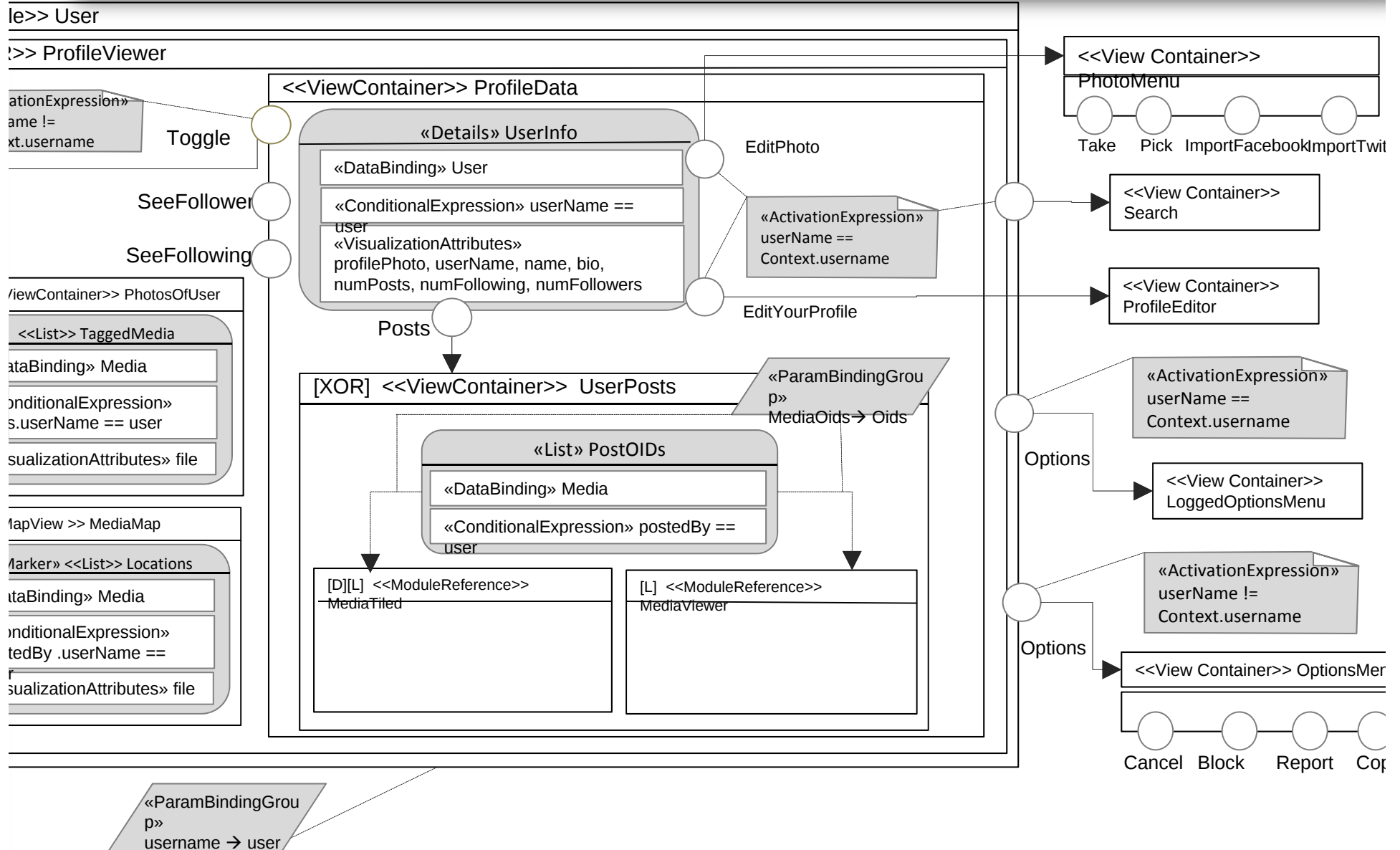




Fig 9.21

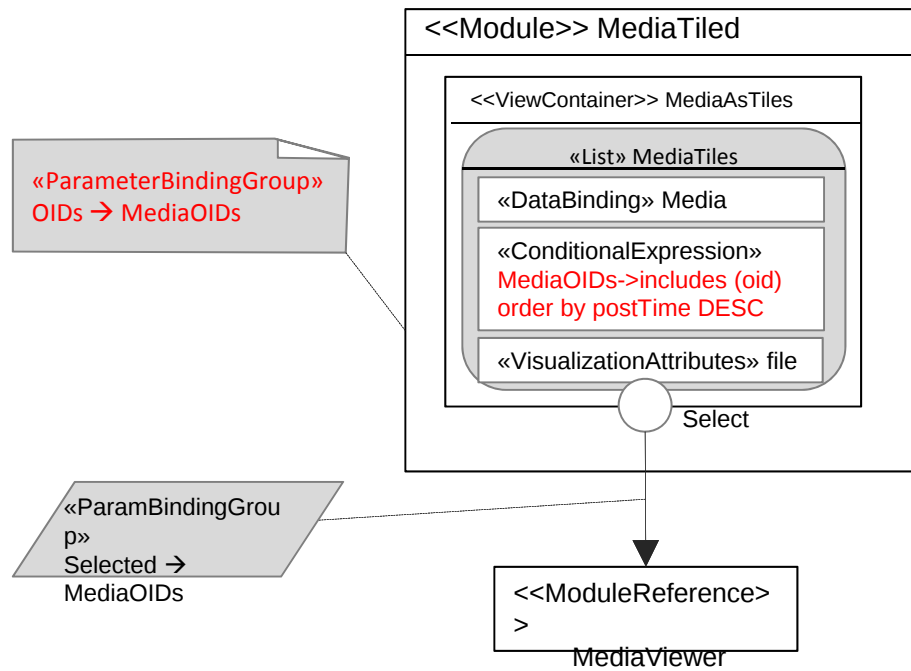


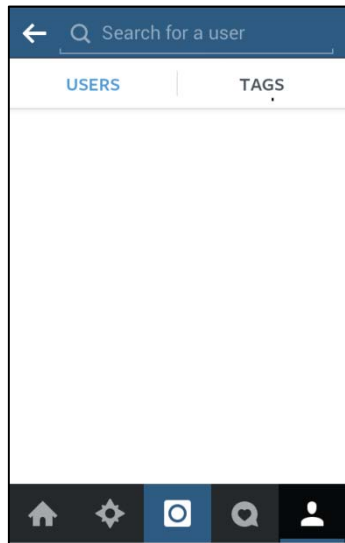


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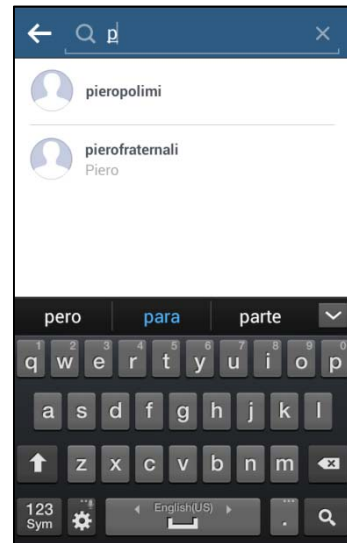




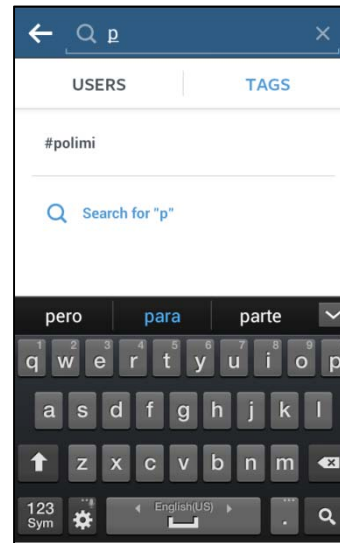
Fig 9.23



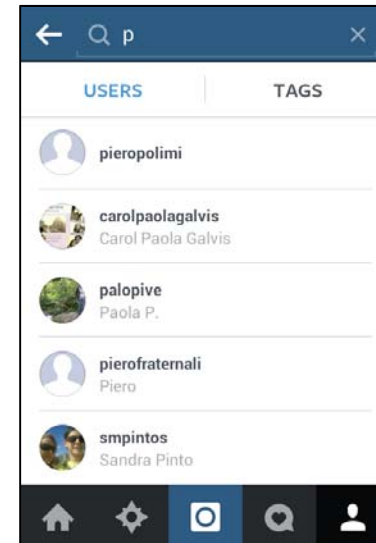
a



b



c



d



Fig 9.23

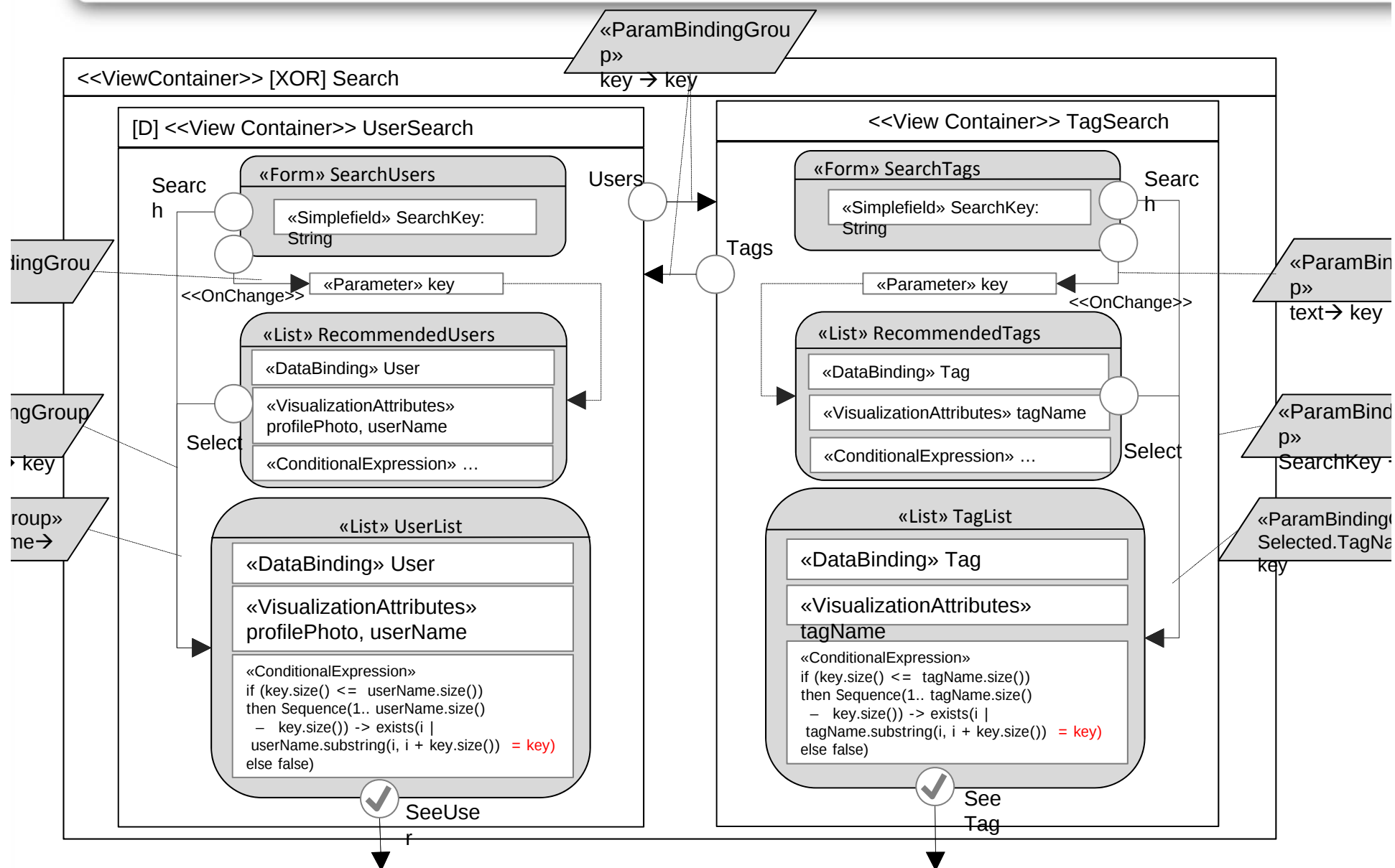




Fig 9.24

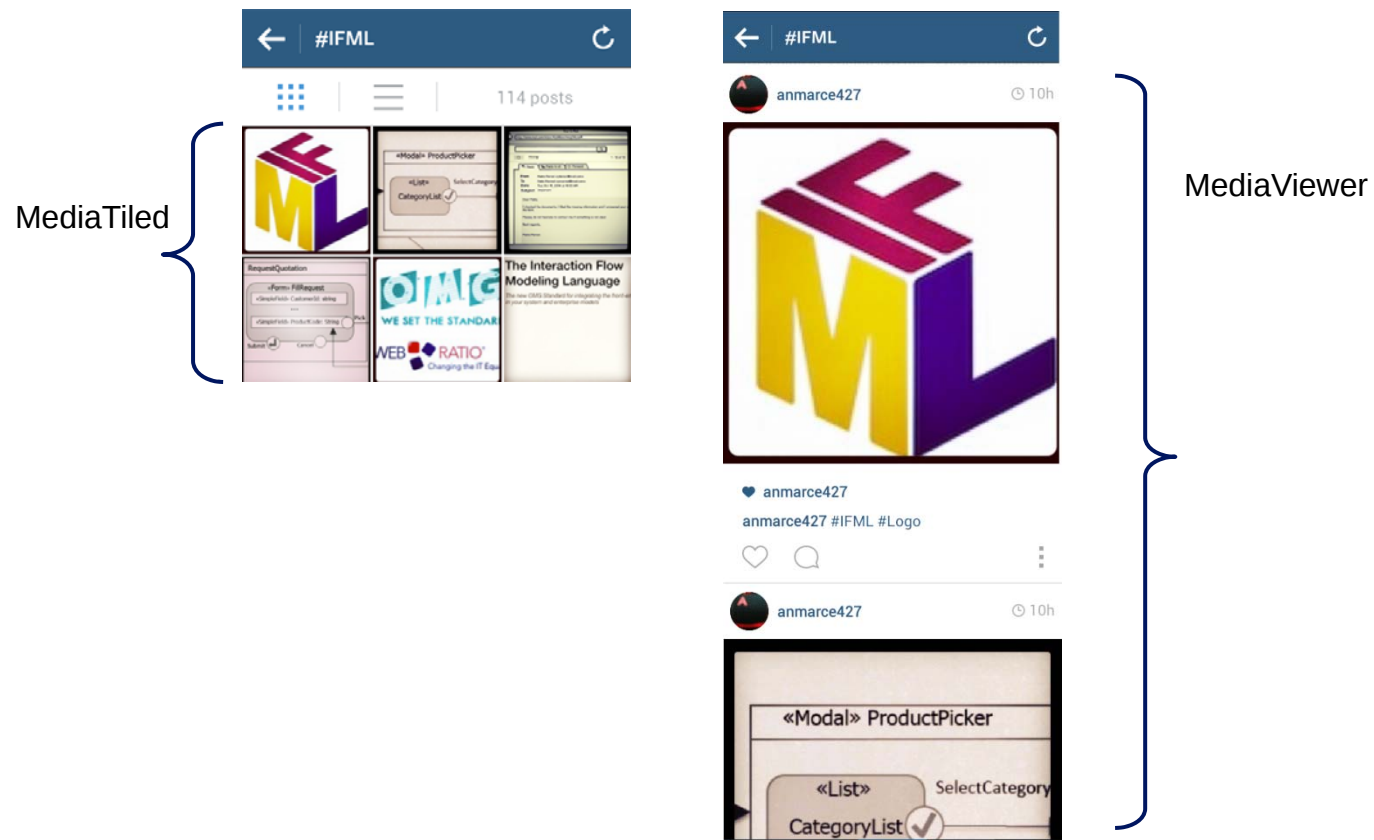
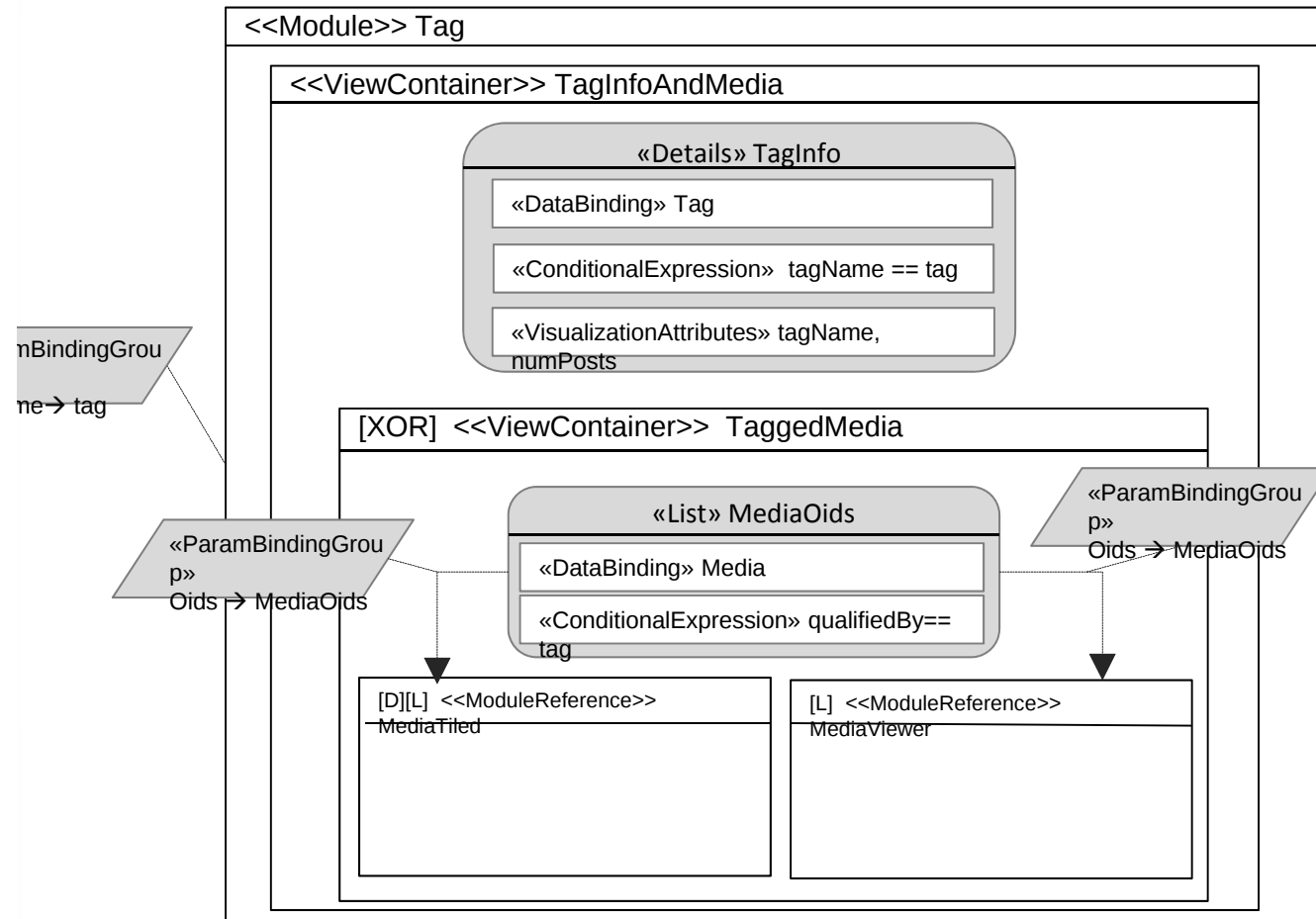




Fig 9.25





Example 3: eBay

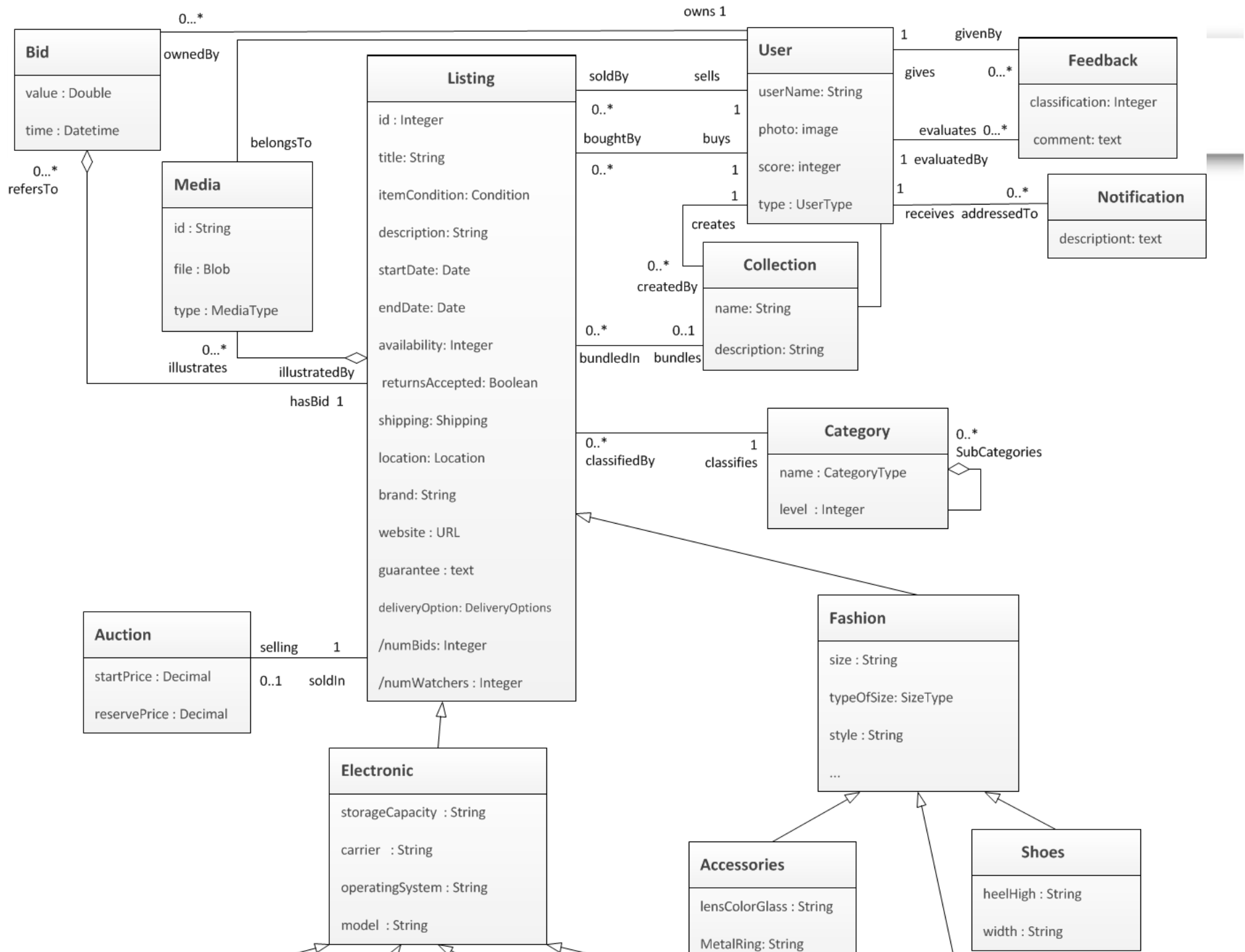




Fig 9.28

Hi, Piero! ▾ | [Daily Deals](#) | [Sell](#) | [Customer Support](#) [SOCCER FEVER](#)
[Shop now ▶](#)

My eBay   1

 Shop by category ▾ Search... All Categories ▾ [Search](#) [Advanced](#)

[Community](#) [About eBay](#) [Announcements](#) [eBay Money Back Guarantee](#) [Security Center](#) [Resolution Center](#) [Seller Information Center](#) [Policies](#) [Site Map](#) [eBay official time](#)

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Fig 9.29

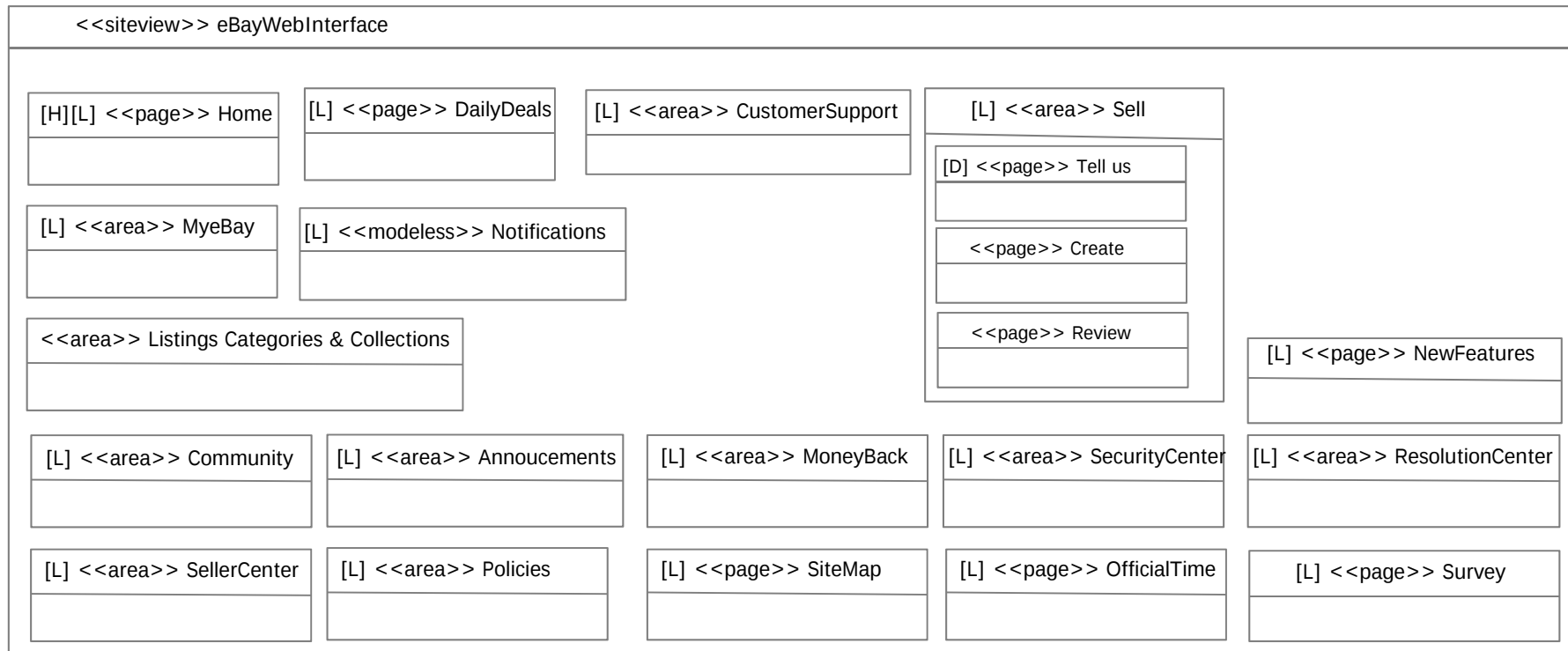




Fig 9.30

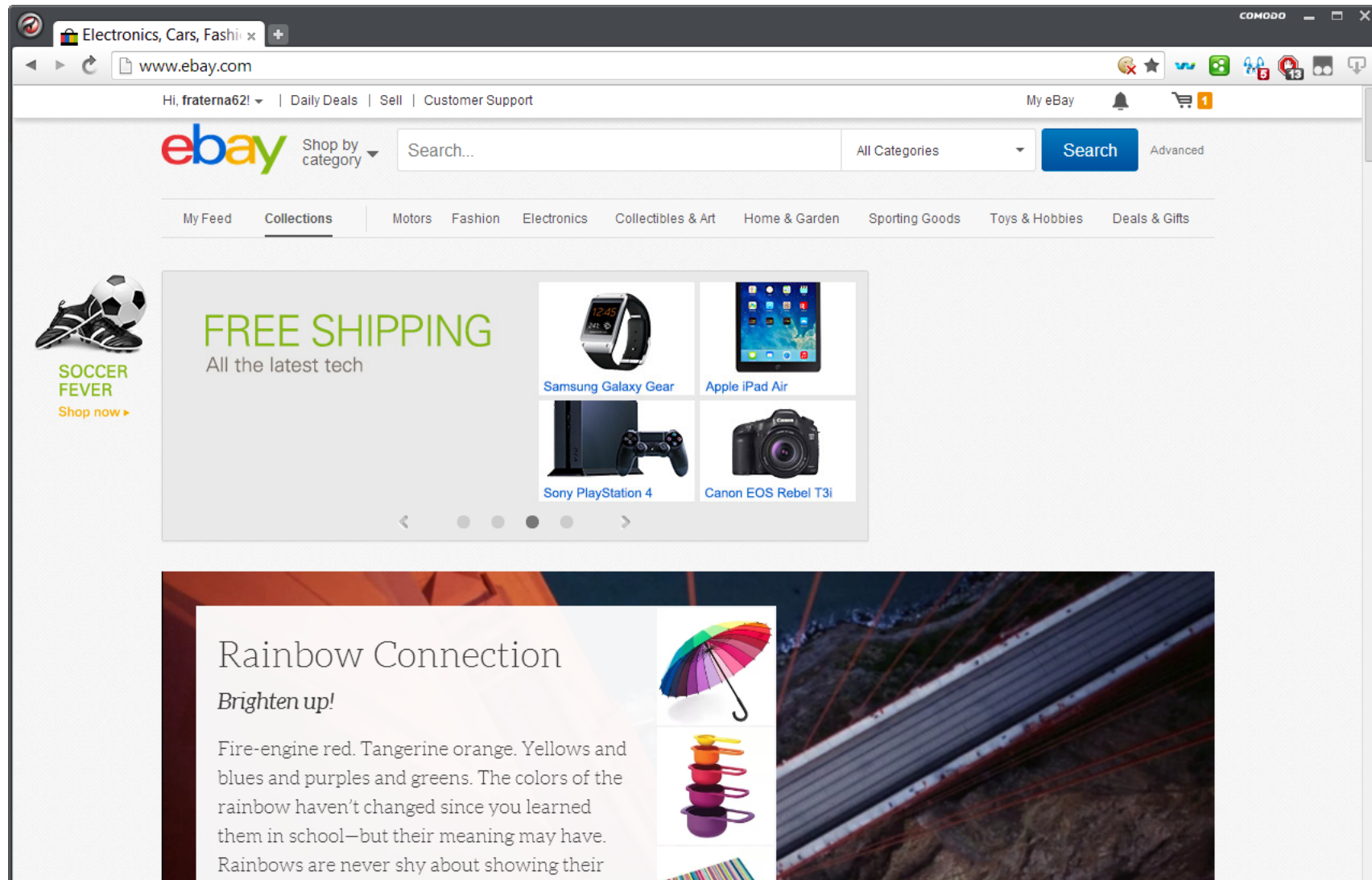




Fig 9.31

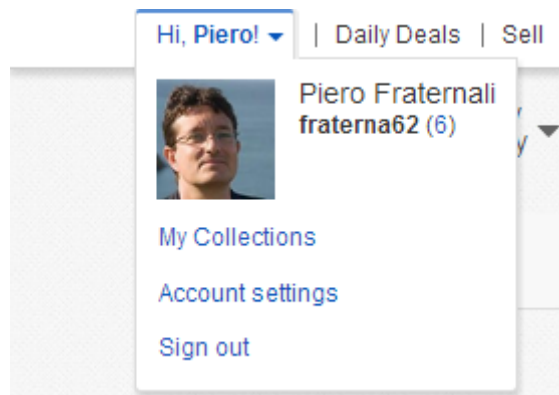




Fig 9.32

Hi, Piero! | Daily Deals | Sell | Customer Support

ebay Shop by category Search... All Categories

My Feed

Buy It Now
TABLET
LAPTOP
Free Shipping

Get It

Collectibles & art

- Collectibles
- Coins & paper money
- Antiques
- Sports memorabilia

Electronics

- Computers & tablets
- Cameras & photo
- TV, audio & surveillance
- Cell phones & accessories

Entertainment

- Video games & consoles
- Music
- DVDs & movies
- Tickets

Fashion

- Women
- Men
- Jewelry & watches
- Shoes

Home & garden

- Yard, garden & outdoor
- Crafts
- Home improvement
- Pet supplies

Motors

- Parts & accessories
- Cars & trucks
- Motorcycles
- Passenger vehicles

Sporting goods

- Outdoor sports
- Team sports
- Exercise & fitness
- Golf

Toys & hobbies

- Collector & hobbyist toys
- Kids toys
- Action figures
- Dolls & bears

Other categories

- Books
- Health & beauty
- Musical instruments & gear
- Business & industrial

Explore [trending collections](#)

[See all categories](#)

ting Goods Toys & Hobbies



Fig 9.33

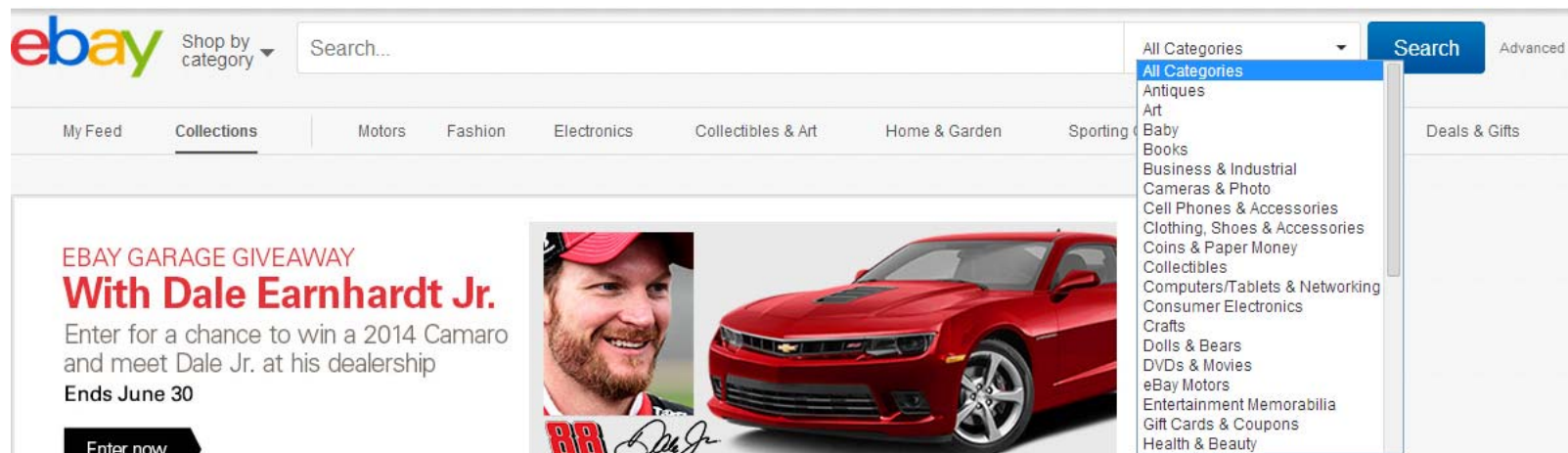




Fig 9.33/b

All Categories

Search

tripod

tripod in Tripods & Supports

tripod head

tripod ball head

tripod camera

tripod bag

tripod dolly

tripod lamp

tripod floor lamp

tripod case

tripod manfrotto

Hide eBay suggestions

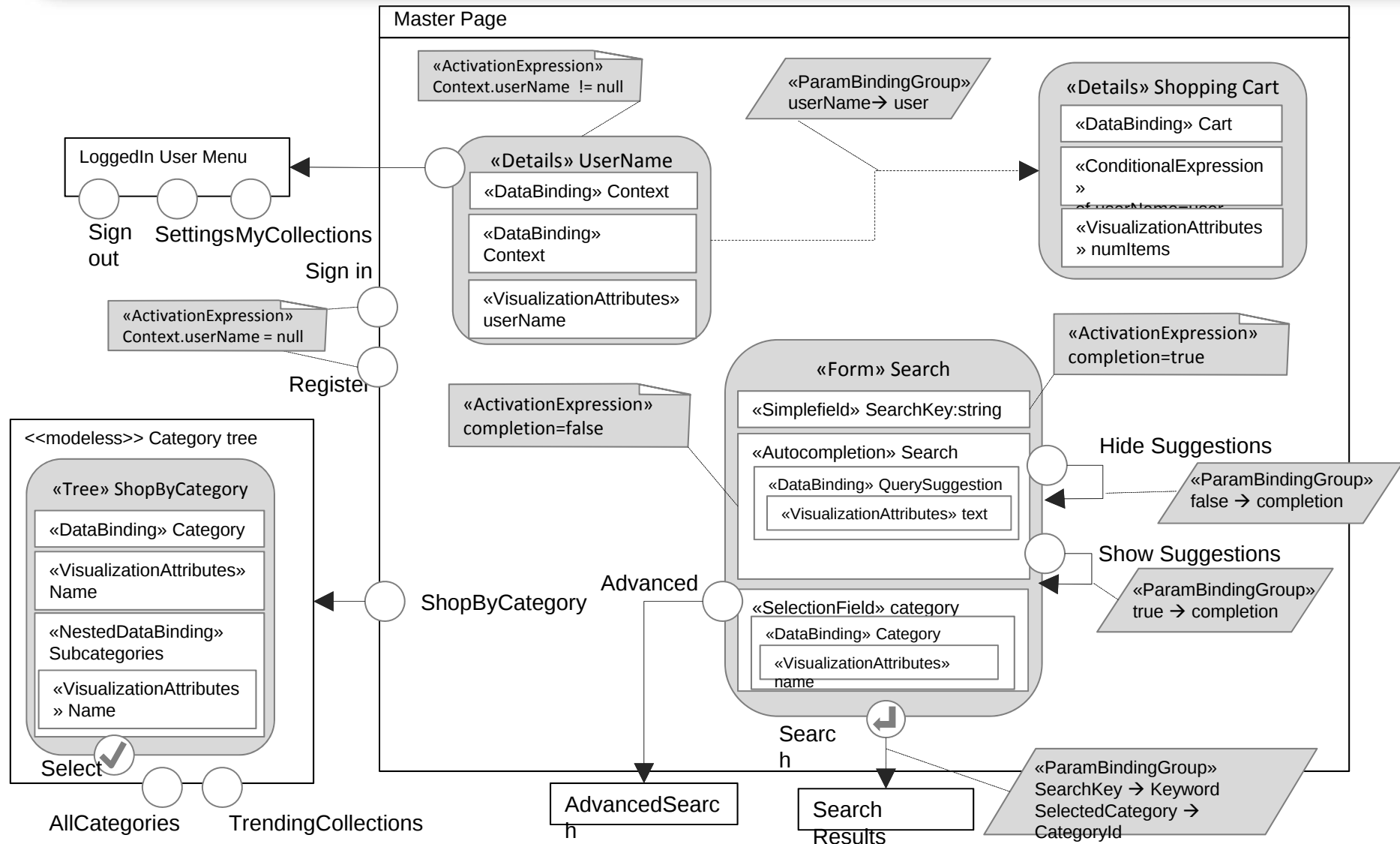
Goods

Toys & Hobbies

Deals & G



Figure 9.34



The diagram illustrates the architecture of a mobile application with three main screens: **Fashion**, **Offers**, and **Collections**. Each screen displays a list of items with specific data binding and conditional expressions.

Screen 1: «List» Fashion

- «OnFocus»**: Search
- «DataBinding» Category**
- «VisualizationAttributes» Name**
- «ConditionalExpression»**: Self.Category.name= "fashion"
- «ConditionalExpression»**: Self.Category.SubCategory-> forAll(c | c.level =1)
- «NestedDataBinding»**:
 - «VisualizationAttributes» name**
 - «ConditionalExpression»**: Self.Category.SubCategory-> forAll(c | c.level =2)

Screen 2: «List» Offers

- «DataBinding» Listing**
- «VisualizationAttributes» title**
- «ConditionalExpression»**: self.listing->forAll(L | L.PurchaseFormat. oclIsKindOf(BuyItKnow)) OR (self.listing->forAll(L | L.Delivery=FreeShipping) AND Min(CurTime -startTime) AND endTime>CurTime OR (self.listing->forAll(L | L =Context.cookies.recent)

Screen 3: «List» Collections

- «DataBinding» Colletion**
- «VisualizationAttributes» name, description**
- «NestedDataBinding»**:
 - «VisualizationAttributes» title**
 - «NestedDataBinding» contains**:
 - «VisualizationAttributes» blob**
 - «NestedDataBinding» SoldBy**:
 - VisualizationAttributes»**: userName
 - «NestedDataBinding» contains**:
 - «VisualizationAttributes» blob**

Navigation and Logic:

- Navigation**: Arrows indicate transitions between screens and within lists (e.g., "Go up in description", "Go down in").
- «ParamBindingGroup»**: Previous → Current, Next → Current, selectedListing → Listing, SelectedIdCollection → idCollection.
- «ModuleReferene»**: Listing, Seller, Search Results.
- «ActivationExpression»**: DayCollection != Collection, Show Description, Hide Description.

OnFocusLost and OnBlur are the same?

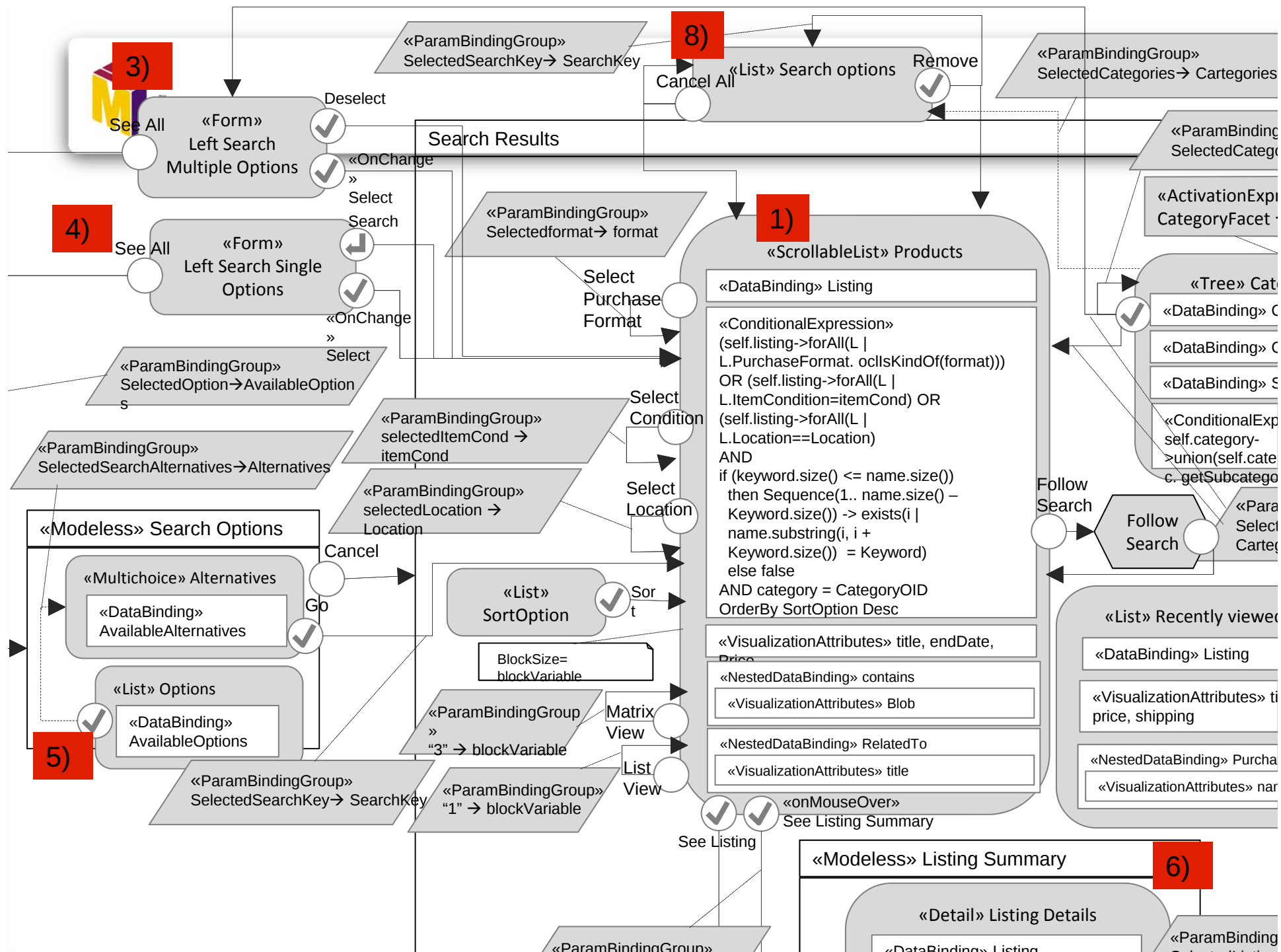


Figure 9.2.22: Left Menu

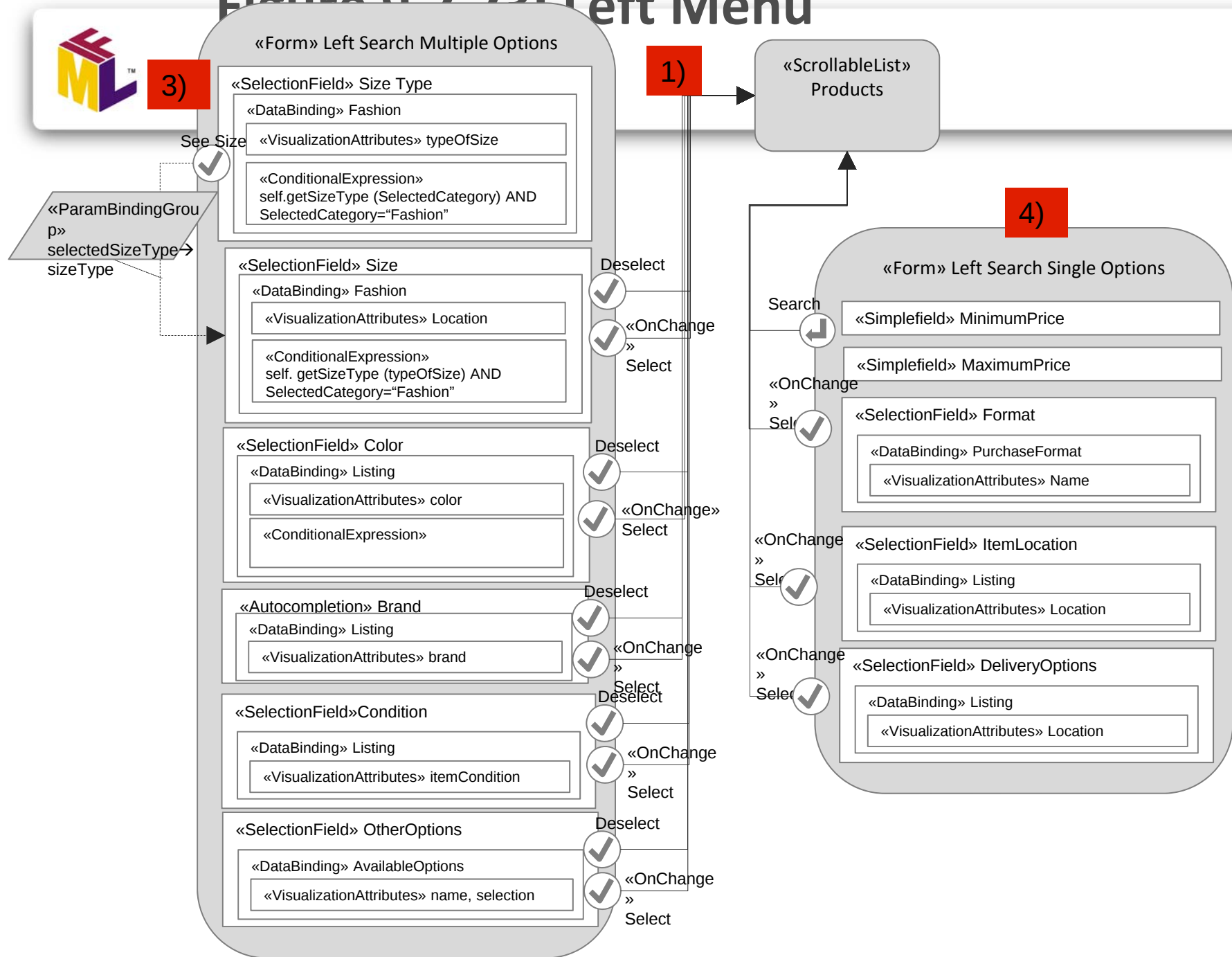
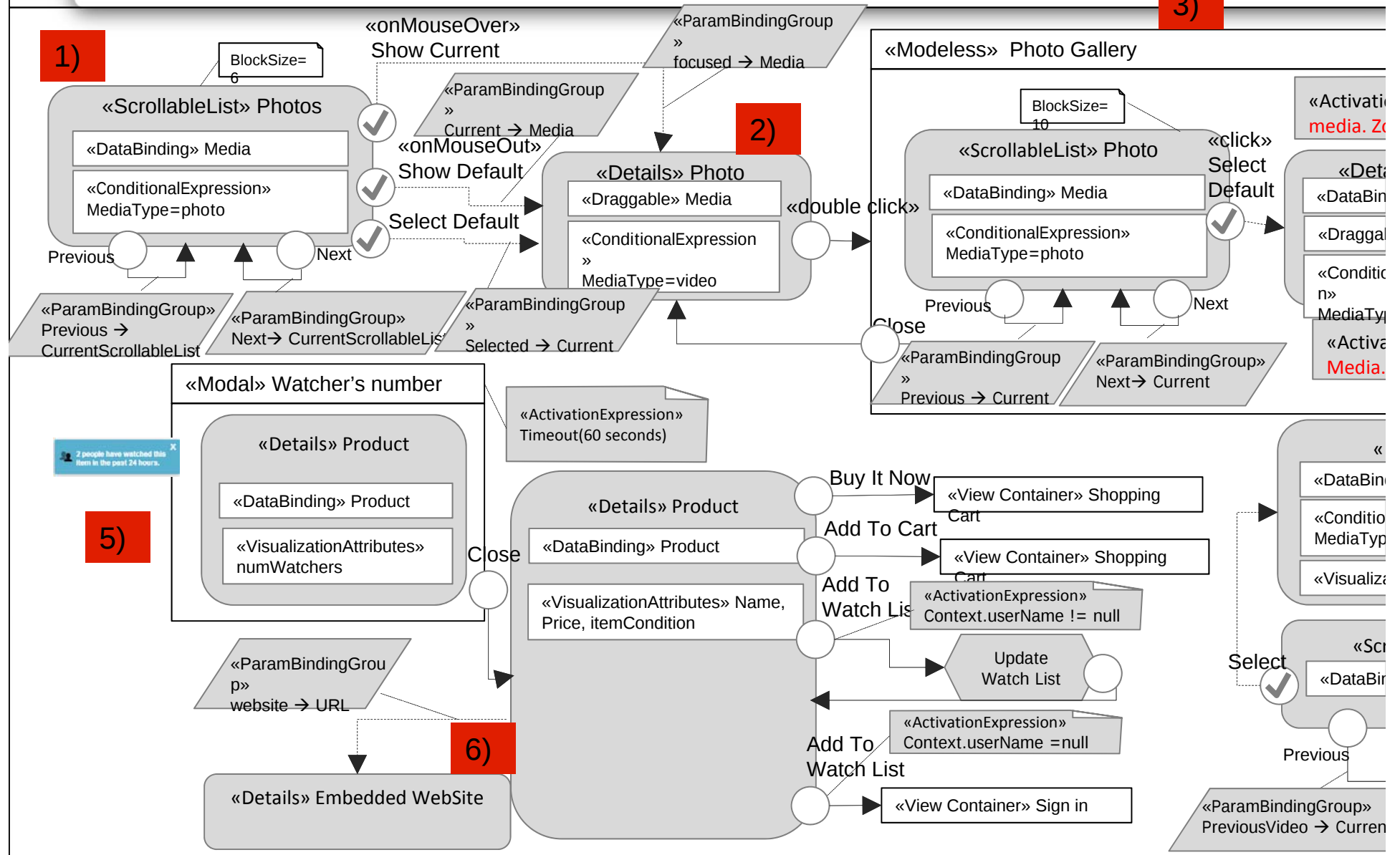


Figure 9.



Listing





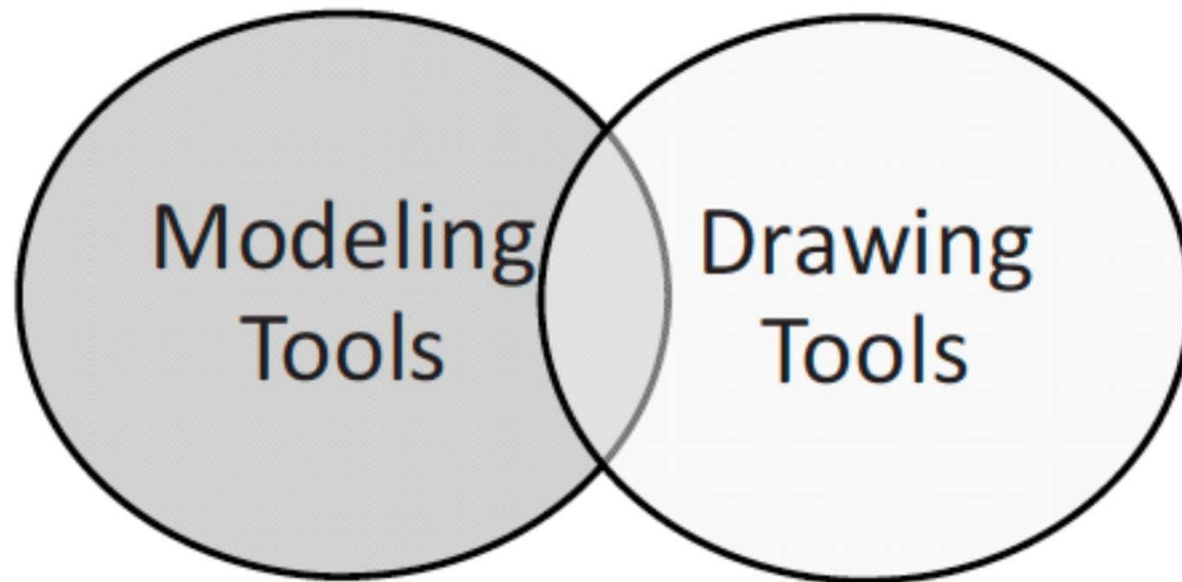
The WebRatio tool





Tool support for MDE/MDD

Drawing vs. modeling

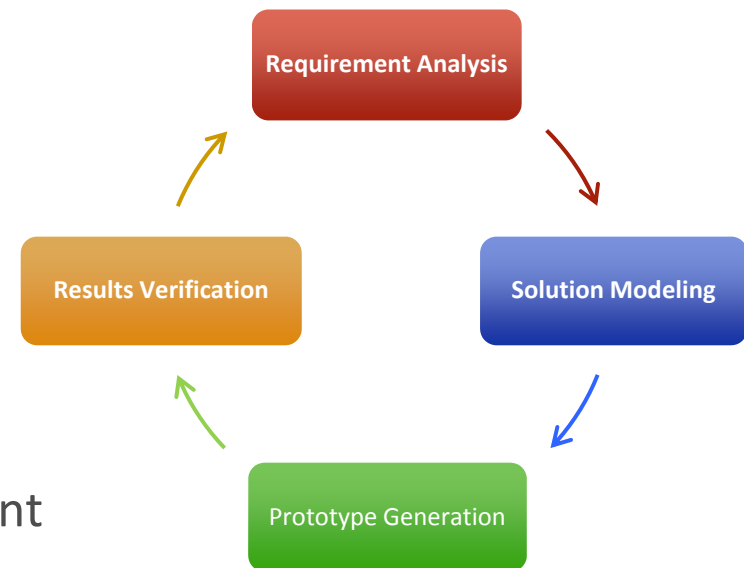




What is WebRatio

An Eclipse-based development environment allowing:

- Modeling: ER + **IFML** + BPMN
- **100% code generation** of standard JEE applications
 - Clear separation between design time and run time
 - No proprietary runtime
- Quick and agile development cycles
- Extending the generation rules
 - Defining new presentation styles
 - Defining new components
- Versioning, teamwork, full lifecycle mgt
- Truly multi-role model-driven development





Some numbers

WebRatio is

- now at 7th release
- on the market since 2001

WebRatio customers

- 130+ companies and 500+ commercial users
- mainly Italy, USA, Europe and Latin America

WebRatio adoption

- 15,000+ users of the free edition
- Used in hundreds of universities all over the world

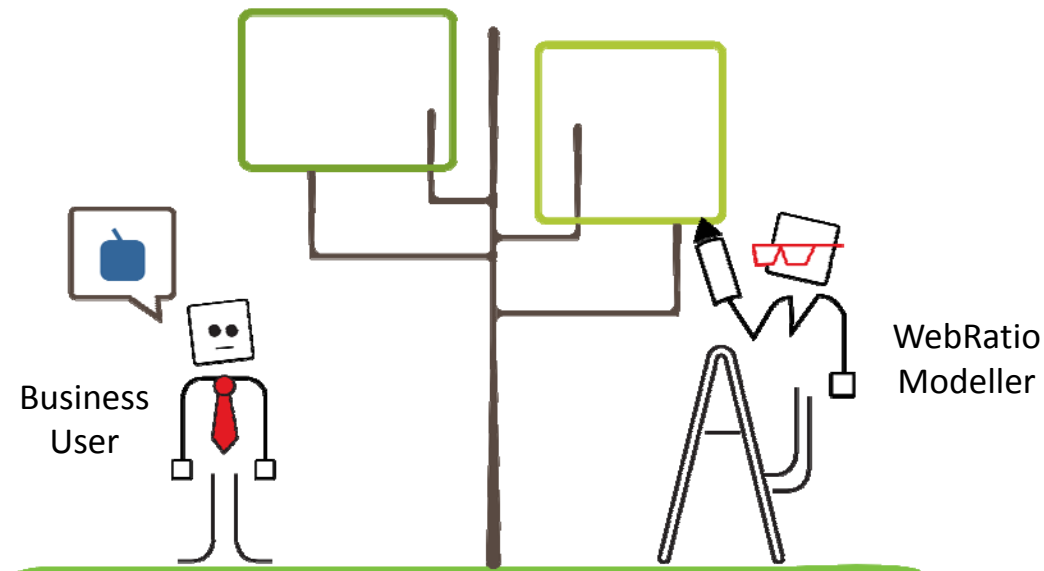
WebRatio partners

- 40+ software houses and system integrators
- 300+ universities worldwide, 13.000+ students



WebRatio – Step 1

You capture business requirements in abstract, technology independent models

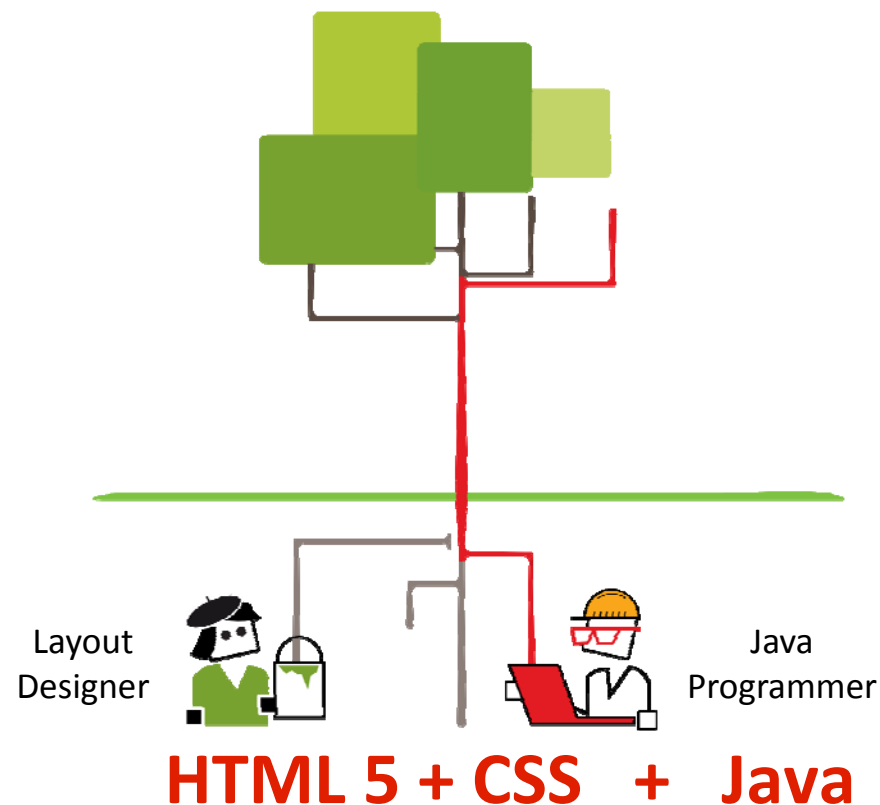


BPMN + IFML



WebRatio – Step 2

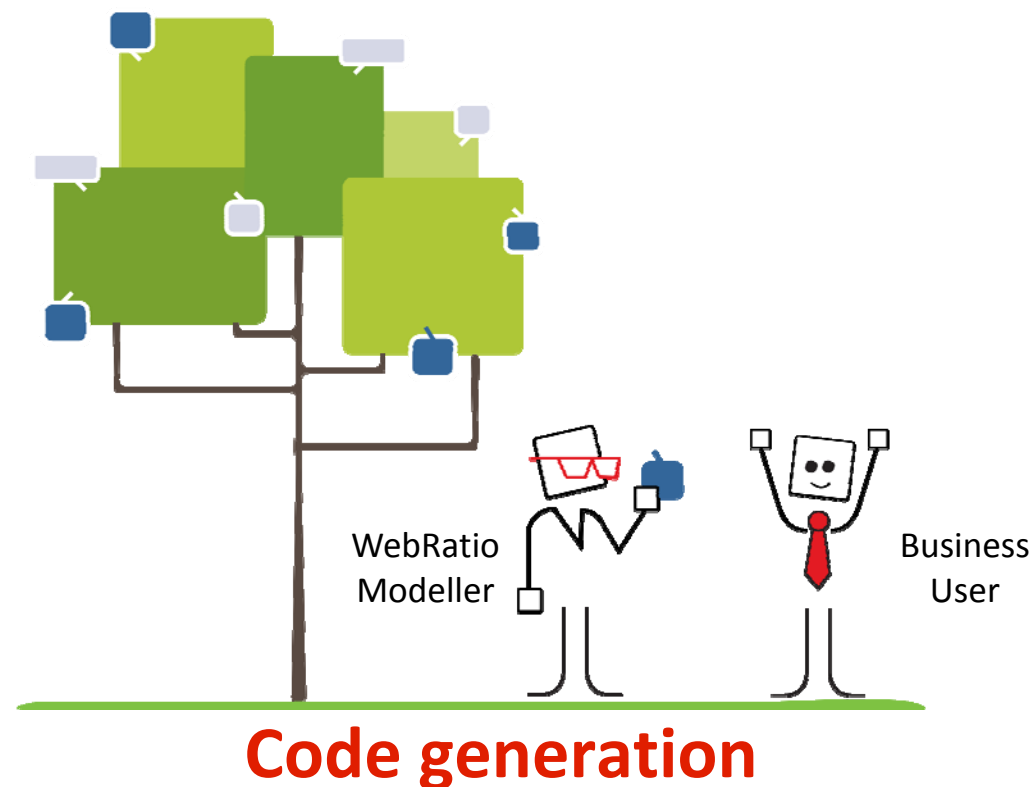
You customize the environment by defining your own generation rules





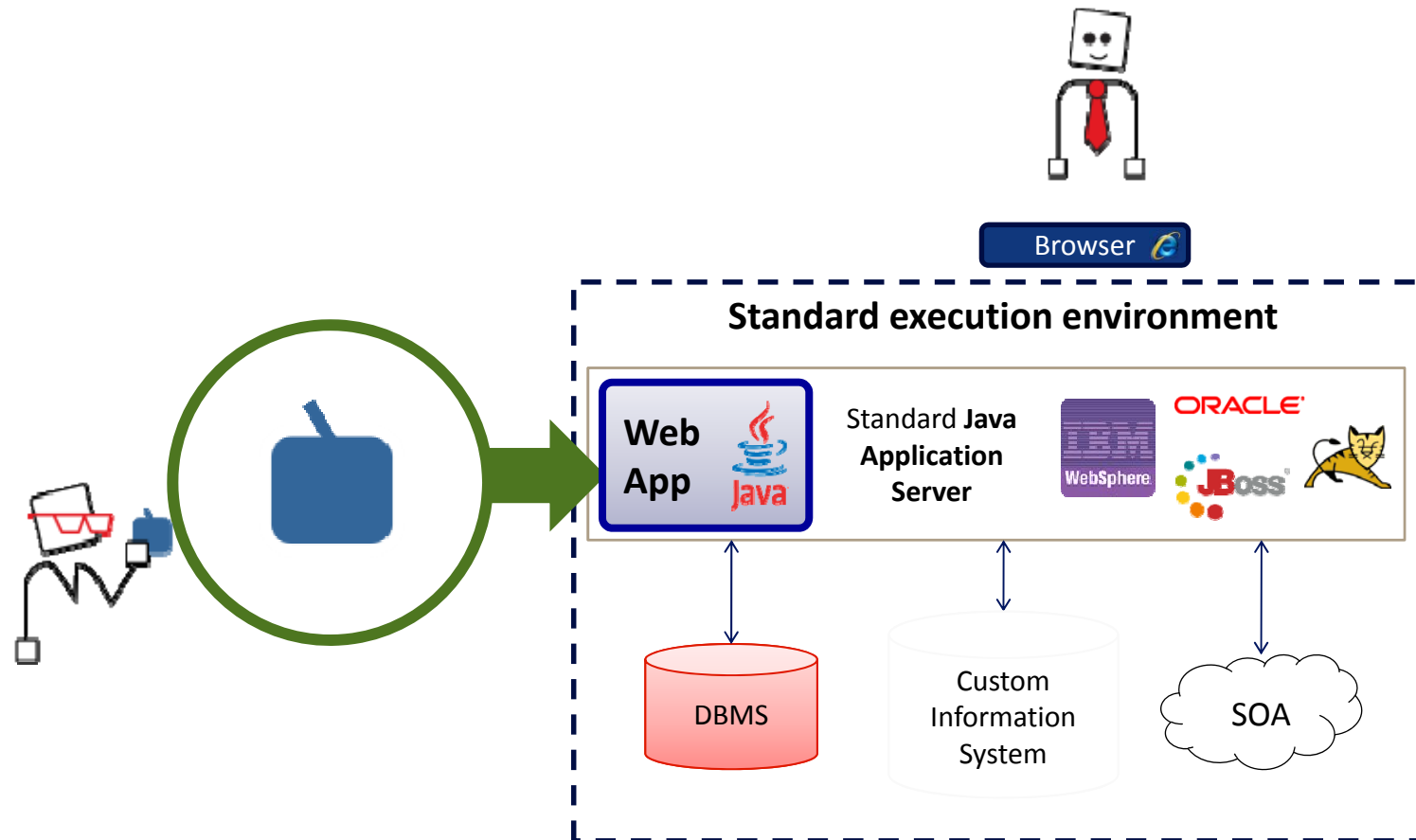
WebRatio – Step 3

You get a tailored, yet standard, Java Web application with no proprietary runtime





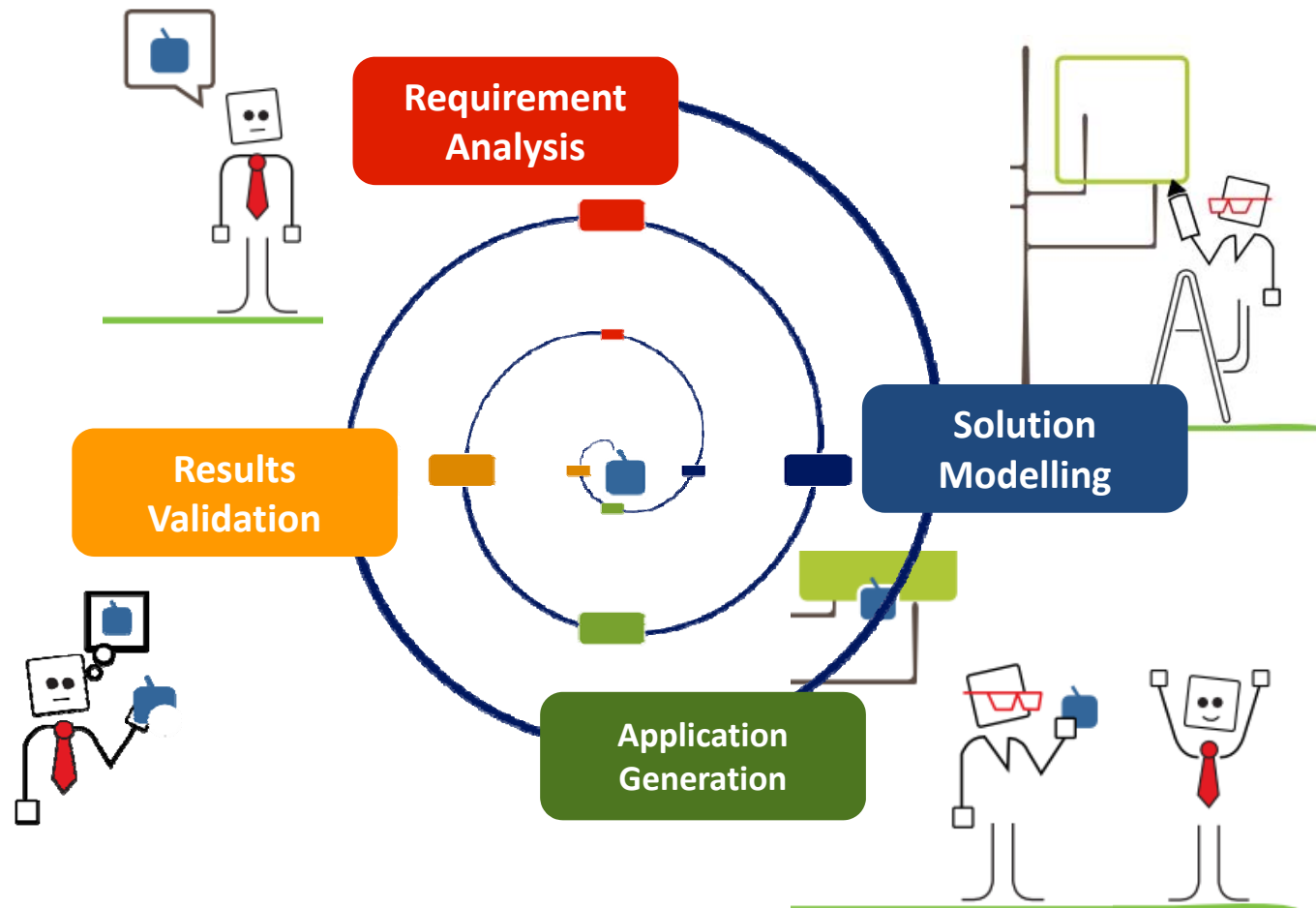
Get the application





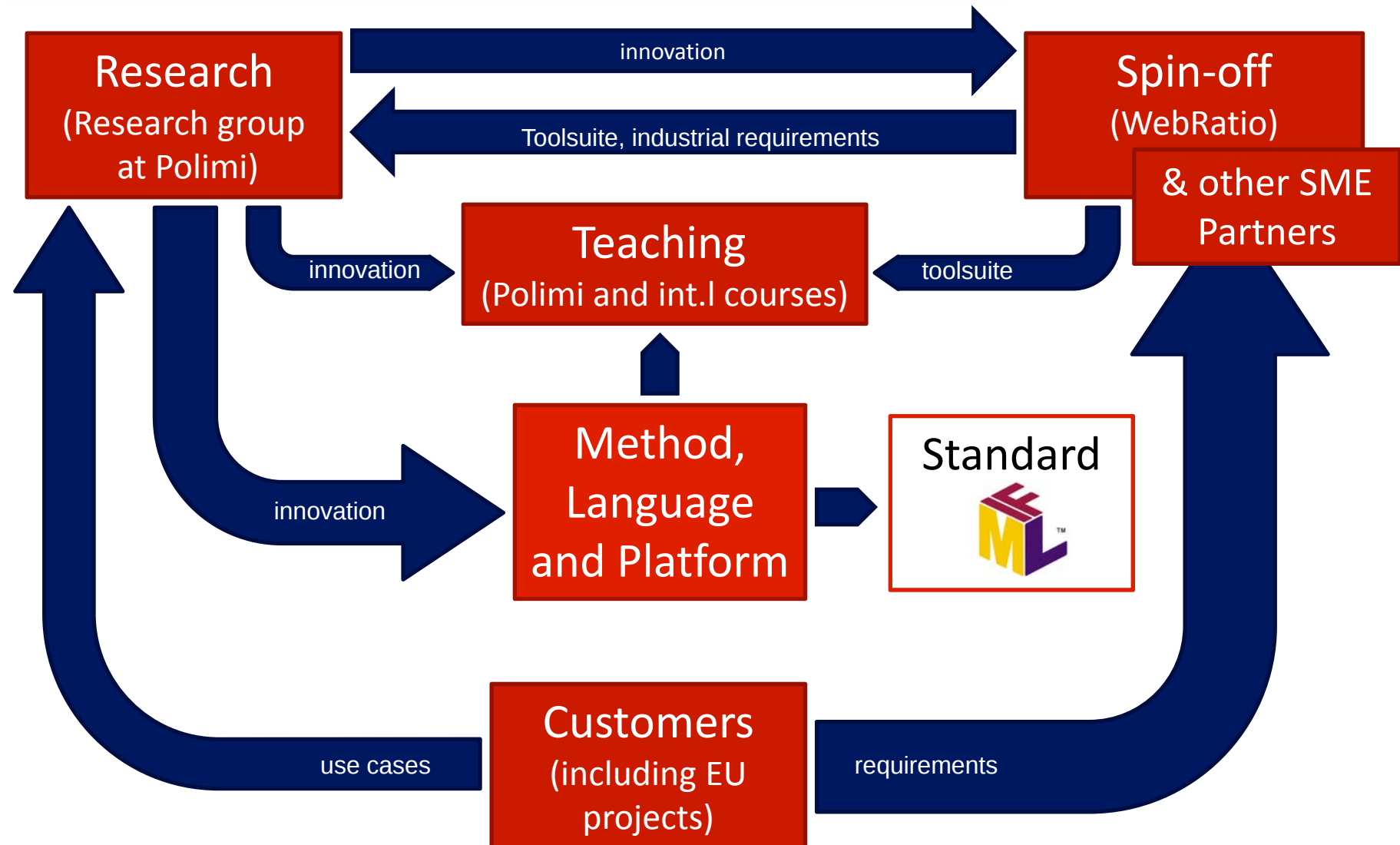
Agile, quick prototyping

Involve business users in the development process and converge quickly to the target





Our innovation environment

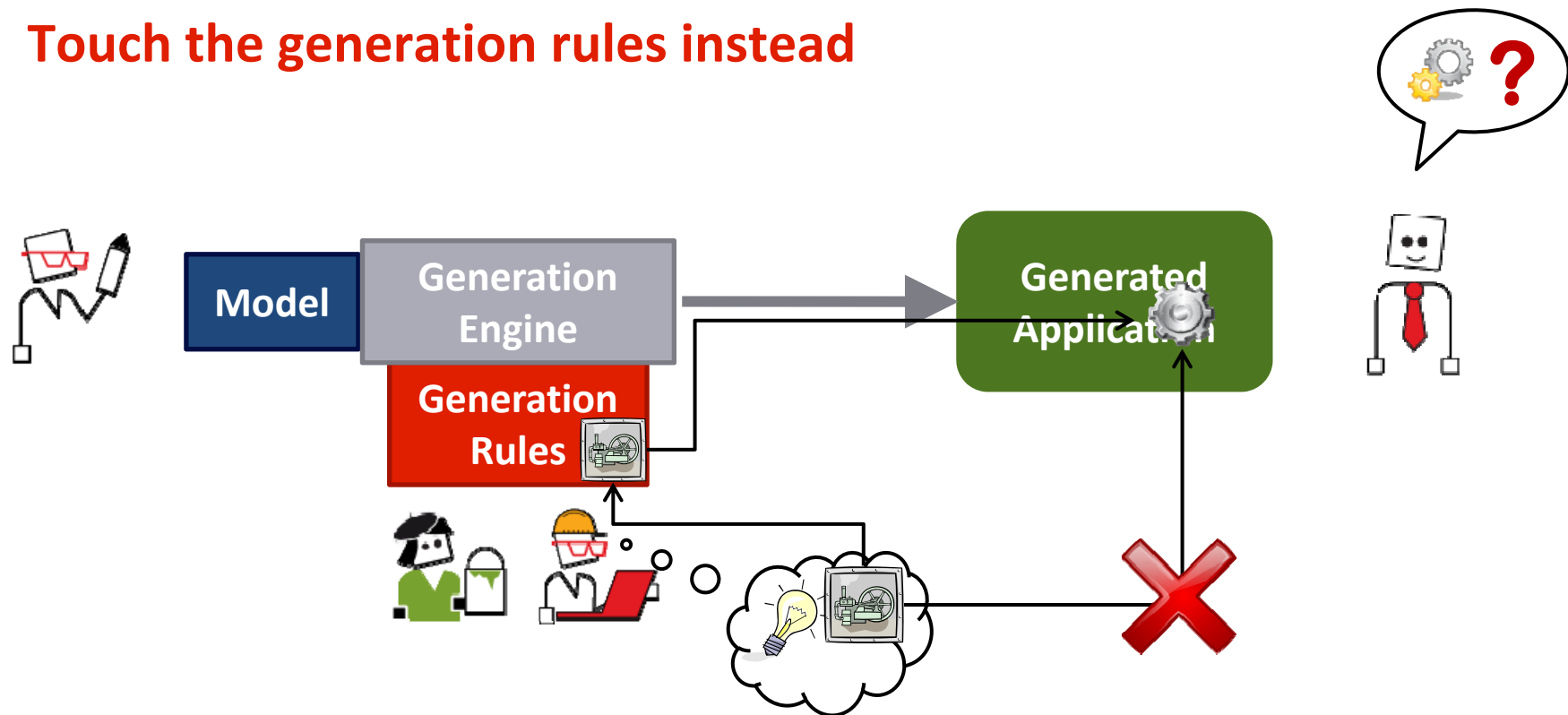




The MDE Virtuous Cycle

Do not change the generated application code

Touch the generation rules instead

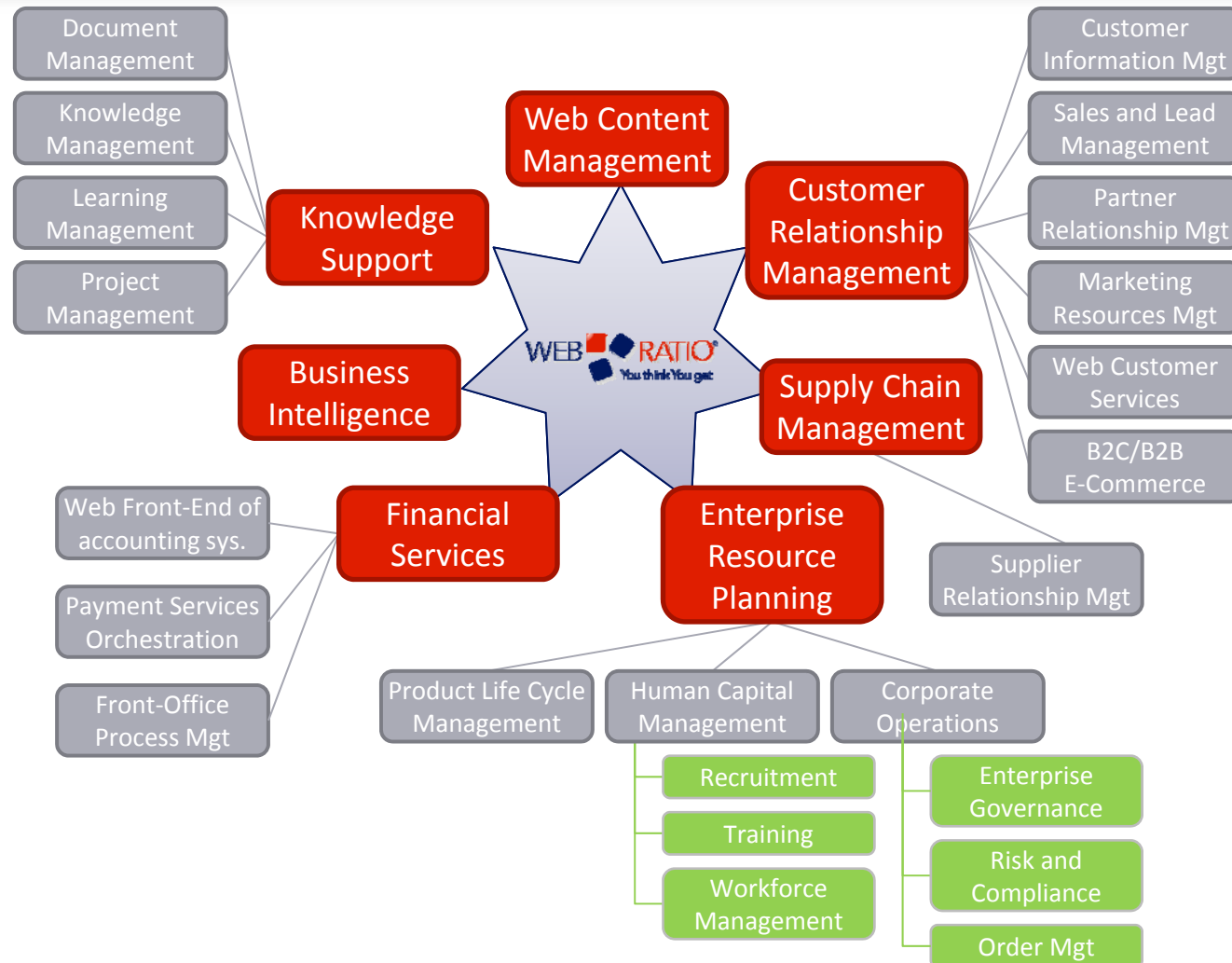


Case Studies





Kinds of application





Acer

B2C + CMS Web applications initially for 14 EU countries

Corporate news, Product technical & commercial data, Service & Partner area, Where to Buy...

Multilingual, multi-actor, distributed workflows for local and central PMs, local and central MarCom managers

... and a: very limited Time to Market (7 weeks!!)



Size & effort

Class	Dimension	Value
Size	Number of localized B2C web sites	14
	Number of main CMS applications	4 (Admin, News, Product, Other content)
	Number of supported languages	12 for B2C Web sites, 1 for CMS
	Number of data entry masks	39
	Number of automatically generated database tables	46
	Number of automatically generated database views	82
	Number of automatically generated database queries	279 for data extraction, 89 for data update
	Number of automatically generated JSP page templates	48
	Number of automatically generated or reused Java classes	250
	Number of automatically generated Java lines of code	12500 Non commented lines of code
Time & effort	Number of elapsed workdays	49
	Number of development staff-months (analysts and developers)	6 staff-months (6 weeks x 4 persons)
	Total number of prototypes	9
	Average elapsed man days between consecutive prototypes	5,4
	Average number of development man days per prototype	15,5



Size & effort

DEGREE OF AUTOMATION	
Number of manually written SQL statements	17(SQL constraints)
Percentage of automatically generated SQL code	96%
Number of manually written/adapted Java classes /JSP templates	10% JSP templates manually adapted
Percentage of automatically generated Java and JSP code	90% JSP templates, 100% Java classes
COST AND ROI	
Total cost of software development of first version	75.000 €
HW, SW licenses, and connectivity cost of first version	70.000 € (db server license)
Return on investment of first version	12-15 months
Average effort of extension to one additional country	0,5 staff-months
Average cost of extension to one additional country	7.500 €
Average ROI of extension to one additional country	2 months
PRODUCTIVITY	
Number of function points	177 (B2C web site) + 612 (CMS) = 789
Average number of function points delivered per staff-month	131,5



Comments

On the positive side:

- Almost 80% of the delivery effort concentrates in the phases of data design, hypertext design and prototyping:
 - more development time is spent with the application stakeholders

MDD allows a more flexible distribution of responsibilities between the IT department and the business units

The peak productivity rates has reached five times the number of delivered function points per staff-month of a traditional programming language like Java



Comments (continued)

On the negative side..

- Acer estimates that it took from 4 to 6 months to have fully productive developers with MDD, IFML, and WebRatio
- Difficult to find skilled people

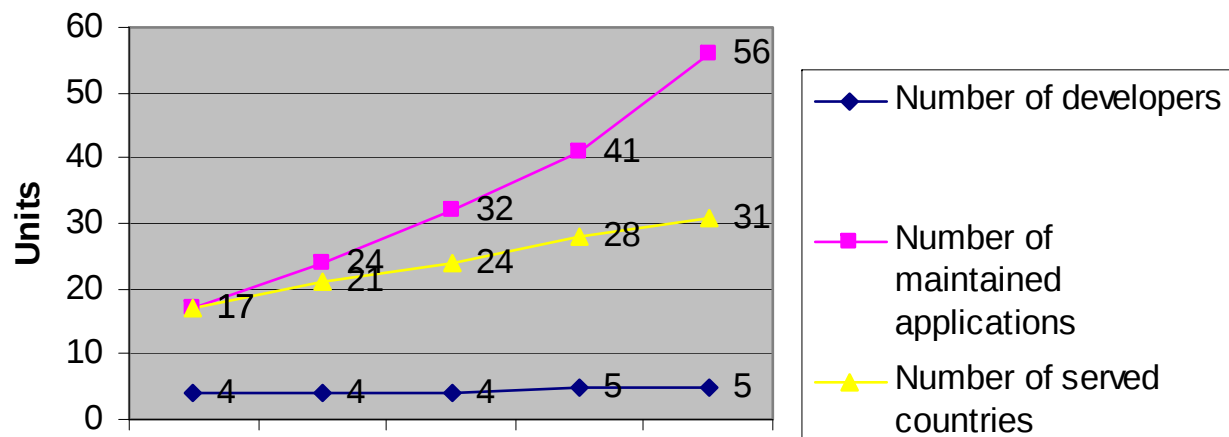
..but..

- The initial investment in human capital required by MDD pays off in the mid term
 - MDD benefits testing, maintenance, and evolution (which account for over 60% of the total lifecycle cost)
 - reasoning on the system is far more effective at the conceptual level



Maintenance effort

Served Contries and Applications





GTT: Turin Transportation Group

- **Public company owned by the City of Turin in Italy**
- **Local public transport serving 190 million passengers every year.**
- **A new e-ticketing system (available at <http://ecommerce.gtt.to.it> and serving 64,000 daily passengers)**
- **published on-line in only 2 months.**
- **The application comprises 100 page templates (IFML pages) and 1215 IFML units.**
- **KEY: iterative and quick prototyping approach supported by WebRatio**



A2A: Utility in Milan

- **Multi-utility company buying and selling wholesale electric power.**
- **Integrated Energy Management System that replaced individual productivity tools used by traders for the management of electric power.**
- **KEY: quick prototyping approach and involvement of actual users in the development process.**
- **Deployment of final app in 6 months after the initial meeting with WebRatio (time to market that took one-third of the time estimated in case of adoption of a traditional development)**



Other experiences

- Banking (UniCredit)
 - BPM + SOA + Web interfaces
 - Crucial points: modularization, multiple models integration, multiple tools integration, strict runtime platform requirements
- Banking (ABI)
 - System integration (Pure backend!)
 - Why IFML?
- Latin America
 - Cooperatives, banks, public bodies, central government
- Wholesale (IKEA)
- Financial / leasing (GE Capital)

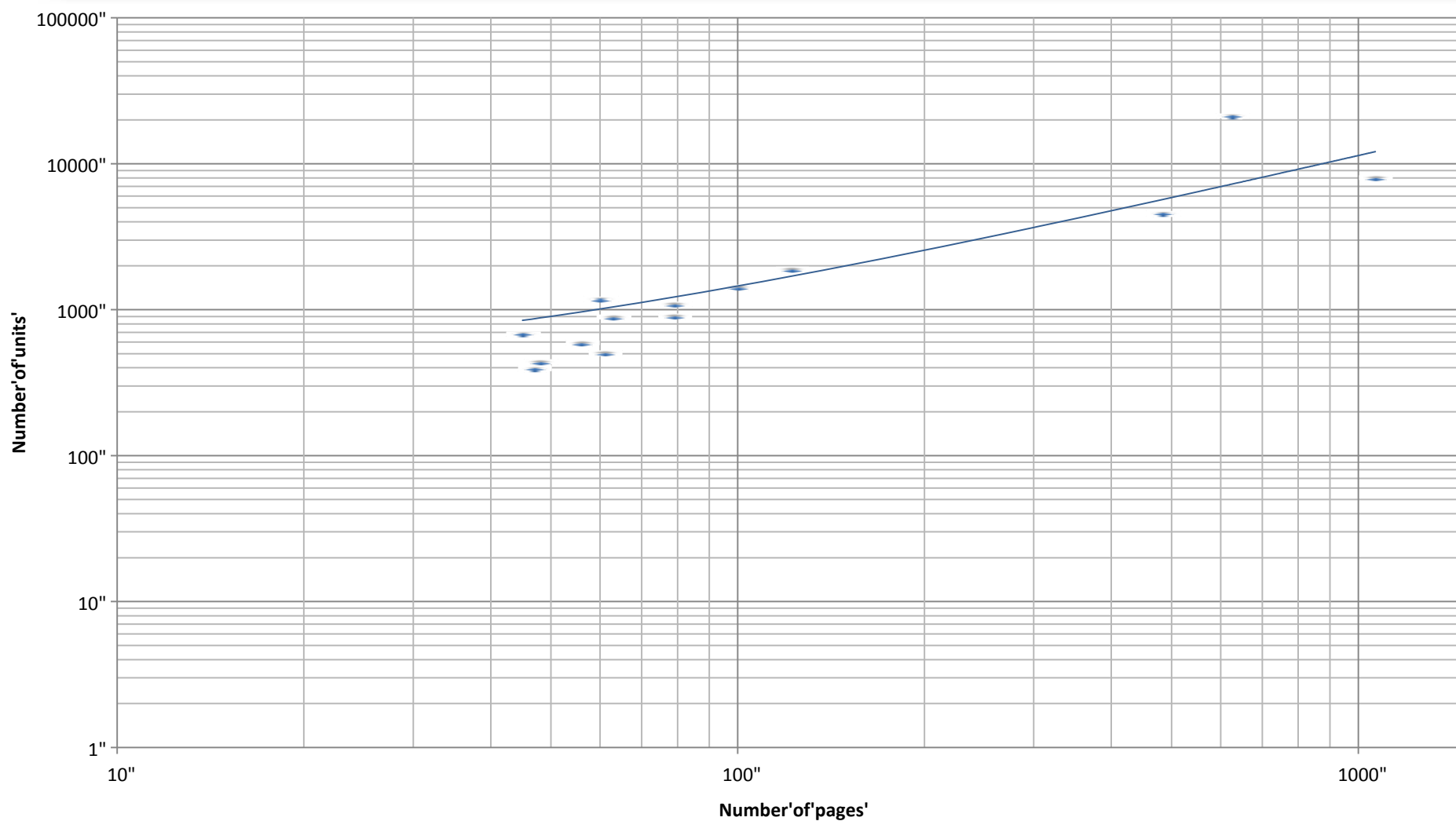


Where IFML works

- **Models integration**
- **Large applications with strong need for coherence and standardized paradigms**
 - Cooperatives, banks, public bodies, central government
- **Service orientation**
- **No pure modeling exists**
- **Code generation still win-win**

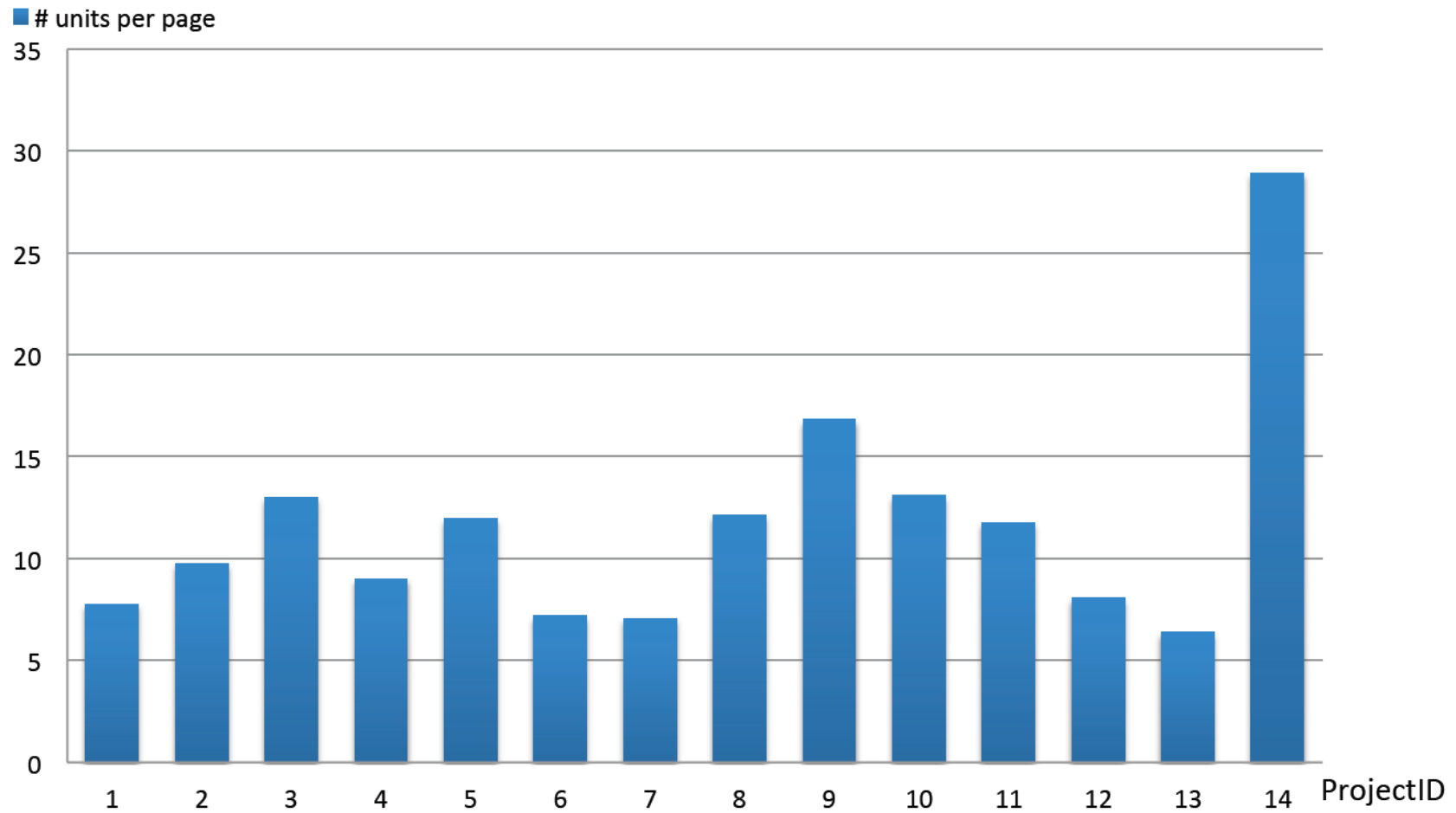


Components and pages per project



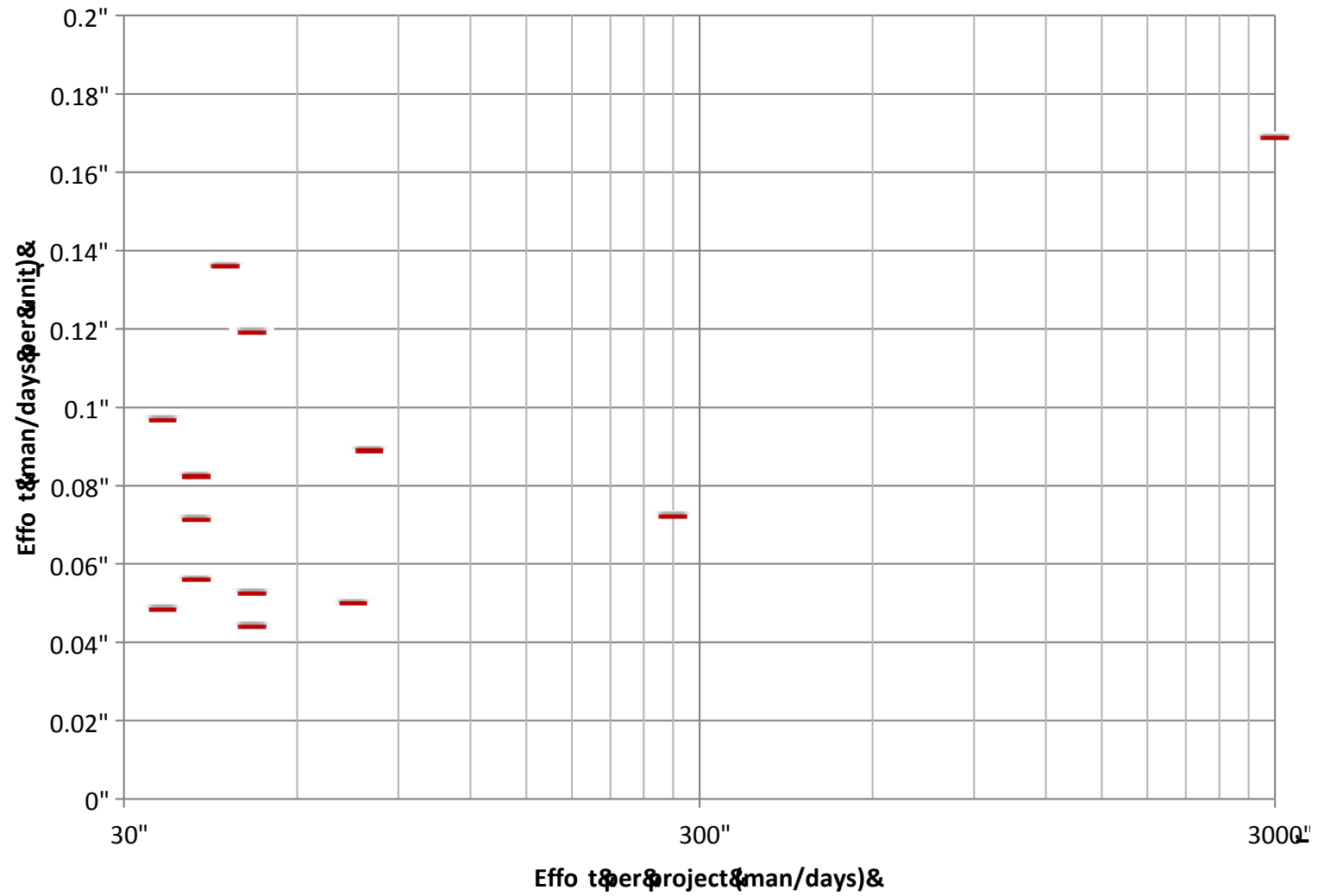


Components per page (avg)



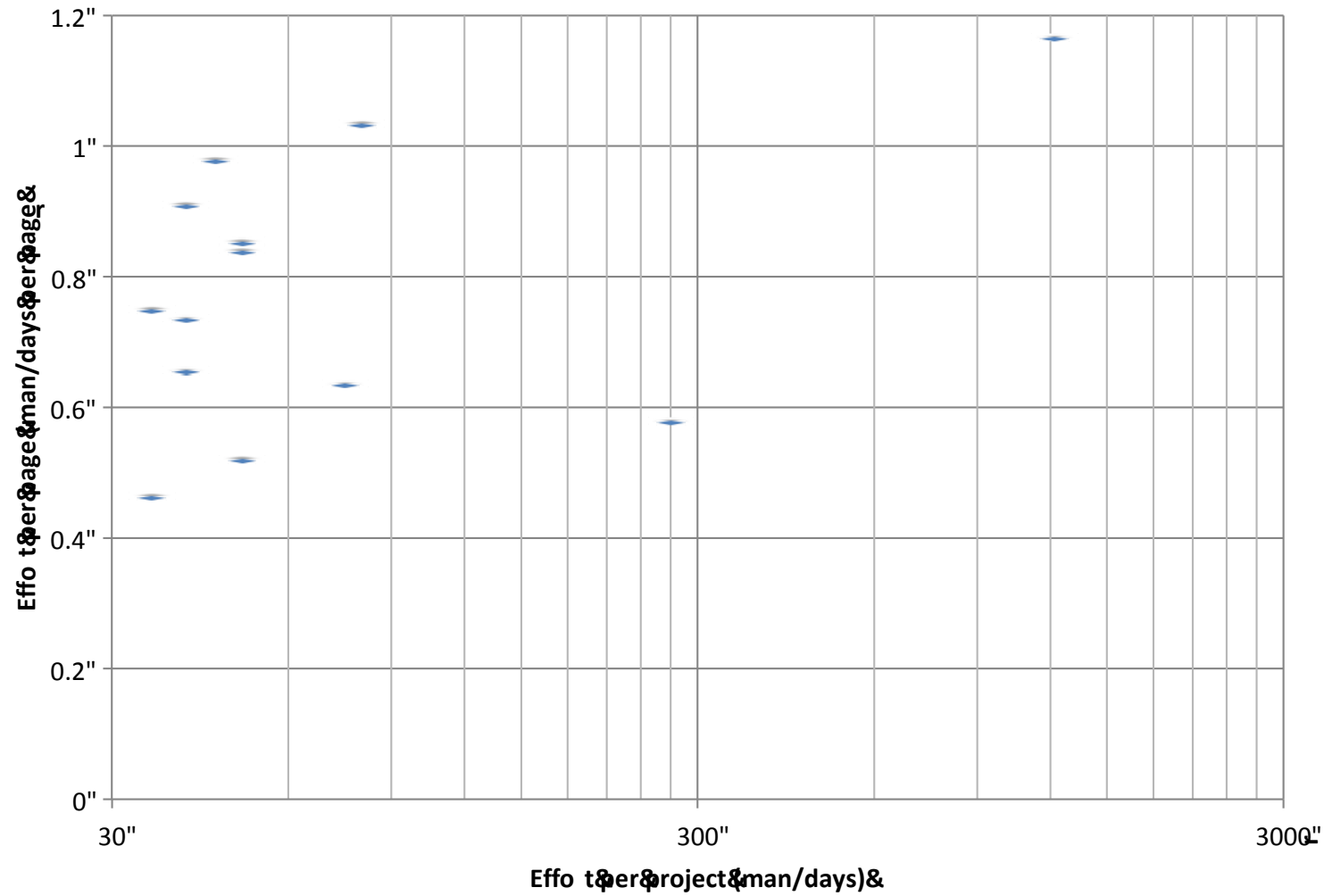


Man/days per component





Man/days per page



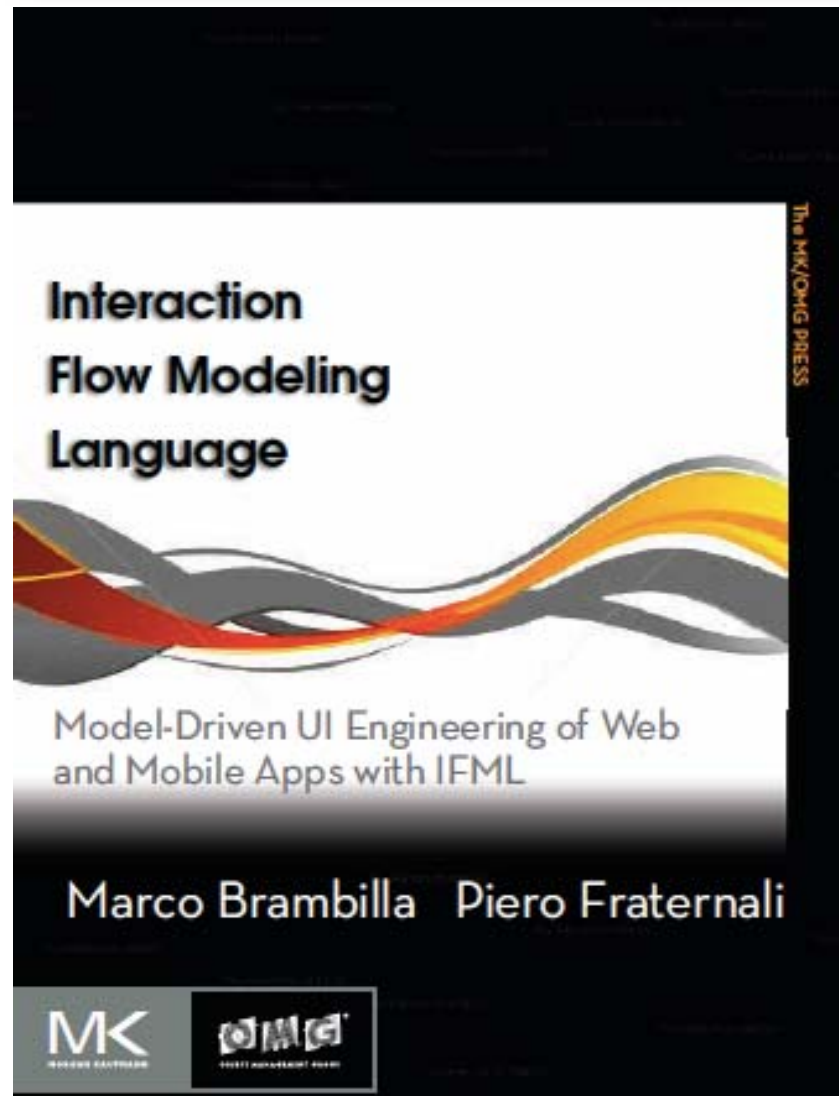


Tool usage stats

Description	Value
# of times the tool has been opened daily	1.79
# of daily code generations	11.76
# of 1-click generation and publishing of the application	0.26
# of checks of the modelling warnings	2.09
# of checks of graphical layout warning	0.11
# of automatic generations of the documentation	0.02

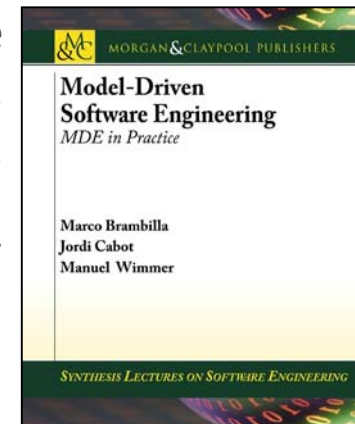


Some Ads



“Model Driven Software Engineering in Practice”.
Brambilla, Cabot, Wimmer.

Morgan&Claypool, USA, 2012



<http://www.modeldrivenstar.org>



The brand new **IFML** book!

Morgan Kauffmann, OMG Press, USA



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Thanks!



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