Meta-modeling ecosystems

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Metamodel for the definition of technological ecosystems focusing on knowledge management

Hi!

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1. Introduction

1.1 Knowledge management (I)

According to Castells, the Knowledge Society is a society in which the conditions of knowledge generation and information processing have been substantially altered by a technological revolution centred on information processing, knowledge generation and information technology.

Knowledge Society → Learning Society

1.1 Knowledge management (II)

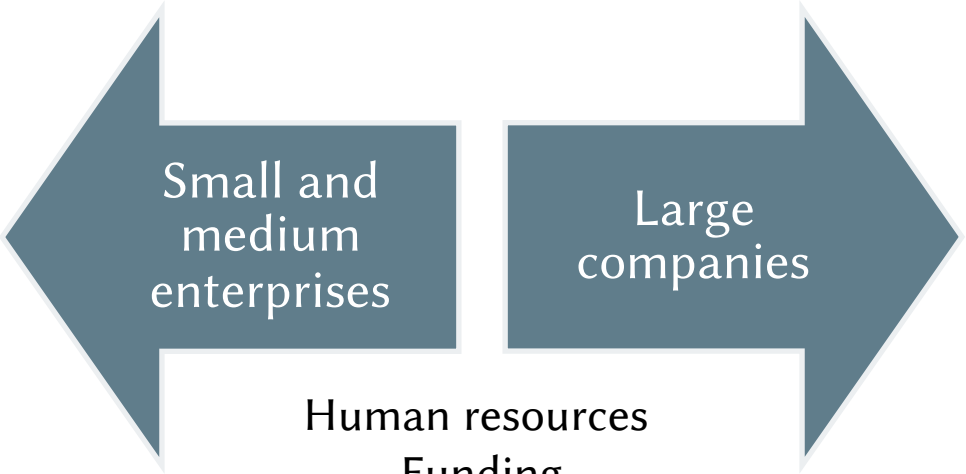
The evolution of the Information Society into the Knowledge Society is directly related to the evolution of information systems

Knowledge management emerges as a competitive advantage in any type of organisation (Nonaka and Takeuchi, 1995)

1.1 Knowledge management (III)

- Knowledge management is not only associated with managing knowledge as a resource, but also with managing the business processes that are carried out using that resource

1.1 Knowledge management (IV)



1.1 Knowledge management (V)

- Knowledge management systems provide the necessary tools to support processes and facilitate access to and re-use of knowledge (Natali and Falbo, 2002)

- Different models of knowledge management have emerged that focus on the human factor and place technology as another element within the model (Rubio, Ocón, Galán, Marrero and Nelson, 2004; Fidalgo-Blanco, Sein-Echaluce and García-Peñalvo, 2014)

1.2 The technological ecosystem (I)

- Technological ecosystems emerge to solve knowledge management problems in heterogeneous contexts, being considered the evolution of traditional information systems (Laudon and Laudon, 1991; Langefors, 1977)
- The ecosystem metaphor comes from the area of biology and has been transferred to the area of technology to reflect the evolutionary nature of software systems.

1.2 The technological ecosystem (II)

A set of organisms or biotic factors, the physical environment they inhabit or abiotic factors, and the relationships both between organisms and between organisms and the environment.

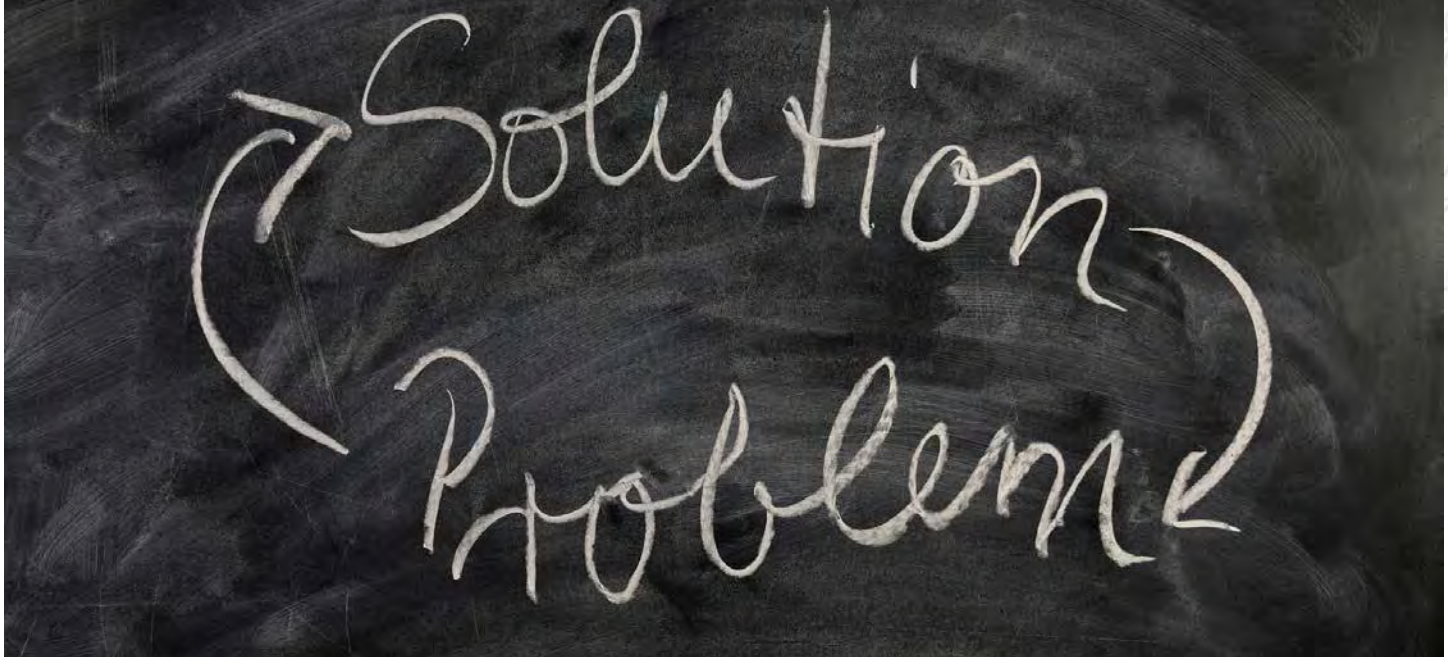
Natural ecosystem

1.2 The technological ecosystem (III)

- In a technological ecosystem, there is a set of people and software components that play the role of organisms; a set of elements that allow the ecosystem to function (hardware, networks, etc.); and a set of information flows that establish the relationships between the software components and between them and the people involved in the ecosystem

1.2 The technological ecosystem (IV)

- Ecosystems must be able to combine some of the tools that already exist for managing knowledge, such as CMSs and repositories, and they must be able to incorporate emerging tools as well as eliminate those that are obsolete or not used by users
- They must also be able to incorporate emerging tools, as well as eliminate those that are obsolete or not used by users



1.2 The technological ecosystem (V)

Despite the advantages, this type of development presents a great deal of complexity

It requires knowing and selecting the right systems and services; achieving a high degree of integration and cohesion; allowing the ecosystem to evolve and adapt to the changing needs of the environment and users

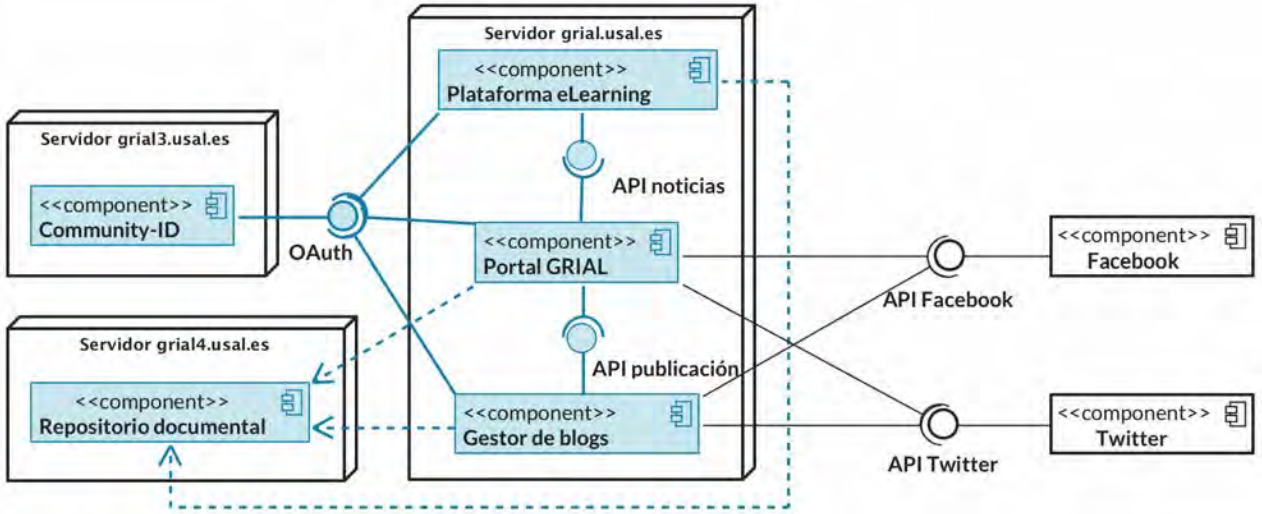
2. Example of a real technological ecosystem

GRIAL Ecosystem (I)

- Since 2010 in continuous evolution
- Internal and external knowledge management
- Sustainability of the research group

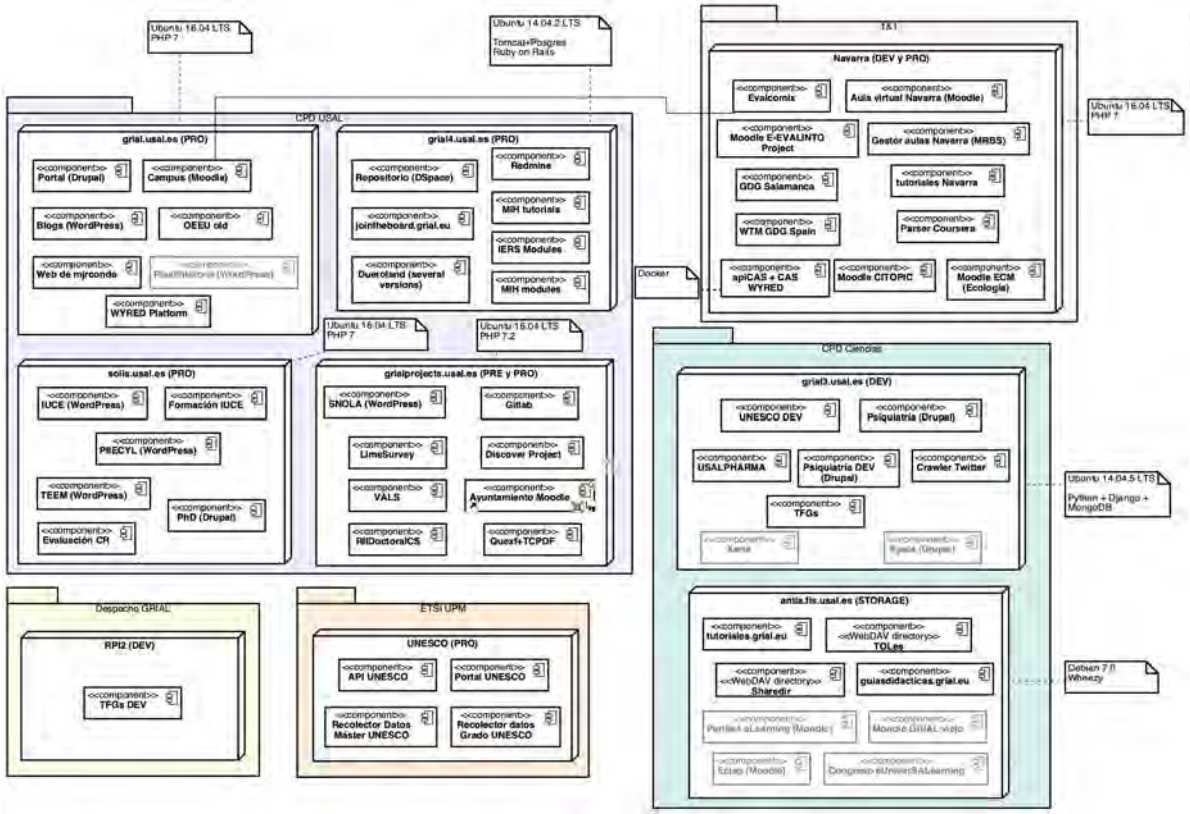
GRIAL Ecosystem (II)

- Initial situation



GRIAL Ecosystem (III)

- Current situation



GRIAL Ecosystem (IV)

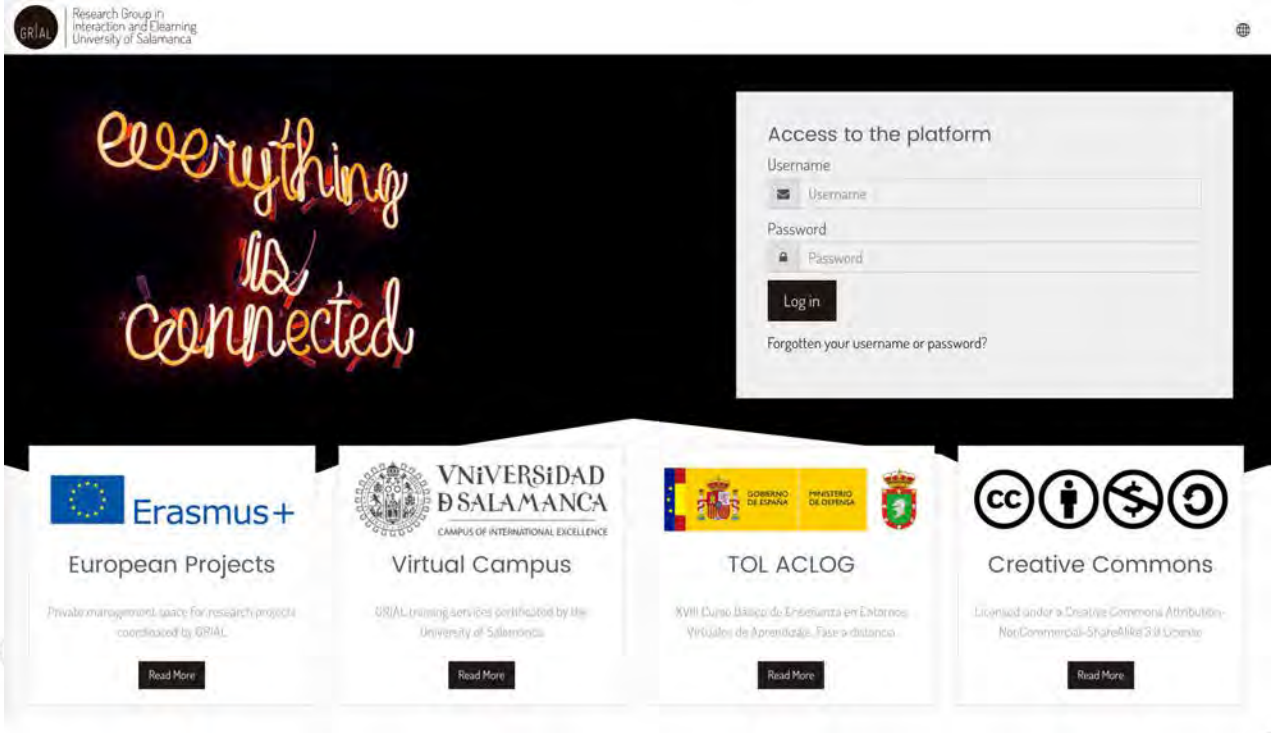
- Public portal https://grial.usal.es

GRIAL Ecosystem (V)

- Websites management system https://agora.grial.eu

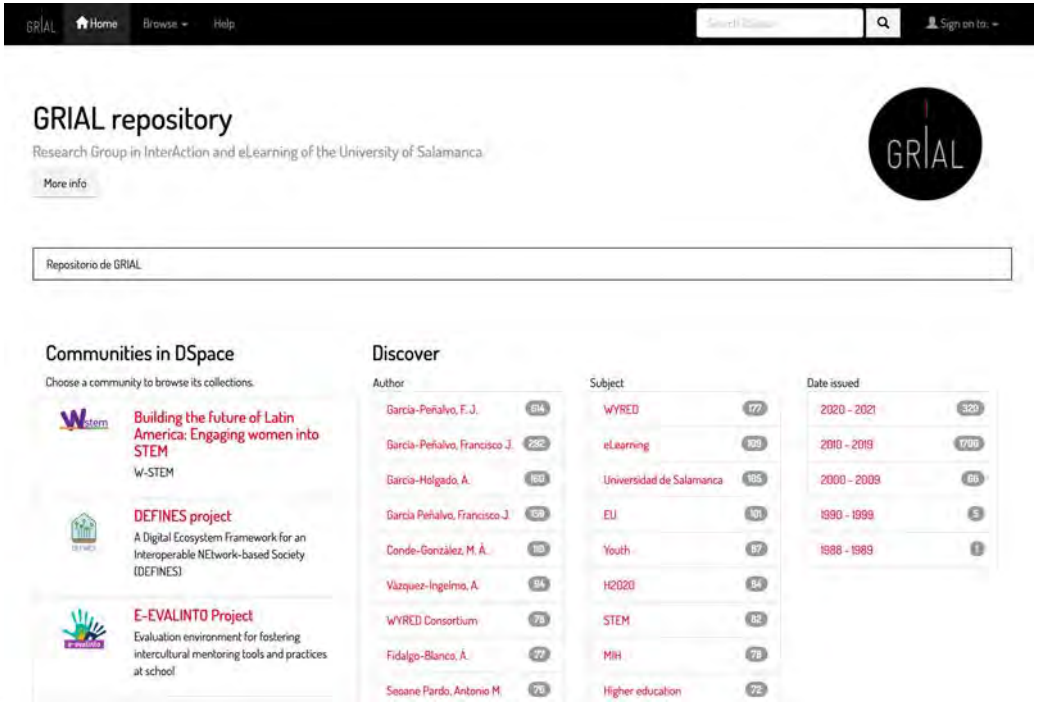
GRIAL Ecosystem (VI)

- Virtual campus https://polis.grial.eu



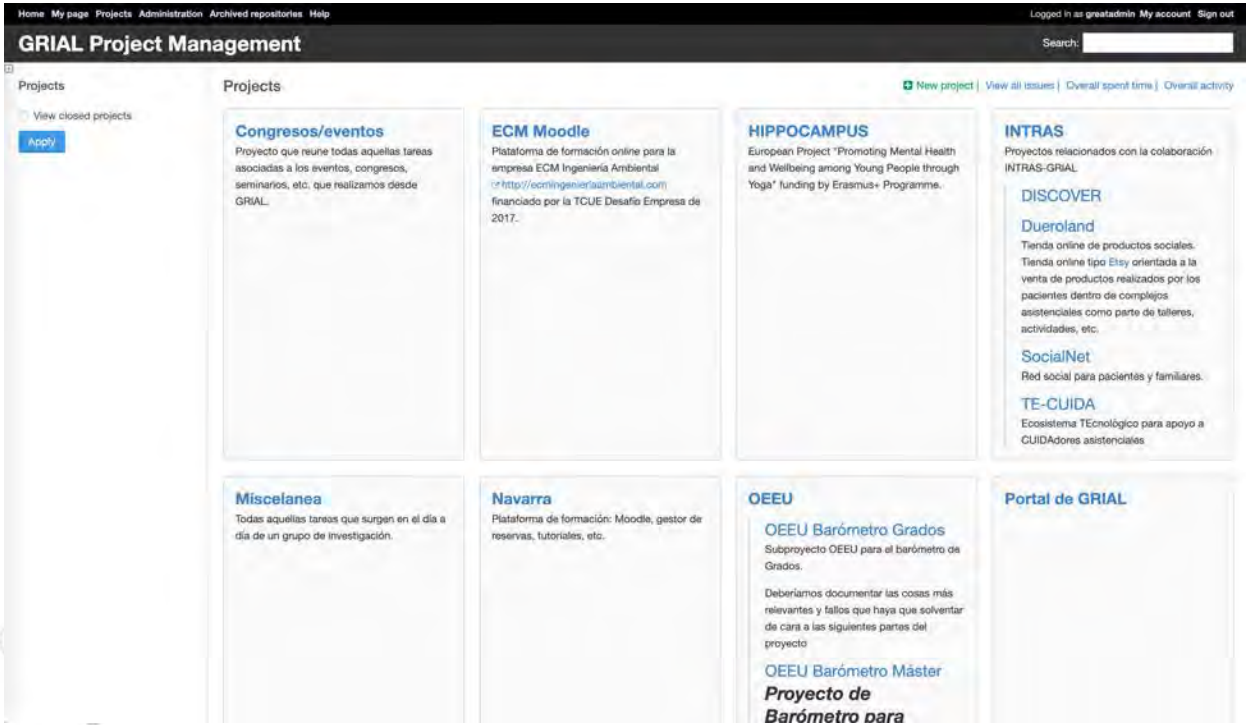
GRIAL Ecosystem (VII)

- Documental repository https://repositorio.grial.eu



GRIAL Ecosystem (VIII)

- Project management https://redmine.grial.eu

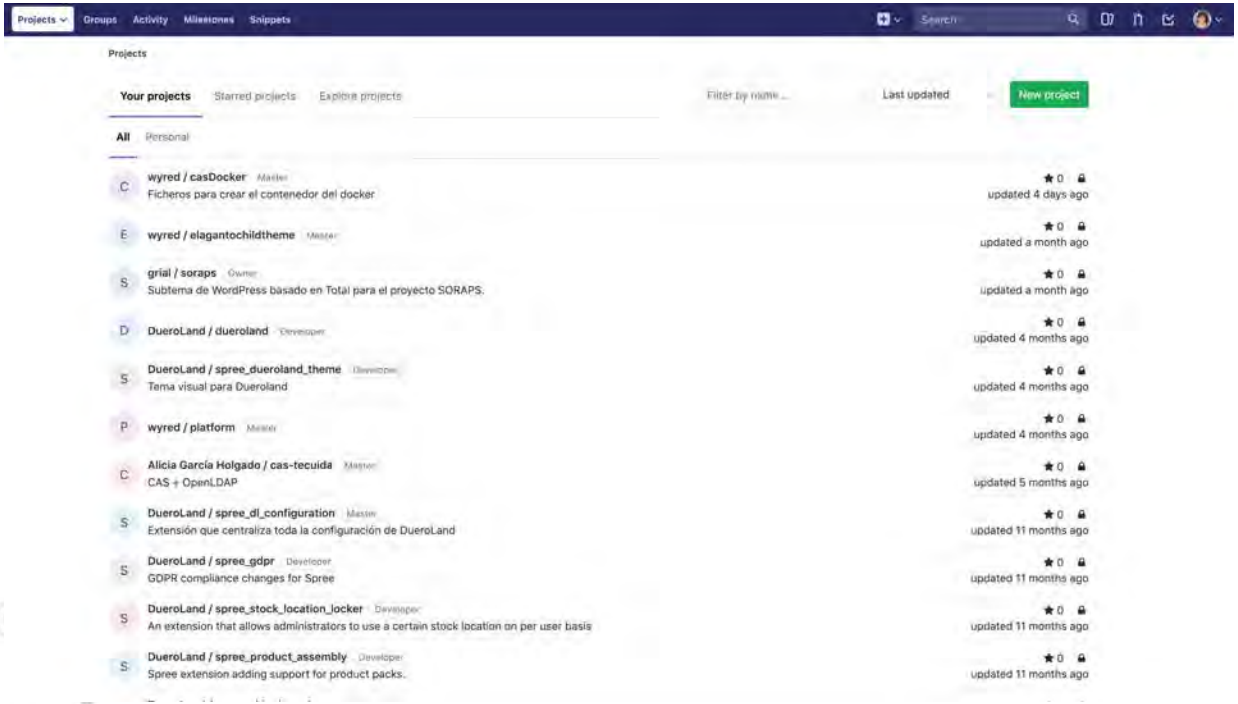


GRIAL Ecosystem (IX)

- Survey tool https://limesurvey.grial.eu

GRIAL Ecosystem (IX)

- Version Manager https://gitlab.grial.eu



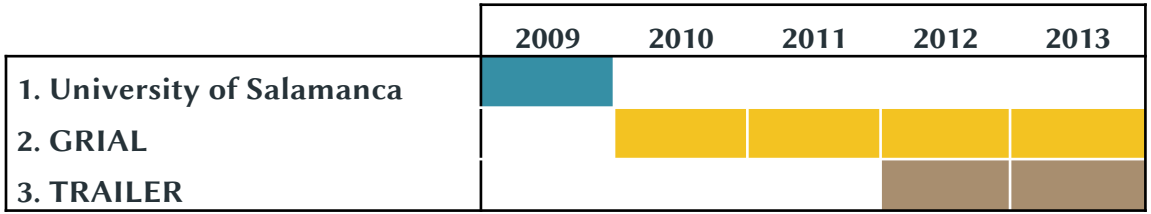
3. Architectural pattern

3.1 Analysis of real ecosystems (I)

- The template must provide solutions to real problems of learning ecosystems in order to improve this type of technological solutions
- The analysis of several real case studies has been carried out in order to obtain a problem domain model
- The technique used to study the different ecosystems has been the analysis of Weaknesses, Threats, Strengths and Opportunities (SWOT) (Hill and Westbrook, 1997)

3.1 Analysis of real ecosystems (II)

- The selected case studies were developed before the start of this doctoral thesis



3.1 Analysis of real ecosystems (III)

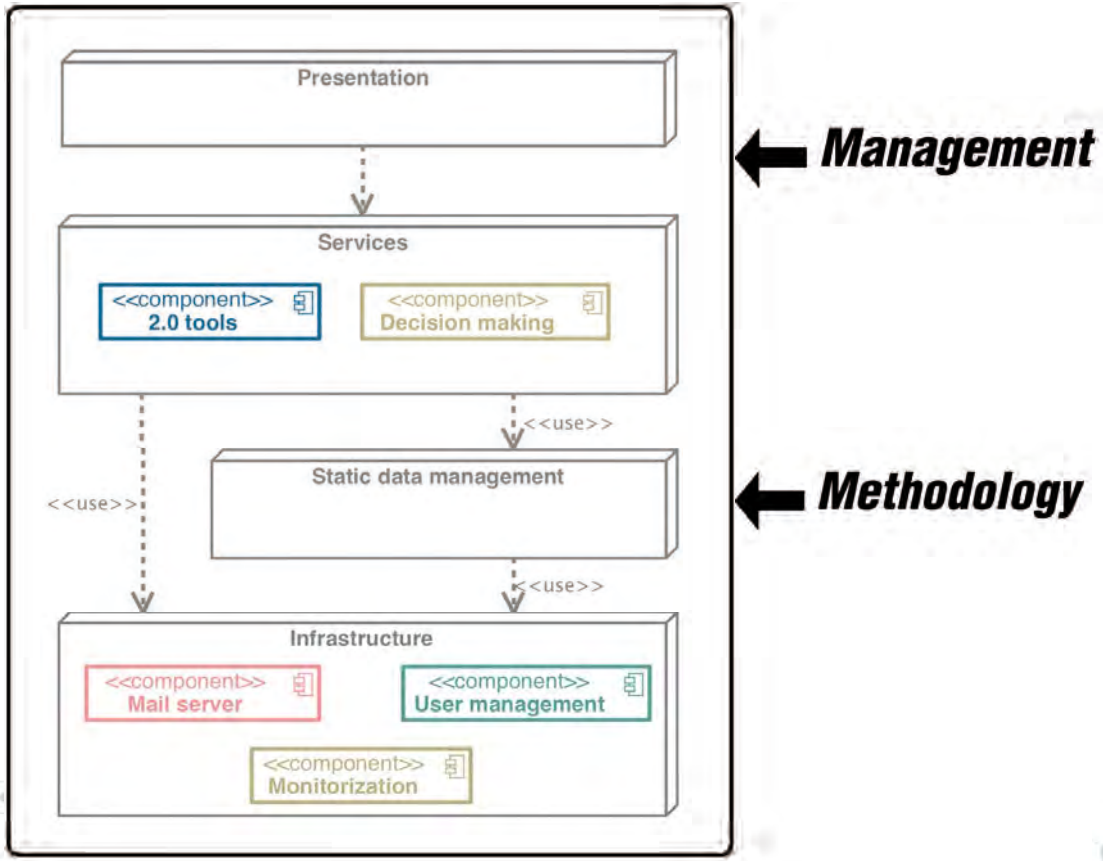
- Comparative analysis of the characteristics analysed in each of the selected case studies

	Universidad	GRIAL	TRAILER
Methodology			
Noverlty			
Users			
Information			
Integration			
Movility			
Social			
Evolution			
Decision-making			
Re-use			
Open source			
Development			
Deployment			

3.2 Characteristics of technology ecosystems

- **Solid methodological**, project and risk management foundation
- Clear definition of the processes and workflows needed to manage the ecosystem
- **Centralised user management** of both data and authentication
- **Centralised management of static data**
- Transparent integration of components to ensure flexibility and adaptability of the system to changes, i.e. a plan for **ensuring the evolution of the ecosystem must be in place**
- Enhancement of the **reusability** of ecosystem components
- **Integration at the level of presentation** that conveys uniqueness
- Strong **social component** that allows integration with social tools
- Support for **decision-making and for the analysis of information flows**, which take place both within the ecosystem and from outside and vice versa.
- Use of **open source software** as a basis for the development of the ecosystem components in order to benefit from the advantages of this type of software
- Definition of the necessary training and immersion strategies and plans **to facilitate the acceptance of the ecosystem** by its end users

3.3 Definition of the architectural pattern

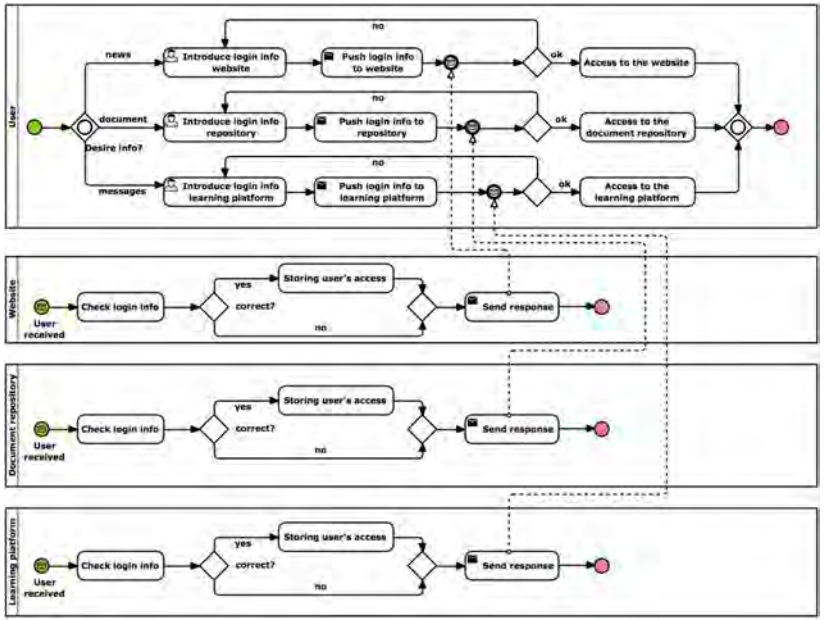


3.4 Validation of the architectural pattern (I)

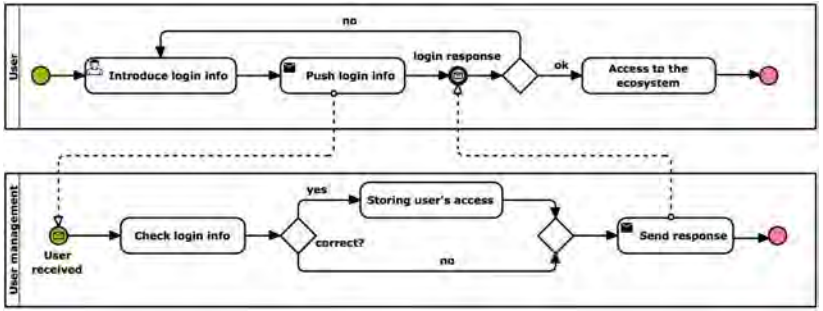
- Although the standard is based only on the analysis of several real technological ecosystems, it is necessary to carry out a validation process

- The process has been divided into three phases
  - Problems related to similar knowledge management processes have been selected and grouped and modelled in BPMN diagrams
  - The same business processes have been modelled by applying the architectural pattern
  - The pattern has been tested in several real case studies

3.4 Validation of the architectural pattern (II)



No pattern

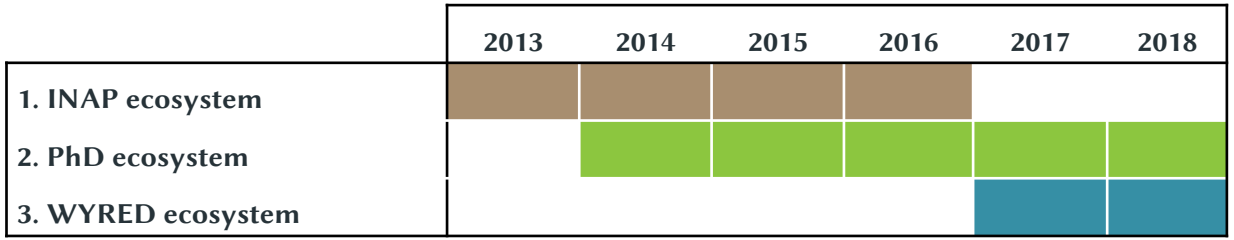


Applying the pattern

Diagramas BPMN para el proceso de autenticación

3.4 Validation of the architectural pattern (III)

Application of the validated pattern in real cases

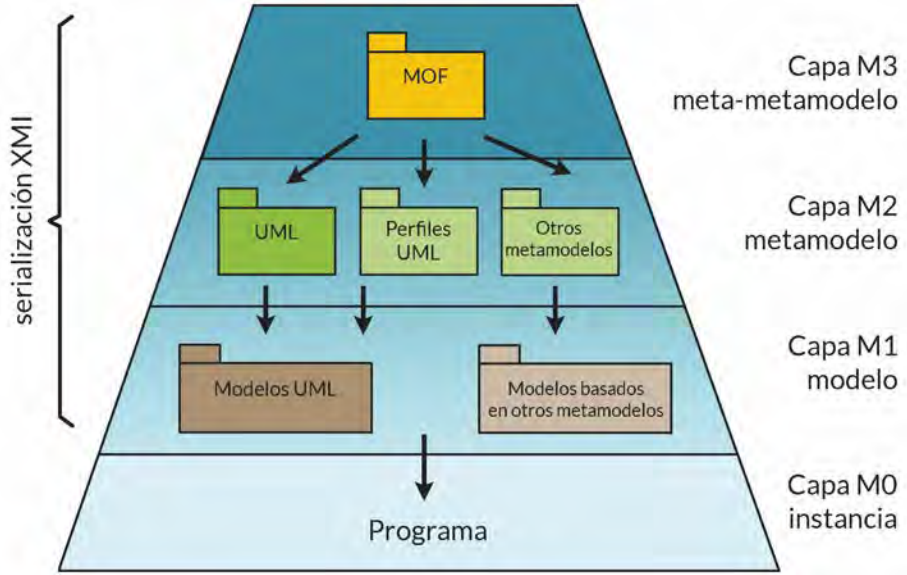


4. Metamodel

4.1 Model-driven development (I)

- There is work on modelling software ecosystems, but most approaches are not supported by a methodology that uses the standards defined by OMG
- Franco-Bedoya, Ameller, Costal and Franch (2017), as other authors (Barbosa and Alves, 2011; Sadi and Yu, 2015), state that the development of analysis and modelling techniques is one of the main challenges of open-source software ecosystems
- Model Driven Development (MDD) is a software engineering approach that involves the application of models and modelling technologies to increase the level of abstraction at which developers create and evolve software (Hailpern, 2006)
- MDA is OMG's approach to implement MDD using the set of standards for visualizing, storing and exchanging designs and software models

4.1 Model-driven development (II)



4.2 Metamodel definition (I)

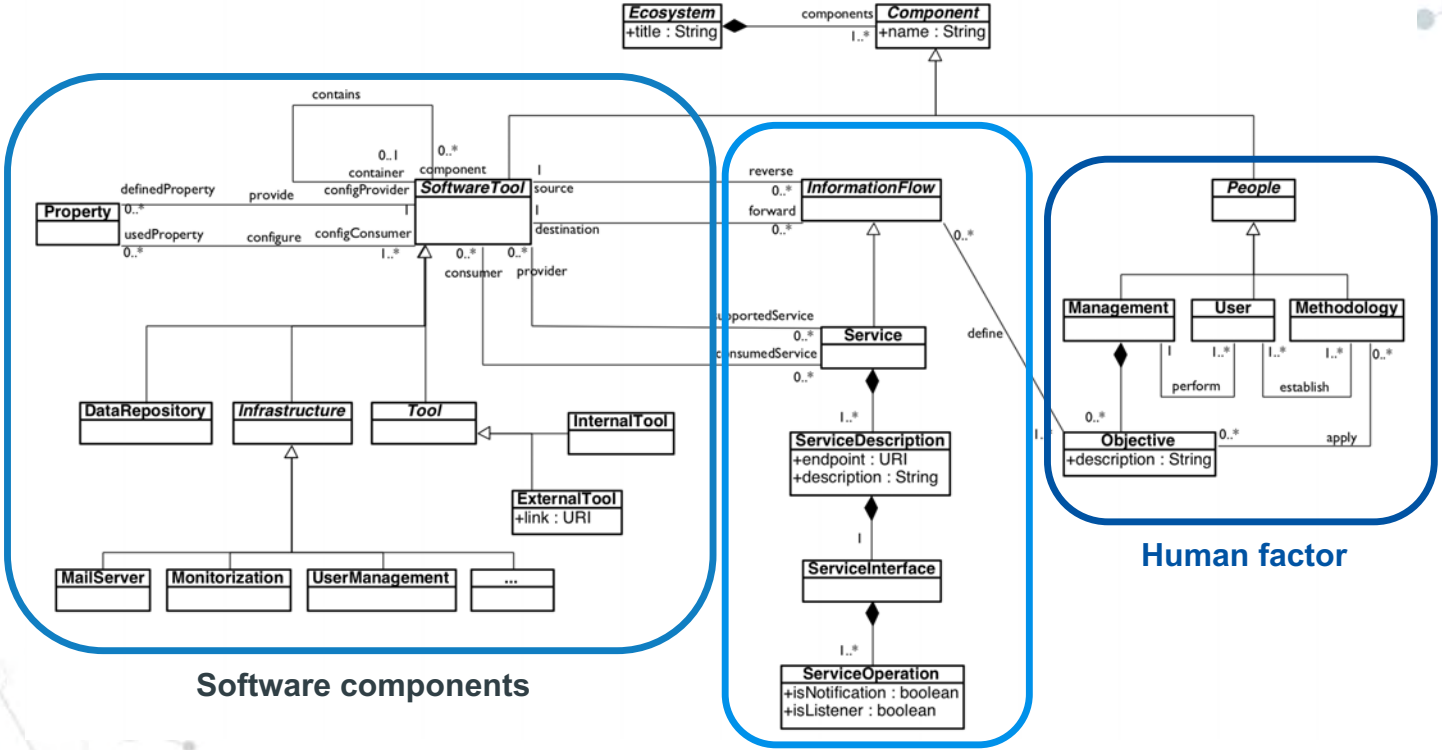
- The learning ecosystem metamodel is a model of the M2 layer of the four-layer architecture, i.e. it is an instance of the MOF
- It is defined on the basis of the architectural pattern in order to model learning ecosystems that follow the pattern, so that in the process of defining the ecosystem a solution is given to the problems detected during the analyses carried out in real ecosystems
- The metamodel is a platform-independent model, i.e. a PIM (Platform-Indepent Model)

4.2 Metamodel definition (II)

- The high-level requirements of the learning ecosystem metamodel are the following (García-Holgado and García-Peñalvo, 2017)

- The metamodel will capture the high-level description of the components of the learning ecosystem
- The metamodel will capture the human factor as part of the learning ecosystem
- The metamodel shall allow capturing the information flows between the components of the learning ecosystem
- The metamodel shall allow capturing the configurations of the software components

4.2 Metamodel definition (III)

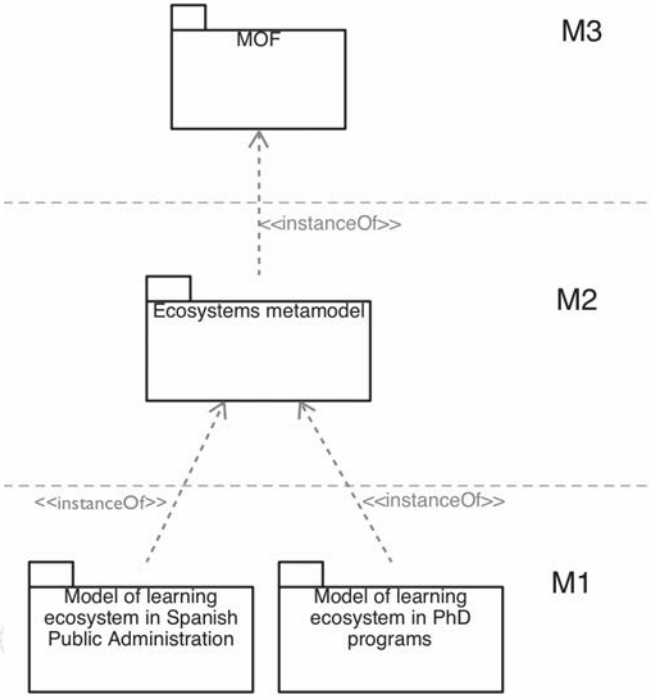


4.2 Metamodel definition (IV)

4 OCL constraints

```
context Ecosystem inv:
self.components -> select(c |
c.oclIsTypeOf(MailServer)) -> size() = 1 and
self.components -> select(c |
c.oclIsTypeOf(Monitorization)) -> size() = 1 and
self.components -> select(c |
c.oclIsTypeOf(UserManagement)) -> size() = 1 and
self.components -> select(c |
c.oclIsTypeOf(InternalTool)) -> notEmpty and
self.components -> select(c |
c.oclIsTypeOf(Management)) -> notEmpty and
self.components -> select(c |
c.oclIsTypeOf(Methodology)) -> notEmpty and
self.components -> select(c |
c.oclIsTypeOf(User)) -> notEmpty
```

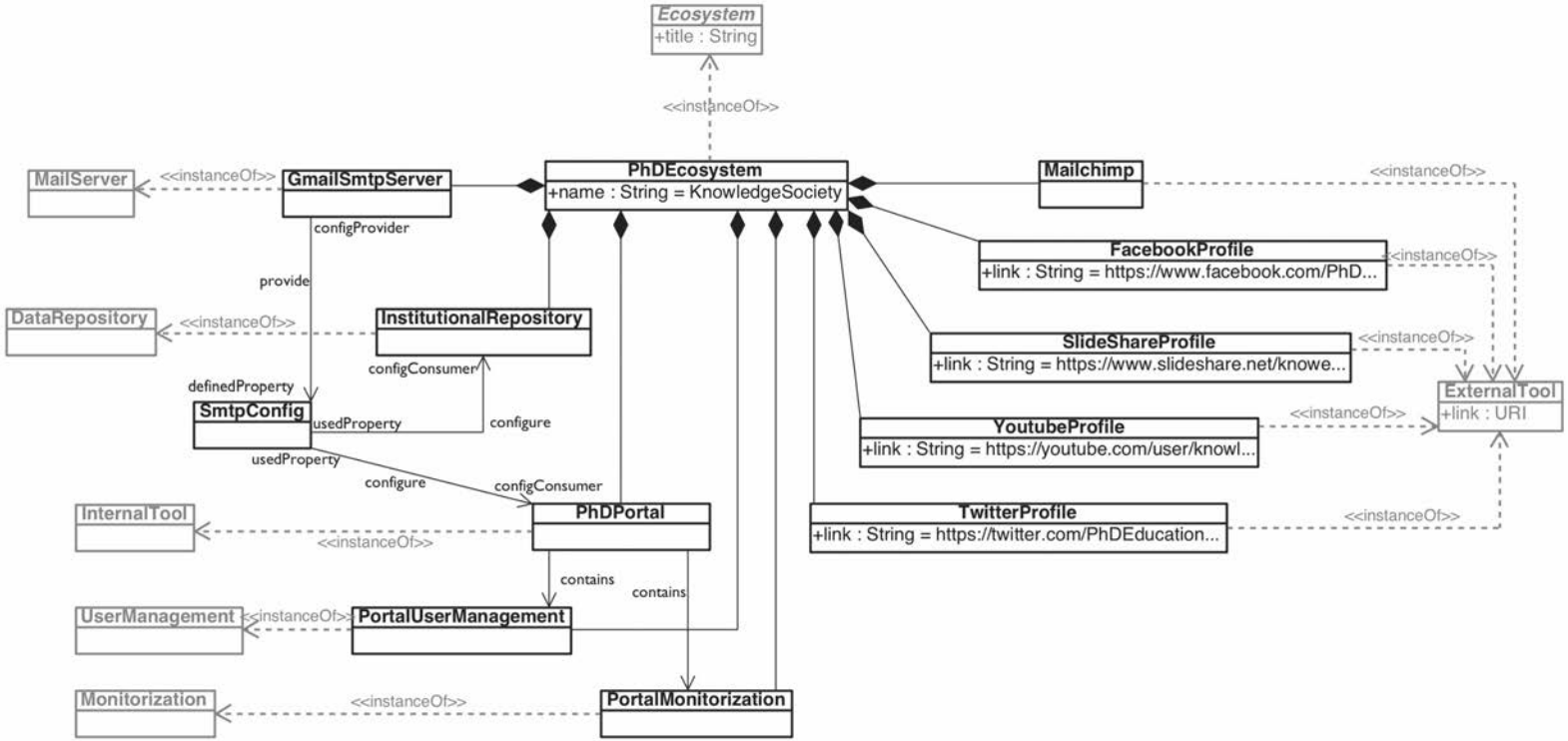
4.3 Case studies (I)



- The learning ecosystem metamodel has been tested in two case studies in order to verify that it allows the definition of real learning ecosystem models
- Two of the learning ecosystems used to validate the architectural pattern have been taken and their corresponding model has been defined from the metamodel

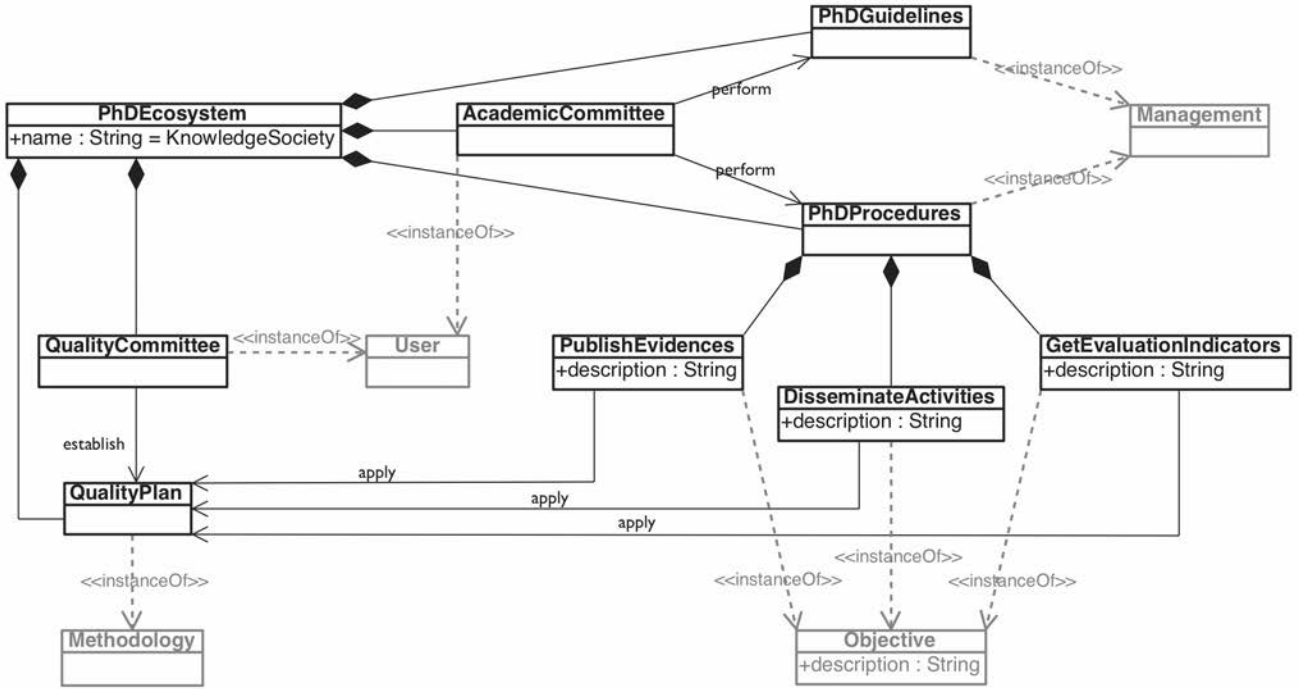
4.3 Case studies (II)

Ecosystem for Knowledge Management in a Doctoral Programme: Software Component View



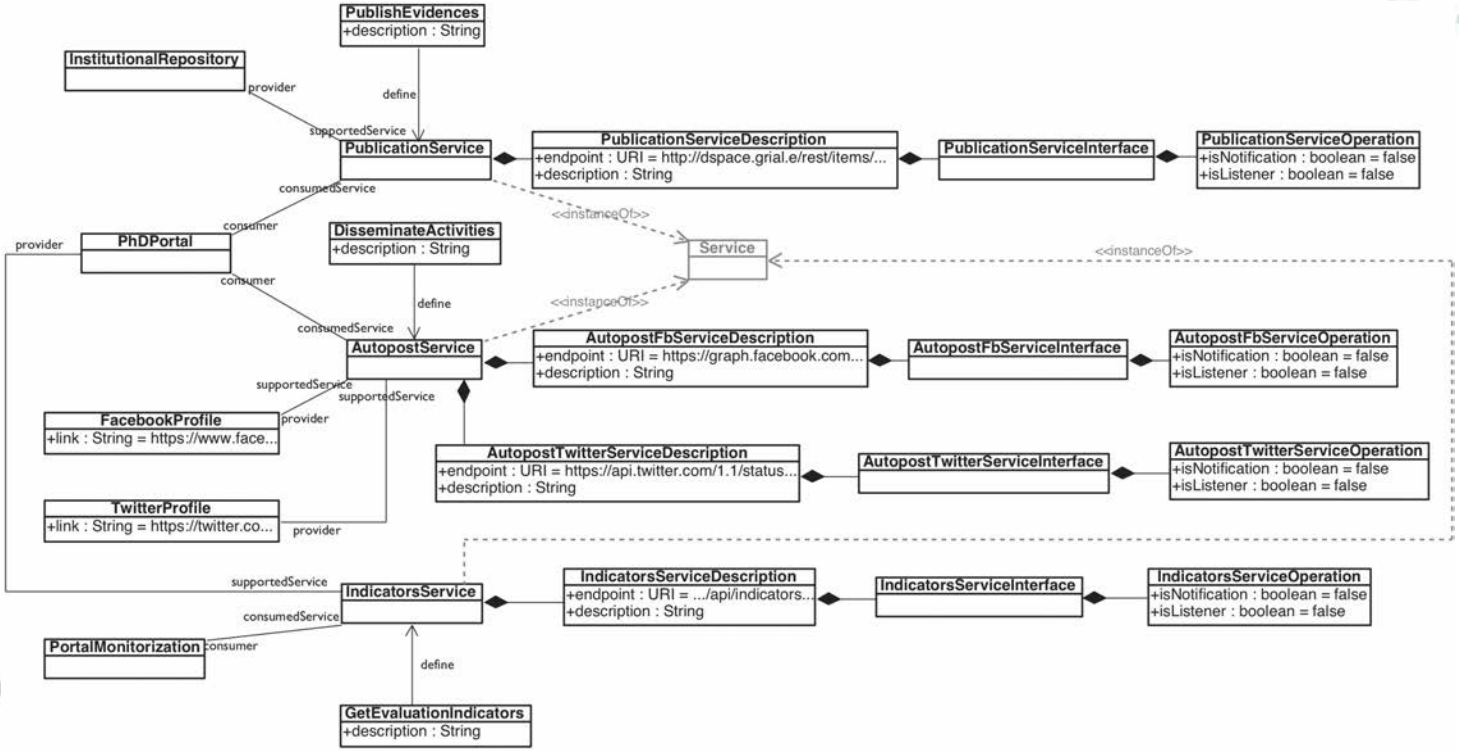
4.3 Case studies (III)

Ecosystem for Knowledge Management in a Doctoral Programme: The Human Factor View



4.3 Case studies (IV)

Ecosystem for Knowledge Management in a Doctoral Programme: View Relationships between Components



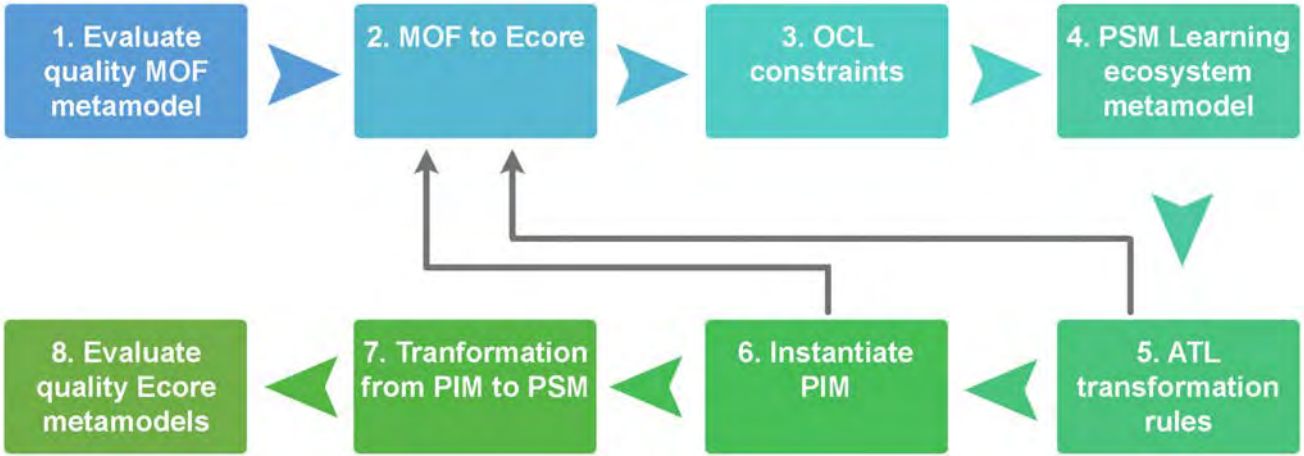
4.4 Metamodel validation (I)

- To ensure the validity of the process it is necessary that transformations between models are performed using tools rather than manually as has been done in the two case studies described in the previous section

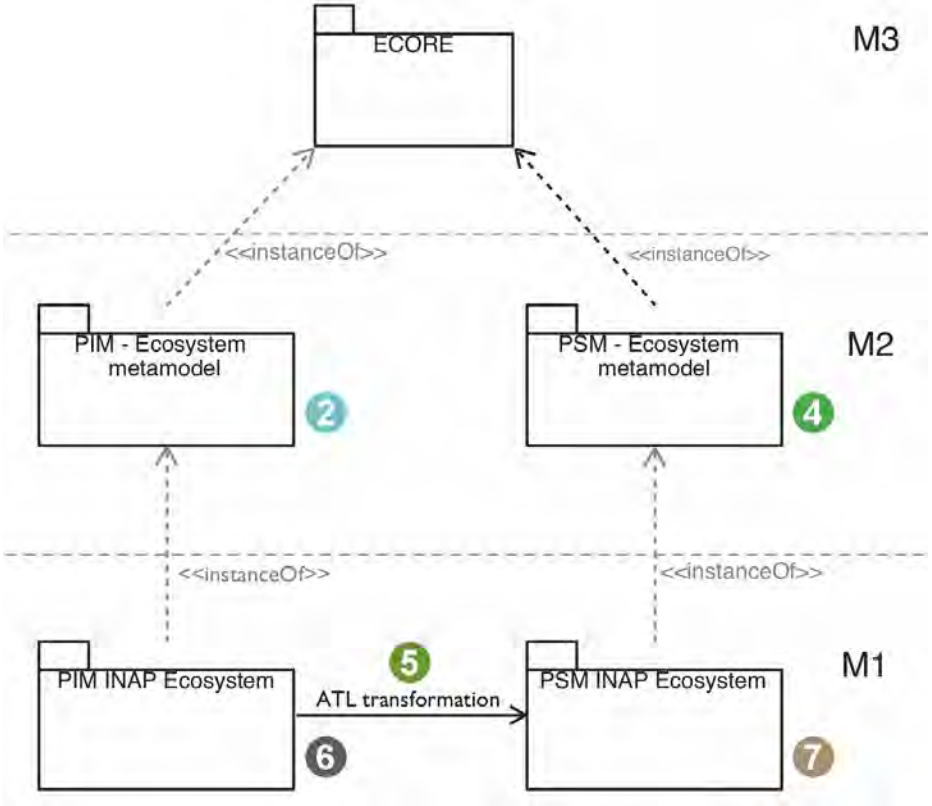
- There are no stable tools that support the MDA standards

- Ecore and the tools provided by Eclipse have been used

4.4 Metamodel validation (I)

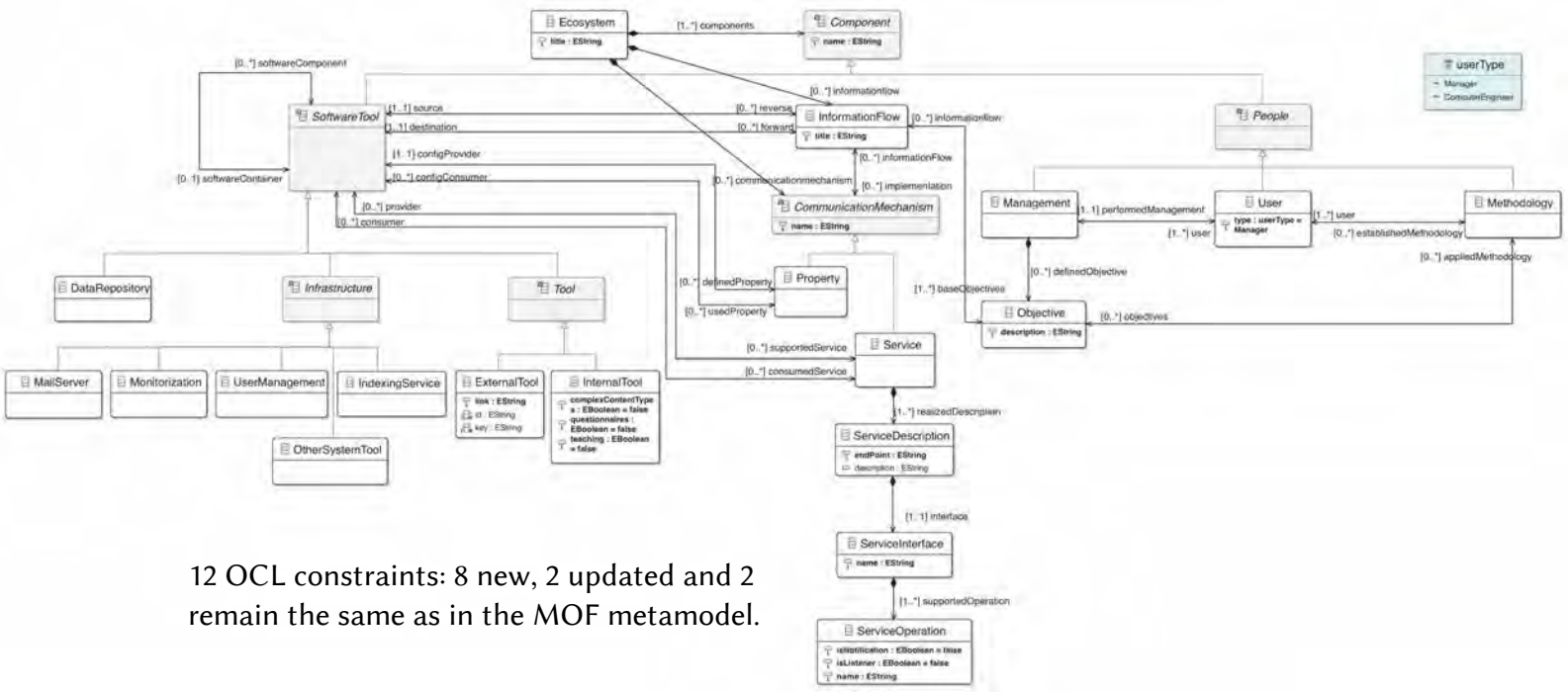


4.4 Metamodel validation (II)



4.4 Metamodel validation (III)

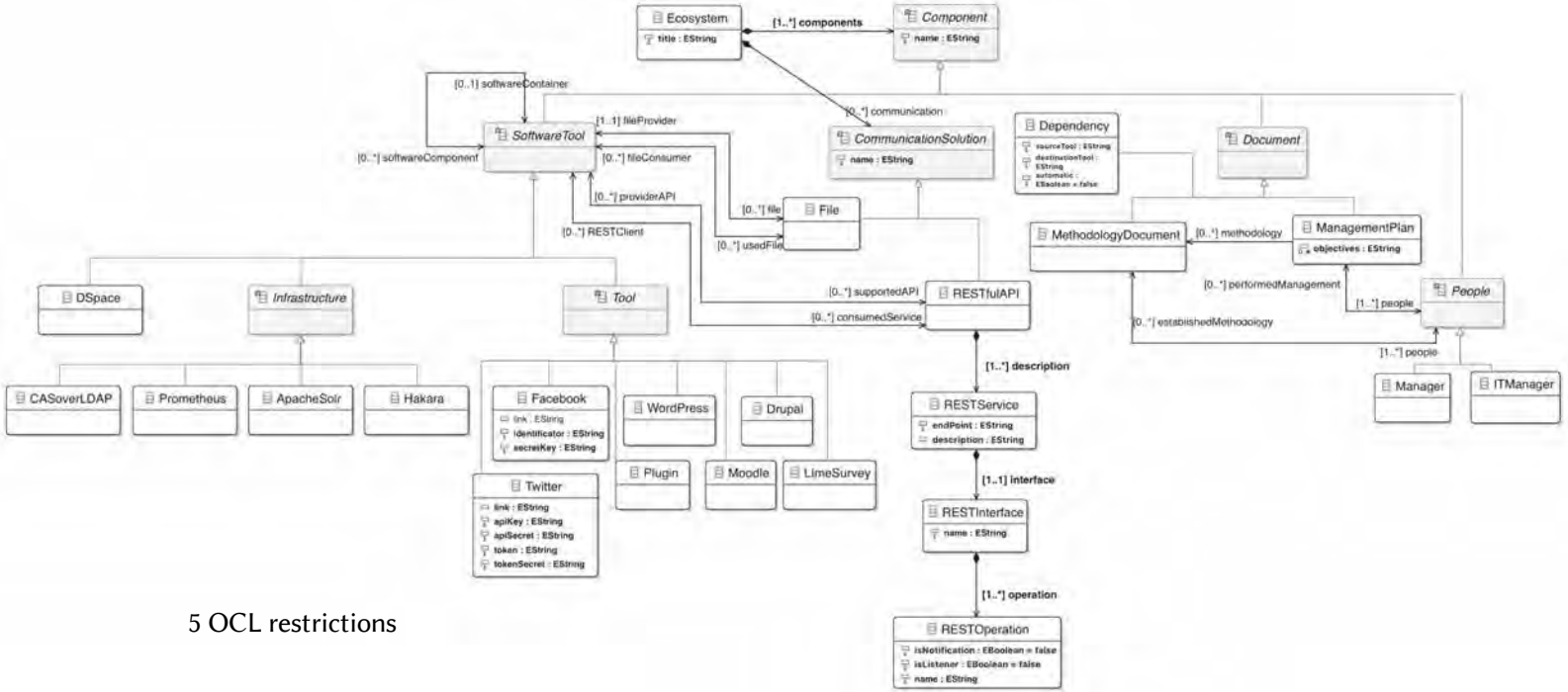
Learning Ecosystem Metamodel in Ecore



12 OCL constraints: 8 new, 2 updated and 2 remain the same as in the MOF metamodel.

4.4 Metamodel validation (IV)

Platform-specific metamodel for open source software-based learning ecosystems



5 OCL restrictions

4.4 Metamodel validation (V)

Transformation from PIM to PSM using ATL rules

PIM (learning ecosystem metamodel)	PSM (to define learning ecosystems)
Software tools	
Ecosystem	Ecosystem
DataRepository	DSpace
MailServer	Hakara
Monitorization	Prometheus
UserManager	CASoverLDAP
IndexingService	ApacheSolr
InternalTool	Moodle
	LimeSurvey
	WordPress
	Drupal
ExternalTool	Facebook
	Twitter
SoftwareTool	Plugin

4.4 Metamodel validation (VI)

Quality of metamodels

- The validation process has two phases aimed at assessing the quality of the metamodels
- The quality assessments have been verified according to the quality framework proposed by López-Fernández, Guerra and de Lara (2014)
- A set of 30 features that basically correspond to syntactic rules that metamodels must follow
- The metamodels defined in Ecore, both the PIM and the PSM, meet all the quality criteria

5. Examples of ecosystems implementing the metamodel

5.1 INAP Ecosystem (I)

- National Institute of Public Administration (INAP)
- Knowledge management within the Spanish Public Administration
  - training of public employees
  - the selection of various Corps and Scales of public employees attached to the Ministry of Finance and Public Administrations
  - and the promotion of research and studies on government and the different levels of public administration from an interdisciplinary perspective

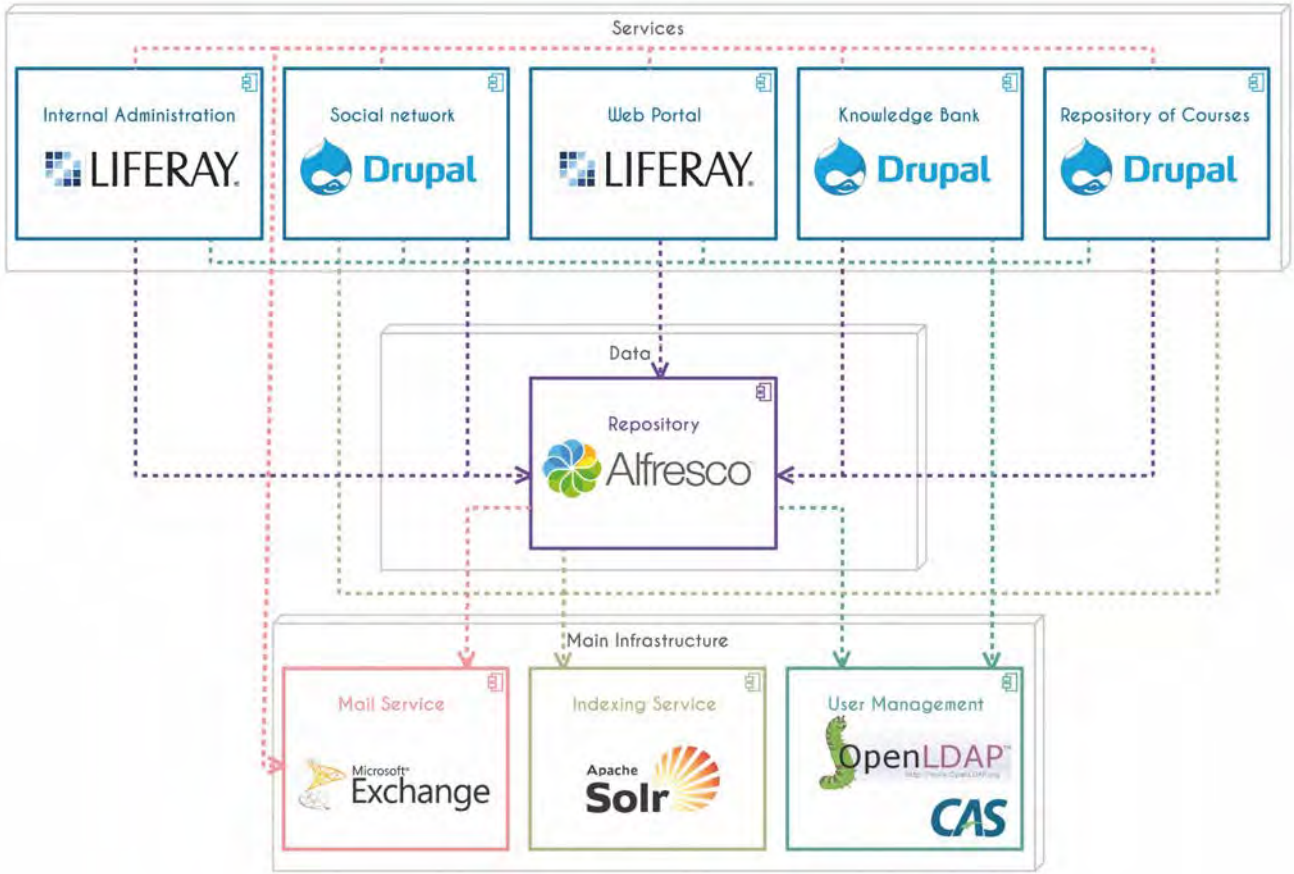
5.1 INAP Ecosystem (II)

Technological ecosystem since 2012

Main objective: to generate knowledge through collaboration between employees of different public bodies.

- Create a space accessible from any public organisation without compromising information security
- Provide procedures and tools with which the user can publish some of the knowledge generated to enforce the transparency law that allows public access to government information
- Support integration with other existing tools to make all institutions and bodies part of the project and collaborate in its evolution
- Provide the user with information about other users with similar interests, promoting social learning and collaboration among users of the system
- Facilitate decision-making and the analysis of information flows in order to improve the system and adapt it to the needs of the Public Administration
- Establish information flows and mechanisms to support the four stages of the knowledge life cycle within the Spanish Public Administration: Socialisation, Externalisation, Combination, Internalisation

5.1 INAP Ecosystem (III)



5.1 INAP Ecosystem (IV)

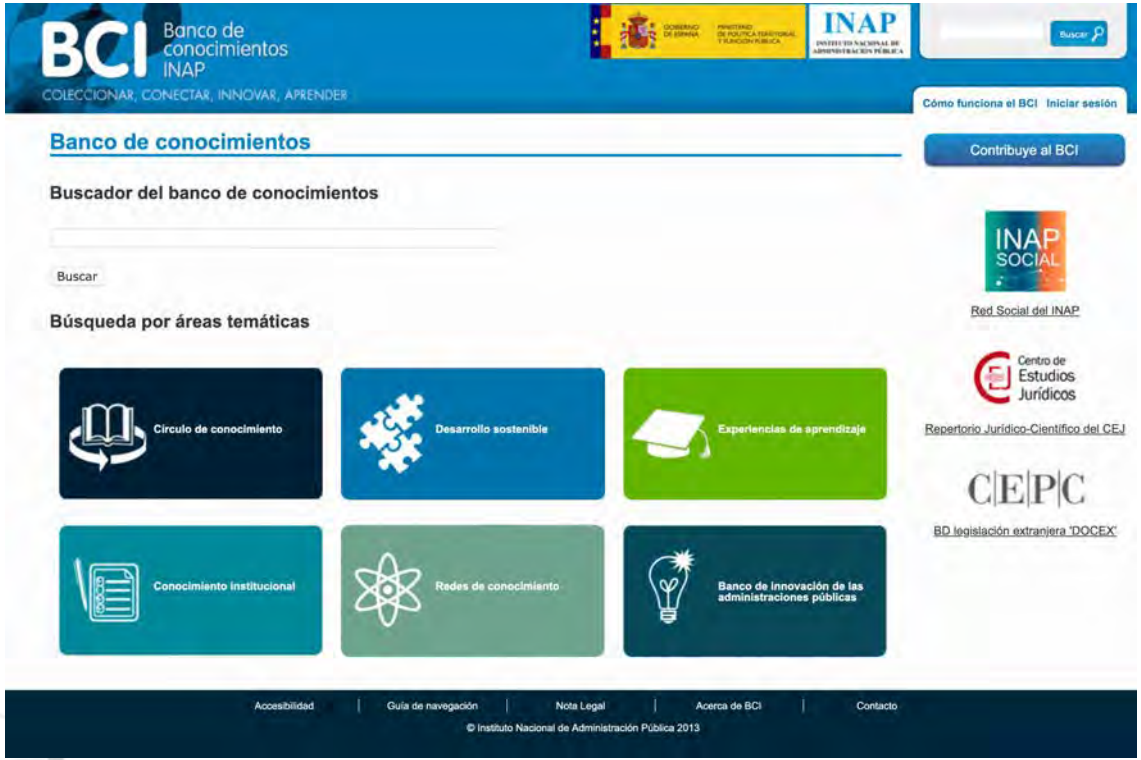
- Public portal http://www.inap.es

6.1 Ecosistema del INAP (V)

- Practices community https://social.inap.es

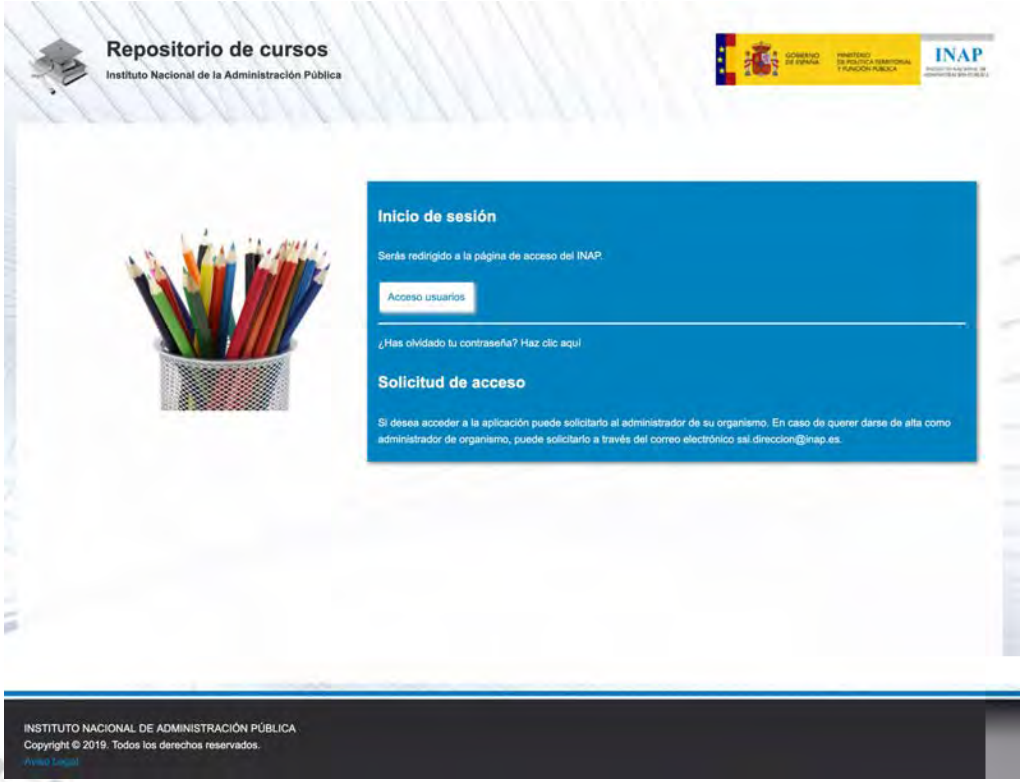
6.1 Ecosistema del INAP (VI)

- Institutional Knowledge Bank https://bci.inap.es



5.1 INAP Ecosystem (VII)

- Course repository https://compartir.inap.es



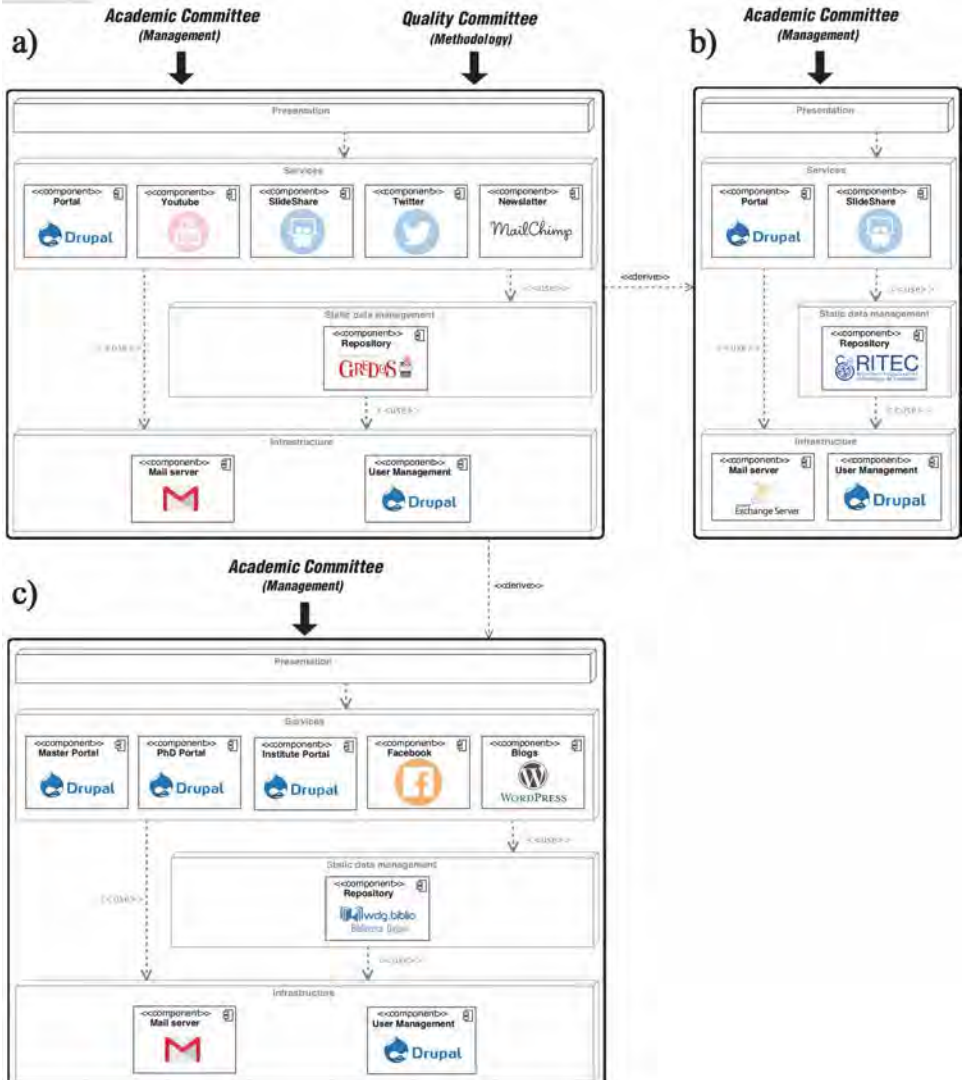
5.2 PhD ecosystem (I)

- Doctoral Programme Training in the Knowledge Society of the University of Salamanca (http://usal.es/webusal/node/30026)
- Born in the University Institute of Education Sciences (IUCE - https://iuce.usal.es)
- To present the teaching-learning processes as authentic motors of the so-called Knowledge Society, in order to be able to discuss and generate new knowledge in this line and under a symbiosis with the most advanced technological advances

5.2 PhD ecosystem (II)

- Objectives of the technology ecosystem
  - To support the internal management of the Doctoral Programme
  - To allow the monitoring of doctoral students enrolled in the Doctoral Programme, in order to keep an updated portfolio of their progress throughout the development of their doctoral thesis
  - To provide visibility to all the knowledge generated by doctoral students as part of their training process as researchers
  - To serve as a communication channel to transmit information of interest to the members of the PhD Programme
  - To support the quality processes of the Doctoral Programme

5.2 PhD ecosystem (III)



5.2 PhD ecosystem (IV)

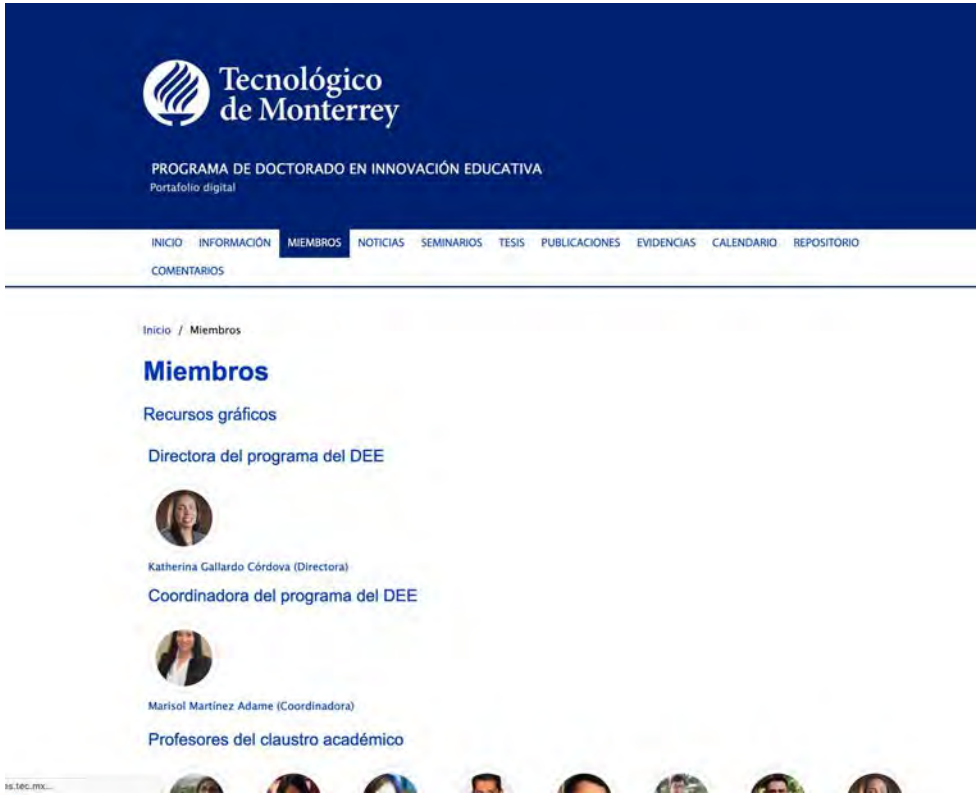
- PhD portal https://knowledgesociety.usal.es

5.2 PhD ecosystem (V)

- Tecnológico de Monterrey (Mexico)
- Doctoral Programme, specifically the Doctorate in Educational Innovation coordinated by the School of Humanities and Education
- Most of the social tools have been removed, the repository has been changed, although both are based on the same open source tool, DSpace, and the mail server has been replaced by the mail server provided by the institution

5.2 PhD ecosystem (VI)

- https://escueladehumanidades.tec.mx/dee



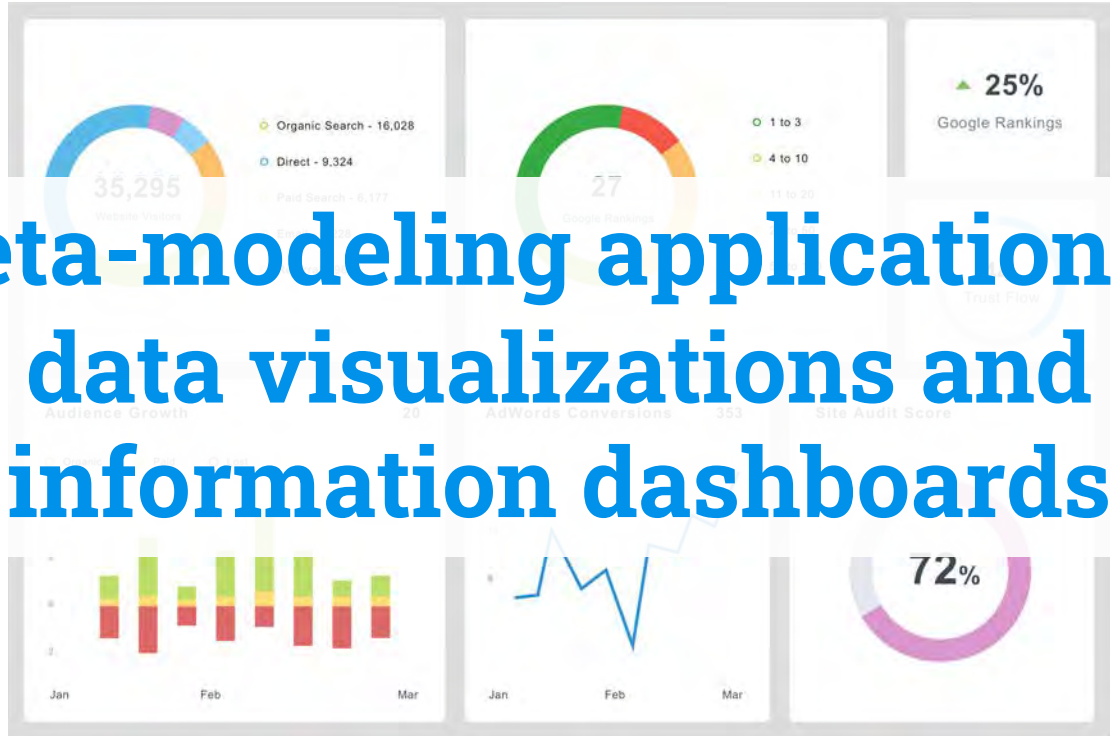
5.2 PhD ecosystem (VII)

- http://escueladehumanidades.tec.mx/deh/

5.2 PhD ecosystem (VIII)

- https://repositorio.tec.mx

Meta-modeling application on data visualizations and information dashboards



Hi!

I’m Andrea Vázquez Ingelmo

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Researcher/Developer at GRIAL Research Group

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Outline

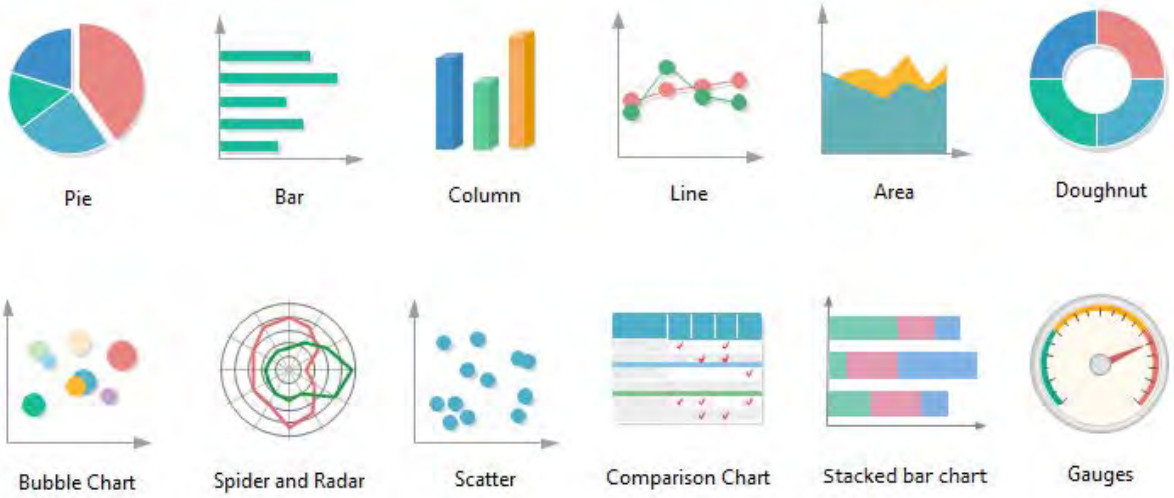
- Dashboards and data visualization
- Building the meta-model
  - Domain engineering
- The complete meta-model
- Dashboards generation
  - Software product lines
- Applications

1.

Dashboards and data visualizations

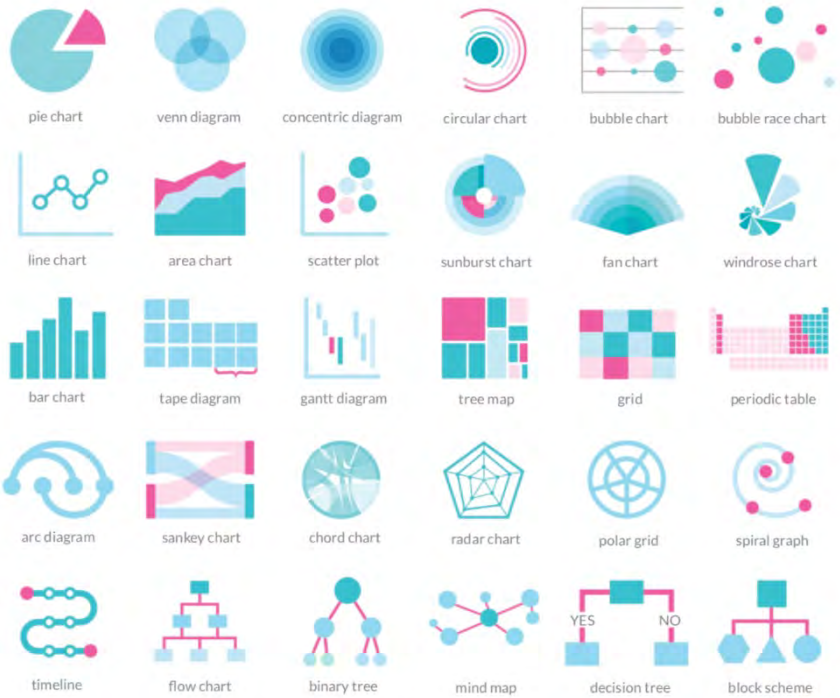
Motivation

Visualizations



https://medium.com/@Lynia_Li/as-you-know-there-are-many-types-of-charts-to-be-used-in-data-visualization-54da9b97092e

Visualizations



https://theunspokenpitch.com/charts/

Dashboards

What Do We Talk About When We Talk About Dashboards?

Alper Sarikaya, Michael Correll, Lyn Bartram, Melanie Tory, and Danyel Fisher

Fig. 1: Klipfolio's Social Media Manager Dashboard (DB065 from our example corpus, left) is a traditional dashboard, with large numbers representing key metrics, and tiled graphs of real-time data. The UNCHR Refugees/Migrants Emergency Response dashboard (DB117, right) also is a juxtaposition of key metrics and simple visualizations, but includes annotations and guided narrative elements. Are both dashboards? Do design principles meant for one transfer to the other?

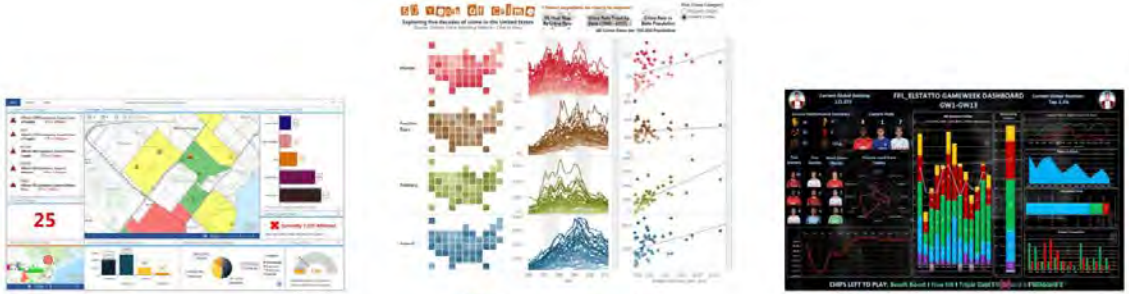
Abstract—Dashboards are one of the most common use cases for data visualization, and their design and contexts of use are considerably different from exploratory visualization tools. In this paper, we look at the broad scope of how dashboards are used in practice through an analysis of dashboard examples and documentation about their use. We systematically review the literature surrounding dashboard use, construct a design space for dashboards, and identify major dashboard types. We characterize dashboards by their design goals, levels of interaction, and the practices around them. Our framework and literature review suggest a number of fruitful research directions to better support dashboard design, implementation, and use.

Index Terms—Dashboards, literature review, survey, design space, open coding

https://alper.datav.is/publications/dashboards/

Dashboards

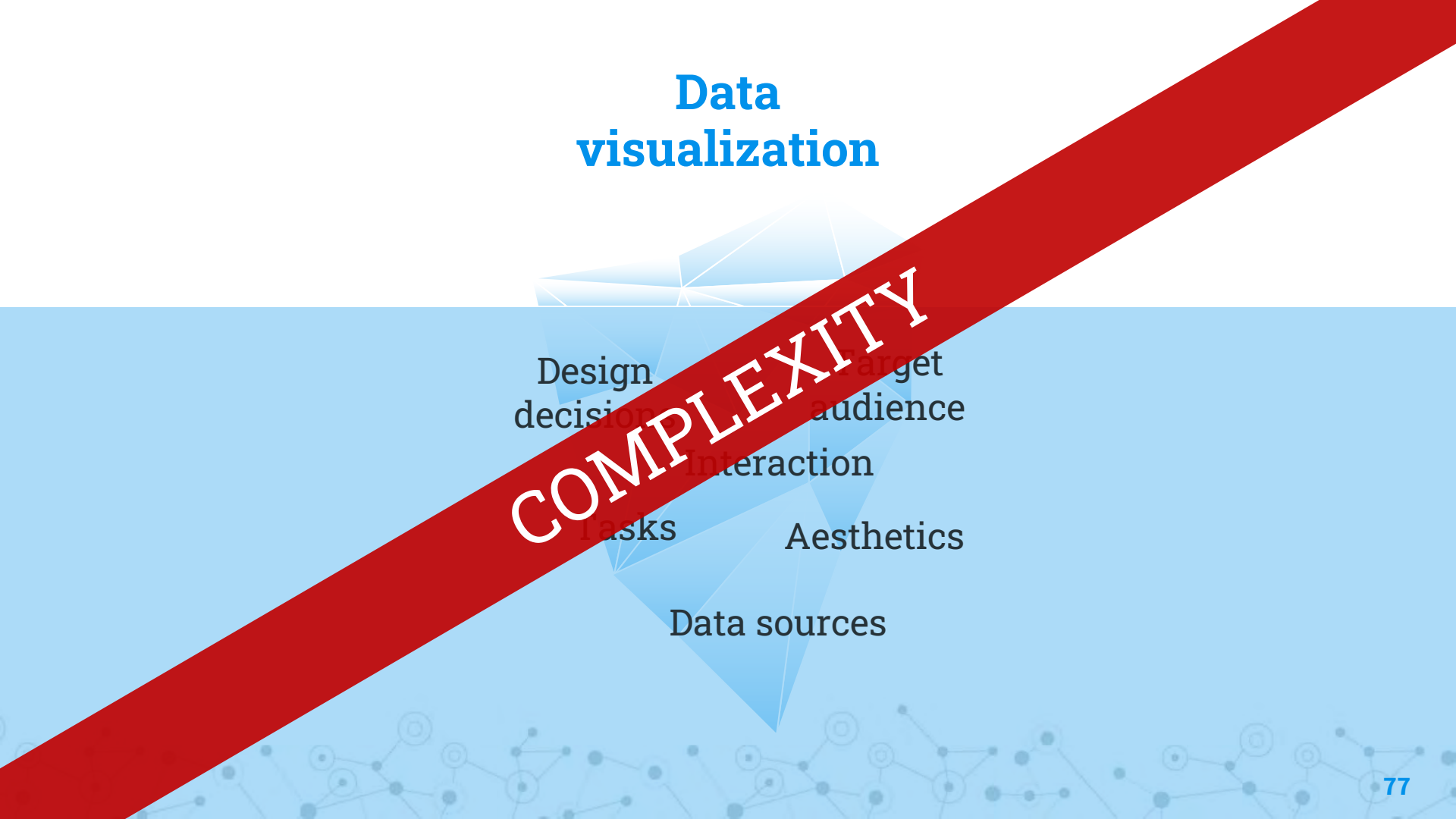
1 Strategic decision-making (DB052) 2 Quantified Self (DB021) 3 Static Operational (DB034) 4 Static Organizational (DB101)



5 Operational decision-making (DB036) 6 Communication (DB005) 7 Dashboards Evolved (DB045)

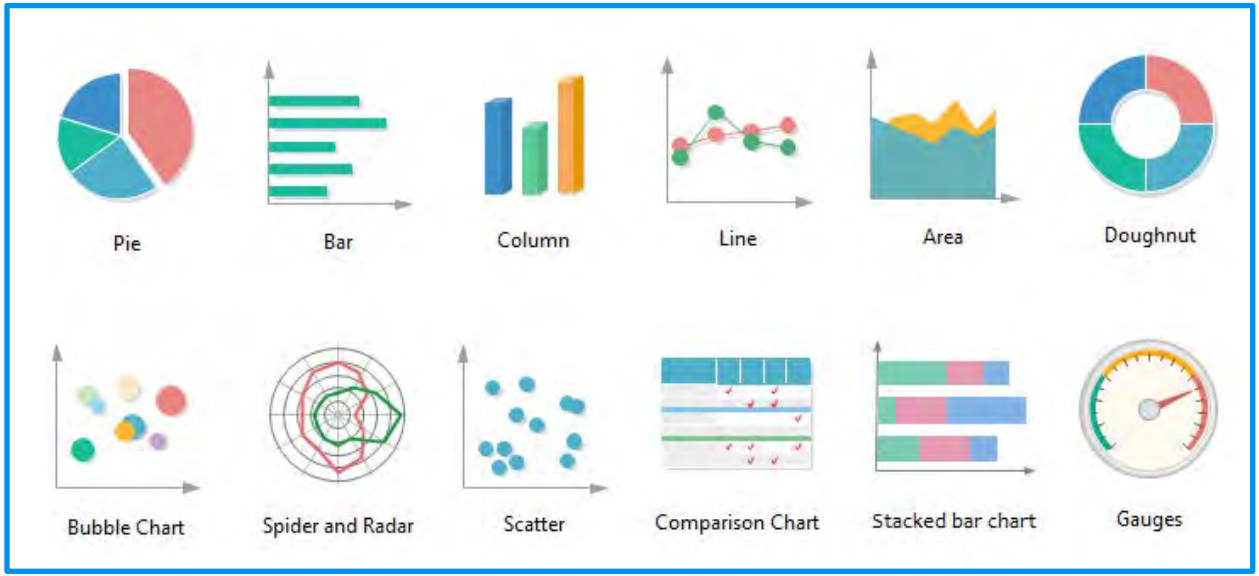
Fig. 4: Exemplar dashboards selected from our seven derived clusters. Clusters 1 and 5 demonstrate dashboards specifically targeting decision-making, while clusters 3 and 4 target awareness on behalf of the consumer. Cluster 2 targets the somewhat novel quantified self scenario (smart-home dashboard), while 6 represents dashboards tailored for general-purpose communication. Cluster 7 captures some novel extensions to traditional dashboards.

Data visualization



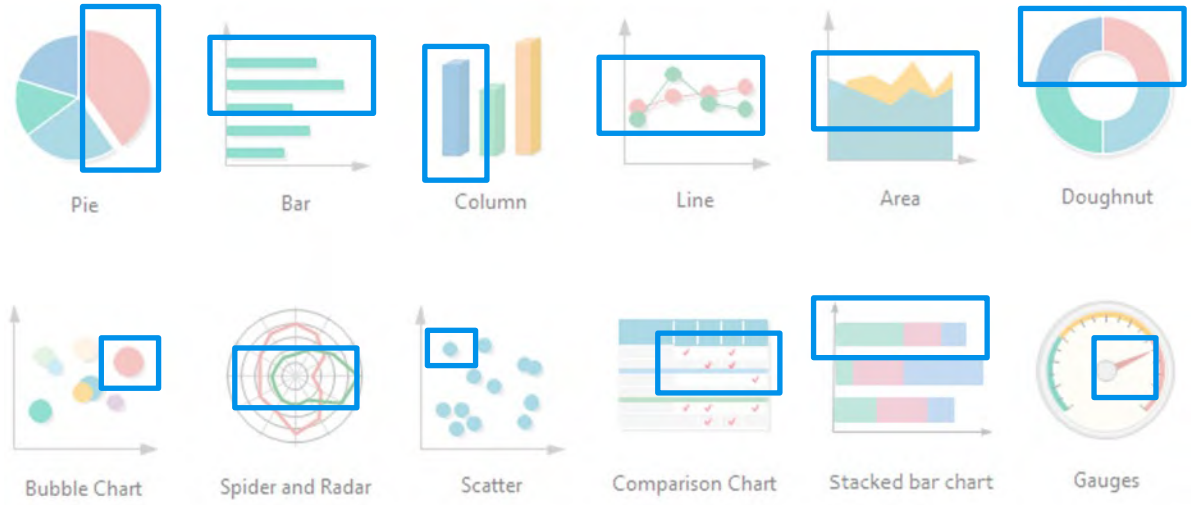
However, we find commonalities within variety

Data



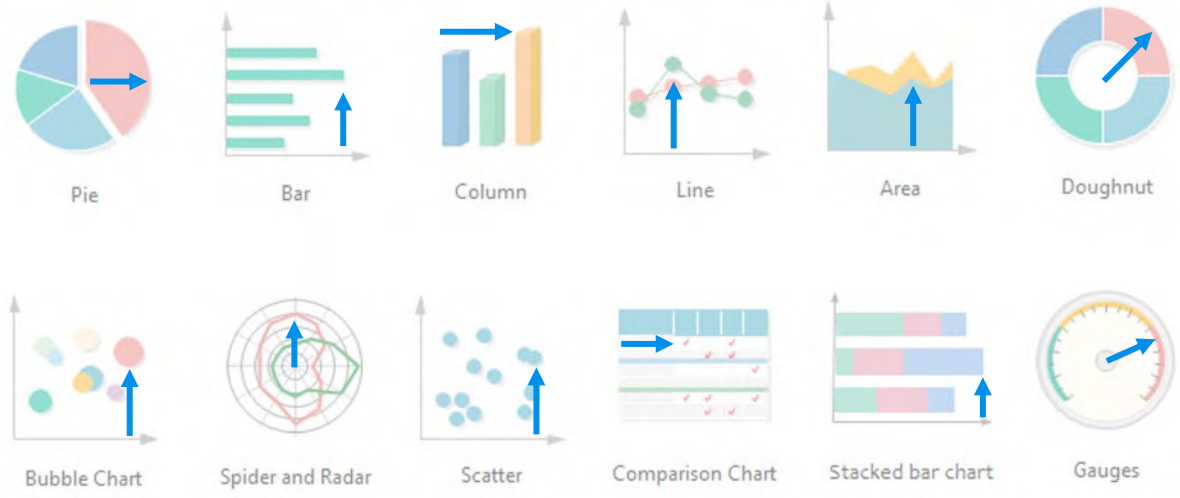
https://medium.com/@Lynia_Li/as-you-know-there-are-many-types-of-charts-to-be-used-in-data-visualization-54da9b97092e

Visual marks



https://medium.com/@Lynia_Li/as-you-know-there-are-many-types-of-charts-to-be-used-in-data-visualization-54da9b97092e

Scales



https://medium.com/@Lynia_Li/as-you-know-there-are-many-types-of-charts-to-be-used-in-data-visualization-54da9b97092e

Feature abstraction to obtain a generic “skeleton”

- ↓ Development times
- ↑ Design decisions traceability
- ↑ Product customization
- ↑ Code reusability
- ↑ Flexibility

How?

2.

Building the meta-model

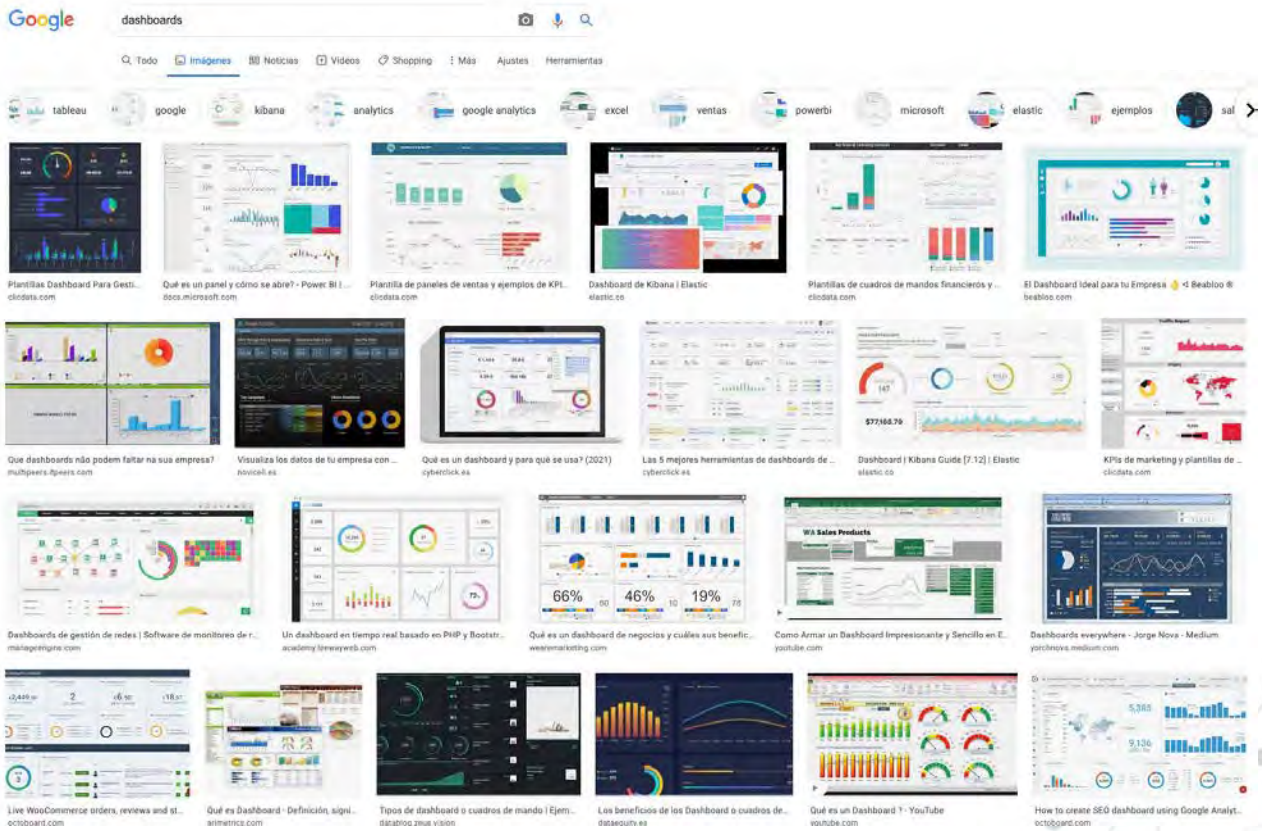
Domain engineering

Domain engineering

Categorize and identify common components or features within a domain

Goal: reuse domain knowledge to produce new software products

Domain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dashboards
Todo
Imágenes
Noticias
Vídeos
Shopping
Más
Ajustes
Herramientas
tableau
google
kibana
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google analytics
excel
ventas
powerbi
microsoft
elastic
ejemplos
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Qué es un panel y cómo se abre? - Power BI |...
docs.microsoft.com
Plantilla de paneles de ventas y ejemplos de KPI...
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Dashboard de Kibana | Elastic
elastic.co
Plantillas de cuadros de mandos financieros y...
clicdata.com
El Dashboard Ideal para tu Empresa
beabloo.com
Que dashboards não podem faltar na sua empresa?
multipoers.4poers.com
Visualiza los datos de tu empresa con ...
novicell.es
Qué es un dashboard y para qué se usa? (2021)
cyberclick.es
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Dashboard | Kibana Guide [7.12] | Elastic
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Dashboards de gestión de redes | Software de monitoreo de r...
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WA Sales Products
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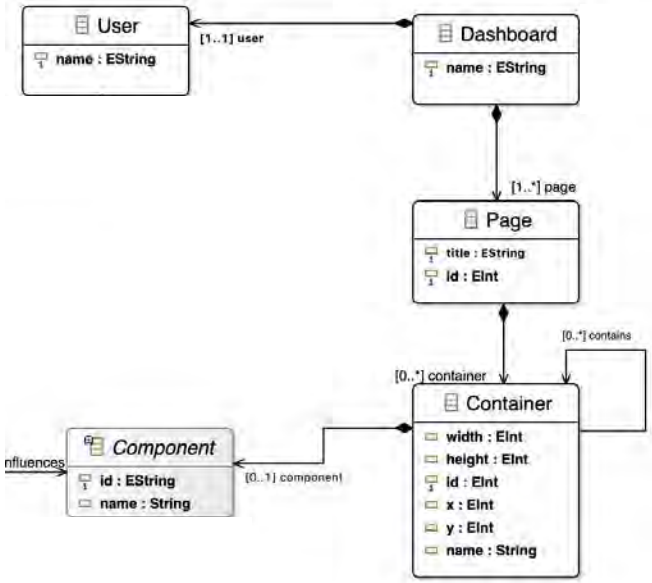
Dashboards everywhere - Jorge Nova - Medium
yorchnova.medium.com
Live WooCommerce orders, reviews and st...
octoboard.com
Qué es Dashboard - Definición, signi...
arimetrics.com
Tipos de dashboard o cuadros de mando | Ejem...
databloo zeus vision
Los beneficios de los Dashboard o cuadros de...
dataequity.es
Qué es un Dashboard ? - YouTube
youtube.com
How to create SEO dashboard using Google Analyt...
octoboard.com

Domain

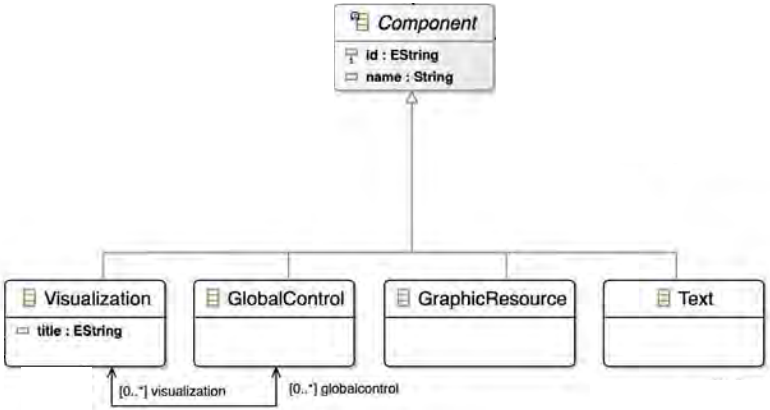
Searching for abstract and technology-independent features

Commonalities

- Users
- Data sources
- Pages
- Containers
- Components
  - Visualizations
  - Resources
  - Controls
  - Interactivity

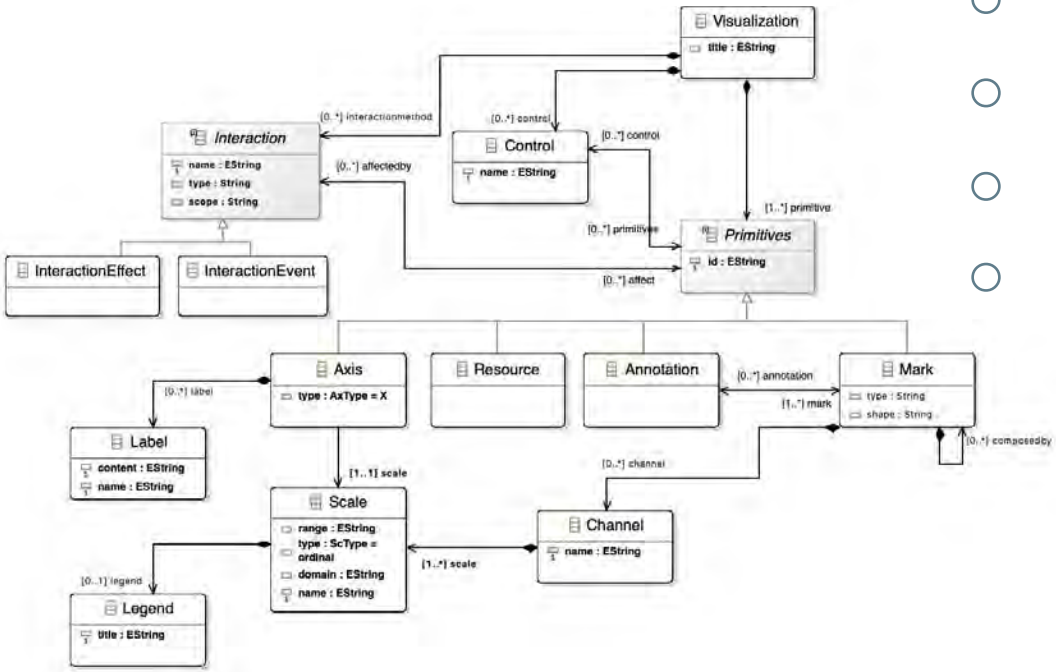


- Users
- Pages
- Containers
- Components

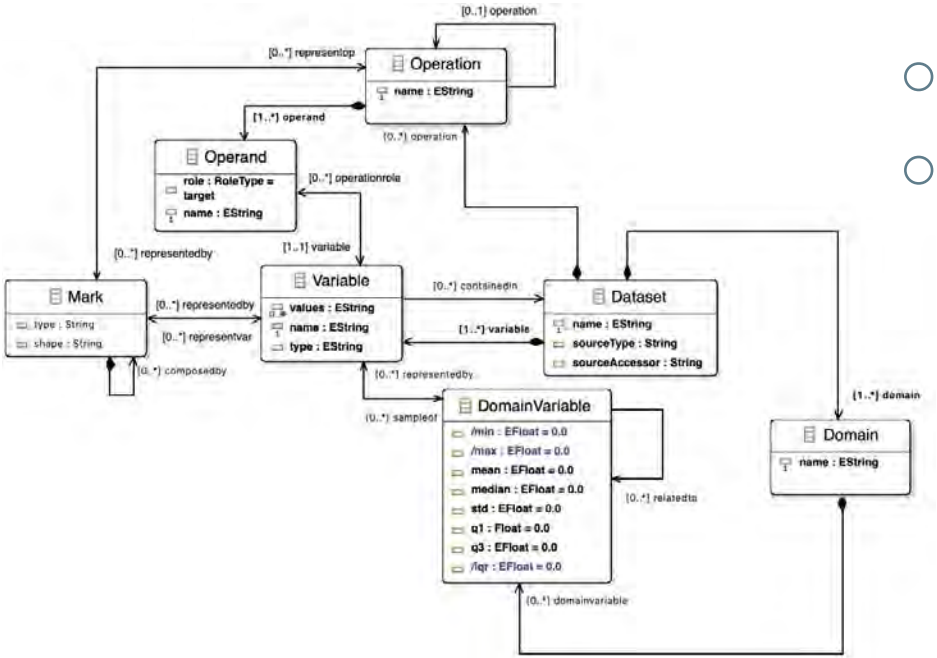


- Components
  - Visualizations
  - Controls
  - Resources
  - Text

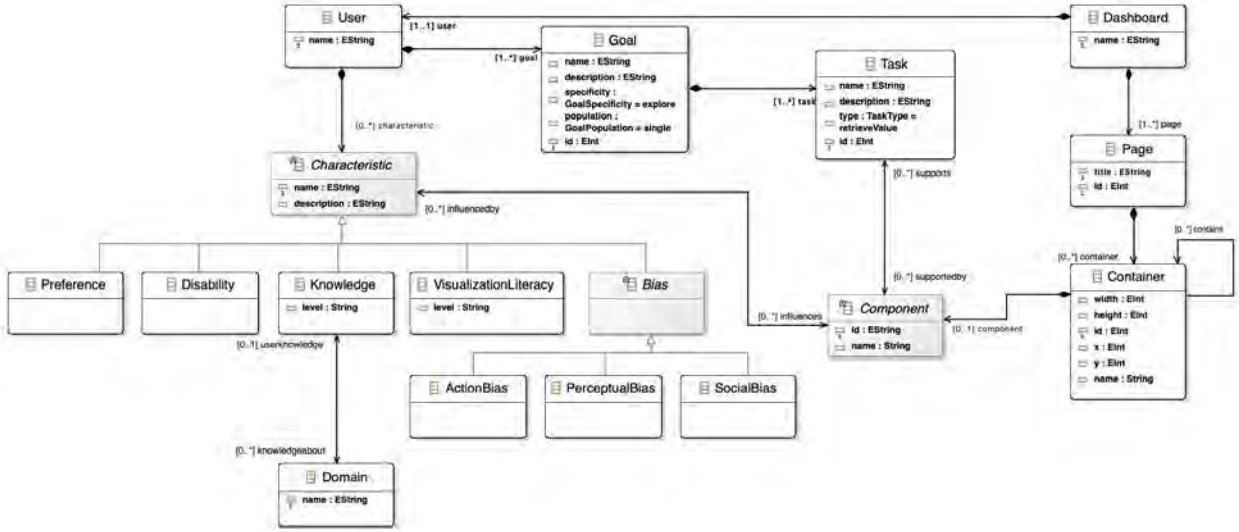
- Visualizations
  - Annotations
  - Marks
  - Axes
  - Scales
  - Channels (color, position, etc.)
  - Interaction



- Data
  - Datasets
  - Data domain
  - Variables
  - Operations

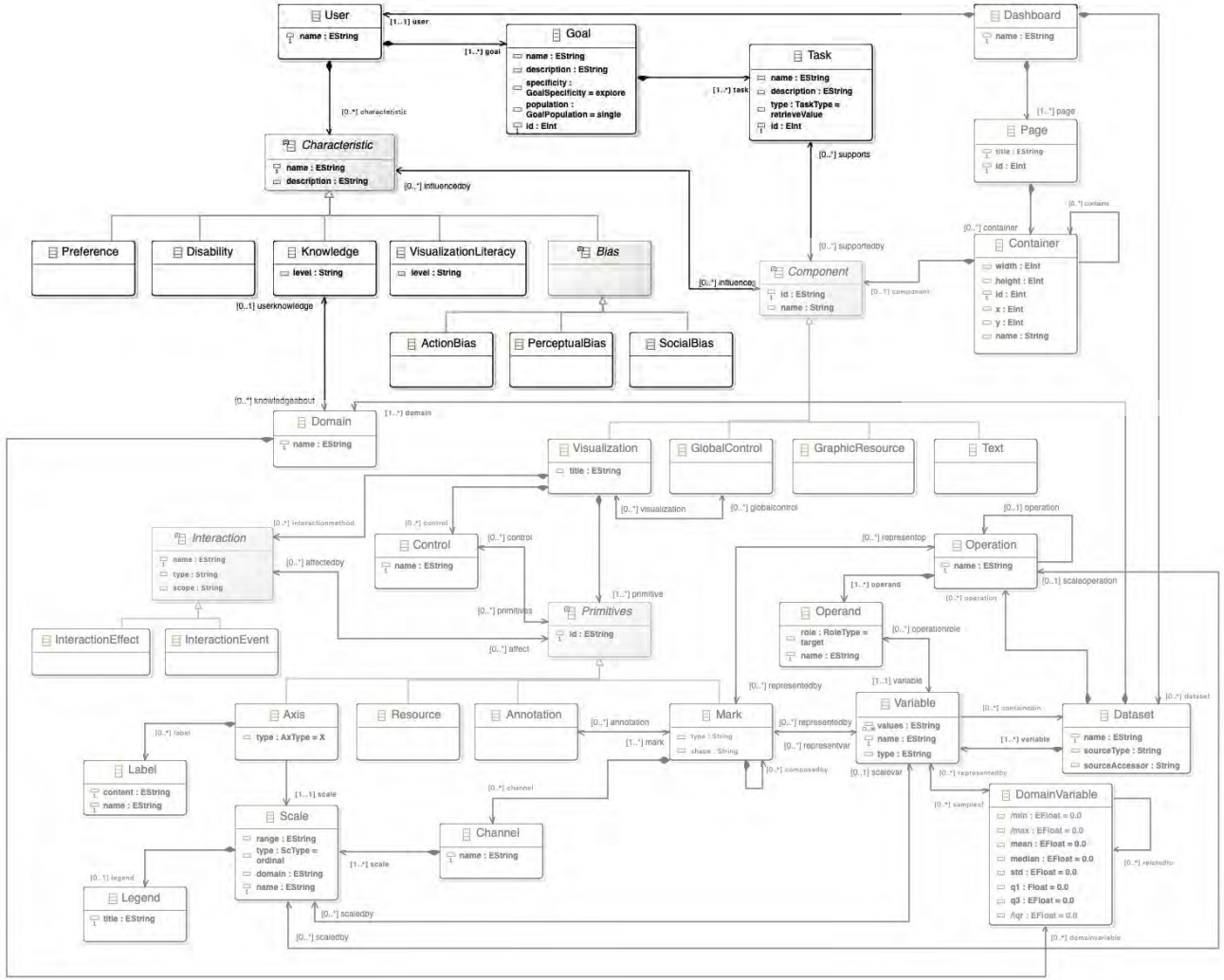


- Users
  - Characteristics
  - Goals
  - Analytical tasks



3.
Meta-model

Final product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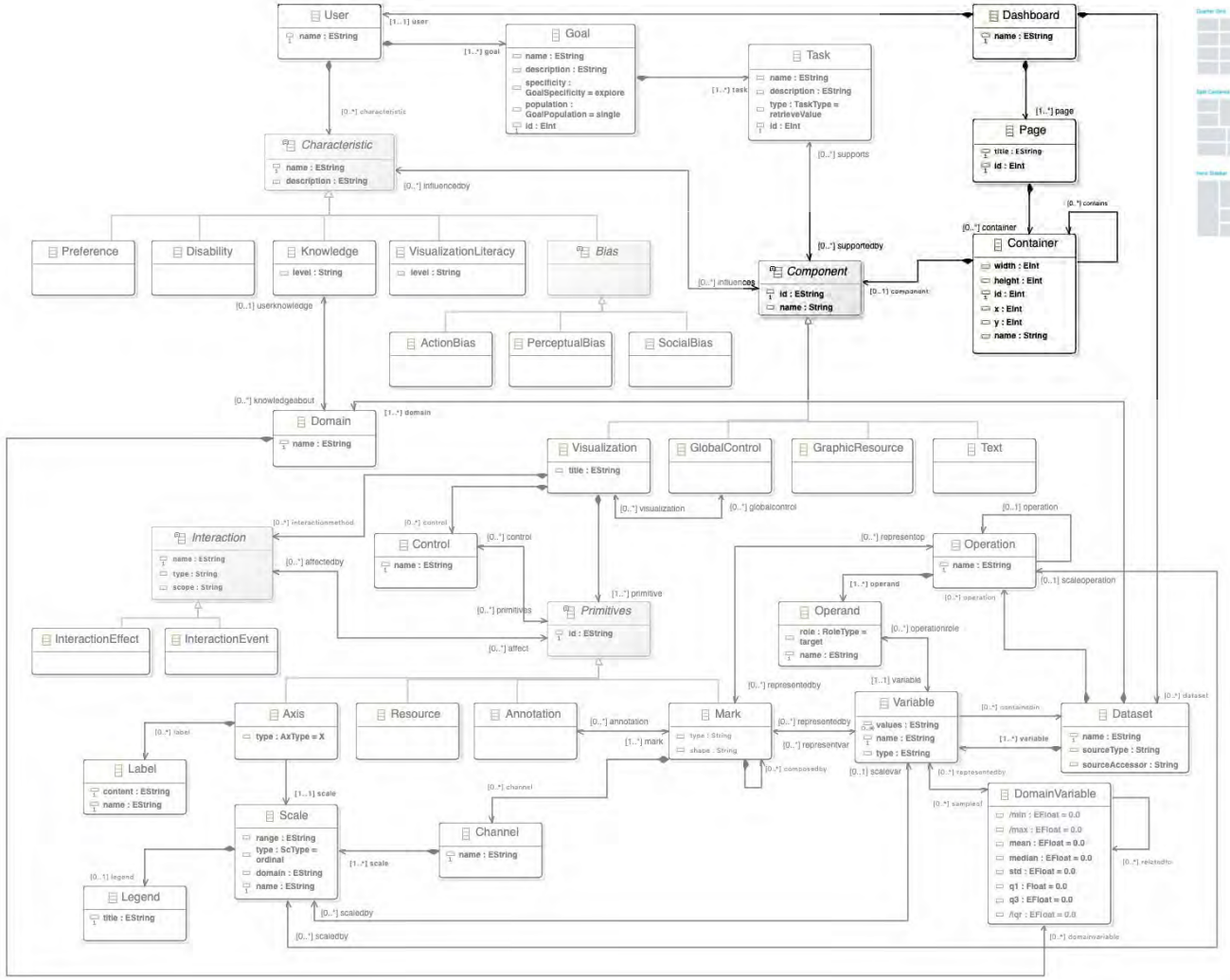
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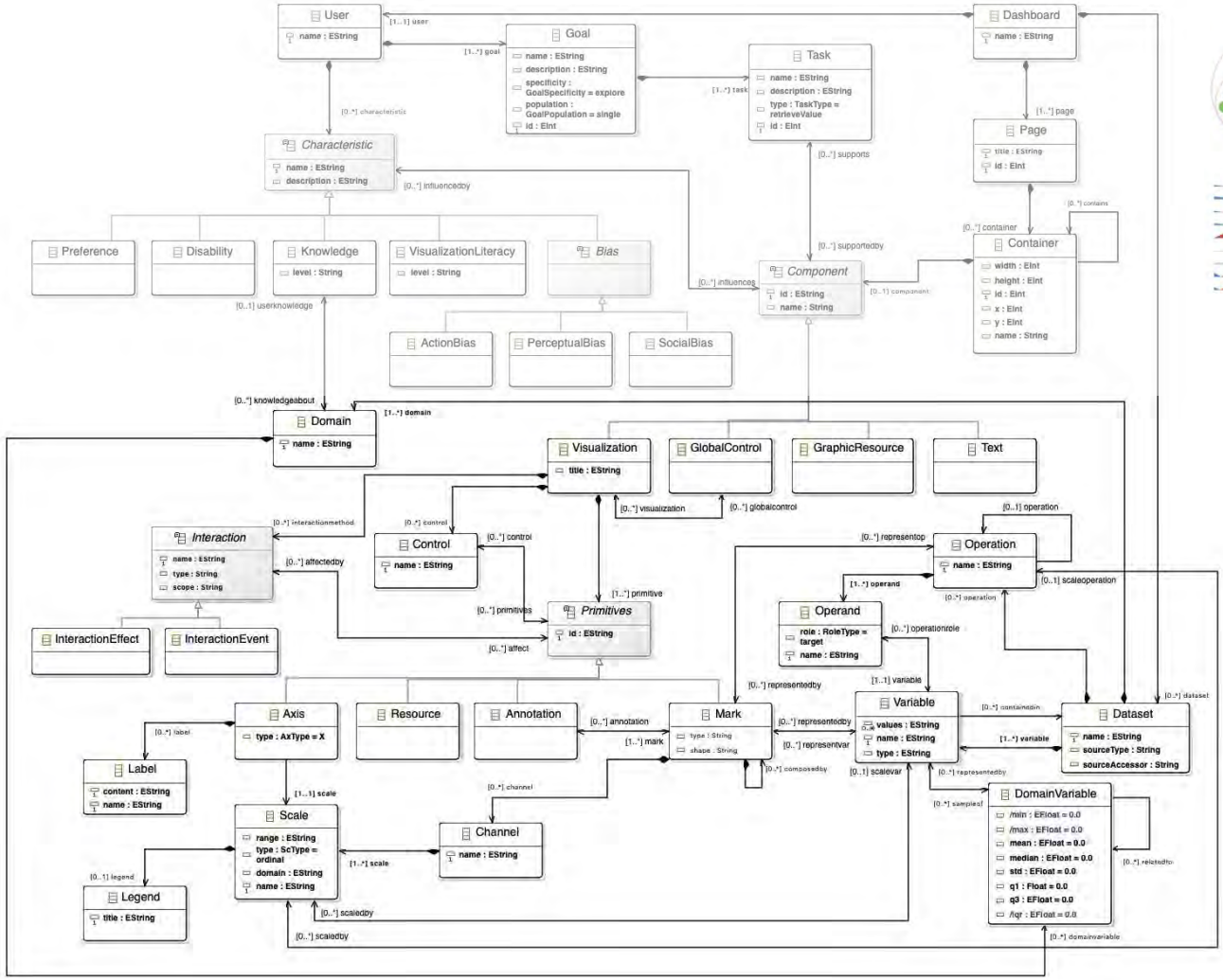
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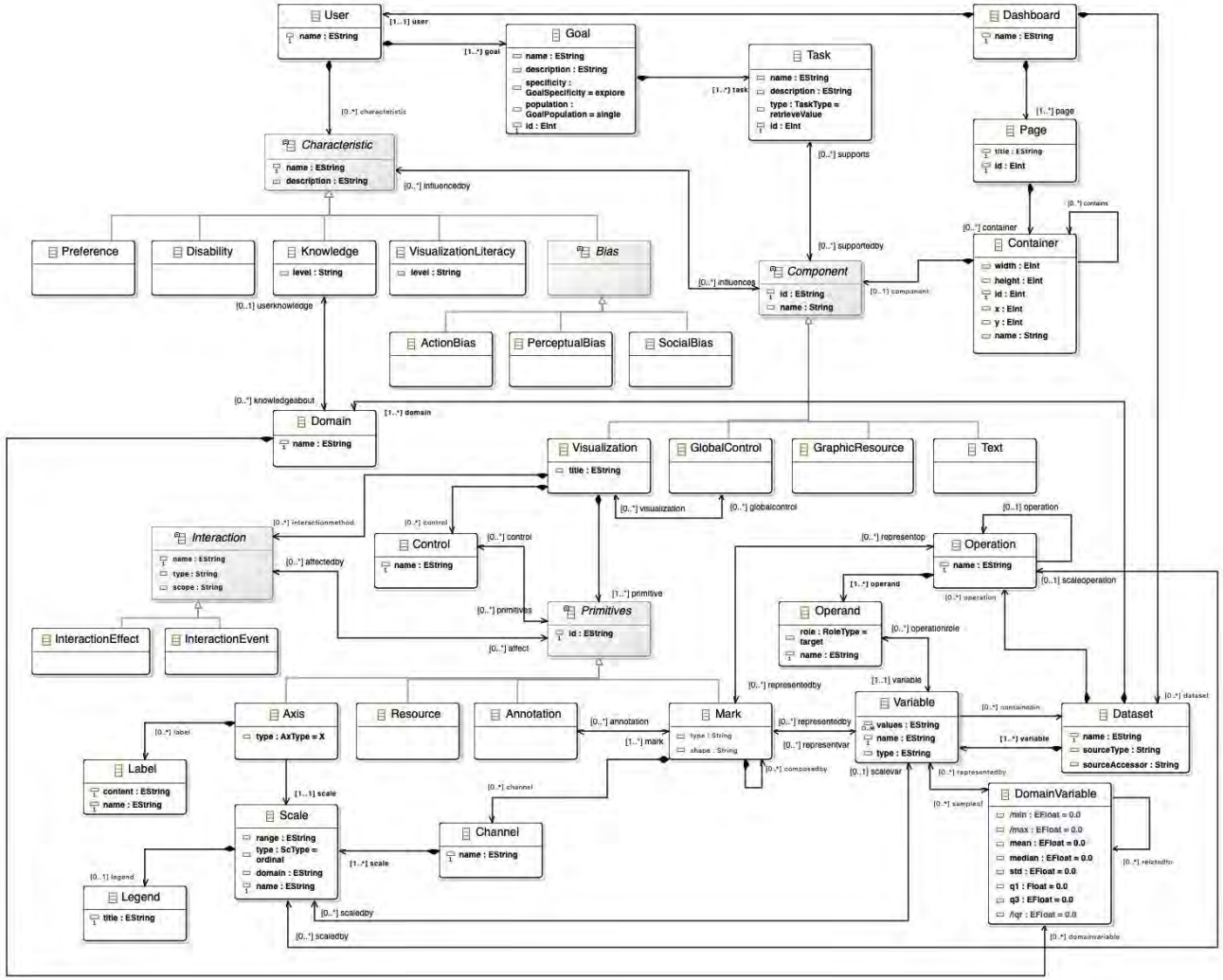
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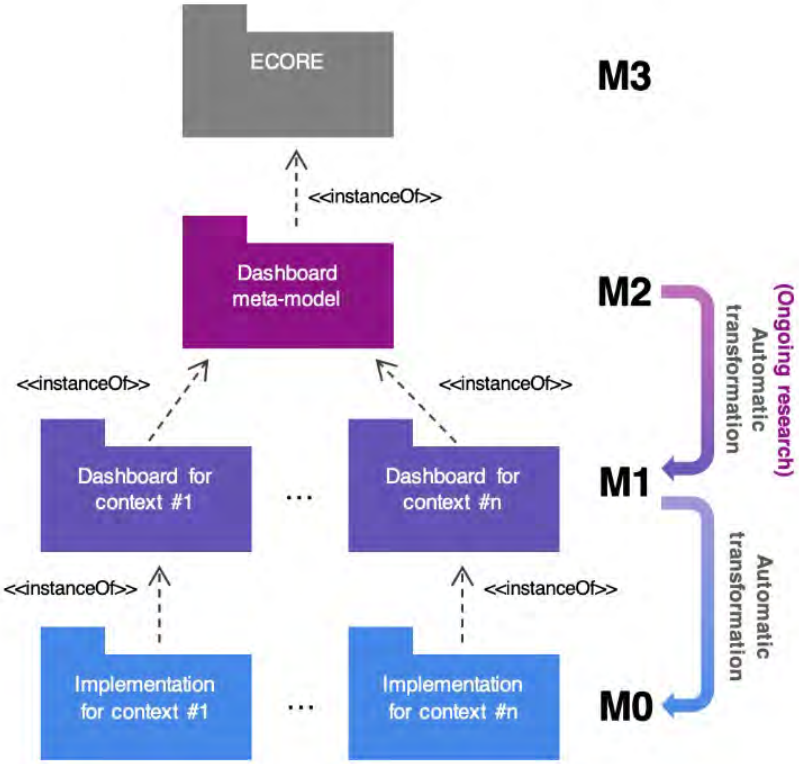
median : EFloat = 0.0
std : EFloat = 0.0
q1 : Float = 0.0
q3 : EFloat = 0.0
/iqr : EFloat = 0.0

Now what?

4.

Dashboards generation

Software product lines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Implementation for context #1
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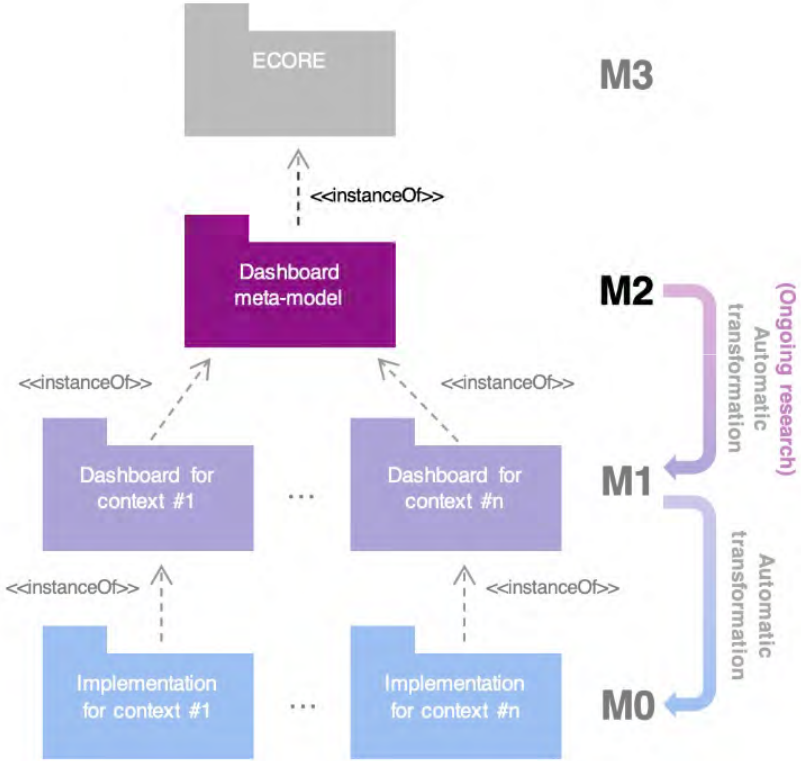
Implementation for context #n
M0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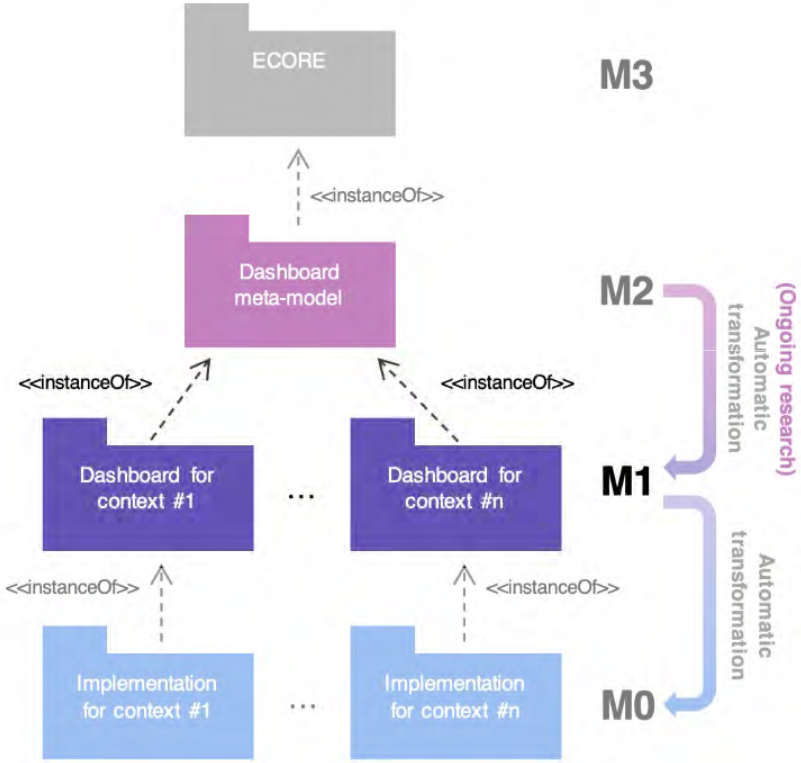
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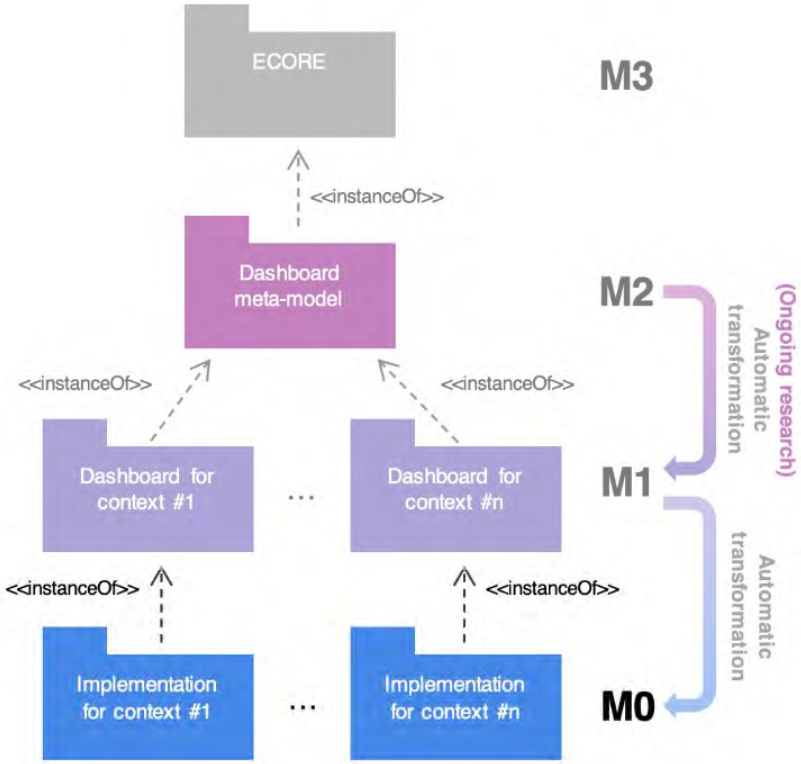
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Implementation for context #1
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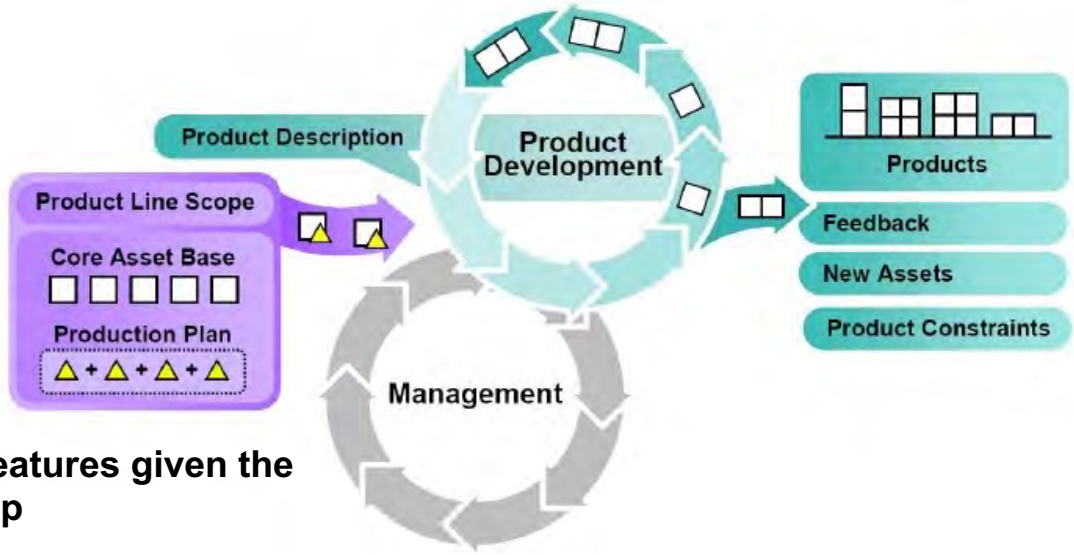
Implementation for context #n
M0

Software product lines

Systematic reuse of software assets to build new products belonging to the same family

Goal: reduce development times and costs

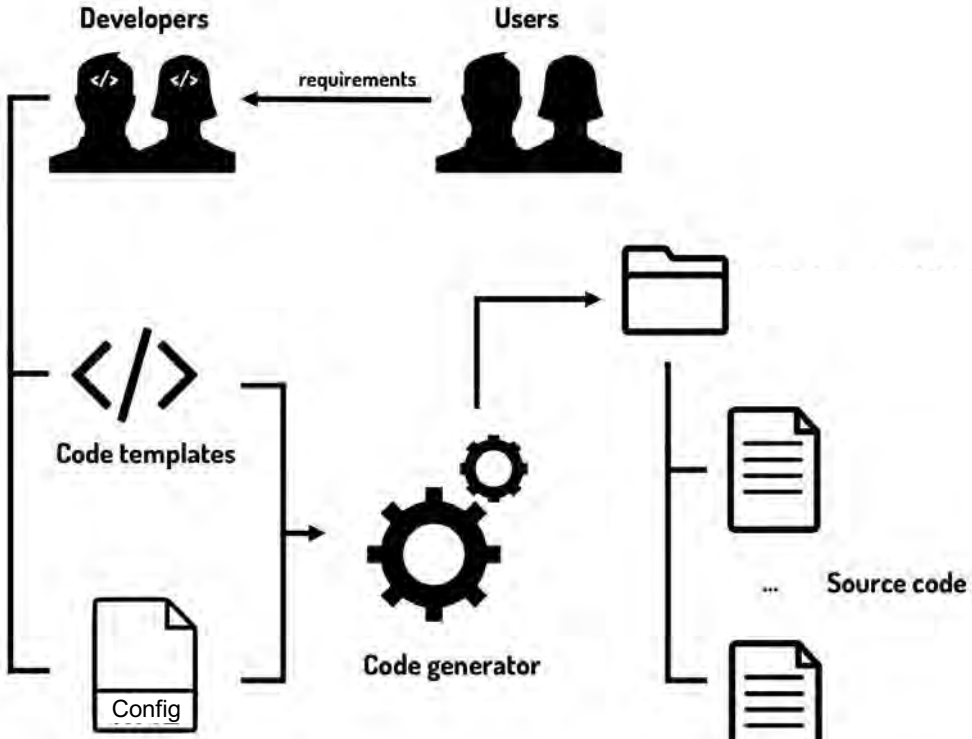
Generation of a customized product



Selection of the features given the product to develop

Variability points

- Core assets based on the meta-model
- Feature specification through configuration files
- Code generation through code templates



Configuration file

Macros call

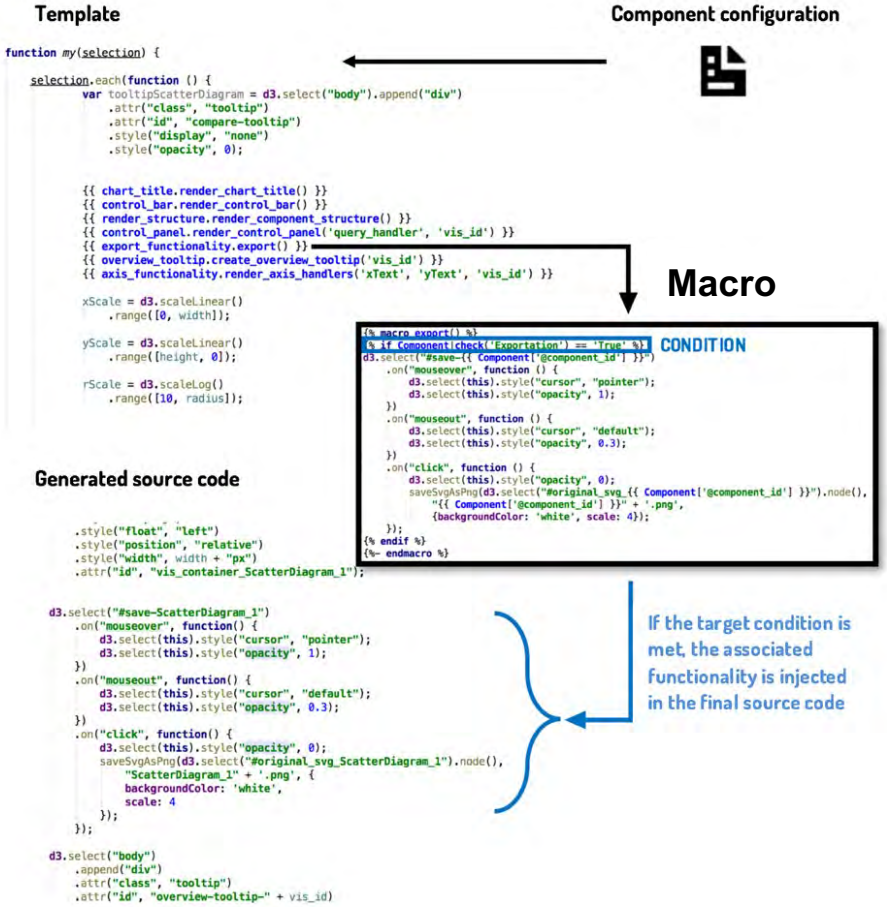
```
{{ global_reference.variable_definition() }}
{{ zoom_functionality.zoom_variable_definition('xScale', 'yScale', 'xAxis',
'yAxis', 'xLineVal', 'yLineVal', 'vis_id') }}
```

Base code

```
function my(selection) {

    selection.each(function () {
            var tooltipScatterDiagram = d3.select("body").append("div")
                .attr("class", "tooltip")
                .attr("id", "compare-tooltip")
                .style("display", "none")
                .style("opacity", 0);

            {{ chart_title.render_chart_title() }}
            {{ control_bar.render_control_bar() }}
            {{ render_structure.render_component_structure() }}
            {{ control_panel.render_control_panel('query_handler', 'vis_id') }}
            {{ export_functionality.export() }}
            {{ overview_tooltip.create_overview_tooltip('vis_id') }}
            {{ axis_functionality.render_axis_handlers('xText', 'yText', 'vis_id') }}

            xScale = d3.scaleLinear()
                .range([0, width]);

            yScale = d3.scaleLinear()
                .range([height, 0]);

            rScale = d3.scaleLog()
                .range([10, radius]);


            if (typeof x_min === 'undefined') {
```

```
{% macro export() %}
{% if Component|check('Exportation') == 'True' %}
d3.select("#save-{{ Component['@component_id'] }}")
    .on("mouseover", function () {
        d3.select(this).style("cursor", "pointer");
        d3.select(this).style("opacity", 1);
    })
    .on("mouseout", function () {
        d3.select(this).style("cursor", "default");
        d3.select(this).style("opacity", 0.3);
    })
    .on("click", function () {
        d3.select(this).style("opacity", 0);
        saveSvgAsPng(
            d3.select("#original_svg_{{ Component['@component_id'] }}")
                .node(),
            "{{ Component['@component_id'] }}" + '.png',
            {backgroundColor: 'white', scale: 4}
        );
    });
{% endif %}
{%- endmacro %}
```

Code fragment wrapped within the “export()” macro (associated to the “Export” functionality)

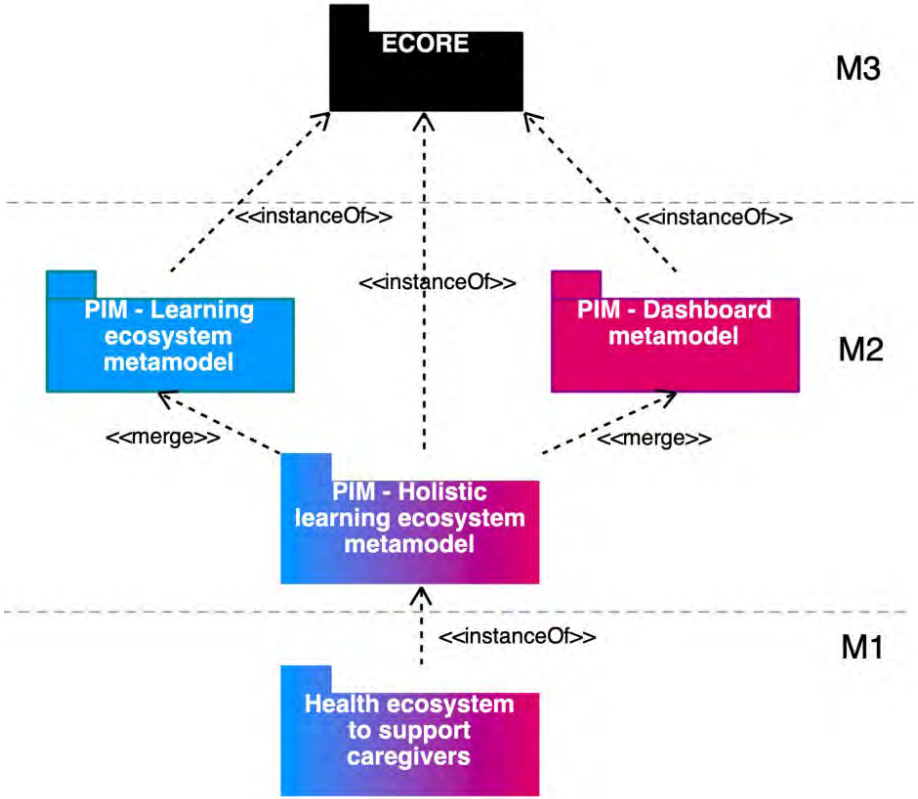

Template
Component configuration
function my(selection) {
selection.each(function () {
var tooltipScatterDiagram = d3.select("body").append("div")
.attr("class", "tooltip")
.attr("id", "compare-tooltip")
.style("display", "none")
.style("opacity", 0);
{{ chart_title.render_chart_title() }}
{{ control_bar.render_control_bar() }}
{{ render_structure.render_component_structure() }}
{{ control_panel.render_control_panel('query_handler', 'vis_id') }}
{{ export_functionality.export() }}
{{ overview_tooltip.create_overview_tooltip('vis_id') }}
{{ axis_functionality.render_axis_handlers('xText', 'yText', 'vis_id') }}
xScale = d3.scaleLinear()
.range([0, width]);
yScale = d3.scaleLinear()
.range([height, 0]);
rScale = d3.scaleLog()
.range([10, radius]);
Macro
{% macro export() %}
{% if Component|check('Exportation') == 'True' %}
CONDITION
d3.select("#save-{{ Component['@component_id'] }}")
.on("mouseover", function () {
d3.select(this).style("cursor", "pointer");
d3.select(this).style("opacity", 1);
})
.on("mouseout", function () {
d3.select(this).style("cursor", "default");
d3.select(this).style("opacity", 0.3);
})
.on("click", function () {
d3.select(this).style("opacity", 0);
saveSvgAsPng(d3.select("#original_svg_{{ Component['@component_id'] }}").node(),
"{{ Component['@component_id'] }}" + '.png',
{backgroundColor: 'white', scale: 4});
});
{% endif %}
{%- endmacro %}
Generated source code
.style("float", "left")
.style("position", "relative")
.style("width", width + "px")
.attr("id", "vis_container_ScatterDiagram_1");
d3.select("#save-ScatterDiagram_1")
.on("mouseover", function() {
d3.select(this).style("cursor", "pointer");
d3.select(this).style("opacity", 1);
})
.on("mouseout", function() {
d3.select(this).style("cursor", "default");
d3.select(this).style("opacity", 0.3);
})
.on("click", function() {
d3.select(this).style("opacity", 0);
saveSvgAsPng(d3.select("#original_svg_ScatterDiagram_1").node(),
"ScatterDiagram_1" + '.png', {
backgroundColor: 'white',
scale: 4
});
});
d3.select("body")
.append("div")
.attr("class", "tooltip")
.attr("id", "overview-tooltip-" + vis_id)
If the target condition is met, the associated functionality is injected in the final source code

5.
Applications

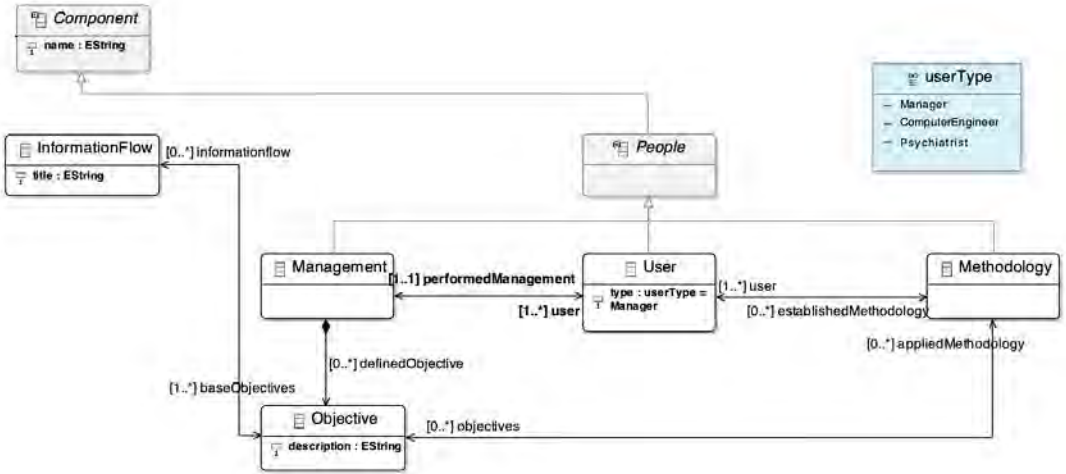
Meta-model integration

HOLISTIC INTEGRATION

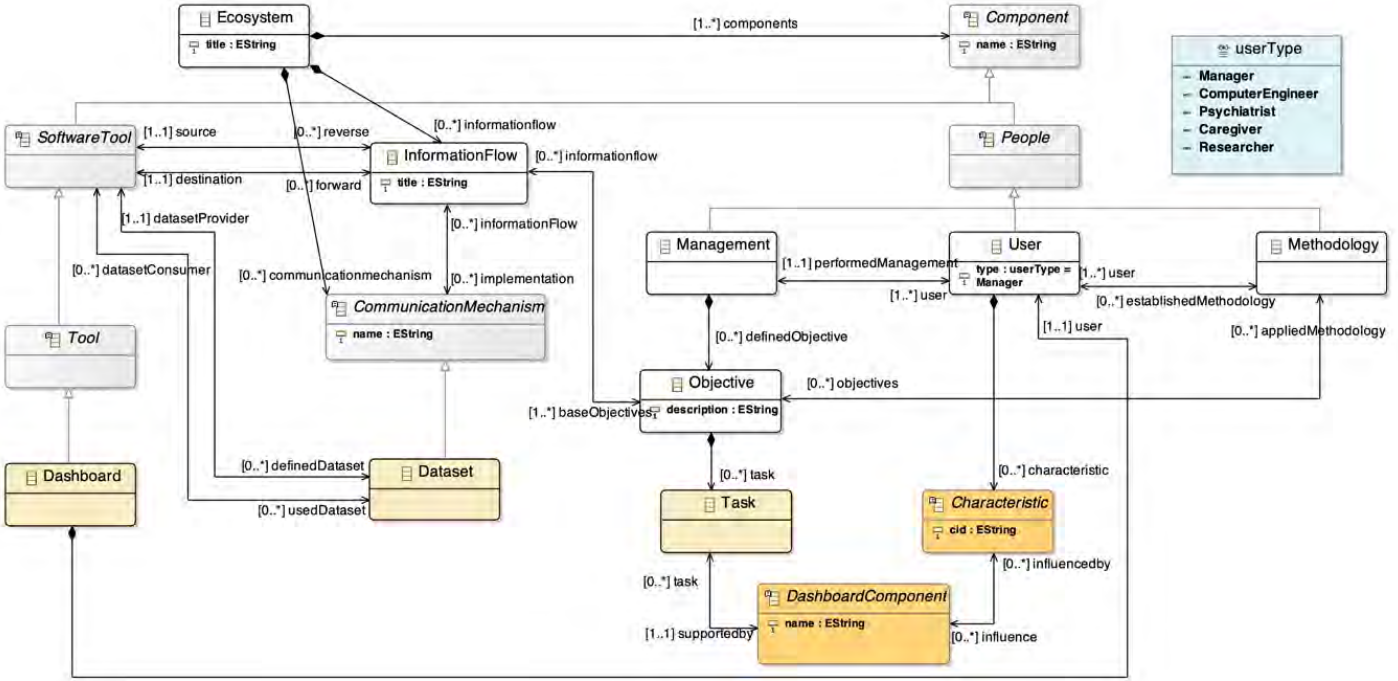
Integration



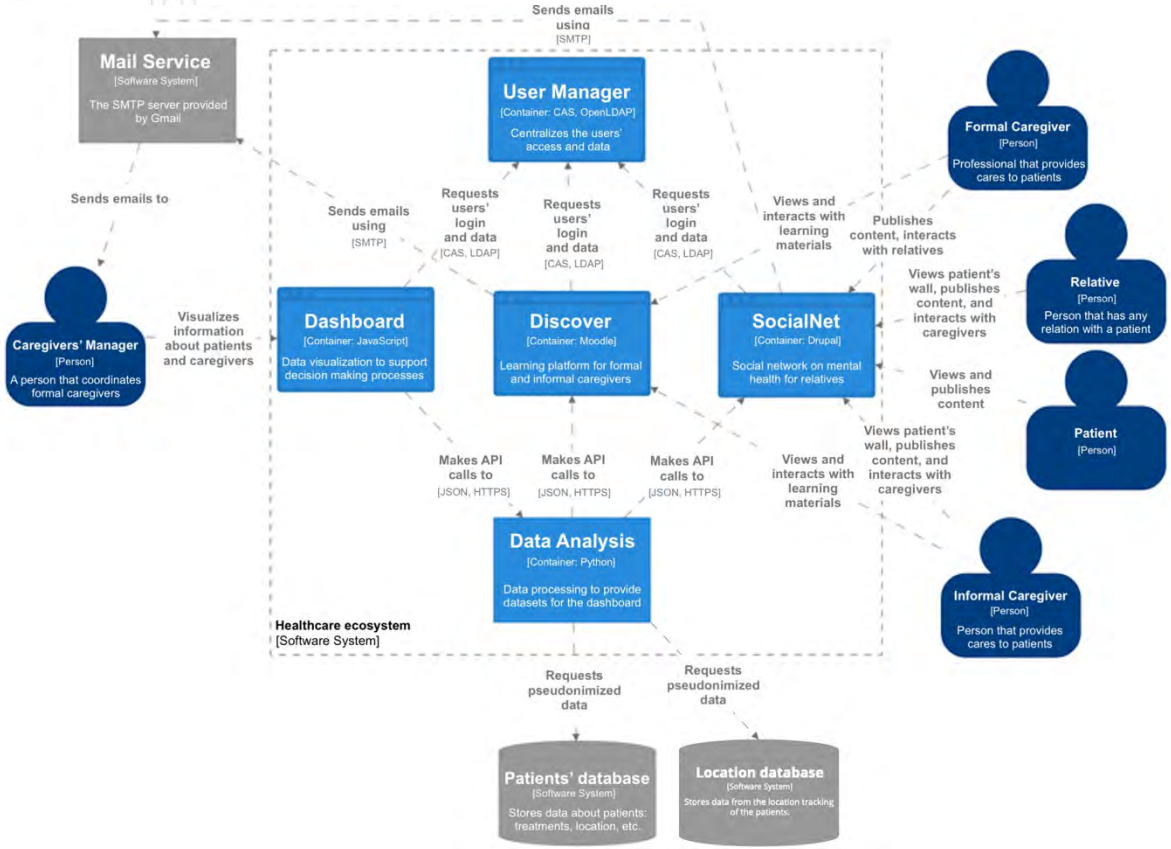
Human factor



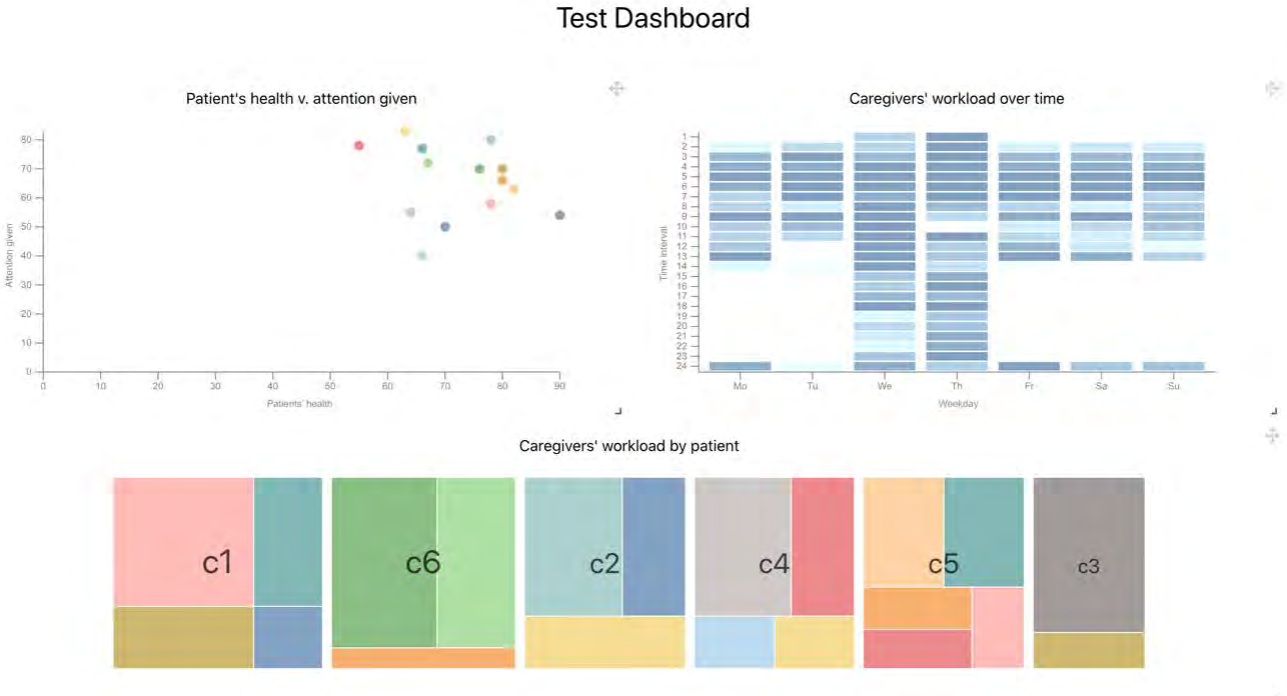
Meta-model integration



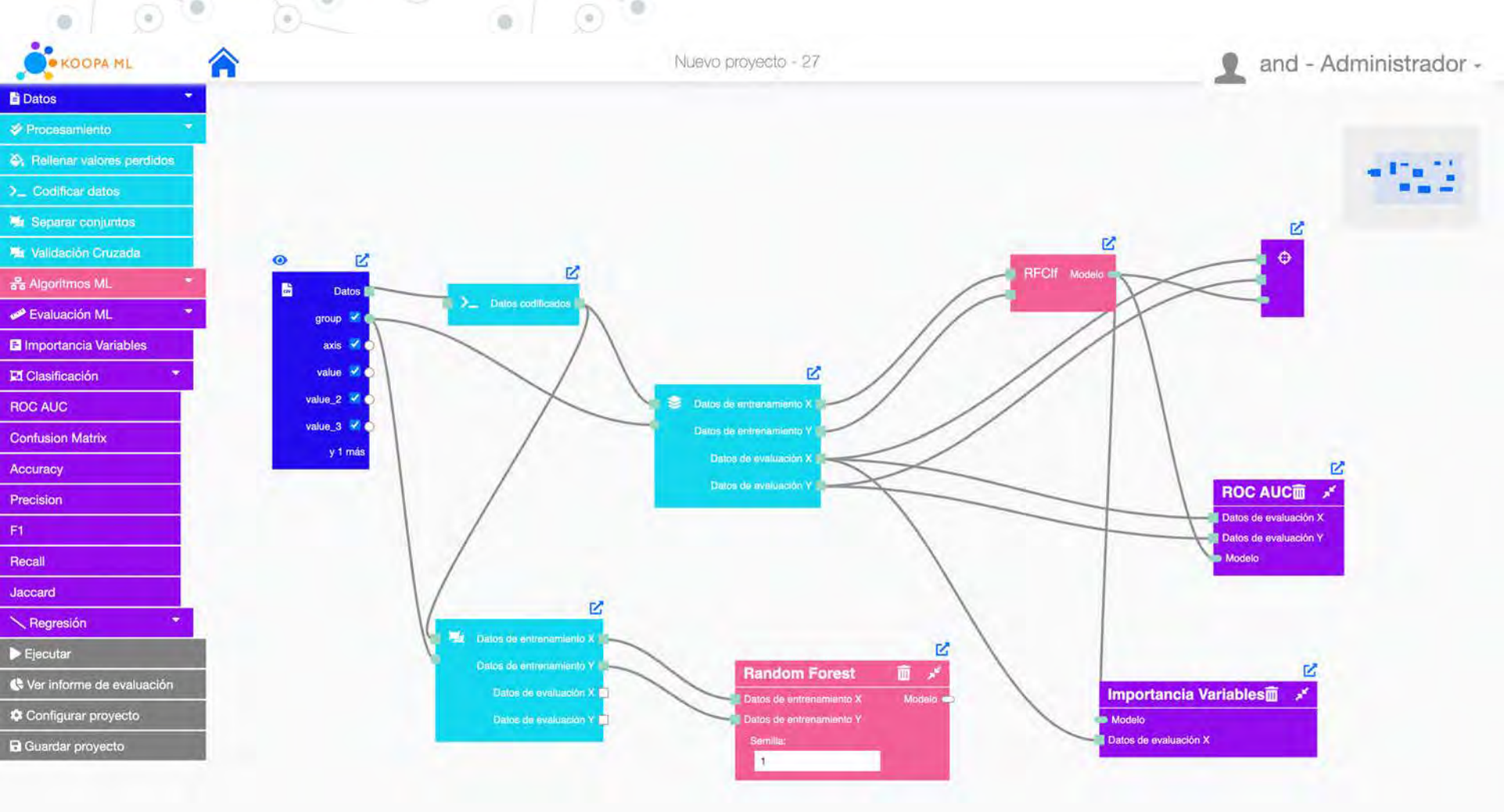
Architecture



Dashboard generation



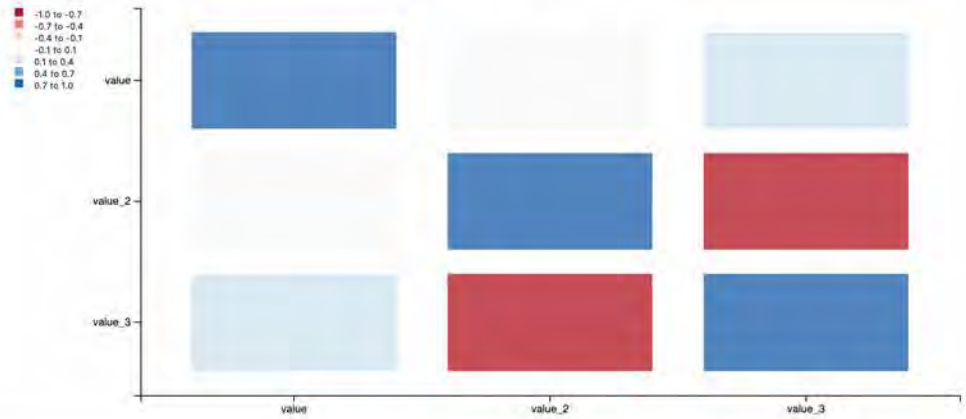
KOOPA-ML


KOOPA ML
Nuevo proyecto - 27
and - Administrador
Datos
Procesamiento
Rellenar valores perdidos
Codificar datos
Separar conjuntos
Validación Cruzada
Algoritmos ML
Evaluación ML
Importancia Variables
Clasificación
ROC AUC
Confusion Matrix
Accuracy
Precision
F1
Recall
Jaccard
Regresión
Ejecutar
Ver informe de evaluación
Configurar proyecto
Guardar proyecto
Datos
group
axis
value
value_2
value_3
y 1 más
Datos codificados
Datos de entrenamiento X
Datos de entrenamiento Y
Datos de evaluación X
Datos de evaluación Y
RFClf
Modelo
ROC AUC
Datos de evaluación X
Datos de evaluación Y
Modelo
Random Forest
Datos de entrenamiento X
Datos de entrenamiento Y
Modelo
Semilla:
1
Importancia Variables
Modelo
Datos de evaluación X

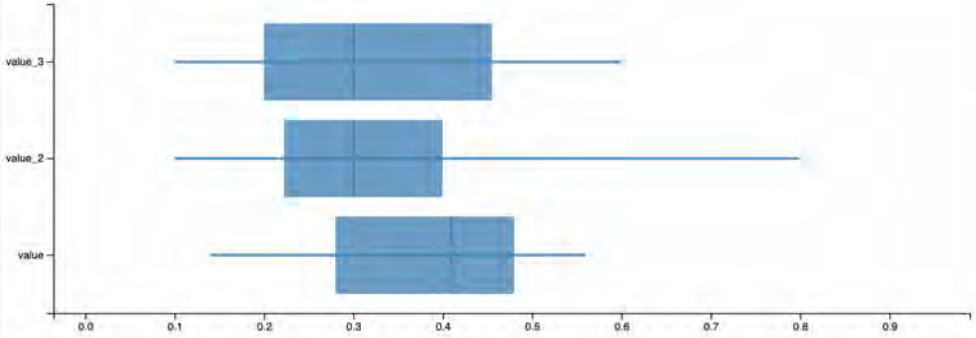
Sumario de los datos

Dataset | Resumen estadístico | Validación 1

Correlation Matrix

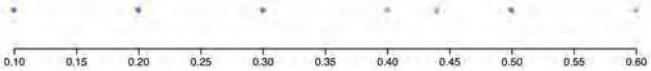


Numeric variables distribution

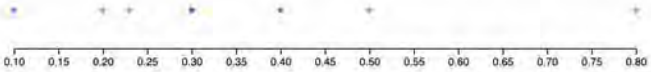


Variable Group2 distribution

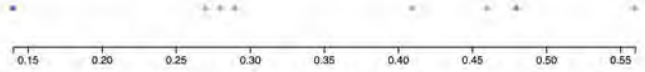
Variable value_3 distribution



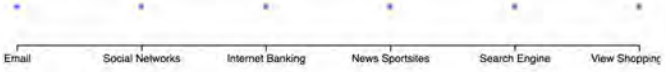
Variable value_2 distribution



Variable value distribution

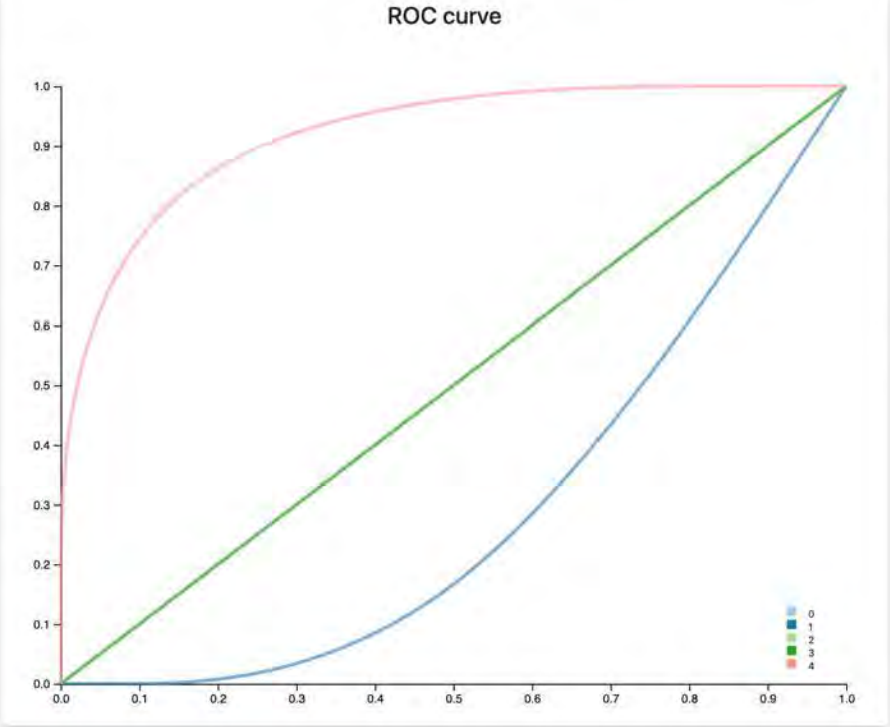


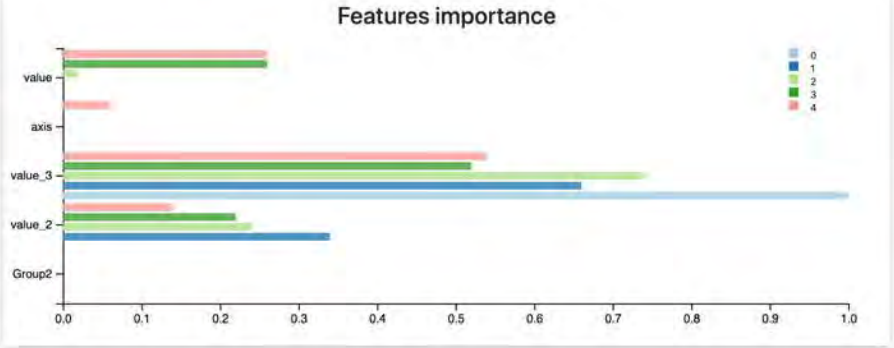
Variable axis distribution

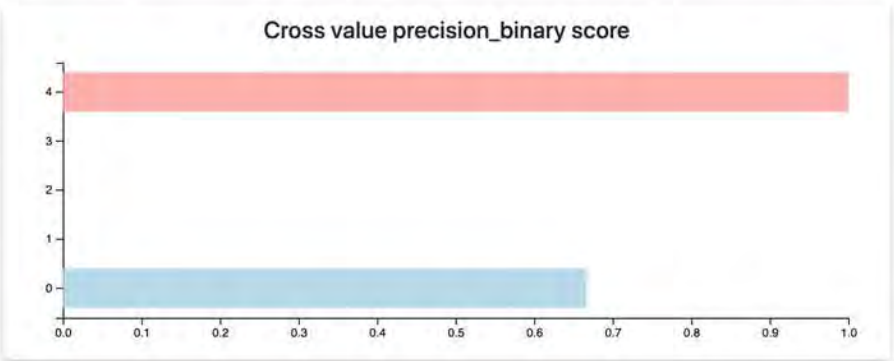


Variable group distribution

Sumario de métricas del modelo Random Forest (id: 16)



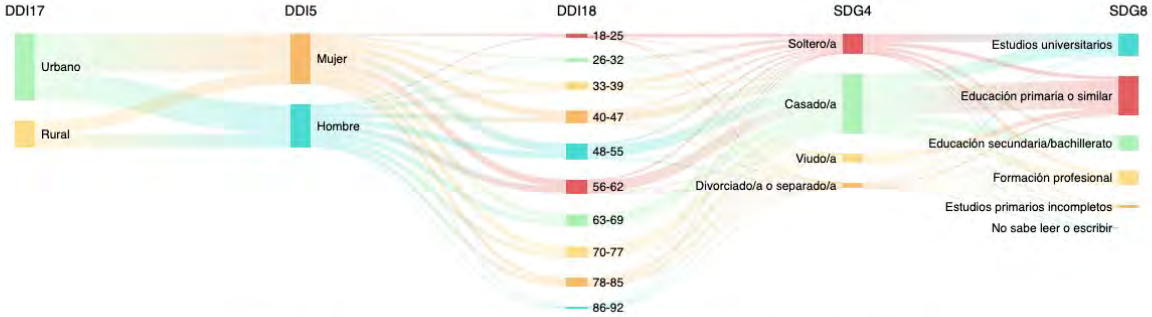




SALMANTICOR

SALMANTICOR | Factores de riesgo | Explorador BETA

- FRH4 Exfumador (desde hace más 1 año) 0 = No; 1 = Si
- FRH6 Vino 0=No; 1=Si
- FRH9 Cerveza 0=No; 1=Si
- FRH12 Chupitos 0=No; 1=Si
- FRH15 Copas 0=No; 1=Si
- FRH18 ¿Tiene usted la TA alta? 0=No; 1=Si; 2=No sabe
- FRH19 ¿Toma algún medicamento para la TA? 0=No; 1=Si; 2=No sabe
- FRH20 ¿Tiene usted el colesterol alto? 0=No; 1=Si; 2=No sabe
- FRH21 ¿Tiene usted el azúcar alto? 0=No; 1=Si; 2=No sabe
- FRH22 ¿Ha padecido usted del corazón? 0=No; 1=Si; 2=No sabe
- FRH23 ¿Algún familiar suyo ha tenido infarto o angina? 0=No; 1=Si; 2=No sabe

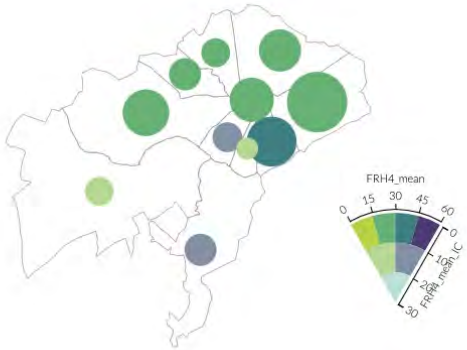


SALAMANCA - Rural

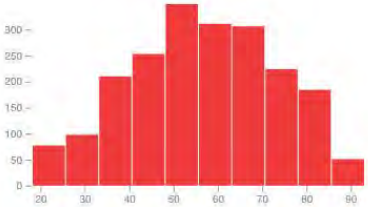
Media por cada 100 habitantes para la variable FRH6

SALAMANCA - Urbano

Media por cada 100 habitantes para la variable FRH6



Edad



Buscar...

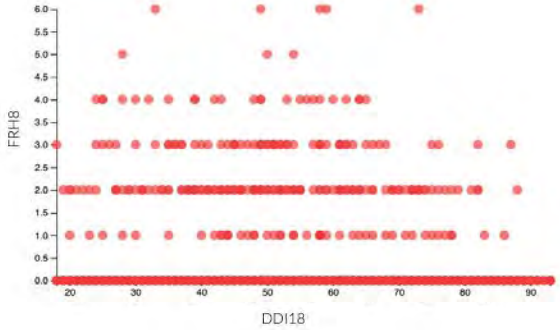
- DDI5
  Sexo 0=H; 1=M
- DDI14
  Código postal Hospital
- DDI15
  E Sing Hospital
- DDI16
  Municipio Hospital
- DDI17
  Ámbito 0=URBANO; 1=RURAL
- DDI18
  Edad

Correlación

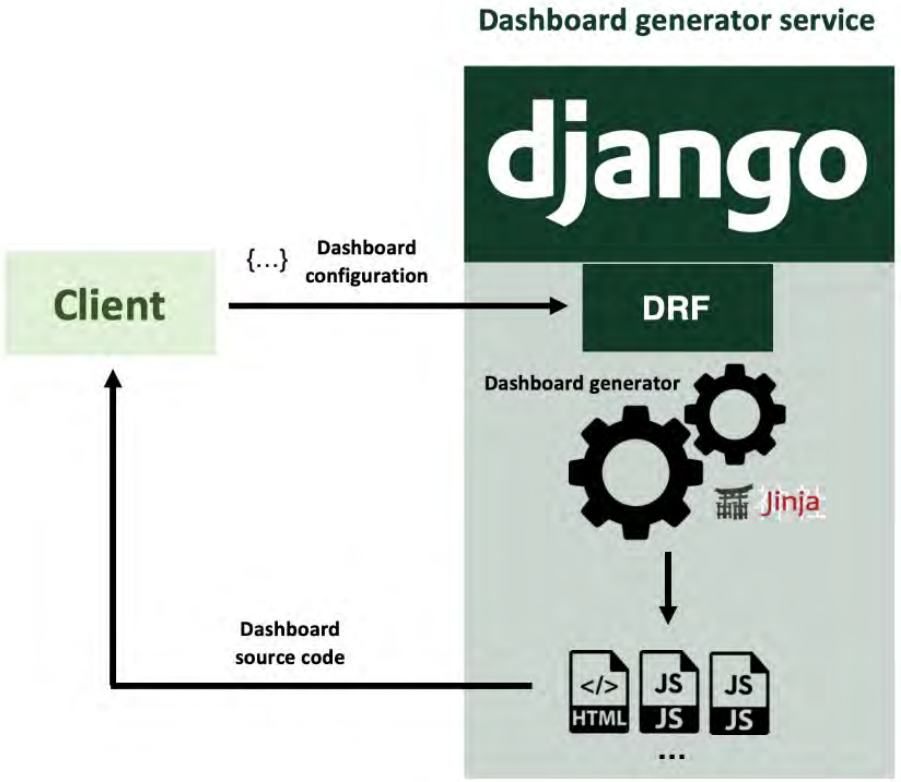
DDI18

FRHI

Vista previa HTML

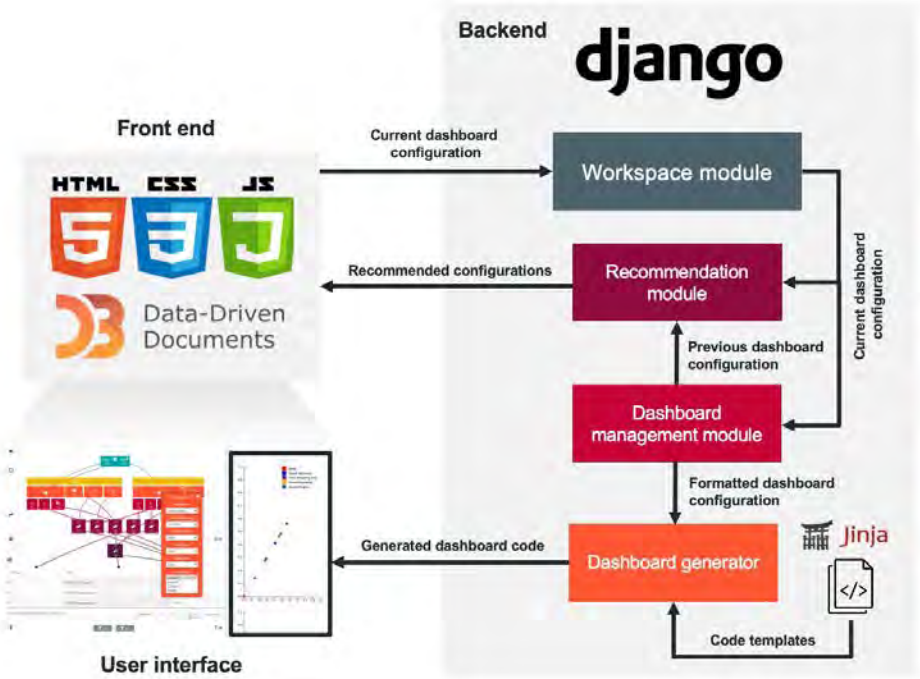


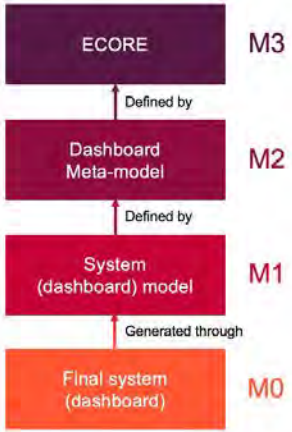
Architecture



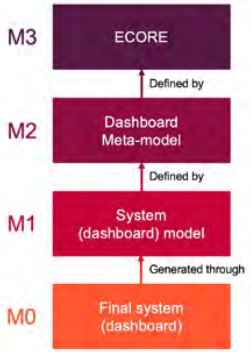
MetaViz

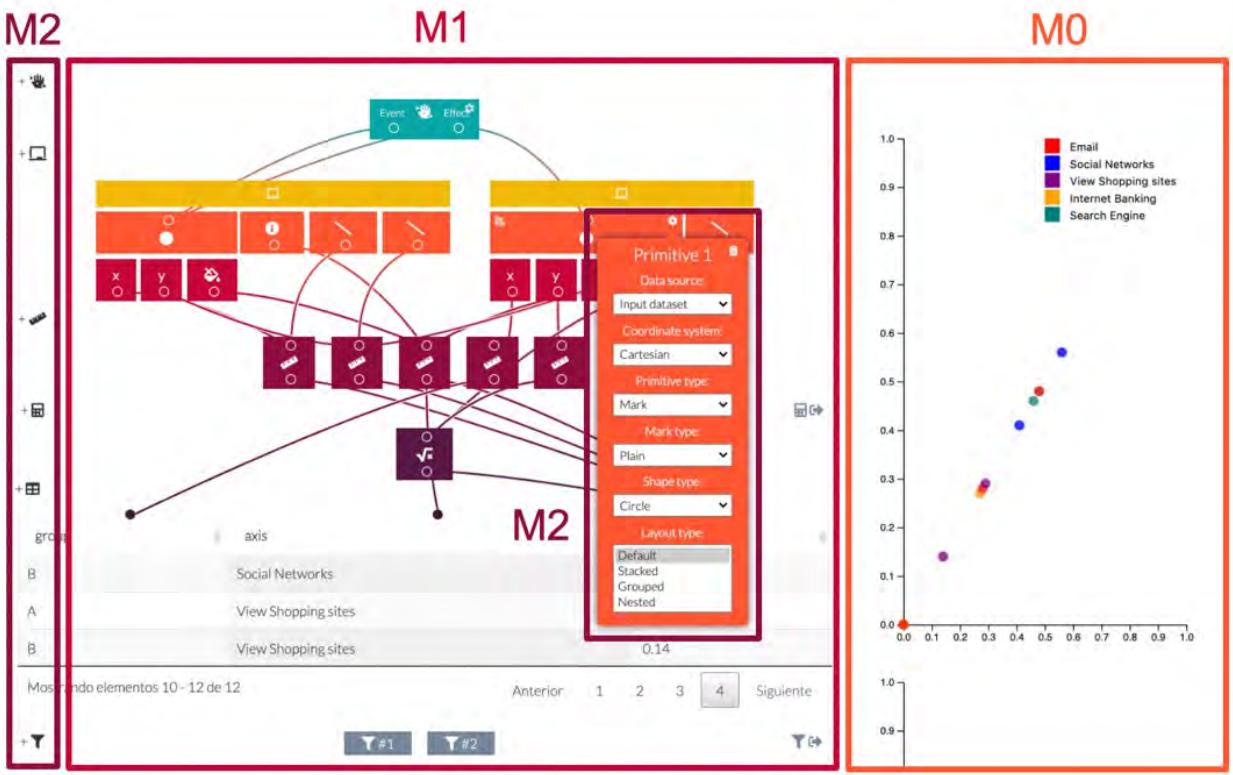
Architecture



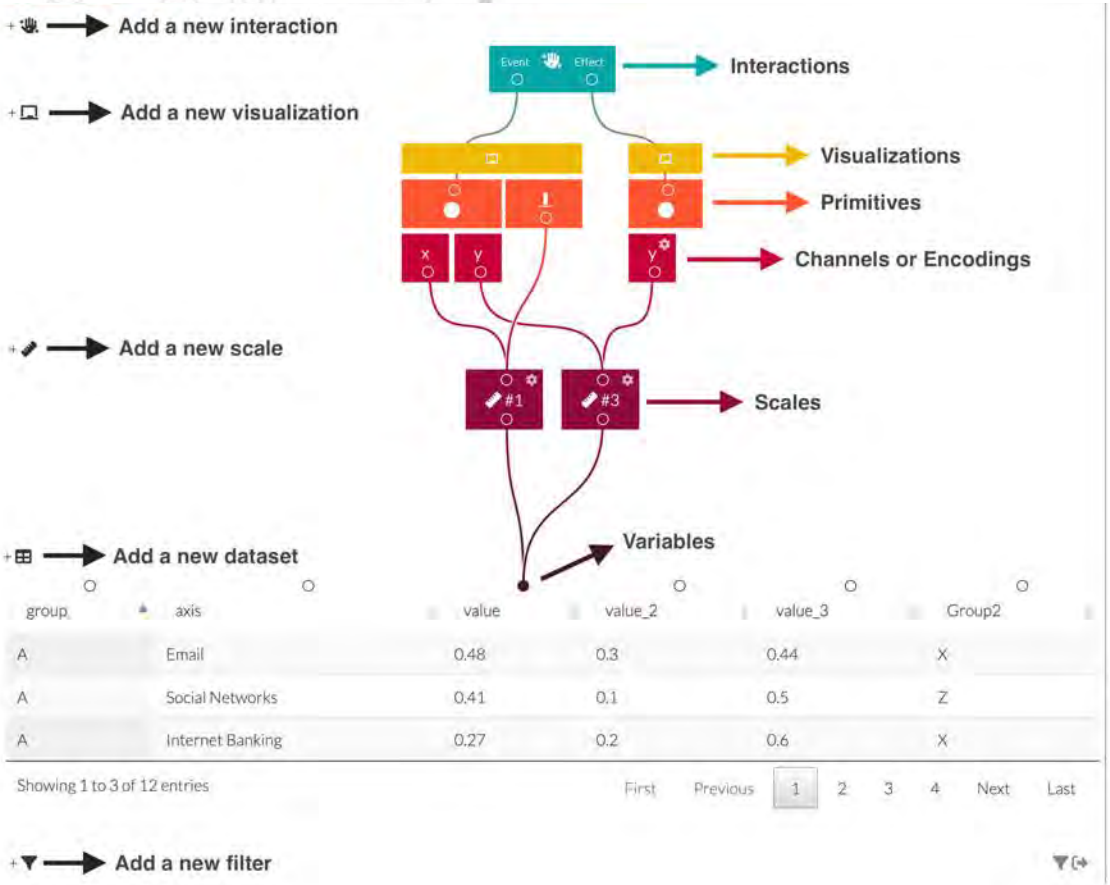


Interface


M3
ECORE
Defined by
M2
Dashboard Meta-model
Defined by
M1
System (dashboard) model
Generated through
M0
Final system (dashboard)


M2
M1
M0
Event
Effect
Primitive 1
Data source:
Input dataset
Coordinate system:
Cartesian
Primitive type:
Mark
Mark type:
Plain
Shape type:
Circle
Layout type:
Default
Stacked
Grouped
Nested
M2
axis
B
Social Networks
A
View Shopping sites
B
View Shopping sites
0.14
Anterior
1
2
3
4
Siguiente
#1
#2
Email
Social Networks
View Shopping sites
Internet Banking
Search Engine

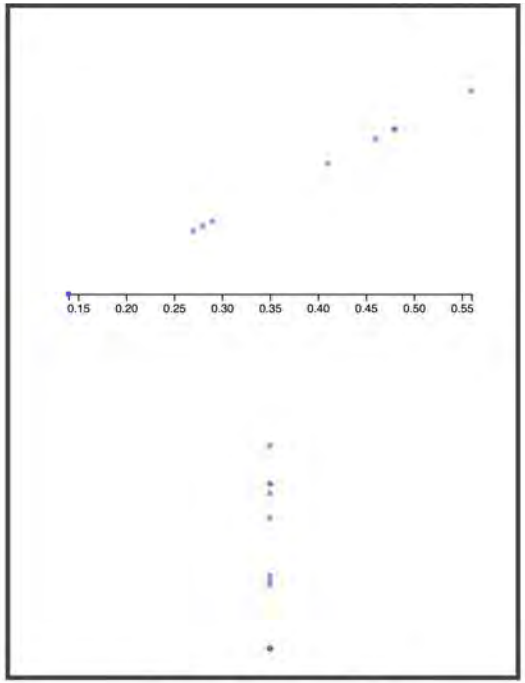
Interface



group	axis	value	value_2	value_3	Group2
A	Email	0.48	0.3	0.44	X
A	Social Networks	0.41	0.1	0.5	Z
A	Internet Banking	0.27	0.2	0.6	X

Showing 1 to 3 of 12 entries

First Previous 1 2 3 4 Next Last



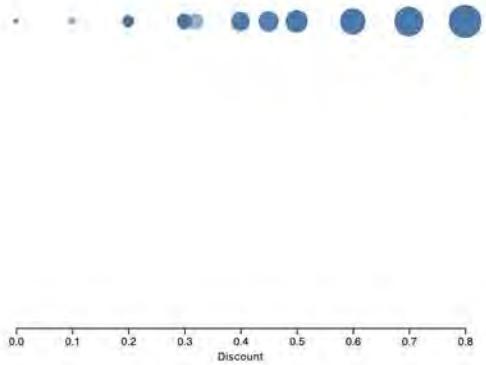
Generated visualizations

Ship Mode	Sales	Quantity	Segment	Discount	Country	City	State	Postal Code	Region	Category	Sub-Category
First Class	1097.5439999999999	7	Corporate	0.2	United States	Richardson	Texas	75080	Central	Technology	Phones
First Class	190.92	5	Corporate	0.6	United States	Richardson	Texas	75080	Central	Furniture	Furnishings
First Class	45.98	2	Corporate	0.0	United States	Eagan	Minnesota	55122	Central	Technology	Accessories

Showing 1 to 3 of 298 entries

First Previous 1 2 3 4 5 ... 100 Next Last

Test 1



Referencias y bibliografía

Barbosa, O., & Alves, C. (2011). A systematic mapping study on software ecosystems. In *3rd International Workshop on Software Ecosystems 2011, IWSECO 2011* (Vol. 746, pp. 15-26). Brussels, Belgium: CEUR-WS.

Casany, M. J., Alier, M., Conde, M. Á., & García-Peñalvo, F. J. (2009). SOA initiatives for eLearning. A Moodle case. In *23rd International Conference on Advanced Information Networking and Applications, AINA 2009, Workshops Proceedings. The International Symposium on Mining and Web (MAW 2009)* (pp. 750-755). IEEE Computer Society. https://doi.org/10.1109/waina.2009.196

Conde-González, M. Á., García-Peñalvo, F. J., Casany, M. J., & Alier, M. (2009). Adapting LMS architecture to the SOA: an Architectural Approach. In H. Sasaki, G. O. Bellot, M. Ehmann, & O. Dini (Eds.), *Proceedings of the Fourth International Conference on Internet and Web Applications and Services – ICIW 2009 (Venice/Mestre, Italy, 24-28 May 2009)* (pp. 322-327). IEEE Computer Society. https://doi.org/10.1109/iciw.2009.54

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2014). Knowledge Spirals in Higher Education Teaching Innovation. *International Journal of Knowledge Management, 10*(4), 16-37. doi:10.4018/ijkm.2014100102

Franco-Bedoya, O., Ameller, D., Costal, D., & Franch, X. (2017). Open source software ecosystems: A Systematic mapping. *Information and Software Technology, 91*, 160-185. doi:10.1016/j.infsof.2017.07.007

García-Holgado, A., & García-Peñalvo, F. J. (2017). A Metamodel Proposal for Developing Learning Ecosystems. En P. Zaphiris & A. Ioannou (Eds.), *Learning and Collaboration Technologies. Novel Learning Ecosystems. 4th International Conference, LCT 2017. Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9–14, 2017. Proceedings, Part I* (Vol. 10295, pp. 100-109). Switzerland: Springer International Publishing.

García-Holgado, A., & García-Peñalvo, F. J. (2019). Validation of the learning ecosystem metamodel using transformation rules. *Future Generation Computer Systems, 91*, 300-310. https://doi.org/10.1016/j.future.2018.09.011

García-Peñalvo, F. J., Vázquez-Ingelmo, A., García-Holgado, A., Sampedro-Gómez, J., Sánchez-Puente, A., Vicente-Palacios, V., Dorado-Díaz, P. I., & Sánchez, P. L. (2021). Application of Artificial Intelligence Algorithms Within the Medical Context for Non-Specialized Users: the CARTIER-IA Platform. *International Journal of Interactive Multimedia and Artificial Intelligence, 6*(6), 46-53. https://doi.org/10.9781/ijimai.2021.05.005

Hailpern, B., & Tarr, P. (2006). Model-driven development: The good, the bad, and the ugly. *IBM Systems Journal, 45*(3), 451-461.

Hill, T., & Westbrook, R. (1997). SWOT analysis: it's time for a product recall. *Long range planning, 30*(1), 46-52.

Langefors, B. (1977). Information systems theory. *Information Systems, 2*(4), 207-219. doi:10.1016/0306-4379(77)90009-6

Laudon, K. C., & Laudon, J. P. (1991). *Essentials of Management Information Systems: Transforming Business and Management*. Upper Saddle River, NJ: Prentice Hall.

López-Fernández, J. J., Guerra, E., & de Lara, J. (2014). Assessing the Quality of Meta-models. En F. Boulanger, M. Famelis, & D. Ratiu (Eds.), *MoDeVVa* (Vol. 1235, pp. 3-22). Valencia, Spain: CEUR Workshop Proceedings.

Marrero, S. R., Nelson, J. C., Galán, M., Ocón, A., & Rubio, E. (2005). Metodología para organizar, recuperar y compartir recursos de información y conocimiento en un centro I+D+i en la Plataforma Suricata.

Natali, A. C. C., & Falbo, R. (2002). *Knowledge management in software engineering environments.* Trabajo presentado en Proceedings of the XVI Brazilian Symposium on Software Engineering (SBES'2002).

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization science, 5*(1), 14-37. doi:10.1287/orsc.5.1.14.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford, UK: Oxford university press.

Sadi, M. H., & Yu, E. (2015). Designing software ecosystems: How can modeling techniques help? En K. Gaaloul, R. Schmidt, S. Nurcan, S. Guerreiro, & Q. Ma (Eds.), *Enterprise, Business-Process and Information Systems Modeling. BPMDS 2015, EMMSAD 2015. Lecture Notes in Business Information Processing* (Vol. 214, pp. 360-375). Cham: Springer.

Vázquez-Ingelmo, A., García-Peñalvo, F. J., & Therón, R. (2019). Information Dashboards and Tailoring Capabilities - A Systematic Literature Review. *IEEE Access, 7*, 109673-109688. https://doi.org/10.1109/ACCESS.2019.2933472

Vázquez-Ingelmo, A., García-Peñalvo, F. J., Therón, R., Amo-Filvà, D., & Fonseca-Escudero, D. (2020). Connecting domain-specific features to source code: Towards the automatization of dashboard generation. *Cluster Computing. The Journal of Networks, Software Tools and Applications, 23*, 1803-1816. https://doi.org/10.1007/s10586-019-03012-1

Vázquez-Ingelmo, A., García-Peñalvo, F. J., Therón, R., & Conde, M. Á. (2020). Representing Data Visualization Goals and Tasks Through Meta-Modeling to Tailor Information Dashboards. *Applied Sciences, 10*(7), Article 2306. https://doi.org/10.3390/app10072306

Vázquez-Ingelmo, A., García-Peñalvo, F. J., & Therón, R. (2021). Towards a Technological Ecosystem to Provide Information Dashboards as a Service: A Dynamic Proposal for Supplying Dashboards Adapted to Specific Scenarios. *Applied Sciences, 11*(7), Article 3249. https://doi.org/10.3390/app11073249

Vázquez-Ingelmo, A., García-Holgado, A., García-Peñalvo, F. J., & Therón, R. (2022). Proof-of-concept of an information visualization classification approach based on their fine-grained features. *Expert Systems*, Article e12872. https://doi.org/10.1111/exsy.12872

Thank you!

Questions?

Meta-modeling ecosystems

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