Model-driven Generation of Graphical Maps for e-Contents

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Outline

- Background
  - Model Driven Software Development (MDSD)
- Motivations
- e-Content Model
- Editor and Grammar Construction
- Generation Process
- Map Visualization
- Conclusions

Model Driven Approach I

- Model Driven Software Development (MDSD) is a strategic issue in the modern software system:
  - it makes explicit knowledge (through the models) that usually remains implicit
  - it promotes automatic generation of code overcoming the gap between model and implementation

Model Driven Approach II

- Eclipse Modeling Framework (EMF) supports the development of *Platform Independent Model* in Ecore providing
  - a runtime support to produce a set of Java classes for the model
  - a set of adapter classes that enable viewing and command-based editing of the model
- Domain Specific Languages (DSL) are the core of MDSD in order to
  - capture the key aspect of the domain
  - promote automatic generation of code

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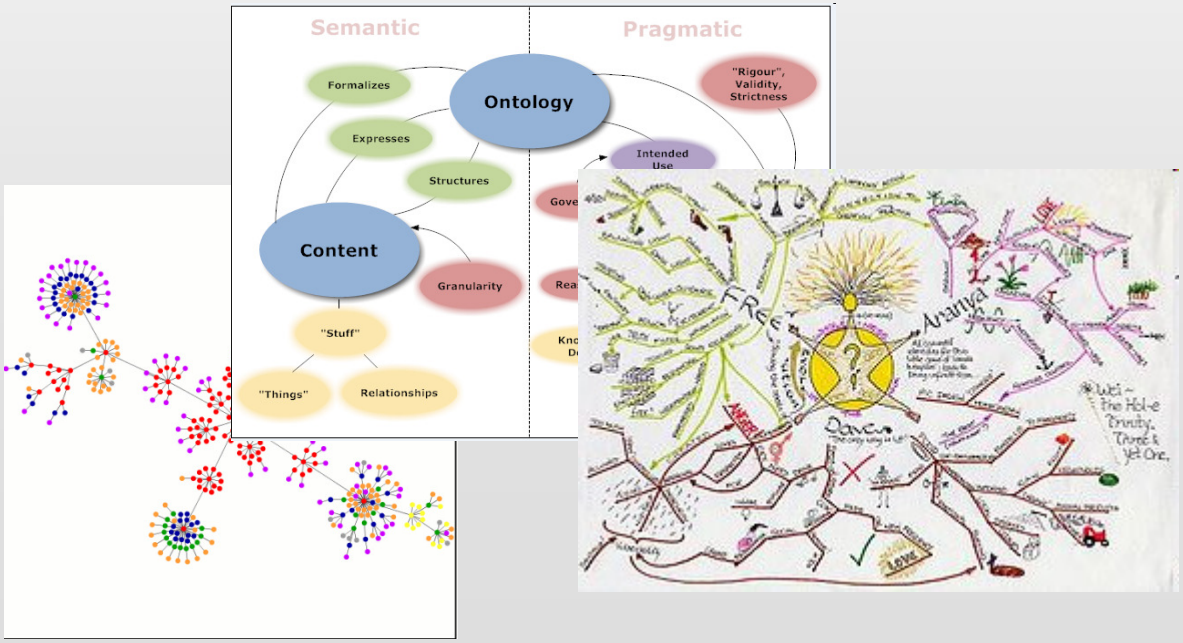
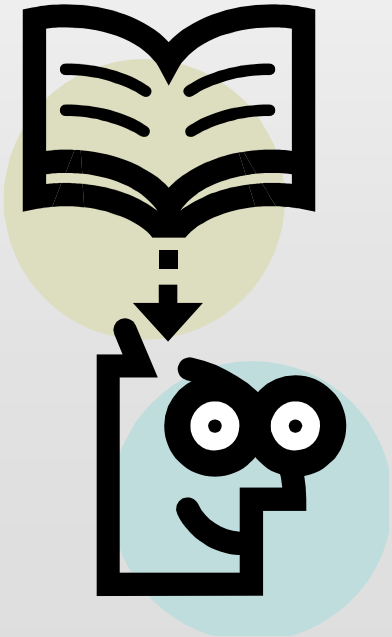
e-Content Organization I

- The content organization has a dramatic impact on the user ability to acquire knowledge
- We promote the use of graphical maps
  - to structure and organize information
  - to enhance understanding and learning

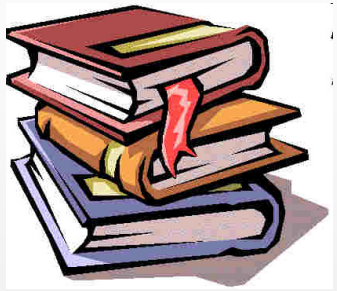




e-Content Organization II

- In our approach the conventional navigation loop

1.select a topic from a index,
2.open the topic, and
3.read the content



is replaced by

→ a semantic navigation that can be customized into reading path pre-planned by the designer and semantic map of contents

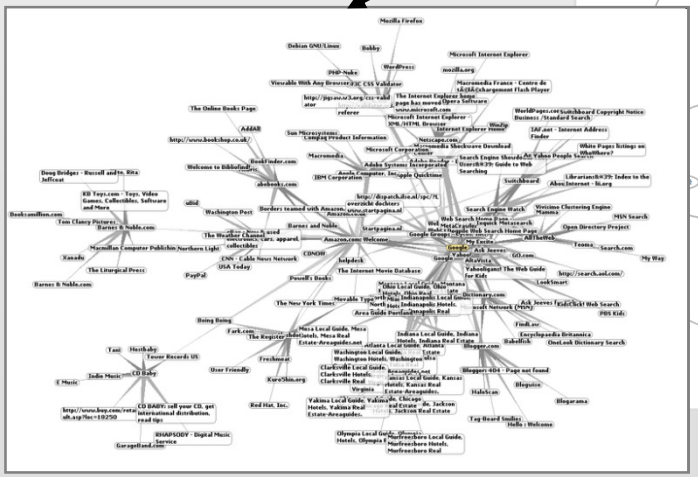
What have we done?

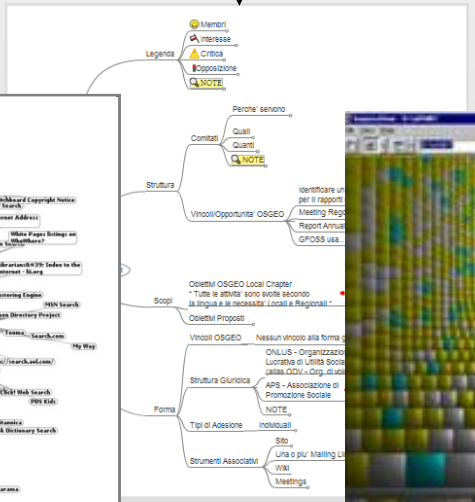
Content Model

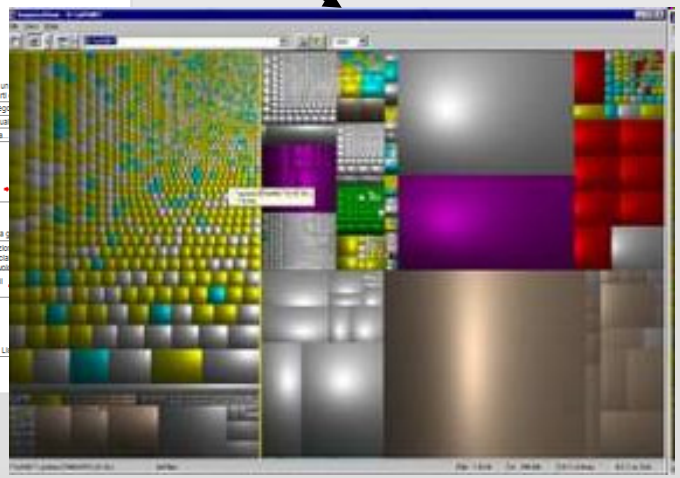
How to construct the model?

Generation System

How to provide the generation?







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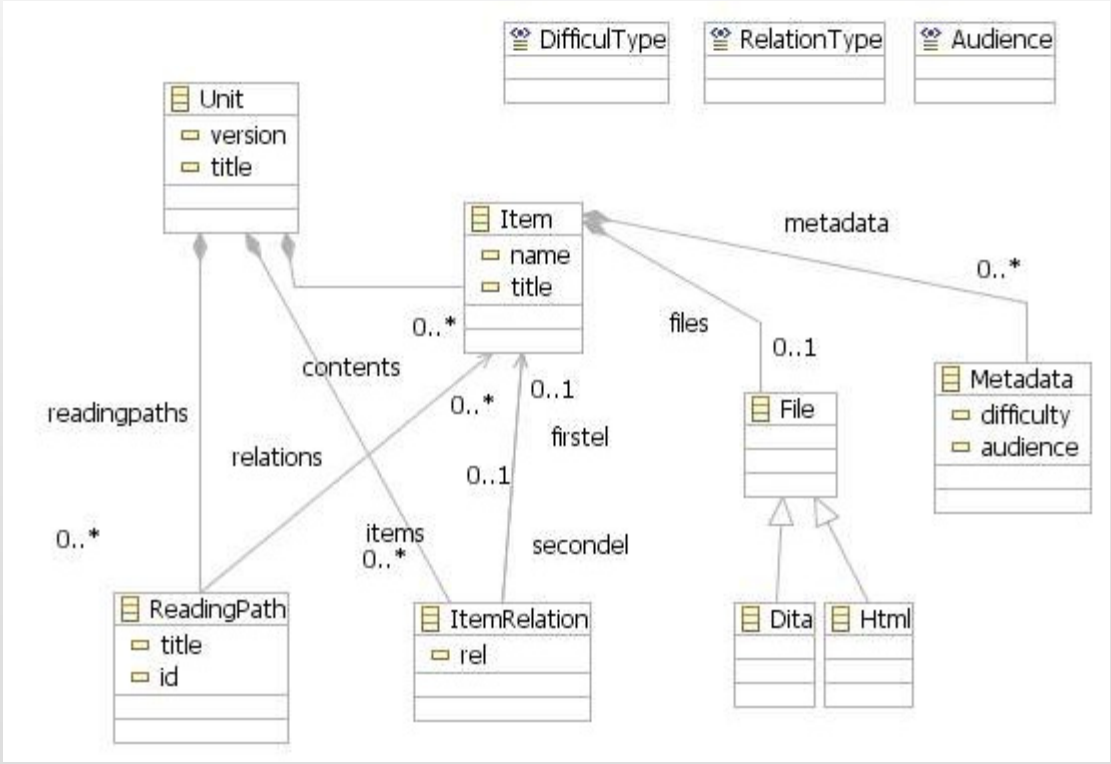
Meta Model

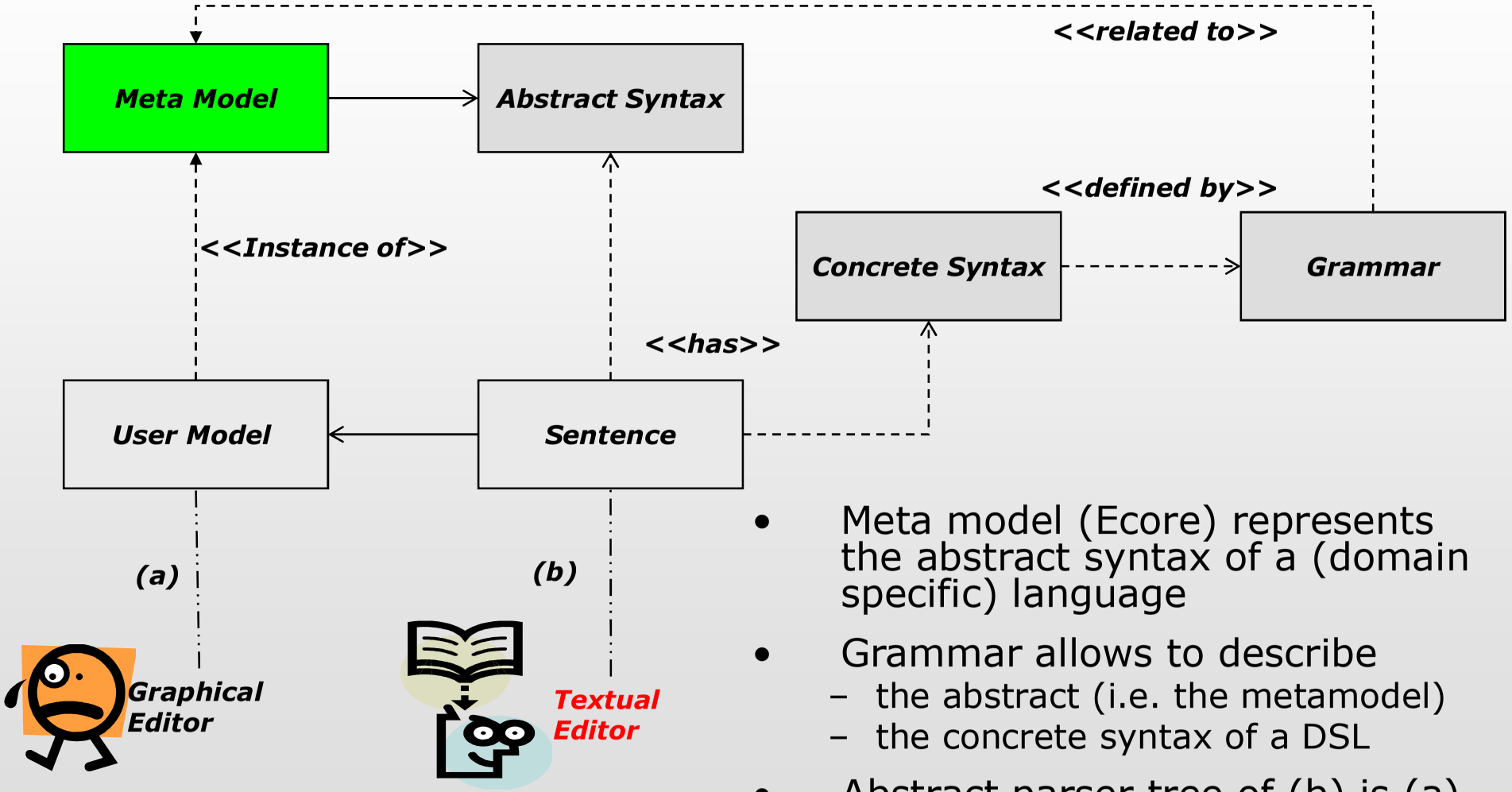
- In *[Natali et al. 2007]* the MDSD approach is adopted which define a formal model for its content:
  - The **meta model** defines (the abstract syntax of) a *domain specific language (*an extension of DITA concepts) for content organization



Textual Editor

- Text model representation
  - is useful for large systems (by experience)
  - is stored in a human-readable format (it is possible to exploit tools as CVS and SVN)
  - is makes easier the integration/transformation between different DSL
- Textual Editor (`xText`) provides
  - DSL specific **constraint checks**
  - **languages support** (code completion, syntax error …)

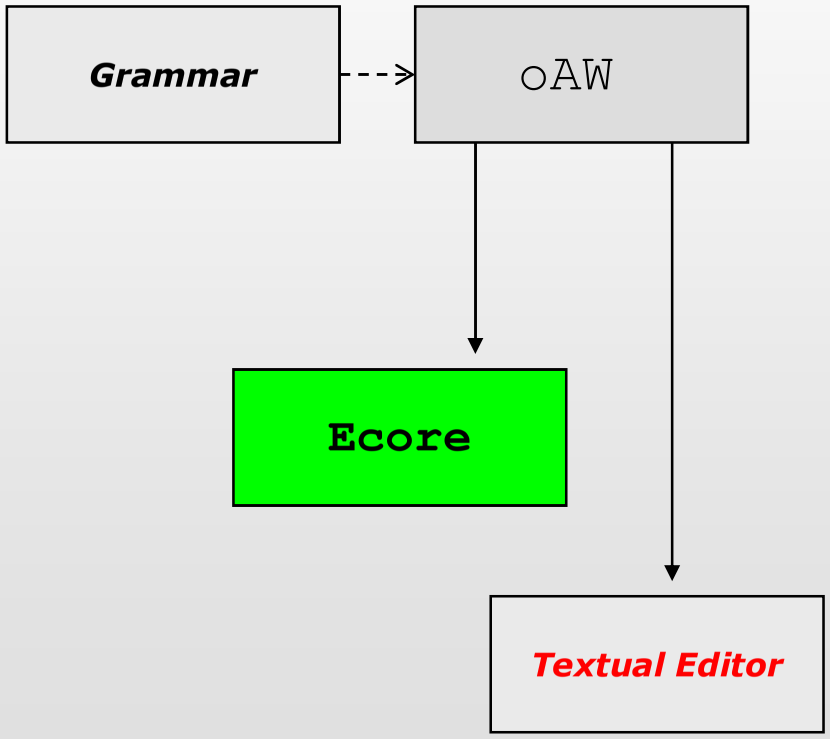
From Model to Grammar



- Meta model (Ecore) represents the abstract syntax of a (domain specific) language
- Grammar allows to describe
  - the abstract (i.e. the metamodel)
  - the concrete syntax of a DSL
- Abstract parser tree of (b) is (a)

Technology

- openArchitectureWare (oAW) is Eclipse Project for model driven software development; it supports:
  - the parser of models
  - the check and transformation of models
  - the code generation
- xText is a component of oAW. It supports:
  - text definition of DSL in EBNF notation
  - automatic generation of **textual editor** for Eclipse
  - automatic generation of Ecore meta model



Example of eContent organization specification

```
econtent Computer Science

item func
   title "Function"
   meta difficulty high audience beginner
   file “course\lp_function.dita”
item stat
   title "Statement“
   meta difficulty low audience beginner
   file “course\tp_statement.dita”
…
readingpath labpath { java prog jadt adt list }
readingpath thpath { func stat val adt list arr }

relation func preknowledge-of prog
relation stat preknowledge-of prog
…
```

Domain Specific Language

- To support the new contents organization our DSL provides the following concepts:
  - Each content `Unit` is composed of a set of logical contents called *Items* or *Topics*.
  - Each `Item` is associated to one or more resource `File` that can be written in any format readable by a conventional browser.
  - Each `Item` can be associated to a (empty) set of *metadata* including binary logical relations with other items.
  - The author can define one or more *reading paths*.
  - *Graphical maps* are used to arrange the items into custom-related highly-readable contexts.

Item Relation

- Item Relations are the key-concept introduced in the formal model in order to
  - specify semantic relations among parts of the content
  - represent content in term of conceptual map
- Set of defined relation types
  - *Preknowledge-of*: S assumes that the reader knows what is written in T
  - *Clarification-of*: T should make the content of S more clear;
  - *Conceptualization-of*: T presents the content of S in a more formal way;
  - *Widening-of*: T is a study in depth of S;
  - *Experiment-of*: T is an experiment related to S;
  - *Exercise-of*: T is an exercise related to S;
  - *Test-of*: T is an evaluation of the student understanding of S.

Grammar Rules in xText

```
Unit :
  "econtent" title=STRING
  ("version" version=ID)?
  (contents += Item)*
  (readingpaths += ReadingPath)*
  (relations += ItemRelation)* ;
Item :
  "item" name=ID
  "title" title=STRING
  ("path" files += File)+
  (metadata += Metadata)* ;
Metadata :  "meta"
   ("difficulty" difficulty=DifficulType)?
   ("audience" audience=Audience)? ;
File : STRING(Dita | Html) ; Dita : ".dita";
Html : ".html";
ReadingPath :
 "readingpath" id=ID title=STRING "{"
 (items += [Item])+ "}";
ItemRelation : "relation" firstel=[Item]
   rel=RelationType secondel=[Item];
Enum RelationType :  A1="widening-of" |…
Enum DifficulType : dt1="low" | … ;
Enum AudienceType : at1="expert"| …;
```

- Production rules are `RuleName:Description`
- `RuleName` is both
  - the name of the rule and
  - the name of the class (metatype) in the metamodel
- `Description` is made up of tokens that can be
  - a built-in token ID
  - KeywordTokens,
  - IdentifierTokens,
  - AssignmentTokens

Conversion Criteria

- For each *attribute* a keyword token (which is exploited by the editor to suggest text completion) must be defined through a standard assignment.
- For each *composition* you must define a += assignment in which the Rpart is the rule associated to the related metaclass.
- For each *association* (cardinality 1) you must define a standard assignment that makes reference to the rule associated to the related metaclass.
- For each *aggregation* you must define a += assignment in which the Rpart is a cross-reference to the rule associated to the related metaclass D (denoted with[D]).
- For each *generalization* you must define an abstract rule made of a sequence of alternatives that reflects the types hierarchy;
- For each *enumeration* type, you must define an enumeration rule Enum composed of a sequence of choices with all literals as terminal symbols.

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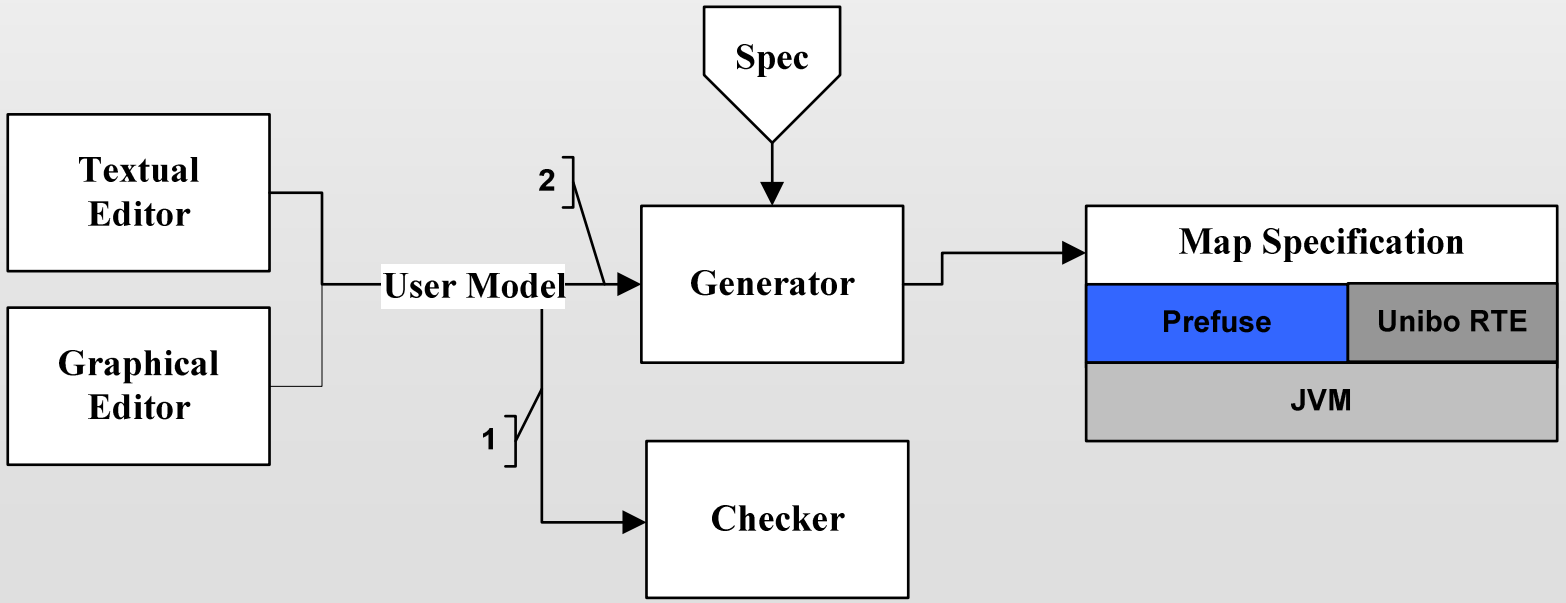
Generation System

- The **User Model** is the input to
  - the **checker** in order to validate the model based on OCL-like expression (`Xtend`)
  - the **generator** in order to produce the run-time support for the chosen platform and a set of graphical maps

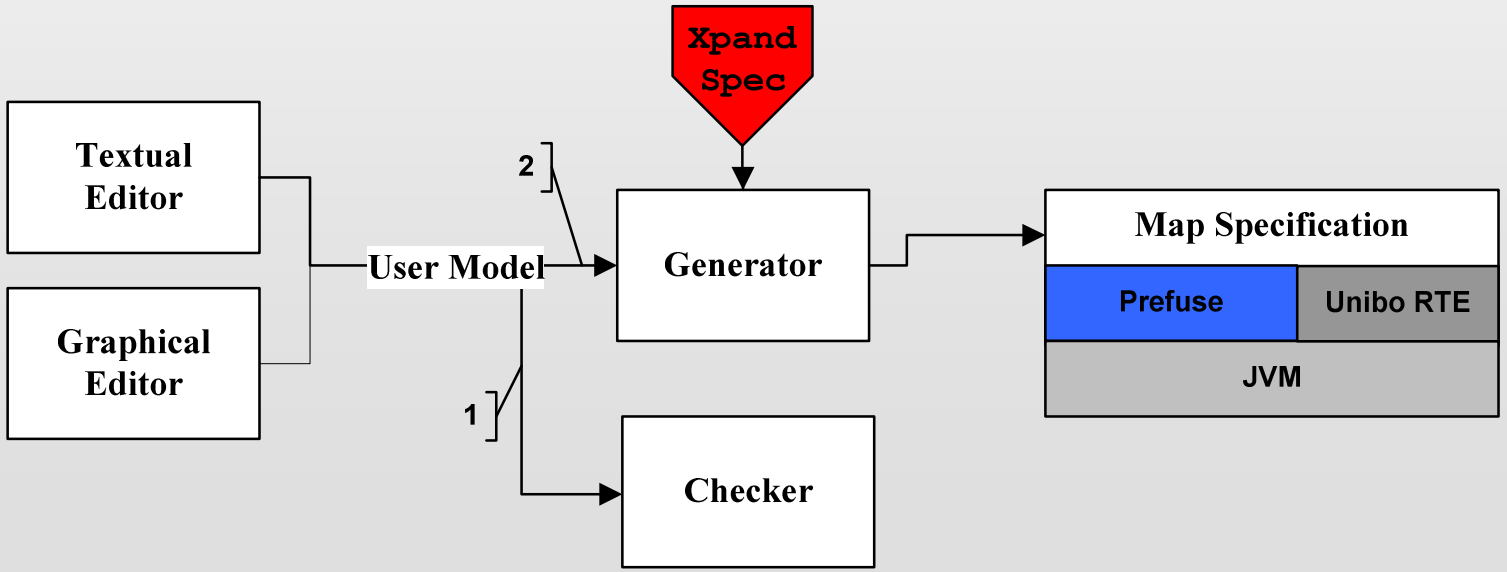


Reference Platform

- Reference platform is `Prefuse` (http://prefuse.org/)
  - It is an open source project to simply the creation of custom visualization
  - It is a highly reconfigurable rendering engine, with abstraction to
    - filter data
    - make actions over contents
    - assign layout

Automatic Code Generation

- To overcome the gap between the model (`course`) and the platform (`prefuse`)
  - we use automatic code generation of `oAW` based on `Xpand`, which
    - is a declarative language
    - is based on `DEFINE` blocks associated to the metamodel



Template (Xpand)

```
«IMPORT coursedsl»
«DEFINE main FOR Unit»
«FILE title+".xml"»
  <?xml version="1.0" encoding="UTF-8"?>
  <!-- Radial graph -->
  <graphml xmlns="http://graphml.graphdrawing.org/xmlns">
  <graph edgedefault="directed">
    <!-- data schema -->
    <key id="name" for="node" attr.name="name" attr.type="string"/>
    <key id="type" for="edge" attr.name="type" attr.type="string"/>
    <key id="diff" for="node" attr.name="diff" attr.type="Real"/>
    <key id="audi" for="node" attr.name="audi" attr.type="string"/>
    <!-- nodes -->
    «EXPAND node FOREACH this.contents»
    <!-- edges -->
    «EXPAND edge FOREACH this.relations»
  </graph>
  </graphml>
«ENDFILE»
«ENDDEFINE» …
```

Declarative specification of the rules (like XSLT)

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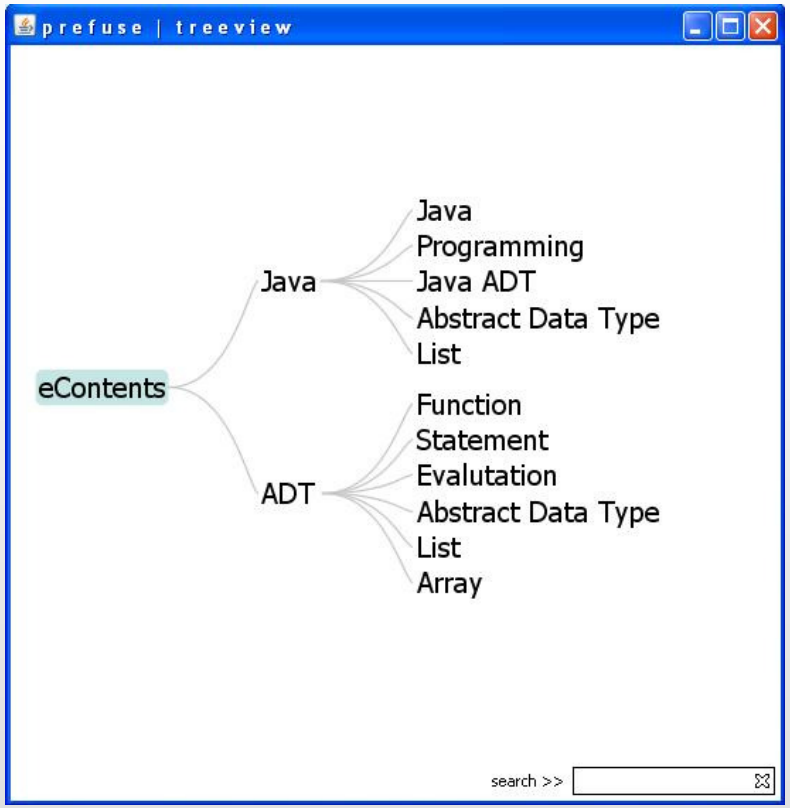
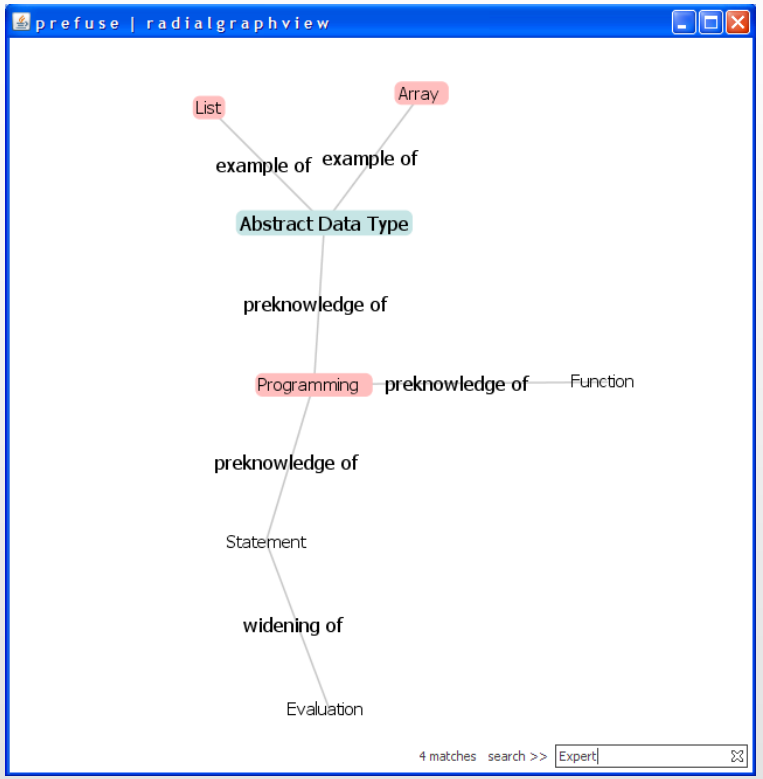
The Map: *tree view*

- Tree view: is a map style organized like classical hierarchical index
  - contents are dynamically opened and closed according to the user's requests



The Map: *radial graph*

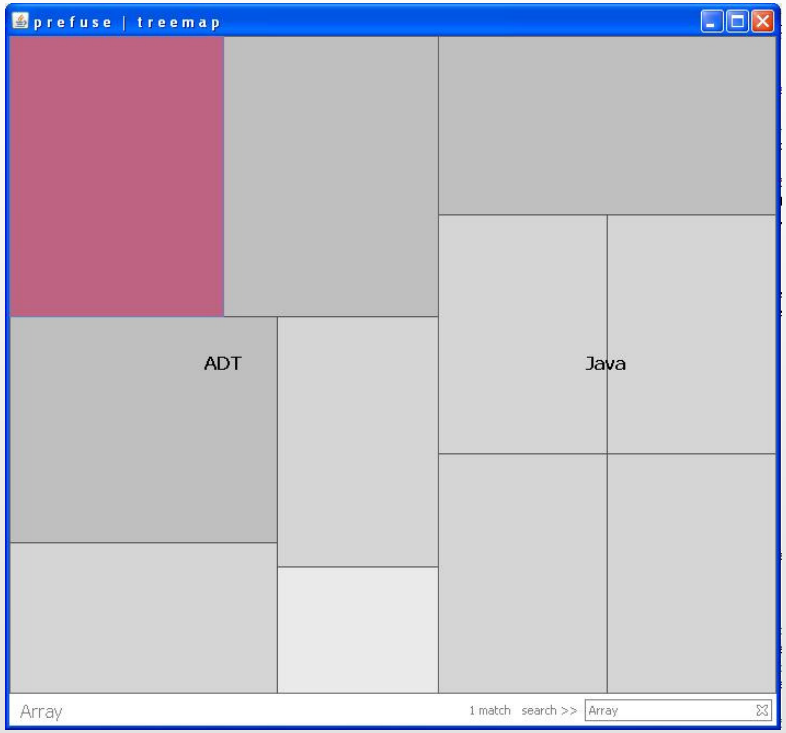
- Radial graph
  - highlights hierarchies or semantic networks of information centered on a specific item
  - produces a reconfiguration of the map by focusing on the selected item
  - promotes a qualitative elaboration of the information



Centered on the `Programming` item that highlights the items written with `expert` metadata

The Map: *tree base*

- Tree base map is a space-filling approach
  - to display data as a set of nested rectangles
  - to organize and represent complex structure of information
    - with several connections, categories and users
  - to recognize patterns or content characteristics in few seconds
  - to organize the views keeping into account metadata values



Dimension and colour of rectangles are related to `difficulty` metadata

Conclusions I

- Definition of a domain specific language for the description of e-Contents with textual syntax
- Definition of a specification for automatic generation of "back-end" equivalent respect to the execution platform based on abstract syntax of the language (`Ecore`, `EMF`, `MOF`)

→ Thanks to Eclipse and oAW!

Conclusions II

- Thanks to Eclipse and oAW!
  - →we focus the attention on business logic
  - →we have a generative DSL process and automatic code generation that could be successfully applied to other environments

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OCL expression in `Xtend`

- We exploit `Xtend`
  - to overcome the limit of meta model expressivity
  - to express and verify model constrains

- Example: "*an instance name must begin with lower case*"

```
Context Instatace Error ="instance error"
: name.toFirstLower()==name;
```