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Initial Implementation of the Domain Model Tool

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Abstract: This report describes the initial development of the Domain Model Tool (DM) Tool. Updates of the Domain Model definition and a technical specification are given in this deliverable. The document contains a description of the integration in the GAT system and with the other authoring tools. A brief tutorial of the tools is provided.

Keyword list: authoring tool, domain model, DM tool, domain model, conceptual adaptation model, CAM

Summary

DMs have been technically specified using XML format, and using IMS VDEX standard. The XML schema can be found in the official IMS Global Site (<http://www.imsglobal.org>). This document describes how the domain model is mapped to IMS VDEX specification in terms of information and structure. Report and implementation together form the Deliverable D3.1b - Initial Implementation of the Domain Model Tool.

The DM Tool works in a common context with other authoring tools (CRT Tool and CAM Tool): for this reason a common software library has been created which offers functionalities to all tools. The overall application including different tools is called Grapple Authoring Toolset (GAT).

Improvements and planned work for the final implementation of the DM Tool (D3.1c) are outlined. Advancing the user interface and making it more intuitive for authors is an important plan for improving the tool. Furthermore, the result of the evaluation of the authoring tools will influence the further development.

The DM Tool will be demonstrated at the EC-TEL 2009 [3] conference.

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List of Acronyms and Abbreviations

CAM	Conceptual Adaptation Model; also called: Adaptive Story Line; Adaptation Strategy
CRT	Concept Relationship Type(s); also called: (Pedagogical) Relationship Type(s)
DM	Domain Model



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GAL	GRAPPLE Adaptation Language
GAT	GRAPPLE Authoring Tool
GALE	GRAPPLE Adaptive Learning Environment
GUID	Globally Unique Identifier
GUMF	GRAPPLE User Model Framework
GRAPPLE	Generic Responsive Adaptive Personalized Learning Environment
GUI	Graphical User Interface
LOM	Learning Objects Metadata
IMS	Instructional Management System Global Learning Consortium.
UI	User Interface
UM	User Model
UUID	Unique User Identifier
VDEX	Vocabulary Definition Exchange

1 Introduction

By using the Domain Model (DM) tool, the author is able to create Domain Models that are the basic elements to build an adaptive course. In fact, the DM tool is one of instruments made available by WP3 and it is part of the GRAPPLE Authoring Toolset (GAT).

The concepts defined by the DM tool can be connected and then build a real storyline by using the Concept Relationship Types (CRT) through the Conceptual Adaptation Model (CAM).

The design of the DM tool and its correlation with CRT and CAM tools is available in D3.1a - Design specification of a DM definition tool.

This document, D3.1b, provides a technical description of the DM tool: the XML format used for the Domain Models (Maps), the software architecture, and the graphical user interface.

Section 2 describes in detail the IMS VDEX format chosen to describe the Domain Models and its elements (terms and relationships). The related XML schema is provided in Appendix.

In Section 3 the software architecture of the DM Tool and its integration with the GAT are described.

Section 4 introduces the graphical user interface with the help of several screenshots that show how to use the DM tool. In the GRAPPLE project, a detailed user guide is given in D9.2 - First documentation and training for GRAPPLE users by WP9.

In the last section (Section 5) the possibilities and plans for improvement are mentioned. Most importantly the user interface should be made more intuitive and the results of the evaluation will influence the further work on the DM Tool.

2 Specification of the DM Format

The Domain Model is specified in an XML based format and it is wrapped in a common part, shared between different models (CAM, CRT). The specific Domain Model section is based on IMS VDEX [2]. IMS VDEX is a standard for vocabulary definition. In the Domain Model, each concept is mapped to a term in the IMS VDEX. Relations between concepts are mapped to relationships in the IMS VDEX between terms. A detailed description will be provided later.

2.1 Structure of the DM format

As already described in the introduction of the chapter a common wrapper is used. Each model, such as CAM, DM, and CRT, has got a wrapper structure, which allows a unified storing and retrieving procedure from and to the database on the Web. The Web service that accepts models for storing and delivers requested models from the database needs not to have knowledge of which type models are.

The following XML code outlines the common structure of GRAPPLE authoring tool models. Each model has a header part, where metadata of the model is located. Metadata include title, common description, creation and update time, author, authorisation, and the UUID of the model.

```
<model>
  <header>
    // meta-data of the DM model
  </header>

  <body>
    <dm>
      // the DM definition
    </dm>
  </body>
```

</model>

The DM definition has two main parts. One is term related; the other is the relationships part. A complete example is available in 6.1

1. Term

A term has a first section that describes the term itself.

```
<termIdentifier>4FDFB0ED-3F11-960E-AC5F-002413333ABE</termIdentifier>
<caption>
  <langstring language="it">Milkyway</langstring>
</caption>
<description>
  <langstring language="en">Top level concept.</langstring>
</description>
```

The termIdentifier is used to uniquely identify the concept, GUID (Globally Unique Identifier) is generated every time a new concept is created. The caption tag identifies the concept name, the description, the concept meaning in a few words.

To better specify the meaning and the context of a concept more resource can be associated. For each resource a mediaDescriptor section should be defined:

```
<mediaDescriptor>
  <mediaLocator>http://en.wikipedia.org/wiki/Milkyway</mediaLocator>
  <interpretationNote>
    <langstring language="x-none">BD49CBED-9D55-4545-299C-7AF210B5E4BE</langstring>
  </interpretationNote>
</mediaDescriptor>
```

The mediaLocator tag contains the reference to the resource. The interpretationNote contains a unique ID that refers to metadata section.

Properties can be added to a concept. This is done by using the metadata section and the IMS Metadata LOM standard.

```
<termIdentifier>D266064B-38BD-E5B0-2BE0-2B5D8B43AEAA</termIdentifier>
<caption>
  <langstring language="it">Titan</langstring>
</caption>
<description>
  <langstring language="en">The only large moon of Saturn</langstring>
</description>
<metadata>
```

```

<concept>
  <lom>
    <general>
      <description>
        <langstring>The available information about Titan.</langstring>
      </description>
      <catalogentry>
        <catalog>text</catalog>
        <entry>
          <langstring>titan_text.xhtml</langstring>
        </entry>
      </catalogentry>
    </general>
  </lom>
</concept>
</metadata>
</term>

```

The tag `concept` says that the metadata is used to define properties for the concept. The `catalog` tag contains the property name, the `entry.langstring` contains the value. The `description` tag contains a brief description of the property. Multiple `concept` tags are allowed.

It is also possible to add information to a resource.

```

<metadata>
  <resource id="B61F38F8-EF25-E7E2-C548-253CF63547B2">
    <lom>
      <general>
        <title>
          <langstring>
            Level
          </langstring>
        </title>
        <description>
          <langstring>
            Beginner
          </langstring>
        </description>
      </general>
    </lom>
  </resource>
</metadata>

```

The resource tag `id` attribute contains the reference to *mediaLocator* value. The title section contains the property name. The `description` tag contains the value. More resource tags are allowed.

2 Relationship

The relationship tag is used to define relationships between two concepts.

```
<relationship>
  <sourceTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</sourceTerm>
  <targetTerm>4FDFB0ED-3F11-960E-AC5F-002413333ABE</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">belongsTo</relationshipType>
  <metadata/>
</relationship>
```

The sourceTerm contains the concept ID, source of the relationship.

The targetTerm contains the concept ID, target of the relationship.

The relationship type describes the relation itself.

Metadata are allowed. Currently not used.

2.2 XML Schema

The IMS VDEX schema is the reference for DM model.

For metadata IMS METADATA schema is used. In Appendix the complete Domain Model data schema is available.

3 Implementation and Integration of the DM Tool

The basic design of the DM Tool has already been outlined in D3.1a - Design specification of a DM definition tool. The DM tool has a user interface where the author can create, edit and modify Domain Models, concepts and relationships. They are stored on the server side using Web service and a database behind the Web service.

For the reason of a more efficient implementation the common functionalities of DM Tool, CRT Tool, and CAM Tool have been integrated into the GRAPPLE Authoring Tools (GAT) shell. The functionalities of the GAT shell are provided to all of these tools. The most important functionalities are providing a container including a menu bar and handling the creation, loading, and saving of data models.

3.1 Implementation of the DM Tool

Implementation of the DM Tool has been done by using Adobe Flex [1] framework in Action Script language. Flex offers good support for Web-based and graphical applications. The user interface is represented as XML file and separated from the other parts of the application. Flex projects are compiled into Flash applications which can be executed by Web browsers which have installed the Flash plugin.

The graphical library Birdeye Ravis was used to allow the user to edit the domain model as a visual graph.

Internally the Domain Model is directly edited as a XML VDEX document adding and removing node from the document. The xml is mapped to the graph structure.

As the graph library is designed to be generic, some specific node, edge and label were defined to meet the domain model needs.

3.2 Integration of the DM Tool with the GAT shell and Web Service

The GAT shell is a Flex library which can be integrated into the tools. It provides a graphical container, a menu and the functionality for loading and saving models from and to the Web service. Figure 1 depicts how the DM Tool is integrated with the GAT shell.

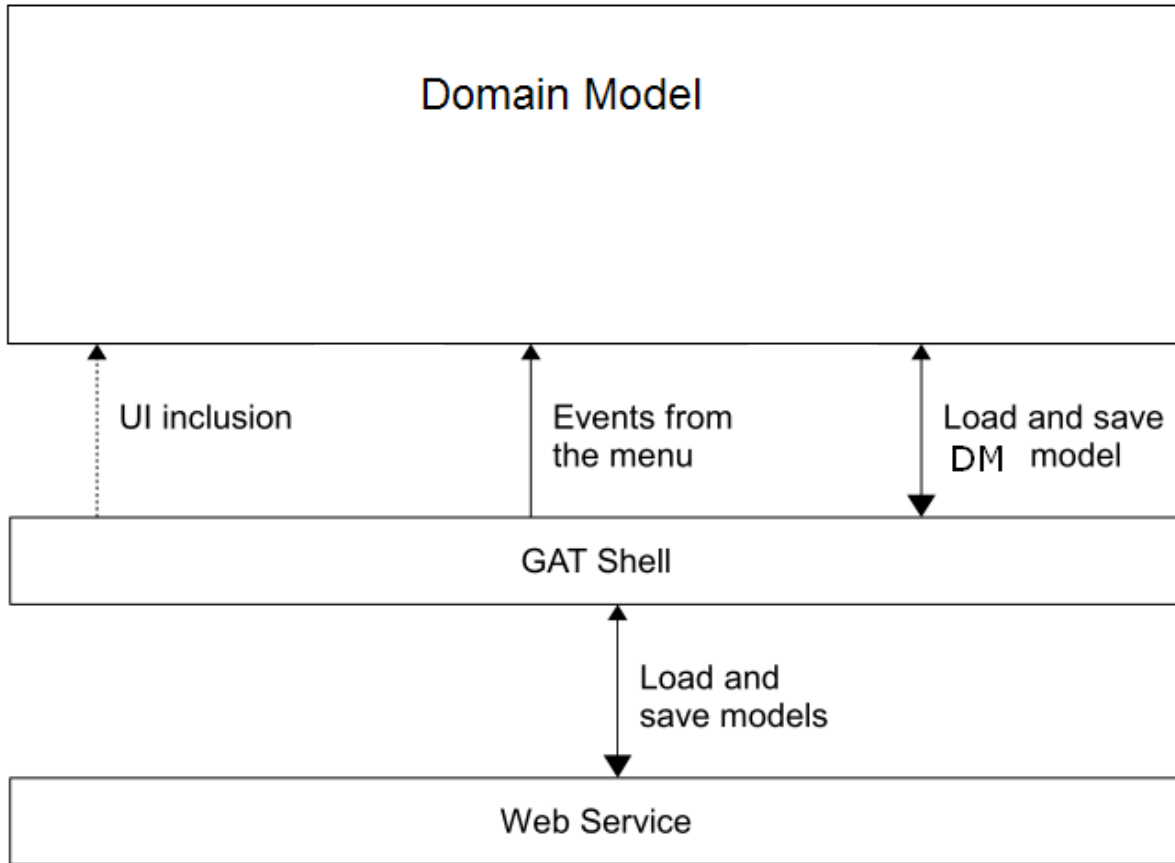


Figure 1: The DM Tool integrated in the GAT shell.

The GAT shell provides the menu from which events are raised if a user activates menu items. Consequently, they have to be sent to the DM Tool. The most important events are "open model", "save model", and "save as". These events are received by the application logic which activates the transformation of the internal DM representation to and from XML format. The XML code can be sent to or retrieved from the GAT shell. The GAT shell is responsible for saving and loading the models to and from the Web service.

In Figure 1, it is possible to identify the relations among the Domain Model and the GAT Shell: the solid lines identify the real interactions between them; the broken line identifies the inclusion of the Domain Model User Interface (UI) from the GAT Shell.

4 Graphical User Interface of the Domain Model Tool

The Graphical User Interface (GUI) has got an important role in the DM tool (and in GAT) to guarantee a friendly usage of the tool for authors that do not have a technical background. Since we have two implementations of the DM tool, the GUI will be improved in the second and last version by using the feedbacks from WP8, WP9 and WP10.

In D3.1a - Design specification of a DM definition tool, it was requested clearly that a graphical tool has to be used to define Domain Models by creating concepts and to link them with relationships by using a drop down box.

The current version of the GUI provides the possibility to edit all the key elements of the DM so that a complete Domain Model can be defined:

- Concepts with its Properties, Resources and Relationships.

For any concept, it is possible to define new Properties, to associate different Resources and to link to other concepts through Domain specific Relationships. The Domain specific relationships (or DM relationships) are binary: the author can use a set of predefined relationships, reuse some he has already defined or he can define a new one. The predefined DM relationships are *is-composed-by*, *is-a*, *belong-to*.

In the following it is explained how to define Domain Models (called also Domain Maps) step by step.

1. Create a new Domain Model

When the author opens the GAT, the Domain Model tab will be the default panel. By clicking on the main bar, the author can create a new Domain Model by clicking on File ->New, as shown in Figure 2.

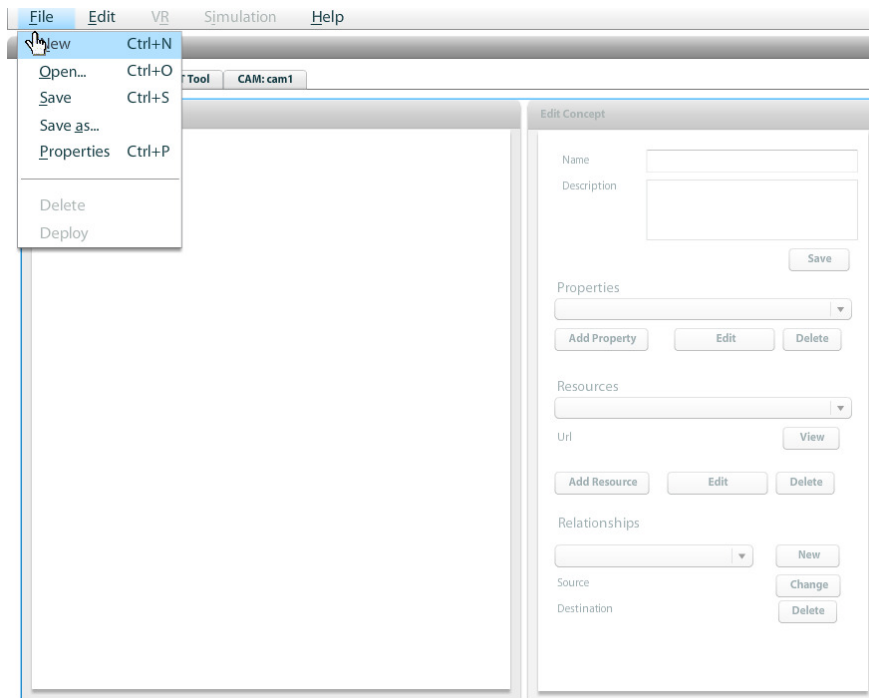


Figure 2: How to create a new Domain Model.

Now the author can add the File name and Description in the dialog that will appear and select the Authorisation rights, and then click Create, as shown in Figure 3. A new Domain model editing window will be created.

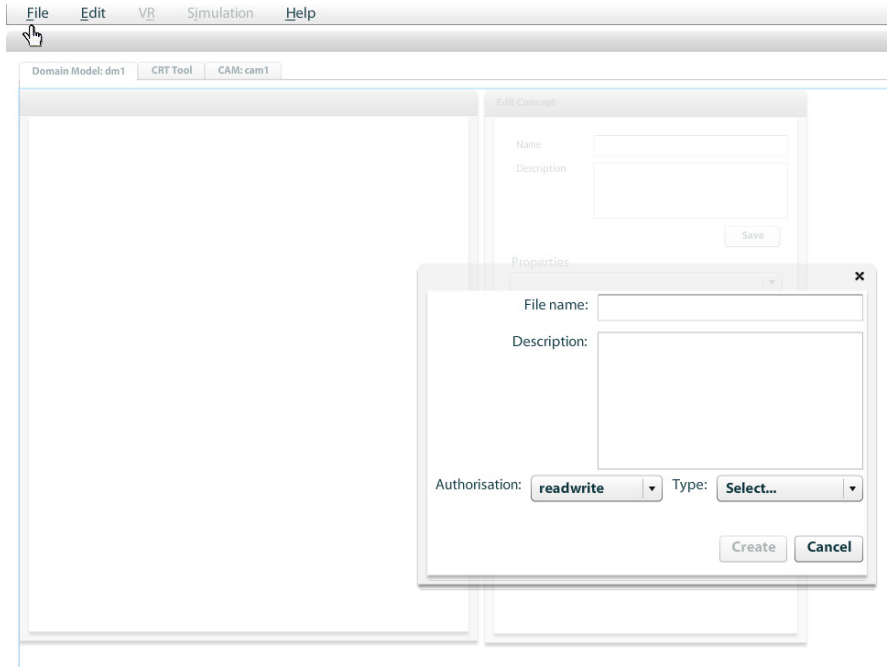


Figure 3: New Domain Model parameters.

It is important in the drop-down list to clarify the author is going to create a new Domain Model by selecting “dm”, as shown in: Figure 4:

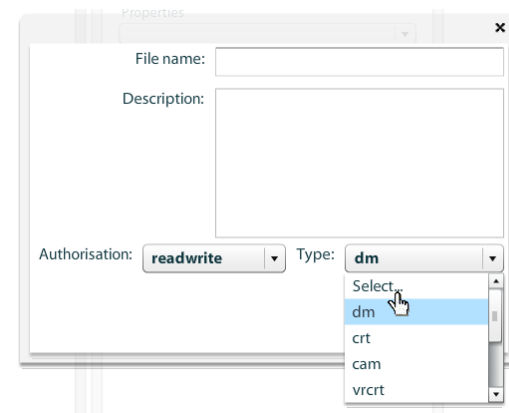


Figure 4: How to specify the file is a Domain Model file.

2. Add Concept

At this stage the author can add a new concept to the new Domain Model, Middle Age: by right clicking on the white section in the left and click “Add Concept” in the menu that will appear. A new node (concept) is created.

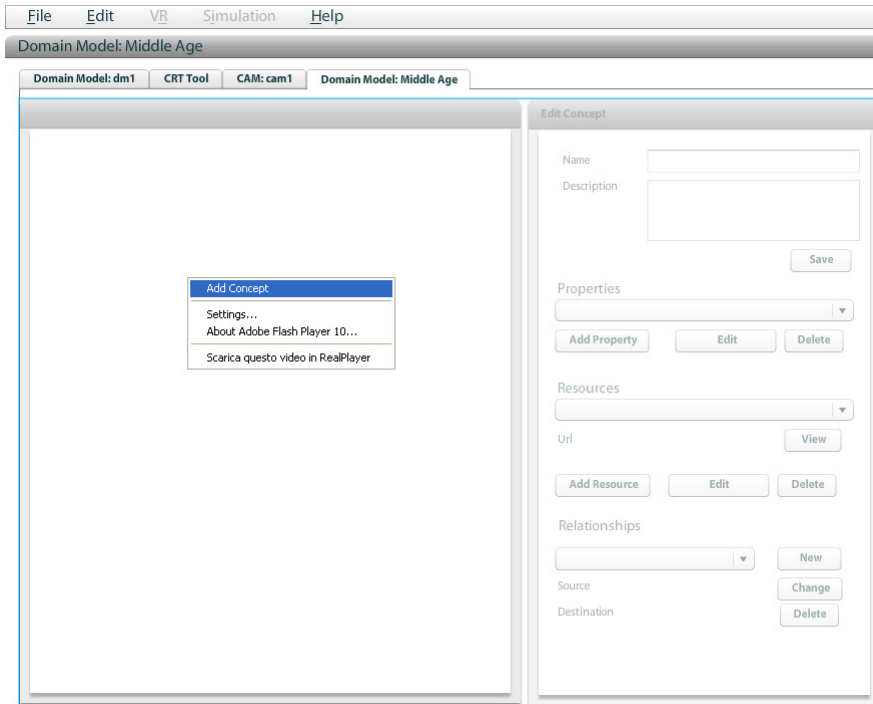


Figure 5: New Concept creation.

It is now possible to edit the concept Properties on the left, such as Name and Description. It is necessary to click the button Save to make these changes permanent.

The author can add, edit and delete Properties. Figure 6 shows what appears to the author when add/edit property is clicked.

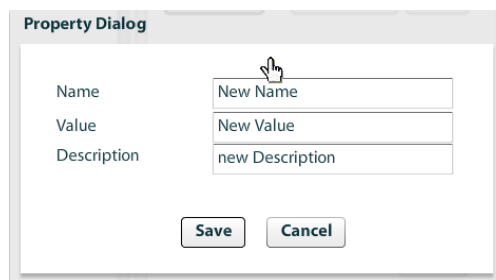


Figure 6: New Property definition.

Then the author can relate a resource to the concept by clicking on “Add Resource” on the left panel, as shown in Figure 7.

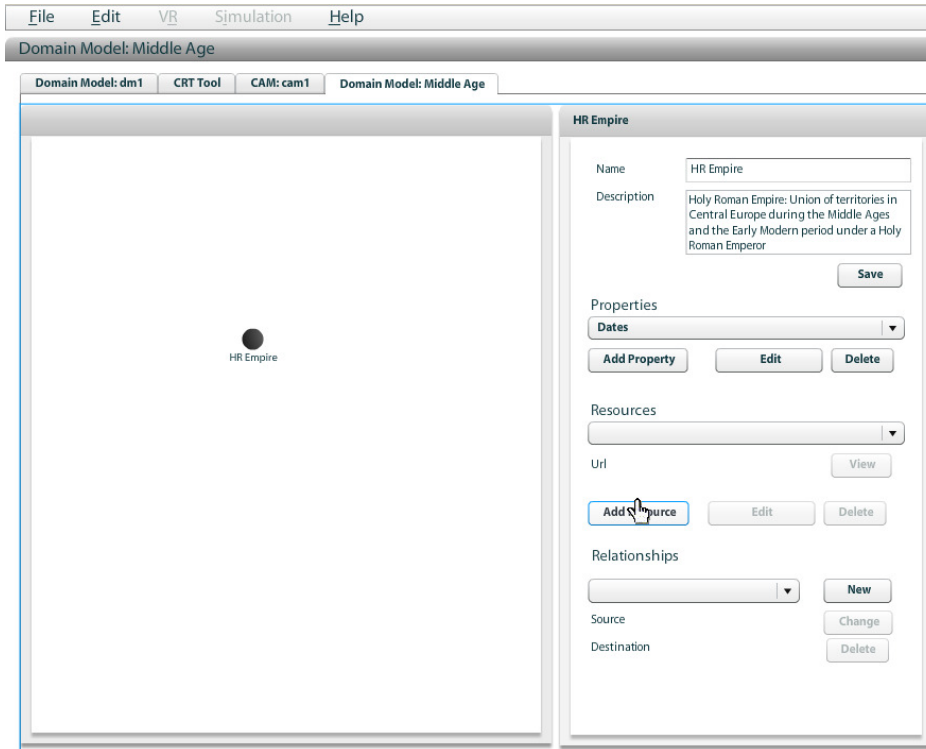


Figure 7: How to add a Resource to a Concept.

Figure 8 shows the window that appears to the author where he can add the url to the resource.

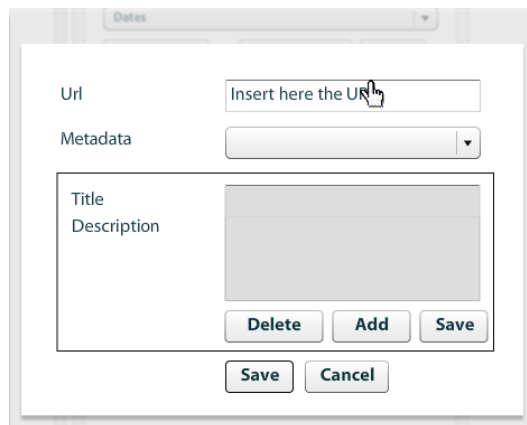


Figure 8: How to add a Resource to a Concept - details.

In the Metadata section the author can associate metadata to the resource by clicking on “Add” button. Each metadata should be saved after Title and Description editing. The metadata can be viewed by selecting them in the combobox. Once finished, the author should push the button “Save” to make the change permanent.

By clicking on View the user can view the selected resource associated to the concept.

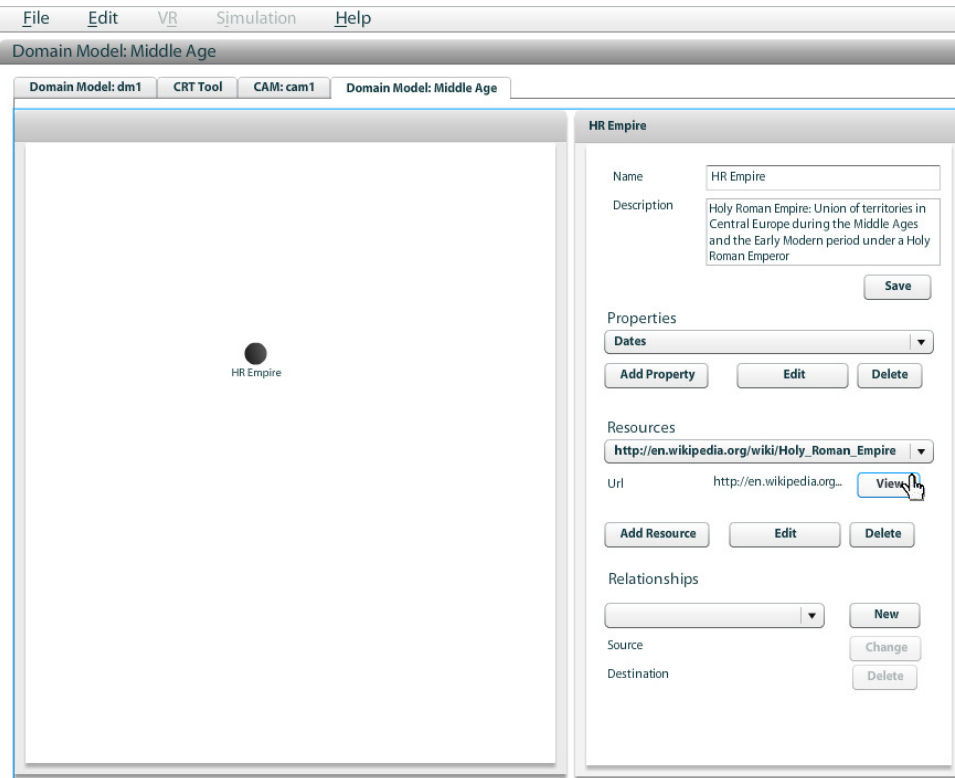


Figure 9: How to view a Resource.

The author can always edit or delete the already associated resources by selecting the button “Edit” or “Delete”.

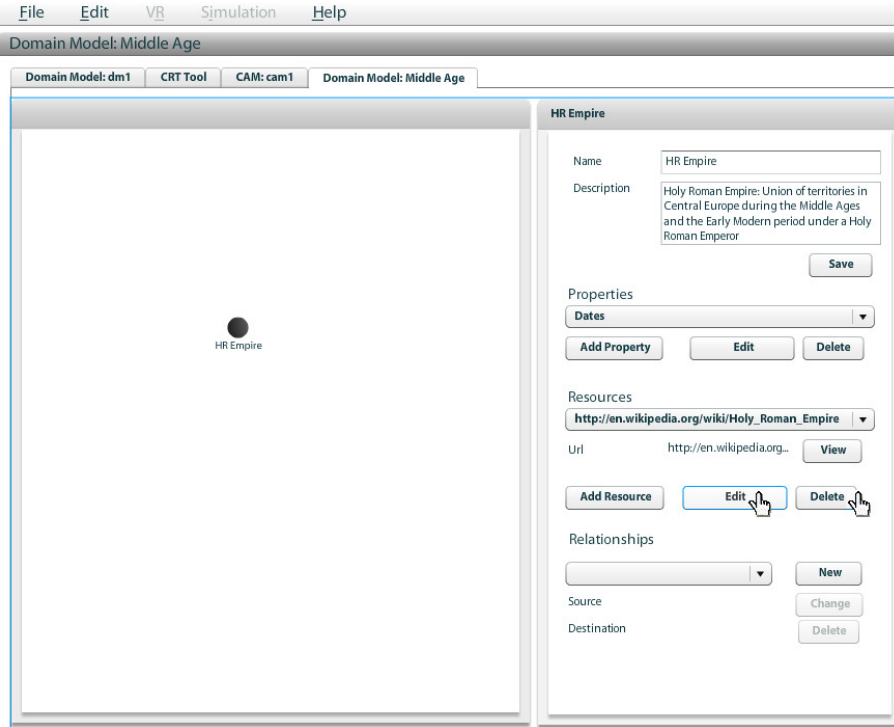


Figure 10: How to edit or delete a Resource.

The author can create a domain specific relationship between concepts in two ways.

- I. By right clicking on a concept and selecting “Relate concept” from the context menu or

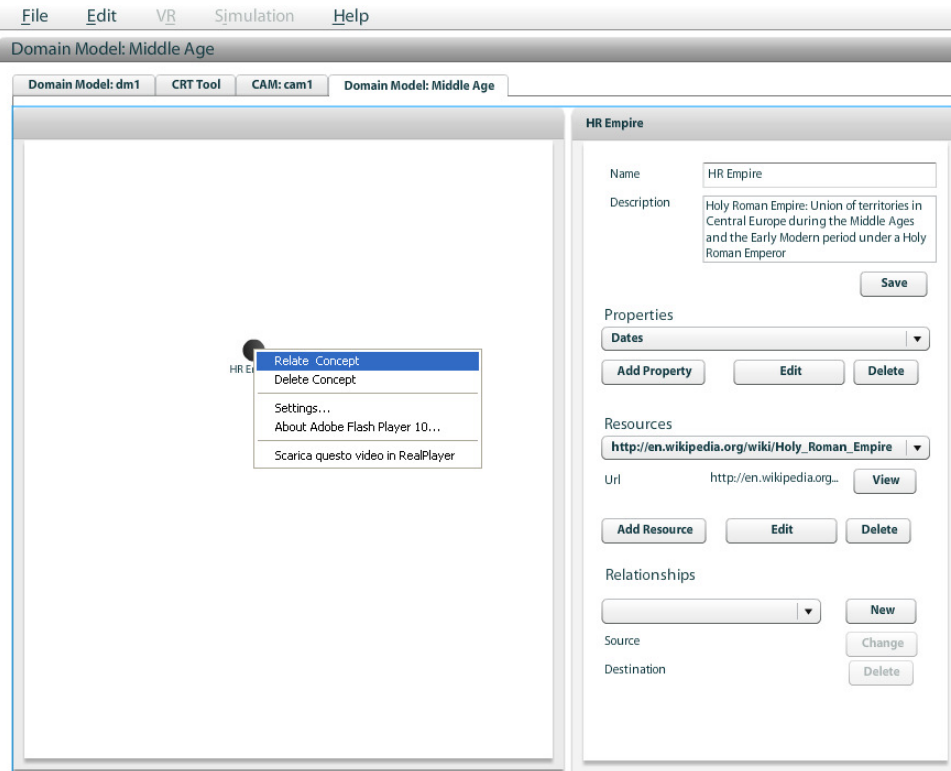


Figure 11: How to create domain specific relationships.

- II. By clicking on “New” button in the Relationships part in the right panel.

In both the cases, the author can edit the domain specific relationship that correlates two concepts. As shown in Figure 12 the author can choose the origin and destination concepts, and the type of the relationship between the already defined ones, under Type.

He can also add new relationship type by checking the checkbox “New Relationship” and inserting the name of the new relationship.

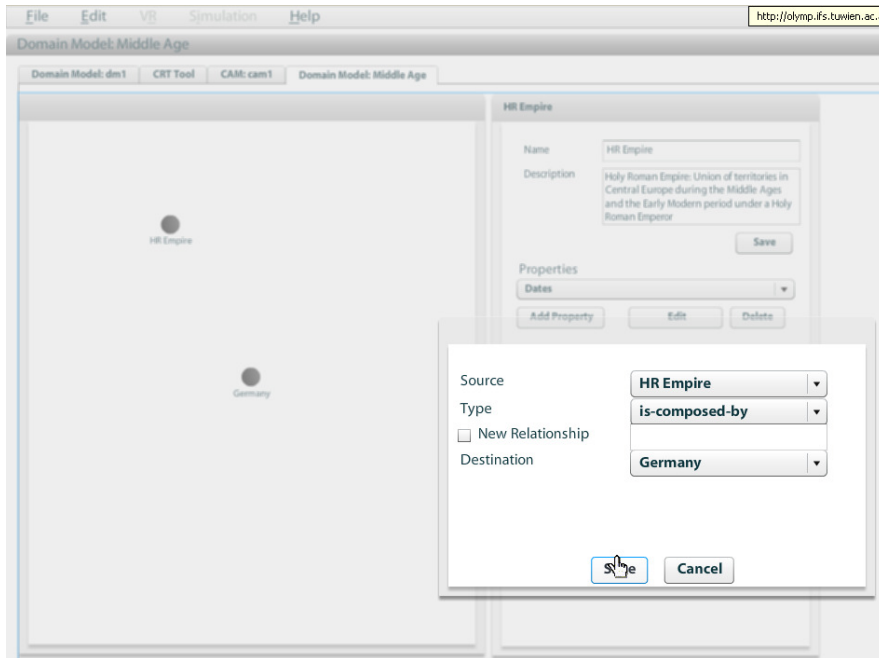


Figure 12: Definition of domain specific relationships.

When the form is fully filled, the author can save and the relationship will be showed as an arrow in the graph.

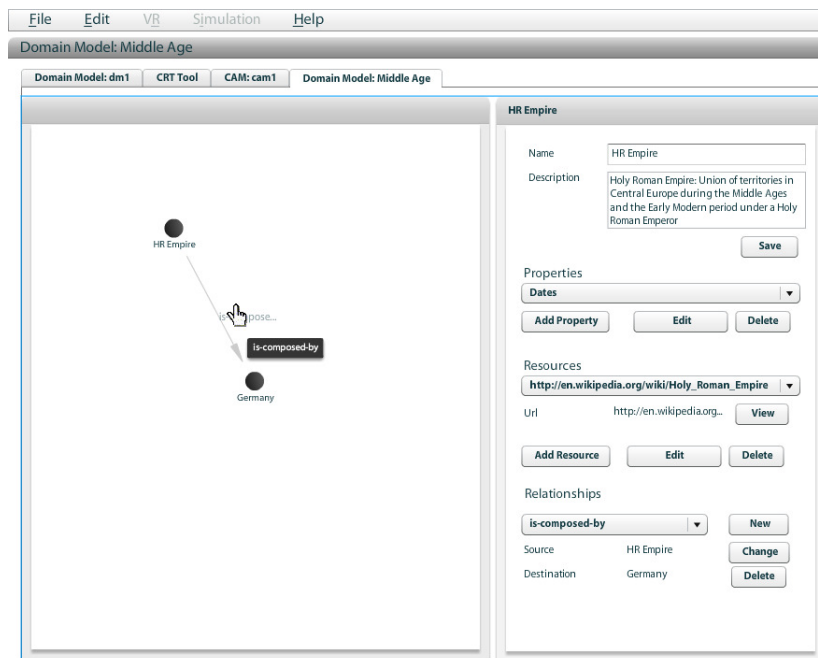


Figure 13: Two concepts correlated by a domain specific relationship.

By clicking on change or delete in the right panel, the author can edit or delete the relationship highlighted in the combo box.

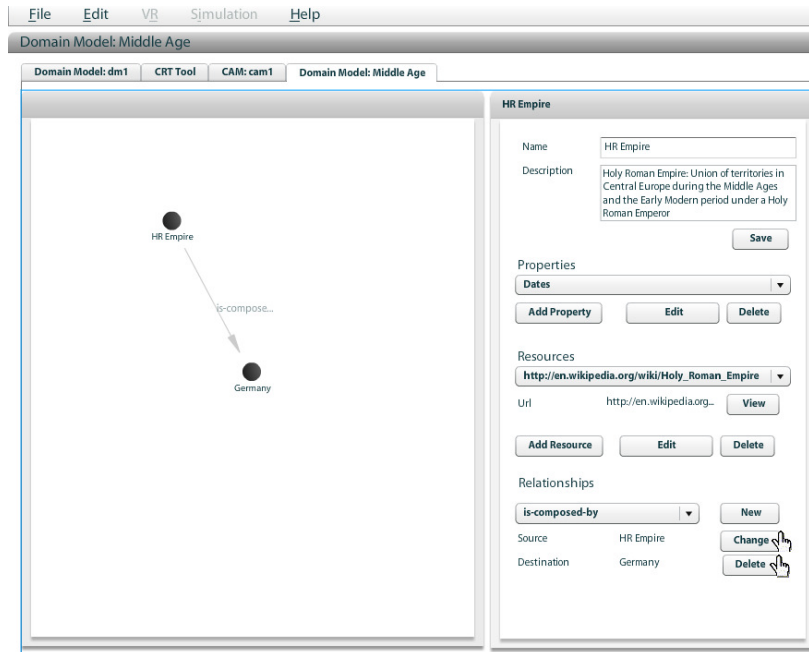


Figure 14: How to edit or delete an existing domain specific relationship.

The concept in the graph can be deleted by right clicking the concept and selecting “Delete Concept” from the menu.

Concept can be moved in the graph by dragging the node.

Once finished, the author can save the Domain Model by clicking “File->Save” in the main menu.

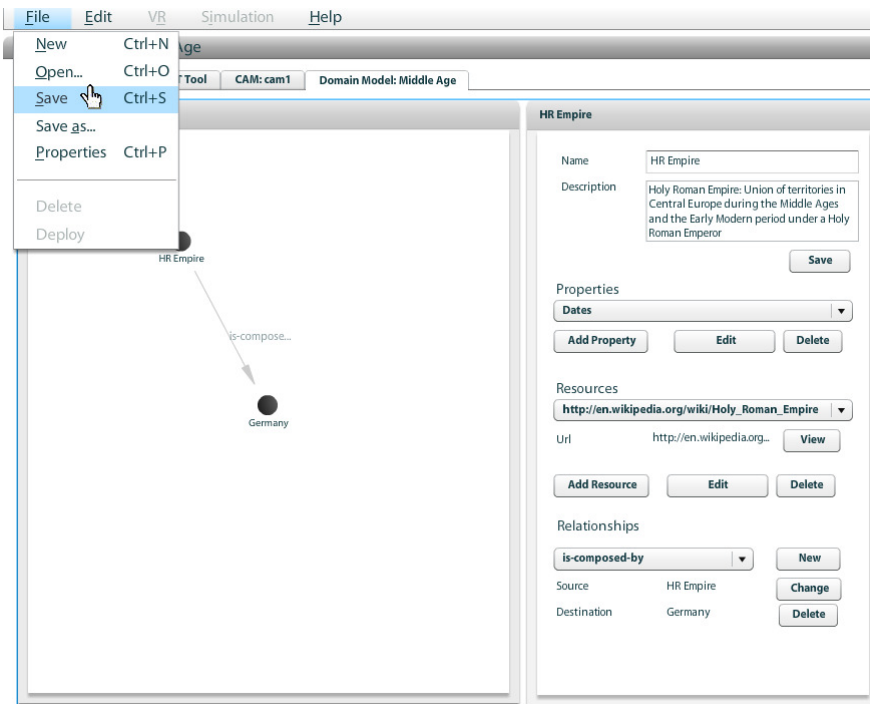


Figure 15: How to save the Domain Model.

3. Open an Existing Domain Model

The author can always open an existing Domain Model: by clicking on the main bar, he can select File->Open, as shown in Figure 16.

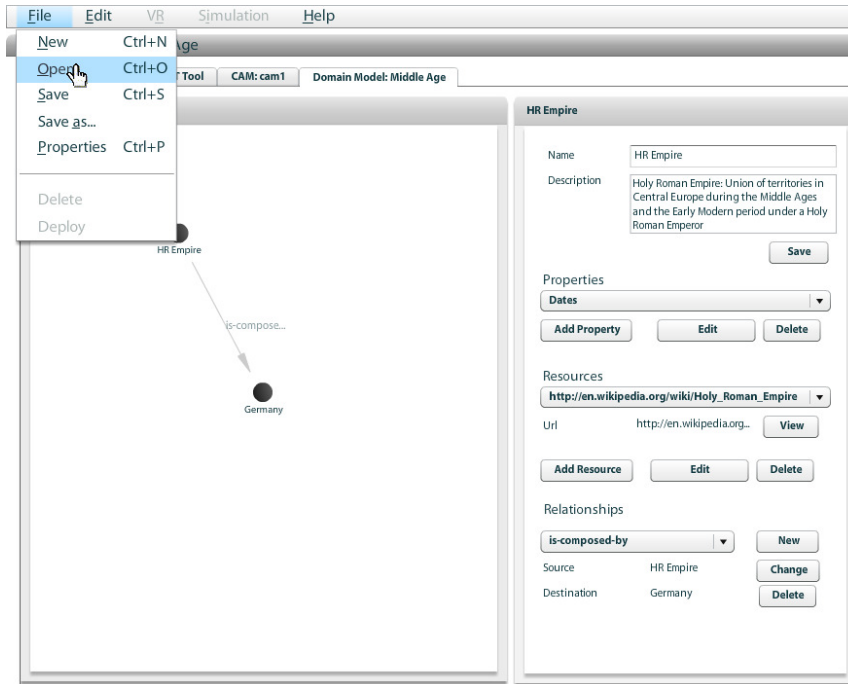


Figure 16: How to open an existing Domain Model.

Now the author can select the Domain Model he wishes to open and work with.

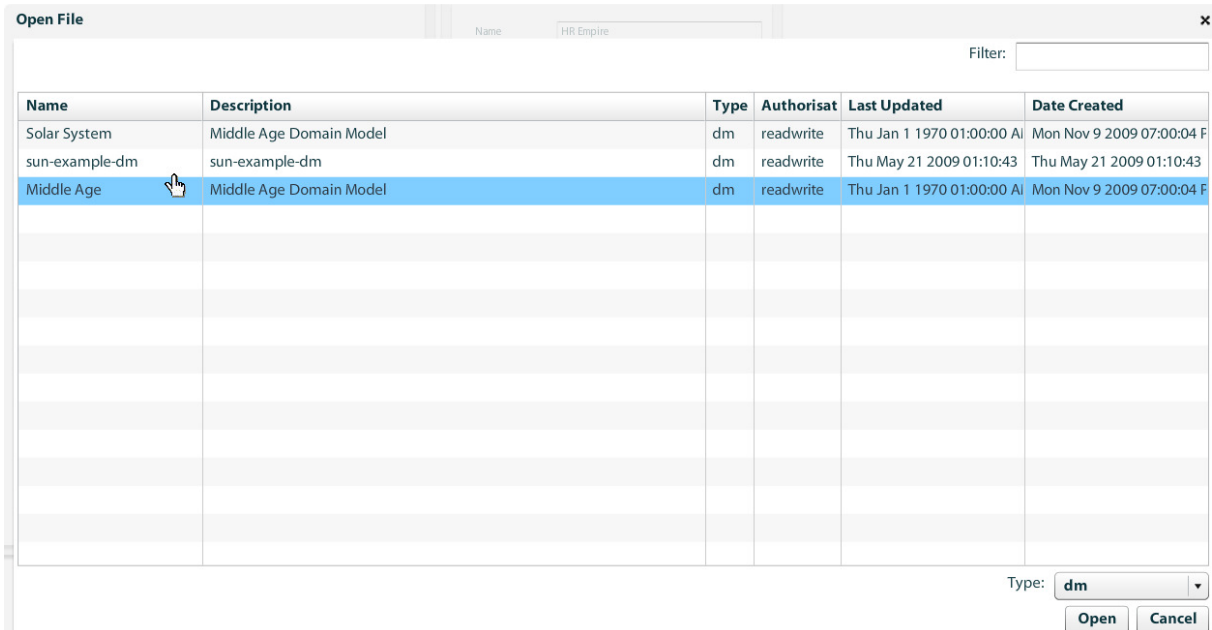


Figure 17: Selection of the Domain Model to open.

5 Conclusion and Outlook

This report presented a description of the initial development of the DM Tool as it has been designed in the former Deliverable D3.1a. It has been shown that this tool is working and fulfils the basic key requirements identified in D3.1a. Domain Models can be defined, modified and saved in IMS VDEX XML format to and from a database on the Web, shared with the other GAT tools. The tool is Web-based and provides a graph-based interface for the author.

The second and final version of the DM Tool will be delivered and described in Deliverable D3.1c. Since the first implementation developed the key elements that compose the Domain Model, the next phase of development of the components will consider further changes suggested by the results of the Evaluation phase. The most important work to be done for the next version will concern a more dynamic sharing of concepts and domain specific relationships among different Domain Models: this means search mechanism, creation of a concept/relationships library, automatic help in the Domain Model creation and definition of more specific authoring roles.

The DM Tool has been demonstrated at the EC-TEL 2009 [3] conference. Feedback from this demonstration and training sessions also might influence the further work.

References

1. Adobe Flex (2009). <http://www.adobe.com/products/flex/>, retrieved on 15 July 2009
2. IMS VDEX Specifications, <http://www.imsglobal.org/vdex/>.
3. Hendrix, M., Nussbaumer, A., Dicerto, M., Oneto, L., Cristea, A.: GAT: The FP7 GRAPPLE Authoring Tool Set. Demonstration at the Fourth European Conference on Technology Enhanced Learning (EC-TEL 2009), 29 September - 2 October 2009, Nice, France.

6 Appendix

6.1 Example of a VDEX Domain Model

```
<vdex>
  <term x="120.5" y="24.5">
    <termIdentifier>4FDFB0ED-3F11-960E-AC5F-002413333ABE</termIdentifier>
    <caption>
      <langstring language="it">Milkyway</langstring>
    </caption>
    <description>
      <langstring language="en">Top level concept.</langstring>
    </description>
    <metadata>
      <resource id="BD49CBED-9D55-4545-299C-7AF210B5E4BE">
        <lom>
          <general>
            <title>
              <langstring>new Title</langstring>
            </title>
            <description>
              <langstring>new Description</langstring>
            </description>
          </general>
        </lom>
      </resource>
      <resource id="BD49CBED-9D55-4545-299C-7AF210B5E4BE">
        <lom>
          <general>
            <title>
              <langstring>new Title</langstring>
            </title>
            <description>
              <langstring>new Description</langstring>
            </description>
          </general>
        </lom>
      </resource>
    </metadata>
  </term>
</vdex>
```

```

<mediaDescriptor>
  <mediaLocator>http://en.wikipedia.org/wiki/Milkyway</mediaLocator>
  <interpretationNote>
    <langstring language="x-none">BD49CBED-9D55-4545-299C-7AF210B5E4BE</langstring>
  </interpretationNote>
</mediaDescriptor>
</term>
<term x="165" y="147">
  <termIdentifier>1B3EF646-F051-EB59-47D1-0024B97CAC18</termIdentifier>
  <caption>
    <langstring language="it">Star</langstring>
  </caption>
  <description>
    <langstring language="en">Star as an abstract concept.</langstring>
  </description>
  <metadata/>
</term>
<term x="24.5" y="130.5">
  <termIdentifier>1C2C9337-4E9A-DD77-FD26-002506895E4A</termIdentifier>
  <caption>
    <langstring language="it">Nebula</langstring>
  </caption>
  <description>
    <langstring language="en">Nebulas produce stars</langstring>
  </description>
  <metadata/>
</term>
<term x="338.5" y="138.5">
  <termIdentifier>B40A0425-4165-07E8-9F81-0025A44F0215</termIdentifier>
  <caption>
    <langstring language="it">Eta Carinae</langstring>
  </caption>
  <description>
    <langstring language="en">Some random star from the Milkyway</langstring>
  </description>
  <metadata/>
</term>
<term x="376.5" y="209.5">
  <termIdentifier>26B57AFA-3B7E-9330-B6AB-0026005FE386</termIdentifier>
  <caption>
    <langstring language="it">Sun</langstring>

```

```
</caption>
<description>
  <langstring language="en">Our closest star</langstring>
</description>
<metadata/>
</term>
<term x="165.5" y="229.5">
  <termIdentifier>C403B750-83E1-E327-6E97-0028C5CF29CC</termIdentifier>
  <caption>
    <langstring language="it">Planet</langstring>
  </caption>
  <description>
    <langstring language="en">Planet as an abstract concept.</langstring>
  </description>
  <metadata/>
</term>
<term x="22.5" y="316.5">
  <termIdentifier>C96D5561-F2C6-1093-6C01-0029F687CE72</termIdentifier>
  <caption>
    <langstring language="it">Mercury</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Mercury</langstring>
  </description>
  <metadata/>
</term>
<term x="74.5" y="316.5">
  <termIdentifier>DB542A44-5209-A701-7358-002A374003EB</termIdentifier>
  <caption>
    <langstring language="it">Venus</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Venus</langstring>
  </description>
  <metadata/>
</term>
<term x="131.5" y="316.5">
  <termIdentifier>BDA46E7B-C872-8C46-5B35-002A91C9B915</termIdentifier>
  <caption>
    <langstring language="it">Earth</langstring>
  </caption>
```

```
<description>
  <langstring language="en">The planet Earth</langstring>
</description>
<metadata/>
</term>
<term x="184" y="317">
  <termIdentifier>B1B94861-CABE-F676-DDEA-002B035E6071</termIdentifier>
  <caption>
    <langstring language="it">Mars</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Mars</langstring>
  </description>
  <metadata/>
</term>
<term x="242.5" y="316.5">
  <termIdentifier>6E536B9A-F321-242E-BFD2-002B67B27F54</termIdentifier>
  <caption>
    <langstring language="it">Jupiter</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Jupiter</langstring>
  </description>
  <metadata/>
</term>
<term x="306.5" y="315.5">
  <termIdentifier>BF3E03CE-C389-2BEF-1310-002D0BD62B6E</termIdentifier>
  <caption>
    <langstring language="it">Saturn</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Saturn</langstring>
  </description>
  <metadata/>
</term>
<term x="366.5" y="314.5">
  <termIdentifier>CF4C0F8B-3A3E-28D2-1EE6-002D803559D4</termIdentifier>
  <caption>
    <langstring language="it">Uranus</langstring>
  </caption>
  <description>
```

```
<langstring language="en">The planet Uranus</langstring>
</description>
<metadata/>
</term>
<term x="420.5" y="315.5">
  <termIdentifier>F074BC44-341E-00C8-29E3-002DC7D3B1C9</termIdentifier>
  <caption>
    <langstring language="it">Neptune</langstring>
  </caption>
  <description>
    <langstring language="en">The planet Neptune</langstring>
  </description>
  <metadata/>
</term>
<term x="20" y="500">
  <termIdentifier>7951738D-B52B-930A-4077-0033FF24CCB0</termIdentifier>
  <caption>
    <langstring language="it">Moon</langstring>
  </caption>
  <description>
    <langstring language="en">Moon as an abstract concept.</langstring>
  </description>
  <metadata/>
</term>
<term x="131" y="380">
  <termIdentifier>B6A7CC1A-1E0B-48FF-1D96-003539D7C8BE</termIdentifier>
  <caption>
    <langstring language="it">Moon(Earth)</langstring>
  </caption>
  <description>
    <langstring language="en">The Earth's Moon.</langstring>
  </description>
  <metadata/>
</term>
<term x="174.5" y="517.5">
  <termIdentifier>7BDB5746-8E98-06E9-BD22-005B61E578A1</termIdentifier>
  <caption>
    <langstring language="it">Phobos</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Mars</langstring>
```

```
</description>
<metadata/>
</term>
<term x="198" y="459">
  <termIdentifier>D6281D9B-44CD-25E6-19F8-005BBAF7E148</termIdentifier>
  <caption>
    <langstring language="it">Deimos</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Mars</langstring>
  </description>
  <metadata/>
</term>
<term x="231" y="366">
  <termIdentifier>C76A9F2C-B81C-3138-2493-005D317A4ABA</termIdentifier>
  <caption>
    <langstring language="it">Europa</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Jupiter</langstring>
  </description>
  <metadata/>
</term>
<term x="254" y="404">
  <termIdentifier>48231F86-DB12-2262-18B1-005E642FF6E2</termIdentifier>
  <caption>
    <langstring language="it">Io</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Jupiter</langstring>
  </description>
  <metadata/>
</term>
<term x="270" y="440">
  <termIdentifier>45EDAA28-E6D2-9105-6CE1-005EAEB989C6</termIdentifier>
  <caption>
    <langstring language="it">Ganymede</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Jupiter</langstring>
  </description>
```

```

<metadata/>
</term>
<term x="289.5" y="480.5">
  <termIdentifier>4F6D92F6-7AB2-44AA-337D-005EF6D5FD7B</termIdentifier>
  <caption>
    <langstring language="it">Callisto</langstring>
  </caption>
  <description>
    <langstring language="en">Moon of Jupiter</langstring>
  </description>
  <metadata/>
</term>
<term x="322.5" y="58.5">
  <termIdentifier>F9595557-A627-D534-8D36-0A5FA6076107</termIdentifier>
  <caption>
    <langstring language="it">Solar System</langstring>
  </caption>
  <description>
    <langstring language="en">general description of the solar system</langstring>
  </description>
  <metadata/>
</term>
<term x="343.5" y="393.5">
  <termIdentifier>D266064B-38BD-E5B0-2BE0-2B5D8B43AEAA</termIdentifier>
  <caption>
    <langstring language="it">Titan</langstring>
  </caption>
  <description>
    <langstring language="en">The only large moon of Saturn</langstring>
  </description>
  <metadata>
    <concept>
      <lom>
        <general>
          <description>
            <langstring>The available information about Titan.</langstring>
          </description>
          <catalogentry>
            <catalog>text</catalog>
          <entry>
            <langstring>titan_text.xhtml</langstring>
          </entry>
        </general>
      </lom>
    </concept>
  </metadata>

```

```

</entry>
</catalogentry>
</general>
</lom>
</concept>
</metadata>
</term>
<relationship>
  <sourceTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</sourceTerm>
  <targetTerm>4FDFB0ED-3F11-960E-AC5F-002413333ABE</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">belongsTo</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>1C2C9337-4E9A-DD77-FD26-002506895E4A</sourceTerm>
  <targetTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">Produces</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>B40A0425-4165-07E8-9F81-0025A44F0215</sourceTerm>
  <targetTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>26B57AFA-3B7E-9330-B6AB-0026005FE386</sourceTerm>
  <targetTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</sourceTerm>
  <targetTerm>1B3EF646-F051-EB59-47D1-0024B97CAC18</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">rotatesAround</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>C96D5561-F2C6-1093-6C01-0029F687CE72</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>

```

```

<metadata/>
</relationship>
<relationship>
  <sourceTerm>DB542A44-5209-A701-7358-002A374003EB</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>BDA46E7B-C872-8C46-5B35-002A91C9B915</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>B1B94861-CABE-F676-DDEA-002B035E6071</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>6E536B9A-F321-242E-BFD2-002B67B27F54</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>BF3E03CE-C389-2BEF-1310-002D0BD62B6E</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>CF4C0F8B-3A3E-28D2-1EE6-002D803559D4</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
  <metadata/>
</relationship>
<relationship>
  <sourceTerm>F074BC44-341E-00C8-29E3-002DC7D3B1C9</sourceTerm>
  <targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>

```

```

<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>7951738D-B52B-930A-4077-0033FF24CCB0</sourceTerm>
<targetTerm>C403B750-83E1-E327-6E97-0028C5CF29CC</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">rotatesAround</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>B6A7CC1A-1E0B-48FF-1D96-003539D7C8BE</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>B6A7CC1A-1E0B-48FF-1D96-003539D7C8BE</sourceTerm>
<targetTerm>BDA46E7B-C872-8C46-5B35-002A91C9B915</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>7BDB5746-8E98-06E9-BD22-005B61E578A1</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>D6281D9B-44CD-25E6-19F8-005BBAF7E148</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>7BDB5746-8E98-06E9-BD22-005B61E578A1</sourceTerm>
<targetTerm>B1B94861-CABE-F676-DDEA-002B035E6071</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>D6281D9B-44CD-25E6-19F8-005BBAF7E148</sourceTerm>

```

```

<targetTerm>B1B94861-CABE-F676-DDEA-002B035E6071</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>C76A9F2C-B81C-3138-2493-005D317A4ABA</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>48231F86-DB12-2262-18B1-005E642FF6E2</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>45EDAA28-E6D2-9105-6CE1-005EAEB989C6</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>4F6D92F6-7AB2-44AA-337D-005EF6D5FD7B</sourceTerm>
<targetTerm>7951738D-B52B-930A-4077-0033FF24CCB0</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">typeOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>C76A9F2C-B81C-3138-2493-005D317A4ABA</sourceTerm>
<targetTerm>6E536B9A-F321-242E-BFD2-002B67B27F54</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>
<sourceTerm>48231F86-DB12-2262-18B1-005E642FF6E2</sourceTerm>
<targetTerm>6E536B9A-F321-242E-BFD2-002B67B27F54</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>

```

```

<sourceTerm>45EDAA28-E6D2-9105-6CE1-005EAEB989C6</sourceTerm>
<targetTerm>6E536B9A-F321-242E-BFD2-002B67B27F54</targetTerm>
<relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
<metadata/>
</relationship>
<relationship>
  <sourceTerm>4F6D92F6-7AB2-44AA-337D-005EF6D5FD7B</sourceTerm>
  <targetTerm>6E536B9A-F321-242E-BFD2-002B67B27F54</targetTerm>
  <relationshipType source="http://www.grapple.org/relations.xml">isMoonOf</relationshipType>
  <metadata/>
</relationship>
</vdex>

```

6.2 DM Schema definition

In this section we have the complete DM Schema used for the first implementation of the Domain Model Tool.

```

<?xml version="1.0" encoding="utf-8" ?>
<!--Created with Liquid XML Studio 6.1.18.0 - FREE Community Edition (http://www.liquid-
technologies.com)-->
<xs:schema attributeFormDefault="unqualified" elementFormDefault="qualified"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="model">
    <xs:complexType>
      <xs:sequence>
        <xs:element minOccurs="0" name="header">
          <xs:complexType>
            <xs:sequence>
              <xs:element minOccurs="0" name="modeluuid" type="xs:string" />
              <xs:element minOccurs="0" name="modeltype" type="xs:string" />
              <xs:element minOccurs="0" name="authoruuid" />
              <xs:element minOccurs="0" name="authorisation" type="xs:string" />
              <xs:element minOccurs="0" name="creationtime" type="xs:unsignedLong" />
              <xs:element minOccurs="0" name="updatetime" />
              <xs:element minOccurs="0" name="title" type="xs:string" />
              <xs:element minOccurs="0" name="description" />
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element minOccurs="0" name="body">
          <xs:complexType>
            <xs:sequence>

```

```
<xs:element minOccurs="0" name="dm">
  <xs:complexType>
    <xs:sequence>
      <xs:element minOccurs="0" name="vdex">
        <xs:complexType>
          <xs:sequence>
            <xs:choice maxOccurs="unbounded">
              <xs:element minOccurs="0" maxOccurs="unbounded" name="term">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element minOccurs="0" name="termIdentifier" type="xs:string" />
                    <xs:element minOccurs="0" name="caption">
                      <xs:complexType>
                        <xs:sequence>
                          <xs:element minOccurs="0" name="langstring">
                            <xs:complexType>
                              <xs:simpleContent>
                                <xs:extension base="xs:string">
                                  <xs:attribute name="language" type="xs:string" use="optional" />
                                </xs:extension>
                              </xs:simpleContent>
                            </xs:complexType>
                          </xs:element>
                        </xs:sequence>
                      </xs:complexType>
                    </xs:element>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
            </xs:choice>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element minOccurs="0" name="description">
        <xs:complexType>
          <xs:sequence>
            <xs:element minOccurs="0" name="langstring">
              <xs:complexType>
                <xs:simpleContent>
                  <xs:extension base="xs:string" use="optional" />
                </xs:simpleContent>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element minOccurs="0" name="metadata">
        <xs:complexType>
          <xs:sequence minOccurs="0">
            <xs:element minOccurs="0" maxOccurs="unbounded" name="concept">
```

```

<xs:complexType>
  <xs:sequence>
    <xs:element minOccurs="0" name="lom">
      <xs:complexType>
        <xs:sequence>
          <xs:element minOccurs="0" name="general">
            <xs:complexType>
              <xs:sequence>
                <xs:element minOccurs="0" name="description">
                  <xs:complexType>
                    <xs:sequence>
                      <xs:element minOccurs="0" name="langstring" type="xs:string" />
                    </xs:sequence>
                  </xs:complexType>
                </xs:element>
                <xs:element minOccurs="0" name="catalogentry">
                  <xs:complexType>
                    <xs:sequence>
                      <xs:element minOccurs="0" name="catalog" type="xs:string" />
                      <xs:element minOccurs="0" name="entry">
                        <xs:complexType>
                          <xs:sequence>
                            <xs:element minOccurs="0" name="langstring" type="xs:string" />
                          </xs:sequence>
                        </xs:complexType>
                      </xs:element>
                    </xs:sequence>
                  </xs:complexType>
                </xs:element>
              </xs:sequence>
            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element minOccurs="0" maxOccurs="unbounded" name="resource">
      <xs:complexType>
        <xs:sequence>

```

```

<xs:element minOccurs="0" name="lom">
  <xs:complexType>
    <xs:sequence>
      <xs:element minOccurs="0" name="general">
        <xs:complexType>
          <xs:sequence>
            <xs:element minOccurs="0" name="title">
              <xs:complexType>
                <xs:sequence>
                  <xs:element minOccurs="0" name="langstring" type="xs:string" />
                </xs:sequence>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element minOccurs="0" name="description">
        <xs:complexType>
          <xs:sequence>
            <xs:element minOccurs="0" name="langstring" type="xs:string" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
  <xs:attribute name="id" type="xs:string" use="optional" />
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
<xs:element minOccurs="0" maxOccurs="unbounded" name="mediaDescriptor">
  <xs:complexType>
    <xs:sequence>
      <xs:element minOccurs="0" name="mediaLocator" type="xs:string" />
      <xs:element minOccurs="0" name="interpretationNote">
        <xs:complexType>
          <xs:sequence>
            <xs:element minOccurs="0" name="langstring">

```

```

<xs:complexType>
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="language" type="xs:string" use="optional" />
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
<xs:attribute name="x" type="xs:decimal" use="optional" />
<xs:attribute name="y" type="xs:decimal" use="optional" />
</xs:complexType>
</xs:element>
<xs:element minOccurs="0" maxOccurs="unbounded" name="relationship">
  <xs:complexType>
    <xs:sequence>
      <xs:element minOccurs="0" name="sourceTerm" type="xs:string" />
      <xs:element minOccurs="0" name="targetTerm" type="xs:string" />
      <xs:element minOccurs="0" name="relationshipType">
        <xs:complexType>
          <xs:simpleContent>
            <xs:extension base="xs:string">
              <xs:attribute name="source" type="xs:string" use="optional" />
            </xs:extension>
          </xs:simpleContent>
        </xs:complexType>
      </xs:element>
      <xs:element minOccurs="0" name="metadata" />
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:choice>
</xs:sequence>
</xs:complexType>
</xs:element>

```



```
</xs:sequence>  
</xs:complexType>  
</xs:element>  
</xs:sequence>  
</xs:complexType>  
</xs:element>  
</xs:sequence>  
</xs:complexType>  
</xs:element>  
</xs:schema>
```