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Modelling Knowledge and Game Based Learning: Model Driven Approach

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Abstract: Research in game based learning area is moving from traditional web-based Learning Management Systems (LMS) towards game-based learning environments, with the intention of integrating advantages of using games in university education. Important issue that requires attention is proper integration of knowledge in to game environments with the focus on reusing existing units of knowledge. This is why main topic of this paper is knowledge modelling in educational games. In our work we proposed a Model Driven Approach (MDA) to educational game development that focuses on models rather than on implementation. This provides many opportunities to primarily reuse existing resources especially when it comes to knowledge. Our work enables reusing Learning Objects between web-based LMSs and game-based learning environments. We used a two-step process defined as the Model Driven Approach to Learning Objects repurposing whereby a Web based Learning Object (LO) is transformed into a more abstract model and then returned, enhanced with game specific attributes to a platform specific model. For that purpose, a new term is proposed: Educational Game Learning Object (EGLO). In order to ensure full reusability of the EGLO the authors of this paper suggested separation of style and content. This enables the designer to adapt presentational aspects of the Learning Object according to the content within as well as to the limitations and needs of the specific platform.

Keywords: Knowledge modelling, Learning Objects, Educational games, MDA, Game-Based Learning, reusability
Categories: K.3.1 L.1.2 L.2.0 L.3.0 L.3.6 L.5.1

1 Introduction

Game based learning promises to be a new successful approach in conducting university education [Pivec, 07]. Motivating today's students with traditional teaching methods such as lectures and written materials proves to be a difficult task and consequently, universities are searching for a new role in the changing context of education. There seems to be a growing awareness of the research potential that lies in gaming as a new promising form of interactive content [Pivec, 07] as well as growing

proof of viability of teaching certain skills and knowledge by means of video games [FAS, 06]. There is also evidence that games have a positive effect on concentration, the decision – making process, problem solving skills, logical thinking creativity, team work and computer skills [De Aguilera 03]. One author has gone so far as to claim [Estallo, 95] that people who play games have more developed intellectual skills than those who don't.

Finding the right way to model the knowledge for use in educational games is an important issue. The problem arises when there is a need to teach specific matter such as subject curriculum at universities. Integrating that kind of knowledge and concurrently keeping the game interesting and playable presents a big challenge. The purpose of this paper is to propose a model that will attempt to establish the balance between knowledge integration on one side, and its reusability on the other.

Applied approach relies on the use of Learning Objects as constructing pieces of knowledge resources which are specialized for educational game design purpose. Learning objects represent small, reusable pieces of content relevant for learning (e.g., an online exercise; a coherent set of introductory readings on a specific topic; or an assessment test) [Jovanović, 07]. Reusability of LO represents using LO in different courses, by different teachers and learners [Gašević, 04], and is therefore, an essential and arguably the most important characteristic of learning objects [Sicilia, 03; De Santiago, 10].

The problem of reusability is more complex in the area of educational games than in the classical web based Learning Management Systems (LMS). A Learning Management System is a software application for the administration, documentation, tracking, and reporting of training programs, classroom and online events, e-learning programs, and training content [Ellis, 09]. Games require much better integration of Learning Objects into virtual environments, both in the context of presentation and interaction. It is certainly not possible to create an own game for each type of player but it would be a great advance if an educational game was flexible and customizable enough to be able to adapt to the heterogeneous needs of different player preferences by using adaptive technologies [Göbel , 10]. That is why we will propose the use of Educational Game Learning Objects (EGLO) and attempt to resolve the reusability problem through the application of MDA method (Model Driven Approach). MDA uses a platform-independent base model (PIM) and one or more platform-specific models (PSM), each describing how the base model is implemented on a different platform [Obrenovic, 04; Aguilar, 10]. EGLO represents a formally specified model, enriched in comparison to classical Learning Object with attributes necessary for application in educational games thereby allowing for it to be reused in different educational games as well as other eLearning forms, online classes, tests etc.

Following section briefly address games developed and applied for education. The latter sections contain the problem statement, the solution proposal, followed by conclusion and discussion about future work directions.

2 Games in Education

Main purpose of educational games is to teach and pass on knowledge and skills and knowledge can be taught in a variety of ways. Some games are using well-known, popular environment and set of rules, adapted for purposes of education i.e., the

educational game based on "Who wants to be a millionaire?" quiz [Reinhardt, 06]. It uses all elements of the TV show, but questions are chosen by the teacher. Some games are developed with certain subject matter in mind, like games for teaching electromagnetism called "Supercharged!" [Squire, 04] or a fantasy adventure game that teaches the basic concepts of programming [Moser, 07]. In some cases, the modification of popular games (game modding) was used for teaching computer science, mathematics, physics and aesthetics [El-Nasr, 06]. Game design was also used to achieve similar goals - developing problem solving skills and teamwork [Steiner, 06].

Regardless of the rapid growth of this research field, knowledge modelling for the purpose of educational games is still in its initial phases. While there are numerous efforts for games to be applied to learning, relatively few attempts can be found where principles of learning and knowledge management were explicitly followed a priori in design [Kickmeier-Rust, 08; Minović, 09]. One of the main obstacles, in this respect, has doubtlessly been the financial cost of the development, since educational games have to compete with commercial video games in terms of quality of graphics, challenges, and game play [FAS, 06]. Nevertheless, position remains that cognitive modelling and assessment tools have to be incorporated into educational games in order to give insight into learning outcomes and enable their evaluation.

The ever-increasing importance of knowledge in the society today, calls for a shift in thinking about innovation in e-learning. An important factor for the success of e-learning lies in knowledge management [Ronchetti, 04; Kostas, 02; Naeve, 08].

It is important to be able to separate content from expression within a LO in order to be able to clearly distinguish two important types of questions: those dealing with the meaning that has to be conveyed by the LO, and those dealing with how meaning is to be expressed [Brajnik, 07].

On the other side, main purpose of educational games is to teach and pass knowledge. That is why a majority of educational games is focused mainly on knowledge. Since every story has more than one side, so does this one. If you focus predominantly on the fun in game you lose when it comes to educating the player. On the other hand if you only regard the knowledge as important there is a strong chance that your player will end up being bored. Finding the right balance is of the essence in this matter.

3 Problem Statement

Educational games that are created using traditional methods pose us with a set of issues. Those games lack the ability of presenting diverse knowledge, because the constructing process itself requires determination on behalf of the creators as to which specific knowledge the player will be exposed to. Environment, as a crucial factor in educational games, plays an important role in motivating the player and involving him/her in the specific matter. In order to get a quality game representation, there must be a strong bond between the environment and the knowledge inserted. Due to the constructing process, that bond is usually created during the programming steps and in eLearning systems; this issue is addressed through the use of Learning Objects. The LOs represent reusable units of knowledge.

This method can also be applied in educational games. Even though every designer is welcome to work on creating the knowledge to be used in his game one must take in to consideration that there is already a substantial repository of Learning Objects that can be easily accessed via World Wide Web. It is a fair scientific assumption that they can and should be used in creation of new games. The problem is that using existing Learning Objects during educational game creation is difficult without significant modifications and the alternative of recreating those same objects for use in educational games, would be far too time-consuming.

With the change of context, learning objects must be transformed, both in terms of their content and the meta-data describing the nature of the learning objects [Wang, 07]. In order to do this, we addressed the matter by using Model Driven Approach to build models that will serve as the basis for transformations of Learning Objects and focus on finding a suitable structure for LOs so that can be used in Educational Games. The rationale behind it lies in the importance of the ability to separate content from expression within an LO, so that a clear distinction could be made between two important types of questions: those dealing with the meaning that has to be conveyed by the LO, and those dealing with how meaning is to be expressed [Brajnik, 07]. Additionally, we will invest an effort to maintain reusability of existing LO's and keep compatibility with existing LO standards.

Today's eLearning systems consist mainly from two parts: Learning Objects and Learning Management Systems. Initial approach in using games in education was to create games that represent Learning Objects [Silva, 09; Torrente, 09] and use them in LMS but, unfortunately, only edutainment level of gameplay was reached this way [Egenfeldt-Nielsen, 07]. Since learning objects should represent small, reusable pieces of content relevant for learning [Jovanović, 07], games created this way would be too simple and it is due to the inability to adhere to these same basic principles of LOs that complex games cannot be structured as LOs. In addition, games require higher interaction levels with users than web based LMS's can provide.

Efforts in modelling the world of educational games, and applying these models in game-based learning field, have brought to a conclusion that a different approach is required. The idea is to approach the problem through models. Initially, a platform independent model will be proposed that describes the Educational Games. Secondly a shift a platform specific model is performed that will finally result with the implementation that presents a complete product. Based on these models the framework will be provided to apply transformations in order to include existing Learning Object in to new games and also to apply a process in the opposite direction.

In the following sections the focus will be on the proposition of models and consequently how to structure LO for Educational Games, how to reuse existing LOs, and how to keep compatibility with existing LO standards.

4 MDA Approach to Knowledge Modelling in Educational Games Development

One of the main reasons researchers are focused on working in the area of Knowledge Management and technology enhanced learning is that the knowledge can be reused. This was done in past by people passing knowledge on to each other. This limited the

number of recipients. The notion is that when someone creates knowledge in this case represented through Learning Objects, whether is made for games or not there is no reason why it should not be used for some other purpose. This, in turn, raises the issue of standardization which would have to entail defining relation between Learning Objects that are used in educational games and standard Learning Objects described by a known standard (such as LOM). In this respect we have decided to apply a concept of using transformations. The main idea behind it was to select an existing standardized LO, ascend it to a higher level of abstraction and enhance it for use in educational games.

Our approach is inspired by the model-driven development. An overview of educational game development through MDA levels is shown [<see> Tab. 1]. It uses a platform-independent base model (PIM) and one or more platform-specific models (PSM), each describing how the base model is implemented on a different platform [Obrenovic, 04; Aguilar, 10].

OMG MDA Level	**Educational Game Metamodeling Architecture**	**Description**
M3 – Meta-metamodel	The Meta Object Facilities (MOF)	The MOF is an OMG standard that defines a common, abstract language for the specification of metamodels. MOF is a meta-metamodel
M2 – Meta models	The Educational Game Learning Object Metamodel (EGLOM)	The Educational Game Learning Object Metamodel provides a common and standardized language about phenomena from various domains relevant to the design of learning objects for educational games. It is called a metamodel as it is the abstraction of platform specific models called Platform independent model (PIM)
M1 – Models	Platform-specific Shemas (XHTML, EGLO XML Schema, LOM XML Schema...)	Platform specific models (PSM) of educational game learning object content.
M0 – Objects, data	Content data (XHTML, EGLO, LOM XML files...)	Instances of platform specific models.

Table 1: Overview of Learning Object development through MDA levels.

In this way, the PIM is unaffected by the specifics of different implementation technologies (eg. web-based LMS, game-based learning environment), and the necessity of remodelling the application or content, each time a new technology or presentation format appears, is circumvented (a virtual-reality LMS in the future). The

views on learning object content from different levels of abstraction can be derived by model transformations. In MDA, platform-independent models are initially expressed in a platform independent modelling language, and are later translated to platform-specific models by mapping the PIMs to some implementation platform using formal rules. The transformation of the content models can be specified by a set of rules defined in terms of the corresponding higher level meta-models. The transformation engine itself may be built on any suitable technology such as XSLT tools.

Our approach is based on standard technologies such as the Unified Modelling Language (UML) and XML, which are familiar to many software practitioners and are well supported by tools. Therefore, it is not necessary to develop complex solutions from scratch, and it is possible to reuse existing model-driven solutions and experiences from other domains. In our work we have relied on existing UML modelling tools, XML parsers and software frameworks, developing only code that extends, customizes, and connects those components according to common and standardized language defined in the Educational Game Learning Object Meta-model.

According to the proposed approach section 4.1 will present the meta-model for Educational Games. Since the focus of this work is on knowledge modelling next section (4.2) will further explain the knowledge segment of the meta-model that will be used as a basis for development of the platform independent model. These models belong to M2 level [<see> Tab. 1]. Section 4.3 describes the M1 level [<see> Tab. 1] model of Educational Game Learning Object that is used as basis for defining a platform specific model. Finally, section 4.4 presents the process of transformation from PIM to PSM of Learning Objects, with resulting object instances that belong to M0 level [<see> Tab. 1].

4.1 Educational Game Meta-model

Defining educational game models requires a vocabulary of modelling primitives. Therefore, our meta-model describes basic educational game concepts. A simplified educational game meta-model is presented [<see> Fig. 1].

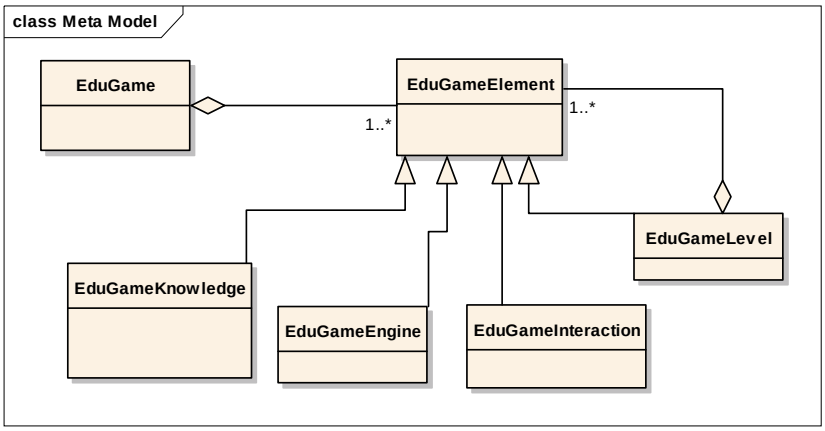

Figure 1: Educational game basic concepts.

The meta-model's main concept is EduGameElement which is used as a basis for defining other concepts of educational game. EduGameKnowledge defines educational content that aims to convey to players in learning process. There is a need for expertise in science area for managing complexities of the underlying knowledge. Educational content needs some form of presentation to the user, therefore we introduce concept of EduGameEngine. It describes the mechanism used to present knowledge, which, for example, might be the learning tool to generate and answer questions that guide learner through the exploration and discovery of the required science area. GameInteraction concept describes communication between player and game. This concept describes interaction at high level of abstraction regardless of specific manifestations. In broad outline, interaction is established using multiple channels of communications, and concept is derived from our existing metamodel of multimodal human-computer interaction [Obrenovic, 04]. The overall goal is to convey knowledge in interactions rather than static data. EduGameLevel comprises previous modelling primitives in order to provide inherent mechanism for game progress as well as creating a sense of achievement. It also allows creating games at multiple scales of knowledge and skills.

4.2 Knowledge Meta-model for Educational Game

Since the aspect of knowledge is in focus of this paper description of models will move in that specific direction. Knowledge meta-model was developed so it provides a good basis for modelling domain knowledge and integration with the game. Model enables manageable learning path, through the game, as well as knowledge reusability. In addition, model provides the ability of knowledge assessment and integrating that assessment in the game.

In order to structure domain knowledge, we introduce basic meta-model [<see> Fig. 2]. EduGameKnowledge consists of EduGame KnowledgeCategory, which defines hierarchy of knowledge, and contains zero or more domain models.

Domain model represents a specific knowledge area and consists of Domain Concepts, which are self-related. Domain Concept represents a specific unit of knowledge that constitutes a building block of the knowledge area. Relation between Domain Concepts has two important aspects. If concept relates to other concept, than correlation attribute will have value between zero and one (one for exactly the same concept and zero for non-related concepts). Second important relation is prerequisite, which signifies concepts that must be adopted before related concept.

We define EduGameLO (Educational Game Learning Object) and EduGameAO (Educational Game Assesment Object) to introduce a relation between game and knowledge. One EduGameLO/EduGameAO is related with one or more Domain Concepts. Finally, EduGame Scene consists of zero or more EduGameLO and zero or more EduGameAO. Inspiration for using the name Scene came from the field of movies. As in movies, scene represents an integral set of constituting parts that are presented to the viewers as a whole. In educational games domain, scene represents a composition of learning materials and assessments, that have a specific educational purpose, but its presentation depends on many different factors. Adequate interaction with learner required from us to develop another part of our framework, targeting Game Interaction [Minović, 2009].

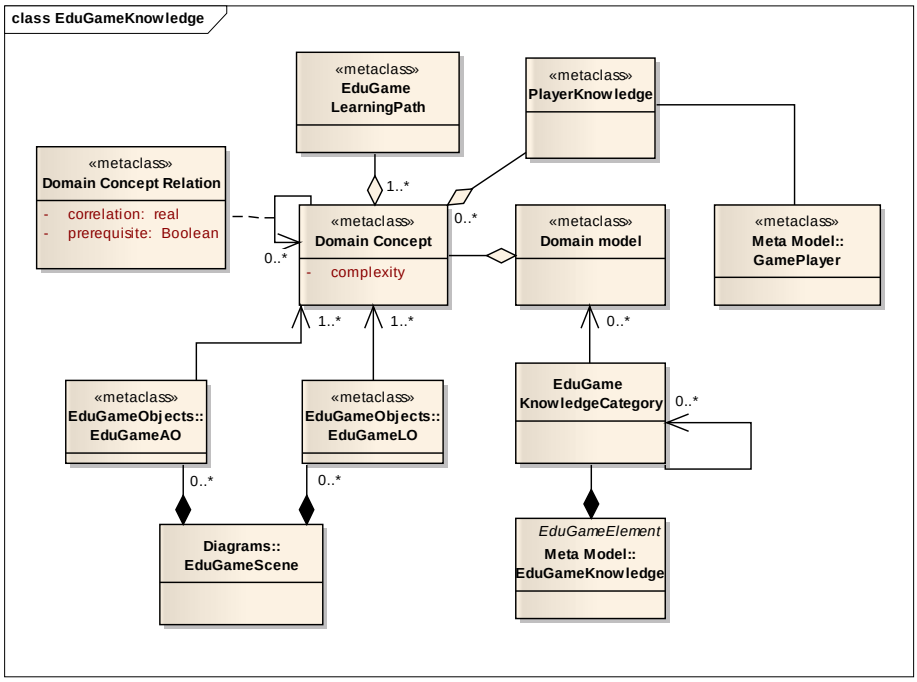

Figure 2: Educational game knowledge meta-model.

Although learning and assessment is often overlapping, in our model we distinguish between Learning Object and Assessment Object. In this way, we can achieve separated management of learning and assessment paths, as well as easier manipulation by computers. Specific nature of educational games leads us to separation of LO and AO. Another reason why we separated two groups of knowledge object is because of the different interaction and presentational aspects that games require. This does not mean that same units of knowledge cannot be used in both these forms; they only require slightly different adaptations through transformations. In order to keep learners motivation high, game should provide a sense of achievement. Learner should be provided with a challenge adequate to his current knowledge state, which is established by use of AOs. Game platforms enable implementation of assessment objects which are different than in classical eLearning (for example mini-game inside the game which will verify acquired knowledge or skills). Finally, for learner this separation does not have to be so clear, since advanced educational games should mix these two concepts and blur the separation line between them. Further, EduGameLO can be Simple or Complex type. Simple LO can be: TextEduGameLO, PictureEduGameLO, VideoEduGameLO or AudioEduGameLO. ComplexEduGameLO represents any combination of Simple Learning Objects as well as combination with other Complex Learning Objects. EduGameAO has same specialization, as Simple and Complex EduGameAO.

Further approach is to decompose simple AO into Question, Simulation, Puzzle and Mini-game [<see> Fig. 3]. Question covers all standard question types for knowledge assessment (like multiple-choice or free-text question). Simulation represents a specific kind of assessment, where learner has some kind of mini-model for manipulation and has to use it in order to solve a given problem. Simulation is particularly convenient for skill assessment. Puzzle refers to a group of tasks described as logical assignments or logical hurdles. Mini-game is assessment object in a form of a game. Important characteristic of every assessment object is to provide EvaluationPoints value (for example, at implementation level this can be valued between 0 and 100) in order to enable verification of knowledge. Complex EduGameAO can be aggregation of Simple EduGameAO (mini-game for example).

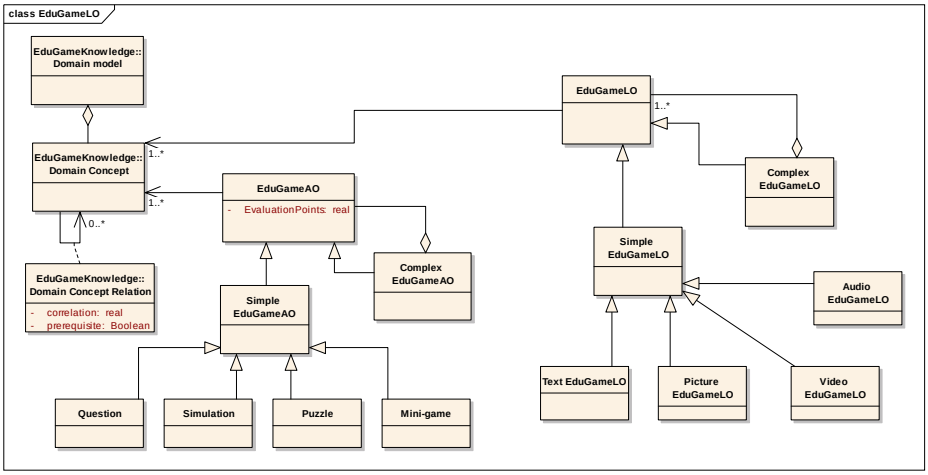

Figure 3: Educational game Learning Object and Assessment Object meta-model.

Major benefit of our meta-model is that construction of educational games is driven by "learning scenario", which actually defines domain concepts and learning path that learner should adopt. Less experienced educator can construct educational game, simply relying on domain model developed by experts in specific knowledge area, utilizing already established relations between concepts for given domain model.

Student knowledge was modelled according to Overlay Student Model. Student's knowledge is presented as a set of domain concepts, that overlays expert model (Domain model). Since LearningPathEduGame also consists from the set of domain concepts, by overlaying students knowledge with learning path we can effectively track student's progress during learning of new concepts.

On the other side, established relation enables us to create transformations on lower MDA levels, in order to automatically generate EduGame Scene. Educator can define "learning scenario" (or use existing one from repository), and educational game will be generated (by use of game template from repository). EduGame Engine can generate adequate EduGame Scene, by choosing Learning and Assessment Objects, and pass it to EduGameInteraction for presentation to learner.

Attribute name	Possible values
Educational.LearningResourceType	info, cognition, assessment, exercise
Educational.Layer	Each element of LO can be placed in a different layer, which enables game-based environment to decide where and how to display elements of LO
Media.ContentType	text, graphic, video, sound, complex
Media.Format	media formats, like: ascii, html, gif, png, jpg, mp3, avi, ...
Graphic.Type	vector, raster
Graphic.DimensionsX	Picture width in pixels
Graphic.DimensionsY	Picture height in pixels
Graphic.ResX	number of dots per inch for X dimension
Graphic.ResY	number of dots per inch for Y dimension
Graphic.Colors.BitDepth	number of bits used to represent colors on picture
Graphic.Colors.Number	number of different colors used on picture
Graphic.Size	Number of bytes that picture occupies in memory
Text.Font	Font, example: Times New Roman
Text.Size	Text size
Text.Color	Text color
Sound.SampleRate	Sound sample rate
Sound.Length	Sound length in seconds
Sound.Size	Sound length in bytes
Video.Length	Video length in seconds
Video.Size	Video length in bytes
Video.FrameRate	Number of frames per second
Video.Dimension	Video Resolution
Interaction.Input	Mouse, Keyboard, GamePad, Voice, GPS position, other
Interaction.Output	Screen, Vibration, other

Table 2: Set of additional EGLO elements.

4.3 Educational Game Learning Object model

Educational Game LO (EGLO) consists of LO elements. Each element possesses five groups of attributes [<see> Tab. 2]. Educational holds additional data, such as LearningResourceType and Layer. LearningResourceType classifies LO by purpose, and Layer classifies LO by presentational importance. These two attributes inform the games as to where and how LO elements are to be presented to the player. Attributes

in Media group define concrete ContentType and Format for each LO element. Following groups are used to describe relevant meta-data for each of the supported content types (e.g. Graphic, Text, Sound and Video) in order to enable appropriate transformation of content and its integration in the game world by the game engines. Last group targets Interaction between LO element and student, defining possible Input and Output interaction styles.

4.4 Transformations of models

The benefits of this approach are numerous. One of the clear profits from using this method is the ability to reuse Learning Objects that are made with the different purpose. This process can be applied to assessment objects as well. In order to further elaborate these benefits we will present a given process of integrating existing Learning Objects in to game environment simply by using transformations according to the defined mode. Initially we will start from a traditional LO that consists of a text and image, and is presented in HTML format. It is not necessary to start from the formed LO, one can just as easily start from independent content create independent model as well. We decided on using an existing LO that has the purpose of explaining a concept of TCP synchronization through performing of three-way handshake [<see> Fig. 4].

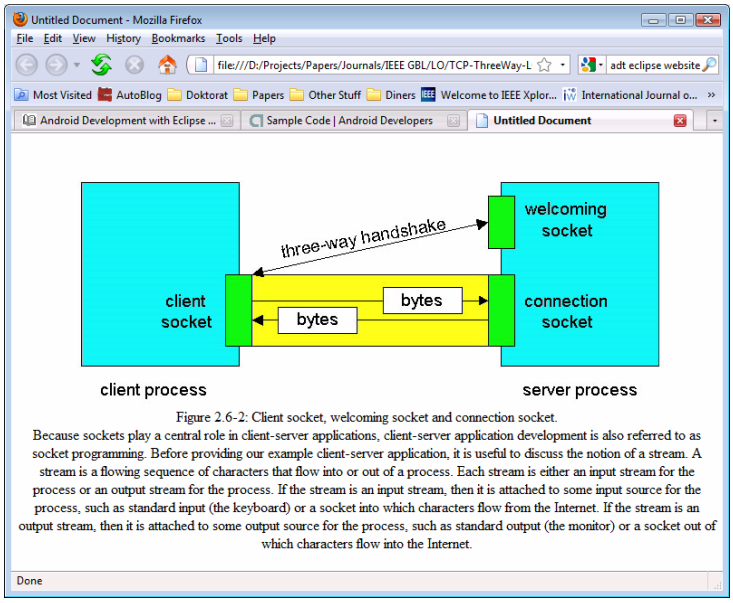

Figure 4: TCP Three Way Handshake HTML.

First step requires us to transform existing platform specific model expressed as HTML Learning Object into a more abstract specification level. For that purpose we developed a software tool for Educational Game Learning Object Management, similar to existing solutions that manipulate with classical LOs [Kyriakou, 11]. Some of its functionalities include importing of HTML LOs, transformation to EGLOs,

creation of new EGLOs, automatic and manual completion of LO meta-data and storing of EGLOs into repository [<see> Fig. 5].

During the import phase, system populates values from LOM elements if they exist. Upon that, it analyses HTML code, and identifies LO elements (text paragraphs, images, videos etc.) and attempts to extract as much meta-data information as possible. As mentioned earlier, one can also import independent content and form it in to LO.

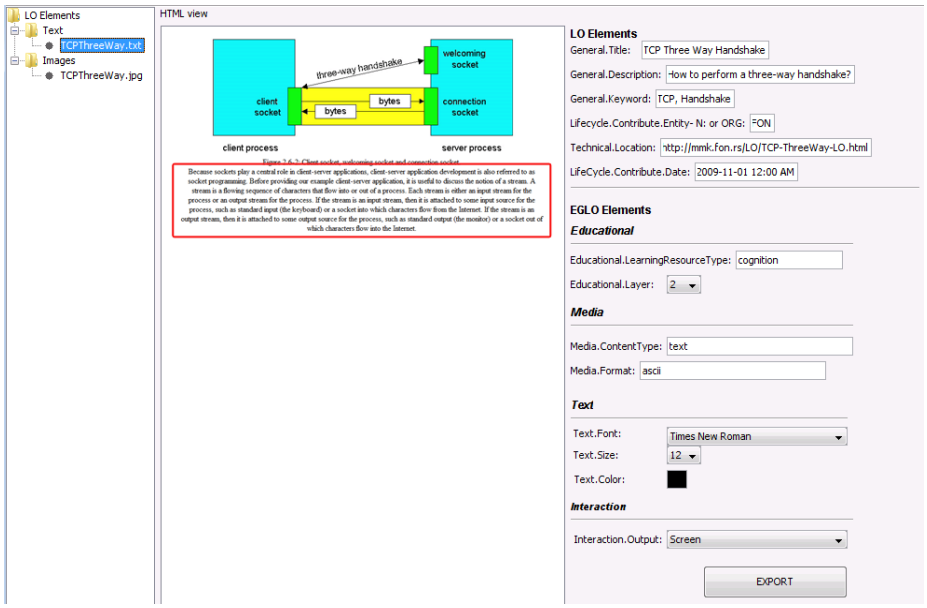

Figure 5: Editor – Transforming from LO to EGLO.

User can manually define LO elements as well as change or fill in missing meta-data. Final result is PIM model ex-pressed as a XML document structured by a formally defined XML schema. Specific document for a used LO example, 'TCP Three Way Handshake', described in high-level modelling language, is presented on Listing 1.. This XML Document contains enough information to enable transformation into platform specific LO description, which can be used in web-based or game-based environment. The resulting PIM model consists of two main elements, out of which one is the image and the other is the following explanatory text.

```
<?xml version="1.0" encoding="utf-8"?>
<LEARNINGOBJECT CODE="TCP_HANDSHAKE">
   <TITLE>TCP Three Way Handshake</TITLE>
   <DESCRIPTION>How to perform a three-way
         handshake?</DESCRIPTION>
          <KEYWORDS>TCP, Handshake</KEYWORDS>
          <AUTHOR>FON</AUTHOR>
          <URL>http://mmk.fon.rs/LO/TCP-ThreeWay-LO.html</URL>
          <DATE>2009-11-01 12:00 AM</DATE>
          <RESOURCE_TYPE> Narrative text </RESOURCE_TYPE>
          <LEARNER_PROFILE>University
         student</LEARNER_PROFILE>
          <INTERACTION>
                <INPUT type="mouse"/>
                <INPUT type="keyboard"/>
                <OUTPUT type="screen"/>
                <OUTPUT type="voice"/>
          </INTERACTION>
   <LOELEMENTS>
                <LOELEMENT layer="1" type="image/jpeg"
         src="TCPThreeWay.jpg" title="Client socket, welcoming
         socket and connection socket" dimensions="720x251px"
         resX="72dpi" resY="72dpi" bitDepth="24" size="30kb"/>
                <LOELEMENT layer="2" type="text/html" font="Times
         New Roman" size="12" color="black">
                Because sockets play a central role in client-server
         applications, client-server application development is also
         referred to as socket programming. Before providing our
         example client-server application, it is useful to discuss the
         notion of a stream. A stream is a flowing sequence of
         characters that flow into or out of a process. Each stream is
         either an input stream for the process or an output stream for
         the process. If the stream is an input stream, then it is
         attached to some input source for the process, such as
         standard input (the keyboard) or a socket into which
         characters flow from the Internet. If the stream is an output
         stream, then it is attached to some output source for the
         process, such as standard output (the monitor) or a socket
         out of which characters flow into the Internet.
                </LOELEMENT>
          </LOELEMENTS>
</LEARNINGOBJECT>
```

Listing 1: PIM for Educational Game Learning Object specification in XML.

The next step includes transformation of the platform independent description of LO into model specific to game based platform. Upon application of XSLT transformation, XML file is produced, which can now be used by game-based

environments [Minovic, 08]. LOM_ATTRIBUTES element covers a basic set of LOM attributes recommended by BELLE project [The Belle Project, 02]. GAME_ATTRIBUTES element carries additional data required by game-based environment, in order to perform integration of LO elements into the game.

```
<?xml version="1.0" encoding="utf-8"?>
<LEARNINGOBJECT CODE="TCP_HANDSHAKE">
<LOM_ATTRIBUTES>
        <LOM_ATTRIBUTE name="Title" lom_id="1.2"
lom_name="General.Title">TCP Three Way Handshake</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Description" lom_id="1.5"
lom_name="General.Description">How to perform a three-way
handshake?</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Description" lom_id="1.6"
lom_name="General.Keyword">TCP, Handshake</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Author or Contributor" lom_id="2.3.2"
lom_name="Lifecycle.Contribute.Entity- N: or
ORG:">FON</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Location, Address or URL" lom_id="4.3"
lom_name="Technical.Location">http://mmk.fon.rs/LO/TCP-ThreeWay-
LO.html</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Date" lom_id="2.3.3"
lom_name="LifeCycle.Contribute.Date">2009-11-01 12:00
AM</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Learning Resource Type" lom_id="5.2"
lom_name="Educational.LearningResourceType"> Narrative text
</LOM_ATTRIBUTE>
        <LOM_ATTRIBUTE name="Learner Level" lom_id="5.6"
lom_name="Educational.Context"> University student </LOM_ATTRIBUTE>
</LOM_ATTRIBUTES>
<LOELEMENTS>
 <LOELEMENT src="TCPThreeWay.jpg" title="Client socket, welcoming
socket and connection socket">
 <GAME_ATTRIBUTES>
        <GAME_ATTRIBUTE
name="Educational.LearningResourceType">info</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Educational.Layer">1</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Media.ContentType">graphic</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Media.Format">jpg</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Graphic.Type">raster</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Graphic.DimensionsX"
unit="px">720</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Graphic.DimensionsY"
unit="px">251</GAME_ATTRIBUTE>
```

```
        <GAME_ATTRIBUTE name="Graphic.ResX"
unit="dpi">72</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Graphic.ResY"
unit="dpi">72</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Graphic.Colors.BitDepth">24</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Graphic.Colors.Number">4</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Graphic.Colors.Histogram"></GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Graphic.Size"
unit="KB">30</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Interaction.Input">Mouse</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Interaction.Input">Keyboard</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Interaction.Output">Screen</GAME_ATTRIBUTE>
        </GAME_ATTRIBUTES>
 </LOELEMENT>
 <LOELEMENT src="TCPThreeWay.txt">
 <GAME_ATTRIBUTES>
        <GAME_ATTRIBUTE
name="Educational.LearningResourceType">cognition
</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Educational.Layer">2</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Media.ContentType">text</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Media.Format">ascii</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Text.Font">Times New
Roman</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE name="Text.Size">12</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Text.Color">Black</GAME_ATTRIBUTE>
        <GAME_ATTRIBUTE
name="Interaction.Output">Screen</GAME_ATTRIBUTE>
        </GAME_ATTRIBUTES>
 </LOELEMENT>
 </LOELEMENTS>
    </LEARNINGOBJECT>
```

Listing 2: PSM for Educational Game Learning Object and Game Based environment specification in XML.

Game Based Learning System we developed during our research has built-in support for generated PSM [Minović, 10]. Specific presentation method, as well as

interaction, strongly depends on gameplay. Game engine utilizes meta-data and decides in runtime how EGLO will perform in the game. In this concrete example a player reaches a Non Playing Character (NPC) and attempts interaction (Figure 6.). Non Playing Character (NPC) act as enemies, partners and support characters to provide challenges, offer assistance and support the storyline [Merrick, 06].

Presentation of different elements depends on information contained in LO and decision made by game engine. When creating EGLO, we can suggest the importance of each LO element through LearningResourceType and Layer attributes. In this case, since the image element has the attribute LearningResourceType set to "info", the game engine decides it should present the image in the info dialogue panel. Since Layer is set to "1" game engine decides that image has to be shown to the player in any case scenario. On the other hand, since Layer attribute for text is set to "2", game engine offers the content to the player optionally, so that player can decide whether to read it or not. By simply clicking on the image, right information panel will pop up and offer the content to player for reading.

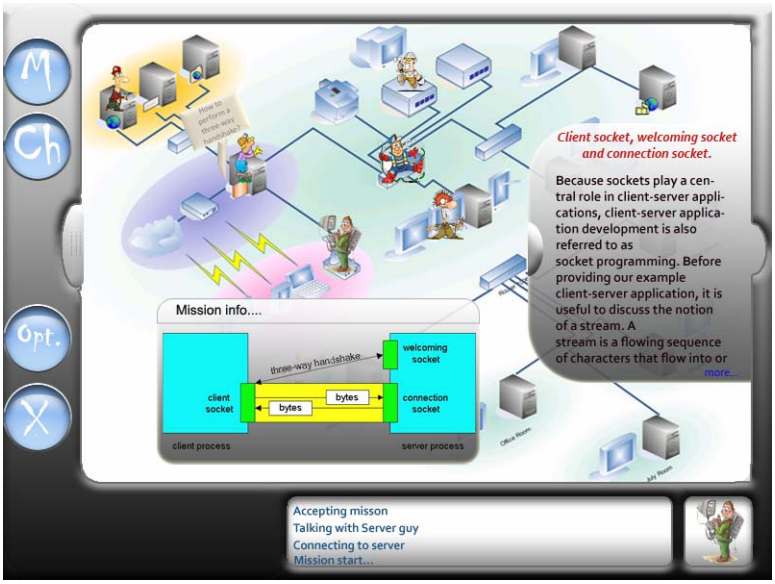

Figure 6: TCP Three Way Handshake LO in a game executed in Java Applet environment.

Advantage of using this method is simpler adaptation of EGLO presentation depending on device platform. Graphical presentation [<see> Fig. 7] shows screenshot same game and same EGLO interpreted on a JME platform [Minović, 11]. In this case, also based on Layer and LearningResourceType attributes, game engine decides to present the image on the first screen, upon meeting the NPC, and provides the text after clicking on the Info option from the menu. As seen the principle is the same, the only difference is in the engine, and its ability to decide the best integration of the LO in the game. In this case adaptation can be done according to platform limitation which will provide better user experience.

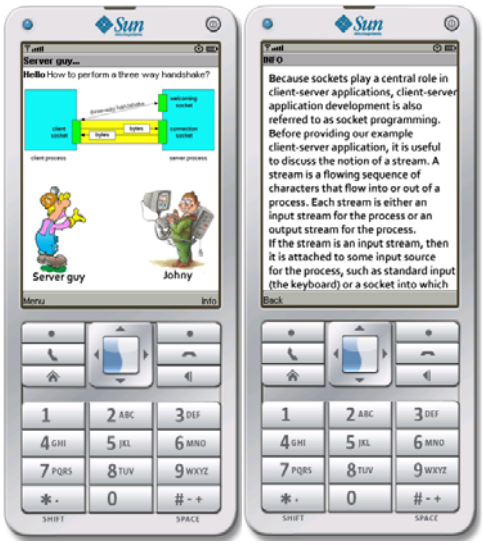

Figure 7: TCP Three Way Handshake LO in JME Mobile Game.

This example shows one of the benefits of using MDA approach. It provides a generic framework that enables the reuse of content and also a proper way to integrate knowledge in to games. The quality of the game will now rely on the quality of the engine and its ability to properly present the knowledge in the game run time. The important fact is that now Learning Objects that are main building blocks of knowledge in proposed game environments have better meta-data that can provide better quality of in-game integration.

5 Conclusions

In this paper the focus was on the area of managing knowledge in game environments. The research is directed towards shifting the focus from traditional web-based LMSs to increase the use of game-based learning environments, with the intention of integrating advantages of using games in university education.

Presented example pointed out key benefits of MDA approach used, and proposed a solution to the issue on how to use a classical LO's in development of educational games. In essence, the approach is based on using MDA content repurposing that consists of two main steps: transformation of a platform specific model of web based LO into a more abstract model expressed in a new language and transformation a resulting model into a platform specific model that is applicable in educational games. For that purpose the development of Educational Game Learning Object Metamodel and related Meta language was done for specification of such LOs. In addition, a new term Educational Game Learning Object (EGLO) was introduced.

One of the benefits of the proposed model is obtaining reusability of Learning Objects between web-based Learning Management Systems and game-based environments. In order to make EGLO fully reusable, it is necessary to preserve LO content, with modified presentation. Thus, there was an introduction of different set of attributes that future game engines should use in order to properly integrate knowledge in to quality presentational mode. In this way, reusability of EGLO's between different games that use different environment and settings was conceived.

Another contribution of this work is a software tool that can be used to import, transform, edit and add meta-data, store and export Learning Objects.

6 Future Work

Further research should be on further development of EGLO meta-model and language in order to support new features required by new game types. Additionally, effort should be invested in further development of new game types by using EGLO's. Also, establishing of public EGLO repository would be beneficiary to further research. Learning object repositories (LOR) are digital collections of educational resources and/or metadata aimed at facilitating reuse of materials worldwide [Alonso, 11]. Future activities for improvements should include development of knowledge engine which would act as a proxy between EGLO repository and game engines. Such engine should enable much easier integration of educational concepts into games.

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