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A Digital Rights Management System based on Semantic Rules

by

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ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ
ΣΧΟΛΗ ΘΕΤΙΚΩΝ ΚΑΙ ΤΕΧΝΟΛΟΓΙΚΩΝ ΕΠΙΣΤΗΜΩΝ
ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΥΠΟΛΟΓΙΣΤΩΝ

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ABSTRACT

Digitization together with the exponential growth of the web have led to a world where digital music, images, video, books, and games can be distributed instantly across the internet to end-users. However, this fact has at the same time led to increased concern about the protection of the rights of owners of the content that is distributed in electronic form.

The main issue that comes up is that without protection of digital rights, digital content can be easily and uncontrollably copied, modified and distributed by a large number of end-users which do not have the essential rights to do such actions.

Our essential proposal to resolve this issue is a system that prevents unauthorized access to digital content and manages content usage rights.

Our contribution is the designing and development of a digital rights management system that based on some specified semantic rules and provides a persistent content protection against unauthorized access to the digital content, limiting access to only those with the proper authorization. Moreover our system is capable to manage content usage rights in such a way where no one other than the copyright owner of the content can perform an action (e.g. copy, distribute) to this content without the owner's authorization. However, certain end-user actions (use for education, private copy) may, in circumstances specified in the current legislation,

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Περίληψη

Η ψηφιοποίηση μαζί με την ραγδαία ανάπτυξη του διαδικτύου οδήγησαν σε ένα κόσμο όπου η ψηφιακή μουσική, οι εικόνες, τα βίντεο, τα βιβλία και τα ηλεκτρονικά παιχνίδια μπορούν να διανεμηθούν αμέσως μέσω του διαδικτύου στους τελικούς χρήστες. Το γεγονός όμως αυτό οδήγησε ταυτόχρονα στο να αυξηθεί το ενδιαφέρον για την προστασία των δικαιωμάτων των ιδιοκτητών του έργου το οποίο διανέμεται σε ηλεκτρονική μορφή δια μέσου του διαδικτύου.

Το βασικό ζήτημα που προκύπτει είναι ότι χωρίς την προστασία των ψηφιακών δικαιωμάτων, ένα ψηφιακό έργο μπορεί εύκολα και χωρίς έλεγχο να αντιγραφεί, να τροποποιηθεί και να διανεμηθεί από ένα μεγάλο αριθμό χρηστών οι οποίοι δεν έχουν τα απαραίτητα δικαιώματα για να εκτελέσουν τέτοιου είδους ενέργειες.

Για την επίλυση του συγκεκριμένου ζητήματος η βασική μας πρόταση είναι ένα σύστημα το οποίο θα εμποδίζει τη μη εξουσιοδοτημένη πρόσβαση σε ένα ψηφιακό έργο και θα διαχειρίζεται τα δικαιώματα χρήσης του συγκεκριμένου έργου.

Η συνεισφορά μας στον τομέα είναι η σχεδίαση και ανάπτυξη ενός συστήματος διαχείρισης ψηφιακών δικαιωμάτων το οποίο βασίζεται σε ένα σύνολο σημασιολογικών κανόνων και παρέχει μια σθεναρή προστασία των ψηφιακών έργων απέναντι σε μια μη εξουσιοδοτημένη πρόσβαση στα συγκεκριμένα έργα, περιορίζοντας την μόνο σε αυτούς με την κατάλληλη εξουσιοδότηση. Επιπλέον, το σύστημα μας έχει τη δυνατότητα να διαχειρίζεται τα δικαιώματα χρήσης των

ψηφιακών έργων με τέτοιο τρόπο ώστε κανένας εκτός των ιδιοκτητών των έργων αυτών να μπορεί να εκτελεί κάποια ενέργεια (π.χ. αντιγραφή, διανομή) στα έργα αυτά χωρίς την άδεια του ιδιοκτήτη. Παρόλα αυτά, ορισμένες ενέργειες (π.χ. χρήση στην εκπαίδευση, αντιγραφή για προσωπική χρήση) από τους χρήστες ενδέχεται κάτω από συγκεκριμένες συνθήκες οι οποίες καθορίζονται από την ισχύουσα νομοθεσία να εκτελεστούν χωρίς την άδεια του ιδιοκτήτη.

Επόπτης Καθηγητής: Δημήτρης Πλεξουσάκης
Καθηγητής

Ευχαριστίες

Στο σημείο αυτό θα ήθελα να ευχαριστήσω τον επόπτη καθηγητή μου κ. Δημήτρη Πλεξουσάκη για την άψογη συνεργασία μας τα τελευταία 2 χρόνια, καθώς επίσης και για την ουσιαστική του καθοδήγηση και συμβολή στην ολοκλήρωση της παρούσας εργασίας.

Επίσης, θα ήθελα να εκφράσω τις ευχαριστίες μου, στον καθηγητή κ. Γρηγόρη Αντώνιου και στον ερευνητή κ. Martin Doerr, για την προθυμία τους να συμμετέχουν στην τριμελή εξεταστική επιτροπή.

Παράλληλα, θα ήθελα να ευχαριστήσω τον κ. Martin Doerr για τη μεγάλη του βοήθεια και καθοδήγηση σε όλη τη διάρκεια εκπόνησης της εργασίας αυτής.

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Contents

List of Figures

Chapter 1

Introduction

Digitization together with the exponential growth of the web have led to a world where digital music, images, video, books, and games can be distributed instantly across the internet to end-users. However, this fact has at the same time led to increased concern about the protection of the rights of owners of the content that is distributed in electronic form.

The main issue that comes up is that without protection of digital rights, digital content can be easily and uncontrollably copied, modified and distributed by a large number of end-users which do not have the essential rights to do such actions.

The main goal of this Master Thesis is to design and develop a digital rights management system that provides a persistent content protection against unauthorized access to the digital content, limiting access to only those with the proper authorization and is capable to manage content usage rights.

An obvious reason for controlling access is economic. When creators and publishers expect revenue from their products, they permit access only to users who have paid. It might be thought that access management would be unnecessary except when revenue is involved, but that is not the case; there are other reasons to control access to materials. For example, materials that donated to a digital library may have conditions attached, perhaps tied to external events such as the lifetime of certain individuals. Moreover organizations may have information in their private collections that they wish to keep confidential, such as commercial secrets, police records, and classified government information. The boundaries of art, obscenity, and the invasion of privacy are never easy to draw. Even when access to the collections is provided openly, controls are needed over the processes of adding, changing, and deleting material, both content and metadata.

Furthermore our system is capable to manage content usage rights in such a way where no one other than the copyright owner of the content can perform an action (e.g. copy, distribute) to this content without the owner's authorization. Specifically, end-users can perform an activity to a digital content only if the copyright owner has granted the appropriate right, through a license, to them.

However, certain end-user actions (use for education, private copy, temporary reproduction) may in circumstances specified in the current legislation, can be done without the authorization of the copyright owner. Although, these copyright exceptions do not mean that the exceptional usage is always free. Some of these exceptions allow use of the content without the authorization of the owner but require the user to pay a fee.

1.1 Contributions

The main contributions of this thesis are:

- A digital rights management system that provides a persistent content protection against unauthorized access to the digital content, limiting access to only those with the proper authorization.
- A system that is capable to manage content usage rights.
- A graphic representation of a set of legislative regulations that our system is based in order to decide if an end-user can perform an action to a digital content or not.
- Transformation of legislative regulations that are represented graphically to a set of semantic rules in SWRL.
- Implementation of a Reasoner in order to manage the semantic rules and decide whether an end-user has the appropriate right to perform an action to a digital content or not.
- Implementation of a web application and specifically of a digital library in which our DRM System is embedded.

1.2 Organization of the thesis

Chapter 2 describes the DRM systems in general and explains how a typical DRM model used by the current DRM implementations works. Moreover, existing commercial or not systems in the domain of digital rights protection are presented in this chapter.

In Chapter 3 we give an overview of the architecture of our system, and we describe the ontology and the rules that our system is based on.

The implementation and the design choices that we made are placed in Chapter 4. Moreover, in this chapter we give a representative usage scenario in order to be more understandable how our system works.

Chapter 5 summarizes the results of this thesis and identifies topics that are worth further work and research.

Chapter 2

Digital Rights Management Systems

1.3 Introduction

The core concept in DRM systems is the use of digital licenses. Specifically, end-users in order to use a digital material they have to obtain a license from the copyright owner granting the appropriate rights to them. A license is a digital data file that specifies certain usage rules for the digital content. Usage rules can be defined by a range of criteria, such as frequency of access, expiration date, restriction of transfer to other devices, copy permission etc. These rules can be combined to enforce certain business models, such as rental or subscription, try-before-buy, pay-per-use and a lot more.

Protected content can be distributed though a client/server system, super-distribution, digital audio/video broadcasting, or CDs. Without possessing digital license to the content, digital content is a sequence of scrambled bits. Often digital content and licenses are stored separately, which makes DRM systems more flexible in such a way that protected content can be freely distributed among users and license requests can take place later.

Through digital licensing, content providers can gain much more control over what the end-users can do with the content decreasing digital piracy and limiting access to only those with the proper authorization.

1.4 A generic model of DRM Systems

Different DRM vendors have different DRM implementations, names and ways to specify the content usage rules. However, the basic DRM process is the same, which usually involves four parties: the content provider, the distributor, the clearinghouse and the consumer. Usually a DRM system is integrated with an e-commerce system that handles financial payments and triggers the function of the clearinghouse. Figure 2.1 displays a generic DRM Architecture [20] for content distribution based on most existing commercial systems. Following the explanation of the common elements [19, 20] of a DRM system, a typical model used by current DRM implementations is presented.

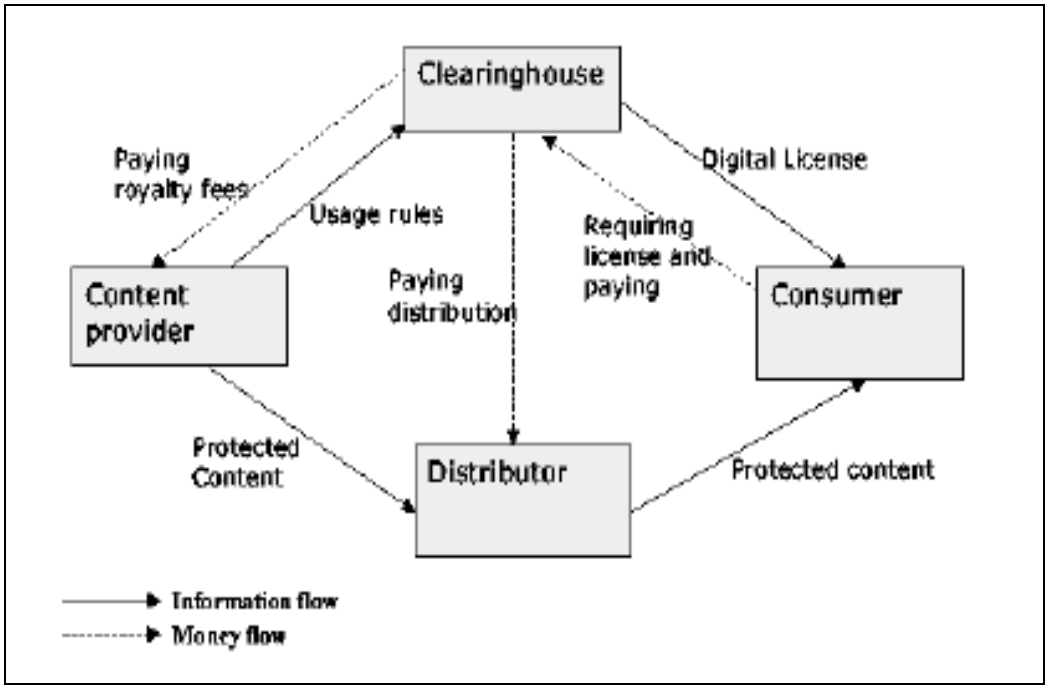

Figure 2.1: A generic DRM Architecture for content distribution

- ***The protected content***. The content that needs to be protected can vary. DRM is currently most known from audio and video content delivery, but DRM is also applied to documents and can in principle be applied to any form of digital content.

- ***The content provider*** such as such as a music record label or a movie studio holds the digital rights of the content and wants to protect these rights.

- ***The distributor*** provides distribution channels, such as an online shop or a web retailer. The distributor receives the digital content from the content provider and creates a web catalogue presenting the content and rights metadata for the content promotion.

- ***The consumer*** uses the system to consume the digital content by retrieving downloadable or streaming content through the distribution channel and then paying for the digital license. The player/viewer application used by the consumer takes charge of initiating license request to the clearinghouse and enforcing the content usage rights.

- ***The clearinghouse*** handles the financial transaction for issuing the digital license to the consumer and pays royalty fees to the content provider and distribution fees to the distributor accordingly. The clearinghouse is also responsible for logging license consumptions for every consumer.

- ***The expression of the rights***. In most systems rights expression languages are used to define the rights that are issued to the content users. Two well-known rights languages are ODRL and XrML. DRM rights languages are often expressed in XML. Since for digital assets in general there are a lot of possible situations, DRM rights languages tend to be complex.

- ***The cryptographic protection scheme***, including a key management scheme. Most DRM systems work with a combination of symmetric and asymmetric keys. Often content is encrypted in layers using a key hierarchy, where keys in the lower layers in the hierarchy are used to encrypt parts of the content.

- ***License management***. The license contains both the encryption key as well as the rights that have been entitled to the user. Without the presence of the license, content access is not possible. Since the license contains both the key and the rights it is important to protect the license as well. It should be impossible for an unauthorized user to get the key from the license or to change the rights expressions. Licenses should therefore be handled with care and either be encrypted or stored in a secure place in the client. Some systems support the explicit separation of content and licenses. This has the advantage

that licenses and content can be send over different channels and at different times.

- ***Compliance regulation***. Compliance is a key issue in DRM systems. Only compliant devices can participate in content exchange. A compliant device is a device that respects the rules of the DRM system. This means that the device guarantees that the content is treated as described by the license rights and that the device also takes certain measures to prevent encryption keys from being obtained by unauthorized users. In the (open) PC environment compliance is often only supported in software by installing DRM client software. In the (closed) CE environment compliance is often supported by a combination of software and hardware. A way to deal with compliance is using certificates. For example a CE device may have a pre-installed certificate indicating that it is compliant with a specific DRM system. Upon request, this certificate can be send to a license server in order to verity compliance. A certificate authority that monitors compliance and acts in the case of violations issues such certificates. Certificates that have been issued to compliant devices that nevertheless violate the rules can be revoked. Revoked systems will not be able to acquire content under the DRM scheme any longer.

A generic DRM model used by current DRM systems works as follows:

Firstly, the content provider encodes the digital content into the format supported by the DRM system. Different DRM systems provided by different DRM vendors may support different content formats. The digital content is then encrypted and packaged for the preparation of distribution. The content provider may use watermarking technology to embed digital codes into the digital content that can identify the ownership of the content and the usage rules.

Next, the protected content is transferred to the appropriate content distribution server, e.g. web server or steaming server, for on-line distribution. The digital license containing content decryption keys and usage rules is sent to the clearinghouse. The usage rules specify how the content should be used, such as copy permit, pay-per-view, a one-day rental etc.

At the other end of the process, the consumer downloads the digital content from the web server or requests streaming content from the streaming server. To be able to consume the protected content, the user has to request a valid license from the clearinghouse. After receiving the license request, the clearinghouse verifies the user's identity for example by having the user present a valid digital certificate, charges his account based on the content usage rules, and generates transaction reports to the content provider. Finally, the license is delivered to the consumer's device after the consumer has paid through the e-commerce system, and the protected content can be decrypted and used according to the usage rights in the license.

1.5 Existing DRM Systems

This section covers a description of some well – known systems that are currently available in the domain of Digital Rights Management.

1.5.1 Microsoft WMRM

Microsoft Windows Media Rights Manager [24], is an end-to-end DRM system for the secure distribution of multimedia files. It is an SDMI-compliant solution based on Windows Media Player and Server. The system only supports Microsoft's proprietary WMA (Windows Media Audio) and WMV (Windows Media Video) formats. Both server and client Software Development Kits (SDKs) are available to develop customized DRM solutions. The supported business models can be subscription, sales, counted operations and secure transfer of protected digital media.

The main advantage of WMRM is that the Windows media format is widely used on the Internet and the Windows media player has already incorporated DRM support. PressPlay, a large online music service company, uses WMRM technology [23] to offer digital music from Sony, Universal, EMI and many independent labels. The main difference from other music service providers is that PressPlay allows the consumer to burn the music onto CDs [4].

1.5.2 InterTrust Rights|System

Rights|System [18] offers a solution for content packaging, distribution and rights management based on a packager program and rights server technology. This system supports pay-per-use, rentals, sales, and try-before-buy business models.

System clients are not only for desktop PCs, but also for mobile phones, set-top boxes, and music players. Examples of supported applications are Adobe Acrobat for documents, MusicMatch for music, and MPEG-4 players for video. There are toolkits for independent software vendors and media player developers to integrate InterTrust's DRM technology into their products.

Nokia has selected InterTrust as its preferred DRM technology for the mobile content distribution [27]. InterTrust has recently gone through a downsizing, reducing its staff by 70 percent and removing its products from the market. A new license agreement with Sony [9] has been made so InterTrust may survive on licensing fees and ongoing royalties from sales of Sony's products that incorporate its DRM technology.

1.5.3 IBM EMMS

Electronic Music Management System [16] was developed for the preparation and secure distribution of all forms of digital content. It supports the goal of SDMI. The supported business models can be pay-per-use, pay-per-time, subscription, controlled printing, and protected transfer to portable devices and portable media.

Currently EMMS only supports Windows platforms. An EMMS-enabled player called "Madison Player 1.0" has been distributed since the beginning of August 2001 and an SDK for the player is available.

EMMS is mainly used in Japan for online music distribution. There are a number of web sites [17] selling digital music using the EMMS in Japan. IBM has strong ties with Sony for mobile content distribution. EMMS has been used in one of the most famous mobile distribution services – DoCoMo's M-stage music service in Japan.

1.5.4 RealNetworks RMCS

RealSystems Media Commerce Suite [31] offers a packaging server, streaming server, license server and a secure file format plug-in for RealPlayer. This system provides Windows and UNIX solutions and supports subscription, video on demand and other business models.

RMCS is currently utilized by MusicNet [26], a joint venture of RealNetworks, AOL Time Warner, Bertelsmann AG, EMI Group and Zomba. MusicNet is offering digital licenses for a music subscription service for the four record labels and its music format is bound to the Real format. Both AOL and RealNetworks (RealOne) have launched a MusicNet - based service [13].

1.5.5 OMA DRM Version 2

OMA DRM v2 [19, 28] follows very much the basic DRM architecture as described in the section 2.2. It distinguishes between a content issuer and a rights issuer as two separate entities. Rights are only issued to trusted DRM agents that reside in client devices (e.g. mobile phones)

Compliance in OMA DRM v2 is realized through the notion of trusted agents. The notion of a trusted agent is important and implemented by means of a public key infrastructure. This means that each trusted agent has a unique public/private key pair and a certificate belonging to it. Certificates play a role in the authentication protocol and are a means to revoke agents that exhibit noncompliant behaviour. Content is encrypted by means of symmetric keys, while licenses (or rights objects as they are called in OMA) are encrypted by asymmetric keys. The symmetric key belonging to some specific encrypted content is sent to a trusted DRM agent by means of a rights object. The rights object is encrypted with the public key of that specific trusted DRM agent. In this way only that specific trusted DRM agent can access the rights object by decrypting it with its corresponding private key. This is a way to bind content to a specific device and to prevent that content from being played on another device.

In order to allow some sharing of content OMA DRM v2 introduces the notion of domains. A domain is a group of devices defined by a rights issuer.

Domains are optional and their use can differ among various content issuers and rights issuers. A rights issuer carries out domain management. In order to join a domain, a device has to register to that domain by making a request to the rights issuer. Once a group of devices has joined the domain, they can access the content that is issued to that domain. This means that devices can directly share rights objects for domain content amongst each other.

In addition to domains, OMA DRM v2 supports another mechanism for sharing content, namely super-distribution. Super-distribution can be used between any two trusted OMA DRM agents. It consists of sending the protected content from one agent to the other. For the other agent to gain access to the content, it has to contact the rights issuer in order to obtain a rights object for that specific content. The nice thing about super-distribution is that it allows direct exchange of the protected content and allows for the rights object to be acquired later. In a mobile environment this may be an advantage since rights objects will be much smaller than content objects. So a user may acquire the content through a fast direct connection with another mobile device, while obtaining the rights object via the mobile network. This is a direct result of the decision in OMA DRM v2 to separate content objects and rights objects.

As far as client-side enforcement is concerned, OMA requires the secure storage of the private device keys and the implementation of a secure clock in connected devices. In addition it is required that the execution of rights evaluation at playtime is secured and cannot be tampered with. The reason for requiring a secure clock is to support time-based usage rights (for example the right to use the content up to a certain date) and to prevent users from manipulating the clock in order to affect the impact of time-based rights.

1.5.6 Marlin

While OMA DRM originates from the mobile world, Marlin originates from the CE (Consumer Electronics) world. The core developers of Marlin [19, 21] are InterTrust, Sony, MEI, Samsung, and Philips. Marlin is an open DRM standard targeting CE devices and supporting the controlled flow of audio and video content over collections of CE devices.

Marlin has a number of characteristics that differentiate it from other DRM systems. We will list them first and then elaborate on them below. Most important is that Marlin is user-based, rather than device-based, which means that licenses are bound to users rather than to devices. A second characteristic that differentiates Marlin is that it does not use a rights expression language, instead rights definition and enforcement in Marlin are taken care of by means of a control program. Such control programs are part of the generic DRM architecture called Octopus. A third characteristic of Marlin is that right from the start the notion of domain is designed in. The Marlin domain model builds on a graph of nodes and links that allow for very flexible rights sharing.

The overall Marlin architecture consists of four classes of actors: the Marlin client, the Marlin domain manager, the Marlin registration service, and the Marlin license service. The Marlin client has the same role as other DRM clients: control the access to the content based on the rights that have been issued to the user. The Marlin domain manager has the role of managing domains consisting of devices and users joining and leaving domains. The Marlin registration service is responsible for admitting users and devices to the Marlin system; it does so by means of issuing nodes and links. Finally, the Marlin license service issues licenses.

Nodes and links play a central role in Marlin. Nodes represent entities in a Marlin system. There are four kinds of nodes: device, domain, user, and subscription. In Marlin, links express an inclusion relationship.

The directed graphs play a central role in determining the access rights to content in a Marlin system. Roughly speaking content can be accessed when there is a path in the graph from the requester to the content. Note that this a pre-requisite, the actual access rights are expressed in the control program, the graph serves as a sharing mechanism that allows sharing of licenses between users and devices in a very flexible way.

Chapter 3

A DRM System based on Semantic Rules

1.6 Introduction

As we can understand from the previous chapter, all of the existing digital rights management systems are based on cryptographic mechanisms in order to protect the digital content that is distributed in electronic form across the web.

In this thesis we propose a different approach of a DRM system that is not based on cryptography. Specifically, our system is based on semantic rules that specify if an end-user is authorized to perform an action to a digital content or not. Because these rules must take into account relevant copyright laws and agreements made between copyright owners and end-users (known as digital licenses), the creation of them has to be done by people that are specialized in this scientific area (i.e. juristic people). Moreover, in order these rules to be understandable by the reasoning engine of our system they have to be written into a programming language such as SWRL [14]. However, it is obvious that the creators of these rules do not have the essential knowledge to write them into a programming language such as SWRL. Thus, we understood that we need a writing form of the current rules that will be familiar to the creators of these rules and at the same time to be able to convert to the programming language of SWRL in order to be understandable by the reasoner of our system. Having all that in mind, we decided that a graphic representation of the specific rules, using a graphics programming tool, will be the best solution. The way in which the rules are created by the graphics programming tool and the conversion of them to SWRL rules will be discussed later in this chapter.

Finally, after the conversion of the graphic rules to SWRL rules, the reasoner of our system is capable to decide whether an end-user holds the appropriate rights to perform an action to a digital content or not. Specifically, if a user is the copyright owner of a digital object then he is able to perform any activity he wants. However, if an end-user does not have the essential (economic) rights to perform an action to the content then our system recommends him if he wants to obtain a digital license from the copyright owners of the specific content in order to be able to perform this particular action. If the end-user answers yes then a message is send to the copyright owners that notify them that an end-user wants to perform an activity to their digital content. In order the end-user to perform an activity to a digital content all of the copyright owners have to grant him the appropriate rights; otherwise the system refuses him permission to carry out the specified operation. Another case that the system refuses user to perform a activity to a digital object is when the system does not have the essential knowledge about the copyright owners of the specific object, due to the fact that are not members of the system or they are not specified in the metadata file of this object, and thus it informs the user that is not able to perform the requested activity (ies). However, if all of the copyright owners are known, then a final message is sent to end-user in order to inform him whether he has obtained the appropriate rights or not.

1.7 System Architecture

After a general overview of what our system provides it should be useful to describe its architecture as well. Our system's architecture is similar to [1] and is shown at the figure below. At the left of this figure are the information managers that are responsible to create the policies which define the access to a digital material. *Policies* relate end-*users* (at the top) to *digital material* (at the bottom). *Authorization*, at the center of the figure, specifies the *access*, at the right. Each of these sections requires elaboration. As we mentioned before, policies-rules that the information managers create must take into account relevant copyright laws and agreements that made between copyright owners and end-users (known as digital licenses). Moreover, users need to be authenticated and their role in accessing materials established. Digital material in the collections must be identified and its

authenticity established. Finally, access is expressed in terms of permitted operations (i.e. copy, distribute, derive).

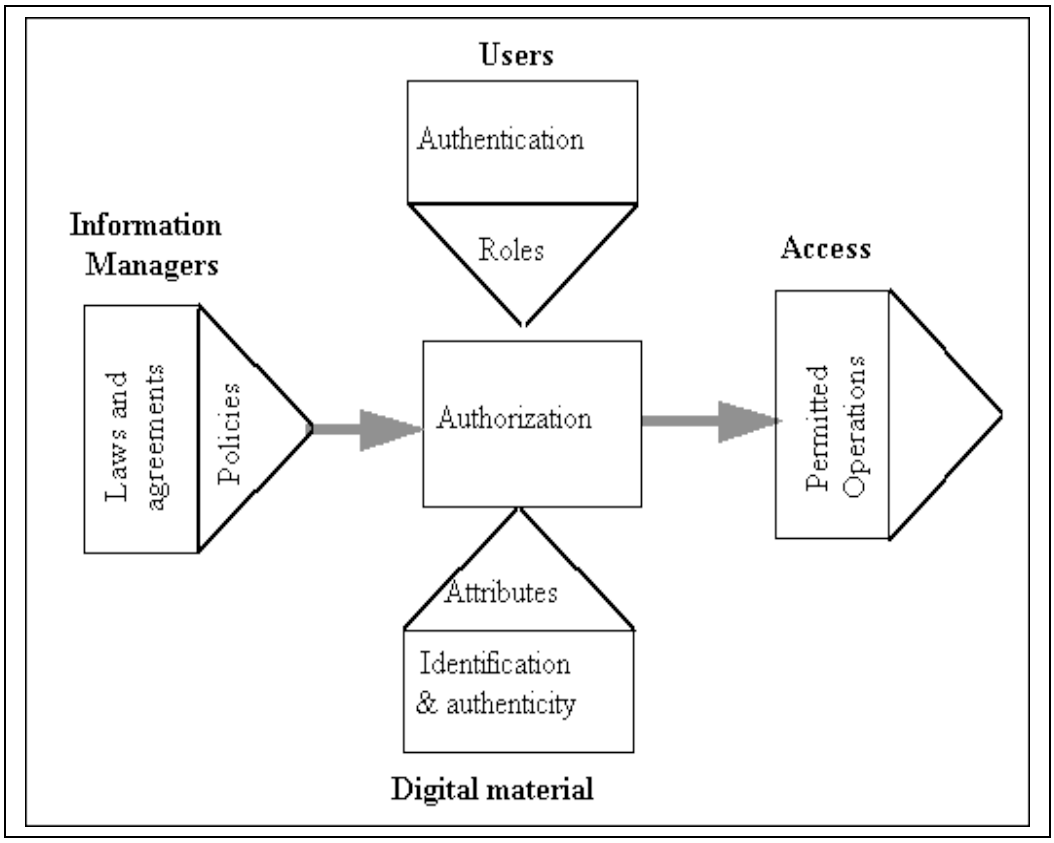

Figure 3.2: A generic Architecture of our DRM System

When end-users request to access the collections (i.e. a digital library), each request passes through a workflow which is based on the above architecture. Specifically, end-users have to be authenticated in order to establish the identity of them and to be determined what the end-user is authorized to do. A standard method of authentication that we used in our system is by providing each user with a login name and a password. After the authentication of the users, authorization procedures that based on relevant copyright laws and agreements made between copyright owners and end-users, grant or refuse them permission to carry out specified activities. More particularly, if a user is a copyright owner of a digital object and at the same time requests to perform any activity he wants to this object, then this request, after takes into account all the current rules, finally it matches with the rule *Copyright-Owner (*subsection 3.4.1*),* and thus the authorization module permits him

to perform the activity he requests. Moreover if a user request to perform any activity (copy, distribute, etc) to a digital object and he is not the copyright owner of it, then this request does not match with any rule of our system and thus the authorization module refuse him to perform this activity. Another case is when a user, that is not the copyright owner of it, request to perform a particular activity to a digital object (i.e. copy) and at the same he has obtained a license from the copyright owner(s) of this object that grant him the essential economic right (Reproduction Right) in order to be authorized to perform this activity. Therefore, the above request, after takes into account all the current rules, it matches with the rule *License-Reproduction-Right (*subsection 3.4.1*),* and thus the authorization module permits him to perform the activity he requests. Similarly to the above case, if a user request to perform another activity (i.e. distribute) to a digital object, then this request will match with the rule *License-Distribution-Right* (subsection 3.4.1). The same stands with the other activities (derive, communicate, perform). A different case from that is when a user request to perform the activity copy to a digital object only for educational purposes. Therefore, in this case, the above request, after takes into account all the current rules, it matches with the rule *Educational-Purpose (*subsection 3.4.1), and thus the authorization module permits him to perform this activity without the owner's authorization. Similarly to the above case, if a user request to perform the activity copy to a digital object, only for private use or for temporary reproduction purposes, then this request will match with the rule Private-*Copy-Purpose (*subsection 3.4.1) or with the rule *Temporary-Reproduction-Purpose (*subsection 3.4.1) accordingly. Finally, if a user that is not the copyright owner of it, request to perform a particular activity (i.e. copy) to a digital object and at the same holds the essential Economic Right: Reproduction Right, then this request, after takes into account all the current rules, it matches with the rule *Reproduction-Right (*subsection 3.4.1) and thus the authorization module permits him to perform this activity. Similarly to the above case, if a user request to perform another activity (i.e. distribute) to a digital object, then this request will match with the rule *Distribution-Right* (subsection 3.4.1). The same stands with the other activities (derive,communicate,perform).

Moreover, our system provides all the essential information about the activities that a user is able to perform to a digital object in order to be ensured from

future activities of the users that could be performed for different purposes(i.e. a user may request to reproduce a digital object for educational purposes and afterwards to use it for different purposes).

Finally, the responsibility for access to digital material lies with whoever sets the policies-rules which are applied to our system. As we referred in the introduction of this chapter, this responsibility belongs to people that have the appropriate knowledge about the current copyright legislation (i.e. juristic people).

1.8 System Ontology

For the purpose of modeling and representing the knowledge that is inherent to our system, we used the Digital Rights Ontology (DRO) that is developed in the CASPAR (**C**ultural, **A**rtistic and **S**cientific knowledge for **P**reservation, **A**ccess and **R**etrieval) project [29].

The development of the Digital Rights Ontology builds on some existing standard or well-established core ontologies of intellectual work and cultural-historical information in general, such as CIDOC CRM [3] and FRBRoo [8] , as well as on IPR-specific works, such as the IPROnto ontology [7]. Besides that, some standard Rights Expression Languages, like MPEG21-REL [25], ODRL [15] and Creative Commons [2] have been used as a guide in the definition of the license-specific concepts and terminology. Finally, the documentation from WIPO (World Intellectual Property Organization) [32] has been used for consultation, with the objective to develop a legal framework independent model of rights, so that it can be applied to any country, and possibly also after relevant changes in the Copyright Law.

The DRO has been developed as an extension of all these standard or well-established core ontologies, adding the specific concepts and terminology of the intellectual property rights domain (see Figure 3.2). For this purpose, the ontologies IPROnto and CopyrightOnto have been identified as a valuable starting point because of the careful and well-documented analysis of the IPR domain, in particular of usage rights. Indeed, several concepts have been adopted from the IPROnto ontology or reinterpreted in order to conform with the ontological rigor applied to the DRO.

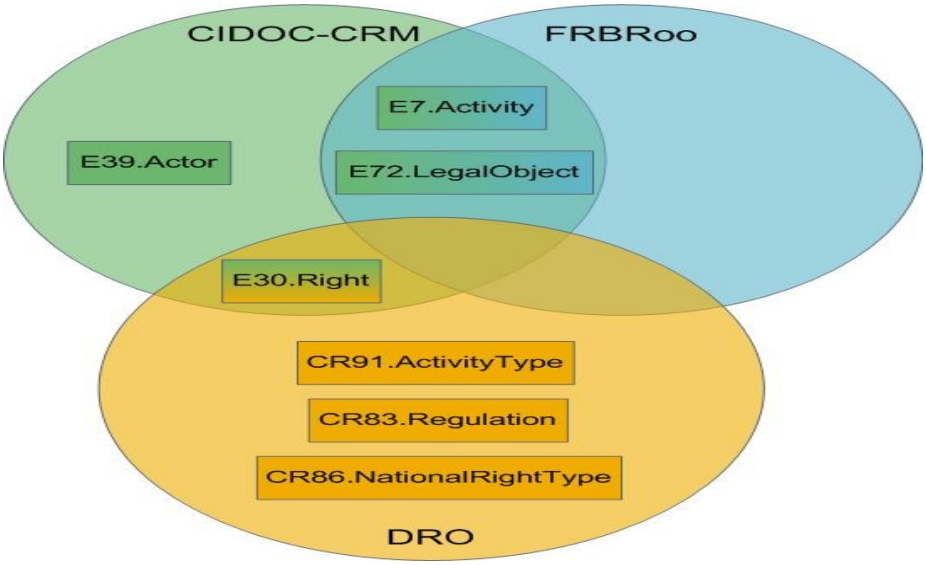

Figure 3.2: Relationships between DRO, CIDOC CRM and FRBRoo

Specifically, DRO addresses modelling of

- constraints of licensed permissions and of permissions given by law
- types of ownership rights and types of activities allowed by such rights
- aspects that influence rights and that might change in the long term: provenance (context of the specific work) and legislation (written norms that define the rights)
- checking of rights as a pattern matching procedure

1.8.1 Description of the Core Entities

The figure below shows an overview of the core entities of the Digital Rights Ontology that is briefly described in [30]. For a broader overview of the Digital Rights Ontology we refer to [29]. A unique prefix is used to identify each concept. Such prefix is composed of a letter that serves as namespace identifier, and a number that identifies the concept. The letter is "E" for the concepts reused from CIDOC-CRM , "C" for CIDOC-CRM extension concepts, "CR", "LF" or "LC" for DRO

specific concepts (which stands respectively for “Copyright”, “Licensing” and “Legal Framework” concepts). The same for properties, “P” and “S” identifies the ones inherited from CIDOC CRM while “A”, “B” and “C” are used for DRO specific properties.”F” means forward, ”B” means backward.

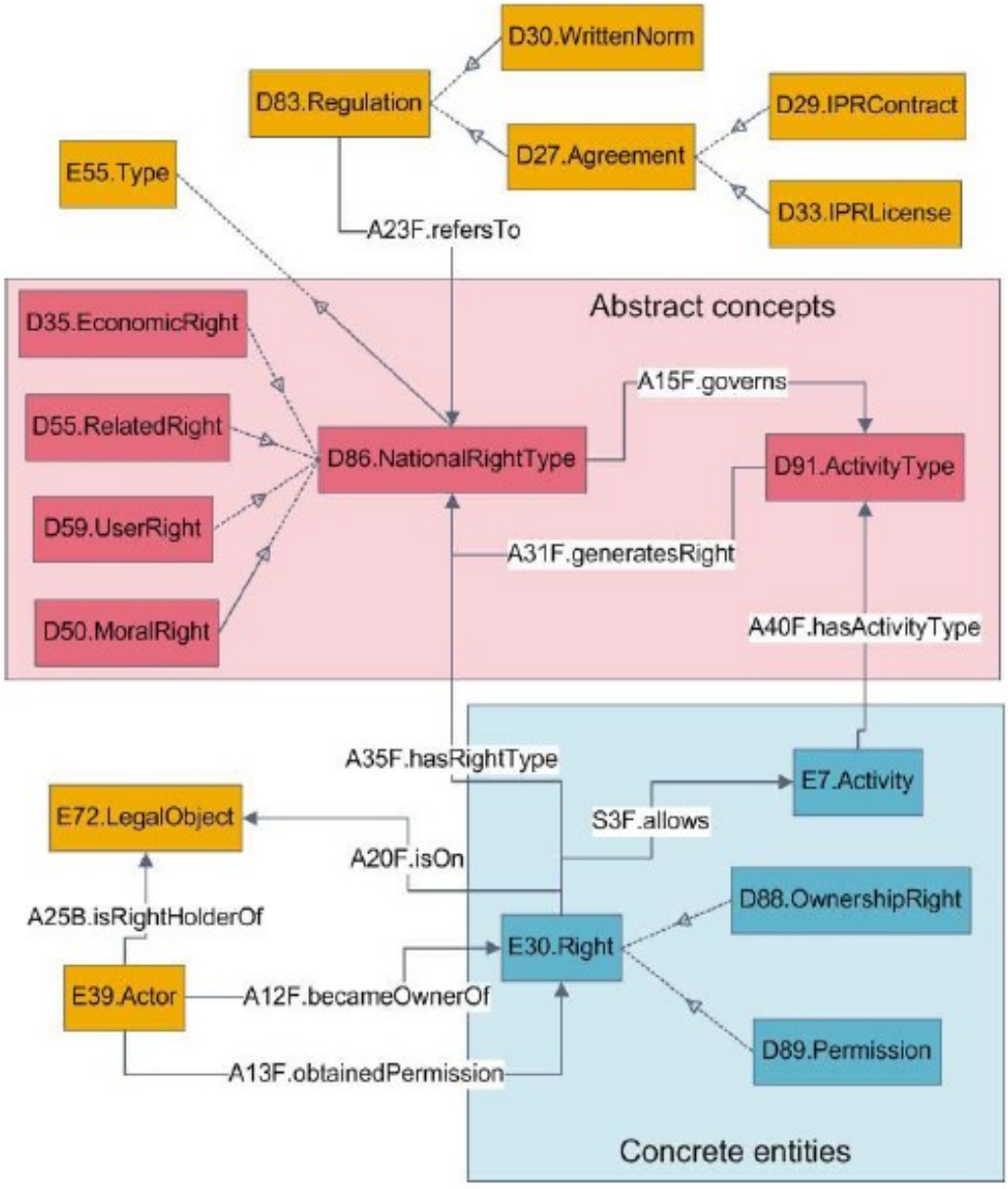

Figure 3.3: Overview of DRO core entities

The main class used to formalise the legal framework is *Regulation*. Regulations describe patterns of situations that are permitted. This is what Rights Expression Languages aim to express and to control. Regulation splits in two

subclasses: *WrittenNorm* and *Agreement*. *WrittenNorm* models all laws and regulations which are valid in a certain country at a certain time; *Agreement* describes both international agreements which override local laws and bilateral agreements between right holders and other people. A right holder may in fact transfer one or more rights that he owns through an *IPRContract* or grant some permissions to other people to act on his digital objects issuing them an *IPRLicense*.

The DRO distinguishes between two kinds of rights: the ownership rights, which are the exclusive rights typically held by the authors of the creative works, and the permissions that are granted by the right holders to other persons to use such works. The class *OwnershipRight* models the first type of rights. Ownership rights might also be transferred through an *IPRContract*, which means that ownership may move from one person to another. The class *Permission* includes all types of authorizations to make use of a content, including the authorizations given by the law and those given by the right holders through licenses. In both cases it is a consequence of a *Regulation*, respectively a *WrittenNorm* and an *IPRLicense*.

The other core entities which are part of the DRO have been adopted from CIDOC CRM and FRBRoo, in particular the Creation and the Action models, i.e. concepts like *Actor*, *LegalObject* and *Activity* with their subclasses and relationships. These concepts have been linked to the concepts which are specific of the copyright domain through the use of suitable relationships. For instance an *Actor owns* a *Right* which *isOn* a *LegalObject* and a *Right allows* (or *disallows*) an *Activity*.

Another important characteristic inherited from the CIDOC CRM is the distinction between individual entities on one side, like persons, objects, licenses, etc., and general concepts on the other side, like types of rights, types of activities, constraints, and others, which are used to categorize individual entities. So in the DRO there are more abstraction levels of rights entities: *Right* represents the instances of rights held by individual legal and physical persons on a precise object, while *NationalRightType* models types of rights that have a validity in a given time and country. The same for *Activity* and *ActivityType*. This approach reflects also looking at the properties, so we have that a *RightType governs* an *ActivityType* and, at the corresponding individual level, a particular *Right allows* a specific *Activity*.

Therefore *OwnershipRight* and *Permission* represent rights of a given person on a precise object, while the pattern of situation that is allowed is represented by

apposite entities, such as *ActivityType*, *PermissionPattern*, *Constraint*, *Condition*, *Validity* and others, together with properties such as *hasDuration*, *hasPurpose*, *hasExerciseLimit*, *hasAuthorizedPrincipals*, *hasFee*. Individual situations, expressed in terms of ontology instances, are then matched against the general patterns, still expressed in terms of the ontology.

1.9 Decision Making

The real intelligence of a context aware system is the ability to infer new knowledge from contextual information. The system takes advantage of semantic technologies in order to make decisions based on context and specified policies. Information about the context is provided by the ontology described in the previous section whereas policies are expressed as a set of rules in SWRL. Semantic Web Rule Language [11] is a proposed prototype developed in order to express such rules, providing interoperability between different systems. At present, SWRL aims to be the standard rule language for the semantic web. Adopting it, the system is not limited to a specific rule engine since any SWRL-compatible rule engine can be applied. Because SWRL has been designed to communicate specifically with OWL ontologies, fortunately our ontology is written in OWL [22] and therefore it is not need to be converted in this language. The set of rules created for the purposes of our system are described in the following subsection.

1.9.1 Rules

Our system uses the reasoner in order to decide whether an end-user is authorized to perform an action to a digital content or not. In particular, a set of rules defines that if someone is the copyright owner of a digital content then he can perform any activity (i.e. copy, distribute, communicate, etc) he wants. Another set defines that if an end-user perform certain actions (i.e. private copy, use for educational purposes,temporary reproduciton,etc) to a digital content may, in circumstances specified in the law,can be done without the authorization of the copyright owner. Other rules decide if an end-user has the appropriate economic rights to perform an activity to a digital content. Finally, the last set of rules defines

if an end-user has acquired an ecomonic right from the copyright owners, through a license, in order to be able to perform an activity to the digital content. For the purposes of these operations, the following rules are defined.

- ***Copyright-Owner***

The graphic representation of this rule is shown in the figure below.

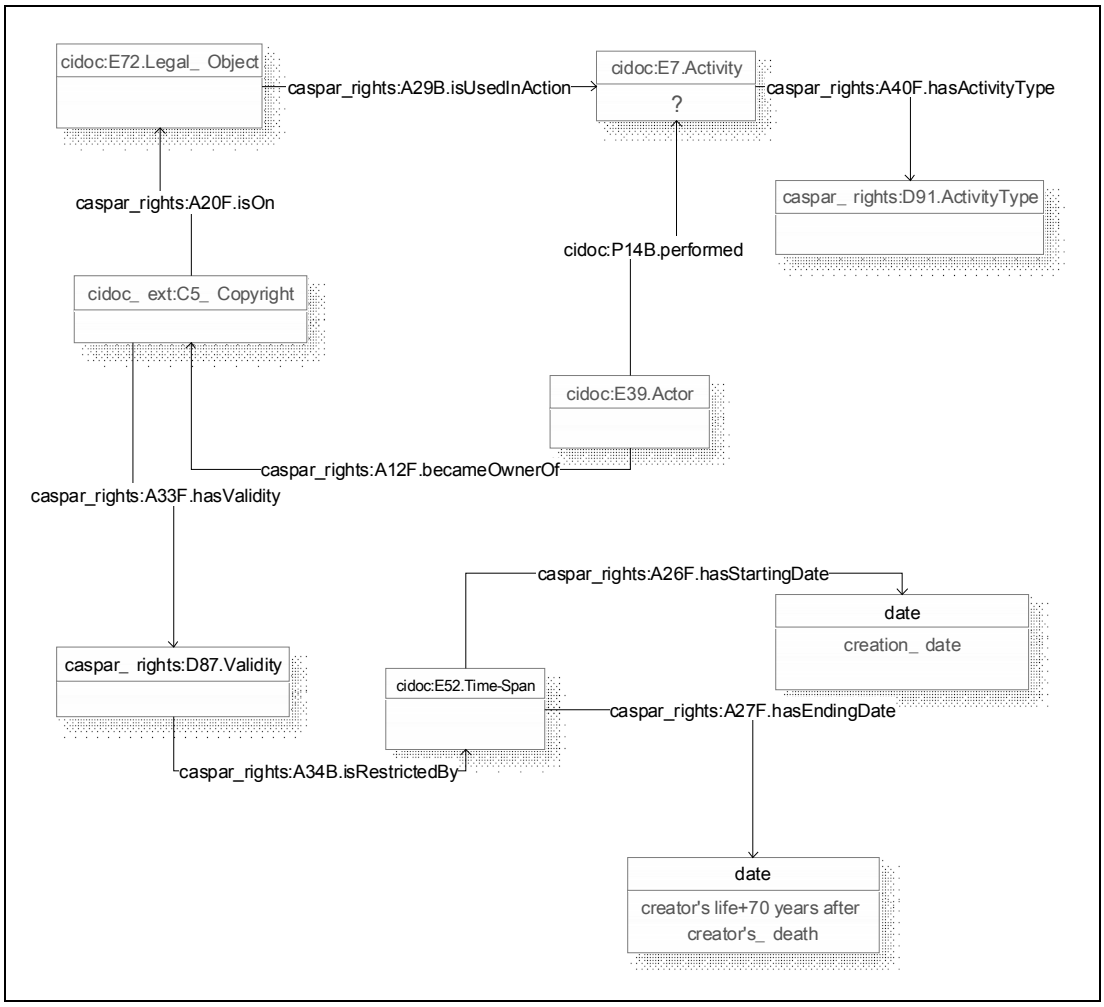

Figure 3.4: Copyright-Owner

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D91.ActivityType(?x1) ^
cidoc:E7.Activity(?x2) ^

cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^
cidoc_ext:C5_Copyright(?x5) ^
caspar_rights:D87.Validity(?x6) ^
cidoc:E52.Time-Span(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x3,?x2) ^
caspar_rights:A20F.isOn(?x5,?x4) ^
caspar_rights:A12F.becameOwnerOf(?x3,?x5) ^
caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x5,?x6) ^ caspar_rights:A34B.isRestrictedBy(?x6,?x7) ^
caspar_rights:A26F.hasStartingDate(?x7,"creation_date") ^
caspar_rights:A27F.hasEndingDate(?x7,"creator's life+70 years after creator's_death") →
caspar_rights:A24F.isPermitted(?x2,true)

This rule, that is based on the Article 1:*Copyright* of the current copyright legislation [6], determines that if someone is the copyright owner of a digital content then he/she can perform any activity (i.e. copy, distribute, communicate, etc) he/she wants. Moreover, the validity of the copyright, that is refered in this rule, is based on the Article 29:*Duration in General,* par.1 of the current copyright legislation. Finally, an assumption that we have done is that the data value "creation_date" is known in our system in order to be specified the starting date of the copyright in this digital object.

- ***Educational-Purpose***

This rule, that is based on Article 20:*School textbooks and anthologies* and on Article 21:*Reproduction for teaching purposes* of the current copyright legislation [6], defines that if an end-user reproduce the digital content only for educational purposes, then he/she can reproduce this digital content without the authorization of the copyright owner. The graphic representation of this rule is shown in the figure below.

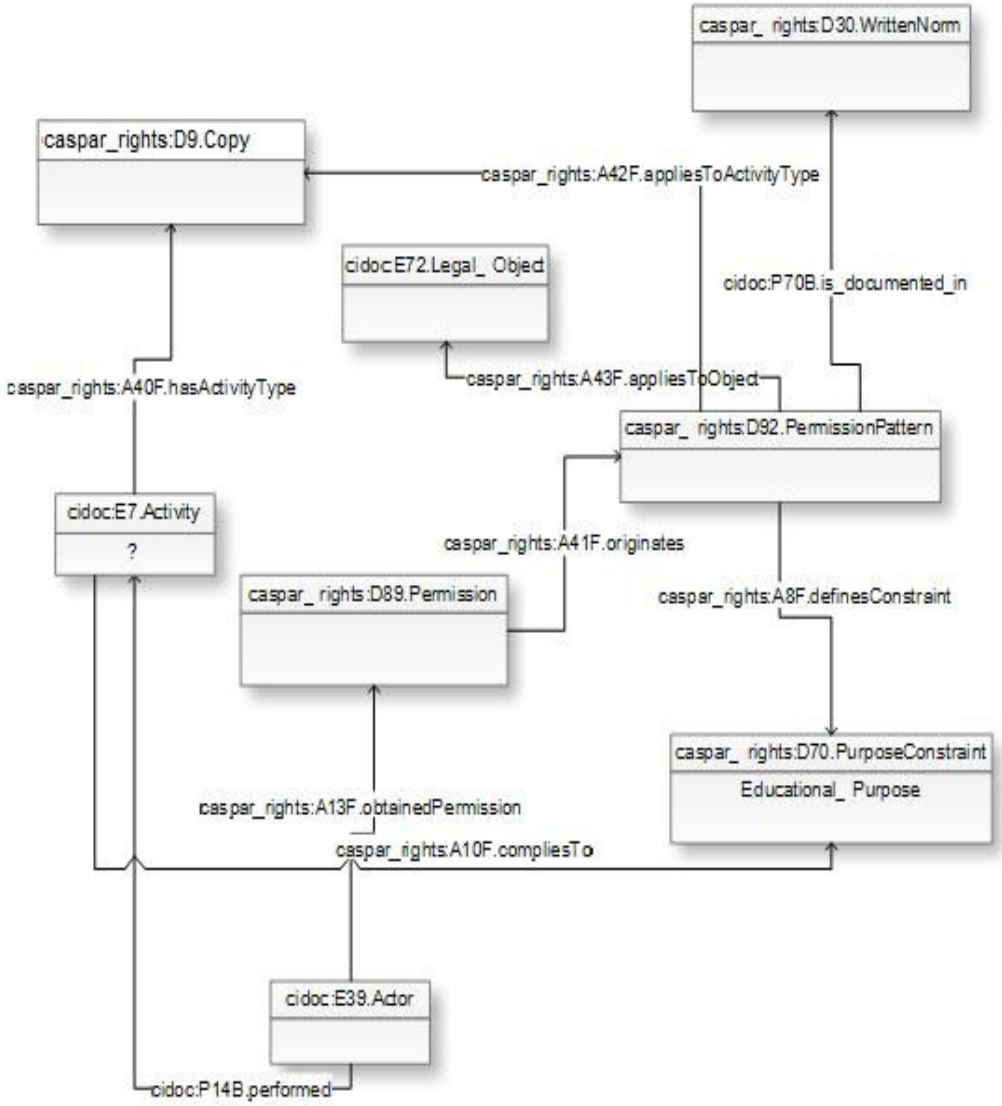

Figure 3.5: Educational-Purpose

The following SWRL rule has been derived after the convertion of the above graphic rule.

cidoc:E39.Actor(?x1) ^
cidoc:E72.Legal_Object(?x2) ^
cidoc:E7.Activity(?x3) ^
caspar_rights:D30.WrittenNorm(?x4) ^
caspar_rights:D89.Permission(?x5) ^
caspar_rights:D92.PermissionPattern(?x6) ^
caspar_rights:D9.Copy(?x7) ^
caspar_rights:D70.PurposeConstraint(Educational_Purpose) ^
cidoc:P14B.performed(?x1,?x3) ^

caspar_rights:A13F.obtainedPermission(?x1,?x5) ^
caspar_rights:A41F.originates(?x5,?x6) ^
cidoc:P70B.is_documented_in(?x6,?x4) ^ caspar_rights:A43F.appliesToObject(?x6,?x2) ^ caspar_rights:A42F.appliesToActivityType(?x6,?x7) ^
caspar_rights:A10F.compliesTo(?x3,Educational_Purpose) ^
caspar_rights:A40F.hasActivityType(?x3,?x7) ^
caspar_rights:A8F.definesConstraint(?x6,Educational_Purpose) →
caspar_rights:A24F.isPermitted(?x3,true)

- ***Private-Copy-Purpose***

This rule, that is based on Article 18:*Reproduction of private use*, par.1 of the current copyright legislation [6], defines that if an end-user reproduces a digital content exclusively for personal and private use (i.e. a backup), then he/she can perform this action without the authorization of the copyright owner. The graphic representation of this rule is shown in the figure below.

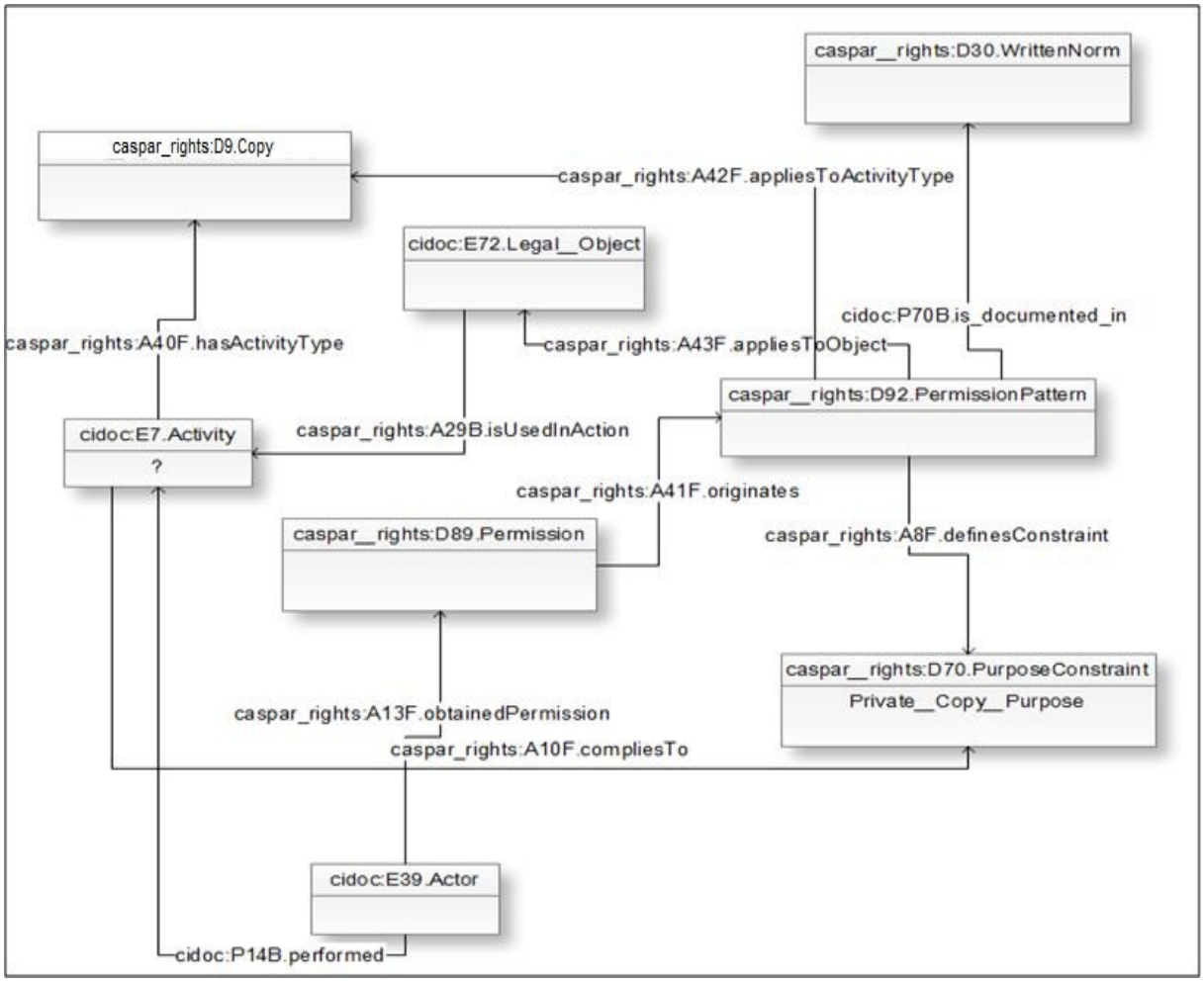

Figure 3.6: Private-Copy-Purpose

The following SWRL rule has been derived after the convertion of the above graphic rule.

cidoc:E39.Actor(?x1) ^
cidoc:E72.Legal_Object(?x2) ^
cidoc:E7.Activity(?x3) ^
caspar_rights:D30.WrittenNorm(?x4) ^
caspar_rights:D89.Permission(?x5) ^
caspar_rights:D92.PermissionPattern(?x6) ^
caspar_rights:D9.Copy(?x7) ^
*caspar_rights:D70.PurposeConstraint(Private_Copy_Purpose)^*
cidoc:P14B.performed(?x1,?x3) ^
caspar_rights:A13F.obtainedPermission(?x1,?x5) ^
caspar_rights:A41F.originates(?x5,?x6) ^

cidoc:P70B.is_documented_in(?x6,?x4)^ caspar_rights:A43F.appliesToObject(?x6,?x2)^ caspar_rights:A42F.appliesToActivityType(?x6,?x7)^ caspar_rights:A10F.compliesTo(?x3,Private_Copy _Purpose) ^ caspar_rights:A40F.hasActivityType(?x3,?x7) ^ caspar_rights:A8F.definesConstraint(?x6,Private_Copy_Purpose) → ***caspar_rights:A24F.isPermitted(?x3,true)***

- ***Temporary-Reproduction-Purpose***

This rule, that is based on Article 28B: *Exception from the Reproduction Right* of the current copyright legislation [6] , defines that if an end-user reproduces a digital content temporarily, then he/she can perform this action without the authorization of the copyright owner. An example of temporary reproduction is caching in the context of the Internet, when a work is temporarily stored in network node that is nearer to the user in order to facilitate its delivery. The graphic representation of this rule is shown in the figure below.

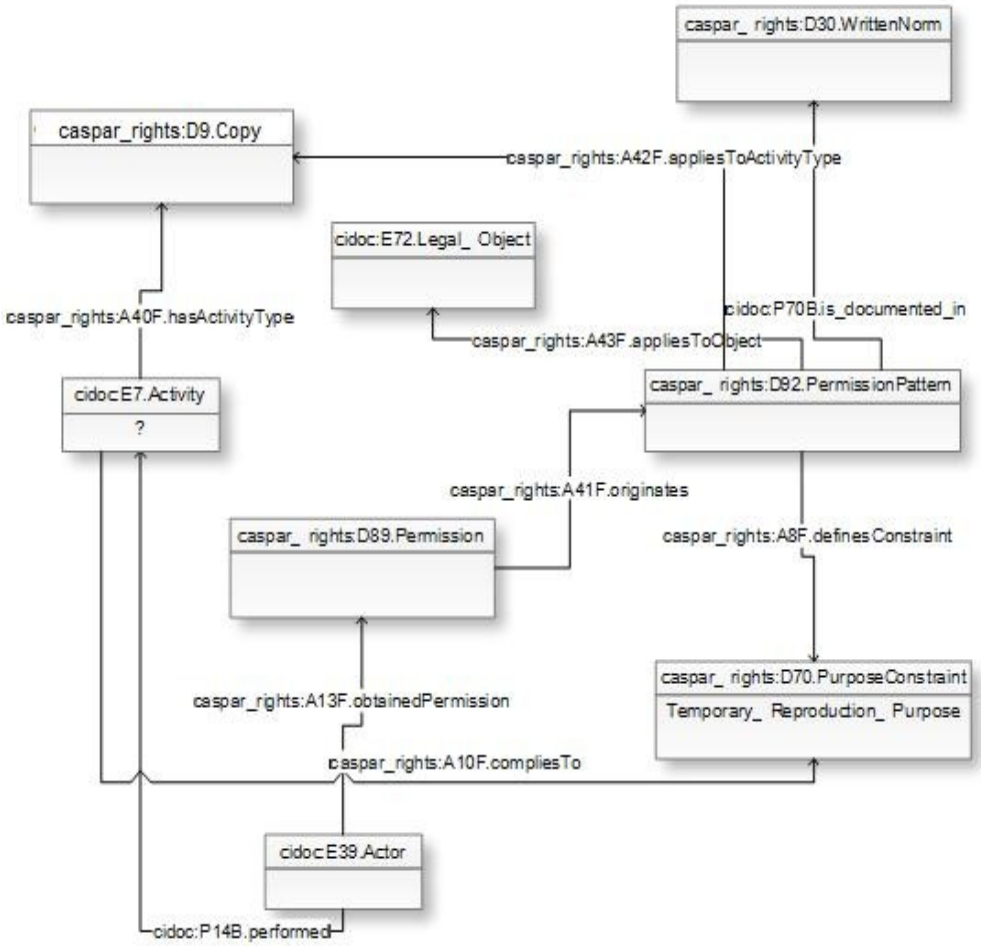

Figure 3.7: Temporary-Reproduction-Purpose

The following SWRL rule has been derived after the convertion of the above graphic rule.

cidoc:E39.Actor(?x1) ^
cidoc:E72.Legal_Object(?x2) ^
cidoc:E7.Activity(?x3) ^
caspar_rights:D30.WrittenNorm(?x4) ^
caspar_rights:D89.Permission(?x5) ^
caspar_rights:D92.PermissionPattern(?x6) ^
caspar_rights:D9.Copy(?x7) ^
*caspar_rights:D70.PurposeConstraint(Temporary_Reproduction_Purpose)^*
cidoc:P14B.performed(?x1,?x3) ^
caspar_rights:A13F.obtainedPermission(?x1,?x5) ^
caspar_rights:A41F.originates(?x5,?x6) ^

cidoc:P70B.is_documented_in(?x6,?x4)^ caspar_rights:A43F.appliesToObject(?x6,?x2)^ caspar_rights:A42F.appliesToActivityType(?x6,?x7)^ caspar_rights:A10F.compliesTo(?x3,Temporary_Reproduction _Purpose) ^ caspar_rights:A40F.hasActivityType(?x3,?x7) ^ caspar_rights:A8F.definesConstraint(?x6,Temporary_Reproduction_Purpose) → ***caspar_rights:A24F.isPermitted(?x3,true)***

- **Reproduction_right**

The graphic representation of this rule is shown in the figure below.

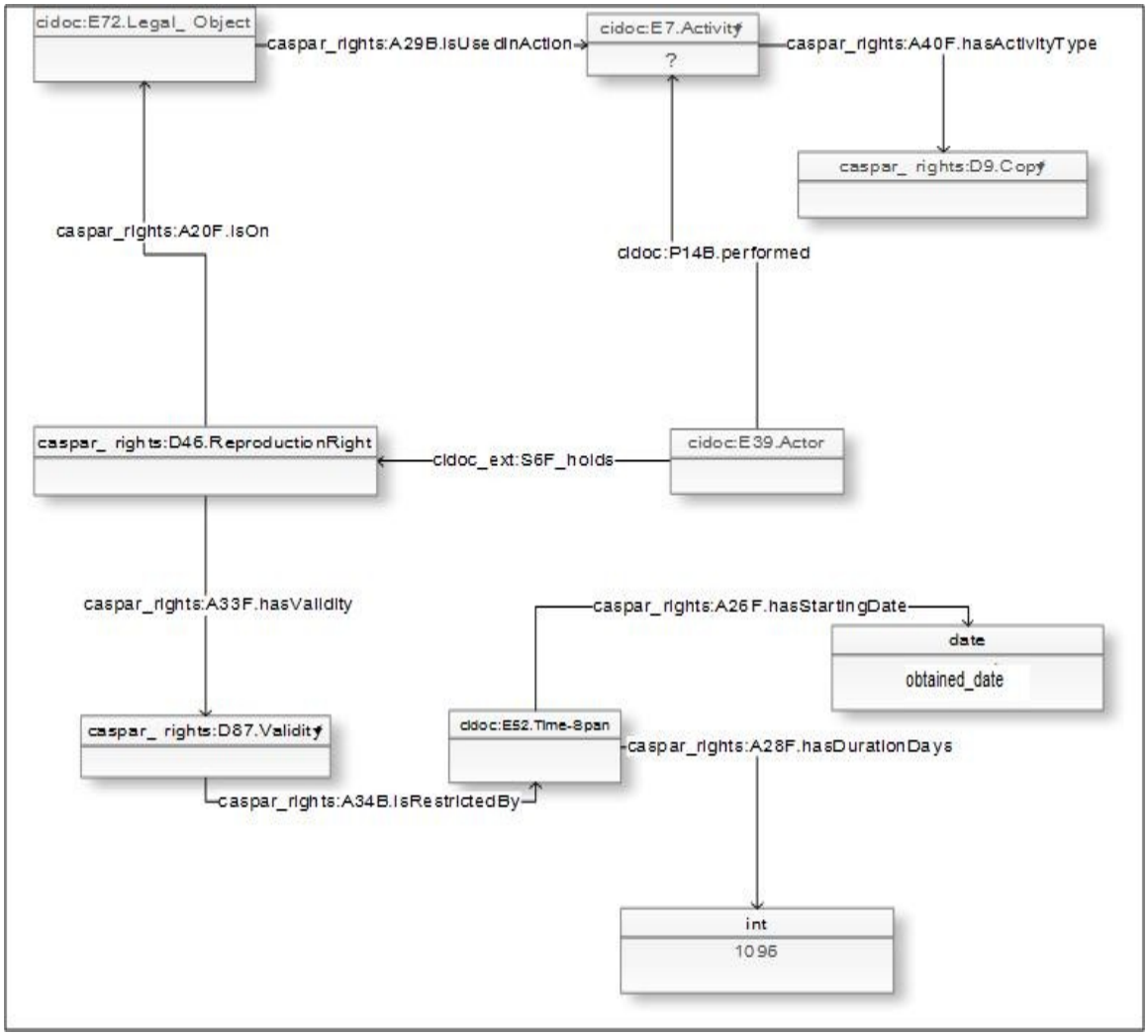

Figure 3.8:Reproduction_Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D9.Copy(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E72.Legal_Object(?x3) ^
caspar_rights:D87.Validity(?x4) ^
cidoc:E52.Time-Span(?x5) ^
cidoc:E39.Actor(?x6) ^
caspar_rights:D46.ReproductionRight(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x6,?x2) ^
caspar_rights:A20F.isOn(?x7,?x3) ^
cidoc_ext:S6F_holds(?x6,?x7) ^
caspar_rights:A29B.isUsedInAction(?x3,?x2) ^ caspar_rights:A33F.hasValidity(?x7,?x4) ^ caspar_rights:A34B.isRestrictedBy(?x4,?x5) ^
caspar_rights:A26F.hasStartingDate(?x5,"obtained_date") ^
caspar_rights:A28F.hasDurationDays(?x5,1095) →
caspar_rights:A24F.isPermitted(?x2,true)

This rule, that is based on Article 3: *Economic Rights,* par. 1a of the current copyright legislation [6], decides if an end-user has the specific Economic Right : *Reproduction Right* in order to be authorized to make a copy of a digital content. Moreover the validity of this Economic Right is limited to three years after the date of obtainment of this Economic Right. Finally, an assumption that we have done is that the data value "obtained_date" is known in our system in order to be specified the date that this Economic Right is obtained.

- **Distribution_right**

This rule, that is based on Article 3: *Economic Rights,* par. 1d of the current copyright legislation [6], decides if an end-user has the specific Economic Right : *Distribution Right* in order to be authorized to distribute to the public a previously made copy of a digital content incorporated in a tangible article. Moreover the validity of this Economic Right is limited to three years after the date of obtainment of this Economic Right. Moreover, an assumption that we have done is that the data

value “obtained_date” is known in our system in order to be specified the date that this Economic Right is obtained. The graphic representation of this rule is shown in the figure below.

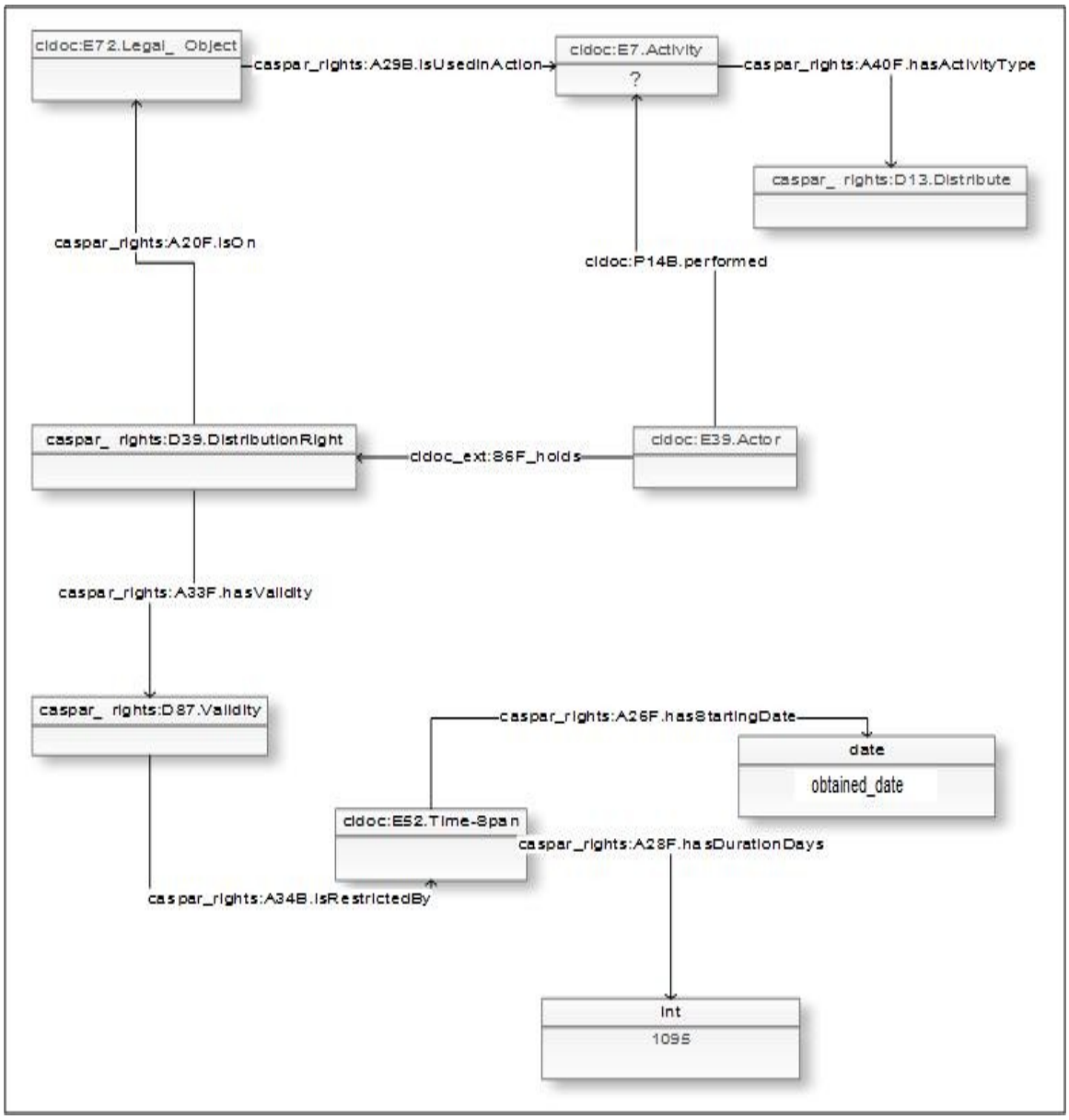

Figure 3.9:Distribution_Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D13.Distribute(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E72.Legal_Object(?x3) ^
caspar_rights:D87.Validity(?x4) ^
cidoc:E52.Time-Span(?x5) ^

cidoc:E39.Actor(?x6) ^
caspar_rights:D39.DistributionRight(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x6,?x2) ^
caspar_rights:A20F.isOn(?x7,?x3) ^
cidoc_ext:S6F_holds(?x6,?x7) ^
caspar_rights:A29B.isUsedInAction(?x3,?x2) ^ caspar_rights:A33F.hasValidity(?x7,?x4) ^ caspar_rights:A34B.isRestrictedBy(?x4,?x5) ^
caspar_rights:A26F.hasStartingDate(?x5,"obtained_date") ^
caspar_rights:A28F.hasDurationDays(?x5,1095) →
caspar_rights:A24F.isPermitted(?x2,true)

- **Transformation_right**

The graphic representation of this rule is shown in the figure below.

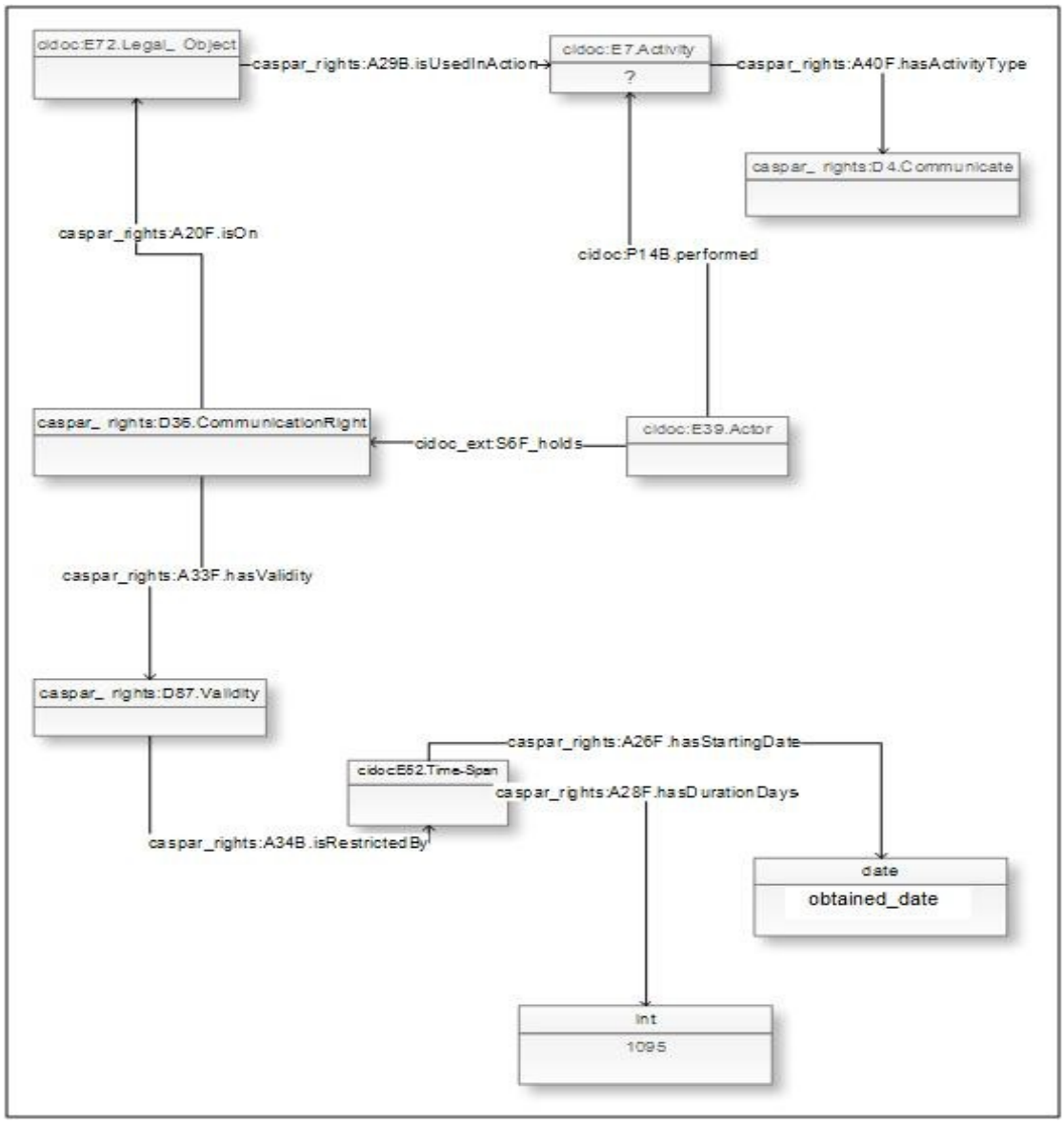

Figure 3.10:Transformation_Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D10.Derive(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E72.Legal_Object(?x3) ^
caspar_rights:D87.Validity(?x4) ^
cidoc:E52.Time-Span(?x5) ^
cidoc:E39.Actor(?x6) ^
caspar_rights:D47.TransformationRight(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^

cidoc:P14B.performed(?x6,?x2) ^
caspar_rights:A20F.isOn(?x7,?x3) ^
cidoc_ext:S6F_holds(?x6,?x7) ^
caspar_rights:A29B.isUsedInAction(?x3,?x2) ^ caspar_rights:A33F.hasValidity(?x7,?x4) ^ caspar_rights:A34B.isRestrictedBy(?x4,?x5) ^
caspar_rights:A26F.hasStartingDate(?x5,"obtained_date") ^
caspar_rights:A28F.hasDurationDays(?x5,1095) →
caspar_rights:A24F.isPermitted(?x2,true)

This rule , that is based on Article 3: *Economic Rights,* par. 1 b and c of the current copyright legislation [6], decides if an end-user has the specific Economic Right: *Transformation Right* in order to be authorized to translate or adapt a digital content. Moreover the validity of this Economic Right is limited to three years after the date of obtainment of this Economic Right.Finally, an assumption that we have done is that the data value "obtained_date" is known in our system in order to be specified the date that this Economic Right is obtained.

- **Communication_right**

This rule, that is based on Article 3: *Economic Rights,* par. 1g of the current copyright legislation [6], decides if an end-user has the specific Economic Right : *Communcation Right* in order to be authorized to communicate to the public the originals or copies of the digital content, including wire or wireless means and to make them available to the public in a way that the members of the public may access the work from a place and at a time individually chosen by them [12]. Moreover the validity of this Economic Right is limited to three years after the date of obtainment of this Economic Right. Moreover, an assumption that we have done is that the data value "obtained_date" is known in our system in order to be specified the date that this Economic Right is obtained. The graphic representation of this rule is shown in the figure below.

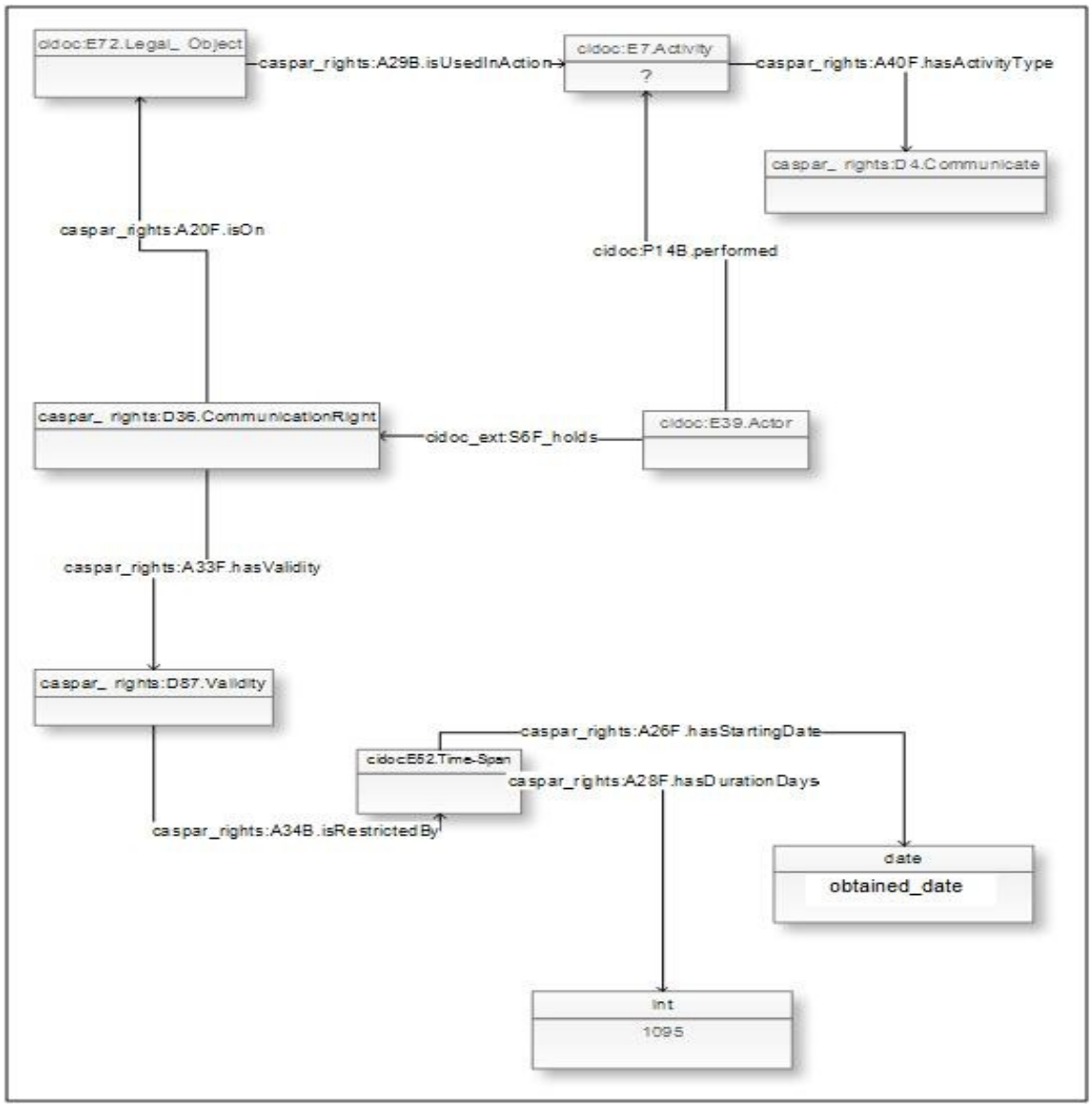

Figure 3.11:Communication_Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D4.Communicate(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E72.Legal_Object(?x3) ^
caspar_rights:D87.Validity(?x4) ^
cidoc:E52.Time-Span(?x5) ^
cidoc:E39.Actor(?x6) ^

caspar_rights:D36.CommunicationRight(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x6,?x2) ^
caspar_rights:A20F.isOn(?x7,?x3) ^
cidoc_ext:S6F_holds(?x6,?x7) ^
caspar_rights:A29B.isUsedInAction(?x3,?x2) ^ caspar_rights:A33F.hasValidity(?x7,?x4) ^ caspar_rights:A34B.isRestrictedBy(?x4,?x5) ^
caspar_rights:A26F.hasStartingDate(?x5,"obtained_date") ^
caspar_rights:A28F.hasDurationDays(?x5,1095) →
caspar_rights:A24F.isPermitted(?x2,true)

- **Public_Performance_right**

This rule, that is based on Article 3: *Economic Rights,* par. 1f of the current copyright legislation [6], decides if an end-user has the specific Economic Right : *Public Performance Right* in order to be authorized to perform to the public a work (i.e. recite, render, play, act), either directly or by means of any device or process or, in the case of a motion picture or other audiovisual work, to show its images in any sequence or to make the sounds accompanying it audible [12]. Moreover the validity of this Economic Right is limited to three years after the date of obtainment of this Economic Right. Moreover, an assumption that we have done is that the data value "obtained_date" is known in our system in order to be specified the date that this Economic Right is obtained. The graphic representation of this rule is shown in the figure below.

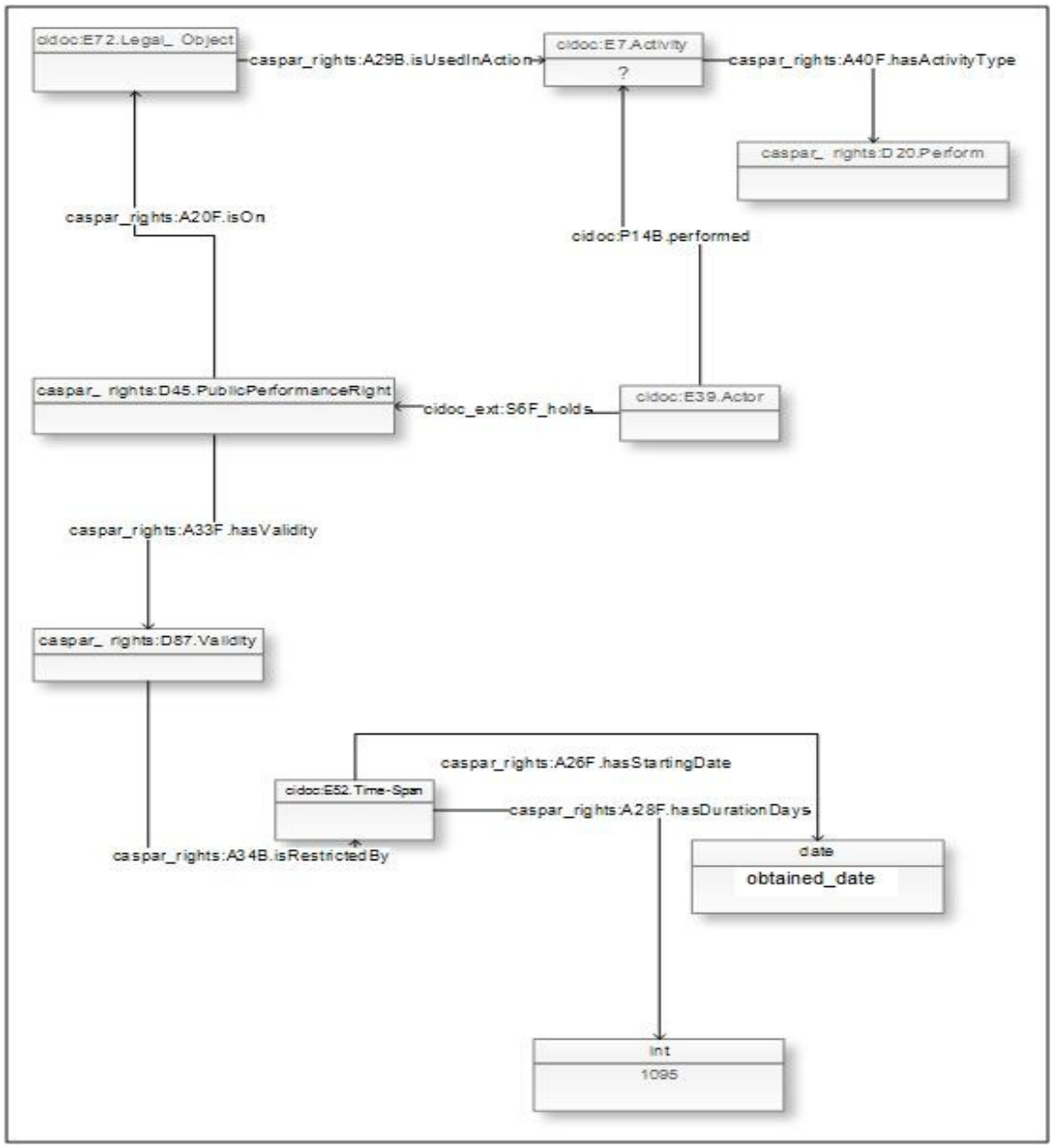

Figure 3.12:Public_Performance_Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:20.Perform(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E72.Legal_Object(?x3) ^
caspar_rights:D87.Validity(?x4) ^
cidoc:E52.Time-Span(?x5) ^
cidoc:E39.Actor(?x6) ^

caspar_rights:D45.PublicPerformanceRight(?x7) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x6,?x2) ^
caspar_rights:A20F.isOn(?x7,?x3) ^
cidoc_ext:S6F_holds(?x6,?x7) ^
caspar_rights:A29B.isUsedInAction(?x3,?x2) ^ caspar_rights:A33F.hasValidity(?x7,?x4) ^ caspar_rights:A34B.isRestrictedBy(?x4,?x5) ^
caspar_rights:A26F.hasStartingDate(?x5,"obtained_date") ^
caspar_rights:A28F.hasDurationDays(?x5,1095) →
caspar_rights:A24F.isPermitted(?x2,true)

- **License-Reproduction-Right**

This rule,that is based on Article 13: *Exploitation Contracts and Licences,* par. 2 of the current copyright legislation [6], defines if an end-user has acquired the specific ecomonic right: *Reproduction Right* from the copyright owner through a license in order to be able to make a copy of the digital content. Moreover the validity of this Economic Right that is specified in this license, is limited to three years after the date that is taken place this license. The graphic representation of this rule is shown in the figure below.

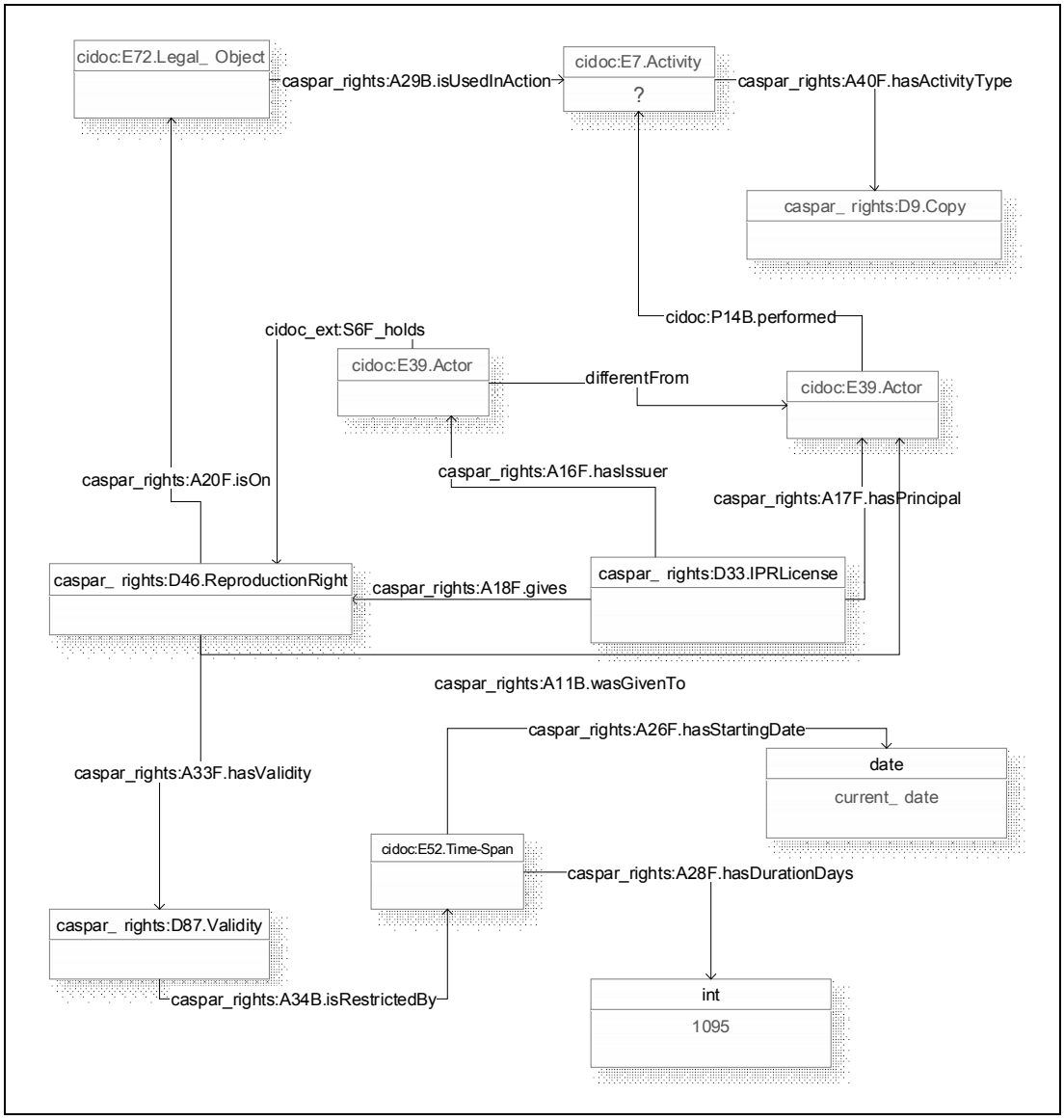

Figure 3.13: License-Reproduction-Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D9.Copy(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^
caspar_rights:D87.Validity(?x5) ^
cidoc:E52.Time-Span(?x6) ^
cidoc:E39.Actor(?x7) ^
caspar_rights:D33.IPRLicense(?x8) ^

caspar_rights:D46.ReproductionRight(?x9) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x7,?x2) ^
caspar_rights:A20F.isOn(?x9,?x4) ^
cidoc_ext:S6F_holds(?x3,?x9) ^
caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x9,?x5) ^ caspar_rights:A34B.isRestrictedBy(?x5,?x6) ^
caspar_rights:A26F.hasStartingDate(?x6,"current_date") ^
caspar_rights:A28F.hasDurationDays(?x6,1095) ^ caspar_rights:A16F.hasIssuer(?x8,?x3) ^
caspar_rights:A17F.hasPrincipal(?x8,?x7) ^
caspar_rights:A18F.gives(?x8,?x9) ^
caspar_rights:A11B.wasGivenTo(?x9,?x7) → ***caspar_rights:A24F.isPermitted(?x2,true)***

- ## License-Distribution-Right

This rule, that is based on Article 13: *Exploitation Contracts and Licences,* par. 2 of the current copyright legislation [6], defines if an end-user has acquired the specific ecomonic right: *Distribution Right* from the copyright owner through a license in order to be able to distribute to the public(i.e. sell, rent, lend) the originals or copies of the digital content. Moreover the validity of this Economic Right that is specified in this license, is limited to three years after the date that is taken place this license. The graphic representation of this rule is shown in the figure below.

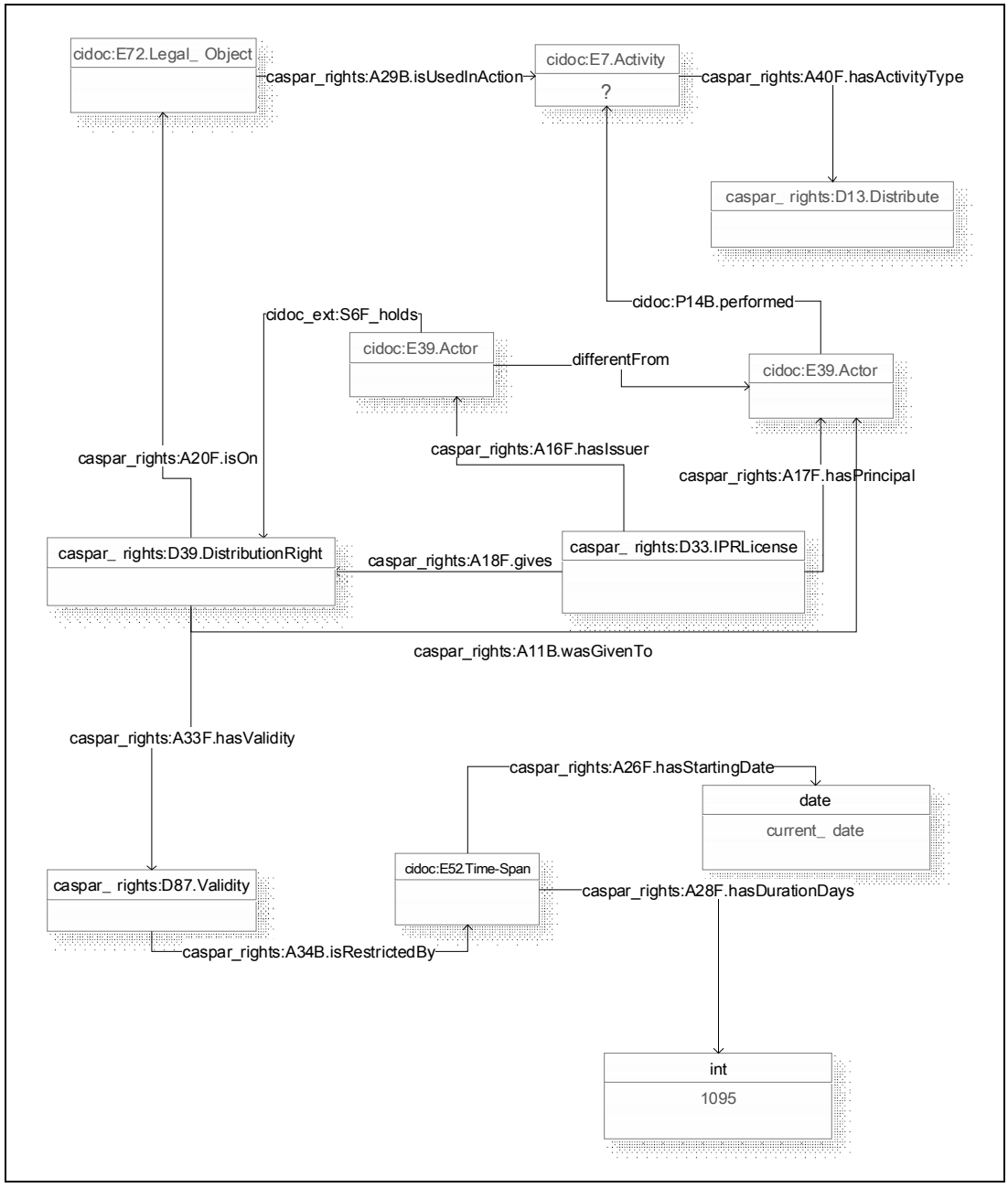

Figure 3.14: License-Distribution-Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D13.Distribute(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^
caspar_rights:D87.Validity(?x5) ^

cidoc:E52.Time-Span(?x6) ^
cidoc:E39.Actor(?x7) ^
caspar_rights:D33.IPRLicense(?x8) ^
caspar_rights:D39.DistributionRight(?x9) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x7,?x2) ^
caspar_rights:A20F.isOn(?x9,?x4) ^
cidoc_ext:S6F_holds(?x3,?x9) ^
caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x9,?x5) ^ caspar_rights:A34B.isRestrictedBy(?x5,?x6) ^
caspar_rights:A26F.hasStartingDate(?x6,"current_date") ^
caspar_rights:A28F.hasDurationDays(?x6,1095) ^ caspar_rights:A16F.hasIssuer(?x8,?x3) ^
caspar_rights:A17F.hasPrincipal(?x8,?x7) ^
caspar_rights:A18F.gives(?x8,?x9) ^
caspar_rights:A11B.wasGivenTo(?x9,?x7) → ***caspar_rights:A24F.isPermitted(?x2,true)***

- ## License-Transformation-Right

This rule, that is based on Article 13: *Exploitation Contracts and Licences,* par. 2 of the current copyright legislation [6], defines if an end-user has acquired the specific ecomonic right: *Transformation Right* from the copyright owner through a license in order to be able to translate or adapt the digital content. Moreover the validity of this Economic Right that is specified in this license, is limited to three years after the date that is taken place this license . The graphic representation of this rule is shown in the figure below.

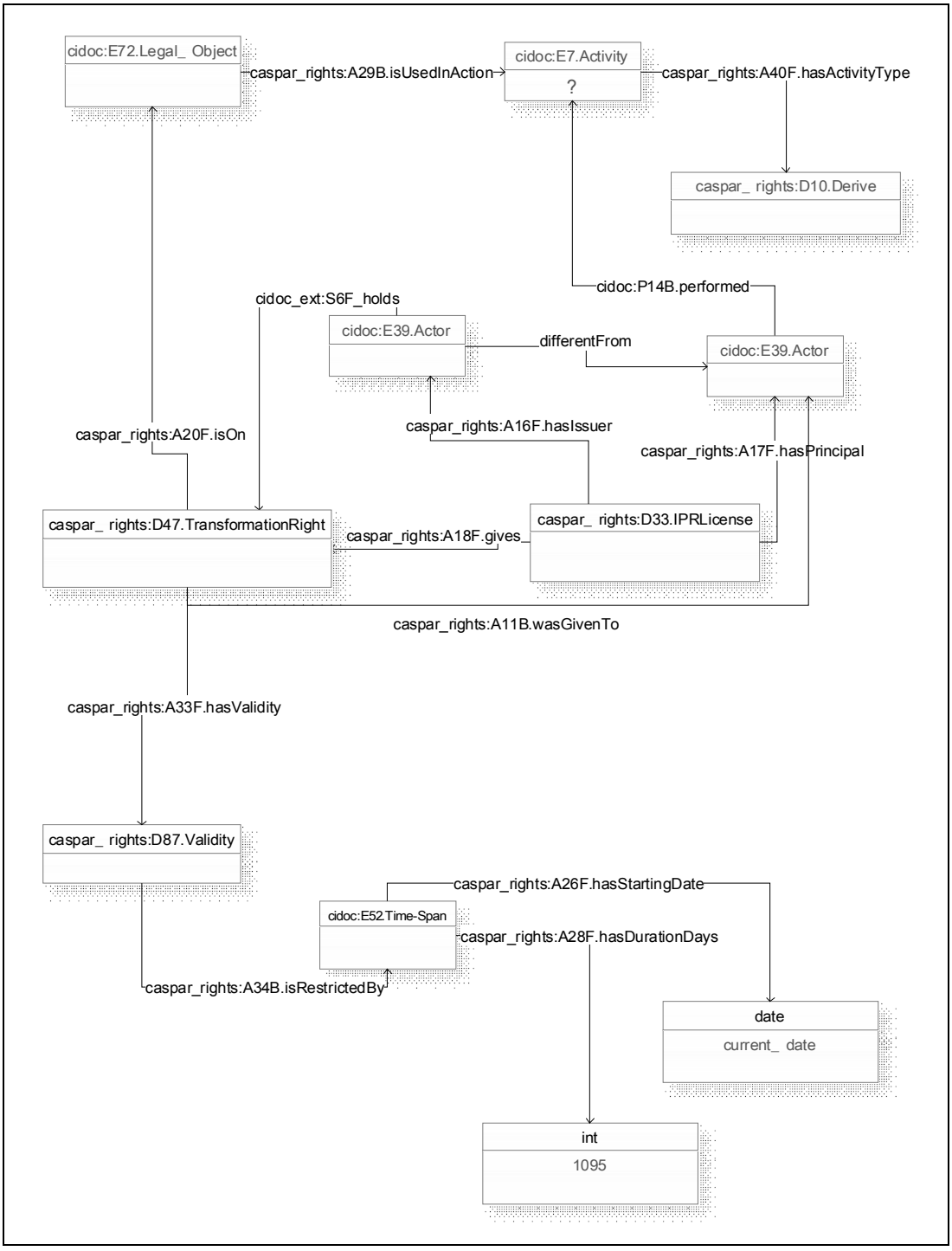

Figure 3.15: License-Transformation-Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D10.Derive(?x1) ^
cidoc:E7.Activity(?x2) ^

cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^
caspar_rights:D87.Validity(?x5) ^
cidoc:E52.Time-Span(?x6) ^
cidoc:E39.Actor(?x7) ^
caspar_rights:D33.IPRLicense(?x8) ^
caspar_rights:D47.TransformationRight(?x9) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x7,?x2) ^
caspar_rights:A20F.isOn(?x9,?x4) ^
cidoc_ext:S6F_holds(?x3,?x9) ^
caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x9,?x5) ^ caspar_rights:A34B.isRestrictedBy(?x5,?x6) ^
caspar_rights:A26F.hasStartingDate(?x6,"current_date") ^
caspar_rights:A28F.hasDurationDays(?x6,1095) ^ caspar_rights:A16F.hasIssuer(?x8,?x3) ^
caspar_rights:A17F.hasPrincipal(?x8,?x7) ^
caspar_rights:A18F.gives(?x8,?x9) ^
caspar_rights:A11B.wasGivenTo(?x9,?x7) → ***caspar_rights:A24F.isPermitted(?x2,true)***

- ## License-Communication-Right

This rule, that is based on Article 13: *Exploitation Contracts and Licences,* par. 2 of the current copyright legislation [6], defines if an end-user has acquired the specific ecomonic right: *Communication Right* from the copyright owner through a license in order to be able to communicate to the public the originals or copies of the digital content, including wire or wireless means and to make them available to the public in a way that the members of the public may access the work from a place and at a time individually chosen by them [12]. Moreover the validity of this Economic Right that is specified in this license, is limited to three years after the date that is taken place this license. The graphic representation of this rule is shown in the figure below.

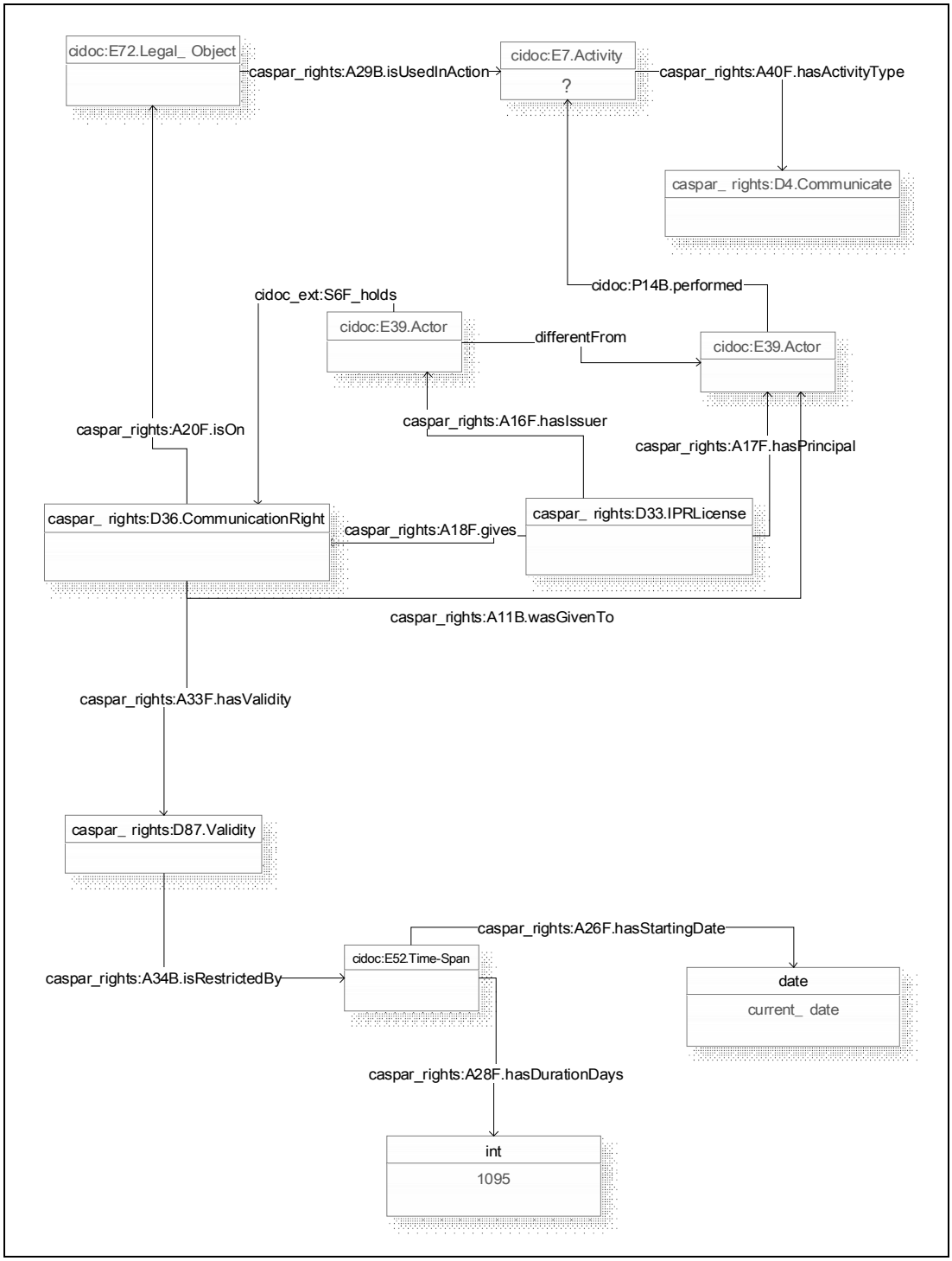

Figure 3.16: License-Communication-Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D4.Communicate(?x1) ^

cidoc:E7.Activity(?x2) ^

cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^
caspar_rights:D87.Validity(?x5) ^
cidoc:E52.Time-Span(?x6) ^
cidoc:E39.Actor(?x7) ^
caspar_rights:D33.IPRLicense(?x8) ^
caspar_rights:D36.CommunicationRight(?x9) ^
caspar_rights:A40F.hasActivityType(?x2,?x1) ^
cidoc:P14B.performed(?x7,?x2) ^
caspar_rights:A20F.isOn(?x9,?x4) ^
cidoc_ext:S6F_holds(?x3,?x9) ^
caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x9,?x5) ^ caspar_rights:A34B.isRestrictedBy(?x5,?x6) ^
caspar_rights:A26F.hasStartingDate(?x6,"current_date") ^
caspar_rights:A28F.hasDurationDays(?x6,1095) ^ caspar_rights:A16F.hasIssuer(?x8,?x3) ^
caspar_rights:A17F.hasPrincipal(?x8,?x7) ^
caspar_rights:A18F.gives(?x8,?x9) ^
caspar_rights:A11B.wasGivenTo(?x9,?x7) → ***caspar_rights:A24F.isPermitted(?x2,true)***

- ## License-Public-Performance-Right

This rule, that is based on Article 13: *Exploitation Contracts and Licences,* par. 2 of the current copyright legislation [6], defines if an end-user has acquired the specific ecomonic right: *Public Perfomance Right* from the copyright owner through a license in order to be able to perform to the public his/her work (i.e. recite, render, play, act), either directly or by means of any device or process or, in the case of a motion picture or other audiovisual work, to show its images in any sequence or to make the sounds accompanying it audible [12]. Moreover the validity of this Economic Right that is specified in this license, is limited to three years after the date that is taken place this license . The graphic representation of this rule is shown in the figure below.

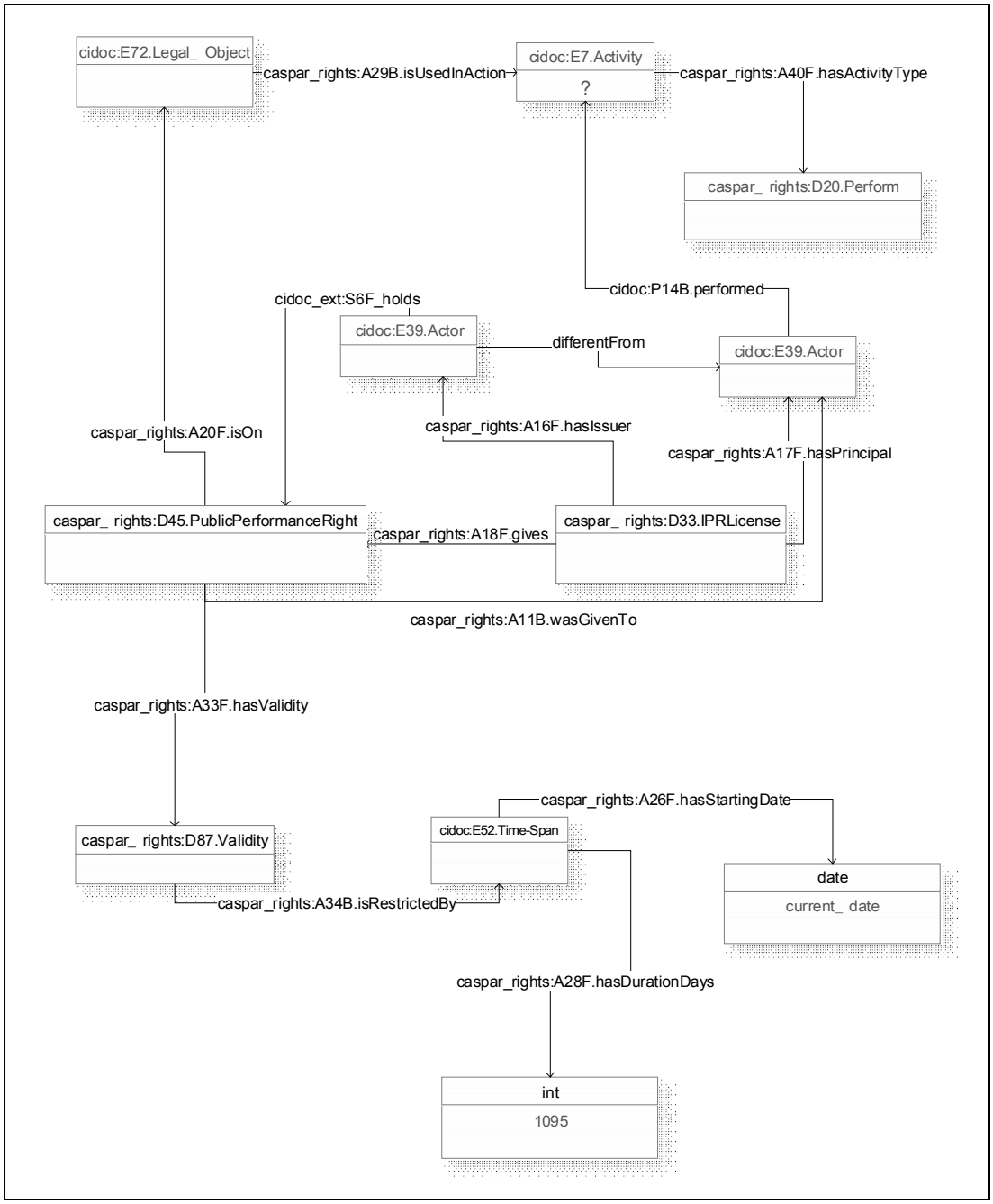

Figure 3.17: License-Public-Performance-Right

The following SWRL rule has been derived after the convertion of the above graphic rule.

caspar_rights:D20.Perform(?x1) ^
cidoc:E7.Activity(?x2) ^
cidoc:E39.Actor(?x3) ^
cidoc:E72.Legal_Object(?x4) ^

caspar_rights:D87.Validity(?x5) ^

cidoc:E52.Time-Span(?x6) ^

cidoc:E39.Actor(?x7) ^

caspar_rights:D33.IPRLicense(?x8) ^

caspar_rights:D45.PublicPerformanceRight(?x9) ^

caspar_rights:A40F.hasActivityType(?x2,?x1) ^

cidoc:P14B.performed(?x7,?x2) ^

caspar_rights:A20F.isOn(?x9,?x4) ^

cidoc_ext:S6F_holds(?x3,?x9) ^

caspar_rights:A29B.isUsedInAction(?x4,?x2) ^ caspar_rights:A33F.hasValidity(?x9,?x5) ^ caspar_rights:A34B.isRestrictedBy(?x5,?x6) ^

caspar_rights:A26F.hasStartingDate(?x6,"current_date") ^

caspar_rights:A28F.hasDurationDays(?x6,1095) ^ caspar_rights:A16F.hasIssuer(?x8,?x3) ^

caspar_rights:A17F.hasPrincipal(?x8,?x7) ^

caspar_rights:A18F.gives(?x8,?x9) ^

caspar_rights:A11B.wasGivenTo(?x9,?x7) → ***caspar_rights:A24F.isPermitted(?x2,true)***

Chapter 4

System Implementation

In this chapter we are going to give an overview of our implementation and show the decisions made while developing our system. At the end, we will give a representative usage scenario in order to understand how our system works.

1.10 UI Design

The operations that are provided from the user interface of the digital library are separated according to the rights that have each user. On the present, they have been forecasted rights for two types of users, the administrator of the system and the simple user that is a simple member of the digital library.

For the administrator of the system, in order to connect to the system, he has to give a username and a password that are predefined by specific values (username: *admin,* password: *1234*). On the contrary, simple users in order to connect to the system, firstly they have to make a registration, giving their personal data (username, password, first name, last name, etc) to the system and afterwards to sign in to the system, giving their username and password.

The home page of the administrator of the system consists of a "tab menu" that contains a set of links that mainly facilitate the control and supervision of the digital library. Each individual page of the "tab menu" of the system's administrator will be presented below:

- **Rights:** All the rights that each end-user of the digital library has. These rights separated to economic rights (i.e. Reproduction Right, Distribution Right) and to some special rights (i.e. Education Right, Private Copy Right) known as copyright exceptions.

- **Digital Objects:** All the digital objects that the digital library has. It consists of different kinds of digital content such as music files, books, documents, and images.
- **Licenses:** All the digital licenses that each end-user has entered. In the digital license the administrator can find who the issuer and the principal are, what kind of economic rights has been granted to the principal and how long they have validity.
- **Rules:** In this link the administrator can inquire all the rules that our system consists of. Also, if it is necessary, the administrator can modify the current rules (i.e. change of the current copyright legislation) in order to keep them updated.

In the figure below it is shown the use of "tab menu" of the system's administrator page.

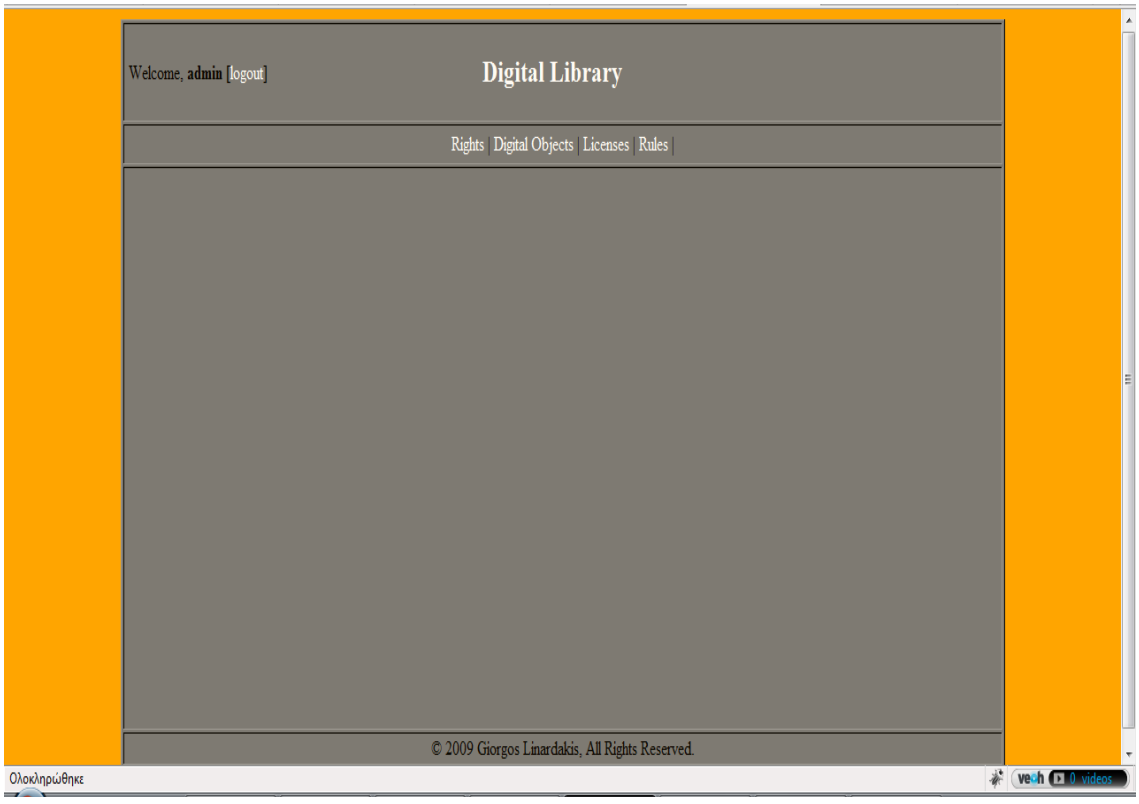

Figure 4.1: The use of "tab menu" of the system's administrator page

The home page of the simple user consists of a “tab menu” that contains a set of links that facilitate the use and promote the personalization of the digital library. Each individual page of the “tab menu” of the simple user will be presented below:

- **My Rights:** All the rights that the end-user has. These rights separated to economic rights(i.e. Reproduction Right, Distribution Right) and to some special rights (i.e. Education Right, Private Copy Right) known as copyright exceptions.
- **Digital Objects:** All the digital objects that the digital library has. It consists of different kinds of digital content such as music files, books, documents, and images.
- **My Licenses:** All the digital licenses that the end-user has entered. In the digital license the user can find who the former and the principal are, what kind of economic rights has been granted to the principal and how long they have validity.
- **Inbox:** In the inbox the user can find all the messages that have been sent to him.
- **About:** Information about the developers of the Digital Library.
- **Sign Up:** Facilitates the registration to the Digital Library.

In the figure below it is shown the use of “tab menu” of the simple user’s page.

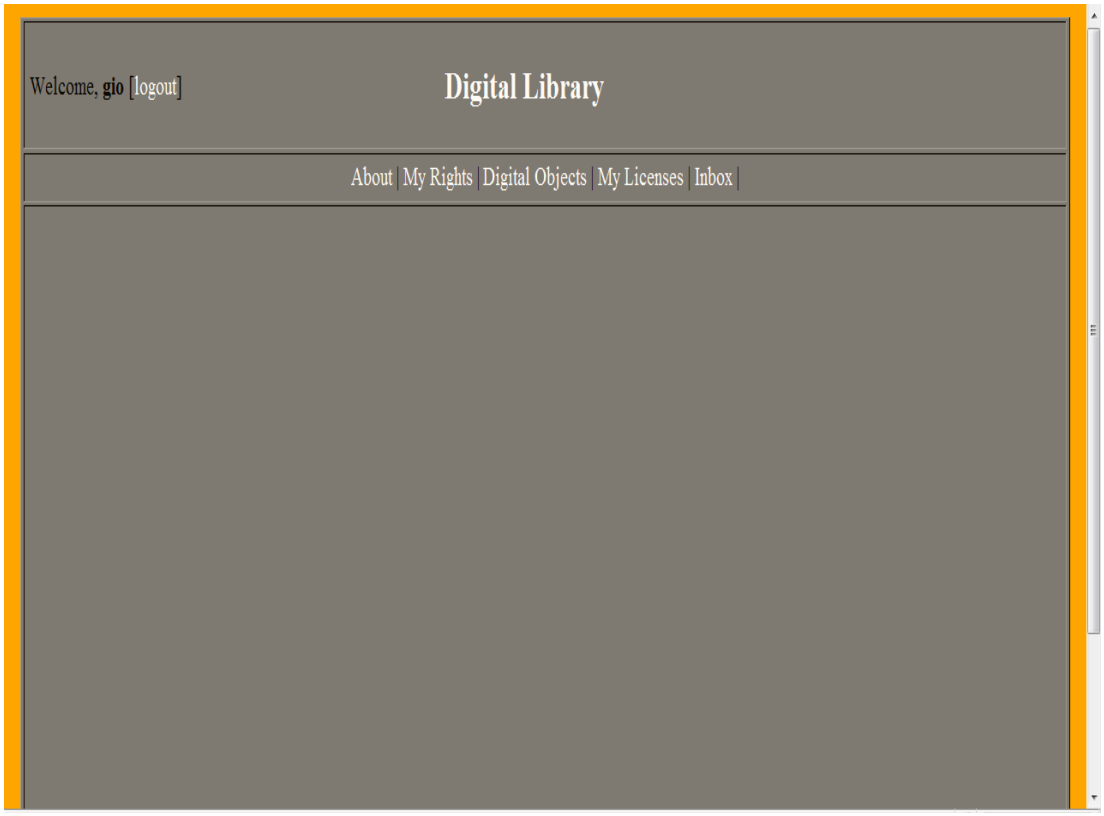

Figure 4.2: The use of "tab menu" of the simple user's page

1.11 Beans

The main intention was to provide a sleek solution that facilitates easier maintenance and further scalability. Our DRM system provides information oriented as information are used either in the decision making process or in the context of briefing / updating users. Thus, there was an imperative need to identify the different information units and design the appropriate classes. The only constraint was the fact that these units should only act as information carriers and provide functions that facilitate retrieval or modification of the contained data. As a result, these components are not interested neither on the alternative data sources (via database query or http request), nor on their possible uses (by Reasoner to make decisions or by server to display information in the Digital Library website). Java beans software pattern was a perfect match for our criteria. Java Beans are classes written in the Java programming language conforming to a particular convention and their main usage is to encapsulate many objects into a single object (the bean), so that they can be passed around as a single bean object instead of as multiple individual objects.

In order to function as a Java Bean class, an object class must obey certain conventions about method naming, construction, and behavior. These conventions make it possible to have tools that can use, reuse, replace, and connect JavaBeans.
The required conventions are:

- The class must have a public default constructor. This allows easy instantiation within editing and activation frameworks.
- The class properties must be accessible using get, set, and other methods (so-called accessor methods), following a standard naming convention. This allows easy automated inspection and updating of bean state within frameworks, many of which include custom editors for various types of properties.
- The class should be serializable. This allows applications and frameworks to reliably save, store, and restore the bean's state in fashion that is independent of the VM and platform.

The Bean designed and developed in order to support our DRM system will be presented below along with a short description of their importance.

1. **Digital_object**: This class models a specific digital object of the digital library and contains its information.

   private int id;
   private String title, subject, type;
   private Person[] Copyright_owner, creators;
   private Person[][] inc_owners;
   private Right covered_by_right;
   private Digital_Object[] incorporated_objects;

   License: This class models a specific digital license that the copyright owners grant to end-users and contains its information.

private int id**;**
private User[] issuer**;**
private User principal**;**
private Right[] granted_Rights**;**
private Digital_Object object**;**

2. **Right**: This class models a specific economic right and contains its information.

private int id**;**
private String name**;**
private Digital_Object object**;**
private User[] person_owners;
private Date startind_date, ending_date;

3. **User**: This class models a specific end-user of the digital library and contains all his relevant information.

private String username**,** password, firstname, lastname, birthday, email**;**
private Right[][] Economic_Rights**;**
private License[] IPR_licenses;
private Right[] copyright_expeptions;
private String[][] messages;
private String[] activities;

4. **Person**: This class models a specific copyright owner and contains all his relevant information.

   private int id;

   private String firstname, lastname;

   private Digital_Object[] own_objs;

   private Right[] own_copyrights;

   private Right[][] Economic_Rights;

   private Right[][] Moral_Rights;

1.12 Reasoner Integration

Initially, one of the most challenging parts of our DRM system was the integration of the Reasoning Engine because of the different technologies. However, Reasoner's implementation permits its use as any common Java library, as long as its external requirements are satisfied. The only precondition is that every component provided as input parameter should implement the appropriate interface.

The Reasoner is mainly used when an end-user wants to perform an activity to a digital object. Specifically, our system uses the reasoning engine in order to decide if the end-user has the appropriate right to perform an activity to a digital content or not.

1.13 Metadata File of a Digital Object

The metadata file is an XML file that provides information about a digital object. An example is shown in the following figure.

```
        <DigitalObject>
        <title>TowardsCore.pdf</title>
        <Creators>
          <creator id="1" name="Martin" surname="Doerr"></creator>
          <creator id="2" name="Carl" surname="Lagoze"></creator>
        </Creators>
        <Subject>Information Integration</Subject>
        <Date>9/4/2003</Date>
        <Identifier>6</Identifier>
        <Covered_By>Copyright</Covered_By>
        <CopyrightOwners state="known">
              <CopyrightOwner id="1" name="Martin" surname="Doerr"> </CopyrightOwner>
              <CopyrightOwner id="2" name="Carl" surname="Lagoze"> </CopyrightOwner>
        </CopyrightOwners>
    <incorporates>
            <object Identifier="7" title="Part of the CIDOC CRM IsA hierarchy of classes"
        type="Figure" number="1">
              <Covered_By>Copyright</Covered_By>
              <CopyrightOwners state="known">
                  <CopyrightOwner id="1" name="Martin" surname="Doerr">
                </CopyrightOwner>
                <CopyrightOwner id="2" name="Carl" surname="Lagoze"> </CopyrightOwner>
              </CopyrightOwners>
              <Creators>
                <creator id="1" name="Martin" surname="Doerr"></creator>
                <creator id="2" name="Carl" surname="Lagoze"></creator>
              </Creators>
            </object>
        </incorporates>
</DigitalObject>
```

In the above file we can find the following information for a digital object:

1. **Title.** The name given to the resource by the creator or publisher.
2. **Creators.** The persons primarily responsible for the intellectual content of the resource. For example, authors in the case of written documents, artists, photographers, or illustrators in the case of visual resources.
3. **Subject.** The topic of the resource. Typically, subject will be expressed as keywords or phrases that describe the subject or content of the resource. The use of controlled vocabularies and formal classification schemes is encouraged.
4. **Date.** A date associated with the creation or availability of the resource.
5. **Format.** The data format of the resource, used to identify the software and possibly hardware that might be needed to display or operate the resource.
6. **Identifier.** A string or number used to uniquely identify the resource. Examples for networked resources include URLs and URNs.
7. **Covered_by.** The right (Copyright) that the digital object is covered by.
8. **Copyright Owners.** The people that are the copyright owners of the digital object.
9. **Incorporates.** In this tag we can find all the incorporated objects (i.e. figures, tables, etc) of the digital object.
10. **Incorporated Copyright Owners.** The people that are the copyright owners of a digital object that is incorporated in the initial digital object. If we don't have knowledge (state=unknown) about these owners, we consider that the copyright owners of an incorporated object are the copyright owners of the entire digital object.

The metadata file is very useful because our system is based on that in order to be able to know all the essential information that it needs, such as who the copyright owners of the digital object are and if the specific digital object incorporates another objects.

1.14 Instructions to Rules Creators

For the purpose of the creation of the graphic representation of the current rules, the creators of them should follow the instructions that are presented below.

1) The classes and the properties that are going to be used, come from the following files:
    a. *caspar_rights_v0.5.owl* (Digital Rights Ontology)
    b. *cidoc_v4.2.owl* (CIDOC CRM)
    c. *cidoc_v4.2_ext.owl* (non official extension to CIDOC about digital objects)
    d. *frbroo_v0.9_extracts.owl* (self-written owl file of a sub-part of FRBRoo)
2) We put the classes in a shape called *divided process* and specifically in the upper level we write the name of the class and in the second level, if it is necessary, we put a data value(i.e. for the class D70.PurposeConstraint a data value would be *Educational_Purpose*).
3) To connect two classes via a property in general, firstly we should check the domain and the range of the corresponding property from the owl file that these property comes from. Then, we choose the *smart connector* tool and a directed line is created. After we write the name of the property over this directed line, we connect the one edge of this line with the one class (specifically with the *divided process* that this class is situated) and the other edge with the other class. For example if we want to express that an actor owns the Economic Right: Reproduction Right we use the classes *cidoc:E39.Actor* and *caspar_rights:D46.ReproductionRight* and connect them via the property *cidoc_ext:S6F_holds* (and specifically we put the left edge of the line to the class *cidoc:E39.Actor* and the right edge to the other class) .

1.15 Technologies Used

The rule engine used for inferring in our system is Jess [11] and was chosen due to the fact that it is light and one of the fastest rule engines available. Jess offers a rule engine and scripting environment, written entirely in Java. It uses an enhanced

version of the Rete algorithm [10] to process rules. Rete makes Jess much faster than a naïve implementation, that would check each rule against the known facts in the Knowledge base, fire that rule if necessary, then move on to the next rule (and loop back to the first rule when finished). A Rete implementation builds a network of nodes, where each node (except the root) corresponds to a pattern occurring in the left-hand-side (the condition part) of a rule. The path from the root node to a leaf node defines a complete rule left-hand-side. Each node has a memory of facts which satisfy that pattern. As new facts are asserted or modified, they propagate along the network, causing nodes to be annotated when that fact matches that pattern. When a fact or combination of facts causes all of the patterns for a given rule to be satisfied, a leaf node is reached and the corresponding rule is triggered.

In order to create and represent the rules of our system graphically, we had to choose a graphics tool that is powerful and at the same time easy-to-use. Moreover, because we had in mind that these graphic rules had to be converted in SWRL rules, the document with the graphic rules had to be saved in a readable form, such as XML, in order to be able to go over it and consequently convert the graphic rules to SWRL. For all the above reasons we chose ConceptDraw PRO [5]. ConceptDraw PRO is a professional and easy-to-use business graphics tool that enables you to create accurate visual representations of project data and process workflows.

For the development of the site of digital library it is used the programming language JSP as server side technology. To avoid any unnecessary rewriting of code and facilitate maintenance the entire site is revolved around one single page. Through this main page (index.jsp) the user can visit all the above links that are existed in this site.

The way that a user can visit all the links of our site through the main page is presented below.

Login: http://localhost:8080/test/index.jsp?loginreq
Sign Up: http://localhost:8080/test/index.jsp?signupreq
Digital Objects: http://localhost:8080/test/index.jsp?dig_objreq
My Licenses: http://localhost:8080/test/index.jsp?sel_lic
My Rights: http://localhost:8080/test/index.jsp?chkrig

Inbox: http://localhost:8080/test/index.jsp?inbox

About: http://localhost:8080/test/index.jsp?about

4.7 Use Cases

1. User “nik” (Nikos Papadakis) enters the system.

    a. Performs the activities *Copy, Distribute* to the digital object: *TowardsCore.pdf*. In the figure below it is shown the above.

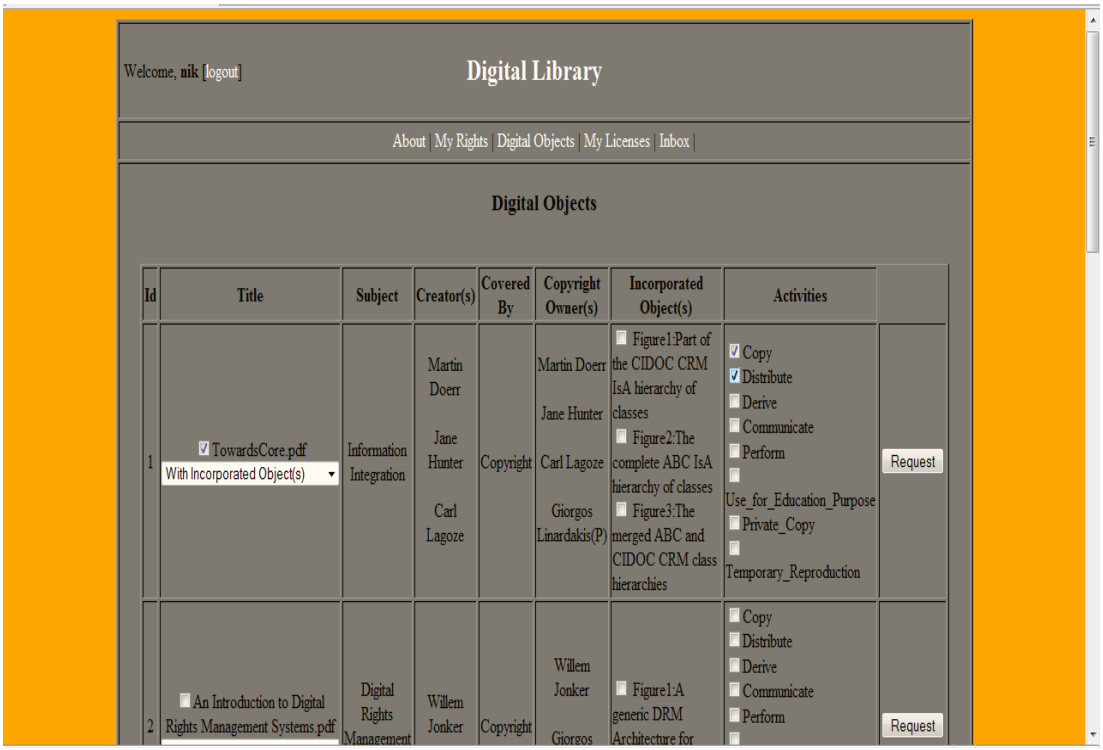

Figure 4.4: An end-user performs the activities *Copy, Distribute* to a specific digital object

1. The Reasoner of our system answers that this user does not have the specific rights to do such activities because this request did not match with any of the current rules and recommend him to obtain a license from the copyright owners of this digital object (see Figure 4.5).

Figure 4.5: Reasoner's answer

a. The user answers "yes" and then our system notify the user that he has to wait in order all the copyright owners answer to him if he will get this license or not (Figure 4.6). In this example we have three owners (Martin Doerr, Jane Hunter and Carl Lagoze) that hold the *overall Copyright* of the specific digital object. The other owner (Giorgos Linardakis) holds the *partial Copyright* of this object because he is the copyright owner only of the incorporated object: *The complete ABC IsA hierarchy of classes* (figure) and not of the entire object. However, due to fact that the user wants to perform some activities to the entire object, all of the copyright owners (even the owner that holds the partial copyright of the specific object) have to grant him the specific Economic Rights in order to be able to perform the requested activities. On the contrary, if the end-user wants to perform an activity only to the digital object: *TowardsCore.pdf* (without the incorporated objects), then only the copyright owners that hold the overall copyright of this object have to answer to the user.

Figure 4.6 System's Notification

2. User "mart" (Martin Doerr) enters the system.

    a. Browses his Inbox. A message informs him that the user *Nikos Papadakis* has requested a license from him, in order to grant him the Economic Rights: *Reproduction Right, Distribution Right* for the digital object *TowardsCore.pdf*. Then the current user has to answer which of these rights is going to grant to the requested user. Finally he grants him all the above rights (see Figure 4.7).

Figure 4.7 Grant of two specific Economic Rights from one of the owners

3. User "ca" (Carl Lagoze) enters the system.

    a. Browses his Inbox. A message informs him that the user *Nikos Papadakis* has requested a license from him, in order to grant him the Economic Rights: *Reproduction Right, Distribution Right* for the digital object *TowardsCore.pdf*. Then the current user has to answer which of these rights is going to grant to the requested user. Finally he grants him only the specific Economic Right: *Reproduction Right* (see Figure 4.8).

Figure 4.8 Grant of a specific Economic Right from one of the copyright owners

4. User "jan" (Jane Hunter) enters the system.

    a. Browses his Inbox. A message informs him that the user *Nikos Papadakis* has requested a license from him, in order to grant him the Economic Rights: *Reproduction Right, Distribution Right* for the digital object *TowardsCore.pdf*. Then the current user has to answer which of these rights is going to grant to the requested user. Finally he grants him all the above economic rights (see Figure 4.9).

Figure 4.9 Grant of two particular Economic Rights from one of the owners

5. User "gio" (Giorgos Linardakis) enters the system.

   a. Browses his Inbox. A message informs him that the user *Nikos Papadakis* has requested a license from him, in order to grant him the Economic Rights: *Reproduction Right, Distribution Right* for the incorporated object: *The complete ABC IsA hierarchy of classes* of the digital object*: TowardsCore.pdf*. As we mentioned above, the user "giorgos Linardakis" is the copyright owner only of the above incorporated object (and not of the entire digital object), thus he has to answer which of these rights is going to grant to the requested user only for the object that it owns to him. Finally he grants to the user both the Economic Rights. (see Figure 4.10).

Figure 4.10 Grant of two particular Economic Rights from one of the partial copyright owners

6. User “nik” enters the system.

    a. Browses his Inbox. A message informs him that all of the copyright owners have accepted to grant him the specific Economic Right: *Reproduction Right*, through a license (with id=1), until 30-7-2010 (see Figure 4.11). The reason that the specific user acquired only the *Reproduction Right* (and not all the requested Economic rights) is that one of the owners (Carl Lagoze) did not grant to him the *Distribution Right*; on the contrary all of the owners grant to him the *Reproduction Right*.

Figure 4.11 Grant of a specific Economic Right from all of the copyright owners

b. Browses the link *My Licenses* in order to find all the licenses that he has entered. Then he chooses to see the license with id = 1. As it is shown in Figure 4.12 in the license you can find who the principal and the issuer(s) are, the digital object that takes part, the Economic Rights that are granted to the principal and the how long these rights have validity.

Figure 4.12 The license with id = 1

c. Browses the link *My Rights* in order to find all the rights that he holds (see Figure 4.13).

Figure 4.12: All the rights that a user holds

Chapter 5

In this chapter we will present the conclusions of our thesis and then we are going to present the directions for future work and research since there are a lot to be done in the area.

Conclusion and Future Work

In this thesis we have presented a different approach of a Digital Rights Management System that is based on some specified semantic rules. The main goal of these rules is to decide if an end-user is authorized to perform an activity to a digital object or not. However, because these rules must take into account relevant copyright laws and agreements made between copyright owners and end-users (known as digital licenses), the creation of them has to be done by people that are specialized in this scientific area. Thus, we understood that we need a writing form of the current rules that will be familiar to the creators of these rules and at the same time to be able to convert to SWRL in order to be understandable by the reasoning engine of our system. Having all that in mind, we have decided that the best solution would be to represent the specific rules graphically, using a powerful and easy-to-use graphics programming tool.

After the conversion of the graphic rules to SWRL rules, the reasoner of our system is capable to decide whether an end-user is authorized to perform an action(s) to a digital content or not. Finally, our system informs the end-user correspondingly and also mentions the reason why he/she is authorized or not to perform the requested activity (ies).

At the end, as a future work, it would be important to extend our system adding more details on that, in order to be more realistic and more accurate and consequently not to exist situations that we do not forecast. For example, they could be applied as much semantic rules as possible in our system and at the same time all

the rules to contain more constraints. (i.e. fee payment in order a user to obtain a license from the copyright owner, time constraints, limitation in the number of uses, territory limitations etc). Another interesting direction is to integrate our system with an e-commerce system that handles the financial transaction for issuing the digital license to the consumer and pays royalty fees to the content provider and distribution fees to the distributor accordingly. With all the above extensions, our system will be able to support and to handle as much situations as possible.

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