Master Thesis

Rights Expression Languages: A Comparison

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Abstract and Summary

In this master thesis the focus of attention lies on Rights Expression Languages. They are one part of a Digital Rights Management System and can express copyright agreements in an unambiguous machine-readable form. RELs are therefore important when it comes to consumption, distribution and protection of products and services in the media sector and will get even more important as the digitization still changes this sector. Although there are more than 60 different RELs, and they exist since the early 1990s, some of them are still not well addressed in research. Thus, it seemed important to address this highly relevant topic in the thesis. Therefore 13 Right Expression Languages were chosen. The selection was made with the paper of Pellegrini et. al. (2018, 243) as they classify the application area of RELs in three areas: contract policy, license policy and access and trust policy. For the thesis, only RELs of the contract policy and license policy were selected. Furthermore, only those RELs where chosen, which get maintained by official standardization bodies. They are going to be described and classified according to a system of categories that was derived from the literature to give a better overview and an overall comparison. This category system covers the six policy models after Chong et. al. (2006, 290-291), the RELs data model and their expressivity as well as a timeline. The construction of the category system was made through a systematic Literature Review based on approximately 300 published peer-reviewed academic works between 1989 and today, each having an explicit reference to RELs as subject of research. This allows to answer the research questions concerning the actual status quo of the RELs, their historical development and genealogy, the application areas in which the RELs are used, the comparability in respect to its expressivity and Data Models as well as future perspectives. The results show, that although RELs were developed in the 1990s, they gain a lot importance today. Concerning the application areas, the RELs can also be differed between special purpose and general purpose RELs depending on what the REL supports. Therefore nine of the 13 RELs got classified as special purpose and four got classified as general purpose RELs. This can also be a connection to the expressivity as general purpose RELs often seem to have a wider range of actions/rights than special purpose RELs. The RELs data models furthermore show that each REL has a specific reason to exist and got

developed out of a specific need as they all differ. Regardless, all have one or more subjects that want a specific resource under certain conditions/constraints. This can be seen in all 13 RELs in one or another way as it represents the core model of the RELs.

Zusammenfassung

Der Fokus dieser Masterarbeit liegt auf Right Expression Languages. Diese sind ein Teil von Digital Rights Management Systems und können Urheberrechtsvereinbarungen in einer eindeutigen, von Maschinen lesbaren Form ausdrücken. RELs spielen daher eine wichtige Rolle, wenn es um die Distribution, die Produktion und den Konsum von Produkten und Dienstleistungen im Mediensektor geht. Dies gerade auch, weil sich durch die Digitalisierung auch der Mediensektor laufend verändert. Obwohl es insgesamt mehr als 60 verschiedene RELs gibt, und diese seit den frühen 1990ern existieren, wurde sich wissenschaftlich nicht intensiv damit auseinandergesetzt. Daher scheint es wichtig, dieses Thema in dieser Masterthese zu bearbeiten. Dafür wurden 13 Right Expression Languages ausgewählt. Die Auswahlkriterien wurden hierbei mit Hilfe des Papers von Pellegrini et. al. (2018, 243) festgelegt. Diese teilen die Verwendungsbereiche der RELs in drei Bereiche ein: die Vertragsstrategie, die Lizenzstrategie und die Zugangs- und Vertrauensstrategie. In dieser Arbeit wurden hierbei nur RELs ausgewählt, die der Vertragsstrategie oder der Lizenzstrategie zugehörig sind. Zudem wurden nur die RELs gewählt, die von offiziellen Standardisierungsinstitutionen instandgehalten werden. Diese werden dann nach einem, aus der Literatur abgeleiteten, Kategoriensystem beschrieben und klassifiziert um einen besseren Überblick und eine generelle Vergleichsmöglichkeit zu bieten. Das Kategoriensystem umfasst die sechs Verwendungsbereiche von Chong et. al. (2006, 290-191), die Datenmodelle der RELs und deren Expressivität, sowie eine Zeitlinie. Die Konstruktion des Kategoriensystems wurde mit Hilfe einer systematischen Literature Review erstellt, die auf zirka 300 publizierten, akademischen peer-reviewed Paper zwischen 1989 bis heute basiert, die alle eine eindeutige Verbindung zu RELs als Forschungsgebiet haben. Dadurch können die gestellten Forschungsfragen beantwortet werden, die den aktuellen Status Quo der RELs, den historischen Hintergrund und deren Genealogie, deren Kompatibilität in

Bezug auf die Expressivität und dem Datenmodell, sowie deren zukünftige Aussichten betreffen. Die Ergebnisse zeigen, dass RELs, obwohl diese bereits in den 1990ern entwickelt wurden, heute immer mehr an Bedeutung gewinnen. Die Verwendungsbereiche betreffend können die RELs zwischen spezifischen und generellen RELs unterschieden werden, je nachdem was die RELs unterstützen. Dahingehend können neun der 13 RELs als spezifische RELs und vier als generelle beschrieben werden. Dies kann auch eine Verbindung zur Expressivität sein, da generelle RELs oftmals eine breitere Auswahl an ausführbaren Rechten und Aktionen aufweisen als spezifische RELs. Die Datenmodelle der RELs zeigen außerdem, dass jede REL einen speziellen Existenzgrund hat und aus einem spezifischen Grund heraus entwickelt worden ist, da die RELs sich alle in ihren Aufgaben unterscheiden. Trotzdem haben sie alle ein oder mehrere Subjekte, die eine spezifische Ressource unter bestimmten Konditionen oder Beschränkungen haben möchten. Dies kann anhand der 13 RELs gesehen werden, da sie alle zumindest dieses Kernmodell der RELs aufweisen.

I Table of contents

II List of abbreviations

ABAC .... Attribute Based Access Control
ACL .... Access Control List
AI..................................... Artificial Intelligence
AES................................. Advances Encryption Standard
AVS................................. Audio And Video Coding Standard
B2B .... Business To Business
ccREL .... Creative Commons Right Expression Language
CEO .... Chief Executive Officer
CPS................................. Cyber-Physical Systems
DES................................. Data Encription Standard
DOI.................................. Digital Object Identifier
DRM................................ Digital Rights Management
DRPL .... Digital Rights Property Language
ebXML.............................. Electronic Business using eXtensible Markup Language
ebXML CPA .... ebXML Collaboration-Protocol Agreement
ebXML CPP .... ebXML Collaboration-Protocol Profile
EPR................................. Endpoint Reference
ETSI .... European Telecommunications Standards Institute
GDPR............................... General Data Protection Regulation
HTTP................................ Hypertext Transfer Protocol
HTML .... Hypertext Markup Language
IP..................................... Internet Protocols
IPMP .... Intellectual Property Management And Protection
IPTC................................ International Press Telecommunications Council
IT..................................... Information Technology
ISBN................................ International Standard Book Number
ISSN................................ International Standard Serial Number
LLD .... Language of Legal Discourse
LDF .... License Data Format
M2M .... Machine to Machine
MPEG .... Moving Picture Experts Group
MPEG CEL....................... MPEG Contract Expression Language
MPEG MCO .... MPEG Media Contract Ontology

METS .... Metadata Encoding and Transmission Standard

MVCO .... Media Value Chain Ontology

Qos .... Quality of Service

OASIS .... Organization for the Advancement of Structured Information Standards

ODRL .... Open Digital Rights Expression Language

OGF .... Open Grid Forum

OMA .... Open Mobile Alliance

ODR .... Online Dispute Resolution

OWL .... Web Ontology Language

P3P .... Platform for Privacy Preferences Project

PLUS .... Picture Licensing Universal System

RBAC .... Role-Based Access Control model

RDD .... Rights Data Dictionary

RDF .... Resource Description Framework

RDFS .... Resource Description Framework Schema

REL .... Rights Expression Language

SLA .... Service-Level Agreement

SPARQL .... SPARQL Protocol And RDF Query Language

TVA RMPI .... TV-Anytime Rights Management and Protection Information

URI .... Uniform Resource Identifier

URL .... Uniform Resource Locator

WIPO .... World Intellectual Property Organization

W3C .... World Wide Web Consortium

WS-Agreement .... Web Service Agreement

XACML .... eXtensible Access Control Markup Lanugage

XACML PAP .... XACML Policy Administration Point

XACML PDP .... XACML Policy Decision Point

XACML PEP .... XACML Policy Enforcement Point

XACML PIP .... XACML Policy Information Point

XML .... Extensible Markup Language

XrML .... Extensible Rights Markup Language

XMP .... Extensible Metadata Platform

III List of figures and tables

1. Introduction

The following master thesis is concerned with Rights Expression Languages. Although RELs exist approximately since the 1990s (Jamkhedkar/Heileman 2009, 1) there is still a lot to learn about them as they are going to get more important when dealing with digital rights management and the still rising digitization. As it is not possible to cover all existing right expression languages, this thesis will give an overview of 13 specific RELs: TV-Anytime, AVS-REL, MPEG-21, PLUS, ebXML, XACML, WS-Agreement, ccREL, ODRL, RightsML, OMA DRM, LegalRuleML and METSRights. They got chosen because they are no access and trust policy, but only contract policy and/or license policy RELs, as stated by Pellegrini et. al. (2018, 246) and are supported and refined by official standardization bodies. To get a better understanding of the whole topic and where to classify RELs within the digital rights management system there are some introduction chapters which are going to lead to the main topic: RELs.

Therefore, the structure of the work is the following: Firstly, this chapter is going to cover the evolution of the web briefly which is a main part and reason of today's change of the media landscape and then lead to the topic of legal technologies as it can be found in various appearances. Secondly, basics and trends of digital rights management like artificial intelligence, law robots and the blockchain technology are discussed. Thirdly, technological automatic rights management is going to be debated, which covers the DRM stack as well as a definition and history of the right expression languages. After that the problem analysis and relevancy of the chosen topic is going to be described. The last point of the first chapter states the approach and method of the work as well as the built research questions.

The second chapter describes the 13 chosen RELs in their functionality and structure and shall give a deeper understanding about how RELs work. Nevertheless, this chapter is fundamental for the following chapters as main parts of the category system and the answer of the research questions relate to the found information in the literature.

The third chapter focuses on the created category system. This consists of the application area, the data model, the expressivity and a timeline of the RELs and are deducted from the used literature. With the built category system, it is easier to compare the 13 RELs and answer the research questions.

The last crucial point is the answer of the research questions. The five questions are answered based on the chapters three and four and their results. After the research questions are answered, a conclusion is going to summarize the results of the thesis, give an outlook of the topic and discuss potential weaknesses of the thesis.

1.1. Evolution of the Web

The world wide web is the best-known part of the internet. It can be described as a techno-social system to humans based on technological networks as it enhances their cognition, communication and co-operation. The idea of the web was first introduced by Tim Burners-Lee in 1989. It is the largest transformable-information construct and has experienced much progress until today. (Aghaei et al. 2012, 1)

Berners-Lee describes the first web-generation as web 1.0. It was mainly static, mono-directional and therefore a read-only web. The web standards in this generation dealt with the problems how to transfer documents to the user and how they can be rendered by a browser. HTTP (Hypertext Transfer Protocol) and HTML (Hypertext Markup Language) are important progresses of the web. System or web of cognition is often a synonym of the web 1.0. (Aghaei et al. 2012, 2 / Hall, Tiropanis 2012, 3859)

In 2004 Dale Dougherty described the web 2.0 as a read-write web and it is also considered as web of communication. With the function of reading and writing the web 2.0 became bi-directional and could also gather collective intelligence. (Aghaei et al. 2012, 3) By that e-commerce and different business models supporting online services emerged and the web got more users as people could beome active contributors and actors to the web (Hall, Tiropanis 2012, 3860).

In 2006 John Markoff suggested the third generation of the web as web 3.0. It is also known as web of co-operation or semantic web. The basic idea is that decisions and tasks are conducted by machines which are provided with machine-readable web-contents. Therefore, the semantic web should be readable by machines and humans. It is created to overcome the problems of the web of documents, in which links are only between documents (or parts of them) and therefore the semantics of links and content are implicit. In the semantic web various data sets are linked, integrated and analyzed to get new information streams and more effective discovery, automation and integration. It is more like a web of data in which links are between things and semantics of links and content is explicit. (Aghaei et al. 2012, 5) Hall and Tiropanis (2012, 3861) also state that the term web 3.0 excludes the important aspects of the rise of online social networks as most of the web data come from them. Furthermore, digital literacy and crowd-sourcing models are important terms as they are the powerhouse of the web of data.

Web 4.0 is still an idea in progress. It is also known as web of integration or symbiotic web as the interaction between humans and machines in symbiosis is the centre of the idea. Machines will be able to read web-contents and react to it in various forms. (Aghaei et al. 2012, 8) It will be a read-write-execution-concurrency web in which a critical mass participates and therefore leads to *"global transparency, governance, distribution, participation, collaboration into key communities such as industry, political, social and other communities"* (Aghaei et al. 2012, 8).

The web today significantly relies on online social networks and can thus be seen as network of network (Hall and Tiropanis 2012, 3861) Today's use of communication and information technology, including the internet results in the change of daily processes with new electronic and technological methods. This includes wearables, smart home-objects, smart stationary objects, smart mobile objects as well as the ideas of smart cities or smart Governments to make public tasks more efficient and faster. These approaches are part of the internet of things and the internet of service and at the same time the core idea of the web 4.0 and the industry 4.0. (Von Lucke 2018, 339f).

Jörn Von Lucke states that the web 4.0 is characterised by the internet of things and the internet of service. The internet of things connects smart objects with their sensors and actuators as well as their cyber-physical systems (CPS) over the internet protocols (IP). Cyber-physical systems are connected constructs that link and combine physical objects with digital information and communication systems. The internet of things can therefore mean a global electronic connection of everyday items as well as a direct information exchange between objects (this is also called machine to machine or also M2M) without human interaction. In the internet of service web services, cloud computing and standardized interfaces enable to depict services and functionalities as fine-granular software components which are provided on demand over the internet. This allows single software components to be integrable. What closely ties the internet of things and the internet of service is, that real objects like paper can also be transferred in web-based services and can even be extended in their functionality. (Von Lucke 2018, 340)

Although many steps in the direction of the web and industry 4.0 are already taken, there is still a lot potential, like services that rely on smart sensor data, big data analysis or cognitive services (Von Lucke 2018, 339). This ongoing automation also takes place in the area of media and therefore also in the domain of rights management. In this area one important term in the social and technical context of the digitisation and especially in the area of legal consultation came up: legal technology. Except for the justice area is legal tech a broad term for software solutions in the legal system. (Mielke/Wolff 2017, 7f) The spectrum of these software solutions is tremendous and ranges from an improved law office software to software for machine learning approaches which can perform functions like predictive analytics during the conduct of a case.

In a study called *How Legal Technology Will Change the Business of Law* from the *Boston Consulting Group* and the *Bucerius Law School*, Legal Tech encompasses mainly three areas:

- basic infrastructure (with the use of cloud services or the deployment of cryptographic infrastructure),
- support area (like support process solutions or document, information and knowledge management),
- and substantive law solutions (applications that affect the core of juristic work). (Mielke/Wolff 2017, 9)

These three points show that legal technologies are not always restricted to juristic functions but include various software-based innovation processes. Through the digitisation these software innovations also find their way into the legal departments. (Mielke/Wolff 2017, 9)

Because Legal Tech can be found in various appearances, the following chapters are going to further explain some trends of legal technology in the context of digital rights management.

1.2. Digital Rights Management: Basics and Trends

Digitisation leads to a massive increase in the capabilities to produce and distribute content at low cost and high speed. As a result, we observe a massive increase in distribution channels accompanied by an increase of content piracy, illegal downloads and many more deviant behaviours. (Becker 2003, 1) The digital revolution can be a curse and a blessing when dealing with this problem. On the one hand, digital content can be easily copied with digital mechanisms. But on the other hand, there are different technological options to limit the ability to copy in digital form. (Godwin 2004, 4)

Digital Rights Management (DRM) can be this technological option through defining certain rules to restrain the use and distribution of digital content (Becker 2003, 1). Digital Rights Management as term refers to any technology that inhibits the use of digital content the owner has not intended (Azad et. al. 2010, 24). According to Becker (2003, 4) Digital Rights Management plays an important role in explaining, identifying, monitoring, protecting and tracking physical and intangible goods in every form of use. The holder of rights has to identify his or her content and create business models to distribute it. Afterwards the holder of rights has to establish certain rules for the DRM system.

Companies such as Sony, Amazon, Apple Inc., Microsoft, AOL and the BBC use digital rights management, although their use is controversial (Azad et. al. 2010, 24). One argument against DRM is that it could wall off parts of our culture when done in the wrong way (Godwin 2004, 5) and with too much control over a DRM it empowers only the rights holders (Arnab, Hutchison 2008, 1).

DRM Proponents argue that it is needed to disallow copyright infringements in order to maintain artistic integrity or to ensure future revenue streams (Azad et. al. 2010, 24). In addition, through DRM sellers can find out more about their buyers and their willingness to pay while they are also provided with tools to control usage which leads to price discrimination at an unprecedented scale. (Odlyzko 2007, 39)

There also had been and still are a lot of researches to improve existing approaches of DRM systems towards a fair system that empowers the consumer without weakening the strength of the security functions. (Cooper, Martin 2006 / Jamkhedkar, Heileman 2004 / Garg et. al. 2013 / Erickson 2004 / Salim et. al. 2010)

Furthermore, in the last years a DRM platform which is service-oriented had been developed primarily by the MOSES project. It is called OpenSDRM, operate independent from the content type, the content protection system and the used business model and encompass the lifecycle phases from the authoring, the distribution and management of the content. It was created to be able to adapt content and have a wide range of business models applicability concerning download, superdistribution, streaming or broadcasting. Licenses in the OpenSDRM model are handled by the OpenSDRM Walled which is a middleware layer at the client-side and can grant access to protected content by various applications concerning content handling. If an application needs access to the content, the walled is contacted that grants or denies access. (Serrao et. al. n.d.,1-4 / Serrao et. al. 2003, 647-648)

1.2.1. Artificial Intelligence (AI)

Artificial Intelligence is one important field of computer science which helped on the development of legal technology and therefore with the appearance and the current developments of digital rights management systems.

There are many definitions of Artificial Intelligence (AI) as there are many concepts and terms. Also, the capabilities of AI changed over time. Between 1970 and 1980 logic-based expert systems which were based on explicit knowledge counted as AI. Today automatic learning methods which can perform deep learning in complex neuronal systems, statistic methods of analysing measurement data or basic technologies that processes natural languages like automatic translation or the recognition of spoken language are considered as AI. (Mielke, Wolff 2017, 10) One broader definition is that AI is an advanced computer-activity that we consider as humanthinking which means actions like decision-making, problem solving or learning (Waltl, Vogl 2018, 113).

Especially deep learning was a breakthrough for AI as the network is many-layered and can learn abstract patterns. Applications for deep learning are found in speech recognition, image recognition or language understanding and the application field is still growing. (Reddy et. al. 2017, 10) Devices like Alexa from Amazon, Siri from Apple or Cortana from Windows can recognize language and react accordingly to it. As this is already becoming part of our daily live research is planning to do the same with vision and robotics.

AI is going to be developed further in the future and is going to be used in fields like health care, self-driving cars or general-purpose robotics. Through deep learning systems can advice doctors, AI doctors can make medical diagnoses as they have access to a database with all medical knowledge or robots can be used in offices or in the household. The technology of self-driving cars even will change how cities and neighbourhoods are designed. Major progress is also made in personalization, which means software and methods that adapt to user behaviour and change our handling with knowledge and how we can access, find and use information. (Reddy et. al. 2017, 10f)

1.2.2. Law Robots

Another appearance of legal technologies with the underlying technology of Artificial Intelligence can be Law Robots. The term can stand for various technologies.

According to Mielke and Wolff (2017, 10ff) some examples of Law Robots are legal search like RIDA or RDB which are big juridical databases or beck-online and WoltersKluwer which are platforms of big juridical specialist printers as well as Legal Case Management systems that can administer juridical cases or accounting and billing systems. Another example would be computer programs that can give legal advices or generate legal documents automatically like Janolaw in Germany or Smartlaw in the USA. Another revolutionizing field are platforms to settle disputes through Online Dispute Resolution (ODR). It is a software which is often used for civil law disputes in the E-Commerce sector.

In recent years so-called Robo-Advisors, which also count as Law Robots, revolutionized the financial advice field. With them people receive virtual financial advisory to invest money without going to professionals. It is even possible to access them with the mobile phone. Robo-Advisors are able to make investment decisions without human interaction. (Garvia 2018, 305) Robo-Advisors developed from the FinTech ecosystem. FinTechs are start-up companies that originated between 2008 and 2010, particularly in the USA and spread afterwards so that they became a global phenomenon. They try to use the digitalization to tear down the entry barriers in the financial service sector, use analytics to become a strong competitor, profit from a narrow, simple and specialized business proposition and target long-tail costumer with offering them cheaper products and disintermediate established providers. (Sironi 2016, 5f) Within that environment Robo-Advisors change the way of personal finance. Their development increased over the years and the number of Robo-Advisors is growing exponentially. The USA already has more than 200 Robo-Advisor while Europe has at least 70. (Garvia 2018, 306)

1.2.3. Blockchain Technology

Blockchain has been a prevalent topic in the information technology (IT) for years and at the moment it is one of the most promising technologies in financial services. (Beck & Müller-Bloch 2017, 5390) On the one hand this is because crypto-currencies like Bitcoin are the best-known applications for blockchain. On the other hand, blockchains are driven by process inefficiencies and a big cost base issue. (Nofer et. al. 2017, 183)

A blockchain holds various data sets. Each data set has a chain of data packages (blocks) and each data package encompasses multiple transactions. The ledger of the blockchain gets extended with each additional block and represents the whole transaction history. The blocks are validated through cryptrographic means and contain a timestamp, a hash value of the previous block and a random number for verification of the hash value of the previous block. This system ensures the integrity of the entire blockchain since changes of a block would change the hash value. A block can only be added to the chain if the majority of nodes in the network agree on its validity by a consensus mechanism. After the block is added to the ledger the information cannot be changed anymore. With the distributed ledger system trust is increased as no intermediary and third party is needed and data security is fostered. (Nofer et. al. 2017, 184)

However, there are still some risks concerning blockchain like theft or loss of Bitcoins through malware attacks or loss through an accident, scalability issues like communication failures or structural problems like deflationary spiral. When dealing with Bitcoin privacy can only be protected by using pseudonyms. Solutions like privacy implications of Bitcoin or a *“fair exchange protocol”* should improve the anonymity of users. (Nofer et. al. 2017, 184)

It is also in question if the blockchain technology meets the standards of the General Data Protection Regulation as it prevents data from being erased and therefore stands in the way of the right to be forgotten. However, this always depends on what the blockchain technology is used for. The blockchain Etherum for example follows the GDPR. Personal data within the blockchain is encrypted and secured with three keys. With that the blockchain technology could also be a solution for personal data protection. (Wiatrowski 2018, 227 ff)

With the rise of the blockchain technology also the term “Smart Contracts” came up. The concept was introduced by Szabo in 1997 and should combine computer protocols with user interfaces to implement the terms of a contract and furthermore replace third parties like lawyers and banks. By Smart Contracts the ownership of tangible properties like houses or intangible like shared or access rights can also be controlled and contracts can be executed in a cost-effective, transparent and secure manner. (Nofer et. al. 2017, 185)

Blockchain technology works best when the following five conditions are given: Transparency, Trust, Disintermediation, Collaboration and Security (e.g. Deloitte University, 2016, p. 84). These aspects are given in the media industry whereby the technology of blockchain offers many opportunities for the media field. One very important aspect for example is the copyright problem which affects all media areas in times of digitization. Blockchain can be a solution to protect software copyright and therefore a big opportunity for media industry. *“Software license validation is one of typical countermeasures to minimize software piracy and protect software copyright.”* (Dai et al. 2017, p. 13)

1.3. Technological automatic rights management

With the evolution of the Internet and changes of the information technology leading to the appearance of digital content in the early 1990's the urge of intellectual property owners to protect their content arose. This protection can be conducted with Digital Rights Management Systems. (Jamkhedkar, Heileman 2009, 3)

1.3.1. DRM stack

Digital Rights Management is used when dealing with digital licenses as consumers do not buy the content itself but a license that is granting certain rights. Through that license usage rules can be defined and business models like a subscription or pay-per-use can be implemented. Digital licenses help content provider to gain more power over their own content. (Liu et. al. 2003, 1)

Although Digital Rights Management systems are used in different ways, some basic processes are always the same. These common processes in a commercial system include the content provider or content owner, the distributor, service provider or license broker, the clearinghouse and the consumer or user. (Liu et. al. 2003, 2/Iannella 2008, 13/Ku, Chi 2004, 392)

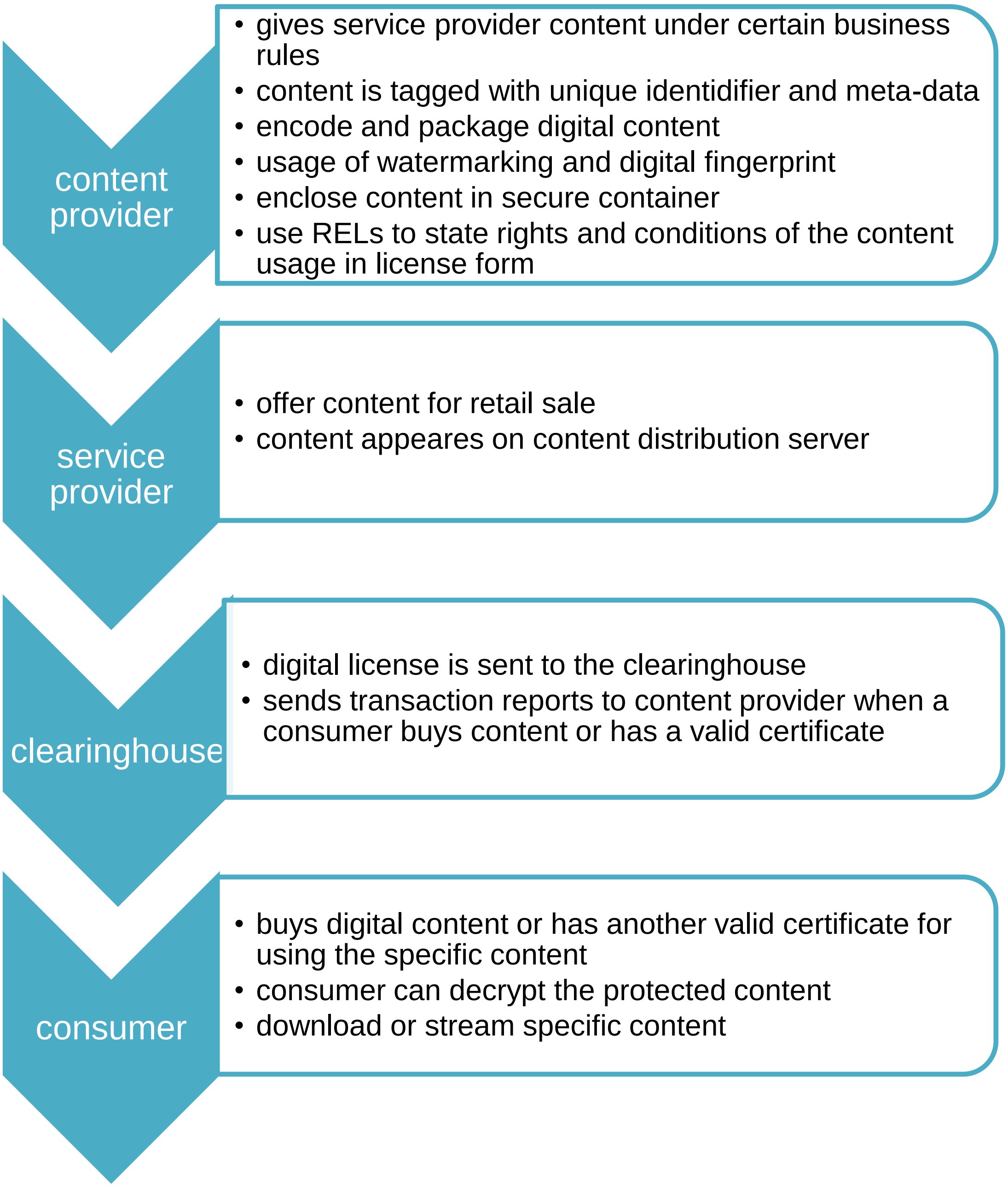
Firstly, the content provider or rights holder that created and owns the content has to give the service provider their content under certain business rules (Iannella 2008, 13). Therefore, the owner encode the specific digital content in the fitting format for the specific DRM system as different DRM vendors support different formats for their system (Liu et. al. 2003, 2). The content is also tagged with an unique identifier and descriptive meta-data. Digital content always has to be unambiguously identified so that users can purchase the right content. The content identifier are numbering schemes like ISBN, DOI or ISSN and stay persistent even when the ownership of the content changes. This alphanumeric string can then be complemented with meta-data as it gives information about how to access the content. (Ku, Chi 2004, 393-394)

Afterwards, the content is encrypted and packaged. For ownership protection and the establishing of usage rules content provider often also use technologies like watermarking to embed a digital code to the content. (Liu et. al. 2003, 2) This can help to control the copies or to identify and trace the content. Often the watermark is a spread spectrum approach which is a pseudo-noise signal that is inserted in the content or onto its frequency domain with a small amplitude. Through correlation methods, the watermark can be detected. Therefore, often a secrete key is used in addition so that only authorized parties can detect and remove the watermark. As at the end-user system the content is especially vulnerable to attacks watermarking is used to detect illegal copies of the content where its protection mechanism (or its Secure Container) has been removed. Important requirements of a watermark are therefore its imperceptibility (the quality of the content should not be affected by the watermark), security (only authorized parties get access) and robustness (the watermark should withstand attacks). (Ku, Chi 2004, 395)

Furthermore, also a digital fingerprint is created from the content and then stored in a database as it can automatically identify content. Fingerprinting is a content-based identification that *"refers to the characterization of the content based on its representation (signals or features) and matching it to an entry in a database."* (Ku, Chi 2004, 396) This technique has typically two processes. Firstly, characteristic features of the content are registered in a database. Secondly, in the recognition phase the fingerprint of the content is matched to a database entry. Important requirements of fingerprinting are therefore its robustness and its compactness. Through robustness content derivations can be associated with the original content. The compactness allows fast fingerprint extraction, search and matching. It is also important that fingerprint techniques and watermarking complement each other as fingerprinting is able to identify the content as long as its characteristic features remain. This could be of help when watermarks are illegally removed. (Ku, Chi 2004, 396)

To prevent unauthorized usage of the content it is enclosed in a secure container and a Rights Expression Language is used to state rights and conditions of the content usage in the form of a license. The Secure Containers are often coupled with digital signatures and certificates to provide content confidentiality and integrity and are implemented in the use of cryptographic algorithms like DES or AES. (Ku, Chi 2004, 393-397)

As rights holders get royalties and so on, trusted service provider offers the content for retail sale. (Liu et. al. 2003, 2) In that way the service provider acts like an intermediary between rights holder and consumer (Iannella 2008, 13). After that procedure the content appears on the appropriate content distribution server, for example a web or streaming server. As the digital content contains certain content decryption keys and usage rules the digital license is sent to the clearinghouse. The consumers can then for example download or stream the specific content if they got the appropriate license from the clearinghouse. The clearinghouse sends transaction reports to the content provider with the verification of the user which therefore must pay a certain amount of money or present a valid digital certificate. After that, the consumer can decrypt the protected content and use it in accordance with the usage rights. (Liu et. al. 2003, 2)



1: DRM stack

1.3.2. Rights Expression Languages: Definition and History

Rights Expression Languages are a subset of Digital Rights Management Technologies. When managing copyright electronically with DRM systems copyright agreements have to be expressed in an unambiguous machine-readable form. Copyright agreements can then be interpreted and computers can check if they are in accordance with the usage of the copyrighted content. These machine-readable forms to express copyright agreements are called Right Expression Languages. Therefore, through RELs behavioural aspects can be governed and usage rights can be clarified. The copyright statements that are written in the RELs are interpreted by rights enforcement mechanisms on consumer devices which supervise the usage of the content by consumers. (Jamkhedkar/Heileman 2009, 1-3) This means that human-readable licenses can be converted into a logical language that can be interpreted by computer programs without ambiguity. Enforcement systems like DRM systems use this to protect the specific content. (Barlas 2006, 7)

However, copyright law by itself is not expressed by Right Expression Languages because they do not have any legal force and do not encode copyright and are not encoded contracts. RELs are rather contract terms that grant permissions under certain conditions. Nonetheless copyright enforcement instruments like the WIPO Copyright Treaty from 1996 grant RELs legal authority. The treaty also deals with technical systems of protection and therefore rights expressions that have been generated by RELs are protected and under the protection of the law as the treaty has to be incorporated in the legislation of the countries which are signing up. (Barlas 2006, 7-8) Important is also, that Right Expression Languages do not necessarily have to be used together with enforcement systems as RELs can also only be used to make the nature of the agreement between certain Parties understandable. (Barlas 2006, 8)

“Originally, rights information was expressed in convoluted ‘bits’ as part of the content package that was the target of the DRM enforcement engine.” (Iannella 2008, 339) Although they had a simple structure and were easy to implement their disadvantages were that they were not interoperable, not traceable, had limited expressivity and were totally proprietary. Examples are the Windows Media DRM or Apple FairPlay. These ‘license bits’ only fulfilled the basic requirements of the DRM enforcement engine. (Iannella 2008, 340) Iannella also states that this was the beginning of the development of Right Expression Languages. Although their implementation is more complex they have an open standard, have a high expressivity, are well traceable, machine interpretable and independent from DRM systems. (Iannella 2008, 340)

In 1989 McCarthy made one of the first attempts of developing a formal Language of Legal Discourse (LLD) based on a logical framework. Within the LLD a deep conceptual model is built through defining a set of categories like space, time, permission, obligation and constraints. Afterwards a knowledge representation language that fits to the structure of that set is developed. (Jamkhedkar/Heileman 2009, 1-3) According to Pellegrini et. al. (2018, 243) since 1990 there is a massive increase of REL-development for purposes like access control, license management or contracting. For example, Stefik and Casey developed a DRM technology in 1994 that included a 'usage rights grammar' which was implemented in the family of computer languages LISP and called the Digital Rights Property Language (DRPL). DPRL became XrML as the Xerox PARC released an eXtensible Markup Language implementation of DRPL version 2.0. (Jamkhedkar/Heileman 2009, 3) The joint venture of Xerox/Microsoft ContentGuard released in 2000 XrML version 1.0 as an evolution of DRPL version 2.0 and in 2002 XrML 2.0 was released. After that the Motion Picture Experts Group (MPEG) released MPEG-21 Part 5 in 2003, Rights Expression Language (ISO/IEC 21000-5) as an evolution of XrML 2.0. (Jamkhedkar/Heileman 2009, 3) Jamkhedkar and Heileman (2009, 3) also describe a similar evolution with ODRL. The REL was introduced by Iannella in 2000 as ODRL version 0.5 and should provide a clear DRM principle, interoperability across different sectors and fair-use principles. In 2001 ODRL version 1.0 appeared. One year after that, in 2002 the Open Mobile Alliance (OMA) REL had been developed. The OMA DRM 1.0 was based on ODRL version 1.1 and got refined in 2004 as OMA DRM 2.0. Today XrML and ODRL are still the major RELs and both try to get standardized in the digital content management industry by forming alliances with major players in the industry.

Another evolution today is called: 'instant licenses' like Creative Commons or AEShareNet. They are simple fixed licenses but are not interoperable and have no extensibility. A community or sector predetermines them for application to relevant content. A unique identifier indicates which license is used. (Iannella 2008, 340)

1.4. Problem analysis & relevancy

As the last chapters showed, RELs are an important subset of digital rights management. Furthermore, as the digitization still changes the media sector and RELs can, for example, express copyright agreements in a machine-readable way, they already have an enormous influence on how media is consumed, distributed and protected today and in the future over the web. Right expression languages are therefore an important topic which will even gain more importance in the future and will probably further develop in the next years.

Although RELs first came up in the early 1990s (Jamkhedkar/Heileman 2009, 1) some of them are still not well addressed in research. When searching the literature, it got noticeable that most researcher are experts for one special REL but there are few describing and comparing more than one or two RELs in their work. Thus, only few documents had been found, where a comparison between many different RELs had been made.

Thus, to addressing right expression languages in the master thesis seemed to be an important and highly relevant topic. To answer the research questions, it is central to cover not only one but more different RELs which led to an explanation and comparison of 13 RELs in the thesis. With the built category system, which is deducted from the literature, it is possible to compare these RELs in a way that was not done before.

1.5. Approach, method and research questions

With these developments RELs are going to be in the centre of the following master thesis. As more than 60 RELs exist today (Pellegrini et. al. 2018, 243) it was not possible to study all of them. Therefore, the released paper from Pellegrini et. al. (2018) was taken to select specific RELs. As they classify the application area of RELs in three areas: contract policy, license policy and access and trust policy only RELs of the contract policy and license policy were selected. Within these RELs only those were chosen who get maintained by official standardization bodies. With these restrictions 13 RELs remain. They are going to be described and classified according to a system of categories to give a better overview and an overall comparison. This category system covers the six policy models after Chong et. al. (2006, 290-291), the RELs data model and their expressivity as well as a timeline.

The construction of the category system was made through a systematic Literature Review based on approximately 300 published peer-reviewed academic works between 1989 and today, each having an explicit reference to RELs as subject of research. The application area after Chong et. al. (2006) was also used by Sha (2006, 99) and Pellegrini et. al. (2018) in their research. The illustration of data models is widely used in the literature such as by Rodríguez-Doncel et. al. (2013, 3), Sha (2006, 92), Ramli et. al. (2014, 81), Kang et. al. (2009, 95), Llorente et. al. (2007, 2) Guth and Strembeck (2004, 2), Steyskal and Polleres (2014, 21) etc. Therefore, it became part of the category system. The Expressivity of the RELs is described in ETSI (2005), Sha (2006), Wang et al. (2005, 409-410), Timmerer and Hellwagner (2008, 578-579), Gallo et. al. (2008, 131), Barlas (2005), PLUS Coalition LTD (2016), Ramli et. al. (2016), UN/CEFACT and OASIS (2002, 70-78), Andrieux et. al. (2011), Rodríguez, Delgado (2006, 2), Abelson et. al. (2008, 6-10), W3C Recommendation (2018), Zhang et. al. (2008, 262), IPTC Right Expression Working Group (2018), IPTC (2013, 5-10), Open Mobile Alliance (2008, 17-25) Smith (2004, 187-188), Cundiff (2004, 53-57), Cantara (2005, 239-250) and Palmirani et. al. (2013) and was thus considered an important part of approaching RELs and included to be one part in the category system.

A timeline was also used by Pellegrini et. al. (2018, 247) in their paper to illustrate the connections of the different RELS and how they developed over time. Thus, it seemed important to include a timeline specifically for the 13 RELs in this master thesis too.

With a basic literature review existing knowledge on a topic is summarized and evaluated. Through plausible evidence based on previous research a thesis position is promoted. With the context and background of the current knowledge of the topic a logical case to defend the thesis position is taken. Therefore, a literature review is a written argument. (Machi/McEvoy 2012, pp. 2-4)

Hence the research questions in this thesis are:

- **RQ1:** What is the actual status quo of these Rights Expression Languages?

- **RQ 1.1:** What are their historical development and their genealogy?
  - **RQ 1.2:** In which application areas are these RELs used?
  - **RQ 1.3:** How is the comparability of the discussed RELs in respect to its expressivity?
  - **RQ 1.4:** How is the comparability of the discussed RELs in respect to its Data Model?
- **RQ2:** What are future perspectives of these RELs?

2. Rights Expression Languages

Right Expression Languages should meet a number of technical and conceptual requirements. As RELs express use and access rights to assets they should be able to express terms and conditions for any digital asset and formulate business models. (Guth 2003, 102) RELs are mainly used in the content meta-data and its associated content (Ku, Chi 2004, 397). Furthermore, the interoperability and consistency through standardized RELs should be given. The needed machine readability (for interoperable reasons) and extensibility (to be prepared for all possible scenarios) of RELs is fulfilled with the serialization in XML as it allows flexible expressions (Ku, Chi 2004, 397) because *"the expression elements are not restricted to the columns of a relational database table".* (Guth 2003, 102) The flexibility also allows a REL to express many different business cases (Guth, Strembeck 2004, 1).

The structure of a Right Expression Language is important due to its interoperability. It can be distinguished between two right expression categories: One that is based on logic language and one that is based on a markup language like XML (Xu et. al. 2011, 186).

XML is the abbreviation for eXtensible Markup Language which implicates that XML is extensible and can be modified. XML was created in 1998 to *mark-up* documents in order to be understood by other applications. This means to add descriptive text around a document item which other applications can decipher. This metadata can further define data elements. Although different markup languages exist, XML became the most popular one as it provides an easy way of creating markup and connect metadata with data. Thus, XML is considered the standard for data representation. (Evjen et. al. 2007, 3-6) The advantage of XML is that it allows to create customized tags, it is flexible and can contain any information needed, it is easy to read and understand, it has a large number of supported platforms, it can be used across available open standards and it is easier than binary formats when representing complex data structures. Its primary purpose is to describe, store and exchange data. (Powell 2007, 1-5/ Evjen et. al. 2007, 6) Although XML can handle data warehouse, data representation and data presentation, it lacks in representing metadata in a standard way. This means for example that if searching for the word cook it does not know if you want to know more about a specific cook or about Tim Cook. Therefore, data relation is important. To structure metadata the Resource Description Framework (RDF) can be used. RDF, as used by the ccREL, the MPEG-21 MCO and PLUS as it uses XMP, can be seen like a human thought pattern as the data is structured like human would structure them. It is built on existing XML and URI technology and is structured in triples with a subject (the central item), a predicate (a property or a relation to the subject) and an object (apply a relation between subject and object). Tim Cook (the subject) is the CEO (the predicate) of Apple (the object) would be one triple with which more relations are possible. One triple is also called a statement. A statement set is called a model. These relations are created with the help of unique identifiers. One example is the Uniform Resource Locator (URL) with which a web page can be uniquely identified. URI's, or Uniform Resource Identifiers, are used to identify other items uniquely as not everything can be a resource that is URL-accessible. (Abelson et. al. 2008, 3-5/ Evjen et. al. 2007, 757-759/Kumar, Kumar 2013, 1) Thus, with RDF information on the web can be expressed in a meaningful and machine accessible way (Kumar, Kumar 2013, 1). The Web Ontology Language OWL 2, which is also used by MPEG-21 MCO, is for the semantic web and can be used together with information written in RDF. OWL2 ontologies are furthermore mainly exchanged as RDF documents (W3C 2012). Although OWL is standardized, ontologies in general are considered as good technology to express semantics. Thus, domain ontologies based on OWL are created. (Yan et. al. 2006, 1-2) Ontology in the artificial intelligence and web fields is considered a domain concept and their relations description. "Ontology is the theory about objects and their ties. It provides standards for differentiating kinds of object (concrete and abstract, existent and non-existent, realistic and ideal, independent and dependent) and their ties (relations and dependency). Ontology is [a] formal structure to support knowledge sharing and reusing." (Yan et. al. 2006, 2) OWL as ontology presents information as well as process the content of information and can interpret web content better than XML or RDF as it provides more vocabulary with formal semantics. (Yan et. al. 2006, 2) The semantic web or also known as web of linked data enables the creation of web data stores, the construction of vocabularies and the writing of rules to handle data. This web is based on machine-readable information and the technology of XML and RDF, but it also includes technologies like RDFS, OWL or SPARQL etc. that describe available metadata on the web and connect them. (Kumar, Kumar 2013, 1)

As there are various activities involved in supervising the consumption of digital goods metadata like the articulation of roles, standard identification systems like DOI, ISBN or ISSN, defining user permission and restriction, express revenue and payment details, security information, technical handling details like viewers and media format and so on should be provided by RELs. What a REL requires ultimately always depends on their field of application and scope. (Guth 2003, 102-103)

To define digital contracts, a straightforward grammar and a fixed, but also extensible and unambiguous vocabulary must be provided (Guth, Strembeck 2001, 1). Therefore, constitutive concerning RELs are its syntax and semantics. Whereas syntax means grammar rules concerning the language vocabulary or rights language concept, semantics mean the validation of a sentence in the language and gives the terms in the grammar rules meaning. It is typically called the rights data dictionary. In the syntax rights, assets and parties are the most basic elements of a REL. Rights are expressions that grant certain permissions but can also contain certain prerequisites or restrictions. The asset needs an unambiguous identifier like a DOI and represents the digital good or service itself. Party means a legal entity or physical person like the rights holder, the author, the creator, the consumer or the content provider that has a relationship to the asset. (Guth 2003, 103/Ku, Chi 2004, 398)

The semantics of a REL often refers to the Rights Data Dictionary (RDD) as each REL has a certain rights vocabulary that defines which vocabularies are permitted and the semantics in REL instances. Such instances could be play or view vocabulary to grant permissions, location or time vocabulary to restrict the permission or payment vocabulary to set some prerequisites to obtain permission. (Guth 2003, 104)

In the rights language concept the basic building blocks of RELs are:

- **Rights**: Permissions and restrictions of content usage are included.
- **Conditions:** Before the right can be exercised there are some prerequisites defined that have to be fulfilled.
- **Resources:** Refers to the specific and unambiguously identifiable content.
- **Parties:** Refers to the involved principals. (Ku, Chi 2004, 398)

2: REL stack

In RELs licenses can be encoded where the rights granted to the user are specified. Licenses are bound to the user device so that they are not transferable across other devices. Therefore, the user has to be individualized so that the licenses are uniquely bound to the specific user. Thus, licenses usually consist of following elements:

- The Content Identifier

- Optional user information
- Rights and restrictions of the usage
- Stateful information to supervise the use of the content
- Content key(s) that are kept secret
- Authentication information to decrypt content keys and binding between the license and the user. (Ku, Chi 2004, 398)

As there is a massive increase of REL-development since 1990 for purposes like access control, license management or contracting this is also resulting in more than 60 different existing RELs until today, although some derivates of older ones and others are developed to serve completely new purposes. One reason is that they are technical heterogeneous and have a high degree of diversification. Therefore, different RELs are used for different purposes and in different areas. (Pellegrini et. al. 2018, 243)

In the following chapter the specific chosen RELs are going to be described. They are also used in the category system later on. These specific RELs are chosen because they are all maintained by official standardization bodies. Furthermore, when describing the RELs a big part of it often consists of the latest specification the standard has published. The use of the specification shall give a further understanding how the specific REL works and which parts are necessary.

2.1. TV Anytime RMPI

The broadcast environment changed in the last years from analog to digital. With this, content-digitalization users can be supported with opportunities like viewing content in high resolution, easily accessing the content or getting more information about the content etc. Furthermore, the internet and broadcast environments converged in the last years. One result of this is that the industry is provided with different service capabilities. (Lim et al. 2008, 433) Concerning the audio-visual content it is important to standardize the elements involved, because in that way it is possible to develop intelligent services that add value for the consumer. With elements that are described in a standardized way, the software that offers the service can *“compare, make decisions or built new and more complex services out of basic components.”* (Solla et al. 2013, 9)

Therefore, the TV-Anytime forum was established in 1999 as non-profit organization to contribute to this standardization. It consists of *“over a hundred of the most important European, American and Asian organizations (government institutions and companies) in the audiovisual and consumer electronics sectors: broadcasters, content owners, service providers, telecommunication companies, device manufacturers, software developers, institutional regulators etc.”* (Solla et al. 2013, 9) The goal was to create an open international standard for audio-visual service, multimedia description information standards and realization mechanism as well as a stronger relation between content producer, service provider and consumer to identify new business models that rely on more interactivity with the user. The forum published a series of specifications to make it able to standardize different aspects of audio-visual content (Concerning for example the search, the description, location, selection or acquisition). Teams that created and generalized the deployment of audio-visual content should be provided with a wide interoperability that is based on consumer devices with high storage capacity and independent of the distribution mechanism. (Solla et al. 2013, 9-10/Wang, Wu 2011, 6318) TVA is XML-based as it offers advantages of extensibility, separation of data and application and a wide usage. It is possible however, to use other optimized binary formats. (ETSI 2007, 29/Ha et. al. 2011, 455)

In phase one of the TV Anytime specifications, TS 102 822 (parts 1 to 9) were published. Part two incorporated improved features to the technical specifications. With TV Anytime, users get better access to multimedia content. Furthermore, metadata can be helpful to consumers to find specific live, on-demand, recorded on personal or cloud storage content. (ETSI 2018)

Part 5 V 1.1.1 of these specifications was published in 2005, is called *“Rights Management and Protection (RMP) Information for Broadcast Applications”* and contains *“a minimum set of usage rules and conditions required to enable protection of broadcast digital television content within a TVA Rights Management and Protection (RMP) compliant domain.”* (ETSI 2005, 4) It got revised in 2006, 2008 and 2009 (ETSI 2009, 29). The RMP Information-Micro Broadcast (RMPI-MB) is for Broadcast

Applications whereas the term RMPI-Micro (RMPI-M) refers to content in a TVA RMP compliant domain (post broadcast/acquisition). (ETSI 2005, 4)

The semantics of RMPI-M and RMPI-MB consist of:

- **Principals** that can be used when granting rights,
- **Rights** like play, analogue export, digital export standard definition, digital export high definition or extended rights
- **Conditions** like geographical control, physical proximity, buffer duration, time window start date and time window end date etc.
- Ancillary RMPI-MB and RMPI-M hold information that is needed to handle the content, like version of RMPI, origin of RMPI etc. (ETSI 2005, 8-12 / ETSI 2009, 8-12)

The syntax and encoding of RMPI-MB and RMPI-M payload defines a set of usage rules and rights that can be transported alongside digital television broadcast. The minimum set consists of at most four grants:

- The **'receiving domain' signals rights and conditions** that apply to content when a given 'receiving domain' is entered.
- **'Any domain' signals rights and conditions** that apply to content when 'any domain' is entered.
- The **'receiving domain' that signals the 'extended rights' and conditions** that are associated.
- **'Any domain' that signals 'extended rights' and conditions** that are associated. (ETSI 2005, 13 / ETSI 2009, 13)

TVA has content description metadata, consumer metadata, instance description metadata and segmentation metadata. These metadata get delivered with the procedures of **fragmentation** (the decomposition of metadata in data units which are called TVA fragments), **encoding** (which represents the metadata in a compressed binary format), **encapsulate** (which encapsulates encoded fragments in data containers), **indexing** (an optional mechanism when the storage capabilities on the receivers are limited. The fragments are listed and can be found quickly if needed over the delivery layer) and **transmitting** (when a terminal device receives the TVA fragment containers they can encode it and reconstruct the original metadata). This is needed to reduce bandwidth consumption and improve the service quality. (Ha et. al. 2011, 455-456/Wang, Wu 2011, 6318-6319/ETSI 2007, 37)

2.2. AVS-REL

The AVS-REL is a right expression language that was proposed by the Audio and Video Coding Standard Workgroup of China (AVS Workgroup). This group was established by the Ministry of Information and Industry in China in 2002 and wanted to establish a *"technical standard of high quality for compression, decompression, processing, and representation of digital audio and video, and thus providing the digital audio-video equipments and systems with high-efficient and economical coding/decoding technologies."* (Audio Video Coding Standard Workgroup China 2018) The standard got approved and came into effect in 2006. In 2008 the group launched the AVS2.0. (Audio Video Coding Standard Workgroup China 2018) Through the AVS-REL a flexible and interoperable mechanism for trade, distribution and usage on digital audio and video resources can be provided. The AVS-REL as right expression language is a component of the AVS-DRM. This DRM protects AVS audio and video resources. As AVS are new audio and video multimedia standards, it has special requirements for the DRM and the REL. (Sha 2006, 91) The AVS-REL is based on the XML-language and supports signature, encryption, etc. as security model. W3C XML Encryption is used to encrypt resources and W3C XML Digital Signature is used to sign License. (Sha 2006, 96)

Sha (2006, 91-95) states in his paper that the AVS-REL data model is constructed with five entities:

- **Rights:** In the AVS-REL, rights include use rights (like display or play), reuse rights (like modify, split or package), resources management rights (like move, copy or backup), rights management rights (like revoke special rights) and fair-use rights. Fair-use rights can be assigned to subjects depending on its roles and can be hold without the permission of the rights issuer's. The rights in the AVS-REL are operations on some objects.

- **Resources:** A subject can obtain the right to a resource which can be a digital content, a service (like an email service), or property information of a subject (like an email address). A group of resources can be defined as ResourcesGroup in AVS-REL.
- **Subjects:** In the AVS-REL the subject can be human, groups, computers, applications or network devices as they can be right issuers or right requestors in the whole digital content value chain. In addition, there are different roles a subject can be assigned.
- **Duties:** Duties means requirements that have to be fulfilled by a subject before it obtains the specific rights. In AVS-REL there are three types of duties: 1.) The payment includes prePay, postPay, perUse and so on, 2.) the interactive requirement is again split into the copyright statement (there the right issuer can indicate his copyright requirement. With that feature the design principle is met as REL can also express the right holder's rights in law.) and pre-operation (where a subject must complete other operations before it gets certain rights), 3.) the requirement for use are functions like record track to record what is done to the resources by users. Fair-use can also be implemented through duties component. Furthermore, duties in AVS-REL express requirements as they have to be fulfilled before the right is granted. The duty component is mainly used for negotiation between rights issuers and receivers.
- **Constraints:** These are conditions that must be fulfilled before a user obtains rights. The AVS-REL supports constraints such as by software network, target, use, device, transformation quality, space and time.

Especially the balance of rights and duties is one design principle of the AVS-REL. Therefore, rights and duties can not only be the content owner's rights, but also the rights of the user. (Sha 2006, 91) The base data structure of AVS-REL is therefore composed of the five entities subject, rights, resources, constraints and duties and is called LicenseUnit (Sha 2006, 95).

2.3. MPEG-21

The MPEG-21 REL was developed from the Moving Picture Experts Group (MPEG) in 2001 with the core architecture and base technology of XrML 2.0 from Content-Guard (Wang et al. 2005, 408 / Jamkhedkar/Heileman 2009, 3). It was designed as an International Standard ISO/IEC 21 000-5 and the open development process took the technological companies, consumer electronic companies, content owners and creators more than two years. The REL is an XML-based declarative language to specify rights and conditions to digital resources and *"provide flexible, interoperable mechanisms to support transparent and augmented use of digital resources in publishing, distributing, and consuming digital content […] in a way that protects the content and honours the rights, conditions and fees specified for the content."* (Wang et al. 2005, 409) A core idea of MPEG-21 is that humans are network elements with billions of content provider, service provider, consumer, etc. Therefore, peer-to-peer networking and flexible user roles were an underlying thought of MPEG-21 (Burnett et. al. 2003, 61).

Thus, the main goals of the MPEG-21 REL are to define rights unambiguously with the syntax and semantics, to offer interoperability by supporting many usage-models in the end-to-end distribution and to provide a formal authorization model to determine if authorization can be granted. Specification of access, use controls and exchange of sensitive or private digital content is also intended. In Addition, it can also be used by enterprises or individuals to protect valuable data and privacy by expressing rights and conditions for the use of the data. (Wang et al. 2005, 409)

The MPEG REL consists of a collection of three XML schemata: the core schema, the standard extension schema and the multimedia extension schema. With these schemas the fundamental elements of the language are expressed. Furthermore, it is designed for digital rights management model and therefore provides a constant vocabulary across all service providers. (Sheppard, Safavi-Naini 2006, 6-7)

"MPEG-21 REL allows access control to digital contents and the conditions of their uses expressed through a set of authorizations based on secure and adaptable architecture." (Rafi 2009, 997)

The data model of the MPEG-21 REL consist of:

- **Issuer:** The issuer is the owner of the rights and states that the principal has a right to a resource under certain conditions. The principal can also sign a digital signature of the license contained by the issuer.
- **Grant:** If a principal is authorized to get certain rights they are called grants. They are elements in a license that grant rights.
- **License:** The entire statement (of principals, rights, resources, conditions, issuer and grants) is called a license and is the central construct of the REL.
- **Principals:** They are authorized to use the digital resources (like users, groups, devices and systems) as a right is granted to them. The principal denotes itself by unique information that often also has some associated authentication mechanism to prove its identity.
- **Rights**: They are accorded to principals to be exercised against resources under some condition. Typically, they specify an act or activity or class of acts of a resource. Such rights could be specific rights like play, print and adapt, or rights that relate to other rights like obtain, issue and revoke.
- **Resources:** Resources are digital resources like content (eBooks, audio files or images), services (email services, B2B transaction services), information (name, email address) or software applications to which a right can be granted. In the MPEG-21 REL mechanisms to encapsulate necessary information to identify a specific resource are provided.
- **Conditions:** Under them the rights are exercised and terms, conditions and obligations are specified (like a time interval within which the right is granted or some prerequisite rights that must be fulfilled first. (Wang et al. 2005, 409-410)

For example, when a movie company allows consumers to play a movie in their library for a 2€ fee and within 24 hours. Then two licenses are needed: One to allow anyone to play the movie for 2€ and one to specify the time limit 24 hours for the use. (Wang et al. 2005, 413)

2.3.1. MPEG-21 IPMP

The MPEG-21 Intellectual Property Management and Protection (IPMP) was created in 2005 (MPEG 2005) and is the digital rights management system of MPEG. It does not support one specific digital rights management system but offers vendor-specific IPMP tools that provide different functionalities. These tools can be downloaded and can support basic functions like decryption and watermarking or complete digital rights management systems in their own right. (Sheppard/Safavi-Naini 2006, 5) The IPMP is a framework proposed by MPEG-21 that offers an interoperable and renewable digital rights management system as proprietary digital rights management features are implemented. With that implementation the use and distribution of multimedia content can be controlled by content providers. (Sheppard 2007, 10, Sheppard/Safavi-Naini 2006, 2) This is important as the vocabulary of the MPEG REL was designed with copyright protection applications but lacks basics to define principals, rights and conditions for the privacy protection applications. (Sheppard/Safavi-Naini 2006, 7)

DRM systems are able to protect copyright but can also be used to protect privacy. Therefore, licenses have to be developed that contain information about individuals' preferences of how their personal information should be used. (Sheppard/Safavi-Naini 2006, 1) Although the MPEG-21 REL is useful in copyright protection it lacks elements for privacy protection applications. With the IPMP components Sheppard and Safavi-Naini (2006, 2) developed a 'privacy extension schema' in the sense of XML schema that allow individuals to express how they want their data used in terms of actions and conditions. With the IPMP implementation a service provider can collect data from individuals in the form of XML documents, but the use and distribution of this data is restricted to the conditions of the data's owner.

A resource is called 'governed' if it is protected by one or more IPMP tools. Through a plaintext identifier and an IPMP information descriptor (which links the resource with a license and describes the required IPMP tools to access the resource) the terminal has to obtain the IPMP tools to access the resource. (Sheppard/Safavi-Naini 2006, 6)

For the preliminary privacy extension schema proposed by Sheppard and Safavi-Naini (2006, 7-9) existing vocabularies for P3P and EPAL (Enterprise Privacy Authorization Language) were used. Alongside the MPEG REL elements, the privacy extension schema also has the elements purpose, obligations and recipients.

- **Purpose:** Languages developed in privacy protection uses the term 'purpose'. To be able to enforce these policies by machines they need to be some combination of a specific principal exercising a specific right under certain conditions.
- **Obligations:** Obligations in the MPEG REL represent conditions that have to be true before access is permitted or actions that have to be carried out after access is permitted. Hence, they can be post-conditions or pre-conditions.
- **Recipients:** Recipients do not have direct access to the database but have data disclosed by someone with direct access. Often the discloser is the principle of an access control rule. In that scenario the identity of the recipient is the condition. In digital rights management models it often makes more sense that the recipient is the principal of a grant that is given directly to him. The discloser does not need to access the data him- or herself as the data can be given to the recipient in its protected form.

The syntax was created by attempting to write licenses for different simple scenarios until the license could be written conveniently. (Sheppard/Safavi-Naini 2006, 7)

2.3.2. MPEG-21 CEL and MPEG-21 MCO

In April 2008 the proposal to extend Part 5 of MPEG-21, the Right Expression Language, was made. The extension should *"support the representation of contracts on audiovisual material".* (Rodríguez 2015, 66) Although it was supported by 11 organizations, it was not successful. Later the PrestoPRIME European Project worked together with many project partners in the broadcast sector and digital archives on a contract formalization in the context of digital preservation of content. This led the MPEG-21 expert group to develop the MPEG-21 Media Value Chain Ontology (MVCO), which is part 19 of the MPEG-21 and is a formal language that represents different kinds of intellectual property of media as well as defines roles for users and actions concerning intellectual property. In this context the MPEG-21 CEL and MCO originated in 2013. They both got revised: The MPEG-21 CEL in 2016 and the MEG-21 MCO in 2017. (Rodríguez 2015, 66-67 / ISO,IEC 2016 / ISO, IEC 2017)

The term CEL means Contract Expression Language and is used to express Media Contracts in machine-readable formats. These XML-based contracts contain the exploitation rights of media content as they are objects of trade and specify the agreements between two or more parties. The CEL is part 20 of MPEG-21 (ISO/IEC 21000-20). (Delgado et al. 2016, 1)

MCO is the short form of Media Contract Ontology and is part 21 of MPEG-21 (ISO/IEC 21000-21). Media Contract Ontology and Contract Expression Language are both effective when the rightful use of media content has to be checked against clauses in media contracts as they are expressed in machine-readable form. In CEL Media contracts as ontologies are represented with OWL. (Delgado et al. 2016. 1)

As media companies have to handle many different contracts it is easier to access them in a digital form which is also done because of mere preservation purposes. Both MCO and CEL are electronic formats to represent media contracts which support machine-readable media contracts. (Rodríguez et al. 2015, 64) The advantages of these contracts are that they represent machine-readable unambiguous documents on rights, they can be legally binding and prove to accept liabilities, they can help to integrate contract services in multimedia content management platforms and can grant business integration over electronic networks. With media contracts the actions and conditions between several actors that trade all with audio-visual content (such as movies, television series or programmes, photographs, music, books or learning material etc.) can be modelled. (Delgado et al. 2016. 3-4)

The basic structure of a media contract contains metadata of the contract, the contract unique identifier, likely relationships with other contracts, the involved parties, a declaration set the parties have to recognize as true, the contract object which is the content or service and provisions like warranties, Termination clauses and legal disclaimer. Furthermore, the operative part of the media contract contains contract information which uses deontic expressions like permissions, obligations and prohibitions and include rights (as the action), the media (digital or analog) as rights object and the conditions. The conditions within that operative part are related to contract parties and can also be called facts, as they can be seen as logical statements. (Delgado et al. 2016. 5/Rodríguez 2015, 67-77)

The Contract Expression Language is organized in a core that defines the structural elements of a contract and an extension that exploits intellectual property rights and include the most common acts and constraints concerning the media field. (Rodríguez et al. 2015, 64-65) Delgado et al. (2016, 11-12) defined the main elements of a CEL contract as following:

- **Parties:** These are the parties who accepted and signed the contract.
- **DeonticStructuredClause:** The rights and conditions are expressed in the deontic structured clause. Four different types of clauses are possible: Prohibition, Permission, Obligation and Statement. Each clause relates the contract parties. Parties can act as Subject or Issuer with the Object, Act and Constraint in the clause. Act means to specify the right. Constraint means to express different conditions. Elements like Metadata and Context which can also be defined are able to provide extra information
- **DeonticStructuredBlock:** With the deontic structured block various clauses can be grouped and can therefore duplicate a contract structure of a current contract.
- **ResultantObject:** Resultant Objects are objects where the act is applied to the object under constraints.
- **Precondition/Postcondition:** These are dependencies between clauses. Other clauses must happen before or after the present clause.

It is also possible to include the text of the original contract in the XML file to clear the relationship between the text and the XML file. In addition, encrypted versions of various elements like blocks can be added in the XML file. (Delgado et al. 2016. 11-12)

The Media Contract Ontology is written in the semantic web language OWL2. The MCO formalizes vocabulary for business contracts in the media environment and is therefore using the Resource Description Framework (RDF). With the representation in RDF with the increasing material, the metadata interoperability and system integration can be dealt. (Rodríguez-Doncel et al. 2016, 1-3) OWL represents complex knowledge of the things itself but also of their relation. The MCO standard provides the so-called TBox in the semantic terminology which refers to *"the terminological component describing the conceptualization, while each MCO contract/document is a part of the ABox, i.e. the assertion component describing the instances of such concepts, together with the individual relations among them."* (Delgado et al. 2016. 12)

The MCO standard and each MCO contract consists of a triple number at the lowest level. That number helps to derive all knowledge about the conceptual model and the contract terms. (Delgado et al. 2016. 12)

According to Delgado et al. (2016, 12-13) and Rodríguez-Doncel et al. (2016, 4-7) the basic elements of the MCO contract are as following:

- **Parties:** These are Users and/or Organizations.
- **Deontic Expression:** In this expression the element Permission is used to model rights, Obligations can be used for payments, notifications or obligation to exploit a right and Prohibitions can prevent the use of a right. User or Organization are issuer of a permission.
- **Action:** This element models the users or organizations right.
- **IPEntity:** The Intellectual Property Entity handles the rights media content or service.
- **Fact:** Facts are also called conditions. They can restrict the validity of the deontic expression or can express dependencies.
- **Textual Clause:** Each deontic expression can be linked with a textual clause as it can be helpful to map an MCO to an original narrative contract.

As the MCO is based on OWL and CEL on XML they are very different technical environments. Therefore, using one or the other can vary depending on contexts and practical reasons. Regardless it is possible to switch between the formats with a special conversion module of MPEG-21. (Rodríguez 2015, 67)

2.4. PLUS

The Picture Licensing Universal System (PLUS) Coalition was created in 2004 and describes itself in the following way: *"The Plus Coalition is an international non-profit organization with a tightly focused mission: to simplify and facilitate the communication and management of image rights".* (PLUS Coalition LTD. 2016) The Coalition consists of associations, leading companies, standards bodies, scholars and industry experts and helps communities who create, distribute, use and preserve images. This Coalition created PLUS in 2004: The Picture Licensing Universal System. It defines and categorizes the usage of images by getting, granting, managing, tracking, etc. licenses. (PLUS Coalition LTD. 2016) Plus uses the open, international ISO standard XMP from Adobe. Adobe's Extensible Metadata Platform is an open and extensible framework that can accommodate existing metadata schemas. With XMP PLUS Universal License Statements can be embedded in digital image files. (Adobe 2018) XMP itself is based on a subset of the RDF syntax. (Adobe System Incorporated 2012, 9)

Although it does not support price negotiation or making contracts, PLUS gets more transparent, fair and simpler through a machine-readable form, a global registry and a standardized language by expressing a licensing language and building and managing data for image rights. PLUS consists of different standards which are enlisted on their website (PLUS Coalition LTD. 2016) and shortly described in the following:

- **The PLUS Picture Licensing Glossary:** This glossary is built by worldwide professionals and regularly updated and expanded. It contains the language on which the license is made of and includes over 1000 licensing terms and definitions.
- **The Media Matrix:** This matrix is an international image license standard and identifies international media categories, media types and media options which are then organized into a structure to use image licensing interfaces. In the PLUS Matrix, each choice has a code that is 4 characters long and all codes together build a code summary (Hess 2016).

- **The License Data Format (LDF):** The information from the Picture Licensing Glossary and the Media Matrix are then used in the machine-readable License Data Format which is considered a worldwide standard for describing licenses and consists only of important information about the understanding of a license. With the LDF image license meta-data can be read and embedded in documents and digital files. The following is a list of available groups of fields of the LDF. Not all fields have to be used. The licensor has to determine which fields to ignore and which to use.
    - **Header:** Contains the PLUS version number.
    - **Parties:** Contains fields like Name and ID of the Licensee, the Licensor, the End User, etc.
    - **Media Permission:** Contains an alphanumeric code string which outlines the media usage.
    - **Constraints:** Contains fields like the license start and end date, Constraints about the media, the region, the product or service, the image duplication or alteration, the image file etc.
    - **Requirements:** Contains fields like credit line requirement and text, adult content warning and other license requirements.
    - **Conditions:** Contains fields like the terms and condition text and URL as well as other license conditions.
    - **Image Info:** Contains fields like the image type, the licensor image ID and title, the image file name, format and size as delivered, the copyright status and registration number, the creation date, the Copyright owner name, ID and image ID etc.
    - **License Info:** Contains fields like the license ID, the licensor and licensee transaction ID, the reuse, the license transaction date etc.
    - **Custom Fields:** Optional fields the licensor can create.

The PLUS Coalition also offers a License Generator, where Universal License Statements can be created by inserting the rights information someone wants in the license, as well as a PLUS Registry. This registry is an online resource to find information about the rights and informative description like meta-data for an image. By registering images and image licenses the images can be found over the PLUS registry and rights holders can allow users to find rights and meta-data with the PLUS ID or image recognition. (PLUS Coalition LTD. 2016) With PLUS it is possible to generate complex licenses with obligations, actions and constraints. This is only possible with images as the taxonomy that is the core of PLUS only intends images and has a strict hierarchy how assets can be used. (Hess 2016)

2.5. ebXML CPP/A 1.0, 2.0

ebXML was developed in 1999 as an initiative of OASIS and the United Nations/ECE agency CEFACT. *“OASIS (Organization for the Advancement of Structured Information Standards) is a non-for-profit, international consortium that drives the development, convergence, and adoption of e-business standards.”* (OASIS Open 2006) The consortium was founded in 1993, has more than 3,500 participants which represent over 600 organizations and individuals in 100 countries. (OASIS Open 2006)

ebXML means Electronic Business using eXtensible Markup Language. It is a set of specifications that empowers enterprises to conduct business over the internet by allowing to exchange messages, build up trading relationships, define and register business processes and communicate data in common terms with a standard method. Originally five layers of data specification has been delivered: XML standards for business processes, for core data components, for collaboration protocol agreements, messaging and registries and repositories. ebXML is a globally developed standard that is based on XML and benefits from rich experience about electronic business. (OASIS open 2006) Version 1.0 of ebXML was published in 2001 and got revised in 2002 as version 2.0. (UN/CEFACT, OASIS 2001 / OASIS 2002)

ebXML Collaboration-Protocol Profile (CPP) is a specification where it is described in which way each party can exchange information in a business collaboration. Thus, the capabilities of every individual party are described. A CPP for example includes: The Party’s information (the name and the contact info), the Transport

Protocol, the Transport Security Protocol, The Messaging Protocol, The link to Process-Specification document etc. The Party's CPPs are then used to create a CPA together by calculating the information intersection in the CPPs. (UN/CEFACT, OASIS 2001, 9-11)

The **ebXML Collaboration-Protocol Agreement (CPA)** can express the agreement between the parties. Thus, it contains the agreed capabilities and behaviour of two parties to perform a particular business collaboration. These electronic documents *"define the "information technology terms and conditions" that enable Business documents to be electronically interchanged between Parties."* (UN/CEFACT, OASIS 2001, 9) The intention of CPAs is to have a high-level specification that is comprehendible by humans but can also enforced by computers. (UN/CEFACT, OASIS 2001, 13)

Together the **ebXML Collaboration-Protocol Profile and Agreement (CPPA)** specifications assume a specific cooperation scheme between business partners. A party can describe itself in one CPP but also set up multiple CPPs which would describe the various business collaborations that it supports, the different regions in which It operates or different organization parts. These CPPs are then stored in a repository provided by the ebXML Registry and together with a discovery process used to find the parties other business partners. Furthermore, there is a process-specification document that is also stored in the ebXML repository and defines the interaction between two parties. The CPP and CPA also include references to the document. (UN/CEFACT, OASIS 2001, 9)

Concerning the XML elements in a CPP the OASIS ebXML CPP/A Technical Committee (2002, 18) structure the CPP as followed:

- **The Process-Specification layer:** This layer is the Business agreements heart between the Parties, as the services the parties agreed to deliver as well as the transition rules that regulate the order of requests are stated in it. The CPP and CPA reference the separate Process-Specification document which this layer defines.

- **The Delivery Channels:** It consists of a document-exchange definition and a transport definition and describes the Party's Message-receiving characteristics. In one CPP many delivery channels can be described.
- **The Document-Exchange layer:** In connection with the process-specification layer the document-exchange layer accepts a Business document from one Party. It then encrypts and adds a digital signature if wished and sends it to the transport layer to deliver it to the other party. The inverse steps are done for received Messages. The chosen options for the document-exchange layer and the transport layer have to complement each other.
- **The Transport layer:** In connection with the selected transport protocol the transport layer is in charge of the Message delivery. The selected protocol is in connection with the choices made in the document-exchange layer and is affecting it. In that way some transport-layer protocols can provide encryption and authentication while others may not.

Together these elements are a layered structure and describe the processing of a unit of Business (conversation). Is a CPP placed in an ebXML or in another Registry, it gets a globally-unique identifier (GUID) which is then part of the metadata and can be used to distinguish between CPPs from the same party. (UN/CEFACT, OASIS 2001, 16) More CPP elements as CPP OASIS ebXML CPP/A Technical Committee (2002, 17-69) states are the following:

- **CollaborationProtocolProfile element**: It is considered the root element of the XML document as it contains the required Namespace, an attribute to version the CPP (like 1.2, 3.4 etc.), the required **PartyInfo** elements to identify an organization, the required Packaging element, if needed a **ds:Signature** element which contains a digital signature and Comment elements if needed.
- **PartyInfo Element**: This element identifies the organization in the CPP as Party and adds detailed information. There can be more elements if the organization wants to represent itself as subdivision with diverse characteristics. The PartyInfo Element consists of the required **PartyId** which is a logical

identifier for the Party, the required **PartyRef**, which contains detailed information about the Party, one or more required **CollaborationRole** elements which set out the roles a Party can play concerning the process specification, one or more required **Certificate** elements which contains the used certificates of a Party concerning security functions, one or more required **DeliveryChannel** elements which characterize each delivery channel the Party can use to receive Messages and include the transport level as well as the messaging protocol, one or more required **Transport** elements which describe the characteristics of the transport protocol(s) a Party can use to receive Messages and one or more required **DocExchange** elements which describe the Message-exchange characteristics, like the Message-exchange protocol, the Party can use.

- **DocExchange Element:** This element contains information both parties have to agree on if they want to exchange documents. It also includes messaging service properties like the ebXML Message Service (ebMS).
- **SimplePart Element:** This element has the required attributes **id**, which provides the value to reference the Message part and the **mimetype** attribute, which provide values of content-type.
- **Packaging Element:** The packaging element is important for information about the way the Message Header and payload constituent(s) are packaged for transfer. It also contains information about the document-level security packaging used and how security features have been applied.
- **Signature Element:** This element is considered the main element for digitally signing the CPP. The element content is described by the XML Digital Signature specification (XMLDSIG).
- **Comment Element**: This is an element on text basis and is written in a language identified by a required xml:lang attribute. This attribute must comply with the given rules for identifying languages in XML. Comment elements may be contained in the CollaborationProtocolProfile.

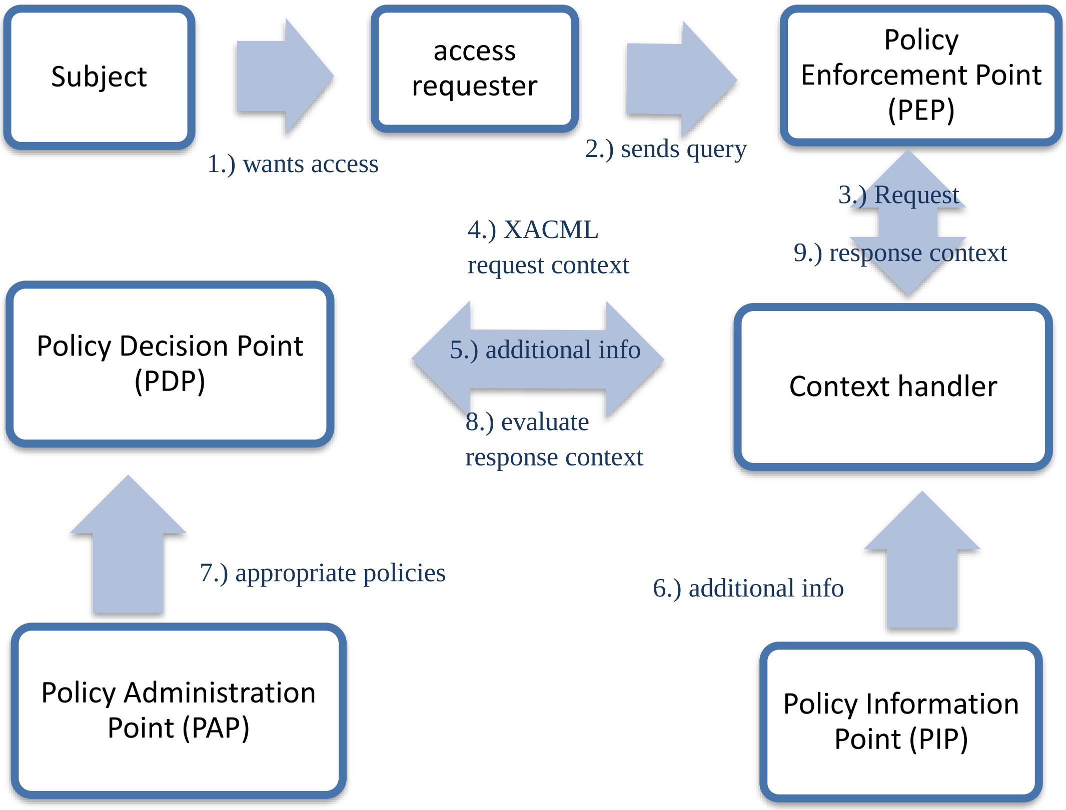
According to the OASIS ebXML CPP/A Technical Committee (2002, 71-53) the CPA is structured in the following way:

- **CollaborationProtocolAgreement Element:** This element is considered the root element of the CPA as it has a required **cpaid** attribute XML CDATA which applies a unique identifier to the document. The value of the cpaid is given by one party and used by both parties. An URI as given value is recommended. It also has an implied attribute to version the CPA (like version 2.3 or 4.5 etc.).
- **Status Element:** This element is responsible for the documentation of the negotiation/composition process in which the CPA is created. This element requires a **value** attribute in which the current state of composition of the CPA is recorded. The value attributes proposed (still negotiating), agreed (both Parties have agreed) or signed (the CPA has been signed. This is also in the form of a digital signature possible) are possible.
- **CPA Lifetime:** Through start and end elements the lifetime of a CPA is defined. They are represented as Coordinated Universal Time (UTC).
- **ConversationConstraints Element:** With this element limits on the conversation numbers under the CPA are placed.
- **PartyInfo Element:** The PartyInfo Element is the same as described in the CPP. One Party each has a PartyInfo element. It specifies the agreed terms for the Business Collaborations which are defined by the process-specification documents referenced by the CPA. Under each PartyInfo element is a PartyId element in the CPA.
- **SimplePart Element:** The same as with CPP
- **Packaging Element:** The same as with CPP
- **Signature Element:** This element is used to digitally sign a CPA document by one or more parties as it ensures its integrity. It is recommended to use the XML Digital Signature specification (XMLDSIG) for this.
- **Comment Element:** This element can be contained in the CollaborationProtocolAgreement. For more information read above in the CPP structure.

2.6. XACML 1.0, 2.0, 3.0

The eXtensible Access Control Markup Lanugage (XACML) was submitted by the Organization for the Advancement of Structured Information Standards (OASIS) in 2003. (Lang et al. 2008, 295) In 2005 the XACML version 2.0 was ratified (Ramli et al., 2013, 89) and in 2013 the XACML 3.0 Specification was released (OASIS open 2013). XACML specifies access control policies with a rich set of datatypes, complex logical expressions and countless user-selected attributes and describes a request/response language. While the policy language expresses who can do what and when, the request/response language expresses queries about whether an access should be allowed (requests) and expresses reactions in form of responses to those queries. (Ramli et al. 2014, 80) XACML is an XML-based language as the XML syntax and semantics can be easily extended to the requirements of XACML

Within the XACML domain there are major actors: Policy administration points (PAPs) create policies and policy sets for specific targets. Then a subject (like a human or a program) wants access to a particular resource. Therefore, a query is submitted from the access requester to the protecting entity of the resource, which is called Policy Enforcement Point (PEP) and could be a filesystem or a web server etc. The PEP sends the request to the Context handler in a natural request format which optionally include attributes of the subjects, resource, action, environment etc. With the XACML request language the context handler makes a XACML request context based on the attributes of the subject, resource and other relevant information and sends it to the policy decision point (PDP). The PDP might request additional attributes like subject, resource, action, environment etc., from the context handler which it requests from a policy information point (PIP). The PIP obtains the attribute and returns them to the context handler which it sends to the PDP. The appropriate policies which are written in the XACML policy language are obtained from the PAP and sent to the PDP. There the request is examined and the policies are evaluated in context of whether access should be granted or not according to the XACML rules for evaluating policies. The response context with the authorization decision is then returned to the context handler. In a next step the context handler returns the response context to the PEP by translating it to the response format. In a last step the PEP fulfils the obligations that might be mandatory. If access is allowed the PEP allows access to the resource. If access is denied the PEP forbid access to the resource. (OASIS open 2013, 19-20/Ramli et. al. 2014, 80-81)



3: XACML model (OASIS open 2013, 19-20/Ramli et. al. 2014, 80-81)

In XACML it is possible to combine two separate **policies** to a single **policy** in order to render an **authorization decision**. Organizing policies into different components helps to obtain modularity in access control. (Ramli et. al. 2013 b, 81) Therefore three top-level policy elements are defined which are the main components of the policy language model described by the OASIS open (2013, 21-24) and Ramli et. al. (2014, 81):

- **Rule**: This element encompasses a Boolean expression and is the smallest component of an XACML policy. Each rule can grant or deny access. Although it can be evaluated in isolation within one of the major actors of the XACML domain it has to be encapsulated in a policy to exchange rules between major actors. A rule can be evaluated based on its content and consists of the following main components: A target, an effect, a condition, obligation expressions and advice expressions.

- **Policy:** This element consists of a set of Rule elements a PAP combines in a policy and a specific procedure for combining the evaluation results. A policy element is meant to be the basic unit of an authorization decision. A target, a rule-combining algorithm-identifier, a set of rules, obligation expressions and advice expressions are the main components of a policy. A policy is applicable to a certain target and only when the request matches the target.
- **Policy Set**: A policy set contains other policy sets or policies. It consists of the following main components: a target, a policy-combining algorithm-identifier, a set of policies, obligation expressions and advice expressions.

XACML also offers a concept of conflict resolution algorithm which is needed when several policies fit with the values of an access control request and have effects that create conflicts (like permit/deny) or conflicting obligations. (Stepien, Felty 2016, 127) When dealing with composite policies a combining operator combines the decisions from multiple policies. This system offers the policy maker three strategies: first-applicable, permit prevails and deny prevails. After XACML 3.0 they got expanded to twelve standard combining operators in XACML as only three strategies were not satisfactory due to the increased use of XACML (Stepien, Felty 2016, 127): permit-overrides and deny-overrides, which can both be unordered, ordered, legacy unordered and legacy ordered and first applicable, only-one-applicable, deny-unless-permit and permit-unless-deny. (Ramli et. al. 2014. 81)

With XACML the shift from a static security approach like ACL (Access Control List) to a dynamic approach, based on Attribute Based Access Control (ABAC) was possible. ABAC was a further development of the traditional role-based access control (RBAC) model by Shen et. al. which was widely used until 2000 (Zhang, Zhang 2017, 160). Nevertheless, these new dynamic security concepts are more difficult to understand and need the right tools and well-founded concepts for creating and manage policies. This is because the specifications of XACML are described in natural language. (Ramli et. al. 2013, 89) Therefore writing down the verbose policies by hand and manual analysis of the effects of a large XACML policy set can be daunting and time-consuming as well as difficult to master (Ramli et. al. 2013, 89/Lang et. al. 2008, 295). Multiple papers want to solve this problem by developing new approaches. Lang et al. (2008) for example suggest a user-oriented ABAC policy conception model which is called Access Control Cube (ACCube) as well as a policy view that has an algorithm of transforming a policy view to a XACML policy. In addition, Zhang, Zhang (2017) propose a special testing of the ABAC system as it became bigger in size and more complex while network security got more important too. With their method of unit testing potential security flaws can be identified.

2.7. WS-Agreement

The Web Services Agreement Specification was developed by the Open Grid Forum (OGF). Although Version 0.1 was released in 2004, the first official version was released in 2007. (Dan et.al. 2004 / Andrieux et.al. 2007) It is a language and a web service protocol that establishes service-level agreements (SLAs) which are based on initial offers and monitors them at runtime. The agreement is made between two parties by using an XML-based language to specify the agreement. (Sharaf, Djemame 2015, 177)

The WS-Agreement plays an important role in connection with grid/cloud computing as the research interest in using infrastructures grew. With cloud computing *“the provision of software as a service over the internet, i.e. providing applications (services) hosted remotely”* is possible. (Galati et. al. 2014, 159) At the same time this development lead to a replacement of the best-effort approach which was used in that environment with a more controlled and reliable one that reaches the high levels of quality of service (Qos) necessary to users. The Qos assurance is important as service consumer pay for the service or job and service provider pay a penalty if the service or job is not fulfilled. The Qos assurance has the form of an electronic contract between the service provider and the service consumer and is called service-level agreement (SLA). The SLA illustrates the offered service in terms of the requirements, guarantee terms and the responsibilities of each party. (Sharaf, Djemame 2015, 177) The SLA contains three parts which can also be used in a composable manner:

> *a schema for specifying an agreement, a schema for specifying an agreement template, and a set of port types and operations for managing agreement life-cycle, including creation, expiration, and monitoring of agreement states.* (Andrieux et.al. 2011, 1)

Andrieux et. al. (2011, 3-4) defined a specification document in which they defined a schema for an agreement template which contains the following information. The two parties in the WS-Agreement are often a service consumer and a service provider or entities that are acting on their behalf. Furthermore, both can initiate the creation of an agreement. As the service consumers like to obtain guarantees concerning the services they use and their service-quality, they should gain state-dependent guarantees from the service provider. These guarantees are represented as a service-agreement as well as an agreement on the associated guarantees. In that sense, the WS-Agreement defines a language and a protocol in which the capabilities of the service providers are stated, agreements are created and agreement compliances are monitored. An agreement creation firstly consists of a predefined agreement template and agreement creation constrains which are rules the parties should follow to create an agreement. The consisting parts of an agreement are information about the parties and a specified term-set. With the WS-Agreement it is possible to standardize

> *the terminology, concepts, overall agreement structure with types of agreement terms, agreement template with creation constraints and a set of port types and operations for creation, expiration and monitoring of agreements, including WSDL [Web Service Description Language] needed to express the message exchanges and resources needed to express the state* (Andrieux et.al. 2011, 4).

The WS-Agreement protocol relies on other WS-* specifications that each are institutional standards like the WS-ResourceProperties and the WS-ResourceLifetime which represent agreements as resources, as well as the WS-Addressing and the WS-BaseFaults (Andrieux et.al., 5-6).

The conceptual model of the WS-Agreement architecture consists of two layers: The agreement layer and the service layer.

In the **agreement layer** a web service-based interface can be used to create, represent and monitor agreements. An agreement is created out of initial term-sets and an Endpoint Reference (EPR) is returned to an agreement service. In the agreement the connection between the agreement and the domain-specific service(s) it manages has to be described but can take different forms. The service(s) can be part of the agreement terms, they can be created as per agreement which gave the agreement layer control over the services as it describes the behaviour of the service(s), or the service(s) can be created externally but with carrying a domain-specific identifier which makes the agreement binding possible.

The service layer is the application-specific layer of the provided service. The offered service can be a web service interface but there are also services which do not have a service oriented representation like network availability. In this layer the interfaces are domain-specific.

When agreements are set in the agreement layer the service layer follow these agreements. The binding between those two layers always have to be defined as it is domain-specific. (Andrieux et.al. 2011, 12-13)

The **structure** of an WS-Agreement is defined by Andrieux et.al. (2011, 14-23) and consists of:

- **An AgreementId:** The agreementId is mandatory and unique between the agreement initiator and the agreement responder. It identifies this particular version of the agreement and helps the initiator and responder to identify the actual version in force. The identifier must be replaced if a document is changed during the agreement resource lifecycle.
- **A name**: This is optional and gives the agreement a name which is human-understandable.
- **The context:** It contains information that is not specified in the terms like the agreement meta-data, the names of the parties, the service on which is being agreed on and the lifetime of an agreement.
- **The Agreement Terms**: The agreement terms define the agreement itself. It consists of:
    - **Term types** which express the consensus or obligation of the parties. It can be distinguished between service terms and guarantee terms.

- **Term compositor structure** which can be used to combine terms with logical AND/OR/XOR operators.
- **Service description terms (SDTs)** which describe the agreement and its service(s) and define the functionality that will be delivered. It is domain-dependent and consists of the name of the SDT, the name of the service and the domain-specific description of the functionality.
- **Service reference** which provides an Endpoint Reference to show a service.
- **Service properties** which describe properties that are connected to a service.
- **Guarantee terms** which provide the needed assurance to the service consumer on things like the service quality, etc. Furthermore, it can be possible that service consumer should give the service provider guarantees if the service depends on it.

Researchers and developers have criticized this specification as it lacks a negotiation process between the parties preceding the WS-Agreement. Furthermore, the WS-Agreement is static as it is unchangeable during the service operation if the agreement is signed. (Sharaf, Djemame 2015, 177-178 / Sakellariou, Yarmolenko 2005) Because of that Sharaf and Djemame (2014) propose a more flexible and reliable service-level agreement support and fulfilment where a renegotiation of the agreed terms during the runtime are possible with dynamic SLAs. Sakellariou and Yarmolenko (2005) stated that an extension to the gurarantee terms of a WS-Agreement can reduce renegotiation overheads. Galanti et. al. (2014) also propose a new SLA implementation for negotiation, monitor and renegotiation of agreed terms and also a requirement for the condition monitoring on a cloud (CMAC) platform. To achieve that they choose the WS-Agreement for Java (WSAG4J) framework which can create and manage SLAs in distributed systems and is an implementation of the WS-Agreement standard. In addition, security considerations are also not addressed in the WS-Agreement specification but can be implemented by blending with other security implementations (Andrieux et.al. 2011, 48).

2.8. ccREL

The Creative Commons Right Expression Language is a recommended standard by the Creative Commons *“for machine-readable expression of copyright licensing terms and related information”.* (Abelson et. al. 2008, 1) With the ccREL CC licenses can be represented in a machine-readable way. An informal W3C working group (Abelson et. al.) developed the ccREL and published the specification in 2008. Although it never got an official W3C recommendation, the REL became de facto standard for the Creative Commons Licenses and will become even more important when license information should automatically be processed over the web. (Pellegrini, Ermilov 2013, 9)

The Creative Commons Community was created in 2002 although it has traces back to the year 2000 as there were many discussions about how to establish a flexible copyright environment over the internet. With the decrease of costs of digital networks new opportunities in the areas of producing, consuming and content-reuse arouse and with that the inflexibility and costs of licensing became even higher. In comparison to earlier recommendations from the CC with the ccREL the content creators and publishers can easier provide and users and tool builders can easier consume, extend and redistribute. (Abelson et. al. 2008, 1-2)

Content creators can currently choose between seven different license types when publishing their work as stated by Pellegrini and Ermilov (2013,7-8) as well as Rodríguez and Delgado (2006, 46):

- The **Attribution Non-commercial No Derivates (by-nc-nd)** allows to download, use and share the original work if the creator is mentioned and does not allow to change the original work or use it commercially. It is the most restrictive CC license.
- The **Attribution Non-commercial Share Alike (by-nc-sa)** allows that the original work can be remixed, tweaked and built upon non-commercially if the creator is credited and the creation is licensed under identical terms the original creator stated.

- The **Attribution Non-commercial (by-nc)** allows that the original work can be remixed, tweaked and built upon non-commercially if the original creator is credited.
- The **Attribution No Derivates (by-nd)** allows that the original work is commercially and non-commercially redistributed if it is passed along in a whole and unchanged and the original creator is credited.
- The **Attribution Share Alike (by-sa)** allows that the original work can be remixed, tweaked and built upon commercially and non-commercially if the creator is credited and the creation is licensed under identical terms the original creator stated.
- The **Attribution (by)** allows that the original work can be remixed, tweaked and built upon commercially if the original creator is credited.
- **No Rights Reserves (0)** allows owners of their copyrighted content to waive those interests and make it as free as possible to let others build upon, enhance or reuse the work without restriction.

To take on the difficult situation of the copyright environment the Creative Commons' founders had two approaches: The first approach was to create licenses that are widely applicable and allow sharing and reusing under certain conditions that are communicated in a human-readable way. The second approach was to help digital networks to make their content more reusable and easier to find by lowering search and transaction costs if copyright holders have granted certain rights to the public beforehand. The important part is to make it possible for machines to detect and interpret licensing terms automatically or as automatic as possible. Furthermore, a user-machine bridge is needed to notice and publish web-based licensing information. In addition, it is important to create tools with whom the collaboration and mixing barriers are lower. For example, users are confused if multiple images on a web page have different licenses and therefore cannot easily determine which rights are granted to which picture. With the ccREL standard implementers can create tools with which these operations are easy. (Abelson et. al. 2008, 2-3)

Since 2001 the Creative Commons wanted to create machine-readable licenses using the Resource Description Framework (RDF) from the World-Wide Web Consortium. RDF is a framework that defines web-entities and provides interoperability and extensibility. The web-entities are named with the URL and its generalization, the URI. If a website is licensed under the Creative Commons Attributions license, this license can also be identified by an own URL. The license itself is in that way a web object which is maintained by the Web Consortium and has its own URL where information about the supported vocabularies are described. Atomic RDF descriptions therefore consist of so called triples: a subject (the website URL), a property (the URL that describes the vocabulary) and a value (the license URL). In text form RDF graphs are often expressed with a XML syntax. Although with XML the representation is self-contained and all identifiers are own URLs, it is also very verbose and therefore difficult to write and read in XML. Therefore, the Web Consortium also developed N3 as alternative to represent the RDF syntax. (Abelson et. al. 2008, 3-5) But also Turtle or other notations are possible (Pellegrini, Ermilov 2013, 17). In general, the publishers can decide freely which syntax they want to use as the ccREL is specified in a syntax-free way (Abelson 2008, 1).

The use of RFD concerning the ccREL is because the CC wanted to make it easy to share creations and collaborate by continue working on others progress. To do so it is important to make the machine expression of licensing information and metadata interoperable. This means that programs can interpret metadata properties but also that vocabularies can evolve and be extended. Furthermore, extensions should also be backward compatible, which means that when new properties are added, existing tools should not be affected but they should handle basic aspects of new properties. (Abelson et. al. 2008, 3-5)

The ccREL can be used by publishers as well as the consumers and therefore by applications and human users. The documentation thus consists of the ccREL specification which is human-readable and contains information for the consumers and the publishers and the RDF licenses. (Pellegrini, Ermilov 2013, 16)

A set of RDF properties are contained in the ccREL and provided with every licensed object. Abelson et. al. (2008, 6-10) distinguish two classes of properties:

- **Work properties:** Aspects of works are described. Mostly publishers are concerned with this kind of properties. For a Creative Commons license at least one RDF triple must be provided, but it is possible to include additional information like the title, the name and the URL for giving attribution and the document type. In Addition, the source (the URI of the modified work) and more Permissions (beyond the CC license) can be available properties for publishers.
- **License properties**: Aspect of licenses are described. The Creative Commons want that publishers provide the license properties of the licenses work. The license description pages are also called Creative Commons Deeds. They include the license properties in the suggested syntax (RDFa). The ccREL include the license properties and contain: permits, prohibits, requires, jurisdiction, deprecated on and legal Code which third parties cannot modify.

2.9. ODRL 1.0, 1.1, 2.0, 2.1, 2.2

The Open Digital Rights Expression Language (ODRL) was introduced in 2000 by Iannella because only closed approaches had been used for DRM systems. The version 0.5 wanted to provide clear DRM principles, cross-sector interoperability and fair-use. The ODRL Initiative started in 2001 with the version 1.0 of ODRL. (Zhang et. al. 2008, 261-262) In 2002, the version 1.1 of ODRL got adopted by the DRM specification of the Open Mobile Alliance (OMA) whereby various handsets support the OMA DRM. In the year 2012, the ODRL version 2.0 developed a more general policy language which allowed also privacy statements and other rule-based assertions. Furthermore, the ODRL Initiative became the first W3C Community Group. (Iannella 2011) The ODRL version 2.1 was released in 2015 and version 2.2 on February 2018 (W3C Community & Business Groups 2018).

It is an XML-based policy expression language that offers an information model, vocabulary and encoding mechanisms that are flexible and interoperable and can express under which condition a resource can be accessed. (W3C 2018a) *“For example, in ODRL, an author can write “Anyone who pays five dollars may download my latest eBook ‘How to Get Rich in Five Dollar Increments’.”* (Pucella, Weissman

2004, 1) With XML the language syntax and basic vocabulary as well as the data dictionary are defined (García et. al. 2005, 1). Each ODRL license is a separate XML document (Kasten, Grimm 2015, 77). ODRL is able to express fine-grained access restrictions, access policies and Linked Data licensing information (Steyskal, Polleres 2015, 360).

Although many RELs can express such statements, ODRL is widely used in the praxis (Pucella, Weissman 2004, 1). In Addition, ODRL *"aims to develop and promote an open international specification for interchangeable policy expression"* (Steyskal, Polleres 2015, 360).

The W3C published a recommendation of the ODRL Information Model 2.2 February the 15 (2018) which contains the following information. The information model of ODRL 2.2 contains policies that express permissions, prohibitions and duties and therefore what is allowed or not allowed concerning the policy, requirements, parties etc. The policies are flexible as they are only as detailed as the policy author likes. The information model consists of the following classes:

- **Policy:** It is the central entity of an ODRL policy and consist of a group of permissions and/or prohibitions and/or duties. It has three subclasses: **set** (express generic rules), **offer** (supports rule offerings from assigner parties) and **agreement** (supports rule-granting from assigner to assignee parties).
- **Asset:** One or more resources that are the rule subject. It has the subclass: **assetcollection** (identifies a group of resources).
- **Party:** one or a collection of entities that execute roles in a rule. It has the subclass: **partycollection** (identifies a group of entities).
- **Action:** It is an asset operation.
- **Rule:** Contains the characteristics of **permission** (an action which can be performed over an asset), **prohibition** (an action which cannot be performed over an asset) and **duties** (the requirement to exercise an action).
- **Constraint/LogicalConstraint:** Defines an action and party/asset collection or the conditions of a rule with a boolean/logical expression.

- ODRL also supports a **Policy Conflict Strategy**. They are needed when a request cannot be answered unambiguously because two or more rules are triggered at the same time which leads to multiple possible answers. (Steyskal, Polleres 2015, 371 / W3C Recommendation. ODRL Vocabulary & Expression 2.2. 2018)

Concerning the syntax of the ODRL vocabulary it is also possible to serialise it in RDF, XML and JSON-LD (W3C Recommendation. ODRL Vocabulary & Expression 2.2. 2018 / Iannella et. al. 2018).

Holzer et. al. (2004) as well as Pucella and Weissmann (2004) propose formal semantics for ODRL in their papers as ODRL still lacks this. The statements of ODRL are described in English which makes agreements in ODRL open for interpretation. In that sense underspecification can be one of the possible problems and questions, like which agreement should be enforced, how should conflicts be resolved and how agreements can be revoked, are evoked (Pucella, Weissman 2004, 18). With formal semantics it can be defined when a permission or prohibition follows specific sets of ODRL statements. (Pucella, Weissman 2004, 2)

Xu et. al. furthermore suggest an extended rights expression model which supports dynamic digital rights management. Licenses in DRM systems are often issued from the content provider. With the rise of digital content more and different business models emerge and readers seek a more flexible fine-grained authorization and the possibility to combine authorization, for example when a reader only wants some specific chapters of two different books in one new book. With ODRL 1.1 fine-grained authorization is supported but the model and syntax about license appending, updating and license aggregating is not supported. (Xu et. al. 2011, 186)

As ODRL only allows right holders to command terms to the end user the negotiation of electronic contracts is limited. Arnab and Hutchison (2008, 1) therefore recommend an extension that allows end users to request changes for example concerning the rights. The rights holder can grant or refuse these requests. With these bi-directional REL fair use for rights holder and user can be ensured.

García et. al. (2005) as well as Kasten and Grimm (2015) and Steyskal and Polleres (2015) want to make the semantics of ODRL explicit to use its hidden semantics and to be able to attribute more complex formalisations. This can be accomplished by ontologies as they are *“formalisations of a shared conceptualisation”* and the semantics are expressed in a machine-readable form. (García et. al. 2005, 2) The ODRL vocabulary describes licenses and their relation to each other while the syntax is described in an XML schema. This schema contains only a small part of the relation-semantics and most of it is described in a natural language. As each license can be interpreted differently the actual meaning can be confusing. The ODRL vocabulary should therefore be transferred to the semantic web language OWL. Then an automatic procession of a license created in ODRL would be possible. (Kasten, Grimm 2015, 77) In an automated environment requests can be compared against a set of control policies and processed automatically while inconsistencies and conflicts can be automatically detected. An official formal specification does not exist due to the open design approach ODRL follows. This allows each application own interpretations of its semantics. (Steyskal, Polleres 2015, 361)

2.10. RightsML 1.0, 1.1, 2.0

The RightsML REL was created by the International Press and Telecommunications Council (IPTC) (Auer et. al. 2014, 151). The basis of RightsML consists of ODRL 2.0 (Iannella 2012). The IPTC itself was founded in 1965 and wants to make the distribution of information easier. It consists of leading news agencies, publishers and industry vendors. (IPTC 2018a) Version 1.0 of RightsML was published in 2012, version 1.1 in 2013 and in 2018 a new draft was announced. As RightsML is based on ODRL since version 1.0 it is also aligned to ODRL changes. As ODRL became a W3C Recommendation in 2018, the RightsML specification also synchronized with it. Therefore, the newest is going to be based on the ODRL 2.2 Recommendation. (IPTC 2018b)

With RightsML the publisher is able to comment each content piece with machine-readable instructions that permit or restrict the use of the content (IPTC 2018b). Thus, it is a REL for the media industry. In the RightsML standard the full ODRL Information Model specification with its core vocabulary are included. Furthermore, RightsML extends the ODRL core vocabulary. In that sense the ODRL Core Model, the ODRL Common Vocabulary and the RightsML Vocabulary are enclosed. (IPTC 2013, 5-10)

2.11. OMA DRM 1.0, 2.0

The working group OMA SpecWorks is a standards development organization (SDO) and focuses on specifications and standards concerning the worldwide mobile terminals across various networks. (OMA SpecWorks 2018) The Open Mobile Alliance was founded in 2002 and consists of over 400 companies representing the industry. *"The OMA is the leading industry forum for developing market-driven, interoperable mobile service enablers to facilitate global user adoption of mobile multimedia services."* (Brenner, Unmehopa 2008,4) In 2018, the Open Mobile Alliance and the IPSO Alliance of SpecWorks even joined together to build technical documents like smart objects, specifications and white papers focusing on a connected world and interoperability across networks. (OMA SpecWorks 2018)

As stated above at the ODRL section, the 1.1 version of ODRL got adopted by the Open Mobile Alliance (OMA). (Iannella 2011) The OMA DRM version 1.0 was issued in 2002, supported more than 50 mobile handsets and provided protection functions for content like simple pictures, videos, animations and sounds. The OMA DRM version 2.0 was issued in 2004 and uses the version 1.0 as foundation. It is able to handle premium content and more powerful handset and network capabilities. (Smith 2004, 187-188)

Even though the OMA Rights Expression Language is a subset of ODRL and has a smaller vocabulary than ODRL, it contains the essential features of it. (Sheppard, Safavi-Naini 2009, 21) The OMA DRM REL has to take into account that the mobile domain requires special needs and characteristics when expressing consumption rights and therefore some goals are to offer a simple way of expressing rights or lower entrance barriers to implement DRM technologies etc. Version 2.0 of the OMA DRM even offers a more comprehensive system than version 1.0. (Open Mobile Alliance 2008, 8)

The goal of OMA DRM is to empower a controlled manner of the consumption of digital content by authenticated devices and with the expressed usage rights of the content owner. Various technical aspects like appropriate specifications for content formats, protocols and the rights expression language are addressed by the OMA DRM. (Open Mobile Alliance 2008, 5)

The structure of the OMA DRM REL is defined by the Open Mobile Alliance (2008, 10-28) as followed: The REL can be described as mobile profile of ODRL version 1.1. Its structure enables metadata like the version or the content ID and the actual rights specification which provides protection information for and linking to the content, as well as specifications of the usage rights and constraints. The following seven models are used to group rights elements.

- **Foundation Model:** This model represents the rights basis by containing the rights element and offer meta- and agreement information. The rights element contains the context and agreement elements which links to corresponding permissions and therefore, incorporate these two models.
- **Agreement Model:** This model expresses the granted content rights. The agreement element connects a rights set with the content which is defined by the asset element. This model incorporated the permission and the security model.
- **Context Model:** This model enriches the agreement, the foundation and the constraint model by offering additional information. It is used in the rights, the asset and the individual element.
- **Permission Model:** This model enriches the agreement model as it enables permission expression over assets which is granted to a device. It incorporates the constraint model by allowing fine-grained content consumption control. Play, display, execute, print and export are the set of permissions.
- **Constraint Model:** This model enriches the permission model as it offers fine-grained content consumption control. All constraints must be fulfilled to get a permission. If no constraints are contained in a constraint element, the element is unconstrained and access has to be granted according to the permission. Timed-count, count, timer, datetime, start, end, interval, individual, system and accumulated are the set of constraints.

- **Inheritance Model:** This model describes how permission and constraints are specified by a parent rights object. This can be one or more content objects, each administered by a child rights object.
- **Security Model:** This model provides the integrity and authenticity of the rights objects which prevents an illegitimate modification of the rights object as well as to add, delete and modify permission and constraints, the integrity of the connection between rights object and the content and the content confidentiality which is important as it enforces consumption control. For the decryption and the encryption, a symmetric algorithm (AES) is used. It is referred to as content encryption key (CEK). The basis for the security model builds the ODRL security model.

The OMA DRM REL is independent concerning the billing mechanism which handles payments. (Open Mobile Alliance 2008, 5)

Furthermore, it has a data dictionary to add further permission and constraints than provided by ODRL. It is defined in an XML schema. The subset, or the mobile profile of ODRL is also defined in XML. (Open Mobile Alliance 2008, 33-35)

2.12. LegalRuleML

Especially today, in a web-enabled context, it is important to provide machine-readable forms (for example in XML) to legal text contents like legislation, regulation, contracts etc. (Palmirani et. al. 2013, 3). In the last ten years, many Legal XML standards like RuleML, semantic web rule language (SWRL), rule interchange format (RIF), legal knowledge interchange format (LKIF) had been created to define legal texts with rules based on XML. At the same time the semantic web had an important influence on the modelling of legal concepts. Therefore, the LegalRuleML Technical Committee wants to extend RuleML *“To close the gap between natural language text description and semantic norm modelling”* (Palmirani et. al. 2013, 3), to offer an XML standard which is expressive and models normative rules according to the requirements of the legal domain and to use approach of the linked open data by extend raw law data to legal concepts and rules with functionality and usage. The LegalRuleML TC’s (which is part of the OASIS) aim is to extend RuleML with formal features specialized to legal norms etc., define a standard which can represent the legal normative rules with a markup language that is rich, articulated and meaningful, create a rule interchange language for the legal domain and create, evaluate and compare legal arguments by using the provided rule representation tools. With these tools the contents of the legal texts can be structured in a machine-readable format and lead to a further process of interchange, comparison, evaluation and reasoning. (OASIS 2017/ Palmirani el. al. 2013, 3/Palmiriani et. al. 2018, 10)

The LegalRuleML was issued in 2013 (Pellegrini et. al. 2018, 250) and should provide a representation of legal textual provisions and the encoded norms. The functionalities of LegalRuleML are the following: (Palmirani et. al. 2018, 19/Palmirani et. al. 2013, 4/Athan et. al. 2015, 153-169/Athan et. al. 2013, 14-15)

- **Qualification of norms:** different norm types (constitutive, technical, prescriptive, etc.) that are contained in legal documents.
- **Represents normative effects:** normative effects like applying rules such as obligation, permission or prohibition articulate effects. Rules also regulate methods for law violation detection. With these constructs a complex rule dependency can occur as one rule violation can activate others.
- **Implements defeasibility of rules:** This means to identify exceptions and conflicts as well as resolve conflicts in a natural representation.
- **Implements isomorphism:** As norms are created, enter into force, are modified and repealed they have a lifecycle. Therefore, the formal expression in LegalRuleML has to change when the provisions language changes. This can be provided by maintaining a link between the natural language textual provisions and the rule sets.
- **Represents alternatives:** Legal documents are often left ambiguous to capture indefinite domain aspects which should be regulated and at the same time the interpretation is left to the end-user. This means it is possible to have multiple interpretations of the same textual source. LegalRuleML can specify these interpretations and select one based on the context.
- **Manages rule reification:** Rules, jurisdiction, authority, temporal attributes etc. are all objects with properties which enable effective legal reasoning. The

jurisdiction for example is a geographic area or subject-matter over which legal rules applicable to a specific region are annotated by an authority.

- **Deontic operators:** Prescriptive rules define the normative effect, like obligations, permissions, prohibitions etc., they produce, the related parties and the specific conditions under which the effects are produced.
- **Temporal management of the rules and temporal expressions within the rules:** As norms are affected in validity and efficacy over time LegalRuleML defines temporal instants and intervals to create complex legal events and situations like the date of publication, interval of suspension, interval of efficacy but not applicability. These are called external temporal characteristics of the norm and permit to represent the temporal rule information.
- **Authorial tracking of the rules:** the textual provisions and the norms are interpreted by rules. In that sense it is important who the author of the interpretation is and to establish a trust level in a ruleset.

The syntax of LegalRuleML is in the Relax NG Compact (RNC) syntax by modular Relax NG schemas. It is written in ‘chameleon’ style, which means the schemas are without a target namespace but the namespace of any included or referenced context are taken on. This maximizes the re-use. (Palmirani et. al. 2018, 53) This metamodel is based on RDF triples and allows LegalRuleML XML into RDF assertions which would lead to a semantic web interoperability and linked open data integration. (Athan et. al. 2013, 15)

LegalRuleML can thus be used in various areas. For example, in the eHealth domain to model privacy issues and security policies, in the open data domain or in the patent law. (Athan et. al. 2013, 18)

2.13. METSRights 1.1-1.11

The Metadata Encoding and Transmission Standard (METS) was developed by multi-institutional libraries. Since 1990 they worked on a project called Making of America II (MoA II) and developed the XML DTD standard, which should be able to encode descriptive, administrative and structural metadata within a digital library object and be interoperable, scalable and help to preserve digital library objects. In

2001 the MoA II decided to make a new version of the DTD. In contrast to DTD, that version should be constructed as an XML schema and descriptive or administrative metadata can optionally be included and expressed by vocabularies which are specified by other existing schemata and included in a document instance with the XML namespace facility. Jerome McDonough, the primary author of the MoA II DTD, had a new draft in 2001 called Metadata Encoding and Transmission Standard. The METS development is an ongoing process to the initiative of the Digital Library Federation. Furthermore, McDonough is serving as chair in the established METS editorial board. (Cundiff 2004, 52-53/Cantara 2005, 238)

Today the METSRights Schema 1.11 is the latest version and got released in May 2015. Version 1.1 was released in June 2002, version 1.2 in December 2002, version 1.3 in May 2003, version 1.4 in May 2004, version 1.5 in April 2005, version 1.6 in October 2006, version 1.7 in October 2007, version 1.8 in April 2009, version 1.9 in February 2010 and version 1.10 in January 2015. (METS Official Web Site 2018)

METS creates XML document instances which expresses digital library objects in its hierarchical structure, file names and file locations that comprises the objects and its descriptive and administrative metadata. The digital library object as well as a METS document has a one-to-one correspondence with a library item, for example a book, a photograph, a sound recording etc. (Cundiff 2004, 53)

The basic structure of a METS document, as described by Cundiff (2004, 53-57) and Cantara (2005, 239-250) and METS Primer (2010, 25-98), consists of up to seven major subsections:

- **The METS Header (metsHdr):** This can be included optionally and contains METS document information, for example about the document creation.
- **The Descriptive Metadata Section (dmdSec):** This can be included optionally. With the Metadata Reference (mdRef) element it points to metadata in external documents or systems or alternatively embed descriptive metadata from various namespace in the documents with the Metadata Wrap (mdWrap) element. Another alternative would be to be to embed the bibliographic data by using the Metadata Wrap and the XML Data or Binary Data subelements.

- **The Administrative Metadata Section (amdSec):** This section is divided into four subsections: The Technical Metadata (techMD), the Rights Metadata (rightsMD) which stores copyright information and licensing, the Source Metadata (sourceMD) and the Digital Provenance Metadata (digiprovMD). To embed administrative metadata in a document each sub-section can contain a Metadata Reference (mdRef) or a Metadata Wrap (mdWrap) subelement.
- **The File Section (fileSec):** File names and locations that contain the digital object are listed in the file section.
- **The Structure Map (structMap):** This is the only mandatory section of the METS document as it is its backbone. With it the hierarchical structure and the components sequence of a digital object are expressed and then archived with nested division (div) elements. The chapters of a book can be these structural divisions for example.
- **The Structural Links (structLink):** This element can be included optionally and contains one or more Structural Map Link (smLink) elements which each express a link among two div elements. Using this, hyperlinks between webpages can be expressed.
- **The Behavior Section (behaviorSec):** This element can be included optionally. It can associate executable behaviours with the content. One behaviour section comprises one or more behaviour element. This element was added because of the FEDORA project. One example for a behaviour can be a page-turning functionality for a book.

Furthermore, the XML-document has a root element <mets> which includes all other elements. The XML identifier or the Object identifier specify the document. The Type attribute specifies the object type, like a book or journal. The Label attribute encompasses the object title. The Profile attribute is used when a registered profile was used to create the document. These five attributes are optional in the root element.

3. Category System

The vast development of Right Expression Languages show that they are a highly topical subject and will probably gain even more importance due to the emergence of digital business models. Therefore, Rights Expression Languages are going to be in the centre of attention in the following category system. The system will encompass the 13 Right Expression Languages which were discussed above and are

3.1. Application area

Chong et. al. (2006, 290-291) differentiate between six known REL policy types:

- **The revenue type:** This model means the systems architecture of payment and refers to revenue models like pay-per-use, pay-up-front, pay-flat-rate, fractional payment like discount and tax etc.
- **The provision type:**
  - Firstly, when rights and obligations fail to meet certain constraints, this model can offer an alternative solution. For example, switch to watch a video in lower quality when higher solution is not possible.
  - Secondly, it reconciles conflicts for example when an identical operation is performed on the same object by more than one subject simultaneously. Therefore, it can handle dynamic license evolutions and content access patterns.
  - Thirdly, the operations default settings over an object are accommodated when it is not associated with any operations.
- **The operational type:** This model is responsible for the systems technological aspects like quality-of-service, watermarking, caching, network operations, bandwidth etc.
- **The contract type**: This model establishes the terms and conditions over the object and constraints between the subjects. Because the copyright model is a controversy, as the user will always see it as copyright enforcement, it is also included in the contract type.

- **The copyright type:** From the end-user's standpoint this model enforces copyright acts like fair use, first sale etc.
- **The security type:** This model describes different security mechanisms like identification, authentication and authorization (IAA), access control, non-repudiation, integrity, audit trails and privacy.

The various rights management systems can fit into different models at the same time but not all RELs support these six models. (Chong et. al. 2006, 290-291) The RELs can be used to express policies for one or more of these six applications at different degrees of specificity. Therefore, there are general purpose RELs and special purpose RELs specialised at one or two application areas. (Pellegrini et. al. 2018, 3) In the following chart the chosen RELs are listed with the information which of the six models after Chong et. al. they support. The information is taken from the descriptions of the 13 RELS above. YES means that the REL is able to support that specific model. This does not mean that is has to support this model everywhere where it is used. NO means that it does not support this model or it has not been mentioned in the searched literature.

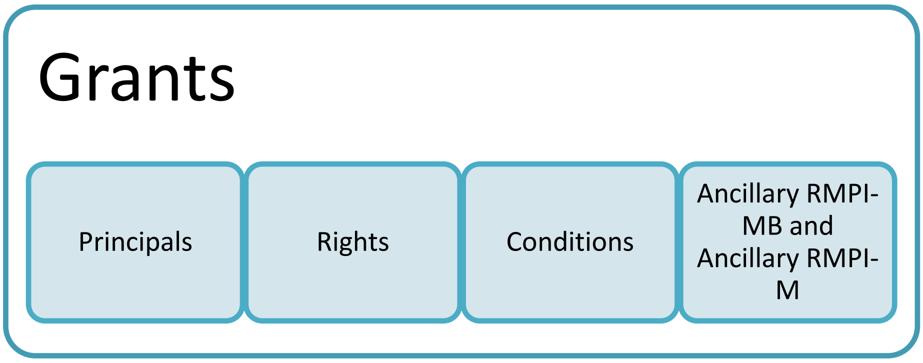
REL	revenue policies	provision policies			operational policies	contract policies	copyright policies	security policies
		Conflicts	Alternatives	Defaults				
TV-Anytime	NO	YES	YES	YES	YES	NO	NO	YES
AVS-REL	YES	NO	YES	YES	YES	YES	YES	YES
MPEG-21 IPMP/CEL/MCO	YES	YES	NO	NO	YES	YES (CEL/MCO)	YES (IPMP)	YES
PLUS	NO	NO	NO	NO	NO	NO	YES	YES
ebXML CPP/CPA 2.0/2.1	NO	NO	NO	NO	YES	YES	NO	YES
XACML 1.0/2.0/3.0	NO	YES	YES	YES	NO	NO	NO	YES
WS-Agreement	NO	NO	NO	NO	YES	YES	NO	NO
ccREL	NO	NO	NO	NO	NO	NO	YES	YES
ODRL 1.0/1.1/2.0/2.1	YES	YES	YES	YES	YES	YES	NO	YES
RightsML	YES	YES	YES	YES	YES	YES	NO	YES
Legal Rule ML	NO	YES	YES	YES	NO	NO	NO	YES
OMA DRM 1.0/2.0	NO	YES	YES	YES	NO	NO	NO	YES
METSRights 1.1-1.11	NO	NO	YES	NO	NO	NO	NO	YES

4: REL application model

3.2. Data model

In the following chapter, the 13 RELs are listed in respect to its data model. To get a better overview and to be comparable, they were simplified. As not every detail can be listed in these charts, they only contain the most important structure information. Each chart is one REL. The overall comparison is made in the research question 1.4 which is chapter 4.5.

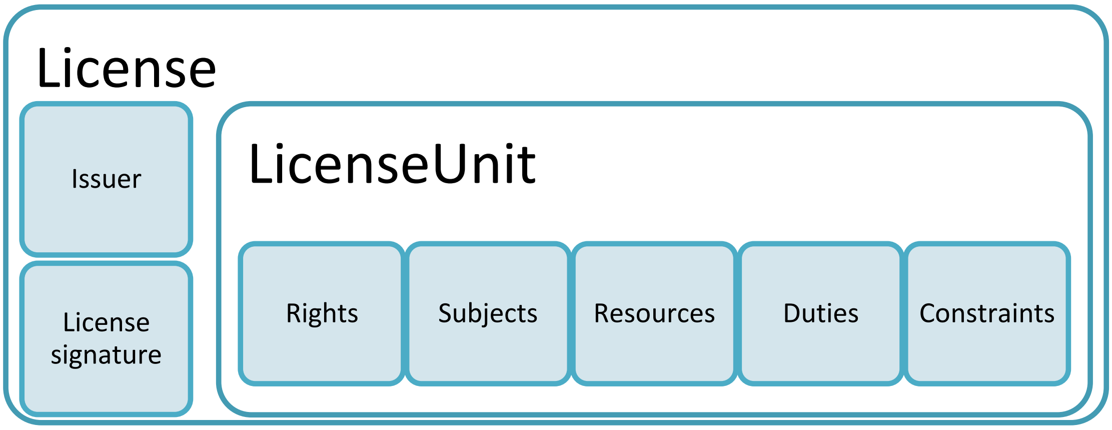
3.2.1. TV-Anytime



5:TV-Anytime Data Model (ETSI 2009)

The semantics of RMPI-M and RMPI-MB consist only of the four parts: Principals, Rights, Conditions and Ancillary RMPI-MB and Ancillary RMPI-M. These four parts are contained in one grant and therefore in the case of TVA for one TV receiver.

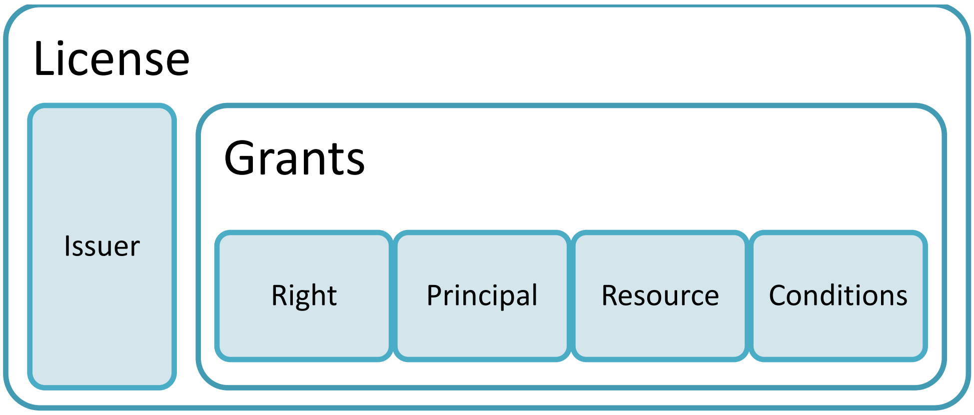
3.2.2. AVS-REL



6: AVS-REL Data Model (Sha 2006, 92-96)

The AVS-REL is divided into five entities: Rights, Subjects, Resources, Duties and Constraints. These five parts together are called a LicenseUnit. This unit can express who can have some rights on certain resources under certain conditions after fulfilling the duties. The base unit for the AVS-REL is a License. This is a statement of rights signed by a subject and issued to another subject. The license includes the information of the issuer, the LicenseUnits and the signature of the license. (Sha 2006, 95)

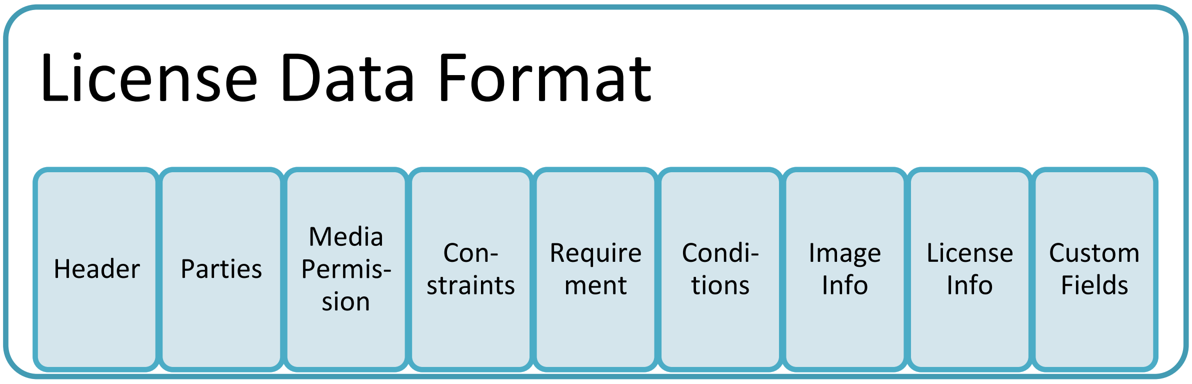
3.2.3. MPEG-21 REL



7: MPEG-21 REL Data Model (Rodríguez-Doncel et. al. 2013, 3 / Kang et. al. 2009, 95)

The central construction of the MPEG.21 data model is the license. It contains the entire statement. The rights owner is called issuer, who states that the principal has a right to a resource under certain conditions. If a principal is authorized to get certain rights they are called grants. They are elements in a license that grant rights. These elements are: Right, Principal, Resource and Conditions. (Wang et al. 2005, 409-410)

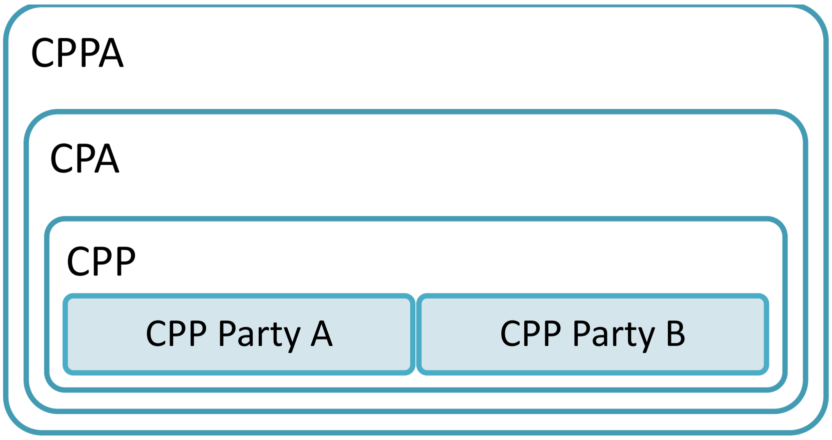
3.2.4. PLUS



8: PLUS Data Model (PLUS Coalition LTD. 2016)

The LDF is a machine-readable worldwide standard for describing licenses and consists of information to understand a license. It enables to read and embed meta-data in document and digital files. Not all depicted groups of fields have to be used by the licensor. (PLUS Coalition LTD. 2016)

3.2.5. ebXML 2.0

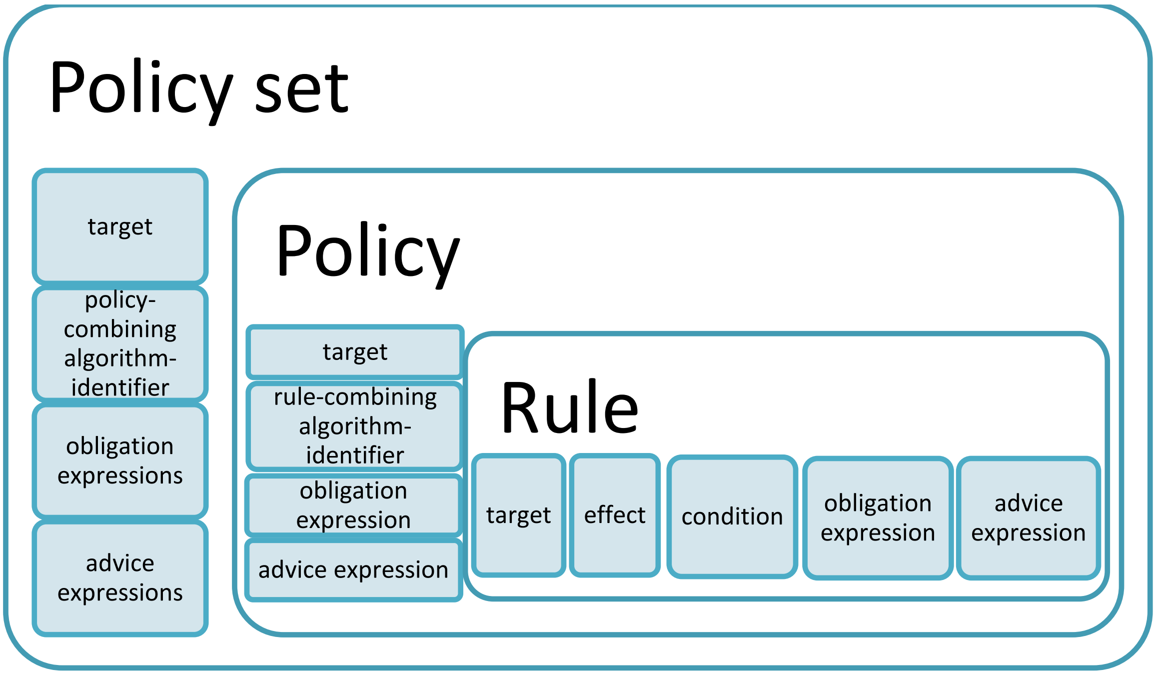


9: ebXML 2.0 Data Model (UN/CEFACT, OASIS 2002, 12-14)

The ebXML Collaboration-Protocol Profile and Agreement (CPPA) consists of the ebXML Collaboration-Protocol Agreement (CPA) and the Collaboration-Protocol

Profile. With the CPA agreements between parties can be expressed. It therefore contains the agreed capabilities and behaviour of two parties to perform a business collaboration. (UN/CEFACT, OASIS 2001, 13) The CPP is a specification where it is described in which way each party can exchange information in a business collaboration. Thus, the capabilities of every party are described. With the CPPA specifications a specific cooperation scheme between business partners is assumed. (UN/CEFACT, OASIS 2001, 9-11)

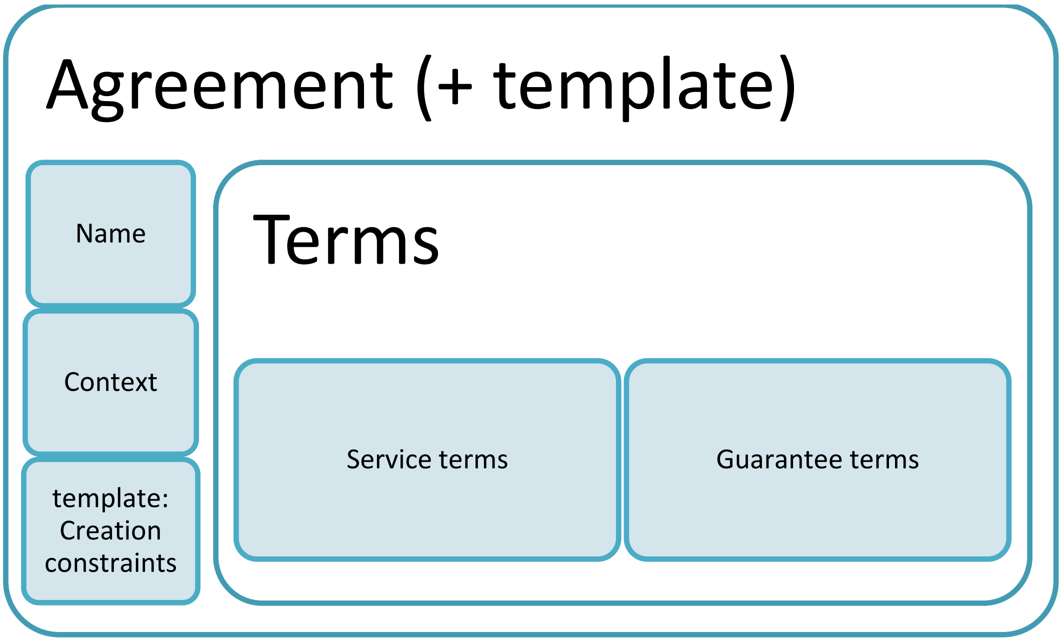
3.2.6. XACML 3.0



10: XACML 3.0 Data Model (OASIS open 2013, 21-24)

In XACML three top-level policy elements are defined, which are the main components of the policy language model. The policy set contains other policy sets or policies and consists of a target, a policy-combining algorithm-identifier, a set of policies, obligation expressions and advice expressions. A policy consists of a set of Rule elements and a specific procedure for combining the evaluation results. A policy element is meant to be the basic unit of an authorization decision. A target, a rule-combining algorithm-identifier, a set of rules, obligation expressions and advice expressions are the main components of a policy. A rule encompasses a Boolean expression and is the smallest component of an XACML policy. Each rule can grant or deny access. A rule consists of the following main components: A target, an effect, a condition, obligation expressions and advice expressions. (OASIS open 2013, 21-24/Ramli et. al. 2014, 81).

3.2.7. WS-Agreement

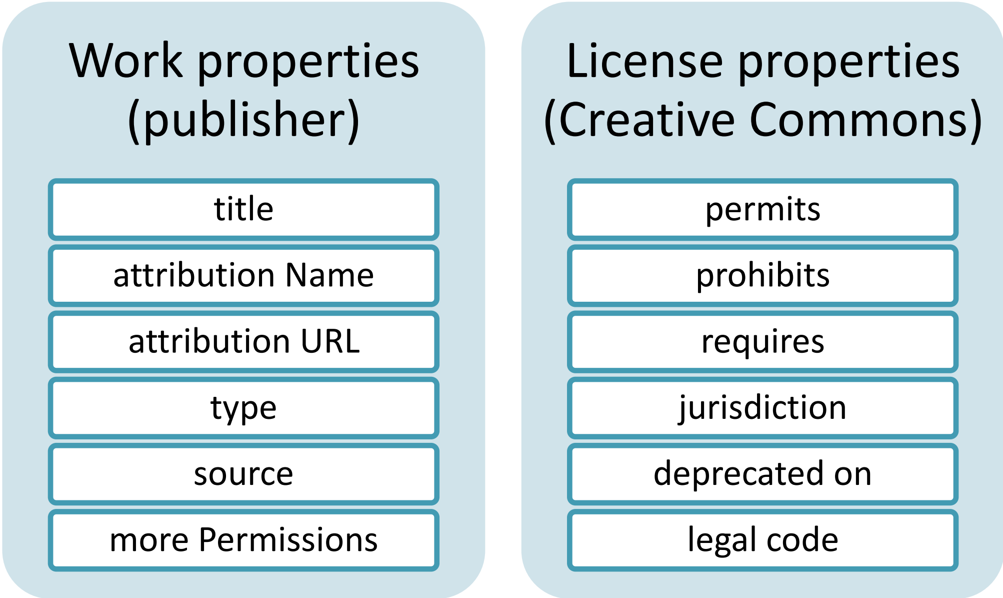


11: WS-Agreement Data Model (Andrieux et. al. 2011, 14)

As a WS-Agreement consists of several different parts, it is summarized and depicted in the data model above. The agreement consists of the optional name, the context which stores the agreement's meta-data, lists the participants and the agreement's lifetime. The terms describe the agreement itself. They are separated into service terms and guarantee terms. The service terms contain information in order to identify a service to which the agreement relates. The guarantee terms provide the needed assurance to the service consumer on things like the service quality, etc. Additionally, it can also be possible that service consumer should give the service provider guarantees if the service depends on it. (Andrieux et. al. 2011, 13-17)

If an agreement factory gets an offer from a client, an agreement must be created. The agreement creation looks similar to the agreement, but it is used by the agreement factory to advertise the offers it accepts. The only difference is the agreement creation constraints it may contain. This section may contain constraints on term values. (Andrieux et. al. 2011, 29)

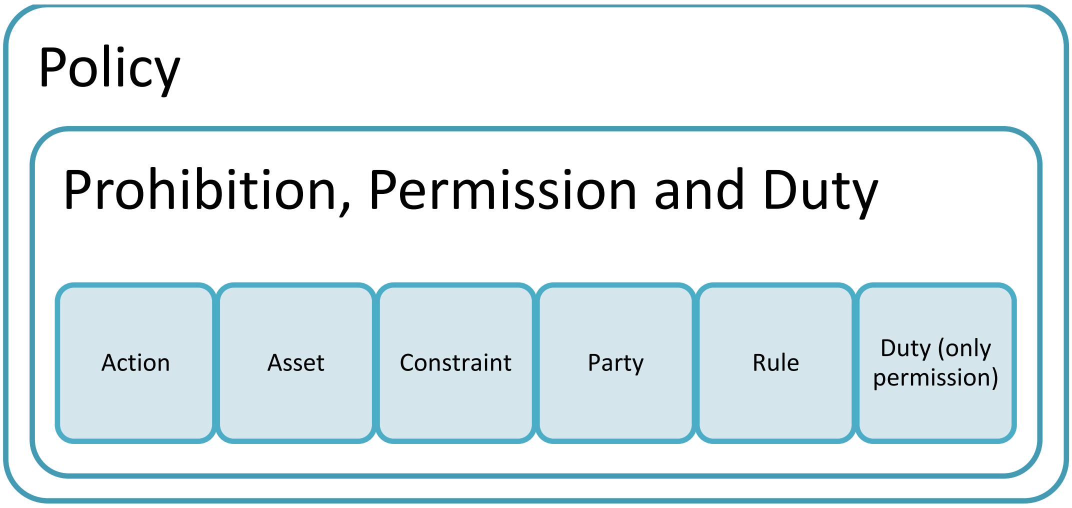
3.2.8. ccREL



12: ccREL Data Model (Rodriguez, Delgado 2006, 2 / Abelson et. al. 2008, 6-10)

It can be distinguished between two classes of properties: Work properties and license properties. In work properties, aspects of works are described. Mostly publishers are concerned with this kind of properties. For a Creative Commons license at least one RDF triple must be provided, but it is possible to include additional information like the title, the name and the URL for giving attribution and the document type. In Addition, the source (the URI of the modified work) and more Permissions (beyond the CC license) can be available properties for publishers. The license properties describe aspects of licenses. The Creative Commons want that publishers provide the license properties of the licenses work. The license description pages are also called Creative Commons Deeds. They include the license properties in the suggested syntax (RDFa). The ccREL include the license properties and contain: permits. prohibits, requires, jurisdiction, deprecated on and legal Code which third parties cannot modify. (Abelson et. al. 2008, 6-10)

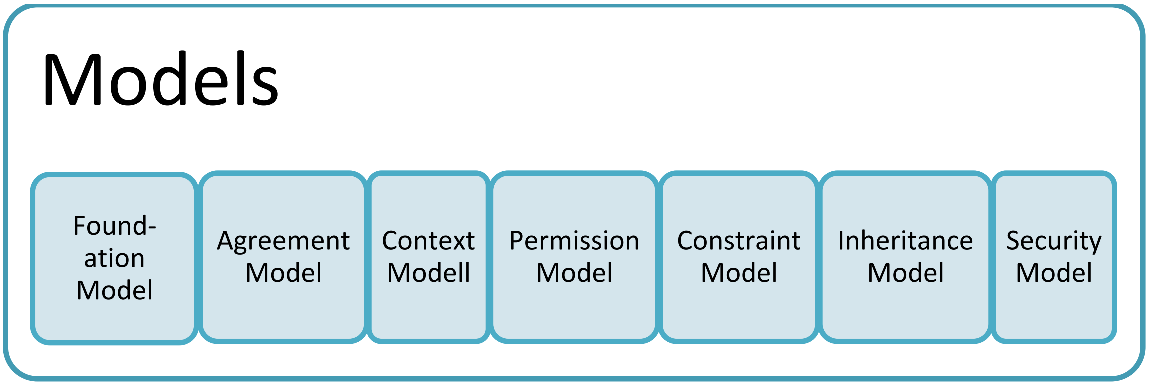
3.2.9. ODRL 2.2 and RightsML 1.1



13: ODRL 2.2 and RightsML 1.1 Data Model (Rodríguez-Doncel et. al. 2013, 3/ Steyskal, Polleres 2015, 362/Iannella et. al. 2018 / IPTC 2013, 5-10)

The information model of ODRL 2.2 contains policies that express permissions, prohibitions and duties and therefore express what is allowed or not allowed concerning the policy, requirements, parties etc. The policies are flexible as they are only as detailed as the policy author likes. They are also the central entity of ODRL and consists of a group of permissions and/or prohibitions and/or duties. These permissions, prohibitions and duties can be connected to a specific action, an asset, a constraint, a party or a duty. (Steyskal, Polleres 2015, 371 / W3C Recommendation. ODRL Vocabulary & Expression 2.2. 2018)

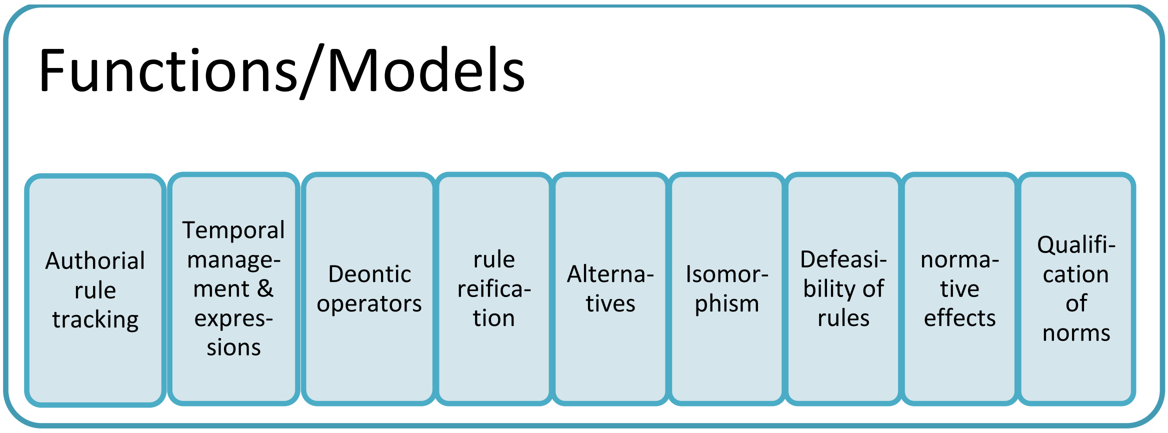
3.2.10. OMA DRM 2.0



14: OMA DRM 2.0 Data Model (Open Mobile Alliance 2008, 10-30)

The structure of the OMA DRM REL can be described as mobile profile of ODRL version 1.1. Its structure enables metadata like the version or the content ID and the actual rights specification which provides protection information for, and linking to the content, as well as specifications of the usage rights and constraints. The seven models depicted above are used to group rights elements: The Foundation Model, the Agreement Model, the Context Model, the Permission Model, the Constraint Model, the Inheritance Model and the Security Model. (Open Mobile Alliance 2008, 10-30)

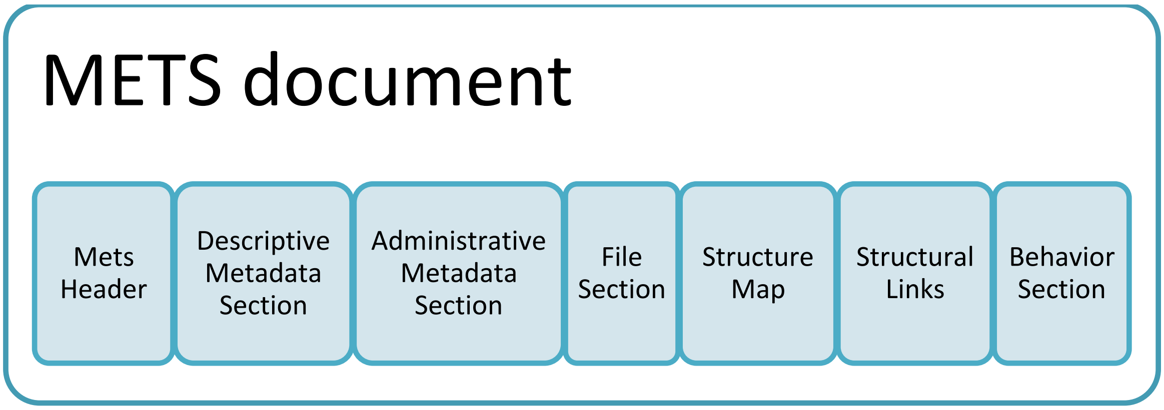
3.2.11. LegalRuleML



15: LegalRuleML Data Model (Palmirani et. al. 2018, 19/Palmirani et. al. 2013, 4/Athan et. al. 2015, 153-169/Athan et. al. 2013, 14-15)

The functionalities of LegalRuleML are the qualification of norms, the representation of normative effects, the implementation of defeasibility of rules, the implementation of isomorphism, the representation of alternatives, the management of rule reification, the deontic operators, the temporal management of the rules and temporal expressions within the rules and the authorial tracking of the rules. What these functions do exactly is described above in chapter 2.12. (Palmirani et. al. 2018, 19/Palmirani et. al. 2013, 4/Athan et. al. 2015, 153-169/Athan et. al. 2013, 14-15)

3.2.12. METSRights 1.11



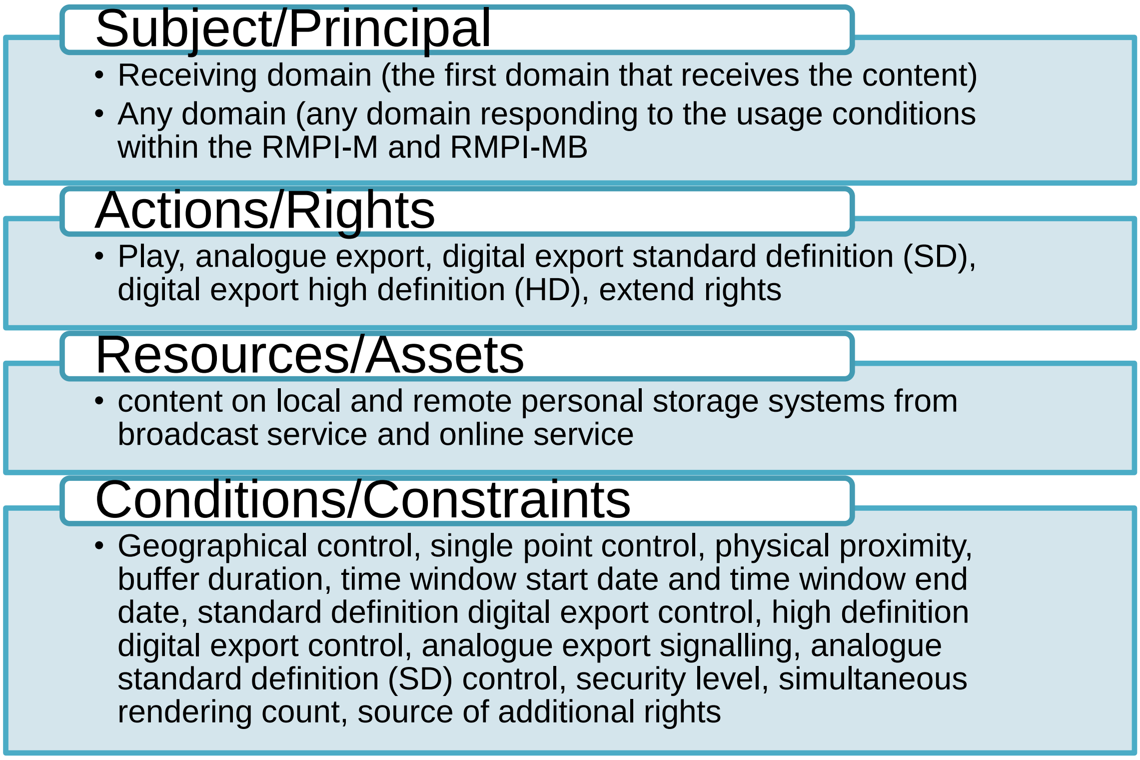
16: METSRights Data Model (Cundiff 2004, 53-57 / Cantara 2005, 239-250)

The basic structure of a METS document as described by Cundiff (2004, 53-57) and Cantara (2005, 239-250) and METS Primer (2010, 25-98) consists of up to seven major subsections: The METS Header (metsHdr), the Descriptive Metadata Section (dmdSec), the Administrative Metadata Section (amdSec), the File Section (fileSec), the Structure Map (structMap), the Structural Links (structLink) and the Behavior Section (behaviorSec). What exactly these elements are used for is described above in chapter 2.13.

3.3. Expressivity

In the following chapter, the 13 RELs are listed in respect to its expressivity. Therefore, a distinction was made between subject/principal, actions/rights, resources/assets and conditions/constraints. These four categories shall examine if the RELs are able to distinguish between many different subject/principal, actions/rights, resources/assets and conditions/constraints or only a few specific. Each chart is one REL. The overall comparison is made in the research question 1.3 which is chapter 4.4.

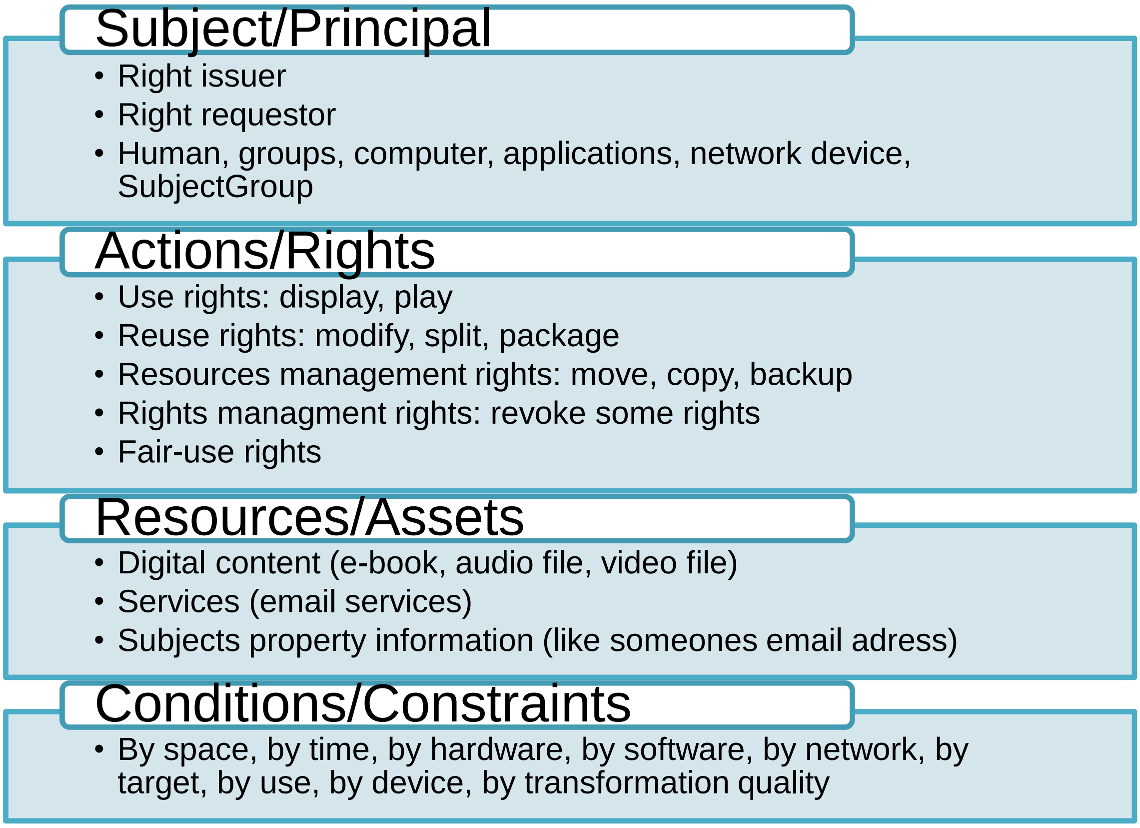
3.3.1. TV-Anytime



17: TV-Anytime Expressivity (ETSI 2009)

TV-Anytime distinguishes between the receiving domain and any domain as subject. The actions/rights as well as the resources/assets are restricted to a few terms concerning the broadcast or the post-broadcast. The conditions/constraints of TVA also focus on the same aspects but are more detailed. (ETSI 2009, 8-12)

3.3.2. AVS-REL



18: AVS-REL Expressivity (Sha 2006)

The subject of the AVS-REL can be human, groups, computers, applications or network devices. They can be the right issuers or requestors in the digital content value chain. These subjects can also be assigned with different roles. The actions/rights include use rights, reuse rights, resource management rights, rights management rights and fair-use rights. Fair-use rights can be assigned to subjects depending on its roles and can be hold without the permission of the rights issuer’s. The rights in the AVS-REL are operations on some objects. The resources/assets can be digital content, a service or property information of a subject. A group of resources can be defined as ResourcesGroup in AVS-REL. The conditions/constraints must be fulfilled before a user obtains rights. The AVS-REL supports selected terms of conditions like space, time, hardware or software etc. (Sha 2006, 92-96)

3.3.3. MPEG-21 REL

Subject/Principal

- A principal which has multiple valid credentials
- A key holder
- other identification technologies
- can be a user, group, device or system

Actions/Rights

- rights relating to other rights: issue, revoke, obtain
- extensions that define rights for specific resource types: like play, print, modify, copy, adapt, delete, diminish, embed, enhance, enlarge, execute, install, move, reduce, uninstall etc. for digital works

Resources/Assets

- digital work (like e-book, audio file, video file, image)
- a service (email service, B2B transaction service)
- piece of information owned by a principal (a name or email adress)

Conditions/Constraints

- time interval, fee, count, territory, freshness, integrity, marking, signed-by
- require existence of a valid, prerequisite right issued to a principal
- extensions that define conditions for specific distribution and usage models (like watermarking, destination, renderer)

19: MPEG-21 REL Expressivity (Wang et al. 2005, 409-410 / Timmerer, Hellwagner 2008, 578-579/Gallo et. al. 2008, 131 / Barlas 2005)

The subject in the MPEG-21 REL is called principal and can be a user, a group, a device or a system. The principals are authorized to use the digital resources as a right is granted to them. The principal denotes itself by unique information that often also has some associated authentication mechanism to prove its identity. The actions/rights are exercised against resources under some condition. They often specify an act or activity or class of acts of a resource. Such rights could be specific rights like play or adapt, or rights that relate to other rights like obtain or issue. The resources/assets can be digital works, a service or a piece of information owned by a principal. Under the conditions/constraints the rights are exercised and specified. (Wang et al. 2005, 409-410)

3.3.4. PLUS

Subject/Principal

- Licensee
- Licensor
- End User

Actions/Rights

- PLUS media summary code (that summarizes the media usage that is included in the license)

Resources/Assets

- Images

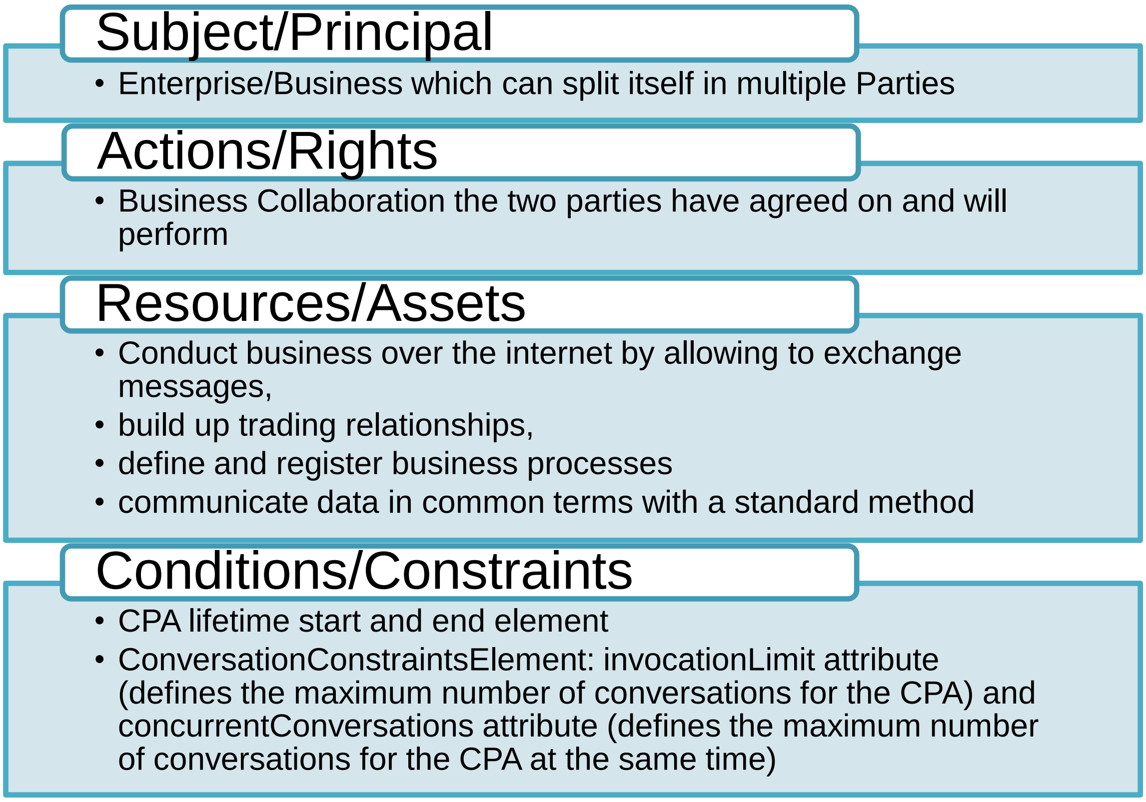
Conditions/Constraints

- Conditions:Terms and conditions text, terms and conditions URL, other license conditions
- Constraints: License start date, license end date, media constraints, region constraints, product or service constraints, image file constraints, image alteration constraints, image duplication constraints, model release status, model release ID, minor model age disclosure, property release status, property release ID, other constraints
- Requirements: Credit line requirement, credit line text, adult content warning, other license requirements

20: PLUS Expressivity (PLUS Coalition LTD. 2016)

PLUS differentiates the subject/principal in the licensee, the licensor and the end user. Concerning the actions/rights PLUS refers to the PLUS media summary code which summarizes the media usage that is included in the license. The resources/assets of PLUS are only images. The conditions/constraints section also expresses terms of requirements. (PLUS Coalition LTD, 2016)

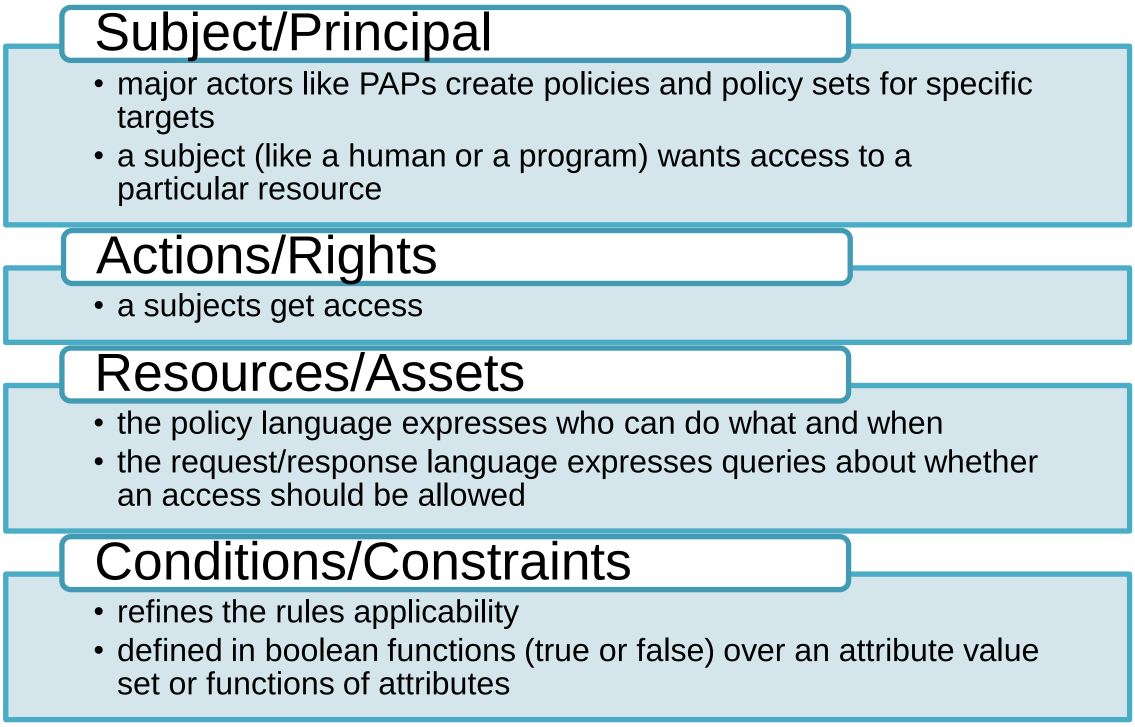
3.3.5. ebXML 2.0 (concentration on the CPA)



21: ebXML 2.0 Expressivity (UN/CEFACT, OASIS 2002, 70-78)

The subject/principal of the ebXML are enterprises and/or businesses. One business can also set up multiple CPPs that describe the various business collaborations and the different regions in which It operates or different organization parts. The actions/rights concern the business collaboration the two parties have agreed on and will perform. The resources/assets and the reason why businesses use ebXML is that they can conduct business over the internet by allowing to exchange messages, build up trading relationships, define and register business processes and communicate data in common terms with a standard method. The conditions/constraints are limited to the determined CPA lifetime start and end element and the ConversationConstraintsElement that records agreements about the conversation. (UN/CEFACT, OASIS 2002, 70-78)

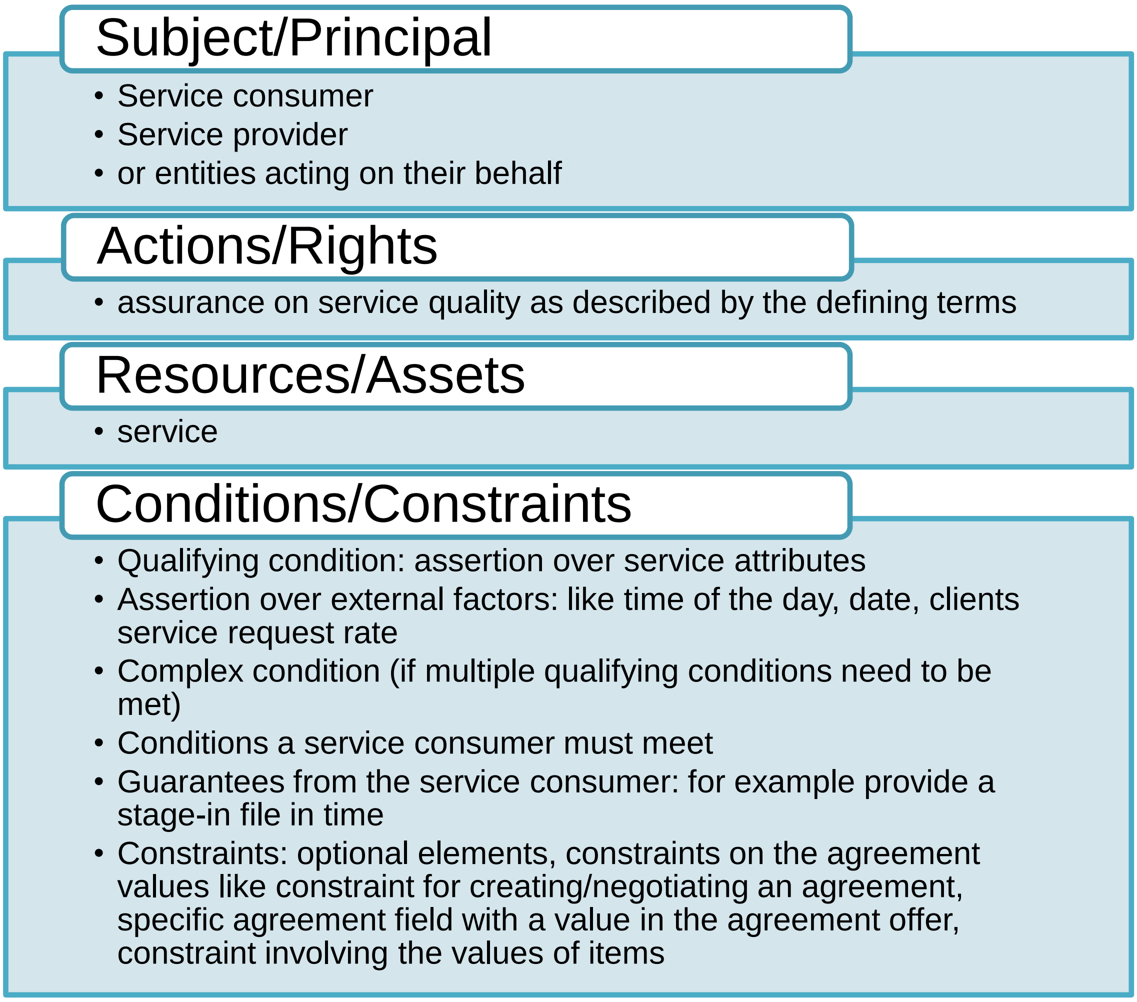
3.3.6. XACML 3.0



22: XACML 3.0 Expressivity (Ramli et al. 2013)

The subjects/principals of XACML can be major actors like PAPs. They create policies and policy sets of specific targets. Subjects, like a human or a program then wants access to a resource. The action/right section of XACML only consists of granting or denying access. The resources/assets of the policy language expresses who can do what when and with the request/response language queries about whether an access should be allowed or not are expressed. The conditions/constraints are defined in Boolean functions and refine the rule applicability. (Ramli et. al. 2013)

3.3.7. WS-Agreement



23: WS-Agreement Expressivity (Andrieux et. al. 2011)

The subjects/principals of the WS-Agreement can be divided into the two parties of the service consumer and the service provider or entities acting on their behalf. Actions/rights are only assurances on the defined service quality from the service provider. The only resource/asset the WS-Agreement handles with are services. The section of conditions/constraints can be divided into qualifying condition, assertion over external factors, complex condition, conditions a service consumer must meet, guarantees from the service consumer and constraints. (Andrieux et. al. 2011, 4)

3.3.8. ccREL

Subject/Principal

- publishers
- consumers
- by applications and human users

Actions/Rights

download, use, share, remix, tweak, redistribute, reproduce, derivative works and build upon depending on the given license:

- The Attribution Non-commercial No Derivates (by-nc-nd)
- The Attribution Non-commercial Share Alike (by-nc-sa)
- The Attribution Non-commercial (by-nc)
- The Attribution No Derivates (by-nd)
- The Attribution Share Alike (by-sa)
- The Attribution (by)
- No Rights Reserves (0)

Resources/Assets

- designed for creative works: websites, music, film, photography, software etc.

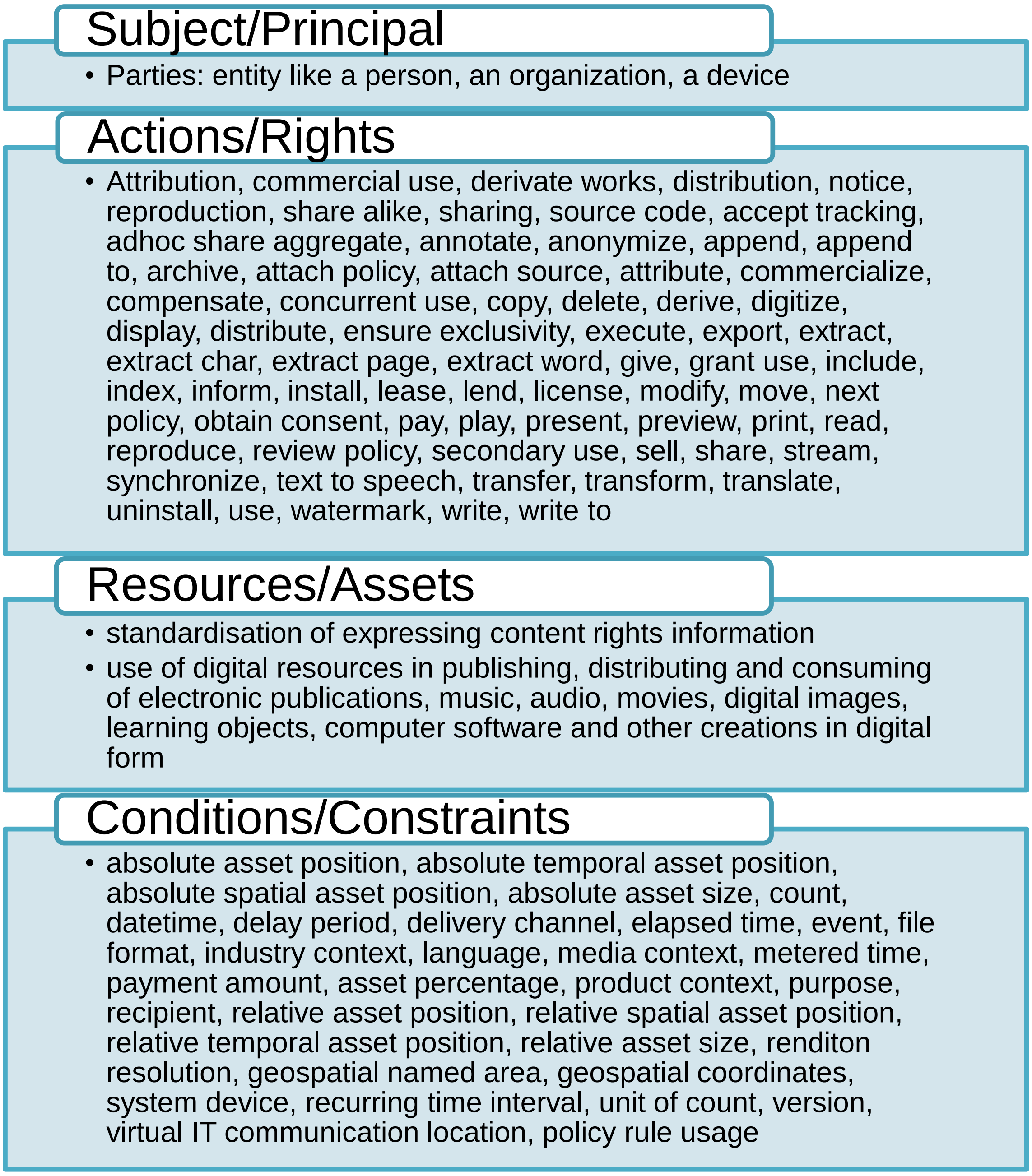
Conditions/Constraints

- prohibits: about the use of the work like commercial use
- requires: action of the user like notice (provide information about the license), attribution (give the creator credit), share alike (use the same license when redistributing derivate works of the work) or source code (the source code must be provided when redistributing the work)

24: ccREL Expressivity (Rodriguez, Delgado 2006, 2 / Abelson et. al. 2008, 6-10)

The subjects/principals in the ccREL are publishers and consumers which can be applications or human users. Concerning the actions/rights content creators can choose between seven different license types when publishing their work. They define if certain actions like download, use, share etc. are allowed or not. ccREL is designed for creative works which means assets can be websites, music, film, photography, software etc. The conditions/constraints comprise a set of prohibits and requires. (Rodrigues, Delgado 2006, 2 / Abelson et. al. 2008, 6-10)

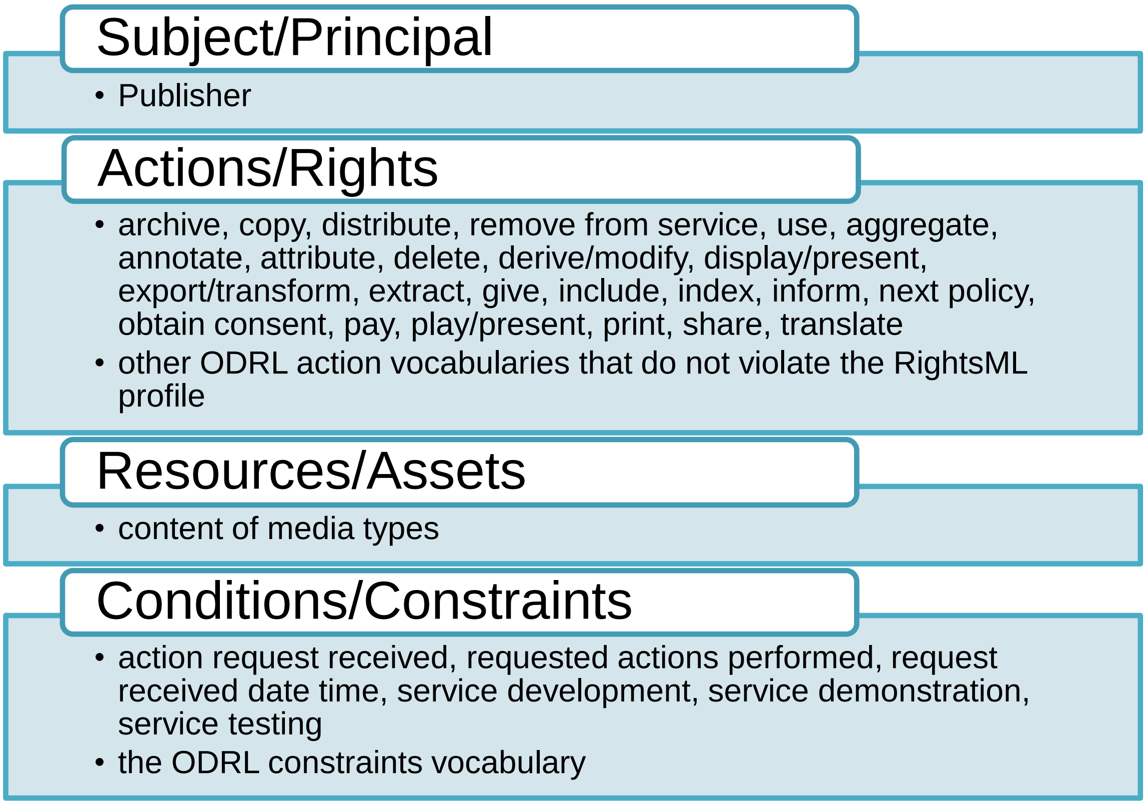
3.3.9. ODRL 2.2



25: ODRL 2.2 Expressivity (W3C 2018b / Zhang et. al. 2008, 262)

The subject/principals are called parties in ODRL and can be entities like a person, an organization or a device. The actions/rights as well as the conditions/constraints can be expressed with a very rich term set depicted above. Therefore, the resources/assets can be various digital resources for example in publishing, distributing and consuming, electronic publications, music, audio, movies etc. (W3C 2018b / Zhang et. al. 2008, 262)

3.3.10. RightsML 1.1



26: RightsML 1.1 Expressivity (IPTC 2013, 5-10)

The subject/principal in RightsML is a publisher as the language was created to help them to comment each content piece with machine-readable instructions that permit or restrict the content use. Therefore, the resource/assets can be various content pieces in the media industry. The basis of RightsML consists of ODRL 2.2. Therefore, all the actions/rights and conditions/constraints ODRL uses can also be used for RightsML. Furthermore, RightsML extends the ODRL core vocabulary to special vocabularies depicted above. (IPTC 2013, 5-10)

3.3.11. OMA DRM 2.0

Subject/Principal
- rights issuer
- content issuer

Actions/Rights
- play, display, execute, print, export (ext.)

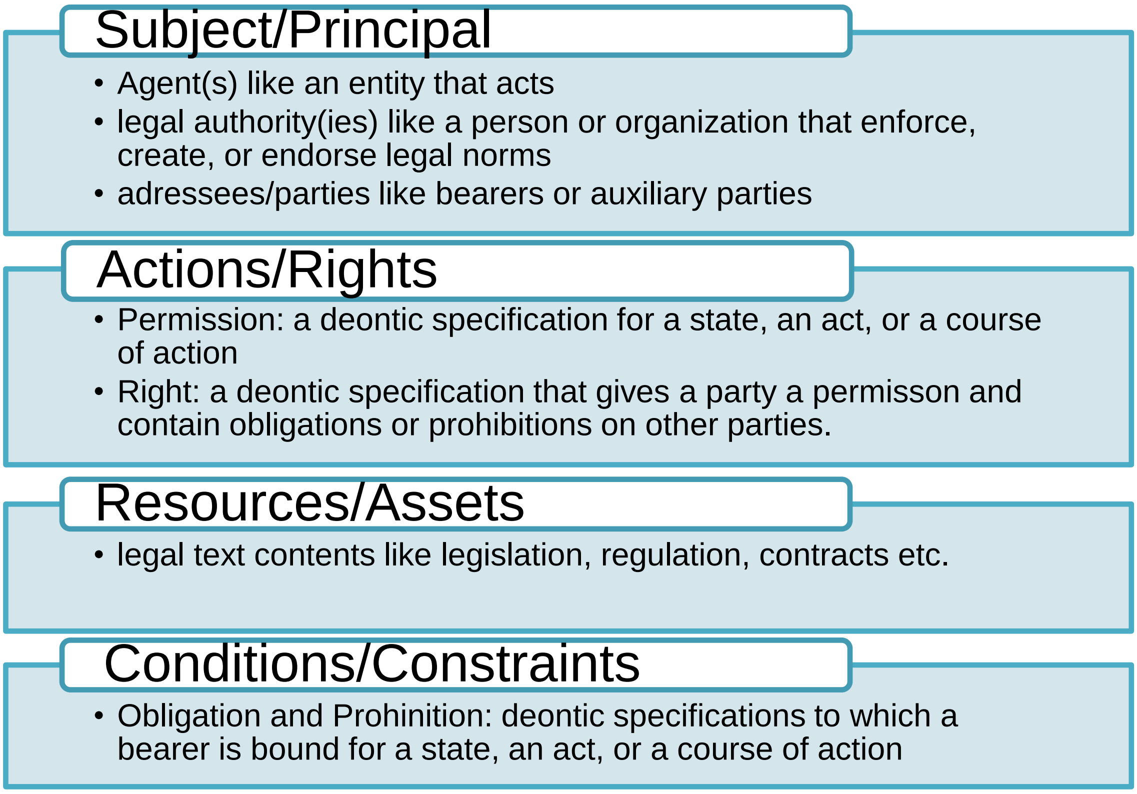
Resources/Assets
- supports mobile handsets
- protection functions for a wide variety like games, ring tones, photos, music clips, video clips, streaming media, animations etc.

Conditions/Constraints
- count, datetime, interval, timed-count (ext.), accumulated, individual, system (ext.)

27: OMA DRM 2.0 Expressivity (Open Mobile Alliance 2008, 17-25 / Smith 2004, 187-188)

The subject/principal of the OMA DRM can be divided into the rights issuer and the content issuer. The OMA Rights Expression Language is a subset and a mobile profile of ODRL and comprises a smaller vocabulary than ODRL concerning the actions/rights as well as the conditions/constraints sections, but it contains the essential features. (Sheppard, Safavi-Naini 2009, 21) As the resources/assets of the OMA DRM is restricted to mobile handsets and protection functions for a wide variety like games, ring tones, photos etc. it must take into account that the mobile domain requires special needs and characteristics when expressing consumption rights. (Open Mobile Alliance 2008, 8)

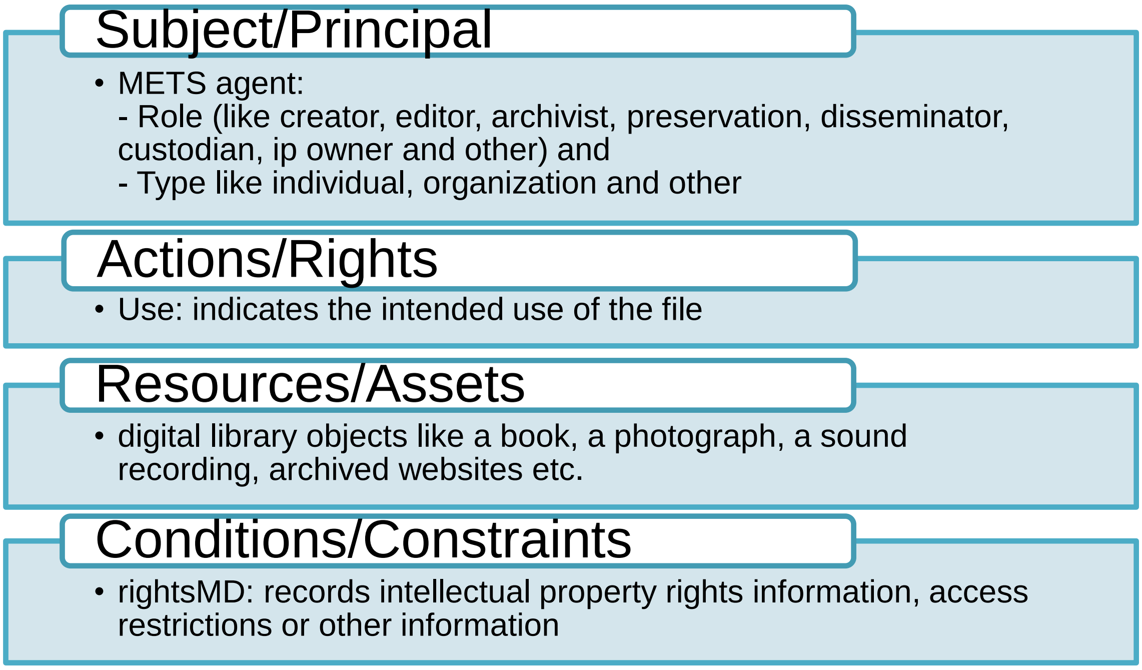
3.3.12. LegalRuleML



28: LegalRuleML Expressivity (Palmirani et. al. 2013, 3/13)

The subjects/principals in LegalRuleML are called agents which are entities that act. These agents can be legal authorities like a person or an organization that enforce, create, or endorse legal norms as well as adressees or parties which are also called bearers or auxiliary parties. The actions/rights are split into some permissions and rights which are deontic specifications. The resources/assets are legal texts like legislations, regulations, contracts etc. The conditions/constraints can be obligations and prohibitions and are also deontic specifications. (Palmirani et. al. 2013, 3)

3.3.13. METSRights 1.11

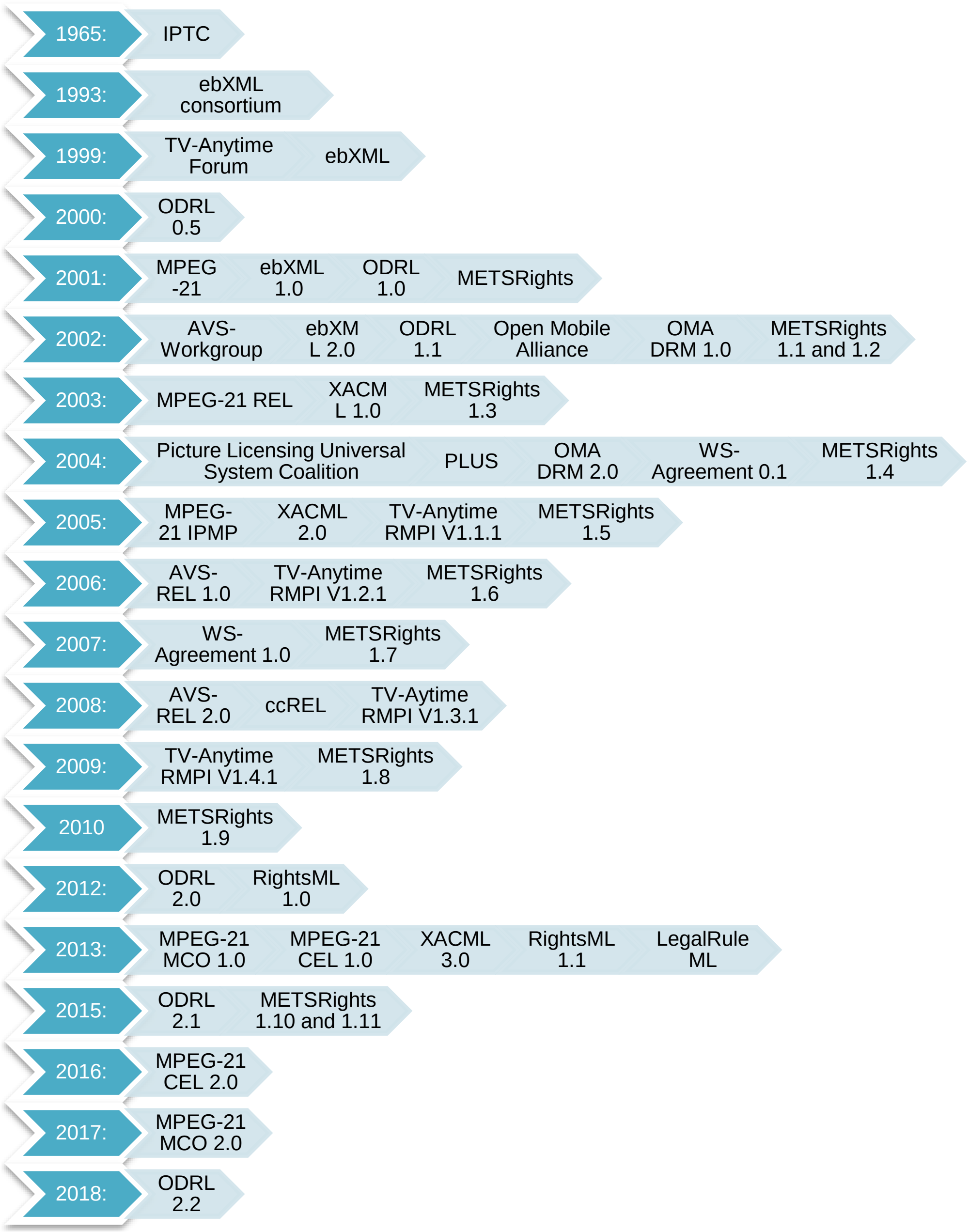


29: METSRights Expressivity (Cundiff 2004, 53-57 / Cantara 2005, 239-250)

The subject/principal of METSRights is called the METS agent. The agent can have a role like a creator, an editor, an archivist etc. and a type like an individual or an organization etc. The resources/assets are various digital library objects like books, photographs or sound recordings etc. Concerning the actions/rights section, the use expression indicates how the file should be used. The conditions/constraints are defined with the rightsMD term. It records intellectual property rights information, access restrictions or other information. (Cundiff 2004, 53-57 / Cantara 2005, 239-250)

3.4. Timeline

This timeline shows when the 13 RELs and the organizations behind them originated. Furthermore, it is listed when the different versions of the RELs accrued over time.



30: REL timeline

4. Answers to the research questions

In the following chapter the six research questions, which were already introduced in chapter 1.5 (Approach, method and research questions), are answered according to the findings of this master thesis.

4.1. RQ1

What is the actual status quo of these Rights Expression Languages?

As illustrated at the timeline in chapter 3.4, there are RELs like the WS-Agreement (2007), ccREL (2008), RightsML (2012) or LegalRuleML (2013) that are relatively young. This can be one indicator that RELs are becoming a more important topic lately and will become in the future as they will get applied in many different media sectors but also in other sectors.

Furthermore, most of the discussed RELs get updated regularly. ODRL version 2.2 got updated this year, but also the MPEG-21 REL got updated in 2016 and 2017 with the CEL and the MCO versions 2.0. In 2013, XACML got the 3.0 version and RightsML the 1.1 version. These are examples that show, that the official standardization bodies try to be on the latest status and have their RELs up-to-date.

4.2. RQ 1.1

What are their historical development and their genealogy?

One of the first attempts of developing a formal Language of Legal Discourse (LLD) was made by McCarthy 1989. After that, since 1990 the development of RELs increased massively. In 1994 a DRM technology called the Digital Rights Property Language (DRPL) got developed by Stefik and Casey. As Xerox PARC released an eXtensible Markup Language implementation of DRPL V2.0, it became XrML. The first version of XrML was released in 2000 by the joint venture of Xerox/Microsoft ContentGuard as an evolution of DRPL V2.0. In 2002 XrML V2.0 was released.

In 2003, The Motion Picture Experts Group (MPEG) released the **MPEG-21 Part 5**, which is the Right Expression Language. It is an evolution of XrML 2.0. The MPEG-21 IPMP specification got published in 2005. The MCO and CEL specification were both issued in 2013. In 2016 version 2.0 of CEL got released and in 2017 version 2.0 of MCO.

ODRL was introduced by Iannella in 2000 as 0.5 version. Version 1.0 was released in 2001. Version 1.1 got published in 2002. The version 2.0 got released in 2012, version 2.1 in 2015 and version 2.2 in 2018.

In 2002, the **Open Mobile Alliance (OMA) REL** was created. The version 1.0 was based on the ODRL version 1.1. In 2004 it got refined as OMA DRM version 2.0.

The basis of **RightsML** also consists of ODRL, but on the version 2.0. Version 1.0 was published in 2012 and version 1.1 in 2013. As RightsML is based on ODRL since version 1.0 it is also aligned to ODRL changes.

TV-Anytime was created by the in 1999 established forum and its REL got the version 1.1.1 in 2005. It got updated in 2006 to version 1.2.1, in 2008 to version 1.3.1 and in 2009 to version 1.4.1.

The **AVS-REL** version 1.0 was created in 2006 by the in 2002 formed Audio and Video Coding Standard Workgroup of China (AVS Workgroup). In 2008, the AVS2.0 got launched by the group.

In 2004, the PLUS Coalition was established which created **PLUS** in the same year.

The 1993 established ebXML consortium created **ebXML** in 1999, but its version 1.0 was released two years later in 2001. It got revised in 2002 as version 2.0.

Version 1.0 of **XACML** got submitted by OASIS in 2003. It got updated in 2005 as version 2.0 and in 2013 as version 3.0.

The **WS-Agreement** was developed by the Open Grid Forum (OGF) which released the version 0.5 in 2004. The first official version was released in 2007.

ccREL was created by an informal W3C working group in 2008. It never became an official recommendation by the W3C, but de facto standard for the Creative Commons Licenses.

In 2013, **LegalRuleML** was issued.

METSRights was developed in 2001 by several libraries which formerly worked on a project called Making of America II (MoA II). That project developed the XML DTD standard but they decided to do a new version of the DTD in 2001. Jerome McDonough, the primary author of the MoA II DTD, had a new draft in 2001 called Metadata Encoding and Transmission Standard. The METS development is an ongoing process to the initiative of the Digital Library Federation.

Today XrML and ODRL are still the major RELs. This can also be seen as many other RELs are using their basis. Nevertheless, there are still many other important RELs who developed in the last years.

4.3. RQ 1.2

In which application areas are these RELs used?

This question can be answered with chapter 3.1 in this thesis. A chart was created and the 13 RELs were analysed by the six possible policy models Chong et. al. suggested. These six policy models are different application areas in which RELs can be found: The revenue model, the provision model, the operational model, the contract model, the copyright model and the security model.

These six models are not supported by every REL but the RELs can express one or more of the six applications in different degrees of specifity.

We can distinguish between special purpose RELs, like **PLUS, ebXML, WS-Agreement, ccREL, XACML, LegalRuleML, OMA DRM, TV-Anytime** or **METSRights** as they only support one to three of these application models, and general purpose RELs like **AVS-REL, MPEG-21, ODRL** and **RightsML** as they support four to six of the application areas.

In the following it is listed which REL supports which of the six models. As the provision policy is split in three in this chart, the following rule is used: If two of three parts are answered with yes, it will count as yes and therefore supported by this model, and if two of three parts are answered with no, it will count as no and therefore not supported by this model.

Special purpose RELs:

- **METSRights** supports 1 model: The security model.
- **PLUS** supports 2 models: The copyright and security model.

- **XACML** supports 2 models: The provision and security model.
- **WS-Agreement** supports 2 models: The operational and contract model.
- **ccREL** supports 2 models: The copyright and security model.
- **LegalRuleML** supports 2 models: The provision and security model.
- **OMA DRM** supports 2 models: The provision and the security model.
- **TV-Anytime** supports 3 models: The provision, operational and security model.
- **ebXML** supports 3 models: The operational, contract and security model.

General purpose RELs:

- **MPEG-21** supports 5 models: The revenue, operational, contract, copyright and security model.
- **ODRL** supports 5 models: The revenue, provision, operational, contract and security model.
- **RightsML** supports 5 models: The revenue, provision, operational, contract and security model.
- **AVS-REL** supports 6 models: The revenue, provision, operational, contract, copyright and security model.

4.4. RQ 1.3

How is the comparability of the discussed RELs in respect to its expressivity?

The expressivity of the RELs have been tested in respect to its subject/principal, actions/rights, resources/assets and conditions/constraints.

When comparing the RELs in respect to its **subject/principals**:

Most of them define only one subject. These RELs are:

- **ebXML,** as it only defines businesses which can split itself in multiple parties,
- **ODRL,** as it only names parties as subjects,

- **RightsML,** as it only defines the publisher as subject,
- **METSRights,** as it defines the METSagent and
- **XACML,** as it only defines a subject that wants access to a resource.

It is possible to differentiate between two subjects. This can be:

- **TV-Anytime,** with receiving domain and any domain,
- **AVS-REL,** with right issuer and right requester,
- **ccREL,** with publisher and consumer,
- **OMA DRM,** with rights issuer and content issuer, or
- **WS-Agreement,** with service provider and service consumer.

Some RELs also distinguish between three subjects or more like:

- **PLUS,** which uses the terms licensee, licensor and end user,
- **MPEG-21,** which just differentiates between a principal which has multiple valid credentials, a key holder and other identification technologies and
- **LegalRuleML,** which defines agents, legal authorities and adressees/parties as subjects.

Important to notice is that these subjects/roles can be different entities like organisations, devices, humans etc.

When comparing the RELs in respect to its **actions/rights** it is important to add that not all detailed information is available in the searched literature. On the found basis it can be distinguished between RELs that have a wide selection of actions/rights available, like **ODRL, RightsML, AVS-REL, MPEG-21** and **ccREL** and RELs that do not but specialize in specific actions/rights, like **TV-Anytime, OMA DRM, LegalRuleML, METSRights, PLUS, ebXML, XACML** and **WS-Agreement.**

To differentiate those two sections, RELs with 5 or less actions/rights are listed in the section with a specialized selection of actions/rights.

When comparing the RELs in respect to its **resources/assets,** it can be distinguished between RELs that can support only one specific resource like:

- **PLUS**, that only supports images,
- **WS-Agreement,** that only offers service-level agreements,
- **TV-Anytime,** that only supports content on local and remote personal storage systems from broadcast service and online service and
- **LegalRuleML,** that only expresses legal text contents like legislation, regulation, contracts etc.,
- **ebXML,** that allows enterprises to conduct businesses over the internet,
- **XACML,** that is a policy language and expresses whether an access should be allowed

or RELs that can support many different resources, like **AVS-REL, MPEG-21, ccREL, ODRL, OMA DRM, RightsML** and **METSRights.**

When comparing the RELs in respect to its **conditions/constraints** it is important to add that not all detailed information is available in the searched literature. On the found basis it can be distinguished between RELs that have a wide selection of conditions/constraints available, like **TV-Anytime, MPEG-21, PLUS, WS-Agreement, ccREL, ODRL, RightsML** and RELs that do not, like **AVS-REL, ebXML, XACML, OMA DRM, LegalRuleML, METSRights.**

To differentiate those two sections, RELs with less than 10 conditions/constraints are listed in the section with a limited range of conditions/constraints.

To get a better overview of the research question 1.2 and 1.3 the following chart summarizes all the built categories.

RELs	application areas		expressivity								
	general purpose	special purpose	subject /principals			actions /rights		resource /asset		conditions /constraints	
			one	two	three or more	wide selection	specialized selection	one specific	many different	wide selection	specialized selection
TV-Anytime		X		X			X	X		X	
AVS-REL	X			X		X			X		X
MPEG-21	X				X	X			X	X	
PLUS		X			X		X	X		X	
ebXML		X	X				X	X			X
XACML		X	X				X	X			X
WS-Agreement		X		X			X	X		X	
ccREL		X		X		X			X	X	
ODRL	X		X			X			X	X	
RightsML	X		X			X			X	X	

OMA DRM		X		X			X		X		X
Legal-RuleML		X			X		X	X			X
METSRights		X	X				X		X		X

31: RELs expressivity and application area

4.5. RQ 1.4

How is the comparability of the discussed RELs in respect to its Data Model?

As every REL has a purpose to exist and got developed out of a specific need most of them work in different ways. These differences can be seen in the Data Model section. Nevertheless, there are Data Models which are similar.

When comparing the different data models of the RELs, the models of **OMA DRM**, **LegalRuleML, PLUS, TV-Anytime, ccREL** and **METSRights** are very similar regarding its structure as it only has one title and many different equal sections.

The **AVS-REL** and **MPEG-21** are similar in its structure as well as both titles are called licenses.

XACML, ODRL and **RightsML** are similar in respect to its structure. Furthermore, their titles are called policy.

The **WS-Agreement** and **ebXML** are both agreement models. The WS-Agreement over service agreements and ebXML over business agreements.

Nevertheless, they all work in similar ways as there is always one or more subjects that want a specific resource under certain conditions/constraints. This can be seen in all 13 RELs in one or another way, as it represents the core model of the RELs.

4.6. RQ2

What are future perspectives of these RELs?

As already stated, RELs are an important topic. Especially in connection with the ongoing digitization and the trend of automation, it will even grow due to its importance.

As the 13 discussed RELs became important standards over the last years they will be updated regularly in the future to stay up-do-date in a fast-changing environment.

RELs are often used in a digital rights management system to manage copyright agreements electronical in an unambiguous machine-readable form. But RELs do not have to be used in a DRM system. RELs can help express certain terms in an machine-readable form. As one example the LegelRuleML can be used in many different areas like the eHealth domain to model privacy issues and security policies, in the open data domain or in the patent law.

But as seen in the chapter 1.2 (Digital Rights Management: Basics and Trends) the REL technology can profit enormous from trends like artificial intelligence, law robots or the blockchain technology in the future and can be used in all areas that need to be machine-readable.

5. Conclusio

This master thesis should give an overview over 13 different RELs and compare them in respect to the built category system. The first answered research question showed that today there exist relatively young RELs. Moreover, most of the existing RELs get regularly updated. This can be an indicator that RELs grew more important over the last years.

The second question illustrated that although RELs were developed in the 1990s, they get even more important today.

In respect to the third question, the RELs were reviewed concerning their possible application areas. If a REL could be used in one to three application areas it got classified as special purpose REL. If it could be used in four to six application areas, it got classified as general purpose REL. This resulted in nine of the 13 RELs getting classified as special purpose and four of the 13 RELs got classified as general purpose RELs.

The fourth question compared the RELs due to its expressivity. Five of 13 RELs only define one subject, five differ between two and three differ between three or more. Concerning the actions/rights five RELs have a wide selection and eight have a special selection. The resources/assets aspect can be differentiated as six RELs can support only one specific resource and seven can support many different resources. The conditions/constraints aspect can be differentiated as seven RELs have a wide selection and six have a special selection. A detailed list of these results can be found above in the chapter 4.4.

In addition, it seems as there is a connection between the expressivity of a REL and its application area. This means that general purpose RELs like AVS-REL, MPEG-21, ODRL and RightsML supporting four to six of the application areas often also seem to have a wider range of actions/rights than special purpose RELs which seem to need only specific actions/rights and support the expression of many different resources/assets whereas many special purpose RELs also support only the expression of one specific resource/asset.

The fifth question discussed the comparability of the RELs due to its data model. In general, each REL has a specific reason to exist and got developed out of a specific need. This can be seen in the simplification of the data models as they all differ. Regardless, all have one or more subjects that want a specific resource under certain conditions/constraints. This can be seen in all 13 RELs in one or another way, as it represents the core model of the RELs.

The sixth question discussed the future perspectives of the RELs and stressed that RELs gain importance in the future. Furthermore, it will spread in its functions as it can be used in many different areas and will profit from trends like the blockchain technology or artificial intelligence.

For this master thesis it was only possible to examine 13 different RELs, although today over 60 RELs exist. Therefore, the comparison of this work only covers a small part. It could be interesting for future works to compare other RELs with the same categories as built in this thesis to be able to compare all 60 RELs. Especially because in this thesis only RELs from official standardization bodies were chosen.

Furthermore, there may also be other vital categories for comparing RELs that have not been built in this thesis.

The 13 discussed RELs became important standards over the last years. As RELs get more important with the digitization and can be used in every area that need to be machine-understandable, it is vital for the future to update them regularly to stay up-to-date in a fast-changing environment.

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Appendix

Exposé Master These

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Name Betreuer	FH-Prof. Mag. Dr. Tassilo Pellegrini	**Bestätigung der Betreuung durch Unterschrift des Betreuers**
Thema	Strategisches Management / Content Management Digital Rights Management	
Arbeitstitel	**Rights Expression Languages:** A Comparison.	
Problemstellung/Forschungs-frage	Digitisation leads to a massive increase in the capabilities to produce and distribute content at low cost and high speed. As a result, we observe a massive increase in distribution channels accompanied by an increase of content piracy, illegal downloads and many more deviant behaviour. DRM can be a solution for this problem through defining certain rules to restrain the use and distribution of digital content (Becker 2003, 1). According to Becker (2003, 4) Digital Rights Management plays an important role to explain, identify, monitor, protect and track physical and intangible goods in every form of use. The holder of rights has to identify his or her content and create business models to distribute it. Afterwards the holder of rights has to establish certain rules for the DRM system.	

	These rules or more accurate, these policies can be established through Rights Expression Languages. RELs are a subset of Digital Rights Management Technologies and are used to explain machine-readable rights of access control and of digital asset management. Through RELs behavioural aspects can be governed and usage rights can be clarified. According to Pellegrini et. al. (2018, 1) since 1990 there is a massive increase of REL-development for purposes like access control, license management or contracting. This is also resulting in more than 60 different existing RELs until today, although some derivates of older ones and others are developed to serve completely new purposes. One reason is that they are technical heterogeneous and have a high degree of diversification. Therefore, different RELs are used for different purposes and in different areas. Although Chong et. al. originally differentiate between six known REL policy types, Pellegrini et. al. (2018, 3) distinguish between three main application areas for RELs: 1) access & trust policies, 2) license policies and 3) contracting policies. The RELs can be used to express policies for one or more of these three applications at different degrees of specificity. Therefore, there are general purpose RELs and special purpose RELs specialised at one or two application areas. These developments show that Rights Expression Languages are a highly topical subject and will probably gain even more importance due to the emergence of digital business models. Therefore, Rights Expression Languages are going to be in the centre of attention in the following master thesis. The existing RELs are going to be described and classified according to a system of categories to give a better overview and an overall comparison of all existing RELs. This comparison is going to

<table>
<tr><td></td><td>cover topics like use and abilities of the certain RELs and their policies. Hence the research question is:

RQ1: What is the actual status quo of Rights Expression Languages?

RQ 1.1: What are their historical development and their genealogy?
RQ 1.2: In which application areas are RELs used?
RQ 1.3: Get the RELs updated regularly or are they deprecated?

RQ2: What are future perspectives of RELs?
</td></tr>
<tr><td>Aufbau und Gliederung</td><td>

Introduction
Problem analysis & relevancy
Approach/methods
Research question
Digital Rights Management
Definition und structure
DRM system types
Rights Expression Languages
Definition
Types
XrML
PSPL
X-SEC
DPAL
MPEG-21
LDR v2.0
ODRL v2.1
etc.
Construction of a category system
category 1
category 2
category 3
etc.
Summary
Literature
</td></tr>
<tr><td>Methodenwahl</td><td>The construction of a category system is going to be made through a systematic Literature Review based on approximately 300 published peer-reviewed academic works between</td></tr>
</table>

	1989 and today, each having an explicit reference to RELs as subject of research.
Literaturhinweise	Becker, E. (Hrsg.). (2003). Digital rights management: technological, economic, legal and political aspects. Berlin; New York: Springer. García, R., Gil, R., & Delgado, J. (2004). Intellectual Property Rights Management Using a Semantic Web Information System. In R. Meersman & Z. Tari (Hrsg.), On the Move to Meaningful Internet Systems 2004: CoopIS, DOA, and ODBASE (Bd. 3290, S. 689–704). Berlin, Heidelberg: Springer Berlin Heidelberg. Abgerufen von http://link.springer.com/10.1007/978-3-540-30468-5_44. Guth, Susanne, Simon, Bernd, Zdun, Uwe. (2003): A Contract and Rights Management Framework Design for Interacting Brokers. in: . Big Island, Hi, USA: IEEE. Pellegrini, T. (2016). Digital Rights Management - Technologien, Anwendungsbereiche und Entwicklungsperspektiven. In J. Krone & T. Pellegrini (Hrsg.), Handbuch Medienökonomie (S. 1–19). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-09632-8_79-1 Pellegrini, T, Schönhofer, A, Kirrane, S, Steyskal, S, Fensel, A, Panasiuk, O, Mireles-Chavez, V, Thurner, T, Polleres, A, Dörfler, M, (2018). Genealogy and Classification of Rights Expression Languages – PreliminaRY RESULTS. Fachhochschule St. Pölten, Vienna University of Business & Economics, University of Innsbruck, Höhne, In der Maur & Partner. p 1-8. Rodriguez-Doncel, V., & Delgado, J. (2009). A Media Value Chain Ontology for MPEG-21. IEEE Multimedia, 16(4), 44–51. http://doi.org/10.1109/MMUL.2009.78. Rodríguez-Doncela, V., Villatab Serena, Gómez-Péreza Asunción (2015): A dataset of RDF licenses. in: Frontiers in artificial intelligence and applications. Amsterdam, Niederlands: IOS Press. Abgerufen von http://oa.upm.es/36806/.