INTERNATIONAL STANDARD

ISO/IEC 21000-23

First edition
2022-11

Information technology — Multimedia framework (MPEG-21) —

Part 23: Smart Contracts for Media

Technologies de l'information — Cadre multimédia (MPEG-21) —
Partie 23: Contrats intelligents pour les médias

Reference number
ISO/IEC 21000-23:2022(E)

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

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Introduction

The Moving Picture Experts Group (MPEG) standards include a set of RDF ontologies for the codification of intellectual property (IP) rights information related to media. The ISO/IEC 21000-19 Media Value Chain Ontology (MVCO) which facilitates rights tracking for fair, timely, and transparent payment of royalties by capturing user roles and their permissible actions on a particular IP entity. The ISO/IEC 21000-19/AMD1 Audio Value Chain Ontology (AVCO) which extends MVCO functionality related to the description of IP entities in the audio domain (e.g. multitrack audio and time segments). The ISO/IEC 21000-21 Media Contract Ontology (MCO) which facilitates the conversion of narrative contracts to digital ones related to exploitation of IP rights, payments and notifications. With respect to the latter, an equivalent standard has also been developed but using XML schemas, known as ISO/IEC 21000-20 Contract Expression Language (CEL).

Furthermore, the axioms in these XML schemas and RDF ontologies can drive the execution of rights-related workflows in controlled environments, for example, Distributed Ledger Technologies (DLTs), where transparency and interoperability are favored toward fair trade of music and media. Thus, the aim of this document is to provide the means (e.g. protocols and application programming interfaces) for converting these XML and RDF media contracts to smart contracts executable on existing DLT environments.

By doing this conversion in a standard way for several smart contract languages it is going to ensure that MPEG schemas and ontologies prevail as the interlingua for transferring verified contractual data from one DLT to another.

Information technology — Multimedia framework (MPEG-21) —

Part 23: Smart Contracts for Media

1 Scope

This document specifies the means (e.g. protocols and application programming interfaces) for converting MPEG-21 XML and RDF media contracts (ISO/IEC 21000-19, ISO/IEC 21000-20, and ISO/IEC 21000-21) to smart contracts executable on existing DLT environments.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 21000-19, *Information technology — Multimedia framework (MPEG-21) — Part 19: Media Value Chain Ontology*

ISO/IEC 21000-20, *Information technology — Multimedia framework (MPEG-21) — Part 20: Contract Expression Language*

ISO/IEC 21000-21, *Information technology — Multimedia framework (MPEG-21) — Part 21: Media contract ontology*

3 Terms, definitions, symbols, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
DLT
distributed ledger technology
distributed network of computers, ideally organized in a decentralized way, mutually agreeing on a common state while tolerating failures (including malicious behavior) to some extent

3.1.2
smart contract
code deployed in a DLT or the source code from which such code was compiled

Note 1 to entry: The execution of smart contract instructions is distributed among the nodes of the DLT in which it is deployed to. This execution is triggered via a DLT transaction and produces a change in the DLT state.

3.1.3
smart contract language
programming language used for creating the code of a smart contract, that is then compiled in another code deployable to a specific DLT

3.1.4
smart contract template
source code of a smart contract written using a specific smart contract language for defining a common behavior.

3.1.5
smart contract specification
set of information needed for the deployment of a smart contract and for populating the data structures that the smart contract instructions are interacting with

3.1.6
DLT address
product of a cryptographic schema operation used to represent identities in a DLT

3.1.7
DLT governance
specification indicating the set of rules followed by the specific DLT protocol

3.1.8
token
object stored in a DLT and managed through one or more smart contracts, representing unique tangible or intangible media assets, possessions, and accountable items

3.1.9
fungible token
token being changeable with other tokens

3.1.10
non-fungible token
token being non interchangeable with other tokens

3.1.11
MPEG-21 CEL/MCO contract
contract represented using ISO/IEC 21000-19, ISO/IEC 21000-20 and ISO/IEC 21000-21 elements

3.1.12
media contractual objects
set of machine-readable objects extracted from a specific MPEG-21 CEL/MCO contract

3.1.13
smart contract for media
deployed smart contract that is the result of the conversion process from a specific MPEG-21 CEL/MCO contract

3.1.14
parser
software component that extracts a set of media contractual objects from an MPEG-21 CEL/MCO contract or a smart contract for media

3.1.15
generator
software component that from a set of media contractual objects generates an MPEG-21 CEL/MCO contract or a smart contract specification

3.1.16
DLT tokens and payments manager
component deploying a smart contract for media on a specific DLT

3.1.17
contract developer
actor providing the means to generate an MPEG-21 CEL/MCO contract or a smart contract in a specific smart contract language (e.g. smart contract templates)

3.1.18
DLT system engineer
actor providing the information needed to deploy a smart contract in a specific DLT (e.g. DLT addresses and governance)

3.2 Abbreviated terms

MVCO	media value chain ontology
AVCO	audio value chain ontology
CEL	contract expression language
MCO	media contract ontology
CEL/MCO	ISO/IEC 21000-19, ISO/IEC 21000-20, and ISO/IEC 21000-21
IP	intellectual property
API	application programming interface

4 Conventions

4.1 Classes representation

The following conventions derive from the Object-Oriented Programming paradigm. In this sense Application Programming Interfaces (APIs) are represented in terms of Classes definitions and Objects.

An Object is an instantiation of a Class while a Class contains the following properties:

— Name of the represented object.

— Type of the represented object. An object Type may be:

  — Abstract which is only showing essential information with respect to an interface, but it cannot be implemented; or,

  — Concrete which is a complete specification that can be implemented.

— Hierarchy with respect to the other objects; it also introduces the sub-class which is a class that inherits the complete set of fields and methods of its super-class.

— Fields which describe the attributes associated to the represented object; Fields consist of a specific Field Type and the number of Occurrences.

— Methods which are operations performed by manipulating the object Fields; Methods accept as input a specific set of Parameter Types and provide as output a specific set of Return Types.

In the following, Table 1 shows the notation for representing Classes with respect to MPEG-21 CEL/MCO objects, while Table 2 describes the Types used for Fields, Parameters and Returns.

Table 1 — Classes notation with respect to MPEG-21 CEL/MCO

Class			**CEL**	**MCO**
Name	**Type and Hierarchy**			
ClassName1	Abstract or Concrete, sub-class of ClassName2		*referenceToCELObject1*	*referenceToMCOObject1*
Fields				
Type	**Field and Description**	**Occ.**		
FieldName1Type	FieldName1	0, 1 or 1, n	*referenceToCELObject2*	*referenceToMCOObject2*

Methods		
Parameters	**Method and Description**	**Return**
ParameterType1	method1()	ReturnType1

Table 2 — Types used for Fields, Parameters and Returns

Type	**Description**
string	A sequence of characters
ushort	An unsigned integer number represented through 2 bytes
ulong	An unsigned integer number represented through 4 or 8 bytes
float	A floating-point number, that is a number that can contain a fractional part, represented through 4 or 8 bytes
enum	A set of enumerated named elements
boolean	A dyadic value with two possible values, True and False
typeName []	An array of elements of type typeName
map(typeName1, typeName2)	A key value mapping where the key of type typeName is used to retrieve a value of type typeName2
void	A type used to represent "no data"
idref	A type used to represent a reference to a specific object, e.g. class instance. The form of classNameIdref is used to reference objects that instantiate the class className, e.g. contractIdref refers to objects that instantiate the contract class.

4.2 Namespace prefixes

Table 3 below shows the namespace prefixes for the MPEG-21 CEL/MCO standards and other related schemas together with their references.

Table 3 — Mapping of prefixes to namespaces for the MPEG-21 CEL/MCO standards and other related schemas

Prefix	**Corresponding namespace**	**References**
dc	https://purl.org/dc/elements/1.1/	ISO 15836 [1]
dii	urn:mpeg:mpeg21:2002:01-DII-NS#	ISO/IEC 21000-3[2]
vcard	http://www.w3.org/2006/vcard/ns#	IETF RFC 2426[3]
mvco	https://purl.oclc.org/NET/mvco.owl#	ISO/IEC 21000-19
avco	https://purl.oclc.org/NET/aumvco.owl#	ISO/IEC 21000-19/Amd1
cel-core	urn:mpeg:mpeg21:cel:core:2015#	ISO/IEC 21000-20:2016
cel-ipre	urn:mpeg:mpeg21:cel:ipre:2015#	ISO/IEC 21000-20:2016

Table 3 *(continued)*

Prefix	Corresponding namespace	References
cel-pane	urn:mpeg:mpeg21:cel:pane:2015#	ISO/IEC 21000-20:2016
cel-rele	urn:mpeg:mpeg21:cel:rele:2015#	ISO/IEC 21000-20:2016
mco-core	urn:mpeg:mpeg21:mco:core:2015#	ISO/IEC 21000-21:2017
mco-ipre	urn:mpeg:mpeg21:mco:ipre:2015#	ISO/IEC 21000-21:2017
mco-pane	urn:mpeg:mpeg21:mco:pane:2015#	ISO/IEC 21000-21:2017
mco-rele	urn:mpeg:mpeg21:mco:rele:2015#	ISO/IEC 21000-21:2017

5 Overview

5.1 General aspects

MPEG-21 CEL/MCO schemas and ontologies can be used by music and media value chain stakeholders to share and exchange, in an interoperable way, all metadata and contractual information connected to creative works, leading to transparent payment of royalties and reduced time spent searching for the right data. The latter is due to inference and reasoning capabilities inherently associated with ontologies. That is, knowledge and data can be derived by evidence and logic based on rich semantic copyright models expressed by MPEG-21 CEL/MCO schemas and ontologies. In this way, the data derived are unambiguously interpretable, facilitating efficient processing in business-to-consumer (B2C) and business-to-business (B2B) music and media value chains.

Furthermore, for contractual music and media asset trading, smart contracts can be used to encode the terms and conditions of a contract. They validate contractual agreements between stakeholders before a DLT value transfer is enabled. In other words, smart contracts could allow music and media royalties to be administered almost instantaneously and manage usage allowances and restrictions. Rather than passing through intermediaries, revenue from a stream or download could be distributed automatically to rights holders, according to agreed terms and conditions (e.g. splits), as soon as an asset is downloaded or streamed.

Therefore, the challenge is converting MPEG-21 CEL/MCO standardized schemas and ontologies to smart contracts that can be executed on existing DLT environments, thus enriching DLT environments with inference and reasoning capabilities inherently associated with ontologies. Note that this process will increase trust among music and media value chain stakeholders for sharing data in the ecosystem since the data will be cryptographically secured and verified on a DLT. By addressing this challenge in a standard and agnostic way, with respect to smart contract languages and thus DLT environments, it would also ensure that MPEG-21 CEL/MCO schemas and ontologies prevail as the interlingua for transferring verified contractual data from one DLT to another[4].

5.2 Relationships between MPEG-21 CEL/MCO and DLTs

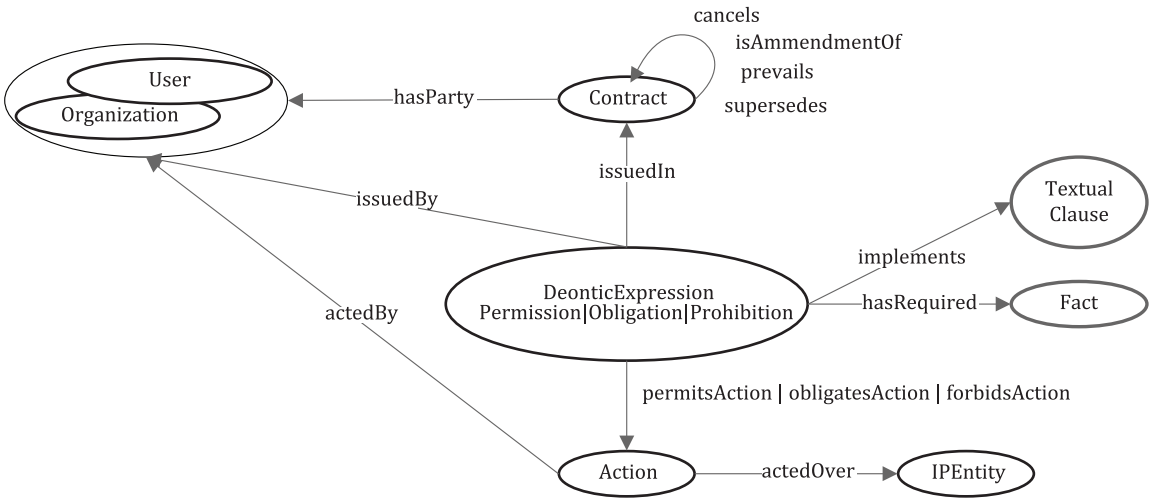
This subclause describes the relationships between MPEG-21 CEL/MCO elements and DLTs components, for the conversion of MPEG-21 CEL/MCO contracts to smart contracts for media and vice versa. Smart contracts for media are distinguished from generic smart contracts since they are the result of the conversion process from a specific MPEG-21 CEL/MCO contract.

For the description of above-mentioned relationships, the main elements identified for MPEG-21 CEL/MCO are the contract, the party, the IP entity, and the deontic expression. The counterparts in a DLT-based scenario have been identified as shown in Table 4.

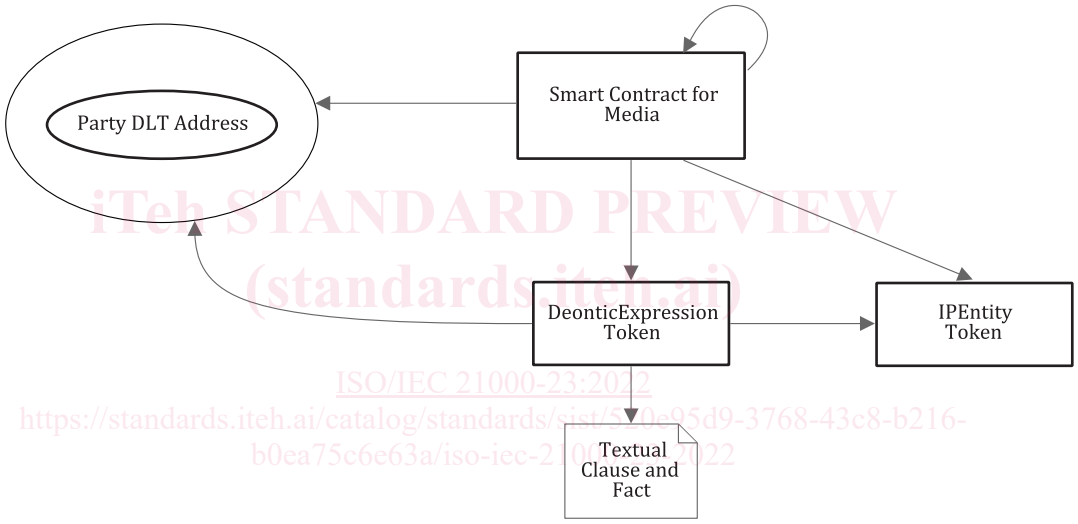
Table 4 — Relationships between MPEG-21 CEL/MCO elements and DLTs components

MPEG-21 CEL/MCO	DLTs
Contract	Smart contract for media
Party	DLT address
IP entity	Non-fungible token
Deontic expression	Non-fungible token

Furthermore, in Figure 1, as for example, the relationships between MPEG-21 MCO and DLTs are depicted, albeit similar relationships apply between MPEG-21 CEL and DLTs. These relationships are further explained in the following.



a) ISO/IEC 21000-21:2017 Media Contract Ontology



b) Relationship between ISO/IEC 21000-21:2017 Media Contract Ontology and DLTs

Key

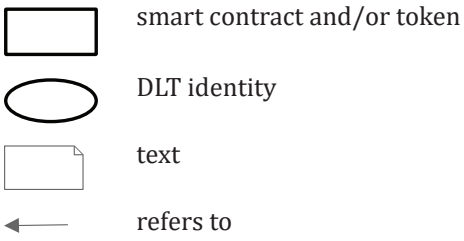


Figure 1 — Relationships between MPEG-21 MCO elements and DLTs components

1) **Contract – Smart contract for media:** the MPEG-21 CEL/MCO contract element is the one that includes or refers to the digitalized contractual information extracted from a narrative contract. Whilst the smart contract for media is the result of the conversion process from the MPEG-21 CEL/MCO contract. Thus, the counterpart of an instance of an MPEG-21 CEL/MCO contract is a unique smart contract for media deployed on a specific DLT.

2) **Party – DLT address:** a Party element is the representation of the identity of a user or organization bound by the narrative contract. Since identities in DLTs are represented through addresses, the

Party element counterpart is a DLT address. Thus, a Party identity represented by a DLT address may also be authenticated in the DLT and referenced in a smart contract for media.

3) **IP entity – Non-fungible token:** an IP Entity element is the representation of an asset, and the reference to this asset can be stored on a DLT. This representation of an asset may be serialized according to the concept of non-fungible tokens. Thus, in smart contracts an IP Entity may be represented by a token. Then, the entire set of information related to a specific IP Entity is linkable to the associated token. Two reasons support this approach:

   i) the linkage between IP Entities and related smart contracts for media is maintained at a high level, particularly when DLTs offer append-only data storage and not a more complex one;

   ii) it makes feasible the process of auditing, exploiting at best the immutability feature of DLTs; the history of all operations executed over an IP Entity, indeed, can be found in one place.

4) **Deontic expression – Non-fungible token**: a Deontic Expression encompasses the properties of an agreed machine-readable contract clause regulating the actions of the Parties (e.g. obligations, permissions, and prohibitions). This representation of a clause may also be serialized according to the concept of non-fungible tokens. The reasons for supporting this approach are:

   i) it enables a unique way for storing clauses on DLTs, that is also beneficial in terms of interoperability, for sharing these clauses with other DLT-based applications;

   ii) it allows the transfer of value in the form of obligations, permissions and prohibitions, similarly to how cryptocurrency transfers are done.

6 Bidirectional conversion between MPEG-21 CEL/MCO contracts and smart contracts for media

This clause describes the bidirectional conversion processes between MPEG-21 CEL/MCO contracts and smart contracts for media. In Figure 2 it is shown the forward conversion from MPEG-21 CEL/MCO contracts to smart contracts for media, while, in Figure 3 it is shown the backward conversion from smart contracts for media to MPEG-21 CEL/MCO contracts.

Both processes interact with several actors and DLTs where a smart contract for media would be (forward conversion) or has been (backward conversion) deployed. In the following subclauses, a set of interrelated components are described, each of which consists of a grouping of related functionality encapsulated behind a well-defined interface (e.g. inputs and outputs).

The smart contract for media may store instances of the MPEG-21 CEL/MCO contract elements either:

— in data structures of the smart contract for media; or

— in non-fungible tokens referenced by the smart contract for media, which are stored on the same DLT but managed through a different smart contract.

By storing these elements in that way, this document also facilitates the backward conversion from smart contracts for media to MPEG-21 CEL/MCO contracts in the XML[5]/RDF[6] form. In turn, MPEG-21 CEL/MCO contracts may be transformed into narrative contracts.

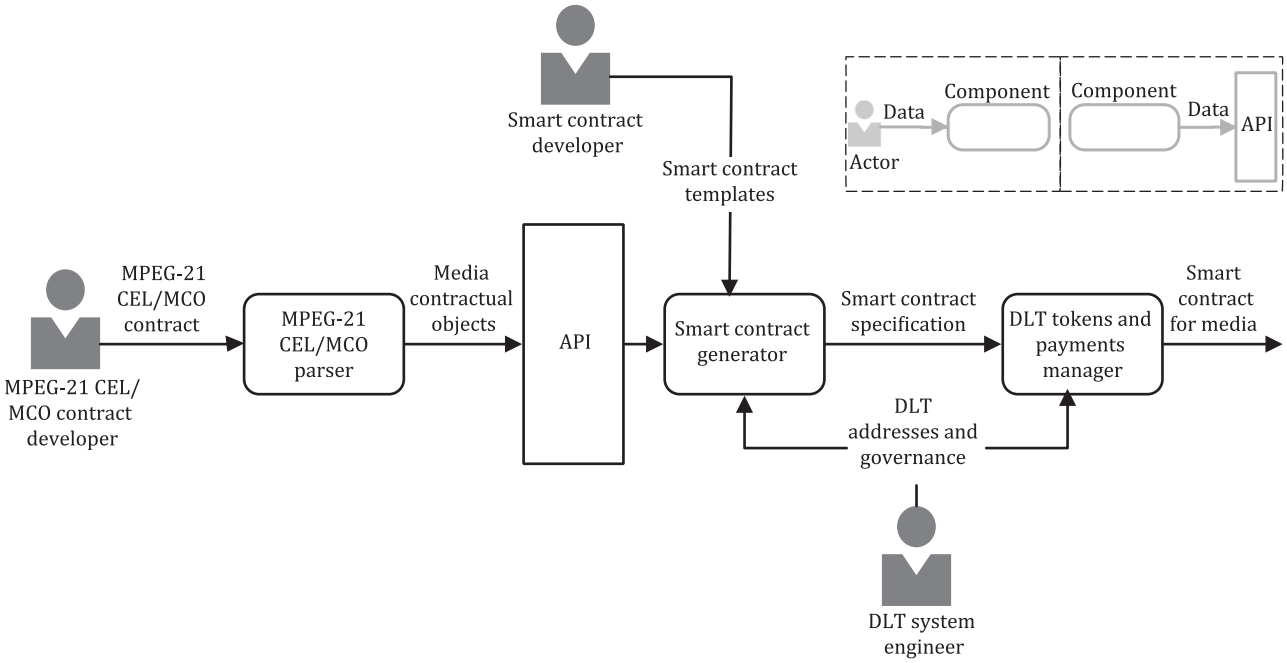


Figure 2 — Conversion workflow from MPEG-21 CEL/MCO contracts to smart contracts for media

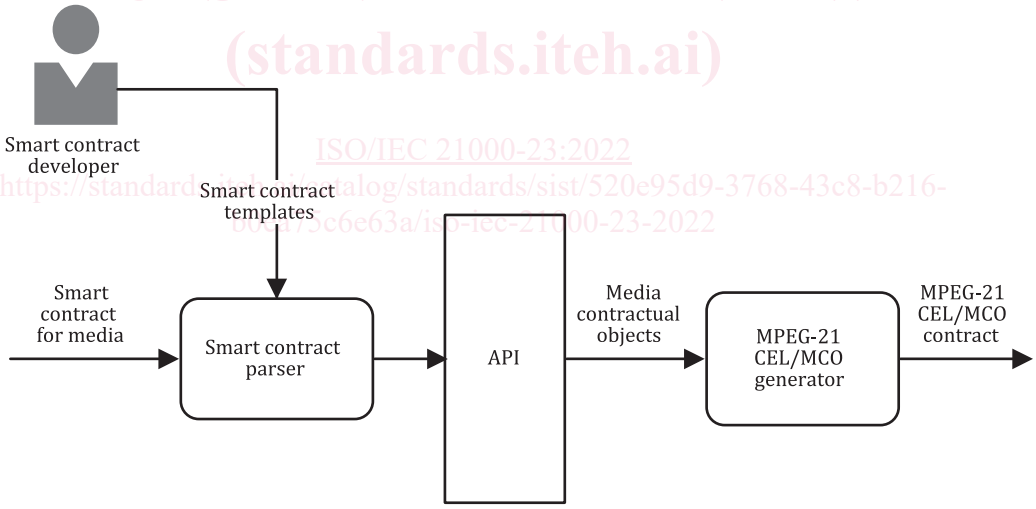


Figure 3 — Conversion workflow from smart contracts for media to MPEG-21 CEL/MCO contracts

6.1 Conversion from MPEG-21 CEL/MCO contracts to smart contracts for media

The process of conversion from an MPEG-21 CEL/MCO contract to a smart contract for media involves the execution of several components and the interaction with three actors and a DLT. This process is graphically illustrated in Figure 2.

6.1.1 MPEG-21 CEL/MCO parser

The MPEG-21 CEL/MCO parser component gets as input an MPEG-21 CEL/MCO contract, provided by an MPEG-21 CEL/MCO contract developer, and produces a set of media contractual objects. It is expected that the MPEG-21 CEL/MCO contract has been checked to be syntactically and semantically