INTERNATIONAL STANDARD

ISO/IEC 23006-1

Second edition
2013-05-01

Information technology — Multimedia service platform technologies —

Part 1: Architecture

Technologies de l'information — Technologies de la plate-forme de services multimédia —

Partie 1: Architecture

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Reference number
ISO/IEC 23006-1:2013(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This second edition cancels and replaces the first edition (ISO/IEC 23006-1:2011) which has been technically revised.

ISO/IEC 23006 consists of the following parts, under the general title *Information technology — Multimedia service platform technologies*:

— *Part 1: Architecture*

— *Part 2: MPEG extensible middleware (MXM) API*

— *Part 3: Conformance and reference software*

— *Part 4: Elementary services*

— *Part 5: Service aggregation*

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Introduction

ISO/IEC 23006 is a suite of standards that has been developed for the purpose of enabling the easy design and implementation of media-handling value chains whose devices interoperate because they are all based on the same set of technologies, especially MPEG technologies, accessible from the middleware APIs, elementary services and aggregated services.

ISO/IEC 23006 was referred to as MPEG Extensible Middleware (MXM) in its first edition, and it specifies an architecture (Part 1), an API (Part 2), a conformance and reference software (Part 3) and a set of protocols which MXM Devices had to adhere (Part 4).

ISO/IEC 23006 is referred to as Multimedia Service Platform Technologies (also abbreviated as MPEG-M) in its second edition, and it conserves the architecture and design philosophy of the first edition, while stressing the Service Oriented Architecture character. It also specifies how to combine elementary services into aggregated services (Part 5).

This second edition has been specified to address the demand of service specification for an advanced IPTV terminal (AIT). It also aims at leveraging on advanced technologies to bring into IPTV services the buoyancy of new exciting initiatives – sometimes assembling millions of users in a fortnight – that pop up almost every day with new features such as open APIs and the possibility for third parties to provide applications to those APIs.

The scope of the MPEG-M is to support the service providers' drive to deploy innovative multimedia services by identifying a set of Elementary Services (ESs) and defining the corresponding set of protocols and APIs to enable any user in an MPEG-M value chain to access those services in an interoperable fashion. Note that an MPEG-M value chain is a collection of users, including creators, end users and service providers that conform to the MPEG-M standard.

In many real-world MPEG-M value chains, service providers would not be able to exploit the potential of the standard if they were confined to only offer ESs. Therefore service providers typically offer bundles of ESs, known as Aggregated Services (ASs). In general, as shown in Figure 1, there is a plurality of service providers offering the same or partially overlapping ASs. For example, an SP offering User Description Services may offer Content Description Services as well.

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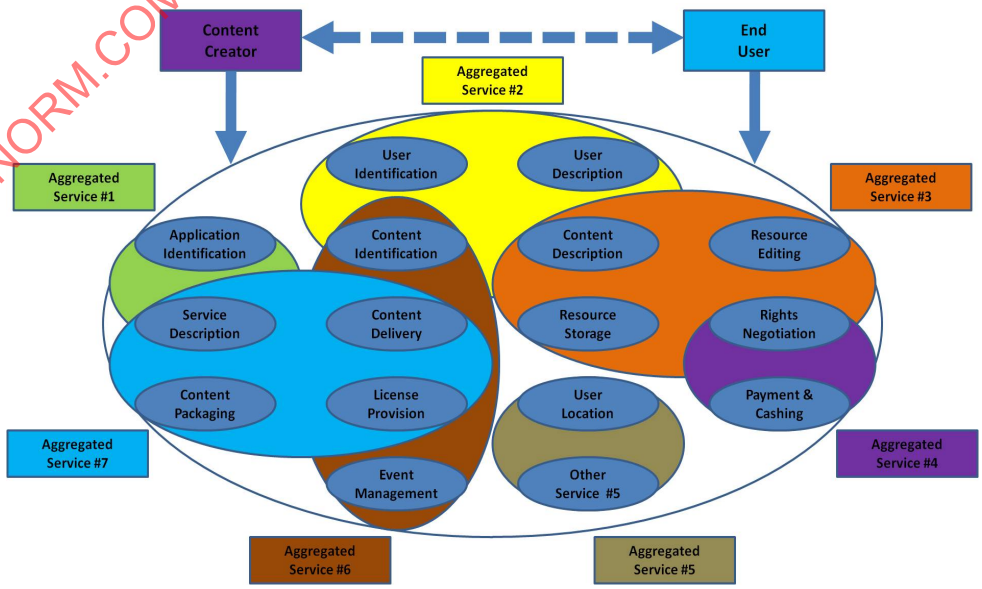

Figure 1 — Typical devices in a media-handling value chain

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Starting from ISO/IEC 23006 elementary services, the aggregation of services can put together a certain amount of services generating a complex ISO/IEC 23006 value network, having different topologies and associating services in several ways. For example, the Payment and Cashing and Rights Negotiation ESs are aggregated to create AS#4, while Content Delivery and License Provision ESs are both shared between AS#6 and AS#7.

Thanks to the ISO/IEC 23006 suite of standards, aimed at facilitating the creation and provisioning of vastly enhanced IPTV services, it is envisaged that a thriving digital media economy can be established, where:

— developers can offer MPEG-M service components to the professional market because a market will be enabled by the standard MPEG-M component service API;

— manufacturers can offer MPEG-M devices to the global consumer market because of the global reach of MPEG-M services;

— service providers can set up and launch new attractive MPEG-M services because of the ease to design and implement innovative MPEG-M value chains;

— users can seamlessly create, offer, search, access, pay/cash and consume MPEG-M services.

The MPEG-M suite of standards extends the devices capabilities with advanced features such as content generation, processing, and distribution by a large number of users; easy creation of new services by combining service components of their choice; global, seamless and transparent use of services regardless of geo-location, service provider, network provider, device manufacturer and provider of payment and cashing services; diversity of user experience through easy download and installation of applications produced by a global community of developers since all applications share the same middleware APIs; and innovative business models because of the ease to design and implement media-handling value chains whose devices interoperate because they are all based on the same set of technologies, especially MPEG technologies.

The ISO/IEC 23006 suite of standards is subdivided into five parts:

Part 1: Architecture (the present document): specifies the architecture that can be used as a guide to an MPEG-M implementation;

Part 2: MPEG Extensible Middleware (MXM) Application Programming Interface (APIs): specifies the middleware APIs;

Part 3: Conformance and Reference Software: specifies conformance criteria and a reference software implementation with a normative value;

Part 4: Elementary Services: specifies elementary service protocols between MPEG-M applications; and

Part 5: Service Aggregation: specifies mechanisms enabling the combination of Elementary Services and other services to build Aggregated Services.

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Information technology — Multimedia service platform technologies —

Part 1: Architecture

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1 Scope

This part of ISO/IEC 23006 specifies the MPEG-M architecture that is made accessible through the set of MPEG-M middleware APIs, elementary services and service aggregation specified in ISO/IEC 23006-2, ISO/IEC 23006-4 and ISO/IEC 23006-5 and as a software implementation in ISO/IEC 23006-3, respectively.

The elements of the MPEG-M Architecture are:

1. MPEG-M Engines: collections of specific technologies that are meaningfully bundled together to provide a specific functionality requested by applications;
2. MPEG-M Engine APIs: APIs that can be used by applications to access an MPEG-M Engine functionality;
3. MPEG-M Orchestrator Engine: a special MPEG-M Engine capable of creating chains of MPEG-M Engines to execute a high-level application call such as “Play” that typically requires the activation of multiple engine functionalities;
4. MPEG-M Orchestrator Engine APIs: APIs that can be used to access the MPEG-M Orchestrator Engine;
5. MPEG-M Device: a device equipped with MPEG-M Engines;
6. MPEG-M Application: an application that runs on an MPEG-M Device and makes calls to the MPEG-M Engine and MPEG-M Orchestrator Engine APIs.

The second edition of this part of ISO/IEC 23006 has been developed with a focus on advanced IPTV terminals. It preserves the architecture and design philosophy of the first edition, but stresses the Service Oriented Architecture character.

2 Normative references

The following referenced documents are indispensable for the application 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 23006-2, *Information technology — Multimedia service platform technologies — Part 2: MPEG extensible middleware (MXM) API*

ISO/IEC 23006-3, *Information technology — Multimedia service platform technologies — Part 3: Conformance and reference software*

ISO/IEC 23006-4, *Information technology — Multimedia service platform technologies — Part 4: Elementary services*

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ISO/IEC 23006-5, *Information technology — Multimedia service platform technologies — Part 5: Service aggregation*

OMG BPMN 2.0, Business Process Model and Notation (BPMN) Version 2.0, Object Management Group, January 2011, http://www.omg.org/spec/BPMN/2.0/

3 Terms and definitions

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

3.1
Device
combination of hardware and software or just an instance of software that allows a user to perform actions

3.2
Domain
set of **devices** sharing a set of common properties such as ownership

3.3
Inter-MPEG-M Protocol
protocol that enables communication between MPEG-M Devices

3.4
MPEG-M Application
application that runs on an MPEG-M Device and makes calls to the MPEG-M Application API and MPEG-M Engine APIs

3.5
MPEG-M Device
device equipped with a selected set of MPEG-M engines

3.6
MPEG-M Engine
collection of specific technologies that are bundled together to provide a specific functionality that is needed by MPEG-M Applications

3.7
MPEG-M Engine API
API of a single MPEG-M Engine

3.8
MPEG-M Orchestrator API
API of the MPEG-M Orchestrator Engine

3.9
MPEG-M Orchestrator Engine
special MPEG-M Engine capable of creating chains of MPEG-M engines, i.e. to set-up a sequence of connected MPEG-M engines for the purpose of executing a high-level application call such as Play.

3.10
MPEG-M Technology
technology that is required to implement (a profile of) MPEG-M

3.11
User
any entity making use of an MPEG-M **device**

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4 Symbols and abbreviated terms

BBL	Bitstream Binding Language
BPMN	Business Process Model and Notation
DIA	Digital Item Adaptation
DID	Digital Item Declaration
DIDL	Digital Item Declaration Language
DII	Digital Item Identification
DIS	Digital Item Streaming
ER	Event Report
ERR	Event Report Request
IPMP	Intellectual Property Management and Protection
REL	Rights Expression Language
RTP	Real Time Protocol
RTSP	Real Time Streaming Protocol
URI	Uniform Resource Identifier

5 Namespace conventions

Throughout this part of ISO/IEC 23006, Qualified Names are written with a namespace prefix followed by a colon followed by the local part of the Qualified Name.

For clarity, throughout this part of ISO/IEC 23006, consistent namespace prefixes are used. Table 1 gives these prefixes and the corresponding namespace.

Table 1 — Namespaces and prefixes

Prefix	Corresponding namespace
mpegm	urn:mpeg:mpegM:schema:02-service-NS:2011
mpegmb	urn:mpeg:mpegM:schema:01-base-NS:2011
dia	urn:mpeg:mpeg21:2003:01-DIA-NS
erl	urn:mpeg:mpeg21:2005:01-ERL-NS
fru	urn:mpeg:mpegB:schema:FragmentRequestUnits:2007
mpeg7	urn:mpeg:mpeg7:schema:2004
mpeg7s	urn:mpeg:mpeg7:systems:2001
cel	urn:mpeg:mpeg21:cel:contract:2011
bbl	urn:mpeg:mpeg21:2007:01-BBL-NS
dii	urn:mpeg:mpeg21:2002:01-DII-NS
mpqf	urn:mpeg:mpqf:schema:2008
mpeg4ipmp	urn:mpeg:mpeg4:IPMPSchema:2002
ipmpdidl	urn:mpeg:mpeg21:2004:01-IPMPDIDL-NS
ipmpmsg	urn:mpeg:mpeg21:2006:07-IPMPMESSAGES-NS
ipmpinfo	urn:mpeg:mpeg21:2004:01-IPMPINFO-NS

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Prefix	Corresponding namespace
didl	urn:mpeg:mpeg21:2002:02-DIDL-NS
didl-mpegm	urn:mpeg:mpegm:2011:12-DIDL-NS
didmodel	urn:mpeg:mpeg21:2002:02-DIDMODEL-NS
didl-msx	urn:mpeg:maf:schema:mediastreaming:DIDLextensions
dii	urn:mpeg:mpeg21:2002:01-DII-NS
rel-r	urn:mpeg:mpeg21:2003:01-REL-R-NS
rel-sx	urn:mpeg:mpeg21:2003:01-REL-SX-NS
xsd	http://www.w3.org/2001/XMLSchema
xsi	http://www.w3.org/2001/XMLSchema-instance
dsig	http://www.w3.org/2000/09/xmldsig#
xenc	http://www.w3.org/2001/04/xmlenc#

6 System overview

The MPEG-M Platform is an end-to-end platform populated with MPEG-M Devices.

Figure 2 shows a rather general configuration of a media value chain with the explicit indication of MPEG-M devices with specific functionalities. The figure also highlights some protocols that are used by different MPEG-M devices to communicate with one another.

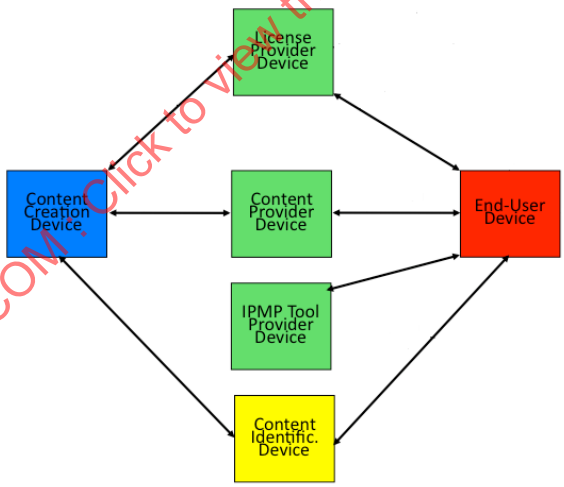

Figure 2 — Typical devices in a media-handling value chain

A general architecture of an MPEG-M Device is given in the figure below where MPEG-M Applications running on an MPEG-M Device call the Engines in the Middleware via an Application-Middleware API.

In general an MPEG-M Device can have several MPEG-M Applications running on it (there may be other applications but these are not relevant here). Some may be “resident”, i.e. they have been loaded by the MPEG-M manufacturer and some may be temporary, i.e. they have been downloaded for a specific purpose.

Engines are of two types: Protocol Engines (specified in ISO/IEC 23006-4) and Technology Engines (specified in ISO/IEC 23006-2).

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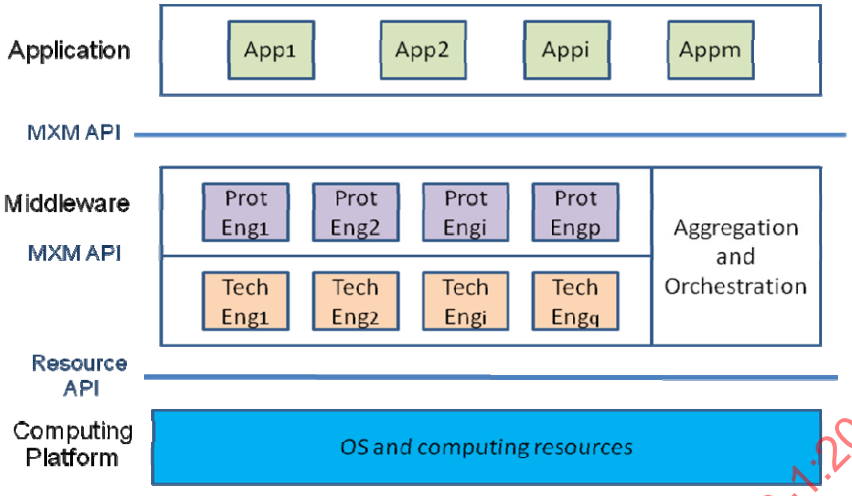

Figure 3 — Generic MPEG-M Device architecture

Two Applications running on networked MPEG-M Devices communicate by executing service protocols as depicted in the figure below.

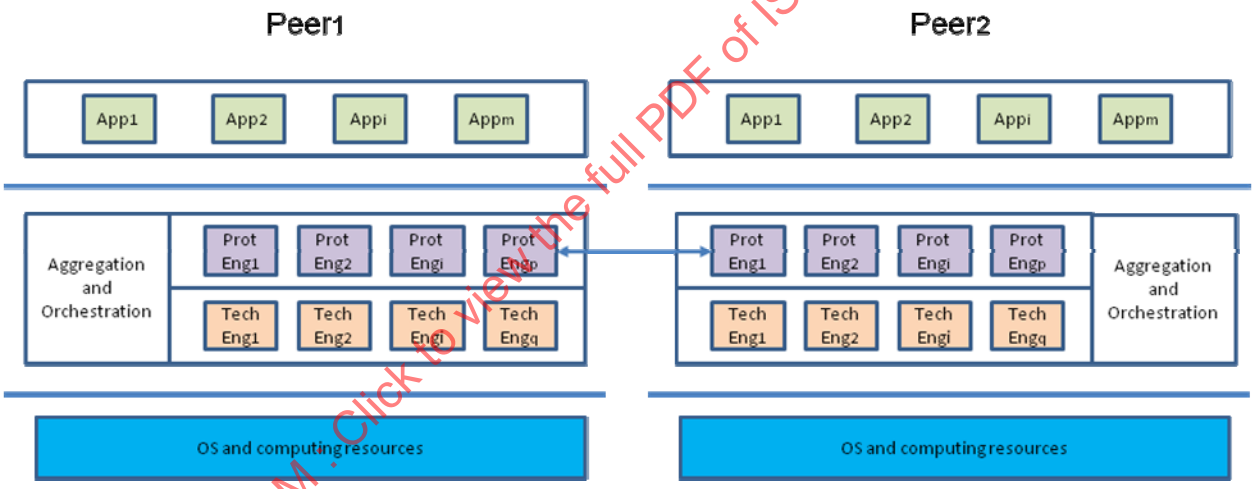

Figure 4 — Communication between two MPEG-M Devices

When the MPEG-M Device on the right hand side (e.g. a “client”) communicates to the MPEG-M Device on the left hand side (e.g. a “server”) the following happens:

1. A client Application makes a Service request (e.g. an Elementary Service such as Create Licence) using a Protocol Engine

2. The corresponding server-side Protocol Engine, upon receiving the request, calls the appropriate Orchestrator Engine’s API functionality (e.g. REL Orchestration) or chain of Engines

3. The Orchestrator Engine on the server, if required, sets up a chain of Engines: in the REL example just one Technology Engine (the REL Engine) creates the requested licence

4. The server-side Protocol Engine returns the Licence to client-side Protocol Engine.

The same happens if the client Application makes an Aggregated Service request. In this case the Orchestrator Engine sets up a more complex chain of Technology and Protocol Engines.

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When an MPEG-M Application is executed, “low-level” calls may be made directly to some MPEG-M Engines using the MPEG-M Engine APIs of each specific Engine, and “high-level” calls like, say, “Play (GovernedContent)” which will be handled by the Orchestrator Engine. This is depicted in the figure below:

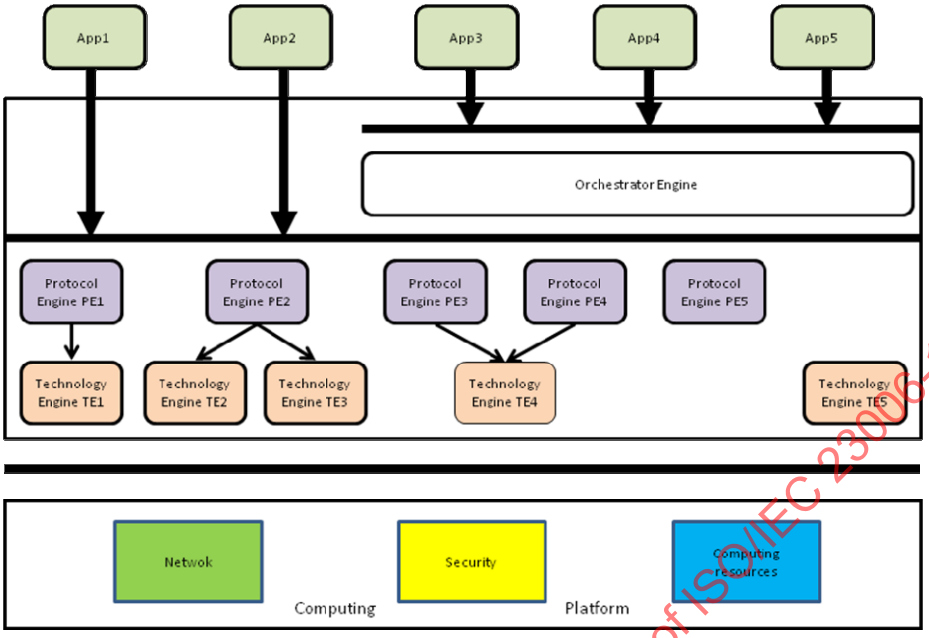

Figure 5 — MPEG-M Device architecture

Making reference to the above figure, the following possibilities exist for an App:

1. It calls a PE which in its turn calls a TE
2. It calls a PE which in its turn calls a plurality of TEs
3. It calls a combination of PEs which call a single TE
4. It calls a PE
5. It calls a TE
6. It calls the Orchestrator Engine APIs

The MPEG-M Orchestrator, by calling the MPEG-M Engine APIs of specific engines, is capable of setting up chains of MPEG-M engines for handling complex operations, orchestrating the intervention and send/receive data to/from the particular chain of Engines that a given high-level call will trigger, thus relieving MPEG-M Applications from the need to carry the logic of handling them. Each MPEG-M Engine will contain a specific set of MPEG-M Technologies accessible by an MPEG-M Application, the MPEG-M Orchestrator and any other MPEG-M Component in MPEG-M, by means of its own MPEG-M Engine API.

For instance, in the case of “Play (GovernedContent)” the Orchestrator engine could set-up the following chain:

a) MP21 File engine (e.g. open the file and extract the Digital item)
b) DI engine (e.g. extract metadata and rights information)
c) REL engine (e.g. verify if the right to play is granted)
d) IPMP engine (e.g. set up IPMP Tools to decrypt protected resources)
e) Security engine (e.g. initialise the IPMP Tools with decryption keys)
f) Metadata engine (e.g. present content metadata to the user)
g) Media Framework engine (e.g. demux, decode and render audio-visual resources) and possibly others.

NOTE Only the APIs of an MPEG-M Engine are mandatory; how each Engine handles the operations needed to carry out a request is dependent on the specific software or hardware MPEG-M Engine implementation.

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Figure 6 depicts the general case of an aggregated service implemented by the aggregation of three PEs (PE_a, PE_b and PE_c), the first calling a single TE, the second three TEs and the third two TEs.

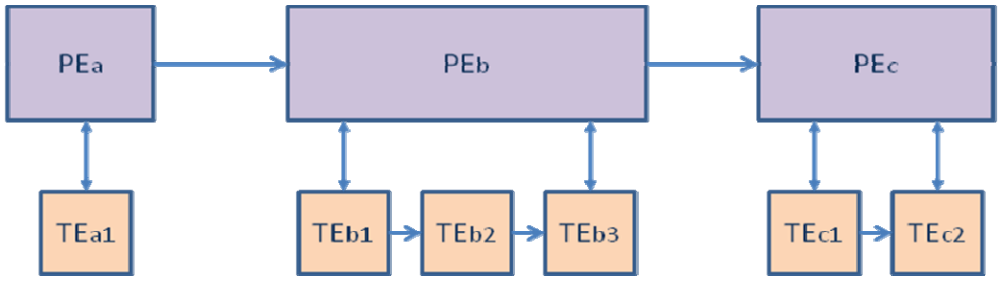

Figure 6 — Engine aggregation and orchestration

Examples of MPEG-M Applications include:

- Video Viewer – a program to view videos
- Photo Player – a program to view still pictures
- Content Creator – a program to create content with audio-visual resources, metadata and rights information
- MPEG-J applet
- Licence server – a remote service issuing licences upon request

7 MPEG-M Architecture

7.1 Introduction

MPEG-M specifies an architecture containing MPEG standard multimedia technologies whose purpose is to enable the easy design and implementation of media-handling value chains whose devices interoperate because they are all based on the same set of technologies exposed through standard APIs.

The elements of the MPEG-M Architecture are:

1. MPEG-M Engines: collections of specific technologies that are bundled together to provide a specific functionality that is needed by MPEG-M Applications
2. MPEG-M Engine APIs: APIs that can be used to access MPEG-M Engine functionality
3. MPEG-M Orchestrator Engine: a special MPEG-M Engine capable of creating chains of MPEG-M Engines to execute a high-level application call such as “Play”
4. MPEG-M Orchestrator Engine APIs: APIs that can be used to access the MPEG-M Orchestrator Engine
5. MPEG-M Device: a device equipped with MPEG-M Engines
6. MPEG-M Application: an application that runs on an MPEG-M Device and makes calls to the MPEG-M Engine API and MPEG-M Orchestrator Engine APIs

The MPEG-M Engine APIs are divided in three categories. The first two categories include those recurring for more than one engine, while the latter category includes those APIs which are specific for one Engine. The terminology for the three categories is given below:

- Creation APIs: these include APIs to create data structures, files, elementary streams, etc. conforming to the respective standards

- Access APIs: these include APIs to parse data structures, files, decode elementary streams, etc. in order to retrieve the information contained within

- Engine-specific APIs: these include specific APIs of an MPEG-M Engine

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7.2 MPEG-M Engines

The list of MPEG-M Engines is provided in the table below.

Table 2 — MPEG-M Engines and classification of their APIs

No.	Engine	Creation	Access	Engine-specific
1	Digital Item	Y	Y	
2	MPEG-21 File Format	Y	Y	
3	REL	Y	Y	• Validation • Authorisation
4	IPMP	Y	Y	• IPMP Tool Instantiation • IPMP Tool Initialisation
5	Media Framework	Y	Y	
6	Metadata	Y	Y	
7	Event Reporting	Y	Y	• Register Events • Transmit Event Reports
8	Security	Y	Y	• Authentication • Integrity
9	Search	Y	Y	
10	CEL	Y	Y	
11	Overlay	Y	Y	• Store/Retrieve messages • Propagate message

NOTE Where no engine-specific API is defined the corresponding MPEG-M Engine has no Engine-specific API

7.3 MPEG-M Elementary Services

For ease of reference the list of MPEG-M Elementary Services is provided below:

Elementary Service	Description
Authenticate Content	Allowing Users to confirm the identity of a Content item in an MPEG-M value chain
Create Content	Allowing Users to create a Content remotely
Deliver Content	Allowing Users to transfer Content between Users of an MPEG-M value chain
Describe Content	Allowing Users to associate metadata to Content in an MPEG-M value chain
Identify Content	Allowing Users to assign Identifiers to Content in an MPEG-M value chain
Package Content	Allowing Users to make Content ready for delivery
Post Content	Allowing Users to let other Users access their Content
Process Content	Allowing Users in an MPEG-M value chain to perform operations on Content
Request Content	Allowing Users to retrieve a Content

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Elementary Service	Description
Revoke Content	Allowing Users to revoke availability of a Content
Search Content	Allowing Users to search for a Content
Store Content	Allowing Users to save Content for later use
Transact Content	Allowing Users to transact a Content
Authenticate Contract	Allowing Users to confirm the identity and signers of a Contract in an MPEG-M value chain
Check With Contract	Allowing Users to verify if a usage request matches with the content (e.g., obligations, prohibitions) expressed in a Contract
Create Contract	Allowing Users to generate a Contract in an MPEG-M value chain
Deliver Contract	Allowing Users to transfer Contract between Users of an MPEG-M value chain
Identify Contract	Allowing Users to assign Identifiers to Contract in an MPEG-M value chain
Negotiate Contract	Allowing Users of an MPEG-M value chain to achieve an agreement on the terms and conditions of use e.g., obligations and prohibitions, with respect to a Content item, a Device or a Service
Present Contract	Allowing Users to understand Contract
Request Contract	Allowing Users to request for a Contract in an MPEG-M value chain
Revoke Contract	Allowing Users to discontinue the validity of a Contract
Search Contract	Allowing Users to search for a Contract
Store Contract	Allowing Users to save Contract for later use
Verify Contract	Allowing Users to check the integrity of a Contract in an MPEG-M value chain
Describe Device	Allowing Users to associate metadata to Devices of an MPEG-M value chain
Identify Device	Allowing Users to assign a unique Identifier to Devices of an MPEG-M value chain
Request Device	Allowing Users to request for a Device in an MPEG-M value chain
Search Device	Allowing Users to search for a Device
Verify Device	Allowing Users to check the integrity of a Device
Request Event	Allowing Users to request the creation of an Event Report for one or more Events that have occurred or are to occur
Store Event	Allowing Users to store an Event
Authenticate Licence	Allowing Users to confirm the identity and issuance of a Licence in an MPEG-M value chain

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Elementary Service	Description
Check With Licence	Allowing Users to obtain authorization of a usage request according to Rights expressed in a Licence
Create Licence	Allowing Users to generate a Licence in an MPEG-M value chain
Identify Licence	Allowing Users to assign Identifiers to Licence in an MPEG-M value chain
Negotiate Licence	Allowing Users to achieve an agreement on the terms and conditions of use e.g., rights and conditions, of a Content item, or a Service
Present Licence	Allowing Users to understand Licence
Process Licence	Allowing Users to change the content of a Licence
Request Licence	Allowing Users to request a Licence in an MPEG-M value chain
Revoke Licence	Allowing Users to discontinue the validity of a Licence
Search Licence	Allowing Users to search for a Licence
Store Licence	Allowing Users to save Licence for later use
Transact Licence	Allowing Users to transact a Licence
Verify Licence	Allowing Users to check the integrity of a Licence in an MPEG-M value chain
Describe Service	Allowing Users to associate metadata to Services of an MPEG-M value chain
Search Service	Allowing Users to search for a particular Service
Authenticate User	Allowing Users to Authenticate Users in an MPEG-M value chain
Authorise User	Allowing Users to obtain authorization of some usage(s) by the User
Describe User	Allowing Users to Describe Users of an MPEG-M value chain
Identify User	Allowing Users to assign unique Identifiers to Users in an MPEG-M value chain
Search User	Allowing Users to search for another User

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7.4 MPEG-M Aggregated Services

MPEG-M Aggregated Services (specified in ISO/IEC 23006-5) express a process flow realizing a specific task as well as a new Elementary Service. A service provider can expose Elementary Services or Aggregated Services, constructed from several other Elementary Services and Aggregated Services. Since service aggregation is a key point of MPEG-M, BPMN (specified in OMG BPMN 2.0) has been adopted because it allows efficient description of service interactions. Moreover many different aggregation topologies (not just only a serial version of aggregation) and interaction contacts among services can be quite easily illustrated employing the BPMN graphical notation.

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7.5 MPEG-M Conformance and Reference Software

MPEG-M Conformance and Reference Software (specified in ISO/IEC 23006-3) describes the reference software and conformance profiles implementing the normative clauses of ISO/IEC 23006-1, ISO/IEC 23006-2, ISO/IEC 23006-4 and ISO/IEC 23006-5.

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Annex A
(informative)

MPEG-M Based Advanced Multimedia Platform

A.1 Introduction

This informative Annex provides an overview of requirements, functionalities and corresponding MPEG-M based technical solutions for an advanced Semantic and Content-Centric Multimedia Platform[1], that shows the ability of the MPEG-M standard to support highly innovative and emerging trends in content distribution.

The Platform supports its users in the creation, retrieval, manipulation and consumption of multimedia content represented by Digital Items, namely:

- Description of resources with metadata extracted from well-known or custom taxonomies of concepts;
- Publication of information on resources into an overlay of peers that arranges its topology based on the very same semantic models;
- Search for resources into focused regions of this semantic overlay, also in cases when a degree of heterogeneity exists between requested resources and their descriptions;
- Fetching and delivering matching content to peers using a content-centric transport of resources at the network level of the Platform.

The following Terms and Definitions will be used throughout this Annex.

Content-centric networking	A network that replaces the concept of host address with that of “name of a content”.
Peer	A device capable of acting both as service provider’s device and as end-user device.
Peer-to-peer (P2P)	A distributed architecture that partitions tasks or workloads between peers
Publication	A request to the Platform to inform an identified subset of users that a DI is available
Scalability	The ability of the Platform to accommodate a growing number of users and content with a linear impact on performance
Semantic metadata	A type of metadata based on standard as well as custom, user-created, ontologies and taxonomies.
Subscription	A request to the Platform to issue asynchronous notifications of all existing and future publications that match a user’s criterion

[1] See http://www.ict-convergence.eu/.

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A.2 Requirements

Security and Trust

- The Platform shall ensure unique and universal identification and authenticity of machines/peers, services, digital content and users.
- The Platform shall ensure privacy and non-tampering of exchanged data.
- The security core of the Platform shall not be able to forge the origin identity of users' actions, digital content and communications.
- The security core of the Platform shall be flexible enough to configure user-perceived security and privacy between the extremes of fully authenticated operations (so that trusted business models can be implemented where users know what they are buying, vendors know who users are), and a high degree of privacy and anonymity in the services deployed.

Semantic Support

- The Platform shall ensure the capability, for its users, of describing multimedia content with semantic metadata, i.e. based on ontologies and taxonomies of concepts.
- The platform shall allow users to employ such ontologies to link content with other content, establishing semantic chains of, e.g. similarity, affinity, extension and so on, between elements of multimedia content.
- The Platform shall embed additional knowledge about such ontologies and taxonomies, in order to assert equivalence of concepts between similar conceptual domains, by means of dictionaries that help translating from one semantic model to another.
- The Platform shall enable searching for content based on descriptions and usage of dictionaries to expand search queries and obtain high quality matches.

Content Centric Operation Support

- The Platform shall enable distribution of content and signalling messages based on a content-centric networking technology.
- The Platform shall ensure a high level of scalability by a decentralized and P2P management of the network between devices in the Platform.

Publish/Subscribe Operation Support

- The Platform shall enable users to publish content and subscribe to content.

Digital Forgetting

- Users shall be able to remove content from the Platform without leaving traces of its prior existence.
- User shall be able to delete previous subscriptions without leaving traces of them.

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A.3 An MPEG-M Based Solution

The Platform is composed of a set of interconnected peers. A complete architecture of a peer, built upon the core MPEG-M architecture, is depicted in Figure A.1. Each of the 3 layers has its own structure and communicates with other layers via standard APIs.

Applications provide users with the means to create, process and consume multimedia content and digital resources. Special re-usable App elements called Tools are defined, so as to facilitate re-use of code in Apps.

Middleware is the layer responsible for creating, retrieving, manipulating and consuming Digital Items and their components. Digital Items are published in the Middleware, so that they can be found via semantic search operations and delivered to users requesting, searching or subscribing to them.

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Computing Platform hosts specialized network and security modules, as well as interfaces to the local resources such as file-system and processing power.

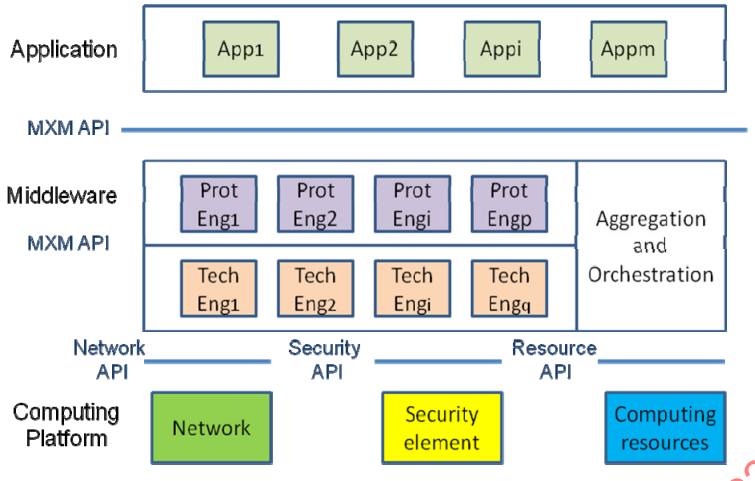

Figure A.1 — Architecture of a Platform peer

The Digital Item

The content-centric paradigm of the multimedia Platform revolves around the MPEG-21 Digital Item (DI) technology. A DI may contain:

1. Unique and persistent Identifiers
2. Semantic links to other DIs
3. Resources
4. Semantically-rich metadata describing resources
5. Licences expressing rights pertaining the manipulation of resources
6. Event reporting requests (ERR) which instruct peers to issue event reports (ER) to specific target users/peers if specific actions (e.g. play/store) are performed
7. Others…

The Platform supports three main types of DI enabling key functionalities such as publish/subscribe:

- Resource (R-DI)
- Publication (P-DI)
- Subscription (S-DI)

Semantic Overlay and Dictionaries

The Platform allows for a semantic organisation of peers in a virtual overlay network of “fractals”, which are dynamically shaped and connected, on the basis of users’ interests.

Peers join or leave a fractal based on what their users currently publish or subscribe, because users categorize published or subscribed content by referring to ontologies that describe a domain of interest.

A core ontology is devised that provides the basic structuring of the overlay into a hierarchical set of fractals, as shown in Figure A.2.

This semantic overlay is managed by Overlay Technology Engine and Post Content Protocol engines.

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Another engine for key semantic functionalities of the Platform is the Community Dictionary Service (CDS) Technology Engine. It maintains *dictionaries* that help translate concepts and properties from one ontology model to another.

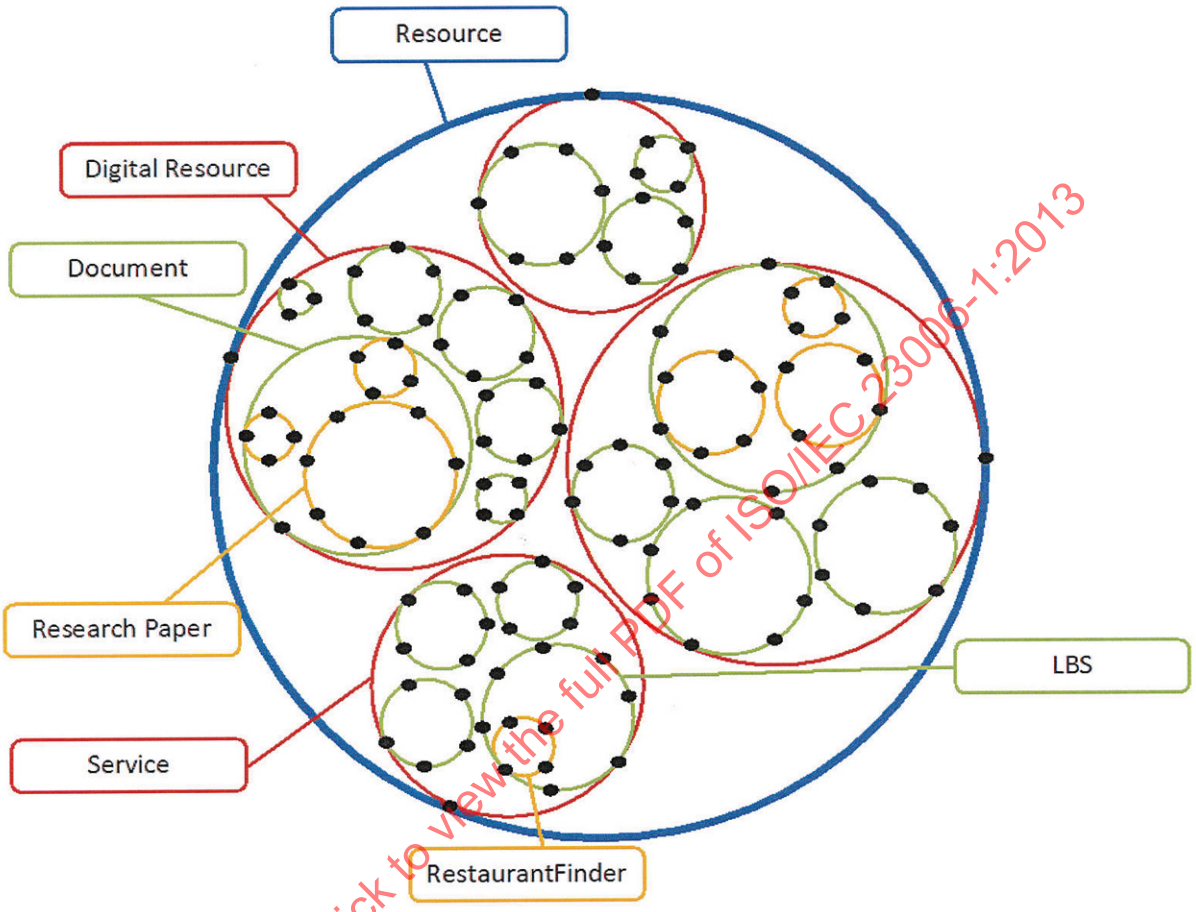

Figure A.2 — Example structuring of the overlay into fractals from the core ontology

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The CDS comes into play when users describe resources via the Describe Content protocol, and when the system performs a match between what is being published and what is being requested or subscribed to, when the knowledge from dictionaries is necessary to translate between concepts and enable the publication-to-subscription match-making.

It is to be noted that the Overlay TE and the CDS TE are Platform-specific Engines developed in accordance to the MPEG-M standard.

Publish/Subscribe Operations

The subscribe operation in the Platform is carried out by invoking a Subscribe Content Service. The publish operation, similarly, is carried out by a Publish Content Service. Publish and Subscribe are Aggregated Services because both publication and subscription are complex operations, which involve a chain of Elementary Services to be set up and run.

The subscription process can be split into three parts:

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- inserting a semantic subscription system wide
- matching a subscription once relevant content is published
- delivering a notification to the entity specified by the subscriber

This process in implemented based on the Event Reporting standard, in conjunction with the concept of a Subscription DI. The MPEG-21 event notification scheme is employed in a distributed and system-wide manner as the Event Reporting Requests are disseminated, throughout the system, by means of their containment within the Subscription DIs. A new verb representing the matching of a publication with an outstanding subscription is used.

The following Figure A.3 explains the steps involved in a complete publish/subscribe/notify cycle.

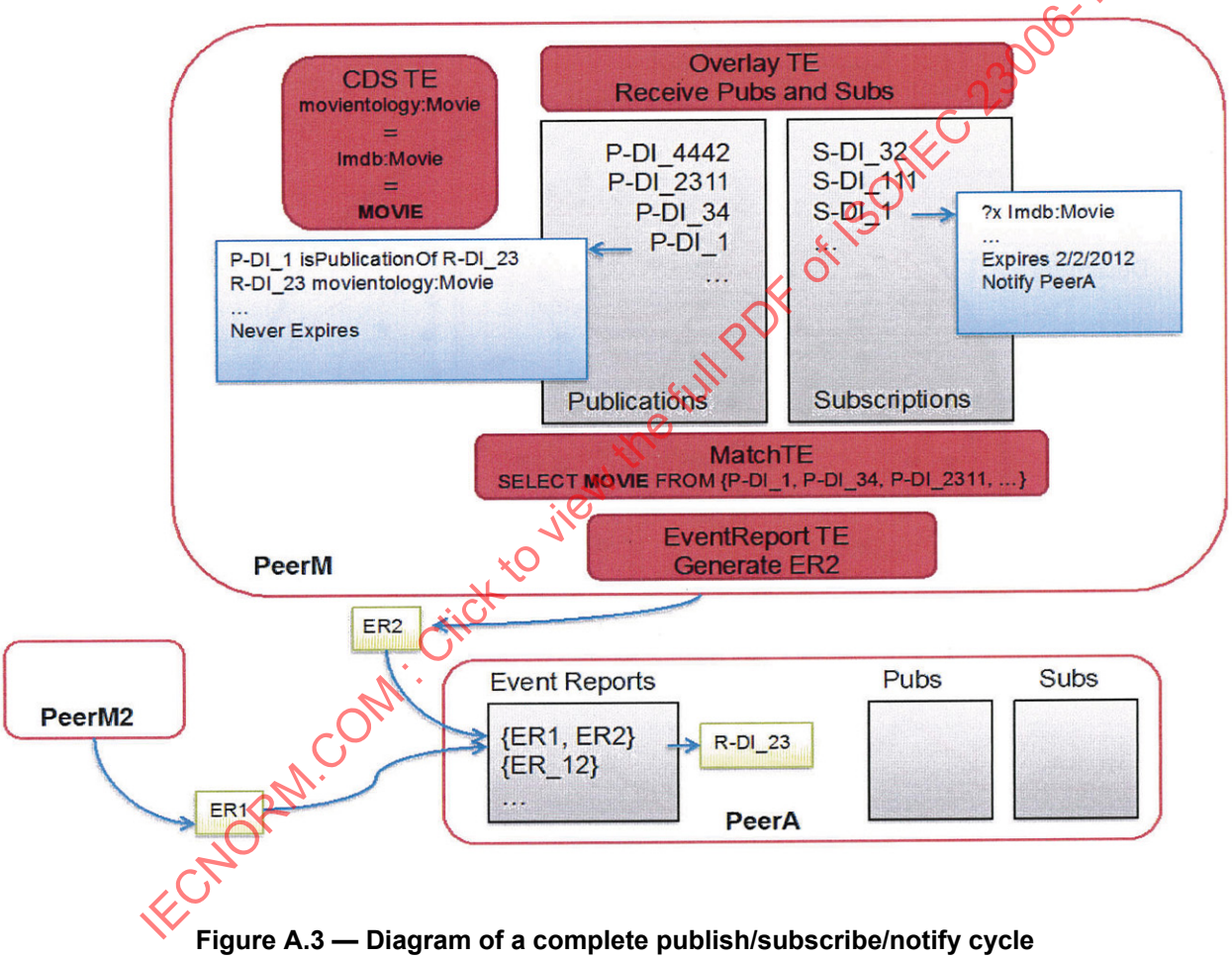

Figure A.3 — Diagram of a complete publish/subscribe/notify cycle

PeerM had received a publication (P-DI_1), which is tagged as being a *Movie* according to a certain ontology called *movientology*. This publication points to the real resource, the movie file, which is contained in a resource DI, specifically R-DI_23. This publication DI was stored in PeerM's pub/sub tables.

The publication was created by invoking the Publish Content Aggregated Service. The Publish Content Aggregated Service for publication of a R-DI involves the following main steps:

- Creation of a P-DI containing
  - Link to the stored R-DI (mandatory)
  - Metadata, usually taken from the R-DI, to be published to the system (mandatory)

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