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1 Introduction

Today, many elements exist to build an infrastructure for the delivery and consumption of multimedia content. There is, however, no 'big picture' to describe how these elements, either in existence or under development, relate to each other. The aim for MPEG-21 is to describe how these various elements fit together. Where gaps exist, MPEG-21 will recommend which new standards are required. ISO/IEC JTC 1/SC 29/WG 11 (MPEG) will then develop new standards as appropriate while other relevant standards may be developed by other bodies. These specifications will be integrated into the multimedia framework through collaboration between MPEG and these bodies.

The result is an open framework for multimedia delivery and consumption, with both the content creator and content consumer as focal points. This open framework provides content creators and service providers with equal opportunities in the MPEG-21 enabled open market. This will also be to the benefit of the content consumer providing them access to a large variety of content in an interoperable manner.

The vision for MPEG-21 is to define a multimedia framework *to enable transparent and augmented use of multimedia resources across a wide range of networks and devices* used by different communities. For a detailed examination and description of the requirements for the MPEG-21 multimedia framework readers are advised to refer to the MPEG-21 Technical Report, "Vision, Technologies and Strategy",[1] the current version of which can be found on the MPEG home page.[2]

2 MPEG-21 Multimedia Framework

Currently, multimedia technology provides the different players in the multimedia value and delivery chain (from content creators to end-users) with an excess of infomation and services. Access to information and services from almost anywhere at anytime can be provided with ubiquitous terminals and networks. However, no complete solutions exist that allow different communities, each with their own models, rules, procedures, interests and content formats, to interact efficiently using this complex infrastructure. Examples of these communities are the content, financial, communication, computer and consumer electronics sectors and their

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[1] *ISO/IEC TR 21000-1:2001(E) Part 1: Vision, Technologies and Strategy*, MPEG, Document: ISO/IEC JTC1/SC29/WG11 N3939

[2] http://www.cselt.it/mpeg

customers. Developing a common multimedia framework will facilitate co-operation between these sectors and support a more efficient implementation and integration of the different models, rules, procedures, interests and content formats. This will enable an enhanced user experience.

The multimedia content delivery chain encompasses content creation, production, delivery and consumption. To support this, the content has to be identified, described, managed and protected. The transport and delivery of content will occur over a heterogeneous set of terminals and networks within which events will occur and require reporting. Such reporting will include reliable delivery, the management of personal data and preferences taking user privacy into account and the management of (financial) transactions.

A multimedia framework is required to support this new type of multimedia usage. Such a framework requires that a shared vision, or roadmap, is understood by its architects, to ensure that the systems that deliver multimedia content are *interoperable* and that transactions are simplified and, if possible, *automated*. This should apply to the infrastructure requirements for content delivery, content security, rights management, secure payment, and the technologies enabling them – and this list is not exhaustive.

The MPEG-21 multimedia framework will identify and define the key elements needed to support the multimedia delivery chain as described above, the relationships between and the operations supported by them. Within the parts of MPEG-21, MPEG will elaborate the elements by defining the syntax and semantics of their characteristics, such as interfaces to the elements. MPEG-21 will also address the necessary framework functionality, such as the protocols associated with the interfaces, and mechanisms to provide a repository, composition, conformance, etc.

The seven key elements defined in MPEG-21 are:

Digital Item Declaration (a uniform and flexible abstraction and interoperable schema for declaring Digital Items);

Digital Item Identification and Description (a framework for identification and description of any entity regardless of its nature, type or granularity);

Content Handling and Usage (provide interfaces and protocols that enable creation, manipulation, search, access, storage, delivery, and (re)use of content across the content distribution and consumption value chain);

Intellectual Property Management and Protection (the means to enable content to be persistently and reliably managed and protected across a wide range of networks and devices);

Terminals and Networks (the ability to provide interoperable and transparent access to content across networks and terminals);

Content Representation (how the media resources are represented);

Event Reporting (the metrics and interfaces that enable Users to understand precisely the performance of all reportable events within the framework);

MPEG-21 recommendations will be determined by interoperability requirements, and their level of detail may vary for each framework element. The actual instantiation and implementation of the framework elements below the abstraction level required to achieve interoperability, will not be specified.

3 MPEG-21 Scope

The scope of MPEG-21 could be described as the integration of the critical technologies enabling transparent and augmented use of multimedia resources across a wide range of networks and devices to support functions such as: content creation, content production, content distribution, content consumption and usage, content packaging, intellectual property management and protection, content identification and description, financial management, user privacy, terminals and network resource abstraction, content representation and event reporting

From its background in key technology and information management standards related to the management, delivery and representation of multimedia content, MPEG is well positioned to initiate such an activity.

However, it is recognised that the integration of such disparate technologies can only be achieved by working in collaboration with other bodies.

In creating its definition of a multimedia framework and in making its proposals and recommendations for further standardisation, it is necessary for MPEG-21 to take account of other related multimedia activities. The Technical Report identifies other multimedia initiatives that are currently in progress that should be considered as candidates for future interaction and collaboration with the standards work plan agreed by MPEG-21.

4 User Model

The Technical Report sets out the User requirements in the multimedia framework. A User is any entity that interacts in the MPEG-21 environment or makes use of a Digital Item. Such Users include individuals, consumers, communities, organisations, corporations, consortia, governments and other standards bodies and initiatives around the world. Users are identified specifically by their relationship to another User for a certain interaction. From a purely technical perspective, MPEG-21 makes no distinction between a "content provider" and a "consumer"—both are Users. A single entity may use content in many ways (publish, deliver, consume, etc.), and so all parties interacting within MPEG-21 are categorised as Users equally. However, a User may assume specific or even unique rights and responsibilities according to their interaction with other Users within MPEG-21.

At its most basic level, MPEG-21 provides a framework in which one User interacts with another User and the object of that interaction is a Digital Item commonly called content. *Some* such interactions are creating content, providing content, archiving content, rating content, enhancing and delivering content, aggregating content, delivering content, syndicating content, retail selling of content, consuming content, subscribing to content, regulating content, facilitating transactions that occur from any of the above, and regulating transactions that occur from any of the above. Any of these are "uses" of MPEG-21, and the parties involved are Users.

The seven MPEG-21 key elements support these transactions (Figure 1):

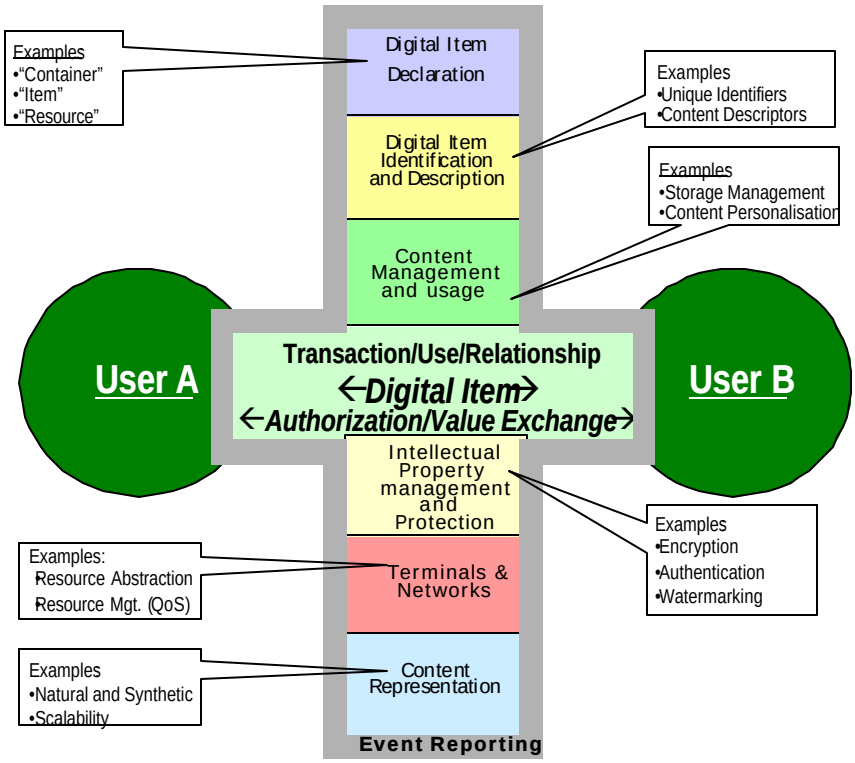

Figure 1: Event reporting, by creating metrics and interfaces, further describes specific interactions

5 Proposals and Recommendations

The following recommendations for WG11 standardisation activities with respect to the MPEG-21 multimedia framework are proposed:

5.1 Digital Item Declaration

To establish a uniform and flexible abstraction and interoperable schema for declaring Digital Items;

To ensure that media resources and descriptive data are fully separable;

To ensure that Digital items are open and extensible to any and all media resources types and description schemes;

To ensure that composite items can be constructed from other items, without losing the structure and properties of the sub-items;

To ensure that flexible configuration decision trees are declarable within the schema;

To ensure that hierarchies of containers and Digital Items can be efficiently searched and traversed;

To ensure that all Users can build and organise annotated hierarchical collections, including referential structures;

To ensure that Identification and revision of Digital Items and their components are supportable in an open and extensible manner.

5.2 Digital Item Identification and Description

WG11 should define a framework of common Digital Item identification (how to assign an ID to a Digital Item) and description:

Investigate functionalities of identifiers and descriptions in potential applications and business models including usage reporting, monitoring, tracking, licensing, etc.;

Investigate appropriate structure of identifiers such as self-descriptive and meaningful ones (e.g. country code included, etc.);

Clarify the requirements for new identification systems which do not presently exist (for 'creations', 'people', and the rights associated with creations and people) and investigate means for extensible identification and description;

Allow and enable various approaches for governance of ID issuing;

Provide, provide for, support, adopt, reference or integrate resolution system(s) to persistently associate identifiers with the location of digital objects;

Provide, provide for, support, adopt, reference or integrate standard access methods to Digital Item ID and descriptions;

Provide, provide for, support, adopt, reference or integrate interfaces to existing identification schemas and applications;

Provide a solid numbering policy and guidelines for identification and description of related Digital Items, granularity, multiple IDs, versioning, etc.;

Provide, provide for, support, adopt, reference or integrate solutions for integrity and security of IDs and descriptions;

Provide, provide for, support, adopt, reference or integrate standard solutions for insertion, modification and extraction of IDs and descriptions;

Provide, provide for, support, adopt, reference or integrate standard ID and description format;

Provide, provide for, support, adopt, reference or integrate solution for interoperability of identifiers by their integration (creating links, relationships and associations between different identification schemes used to identify components of multimedia objects);

Provide, provide for, support, adopt, reference or integrate solutions for organisation of identifiers in association with Digital Item (how is each identification system is identified and how identifiers are structured when associated with content);

Harmonisation/integration with/of existing standards.

5.3 Content Handling and Usage

Define interfaces and protocols for search, storage & management of Digital Items and descriptions that enable and support:

User(s) to express their preferences;

User(s) to locate relevant content in the network, device etc.;

The integration and interoperability of different asset management systems;

Content lifetime management and associated configurable policies;

Tracking changes to Digital Items and Descriptions;

User(s) to identify where all copies of content they own are located with associated usage restrictions.

Define interfaces and protocols for User Profile Management and Metrics that enable and support:

Creating, modifying and managing User profiles;

Creating, tracking and packaging of content usage metrics information;

Interchange formats for User profiles with other systems.

Define interfaces and protocols to bring the benefits of intelligent agents within the framework.

To operate, intelligent agents need a representation of the User's self (User profile), a knowledge about the specific domain (an ontology) and a standard language that allows the non-human entities to entertain a dialogue with other non-human entities (which will again possess knowledge about the humans they represent and a shared ontology) to achieve the goal that has been set;

To allow that a single language (Agent Communication Language) be defined. Therefore, a standardised representation of User information will be needed. Ontologies for the different domains will also need to be referenced, when available, and their development stimulated when not available. In some specific cases WG11 may need to develop specific ontologies itself.

5.4 Intellectual Property Management and Protection

In the area of managing and protecting Digital Items, it is essential to work on a trusted framework of IPMP Systems. One approach that has been suggested by a number of MPEG experts is detailed in Annex G of the Technical Report. Issues to be addressed are:

Define the attributes of a trusted environment (including technical, legal, financial, commercial, etc) for persistent management and protection of Digital Items;

Define the attributes of the interfaces between Users and agents;

Specify a framework for the enforcement of the management and protection of Digital Items;

Encompass work for the management and protection of MPEG-4 Audio-visual Objects and MPEG-7 Descriptors, Description Schemes and Descriptions, and adapt this to MPEG-21 as appropriate. In addition, the work shall be extended to cover the management and protection of other Digital Item types including personal data and rights to its use;

Specify the interfaces between transaction systems for rights management and the systems that manage and protect Digital Items.

5.5 Terminals and Networks

To achieve interoperable transparent access to (distributed) Digital Items by shielding Users from network and terminal installation, management and implementation issues, MPEG should standardise:

- APIs and associated protocols (behaviour) for terminal QoS management;
- NPIs and associated protocols (behaviour) for network QoS management;
- APIs and associated protocols (behaviour) for joint terminal and network QoS management;

- Rules for QoS contract negotiation and implementation;
- APIs enabling QoS agent technologies.

5.6 Content Representation

The goal of the 'Content Representation' item has as its goal to provide, adopt or integrate content representation technologies able to efficiently represent MPEG-21 content, in a scalable and error resilient way. The content representation of the media resources shall be synchronisable and multiplexed and allow interaction.

5.7 Event Reporting

MPEG-21 Event Reporting should standardise metrics and interfaces for performance of all reportable events in MPEG-21 and provide a means of capturing and containing these metrics and interfaces that refers to identified Digital Items, environments, processes, transactions and Users.

Such metrics and interfaces will enable Users to understand precisely the performance of all reportable events within the framework. "Event Reporting" must provide Users a means of acting on specific interactions, as well as enabling a vast set of out-of-scope processes, frameworks and models to interoperate with MPEG-21.

6 MPEG-21 Work Plan

Based on the above proposals and recommendations MPEG-21 has established a work plan for future standardisation. Three parts of standardisation within the Multimedia Framework have already started (note that the Technical Report is part 1 of the MPEG-21 Standard):

Digital Item Declaration (DID – part 2): this work item has progressed to Committee Draft level and is expected to become International Standard in 2002;

Digital Item Identification and Description (DII&D – part 3): this work item is expected to progress to CD level in October 2001 and is also expected to become International Standard in 2002.

Intellectual Property Management and Protection (IPMP – part 4): this work is at Committee Draft stage, and will be an International Standard in 2002.

All these specifications can be accessed from MPEG's website, www.cselt.it/mpeg .

6.1 ISO/IEC TR 21000-1: MPEG-21 Multimedia Framework Part 1: Vision, Technologies and Strategy

A Technical Report has been written to describe the multimedia framework and its architectural elements together with the functional requirements for their specification. This reached the status of Draft Technical Report (DTR) at the Sydney MPEG meeting in July and will be approved as a Technical Report in September 2001.

The title "Vision, Technologies and Strategy" has been chosen to reflect the fundamental purpose of the Technical Report. This is to:

Define a 'vision' for a multimedia framework to enable transparent and augmented use of multimedia resources across a wide range of networks and devices to meet the needs of all users

Achieve the integration of components and standards to facilitate harmonisation of 'technologies' for the creation, management, transport, manipulation, distribution, and consumption of digital items.

Define a 'strategy' for achieving a multimedia framework by the development of specifications and standards based on well-defined functional requirements through collaboration with other bodies.

6.2 MPEG-21 Part 2 – Digital Item Declaration

A Digital Item is a structured and hierarchical digital object containing several multimedia elements (e.g., several sound recordings and video clips) and metadata. In order to declare the structure of such a Digital Item to a user (and the device/application the user uses to interact with the content), MPEG-21 is developing an XML-based language called the Digital Item Declaration Language (DIDL). DIDL is intended to express the relationships of different objects within a particular Digital Item.

6.3 MPEG-21 Part 3 – Digital Item Identification and Description

For dealing with (1) the unique identification and (2) the description of a Digital Item (or part thereof) MPEG is developing a Digital Item Identification & Description framework.

With respect to content *identification*, the DII&D framework provides the ability to associate Uniform Resource Identifiers [3] (URIs) with an entire Digital Item or parts thereof.

With respect to the content *description*, the DII&D framework provides the ability to include metadata from various sources and in various formats including XML or plain text. DII&D allows the binding of existing Description Schemes to metadata to allow the correct processing of such metadata. This enables, for example, to include MPEG-7 descriptions or Dublin Core descriptions into a DII&D element.

6.4 MPEG-21 part 4 – Intellectual Property Management and Protection (IPMP)

The 4th part of MPEG-21 defines an interoperable framework for Intellectual Property Management and Protection (IPMP). Fairly soon after MPEG-4, with its IPMP hooks, became an International Standard, concerns were voiced within MPEG that many similar devices and players might be built by different manufacturers, all MPEG-4, but many of them not interworking. This is why MPEG decided to start a new project on more interoperable IPMP. The project includes standardized ways of retrieving IPMP tools from remote locations, exchanging messages between IPMP tools and between these tools and the terminal. It also addresses authentication of IPMP tools, and has provisions for integrating Rights Expressions according to the Rights Data Dictionary and the Rights Expression Language.

6.5 MPEG-21 part 5 – Rights Data Dictionary and MPEG-21 part 6 – Rights Expression Language

Following an extensive requirements gathering process which started in January 2001 with a Call for Requirements, MPEG completed the task during its July meeting in Sydney of defining the requirements for a Rights Data Dictionary and a Rights Expression Language. These requirements will be used in two ways: Firstly, as a basis for comparison against submissions in response to a Call for Proposals to evaluate the ability of each proponent's solutions to fulfil the stated requirements; And secondly, as a guide to measure the functionality and scope of an MPEG specification for a Rights Data Dictionary and a Rights Expression Language.

MPEG sees a **Rights Data Dictionary** as a dictionary of key terms which are required to describe rights of all Users, including intellectual property rights, that can be unambiguously expressed using a standard syntactic convention, and which can be applied across all domains in which rights need to be expressed. A **Rights Expression Language** is seen as a machine-readable language that can declare rights and permissions using the terms as defined in the Rights Data Dictionary.

The Rights Data Dictionary and Rights Expression Language are intended to provide flexible, interoperable mechanisms to support transparent and augmented use of digital resources in publishing, distributing, and consuming of electronic books, broadcasting, digital movies, digitd music, interactive games, computer software and other creations in digital form, in a way that protects digital content and honours the rights,

[3] For details on URIs refer to: IETF RFC 2396. *Uniform resource identifiers (URI): Generic syntax*. http://www.ietf.org/rfc/rfc2396.txt.

conditions, and fees specified for digital contents. It is also intended to support specification of access and use controls for digital content in cases where financial exchange is not part of the terms of use, and to support exchange of sensitive or private digital content.

The Rights Data Dictionary and Rights Expression Language are also intended to provide flexible interoperable mechanisms to ensure personal data is processed in accordance with individual rights and to meet the requirement for Users to be able to express their rights and interests in a way that addresses issues of privacy and use of personal data. (Note: Users, in this context, is as defined in the MPEG-21 Technical Report. However, it is recognized that, for the purpose of the requirements for a Rights Data Dictionary and a Rights Expression Language, such a high-level definition must be supported by more precise definitions for the different categories of User to reflect their respective roles).

A standard Rights Data Dictionary should define an extensive and unambiguous set of semantics covering the vocabulary of terms for rights expressions used in the Rights Expression Language.

A standard Rights Expression Language should be able to support guaranteed end-to-end interoperability, consistency and reliability between different systems and services. To do so, it must offer richness and extensibility in declaring rights, conditions and obligations, ease and persistence in identifying and associating these with digital contents, and flexibility in supporting multiple usage/business models.

A Call for Proposals was issued at the Sydney MPEG meeting inviting all parties that believe they possess relevant technologies for a Rights Data Dictionary or a Rights Expression Language to submit proposals for consideration by MPEG.

6.6 Future Work

6.6.1 Digital Item Usage Environment Description

Under the umbrella of Terminals and Networks (see Section 5.5) MPEG has set out to define a description of the environment in which Digital Items are used and consumed. Such a description will allow content to be adapted to usage conditions; like the environment, that could be stable or changing, the adaptation can be static or dynamic as well. In principle, all elements in the network, from source to sink, can use the description to adapt content, either the content itself (e.g. according to where a consumer is and what the circumstances are) or the way it is represented (e.g., depending on terminal capabilities and network characteristics.

A requirements effort has started, and a Call for Proposals is planned for Oct 2001.

6.6.2 Persistent Association of Digital Item identifiers and Other Identifiers to Content

As a logical extension to the ongoing specification of the Digital Item Declaration and Digital Item Identification and Description, MPEG intends to consider the requirements for the persistent association of identifiers to content. During the MPEG meeting in Sydney in July 2001 it is therefore planned to define the functional requirements for persistent association of identifiers.

The term “persistent association” is used to categorise all the techniques for managing identifiers with content. This will include the carriage of identifiers within the context of different content file formats, including file headers and embedded into content as a watermark. It also encompasses the ability for identifiers associated with content to be protected against their unauthorised removal and modification.

6.7 Timetable for MPEG-21 Standardisation

The following table sets out the current timetable for MPEG-21standardisation:

Part	Title	CfP	WD	CD PDAM PDTR	FCD FPDAM	FDIS FDAM DTR DCOR	IS AMD TR COR
MPEG-21							

1	Vision, Technologies and Strategy			01/01		01/07	01/09
2	Digital Item Declaration		01/01	01/07	01/10	02/03	02/05
3	Digital Item Identification and Description	01/01	01/03	01/10	02/03	02/07	02/09
4	Intellectual Property Management and Protection			01/07	01/10	02/03	02/05
5	Rights Expression Language	01/07	01/12	02/07	02/10	02/03	03/05
6	Rights Data Dictionary	01/07	01/12	02/07	02/10	02/03	03/05
7	Digital Item Usage Environment Description	01/10	02/03	02/07	02/10	02/03	03/05