Introduction to the Special Section on MPEG-21

THE MOVING Picture Experts Group (MPEG) is widely known and highly regarded for its pioneering work in creating the MPEG-1, -2, -4, and -7 standards. These standards define an extensive set of tools for audio-visual compression and transport as well as metadata for multimedia content description. Looking beyond these fundamental building blocks, it is clear that communication infrastructures have evolved to enable access of multimedia services anytime and anywhere. However, secure and interoperable end-to-end solutions are still not available for broad ranges of users.

MPEG-21, formally referred to as ISO/IEC 21000 Multimedia Framework, aims to address the above problem by standardizing interfaces and tools to facilitate the exchange of multimedia resources across heterogeneous devices, networks and users. More specifically, MPEG-21 standardizes requisite elements for packaging, identifying, adapting and processing these resources as well as managing their usage rights. This framework will benefit the entire consumption chain from creators and rights holders to service providers and consumers.

The basic unit of transaction in the MPEG-21 Multimedia Framework is the *Digital Item*, which packages resources along with identifiers, metadata, licenses and methods that enable interaction with the Digital Item. Another key concept in the MPEG-21 Multimedia Framework is that of a User (with a capitalized "U"), which stands for any entity that interacts in the MPEG-21 environment or makes use of Digital Items. Such Users include individuals, consumers, communities, organizations, corporations, consortia, and governments. At the most basic level, MPEG-21 can be seen as providing a framework in which one User interacts with another User and the object of that interaction is a Digital Item. Some example interactions include content creation, management, protection, archiving, adaptation, delivery and consumption.

Thus far, many of the basic normative parts of MPEG-21 have been published or approved. Table I provides a current list of the parts along with dates (or expected dates) of publication. This special section is comprised solely of invited technical papers written by authors directly involved in defining the MPEG-21 standard and applying it in practice. By describing the basic components in detail and examining related technical challenges, this special section aims to provide a definitive technical resource for MPEG-21.

This special section is organized into two major parts. The first part describes the basic components of MPEG-21, emphasizing their interaction in the Multimedia Framework. The second part investigates Digital Item Adaptation (DIA) in particular, which is central to the MPEG-21 vision of transparent use of multimedia across networks and devices. This part examines practical adaptation scenarios and reports on recent research on specific DIA algorithms and techniques.

TABLE I
PARTS OF THE MPEG-21 STANDARD

Pt.	Title	Publication Date (*Est.*)
1	*Vision, Technologies and Strategy, 2nd Edition*	Nov. 2004
2	*Digital Item Declaration, 2nd Edition*	*April 2005*
3	*Digital Item Identification*	April 2003
4	*Intellectual Property Management and Protection Components*	*Jan. 2006*
5	*Rights Expression Language*	April 2004
6	*Rights Data Dictionary*	May 2004
7	*Digital Item Adaptation*	Oct. 2004
8	*Reference Software*	*July 2005*
9	*File Format*	*Apr. 2005*
10	*Digital Item Processing*	*July 2005*
11	*Evaluation Methods for Persistent Association Tools*	Nov. 2004
12	*Test Bed for MPEG-21 Resource Delivery*	*Feb. 2005*
13	*EMPTY*	---
14	*Conformance*	*Apr. 2006*
15	*Event Reporting*	*Jan. 2006*
16	*Binary Format*	*July 2005*
17	*Fragment Identification for MPEG Resources*	*Apr. 2006*

The first overview paper by Burnett *et al.* introduces the Digital Item Declaration Language (DIDL), which uses Extensible Markup Language (XML) to declare Digital Items in the MPEG-21 Framework. Moreover, the paper discusses how DIDL integrates with the other parts of MPEG-21 and examines sample declarations of Digital Items using DIDL. The paper also discusses how Digital Item Identification (DII) is used within DIDL to address requirements for identifying items and resources in a way that is compatible with a wide range of industry practices and applications. Finally, the paper addresses the problem of binarization and compression of the XML instances of Digital Items to allow for more efficient storage and delivery.

The second paper by Wang *et al.* describes the MPEG-21 Rights Expression Language (REL), which is an XML-based language for digital rights management (DRM). REL is used to create licenses in a machine-readable form that specify rights and conditions for use of resources and services. The paper describes both the REL license data model and authorization model and presents ideas for supporting extensibility and

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profiling. The paper also describes the relationship of REL with the MPEG-21 Rights Data Dictionary (RDD). Finally, the paper investigates the expressiveness of REL by examining use cases and discusses several example applications using REL to specify licenses.

Metadata for assisting the adaptation of Digital Items according to various constraints on the storage, transmission and consumption is central to the delivery of multimedia content across diverse usage environments. The third paper, by Vetro and Timmerer, provides an overview of the Digital Item Adaptation (DIA) standard. The objective of DIA is to specify description tools and metadata that facilitate the adaptation of Digital Items. This paper also describes DIA related research activities and its use in practical multimedia applications. Finally, it reports on some of the ongoing activities in MPEG on extending DIA for use in rights governed environments.

The above papers collectively address various aspects of packing multimedia resources into Digital Items along with licenses and metadata. However, when a particular behavior of an MPEG-21 peer or terminal for processing a Digital Item is required, it must be specifically defined. The paper by De Keukelaere *et al.* describes how MPEG-21 Digital Item Processing (DIP) addresses the behavior of Digital Items through operators, methods and scripts that assist in programming of multimedia experiences. The paper describes the motivation for DIP and discusses a DIP Application Programming Interface (API) available to authors of Digital Item Methods (DIMs). Finally, the paper illustrates the interaction of DIP with the other parts of MPEG-21 and presents a walkthrough highlighting creation of interoperable DIP peers.

Following the above papers on the basic components of MPEG-21, five papers address DIA in close detail by examining specific multimedia adaptation techniques that make use of standardized DIA description tools.

As multimedia is becoming more ubiquitous, accommodating accessibility for users with visual deficiencies is becoming increasingly important. The paper by Nam *et al.* proposes techniques for personalizing the visual presentation of multimedia according to individual users' perceptual deficiencies and preferences. The authors develop approaches for adapting visual content to accommodate color vision deficiencies, low vision capabilities and preferences for color temperature. The paper reports on recent experimental results of adapting visual content using corresponding MPEG-21 DIA tools.

The next paper, by Feitan *et al.*, investigates the problem of adapting audio content using MPEG-21 DIA. The authors examine DIA tools for describing audio usage environments along with the related tools for making adaptation decisions. The paper presents several techniques for audio resource adaptation and discusses subjective and objective quality metrics that guide adaptation to obtain high audio quality.

In many cases, the challenge of DIA is to select parameter settings for maximizing Quality-of-Service (QoS) while satisfying constraints imposed by terminals, networks and users. To facilitate this, DIA specifies tools that describe relationships between constraints, feasible adaptation operations and associated utilities. The paper by Mukherjee *et al.* reviews these tools and proposes techniques for reducing compute-intensive operations that arise when solving constrained DIA optimization problems in high-dimensional spaces.

The paper by Devillers *et al.* expands on these content adaptation techniques by proposing a novel approach for coding format independent adaptation. The basic idea is to use DIA tools to describe the high-level structure of bitstreams and then transform these descriptions to form the adapted bitstreams. The paper also proposes solutions addressing difficulties in bitstream adaptation using resource-constrained devices and in streaming environments.

Finally, the paper by van der Schaar and Andreopoulos proposes a generic rate-distortion-complexity model able to generate descriptions for DIA. The model addresses network conditions and terminal resources for decoding algorithms. The solution creates a generic model of decoding complexity and adapts it for specific hardware architectures. The technique allows terminals to negotiate with servers and proxies for bitstreams with complexity levels that meet their resource constraints. This allows delivery to be optimized in an integrated rate-distortion-complexity setting, thus minimizing distortion under joint rate-complexity constraints.

We hope that this special section provides readers with a better understanding of MPEG-21 from the vision of creating a standardized interoperable multimedia framework to the technical level of the individual components. We also hope the research papers focusing specifically on multimedia access, delivery, and adaptation provide avenues for further exploration within the multimedia community.

In closing, we would like to thank the authors for their terrific efforts in preparing the manuscripts for this special section. We also thank the many reviewers for their valuable feedback throughout the review process and tremendous contribution toward producing the highest quality special section. We would also like to thank the many MPEG-21 contributors and practitioners for their efforts on realizing the MPEG-21 Multimedia Framework. We are extremely grateful to Prof. Tsuhan Chen, the past Editor-in-Chief, and Dr. Hong-Jiang Zhang, the current Editor-in-Chief, for their constant support and guidance. Lastly, we would like to thank Deborah Tomaro, Jo-Ellen Snyder, and Mercy Kowalczyk of the IEEE Signal Processing Society for their wonderful effort and guidance in preparing the MPEG-21 special section.

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