Formatting Culture.

The Mpeg group and the technoscientific innovation by digital formats

Leonardo Chiariglione and Paolo Magaudda.

Abstract This conversation reconstructs the process of technoscientific innovation of digital formats pursued in the '80s by the MPEG group led by Leonardo Chiariglione. Through a historical and cultural frame provided by Paolo Magaudda and the very words of the main character of this technoscientific story, Leonardo Chiariglione, the contribution gives fresh insights into the relationship between sociotechnical standards and the digitization of media culture.

Keywords: digital formats, standards, innovation, MPEG group, music industry.

Chiariglione, the Mpeg group and the process of standardization of digital formats

Paolo Magaudda

1. Chiariglione, digital standards and the Italian tradition of innovation

In this issue of "Tecnoscienza", we host a reflection by the Italian engineer Leonardo Chiariglione, who in 1988 founded the Moving Picture Experts Group (MPEG), the standards committee that has created digital standard for video and audio within the ISO (the International Standards Organization), and has since been in charge of the international process of standardization of digital media and formats for distributing contents. The work at Mpeg has produced some of the most important digital standards for consuming digital culture, such as the Mpeg standard for video and the even more famous Mp3, which ruled the spread of digital music, initially through diffusion of file sharing and then with the triumph of portable players such as the iPod. In sum, as founder and director of the Mpeg, Leonardo Chiariglione was one of the protagonists of some of the most delicate, yet unrecognized, process of technology transition from analogue to dig-

[1] This conversation is an expanded and edited version of the plenary session at the 4th STS Italia Conference "Emerging Technologies, Social Worlds" (Rovigo, 2012, June 21-23).

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ital encoding of culture.

It is for these reasons – the importance of the Mpeg's work, the lack of information about these processes, and the fact that Chiariglione represents one of the most important Italian innovators – that the Italian STS Society invited him to give a speech at the IV STS National Conference, held in Rovigo on 21 and 22 June 2012, and titled *Emerging Technologies, Social Worlds*. On that occasion, Chiariglione explained to the audience some aspects of the Mpeg's work and the text that follows in this section is an adaptation from his Rovigo's speech.

Although much of the work developed as Mpeg has been carried out at international level and it is only marginally linked with the Italian context, nevertheless Chiariglione represents the ongoing trajectory of a prestigious and important, even if partially forgotten, Italian tradition of innovation in the field of communication technologies. Graduated in 1967 at the Polytechnic of Turin, after a PhD gained in Japan in electrical communication, Chiariglione started his career at the end of the sixties at the CSELT, *Centro Studi e Laboratori Telecomunicazioni* [Center for Studies, Laboratories for Telecommunication], founded in Turin in 1964 within the STET group, the main firm involved at that time in developing new technical systems for telecommunications, later absorbed by the Telecom Italia Group (see Mossotto 2011).

With this professional origin, Chiariglione is without doubt a representative of a «golden age» of the Italian innovation in telecommunications. This was mostly rooted in the city of Turin, where there has been a strong focus in this area of research and still well-established institutions are located, such as the National Electrotechnical Institute Galileo Ferraris (founded in 1934) and the Center for experimental research (founded in 1930) inside the Rai, the Italian public radio-tv broadcaster. Especially, we cannot overlook the fact that Turin is also the province where the most important Italian producer of computers had his headquarters: Olivetti. Olivetti has a relevant role in early computer history, having created in 1965 what is often credited to be the first personal computer, the Programma 101 (Zane 2008; De Marco et al. 1999). Thus, the trajectory and the work of Chiariglione is significant not just for his involvement in the shaping of digital standards, but also because he represents the continuation of an important Italian tradition in the sector of telecommunication technologies, today unfortunately in decline from the technical point of view and often forgotten in public portraits of Italian cultural and industrial history.

However, the importance of Chiariglione's profile is not just central for the history of Italian technology. Over the decades, he has been involved in many projects and activities that have been relevant for development of the digital technology environment, although not all of them have been successful as the Mpeg group did. One less fortunate case was Secure Digital Music Initiative (SDMI), a forum started in 1998 and sponsored by the US recording industry, which aimed to develop specification that would enable new ways of doing business with digital music and where Chiariglione was named Executive Director (see Chiariglione 2003). Unfortunately, as narrated by media scholar Tarleton Gillespie (2008, 144-154), the project failed, having been not able to find an ef-

fective technical solution and a consensual outcome.

Considering this last failure and, more in general, how complicated is to develop collaborative processes within the entertainment industry, is thus even more interesting to analyze the instances highlighted by Chiariglione about the successful work of the MPEG working group. Hence, this *Conversation* represents a direct insight, highly significant for scholars in the social history of digital media and culture.

2. The MPEG group and the standardization of digital formats

For different reasons, it is common to recognize, among social scientists involved in media history, a scarce interest on the actual technical processes behind standards, which are often considered as transparent, mostly taken for granted tools for communication. It is surprising to note that, despite over last ten years the Internet has been subject to significant research on its history and social implications, very few analysis has been done about the actual processes that led to the creation of digital standards, formats and protocols. These forms of standardization constitute the invisible and hidden technical bases for the evolution of the internet and have deeply influenced the shaping of contemporary markets for digital culture. Among these standards and protocols, the Mpeg standards for compressed video and audio have certainly been decisive for the emergence of digital circulation of culture in the ways we today know it.

The standardized infrastructure of digital communication has often been seen as the outcome of political or strategic social processes, connected with structural powers fighting within society, as it happens in the big picture drawn by Castells (1996) about the rising of the network society or, in different way, through the goffmanian-inspired interpretation of the electronic media's effects traced by Meyrowitz (1985). In media studies we have just small niches of scholars who have focused on the materialities and technicalities of media artefacts and infrastructures (i.e. Sterne 2003; Gittleman 2006). This has meant that the history of the media has often overlooked not only emerging technologies, but also the interrelationship between their technical and material shape and contents, structures of power and social changes generated from the diffusion of media technologies.

On the other side, also STS scholars have scarcely contributed on the processes of generation of digital standards and how they affected the shaping of digital society. Even if STS have rightly recognized that information infrastructures and standards are a privileged terrain on which to develop analysis of socio-material processes and practices, STS scholars have mostly tended to focus on situations related with production and organization, rather than on phenomena directly intertwined with media, cultural consumption and cultural industries. As Wajcman and Jones have recently pointed out on this matter, "while STS has developed into a major field of social science over the last 30 years or so, media or communication technologies have not been as central a topic for it as have bio-

technologies, for example." (Wajcman and Jones 2012, p. 674). This is certainly another part of the reason why STS have not being really proactive in the analysis of standardization related with video, music and other digital cultural stuff.

This is a pity, because the study of standards of digital culture may find fruitful concepts and ideas within the STS toolbox. Looking at the role of formats and standards in shaping digital culture, STS potentialities can certainly draw from the whole theoretical framework connected with the study of infrastructures and classifications, a major trajectory in the STS field (Star and Ruhleder 1994; Bowker, Timmermans and Star 1995; Bowker and Star 1999). However, as part of the broader STS "productivistic bias", the study of informative infrastructures has privileged professional and productive contexts and it has just rarely found applications to the study of media and cultural contents (with some kind of exceptions, such as Christine Borgman's book on digital libraries, 2003). With Chiariglione's collaboration, the focus on the Mpeg experience could offer an opportunity to put in a new perspective the relationship between STS, media studies and the generation of standards for digital culture and consumption.

As Tarleton Gillespie (2008, 280) has argued in his book on the relationship between technology, copyright and digital culture, the analysis of digital flows asks us to consider as crucial those processes by which digital contents are "closed" through algorithms, formats, standards, protection systems. These processes touch the heart of the debate about which culture we want to support in the transition and translation to the digital environment. And all this implies to force media analysis to consider more carefully the heterogeneous processes – at the same time technological and commercial, institutional and social, ethical and cultural – of construction of standards, protocols and algorithms that materially shape and set the boundaries around digital culture.

3. Chiariglione and the MP3 birth

One of the rare scholarly attempts to frame the relevance of the MPEG group's work for the standardization of digital culture comes from the sociologist of sound media Jonathan Sterne, who has dedicated to this issue part of his recent book *MP3: the meaning of a format* (Sterne 2012). In this volume, the author traces the history of the mp3 music format, from the nineteenth century advancements in perceptual techniques to the present days, with several pages discussing the contribution of the Mpeg group to the digital music history. Let's see shortly what Sterne says on the Mpeg.

We are back in the eighties: the Compact Disc is gaining its *momentum*, and no one thinks that digital compressed audio would revolutionize music industry. At that time, many big companies were working in algorithms to compress the audio, but no one seemed achieving a truly satisfying solution. It is in this context that Chiariglione founded the Mpeg group to develop a decision-making process for digital compressed formats by starting a completely new procedure in the history of music industry formats, where people were used to establish new formats

trough strong, fierce commercial fights and aggressive commercial strategies. In opposition to this usual pattern, the Mp3, as Sterne writes, was instead "the result of international standard and exercise, complete with rules for participation and debate, elaborate testing systems with well-documented results." (2012, 134).

The output of the Mpeg initiative has been a strange format, originated outside of the full control of music industry and consumer electronic industries, and open to be distributed freely, even if owned by someone (the German Fraunhofer Institute, which gave the strongest technical contribution to the algorithm, has owned several patents included into the format). Mp3 peculiar features derived from the fact that the Mp3 standard incorporated practices and procedures coming from at least three distinct technical standard traditions: for consumer general devices, for broadcasting and at a lesser degree standards for computers. Three professional sectors that have been historically very different both for the relationships between their main actors and for what a "standard" was for them.

As observed again by Sterne, "the MPEG standard devised approved in 1993, "did not put to rest matters of industrial competition, nor did it ultimately settle questions of sound quality in perceptually audio codecs. But it marked an emergent, crystallized set of understandings, practices, protocols, and industrial relationships" (Sterne 2012, 146). Further details in the development of the MP3 make it clear that the process that led to the standardization of audio compression algorithms into the mp3 produced huge consequences on the shape eventually assumed by digital music.

The originality of the work carried out at Mpeg has scored a major break with the traditional paths of innovation in the field of music formats and, consequently, it has generated disruptive effects on the industry stability. Historically, patterns of innovation in this sector have been characterized by the selection of standard through forms of conflict between companies (or consortia of companies) in competition between them, or the so-called "war of formats" (see Millard 2005; Greenberg 2007). The different way represented by an open consensus process embedded by the Mpeg group led to the creation of a format, the mp3, that not only has different characteristics in terms of how it can be appropriated and used, but that also gave rise to a real revolution in the musical industry.

While in the course of the twentieth century, musical formats have been one of the tools in the hands of large corporations to control markets, technical innovation and cultural contents, in about ten years the Mp3 generated the loss of control of market by established music industry. Moreover, Mp3 was also the basis for the emergence of a new powerful actor in the music business, the Californian computer company Apple, which, while it was not in the music business as far as 2003, today controls 75% of the digital music sales in Us, more than one third of the whole music sales in that country: it is much more than how a single music company has ever controlled in recording music history. In short, when we look at the process of standardization of mp3 and at the work performed by Chiariglione's Mpeg group, we have the opportunity to see how the work of standardization has been crucial, and still remains so, in the evolution of a specific dimension of contemporary digital culture.

4. Chiariglione's perspective on MPEG work

Although it is just a perspective from a distinct protagonist of this process – thus carrying with it his biases on this matter – the following text of Leonardo Chiariglione goes through some of the points considered so far: the history of the MPEG working group, certain ideas that animated the group, some of the procedures adopted. Moreover, in his text Chiariglione also describes some of the new areas on which the group is actually at work on, including new standards for broadcasting and the new standard Media Transport (MMT) for the management of the distribution of contents to multiple devices simultaneously.

It is probably useful to highlight some of the most interesting points raised by Chiariglione. The first point he remarks at the beginning of the article is about the definition of what is a "standard". First of all, a standard is a reference "that is established by consent" and not "by authority". This subjective view reflects one of the aspects that have characterized the differences between the Mpeg work and the patterns of innovation that preceded it, focusing on the features of decision-making in establishing the standard.

He thus writes that standards are "codified agreement between parties who recognise the advantage gained from the fact that the members of a group do an agreed number of things in the same way" and that this was useful because it allowed "to convert the traditional battle between competing solutions in the marketplace to a battle between experts in a standards committee." Here we can see some of the key argumentative tools that contributed to allow the emergence of a different process of standard generation: consent, collaboration and the possibility to avoid market battles, usually cause of huge overall losses for electronic industries.

The report by Chiariglione around the Mpeg activities and practices could maybe appear a very positive and idealistic perspective, also concerning initial motivations and goals obtained by the group. For example he does not make references to conflicts and battles presumably occurred also among Mpeg members. However, as Sterne pointed out in his Mp3 history, even if Chiariglione "casts the history of computer standards in a sunnier light then probably warranted […] his idealism certainly is part of the reason MPEG worked at all" (Sterne 2012, 132). But Chiariglione would certainly tell the matter differently. As he has commented reading these notes, even if his perspective could be referred as idealistic, it is however better to make reference to "realism". Indeed – he commented – only by isolating Mpeg from the rest of the world it has been possible to overcome complexity, also highlighting that who tries to bring complexity into the business of standards is doomed to fail.

Digital Media Standardisation and Society: The MPEG experience

Leonardo Chiariglione

1. Introduction

We define digital media as digital representation of information primarily used for generation and consumption by humans. The history of mankind is dotted by many attempt to represent such information: for thousands of years handwritten characters have been engraved on all sort of physical carriers; printed characters and fonts came to the fore some 500 years ago; photographs were the result of chemical processes, characters were represented by dashes and dots; audio and video were carried on physical and immaterial carriers and so on. But the digital representation of information made possible by the latest generation of technologies has incomparable power.

The greatest attention has been dedicated so far to digital media for eyes and ears (audio, speech, video, still images, natural and synthetic graphics), but increasingly other senses are also being served (touch, smell, taste) and possibly even beyond that.

Digital media is the cleanest form (so far) of disconnection between the carrier and the information carried. To some extent that was already true of magnetic tape and cassette, to a much lesser extent it was true of radio and to an even less extent of vinyl. It can be said that before digital the carrier had so much analogue influence on the information. This paper will study some of the effect of digital standards on society and the important part of society called market.

2. About standards

There is not a single form of digital representation of information and this, again, was true also of the analogue world: posterity should be spared the epic battles between PAL and SECAM, Philips and Bosch audio cassette, VHS and Betamax, Philips/Sony and RCA Compact Disc.

A specific information representation is called format. The history of consumer electronics (but not only) is littered with "format wars". There are sufficient examples now to state that a format war is a lost opportunity for all parties engaged in the war and, primarily, the consumers, who are unwilling casualties in the battle. A format is, in the end, a form of standard, a much abused word that it will be of great help give a proper definition.

We start from the Webster's which provides not one but two definitions: "a conspicuous object (as a banner) formerly carried at the top of a pole and used to

mark a rallying point especially in battle or to serve as an emblem" and "something that is established by authority, custom or general consent as a model or example to be followed". These two definitions convey an important message: a standard is a "reference" that is established, forget by "authority", but by "consent".

The *Encyclopaedia Britannica* uses a definition that concentrates on one of the benefits of a standard because it calls a standard a technical specification "that permits large production runs of component parts that are readily fitted to other parts without adjustment".

To remove any ambiguity I would like to make reference from now on to my definition of standard:

> "codified agreement between parties who recognise the advantage gained from the fact that the members of a group do an agreed number of things in the same way".

Four issues deserve some attention:

1. The actual process (*de jure* or *de facto*) that produces the agreement is irrelevant, provided it is fair to all parties concerned (otherwise it is market distortion) and carried out to match the needs of users (otherwise the result may not be very useful);
2. The process of setting standards may be very different, even though the "status" of some agreements may be "higher" than that of other agreements;
3. The means to decide whether an implementation conforms to the agreement are part of the agreement;
4. The means to enforce the agreement are not part of the agreement.

It may also help to identify the entities in charge of defining standards for information representation. Since about 150 years the need for standards bodies with the task to ratify and sometimes develop "formats" has been recognized. Today they exist at the international, regional or national level; designed to serve the needs of specific industries or, more rarely, across industries; tightly overseen by or largely independent of governments. Here are some examples at different levels:

- International
  - International Telecommunication Union (ITU), with two branches: Telecommunication (ITU-T) and Radio (ITU-R);
  - International Organisation for Standardisation (ISO);
  - International Electrotechnical Commission (IEC).
- Regional
  - European Telecommunication Standards Institute (ETSI).
- National
  - Institute of Electrical and Electronic Engineers (IEEE);
  - American National Standards Institute (ANSI).

Standards bodies typically produce standards for certain areas. This is true also at the international level where ITU deals with "telecommunication standards", IEC deals with "electro-technical standards" and ISO deals with "everything else". Also the juridical nature of standards bodies is different: ISO and IEC are not-for-profit organisations registered in Switzerland, ITU is a Treaty Organisation and a UN agency, ETSI is an association under French law and IEEE is a professional organisation of electrical and electronic engineers. Before moving to the next chapter it is useful to dig a bit more into what is and is not a standard.

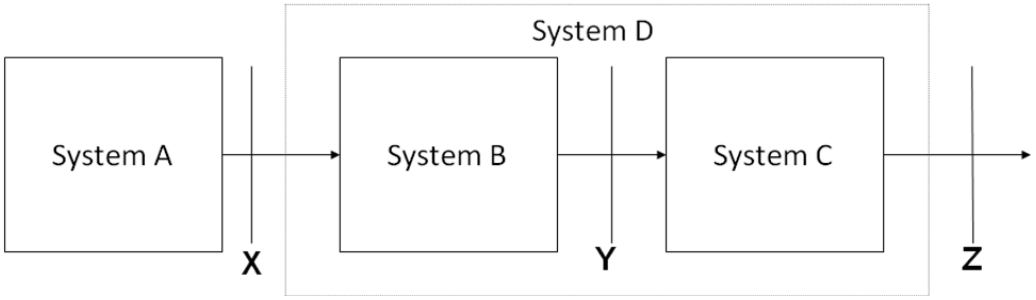

Figure 1 – Standards and interfaces

In general a standard addresses interfaces. System A interworks with System D via Interface X. System D may be subdivided in two subsystems: B and C. They are separated by interface Y. An implementation of System D may or may not implement interface Y. In the former case the interface is exposed, in the latter case nothing is said of the internals of System D, but conformance to interfaces X and Z is mandatory.

3. Enter MPEG

The MPEG idea was born toward the end of the 1980's from the consideration of the maturity of the digital audio-visual compression technology, the desirability of "audio-visual information representation" standards that were application neutral and of a global scope. Such standards would put in touch billions of communicating people without barriers and would stimulate manufacturing of communication equipment and services. The body that would carry out this task should also act as a preferential channel between research and standardization. Indeed it could only be expected that, as digital media standards were deployed, more investment in research would create more technology suitable for standardisation.

Finding a place where this grand vision could be implemented was not easy because the panorama of standardisation environment at that time was quite complex:

- In ITU-T[2], "SG XV WP 1" dealt with transmission of speech and "WP 2" with transmission of video
- In ITU-R, "SG 10" with broadcasting of audio and "SG 11" with broadcasting of video
- In IEC, "SC 60 A" dealt with recording of audio, "SC 60 B" with recording of video; "TC 84" with audio-visual equipment, and "SC 12A" and "G" dealt with receivers
- In ISO, "TC 42" dealt with Photography, "TC 36" with Cinematography and "TC94/SC 2" with Character sets.

The choice fell on the Joint ISO/IEC Technical Committee 1 (JTC 1) on Information Technology recently (1987) established by concentrating in one Technical Committee various Information Technology related standardisation activities of IEC and ISO, particularly "ISO TC 94 Data Processing".

MPEG started as an Experts Group of Working Group 8 Coding of Audio and Picture Information of Subcommittee 2 Character sets and information coding.

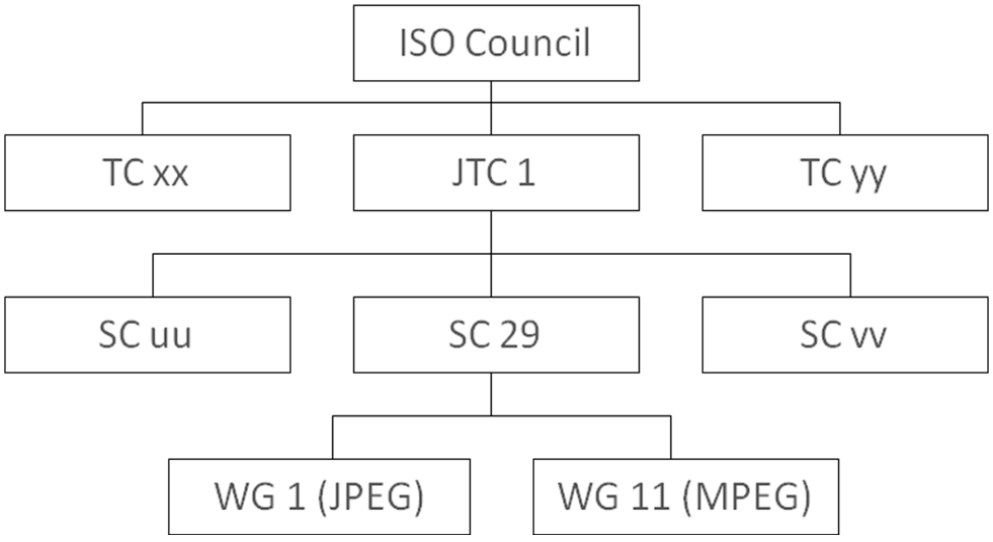

Figure 2 – Simplified ISO hierarchy.

[2] ITU-T and ITU-R stand respectively for the "T" Branch and "R" branch of ITU.

Having a body that was sufficiently neutral vis-à-vis the various industries with a stake in digital audio and video was essential to achieve the goal of making different competences add and different agendas mutually neutralize. Moreover, as digital audio and video were largely based on software it was possible to convert the traditional battle between competing solutions in the marketplace to a battle between experts in a standards committee. A fight between technologies is less expensive than a fight between assembly lines and the result is also better in terms of technology cost, functionality and performance.

The current position of MPEG in the ISO hierarchy is given in Fig. 2.

Before moving on it is important to note that decisions in MPEG are not taken by the force of numbers, but by the force of technical arguments based on which "consensus" is reached on a decision. This means that participants come to meetings with a background of intense home work to be used to fight for their arguments. Sometimes that is sufficient, but rarely there is a need to make (impose) a decision. Here is the ISO definition of consensus:

«Consensus: General agreement, characterised by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments.». (NOTE: Consensus need not imply unanimity).

4. How MPEG works

The MPEG philosophy can be summarized by the following list:

- develop standards for converging media;
- integrate the required technologies using research results from multiple sources;
- act as a bridge between academia/research and industry;
- develop software implementations of the standards as a platform for peer review and optimisation;
- verify the performance of the standard.

This philosophy is executed by a body with some remarkable figures:

- meeting frequency: 4 meetings/year;
- number of meetings: 102 until October 2012;
- attendance: ~500 experts;
- countries actively represented: ~25;
- industries represented:
  - Academia;
  - Broadcasting;
  - Computers;
  - Consumer Electronics;
  - Content;

  - Research;
  - Services;
  - Telecom;
  - …

It is interesting to study the workflow through which MPEG develops its standards:

- Identify the need for a new standard:
  - Identify the need for a standard;
  - Approval of a new standard project.
- Explore the field:
  - Seek Industry experts;
  - Open seminars;
  - Search for required technology.
  - Develop requirements:
  - Establish scope of work;
  - Call for Proposals.
- Competitive phase:
  - Study response to Calls for Proposals;
  - Initial technology selection.
  - Collaborative phase:
  - Core Experiments;
  - Working Drafts.
- Approval:
  - Committee Draft;
  - Draft International Standard;
  - Final Draft International Standard;
  - International Standard.
- Assessment of performance:
- Verification Tests.
  - Maintenance:
  - Corrigenda;
  - Amendments;
  - Withdrawal.

MPEG standards have changed the landscape of media, as this brief summary shows:

- MPEG-1, -2, -4 are used in hundreds of million devices;
- Video CD players;
- MP3 players;
- Digital TV set top boxes;
- DVD players;
- Photo cameras;
- Mobile handsets;
- Movie players.

5. An overview of some MPEG standards

MPEG-1 started from expected promising markets: interactive video on CD and Digital Audio Broadcasting (DAB). The product drivers were: Compact Disc Interactive (CD-i), Digital Compact Cassette (DCC) and Digital Audio Broadcasting (DAB). However, the result were quite discomforting: CD-i is dead, DCC is dead and DAB is (almost) dead.

By relying on the wisdom of product departments MPEG thought that:

1. Compact disc interactive would be *the* product. Instead CD-i failed but Video CD (VCD) thrived. Lesson to learn is the "Keep It Simple, Stupid" (KISS) principle.
2. Digital Audio Broadcasting would be the service but what actually happened is "mixed results". Lesson to learn is that it is hard fighting against the good enough (FM radio).
3. Digital Compact Cassette would be the product, but DCC failed. Lesson to learn is that it is hard to sell new wine in old barrels.

Still it would be hard to say that MPEG-1 is a failure, because Video CD thrives because it is a "better" VHS with hundreds of million players and billions of titles sold, admittedly as a result of industrial policy of some governments; MP3 thrives because it provides new ways of experiencing music and billions of MP3 files have about the same quality of CD.

From the technical level one could also add that, although MPEG-1 is composed of 3 parts (Systems – Video – Audio), the parts can be used independently, because it is good to give a single package as a solution, but some users may only need one or two parts. Moreover, MPEG standards only define syntax and semantics that can apply to any value (picture resolution, frame frequency, audio sampling frequency etc.) but products need "maximum parameter values". So MPEG-1 defined the Video "Constrained Parameter Set". Also, not everybody needs the same amount of technology, so MPEG-1 defines audio "layers" where to a higher layer number corresponds more performance (and complexity).

Focusing on audio, MPEG-1 teaches a few more lessons. Some thought that high compression digital music (layer III) was too complex and would never fly, but what actually happened is that MP3 is all over the place. The lessons to learn are:

1. The power of software that allowed thousands of people to develop their own software encoders and decoders, but also the power of silicon to make inexpensive devices.
2. It is very hard to stop a technology that tears down walls, particularly when the result is a cheap substitute of the original.

Speaking of cheap substitutes, some thought pay music will never fly, but

what actually happened is that a company that used to be on a drip has become the most valuable company in the world. Such is the power of packaging and the power of the faithful. The recording industry was taken by surprise by the MP3 phenomenon because, with MP3, people can find and play any song any time anywhere on any device over and beyond the "vinyl/CD straightjacket". Unfortunately, instead of giving their customers more of what they wanted, they brought them to court... The result? Today the recording industry is worth one half of what was worth in 2000.

MPEG-2 is a proof that, if you try hard, devil and holy water can live together.

MPEG-2 is also largely a 3-part standard:

1. For Systems, some wanted it ATM-friendly (ATM was a telco-sponsored broadband technology that was superseded by the Internet), some wanted it interfaced with physical channels and some wanted it storage-friendly.
2. For Video, European broadcasters and telcos wanted scalable video, American broadcasters wanted non-scalable and high definition video and Japanese broadcasters wanted non-scalable and standard definition video.
3. For Audio, some wanted it backward compatible with MPEG-1 and some wanted it independent of MPEG-1.

MPEG managed the challenges: Profiles allowed different groupings of technology serving different purposes, and Levels allowed the definition of sets of application-driven parameter values.

It is fair to say that MPEG has provided the means for the television business on air, cable and satellite to migrate from the analogue to the digital age and today there is virtually no broadcasting system that is not based, at least partially, on MPEG standards. MPEG has achieved this through a collective effort where representatives from the entire spectrum of the broadcasting world provided their requirements.

We should not underestimate the creation of packages of patent licenses (developed outside of MPEG, because MPEG only deals with technology, not licensing). These gave the means to anybody to legally use MPEG standards through open and non-discriminatory royalties.

The MPEG-7 standard is about description of audio, video and multimedia. It was a new type of coding for MPEG: not coding of assets, but coding of its descriptions. The standard has not encountered the success of MPEG-1, -2 and -4, because there is too much conservatism in incumbents. Even today few, if any, textual metadata accompany television programs, while metadata is the enabling technology for doing business with digital media.

The MPEG-21 standardisation project was born in October 1999 with the "goal to enable diffuse trading of content where every human is potentially an element of a network involving billions of content providers, value adders, pack-

agers, service providers, resellers, consumers ...". The basic elements are:

- Digital Item: a structured digital object with a standard representation, identification and metadata.
- User: a Creator, an End User or an Intermediary interacting in the MPEG-21 environment or making use of Digital Items.

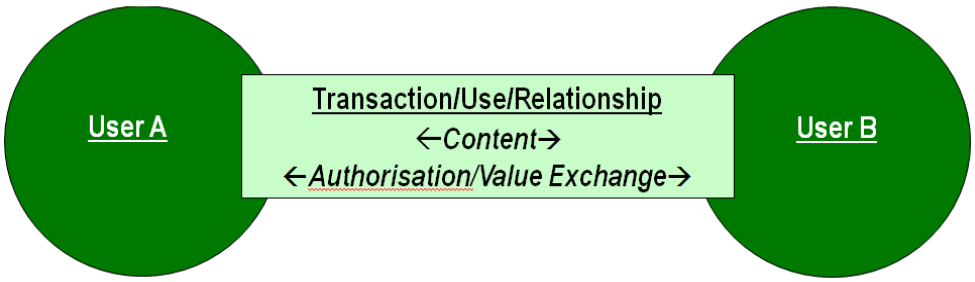

Figure 3 – The MPEG-21 elements

Unified Speech and Audio Coding was developed with the goal to achieve a single coding technology that could encode mixed content (Speech, Music and Speech mixed with Music) while being consistently as good as the best of: AMR-WB+ (state of the art speech coder) and HE-AAC V2 (state of the art music coder) in the range of 24 kb/s stereo to 12 kb/s mono.

6. Looking to the future

So far MPEG standards have addressed the problem of defining syntax and semantic of bitstreams that represent a given source of information (audio and video), like depicted in the figure 4 in the next page:

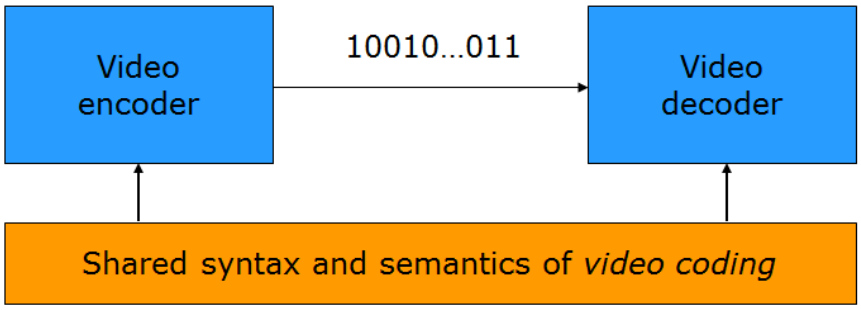

Figure 4 – Transmission of encoded video stream

The next stage in the development of technology lies in defining syntax and semantic of the algorithm used to compress the signal.

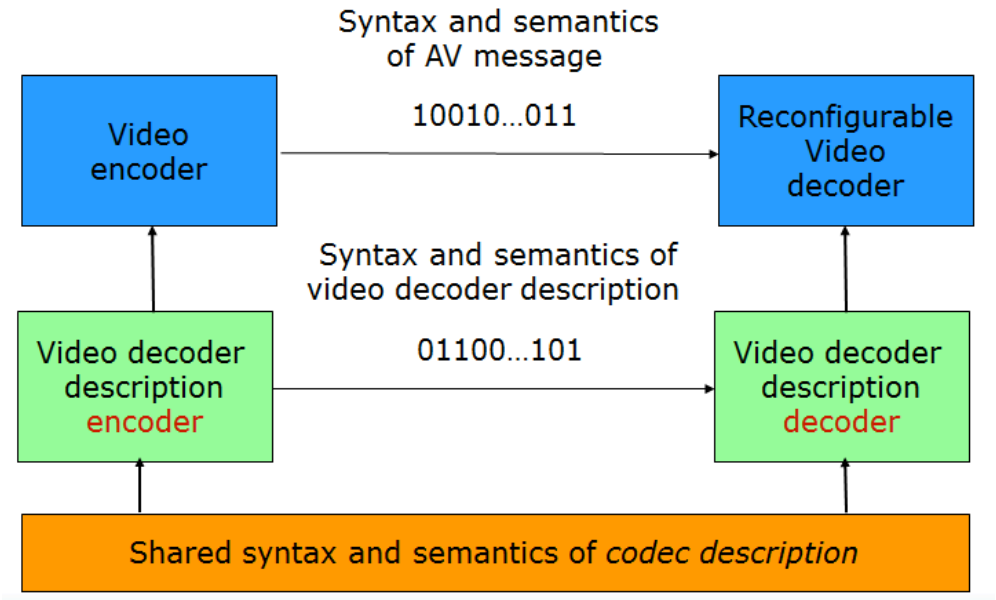

Figure 5 – Transmission of decoder description

Some of the more recent efforts are directed at extending the user experience. For instance in the figure in the next page:

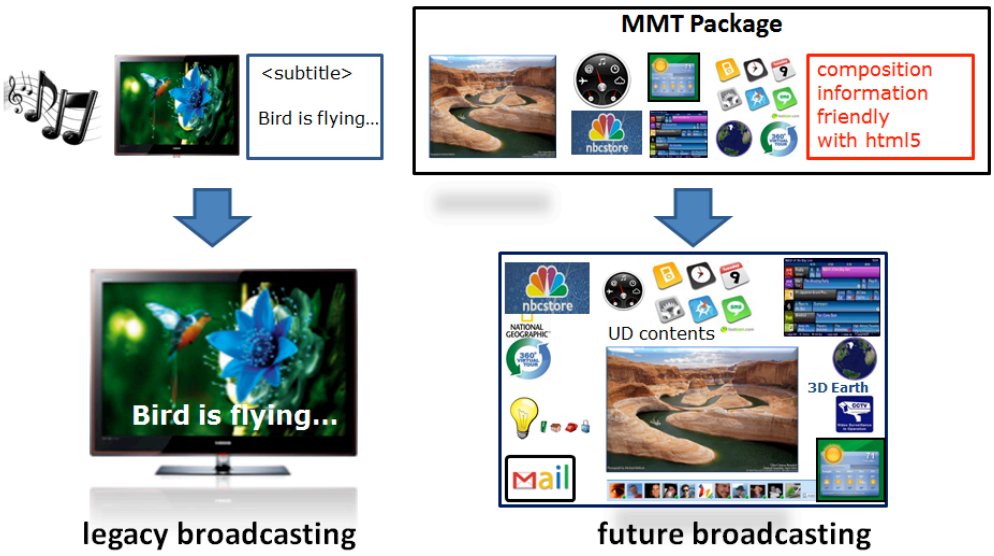

Figure 6 – Multimedia in broadcasting systems

The left hand side represents what can be achieved with today's broadcasting technology, where the delivery of a multimedia package is rather primitive, while the right hand side represents the ability to send real multimedia information offered by the emerging MPEG Media Transport (MMT) standard.

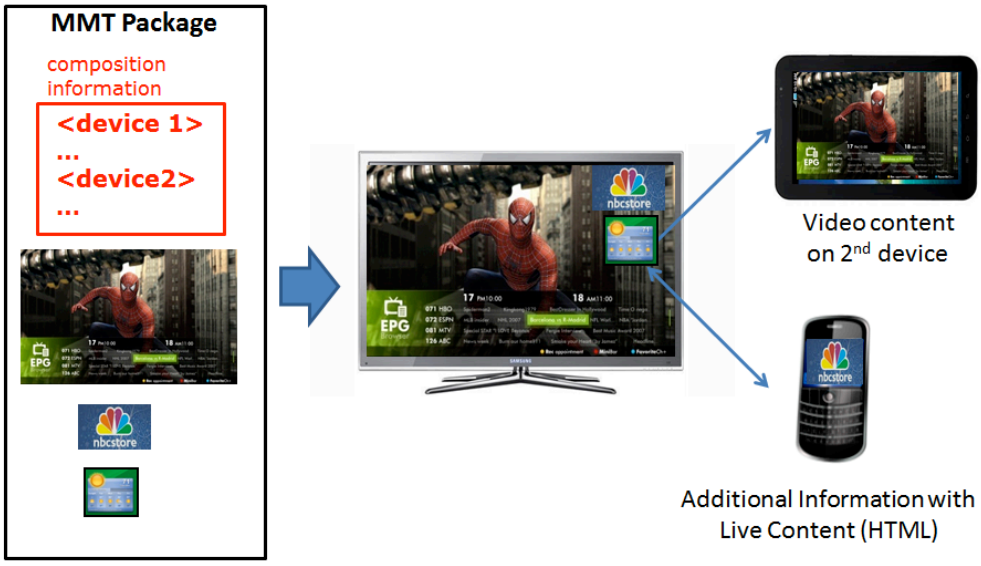

Figure 7 – Multimedia in broadcasting systems

The figure above depicts the possibilities open to the definition, on the broadcaster's side, of how content is best presented on multiple screens.

Television has undergone several stages: in the 1950s analogue, backward compatible colour TV was introduced; in the 1990s Digital TV and the transition from SD to HD required a new infrastructure ; in the 2010s it is expected that 3D Television will have a mass deployment.

The underlying 3D Video technology is rather complex. The MPEG plans can be described by the figure 8.

At the source the information from a limited number of cameras is compressed, transmitted and reconstructed at the receiving side to provide left/right images for stereoscopic displays or an arbitrary number of views for auto-stereoscopic displays.

Another area for standardization is the definition of a package of information that includes, in addition to the usual audio and video in different forms, also olfactory and various other tactile and positioning information.

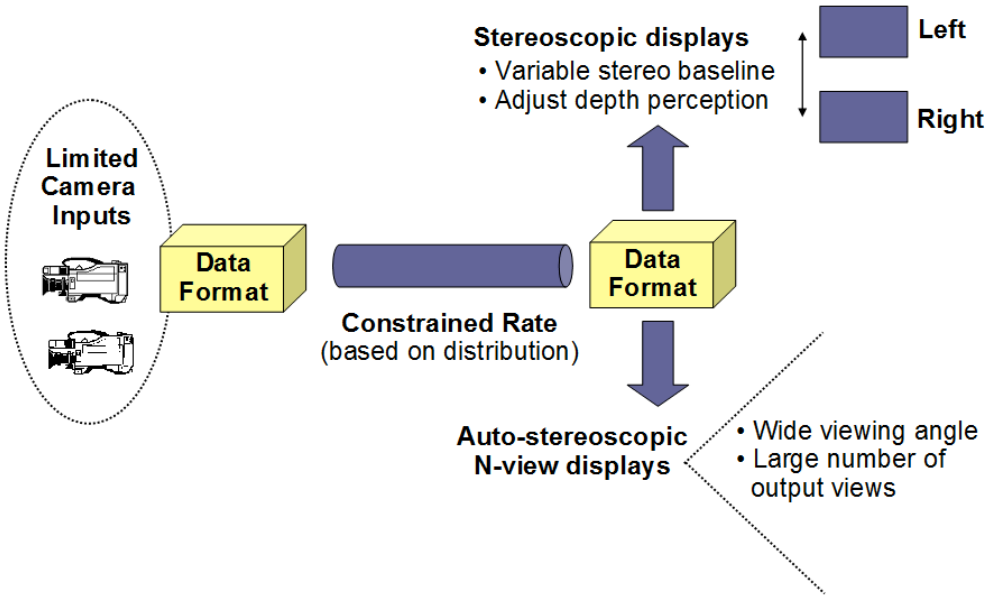

Figure 8 – 3D Video modes.

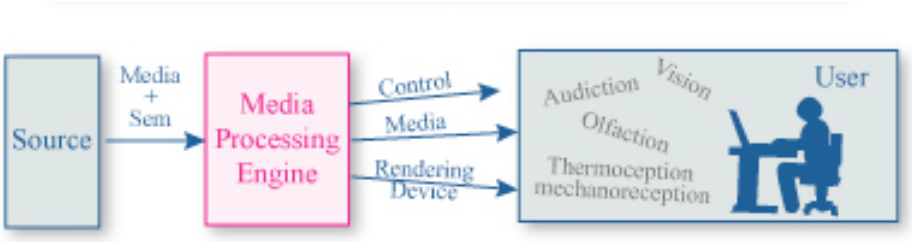

Figure 9 – Transmissions of other sense information

7. The role of software

Most MPEG standards are expressed with a combination of a human language (English) and a computer language (pseudo C-code). Most MPEG standards were developed using software and most MPEG standards have reference software. The MPEG-1 and MPEG-2 development process (ca. 1990) followed a rather simple (but at that time very innovative) process. MPEG members collaborated to produce the text of the standard and active members translated the standard into their own version of the software used to develop the standard.

The originators of technology proposals were requested to translate the relevant portions of their software back to text and "donate" the relevant portions of their software for the ISO reference software. But with MPEG-4 (ca. 1995) a new world took shape because software was no longer just a tool to develop the standards but also a tool to make conforming products.

Priorities changed: there was still a need for standards in textual form (we are humans), but the "real" reference was expressed in a programming language with the same normative status as the textual part. The reference software was developed collaboratively (because it is easier to compare results), improve quality of the standard (because there were two different manifestations of the standard) and accelerate adoption (because there was an implementation already available).

Looking more in detail into the process one can see that the rules of the MPEG-4 reference software are comparable (with some notable differences) with those of the "Open Source Software":

1. Each component of the standard is to be implemented in software:
   - Normative (decoder);
   - Informative (encoder).
2. A code manager is appointed for each portion of the standard;
3. for each accepted proposal software must be provided;
4. discussions on software happen on open email reflectors;
5. only MPEG members can decide;
6. copyright of reference software is assigned to ISO;
7. ISO grants licence of the *copyright* of the code for products that con-

form to the standard;
8. Those donating code need not donate patents that may be required in an implementation.

8. We need more than digital media technology

Digital Media in Italia (dmin.it) is an interdisciplinary, open, not-for-profit group established in November 2005 whose members are professionals and representatives of companies, institutions and associations. The goal is to explore and identify opportunities for Italy *to play a primary role in the exploitation of the global "digital media" phenomenon*.

How can we get there? By maximising the profitable flow of digital media.

The lever to achieve that acts on the offer of/access to content; broadband network; payment/cashing services, while balancing the requirements of the different parties:

- *Author:* "I want to be able to offer my works".
- *Intermediary:* "I want to be able to choose and play my role".
- *Consumer:* "I want to be able to find, access and use the content I need".

Dmin.it has concentrated on three legs:

- iDrm: to manage and protect digital media (technology was selected and several demo applications were developed).
- iNet: to access broadband digital networks (relevant IETF standards to achieve this were identified).
- iPay: to pay and cash micro amount effectively (specification and reference software were developed).

9. Conclusions

Media is what enriches human life. Digital media, because of its flexibility, is what comes closest today to human perception and processing, and its impact on society has already been proven. Standardisation plays a unique role for an orderly introduction of more effective communication means and its ties with society should be strengthened.

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