# Tutorial on Multimedia content distribution and protection

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## Preface

- *Currently, the digital-content market is growing very fast and it needs solutions of production, protection and distribution of massive content collections. This is a real challenge for many industries that are discovering the complexity of managing large digital content factories and distribution chains.*
- Content producers, providers, aggregators and distributors constantly need to adopt innovative means of increasing efficiency in order to reduce cost and to cope with large scale traffic.
- Possible solutions to this challenge could be found by automating, accelerating and restructuring production and protection processes. Such solutions will enable the production processes to be faster and cheaper, while at the same time providing new capabilities to support safer distribution.
- *Duration 8:30 – 12:00*



- The tutorial is mainly focused on presenting the major problems, architectures and solutions for content production, protection and distribution.
- The experience of the speaker mainly refers to a set of international research and development projects such as WEDELMUSIC, MUSICNETWORK and AXMEDIS in which technologies for the production, protection and distributions of digital content have been analyzed and developed for the major European industries of the sector.

## Summary

- **Business and Value Chains**
- **Architectures for Content Distribution**
  - General architecture for content distribution
  - Architectures for Single Channel
  - Multichannel Architecture
  - Super-Distribution Concepts
  - Content Sharing
  - Distribution/transaction models, Business models
- **Content Production and Packaging**
  - Content Models and Packaging
  - Content Gathering from Content Management Systems
  - Content Adaptation
  - Content production with GRID support
  - Content queries, indexing
- **Content Protection and Tracking**
  - Registration, Certification and Verification/Authentication
  - Digital Rights Management
  - Formalizing and Processing Licenses
  - Supervising tools for protection, tracking, black lists
  - Accounting and event reporting
- **Examples that have been considered**
  - Apple i-TUNES
  - AXMEDIS/WEDELMUSIC
  - DMP
  - MPEG-21
  - Windows Media



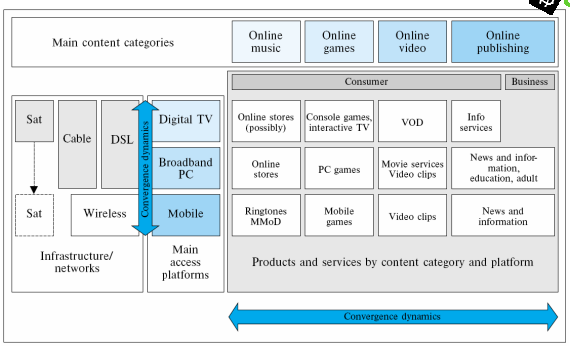
# Business and Value Chains



## Business and Value Chains

- **Content Type and fruition paradigm**
- **Distribution of the Business**
- **Not on Content for Entertainment**
- **The Network for Business transaction or for Consumers**
- **Some Examples of Value chains**
- **Content exploitation for the end users**
  - MPEG Multimedia Middleware, M3W

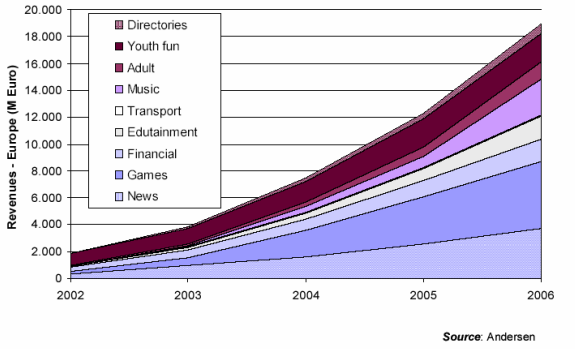
## Content and channels




Source EITO2005



## Total market revenues split between content-based applications




***Source***: Andersen

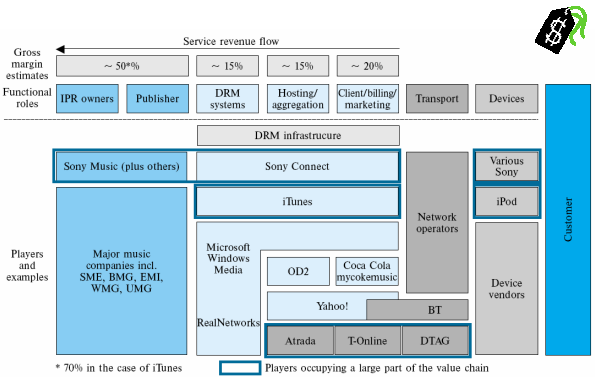


## Western European Online Content revenues

| Main content categories | Online music | Online games | Online video | Online publishing | |
|---|---|---|---|---|---|
| | Consumer | | | | Business |
| Digital TV | € 0 (no service today) | € 236 million | € 166 million | € 0 (no service today) | |
| Broadband PC | € 40 million | € 82 million | € 46 million | € 373 million | € 8,374 million |
| Mobile | € 0.6 million | € 254 million | € 150 million | € 288 million | € 88 million |
| Main access platforms | Products and services by content category and platform | | | | |
| Offline (in € billion) | 7.9 | 3.5 | 13.4 | 80 | 5 |
| Online (% of total) | 0.5 | 16 | 2.7 | 0.8 | 65 |

Source EITO2005

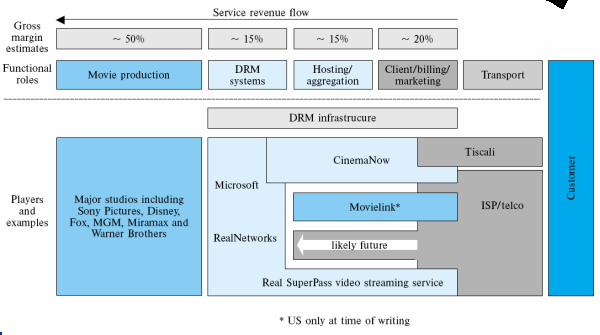
## Emerging On Line Music Value Chain




Source EITO2005



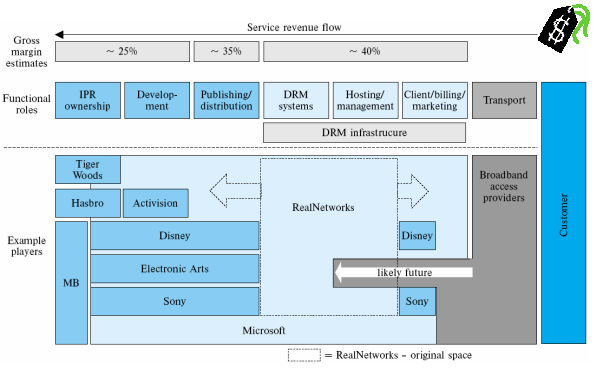
## Emerging Broadband VOD value chain




Source EITO2005



## Emerging On Line Gaames value chain

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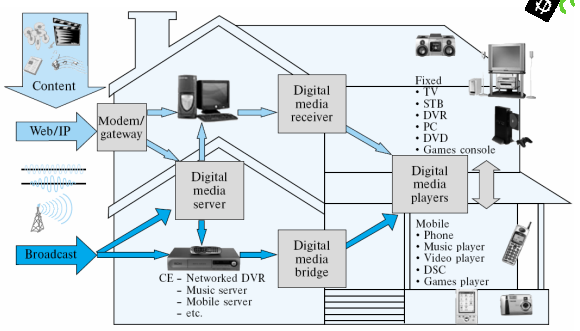
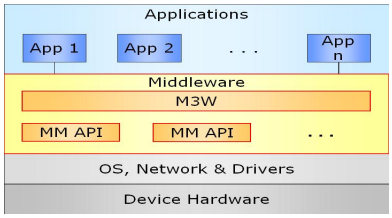
## The Media Usage at home




Source EITO2005



## M3W: MPEG Multimedia Middleware




- **Standardization of the APIs for components and their interaction**
- **Dynamic management of Components**
- **Replacement of Components**
- **Consumer Electronics devices**
- **First Working Draft for the next MPEG Meetings**



## State of the art for Media Centers

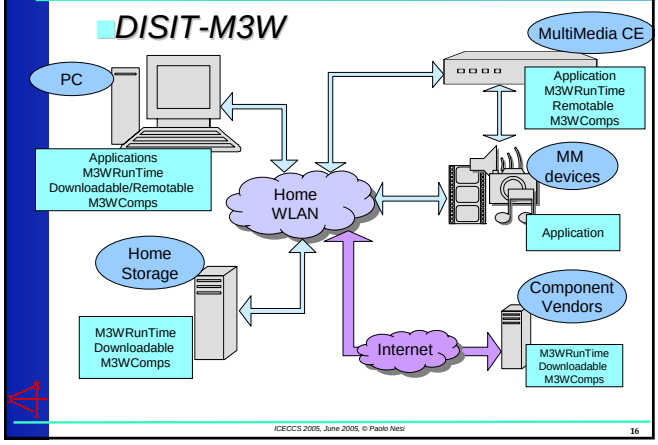
**Open Source (GPL)**

- Example MythTV, MediaPortal, etc.
- Open source code
- Liberal extendibility
- Short ttm, strong user driven community and innovation
- No Trustworthiness, limited Industry support, immature
- "Open standards"
- Royalty free
- OS: Linux, Windows

**Proprietary closed**

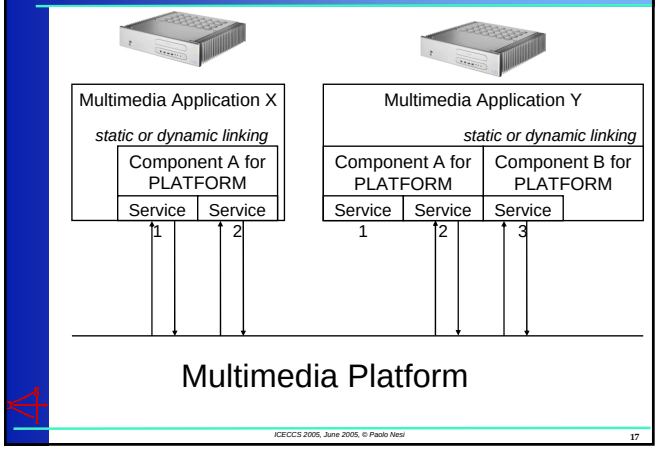
- Example MCE
- Closed source code
- Vendor controlled
- Limited extendibility, large (industry) ecosystem
- Weak differentiation
- Proprietary standards
- IP revenues
- OS: Windows MCE, XP, CE

## Home-network of devices scenario






## DISIT M3W a distributed solution






## Major Related Organisations

- **Standardisation Bodies for elements**
  - MPEG-2, MPEG (Motion Picture Expert Group)
  - OMA (Open Mobile Alliance)
  - MI3P (ID and licensing aspects)
  - OASIS (Organisation for advancement in Structured Information Standards)
  - TV-AnyTime (DVB….)
- **Associations/organization:**
  - OeB (Open eBook Forum)
  - CRF (Content Reference Forum)
  - WIPO (World Intellectual Property Organization)
  - RIAA (Recording Industry Association of America)
  - WS-I (Web Services Interoperability Organisation)
  - ISMA (Internet Streaming Media Alliance)
  - CC (Creative Commons)
- **Projects on Architecture and Value chain solutions**
  - AXMEDIS Project
  - DMP (Digital Media Project)
  - Etc.

## Major Technology Providers in different area

- Adobe
- Apple
- AXMEDIS
- Beep Science
- ContentGuard of Xerox and a part of Microsoft
- Digital World Services (Bertelsmann)
- DMDsecure
- IBM
- Intertrust is of Sony and Philips
- LiquidAudio
- Lockstream: Mobile DRM, OMA, Catalyst DRM,
- Macrovision in partnership with Microsoft
- Microsoft
- NDS
- Panasonic Europe
- Philips
- RealNetworks, used by IBM
- Roxio
- WEDELMUSIC
- Yacast



## E-Content Distribution

- **E-Content Distribution applications are:**
  - Distributed Applications
  - "Mission Critical" Applications
  - Require Built-in System Management, High-Availability
  - Transactional Applications
    - Changing the status
    - Bank operations
  - Digital Good or not, mainly digital in this tutorial



## Applications of Content Distribution with protection

- **Entertainment and leisure**
- **Banking**
- **Administration**
  - Sharing data
  - Sharing CV and personal information
  - Sharing medical results, and medical information
- **E-Commerce**
- **Cultural:**
  - Archive and museum for content sharing
  - E-learning, Distance learning
- **Government**
  - Sharing of legal information on legal actions
  - Sharing military information

## ACID

- Atomicity: complete all-or-nothing
- Consistency: transaction must leave the system in a correct state or it must abort
- Isolation: the transaction behavior is not effected by other transactions or its effect is hidden to the user and in any case the atomicity is guarantee
- Durability: the transaction's effects are permanent after it commits. They survive system failures



# Architectures for Content Distribution



## Summary

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  - Multichannel Architecture
  - Super-Distribution Concepts
  - Content Sharing
  - Distribution/transaction models
  - Business models
- **Content Production and Packaging**
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  - Content Adaptation, description, composition, and processing
  - Content production with GRID support
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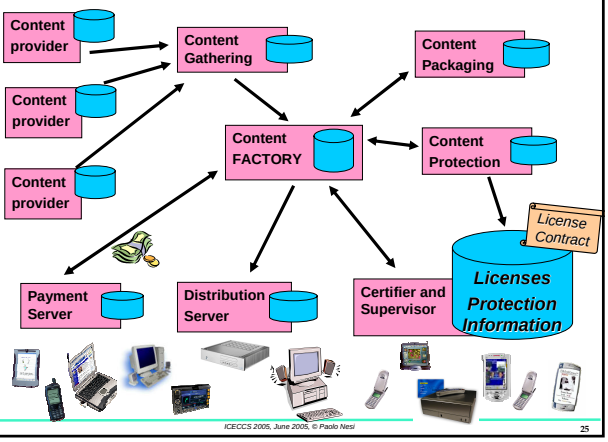
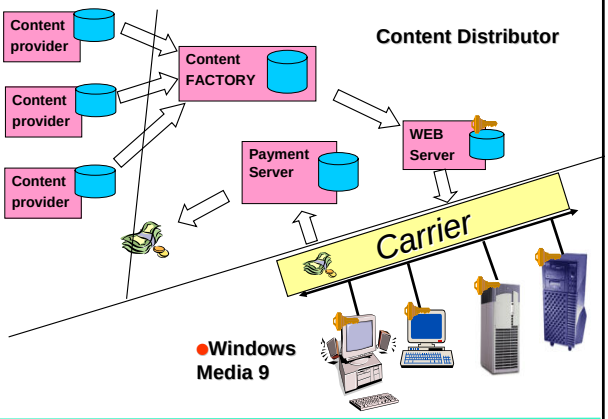
## General Architecture Overview



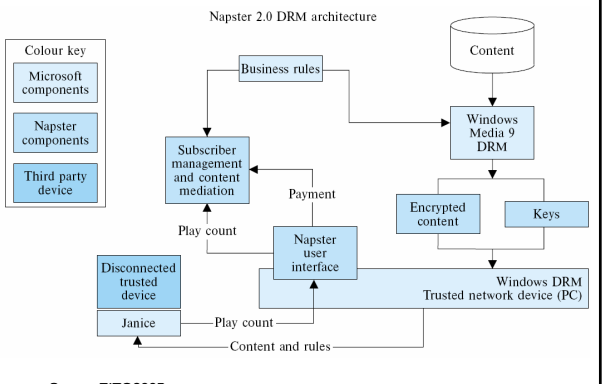



## Content Distribution a Conceptual Model






## The Case of Napster and Windows Media

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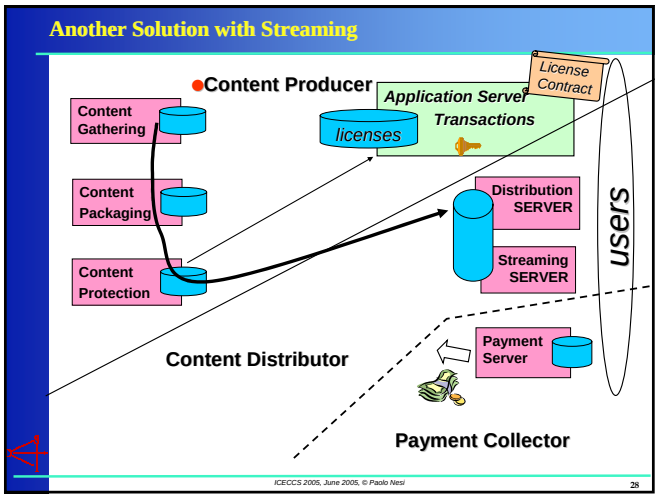
Another Solution with Streaming
Content Producer
Content Gathering
Content Packaging
Content Protection
licenses
Application Server
Transactions
License Contract
Distribution SERVER
Streaming SERVER
users
Payment Server
Content Distributor
Payment Collector
ICECCS 2005, June 2005, © Paolo Nesi
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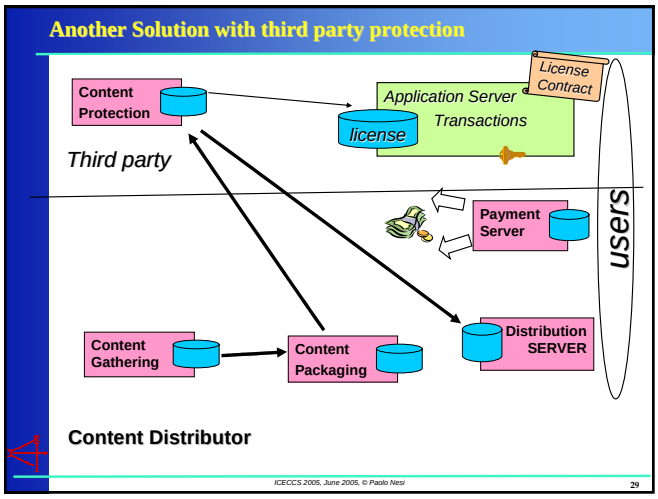
Another Solution with third party protection
Content Protection
Application Server
Transactions
License Contract
license
Third party
Payment Server
users
Content Gathering
Content Packaging
Distribution SERVER
Content Distributor
ICECCS 2005, June 2005, © Paolo Nesi
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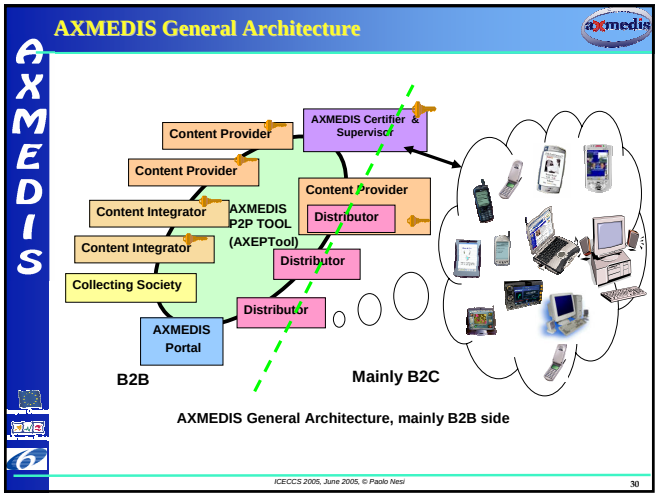
AXMEDIS General Architecture
AXMEDIS
Content Provider
AXMEDIS Certifier & Supervisor
Content Provider
Content Integrator
AXMEDIS P2P TOOL (AXEPTool)
Content Provider
Distributor
Content Integrator
Distributor
Collecting Society
Distributor
AXMEDIS Portal
B2B
Mainly B2C
AXMEDIS General Architecture, mainly B2B side
ICECCS 2005, June 2005, © Paolo Nesi
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## Multichannel Problems

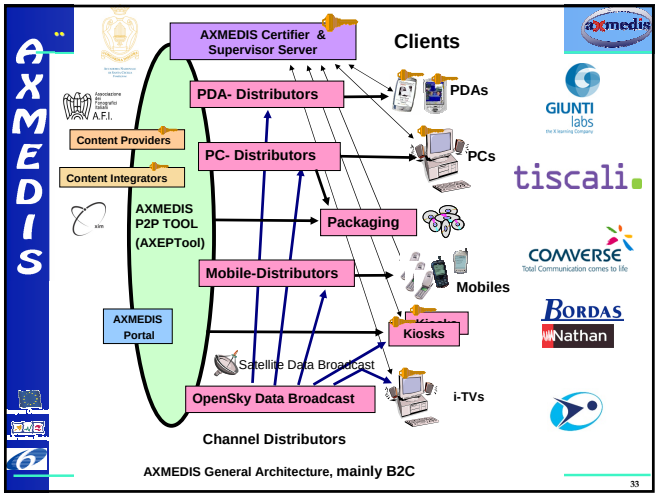
- **Different Channels:**
  - i-TV, Interactive TV, Satellite/terrestrial databroadcast (MPEG4, MHP), mainly streaming or Push
  - Internet, streaming or download
  - Kiosks, mainly download
  - Cellular network: mobiles, PDA, Smart Phone, etc.., mainly streaming
  - Traditional physical media
  - Etc.
- **Content Coming from a single factory**
  - Content has to be smartly prepared in advance
  - Content can be requested on Demand if streaming
  - Content should be produced on demand



## Multichannel Problems

- **Different channels means:**
  - Different formats to be produced
  - Different content type: video, audio, multimedia, etc.
  - Needs of Real Time Adaptation
  - Large number of final user devices, need of profiling for users and devices with channel
  - Need of Content on demand ??
  - Different methods for payments
  - Different business and transaction models






AXMEDIS General Architecture, mainly B2C

## Super Distribution Concepts

- **What is intended**
  - A distribution in which the users collaborate to the distribution, such as in the P2P environments
  - A solution in which the content is separate from the Protection Information, while the License can be in the object or no
  - *A Solution in which the Certifier and Supervisors and/or the device are capable of detecting violations thus activating some recovering activity*
- **Examples are:**
  - AXMEDIS:
    - B2B with AXEPTool
    - B2C, C2C with AXMEDIA tool



## Content Sharing

- **Can be among Business entities or Consumers**
  - B2B: Business to Business
  - C2C: Consumer to Consumer
- **Only if allowed at Contractual Level**
  - A sort of redistribution towards third parties
  - Typical for
    - non protected content, or for
    - protected content with resource separate from the license and protection information
- **Practical for Archives, Conservatories, Libraries, etc.**
- **An example is the WEDELMUSIC Solution that is also feasible with AXMEDIS environment/technology.**



## Web DELivering of MUSIC scores

**http://www.wedelmusic.org**

Dipartimento Sistemi e Informatica

SCUOLA DI MUSICA DI FIESOLE FONDAZIONE

Edizioni Suvini Zerboni

Fraunhofer Institute for Computer Graphics

Ircam Centre Georges-Pompidou

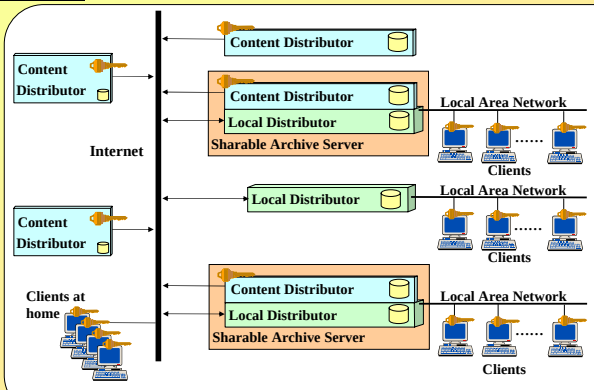
Institut Graphische Datenverarbeitung

## Transaction Models

- ***Mediateques and Libraries***
  - Agreement for free consultation
  - Percentage, forfeit, etc.
  - Collecting content from several content owners and other mediateques
- ***Mediateques as Content Distributors***
  - pay per play, special contracts, …
  - *precise DRM:* protection + certification + control of exploited functionalities
  - respect of the privacy



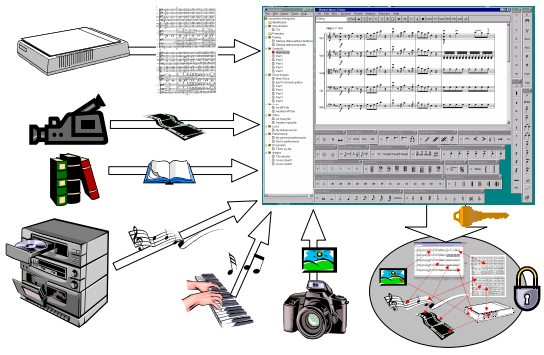
## Sharing Content Model

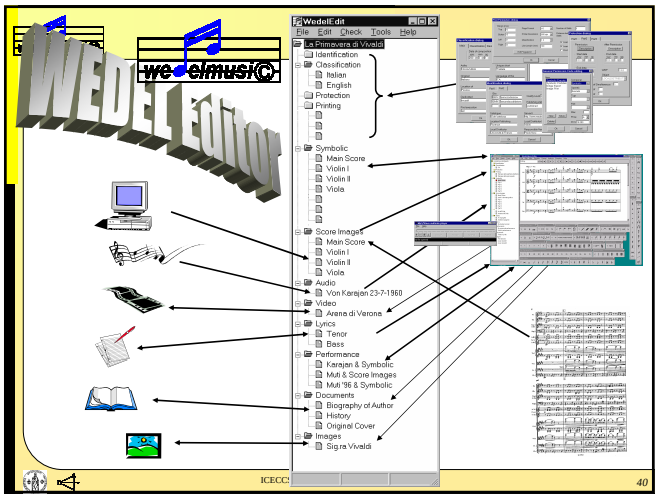


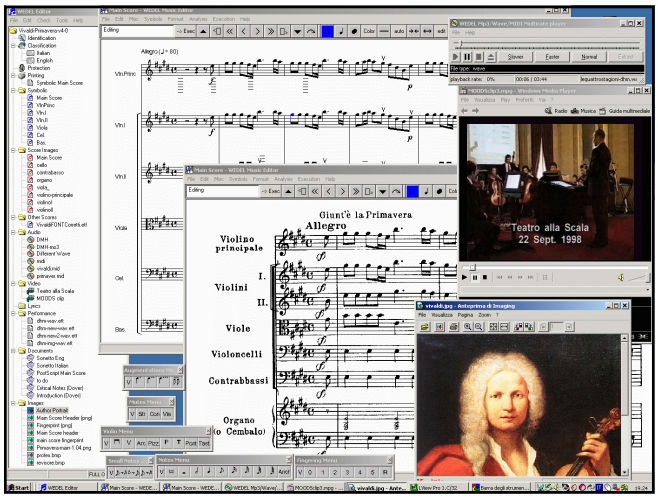



## WEDELMUSIC Editor and Integrator

- To build your WEDELMUSIC objects






## Distribution/transaction models

- **B2B: Business to Business**
  - Among digital good producer, publishers, integrator, resellers, etc.
  - They add values and thus …
- **B2C: Business to Consumer**
  - From distributors to consumers
- **C2C: Consumer to Consumer**
  - File sharing
  - Virtual Good sharing
- **B2B2C**
  - Integrated B2B to B2C

## Business models

| | On Line delivering | Off Line delivering |
|---|---|---|
| On Line Payment | Digital good | Any good |
| Off Line Payment | Digital good | Any good |

| | On Line usage | Off Line usage |
|---|---|---|
| Digital good | Yes | Yes |
| Physical good | No sense | Yes |



## Business Problem

- **Identification of the user for the business**
  - Respect of the privacy for the usages
  - Payment model
- **Legal contract for the license**
  - Tools for controlling the actions
- **Delivering of physical or digital objects**
- **Tracking/control of the usage in terms of rights exploited by the end user**
  - Action tracking and log, accounting, etc.



## Business Rules, a way to formalize allowed rights

- **Exploitation Models (contracts from the consumers to the provider are aligned to the exploitation model):**
  - Subscription to a collection or service
  - All you can heat
  - Pay per renting
  - Pay per use, pay per play, pay per print, etc.
  - Pay per stream, download, etc…
  - Pay per minute all you can heat
  - Burning the CD
  - Copy the object
  - Moving the object
  - Passing the object to a different device
  - Pay per building a collection
  - Preview without paying
  - Try and buy
- **Etc.**

## Business Rules, a way to formalize allowed rights

- **It may be based on limiting**
  - Number of times you can do an action, and usage
  - in a temporal window for the exploitation of any rights
    - renting
  - in a space
    - regional area or
    - domain (set of computers, etc.)
  - The usage according to the user profile:
    - impaired,
    - student,
    - Archival
    - etc.



## Content Distributors web sites

- **TISCALI, 12 portals**
  - Audio tracks of OD2 and videos (MIKADO)
  - Windows Media DRM
- **SKY, EUTELSAT**
  - Video, MPEG4
- **BuyMusic.com**
  - SDMI, Windows Media DRM
- **Real Networks**
- **ROXIO, Napster**
  - Windows Media DRM
- **Warner Music UK is using the** Share!
  - Windows Media DRM
- **Musicmatch.com**
  - 360.000 tracks, Windows Media DRM



# Content Production and Packaging

## Summary

- **Content Production and Packaging**
  - Content Models and Packaging
  - Content Adaptation
  - Content Description
  - Content Composition and Formatting
  - Content Processing with GRID support
  - Content Gathering from Content Management Systems
  - Content Queries, indexing
- **Content Protection and Tracking**
  - Registration, Certification and Verification/Authentication
  - Digital Rights Management
  - Formalizing and Processing Licenses
  - Supervising tools for protection, tracking
  - Managing black lists
  - Accounting and event reporting



## Content Production and Packaging

- **Content Models and Packaging:**
  - MPEG-21, LOM, WEDELMUSIC
- **Content Processing**
  - Content Adaptation
  - Content Description
  - Content Composition and Formatting
- **Content Processing Control**
  - Content production with GRID support,
    - Automatic Processing
  - Workflow
- **Content Gathering/Ingestion**
- **Content Management Systems**
  - Content database
  - Content description
  - Content queries, indexing,



## Content Model

- **Content is typically comprised of several aspects**
- **For content is typically intended all:**
  - From metadata to digital resources
  - From complex composed digital objects to simple resources
  - From licenses to games, etc.
  - From MS-WORD files to MPEG4, HTML, LOM, etc.
- **Main aspects of a content can be**
  - Metadata, many types
  - Digital Resource, hierarchical or not
  - Licensing information and license itself
  - Protection information

## Metadata and digital resources

- **Metadata, many types**
  - Identification codes: UUID, AXOID, ISRC, etc…
  - Classification codes: Dublin Core, etc…
  - Descriptors: technical or conceptual
  - Fingerprint
  - Historical and versioning aspects
  - Producer, etc.
- **Digital Resource, hierarchical or not**
  - Single Files:
    - image, video, doc, game, animation, education, audio, etc.
  - Multimedia files, hierarchies of files:
    - HTML, LOM, WEDELMUSIC, MPEG-4, etc.
  - Etc.

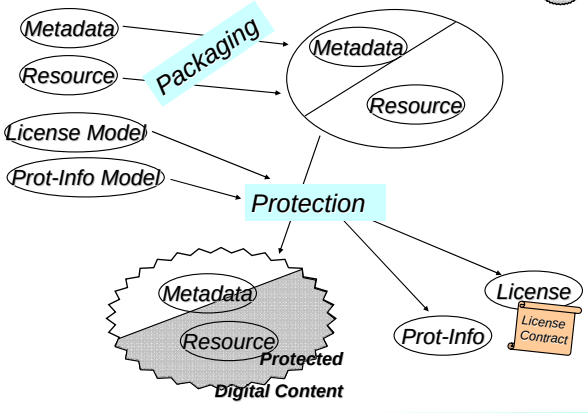


## Licensing and Protection Information

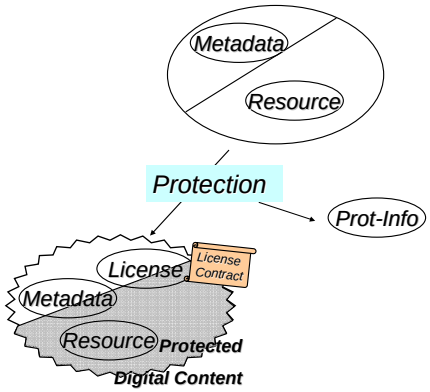
- **Licensing information and license itself**
  - License Model, referencing a PAR
  - Formal models:
    - MPEG21 REL/RDD, Patents, mainly from XrML (Content Guard)
    - ODRL, Open Digital Rights Management, very open and no cost
    - XrML: Extensible Rights Markup Language, initially from XEROX
    - etc.
  - Processing Licenses for various purposes
- **Protection information Model**
  - Protection Information For each Single Protected Object
  - How an object is protected
  - Which algorithms are used for encryption, scrambling, compressing, etc.
  - How they are applied: sequence, segment, etc.
  - Protection behavior and streaming
  - Any associated key and parameter
  - Etc.



## Packaging and Protection, Open Model

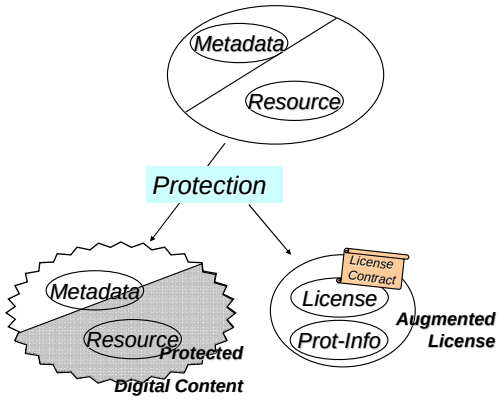


## Production of Governed Objects



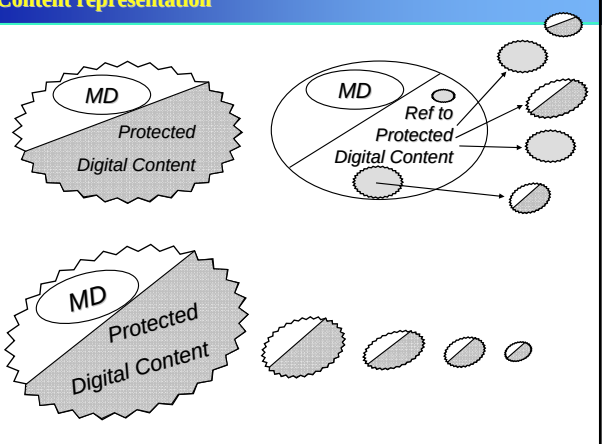



## Production of Objects and Augmented License






## Content representation



## MPEG

- **MPEG is a working group of ISO**
  - ISO/IEC JTC 1/SC 29/WG 11
  - Working Group ISO/IEC
  - Coding of moving pictures and audio
  - MPEG-1: Standard for storage and retrieval of moving pictures and audio on storage media
  - MPEG-2: Standard for digital television
  - MPEG-4: Standard for representing multimedia content, video and 3D virtual model integrated with audio, etc.
  - MPEG-7: Standard for description of audio and visual content
  - MPEG-21: Multimedia Framework, provides a truly interoperable multimedia framework
- **Development of international standards for**
  - compression, decompression,
  - processing and coded representation of moving pictures, audio, and their combination,
  - in order to satisfy a wide variety of applications



## MPEG-21 Multimedia Framework

- **Part 1: Vision, Technologies and Strategy**
- **Part 2: Digital Item Declaration, DID**
- **Part 3: Digital Item Identification, DII**
- **Part 4: Intellectual Property Management and Protection, IPMP**
- **Part 5: Rights Expression Language, REL**
- **Part 6: Rights Data Dictionary, RDD**
- **Part 7: Digital Item Adaptation, DIA**
- **Part 8: Reference Software**
- **Part 9: File Format, FF**
- **Part 10: Digital Item Processing, DIP**
- **Part 11: Evaluation Methods for Persistent Association Technologies**
- **Part 12: Test Bed for MPEG-21 Resource Delivery**
- **Part 13: Scalable Video Coding**
- **Part 14: Conformance**
- **Part 15: Event Reporting, ER**
- **Part 16: DID binarisation**



## Aim and Parts of MPEG-21

- **Content Handling and Usage**
  - Provide interfaces and protocols that enable creation, manipulation, search, access, storage, delivery, and reuse of content across the content distribution and consumption value chain
- **Terminals and Networks**
  - The ability to provide interoperable and transparent access to content across network and terminal
- **Parts:**
- **P2: Digital Item Declaration, DID**
  - A uniform and flexible abstraction and interoperable schema for declaring Digital Items
- **P3: Digital Item Identification and Description**
  - A framework for identification and description of any entity regardless of its nature, type or granularity

## Parts of MPEG-21

- **P4: Intellectual Property Management and Protection, IPMP**
  - The means to enable content to be persistently and reliably managed and protected across a wide range of networks and devices
- **P5: Rights Expression Language**
  - specifies a machine-readable language that can declare rights and permissions using the terms as defined in the Rights Data Dictionary
- **P6: Rights Data Dictionary**
  - specifies a dictionary of key terms required to describe users' rights
- **P7: Digital Item Adaptation, DIA**
  - defines description tools for usage environment and content format features that might influence the transparent access to the multimedia content



## Parts of MPEG-21

- **P8: Reference Software**
  - includes software that implements the tools specified in the MPEG-21 Spec.
- **P9: File Format**
  - defines a file format for storing and distributing Digital Items.
- **P10: Digital Item Processing**
  - defines mechanisms for standardized and interoperable processing of the information in Digital Item.
- **P11: Evaluation Methods for Persistent Association Tools**
  - This Technical Report documents best practice in the evaluation of persistent association technologies, i.e., technologies that link information to identify and describe content using the content itself.



## Parts of MPEG-21

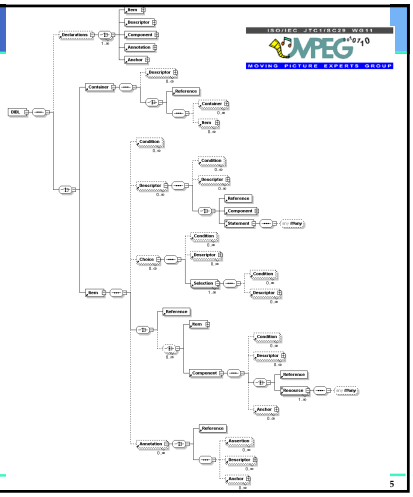
- **P12: Test Bed for MPEG-21 Resource Delivery**
  - provides a software-based test bed for delivering scalable media and testing/evaluating this scalable media delivery in streaming environments.
- **P14: Conformance**
  - Provide suitable criteria to evaluate conformance to MPEG-21 parts of a complaint system
- **P15: Event Reporting**
  - Specifies how to express ER-Request and Event Report and how they are represented as digital item
- **P16: Binary Format**
  - Specifies the MPEG-21 binary format which is an alternative serialization format of MPEG-21 descriptions as specified within other MPEG-21 parts

## MPEG-21 Part 2 — Digital Item Declaration

- **Index a Digital Item**
- **Purpose: describe a set of abstract terms and concepts to form a useful model for defining Digital Items**
- **Three normative sections:**
  - Model
    - set of abstract terms and concepts
  - Representation
    - normative description of syntax & semantics of DID elements
  - Schema
    - normative XML schema comprising the entire grammar of DID

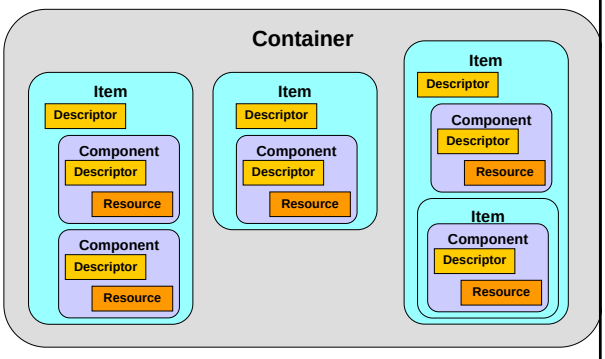


## Digital Item Declaration in more detail





## Digital Item Declaration example





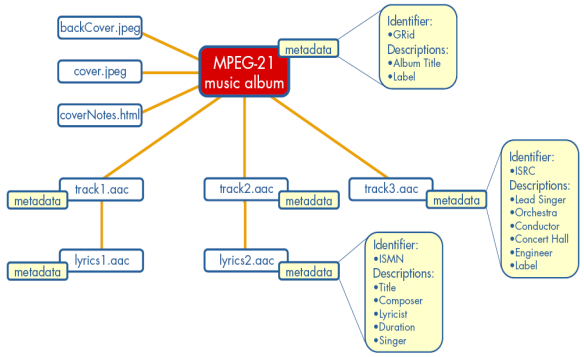

Prof. Paolo Nesi, nesi@dsi.unifi.it

## MPEG-21 Part 3 — Digital Item Identification

- **The scope of the Digital Item Identification (DII) specification includes:**
  - How to uniquely identify Digital Items and parts thereof (including resources)
  - How to uniquely identify IP related to the Digital Items (and parts thereof), for example abstractions
  - How to uniquely identify Description Schemes
  - How to use identifiers to link Digital Items with related information such as descriptive metadata
  - How to identify different types if Digital Items

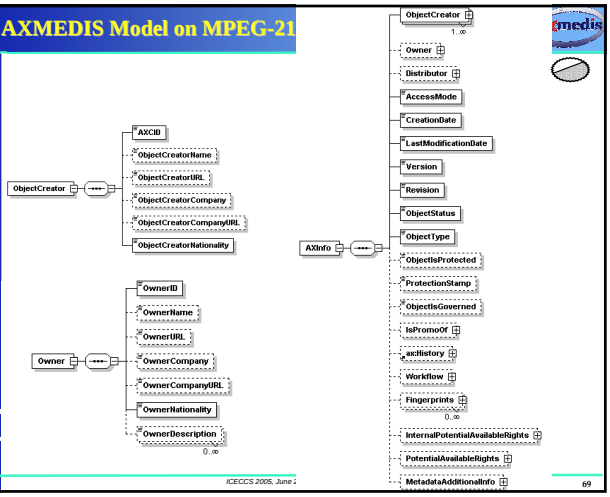


## DII example: MPEG-21 music album

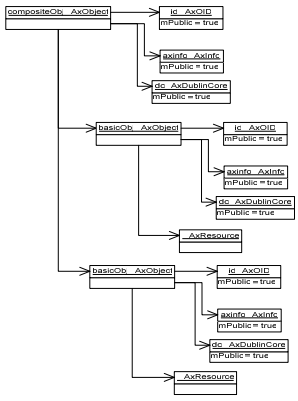





## AXMEDIS Model on MPEG-21



## AXMEDIS Model on MPEG-21



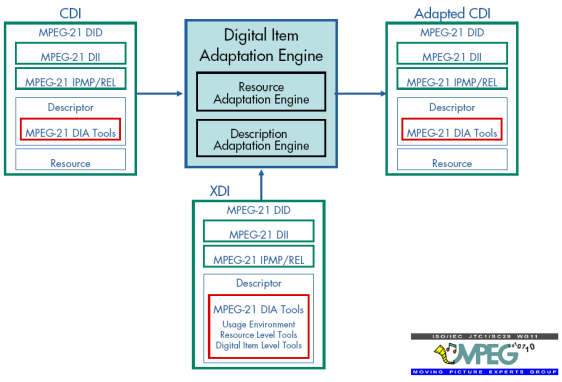



## The process of Content Adaptation

- **It is a Processing**
  - Resource: Resizing, rate, transcoding, etc.
    - Scaling of: time, spatial, frequency, color, etc.
  - License: filtering, re-issuing, transcoding, etc.
  - Metadata: filtering, transcoding, etc.
  - Protection Information: change, update, etc.
- **Digital Adaptation**
  - It has to be authorized to be performed on protected content
  - Depending on the device capabilities
  - Depending on the final user needs



## Relation between DIA and other MPEG-21parts



## Where to perform the Content Adaptation

- **On the Provider in delivering content to distributors**
  - Relevant numbers of versions (protection models, etc.) for the same content
  - High performance
- **On the Distributor server in delivering content to the end-user**
  - Huge number of adaptation/protection per second,
    - typically solution used for distributing content on mobiles
    - Thousands of different models of mobiles
  - Very High performance, GRID solutions
  - Very hard to protect all these different versions and single objects
- **On the client terminal before rendering**
  - Delay for the end user
  - Cost in terms of capabilities for the terminal device, a lot of software is needed
- **The solutions used are typically a balance**
  - from the last two for the Mobiles
  - From the first two for Internet
  - No adaptation is typically provided for I-TV STB



## Content Adaptation Quality of Service

- **Content Adaptation means also QoS**
- **Adaptation of Content during streaming**
  - It has to be performed on the stream on the binary information
  - The stream has to be provide specific references to
- **Adaptation can be performed on**
  - Server (if the bidirectional channel is preent)
  - Client (only solution for Push)
- **When content is protected**
  - It has to be performed on segment that can be unprotected



## Content Description

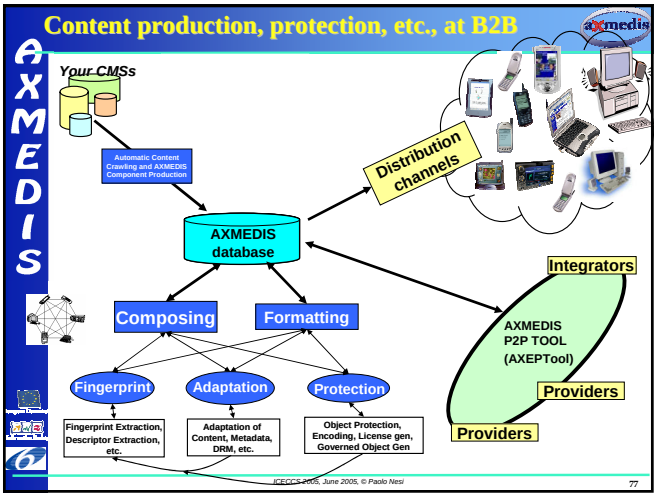
- **Any formal description of a digital resource**
  - Audio: Rhythm, tonality, duration, genre, etc.
  - Video: number of scenes, description of the scene, etc.
  - Text: main keywords, summary, topics, etc.
  - Etc.
  - But also: fingerprint such as MD5, etc.
- **Usage of Descriptors:**
  - Indexing into the database
  - Query into the database
  - Recognition for protection
- **MPEG-7**
  - Metamodel for descriptors:

## Content Descriptors Features

- **Expected Features:**
  - Robustness with respect to adaptation
    - Scaling: time, space, color, etc.
  - Short and concise
  - Repeatable
  - Light to be estimated
- **If used as Fingerprint of the Content**
  - Unique or close to be unique if used as Easily to be estimated, low computational complexity
  - Real-time estimation in streaming, estimable on the basis of a short duration of the content streaming
  - Etc.

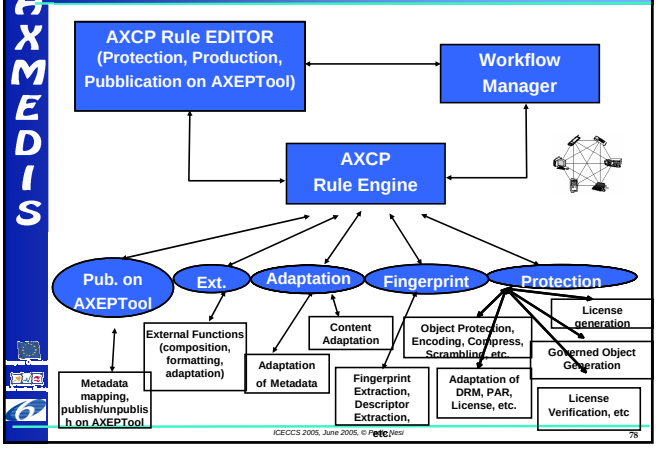


## Content production, protection, etc., at B2B

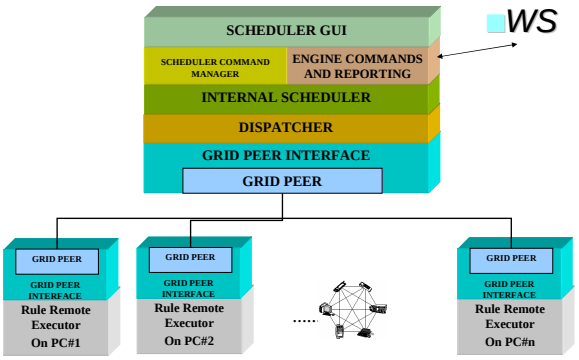





## AXMEDIS Content Processing GRID

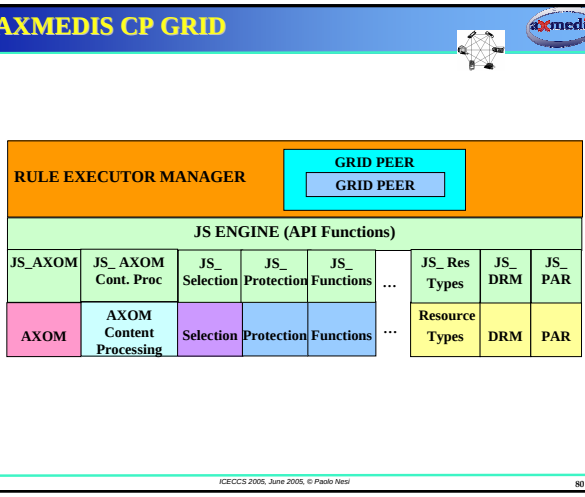


## AXMEDIS CP GRID



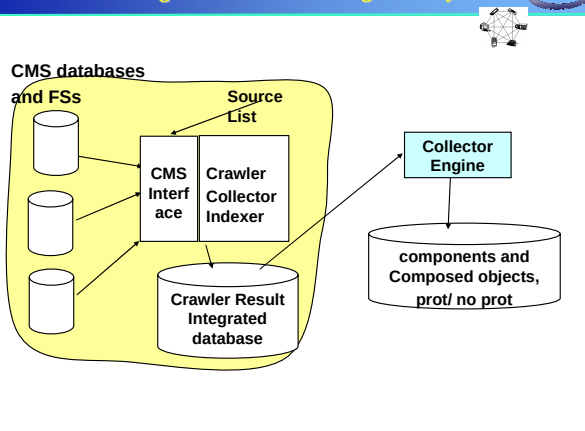



## AXMEDIS CP GRID






## Content Gathering from Content Management Systems



## Content Gathering from Content Management Systems

- **Access to several different resources:**
  - File Systems: Win, Linux, MAC, etc.
  - ODBC, JDBC, etc.
  - Native DB: DB2, Oracle, MS-SQL, MySQL, etc.
  - Protocols: IMAP, POP, Z39.50, etc.
- **Integrated with AXMEDIS Content Processing Capabilities:**
  - Processing of any digital resources and metadata
  - GRID executing and computing, high performance

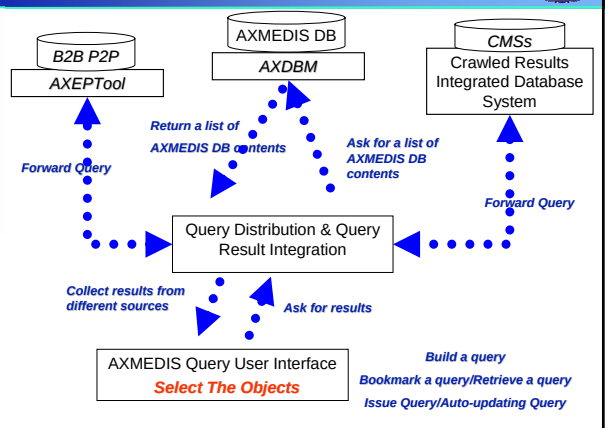


## Content management systems, CMS

- **Scalable to manipulate a large number of:**
  - Objects, components, protected objects
  - Licenses, protection information
  - Digital resources
  - Etc.
- **Making queries on the basis of**
  - Descriptions
  - Classification metadata
  - Indexing on the basis of selected information
- **Direct access via IDs**
  - Fast Retrieval
  - Typically objects on File Systems
  - Modeling of XML information



## Content Accessibility and recovering (EXITECH)



# Content Protection and Tracking

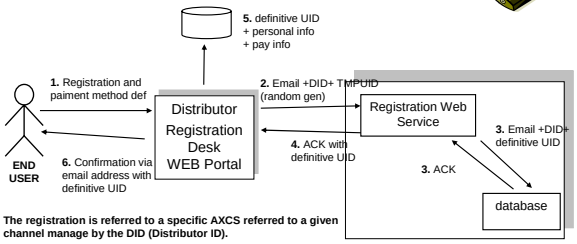


## Content Protection and Tracking

- Registration and Certification
  - of users and devices
- Verification/Authentication
  - Of users and devices
- Usage of Watermarking
- Usage of Fingerprinting
- Digital Rights Management
- Formalizing Licenses and Rights
- Processing Licenses and Rights
- Supervising tools for protection, tracking
- Accounting and event reporting
- Infringement detection, Managing black lists



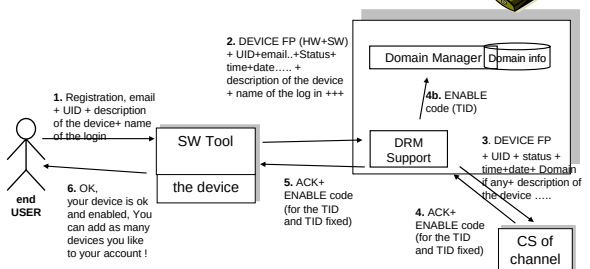
## Registration of a new end User on Channel




**The registration is referred to a specific AXCS referred to a given channel manage by the DID (Distributor ID).**

**Instead of a definitive UID we can use a "Certificate". It can be a certificate that one can exhibit to authenticate himself/herself in the circuit, a check is typically done with that ID and the email ,etc...**

## Certification of a new Device

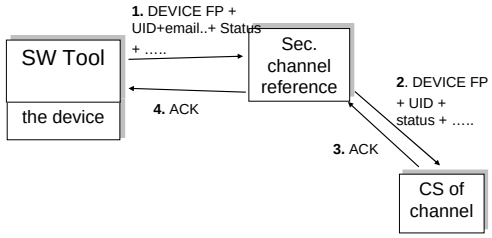



The Protection Support is capable of producing the HW code, SW code, -….to estimate the DEVICE FP and management of the status depending on time, history of actions, etc. The ENABLE code activate the Tool and will fix for ever the TID of the combination HW+SW+installation.

As a limit case the information maintained on the device by the Protection Processor could be encrypted with a different code for each transaction/verification, this could add dynamism to protection model.



## Authentication of a Device






## Usage of Watermark

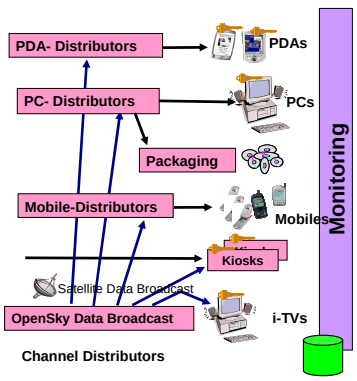
- **What is the watermark**
  - It is a code included in content by the content owner that can be read/shown to demonstrate the ownership of the content
  - Also called steganographic
- **Main Features**
  - Hidden or visible
  - Removable or not: when it is separable from the digital resource obtaining the original digital resource
  - Single of multiple: when more than one WM is present
  - Readable by all or only by the owner: when there is not need to have a special key/parameters to read it
  - Readable with an absolute certainty or with some statistical confidence
  - Robustness against the Adaptation
  - Robustness to passage from D-A-D again
  - Etc.

## Usage of Watermark

- **Which code is watermarked:**
  - Object ID
  - Owner ID
  - Distributor ID
  - Eventual coding of the license (governed object)
- **What happen**
  - Content Producers typically watermark the content (images, audio, video, etc.)
  - Content integrators and distributors are informed and may add one more watermark with their code
  - End user are not aware about that if it is undetectable is easy



## Usage of Watermark



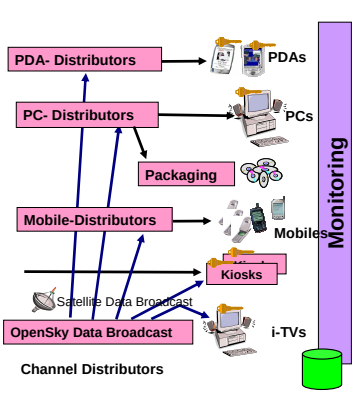

- **Then Content Owners, may monitor**
  - distribution channels
  - published content collection
  - Etc.
- **Reading the WM**
  - To detect the passage of their content
  - To verifying the presence of violations of IPR



## Usage of Fingerprint

- **What is the Fingerprint**
  - It is a code estimated on the digital content or resource that present in practical an high probability to be unique for that content with respect to other similar content
- **Features:**
  - Never included with the content if its aim is the usage for content protection
  - Included in the content only if it is used as content descriptor
  - Robust to adaptation processing
  - Robust to eventual watermark addition
- **Typically more computational intensive with respect to WM:**
  - The WM code is read/extracted from the content
  - The FP code has to be estimated from the content

## Usage of Fingerprint




- **Then Content Owners, may monitor**
  - distribution channels
  - published content collection
  - Etc.
- **To detect the passage of their content by**
  - estimating in real time the fingerprint the
  - searching into the database



## Digital Rights Management

- **Many definitions but I think that DRM is**
  - A set of mechanisms to manage Rights
  - Rights are the actions that can be performed a digital content
  - They are typically formalized in the so called Licenses
- **DRM implies:**
  - To protect the content with some algorithms saving what is called the **Protection Information** (they are needed to unprotect the object)
  - To formalize the rights in some manner creating what is called a **License**



## Formal Models for License Rights

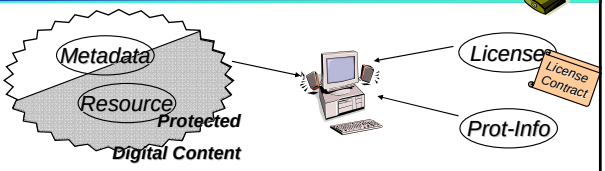
- **The rights acquired with a contract from the Content Provider are the Potential Available Rights, PARs**
- **Each *License* produced may**
  - at most cover those PARs
  - Formalize the allowed actions/Rights exploitable on a given object/content, digital resource
  - Refer to other Licenses, creating a chain of Licenses for the evaluation of a grant
- **Licenses have to be formalized in some language**
  - REL/RDD of MPEG-21
  - ODRL, Open Digital Right Management
  - Etc.

## Digital Rights Management implies

- **To set up a set of tools and mechanisms to**
- **Impose the respect of the Rights:**
  - Distribution tools (specific are needed in the case of streaming)
  - Terminal players based on certification and authentication mechanisms
- **Verify if the Rights/Licenses have been:**
  - Respected and
  - in which measure (for instance how many times a music piece has been played, how many print out have been produced, etc.)
- **Communicate to Content Owners, Content Distributors and third parties Collecting Societies:**
  - The effective exploitation of the content Rights



## Managing License and Protection Information




- **Once obtained the content you need the license to know what you can do on it, which Right you have acquired**
- **On the License you can get a reference to the Protection Information that for each Right and Resource provide the information to Unprotect the object**
- **During all these phases the Device can be verified with its SW, HW, users, etc.**
- **Similarly if the Object is Governed (if the license is included into the object)**
- **License and Protection Information are typically located in external and remotely located Servers that are called Certifier and Supervisors**



## Additional features and security issues

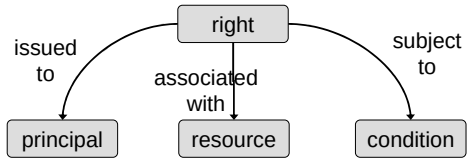
- **The devices and the Servers providing License and/or Protection Information may have algorithms and tools for**
  - detecting infringement and violations
  - Counting the usage,
  - Collecting every event for further reporting
  - etc..
- **Thus black lists of License, Objects, Devices, Users have to be managed**

## MPEG-21 P5 — REL, Rights Expression Language

- A machine-readable language, XML
- To declare rights and permissions
- Uses terms defined in the Rights Data Dictionary
- REL consists of licenses and grants that give specific permissions to Users to perform certain actions on certain resources, given that certain conditions are met
  - Grants can also allow Users to delegate authority to others
- User's system device has to
  - parse and validate the RE
  - check permissions before any further action is done
- DID parser is responsible for discovering and identifying where to gather licenses
- REL licenses are wrapped in Digital Items when the object if governed



## REL data model



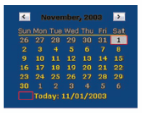

- REL grant consist of
  - principal to whom grant is issued
  - rights the grant specifies
  - resource to which right in grant applies
  - condition to be met before grant can be exercised



## REL – Principal and Rights

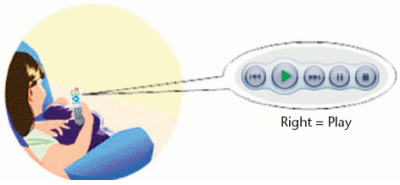
- Principal: Party to whom a grant conveys usage rights.
  - It has to provide some authentication mechanism by which the principal can prove its identity.
  - The Principal supports the following identification technologies: a principal that must present multiple credentials, all of them must be simultaneously valid, to be authenticated.
    - A keyHolder, meaning someone identified as possessing a secret key such as the private key of a public / private key pair.
    - Other identification technologies that may be invented by others.
- Right:
  - Action or activity that a principal may perform using a resource under some condition.
- Resource:
  - Object to which the principal can be granted a right.
- Condition:
  - Terms under which rights can be exercised.
- MPEG REL provides a right element to encapsulate information about rights and provides a set of commonly used, specific rights, notably rights relating to other rights, such as issue, revoke and obtain. Extensions to MPEG REL could define rights appropriate to using specific types of resource. For instance, the MPEG REL content extension defines rights appropriate to using digital works (e.g., play and print)

## An example of statement



Condition = November 2003

Resource = Ocean Wilds



Right = Play

- Rosy can Play 3 times the Ocean Wilds in November 2003.



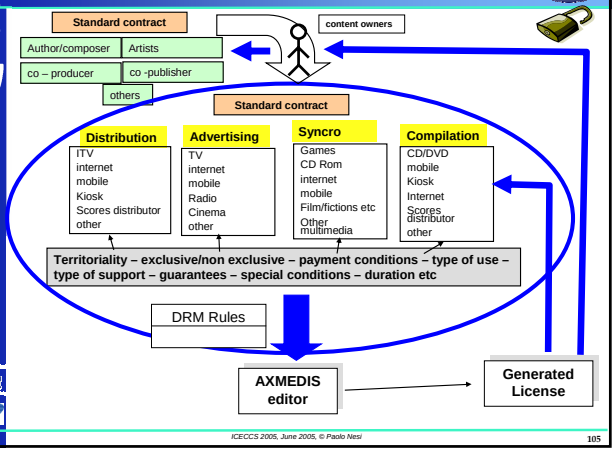
## Possible values for terms

- Principal
  - AllPrincipals and KeyHolder
- Rights
  - Issue, Obtain, PossesProperty and Revoke
- Resources
  - DigitalResource, Revocable and ServiceReference
- Conditions
  - AllConditions, ExerciseMechanism, ExistsRight, Fullfiler, PrerequisiteRight, RevocationFreshness, ValidityInterval
  - CallForCondition
  - ExerciseLimit
  - FeeFlat
  - FeeMetered
  - FeePerInterval
  - FeePerUse
  - FeePerUsePrePay
  - SeekAproval
  - Territory
  - TrackQuery
  - TrackReport
  - TransferControl
  - ValidityIntervalFloating
  - ValidityIntervalStartsNow
  - ValidityTimeMetered
  - ValidityTimePeriodic
- **Examples of Rights**
  - Adapt
  - Delete
  - Diminish
  - Embed
  - Enhance
  - Enlarge
  - Execute
  - Install
  - Modify
  - Move
  - Play
  - Print
  - Reduce
  - Uninstall



## from contracts to formal license

AXMEDIS

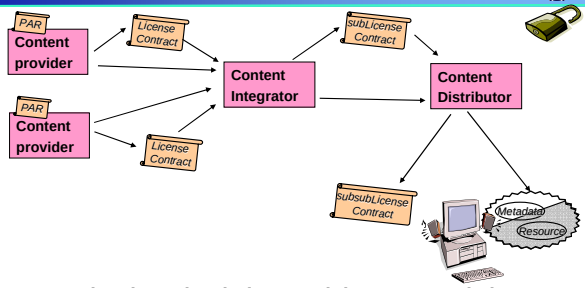


## MPEG-21 Part 6 — Rights Data Dictionary

- Set of clear, consistent, structured, integrated and uniquely identified Terms to support REL
- Specification of dictionary structure and methodology to create dictionary
- Dictionary is prescriptive, inclusive, and has audit provisions
- Legal definitions are mapped from other Authorities
- Supports mapping & transformation of metadata from terminology of one namespace (or Authority) into that of another namespace in automated or partially-automated way
- Dictionary is based on a logical model, the Context Model, which is the basis of the dictionary ontology



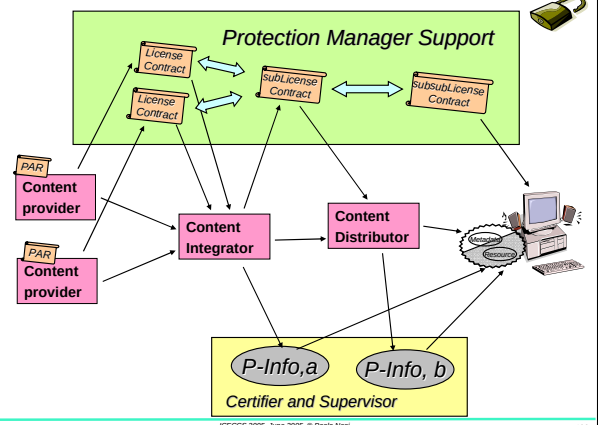
## Managing License Chain in AXMEDIS




- To solve the SubSubLicense al the connected Linceses are needed
- They have to be accessible on Processing Servers, called for example in AXMEDIS PMS



## Managing License Chain in AXMEDIS



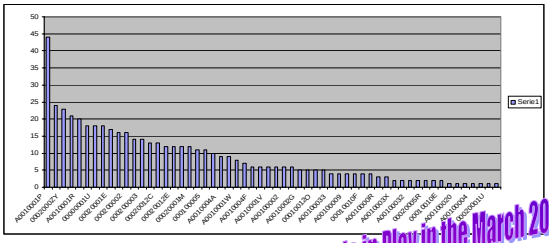
## MPEG-21 Part 15 — Event Reporting

- Standardise metrics and interfaces for performance of all reportable events in MPEG-21;
- 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.



## Event reporting

- Single traces
- Statistical data for reporting and analysis




Distribution of exploited objects in Play in the March 2005



## Reporting, accounting manager and tool, examples

- **Reporting to Distributor**
  - Each exploited right with references to the User-ID for each distributed object (objects that contains its Dist-ID)
- **Reporting to the Integrator/creator**
  - Who create new object from other objects of from scratch
  - The number of exploited rights for each object that contains the Creator-ID and the Dist-ID for each of them
- **Reporting for the Collecting societies, CS**
  - Who is monitoring the exploited rights for third parties, for other creators
  - The number of exploited rights for each Creator-ID associated with the CS, for each object that contains the Creator-ID and the Dist-ID for each of them, in a certain Geographic Region or State

# Some Examples of solutions

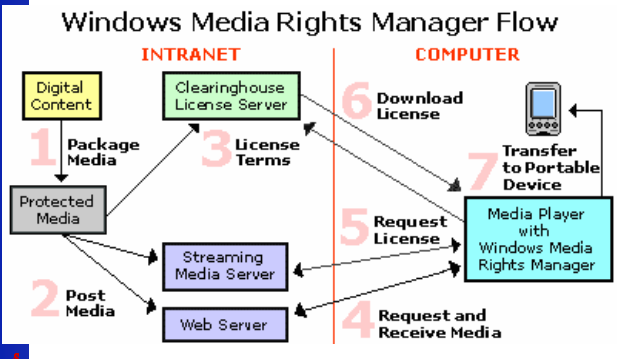


## Comments on the prominent technologies

- MPEG-21, several example have been provided along the tutorials
- Microsoft with Windows Media 9/10
- Apple i-Tune and iPod
- DMP: Digital Media Project
- AXMEDIS: www.axmedis.org
- Content Guard
  - Owner of XrML, source for MPEG21 REL
  - Owned by Microsoft in large part
- Adobe
  - Mainly for PDF, EBX DRM
- DMDFusion
  - DRM included
- ODRL: Open Digital Rights Language
  - Accepted by OMA, Open Mobile Alliance
- DWS: Digital World Service, BMG
  - ADO2RA DRM



## Windows Media Rights Manager



## Windows Media Rights Manager

- **Packaging**
  - Windows Media Rights Manager packages the digital media file.
  - The packaged media file has been encrypted and locked with a "key." This key is stored in an encrypted license, which is distributed separately.
  - Other information is added to the media file, such as the URL where the license can be acquired.
  - This packaged digital media file is saved in Windows Media Audio format (with a .wma file name extension) or Windows Media Video format (with a .wmv file name extension).



## Windows Media Rights Manager

- **Establishing a License Server**
  - The content provider chooses a license clearing house that stores the specific rights or rules of the license and implements the Windows Media Rights Manager license services.
  - The role of the clearing house is to authenticate the consumer's request for a license.
  - Digital media files and licenses are distributed and stored separately, making it easier to manage the entire system.



## Windows Media Rights Manager

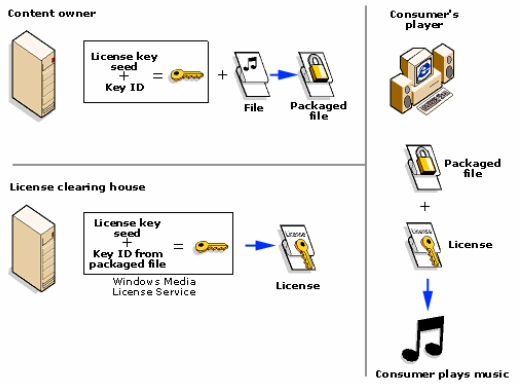
- **License Acquisition**
  - To play a packaged digital media file, the consumer must first acquire a license key to unlock the file.
  - The process of acquiring a license begins automatically when the consumer attempts to acquire the protected content, acquires a predelivered license, or plays the file for the first time.
  - Windows Media Rights Manager either sends the consumer to a registration page where information is requested or payment is required, or "silently" retrieves a license from a clearing house.

## Windows Media Rights Manager

- **Playing the Media File**
  - To play the digital media file, the consumer needs a media player that supports Windows Media Rights Manager.
  - The consumer can then play the digital media file according to the rules or rights that are included in the license.
  - Licenses can have different rights, such as start times and dates, duration, and counted operations. For instance, default rights may allow the consumer to play the digital media file on a specific computer and copy the file to a portable device.
  - Licenses, however, are not transferable. If a consumer sends a packaged digital media file to a friend, this friend must acquire his or her own license to play the file.
  - This PC-by-PC licensing scheme ensures that the packaged digital media file can only be played by the computer that has been granted the license key for that file.



## Windows Media Rights Manager






## Microsoft License

- **Each license contains the key to unlock the Windows Media file.**
- **The license also contains the rights, or rules, that govern the use of the digital media file. The content owner sets these rights to determine which actions are allowed from minimal control over playback to more restrictive licenses. The licenses in Windows Media Rights Manager can support a wide range of different business rules, including:**
  - How many times can a file be played.
  - Which devices a file can be played or transferred on. For example, rights can specify if consumers can transfer the file to portable devices that are compliant with the Secure Digital Music Initiative (SDMI).
  - When the user can start playing the file and what is the expiration date.
  - If the file can be transferred to a CD recorder (burner).
  - If the user can back up and restore the license.
  - What security level is required on the client to play the Windows Media file.
  - And many others.

## Microsoft License delivering

- Licenses can be delivered in different ways and at different times, depending on the business model.
- The content owner might want licenses pre-delivered, or they might want the license delivered after a consumer has downloaded and attempted to play a packaged file for the first time.
- Licenses can be delivered with or without the consumer being aware of the process using silent or non-silent license delivery.

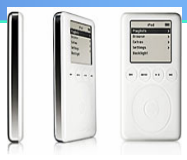


## i-Tunes of Apple, iTMS, I-Tunes Music Store

- AAC 128 Kbit, comparable with 160Kbit MP3
- 70 Millions of Files in the first year of work
- > 500.000 traces
- Very easy
- Pay per download (0.99$ per file, 9.99$ per collection)
- No subscription
- Tools: download, player, burning, play lists, etc.
- DRM proprietary, “FairPlay”, cracked in April 2004



## I-Tune and DRM limits



- Transfer of a trace to at most
  - 7 CDs, burning
  - 3 authorized computers
- Authorized transfer on a non limited number of i-POD
  - Market and money on iPods
- Authorized transfer on any computer but they can be played only on those that are authorized
- No costs for subscription
- Content I bought forever
- .

## DMP, Digital Media Project

- **Leonardo Chiariglione: DMP, www.chiariglione.org**
- **On top of MPEG-21, new standardization aim on DRM and content distribution model**
- **Major partners: Panasonic, Mitsubishi, METI, JVC, BT, SDAE, France Telecom, BBC, EPFL, INESCPORTO, EXPWAY, ENIKOS, ADETTI, MEDIALIVE, ETRI, WIPO, Dolby, etc.**
- **Standardization of terminals and the whole components for the architecture of audio visual content toward mobiles mainly**
  - A restricted domain and model with respect to MPEG21 and AXMEDIS
  - A focus mainly on players, up to now, with single objects and B2C distribution, only governed objects



## The Digital Media Project

- **Launched as Digital Media Manifesto in Jul 2003**
- **Manifesto published in Sep 2003**
  - http://www.chiariglione.org/manifesto/dmm.htm
- **Digital Media Project established in Dec 2003**
  - http://www.digital-media-project.org/
- **The basic DMP position**
  - Digital technologies are an **asset** of mankind
  - Creators, end-users and the multitude of other value-chain users should **benefit** from them
  - This goal can be achieved by **standardising**
    - Appropriate protocols between value-chain users
    - At suitably identified interfaces
- **The above is the DMP "Interoperable DRM" proposition**

http://digital-media-project.org



## Devising a strategy

- **DMP specifications should enable** innovation **of value-chains**
- **DMP** cannot **standardise protocols for**
  - Functions performed in **today's** value-chain
    - We do not know if today's value-chain will continue to exist
  - Functions performed in **future** value-chains
    - We do not know what future value-chains will be
- **DMP** can only **standardise protocols for *Primitive Functions* performed by value-chain users**
  - **Today's** Functions are a combination of Primitive Functions
  - Primitive Functions are "re-used" in different Functions
  - The Functions performed by **future** value-chain users will consist of
    - Different combinations of today's Primitive Functions and
    - New Primitive Functions

http://digital-media-project.org

AXMEDIS

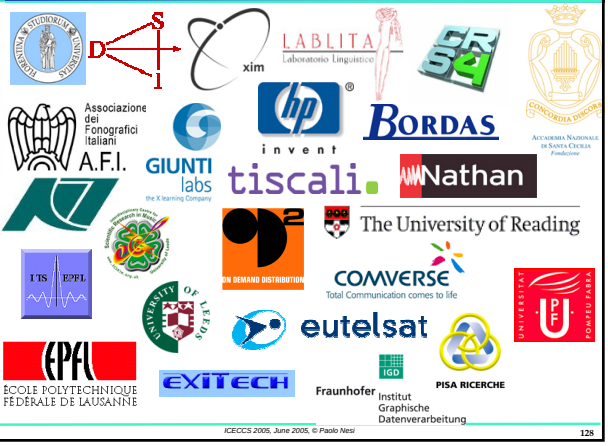
axmedis

- *Automating Production of Cross Media Content for Multichannel Distribution*
- www.AXMEDIS.ORG



AXMEDIS

## AMXEDIS Consortium






AXMEDIS

## Main general Objectives

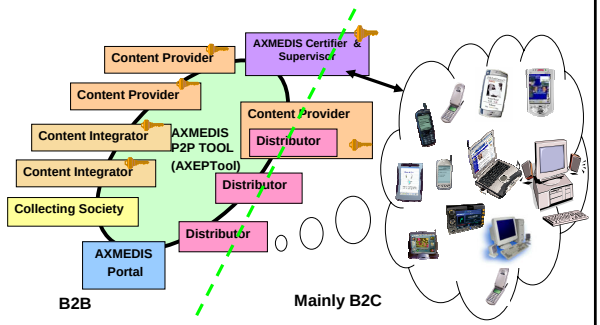
- Produce and distribute cross media content in protected manner, integrating B2B and B2C sides
- Allowing the content distribution and collaborative production at B2B level
- Create a unified European platform for content distribution in terms of DRM and interoperability
- Increase accessibility to the European audio visual content for its exploitation for entertainment, valorization, etc.

## Main technical Objectives

- reducing costs for content production and management by applying Artificial Intelligence techniques to content creation, representation (format) and workflow;
- reducing distribution and aggregation costs in order to increase accessibility with a Peer-to-Peer (P2P) platform at Business-to-Business (B2B) level, which can integrate content management systems and workflows;
- developing and providing new methods and tools for innovative and flexible Digital Rights Management (DRM), including the exploitation of MPEG-21 and overcoming its limitations and support different business and transaction models.
- Integrating present CMSs with AXMEDIS framework and tools
- Creating a technical AXMEDIS framework for all



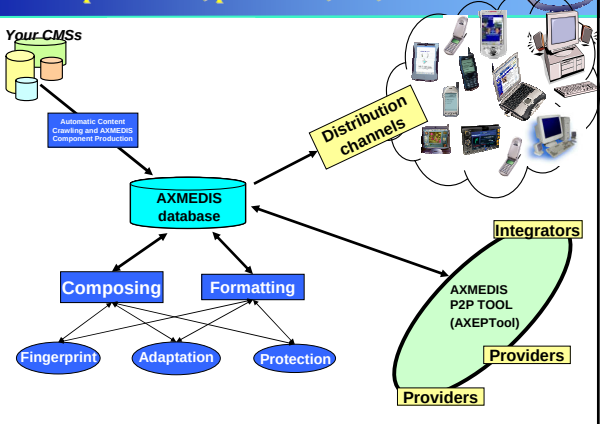
## AXMEDIS General Architecture

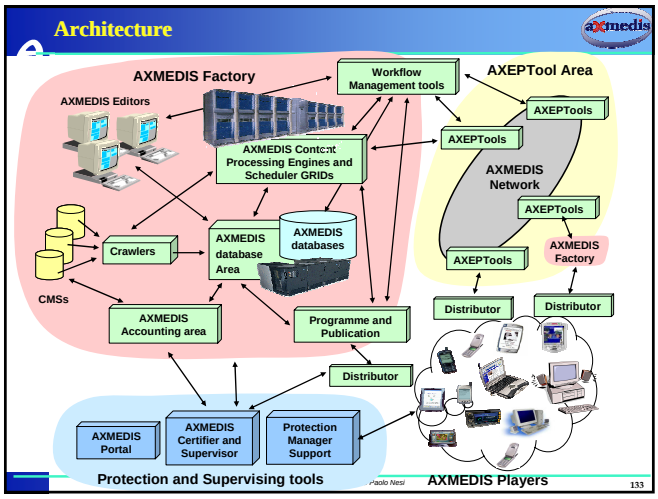


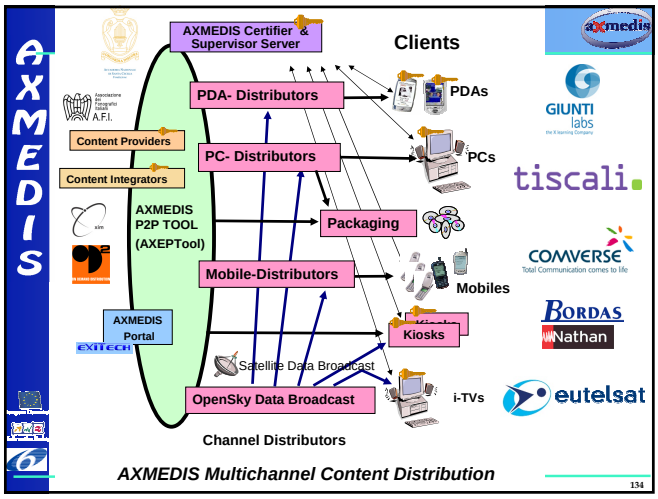

AXMEDIS for B2B Cooperative Content Production

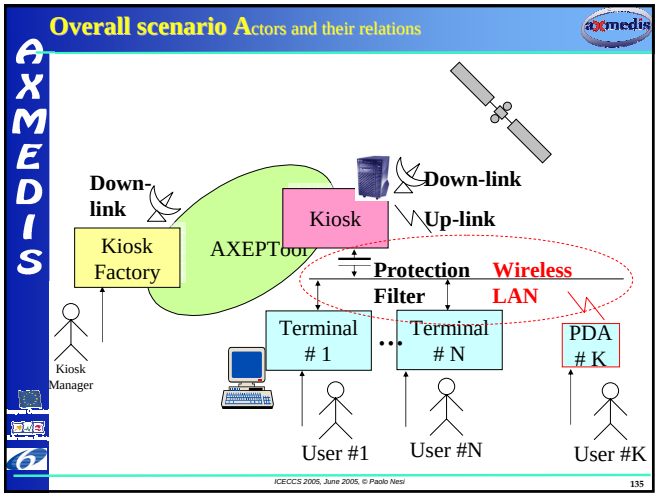


## Content production, protection, etc., at B2B




Architecture
AXMEDIS Factory
AXMEDIS Editors
Workflow Management tools
AXEPTool Area
AXEPTools
AXEPTools
AXMEDIS Content Processing Engines and Scheduler GRIDs
AXMEDIS Network
AXEPTools
AXEPTools
AXMEDIS Factory
Crawlers
AXMEDIS database Area
AXMEDIS databases
CMSs
AXMEDIS Accounting area
Programme and Publication
Distributor
Distributor
Distributor
AXMEDIS Portal
AXMEDIS Certifier and Supervisor
Protection Manager Support
Protection and Supervising tools
AXMEDIS Players
133


AXMEDIS
AXMEDIS Certifier & Supervisor Server
Clients
PDA- Distributors
PDAs
Content Providers
PC- Distributors
PCs
Content Integrators
AXMEDIS P2P TOOL (AXEPTool)
Packaging
Mobile-Distributors
Mobiles
AXMEDIS Portal
Kiosks
Satellite Data Broadcast
OpenSky Data Broadcast
i-TVs
Channel Distributors
GIUNTI labs
tiscali
COMVERSE
BORDAS
Nathan
eutelsat
AXMEDIS Multichannel Content Distribution
134


AXMEDIS
Overall scenario Actors and their relations
Down-link
Kiosk Factory
AXEPTool
Kiosk
Down-link
Up-link
Protection Filter
Wireless LAN
Terminal # 1
Terminal # N
PDA # K
Kiosk Manager
User #1
User #N
User #K
ICECCS 2005, June 2005, © Paolo Nesi
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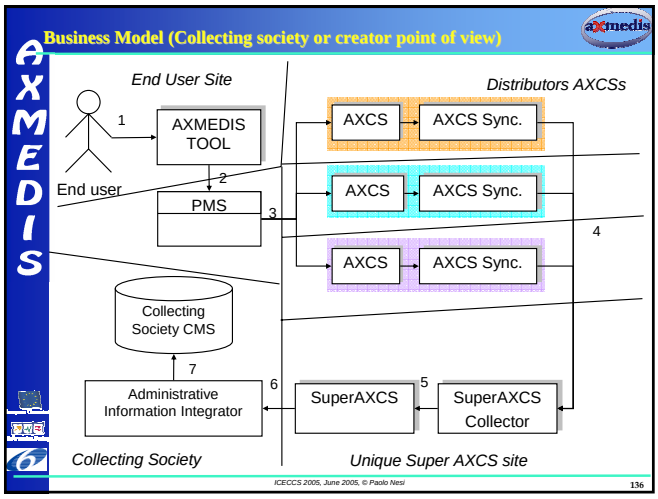
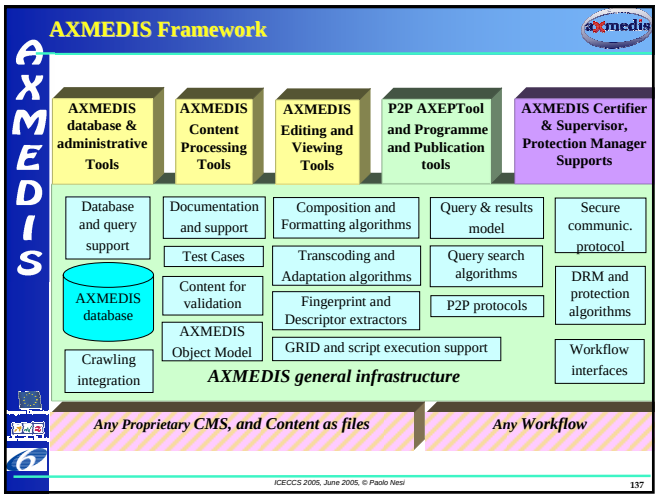

Business Model (Collecting society or creator point of view)
End User Site
Distributors AXCSs
End user
1
AXMEDIS TOOL
2
PMS
3
AXCS
AXCS Sync.
AXCS
AXCS Sync.
AXCS
AXCS Sync.
4
Collecting Society CMS
7
Administrative Information Integrator
6
SuperAXCS
5
SuperAXCS Collector
Collecting Society
Unique Super AXCS site
ICECCS 2005, June 2005, © Paolo Nesi
136


AXMEDIS Framework
AXMEDIS database & administrative Tools
AXMEDIS Content Processing Tools
AXMEDIS Editing and Viewing Tools
P2P AXEPTool and Programme and Publication tools
AXMEDIS Certifier & Supervisor, Protection Manager Supports
Database and query support
AXMEDIS database
Crawling integration
Documentation and support
Test Cases
Content for validation
AXMEDIS Object Model
Composition and Formatting algorithms
Transcoding and Adaptation algorithms
Fingerprint and Descriptor extractors
GRID and script execution support
Query & results model
Query search algorithms
P2P protocols
Secure communic. protocol
DRM and protection algorithms
Workflow interfaces
AXMEDIS general infrastructure
Any Proprietary CMS, and Content as files
Any Workflow
ICECCS 2005, June 2005, © Paolo Nesi
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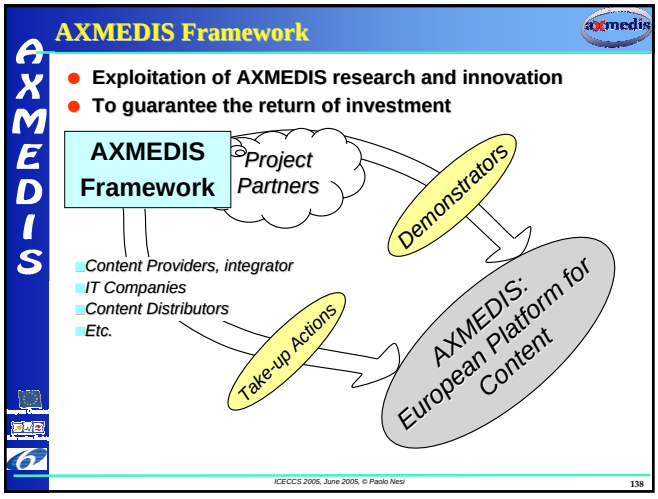
AXMEDIS Framework
Exploitation of AXMEDIS research and innovation
To guarantee the return of investment
AXMEDIS Framework
Project Partners
Content Providers, integrator
IT Companies
Content Distributors
Etc.
Demonstrators
Take-up Actions
AXMEDIS: European Platform for Content
ICECCS 2005, June 2005, © Paolo Nesi
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## Short Biography of Paolo Nesi

- Full Professor at the University of Florence, Department of Systems and Informatics, and chair of the Distributed Systems and Internet Technology Lab.
- He is working on technologies related to content production, protection, security and distribution since several years: (i) languages and tools for the specification of real time systems by means of interval temporal logic; (ii) metrics and tools for the assessment of software systems; (iii) languages and tools for the co-operative work; (iv) protection and security tools and solutions (IMP, MPEG21, certification of devices, etc), (v) distributed systems, P2P, GRID, etc.; (vi) distributed architectures for automatic control, optimisation, industrial applications, supervision, etc.
- He has been Chair of several international conferences (CSMR'98; CSMR'99; WEDELMUSIC2002), General Chair of IEEE ICSM2001, WEDELMUSIC2001, IEEE ICECCS 2004. He has published more than 170 papers on journals and on conference proceedings.
- He has been the project manager several multipartner international projects (see those in the reference for example), and co-chair of MPEG AHG on SMR, coordinating projects with partner companies and research institutions, such as: AFI, ANSC, BMG RICORDI, EUTELSAT, COMVERSE, CRS4, EPFL, FHG-IGD, GIUNTI, HP, IRCAM, OD2, SEJER BORDAS and NATHAN, SUGARMUSIC, CRS4, TISCALI, Univ, Readings, Univ. Pompeo Fabra, etc.



## References

- **AXMEDIS:** www.axmedis.org
- **CRF: Content Reference Forum:** http://www.crforum.org/
- **DMP: Digital Media Project,** www.chiariglione.org
- **EITO 2005: European Information Technology Observation 2005:** http://www.eito.com/index-eito.html
- **ODRL:** http://odrl.net/
- **OMA:** www.openmobilealliance.org
- **MI3P, Music Industry Integrated Identifier Project,** http://www.mi3p-standard.org/
- **MPEG, MPEG-21:** www.chiariglione.org
- **MUSICNETWORK:** www.interactivemusicnetwork.org
- **WEDELMUSIC:** www.wedelmusic.org
- **Windows Media:** http://www.microsoft.com/windows/windowsmedia/default.aspx



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*Thanks for your attention!*