Automating Production of Cross Media Content for Multi-channel Distribution

www.AXMEDIS.org

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AXMEDIS Framework for all

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Abstract: this document presents a complete overview of the AXMEDIS Framework. The document is particularly suitable for who is interested in understanding the purpose and the architecture of the framework and how it can be used to solve your problems in the area of content production, protection and distribution.

Keyword List: content production, content protection, cross media authoring, Digital Rights Management, MPEG-21, DRM, IPMP, GRID, AXMEDIS, REL, fingerprint, descriptor, content distribution, OMA, ODRL, plug-in, protection tools, database, crawling, ingestion, gathering, players, SMIL, XML, workflow.

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1 Introduction

AXMEDIS is an ambitious Integrated Project of Research and Development partially founded by the European Commission in IST FP6 and including about 20 partners such as University of Florence, HP, EPFL, FHGIGD, ACIT, AFI, TISCALI, University Pompeo Fabra, University of Leeds, CPR, EXITECH, XIM, University of Reading, etc. The duty of AXMEDIS is to work on research activities, develop new tools and products and trial them as effective demonstrators.

AXMEDIS goals

AXMEDIS is creating and developing the AXMEDIS Framework, an open solution exploiting a set of new technologies and tools, which can be used by your solutions and applications for:

- reduction of costs and increasing efficiency for content production, protection, management and distribution; better pricing and value-for-money for industry products and services, containing costs to set up sustainable business ventures in the digital cross media content:
    - integrating your Content Management Systems, CMSs, with the distribution systems by automating the communication and update of content and information between the two systems;
    - automating content gathering and ingestion processes from local or remote CMSs and file systems;
    - automating composition, allowing parallel processing, exploiting GRID technology, and optimization techniques for content ingestion, production, protection and formatting;
    - managing the workflow at level of the content factory and among different content factories sharing the same content production objectives;
    - automating the whole process allowing content production on demand;
- support for the whole value chain: composition, packaging, integration, aggregation, synchronization, formatting, adaptation, transcoding, indexing, integration in the same objects protected and non protected components, definition of relationships with other resources, metadata integration and remapping/transcoding, protection, license production and verification;
- convergence of the media, interoperability of content supporting the multichannel distribution, support content distribution:
    - on different channels such as satellite data broadcast, Internet, cellular network, wireless, traditional supports as DVDs, internet, mobiles networks, local and wireless networks;
    - including Peer-to-Peer (P2P) in both B2B (Business-to-Business) and B2C (Business-to-Consumer) levels;
    - on different devices such as PC, PDA, i-TV, STB, etc.;
    - with different transaction models on the same channels and content with flexibility in the business and transaction models;

- adoption of new methods and tools for innovative, flexible and interoperable Digital Rights Management (DRM), including
    - exploitation of MPEG-21 REL (Right Expression Language) and overcoming its limitations with specific extensions,
    - supporting different business and transactions models and their integration,
    - supporting the integration/interoperation of different DRM models such as MPEG-21 REL and ODRL OMA (Open Mobile Alliance);
- harmonization of B2B and B2C areas for DRM, bringing the DRM model in the B2B area, supporting production and protection models in the whole value chain;
- increment of content accessibility with a P2P platform at B2B level, which can integrate content management systems and workflows.

AXMEDIS implements the AXMEDIS Framework for all, and especially for small and large industries sharing a common interest in the exploitation of new technologies and solutions. The AXMEDIS Framework can be used to setup and built a set of complete applications and services in the area of content production, protection and distribution. With the flexibility of AXMEDIS dynamic Plug-In technology, you can customize your applications and processes according to your needs.

The AXMEDIS digital content and content components is an **open format** capable of integrating any kind of cross media format (video, images, animations, games, learning objects, multimedia, audiovisual, document, audio, etc.) in any digital format, any kind of metadata including identification, classification, categorization, indexing, descriptors, annotation, relationships and play activities and protection aspects.
The AXMEDIS format permits the combination of content components and their secure distribution in respect of the copyright laws, supporting a large variety of DRM rules and models according to concepts of interoperability among DRM models (mainly, but not only, based on MPEG-21, with both binary and XML low level formats). AXMEDIS is open to any DRM model and solution.
Within the AXMEDIS content any type of cross media content can be included from simple multimedia files to games or software components, for leisure and entertainment, infotainment, and also for managing protected governmental content, healthcare information, business of value information, etc.

This document describes the **AXMEDIS open architecture and framework**. It is open since:

- all the AXMEDIS specification is public and its specific use is royalty free. Any company or third party can use the document to create an AXMEDIS compatible solution;
- all the source code of AXMEDIS Framework is accessible by getting affiliated with AXMEDIS. The affiliation fee is low and affordable for all;
- the affiliation to AXMEDIS can be obtained also providing work or results to the community. So that you can have the access to the AXMEDIS Framework in change of your contribution in improving and extending it;
- the AXMEDIS plug-in technology is public, and the source code for creating new plug-in is public without needs to be affiliated;
- in AXMEDIS the focus is on interoperability and openness of content model, including multichannel distribution;
- in AXMEDIS the focus is on interoperability of DRM model, including multichannel distribution.

More technical information on AXMEDIS architecture and framework and about how to access at the AXMEDIS framework getting affiliated to AXMEDIS are available on http://www.axmedis.org .

2 Business to Business areas

In order to ease the collaboration among the business area, AXMEDIS is providing a wide set of tools and especially the AXEPTool, a P2P tool for B2B distribution of content. AXMEDIS supports DRM and Reporting of the use of the content. This tool gathers the information related to the exploitation of rights along the value chain and by the final user and reports it back to the concerned actors. These utilities are very useful to provide the evidence of the exploited rights in a transparent manner to collecting societies or other business partners.

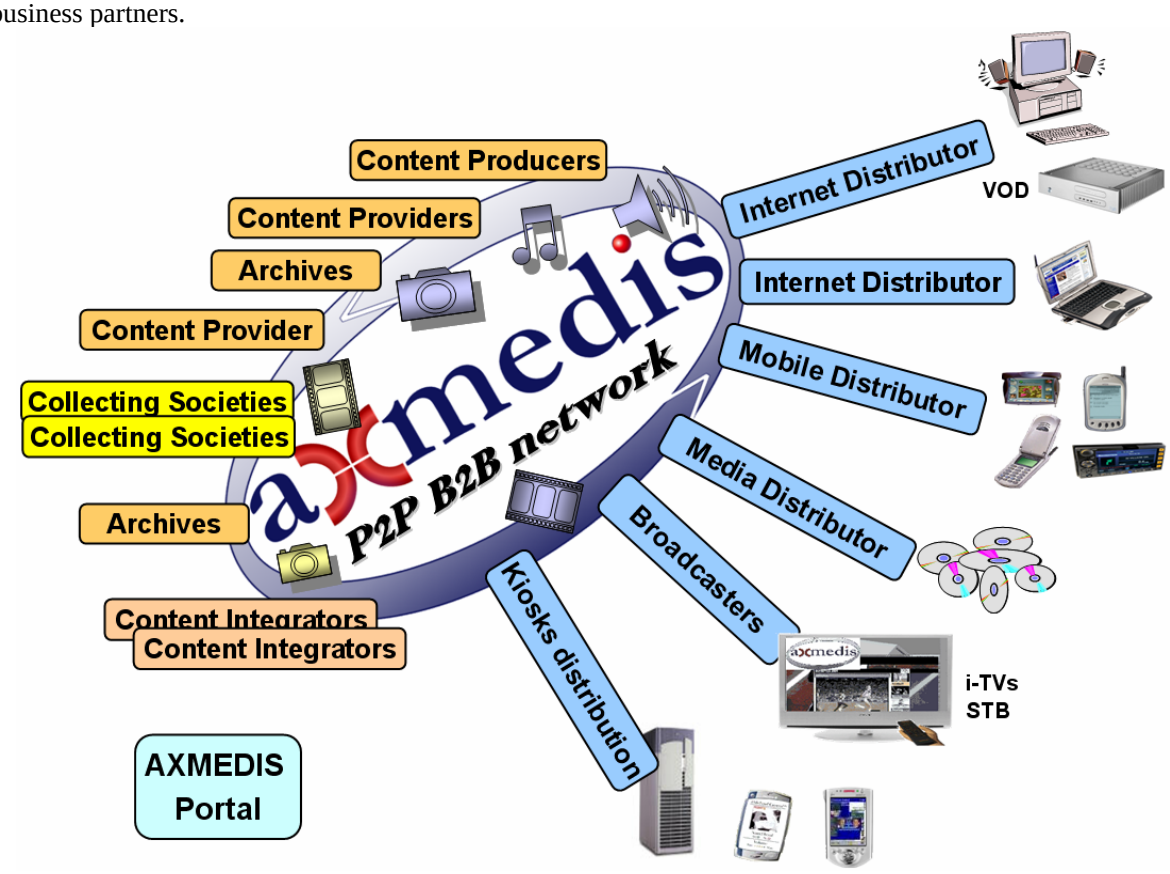

Fig.2 -- AXMEDIS Business to Business area with some distributors

The distribution side may present one or more single distribution paths for each type of content. In AXMEDIS, the content distributors can continue their preferred mechanisms for reaching the final users. The possible Channel Distributors have a large variety of capabilities, they are both of pull and push, and may include off-line and on-line connection from the client to the distributor.

3 AXMEDIS General Architecture

In Figure 3, a more detailed version of AXMEDIS architecture is reported. The diagram includes all the major areas of the AXMEDIS framework and architecture. The following description for each major component is mainly related to the flow of the content from its acquisition to distribution.

The major AXMEDIS areas are the:

- **AXMEDIS Factory** for automatically: collecting content from legacy CMSs, producing the content, programming and scheduling the production process, processing metadata, composing and formatting content, collecting content information from content usage, producing licenses to harmonize the production with workflow applications in the factory and among geographically distributed factories, etc. The AXMEDIS Factory is scalable in the sense that it can satisfy the needs of small and large content producers, integrators, and distributors. The factory is supported by tools for automating the production process and to perform manual editing.
- **AXMEDIS Distribution Area** for automating the content publication and acquisition in the business area allowing the interconnection of AXMEDIS Factories by means of the AXEPTools which is a secure and legal P2P tool. Among connected AXMEDIS Factories, it is also possible to make distributed queries to search for content, and to automatically publish and acquire/update content from/to the business partners, etc. The tools in this area also allow scheduling content distribution and publication towards external web services for example those of front end distribution servers.
- **AXMEDIS Player** for content playing and execution on several different platforms, to built specific and customized content players, for distributing and sharing content among final users by means of secure P2P tools such as AXMEDIA P2P tool.
- **AXMEDIS Protection and Supervising tools** for registering users, certificating users, authenticating devices and tools, monitoring all the activities on the AXMEDIS content on AXMEDIS players and tools, processing licenses, managing black lists, and collecting and reporting the information about content usage and rights exploitation, etc.

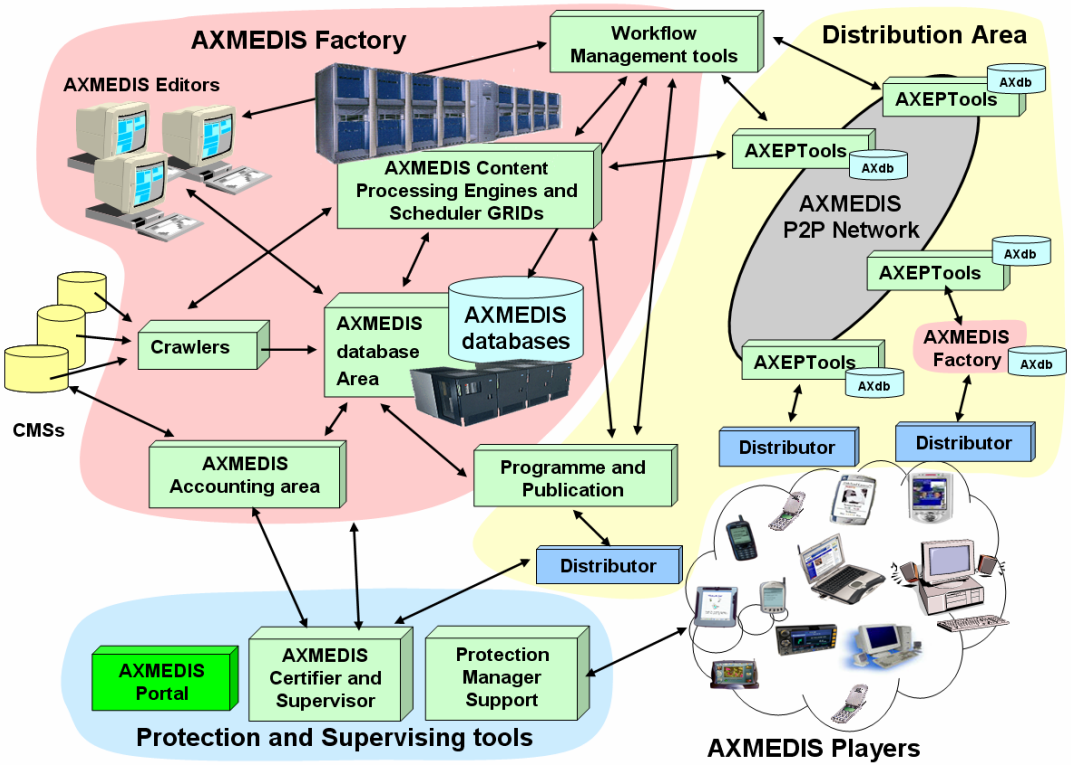

Fig.3 – AXMEDIS Architecture

4 AXMEDIS Factory

A content factory can be built on the basis of AXMEDIS tools in a scalable and flexible manner. Also tuning for example, GRID size, database size and type, number of authoring tools, number and types of tools/algorithms and libraries for processing content, licenses, integration support based on Workflow or not, etc. This allows setting up a large range of configurations to satisfy the needs of small and large content producers, integrators, and distributors.

The **AXMEDIS Database Area** includes the AXMEDIS/MPEG-21 database model, supporting the storage and access to AXMEDIS content via a large set of metadata for each object grouped in what it is called AXInfo, and that can be customized with your needs. The database also includes produced licenses for the objects, history of performed actions on content, potentially available rights for each digital resource, models of contracts, etc. The AXInfo includes Dublin core plus descriptors and many other metadata for managing protection, lifecycle, etc. Any descriptors and metadata can be added in a flexible manner. Thus, different AXMEDIS factories may be based on different AXInfo and metadata, while automatic adapters can be defined and activated. The database area is based on a scalable database, a powerful AXMEDIS Database manager, and an effective **AXMEDIS Query Support** endowed of an easy to use user interface. The User may perform queries to search for objects and content located in the CMSs, in the local AXMEDIS database and in the virtual database comprised of the AXMEDIS content accessible/published via the P2P network of AXEPTools in the AXMEDIS B2B Network.

The **AXMEDIS Content Processing Area** (AXCP Area) is based on a GRID solution for automating all the activities to be performed for the production, and processing of content. The major tools are the **AXCP GRID Node (Engine) and AXCP Scheduler,** which are respectively the single node (computer) of the GRID and the organizer of processes on the GRID Nodes. They implement a scalable solution to process from smaller collections to huge amount of content per day, per minute. The processing algorithms can be specified in terms of script code (in Spider Monkey) allowing the manipulation of complex AXMEDIS data types and simple digital resources and content in general, and for the direct access to the AXMEDIS database and processing queries with the help of the AXMEDIS Query Support. The solution allows the writing of any kind of content processing algorithms, to activate them automatically on some query result, and these can be put in execution as independent processes on a scalable GRID for massive production and processing of digital resources in respect of the DRM.

The available data types, operators and accessible algorithms allow manipulation of any digital resources in a large number of formats. Algorithms can be defined for massive content composition (packaging, combination, etc.) and content layout formatting (synchronization, image and screen layout, from image sequence to video, etc.), content adaptation (change in resolution, subsampling, change in format, etc.), transcoding, coding, decoding, fingerprint extraction, estimation of descriptors, license adaptation and transcoding, license production and verification, etc.;

The users of the **AXMEDIS Content Processing Area** can code in terms of Java Script rules any kind of processing procedures and algorithms to manipulate/produce:

- Any digital resource:
    - such as images (more than 150 different formats), audio (more than 50 formats), video (more than 50 formats), documents (TXT, PS, HTML, PDF, RTF, DOC, etc.), multimedia (more than 20 formats including MPEG-4, HTML, LOM, etc.);
    - for their transcoding, adaptation, feature and descriptor extraction, recognition, certification, etc.;
    - with functionalities of many well know and powerful processing libraries such as: FFMPEG lib, LibSNDFile, TreTagger, DocFrac, GhostScript, XPDF, HTMLDOC, ImageMagik, MP4Box, Xerces, XALAN, CCPP, etc. (if you are interested in adding more libraries please contact AXMEDIS people);
- Packages and their composition and formatting
    - AXMEDIS objects with AXInfo Metadata and indexing,
    - MPEG-21 Objects,

  - including digital resources, metadata (e.g., Dublin Core, etc.),
  - protection information, etc.
- Protected objects and resources, managing protection information:
  - by using MPEG-21 IPMP model, and format
  - using algorithms such as encryption/decryption, scramble, compression, key production, different sizes for keys, etc.
- Licenses on the basis of the business models chosen:
  - stating grants, conditions, etc.,
  - verifying license consistency with respect to the potentially available rights, with the license in production, etc.,
  - by using formalism of MPEG-21 REL, and with OMA ODRL – MPEG-21 REL transcoding
- Automatic content and information access
  - database accesses (ODBC, etc.) with direct facilities;
  - database access by means of crawling facilities to access to a larger set of possible database models. They may contain digital content, resources, files, metadata, administrative and licensing information, etc., and can be physically located in several different computer systems and based on several different database models: ODBC, MySQL, ORACLE, MS-SQL, Tamino Lobster XML, etc., or files systems. The access to this information is performed by means of Focuseek Crawler;
  - file system and operating system access;
  - http and ftp accesses;
  - AXMEDIS database access with query support, actualization of selections, active queries, etc.
- Device capabilities format and processing facilities, to take into account for adaptation and/or processing;
- User Profile format and processing facilities, to take into account for adaptation and/or processing;
- WSDL facilities for the activation of WEB services dynamically on the basis of their definition;
- XML facilities for the application of styles and general processing;
- SMIL facilities for the application of templates and styles and processing;
- etc.

The algorithms and procedures used in the AXCP Area can be expanded by using the AXMEDIS Plug In technology that allows customizing and easily expanding the processing capabilities of the AXMEDIS GRID. Algorithms for the extraction of fingerprint, descriptors, adaptation, content processing, DRM adaptation, metadata adaptation, are built as pluggable algorithms. ***Any other library, model and format and related algorithms for their manipulation can be plugged in the AXCP in a very easy manner.***

The AXMEDIS **Workflow Management tools** include a set of micro tools and interfaces which are pervasively connected to all the AXMEDIS tools and plug-ins to allow interfacing the whole content factory to Workflow tools such as Open Flow and BizTalk. The control is performed to define AXMEDIS factory workflow policies and to manage inter-factory workflows policies.

The **AXMEDIS Editor** is the authoring tool for manually producing AXMEDIS objects when needed and for supporting the designer to create the scripts for the AXCP that could be considered macros of the AXMEDIS Editor. It is based on the AXMEDIS Object Model, called AXOM and based on MPEG-21, and all the modules and tools to manipulate and create AXMEDIS objects and related information and digital resources such as:

- resource hierarchy viewer and editor;
- visual and behavioral viewer and editor to show/manipulate visual and temporal aspects of related digital resources according to SMIL;
- metadata editor and viewer, to manipulate and view general XML metadata and specific AXInfo metadata;
- DRM viewer and editor to create and verify the licenses;

- Protection Information viewer and editor to specify, apply and browse protection aspects on the basis of the MPEG-21 IPMP format with extension of AXMEDIS;
- set of plug-ins to use algorithms for content processing as those mentioned and used in the AXCP Area mentioned above;
- set of plug-ins to allow the integration of AXMEDIS Editor within other editing and viewing applications such as: Video Editors, Image Editors, etc.;
- an interface to connect the AXMEDIS Editor with other external powerful editor tools;
- an interface with workflow (OpenFlow and BizTalk);
- set of internal viewers and players for digital resources such as document, images, video, MPEG-4, and audio resources, etc., for more than 250 different file formats.

The **AXMEDIS Accounting Area** includes a set of tools which allows content producers, distributors or collecting societies to collect administrative information and reports about their content in order to gathering information about the list of rights that have been exploited on their AXMEDIS objects by the final users and by the business users. This information is collected into the AXMEDIS database for further analysis. The acquisition of accounting information is performed by collecting it from the AXMEDIS Certifier and Supervisor, AXCS. The local database and the AXCS provide support to make queries to obtaining statistics data on content usage in the area, in the channel, for a type of content, for a period, etc. A specific tool allows extracting data from the AXMEDIS Database to migrate them towards the administrative side of the CMS, such as high level administrative information to prepare the bill at the content users, distributors, etc., to interface with customer relationships services.

5 AXMEDIS Distribution Area and Players

The AXMEDIS tools for the distribution area allow automating the content publication and acquisition in the business area establishing also interconnection among different AXMEDIS Factories by means of the so called AXEPTools (AXMEDIS P2P Tool for B2B distribution) which is a secure and legal P2P tool. The tools in this area also allow scheduling content distribution and publication towards external web services for example those of front end distribution servers.

Each **AXEPTool** includes an instance of the AXMEDIS Database that allows making distinction from content in the AXMEDIS Factory and content published to be distributed and shared with other business partners. It also allows searching for content among business partners connected on the AXMEDIS Network. Typically the network allows sharing content among producers, integrators, distributors, publishers, archives, etc. Among the interconnected AXEPTools it is possible to make distributed queries to search for content, and to automatically publish and acquire/update content from/to the business partners, etc. The Potentially Available Rights and the contact information are the instruments to start the negotiation of content acquisition. This mechanism makes the B2B content distribution fasters, simpler and more secure. Each transaction and trial is monitored by the AXEPTool and by the AXCS. During queries, the content and the technical metadata are certified thus avoiding trivial problems of many P2P architectures.

The AXMEDIS **Programme and Publication tool, AXP&P,** includes a set of tools which allow interconnecting AXMEDIS Databases content to the distribution channels for producing programs to public content on the distribution channel, and to transfer the related to content on the channel. It also allows the management of requests for content production/adaptation on demand. The production of content programs is capable of scheduling the production/adaptation of content depending on the distribution profile, production time costs and on delivering time. These tools also provide a front end in terms of web services to delivering content ready for the distribution.

The **Distributors** represent any kind of content distribution services (see Fig.3): Internet, satellite and terrestrial broadcast, mobile, towards: PC, STB, I-TV, mobiles, PDAs, etc.
Distributors may be also interested in having in their plant some components of the AXMEDIS factory such as an instance of the AXMEDIS Database to make queries, license editor to produce licenses, AXCP for content adaptation and/or to protect content in massive manner, for content production on demand, etc. In order cases, they can delegate these actions to other parties or to external web services. Some examples about

the usage of AXMEDIS tools to set up solutions for content distribution are reported in the following. In some cases, the Distributors may be interested in establishing a connection with the AXMEDIS Certifier and Supervisor for obtaining reports about the rights exploitation or for getting statistical information.

Some Distributors may be interested in exploiting AXMEDIS technology to set up a legal P2P service for content distribution. This solution can be realized by using the so called **AXMEDIA** tools. It is a P2P tool for distributing and sharing AXMEDIS content among end users, the distributor may insert AXMEDIS content in the network of peers and this may freely navigate among them but with the supervision and control of AXMEDIS protection and monitoring models.

The **AXMEDIS players** are based on the AXMEDIS object model and manager called AXOM (AXMEDIS Object Manager). They are capable of reading and playing/executing AXMEDIS objects according to the business models chosen and the license associated with the user/device. AXMEDIS player are available mainly for PC (as independent tools, as plug in for Internet Explorer and Mozilla browsers) and PDA with Pocket PC 2003. The AXOM module can be integrated in any other content processing tool in order to manipulate AXMEDIS and/or MPEG-21 objects.

AXMEDIS framework provides tool kits and libraries to create a large number of different players on different platforms, leaving free the customization of the user interface, skin, and much more; mainly MS-Windows, MAC and Linux, for PC, PDA and may be for mobiles and Set Top Boxes.

6 AXMEDIS Protection and Supervising Tools

AXMEDIS Protection and Supervision Tools provide support for registering and certificating users, providing unique IDs for the AXMEDIS objects, authenticating of devices and tools, processing licenses, managing black lists, continuous monitoring of the user activities on the AXMEDIS content on AXMEDIS players and tools on the basis of licenses, and collecting and reporting the information about content usage and rights exploitation, etc. The tools of this area are described in the following.

The **AXMEDIS Certifier and Supervisor, AXCS,** is the responsible of user registration, for device and tools authentication and certification, and for the registration and tracking of the activities performed on AXMEDIS objects on any AXMEDIS compliant tool. The AXCSs provide protection information and share with the AXMEDIS Protection Manager Supports (PMS) the responsibility of managing the protection for distribution channels and domains. The AXCS also manages black lists of users, devices and tools to restrict their activities when irregularities are detected.

The **AXMEDIS User Registration portal** is a service that can be used by content Distributors to make the registration of AXMEDIS final users (if they do not prefer to automatically register all their users). In any case, the User has to make a registration on AXMEDIS to obtain a certificate that could allow him/her to install tools and to cope with the related AXMEDIS licenses. Some Distributors may prefer to use a direct Web Service to automatically register their users in for AXMEDIS. Both solutions can be used.

The **AXMEDIS Object Registrator** is a service to produce and assign a unique object ID to AXMEDIS objects. In the process, the most important metadata may be provided as well by allowing establishing relationship from standard and/or proprietary identification codes with those used in AXMEDIS. It is a service accessible by all tools capable of creating new AXMEDIS objects for any AXMEDIS Factory (such as: AXMEDIS Editor, AXCP GRID Node) and it is a WEB service directly connected to the AXMEDIS Certifier and Supervisor.

The AXMEDIS **Protection Manager Support**, **PMS,** collects the licenses and has the duty of processing chains of licenses on the basis of the requests received from AXMEDIS players, and all other AXMEDIS tools that include an AXOM to manipulate objects. The PMS allows the management of licenses and the sharing of these along other PMSs by means of a network of AXCSs. Each PMS can be associated with one or more different distribution channels or can be geographically distributed, e.g., to cover a geographic area. The definition of licenses and the management of information into PMS and AXCS allow to set up of a large variety of different distribution and transactions models, from client server to P2P, from satellite data

broadcast toward i-TV to content distribution to cellular phones. The PMS is also provided in versions that allow managing Domains (the so called PMS Domain) such as those that can be set up for managing licenses for a school, a house, or a company, etc. Each PMS Server allows to receive the posting of new licenses by means of a Web Service, this ca be used for automating their production from the Distributor Front End Sale server. In alternative, the **AXMEDIS DRM Editor** (license editor) can be used.

The **AXMEDIS Portal** includes services for all the AXMEDIS users including those that support AXMEDIS and contribute to the construction and improvement of the AXMEDIS framework. It provides a set of service including the database of AXMEDIS documentation, the deployment of the AXMEDIS framework, the management of the mailing lists, etc. It allows providing updated tools and information to AXMEDIS partners. On AXMEDIS portal, you can get the list of AXMEDIS compliant tools, devices, registered companies, test cases, documentation, libraries, etc. In addition, you can find from the AXMEDIS Portal references to the AXMEDIS services that allow the authentication, certification and continuous monitoring and control of any AXMEDIS tools.

7 AXMEDIS Framework

The AXMEDIS Framework is the set of information and tools that is at the basis of the above mentioned applications and solutions. In the next Figure, the simplified version of the AXMEDIS Framework structure is reported. It contains all the necessary tools to set up a large set of services and solutions in the area of content production, protection and distribution. The AXMEDIS Framework is an infrastructure on which several other models for content modeling, protection, production, DRM and distribution can be built in a very simple manner reusing the components and functionalities provided.

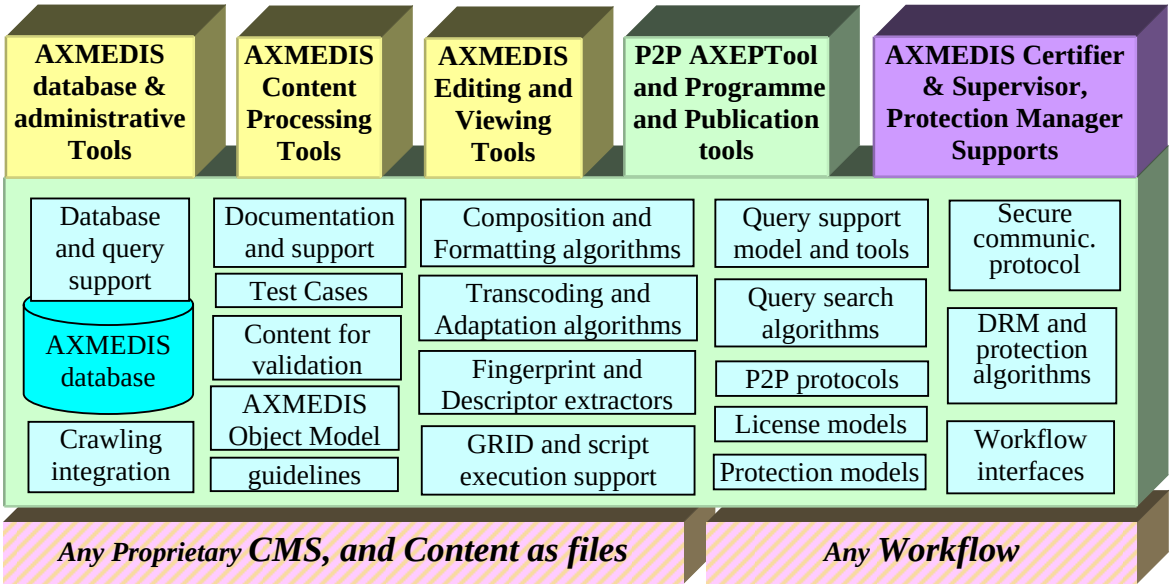

Fig.4 -- AXMEDIS Framework structure, a simplified view

The general infrastructure gives a common ground on the base of which other content based applications and tools can be built. In addition, to the modules and tools described before, the most relevant parts of the **AXMEDIS Framework** are:

- Requirements and their revisions,
- test cases and uses cases and their revisions,
- content for validations, both single resources and metadata and demonstrative AXMEDIS objects,
- general documentation of AXMEDIS tools and supports, including the:
    - whole specification of the AXMEDIS framework and the

    - detailed technical documentation of the source code,
- CVS tree with source codes of the several modules of the AXMEDIS framework,
- examples of AXCP scripts modeling algorithms for content compositions and formatting, for transcoding and adaptation, for extraction of fingerprint and descriptors, content processing, license manipulation and verification, license adaptation, etc., for many different formats of digital resources and for any categories of them: audio, video, document, multimedia, images, animations, text, metadata, etc.,
- examples and models of licenses,
- example and models for protection information,
- examples of workflow usage and programming for controlling AXMEDIS Factories,
- examples of queries and selections for accessing to the database,
- tutorials on content:
    - general aspects and state of the art,
    - content production,
    - content protection,
    - on AXMEDIS tools,
    - on distribution tools,
    - on general AXMEDIS aspects, etc.,
- guidelines for source code production for contributing to the AXMEDIS framework,
- guidelines on content production and distribution,
- guidelines for the production of AXMEDIS Plug-ins for AXCP and AXMEDIS Editors,
- guidelines for the production of licenses on the basis of contracts,
- ready to use/install AXMEDIS tools such as: AXMEDIS Players, AXEPTool, AXMEDIA tool, AXMEDIS Editors, AXMEDIS Programme and Publication tools, AXMEDIS Content Processing Tools, AXCS, AXMEDIS PMS.

7.1 Accessing to the AXMEDIS Framework

The present status of the AXMEDIS Framework can be obtained from its coordinator or partners. Demonstrations of the AXMEDIS tools and of the whole AXMEDIS Framework are provided at AXMEDIS conferences and in other occasions listed on the AXMEDIS Portal. The AXMEDIS Framework can be accessed by all affiliated partners. The Affiliation to AXMEDIS is performed by subscribing an Affiliation Agreement with an AXMEDIS Contractor. The Affiliation Agreement and the list of Contractors are accessible on the AXMEDIS portal.

There are many **reasons to get affiliated to AXMEDIS,** which can be summarized as follow:

- Obtaining access to an *open platform* that can be customized for your production., protection and distribution needs;
- *Reduction of costs* for content gathering, processing, production, protection and distribution;
- Adopting a standard model (MPEG-21) for content and licenses modeling and thus for inserting DRM in your business;
- Establishing contacts with other business partners interested in exploiting similar technology;
- Acquiring a greater control about content usage;
- Creating customized players;
- Exploiting and trial of new business models;
- Exploiting capabilities of secure legal P2P distribution;
- Setting up and create a customized distribution channel interoperable with others;
- Setting up some new service (empowering your present solution) on the basis of AXMEDIS technology;
- Setting up of one-stop service for content protection and DRM set up;
- Allowing reporting to your business customers which rights are exploited on their content;
- Allowing the management of rights reporting for multimedia products;
- Allowing using a solution that can be safer and more flexible with respect to state of the art;
- Saving money in accessing at innovative technologies for content production and distribution, integrated environment;

- Accessing to strongly innovative technology to trial it;
- Contributing to the AXMEDIS Framework is allowing you to continuing accessing to the framework reducing the costs for its accessibility.

Research institutions and technology providers are interested in getting affiliated with AXMEDIS to:

- make visible, promote, produced algorithms and tools that can be used for content processing and modeling and that can be in some how integrated into the AXFW. These tools may be provided as demonstrators with limited capabilities;
- exploit the AXMEDIS Framework to make business with it for the reasons reported in the above list;
- add new content models and new DRM models and make them interoperable with MPEG-21 and others already in place on AXMEDIS;
- test new algorithms and tools with respect to the state of the art solutions, in a very easy and cheep manner;
- access at low cost a framework by means of which several different configurations and solutions may be built to cover the needs of the value chain actors and tested with low effort;
- access at tools based on MPEG-21 standard;
- collaborate with very relevant and well known research institution and companies of the areas;
- etc.

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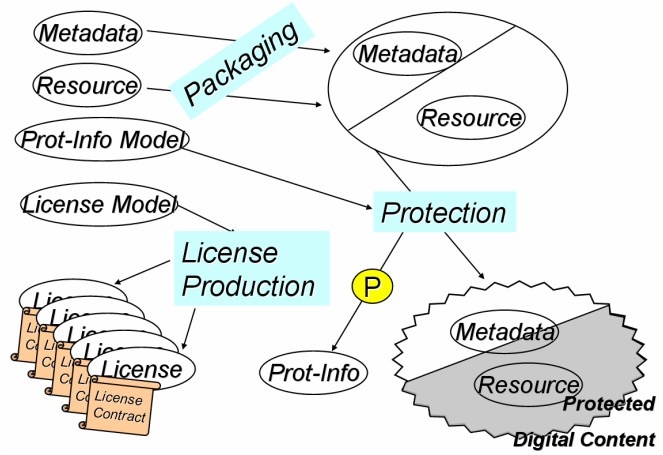
The AXMEDIS 2006 conference will be held in Leeds in December 2006. The Call For Papers is open until April 2006. http://www.axmedis.org/axmedis2006/

8 AXMEDIS Framework Details

8.1 AXMEDIS Object Model

The state of the art of content production, distribution, modeling, composition, formatting, protection and management is grounded on the content formats. Presently, there is a number of content formats that ranges from the simple files: documents, video, images, audio, multimedia, etc., to integrated content models such MPEG-21, SCORM, HTML, and WEDELMUSIC. These models attempt to wrap any digital resource in a container to make them ready for delivering by using a large range of business and transaction models and supporting them with some DRM (Digital Rights Management) model (only for MPEG-21 and WEDELMUSIC). More specifically, MPEG-21 is mainly focused on the standardization of the DRM aspects while WEDELMUSIC is mainly focused on Multimedia Music and provided limited DRM flexibility with an effective implementation of tools for digital item collection and distribution. The latter, SCORM, is mainly focused on packaging collections of digital content/resources/files for educational purpose.



AXMEDIS has an object model (cross media content model) derived from the integration of MPEG-21 and WEDELMUSIC models. Any AXMEDIS object is MPEG-21 compliant. It formalizes how a cross media collection/group of digital resources and their metadata are organized to be protected and delivered.

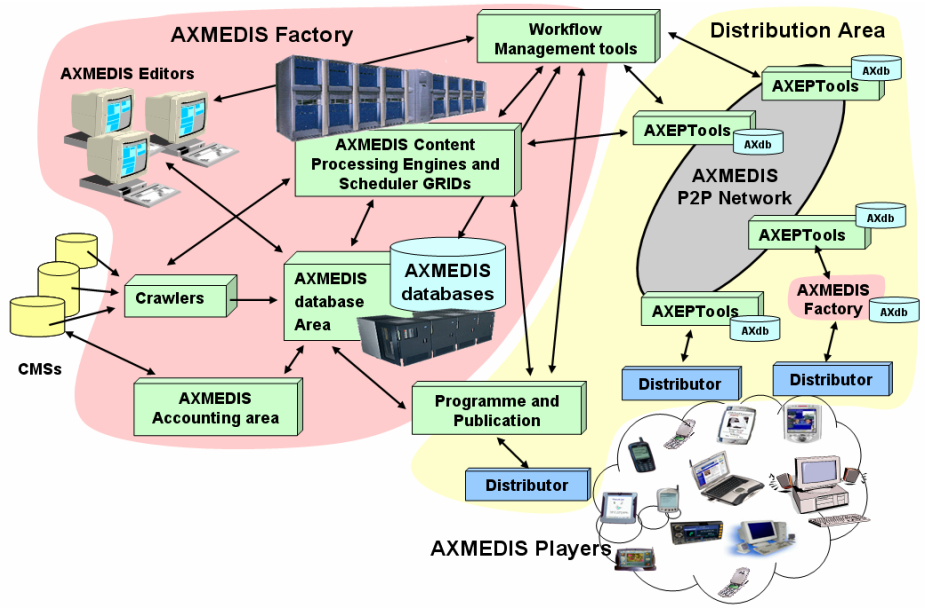
AXMEDIS formalizes:

- **Metadata that are also visible in protected and non protected objects and are certified**
  - Identification information, unique ID, distributor ID, any proprietary IDs, any ISxx IDs, etc.
  - Classification information also for indexing such as Dublin core, plus any other format you may be interested to add, formalised in XML and not only;
  - Any descriptors for indexing digital resources, such as MPEG-7;
  - A set of references to value chain actors that have been involved in the creation and distribution of the object: owner, distributor, producers, editor, etc.;
  - Potentially Available Rights, PAR, that can be acquired from that object.
- **Digital Resources:**
  - Any digital information file: images, doc, txt, video, game, application, file, audio, etc.;
  - Organised as a: hierarchy, list, cluster, nesting levels, or other. An object may contain other objects inside and thus several nesting levels can be created;
  - Included in the object or simply referred with a link.

Once the object is packaged it can be protected. In that process, Protection Information (Prot-Info) is produced to be used to exploit the rights related to the digital resources: play, print, view, etc. The Prot-Info is provided to the final user device tool if it has the “rights”. The “rights” are formalised with a license specifically created for that user, or device or group of them, according to eventual conditions such as territorial, temporal, number of times, etc.

8.2 AXMEDIS Content Production

The Content Production area of AXMEDIS is mainly focussed on what it is called AXMEDIS Factory automating: (i) the packaging containing the digital resources (the real content), (ii) adapting and transcoding, (iii) protecting content and producing corresponding Prot-Info, (iv) publishing and distributing the produced package, (v) producing licenses for the users, etc.



Content Object Production

- Existing contents (e.g., resources and metadata located in databases, CMSs, file systems) are crawled and collected using automated processes and rules (e.g., Crawler, rule editing);
- Crawled contents or new contents can be inserted into the AXMEDIS Database;
- Content can be automatically packaged in AXMEDIS model (which is MPEG-21 compliant);
- Content production and elements (metadata, resources, protection information and licenses) can be processed manually with authoring tools and editor or automatically with AXMEDIS Content Processing tools based on executable rules that can be hosted on single or massive GRID of computers;
- Authoring tools can be used to insert/revise metadata, define protection information, define DRM licenses models, to modify content or simply to view the objects;
- Various processing are offered (adaptation, transcoding, protection, etc.), either automatically or manually (using GUI editor);
- The various components and digital resources can be glued together by means of SMIL based templates and style that may be used to define the usage interface (format) of the whole object: karaoke, collection, menus, sliding presentation, buttons, live, animations, etc.;
- Results can be sorted in a database or on file systems or published in towards distributors or on the B2B P2P AXMEDIS network;
- They are now available on the AXMEDIS network, for further aggregation, distribution, etc., to be searched, modified, or shared;
- Queries and P2P allow retrieving content located in all the connected AXMEDIS Factories;
- The queries can be activated to automatically react at eventual changes in the sources, and thus to perform an automatic production/update;
- Queries can be performed on the basis of classification and identification metadata, but also on technical features, descriptors, licensing information (PAR), etc.;
- Once identified the objects or queries, they can be used as input parameter of processing rules for the GRID AXMEDIS Content Processing;
- All these activities can be governed by Workflow Management Tools for defining process production flow and information of the content factory and among different factories.

8.3 AXMEDIS Content Processing Capabilities

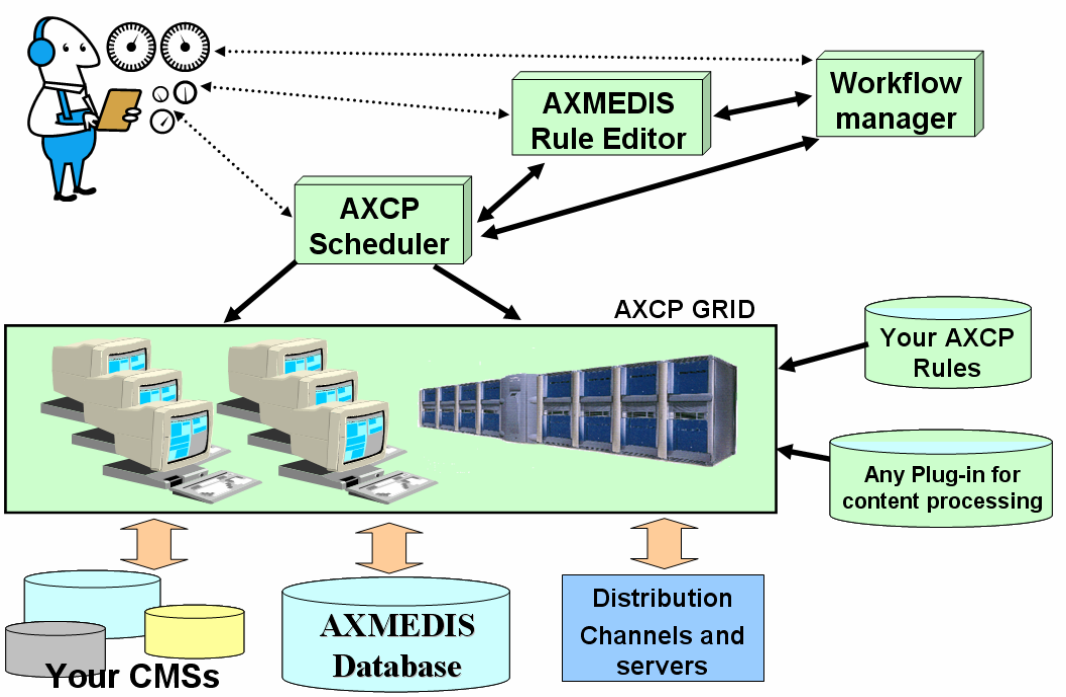
The AXMEDIS Content Processing Area has been designed to provide a set of digital content processing tools to aid content designers to create rules/script for **automating** content production and processing and in more details for:

- **Content Ingestion and Gathering** from
  - Content Management Systems, from file system, or protocols;
  - processing resources and coupling them with metadata;
- **Content Retrieval** from
  - AXMEDIS database;
  - other AXMEDIS content Factories by means of the P2P tools, namely AXEPTool;
  - Content Management Systems, CSMs;
- **Content Storage** into
  - an AXMEDIS database;
  - ODBC based databases, other databases via Web Services, and other models will added later;
- **Content Processing** such as
  - digital resources adaptation, extraction of descriptors, transcoding, synchronisation, metadata processing, estimation of fingerprint, watermarking, indexing, content summarization, etc.;
  - metadata manipulation, mapping and adaptation;
- **Content Composition** for
  - creation of content components or objects as a combinations of raw assets such as Text, Images, Audio, Video (actual shot), Animation (synthetic), metadata, descriptors, licenses, multimedia objects such as MPEG-4, HTML, SCORM, macromedia tool file, animations, games, etc.;
  - creation of content as linear or hierarchical combination of content components;
- **Content Formatting**
  - gluing content elements together by means of SMIL based templates and applying style sheets to define the usage interface (format, layout) of the whole collection of content elements and the interested content usage paradigms (leaving open some parameters). For example, karaoke, collection browsing, selection menus, sliding presentation, stable background with a window with live video, animated text moving on an image, running text, etc.;
  - optimization of styling parameters left open or defining them manually to arrange for example: best fitting of images in the screen, optimizing the amount of text in the page, best time fitting, etc.;
- **Content Protection** such as:
  - protection of digital resources and full objects with their complex structure;
  - creation of Protection Information parameters, such as keys, or other features;
  - applying Protection Information model to AXMEDIS object, segmenting digital resources, slicing objects, applying encryption, scrambling, compression, and many other algorithms;
  - posting specific protection information for each given object to the AXMEDIS Certifier and Supervisor server;
- **Content Licensing** for
  - generating license from license model and additional information, storing licenses, posting them on license server automatically;
  - transcoding/translating licenses;
  - invocation of some verification algorithms about licenses and available rights to simulate the usage from the user site;
- **Content Publication and Distribution** towards
  - any distribution channel, producing programme and its schedule;
  - P2P network of other AXMEDIS Factories of content integrators, producers, and distributors.

8.4 AXMEDIS Content Processing Tools

In order to exploit the above list of features to process/manipulate content, resources, licenses, XML, SMIL, databases, protection information, etc., the AXMEDIS Content Processing Area is governed by a set of tools:

- **AXMEDIS Rule Editor**: to produce, debug, test and validate the executable AXCP Rules that can be:
  - written with a simple **AXCP language for content production** which is an extension of Java script;
  - created as macros from AXMEDIS Editor and authoring tools;
  - tested, debugged and validated on the AXMEDIS Rule Editor;
  - activated for content processing on any AXCP GRID Node or on a single computer;
  - used for B2B or B2C purpose;
  - used/parameterized for producing content on demand or to be integrated in your content factory;
  - activated from your Workflow Manager engine via web service;
  - activated by changes in remote objects and queries in the local database and on the P2P network.
- **AXCP GRID**: a set of general purpose or specialized computers to execute AXCP Rules governed by the AXCP Rule Scheduler;
- **AXCP GRID Node**: a single general purpose or specialized computer of the AXCP GRID;
- **AXCP Scheduler**: to schedule the AXCP rule of GRID nodes according to the content production and processing needs in terms of time and resources.



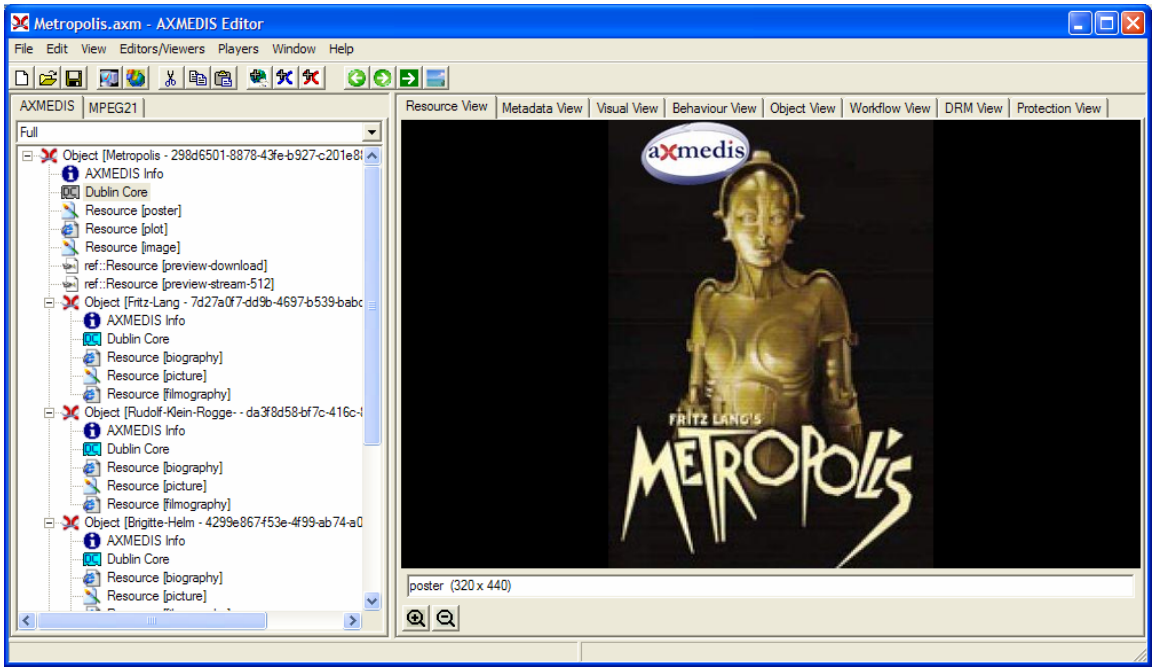
The processing capabilities and functionalities reported in the previous section and that can be exploited from AXCP Tools and Rules can be simply expanded by means of realizing or installing a set of additional plug-ins. The AXMEDIS Plug-in technology is open since:

- the specification of plug-in format is public;
- a plug-in tool kit (including examples and source code for creating those plug in) are public and accessible to all;
- a large part of the above mentioned features are provided by means of AXMEDIS Plug-ins. This demonstrate the solution flexibility;
- any user or third party company can create its own plug-in or include in a plug-in any open third party library including those open source.

8.5 AXMEDIS Editors, the authoring tools

AXMEDIS Editor is used for the manual production of AXMEDIS Objects, and allows creating and manipulating object features and their different aspects:

- ***Structure***, to add, remove, move digital resources and metadata inside the AXMEDIS Object (hierarchy editor and viewer of the object);
- ***Resource manipulation***, to use content processing plug-ins for generic and customizable resource manipulation (the same algorithms and tools used in the AXMEDIS Content Processing);
- ***Metadata editing***, allowing to edit/mapping the metadata related to digital resources and objects (metadata editor and viewer);
- ***Visual and behavioral editing,*** allowing to define content usage paradigm with SMIL organization of resources to present/layouting the digital content contained inside the AXMEDIS Object (visual and behavioral editor and viewer);
- ***Protection editing,*** allowing to specify the protection algorithms to be used for the AXMEDIS Object protection, and thus to define the Protection Information (Protection Editor and Viewer);
- ***DRM editing***, allowing to produce and verify licenses for end users and/or distributors of the AXMEDIS Object as well as the Potentially Available Rights, PAR, that could be acquired on objects shared in the P2P Network (DRM editor and viewer);
- ***Workflow***, allowing editing and viewing the status and the work to be done on the AXMEDIS Objects involved in the workflow process (workflow editor and viewer).



Moreover, **AXMEDIS Editor:**

- allows to perform queries to look for content to produce AXMEDIS Objects integrating other AXMEDIS objects coming from the internal AXMEDIS Database, the AXMEDIS P2P network or possibly from the factory CMS;
- allows download/upload AXMEDIS Objects from/to the AXMEDIS Database and file system;
- can be controlled by the AXMEDIS workflow system to integrate manual operations on AXMEDIS objects inside the production process formalized with the workflow system;
- can be used to inspect automatically generated objects for validation;
- can finalize the production of automatically produced objects;
- can produce rules/script to be used as templates for the AXMEDIS Content Processing environment.

8.6 Content Adaptation facilities

AXMEDIS objects can be created to be distributed over heterogeneous networks and towards different kind of terminals, client tools/devices. Moreover, the people who will ultimately consume and interact with the content may have different behavior and preferences, and the best formats to provide them the best experience on their terminal could be different. Consequently, digital items may need to be adapted to fit any particular usage environment. This is the goal of AXMEDIS content adaptation tools which aim at achieving interoperable transparent access to (distributed) advanced multimedia content by shielding Users from network and terminal installation, management and implementation issues.

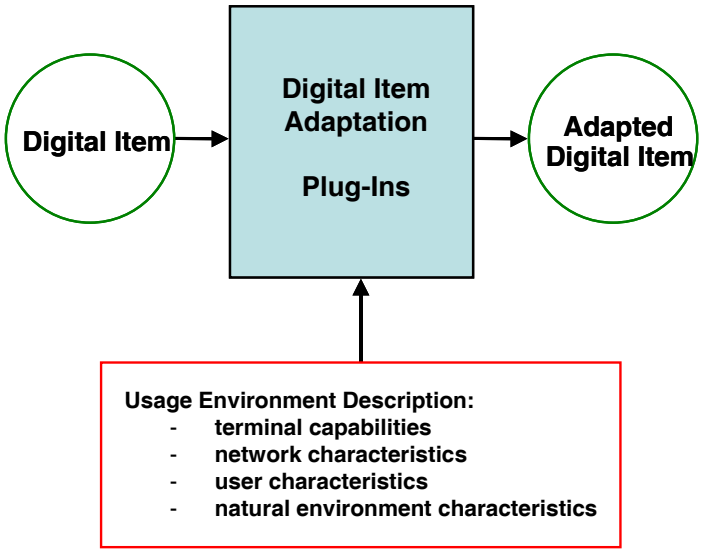
Adaptation may involve:

- transcoding of digital resources that means to change the format (for example, from TIF to GIF, from MPEG-4 to video, from a video to MPEG-4, from MPEG-4 video to a MPEG-2, from audio to symbolic music, from audio to MIDI, from audio in PCM to a ringtone format for mobiles, etc.), re-sampling, shrinking, stretching; In some cases, some features related to resolution, interactivity, are lost in the process in favor of having the content usable in another format. Typically the content is produced in a format that is transcoded scaling down its features and not the vice versa;
- manipulation of licenses, reduction of license scope, reduction of time or territorial information, transformation of format, translation of license (such as passing from ODRL to MPEG-21 REL), etc.;
- manipulation of metadata, metadata mapping, metadata reduction, translation of metadata, etc.

The **adaptation process** can be performed:

- during the content production (for digital resources, licenses and metadata) by exploiting functionalities accessible from the AXMEDIS Editors and/or for the AXMEDIS Content Processing tools
- directly on the player terminal/device (mainly for digital resources and metadata). In this case, ISO/IEC 21000 (MPEG-21) specified a set of normalized tools for the adaptation of digital content describing the usage environment of a digital item to command adaptation tools. Within the AXMEDIS players, MPEG-21 usage environment descriptions are used to drive the adaptation tools considering:
  - Terminal capabilities (codec, formats, input-output, etc., supported by the terminal),
  - Network characteristics (for example, the minimum guaranteed bandwidth of a network),
  - User characteristics (presentation preferences, auditory or visual impairment etc.),
  - Natural environment characteristics (for example, the illumination characteristics that may affect the perceived display of visual information).

The conceptual architecture of the adaptation engine is shown below: a digital item is subject to adaptation thanks to dedicated plug-ins to produce the adapted digital item; the adaptation performed by the plug-ins is parameterized according to MPEG-21 usage environment descriptions.

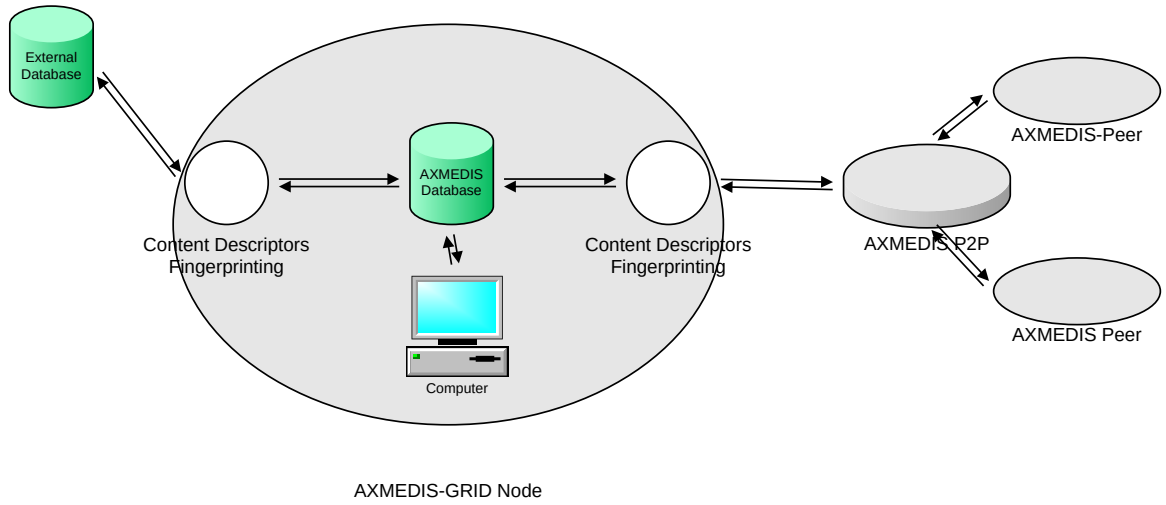


8.7 Content Fingerprint and Descriptors extraction

Among the several content processing algorithms that can be applied in AXMEDIS, a large set can be classified as extractors or estimators of Fingerprint and/or Descriptors of content.

Content fingerprints and descriptors can be used in the AXMEDIS framework for different purposes:

- Classification and recognition of content and/or digital resources;
- Identification of a single piece of content/resource and thus for content certification;
- Authentication/verification of content integrity.



They can be of classified as:

- **High-level descriptors** to describe content with a set of high-level features independent on the format and content resolution. They are typically high level features immediately related with concepts understandable by humans, such as: rhythm and tonality for music, subject for text, etc. They can be very easily used as Descriptors by humans to make queries in the data bases, and thus to retrieve similar content;
- **Digital fingerprints** (or **perceptual hash values**). They can be compared with human fingerprints and may be used to identify a specific content and are robust against data transformation;
- **Low-level descriptors** to describe digital information at lower level and sometime these descriptors are not independent on the format and resolution, such as: energy for music, spectra for images, dynamic, duration, etc. Similar content may share similar low-level descriptors. In some cases, they are used at the basis to estimate high-level descriptors. They can be used for recognition of content as well;
- **Low-level fingerprints** to estimate a value from a specific digital resource, in many cases estimated with algorithms that do not take into account the content type, such as: cryptographic hash value that can be estimated for any digital file. They can be used for content and digital resource verification of consistency and authentication.

In AXMEDIS, Content Fingerprints and Descriptors can be:

- manually selected and estimated via the AXMEDIS Editors;
- automatically estimated and stored in the object metadata or other places by means of an AXMEDIS Content Processing Rule script. For example: during the acquisition/crawling of content from CMS, during content composition and/or formatting, during any content processing also included in the production on demand;
- estimated to verify integrity of content when the content is opened by an AXMEDIS Editor, or by an AXMEDIS Player, or processed by a AXMEDIS P2P tool such as AXEPTool or AXMEDIA, etc., that is any time that an AXMEDIS object is loaded into the AXOM core component of AXMEDIS Framework.

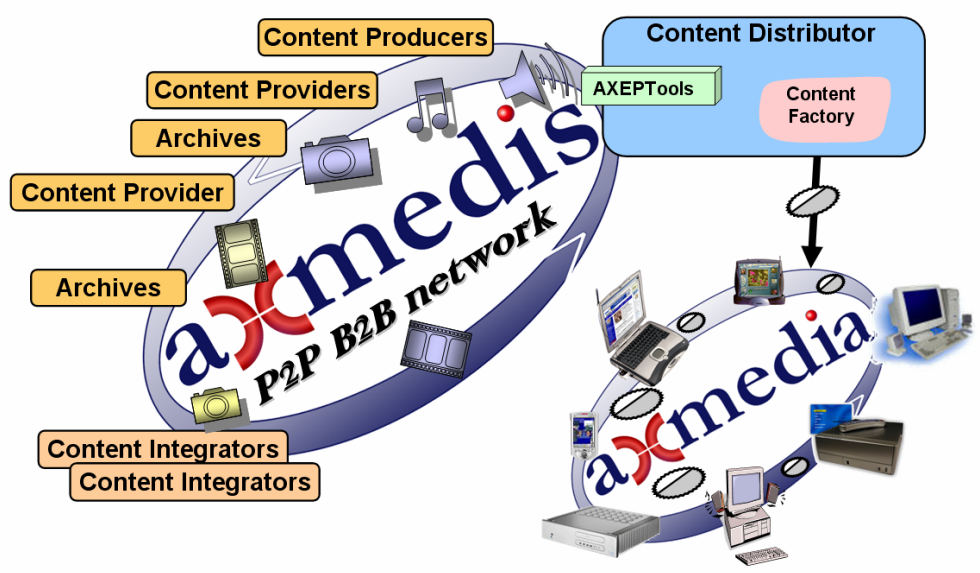
8.8 AXMEDIS P2P Tools: AXEPTool and AXMEDIA tool

In AXMEDIS, the P2P technology is used for sharing AXMEDIS Content among:

- B2B partners such as content: producers, integrators, distributors, publishers, archives, etc.; realized with AXEPTool;
- final users of a content distributor, realized with AXMEDIA tool.

The **general features of any AXMEDIS P2P tool** are:

- legal usage of P2P content distribution;
- guarantee of consistency between the exposed metadata and the downloaded content;
- verification and certification of content distribution and sharing;
- monitoring of downloads and uploads in the P2P network.



From the point of view of B2B, the major features are:

- integration of P2P channel with the Content Factory;
    - automating the download and publishing of content;
    - separation of content to be shared from that maintained in the AXMEDIS database of the content factory;
- monitoring the content downloads and usages of published content;
- reduction of costs for content distribution and sharing:
    - automatic update of published content in the P2P network;
    - automatic download of updated content in other peers of the P2P network;
- reduction of costs for content promotion;
- reduction of costs for content search and acquisition:
    - possibility of making queries on the all connected content factories and these queries also include: classification, identification, technical descriptors of content and licensing information;
    - access to content coming from all the other connected business partners endowed by an AXEPTools.

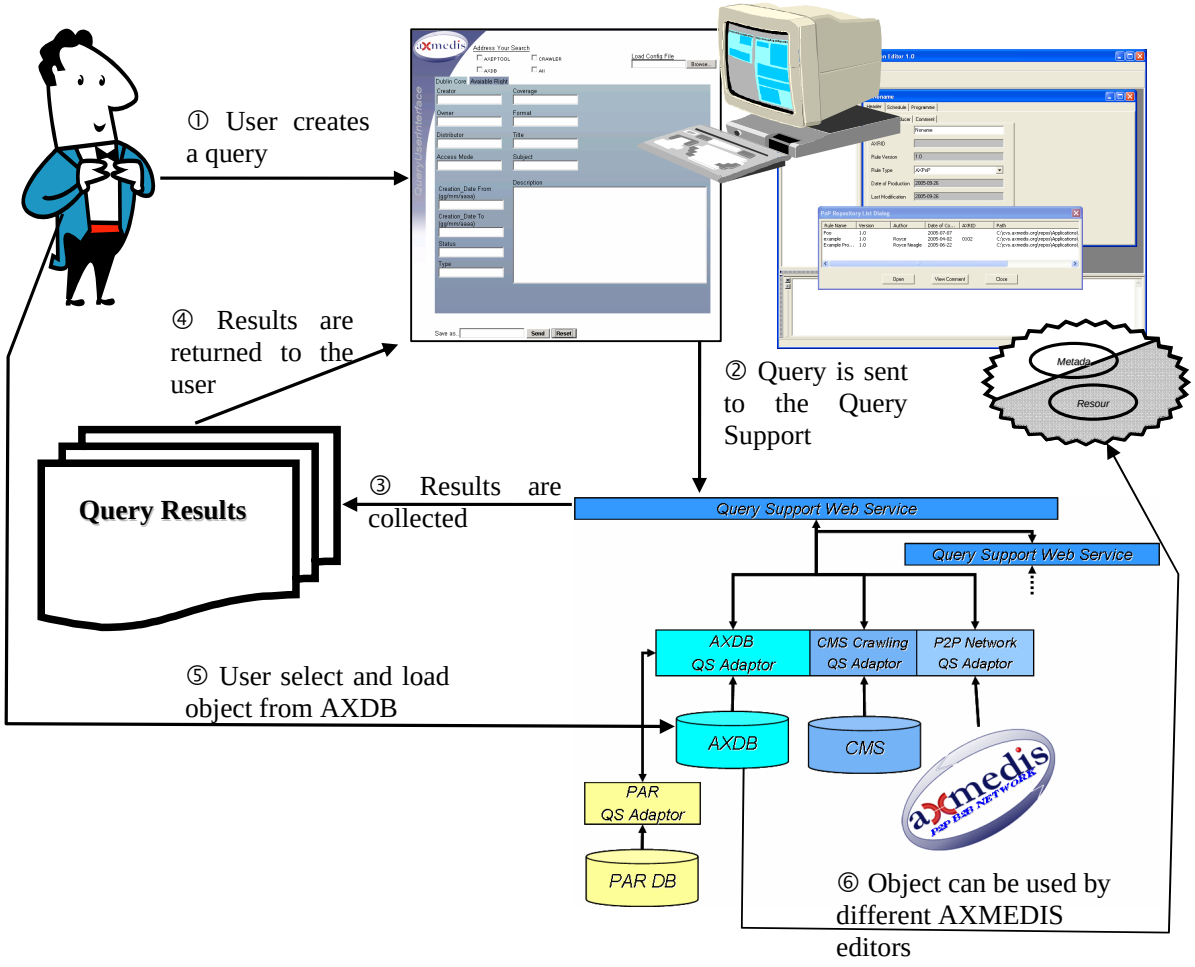
Some Distributors may be interested in exploiting AXMEDIS technology to set up a legal P2P service for content distribution among their users. This solution can be realized by using the **AXMEDIA** tools. It is a P2P tool for distributing and sharing AXMEDIS content among end users, the distributor may insert AXMEDIS content in the network of peers and that content may freely navigate among the peers with the supervision and control of AXMEDIS protection and monitoring model.

8.9 AXMEDIS Database and query Support

In any content factory and for many actors of the value chain, one of the most relevant problems is the storage and retrieval of digital content. In many cases, the problems is complicated by the fact that several different formats and information types have to be managed and maintained related, such as: digital resources, packages, styles, licenses, protection information, contracts, license models, etc.

The AXMEDIS database area with the query support is the answer to such a problem since it:

- is capable of storing object with an efficient and customizable indexing of metadata in order to help in a future object retrieving.
- permits to make integrated queries by the means of a query user interface that is able to return back results provided by the Query Support Web Service. Those queries can be applied on different sources and results are returned in an integrated manner:
    - local AXMEDIS database;
    - connected CMS via the crawler;
    - AXMEDIS P2P network and thus on all the other AXEPTools connected.



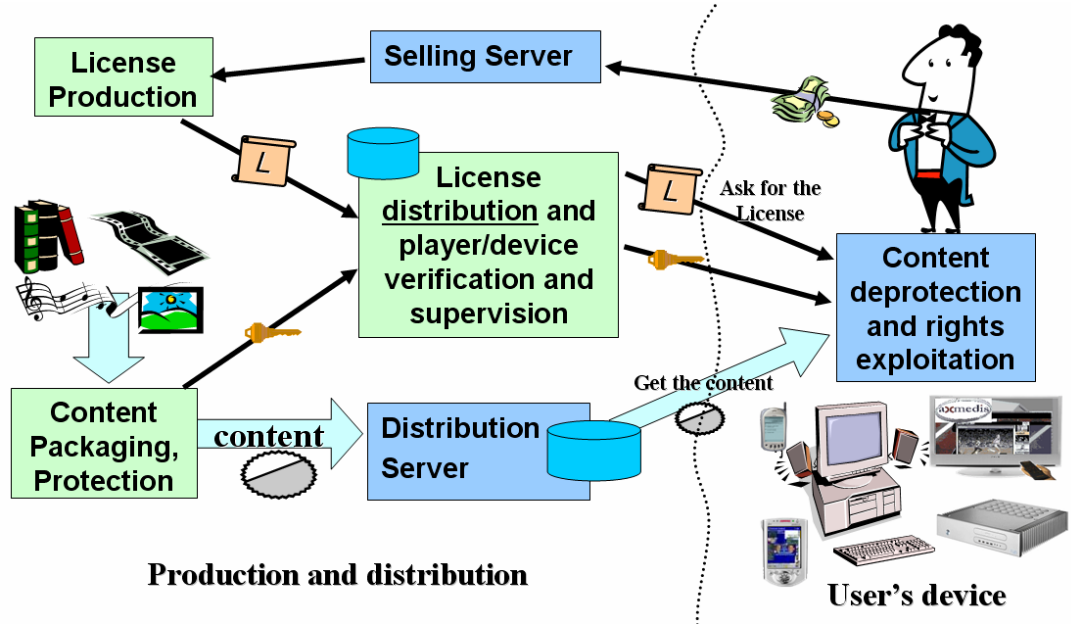
Among the returned results the user can easily decide to load one of more objects from the AXMEDIS database directly in the AXMEDIS editor he/she is using.
In short, the AXMEDIS database are and query support is part of the core infrastructure of the user factory dedicated to the storage of AXMEDIS object with the capability of querying itself and other source such as legacy CMS and other factories by the means of the P2P network.

8.10 AXMEDIS License Definition and Usage

AXMEDS allows managing protected and non protected content, and related mechanisms to protect and monitoring the rights exploitation (that will presented in the following sections). One of the major goals of AXMEDIS is interoperability of content to permit its production once and distribution on many different channels. These two issues are mainly enforced by the capabilities of the AXMEDIS Content Processing tools and by the interoperable support for Digital Rights Management, DRM, and thus on its REL, Right Expression Languages, that allows you to formalise the digital licenses.

In AXMEDIS, the REL is mainly based on MPEG-21 and related RDD (Right Data Dictionary). MPEG-21 REL not only describes a rights expression language, for the definition of licenses, offers and other kind of rights expression, but it also describes an authorisation algorithm for the enforcement of rights and it is used in AXMEDIS to formalize the Potentially Available Rights, PARs, which are the rights that potentially can be acquired for using a given object. They are a vehicle for promoting content.

AXMEDIS licenses are in XML, on this regard a relational model and processing have been set up to process chain of licenses; such as those that can be created from the content owner giving rights to the distributor of producing licenses to the end-users. The AXMEDIS Protection Manager Support Server, PMS, allows processing licenses to provide authorisations for all activities related to rights; from the license production to the license verification against the content usage. The PMS is directly connected to the tools that manipulated AXMEDIS objects that enforce an AXOM.



AXMEDIS provides modules and tools for exploiting DRM capabilities of:

- producing licenses (DRM Editors and/or in the AXCP tools);
- distribution licenses to the final users (PMS tools);
- authorising the use of content depending on the licenses owned by users and distributors, resolving the chain of licenses, verifying the device integrity and supervising the rights exploitation (PMS Server and AXMEDIS Certifier and Supervisor Tools);
- protecting multimedia content (Protection editor and/or in the AXCP tools).

8.11 From paper Contracts to Licenses

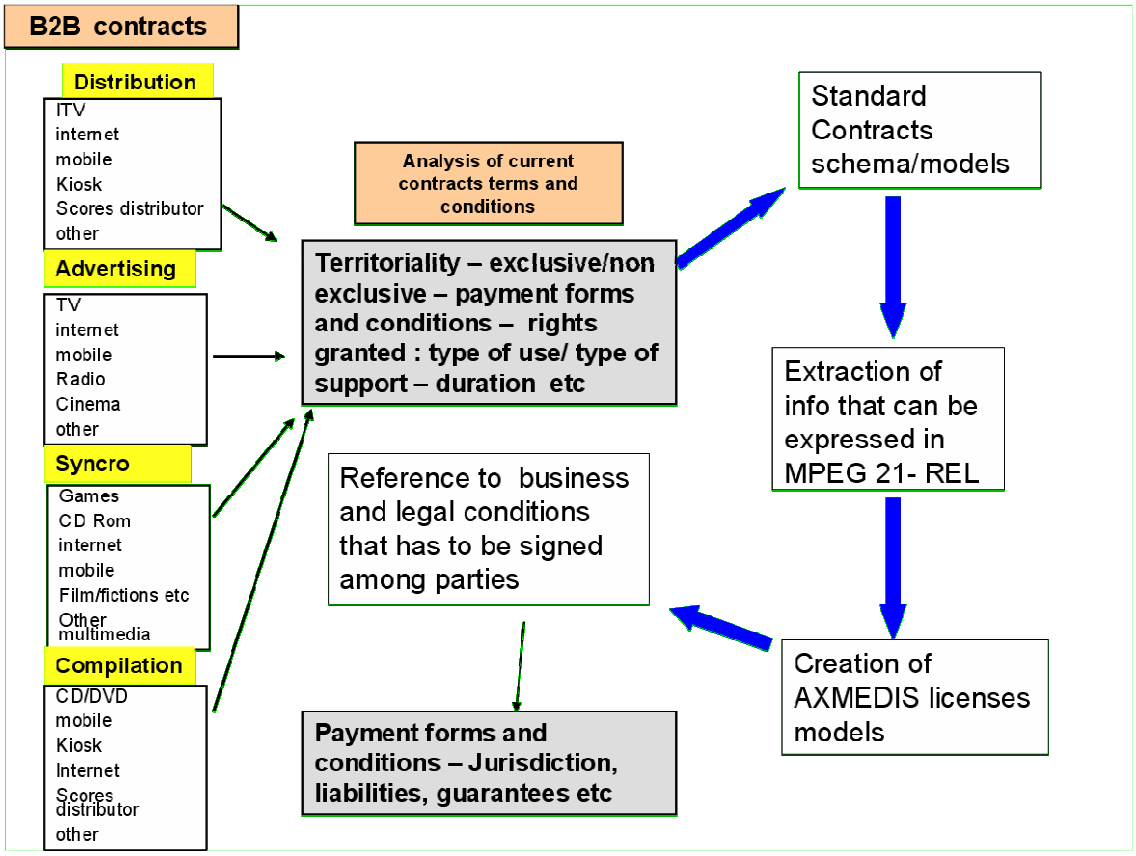
AXMEDIS is working on allowing the (semi-)automatic generation of licenses for the rights exploitation in all distribution channels and digital media format. This aspect implies that contracts rights and conditions that can be expressed in REL will be extracted from current contracts in order to implement the MPEG-21 and AXMEDIS license models.

Starting from the study and analysis of the contracts currently in use for the exploitation and distribution of content, this task aims to provide content users and providers with a tool facilitating them the generation of the license suitable to their needs. It will be possible to specify usage rights at both a B2B and B2C level, with B2B distribution rights inheriting the B2C rights for onward distribution. The license generator tools will therefore allow defining right usage and conditions for multi channels distribution, super distribution and multi-usage of the content. Once an AXMEDIS object has its license incorporated, the given inherent rights conditions will always follow the object by avoiding unauthorized use of it.

Contracts conditions and terms that cannot be "translated" in an MPEG-21-REL language are considered as well. The AXMEDIS license will allow making a reference to the contracts' parties and to the business and legal conditions that have to be signed.

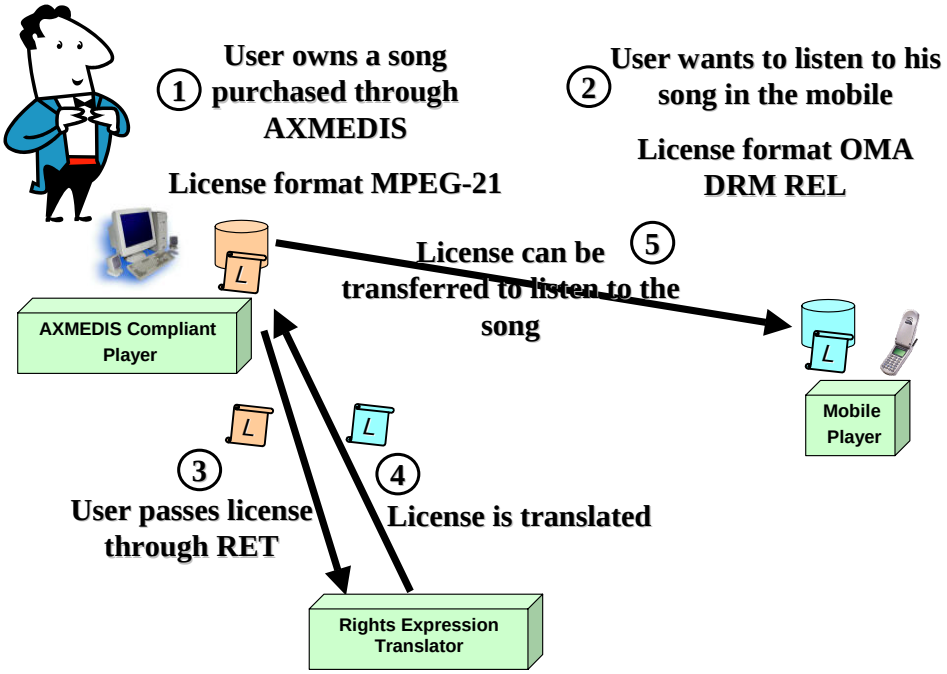
AXMEDIS license models will overcome main issues actually faced by content providers and users for the right clearance process and contracts negotiation such as the immediate identification of the right holders (through a simple query users receive available resources with relevant data) and the immediate verification of available rights (users receive the digital license associated to the requested resource). In addition the AXMEDIS reporting tools allow the content provider/owners to receive in real time the info on the rights usage and this info are also automatically delivered to relevant collecting societies.

The below figure shows the activity performed in order to obtain the above described scenario.



8.12 AXMEDIS License Translation and DRM interoperability

AXMEDIS supports MPEG-21 REL and also OMA ODRL (Open Mobile Alliance, Open Digital Rights Language) which is a largely diffused REL for the mobile environment. The native model of AXMEDIS in the PMS is the MPEG-21 REL.



AXMEDIS is an open solution, other Right Expression Languages, RELs, and models can be added. The support of several RELs gives the opportunity to link with other DRM systems and environments, which may use one or the other. The use of standardised mechanisms to provide DRM capabilities allows the connection with other proprietary solutions in an easiest way. Related to these activities, AXMEDIS is realizing tools for translating rights expressions from one language to other language (Right Expression Translator). This allows providing the correct license for a specific environment, for instance, a license expressed in the language supported by the device.

8.13 AXMEDIS Protection Tools

In AXMEDIS, the content protection can be performed automatically (in the AXCP Rules) or manually (with AXMEDIS Editor, Protection Editor) on any kind of content, from simple digital resources to complex AXMEDIS objects that may contain nested and hierarchies of other content and/or resources and metadata.

The content protection consists of:

- changing the digital coding of content for example by using algorithms such as encryption, compression, scrambling, etc. Any other protection tool can be added by using AXMEDIS plug-in technology;
- applying the algorithms mentioned at the previous point with some parameters (such as keys) and additional information (such as the algorithm type, the size of segments, the order in which the algorithms are applied, etc.). These data are the Protection Information that are need to unprotect the objects, and are delivered to the Players only when the needed authorisation is provided on the basis of the license. AXMEDIS Protection Information is an extension of MPEG-21 IPMP model.

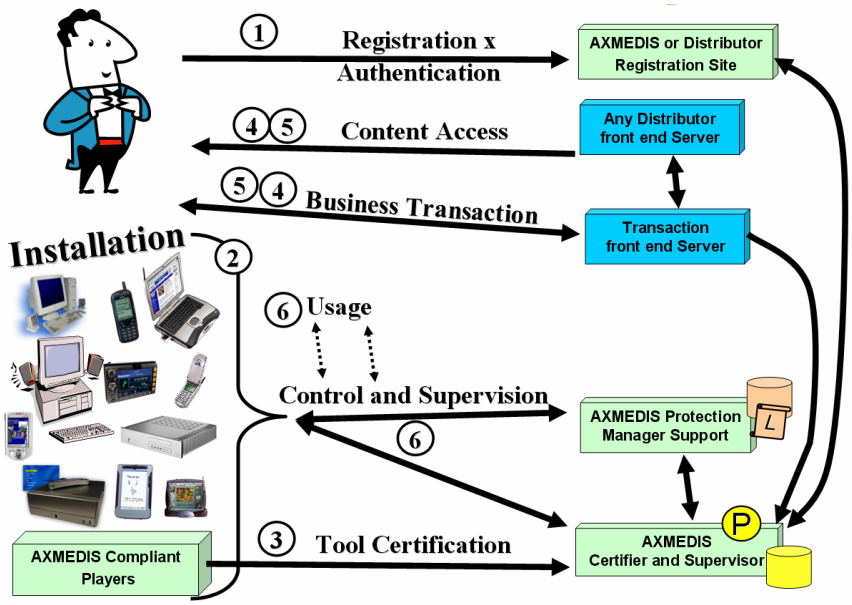
Thus the protection model of AXMEDIS is based on the combination of protection techniques together with the use of DRM technology. In this sense, the Protection Information and the License are provided to the AXMEDIS players following different paths and in different moments. This allows setting up and managing a large number of solutions for content distribution based on different transaction and business models.

8.14 AXMEDIS Certification and Supervision/Control about the rights usage

In AXMEDIS, the user credentials and tools have to be registered and certified before the effective their use. To this end the AXMEDIS Certifier and Supervisor (AXCS) allows registering:

- tools. Only AXMEDIS tools registered with an AXCS can be authorized to access and manipulate AXMEDIS contents. This activity has to be performed offline by the builders of all AXMEDIS compliant tools, such as: AXCP GRID Node, AXMEDIS Editor, AXMEDIS Player, AXEPTool;
- (1) business users and final users. It generates and assigns unique user identifiers and maintains user (not personal) data needed to determine users role, status, credential to access the system.

Once both the user and tool have been registered, they can begin the certification process with an AXCS (3), which verifies the tool has not been compromised (during the first execution and before the tool installation (2)). With the Tools Certification a unique identifier is assigned, and certificate is delivered to the tools. The certificate contains data needed to establish protected communications when authorizations to perform actions over AXMEDIS objects are requested: in fact any action performed has to be authorized by a PMS and AXCS.



The AXCS is also responsible for:

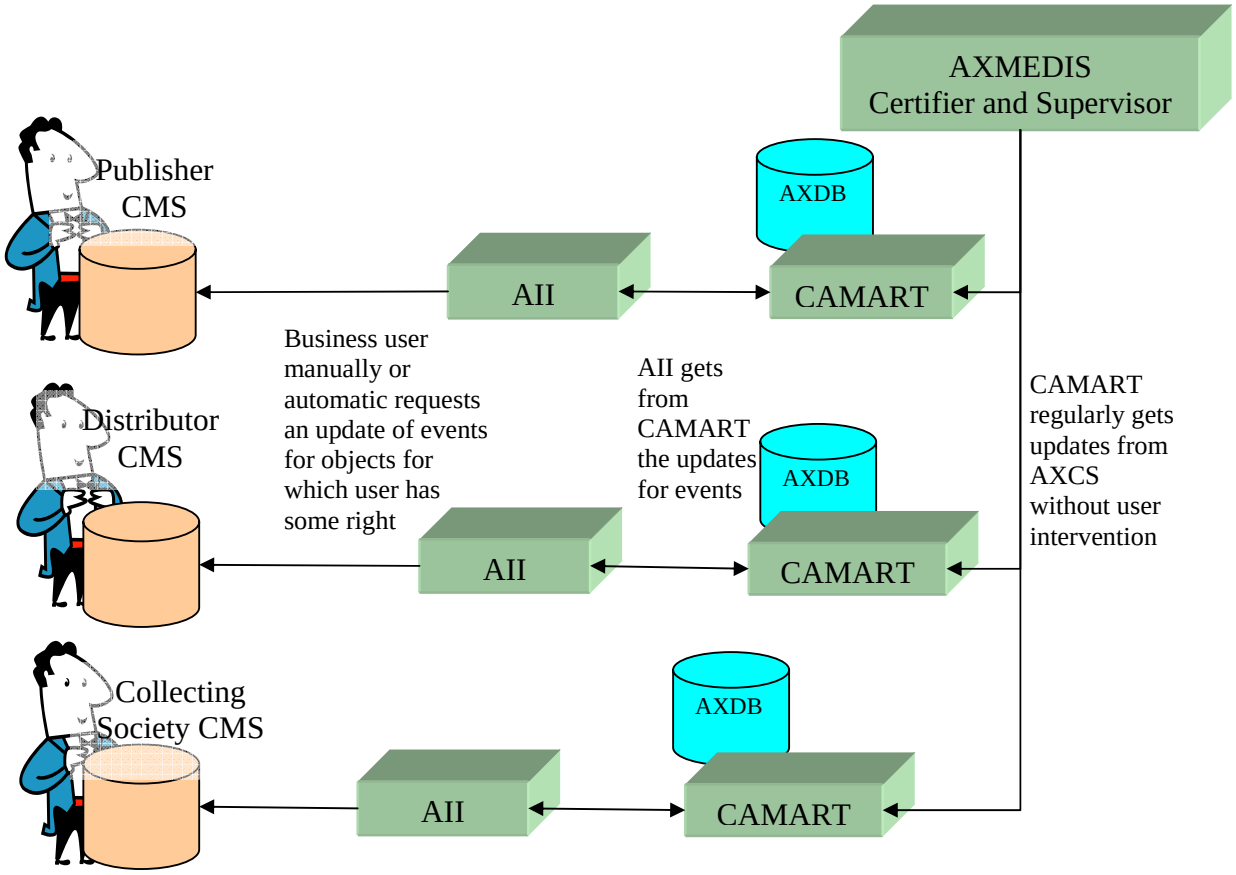
- the generation and assignment of unique object identifiers;
- the registration of objects passing some metadata;
- keeping Protection Information related to objects eventually used in successive transactions;
- verifying consistency and integrity of any AXMEDIS tool capable of manipulating or playing objects;
- tracking every action performed on contents and storing a corresponding report called Action Log, this model is based on an extended version of MPEG-21 Event Reporting;
- providing information about list of Actions (exploited rights) performed on content to: producers, distributors, collecting societies, etc. This allows managing and producing accounting information related to the whole value chain activities;
- maintaining blacklists of blocked user, objects, devices, and tools, that contain those entities that cannot be any more used for some reasons.

During the usage (6) the user may have acquired a license to allow playing a song. When the user is authorised, the AXMEDIS PMS contacts AXCS to inform of the authorised operation. Afterwards, all the database records regarding user actions can be checked and some analysis is performed. The verification may fail, for example, for the lack of integrity in the AXMEDIS player. This may provoke the blocking of the tool, and this action can be stored in the Action Log database of the AXCS for a further analysis.

8.15 Using the Action Logs about the exploitation of rights

The information regarding the exploitation of each right is collected in the AXCS and can be obtained from the authorized value chain actors. The access may be performed by the means of the Core Accounting Manager and Reporting Tools (CAMART) and by the Administrative Information Integrator (AII) tool.
The different business actors of the value chain are interested in getting different information and in feeding the administrative CMSs with the Actions Logs temporary stored in the AXCS. Since after a certain amount of time AXCS eliminates its older records, it is necessary to have a local AXDB to keep copy of all the logs. AXDB is automatically filled with Actions Logs by the CAMART tool.

On the other side, **AII tool** may read from CAMART the logs, and reformat them according the administrative CMS format required by the value chain actor. This process permits at the different actors of the value chain to have a precise report about the exploitation of their rights. It is a transparent solution for reporting rights exploitation and extremely useful for Collecting Societies.



Independently of the ways and methodologies rights are granted to users (e.g. compulsory license, individual license) the Administrative Information Integrator tool provides data needed to check, verify and monitor the use of the AXMEDIS objects in conformity with the rights granted by the relevant license and with information necessary to identify right owners. When the access is performed by distributor they have also access to the information regarding the unique identification of the user that may allow them to match the exploited rights with the personal and accounting information of their customers.

8.16 AXMEDIS Players

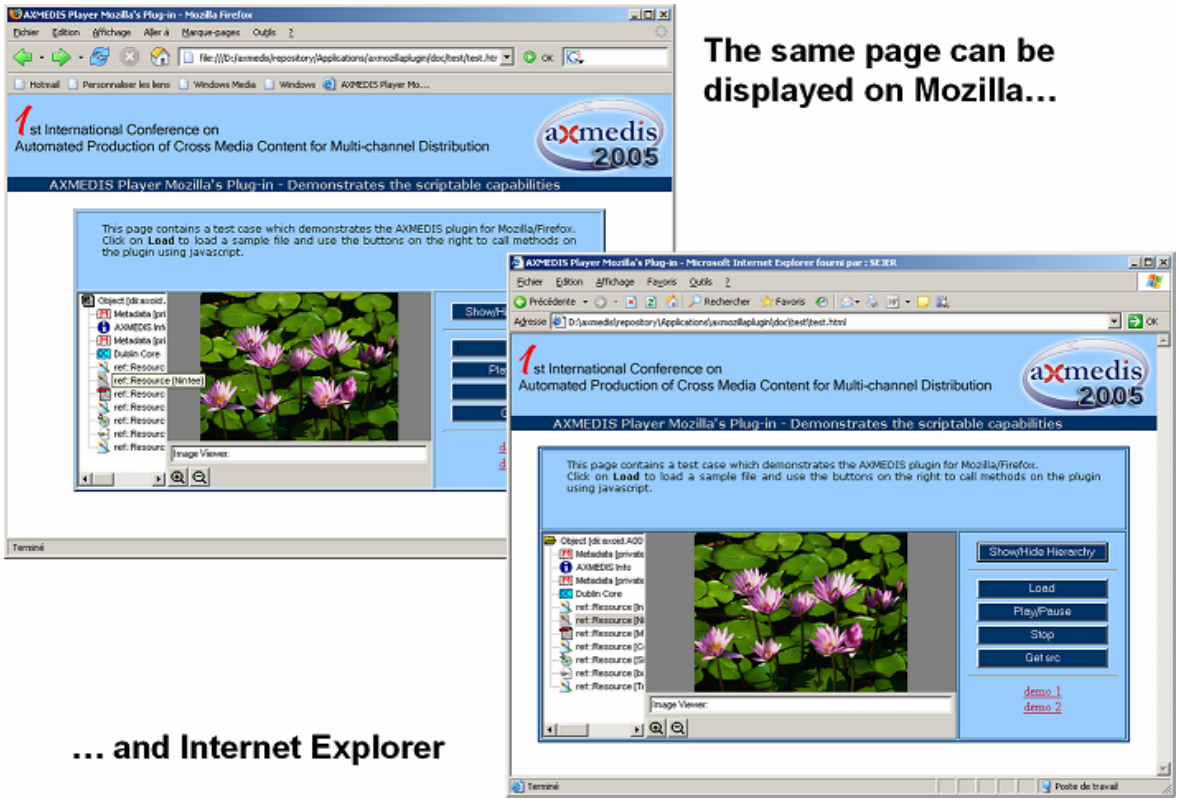
The AXMEDIS Players' role is to allow the end-users to download, play and interact with the AXMEDIS objects. In some cases, the download is performed with other tools such as AXEPTool or AXMEDIS P2P tools or via a simple file transfer such as: FTP, operative system copy, FHTTP, etc.

The **AXMEDIS players** are based on the AXMEDIS Object Manager, called AXOM. They are capable of reading and playing/executing AXMEDIS objects according to the business models chosen and the license associated with the user/device. Each player has to be registered and certified to be used. This process is performed in a guided manner while completing the installation.

AXMEDIS player are available for **Personal Computer** based on Microsoft Windows as:

- a complete **executable** independent tools;
- an **Active X**: to be embedded in third-party applications to load, manage and display AXMEDIS objects, and also in HTML pages displayed inside Internet Explorer;
- a **Mozilla Plug-in**: to be embedded in third-party applications to load, manage and display AXMEDIS objects, and also in HTML pages displayed inside Mozilla and Firefox;

Both the last two solution players expose the same interface that can be used by the host application, or by JavaScript in the case of the HTML Browsers.



HTML page playing AXMEDIS object on both Internet Explorer and Mozilla Firefox

A stand-alone AXMEDIS Player for the most used user platforms will be realized as well as for PDAs and cellular phones.

8.17 AXMEDIS Programme and Publication Tools

AXMEDIS Programme and Publication (P&P) Area is the section of the AXMEDIS framework that connects the AXMEDIS Factory to the distributors. This means that AXMEDIS digital multimedia objects can be delivered to AXMEDIS players using AXMEDIS factory tools with the correct attributes such as format, size etc. depending on the distribution channel and even the client profile.

The P&P tools are using two concepts for the distribution of AXMEDIS content or any other digital multimedia objects (images, doc, txt, video, game, application, file, audio, etc) over various channels (mobile, satellite, PC etc.) to terminals of various specifications. The two concepts are:

(i) Requesting content or objects On-demand where users can search on their device and the selected object is passed through the P&P Area for distribution, and

(ii) Sending content or objects over specified distribution channels with distribution details such as delivery date and time etc. specified in a distribution programme (P&P Programme).

The P&P Editor tool provides an interface for a user such as a programme manager to create a P&P Programme. This includes providing functionalities not only creating, editing and saving programmes, but where AXMEDIS Objects can be searched and selected to add them into a P&P Programme. Once selected, the user can specify the distribution details including the time, date and channel for each object to be distributed. The state of the art occurs once a P&P Programme has been activated (set for publishing) and delivered to the P&P Engine for distribution. The P&P Engine begins the automated process by checking whether the object can be delivered as required for a specific channel or terminal. If not, the AXMEDIS objected selected for distribution is automatically adapted using the AXCP factory tool (see section 9.10 AXMEDIS Content Processing). The newly adapted object with the correct attributes for the distribution channel is then retrieved from the AXMEDIS database and delivered to the distribution server(s). In this way the received digital objects are correctly formatted which is a seamless process for the user.

For On-Demand requests of an object, the same process occurs with no time delay. The engine receives information on the distribution profile and client profile from the On-Demand tool and using this information, the requested digital objects are adapted, if required, and distributed as soon as the object is available.

In short, the P&P Area allows the users (distributors, programme managers, etc) to distribute and/or receive AXMEDIS objects with no concerns on the details of the object such as size, compression, format etc.

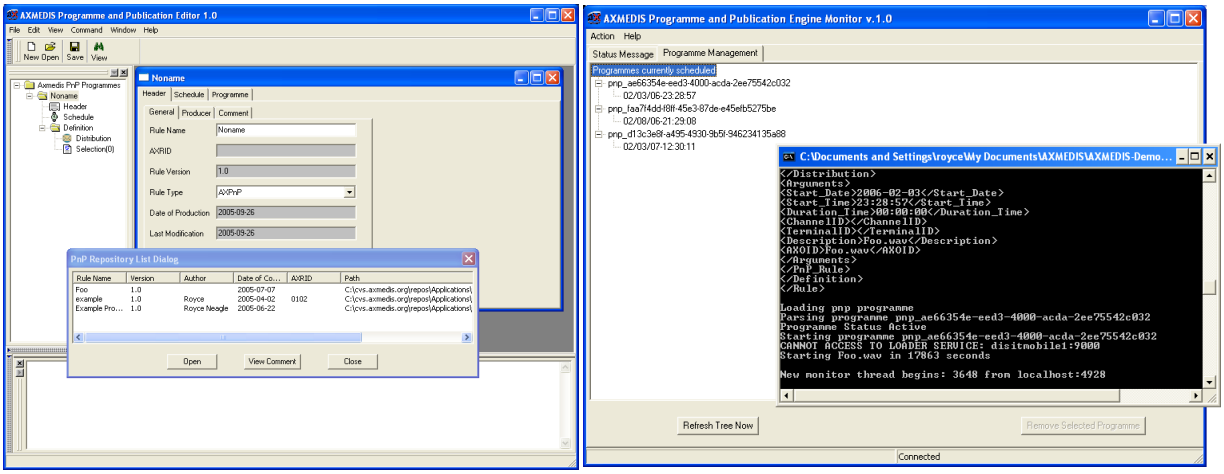


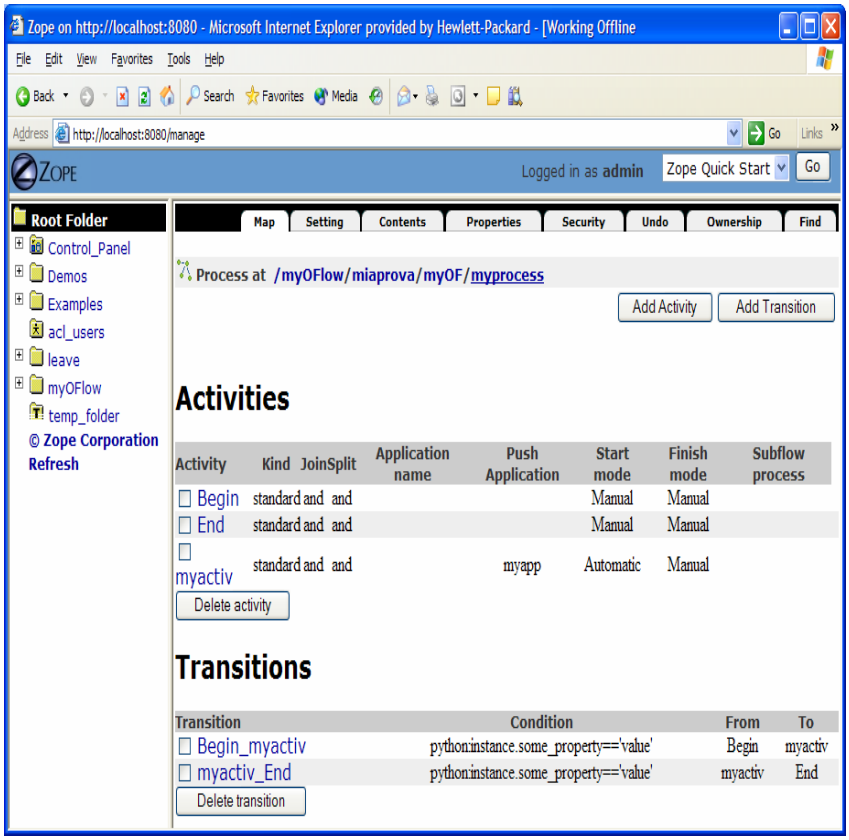
Figure: P&P Editor (left) and the P&P Engine and P&P Engine Monitor (right).

8.18 AXMEDIS Workflow

The AXMEDIS Workflow Management Systems (WfMS) satisfies the needs of multimedia content creators that would harmonize and coordinate all the activities performed in the Content factory including automatic content production and processing, manual content manipulation, movement of content files, publication, downloading, and database management, etc. It allows support the harmonization of these activities when they are performed on AXMEDIS factory geographically located.

For this purpose AXMEDIS Workflow provides integration and control of: AXMEDIS Editors, AXMEDIS Rule Editor, AXCP Scheduler, AXMEDIS Engine in the GRID Node, Program and Publications Engine, and AXMEDIS Query Support. The AXMEDIS Workflow is going to support all the actions that are typically to be performed for content locating, retrieving, authoring, formatting, rendering, packging, bundling and distribution.

Through the WfMS User Interface users are able to log-in, interactively produce and set up their own workflow process instances by means of a graphical interface for programming and to see all the work items in which they are involved or committed and, by accessing one of these work items, are able to perform the actions required on multimedia objects e.g. launching the required tools for content authoring. Thus AXMEDIS Workflow helps to automate and thus reduce the cost of inter/intra-factory content production and its P2P, B2C and B2B distribution for all stakeholders.



For a streamlined integration with open and flexible interfaces to third party WfMSs, the AXMEDIS WfMS provides uniform integration channels comprising dedicated Request and Response Gateways, Adaptors and Plug-ins for all AXMEDIS tools and Engines as illustrated below. This integration framework exploits Web Services and XML Technology to allow seamless interfacing to server side components with specified APIs regardless of their language, platform or location.

The present version of AXMEDIS WfMS is based on an open-source workflow (Openflow) running on the Microsoft Windows XP Operating System; however clients from various platforms including Linux, Mac/OS will be supported. The Web Services needed to interface with the WfMS can be easily developed and customized. For example, by using the open-source AXIS product with JAVA application server (Apache Tomcat, JBoss) or in Microsoft environment they can be developed using IIS web server and .Net Framework.

9 Examples of AXMEDIS Framework and tool Exploitation

By using AXMEDIS tools and technology, the content Distributors may realize a large set of content distribution services: Internet, satellite and terrestrial broadcast, mobile, towards: PC, STB, I-TV, mobiles, PDAs, etc. In some cases, the distributors may be also interested in having/exploiting in their plants some components of the AXMEDIS factory such as an instance of the AXMEDIS Database to make queries, license editor to produce licenses, AXCP for content adaptation and/or to protect content in massive manner, for content production on demand, etc. In order cases, they can delegate these actions to other parties or to external web services.

Some examples about the usage of AXMEDIS tools to set up solutions for content distribution are reported in this section. In some of the examples provided, the Distributors may be interested in establishing a connection with the AXMEDIS Certifier and Supervisor, AXCS, for obtaining reports about the rights exploitation or for getting statistical information, in other cases, they may prefer to use their logs and this information is only accessed by other value chain actors for verifying the effective correctness and exploited rights. According to the exposed flexibility, the Distributors with AXMEDIS may decide to change configuration and business model at reasonable costs, and many different models can be supported by the same distribution channel or in more of them.

In the following subsections: some examples are provided related to the demonstrators that will be set up and make accessible for final user in the last year of the AXMEDIS project, starting from the mid of the 2007:

- Content Distribution via Internet toward PC
    - Direct download or by means of
    - P2P content sharing of content via AXMEDIA tool;
- Content Distribution toward PDAs and mobiles from:
    - Local Distributor kiosks, local communication by means of WiFi;
    - GPRS or UMTS communication;
- Content Distribution via satellite data broadcast toward:
    - Local Distributors for B2B, for updating their archive;
    - PC of final users, in push;
    - AXMEDIS compliant Set Top Boxes of final users.
- Content sharing among archives managed by Local Distributors with AXEPTool and from them to
    - PC connected and located in the archive;
    - PDA connected to the Local Distributor via WiFi.

In all these cases, the **major AXMEDIS tools** and features and tools used are:

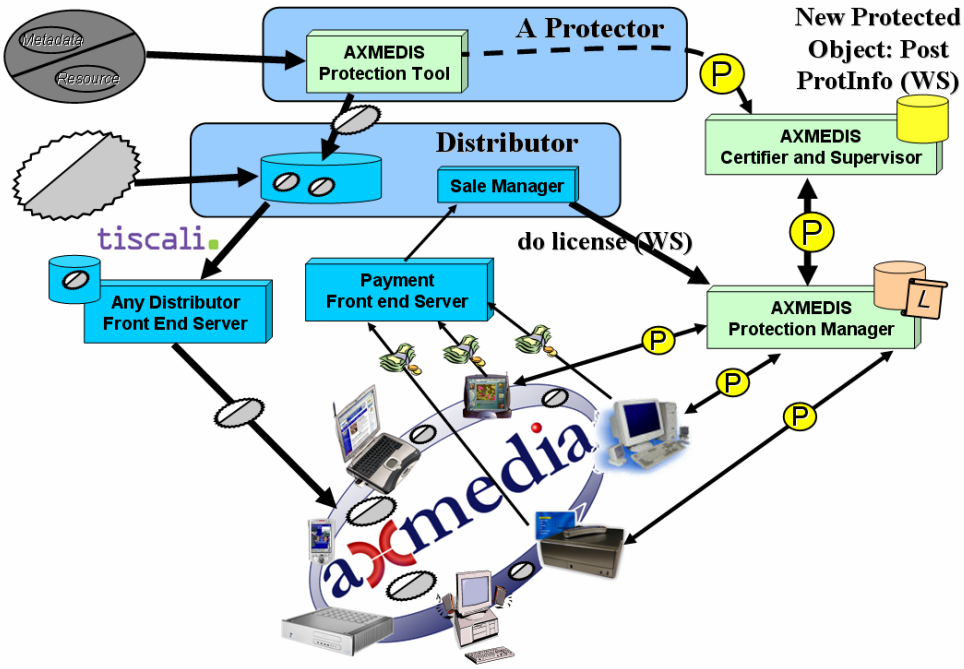
- Production of AXMEDIS objects and their protection
    - AXMEDIS Editors and AXCP tools
    - Metadata mapping and manipulation
    - Algorithm for extracting fingerprint, descriptors, etc.
    - Programme and publication tools
- Production and posting of licenses, protection
    - DRM editor, Protection Editor and AXCP tools
    - PMS for posting licenses, AXCS for posting protection information
- Registration of AXMEDIS players
    - AXCS and AXMEDIS Registration Portal
- Control of rights exploitation with
    - PMS and AXCS
- Reporting to value chain actors the Action Logs about the exploitation of rights
    - AXCS, CAMART, and AII

In the following subsections, some simplifications have been performed in order to make them understandable. For additional details please refer to the AXMEDIS Framework Specification.

9.1 Distribution on Internet, the TISCALI demonstrator

This demonstrator for the exploitation of AXMEDIS tools presents the following features:

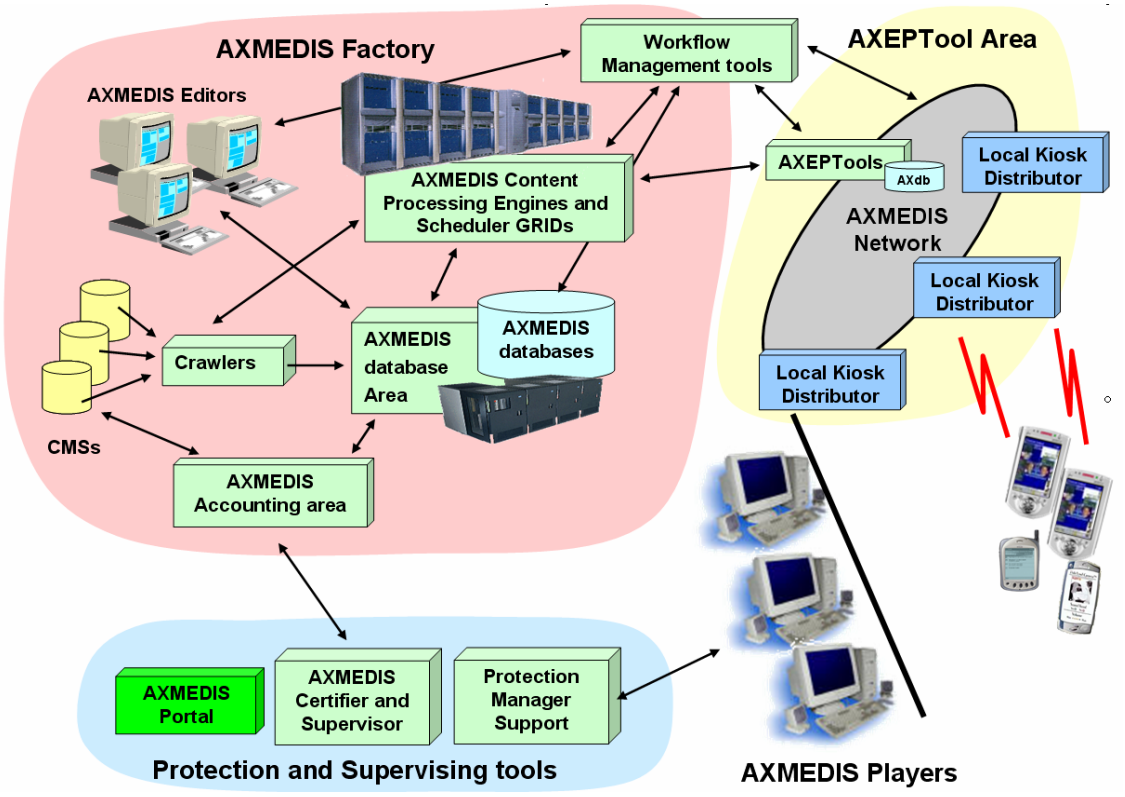
- B2C distribution
- AXMEDIS objects with
  - Video and Audio Files
  - metadata
- Protection Information not in the object
  - Produced with the AXCP with an automatic massive processing of objects, with the protection tool
  - Automatically Posted in the AXCS by the Protection Tool
- License
  - Produced on the fly when an AXMEDIS object is bought by clicking on the TISCALI payment front end server
- License allows
  - Content download and sharing on AXMEDIA peers, content copy
  - Content play
  - Content Adaptation…
  - Content Migration on other P2P channels…
  - Content Migration on any other AXMEDIS terminal
  - Other rights according to the content type
- The AXMEDIS Objects are
  - Initially put in the P2P AXMEDIA by a Peer of TISCALI or by the first download of the final user
  - shared among consumers with AXMEDIA Tool a P2P tool
  - Visualized and played on AXMEDIS players free downloaded from their portal
- The users operates mainly on PC and have perform the registration of
  - themselves on an AXMEDIS user registration portal
  - any AXMEDIS player tool they would use, mainly on PC and Media Centres



9.2 Distribution on PDAs and mobiles, the ILABS demonstrator

This demonstrator for the exploitation of AXMEDIS tools presents the following features:

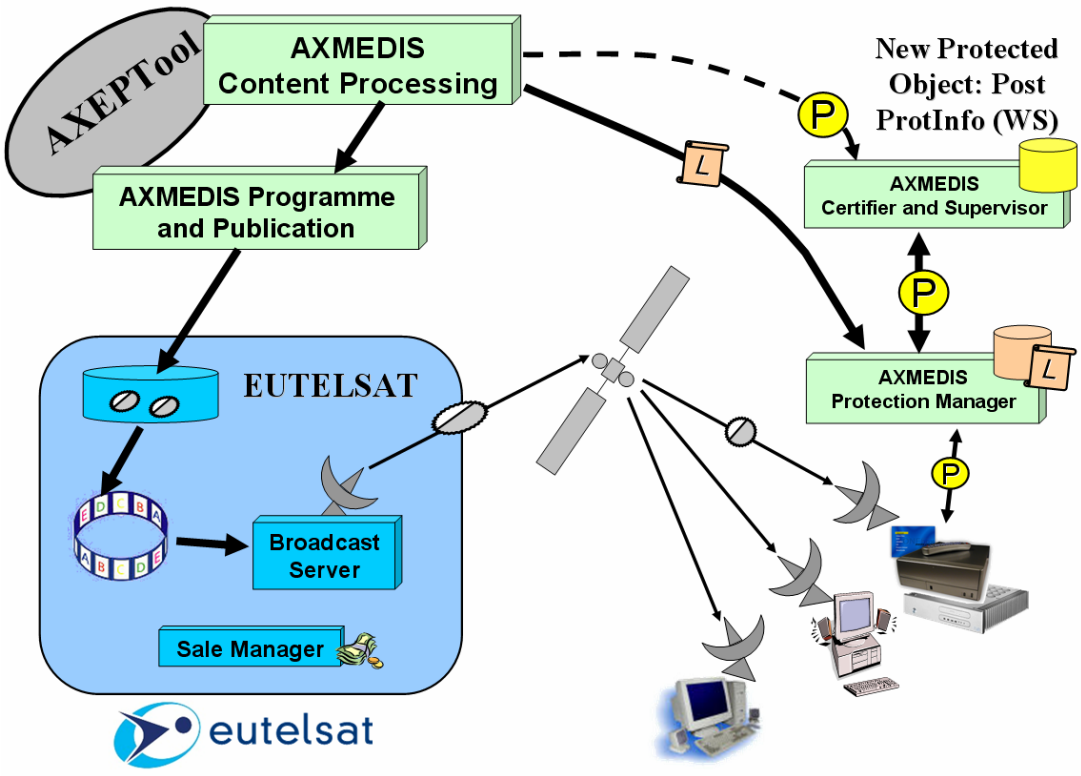
- B2B and B2C distribution
  - B2B distribution mainly on IP and satellite data broadcast for feeding the Local Kiosk Distributors
  - B2C distribution from Local Distributor Kiosk to client connected to the local network, as an archive or library, and/or via WiFi towards mobile phones and PDAs.
  - B2C distribution from a Distributor toward mobile connected in GPRS or UMTS
- AXMEDIS objects with
  - Educational and cultural content
  - Text, images, audio, animations, etc.
- Protection Information not in the object: produced with the AXCP with an automatic massive processing of objects, with the protection tool, automatically Posted in the AXCS by the Protection Tool
- License: produced on the fly when an AXMEDIS object is bought by clicking on the payment web page.
- License allows
  - Content play
  - Content print
  - Content Adaptation needed for distribution
  - Content Migration on any other AXMEDIS terminal (only in some cases)
- The AXMEDIS Objects may be
  - Visualized and played on AXMEDIS players (free downloaded)
- The users have operate mainly on terminals and PDA and possibly also on some selected mobiles .They have to perform the registration of
  - themselves as users (on an AXMEDIS portal)
  - any AXMEDIS player tool they would use



9.3 Distribution via Satellite data broadcast, the EUTELSAT Demonstrator

This demonstrator for the exploitation of AXMEDIS tools presents the following features:

- B2B and B2C distribution mainly on IP by means of satellite data broadcast for feeding a:
  - PC or a
  - Local Distributor, or an
  - AXMEDIS compliant Set Top Box, STB
- AXMEDIS objects with
  - Any kind of content, all types mentioned in the other examples
  - Video, images, document, audio, animations, etc.
- Protection Information not in the object:
  - produced with the AXCP with an automatic massive processing of objects, with the protection tool, automatically Posted in the AXCS by the Protection Tool
- License:
  - produced on the fly when an AXMEDIS object is bought by clicking on the payment web page.
- License allows
  - Content play
  - Content Adaptation needed for distribution
  - Content Migration on any other AXMEDIS terminal (only in some cases)
  - Other rights according to the content type
- The AXMEDIS Objects may be
  - Visualized and played on AXMEDIS players (free downloaded), or on
  - An AXMEDIS compliant Set Top Box, STB
- The users mainly operate on PC or on STB. In the case of PC, the user has to perform the registration of
  - themselves as users (on an AXMEDIS portal)
  - any AXMEDIS player tool they would use

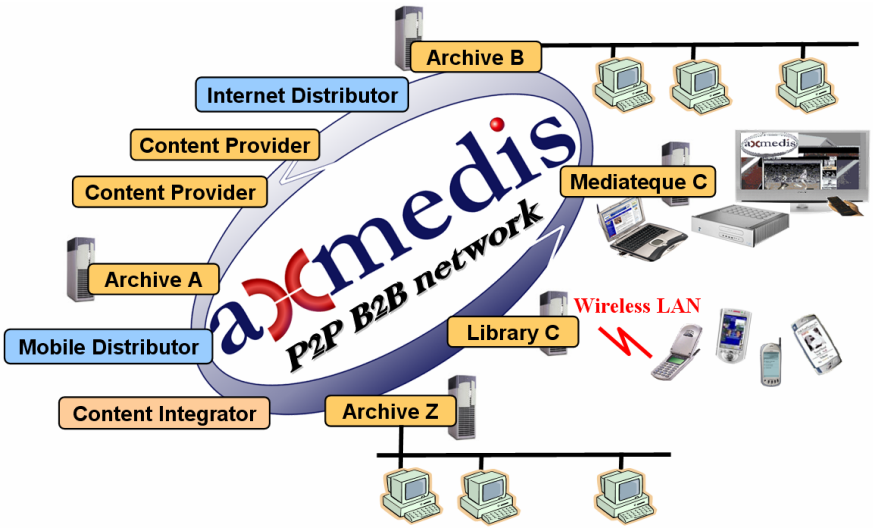


9.4 Content Sharing among Archives, the ANSC case

With the new possibilities resulted from the AXMEDIS framework, Libraries and Archives will have the possibility to promote, manage and distribute their content on a global scale with less effort.
One of the key benefits offered by the AXMEDIS framework is the functionalities and capabilities to process and manage combinations of contents and create complex digital objects.
Depending on the ownership, each institution has the right to produce licenses which are modelled as profiles for the use of the content (i.e., print, play, save, time limited use, etc., to control the access and proper usage). On the basis of the profile, each library or archive can issue licenses and establish relevant fees and/or to limit the usage of the content only in some specific locations, such as in other archives, or education institutions.

AXMEDIS permits the content production according to different editorial and presentation formats and their distribution by using multichannel. AXMEDIS provides a complete framework for the normal processes required in an archive, or in a Museum, regarding content management, control, processing, distribution, transaction (selling and buying), etc. With AXMEDIS, the objects are stored in a database within the institution (reachable through IP address), or in a Kiosk, and the process of digital contents transaction can be improved in several different contexts:

- in normal day-to-day operations;
- new possibility of complete/share content collections (virtually), with access to digital contents from other museums/archives and, at the same time, widen the accessibilities and availabilities of the contents.



With AXMEDIS, the customer can go through the whole process online and receives the contents requested in real time. The library staff has only to check the results of the process and does not need to manually perform all the time-consuming individual sub-tasks.

There are many different ways in which AXMEDIS can promote and stimulate the library related market. For examples, on a B2C scenario, the library can make use of the AXMEDIS environment to support the sale of the contents from the library (self) for example digital reproduction, the merchandising of digital objects owned by the library to its own customer, a system of preview / requesting material service using, for instance, mobile phone provided to the customer in advance In other terms, customer can preview the catalogue and the digital resources of the library some time before coming and buying them for PC use. In addition, the framework can also provide the sale of the contents from other libraries to their own customers. On a B2B scenario, the AXMEDIS environment can be used to support the sale of the contents from their own library to other libraries, or to support the sale of the contents from their own library to another business user.

10 Conclusions

The duty of AXMEDIS is to work on research activities, develop new tools and products and trial them as effective demonstrators.

AXMEDIS is creating and developing the **AXMEDIS Framework, an open solution** exploiting a set of new technologies and tools, which can be used by your solutions and applications for:

- reduction of costs and increasing efficiency for content production, protection, management and distribution; better pricing and value-for-money for industry products and services, containing costs to set up sustainable business ventures in the digital cross media content
- support for the whole value chain: composition, packaging, integration, aggregation, synchronization, formatting, adaptation, transcoding, indexing, integration in the same objects protected and non protected components, definition of relationships with other resources, metadata integration and remapping/transcoding, protection, license production and verification;
- convergence of the media, interoperability of content supporting the multichannel distribution, support content distribution
- adoption of new methods and tools for innovative, flexible and interoperable Digital Rights Management (DRM),
- harmonization of B2B and B2C areas for DRM, bringing the DRM model in the B2B area, supporting production and protection models in the whole value chain;
- increment of content accessibility with a Peer-to-Peer (P2P) platform at Business-to-Business (B2B) level, which can integrate content management systems and workflows;

AXMEDIS implements the AXMEDIS Framework for all, and especially for small and large industries sharing a common interest in the exploitation of new technologies and solutions. The AXMEDIS Framework can be used to setup and built a set of complete applications and services in the area of content production, protection and distribution. With the flexibility of AXMEDIS dynamic Plug-In technology, you can customize your applications and processes according to your needs.
The AXMEDIS digital content and content components is an **open format** capable of integrating any kind of cross media format (video, images, animations, games, learning objects, multimedia, audiovisual, document, audio, etc.) in any digital format, any kind of metadata including identification, classification, categorization, indexing, descriptors, annotation, relationships and play activities and protection aspects.
The AXMEDIS format permits the combination of content components and their secure distribution in respect of the copyright laws, supporting a large variety of DRM rules and models according to concepts of interoperability among DRM models. AXMEDIS is open to any DRM model and solution.
Within the AXMEDIS content any type of cross media content can be included from simple multimedia files to games or software components, for leisure and entertainment, infotainment, and also for managing protected governmental content, healthcare information, business of value information, etc.

More technical information and about how to make registration and affiliation to AXMEDIS can be recovered on www.axmedis.org

11 Acknowledgments

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AXMEDIS Tutorials

- General Tutorial and Overview http://www.axmedis.org/documenti/view_documenti.php?doc_id=1582
- Content Production Tutorial http://www.axmedis.org/documenti/view_documenti.php?doc_id=1559
- Content Distribution Tutorial http://www.axmedis.org/documenti/view_documenti.php?doc_id=1555

Basic knowledge reports (an updated version will be available soon)

- User requirements http://www.axmedis.org/documenti/view_documenti.php?doc_id=1062
- Use Cases http://www.axmedis.org/documenti/view_documenti.php?doc_id=774
- Test Case http://www.axmedis.org/documenti/view_documenti.php?doc_id=1395

AXMEDIS Framework Specification (an updated version will be available soon)

- AXMEDIS Framework General aspects, Editor and Model http://www.axmedis.org/documenti/view_documenti.php?doc_id=1379
- AXMEDIS Viewers and Players http://www.axmedis.org/documenti/view_documenti.php?doc_id=1380
- AXMEDIS Content Processing tools http://www.axmedis.org/documenti/view_documenti.php?doc_id=1381
- Estimation of Fingerprints and Descriptors http://www.axmedis.org/documenti/view_documenti.php?doc_id=1382
- AXMEDIS Database modeling and content Gathering http://www.axmedis.org/documenti/view_documenti.php?doc_id=1383
- P2P tools, AXEPTools and Programme and Publication http://www.axmedis.org/documenti/view_documenti.php?doc_id=1384
- AXMEDIS Workflow aspects http://www.axmedis.org/documenti/view_documenti.php?doc_id=1385
- Protection aspects and rights Accounting aspects http://www.axmedis.org/documenti/view_documenti.php?doc_id=1386
- Applications of Content Distribution and AXMEDIS Portal http://www.axmedis.org/documenti/view_documenti.php?doc_id=1387
- Definitions Terms tables links http://www.axmedis.org/documenti/view_documenti.php?doc_id=1388

AXMEDIS reports on basic enabling technologies

- Content Model and Managing, MPEG-21, authoring, etc. http://www.axmedis.org/documenti/view_documenti.php?doc_id=1423
- Content indexing and querying http://www.axmedis.org/documenti/view_documenti.php?doc_id=1422
- Content processing, Composition and formatting, workflow http://www.axmedis.org/documenti/view_documenti.php?doc_id=1479
- Content Protection and Supervision http://www.axmedis.org/documenti/view_documenti.php?doc_id=1429
- Content Sharing and Distribution via P2P http://www.axmedis.org/documenti/view_documenti.php?doc_id=1419
- Content Distribution via Internet http://www.axmedis.org/documenti/view_documenti.php?doc_id=1470
- Content Distribution via Mobile http://www.axmedis.org/documenti/view_documenti.php?doc_id=1452
- Content Distribution via Satellite data broadcast http://www.axmedis.org/documenti/view_documenti.php?doc_id=1448
- Usability issues http://www.axmedis.org/documenti/view_documenti.php?doc_id=1467

- AXMEDIS vs DMP MPEG21 Analysis http://www.axmedis.org/documenti/view_documenti.php?doc_id=1063
- AXMEDIS Framework Infrastructure, guidelines and some tools http://www.axmedis.org/documenti/view_documenti.php?doc_id=1391
- AXMEDIS Framework Validation and integration http://www.axmedis.org/documenti/view_documenti.php?doc_id=1392

Content Modeling and Test Cases

- Content Aspect Specification http://www.axmedis.org/documenti/view_documenti.php?doc_id=1389
- Content Aspect Specification Appendix http://www.axmedis.org/documenti/view_documenti.php?doc_id=1670
- Content for Test Cases and Validation http://www.axmedis.org/documenti/view_documenti.php?doc_id=1393
- Content Selection Guidelines http://www.axmedis.org/documenti/view_documenti.php?doc_id=1390
- Multilingual Guidelines and Technical Solutions http://www.axmedis.org/documenti/view_documenti.php?doc_id=1427
- AXMEDIS Editorial Format Guidelines and basic examples http://www.axmedis.org/documenti/view_documenti.php?doc_id=1394

Brochures and press cutting

- AXMEDIS Short Presentation ENG http://www.axmedis.org/documenti/view_documenti.php?doc_id=231
- AXMEDIS Short Presentation ITA http://www.axmedis.org/documenti/view_documenti.php?doc_id=236
- AXMEDIS Long Presentation ENG http://www.axmedis.org/documenti/view_documenti.php?doc_id=230
- AXMEDIS Long Presentation ITA http://www.axmedis.org/documenti/view_documenti.php?doc_id=234
- AXMEDIS Flyer http://www.axmedis.org/documenti/view_documenti.php?doc_id=1163
- Project Presentation http://www.axmedis.org/documenti/view_documenti.php?doc_id=1667
- Project Presentation (M12) http://www.axmedis.org/documenti/view_documenti.php?doc_id=1440
- Annual Public Report (2005) http://www.axmedis.org/documenti/view_documenti.php?doc_id=1439
- AXMEDIS Overview Slides http://www.axmedis.org/documenti/view_documenti.php?doc_id=347
- MIDEM Daily News (Jan 2005) http://www.axmedis.org/documenti/view_documenti.php?doc_id=651
- AXMEDIS Project Synopsis http://www.axmedis.org/documenti/view_documenti.php?doc_id=1668
- Digital Media in Italy presentation http://www.axmedis.org/documenti/view_documenti.php?doc_id=1669