Automating Production of Cross Media Content for Multi-channel Distribution

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DE4.2.1.2
Content Indexing, Monitoring and Querying, 1ST Update

Version: 1.0
Date: 26/09/2006
Responsible: FHGIGD (revised and approved by coordinator)

Project Number: IST-2-511299
Project Title: AXMEDIS
Deliverable Type: Report and Prototype
Visible to User Groups: Yes
Visible to Affiliated: Yes
Visible to Public: Yes

Deliverable Number: DE4.2.1.2
Contractual Date of Delivery: M24
Actual Date of Delivery: 28/09/2006
Work-Package contributing to the Deliverable: WP4.2
Task contributing to the Deliverable: WP4.2
Nature of the Deliverable: Report and Prototype
Author(s): FHGIGD, DIPITA, DSI, EPFL, EXITECH, UNIVLEEDS

Abstract:
This deliverable aim is to show the research work done in the area of content indexing, monitoring and querying. It also reports the prototypes implemented to demonstrate the research work done in the different areas studied. The prototypes presented will be used inside the WP5, AXMEDIS Framework, WP9, Demonstrators and, obviously, in the continuation of WP4.
Keyword List:
Content Indexing, Crawler, Database, Querying, Content Descriptor, Fingerprinting

Table of Contents

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1 Executive Summary and Report Scope (FHGIGD)

Market and end-users are pressing content industry to reduce prices. This is presently the only solution to setup viable and sustainable business activities with e-content. Production costs have to be drastically reduced while maintaining product quality. Content providers, aggregators and distributors need innovative instruments to increase efficiency. A solution is automating, accelerating and restructuring the production process to make it faster and cheaper. The goals will be reached by: (i) accelerating and reducing costs for content production with artificial intelligence algorithms for content composition, formatting and workflow, (ii) reducing distribution and aggregation costs, increasing accessibility, with a P2P platform at B2B level integrating content management systems and workflows, (iii) providing algorithms and tools for innovative and flexible Digital Rights Management, exploiting MPEG-21 and overcoming its limits, supporting several business and transactions models. AXMEDIS consortium (producers, aggregators, distributors and researcher) will create the AXMEDIS framework with innovative methods and tools to speed up and optimise content production and distribution, for *production-on-demand*. The content model and manipulation will exploit and expand MPEG-4, MPEG-7 and MPEG-21 and others real and de-facto standards. AXMEDIS will realise demonstrators, validated by means of real activities with end-user by leading distributor partners: (i) tools for content production and B2B distribution; (ii) content production and distribution for i-TV-PC, PC, kiosks, mobiles, PDAs. The most relevant result will be to transform the demonstrators into sustainable business models for products and services during the last project year. Additional demonstrators will be 2-3 associated projects launched as take up actions. The project will be supported by activities of training, management, assessment and evaluation, dissemination and demonstration at conference and fairs.

This deliverable is devoted to the description of content protection and supervision done inside WP4.5.

This activity is by no means finished with the completion of this deliverable, but it has to be revised during the development of the project.

Main deliverables in WP4 are:

- DE4.1.2 – Content Modelling and managing (M24), report and prototype;
- DE4.2.2 – Content indexing, monitoring and querying (M24), report and prototype;
- DE4.3.2 – Content Composition and formatting (M24), report and prototype. It also includes the details about the integration of AXMEDIS with workflow management tools;
- DE4.4.2 – Content sharing and production on P2P (M24), report and prototype;
- DE4.5.2 – Content Protection and Supervision (M24), report and prototype;
- DE4.6.2 – Content Distribution via Internet (M24), report and prototype;
- DE4.7.2 – Content Distribution towards mobiles (M24), report and prototype;
- DE4.8.2 – Content Distribution via satellite data broadcast, the push optimisation and the on demand problem (M24), report and prototype;
- DE4.9.1 – The Usability issues for the AXMEDIS production tools (M13), report.

The main activities that have supported the production of this deliverable are related to:

WP4.2 - Content Indexing, Monitoring and Querying – In this sub-workpackage, the main functional aspects for accessing content are specified, designed and described. For the specification existing standards have been considered.

- The Crawling and indexing collector engine fulfils the requirements of collecting content from existing databases. This allows users to easily transfer existing content stored in their content management systems to be transferred into the AXMEDIS framework.

- The definition of content descriptors considers the standardisation activities for meta data descriptors in MPEG-7. Thus, the content descriptors used within AXMEDIS are compatible and can be exchanged with other solutions that are able to read MPEG-7 meta data descriptors.

- Like the general content descriptors, fingerprints are compatible with the MPEG-7 descriptors. Additionally the requirements of MPEG-21 are consider for content authentication and verification as well as for content identification within DRM environments.

- Query Support considers existing standards for identifying and accessing content.

- In Query Support for PCs a prototype for accessing content and digital item adaptation based on a general client profile is developed.

2 Introduction (FHGIGD)

The integrated, flexible and scalable AXMEDIS solution addressing content creation independent of the content type and multi-channel content distribution faces this challenge: providing access to content by effective content indexing and querying techniques as well as monitoring the content distribution and content exchange in a scalable way.

These content indexing, monitoring and querying techniques are essential for the content creation as well as for content consumption. Thus, the main goals of the research and development activities described in this deliverable address these fundamental parts of the AXMEDIS framework.

T4.2.1: Crawling and Indexing, Collector Engine

Managed by DSI
The aim of this task is indexing of the databases. This is achieved crawling into the CMSs and the databases of the content providers, integrators, and distributors to access content to indexing it. Specific interfaces for accessing to these databases will be defined and developed in WP9. The general infrastructure and the integration of content indexed with the AXMEDIS data model and database identified in WP4.1 have to be produced in this WP.

- Corresponding to the requirements of the project, the subWP leader will design and develop a framework which allows collecting and indexing different media sources (databases, file systems, etc.);
- The idea is to access already available information and metadata into CMSs and transfer it into a cache of the Content (see also WP4.1). Those may have information related to the content, their metadata, their technical details, DRM aspects, licensing aspects, possible products that use the content, multilingual information, etc.;
- Tool for collecting content from several sources. Indexing content contained into the Content management systems of the content distributors and producers. This tool is called in the General Architecture as **Crawler Collector Indexer**. It may navigate on any kind of source by means of special plug-ins that will be developed in the subWP related to the content distributors in WP4 and in the subWPs of WP9;
- This task also includes the development of a tool called **Collector/Transcoder Engine** that will allow accepting the maps defined in the WP4.1 to migrate the content from the Crawled Results Integrated Database to the AXMEDIS format and database. These tools will be capable of processing data automatically updating the content into the AXMEDIS database when these are updated into the CMSs. In addition, the same engine tool will be capable to integrate tools for direct estimation of fingerprint to complete the indexing by using the results of the following task;
- The Collector Engine will be endowed of a specific interface to receive from the query support queries for searching into the Crawler Results Integrated database and sending back the information to the AXMEDIS database manager.

This task will be performed by acquiring the license of a product called Focuseek and integrating it in the AXMEDIS framework. The license will come with editable manual to customize the installation to the AXMEDIS solution (see Table in Section 9.5 regarding the costs of the License). Moreover Focuseek company will be also used for a development of an interface with its product, see T4.2.5).

T4.2.2: Estimating Fingerprint for Indexing

Managed by FHGIGD, with EPFL, DIPITA.
This task will be dedicated to processing content in its several forms and formats and producing specific technical metadata and high level information that can be used for fingerprinting and for content search. The creation of the information necessary for retrieval can be performed when the content is processed to be ported and stored into the AXMEDIS database. The same tool for feature calculation will be used in the

distribution tool for monitoring the content distribution. The feature calculation depends on the application (indexing or monitoring). The tool is called in the general architecture as Feature Extractor Engine. The same tool can be used for monitoring the content passing on the AXEPTool for verifying its certification and consistency, see WP4.5. This last activity is called of Content Monitoring. The feature extraction will have to be performed by implementing algorithms for descriptors estimation and defining specific MPEG-7 descriptors. Making them independent on the language and on the digital item adaptation used.
Implementing state of the art algorithms and comparison of them with the newly implemented algorithms for estimating robustness to DIA (digital item adaptation), flexibility, format independence, etc. The whole set of fingerprints for a given digital item should be usable also as unique identification, see WP4.5.

- FHGIGD: specific algorithms will be defined for processing content and metadata: audio files, video, documents, images, etc.
- FHGIGD: Development/adjustment of algorithms for feature extraction and metadata generation (for any cross media production: audio, video, documents, etc.). Processing algorithms will be also obtained by integrating existing algorithms from commercial tools or open source. Formalisation of descriptors in terms of MPEG-7.
- EPFL: While working already on feature extraction issues such as chord classification and polyphonic extraction, EPFL will focus on research in rather innovative but important fields such as those of automatically detecting the music genre and the type of sound source, i.e. if the source is for instance a male or female voice, a musical instrument, and which instrument, or musical ensemble, etc. In terms of music genre detection the investigation will be carried on in both the time domain (rhythm/beat analysis) and basic spectral attributes (music texture), with successive comparison with pre-selected classes of music (middle-age, symphonic, jazz, metal, rock, etc.). Instrument recognition is a typical timbre analysis problem, where instruments are normally characterized by specific spectra, which can be classified by well-trained neural networks. The problem is easier when, like in authoring for object-oriented approaches, sound sources are still separated from each other, while for playback application it will be as well important to test the recognition of one or two main “voices” in a noisy environment (i.e. the other voices or instruments). The test bed that will be used for this research will be first based on standard test material like AES/EBU, MPEG, etc., adding in a second phase other real life cases and the new MIR/MDL evaluation frameworks.
- DIPITA: estimation of fingerprint for audio reporting human voice and text documents. DIPITA will be concerned with the fingerprint of wave signals that bear a dialogue structure and with the definition of minimal conditions for textual identity. Among the set of features that characterize dialogic contexts the turns alternation and music voice- alternation are reasonable candidate for an automatic detection. Both phenomena are essential features of audio tracks that may be recorded as essential metadata of a given object. DIPITA will concentrate on the specification of features characterizing turns and voice alternation and the corresponding length of dialogic turns. The present technologies for marking voice / music transitions will be considered and implemented. Also techniques for extraction of textual information for metadata compilation will be reviewed for their possible use in the AXMEDIS framework.

T4.2.3: General Query support

Managed by EXITECH.
The query support is a combination of query mechanisms for retrieving content objects among the indexed information, in the AXMEDIS database (for content processing, composition, formatting, etc.), on the P2P AXEPTool, on the content collector referencing the content contained in the CMSs (Crawled Results Integrated Database). From the AXMEDIS database interface it has to be possible to make valid queries for all the environments and read unified results. From the AXEPTool or from the Collector the queries can be performed only on their environment. This Task is about the definition of a common format for sending queries and exchanging results.
The query support into the AXEPTool distributed database allows the specification of technical/professional query including metadata, technical information, business and licensing aspects, content based, DRM rules,

etc. Studying a specific user interface integrated into the AXEPTool for defining technical queries and it is integrated into WP4.4.

T4.2.4: The query support in the AXMEDIS database

Managed by EXITECH.
This Task is developed on the bases of the analysis and specified model in T4.2.3. Specialized query tools for media searching for the distributors and aggregators will be developed. This will include the possibility of performing remote querying and integrating the results with those coming from the AXEPTool and Crawled Results Integrated database of Content. This part is performed in Collaboration with T4.4.1 of the WP4.4.Query for the distributors

- Query search engine joined in the B2B-P2P model for content components sharing among producers and distributors.
- The query engine will be powerful and the usage of all:
    - details related to the description of components, see below for the formatting;
    - costs and DRM rules, for each action a price, play, excerpts, redistribution, resizing, distribution on a different area, validity of the DRM rule and copyright coverage, etc.;
    - available languages if there is speaker or text;
    - range of age suggested;
    - business model suggested;
    - time of delivering and availability in terms of first delivering, if not ready;
    - type of delivering: on-line, offline, etc.;
    - if on-line time of downloads or acquisition;
    - cultural level;
    - subject, description of content with simple metadata;
    - textual description of subject and evolution.

T4.2.5: Collector Engine and query support in the database of Crawler Results Integrated database

Managed by DSI, while it is planned to be realised by a subcontract (see Focuseek in the list of subcontracts), and will be integrated by partners (see table in Section 9.7, for other details regarding to the subcontract with Focuseek). More specific details will be provided to the subcontractor to better specify its work and integration with AXMEDIS.

- This task also includes the development of a tool called Collector/Transcoder Engine that will allow accepting the maps defined in the WP4.1 to migrate the content from the Crawled Results Integrated Database to the AXMEDIS format and database. These tools will be capable of processing data automatically updating the content into the AXMEDIS database when these are updated into the CMSs. In addition, the same engine tool will be capable to integrate tools for direct estimation of fingerprint to complete the indexing by using the results of the following task.
- The Collector Engine will be endowed of a specific interface to receive from the query support queries for searching into the Crawler Results Integrated database and sending back the information to the AXMEDIS database manager.
- Query support. Support developed on the bases of the analysis and specified model in T4.2.3. The above query for the AXMEDIS database has to be also forwarded (when explicitly requested) into the database of information and content of the CMS which is present in the content factory (content provider, content integrator, etc.). The information obtained as a result has to be integrated with the results obtained from the of the AXMEDIS database general query. To access at the Crawler Results Integrated Database. The results of the query will not have to include equivalent content that is already available on the AXMEDIS database since it is automatically pushed in by the Collector Engine tool.

T4.2.6: Query support for connecting AXMEDIS tools with content distributors

Managed by FHGIGD

This task is mainly focussed on establishing the possibility for the distributors to pass into the AXMEDIS tools and database the queries performed by the final clients on their devices, and return back the corresponding results (managing the production of content via the Formatting Tools). The final clients are interested in making queries to the content distributor server to get content over that has been explicitly promoted by programme, etc. (content on demand). Thus the user could ask to have content on demand out of the proposed set of content for the week or for the month, which is in general over the content programmed for the distribution. This content can be ready to be distributed and thus available for distribution or could be created/formatted on demand.

Technically, the query performed by the final users (done in XML, SQL or OSQL) on the distributor server has to be traduced for the AXMEDIS database passing it to the Programme and Publication tool engine. The results are produced in some way and have to be traduced back for the distributor server and thus for the final clients. Other related activities are specialized query tools for media searching for the end users.

The results produced will be used in WP9.5.1 and WP9.6.1 and related subWPs. In those cases, the information needed to identify the single object into a database is more related to the content description and metadata rather than on technical details as in the previous one.

Planned activities and targets of WP4.2 include:

- M6: usage and test of the first version of the Crawler and Indexing. Content acquisition with customisable engine for navigating in sources and collecting content and indexing it;
- M11: Analysis of the query support, definition of the first version of support model for technical queries;
- M12: First version of the Collector Engine;
- M12: First version of the set of fingerprint estimation algorithm for video, audio, and text files. First version of their description in terms of MPEG-7;
- M13: First version of query Support for AXMEDIS database;
- M13: First version of query support for Crawler Content integrated with that of the AXMEDIS database;
- M18: Final version of the Collector engine;
- M18: revised First version of the set of fingerprint estimation algorithm for video, audio, and text files;
- M24: First version of the specialized query tools for media searching for the distributors, aggregators and end users;
- M24: revised First version of the set of fingerprint estimation algorithm for video, audio, and text files;
- M36: Final version of specialized query tools for media searching for the distributors, aggregators and end users.

3 Content Flow within AXMEDIS (FHGIGD) (completed)

As described in [Bazea-Yates99] information retrieval addresses different areas:

- Representation of information items
- Information item storage
- Organisation of information items
- Access to information items

These aspects are addressed within AXMEDIS in the corresponding work packages:

- Content within AXMEDIS are crawled and indexed. This is done by the collector engine (see also the document DE3.1.2 – Part E – database gathering).

- For each content, content descriptors are automatically calculated. Within AXMEDIS low level and high level descriptors, as well as fingerprints are considered. So far, the development focus within AXMEDIS is on audio, video and text descriptors. Fingerprinting methods are developed for text, audio, image and video content (see also the document DE3.1.2 – Part D – fingerprinting descriptors).

- These content descriptors as well as other stored information are accessible via the so-called query support. Additionally, an interface is provided for clients. The demonstrator is query support for PC using web interfaces (see also the document DE3.1.2 – Part E – database gathering).

In the following chapters the state of the art, the problems identified, and the work performed for each of the relevant tasks are described.

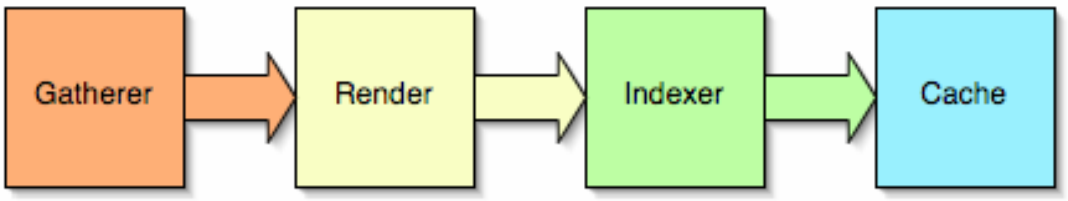
4 Crawling and Indexing, Collector Engine (DSI)

4.1 Crawling and Indexing Process

A very important aspect of the AXMEDIS project is about the interfacing with data repository of Content Providers. The Content Providers world is very heterogeneous so that the integration process with AXMEDIS system should be mediated by a flexible gathering system. The goal of this approach is to minimize the impact of AXMEDIS system on the infrastructure of Content Providers that must continue using their old archiving and publishing system without any modification.

focuseek is a multimedia Content Gathering and Indexing platform whose main goal to manage huge amount of data coming from different and distributed information sources. focuseek architecture can be successfully used to implement Information Retrieval projects for large enterprises, government institution and large internet portals.

focuseek platform can collect information from various kind of sources, implement a way to analyze the gathered content and provides a very flexible, high performance indexing system for content retrieval.



In the above figure, main components of focuseek system are shown.

The ***Gatherer*** is the coordinator of a pool of gathering agents whose task is to acquire new data from an information source, as soon it is available. A specific implementation of a gathering agent is for instance a Web Crawler that, starting form a set of initial seed Web pages is able to explore a portion of the Web using a breadth first strategy to visit its graph. focuseek substitute the concept of "web crawler" with the more flexible concept of "Source+Gatherer". With this metaphor, focuseek is able to natively acquire information from a various type of remote sources like Databases, Web Services, News Servers, WebDav, IMAP folders, Filing Systems, and some other proprietary sources. The Gatherer module is fully programmable and fully customizable writing Plug-Ins for specific sources.

The **Renderer** is a very central component in the focuseek architecture. focuseek indexing and retrieval system does not work on the original version of data but on a so called "rendered version". The idea is that from any piece of information (a document, for instance) a set of features can be extracted if we provide a suitable algorithm for that. A typical example is a portion of text where the extracted features are the list of

words contained in it or a bitmap image from which some text can be extracted by an OCR engine. Obviously more sophisticated extraction algorithm must be used for different type of information (like images of sounds) but the main concept does not change. All extracted features are then compiled in an internal XML format and passed to the indexing module. The extraction process of renderer component is executed by a pipeline of Plug-Ins, which provide the compilation of the internal XML representation. focuseek provides some default Plug-Ins for some basic type of content and an API to write custom Plug-Ins.

The **Indexer** creates the index of a collection of information gathered from multiple sources and offers a complete query language for retrieving original contents. The index produced is fully dynamic in the sense that any indexed content is almost immediately available for the query. This is a crucial feature for all always-on systems because there is no need of periodically index reconstruction.

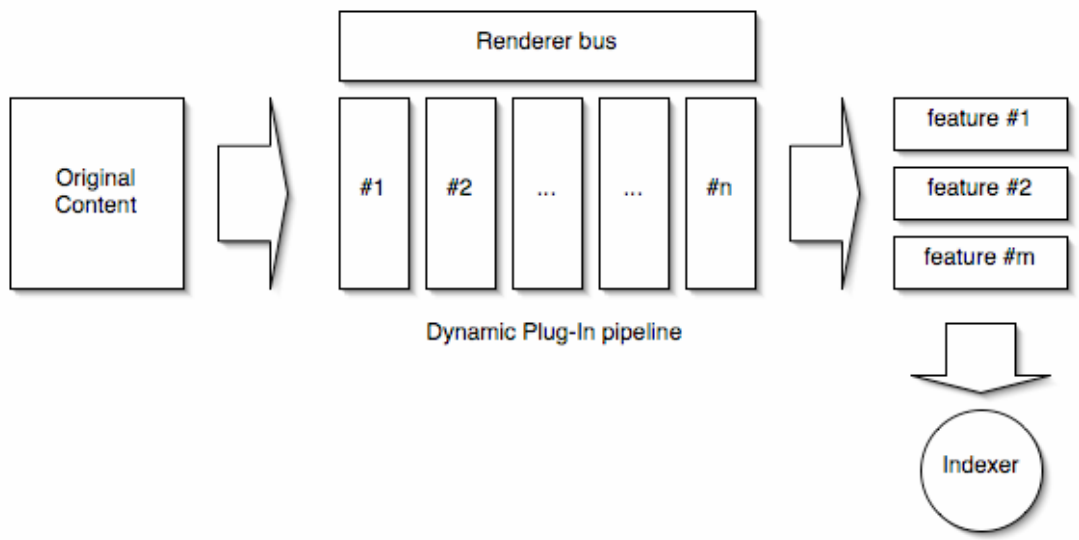
The content **Cache** is highly coupled with the index and acts like a cache for the content that needs to be locally mirrored. It is a multilevel cache and it can be used to store, and index, multiple version of the same content. Setting depth parameter equal to zero, no content will be mirrored.

Some main technical objectives had been followed during *focuseek* development:

Minimum environmental impact
Information access in complex organizations, with multiple data sources, multiple document formats, multiple access permission, etc. is often a very difficult task to manage. focuseek gathering approach is very straightforward and assumes as default the worst case: the data source is reachable but it is like a black box. It means that a gathering agent can access to data of a source using its standard access interface but it cannot influence the way of data are provided or formatted into the source itself. In addition, the agent is not interested in the internal format of such data because it has only to cope with its public interface. To be successful in this kind of approach the focuseek gathering system is highly adaptable to various source and data format, in many cases it is able to automatically obtain needed information from a source sniffing, in other cases it needs a manual configuration; in the worst case a gathering plug-in must be written.

Flexibility
The same flexibility of the gathering system is exploited by the indexing system too. The focuseek indexer module can manage any feature that a specific parsing module (see Renderer) is able to extract from original raw content. All extracted and indexed feature can be combined in the query language exposed by the query interface of the indexer module.

In the following figure, we can see the original content that is filtered by a Plug-In pipeline where each Plug-In is specialized in extracting a specific feature. Extracted features are then transformed in metadata and passed to the indexer module.



As example, in the case of musical content, a pipeline of Plug-In able to extract information like music class, type of instruments, etc. will provide to the indexer a set of useful selective features that can be used in the retrieval process directly from the query interface.

As default, focuseek provides Plug-Ins to extract text from a various types of documents: HTML, XML, TXT, PDF, PS, DOC, RTF. Other formats can be added with specific Plug-Ins.

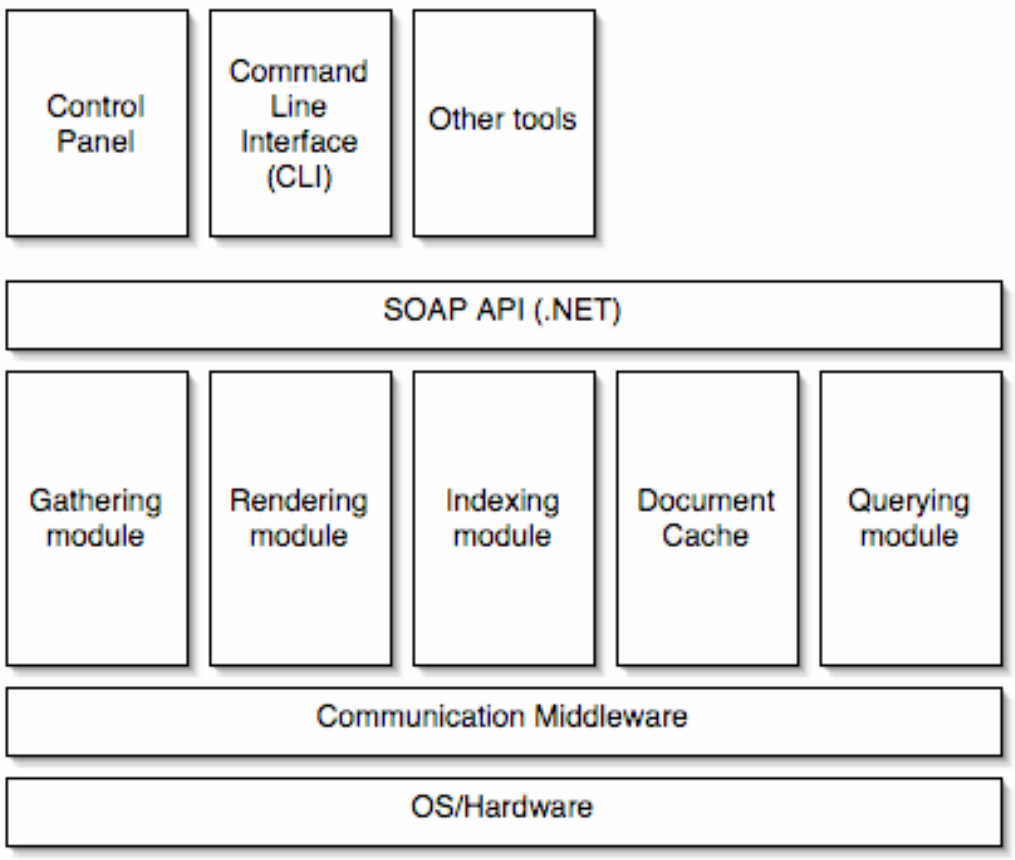
Performance
Every component of focuseek system is implemented with a custom technology focused to obtain very high performance in every situation regarding retrieval of information from unstructured repositories. In such sense, critical parameters are the gathering and indexing speed. In a current version of the system a single server, single processor installation is able to index up to one million of documents (a document is conventionally defined as a content with 1000 index-able attributes. For a text document, those attributes are, for instance, the words composing it), it supports more than 20 query/sec and can reach a gathering transfer rate of about 10 docs/sec depending from the available bandwidth.

Dynamism
focuseek is a native full dynamic system. It has been developed with the main goal to manage very dynamic information so that all changes in any of the monitored source is almost immediately propagated in every component of the system with a latency time of few seconds. focuseek has been though as a 24/24h, 7/7d online system so it does not need periodical index rebuilding and all other maintenance work can be made online directly on the production environment.

Scalability
focuseek supports both vertical and horizontal scalability. Due to its component based architecture and its fully multithread implementation, focuseek is able to take full advantage of multiprocessor server deployment. For huge implementations, a deployment model based on GRID approach is also possible. In this case, all focuseek components are deployed on a suitable number of single processor, low cost server connected together in a local or geographical network. A communication infrastructure between nodes is provided by focuseek itself.

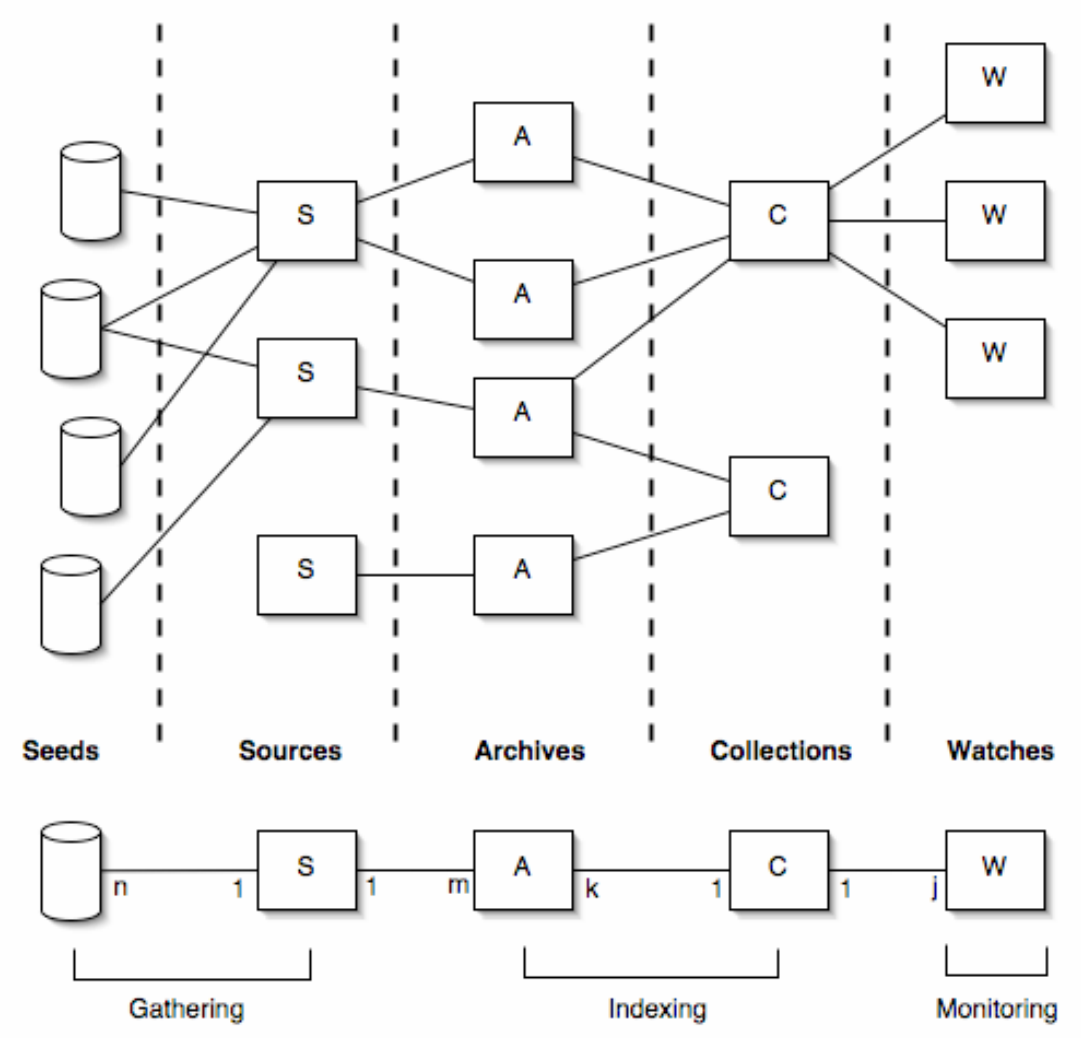
4.1.1 The focuseek architecture

The following figure shows the physical components of current focuseek architecture



focuseek is a component based platform completely developed in C++ language and available for Windows, Linux and OSX operating systems. All focuseek features are accessible using a complete SOAP API that is compliant with the latest Microsoft .NET standard. A complete suite of administrative tools comes with focuseek both as GUI and Command Line.

This other figure shows how the main concepts exposed by focuseek are connected to each others.



From the user point of view focuseek offer some basic concept that can be combined together in order to achieve the needed gathering and indexing functionalities. Such concepts are divided in three groups according with the SOAP API:

Gathering group. The central gathering concept is the Source. The goal of a Source is grouping a certain number of Seeds and configuring for them a suitable access protocol. A seed can be a database table or a Web Page, a complete Web Site, a specific portion of the Web or a fully custom data repository. The Source natively supports access to seeds with digital certificate, password, cookies etc. A Seed can be shared by many Sources.
The current version of focuseek platform is natively able to gather information from the following types of sources:

Breadth-First Web Crawling	from a set of initial seeds a web crawler can explore the Web Graph recursively following hyperlink contained in.
Site Crawling	same of above but the crawling activity is limited to the sites containing original seeds.
File Systems	any local or remote file system, accessible from the server where focuseek platform is installed

Newsgroups	usenet groups through NNTP protocol
DB	direct access to database tables. Compatibility with Oracle, DB2 and MySQL. An ODBC adapter is also available.
IMAP4	any mail folder accessible through an imap server.
POP3	same of above but with POP access protocol
WebDAV	a set of extensions to the HTTP protocol which allows users to collaboratively edit and manage files on remote web servers
RSS feeds	a format for syndicating news and the content of news-like sites

The gathering module provides an application interface (API) that can be used to implement new gathering protocols in order to match custom data repositories.

Indexing group. An Archive represents an index of contents coming from a Source. Multiple Archives can be connected to a single Source because every Archive can have different configuration rules to create the index (i.e. caching or no caching). In order to create indexes from different kind of Source many Archives can be grouped together by a Collection. Both Archive and Collection are query-able objects.

Monitoring group. focuseek can be used as monitoring tool too. Watches are contains a set of static filters on the information stream coming from a Collection so that they can be used to implement a custom view on any information stream. Watches supports subscriptions from any client application that needs to be alerted as soon a specific condition is matched.

4.2 State of the Art

The following is a brief summary of the most important products dealing with content crawling and indexing:

Google Appliance (www.google.com/appliance/)
It is the hardware/software solution from the most famous search engine company of the world. The appliance implements exactly the product available on the web but with a specific focus on the large enterprise market.

Verity Ultraseek (www.verity.com/products/ultraseek/)
Verity had recently acquired Inktomi search engine software division. Ultraseek is a pure search engine solution very well integrated with other Verity products.

Fast ESP (www.fast.no/us/esp/)
It is the main competitor of Google. Fast has been recently acquired by Overture, which has been acquired by Yahoo! together with Altavista. Fast technology now replaces Google in the Yahoo! portal.

Some other good Open Source projects can be found on the web but none of them has already reached the state of a mature product. For a good reference, see the DMOZ directory at the address
http://dmoz.org/Computers/Software/Internet/Servers/Search/

4.3 Work Done: Integration and Modification/Extensions

Crawling and indexing are realized with an already existing tool (focuseek searchbox), it allows to index from many sources (http, odbc, xml files, etc.), however to allow to access to other CMSs some new crawling plugins have been developed:

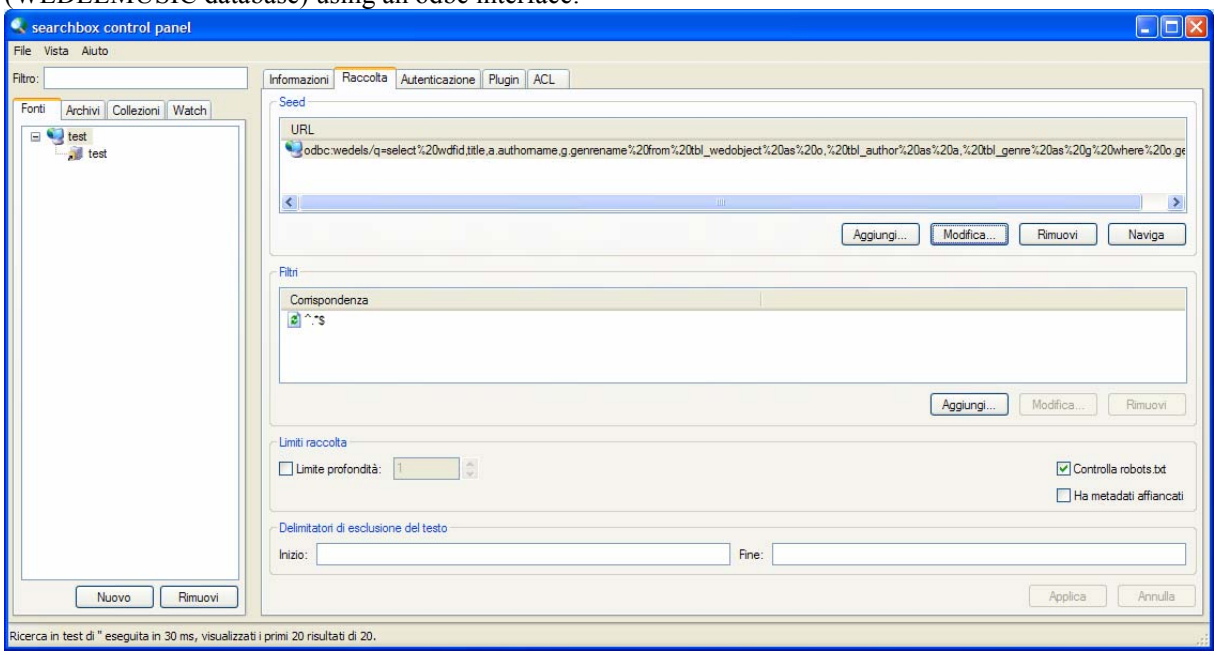
- A plugin for TAMINO/Lobster to allow to access to the ILABS CMS trought their propietary WebService interface
- A plugin to crawl a searchbox specific web service (the CMS has to implement this Web service in order to be crawled)

The focuseek searchbox has been tested with:

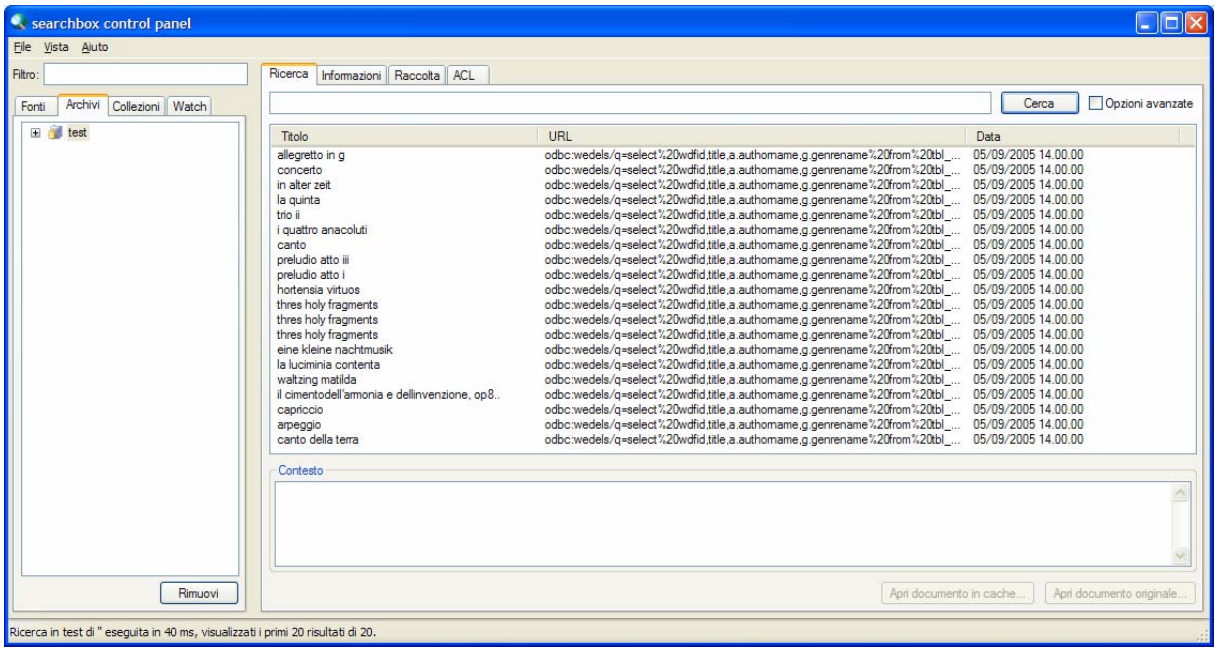
- The TISCALI CMS, to acces to the mediaclub content throught a mixed ODBC and XML access
- The AFI CMS, throught ODBC access
- The ILABS CMS, throught the newly developed TAMINO/Lobster plugin

Regarding the communication of updated content to the Collector Engine (AXMEDIS Content Processing Engine) focuseek supports watch management which communicates via a call to a searchbox specific WebService (but also via mail and RSS feeds) the documents that have been updated.
An adpting application has been developed to implement the searchbox WebService and to forward the activation requests to the AXMEDIS scheduler in order to run the rules to perform the updating work.

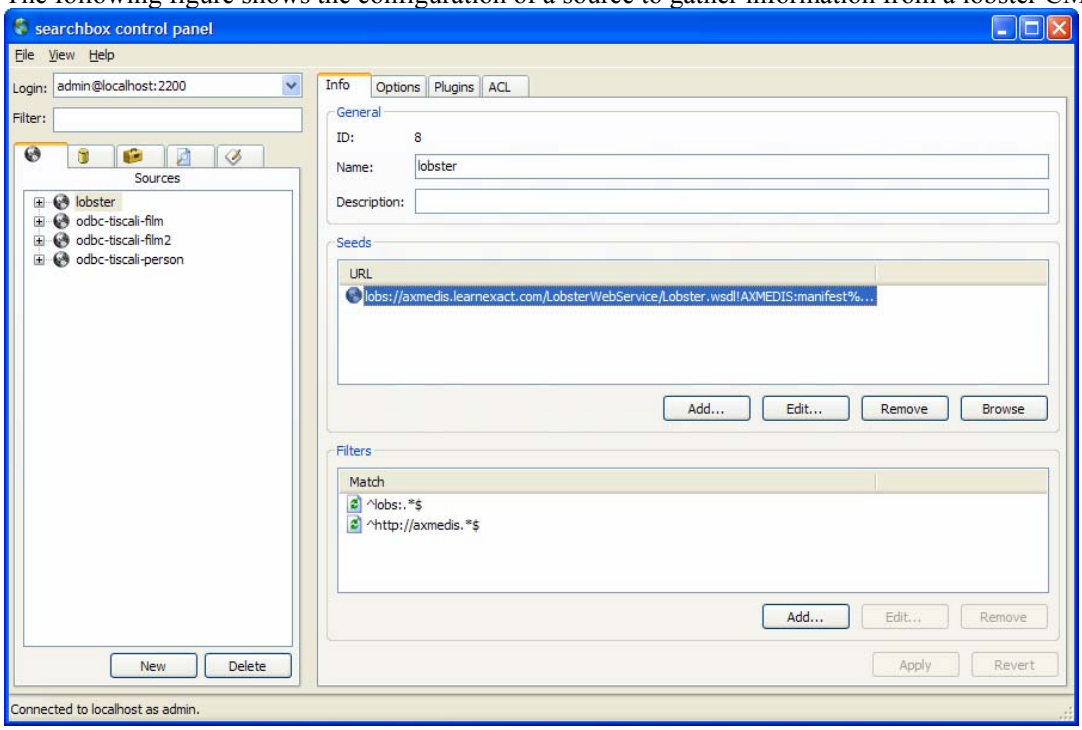
The figure shows the configuration of a source to gather information from a mysql database (WEDELMUSIC database) using an odbc interface:



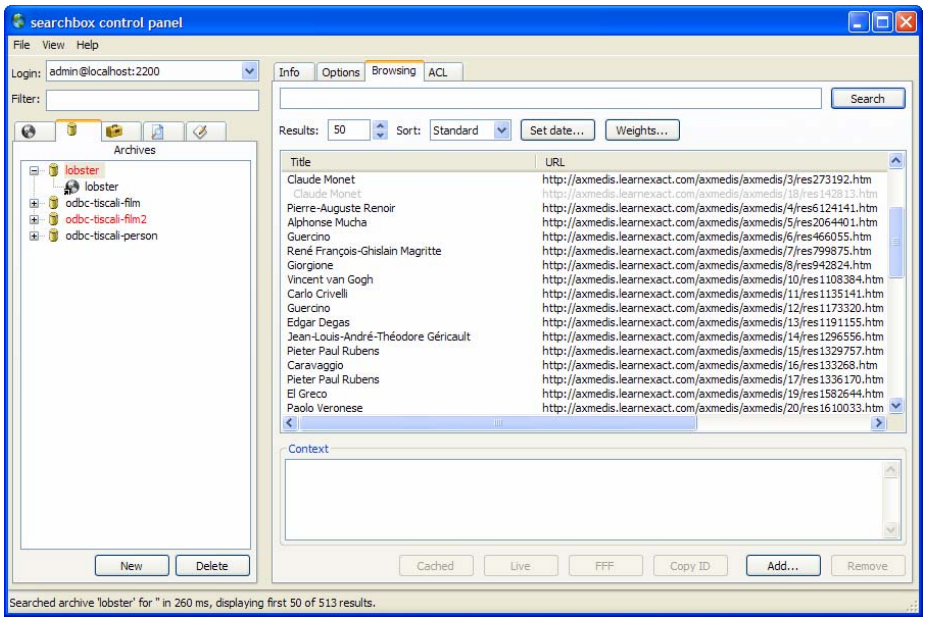
The result of a query is shown below:



The following figure shows the configuration of a source to gather information from a lobster CMS (ILABS)



The following picture shows the result of a query:



5 Estimating Fingerprint for Indexing - Content Descriptors (FHGIGD) (completed)

From a human point of content descriptors are required for efficient and effective content retrieval of content databases. Traditionally this annotation was created by human experts. The human experts analyse the content and extract information from its interpretation. This information is used to classify the content according to a domain specific taxonomy. However, this traditional way of creating this information is time consuming and therefore costly.

Different methods for automatic creation of these content descriptors have been developed. Depending on the resulting content descriptors two different categories can be distinguished:

- Low-level descriptors are closer related to the information signal than to the content itself. In other words, the content is decomposed in different signals, which are analysed. Thus, low-level descriptors provide little or no meaning to end-users: The content descriptors describe content properties that are not directly perceived by humans.

  Different level of extraction granularity can be distinguished:
  1. single sample/signal value
  2. small regions/short signal window
  3. bigger regions/longer signal window

- High-level descriptors are content descriptors that can be perceived by humans. They can be calculated from the content or from the low-level descriptors.

  Different
  1. Syntactic descriptors can be understood without signal processing knowledge. Yet, they do not provide a semantic description of the content.
  2. Semantic descriptors are meaningful for humans but can also vary in their concreteness.

Obviously, semantic high-level features are the first choice for content descriptors that are used by humans. Unfortunately there is no clear separation between high- and low-level features. Additional high-level descriptors are not available for all kinds of formats.

6 Audio Content Descriptors (EPFL)

The creation of huge databases of audio content coming from both restoration of existing analog archives and new content is demanding fast and more and more reliable tools for content analysis and description, to be used for searches, content queries and interactive access. In that context, MPEG-7 has normalized a number of low-level descriptors to help characterizing audio titles for retrieving. Yet such descriptors make no sense for human users and cannot be used for intuitive navigation. Higher-level descriptors such as musical genres are of a greater interest since they have been widely used for years to organize music catalogues, libraries and record shops.

The automatic music genre recognition problem is of a particular interest in the context of audio context description since it shares a number of similarities with other applications in which one aims at extracting automatically *semantic* descriptors of audio content (such descriptors may for example characterize instrumentation or *moods* and may be associated to keywords such as *dark, simple, brassy, soft…*). As a matter of fact, based on the architecture of a genre recognizer, one can derives a number of other extractor of semantically meaningful descriptors. We thus focus in the following on the genre recognition problem as a typical pattern recognition problem of the music information retrieval community. Moreover, to characterize a high-level descriptor such as genre, one needs to extract a number of lower-level descriptors so that the following description focused on genre will review the complete state-of-the-art in audio content description.

6.1 State of the Art

Musical genres are the main top-level descriptors used by music dealers and librarians to organize their music collections. Though they may represent a simplification of one artist's musical discourse, they are of a great interest as summaries of some shared characteristics in music pieces.

With Electronic Music Distribution (EMD), music catalogues tend to become huge (the biggest online services propose around 1 million tracks [1]); in that context, associating a genre to a musical piece is crucial to help users finding what they are looking for.

In fact, the amount of digital music data urges for efficient ways to browse, organize and dynamically update collections: it definitely requires new means for automatic annotation. In the case of music genre annotation, Weare [2] reports that the manually labeling of hundred thousand songs for Microsoft's MSN Music Search Engine needed about 30 musicologists for one year.

At the same time, even if terms such as *jazz*, *rock* or *pop* are widely used, they remain poorly defined concepts so that the problem of automatic genre classification becomes a non-trivial task. In the second section of this survey, we discuss the importance of musical genres with their definitions and hierarchies. The third section presents low-level techniques to extract meaningful information from audio data to characterize musical excerpts. We then review the state of the art in genre classification through three main paradigms: expert systems, unsupervised classification, and supervised classification.

6.1.1 MUSICAL GENRES

Musical genres are categories that have arisen through a complex interplay of culture, art and market forces to characterize similarities between musicians or compositions and organize music collections. Fabbri [3] attempts to define musical genres based on a combination of formal, technical, semiotic, behavioral, social, ideological, economical and juridical rules. The boundaries between genres as well as their definition still remain pretty fuzzy making the problem of automatic classification a non trivial task; yet, music catalogues are part of our life and culture.

The music genre classification problem asks for a taxonomy of genres i.e. a hierarchical set of categories to be mapped onto a music collection (though artists may not like the idea of being classified into a category). Pachet and Cazaly [4] studied a number of musical genre taxonomies used in industry and on the Internet and showed that it is not straightforward to build up such a hierarchy of genres. As a good classification relies on a carefully thought taxonomy, we summarize here a number of question and difficulties.

- Artists, albums or titles?

One question to be raised is to what kind of musical item genre classification is to apply: to a title, to an album or to an artist.

If we assume that one song may be classified into one genre (which is discussable), it is not that simple for an album. Consider for example the White Album of the Beatles that contain acoustic folk songs ("Rocky Raccoon"), brutal hard-rock songs ("Helter Skelter"), experimental compositions ("Revolution 9"), British blues songs ("Yer blues").

The same remark applies to artists. Some of them have covered such a wide range of genres that it does not make sense to try to associate them to a specific class. Take the example of Frank Zappa who has recorded contemporary pieces for orchestra ("The Yellow Shark"), doo-wop ("Cruising with Ruben & The Jets"), jazz-rock ("Hot rats") or strange objects that may be considered as experimental rock ("Uncle Meat").

• Non-agreements on taxonomies

Pachet and Cazaly [4] have showed that there is no general agreement on genre taxonomies. Taking the example of **http://www.allmusic.com** (531 genres), **http://www.amazon.com** (719 genres) and **http://www.mp3.com** (430 genres), they only found 70 words common to the 3 taxonomies. They notice that some widely used terms like *rock* or *pop* denote different sets of songs and those hierarchies of genres are differently structured from one taxonomy to the other.

• Ill-definition of genre labels

If we take a close look at some specific and widely used musical genres, we observe how varied can be the criteria that define a specific genre:

- indian music is a geographically defined genre;
- baroque music is related to a period of time (while encompassing a wide range of styles and a wide geographic region);
- barbershop music is defined by a set of precise technical requirements;
- post-rock is a term devised by music critic Simon Reynolds...

Pachet and Cazaly [4] argues that this semantic confusion within a single taxonomy may lead to redundancies that may not be confusing for human users but that may hardly handled by automatic systems. Furthermore, genre taxons may be dependant on cultural references. For example, a song by french singer Charles Aznavour would be considered as "Variety" in France but would be filed as "World Music" in the UK.

• Scalability of genre taxonomies

Hierarchies of genres should also consider the possibility to add new genres to take into account music evolution. New genres appear frequently (trip-hop, acid-jazz, post-rock) and are typically the result of some merging of different genres (psychobilly can be seen as the merging of rockabilly and punk) or the splitting of one genre into subgenres (original hip-hop has lead to different subgenres such as gangsta rap, turntablism, conscious rap...).

It is a major issue for automatic system. Adding new genres and subgenres to a taxonomy is possible but having an automatic system requiring supervised training to adapt itself is more tricky. In any case, an automatic system needs to be thought in a hierarchical way so that the process of expending a genre taxonomy both in width (new root genres) and depth (subgenres) is equivalent to add a new classification tree or new leaves to an existing tree.

• Local conclusion

Due to the difficulty of building a universal taxonomy one has to consider a more reasonable goal. Actually, Pachet and Cazaly eventually gave up their initial goal of defining a general taxonomy of musical genres [4] and Pachet and al. decided to use a simple two-level genre taxonomy of 20 genres and 250 subgenres in the context of the Cuidado music browser [5].

In the case of automatic genre classification, most authors have used only a very reduced set of genres (between 3 and 10; notice that the genres chosen are more dependent on the data available to the researchers than on carefully defined taxonomies).

As we're going to see, the state of the art in automatic classification does not allow yet very refined genres hierarchies (at the moment it is not easy to distinguish "rock" from "pop" so it will be even harder to distinguish subcategories such as "surf music" and "garage rock").

6.1.2 FEATURES EXTRACTION

In the digital world, audio information is represented by bits allowing a direct reconstruction of an analogue waveform. Music information may also be described more or less rigorously by some higher-level model-based representation – typically some event-like formats such as MIDI or symbolic formats such as MusicXML.

However, in real world applications a precise symbolic representation of a (new) song is rarely available and one has to deal directly with audio samples. Audio samples, though they encode accurately the audio waveform, can not be used directly by automatic analysis systems because of the amount of data they represent and because of the little information contained in audio samples taken independently. The first step of analysis systems is thus to extract some *features* from the audio data to manipulate more meaningful information and to reduce the further processing.

Extracting features is the first step of most pattern recognition system. Indeed, once significant features are extracted, any classification scheme may be used. In the case of audio signals, features may be related to the main dimensions of music including melody, harmony, rhythm, timbre and spatial location. As a matter of fact when dealing with music one should also consider the presence of singing voice and the content of the eventual lyrics (though keyword extraction from singing segments in polyphonic music is pretty far from the state-of-the-art).

We describe here the main features used in general applications of MIR with a focus on those that make sense when modelling genre.

- Timbre

Timbre is currently defined in the literature as the perceptual features that make two sounds having the same pitch and loudness sound different, Features characterizing timbre describe spectral distribution of the signal though some of them are computed in the time domain. These features are global in the sense that they integrate the information of all sources and instruments in the music,

Most of these descriptors are to be computed at regular time interval over short windows of signal of length typically between 10 and 30 ms. In the context of classification, timbre descriptors are often summarized by evaluating low-order statistics of the descriptors' distribution over larger windows (called texture windows in [6] or bags of frames in [7]). Not only does it reduce further computations but it is also perceptually more relevant to model timbre on a higher time scale as the short frames of signal used to evaluate features are not long enough for human listeners to perceive something (as a matter of fact, short frames are used so that one can consider the signal stationary so that it is more coherent to use standard signal processing tools),

The impact of the size of the texture window over classification accuracy has been studied in [6]. It is shown that the use of a window does indeed increase significantly the classification accuracy compared to the direct use of the analysis frames. They conclude that texture windows of 1 second are a good compromise since no significant gain in classification accuracy is obtained by taking larger windows while the accuracy decreases (almost linearly) as the window is shortened.

We enumerate here a number of descriptors commonly used to characterize timbre. Most of them come directly from the speech recognition literature [8] while some others have been normalized in the context of MPEG-7 [9].

- Zero-Crossing Rate [6], [10]: it is defined as the number of zero-crossings of the signal in the time domain. It is a measure of noisiness of the signal and is correlated with pitch.
- RMS [10]: the simple root mean square energy of the signal frame,
- Loudness [10]: simple models of loudness consist typically of an exponentiation of the energy of

the frame.

- Low Energy Feature [6], [10]: it is the percentage of frames within a larger window that have a RMS energy lower than the mean RMS energy across the window.
- Linear Prediction Coefficients [11], [12]: linear prediction has been designed in the context of speech recognition to model sound production: the observed sound is supposed to be the result of the linear filtering of a simple signal. The estimated coefficients of the filter can be used as timbre descriptors since they encode the effect of the resonating body of the instrument (or of the vocal track in the case of speech production).
- FFT coefficients [12], [13], [14]: the feature vector is simply the vector of the FFT coefficients.
- Mel-Frequency Cepstrum Coefficients [6], [7], [10], [11], [15]: Mel-Frequency Cepstrum Coefficients (MFCCs) are perceptually motivated features obtained by taking the log-amplitude of the magnitude spectrum, warping the spectrum onto a perceptual frequency scale, the Mel frequency scale and by applying a discrete cosine transform on the Mel coefficients so as to decorrelate the resulting feature vector. 13 coefficients are tycically used for speech recognition. The number of MFCCs is a discussed parameter in the music analysis community [16].
- Spectral Centroid [6], [10]: describes the center of gravity of the power spectrum. It is an economical description of the shape of the power spectrum. It indicates whether an audio spectrum is dominated by low or high frequencies and, additionally, it is correlated with a major perceptual dimension of timbre; i.e.sharpness.
- Spectral Roll-Off [6], [10]: spectral roll-off is a measure of spectral shape. It is defined as the frequency below which most of the power spectrum is concentrated (typically 85 % of the power spectrum).
- Spectral Flux [6], [10]: spectral flux is a measure of the amount of local spectral change. It is evaluated as the difference between the normalized magnitudes of successive spectral distribution.
- Spectrum Spread [10]: spectrum spread describes the second moment of the power spectrum. It is an economical descriptor of the shape of the power spectrum that indicates whether it is concentrated in the vicinity of its centroid, or else spread out over the spectrum. It allows differentiating between tone-like and noise-like sounds.
- Spectrum Flatness [10]: spectrum flatness expresses the deviation of the signal's power spectrum over frequency from a flat shape (corresponding to a noise-like or an impulse-like signal). A high deviation from a flat shape may indicate the presence of tonal components.
- Harmonic Ratio [10]: harmonic ratio is loosely defined as the proportion of harmonic components within the power spectrum. It is derived from the correlation between the signal and a lagged representation of the signal, lagged by the fundamental period of the signal.
- Wavelet [17]: the wavelet decomposition scheme allows a division of the signal into octave sub-bands while providing good time and frequency resolution. The Daubechies Wavelet Coefficients Histograms (DWCHs) proposed in [17] are histograms of wavelet coefficients over a large window from which features are extracted by evaluating moments.

• Melody, Harmony

Harmony may be loosely defined as the use and study of pitch simultaneity and chords, actual or implied, in music. On the contrary, melody is a succession of pitched events perceived as a single entity. Harmony is sometimes referred to as the vertical aspect of music with melody being the horizontal aspect,

Melodic and harmonic analysis having been for a long time used by musicologists to study musical structures, it is tempting to try to integrate such analysis when modeling genre. Though rather evolved analysis algorithms have been proposed when dealing with symbolic MIDI data where the pitch and time position information is known, the state-of-the-art of melodic and harmonic analysis of unrestricted audio signals is far less advanced because of the difficulty to extract reliably note onsets, pitch and chords.

A good overview of melody description and extraction in the context of audio content processing may be found in [18]. For the estimation of multiple fundamental frequencies of concurrent musical sounds, one may

refer to [19] while chord extraction is addressed in [20]. Analogously to the case of speech recognition in which models of words and language are used to improve performances, use of higher-level knowledge such as *typical* chord progressions may greatly improve analysis results.'

In any case, for the time being, melodic and harmonic content are more robustly described by lower level attributes than notes or chords. To our knowledge, there has been only one attempt to use pitch features when modeling genres of audio signals [6].

The idea is to use a function characterizing pitch distribution of a short segment like most melody/harmony analyzer; the difference is that no decision on the fundamental frequency, chord, key or other high-level feature is undertaken. On the contrary, a set of descriptors are computed from this function including amplitude and positions of its main peaks, interval between peaks, sum of the detection function and possibly any kind of statistical descriptor of the distribution of the pitch content function. Two versions of the pitch function are used: an *unfolded* version that contains information about the pitch range of the piece and a *folded* one in which all pitches are mapped to a single octave giving a good description of the harmonic content of the piece.

- Rhythm

A precise definition or rhythm does not exist. Yet most authors refer to the idea of *temporal regularity*, As a matter of fact, the perceived regularity is distinctive of rhythm and distinguishes it from *non-rhythm*. More generically, the word rhythm may be used to refer to all of the temporal aspects of a musical work.

Intuitively, it is clear that rhythmic content may be a dimension of music to consider when trying to discriminate between *straight-ahead* rock music from rhythmically more complex latin music for example, or to isolate some classical music in which the sensation of pulse is not so evident and the expressive rhythm variation more common.

Here again rhythmic content analysis of symbolic MIDI data has preceded analysis of real world audio. A review of automatic rhythm description systems may be found in [21]. These automatic systems may be oriented towards different applications dedicated to rhythm: tempo induction, beat tracking, meter induction, quantization of performed rhythm, or characterization of intentional timing deviations.

In [22], Gouyon et al. study genre classification with a focus on the use of tempo. They show that by using manually assigned tempo values, genre classification may be improved but that with automatically induced tempi, a lower level approach leads to a better classification (see [23]): the state-of-the-art tempo tracking algorithms typically make errors of metrical levels (e.g. they often output multiples or sub-multiples of the correct tempo).

The same authors report on genre classification based on rhythmic patterns [24] obtained by averaging amplitude envelopes of the signal between measure bars. Though they show that rhythmic patterns help at improving classification results, the measure bars needed for their experiences are obtained semi-automatically by running a beat-tracking algorithm and selecting the measure bars by hand. Given the state-of-the-art accuracy of measure bars detection algorithm (see [25]), it is reasonable to think that here again a lower level approach would be best suited for the moment.

Following the same approach as the one introduced for low-level pitch attributes, descriptors may be extracted from a function measuring the importance of periodicities in the range of perceivable tempi (typically 40 to 200 bpm in genre classification applications). Such function may be obtained by autocorrelation-like transform of features over time [25] (interesting features being usually energies in different frequency bands). It is also possible to use FFT to evaluate modulations of features [26] or to build a histogram of inter-onset intervals [27].

Gouyon et al. [23] give an in-depth study on low-level rhythmic descriptors extracted from different periodicity representations. In particular, they obtain encouraging results with a set of MFCCs-like descriptors computed from a periodicity function (rather than from a spectrum).

- Extracting features from semantically significant audio segments

The descriptors presented earlier may be extracted for the complete audio signals. Yet, in many classification tasks, a small segment of audio is used as it may contain sufficient information to characterize the content of a complete song because of the repetitions in musical structure observed in many musical

genres. This idea is all the more significant that the required computations may be greatly reduced by considering only a small part of the signal.

Most of the proposed algorithms for musical genre classification use indeed one small segment of audio per title: typically a 30 seconds long segment starting 30 seconds after the beginning of the piece to avoid introductions that may not be representative of the whole piece.

In the context of artist identification, Berenzweig et al. [28] have proposed to detect automatically singing segments and have obtained improved results by analyzing only the singing part: it may indeed be easier to identify artists by listening to their voices rather than their music.

Of course, this only applies to titles with singing voice but a more general approach based on recent research on automatic summarization of titles [29] may help genre characterization: for example, the most repeated part of a title (typically the chorus in popular music or the theme in jazz) could be identified and analyzed in term of genre rather than a random part of the signal which may be less representative. Yet, as far as known no such approach has been evaluated in the context of genre classification.

- Cultural features

Alternatively some authors have proposed to take some cultural features into account arguing that there may not be sufficient information in audio signals to characterize the musical genre of a title. Indeed, when one tries to derive genre from audio only, he assumes that genre is an intrinsic attribute of a title as its tempo for example, which is definitely arguable (see section II).

The proposed approach is thus to mine the web to find keywords associated to the artist names. Pachet et al. [30] use this technique in the context of unsupervised clustering of a music collection (i.e. without explicitly associating a genre label to a title) while in [31], keywords are used to characterize musical genres in a supervised fashion. In [32], cultural features are used to improve standard genre characterization based on audio features: in this case cultural features help at classifying properly acoustically dissimilar music within the same genre and similar music belonging to different genres.

- Local conclusion

Extraction of high-level descriptors from unrestricted polyphonic audio signals is not yet state of the art. Thus most approaches focus on timbre modeling based on combinations of low-level descriptors. Timbre may contain sufficient information to characterize roughly musical genres as research has found that humans with little to moderate musical training were able to perform a correct classification of music (among 10 genres) in 53 % of the cases after listening to only 250 milliseconds and in 72% of cases based on only 3 seconds of audio [33]. This suggests that no high-level understanding of music is needed to characterize genres as 250 milliseconds and in a lesser manner 3 seconds are too little time to recognize a musical structure.

Aucouturier and Pachet [34] have a more pessimistic point of view. They have studied the correlation between timbre similarity and genre. They used a state-of-the-art timbre similarity measure [35] and a database of 20000 titles distributed over 18 genres. Their results show that there is only little correlation between timbre and genres suggesting that classification schemes based solely on timbre are intrinsically limited. They also suggest that such classification schemes may hardly scale in both the number of titles and in the number of genre classes.

6.1.3 EXPERT SYSTEMS

Expert systems explicitly implement sets of rules. For the genre classification task, this would be equivalent to enumerate a number of rules that would characterize precisely and uniquely a genre. As far as we know, no model based on expert systems has been proposed to characterize musical genres. The work by Pachet and Cazaly [4] on a taxonomy of musical genres can be compared to an expert system approach though it did not lead to an actual implementation. Yet it is worth mentioning as it allows a deeper comprehension of the difficulties of music genres classification.

Pachet and Cazaly have tried to define characteristics of genres and their relations. They have formally stated differences among genres with a language based on descriptors such as the instrumentation, the type of voice, the type of rhythm, the tempo of the song (for example, *Ska* is derived from *Mento* and is different because it has a faster tempo and has a brass section). This implies that these descriptors must be detailed enough to characterize subgenres differences.

This approach, if possible at all, is not appropriate for genre classification given the complexity of the task and the difficulty to objectively describe very specific subgenres. Moreover it requires a (automatic) manner to obtain reliable high-level descriptors from the audio signal, which is not state-of-the-art as seen in the previous section.

Expert systems, though they incorporate deep knowledge of their subject, are expensive to build and to maintain. As the number of manually generated rules grows, they may yield unexpected interactions and side effects, so that software engineering issues become increasingly important, In the last few years, the machine learning approach has garnered increasing interest. From the point of view of related disciplines, the machine learning approach has come to dominate similar areas of natural language processing and pattern recognition such as automatic speech recognition or face recognition. Finally from the point of view of objectively evaluated performance, systems based at least partly on machine learning have outperformed those based purely on expert systems in recent quantitative evaluations.

6.1.4 UNSUPERVISED CLASSIFICATION

While other approaches tend to classify music given an arbitrary taxonomy of genres, another point of view is to cluster the data in a non-supervised way so that a classification will emerge from the data based on objective similarity measures. The interest is to avoid the constraint of a fixed taxonomy, which may suffer from ambiguities and inconsistencies as it has been seen earlier, Moreover, some titles may simply not fit into a given taxonomy.

In the unsupervised approach, an audio title is represented by a set of features as seen in section III and a similarity measure is used to compare titles one with another. Unsupervised clustering algorithms then take advantage of the similarity measure to organize the music collection with clusters of similar titles.

- Similarity measures

The simplest choice to measure distance between two feature vectors is to use a Euclidean distance. It is used in [26] in the context of unsupervised clustering of a music collection by sound similarity. Another popular distance measure is the cosine distance used in [36].

Notice however that these distances will only make sense if the feature vectors are time-invariant. If not two perceptually similar titles may be distant according to the measure if the similar features are time-shifted. One solution to build a time-invariant representation of a time series of feature vectors is to first build a statistical model of the distribution of the features and use the distance to compare models directly. Typical models include K-means, Gaussian and Gaussian mixtures (GMMs).

The Kullback-Lleiber divergence or relative entropy is the natural way to evaluate distance between probability distributions but is not suited for GMMs. Alternative measures include sampling [35], Earth's Mover distance [37] and the Asymptotic Likelihood Approximation [38].

Considering the fact that, unlike most classic pattern recognition problems, the data to be classified are time series data, Shao et al. [11] use Hidden Markov Models (HMMs) to model the relationship between features over time. One interest of HMMs is that they provide a proper distance metric [8] so that once each piece is characterized by its own HMM, the distance between any pieces of the database can be computed.

- Clustering algorithms

K-means is probably the simplest and most popular clustering algorithm [39]. It allows for partitioning a set of vectors into K disjoint subsets. One of its weaknesses is that it requires the number of clusters (K) to be known in advance,

Shao et al. [11] cluster their music collection with the Agglomerative Hierarchical Clustering [40], a clustering algorithm that starts with *N* singleton clusters (where *N* is the number of titles of the database) and that forms a sequence of clusters by successive merging. When the number of desired clusters is known, the merging process will be stopped when this number of cluster is reached while if it is unknown, the merging process will be stopped when the distance between two nearest clusters is above a threshold.

The Self-Organizing Map (SOM) [41] and the Growing Hierarchical Self-Organizing Map (GHSOM) [42] are used to cluster data and organize it on 2-dimensional space in such a way that similar feature vectors are grouped close together. SOMs are unsupervised artificial neural networks that map high dimensional input data onto lower dimensionality output spaces while preserving the topological relationships between the input data items as faithfully as possible. GHSOMs are a special case of SOMs which make use of a

hierarchical structure of multiple layers where each layer consists of a number of independent SOMs. Rauber et al. [26] use an output space of dimension 2 to allow for a visual representation of a music collection with a GHSOM.

- Local conclusion

In some terms, the major drawback of unsupervised techniques can be that the obtained clusters are not labeled. In any case, the obtained clusters do not always reflect genre hierarchies, rather similarities dependent on the type of features (rhythmical similarities, melodic similarities, etc.).

Rousseaux and Bonardi [43] argue anyway that in the context of EMD, the notion of genre may disappear as develops an *ad-hoc* organization of audio sample centred on prototypes and similarity. Up to a certain extent, we agree that some forward thinking leads to a more "perceptual" approach to music classification, based at the same time on the combination of multiple labels and *cross-genre* references: people like different styles of music, and what they like in each one may share well identified features.

SUPERVISED CLASSIFICATION

The supervised approach to music genre classification has been studied more extensively. These methods suppose that a taxonomy of genres is given and they try to map a database of songs into it by machine learning algorithms. As a first step, the system is trained with some manually labeled data, and then it is used to classify unlabelled data.

We describe here a number of commonly used supervised machine learning algorithms. We do not pretend to make an exhaustive list of such algorithms but focus on those that have been used in the context of music genre classification. We then present the results obtained with these algorithms in the literature.

- Supervised classifiers

1. K-Nearest Neighbor (KNN): it is a non-parametric classifier based on the basic idea that a small number of neighbours influence the decision on a point. More precisely, for a given feature vector in the target set, the K closest vectors in the training set are selected (according to some distance measures) and the target feature vector is assigned the label of the most represented class in the K neighbours. Of course the computing time goes up as K goes up but the advantage is that higher values of K provide smoothing that reduces vulnerability to noise in the training data. It has been proven that the error of KNN is asymptotically at most twice as large as the Bayesian error rate. KNNs are evaluated in the context of genre classification in [44], [17], [6].
2. Gaussian Mixture Models (GMM): GMMs model the distribution of feature vectors. For each class, we assume the existence of a probability density function expressible as a mixture of a number of multi-dimensional Gaussian distributions. The iterative Expectation Maximization (EM) algorithm is used to estimate the parameters for each Gaussian component and the mixture weights. GMMs have been widely used in the music information retrieval community, notably to build timbre models as seen in section (V. A.). They have been used to model directly musical genres in [17], [6], [7],
3. Linear Discriminant Analysis (LDA): LDA is known to learn discriminative feature transformations very well. The basic idea of LDA is to find a linear transformation that best discriminates among classes and perform classification the transformed space based on some metric such as Euclidean distances. LDA has been tested for musical genre classification in [17], [45], [7].
4. Support Vector Machines (SVM): SVMs have shown excellent results for data classification and regression [46]. Their success in practice is based on two properties: margin maximization (which allows for a good generalization of the classifier) and nonlinear transformation of the feature space with kernels (as a data set is more easily separable in a high dimensional feature space), SVMs have been notably used in the context of genre classification by [17], [45].
5. Maximal Binary Classification Tree: West and Cox [7] use a Maximal Classification Binary Tree built by forming a root node containing all the training data and then splitting that data into two child nodes by using either a LDA or a single Gaussian classifier with Mahalanobis distance

measurements. To split a node, all possible combinations of classes are formed and the combination of classes yielding the best split is chosen. The maximal tree, over-fitting the training set is evaluated before a pruning the tree back to a more sensible size. Notice that the building of the tree is unsupervised while the classifiers used for splitting on each node are trained in a supervised manner.

6. Artificial Neural Network (ANN): An ANN is an information-processing paradigm inspired by the way biological nervous systems, such as the brain, process information. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. The most widely used supervised ANN for pattern recognition is the Multi-Layer Perceptron (MLP). It is a very general model that can in principle approximate any non-linear function. A combination of three different MLPs is used in [44] to characterize musical genres. The idea is use different segments of the audio stream and to combine the classification results to increase overall accuracy. A MLP is used in [28] for a close problem, artist identification; the architecture used takes advantage of contextual information by inputting to the network 5 adjacent feature vectors (this architecture is also referred to in the literature as the Feedforward Time-Delay Neural Network, TDNN). A TDNN is also used in [32].
7. Explicit Time Modelling with Neural Networks (ETM-NN): Neural Networks, as well as the other reviewed architectures, can only handle static patterns, Some architectures oriented towards the processing of temporal sequences have been proposed (Recurrent Networks such as the Elman-Network [47] but have not been used yet in the context of music genre classification. Soltau et al. [15] have introduced in the context of recognition of music genres an original method for explicit time modeling of temporal structure of music (ETM-NN). In this architecture, a multi-layer perceptron is trained to recognize given input feature vectors that are 0.4 seconds long. The main idea is to use the hidden layer of the perceptron and not its output, which is supposed to give the genre. As a matter of fact, it is known that the first half of a feed-forward network performs a specific nonlinear transformation of the input data into a space in which the discrimination should be simpler. The activation of these hidden neurons corresponds to the use of a compact representation of the input feature vector. Each hidden neuron can be understood as an abstract musical event – not necessarily related to an actual musical meaning. An abstract event e_i occurs if the hidden unit i has the highest activation of all hidden units. The sequence of abstract events over time is then analysed to build one single feature. More specifically, the number of events e_i (unigram), the number of pairs e_i e_j (bigram) and the number of triplets e_i e_j e_k (trigram) are evaluated as well as the event durations, the mean, the maximum and the variance of event activations. All of these features, normalized over the length of the sequence are combined into a single vector that is given to another neural network. This second network implements the final decision about the genre of the musical piece.
8. Hidden Markov Model (HMM): Hidden Markov Models (HMMs) already introduced in section earlier as a similarity measure can also be used for classification purposes. They have been extensively used in speech recognition [48] because of their capacity to handle time series data. HMMs may be understood as a doubly embedded stochastic process: one process is not observable (hidden) and can only be observed through another stochastic process (observable) that produces the time set of observations. A HMM is defined by its number of states, the transition probability between its states, the initial state distribution and the observation probability distribution. Mixtures of Gaussians typically model observation probability densities. This implies a strong assumption on the distribution of the emission probability that may be relaxed by modelling emission probabilities with neural networks (see [49]). HMMs may have a low discriminative power because they are usually trained with a maximum likelihood criterion rather than with an optimal maximum a-posteriori criterion. In other words, during the training, the likelihood that the model of a genre did produce an observation is maximised but the likelihood of the other models is not minimized. A number of alternative solutions for the training of HMMs have been proposed to ensure them a better discrimination power (see [50]). Though they may be well suited to modelling music, to our knowledge, HMMs have only been used in [18] for genre classification of audio content (they have been used in [16] as well but in the case of unsupervised organization of a music collection).

Mixture of Experts (ME): A Mixture of Experts solves a classification problem by using a number of classifiers to decompose it into a series of sub-problems. Not only does it reduce the complexity of each single task but it also improves the global accuracy by combining the results of the different classifiers (experts). Of course, the number of needed classifiers is increased but having each of them a simpler problem to handle, the overall required computational power is reduced. Using a mixture of classifiers, each subtask may focus either on a subset of the attributes (feature selection), on different sample data (resampling, i.e. sub-sampling, bagging, boosting…), or on a different data labelling (decomposition of polychotomies into dichotomies). A range of solutions has been proposed in literature for the combination of different models into a global system. A possible solution is to use a majority vote of the different experts. This solution is used in [44] where 3 different MLPs characterize three different segments of a single song. Another possibility is to average the output probability estimates of each expert for each class. A more elaborated strategy is to consider the combination of the outputs of each expert as another learning problem. When each expert is working on a different feature set, the combination of results can be itself a function of the features so that inputs control the weights associated to each expert: such a method implements a sort of dynamic feature selection strategy. This latter classification scheme is used in our prototype for AXMEDIS with SVM expert and three different feature sets (timbre, energy and rhythm).

- Classification results

The taxonomy used in state-of-the-art works on genre classification is often very simple and incomplete (between 2 and 10 genres and rarely more than 1000 songs) and usually reflect more the data available to the authors than a rigorous analysis of genres; it is consequently rather difficult to compare the different approaches. The Music Information Retrieval Evaluation eXchange 2005 (MIREX) [51] is trying to unify efforts and give a rigorous comparison of algorithms.

- Local conclusion

The major interest of supervised classification compared to the expert system approach is that one does not need to describe explicitly musical genres: the classifier attempts to form automatically relationships between the features of the training set and the related categories.
An important point to consider in supervised approaches is how to expand the taxonomy of genres they are built upon. New genres appear frequently (*trip-hop*, *acid-jazz*, *post-rock*) and are typically the result of some merging of different genres (*psychobilly* can be seen as the merging of *rockabilly* and *punk*) or the splitting of one genre into subgenres (original *hip-hop* has lead to different subgenres such as *gangsta rap*, *turntablism*, *conscious rap*…). Hierarchical systems have to be favoured as the process of expending their genre taxonomy both in width (new root genres) and depth (new subgenres) is equivalent to adding a new classification tree or new leaves to an existing tree.

6.2 Problems

Three main difficulties emerge from works on audio content description:

1. Training data: In the context of machine learning, the more abundant the training data, the better. Yet freely available audio content is rare and does not represent accurately the variety of music composed up to now. One solution proposed in the context of music information research is to exchange standardised low-level descriptors of audio content between laboratories so that researchers can take advantage of the audio content of their colleagues (researchers usually using their personal CD collections).
2. Ground truth: In a classification task, the labels associated to an item are crucial. In the context of semantic description of audio content, labels may be difficult to obtain: as we have seen earlier, musical genres are ill-defined and ambiguous and it is all the more true for descriptors such as *moods*. In the context of AXMEDIS, we will use labels mined from the AllMusicGuide (**http://www.allmusic.com**) as a reference (genre, moods and instrumentation) and labels from the Epitonic collection for the data available from Epitonic (http://www.epitonic.com).

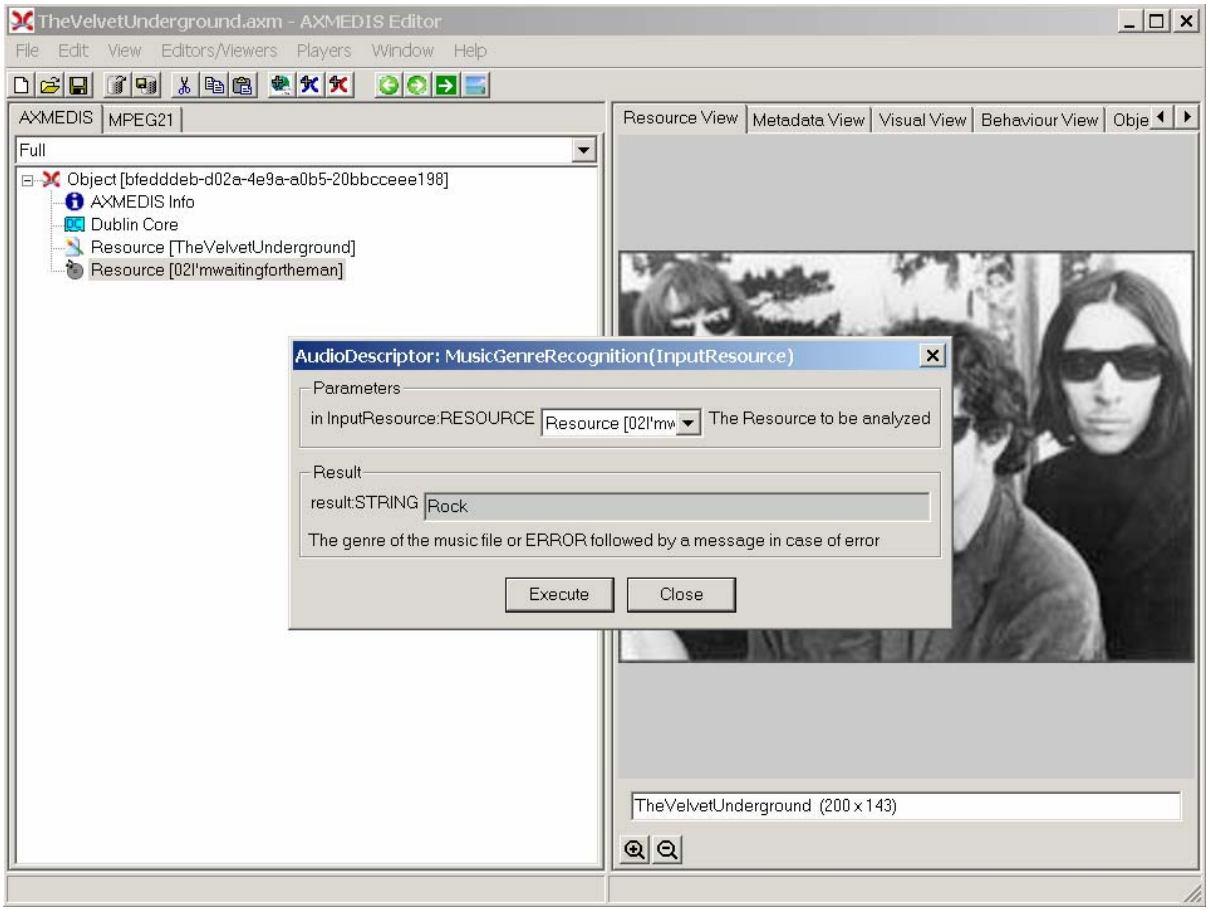
3. Evaluation of similarity measures: No rigorous evaluation of audio similarity measures has been proposed yet because of the lack of available data describing similarities between titles. In the context of MIREX [51], we will set up a database of similarity relations between artists based on the AllMusicGuide (**http://www.allmusic.com**) and Epitonic (http://www.epitonic.com).

6.3 Work Performed

The audio descriptors extraction functionalities are implementated as plug-ins through the AXCP interface. The interface of AXCP plug-ins maps exactly the formal description of the function and allows entering textually all parameters of the function. Moreover, it displays a brief description of the meaning of the parameters of the function to ease their use. The result of the adaptation is displayed as a textual message in the *Result* box of the interface.

The adaptation is launched by clicking the *Execute* button and the window can be closed with the *Close* button once the adaptation has been performed.

The following figure shows the user interface of the music genre recognizer function. Please refer to section 15.4.10 for the formal description of the music genre recognizer function and to understand how the user interface reflects this formal description.



Low-Level Descriptors

The Low-Level Descriptors extractor allows extracting morphological descriptors of the audio signal:

- **AudioWaveform**: describes the audio waveform envelope, typically for display purpose.
- **AudioPower**: describes the temporally smoothed instantaneous power.

- **AudioSpectrumEnvelope**: describes the spectrum of the audio according to a logarithmic frequency scale.
- **AudioSpectrumCentroid**: describes the center of gravity of the log-frequency power spectrum.
- **AudioSpectrumSpread**: describes the second moment of the log-frequency power spectrum.
- **AudioSpectrumFlatness**: describes the flatness properties of the spectrum of an audio signal within a given number of frequency bands.
- **Mel Frequency Energies:** energy on the Mel scale which is a perceptually motivated scale of pitches.
- **MFCCs**: Mel-Frequency Cepstral Coefficients, e.g. spectral shape descriptors.
- **ZCR**: number of time domain zero crossing of the signal.

Audio Files Segmentation

The Speech / Noise / Music discriminator allows segmenting the audio stream into three kind of semantically coherent segments:

- Speech segment: speech segments are defined as regions of the audio file in which spoken content is dominant.
- Music segment: music segments are defined as regions of the audio file in which music content is dominant.
- Noise segment: noise segments are defined as regions of the audio file in which noise is dominant; noise is loosely defined as audio content which is not speech, music nor silence.

Music Genre Recognizer

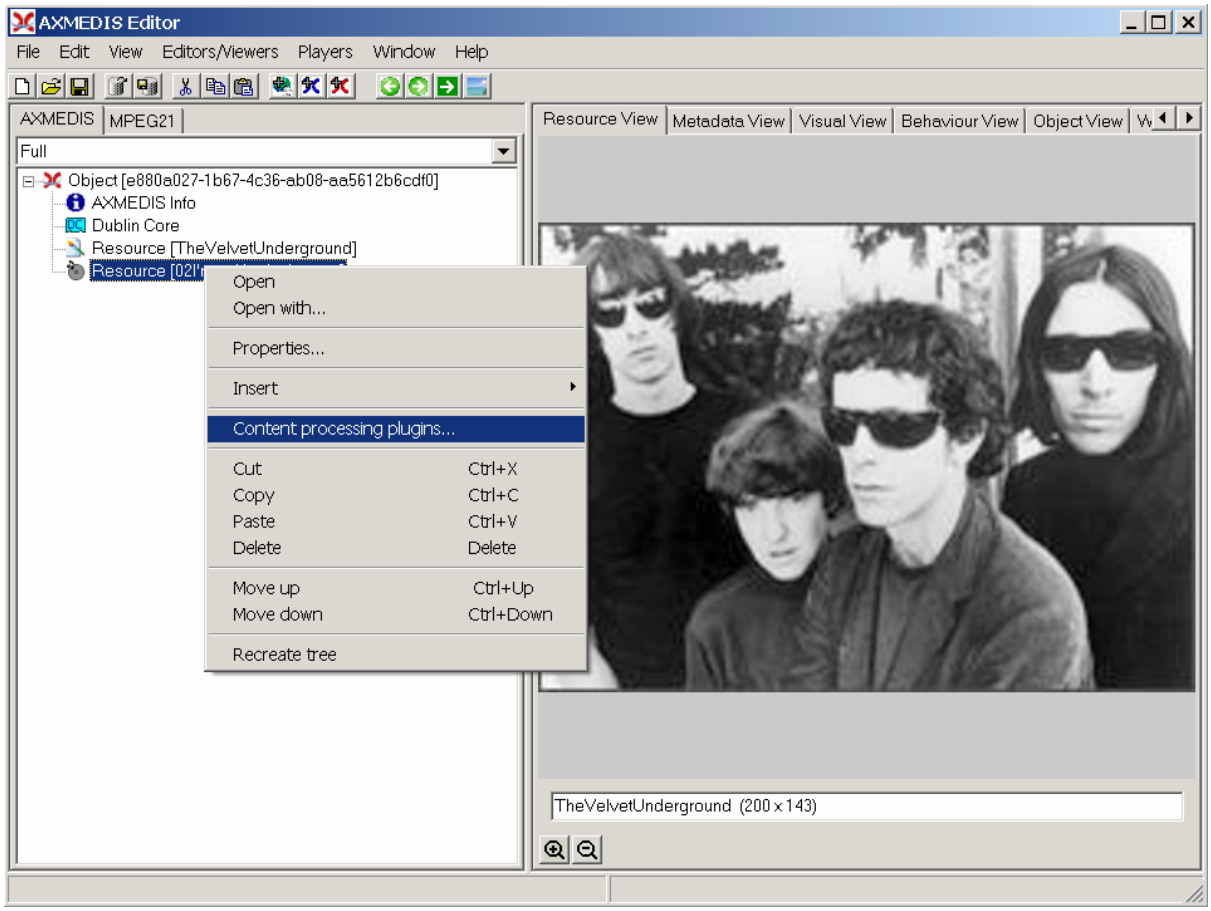
The Music Genre recognizer allows characterizing music segments in terms of music genres. The provided model classify music in the following genres:

- Classical
- Jazz
- Electronic
- Rap
- Rock

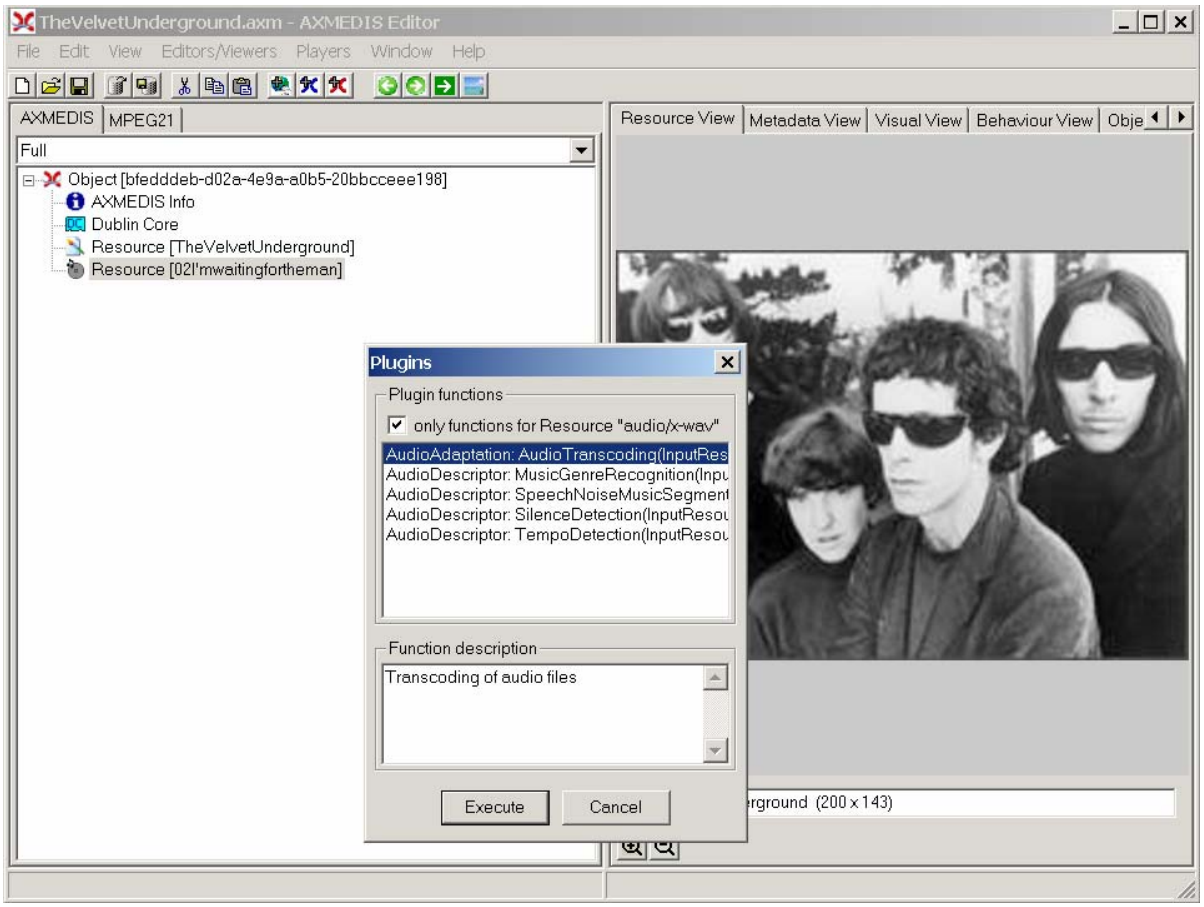
Rhythm Characterization

The rhythm characterization tool allows extracting tempo and meter from audio files.

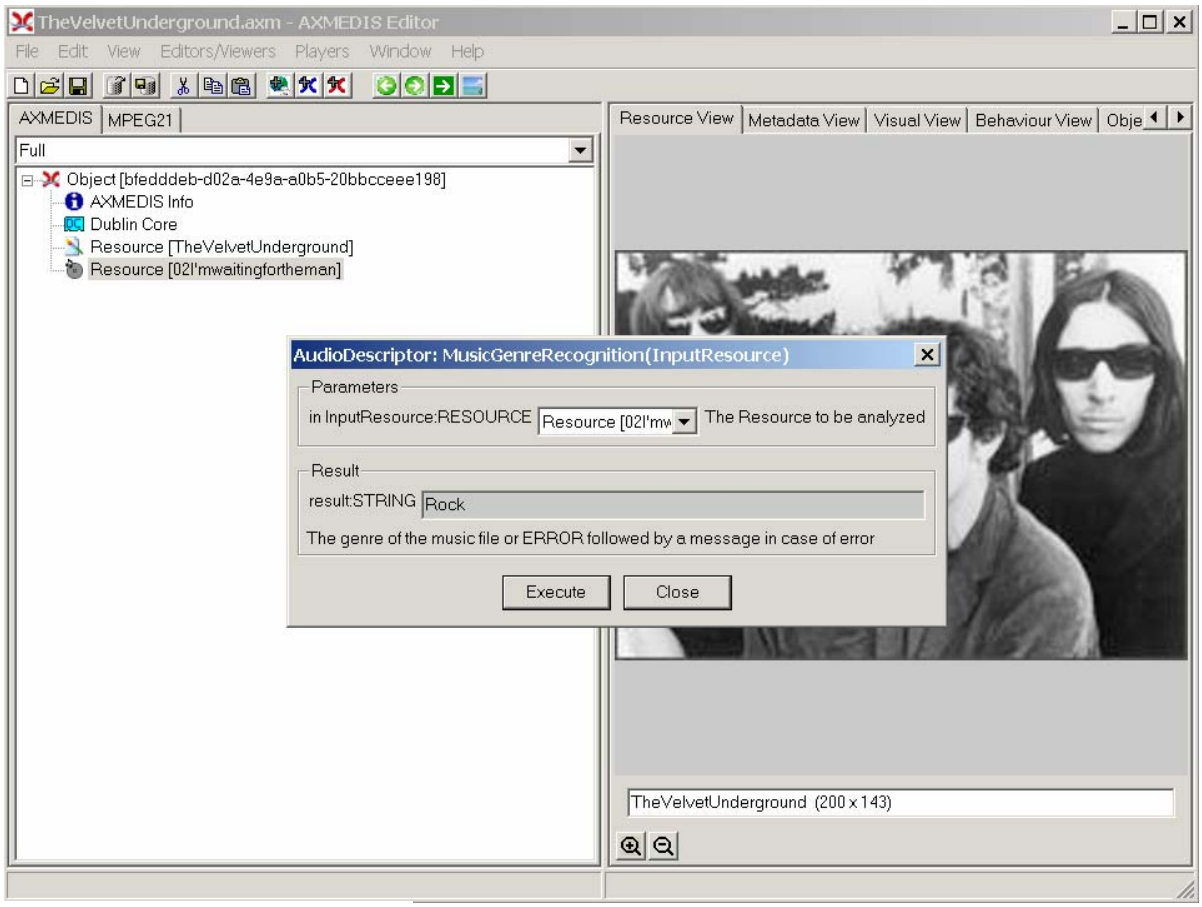
The plug-in must be applied on an audio resource of an AXMEDIS object. The adaptation plug-in is called by right-clicking on the interesting resource and selecting the ‘Plugin…’ command:



A window showing the functionalities available for the kind of resource selected appears:



The Music Genre recognizer is called by selecting the **AudioDescriptor: MusicGenreRecognition** function. A new window appears showing the interface to the music genre recognizer (see below). In the current implementation, the result of the recognition is displayed in the **Result** part of the graphical interface. In future implementation, an MPEG-7 compliant description of the audio segment along with its genre label will be produced and saved in the AXMEDIS object to allow for intelligent retrieval of audio files.



1. Low-Level Audio Descriptors

By Low-Level Audio Descriptors (LLDs), we refer here to simple and low complexity descriptors that can be extracted automatically from the audio data in a systematic way and that represent audio signals in an objective manner.

Such descriptors are purely morphologic i.e. they do not carry any information on the actual meaning of the source or in other words they do not have a direct mapping to a high-level human percept. On the contrary, LLDs refer to the inner structural elements of the signal such as energies in some specific frequency bands or main spectral components etc.

Extraction of LLDs is crucial however since their combination (with automated learning techniques forexample) allows the building of higher-level descriptors i.e. descriptors which actually have a semantic or syntactic meaning for human users.

In the context of MPEG-7 [1], a standardization initiative of the Motion Picture Expert Group meant to describe multimedia content, a number of LLDs have been described. The following MPEG-7 LLDs have notably been implemented in the context of AXMEDIS:

- **AudioWaveform**: describes the audio waveform envelope, typically for display purpose.
- **AudioPower**: describes the temporally smoothed instantaneous power.
- **AudioSpectrumEnvelope**: describes the spectrum of the audio according to a logarithmic frequency scale.
- **AudioSpectrumCentroid**: describes the center of gravity of the log-frequency power spectrum.
- **AudioSpectrumSpread**: describes the second moment of the log-frequency power spectrum.

- **AudioSpectrumFlatness**: describes the flatness properties of the spectrum of an audio signal within a given number of frequency bands.

MPEG-7 also proposes a low-dimensional description of a spectrum obtained by projection on a reduced rank basis obtained by singular value decomposition. Mel-Frequency Cepstral Coefficients (MFCCs) describe the spectral shape of an audio signal in a similar way and have been widely used in the contexts of speech recognition [2] and music information retrieval [3]. Recent experiments [4] seem to demonstrate that MFCCs yield similar or even better results than MPEG-7 spectrum projection in a variety of applications. Consequently, we choose to implement MFCCs rather than MPEG-7 spectrum projections since the former are simpler to extract than the latter. As a side product of MFCCs extraction, the spectrum according to the Mel scale is evaluated. The Mel scale is a perceptually relevant scale of pitches, which is slightly different from the logarithmic scale used in the MPEG-7 **AudioSpectrumEnvelope** descriptor.

[1] MPEG-7, "Information Technology – Multimedia Content Description Interface – Part 4: Audio", ISO/IEC JTC 1/SC29, ISO/IEC FDIS 15938-4:2002, 2002.
[1] [2] L. Rabiner, B.H. Juang, "Fundamentals of speech recognition", Englewood Cliffs, NJ, Prentice-Hall, 1993.
[2] [3] B. Logan, "Mel Frequency Cepstral Coefficients for Music Modeling", in International Symposium on Music Information Retrieval, 2000.
[4] H. Kim, T. Sikora, "Comparison of MPEG-7 Audio Spectrum Projection Features and MFCC Applied to Speaker Recognition, Sound Classification and Audio Segmentation", in Proc. of IEEE Int. Conf. on Acoustics, Speech and Signal Processing, Montreal, Canada, 2004.

2. Audio Files Segmentation

Audio segmentation consists in segmenting a continuous audio stream in terms of acoustically homogeneous regions (the definition of homogeneity of regions actually depends on the task considered). Segmentation plays an important role in the pre-processing stages of analysis systems since it allows using descriptors extraction algorithms dedicated to specific audio segments and consequently allows improving transcription accuracy. Moreover, segmentation is useful in itself for indexing and browsing audio documents. For example, it allows navigating efficiently in large multimedia documents such as recorded radio web cast or movies.

The semantic regions we want to identify at first reflect the basic physical structure of the audio file and are the following:

1. Silence
2. Spoken content
3. Music content
4. Other noises

The segmentation process is as follow. Firstly the signal is parameterized locally in terms LLDs. The LLDs considered here are MFCCs, which give a good description of timbre and the modulation of the spectrum envelope around 4 Hz and 2 Hz, which corresponds respectively to typical rates of human speech and music. Low order statistics of these LLDs are computed over 250 milliseconds windows to diminish their variability.

To each window is associated an estimation of the probability of belonging to each of the 4 considered classes. This probability is obtained by feeding the low order statistics of LLDs to a Support Vector Machine (SVM) previously trained in a supervised manner. SVMs are highly efficient classifiers based on the structure risk minimization inductive principle and non-linear projection into high-dimension feature spaces. For more details, please refer to some authoritative literature [1].

Once class conditional posterior probabilities estimated for each window, a segmentation of the file is obtained by using the Viterbi algorithm to find the best possible state sequence, which could have emitted this observation sequence, according to the maximum likelihood criterion. This algorithm is similar to a 4 state fully connected Hidden Markov Model [2] with state posterior probabilities being estimated with SVMs. The state transition probabilities are set manually to favor staying in the same class for a minimum duration. The initial probabilities are also set manually to make classes equally likely at the beginning of the stream.

[3] [1] C. Burges, "A Tutorial on Support Vector Machines for Pattern Recognition", in Data Mining and Knowledge Discovery, 2(2): 121-167, 1998.
[2] L.R. Rabiner, "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", in Proc. of the IEEE, vol. 37, no. 2, pp. 257-86, 1989.

3. Music Genre Recognition

Musical genres are categories that have arisen through a complex interplay of cultures, artists and market forces to characterize similarities between musicians or compositions. Though they may represent a simplification of one artist's musical discourse, they are crucial descriptors of music content since they have been widely used for years to organize music catalogues, libraries and music stores.

At the same time, even if terms such as *jazz*, *rock* or *pop* are widely used, they often remain loosely defined so that the problem of automatic genre classification becomes a non-trivial task. A lot of researchers have focused their attention in the recent years on this classification problem (see [1] for a review) and an evaluation of music genres classification algorithms has even been conducted at the Music Information Retrieval Evaluation exchange 2005 (MIREX 2005: http://www.music-ir.org/mirex2005) on 2 databases of audio files (one composed of 1515 songs over 10 genres and the other of 1414 songs over 6 genres).

The music genre classification algorithm implemented in the AXMEDIS framework achieved 74.99% normalized classification accuracy on the MIREX 2005 datasets (14 algorithms were evaluated with accuracies between 77.98% and 51.83%). Here follows a brief overview of this algorithm. For a more complete presentation, please refer to [2].

Three different sets of LLDs characterizing audio content are considered to determine genre: timbral features (MFCCs), intensity features (notably log compressed energies in different frequency bands) and some rhythmic features (extracted from the periodicity function used to estimate tempo; see section 15.4). Low order statistics of these LLDs are computed over 1 second window to diminish their variability.

For each texture window, a local decision about the music genre is evaluated. The local decision is given by independent SVMs specialized on the different LLDs sets. These SVMs receive as input the information features of the texture window plus those of the surrounding windows to provide for contextual. A single decision is obtained for the considered music excerpt by averaging the outputs of each SVM over time.

[4] [1] N. Scaringella, G. Zoia, D. Mlynek, "Automatic Genre Classification of Music Content: A Survey", in IEEE Signal Processing Magazine: Special Issue on Semantic Retrieval of Multimedia, vol. 23, no. 2, pp. 133-141, March, 2006.
[2] N. Scaringella, D. Mlynek, "A Mixture of Support Vector Machines for Audio Classification", Music Information Retrieval Evaluation exchange, 2005 [Online]. Avalaible: http://www.music-ir.org/evaluation/mirex-results/audio-genre/scaringella.pdf.

4. Rhythm Description

A precise definition of musical rhythm does not exist. Most authors converge on the idea of *temporal regularity*. As a matter of fact, the perceived regularity is distinctive of rhythm and distinguishes it from *non-rhythm*. Extracting rhythmic information from music signals allows retrieving rhythmically similar items and can facilitate synchronisation between audio signals or audio and video for example.

A review of automatic rhythm description systems may be found in [1]. These automatic systems may be oriented towards different applications dedicated to rhythm: tempo induction, beat tracking, meter induction, quantization of performed rhythm, or characterization of intentional timing deviations.

The simplest and probably most important descriptor of musical rhythm is certainly tempo. It is indeed correlated to the perceived *speed* of a song and consequently makes sense to any listener. Moreover, it seems also correlated with the perceived intensity of a song, which can be loosely defined as the subjective impression of energy that music titles convey (see [2]).

The tempo induction algorithm implemented in the AXMEDIS framework was proposed by Klapuri *et al.* in [3]. This algorithm won the tempo induction algorithm contest held as part of the International Symposium on Music Information Retrieval (ISMIR) in 2004 [4] with an overall accuracy of 76.15% on 3199 test samples (12 algorithms were evaluated with accuracies between 76.15% and 39.95%). We provide here a brief overview of this algorithm.

In a first step, a time frequency analysis of the audio signal is performed. In our implementation, this analysis is done using the **AudioSpectrumEnvelope** LLD (see section 15.2). From this representation, a measure of the degree of musical accentuation as a function of time is evaluated at 4 different frequency ranges. Periodicities of these musical accentuation functions are analyzed thanks to a bank of comb filter resonators and combined into a single periodicity function. A probabilistic model including prior knowledge of musical meter and taking into account the temporal dependencies between successive estimates is used in a final step to do successive estimation of tempo along time.

The same algorithm can be used to estimate musical bars length. The ratio of the bar length and the musical beats period (which is inversely proportional to the tempo) allows estimating if the meter of the piece is binary or ternary.

[5] [1] F. Gouyon, S. Dixon, “A review of automatic rhythm description system”, in Computer Music Journal, vol. 29, pp. 34-54, 2005.
[6] [2] A. Zils, F. Pachet, “Extracting automatically the perceived intensity of music titles”, in Proc. of the 6th Int. Conf. on Digital Audio Effects (DAFX-03), London, UK, September 8-11, 2003.
[7] [3] A. Klapuri, A. Eronen, J. Astola, “Analysis of the Meter of Acoustic Musical Signals”, in IEEE Transactions on Speech and Audio Processing, Vol. 14(1), 2006.
[4] F. Gouyon, A. Klapuri, S. Dixon, M. Alonso, G. Tzanetakis, C. Uhle, P. Cano, “An Experimental Comparison of Audio Tempo Induction Algorithms”, in IEEE Transactions on Speech and Audio Processing, Vol. 14(5), 2006.

7 Video Content Descriptors (FHGIGD)

7.1 State of the Art (completed)

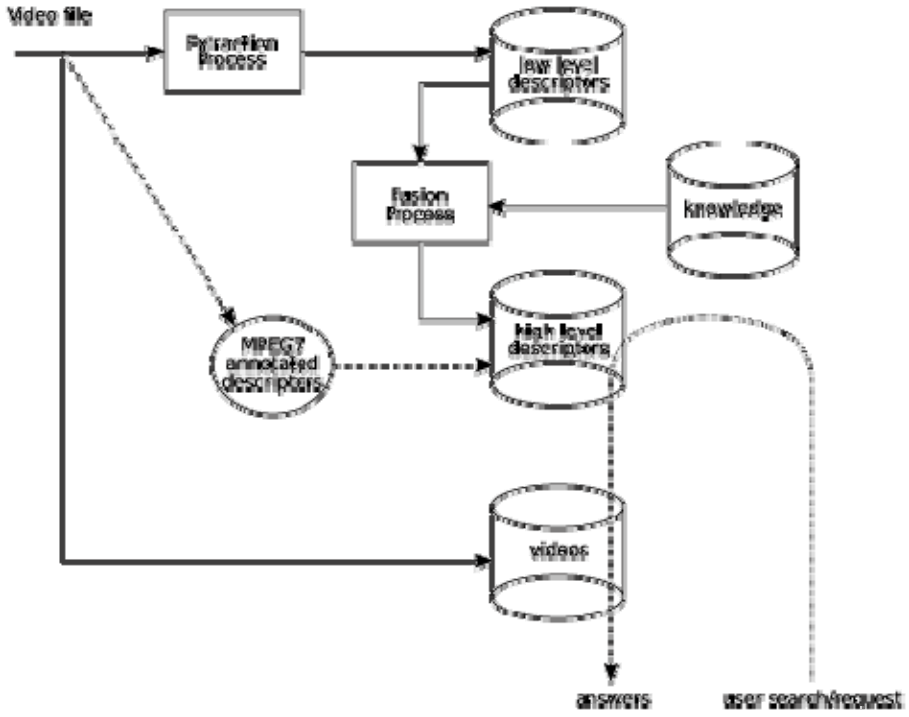
"An image is worth a thousand words", but video is a series of images, with sound in addition; therefore we should be able to collect a huge amount of metadata from the shortest video sequence. Linguistics-oriented considerations, like connotation and denotation are necessary in many cases. But we should remember that we can only achieve extraction of denoted semantics, and no connoted semantic (relative sense due to culture, context etc.), without a huge amount of knowledge and an appropriate artificial intelligence. It is well understood that the "weight" of the context, for example the cultural environment of the end user, can be decisive in the process of data indexing/storing/retrieving. A Video is an evolving 2-dimensional projection (evolving point of view, sequencing consists in cuts in the time-dimension) in a 4-dimensional physical environment with synchronised sound (1 dimension).

7.1.1 Structure of the extraction process

The structure of the extraction process is shown in the following figure. It can be seen that the low level descriptors are extracted from the video data. These low level descriptors can be combined with some kind of knowledge to result in high level descriptors – descriptors that are semantically meaning full for humans.

Examples for these high level descriptors are:

1. Voice recognition (who speaks) / extraction (what is said)
2. Music recognition (style) / extraction (notes)
3. Audio-video relations: global relations; local relations (explosions...)
4. face position, face recognition
5. Text extraction
6. events extraction (flashs...)



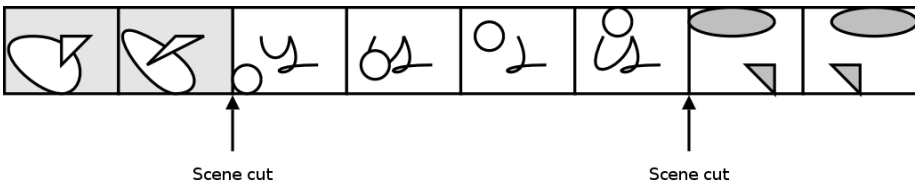
Low level descriptors are not semantically meaningful for humans. They can be calculated from

- inter-frame information, e.g. clip detection, moving blocks, …
- intra-frame information, e.g. dominant colours, textures, …

7.1.2 Low-level descriptors: Interframe (completed)

These descriptors are computed from the differences between frames, or from series of consecutive frames.

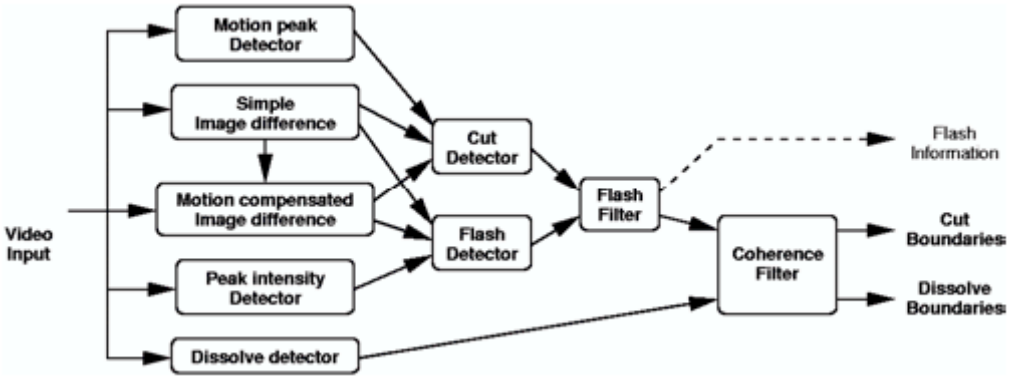
Scene Cut detection/sequencing/shot boundary detection/video parsing



Videos are mostly concatenations of different scenes, shot at various places or moments; scenes are the base elements of videos. Instead of processing the whole video, it can be cut into sequences, which have more or less a special content/meaning/interest at a semantic point of view. The descriptor is mainly a list of pointers to the detected scene cuts; statistics on length of scenes can be done.

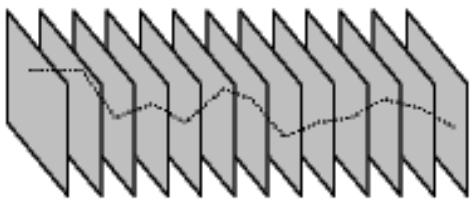
Comparison between consecutive frames can lead to false positives for cut detection (flashes, bad encoding, source chemical film degradation), therefore series of frames must be examined, corrections made to images, thresholding etc. in order to eliminate these artefacts. Moreover, a lot of inter-scenes are not pure cuts but transitions (like cross-fades, sweeps etc.) and more elaborate processes are necessary.

In [4]: The process has to find video sequence boundaries with (times-tamp, type of transition). They use the "CLIPS-IMAG shot segmentation system" to detect two types of transition effects: "cuts" and "dissolves" (including fades in and out) It detects cut transitions by direct images comparison after motion compensation and dissolve transitions by comparing the norms of the first and second temporal derivates of the images. It eliminates some artefacts thanks to a special module which detects photographic flashes and a special module consisting of a motion peak detector.



In [3]: evolution of grey-level centroids over time. They discuss about a relation between audio and visual signature. They show that audio-visual signature is more robust than video-only signature and permit better detection of video clips of shorter duration (about 2 seconds).

As they say, the video clip detection principle is the same for the audio, video or audio-visual signature. Over M frames, each of which an 8-dimensional vector is the signature, a distance is computed, on which an adaptive threshold is applied, function of the mean and standard deviation of the distance curve. They have chosen the grey level centroid as a visual signature, coordinates of which are computed as the weighted (by the grey value) sum of the pixel positions. This signature is valuable for a series of successive frames and characterizes spatio-temporal features. A single centroid can be insufficient, and applying it on sub-images like the four quarters is a good compromise. Then, an amplification of the centroids' movements can be done by biasing the computation toward brighter areas. The signature's uniqueness is not certain but is a consequence of the complexity of the signature.

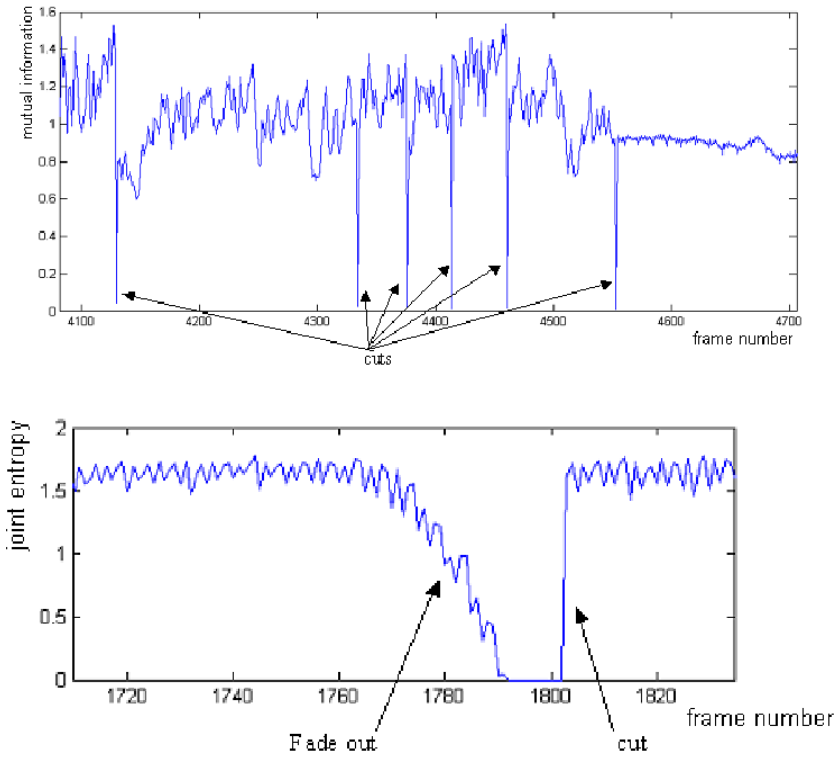


Note: this could build a video sequence signature, which could be useful in identifying sequences. It is very robust to very high compression ratio, with exactly the same results.

Others like [33] are based on the concept of continuity, extract scene boundaries. Uses the concepts of visual, position, camera focal distance, motion, audio and semantic continuity to group shots that exhibit some form of continuity into scenes. The TMR method (Chua et al 2000) filters commercials (Koh & Chua (2000)).

In [21] the detection and classification is based on dissolved video sequences. Multi-resolution of temporal slices extracted from 3D image volume.

The method proposed in [22] considers joint entropy between frames. CLIPS [19] experiments in Video Retrieval direct image comparison after motion compensation and "dissolve" transitions, comparing the norms of the first and second temporal derivates of the images. In [7] a quite simple cut detection algorithm is described. IRISA (http://www.irisa.fr/vista/Themes/Logiciel/MdShots/MdShots.english.html) proposed table of markers, each of which indicates a timestamp and a type of transition. It might also contain the duration of the transition.



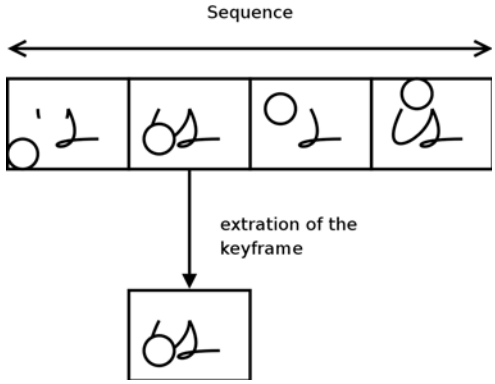
Visual perturbance

The visual perturbance characterises the amplitude of the motions inside a scene, at a global point of view, and over time. It is quite robust to different encodings of the same content and presents some semantic interest, possibly to classify the genre of a sequence, make searches, extract a (some) key frame(s). The descriptor is a couple of values evolving over time, corresponding to vertical and horizontal-direction perturbance.

Key framing - Extraction of a (the most) representative

For each sequence one or multiple frame can be chosen in order to be representative of the whole semantic content. It can be used for browsing in movies (iconographic overview), and also for some content extraction

(which is quite limitative because this frame has no duration extend), or in order to recognize duplicates scenes in different movies.



In each sequence, the process extracts one or multiple frame which is/are identified as representative to the whole sequence. It could reveal unsuitable for identification of similar contents in case of low robustness. A simple and non-robust way to make this is to select the first frame of every scene; but it doesn't truly represent the real content of the scene, because of transitions, of complex action etc.

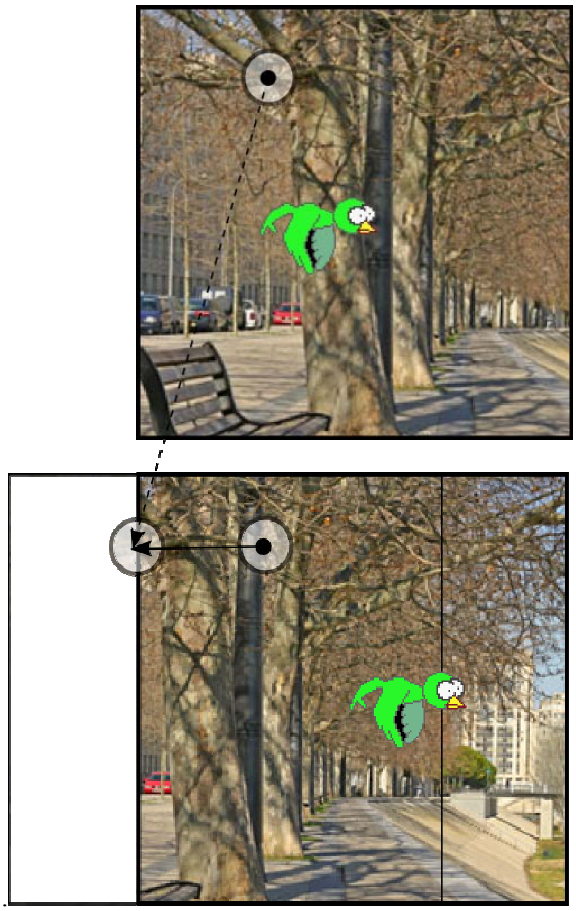
In [7] the Vitamin framework (a video content indexing system) is introduced: key frame detection, key frame signature extraction and key frame elimination technique, using DCT coefficients. The signature is build upon the DC and highest values of the AC coefficients of the MPEG or JPEG macro blocks. It acts at the middle of the compression/decompression process, making it available for real-time applications.

For key frame extraction, it assumes that first frame of a sequence is a key frame, and the first frame of a mostly static set of frames is a key frame; then it eliminates the repetitive and some meaningless frames (like a dialogue or black or unicolor screens). The robustness of this method is not proven.

The descriptor is a marker made of the timestamp of the key frame (or each key frame) and a pointer to the sequence (like a couple of sequence boundaries - i.e. detected transitions).

Background motion tracking & background extraction

When the video camera changes its viewing angle (for instance in order to make a panorama or to follow actors in a scene), the background acts like more or less like a still image translating and/or rotating, while some objects in the middle of the frame move.

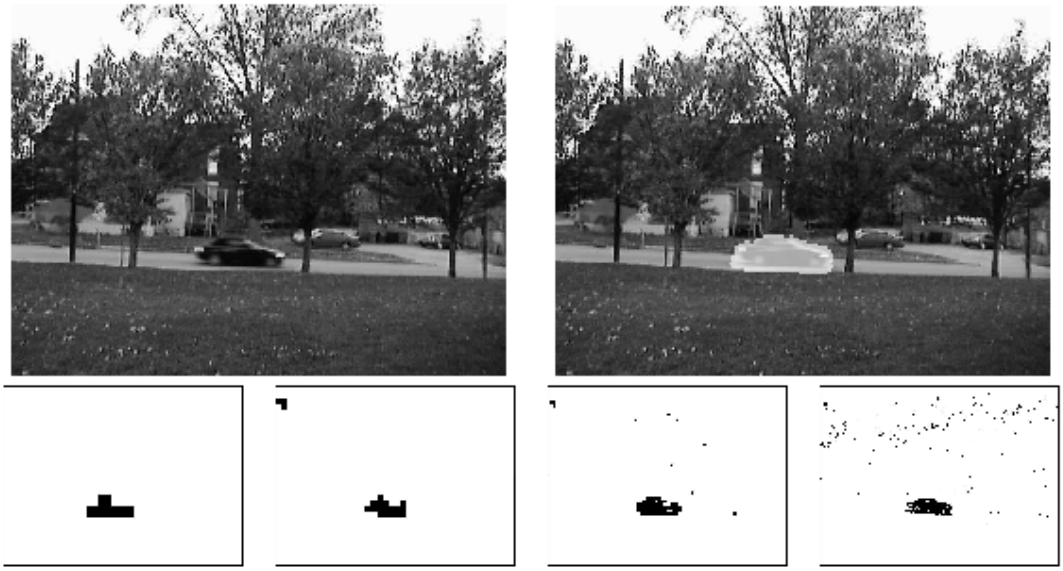


The background can reveal quite representative of the semantic surrounding of a scene (environment recognition/classification), while the camera motion can act like a perturbance value. It is quite robust to different encodings of the same content, and statistics over the camera movements can be useful for semantic identification and recognition of same content.

Reconstruct the motion of the background part of the sequence while eliminating objects of the foreground; possibly reconstruct the large background image. Lens deformations can perturb this process.

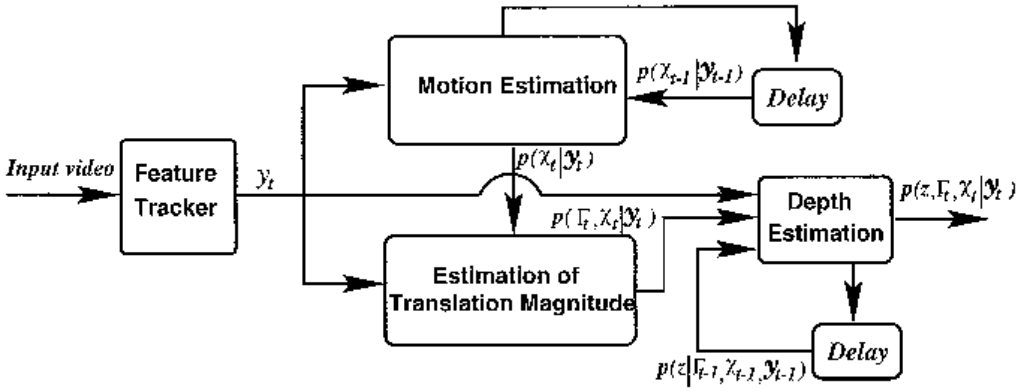
There are frameworks which work on still background, others which work on non-still backgrounds (in relief); the latter produces a 3-D reconstruction of the background and a detection of moving objects.

In [34] the frame work is based on background/foreground segmentation, construction of filters on sub-images, construction of a background model, multi-resolution approach. For each pixel and each resolution, spatial variation is calculated, in order to classify it. A hierarchical tree visit is made on the titles from the low resolution to higher resolution, in order to classify the block/have a more precise idea of the composition of the block. It has been well tested for diverse application purposes, false positives 8-12 % which is rather small.



The method proposed in [27] is based on random sampling, in order to obtain camera motion structure and scene structure (recover 3D from 2D). It is a relatively high-level process. There is a proposed framework with possible ameliorations.

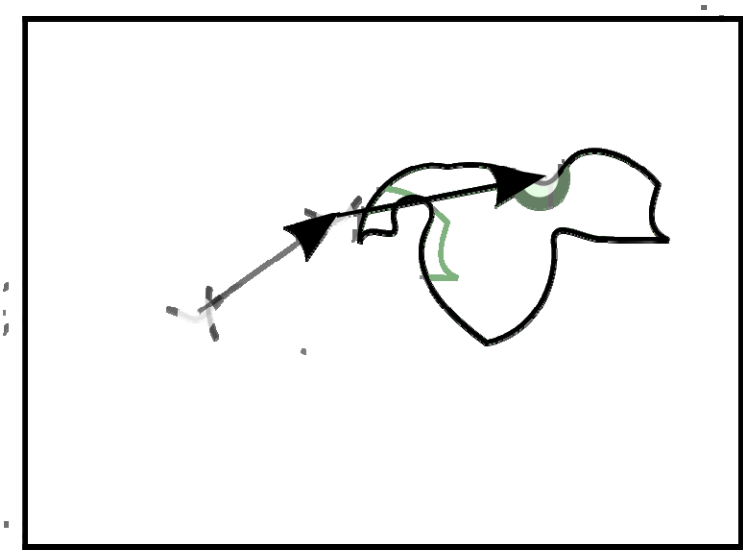
In [11] a method is proposed that permits to recover scene 3-D structure, moving objects (only linearly), and random camera motion. There is no evaluation of their results which seem qualitatively quite acceptable.



Tensor voting based tracking is proposed in [14]; but it uses multiple stationary cameras, therefore it is bad within AXMEDIS. It needs motion blobs: background model with statistical techniques. The applicability depends on purposes (video surveillance etc.), but it seems to be applicable to a too tight domain. Other methods are presented in [32] or [6].

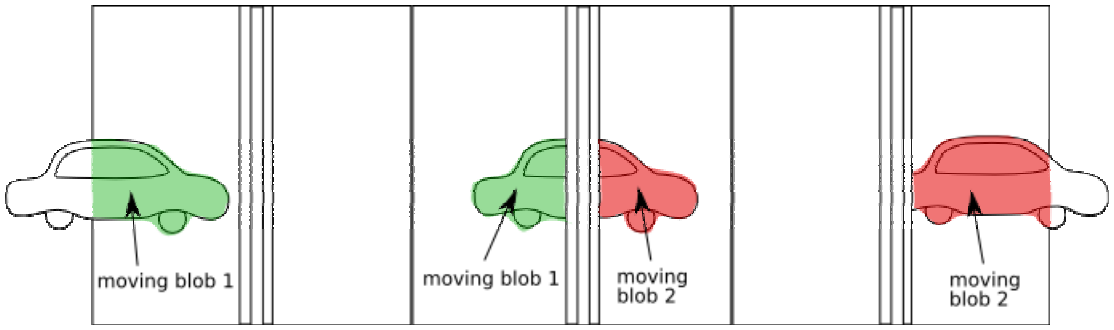
Block shape and motion tracking

Some portions ("blobs") of the image can move over the background. These blobs can have their shape and motion extracted.



At a semantic point of view, the shape, the dimension, the trajectory and relations between objects are meaningful. Statistics on size/movements and some high-level semantic purpose can use it, for instance for identifying the genre of a video film or following players in a sport video film.

An unsolved issue is the overlapping of objects: one object can overlap another object, making the former object totally disappear, at a computer point of view; then a new one (and one) appears. Then, two different objects can be recognized when only one has been hidden.



The descriptor is a set of curves (one per "blob") moving over time.

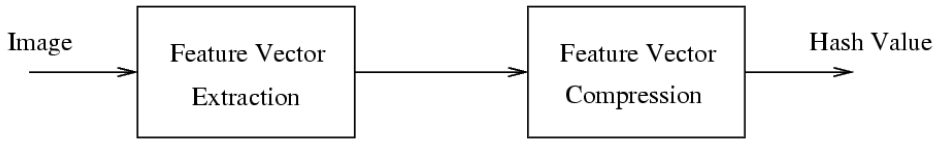
7.1.3 Video descriptors: Interframe/intraframe

These descriptors can be applied either between frames or in some specific frames.

Image/video hash value

It's a one-way process which outputs a number (a short bit stream) from an frame (an image). If two images are perceived identical at a visual point of view (that means that the binary data have slightly different values), the output hash value should be the same (whereas binary data hash functions will output totally different numbers for two different images). It can be associated with a robust key framing process or be done on each frame.

It aims at simplifying the recognition of duplicate frames/sequences for instance in an image database: only the perceptual hash values need to be compared. The method proposed in [13] splits the decomposition of the hash process into two stages: the feature vector extraction and the hashing of this vector.

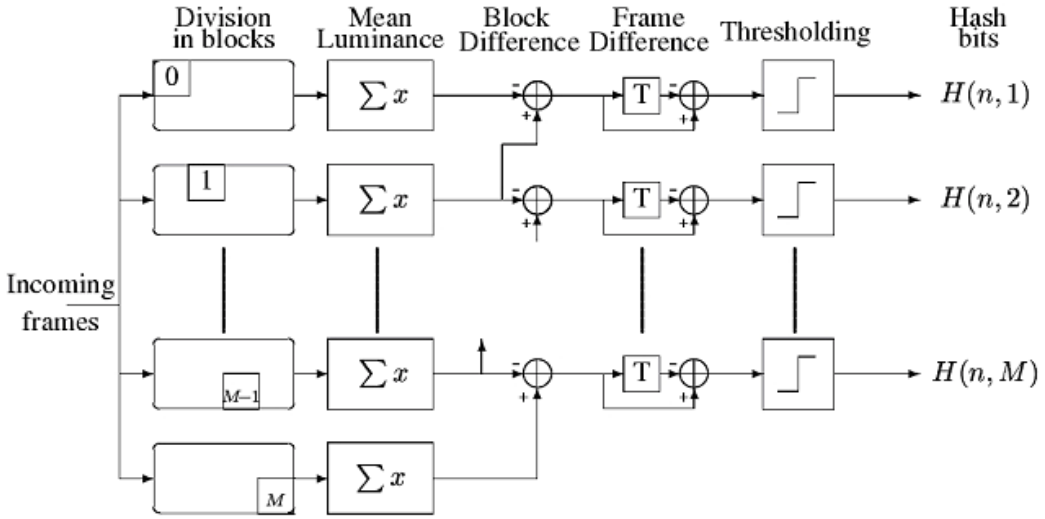


The features which can be extracted vary from filtering of the radon transform to extraction of feature points like used in watermarking or to statistics on sub bands of wavelet decomposition of parts of the image. Then, using a distributed coding method, it produces a hash value.

The experimental results seem quite good: few or no bit difference for most of the slight modifications of the image (1 degree rotation, scaling, flipping, 1% cropping, low pass filter, row/column deletion, linear transform), thus, being "robust", and bit difference between different images mostly around 50%. But too few statistics have been made on their results on order to verify the distribution of the number of bits in difference.

The separation into two stages raises an issue about the utility of the second part of the process: the vector extraction, if robust, would satisfy the application purposes in case only of detection of copy of an image in a database; the encoding of the vector is mostly necessary in order to prevent an attacker to make an image have the same vector as the vector he has already seen in a database. This latter condition is very tight in case of a close database. Anyway, it seems that later encryption (or hashing) of the extracted feature vector would lead to the same advantages as the ones of the process described above.

Monga et al. [2] present a clustering algorithm for the hashing of the feature vector. In [23] a robust video sequence hash process is presented, which is not any more a "hash" in the cryptographic sense because visual differences don't lead to half of the bits switched but to small changes.



It proposes a solution for finding the movie from which is extracted a sequence, out of a video database. It admits some bits in difference, but supposes that out of the 30 frames surrounding the moment of the movie for which we expect to find a duplicate in our movie database, there will be one (frame) which will have no bits in difference. Then, it tries to match the hash values of sequences found in the database and the current sequence; it evaluates the Hamming distance on the 30 frames, thresholds it and answers.

The authors in [30] say that global DCT is more robust to compression than wavelets and local block-based DCT. Descriptor Set of bits associated with a timestamp (frame pointer) or a block (group of frames) timestamp.

Image/video segmentation

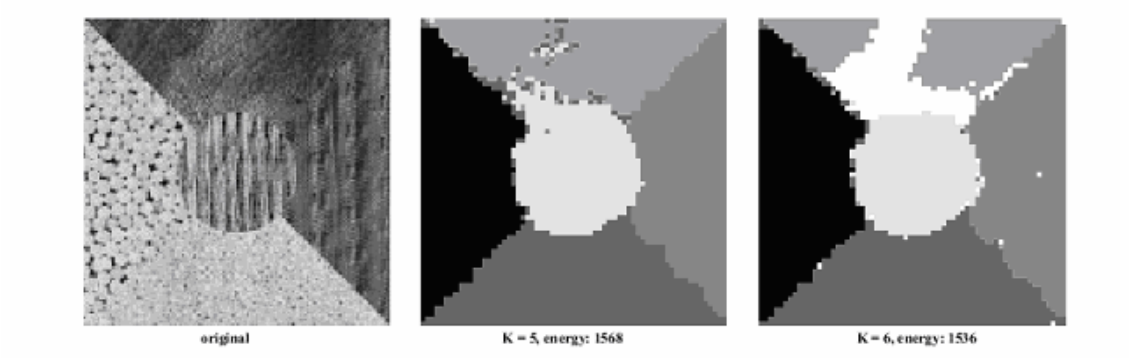
In each frame, the image is perceived by the human eye as segmented into regions with a certain unicity of colour, texture, etc. The image segmentation process identifies regions and contours in each image (or one image out of a certain number) or key frame, delimiting homogenous colour/texture areas, possibly their evolutions through the video sequence.

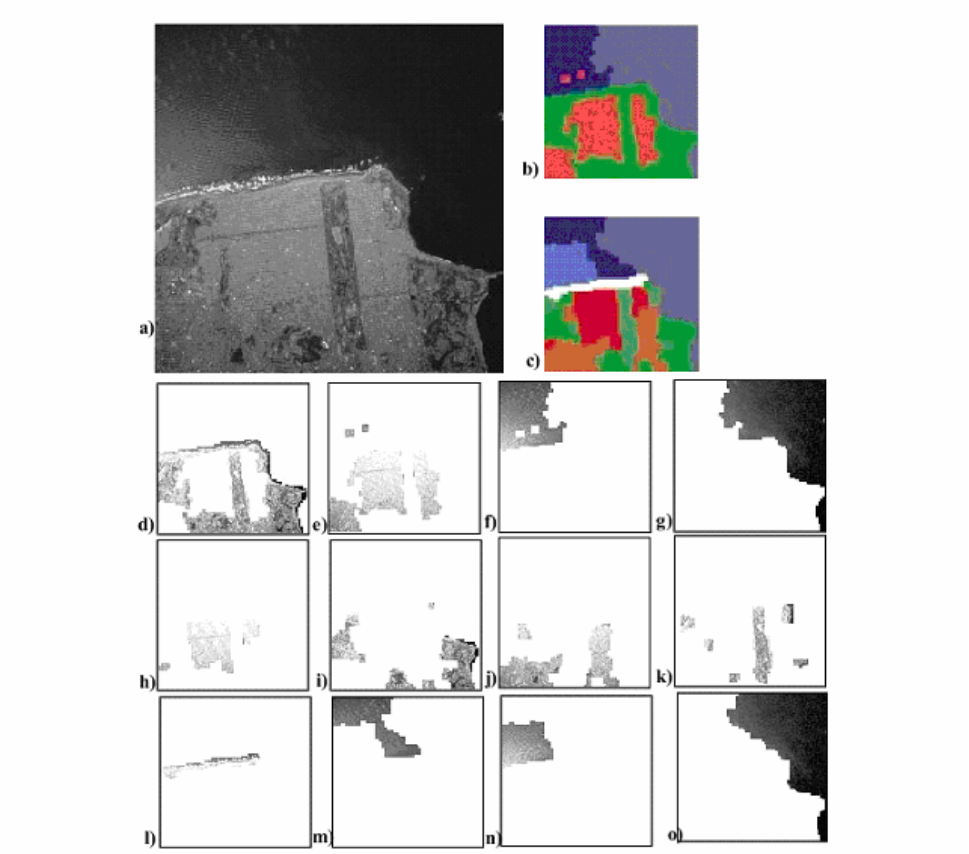
Give the shape of objects or sub-objects and their content (colour/texture) characteristics in order to make statistics or allow searches in a database of these shapes and/or colour/texture characteristics

How to "optimally partition an image into homogeneous regions" [26]. It has been well-tested on still image. What is more undetermined is when it is evolving over time; succeed in recognising moving contours of same-content zones, while the content characteristics are evolving.

In [16] geodesic active contours and edge flow segmentation are used for a semi-automated segmentation method. It works on intensity, colour, and texture features. An initial contour is deformed towards the object boundary (see also [17] and [18]). The method proposed in [5] is quite old and uses mean shift algorithm.

In [26] texture segmentation (quite old: 1998) "unsupervised segmentation" is proposed. It says that a general vector space approach has huge drawbacks because the used metric is adapted to a too small population of image content. They use instead non-parametric statistical tests, which they find reliable to measure local texture similarities. The method proposed in [29] is based on Gabor decomposition, vector space approach, and auto classification.





Further algorithms based on segmentation can be found in [15], [28] and [26]

Texture hash value

A texture hash method is a one-way process which outputs a more or less unique number from a texture in a certain area of an image. It is very similar to the image segmentation and the image hash function processes. It can be used to recognise some elements appearing in different scenes. Depending on the process, we can extract two types of

- Intra frame (still shape): key frame pointer, shape, texture hash value
- Inter frame (evolving shape): sequence pointer, shape evolving over time, texture hash value

7.1.4 Video descriptors: Intraframe

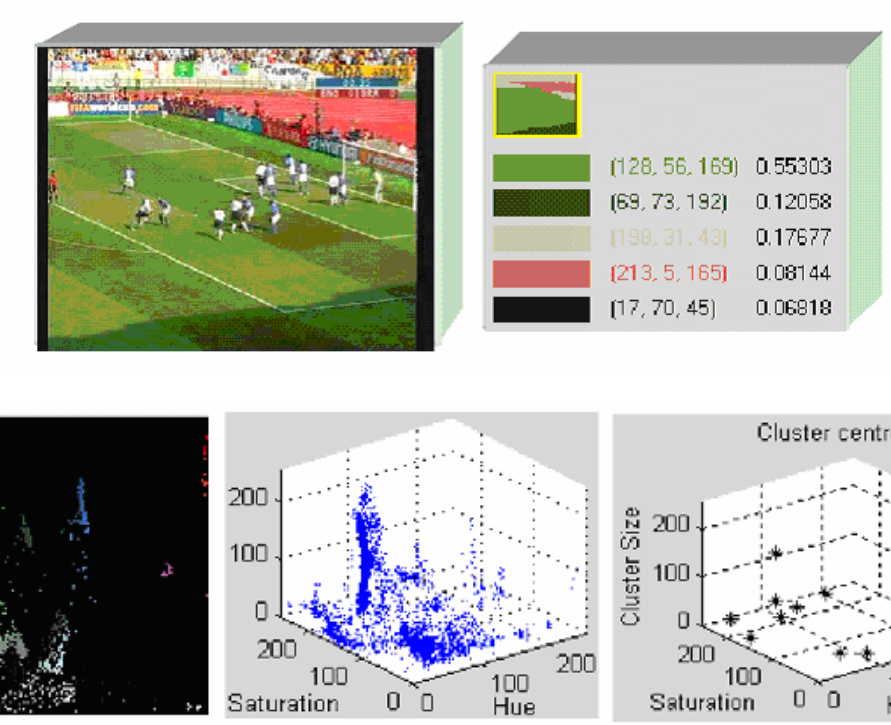
These descriptors are computed from a single frame.

Colour space

The first, second and third colour moments of spatial sub regions of the video sequence can be extracted and computed, the colour quantization of the container can also be extracted. Their histogram and evolution along time give some semantic information about the content (for classification etc.) The robustness of the histogram and its spatio-temporal evolution is quite relative: it is not robust to analog copies, some types of re-encodings, but it is robust to scaling and rotation of the video, and content variations like slightly different points of view, and some occlusions (see also [8]).

In [8] the authors say that the histogram is not robust and effective for colour characterization (e.g. dominant colour) in large video databases, because of the lack of context and spatial information. It presents

nonparametric colour characterisation model (NCCM) using mean shift procedure, with an emphasis on spatio-temporal consistency. The process selects the mean colour sets of a sequence (thanks to a good colour mode seeking function), through consecutive frames, and computes their extend over the screen.



Some specific applications of this process (e.g. detection of a tennis court scene in a sport sequence) have very good results (e.g. recall 98.7%, precision 97.2%). The process is quite fast and permits (more than) real-time applications.

7.2 Problems (completed)

The problems of the individual low-level descriptors are identified and described in the previous section 'state of the art' in the description of the individual low-level descriptors.

Besides the problems described in the previous section of the individual low-level descriptors, one general problem can be identified: High-level descriptors are only available for specific types of video sequences or specific scenarios. For example for the surveillance of high ways the position of the cars and lorries can be extracted.

7.3 Work Performed

- Analysis state of the art: The state of the art has been analysed. The focus was on low-level descriptors and existing frameworks. Existing frameworks suggest the combination of different descriptors. Depending on the descriptor the corresponding database has to be designed.

- Evaluation criteria have been identified. Different methods for benchmarking and evaluating video descriptors and their extraction algorithms have been published. These methods have been analysed and an evaluation scheme suitable for AXMEDIS was identified.

- The direct result of the state of the art analysis and the identified evaluation criteria was the pre-selection of suitable video descriptors.

- The available MPEG-7 descriptors in the XIM reference implementation [36] have been investigated. Suitable algorithms for video description that are suitable for integration into the AXMEDIS framework have been identified.

- Integration of the XIM reference implementation of the GoF/GoP Color Descriptor.

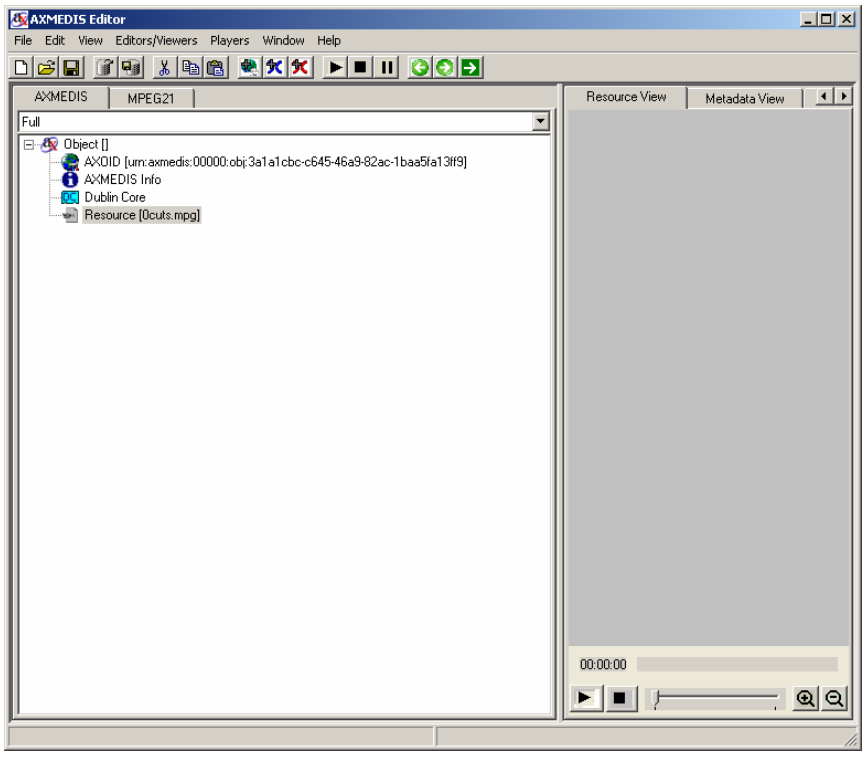
7.4 GoF/GoP Color Descriptor

This library implements the GoF/GoP Color descriptor, which is used to describe the colour characteristics of a collection of video frames (and a collection of images), consists of one primary and four secondary attributes. Since the feature vector is short, a simple absolute distance or squared distance criterion can be set for matching.

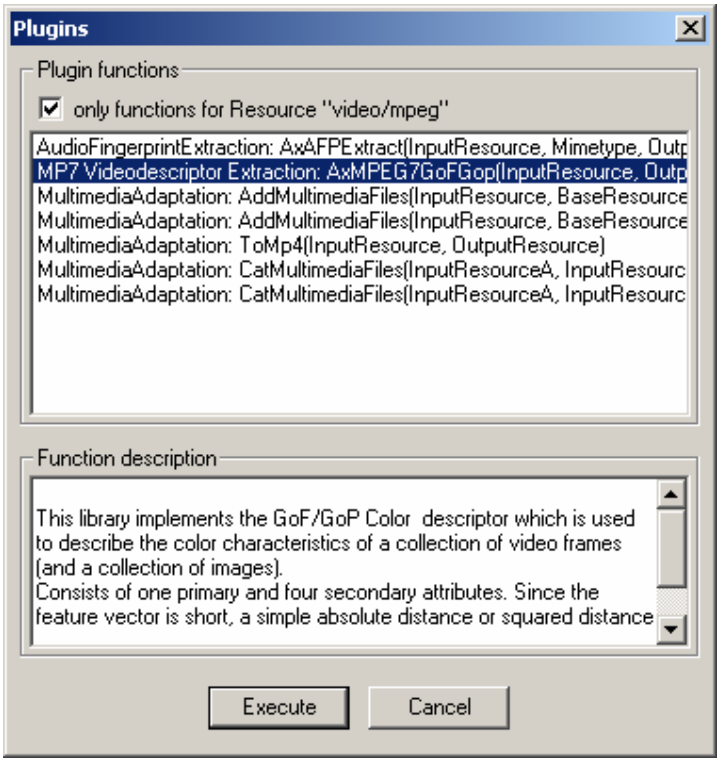
Technique	GoF/GoP Color Descriptor
Document	MPEG-7 Visual XM and CD, see GoF/GoP Color
Name	Santhana Krishnamachari, Mufit Ferman
Contact	santhana.krishnamachari@philips.com
Type	Application
External Libraries	None
Related	Ds/DSs Scalable Color, Video Segment DS, Collection DS
Used Ds	/DSs Scalable Color
Input	Video, Image
Extraction	Yes
Client Appl	Search & Retrieval
Strong Points	None.
Limitations	Use mean or median aggregation for matching
Known Problems	None.
Parameters	None.

The plug-in can be applied to video MPEG resources, provided this was declared in the mime type attribute of the resource. The output is a XML file containing the descriptor data.

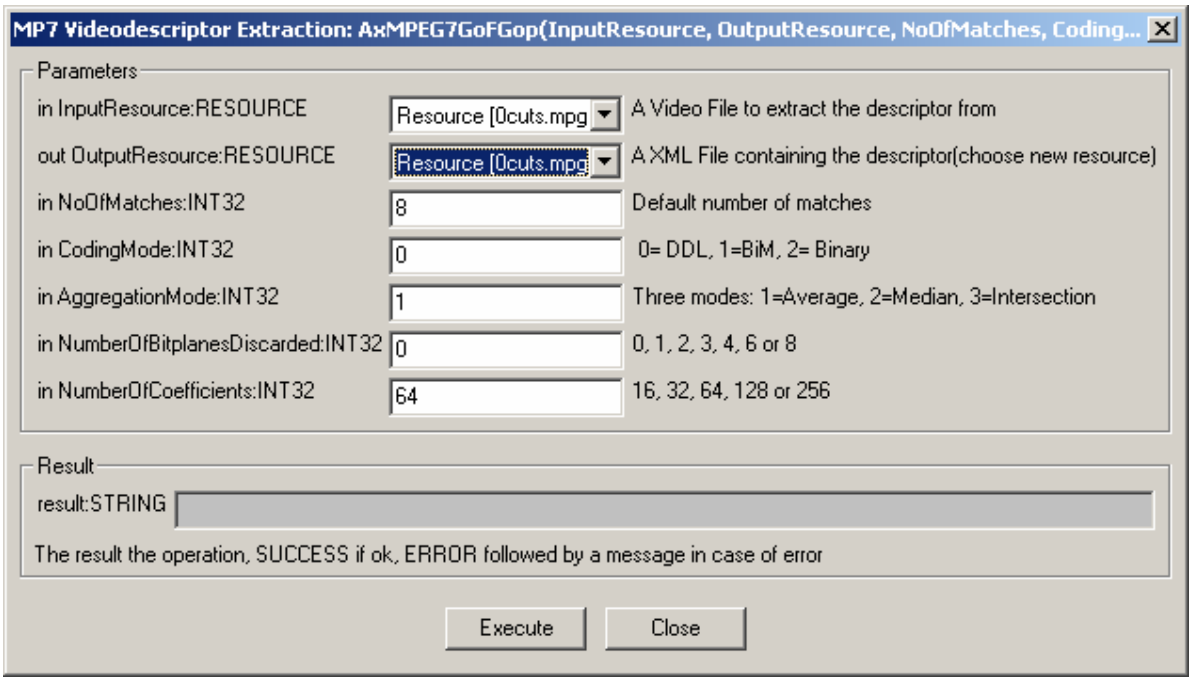
Create a new AXMEDIS object and add a MPEG file as a embedded resource by right clicking on the new created object.



Right click on the MPEG resource and select ‘Content Processing Plug-ins’

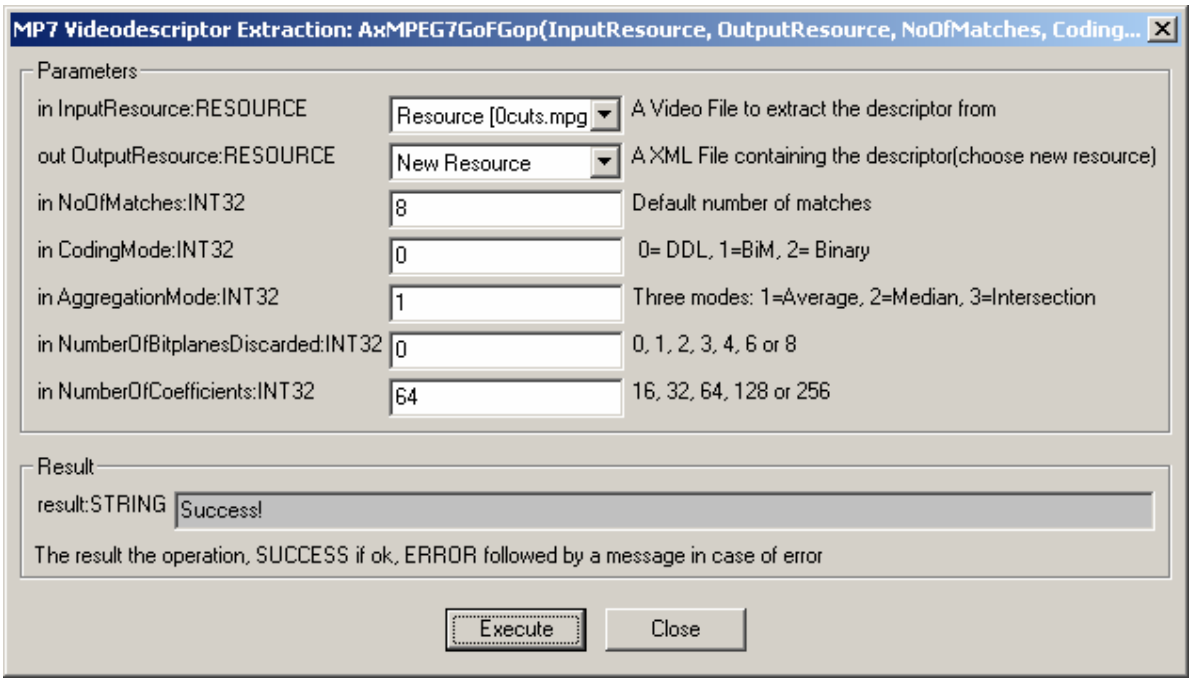


In the upcoming menu select ‘MP7 Videodescriptor Extraction: AxMPEG7GoFGop’. Press “Execute”and the following window should appear:

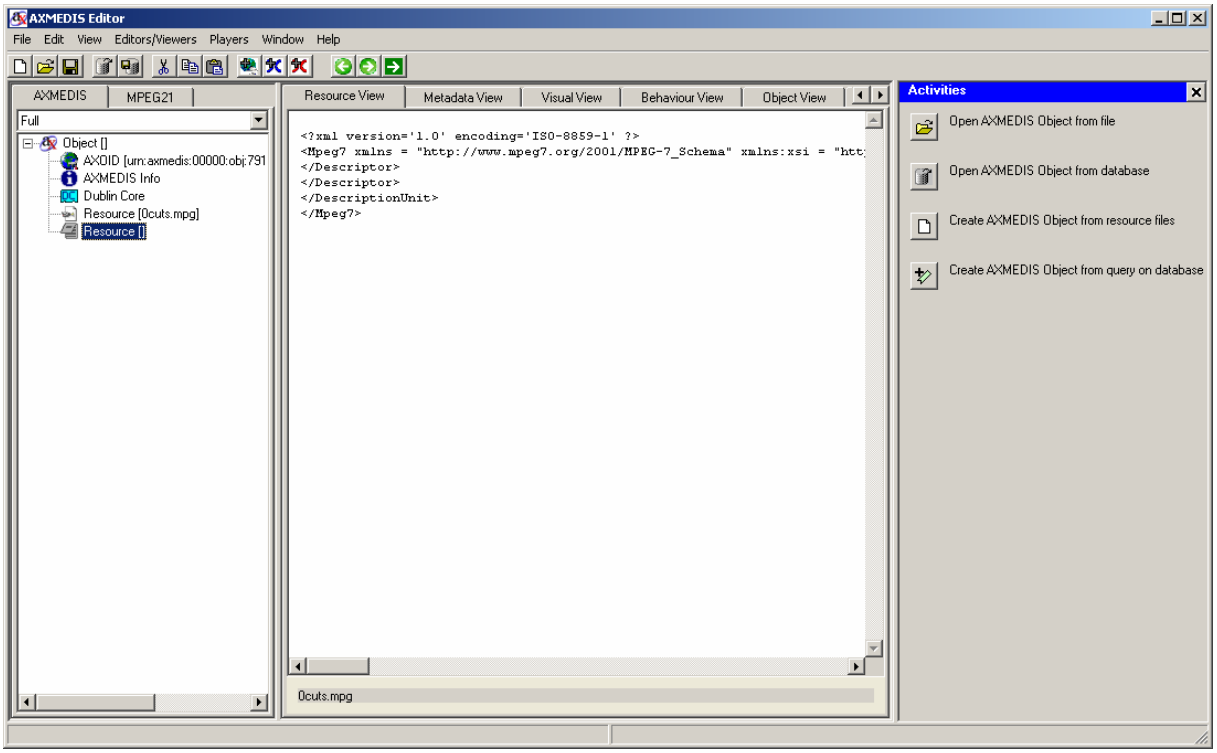


.

The preset configuration should be optimal for most use cases. Choose as the output a new resource and click "Execute". A console window will appear and stay for a few seconds. This is normal due to the nature of the used original Extraction module.



After receiving the "success"-message, close the window and you should have a text resource in the AXEditor containing the XML descriptor data. It is advised to edit the objects properties and add the original resource filename



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8 Text Documents Content Descriptors (DIPITA) (completed)

High-level metadata are needed for enhanced document retrieval in a multimedia environment. Information about the keywords and the domain of a document allows advanced searches within the collection of documents, improving the standard information retrieval techniques with a set of descriptors which represent the contents.

The procedure outlined in this section aims to exploit current resources and tools and to produce an integrated architecture for keyword (and domain) extraction. In this perspective, it is important to point out the need for an open-domain extraction technique, i.e. a technique that is not restricted to a specific type of document. A further task to be taken into account is the multilingual environment of the repositories. This is relevant in multimedia that may comprise all kinds of contents in many languages.

The proposed system tries to respond to both requirements, integrating the process of keyword extraction with multilingual resources which allow the treatment of documents written in different languages (covering English, French, German, Italian, and Spanish), regardless of their domain and typology.

8.1 State of the Art

Previous experiences of keyword detection procedures pointed out two main strategies, that have been merged in various ways according to practical needs: (a) the use of statistical-based technologies; (b) the use of linguistic-driven tools and databases.

The statistical-based technologies mostly rely on **statistical comparison** with a general corpus. For example, Salton [9] suggested the TF.IDF to capture the "weight" of a word in a collection of documents (using the words frequency of distribution). Other well-known proposed methods are Mutual Information (MI), by Church and Hanks [2]; log-likelihood measure, by Dunning [4]; χ^2 measure[1].

Exploiting the last of these measures, Matsuo [8] proposed a keyword extraction algorithm based on the statistical analysis of a single document, starting from words-association measures of co-occurrence in a given context (i.e. the period). Such a technique is particularly suitable for languages with a lack of resources (PoS taggers, referring corpora etc.), since it doesn't require any further tool but a simple stemmer.

In general, linguistic-driven techniques start to run after a first statistical analysis. For example, in Van der Plas et al. [13] there is a first stage of statistical analysis based on RFR (Relative Frequency Ratio) algorithm, and a second stage of semantic analysis, based on lexical databases such as WordNet (see below) or EDR (an electronic dictionary).

Within the JRC experience (see [12]; http://www.jrc.cec.eu.int/langtech/index.html) it was proposed to merge different methods in order to construct a two-stages architecture for keyword extraction in a multilingual environment. As a first step, the JRC method assigns to a given document an open-set of monolingual keywords, using a statistic method based on the log-likelihood algorithm. The monolingual keywords are then associated to domain-descriptors belonging to a restricted and pre-defined set, the EUROVOC thesaurus, "a multilingual thesaurus covering the fields in which the European Communities are active; it provides a means of indexing the documents in the documentation systems of the European institutions and of their users" (http://europa.eu.int/celex/eurovoc/). This parallel multilingual resource assures the translatability of the information extracted.

The IRC experience points out strategies that may also be significant in a multimedia environment, however the use of thesauruses cannot be maintained once the open-domain requirement is taken into account. The

[1] See Kilgarriff [6] and Chung [1] for the evaluation of the results achieved with different techniques.

following sections will outline three alternative algorithms needed to ensure metadata extraction in open-domains, combining statistic methods and available language resources and tools.

Proposal based on the state of the art

The principles of the three main algorithms (Algorithm A, Algorithm B, and Algorithm C) that will be used for keyword-extraction procedure are described as follows. The description consists of two parts:

1. Pre-processing: Step 1 – 3
2. Content Description/Meta data Extraction: Step 4 and following

To extract metadata and content descriptors, the following pre-processing steps has to be performed before extraction:

1. Conversion of the file from the given format to plain text format without representation or formatting information (e.g. ASCII-TXT).

2. Identification of the main language of the document through the statistical language guesser component. This is done by a statistical comparison between document characters n-grams distribution and reference statistics. The range of identifiable "language" metadata is English (en), French (fr), German (de), Italien (it), and Spanish (es).

3. Pre-processing

- *Disambiguation of the periods:* The identification of periods that have a full stop value is needed to tokenize the document in relevant linguistic units.
- *Text tokenization*: Different units of tokenization: words, chunks, periods.
- *Lemmatization:* Each word receives a tag regarding the part of speech (PoS) and the lemma. To be accomplished by an external multilingual tagging tool (e.g. TreeTagger, Xerox Tagger, Connexor Machinese) for de, en, fr, it.
- *Selection of nouns*: From the results of lemmatization, only nouns are assumed to be potential keyword/descriptors of the document. Output of the document-specific nouns frequency list.

Algorithm A

4A. Statistic Processing

- *Selection of the n% most frequent nouns*
- *Statistic clustering.* The clustering process is based on two co-occurrence measures of the output items of the previous step (co-occurrence is estimated within period contexts): similarity-based clustering (terms with similar distribution of co-occurrence with other terms even if they are not frequent, measured by the Jensen-Shannon divergence); pairwise clustering (terms that co-occur frequently in the same period contexts, measured by mutual information score)
- *Keyness value estimation.* Estimation of the importance of the pre-selected words of a document. Various algorithms can be used: χ^2, log-likelihood, z-score. The estimation generates a score for the keyword candidates.

5A. Fine grained collocation extraction.

Analysis of the strict co-occurrence (in contiguous context of fixed length) of each selected keyword with other related words. If the co-occurrence overruns a fixed threshold (to be experimentally detected) the keyword become a complex keyword.

6A. Output of the document keyword

Selection of the words (or multi-words) with the highest score.

Algorithm B

4B. Statistic comparison with general corpus frequency lists.

The frequency list extracted from a specific document is compared with a general one, extracted form a big corpus.The more prominent differences (mostly within the nouns) are taken into account as a fist step to recognize the document specific lexicon, that is assumed to contain the relevant keyword candidates. The TFIDF algoritm has been choose to accomplish this task (In principle the result of this process could be also compared , and refined, with the internal statistic scoring discussed at point 4A.)

5B. Fine grained collocation extraction.

Analysis of the strict co-occurrence (in contiguous context of fixed length) of each selected keyword with other related words. If the co-occurrence overruns a fixed threshold (to be experimentally detected) the keyword become a complex keyword.

6B. Output of the document keyword

Selection of the words (or multi-words) with the highest score(s).

Algorithm C

4C. Statistic comparison with general corpus frequency lists.

The frequency list extracted from a specific document is compared with a general one, extracted form a reference corpus. The more prominent differences (mostly within the nouns) are taken into account as a fist step to recognize the document specific lexicon, that is assumed to contain the relevant keyword candidates. The result of this process can be compared (and refined) with the internal statistic scoring discussed at point 4A.

5C. Output of the keyword candidates.

Wide selection of the words (or multi-words) with the highest score(s).

6C. Semantic processing

- *Word Sense Disambiguation (WSD):* Words can be ambiguous about their meaning. With respect to this point, in WordNet a word can be associated with one or more concepts, that describe the possible meanings of a single lemma. WSD strategies take into account the semantic context in which the word occurs. The output is the association of each word with one concept, that makes possible the translation of the selected (key)words into the different languages (associated in the multilingual WordNet).
- *Semantic Similarity estimation (SS):* The Leacock-Chorodow concept similarity measure can be used to measure the semantic similarity between two concepts. This measure is based on the length of the paths between pairs of concepts in the WordNet IS-A hierarchy.
- *Semantic clustering:* Clusters of concepts related to each other with decreasing values of *SS* (up to a predefined lower threshold).
- *Scoring:*
    1. first level: *cluster level score*: This score is defined as the sum of two components:
        - *connectivity*, corresponding to a global measure of the semantic relatedness between all concepts in the cluster;

- . *reiteration*, corresponding to a global measure of the importance of the concepts in the cluster.

2. second level: *concept level score:* This score is defined in a similar way as the sum of two components:
   - *concept level connectivity*;
   - *concept level reiteration*.

   These two measures are combined by a function that produces a unique score for each concept.

   Words that correspond to concepts with the highest global score are the best candidates to be document keywords.

   The cluster with the higher score can be associated with a descriptor (as the ones in the MultiWordNet Domains). The result is the output of the domain of the document.

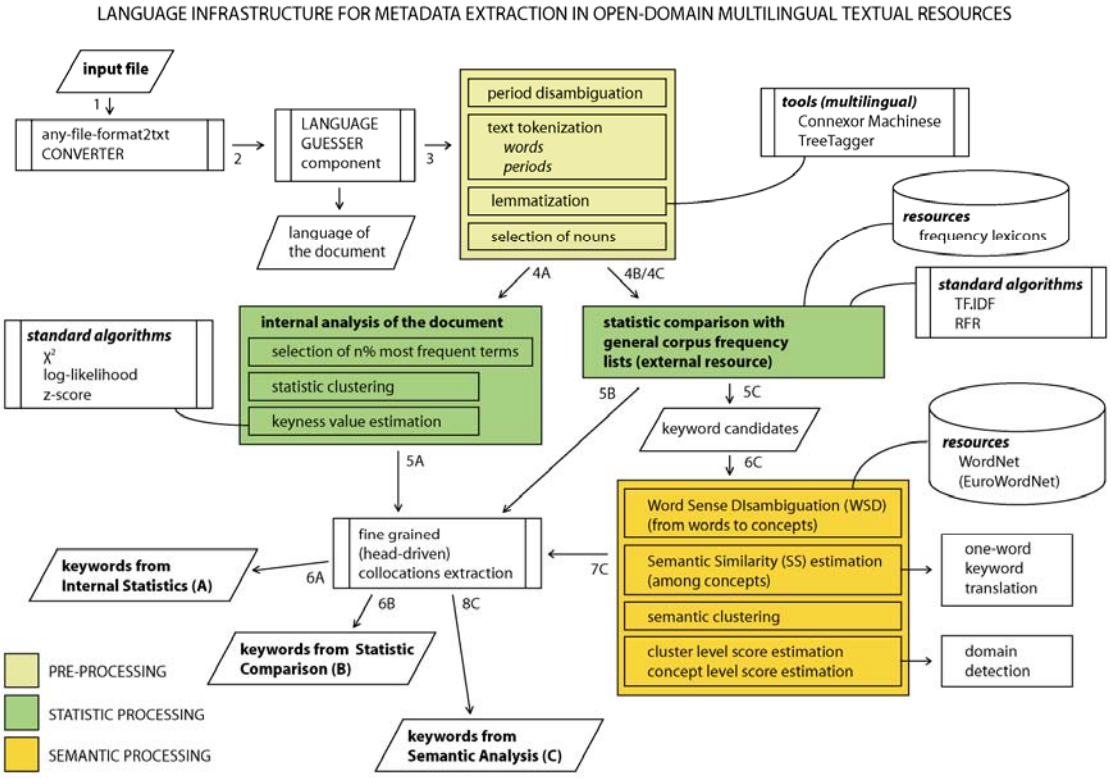
7C. Fine grained collocation extraction.

Analysis of the strict co-occurrence (in contiguous context of fixed length) of each selected keyword with other related words. If the co-occurrence overruns a fixed threshold (to be experimentally detected) the keyword become a complex keyword.

8C. Output of the document keyword

Words (or multi-words) with the highest score(s) are selected and returned.

The components needed for the extraction of metadata from text documents and the information flow in between them is shown in the next figure.



8.2 Problems

1. Reference statistics for all languages other then English are not freely available.
Solution: Statistics will be implemented by DIPITA.

2. Neither Multilingual tagger nor Language infrastructures like WordNet are freely avaliable for commercial use. The Use of Tree-Tagger and WordNet -English are free for research, but they subjet to licence for commercial use.
Solution: To be provided in accordance with the AXMEDIS general policy

3. The Use of WordNet for *Semantic Similarity estimation (SS) and Semantic clustering*, that have been proposed in the literature, leads partially to negative results, due to the internal structure of the data base. It turns out that Semantic similarity estimation based on the distance between Synsets can be used for word sense disambiguation but not for clustering.
Solution: A version of Word-net for English where synsets are linked to Domain information is available for research (Wordnet Domains 3.0 http://tcc.itc.it/research/textec/topics/disambiguation/download.html).

4. Translation of text descriptors to MPEG-7 format is problematic due to the lack of specific descriptors for text in the MPEG standard, which is oriented to the multimedia objects. More specifically, so far text is considered an attribute of the object and not the content of the object. As a consequence descriptors for text characteristics are not taken into account.
Solution: A proposal to MPEG-7 standard body for the integration of text descriptors will be presented.The proposal will be based on the existing standard for text description (e.g.: Text Encoding Initiative)

8.3 Work Performed

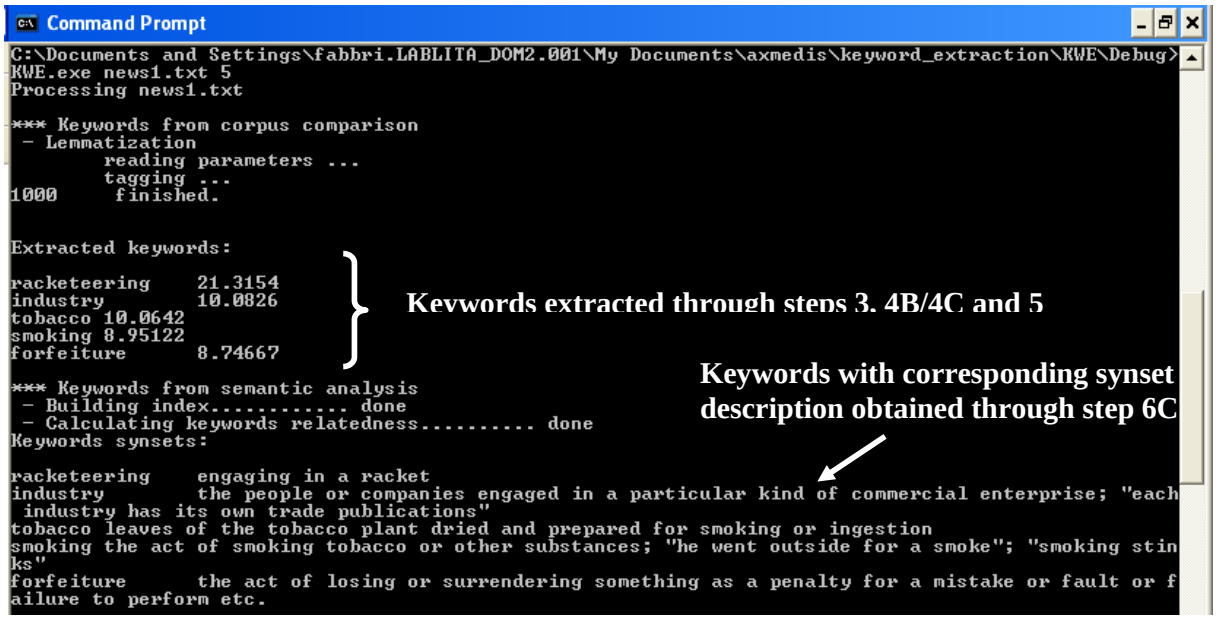
1- Language resource collection:
a) Multilingual Taggers; b) Reference Corpus for English; c)WordNet Data Base for English

2- Collection of Parallel texts (en; it, fr, sp, ge) for testing (see DE8.1.1)

3- A prototype demonstrator working on Microsoft Windows platform has been posted in the AXMEDIS' CVS repository. The demonstrator performs the following core components of Keyword extraction, limited to English documents (numbered in accordance with the above description):

3. Pre-processing. a) Text tokenization; b) Lemmatization (accomplished with TreeTagger)
Selection of nouns
4B/4C. Statistic comparison with general corpus frequency lists.
The frequency list extracted from a specific English document is compared through TFIDF algoritm with the statistics generated from the British National Corpus, taken as general reference corpus .
5.C. Keyword candidates are extracted
6C. Semantic processing
Word Sense Disambiguation (WSD*) w*ith respect to WordNet data base for English
The WordNet synset description derived from the word sense disambiguation has been associated to each keyword candidate.

All components have been object of positive early testing by DIPITA
Below a snapshot of the output of the prototype demonstrator:



news1.txt is an English plain text file containing a news regarding a civil case against some tobacco industries accused of fraud and racketeering; in this example, *5* keywords were requested.
Steps 3, 4B/4C and 5 extract keyword candidates (*racketeering*, *industry*, *tobacco*, *smoking* and *forfeiture*).
Step 6C disambiguates keywords candidates senses and associates the synset description to each candidate in accordance to WordNet synsets database.

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9 Fingerprints (FHGIGD) (completed)

9.1 State of the Art

Fingerprinting technologies are also called perceptual hashing technologies. "Perceptual hashing" indicates the common aspects with cryptographic hash functions while considering perceptual similarity. In the following subsections cryptographic hash functions are explained. Their drawbacks – when they are applied to multimedia content – are described. The advantages of perceptual hash functions are motivated.

An more detailed introduction that focuses on the common issues of perceptual hashing and cryptographic hashing can be found in DE4-5-1-Content-Protection-and-Supervision. Here, only the basic terms are shortly explained for providing a common understanding.

A hash functions maps a larger input space to a smaller one. The output of a hash function is called digest. It serves as a unique digital fingerprint for the input data. General prerequisites of cryptographic hash functions are:

- **Pre-image resistant**: given the hash h it should be hard to find the message m such that $h = hash(m)$ (one-way function).
- **Second pre-image resistant**: given an input m_1, it should be hard to find another input m_2 (not equal to m_1) such that $hash(m_1) = hash(m_2)$.
- **Collision-resistant**: it should be hard to find two different messages m_1 and m_2 such that $hash(m_1) = hash(m_2)$.
- **Random oracle property**: the hash function h behaves as a randomly chosen function.

Digital data streams are typically processed by computers. In contrast to these data streams multimedia data is perceived by humans. Obviously humans do not notice certain types of content modifications, e.g. the noise addition below the perceptual masking threshold. This property is exploited by lossy compression techniques, e.g. MP3 compression. Cryptographic hash functions however are bit-sensitive. Thus, using cryptographic hash functions for authenticating multimedia data is restricted to application where content is not processed or not available in different formats: Even format conversions are critical as the content modifications result in different hash values.

Perceptual hash functions

A perceptual hash function (fingerprinting function) should also satisfy the previously described requirements on cryptographic hash functions:

- Pre-image resistant
- Second pre-image
- Collision-resistant
- Random oracle property

Additionally, a perceptual hash function has to fulfil a different requirement which contradicts the prerequisites of the “second pre-image resistant” and the “collision-resistant”:

- **Perceptual similarity**: If two given inputs m_1 and m_2 are perceptually equal (similar) their corresponding hash values should be equal: $hash(m_1) = hash(m_2)$ (rsp. similar: $hash(m_1) \approx hash(m_2)$).

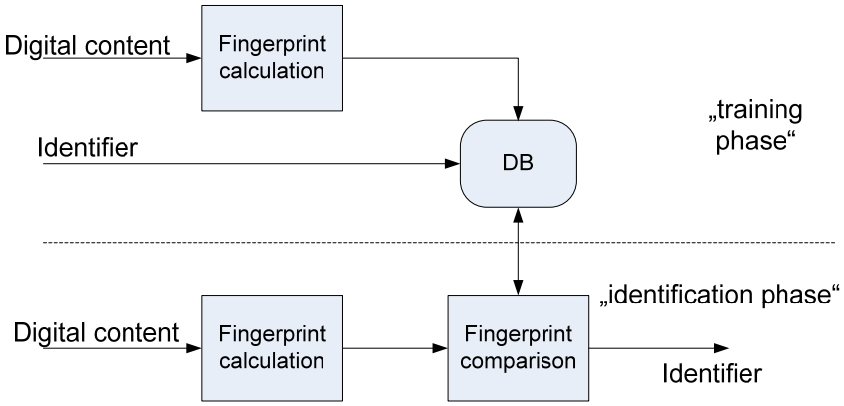
Perceptual similarity requires fingerprinting methods to be individually developed for different content types (like watermarking technologies).

General Requirements on fingerprinting technologies

- Discriminability
- Size
- Performance Characteristics
- Robustness
- Searching Complexity
- Security

Application: Content Description and Identification

To identify content, the unique descriptor calculated by fingerprinting and perceptual hashing techniques has to be stored in a database as shown in **Errore. L'origine riferimento non è stata trovata.**. This first phase is the training phase and can be compared with the training phase of a classifier. Having this image in mind, each piece of content is its own classification class. Content manipulations result in perturbations of the content and thus to potential "mis-classifications" in the identification phase.



Typical evaluation criteria for this application scenario are:

- Correct recognition rate
- False detection rate
- False alarm rate
- Feature extraction complexity
- Training complexity
- Retrieval complexity

9.2 Problems and Work Performed

The description of the problems and work done can be found in the following sections on the individual technologies. A description of the demonstration prototype together with implementation specific details is given in the Appendix A.

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10 Audio Fingerprints (FHGIGD)

10.1 State of the Art (completed)

Audio fingerprinting or content-based identification (CBID) technologies associate an audio signal to a much shorter mimetic sequence (the "fingerprint") and use this sequence to identify the audio signal (Cano, Gómez et al., 2002). Audio fingerprinting is best known for its ability to link unlabeled audio to corresponding metadata (e.g. artist and song name), regardless of the audio format.

As there is significant variance in audio data for perceptually similar content and direct comparison of the audio content itself is neither efficient not effective, a special hash method is seen as the best solution. The output of this hash function should be invariant under small perceptually insignificant modifications such that two audio excerpts are classified as "perceptually identical" if the human ear cannot distinguish between them.

10.1.1 Requirements

The prime demand of audio fingerprinting system is an efficient mechanism to establish the perceptual equality of two audio objects: not by comparing the (typically large) objects themselves, but by comparing the associated fingerprints (small by design).

In reality the design of an efficient mechanism depends heavily on the different applications. So during the design of an audio fingerprinting algorithm the various demands should be fulfilled, such as accuracy, reliability, robustness, security, versatility, scalability, and complexity. Generally, the fingerprint should be (Cano, Batlle et al., 2002):

- A perceptual digest of the recording. The fingerprint must keep as much acoustically relevant information as possible and should allow discrimination between large numbers of fingerprints.
- Invariant to distortions. The fingerprint must be accurately connected with its original recording, regardless of the level of compression and distortion or interference in the transmission channel.
- Compact. Because a large number (millions) of fingerprints need to be stored and compared, a small-sized representation is necessary. At the same time an excessively short representation might not be sufficient to discriminate among recordings, affecting thus accuracy, reliability and robustness.
- Easily computable. In order to reduce complexity, the extraction of the fingerprint should be easy to compute.

According to those demands 5 basic parameters must be focused on (Haitsma et al., 2002):

- Robustness: An audio clip must be identifiable even after severe signal degradation. The fingerprint should use perceptual features that are invariant in order to achieve this. Ideally, severely degraded audio still leads to very similar fingerprints. The False Rejection Rate (FRR), i.e. the probability that two signals are "equal", but not identified as such, can be used as robustness metrics.
- Reliability: Results must be consistent for variety of input signals. The False Acceptance Rate (FAR), i.e. the rate at which audio signals are incorrectly considered "equal", is always used to specify reliability.
- Fingerprint size: Fingerprints are usually stored in RAM memory to enable fast searching. Thus the fingerprint size should be kept to a minimum.

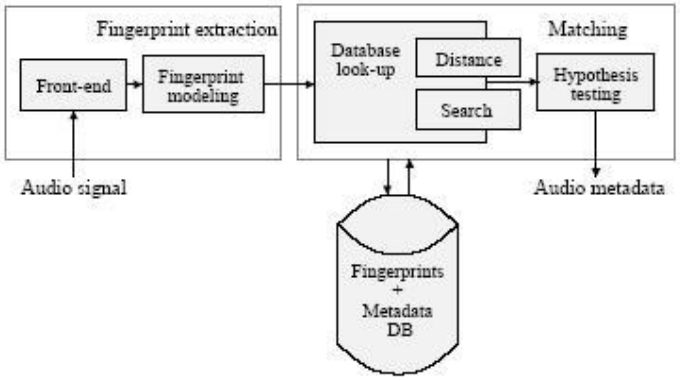
- Granularity: The length of an audio excerpt to identify an audio clip is an application dependent parameter.
- Search speed and scalability: The time needed to find a fingerprint in the fingerprint database is a crucial parameter for commercial deployment of audio fingerprint systems.

These five basic parameters are all intertwined. For instance, search speed will increase when a more robust, smaller fingerprint is designed. On the other hand the smaller fingerprint may impact the reliability parameter.

10.1.2 Basic Schema

Although the design of an audio fingerprinting system depends on the application scenario, there are two components that are common all audio fingerprinting systems: the fingerprint extraction and the matching algorithm (Cano et al., 2002).

Errore. L'origine riferimento non è stata trovata. shows a content-based audio identification framework as described by Cano et al., 2002. The first block is the processing stage, which actually computes a fingerprint, while the second block involves sophisticated search algorithms to scan a database of previously computed fingerprints for matches. In order to fulfil the requirements of audio fingerprinting, the extraction step consists of a front-end and a fingerprint modelling block, which implies a trade-off between dimensionality reduction and information loss. The fingerprint model block is supported by the front-end, which converts an audio signal into a sequence of relevant features, while the fingerprint model block defines the final fingerprint representation, e.g.: a vector, a trace of vectors, or a codebook. Distance measures and searching algorithms are utilized during the database look-up step. Finally, the hypothesis testing component gives us a reliability measure that indicates the quality of the match.



In the following sections we will describe the modules of the basic schema in more detail.

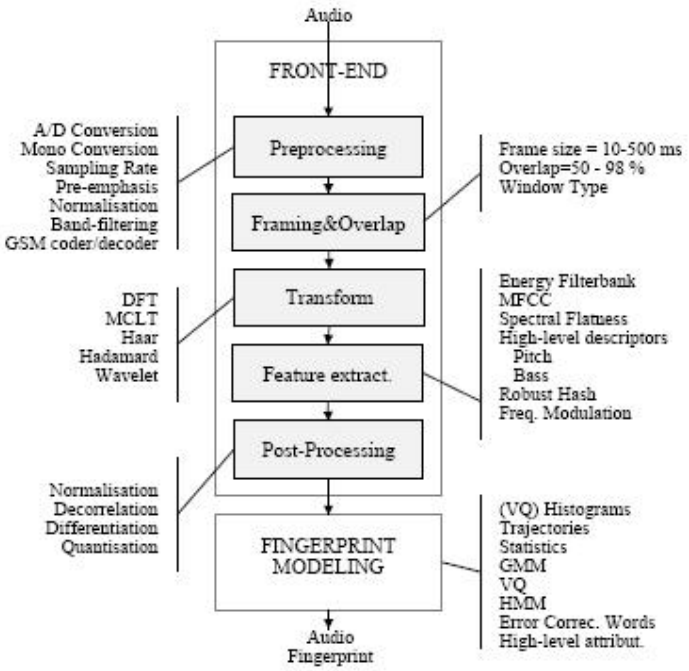
Front-end

The front-end consists of 5 sub-modules, which are shown in **Errore. L'origine riferimento non è stata trovata.**6:

- Pre-processing: The audio stream is digitized (if necessary) and will be subject to operations such as re-sampling, normalisation, and band-filtering, resulting in a canonical presentation of the data.
- Framing and Overlap: The signal is divided into frames such that the signal within the frame can be regarded as stationary over the frame interval. The frames have some time overlap to assure robustness to time shifting.
- Linear Transforms: In order to significantly reduce the redundancy within the original signal and to facilitate further processing steps, linear transforms are applied to convert the original data to a new domain. Standard transforms from time to frequency domain can ease efficient compression, noise

removal and subsequent processing. The Fast Fourier Transform (FFT) is one of the most popular transformations in this scenario.

- Feature Extraction: Usually based on the time-frequency representation mentioned above (framing and FFT), a variety of algorithms can be applied to reduce the dimensionality of the data and, at the same time, to increase the invariance to distortions. The outcome of this processing stage is the final feature vectors.
- Post-processing: The most common post-processing step is to apply low resolution quantization to the features: ternary or binary, which can ease hardware implementations and make a convenience of subsequent parts of the system.



Fingerprint Models

The objective of this phase is to further reduce the fingerprint size. Because the fingerprint modelling block always consists of a sequence of feature vectors, which are calculated based on a frame, it is suggested to exploit redundancies in the frame time vicinity, inside a recording and across the whole database. Fingerprint models are the preconditions to select the distance metric and design indexing algorithms for fast retrieval. While a very concise form of fingerprint is achieved by summarizing the multidimensional vector sequences of a complete audio stream (or a fragment of it) into a single vector, fingerprints can also be formed through the concatenation of sequences (traces, trajectories) of features.

Distance Metrics, Search Methods and Hypothesis Testing

According to a predefined distance metrics both the set of reference patterns (the fingerprints stored in the database) and the test pattern (the fingerprint extracted from the data stream to be classified) are compared. Distance metrics are dependent on the type of fingerprint model. For instance, a correlation is used to compare vector sequences, while the hamming distance is used to compare single vectors.
The basic goal is to build a data structure which reduces the number of distance computations required for a query. A good search method should be fast, correct, memory efficient and easily updateable.
Hypothesis Testing: This last step decides, based on a threshold value, if a fingerprint is present in the databases.

10.1.3 Existing Algorithms

Different features have been proposed and implemented for the calculation of audio fingerprints. The can be categorised in two groups:

- Signal characterising features are derived from the signal itself. They are low-level features, which are no directly perceived by human listeners. However, they change if the audio signal changes. Examples for these features are loudness, energy, sharpness, spectral centroid, or zero crossing rate.

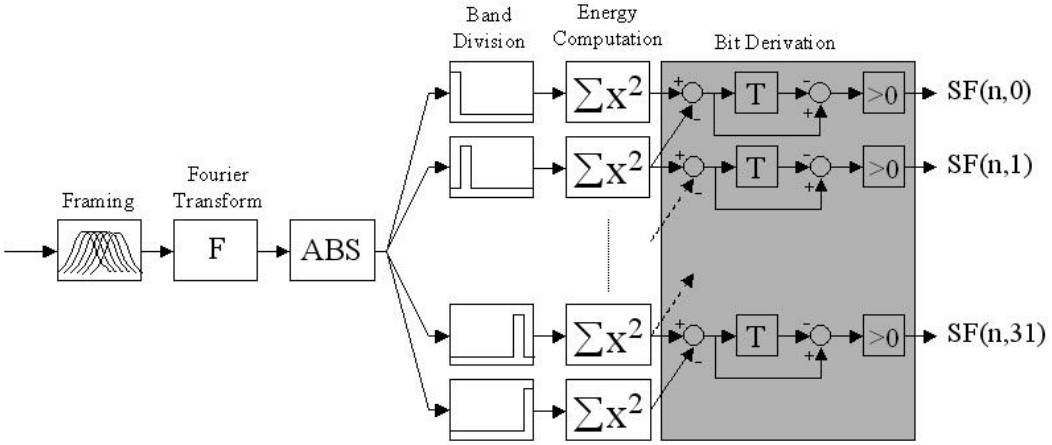
- Perceptually relevant features are related to the sound perceived by humans. Like tone-likeness or tonality. These features, which are perceptually meaningful, are supposed to be more robust with respect to distortions.

Signal Characterising Features

A good example for an audio fingerprinting algorithm based on (statistical) signal characterising features is the algorithm presented in [Haitsma2002a]. The following steps can be identified:

1. The audio stream is segmented into overlapping frames (time segments).
2. For each frame:
    a. The coefficients are transformed in the Fourier-domain and the absolute values of the Fourier coefficients are calculated.
    b. The Fourier coefficients are separated into different bandwidths (frequency segments). For each segment the energy is computed.
    c. Instead of directly considering the energy values, the energy differences of neighbouring frequency bands are calculated and their temporal change (increasing/decreasing) is chosen for a single fingerprint value.

The overall architecture is shown in the next figure.

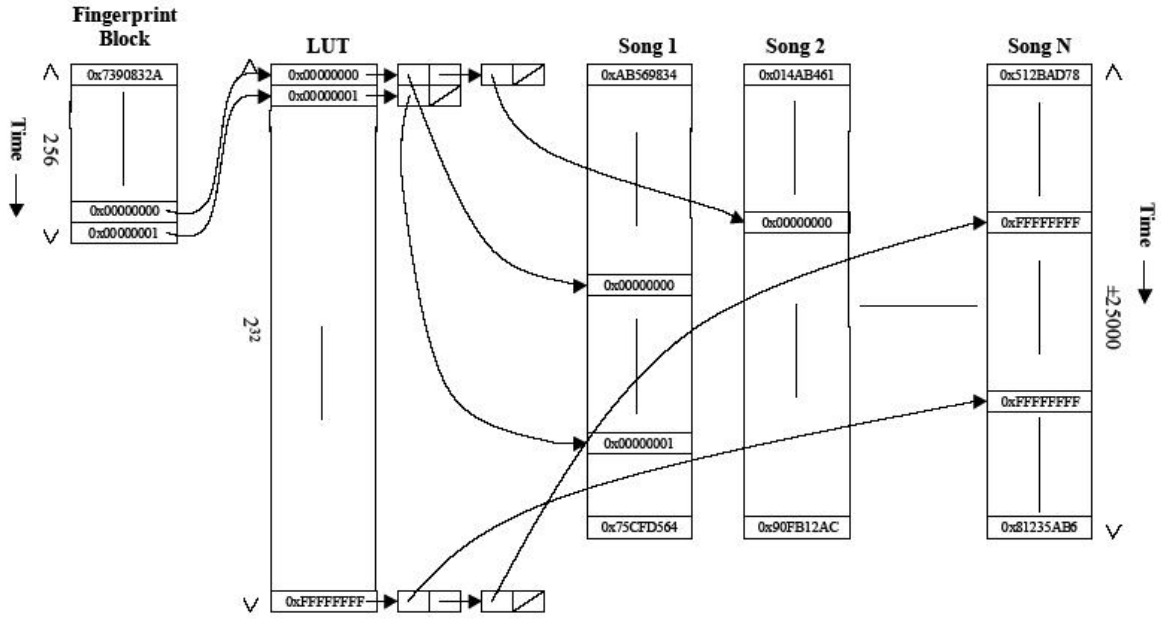


The resulting hash values for each window are called a sub-fingerprint. The retrieval itself is based on a "collection" of sub-fingerprints, which are called the "fingerprint".

The retrieval of the algorithm based on a complex database structure. The complexity of the database structure is derived from the requirement of breaking "the curse of dimensionality". Only by limiting the high-dimensional search space (time-) efficient retrieval can be guaranteed. The retrieval process consists of the following steps.

1. Each (sub-) fingerprint is used as an index to a hash table. By this step the possible song candidates are pre-selected. Also the temporal position of fingerprint in the song is identified.
2. This pre-selection together with the position identification strongly limits the search space. Based on this, the input fingerprint can be compared with the stored fingerprints.

This process together with the corresponding database structure is shown below.



Perceptually Relevant Features

As described in [Herre2001] perceptually relevant features, which indicate tone-likeness or tonality include:

- Spectral peaks indicate the presence of a tonal component in the Power Spectrum Density (PSD).
- A high predictability of the spectral coefficients of the audio signal indicate tonality.
- The Spectral Flatness Measure (SFM) quantifies the tonal quality, which is defined as the ratio of the geometric mean to the arithmetic mean of the power spectral density components:

$$SFM(s(t)) = \frac{\left[\prod_{k=0}^{N-1} S_{xx}(f)\right]^{\frac{1}{N}}}{\frac{1}{N}\sum_{k=0}^{N-1} S_{xx}(f)}$$

- The Spectral Crest Factor (SCF) is the ratio of the largest PSD coefficient and the mean PSD value in a frequency band. The Crest Factor "is equal to the peak amplitude of a waveform divided by the RMS value. The purpose of the crest factor calculation is to give an analyst a quick idea of how much impacting is occurring in a waveform." [Friedman05]. Thus, the SCF

According to [Herre2001] the most promising feature candidates are the SFM and the SCF. Alternative variations of these features are also suggested in [Herre2001], which are called a "family of flatness oriented spectral features".

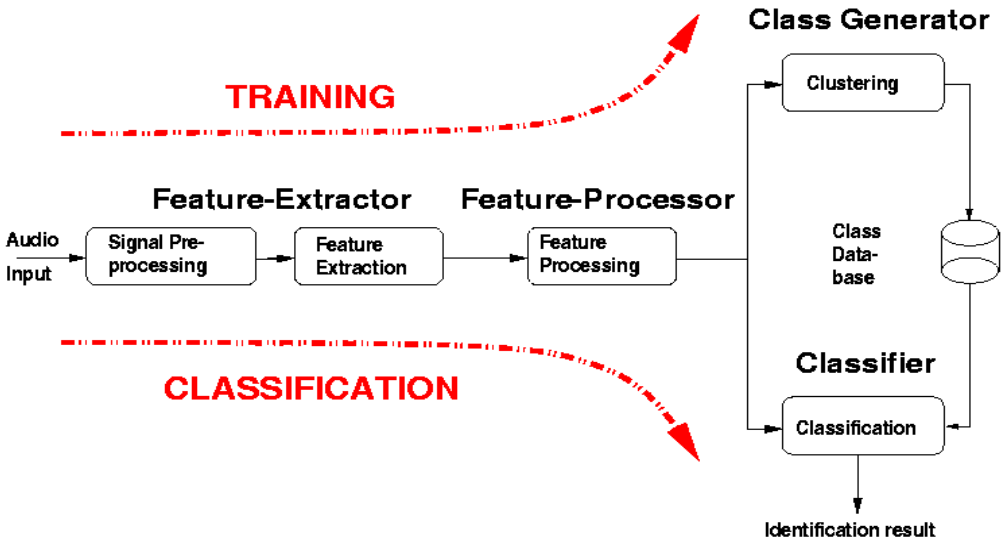
In [Herre2002] the SFM and the relation to the MPEG-7 standard is described:

- The "AudioSpectrumFlatness Low Level Descriptor (LLD)" defines how to extract this feature from the audio signal.
- The "AudioSignature Description Scheme (DS)" defines how an interoperable hierarchy of scalable fingerprints can be established.

The AudioSignature DS considers the following three parameters:

- The so-called temporal scope identifies the start position and the length where the feature has to be or was extracted.
- The temporal resolution is a kind of grouping parameter for single frames of 30ms. The SFM are computed and statistically summarized for one group.
- The spectral coverage or spectral bandwidth of the identifies the frequency bands that have to be selected for the feature calculation.

The retrieval process described in [Herre2001, Herre2002] groups several features – these groups are called super vectors (c.f. fingerprints and sub-fingerprints in the previous description) – and use statistical measures for the retrieval of the nearest neighbour. No details are given in [Herre2001, Herre2002]. However, it seems that techniques from pattern recognition and string matching are applied in the "classification" or "retrieval phase" to identify the "best approximation" stored in the database during the "training phase". The different steps involved are shown in the figure below.



Further developments

Besides the above described algorithms different developments and improvements exists.

In [Bardeli04] an algorithm is proposed that is similar to [Herre2001] or [Haitsma2002]: The audio data is segmented. For each segment a binary string is calculated. Retrieval is based on a clustering algorithm. The segmentation is based on prominent local maxima from the spectrum. For the calculation of the binary sequence the equally spaced frequency bands are chosen and the energies in these sub-bands are considered.

Burges et al. [Burges02, Burges03] derive features for the identification of audio by using an oriented PCA as suggested in [Diama96]. This method for Distortion Discriminant Analysis (DDA) is iteratively applied three times to the input frames of the audio stream. In the "learning phase" a transformation of the input data is identified that maximizes inter-class variance and minimizes intra-class variance. In the "classification phase" the identified transformation(s) is (are) applied to the input data. The distance to stored dimensionality reduced features are used for the audio identification process.

The Mel-Cepstrum Coefficients (MFCC) are proposed in [Batlle02] for the calculation of the features. A Hidden Markov Model (HMM) is used for the calculation of the feature vector.

The audio fingerprinting method suggested by [Lu02] is based on wavelet coefficients: As described in [Mallat92] finding the local wavelet maxima is equivalent to multi-scale Canny edge detection. Thus, an approximately reconstruction of a signal is possible from its local wavelet maxima.

The problem of the linear speed change is the focus of the research in [Seo02]. The authors propose to use the invariance properties of the Fourier-Mellin Transform on the method presented in [Haitsma2002, Haitsma2002b].

10.2 Problems (completed)

It can be clearly seen that the focus of existing audio fingerprinting systems is on content identification. The application of content authentication/content verification has not been considered so far.
A detailed benchmarking of the fingerprinting system regarding verification is missing. The decision threshold during the verification step has to be evaluated regarding the acceptable distortion for different kind of manipulations in the envisaged application scenario. Regarding the robustness of the audio fingerprint system against time scale modification further research is necessary.

10.3 Work Done

In general every audio fingerprinting system consists of an feature extraction and matching algorithm. The following sections describe the various building blocks of the audio fingerprint system developed by IGD.

Feature Extracting Block

Data preparation

The audio data is converted to a raw mono signal with 16 bit amplitude resolution and a sampling rate of 44.1 kHz. Pre-processing of the audio samples like normalization of the amplitudes can be optionally applied but is currently not necessary. The input architecture of the audio fingerprint system will uses parts of the psychoacoustic model of MPEG 1 Layer I [Pan95].

Segmentation into Frames

The basic algorithm splits the audio track into time slices (frames) for extracting parts of the whole fingerprint, the so-called sub-fingerprints. The number of samples per frame is 512. The number of samples is determined by the performance of linear transform (see below) applied to the frame and the usage of the underlying psychoacoustic model (MPEG 1 Layer I). In order to minimize the leakage effect due to the edges of the frames the input block is multiplied with a weighting window. The Hanning window is used as a weighting function.

Overlapping of the Frames

Due to the fact that a misalignment of the frames during feature extraction and matching can occur, the individual frames are overlapped by 384 samples to introduce a correlation along the time axis. The

overlapping transforms the correlation of the audio tracks within a few milliseconds to correlation within the fingerprints, which can be utilized to improve the robustness against shifting during the matching of the fingerprints of two different audio tracks.

Transformation of the Individual Frames

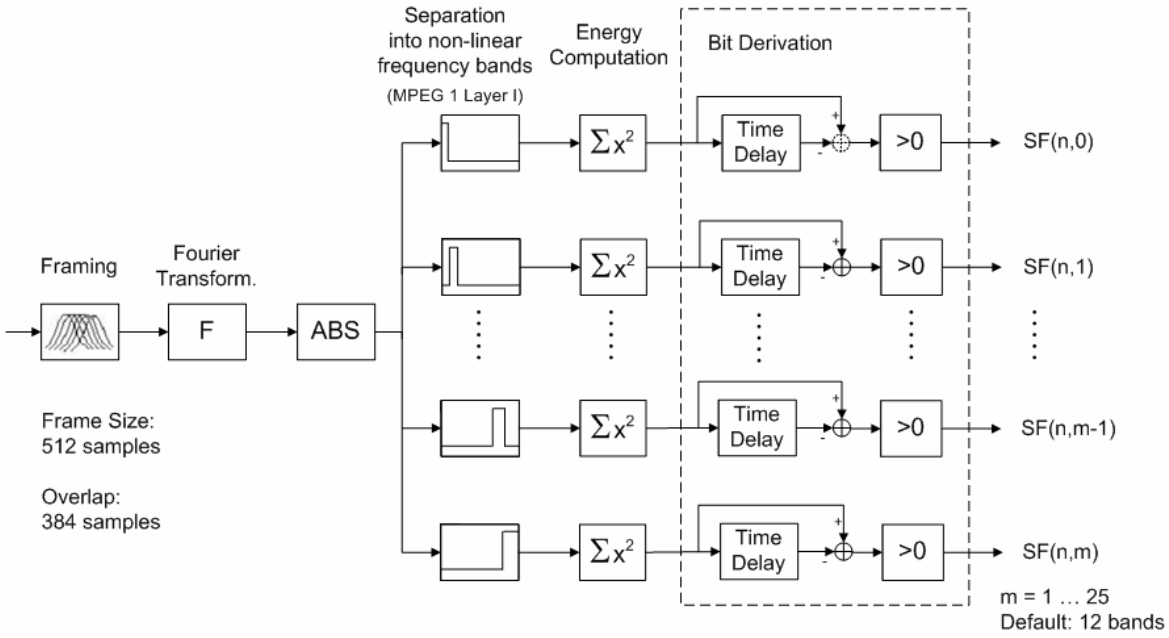
Due to the fact that most of the signal processing like lossy compression, filtering, adding noise, etc. can be described in the fourier domain and the fact that very fast implementations exist, it seems to be the most appropiate working domain. Furthermore perceptual relevant characteristics representing suitable features are often computed in the Fourier domain. The successive frames in the time domain are transformed via a Fourier transformation in order to compute a time-frequency representation of the audio signal.

Extraction of the Features

The feature extraction procedure reduces the dimensionality and increases the robustness against distortions. Furthermore knowledge about the human auditory system in order to extract perceptual relevant parameters are exploited in this step. Therefore a mapping is performed between the Fourier domain and the Bark scale. The spectrum is analyzed in critical bands, which are investigated regarding their energy. This includes the calculation of the energy in the frequency domain and the difference between successive frames along the time axis.

Processing and Modelling of the Features

The extraction of the energy differences is performed for every pair of successive audio frames as shown in the next figure. The individual sub-fingerprints are concatenated to construct the fingerprint of the whole audio track. In order to calculate a more compact representation of the audio fingerprint and to provide a higher robustness against distortions the calculated energy components are quantized to a binary representation.



Matching Algorithm and Distance Metric

The resulting audio fingerprint is modelled by a combined binary vector being composed of binary vectors for the individual sub-fingerprints. The fingerprint template used determines the distance metric used during the comparison of the fingerprints from two audio tracks.

Matching Algorithm

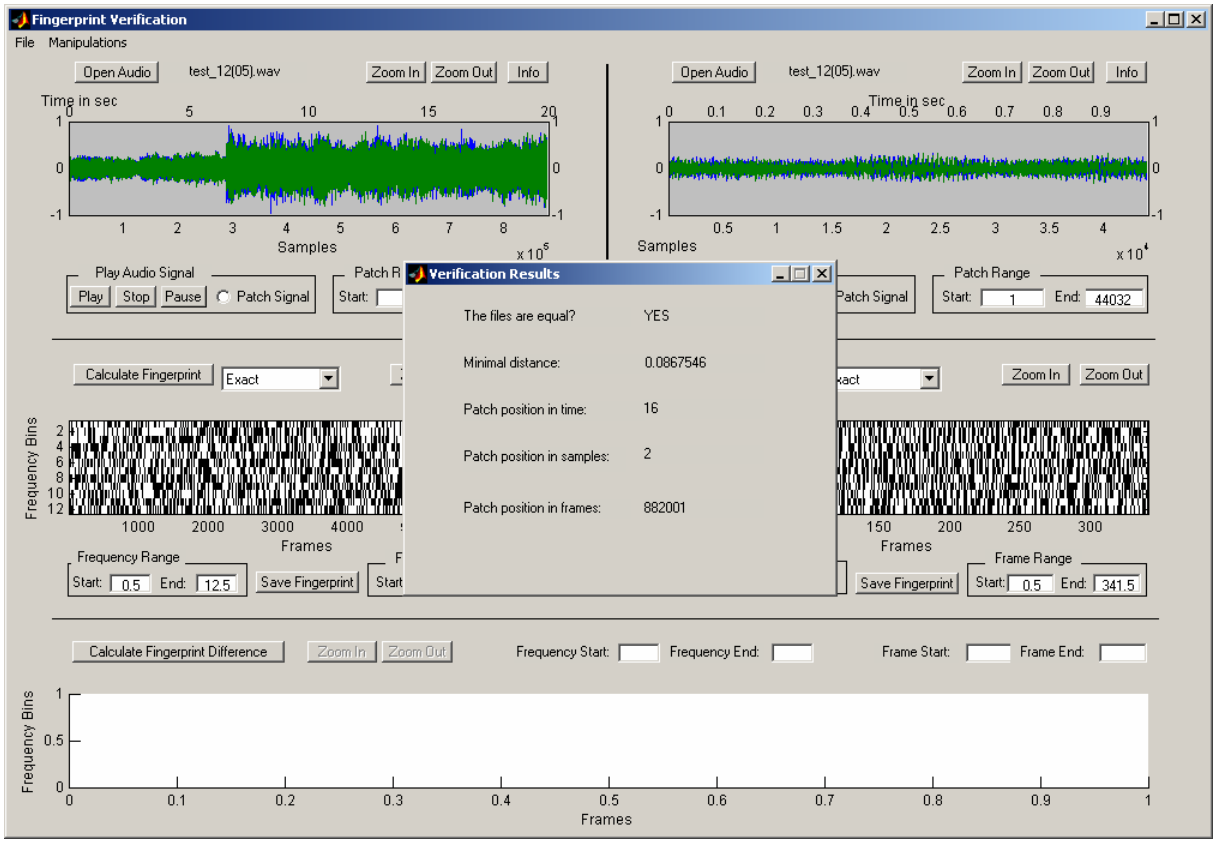
One of the fundamental requirements of audio fingerprint systems is the ability to accurately identify the audio tracks from excerpts of a few seconds. This requirement of robustness against cropping corresponds to the minimum watermark segment and is often denoted as granularity. The fingerprints for the individual frames can be used as indexing mechanism in order to identify the position in the song. The binary vectors are compared by calculating the normalized Hamming distance. This distance metric is equivalent to the BER if the fingerprints of the same audio track are compared.

Decision Block

The decision block uses the distance metric in order to formulate the hypothesis whether the audio track is the same as the presented one or not. The decision threshold will depend on the false acceptance and false rejection rate acceptable for the application and the discrimination ability of the fingerprint system which is directly related to the number of audio tracks in the system. The decision threshold for different kinds of manipulations is currently evaluated.

Demonstration Graphical User Interface

The implemented prototype functionality was integrated in a Graphical User Interface (GUI). This GUI allows an simple demonstration of the capabilities of the implemented algorithm.



PlugIn Implementation

All of the individual functionalities that were implemented for prototype were reimplemented in C++ for the plugin:

- Feature Extracting Block
  - Data preparation
  - Segmentation into Frames
  - Overlapping of the Frames

  - Transformation of the Individual Frames
  - Extraction of the Features
  - Processing and Modelling of the Features

- Matching Algorithm and Distance Metric

  - Matching Algorithm
  - Decision Block

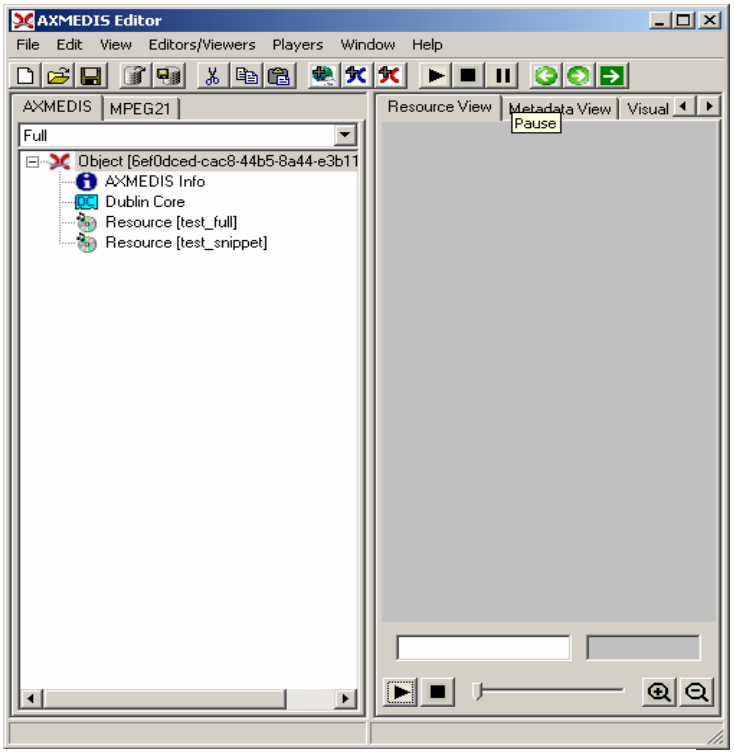
In addition, the resulting algorithm was integrated as a plug-in.

For demonstration, returning the fingerprinting as image output was provided as well as the functionality that is required to compare different fingerprints.

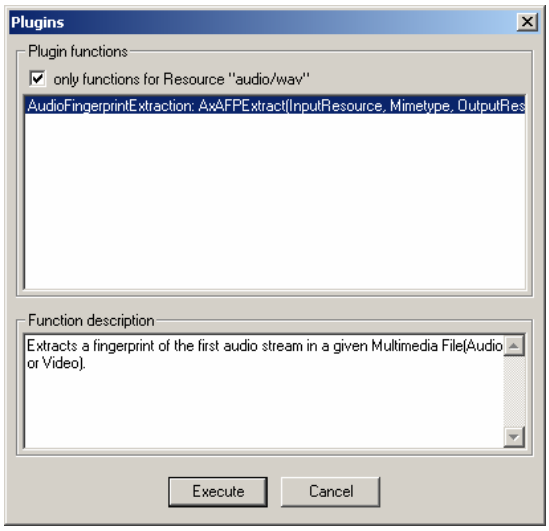
The existing fingerprinting plugin from M2ANY has been integrated as well as the corresponding matching functionality.

10.4 FIPSAudio - PlugIn Description

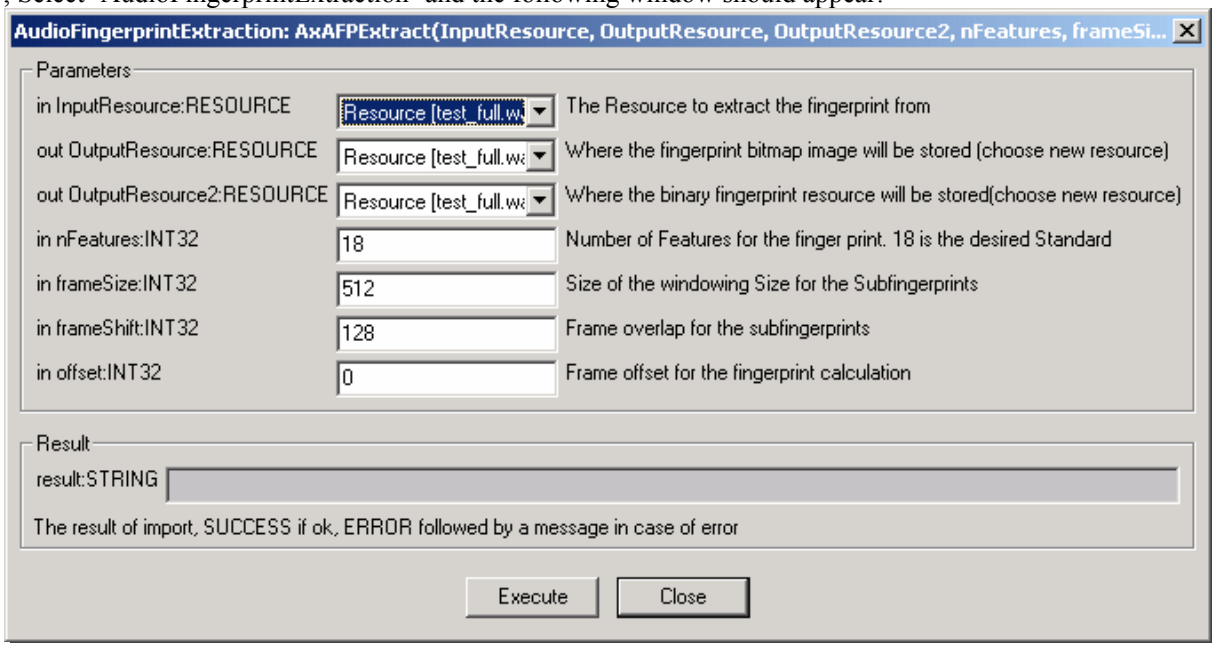
The plug-in can be applied to any audio or video resources, provided this was declared in the mime type attribute of the resource. The output is a binary file containing the fingerprint itself and an image file of any supported format (more than 90 mimetype formats within the image/* range). The PNG format is recommended.
For demonstration purposes the package contains a 10 second sample wave file: “test_full.wav” and a 3 second short extract of this file: “test_snippet.wav”.
Create a new AXMEDIS object and add the wave files as embedded resources by right clicking on the object.



Right click on the “test_full.wav” resource and select ‘Content Processing Plug-ins’



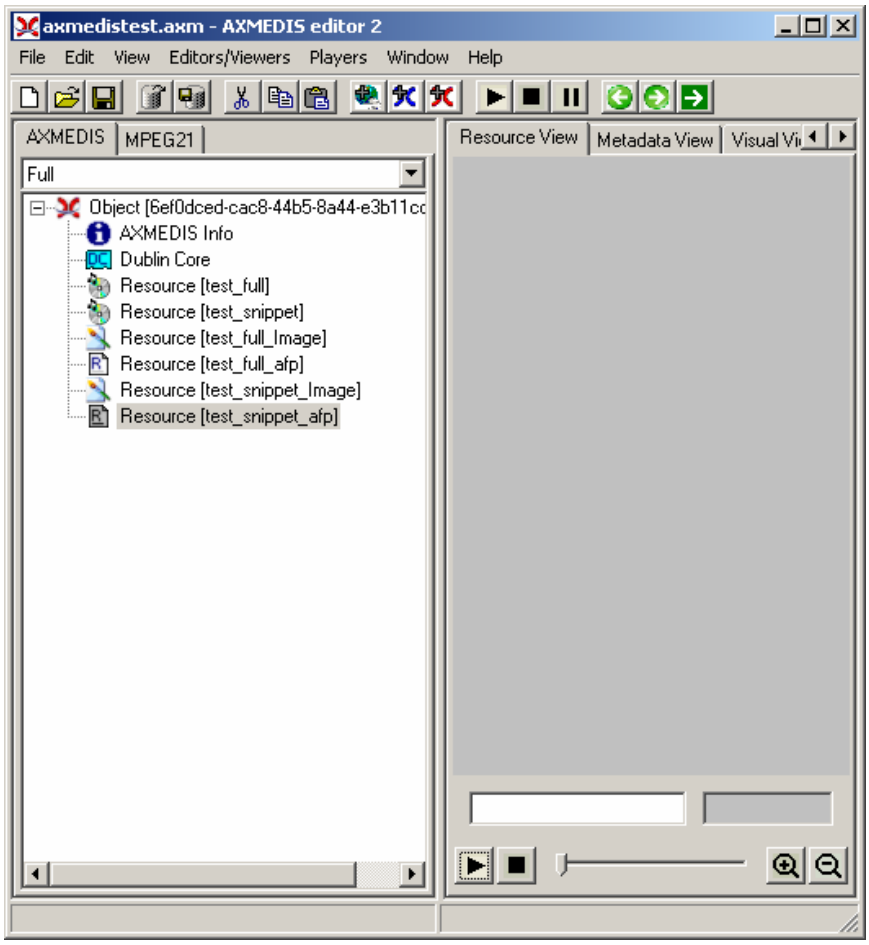
, Select 'AudioFingerprintExtraction' and the following window should appear:



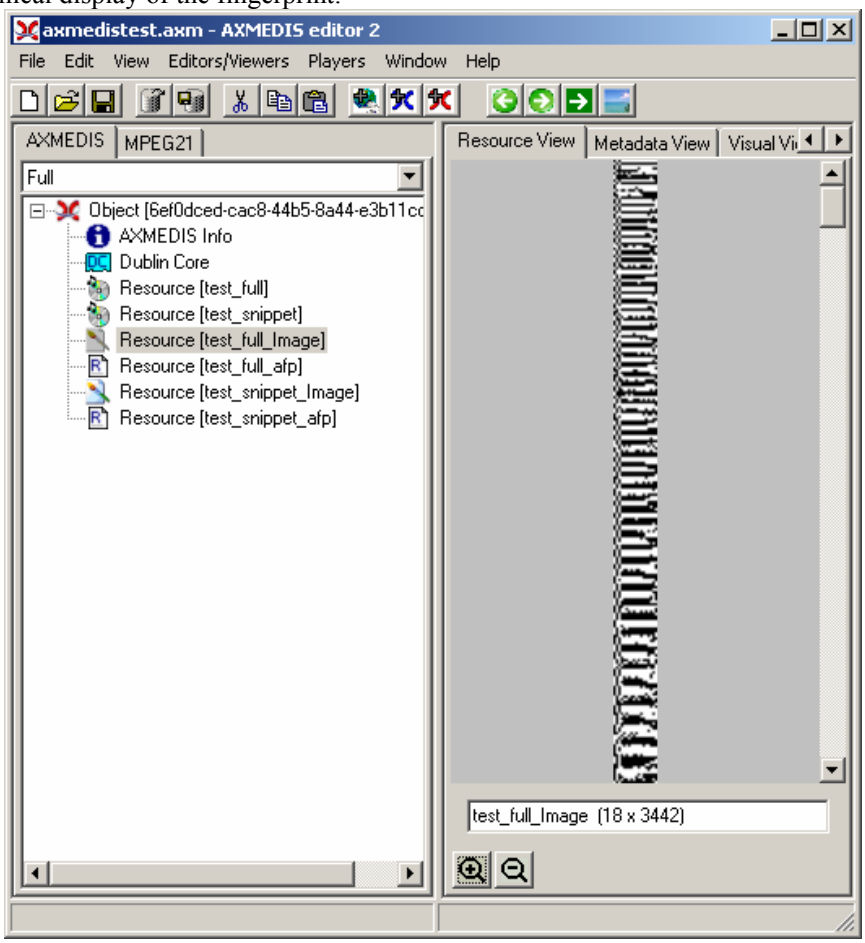
.

Choose for both outputs a new resource and click execute.

After receiving the “success”-message, close the window and you should have a new image resource and a new resource of the mimetype “fingerprint/audio” in the Axmedis editor. It is advised to edit the objects properties with the original resource filename

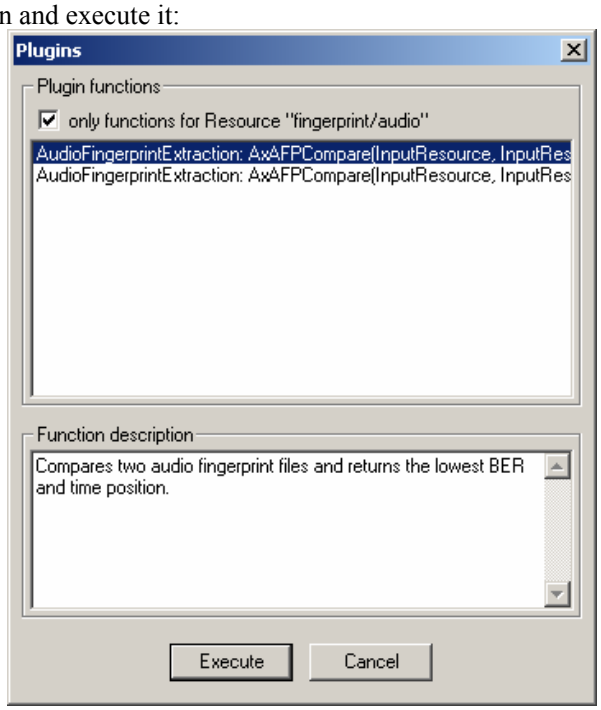


To view it, just double-click on the image resource.
Here's the graphical display of the fingerprint:

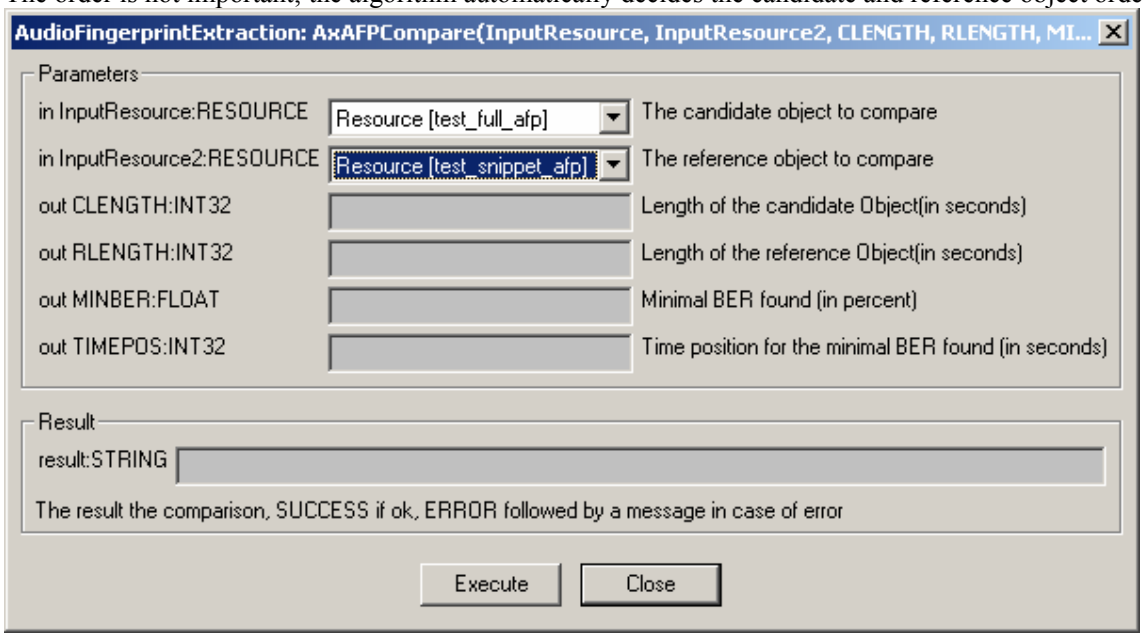


10.4.1 Fingerprint Matching

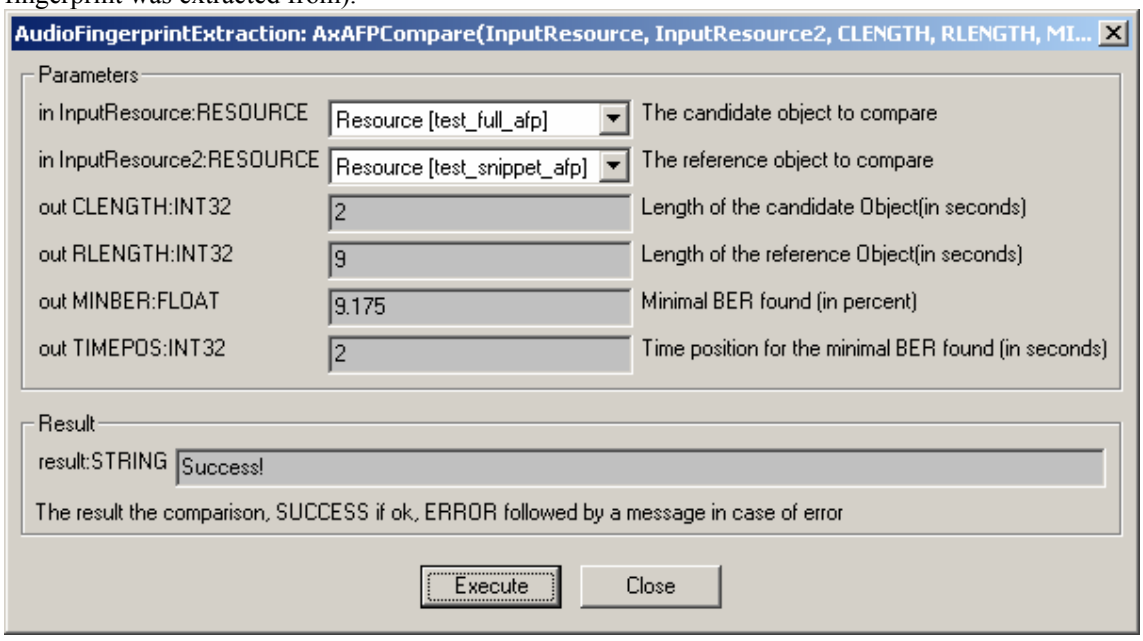
For demonstration purposes a basic matching function was implemented.
Repeat the extraction steps for the "test_snippet.wav" file.
After the extraction process has finished right click on any "fingerprint/audio" object, select the "AXAFPCompare" function and execute it:



On the following window just select the two fingerprint files to be compared and click on execute
The order is not important; the algorithm automatically decides the candidate and reference object order:



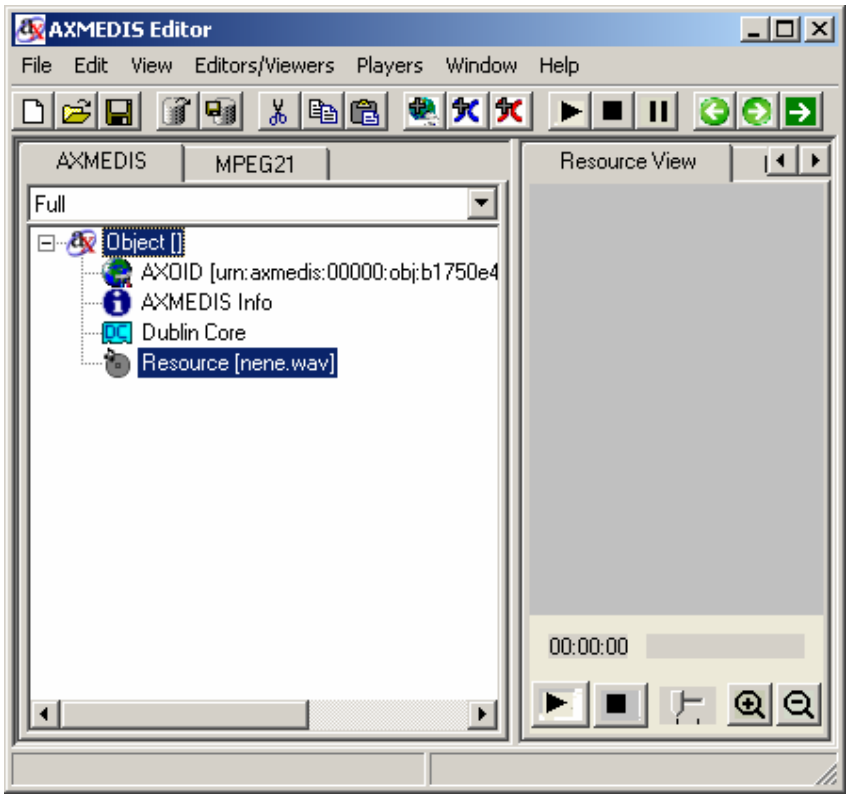
The result shows the length in seconds of the original candidate and reference objects (the audio files the fingerprint was extracted from).



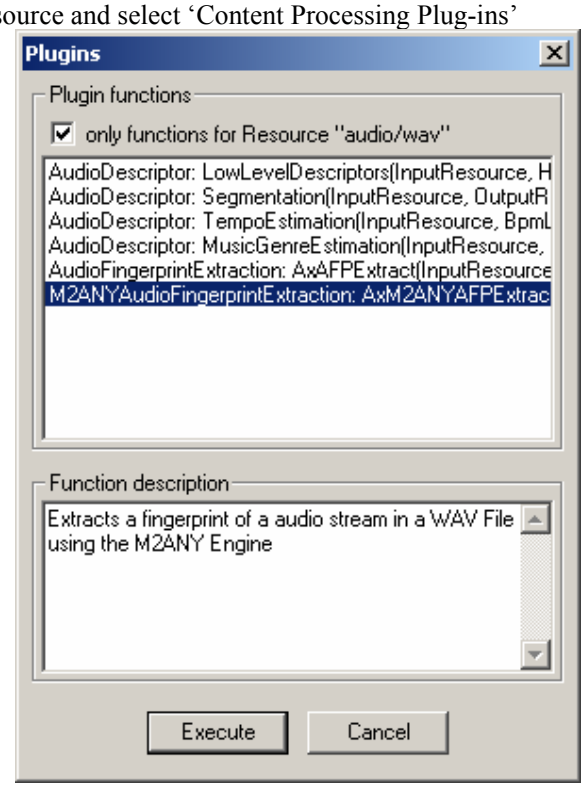
The MINBER value is the minimal BER found during the comparison. The TIMEPOS is the time position for the minimal BER.
The result value will show “Success!” if the comparison was performed without errors. Else an error message will display. Please note, that the “Success!” message is a display of the technical success of the comparison process and not the matching probabilty.

10.5 M2ANY - PlugIn Description

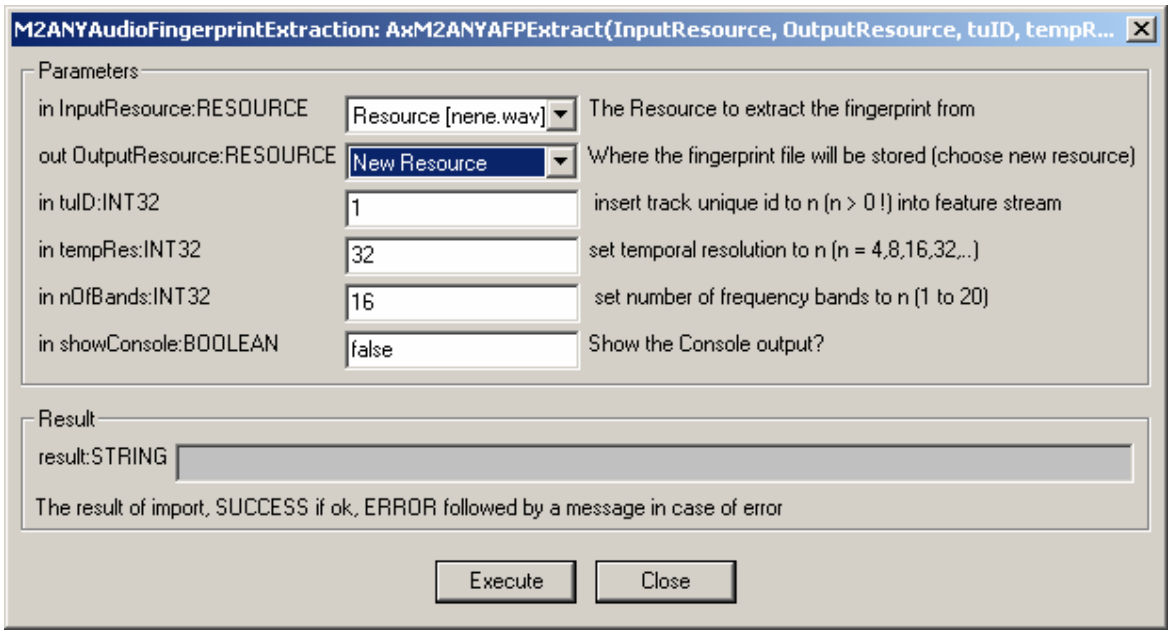
The plug-in can be applied to WAV files, provided this was declared in the mime type attribute of the resource. The output is a binary file containing the fingerprint in binary format.
Create a new AXMEDIS object and add a wave file as a embedded resource by right clicking on the object. The provided audio file excerpt (nene.wav) is specially useful as a complete fingerprint is contained within the M2ANY Database.



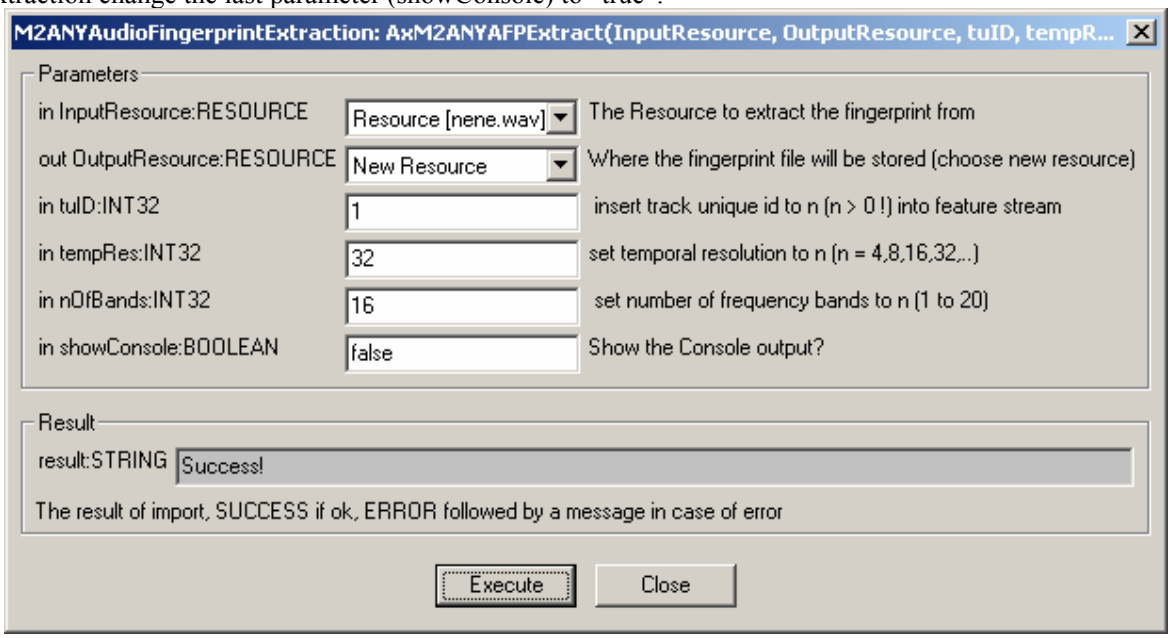
Right click on the WAV resource and select ‘Content Processing Plug-ins’



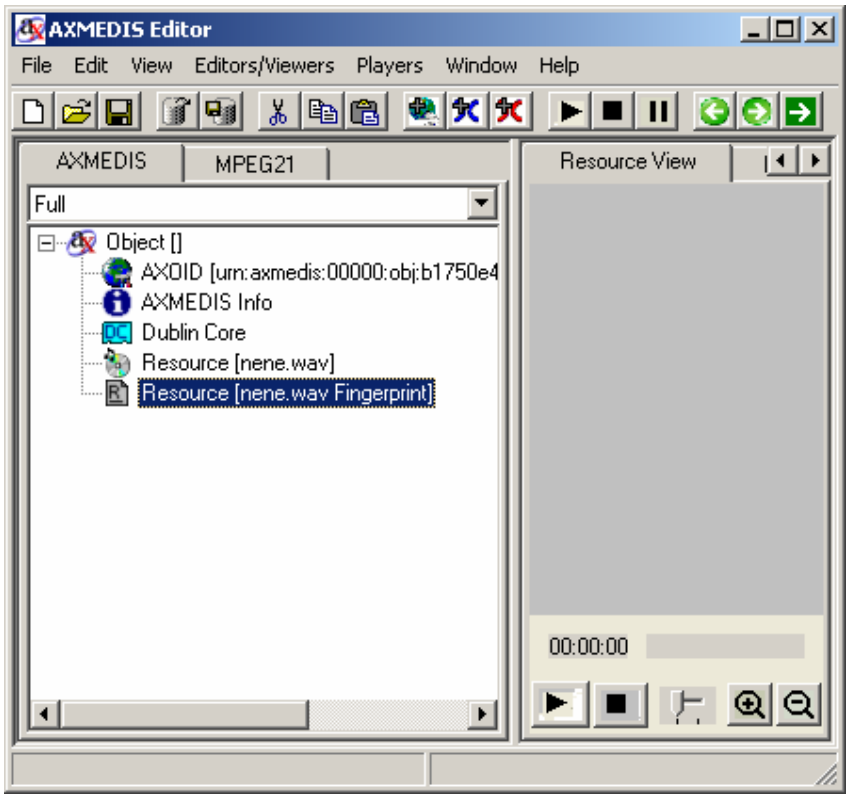
, Select ‘M2ANYAudioFingerprintExtraction’ and click “Execute”the following window should appear:



.
Choose for the output a new resource and click execute. If you want to see the console output of the extraction change the last parameter (showConsole) to "true".

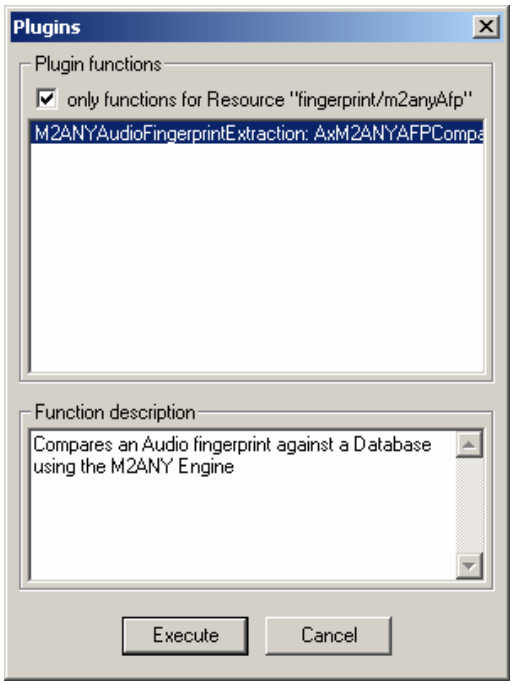


A console window will shortly appear indicating the extraction process. After receiving the "success"-message, close the window and you should have a new resource of the mimetype "fingerprint/m2anyAfp" in the Axmedis editor. It is advised to edit the objects properties with the original resource filename

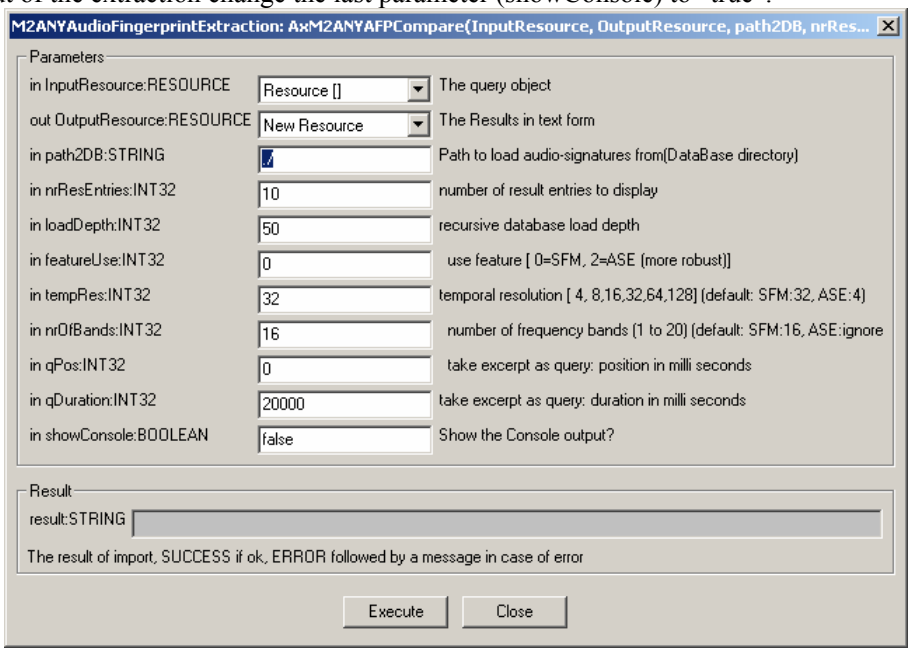


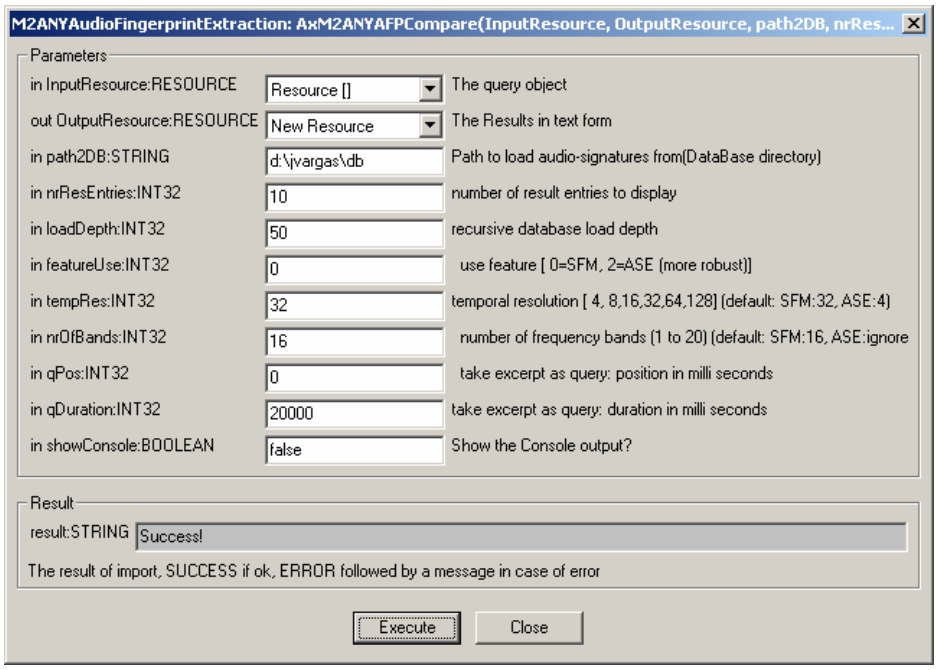
10.5.1 Fingerprint Matching

For demonstration purposes a basic matching function was included.
For this section the fingerprint generated in section **3.1** will be used.
After the extraction process has finished right click on any "fingerprint/ m2anyAfp" object, select the "M2ANYAXAFPCompare" function and execute it:



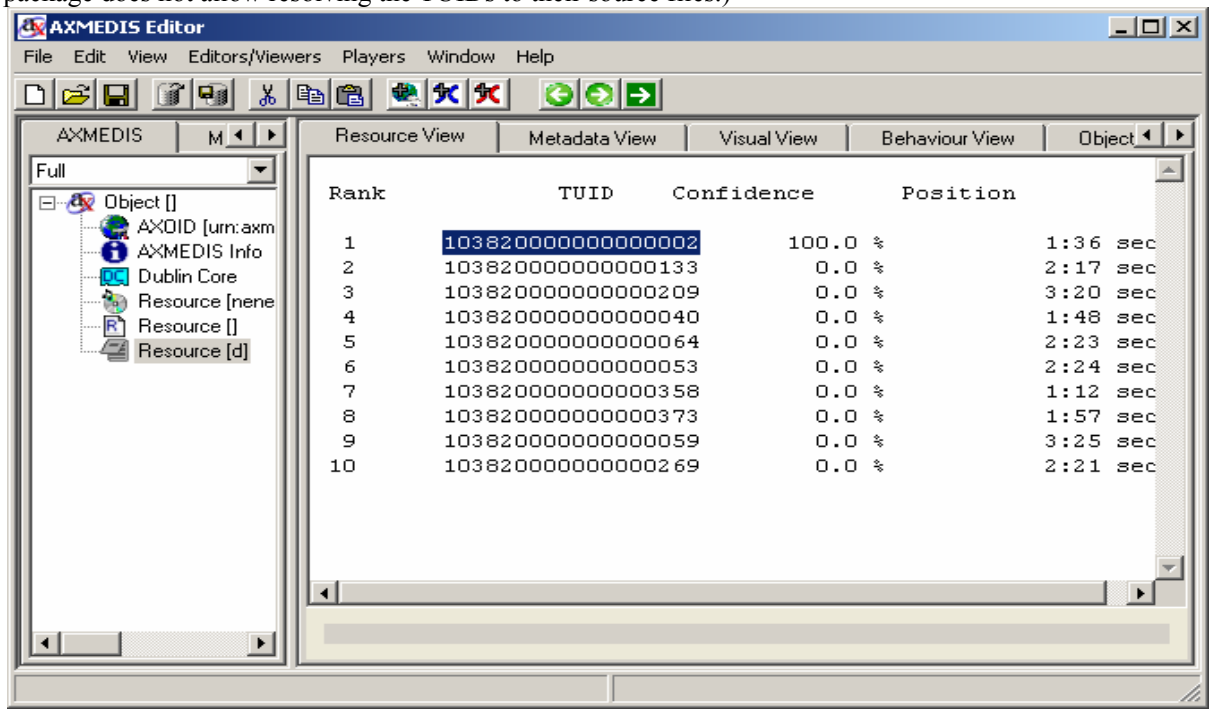
On the following window select a new resource as the output resource and provide the path to an existing database directory (containing at least 10 fingerprint files in it) and click on execute. If you want to see the console output of the extraction change the last parameter (showConsole) to "true".





The result value will show “Success!” if the comparison was performed without errors. Else an error message will display. The resulting resource will be a text file. Please edit its properties and add an arbitrary contentid. This prevents the AXEditor from crashing. This issue is soon to be fixed.

The matching TUID (Track unique ID) for the excerpt should be the ID: 103820000000000002 which belongs to the song “7 Seconds” by Neneh Cherry. (Unfortunately the provided binary demonstration package does not allow resolving the TUIDs to their source files.)



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11 Image Fingerprints (FHGIGD)

11.1 State Of The Art (completed)

Schneider and Chang proposed the first image fingerprinting methods [Schn96]. This method is based on image histograms. Its development aim was the authentication of digital content. Different methods have been proposed since then.

Methods that have been recently published try to increase the robustness of the calculated fingerprints by pre-processing the content before fingerprint calculations. These transformation can range from wavelet transforms, which simulate the human perception, to other complex mathematical transformation to increase the robustness of the calculated fingerprints against rotation, scaling and translation (R,S,T).

The so-called “soft hash algorithm” as proposed by Lefebvre and Macq [Lefe03] is based on the Radon transform and on Principal Component Analysis (PCA). The medium point of each projection is used as a fingerprint. An improved version was presented by Seo [Seo03].

A method that is based on image statistics was presented by Datta et al. [Datta03]. These pixel statistics are simple moments including area, extent, and eccentricity. They are calculated for image segments. Thus a region segmentation of the input image has to be calculated prior to the fingerprint calculation.

Lu et al. [Lu04] proposed a method inspired from the idea of Bas' method [Bas02], which is based on a feature-driven triangulation and which resistant to almost all geometric distortions introduced by Stirmark.

11.2 Problems (completed)

Methods based on image intensities like histogram based methods generally give good results. They depend on the intensity of the image. Thus they are sensitive against colour changes like grayscale reduction. Also, the effect of gaussian blur and lossy compression cannot be neglected practically.

Methods based on radon transform are based on search and energy modification for robustness against rotation and scaling. Also, the published methods don't provide keyed hash function, which is important for content authentication. In addition to that, the improved method by [Seo03] as well as in the original method [Lefe03] lack in the robustness of the fingerprint against geometrical modifications strongly depend on the limited invariance property of the Radon transform.

Methods based on image segmentation are influenced by operations affecting the segmentation. Thus, one can expect, that colour reduction as well as low- or high-pass filter operations affect the segmentation. In [Datta03] experimental results are not specified. This makes a comparison and evaluation difficult.

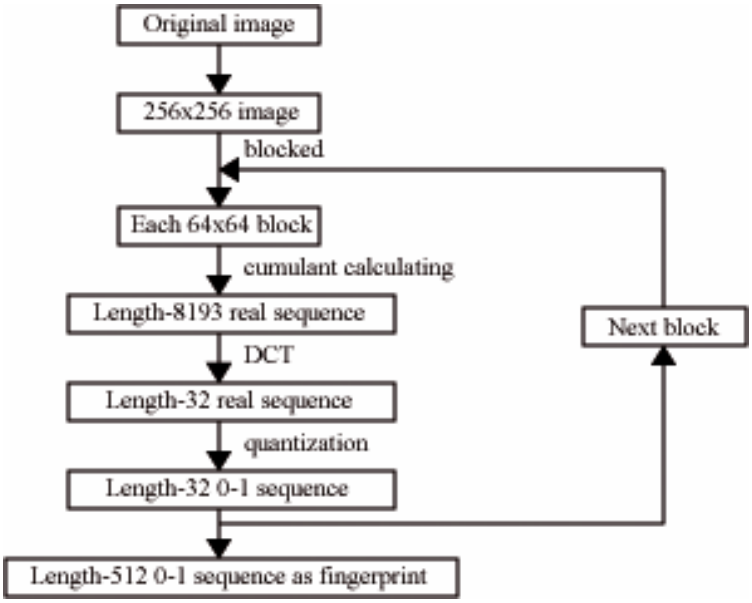
Methods based on image triangulation are influenced by operations affecting the triangulation. Geometrical attacks - especially cropping - cannot not well settled due to the destruction of mesh triangulation. In addition, problems can be foreseen with small sized images as robust mesh extraction is difficult.

11.3 Work Done

In general every audio fingerprinting system consists of an feature extraction and matching algorithm. The following sections describe the various building blocks of the audio fingerprint system developed by IGD.

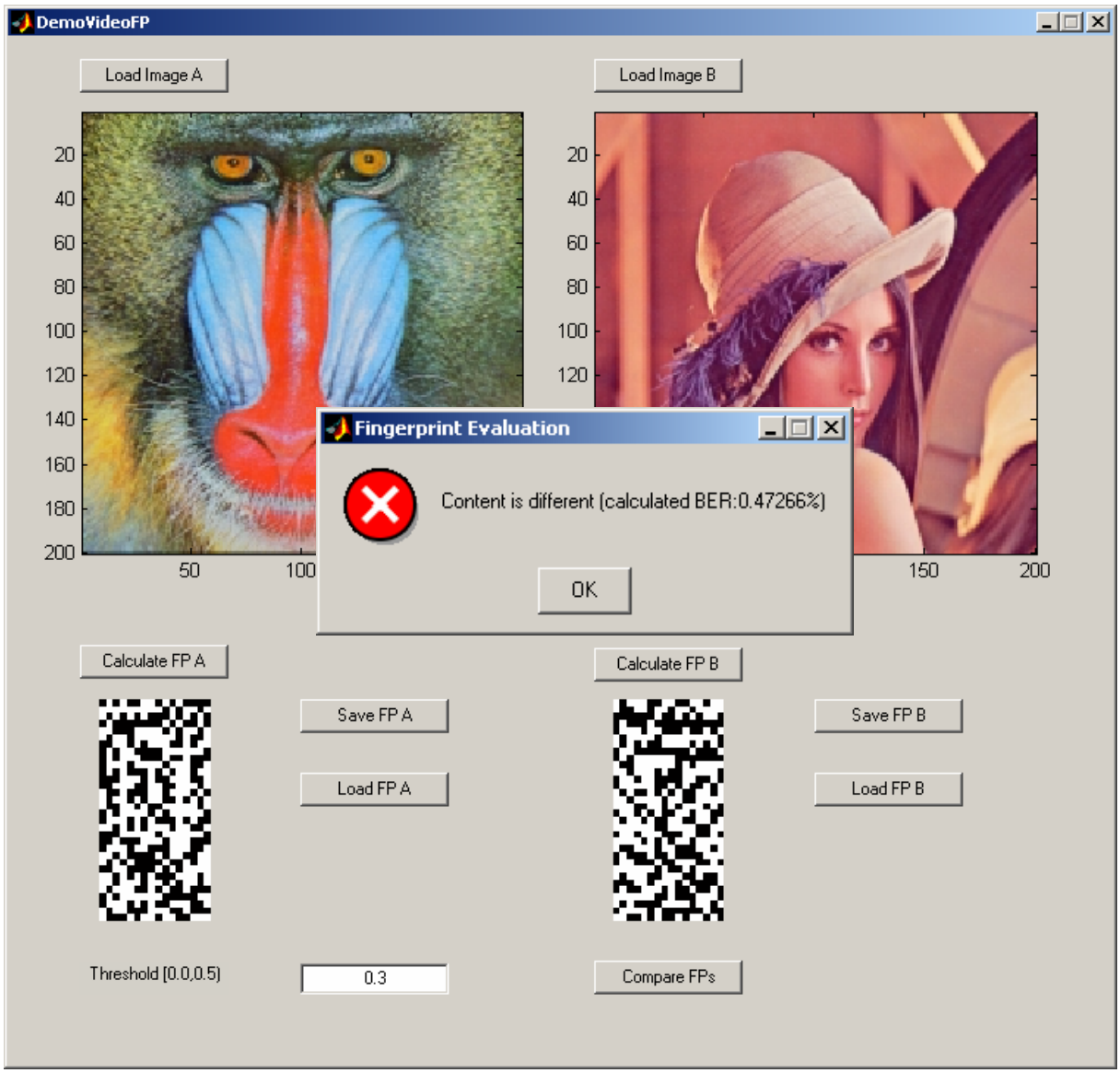
1. Identification of suitable features for the calculation of image fingerprints: The basic features are higher order statistics/moments: cumulants. Cumulants are often used in modern signal analysis. In some signal processing applications, moments provide some inherent advantage, especially when objects are assumed as Gaussian signals. However, many real world signals are not Gaussian signals and techniques used in traditional spectrum analysis are not longer adaptable. In these cases cumulants are introduced as a measure to evaluate the non-Gaussianity of a signal. Since cumulants are very stable even in noise-dominating environments, they are often taken as a method to extract the signal from noise.

2. Development and implementation of an image fingerprinting algorithm based on cumulants. The scheme of the developed algorithm is shown in the below. The original image is rescaled and tiled. For each tile the forth order statistics (cumulants) are calculated. These cumulants “summarize” the dependencies of four pixels in the individual tile/block. As cumulants are real values, the resulting real valued vector is binarized resulting in a 512 bit fingerprint that is characteristic for each image.



3. First analysis of the implemented algorithm: Based on the some internal test images the developed algorithm was analysed and its performance has been successfully compared with other state-of-the-art algorithms.

4. The implemented prototype functionality was integrated in a Graphical User Interface (GUI). This GUI allows an simple demonstration of the capabilities of the implemented algorithm.



Among the basic functionality that is required is the high order statistics analysis. This functionality has been implemented in C++ and tested to ensure the correctness of the results.

The implantation of the image fingerprint functionality is still ongoing.

11.4 References (completed)

[Schn96] M. Schneider and S. F. Chang, “A Robust Content Based Digital Signature for Image Authentication” , ICIP'96, IEEE, 1996

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12 Video Fingerprints (FHGIGD)

12.1 State of the Art (completed)

As the main characteristic of video is time-dependency, the general video fingerprinting architecture has much in common with the general audio fingerprinting architecture. The difference lies in the feature derived from the visual content. Two different approaches can be identified:

- Methods based on features which are based on very low-level features
- Methods based on features which have a

As described in [Caspi2004] only few methods consider the temporal structure of a video. Instead the extract key-frames form the video. For these key-frames the fingerprint is calculated.

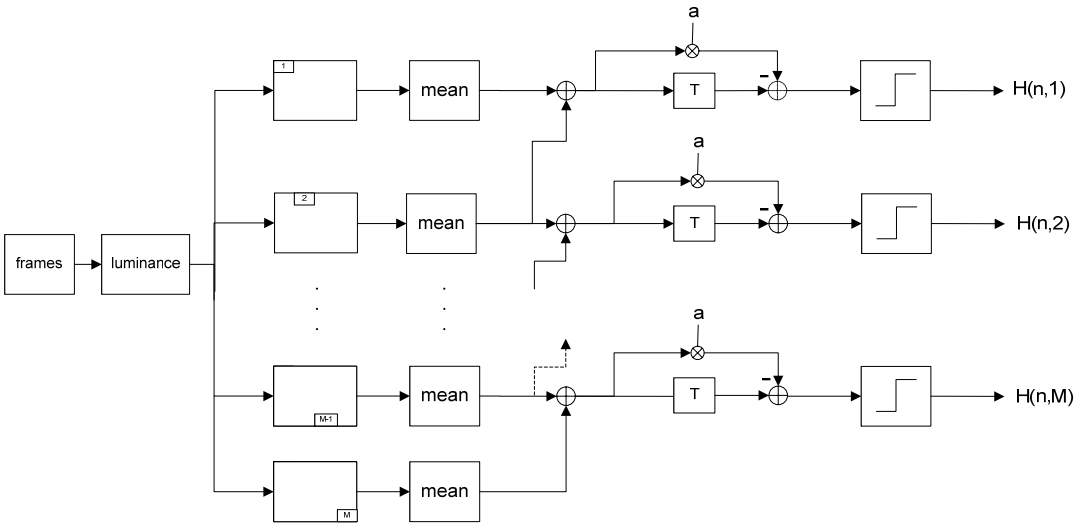
12.1.1 Video Fingerprints based on Frame Statistics

The method described in [Oost02] extracts the fingerprint in the spatial-temporal domain due to performance reasons: DCT and DFT are considered as complex and therefore costly operations. Thus, the algorithm is based on simple statistics, like mean and variance. These statistics are calculated in image regions.[2]

The algorithm is shown in **Errore. L'origine riferimento non è stata trovata.**. Different individual steps can be identified:

- For each frame the luminance is chosen for the calculation of the fingerprint. (This algorithm is not necessary restricted to the luminance channel).
- Each frame is divided into spatial blocks.
- For each spatial block the mean luminance is calculated.
- The spatial difference with a spatial neighbouring block is calculated.
- The temporal difference with the previous calculated block difference is calculated.
- The temporal difference is binarized and thus directly contributes to as a single bit to the fingerprinting vector.

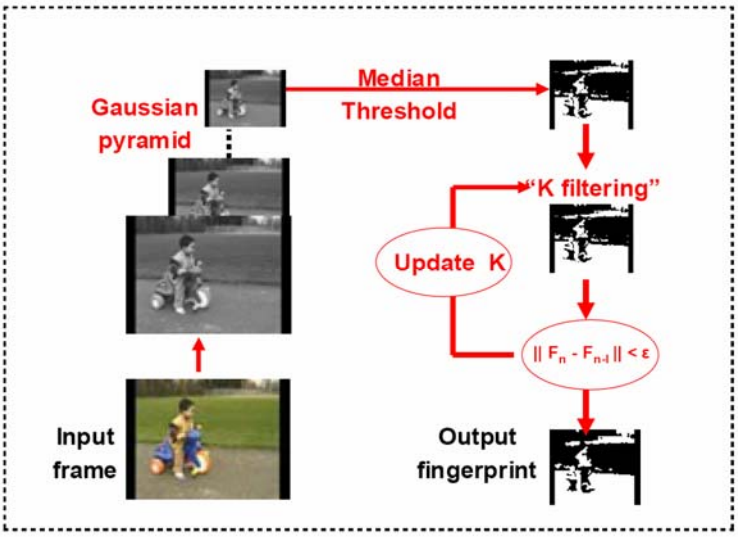
[2] In [Oost02] the authors explicitly state that the focus of this algorithm is on robustness and not on security.



For retrieval the same authors proposed an efficient data structure to speed up searching in databases. This data structure considers the temporal dependencies: A lookup-table (LUT) allows to identify the songs which potentially include the calculated fingerprint. A hypothesis test identifies or rejects the candidates by considering the temporal dependency of the video: For each song the consecutive fingerprints are stored.

Summarized, the previously described method considers spatio-temporal block differences. Other methods are proposed which are also based on the tiling of individual frames. The difference lies in the prposed features. For example, the method proposed in [Muce04] is based on simple statistics. It uses the characteristic variance maxima or minima positions in block.

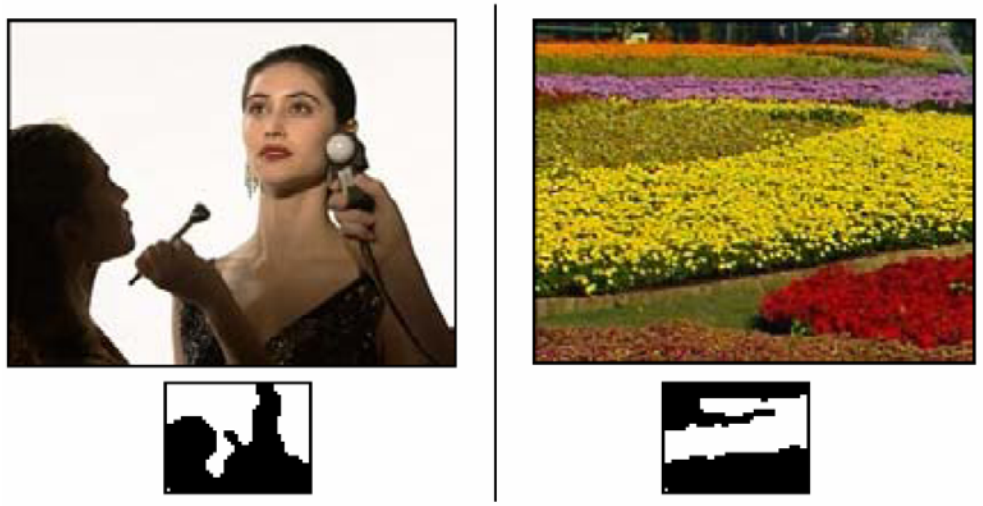
12.1.2 Video Fingerprints based on (Key) Frame Content



In contrast to the previously described methods, which consider temporal changes, there is a second class of identification algorithms, which are based on the content of key-frames.

For example, the algorithm proposed in [Caspi2004] is based on the intensities of key-frame. Key frames can be typical shot frames and partially extracted automatically [Hanj2002]. On this input frame a Gaussian pyramid is calculated (multi-scale representation). The low resolution is thresholded (binarised). To increase the robust of this method a so-called "k-filtering" based on morphological operations is iteratively applied until a equilibrium is reached.

The result of this process is a binary (two-dimensional) vector. This vector is the fingerprint (perceptual hash) corresponding to the key frame. An example of different resulting bit-representations is shown below.



In [Yang04] a so-called "locality sensitive hashing" (LSF) is proposed. The LSF hashing is based on approximate ε-nearest neighbour search. This solves the problem of similarity search.

12.2 Problems (completed)

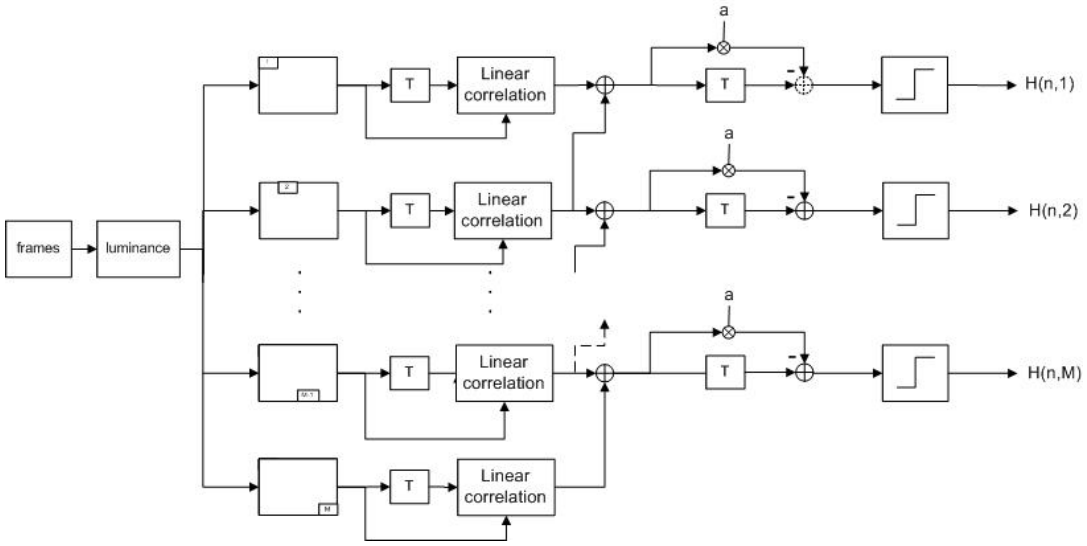
As for audio fingerprinting, the focus of existing video fingerprinting systems is on content identification. The application of content authentication/content verification has not been considered so far. Also, a detailed benchmarking of the fingerprinting system regarding verification is missing. The decision threshold during the verification step has to be evaluated regarding the acceptable distortion for different kind of video processing operations in the envisaged application scenario.

12.3 Work Done

In general every video fingerprinting system consists of a feature extraction and matching algorithm. The following sections describe the various building blocks of the video fingerprint system developed by FHGIGD.

- Identification of suitable features for the calculation of video fingerprints: The basic feature is the similarity between different blocks in consecutive frames. This temporal similarity sequences is chosen due to is discriminability.

- Development and implementation of a video fingerprinting algorithm based on the temporal block similarity sequence as shown in the next figure.



- First analysis of the implemented algorithm: Based on the some internal test images the developed algorithm was analysed and its performance has been successfully compared with other state-of-the-art algorithms.

- The implemented prototype functionality was integrated in a Graphical User Interface (GUI). This GUI allows an simple demonstration of the capabilities of the implemented algorithm.

- The prototype functionality was implemented in C++ and the implemented functions tested and compared with the prototype functionality.

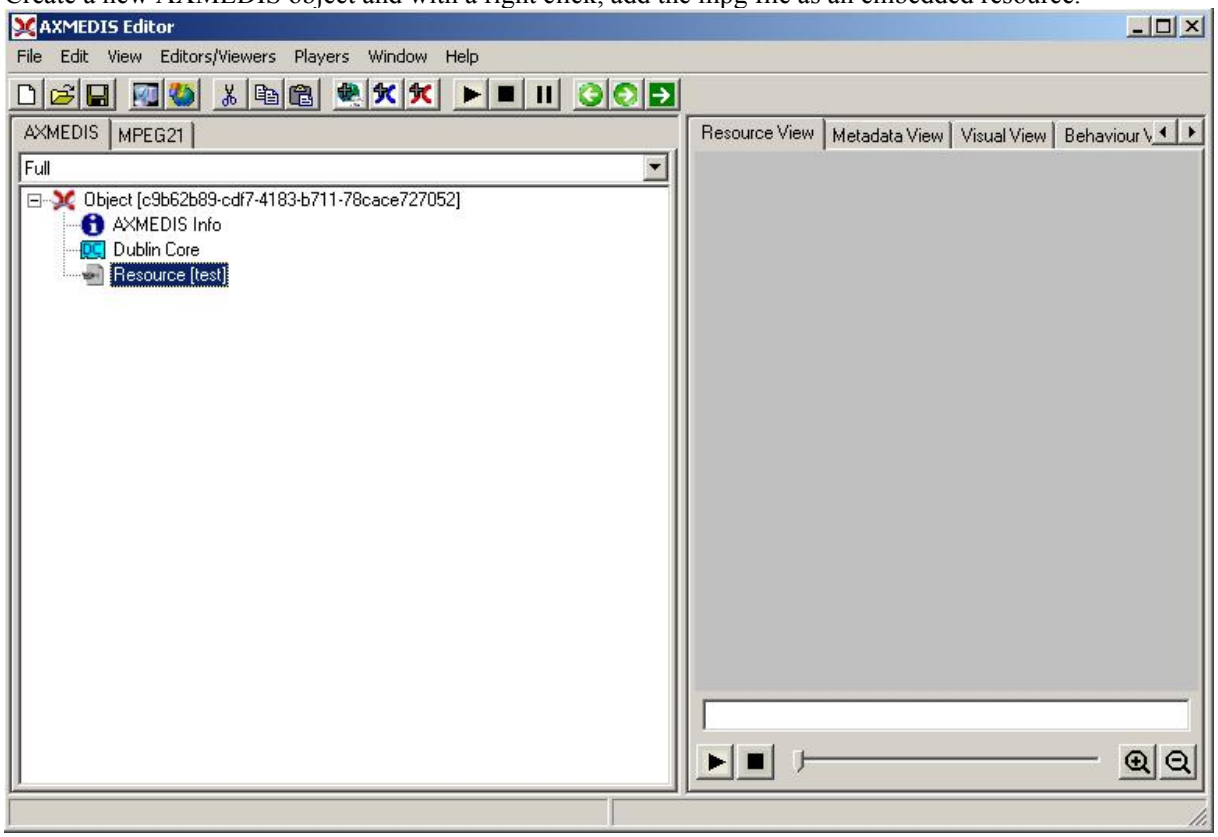
- The resulting video fingerprinting algorithm was integrated in a plugin and integrated and tested with the AXEditor.

- Research activities focused on combined spatial and temporal fingerprinting descriptors. A first prototype version was implemented that shows improved performance for slow moving video sequences.

12.4 PlugIn Description

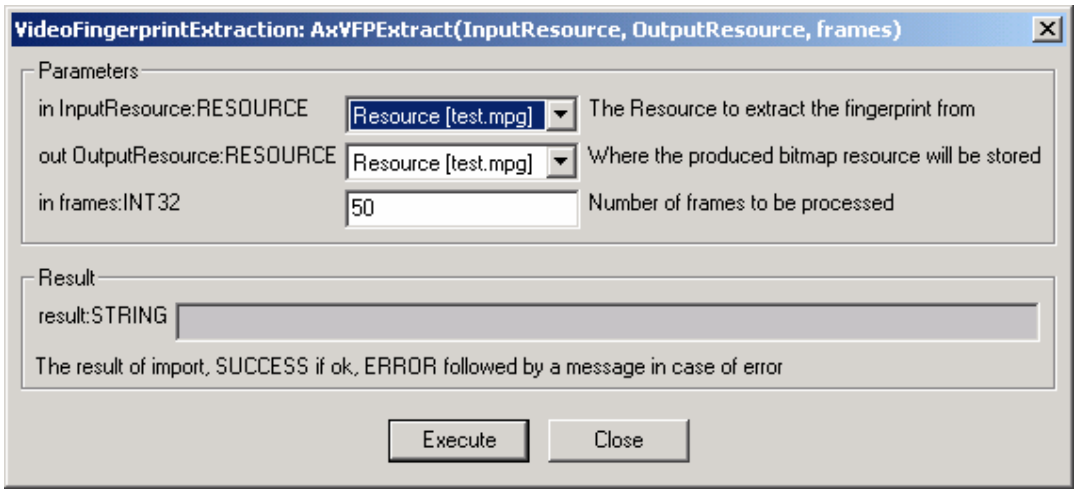
The plug-in can be applied to any video resources, provided this was declared in the mime type attribute of the resource. The output can be any mimetype within the image/* format. The **PNG** format is recommended. In the package there is a sample mpg file to do a test: <test.mpg>.

Create a new AXMEDIS object and with a right click, add the mpg file as an embedded resource.

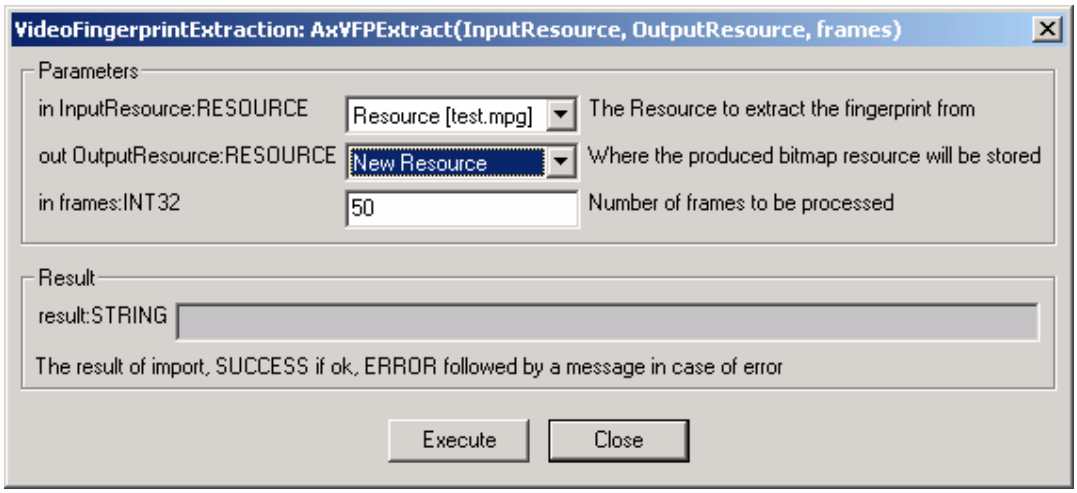


With a right Click on the resource, select 'Content Processing Plug-ins'. Then you should search for the option 'VideoFingerprintExtraction' and click execute.

After the selection, the following window should appear:

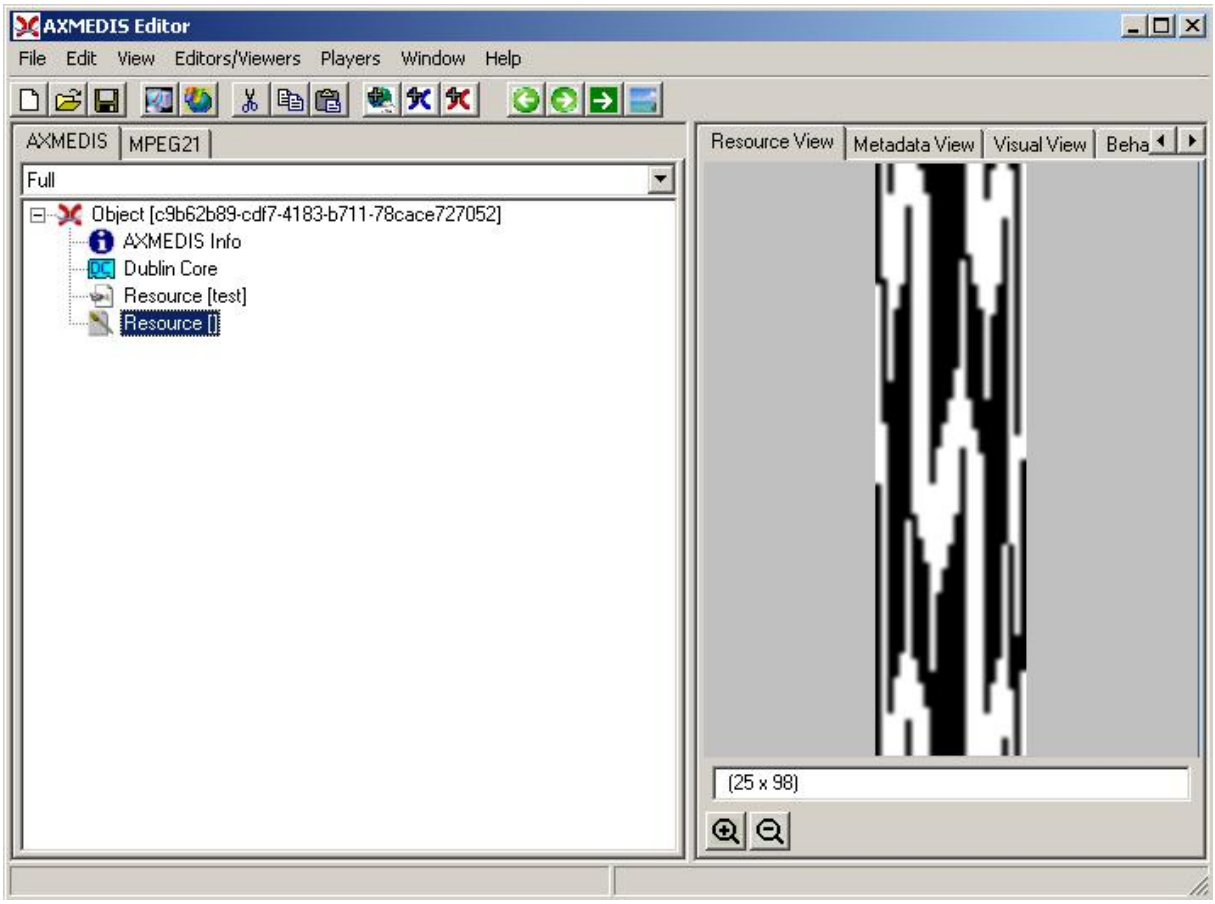


Make output a new resource, select the desired number of frames to be processed and click execute.



After receiving the 'success' message, close this window. You should have a new resource in the axmedis editor.

With a double click in the resource, the following graphical of the fingerprint will be showed:



12.5 References (completed)

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[Hanj2002] A. Hanjalic, “Shot-boundary detection:unraveled and resolved?,” *IEEE Trans. on CSVT*, vol. 12, no. 2, Feb. 02.

[Hamp2001] A. Hampapur and R. Bolle, “Comparison of Distance Measures for Video Copy Detection”, IBM Research Report, May 2001.

[Oost2001] J. Oostveen, A. Kalker, and J. Haitsma, "Visual Hashing of Digital Video: Applications and Techniques", *Proc. of SPIE applications of digital image processing 24*, July 2001, San Diego, USA.

[Oost2002] J. Oostveen, T. Kalker, and J. Haitsma, "Visual hashing of digital video: application and techniques," *SPIE*, 01.

13 Text Fingerprints (DIPITA)

13.1 State of the Art

Fingerprint estimation for textual contents aims to compare texts and estimate similarities among them. While the detection of exact copies through the comparison of the whole document checksums is simple and reliable, the detection of partial modifications is an harder task. Another point is to distinguish between fingerprinting procedures that: (a) are able to detect *resemblance* among documents; (b) are able to detect *containment* relationships among documents (Broder 1997).
As pointed out by Heintze (1996), the major topics to be considered in fingerprint estimation are:

- **stored fingerprint / processed fingerprint**. To the aim of comparing fingerprint values, we have to take in account a pair of fingerprints: the one extracted from the original file (and, in case, stored in a repository), the other extracted from the processed file that we have to compare with the original;
- **degree of similarity among documents**. The fingerprint must be usable to estimate the similarity (and containment) relations among documents, through a gradable scale;
- **fingerprint size**. The algorithm must take in account the fingerprints file-size with respect to the granularity of the analysis: since the fingerprint value derives from an hashing procedure on the textual information, the finer is the grain of the hash, the bigger is the size of the fingerprint file; it is needed to get a balance between these two opposite requirements;
- **fingerprint matching**. It involves the structure of the algorithm that match similarities among different fingerprints: linear comparison vs. cross comparison (with respect to the document structure and sub parts);
- **full fingerprint / selective fingerprint**. This topic is related with the two previous ones: calculating the full fingerprint of a document implies to get a large-size extracted file; the extraction of a selective fingerprint deal to the possibility of fine-grained matching task among documents (and their sub-parts).

13.1.1 General requirements

The main requirement to be satisfied by a fingerprint extractor is the independence from the file format. The main technique to solve this problem is to convert all the file formats to ASCII files. Reliable format-conversion libraries are required to assure us to get the same fingerprint value from the same text content given in different format.

As it emerges form the state of the art, fingerprint and copy-detection algorithms should satisfy these three further general requirements:

1. *White space / punctuation insensitivity:* In matching text files, matches should be unaffected by such things as extra white space, capitalization, punctuation, etc. this requirement may deal with some domain specific requirements of insensitiveness (for example, in matching software text it is desirable to make matching insensitive to variable names). Samples of treatment: white space and punctuation are removed,; all letters are converted to lower case; all variable names are replaced by one string

2. *Noise suppression:* Discovering short matches, such as the fact that the word *the* appears in two different documents, is uninteresting. Any match must be large enough to imply that the material has been copied and is not simply a common word or phrase of the language in which documents are written. This requirement deals with the choose of the *k* length of the *k*-grams (it has to be longer, in terms of number of characters, than the most common locution phrases).

3. *Position independence:* coarse-grained permutation of the contents of a document (e.g., scrambling the order of paragraphs) should not affect the set of discovered matches. Adding to a
document should not affect the set of matches in the original portion of the new document. Removing part of a document should not affect the set of matches in the portion that remains.

K-gram techniques

Most previous techniques used to extract fingerprints and detect partial copies make use of the *k-grams*, i.e. contiguous sub-strings of length *k*. the process require to divide a document into *k*-grams, and extract an hash value from each one. The result of this process is a fingerprint that represent the document in each of its sub-parts of length k.
As Karp and Rabin's (1987) algorithm for fast sub-string matching is apparently the earliest version of fingerprinting based on *k*-grams, the first scheme to apply fingerprinting to collections of documents was developed by Manber (1994). He exploited Karp-Rabin string matching and applied it to detecting similar files in file systems. Rather than having a single candidate string to search for, in this problem the aim is to compare all pairs of *k*-grams in the collection of documents.
As a matter of fact, the use of *k*-grams involves the creation of hashes value for each pattern of length *k*. In a document, there are almost as many *k*-grams as characters, as every position in the document marks the beginning of a *k*-gram (except for the last $k - 1$ positions).

Since there is a *k*-gram for every byte of an ASCII file, and at least 4-byte hashes are needed for most interesting data sets, a naive scheme that selected all hashed *k*-grams would create an index much larger than the original documents. This is impractical for large document sets, and the obvious next step is to select some subset of the hashes to represent each document.

Various techniques have been proposed to solve the problem of the fingerprint size and storage. The accuracy of the document fingerprint and of the comparison among different document fingerprints depends on the size-reduction parameters.
Heintze (1996) proposed to choose the *n* smallest hashes of all *k*-grams of a document as the fingerprints of that document. By fixing the number of hashes per document, the system would be more scalable as large documents have the same number of fingerprints as small documents.
The price for a fixed-size fingerprint set is that only near-copies of entire documents could be detected. Documents of vastly different size could not be meaningfully compared, with the lack of detection of *containment* relationship among documents.
In Schleimer, Wilkerson and Aiken (2003) the authors propose an innovative method (the *winnowing* algorithm) to solve the problem of fingerprint size and *k*-grams selection.

Other techniques in comparing document

Instead of using *k*-grams, the strings to fingerprint can be chosen by looking for sentences or paragraphs, or by choosing fixed-length strings that begin with "anchor" words [Brin et al.]. Recently, a system for document similarity detection has develop by the DANCER team, based on a two stage architecture (step 1: chunk similarities detection; step 2: document similarity detection) with a specific a linguistic insight within the analysis (Mandreoli et al. 2003).

13.1.2 Document comparison and plagiarism detection initiatives

Turnitin

http://www.turnitin.com/static/home.html
Recognized worldwide as the standard in online plagiarism prevention, Turnitin helps educators and students take full advantage of the Internet's educational potential. Used by thousands of institutions in over fifty countries, Turnitin's products promote originality in student work, improve student writing and research skills, encourage collaborative learning, and save valuable instructor time. The system is based on the *document source analysis* techniques developed by a team of researcher at UC Berkley.

Koala

http://www-2.cs.cmu.edu/afs/cs/user/nch/www/koala-info.html
Most pieces of research writing evolve over a period of time. Different versions of document are published or otherwise made available at various stages along this process. The purpose of the KDF system is to trace the history of a document by identifying common segments of text between documents. Typical uses of the system include:

- **finding citations:** you have an draft version of a document and want to know where it was eventually published
- **tracing references:** you have a conference abstract and want to know if there is a revised or journal version of the article.
- **tracing plagiarism:** you have a paper and want to check whether it has been previously published in whole or part
    - by the same authors.
    - by different authors.

Document searches proceed in a number of steps. First the document (URL) is loaded by the KDF server. If necessary, the document is converted to a textual representation. Then, using this text, a fingerprint of the document is generated. Finally, this fingerprint is matched against the current document fingerprint database to find related documents.

WCopyFind

http://plagiarism.phys.virginia.edu/Wsoftware.html
This opensource program examines a collection of document files. It extracts the text portions of those documents and looks through them for matching words in phrases of a specified minimum length. When it finds two files that share enough words in those phrases, WCopyfind generates html report files. These reports contain the document text with the matching phrases underlined.

1. WCopyfind 2.4 can compare news services for shared headlines or content.
2. WCopyfind 2.4 can find which words are most common in the news.
3. WCopyfind 2.4 can look for lobbiest language appearing directly in finished legislation.
4. WCopyfind 2.4 can list and count the matching words between two documents.

It cannot search the web or internet to find matching documents for you. You must specify which documents it compares. Those documents can be local ones—on your computer or a file server—or, with versions 2.1 and higher, web-resident documents that are pointed to by local internet shortcuts. If you suspect that a particular web page has been copied, you must create an internet shortcut to that page and include this shortcut in the collection of documents that you give to WCopyfind.
Sourcecodes given in Microsoft Visual C++.Net language.

EVE2 (Essay Verification Engine)

http://www.canexus.com/eve/index.shtml
Eve performs a large number of complex searches to find material from any Internet site. While it would be technically impossible with today's technology to build a program that could check every web site on the entire Internet, EVE2 comes as close as possible by employing the most advanced searching tools available to locate suspect sites. Not only does it find these suspect sites, but it then does a direct comparison of the submitted essay to the text appearing on the suspect site. If it finds evidence of plagiarism, the URL is recorded. Once the search has completed, the teacher is given a full report on each paper that contained plagiarism, including the percent of the essay plagiarized, and an annotated copy of the paper showing all plagiarism highlighted in red.

Moss

http://www.cs.berkeley.edu/~aiken/moss.html
Moss (for a Measure Of Software Similarity) is an automatic system for determining the similarity of C, C++, Java, Pascal, Ada, ML, Lisp, or Scheme programs. To date, the main application of Moss has been in detecting plagiarism in programming classes. Since its development in 1994, Moss has been very effective in

this role. The algorithm behind Moss is a significant improvement over other cheating detection algorithms (at least, over those known to us).

13.2 Problems

Fingerprint for the content of a textual file is at present a puzzling task. The state of the art does not provide us even with a reliable procedure to ensure even the exact matching of fingerprints derived from documents with same content in different format, that in principle should be the easiest case.

Solution:
Given this, the strategy of document comparison must ensure at least the possibility to evaluate the degree of similarity between texts.
In the AXMEDIS framework, similarity evaluation is a method enabling the identification of plagiarism at the textual level. Through the Content fingerprint and similarity estimation a provider can assess the degree of similarity of a given texts with those stored in the repository.

13.3 Work Performed

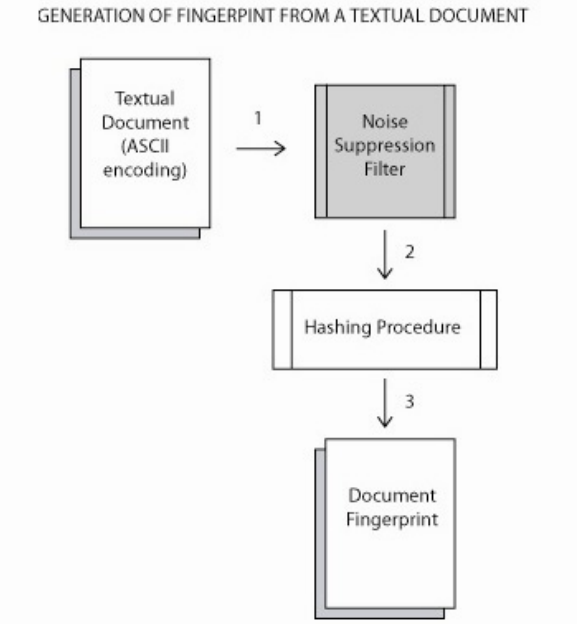
Given the fore mentioned problems we developed a plugin which is also able to return a degree of similarity between documents. The text fingerprints plug-in aim is twofold, it provides a way of calculating a fingerprint value of the documents provided as input, moreover it provides functionalities for similarity estimation between two documents without making prior assumptions on the language.

The text fingerprint plug-in output will be a string in which the value is stored.

Moreover the document comparison functionality also implemented in the plug-in will give as a result a normalized floating point value representing the degree of similarity between two given input documents.

A) Generation of fingerprint from a textual document

Given a plain text file (ASCII encoding), the content fingerprint is generated through the following steps:
1. Noise Suppression Filter (pre-processing that aims to eliminate or convert problematic characters: suppression of blank spaces, paragraphs, punctuation, characters out of the ASCII-standard encoding); vowels may be eliminated, taking into account only consonant sequences; all letters are converted to lower case.
2. Hashing Procedure: k-gram hashing algorithm (dimension of k-grams has to be over a certain threshold, that ensure to consider significant portion of text, over the common locution phrases). Reliable hashing algorithms to be taken into account for this purpose are described in Heintze 1996 and Schleimer et el. 2003.
3. Document Fingerprint: output of the hash.

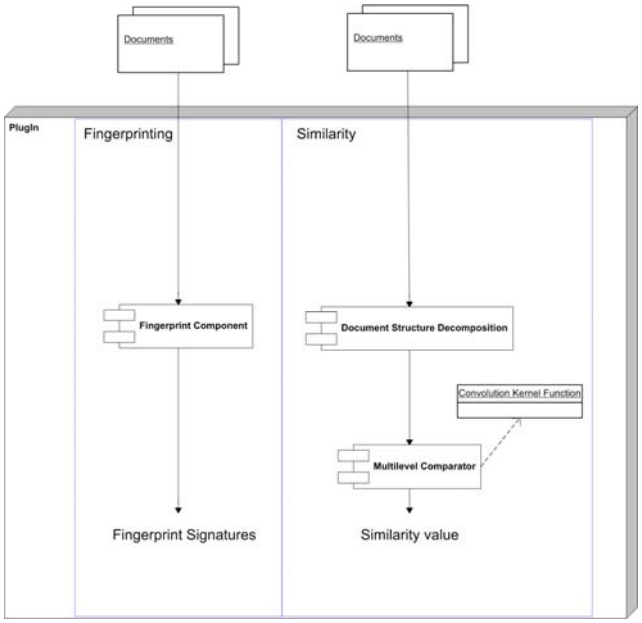


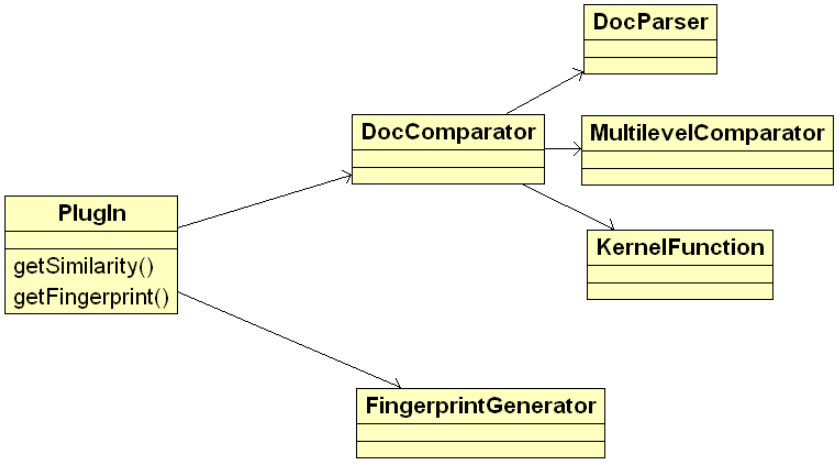
B) Document comparison

For similarity comparison a plug-in specifical function is provided. This functionality could be exploited by several use cases including: identification of content from a sub part or when the different formats comparison is not straightforward, plagiarism detection and so on. The algorithm allows for robust multilevel comparison of documents taking into account document structure. At any level of structure the same convolutional kernel function is used, which allows for approximate matching of subcomponents (sentence, paragraph etc.). The convolutional kernel function takes into account the plagiarist behaviour (Deletion, Insertion, Substitution) through a decay function.

For what concerns fingerprint it has to be said that in MPEG-7 this kind of meta-information (for verification of the text documents) is not consider so far. Within AXMEDIS it has to be identified, how cryptographic hash values can be integrated best into MPEG-7 and the relationship with MPEG-21.

Module Design in terms of Classes





13.4 References

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Heintze, N. (1996), Scalable document fingerprinting. In *1996 USENIX Workshop on Electronic Commerce*.

Karp, R. M., Rabin M. O. (1987), Pattern-matching algorithms. *IBM Journal of Research and Development, 31(2)*.

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Mandreoli, F., Martoglia, R. Tiberio, P. (2003), Un metodo per il riconoscimento di duplicati in collezioni di documenti.

Schleimer, S., Wilkerson, D. S., Aiken, A. (2003), Windowing: Local Algorithms for Document Fingerprinting. In *Proceedings of the ACM SIGMOD Conference, 2003*.

14 Any Digital Media Types (FHGIGD)

14.1 State of the Art (completed)

14.1.1 MD5

The MD5 algorithm is a cryptographic *one-way hash function* which means that it operates on an arbitrary-length message and returns a fixed-length *hash value*, sometimes called the *message digest* (therefore MD) which is a condensed representation of the *hashed* message and can hence be looked at as a fingerprint of that message.

MD5 is an improved version of MD4, designed by Ronald L Rivest of MIT. Since some parts of the MD4 algorithm had successfully been attacked Rivest strengthend MD4 resulting in MD5. Although more complex than MD4, it is similar in design and also produces a 128-bit hash value.

In general, the one-wayness of one-way hash functions is realized by using a *compression function* which is itself a one-way function. It outputs a hash value of length n given an input of some larger length m, namely a block of a message and the ouput of the previous call of the compression function (last hash value). That is, the message is divided into blocks which are then sequentially processed by using the compression function of the algorithm. The result of each call of this function is then the *updated hash* which is the hash value of all blocks of the message up to that point. In case the length of the message is not a multiple of the block length, the message has to be padded by appending bits in a prespecified way. The message is then referred to as *padded message* while messages before any addition of padding bits are referred to as *original messages*.

In general, cryptographic one-way hash functions have the following characteristics:

1. Given a message, it is easy to compute its hash value.
2. Given a hash value it is hard to compute the message.
3. Given a message, it is hard to find another message which hashes to the same value.
4. It is hard to find two random messages which hash to the same value.

The last point is not a characteristic of one-wayness, but it is an absolute requirement, when the hash function is used along with a signature algorithm to compute a digital signature. It is called *collision-resistance*. A hash algorithm which meets all requirements listed here may then be called *secure* or a *cryptographic* one-way hash function. (See [2] for more information about how a birthday attack can successfully be applied on a hash algorithm which is not collision-resistant.) Since MD5 is intended to be used in digital signature applications, it requires to be collision-resistant. In [1] this requirement is claimed to be met by the algorithm.

It is conjectured that it is computationally infeasible to produce two messages having the same message digest, or to produce any message having a given prespecified target message digest. 1em — [1]

This is point 4 and 3 respectively of the characteristics mentioned above. Here it is *conjectured* that the algorithm is collision-resistant since this property depends first on the length of the computed hash value in bits (which should be sufficient even today since it is $128\ bit$) and second, the security of the compression function since it is assumed that the hash algorithm is secure as long as there is no known successful attack against its compression function. Therefore the conjecture was ok at the time the RFC was written. But

unfortunately, meanwhile the compression function of MD5 can no longer be considered as being collision-resistant.
A more successful attack by den Boer and Bosselaers produces collisions using the compression function in MD5. ... It does mean that one of the basic design principles of MD5 – to design a collision-resistant compression function – has been violated. — [2]
Although some people assume that this weakness of the compression function has *no practical impact* on the security of MD5, hash algorithms like SHA-1 should be used instead of MD5 whenever possible. Additionaly the SHA-1 provides a security of $2^80\ bits$ against birthday attacks.

14.1.2 SHA-1

NIST, along with the NSA, designed the Secure Hash Algorithm (SHA/SHA-1) which is used in the Secure Hash Standard (SHS). The SHA-1 is specified in FIPS PUB 180-1 ([3]).
According to this publication:
This standard specifies a Secure Hash Algorithm (SHA-1) which can be used to generate a condensed representation of a message called a message digest. The SHA-1 is required for use with the Digital Signature Algorithm (DSA) as specified in the Digital Signature Standard (DSS) and whenever a secure hash algorithm is required for federal applications. The SHA-1 is used by both the transmitter and intended receiver of a message in computing and verifying a digital signature.— [3]
Although this module is named *C_SHA*, it is an implementation of the SHA-1 algorithm which is an updated version of the original SHA. Both, the SHA and the SHA-1 are cryptographic one-way hash functions which means that they operate on an arbitrary-length message and return a fixed-length *hash value*, sometimes called the *message digest*. Additionally, one-way hash functions have the following characteristics:

5. Given a message, it is easy to compute its hash value.
6. Given a hash value it is hard to compute the message.
7. Given a message, it is hard to find another message which hashes to the same value.
8. It is hard to find two random messages which hash to the same value.

The last point is not a characteristic of one-wayness, but it is a very useful characteristic of any hash function. It is called *collision-resistance*. Collision-resistance is an absolute requirement, when the hash function is used along with a signature algorithm to compute a digital signature. See [2] for more information.
These requirements given by point one to four are met by the SHA-1 algorithm:
The SHA-1 is called secure because it is computationally infeasible to find a message which corresponds to a given message digest, or to find two different messages which produce the same message digest. Any change to a message in transit will, with very high probability, result in a different message digest, and the signature will fail to verify. — [3]
The standard of the SHA-1 algorithm, the SHS also explains why the message digest is used by the DSA algorithm rather then the original message. It also specifies the maximum length of that message and the length of its message digest.
When a message of any $length < 2^{64}\ bits$ *is input, the SHA-1 produces a 160-bit output called a message digest. The message digest can then be input to the Digital Signature Algorithm (DSA) which generates or verifies the signature for the message. Signing the message digest rather than the message often improves the efficiency of the process because the message digest is usually much smaller in size than the message. The same hash algorithm must be used by the verifier of a digital signature as was used by the creator of the digital signature.* — [3]

14.2 Problems

In the last months, several new attacks on cryptographic hashing algorithms have been published. These attacks have strong implications on the security of the available cryptographic hashing algorithms. As a consequence existing risk analyses have to be revised carefully and consider recent attacks.

For MD5-hash functions Xiao Yun Wang's discovery [Wang04] proves that in theory some commonly used encryption algorithms including MD5 are not secure. Similarly, attacks on SHA-1 from the same author

together with other colleagues showed also weaknesses in this commonly used cryptographic hash algorithm. Although research is looking for alternatives, a short-term solution is not in sight.

SHA-1 is nevertheless considered to be valid till 2009. Within AXMEDIS, new developments and insights have to be considered carefully. Due to the modular design and the plug-in interface new algorithms can be integrated easily.

14.3 Work performed

So far, the first algorithms have been integrated and tested extensively using regression tests, including:

../Framework/source/fingerprint/general_resource/crypto/AXM_Digest/AXM_Digest.c
../Framework/source/fingerprint/general_resource/crypto/AXM_MD5/AXM_MD5.c
../Framework/source/fingerprint/general_resource/crypto/AXM_SHA/AXM_SHA.c
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_Digest/AXM_TestDigest.h
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_Digest/AXM_TestDigest_ErrorsHarnesses.h
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_Digest/AXM_TestDigest_HashFile.c
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_Digest/AXM_TestDigest_PreCondVfctn.c
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_MD5/AXM_ErrorsTestMD5.h
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_MD5/AXM_TestMD5.h
../Framework/source/fingerprint/general_resource/tests/crypto/AXM_MD5/AXM_TestMD5_TestAll.c
../Framework/source/fingerprint/general_resource/tests/tools/AXM_ToolLib/AXM_AsciiBinary_Test.c
../Framework/source/fingerprint/general_resource/tests/tools/AXM_ToolLib/AXM_AsciiBinary_Test.h
../Framework/source/fingerprint/general_resource/tools/AXM_TestOutput/AXM_TestOutput.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_AsciiBinary.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_Base64.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_CmdLine.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_EnDeCode.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_Error.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_File.c
../Framework/source/fingerprint/general_resource/tools/AXM_ToolLib/AXM_Trace.c

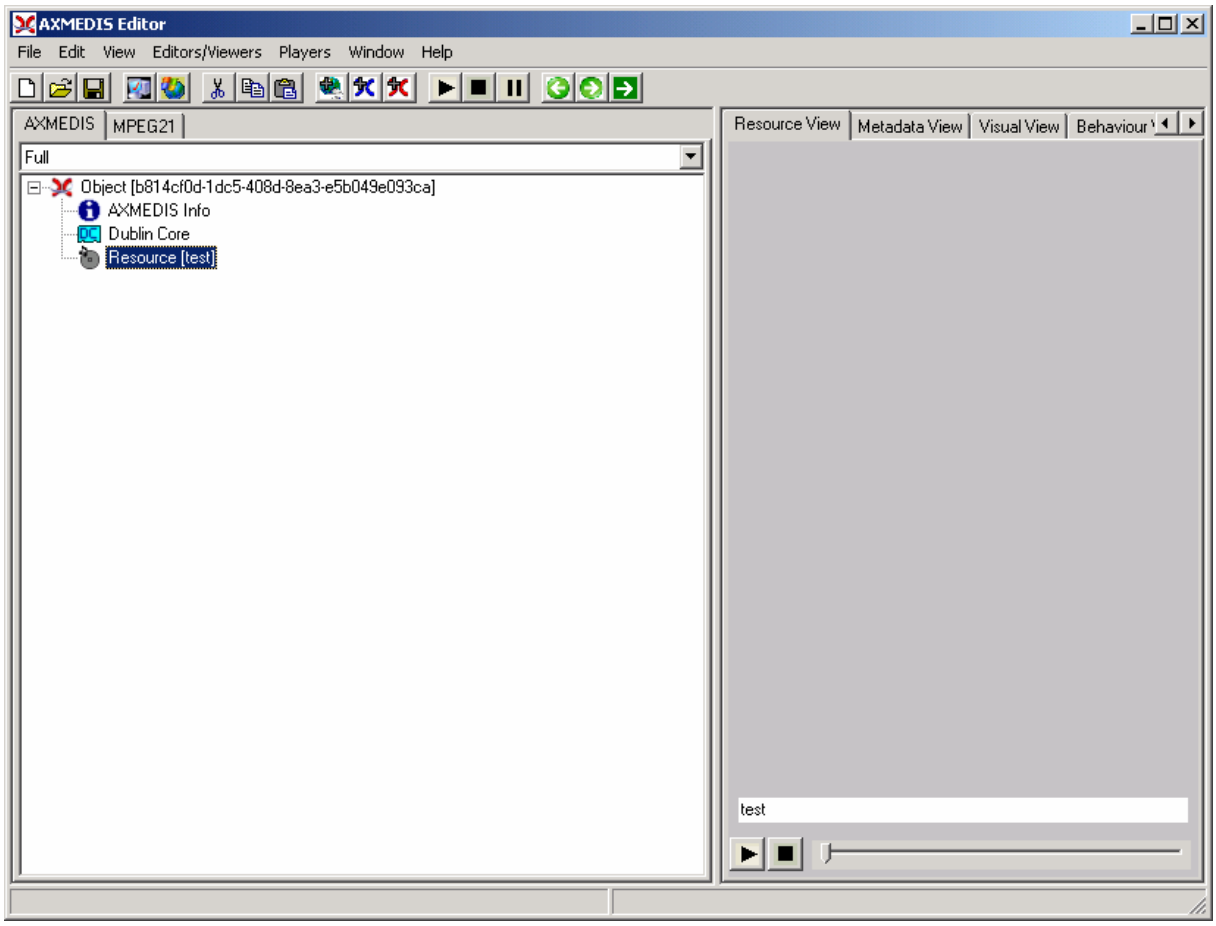
The complete source code is available in the AXMEDIS version control system (see above paths).

The plugin has been implemented, integrated and tested. A user manual has been created.

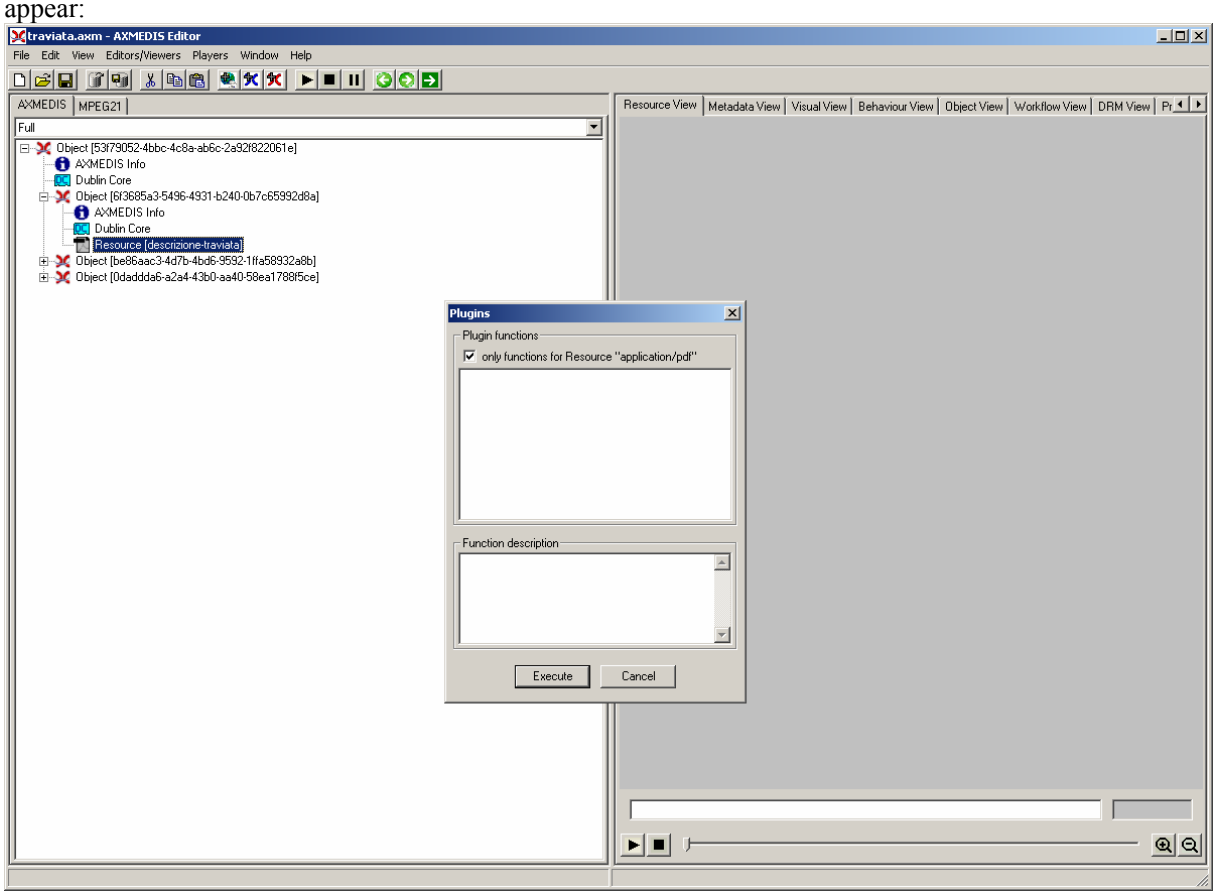
14.4 PlugIn Description

The plug-in can be applied to any content type. The output is a string. In the package there is a test file: test.pdf.

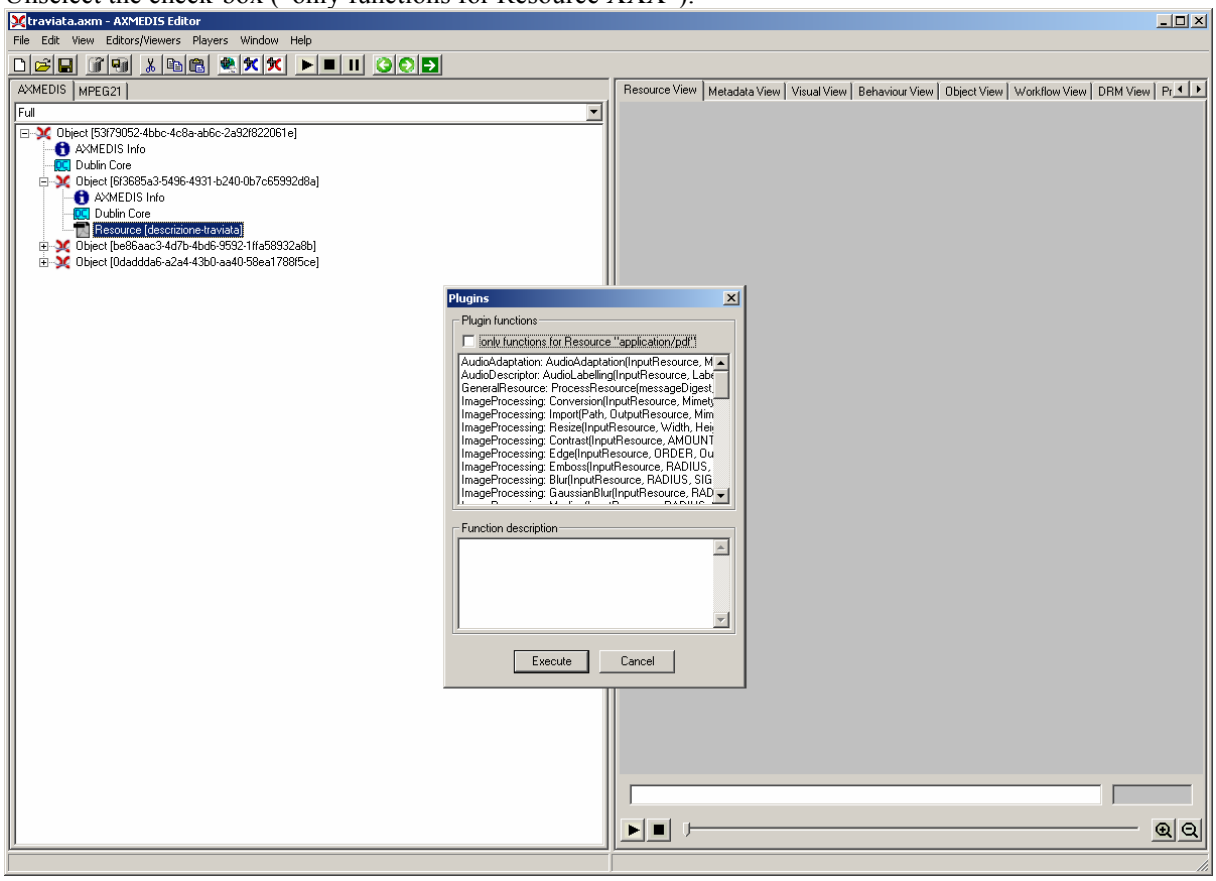
Create a new AXMEDIS object and add the wav file as an embedded resource.


AXMEDIS Editor
File Edit View Editors/Viewers Players Window Help
AXMEDIS MPEG21
Full
Object [b814cf0d-1dc5-408d-8ea3-e5b049e093ca]
AXMEDIS Info
Dublin Core
Resource [test]
Resource View
Metadata View
Visual View
Behaviour
test

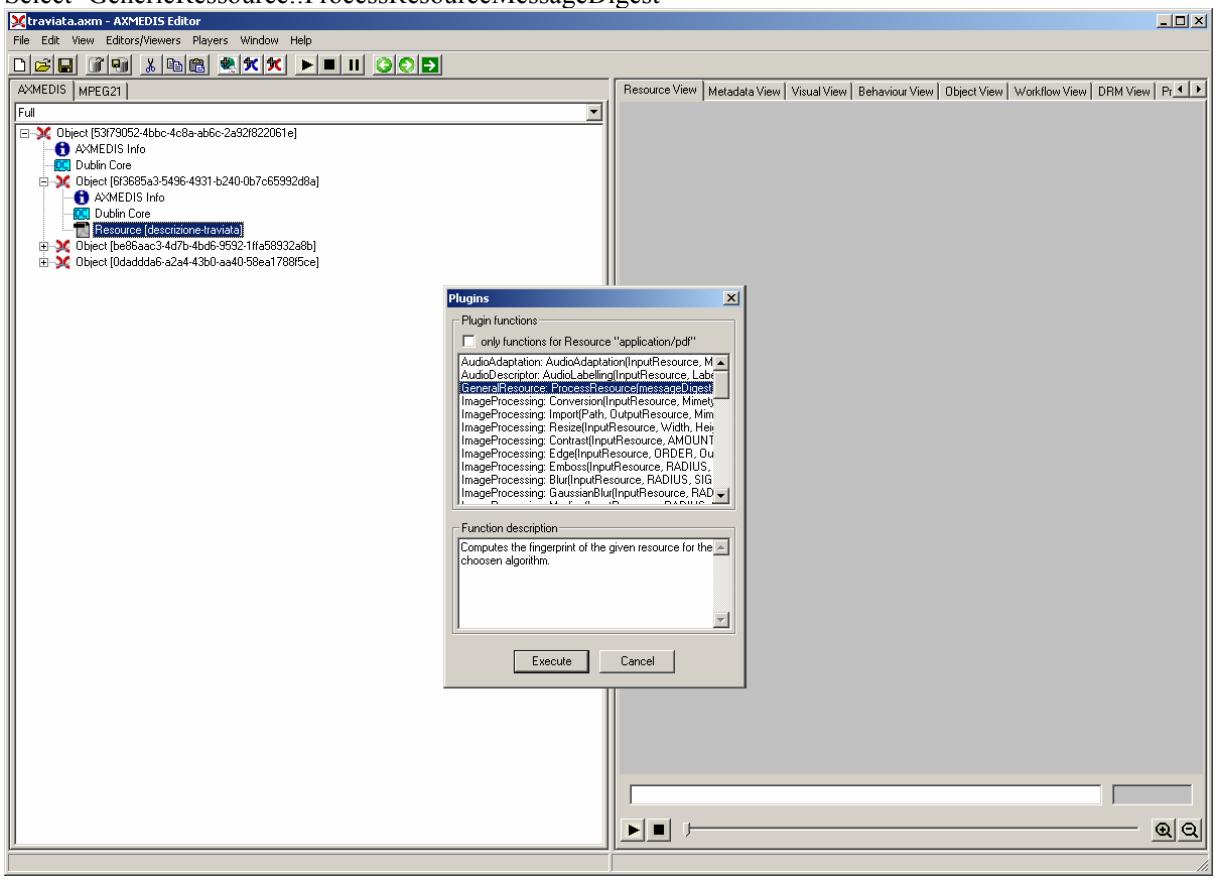
Right Click on the resource and select ‘Content Processing Plug-ins’. The following window should appear:



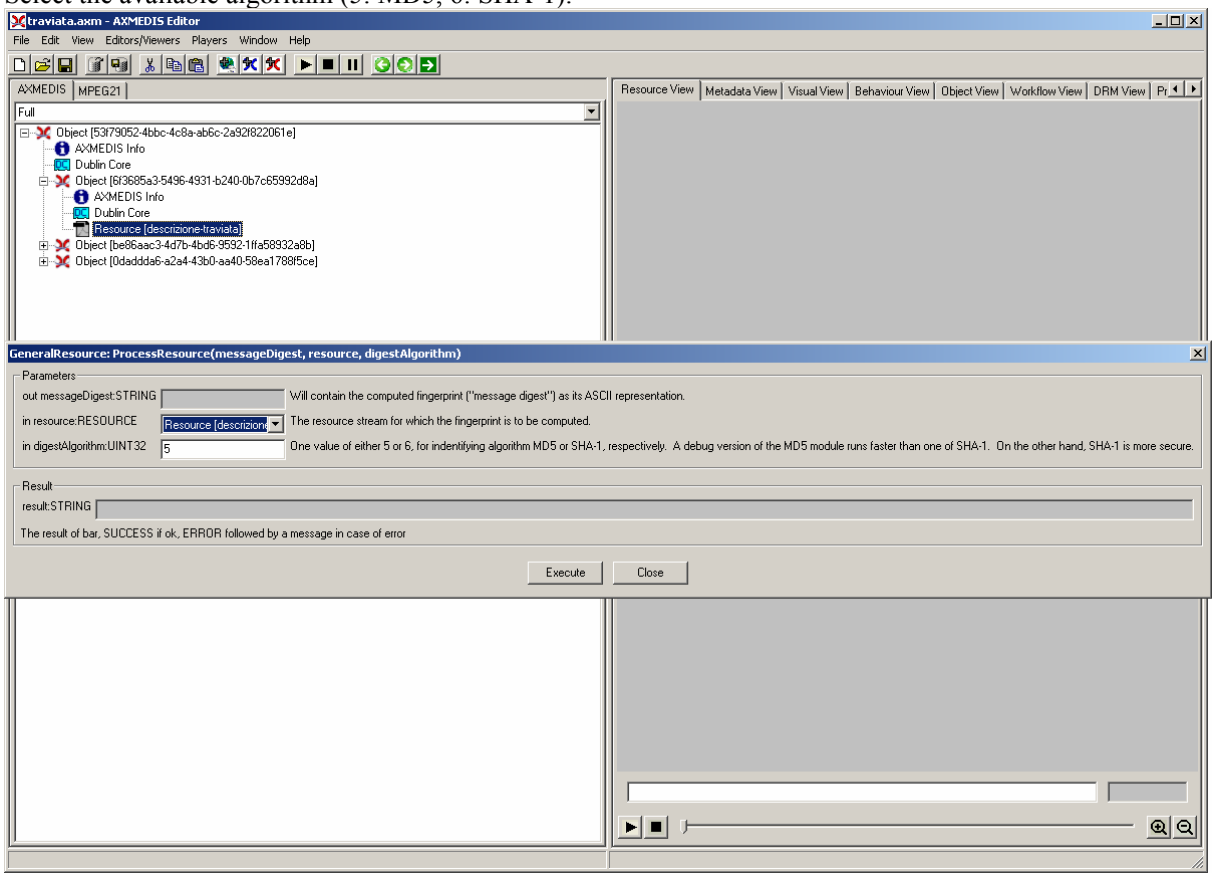
Unselect the check-box (“only functions for Resource XXX”):



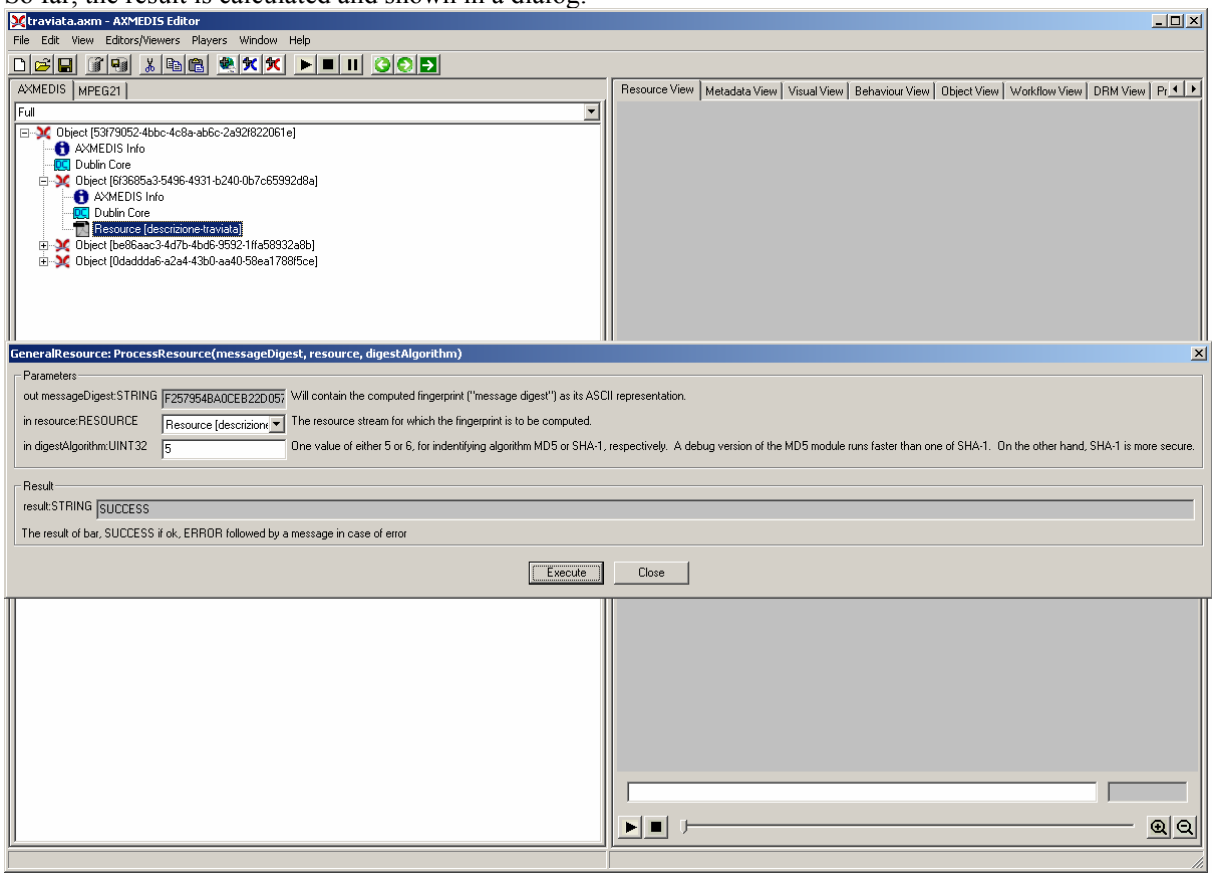
Select ‘GenericRessource::ProcessResourceMessageDigest’



Select the available algorithm (5: MD5, 6: SHA-1):



So far, the result is calculated and shown in a dialog:



14.5 References (completed)

[1] Ronald L. Rivest. *RFC 1321: The MD5 Message-Digest Algorithm*. The Internet Engineering Task Force (IETF), Status: Informational edition, April 1992.

[2] Bruce Schneier. *Applied Cryptography (Second Edition)*. John Wiley & Sons, Second Edition edition, 1996.

[3] National Institute of Standards and Technology. *FIPS PUB 180-1: Secure Hash Standard*. Gaithersburg,

15 Query Support in the AXMEDIS Database (EXITECH)

The query support is a combination of query mechanisms for retrieving content objects among the indexed information, in the AXMEDIS database (for content processing, composition, formatting, etc.), on the P2P AXEPTool, on the content collector referencing the content contained in the CMSs (Crawled Results Integrated Database). From the AXMEDIS database interface it has to be possible to make valid queries for all the environments and read unified results. From the AXEPTool or from the Collector the queries can be performed only on their environment.

The query support allows the specification of technical/professional query including metadata, technical information, business and licensing aspects, content based, DRM rules, etc.

The query Support Web Service Interface communicate with the backend of the AXDB for gathering information directly on the object stored in the AXMEDIS database, while access via a web service interface to the crawling system and to the AXEPTOOL. The web service interface and therefore the WSDL offered by the AXEPTOOL and by the Crawling system must be the same as that offered by Query Support in order to have a unique format for data exchanging.

The Query User Interface access via web service to the Query support in order to send query and gather information.

15.1 State of the Art (completed)

There is nothing in the literature about this model since it has been developed specifically for AXMEDIS. The state of the art is discussed directly in this document commenting the Query Support for the AXDB.

15.2 Problems (completed)

The main problems related to the translation of a query on the AXDB are related to the presence of optional fields and of translation of fields that compel to have a very complex structure in terms of equivalent SQL query.
Another principal problem is related to the complexity of the resulting query that contains a lot of JOINS over all the tables that are considered in the query.
The third aspect to be considered is related to the distribution of queries towards the database of licenses and PAR and the related unification of results.

15.3 Work Performed

The work performed is mainly related to the solution of the cited problems in terms of automatic translation of queries minimizing the number of joins and using inner joins instead of outer joins to minimize the complexity of the resulting query.
The other aspects are mainly related to the mapping of metadata and to the definition of a query language independent of the different languages that can be adopted inside the project.

15.3.1 General overview of the work performed

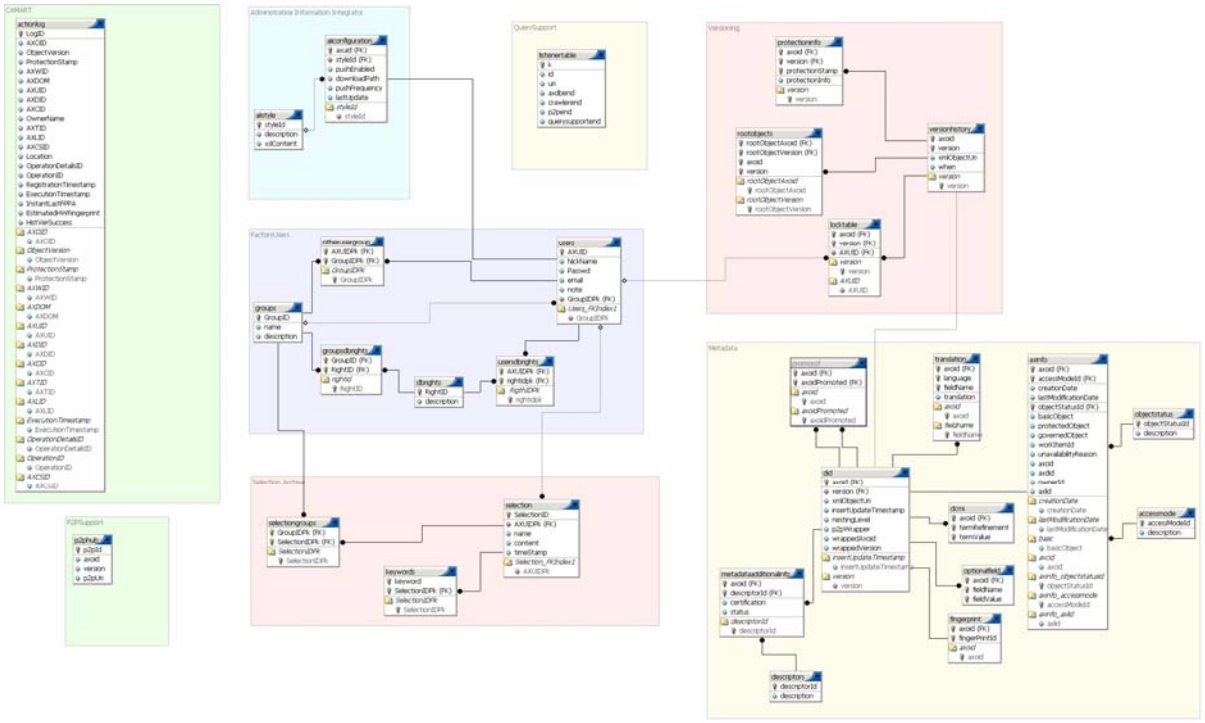
In the following a general description of the work performed in this period has been summarized together with the percentages of completion with respect to functionalities; 100% means that the functionality is present completely, but some refinement should be needed and maintenance is always performed.

- AXMEDIS OBJECTS REPOSITORY RELATION SCHEMA
  - OK 100%
- DESCRIPTORS METADATA MAPPING IN RELATIONAL SCHEMA
  - OK 100%
- ACCOUNT LOG FOR AXMEDIS OBJECTS REPOSITORY
  - OK 100%
- DATABASE SCHEMA FOR SUPPORTING AXMEDIS
  - OK 100%
- AXMEDIS DATABASE INTERFACE
  - OK, 100%, apart form some issue that will emerge in the new P2P activities after CRS4 has abandoned the project and therefore some new requests can arise from HEXAGLOBE (DSI subcontractor).
- AXMEDIS DATABASE WEBSERVICE INTERFACE
  - Descriptor_Support
    - OK, 1st prototype ready (100%)
  - Publication_Support
    - OK, 1st prototype ready (100%)
  - User_Support
    - OK, 1st prototype ready (100%)
  - AXDBQuerySupport
    - OK, 100%
  - P2PHubNode
    - Deprecated, since requested from CRS4
- AXMEDIS ADMINISTRATIVE WEB DATABASE INTERFACE
  - OK, 90%, some refinement to be performed yet.
- AXMEDIS OBJECT LOADER/SAVER
  - Loader:

        - OK, 100%
    - Saver
        - OK, 90%. Second prototype that works with the new AXOM model has been provided and posted and we are in the optimization phase for the concurrent access to the service.
- HISTORY OF AXMEDIS OBJECTS EVOLUTION IN PRODUCTION REPOSITORY (EXITECH, FUPF)
    - OK, 100%.
- QUERY AND SELECTION ARCHIVE FOR EACH USER (EXITECH, DSI, HP, XIM, IRC)
    - OK, 100%, integrated with quesry support for actualization of Selections.
- QUERY SUPPORT WEB SERVICE INTERFACE (EXITECH)
    - OK, 100%
- QUERY DISTRIBUTION (EXITECH)
    - OK, 100%
- QUERY RESULTS INTEGRATION (EXITECH)
    - OK, 100%

15.3.2 Data model incl. meta data selection and mapping

With respect to the previous version of this deliverable, several changes have been made on database. These changes have been documented in the DE 3.1.2.2.9. Some additional tables will be added in order to develop the Query Web Interface that was originally in charge to CRS4 and then assigned to EXITECH.
The following schema is the AXDB schema really implemented and running under the services that will be detailed in the following.



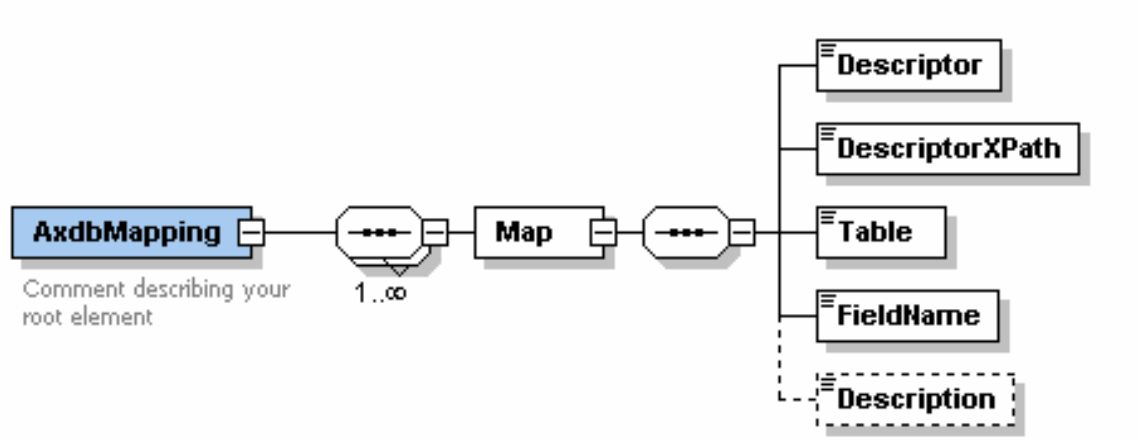
Over this database structure some major functionalities have been implemented:

- **`authenticateUser`**: verifies if a user is authenticated with a password for performing a certain operation
- **`deleteObjectVersion`**: allows the elimination of one version or all versions of an object
- **`getAxobj`**: allows to obtain from an axoid, the Did representation of an object.

- **`getModifiedAxoidAfter`**: returns a list of AXOIDs that have been modified after a certain timestamp given as input parameter.
- **`getObjectURI`**: returns the URI of the object/version passed as in parameters
- **`getUserIdFromNick`**: returns the userId (axuid) associated to the given nickname
- **`listAvailableVersion`**: allows to get th numbers of all the available versions of an object

Other functionalities implemented are related to the web services that are related to the database.
Implemented web services, which details can be found in the specification document DE 3.2.1.2.9.

The main aspect related to the metadata mapping is related to the fact that each company can have inside the factory a different mapping of the metadata of the AXMEDIS object inside the AXDB. This fact compels us to add a mapping mechanism to associate each database field to an Xpath inside the AXMEDIS object. The same Xpath must be present in the queries in order to identify univocally the desired field.
The data model identified
The format proposed for the mapping has to consider the descriptor where the record is (only for reference), the full path of the item to be found inside the object and the name of the table and of the field that is wanted in the AXDB.
In the case of OptionalFields, the fieldname will be used as a record of the table as for all the other 1 to n relationship in ER model.
The schema for this representation is reported in the following schema, using XPath for describing the fullPath in the DecriptorXPath tag:



The textual version of the schema follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2005 sp1 U (http://www.xmlspy.com) by Fabrizio Fioravanti (Exitech) -->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
	<!--version 1.4 of 21/04/2006 -->
	<xs:element name="AxdbMapping">
		<xs:annotation>
			<xs:documentation>Comment describing your root element</xs:documentation>
		</xs:annotation>
		<xs:complexType>
			<xs:sequence maxOccurs="unbounded">
				<xs:element name="Map">
					<xs:complexType>
						<xs:sequence>
							<xs:element name="Descriptor">
								<xs:complexType>
									<xs:simpleContent>
```

```
                                                                    <xs:extension base="xs:string">
                                                                        <xs:attribute
name="alias" type="xs:string" default="tns"/>
                                                                    </xs:extension>
                                                                </xs:simpleContent>
                                                            </xs:complexType>
                                                        </xs:element>
                                                        <xs:element name="DescriptorXPath" type="xs:string"/>
                                                        <xs:element name="Table" type="xs:string"/>
                                                        <xs:element name="FieldName" type="xs:string"/>
                                                        <xs:element name="Description" minOccurs="0"/>
                                                    </xs:sequence>
                                                </xs:complexType>
                                            </xs:element>
                                        </xs:sequence>
                                    </xs:complexType>
                                </xs:element>
</xs:schema>
```

In the following example file, it is reported a complex example of a db mapping file that covers different aspects of query and saving.

```
<?xml version="1.0" encoding="UTF-8" ?>
<AxdbMapping xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="axdb-mapping-v-
1-4.xsd">
        <Map>
                <Descriptor alias="axoid_gg">DCMI</Descriptor>
                <DescriptorXPath>format_medium</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>format_medium</FieldName>
                <Description>Medium Format</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>contributor</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>contributor</FieldName>
                <Description>Contributor</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>coverage</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>coverage</FieldName>
                <Description>Coverage</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>coverage_spatial</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>coverage_spatial</FieldName>
                <Description>Spatial Coverage</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>coverage_temporal</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>coverage_temporal</FieldName>
                <Description>Temporal Coverage</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>creator</DescriptorXPath>
                <Table>dcmi</Table>
```

```
            <FieldName>creator</FieldName>
            <Description>Creator</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date</FieldName>
            <Description>Date</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_available</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_available</FieldName>
            <Description>Available Date</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_created</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_created</FieldName>
            <Description>Created Date</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_dateAccepted</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_dateAccepted</FieldName>
            <Description>Date Accepted</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_dateCopyrighted</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_dateCopyrighted</FieldName>
            <Description>Date Copyrighted</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_dateSubmitted</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_dateSubmitted</FieldName>
            <Description>Date Submitted</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_issued</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_issued</FieldName>
            <Description>Date Issued</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_modified</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_modified</FieldName>
            <Description>Date Modified</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>date_valid</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>date_valid</FieldName>
            <Description>Date Valid</Description>
```

```
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>description</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>description</FieldName>
                <Description>Description</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>description_abstract</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>description_abstract</FieldName>
                <Description>Abstract</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>description_tableOfContents</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>description_tableOfContents</FieldName>
                <Description>Table of Contents</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>format</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>format</FieldName>
                <Description>Format</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>format_extent</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>format_extent</FieldName>
                <Description>Format Extent</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>format_medium</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>format_medium</FieldName>
                <Description>Medium Format</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>identifier</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>identifier</FieldName>
                <Description>Identifier</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>identifier_bibliographicCitation</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>identifier_bibliographicCitation</FieldName>
                <Description>Bibliographic Citation</Description>
        </Map>
        <Map>
                <Descriptor>DCMI</Descriptor>
                <DescriptorXPath>language</DescriptorXPath>
                <Table>dcmi</Table>
                <FieldName>language</FieldName>
                <Description>Language</Description>
        </Map>
        <Map>
```

```
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>publisher</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>publisher</FieldName>
            <Description>Publisher</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation</FieldName>
            <Description>Relation</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_conformsTo</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_conformsTo</FieldName>
            <Description>Conforms To</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_hasFormat</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_hasFormat</FieldName>
            <Description>Has Format</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_hasPart</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_hasPart</FieldName>
            <Description>Has Part</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_hasVersion</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_hasVersion</FieldName>
            <Description>Has Version</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isFormatOf</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_isFormatOf</FieldName>
            <Description>Is Format Of</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isPartOf</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_isPartOf</FieldName>
            <Description>Is Part Of</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isReferencedBy</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_isReferencedBy</FieldName>
            <Description>Is Referenced By</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isReplacedBy</DescriptorXPath>
```

```
            <Table>dcmi</Table>
            <FieldName>relation_isReplacedBy</FieldName>
            <Description>Is Replaced By</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isRequiredBy</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_isRequiredBy</FieldName>
            <Description>Is Required By</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_isVersionOf</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_isVersionOf</FieldName>
            <Description>Is Version Of</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_references</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_references</FieldName>
            <Description>References</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_replaces</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_replaces</FieldName>
            <Description>Replaces</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>relation_requires</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>relation_requires</FieldName>
            <Description>Requires</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>rights</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>rights</FieldName>
            <Description>Rights</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>rights_accessRights</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>rights_accessRights</FieldName>
            <Description>Access Rights</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>rights_license</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>rights_license</FieldName>
            <Description>License</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>source</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>source</FieldName>
```

```
            <Description>Source</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>subject</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>subject</FieldName>
            <Description>Subject</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>title</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>title</FieldName>
            <Description>Title</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>title_alternative</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>title_alternative</FieldName>
            <Description>Alternative Title</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>type</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>type</FieldName>
            <Description>Type</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>accrualMethod</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>accrualMethod</FieldName>
            <Description>Accrual Method</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>accrualPeriodicity</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>accrualPeriodicity</FieldName>
            <Description>Accrual Periodicity</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>accrualPolicy</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>accrualPolicy</FieldName>
            <Description>Accrual Policy</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>audience</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>audience</FieldName>
            <Description>Audience</Description>
        </Map>
        <Map>
            <Descriptor>DCMI</Descriptor>
            <DescriptorXPath>audience_educationLevel</DescriptorXPath>
            <Table>dcmi</Table>
            <FieldName>audience_educationLevel</FieldName>
            <Description>Education Level</Description>
        </Map>
```

```
<Map>
        <Descriptor>DCMI</Descriptor>
        <DescriptorXPath>audience_mediator</DescriptorXPath>
        <Table>dcmi</Table>
        <FieldName>audience_mediator</FieldName>
        <Description>Mediator</Description>
</Map>
<Map>
        <Descriptor>DCMI</Descriptor>
        <DescriptorXPath>instructionalMethod</DescriptorXPath>
        <Table>dcmi</Table>
        <FieldName>instructionalMethod</FieldName>
        <Description>Instructional Method</Description>
</Map>
<Map>
        <Descriptor>DCMI</Descriptor>
        <DescriptorXPath>provenance</DescriptorXPath>
        <Table>dcmi</Table>
        <FieldName>provenance</FieldName>
        <Description>Provenance</Description>
</Map>
<Map>
        <Descriptor>DCMI</Descriptor>
        <DescriptorXPath>rightsHolder</DescriptorXPath>
        <Table>dcmi</Table>
        <FieldName>rightsHolder</FieldName>
        <Description>Rights Holder</Description>
</Map>
<Map>
        <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
        <DescriptorXPath>nms:prevdown/nms:bitrate</DescriptorXPath>
        <Table>optionalfield</Table>
        <FieldName>prevdown/bitrate</FieldName>
        <Description>Download BitRate</Description>
</Map>
<Map>
        <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
        <DescriptorXPath>nms:prevdown/nms:height</DescriptorXPath>
        <Table>optionalfield</Table>
        <FieldName>prevdown/height</FieldName>
        <Description>Download Height</Description>
</Map>
<Map>
        <Descriptor alias="nms">http://schema.wisesoft.org/WiseCms</Descriptor>
        <DescriptorXPath>nms:prevdown/nms:name</DescriptorXPath>
        <Table>optionalfield</Table>
        <FieldName>prevdown/name</FieldName>
        <Description>Download Name</Description>
</Map>
<Map>
        <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
        <DescriptorXPath>nms:prevdown/nms:size</DescriptorXPath>
        <Table>optionalfield</Table>
        <FieldName>prevdown/size</FieldName>
        <Description>Download Size</Description>
</Map>
<Map>
        <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
        <DescriptorXPath>nms:prevdown/nms:url</DescriptorXPath>
        <Table>optionalfield</Table>
        <FieldName>prevdown/url</FieldName>
        <Description>Download Url</Description>
</Map>
<Map>
        <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
```

```
            <DescriptorXPath>nms:prevdown/nms:width</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevdown/width</FieldName>
            <Description>Download Width</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:bitrate</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/bitrate</FieldName>
            <Description>Stream Bitrate</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:heigh</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/heigh</FieldName>
            <Description>Stream Height</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:name</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/name</FieldName>
            <Description>Stream Name</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:size</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/size</FieldName>
            <Description>Stream Size</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:url</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/url</FieldName>
            <Description>Stream Url</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:prevstream/nms:width</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>prevstream/width</FieldName>
            <Description>Stream Width</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:bitrate</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videostream/bitrate</FieldName>
            <Description>Video Stream BitRate</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:height</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videostream/height</FieldName>
            <Description>Video Stream Height</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:name</DescriptorXPath>
            <Table>optionalfield</Table>
```

```
            <FieldName>videostream/name</FieldName>
            <Description>Video Stream Name</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:size</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videostream/size</FieldName>
            <Description>Video Stream Size</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:url</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videostream/url</FieldName>
            <Description>Video Stream Url</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videostream/nms:width</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videostream/width</FieldName>
            <Description>Video Stream Width</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:bitrate</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/bitrate</FieldName>
            <Description>Video Download BitRate</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:height</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/height</FieldName>
            <Description>Video Download Height</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:name</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/name</FieldName>
            <Description>Video Download Name</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:size</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/size</FieldName>
            <Description>Video Download Size</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:url</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/url</FieldName>
            <Description>Video Download Url</Description>
        </Map>
        <Map>
            <Descriptor>http://schema.wisesoft.org/WiseCms</Descriptor>
            <DescriptorXPath>nms:videodown/nms:width</DescriptorXPath>
            <Table>optionalfield</Table>
            <FieldName>videodown/width</FieldName>
            <Description>Video Download Width</Description>
```

```
        </Map>
</AxdbMapping>
```

15.3.3 Query description language formalisation (including metadata, technical information, business and licensing aspects, content based, DRM rules, etc)

In this section the general schema for representing an AXMEDIS query is reported and commented.
The schema of the query is mainly composed by three parts. In the first part the location on which the query has to be distributed is reported, in the second parts a list of fields that the query should give as the result is contained and in the third and final part, the conditions under which a query has to be executed are imposed.
The three different parts are separately commented after the textual and graphic representation of the Query schema in sections

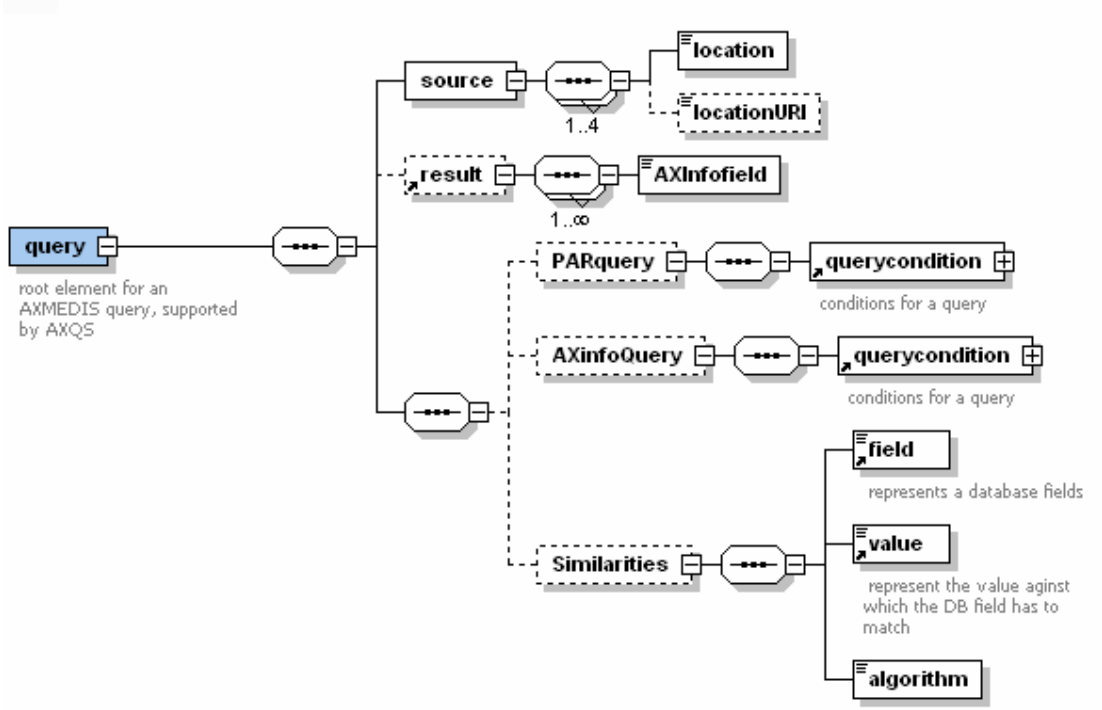
The proposed schema is reported below, in text format and in a more fashionable graphic format that cen be useful to have a general overview.

According to the last revision of the query model and of the way in which query can be submitted by the user, it can be noted that user performs queries on Descriptors and PAR/InternalPar for obtaining a list of results that satisfy the criteria. The DRM part is managed in a second step of the query, where from the licence DB, all the user that have a licence to sell a licence to the user according to the PAR limitation imposed, are automatically extracted, so that the user the performed the query can select the most appropriate to its needs. For these reasons the limitation on DRM that were present in the previous query model have been removed, moving this functionality to the automatic generation of a list of possible licensors.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
        <xs:element name="result">
                <xs:complexType>
                        <xs:sequence maxOccurs="unbounded">
                                <xs:element name="AXInfofield" type="xs:string"/>
                        </xs:sequence>
                </xs:complexType>
        </xs:element>
        <xs:element name="query">
                <xs:annotation>
                        <xs:documentation>root element for an AXMEDIS query, supported by AXQS</xs:documentation>
                </xs:annotation>
                <xs:complexType>
                        <xs:sequence>
                                <xs:element name="source">
                                        <xs:complexType>
                                                <xs:sequence maxOccurs="4">
                                                        <xs:element name="location">
                                                                <xs:simpleType>
                                                                        <xs:restriction base="xs:string">
                                                                                <xs:enumeration
value="CRAWLER"/>
                                                                                <xs:enumeration
value="AXEPTOOL"/>
                                                                                <xs:enumeration value="AXDB"/>
                                                                                <xs:enumeration value="QS"/>
                                                                        </xs:restriction>
                                                                </xs:simpleType>
                                                        </xs:element>
                                                        <xs:element name="locationURI" type="xs:anyURI"
minOccurs="0"/>
                                                </xs:sequence>
                                        </xs:complexType>
                                </xs:element>
```

```
                                        <xs:element ref="result" minOccurs="0"/>
                                        <xs:sequence>
                                                <xs:element name="PARquery" minOccurs="0">
                                                        <xs:complexType>
                                                                <xs:sequence>
                                                                        <xs:element ref="querycondition"/>
                                                                </xs:sequence>
                                                                <xs:attribute name="InternalPAR" type="xs:boolean"
use="optional"/>
                                                        </xs:complexType>
                                                </xs:element>
                                                <xs:element name="AXinfoQuery" minOccurs="0">
                                                        <xs:complexType>
                                                                <xs:sequence>
                                                                        <xs:element ref="querycondition"/>
                                                                </xs:sequence>
                                                        </xs:complexType>
                                                </xs:element>
                                                <xs:element name="Similarities" minOccurs="0">
                                                        <xs:complexType>
                                                                <xs:sequence>
                                                                        <xs:element ref="field"/>
                                                                        <xs:element ref="value"/>
                                                                        <xs:element name="algorithm">
                                                                                <xs:simpleType>
                                                                                        <xs:restriction base="xs:string">
                                                                                                <xs:enumeration
value="REGULAREXPRESSION"/>
                                                                                                <xs:enumeration
value=""/>
                                                                                        </xs:restriction>
                                                                                </xs:simpleType>
                                                                        </xs:element>
                                                                </xs:sequence>
                                                        </xs:complexType>
                                                </xs:element>
                                        </xs:sequence>
                                </xs:sequence>
                                <xs:attribute name="name" type="xs:string" use="optional" default="QUERY"/>
                        </xs:complexType>
                </xs:element>
                <xs:element name="field" type="xs:string">
                        <xs:annotation>
                                <xs:documentation> represents a database fields</xs:documentation>
                        </xs:annotation>
                </xs:element>
                <xs:element name="value" type="xs:anySimpleType">
                        <xs:annotation>
                                <xs:documentation> represent the value aginst which the DB field has to match</xs:documentation>
                        </xs:annotation>
                </xs:element>
                <xs:element name="test">
                        <xs:annotation>
                                <xs:documentation> test element of a query: it is in the form field OP value</xs:documentation>
                        </xs:annotation>
                        <xs:complexType>
                                <xs:sequence>
                                        <xs:element ref="field"/>
                                        <xs:element name="operator">
                                                <xs:simpleType>
                                                        <xs:restriction base="xs:string">
                                                                <xs:enumeration value="GT"/>
                                                                <xs:enumeration value="LT"/>
                                                                <xs:enumeration value="EQ"/>
                                                                <xs:enumeration value="GE"/>
```

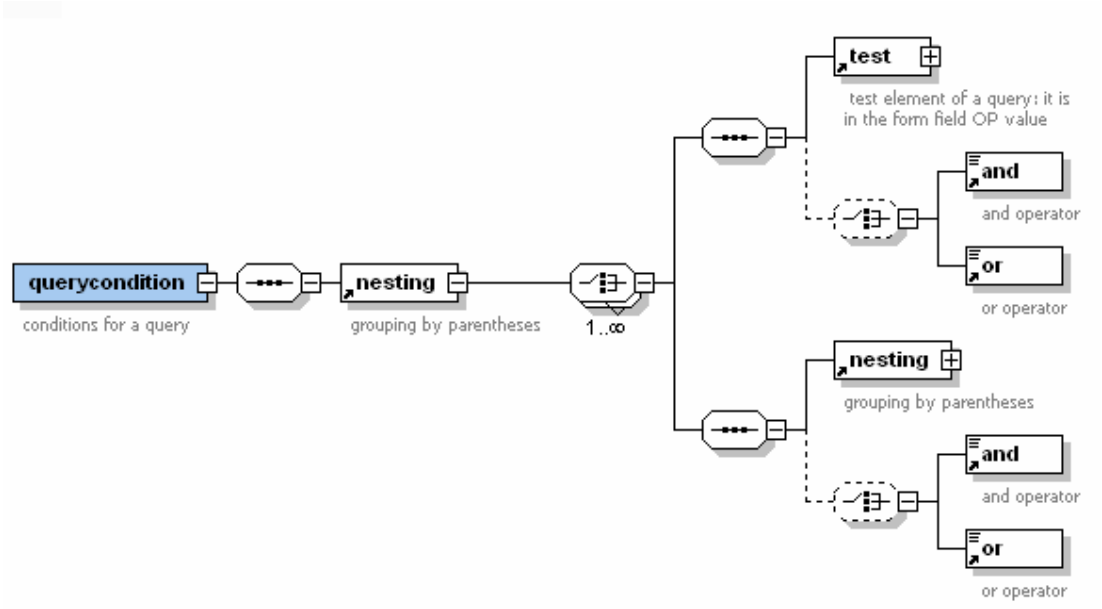
```
                                                <xs:enumeration value="LE"/>
                                                <xs:enumeration value="NE"/>
                                                <xs:enumeration value="STARTWITH"/>
                                                <xs:enumeration value="ENDWITH"/>
                                                <xs:enumeration value="CONTAINS"/>
                                                <xs:enumeration value=""/>
                                        </xs:restriction>
                                </xs:simpleType>
                        </xs:element>
                        <xs:element ref="value"/>
                </xs:sequence>
                <xs:attribute name="NOT" type="xs:boolean" use="optional" default="false"/>
        </xs:complexType>
</xs:element>
<xs:element name="nesting">
        <xs:annotation>
                <xs:documentation>grouping by parentheses</xs:documentation>
        </xs:annotation>
        <xs:complexType>
                <xs:choice maxOccurs="unbounded">
                        <xs:sequence>
                                <xs:element ref="test"/>
                                <xs:choice minOccurs="0">
                                        <xs:element ref="and"/>
                                        <xs:element ref="or"/>
                                </xs:choice>
                        </xs:sequence>
                        <xs:sequence>
                                <xs:element ref="nesting"/>
                                <xs:choice minOccurs="0">
                                        <xs:element ref="and"/>
                                        <xs:element ref="or"/>
                                </xs:choice>
                        </xs:sequence>
                </xs:choice>
        </xs:complexType>
</xs:element>
<xs:element name="querycondition">
        <xs:annotation>
                <xs:documentation>conditions for a query</xs:documentation>
        </xs:annotation>
        <xs:complexType>
                <xs:sequence>
                        <xs:element ref="nesting"/>
                </xs:sequence>
        </xs:complexType>
</xs:element>
<xs:element name="and" type="xs:token">
        <xs:annotation>
                <xs:documentation> and operator</xs:documentation>
        </xs:annotation>
</xs:element>
<xs:element name="or" type="xs:token">
        <xs:annotation>
                <xs:documentation> or operator</xs:documentation>
        </xs:annotation>
</xs:element>
</xs:schema>
```



In this first diagram we suppose that a query can be performed on different sources, returning different AXINFO fields and that the query conditions can be expressed on three different information sources:

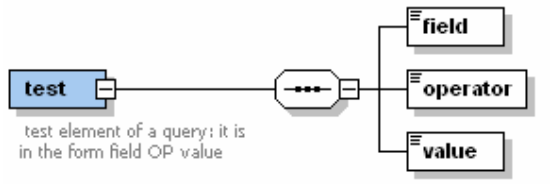
- PARquery, that are the info related to Possible Available Rights
- DRMMquery, that are the information about licensing
- AXinfoQuery, that are the info related to the medatada of the AXMEDIS object.

For each one of these groups a query condition applies and the groups are merged on an AND basis.
Querycondition is reported in the following schema:



Querycondition is then a set of nesting elements that represents basically the parentheses levels.

A nesting can be nested in another nesting element of it can be a part of the real query, in the case it is part of a real query it is a combination of test items that are reported in the following:



Test is the basic element where a fields can be compared to a value by the means of an operator that will be discussed in more details in the following.
Test element has also an attribute that allows to specify if it must be negated or not.

15.3.3.1 Query sources (completed)

The AXMEDIS query can be distributed on four different locations that are: CRAWLER, AXDB, AXEPTOOL, and other remote query supports. This is the way the source tag has between 1 and 4 locations that can have a value in the enumeration CRAWLER, AXEPTOOL, AXDB, QS and have also an optional URL for covering the need of a remote Query Support that is needed by the Kiosk, when the kiosk will look in the kiosk factory if an object is preseeent or not. This new addition allows also to create a network of query supports that are cooperatively in an hierarchy tree.

15.3.3.2 Query result (completed)

The second part of the schema is used to describe the fields that the query should return together with the AXOID (or the temporary AXOID in the case of CRAWLER) that is considered a mandatory field. If the result tag is not present, then only the list of AXOID will be returned; otherwise at least one field must be specified. After the field list an optional array of sorting parameter can be inserter; each sortby tag has an optional attribute (not shown in the graphic version) that by default assumes the asc=true value, that means ascending sorting. If imposed to false, it means that sorting is descending.
The field tag will be limited to the possible list of fields, once the database schema will be defined and a selecting among the possible fields to be queried will be defined.

15.3.3.3 Query conditions (completed)

The most relevant part of a query is the section related to query conditions that is of course optional, but if present must have the structure reported in the previous XML schema. All the field tag must contains the database field that must match, all value field must contain the value against which the field is checked and operator is one of the following:

- GT: greater than
- LT: less than
- GE: greater equal
- LE: less equal
- EQ: Equal
- NE: Not equal
- STARTWITH: field must start with the value
- ENDWITH: field must end with the value
- CONTAINS: field must contain in any position the value

The field tag will be limited to the possible list of fields, once the database schema will be defined and a selecting among the possible fields to be queried will be defined.

15.3.3.4 Similarities (completed)

Similarities are a particular way of making a specific similarity request on the set ob objects selected by the previous queryconditions. By now only one similarity field as been inserted in order to reduce the complexity of the query. Similarities can be addressed by regular expressions (i.e. for searching a partially known AXOID) or by more advanced algorithms to be defined on the basis of the needs of the project.

15.3.3.5 XML Query example file (completed)

In this example the query proposed as a sample by ILABS that is:

SELECT * **FROM** * **WHERE ((**AUTHOR **.EQ.** ”BOTTICELLI” **.AND. (** MEDIA **.EQ.** “VIDEO” **.OR.** MEDIA **.EQ.** “AUDIO” **.OR.** MEDIA **.EQ.** “TEXT”**)) .AND.** (IPR **.EQ.** “FREE” **.AND.** COST .LT. “10.00”**))**

Apart from the fields for which we suppose to have only the AXOID and

```
<?xml version="1.0" encoding="UTF-8"?>
<query xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="QUERY-v1-6.xsd">
        <source>
                <location>CRAWLER</location>
                <location>AXEPTOOL</location>
                <location>AXDB</location>
        </source>
        <AXinfoQuery>
                <querycondition>
                        <nesting>
                                <nesting>
                                        <nesting>
                                                <test>
                                                        <field>AUTHOR</field>
                                                        <operator>EQ</operator>
                                                        <value>BOTTICELLI</value>
                                                </test>
                                        </nesting>
                                        <and/>
                                        <nesting>
                                                <test>
                                                        <field>MEDIA</field>
                                                        <operator>EQ</operator>
                                                        <value>VIDEO</value>
                                                </test>
                                                <or/>
                                                <test>
                                                        <field>MEDIA</field>
                                                        <operator>EQ</operator>
                                                        <value>AUDIO</value>
                                                </test>
                                                <or/>
                                                <test>
                                                        <field>MEDIA</field>
                                                        <operator>EQ</operator>
                                                        <value>TEXT</value>
                                                </test>
                                        </nesting>
                                </nesting>
                                <and/>
                                <nesting>
                                        <test>
                                                <field>IPR</field>
                                                <operator>EQ</operator>
                                                <value>FREE</value>
                                        </test>
                                        <and/>
                                        <test>
                                                <field>COST</field>
                                                <operator>LT</operator>
                                                <value>10.00</value>
                                        </test>
                                </nesting>
                        </nesting>
```

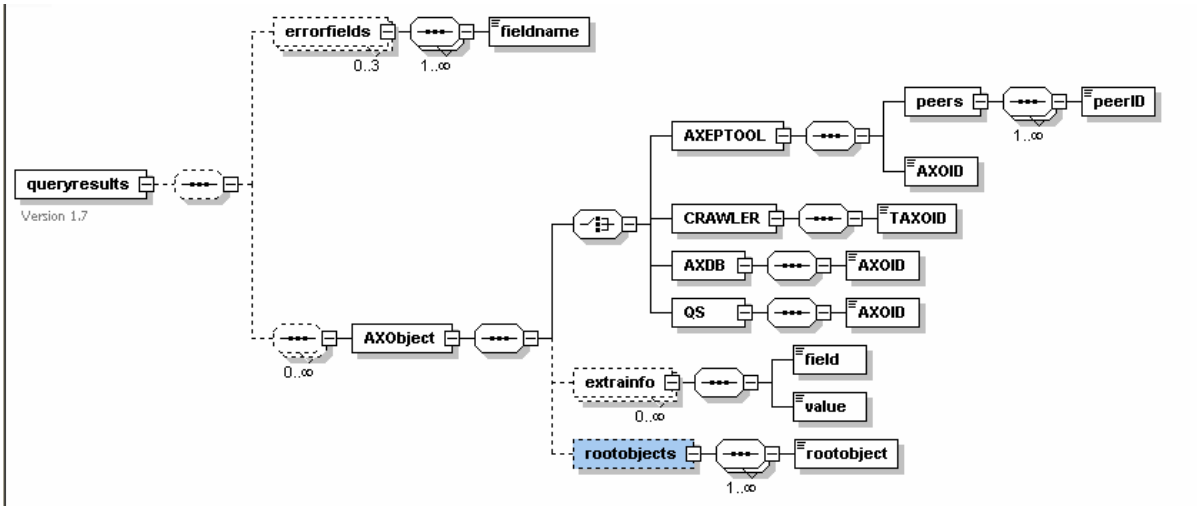
```
                </querycondition>
        </AXinfoQuery>
</query>
```

Examples can be as complex as we want since the possibility of combining with AND and OR the number of desired nesting levels.
Another sample of a simpler query is reported in the following:

```
<?xml version="1.0" encoding="UTF-8"?>
<query xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation=" QUERY-v1-6.xsd">
        <source>
                <location>AXDB</location>
        </source>
        <AXinfoQuery>
                <querycondition>
                        <nesting>
                                <test>
                                        <field>PIPPO</field>
                                        <operator>EQ</operator>
                                        <value>3</value>
                                </test>
                                <and/>
                                <nesting>
                                        <test>
                                                <field>PAPERINO</field>
                                                <operator>EQ</operator>
                                                <value>1</value>
                                        </test>
                                        <or/>
                                        <test>
                                                <field>PLUTO</field>
                                                <operator>GT</operator>
                                                <value>1</value>
                                        </test>
                                </nesting>
                        </nesting>
                </querycondition>
        </AXinfoQuery>
</query>
```

15.3.4 Query and results exchange and mapping (including languages)

The query result model has been evolved and also if it maintains the backward compatibility, in the sense that old result file are correctly parsed, it contains new elements for addressing the problem of nested objects by considering object container namely defined as root objects.
This allows also to retrieve an object embedded in another object without having the contained object as a single file.
The new schema follows:



The modified part is evidenced and the new textual xsd is reported below:

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2005 sp1 U (http://www.xmlspy.com) by Fabrizio Fioravanti (Exitech) -->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
	<xs:element name="queryresults">
		<xs:annotation>
			<xs:documentation>Version 1.7</xs:documentation>
		</xs:annotation>
		<xs:complexType>
			<xs:sequence minOccurs="0">
				<xs:element name="errorfields" minOccurs="0" maxOccurs="3">
					<xs:complexType>
						<xs:sequence maxOccurs="unbounded">
							<xs:element name="fieldname" type="xs:string"/>
						</xs:sequence>
						<xs:attribute name="source" use="required">
							<xs:simpleType>
								<xs:restriction base="xs:string">
									<xs:enumeration value="AXEPTOOL"/>
									<xs:enumeration value="AXDB"/>
									<xs:enumeration value="CRAWLER"/>
								</xs:restriction>
							</xs:simpleType>
						</xs:attribute>
					</xs:complexType>
				</xs:element>
				<xs:sequence minOccurs="0" maxOccurs="unbounded">
					<xs:element name="AXObject">
						<xs:complexType>
							<xs:sequence>
								<xs:choice>
									<xs:element name="AXEPTOOL">
										<xs:complexType>
											<xs:sequence>
												<xs:element
name="peers">

	<xs:complexType>

	<xs:sequence maxOccurs="unbounded">

		<xs:element name="peerID" type="xs:string"/>
```

```
            </xs:sequence>

            </xs:complexType>
                                                                                    </xs:element>
                                                                                    <xs:element
name="AXOID" type="xs:string"/>
                                                                                            </xs:sequence>
                                                                                    </xs:complexType>
                                                                            </xs:element>
                                                                            <xs:element name="CRAWLER">
                                                                                    <xs:complexType>
                                                                                            <xs:sequence>
                                                                                                    <xs:element
name="TAXOID" type="xs:string"/>
                                                                                            </xs:sequence>
                                                                                    </xs:complexType>
                                                                            </xs:element>
                                                                            <xs:element name="AXDB">
                                                                                    <xs:complexType>
                                                                                            <xs:sequence>
                                                                                                    <xs:element
name="AXOID" type="xs:string"/>
                                                                                            </xs:sequence>
                                                                                    </xs:complexType>
                                                                            </xs:element>
                                                                            <xs:element name="QS">
                                                                                    <xs:complexType>
                                                                                            <xs:sequence>
                                                                                                    <xs:element
name="AXOID" type="xs:string"/>
                                                                                            </xs:sequence>
                                                                                    </xs:complexType>
                                                                            </xs:element>
                                                                    </xs:choice>
                                                                    <xs:element name="extrainfo" minOccurs="0"
maxOccurs="unbounded">
                                                                            <xs:complexType>
                                                                                    <xs:sequence>
                                                                                            <xs:element
name="field" type="xs:string"/>
                                                                                            <xs:element
name="value" type="xs:string"/>
                                                                                    </xs:sequence>
                                                                            </xs:complexType>
                                                                    </xs:element>
                                                                    <xs:element name="rootobjects" minOccurs="0">
                                                                            <xs:complexType>
                                                                                    <xs:sequence
maxOccurs="unbounded">
                                                                                            <xs:element
name="rootobject" type="xs:string"/>
                                                                                    </xs:sequence>
                                                                            </xs:complexType>
                                                                    </xs:element>
                                                            </xs:sequence>
                                                    </xs:complexType>
                                            </xs:element>
                                    </xs:sequence>
                            </xs:sequence>
                            <xs:attribute name="end" type="xs:boolean" use="required"/>
                    </xs:complexType>
            </xs:element>
</xs:schema>
```

15.3.4.1 XML results example file (completed)

In this section are collected sample XML file compliant to the proposed schema that can be useful to understand the practical structure of the results of a query.

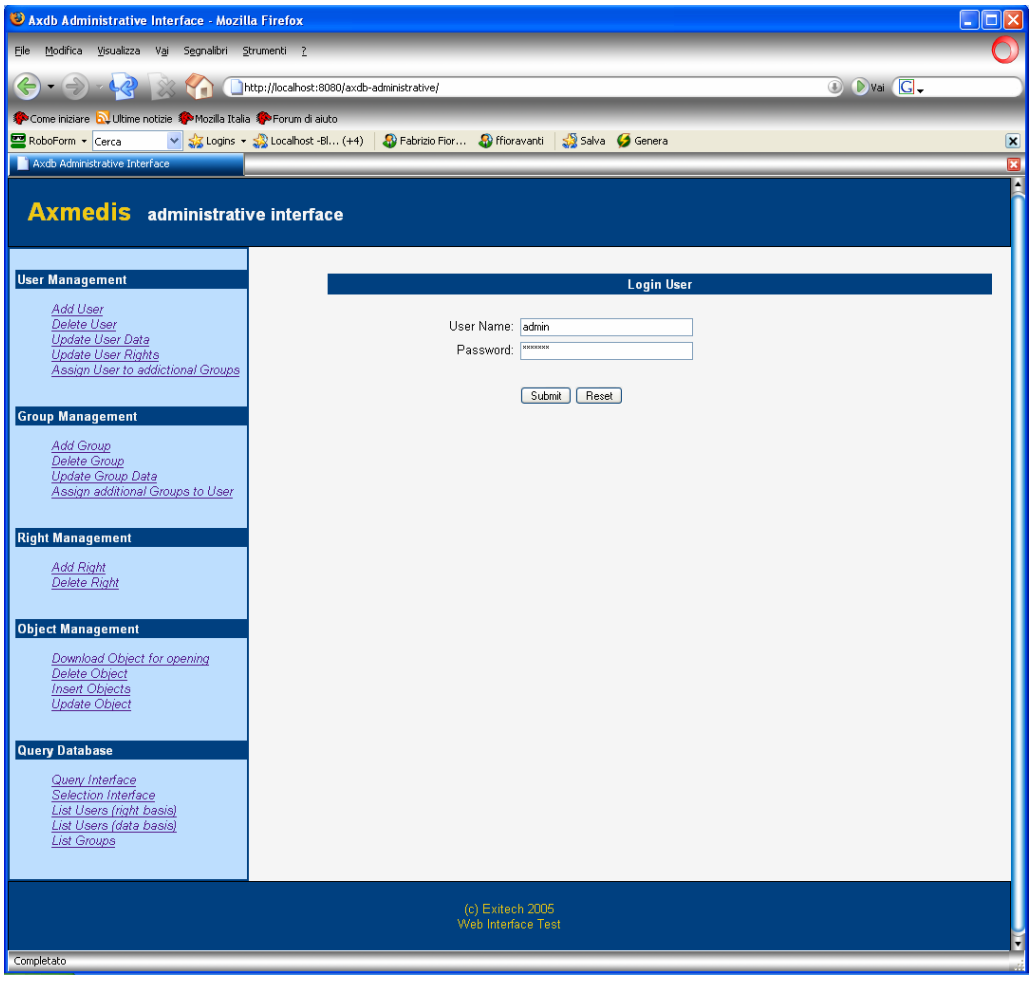
```
<?xml version="1.0" encoding="UTF-8"?>
<queryresults xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="AXQS-Result-v-1-3.xsd">
	<AXObject>
		<AXEPTOOL>
			<peers>
				<peerID>12234</peerID>
				<peerID>56454</peerID>
				<peerID>12784</peerID>
			</peers>
			<AXOID>12248766-gftr</AXOID>
		</AXEPTOOL>
		<extrainfo>
			<field>Author</field>
			<value>Ramazzotti</value>
		</extrainfo>
		<extrainfo>
			<field>YearOfPublication</field>
			<value>1996</value>
		</extrainfo>
		<extrainfo>
			<field>Duration</field>
			<value>315</value>
		</extrainfo>
	</AXObject>
	<AXObject>
		<CRAWLER>
			<TAXOID>5383999-temp</TAXOID>
		</CRAWLER>
		<extrainfo>
			<field>Author</field>
			<value>Ramazzotti</value>
		</extrainfo>
		<extrainfo>
			<field>YearOfPublication</field>
			<value>1997</value>
		</extrainfo>
		<extrainfo>
			<field>Duration</field>
			<value>417</value>
		</extrainfo>
	</AXObject>
	<AXObject>
		<AXDB>
			<AXOID>35423912843.fkhwgywe</AXOID>
		</AXDB>
		<extrainfo>
			<field>Author</field>
			<value>Ramazzotti</value>
		</extrainfo>
		<extrainfo>
			<field>YearOfPublication</field>
			<value>1995</value>
		</extrainfo>
		<extrainfo>
			<field>Duration</field>
			<value>234</value>
		</extrainfo>
	</AXObject>
```

```
</queryresults>
```

Here follows another example of results considering that crawler will report an error

```
<?xml version="1.0" encoding="UTF-8"?>
<queryresults xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="AXQS-Result-v-1-3.xsd">
<errorfields source="CRAWLER">
        <fieldname>/descriptor/mine/duration</fieldname>
        <fieldname>/descriptor/dcmi/authir</fieldname>
</errorfields>
        <AXObject>
                <AXEPTOOL>
                        <peers>
                                <peerID>12234</peerID>
                                <peerID>56454</peerID>
                                <peerID>12784</peerID>
                        </peers>
                        <AXOID>12248766-gftr</AXOID>
                </AXEPTOOL>
                <extrainfo>
                        <field>Author</field>
                        <value>Ramazzotti</value>
                </extrainfo>
                <extrainfo>
                        <field>YearOfPublication</field>
                        <value>1996</value>
                </extrainfo>
                <extrainfo>
                        <field>Duration</field>
                        <value>315</value>
                </extrainfo>
        </AXObject>
        <AXObject>
                <AXDB>
                        <AXOID>35423912843.fkhwgywe</AXOID>
                </AXDB>
                <extrainfo>
                        <field>Author</field>
                        <value>Ramazzotti</value>
                </extrainfo>
                <extrainfo>
                        <field>YearOfPublication</field>
                        <value>1995</value>
                </extrainfo>
                <extrainfo>
                        <field>Duration</field>
                        <value>234</value>
                </extrainfo>
        </AXObject>
</queryresults>
```

These functionalities have been partially used in the AXMEDIS database administrative interface. They have been implemented during this period.



AXMEDIS Administrative Web Database Interface provides to the AXMEDIS administrator access to the main functionalities of AXMEDIS that are related to the database.
Among the planned functionalities, the implemented functionalities also in form of a working prototype without frills, are:

- Add user
- Delete User
- Update user data
- Update user rights
- Add Group
- Delete Group
- Update group data
- Assign users to group
- Assign groups to user
- Lists user of the basis of the rights
- List users on the basis of the user data
- List group

Regarding the work performed on query support a large work have been done regarding the query adaptor for AXDB, that is the module that manages the query on the AXDB and translates the query from XML to XML managing also multilingual problems and optional fields related problems.
The current specification can be found in the specification document DE 3.1.2E Database-Gathering version 2.3 or higher.
Web service are described in the specification document that have been realized are the following:

- AXDBQuerySupport (only sync functionalities have been implemented according to what has been scheduled)
- QuerySupport Web service interface (only sync functionalities have been implemented according to what has been scheduled)

Moreover the work that has been done is not only the implementation of the functionalities but also the test of all the functionalities also implementing other web service (such as Crawling web service, Licence web service, P2P webservice) in order to simulate distribution and collection of queries.

16 Collector Engine and Query Support in the Database of Crawler Results Integrated Database (DSI)

16.1 Collector Engine

The *Collector Engine* will allow migrating content from the *Crawled Results Integrated Database* to the AXMEDIS format and database.
Using the focuseek Watch Manager the user can make a persistent query to select the content to be acquired (e.g. all the songs of Ramazzotti) and when a new content satisfying the query is present or it is updated the acquisition/update of the object is performed.
The acquisition/update is done using a *javascript* script to:

1. access to the metadata associated with the "document" to be acquired stored in the Crawler DB
2. create an AXMEDIS object integrating the content and the metadata acquired
3. use the fingerprinting tools to add new descriptors to the content
4. put the object in the AXMEDIS Database

The *Collector Engine* is implemented using the *AXMEDIS Content Processing Rule Engine* (see DE 4.3.1) which is used to execute JS scripts for content & metadata acquisition from the *Crawled Results Integrated Database.* To allow the interaction of javascript rules with searchbox tools specific JS classes have been realized.

For example the following script makes a query using term "string" and for each document displays the mimetype, the document size and all the metadata associated with the document.

```
// connects with searchbox
var sb = new AXSearchbox();

sb.Host = "localhost";
sb.Port = "2200";
sb.Username = "admin";
sb.Password = "password";

// creates the QuerySpec object with the query to be performed
var qs = new QuerySpec();
qs.Collection = -1; // search on all the archives
qs.Parser = QueryParser.ALGPARSER;
qs.Info = QueryInfo.INFO_CONTEXT;
qs.View = QueryView.VIEW_PUBLISHED;
qs.Sort = QuerySort.SORT_STANDARD;
qs.QueryString = "string"; // the query string
```

```
qs.FirstDoc = 0;
qs.LastDoc = 1;

// makes the query and gets the results in qr array
var qr = new Array();
var maxres = sb.Query(qs, qr);

// i
var i, j;
for(i = 0; i < qr.length; ++i)
{
      print(qr[i].ID+" "+qr[i].Url);

      // gets the document by ID from the searchbox document store
      var doc = sb.GetDocument(qr[i].ID);
      print("-> "+doc.MimeType+" ["+doc.Size+"]");
      // extracts the document to the file system
      doc.Write("C:/demo/file."+extFromMimeType(doc.MimeType));

      // gets the metadata of document by ID
      var meta = sb.GetDocumentMetadata(qr[i].ID).getAllMetadataValues();
      for(j = 0; j < meta.length; ++j)
      {
            print("--> "+meta.Key+"["+meta[j].Slice+"]="+meta[j].Value);
      }
}
```

16.1.1 Work Performed

- Improved the JS AXSearchbox interface to allow:
  - an easier access to document metadata,
  - access to document links,
  - retrieve a document by link,
  - access to FFF document representation
- faster access to big documents (e.g. audio, video) throught a REST interface

16.2 Query Support

The Query Support in the Crawler Database adapts AXMEDIS queries to focuseek queries

16.2.1 Work Performed

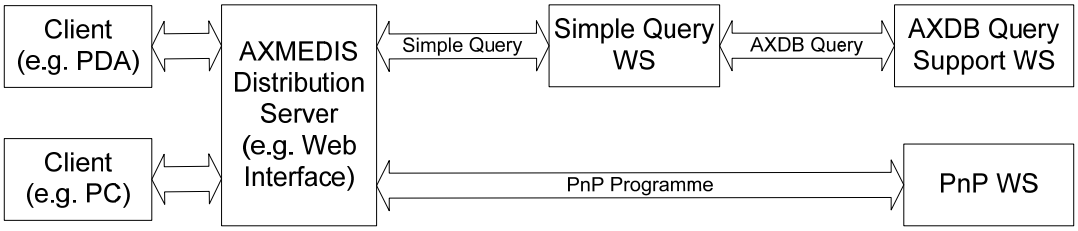
Integration and testing with Main Query Support module, a axquerybridge application has been developed to adapt the different formats used in the encoding of Web Services: searchbox uses RPC encoded services and Main Query support requests a document literal service.

17 Query Support for PC using Web Interface (FHGIGD, UNIVLEEDS)

17.1 User/Web Interface (FHGIGD)

The demonstrator web interface provides the possibility to query the AXDB Query Support for information about the available multi-media content. The AXDB Query Support provides a powerful query language that is too complex to be handled by an end user in this case. For this purpose the AXMEDIS specification defines the simplified query language schema. The user/web interface therefore creates a request based on this language schema, which is processed by the Simple Query Web Service as described in the next section.

After the server has evaluated the user request and returned the results, the demo client presents a list of matching content to the user. The user then chooses the content she/he wants to see or goes back to enter another query. If the user requests content, this request is delegated to the Programme and Publication Tool (PnP) module, which prepares the content if it is not yet available in the right format using the AXMEDIS Content Processing (AXCP) engine, based on the determined AXOID.



General Architecture of Query and Production on Demand

Since the AXMEDIS platform needs to support also various other devices besides personnel computers, it is necessary that the Web interface contains further functionalities. Besides the base functionality described above, the provision and determination of the User, Device and Context Profiles is needed. On the one hand these profiles are used to refine the queries of a user and on the other hand to generate the requested content adapted for the specific device.

17.1.1 State of the Art

The user/Web Interface is based on the Apache Struts Framework. For determining the Device Profile, which describe the specific properties of a user device in more detail, the User/Web interface uses the CC/PP protocol. The CC/PP protocol is the result of the CC/PP Work Group, which is now continued by the DEVICE Independence Work Group (DI WG) of the W3C, and permits the definition and the exchange of device dependent attributes. The web interface uses the User Agent Profiles (UAProf), which is the first large-scale deployment of CC/PP. MPEG-21 profiles for digital item adaptation (DIA) are used for content processing within AXMEDIS. These profiles are passed to the AXCP engine to determine the processing steps to format and adapt content in a suitable way.

17.1.2 Problems

Web based input of the user query

The primary task of this module is the conversion of the query information collected by means of an HTML form to a well-defined XML data structure (Simple Query Language). In order to reduce the number of client/server requests and to improve the user friendliness, the input of the user query was optimized using JavaScript, which however requires a server-side work necessary afterwards because of its dynamic nature.

Support for different devices

The structure and the vocabularies of the CC/PP has become a W3C recommendation, 15 January 2004. Unfortunately, currently, no standardized exchange protocol is defined. There are two main ways of transporting CC/PP over HTTP: Using the CC/PP Exchange Protocol defined by the DI Workgroup, or using the UAProf W-HTTP Protocol defined by the WAP-Forum (Open Mobile Alliance). Since not all devices support the CC/PP protocol, there is still a need for a fallback solution.

Collaboration with other AXMEDIS modules

The query and the profile retrieved had to be communicated to the AXDB server via the Simple Query Web Service module. This module can be accessed via web service. A Java library is available which wraps the logic required for the web service communication. The Programme and Publication Tool is accessed by a

web service interface as well. The content retrieved is passed on by a HTTP response to the web browser on the client device.

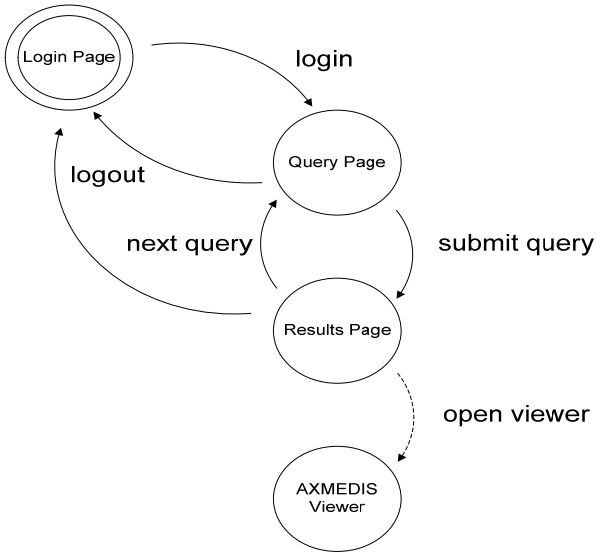
17.1.3 Work performed

The current implementation permits the Web based input of search parameters, the preparation and conversion of these request parameters into the simplified query format (Simple Query Format), to call the responsible AXMEDIS component (Simple Query Web Service) for subsequent treatment of the query and the presentation of the query results as list. The handling of the User, Device, and Context Profiles, as well as the communication between Web interface and PnP Tool are performed by this demonstrator module as an example to show how the different components can be integrated into a distribution server.

In the following the different steps are described in more detail.

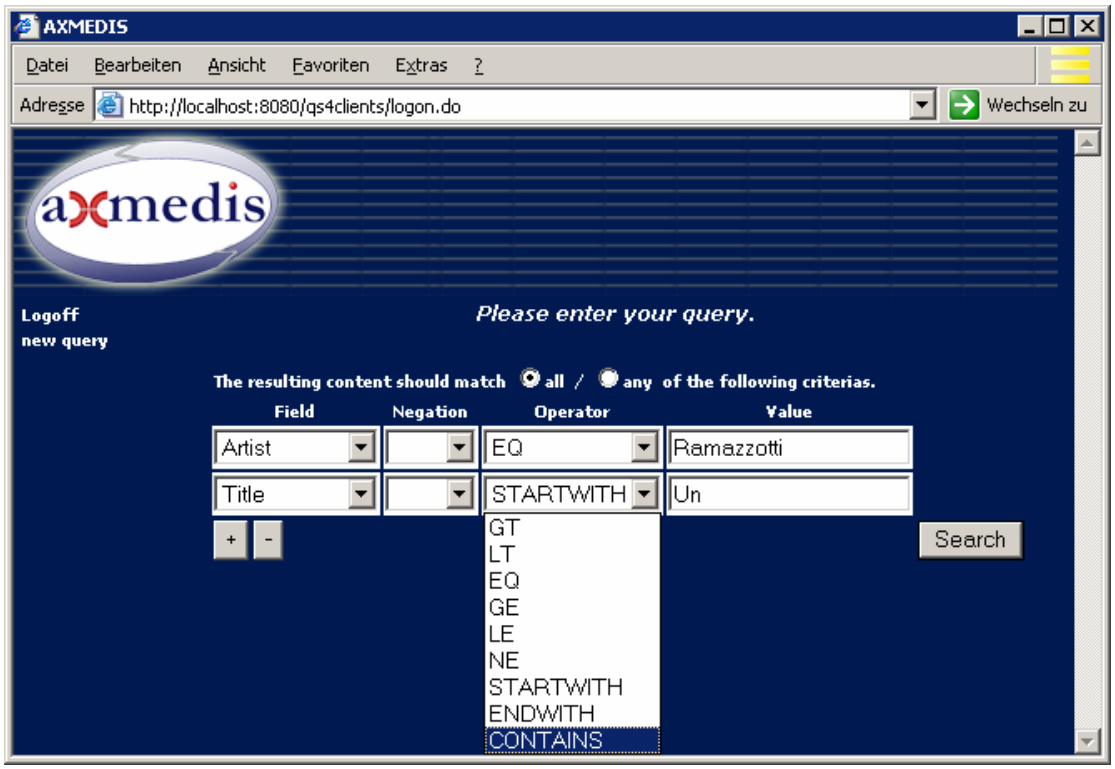
Interaction of the system with the user

The following state chart shows the interaction between the users and the AXMEDIS framework. The implementation of the user/Web interface is based on the Struts Framework of Apache. More information about this framework can be found at [http://struts.apache.org/index.html].

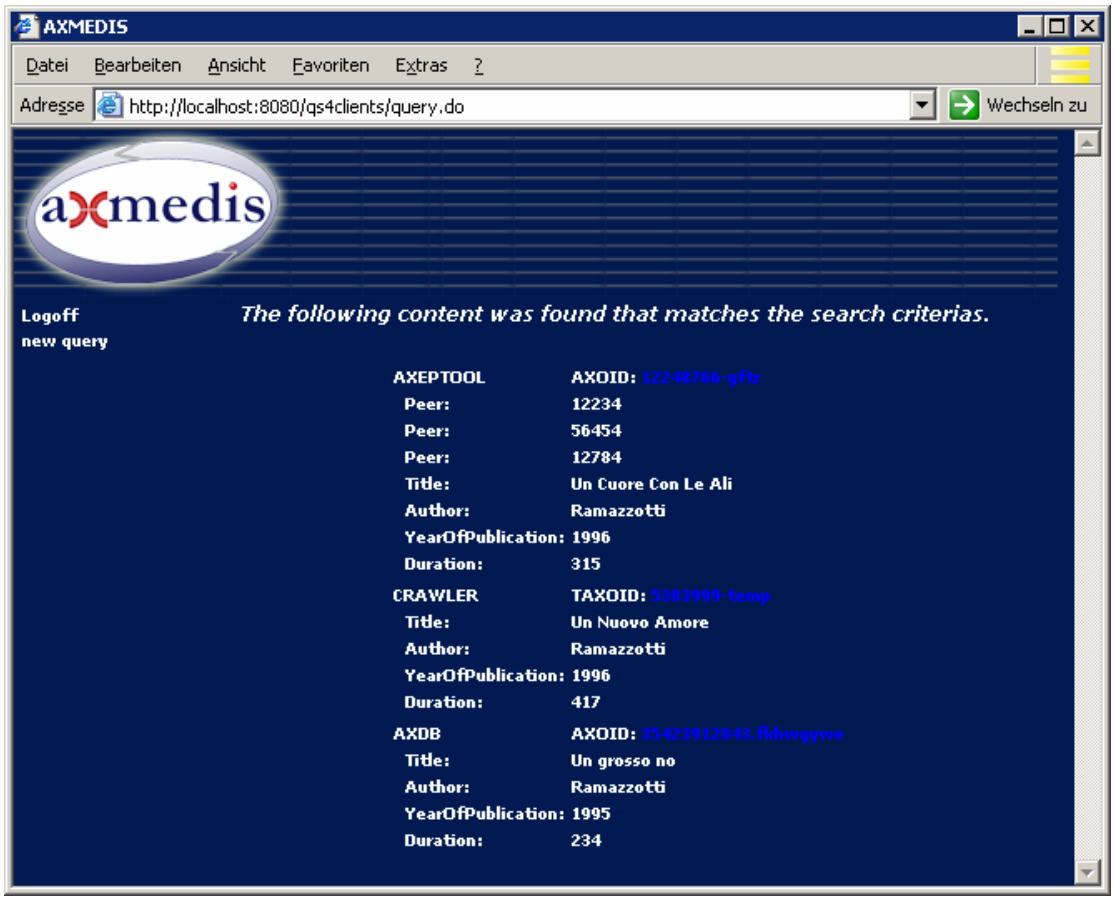


State chart of web application

After the user profile is determined, the user is requested to enter her/his query. This procedure is supported on the client with JavaScript to minimize the number of client/server requests and therefore to ensure a smooth and intuitive operation of the query interface.



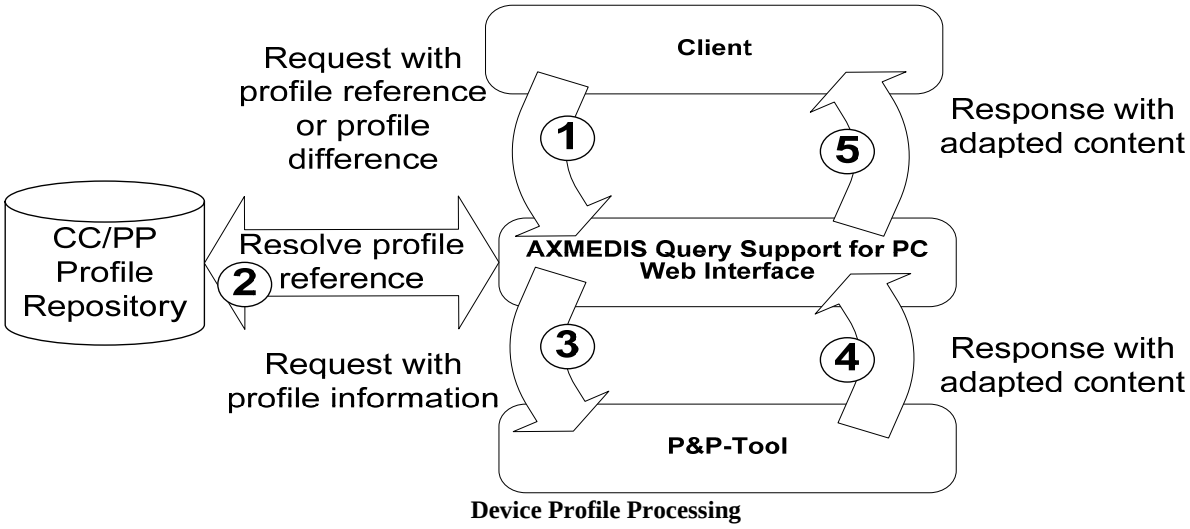
After the user query was sent to the distribution server, the results that were determined by the AXMEDIS system are presented to the user.



Why Struts?
The Struts Framework is a slim and efficient Open Source Framework for thin client Web applications that shines by its prevalence and the good support with tools. The framework achieves this by successfully implementing the Model View Controller paradigm (struts.apache.org)

Besides Struts also the Cocoon Framework was taken into account. This Framework offers a better support for CC/PP (via DELI) as well as a better expandability concerning various devices. The larger complexity and thereby increased implementation cost of the framework made this framework however unsuitable for the implementation of the client demonstrator (cocoon.apache.org)

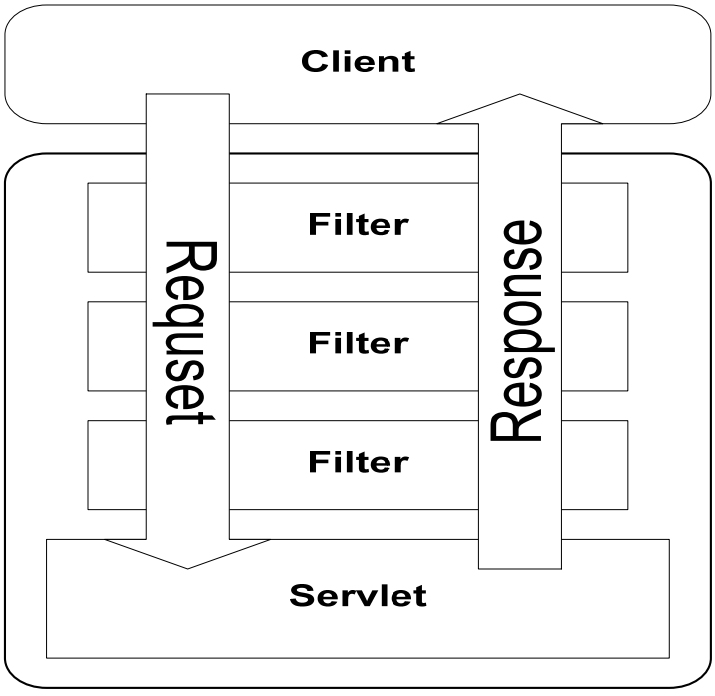
Device Profile Resolution
The user/Web interface could use additional information with each query of a CC/PP or UAProf capable device in the HTML headers. This information can be used to create a Device Profile. The resulting profile together with the other profiles is passed on by the Programme and Publication Tool to the AXCP to prepare and adapt the requested content for the device using the profile information.



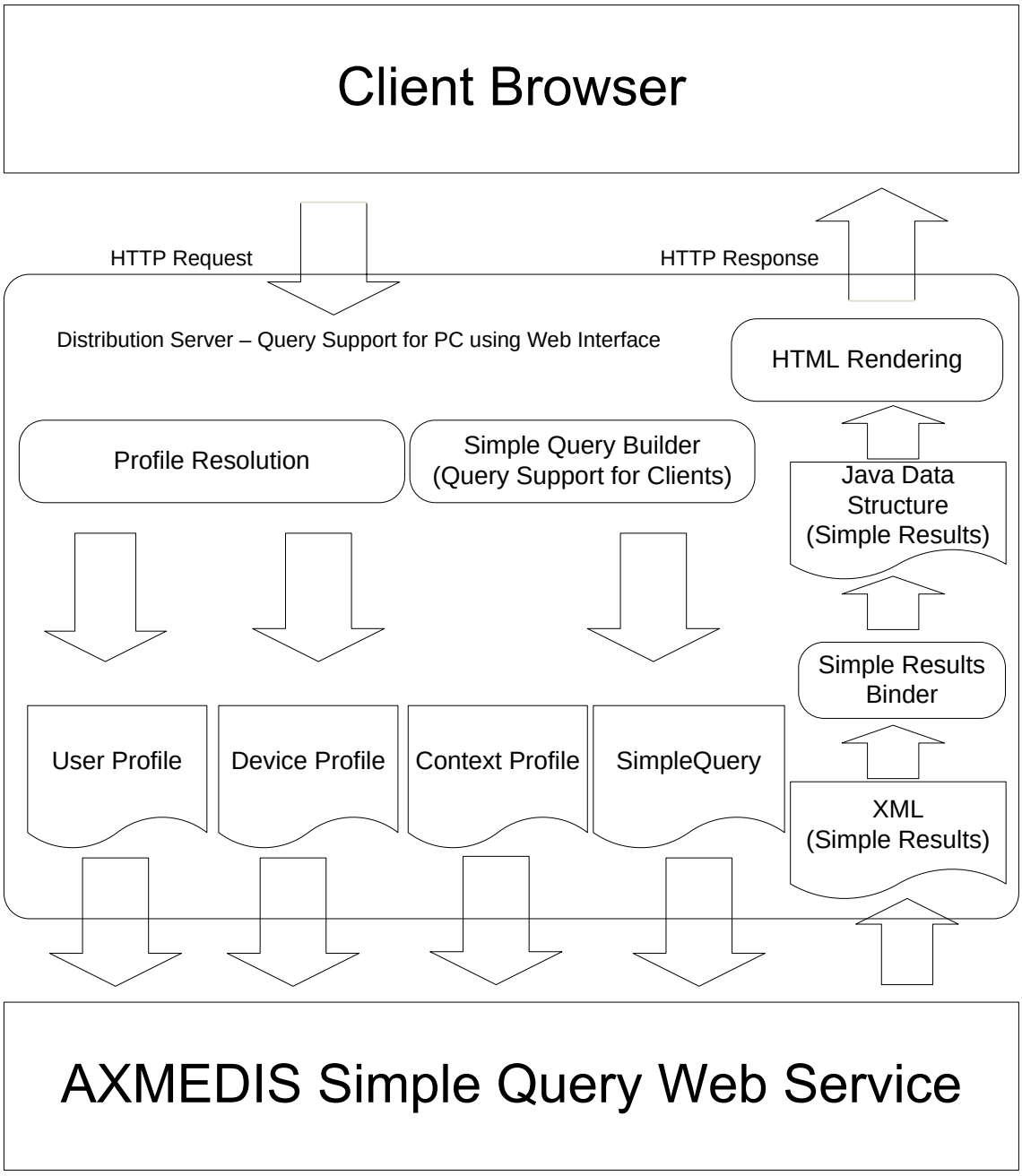
Device Profile Processing

Both available transportation protocols (HTTP-Ex as well as W-HTTP) are structured in a similar way and could be treated equally up to a certain level. However, the UAProf protocol offers a better selection of vocabularies. If the device does not provide any profile information, the user/Web interface assumes that the device is a standard PC with typical characteristics and falls back to a default Device Profile that is stored on the distribution server.

The determination of the profiles is independent of the actual query and is done using a servlet filter mechanism. Servlet filters are powerful tools that are available to web application developers using the Servlet specification version 2.3 or higher. Filters are designed to be able to manipulate a request or response (or both) that is sent to a web application, yet provide this functionality in a method that will not affect servlets and Java Server Pages that are used by the web application unless that effect is the desired. A good way to think of servlet filters is as a chain of steps that a request and response must go through before reaching a servlet, JSP, or static resource such as an HTML page in a web application."
(http://www.onjava.com/pub/a/onjava/2003/11/19/filters.html)



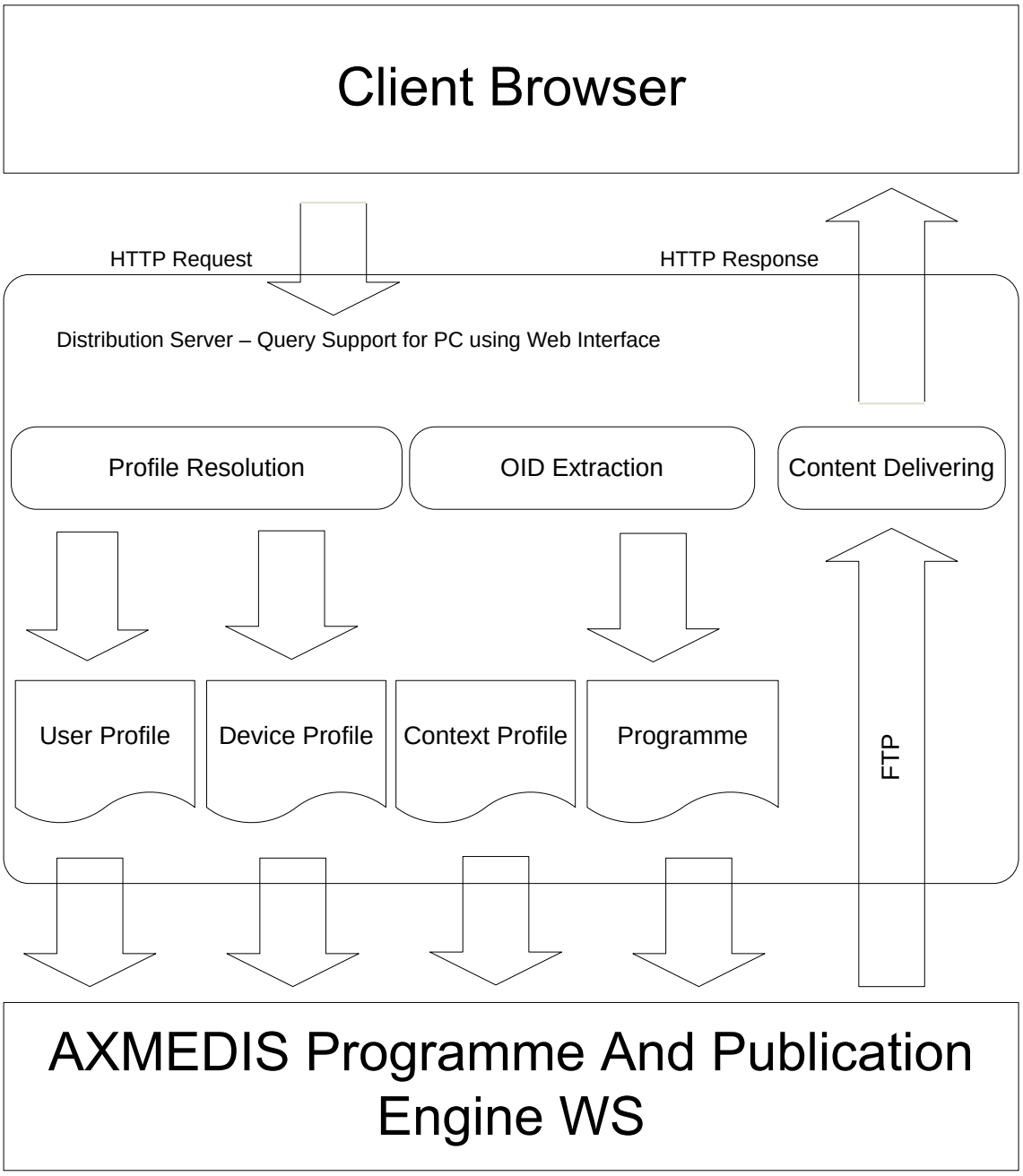
Communication with the AXDB Query Support
This following figure describes the different processing steps between the submission of the query and the presentation of the search results.



The Simple Query Language and the Simple Query Web Service are described in more detail in the next section.

Communication with the PnP Tool

This section describes the processing steps between the selection of a specific content from the presented list of results and the retrieval of this content from the PnP tool. After the determination of the User, Device and Context Profile and the desired content (by its AXOID), the resulting request is sent to the Programme and Publication Tool. The response of the PnP Tools is transferred, if no errors occurred, into a HTTP response. After receiving this HTTP message, the client browser opens an appropriate viewer based on the returned MIME type.



17.2 Simple Query Web Service (FHGIGD, UNIVLEEDS)

The Simple Query Web Service serves as a link between the different distribution channels (e.g. the demonstrator Web Interface) and the AXDB server. The reduced scope of the Simple Query Language for a simple interaction with the final user requires an appropriate transformation of this query language into the more complex, but thereby also more powerful, server-side fully-fledged AXDB query language.
Apart from this transformation this module could include further information from the User, Device, and Context Profile into the query, in order to retrieve suitable content for the client device.
In the next step the refined query is sent via the AXDB Query Support Web Service to the AXDB server. The response of the server is again examined, checked for errors and passed on to the querying distribution channel.

17.2.1 Problems

The transformation of the given query to a more complex query structure using a procedural language like Java is a time-consuming process and results in unstable code. That means minor changes in the used schemas can led to many changes at the Java code. The developer has to transfer the XML document into a corresponding Java data structure, navigate inside the source structure while evaluating several attributes, and finally transfers the resulting Java structure back to XML.
To refine the user query the necessary information, e.g. resolution of the client device, could be extracted from the Device Profile and integrated entry by entry into the resulting profile. However, since all data is available in XML and also the outgoing interface is based on XML, the link of the data from the individual data sources was accomplished using direct XSL transformations.
After the server-side query is generated the module had to invoke the responsible web service provided by the AXDB Query Support to handle this query request. Therefore the module had to implement the required client stub logic and error handling routines.

17.2.2 Work performed

The current implementation transforms the retrieved Simple Query into the server-side query language, calls the web service provided by the AXDB Query Support converts the server response into Simple Results and passes them on to demonstrator Web interface. Which first converts the Simple Results in Java data structure based on the simple results schema transfers the result into HTML and passes on to requesting user. The implementation to invoke the server-side web service is based on the Apache AXIS framework. The server response is converted into the Java data structure using the JAXB (Java XML Binding) API.

This section describes the different processing steps between the submission of the query and the presentation of the search results.

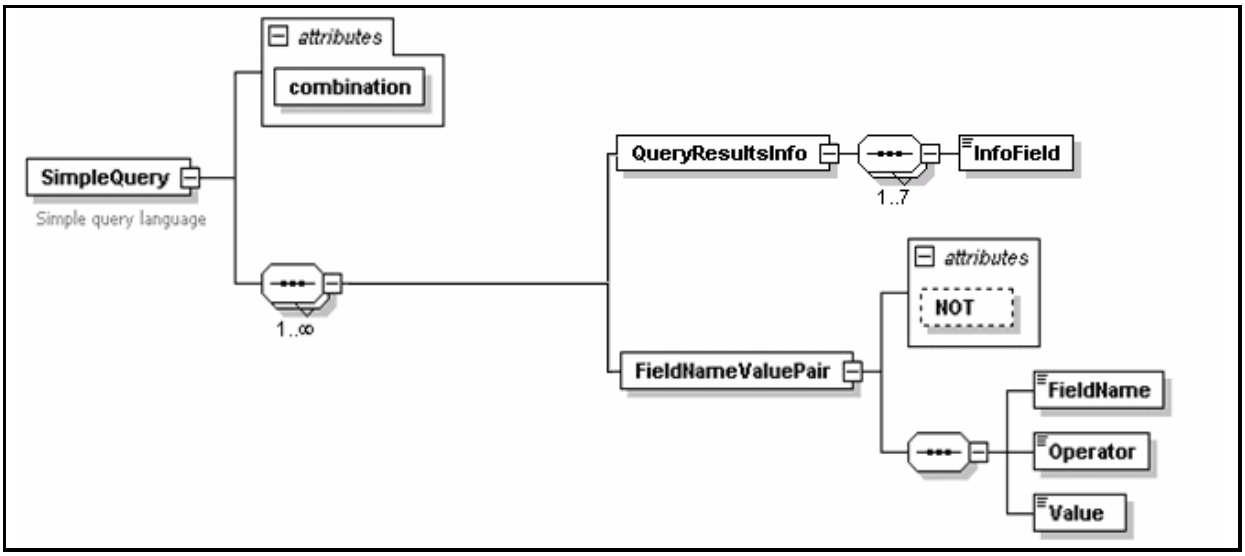
Simple Query Language

After the profiles are determined the request parameters are sorted and grouped into the respective query terms. By means of the JAXB (Java XML being thing) API they are then transferred into XML. This is based on the XML schema shown below.
The schema is an extension of the pattern described in the specification document. The new pattern permits the specification of a logic connection of all search terms, as well as the specification of comparison operators concerning the individual terms. Furthermore the pattern defines a range of valid values for the individual elements, which permits a simple validation of the query at an early stage. A graphical representation of the schema can be found below the following text.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
<xs:element name="SimpleQuery">
```

```
<xs:annotation>
<xs:documentation>Simple Query language</xs:documentation>
</xs:annotation>
        <xs:complexType>
                <xs:sequence maxOccurs="unbounded">
                        <xs:element name="QueryResultsInfo">
                                <xs:complexType>
                                        <xs:sequence maxOccurs="7">
                                                <xs:element name="InfoField">
                                                        <xs:simpleType>
                                                                <xs:restriction base="xs:string">
                                                                        <xs:enumeration value="title"/>
                                                                        <xs:enumeration value="description"/>
                                                                        <xs:enumeration value="type"/>
                                                                        <xs:enumeration value="creator"/>
                                                                        <xs:enumeration value="contributor"/>
                                                                        <xs:enumeration value="date"/>
                                                                        <xs:enumeration value="uri"/>
                                                                </xs:restriction>
                                                        </xs:simpleType>
                                                </xs:element>
                                        </xs:sequence>
                                </xs:complexType>
                        </xs:element>
                        <xs:element name="FieldNameValuePair">
                                <xs:complexType>
                                        <xs:sequence>
                                                <xs:element name="FieldName">
                                                        <xs:simpleType>
                                                                <xs:restriction base="xs:string">
                                                                        <xs:enumeration value="Tittle"/>
                                                                        <xs:enumeration value="Artist"/>
                                                                        <xs:enumeration value="Subject"/>
                                                                        <xs:enumeration value="Keywords"/>
                                                                        <xs:enumeration value="Description"/>
                                                                        <xs:enumeration value="Media type"/>
                                                                        <xs:enumeration value="Year"/>
                                                                </xs:restriction>
                                                        </xs:simpleType>
                                                </xs:element>
                                                <xs:element name="Operator">
                                                        <xs:simpleType>
                                                                <xs:restriction base="xs:string">
                                                                        <xs:enumeration value="GT"/>
                                                                        <xs:enumeration value="LT"/>
                                                                        <xs:enumeration value="EQ"/>
                                                                        <xs:enumeration value="GE"/>
                                                                        <xs:enumeration value="LE"/>
                                                                        <xs:enumeration value="NE"/>
                                                                        <xs:enumeration
                                                                value="STARTWITH"/>
                                                                        <xs:enumeration value="ENDWITH"/>
                                                                        <xs:enumeration value="CONTAINS"/>
                                                                </xs:restriction>
                                                        </xs:simpleType>
                                                </xs:element>
                                                <xs:element name="Value" type="xs:string"/>
                                                </xs:sequence>
                                        <xs:attribute name="NOT" type="xs:boolean" use="optional" default="false"/>
                                        </xs:complexType>
                                </xs:element>
                </xs:sequence>
        <xs:attribute name="combination" type="andOr" use="required"/>
        </xs:complexType>
</xs:element>
```

```
<xs:simpleType name="andOr">
        <xs:restriction base="xs:string">
                <xs:enumeration value="AND"/>
                <xs:enumeration value="OR"/>
        </xs:restriction>
</xs:simpleType>
</xs:schema>
```



Simple Results

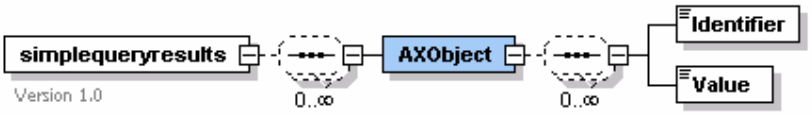
Simple Results consist of a list of (Identifier, Value) pairs based on the Simple Results schema. Each pair represents the name of a field (Identifier) and the related data (Value) which the user gets as a response on his Simple Query request. For example:

```
<Identifier>AXOID</Identifier>
<Value>234234234234</Value>
<Identifier>Title</Identifier>
<Value>Frank Sinatra</Value>
```

The schema and a graphical representation can be found below.

```
<? Xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2005 sp1 U (http://www.xmlspy.com) by Fabrizio Fioravanti (Exitech) -->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
        <xs:element name="simplequeryresults">
                <xs:annotation>
                        <xs:documentation>Version 1.0</xs:documentation>
                </xs:annotation>
                <xs:complexType>
                        <xs:sequence minOccurs="0" maxOccurs="unbounded">
                                <xs:element name="AXObject">
                                        <xs:complexType>
```

```
                                        <xs:sequence minOccurs="0" maxOccurs="unbounded">
                                            <xs:element name="Identifier" type="xs:string"/>
                                            <xs:element name="Value" type="xs:string"/>
                                        </xs:sequence>
                                    </xs:complexType>
                                </xs:element>
                            </xs:sequence>
                        </xs:complexType>
                    </xs:element>
</xs:schema>
```



Simple Query Web Service

The resulting query represented as a XML document is then passed on to the Simple Query Web Service together with the profiles.

The Simple Query Web Service transforms the Simple Query into a fully-fledged AXMEDIS query using XSLT.

The AXMEDIS query is then passed on the AXMEDIS Web Service interface, after processing the AXMEDIS query the AXMEDIS Web Service interface returns the AXMEDIS Query Results to the Simple Query Web Service as XML document.

The Simple Query Web Service transforms these Results into Simple Results using a XSLT and returns the Simple Results Query Support Interface .Which then converts these results into java-data Structure.

This data structure is then transferred into an appropriate HTML representation and is send back to client. The definition of the Simple Query Web Service interface is shown by the following WSDL document.

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions xmlns="http://schemas.xmlsoap.org/wsdl/" xmlns:tns="http://simplequeryws.qs4dc.axmedis.a8.igd.fhg.de/skeleton"
xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/" xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
:parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de="urn:parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de"
xmlns:SOAP="http://schemas.xmlsoap.org/wsdl/soap/" xmlns:MIME="http://schemas.xmlsoap.org/wsdl/mime/"
xmlns:DIME="http://schemas.xmlsoap.org/ws/2002/04/dime/wsdl/" xmlns:WSDL="http://schemas.xmlsoap.org/wsdl/"
name="SimpleQuery" targetNamespace="http://simplequeryws.qs4dc.axmedis.a8.igd.fhg.de/skeleton">
<types>
<schema xmlns="http://www.w3.org/2001/XMLSchema"
targetNamespace="urn:parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de" elementFormDefault="qualified"
attributeFormDefault="qualified">
<import namespace="http://schemas.xmlsoap.org/soap/encoding/"/>
        <complexType name="simplequery">
                <sequence>
                        <element name ="user"    type="xsd:string" minOccurs="1" maxOccurs="1"/>
```

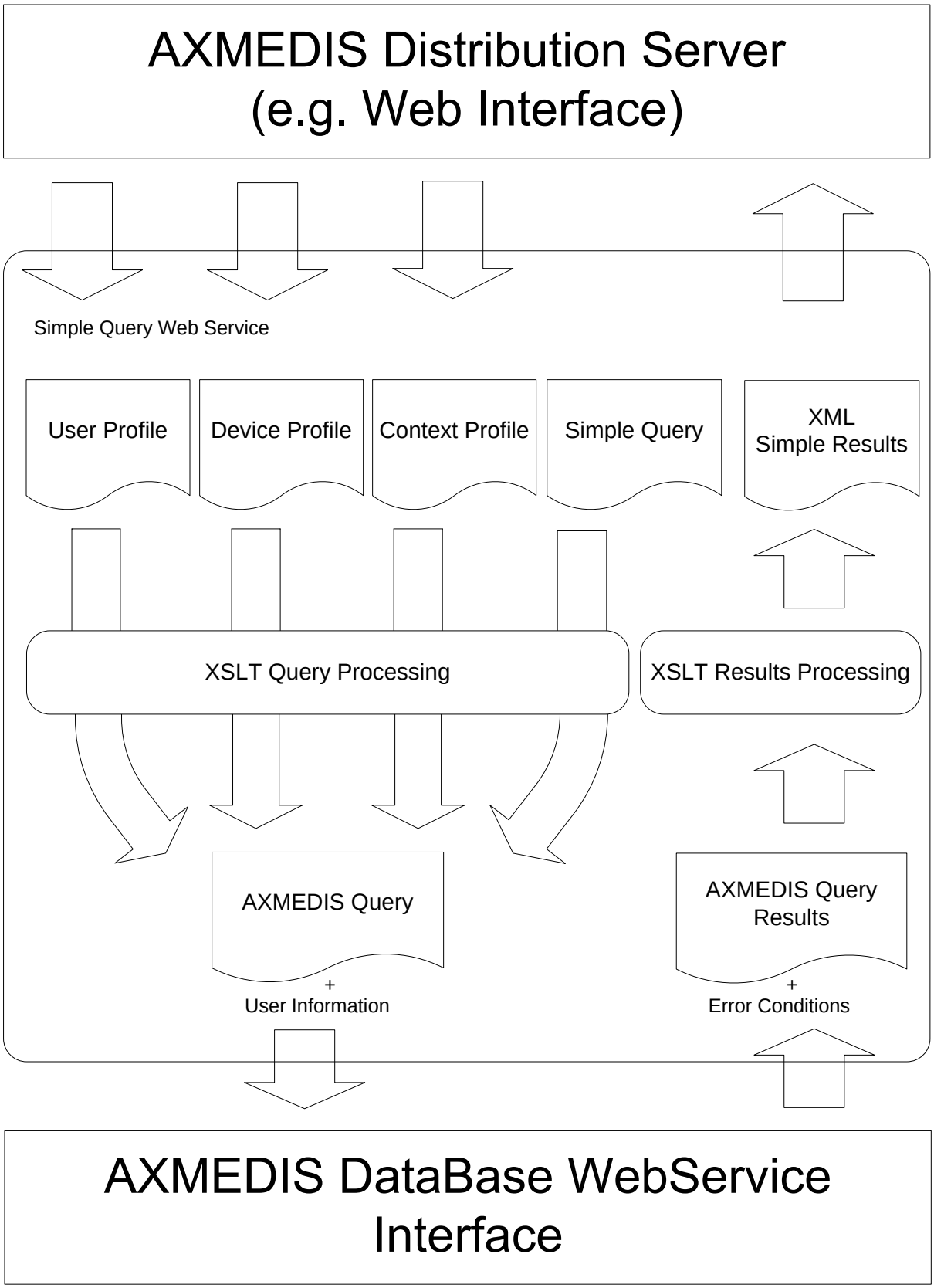
```
                        <element name ="pass"    type ="xsd:string"  minOccurs="1" maxOccurs="1"/>
                        <element name ="query"  type ="xsd:string"  minOccurs="1" maxOccurs="1"/>
                </sequence>
        </complexType>
        <complexType name ="sq_r">
                <sequence>
                        <element name="simpleresults" type="xsd:string" minOccurs="1" maxOccurs="1"/>
                </sequence>
        </complexType >
        <!-- operation request element -->
        <element name="MakeSimpleQuery">
                <complexType>
                        <sequence>
                                <element name  ="simple_query"      type
="parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de:simplequery" minOccurs="1" maxOccurs="1"/>
                                <element name ="userprofile" type ="xsd:string" minOccurs="1" maxOccurs="1"/>
                                <element name ="deviceprofile" type ="xsd:string"  minOccurs="1" maxOccurs="1"/>
                                <element name ="contextprofile" type ="xsd:string"  minOccurs="1" maxOccurs="1"/>
                        </sequence>
                </complexType>
         </element>



 <!-- operation response element -->
 <element name="queryresults">
        <complexType>
                <sequence>
                        <element name="return"  type="parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de:sq_r"
minOccurs="1" maxOccurs="1"/>
                </sequence>
        </complexType>
</element>
</schema>
 </types>
<message name="MakeSimpleQueryRequest">
<part name ="para" elment="parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de:MakeSimpleQuery"/></message>
<message name="queryresults">
<part name ="para" element ="parameters.simplequeryws.qs4dc.axmedis.a8.igd.fhg.de:queryresults"/></message>
<portType name="SimpleQueryPortType">
<operation name="MakeSimpleQuery">
<documentation>Service definition of function parameters_MakeSimpleQuery</documentation>
<input message="tns:MakeSimpleQueryRequest"/>
<output message="tns:queryresults"/>
</operation>
</portType>
<binding name="SimpleQuery" type="tns:SimpleQueryPortType">
<SOAP:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
<operation name="MakeSimpleQuery">
<SOAP:operation soapAction=""/>
<input>
<SOAP:body use="literal"/>
</input>
<output>
<SOAP:body use="literal"/>
</output>
</operation>
</binding>
<wsdl:service xmlns:http="http://schemas.xmlsoap.org/wsdl/http/" xmlns:mime="http://schemas.xmlsoap.org/wsdl/mime/"
xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/" xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/" name="simplequery_WS">
<wsdl:port name= "SimpleQueryPortType" binding="tns:SimpleQuery">
<address xmlns="http://schemas.xmlsoap.org/wsdl/soap/" location="http://localhost:8080/axis/services/SimpleQueryPortType"/>
</wsdl:port>
```

```
</wsdl:service>
</definitions>
```

17.2.3 Work in Progress

Further steps are the identification of relevant attributes within the profiles. The logic to access these attributes, which are used to refine the user query, had to be embedded into the existing XSL style sheet. Further the XSLT processing has to be modified to pass in the references to the used profiles.

The following chart shows the operational sequence described.


AXMEDIS Distribution Server
(e.g. Web Interface)
Simple Query Web Service
User Profile
Device Profile
Context Profile
Simple Query
XML
Simple Results
XSLT Query Processing
XSLT Results Processing
AXMEDIS Query
+
User Information
AXMEDIS Query
Results
+
Error Conditions
AXMEDIS DataBase WebService
Interface

17.3 Production on Demand (UNIVLEEDS)

17.3.1 State of the Art

Universal multimedia access (UMA) has become the driving concept behind a significant amount of research and standardization activity [Vetro2003]. These concepts are used for terminals of any type to access a rich set of multimedia content for consumption. Ideally this is achieved over dynamic and heterogeneous networks and devices independent of location or time [Vetro2005].

Toward this goal of universal accessibility, techniques for scalable coding and transcoding were developed. An early application of such techniques was in the distribution of television programming from the studio over bandwidth-limited broadcast networks. Shortly after, the challenges in transmitting video over wireless networks and the Internet emerged. While scalable coding and transcoding are quite different approaches, they both offer a means to adapt various coding parameters of the media, such as the bit-rate and spatial/temporal resolution .

An alternative to real-time transcoding and scalable coding is the creation of content in multiple formats and a multiple bit-rates where an appropriate selection is made at delivery time [Smith1999]. While this solution is not intensive for computer processing, it can be highly storage intensive if the received terminals are not limited. In the scenario of no limitations on terminal or access network, Vetro and Timmerer state real-time adaptation is necessary. In this ongoing research, tools are being developed to support universal accessibility and are linked with MPEG-7 [Manjunath2002]. The MPEG-7 framework is based on XML and has standardised a set of description tools and a review of applying tools applied towards the UMA problem is given in [Beek2003]

[MPEG-21] recognised there were missing elements and attempts to fill these elements for multimedia delivery and consumptions across a wide range of networks and devices [Brunet2003]. One aspect of the requirements for MPEG-21 is Digital Item Adaptation (DIA) which is based on a Usage Environment Description (see section 4.7.2 in [MPEG-21]). It proposes the description of capabilities for at least the terminal, network, delivery, user, and natural environment, and notes the desirability of remaining compatible with other recommendations such as CC/PP [W3C2005] and UAProf. In Digital Item Adaptation: Vetro and Timmerer point out that the W3C Consortium [W3C2005] is also engaged in efforts to bridge the gap between multimedia content and devices.

17.3.2 Problems

As discussed earlier, one of the problems of creating content in multiple formats and bit-rates is being storage intensive. Real-time adaptation alone is not a solution when requested objects that have been transcoded as a programme may be required for further distribution.

The solution proposed using the Formatting Engine is to request adaptation when required using the Programme and Publication Engine and store the new object for future distribution. Therefore only original and newly adapted objects are stored. However for on-demand when an object is requested for direct distribution via the PnP Engine, incompatible objects not adapted for the requested distribution channel are required to be adapted in real-time (or as close to real-time as possible) and therefore there is a possible transmission delay. This problem does not apply when objects are processed in programmes delivered in advance of the distribution time using the PnP Editor and subsequently activated from the editor unless immediate distribution is also required.

AXMEDIS Methods for Production On-demand

The AXMEDIS Programme and Publication (PnP) Engine is devised to process programmes of various multimedia content, request adaptation if required, and retrieve the requested objects, either original or newly formatted from the AXMEDIS database for distribution. With respect to on-demand, the request for content is processed immediately when received. Scalable coding and transcoding required for distribution over different terminals and networks, is achieved but utilising the AXMEDIS Content Processor (AXCP). This is

processed by requesting AXCP adaptation rules and specifying the parameters to correctly format objects for the specified distribution channel and client device.

The first prototype of the Programme and Publication Engine will be used for testing and demonstrating the on-demand publications where adaptation is requested from the XML domain. The P&P Engine requests adaptation of the AXMEDIS Objects by requesting an adaptation rule in the AXMEDIS Content Processor (AXCP) with three profile parameters. These profile parameters required for distribution adaptation are the user profile; device profile; and network profile which makes adaptation possible in a flexible manner without the need of the digital object. This is achieved when the profile of the AXMEDIS object is incompatible with the destination profile, the P&P Engine interfaces with the Formatting Engine to provide the appropriate processing on the object and provides the means to access the correctly formatted object for distribution.

This application will be implemented in C++ using wxWindows and Xerces libraries as specified in DE3-1-2. This prototype will be developed for as a win32 application only. The engine will be tested using the XML P&P programmes saved using the first prototype of the P&P Editor using the Programme and Publication libraries (the PnPModel) developed to create new programmes and editing existing programmes (AxPnPRule.lib).

The PnPModel (PnP programme) provides description in three sections. The Header element provides general information such as the Programme Name, Programme ID, version, date of production etc; and production information such as Author, affiliation etc. The Schedule element specifies information such as start date and time, the expiration date and time, and the periodicity. The Definition element provides the rest of the information for distribution i.e. the programme including either the object or a selection of objects, the delivery date and time, duration and where to distribute such as the channel id and terminal id. This provides the minimum amount of information for distribution over different channels of various digital media.

The testing tool will accept a XML programme string from on-demand created utilising the programme libraries. The process required is described in the following section Work Done. Using SOAP messages to send the string, the P&P engine will validate the string. A failed process returns and error message to on demand. A successful process will return the prepared test content to the on-demand.

17.3.3 Work Done

Programme and Publication Model: The PnP Model library can be located from the AXMEDIS repository (see DE5.2.1 for repository lay out). The precompiled libraries are located at Framework/lib/pnpmodel/win32 and named axpnpmodel.lib (release) and axpnpmodel_d.lib (debug). To compile the pnpmodel the project files for .NET VC++ are located at Framework/project/pnpmodel/win32. Compilation of the pnpmodel requires wxWindows and Xerces to be installed and two system variables to be set: WXWIN to specify the location of wxWindows-2.4.2 and XERCES to specify the location of xerces-c_2_6_0 (NB. XERCESCROOT is required for compiling Xerces if not using the precompiled libraries available for download).

For on-demand to create a PnP programme, the following steps are required:

1. Create the PnP Programme Rule and set header information

```
AxPnPRule* newProgramme = new AxPnPRule( )
newProgramme->setFilename(name);
newProgramme->getHeader()->setRuleName(rule_name);
newProgramme->getHeader()->setSoftwareName(software_name);
newProgramme->getHeader()->setSoftwareVersion(software_version);
```

2. Add a selection to the rule distribution and set the required selection parameters

```
AxRuleDistribution* newDistribution = new AxRuleDistribution();
newDistribution->setAXOID(wxString axoid);
newDistribution->setStartDate((wxDateTime)date_to_start_distribution);
```

```
newDistribution->setStartTime((wxDateTime)time_to_start_distribution);
newDistribution->setChannelId(channel_for_distribution);
newDistribution->setTerminalId(terminal_for_distribution);

newProgramme->appendDistribution(newDistribution);
```

3. Write programme to XML string and send to the PnPEngine
   ```
   char* XMLString = newRule->writeXMLString()
   // code to send the XMLString to the PnP Engine
   ```

   The timestamp is set at the current time by default of the creation of a new `AxRuleDistribution`. The PnP Model is designed to be simple to use.

4. Sending On-Demand request to the P&P Engine including the P&P Programme (XML string), Distribution End Point, and three profiles (User, Device and Network) required for adaptation and distribution.

The P&P Engine (part 4 above) is a multi-threaded server capable of processing multiple P&P Programmes with the distribution specification for one or more objects in a P&P Programme. The P&P Engine parses the P&P Programme and schedules the processing of the P&P Programme and each distribution thread also schedules the distribution of the AXMEDIS object within the programme. On distribution of an AXMEDIS object, the P&P Engine uses either FTP or Distribution Plugins depending on the distribution channel specified in the P&P Programme. Distribution Plugins are required when the distribution channel has a distribution API such as EUTELSAT's distribution model. Functionalities of the P&P Engine include:

- Communicate with P&P Editor using SOAP or Socket
- Parsing a P&P Programme to process
- Processing a P&P Programme and creating distribution threads
- Scheduling AxObjects in the distribution threads as specifed in the P&P Programmes
- Communicate with AXCP Rule Scheduler using WSDLPull Web services (this is to be further tested)
- Distribute AXMEDIS Objects using either: FTP, Opening local AxPlayer, or using EUTELSAT.dll library and the EUTELSAT API

Work in Progress

The P&P Engine is currently being developed to take a request for an AXMEDIS object using SOAP messages. Parameters include the Distribution End Point, P&P Programme, User Profile, Device profile and Network profile. From the requested channel specified, the P&P Engine selects a predefined processing rule and send the request to the AXCP which returns either a newly adapted object with the correct distribution criteria or the same object if no adaptation is required. At the specified time for distribution, the objects specified in the selection are returned to On-Demand in the correct format for the distribution channel, device and the user's specifications.

Current work includes:

- The communication from On-demand to the P&P Engine and the SOAP parameters to be sent.
- Testing communication from the P&P Engine to the AXCP and implementation to select the adaptation rule required and set the parameters to adapt the AXMEDIS object for the specified distribution channel.
- Returning the results to On-demand. This is either the AXMEDIS Object correctly formatted or reported error/warning message.

17.3.4 References

[Beek2003] P. van Beek, J. R. Smith, T. Ebrahimi, T. Suzuki, and J. Askelof, "Metadata- driven multimedia access," *IEEE Signal Process. Mag*., vol. 20, no.2, pp. 40–52, Mar. 2003

[Brunet2003] I. Brunet, R. Van de Walle, K. Hill, J. Bormans, F. Pereira, "MPEG-21: Goals and achievements", *IEEE Multimedia*, Vol. 9, No. 2, October-December 2003, pp. 60-70.

[Manjunath2002] B. S. Manjunath, P. Salembier, and T. Sikora, Eds., *Introduction to MPEG 7: Multimedia Content Description Language.* New York: Wiley, 2002

[MPEG-21] MPEG-21 Requirements v.2 , http://www.chiariglione.org/mpeg, Dec. 2003, Last accessed July 2005.

[Smith1999] J. R. Smith, R. Mohan, and C.-S. Li, "Scalable multimedia delivery for pervasive computing," *Proc. ACM Multimedia*, pp. 131–140, 1999.

[Vetro2003] A. Vetro, C. Christopoulos, and T. Ebrahami, Eds., *IEEE Signal Process Mag. - Special Issue on Universal Multimedia Access*, vol. 20, no. 2, Mar. 2003.

[Vetro2005] A. Vetro, and C. Timmerer, Eds., "*Digital Item Adaptation: Overview of Standardization and Research Activities*" IEEE Transaction on Multimedia, vol. 7, no. 3, Jun. 2005.

[W3C2005] W3C World Wide Web Consortium, http://www.w3.org/ Last accessed, July 2005.

[XercesC2005] XML Apache Project, Xerces C++ Parser, http://xml.apache.org/xerces-c/ Last accessed July 2005.

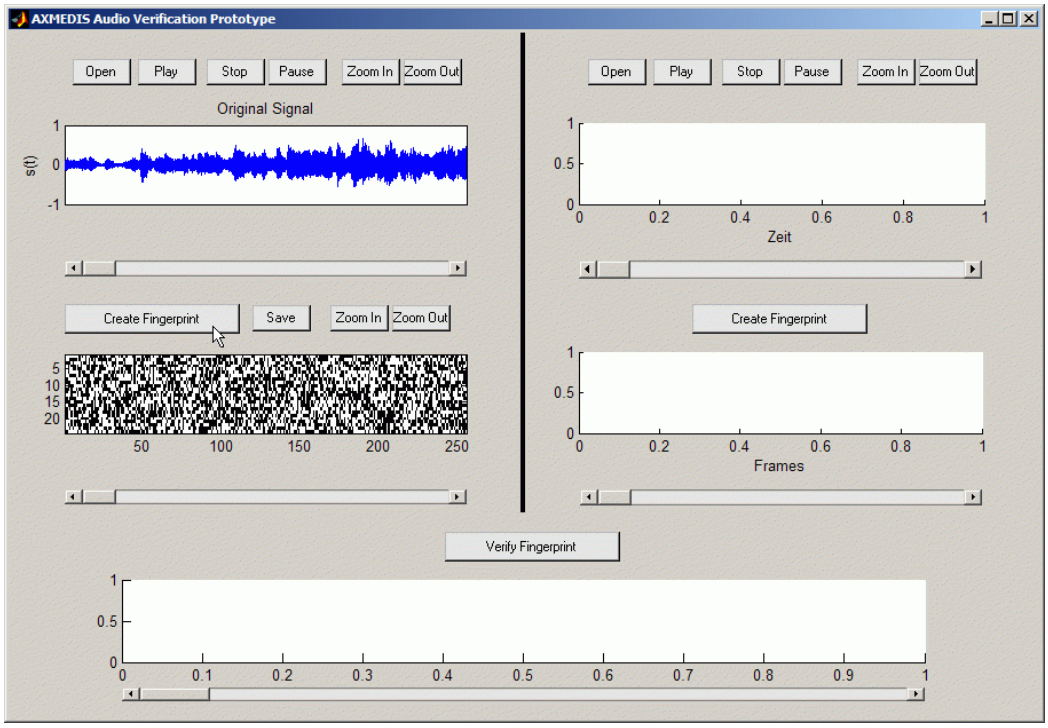
18 Bibliography (FHGIGD) (completed)

The bibliography and the references can be found in the individual sections.

A. Appendix: Fingerprinting Demonstration Prototype

A. Audio Fingerprinting Demonstration

The demonstrator is started in MatLab.

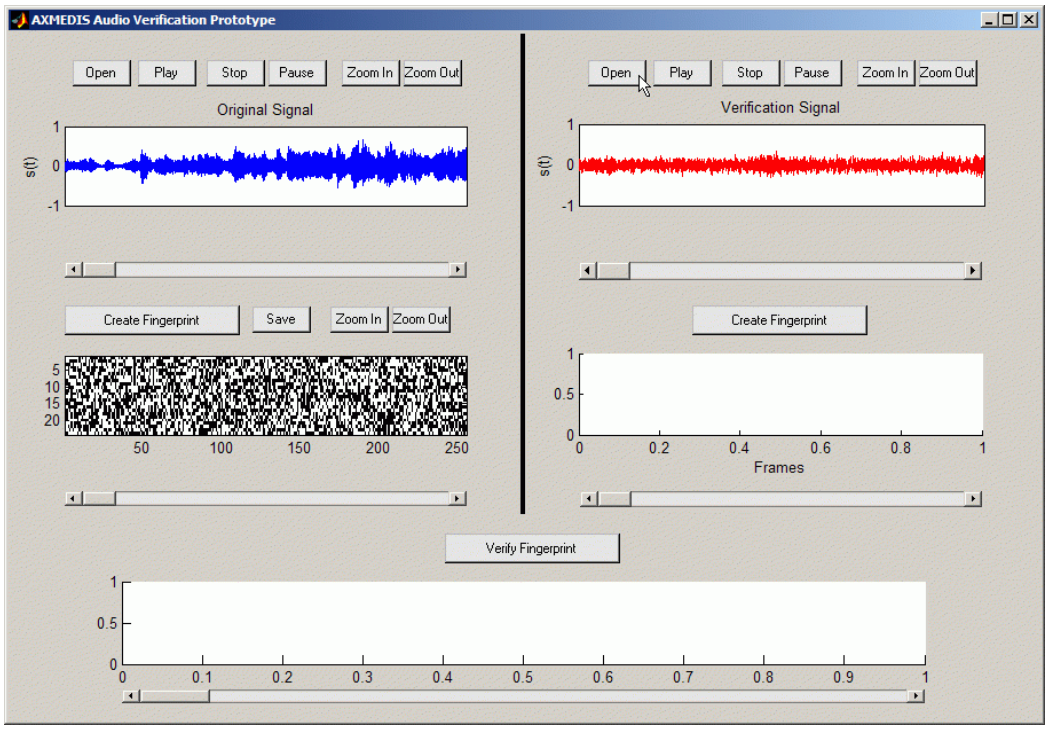


The main window is split in three parts:

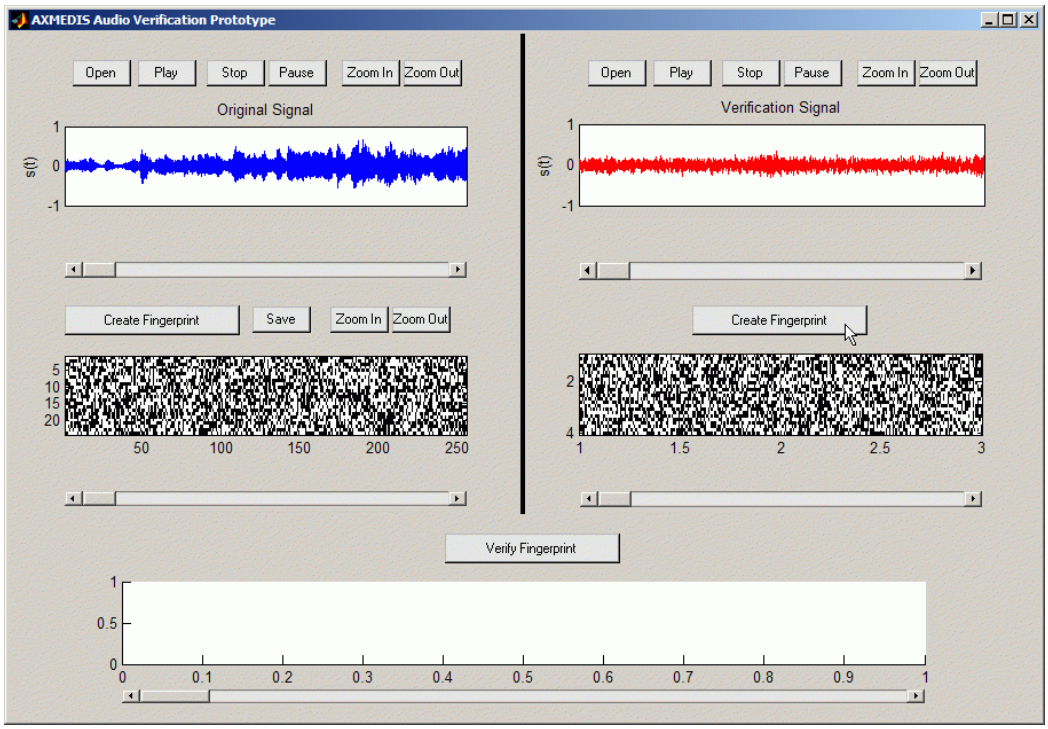
- The (upper) left part of the windows shows the information related to the original signal. The audio can be played and is also visualized as a 1D-temporal function. For this audio signal, the fingerprint can be calculated and viewed.
- The (upper) right part of the window contains the information related to the signal that should be verified. This audio signal is the processed or manipulated. The signal as well as the corresponding fingerprint can be viewed.
- The lower part contains the difference between the fingerprint of the original and the fingerprint of the signal that should be verified.

The demonstration starts with loading the original signal (as shown above). For this signal the fingerprint is calculated.

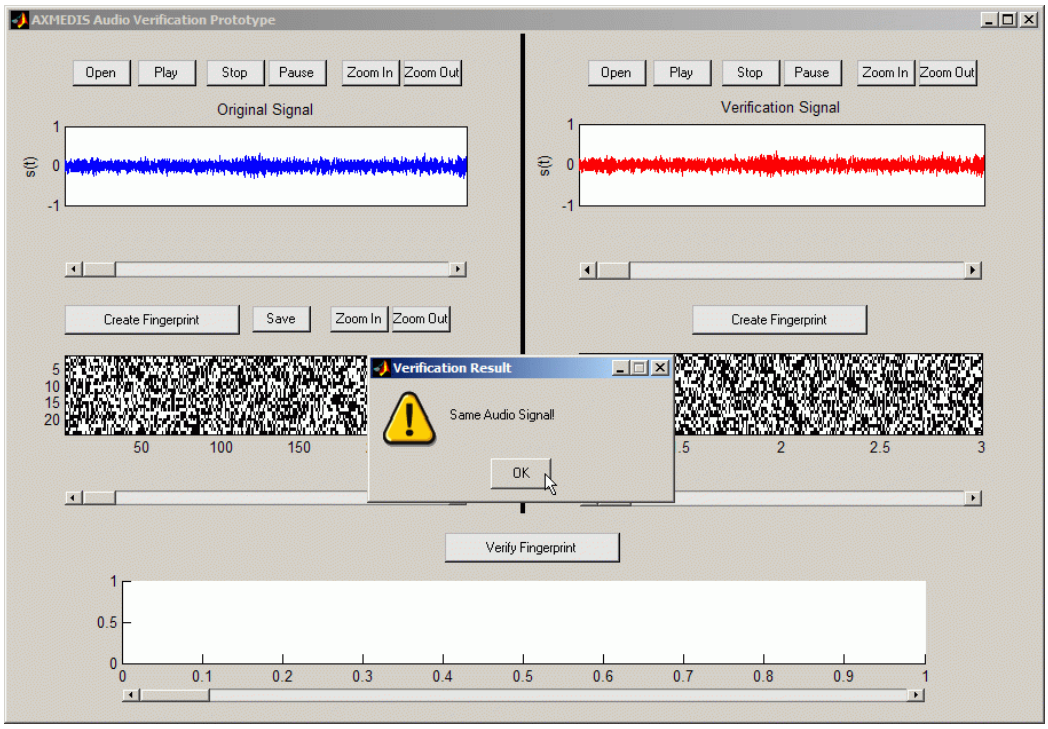
In the second step, the verification signal is loaded as shown below.



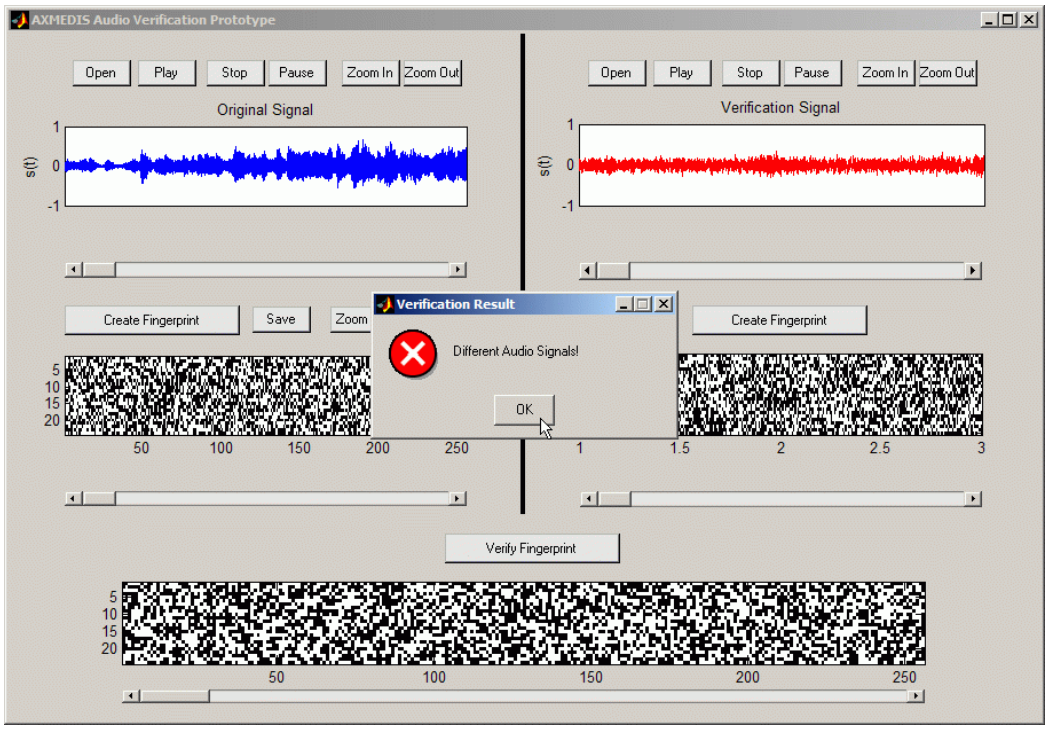
After loading the reference signal, its fingerprint is calculated.



The fingerprint of the original signal and the reference signal are compared. If the signals are similar, a corresponding message box opens:

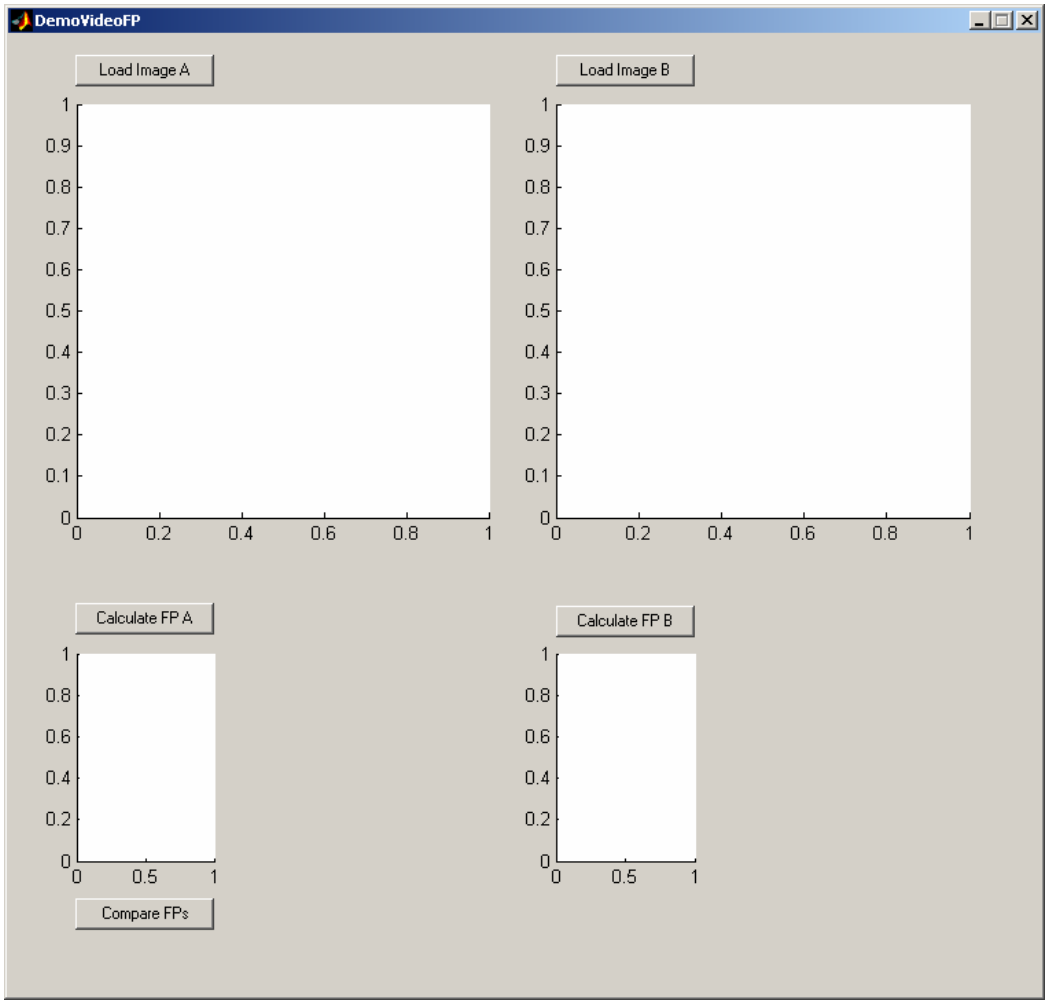


In the case of different signals, an error is shown:



B. Image Fingerprinting Demonstration

When the application is started in MatLab, a dialog is shown.

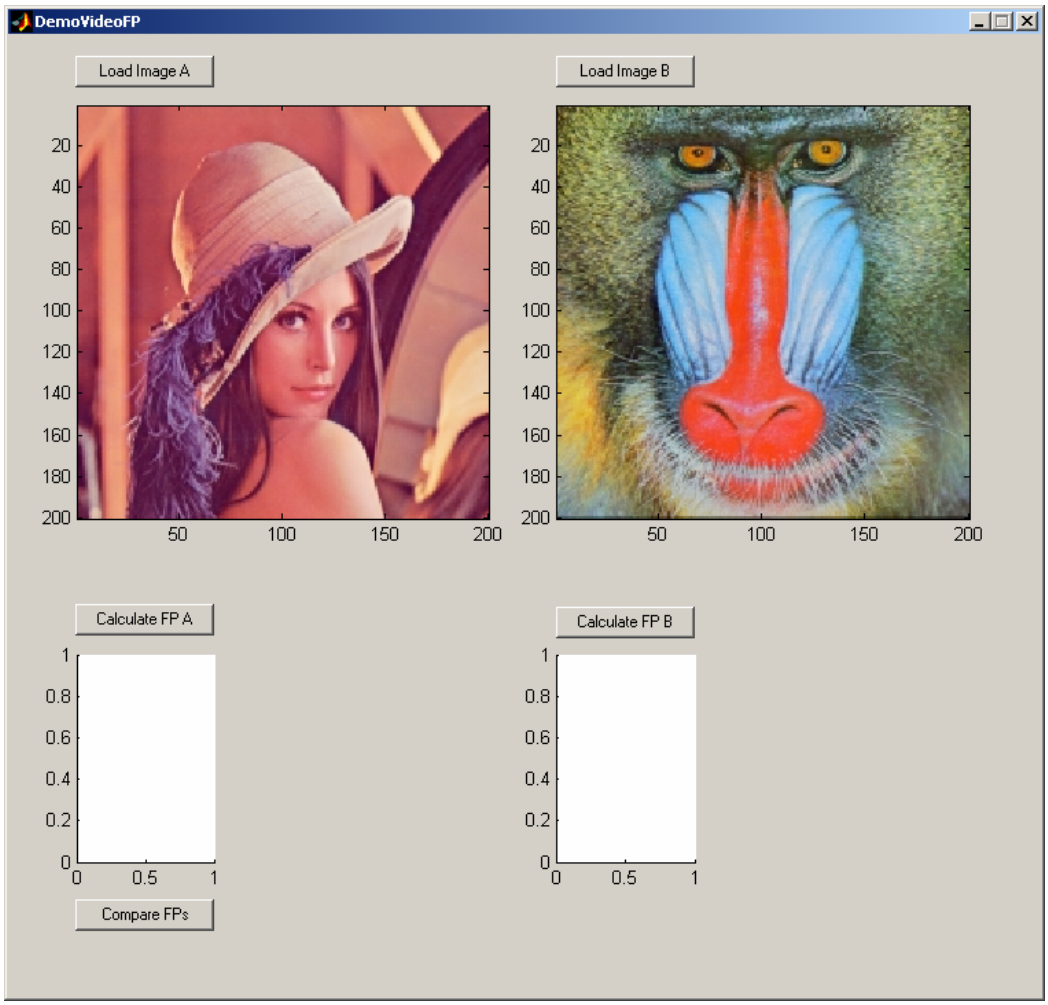


This dialog consists of four buttons, which allows to

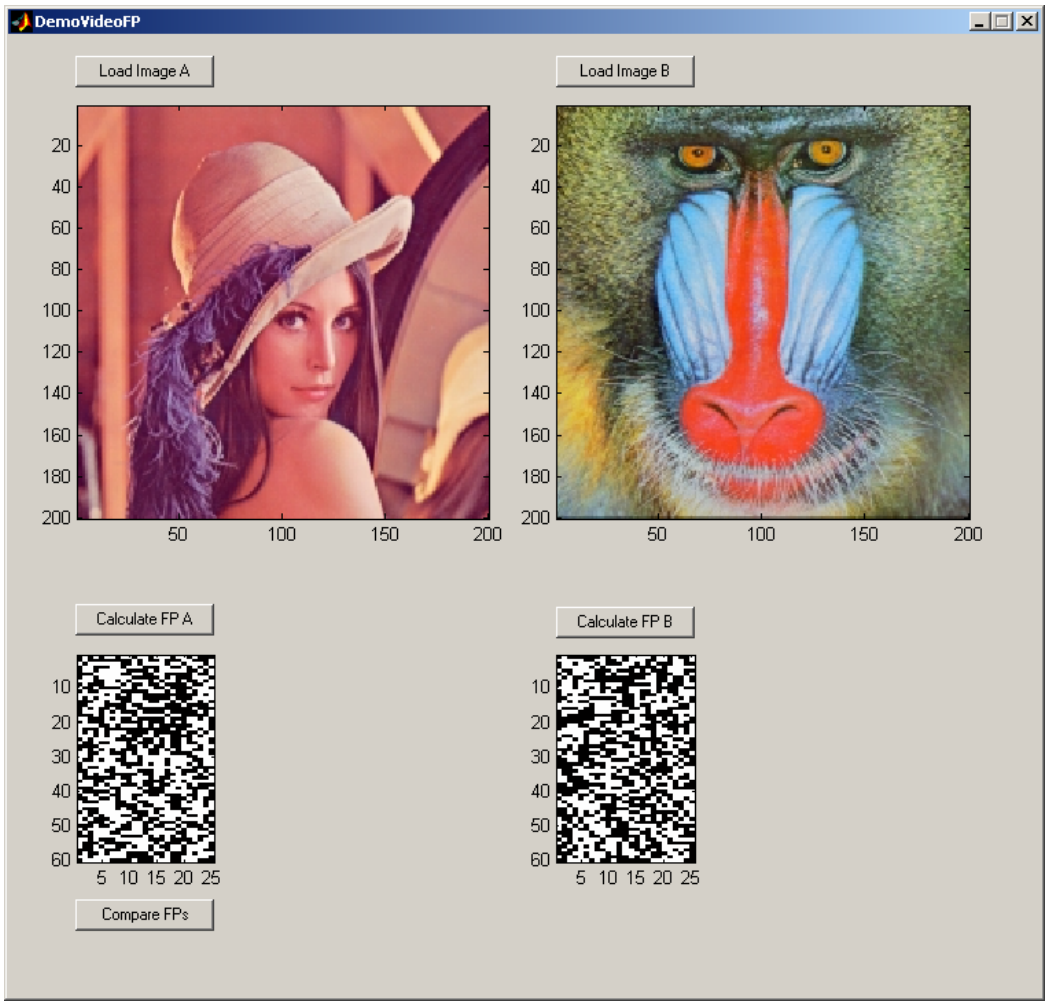
- load the reference image and the image under evaluation, to
- calculate the fingerprints for the reference image and the image under evaluation, and to
- compare the calculated fingerprints.

For the visualization of the input images and the calculated fingerprints different areas are available in the user interface.

For the demonstration, the users can load selected images:



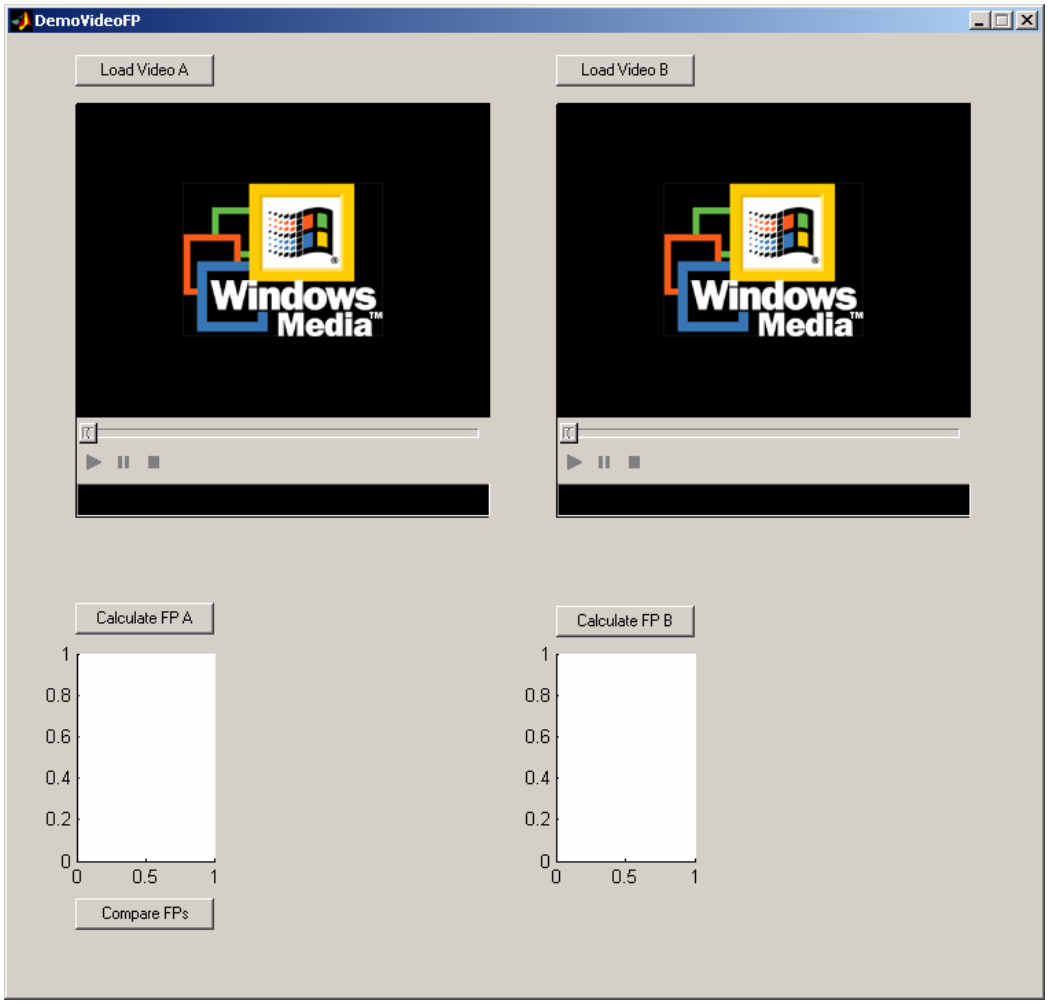
The fingerprints are calculated for the loaded images and shown visually:



After calculation of the fingerprints, the fingerprints can be compared. Dependent on the input content the fingerprints are either different (as in the above example) or similar.

C. Video Fingerprinting Demonstration

When the application is started in MatLab, a dialog is shown.

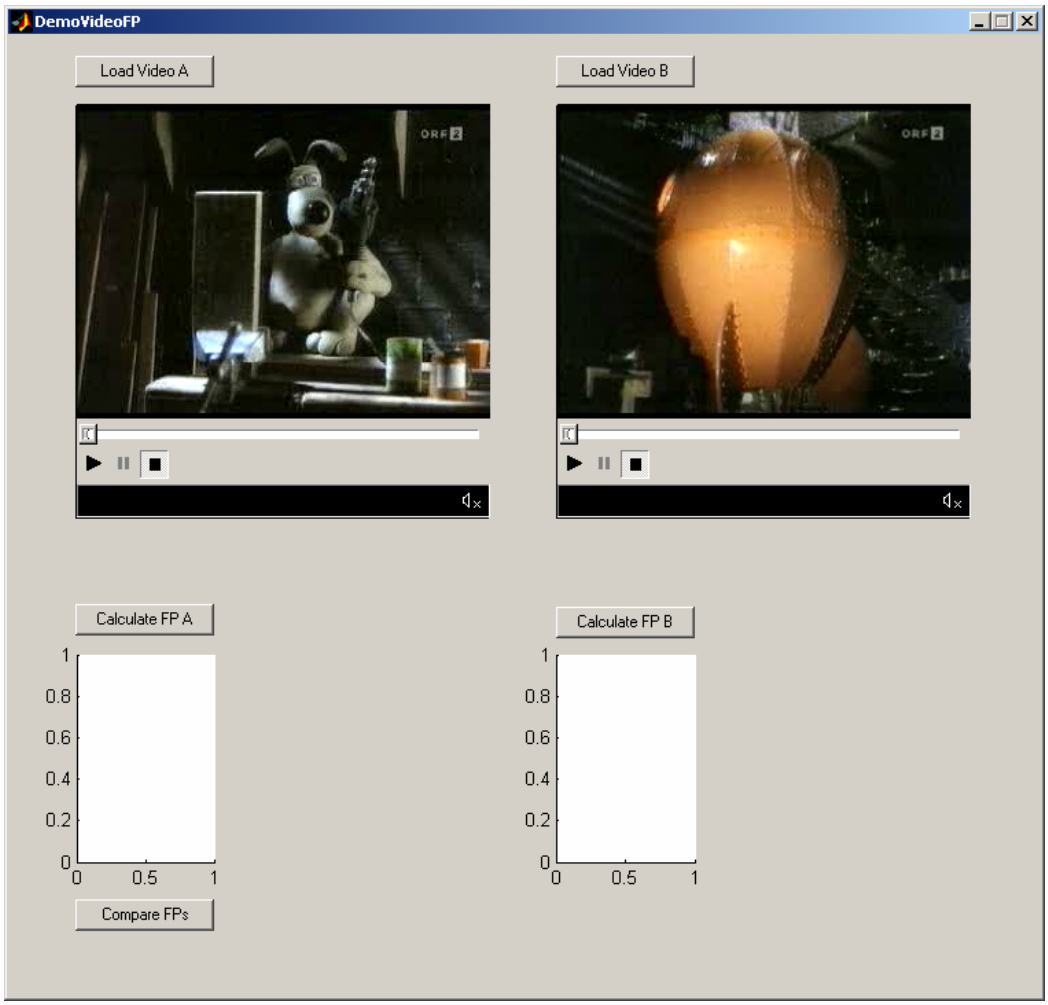


This dialog consists of four buttons, which allows to

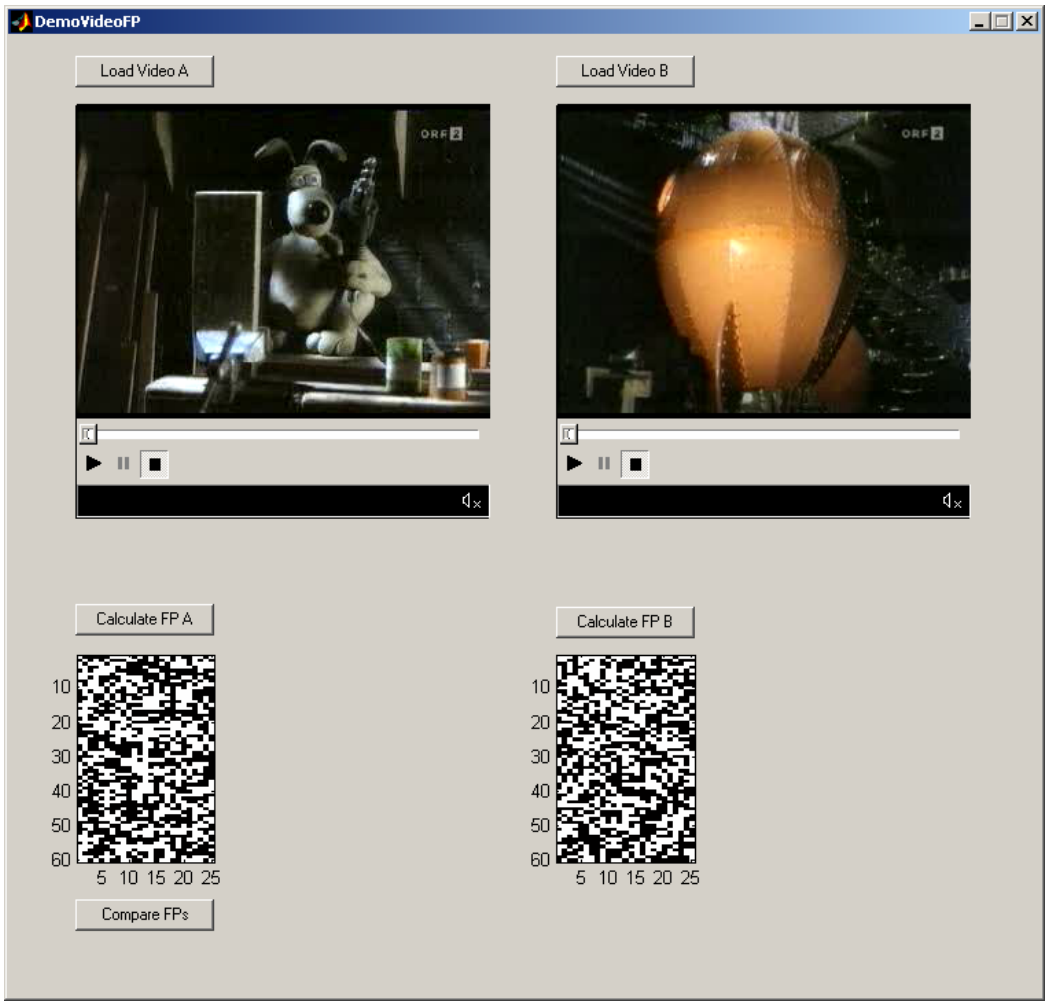
- load the reference video and the video under evaluation, to
- calculate the fingerprints for the reference video and the video under evaluation, and to
- compare the calculated fingerprints.

For the visualization of the input videos and the calculated fingerprints different areas are available in the user interface.

For the demonstration, the users can load selected videos:



The fingerprints are calculated for the loaded images and shown visually:



After calculation of the fingerprints, the fingerprints can be compared. Dependent on the input content the fingerprints are either different (as in the above example) or similar.