

Audio/Video Digital Libraries: the ECHO Experience

ICDAT2006

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Talk overview

Provide a review on the techniques and the methodologies for the **organization, creation, and management** of an Audio/Video Digital Library through the illustration of the results of the ECHO project.

- Characteristics of A/V Digital Libraries
- The ECHO Project and Prototype System
 - Automatic Audio/Video Indexing
 - Content-Based Retrieval of Audio/Video documents
 - The ECHO Metadata Model
 - Visualization and Browsing of search results
- Evolution of the ECHO solution

What is a Digital Library?

A Digital Library is an **organized collection** of digital objects, including **text, images, audio, video** and **services** for its access and retrieval, as well as for **selection, organization and maintenance** of the collection.

The importance of video

- Video can be considered today the primary information and communication channel, due to
 - Richness in information contained
 - Appeal
 - Approximately 50% of what is seen and heard simultaneously is retained
- Video libraries are becoming essential in many application fields
 - Media and entertainment
 - Personal information
 - Distance learning
 - Education
 - Telemedicine
 - Surveillance

Services of A/V Digital Libraries

- Digital Video Libraries are more complex than traditional DLs; they require the integration of several specialized technologies
- They offer the same services of text digital libraries
- Specific characteristics of Indexing and retrieval services
 - Indexing based on the integration of different technologies for the automatic feature extraction
 - Integration of manual and automatic indexing
 - Retrieval based on different video features

Advantages of A/V DLs

- Most of the video material produced is used only once, due to the **difficulty to archive** it, to **protect** and to **retrieve**.
- A large video library of distributed and network searchable videos would enable
 - **Preservation** of precious and expensive material
 - **Reduction of production costs** for new videos, through the reuse of existing material
 - **Diffusion of knowledge**

A/V vs traditional DLs [1/2]

- Library creation
 - Traditional DLs, contain text documents
 - Library creation requires automatic acquisition of text, extraction of document content, and indexing
 - This process is well known and many different techniques have been developed
 - Video is extremely rich in “content” but
 - the indexing of video content is difficult, expensive, and extremely dependent from the user and the application
 - A possible approach consists in an appropriate integration of automatic content extraction (e.g. speech recognition, image analysis, etc.) and manual indexing

A/V vs traditional DLs [2/2]

- Library exploration
 - Traditional DLs, contain text documents
 - Library exploration requires simple interfaces to formulate queries on free text and document metadata.
 - Video libraries should permit
 - To formulate queries on many different “dimensions”
 - Text, as extracted from speech and captions
 - Images extracted as key frames
 - Motion information
 - Other features automatically extracted
 - Metadata provided manually

- Characteristics of A/V Digital Libraries
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The ECHO Project

- ECHO: European CHronicles On line
- International research cooperation **funded by the European Union** under the IST fifth Framework Program.
- The project started on **February 2000** and ended on **May 2003**.
- Cooperation among **research institutions, audio/video archives, and industry**.

The Partners

- **Project coordinated** by ISTI-CNR
- **Content providers**
 - Istituto Luce (I), Institut National de l'Audiovisuel (F), Stichting Nederlands Audiovisueel Archief (NL), Memoriav (CH)
- **Industrial partners**
 - Tecmath (D), Eurospider Information Technology (CH)
- **Research Institutions**
 - ISTI-CNR (I), Istituto Trentino di Cultura (I), Centre National de la Recherche Scientifique (F), University of Mannheim (D), Carnegie Mellon University (USA)

Main project motivations

Large collections of **historical documentary films** owned by private and public institutions

Four main national video archives participated to the ECHO project



Main project results

Development of an Audio/Video Digital Library system which makes possible to **access** and **search** by content over the net, **large** and **inter-operating** audio visual archives.

- Management of **historical documentaries**
- Definition and adoption of an appropriate **metadata format**
- Integration of **manual** and **automatic indexing**
- Support of **multiple languages**
- Creation of **automatic video summaries**
- Validation through **test beds** of documentary film archives

Operations of the ECHO A/V Digital Library

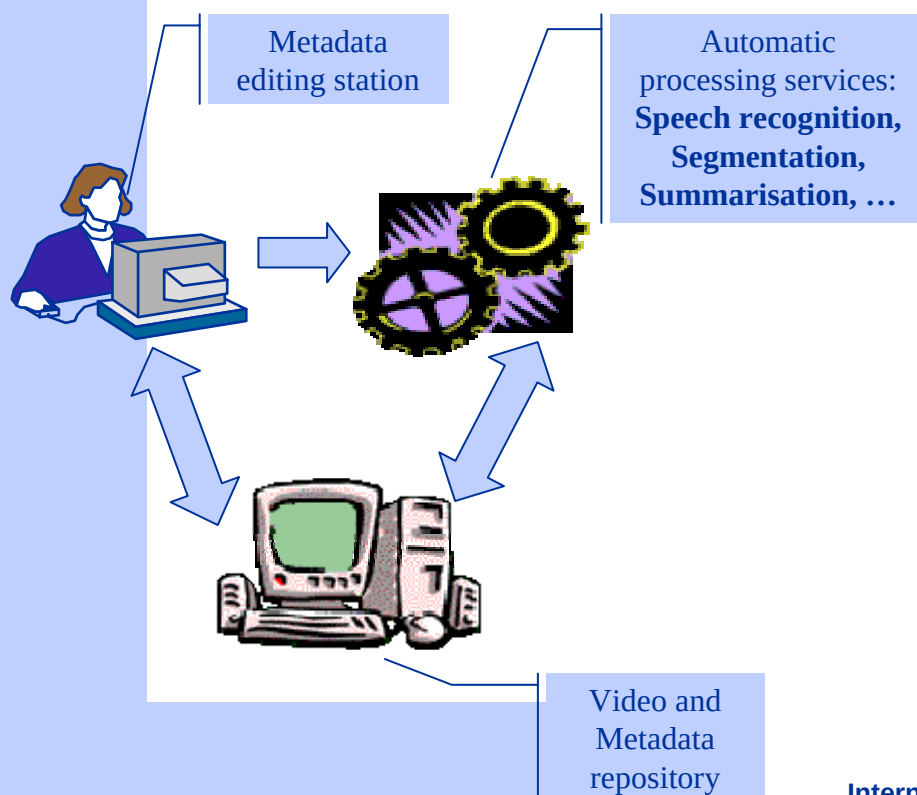
- Video archiving and indexing
- Video storage
- Content-based search
- Visualization of search results
- Video access (visualization and copy)

ECHO System Functionality

- **Indexing**
 - Automatic indexing: key frames, object recognition, text extraction, face detection
 - Manual semantic indexing through a specialized video metadata editor
 - Automatic speech recognition for multiple languages (italian, dutch, german, english)
 - Automatic generation of video abstracts
- **Retrieval**
 - Content-based retrieval based on speech transcript, image similarity search, metadata
 - Multilingual retrieval support for free text, and selected metadata fields
- **Metadata model**
 - The model supports the video description at different levels and includes the management of metadata automatically extracted or associated manually
 - Support of multilingual indexing
- **Result presentation**
 - Support of multiple visualization modes of retrieved videos
 - Metadata only
 - Key frames
 - Speech transcripts

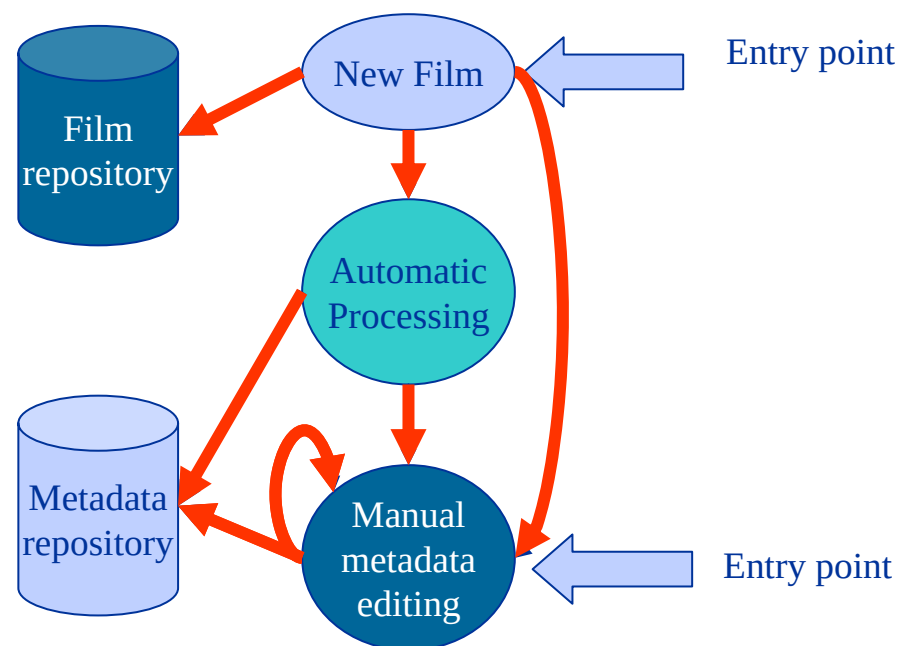
Video Indexing

Main components:



Consiglio Nazionale delle Ricerche

Indexing Workflow:



International Conference on Digital Archive Technologies (ICDAT 2006)

Taipei, Taiwan, 19-20 October 2006

Pasquale Savino
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Video Indexing

- **Automatic** vs **manual** indexing
- **Manual Indexing** of all bibliographic metadata
 - Background information, e.g.
 - Creation date
 - Author
 - Names of the actors
 - Semantic information
 - Relations among different shots
 - Interpretation of the meaning of a shot
 - Interpretation of the meaning of a frame
 - All this type of information is provided manually, by using a specific tool, the **ECHO metadata editor**

Video Indexing

- **Automatic indexing**

- Automatic indexing is expected to be
 - Fast
 - Reliable (user independent, error reduction)
- Features that can be extracted from the **entire video**,
 - e.g. frame rate, resolution, b&w or color video, etc.
- Features that are associated to the **audio part**
 - e.g. the transcript of the speech
- Features that can be extracted from each **shot**
 - e.g. object track, camera movement, recognition of specific objects, recognition of faces, text captions, key frames
- Features that can be extracted from each **frame**
 - typical image features, e.g. color distribution, texture, object's shapes
- **Object recognition, text extraction, face detection**

Text recognition inside key frames



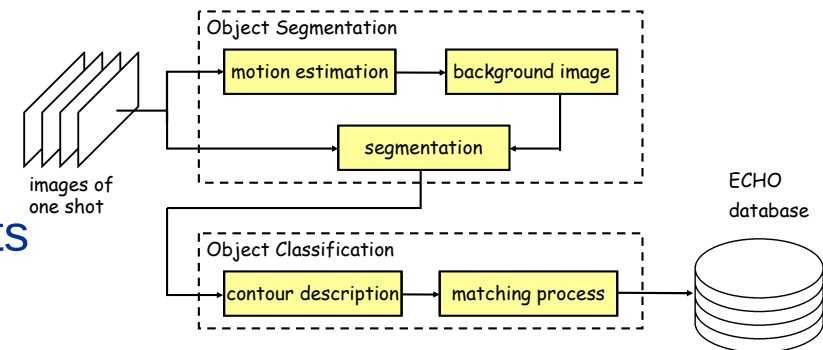
Identification

Speech recognition

- The purpose of speech recognition is the **generation of a transcript** to be used as a **support for retrieval**
- Main functionality required
 - Speaker independent
 - Multiple languages
 - Operating also with low quality audio
- Does not require perfect recognition
 - Retrieval quality is **acceptable for W.E.R. up to 30-40%**

Object detection and recognition

- The system for moving-object recognition consists of two components, a *segmentation module* and a *classification module*.
- For each shot in the video, a background panorama image is constructed. The foreground objects in this background image are removed by means of temporal filtering (median).
- The object is segmented by comparing each frame of the video to the background image.

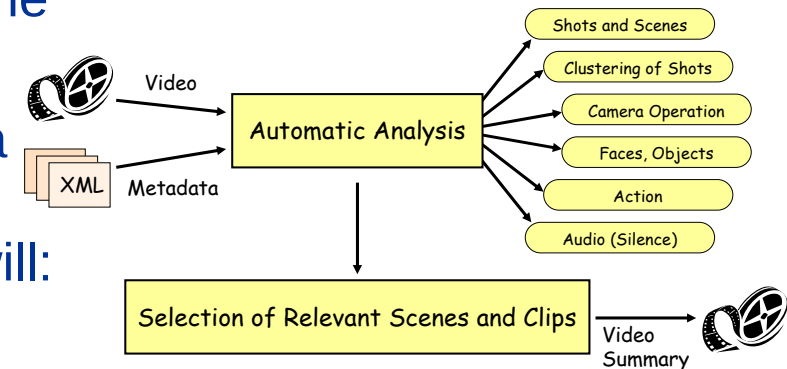


Example: Cars



Video abstract generation

- A video abstract is a part of a much longer video, which preserves the essential message of the original video.
- A video abstract does not change the presentation medium.
- The users get a quick overview of a much longer video.
- The video abstracting application will:
 - Select relevant clips
 - Order these clips
 - Define a transition between two clips
 - Modify the audio track

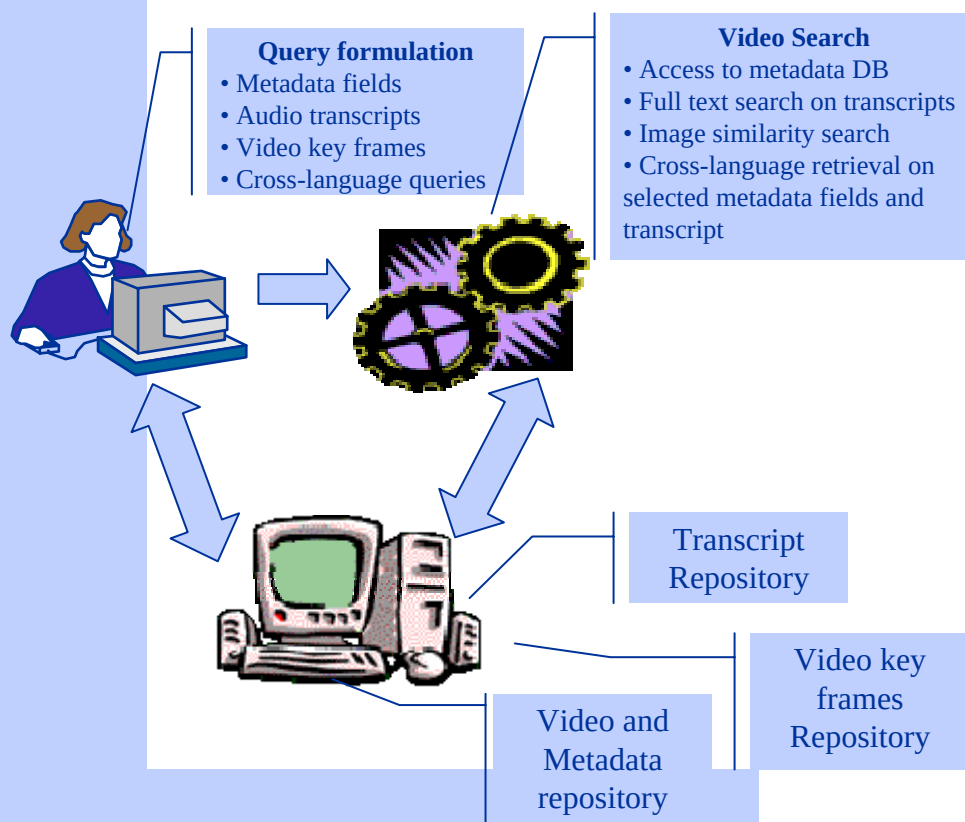


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Video Retrieval

Main components:



Query examples:

- Metadata associated to the entire video
 - E.g. *find b&w videos produced before II world war by Istituto Luce*
- Metadata associated to video shots
 - E.g. *find a shot where the audio transcript contains the words "Attentato Banca Nazionale dell'Agricoltura"*
- Metadata associated to single frames
 - E.g. *find a video that contains a frame similar to this image [the image is provided as an example]*
- Any combination of the previous cases

Retrieval characteristics

- Retrieval is based on **queries expressed on metadata values**. Automatically extracted metadata, as well as metadata associated manually to the video can be used.
- Retrieval is based on an **approximate match** between the query and the retrieved videos. This is mainly the case when imprecise query elements are used (e.g. free text, images)
- Retrieved videos are returned to the user in decreasing relevance order, possibly indicating the **degree of relevance** of the retrieved items.

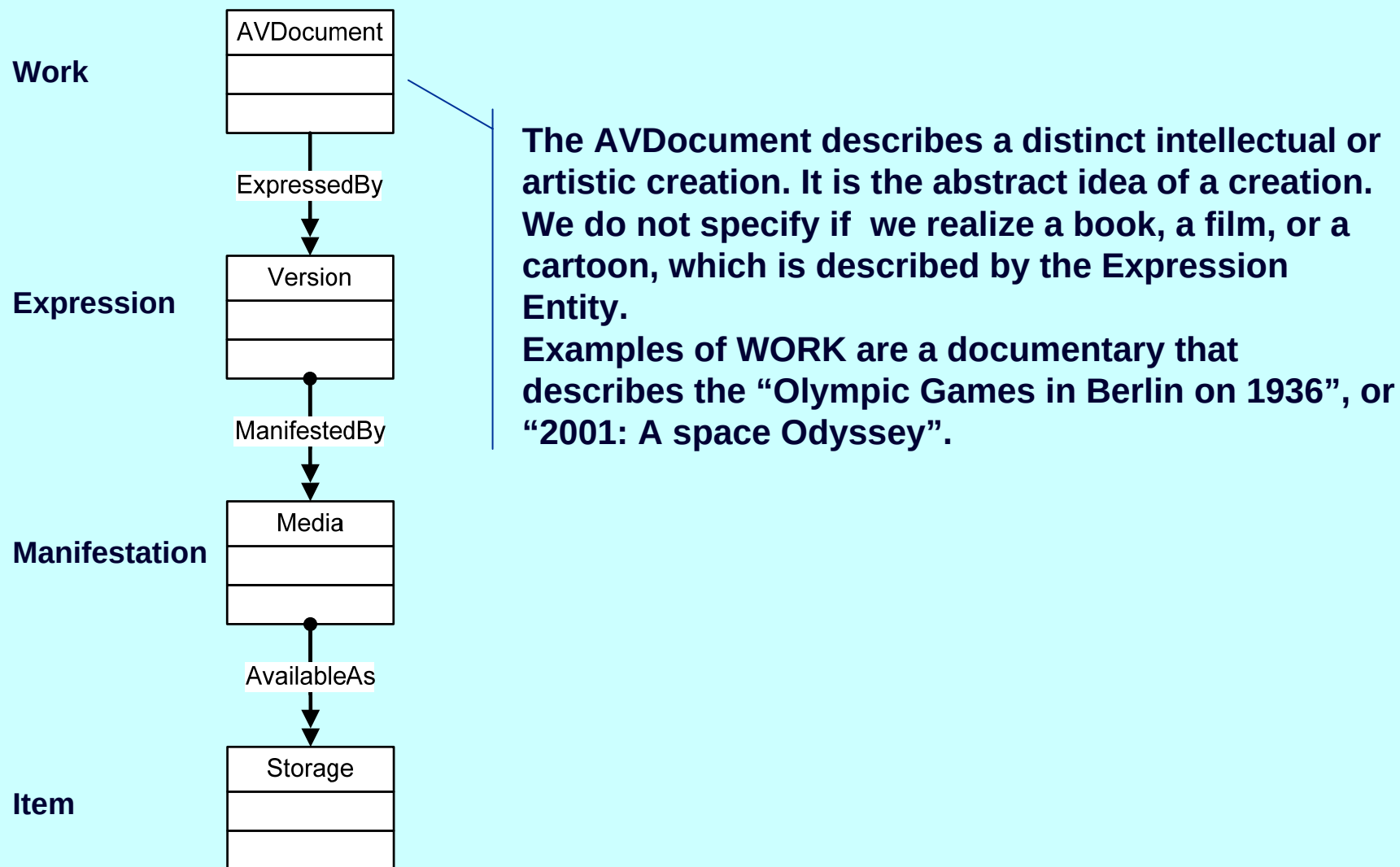
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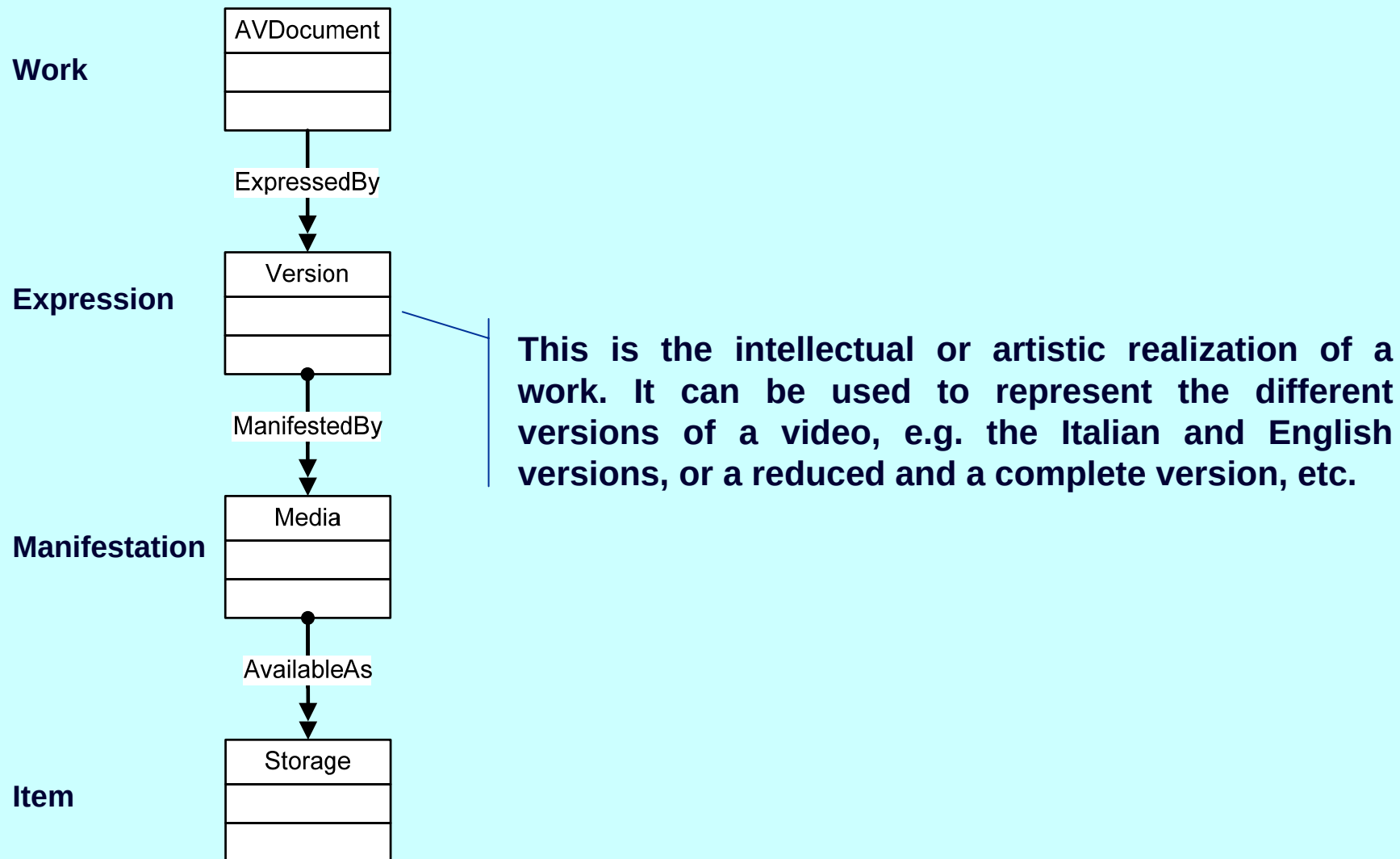
The ECHO Metadata Model

- The ECHO metadata model is an **extension of the IFLA/FRBR model**. IFLA/FRBR is structured into four levels which describe all aspects of an intellectual or artistic object: **Work**, **Expression**, **Manifestation** and **Item**.
- The entities of ECHO metadata model are organized according to a **hierarchy** which is strictly related to these four levels: there are four classes – **AVDocument**, **Version**, **Media** and **Storage** – which correspond to the four levels of IFLA/FRBR.

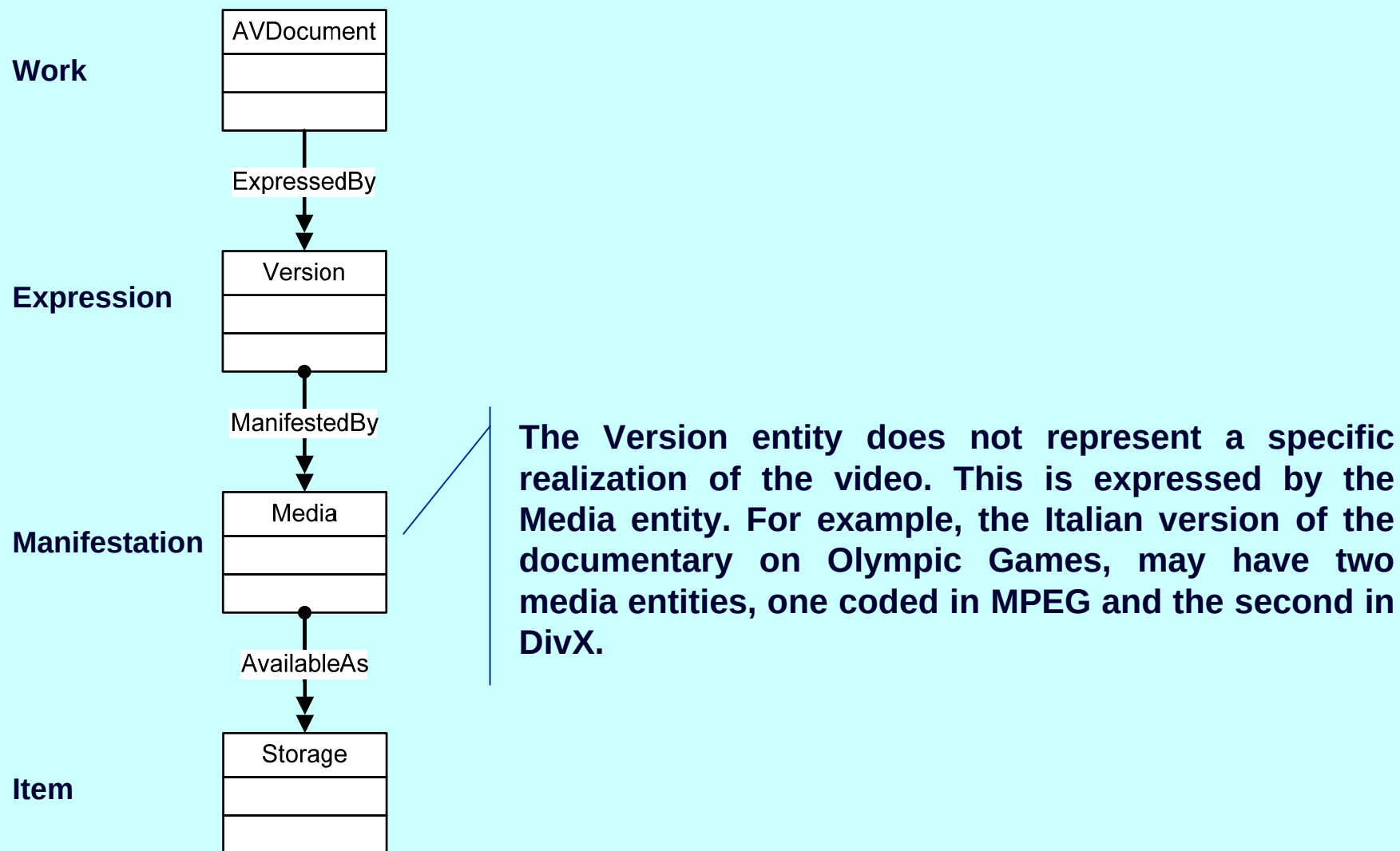
The structure of the ECHO metadata model



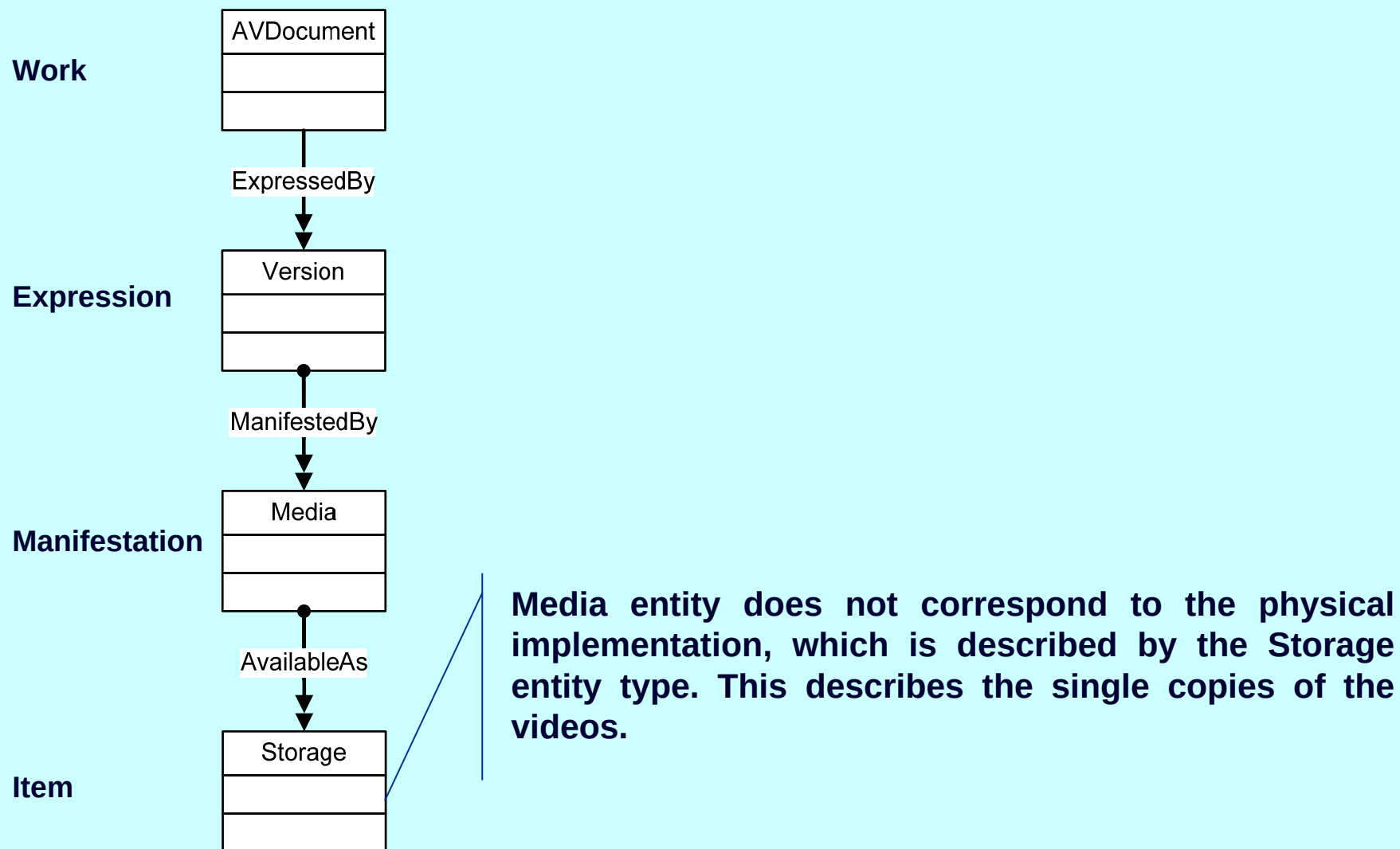
The structure of the ECHO metadata model



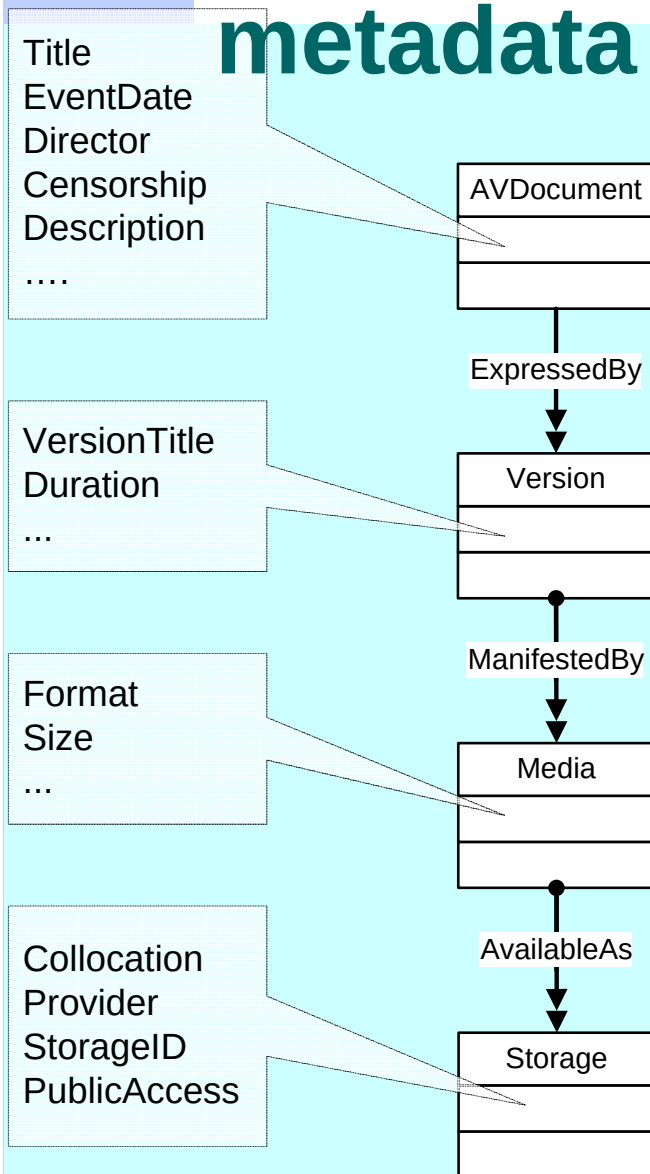
The structure of the ECHO metadata model



The structure of the ECHO metadata model

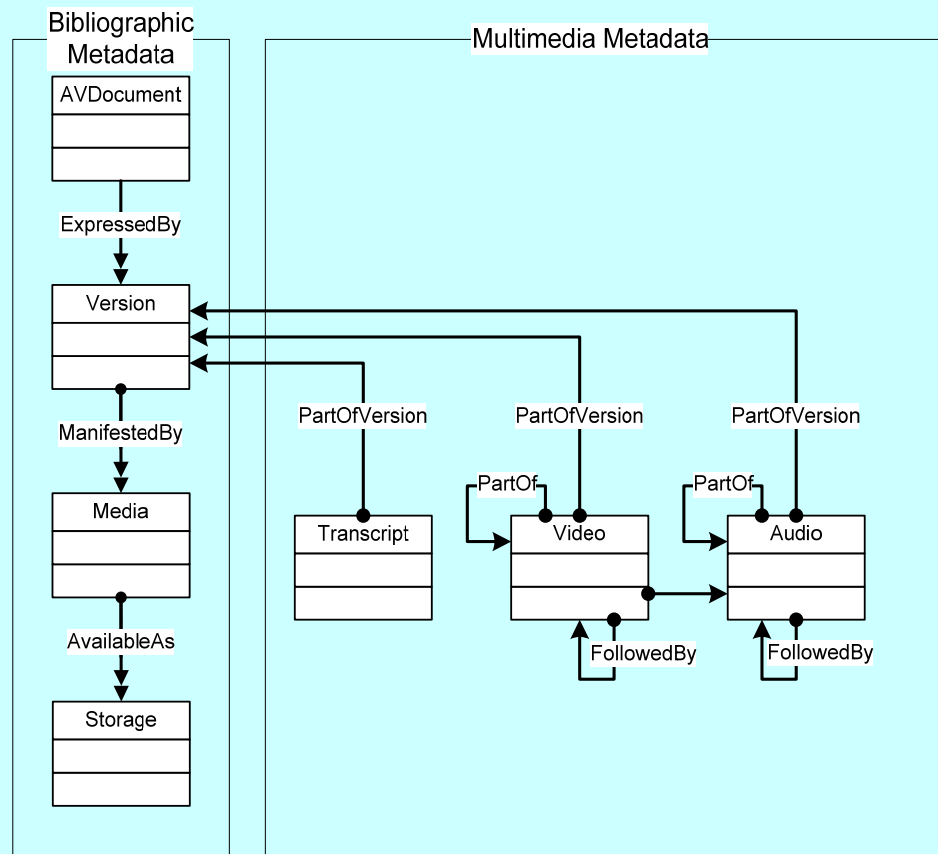


The structure of the ECHO metadata model



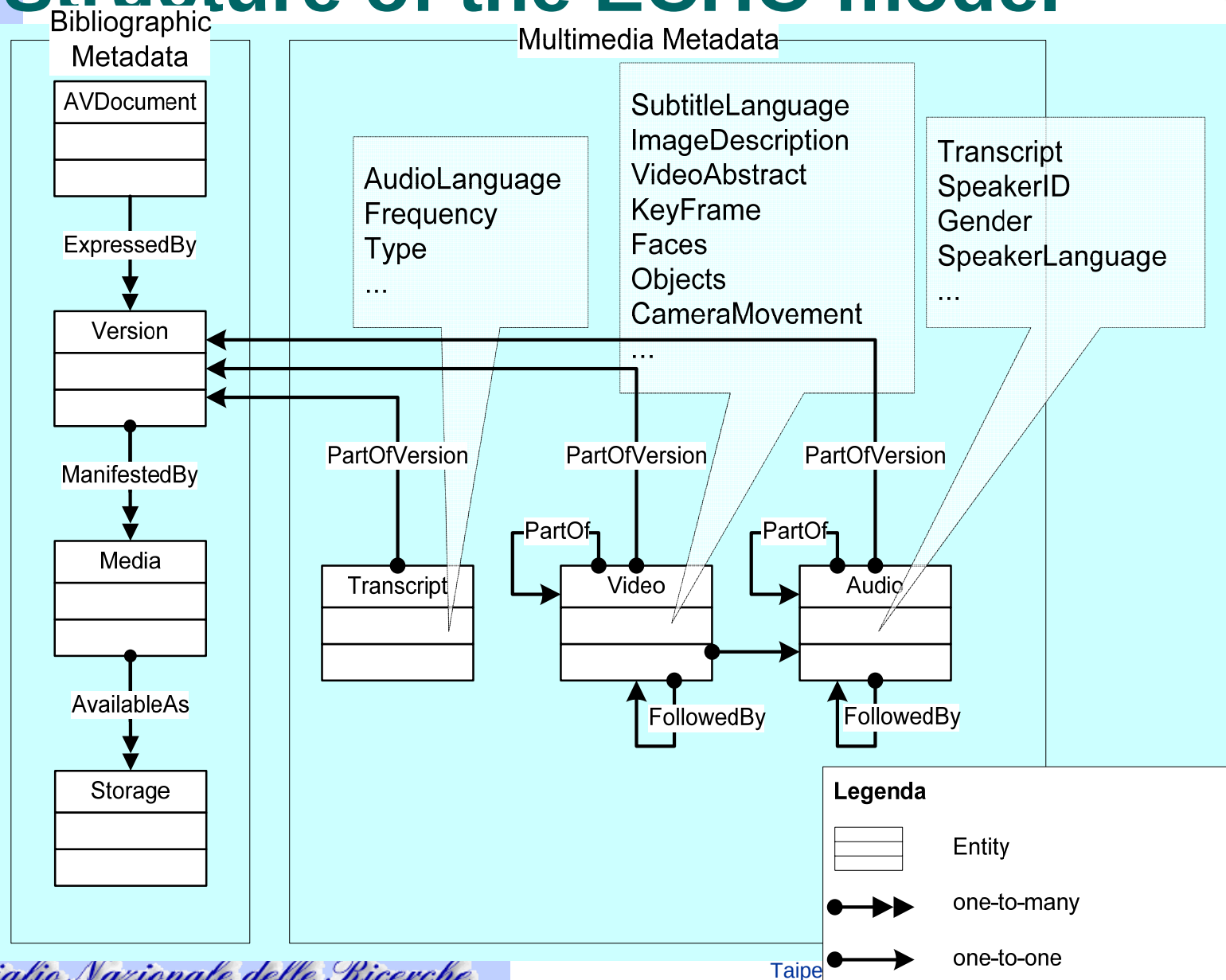
Each entity has a number of metadata attribute fields used to describe the video document.

The (complete) structure of the ECHO metadata model

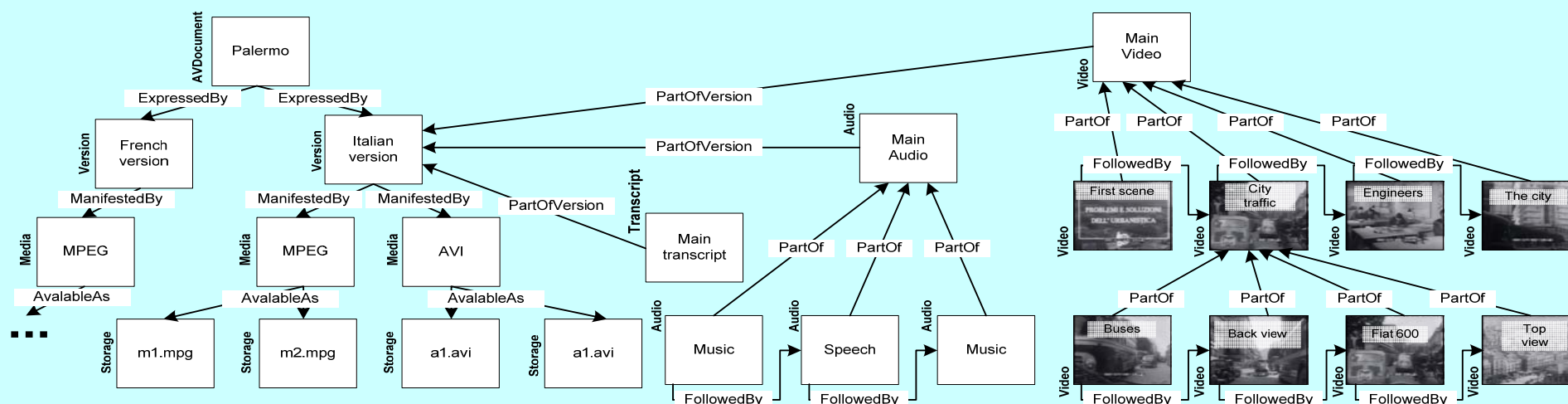


- Entities are divided in “Bibliographic Metadata” and “Multimedia Metadata”, composed of *Video*, *Audio* and *Transcript*. They belong to the Expression level of the IFLA/FRBR model.
- Each version object is composed of a *Video*, *Audio* and a *Transcript*.
- These objects represent the entire audio/video object.
- Smaller segments (e.g. a shot or a scene) can be represented by a new instance of Video, Audio, and Transcript.
- Objects at the same level are linked (FollowedBy) in order to represent the temporal sequence of different objects.

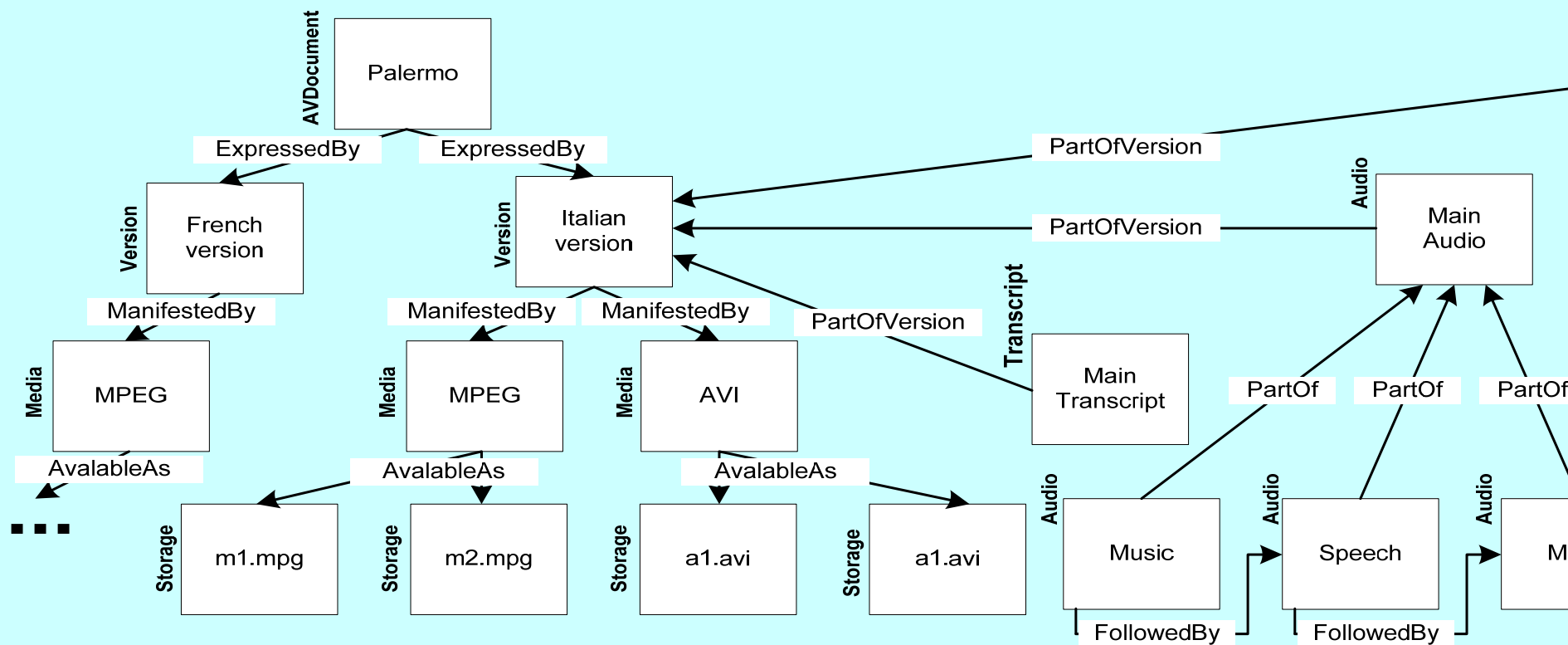
Structure of the ECHO model



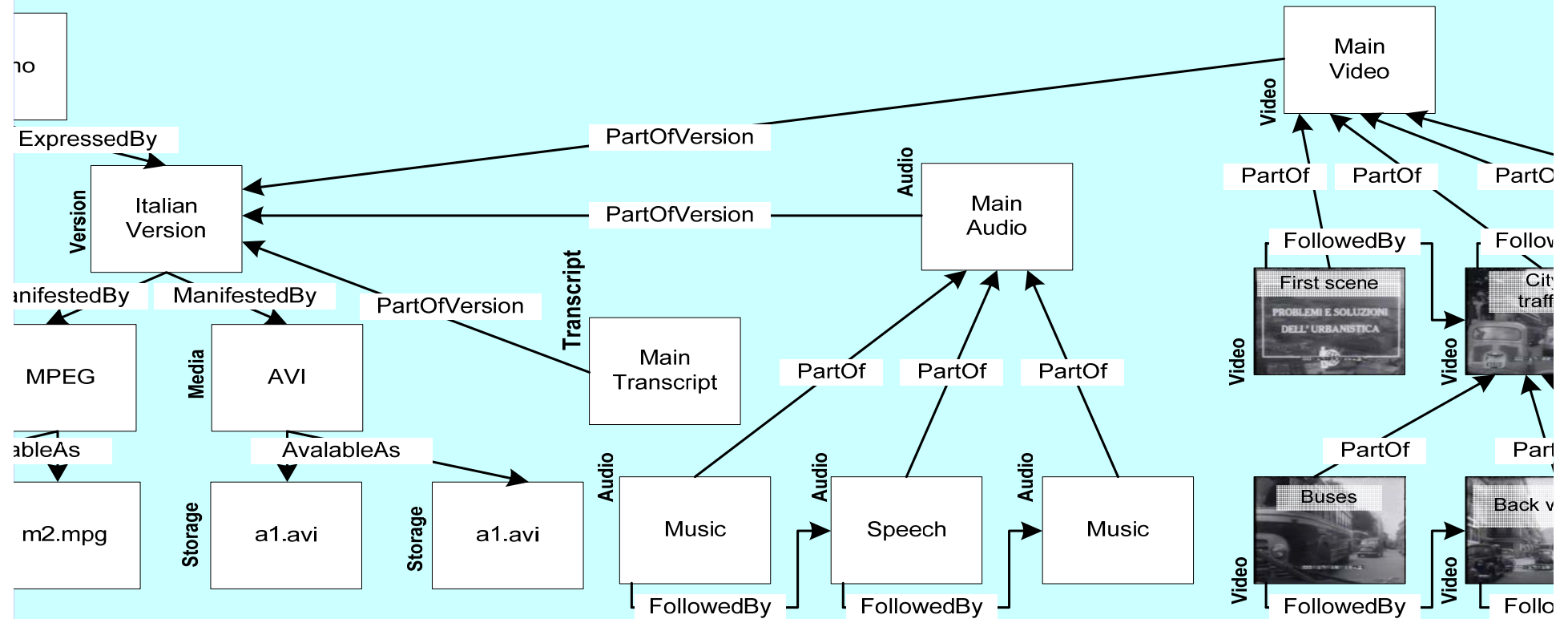
An example



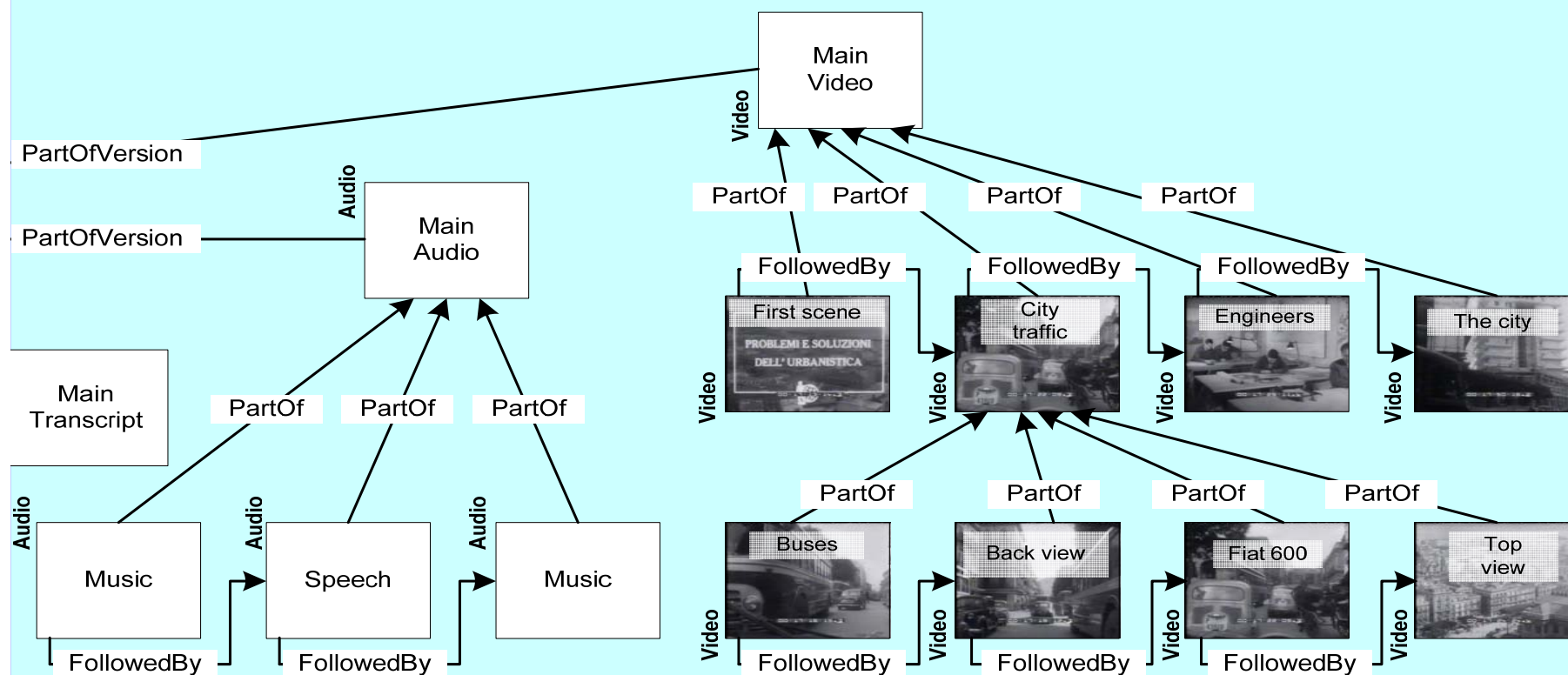
An example



An example



An example



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ECHO Prototype 3 Web Service - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indirizzo <http://pc-echo2:8081/MediaArchive/servlet/startView> Vai Collegamenti >>

Google train Cerca nel Web Cerca nel sito PageRank Info sulla pagina Su Evidenzia train

Browsing Metadata Editor Export Import Delete

EC-HO
European Chronides Online

Find train Submit
as of unlimited show 100 hits of type

Metadata of Selected documents

AV [Berqkinder fliegen](#)

AV [2. Internationale Modellausstellung](#)

AV [NPS.DOC Bleekneusie](#)

AV [CH Chiasso, TI: Italienischer Zöllner-Streik legt Güterverkehr lahm](#)

AV [Anbauwerk und Arbeitseinsatz](#)

Lists of retrieved documents

00:00:00.00...00:02:29.16 [00:02:29.16]

1300
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und Vor
denn di
in die
für Jah
Hände
Reisepr
wurden
der Abs
Schulkinder

Administration tools

Search interface

aus anderen Bergtälern,
graubündischen und
tessinischen, Hunderte von Kin
dern erwartungsfroh abreisen,
sitzen im Juradorf La Brevine

Operazione completata Intranet locale

ECHO Prototype 3 Web Service - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indirizzo <http://pc-echo2:8081/MediaArchive/servlet/startView>

Google train Cerca nel Web Cerca nel sito PageRank Info sulla pagina Su Evidenzia train

Browsing Metadata Editor Export Import Delete

ECHO European Chronicles Online

Transcript

Find train Submit

as of unlimited show 100 Hits of type

in archive * sorted by Relevance in ascending order

Hits: 19

AV [Bergkinder fliegen](#)

AV [2. Internationale Modellbau](#)

AV [NPS.DOC Bleekneusie](#)

AV [CH Chiasso, TI: Ita](#)

AV [Anbauwerk und Ar](#)

00:00:00.00...00:02:29.16 (00:02:29.16)

1300 Bergkinder... In Vals, wo der zurückweichende Schnee die Trümmer aus der Lawinnennacht freigibt, schmecken frische Kränze die Gräber der Verschütteten; aber in manchem der sonnenbraunen Häuser war in den ersten Maitagen ein freudiges, eifervolles Packen und Vorbereiten. 1-täter stiegen denn dies ist eine Männersache in die Kammer, wo die Vorräte für Jahre hängen; fürsorgliche Hände bereiteten Reiseproviand zu, Rucksäcke wurden prall gefüllt; freudig war der Abschied: Die Zürcher Schulkinder hatten 1300 Bergkinder in die grosse Stadt am See geladen. Und während wir dem Abschied der Valserkinder zusehen, während aus anderen Bergtälern, aus graubündischen und tessinischen, Hunderte von Kindern erwartungsfroh abreisen, sitzen im Juradorf La Brevine

AV [Bergkinder fliegen](#)

AV [2. Internationale Modellbau](#)

AV [NPS.DOC Bleekneusie](#)

AV [CH Chiasso, TI: Ita](#)

AV [Anbauwerk und Ar](#)

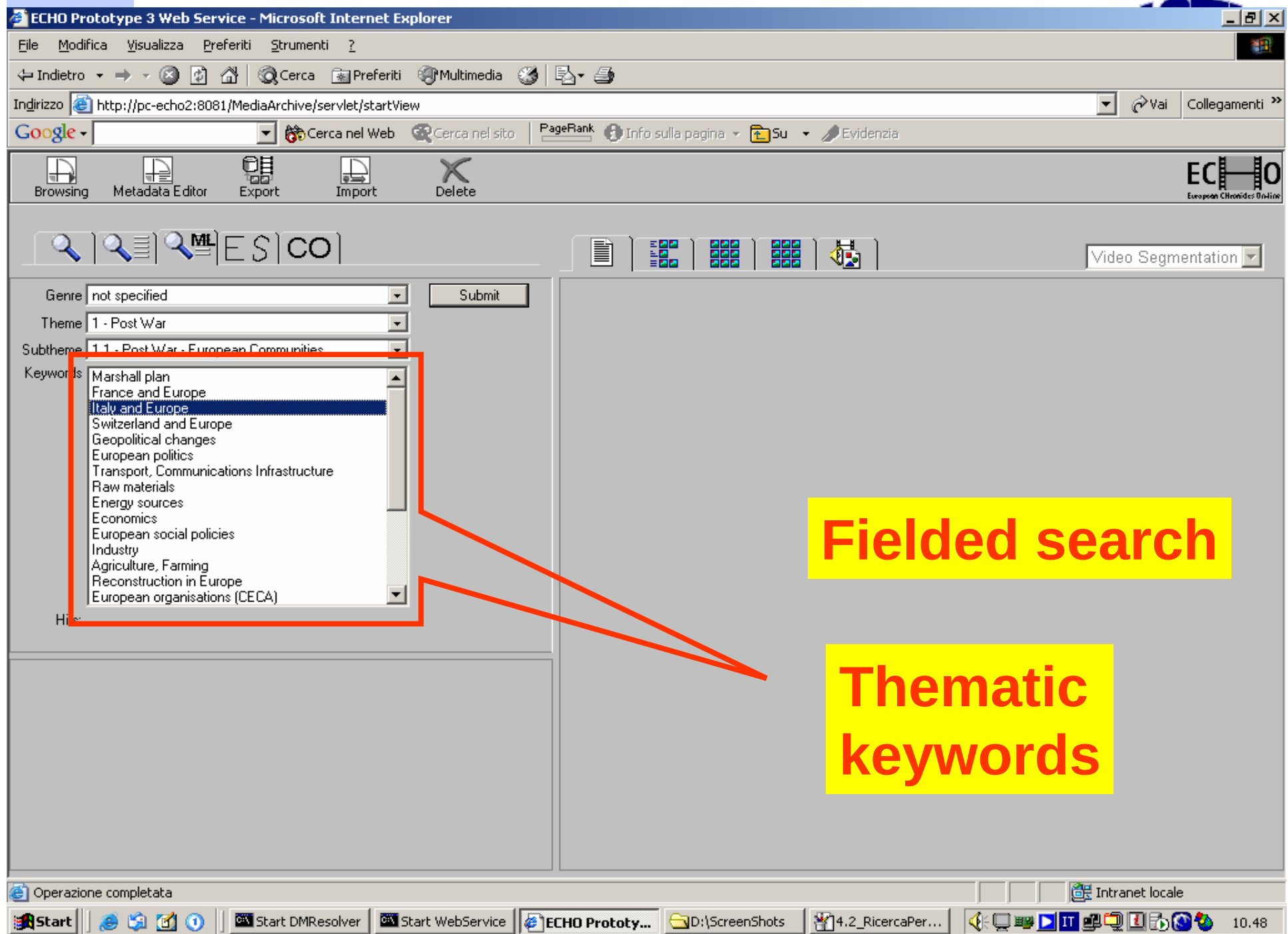
Operazione completata

Intranet locale

Free-text query

Search results

Display video Key-frames



ECHO Prototype 3 Web Service - Microsoft Internet Explorer

Adressleiste: <http://cms289.8080/MediaArchive/servlet/startView>

Navigation: Zurück, Vorwärts, Abbrechen, Aktualisieren, Startseite, Suchen, Favoriten, Verlauf, E-Mail, Drucken, Bearbeiten, Diskussion, Real.com

Werkzeuge: Browsing, Metadata Editor, Export, Import, Delete

Rechts: Links, Wechseln zu

Suche: Video Segmentation

Kind of Search:

☒ Nearest Neighbours ☐ Range

Strategy:

Tune Parameter:

Hits:

hits: 10

Metadata

	DMGuid: 444C4755494400DF3AB8C2F7B10F009518EE810 Timecode: 00384960 Distance: 0.63827
	DMGuid: 444C4755494400897DA0F56A9052001782671B03 Timecode: 0001280 Distance: 0.638392
	DMGuid: 444C4755494400897DA0F56A9052001782671B03 Timecode: 00004240 Distance: 0.676915
	DMGuid: 444C47554944000779CB40F7B10F002E6F2A5403 Timecode: 00051960 Distance: 0.680515

ECHO Model Entity

Work Title: [Nozze principesche a Monaco](#)

Duration: 00:08:20:19

Date of Ingest: 21.08.2002-14:38:46

Material: video

Diagram:

```
graph TD; AV[AV-Document] --> V[Version]; V --> M[Media]; M --> S[Storage]; V --> Video[Video]; V --> Audio[Audio]; V --> Transcript[Transcript];
```

Title: [Nozze principesche a Monaco](#)

Has Version: [\(To Version object\)](#)

Has Audio: [\(To Audio object\)](#)

Has Transcript: [\(To Transcript object\)](#)

Unit Indication: Whole

Silent: Sound

Color: BW

Person: Kelly, Grace; Ramon, ...

Locations: Principato di Monaco; New York; Statua della libert 

Image search

Fertig

Lokales Intranet

ECHO Prototype 3 Web Service - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indirizzo <http://pc-echo2:8081/MediaArchive/servlet/startView> Vai Collegamenti »

Google train Cerca nel Web Cerca nel sito PageRank Info sulla pagina Su Evidenzia train

Browsing Metadata Editor Export

Faces identified

Find train Submit

as of unlimited show 100 hits of type

in archive * sorted by Relevance in ascending order

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AV [Anbauwerk und Arbeitseinsatz](#)

Audio Segmentation

Operazione completata Intranet locale

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Google train Cerca nel Web Cerca nel sito PageRank Info sulla pagina Su Evidenzia train

Browsing Metadata Editor Export

Face displayed

Audio Segmentation

Find train Submit

as of unlimited show 100 hits of type

in archive * sorted by Relevance in ascending order

Hits: 19

Face Detection - ...



[AW Bergkinder fliegen](#)

[AW 2. Internationale Modellausstellung](#)

[AW NPS.DOC Bleekneusje](#)

[AW CH Chiasso, TI: Italienischer Zöllner-Streik legt Güterverkehr lahm](#)

[AW Anbauwerk und Arbeitseinsatz](#)

Operazione completata

Intranet locale



Bergkinder fliegen - Browsing Player

File View ?



Pause 01:14:44.16 / 00:02:29

01:14:30.01

Scene duration

Display video shots

Submit

type

- ☐ type
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]
- ☐ [icon]

00:00:00.00...00:00:03.02 (00:00:03.02)

1300 BERGKINDER...

00:00:03.05...00:00:06.03 (00:00:02.23)

00:00:06.04...00:00:16.20 (00:00:10.16)

00:00:16.24...00:00:18.19 (00:00:01.20)

Operazione completata

Intranet locale

ECHO limitations

- Supports the management of **video data only**
- Based on a **proprietary metadata model**
- **Efficiency** limitations
- Complex system architecture

Evolution

- We built a general purpose **Multimedia Content Management System (MILOS)** that supports the archiving, indexing and content based retrieval of many different types of data
- MILOS supports the **interoperability** of different metadata models
- We built, on top of MILOS, an A/V Digital Library with the same functionality offered by ECHO

The MILOS MCMS

- Search capabilities:
 - Traditional fielded search capabilities
 - Full text search (e.g. on video transcripts)
 - Search on automatically associated classification categories
 - Visual content similarity search
- The system is not tied to a specific metadata schema
 - Any XML encoded metadata can be managed by the system (e.g. DC, MPEG-7, ECHO, proprietary model)
 - Metadata mapping techniques are used to provide users with a homogeneous view
 - Several different and heterogeneous applications can be supported

Digital Library Examples

- We have tested MILOS building the following DL applications
 - **ECHO**
 - 50 hour of A/V data with IFLA-FRBR and MPEG-7 metadata (21 Gb of MPEG-1, 43.000 XML files)
 - **REUTERS**
 - 810.000 XML encoded, news agencies (2.6 Gb)
 - **DBLP and SIGMOD Records**
 - 187 Mb of XML files
 - **Image archive**
 - 1000 Color images, with MPEG-7 visual descriptor metadata
 - Each application was developed on average in a week
 - User queries are processed in less than a second on average

Milos - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Multimedia

Indirizzo http://localhost:5900/milos/echo.html

Vai Collegamenti Assistente Web

MILOS Multimedia digital Library for Online Searches

Search ECHO Metadata: echo_AVDocument

Fulltext Value: young director documentary Fulltext Field: EnglishAbstract

Value: NL Field: DescriptionLanguage

Exact Match

Search Reset

results 1-10 of 56

[JOURNAAL](#)

[GOUDEN VLEUGELS](#)

[HET LEVEN EEN FEEST](#)

[VERLAAT DE STOFFIGE STAD](#)

[ALETTA JACOBS](#)

[JAZZ-KELDER](#)

Version

Title: HET LEVEN EEN FEEST

Series Title:

Genre: Not assigned

Location:

Themes: 4 - Daily Life

SubThemes: 4.1 - Daily Life - Work and Leisure

Thematic Keywords: Leisure activities

English abstract: Four-part documentary made by four young directors. Central is the theme: Life is a Celebration! In this second episode, a documentary made by Tamara Miranda about two former class members. The documentary received an award Nomination at the Dutch Filmfestival in Utrecht.

Description Language: NL

Production date: 1998-11-12

Makers:

AVDocument **Media** **Video** **Audio** **Transcript**

Title: HET LEVEN EEN FEEST

Duration:

Version

Title: HET LEVEN EEN FEEST

Indication video unit: Whole

Location:

Silent:

Time: start: 0 end: 1509640

Frame rate: 25

Color: Color

Milos - Similarity ECHO - Microsoft Internet Explorer

HET LEVEN EEN FEEST 73

HET LEVEN EEN FEEST 69

HET LEVEN EEN FEEST 78

JOODS ONDERWIJS IN NEDERLAND

af. 8 134

HET LEVEN EEN FEEST 10

HET LEVEN EEN FEEST 11

HET LEVEN EEN FEEST 12

HET LEVEN EEN FEEST 13

HET LEVEN EEN FEEST 14

JOODS ONDERWIJS IN NEDERLAND

HET LEVEN EEN FEEST 149

HET LEVEN EEN FEEST 156

HET LEVEN EEN FEEST 68

CH Z?ich, ZH: Er?ffnung Gem.

Intranet locale IST-CNR

Milos - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Multimedia

Indirizzo http://localhost:5900/milos/reuters.html

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The Russian took up the ground she had lost in previous non-race to improve on the previous best of 2:29.66 set by Irina Lashina at the same stadium in August last year.

Former 800 metres world champion Mutola pushed the Russian all the way and took second in 2:29.66. An exhausted Masterkova, who earned a bonus of \$25,000 for the performance, paid tribute to her rival after the race.

"That really finished me," she said. "If it wasn't for Maria, I couldn't have done it. She pushed me...It was a fast track, a terrific atmosphere. The Mexican waves in the crowd gave me wings."

"In the last 400 metres I felt Mutola closing in and that drove me to the decisive extra effort."

Masterkova dominated the middle-distance races at the recent Atlanta Games after returning to competition after a three-year maternity break.

In her first mile race at the richest meeting in Zurich, she slashed 3.05 seconds off the previous record, earning a bonus of \$50,000 plus one kilo of gold.

After Friday's performance in front of a capacity 40,000 crowd who were all on their feet at the end of the race, the Russian will have earned well over \$100,000 in less than a fortnight, taking her appearance money into account.

She celebrated by pointing at the clock in delight after she crossed the line.

Brussels organisers had laid a new track for the meeting comparable to the surface at the Atlanta Games but put down on a softer surface. It was clearly fast.

Despite damp conditions after a downpour at the start of the meeting, there were some superb performances in both the sprint and distance events.

American Dennis Mitchell upstaged a trio of Olympic 100 metres champions. Kenyan Daniel Komen produced another historic 3,000 metres and American high hurdler Allen Johnson went within 0.01 seconds of the world record despite damp conditions.

Sporting his ubiquitous bright green outfit, Mitchell ran 10.03 seconds to take the scalp of Canada's reigning sprint champion Donovan Bailey, 1992 Olympic 100 metres champion.

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[EE Giuseppe Amato Fausto Rabitti Pasquale Savino Pavel Zezula](#) *Region proximity in metric spaces and its use for approximate similarity search. ACM Trans. Inf. Syst. vol. 21 n. 2 pages: 192-227*

Book Title : DELOS Workshop: Information Seeking, Searching and Querying in Digital Libraries Year: 2000

[EE David A. Grossman Steven M. Beitzel Eric C. Jensen Ophir Frieder](#) *The IIT Intranet Mediator: An Overview.*

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[EE Dieter Merkl Andreas Rauber](#) *Representation of Document Archives for Interactive Exploration.*

[EE Pavel Zezula](#) *A Hashed Schema for Similarity Search in Metric Spaces (invited talk).*

[EE Ophir Frieder](#) *On the Integration of Structured Data and Text: A Review of the SIRE Architecture (invited talk).*

[EE Wolf-Tilo Balke Werner Kießling Ulrich Güntzer](#) *Applications of Quick-Combine for Ranked Query Models.*

[EE John R. Smith](#) *Interoperable Content-based Access of Multimedia in Digital Libraries (invited talk).*

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- <http://milos.isti.cnr.it/>
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