



Digital Asset Management

数字媒体资源管理

3. Multimedia Database System



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2019-10-10

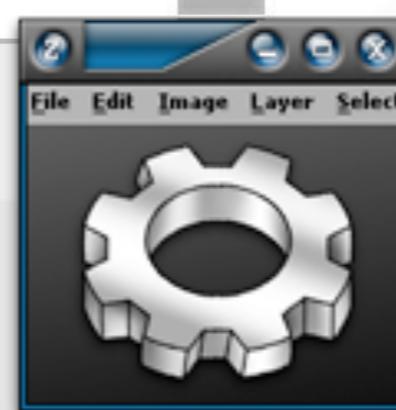
多媒体数据库系统的挑战

- 多媒体数据的独特数据特性
 - 单个条目数据规模和吞吐大
 - 多通道数据需要同步
 - 连续媒体数据需以流媒体形式提取
 - 对于不同客户的QoS需求
 - 相似性比较和搜索困难
- The answer is metadata

Homework and the project

- Homework 02a
- Team organization and rough ideas

Outline



1. MM content organization

2. MM database system architecture

3. MM system service model



4. Multimedia Data Storage

5. Multimedia application





3.1. Multimedia Content Organization



Metadata Model Organization



- Content-dependent Metadata
- Content-descriptive Metadata
- Content-independent Metadata

Metadata Model



- Metadata => **data about data**
 - forms an essential part of any database
 - providing **descriptive data** about each stored object, and
 - is the key to **organizing** and **managing data** objects
 - critical for describing essential aspects of content:
 - main topics, author, language, publication, etc.
 - events, scenes, objects, times, places, etc.
 - rights, packaging, access control, content adaptation, ...

Domain-independent Metadata Standards

- The Dublin Core Metadata set

http://purl.org/metadata/dublin_core

- Originally for resource description records of **online libraries** over Internet
- version 1.1
 - broaden to other media with a link to the ISO/IEC 11179 standard
 - Each Dublin Core element is defined using a set of 10 attributes from the ISO/IEC 11179
 - Six of them are common to all the Dublin Core element (3-5, 7-9)
 - 15 metadata elements (the Dublin Core) has been proposed
 - which are suggested to be the minimum number of metadata elements to support retrieval of a document-like object (DLO) in a networked environment



The Dublin Core Metadata set

ID	Core element	Semantics
1	Subject	topic addressed by the work
2	Title	the name of the object
3	Creator	entity responsible for the intellectual content
4	Publisher	the agency making the object available
5	Description	an account of the content of the resource
6	Contributor	an entity making contributions to the resource content
7	Date	associated with an event in the life cycle of the resource
8	Resource type	the nature/genre of the resource content
9	Format	physical/digital manifestation of the resource; format of the file (e.g., postscript)
10	Id	unique identifier
11	Relation	a reference to a related resource
12	Source	a ref. to a resource from which the current resource is derived
13	Language	language of the intellectual content
14	Coverage	extent/scope of the resource content; typically include location, period
15	Rights	Information about rights held in and over the resource

Domain-independent Metadata Standards

- Resource Description Framework (RDF)
 - Being developed by the W3C as a foundation for processing metadata
 - Allows multiple metadata schemes to be read by human and parsed by machines
 - Specific objectives include:
 - **Resource discovery** – to provide better search engine capabilities
 - **Cataloging** – for describing the content and relationships available through intelligent software agents
 - **Content rating** – describing collection of pages that represent a single logical “document”
 - **IP rights** – describing the intellectual property of web pages
 - **Privacy preferences and policies** – for users and website
 - **Digital signatures** – to create a “web of trust” for e-commerce, collaboration, and other applications

Resource Description Framework (RDF)

- The formal model of the RDF framework:
 - *Resources* (set).
 - *Literals* (set).
 - a subset of resources called *Properties*
 - There is a set called *Statements*, each element of which is a triple of form <pred, sub, obj>, where
 - pred is a property,
 - sub is a resource (member of *Resources*)
 - obj is either a resource or a literal
- The preferred language for writing RDF schemas is XML

Dublin Core Data in XML

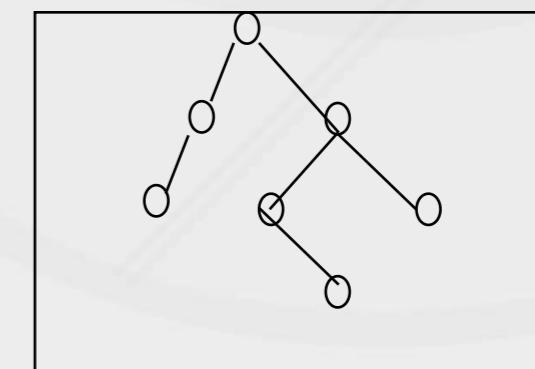
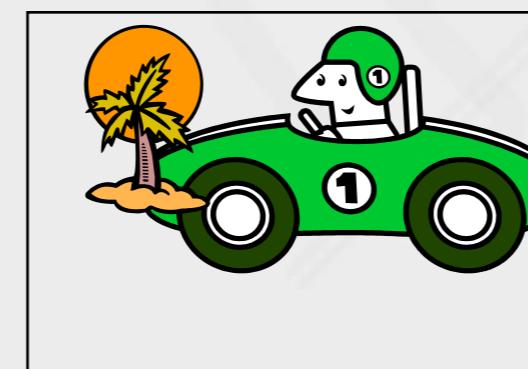
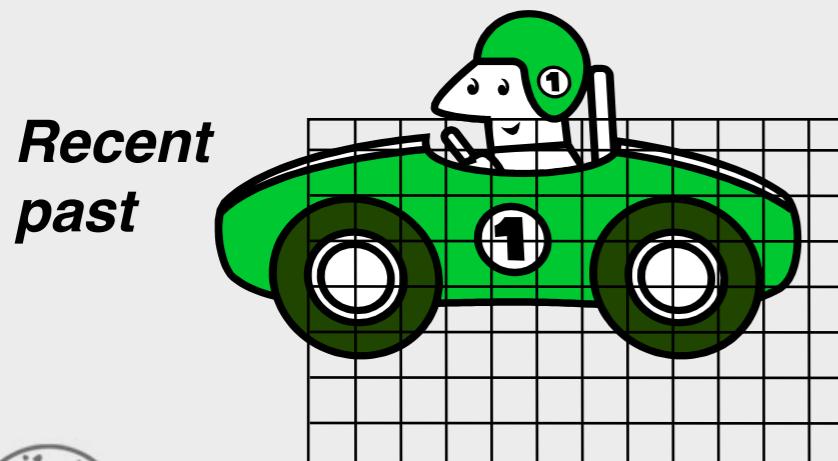
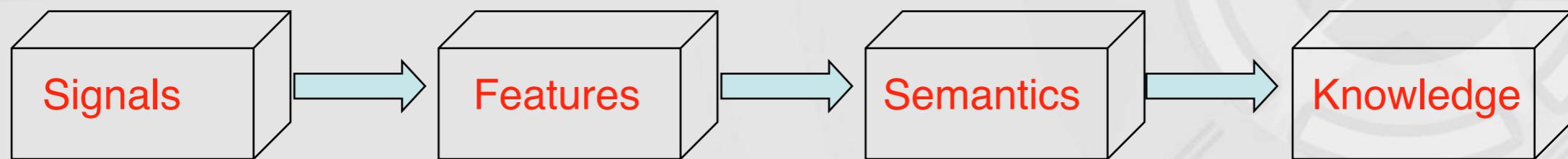
- <http://dublincore.org/documents/dc-xml-guidelines/>

```
<?xml version="1.0"?>
<metadata
  xmlns="http://example.org/myapp/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://example.org/myapp/ http://example.org/myapp/schema.xsd"
  xmlns:dc="http://purl.org/dc/elements/1.1/">

  <dc:title>
    UKOLN
  </dc:title>
  <dc:description>
    UKOLN is a national focus of expertise in digital information
    management. It provides policy, research and awareness services
    to the UK library, information and cultural heritage communities.
    UKOLN is based at the University of Bath.
  </dc:description>
  <dc:publisher>
    UKOLN, University of Bath
  </dc:publisher>
  <dc:identifier>
    http://www.ukoln.ac.uk/
  </dc:identifier>
</metadata>
```

Domain-dependent Metadata Standards

- MPEG series
 - Moving Picture Experts Group (MPEG) since 1998
 - responsible for developing standards of the coded representation of moving pictures and associated audio



Domain-dependent Metadata Standards

Applications

MPEG-1,-2,-4 Video storage Broadband, streaming video delivery	MPEG-4,-7 CBR Multimedia filtering Content adaptation	MPEG-7 Semantic-based retrieval and filtering Intelligent media services (iTV)	MPEG-21 Multimedia framework e-Commerce
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Problems and Innovations

Compression coding communications	Similarity search object- & feature- based coding	Modeling & classifying, personalization, summarization	Media mining, decision support
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MPEG-1,-2

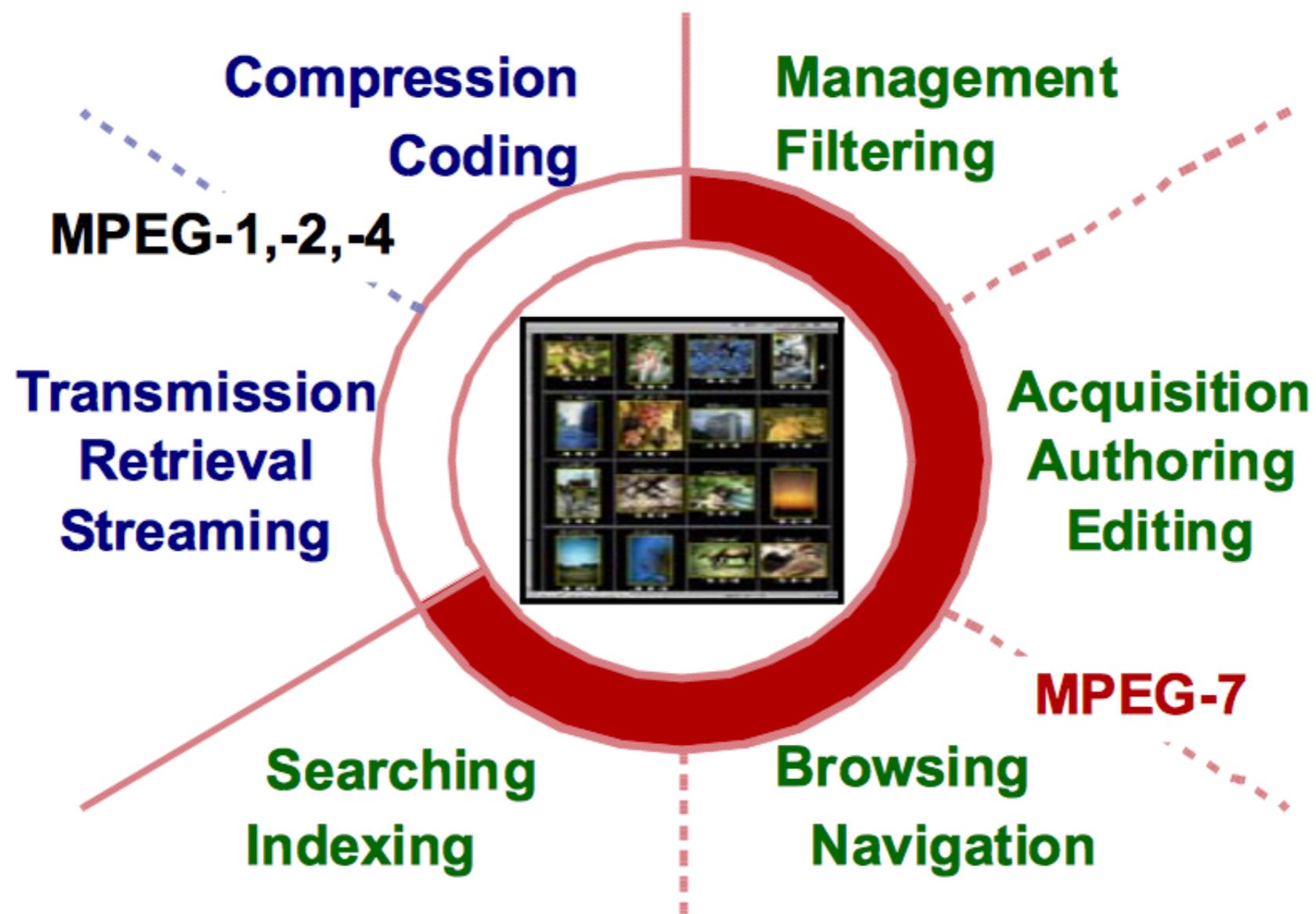
MPEG-4

MPEG-7

MPEG-21



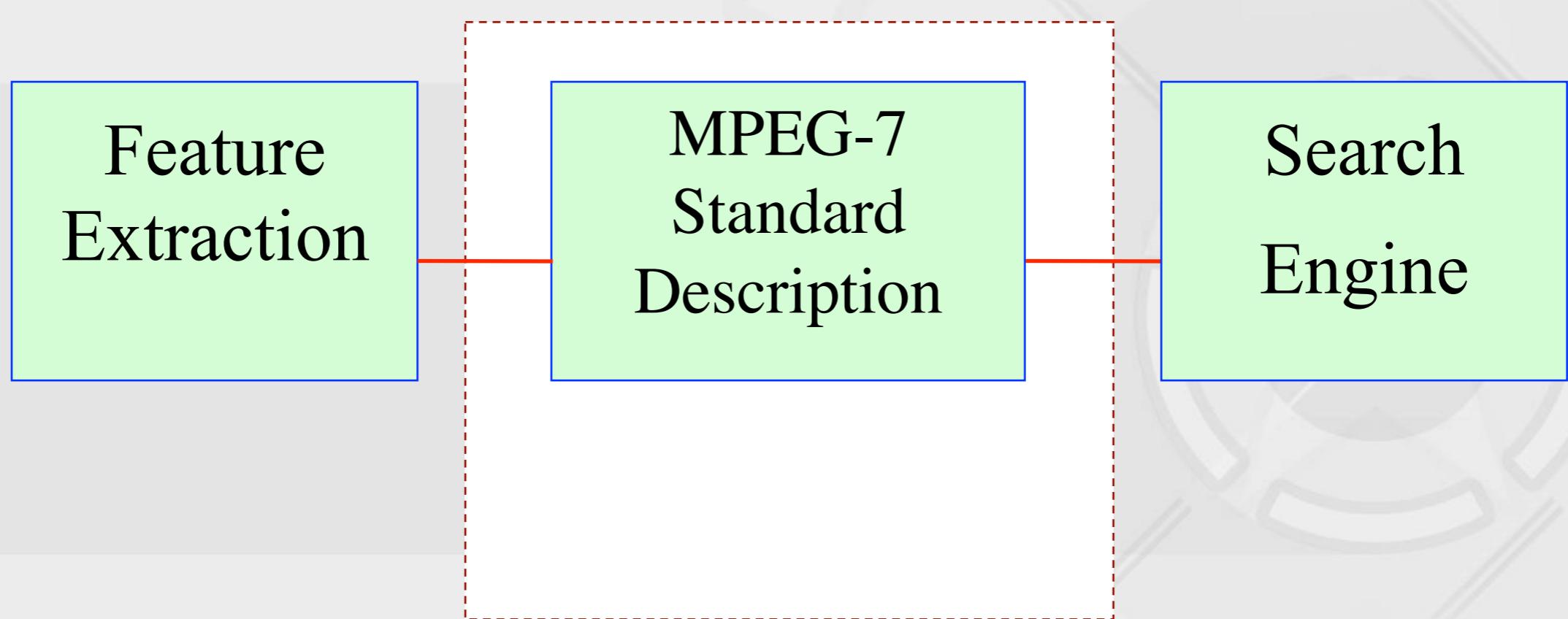
(XML for Multimedia Content Description)



MPEG-7 does NOT ...

- Standardize the extraction of Audiovisual descriptions/features
- Specify the software programs that can use the descriptions
- Specify how to measure similarity between contents

Domain-independent Metadata Standards

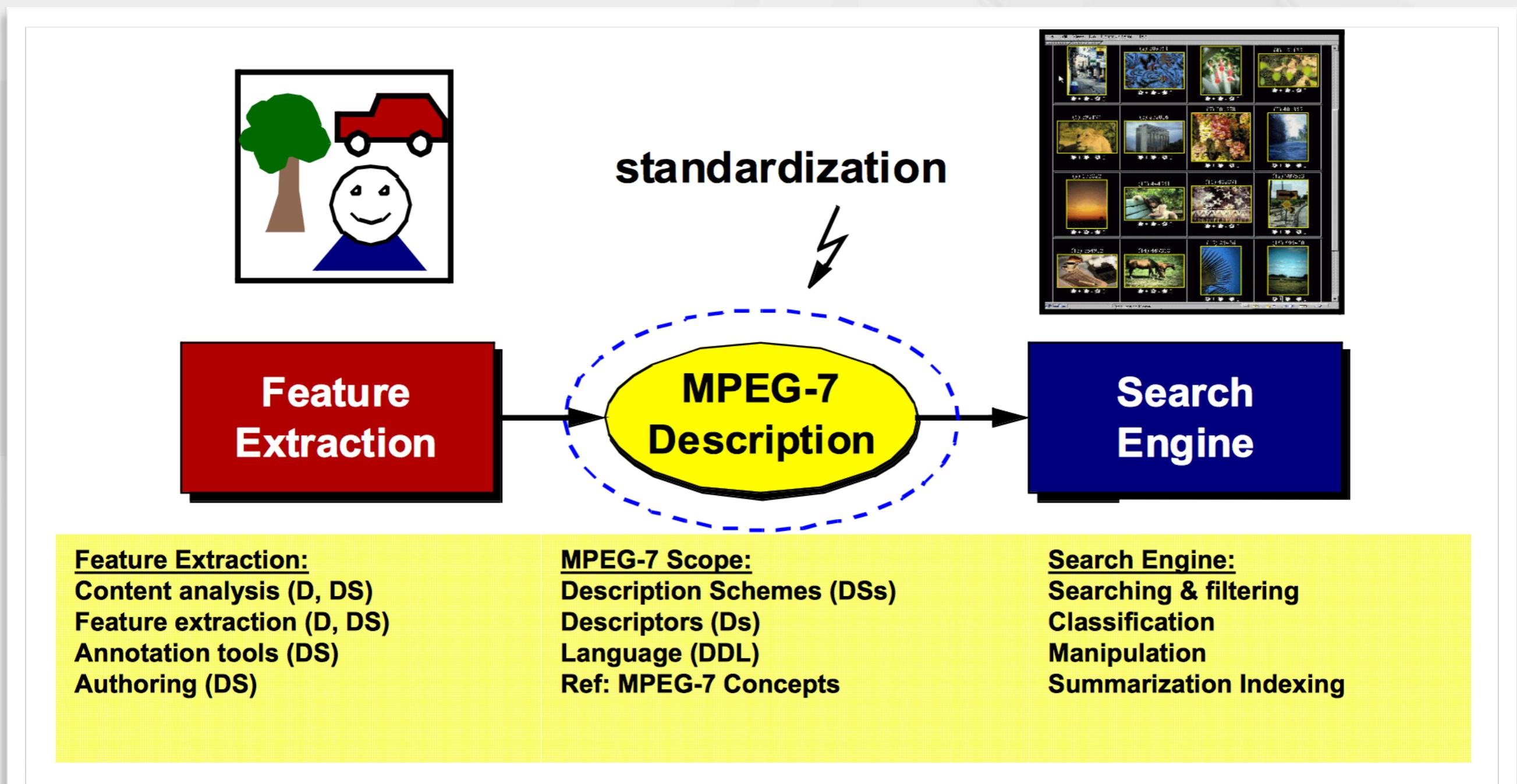


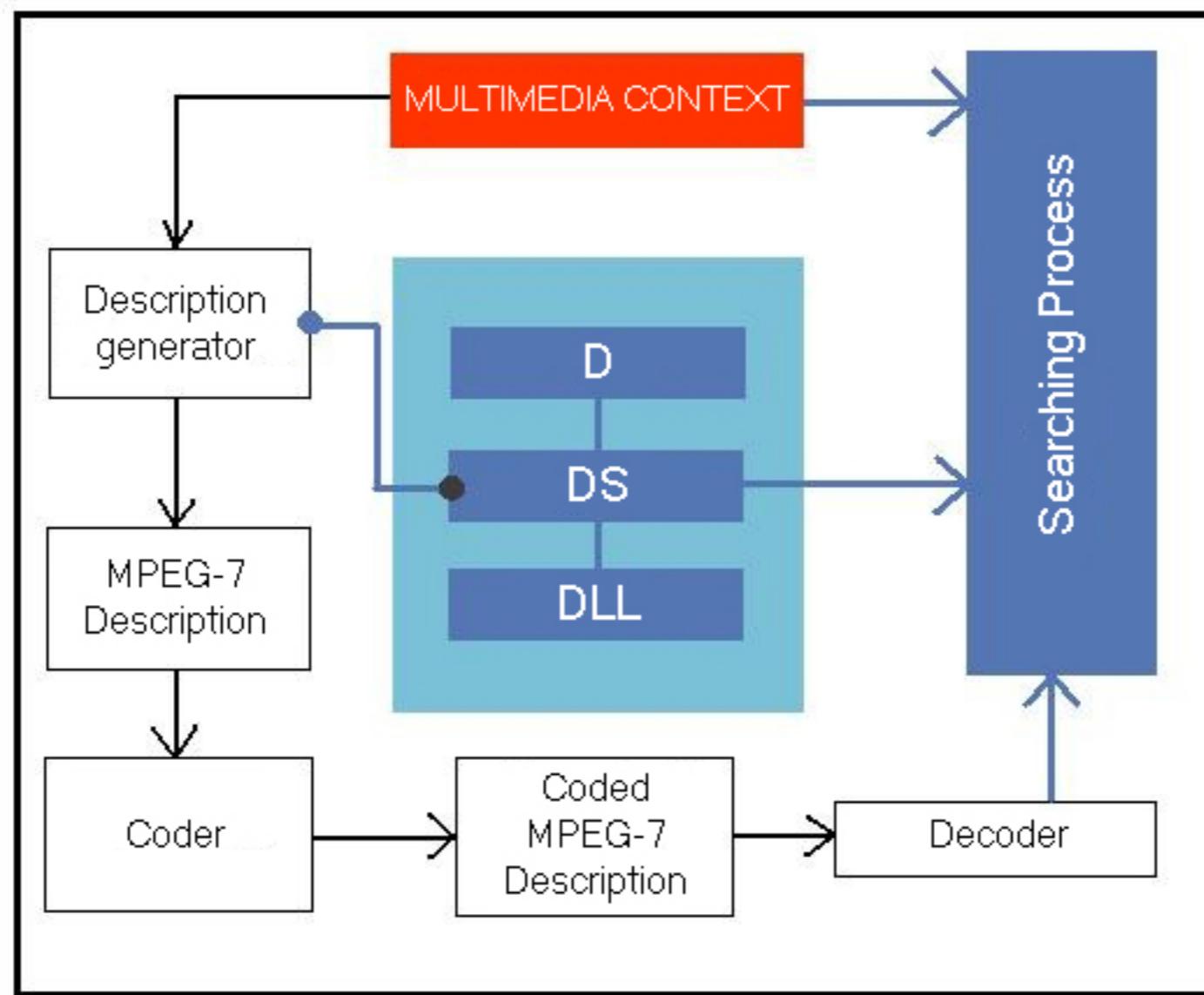
Scope of MPEG-7

MPEG-7 Tools

- **Descriptor (D)**: It is a representation of a feature defined syntactically and semantically. It could be that a unique object was described by several descriptors
- **Description Schemes (DS)**: Specify the structure and semantics of the relations between its components, these components can be descriptors (D) or description schemes (DS)
- **Description Definition Language (DDL)**: It is based on XML language used to define the structural relations between descriptors. It allows the creation and modification of description schemes and also the creation of new descriptors (D)
- **System tools**: These tools deal with binarization, synchronization, transport and storage of descriptors. It also deals with Intellectual Property protection

MPEG-7

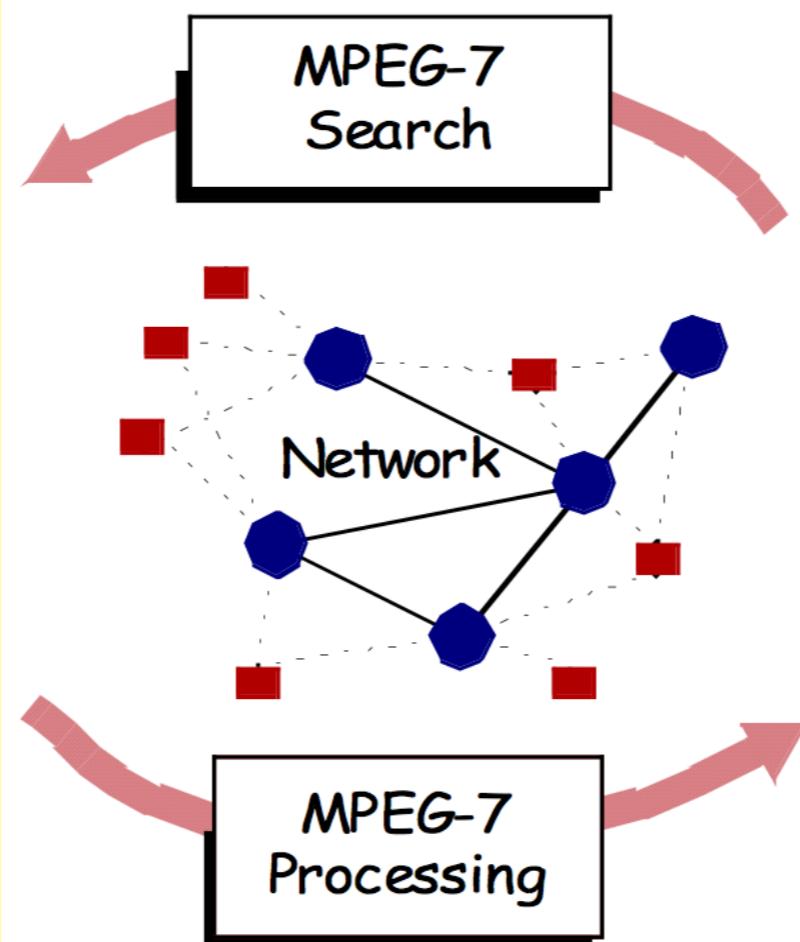
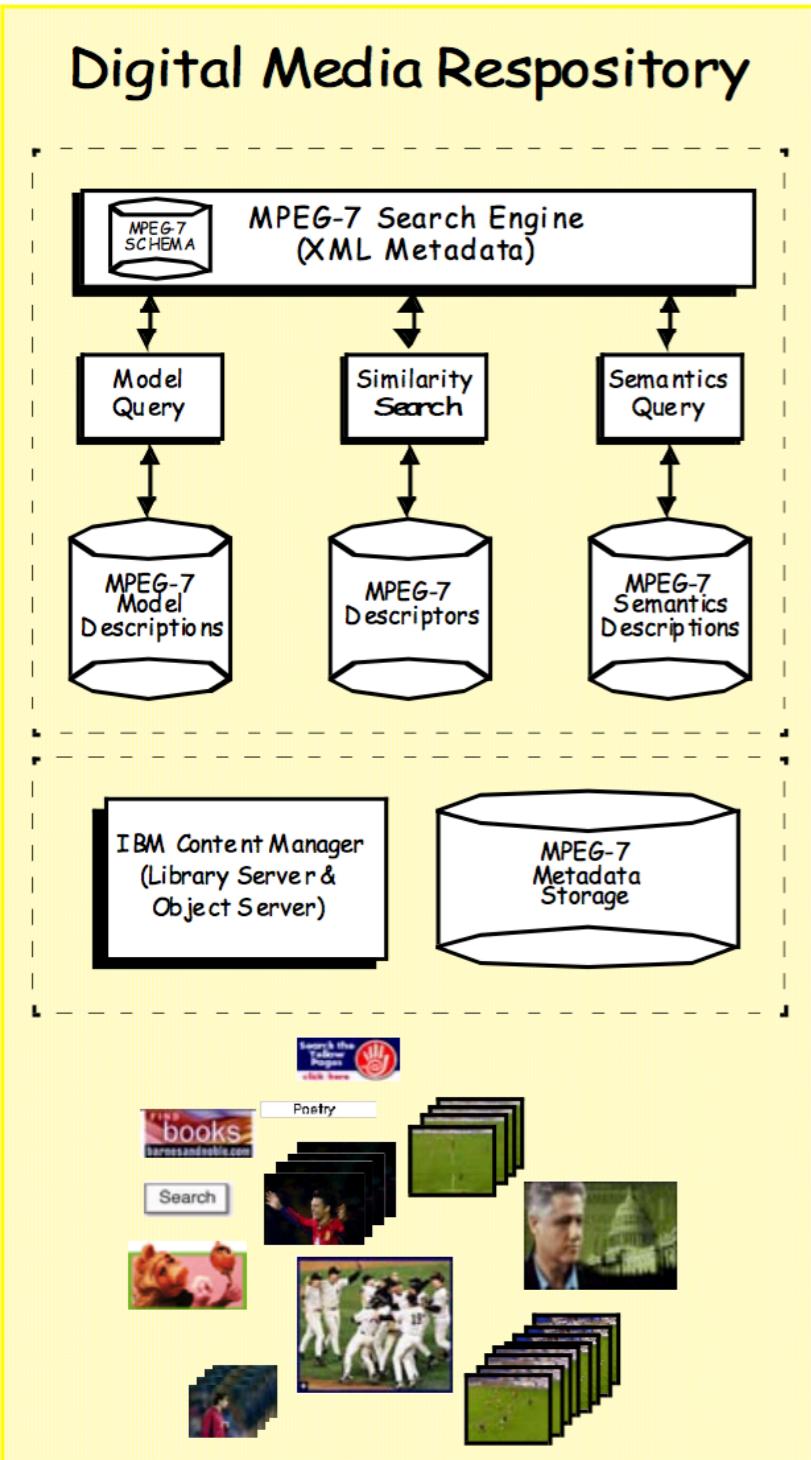




MPEG-7 Multimedia Indexing and Searching

■ MPEG-7 Indexing & Searching:

- Semantics-based (people, places, events, objects, scenes)
- Content-based (color, texture, motion, melody, timbre)
- Metadata (title, author, dates)

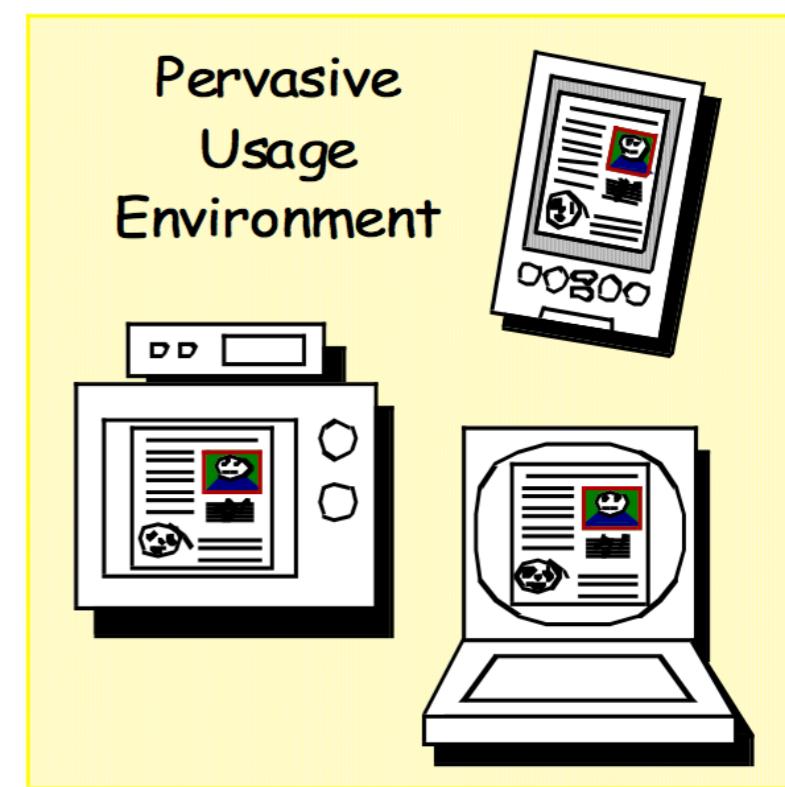
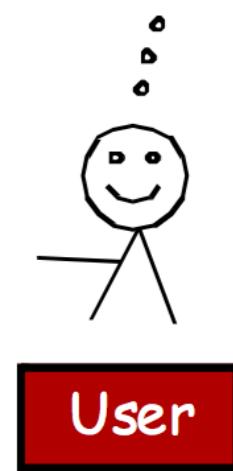


■ MPEG-7 Access & Delivery:

- Media personalization
- Adaptation & summarization
- Usage environment (user preferences, devices, context)



Sounds like ...
Looks like ...



MPEG-7 Applications

- Digital library: Image/video catalogue, musical dictionary
- Multimedia directory services: e.g. yellow pages
- Broadcast media selection: Radio channel, TV channel
- Multimedia editing: Personalized electronic news service, media authoring
- Security services: Traffic control, production chains...
- E-business: Searching process of products
- Cultural services: Art-galleries, museums...
- Educational applications.
- Biomedical applications.
- Intelligent multimedia applications that leverage low-level multimedia semantics via formal representation and automated reasoning

MPEG-7 Standard

Parts [edit]

The MPEG-7 (ISO/IEC 15938) consists of different Parts. Each part covers a certain aspect of the whole specification.

MPEG-7 Parts^{[4][6]}

Part	Number	First public release date (First edition)	Latest public release date (edition)	Latest amendment	Title	Description
Part 1	ISO/IEC 15938-1	2002	2002	2006	Systems	the architectural framework of MPEG-7, the carriage of MPEG-7 content - TeM (Textual format for MPEG-7) and the binary format for MPEG-7 descriptions (BiM) ^[7]
Part 2	ISO/IEC 15938-2	2002	2002		Description definition language	
Part 3	ISO/IEC 15938-3	2002	2002	2010	Visual	
Part 4	ISO/IEC 15938-4	2002	2002	2006	Audio	
Part 5	ISO/IEC 15938-5	2003	2003	2015	Multimedia description schemes	
Part 6	ISO/IEC 15938-6	2003	2003	2011	Reference software	
Part 7	ISO/IEC 15938-7	2003	2003	2011	Conformance testing	
Part 8	ISO/IEC TR 15938-8	2002	2002	2011	Extraction and use of MPEG-7 descriptions	
Part 9	ISO/IEC 15938-9	2005	2005	2012	Profiles and levels	
Part 10	ISO/IEC 15938-10	2005	2005		Schema definition	
Part 11	ISO/IEC TR 15938-11	2005	2005	2012	MPEG-7 profile schemas	
Part 12	ISO/IEC 15938-12	2008	2012		Query format	
Part 13	ISO/IEC 15938-13	2015	2015		Compact descriptors for visual search	

MPEG-7



- *Multimedia Content Description Interface*
 - Representation of information **about** the content
 - still pictures, graphics, 3D models, audio, speech, video & their combination
 - Goal:
 - to **support efficient search** for multimedia content using **standardized descriptions**
 - desirable to use textual information for the descriptions

</description>

<xml>
<resource>

MPEG-7

Set of description tools

Functionality

Media

Description of the storage media: typical features include the storage format, the encoding of the multimedia content, the identification of the media. Note that several instances of storage media for the same multimedia content can be described.

Creation & Production

Meta information describing the creation and production of the content: typical features include title, creator, classification, purpose of the creation, etc. This information is most of the time author generated since it cannot be extracted from the content.

Usage

Meta information related to the usage of the content: typical features involve rights holders, access right, publication, and financial information. This information may very likely be subject to change during the lifetime of the multimedia content.

Structural aspects

Description of the multimedia content from the viewpoint of its structure: the description is structured around segments that represent physical spatial, temporal or spatial-temporal components of the multimedia content. Each segment may be described by signal-based features (color, texture, shape, motion, and audio features) and some elementary semantic information.

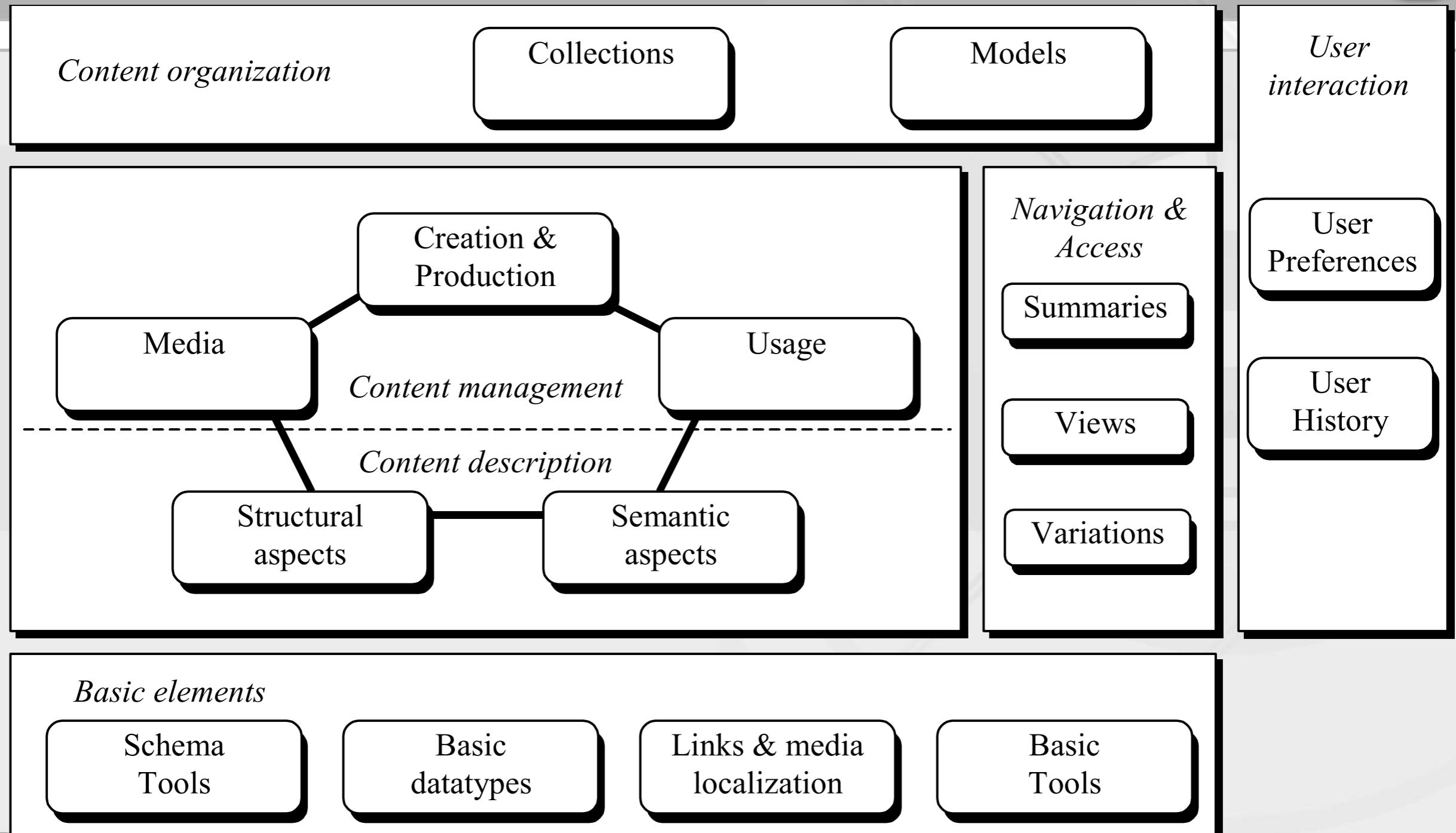
Semantic aspects

Description of the multimedia content from the viewpoint of its semantic and conceptual notions. It relies on the notions of objects, events, abstract notions and their relationship.

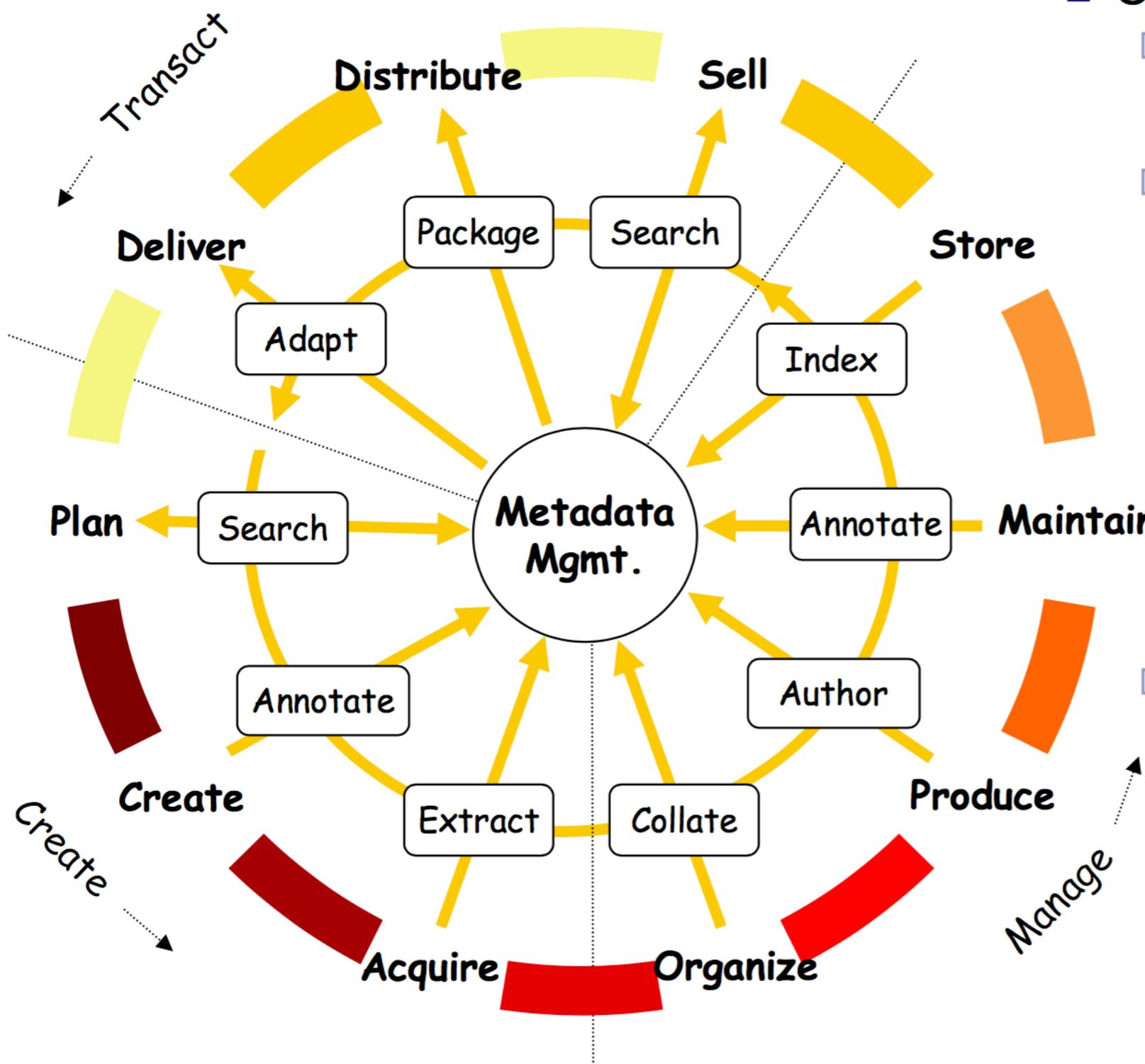
Reference

- [http://web.cecs.pdx.edu/~mperkows/
CAPSTONES/HAAR/MPEG7_041025.pdf](http://web.cecs.pdx.edu/~mperkows/CAPSTONES/HAAR/MPEG7_041025.pdf)

MPEG-7



Digital Media Value Chain (MPEG-7 Metadata Management)

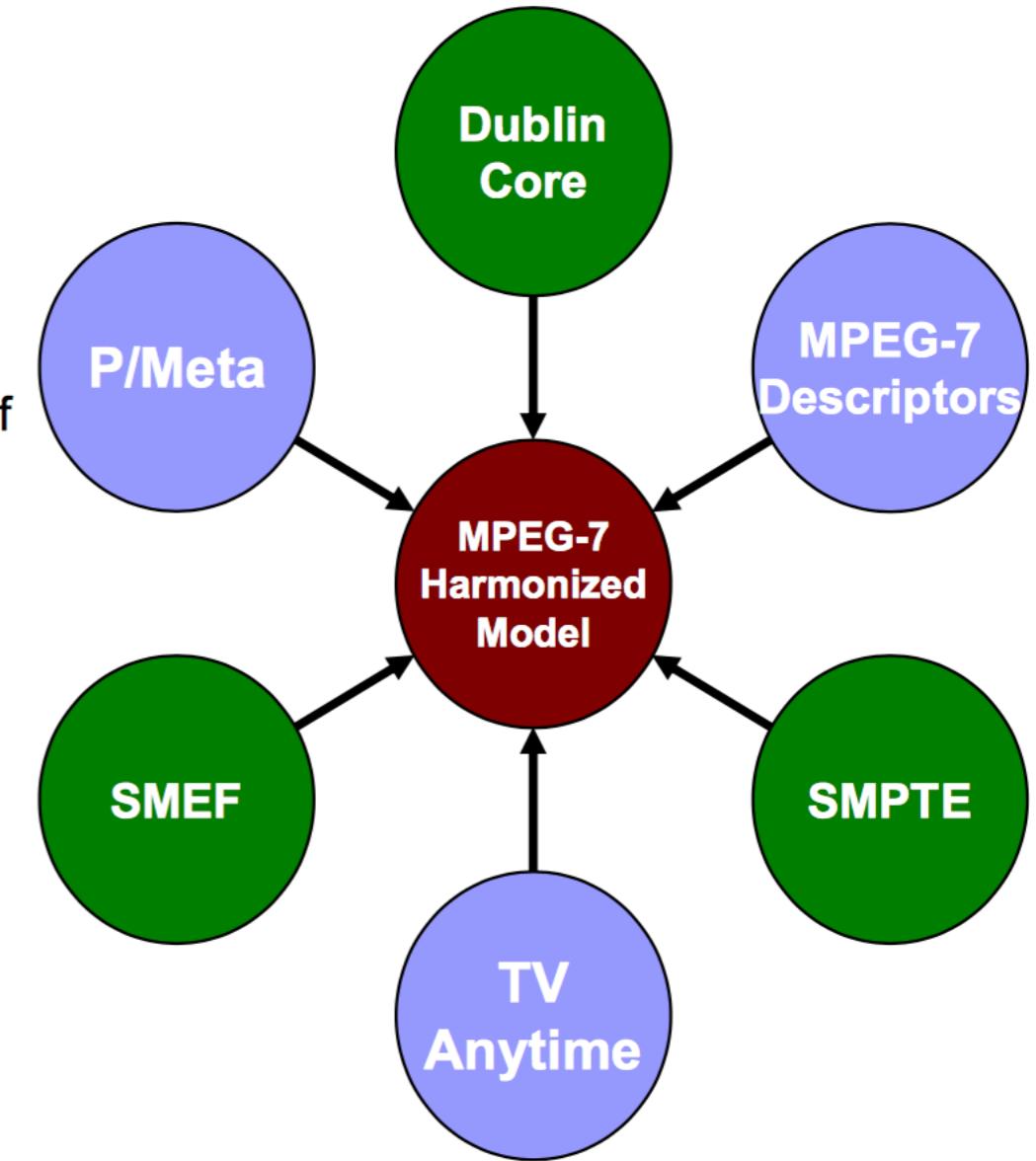


- Content value chain:
 - Life-cycle:
 - Increase content asset value through repurposing
 - Metadata layer:
 - First-class role of metadata (smart bits) throughout digital media lifecycle
 - Central role of metadata management (XML schemas, catalog records, ontologies)
 - MPEG-7 for content description
 - MPEG-21 for packaging, rights mgmt, transactions
 - Digital media metadata access functions:
 - **Create:** search, annotate, extract
 - **Manage:** index, annotate, collate
 - **Transact/Distribute:** search, package, adapt

Harmonization of Multimedia Metadata Standards

MPEG-7, SMEF, P/Meta, SMPTE, Dublin Core, TV-Anytime, Indecs

- **MPEG-7: Moving Picture Experts Group**
 - Infrastructure standard for Multimedia Metadata
 - Supports interpretation of the information's meaning
 - Supports broad range of applications
- **SMEF – Standard Media Exchange Framework:**
 - BBC developed data models for information involved in the Production, Development, Use, and Management of media assets
- **P/Meta – EBU P/Meta Project:**
 - Exchange of program content between high-level business functions of EBU members: Production, Delivery/Broadcast, & Archive
- **SMPTE – Metadata dictionary & MXF:**
 - Addresses Program Interchange independent of format
- **Dublin Core Metadata Initiative:**
 - Interoperable online metadata standards supporting broad range of purposes and business models.
- **TV-Anytime – TV-Anytime Metadata:**
 - Attractors/descriptors used e.g. in Electronic Program Guides (EPG), or in Web pages to describe content.
- **Indecs – Indecs Metadata Framework**
 - An international initiative of rights owners creating metadata standards for e-commerce.



- **MPEG-7 Harmonized Model:**
 - Harmonized elements with other standards and existing practices
 - Extensible framework
 - Registration authority for classification schemes, controlled terms, ontologies

Outline



1. MM content organization



2. MM database system architecture



3. MM system service model



4. Multimedia Data Storage



5. Multimedia application

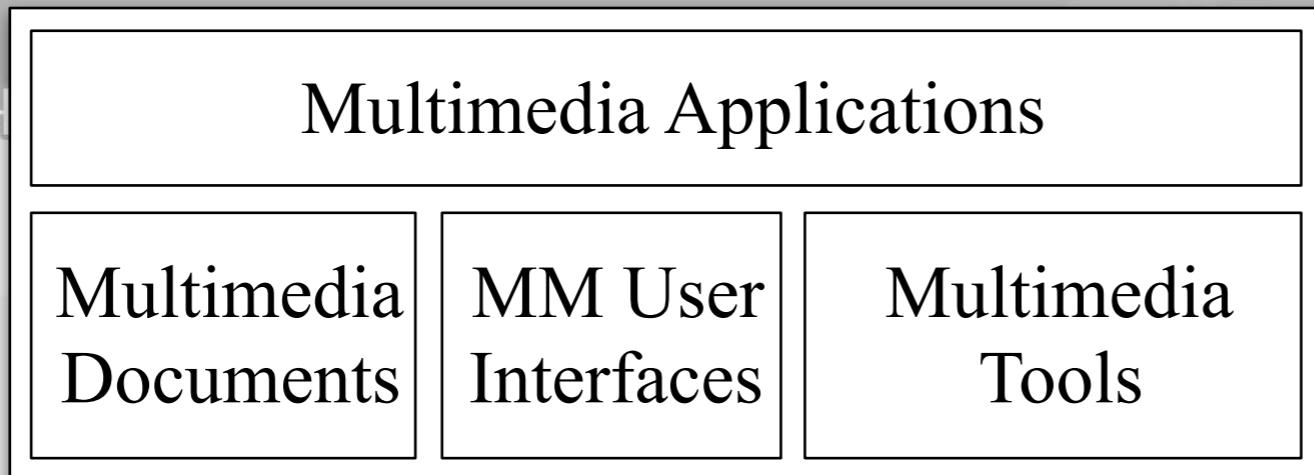




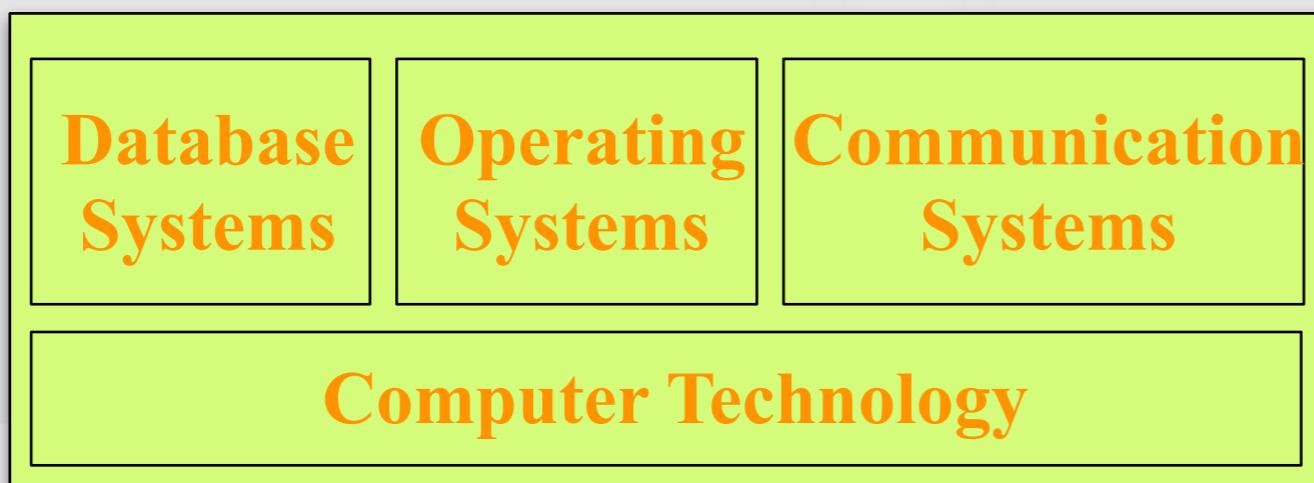
3.2 Multimedia Database System Architecture



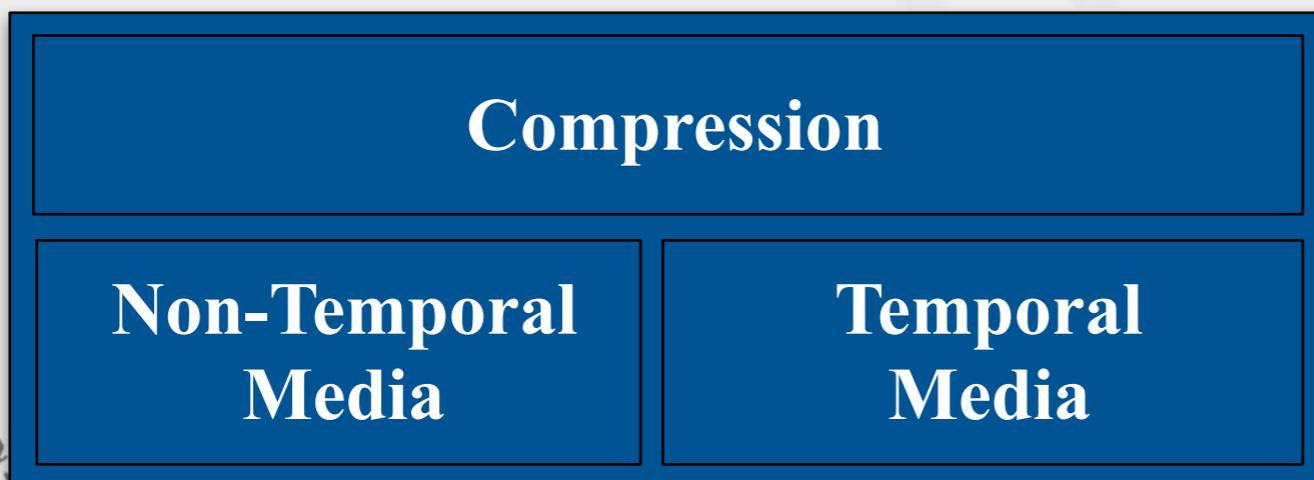
Multimedia System Architecture



Applications
Domain



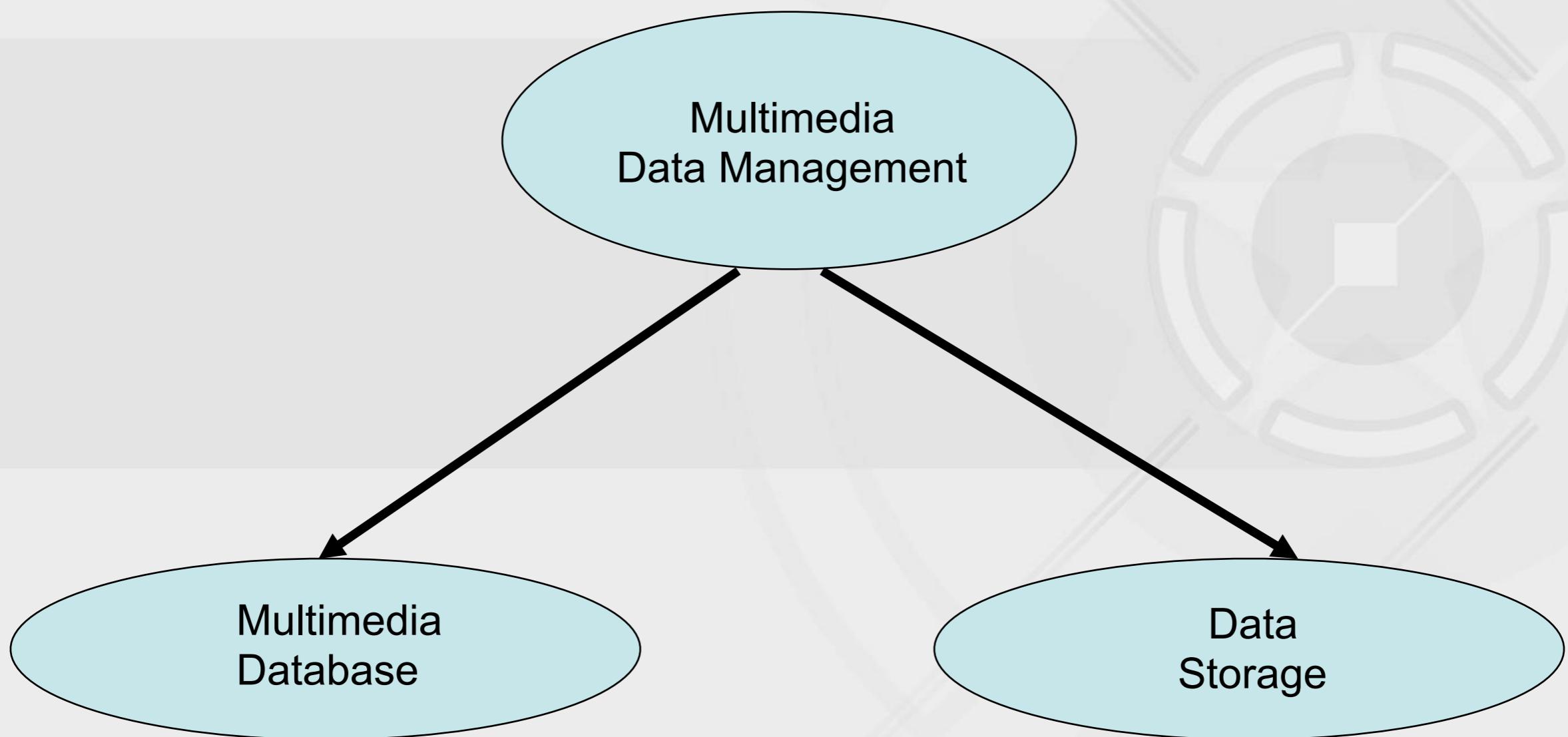
Systems
Domain



Media
Domain



Multimedia Database System



Multimedia Database System

- **Multimedia database** v.s. **text database**
 - **Temporal data**: Requires temporal modeling
 - **Huge amount of data**: Compression helps get around this.
 - Data is **not easily indicative** of the information
 - Requires a lot of **pre-processing** in order to store data efficiently:
 - PCA, feature extraction and segmentation
 - **Novel Query mechanisms**
 - **Hypermedia**: The ability to interactively move around in the data.

How to Build Multimedia Database Systems?

How to build text database?

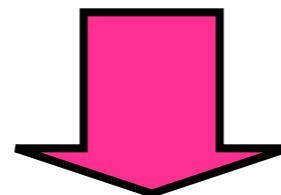
Yahoo, Google

Text document

Natural language processing

Actions
Transmission \longleftrightarrow Text database

Tree-based indexing



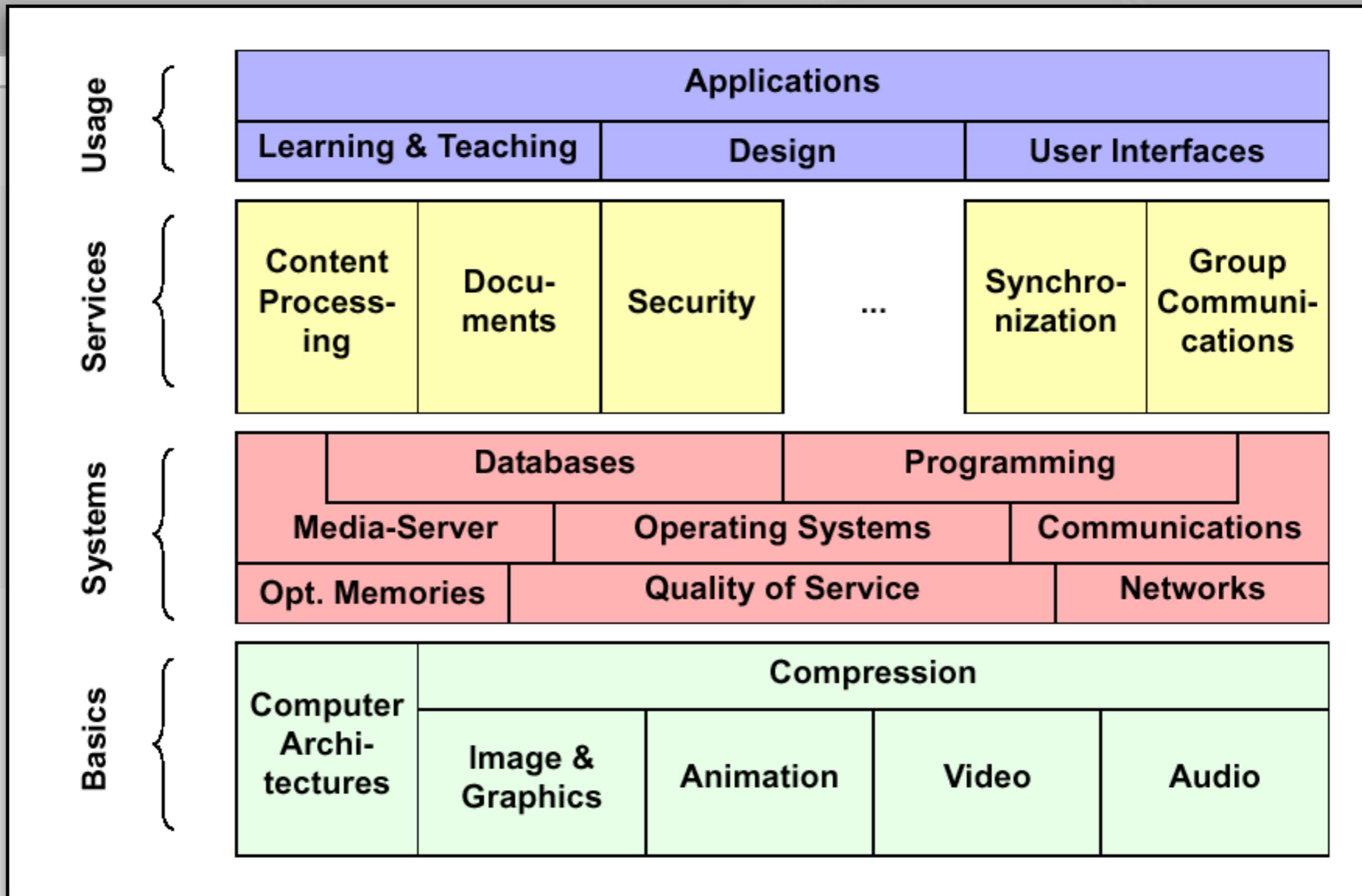
Multimedia data

Multimedia analysis

Actions
Transmission \longleftrightarrow Multimedia database

Multimedia
Indexing

Scope



A Reference Architecture for MMDB System

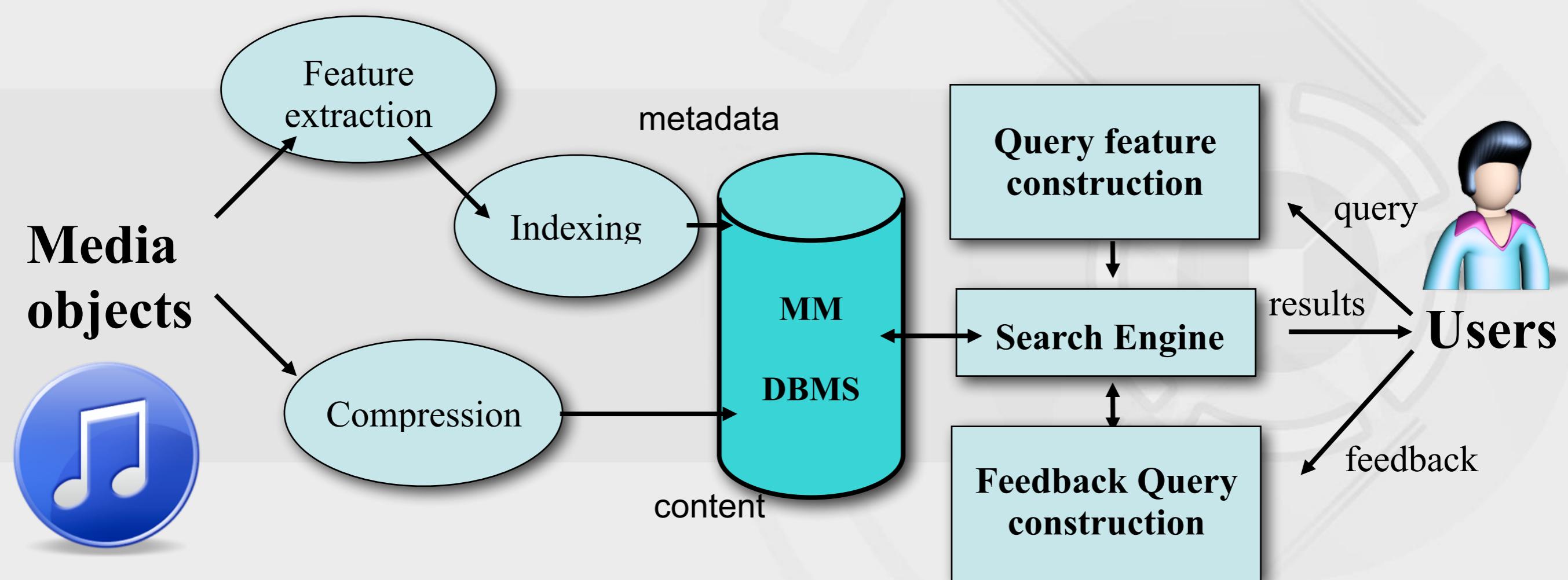
- **Considerations:**
 - **Real time aspects/constraints impose strong demands on the systems**
 - Simultaneous presentation of multimedia objects may cause performance problems.
 - **Data Sharing**
 - Due to the possibly very large multimedia data, traditional replicated data technique may not be applicable, hence data sharing is essential
 - **Multiple Client/ Multiple Server Architecture**

A Reference Architecture for MMDB System

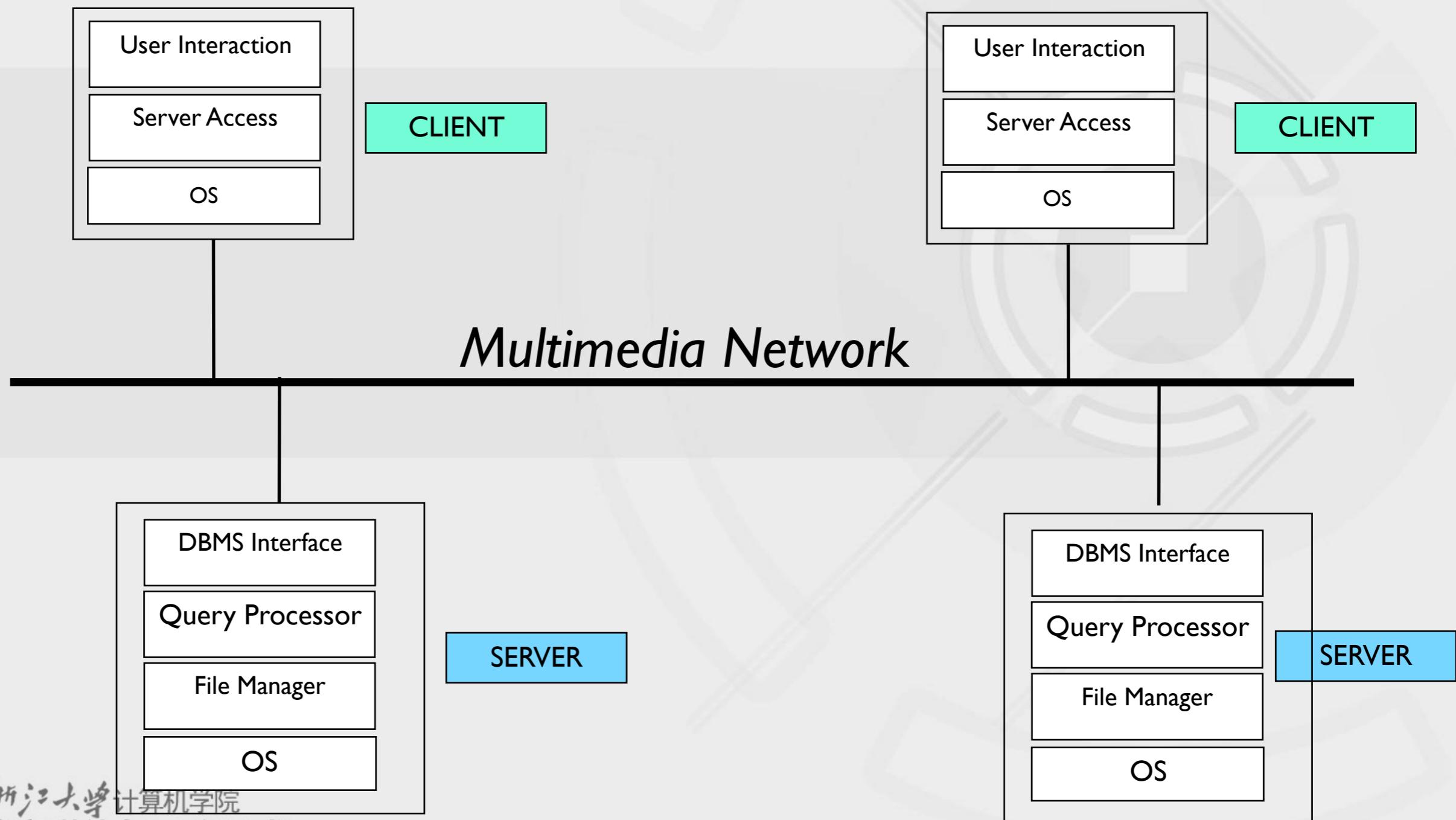
– **Considerations:**

- **Real time aspects/constraints**
- **Data Sharing**
- **Multiple Client/ Multiple Server Architecture**
 - Many multimedia applications work with data that are stored on remote sites (e.g, VOD, tele-learning), which suggests for client / server architecture.
 - A **client** consists of **three** layers...
 - **User Interaction** – takes care of input and output of multimedia data
 - **Server Access** – allows searching of servers by the client
 - **Operating System** – not a real part of the MMDBS
 - A **server** consists of **four** layers:
 - **DBMS Interface**
 - **Query Processor**
 - **File Manager**
 - **Operating System**

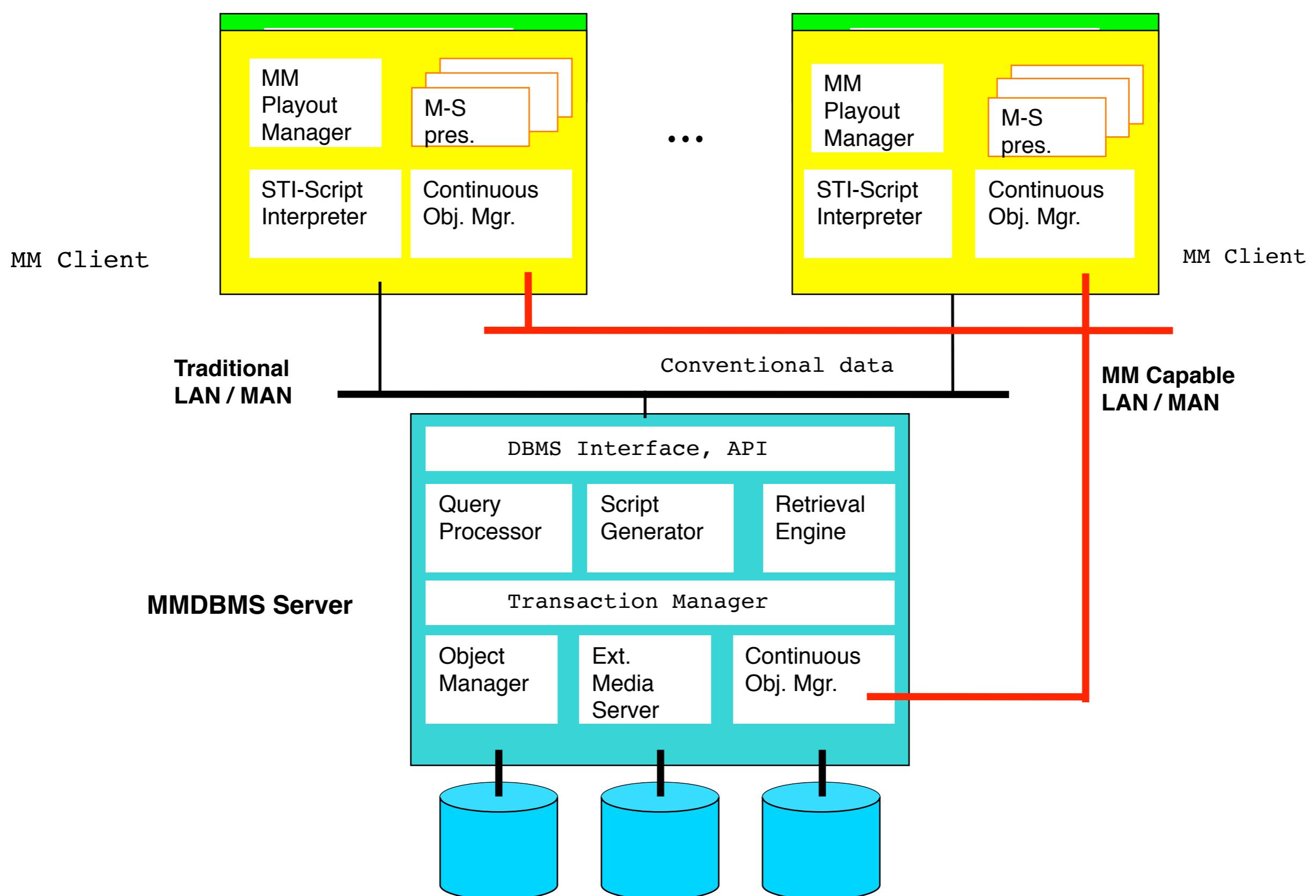
A Generic Architecture of MMDBMS



MMDB Reference Architecture: “Simplified View”



Detailed View of MMDB Architecture



MMDBMS Development

Major steps in developing MMDBMS

1. **Media acquisition:**

- collect media data from various sources, such as WWW, CD, TV, etc.

2. **Media processing:**

- extract media representations and their features, including noise filtering, rendering, etc.

3. **Media storage:**

- store the data and their features in the system based on application requirement.

4. **Media organization:**

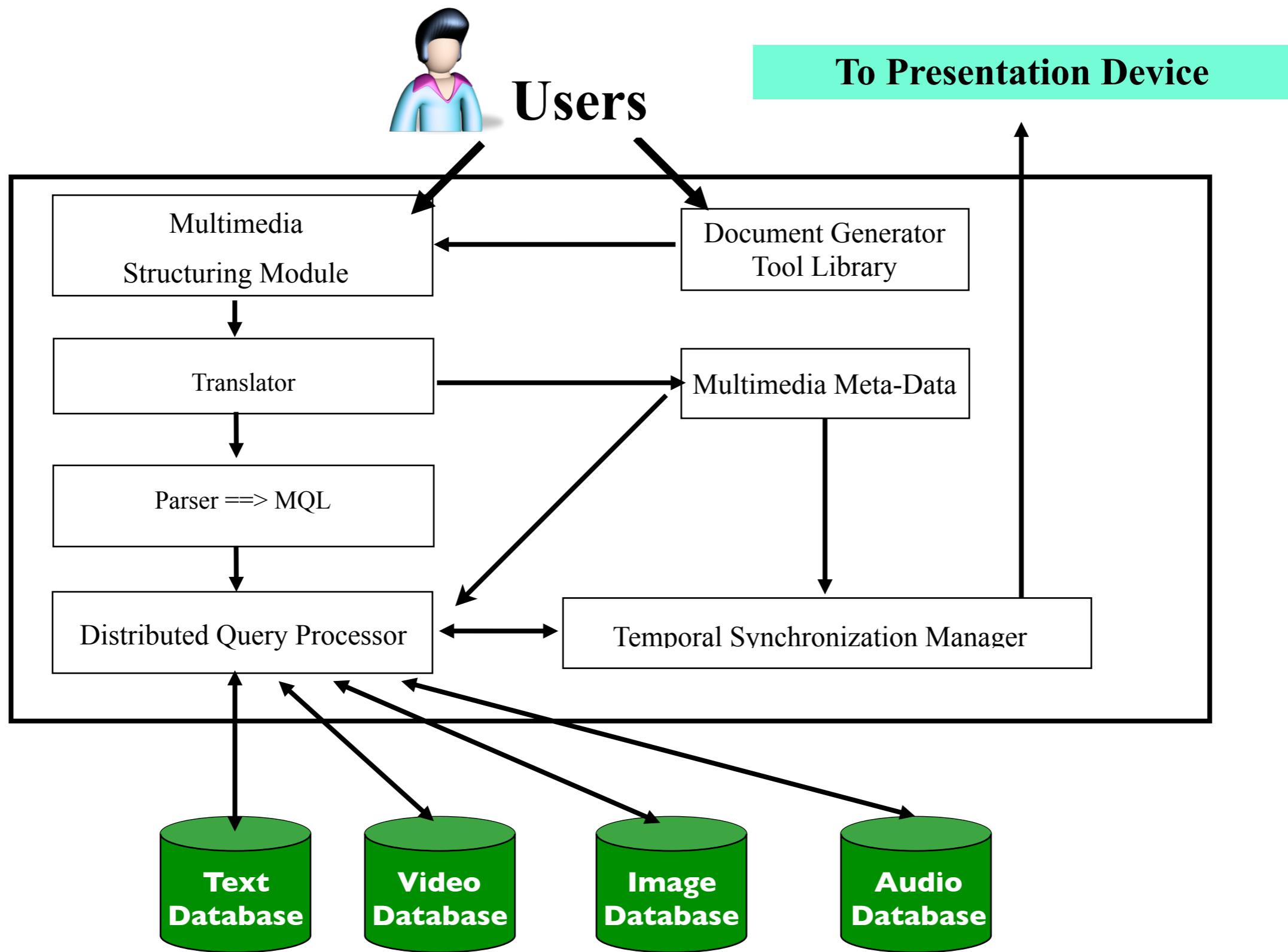
- organize the features for retrieval. i.e., indexing the features with effective structures.

5. **Media query processing:**

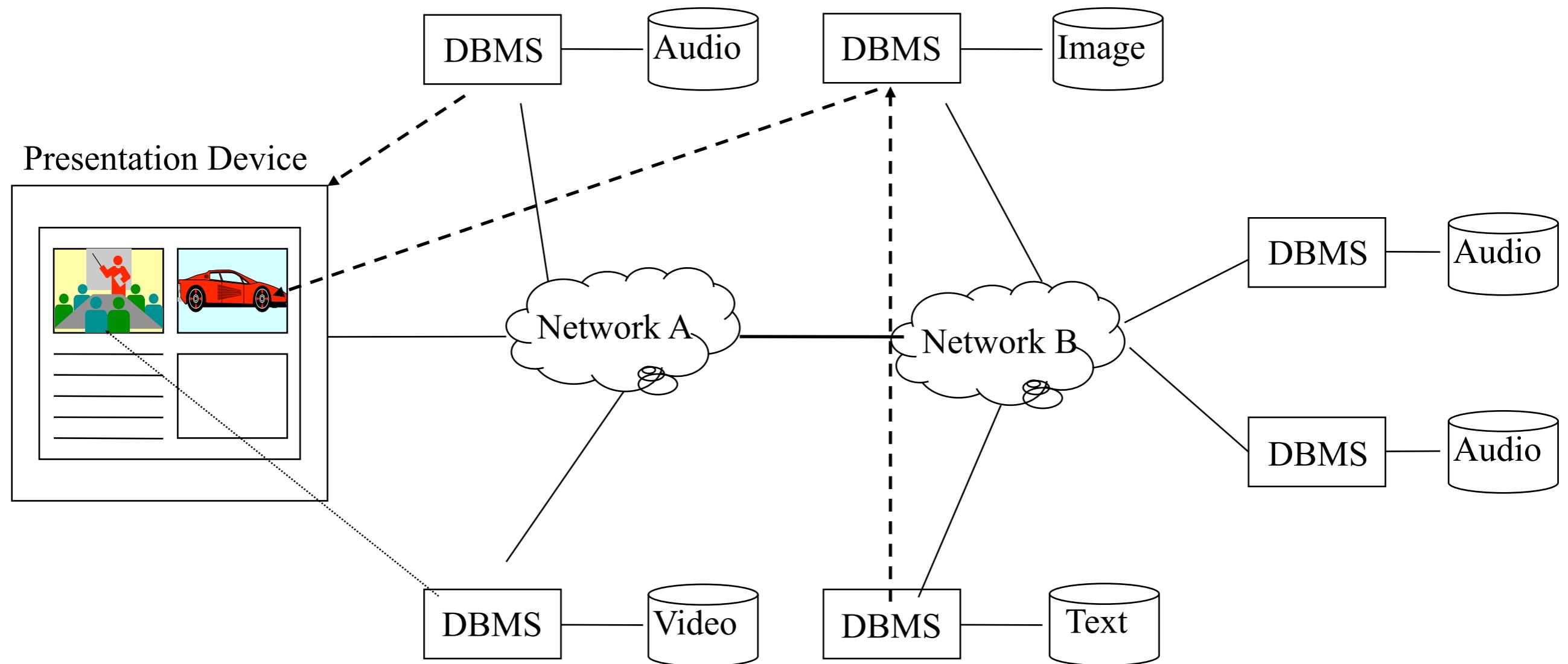
- Accommodated with indexing structure, efficient search algorithm with similarity function should be designed.



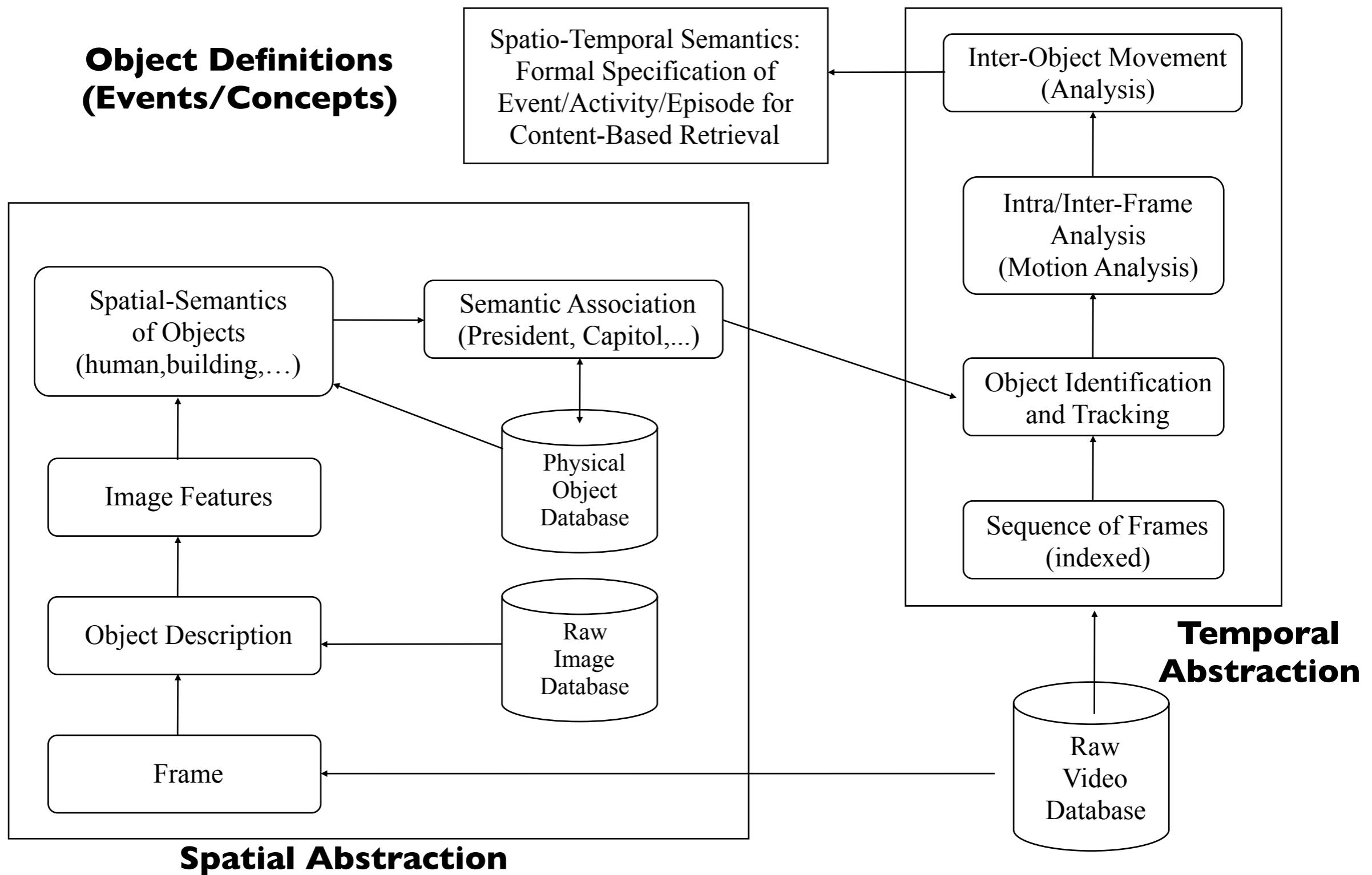
Software Architecture of MMDBMS



Distributed Multimedia Database Systems



An Architecture for Video Database System



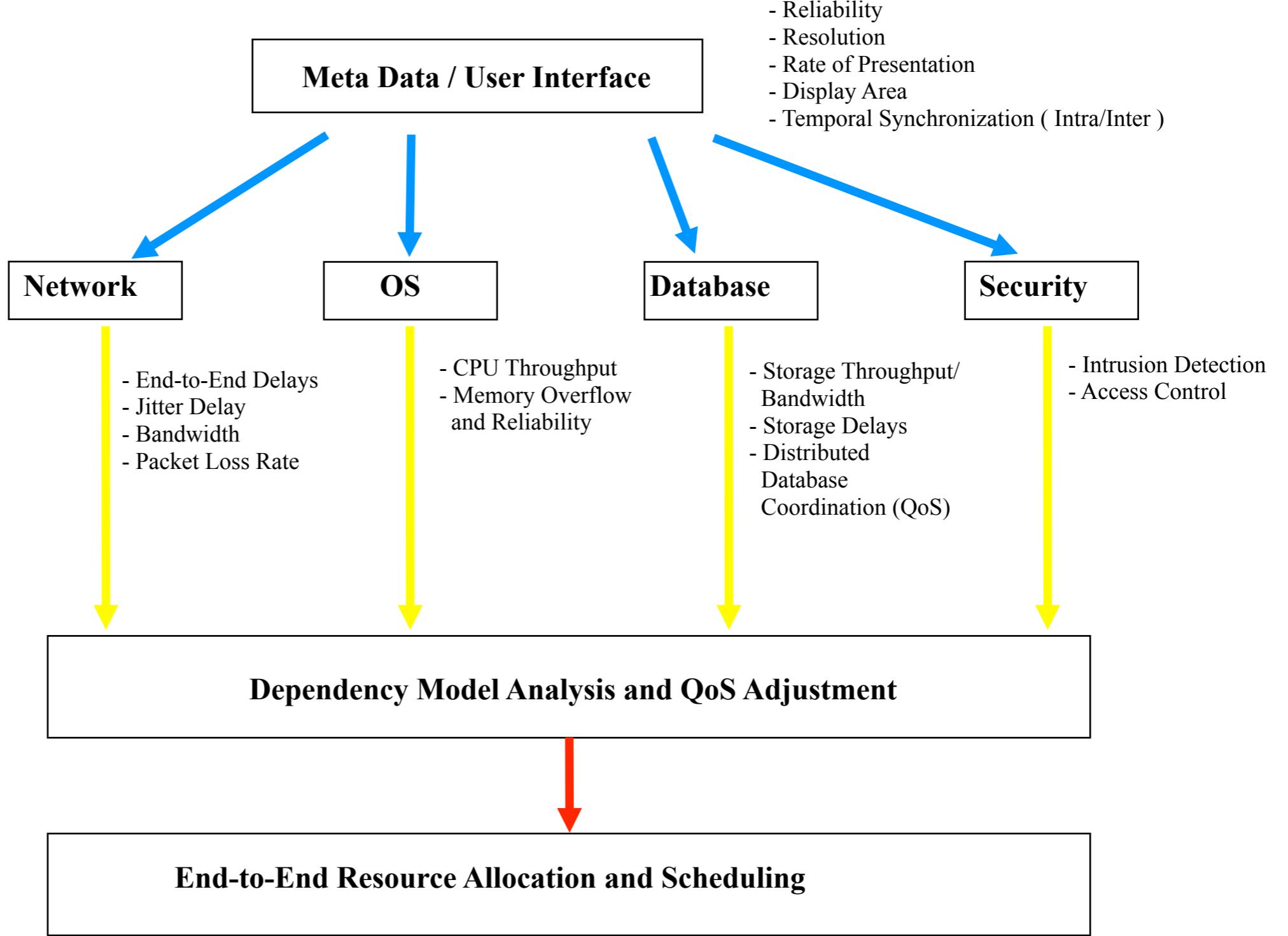
End-to-End QoP / QoS Management

Specification

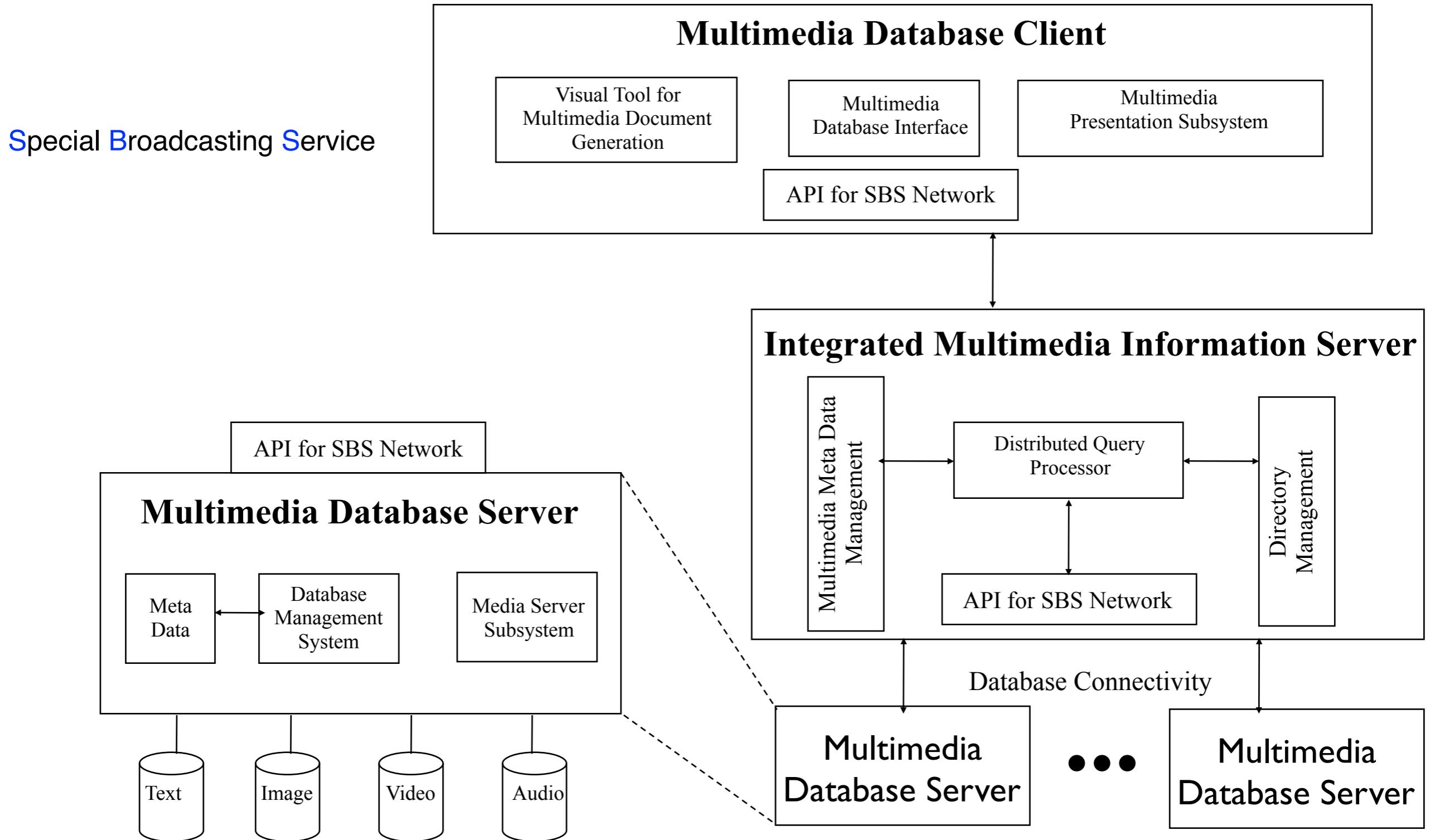
Translation

Negotiation

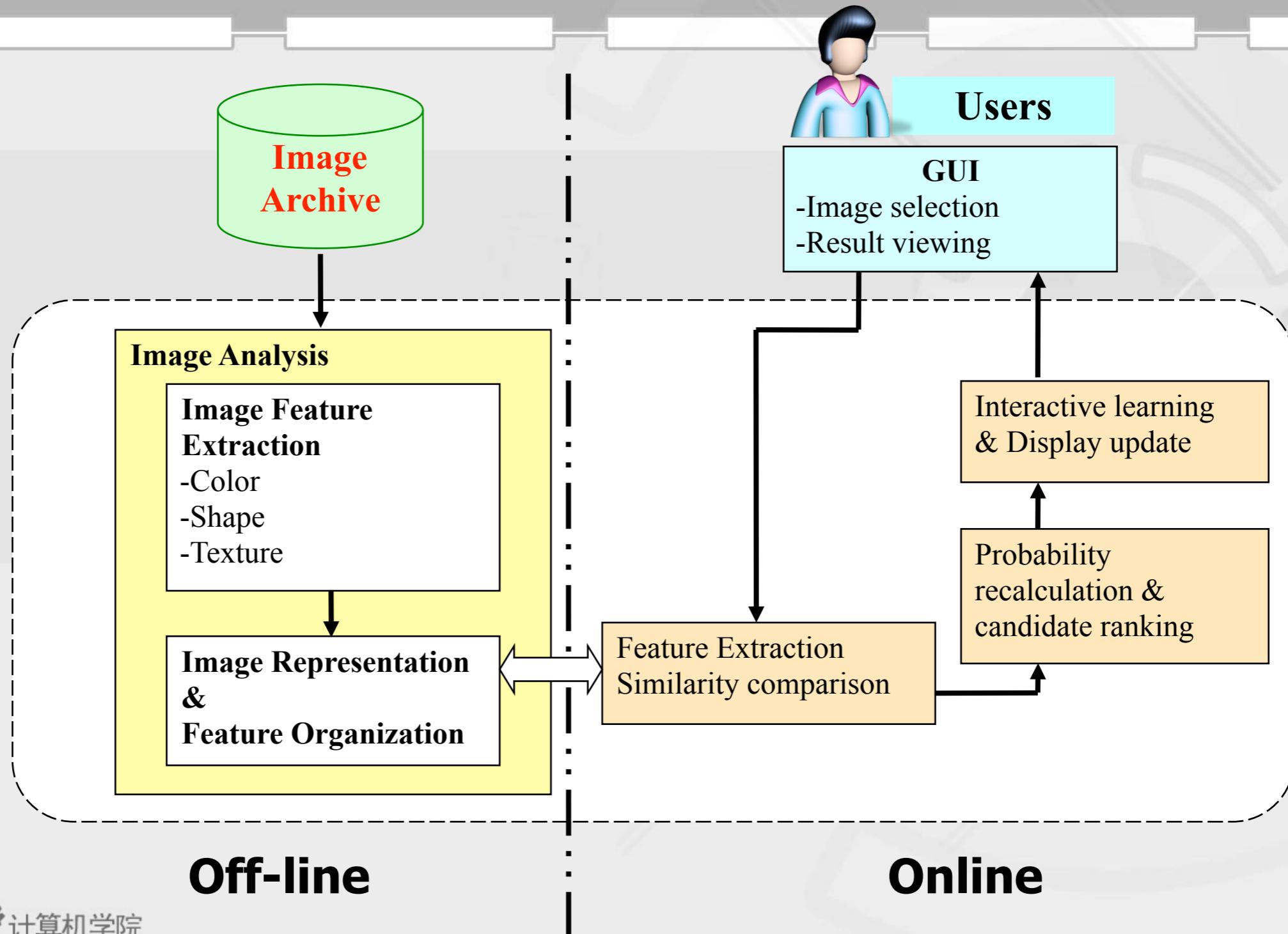
End-to-End Run Time Scheduling



Architecture of a Distributed Multimedia Database Management



Overview of the System



Outline



1. MM content organization

2. MM database system architecture

3. MM system service model



4. Multimedia Data Storage

5. Multimedia application





3.3 Multimedia System Service Model



What is a Media Service/Server?



- A scalable storage manager
 - **Allocates multimedia data optimally** among disk resources
 - Performs memory and disk-based **I/O optimization**
- Supports
 - real-time and non-real-time **clients**
 - presentation of **continuous-media data**
 - mixed workloads: schedules the **retrieval of blocks**
- Performs **admission control**

Service Models



- Random Access
 - **Maximize the number of clients** that can be served concurrently at any time with a low response time
 - **Minimize latency** (等待时间)
- Enhanced Pay-per-view (EPPV)
 - **Increase the number of clients** that can be serviced concurrently beyond the available disk and memory bandwidth, while guaranteeing a constraint on the response time

Service Models

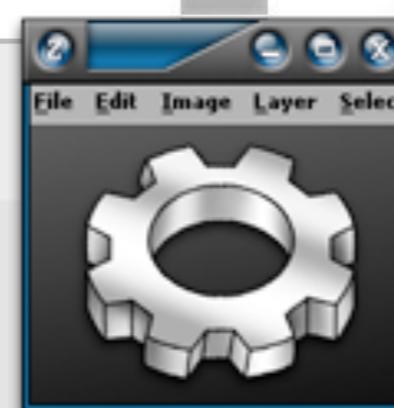
- Example
 - Server
- Random Access Model
 - Case 1: after 20 movies, no more memory left. 21st movie waits for 80 minutes, 22nd movie waits for 81 minutes ...
 - Case 2: after 20 movies, more memory can be allocated. 21st movie has to wait (initial latency) till one round of the previous 20 movies each has been served.
- EPPV Model:
 - At any time 20 movies are served, movies are initiated every 5 minutes
 - Streams are distributed uniformly during these 20 minutes



Outline



1. MM content organization



2. MM database system architecture



3. MM system service model



4. Multimedia Data Storage



5. Multimedia application





3.4 Multimedia Data Storage



Multimedia Data Storage

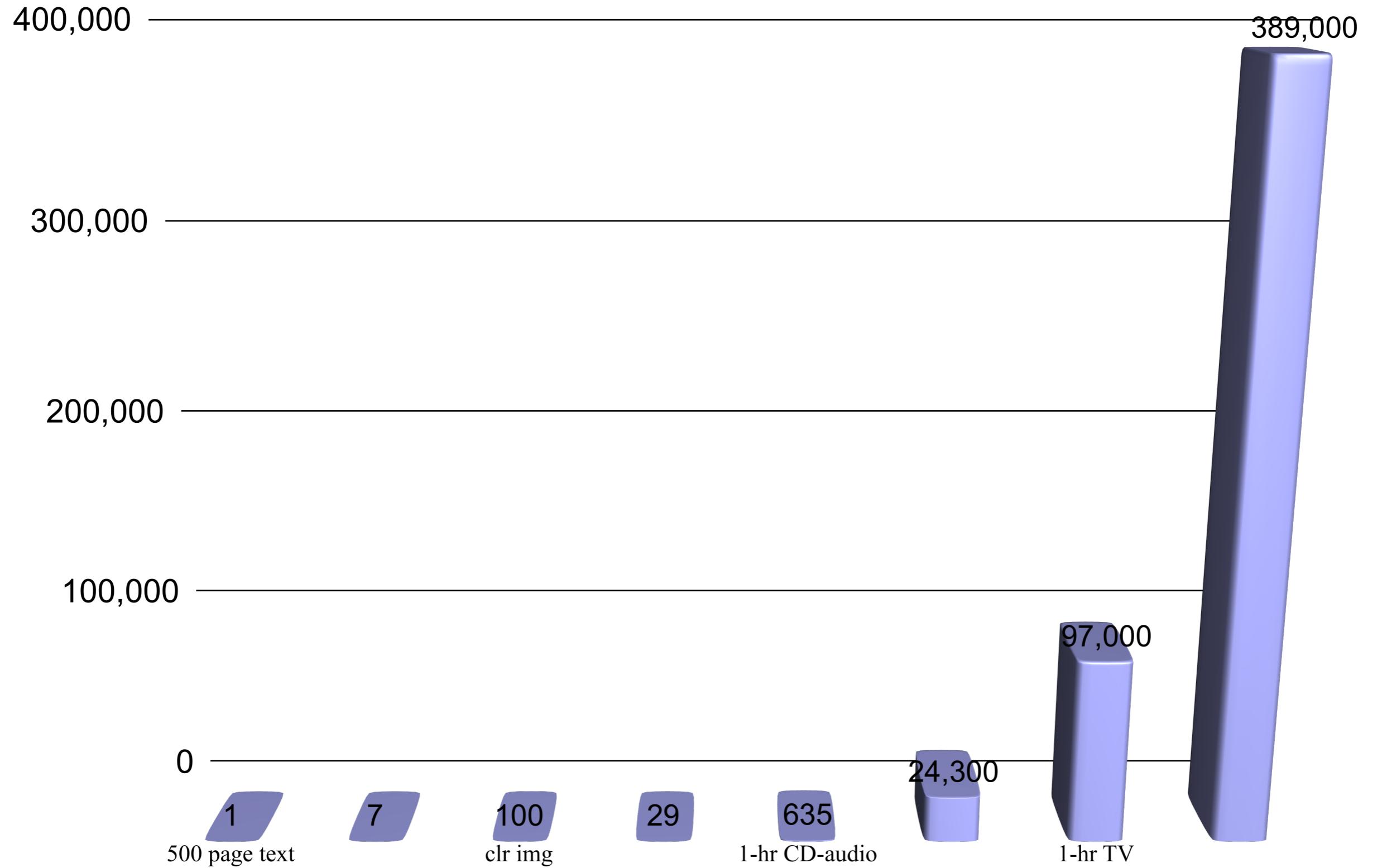
- Storage Requirements
- RAID Technology
- Optical Storage Technology



Requirements of MM Information

- Storage and Bandwidth Requirement
 - measured in bytes or Mbytes for storage
 - measured in bits/s or Mbits/s for bandwidth
 - An image 480 x 600 (24 bits per pixel),
 - 864k bytes (without compression).
 - To transmit it within 2 sec => 3.456Mb/s.
 - 1GB Hard-disk
 - 1.5 hr. of CD-audio or
 - 36 seconds of TV quality video
 - require 800s to be transferred (10Mbits/s network).

Storage & Bandwidth Requirements



Delay and Delay Jitter Requirements

- Digital audio and video are **time-dependent** continuous media
- **dynamic media** => achieve **a reasonable quality playback** of audio and video, media samples must be received and played back at regular intervals.
- E.g. audio playback, 8K samples/sec have to be achieved
- **End-to-end delay is the sum of all delays** in all the components of a MM system, disk access, ADC, encoding, host processing, network access & transmission, buffering, decoding, and DAC
 - In most conversation type applications, end-to-end delay should be kept below **300ms**
- Delay variation is commonly called **delay jitter**. It should be small enough to achieve smooth playback of continuous media, e.g.,
 - < **10ms** for telephone-quality voice and TV-quality video,
 - < **1ms** for stereo effect in high quality audio.

Other Requirements

Quest for Semantic Structure

- For alphanumeric information, **computer can search & retrieve alphanumeric items** from a DB or document collection.
- It is **hard to automatically retrieve** digital audio, image, & video as no semantic structure is revealed from the series of sampled values

Spatial-Temporal Relationship Among Related Media

- **Retrieval and transmission of MM data must be coordinated and presented** so that their specified temporal relationship are maintained for presentation
- A synchronization scheme therefore defines **the mechanisms used to achieve the required degree of synchronization**
- Two areas of works: user-oriented and system-oriented synchronization

Other Requirements

Error and Loss Tolerance

- Unlike alphanumeric information, we can tolerate some error or loss in MM
- For voice, we can tolerate a bit error rate of 10^{-2}
- For images and video, we can tolerate a bit rate from 10^{-4} to 10^{-6} .
- Another parameter: **packet loss rate** - a much more stringent requirement

Text v.s. MM Data Requirements

Characteristics	Text-based Data	Multimedia Data
Storage Req.	Small	Large
Data Rate	Low	High
Traffic Pattern	Bursty	Stream-oriented, highly bursty
Error/Reliability Req.	No loss	Some loss
Delay/Latency Req.	None	Low
Temporal Relationship	None	Synchronized Trans.



Quality of Service (QoS)

- To provide a uniform framework to specify and guarantee these diverse requirement, a concept called **QoS** has been introduced.
- QoS is **a set of requirement, but there is no universally agreed one.**
- QoS is **a contract** negotiated and agreed **among MM applications and MM system** (service provider)
- The QoS requirement is normally specified in two grades: the **preferable quality** and the **acceptable one.**
- The QoS guarantee can be in one of three forms: hard or deterministic (**fully satisfied**), soft or statistic (**guaranteed with a certain probability**), and best effort (**no guarantee at all**)
- A lot of research issues are involved and still undergoing!!



File Systems

- **The most visible part** of an operating system.
- **organization of the file system**
 - an important factor for the usability and convenience of the operating system.
- Files are stored in secondary storage, so they can be **used by different applications**.
- In **traditional file systems**, the information types stored in files are sources, objects, libraries and executables of programs etc.
- In **multimedia systems**, the stored information also covers digitized video and audio with their related real-time “**read**” and “**write**” demands.
- ==>>> additional requirements in the design and implementation



File Systems

Traditional File Systems

- The main goals of traditional files systems are:
 - to **provide** a comfortable interface for file access to the user
 - to **make** efficient use of storage media
 - to **allow** arbitrary deletion and extension of files

Multimedia File Systems

- the main goal is to provide a **constant and timely retrieval** of data.
- It can be achieved through providing enough buffer for each data stream and the employment of disk scheduling algorithms, especially optimized for real-time storage and retrieval of data.

Multimedia File Systems

- The much greater size of continuous media files and the fact that they will usually be retrieved sequentially are reasons for an **optimization of the disk layout**
- Continuous media streams predominantly **belong to the write-once-read-many nature (ROM?)**, and streams that are recorded at the same time are likely to be played back at the same time.
- Hence, it seems to be reasonable to **store continuous media data in large data blocks contiguously on disk**.
- Files that are likely **to be retrieved together are grouped together on the disk**.
- With such a disk layout, the buffer requirements and seek times decrease.
- The disadvantage of the continuous approach is **external fragmentation** and **copying overhead** during insertion and deletion.

Data Management & Disk Spanning

Data Management:

- **Command queuing:** allows execution of **multiple sequential commands** with system CPU intervention. It helps in minimizing head switching and disk rotational latency.
- **Scatter-gather:** scatter is **a process** whereby data is set for best fit in available block of memory or disk. **Gather reassembles data** into contiguous blocks on disk or in memory.

Disk Spanning

- Attach **multiple devices** to a **single host adapter**.
- good way to increase storage capacity by adding incremental drives.

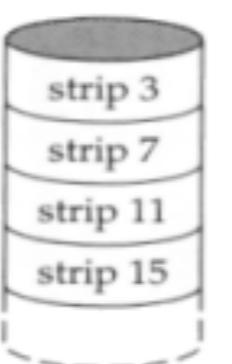
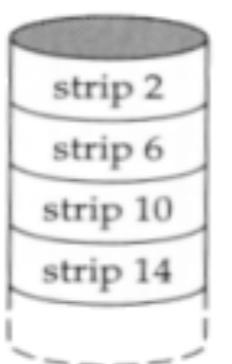
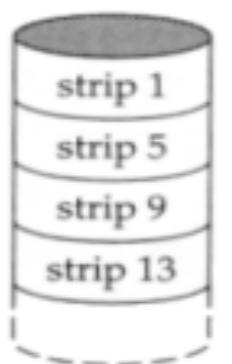
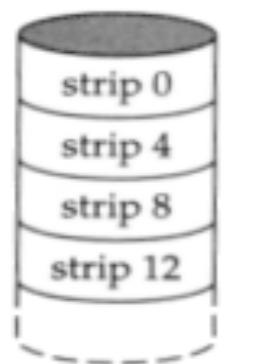
RAID Redundant Arrays of Inexpensive Disks

- **By definition RAID has three attributes:**
 - a set of disk drives viewed by the user as one or more logical drives
 - data is distributed across the set of drives in a pre-defined manner
 - redundant capacity or data reconstruction capability is added, in order to recover data in the event of a disk failure
- **Objectives of RAID**
 - Hot backup of disk systems (as in mirroring)
 - Large volume storage at lower cost
 - Higher performance at lower cost
 - Ease of data recovery (fault tolerance)
 - High MTBF (mean time between failure)

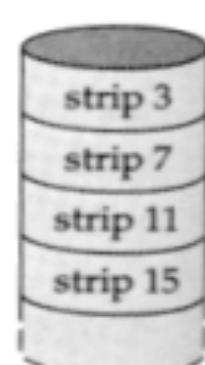
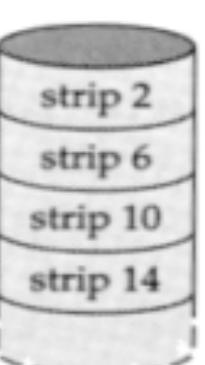
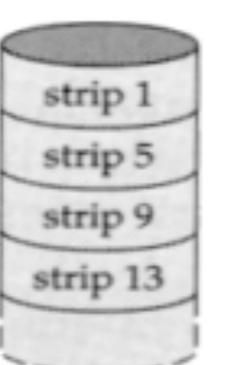
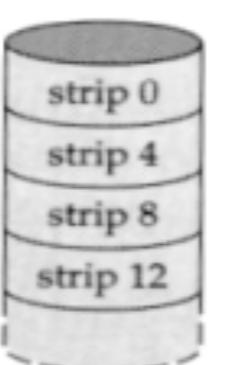
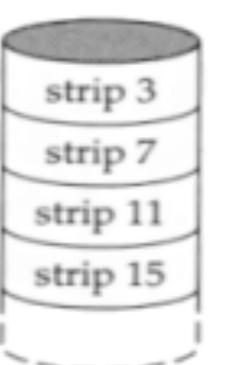
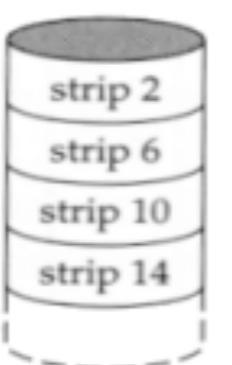
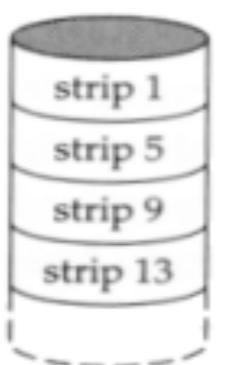
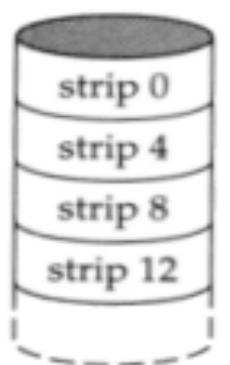


Different Levels of RAID

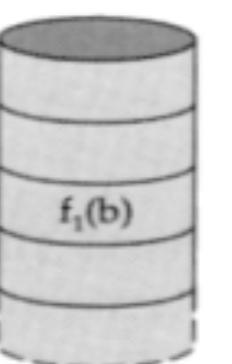
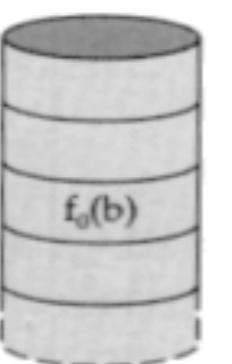
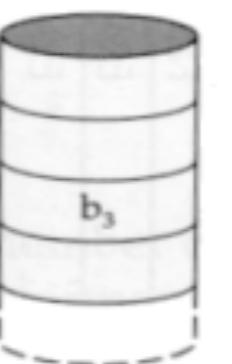
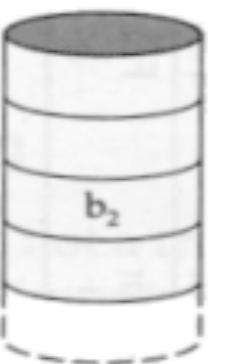
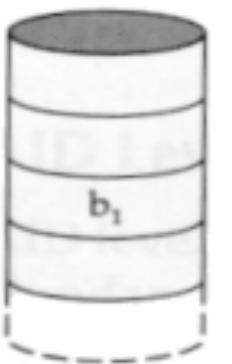
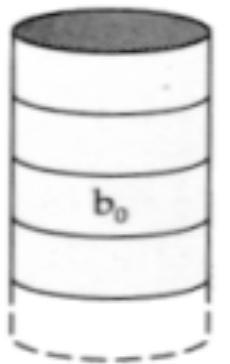
- **Eight discrete levels of RAID functionality**
 - Level 0 - disk striping
 - Level 1 - disk mirroring
 - Level 2 - bit interleaving and Hamming Error Correction (HEC) parity
 - Level 3 - bit interleaving and XOR parity
 - Level 4 - block interleaving with XOR parity
 - Level 5 - block interleaving with parity distribution
 - Level 6 - Fault tolerant system
 - Level 7 - Heterogeneous system
- Data is spread across the drives in units of **512 bytes** called **segments**.
Multiple segments form a block.



(a) RAID 0 (Non-redundant)



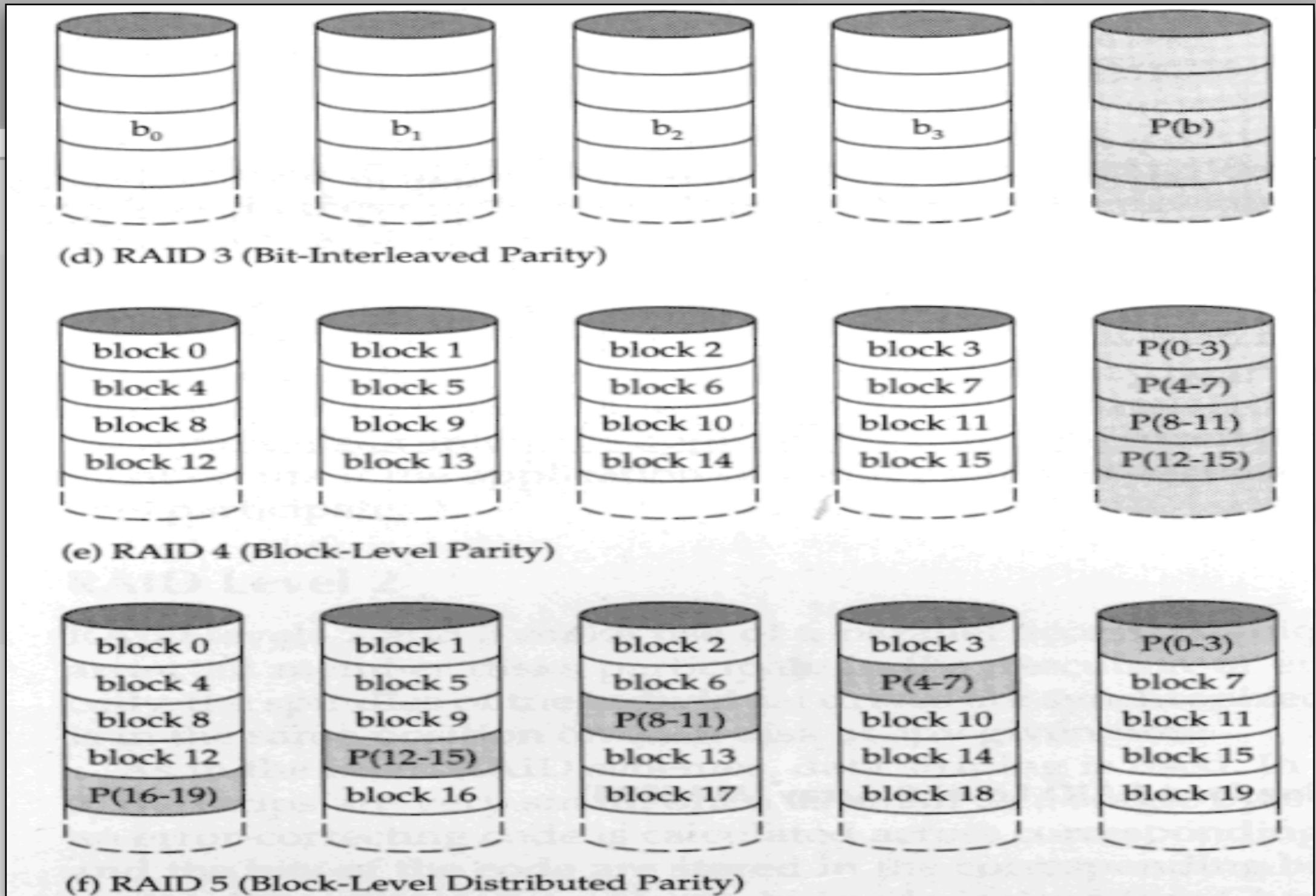
(b) RAID 1 (Mirrored)



(c) RAID 2 (Redundancy Through Hamming Code)

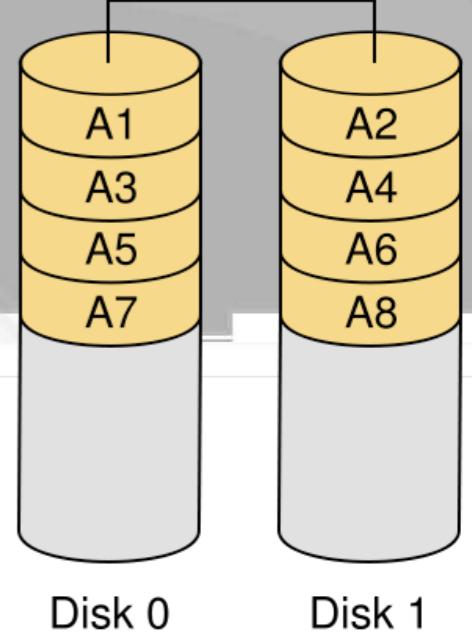
FIGURE 5.5. RAID Levels





RAID Level 0 - Disk Striping

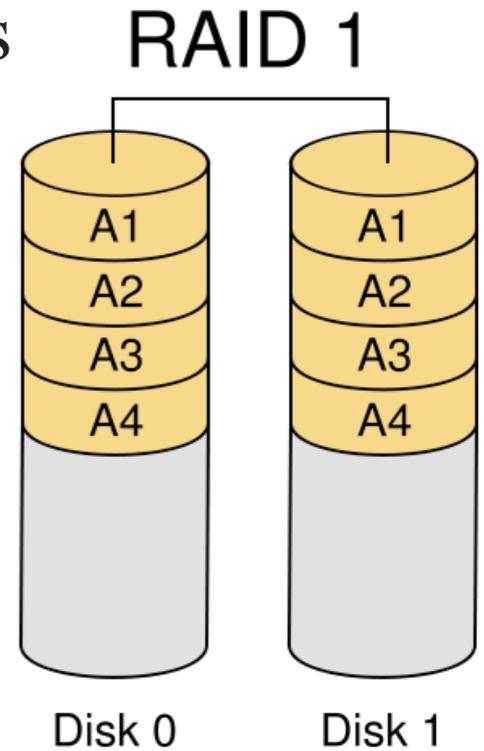
RAID 0



- To improve performance by overlapping disk reads and writes
- Multiple drives connected to a single disk controller
- Data is striped to spread segments of data across multiple drives in block sizes ranging from 1 to 64 Kbytes
- Disk striping provides a higher transfer rate for write and retrieve block of data
- Typical application: database applications
- Drawbacks:
 - If one drive fails, the whole drive system fails
 - Does not offer any data redundancy, no fault tolerance

RAID Level 1 - Disk Mirroring

- Each main drive has a **mirror drive**
- Two copies of every file will write to two separate drives
complete redundancy
- Performance:
 - * Disk write : take almost twice time
 - * Disk read : can be speed up by overlapping seeks
- Typical use:
 - * in file servers provides **backup in the event of disk failure**
- Duplexing:
 - * Use two separate controllers
 - * The second controller enhances both fault tolerance and performance
 - * Separate controllers allow parallel writes and parallel reads



RAID Level 2

- Bit Interleaving and HEC Parity

- Contain arrays of multiple drives connected to a disk array controller.
- Data is written interleaved across multiple drives (often one bit at a time) and multiple check disks are used to detect and correct errors.
- **Hamming error correction (HEC)** code is used for error detection and correction.
- The drive spindles must be **synchronized** as a single I/O operation accesses all drives
- Benefits:
 - * High level of data integrity and reliability (error correction feature)
 - * Mainly use for **supercomputers** to access large volumes of data with a small number of I/O request.

RAID Level 2

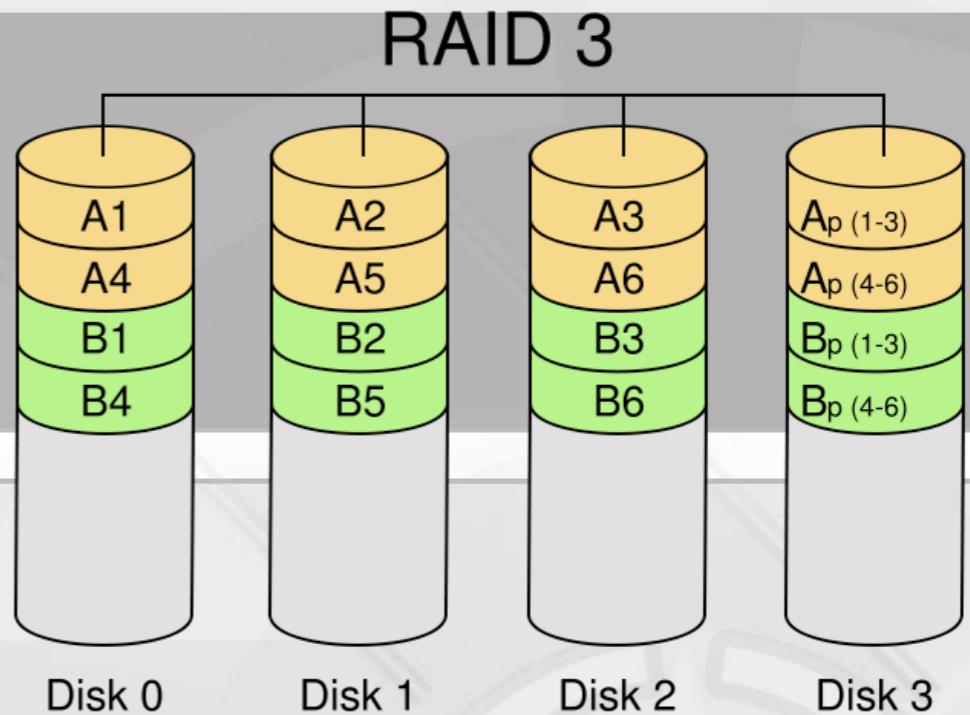
- Bit Interleaving and HEC Parity

Drawbacks:

- **Expensive** - requires **multiple drives** for error detection and correction
- **Error-correcting scheme: slow** and **cumbersome**
- Multimedia applications can afford to **lose occasional bit** or there without any significant impact on the system or the display quality.
- Each sector on a drive is associated with sectors on other drives to form a single storage unit, it takes multiple sectors across all data drives to storage even just a few bytes, **resulting in waste of storage**.
- Should not be used for transaction processing where **the data size of each transaction is small**.

RAID Level 3

- Bit Interleaving with XOR Parity



- **Bit interleaved** across multiple drives
- **Only offer error detection** - not error correction
- **More efficient than RAID 2**: parity bits are written **into the data stream** and **only one parity drive** is needed to check data accuracy.
- Parity generation and parity checking performed by **hardware**
- **Not suitable for small transaction**
- **Good for supercomputer and data server**: large sequential I/O request

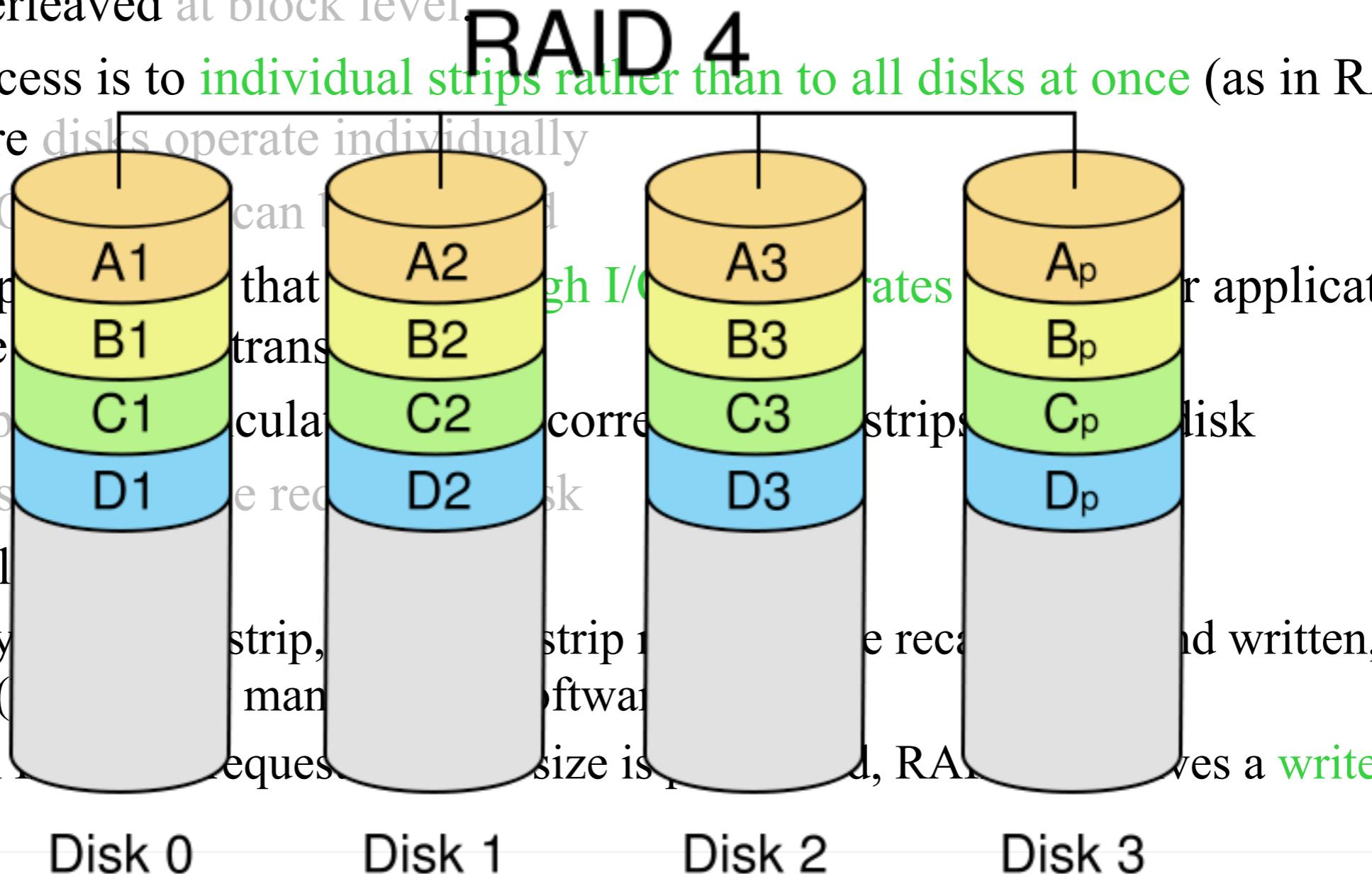


RAID Level 4

- Block Interleaving with XOR Parity

■ Write successive blocks of data on different drives.

- Data is interleaved at block level.
- RAID 4 access is to individual strips rather than to all disks at once (as in RAID 3); therefore disks operate individually
- Separate I/O controller can handle multiple disks simultaneously
- Good for applications that require high I/O rates
- Bit-by-bit parity calculation requires more time
- Parity bits stored on one disk
- Write penalty
 - For every strip, many man pages updated (manually)
 - When an application requests a write, size is small, RAID controller writes a write penalty.

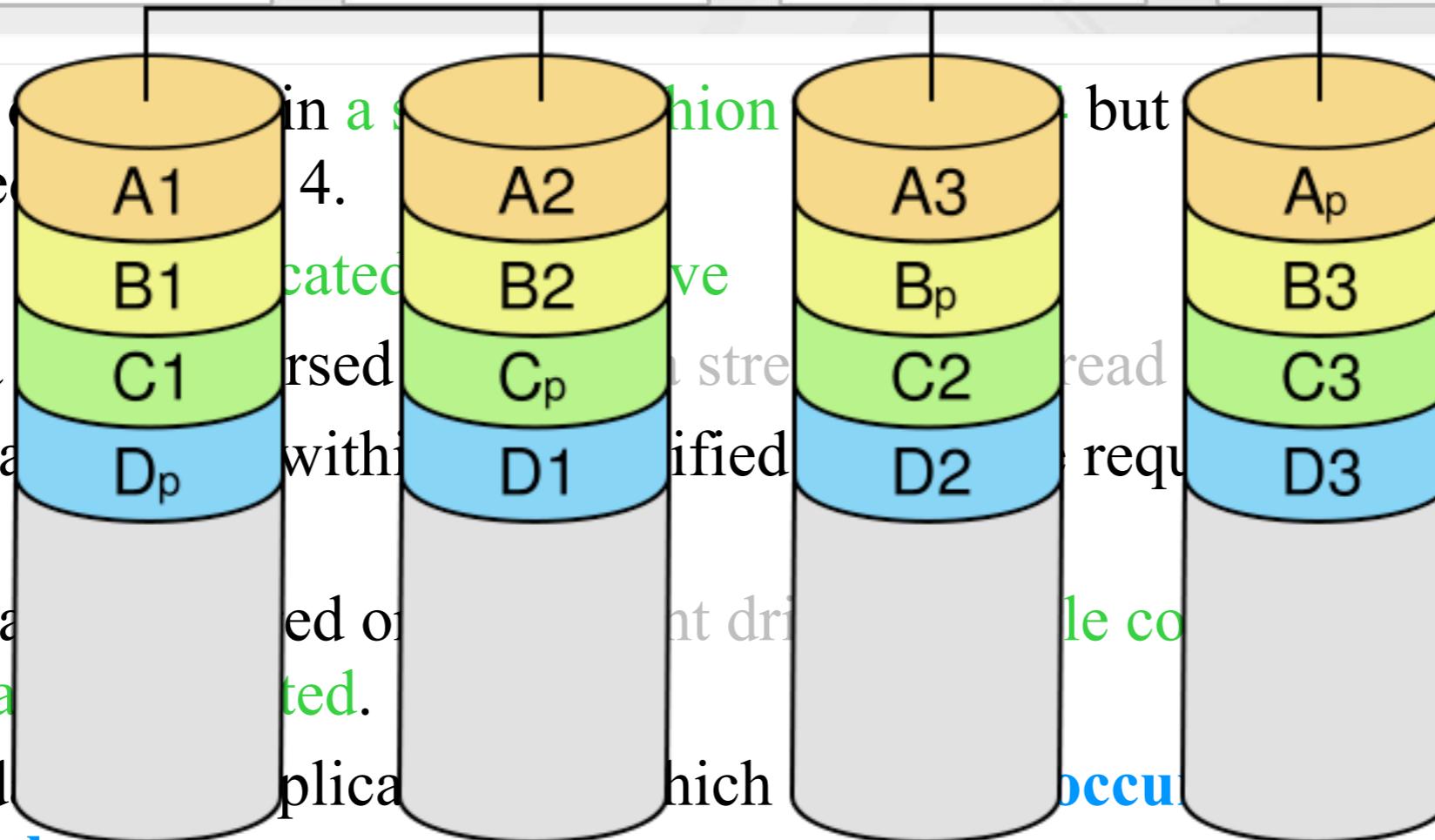


RAID Level 5

- Block Interleaving with Parity Distribution

RAID 5

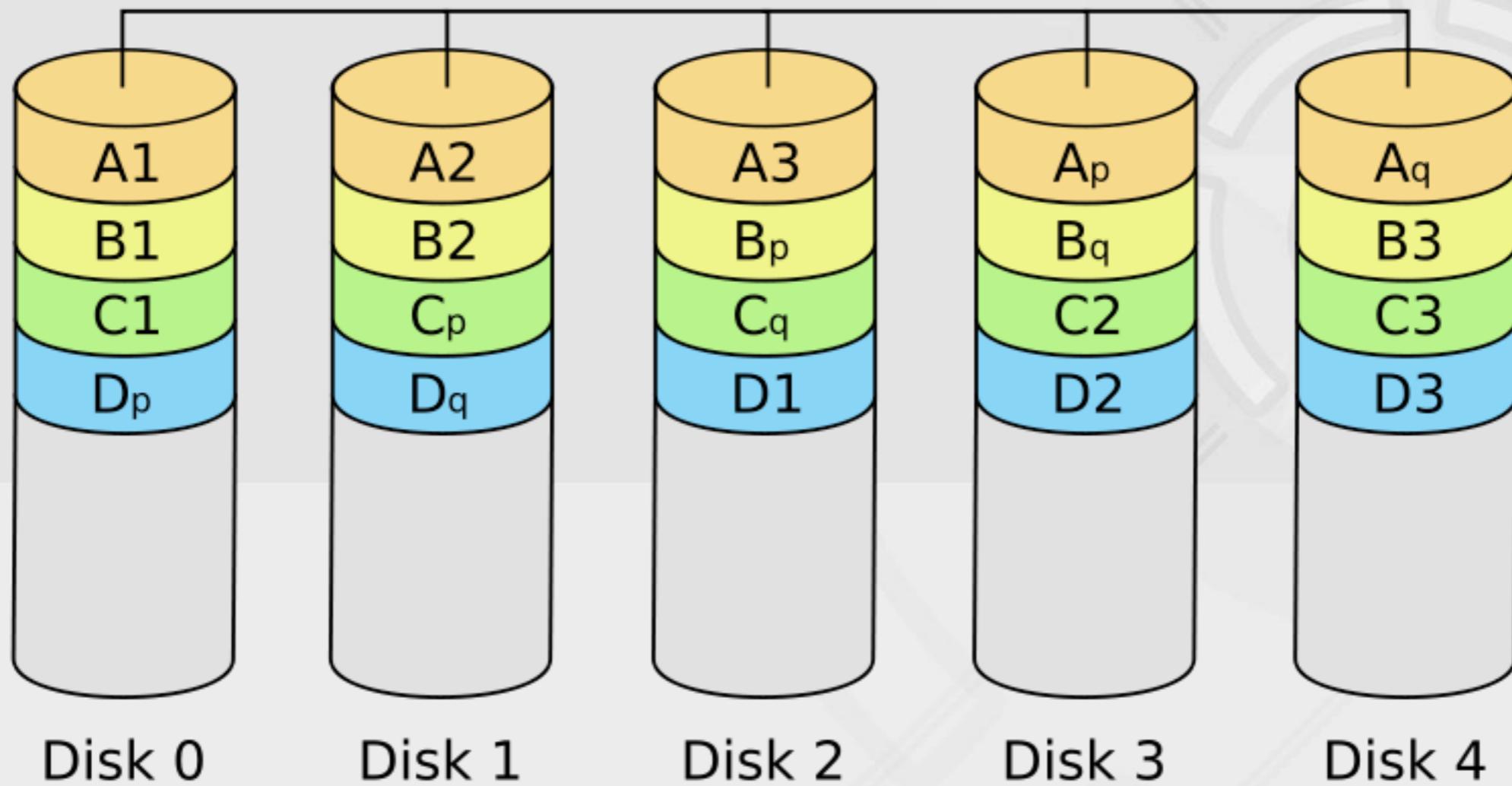
- RAID 5 is a **block interleaved parity distribution** scheme.
- It does **not** have a dedicated parity drive.
- Parity data is **distributed** across all drives.
- Block of data is **written** within a single I/O access.
- Block of data is **read** from multiple drives.
- **Accesses can be interleaved**.
- Good for **data redundancy** which **occurs only and in small chunks**.
- Drawbacks: **high cost and low performance** for large block sizes objects such as audio and video.



RAID Level 6-7

- Fault-Tolerant and Heterogeneous System

RAID 6



RAID Level 6-7

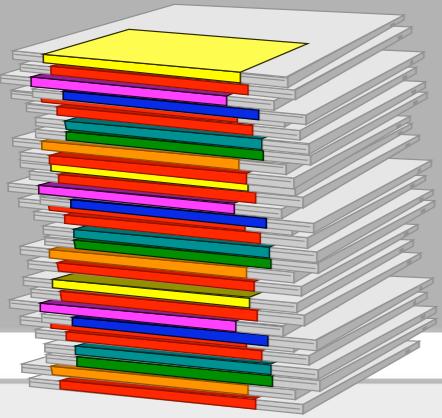
- Fault-Tolerant and Heterogeneous System

- RAID 6 has become a common feature in many systems. RAID 6 is **an improvement over RAID 5** model through the **addition error recovery information**.
- Conceptually, the disks are considered to be in a matrix formation and the parity is generated for rows and for columns of disks in the matrix. The **multi-dimensional level of parity** is computed and distributed among the disks in the matrix.
- RAID 7 is the most recent development in the RAID taxonomy. Its architecture allows **each individual drive to access data as fast as possible** by incorporating a few crucial features.
- With the growth in **the speed of computers** and communications in response to **the demands for speed & reliability**, the RAID theme has begun to attract significant attention as a potential **mass storage solution** for the future.

RAID5 and SSD

Data Storage

- The strategy adopted for data storage will depend on the **storage technology, storage design, and the nature of data itself.**
- Any storage has the following parameters:
 - Storage capacity
 - Standard operations of Read and Write
 - Unit of transfer for Read and Write
 - Physical organization of storage units
 - Read-Write heads, Cylinders per Disc, Tracks per Cylinder, and Sectors per Track
 - Read time and seek time
- Of the storage technologies that are available as computer peripherals, the optical medium is the most popular in the multimedia context.



Magnetic

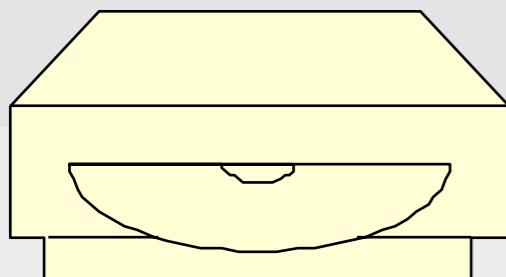
- Hard Disk
- Floppy Disk
- PCMCIA

Advantages:

- Faster than tape
- Allows direct access to data

Disadvantages:

- Performance relies on speed of mechanical heads
- Neither fault nor damage resistant



Optical

- CD-ROM, DVD
- Magneto-Optical Disk

Advantages:

- More data capacity than magnetic disk
- High quality storage of sound and images

Disadvantages:

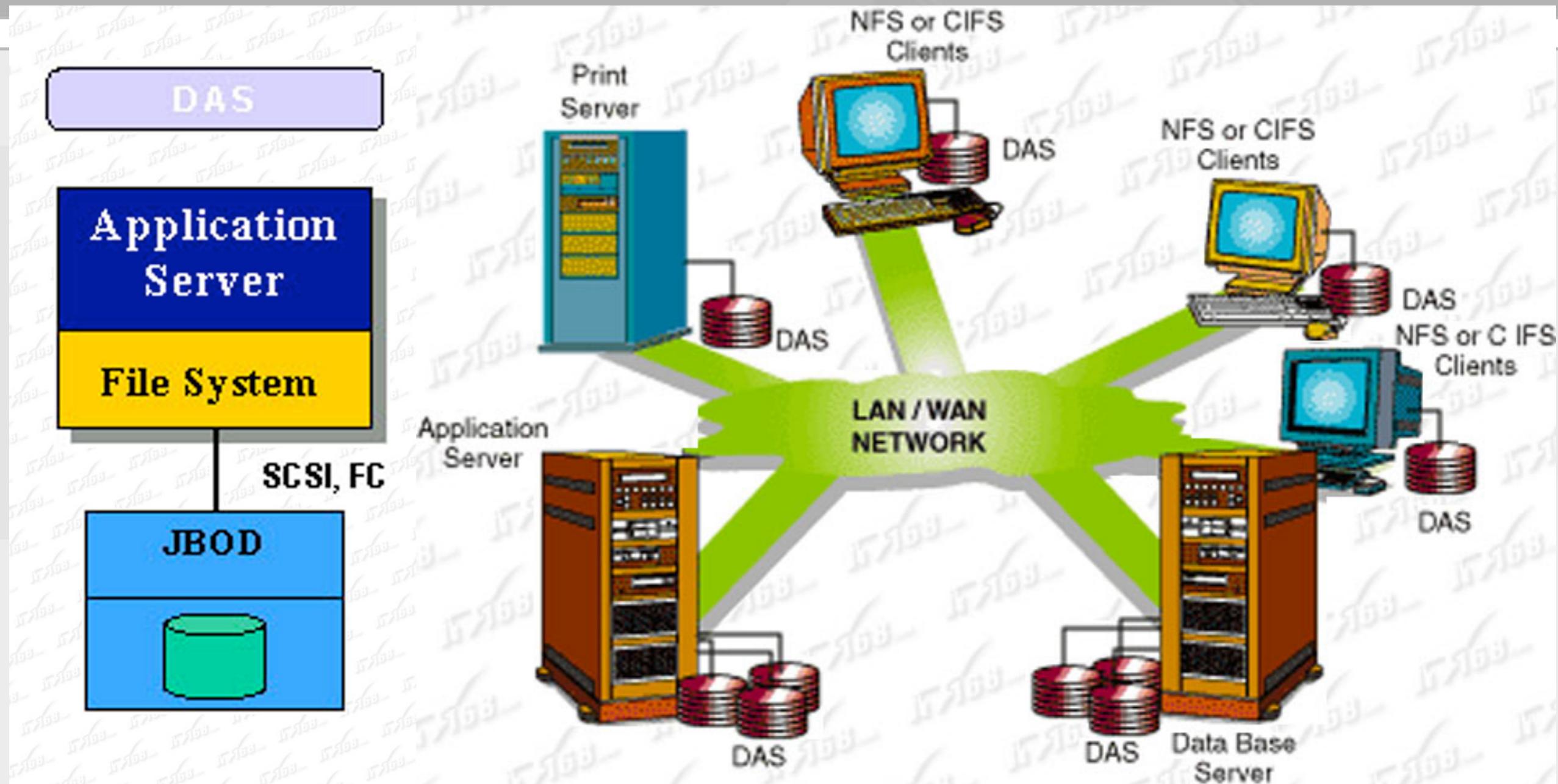
- Data capacity is small for videos in CD and DVD are better
- Limited Data densities



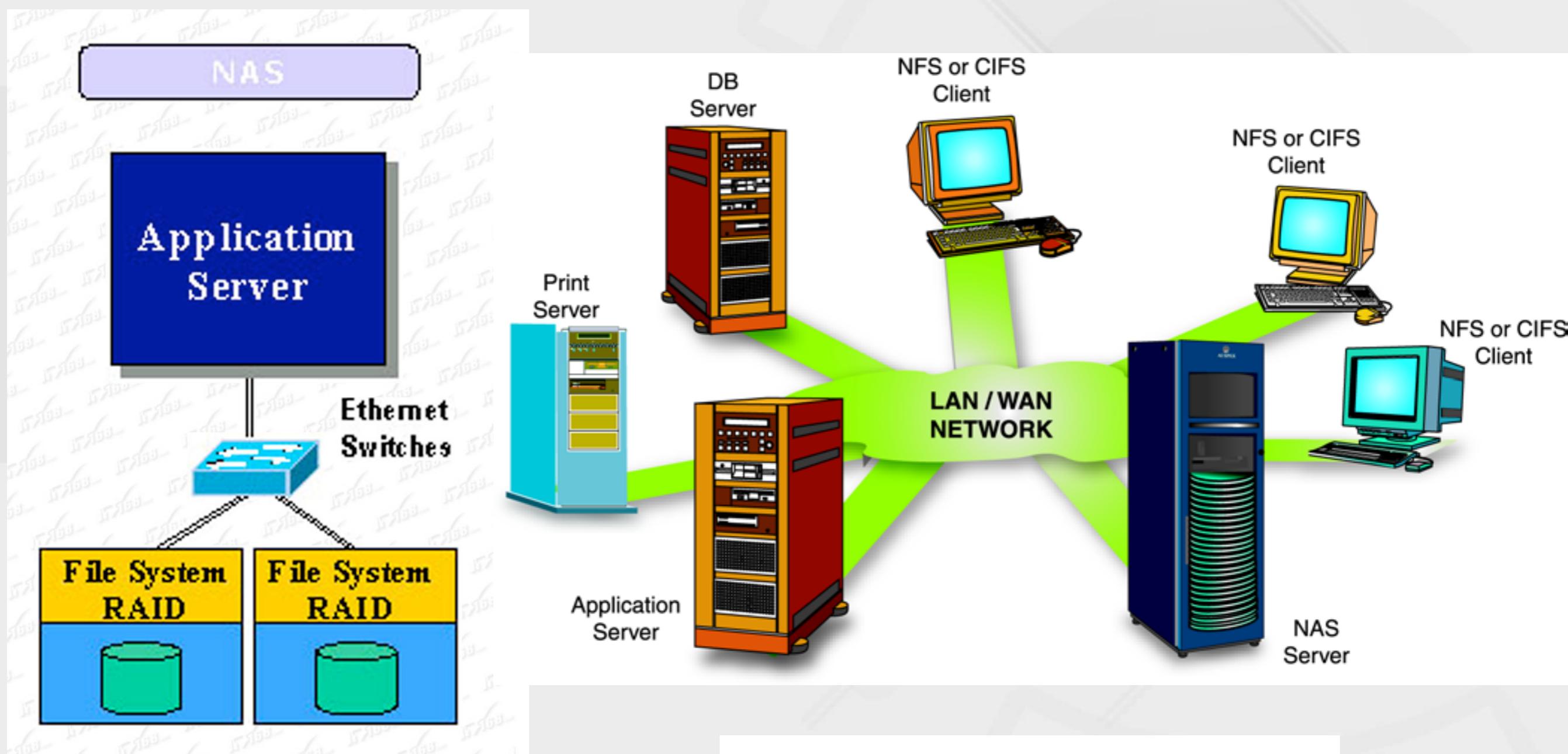
Storage solutions

- DAS: Direct Attached Storage
 - 直联存储 参考：
<http://publish.it168.com/2004/0819/20040819005703.shtml>
<http://www.storagesearch.com/auspexart.html>
- NAS: Network Attached Storage
 - 网络附加存储
- SAN: Storage Area Network
 - 存储区域网络

DAS: Direct Attached Storage



NAS: Network Attached Storage

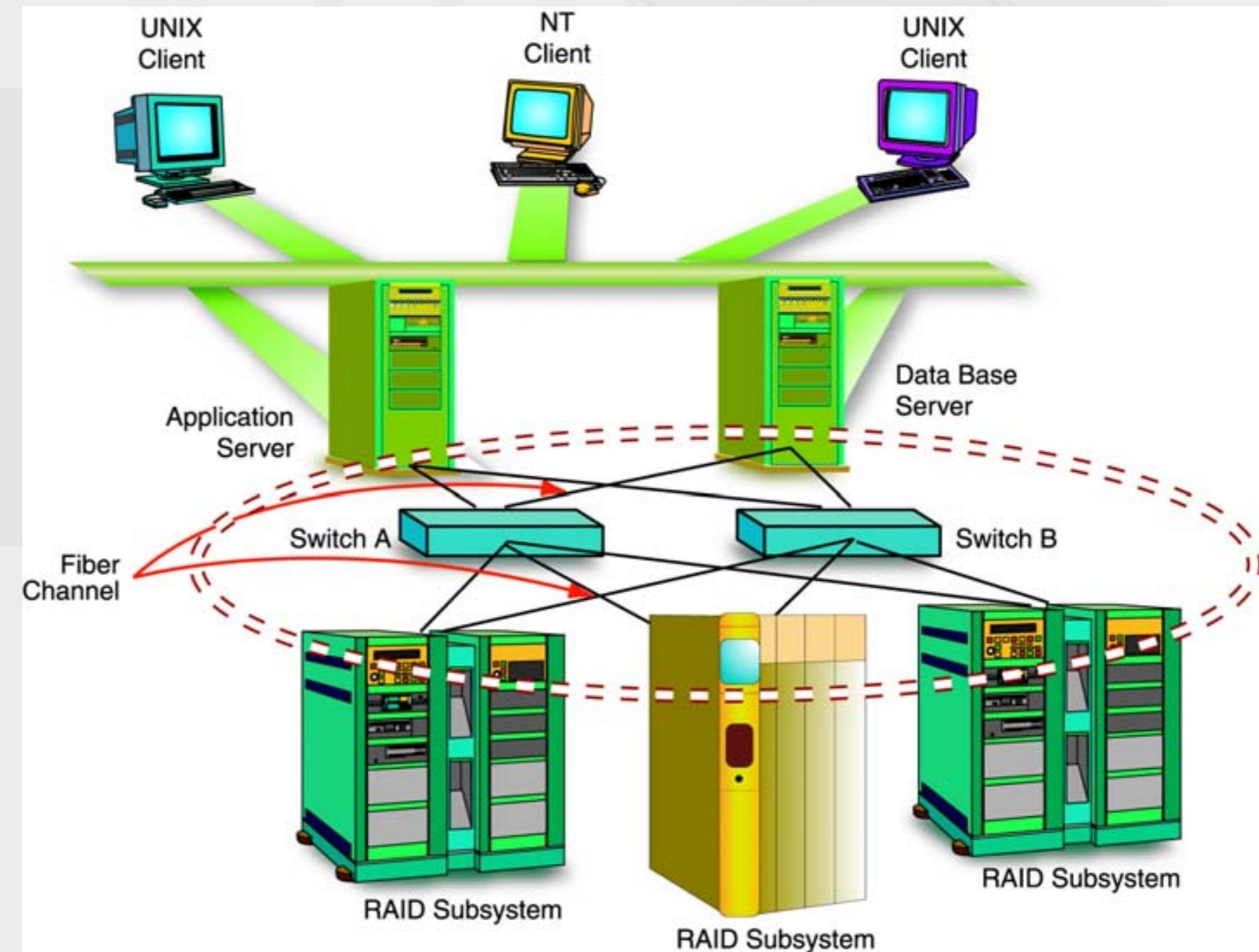


适于文件共享存储

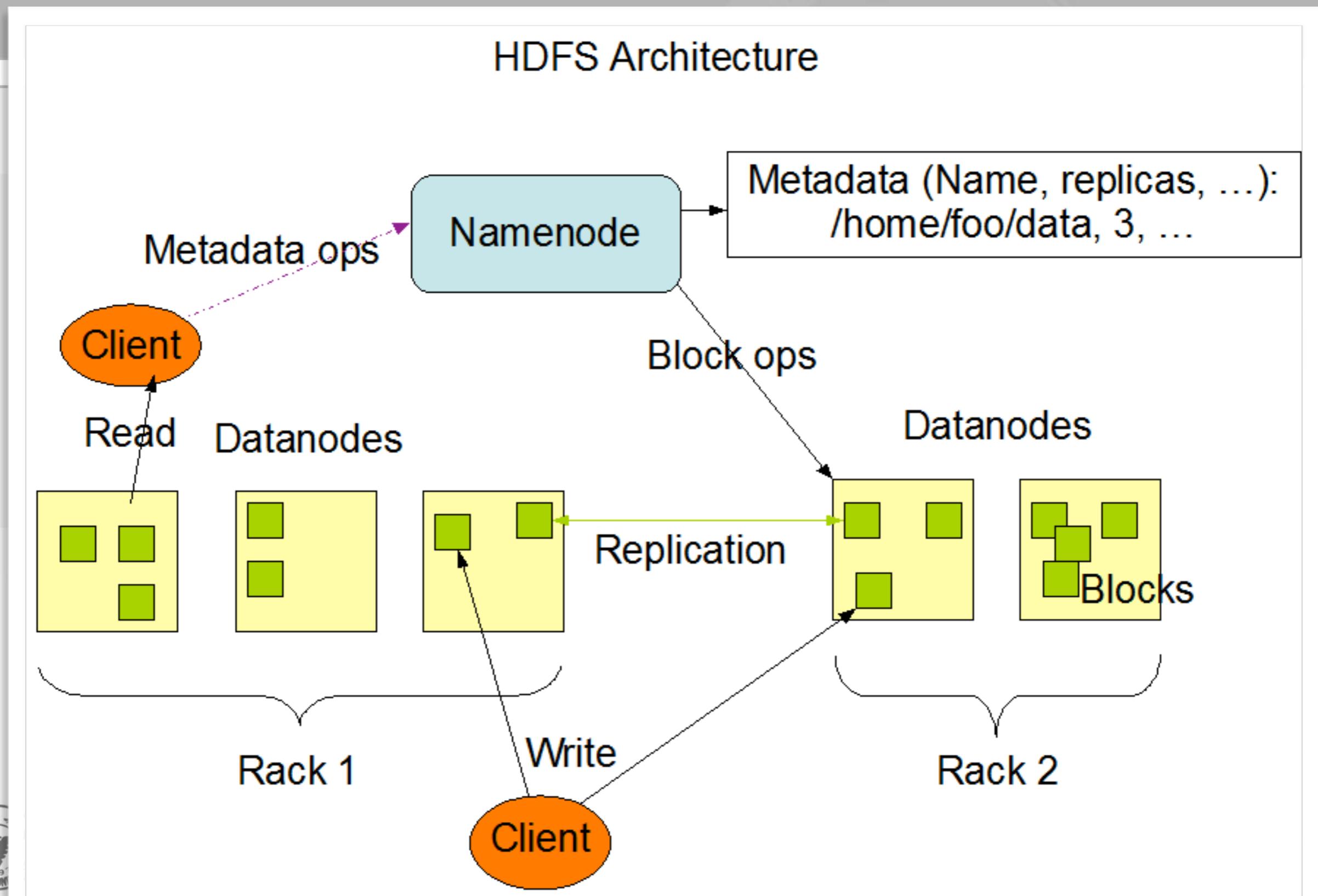


SAN: Storage Area Network

SAN是独立出一个数据存储网络，网络内部的数据传输率很快，但操作系统仍停留在服务器端，用户不是在直接访问SAN的网络



云存储 GFS/HDFS/OpenStack ...



实例

- 阿里云：渲染云项目
 - 存储使用OSS
 - <http://oss.aliyun.com>
- 课后思考题：
 - 学习使用OSS
 - 可作为作业1, 2的加强版
 - 但不用上交了，可发截图给我看

No (Not Only) SQL

- [http://sebug.net/paper/databases/nosql/
Nosql.html](http://sebug.net/paper/databases/nosql/Nosql.html)
 - e.g. MongoDB, HBase
 - Key-Value database
 - Huge size
 - High scalability
 - distribution

更多参考

《大话存储II》



IPFS and FileCoin (blockchain)

<https://github.com/ipfs/ipfs>

IPFS is a protocol:

- defines a content-addressed file system
- coordinates content delivery
- combines Kademlia + BitTorrent + Git

IPFS is a filesystem:

IPFS is a web:

IPFS is modular:

IPFS uses crypto:

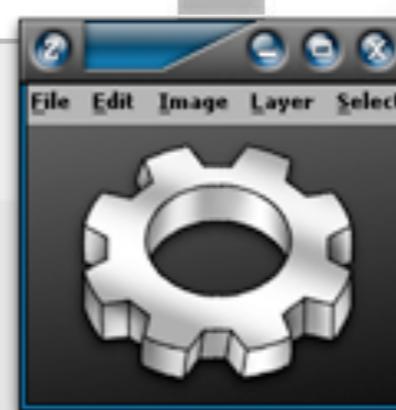
IPFS is p2p:

IPFS is a cdn:

IPFS has a name service:



Outline



1. MM content organization

2. MM database system architecture

3. MM system service model



4. Multimedia Data Storage

5. Multimedia application

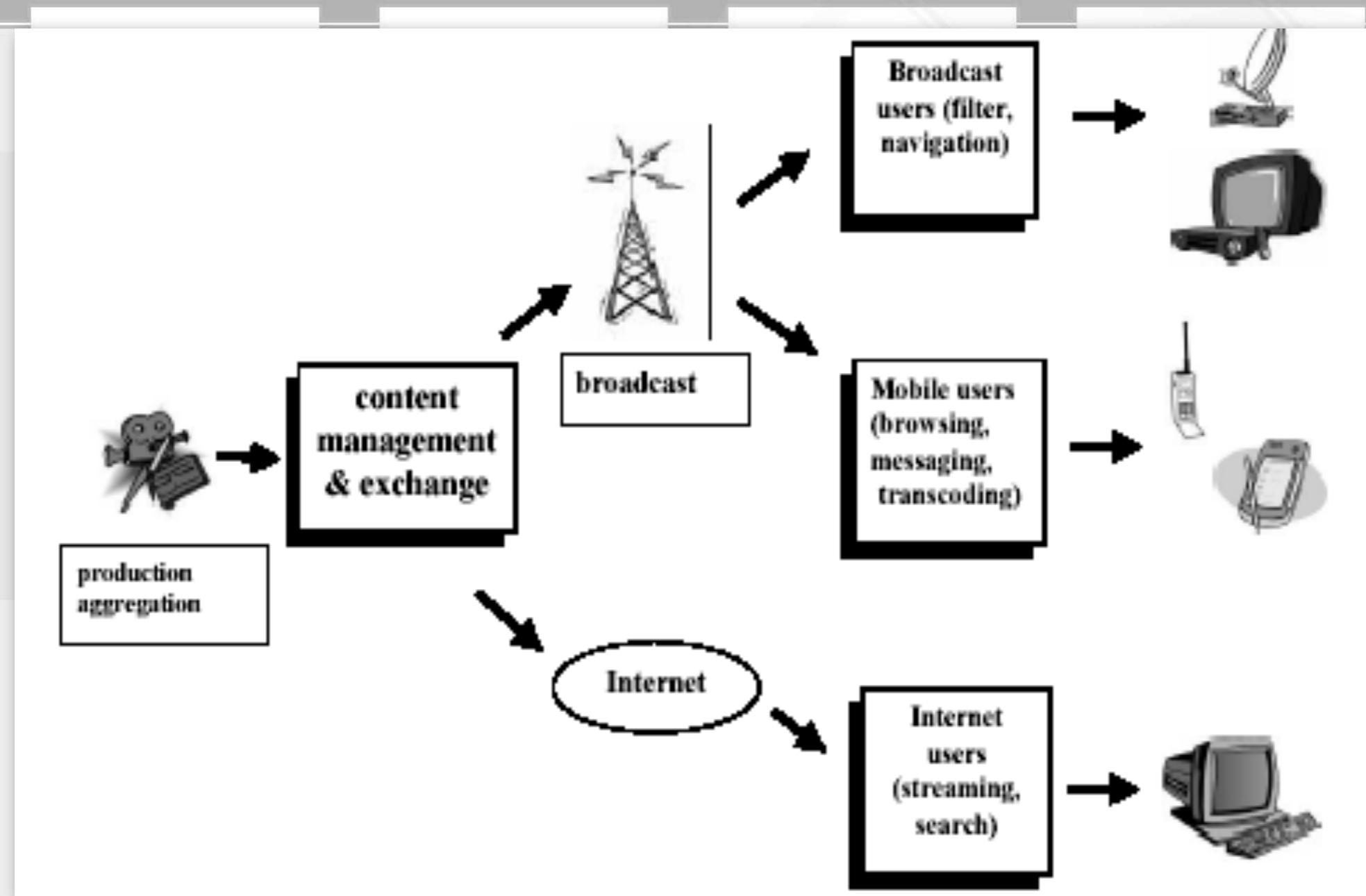




3.5 Multimedia System Application



Multimedia Systems Application Chain



Applications of Multimedia

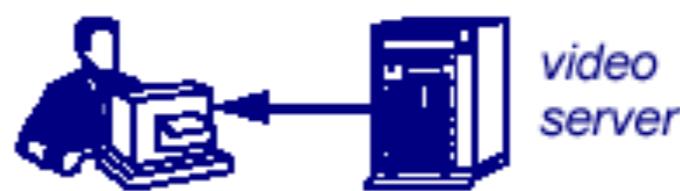
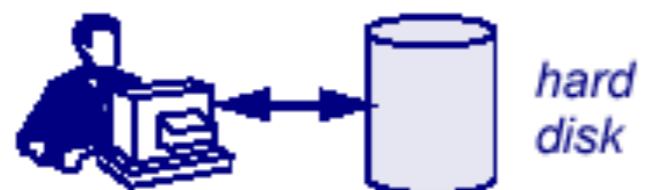
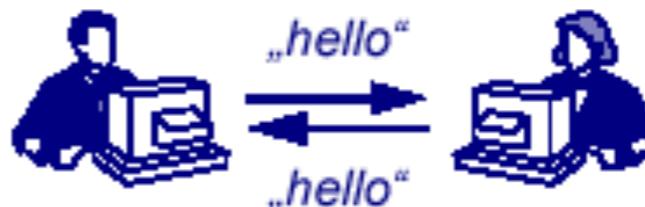
Application classes:

- Local
- Distributed



Basic multimedia services:

- Interpersonal communication
- Information retrieval
- Information recording and editing



Application Areas, Industries and Usage

Application areas:

- Learning and education
- Simulation
- Visualisation
- Presentation
- Documentation
- Archivation
- Customer information
- Cooperative work
- Supervision and control
- Entertainment

Industries:

- Bank
- Trade
- Insurance
- Research
- Education
- Manufacturing
- ...

Information

- Books on CDs
- Electr. Newspaper
- Kiosks

Communication

- CSCW
- Video conferences
- Remote diagnosis

Entertainment

- Interactive TV
- Interactive Audio
- Games



Multimedia Applications

- Hypermedia courseware
- Video conferencing
- Video on demand
- Interactive TV
- Home shopping
- Game
- Digital video editing and production systems

Multimedia after 100 years

