Multimedia Databases

Multimedia Databases

- To provide such database functions as indexing and consistency, it is sometimes desirable to store multimedia data in a database
  - rather than storing them outside the database, in a file system
- The database must handle large object representation.
- Similarity-based retrieval must be provided by special index structures.
- Must provide guaranteed steady retrieval rates for continuous-media data.

Multimedia Data Formats

- Store and transmit multimedia data in compressed form
  - JPEG and GIF the most widely used formats for image data.
  - MPEG standard for video data use commonalties among a sequence of frames to achieve a greater degree of compression.
- MPEG-1 quality comparable to VHS video tape.
  - stores a minute of 30-frame-per-second video and audio in approximately 12.5 MB
- MPEG-2 designed for digital broadcast systems and digital video disks; negligible loss of video quality.
  - Compresses 1 minute of audio-video to approximately 17 MB.
- Several alternatives of audio encoding
  - MPEG-1 Layer 3 (MP3), RealAudio, WindowsMedia format, etc.

Continuous-Media Data

- Most important types are video and audio data.
- Characterized by high data volumes and real-time information-delivery requirements.
  - Data must be delivered sufficiently fast that there are no gaps in the audio or video.
  - Data must be delivered at a rate that does not cause overflow of system buffers.
  - Synchronization among distinct data streams must be maintained
    - video of a person speaking must show lips moving synchronously with the audio

Video Servers

- **Video-on-demand** systems deliver video from central video servers, across a network, to terminals
  - Must guarantee end-to-end delivery rates
- Current video-on-demand servers are based on file systems; existing database systems do not meet real-time response requirements.
- Multimedia data are stored on several disks (RAID configuration), or on tertiary storage for less frequently accessed data.
- Head-end terminals - used to view multimedia data
  - PCs or TVs attached to a small, inexpensive computer called a set-top box.

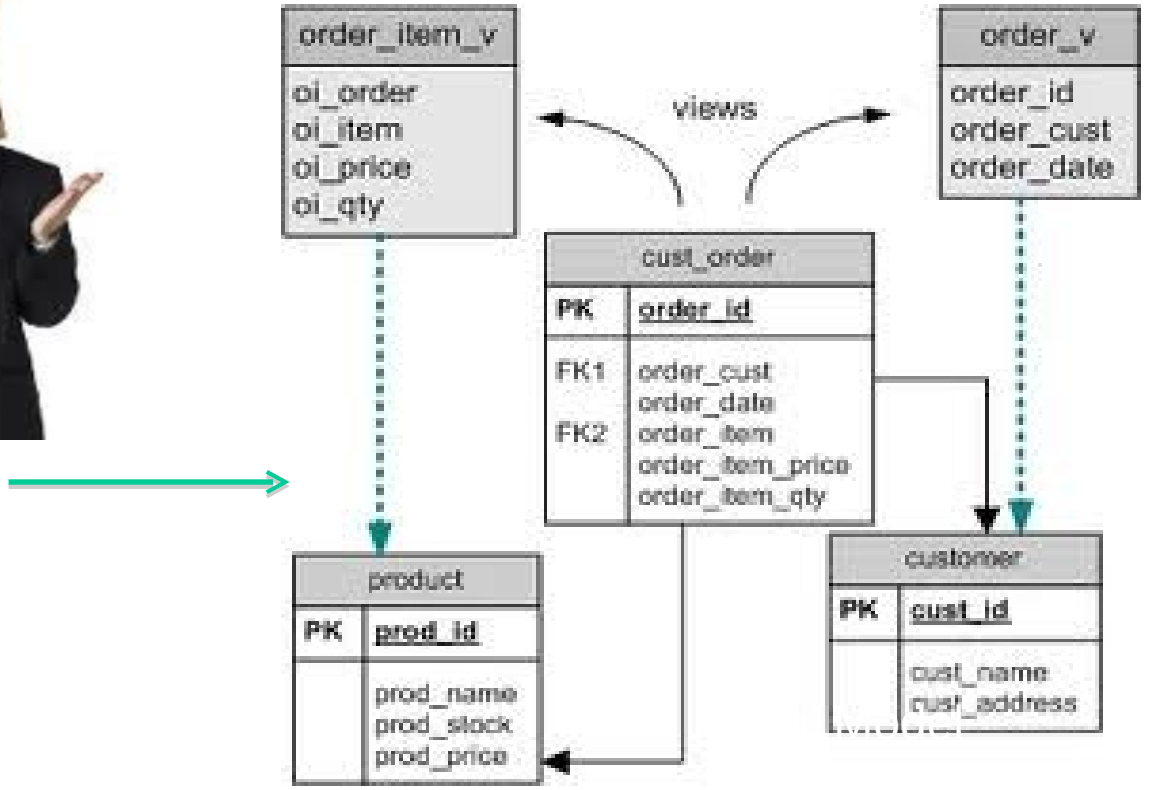
Data Type

- Binary Large Object (BLOB)
- Character Large Object (CLOB)
- Advantages:
  - Multimedia Data is integrated into the database system
  - Not dependent on the physical location of multimedia data (disk/directory/filename)
- Disadvateges:
  - Database storage can be very large
  - Sometimes this will decrease the performance

Modelling

Activities in information system analysis and design that identifies and develops a model of the information requirements for a proposed computer-based application

- *Identifying and describing* the information requirements for an information system,
- *Specifying* the data to be maintained by the data management system, and
- *Specifying* the *data structures* to be used for data storage that best support the information requirements by providing *efficient* and *effective* information retrieval


order_item_v
oi_order
oi_item
oi_price
oi_qty
views
order_v
order_id
order_cust
order_date
cust_order
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FK1
order_cust
order_date
FK2
order_item
order_item_price
order_item_qty
product
PK
prod_id
prod_name
prod_stock
prod_price
customer
PK
cust_id
cust_name
cust_address

Data Model Type

Data structure

data types and inter-relationships,

Constraints

allowable values, relationships, and cardinalities

Basic operations

for data storage, retrieval, modification, maintenance, and control.

Data structure

entity types: real world phenomena about which data is collected.

f.ex.: person, teacher, student, course, report, ...

relationship types: between entity-types.

associative relationships: between different types of entities. *f.ex:* student *takes* course, teacher *teaches* course

generic relationships: which identify sub-classes or *roles* within an entity type. *f.ex* student *IS_A* person, teacher *IS_A* person, ...

attribute types: for each entity and associative relationship type.

f.ex.: name and *address* for the "person" entity type,

semester and *grade* for the "takes" relationship type.

data types: to be used for recording the values of each attribute type,

f.ex. name ::= *character string*, picture ::= *image*

Constraints

rules for determining valid values and structures

entity identifier, synonym: *primary key, PK*

one or more attributes whose value uniquely identifies an individual entity.

f.ex: a *social security number (SSN)* or the *person.Id, course.Id, and date* for a grade.

reference link, synonym: *foreign key, FK,* uniquely identifies a related entity.

f.ex: person.*spouse*::= SSN that references a given person's spouse.

relationship cardinality: for each entity to relationship type.

f.ex.: Student *(0:m)* takes *(0:m)* courses, meaning that a student may take more than 1 course and a course may be taken by more than 1 student.

Constraints

participation constraints: for generic hierarchies,

specify the relationship between the parent and sub-class entity-types

f.ex. a *partial, overlapping (p,o)* participation constraint for the person heirarchy indicates that each person (in the DB) may be a student, a teacher, both or neither.

domain constraints: define the valid value sets for attributes,

f.ex: course.level must have a value between [1..6]

Basic operations

define how data values are calculated when some event occurs.

F.ex: age and wage can be calculated upon request using a function definition:

person.age = todays_date - birth_date

student.wage = hourly_wage * number_of_hours_worked

Functions can also check that data constraints are maintained.

F.ex: ON INSERT person CHECK UNIQUE person.Id

Modelling Processes

- Development of a *semantic model* of the information requirements for an information system.
- Translation of the semantic model to a *structural model* that describes the data types and structures using the concepts of a particular data model type (relational, semantic, object-oriented, ...).
- Adaptation and/or translation of the structural model to an *implementation model*, as required by the specific DMS chosen to manage the user's data.

Semantic Model

- A conceptual data model where semantic information is included
- Semantic information is a fact oriented as opposed to object oriented
- Fact oriented is usually expressed as a binary relationship
  - Mount Merapi [is located in] Indonesia
  - Jokowi [is the president of] Indonesia

Data Model

Graphical

Easier for a human reader to interpret and check for completeness and correctness than list models

List

Meta Data, Data Definition Language

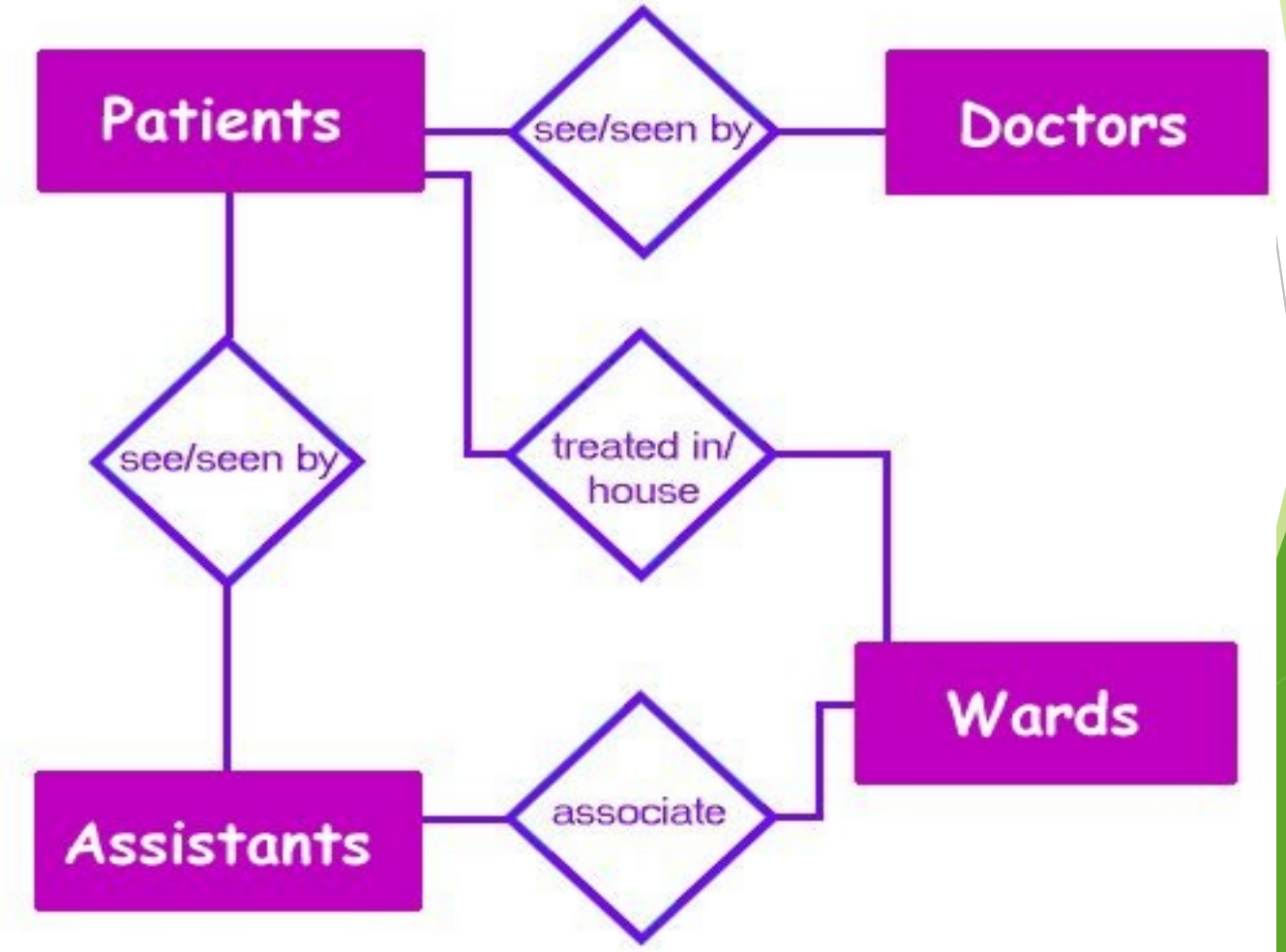
Tabular

DB Schema

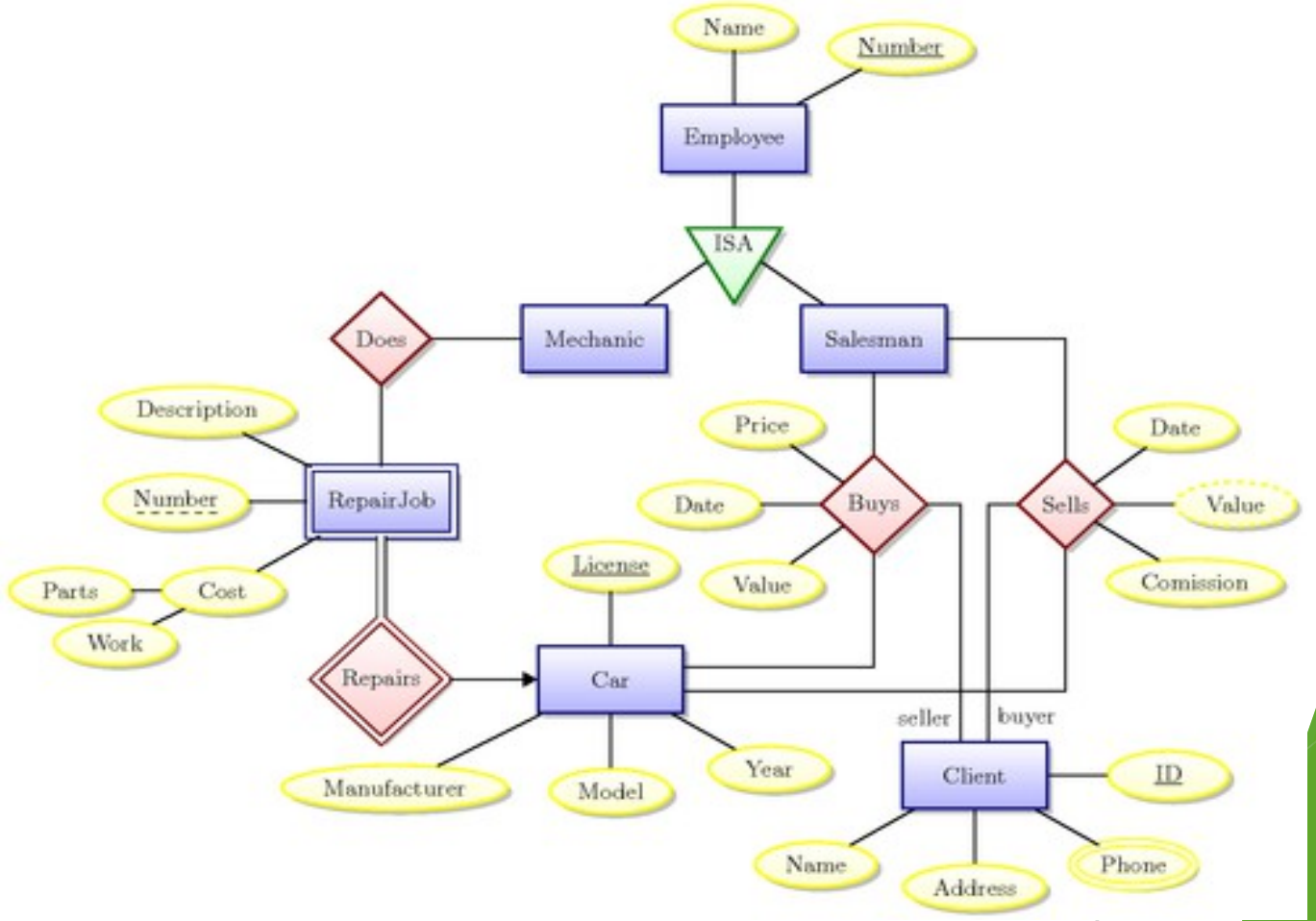
Model Type

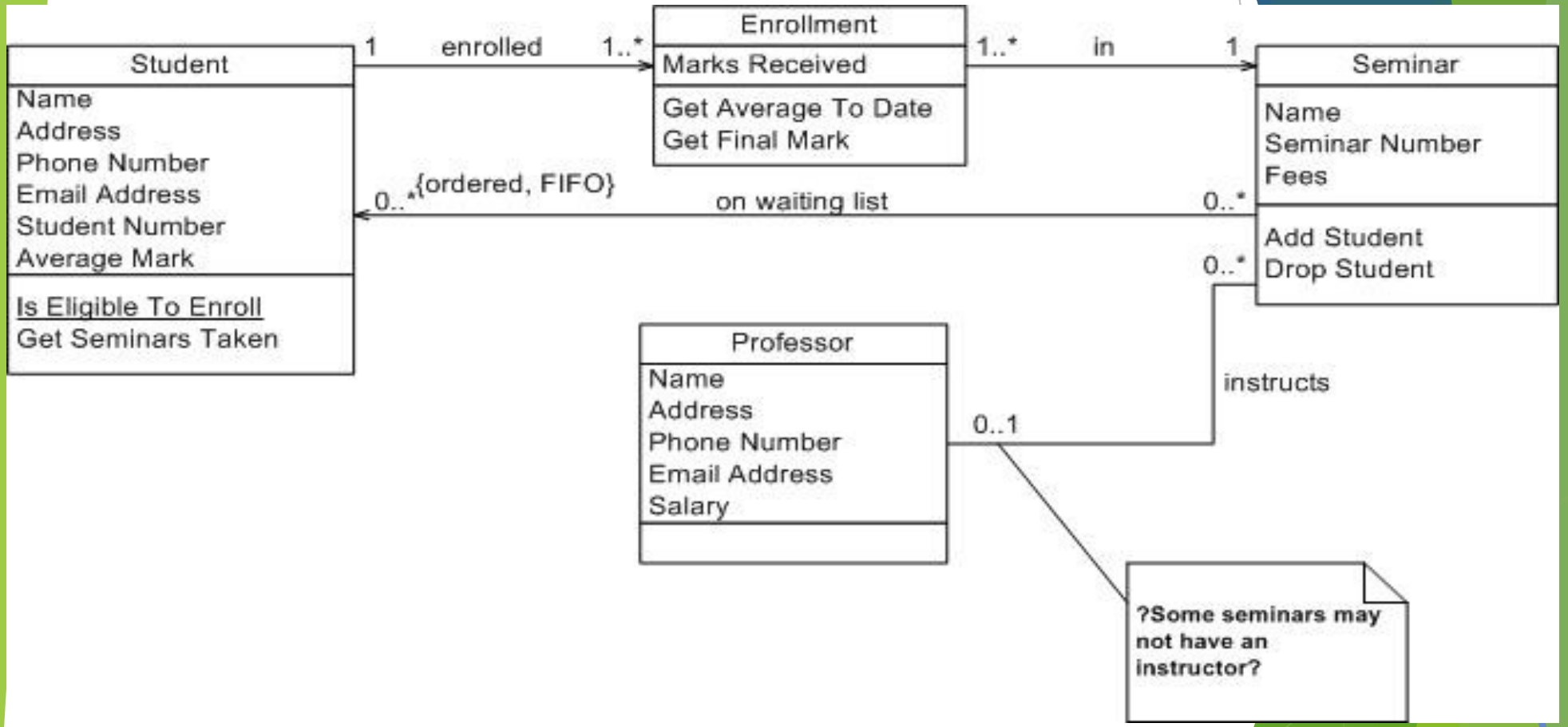
- Entity-Relationship
- Extended Entity-Relationship
- Object Oriented Model
- Structural Semantic Model

Entity-Relationship Model

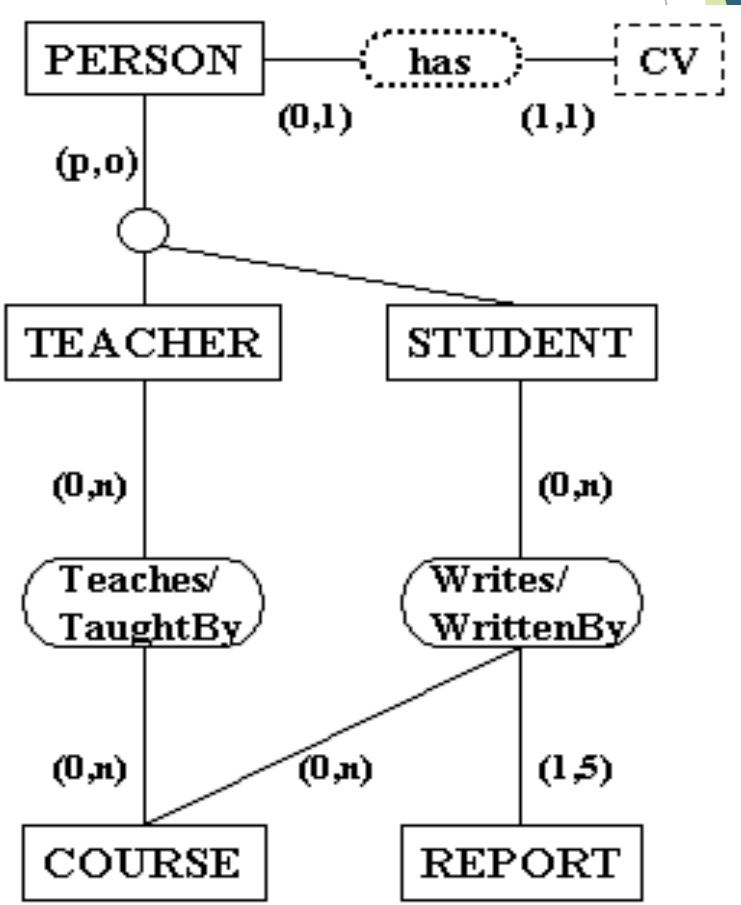


Extended Entity-Relationship Model

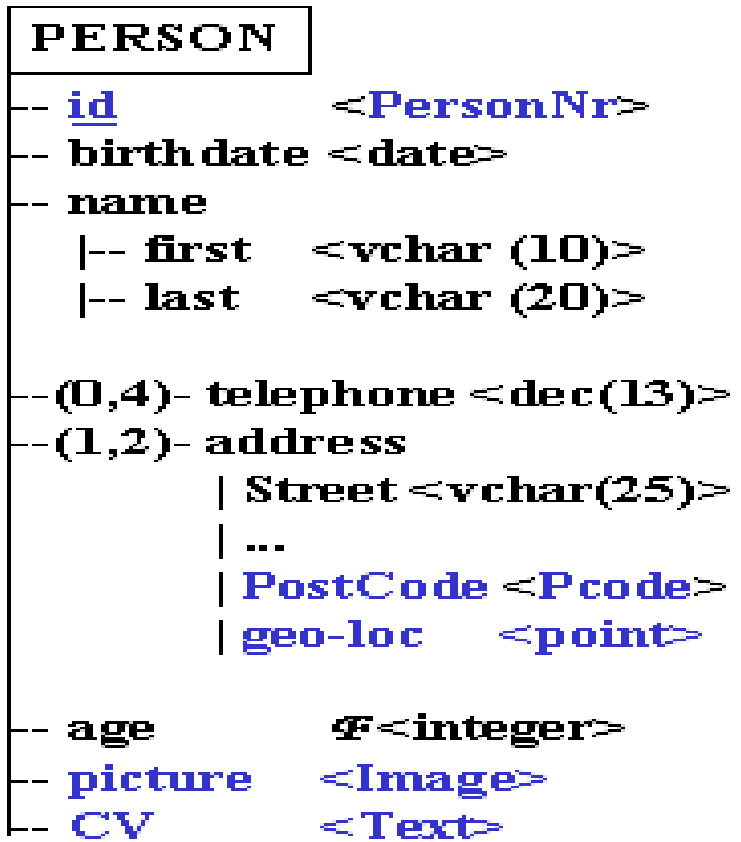



Student
Name
Address
Phone Number
Email Address
Student Number
Average Mark
Is Eligible To Enroll
Get Seminars Taken
1
enrolled
1..*
Enrollment
Marks Received
Get Average To Date
Get Final Mark
1..*
in
1
Seminar
Name
Seminar Number
Fees
Add Student
Drop Student
0..*
{ordered, FIFO}
on waiting list
0..*
0..*
instructs
Professor
Name
Address
Phone Number
Email Address
Salary
0..1
?Some seminars may not have an instructor?

Structural Semantic Model (SSM)



SSM Attribute and Data Typ



Meta Data

Data about Data

Uses

Specification and interpretation of user requests - queries - for information

Determining storage, indexing, and retrieval of the data to/from the database

Meta Data Specification

Database design –

a semantic data model

metadata standard for description of user requirements, data structures, and constraints

Data storage –

using a data definition language, DDL, to add metadata values.

Meta Data for Multimedia

Semantic metadata

characterize the subject matter of the document,

Context metadata

describe relationships to external (to the meaning of the document) objects, such as author and publisher

Structural metadata

describe the internal structure and presentation layout for the media object

Semantic Metadata

Speficy *features* that describe the semantic content of the media object

- Index terms or keywords
- Shapes
- Colors
- Textures
- Categories

Context Metadata

specify the relationships that the media object has to its environment

- author/creator, publisher, the date of creation/purchase/publication, and the current location of the object
- typically represent 'facts' about the object that need to be determined and recorded manually
- can be modelled as objects, attributes and/or relationships in a traditional data model

Structural Metadata

describe the implementation, layout

- spatial and temporal placement of objects within a document
- presentation style of the media object
- Language, length, presentation media

Multimedia Metadata

Dublin Core

originally developed for description of text-based documents,

Mpeg-7

developed for description of streamed multimedia such as film

CIDOC/CRM

developed for description of museum artifacts

Dublin Core

- Metadata for Electronic Documents

Metadata Type	***DC element***
Semantic	Title, Subject, Description, Type, Coverage
Context	Creator, Contributor, Publisher, Date, Rights, Source, Relation
Structural	Type, Format, Language, Identifier

1. TITLE The name given to the resource by the CREATOR or PUBLISHER. **2. CREATOR** The person(s) or organization(s) primarily responsible for the intellectual content of the resource; the author. **3. SUBJECT** The topic of the resource; also keywords, phrases or classification descriptors that describe the subject or content of the resource.

Dublin Core

4. DESCRIPTION A textual description of the content of the resource, including abstracts in the case of document-like objects; also may be a content description in the case of visual resources. **5. PUBLISHER** The entity responsible for making the resource available in its present form, such as a publisher, university department or corporate entity. **6. CONTRIBUTORS** Person(s) or organization(s) in addition to those specified in the CREATOR element, who have made significant intellectual contributions to the resource but on a secondary basis. **7. DATE** The date the resource was made available in its present form. **8. TYPE** The resource type, such as home page, novel, poem, working paper, technical report, essay or dictionary. It is expected that TYPE will be chosen from an enumerated list of types.

9. FORMAT The data representation of the resource, such as text/html, ASCII, Postscript file, executable application or JPG image. FORMAT will be assigned from enumerated lists such as registered Internet Media Types (MIME types). MIME types are defined according to the RFC2046 standard.

Dublin Core

10. IDENTIFIER A string or number used to uniquely identify the resource. Examples from networked resources include URLs and URNs (when implemented).**11. SOURCE** The work, either print or electronic, from which the resource is delivered (if applicable). **12. LANGUAGE** The language(s) of the intellectual content of the resource. **13. RELATION** The relationship to other resources. Formal specification of RELATION is currently under development. **14. COVERAGE** The spatial locations and temporal duration characteristics of the resource. Formal specification of COVERAGE is also now being developed. **15. RIGHTS MANAGEMENT** A link (URL or other suitable URI as appropriate) to a copyright notice, a rights-management statement or perhaps a server that would provide such information in a dynamic way.

MPEG-7

Dublin Code

does not describe basic characteristics of moving pictures (streamed data), such as the temporal and sequencing requirements or the object identification and inter-relationships depicted in the film media.

The Moving Picture Experts Groups

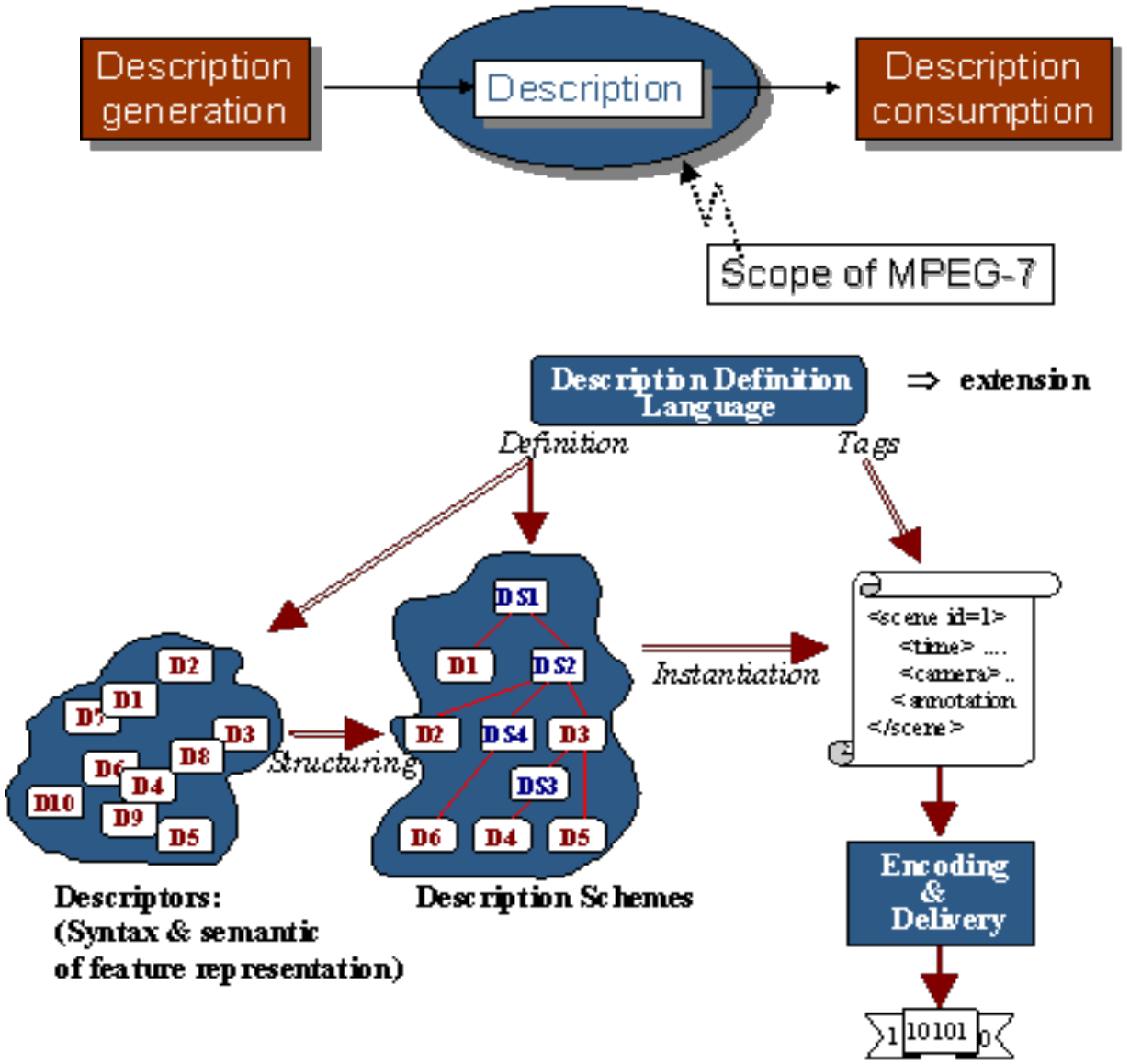
establishes standards for transmitting digital films and videos on the Internet

focused on describing the semantic and structural content of multimedia

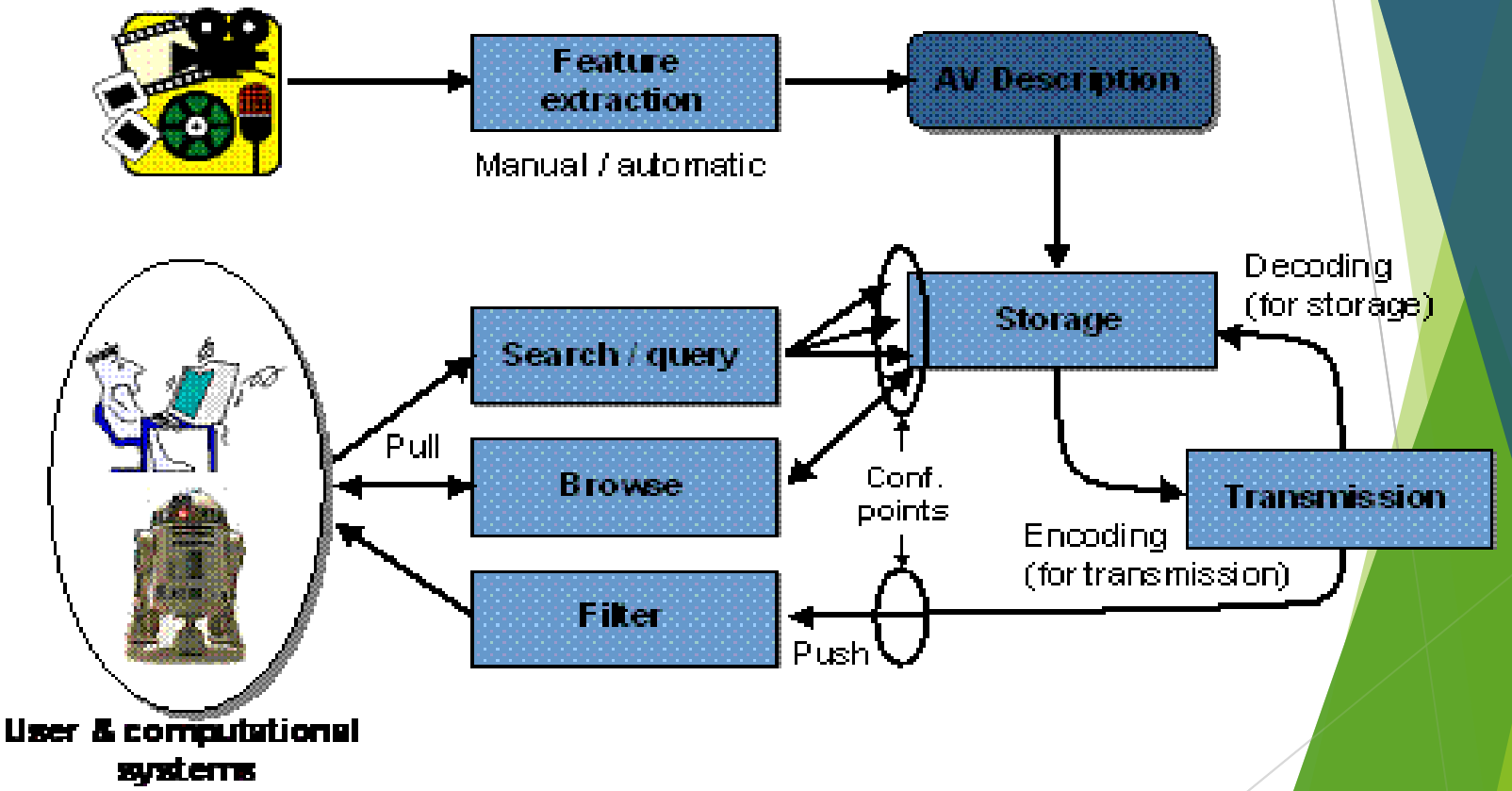
formally named as "Multimedia Content

Elements of MPEG-7 Standards

- Description Tools: Descriptors (D), that define the syntax and the semantics of each feature (metadata element); and Description Schemes (DS), that specify the structure and semantics of the relationships between their components, that may be both Descriptors and Description Schemes;
- A Description Definition Language (DDL) to define the syntax of the MPEG-7 Description Tools and to allow the creation of new Description Schemes and, possibly, Descriptors and to allow the extension and modification of existing Description Schemes;
- System tools, to support binary coded representation for efficient storage and transmission, transmission mechanisms (both for textual and binary formats), multiplexing of descriptions, synchronization of descriptions with content, management and protection of intellectual property in MPEG-7 descriptions


Description generation
Description
Description consumption
Scope of MPEG-7
Description Definition Language
⇒ extension
Definition
Tags
Instantiation
Structuring
<scene id=1>
<time> ....
<camera>..
<annotation
</scene>
Encoding & Delivery
1 10101 0
Descriptors: (Syntax & semantic of feature representation)
Description Schemes

Possible Application

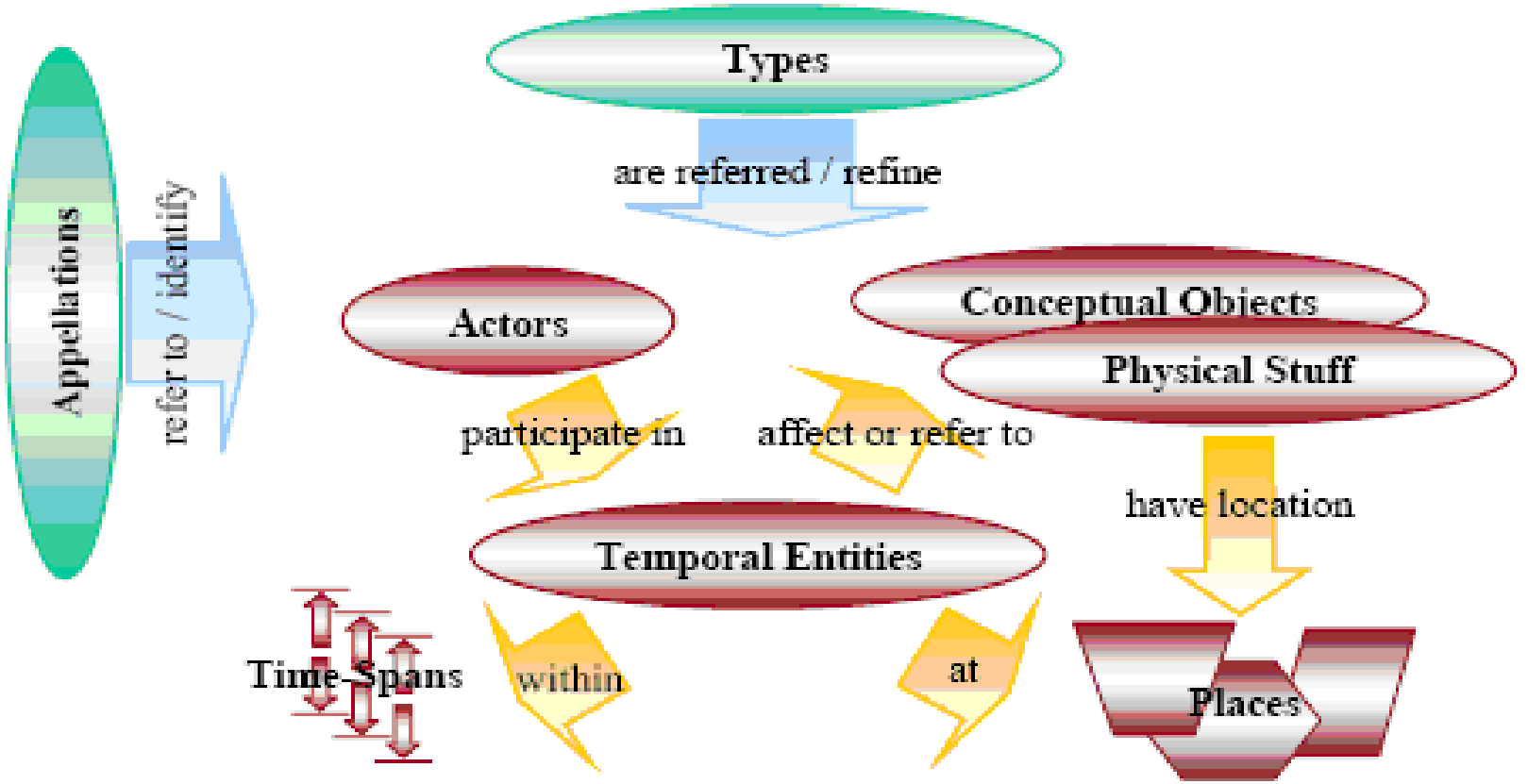


CIDOC-CRM

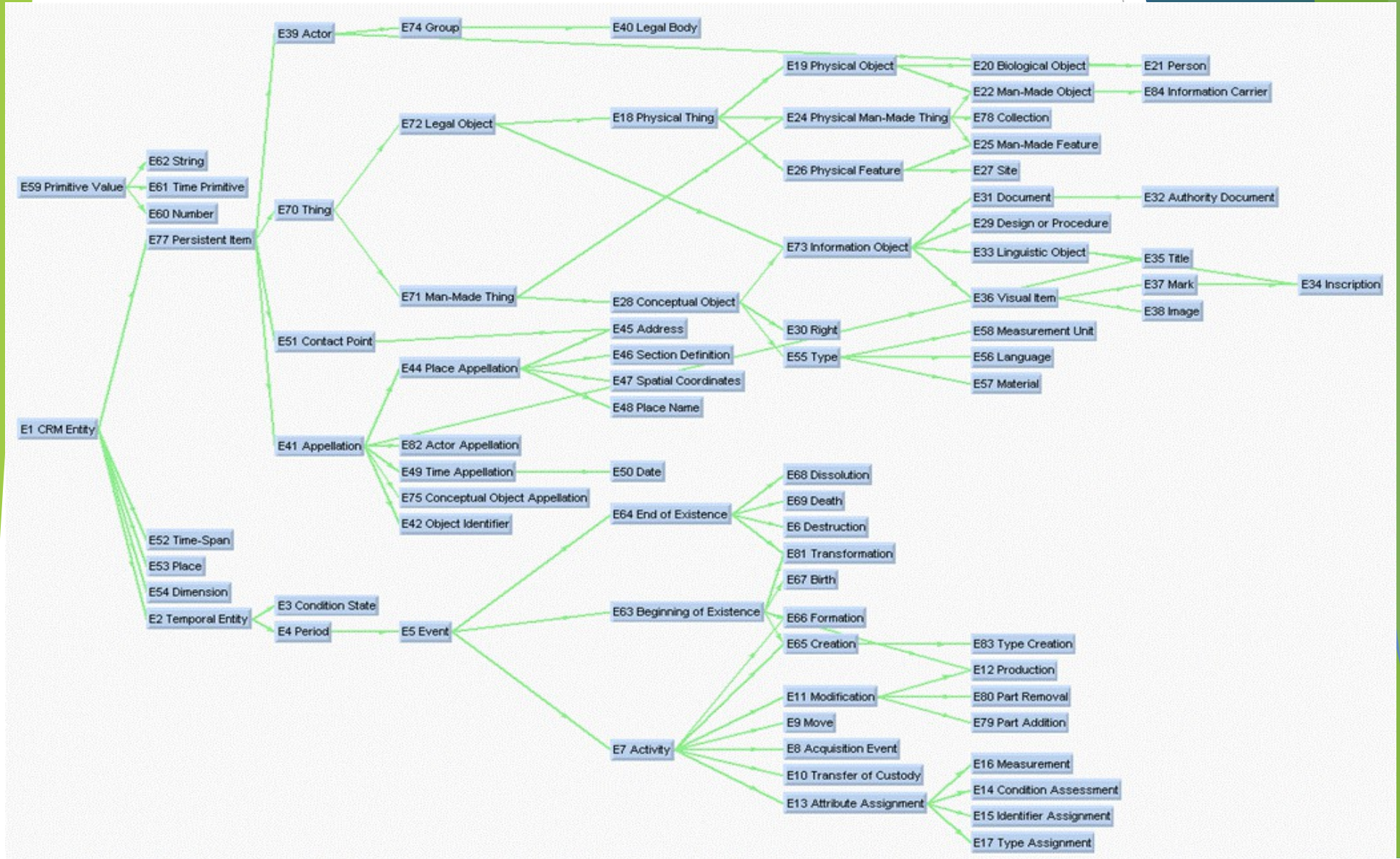
Developed by The International Committee for Documentation, CIDOC, of international council of museums, ICOM

for describing cultural heritage objects, particularly those found in museum collections

descriptions include the spatial, temporal and event aspects of museum objects, in addition to the semantic, context and structural aspects emphasized in the Dublin


Types
are referred / refine
Appellations
refer to / identify
Actors
Conceptual Objects
Physical Stuff
participate in
affect or refer to
have location
Temporal Entities
Time-Spans
within
at
Places

CIDOC-CRM Class Hierarchy



Multiple Media Documents

A report, containing text, images, as well as structured data for title, author, date, ...

A map, containing points, lines, areas or regions, as well as title, place names, facts (distances, heights), and icons, ...

A film, containing image stream, and (multiple) audio streams as well as a title, actor list, producer, ...

Text Documents

can be *described* from 3 perspectives:

- Semantic content of the document, i.e. representation of its meaning,
- Context of the document, e.g. its author, publisher
- Structure of the document, e.g. its language, style, length, .

Images

- do not have a standard 'vocabulary' or grammar that can be used for automatic interpretation of the semantic content, or meaning of the images
- Through text annotations
- Using content descriptors or features of images

Level	Feature	examples
1	structural	color, texture, shape location in image
2	Objects in image	building, trees, people, band spatial relationships between objects
3	Identification of objects in image	The White House, US army fife and drum corps
4	Event/action representation	marching, welcome ceremony
5	Emotion represented	formal, official, at 'attention'

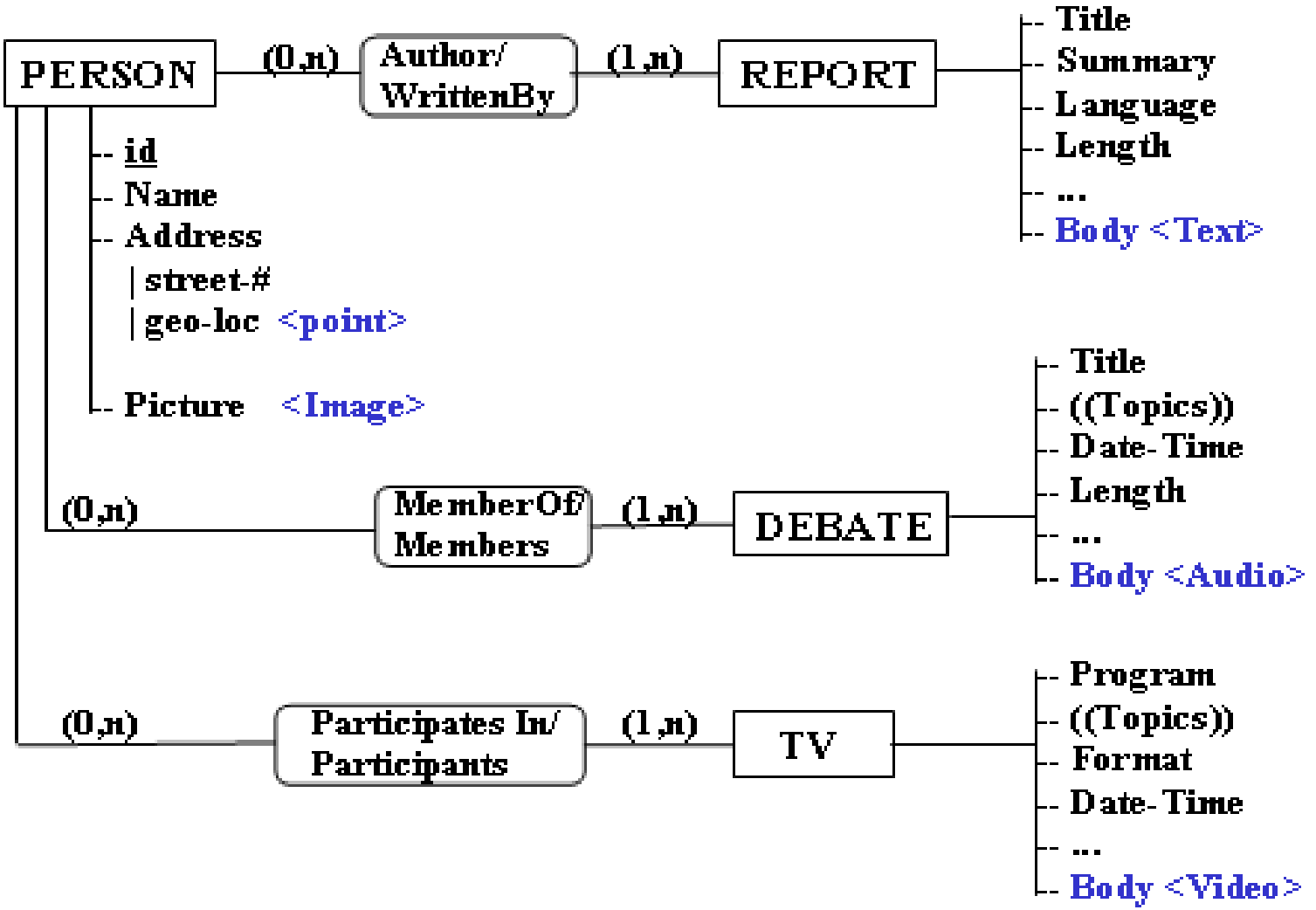
Image color-signature example

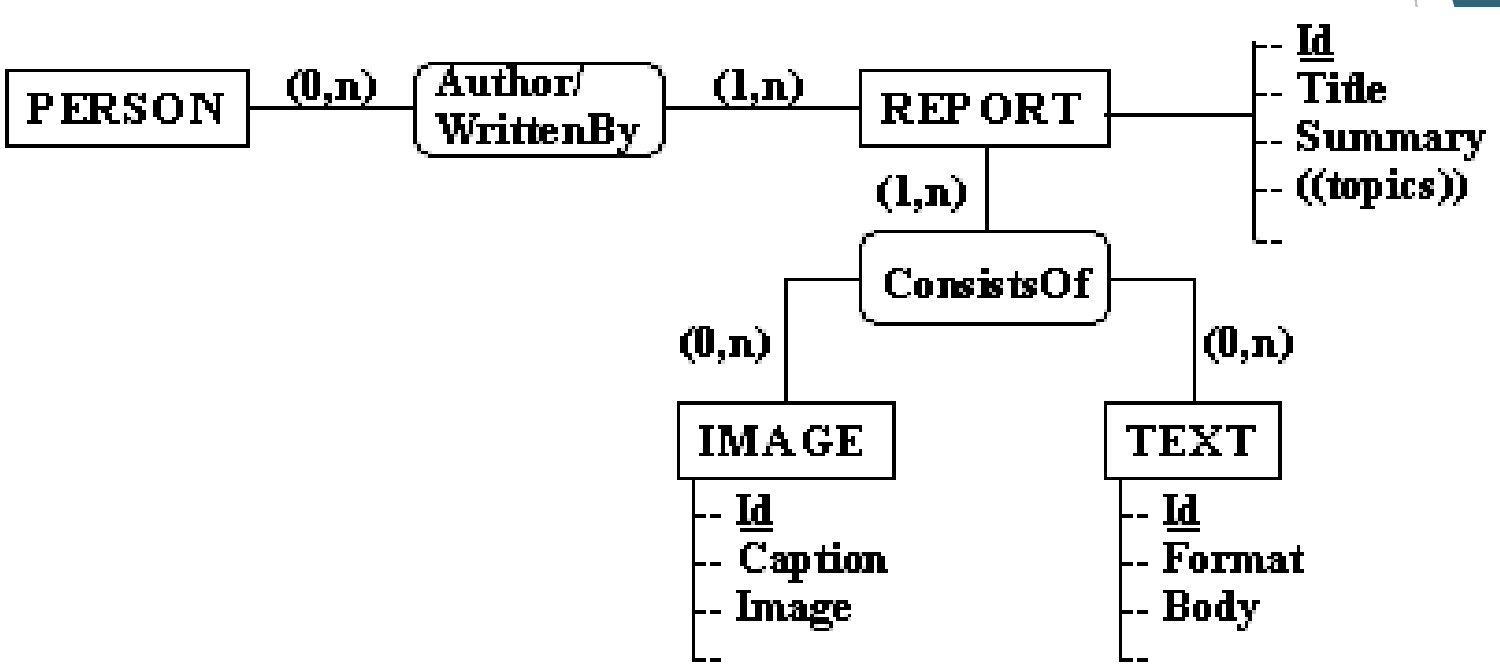
Color	Cell-1		Cell-2		Cell-3		Cell-4		Cell-5	Cell-6	Cell-7	Cell-8	Cell-9
red	-	1	-	1	5	1	20	20	-				
green		40	2	30	89	20	85	70	75	70			
blue	60	48	20	-	-	1	-	-	25				
white		-	49	50	10	75	13	5	5	5			

Modelling Multimedia Data in SSM

media objects can be modelled as:

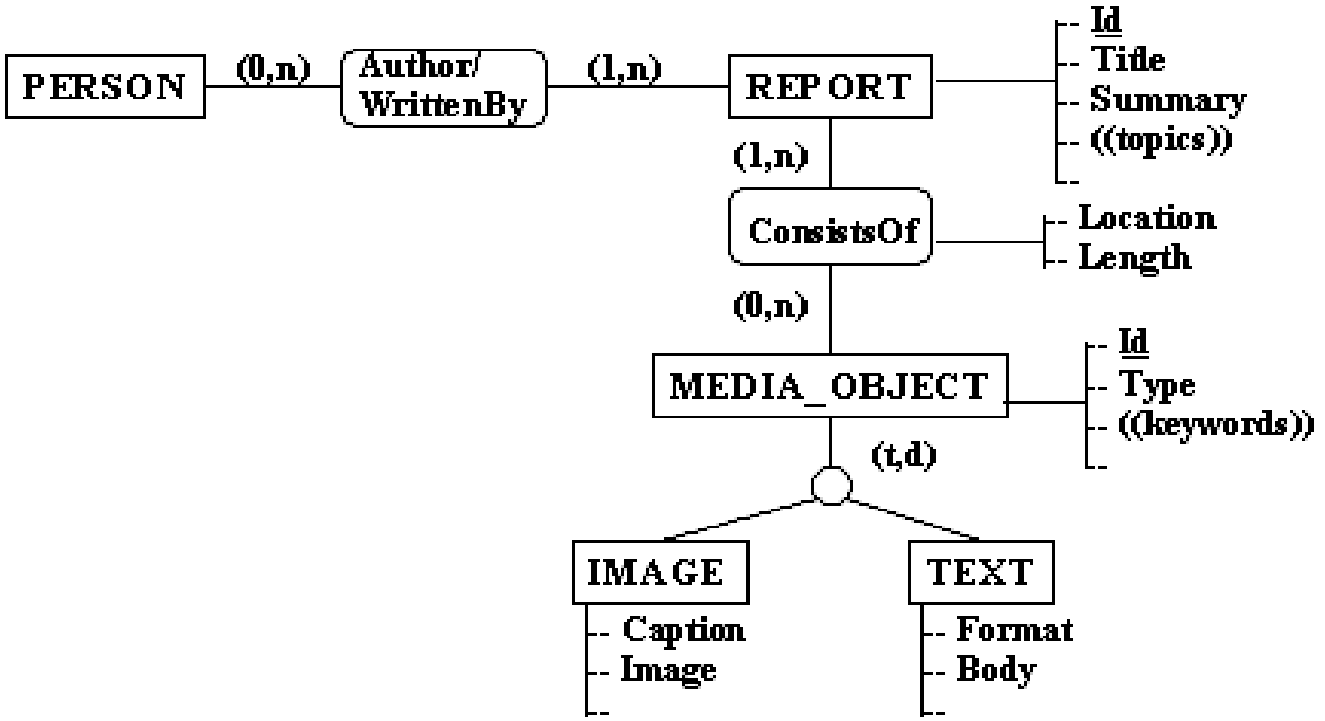
- An attribute of an entity-type: ex. Person.picture or Person.geographic_location
- An entity-type: ex. Report with such attributes as {id, title, keywords, summary, content}
- A set of related entity-types: ex. Report consists of Media Objects of text and image type.


PERSON
(0,n)
Author/
WrittenBy
(1,n)
REPORT
-- Title
-- Summary
-- Language
-- Length
-- ...
-- Body <Text>
-- id
-- Name
-- Address
| street-#
| geo-loc <point>
-- Picture <Image>
(0,n)
MemberOf/
Members
(1,n)
DEBATE
-- Title
-- ((Topics))
-- Date-Time
-- Length
-- ...
-- Body <Audio>
(0,n)
Participates In/
Participants
(1,n)
TV
-- Program
-- ((Topics))
-- Format
-- Date-Time
-- ...
-- Body <Video>



useful when a balanced set of related media objects occur in the 'parent' multimedia object

Media Objects as a Classification Hierarchy



useful when the sets of media objects are relatively independent and used in multiple multimedia objects