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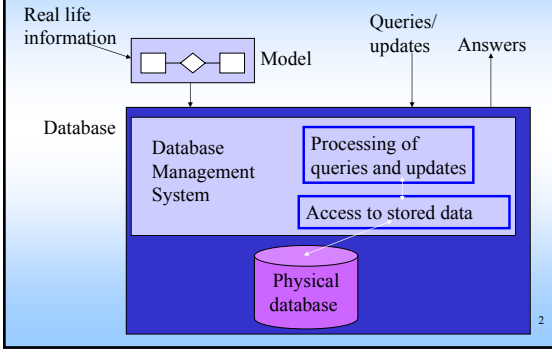
Object-oriented databases

1

Databases



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Database

- DataBase Management System (DBMS): a collection of programs that allows a user to create and maintain a databank
- database system = physical database + DBMS

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Some Issues

- What information is stored?
- How is the information stored? (high level)
- How is the information accessed? (user level)

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Some Issues

- How can different types of users be authorized to access different pieces of information?

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DEFINITION	Homo sapiens adrenergic, beta-1-, receptor
ACCESSION	NM_000684
SOURCE ORGANISM	human
REFERENCE	1
AUTHORS	Frielle, Collins, Daniel, Caron, Lefkowitz, Kobilka
TITLE	Cloning of the cDNA for the human beta 1-adrenergic receptor
REFERENCE	2
AUTHORS	Frielle, Kobilka, Lefkowitz, Caron
TITLE	Human beta 1- and beta 2-adrenergic receptors: structurally and functionally related receptors derived from distinct genes

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What information is stored?

- Model of reality
  - Extended Entity-Relationship diagrams (EER)
  - Unified Modeling Language (UML)

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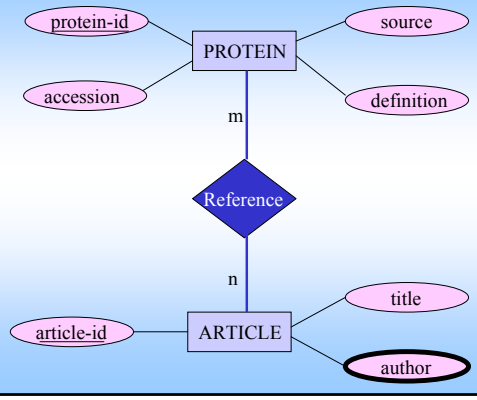
Entity-relationship



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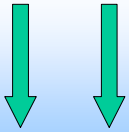
How is the information stored? (high level) How is the information accessed? (user level)

- Text (IR)
- Semi-structured data
- Data models (DB)
- Rules + Facts (KB)

structure precision



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Databases

- Relational databases:
  - model: tables + relational algebra
  - query language (SQL)
- Object-oriented databases:
  - model: persistent objects, messages, encapsulation, inheritance
  - query language (e.g. OQL)

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Relational databases

PROTEIN

PROTEIN-ID	ACCESSION	DEFINITION	SOURCE
1	NM_000684	Homo sapiens adrenergic, beta-1-, receptor	human

REFERENCE

PROTEIN-ID	ARTICLE-ID
1	1
1	2

ARTICLE

ARTICLE-ID	AUTHOR	TITLE
1	Frielle	Cloning of the cDNA for the human ….
1	Collins	Cloning of the cDNA for the human ….
1	Daniel	Cloning of the cDNA for the human ….
1	Caron	Cloning of the cDNA for the human ….
1	Lefkowitz	Cloning of the cDNA for the human ….
1	Kobilka	Cloning of the cDNA for the human ….
2	Frielle	Human beta 1- and beta 2-adrenergic receptors
2	Kobilka	Human beta 1- and beta 2-adrenergic receptors
2	Lefkowitz	Human beta 1- and beta 2-adrenergic receptors
2	Caron	Human beta 1- and beta 2-adrenergic receptors

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Relational databases

PROTEIN

PROTEIN-ID	ACCESSION	DEFINITION	SOURCE
1	NM_000684	Homo sapiens adrenergic, beta-1-, receptor	human

REFERENCE

PROTEIN-ID	ARTICLE-ID
1	1
1	2

ARTICLE-AUTHOR

ARTICLE-ID	AUTHOR
1	Frielle
1	Collins
1	Daniel
1	Caron
1	Lefkowitz
1	Kobilka
2	Frielle
2	Kobilka
2	Lefkowitz
2	Caron

ARTICLE-TITLE

ARTICLE-ID	TITLE
1	Cloning of the cDNA for the human beta 1-adrenergic receptor
2	Human beta 1- and beta 2-adrenergic receptors: structurally and functionally related receptors derived from distinct genes

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SQL

select source
from protein
where accession = NM_000684;

PROTEIN

PROTEIN-ID	ACCESSION	DEFINITION	SOURCE
1	NM_000684	Homo sapiens adrenergic, beta-1-, receptor	human

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SQL

select title
from protein, article-title, reference
where protein.accession = NM_000684
and protein.protein-id
= reference.protein-id
and reference.article-id
= article-title.article-id;

REFERENCE

PROTEIN-ID	ARTICLE-ID
1	1
1	2

PROTEIN

PROTEIN-ID	ACCESSION	DEFINITION	SOURCE
1	NM_000684	Homo sapiens adrenergic, beta-1-, receptor	human

ARTICLE-TITLE

ARTICLE-ID	TITLE
1	Cloning of the …
2	Human beta 1- …

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From relational to object model

- CASE
- CAD
- office automation
- multimedia applications

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Object-Oriented Databases (OODB)

- World is modeled using objects.
- An object has a state (value) and a behavior (operations).
- Persistent objects - permanent storage (sometimes transient objects are allowed)

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Object

- An object has an object identifier (OID) that is not visible to the user.
- OID cannot be changed.
- object versus value
  (a value has no OID)
- object structure can be arbitrarily complex (atom, tuple, set, bag, list, array)

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Example - object state

- o1(id1, tuple,
  <accession: NM_000684,
  source : human,
  definition: 'Homo sapiens adrenergic …',
  reference: o2>)
- o2(id2, set, {o3,o4})

Remark: These examples do not use a standard syntax

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Example - object state

- o3(id3, tuple,
  <title: `Cloning of …', author: o5 >)
- o4(id4, tuple,
  <title: `Human beta-1 …', author: o6 >)
- o5(id5, list, [Frielle, Collins, Daniel, Caron, Lefkowitz, Kobilka])
- o6(id6, list, [Frielle, Kobilka , Lefkowitz, Caron])

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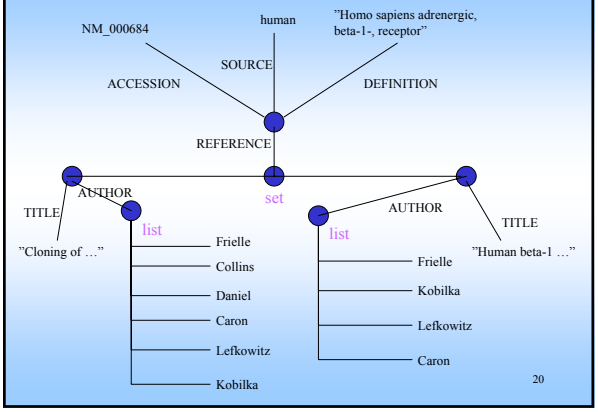

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Classes

```
define class protein
type tuple (
    accession: string;
    source : string;
    definition: string;
    reference: set(article); );
operations
   create-protein(string,string,string,set(article)): protein;
   get-accession: string;
   get-source: string;
   get-definition: string;
   get-references: set(article);
   add-reference(article): void;
end protein;
```

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Classes

```
define class article
type tuple (
    title: string;
    author: list(string); );
operations
   create-article(string, list(string)): article;
   get-title string;
   get-authors: list(string);
   print-article-info string;
end article;
```

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Example program

```
program
variables: article1, article2, protein1;
begin
article1 := create-article('Cloning….', list(Frielle, Collins,
    Daniel, Caron, Lefkowitz, Kobilka));
protein1 := create-protein(NM_000684, human,'Homo
    sapiens adrenergic …', set(article1));
article2 := create-article(' Human beta-1….', list(Frielle,
    Kobilka , Lefkowitz, Caron]);
protein1.add-reference(article2);
end;
```

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Operations

- encapsulation: operation = interface + body
  - interface: how is the operation called?
    What is the result of the operation?
    > visible to user, used in programs
  - body: how is the operation implemented?
    > invisible for user
- program is based on message passing

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Inheritance

- journal-article **subtype-of** article:
  journal-name journal-volume page-numbers

journal-article inherits all attributes and operations from article and has in addition also journal-name, journal-volume and page-numbers as attributes

- human-protein **subtype-of** protein (source = 'human')

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Composite objects

- Composite objects are complex objects that are conceptualized as a hierarchy of objects such that the hierarchical links represent the part-of relation.
- Dependent parts: existence of part depends on existence of the whole
  →special semantics for delete operation
- Exclusive and shared parts: exclusive part can belong to only one whole at the time; a shared part can belong to different wholes at the same time.

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Operator overloading

- The same operator name can be used for different implementations
- example:
  print-article-info for article prints information on title and author.
  print-article-info for journal-article prints information on title, author and also on the journal's name, volume and page number..

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Query language OQL

- select … from … where
  select distinct … from … where
- iterator variables
- path expressions
- struct

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Queries

select o.source
from o **in** protein
where o.accession = NM_000684;

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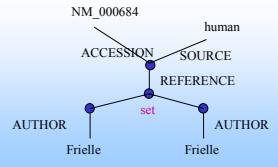
Queries

select struct (accession: o.accession, source: o.source**)**
from o **in** protein
where Frielle **in**
(select a.author
from a **in** o.reference**);**



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Query language OQL

OQL also allows:
- views
- aggregation
- special operations for list and array (first, last, nth)
- order-by
- group-by

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Third-Generation DB Manifesto

- Objects and Rules
- rich type system
- inheritance
- methods and encapsulation
- unique identifiers
- rules (triggers, constraints)

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Third-Generation DB Manifesto

- DBMS functionality
- access through non-procedural high-level language
- specify collections intensionally and extensionally
- updatable views
- no performance indicators in the model

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Third-Generation DB Manifesto

- Open systems
- accessible via several high-level languages
- persistency
- SQL-like language
- queries and answers are the lowest level of communication between client and server

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OODBS Manifesto

Thou shalt ...
- complex objects
- object identity
- encapsulation
- types and classes
- inheritance
- overriding, overloading, late binding

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OODBS Manifesto

- computational completeness
- extensibility
- persistence
- secondary storage management
- concurrency
- recovery
- query facility

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OODBS Manifesto

Optional
- multiple inheritance
- distribution
- long and nested transactions
- versions

Thou shalt question the golden rules.

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Authorization

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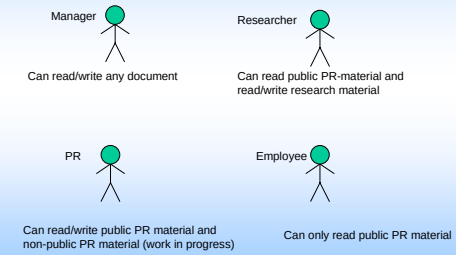
Real world example

Roles: Manager, researcher, PR person, employee



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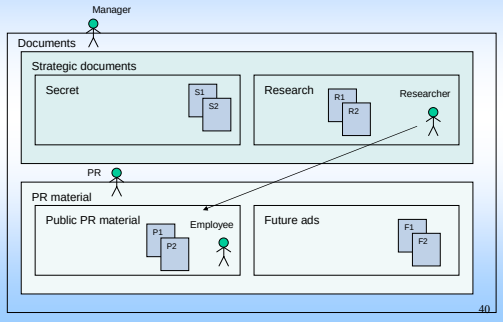
Real world example



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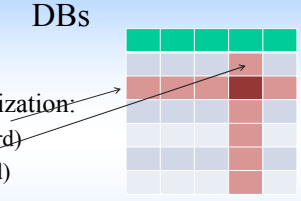
Authorization model in relational DBs

- Coarse-grained
- Units of authorization:
  - Relation (record)
  - Attribute (field)



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Authorization

- Extensions for the OO model
  (class, inheritance, composite objects, (versions))
- Authorization mechanisms
  (implicit/explicit, strong/weak, positive/negative)

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Basic authorization concepts

- (s,o,a) s∈S
  o∈O
  a∈A
  F: S×O×A →(True, false)
- Subject (a user or group of users)
- Authorization object (single object, group of objects, entire database)
- Authorization type (read, update, create, …)

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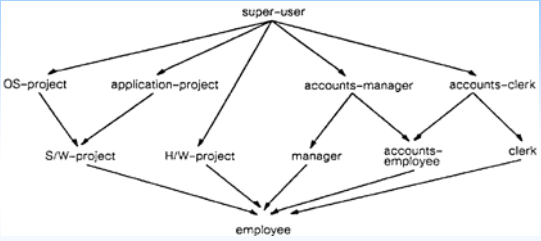

Role lattice

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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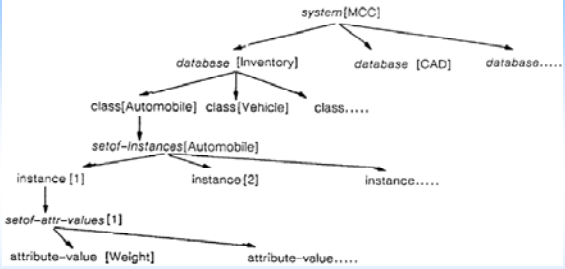

Object lattice

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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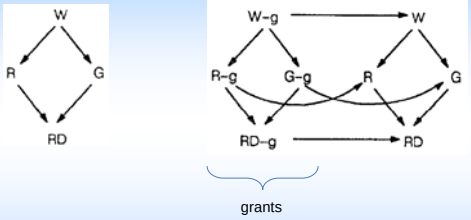

Type lattice

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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Authorization notions

- Explicit – Implicit
  - Explicit: set <s,o,a> triplets
  - implicit.: derive <s,o,a> triplets
- Positive – Negative
  - Positive: allowed to access
  - Negative: not allowed to access
- Strong - Weak
  - Strong: cannot be overridden
  - Weak: can be overridden

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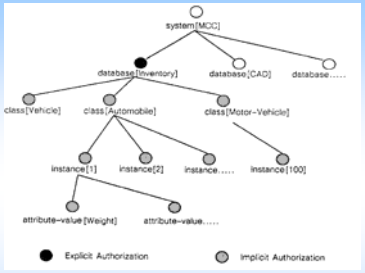

Explcit and implicit authorization

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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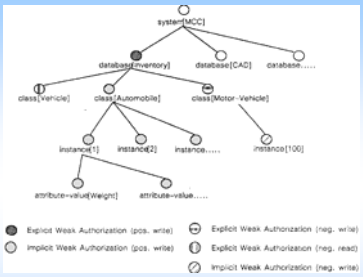

Weak authorization

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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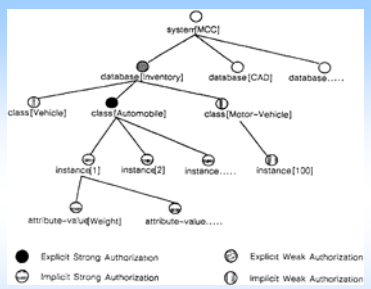

Strong authorization

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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Implicit authorization

- Pros:
  - No need to store all combinations
  - No need to set all combinations
- Cons:
  - Sometimes hard to grasp why a specific authorization is determined as it is
  - Conflicts
  - Computational overhead

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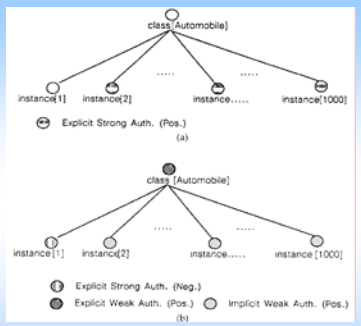

Positive/negative authorization

Rabitti, F., Bertino, E., Kim, W., Woelk, D. 1991

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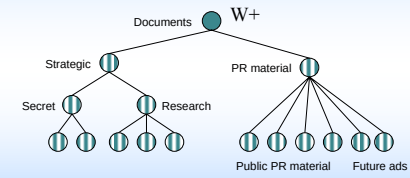
Applied real world example

Manager: Can read/write any document



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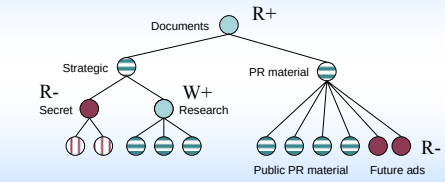
Applied real world example

Researcher: Can read public PR-material and read/write research material



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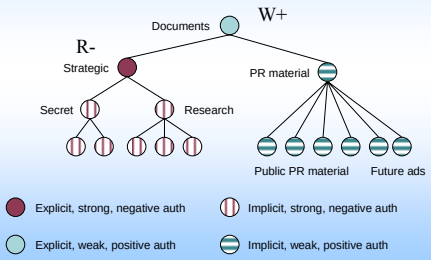
Applied real world example

PR person: Can read/write public PR material and non-public PR material



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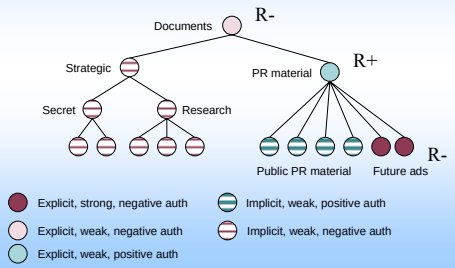
Applied real world example

Employee: Can only read public PR material



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Possible topics for ’plus’-grade

- Read articles about a specific OO database and summarize.
- Test run a specific OO database and write report.
- Read articles or experiment with OO system regarding a particular issue. Examples for issues are: authorization, versioning, schema evolution, query optimization, duplicate detection in OODBs, storage management and indexing in OODBs.

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