Databases : Lecture 11: Entity/Relationship modelling Timothy G. Griffin Lent Term 2009

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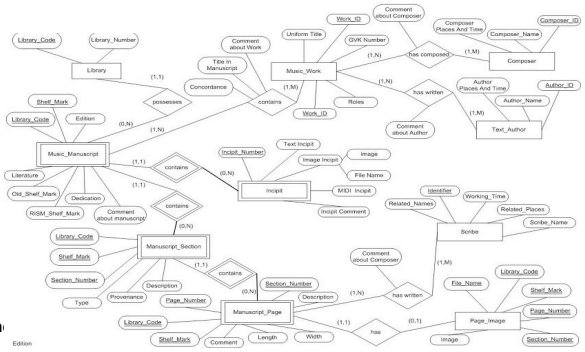

www.cl.cam.ac.uk/Teaching/current/Databases/

Conceptual Design

- What are the *entities* and *relationships* in the enterprise?
- What information about these entities and relationships should we store in the database?
- What are the integrity constraints (business rules) that hold?
- We can represent this information pictorially in E/R diagrams (and then map these to a relational schema later).

E/R basics

- An **entity** is a real-world object that is distinguishable from other objects
- Each entity has **attributes** (with domains)
- A particular entity will have a value for each of its attributes
- An **entity type** defines a set of entities that have the same attributes
- An **entity set** is the collection of all entities of a particular entity type (at a particular point in time)

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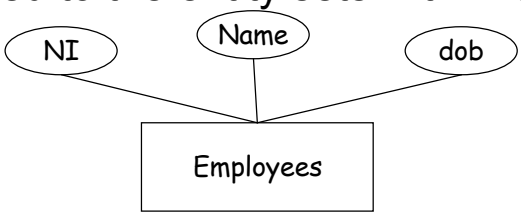
Entities and attributes

- Entity types are drawn as rectangles, e.g.

- Attributes are drawn as ovals, and attached to the entity sets with lines, e.g.



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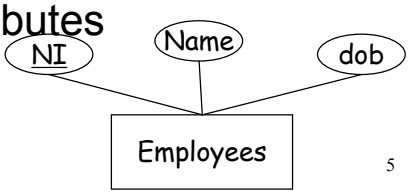
Key attributes

- A **key attribute** of an entity type is an attribute whose values are distinct for each entity
- Sometimes several attributes (a composite attribute) together form a key
  - NB: Such a composite should be **minimal**
- We <u>underline</u> key attributes



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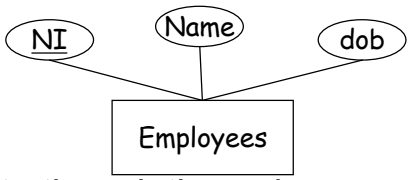
Entity types to relations

- A (strong) entity type maps to a relation schema in the obvious way, e.g.



is mapped to the relation schema

$$\text{Employees}(\underline{\text{NI}}:\tau_1, \text{Name}:\tau_2, \text{dob}:\tau_3)$$

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Relationships

- A **relationship type** among two or more entity types defines a set of associations between entities from those types
  - Mathematically, relationship type R

$$R \subseteq E_1 \times \ldots \times E_n.$$

- The set of instances of the relationship type is called the **relationship set**

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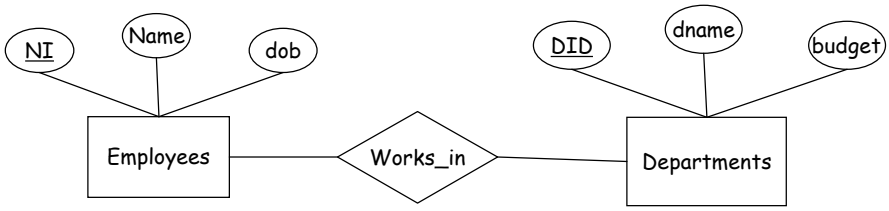
Relationships in E/R

- Relationship types are represented by diamonds
- They connect the participating entity types with straight lines, e.g.



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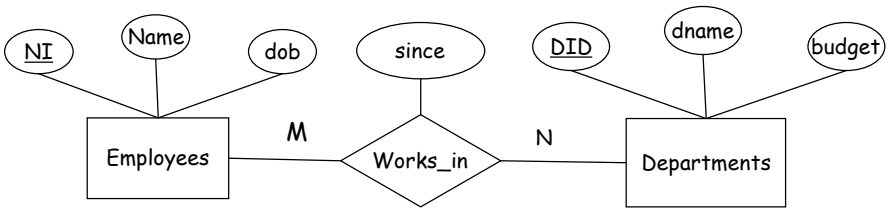
Map to relation



is mapped to the relation schema:

Works_in(NI:τ_1, DID:τ_2, since:τ_3)

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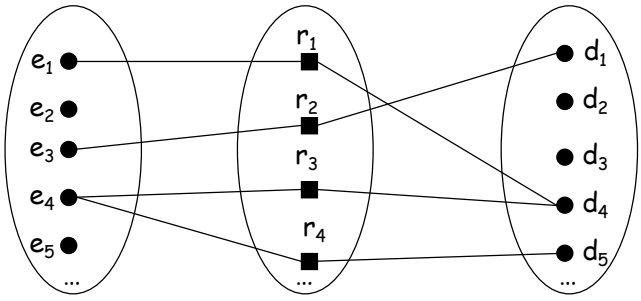
Relationship set diagrams

- Sometimes its useful to represent the relationship set diagrammatically



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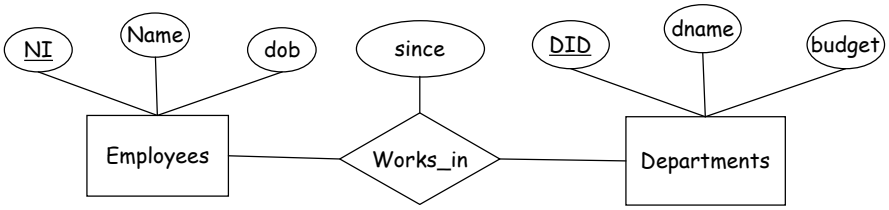
Relationship attributes

- Relationships can also have **attributes**
  - NB: A relationship must be uniquely determined by the entities, without reference to the relationship attributes



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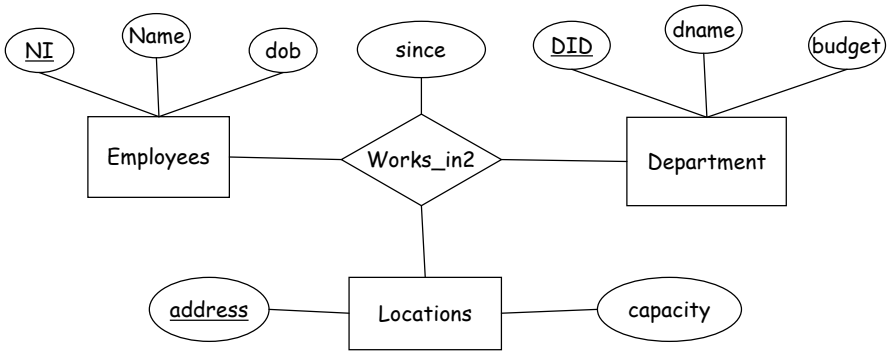
N-ary relationships

- Although relatively rare, we can have n-ary relationships, e.g.



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Recursive relationships

- Each entity type in a relationship plays a particular **role**, which is associated with a **role name** (this is usually suppressed)
- An **recursive relationship** is when an entity type plays more than one role in the relationship type
- In this case the role name is required

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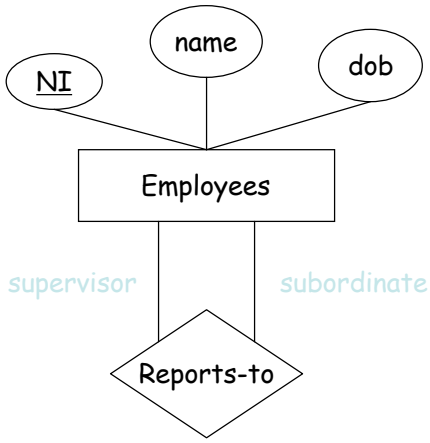
Recursive relationships in E/R

e.g.



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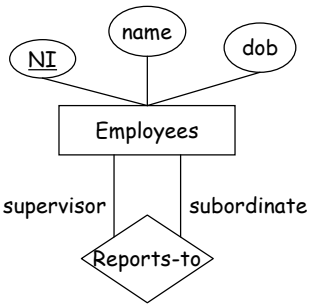
Recursive relationship sets

- Just pick appropriate field names! E.g.



is mapped to

Reports_to(sup_NI:τ_1, sub_NI: τ_1)

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Constraints on relationship types

- For example:
  - An employee can work in many departments; a department can have many employees
  - In contrast, each department has at most one manager
- Thus we need to be able to specify the number of relationship instances that an entity can participate in.
- For binary relationships the possible ratios are: **1:1**, **1:N**, **N:1**, **M:N**

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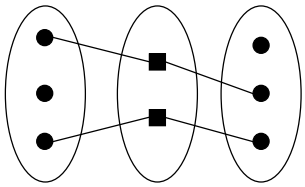
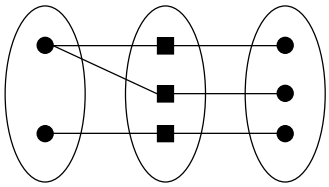
Cardinality ratios

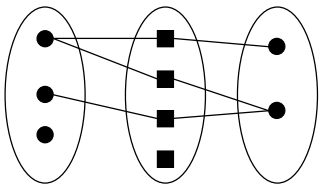
1:1



1:N



M:N



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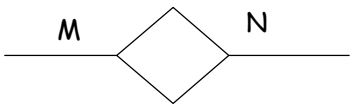
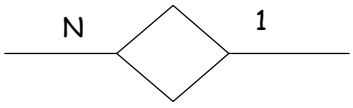
Cardinality ratios in E/R

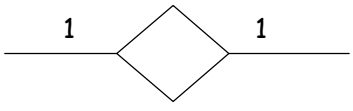
M:N



N:1



1:1



Note: Sometimes this is written using different arrowheads

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Participation constraints

Every department must have a manager

- This is an example of a **participation constraint**
- The participation of an entity set, E, in a relationship set R is said to be **total** if every entity in E participates in at least one relationship in R. (If not its participation is said to be **partial**)

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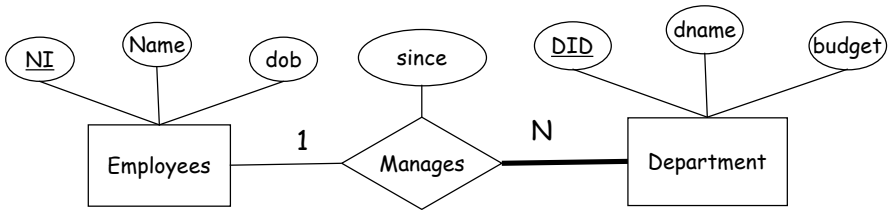
Participation in E/R diagrams

- Total participation is displayed as a **bold** line between the entity type and the relationship
  - NB. Sometimes this is written as a double line



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Weak entity types

- An entity type may not have sufficient attributes to form a primary key
- Such an entity type is called a **weak entity type**
- A weak entity can only be identified uniquely by considering the primary key of another (**owner**) entity

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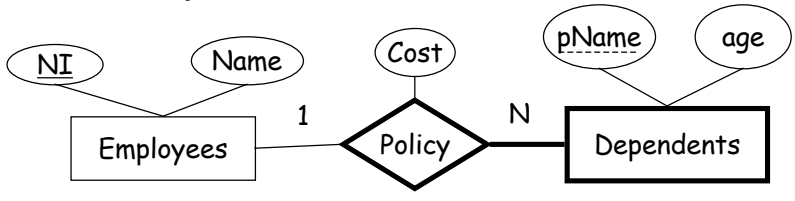
Weak entity types cont.

- Thus the owner and weak entity types must participate in a **1:N** relationship
- Weak entity set must have total participation in this **identifying** relationship set.



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Implementng Weak entity types

- Given a weak entity type, W, we generate a relation schema with fields consisting of the attributes of W, and the primary key attributes of the owner entity type
- For any relationship in which W appears we generate a relation schema which must take as the key for W all of its key attributes, including those from its owner set

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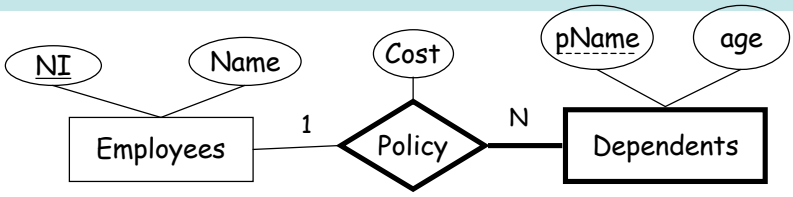
Example



is mapped to the following schema:

Dependents(pName:τ_1, NI:τ_2, age:τ_3)

Policy(pName:τ_1, NI:τ_2, Cost:τ_4)

Alternatively:

Policy(pName :τ_1, NI :τ_2, age :τ_3, Cost :τ_4)

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Extended E/R modelling

- What we've seen so far is "classic" E/R
- Over the years a number of features have been added to the model and the modelling process
- These features include:
  - Sub- and super-classes
  - Specialisation
  - Generalisation
  - Categories
  - Higher/Lower-level entity sets
  - Attribute inheritance
  - Aggregation

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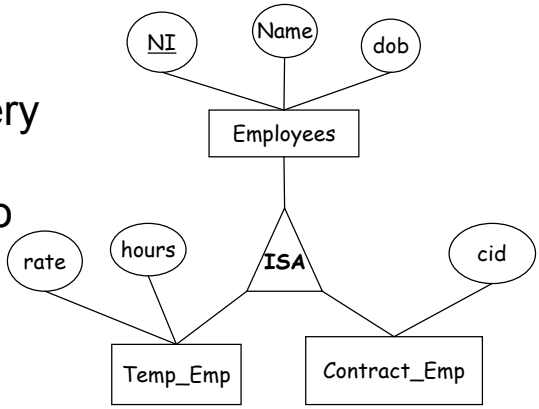
ISA hierarchies

- We can devise **hierarchies** for our entity types
- If we declare *A* **ISA** *B*, every *A* entity is considered to be a *B* entity



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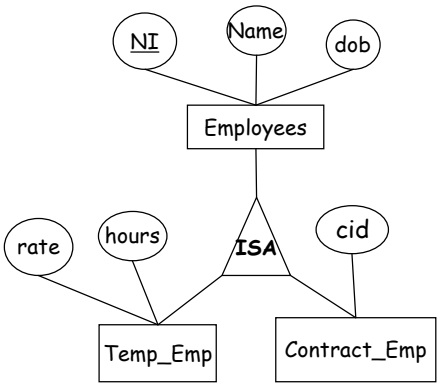
ISA Hierarchies



Two choices:

1. 3 relations
   (Employees, Temp_Emp and Contract_Emp)
2. 2 relations
   (Temp_Emp and Contract_Emp)

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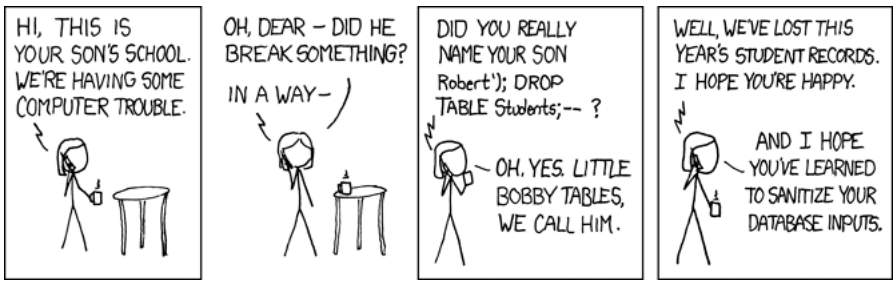
Databases Lecture 12: Database Systems

Timothy G. Griffin
Lent Term 2009



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What is a database system?

- A **database** is a large, integrated collection of data
- A database contains a model of something!
- A **database management system** (DBMS) is a software system designed to store, manage and facilitate access to the database

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What does a database system do?

- Manages Very Large Amounts of Data
- Supports **efficient** access to Very Large Amounts of Data
- Supports **concurrent** access to Very Large Amounts of Data
- Supports **secure**, **atomic** access to Very Large Amounts of Data

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Database system architecture

- It is common to describe databases in two ways
  - **The logical level**:
    - What users see, the program or query language interface, …
  - **The physical level**:
    - How files are organised, what indexing mechanisms are used, …
- It is traditional to split the logical level into two: overall database design (**conceptual**) and the views that various users get to see
- A **schema** is a description of a database

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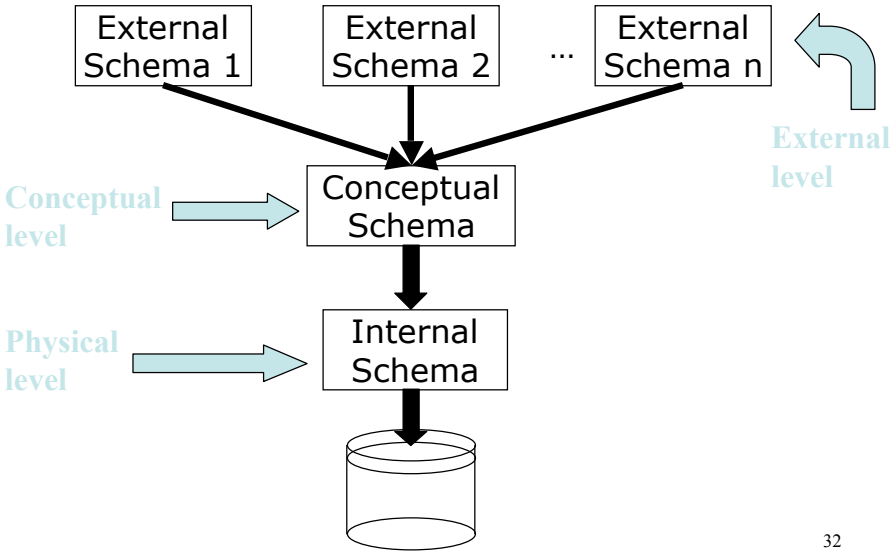
Three-level architecture



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Logical and physical data independence

- Data independence is the ability to change the schema at one level of the database system without changing the schema at the next higher level
- Logical data independence is the capacity to change the conceptual schema without changing the user views
- Physical data independence is the capacity to change the internal schema without having to change the conceptual schema or user views

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Database Context

Database systems are more and more likely to support features that "unlock" databases and allow them to aasily interact in a larger context

- Data-warehousing features
  - Data cube
- Inter-database exchange features
  - XML

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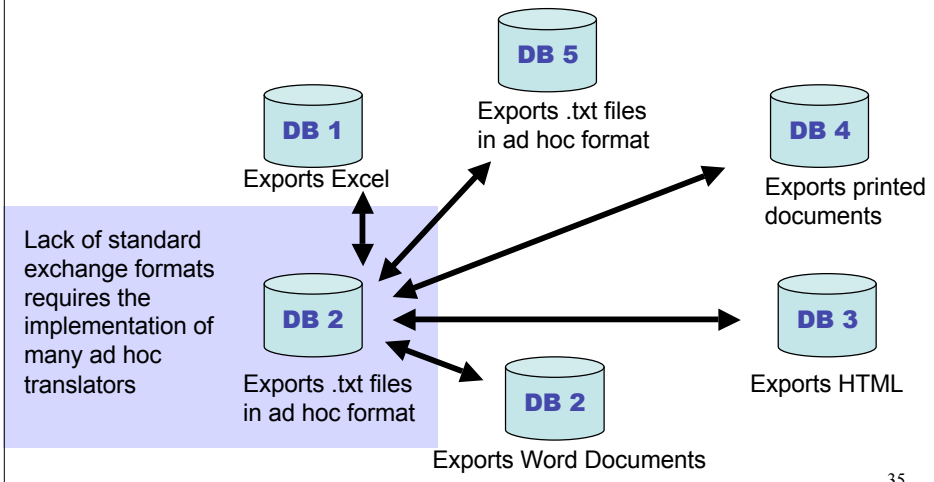
The "Data Publishing" Problem

Need to share data without exposing internal details of your database.



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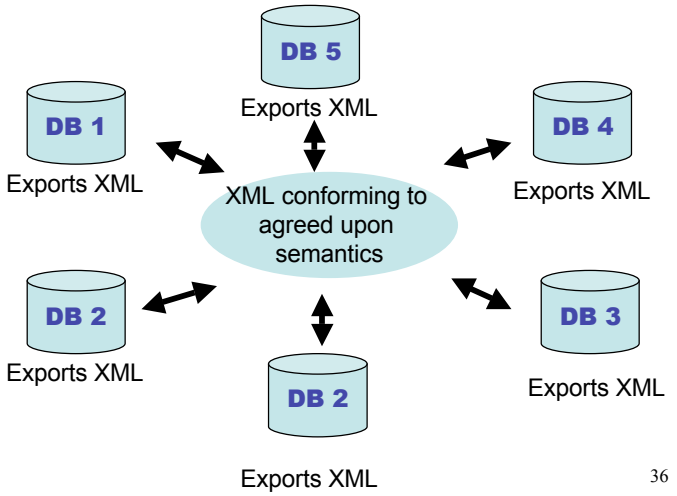
XML as a data exchange format



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XML and Databases

- **XML-enabled databases:**
  - Data stored in structured (usually relational) format.
  - XML primarily used as a data exchange format
  - Interfaces and SQL extensions provided to facilitate generation of XML and parsing of XML.
  - "Data-centric"
- **Native XML database:**
  - Allows direct storage and manipulation of XML data.
  - "Document-centric"

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What is XML?

- **Extensible Markup Language**
- **W3C proposal, Current version 1.0 (3rd ed.) February 2004**
- **Authors:**
  - **Tim Bray (Netscape)**
  - **Jean Paoli (Microsoft)**
  - **C.M. Sperberg-McQueen (W3C)**
  - **Eve Maler (Sun)**
  - **François Yergeau**

http://www.w3.org/TR/REC-xml

XML has roots in HTML

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HTML

- *Lingua-franca* for publishing hypertext on the web
- Designed to inform a web-browser both what information to render, **and** how it should be rendered
  - (Actually these shouldn't be mixed up)
- Easy to learn (Big win)
- Fixed tag set, rather odd syntax

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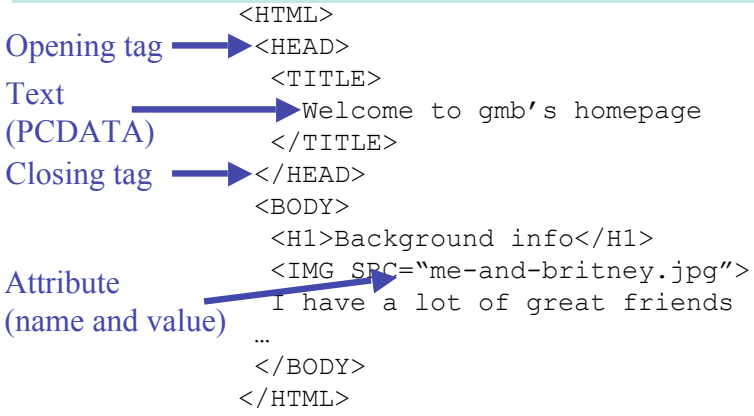
HTML: An example




```
<HTML>
<HEAD>
 <TITLE>
  Welcome to gmb's homepage
 </TITLE>
</HEAD>
<BODY>
 <H1>Background info</H1>
 <IMG SRC="me-and-britney.jpg">
 I have a lot of great friends
…
 </BODY>
</HTML>
```

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XML structure

- The fundamental construct is the **element**, which is essentially a pair of matching tags and the text between them, e.g.
  - `<name>Britney</name>` is an element
  - `<name>Victoria</nom>` is not an element
- XML documents must have single root element
- No fixed set of tags
- Elements can be properly nested, thus
  - `<name> … <address> … </address> … </name>` ☺
  - `<name> … <address> … </name> … </address>` ☹

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XML structure cont.

- We can represent various structures using nesting and repetition
- Tuple (Record):

```
<person>
  <name>Emma Bunton</name>
  <tel>020 8777 1234</tel>
  <email>baby@spicegirls.com</email>
</person>
```

- Lists:

```
<addresses>
  <person> … </person>
  <person> … </person>
  <person> … </person>  …
</addresses>
```

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XML structure cont.

- Nesting can be used to avoid joins, e.g.

```
<bank>
  <cust><name>Britney Spears</name>
        <address>Florida</address>
  </cust>   …
  <acc>
      <accno>BS001</accno>
      <branch>Florida High Street</branch>
      <balance>10,000,000</balance>
  </acc>    …
  <saver>
    <sname>Britney Spears</sname>
    <saccno>BS001</saccno>
  </saver>      …
 </bank>
```

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XML structure cont.

- Join avoiding:

```
<bank2>
 <cust>
   <name>Britney Spears</name>
   <address>Florida</address>
   <acc>
     <accno>BS001</accno>
     <branch>Florida High Street</branch>
     <balance>10,000,000</balance>
   </acc>
 </cust>
 …
</bank2>
```

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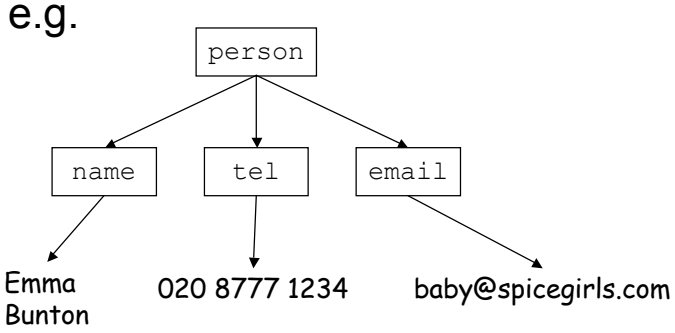
XML and trees

- One can visualise XML documents as trees, e.g.



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Attributes

- In addition to elements we have **attributes**
- Attributes appear as `name=value` pairs in opening tags, e.g.
  - `<acc type="deposit"> … </acc>`
  - `<acc type="saving" status="closed"> … </acc>`
- (Aside: An element with no body can be abbreviated from `<foo></foo>` to `<foo/>`)

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DTDs

- XML documents can be created without any schema
- XML documents can contain a **document type definition** (**DTD**), which is similar to a schema

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Example DTD

```
<!DOCTYPE bank [
  <!ELEMENT bank    ((acc|cust|saver)+)>
  <!ELEMENT acc     (accno branch balance)>
  <!ELEMENT cust    (name address)>
  <!ELEMENT saver   (sname saccno)>
  <!ELEMENT accno   (#PCDATA)>
  <!ELEMENT branch  (#PCDATA)>
  <!ELEMENT balance(#PCDATA)>
  <!ELEMENT name    (#PCDATA)>
  <!ELEMENT address(#PCDATA)>
  <!ELEMENT sname   (#PCDATA)>
  <!ELEMENT saccno  (#PCDATA)>
]>
```

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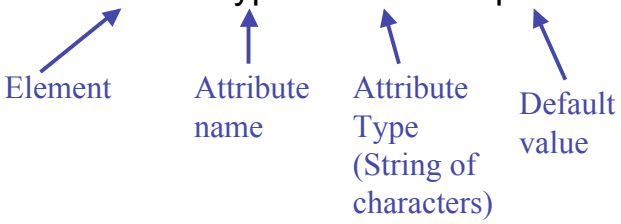
DTD details

- '|' denotes alternative, '+' denotes one or more, and '*' denotes zero or more
- '#PCDATA' (Parsed Character Data) means any text!
- We can also specify attributes, e.g.
- <!ATTLIST acc acctype CDATA "deposit">



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Attributes

- An attribute of type **ID** provides a unique identifier for the element
- An attribute of type **IDREF** is a reference to an element
- Example:

```
<!ATTLIST account number ID     #REQUIRED
                 owners IDREFS #REQUIRED>

<account number="A001" owners="C001 C007">
…</account>
```

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Using DTDs

- DTDs are placed at the start of an XML document
- A document that conforms to its DTD is said to be **valid**
- Alternatively you can give a URL for a DTD, e.g.

```
<!DOCTYPE mybank SYSTEM
          "http://www.hsbc.com/mybank.dtd">
<mybank>
…
</mybank>
```

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Aside on DTDs

- Wouldn't it be better in ML?

```
datatype bank     = BANK of bankitem list
   and   bankitem = ACC of accno*branch*balance
                  | CUST of name*address
                  | SAVER of sname*saccno;
type accno   = string;
type branch  = string;
type balance = string; (*could be int!*)
type name    = string;
type address = string;
type sname   = string;
type saccno  = string;
```

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Schema

- You'll have noticed weaknesses with DTDs from a database schema point of view
  - Individual text elements and attributes can't be typed further
  - We don't need ordered sub-elements in database world
  - There is a lack of typing in IDs and IDREFs
- An effort to address these problems has led to a better schema language: **XML schema**

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Domain specific DTDs

- There are now lots of DTDs that have been agreed by groups, including
  - WML: Wireless markup language (WAP)
  - OFX: Open financial exchange
  - CML: Chemical markup language
  - AML: Astronomical markup language
  - MathML: Mathematics markup language
  - SMIL: Synchronised Multimedia Integration Language
  - ThML: Theological markup language ☺

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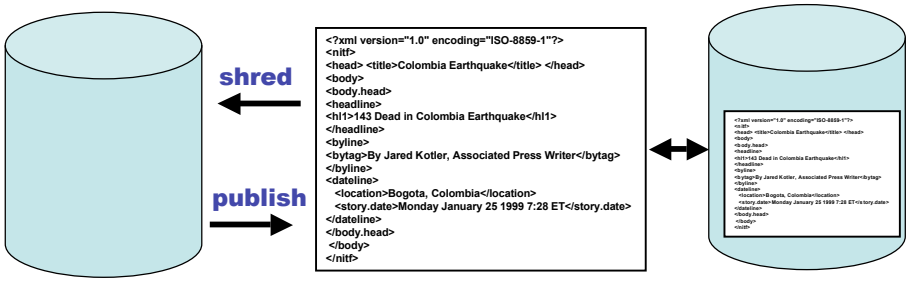
Native XML Databases



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Documents vs databases

- But this is a document, which is quite different from our world of databases

Document world	Database world
Lots of small documents	A few large databases
Static (normally)	Dynamic
Implicit structure	Explicit structure (schema)
Tagging	Records
Human friendly ☺	Machine friendly
Meta data: Author, title, date	Meta data: schema
Editing	Updating
Retrieval (IR)	Querying

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