**Databases** 

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Look up value of key x.

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- Find me rows where column 'lastname' is Jordan.

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## (Efficiently Supported) Operations

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- Get next n bytes.

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- How are the data stored on disk the physical data model?
- How are data organized internally the abstract data model?

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- Data + Metadata about structure and organization.
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- Generally accessed through a Database Management System.

 Provide efficient, reliable, convenient and safe, multi-user storage of and access to massive amounts of data.

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  - **Reliable:** 99.99999% up time.

### Key concepts

 Data model XML, relational model, etc.

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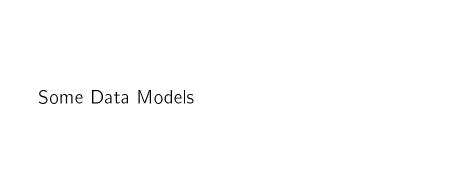
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   For setting up schema
- Data manipulation or query language (DML)
   For querying and modifying the database



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  - Not all elements have attributes

#### Plain Text

June 5, 2006

Floor Statement of Senator Barack Obama Federal Marriage Amendment

I agree with most Americans, with Democrats and Republicans, with Vice President Cheney, with over 2,000 religious leaders of all different beliefs, that decisions about marriage, as they always have, should be left to the states.

```
<DOC>
<DOCNO>obama-2006-06-05-01</DOCNO>
<TEXT>
```

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```
</TEXT>
```

### **JSON**

```
{u'category': u'Government official', u'username':
u'RepJohnLewis', u'about': u'Official Congressional
page for Rep. John Lewis', ... u'name': u'John
Lewis', u'hometown': u'Troy, AL', ... u'website':
u'johnlewis.house.gov', u'phone': u'(404) 659 -
0116', u'birthday': u'02/21/1940', u'likes': 62974,
...}
```

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- Hierarchical can be guicker if all students in one course
- But to look up all courses student X has taken, just as good (bad)

# Relational Vs. XML

	Relational	XML
Structrure	Tables	Hierarchical
Schema	Fixed in advance	Flexible, self-describing
Queries	Easy	Querying not as easy
Ordering	Unordered	Implied order (document)

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- Cost-based optimization
- We can leave this optimization to program

Basic Relational Algebra

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# Sets Vs Bags

- Sets: {a,b,c} (RA, Papers)
- Bags: {a,a,b,c} (SQL)

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- In SQL, selection using 'Where' (and project using 'Select')

# Project

Π<sub>A1, A2</sub>Relation
 Pick Certain Columns

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# Project

- Π<sub>A1, A2</sub>Relation
   Pick Certain Columns
- Π<sub>SSN. GPA</sub>Student
- Both Select and Project  $\Pi_{SSN, GPA}(\sigma_{GPA>3}Student)$   $\Pi_{A1, A2}Expression$   $\sigma_{condition}Expression$

# SQL

Select Col1, Col2 (or \*) FROM R1 Where Condition

Cartesian Product

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- SELECT \*FROM R1, R2;

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- Or, do the cross-product and then filter

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- Select \*From R1 Join R2On R1 A = R2 B

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- Find ALL weather stations within 5 miles of centroid of a zip code
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- Join without the equality condition
- Equi-Join is a special case of theta join
- Find ALL weather stations within 5 miles of centroid of a zip code
- Select Distinct WStations
   From Wstations h, ZipCode s
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- 'distance' is a user-defined function
- Band Joins or Range Joins

Outer Join

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**NULLs** 

- All tuples in R1 and pad out other values with

#### Theta Join

- Outer Join
- All tuples in R1 and pad out other values with NULLs
- Left outer join
   Select \*
   From R1 LEFT OUTER Join R2
   On R1.A = R2.B

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- Right outer join
- Full outer join

## Union

- R1 U R2

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   Removes duplicates by default
- Select \* FROM R1UNIONSelect \* FROM R2
- If you wanted duplicates, you want to do 'UNION ALL'

## Difference

- R1 - R2

#### Difference

- R1 R2
- Select \* From R1ExceptSelect \* From R2

#### Difference

- R1 R2
- Select \* From R1ExceptSelect \* From R2
- Looks up all tuples in R1 and takes out tuples that it also sees in R2 R2 can have other tuples
   Everything in R1, remove things that also appear in R2

#### Intersection

Not a fundamental operator

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-R1 Intersect R2 = R1 - (R1 - R2)

#### Intersection

- Not a fundamental operator
- -R1 Intersect R2 = R1 (R1 R2)
- Can also express it as join

# (Virtual) Views

Defining and Using (Virtual) Views
 Three-level vision of database
 Physical layer, Conceptual (abstraction of the data, relations), Logical layer (further abstraction, )

 Real applications use lots and lots of views

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   Physical layer, Conceptual (abstraction of the data, relations), Logical layer (further abstraction, )
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- Benefit of Views
   Hide some data from some users (Authorization etc.)
   Make certain queries easier, more natural
   Modularity of database access

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 Three-level vision of database
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 Real applications use lots and lots of views

# Benefit of Views Hide some data from some users (Authorization etc.) Make certain queries easier, more natural Modularity of database access

# Views Query over relations View V = ViewQuery(R1, R2,... RN) Schema of V is schema of guery result

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- View contents not stored
- A convenient view is a join

# Modifying Views

 We cannot insert, update, delete as V isn't stored

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- To alter V, we have to modify the base tables

- Creates a physical table

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- But ...

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  - Tables can be very large

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  - What happens when modifications happen to the base tables

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- But . . .
  - Tables can be very large
  - What happens when modifications happen to the base tables
  - Modification to base data can invalidate the view

- NULL - The value is a NULL value

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INTEGER – a signed integer

- NULL The value is a NULL value
- INTEGER a signed integer
- REAL a floating point value

- NULL The value is a NULL value
- INTEGER a signed integer
- REAL a floating point value
- TEXT a text string

- NULL The value is a NULL value
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- REAL a floating point value
- TEXT a text string
- BLOB a blob of data