CSCI3030U Database Models

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RELATIONAL MODEL

SEMISTRUCTURED MODEL

Content

Design of databases.

- relational model, semistructured model.

Database programming.

- SQL, XPath, XQuery.

Not DBMS implementation.

Do You Know SQL?

Explain the difference between:

```
SELECT b
FROM R
WHERE a<10 OR a>=10;
```

and

```
SELECT b
FROM R;
```

a	b
5	20
10	30
20	40
…	…

Table R

And How About These?

```
SELECT a
FROM R, S
WHERE R.b = S.b;
```

```
SELECT a
FROM R
WHERE b IN (SELECT b FROM S);
```

Interesting Stuff About Databases

It used to be about boring stuff: employee records, bank records, etc.

Today, the field covers all the largest sources of data, with many new ideas.

- Web search.
- Data mining.
- Scientific and medical databases.
- Integrating information.

More Interesting Stuff

Database programming centers around limited programming languages.

- Leads to very succinct programming, but also to unique query-optimization problems.

Still More …

You may not notice it, but databases are behind almost everything you do on the Web.

- Google searches.
- Queries at Amazon, eBay, etc.

And More…

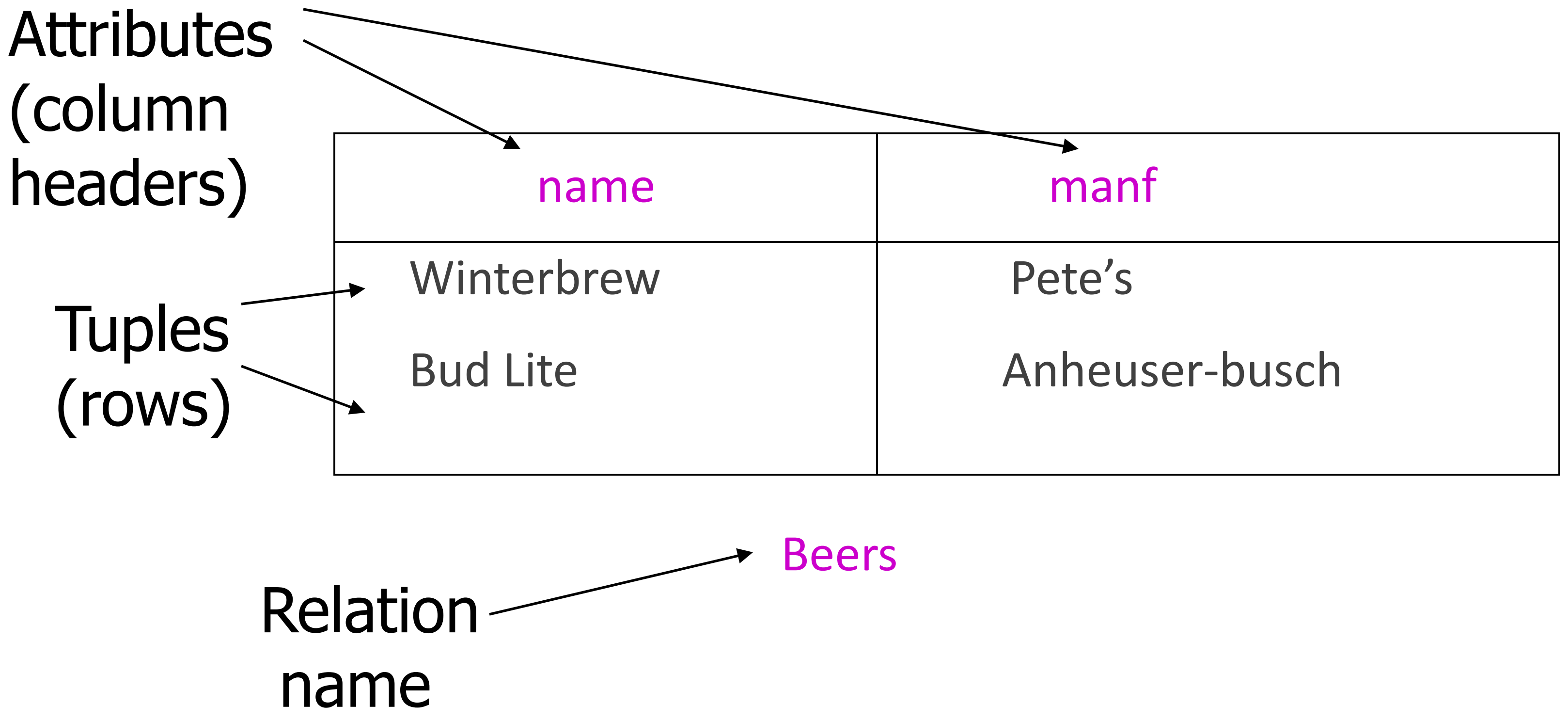
Databases often have unique concurrency-control problems

- Many activities (transactions) at the database at all times.
- Must not confuse actions, e.g., two withdrawals from the same account must each debit the account.

What is a Data Model?

1. Mathematical representation of data.
   - Examples: relational model = tables; semistructured model = trees/graphs.
2. Operations on data.
3. Constraints.

A Relation is a Table



name	manf
Winterbrew	Pete’s
Bud Lite	Anheuser-busch

Schemas

Relation schema = relation name and attribute list.

- Optionally: types of attributes.
- Example: Beers(name, manf) or Beers(name: string, manf: string)

Database = collection of relations.

Database schema = set of all relation schemas in the database.

Why Relations?

Very simple model.

Often matches how we think about data.

Abstract model that underlies SQL, the most important database language today.

Our Running Example

Beers(name, manf)

Bars(name, addr, license)

Drinkers(name, addr, phone)

Likes(drinker, beer)

Sells(bar, beer, price)

Frequents(drinker, bar)

Underline = *key* (tuples cannot have the same value in all key attributes).

- Excellent example of a *constraint*.

Database Schemas in SQL

SQL is primarily a query language, for getting information from a database.

But SQL also includes a *data-definition* component for describing database schemas.

Creating (Declaring) a Relation

Simplest form is:

```
CREATE TABLE <name> (
        <list of elements>
);
```

To delete a relation:

```
DROP TABLE <name>;
```

Elements of Table Declarations

Most basic element: an attribute and its type.

The most common types are:

- INT or INTEGER (synonyms).
- REAL or FLOAT (synonyms).
- CHAR(*n*) = fixed-length string of *n* characters.
- VARCHAR(*n*) = variable-length string of up to *n* characters.

Example: Create Table

```
CREATE TABLE Sells (
     bar        CHAR(20),
     beer  VARCHAR(20),
     price REAL
);
```

SQL Values

Integers and reals are represented as you would expect.

Strings are too, except they require single quotes in many database engines.

- Two single quotes = real quote, e.g., `’Joe’’s Bar’`.

Any value can be NULL.

Dates and Times

DATE and TIME are types in SQL.

The form of a date value is:

DATE ’yyyy-mm-dd’

- Example: `DATE ’2007-09-30’` for Sept. 30, 2007.

Times as Values

The form of a time value is:

TIME ’hh:mm:ss’

with an optional decimal point and fractions of a second following.

- Example: `TIME ’15:30:02.5’` = two and a half seconds after 3:30PM.

Declaring Keys

An attribute or list of attributes may be declared PRIMARY KEY or UNIQUE.

Either says that no two tuples of the relation may agree in all the attribute(s) on the list.

There are a few distinctions to be mentioned later.

Declaring Single-Attribute Keys

Place PRIMARY KEY or UNIQUE after the type in the declaration of the attribute.

Example:

```
     CREATE TABLE Beers (
           name  CHAR(20) UNIQUE,
           manf  CHAR(20)
     );
```

Declaring Multiattribute Keys

A key declaration can also be another element in the list of elements of a CREATE TABLE statement.

This form is essential if the key consists of more than one attribute.

- May be used even for one-attribute keys.

Example: Multiattribute Key

The bar and beer together are the key for Sells:

```
CREATE TABLE Sells (
    bar         CHAR(20),
    beer        VARCHAR(20),
    price       REAL,
    PRIMARY KEY (bar, beer)
);
```

PRIMARY KEY vs. UNIQUE

1. There can be only one PRIMARY KEY for a relation, but several UNIQUE attributes.
2. No attribute of a PRIMARY KEY can ever be NULL in any tuple. But attributes declared UNIQUE may have NULL's, and there may be several tuples with NULL.

Semistructured Data

Another data model, based on trees and graphs.

Motivation: flexible representation of data.

Motivation: sharing of *documents* among systems and databases.

Graphs of Semistructured Data

Nodes = objects.

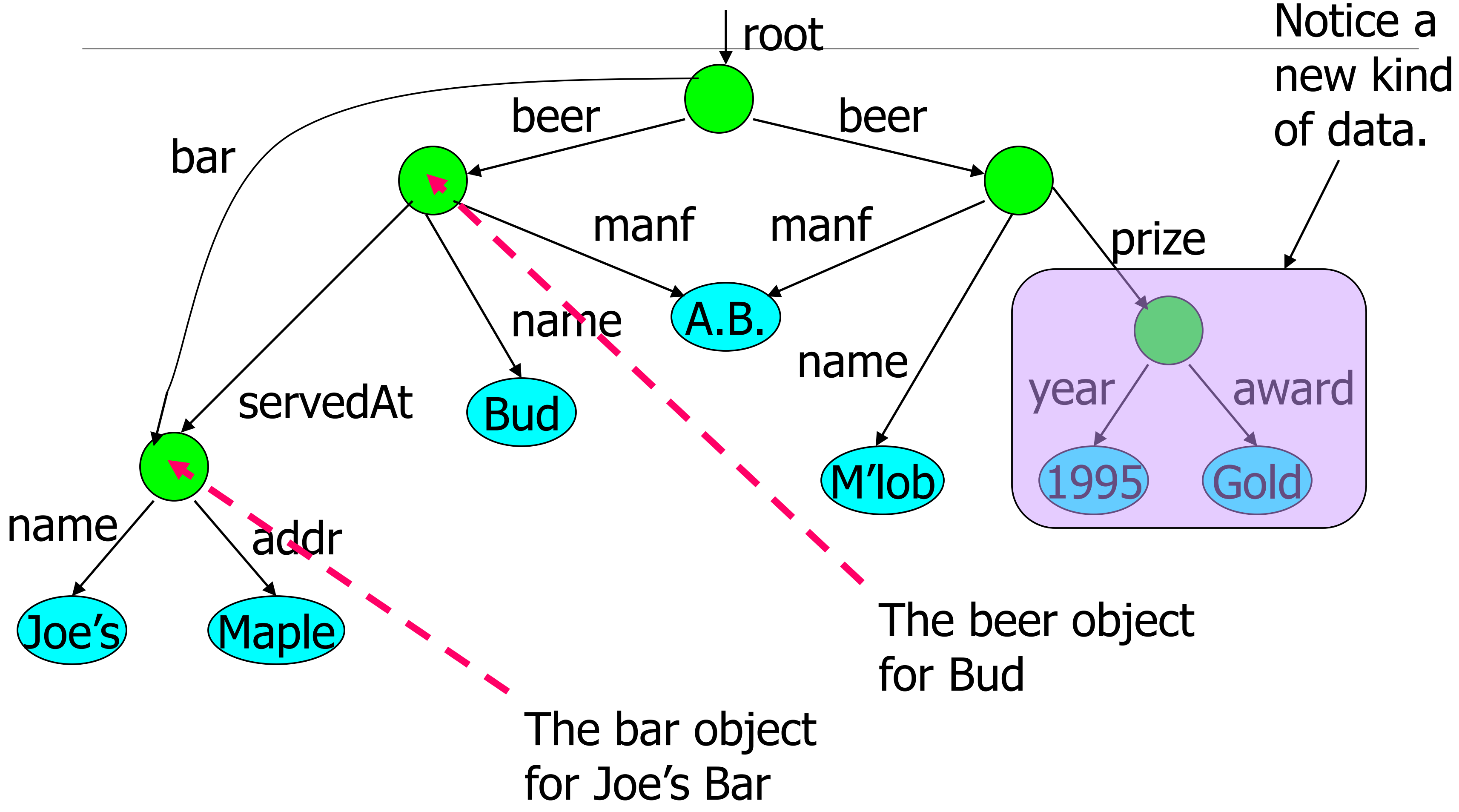
Labels on arcs (like attribute names).

Atomic values at leaf nodes (nodes with no arcs out).

Flexibility: no restriction on:

- Labels out of a node.
- Number of successors with a given label.

Example: Data Graph



Notice a new kind of data.

The beer object for Bud

The bar object for Joe's Bar

XML

XML = *Extensible Markup Language*.

While HTML uses tags for formatting (e.g., “italic”), XML uses tags for semantics (e.g., “this is an address”).

Key idea: create tag sets for a domain (e.g., genomics), and translate all data into properly tagged XML documents.

XML Documents

Start the document with a *declaration*, surrounded by <?xml … ?> .

Typical:

```
<?xml version = "1.0" encoding = "utf-8" ?>
```

Balance of document is a *root tag* surrounding nested tags.

Tags

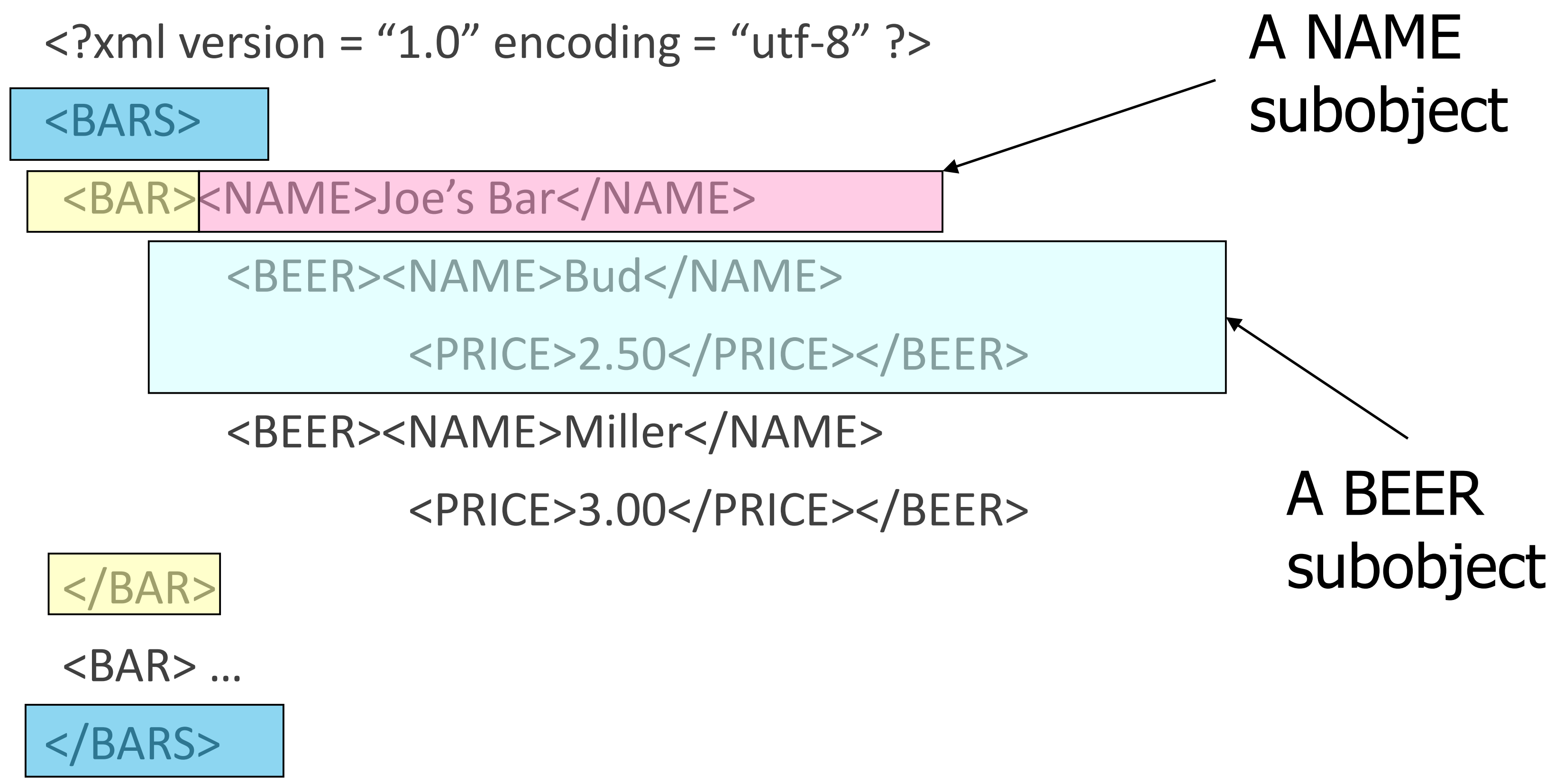
Tags, as in HTML, are normally matched pairs, as <FOO> … </FOO>.

- Optional single tag <FOO/>.

Tags may be nested arbitrarily.

XML tags are case sensitive.

Example: an XML Document



```
<?xml version = "1.0" encoding = "utf-8" ?>
<BARS>
  <BAR><NAME>Joe's Bar</NAME>
        <BEER><NAME>Bud</NAME>
                <PRICE>2.50</PRICE></BEER>
        <BEER><NAME>Miller</NAME>
                <PRICE>3.00</PRICE></BEER>
  </BAR>
  <BAR> …
</BARS>
```

The Difference Between XML and HTML

XML is not a replacement for HTML.

XML and HTML were designed with different goals:

- XML was designed to describe data, with focus on what data is
- HTML was designed to display data, with focus on how data looks

HTML is about displaying information, while XML is about carrying information.

Attributes

Like HTML, the opening tag in XML can have atttribute = value pairs.

Attributes also allow linking among elements (discussed later).

Bars, Using Attributes

```
<?xml version = "1.0" encoding = "utf-8" ?>
<BARS>
 <BAR name = "Joe's Bar">
         <BEER name = "Bud" price = 2.50   />
         <BEER name = "Miller" price = 3.00 />
 </BAR>
 <BAR> …
</BARS>
```

name and price are attributes

Notice Beer elements have only opening tags with attributes.

DTD's (Document Type Definitions)

A grammatical notation for describing allowed use of tags.

Definition form:

```
<!DOCTYPE <root tag> [
 <!ELEMENT  <name> (<components>) >
 . . . more elements . . .
]>
```

Example: DTD

```
<!DOCTYPE BARS [
 <!ELEMENT BARS (BAR*)>
 <!ELEMENT BAR (NAME, BEER+)>
 <!ELEMENT NAME (#PCDATA)>
 <!ELEMENT BEER (NAME, PRICE)>
 <!ELEMENT PRICE (#PCDATA)>
]>
```

A BARS object has zero or more BAR's nested within.

A BAR has one NAME and one or more BEER subobjects.

A BEER has a NAME and a PRICE.

NAME and PRICE are HTML text.

Attributes

Opening tags in XML can have *attributes*.

In a DTD,

`<!ATTLIST` *E* `...>`

declares an attribute for element *E*, along with its datatype.

Example: Attributes

No closing tag or subelements

```
<!ELEMENT BEER EMPTY>

      <!ATTLIST name         CDATA    #REQUIRED,
           manf CDATA    #IMPLIED>
```

Character string

Required = “must occur”; Implied = “optional

Example use:
<BEER name=“Bud” />

Actions

Read chapter 1 and chapters 2.1, 2.2 and 2.3 from course book!