CSCI3030U Database Models

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RELATIONAL MODEL

SEMISTRUCTURED MODEL

Content

Design of databases.

- relational model, semistructured model.

Database programming.

- SQL, XQuery, SPARQL.

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.

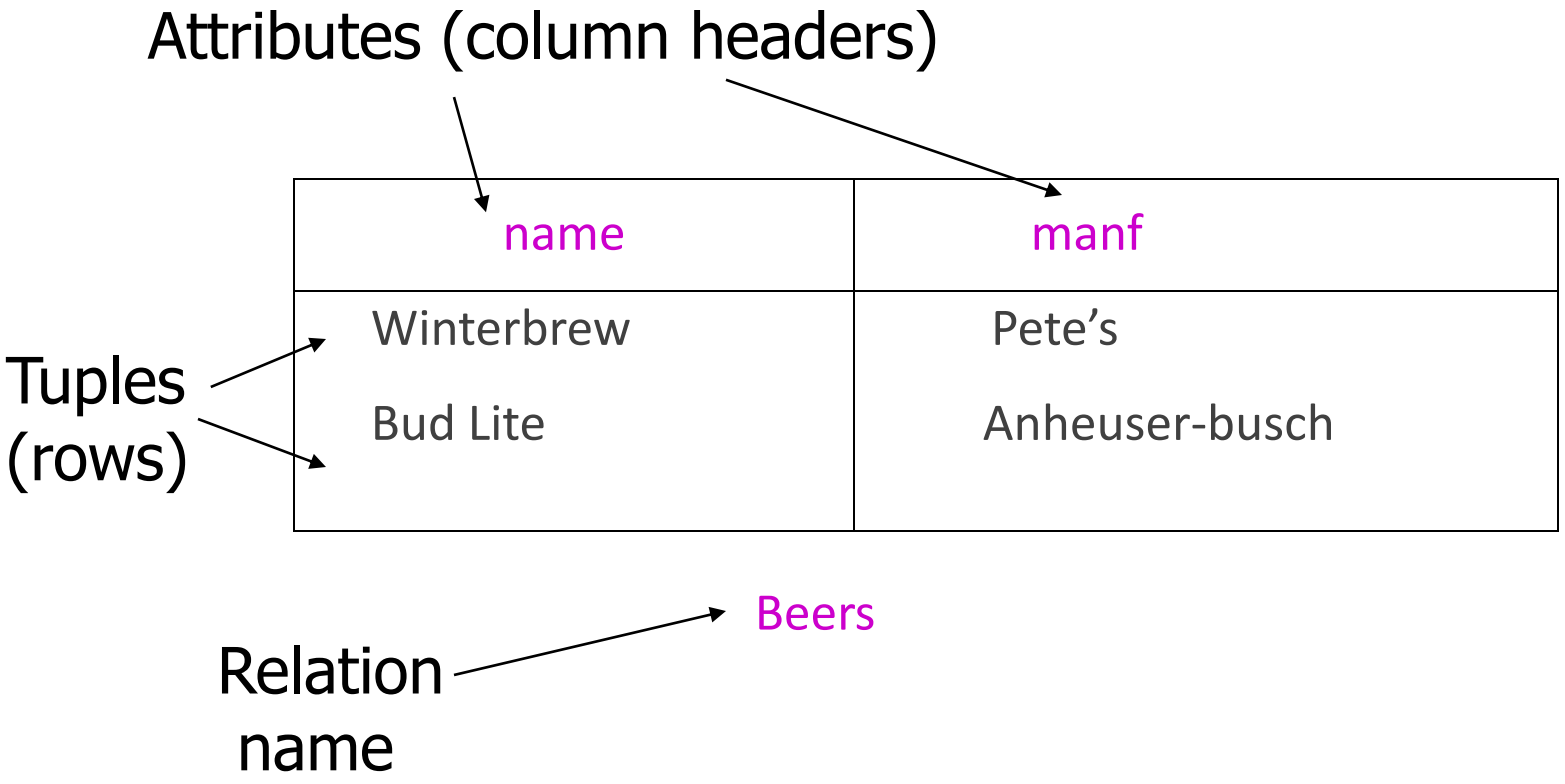
What is a Data Model?

A data model is a notation for **describing data** or **information**.

The description generally consists of three parts:

1. Mathematical representation of data (Structure of data).
   - Examples:
     - relational model = tables;
     - semistructured model = trees/graphs.
2. Operations on data.
   - Limited set of operations that can be performed
3. Constraints.
   - Database data models usually have a way to describe **limitations** on what the data can be

A Relation is a Table



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 '2019-09-30'` for Sept. 30, 2019.

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.

PRIMARY KEY	UNIQUE KEY
• Helps to identify a unique row from a table.	• Helps to maintains Unique data in a column of a table.
• Does not allow null values	• Nulls are allowed
• One per table	• Multiple per table
• Unique Index is created on the column where PK is defined.	• Unique Index is created on the column where UK is defined.
• Foreign Key can refer to PK	• Foreign Key can refer to UK.
• Column Level and Table Level	• Column Level and Table Level

Student

Roll_no (Primary Key)	Name	Class	Phone_no (Unique Key)
1	Andrew	5	9854672256
2	Andrew	6	9955512456
3	Augusto	5	

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.

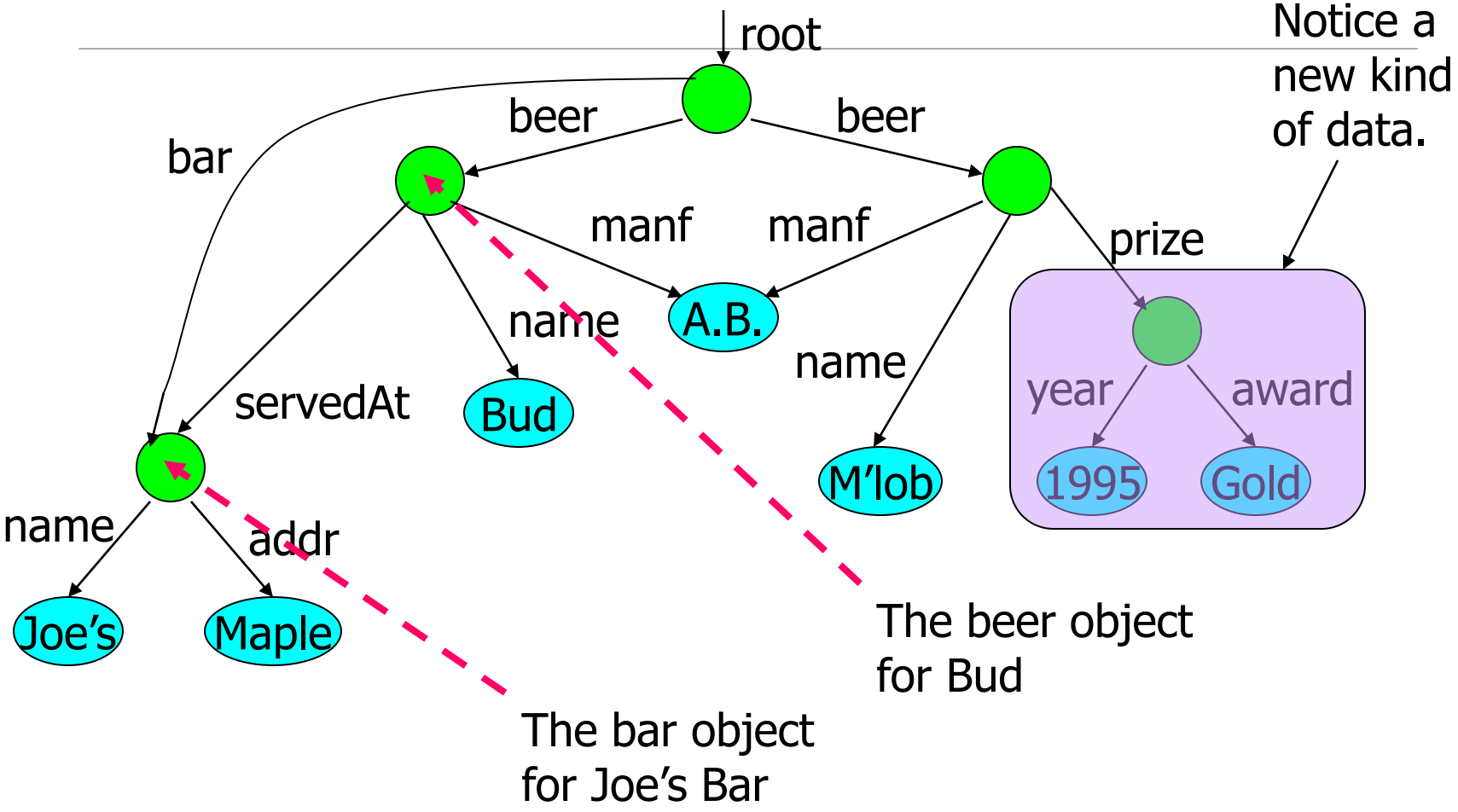
Labels on arcs (like attribute names).

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



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., sales catalog), 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>

A NAME subobject

A BEER subobject

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**.

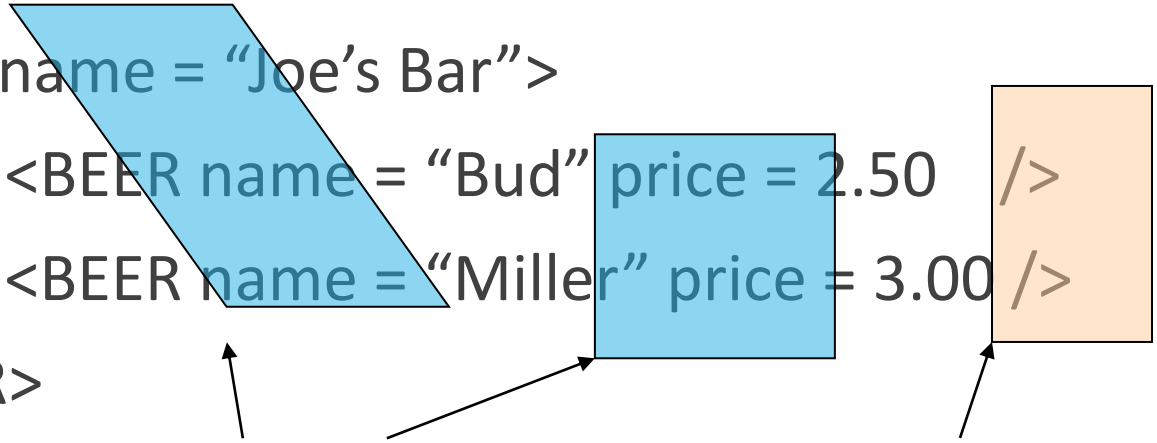
Attributes

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:

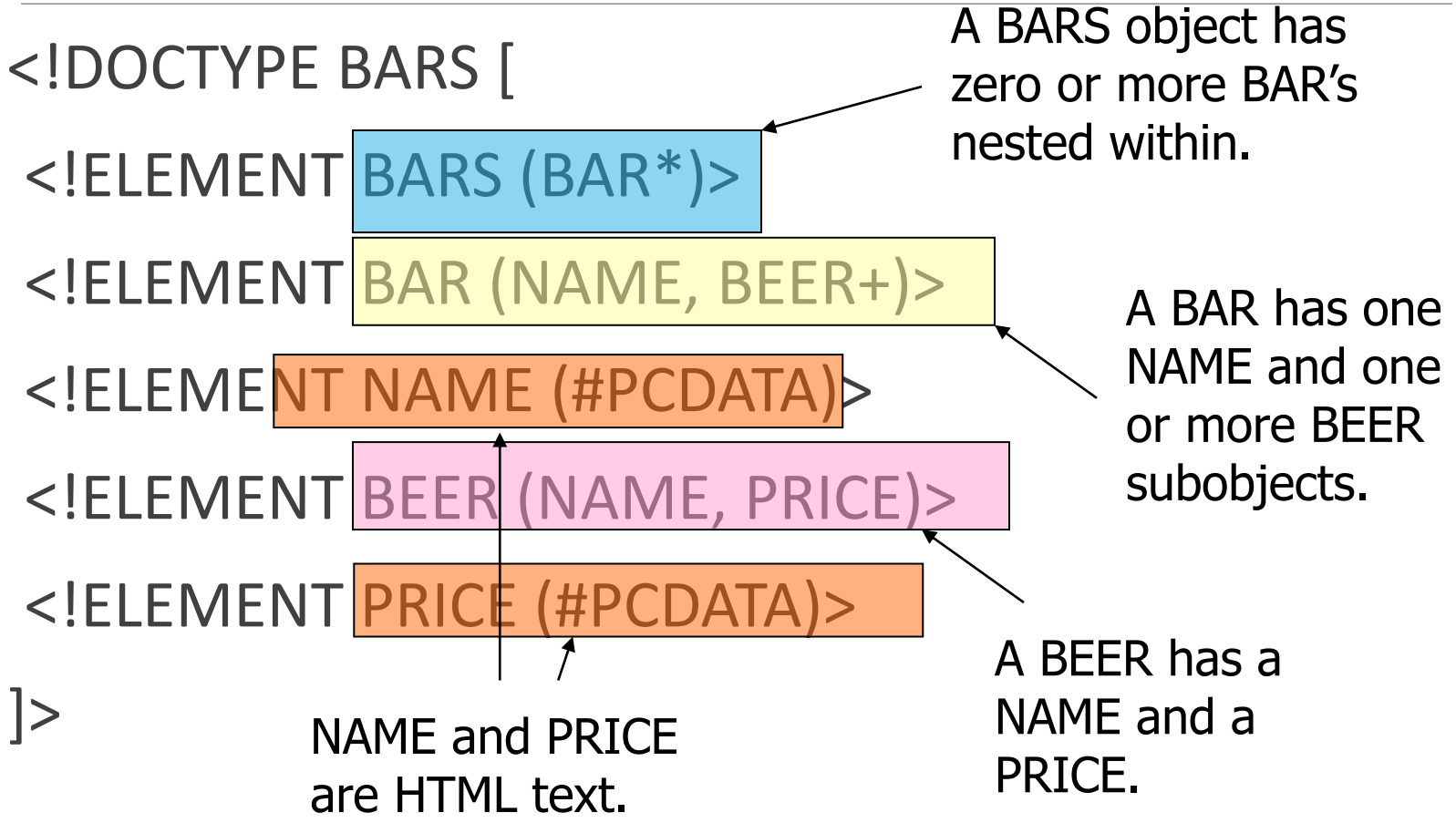
<!DOCTYPE <root tag> [

<!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

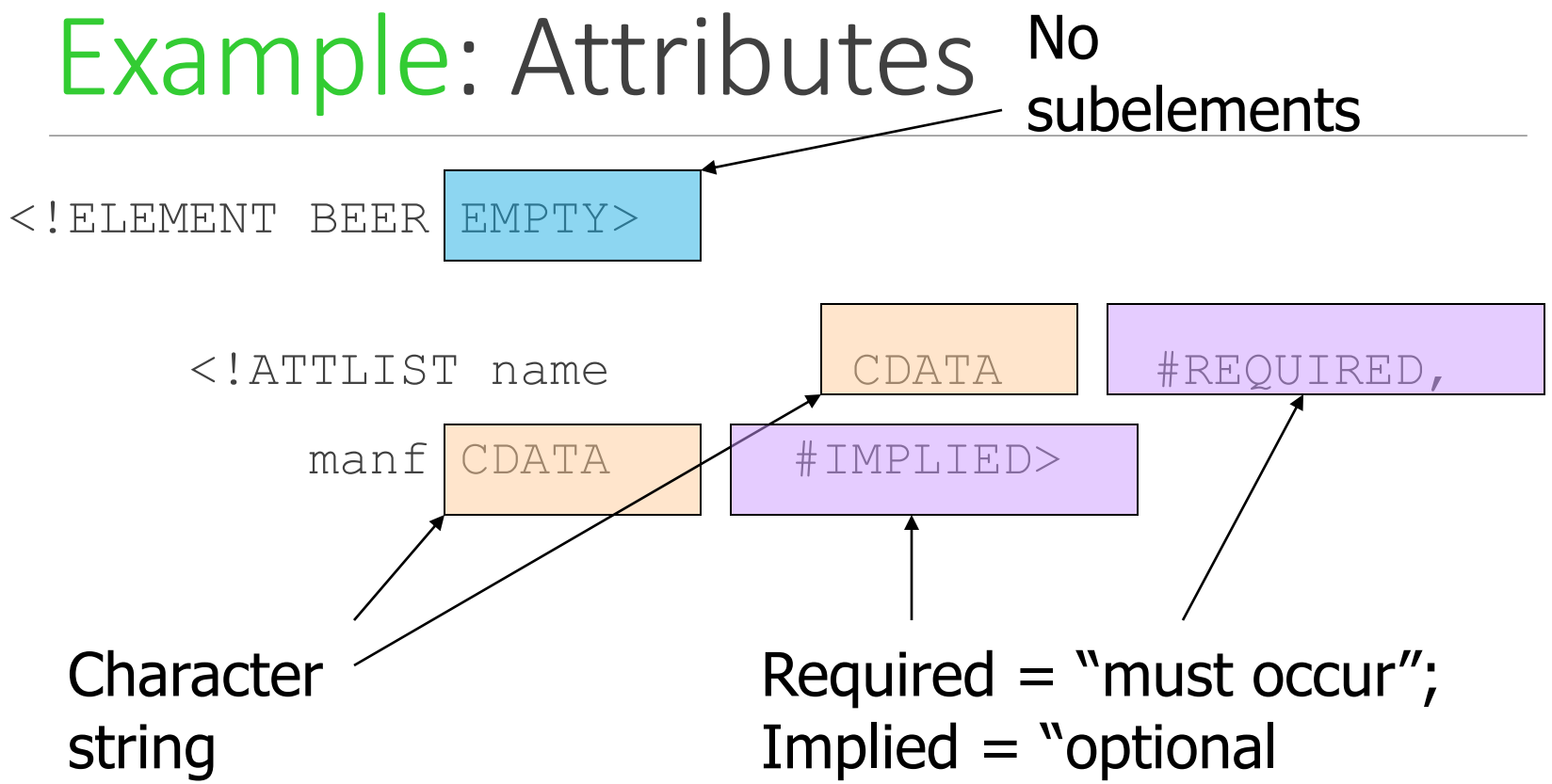
Opening tags in XML can have *attributes*.

In a DTD,

<!ATTLIST *E* . . . >

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

Example: Attributes



Example use:
<BEER name="Bud" />

SQL-Try it Yourself!

With the online SQL editor, you can edit the SQL statements, and click on a button to view results.

https://www.w3schools.com/sql/

Actions

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