COSC 122

Computer Fluency

How It Works and Databases

Dr. Firas Moosvi

Acknowledgement: Original slides provided courtesy of Dr. Lawrence and Dr. Abdallah Mohamed.

Announcements

1) Unfortunately, Test 4 manually graded questions will NOT be done for Bonus Test 4, but I will release the Test questions back to you so you can use it for practice!

- Bonus Test 4 will **be in class on Friday at 2 PM**!

3) Lab 10 will be released in the next couple of days, it will be a GPA calculator that you have to create!

4) Reminder: your 10 best labs will be counted for your lab score.

- Lab 11 will be your final lab, where you build a portfolio of your work in labs this term.

Key Points

1) Use our knowledge to understand how popular applications and systems work: Amazon, Facebook, Twitter, BitTorrent, iPhone.

Amazon.com Overview

Amazon.com is America's largest online retailer and sells books, DVDs, software, and other products.

- Headquartered in Seattle, Washington.
- Founded by Jeff Bezos in 1994.
- "Amazon" is named after the world's largest river.
  - Since 2000, Amazon's logo has an arrow from A to Z, representing customer satisfaction (as it forms a smile).

Amazon's Canadian site comes from the US, as it was legally prevented until March 2010 of operating any fulfillment centers in Canada. Products ship from Canada Post's Mississauga, ON.

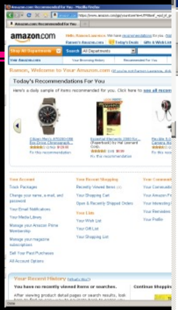
Amazon provides technology and online hosting and services for many other retailers. Affiliates can sell through Amazon's system and link to Amazon's product database.

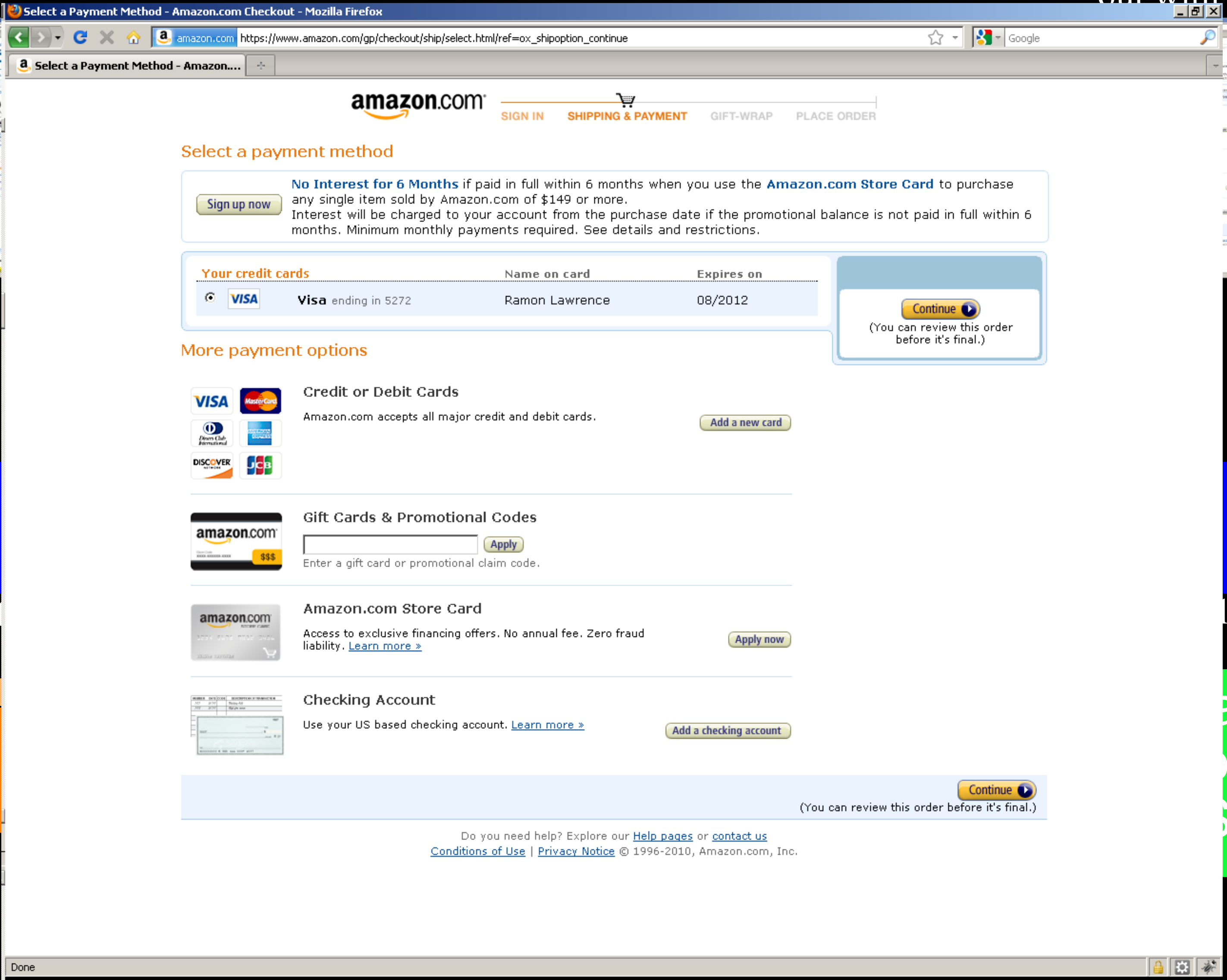
Amazon.com – How it Works

1) User goes to Amazon.com

6) User adds item to cart

10) User checks out with card





Select a Payment Method - Amazon.com Checkout - Mozilla Firefox
amazon.com https://www.amazon.com/gp/checkout/ship/select.html/ref=ox_shipoption_continue
Google
Select a Payment Method - Amazon....
amazon.com
SIGN IN
SHIPPING & PAYMENT
GIFT-WRAP
PLACE ORDER

Select a payment method

Sign up now

No Interest for 6 Months if paid in full within 6 months when you use the Amazon.com Store Card to purchase any single item sold by Amazon.com of $149 or more.
Interest will be charged to your account from the purchase date if the promotional balance is not paid in full within 6 months. Minimum monthly payments required. See details and restrictions.

Your credit cards	Name on card	Expires on
● VISA Visa ending in 5272	Ramon Lawrence	08/2012

Continue
(You can review this order before it's final.)

More payment options

Credit or Debit Cards
Amazon.com accepts all major credit and debit cards.
Add a new card

Gift Cards & Promotional Codes
Apply
Enter a gift card or promotional claim code.

Amazon.com Store Card
Access to exclusive financing offers. No annual fee. Zero fraud liability. Learn more »
Apply now

Checking Account
Use your US based checking account. Learn more »
Add a checking account

Continue
(You can review this order before it's final.)

Do you need help? Explore our Help pages or contact us
Conditions of Use | Privacy Notice © 1996-2010, Amazon.com, Inc.

Done

2) Send request (cookie)

14) Display confirmation

4) User inf
+ product

12) Send secure payment info

ayment
cessing
system

and Fulfillment

18) Ship products

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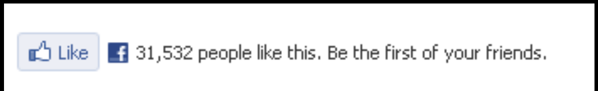
Facebook Overview

Facebook is a social networking site with over 1.1 billion active users as of June 2013.

- Allows users to create personal profiles, add people as friends and send messages and updates to them.
- Founded by Mark Zuckerberg in 2004.
- Revenue ($5B+) from advertising (banner ads, news feed).
- Accessible directly or through applications on smartphones.
- 250+ billion user photos taking up more than 8 petabytes
  - 350 million photos added each day (50 terabytes)
- 4.5 billion likes per day
- Facebook Platform is an API (application programming interface) allowing developers to write own applications.
  - Currently more that 10 million applications with games being extremely popular.

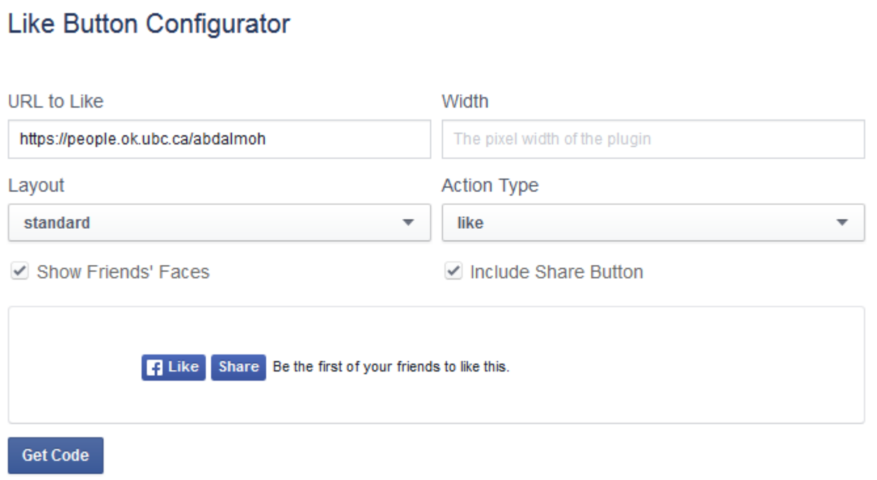
Facebook.com – Like Button

User adds Like button to page



31,532 people like this. Be the first of your friends.

1) Configure Button



Like Button Configurator

URL to Like: https://people.ok.ubc.ca/abdalmoh

Width: The pixel width of the plugin

Layout: standard

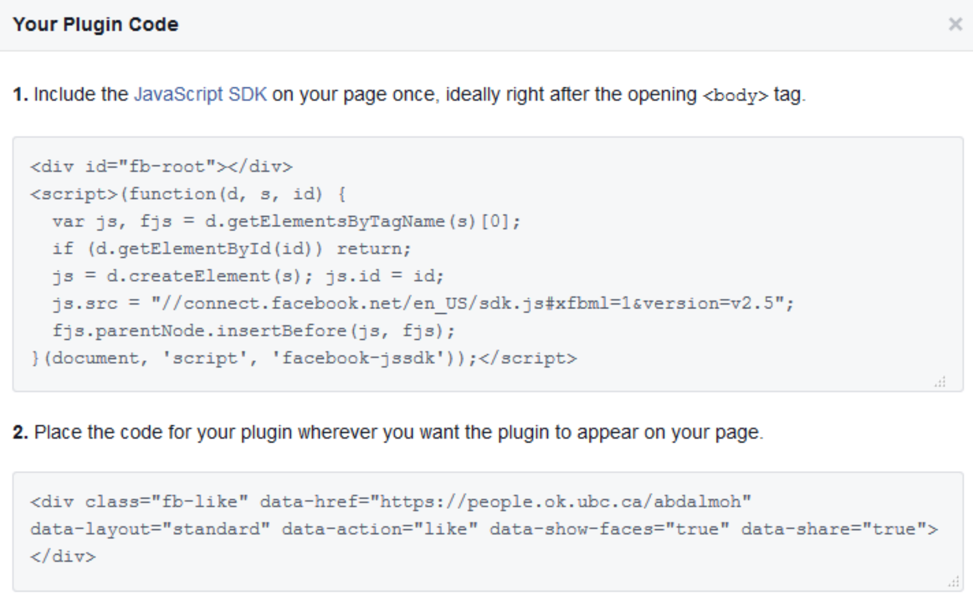
Action Type: like

☑ Show Friends' Faces

☑ Include Share Button

Be the first of your friends to like this.

2) Added Code



Your Plugin Code

1. Include the JavaScript SDK on your page once, ideally right after the opening `<body>` tag.

```
<div id="fb-root"></div>
<script>(function(d, s, id) {
  var js, fjs = d.getElementsByTagName(s)[0];
  if (d.getElementById(id)) return;
  js = d.createElement(s); js.id = id;
  js.src = "//connect.facebook.net/en_US/sdk.js#xfbml=1&version=v2.5";
  fjs.parentNode.insertBefore(js, fjs);
}(document, 'script', 'facebook-jssdk'));</script>
```

2. Place the code for your plugin wherever you want the plugin to appear on your page.

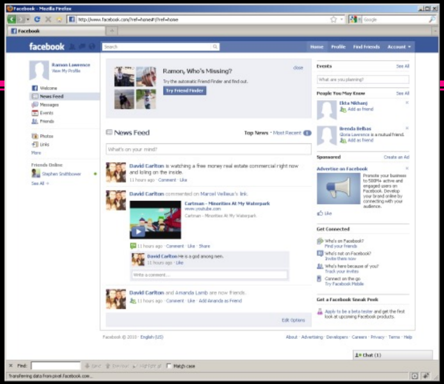
```
<div class="fb-like" data-href="https://people.ok.ubc.ca/abdalmoh"
data-layout="standard" data-action="like" data-show-faces="true" data-share="true">
</div>
```

When user clicks on Like request is sent to Facebook servers.

Build your own at:
http://developers.facebook.com/docs/reference/plugins/like

Facebook.com – Applications

1) User goes to facebook.com



Facebook - Mozilla Firefox

http://www.facebook.com/?ref=home#!/?ref=home

facebook | Search | Home · Profile · Find Friends · Account

Ramon Lawrence
View My Profile

Welcome · News Feed · Messages · Events · Friends · Photos · Links · More

Friends Online: Stephen Smithbower · See All

Ramon, Who's Missing?
Try the automatic Friend Finder and find out.
Try Friend Finder

News Feed — Top News · Most Recent

What's on your mind?

David Carlton is watching a free money real estate commercial right now and loling on the inside.
11 hours ago · Comment · Like

David Carlton commented on Marcel Veilleux's link.
Cartman - Minorities At My Waterpark
www.youtube.com
Cartman - Minorities At My Waterpark.
11 hours ago · Comment · Like · Share
David Carlton He is a god among men.
11 hours ago · Like
Write a comment...

David Carlton and Amanda Lamb are now friends.
11 hours ago · Comment · Like · Add Amanda as Friend

Edit Options

Events — See All
What are you planning?

People You May Know — See All
Ekta Nikhanj — Add as friend
Brenda Belbas — Gloria Lawrence is a mutual friend. Add as friend

Sponsored — Create an Ad
Advertise on Facebook
Promote your business to 500M+ active and engaged users on Facebook. Develop your brand online by connecting with your audience.
Like

Get Connected
Who's on Facebook? Find your friends
Who's not on Facebook? Invite them now
Who's here because of you? Track your invites
Connect on the go. Try Facebook Mobile

Get a Facebook Sneak Peek
Apply to be a beta tester and get the first look at upcoming Facebook products.

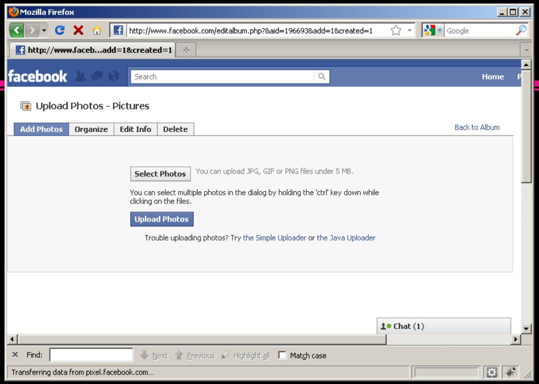
Facebook © 2010 · English (US) — About · Advertising · Developers · Careers · Privacy · Terms · Help

Chat (1)

Find: — Next · Previous · Highlight all · □ Match case

Transferring data from pixel.facebook.com...

8) User uploads photos



Mozilla Firefox

http://www.facebook.com/editalbum.php?&aid=196693&add=1&created=1

http://www.faceb...add=1&created=1

facebook | Search | Home

Upload Photos - Pictures

Add Photos | Organize | Edit Info | Delete — Back to Album

Select Photos — You can upload JPG, GIF or PNG files under 5 MB.

You can select multiple photos in the dialog by holding the 'ctrl' key down while clicking on the files.

Upload Photos

Trouble uploading photos? Try the Simple Uploader or the Java Uploader

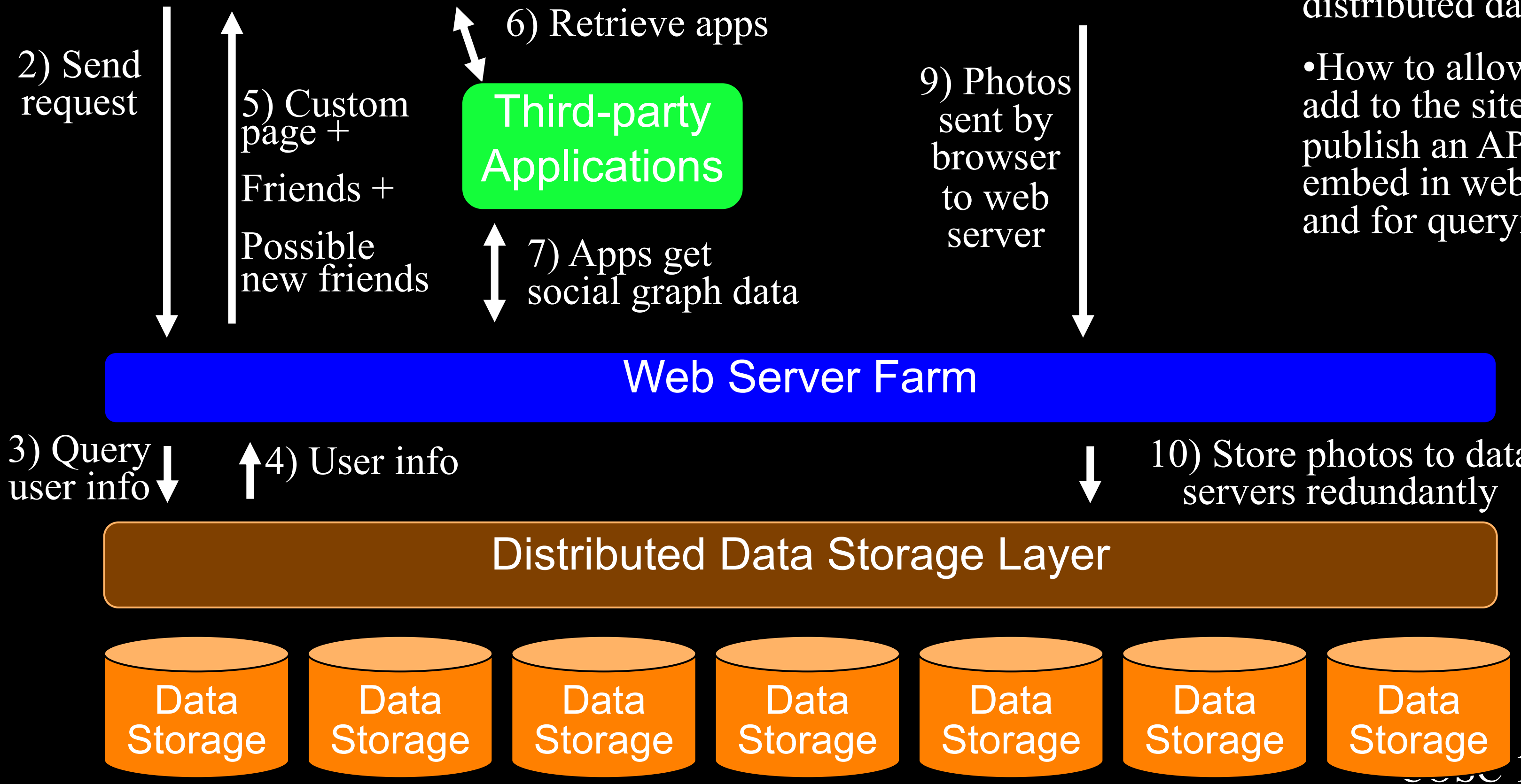
Chat (1)

Find: — Next · Previous · Highlight all · □ Match case

Transferring data from pixel.facebook.com...

Facebook CS Challenges:

- How to support a billion users? **Answer:** server farms, clusters, cloud computing
- How to store and retrieve massive amounts of data (photos)? **Answer:** beyond relational DBMSs, distributed data stores
- How to allow developers to add to the site? **Answer:** publish an API with code to embed in web sites (FBML) and for querying (FQL)



2) Send request

5) Custom page + Friends + Possible new friends

6) Retrieve apps

7) Apps get social graph data

9) Photos sent by browser to web server

3) Query user info

4) User info

10) Store photos to data servers redundantly

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How do they make money?

Facebook and Google make billions of dollars of revenue from advertising.

Facebook advertising

- primarily **banner advertising** (display ads) and advertising **in news feed**.
- A company gets paid for banner advertising based on the **number of displays ("impressions")** and the **number of user clicks ("click throughs")**.
  - "*Click through*" rates may be as low as 0.05% (Facebook). Each click may only represent $0.10 to $0.50 of revenue.

Google advertising

- primarily as **sponsored results**.
- Google gets paid each time a user clicks on a sponsored link.
  - A user clicks these ads an average of 8% of the time

Companies make money due to the billions of page views and clicks.

Twitter Overview

Twitter is a social networking and blogging service that allows users to send and read user messages called tweets.

- ***Tweets*** are displayed on an user's page and can be up to 140 characters long (due to SMS compatibility).
- Users may subscribe (*followers*) to other user tweets.
- Tweets can be sent via the website, external applications (for smartphones/PCs), and the Short Message Service (SMS).
- Service is free but may be charged to use SMS or phone fees.
- Created in 2006 by Jack Dorsey.
- Currently has more than 500 million users and over 350 million tweets per day.

Twitter – How it Works

1) User **A** registers and follows user **B** (twitter.com)

2) Send request

3) Register user A and follows B

4) User B's tweets

5) Confirmation + latest tweets

Web Server

User + Message Database

6) User **B** tweets on phone. Message sent on control channel to tower.

7) Tower sends to Short Message Service Center. Performs store and forward.

SMSC

8) Message sent to Twitter's SMS handler.

Twitter – SMS Interface

9) Message stored in DB.

10) Outbound message to user A

11) User B's tweet sent to SMSC for User A's network.

SMSC

12) Message delivered to User A when "online".

Compared to what we know:

- SMS is a ***protocol***. Protocol affects size of messages sent.
- Transmission of message free for providers, but costs are very high relative to ***bandwidth***.

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BitTorrent Overview

BitTorrent is a peer-to-peer file sharing protocol for data distribution. It is estimated to be the majority of Internet traffic.

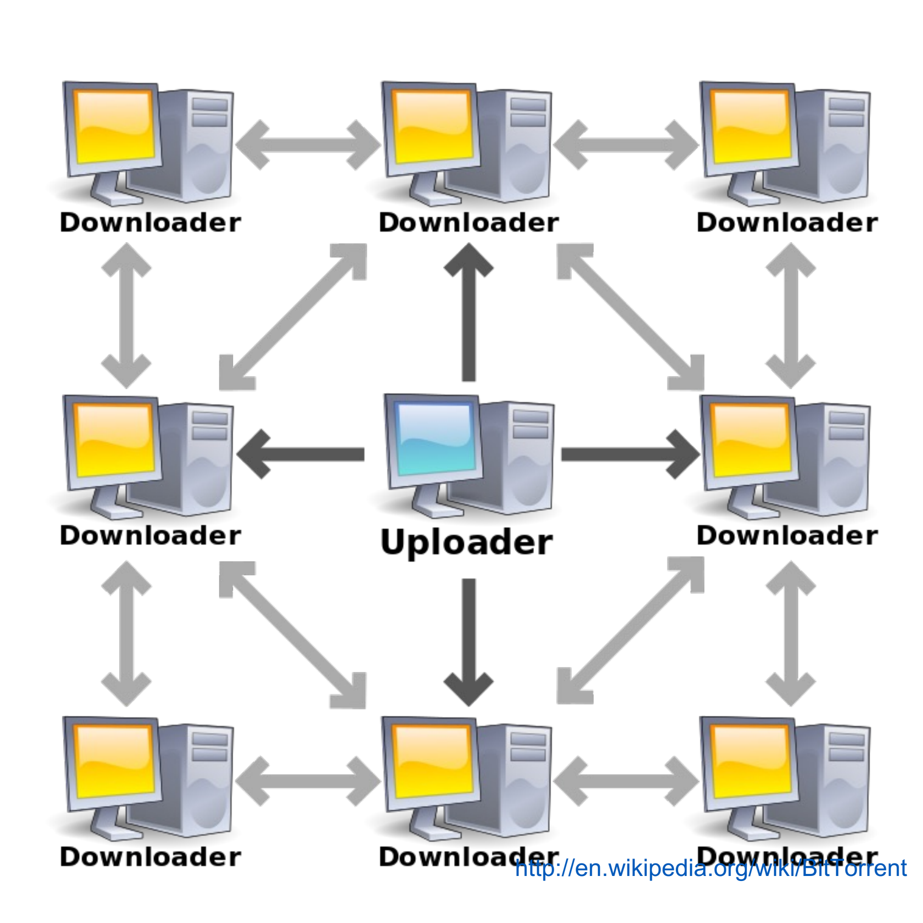
Basic idea: Instead of downloading a large file from one source, the file is downloaded in pieces from many sources and re-assembled. This improves performance and reliability.

A **BitTorrent tracker** is a server that keeps track of where file pieces reside on peer machines and which ones are available at time of the client request. A client need to first contact the tracker to initiate downloads.

BitTorrent™

How it works:

- 1) A user creates a torrent descriptor file of the file to be shared. The file itself is put on a **BitTorrent "seed" node** and divided into pieces.
- 2) Another user downloads the torrent descriptor file and begins to download the file pieces. It may acquire pieces from other peers that had previously downloaded the file.
- 3) Once a peer has the complete file, it can function as a seed.



http://en.wikipedia.org/wiki/BitTorrent

iPhone Overview

The ***iPhone*** is a ***smartphone*** manufactured by Apple that supports voice, text, browsing, email, and Wi-Fi. Distinctive features include its multi-touch screen, virtual keyboard, and thousands of third-party applications ("apps").

Smartphones are mini-computers that have an operating system capable of running programs both within and outside of a web browser.

- A major battle for market share between operating systems: Android, iPhone, Microsoft, Blackberry.

These devices are chosen more for their program capabilities and user interface features than phone service provider plans.

iPhone
How it Works – Apps

1) An iPhone application is built by a developer in *Swift* or *Objective-C* programming language and compiled into a binary.

- Each smartphone platform supports a different language:
  - RIM/Android – Java

2) The application is verified by Apple, and if it passes, is loaded onto the App store.

3) Users search the store for applications and download and run the binary file on their device. An App runs on the device directly rather than in the browser.

What we have learned:

- Basic programming skills (can be extended to develop apps)
  - By 3rd year CS (or time on your own), you could do it.
- Hardware components and how computer works/run programs
- Components of applications and user interfaces

Conclusion

We have investigated how some of the most popular systems and applications work. Each system requires ***creativity*** and a significant software ***engineering effort*** to design and build it.

We saw how the concepts ***we have learned*** in programming, computer systems, and networking/Internet are used in these systems and the research/technical challenges being faced.

Operational systems are continually improved, fixed for errors, and must remain working all the time. It takes considerable resources and people to operate.

The popular systems typically started from basic ideas and were expanded over time. It has never been easier to create a system and scale it up to millions of users.

Objectives

- Understand some of the ideas behind common applications and systems and how it relates to the concepts discussed in the course.

COSC 122

Computer Fluency

Databases

Dr. Firas Moosvi

Acknowledgement: Original slides provided courtesy of Dr. Lawrence and Dr. Abdallah Mohamed.

Key Points

1) Databases allow for easy storage and retrieval of large amounts of information.

2) Relational databases organize data into tables consisting of rows and columns.

3) SQL is the common language to query a database for results.

What is a database?

A ***database*** is a collection of logically related data for a particular domain.

A ***database management system*** (***DBMS***) is software designed for the creation and management of databases.

- e.g. Oracle, DB2, Microsoft Access, MySQL, SQL Server

Bottom line: A ***database*** is the *data* stored and a ***database system*** is the *software* that manages the data.

Databases in the Real-World

Databases are everywhere. Examples:

- Online web sites such as Amazon, eBay, and Expedia track orders, shipments, and customers using databases.
  - eBay, with 5 petabytes (*Computerworld, Oct 14, 2008*)
- Retailers manage their products and sales using a database.
  - Wal-Mart, with 2.5 petabyte. (Computerworld, Oct 14, 2008)
  - Wal-Mart: Daily data from 800 million transactions by 30 million customers
- The university maintains all your registration information and marks in a database.

Can you think of other examples? What data do ***you*** have?

DBMS

A database management system provides *efficient*, *convenient*, and *safe multi-user* storage and access to *massive* amounts of *persistent* data.

Efficient - Able to handle large data sets and complex queries without searching all files and data items.

Convenient - Easy to write queries to retrieve data.

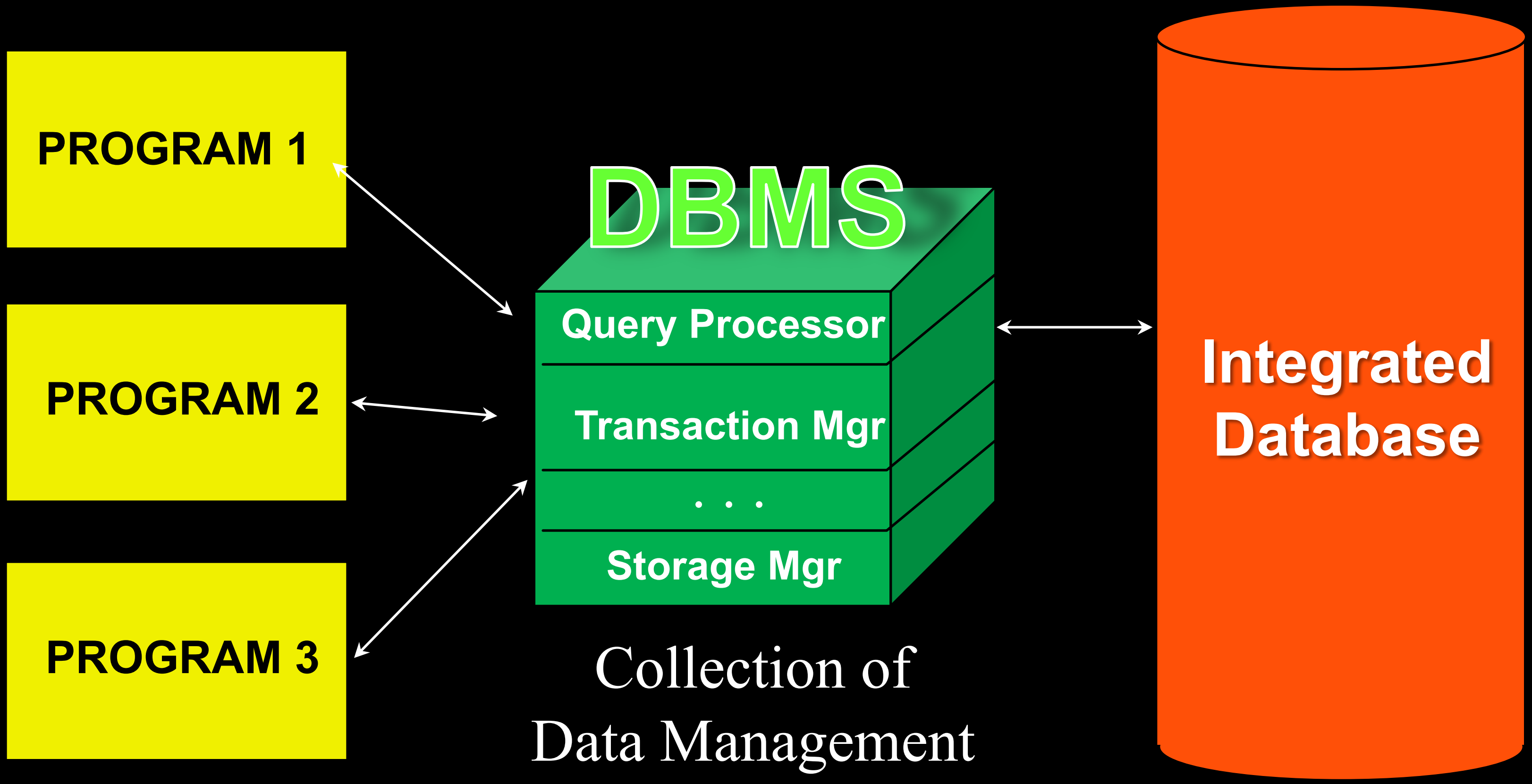
Safe - Protects data from system failures and hackers.

Massive - Database sizes in gigabytes and terabytes.

Persistent - Data exists even if have a power failure.

Multi-user - More than one user can access and update data at the same time while preserving consistency.

Database System Approach



Collection of Data Management Functions

Advanced: Databases and Abstraction

One of the major advantages of databases is they provide data abstraction.

- ***Data abstraction*** allows the implementation of an object to change without affecting programs that use the object through an external definition.

That is, as a database user or programmer, **you do not have to worry about how the data is stored or organized.**

A DBMS achieves data abstraction by allowing users to define the database and then handling all the low-level details of how to store it, retrieve it, and handle concurrent access to it.

The Relational Model: Terminology

The ***relational model*** organizes database information into tables called relations.

- The relational model was developed by E. F. Codd in 1970 and is used by almost all commercial database systems.

Terminology:

A ***relation*** is a table with columns and rows.

An ***attribute*** is a named column of a relation.

A ***tuple*** is a row of a relation.

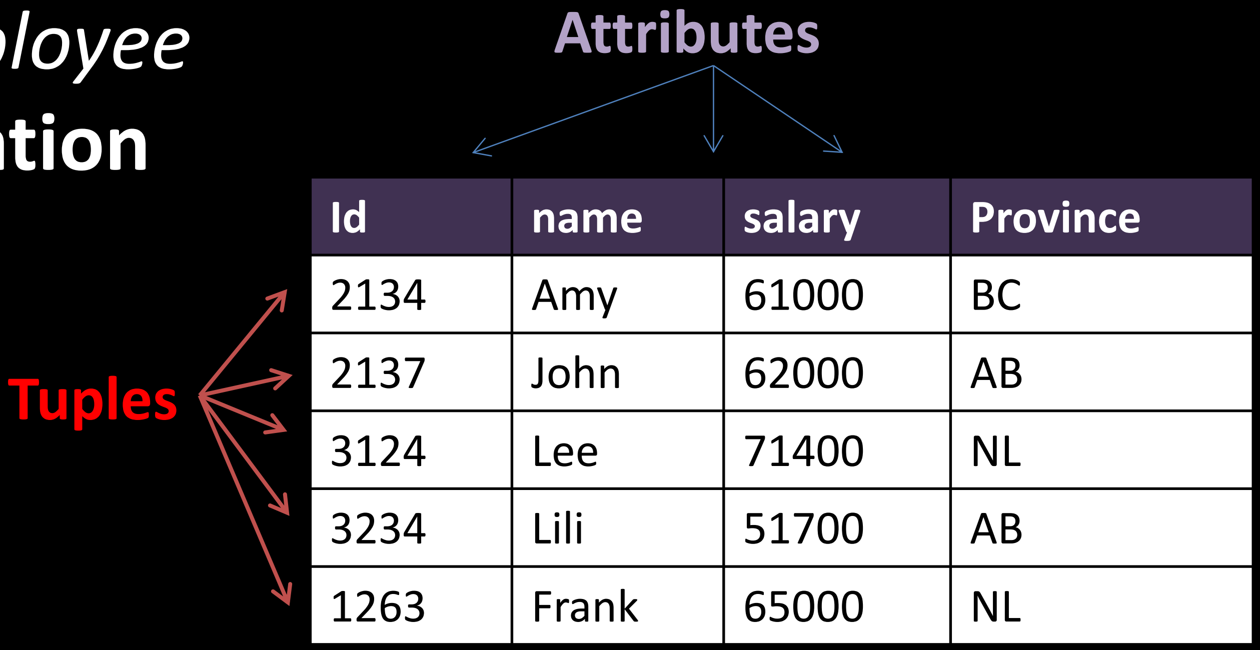
A ***domain*** is a set of allowable values for one or more attributes.

The ***degree*** of a relation is the number of attributes it contains.

The ***cardinality*** of a relation is the number of tuples it contains.

Relation Example

Employee
Relation



Attributes

Tuples

Id	name	salary	Province
2134	Amy	61000	BC
2137	John	62000	AB
3124	Lee	71400	NL
3234	Lili	51700	AB
1263	Frank	65000	NL

Degree = 4
Cardinality = 5

Domains of Employee Relation

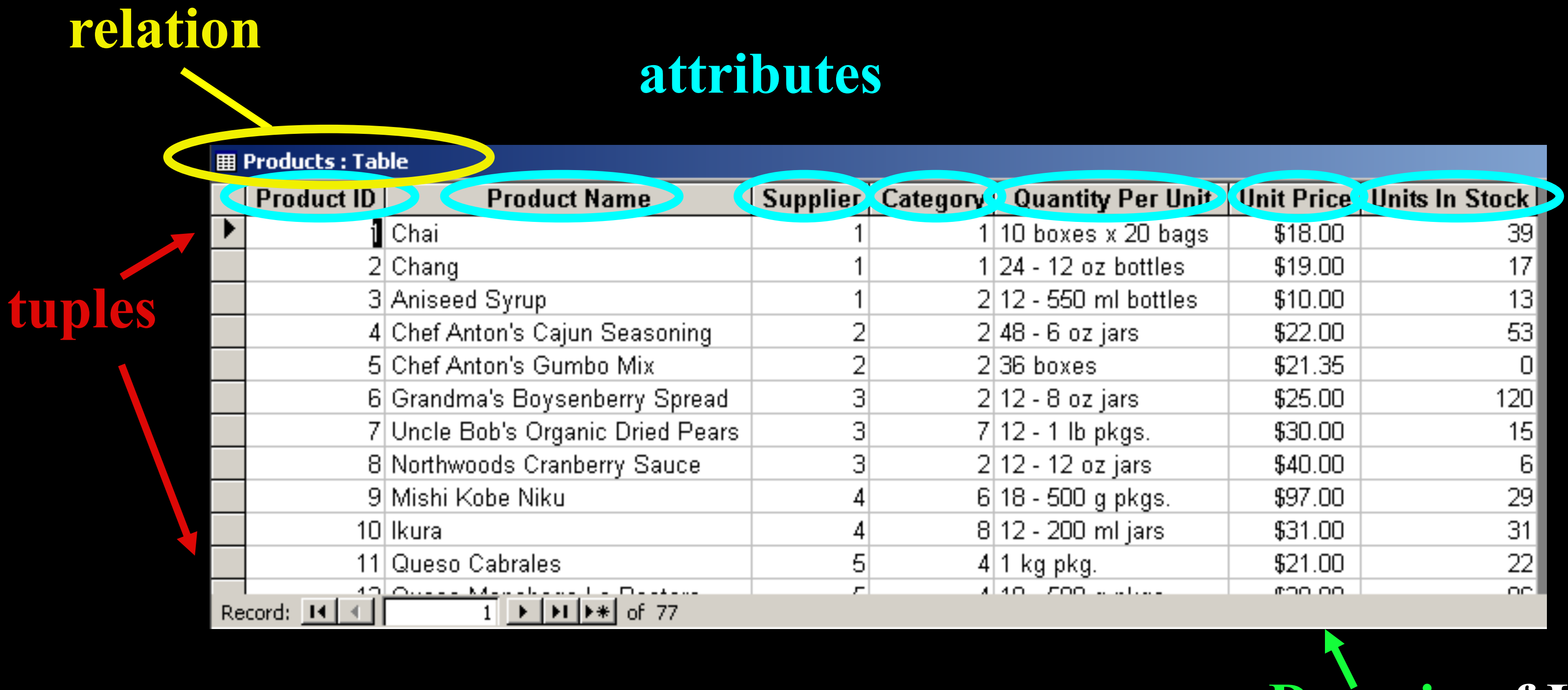
Id – *integer*

Name - string of alphabet characters

Salary - *currency.*

Province – set of provinces of Canada

Relation Example



relation

attributes

tuples

Products : Table

Product ID	Product Name	Supplier	Category	Quantity Per Unit	Unit Price	Units In Stock
1	Chai	1	1	10 boxes x 20 bags	$18.00	39
2	Chang	1	1	24 - 12 oz bottles	$19.00	17
3	Aniseed Syrup	1	2	12 - 550 ml bottles	$10.00	13
4	Chef Anton's Cajun Seasoning	2	2	48 - 6 oz jars	$22.00	53
5	Chef Anton's Gumbo Mix	2	2	36 boxes	$21.35	0
6	Grandma's Boysenberry Spread	3	2	12 - 8 oz jars	$25.00	120
7	Uncle Bob's Organic Dried Pears	3	7	12 - 1 lb pkgs.	$30.00	15
8	Northwoods Cranberry Sauce	3	2	12 - 12 oz jars	$40.00	6
9	Mishi Kobe Niku	4	6	18 - 500 g pkgs.	$97.00	29
10	Ikura	4	8	12 - 200 ml jars	$31.00	31
11	Queso Cabrales	5	4	1 kg pkg.	$21.00	22

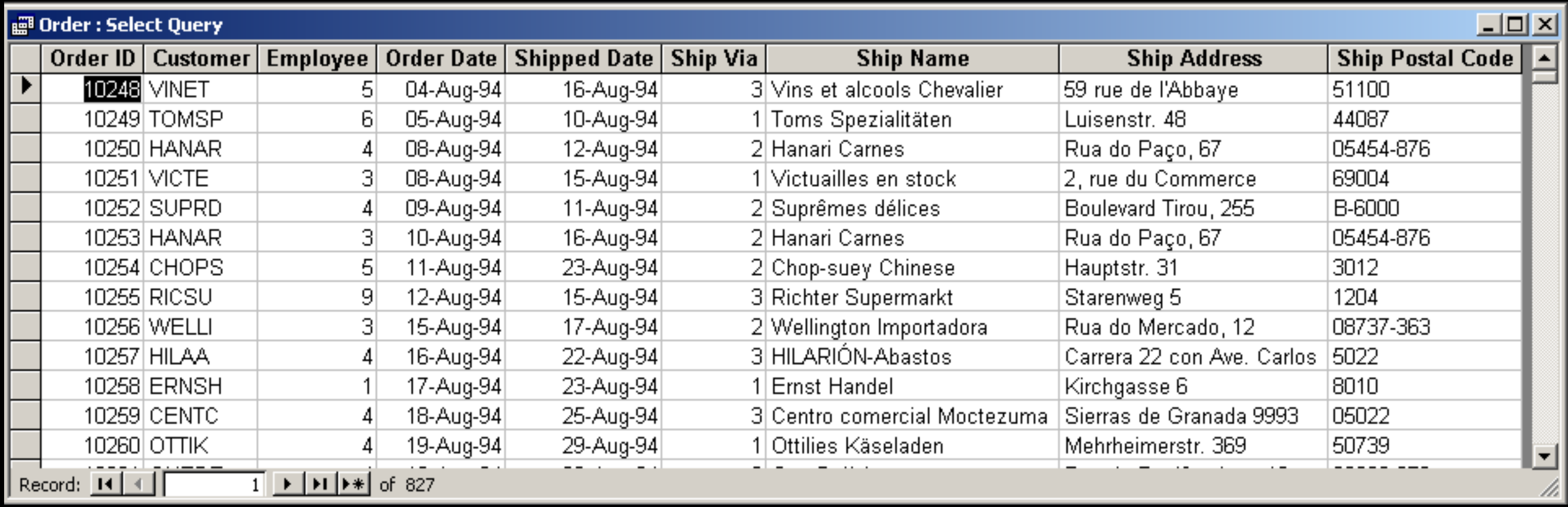
Record: |◀ ◀ 1 ▶ ▶| ▶* of 77

Domain of Unit Price is *currency*.

Degree = 7

Cardinality = 77

Relation Practice Questions



Order : Select Query

Order ID	Customer	Employee	Order Date	Shipped Date	Ship Via	Ship Name	Ship Address	Ship Postal Code
10248	VINET	5	04-Aug-94	16-Aug-94	3	Vins et alcools Chevalier	59 rue de l'Abbaye	51100
10249	TOMSP	6	05-Aug-94	10-Aug-94	1	Toms Spezialitäten	Luisenstr. 48	44087
10250	HANAR	4	08-Aug-94	12-Aug-94	2	Hanari Carnes	Rua do Paço, 67	05454-876
10251	VICTE	3	08-Aug-94	15-Aug-94	1	Victuailles en stock	2, rue du Commerce	69004
10252	SUPRD	4	09-Aug-94	11-Aug-94	2	Suprêmes délices	Boulevard Tirou, 255	B-6000
10253	HANAR	3	10-Aug-94	16-Aug-94	2	Hanari Carnes	Rua do Paço, 67	05454-876
10254	CHOPS	5	11-Aug-94	23-Aug-94	2	Chop-suey Chinese	Hauptstr. 31	3012
10255	RICSU	9	12-Aug-94	15-Aug-94	3	Richter Supermarkt	Starenweg 5	1204
10256	WELLI	3	15-Aug-94	17-Aug-94	2	Wellington Importadora	Rua do Mercado, 12	08737-363
10257	HILAA	4	16-Aug-94	22-Aug-94	3	HILARIÓN-Abastos	Carrera 22 con Ave. Carlos	5022
10258	ERNSH	1	17-Aug-94	23-Aug-94	1	Ernst Handel	Kirchgasse 6	8010
10259	CENTC	4	18-Aug-94	25-Aug-94	3	Centro comercial Moctezuma	Sierras de Granada 9993	05022
10260	OTTIK	4	19-Aug-94	29-Aug-94	1	Ottilies Käseladen	Mehrheimerstr. 369	50739

Record: 1 of 827

1) What is the name of the relation?

2) What is the cardinality of the relation?

3) What is the degree of the relation?

4) What is the domain of order date? What is the domain of order id?

Databases
Database and Database System

Question: Which of these two definitions below are an example of software?

A) database

B) database system

Databases
Database Properties

Question: True or False: The data in a database is lost when the power to the computer is turned off.

A) true

B) false

Databases
Database Properties (2)

Question: True or False: More than one user can use the database managed by the DBMS at the same time.

A) true

B) false

Databases
Definition Matching

Question: Given the three definitions, select the ordering that contains their related definitions.

Relation, Tuple, Attribute

A) column, row, table

B) row, column, table

C) table, row, column

D) table, column, row

Databases
Cardinality and Degree

Question: A database table has 10 rows and 5 columns. Select ***one*** true statement.

A) The table's degree is 50.

B) The table's cardinality is 5.

C) The table's degree is 10.

D) The table's cardinality is 10.

Relational Keys

Keys are used to ***uniquely identify*** a tuple in a relation.

A ***superkey*** is a set of attributes that uniquely identifies a tuple in a relation.

A ***key*** is a *minimal* set of attributes that uniquely identifies a tuple in a relation.

A *key* is always a *superkey*, but not vice versa.

Question:

- What is a key to identify a student in this class?

Databases
Keys and Superkeys (2)

Question: True or false: It is possible to have more than one key for a table and the keys may have different numbers of attributes.

A) true

B) false

Databases
Keys and Superkeys

Question: True or false: A key is always a superkey.

A) true

B) false

Example Relations

Relations:

emp (eno, ename, bdate, title, salary, supereno, dno)
proj (pno, pname, budget, dno)
dept (dno, dname, mgreno)
workson (eno, pno, resp, hours)

`Emp` - one row per employee storing name, birth date, supervisor, and department that they are in

`Proj` - one row per project storing name and its department

`Dept` - one row per department storing name and manager

`WorksOn` - stores that an employee works on a particular project for a certain amount of time in a given role

Note: Key fields are underlined.

Example Relation Instances

Emp Relation

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

WorksOn Relation

eno	pno	resp	hours
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36

Proj Relation

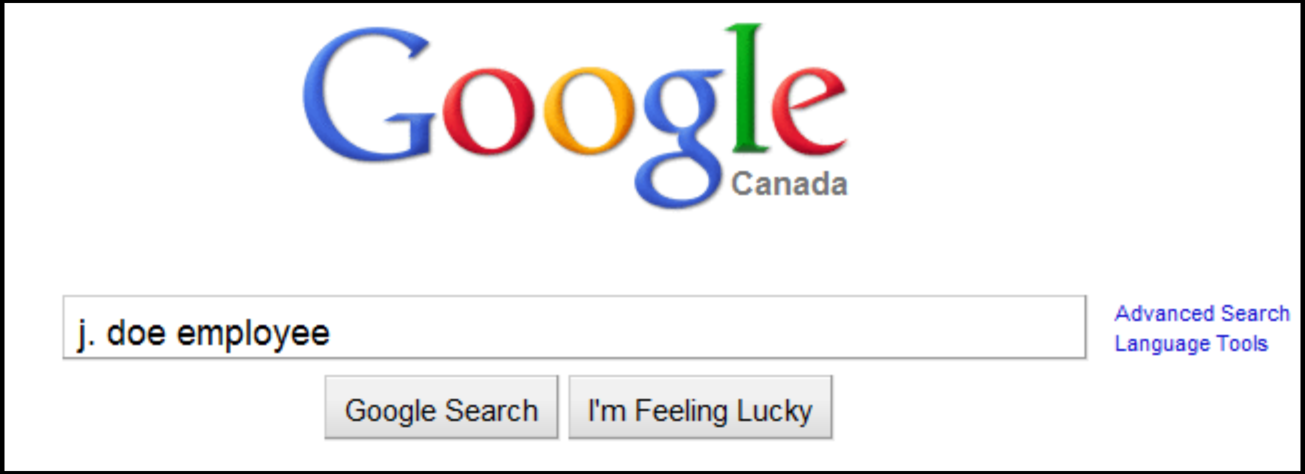
pno	pname	budget	dno
P1	Instruments	150000	D1
P2	DB Develop	135000	D2
P3	Budget	250000	D3
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

Dept Relation

dno	dname	mgreno
D1	Management	E8
D2	Consulting	E7
D3	Accounting	E5
D4	Development	null

A Simple Query Language: Keyword Searching

Keyword (or English-language) ***search*** allows a user to type keywords or phrases and returns a best answer estimate.


j. doe employee

This works fairly well for web searches, although we lack precision. Precision is required for many applications.

- Example: How would you return all employees with salary greater than 30,000 using keyword search?

SQL Overview

Structured Query Language or SQL is the standard database query language to retrieve *exact answers*.

- SQL is a ***declarative language*** (non-procedural).
  - A SQL query specifies ***WHAT*** to retrieve but ***not HOW*** to retrieve it.
- SQL is used by Microsoft Access.

Some basic rules for SQL statements:

- 1) There is a set of *reserved words* that cannot be used as names for database fields and tables.
  - `SELECT`, `FROM`, `WHERE`, etc.
- 2) SQL is generally *case-insensitive*.
  - Only exception is string constants. 'FRED' not the same as 'fred'.
- 3) SQL is *free-format* and white-space is ignored.

More about databases…

At the end of the slides for this week, there is some OPTIONAL content for you to explore if you're interested in databases!

Databases are fascinating structures and are the lifeblood of the internet, but are beyond the scope of COSC 122!

At UBCO, there is a whole course dedicated to Databases, COSC 304 taught by a leading expert in the field, Dr. Ramon Lawrence

Conclusion

A ***database*** is a collection of related data. A ***database system*** allows storing and querying a database.

The basic query operations are selection (subset of rows), projection (subset of columns), and join (combine two or more tables).

SQL is the standard query language for databases, although Microsoft Access also provides a graphical user interface.

Objectives

- Define: database, database system
- Explain how a DBMS achieves data abstraction.
- Define: relation, attribute, tuple, domain, degree, cardinality, superkey, key
- Given a relation, know its cardinality, degree, domains, and keys.

★

Given a relational schema and instance be able to translate very simple English queries into SQL.

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COSC 122
Computer Fluency

SQL (Optional content for 2022)

Dr. Firas Moosvi

Acknowledgement: Original slides provided courtesy of Dr. Lawrence and Dr. Abdallah Mohamed.

SQL Queries

A query in SQL has the form:

```
SELECT (list of attributes)
FROM    (list of tables)
WHERE  (filter conditions)
```

Notes:

- 1) Separate the list of attributes and list of tables by **commas**.
- 2) The "*" is used to select all attributes.

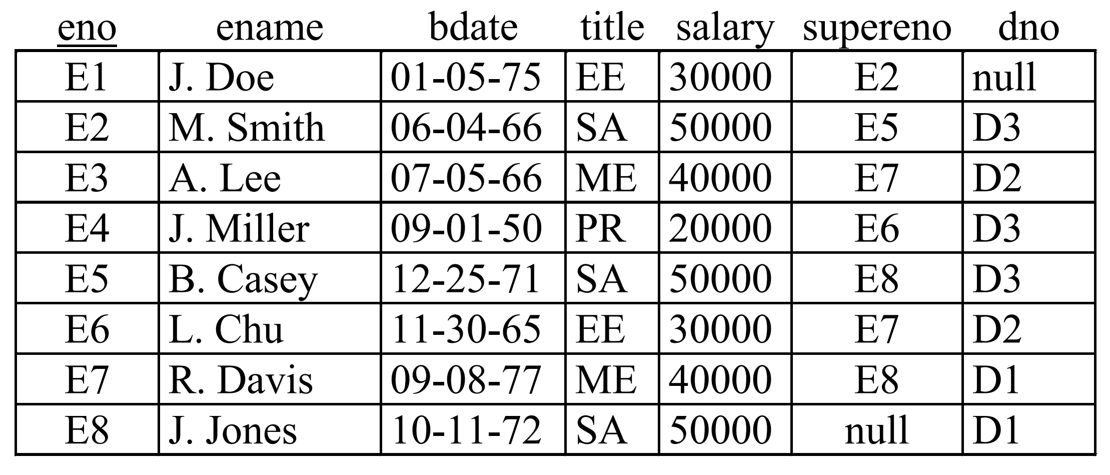
SQL
Retrieving Only Some of the Columns

The ***projection operation*** creates a new table that has some of the columns of the input table. In SQL, provide the table in the `FROM` clause and the fields in the output in the `SELECT`.

Example: Return only the `eno` field from the `Emp` table:

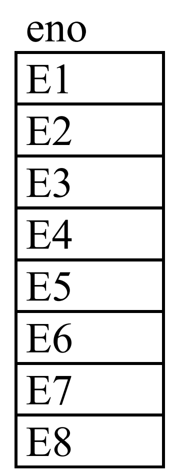
```
SELECT eno
FROM   emp
```

Emp Relation



eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

Result



eno
E1
E2
E3
E4
E5
E6
E7
E8

SQL Projection Examples

Emp Relation

eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

```
SELECT eno,ename
FROM   emp
```

eno	ename
E1	J. Doe
E2	M. Smith
E3	A. Lee
E4	J. Miller
E5	B. Casey
E6	L. Chu
E7	R. Davis
E8	J. Jones

```
SELECT title
FROM   emp
```

title
EE
SA
ME
PR
SA
EE
ME
SA

Note: Duplicates are not removed during SQL projection.

Databases
Projection

Question: Given this table and the query:

```
SELECT eno, ename, salary
FROM   emp
```

How many columns are returned?

A) 0

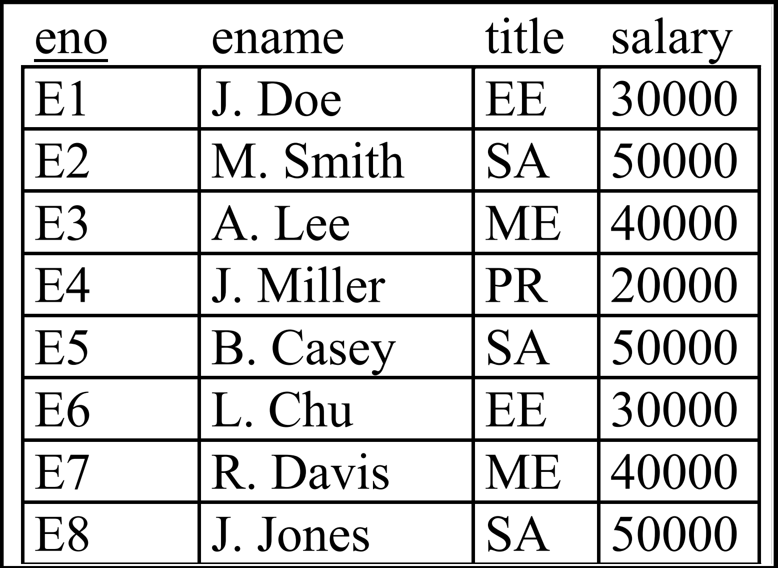
B) 1

C) 2

D) 3

E) 4

Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

Databases
Projection (2)

Question: Given this table and the query:

```
SELECT salary
FROM   emp
```

How many rows are returned?

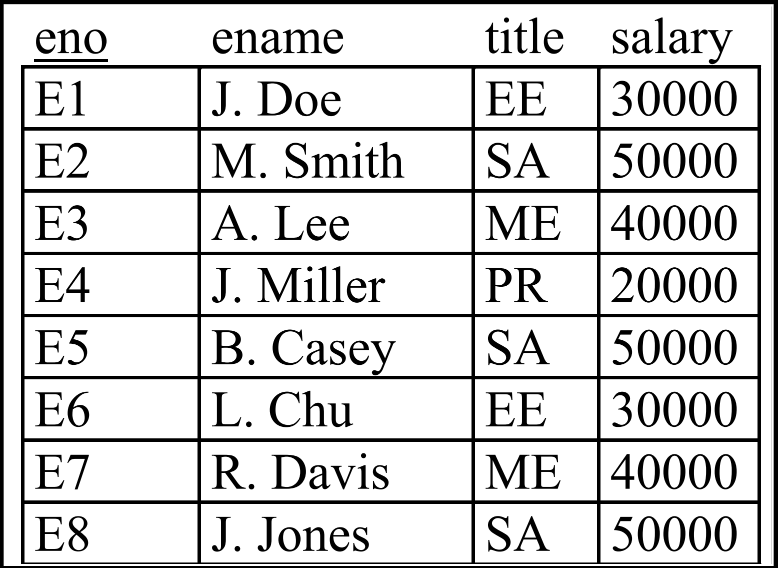
A) 0

B) 2

C) 4

D) 8

Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

SQL Projection Questions

WorksOn Relation

eno	pno	resp	dur
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P5	Engineer	23
E8	P3	Manager	40

Write the SQL statement that:

1) Returns only attributes *resp* and *dur*.

2) Returns only *eno*.

3) Returns only *pno*.

List the number of result rows and columns in each case.

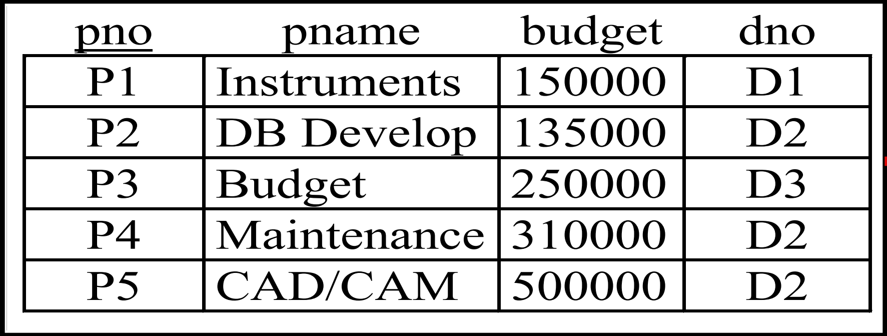
One Table Query Example
Retrieving Only Some of the Rows

The ***selection operation*** creates a new table with some of the rows of the input table. A condition specifies which rows are in the new table. The condition is similar to an `if` statement.

Example: Return the projects in department `'D2'`:

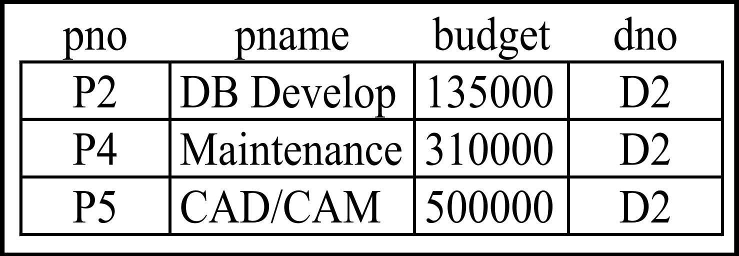
```
SELECT pno, pname, budget, dno
FROM   proj
WHERE  dno = 'D2';
```

Proj Relation



pno	pname	budget	dno
P1	Instruments	150000	D1
P2	DB Develop	135000	D2
P3	Budget	250000	D3
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

Result



pno	pname	budget	dno
P2	DB Develop	135000	D2
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

Algorithm: Scan each tuple and check if matches condition in `WHERE` clause.

Retrieving Only Some of the Rows Selection Conditions

The condition in a selection statement specifies which rows are included. It has the general form of an if statement.

The condition may consist of attributes, constants, comparison operators (`<`, `>`, `=`, `!=`, `<=`, `>=`), and logical operators (`AND`, `OR`, `NOT`).

SQL Selection Examples

Emp Relation

eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

```
SELECT eno, ename, title, salary
FROM   emp
WHERE  salary > 35000 OR
         title = 'PR'
```

eno	ename	title	salary
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

```
SELECT *
FROM   emp
WHERE  title = 'EE'
```

eno	ename	title	salary
E1	J. Doe	EE	30000
E6	L. Chu	EE	30000

Databases
Selection

Question: Given this table and the query:

```
SELECT *
FROM   emp
WHERE  title='EE'
```

How many rows are returned?

A) 0

B) 1

C) 2

D) 3

Emp Relation

eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

Databases
Selection

Question: Given this table and the query:

```
SELECT *
FROM   emp
WHERE  salary > 50000 or title='PR'
```

How many rows are returned?

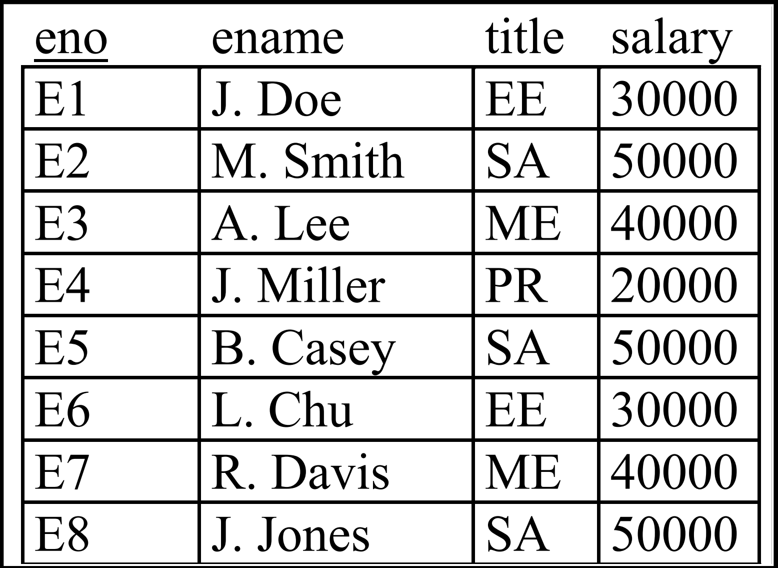
A) 0

B) 1

C) 2

D) 3

Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

Databases
Selection

Question: Given this table and the query:

```
SELECT *
FROM   emp
WHERE  salary > 50000 or title='PR'
```

How many columns are returned?

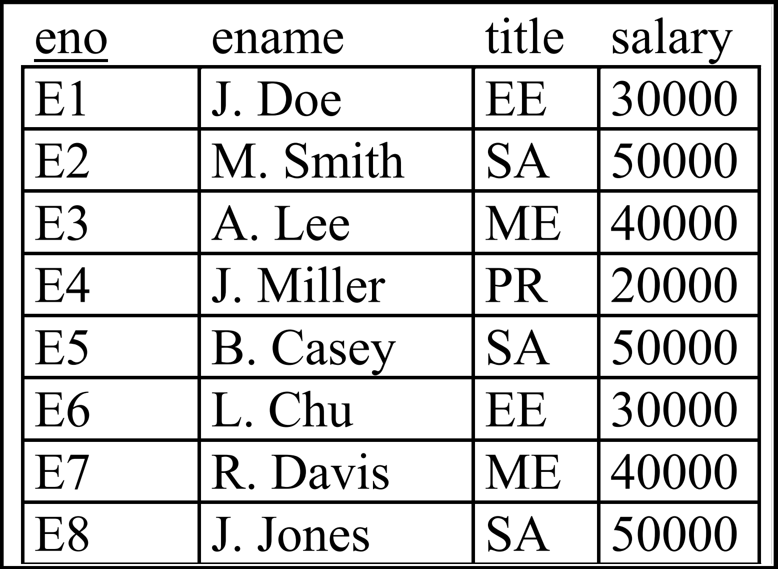
A) 0

B) 2

C) 3

D) 4

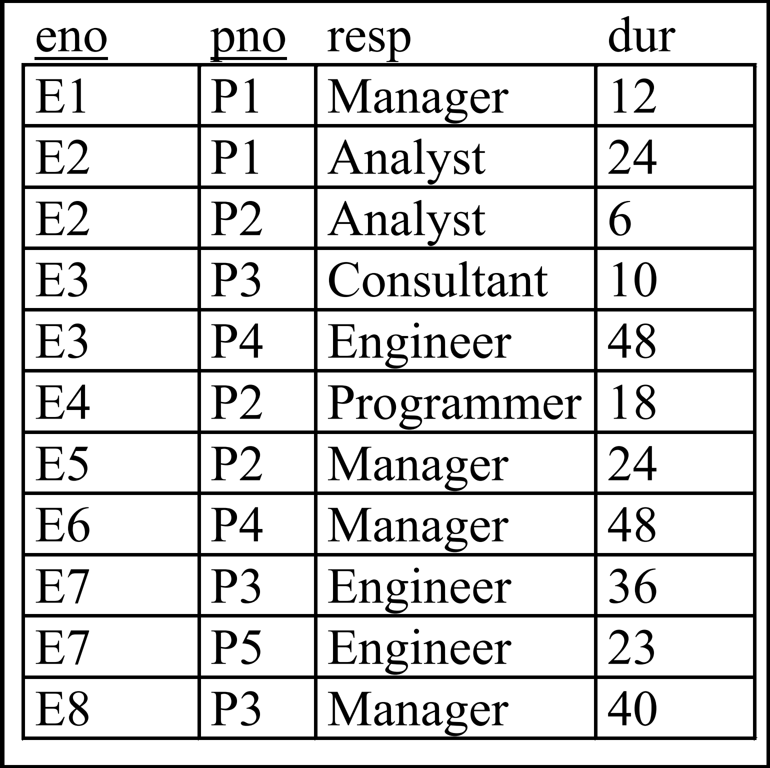
Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

SQL Selection Questions

WorksOn Relation



eno	pno	resp	dur
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P5	Engineer	23
E8	P3	Manager	40

Write the SQL statement that:

1) Returns all rows with a project `P2`.

2) Returns all rows with responsibility of a `Manager`.

3) Returns all rows with a responsibility of `Manager` **and** duration of more than `40` months.

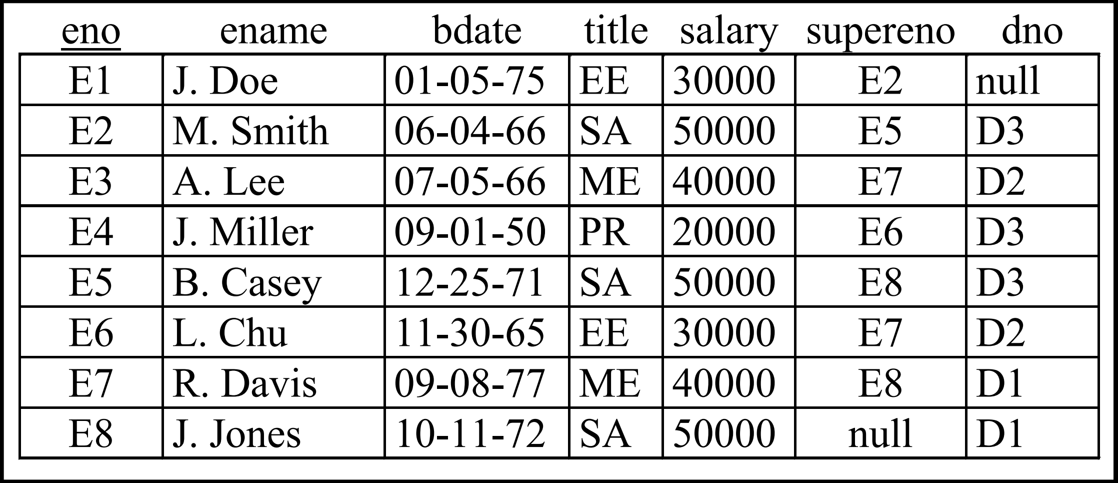
List the number of result rows for each case.

One Table Query Example
Retrieving Some of the Rows/Columns

Return the employee name and salary of all employees whose title is 'EE':

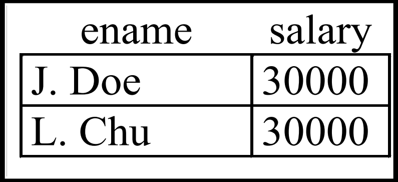
```
SELECT ename, salary
FROM   emp
WHERE  title = 'EE';
```

Emp Relation



eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

Result



ename	salary
J. Doe	30000
L. Chu	30000

One Table Query Examples

Return the birth date and salary of employee 'J. Doe':

```
SELECT bdate, salary
FROM   emp
WHERE  ename = 'J. Doe'
```

Return all information on all employees:

```
SELECT *
FROM   emp
```

* returns all attributes

Return the employee number, project number, and number of hours worked where the hours worked is > 50:

```
SELECT eno, pno, hours
FROM   workson
WHERE  hours > 50
```

Databases
Projection and Selection

Question: Given this table and the query:

```
SELECT eno, salary
FROM   emp
WHERE  salary >= 40000
```

What is the degree of the result?

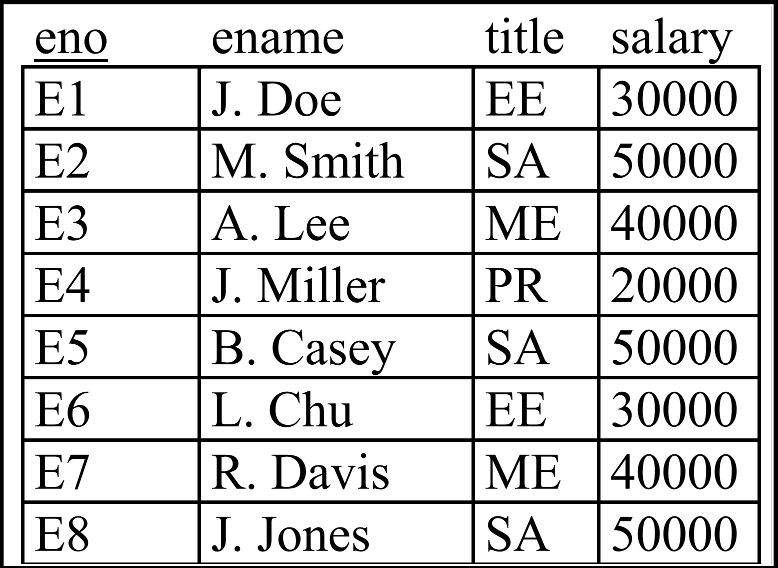
A) 2

B) 3

C) 4

D) 5

Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

Databases
Projection and Selection (2)

Question: Given this table and the query:

```
SELECT eno, salary
FROM   emp
WHERE  salary >= 40000
```

What is the cardinality of the result?

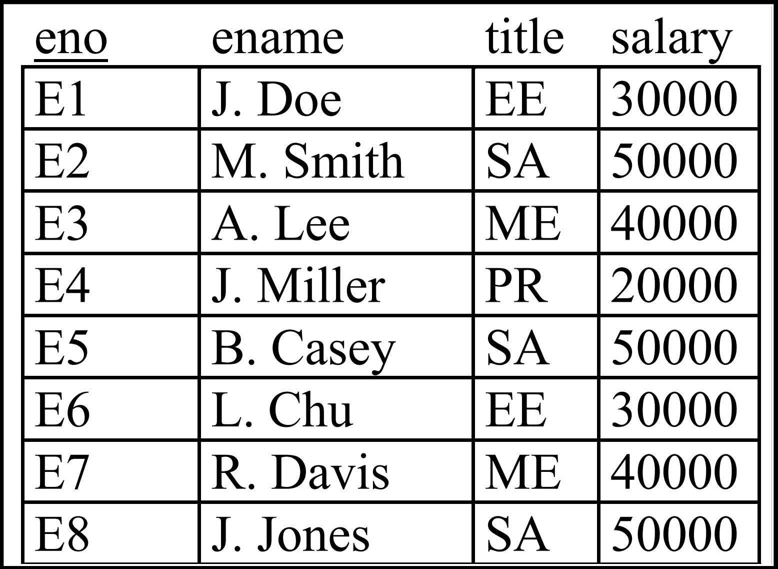
A) 2

B) 3

C) 4

D) 5

Emp Relation



eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

SQL Projection/Selection
One Table Questions

Relations:

emp (eno, ename, bdate, title, salary, supereno, dno)
proj (pno, pname, budget, dno)
dept (dno, dname, mgreno)
workson (eno, pno, resp, hours)

1) Returns all `employees` making more than $`50,000`.

2) Show the `WorksOn` records with less than `20` hours but more than `10` hours.

3) Return only the `pno` and `dno` for each `project`.

4) Return the name for each employee in department `'D1'`.

5) **Challenge:** Display the employees who (make less than $`40,000` or have title `'EE')` and are born after June 1, 1970.

- Dates are in `YYYY-MM-DD` format. e.g. `'1970-06-01'`

Join

A join combines two tables into a single table.

If the join has no condition that specifies which rows are in the result, all possible combinations of rows are in the result.

This is called a ***Cartesian or cross product***.

- If table *R* has *N* rows and *X* columns and table *S* has *M* rows and *Y* columns, then there are *N*M* rows and *X+Y* columns in the cross product result.

In SQL, a cross product is done automatically if you put more than one table in the `FROM` clause and do not specify a condition on how to combine them.

- In most cases, this is **NOT** what you want to do!

Cartesian Product SQL Example

Emp Relation

eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000

Proj Relation

pno	pname	budget
P1	Instruments	150000
P2	DB Develop	135000
P3	CAD/CAM	250000

```
SELECT *
FROM   emp, proj
```

eno	ename	title	salary	pno	pname	budget
E1	J. Doe	EE	30000	P1	Instruments	150000
E2	M. Smith	SA	50000	P1	Instruments	150000
E3	A. Lee	ME	40000	P1	Instruments	150000
E4	J. Miller	PR	20000	P1	Instruments	150000
E1	J. Doe	EE	30000	P2	DB Develop	135000
E2	M. Smith	SA	50000	P2	DB Develop	135000
E3	A. Lee	ME	40000	P2	DB Develop	135000
E4	J. Miller	PR	20000	P2	DB Develop	135000
E1	J. Doe	EE	30000	P3	CAD/CAM	250000
E2	M. Smith	SA	50000	P3	CAD/CAM	250000
E3	A. Lee	ME	40000	P3	CAD/CAM	250000
E4	J. Miller	PR	20000	P3	CAD/CAM	250000

Databases
Cartesian Product

Question: R is a relation with 10 rows and 5 columns. S is a relation with 8 rows and 3 columns.

What is the degree and cardinality of the cartesian product?

A) degree = 8, cardinality = 80

B) degree = 80, cardinality = 8

C) degree = 15, cardinality = 80

D) degree = 8, cardinality = 18

Equijoin

In most cases, you only want to combine two tables and have rows in the result that satisfy a certain condition.

The most common type of join is an ***equijoin*** that combines two tables by matching columns that have the same value.

- Equijoin gets its name because the columns are compared using the equality operator (=).
- e.g. `WorksOn.pno = Proj.pno`

Equijoin Example

WorksOn Relation

eno	pno	resp	dur
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P4	Engineer	48
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P4	Engineer	23

Proj Relation

pno	pname	budget
P1	Instruments	150000
P2	DB Develop	135000
P3	CAD/CAM	250000
P4	Maintenance	310000
P5	CAD/CAM	500000

```
SELECT *
FROM   WorksOn, Proj
WHERE  WorksOn.pno = Proj.pno
```

eno	pno	resp	dur	P.pno	pname	budget
E1	P1	Manager	12	P1	Instruments	150000
E2	P1	Analyst	24	P1	Instruments	150000
E2	P2	Analyst	6	P2	DB Develop	135000
E3	P4	Engineer	48	P4	Maintenance	310000
E5	P2	Manager	24	P2	DB Develop	135000
E6	P4	Manager	48	P4	Maintenance	310000
E7	P3	Engineer	36	P3	CAD/CAM	250000
E7	P4	Engineer	23	P4	Maintenance	310000

What is the meaning of this join?

Equijoin in SQL

There are **two ways** of using equijoin in SQL.

In `WHERE` clause:

```
SELECT *
FROM   WorksOn, Proj
WHERE  WorksOn.pno = Proj.pno
```

In `FROM` clause:

```
SELECT *
FROM   WorksOn JOIN Proj ON WorksOn.pno = Proj.pno
```

Can simplify syntax by using alias to shorten table name:

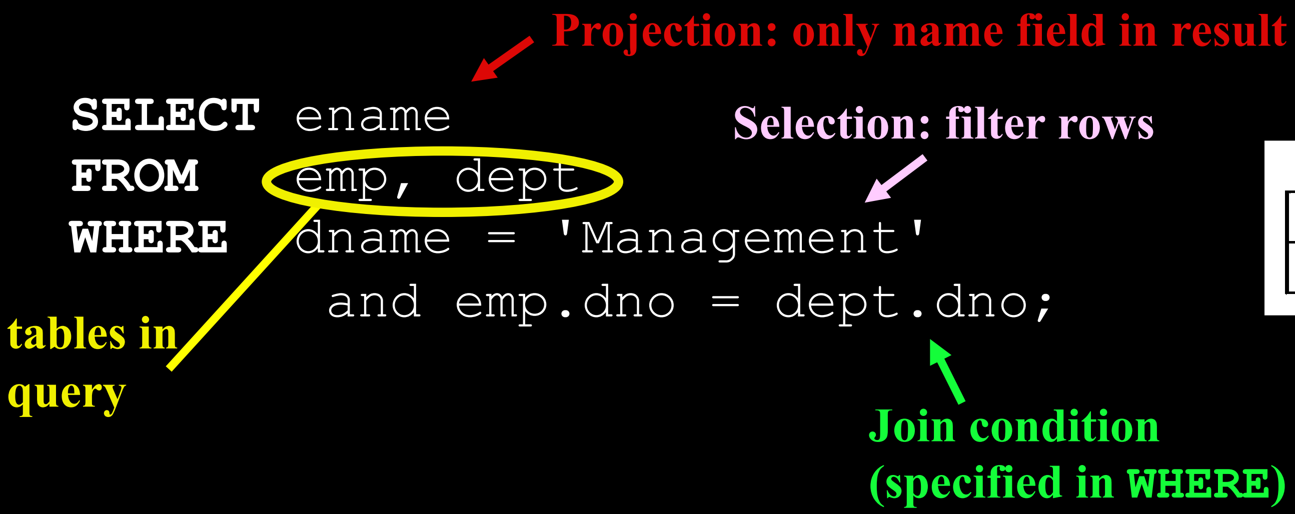
```
SELECT *
FROM   WorksOn AS W, Proj AS P
WHERE  W.pno = P.pno
```

Join Query with Selection Example

You can use join, selection, and projection in the same query.

- Recall: Projection returns columns listed in `SELECT`, selection filters out rows using condition in `WHERE`, and join combines tables in `FROM` using condition specified in `FROM` or `WHERE`.

Example: Return the employee names who are assigned to the 'Management' department.



```
SELECT ename
FROM   emp, dept
WHERE  dname = 'Management'
        and emp.dno = dept.dno;
```

Projection: only name field in result

Selection: filter rows

tables in query

Join condition (specified in **WHERE**)

Result

ename
R. Davis
J. Jones

Join Query Examples

Return the department names and the projects in each department:

```
SELECT dname, pname
FROM   dept, proj
WHERE  dept.dno = proj.dno
```

Return the employees and the names of their department:

```
SELECT ename, dname
FROM   emp JOIN dept ON emp.dno=dept.dno
```

Return all projects who have an employee working on them whose title is 'EE':

```
SELECT pname
FROM   emp, proj, workson
WHERE  emp.title = 'EE' and workson.eno=emp.eno
        and workson.pno = proj.pno
```

Join Practice Questions

Emp Relation

eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

WorksOn Relation

eno	pno	resp	dur
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P5	Engineer	23
E8	P3	Manager	40

Proj Relation

pno	pname	budget
P1	Instruments	150000
P2	DB Develop	135000
P3	CAD/CAM	250000
P4	Maintenance	310000
P5	CAD/CAM	500000

Compute the following joins (how many tuples?):

```
1) SELECT * FROM Emp JOIN WorksOn
                ON Emp.eno = WorksOn.eno
2) SELECT * FROM Emp, Proj, WorksOn
     WHERE Emp.eno = WorksOn.eno AND
           Proj.pno = WorksOn.pno
```

Ordering Result Data

The query result returned is not ordered on any column by default. We can order the data using the **ORDER BY** clause:

```
SELECT   ename, salary, bdate
FROM     emp
WHERE    salary > 30000
ORDER BY salary DESC, ename ASC;
```

- 'ASC' sorts the data in ascending order, and 'DESC' sorts it in descending order. The default is 'ASC'.
- The order of sorted attributes is significant. The first column specified is sorted on first, then the second column is used to break any ties, etc.

More Advanced Querying

There are many more queries that we can ask a database:

- compute expressions and functions
- group data by value and meaning
- compute summary (aggregate) functions (max, min, sum, etc.)
- subqueries (queries within queries)

We will not study the notation for this advanced querying.

Putting it All Together

The steps to write an English query in SQL are:

- 1) Find the columns that you need and put in `SELECT` clause.
- 2) List the tables that have the columns in the `FROM` clause. If there is more than one, join them together.
- 3) If you must filter rows, add a filter criteria in `WHERE` clause.

Example: List project name and budget where a ‘Manager’ is working on the project.

```
SELECT pname, budget
FROM   WorksOn, Proj
WHERE  resp='Manager' AND WorksOn.pno = Proj.pno
```

Practice Questions

Relational database schema:

emp (eno, ename, bdate, title, salary, supereno, dno)
proj (pno, pname, budget, dno)
dept (dno, dname, mgreno)
workson (eno, pno, resp, hours)

1) Return the project names that have a budget > 250000.
2) List all project names in department with name 'Accounting'.

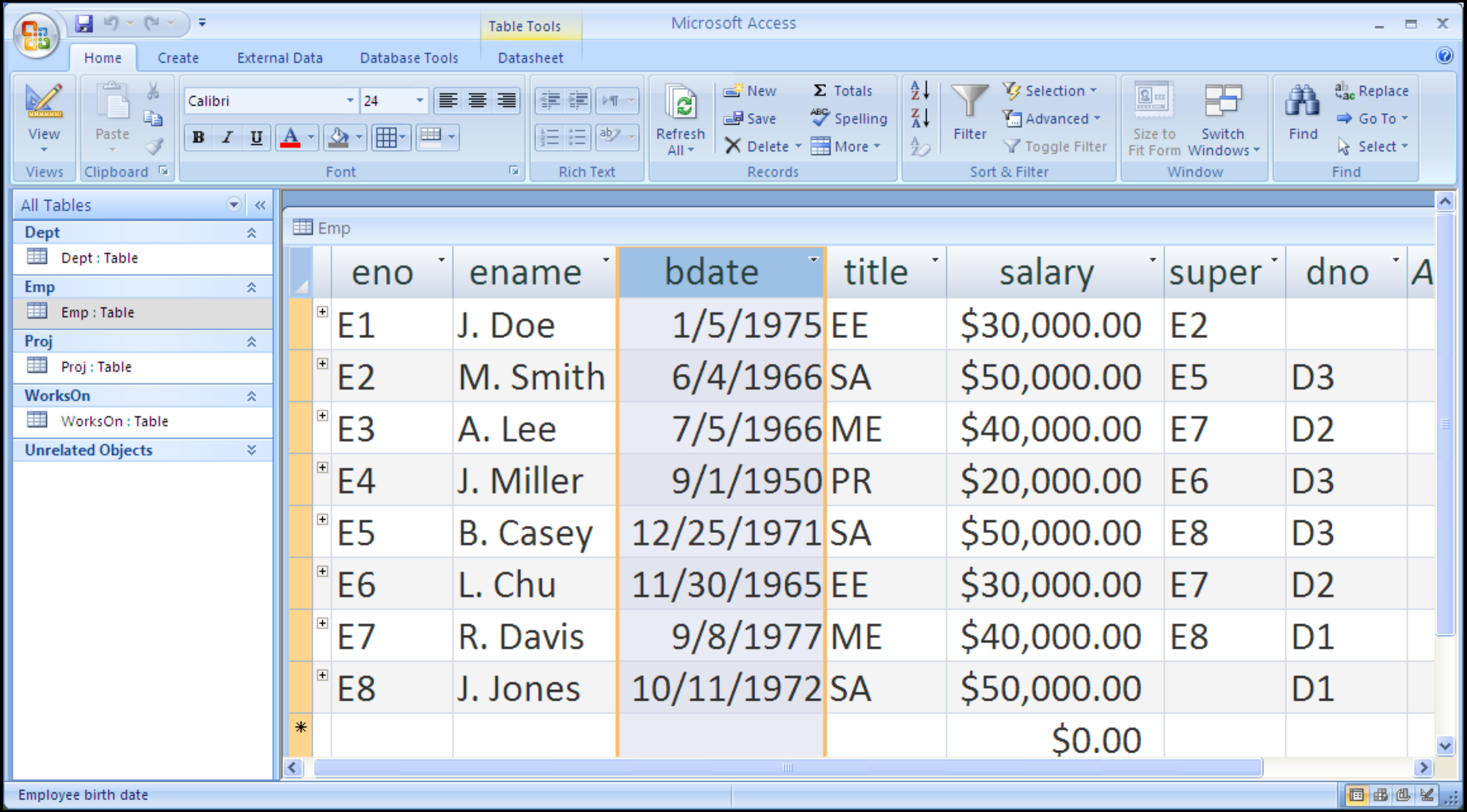
3) For employee 'M. Smith' list the project number and hours for all projects that he worked on.

4) Return a list of all department names, the names of the projects of that department, and the name of the manager of each department.

Microsoft Access

Microsoft Access is a simple database management system.

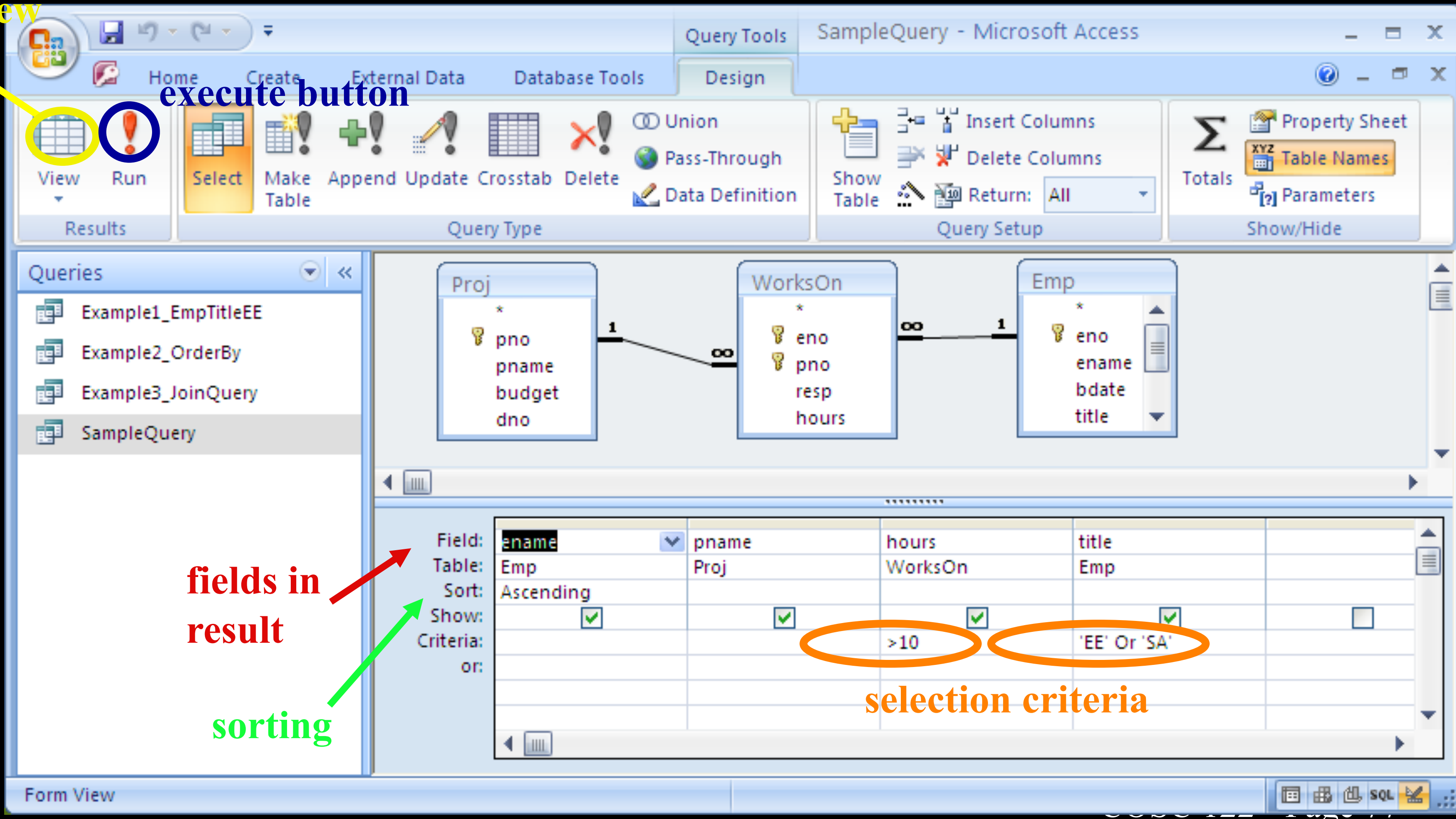
- It allows you to create databases, forms, reports, and programs.



eno	ename	bdate	title	salary	super	dno	A
E1	J. Doe	1/5/1975	EE	$30,000.00	E2		
E2	M. Smith	6/4/1966	SA	$50,000.00	E5	D3	
E3	A. Lee	7/5/1966	ME	$40,000.00	E7	D2	
E4	J. Miller	9/1/1950	PR	$20,000.00	E6	D3	
E5	B. Casey	12/25/1971	SA	$50,000.00	E8	D3	
E6	L. Chu	11/30/1965	EE	$30,000.00	E7	D2	
E7	R. Davis	9/8/1977	ME	$40,000.00	E8	D1	
E8	J. Jones	10/11/1972	SA	$50,000.00		D1	
				$0.00			

Microsoft Access Query Interface

Tables are boxes. Relationships are lines. Condition specified on bottom.



Field:	ename	pname	hours	title	
Table:	Emp	Proj	WorksOn	Emp	
Sort:	Ascending				
Show:	☑	☑	☑	☑	☐
Criteria:			>10	'EE' Or 'SA'	
or:					

switch view button

execute button

fields in result

sorting

selection criteria

Microsoft Access Querying Basics

1) Projection is performed by selecting the fields in the output in the field row in the table at the bottom of the screen.

2) Selection is performed by entering the condition in the criteria box. The criteria applies to the field in that column.

3) The tables used are added to the query by the **`Show Table…`** option.

4) Joins (based on relationships) are often automatically added, but if not, you can add them by selecting the join field in one table, holding the mouse button, then dragging to the join field in the other table.

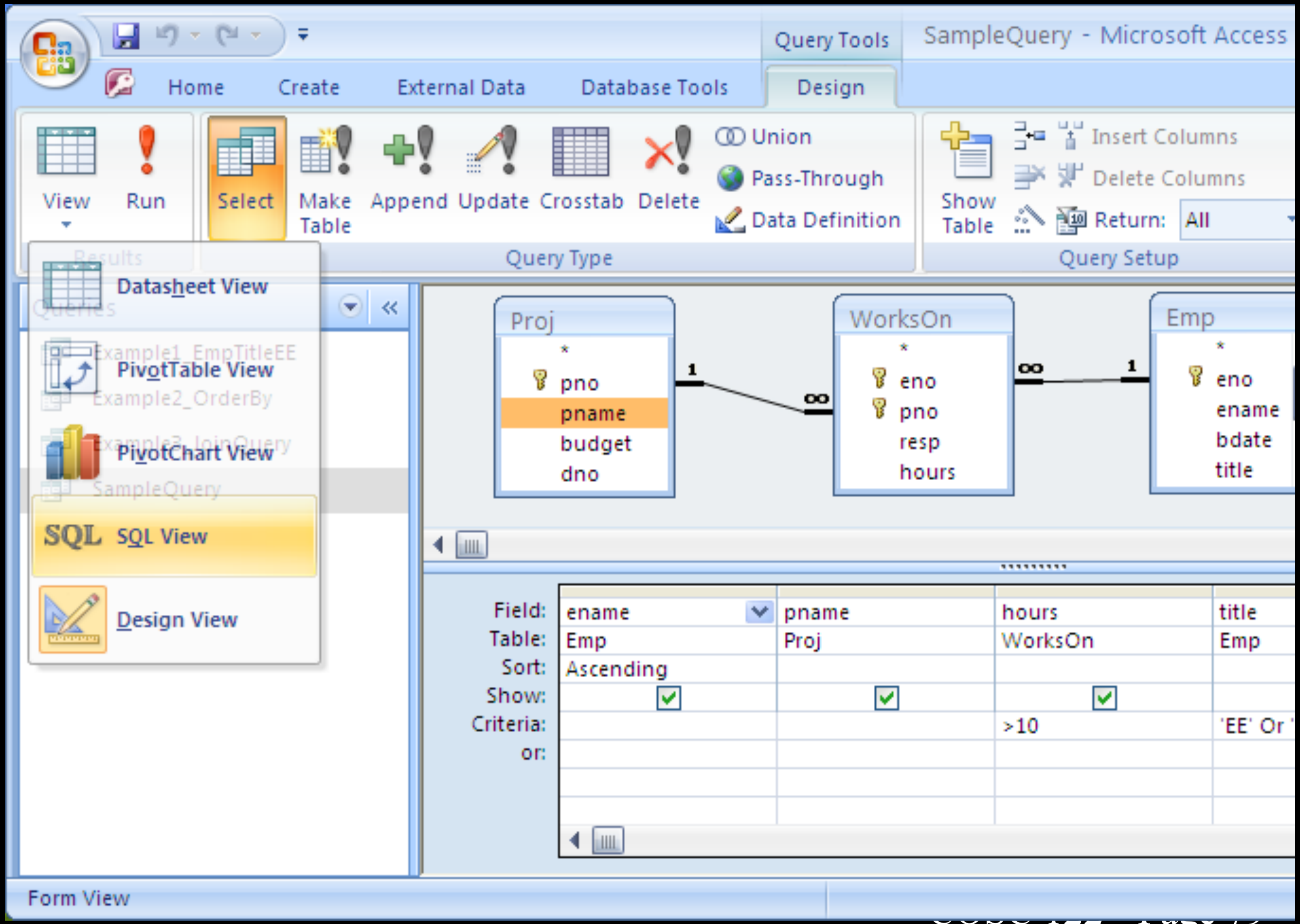
Microsoft Access Query Views

You may view your data, your query graphically, or your query in SQL.

show query result (data) →

show query in SQL →

show query graphically →



Field:	ename	pname	hours	title
Table:	Emp	Proj	WorksOn	Emp
Sort:	Ascending			
Show:	☑	☑	☑	
Criteria:			>10	'EE' Or '
or:				