

Relational Databases

CS 272 Software Development

Temporary Storage

- Information is stored in memory
 - *e.g. an inverted index*
 - *e.g. loading a file into memory*
- Provides fast access to information
- Disappears when program exits or system powered off



Persistent Storage

- Information is stored on disk (may be distributed)
 - *e.g. a file saved on a hard drive*
 - *e.g. a file saved on a USB flash drive*
- Provides slower access to information
- Persists when program exits or system powered off



Flat Files

- Several disconnected tables stored as text
 - *e.g. comma-separated values (csv)*
- Time consuming to find data
- Complex to manage consistency across files
- Complex to manage concurrency within a file



Flat Files

Customer File

Customer ID	Company Name	Contact First Name	Contact Last Name	Job Title	City	State
6	Company F	Francisco	Pérez-Olaeta	Purchasing Manager	Milwaukee	WI
26	Company Z	Run	Liu	Accounting Assistant	Miami	FL

Employee File

Employee ID	First Name	Last Name	Title
2	Andrew	Cencini	Vice President, Sales
5	Steven	Thrope	Sales Manager
9	Anne	Hellung-Larsen	Sales Representative

Product File

Product ID	Product Code	Product Name	Category	Quantity Per Unit	List Price
5	NWTO-5	Northwind Traders Olive Oil	Oil	36 boxes	\$21.35
7	NWTFREN7	Northwind Traders Dried Beans	Dried Fruit & Nuts	12 1 lb. boxes	\$20.00

"[Databases A Beginner's Guide](#)" by Andy Oppel, McGraw-Hill, 2009



Flat Files

Order File

Order ID	Customer ID	Employee ID	Order Date	Shipped Date	Shipping Fee
51	26	9	4/5/2006	4/5/2006	\$60.00
56	6	2	4/3/2006	4/3/2006	\$0.00
79	6	2	6/23/2006	6/23/2006	\$0.00

Order Detail File

Order ID	Product ID	Unit Price	Quantity
51	5	\$21.35	15
51	41	\$9.65	21
51	40	\$18.40	2
56	48	\$12.75	20
79	7	\$30.00	14
79	51	\$53.00	8

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Relational Tables

Customer Table

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Order Table

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Database Management System

- Handles data storage, maintenance, and retrieval
- Manages concurrent data access
- Transactions are atomic (all-or-nothing)
- Often separate physical, logical, and external layers
 - *e.g. how data is stored separate from how it is viewed*



Relational DBMS

- Supports relationships between tables
 - *e.g. one-to-one, one-to-many, many-to-many*
- Able to join data across tables together using queries
- Stable and mature with many providers
 - *e.g. MySQL or MariaDB, PostgreSQL, SQL Server, Oracle, IBM DB2, SQLite, ...*

<https://docs.oracle.com/javase/tutorial/jdbc/overview/database.html>



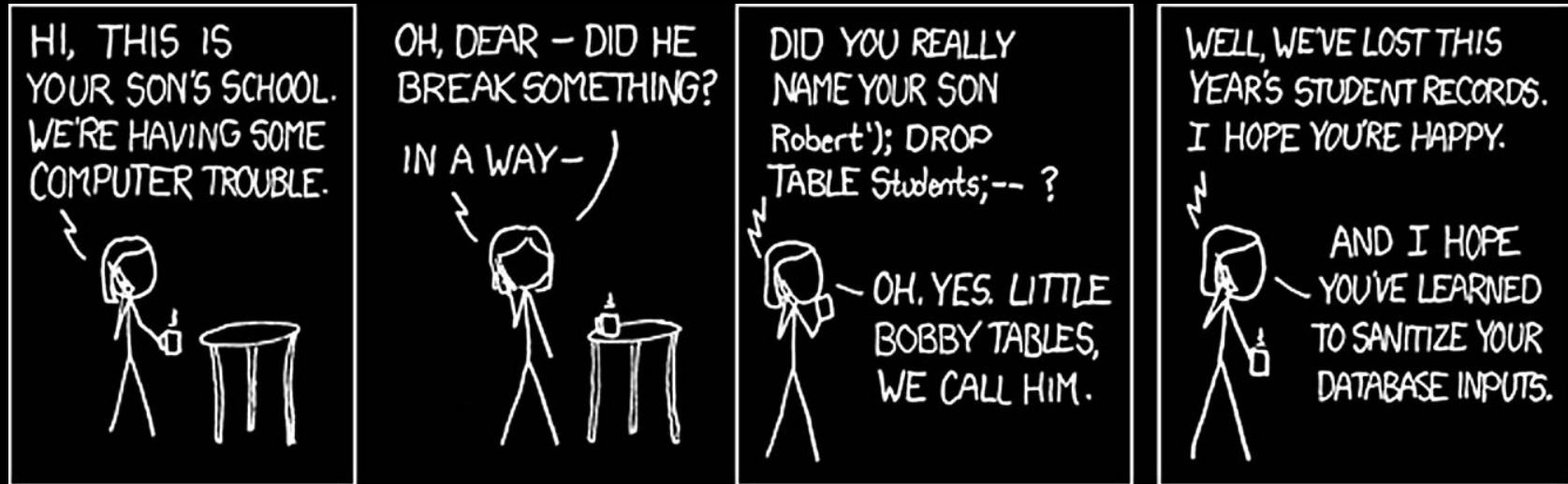
Top 10 Security Flaws

1. Broken Access Control
2. Cryptographic Failures
3. Injection (XSS, SQL, ...)
4. Insecure Design
5. Security Misconfig
6. Vulnerable and Outdated Components
7. Identification/Authentication Failures
8. Software/Data Integrity Failures
9. Security Logging/Monitoring Failures
10. Server-Side Request Forgery (SSRF)

<https://owasp.org/www-project-top-ten/>



Bobby Tables



<https://xkcd.com/327/>

Sweden Election Hack

```

mstad;02;Halmstads östra valkrets;0801;Trönninge;Piratpartiet;1
mstad;02;Halmstads östra valkrets;0801;Trönninge;Piratpartiet;1
mstad;01;Halmstads västra valkrets;0902;Söndrum 2;Piratpartiet;1
mstad;01;Halmstads västra valkrets;0902;Söndrum 2;Feministiskt initiativ;1
mstad;01;Halmstads västra valkrets;0903;Söndrum 3;Feministiskt initiativ;3
mstad;01;Halmstads västra valkrets;0903;Söndrum 3;Piratpartiet;1
mstad;01;Halmstads västra valkrets;0903;Söndrum 3;Syndikalisterna;1
mstad;01;Halmstads västra valkrets;0904;Söndrum 4;pwn DROP TABLE VALJ;1
mstad;01;Halmstads västra valkrets;0904;Söndrum 4;pwn DROP TABLE VALJ;1
mstad;01;Halmstads västra valkrets;0905;Söndrum 5;Feministiskt initiativ;1
mstad;01;Halmstads västra valkrets;0906;Söndrum 6;Feministiskt initiativ;1
mstad;01;Halmstads västra valkrets;1001;Holm-Vapnö;Raggarpartiet;1
mstad;01;Halmstads västra valkrets;1001;Holm-Vapnö;Raggarpartiet;1
mstad;01;Halmstads västra valkrets;1101;Harplinge;Skånepartiet;1
mstad;01;Halmstads västra valkrets;1101;Harplinge;Piratpartiet;2

```

<https://www.wired.co.uk/article/sweden-election-hack>



Traffic Cameras



<https://gizmodo.com/sql-injection-license-plate-hopes-to-foil-euro-traffic-5498412>

Other Considerations

- Database design, optimization, theory, implementation
 - *e.g. CS 333 Introduction to Database Systems*
- Non-Relational (NoSQL) Databases
 - *e.g. column/distributed (e.g. Cassandra), document (MongoDB), graph (Neo4j), key/value (Dynamo), ...*



CS Database Accounts

- Lookup username on course website
- Log into a CS vlab computer
 - `ssh user###@stargate.cs.usfca.edu`
 - `ssh user###@vlab##.cs.usfca.edu`
- Log into database server
 - `mysql -h sql -u user### -D user### -p`



Questions?

