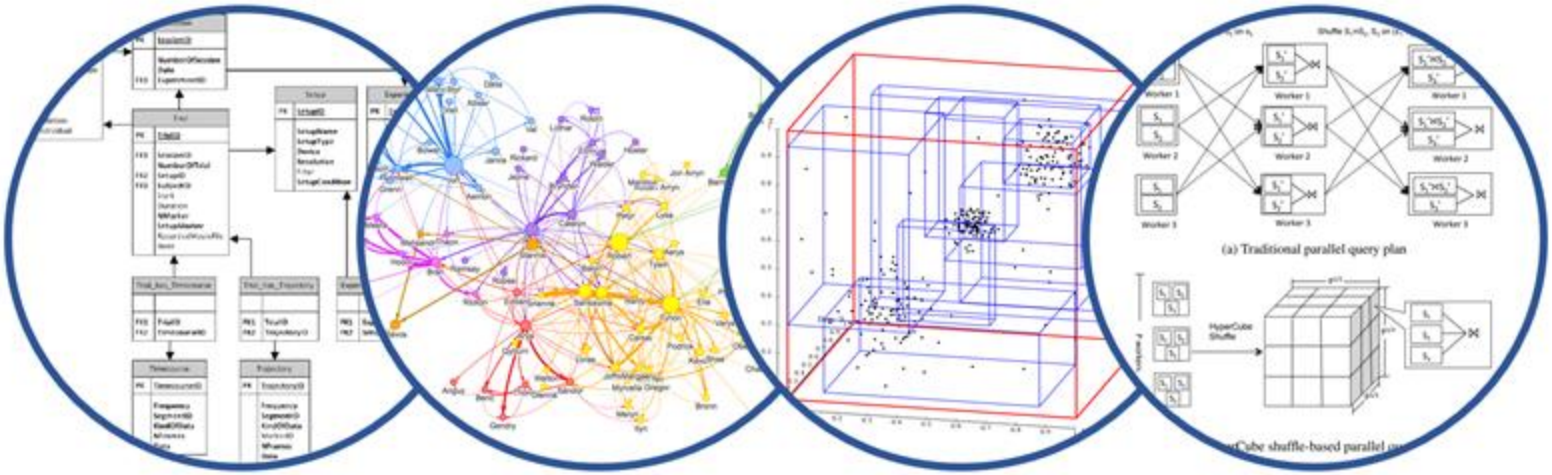

Introduction to Data Management

Application Data Management

Amal Jacob, Guest Lecturer

Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

Announcements

- HW5 is due on Friday
- HW6 M1 will be released end of this week
  - HW6 is substantial - don’t procrastinate
  - **No late days for M1**
- Go to section!
  - Connect to Azure + setup, demo, useful tips

Agenda

- **Access Control**
- Passwords
- Data Privacy

DBMS controls

- Block unauthorized access
  - Tiered-access hierarchy
- Usually a built-in access control

DBMS controls

- Block unauthorized access
  - Tiered-access hierarchy
- Usually a built-in access control
- HW3/HW6 autograder runs student submissions on staff tables in Azure
  - How do we protect from student INSERTs, DELETEs, etc. on read-only tables?

DBMS controls

Example: On Azure…

- Create a user

```
CREATE USER <username>
WITH PASSWORD = <password>
```

```
CREATE USER autograder
WITH PASSWORD = 'pass123'
```

DBMS controls

Example: On Azure…

- Create a user

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- Set permissions

```
GRANT <permissions>
ON <table>
TO <user/role>
```

```
GRANT SELECT
ON MySecureTable
TO autograder
```

DBMS controls

Example: On Azure…

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- Set permissions

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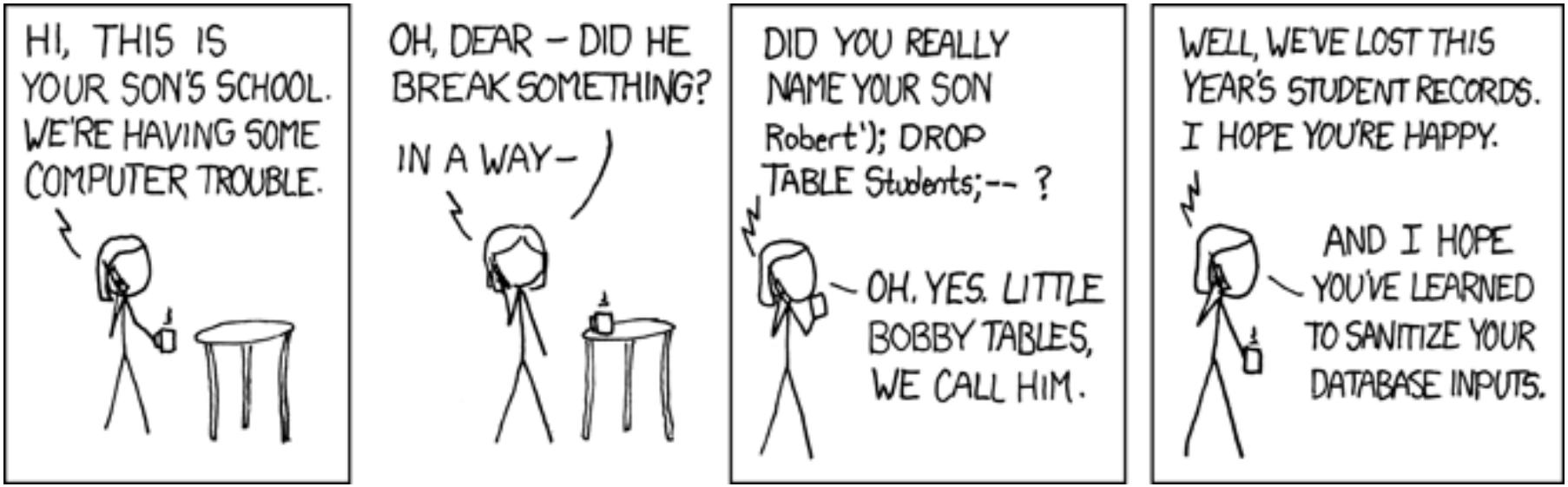
GRANT <permissions>
ON <table>
TO <user/role>
```

```
GRANT SELECT
ON MySecureTable
TO autograder
```

If you login to *autograder*, you won't be able to UPDATE, DELETE, etc.!

SQL Injection



SQL Injection

- **SQL Injection**: Application input acts as code
- In applications, SQL queries are strings
  - Partly consists of user input
- Malicious user can trick DBMS into thinking their input is part of SQL code

SQL Injection

- Example: School admin database

```
INSERT INTO Students (id, 'name');
```

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id = 123
name = "Robert');   DROP TABLE Students;--"
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SQL Injection

- Example: School admin database

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INSERT INTO Students (id, 'name');
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```

- Send application's query string to database:

```
INSERT INTO Students (123, 'Robert'); DROP TABLE Students;-- ');
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SQL Injection

- Example: School admin database

```
INSERT INTO Students (id, 'name');
```

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id = 123
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- Send application's query string to database:

```
INSERT INTO Students (123, 'Robert'); DROP TABLE Students;-- ');
```

```
INSERT INTO Students (123, 'Robert'); DROP TABLE Students;-- ');
```

SQL Injection

- Other types of SQL injections
  - Union attack, retrieve another table's data

```
SELECT username, email
FROM Users
WHERE id =
    'user1' UNION SELECT username, password FROM AdminUsers --';
```

SQL Injection

- Other types of SQL injections
  - Union attack, retrieve another table's data

```
SELECT username, email
FROM Users
WHERE id =
    'user1' UNION SELECT username, password FROM AdminUsers --';
```

  - Tautology attack, force TRUE condition to bypass filters

```
SELECT *
FROM Users
WHERE username = 'user1' OR 1 = 1 --' AND password = 'pass'
```

SQL Injection

- Consistently one of the top web-based attacks
  - In 2012, Yahoo! exposed ~450k emails/passwords
  - In 2011, Sony potentially exposed PII from 1M+ users
  - ~23% of all web vulnerabilities in 2023

SQL Injection

- Consistently one of the top web-based attacks
  - In 2012, Yahoo! exposed ~450k emails/passwords
  - In 2011, Sony potentially exposed PII from 1M+ users
  - ~23% of all web vulnerabilities in 2023

- Considered a “solved” problem
  - **Parameterize queries with prepared statements**

Java: JDBC

- Java API library to access DBMS
- PreparedStatement: prevent SQL injection attacks

Java: JDBC

- Java API library to access DBMS
- PreparedStatement: prevent SQL injection attacks

```
Statement withoutPlaceholder = con.createStatement();
withoutPlaceholder.execute("INSERT INTO Students VALUES('" + userInput + "')");

PreparedStatement withPlaceholder =
                 con.prepareStatement("INSERT INTO Student VALUES(?)");
withPlaceholder.setString(1, userInput);
withPlaceholder.execute();
```

Agenda

- Access Control
- **Passwords**
- Data Privacy

Storing Passwords

- Passwords are special
  - High potential for additional security compromises
  - Only operation that should be done is equality comparison

Storing Passwords

- Naive solution?

Storing Passwords

- Naive solution?

Username	Password
bobtheninja246	password
xDragonSlayerx	asdf
annabelle2001	password
lamamaster123	ilovefish
theSQLexpert234	j62ld12446
seahawksrule12	j62ld12446

Storing Passwords

NEVER store passwords in plaintext!!

Username	Password
bobtheninja246	password
xDragonSlayerx	asdf
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Hashing

- Hash(input) → hash value
  - Input → “scrambled” output

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- Hash(input) → hash value
  - Input → “scrambled” output
- Hashing is <u>deterministic</u>
  - Same input → same output
- Hashing (should be) <u>noninvertible</u>
  - For secure hash functions, computationally infeasible to derive input from the hash value

Storing Hashed Passwords

- Store hash instead

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bobtheninja246	password
xDragonSlayerx	asdf
annabelle2001	password
lamamaster123	ilovefish
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Username	HashedPassword
bobtheninja246	3da541…
xDragonSlayerx	bfd361…
annabelle2001	3da541…
lamamaster123	5baa61…
theSQLexpert234	ca8612…
seahawksrule12	ca8612…

Validating Hashed Passwords

- Store hash instead
  - Validate any given password by hashing it and comparing with stored hash

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- lamamaster123 logs in with "ilovefish"

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- hash(“ilovefish”) → 5baa61…

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Validating Hashed Passwords

- Store hash instead
  - Validate any given password by hashing it and comparing with stored hash

- lamamaster123 logs in with "ilovefish"
- hash("ilovefish") → 5baa61…
- 5baa61… == 5baa61…
  - Accept login

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Storing Passwords

- But… there are always users with bad passwords

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bobtheninja246	**password**
xDragonSlayerx	**asdf**
annabelle2001	**password**
lamamaster123	ilovefish
theSQLexpert234	**j62ld12446**
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  - Easy to search for common password hashes!

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Storing Passwords

- But… there are always users with bad passwords
  - Easy to search for common password hashes!
  - Easy to spot shared or reused passwords!

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- **Salting** adds randomness to password

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salt = getRandomSalt();
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- Generate random salt, pass it to hash function

```
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saltedPasswordHash = hash(password, salt)
```

- Store salt and salted hash in database

Storing Salted + Hashed Passwords

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xDragonSlayerx	**asdf**
annabelle2001	password
lamamaster123	ilovefish
theSQLexpert234	j62ld12446
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Username	Salt	HashedPassword
bobtheninja246	17	**7a4959…**
xDragonSlayerx	m9	**59438a…**
annabelle2001	23	4c812e…
lamamaster123	q7	3e0e04…
theSQLexpert234	k3	dcfea6…
seahawksrule12	ji	e840fc…

- Harder for attackers to search for common hashes
  - Unique salts → unique hashes for the same password

Storing Salted + Hashed Passwords

Username	Password
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- Harder to spot pairs of users ***sharing passwords***
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- Harder to spot pairs of users ***sharing passwords***
  - Unique salts → unique hashes within dataset
- Harder to spot users ***reusing passwords*** from other stolen datasets
  - Unique salts → unique hashes across datasets

Validating Hashed Passwords

- Validate by applying the stored salt before hashing

Username	Salt	Hashed Password
…	…	…
lamamaster123	q7	3e0e04…
…	…	…

- lamamaster123 logs in with “ilovefish”

Validating Hashed Passwords

- Validate by applying the stored salt before hashing

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- **salt = *getSaltFromDB*(‘lamamaster123’)**

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- lamamaster123 logs in with “ilovefish”
- **salt = *getSaltFromDB*(‘lamamaster123’)**
- hash(“ilovefish”, **salt**) → 3e0e04…

Validating Hashed Passwords

- Validate by applying the stored salt before hashing

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…	…	…
lamamaster123	q7	3e0e04…
…	…	…

- lamamaster123 logs in with “ilovefish”
- **salt = *getSaltFromDB*(‘lamamaster123’)**
- hash(“ilovefish”, **salt**) → 3e0e04…
- 3e0e04… == 3e0e04…
  - Accept login

Agenda

- Access Control
- Passwords
- **Data Privacy**

Existing Laws and Regulations

- HIPAA (Health Information Portability and Accountability Act), 1996
  - Mandatory for healthcare and health insurance institutions
  - Privacy rule - patient rights, PHI, use/disclosure
  - Security rule - standards for safeguards

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- GDPR (General Data Protection Regulation), 2018
  - Corporate disclosure and limits on user data storage
  - User data rights over PII

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- Mandatory for education institutions
  - Requires written consent to disclose academic info, with certain exceptions (court orders, school officials, etc.)

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  - Requires written consent to disclose academic info, with certain exceptions (court orders, school officials, etc.)

- Allows institutions to disclose “directory information” without consent (institution policies can be stronger)
  - Name
  - Email
  - Photographs
  - Phone Number

Implicit Disclosure

- If users can derive sensitive information like grades, it violates FERPA

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FERPA Deidentification

1) ID to anonymous ID mapping should be secret

2) Aggregate data (minimum n-size)
   - **Suppression** → Don't provide data ☹
     - Necessary for very small groups
   - **Rounding** → Bucket data or introduce noise ☺
     - More people means you can be more specific

Implicit Disclosure

- “Hey, can you give me the directory information for students with a GPA of 3.5?”

Reveals sensitive information by context

```
SELECT D.*
  FROM Directory AS D, Grades AS G
 WHERE D.id = G.id AND
       G.gpa = 3.5
```

Implicit Disclosure

- "Hey, can you give me the directory information for students with a GPA of 3.5?"

Reveals sensitive information by context

```
SELECT D.*
  FROM Directory AS D, Grades AS G
 WHERE D.id = G.id AND
       G.gpa = 3.5
```

- Database admins/designers should prevent these sorts of queries from being possible!

Anonymity

- Common practice for making a dataset private: remove Personal Identifiable Information (PII)

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- But by linking data from distinct datasets one can reveal private information
- In her PhD thesis* (2001) Latanya Sweeney described a famous example

* https://dspace.mit.edu/handle/1721.1/8589

Implicit Disclosure

Re-identification of Mass. Governor William Weld

- **Public voter data**
  - Name
  - ZIP code
  - Sex
  - Birth date
  - …
- **Anonymous insurance data** (released under assurance of anonymity from Gov. Weld)
  - ZIP code
  - Sex
  - Birth date
  - Prescription
  - Diagnosis
  - …

Latanya Sweeney's Finding

- Massachusetts: GIC* is responsible for health insurance of state employees; public data

```
GIC(zip, dob, sex,
 diagnosis, procedure,...)
```

*Group Insurance Commission

Latanya Sweeney's Finding

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- Sweeney paid $20 and bought voter registration list for Cambridge, MA

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VOTER(name, party, ...,
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- Massachusetts: GIC* is responsible for health insurance of state employees; public data
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- William Weld** lived in Cambridge: in VOTER

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**former governor

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- 6 people had same **dob**

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- William Weld** lived in Cambridge: in VOTER
- 6 people had same **dob**
- 3 had also **sex**='M'

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- Sweeney paid $20 and bought voter registration list for Cambridge, MA
- William Weld** lived in Cambridge: in VOTER
- 6 people had same **dob**
- 3 had also **sex**='M'
- Weld only one in that **zip**

```
GIC(zip, dob, sex,
 diagnosis, procedure,...)
```

```
VOTER(name, party, ...,
     zip, dob, sex)
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Latanya Sweeney's Finding

Cambridge, MA Voter Data ($20)

Name	ZIP	Sex	Bday
…	…	…	…
W. Weld	12345	M	Feb 30
…	…	…	…

$\bowtie$

Anon. Insurance Data for Researchers

ZIP	Sex	Bday	MedInfo
…	…	…	…
12345	M	Feb 30	Afluenza
…	…	…	…

Latanya Sweeney's Finding

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Anon. Insurance Data for Researchers

ZIP	Sex	Bday	MedInfo
…	…	…	…
12345	M	Feb 30	Afluenza
…	…	…	…

6 matches on ZIP
3 matches on Sex
1 match on Bday

Name	…	MedInfo
…	…	…
W. Weld	…	Afluenza
…	…	…

Sweeney learned Weld's medical records !

Latanya Sweeney's Finding

Cambridge, MA Voter Data ($20)

Name	ZIP	Sex	Bday
…	…	…	…
W. Weld	12345	M	Feb 30
…	…	…	…

⋈

Anon. Insurance Data for Researchers

ZIP	Sex	Bday	MedInfo
…	…	…	…
12[illegible]	M	Feb 30	Afluenza
…	…	…	…

Legal in 1997
Deemed private since 2003

6 matches on ZIP
3 matches on Sex
1 match on Bday

Name	…	MedInfo
…	…	…
W. Weld	…	Afluenza
…	…	…

Sweeney learned Weld's medical records !

Sensitive Information

- Personal Identifiable Information (PII)
  - Names
  - Student ID
  - Social security number
  - License number
- Protected data (for legal and/or ethical reasons)
  - Academic records (FERPA)
  - Protected Health Information (HIPAA)
  - User Web Data (GDPR)
- Passwords

Takeaways

- Always parameterize input into prepared statements to prevent SQL injection
  - JDBC PreparedStatements for HW6
- Always hash + salt passwords before storing them in a database
  - You will implement this in HW6
- Be careful about what information can be inferred from your datasets
  - Always protect sensitive data!