Lecture 13:
Security

Wednesday, October 26, 2006

Midterm !

Friday, 10:30-11:20, in class.

- Problem 1: SQL
- Problem 2: E/R diagrams
- Problem 3: Conceptual design, BCNF

Open book exam

Outline

SQL Security – 8.7

Two famous attacks

Two new trends

Discretionary Access Control in SQL

```
GRANT privileges
   ON object
   TO users
   [WITH GRANT OPTIONS]
```

```
privileges =  SELECT  |
              INSERT(column-name)  |
              UPDATE(column-name) |
              DELETE |
              REFERENCES(column-name)
object = table  |  attribute
```

Examples

```
GRANT INSERT, DELETE ON Customers
  TO Yuppy WITH GRANT OPTIONS
```

Queries allowed to Yuppy:

```
INSERT INTO Customers(cid, name, address)
     VALUES(32940, ‘Joe Blow’, ‘Seattle’)

DELETE Customers
      WHERE LastPurchaseDate < 1995
```

Queries denied to Yuppy:

```
SELECT Customer.address
FROM Customer
WHERE name = ‘Joe Blow’
```

Examples

```
GRANT SELECT ON Customers TO Michael
```

Now **Michael** can SELECT, but not INSERT or DELETE

Examples

```
GRANT SELECT ON Customers
   TO Michael WITH GRANT OPTIONS
```

Michael can say this:

```
GRANT SELECT ON Customers TO Yuppi
```

Now **Yuppi** can SELECT on Customers

Examples

```
GRANT UPDATE (price)  ON Product TO Leah
```

Leah can update, but only Product.price, but not Product.name

Examples

Customer(<u>cid</u>, name, address, balance)
Orders(<u>oid</u>, cid, amount)   cid= foreign key

Bill has INSERT/UPDATE rights to Orders.
BUT HE CAN'T INSERT ! (why ?)

GRANT REFERENCES (cid) ON Customer TO **Bill**

Now **Bill** can INSERT tuples into Orders

Views and Security

David owns

Customers:

Name	**Address**	**Balance**
Mary	Huston	450.99
Sue	Seattle	-240
Joan	Seattle	333.25
Ann	Portland	-520

Fred is not allowed to see this

David says

```
CREATE VIEW PublicCustomers
        SELECT Name, Address
        FROM Customers
GRANT SELECT ON PublicCustomers TO Fred
```

David owns

Views and Security

Customers:

Name	**Address**	**Balance**
Mary	Huston	450.99
Sue	Seattle	-240
Joan	Seattle	333.25
Ann	Portland	-520

John is allowed to see only <0 balances

David says

```
CREATE VIEW BadCreditCustomers
        SELECT *
        FROM Customers
        WHERE Balance < 0
GRANT SELECT ON BadCreditCustomers TO John
```

David says

Views and Security

- Each customer should see only her/his record

Name	**Address**	**Balance**
Mary	Huston	450.99
Sue	Seattle	-240
Joan	Seattle	333.25
Ann	Portland	-520

```
CREATE VIEW CustomerMary
        SELECT *  FROM Customers
        WHERE name = ‘Mary’
GRANT SELECT
ON CustomerMary TO Mary
```

```
CREATE VIEW CustomerSue
        SELECT *  FROM Customers
        WHERE name = ‘Sue’
GRANT SELECT
ON CustomerSue TO Sue
```

Doesn’t scale.

Need *row-level* access control !

• • •

Revocation

```
REVOKE   [GRANT OPTION FOR]   privileges
         ON object FROM users  {  RESTRICT  |  CASCADE  }
```

Administrator says:

```
REVOKE SELECT ON Customers  FROM David CASCADE
```

John loses SELECT privileges on BadCreditCustomers

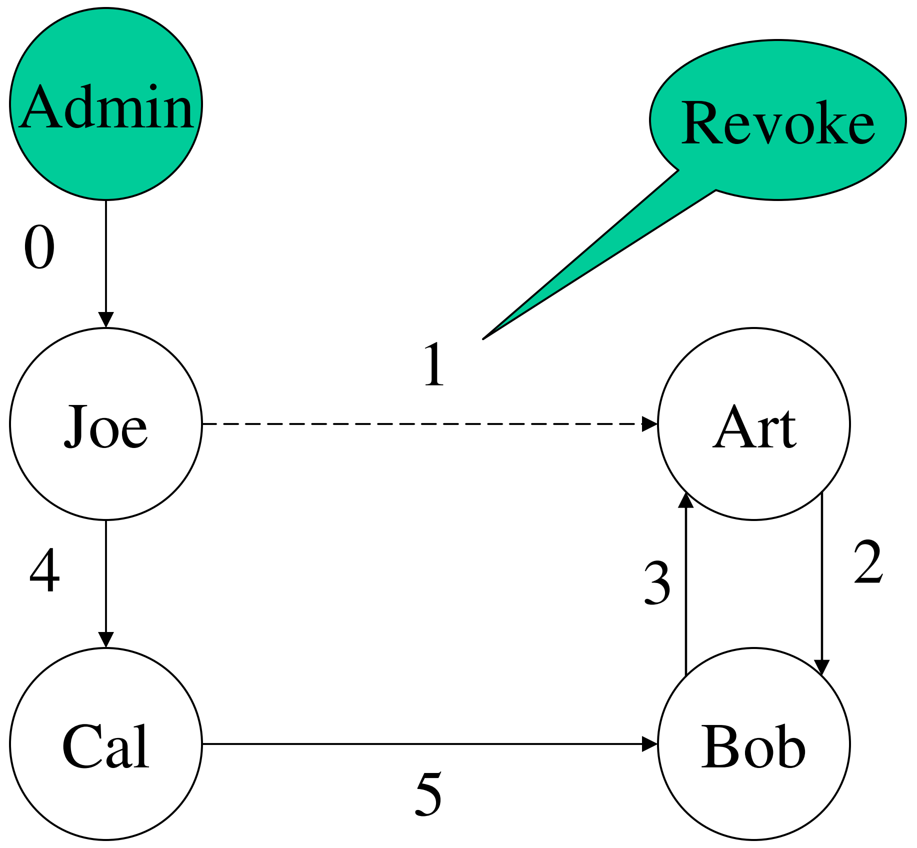
Revocation

```
Joe:  GRANT [….]  TO Art  …
Art:  GRANT [….]  TO Bob …
Bob: GRANT [….]  TO Art  …
Joe:  GRANT [….]  TO Cal  …
Cal:  GRANT [….]  TO Bob  …
Joe:   REVOKE [….] FROM Art CASCADE
```

Same privilege,
same object,
GRANT OPTION

What happens ??

Revocation



According to SQL everyone keeps the privilege

Summary of SQL Security

Limitations:

- No row level access control
- Table creator owns the data: that’s unfair !

Access control = great success story of the DB community...

… or spectacular failure:

- Only 30% assign privileges to users/roles
  - And then to protect entire tables, not columns

Summary (cont)

- Most policies in middleware: slow, error prone:
  - SAP has 10**4 tables
  - GTE over 10**5 attributes
  - A brokerage house has 80,000 applications
  - A US government entity thinks that it has 350K

- Today the database is not at the center of the policy administration universe

[Rosenthal&Winslett'2004]

Two Famous Attacks

- SQL injection
- Sweeney’s example

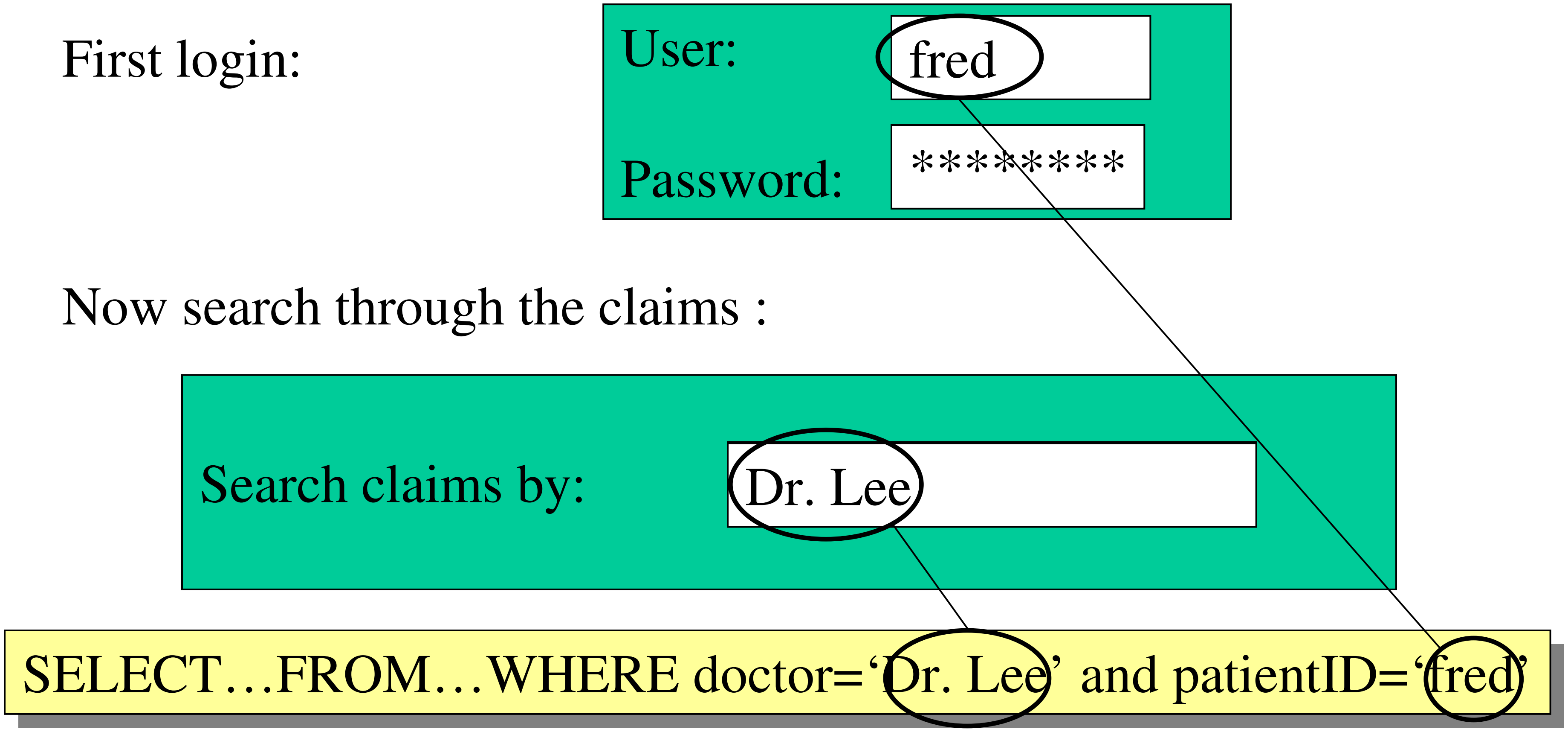
[Chris Anley, *Advanced SQL Injection In SQL*]

SQL Injection

Your health insurance company lets you see the claims online:

First login:

Now search through the claims :



User: fred

Password: *********

Search claims by: Dr. Lee

SELECT…FROM…WHERE doctor='Dr. Lee' and patientID='fred'

SQL Injection

Now try this:

Search claims by: Dr. Lee'   OR patientID = 'suciu';   --

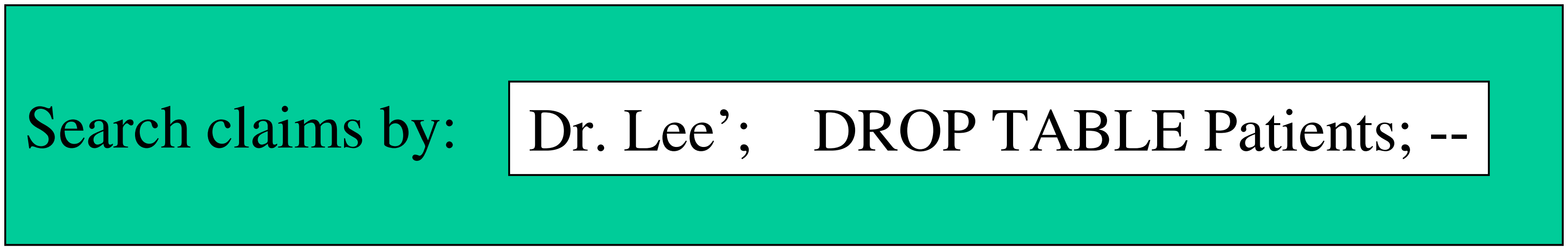
…..WHERE doctor='Dr. Lee' OR patientID='suciu';   --' and patientID='fred'

Better:

Search claims by: Dr. Lee'   OR   1 = 1;   --

SQL Injection

When you’re done, do this:



Search claims by: Dr. Lee’; DROP TABLE Patients; --

SQL Injection

- The DBMS works perfectly. So why is SQL injection possible so often ?

- Quick answer:
  - Poor programming: use stored procedures !
- Deeper answer:
  - Move policy implementation from apps to DB

Latanya Sweeney's Finding

- In Massachusetts, the Group Insurance Commission (GIC) is responsible for purchasing health insurance for state employees
- GIC has to publish the data:

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

Latanya Sweeney's Finding

- Sweeney paid $20 and bought the voter registration list for Cambridge Massachusetts:

GIC(**zip, dob, sex**, diagnosis, procedure, ...)
VOTER(name, party, ..., **zip, dob, sex**)

Latanya Sweeney’s Finding

zip, dob, sex

- William Weld (former governor) lives in Cambridge, hence is in VOTER
- 6 people in VOTER share his **dob**
- only 3 of them were man (same **sex**)
- Weld was the only one in that **zip**
- Sweeney learned Weld’s medical records !

Latanya Sweeney's Finding

- All systems worked as specified, yet an important data has leaked

- How do we protect against that ?

Some of today's research in data security address breaches that happen even if all systems work correctly

Summary on Attacks

SQL injection:

- A correctness problem:
  - Security policy implemented poorly in the application

Sweeney’s finding:

- Beyond correctness:
  - Leakage occurred when all systems work as specified

Two Novel Techniques

- K-anonymity, information leakage
- Row-level access control

[Samarati&Sweeney'98, Meyerson&Williams'04]

Information Leakage: k-Anonymity

Definition: each tuple is equal to at least k-1 others

Anonymizing: through suppression and generalization

First	**Last**	**Age**	**Race**	**Disease**
*	Stone	30-50	Afr-Am	Flue
John	R*	20-40	*	Measels
*	Stone	30-50	Afr-am	Pain
John	R*	20-40	*	Fever

Hard: NP-complete for suppression only

Approximations exists; but work poorly in practice

[Miklau&S'04, Miklau&Dalvi&S'05,Yang&Li'04]

Information Leakage: Query-view Security

Have data: TABLE Employee(name, dept, phone)

Secret Query	View(s)	Disclosure ?
S(name)	V(name,phone)	total
S(name,phone)	V1(name,dept) V2(dept,phone)	big
S(name)	V(dept)	tiny
S(name) where dept='HR'	V(name) where dept='RD'	none

Fine-grained Access Control

Control access at the tuple level.

- Policy specification languages
- Implementation

Policy Specification Language

No standard, but usually based on parameterized views.

```
CREATE AUTHORIZATION VIEW PatientsForDoctors AS
  SELECT Patient.*
  FROM Patient, Doctor
  WHERE Patient.doctorID = Doctor.ID
      and    Doctor.login = %currentUser
```

Context parameters

Implementation

```
SELECT Patient.name, Patient.age
FROM Patient
WHERE Patient.disease = ‘flu’
```

↓

```
SELECT Patient.name, Patient.age
FROM Patient, Doctor
WHERE Patient.disease = ‘flu’
        and Patient.doctorID = Doctor.ID
        and Patient.login = %currentUser
```

e.g. Oracle

Two Semantics

- The Truman Model = filter semantics
  - transform reality
  - ACCEPT all queries
  - REWRITE queries
  - Sometimes misleading results

```
SELECT count(*)
FROM Patients
WHERE disease='flu'
```

- The non-Truman model = deny semantics
  - reject queries
  - ACCEPT or REJECT queries
  - Execute query UNCHANGED
  - May define multiple security views for a user

[Rizvi'04]

Summary on Information Disclosure

- The theoretical research:
  - Exciting new connections between databases and information theory, probability theory, cryptography

[Abadi&Warinschi'05]

- The applications:
  - many years away

Summary of Fine Grained Access Control

- Trend in industry: label-based security
- Killer app: application hosting
  - Independent franchises share a single table at headquarters (e.g., Holiday Inn)
  - Application runs under requester’s label, cannot see other labels
  - Headquarters runs Read queries over them
- Oracle’s Virtual Private Database

[Rosenthal&Winslett’2004]