Lecture 13: Security

Monday, February 6, 2006

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Outline

SQL Security – 8.7

Two famous attacks

Two new trends

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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

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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

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Examples

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

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

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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

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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
```

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Views and Security

David owns

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
```

Views and Security

David says

- 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 !

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Revokation

```
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

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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 ??

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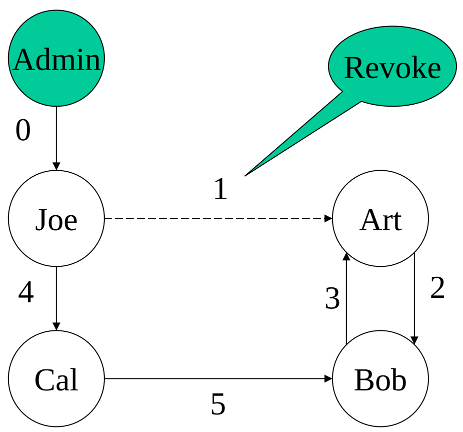
Revocation



According to SQL everyone keeps the privilege

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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

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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 <u>not</u> at the center of the policy administration universe

[Rosenthal&Winslett'2004]

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Two Famous Attacks

- SQL injection
- Sweeney's example

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

SQL Injection

Your health insurance company lets you see the claims online:

First login:

User: fred

Password: ********

Now search through the claims :

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; --

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SQL Injection

When you're done, do this:

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

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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

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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, ...)

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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**)

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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 !

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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

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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

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Two Novel Techniques

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

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[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

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[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

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Fine-grained Access Control

Control access at the tuple level.

- Policy specification languages
- Implementation

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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

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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

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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]

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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

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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

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[Rosenthal&Winslett’2004]