IT Security

Database Authorization

Nikolaus Augsten

nikolaus.augsten@sbg.ac.at

Dept. of Computer Sciences
University of Salzburg

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All infos about the database part in this lecture

http://dbresearch.uni-salzburg.at/teaching/2016ws/its/

Acknowledgments

The sections “Authorization in SQL” and “Application Security” are adapted with kind permission from Sven Helmer’s slides on these topics:

`http://www.inf.unibz.it/dis/teaching/DBS/`

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Access Control Models

- Discretionary Access Control (DAC)
  - File permissions in Unix (read/write/execute for user, group, and others)
  - ACL: Access Control List (supported by Windows since NT and many Unix file systems)
  - RBAC: Role Based Access Control (supported by many database systems)
- Mandatory Access Control (MAC)
  - allows policies to be enforced
  - safer than DAC for sensitive information
  - governmental and military use

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Authorization

- A user may be assigned authorizations on parts of a database
- Authorizations cover
  - reading data
  - inserting new data
  - updating data
  - deleting data
- Each type is called a *privilege*
- A user may have all, none, or a combination of privileges (for parts of a DB)

Granting Privileges

- Privileges can be granted to a user . . .
- . . . and later on be revoked again
- One user, the *database administrator*, has all the privileges
- Granting and revoking privileges is done via SQL commands
  - This is part of the Data Definition Language (DDL)

SQL Syntax

- The general statement for granting privileges is:

  grant *privilege list*
  on *relation or view name*
  to *user or role list*;

- A *privilege list* is made up of a combination of **select**, **insert**, **update**, and **delete**
  - . . . or **all privileges** for all of them
- This is followed by a relation or view name
- and a user name (we'll come to roles in just a moment)

Examples

- **grant** select
  on student
  to peter, paul, mary;
- The users `peter`, `paul`, and `mary` may run select queries on the relation `student`
- When granting `update` and `insert` privileges, attributes can be specified:

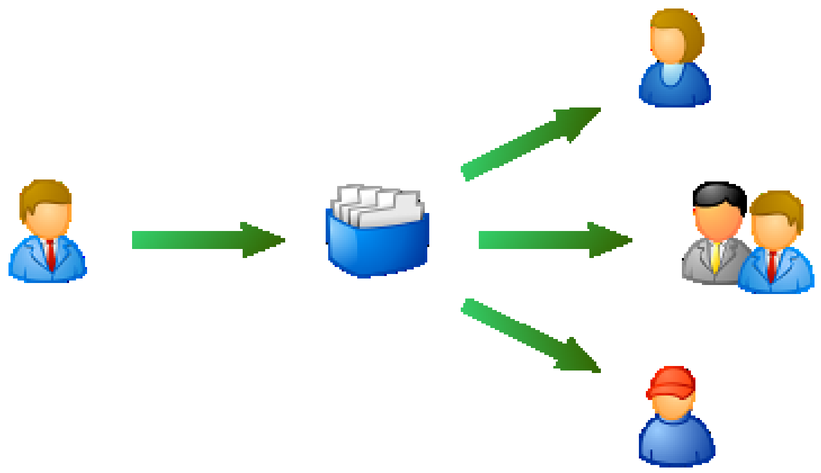
  grant update(office_no)
  on professor
  to peter;
- This allows the user `peter` to update the attribute `office_no` in the relation `professor`

Revoking Privileges

- Privileges can also be withdrawn via a `revoke` statement
- The general syntax is:

  revoke *privilege list*
  on *relation or view name*
  from *user or role list*;
- Works like a `grant` statement in reverse

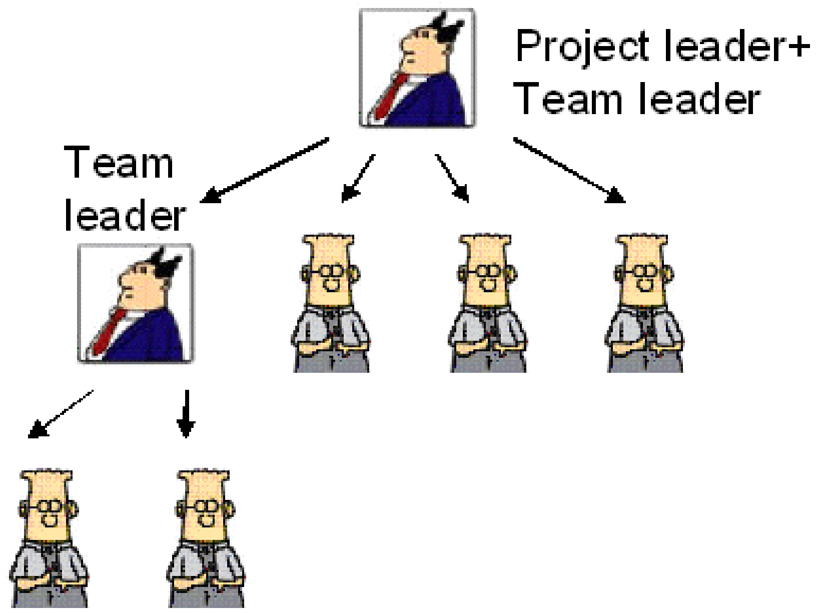
Multiple Users



- Large database system may have hundreds or even thousands of users
- Granting and revoking privileges individually on all relations may be very tedious
- The user name `public` grants a privilege to every user of the system
- A more fine-grained approach uses *roles*

Roles

- Often groups of people do similar work and need the same privileges
- In a database it is possible to
  - define a role
  - give privileges to this role
  - and add users to this role



SQL Syntax

- Here are some examples on how this looks in SQL:

```
create role instructor;

grant  select
on     course
to     instructor;

grant  instructor to john;
create role professor;
grant  instructor to professor;
grant  professor to sven;
```

Authorization and Views

- Privileges in combination with views can be used to make parts of a relation visible
- For example, an administrator may only see records of computer science assistants
  - Create the following view:

    ```
    create view csasst as
    select  *
    from    assistant
    where   area = 'computer science';
    ```

  - Then grant `select` privilege on `csasst` and revoke all privileges on base table `assistant`

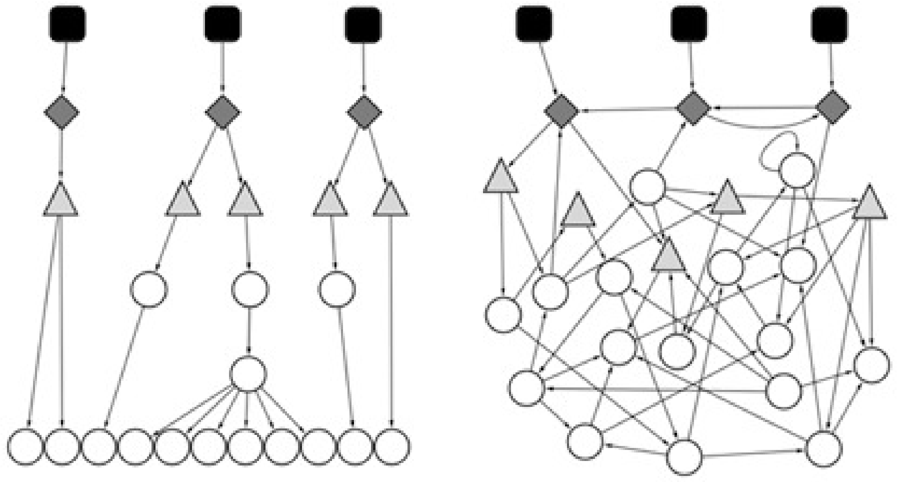
Transfer of Privileges [1]

- A user who has been granted a privilege may be allowed to pass it on
  - The default does not allow this
- If we want to allow someone to grant a privilege to others, we use the `with grant option`

grant select
on student
to peter **with grant option**;

Transfer of Privileges [2]

- Usually the creator of a database object holds all privileges
  - This includes the privilege to grant privileges
- What happens if there is a whole chain of granted privileges and we start revoking some?



Authorization Graph

- We can use an *authorization graph* to check:

$$\begin{tikzcd}
 & U_1 \arrow[r] \arrow[dr] & U_4 \\
DBA \arrow[ur] \arrow[r] \arrow[dr] & U_2 \arrow[r] & U_5 \\
 & U_3 &
\end{tikzcd}$$

- A user has a privilege, iff there is a path from the root (DBA) to the user node
- Revoking a privilege from a user
  - removes that user
  - and everyone on outgoing edges of that user not connected to the root otherwise

Cascading Revokes [1]

- Revoking a privilege from U_1 from the previous graph
  - also removes U_4's privilege
  - but not U_5's, as he/she is still connected via U_2
- Recursively revoking privileges is called a *cascading revoke*
- Can be prevented by the `restrict` clause
  - Will return an error if there is a cascading revoke

Cascading Revokes [2]

- Sometimes privileges should be granted by a role, not an individual
- For example, the role of *dean* can grant privileges associated with the role of *professor* or *instructor*
  - If the current dean steps down and the user account is removed, granted privileges should stay
  - Can be done by adding the clause `granted by current_role`

Limits of Authorization in SQL [1]

- While SQL supports a fairly flexible system, it has limits
- Many applications require a very fine-grained authorization
- For example, we want students to see only their own grades
- That means, we need authorization on the tuple level
  - Databases only support relation, view, or attribute level

Limits of Authorization in SQL [2]

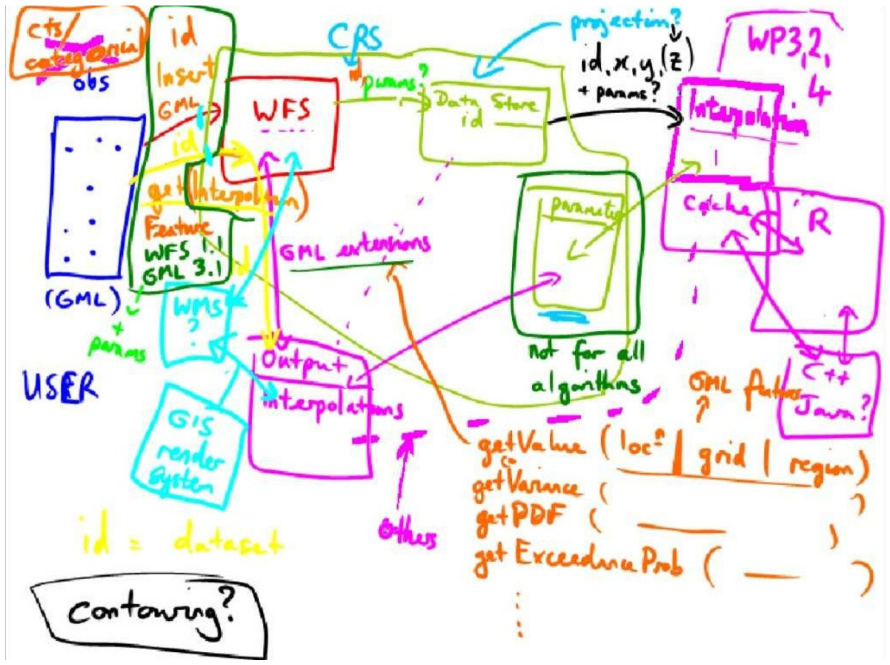
- Often, there is a lack of end-user information
- For example, in web applications end users usually do not have individual user IDs in the database
- Makes it difficult to apply the SQL authorization scheme

DATE AND PLACE OF BIRTH
19-08-1966
TOWN OR CITY
SEX F
NATIONALITY COUNTRY
REMARKS
NO PUBLIC FUNDS

```
IRGBRZU12345673<<<<<<<<<<<<<<<
6608198F0808088COU<<<<<<<<<<<6
SAMPLE<<SUSANNA<<<<<<<<<<<<<<<
```

Limits of Authorization in SQL [3]

- As a consequence a lot of the authorization moves into the application code
- The point of a DBS was to provide infrastructure and have clear responsibilities



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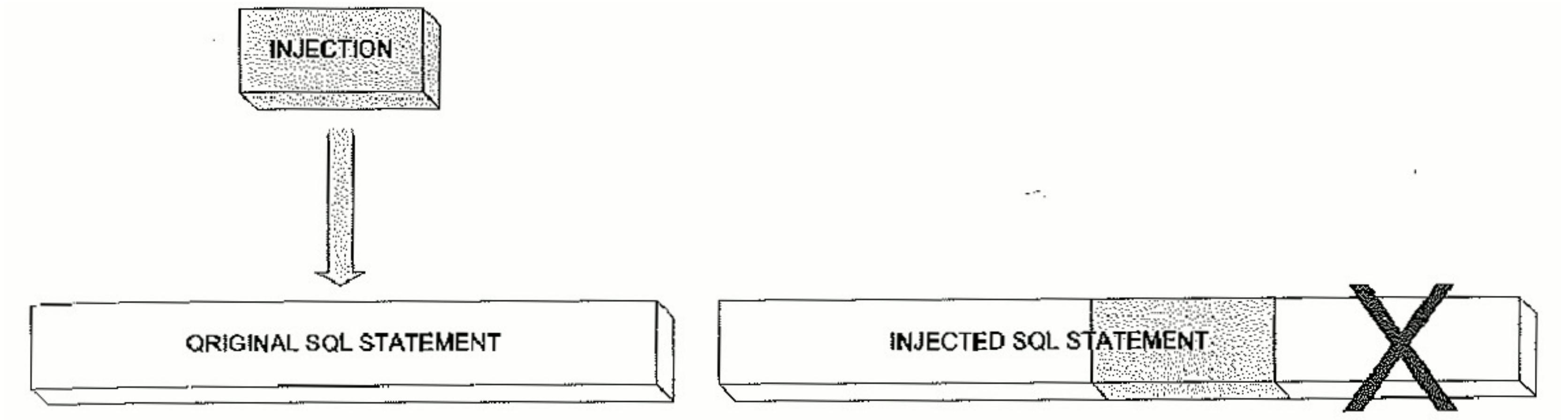
Application Security

- Even if the database is pretty secure, a badly written application can compromise the whole system
- Many database applications have a web (or mobile) interface that can be exploited
- In particular, we are looking at
  - SQL injection
  - Cross-site scripting and request forgery

SQL Injection [1]

- In SQL injection attacks, the database runs an SQL query created by an attacker
- This is usually done by manipulating a valid SQL statement:



SQL Injection [2]

- Applications that build SQL queries on the fly are especially vulnerable to this
- For example, assume a Java application gets a string `name` and constructs the query

  ```
  "select * from student where name = '"+name+"';"
  ```

- Instead of a name, a user might enter some SQL:

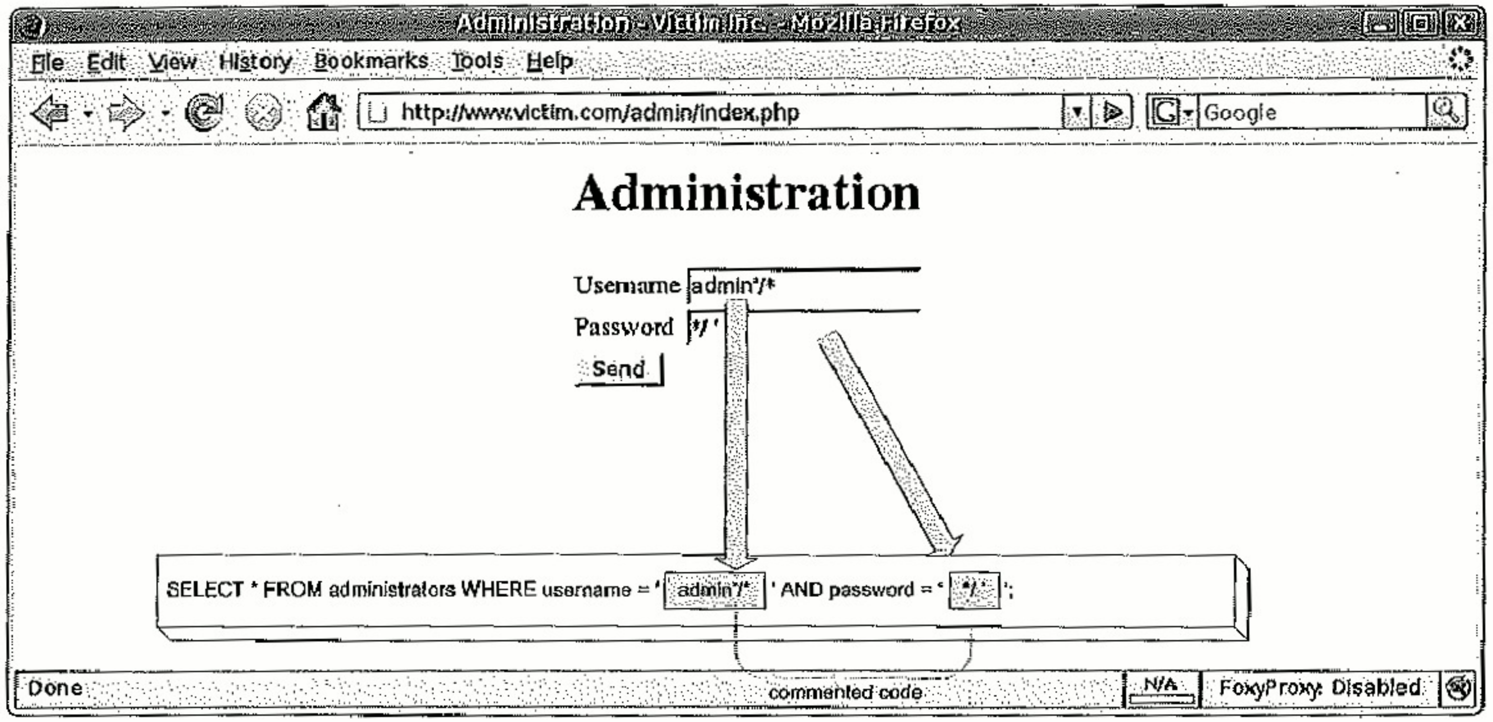
  ```
  X' or 'Y' = 'Y
  ```

  turning the SQL statement into

  ```
  select * from student
  where name = 'X' or 'Y' = 'Y';
  ```

SQL Injection [3]

- Depending on the application, this can have serious consequences:



Administration - Victim Inc. - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.victim.com/admin/index.php
Google
Done
N/A
FoxyProxy: Disabled

Administration

Username admin'/*
Password */ '
Send

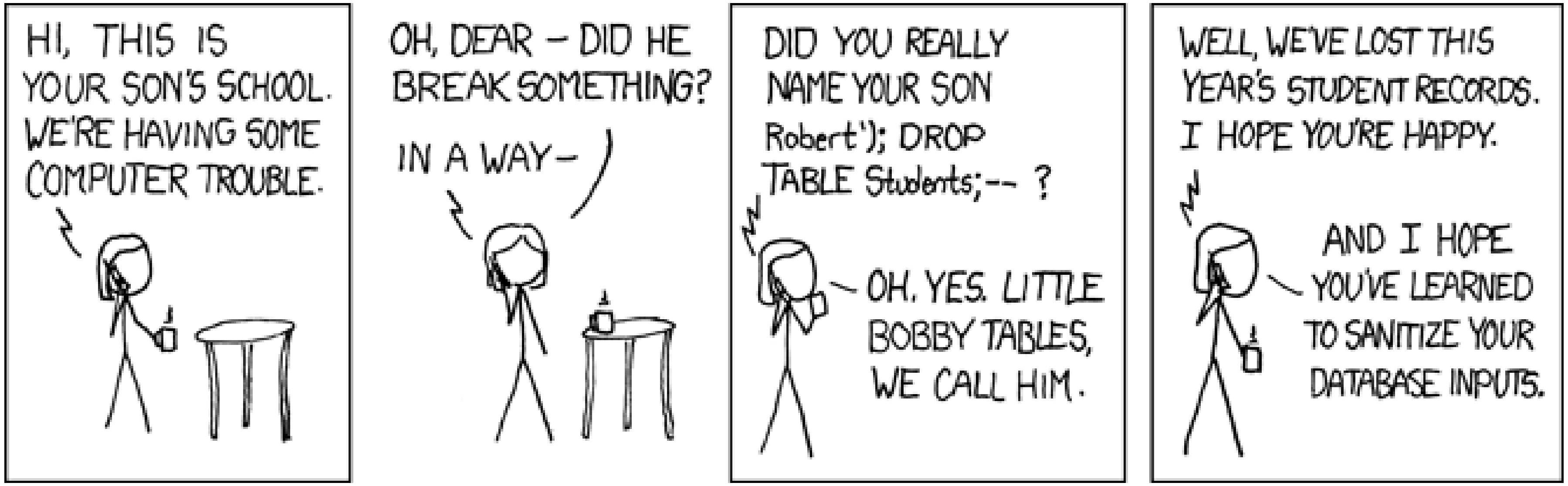
```
SELECT * FROM administrators WHERE username = ' admin'/* ' AND password = ' */ ';
```

commented code

- Here comments are used to cut part of the SQL query

SQL Injection [4]

- This is not just limited to select statements
- Depending on the configuration of the server, multiple statements may be executed in one go


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

Source: `http://xkcd.com/327/`

Remedies

- So, how should you build your database application?
- Any query that relies on user input should use prepared statements
- In prepared statements, some values are replaced by "?"
- For example, the following will insert a tuple

```
PreparedStatement pSt = con.prepareStatement(
       "insert into student values (?,?,?)");
pSt.setInt(1, 102093);
pSt.setString(2, "James Smith");
pSt.setDate(3, "1991-10-05");
pSt.executeUpdate();
```

Prepared Statement

- Not only will this run faster (if SQL statement is used multiple times)
- It will also escape special characters
- For example, the string

  `X' or 'Y' = 'Y`

  would become

  `X\' or \'Y\' = \'Y`

  rendering the attempted attack harmless

Other Forms of Attack

- Not every attack can be prevented with prepared statements
- For example, the following lets a user sort a result:

  ```
  "select * from student order by "+orderAtt+";"
  ```
- Application has to make sure that the variable `orderAtt` can only contain valid attribute names
- In general, any input coming from a user has to be sanitized!

Cross-Site Scripting (XSS) [1]

- Many web sites rely on the execution of code embedded in HTML on the client side
  - Client-side scripting languages such as JavaScript are a popular option
- If an attacker is able to smuggle code onto a web site, it may be executed on a client
- For a database-related example, assume the following:
  - Users enter data into a database via a web site
  - Later on, other users view this information
  - Malicious users can enter JavaScript instead of data

Cross-Site Scripting (XSS) [2]

- The effects of executing malicious code include
  - changing or deleting files on the local system
  - monitoring key strokes
  - sending out confidential information (e.g. cookies)
  - interacting with other web sites of a user

Cross-Site Request Forgery (XSRF)

- XSRF attempts to hijack a session running in another tab or window of the browser
- Can fool a server, as request is coming from a valid client
- Can even be done without scripting, e.g.

```
<img src="http://site.com/action?user=alice&action=doThing">
```

Protection from XSS/XSRF

- We provide some general remarks (there are more complex attacks)
- Preventing your site from becoming an attack launch pad:
  - Sanitize all user input
  - There are functions to strip out HTML, scripts, or other code
- Preventing your site from becoming a target:
  - Check referer in the HTTP header
  - Tie session not only to cookies, but also to IP address
  - Never use `GET` to update any data or to send sensitive data

Password Leakage

- Storing passwords in clear text in application code or a database is not a good idea
- If you have to store a password, it needs to be encrypted
- Many databases can be configured to use authentication scheme of operating system