CSE 127: Computer Security

SQL Injection

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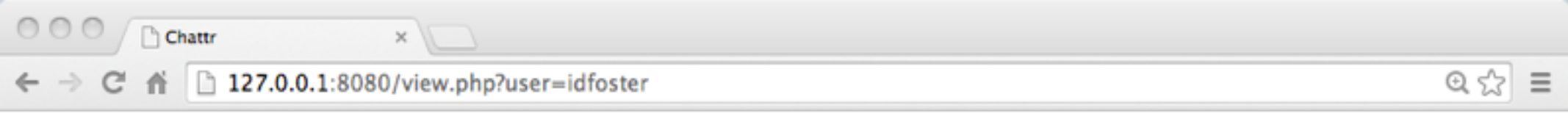
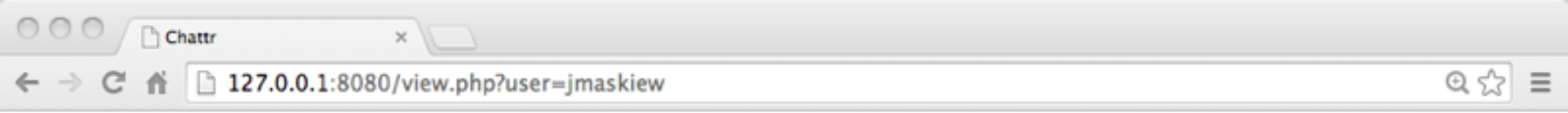


Chattr

When	Who	What
2014-11-24 18:07:55.925434	idfoster	omg i luv chattr!


Chattr
127.0.0.1:8080/view.php?user=idfoster
Chattr
When
2014-11-24 18:07:55.925434



Chattr

When	Who	What
2014-11-24 18:08:19.99257	jmaskiew	lol hack the planet

A Magic Trick

- The functional specification only allowed seeing one user's posts at a time
  - Current user's posts on `view.php` without URL arguments
  - Any user's posts with `view.php?user=`*USERNAME*

Chattr

127.0.0.1:8080/view.php?user=%27%20or%20%27%27%20=%20%27

Chattr

When	Who	What
2014-11-24 18:07:55.925434	idfoster	omg i luv chattr!
2014-11-24 18:08:19.99257	jmaskiew	lol hack the planet

Wow!

very hack

http://127.0.0.1:8080/view.php?
user=%27%20or%20%27%27%20=%20%27

encodes

http://127.0.0.1:8080/view.php?user=user1' or '' = '

What is going on?

*From Someone's **view.php**:*

```
<?php

if (isset($_GET["user"])) {
    $user = ($_GET["user"]);
}

$exists = true;

$dbconn = pg_connect("host=localhost dbname=chattr user=student
password=hacktheplanet");

$query = "SELECT * FROM messages WHERE name = '$user'";
$result = pg_query($query);

… …
?>
```

From Someone's ***view.php****:*

```
<?php

if (isset($_GET["user"])) {
    $user = ($_GET["user"]);
}

$exists = true;

$dbconn = pg_connect("host=localhost dbname=chattr user=student
password=hacktheplanet");

$query = "SELECT * FROM messages WHERE name = '$user'";
$result = pg_query($query);

… …
?>
```

```
http://127.0.0.1:8080/view.php?
user=%27%20or%20%27%27%20=%20%27
```

encodes

```
http://127.0.0.1:8080/view.php?user=' or '' = '
```

results in query

```
select * from posts where name = '' or '' = '';
```

always true

*From Someone's **view.php**:*

```
<?php

if (isset($_GET["user"])) {
    $user = ($_GET["user"]);
}

$exists = true;

$dbconn = pg_connect("host=localhost dbname=chattr user=student
password=hacktheplanet");

$query = "SELECT * FROM messages WHERE name = '$user'";
$result = pg_query($query);

… …
?>
```

untrusted user input inserted directly into query that is sent to the database

From Someone's ***login.php****:*

```
<?php
… …
 else {
    $query = "SELECT username FROM chattrdb.users WHERE
username='$username' AND password='$password'";
    $result = pg_query($conn, $query);
    if (!$row = pg_fetch_row($result))
    {
        session_unset();
?>
… …
<?php
    } else {
          $_SESSION['username'] = $username;
          header("Location: view.php?user=$username");
    }
?>
```

What can we do?

SQL Injection

- **SQL Injection:** Inserting SQL fragment into query sent by an application to an SQL database
- Application assumes user input is **data**
- Databases parses user input as **code**

Is it a Real Problem?

SQL Injection Possibilities

- **Dump the entire database** (violate secrecy)
- **Drop the entire database** (deny availability)
- **Modify database data** (violate integrity)

From Someone's ***post.php****:*

```
<?PHP
… …

$username = $_SESSION['username'];
$timeStamp = date("Y-m-d H:i:s");
$userMessage = $_POST['TEXT'];

//Insert into database
$insertQuery = "INSERT INTO messages (username, time, message)
                VALUES ('$username', '$timeStamp', '$userMessage')";

$result = pg_query($insertQuery);

//Navigate to view the posts
header('Location: view.php?user=' . $username)

?>
```

Delete user's posts through SQL injection

Constraints

- Easiest case (for attacker): known application code and database schema, direct access to query results
  - **HW2:** `view.php?user=`
- Hardest case (for attacker): unknown code and schema, one bit of output per query
  - **1 bit output:** success or failure
  - **HW2:** `login.php`

*From Someone's **view.php**:*

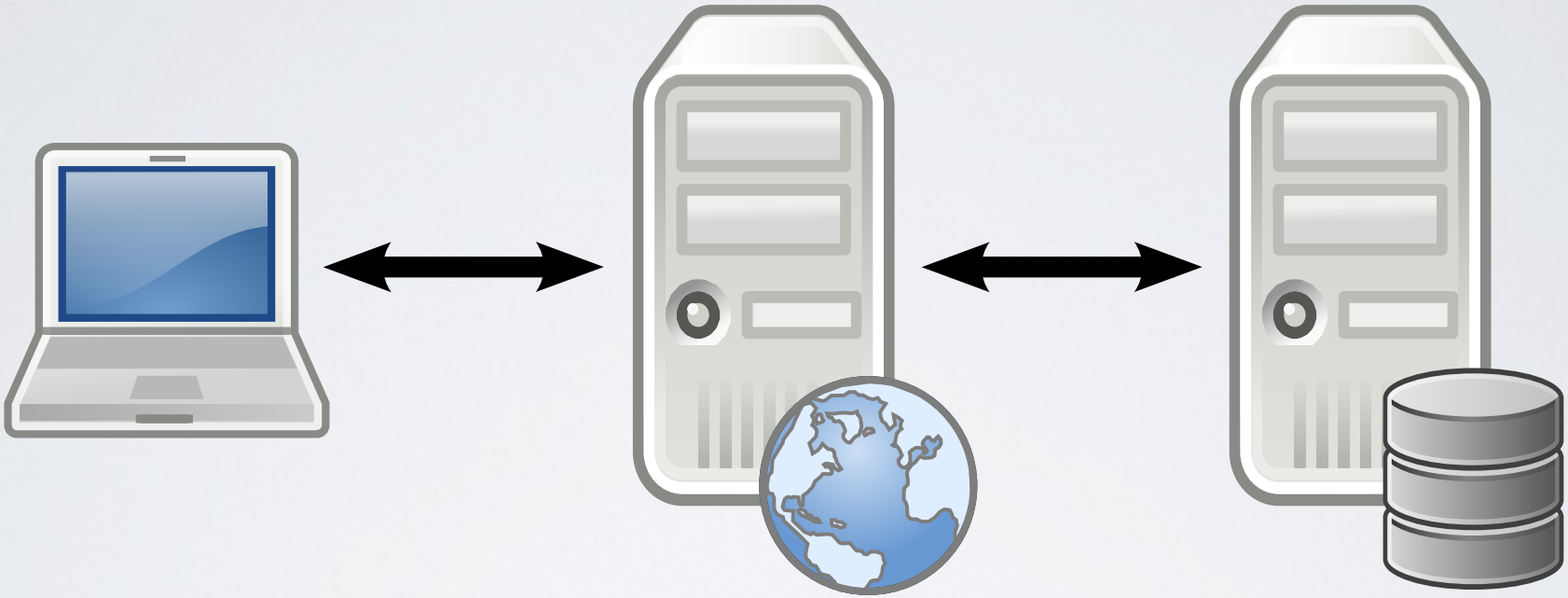
```
<?php

if (isset($_GET["user"])) {
    $user = ($_GET["user"]);
}

$exists = true;

$dbconn = pg_connect("host=localhost dbname=chattr user=student
password=hacktheplanet");

$query = "SELECT * FROM messages WHERE name = '$user'";
$result = pg_query($query);

… …
?>
```

View users' passwords through SQL injection

SQL Injection

- **SQL Injection:** Inserting SQL fragment into query sent by an application to an SQL database
- Application assumes user input is data
- Databases parses user input as code
- Attacker gains ability to submit SQL directly to backend database on behalf of *application database user*

Web Application Architecture



User system
Client side

Application server
Server side

DBMS server
Database

User Domains

- Operating system
  - **HW2:** `root` and `student`
- Database
  - **HW2:** `postgres`, `student`, `chattr`
- Application
  - **HW2:** `idfoster`, `jmaskiew` (in examples)

SQL Injection Privileges

- Server-side application process connects to database as a particular database user (application database user)

```
<?php
$db_host = 'localhost';
$db_user = 'student';
$db_pass = 'hacktheplanet';
$db_name = 'chattr';

$conn = pg_connect (
  "host=$db_host dbname=$db_name user=$db_user password=$db_pass")
```

- Attacker gains direct access to database with application database user privilege

Mitigation

- Sanitize user input
  - Escape SQL delimiters to input treated as quote
- Use prepared statements
  - Complete separation of control and data
  - *Preferred way*

Sanitizing User Input

- Escape special characters
  - E.g. change `'` to `''` (`''` treated as single `'` inside quote)
- Easy to get wrong
  - With above rule `\'` in input becomes `\''` which closes quote
  - Each database has its own special quoting rules
- Use DB-specific string escape function instead
  - **PHP & PostgreSQL:** `pg_escape_literal`
  - **PHP & MySQL:** `mysqli_real_escape_string`

Prepared Statements

- Separate control and data
- **Prepare:** define statement with parameters

```
pg_prepare($conn, "get_posts",
    'select * from posts where name = $1');
```

- **Execute:** execute query with given parameters

```
$rows = pg_execute($conn, "get_posts",
    array($user));
```

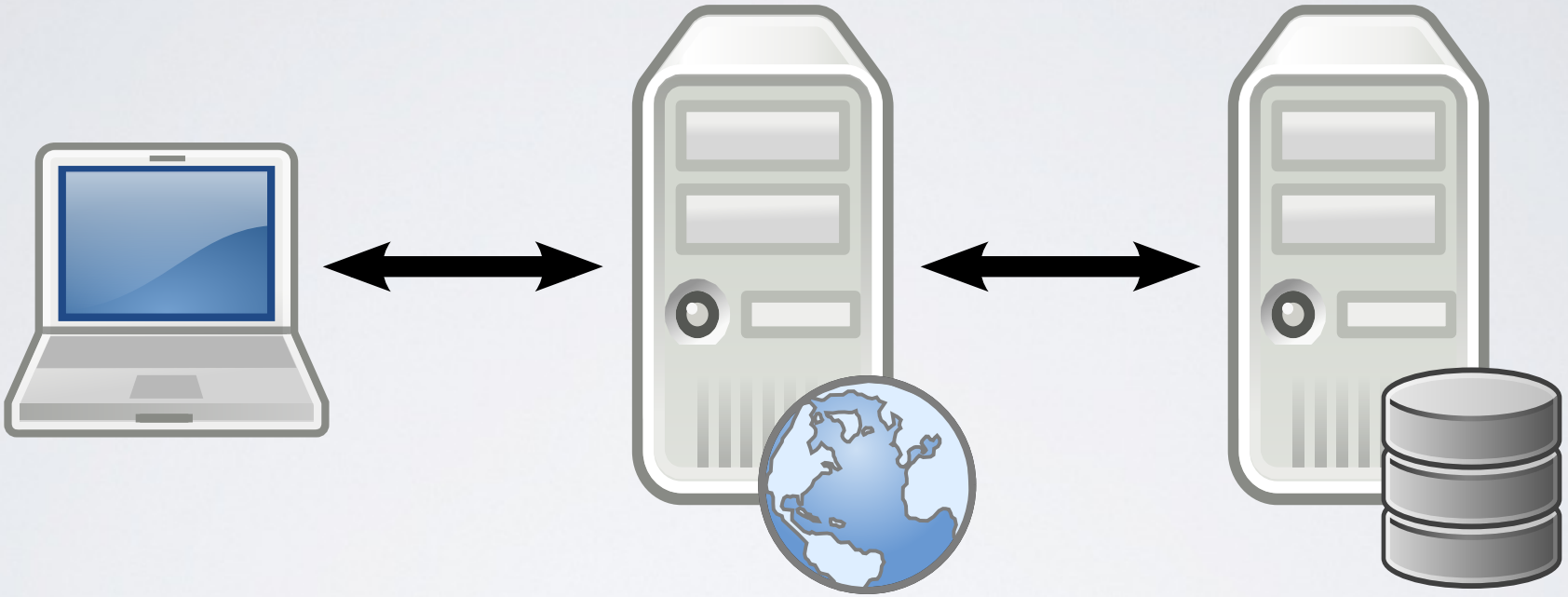
Prepared Statements vs Sanitizing Input

- Economy of Mechanism argues against sanitizing
  - String parsing implemented in database code
    - Tempting to add additional escape mechanisms as a “feature”
  - String escaping implemented in database connector
    - Database connector usually maintained by third party (not database vendor)
  - Two mechanisms must be exactly in sync
- Prepared statement escaping (if any) is at lower level
  - Handled by common library maintained by DB vendor
  - Invisible to user

Escaping Problems

- **Robustness principle** (Postel's law)**:**
  "Be conservative in what you do, be liberal in what you accept from others." (RFC 793)
- Historically considered good protocol design philosophy
- Security problems can occur when assumptions at interfaces of two systems differ

The Bigger Problem



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The Bigger Problem

- Application server accesses with database on behalf of application user
- In most cases application users have distinct privileges
- Application uses database as single database user
- This application database user must have *union* of all user's privileges in order to implement functionality

```
<?php
$db_host = 'localhost';
$db_user = 'student';
$db_pass = 'hacktheplanet';
$db_name = 'chattr';

$conn = pg_connect (
    "host=$db_host dbname=$db_name
     user=$db_user password=$db_pass")
```

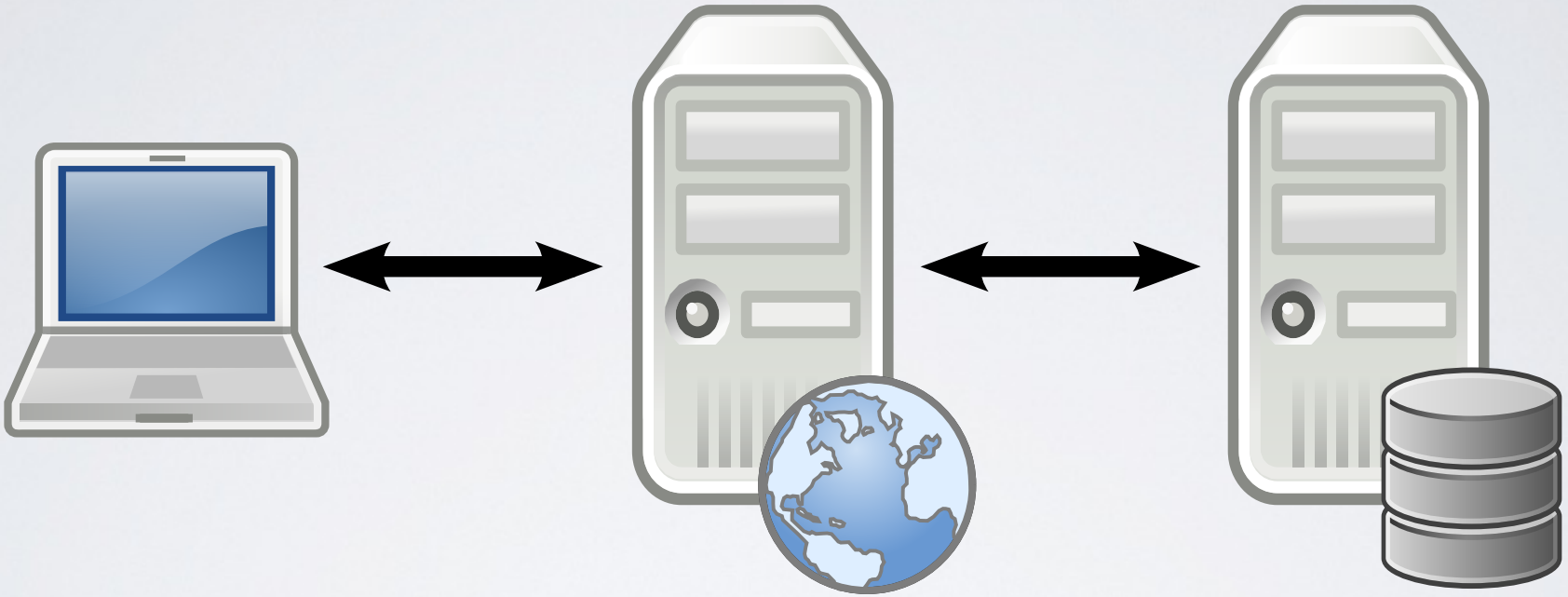
The Bigger Problem

- Compromising application gives attacker access to database as application database user
- **Best case**: attacker gains union of all application user's access privileges to data
- **Worst case:** application database user is DB superuser

DB User = App User?

- Database user domain managed by database admin
- Application user domain managed by application code
- No easy way to map application user to database user

The Bigger Problem



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The Bigger Problem

- Application similar to setuid executable in Unix
- Application code must ensure all interaction consistent with security policy
- Application code part of TCB
- Is there a better way?