Secure Computer Systems I: Lab 1

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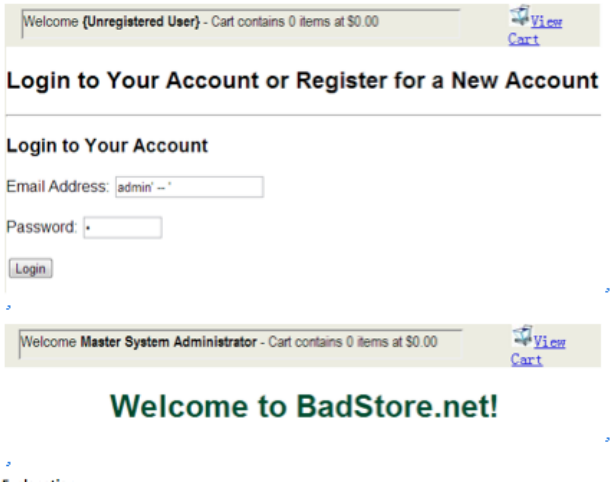
Task 1: SQL injections

Exercises:

(a) The input field on the BadStore website in which a SQL injection was performed is that for the email address on the login page, shown in upper half of Figure 1. The result—being logged on as the administrator—is shown in the lower half of the figure.

Figure 1: SQL Injection and Logged in as Administrator

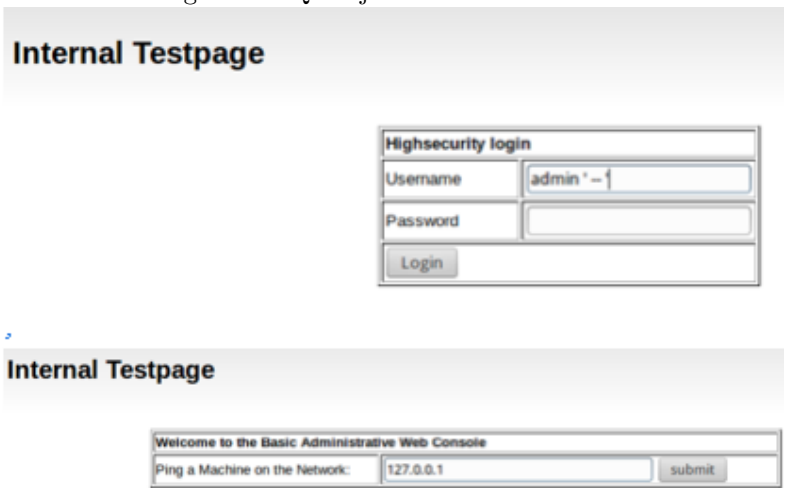


Explanation Without injection, the SQL code executed when a login request is made is believed to be `SELECT * FROM user WHERE EmailAddress = 'emailaddress' AND Password = 'password'`. Then during the injection, we input `admin' -- '` in the text box for the email address and some arbitrary password in the text box for the password. The WHERE condition is altered into `WHERE EmailAddress = 'admin' -- '' AND Password = 'password'`, where the part following the two dashes is interpreted as a SQL comment. In other words, the WHERE condition is turned into `WHERE EmailAddress = 'admin'`. Thus there is no need for a password and we can directly log into the admin account.

One would think that the apostrophe following the two dashes would be ignored and thus not be necessary to include, but without it, an error message is received. Running `nmap` on the BadStore server shows that it is running MySQL 4.1.7. There appears to have been several bugs in MySQL related to apostrophes in comments[1][2], and we believe that a similar bug may be the cause of the odd behavior experienced on BadStore.

(b) The login page for host 192.168.2.134 and that it was was circumvented successfully using SQL injection is shown in Figure 2.

Figure 2: SQL Injection and the Result



Explanation The underlying SQL code for the login screen for host 192.168.2.134 is believed to be the same as before: without injection, the SQL code is thought to be `SELECT * FROM user WHERE UserName = 'username' AND Password = 'password'`. Then during the injection, we input `admin '-- '` in the text box for the username and some arbitrary password in the text box for the password. The WHERE condition is altered into `WHERE UserName = 'admin' -- ' AND Password = 'password'` (or equivalently, `WHERE UserName = 'admin'`). So there is no need for a password and we can directly log into the admin account.

(c) **Prepared Statement** A prepared statement, which is also called a parametrized statement, is a SQL query with variables inside of it. That is to say, we prepare the query with blank spots to fill and it will automatically protect the query from SQL injection.

Here is a code snippet for using a prepared statement in PHP[3]:

```
stmt = dbh->prepare("INSERT␣INTO␣REGISTRY␣(name,␣value)␣VALUES␣(:
    name,␣:value)");
stmt->bindParam(':name', name);
stmt->bindParam(':value', value);
```

In our case, a system administrator could prevent the SQL injections in the previous exercises by using a prepared statement such as the following:

```
prepare("SELECT * FROM user WHERE UserName = :username AND
    Password = :password");
bind(':username', username);
bind(':password', password);
```

Explanation There are two variables in the prepared statement: username and password. Without injection, for instance with the username `admin` and the password `test`, the SQL query for logging on would be `SELECT * FROM user WHERE username = 'admin' AND password = 'test'`. During an injection attempt, for instance with the username `admin' -- '` and password `123`, the SQL query becomes `SELECT * FROM user WHERE username = 'admin\' -- ' AND password = '123'`. This is because the binding system will automatically change the input to protect the query. Thus, the SQL injection doesn't work in this situation.

(d) The school lost all the student records because the table Students in the database is dropped by SQL injection. The SQL statement intended to be executed can be assumed to be of the form `INSERT INTO Students VALUES ('Robert');`. The SQL injection had this query altered into the following two statements and comment: `INSERT INTO Students VALUES ('Robert'); DROP TABLE Students ; --');`. When the query is executed, the table Students will be dropped.

What the school should do is to sanitize the database inputs by utilizing prepared statements as mentioned above. They can create the prepared statement as follows:

```
prepare("INSERT INTO Students VALUES (':name')");
bind(':name',name);
```

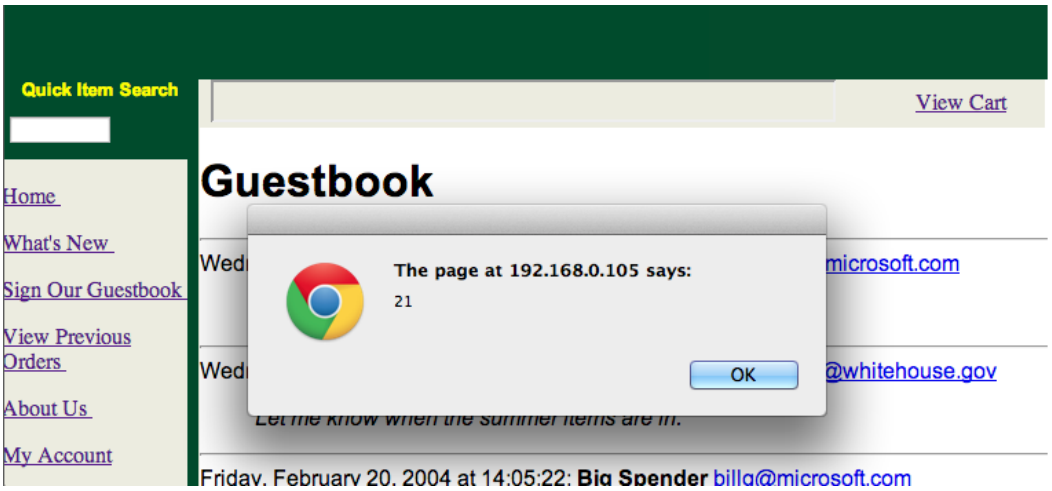
Task 2: XSS and CSRF

Exercises:

(a) The steps for performing an XSS attack on BadStore are as follows:

- Open BadStore in your browser.
- Click "Sign Our GuestBook" on the left side of the page.
- In the "Your Name" field, type whatever you want.
- In the "Email" field, type whatever you want.
- In the "Comments" field, type *<script>alert("1")</script>* .
- Click "Add Entry", the page should like this below:

Figure 3: Alert Made by XSS Attack



Explanation: In the example, we write a piece of Javascript code (which simply opens a message box) enclosed in script tags in the comment area and submit it to the guest book. The attack is successful because the website has an XSS vulnerability which enables us to insert Javascript into the website and have it executed by other users. When the page reloads, the server will just paste the tag-embraced Javascript code into the HTML code in such a way that it is interpreted as a Javascript snippet rather than the text `<script>alert("1")</script>`.

(b) To perform a CSRF attack, we need to create a custom web page containing deceptive information. The objective of the attack is to have an unsuspecting user make an XSS comment in the guestbook for generating countless alert messages. The key point necessary to execute the attack is to guide the victim to our page and have him or her click on the button. As we demonstrate it just as an example, we can suppose that the victim will click on it. The custom page is so simple that it is just written as a demo. Below are the steps for carrying out the attack:

- As the attacker, write a simple page containing this code:

```
<!DOCTYPE html>
<html>
<head>
<title>iPhone Free!</title>
</head>
<body>
<FORM METHOD="POST" ACTION="http://10.0.2.5/cgi-bin/badstore.cgi?action=doguestbook">
<INPUT TYPE=hidden NAME=name value="<script>for(var␣i=0;i<10000;i++){alert('HHHH');}</script>"
     SIZE=30>
<INPUT TYPE=hidden NAME=email value="1" SIZE=40>
<TEXTAREA style="display:none" NAME=comments COLS=60 ROWS=4 value="aaa"> </TEXTAREA>
<INPUT TYPE=submit VALUE="Get␣Now!">
<INPUT style="display:none" TYPE=reset></Center>
</FORM>
</body>
</html>
```

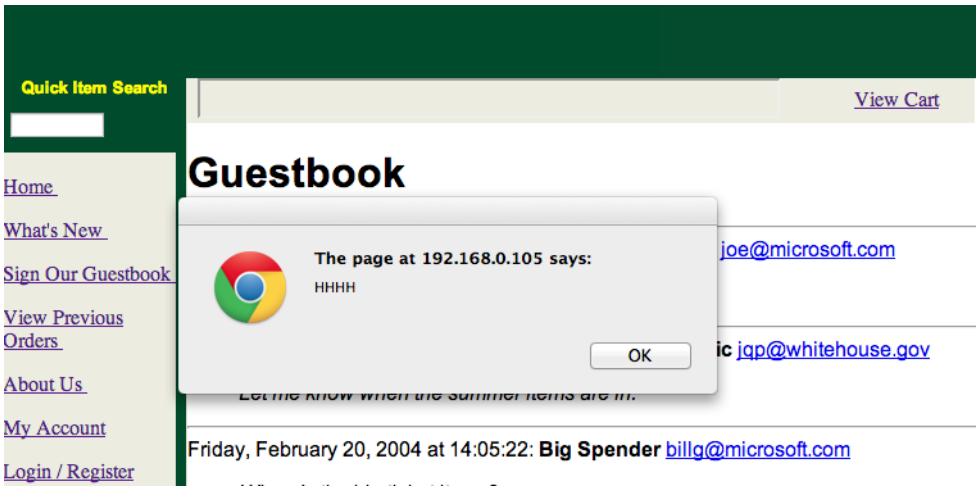
- The page shows like this:

Figure 4: Fake Page

- As the victim, visit the malicious page and click the "Get Now!" button.
- The victim will then be redirected into BadStore, as is shown in Figure 5.
- The alert will repeat again and again as well as leaving many comments.
- Note: There might be some different performance in different browsers. i.e. Safari will operate the code after you quit it and reopen it.

Explanation: In the example, we use a self-written page to perform the CSRF attack. As mentioned above, the key point is that the attacker needs to persuade the victim to visit the deceived page which

Figure 5: Result after Performing CSRF Attack



contains the evil code. The code works as follows: When the user clicks the "Get Now!" button, a request is sent to the server (BadStore), which could be as serious as submitting an order or transferring money to another account but in this case is just making a (malicious) guest book entry. As a result, when the server receives the disingenuous request, it will think that the victim knowingly made the request and perform the related operation.

In the more serious case of submitting an order through a CSRF attack (or any other action that requires the user to be logged on) the victim has to be logged on to BadStore before clicking the "Get Now!" button. Under that additional circumstance, the CSRF attack would still work despite there not being any user credentials specified in the malicious code; the misled browser provides the session cookie itself.

(c) The difference is that, in an XSS attack, the attacker makes the attack by inserting Javascript code (or other code) into the site, such that users visiting the site receive and execute malicious code. In some sense, the users trust the server not to serve them harmful scripts. XSS attacks may be possible if the site does not have strict checks on user inputs.

On the other hand, in CSRF attacks, the attacker sets up some page that tricks the browser of a visitor to send a request to another web server. Such an attack is possible if the server does not check the origin of the request. In other words, it is possible if the server trusts the client not to make bogus requests. Another type of trust necessary for performing the attack is that of the user for the site that deceives the browser into making the requests. For most CSRF attacks (those involving actions that require the user to be logged on), the victim is required not to log out from the target page because the code will only work when the cookie of the target page stays in the browser. It is not the attacker himself that makes it work.

(d) [**higher grades only**]

(e) [**higher grades only**]

Task 3: Authentication

The third and last task of the lab was about authentication, and the exercises were of a theoretical rather than practical nature.

Exercises:

(a) Hashing a list of passwords with a one-way hash function, say f, rather than having the passwords stored in cleartext is a method for reducing the impact of a database leak. Authentication given a password p in such a system is done by computing the hash $f(p)$ of the password and comparing it with the hash for the specific user stored in the database.

In the event that the password hashes are exposed to an attacker, there is no trivial way for him or her to retrieve the passwords corresponding to the compromised password hashes, by the definition of a one-way hash function. Thus, there is no trivial way of authenticating despite having access to both the hash function and the hashes. If an attacker finds the passwords stored in cleartext, on the other hand, he or she can authenticate as any of the affected users on the system. Furthermore, because passwords are frequently reused in more than one system, the attacker might be able to authenticate falsely on other systems as well. In other words, the impact of a cleartext password leak could encompass more than just the attacked system.

While there is no *trivial* way of finding a password corresponding to a specific hash value, there is a cumbersome but in practice feasible way of doing so: password guessing[5]. The idea is to repeatedly come up with a guess for the password, hash it, and compare the result with the hash value in question, continuing until a password guess with the specific hash is found. The hash values for guesses for common passwords can be precomputed into a so-called rainbow table[7] that allow for these passwords to be looked up given their hash value.

Salting is a method for making password guessing more difficult. In addition to storing a hash value for each user, a random string s—the salt—is stored for each user as well. Authentication given a password p is done by computing the hash of a combination of the password and the salt, such as $s+p$ where "+" denotes a concatenation. The resulting hash, $f(s+p)$, is then compared with the hash value in the database.

If an attacker gets hold of the database, which contains a salt and hash for each user, and aims for finding the password of *any* of the users, the addition of the salt will make password guessing more difficult. Let n be the number of users. Under the assumption that each user has a unique salt, the attacker will have to compute n hashes for each password guess, compared to the single computation that is required with hashing alone[6]. Salting offers increased security also against attacks with precomputed tables, seeing as one table would be needed for each possible salt in order to cover the same passwords as without salting.

(b) Assuming that the salt and salted hash are known to an attacker, salting may make the attack on a specific account more difficult, depending on whether precomputed tables are used.

If precomputed tables are used and the attacker did not choose the specific user because the attacker had a precomputed table for that specific salt, salting will make the attack more difficult in that more precomputed tables will be required.

Without precomputation, however, each password guess will require one computation of a hash value, assuming that the hash is computed like mentioned before: $f(s+g)$ for hash function f, salt s, password guess g, and concatenation operator $+$. The only difference in the case that salting is not used is that no salt has to be concatenated; the hash function still has to be evaluated once for each guess. Under the assumption that concatenating the string takes negligible time compared to evaluating the hash function, salting does not make the attack in question harder.

(c) [**higher grades only**]

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(d)
- While the fingerprint sensor of the iPhone 5s can evidently be deceived in a variety of ways, there are at least two reasons that it is a good addition to the iPhone security. The first reason is that

the use of the fingerprint sensor in conjunction with more traditional authentication methods such as PIN codes adds another layer for the attacker to get past. The other reason, while not as convincing as the first, is that the sensor might provide a strong enough protection for some users, by the principle of adequate protection.

- The principle of authenticating with something you have could be leveraged to increase the security of the phone unlocking mechanism drastically. One could imagine that the presence of a physical device—a *token*—capable of communicating with the phone in a wireless manner would be required to unlock the phone. With a challenge-response system, the token could prove its presence without opening up the possibility of a replay attack.

  In this, the time of smart devices, the token need not be a piece of special-purpose hardware with the only purpose of authenticating the possessor to the phone; for instance, a smartwatch could be assigned the task of authentication on the phone.

  While requiring a separate device of some sort to unlock the phone is obviously beneficial in the case that the phone but not the device is lost, a downside of the system is apparent in the opposite scenario: losing the device but not the phone. In that case, the phone is rendered unusable. There being ramifications of an authentication system is not unique to those based on the principle of what you have though; the situation of losing one's device can be likened to that of forgetting one's PIN code, which also renders the phone unusable.

References

[1] MySQL Bugs, "Apostrophes and quotes within a comment confuse the mysql client" accessed 2014–03–23. [Online] Available: `http://lists.mysql.com/bugs/97`

[2] MySQL Bugs, "MySQL Workbench Model Synchronization Single Quote in Comments" accessed 2014–03–23. [Online] Available: `http://bugs.mysql.com/bug.php?id=66680`

[3] php.net, "Prepared statements and stored procedures" accessed 2014–03–22. [Online] Available: `http://www.php.net/pdo.prepared-statements`

[4] Wikipedia, "Cross-site request forgery", accessed 2014–02–01. [Online] Available: `http://en.wikipedia.org/wiki/Cross-site_request_forgery`

[5] M. Bishop, "Computer Security: Art and Science", *"Attacking a Password System"*

[6] M. Bishop, "Computer Security: Art and Science", *"Countering Password Guessing"*

[7] Wikipedia, "Rainbow table", accessed 2014–01–29. [Online] Available: `http://en.wikipedia.org/wiki/Rainbow_table`