Security Principles for PHP Applications

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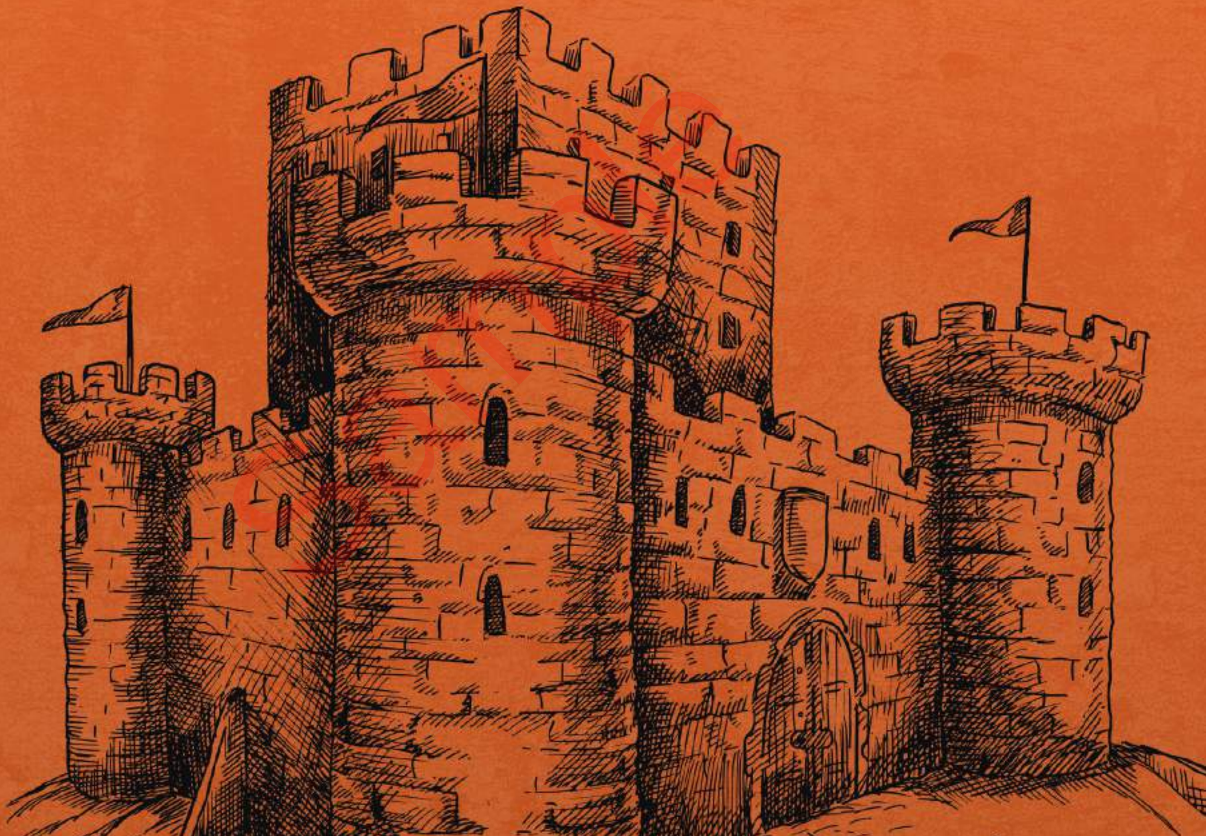

a php[architect] guide

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Chapter 4

ASR1: Injection

Injection flaws, such as SQL, OS, and LDAP injection occur when untrusted data is sent to an interpreter as part of a command or query. The attacker's hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization.

The risk of injection is one of the most common and well-known vulnerabilities in application development. From a high level, injection attacks happen when an attacker has the ability to control the input of your program. If they can write directly to a database, such that their nefarious data is passed unfiltered, they can inject whatever control systems they wish.

A common injection vulnerability is passing parameters directly from the `$_POST` superglobal, which is user-controlled, into a SQL statement:

VULNERABLE

```
// a common SQL injection vulnerabilty
$name = $_POST['name'];
$sql = "SELECT * FROM users WHERE email='$name'";
$result = $db->query($sql);
```

Assume for a moment this code is meant to look up ticket information for a given user attending a conference. A regular form submission would send the user's email to the server and return a row from the database representing that ticket. Consider instead what would happen if an attacker were to trigger the following cURL request:

```
curl -X POST -d "name=a@b.com' OR 1=1;--" http://yoursite.com
```

The server would accept this value and happily concatenate it into the SQL query, generating the following statement:

```
SELECT * FROM users WHERE email='a@b.com' OR 1=1;--'
```

The `OR` in this query will always evaluate to true, and the `--` at the end forces any content following the broken query to be treated as a comment. Instead of returning a specific user's data, this new query will return the entire users table from the database! The attacker now has all of your attendees' information and can do whatever they wish with it. Further, an attacker could inject any query following this same pattern, potentially injecting, modifying, or even *deleting* data.

In the PHP world, injection like this occurs when developers erroneously trust user input. The vulnerable code above allowed users direct input into SQL queries, making the database do something other than it was intended. Other users can manipulate query variables that are used internally to switch application logic from one, expected flow to another. Still, other users might inject executable PHP code into a header that is extracted and inadvertently executed by the application, giving this user control over the PHP stack itself.

Said another way, injection is when you, the developer, give a user the power to dictate what code is being executed. You're then running their application, and they can do whatever they want. They can dump sensitive data to output. They can write extraneous files to disk. They can insert malicious information into the database. The sky is the limit.

At a minimum, allowing users to download, install, and execute arbitrary scripts could let them fill your server's hard disk with junk. The worst-case scenarios, however, are far more chilling. Among other things, an attacker could:

- Use your server as part of a network to launch a denial-of-service attack against someone else.
- Send spam or phishing emails to third parties.
- Use your server as a proxy or host for other illegal activities.

Abdicating control over the behavior of your application to arbitrary users gives those users a great deal of power; at the end of the day, though, *you* are still ultimately responsible for what your server does.

How Big of a Deal Is This?

It's easy as a developer to discount injection as a serious risk to your application. Often, injection vulnerabilities are reported as the ability for a rogue user to input garbage into an application—the easiest response to such a report is to shrug it off as "garbage in, garbage out."

> **Note:** *It's equally easy to discount injection vulnerabilities applying only to trusted admin or superuser access. Many developers will, mistakenly, assume the only users who ever have access to these accounts are "trusted" in the first place. However, if the application ever exposes a privilege escalation vulnerability, or one of these privileged users is tricked into running a malicious command, the consequences to your application could be huge. The chapters on ASR5: Broken Access Control and Cross-Site Request Forgery have deeper explanations of each issue.*

These reports of garbage being inserted into database fields often come from researchers using tools to "fuzz test"[1] your application. Fuzz testing is the practice of providing broken, unexpected, or purely random input to an application to see what happens. With binary, non-memory-safe applications this is an excellent way to test the handling of invalid input.

Are strings accepted in place of integer inputs? What happens when I pass a control character to a function which otherwise takes benign input? Can I make the application do something unexpected? Can I use this behavior to manipulate the application into doing something other than what was intended?

In some situations, though, the garbage input does make the application behave in ways it's not supposed to. The popular webcomic, xkcd.com, illustrates various security principles on occasion. In this instance, the danger of allowing user input into a SQL statement, see *Exploits of a Mom*[2].

The ability to inject non-alphanumeric characters into a SQL statement makes it trivial to inject your own queries into an otherwise trusted framework. An attacker can `SELECT` data to which they'd otherwise lack access. Another attacker could insert themselves into a list of "administrator" users in the database and take control of the system. Yet another attacker could merely destroy the data upon which your application relies.

Further, not protecting against certain character sets can negatively impact your users down the road. Consider users with names containing apostrophes ("O'Malley" or similar) or non-Latin characters. Any of these could potentially break a SQL statement if not properly escaped.

Injection attacks happen frequently in the wild, most frequently when developers are using unparameterized SQL queries or otherwise passing untrusted user input into executable environments. They give the user (or an attacker) a level of control over the system equivalent to the application itself.

How Would This Look in Production?

Attackers can inject their code into your application in three different ways:

1. They can inject additional queries into a SQL statement.
2. They can render malicious user-submitted input through a form (or query or header) that is then used directly in PHP. This also allows cross-site scripting attacks, covered in detail later

[1] *"fuzz test": http://phpa.me/wikipedia-fuzzing*
[2] *Exploits of a Mom: https://xkcd.com/327/*

in the chapter on *CSRF*.

3. They can upload an executable script which is later invoked through another exposed vulnerability.

The code exposing these vulnerabilities looks slightly different in each case, but all have the same root characteristic: the code trusts user input to fall within certain bounds. It also fails to validate the input or those bounds.

SQL Injection

An older WordPress plugin I built suffered from an injection-related flaw somewhat recently. While I was trying to do my best to protect code from untrusted user input, I mistakenly assumed certain parameters were escaped that, in fact, were not.

The code in question had two fatal flaws. The code was trusting data stored within user-provided cookies; in this case, it trusted it had generated a session ID stored within a cookie itself.

In the application's session controller, the following constructor would grab a predefined cookie and extract various data from it. The code assumes the first part of the cookie is a valid session ID and stores it in the controller for later use.

Listing 4.1 VULNERABLE

```
protected function __construct() {
   if (isset($_COOKIE[WP_SESSION_COOKIE])) {
      $cookie = stripslashes($_COOKIE[WP_SESSION_COOKIE]);
      $cookie_crumbs = explode('||', $cookie);

      $this->session_id = $cookie_crumbs[0];
      $this->expires = $cookie_crumbs[1];
      $this->exp_variant = $cookie_crumbs[2];

      // Update the session expiration if we're past the variant time
      if (time() > $this->exp_variant) {
         $this->set_expiration();
         delete_option("_wp_session_expires_{$this->session_id}");
         add_option("_wp_session_expires_{$this->session_id}",
                    $this->expires, '', 'no');
      }
   } else {
      $this->session_id = WP_Session_Utils::generate_id();
      $this->set_expiration();
   }

   $this->read_data();
   $this->set_cookie();
}
```

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