SEMINAR 5
INPUT VALIDATION AND SECURE CODING TECHNIQUES

Strategies to reject invalid data

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What is this seminar?

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- **In this seminar we will give practical examples of how to do certain security tasks linked to the coding phase of the SSDLC, as complement to the theory topic 6**
  - Many in the form of a checklist that allow you to easily check if they have been implemented
- **These examples are shown in the technologies that are used in other courses of the degree on purpose, to favor integration**
  - Node and Spring Boot (SDI)
  - PHP (SEW)
- **We will also mention concepts of**
  - TPP: Concurrency handling
  - DLP/AMD: Handling and validating regular expressions
- **The full (and editable) checklist can be downloaded here**
  - https://github.com/jose-r-lopez/SSI_Extra_Materials/wiki/5.-%E2%9C%85-Secure-Coding-Checklist
  - It aims to be used in your TFG or future software projects

INDEX

< Go to Index

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SECURITY REQUIREMENTS

In the Requisites Engineering course (IR) format

Sample security requirements

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- **This is a list of potential security requirements**
  - They can be used as a base to develop your own
  - Adapt them to you application purpose, users, and restrictions
- **Once you master it, you must use a more complete source**
  - The OWASP* Application Security Verification Standard (ASVS)
    - Free, international, and validated
    - https://github.com/OWASP/ASVS/tree/v4.0.3#latest-stable-version---403
  - Also usable in the next phases: **design**, **implementation**, and **testing**

*The Open Web Application Security Project (OWASP) is a global community dedicated to create more secure software

- **RS1 Validation**
  - RS1.1 **Do not trust anyone**: Validate and sanitize (if required) all data, including those in the DBMS
  - RS1.2 **Do all validation on the server**
    - Favor an allow-list strategy
  - RS1.3 **Encode** all outputs
- **RS2 Encryption**
  - RS2.1 **Encrypt all saved data**
  - RS2.2 **Encrypt all data "in transit"**
    - Sent / received by the user, databases, APIs, etc.
  - RS2.3 **Hash an add salt bits** (at least 28 characters) to all stored passwords (or avoid storing them)
  - RS2.4 **HTTPs** is mandatory on all the application
  - RS2.5 Use the **latest TLS version** for encryption
- **RS3 Dependency Management**
  - RS3.1 **Scan all third-party code** (SCA)
    - To find known vulnerabilities before using it
    - And periodically once the code is incorporated
  - RS3.2 **Minimize the attack surface**
    - Including as few dependencies as possible

SAMPLE SECURITY REQUIREMENTS

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RS4 Data Management

- RS4.1 **Classify and tag** all application data (stored, collected, created…)
  - According to its **criticality**
- RS4.2 Save all app secrets to a **secret store**
- RS4.3 Strictly prohibit secret "**hardcoding**"
- RS4.4 **NO sensitive data** in comments
  - Connection strings, API keys, passwords…
- RS4.5 **Error messages** never contain technical information
- RS4.6 **Only parametrized queries are allowed** for data access
- RS4.7 Do not pass important data in URL parameters

RS5 Technological

- RS5.1 Use all applicable HTTP security headers and **CSP**
- RS5.2 Use **secure cookie settings**
- RS5.3 Use existing **security features**
  - E. g.: Those of the frameworks you use
- RS5.4 Use stable, supported, and updated framework/third-party modules **versions**
- RS5.5 Keep dependencies up **to date**
- RS5.6 Use **security tools (SAST, DAST…)**
  - Before the application goes to production
- RS5.7 **Code review** the application
  - Also before it goes production
- RS5.8 **Capture and handle all errors**
  - Without falling into unexpected states
- RS5.9 **Disable caching** on pages containing private information (e. g. passwords)

SAMPLE SECURITY REQUIREMENTS

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RS6 User Accounts

- RS6.1 All application accounts must be **service accounts**
  - Never user accounts, a unique account per application
- RS6.2 Use password managers and **prohibit key reuse**
- RS6.3 Force **using of long passwords** (pass phrases)
  - With a minimum of complexity
- RS6.4 Verify passwords have not already been **filtered**
  - Using an external service that collects leaks
- RS6.5 **Enable MFA** on all important accounts
- RS6.6 **Do not force periodic password change**
  - Only after a breach
- RS6.7 Assign **roles** to users and permissions to roles
- RS6.8 Use a **unique authentication and identity** management method for the entire application
  - **Avoid storing passwords** (third-party auth service)
- RS6.9 Force the **least privilege** for all accounts
- RS6.10 Enable copy/paste on **password UI elements**
  - Allows using password managers
  - Also disable autocomplete on password fields

RS7 Particular features

- RS7.1 Use application **threat modeling**
- RS7.2 Avoid **user file uploads** (too problematic)
  - If not possible, follow OWASP recommendations
  - https://cheatsheetseries.owasp.org/cheatsheets/File_Upload_Cheat_Sheet.html

RS8 Log

- RS8.1 **Record all access attempts**
- RS8.2 Do not include **sensitive information** in log files
- RS8.3 Use a log format **compatible** with your log analysis tools (SIEMs, …)
- RS8.4 Send your application logs to a **central storage**
  - Favors analysis and correlation of application logs
- RS8.5 Log **improper access attempts**
  - Detect malicious attempts (e. g.: malicious user input) with application code (**proactive defense**)
  - Allow generating security alerts if the application is under attack

< Go to Index

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Input validation and output encoding

Practical ways to deal with input or output information

INPUT VALIDATION

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- **As seen in theory, the input of external users/files/APIs should be treated with extreme caution**
  - It is one of the most important attack vectors
- **Input must be validated**
  - With centralized tested APIs and according to their context
- **Input validation must**
  - Apply to at least all input data
  - Define an allowed set of characters to be accepted
  - Define a minimum and maximum length
    - Decimal and non-decimal digits, maximum string size...
  - Define an expected type or range

1. Input Validation Checklist	
Ensure compliance with mandatory input validation principles	
	Conduct all data validation on a trusted system (e.g., The server)
	Identify all data sources and classify them into trusted and untrusted. Validate all data from untrusted sources(e.g., Databases, file streams, etc.)
	There should be a centralized unique input validation routine for the application
Perform proper data encoding	
	Determine if the system supports UTF-8 extended character sets and if so, validate after UTF-8 decoding is completed
	Encode data to a common character set before validating (Canonicalize)
	Specify proper character sets, such as UTF-8, for all sources of input
	Verify that HTTP header values in both requests and responses contain only ASCII characters
Implement secure management of data contents	
	If any potentially hazardous characters must be allowed as input, be sure that you implement additional controls like output encoding, secure task specific APIs, and implement accounting of the utilization of that data throughout the application. Examples of common hazardous characters include: < > " ' % ( ) & + \\' \"
	If your standard validation routine cannot address the following inputs, then they should be checked discretely
	Check for null bytes (%00) Check for new line characters (%0d, %0a, \r, \n) Check for "dot-dot-slash" (../ or ..\) path alterations characters. In cases where UTF-8 extended character set encoding is supported, address alternate representations like: %c0%ae%c0%ae/ (Utilize canonicalization to address double encoding or other forms of obfuscation attacks)
	Validate all input against a "white" list of allowed characters, whenever possible
Validate data types and limits	
	Validate data length
	Validate data range
	Validate for expected data types
Perform data validation in a secure way	
	All validation failures should result in input rejection
	Validate all client provided data before processing, including all parameters, URLs and HTTP header content (e.g. Cookie names and values). Be sure to include automated post backs from JavaScript or other embedded code
	Validate data from redirects (an attacker may submit malicious content directly to the target of the redirect, thus circumventing application logic and any validation performed before the redirect)

Data validation strategies

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- **Data that comes from an external entity should never be trusted**
  - "*All input is evil*" – Michael Howard ("*Writing Secure Code*")
- **Data validation must be syntactic and semantic**
  - **Syntactic** forces the data to have correct syntax and structure: Dates, currency, DNIs, telephones...
  - **Semantic** forces values to be correct in a context, or according to given business rules
    - The start date must be earlier than the end date, the price of an item is within a supported range, the type of residential road is within the admitted types (street / square /...) ...
- **If these things are checked as soon as possible, unauthorized entries can be detected quickly and act upon it**
  - Must be done in a planned and thorough manner, as part of the system requirements
  - If it is a clear malicious case, responses against the user must be implemented in the software (account suspension, block ...) and create security alerts, as saw in theory (**not just discard the data**)
- **Always favor allowlists (list of allowed items, the rest is blocked)**
  - Over blocklists (list of blocked items, the rest are allowed)

ALLOWLIST VS BLOCKLIST

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- **Use blocklists when the set of items to block is finite, fully known, and not large**
  - **Blocking known specific clients/networks** with a restricted/known number of clients (LAN)
  - **Regional blockades** (by country/area): countries known to be the source of many attacks
  - **Client connections from the ToR network**: The number of output nodes in the ToR network is known
    - They can be blocked individually (https://www.dan.me.uk/torlist/?exit)
  - **Blocking domains known as malicious**: https://github.com/StevenBlack/hosts
  - **Blocking of specific pages for different reasons**, if its number limited
- **Validating with an allowlist is usually more suitable for user input**
  - It requires **defining exactly what is authorized**
    - Anything that is not in that definition **is NOT AUTHORIZED**
  - In case of **well-structured data** (dates, social security numbers, postal codes, emails...) it is feasible to define a very strong validation pattern, **usually with regular expressions**
    - These are generally predefined and standardized for common data types
  - If the input comes from a **fixed set of options**, such as a drop-down list, it **must match exactly one of the values offered to the user**

Implementing input validation strategies

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- **Input validation can be implemented with any technique that ensures syntactic and semantic correctness; usually one of these**
  - **Native validators** of any modern development framework/framework used to create the website
    - Django validators: https://docs.djangoproject.com/en/2.2/ref/validators/
    - Apache Commons validators: https://commons.apache.org/proper/commons-validator/
    - PHP (SEW): https://www.w3schools.com/php/php_form_validation.asp
    - Node.Js (SDI): https://www.npmjs.com/package/validator?activeTab=readme
    - Spring Boot (SDI): https://reflectoring.io/bean-validation-with-spring-boot/
    - ...
  - **Validation with JSON and XML (XSD)** schemas for inputs that follow these formats
  - **Type conversion** (e.g., `Integer.parseInt()` in Java, `int()` in Python...) with **strict exception handling**
  - **Checking the minimum and maximum** value for numeric parameters and dates, and **Length** for strings
  - **Strict checking of a set of allowed values**: especially for string parameters that can only have a small number of possible values (days of the week, months...)
  - **Regular expressions** for any other structured data (see the input validation seminar)
    - The entire input string must be validated, **avoiding the use of wildcards**

TYPE CONVERSION IS IMPORTANT

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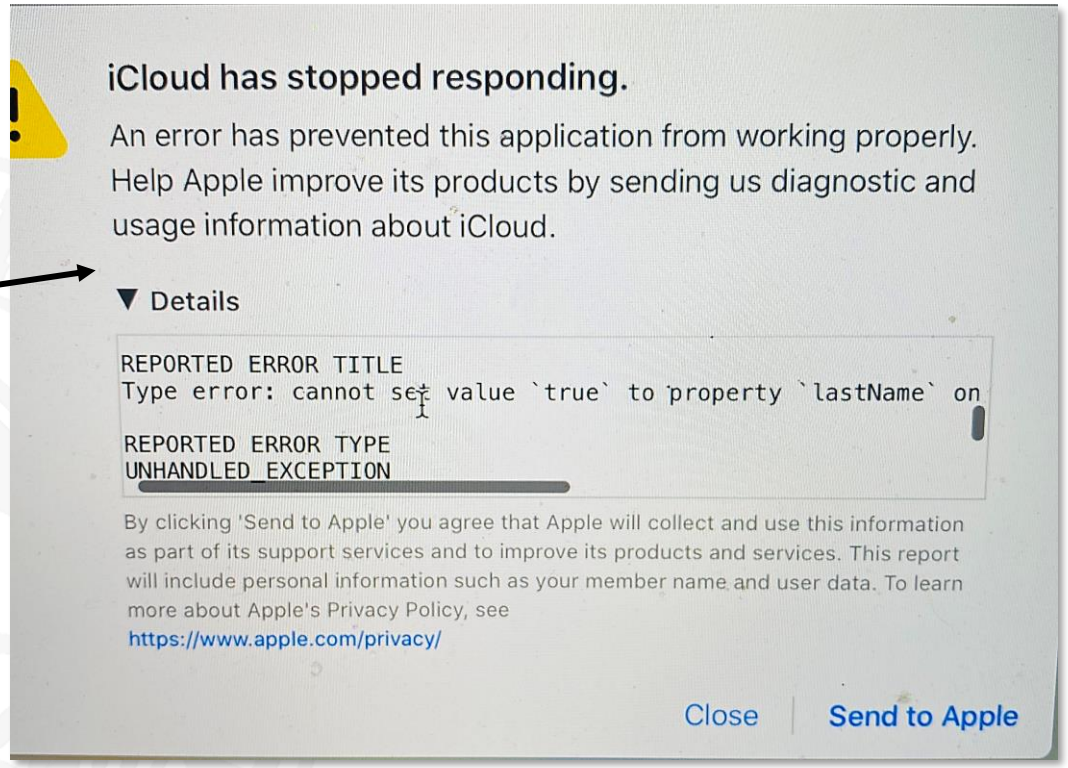
- **Type conversion may be neglected, thinking that syntactic/semantic validation is enough**
  - But this might cause errors in special conditions
- **iCloud: The case of “Rachel True"**
  - Someone forgot to force `lastName` type to **`string`**
  - Therefore, it was inferred that it was `boolean`
    - They didn't add '' to the value so...
  - The program failed to run on a lower layer
  - **Consequence**: Rachel was unable to access iCloud for more than 6 months
    - His only "sin" is to have "True“ as surname...
- **The guy that put "null" as his car license plate**
  - It appeared even in the news!
  - He had to pay 12k in parking tickets from others!



Source: https://blog.elhacker.net/2021/03/usuaria-con-apellido-TRUE-bloquea-sistema-iCloud-Apple-boolean.html

Source: https://www.wired.com/story/null-license-plate-landed-one-hacker-ticket-hell/

Validation of free-form Unicode text

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- **Free-form text, especially with Unicode characters, is often difficult to validate**
  - It has a large set of characters
  - In these cases, it is also important to **encode** the text according to the context of the application
- **If your text legitimately supports potentially dangerous characters (', <, or >)…**
  - They must be encoded correctly throughout the data lifecycle
- **To validate free-form text inputs these techniques are used**
  - **Normalization**: Make sure that there is a canonical encoding that is used throughout the application
    - And that there are no invalid characters present at any time
  - **Character category allowlists**: Unicode allows allowlist categories such as "decimal digits" or "letters"
    - They not only cover the Latin alphabet, but also other global alphabets (e.g., Arabic, Cyrillic...)
  - **Allowlists of individual characters**: E.g.: if letters and apostrophes are allowed (Irish names)
    - But not the entire category of punctuation marks for a given data
- **This is beyond the scope of the course, but you can learn more here**
  - https://ipsec.Pl/python/2017/input-validation-free-form-unicode-text-python.Html

REGULAR EXPRESSIONS

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- **Regular expressions you've seen in AMD or DLP are one of the most common data validation tools**
  - Creating regular expressions for data validation can be complicated
    - It is beyond the scope of this course
  - But there are many resources that provide us with **already created regular expressions**!
    - **Appropriate for validating common data types**
    - One of the best known is: https://www.owasp.org/index.php/OWASP_Validation_Regex_Repository
    - Some frameworks can also define default regular expressions for certain data types
- **The PCRE (Perl-Compatible Regular Expression) regular expression format is one of the most widely used formats**
  - Many languages have libraries that process these regular expressions

Examples of regular expression whitelists

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- **Regular expression for URLs**
  - `![CDATA[^((((https?|ftps?|gopher|telnet|nntp)://)|(mailto:|news:))(%[0-9A-Faf]{2}|[-()_.!~*';/?:@&=+$,A-Za-z0-9])+)([).!';/?:,][[:blank:]])?$]]`
- **Regular expression for IPv4 addresses**
  - `![CDATA[^(25[0-5]|2[0-4][0-9]|[01]?[0-9][0-9]?)\.(25[0-5]|2[0-4][0-9]|[01]?[0-9][0-9]?)\.(25[0-5]|2[0-4][0-9]|[01]?[0-9][0-9]?)\.(25[0-5]|2[0-4][0-9]|[01]?[0-9][0-9]?)$]]`
- **Regular expression for emails**
  - `![CDATA[^[a-zA-Z0-9_+&*-]+(?:\.[a-zA-Z0-9_+&*-]+)*@(?:[a-zA-Z0-9-]+\.)+[a-zAZ]{2,7}$]]`
- **Regular expression for English numbers expressed in words**
  - `![CDATA[^(zero|one|two|three|four|five|six|seven|eight|nine)$]]`

PROTECTION AGAINST CODE INJECTION ATTACKS

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- **All user-controlled data received on the server must be encoded when it is part of the HTML response to a request**
  - E. g.: `<script>` would be returned as `&lt;script&gt;`
- **If we don't do this, we may be facilitating code injection attacks.**
- **The type of encoding that data received from users needs depends on the context of the page where that data is inserted**
  - For example, **HTML encoding** is appropriate for data placed in the HTML body of the response
  - However, user data placed within the scripts of an HTTP response page would require **JavaScript-specific encoding** (or encoding appropriate for the scripting language you use)
  - The same happens with user data placed within CSS, URLs...
  - **Encoding HTML entities alone is not enough!**
  - You can find a complete guide on how to do it here (**XSS prevention rules**)
    - https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.md

PROTECTION AGAINST CODE INJECTION ATTACKS

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- **Although there are many XSS attack vectors, following the mentioned XSS prevention rules rules allows us to prevent them**
- **We must treat HTML pages as a "template" with "placeholders"**
  - The developer can only place untrusted data within these "placeholders"
  - For each of them, we implement slightly different security rules
- **Why?**
  - Each "placeholder" has a different context
  - Actions to prevent content from being interpreted as code change based on that context
- **Untrusted data should never be used on parts of the page other than those "placeholders" defined in the OWASP URL on the previous slide**
  - The effort to make sure they're not a problem is too high, and not worth it in most cases
  - So, it is necessary to keep user input restricted to the “placeholders" defined by the rules
  - **Rules 2 and 3 of the previous OWASP URL cover most common cases**

Encoding libraries

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- **Manually encoding data is not recommended**
- **There are public, free, and tested libraries that will do a better job**
- **The likelihood of skipping validations due to implementation details is much lower**
- **Some examples are**
  - ASP .NET: https://docs.microsoft.com/es-es/aspnet/core/security/cross-site-scripting?view=aspnetcore-3.1
  - OWASP Java Encoder Project: https://www.owasp.org/index.php/OWASP_Java_Encoder_Project
  - PHP (SEW): https://www.virtuesecurity.com/preventing-cross-site-scripting-php/
  - NodeJS (SDI) uses **template engines** for XSS prevention through coding
  - Spring Boot (SDI): https://stackabuse.com/securing-spring-boot-web-applications/
    - Spring security should also be checked and used to prevent multiple attack types: https://spring.io/projects/spring-security
    - ...

ENCODING

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- **Another alternative is the OWASP Java Encoder Project**
  - https://www.owasp.org/index.php/owasp_java_encoder_project
  - Provides numerous coding features to help defend against XSS **in a variety of different contexts**: HTML, JavaScript, XML, and CSS, with no dependencies and high performance
- **Encoding is done with the `Encode` class**
  - Contains methods for the multiple supported encoding contexts
- **Examples of context-dependent coding**
  - HTML
    - Basic: `<body><%= Encode.forHtml(UNTRUSTED DATA)%></body>`
    - Content: `<textarea name="text"><%= Encode.forHtmlContent(UNTRUSTED DATA)%></textarea>`
    - Attribute: `<input type="text" name="name" value="<%= Encode.forHtmlAttribute(UNTRUSTED DATA) %>"/>`
  - CSS: `<div style="width:<= Encode.forCssString(UNTRUSTED DATA)%>">`
  - JavaScript
    - Block: `<script type="text/javascript"> var txt= "<%= Encode.forJavaScriptBlock(UNTRUSTED DATA)%>"; … </script>`
    - Variable: `<button onclick="alert('<%= Encode.forJavaScriptAttribute(UNTRUSTED DATA) %>');"> Submit </button>`

ENCODING

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- URL
  - Parameter values: `<a href="/search?value=<%= Encode.forUriComponent(UNTRUSTED DATA)%>&order=1#top">`
  - Parameters of a REST URL: `<a href="/public/<%= Encode.forUriComponent(UNTRUSTED DATA)%>">`

Handling an untrusted full URL

- When controlling a fully qualified URL, first verify that it is a legal URL
  - `String url = validateURL(untrustedInput);`
- Then encode the URL as an HTML attribute when you type it on the page
- Linkable text must be encoded in a different context

```
<a href="<%= Encode.forHtmlAttribute(Untrusted URL) %>">
<%= Encode.forHtmlContent(Name of the untrusted link) %>
</a>
```

HTML SANITIZER

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- **HTML needs to be cleaned up when only a subset of it is valid in a given context**
  - Again, we must rely on proven third-party tools to get this job done
- **One of the most popular is OWASP Java Html Sanitizer**
  - https://github.Com/owasp/java-html-sanitizer
  - Defines a series of policies that determine the allowed HTML elements
    - You can define custom elements
  - **`BLOCKS`**: Allows common block elements, including `<p>`, `<h1>` etc.
  - **`FORMATTING`**: Allows common formatting elements, including `<b>`, `<i>` etc.
  - **`IMAGES`** : Allows `<img>` HTTP, HTTPS and relative sources
  - **`LINKS`** : Allows `HTTP`, `HTTPS`, `MAILTO`, and relative links
  - **`STYLES`** : Allows certain secure CSS properties in `style= "..."`
  - **`TABLES`** : Allows common table elements

```
import org.owasp.html.Sanitizers;
import org.owasp.html.PolicyFactory;
PolicyFactory sanitizer = Sanitizers.FORMATTING.and(Sanitizers.BLOCKS);
String cleanResults = sanitizer.sanitize("<p>Whatever <b>it takes</b>");
```

AUTO-ENCODING TEMPLATES

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- **Many application frameworks (especially web frameworks) provide templates that automatically code context-based elements**
- **Obviously, this type of technology saves us a lot of problems: encoding operations**
- **Examples**
  - Strict Contextual Scaping (from AngularJS): https://docs.angularjs.org/api/ng/service/$sce
  - Go Templates (from Go): https://golang.org/pkg/html/template/
  - Node.js Template Engines (for SDI) : https://www.veracode.com/blog/secure-development/nodejs-template-engines-whydefault-encoders-are-not-enough
  - Spring Boot (for SDI): Use Spring Security features (https://spring.io/guides/gs/securing-web/)
- **It is always convenient to see if our framework has this type of technology**
  - Or choose it only if you own these technologies, as you take security seriously

ENCODING THE OUTPUTS

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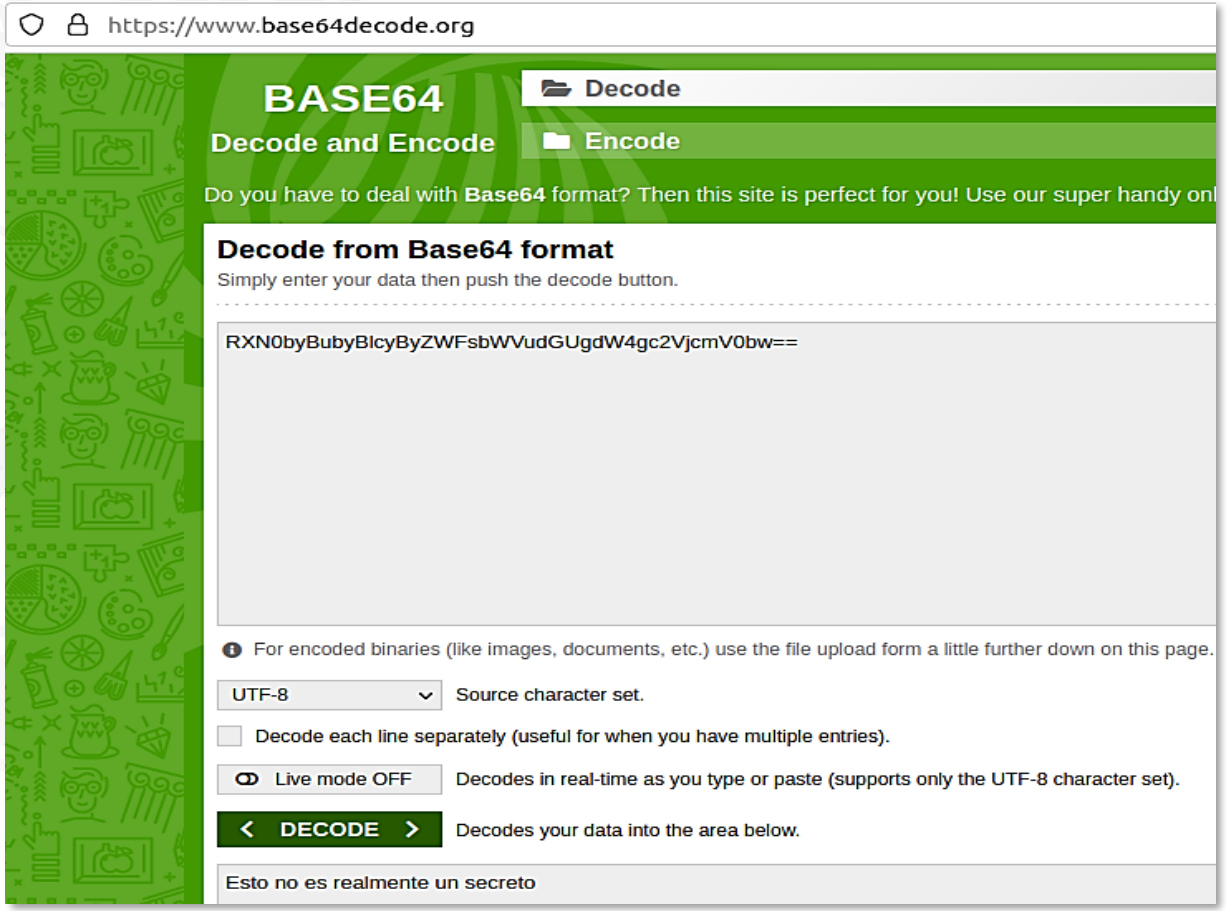
- **Our data must be encoded to not cause problems to other systems that depend on our data**
  - Encoding avoids taking advantage of our flaws to deploy attacks on third-party software
  - To do this, we must follow the same rules that we saw in the previous slides
- **Try to avoid using OS commands as recipients of our data**
- **Encoding is not encryption**
  - It only converts character encoding to ASCII, the format supported by HTTP
  - It is easily decoded by multiple tools/APIs, even online (www.base64decode.org, Cyberchef)
  - One popular encoding method is Base64

2. Output Encoding	
Ensure compliance with mandatory output encoding principles	
	Conduct all encoding on a trusted system (e.g., The server)
	Use a standard, tested routine for each type of outbound encoding performed over the data that the application emits
Encode output according to its context	
	Encode all data returned to the client that originates outside the application's trust boundary. HTML entity encoding is one example, but does not work in all cases
	Contextually sanitize all untrusted outputs that are going to be used in SQL, XML, and LDAP queries
	Encode all characters, unless they are known to be safe for the intended interpreter
	Sanitize all output of un-trusted data that is going to be used with operating system commands



< Go to Index

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Access control

Authorization. MFA

Access control (authorization)

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- **It is best to have a single centralized authorization mechanism for the entire application**
- **Each request must be explicitly authorized**
- **Restrict access to anything valuable to authorized users**
  - Functions, information...
- **Allowed user accounts and their privileges must be set in the design phase**

3. Access Control (Authorization)	
Ensure compliance with mandatory authorization principles	
	Access controls should fail securely
	Deny all access if the application cannot access its security configuration information
	Use a single application-wide component to check access authorization. This includes libraries that call external authorization services
	Use only trusted system objects (e.g. server-side session objects), for making access authorization decisions
Enforce proper restrictions only to authorized users	
	Restrict access to application data to only authorized users
	Restrict access to files or other resources, including those outside the application's direct control, to only authorized users
	Restrict access to protected functions to only authorized users
	Restrict access to protected URLs to only authorized users
	Restrict access to security-relevant configuration information to only authorized users
	Restrict access to services to only authorized users
	Restrict access to user and data attributes and policy information used by access controls
	Restrict direct object references to only authorized users
Implement security best access control practices in business logic code	
	Enforce application logic flows to comply with business rules
	If state data must be stored on the client, use encryption and integrity checking on the server side to catch state tampering.
	Limit the number of transactions a single user or device can perform in a given period of time. The transactions/time should be above the actual business requirement, but low enough to deter automated attacks
	Server-side implementation and presentation layer representations of access control rules must match
	Use the "referer" header as a supplemental check only, it should never be the sole authorization check, as it is can be spoofed
Implement proper authorization management	
	Create an Access Control Policy to document an application's business rules, data types and access authorization criteria and/or processes so that access can be properly provisioned and controlled. This includes identifying access requirements for both the data and system resources
	Enforce authorization controls on every request, including those made by server-side scripts, "includes" and requests from advanced client-side technologies like AJAX
	If long authenticated sessions are allowed, periodically re-validate a user's authorization to ensure that their privileges have not changed and if they have, log the user out and force re-authentication
	Segregate privileged logic from other application code
Manage user accounts securely	
	Implement account auditing and enforce the disabling of unused accounts (e.g., After no more than 30 days from the expiration of an account's password.)
	Service accounts or accounts supporting connections to or from external systems should have the least privilege possible
	The application must support disabling of accounts and terminating sessions when authorization ceases (e.g., Changes to role, employment status, business process, etc.)

4. Authentication and Password Management

Ensure compliance with mandatory authentication principles

- [ ] All authentication controls must be enforced on a trusted system (e.g., The server)
- [ ] All authentication controls should fail securely
- [ ] Establish and utilize standard, tested, authentication services whenever possible
- [ ] Require authentication for all pages and resources, except those specifically intended to be public
- [ ] Segregate authentication logic from the resource being requested and use redirection to and from a centralized authentication control
- [ ] Use a centralized implementation for all authentication controls, including libraries that call external authentication services

Implement proper password storage policies

- [ ] Authentication credentials for accessing services external to the application should be encrypted and stored in a protected location on a trusted system (e.g., The server). The source code is NOT a secure location
- [ ] If your application manages a credential store, it should ensure that only cryptographically strong one-way salted hashes of passwords are stored and that the table/file that stores the passwords and keys is writeable only by the application. Do not use the MD5 algorithm
- [ ] Password hashing must be implemented on a trusted system (e.g., The server).

Enforce secure password transmission

- [ ] Only send passwords over an encrypted connection or as encrypted data, such as in an encrypted email
- [ ] Use only HTTP POST requests to transmit authentication credentials

Enforce a secure password policy

- [ ] Enforce password complexity requirements established by the application policy or regulation. Authentication credentials should be strong enough to withstand typical attacks (e.g., requiring the usage of alphanumeric and special characters)
- [ ] Change all vendor-supplied default passwords and user IDs or disable the associated accounts
- [ ] Enforce password changes based on requirements established in the application policy or regulation. Critical systems may require more frequent changes. The time between resets must be administratively controlled
- [ ] Enforce password length requirements established by the application policy or regulation. Consider the use of multi-word pass phrases
- [ ] Passwords should be at least one day old before they can be changed, to prevent attacks on password re-use
- [ ] Prevent password re-use

Implement secure authentication mechanism practices

- [ ] Validate the authentication data only on completion of all data input, especially for sequential authentication implementations
- [ ] Authentication failure responses should not indicate which part of the authentication data was incorrect. For example, instead of "Invalid username" or "Invalid password", just use "Invalid username and/or password" for both. Error responses must be truly identical in both display and source code
- [ ] If using third party code for authentication, inspect the code carefully to ensure it is not affected by any malicious code
- [ ] Use Multi-Factor Authentication for highly sensitive or high value accounts
- [ ] Utilize authentication for connections to external systems that involve sensitive information or functions

Manage account passwords securely in GUIs / application logic

- [ ] All administrative and account management functions must beat least as secure as the primary authentication mechanism
- [ ] Disable "remember me" functionality for password fields
- [ ] Enforce account disabling after an established number of invalid login attempts (e.g. five attempts is common). The account must be disabled for a period of time sufficient to discourage brute force guessing of credentials, but not so long as to allow for a denial-of-service attack to be performed
- [ ] Enforce changing temporary passwords on the next account usage
- [ ] If using email based resets, only send email to a pre-registered address with a temporary link/password
- [ ] Notify users when a password reset occurs
- [ ] Password entry should be obscured on the user's screen (e.g., on web forms use the input type "password")
- [ ] Password reset and changing operations require the same level of controls as account creation and authentication
- [ ] Password reset questions should support sufficiently random answers. (e.g., "favorite book" is a bad question because "The Bible" is a very common answer). However, it is best not to use this reset mechanism
- [ ] Re-authenticate users prior to performing critical operations
- [ ] Temporary passwords and links should have a short expiration time

Implement a password log

- [ ] Implement monitoring to identify attacks against multiple user accounts, utilizing the same password (password spray). This attack pattern is used to bypass standard lockouts, when user IDs can be harvested or guessed
- [ ] The last use (successful or unsuccessful) of a user account should be reported to the user at their next successful login

Implementing an MFA

José Manuel
Redondo López

- **Implementing an MFA can seem to be a very advanced and difficult operation**
  - But the usage of MFA is so common today that there are APIs that considerably simplify their implementation
- **We must look for the best API for our framework / language**
- **And, if possible, use existing third-party MFA solutions**
- **Some examples of implementation**
  - Google OAuth2: https://developers.google.com/identity/protocols/OAuth2
  - Google Authenticator: https://medium.com/@richb_/easy-two-factor-authentication-2fa-with-googleauthenticator-php-108388a1ea23
  - PHP (for SEW): https://medium.com/@richb_/easy-two-factor-authentication-2fa-with-googleauthenticator-php-108388a1ea23
  - Node .js (for SDI): https://developer.okta.com/blog/2018/05/22/simple-multifactor-authentication-innode
  - Spring Boot (for SDI): https://sultanov.dev/blog/multi-factor-authentication-with-spring-boot-andoauth2/

< Go to Index

Source: zona-militar.com

Cryptography and data security

How to protect your private data

PRACTICAL TIPS ON CRYPTOGRAPHY

José Manuel
Redondo López

- Never expose secret information
- Always encrypt private information
- Never use unreliable, outdated or unvalidated cryptography modules
- Follow the principles described in cryptography and application security theory topics

5. Cryptographic Practices	
Ensure compliance with mandatory cryptography management policies	
	All cryptographic functions used to protect secrets from the application user must be implemented on a trusted system (e.g., The server)
	Establish and utilize a policy and process for how cryptographic keys will be managed
	Protect master secrets or passwords from unauthorized access
Use only adequate cryptography modules	
	All random numbers, random file names, random GUIDs, and random strings should be generated using a cryptographic module's recommended random number generator when these random values are intended to be un-guessable
	Cryptographic modules should fail securely
	Cryptographic modules used by the application should be compliant to FIPS 140-2 or an equivalent standard. (See http://csrc.nist.gov/groups/STM/cmvp/validation.html)

COMMUNICATIONS SECURITY

José Manuel
Redondo López

- **To avoid problems and to ensure maximum protection, always use TLS**
  - Regardless of the content of the transmitted data
  - **HTTPs is mandatory on production!**
- **Always use a secure TLS version**
- **Follow the principles described in the cryptography topic**
- **Use proper TLS settings on the web server**
  - This is not difficult if we follow Mozilla's recommendations
  - https://ssl-config.mozilla.org/

6. Communication Security	
Ensure compliance with mandatory communication security principles	
	Filter parameters containing sensitive information from the HTTP referrer, when linking to external sites
	Implement encryption for the transmission of all sensitive information (or for all information, in general). This should include TLS for protecting the connection and may be supplemented by discrete encryption of sensitive files or non-HTTP based connections
	Specify character encodings for all connections
Implement secure TLS management policies	
	Failed TLS connections should not fall back to an insecure connection
	TLS certificates should be valid and have the correct domain name, not be expired, and be installed with intermediate certificates when required
	Utilize a single standard TLS implementation that is configured appropriately
	Utilize TLS connections for all content requiring authenticated access and for all other sensitive information
	Utilize TLS for connections to external systems that involve sensitive information or functions

< Go to Index

General secure code creation practices

Concrete actions when creating your code

Source: zona-militar.com

General code creation practices

José Manuel Redondo López

- **Update everything**
  - A vulnerability in our software (and its CVE) can be the problem
- **Use measures to prevent the forgery of third-party dependencies**
  - File hashes (topic 2) or SCA tools
- **Don't use metaprogramming**
  - TPP: `eval`, `exec`...
- **Expose yourself as little as possible**
  - Minimize privileged access
  - Implement measures to hinder code reverse engineering (code obfuscation)
- **Program defensively**
  - https://latteandcode.medium.com/qu%c3%a9-es-eso-de-la-programaci%c3%b3n-defensiva6a89d3bcab8e

7. General Coding Practices	
Ensure compliance with mandatory secure coding practices	
	Use tested and approved managed code rather than creating new unmanaged code for common tasks
Implement a secure policy to use external APIs / Libraries	
	Implement safe updating. If the application will utilize automatic updates, then use cryptographic signatures for your code and ensure your download clients verify those signatures. Use encrypted channels to transfer the code from the host server
	Review all secondary applications, third party code and libraries to determine if they are necessity and validate its safe functionality, as these can introduce new vulnerabilities
	Use checksums or hashes to verify the integrity of interpreted code, libraries, executables, and configuration files
	Utilize task specific built-in APIs to conduct operating system tasks. Do not allow the application to issue commands directly to the Operating System, especially using application-initiated command shells
Use secure programming techniques	
	Avoid calculation errors by understanding your programming language's underlying representation and how it interacts with numeric calculation. Pay close attention to byte size discrepancies, precision, signed/unsigned distinctions, truncation, conversion and casting between types, "not-a-number" calculations, and how your language handles numbers that are too large or too small for its underlying representation
	Do not pass user supplied data to any dynamic execution function
	Explicitly initialize all your variables and other data stores, either during declaration or just before the first usage
	In cases where the application must run with elevated privileges, raise privileges as late as possible, and drop them as soon as possible
	Protect shared variables and resources from inappropriate concurrent access
	Restrict users from generating new code or altering existing code
	Utilize locking to prevent multiple simultaneous requests or use a synchronization mechanism to prevent race conditions
(EXTRA) counter-reverse engineering features	
	Use a packer
	Use code obfuscation
	Use code trimming

DATA PROTECTION

José Manuel
Redondo López

- **Always apply the least necessary privilege to data access**
- **Do not give information about yourself**
  - User, staff, developer ...), the structure of the application, or the used technologies
- **Avoid remembering sensitive data in the application's GUI**
- **Protect source code at all costs**
- **These techniques were discussed in**
  - Topic 2 (Cryptography)
  - Topic 3 (OS Security)
  - Topic 6 (Application Security)

8. Data Protection	
Implement secure data permission handling	
	Implement appropriate access controls for sensitive data stored on the server. This includes cached data, temporary files and data that should be accessible only by specific system users
	Implement least privilege, restrict users to only the functionality, data and system information that is strictly required to perform their tasks
	Protect all cached or temporary copies of sensitive data stored on the server from unauthorized access and purge those temporary working files as soon as they are no longer required.
	Protect server-side source-code from being downloaded by a user
Encrypt data securely	
	Encrypt highly sensitive stored information, like authentication verification data, even on the server side. Always use well vetted algorithms, and see "Cryptographic Practices" for additional guidance
Implement secure information storage	
	Do not store passwords, connection strings or other sensitive information in cleartext or in any non-cryptographically secure manner on the client side. This includes embedding data in insecure formats like: Microsoft viewstate or compiled code
	The application should support the removal of sensitive data when that data is no longer required. (e.g. personal information or certain financial data)
Remove any information the application gives about itself	
	Do not include sensitive information in HTTP GET request parameters
	Remove comments in user accessible production code that may reveal data about the backend system or other sensitive information
	Remove file metadata and any kind of additional information files may give
	Do not use default templates of structures that may reveal technologies you are using
	Remove unnecessary application and system documentation as this can reveal useful information to attackers
Implement secure GUI practices to deal with sensitive data	
	Disable auto complete features on forms expected to contain sensitive information, including authentication
	Disable client-side caching on pages containing sensitive information. Cache-Control: no-store, may be used in conjunction with the HTTP header control "Pragma: no-cache", which is less effective, but is HTTP/1.0 backward compatible

SESSION MANAGEMENT

José Manuel
Redondo López

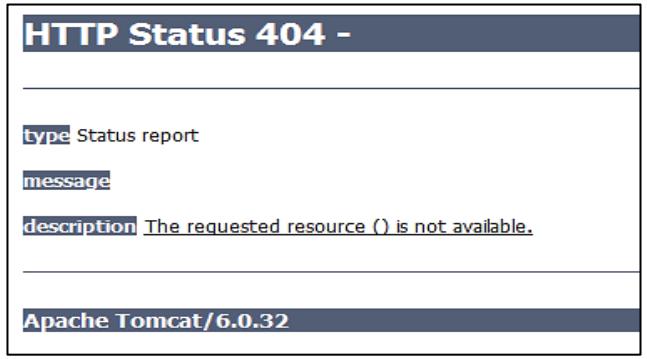
- **Stealing sessions allow taking other users identities: it MUST be avoided**
  - Never reveal a valid session ID
  - Follow the recommended session ID secure handling rules
- **Follow the guidelines to implement cookies securely**
  - Session IDs are typically stored as cookie attributes
- **Control user suspicious behavior**
  - Simultaneous sessions from different geolocations...
- **Make sure that the logout function invalidates the session**

9. Session Management	
Ensure compliance with mandatory session management practices	
	Session identifier creation must always be done on a trusted system (e.g., The server)
	Session management controls should use well vetted algorithms that ensure sufficiently random session identifiers
	Use the server or framework's session management controls. The application should only recognize these session identifiers as valid
Implement secure cookie management	
	Do not expose session identifiers in URLs, error messages or logs. Session identifiers should only be in the HTTP cookie header. For example, do not pass session identifiers as GET parameters
	Set cookies with the HttpOnly attribute, unless you specifically require client-side scripts within your application to read or set a cookie's value
	Set the "secure" attribute for cookies transmitted over an TLS connection
	Set the domain and path for cookies containing authenticated session identifiers to an appropriately restricted value for the site
Implement secure login management	
	Do not allow concurrent logins with the same user ID, unless it is a requisite
	Generate a new session identifier on any re-authentication
	If a session was established before login, close that session and establish a new one after a successful login
Implement secure logout management	
	Disallow persistent logins and enforce periodic session terminations, even when the session is active. Especially for applications connecting to critical systems. Termination times should support business requirements and the user should receive a notification with sufficient warning time to mitigate negative effects
	Establish a session inactivity timeout that is as short as possible, based on balancing risk and business functional requirements. In most cases it should be no more than several hours
	Logout functionality should be available from all pages protected by authorization
	Logout functionality should fully terminate the associated session or connection
Handle session data securely	
	Generate a new session identifier and deactivate the old one periodically. (This can mitigate certain session hijacking scenarios where the original identifier was compromised)
	Generate a new session identifier if the connection security changes from HTTP to HTTPS, as can occur during authentication. Within an application, it is recommended to consistently utilize HTTPS rather than switching between HTTP to HTTPS
	Protect server-side session data from unauthorized access, by other users of the server, by implementing appropriate access controls on the server
	Supplement standard session management for highly sensitive or critical operations by utilizing per-request, as opposed to per-session, strong random tokens or parameters
	Supplement standard session management for sensitive server-side operations, like account management, by utilizing per-session strong random tokens or parameters. This method can be used to prevent Cross Site Request Forgery attacks

ERROR HANDLING

José Manuel
Redondo López

- **Avoid errors showing too much information**
  - Generic messages for the user, detailed for developers
  - Avoid errors such as the one in the image
- **Log all important error messages,**
  - But make sure they don't reveal private information!
- **Limit access to logs**
  - Only authorized users can access



10. Error Handling and Logging	
Ensure compliance with mandatory logging practices	
	All logging controls should be implemented on a trusted system (e.g., The server)
Do not disclose excessive information on error messages	
	Do not disclose sensitive information in error responses, including system details, session identifiers or account information
	Implement generic error messages and use custom error pages
	Use error handlers that do not display debugging or stack trace information
Implement secure error handling	
	Error handling logic associated with security controls should deny access by default
	Properly free allocated memory when error conditions occur
	The application should handle application errors and not rely on the server configuration
Enable secure error log creation and management	
	Do not store sensitive information in logs, including unnecessary system details, session identifiers or passwords
	Ensure log entries that include un-trusted data will not execute as code in the intended log viewing interface or software
	Ensure logs contain important log event data
	Ensure that a mechanism exists to conduct log analysis
	Logging controls should support both success and failure of specified security events
	Restrict access to logs to only authorized individuals
	Use a cryptographic hash function to validate log entry integrity
	Utilize a unique "master" function for all logging operations
Log the adequate types of information related to security	
	Log all access control failures
	Log all administrative functions , including changes to the security configuration settings
	Log all apparent tampering events, including unexpected changes to state data
	Log all authentication attempts, especially failures
	Log all backend TLS connection failures
	Log all input validation failures
	Log attempts to connect with invalid or expired session tokens
	Log all system exceptions
	Log cryptographic module failures

File management

José Manuel
Redondo López

- **Try to avoid a file upload functionality in the application**
- **If it is mandatory, follow recommended file upload rules**
  - https://cheatsheetseries.owasp.org/cheatsheets/File_Upload_Cheat_Sheet.html
  - Especially those that prevent malicious file uploads
  - Or, better, **use a tested and verified third-party module that implements this**
- **Always check access to external files**
- **Never allow users to specify routes**
  - Even partially!
- **Use allowlists for restricting file types**

11. File Management	
Ensure compliance with mandatory file management practices	
	Ensure application files and resources are read-only
Securely handle includes and references to files	
	Do not pass user supplied data directly to any dynamic include function
	Do not pass directory or file paths, use index values mapped to pre-defined list of paths
	Do not pass user supplied data into a dynamic redirect. If this must be allowed, then the redirect should accept only validated, relative path URLs
	Never send an absolute file path to the client
	When referencing existing files, use a whitelist of allowed file names and types. Validate the value of the parameter being passed and if it does not match one of the expected values, either reject it or use a hard-coded default file for the content instead
Implement secure file uploads, if this functionality is necessary	
	Do not save files in the same web context as the application. Files should either go to the content server or in the database
	Implement safe uploading in Linux by mounting the targeted file directory as a logical drive using the associated path or a chrooted environment
	Limit the type of files that can be uploaded to only those types that are needed for business purposes
	Prevent or restrict the uploading of any file that maybe interpreted by the web server
	Require authentication before allowing a file to be uploaded
	Scan user uploaded files for viruses and malware
	Turn off execution privileges on file upload directories
	Validate uploaded files are the expected type by checking file headers. Checking for file type by extension alone is not sufficient

VALIDATING FILES THAT ARE UPLOADED TO AN APPLICATION

José Manuel
Redondo López

- **Many applications (especially websites) allow users to upload files, such as profile pictures**
- **This functionality can be used to attempt to load an unauthorized file type**
  - Putting executable code or another type of malicious file on a server
- **Therefore, we must correctly check the uploaded files**
  - The uploaded **file name** must be validated to make sure it has an allowed extension
  - The uploaded **file size** should not be larger than the maximum allowed file size
    - Which should always be set!
  - If **uploading zip files** is supported, you must perform the following checks before you unzip it
    - Consistent and not excessively long destination route
    - Reasonable compression level (extreme compression levels can overwhelm server processing)
    - Estimating the uncompressed size: avoiding attacks such as zip bombs

VALIDATING FILES THAT ARE UPLOADED TO AN APPLICATION

José Manuel
Redondo López

- **Typical uploaded Office documents (Word, Excel...) can be malicious**
  - They can contain malicious code that runs when a user opens them
- **The most common types of malicious file attack vectors are**
  - Word/Excel/PowerPoint documents: Using VBA Macros and the OLE Package
  - **PDF** documents: with malicious code inserted as an attachment
  - **Images**: Malicious code embedded in the file, executable binary files with an image extension
- **To avoid problems of this type we must**
  - Word/Excel/PowerPoint/PDF: Detect when a document contains OLE or JavaScript objects
    - If this is detected, it is safer to block the upload process and **do NOT to try to "clean" the file**
  - **Images**: blocking the upload, as there is no legitimate reason why the user should upload images with embedded code
- **All validations must be coded manually or (better) look for reputable third-party components that do so. Examples in Java:**
  - https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/Protect_FileUpload_Against_Malicious_File.md

STORING FILES THAT ARE UPLOADED TO AN APPLICATION

José Manuel
Redondo López

- **A new file name must be used to save all uploaded files**
- **The name must never contain any data provided by the user, and must be random**
  - E.g. : If you upload a file `photo.jpg` you can rename it to something like `as345ajrbbe.jpg` (random)
  - You get the following advantages
    - That the uploaded file cannot be directly accessed
    - Avoid malicious names created to evade filters, such as `photo.jpg;.asp` or `/../../../../../photo.jpg`
  - Every time you download an image from a social network this is exactly what happens
- **Uploaded files should be scanned for malicious content**
  - Anti-malware, static scanning, etc.
- **The file path must not be specified by the client, the server must set it**

SERVING FILES THAT ARE UPLOADED TO AN APPLICATION

José Manuel
Redondo López

- **When serving user-uploaded content you must ensure that the correct MIME type is used**
  - For example, images should be used as an `image/jpeg` type
- **There are files with special significance and, if uploaded, they could lead to vulnerabilities**
  - `crossdomain.xml`/`clientaccesspolicy.xml`: allows cross-domain data loading in Java
  - `.htaccess` and `.htpasswd`: Contain web server configuration options for the directory that has them, and may overwrite the default server settings
- **Never allow uploading files with executable code**
  - Examples: `.aspx`, `.asp`, `.css`, `.xhtml`, `.rhtml`, `.shtml`, `.jsp`, `.js`, `.pl`, `.php`, `.cgi`...

VERIFYING FILES THAT ARE UPLOADED TO AN APPLICATION

José Manuel
Redondo López

- **When uploading images, use image rewrite libraries that verify that the image is valid and remove "foreign" content**
  - These libraries also allow you to find out the type of content by analyzing the image
  - This type is the one to use to determine the extension of the saved image file
    - And not the one detected in the image header
  - **Images can be maliciously altered**
  - Once this data is obtained, the image should be checked again to see if its type is within the list of allowed image types (`.jpg`, `.png`, `.gif`...)
- **The following link can help with these tasks**
  - https://stackoverflow.Com/questions/55869/determine-file-type-of-an-image

< Go to Index

System configuration, development tools and dependencies

Security in application configuration

Source: zona-militar.com

SYSTEM CONFIGURATION

José Manuel
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- **On the production server**
  - Do not upload unnecessary content
  - Do not enable unnecessary functionality
  - Configure it securely following validated automated strengthening procedures (topic 4)
    - CIS Benchmarks, STIGs, OpenSCAP...
- **Basic Apache 2/IIS installation is reviewed in ASR**

13. System Configuration	
Use a secure software update policy	
	Ensure servers, frameworks and system components are running the latest approved version
	Ensure servers, frameworks and system components have all patches issued for the version in use
Deploy a secure web server configuration regarding software elements	
	Define which HTTP methods, GET or POST, the application will support and whether it will be handled differently in different pages in the application
	Disable unnecessary HTTP methods, such as WebDAV extensions. If an extended HTTP method that supports file handling is required, utilize a well-vetted authentication mechanism
	If the webserver handles both HTTP 1.0 and 1.1, ensure that both are configured in a similar manor or insure that you understand any difference that may exist (e.g. handling of extended HTTP methods)
	Remove unnecessary information from HTTP response headers related to the OS, web-server version and application frameworks
	Restrict the web server, process and service accounts to the least privileges possible
	Turn off directory listings
Minimize and remove unnecessary files in the server	
	Prevent disclosure of your directory structure in the robots.txt file by placing directories not intended for public indexing into an isolated parent directory. Then "Disallow" that entire parent directory in the robots.txt file rather than Disallowing each individual directory
	Remove all unnecessary functionality and files
	Remove test code or any functionality not intended for production, prior to deployment
Deploy a secure application configuration policy	
	Implement a software change control system to manage and record changes to the code both in development and production
	Implement an asset management system and register system components and software in it
	Isolate development environments from the production network and provide access only to authorized development and test groups. Development environments are often configured less securely than production environments and attackers may use this difference to discover shared weaknesses or as an avenue for exploitation
	The security configuration store for the application should be able to be output in human readable form to support auditing
	When exceptions occur, fail securely

DATABASE SECURITY

José Manuel
Redondo López

- **ALWAYS USE PARAMETERIZED QUERIES**
- **Treat the DB like any external system**
  - Properly encode the input
  - Do not trust the data you return; validate them
  - Update the DBMS software
- **Use a security management policy**
  - Passwords (strong, non-default...)
  - Remove unnecessary content
  - And use the corresponding CIS Benchmark (or similar) for the secure configuration of the DBMS

14. Database Security	
Ensure compliance with mandatory secure database management principles	
	Use strongly typed parameterized queries
Securely handle types	
	Ensure that variables are strongly typed
	Utilize input validation and output encoding and be sure to address meta characters. If these fail, do not run the associated database command
Enforce proper secure database permission	
	The application should connect to the database with different credentials for every trust distinction (e.g., user, read-only user, guest, administrators
	The application should use the lowest possible level of privilege when accessing the database
Implement secure database management policies	
	Close the connection as soon as possible
	Connection strings should not be hard coded within the application. Connection strings should be stored in a separate configuration file on a trusted system and they should be encrypted.
	Disable any default accounts that are not required to support business requirements
	Remove or change all default database administrative passwords. Utilize strong passwords/phrases or implement multi-factor authentication
	Remove unnecessary default vendor content (e.g., sample schemas)
	Turn off all unnecessary database functionality (e.g., unnecessary stored procedures or services, utility packages, install only the minimum set of features and options required (attack surface reduction))
	Use secure credentials for database access
	Use stored procedures to abstract data access and allow for the removal of permissions to the base tables in the database

Secure use of development frameworks/languages

José Manuel Redondo López

- **Modern frameworks/languages have built-in anti-XSS protections**
  - They must be correctly used to create our applications (**never validate manually**)
  - **Do not deactivate them**
- **Always use the latest possible stable version (patches)**
  - Deploy to production using the framework options (e.g.: Angular 2+: `ng build-prod`)
- **Many frameworks/languages integrate security protections**
  - The image lists common PHP ones (SEW)
  - Next slide, for Node.js and Spring Boot (SDI)
  - HTML5 has many security features
    - https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/HTML5_Security_Cheat_Sheet.md

REV 2 / 2010-Apr-12

PHP Application Security Checklist

BASIC

- ☐ Strong passwords are used.
- ☐ Passwords stored safely.
- ☐ register_globals is disabled.
- ☐ Magic quotes is disabled.
- ☐ display_errors is disabled.
- ☐ Server(s) are physically secure.

INPUT

- ☐ Input from $_GET, $_POST, $_COOKIE, and $_REQUEST is considered tainted.
- ☐ Understood that only some values in $_SERVER and $_ENV are untainted.
- ☐ $_SERVER['PHP_SELF'] is escaped where used.
- ☐ Input data is validated.
- ☐ \0 (null) is discarded in input.
- ☐ Length of input is bounded.
- ☐ Email addresses are validated.
- ☐ Application is aware of small, very large, zero, and negative numbers. Sci. notation too.
- ☐ Application checks for invisible, look-alike, and combining characters.
- ☐ Unicode control characters stripped out when required.
- ☐ Outputted data is sanitized.
- ☐ User-inputted HTML is santized with HTMLPurifier.
- ☐ User-inputted CSS is sanitized using a white-list.
  - ☐ Abusable properties (position, margin, etc.) are handled.
  - ☐ CSS escape sequences are handled.
  - ☐ JavaScript in CSS is discarded (expressions, behaviors, bindings).
- ☐ URLs are sanitized and unknown and unwanted protocols are disallowed.
- ☐ Embedded plugins are restricted from executing JS.
- ☐ Embedded plugin files (Flash movies) are embedded in a manner so that only the intended plugin is loaded.
- ☐ The application uses a safe encoding.
  - ☐ An encoding is specified using a HTTP header.
  - ☐ Inputted data is verified to be valid for your selected encoding if using an unsafe encoding.

FILE UPLOADS

- ☐ Application verifies file type.
  - ☐ User-provided mime type value is ignored.
  - ☐ Application analyzes the content of files to determine their type.
  - ☐ It is understood that a perfectly valid file can still contain arbitrary data.
- ☐ Application checks the file size of uploaded files.
  - ☐ MAX_FILE_SIZE is not depended upon.
  - ☐ File uploads cannot "overtake" available space.
- ☐ Content is checked for malicious content.
  - ☐ Application uses a malware scanner (if req.).
  - ☐ Uploaded HTML files are displayed securely.
- ☐ Uploaded files are not moved to a web-accessible directory.
- ☐ Extensive path checks are used when serving files.
- ☐ Uploaded files are not served with include().
- ☐ Uploaded files are served as an attachment using the Content-Disposition header.
- ☐ Application sends the `X-Content-Type-Options: nosniff` header.
- ☐ Files are not served as "application/octet-stream", "application/unknown", or "plain/text" unless necessary.

DATABASE

- ☐ Data inserted into the database is properly escaped or parameterized/prepared statements are used.
  - ☐ addslashes() is not used.
- ☐ Application does not have more privileges to the database than necessary.
- ☐ Remote connections to the database are disabled if they are unnecessary.

SERVING FILES

- ☐ User input is not directly used in a pathname.
  - ☐ Directory traversal is prevented.
  - ☐ Null (\0) in paths filtered.
  - ☐ Application is aware of ":"
  - ☐ PHP streams are filtered.
- ☐ Access to files is not restricted by hiding the files.
- ☐ Remote files not included with include().

AUTHENTICATION

- ☐ Bad password throttling.
  - ☐ CAPTCHA is used.
- ☐ SSL used to prevent MITM.
- ☐ Passwords are not stored in a cookie.
- ☐ Passwords are hashed.
  - ☐ Per-user salts are used.
  - ☐ crypt() is used with sufficient number of rounds.
  - ☐ MD5 is not used.
- ☐ Users are warned about obvious password recovery questions.
- ☐ Account recovery forms do not reveal email existence.
- ☐ Pages that send emails are throttled.

SESSIONS

- ☐ Sessions only use cookies. (session.use_only_cookies)
- ☐ On logout, session data is destroyed.
- ☐ Session is recreated on authorization level change.
- ☐ Sites on the same server use different session storage dirs.

3RD-PARTIES

- ☐ CSRF issues are prevented with tokens/keys.
  - ☐ Referrers are not relied upon.
  - ☐ Pages that perform actions use POST.
  - ☐ Important pages (logout, etc.) are protected.
- ☐ Your pages are not written in a way (i.e. JSON, JS-like) where they can be included and read on a remote website successfully.
- ☐ Aware that Flash can bypass referrer checks to load images and sound files.
- ☐ The following things will not reveal significant information if included remotely:
  - ☐ Images.
  - ☐ Pages that take a longer time to load.
  - ☐ CSS files.
  - ☐ Existence or ordering of frames.
  - ☐ Existence of a JS variable.
  - ☐ Detected visit of a URL.
- ☐ Inclusion of your website in an inline frame with JS disabled does not reveal a threat.
- ☐ Application uses frame bursting code and sends the `X-Frame-Options` header.

MISCELLANEOUS

- ☐ A cryptographically secure PRNG is used for secret randomly-generated IDs (activation links, secret IDs, etc.).
  - ☐ Suhosin is installed or you are not using rand() or mt_rand() for this.
- ☐ Anything that consumes a lot of resources should be throttled and limited.
  - ☐ Pages that use 3rd-party APIs are throttled.
- ☐ You did not create your own encryption algorithm.
- ☐ Arguments to external programs (i.e. exec()) are validated.
- ☐ Generic internal and external redirect pages are secured.
- ☐ Precautions taken against the source code of your PHP pages being shown due to misconfiguration.
- ☐ Configuration and critical files are not in a web-accessible directory.

SHARED HOSTING

- ☐ Using a secure shared host where users cannot access the files of other users.
- ☐ Aware that fellow shared hosting users:
  - ☐ Can, if on the same IP address, issue requests against your site with XMLHttpRequest in IE6.
  - ☐ Can access your website from 127.0.0.1 or ::1.
  - ☐ Can host a server on the same IP address.
  - ☐ Are not "remote" as far as your DB is concerned.
- ☐ Session & file upload directories are not shared.

Find the annotated original at http://sk89q.com/phpsec/

snyk Spring Boot Security Cheat Sheet

www.snyk.io

1. Use HTTPS in Production

To use HTTPS in your Spring Boot app, extend `WebSecurityConfigurerAdapter` and require a secure connection (Note: this forces HTTPS in development also):

```
@Configuration
public class WebSecurityConfig extends
                    WebSecurityConfigurerAdapter {
 @Override
 protected void configure(HttpSecurity http)
                                  throws Exception {
    http.requiresChannel().requiresSecure();
  }
}
```

2. Test Your Dependencies

Ensure your application does not use dependencies with known vulnerabilities. Use a tool like Snyk to:

- Test your app dependencies for known vulnerabilities.
- Automatically Fix issues that exist.
- Continuously Monitor for new vulns.

3. Enable CSRF Protection

Spring Security enables CSRF support by default. If you use a JavaScript framework, configure the `CookieCsrfTokenRepository` so cookies are not HTTP-only.

```
@EnableWebSecurity
public class WebSecurityConfig extends
                    WebSecurityConfigurerAdapter {
  @Override
  protected void configure(HttpSecurity http)
                                  throws Exception {
  http.csrf()
      .csrfTokenRepository(CookieCsrfTokenRepository
                          .withHttpOnlyFalse());
  }
}
```

4. Use a Content Security Policy

Enable to avoid XSS attacks.

Spring Security provides a number of security headers by default, but not CSP. Enable in your Spring Boot app as follows:

```
@EnableWebSecurity
public class WebSecurityConfig extends
                        WebSecurityConfigurerAdapter {
  @Override
  protected void configure(HttpSecurity http)
                                      throws Exception {
  http.headers().contentSecurityPolicy("script-src
'self' https://trustedscripts.example.com; object-src
https://trustedplugins.example.com; report-uri /csp-
report-endpoint/");
  }
}
```

5. Use OpenID Connect

OpenID Connect (OIDC) provides user information via an ID token in addition to an access token.
Query the `/userinfo endpoint` for additional user information.

6. Use Password Hashing

Don't store passwords in plain text. Spring Security doesn't allow plain text passwords by default.

`PasswordEncoder` is the main interface for password hashing in Spring Security:

```
public interface PasswordEncoder {
  String encode(String rawPasswd);
  boolean matches(String rawPasswd, String encPasswd);
}
```

7. Use the Latest Releases

The start.spring.io site automatically uses the latest versions of libraries for new apps.

For existing apps, when upgrades aren't possible, consider patches from a security vendor, like Snyk.

8. Store Secrets Securely

Store secrets in Vault by HashiCorp or Spring Vault

Extract secrets from the Spring Vault using annotations.

```
@Value("${password}")
String password;
```

9. Pen Test Your App

The OWASP ZAP security tool is a proxy that performs penetration testing. It runs in Spider and Active Scan modes to identify and map all hyperlinks in your app, and automatically test your selected targets against a list of potential vulnerabilities.

10. Have Your Security Team do a Code Review

Code reviews are essential. Ensure all your code changes undergo:

- a security team code review.
- Automatic testing on every pull request using Snyk

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snyk Cheat Sheet: 10 npm Security Best Practices

www.snyk.io

1. Avoid publishing secrets to the npm registry

1. Run `npm publish --dry-run` to review the package before publishing
2. Put sensitive files in `.gitignore`
3. Use the `files` property in package.json to whitelist files and directories

2. Enforce lockfile

Freeze lockfile and ensure the npm CLI installs per lockfile only, without changing it. In CI and build environments favor:

1.
```
$ npm ci
```
2.
```
$ yarn install --frozen-lockfile
```

3. Minimize attack surface—ignore run-scripts

Malicious packages take advantage of key lifecycle events when an npm install runs arbitrary commands.

To minimize this attack surface:

1. Assess a project's health status and credibility before installing a package
2. Disable run-scripts during install such as:

```
$ npm install <package> --ignore-scripts
```

4. Assess npm project health

Review a project for outdated dependencies, and assess environment health with CLI commands:

```
$ npm doctor
$ npm outdated
```

5. Scan and monitor for vulnerabilities in open source dependencies

Don't let vulnerabilities in your project dependencies reduce the security of your application. Make sure to:

1. Connect Snyk to GitHub or other SCMs for optimal CI/CD integration with your projects
2. Run `snyk test` to scan a new project from the CLI
3. Run `snyk monitor` to track and open PRs to automatically fix security vulnerabilities in open source dependencies.

6. Use a local npm proxy

A local private registry such as Verdaccio will give you an extra layer of security, enabling you:

1. Full control of lightweight private package hosting
2. To cache packages and avoid being affected by network and external incidents

Easily spin up verdaccio using docker:

```
$ docker run verdaccio/verdaccio
```

7. Responsible disclosure

Publicly disclosed security vulnerabilities without prior warning and proper coordination pose a potentially serious threat.

We are happy to collaborate on responsible security disclosures for the npm community:

1. Report a security issue via the vulnerability disclosure form
2. Email us at security@snyk.io

8. Enable 2FA

Enable two-factor authentication on npm with

```
$ npm profile enable-2fa auth-and-writes
```

9. Use npm author tokens

Make use of restricted tokens for querying npm packages and functionalities from CI by creating a read-only and IPv4 address range restricted token:

```
$ npm token create --read-only –cidr=192.0.2.0/24
```

10. Understand typosquatting risks

Typos in package installation can be deadly.

1. Be mindful when copy-pasting package install instructions to the terminal and verify authenticity.
2. Opt to have a logged-out npm user in your developer environment
3. Favor npm install with `--ignore-scripts`

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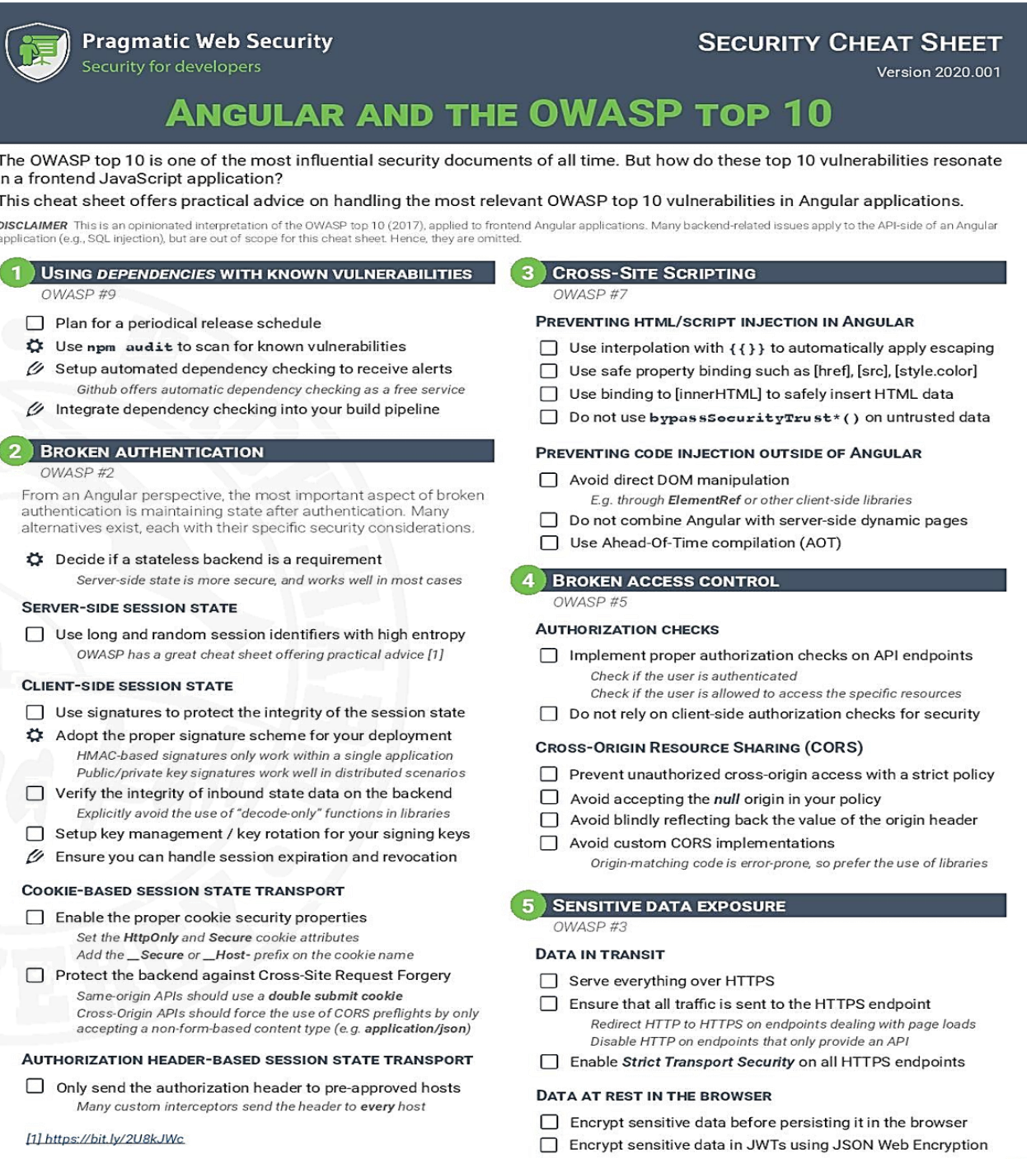
Framework-specific security technologies

José Manuel Redondo López

- **Each framework / technology has its security functionalities**
- **We can find secure development cheat sheets here**
  - https://cheatsheetseries.owasp.org/Glossary.html
  - Ajax: https://cheatsheetseries.owasp.org/cheatsheets/AJAX_Security_Cheat_Sheet.html
  - .Net: https://cheatsheetseries.owasp.org/cheatsheets/DotNet_Security_Cheat_Sheet.html
  - REST: https://cheatsheetseries.owasp.org/cheatsheets/REST_Security_Cheat_Sheet.html
  - …
- **If the application is hosted in the cloud, the threat landscape changes**
  - https://cloudsecurityalliance.org/press-releases/2019/08/09/csa-releases-new-research-top-threats-to-cloud-computing-egregious-eleven/



Pragmatic Web Security
Security for developers

SECURITY CHEAT SHEET
Version 2020.001

ANGULAR AND THE OWASP TOP 10

The OWASP top 10 is one of the most influential security documents of all time. But how do these top 10 vulnerabilities resonate in a frontend JavaScript application?

This cheat sheet offers practical advice on handling the most relevant OWASP top 10 vulnerabilities in Angular applications.

DISCLAIMER This is an opinionated interpretation of the OWASP top 10 (2017), applied to frontend Angular applications. Many backend-related issues apply to the API-side of an Angular application (e.g., SQL injection), but are out of scope for this cheat sheet. Hence, they are omitted.

1 USING *DEPENDENCIES* WITH KNOWN VULNERABILITIES

OWASP #9

- ☐ Plan for a periodical release schedule
- ☐ Use `npm audit` to scan for known vulnerabilities
- ☐ Setup automated dependency checking to receive alerts
  Github offers automatic dependency checking as a free service
- ☐ Integrate dependency checking into your build pipeline

2 BROKEN AUTHENTICATION

OWASP #2

From an Angular perspective, the most important aspect of broken authentication is maintaining state after authentication. Many alternatives exist, each with their specific security considerations.

- ☐ Decide if a stateless backend is a requirement
  Server-side state is more secure, and works well in most cases

SERVER-SIDE SESSION STATE

- ☐ Use long and random session identifiers with high entropy
  OWASP has a great cheat sheet offering practical advice [1]

CLIENT-SIDE SESSION STATE

- ☐ Use signatures to protect the integrity of the session state
- ☐ Adopt the proper signature scheme for your deployment
  HMAC-based signatures only work within a single application
  Public/private key signatures work well in distributed scenarios
- ☐ Verify the integrity of inbound state data on the backend
  Explicitly avoid the use of "decode-only" functions in libraries
- ☐ Setup key management / key rotation for your signing keys
- ☐ Ensure you can handle session expiration and revocation

COOKIE-BASED SESSION STATE TRANSPORT

- ☐ Enable the proper cookie security properties
  *Set the **HttpOnly** and **Secure** cookie attributes*
  *Add the **__Secure** or **__Host-** prefix on the cookie name*
- ☐ Protect the backend against Cross-Site Request Forgery
  *Same-origin APIs should use a **double submit cookie***
  *Cross-Origin APIs should force the use of CORS preflights by only accepting a non-form-based content type (e.g. **application/json**)*

AUTHORIZATION HEADER-BASED SESSION STATE TRANSPORT

- ☐ Only send the authorization header to pre-approved hosts
  *Many custom interceptors send the header to **every** host*

[1] https://bit.ly/2U8kJWc

3 CROSS-SITE SCRIPTING

OWASP #7

PREVENTING HTML/SCRIPT INJECTION IN ANGULAR

- ☐ Use interpolation with `{{}}` to automatically apply escaping
- ☐ Use safe property binding such as [href], [src], [style.color]
- ☐ Use binding to [innerHTML] to safely insert HTML data
- ☐ Do not use `bypassSecurityTrust*()` on untrusted data

PREVENTING CODE INJECTION OUTSIDE OF ANGULAR

- ☐ Avoid direct DOM manipulation
  *E.g. through **ElementRef** or other client-side libraries*
- ☐ Do not combine Angular with server-side dynamic pages
- ☐ Use Ahead-Of-Time compilation (AOT)

4 BROKEN ACCESS CONTROL

OWASP #5

AUTHORIZATION CHECKS

- ☐ Implement proper authorization checks on API endpoints
  Check if the user is authenticated
  Check if the user is allowed to access the specific resources
- ☐ Do not rely on client-side authorization checks for security

CROSS-ORIGIN RESOURCE SHARING (CORS)

- ☐ Prevent unauthorized cross-origin access with a strict policy
- ☐ Avoid accepting the ***null*** origin in your policy
- ☐ Avoid blindly reflecting back the value of the origin header
- ☐ Avoid custom CORS implementations
  Origin-matching code is error-prone, so prefer the use of libraries

5 SENSITIVE DATA EXPOSURE

OWASP #3

DATA IN TRANSIT

- ☐ Serve everything over HTTPS
- ☐ Ensure that all traffic is sent to the HTTPS endpoint
  Redirect HTTP to HTTPS on endpoints dealing with page loads
  Disable HTTP on endpoints that only provide an API
- ☐ Enable ***Strict Transport Security*** on all HTTPS endpoints

DATA AT REST IN THE BROWSER

- ☐ Encrypt sensitive data before persisting it in the browser
- ☐ Encrypt sensitive data in JWTs using JSON Web Encryption

MICROSOFT APPLICATION INSPECTOR

José Manuel
Redondo López

- **Tool that helps minimize risks when using third-party software**
- **It is a source code parser for open-source code that identifies "interesting" features and metadata**
  - Use of cryptography, connections to remote sites, platforms running...
- **Not only does it identify flawed programming practices**
  - But it also identifies and reports code features that may be difficult to detect by manual analysis
  - They are not evaluated; they are only reported so that you better understand what the application does
- **More information**
  - https://www.microsoft.com/security/blog/2020/01/16/introducing-microsoft-application-inspector/
  - https://www.genbeta.com/desarrollo/microsoft-libera-herramienta-open-source-que-permite-analizar-todocodigo-fuente-aplicacion-busca-amenazas
- **Download**
  - https://github.com/MICROSOFT/APPLICATIONINSPECTOR

MICROSOFT APPLICATION INSPECTOR

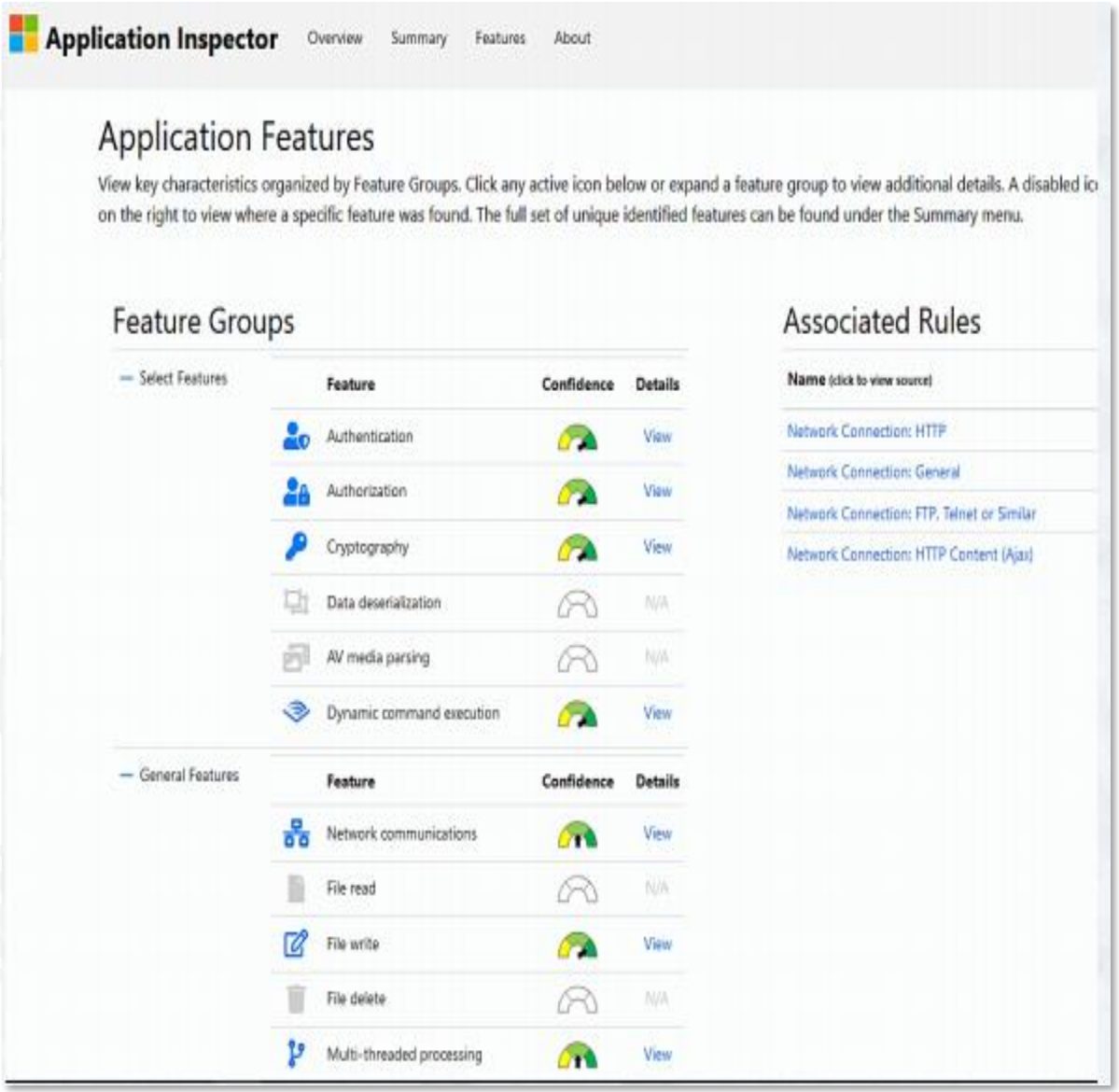
José Manuel
Redondo López

- **It is cross-platform and uses hundreds of feature detection patterns, covering many popular programming languages**
- **Supports identification of the following types of features**
  - **Application frameworks**: development, testing...
  - **Cloud / Service APIs**: Microsoft Azure, Amazon AWS, and Google Cloud Platform
  - **Cryptography**: symmetric, asymmetric, hashing and TLS
  - **Types of data**: sensitive, personally identifiable information.....
  - **Operating System Functions**: platform identification, file system, registration and user accounts
  - **Security Features**: Authentication and Authorization

MICROSOFT APPLICATION INSPECTOR

José Manuel
Redondo López

- **It has many modes of operation, but the main one is "Analyze"**
  - Inspects source code in compressed directories / files (`.tgz`, `.zip`) looking for defined characteristics
- **This is the analysis of the source code of Angular v1.7.9**
  - The "features" category shows the different feature types used in the angular code, classifying it
  - If we select a feature, the tool navigates to the source code where it think it is implemented
  - This makes it very easy to locate and inspect the behavior of the program



Self-evaluation achievement list: Seminar 5

José Manuel
Redondo López

Rank	Concept
	Know the difference and the application of a whitelist and a blacklist
	Be able to perform appropriate type conversions and range checks
	Know how to use encoding libraries
	Use proper encoding libraries and HTML sanitizers
	Know how to choose the most appropriate security requirements
	Know the validation strategies adapted to each context
	Understand the validation mechanisms of modern web frameworks
	Know all the general aspects to create a secure code
	Know how to handle the functionality of uploading files to an application
	Know rules to prevent XSS attacks
	**Enter the security code**: Be able to implement the most appropriate secure coding techniques

SEMINAR 5. INPUT VALIDATION

Source: zona-militar.com