So you thought you were safe using AngularJS. . . . Think again!

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Who Am I?

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Research Interests:

- Browser Security
- JavaScript
- HTML5
- Static analysis

Agenda

- AngularJS In A Nut Shell
- AngularJS Security Protections
- AngularJS Security Issues
- Third-Party Library Security Issues
- Look To The Future

AngularJS In A Nut Shell

- AngularJS is an open source front-end JavaScript framework
- What is the current version of AngularJS:
  - AngularJS 1.6.5
  - Angular 4.3.0
- Angular
  - MVC - Model View Controller
  - MVVM - Model View ViewModel
  - MVW - Model View Whatever
- Originally developed by Miško Hevery, then open sourced, and now maintained by Google
- What are the benefits of AngularJS?
  - Separation of HTML, CSS, and JavaScript logic
  - Convenience in DOM manipulations
  - Performance
- If AngularJS is on the front-end, what technologies are used on the back end?
  - Whatever: NodeJS, Java, C#, you name it
- A lot of Angular applications are built as single-page applications (SPA)

Angular and OWASP Top 10

- OWASP Top 10 issues that Angular code may have:

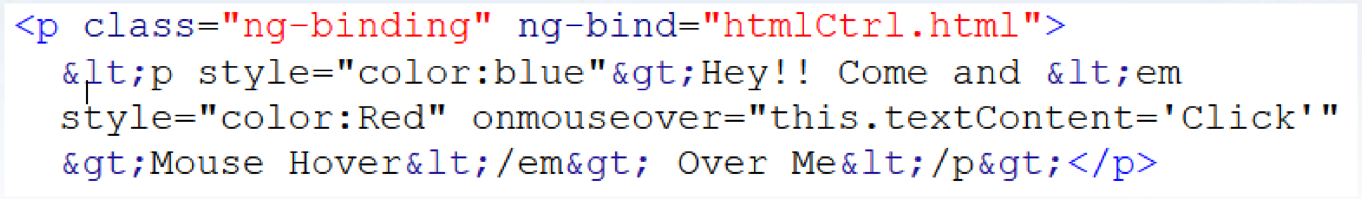
OWASP Top 10	
Injection (SQL, Command, LDAP)	Kinda
~~Broken AuthN and Session Management~~	
Cross-site scripting	
~~Insecure Direct Object Reference~~	
Security Misconfiguration	
Sensitive Data Exposure	
Missing Function Level Access Control	Kinda
CSRF	Kinda
Using Components with Known Vulnerabilities	
Unvalidated Redirects and Forwards	

AngularJS Security Protections

XSS Protection: Output Encoding

- Automatic output encoding
  - Encoding is context aware (HTML element, attribute, URL)
  - All unsafe symbols are encoded, nothing is removed
  - Used with ng-bind

```
<p ng-bind="htmlCtrl.welcome"></p>
```



```
<p class="ng-binding" ng-bind="htmlCtrl.html">
  &lt;p style="color:blue"&gt;Hey!! Come and &lt;em
  style="color:Red" onmouseover="this.textContent='Click'"
  &gt;Mouse Hover&lt;/em&gt; Over Me&lt;/p&gt;</p>
```

XSS Protection: Strict Contextual Escaping

- Before AngularJS version 1.2
  - ng-bind-html-unsafe directive

- SCE (Strict Contextual Escaping) – uses ngSanitize module
  - Sanitization for a particular context: HTML, URL, CSS
  - Used with ng-bind-html
  - Enabled by default in versions 1.2 and later, but can be disabled
    - $sceProvider.enabled(false)
    - $sce.trustAs(type, value) or $sce.trustAsHtml(value)
    - Other $sce.trustAs methods can be in custom directives

XSS Protection: Content Security Policy

- CSP disallows the use of eval() and inline scripts by default
- CSP is configurable
- Angular separates HTML, CSS, and JavaScript > no inline scripts!
- Angular code is compatible with CSP out of the box
- Caveats:
  - Angular uses eval() internally to parse expressions
    - https://github.com/angular/angular.js/blob/0694af8fc4c856f5174545450091602e51f02a11/src/Angular.js#L1120
  - Angular may use inline styles, not inline scripts (for ngCloack, ngHide)
    - https://github.com/angular/angular.js/blob/0694af8fc4c856f5174545450091602e51f02a11/src/Angular.js#L1111
  - Angular without unsafe eval() runs 30% slower when parsing expressions

XSS Protection: Enforcing Content Security Policy

Angular Setting	Code	Angular Behavior
Nothing	<body ng-app>	Use inline scripts, check for unsafe eval in the CSP header
Default CSP	<body ng-app ng-csp>	No inline scripts, no eval
No-unsafe-eval	<body ng-app ng-csp="no-unsafe-eval">	Eval cannot be used, but it's ok to use inline styles CSP must have: style-src 'unsafe-inline'
No-inline-style	<body ng-app ng-csp="no-inline-style">	Angular can use eval, but cannot use inline styles CSP must have: script-src 'unsafe-eval'

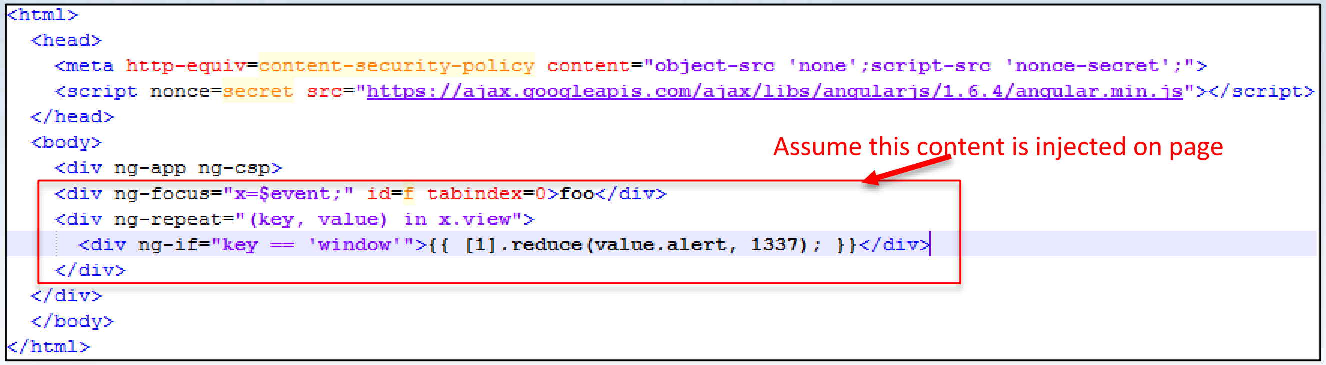
Note: inline styles may be abused by attackers

- See Mario Heiderich's paper on scriptless attacks
  - https://www.nds.rub.de/media/emma/veroeffentlichungen/2012/08/16/scriptlessAttacks-ccs2012.pdf

Instead of allowing 'unsafe-inline' for styles, developers can include angular-csp.css in the HTML for ngShow and ngHide directives to work.

XSS Protection: Bypassing The Content Security Policy

- Injected content can abuse Angular to execute code despite the CSP



```
<html>
  <head>
    <meta http-equiv=content-security-policy content="object-src 'none';script-src 'nonce-secret';">
    <script nonce=secret src="https://ajax.googleapis.com/ajax/libs/angularjs/1.6.4/angular.min.js"></script>
  </head>
  <body>
    <div ng-app ng-csp>
    <div ng-focus="x=$event;" id=f tabindex=0>foo</div>
    <div ng-repeat="(key, value) in x.view">
      <div ng-if="key == 'window'">{{ [1].reduce(value.alert, 1337); }}</div>
    </div>
  </div>
  </body>
</html>
```

Slightly modified CSP bypass example from http://sirdarckcat.github.io/csp/angular.html#f

http://sebastian-lekies.de/csp/bypasses.php

XSS Protection: Sandbox? Not Really

- All versions of Angular up to 1.6 executed Angular Expressions in a sandbox
- Every version had a sandbox escape “vulnerability”
- Sandbox was never considered to protect code for security reasons
- What does it mean “to escape a sandbox”?
  - Directly manipulate the DOM
  - Execute plain old vanilla JavaScript

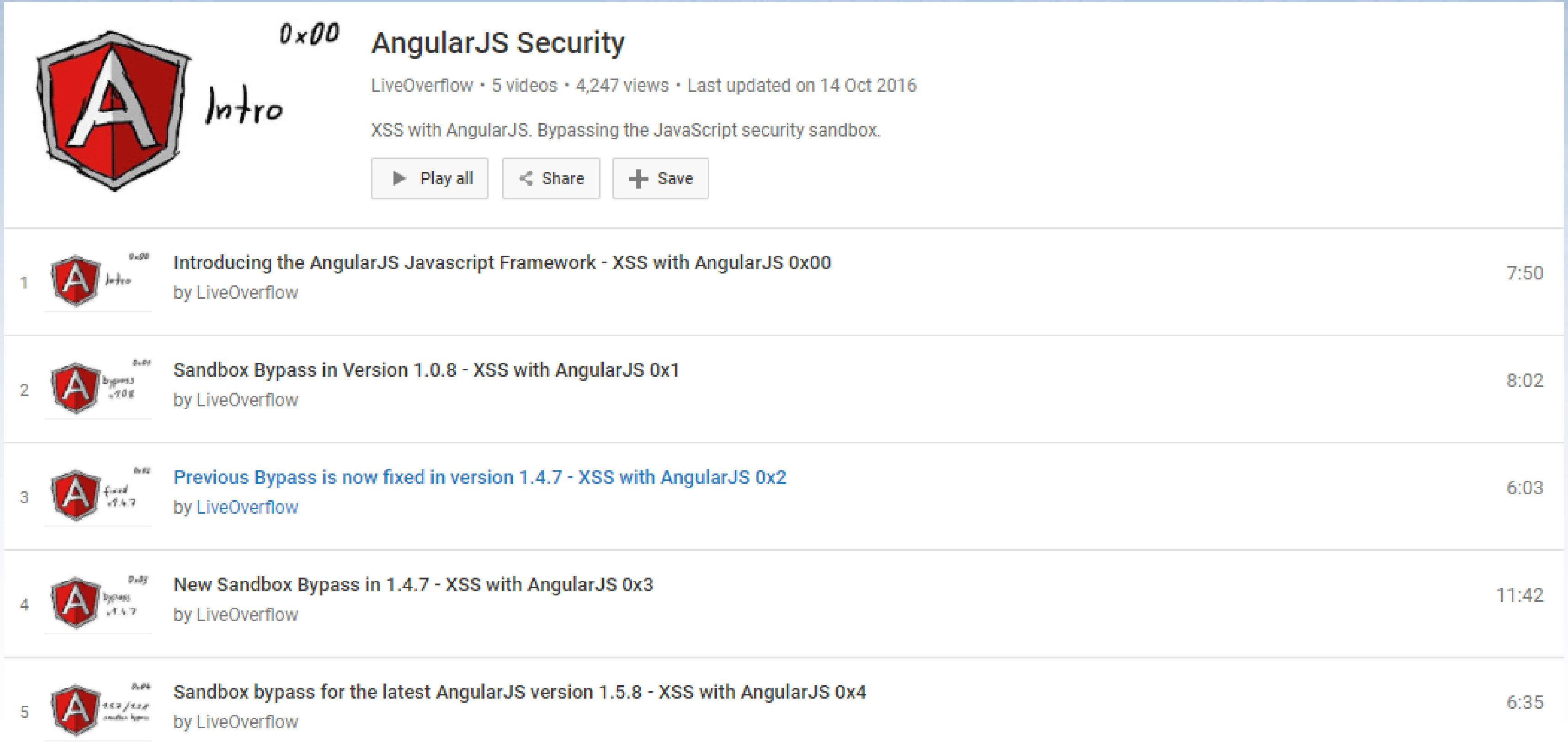
- Example payload:

```
{{x = {'y':''.constructor.prototype}; x['y'].charAt=[].join;$eval('x=alert(1)');}}
```

  - http://blog.portswigger.net/2016/01/xss-without-html-client-side-template.html

- As of Angular 1.6 sandbox has been completely removed
  - https://blogs.synopsys.com/software-integrity/2016/12/28/angularjs-1-6-0-sandbox/

https://www.youtube.com/playlist?list=PLhixgUqwRTjwJTIkNopKuGLk3Pm9Ri1sF



AngularJS Security

LiveOverflow • 5 videos • 4,247 views • Last updated on 14 Oct 2016

XSS with AngularJS. Bypassing the JavaScript security sandbox.

1 Introducing the AngularJS Javascript Framework - XSS with AngularJS 0x00 by LiveOverflow 7:50

2 Sandbox Bypass in Version 1.0.8 - XSS with AngularJS 0x1 by LiveOverflow 8:02

3 Previous Bypass is now fixed in version 1.4.7 - XSS with AngularJS 0x2 by LiveOverflow 6:03

4 New Sandbox Bypass in 1.4.7 - XSS with AngularJS 0x3 by LiveOverflow 11:42

5 Sandbox bypass for the latest AngularJS version 1.5.8 - XSS with AngularJS 0x4 by LiveOverflow 6:35

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CSRF Protection: Help from the Client

- CSRF token must be generated and validated on the server side
- Angular automatically reads a cookie sent from the server and appends the value to an HTTP header
- What a developer needs to do:
  - Securely generate CSRF token on the server-side
  - Add a cookie XSRF-TOKEN with the token value
  - Angular will add a custom header X-XSRF-TOKEN with the token value
  - Verify on the server if the X-XSRF-TOKEN value matches the cookie XSRF-TOKEN value
  - If the token and the cookie values do not match, reject the request
  - The cookie and header values may be changed in Angular via the $http.xsrfHeaderName and $http.xsrfCookieName options to support whatever backend solution

https://www.synopsys.com/blogs/software-security/angularjs-security-http-service/

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AngularJS Security Issues

Loading Angular templates insecurely

- The templateURL which is used to render angular templates for routing, directives, ngSrc, ngInclude, etc
- By default resources are restricted to the same domain and protocol as the application document
- To load templates from other domains or protocols you may either whitelist or wrap them as trusted values
- You can change these by setting your own custom whitelists and blacklists for matching such URLs.

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Loading Angular templates insecurely

- To solve the problem of not being able to load resources from another domain, an insecure whitelist may have been created in which any domain is allowed by configuring the $sceDelegateProvider.resourceUrlWhitelist using wildcards like the example below

```
angular.module('myApp', []).config(function($sceDelegateProvider) {
  $sceDelegateProvider.resourceUrlWhitelist([
    // Insecure - the wildcard allows resource loading from any domain using any protocol
    '**'
  ]);
});
```

```
angular.module('myApp', []).config(function($sceDelegateProvider) {
  $sceDelegateProvider.resourceUrlWhitelist([
    // Insecure - loads over HTTP, wildcard allows for any subdomain and any directory
    ‘http://**.example.com/**'
  ]);
});
```

Loading Angular templates securely (Remediation)

- Configure the specific protocol and domain or sub domain(s) for the resources you trust
- Never use just the double asterisk (**) wildcard to allow arbitrary domains and protocols
- Never use the double asterisk (**) wildcard as part of the protocol or domain, only at the end of a URL
- Ensure resources are loaded over a secure protocol (e.g, only allow https:// URLs)
- The blacklist can be used as a defense-in-depth measure to prevent resourcing templates that have known vulnerabilities within your application

Open Redirect

- The $window.location property enables developers to read/write to the current browser location
- The API exposes the "raw" object with properties that can be directly modified
- By setting the $window.location.href property to a URL, the browser will navigate to that page, even if it is outside of the domain of the current application
- An attacker could use this vulnerability to perform a XSS attack by using a URL that starts with javascript:

Open Redirect (Remediation)

- Open redirects can be prevented by hardcoding the URLs.

```
var redirecturl = 'welcome.html';
```

- Use a whitelist of accepted URLs

```
if(redirecturl != 'welcome.html')
    return;
```

- Use indirect reference maps

```
var dict = {
  'welcome': "welcome.html"
};
if(dict[redirecturl])
    redirecturl = dict[redirecturl];
else
    redirecturl = 'welcome.html';
```

- If absolute URLs need to be used, verify that they start with http(s):

```
var pattern = /^((http|https):\/\/)/;
if(!pattern.test(redirecturl))
    return;
```

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Open Redirect

DEMO

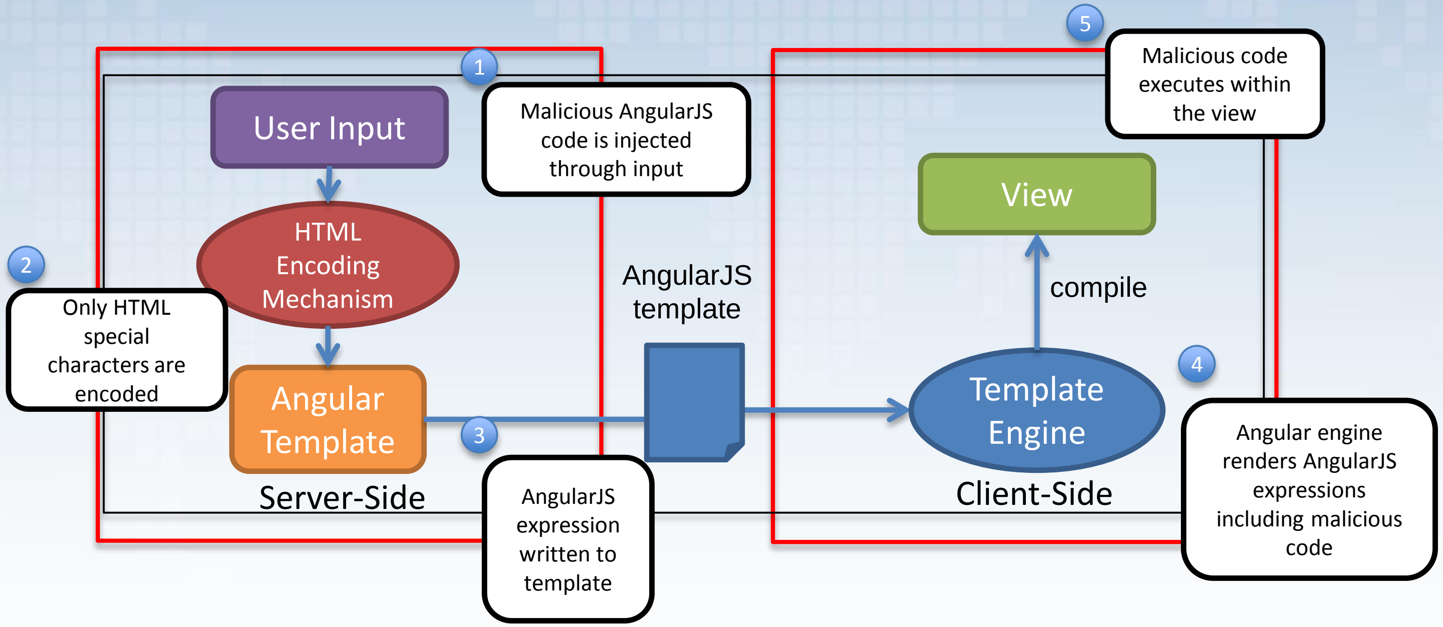
Expression Injection

Server-side templates	Client-side templates
JavaScript: Jade, ejs, Pug	AngularJS ReactJS
Java: JSP	
PHP: Smarty	

- Mixing server-side and client-side templates can cause XSS without the need to inject HTML tags
- User input added to server-side template and then sent to client-side template:
  - Server-side template engine only escapes malicious HTML characters (e.g., <, >, “, ‘)
  - Attacker can place AngularJS expression language within {{ }}
    - Will not be escaped by server-side code
    - Will be executed by the client-side AngularJS template
    - Will run within a sandbox with limited execution of JavaScript (prior to version 1.6)
    - Sandbox bypass is always possible!

- Avoid using both client-side and server-side templates!
  - Keep app logic on server side and presentation on client side

Expression Injection


1
Malicious AngularJS code is injected through input
User Input
HTML Encoding Mechanism
2
Only HTML special characters are encoded
Angular Template
3
AngularJS expression written to template
Server-Side
AngularJS template
Template Engine
4
Angular engine renders AngularJS expressions including malicious code
compile
View
5
Malicious code executes within the view
Client-Side

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Expression Injection (Remediation)

- Where possible re-write Angular templates to be purely an AngularJS page instead of being rendered from the server
  - Assign the returned data to a $scope object and display that data within an expression
  - Return data to ng-bind or ng-bind-html
- Reduce the scope of the *ng-app* directive.
  - ➢ Bind to a specific <div>, <table>, etc. rather than <body>

```
<body>
    ...
    <div ng-app='myApp'>
       ...
    </div>
</body>
```

- Use the *ng-non-bindable* directive

```
<p ng-non-bindable id='message'></p>
```

- Sanitize untrusted input to remove curly braces

- **Note: An attacker with the ability to inject HTML markup could bypass these controls**

Expression Injection

DEMO

Untrusted input treated as Angular expressions

- Angular expressions are code snippets (similar to JavaScript) that can be executed through various methods in Angular
- AngularJS can evaluate expressions
- AngularJS can order data using expressions
- AngularJS can parse expressions

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Untrusted input treated as Angular expressions

$scope Methods
$eval([expression], [locals]);
$evalAsync([expression], [locals]);
$apply([exp]);
$applyAsync([exp]);
$watch(watchExpression, listener, [objectEquality]);
$watchGroup(watchExpressions, listener);
$watchCollection(obj, listener);

orderBy
{{ collection | orderBy: expression : reverse : comparator}}
$filter('orderBy')(collection, expression, reverse, comparator)
angular.controller('ExampleController', ['$scope', 'orderByFilter', function($scope, orderByFilter) { … $scope.friends = orderByFilter(collection, expression, reverse, comparator); }])

Services
$compile(element, transclude, maxPriority);
$parse(expression);
$interpolate(text, [mustHaveExpression], [trustedContext], [allOrNothing]);

http://blog.portswigger.net/2017/05/dom-based-angularjs-sandbox-escapes.html

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Untrusted input treated as Angular expressions (Remediation)

- If possible, avoid using user-input to create expressions.
- If user-input needs to be used in expressions, only use it as data within those expressions, not as part of the expression code.

```
$scope.$evalAsync('result = "Hello " + userInput + "!"');
```

- If user-input needs to be evaluated as part of the expression code, strict input validation **must** be used to prevent arbitrary code execution.

```
if(window.location.search) {
  var orderby = decodeURIComponent(window.location.search.split("=")[1]);
  //Using the external Object.prototype.hasOwnProperty.call() in the unlikely event that 'hasOwnProperty' has been overwritten on the object we check
  //In most cases, the simpler $scope.friends[0].hasOwnProperty(orderby) would work fine.
  if($scope.friends[0] !== undefined && Object.prototype.hasOwnProperty.call($scope.friends[0], orderby))
{
    $scope.orderby = orderby;
  }
}
```

OrderBy Filter

DEMO

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angular.element

- Angular provides its own subset of the JQuery language that is accessible via the angular.element global function

- Using untrusted input in some of the element functions may lead to XSS:
  - angular.element.after
  - angular.element.append
  - angular.element.html
  - angular.element.prepend
  - angular.element.replaceWith
  - angular.element.wrap

- As a developer you must validate the input before sending it to the angular.element functions with functions such as *$sce.getTrustedHtml* or *$sanitize.*

XSS in angular.element

- Reading data from user

```
<form>
    <label>After:</label><input type="text" ng-model="afterinput" />
    <button type="submit" ng-click="aftersubmit()">Submit</button>
</form>

<div ng-controller="View1Ctrl">
        <div id="testDiv">{{name}}</div>
</div>
```

- Inserting data in Angular code

```
controller('View1Ctrl', ['$scope', '$document', function($scope, $document) {
    $scope.name = "ChangeMe";
    var element = angular.element($document[0].querySelector('#testDiv'));
    $scope.aftersubmit=function()
    {
        if($scope.afterinput) element.after($scope.afterinput);
    }
```

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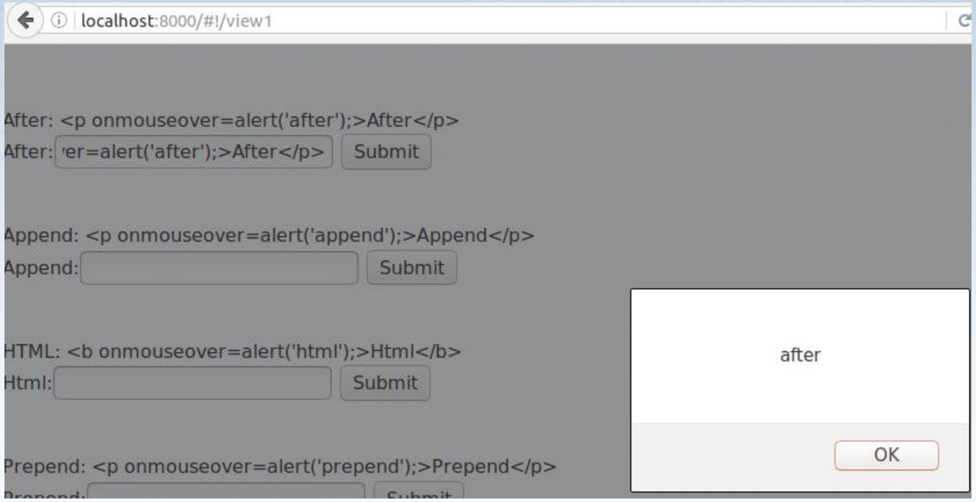
XSS in angular.element

- Payload: <p onmouseover=alert('after');>After</p>



localhost:8000/#!/view1

After: <p onmouseover=alert('after');>After</p>
After: 'er=alert('after');>After</p>

Append: <p onmouseover=alert('append');>Append</p>
Append:

HTML: <b onmouseover=alert('html');>Html</b>
Html:

Prepend: <p onmouseover=alert('prepend');>Prepend</p>

after

- Why is there an injection?
- SCE is not automatically applied to angular.element

Third-Party Library Security Issues

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Third-Party Libraries

- Third-party libraries enhance our applications
- There is always a risk with using third-party code
- AngularJS libraries are no different
- When looking at incorporating libraries in to your application you should:
  - Review the projects Github issue list
  - Use OSS tools such as ESLint (eslint-plugin-scanjs-rules)
  - Identify components with known vulnerabilities using Retire.js and Snyk
  - Look for XSS with tools such as Blue Closure Detect
  - Manually review the code (time consuming)

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XSS in angular-translate

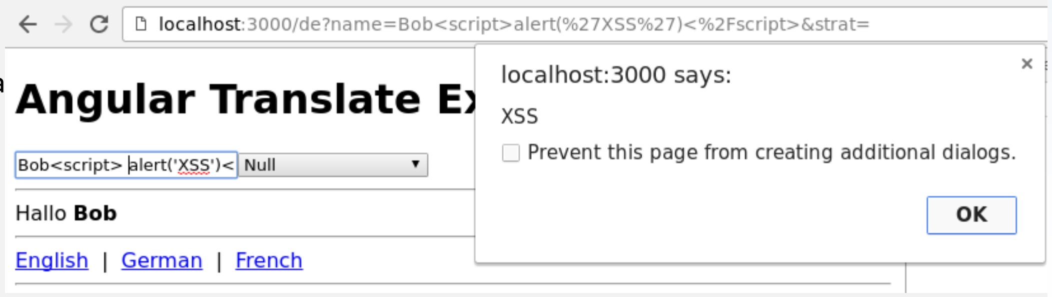
- Plugin angular-translate is used for pages internationalization

```html
<div translate="GREETING" translate-values="{translateValues.name}"></div>
```

- Setting translation strategy to ‘null’ or leaving it out (default) leads to XSS

```javascript
angular.module('app').config(function($translateProvider) {
  $translateProvider.translations('en', {GREETING: 'Hello <b>{{name}}</b>'});
  $translateProvider.translations('de', {GREETING: 'Hallo <b>{{name}}</b>'});
  $translateProvider.preferredLanguage('en');
});

angular.module('app').controller('Ctrl', function($scope, $translate, $routeParams,
$route,  $translateSanitization){
  $translateSanitization.useStrategy();
  $scope.translateValues = {name: $routePa
  var lang = $routeParams.lang;
  if (lang !== undefined) {
    $translate.use(lang);
  }
...
}
```



```
localhost:3000/de?name=Bob<script>alert(%27XSS%27)<%2Fscript>&strat=
```

Angular Translate Ex

Bob<script> alert('XSS')< Null

Hallo **Bob**

English | German | French

localhost:3000 says:

XSS

☐ Prevent this page from creating additional dialogs.

OK

textAngular

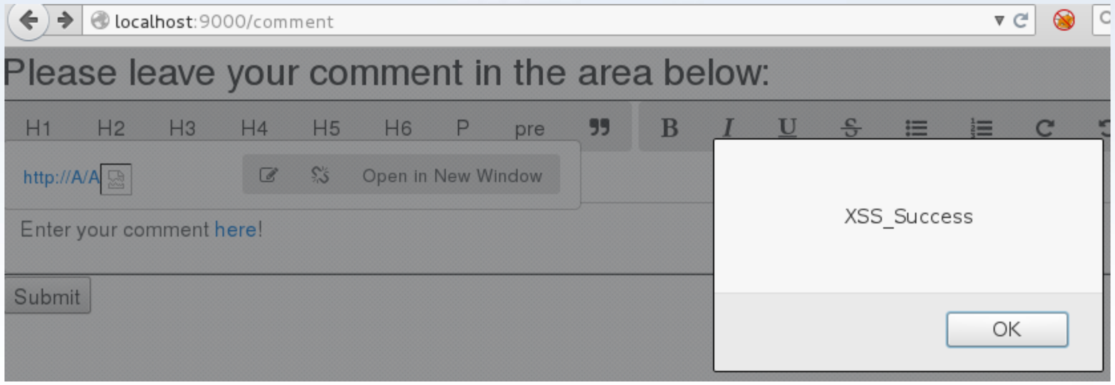
- The textAngular module is a WYSIWYG editor with collaborative editing functionality
- The editor processes the input and displays it (including HTML tags)
- textAngular uses textAngular-sanitizer module
  - Only verifies that an href starts with “http”
  - The string is then encoded and saved on the server
- textAngular parses the link and creates a new element with the content of the link as an unencoded HTML element

XSS in TextAngular

- Sample payload:

http://A/A<img src=x onerror=alert('XSS_Success')>

```
<p>
Enter your comment
<a target="" href="http://A/A<img src=x onerror=alert('XSS_Success')>">here!</a>
</p>
```



Please leave your comment in the area below:

Enter your comment here!

XSS_Success

XSS in TypeAhead

- TypeAhead module shows hints as the user starts typing in a text field
- The list of hints is not sanitized if at least one condition is met:
  - ui.bootstrap version prior to 0.13.4 is used

```
<script src="http://angular-ui.github.io/bootstrap/ui-bootstrap-tpls-0.13.3.js"></script>
```

  - ngSanitize is not included

```
var module = angular.module('app', ['ui.bootstrap']
```

```
<form ng-submit="submit()">
  <input type="text"
    ng-submit="submit()"
    ng-model="search_val"
    typeahead="search_val for search_val in
searches"
    class="form-control">
  <input type="submit" value="Search"/>
</form>
```

```
module.controller(
  'TypeaheadCtrl',
  function($scope,$http) {
    $scope.selected = undefined;
    $scope.searches = [
  decodeURIComponent(window.location.search.split("?")[1]
)
    ];
}
```

Angular 2,4,*,*,*

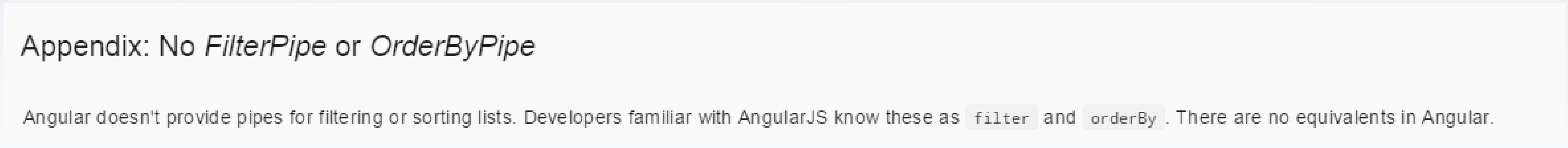
Look To The Future

Angular 2, 4 and beyond

- It’s difficult to write complex but secure applications
- Angular 1.X contained many features that could introduce security problems
- Angular 2 attack surface is much smaller

Angular 2, 4 and beyond

- Unidirectional data binding
  - Interpolation, One/two way binding, Event Binding
- No more watchers, $apply/Async, $compile, $interpolate, $eval/Async
- Vulnerable features not introduced



Appendix: No *FilterPipe* or *OrderByPipe*

Angular doesn't provide pipes for filtering or sorting lists. Developers familiar with AngularJS know these as `filter` and `orderBy`. There are no equivalents in Angular.

- ES6

Angular 2, 4 and beyond

- Encoding and Sanitization by default

- Harmonizes with the Content Security Policy (CSP)

- Better naming conventions
    - bypassSecurityTrustHtml(value: string)
    - bypassSecurityTrustStyle(value: string)
    - bypassSecurityTrustScript(value: string)
    - bypassSecurityTrustUrl(value: string
    - bypassSecurityTrustResourceUrl(value: string)

- Build-time security
    - Precompiled templates (see AoT https://angular.io/docs/ts/latest/cookbook/aot-compiler.html)

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Angular 2, 4 and beyond

Important notes:

- AngularJS is a client-side framework
  - The production flag can be disabled by the user
  - Client elements can be modified
    - ngShow and ngHide
    - RouteGuards are boolean
  - Sensitive data can be retrieved from localStorage and sessionStorage

- Security should be enforced on the server
  - Access control
  - AuthN/AuthZ
  - Strict input validation
  - Escaping/Encoding/Sanitization

Angular 2, 4 and beyond

Important notes:

- XSS can still occur through
  - Explicitly trusting user data
  - Expression injection
  - Third-party libraries

```
$('#message').text(params['user']);
```

  - Server-side interaction

```
<?php
  echo htmlentities($_GET["myParameter"])
?>
```

Conclusion

- Use Angular, as it is a very secure framework:
  - Contextually-aware encoding
  - Strict contextual escaping
  - Separation of HTML and JavaScript – CSP compatible
- Do not mix server-side and client-side templates
- Do not directly use user-input in expressions
- Check plugins for security issues and use the latest version
- Embrace the Angular Migration from 1 to 4
- …
- Profit

Thank you!

Questions?

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