The case for client-side HTML sanitization

# Insane in the IFRAME

David Ross
Principal Software Security Engineer
Trustworthy Computing Security
Microsoft

## Who am I?

- MSRC Engineering team member
  - Up in your vuln reports, helping to remediate

You may know me from…

- Bug bounty triage v-team lead for design-level issues
- IE XSS Filter
- Internet Explorer security
- Twitter (@randomdross)

# Agenda

- HTML Sanitization – An Introduction
- The many bugs
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- Is there a better mousetrap?
- jSanity
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# HTML Sanitization – An Introduction

## What is HTML sanitization?

- HTML sanitization takes markup as input, outputs “safe” markup / DOM
  - …for some definition of “safe”
  - Distinct from *encoding* (eg: URLEncoding, HTMLEncoding, etc.)

- HTML sanitization is everywhere
  - Canonical example: web forum posts w/markup
  - Modern applications with client-side business logic
    - Eg: Javascript-based Windows 8 Store apps
  - Outlook.com

# HTML Sanitization – An Introduction

## Why are HTML sanitization bypass bugs important?

- Worst case scenario
  - Script running from a mail message executes within the security context of the mail application
  - ...from the preview pane that appears automatically
  - Attacker could set up auto-forwarding, impersonate you, steal all your mail, etc.

## Yet, HTML sanitization bugs are pervasive

- Fuzzing? Can be helpful, but difficult*...
- Threat modeling? Not so relevant...
- Smart hackers with some free time – very relevant

## And the underlying platforms continue to change. All of them.

## This is a hard problem.

## The Many Bugs – Example #1

- Sanitizer Bypass in validator Node.js Module by @NealPoole (https://t.co/5omk5ec2UD)
  - Nesting

```
Input: <scrRedirecRedirect 302t 302ipt
type="text/javascript">prompt(1);</scrRedirecRedirect 302t 302ipt>

Output: <script type="text/javascript">prompt(1);</script>
```

Observation: Removing data from markup can create XSS where it didn't previously exist

# The Many Bugs – Example #2

- CVE-2011-1252 / MS11-074
  - SharePoint / SafeHTML

```
Input:
<style>div{color:rgb(0,0,0)&a=expression(alert(1))}</style>

& → &amp;

Output:
<style>div{color:rgb(0,0,0)&amp;a=expression(alert(1))}</style>
```

Observations:

- Sanitizer created a delimiter (the semi-colon)
- Legacy IE CSS expression syntax required to execute script
- Context mismatch
  - Sanitizer: "expression" is considered to be in a benign location
  - Browser: "expression" is considered to be the RHS of a CSS property set operation

# The Many Bugs – Example #3

- CodeIgniter <= 2.1.1 xss_clean() sanitizer bug (CVE-2012-1915)
  - Credit: Krzysztof Kotowicz (@kkotowicz)
    - Thx @NealPoole and @adam_baldwin!
  - Fake tag closure

```
Input and Output:

<img/src=">" onerror=alert(1)>

<button/a=">" autofocus onfocus=alert&#40;1&#40;></button>
```

Observations:

- No content modification required to trigger the vulnerability
- Sanitizer: ">" recognized as closing the IMG or BUTTON element
  - Allows script through, believing it to be in the raw HTML context
- Browser: ">" recognized as an attribute value
  - Browser executes onerror / onfocus event handlers

## The Many Bugs – Example #4

- Wordpress 3.0.3 (kses.php)
  - Credit: Mauro Gentile (@sneak_)
    - Thx @superevr!
  - Lower case attribute name check

```
Input and Output:

<a HREF="javascript:alert(0)">click me</a>
```

Observations:

- No content modification required to trigger the vulnerability
- Sanitizer: Only lower case "href" recognized as an attribute name
- Browser: HREF attribute recognized, javascript: URL executes on click
- Sanitizer and browser don't agree on what constitutes an attribute name

## What's the lesson?

1. High level: Parsing / "context management" is <u>hard</u>

   Sanitizers must *exactly* emulate client-side parsing

   - An opportunity for a vulnerability any time the sanitizer and browser get out of sync
   - Sanitizer output must be safe for *all* useragents
     - If this is even possible!

# What’s the lesson? (cont.)

2. Parsing is the difficult part of sanitization

   - The “business logic” is easy
     - Eg: What tags, attributes, CSS, etc. are considered acceptable
   - Logically, the sanitizer was built to define this business logic
     - The sanitizer’s value is not derived from being yet another HTML parser!
   - All the bugs identified previously are parsing / “context management” related

# Is there a better mousetrap?

- Why not use the browser’s own parsing!
  - …the browser can never be “wrong”
    - No opportunity for a parsing mismatch
- Implication: Sanitization is client-side
  - So is jQuery!

# Introducing… jSanity

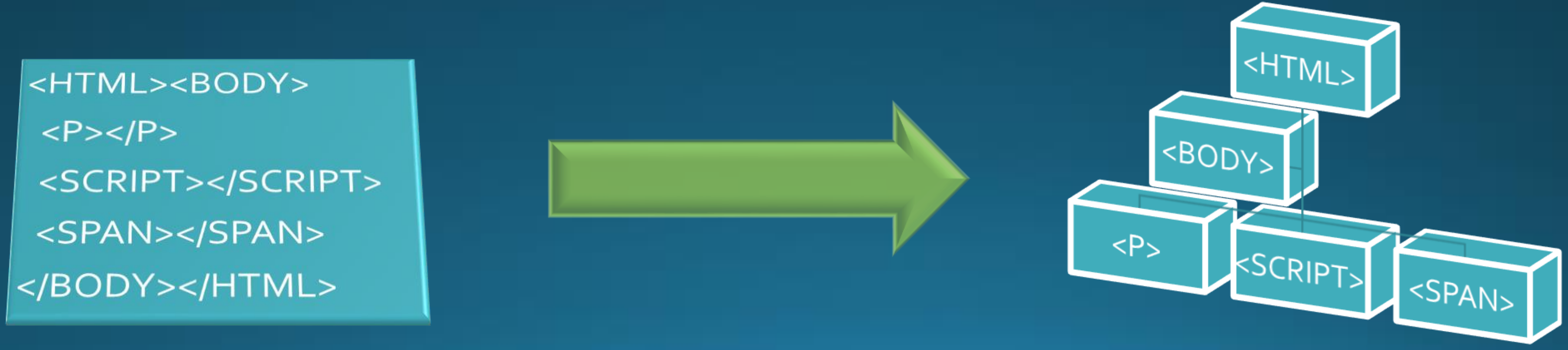
- An experiment in creating a better kind of sanitizer API
- Security advantages
  - No independent parsing / context handling
    - Thus fundamentally invulnerable to the most prevalent and most difficult to address sanitization vulnerabilities
    - No regular expressions!
  - Pervasive allow-list strategy (no block-listing)
  - Doesn’t trigger mutation-based XSS (mXSS)
    - HTML → DOM only, never HTML → DOM → HTML → DOM
  - Configurable to provide the right level of sanitization for a given scenario
    - Eg: Allow data-foo attributes, otherwise block data-*
  - Simple
    - Straightforward, explicitly defined ruleset for “business logic”
      - Isolated within the code, not strewn across a large codebase
    - So much tricky sanitization / parsing logic is unnecessary!

# jSanity Design principles

- Secure by Default
  - Against injection of script
  - Against everything else (configurable)
    - CSS-based overlay attacks
    - IFRAME or FORM injection
    - External content download (privacy for mail scenarios)
    - Namespace squatting
    - Unclosed tags / attributes, etc.
- Compatible
  - Cross-browser
  - IE9+, at minimum
- Performant
  - Competitive with other techniques

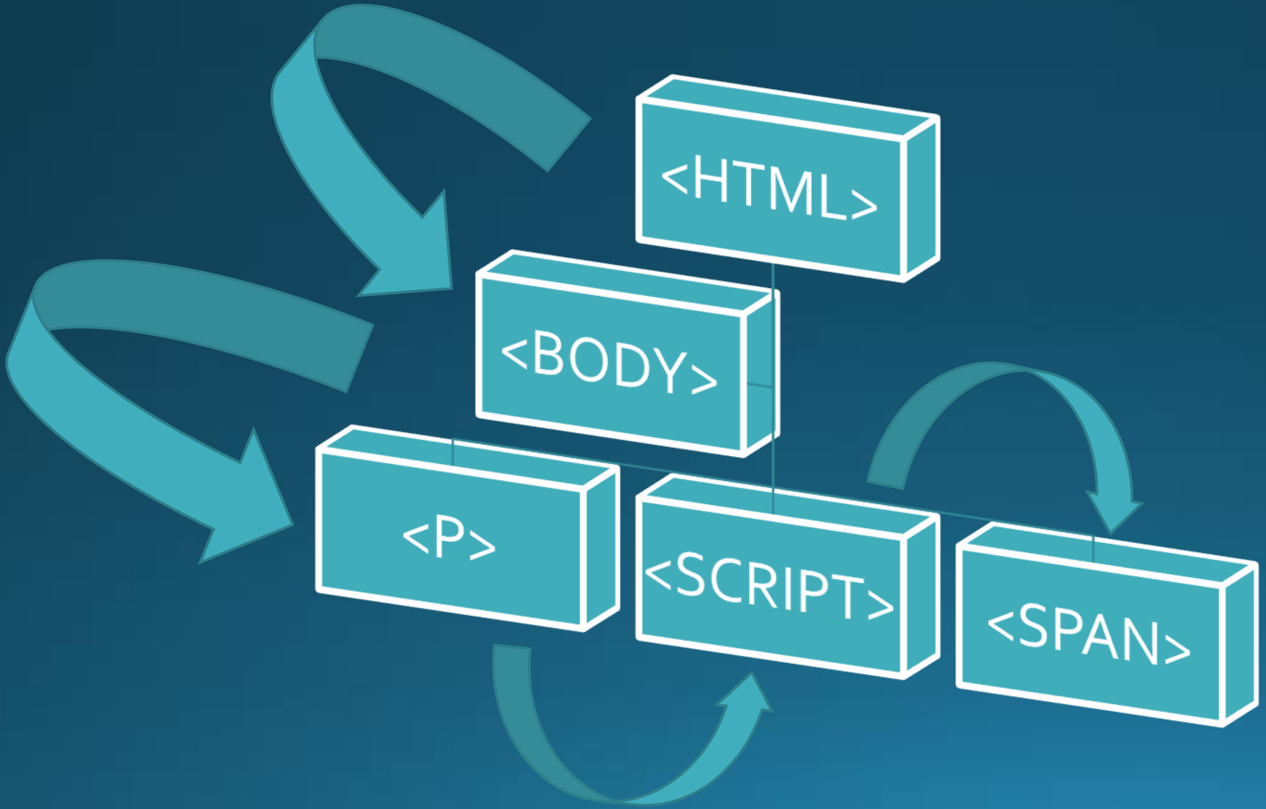
## jSanity Implementation

- Basic facts
  - jQuery plugin
  - ~1K LoC, currently
- Sanitization process
  1. Use `document.implementation.createHTMLDocument` to parse input into a DOM



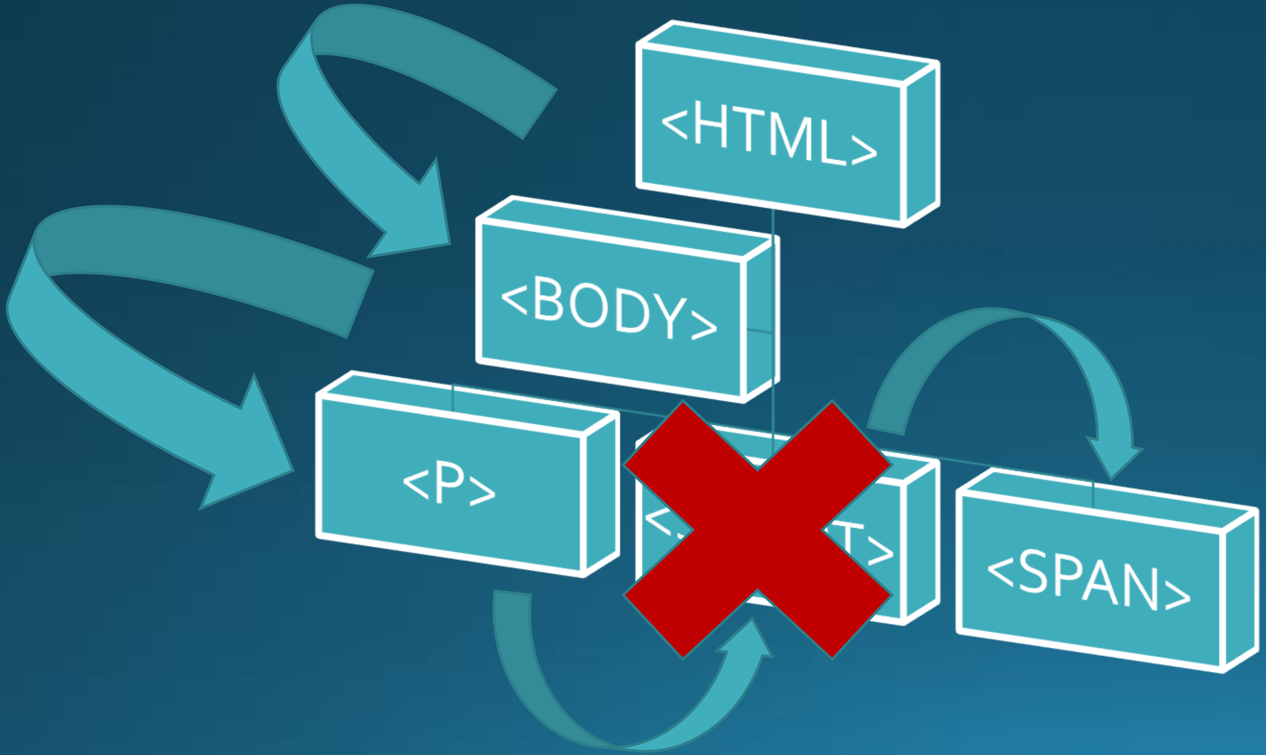
# jSanity Implementation (cont.)

- Sanitization process (cont.)
  2. Use `document.createTreeWalker` to walk the DOM



# jSanity Implementation (cont.)

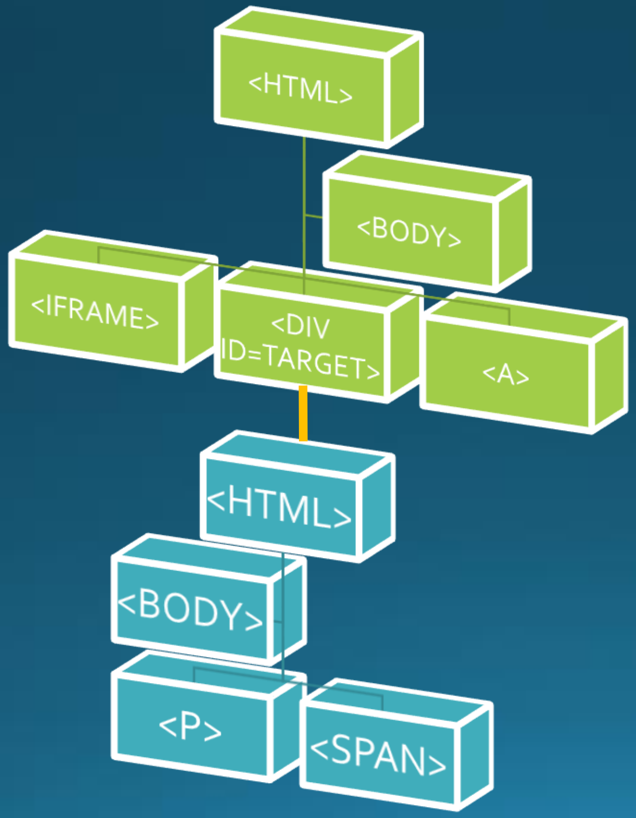
- Sanitization process (cont.)
  3. Remove elements / attributes / etc. not explicitly allowed*



* Old (less-performant) approach:
Build yet another DOM by copying safe elements / attributes / etc. to a new DOM during tree walk

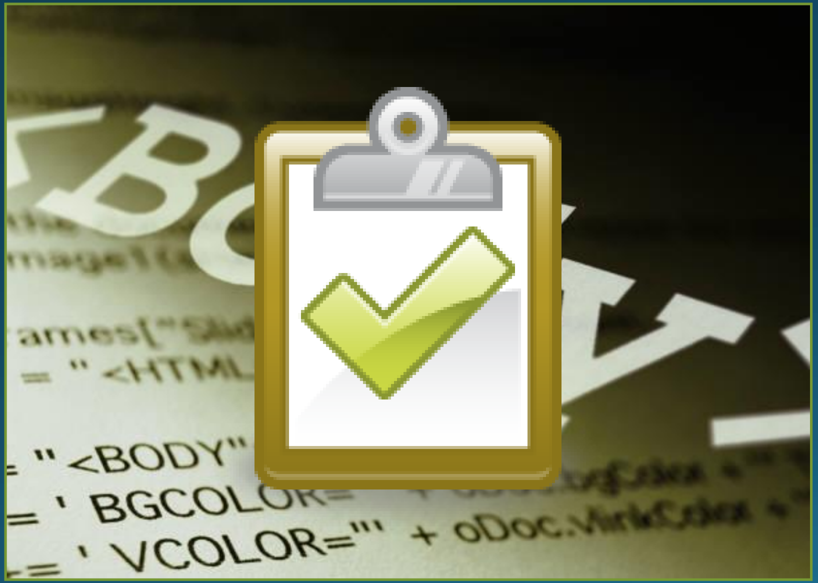
# jSanity Implementation (cont.)

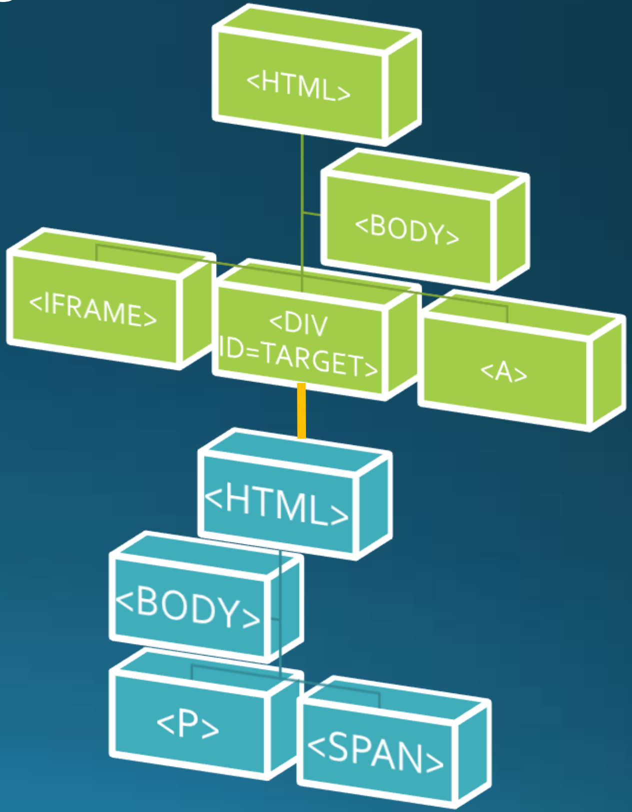
- Sanitization process (cont.)
  4. Finalized DOM is attached into the page DOM under a specified element



# jSanity Implementation (cont.)

- Sanitization process (cont.)
  5. Resolve jQuery Promise to notify hosting page





# jSanity Security

- `document.implementation.createHTMLDocument`
  - Must never run script
  - Must never pull external content
  - Just parse and build a DOM, that's it!
  - Implementation bugs in this API should be straightforward to fix
- Additional security properties
  - Allow-lists elements, attributes, CSS, etc.
    - Namespace support (eg: SVG)
  - Prefixes NAME / ID attributes to avoid squatting
    - CLASS attributes must be optionally handled by a callback
  - Constrains display area of output to mitigate overlay attacks

## jSanity Security (cont.)

- Additional security properties (cont.)
  - Validates link URLs to avoid script injection, etc.
    - Callbacks allow for custom validation / translation
    - Callers can specify script that runs onClick
      - Eg: “Do you really want to navigate to this link?”
  - Allows for regulation of external content
  - Conservative ruleset by default
  - Validates supported / secure environment
    - Browser version, docmode, etc.

# jSanity Security (cont.)

- Bugs found in pentest  (Credit: Gareth Heyes)
  - CLASS attributes can contain multiple class names
    - …so simple prefixing doesn’t work as it does with NAME / ID
    - `INPUT: <a name=x class="x y">test</a>`
    - `OUTPUT: <a name="jSanity_targetDiv_x" class="jSanity_targetDiv_x y">test</a>`
  - DoS conditions
    - `<math>` bomb
      - `<math>` element doesn’t contain a style property
    - `<div data-"A>`
      - Causes `elementNode.setAttribute(name,value)` to explode
      - Fixed with a try/catch
    - DOM squatting preventing node removal
      - Eg: `foo<form><input name=parentNode>`
      - Confused node removal code, fortunately failed secure
  - Various other implementation bugs

# jSanity Compatibility

- Cross-platform
- Based on javascript
  - A javascript-based sanitizer is easily auditable (vs. a “black box”)
  - HTML updated frequently enough that sanitizers are often under pressure to add support for new elements, attributes, etc.
    - Simple and extensible for customers
      - HTML elements, attributes, etc. may be…
        - Allowed by default
        - Allowed on an opt-in basis
        - Allowed via custom callbacks
  - Drawback: Requires browser primitives
    - No support prior to IE9

# jSanity Performance

- Async (vs. synchronous toStaticHTML API)
  - Leverages jQuery promises / deferreds
  - setImmediate
    - Uses NobleJS setImmediate polyfill where setImmediate isn't available
  - Work is performed with minimal blocking of other script on the page
- Sorry, no multithreading
  - Web Workers can't touch the DOM
- Competition
  - Server-side sanitizers
    - Zero client-side perf impact
    - Results of jSanity sanitization may be pre-computed and cached
  - .toStaticHTML() API

## jSanity Performance - Benchmarks

- Sanitization of ~1MB markup from the front page of 10 major sites
- Visual output
  - Dot (.) == 10ms heartbeat
  - X == ~5 skipped heartbeats
  - # == "All Done"
- Where we started
  - XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX#.........
  - ☹ Slow synchronous return, lots of UI non-responsiveness
- Where we wound up after going async, and perf improvements
  - XXXX..XX.XX.....XX.XX..#.........
  - ☺ Immediate synchronous return, opportunity for script on the page to execute alongside sanitization
  - "All Done" (including rendering) in ~650ms on a standard desktop w/IE10

## jSanity Performance – Benchmarks (cont.)

- The competition
  - .toStaticHTML
    - No DOM insertion
      - XXX..#
      - Fast ~140ms to “All Done”
      - At least jSanity still wins on synchronous response ☺
    - With DOM insertion
      - XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX..#
      - Long freeze
        - Due to STYLE elements passing through
      - Liberal sanitization allows CSS overlay

# jSanity Performance – Benchmarks (cont.)

- Conclusions
  - Raw toStaticHTML is tough to beat
    - …but we win on synchronous response time
    - jSanity is fast enough that rendering speed dictates overall sanitizer performance
      - We will edge closer to toStaticHTML's rendering time as more safe CSS is allowed through sanitization
      - Still, jSanity will never be as liberal as toStaticHTML
        - More secure
        - Now also demonstrated to aid performance
  - Pervasive use of Deferred w/setImmediate is proven to maintain a responsive UI

## Demo / Hosting jSanity

```
// Specify options on sanitization target element #1
$('#targetDiv').data('jSanity',
         {
           inputString: $("#badHtmlDiv").val(),
           allowLinks: true
         });

// Specify options on sanitization target element #2
$('#targetSpan').data('jSanity',
         {
           inputString: $("#badHtmlSpan").val(),
           linkClickCallback: 'alert(\'Link clicked!\');
           return false;'
         });
```

```
// Call the sanitize method across all
selected elements
$(".jSanitizeMe").jSanity('sanitize',
         {
           allowLinks: true,
           customProtocols:
           { 'someProtocol://' : 1 }
         });
```

[Demo] [Benchmark]

Options precedence / inheritance rules:
(Options specified on target element) > (options specified on sanitize() call) > (default options)

## jSanity Status

- Feature complete
- Certainly not “done”
  - Needs real-world testing
- Challenges
  - We need a better solution for <STYLE> elements
    - Today we call back into host to handle <STYLE> elements
    - May not be possible to solve this today without custom parsing logic

## The future

- Investigating how to make jSanity broadly available
- But… If you can’t wait, feel free to build your own!
  - Remember: Building your own sanitizer can be harder than it looks!

- Framework integration
- Transparently override default sanitization in platforms that are based on web technology

# The future

- Where do these new technologies fit into the picture…
  - Shadow DOM
    - Isolation within a single DOM
    - Something jSanity can leverage in the future
  - Seamless frames + SANDBOX + SRCDOC
    - Solves some of the biggest problems with IFRAME-based isolation
      - CSS bleed-through
      - Non-rectangular shape
    - Potential disadvantages
      - Limited configurability
      - Limited browser support (today)
      - Agility in the event of a bypass, globally or due to an application artifact

## Credits

- jSanity is simply an API that leverages client-side sanitization techniques pioneered by a few amazing individuals
  - Mario Heiderich (**@0x6D6172696F**)
    - JSAgents / IceShield
  - Gareth Heyes (@garethheyes)
    - JSLR
- Special thanks to…
  - Ben Livshits
  - Loris D'Antoni
    - Used jSanity in demonstrating FAST domain specific language for tree manipulation
- Other shout-outs
  - Google Caja HTML sanitizer
    - Client side, parses HTML
  - Stefano Di Paola, Eduardo 'Sirdarckcat' Vela N.

## Conclusion

- HTML sanitizers as they exist today have recurring, unnecessary bypass vulnerabilities due to parsing / “context management”
- It is possible to build a client-side sanitizer offering a fundamental security advantage relative to server-side approaches
  - Based on browser primitives that exist today
  - Acceptable compatibility and performance characteristics
- Not-so-bold prediction
  - In five years, the majority of top tier applications and frameworks will support client-side sanitization based on browser primitives

# Questions

↑ I just presented on HTML sanitization at OWASP AppSec EU 2013.  AMA! (self.AMA)

1 Submitted 1 second ago by randomdross

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