Beyond HTTPS - HSTS, TLS, HPKP, CSP and friends

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SSL / TLS

If not already, consider HTTPS (TLS 1.1 or 1.2)

Make sure all site is using HTTPS

Use strong certificate – at least SHA-256, 2048 bit key (no SHA-1, SSL 1, etc.)

Test here: https://www.ssllabs.com/ssltest/

Self-signed SHA-256 Certificate

```
makecert.exe -r -pe -n "CN=%1" -b 01/01/2015 -e 01/01/2020
-eku 1.3.6.1.5.5.7.3.1 -sky exchange -a sha256 -len 2048 -ss my
-sr localMachine -sp "Microsoft Enhanced RSA and AES
Cryptographic Provider" -sy 24
```

(See **CreateSelfSignedSHA256SslCert.bat** under https://github.com/rhurlbut/HttpsTools)

Installs self-signed SHA256 certificate into the My/LocalMachine store

Useful for local dev / testing websites

Security Headers

Added layer of security sent with HTTP/S Response Headers

Others: Content-Security-Policy, X-Content-Type-Options, X-Frame-Options and X-XSS-Protection.

HTTPS only: Strict-Transport-Security and Public-Key-Pin

Test: https://securityheaders.io/

This talk is based on a talk given by Sun Hwan Kim and Julien Sobrier (both work at Salesforce) at AppSecCali 2017 – slides used by permission.

See original here: https://appseccali2017.sched.com/event/8wRA/hsts-tls-hpkp-csp-putting-them-all-together-to-move-to-https

Acronyms, etc.

We're talking about HTTP response headers

HPKP = HTTP Public Key Pinning (report or block)

HSTS = HTTP Strict Transport Security

CSP = Content Security Policy (report or block)

Secure cookie = cookie with secure flag

HTTPS/SSL = TLS (for this talk)

Agenda

- Divide and conquer
  - Domain separation
- TLS version(s)
- Enforce HTTPS on your domains
  - HSTS and secure Cookie
  - Public Key Pinning
- CSP
  - CSP reports
- Enforce HTTPS on 3rd party domains
  - CSP enforced

Multiple domains

Divide and conquer

Use multiple domains or subdomains to divide a big problem into smaller problems

- API vs Browser
- Static vs live content
- CDN as a separate domain/subdomain
- Subdomain per customer

But letting users bring their own CNAME makes things more complicated.

Why sub-domains?

Divide and conquer

HSTS/HPKP headers apply to a domain (and its subdomains optionally)

TLS can be managed per subdomain (SNI)

Isolate customer/systems for later update to HTTPS

- … while taking care of mixed-content issue
- Upgrade static content servers first (server)

Cached content/CDN: headers may be cached or the same for all users (no authentication)

TLS version

TLS version(s)

What version of TLS will you support?

… the latest of course! (1.2)

Except if you need to support:

- Java 1.6 and earlier (API)
- Other libraries that only support SSL 3.0 and TLS 1.0
- Internet Explorer 10 and below out of the box

TLS 1.0 has to be disabled on server side to prevent downgrade attack

- PCI compliance helps (deadline June 2016 then June 2018)

Certificate

TLS version(s)

What Certificate authority will you choose?

- Which hasn’t suffered a big breach previously (DigiNotar, Comodo)
- Which has not been backdating certificates (WoSign)
- Which has not been silently sold to the Chinese in secret (StartCom)

HTTP Headers

Enforce HTTPS on your domains

HSTS/HPKP/CSP are great if you browser support them

	IE6-10	IE11-Edge	Chrome	Firefox	Safari
HSTS	🟥	🟩 2015	🟩 4	🟩 4	🟩 Maverick 2013
HPKP	🟥	🟥	🟩 46	🟩 35	🟥
CSP 1.1/2.0	🟥	🟥	🟩 47/47	🟩 49/49	🟩 9.1/10

🟩	Supported by the browser
🟥	Not supported by the browser

DEMO – SSL Strip

Moxie Marlinspike: More Tricks for Defeating SSL

https://youtu.be/5dhSN9aEljg?t=10m

HSTS

Enforce HTTPS on your domains

Force HTTPS Only with HSTS

HSTS tells the browsers to connect over HTTPS only

- Optionally includes all sub-domains
- "cache" duration of header

Strict-Transport-Security: max-age=31536000; includeSubDomains

First time connection

- Does not solve the first-connection issue
- Many "first time": HSTS cache expired (occasional login), new subdomain
  - Use includeSubDomains and make a call to the top domain

Limitations of HSTS

Enforce HTTPS on your domains

- HSTS preload list
  - Only possible on top domain with includeSubDomains
- Don’t forget about IE
  - Redirect HTTP to HTTPS
  - Use Secure cookies

… but credentials might still be sent directly over HTTP

- Use HTTPS-only domain for authenticated traffic (no port 80)

Separate HTTPS login

Enforce HTTPS on your domains

Use HTTPS-only domain for authenticated traffic

Should include login page

- If you want to do fancy (AJAX) login forms from HTTP to HTTPS sub-domain, you need to enable CORS

Might be a good idea in theory; not seen widely adopted.

HPKP: Public Key Pinning

Public Key Pinning

Public Key Pinning: indicate to the browser what certificate to expect

Public-Key-Pins and *Public-Key-Pins-Report-Only* headers

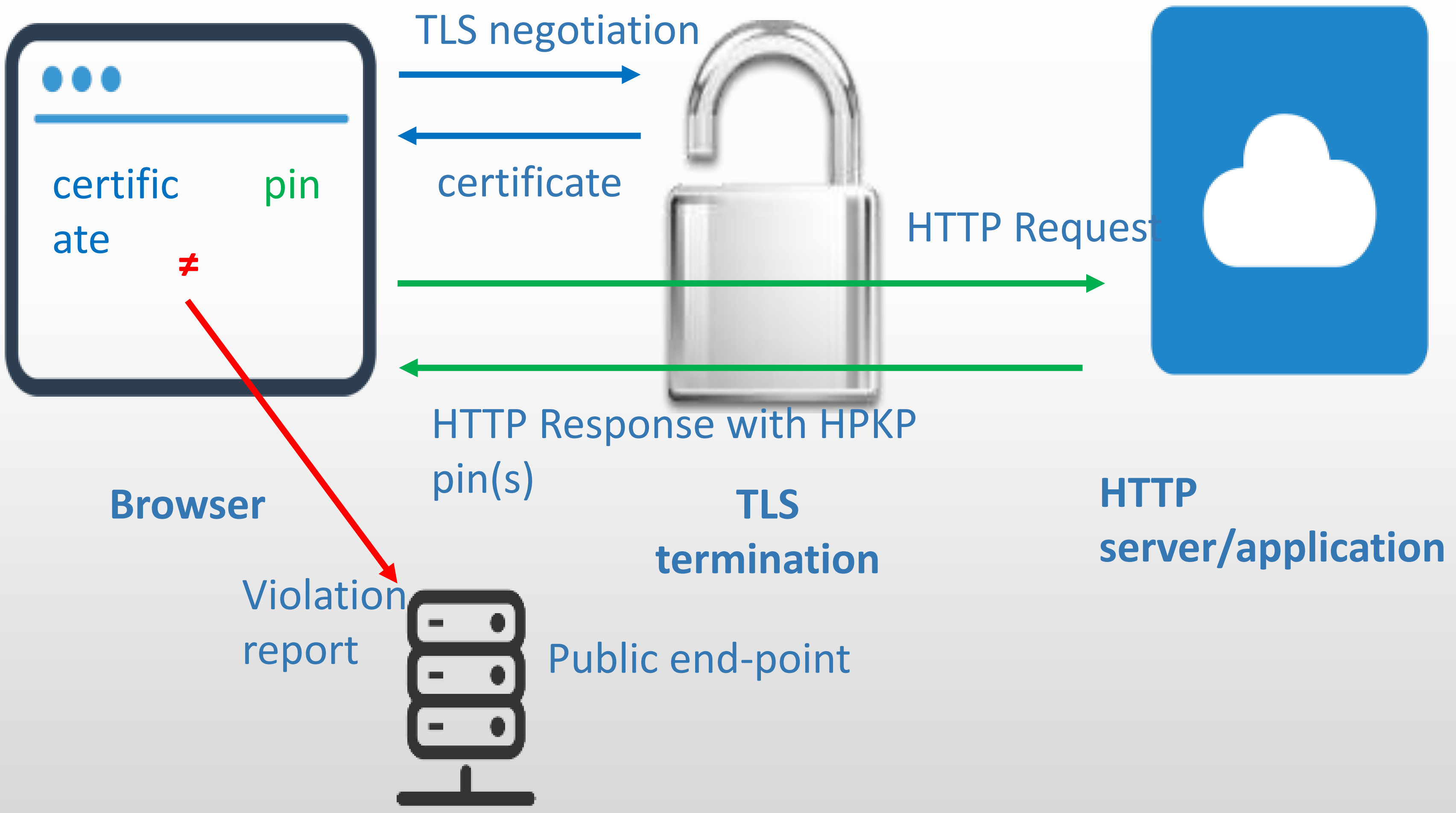
What certificate or key to pin:

- Leaf certificate: best for security but changes often, may change per host
- Public key: great if you rotate leaf certificate often but use the same key to generate them
- Intermediate CA: typically changes every few years, trust put in your CA to never issue certificates to the wrong people

Public-Key-Pins-Report-Only: pin-sha256="9n0izTnSRF+W4W4JTq51avSXkWhQB8duS2bxVLfzXsY="; pin-sha256="6m4uJ26w5zoo/DLDmYNWG1dWpZ8/GSCPe6SBri8Euw0="; max-age=604800; report-uri="https://**otherdomain.com**/path";

HPKP Workflow

Public Key Pinning



HPKP in practice

Public Key Pinning

Consider using HPKP in reporting mode only

Several issues found:

- CDN use a subdomain of xyz.com but generate the certificate themselves.
  Hard to use includeSubDomains
- Public proxies/anomymizers: do not rewrite response headers but use different CA
  example: https://nodeunblock.herokuapp.com/
- Chrome 38/39 uses expired pins until browser restart
  It looks like some other browser has the same behavior, expired pin is used one time for new access
- Internal proxy: end up setting the HPKP header for custom CNAMEs with customer certificates

Scott Helme on Pinning

Guidance on setting up HPKP (9/15/2015)

https://scotthelme.co.uk/guidance-on-setting-up-hpkp/

I'm giving up on HPKP (8/24/2017)

https://scotthelme.co.uk/im-giving-up-on-hpkp/

Your mileage may vary …

Dealing with 3rd party assets

Mixed content

- You want to make sure that you don’t have mixed-content (HTTPS loading HTTP assets)
    - From your own site (hardcoded references) or 3rd party
    - Browsers don’t (yet) block mixed-content for images (img or CSS) , audio, video and object (“passive” content)
- In a heavily customized sites, how do you check that all assets are always loaded over HTTPS?

Customized content

Content Security Policy to the rescue!

- A way of whitelisting allowed sources
- HTML Meta elements can be used in place/addition of HTTP header
- CSP applies to a URL.

Customized content

- CSP has many directives addressing different issues
  - Type of content: font-src, img-src, child-src, script-src, connect-src, etc.
  - Origin allowed: 'self', https: (Any HTTPS URL), data: (inline data), none, etc.
- 2 CSP headers
  - Content-Security-Policy-Report-Only : Report only, does not work with all directives
  - Content-Security-Policy : Enforce and report (when possible)

CSP format - Server

Example of CSP headers, describe where assets can be accessed from

```
Content-Security-Policy-Report-Only:                # Check policy but do not enforce
        default-src 'self' https://*.site.com;      # Default for all assets: same origin or site.com
        img-src https://*.cdn.com;                  # But images should be download for cdn.com
        report-uri /my-url                          # Report any violation to this URL
```

CSP for HTTPS

Example of CSP policy to check that all requests are done over https

```
Content-Security-Policy-Report-Only:
            default-src https:;                                         Any HTTPS
            script-src https: 'unsafe-inline' 'unsafe-eval';            Any HTTPS,
inline, eval()
            style-src https: 'unsafe-inline';                                    Any
HTTPS, inline
            img-src https: data:;                                                Any
HTTPS, inline
            font-src https: data:;                                               Any
HTTPS, inline
            connect-src: https:;                                                 Any
HTTPS (AJAX)
            report-uri: https://www.xyz.com/csp-report
```

CSP format – Violation report

Example of violation report (Firefox)

{"*csp-report*":{

*"**blocked-uri**":"http://pbs.twimg.com/profile_images/569909141204770816/Z4St3wts_normal.jpeg",*
"***document-uri***":*"https://intertnal.my.salesforce.com/00XXXXXXXXX"*
"original-policy":"default-src https:; script-src https: 'unsafe-inline' 'unsafe-eval'; style-src https: 'unsafe-inline'; img-src https: data:; font-src https:; connect-src https://www.salesforce.com https:; frame-ancestors https://www.salesforce.com https://force.com https://salesforce.com; eport-uri /_/ContentDomainCSPNoAuth?type=mydomain",
"referrer":" https://intertnal.my.salesforce.com/00XXXXXXXXX ",
"***violated-directive***":"img-src https: data:"
}}

How to use CSP?

Learned from report-only mode

Inline scripts used widely

Customers using external scripts from Facebook, Skype, AWS, Twitter, etc.

Lots of assets loaded over http

Even Report-Only Mode can cause an issue

100+ reports were generated in one page, and slowed down performance

How to use CSP?

Different Features required different Policy

If there are multiple CSP headers, each one is applied separately

Default CSP for every request, additional CSP headers where needed

Enforce HTTPS on 3rd Party Domains

CSP Report Only Mode First – Analyzing reports periodically

- Make necessary adjustments – whitelist several sources, fine-tune the policy
- Make sure automatic redirection from http to https do not cause any service interruption

Staged rollout

- Based on report analysis, enforce https selectively

Give Customers option to disable CSP temporarily

Upgrade-insecure-requests & blocked-all-mixed-content

upgrade-insecure-requests: upgrade all HTTP requests to HTTPS

Can be dangerous with 3rd-party domains: no HTTPS or invalid certificate (EC2…)

Good to use if all assets are on your own servers

block-all-mixed-content: block mixed content for passive tags too.

Obviously these directives must be enforced (no report-only). First directive has no report, fail silently. Second directives has reports.

General Advice for CSP

- CSP is constantly changing
  - Stay up-to-date with new CSP directive
  - Introduce new CSP directive in report only mode first
- Behaviors might vary depending on browsers
  - Some browsers did not send cookies required for authentication
  - Not all directives are supported by browsers

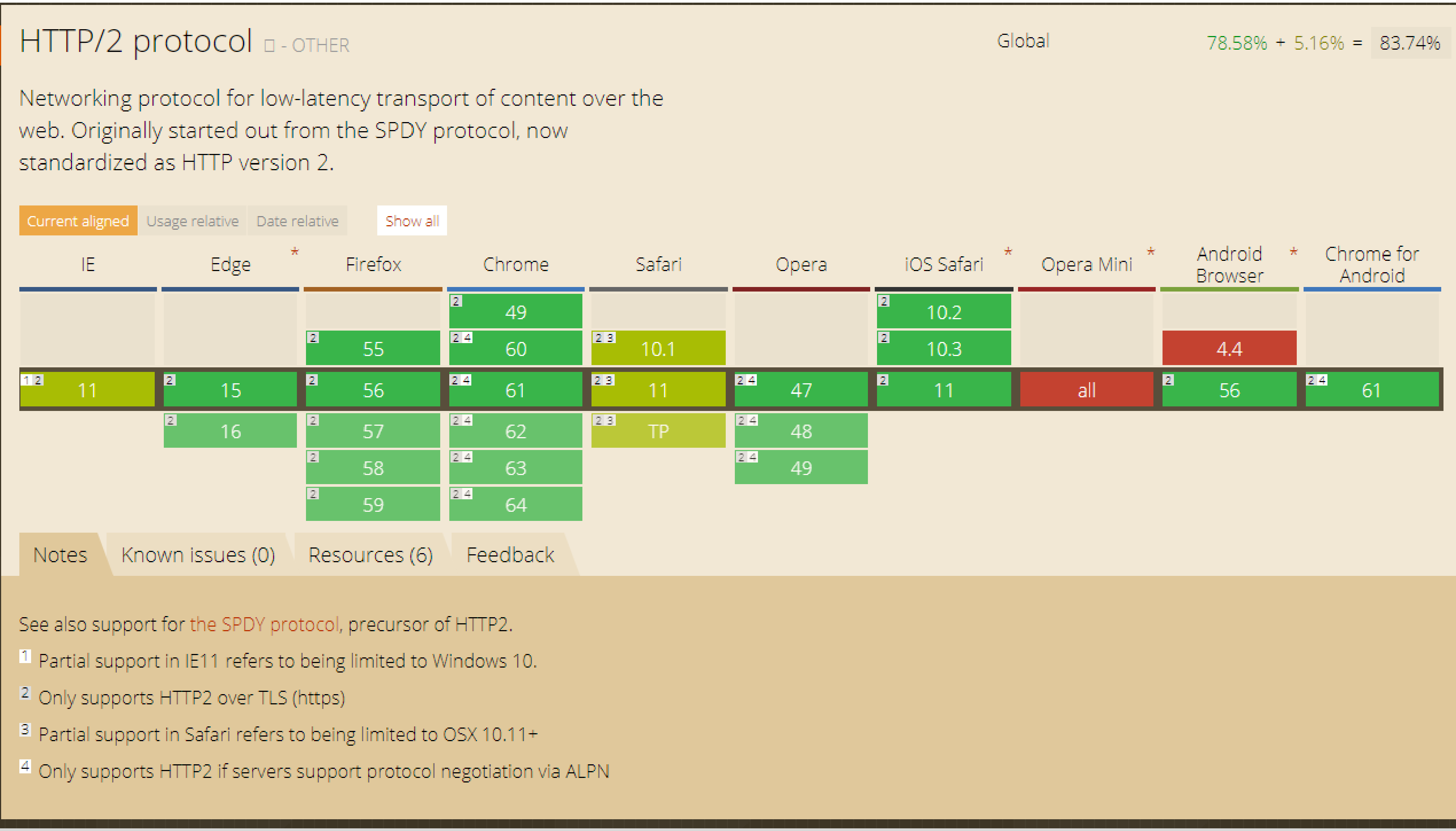
HTTP/2

Only available for use by ***HTTPS***

Performance improvements in all requests (binary vs textual, fully multiplexed, header compression, etc.)

Available IIS 10 (seamless)

HTTP/2



HTTP/2 protocol - OTHER

Global 78.58% + 5.16% = 83.74%

Networking protocol for low-latency transport of content over the web. Originally started out from the SPDY protocol, now standardized as HTTP version 2.

Current aligned | Usage relative | Date relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			[2] 49			[2] 10.2			
		[2] 55	[2 4] 60	[2 3] 10.1		[2] 10.3		4.4	
[1 2] 11	[2] 15	[2] 56	[2 4] 61	[2 3] 11	[2 4] 47	[2] 11	all	[2] 56	[2 4] 61
	[2] 16	[2] 57	[2 4] 62	[2 3] TP	[2 4] 48				
		[2] 58	[2 4] 63		[2 4] 49				
		[2] 59	[2 4] 64						

Notes | Known issues (0) | Resources (6) | Feedback

See also support for the SPDY protocol, precursor of HTTP2.

[1] Partial support in IE11 refers to being limited to Windows 10.

[2] Only supports HTTP2 over TLS (https)

[3] Partial support in Safari refers to being limited to OSX 10.11+

[4] Only supports HTTP2 if servers support protocol negotiation via ALPN

Key takeaways

Staged rollout

- Static content first

TLS set up

- Decide what clients you want to support

HSTS + HPKP

- Can you includeSubDomains?
- Start with small max-age durations
- (**consider not using HPKP because of problems**)

CSP

- Check for http requests
- Ensure not too many violations are generated
- See if upgrade-insecure-requests is an option for you

HTTP/2

- Check into setting up on server for performance improvements of HTTPS

Resources - Books

Bulletproof SSL and TLS by Ivan Ristic

The Tangled Web: A Guide to Securing Modern Web Applications by Michal Zalewski

Iron-Clad Java: Building Secure Web Applications by Jim Manico and August Detlefsen

Secure Your Node.JS Web Applications: Keep Attackers Out and Users Happy by Karl Duuna

Resources - Tools

HSTS Preload

- https://hstspreload.org/

Qualys SSL Labs – SSL Server Test

- https://www.ssllabs.com/ssltest/

Security Headers

- https://securityheaders.io/

Automated Security Analyzer for ASP.NET Websites

- https://asafaweb.com

Questions?

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