
DEFCON
HACK ALL THE THINGS
DEFCON

No Way, JOSE!

Designing Cryptography Features for Mere Mortals

Scott Arciszewski

- Paragon Initiative Enterprises, LLC
  - Software development (open source)
    - The person to blame for getting libsodium into PHP 7.2
    - Also wrote the sodium_compat polyfill for PHP 5.2 – 7.1
    - Many PHP security libraries
  - Security research
    - Handfuls of CVEs
    - Sometimes published on Full Disclosure
- Twitter handle: @CiPHPerCoder

Why are we here today?

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SECURITY | By Joseph Cox | Dec 10 2015, 1:29pm

Why You Don't Roll Your Own Crypto

The golden rule of encryption.

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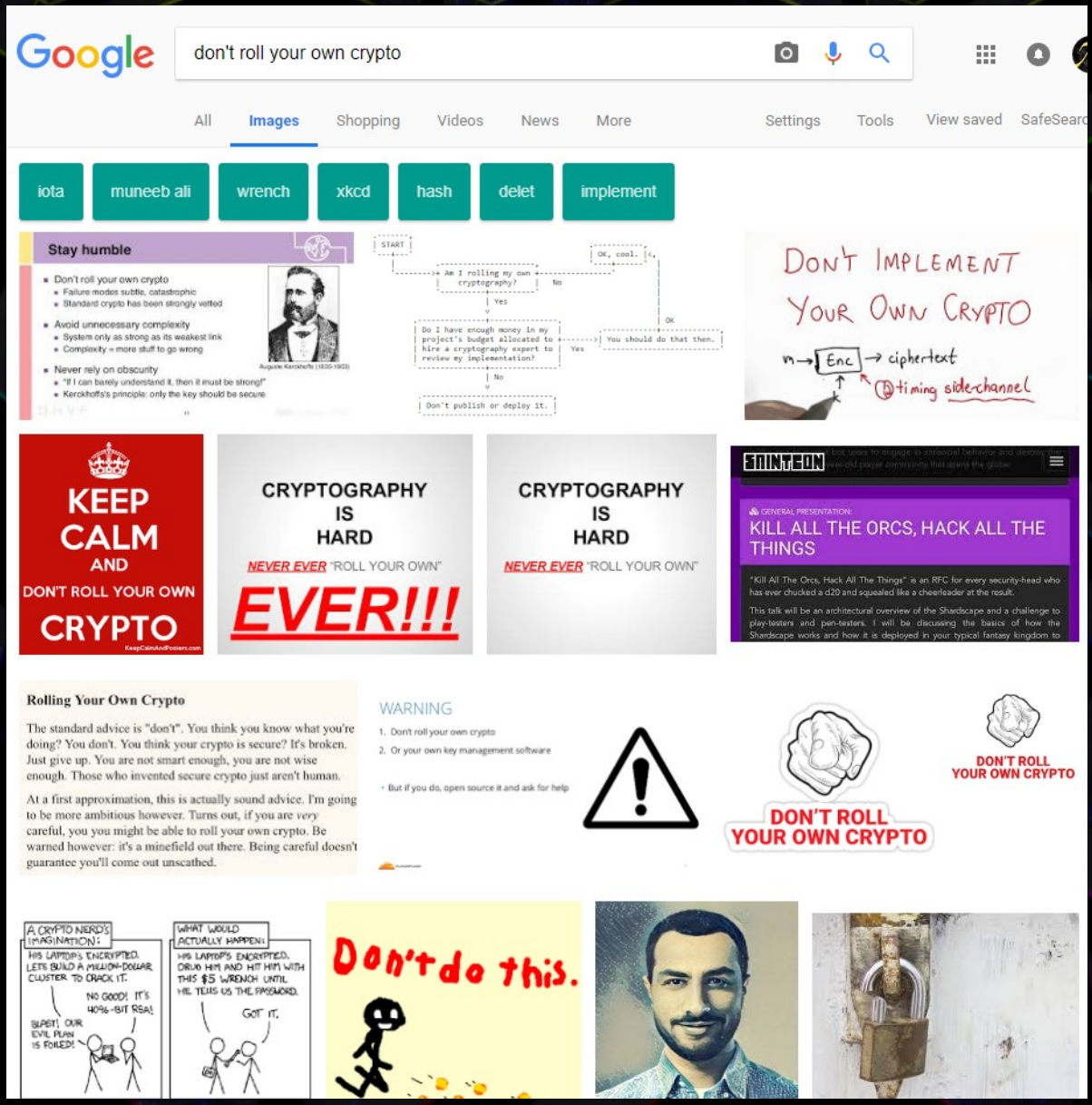

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- The problem: the buck usually stops there.

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- Developers need cryptography features to solve problems.
- If we don’t want them rolling their own, they need easy-to-use tools that don’t open the door to a ton of attacks.

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  - Short-lived claims (usually signed by a third party)
  - A laundry list of misuse

JSON Web Tokens

- Quoth the RFC:
  - JSON Web Token (JWT) is a compact, URL-safe means of representing claims to be transferred between two parties. The claims in a JWT are encoded as a JSON object that is used as the payload of a JSON Web Signature (JWS) structure or as the plaintext of a JSON Web Encryption (JWE) structure, enabling the claims to be digitally signed or integrity protected with a Message Authentication Code (MAC) and/or encrypted.

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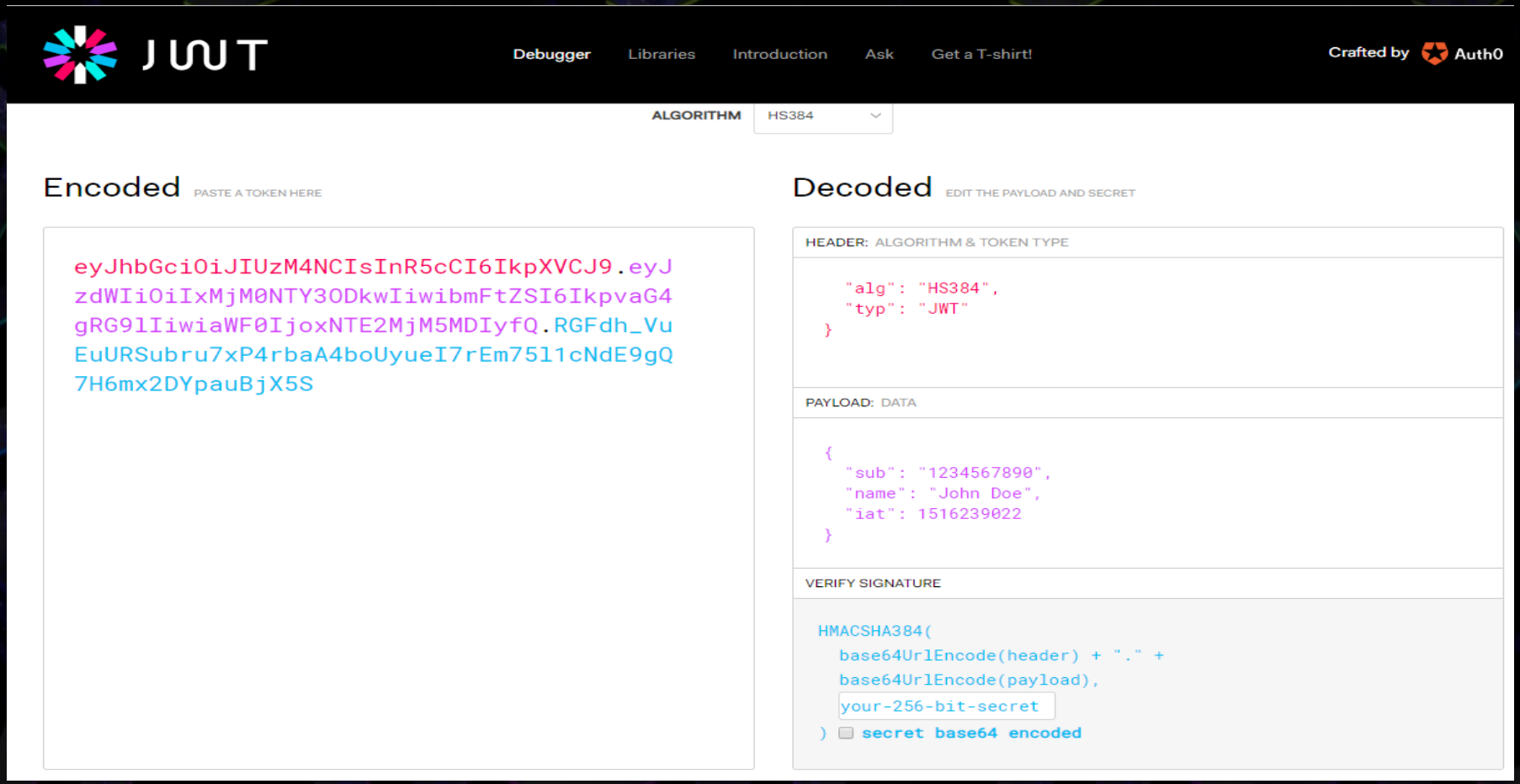
- Translation: a JWT uses JWE or JWS.
  - Consequently, JWS/JWE security flaws are almost always relevant to JWT.

JSON Web Token (structure)



- Above: https://jwt.io (a tool from Auth0)

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  - Attackers can alter tokens and choose this header

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- RFC 7515 section 4.1.1:
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- This has led to critical vulnerabilities in JWT libraries. (CVE-2015-2964, etc.)

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- Key encryption options:
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- One of these things is not like the other.

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  - Failing that, making point validation explicit.

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  - The architects insist this lets you freely swap out clay bricks with concrete bricks if termites adapt to eat clay, or vice versa.
  - Would you trust that wall to hold up the roof?

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- If we want secure systems, this is an antipattern!

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  - ...can you *really* blame them?

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My proposal: Design a better standard that is a lot easier to use securely than to use insecurely

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  - Less knobs and levers for end users

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- Payload and optional footer are Base64url encoded (as specified in RFC 4648)

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- Version 2: Recommended
  - Uses libsodium (or a compatible implementation)
    - Local: XChaCha20-Poly1305
    - Public: Ed25519

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  - Payload: “foo”
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    - k = `0xa71913ea1750aa39142e00089dcc47990da5173521b6201c4badd460b1f50ab0`

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  - v2.public.Zm9vknDoCUzU05m6yyiYFFQcsO9WnBJPjatGpfL2Okyb9Q_abkUcSa-Pwzmn8fCuc6kYpmAkOz3e9WzMg-yqhMb1CA.YmFy

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  - v2.public.Zm9vknDoCUzU05m6yyiYFFQcsO9WnBJPjatGpfL2Okyb9Q_abkUcSa-Pwzmn8fCuc6kYpmAkOz3e9WzMg-yqhMb1CA.YmFy
    - pk = `0x72bbbb1c8b77b1e5d71e7ec11f3b53cc69097757053b530a035237c2e278a33d`

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    - pk = `0x72bbbb1c8b77b1e5d71e7ec11f3b53cc69097757053b530a035237c2e278a33d`
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- Example without a footer:
  - Payload: “foo”
    Footer: NULL
  - v2.local.0mdhlsOmc4H5kWCBX5Tdty1jX-tzyvJclRptsvvhqtQD9P9gb1OPsSXb8Q
    - k = `0xa71913ea1750aa39142e00089dcc47990da5173521b6201c4badd460b1f50ab0`
  - v2.public.Zm9vybtfJiXsVkxfXsW8JW_Fb-mpAspqVZ9cpTtmvHdYrDaWnIZp1cf0jFB9NXe-SujwmwXpvVl0pJM0GSCTzOguAA
    - pk = `0x72bbbb1c8b77b1e5d71e7ec11f3b53cc69097757053b530a035237c2e278a33d`
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PASETO Internals

End-users don’t need to know this stuff

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- When possible, do everything in constant-time

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- Formal specification regarding key/nonce-gen:
  - Just use urandom. Userspace PRNGs are forbidden. No more Mersenne Twister or LCGs.
- No IND-CCA2 insecure public key cryptography
  - PKCS #1 v1.5 is explicitly forbidden, forever
    - Bleichenbacher's 1998 padding oracle attack is almost old enough to drink
    - ROBOT just won a Pwnie at Black Hat this week
- When possible, do everything in constant-time
  - Including base64url encoding

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  - PAE([“test”]) => \x01\x00\x00\x00\x00\x00\x00\x00\x04\x00\x00\x00\x00\x00\x00\x00test

PAE in Practice

- Version 1
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    - The message input for the Ed25519 signature is PAE([“v2.public.”, message, footer]).

JWT vs PASETO

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- PASETO
  - Only two options:
    - Version
    - Purpose
  - Everything is authenticated
    - Local-only tokens are also encrypted
  - Does its job, gets out of the way

To learn more about PASETO, visit:

https://paseto.io

https://github.com/paragonie/paseto

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- Versioned protocols with hard-coded cipher-suites, vetted by cryptographers
  - If a vulnerability is found in the current version, publish a new version with a better hard-coded ciphersuite

Cryptography for Mere Mortals, cont’d.

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- Don’t just use simple binary strings for cryptography keys. Encapsulate them in a Key object.
  - This discourages the use of human-sourced passwords as a cryptography key, without the added steps of a secure KDF function (Argon2)
  - In many languages, this also prevents keys from leaking into stack traces and ending up in JIRA/Trac tickets

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  - If the developer doesn’t catch the exception, your code fails closed. If they do, they can handle failure gracefully in a way that doesn’t seem like crashing.
  - The alternatives (unavoidable crash, fail open) are bad. One scares developers, the other creates security holes in production systems.

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  - Every asterisk is a disaster risk
- Prefer versioned protocols over *cipher agility*
- Error-prone standards (JOSE) should be avoided in favor of safer designs (PASETO)

Questions?

Scott Arciszewski

- Paragon Initiative Enterprises, LLC
  - Software development (open source)
    - The person to blame for getting libsodium into PHP 7.2
    - Also wrote the sodium_compat polyfill for PHP 5.2 – 7.1
    - Many PHP security libraries
  - Security research
    - Handfuls of CVEs
    - Sometimes published on Full Disclosure
- Twitter handle: @CiPHPerCoder