

## PBKDF2: performance matters

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1. Quick intro to PBKDF2



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2. The standard is bad





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4. A faster PBKDF2



## PBKDF2: quick intro



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## Usage

- ▶ Password verification (web sites, network services, etc.)
- ▶ Key derivation (disk encryption, key management, etc.)



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## Simplification

PBKDF2 can produce arbitrary length output.  
We're going to ignore this capability from here on in: only considering the first block of output.

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and typically

$$\text{PRF}(\text{pw}, x) = \text{HMAC-H}(\text{pw}, x)$$

$H = \text{SHA-1, SHA-256, SHA-512, or ...}$

## Zoom, enhance



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Assumption: password and salt much shorter than SHA-256's 64-byte block size.

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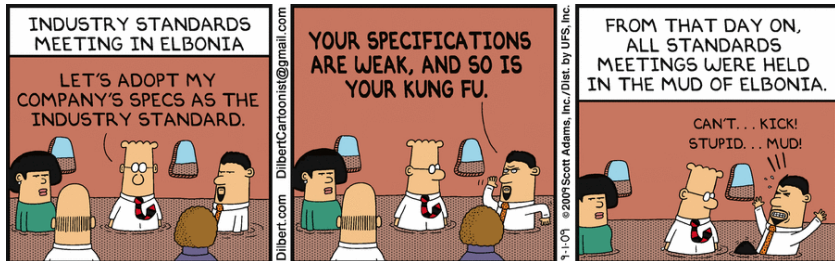
block 3 :  $key \oplus \text{opad}$

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Therefore, we need to compute  $4i$  SHA-256 blocks.

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### How many times?

Actually, we only need compute  $2 + 2i$  SHA-256 blocks.

# Survey of defender implementations

I looked at the following PBKDF2s:

- ▶ FreeBSD 10
- ▶ GRUB 2.0
- ▶ Truecrypt 7.1a
- ▶ Android (disk encryption)
- ▶ Android (BouncyCastle)
- ▶ Django
- ▶ OpenSSL
- ▶ Python core ( $\geq 3.4$ )
- ▶ Python (pypi pbkdf2)
- ▶ Ruby (pbkdf2 gem)
- ▶ Go (go.crypto)
- ▶ OpenBSD
- ▶ PolarSSL/mbedTLS
- ▶ CyaSSL/wolfSSL
- ▶ SJCL
- ▶ Java
- ▶ Common Lisp (ironclad)
- ▶ Perl (Crypt::PBKDF2)
- ▶ PHP5
- ▶ .NET framework
- ▶ scrypt/yescrypt<sup>1</sup>
- ▶ BouncyCastle

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<sup>1</sup>never called for scrypt/yescrypt with iterations != 1

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- ▶ Java (OpenJDK)
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- ▶ PHP
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- ▶ ...

## Selected performance measurements

- ▶ Question: how much practical difference does this make?



# Selected performance measurements

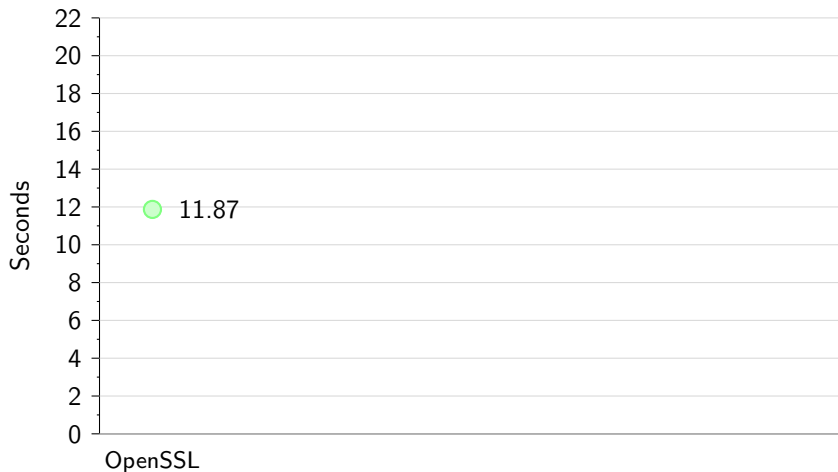
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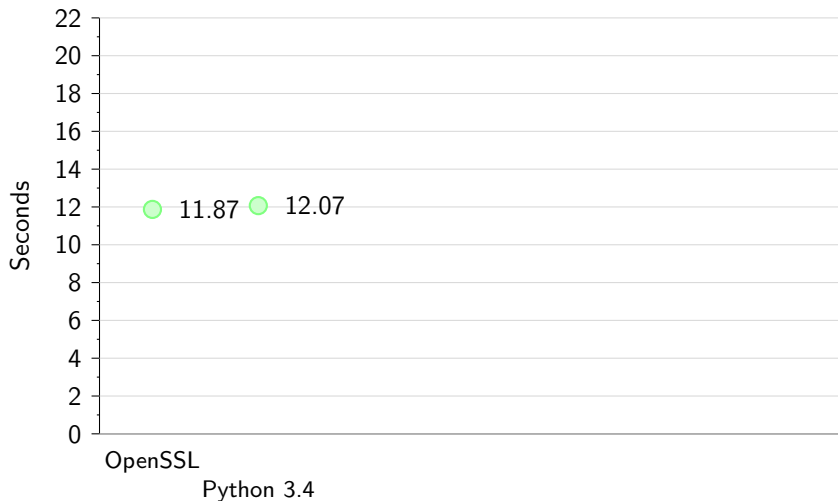
Measured on Intel Atom N2800 (1.86GHz), best of five runs, CPU time in user mode.

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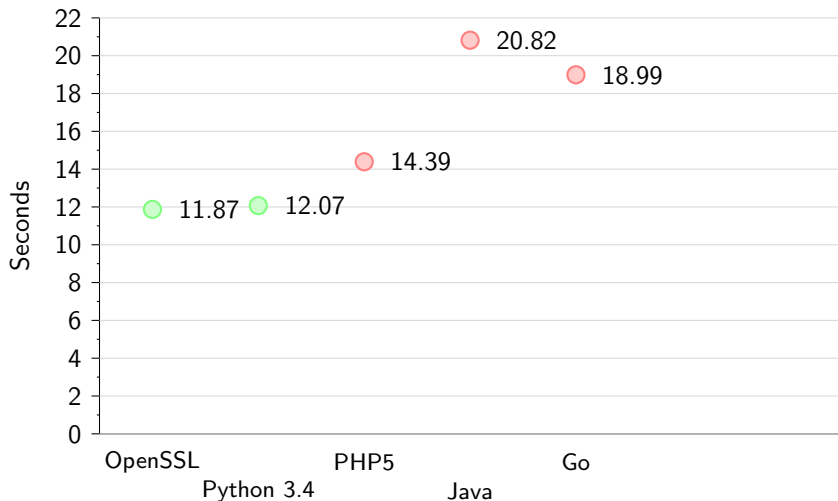
**Figure :** PBKDF2-HMAC-SHA1, one block output,  $2^{22}$  iterations

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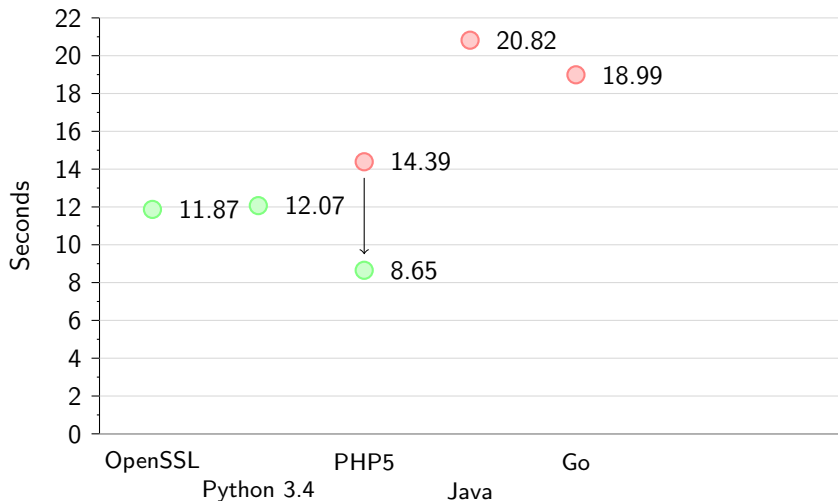
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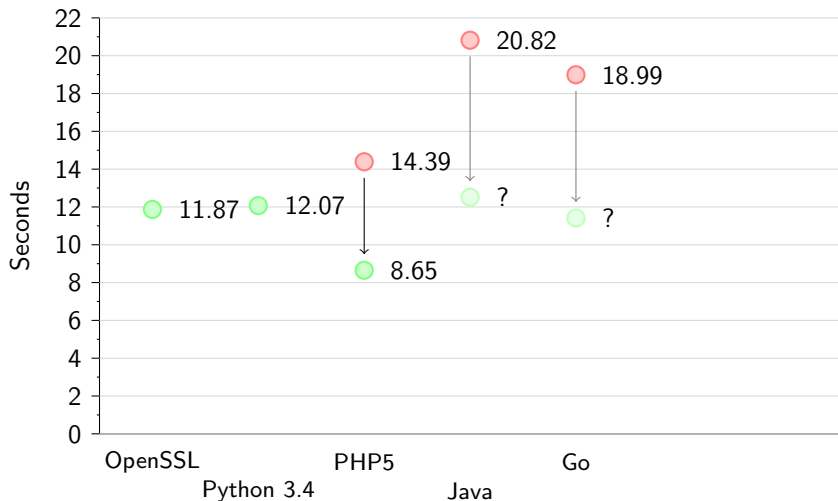
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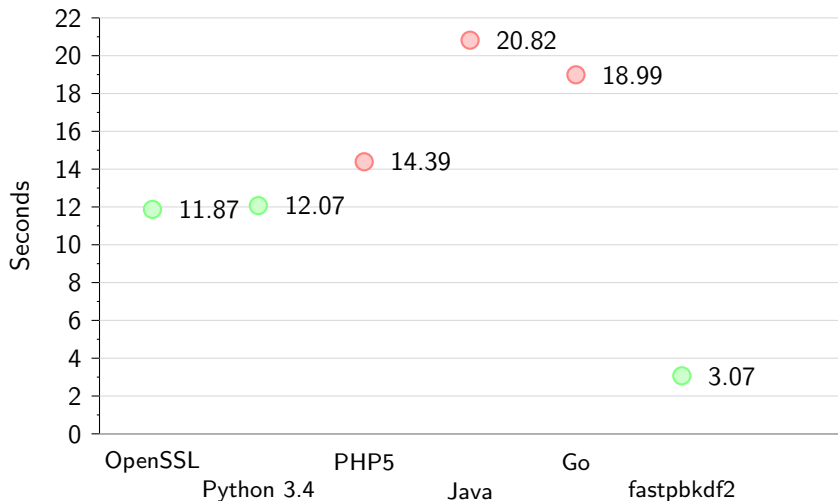
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A faster PBKDF2-HMAC- $\{\text{SHA-1}, \text{SHA-256}, \text{SHA-512}\}$  for defenders.

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- ▶ <https://github.com/ctz/fastpbkdf2/>

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- ▶ Most implementations waste time and power.
- ▶ If you use PBKDF2, you can probably drop in a faster implementation and either increase security margin, or improve time/power performance.
- ▶ Please try not to use PBKDF2 any more.



# Thank you!

Questions?

Twitter: @jpixton

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Web: <https://jbp.io/>

Slides and benchmarking code: <https://github.com/ctz/talks/>