pyblake2 Documentation

Release 0.9

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CONTENTS

pyblake2 is an extension module for Python implementing BLAKE2 hash function.

BLAKE2 is a cryptographic hash function, which offers highest security while being as fast as MD5 or SHA-1, and comes in two flavors:

- **BLAKE2b**, optimized for 64-bit platforms and produces digests of any size between 1 and 64 bytes,
- **BLAKE2s**, optimized for 8- to 32-bit platforms and produces digests of any size between 1 and 32 bytes.

BLAKE2 supports **keyed mode** (a faster and simpler replacement for HMAC), **salted hashing**, **personalization**, and **tree hashing**.

Hash objects from this module follow the API of standard library's `hashlib` objects.

Contents:

CHAPTER

ONE

MODULE

1.1 Creating hash objects

New hash objects are created by calling constructor functions:

`pyblake2.`**`blake2b`**(*data=b'', digest_size=64, key=b'', salt=b'', person=b'', fanout=1, depth=1, leaf_size=0, node_offset=0, node_depth=0, inner_size=0, last_node=False*)

`pyblake2.`**`blake2s`**(*data=b'', digest_size=32, key=b'', salt=b'', person=b'', fanout=1, depth=1, leaf_size=0, node_offset=0, node_depth=0, inner_size=0, last_node=False*)

These functions return the corresponding hash objects for calculating BLAKE2b or BLAKE2s. They optionally take these general parameters:

- *data*: initial chunk of data to hash, which must be interpretable as buffer of bytes.
- *digest_size*: size of output digest in bytes.
- *key*: key for keyed hashing (up to 64 bytes for BLAKE2b, up to 32 bytes for BLAKE2s).
- *salt*: salt for randomized hashing (up to 16 bytes for BLAKE2b, up to 8 bytes for BLAKE2s).
- *person*: personalization string (up to 16 bytes for BLAKE2b, up to 8 bytes for BLAKE2s).

The following table shows limits for general parameters (in bytes):

Hash	digest_size	len(key)	len(salt)	len(person)
BLAKE2b	64	64	16	16
BLAKE2s	32	32	8	8

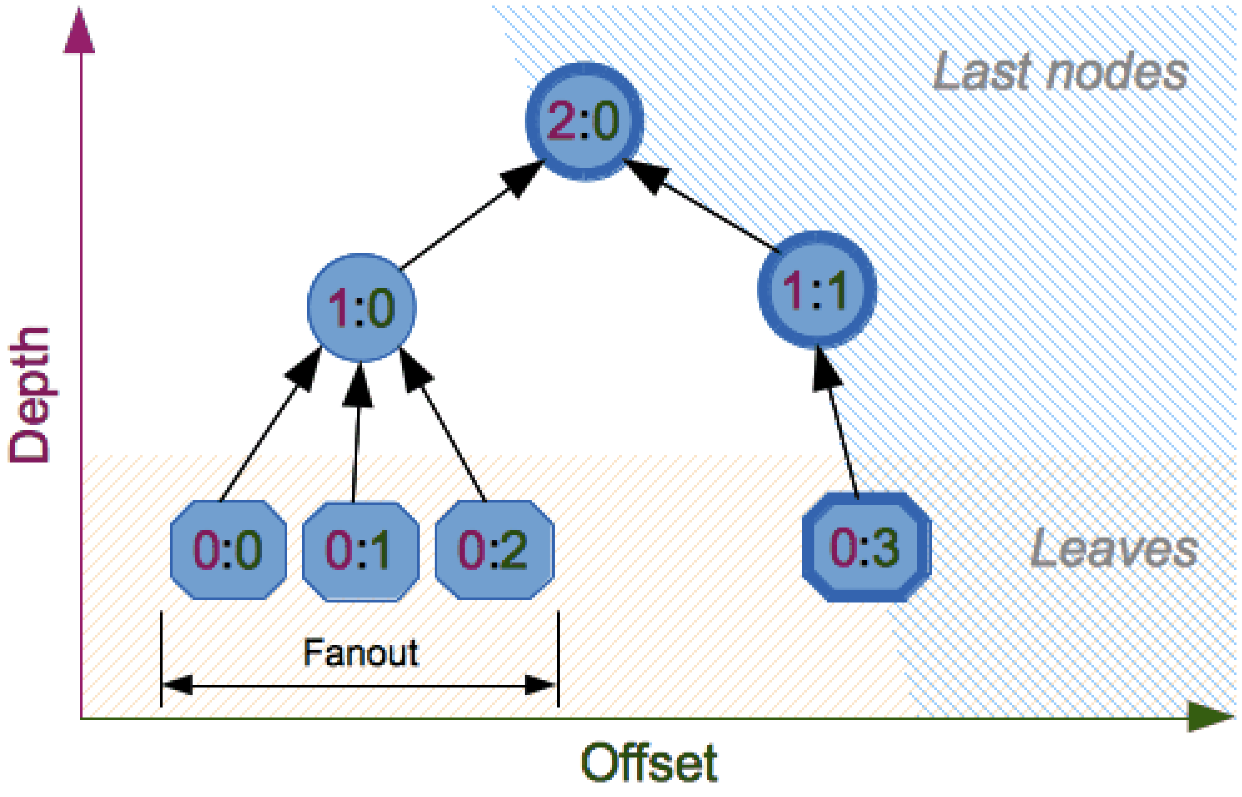
Note: BLAKE2 specification defines constant lengths for salt and personalization parameters, however, for convenience, this implementation accepts byte strings of any size up to the specified length. If the length of the parameter is less than specified, it is padded with zeros, thus, for example, `b'salt'` and `b'salt\x00'` is the same value. (This is not the case for *key*.)

These sizes are available as module constants described below.

Constructor functions also accept the following tree hashing parameters:

- *fanout*: fanout (0 to 255, 0 if unlimited, 1 in sequential mode).
- *depth*: maximal depth of tree (1 to 255, 255 if unlimited, 1 in sequential mode).
- *leaf_size*: maximal byte length of leaf (0 to 2**32-1, 0 if unlimited or in sequential mode).
- *node_offset*: node offset (0 to 2**64-1 for BLAKE2b, 0 to 2**48-1 for BLAKE2s, 0 for the first, leftmost, leaf, or in sequential mode).

- *node_depth*: node depth (0 to 255, 0 for leaves, or in sequential mode).
- *inner_size*: inner digest size (0 to 64 for BLAKE2b, 0 to 32 for BLAKE2s, 0 in sequential mode).
- *last_node*: boolean indicating whether the processed node is the last one (*False* for sequential mode).



See section 2.10 in BLAKE2 specification for comprehensive review of tree hashing.

1.2 Using hash objects

Hash objects have the following attributes and methods:

`hash.digest_size`

The size of the resulting digest in bytes. This is the value given to hash object constructor in *digest_size* argument.

`hash.block_size`

The internal block size of the hash algorithm in bytes.

`hash.update(arg)`

Update the hash object with the object, which must be interpretable as buffer of bytes

Note: For better multithreading performance, the Python GIL is released for data larger than 2047 bytes at hash object creation or on update to allow other threads to run.

`hash.digest()`

Return the digest of the data so far.

`hash.`**`hexdigest`**`()`

Like `digest()` except the digest is returned as a string of double length, containing only hexadecimal digits.

`hash.`**`copy`**`()`

Return a copy of the hash object.

1.3 Constants

`pyblake2.`**`BLAKE2B_SALT_SIZE`**

`pyblake2.`**`BLAKE2S_SALT_SIZE`**

Salt length (maximum length accepted by constructors).

`pyblake2.`**`BLAKE2B_PERSON_SIZE`**

`pyblake2.`**`BLAKE2S_PERSON_SIZE`**

Personalization string length (maximum length accepted by constructors).

`pyblake2.`**`BLAKE2B_MAX_KEY_SIZE`**

`pyblake2.`**`BLAKE2S_MAX_KEY_SIZE`**

Maximum key size.

`pyblake2.`**`BLAKE2B_MAX_DIGEST_SIZE`**

`pyblake2.`**`BLAKE2S_MAX_DIGEST_SIZE`**

Maximum digest size that the hash function can output.

CHAPTER TWO

EXAMPLES

2.1 Simple hashing

To calculate hash of some data, you should first construct a hash object by calling the appropriate constructor function (`blake2b()` or `blake2s()`), then update it with the data by calling `update()` on the object, and, finally, get the digest out of the object by calling `digest()` (or `hexdigest()` for hex-encoded string).

```
>>> from pyblake2 import blake2b
>>> h = blake2b()
>>> h.update(b'Hello world')
>>> h.hexdigest()
'6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb495dc8
```

As a shortcut, you can pass the first chunk of data to update directly to the constructor as the first argument (or as *data* keyword argument):

```
>>> from pyblake2 import blake2b
>>> blake2b(b'Hello world').hexdigest()
'6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb495dc8
```

You can call `hash.update()` as many times as you need to iteratively update the hash:

```
>>> from pyblake2 import blake2b
>>> items = [b'Hello', b' ', b'world']
>>> h = blake2b()
>>> for item in items:
...     h.update(item)
>>> h.hexdigest()
'6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb495dc8
```

2.2 Using different digest sizes

BLAKE2 has configurable size of digests up to 64 bytes for BLAKE2b and up to 32 bytes for BLAKE2s. For example, to replace SHA-1 with BLAKE2b without changing the size of output, we can tell BLAKE2b to produce 20-byte digests:

```
>>> from pyblake2 import blake2b
>>> h = blake2b(digest_size=20)
>>> h.update(b'Replacing SHA1 with the more secure function')
>>> h.hexdigest()
'd24f26cf8de66472d58d4e1b1774b4c9158b1f4c'
>>> h.digest_size
```

```
20
>>> len(h.digest())
20
```

Hash objects with different digest sizes have completely different outputs (shorter hashes are *not* prefixes of longer hashes); BLAKE2b and BLAKE2s produce different outputs even if the output length is the same:

```
>>> from pyblake2 import blake2b, blake2s
>>> blake2b(digest_size=10).hexdigest()
'6fa1d8fcfd719046d762'
>>> blake2b(digest_size=11).hexdigest()
'eb6ec15daf9546254f0809'
>>> blake2s(digest_size=10).hexdigest()
'1bf21a98c78a1c376ae9'
>>> blake2s(digest_size=11).hexdigest()
'567004bf96e4a25773ebf4'
```

2.3 Keyed hashing

Keyed hashing can be used for authentication as a faster and simpler replacement for Hash-based message authentication code (HMAC). BLAKE2 can be securely used in prefix-MAC mode thanks to the indifferentiability property inherited from BLAKE.

This example shows how to get a (hex-encoded) 128-bit authentication code for message `b'message data'` with key `b'pseudorandom key'`:

```
>>> from pyblake2 import blake2b
>>> h = blake2b(key=b'pseudorandom key', digest_size=16)
>>> h.update(b'message data')
>>> h.hexdigest()
'3d363ff7401e02026f4a4687d4863ced'
```

As a practical example, a web application can symmetrically sign cookies sent to users and later verify them to make sure they weren't tampered with:

```
>>> from pyblake2 import blake2b
>>>
>>> SECRET_KEY = b'pseudorandomly generated server secret key'
>>> AUTH_SIZE = 16
>>>
>>> def sign(cookie):
...     h = blake2b(data=cookie, digest_size=AUTH_SIZE, key=SECRET_KEY)
...     return h.hexdigest()
>>>
>>> def verify(cookie, sig):
...     good_sig = sign(cookie)
...     if len(sig) != len(good_sig):
...         return False
...     # Use constant-time comparison to avoid timing attacks.
...     result = 0
...     for x, y in zip(sig, good_sig):
...         result |= ord(x) ^ ord(y)
...     return result == 0
>>>
>>> cookie = b'user:vatrogasac'
>>> sig = sign(cookie)
>>> print("{0},{1}".format(cookie.decode('utf-8'), sig))
```

```
user:vatrogasac,349cf904533767ed2d755279a8df84d0
>>> verify(cookie, sig)
True
>>> verify(b'user:policajac', sig)
False
>>> verify(cookie, '0102030405060708090a0b0c0d0e0f00')
False
```

Even though there's a native keyed hashing mode, BLAKE2 can, of course, be used in HMAC construction with `hmac` module from the standard library:

```
>>> import hmac, pyblake2
>>> m = hmac.new(b'secret key', digestmod=pyblake2.blake2s)
>>> m.update(b'message')
>>> m.hexdigest()
'e3c8102868d28b5ff85fc35dda07329970d1a01e273c37481326fe0c861c8142'
```

2.4 Randomized hashing

By setting *salt* parameter users can introduce randomization to the hash function. Randomized hashing is useful for protecting against collision attacks on the hash function used in digital signatures.

> Randomized hashing is designed for situations where one party, the message preparer, generates all or part of a message to be signed by a second party, the message signer. If the message preparer is able to find cryptographic hash function collisions (i.e., two messages producing the same hash value), then she might prepare meaningful versions of the message that would produce the same hash value and digital signature, but with different results (e.g., transferring $1,000,000 to an account, rather than $10). Cryptographic hash functions have been designed with collision resistance as a major goal, but the current concentration on attacking cryptographic hash functions may result in a given cryptographic hash function providing less collision resistance than expected. Randomized hashing offers the signer additional protection by reducing the likelihood that a preparer can generate two or more messages that ultimately yield the same hash value during the digital signature generation process – even if it is practical to find collisions for the hash function. However, the use of randomized hashing may reduce the amount of security provided by a digital signature when all portions of the message are prepared by the signer.
>
> (NIST SP-800-106 "Randomized Hashing for Digital Signatures")

In BLAKE2 the salt is processed as a one-time input to the hash function during initialization, rather than as an input to each compression function.

Warning: *Salted hashing* (or just hashing) with BLAKE2 or any other general-purpose cryptographic hash function, such as SHA-256, is not suitable for hashing passwords. See BLAKE2 FAQ for more information.

```
>>> import os
>>> from pyblake2 import blake2b, BLAKE2B_SALT_SIZE
>>> msg = b'some message'
>>> # Calculate the first hash with a random salt.
>>> salt1 = os.urandom(BLAKE2B_SALT_SIZE)
>>> h1 = blake2b(salt=salt1)
>>> h1.update(msg)
>>> # Calculate the second hash with a different random salt.
>>> salt2 = os.urandom(BLAKE2B_SALT_SIZE)
>>> h2 = blake2b(salt=salt2)
>>> h2.update(msg)
>>> # The digests are different.
>>> h1.digest() != h2.digest()
True
```

2.5 Personalization

Sometimes it is useful to force hash function to produce different digests for the same input for different purposes. Quoting the authors of the Skein hash function:

> We recommend that all application designers seriously consider doing this; we have seen many protocols where a hash that is computed in one part of the protocol can be used in an entirely different part because two hash computations were done on similar or related data, and the attacker can force the application to make the hash inputs the same. Personalizing each hash function used in the protocol summarily stops this type of attack.
>
> (The Skein Hash Function Family, p. 21)

BLAKE2 can be personalized by passing bytes to the *person* argument:

```
>>> from pyblake2 import blake2b
>>> FILES_HASH_PERSON = b'MyApp Files Hash'
>>> BLOCK_HASH_PERSON = b'MyApp Block Hash'
>>> h = blake2b(digest_size=32, person=FILES_HASH_PERSON)
>>> h.update(b'the same content')
>>> h.hexdigest()
'20d9cd024d4fb086aae819a1432dd2466de12947831b75c5a30cf2676095d3b4'
>>> h = blake2b(digest_size=32, person=BLOCK_HASH_PERSON)
>>> h.update(b'the same content')
>>> h.hexdigest()
'cf68fb5761b9c44e7878bfb2c4c9aea52264a80b75005e65619778de59f383a3'
```

Personalization together with the keyed mode can also be used to derive different keys from a single one.

```
>>> from pyblake2 import blake2s
>>> from base64 import b64decode, b64encode
>>> orig_key = b64decode(b'Rm5EPJai72qcK3RGBpW3vPNfZy5OZothY+kHY6h21KM=')
>>> enc_key = blake2s(key=orig_key, person=b'kEncrypt').digest()
>>> mac_key = blake2s(key=orig_key, person=b'kMAC').digest()
>>> print(b64encode(enc_key).decode('utf-8'))
rbPb15S/Z9t+agffno5wuhB77VbRi6F9Iv2qIxU7WHw=
>>> print(b64encode(mac_key).decode('utf-8'))
G9GtHFE1YluXY1zWPlYk1e/nWfu0WSEb0KRcjhDeP/o=
```

2.6 Tree mode

Here's an example of hashing a minimal tree with two leaf nodes:

```
  10
 /  \
00  01
```

The example uses 64-byte internal digests, and returns the 32-byte final digest.

```
>>> from pyblake2 import blake2b
>>>
>>> FANOUT = 2
>>> DEPTH = 2
>>> LEAF_SIZE = 4096
>>> INNER_SIZE = 64
>>>
>>> buf = bytearray(6000)
>>>
>>> # Left leaf
... h00 = blake2b(buf[0:LEAF_SIZE], fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=0, node_depth=0, last_node=False)
>>> # Right leaf
... h01 = blake2b(buf[LEAF_SIZE:], fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=1, node_depth=0, last_node=True)
>>> # Root node
... h10 = blake2b(digest_size=32, fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=0, node_depth=1, last_node=True)
>>> h10.update(h00.digest())
>>> h10.update(h01.digest())
>>> h10.hexdigest()
'3ad2a9b37c6070e374c7a8c508fe20ca86b6ed54e286e93a0318e95e881db5aa'
```

CHAPTER

THREE

INSTALLATION

`pyblake2` works with Python 2.6, 2.7 and 3.x.

You can install it from PyPi using pip:

```
$ pip install pyblake2
```

or download sources and run:

```
$ python setup.py install
```

3.1 Download

See list of files here:

https://pypi.python.org/pypi/pyblake2

3.2 Development

Git repository: https://github.com/dchest/pyblake2

When submitting pull requests, please include public domain dedication / CC0 header text as written in the *Credits* topic into the text of your pull request, including your full legal name. (We cannot accept changes if you are not willing to place them into the public domain.)

3.3 Version history

0.9.2:

- Made tests compatible with Python 2.6 and 3.2.
- Made examples from documentation compatible with Python 3.
- Removed compiled documentation from source distribution.

0.9.1:

- Fixed Windows build.

0.9.0:

- First release.

CHAPTER

FOUR

CREDITS

BLAKE2 was designed by *Jean-Philippe Aumasson*, *Samuel Neves*, *Zooko Wilcox-O'Hearn*, and *Christian Winnerlein* based on SHA-3 finalist BLAKE created by *Jean-Philippe Aumasson*, *Luca Henzen*, *Willi Meier*, and *Raphael C.-W. Phan*.

It uses core algorithm from ChaCha cipher designed by *Daniel J. Bernstein*.

Python extension module was written by *Dmitry Chestnykh* based on C implementation written by *Samuel Neves*.

The following public domain dedication applies for both C hash function implementation, extension code, and this documentation:

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The following people have helped with development or contributed their changes to the project and the public domain according to the Creative Commons Public Domain Dedication 1.0 Universal:

- *Alexandr Sokolovskiy*

See Also:

Official BLAKE2 website: https://blake2.net

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