Ethereum SLIP-39 Account Generation

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Creating Ethereum, Bitcoin and other accounts is complex and fraught with potential for loss of funds.

A BIP-39 seed recovery phrase helps, but a **single** lapse in security dooms the account (and all derived accounts, in fact). If someone finds your recovery phrase (or you lose it), the accounts derived from that seed are *gone*.

The SLIP-39 standard allows you to split the seed between 1, 2, or more groups of several mnemonic recovery phrases. This is better, but creating such accounts is difficult; presently, only the Trezor supports these, and they can only be created "manually". Writing down 5 or more sets of 20 words is difficult, error-prone and time consuming.

The python-slip39 project (and the SLIP-39 macOS/win32 App) exists to assist in the safe creation and documentation of Ethereum HD Wallet seeds and derived accounts, with various SLIP-39 sharing parameters. It generates the new random wallet seed, and generates the expected standard Ethereum account(s) (at derivation path `m/44'/60'/0'/0/0` by default) and Bitcoin accounts (at Bech32 derivation path `m/84'/0'/0'/0/0` by default), with wallet address and QR code (compatible with Trezor derivations). It produces the required SLIP-39 phrases, and outputs a single PDF containing all the required printable cards to document the seed (and the specified derived accounts).

Output of BIP-38 or JSON encrypted Paper Wallets is supported, for import into standard software cryptocurrency wallets.

On an secure (ideally air-gapped) computer, new seeds can safely be generated and the PDF saved to a USB drive for printing (or directly printed without the file being saved to disk.). Presently, `slip39` can output example ETH, BTC, LTC and DOGE addresses derived from the seed, to illustrate what accounts are associated with the backed-up seed. Recovery of the seed to a Trezor is simple, by entering the mnemonics right on the device.

Contents

1 Security with Availability

For both BIP-39 and SLIP-39, a 128-bit random "seed" is the source of an unlimited sequence of Ethereum and Bitcoin HD (Heirarchical Deterministic) derived Wallet accounts. Anyone who can obtain this seed gains control of all Ethereum, Bitcoin (and other) accounts derived from it, so it must be securely stored.

Losing this seed means that all of the HD Wallet accounts are permanently lost. It must be *both* backed up securely, *and* be readily accessible.

Therefore, we must:

- Ensure that nobody untrustworthy can recover the seed, but
- Store the seed in many places, probably with several (some perhaps untrustworthy) people.

How can we address these conflicting requirements?

1.1 Shamir's Secret Sharing System (SSSS)

Satoshi Lab's (Trezor) SLIP-39 uses SSSS to distribute the ability to recover the key to 1 or more "groups". Collecting the mnemonics from the required number of groups allows recovery of the seed. For BIP-39, the number of groups is always 1, and the number of mnemonics required for that group is always 1.

For SLIP-39, a "group_threshold" of how many groups must bet successfully collected to recover the key. Then key is (conceptually) split between 1 or more groups (not really; each group's data alone gives away no information about the key).

For example, you might have First, Second, Fam and Frens groups, and decide that any 2 groups can be combined to recover the key. Each group has members with varying levels of trust and persistence, so have different number of Members, and differing numbers Required to recover that group's data:

Group	Required		Members	Description
First	1	/	1	Stored at home
Second	1	/	1	Stored in office safe
Fam	2	/	4	Distributed to family members
Frens	3	/	6	Distributed to friends and associates

The account owner might store their First and Second group data in their home and office safes. These are 1/1 groups (1 required, and only 1 member, so each of these are3 1-card groups.)

If the account needs to be recovered, collecting the First and Second cards from the home and office safe is sufficient to recover the seed, and re-generate the HD Wallet accounts.

Only 2 Fam member's cards must be collected to recover the Fam group's data. So, if the HD Wallet owner loses their home and First group card in a fire, they could get the Second group card from the office safe, and 2 cards from Fam group members, and recover the wallet.

If catastrophe strikes and the owner dies, and the heirs don't have access to either the First (at home) or Second (at the office), they can collect 2 Fam cards and 3 Frens cards (at the funeral, for example), completing the Fam and Frens groups' data, and recover the seed, and all derived HD Wallet accounts.

Since Frens are less likely to persist long term, we'll produce more (6) of these cards. Depending on how trustworthy the group is, adjust the Fren group's Required number higher (less trustworthy, more likely to know each-other, need to collect more to recover the group), or lower (more trustworthy, less likely to collude, need less to recover).

2 SLIP-39 Account Creation, Recovery and Address Generation

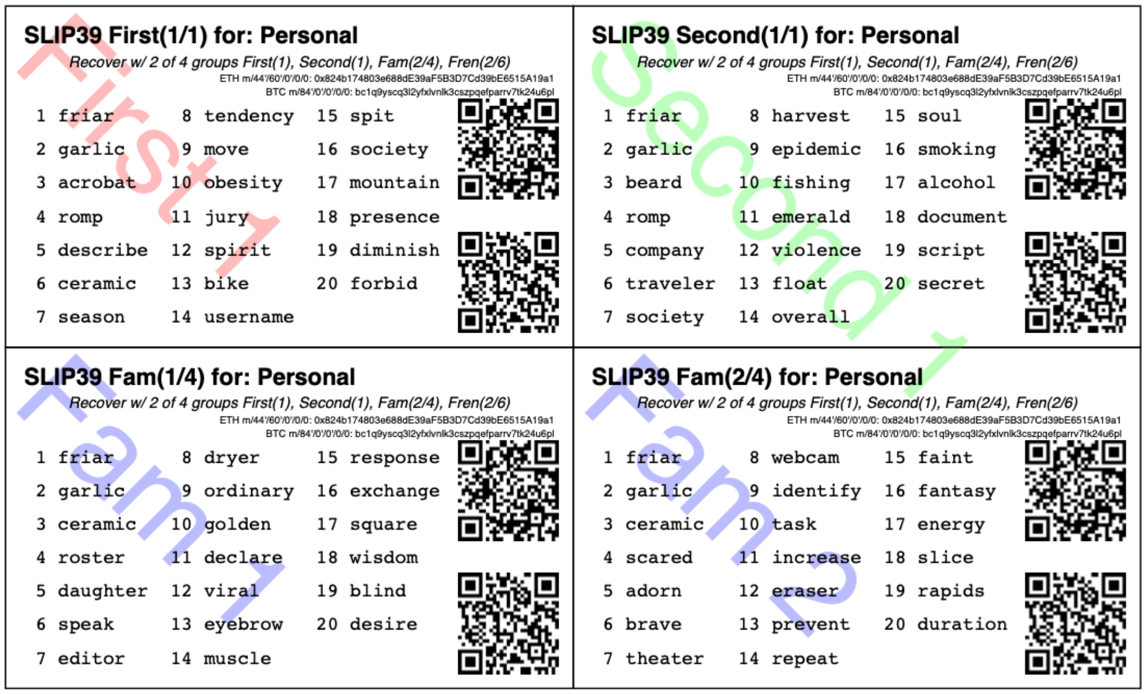
Generating a new SLIP-39 encoded seed is easy, with results available as PDF and text. Any number of derived HD wallet account addresses can be generated from this seed, and the seed (and all derived HD wallets, for all cryptocurrencies) can be recovered by collecting the desired groups of recover card phrases. The default recovery groups are as described above.

2.1 Creating New SLIP-39 Recoverable Seeds

This is what the first page of the output SLIP-39 mnemonic cards PDF looks like:

Run the following to obtain a PDF file containing index cards with the default SLIP-39 groups for a new account seed named "Personal"; insert a USB drive to collect the output, and run:

```
$ python3 -m pip install slip39        # Install slip39 in Python3
$ cd /Volumes/USBDRIVE/                # Change current directory to USB
$ python3 -m slip39 Personal           # Or just run "slip39 Personal"
2021-12-25 11:10:38 slip39           ETH m/44'/60'/0'/0/0    : 0xb44A2011A99596671d5952CdC22816089f142FB3
```


First 1
Second 1
Fam 1
Fam 2

SLIP39 First(1/1) for: Personal

Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Fren(2/6)

ETH m/44'/60'/0'/0/0: 0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
BTC m/84'/0'/0'/0/0: bc1q9yscq3l2yfxlvnlk3cszpqefparrv7tk24u6pl

1 friar	8 tendency	15 spit
2 garlic	9 move	16 society
3 acrobat	10 obesity	17 mountain
4 romp	11 jury	18 presence
5 describe	12 spirit	19 diminish
6 ceramic	13 bike	20 forbid
7 season	14 username	

SLIP39 Second(1/1) for: Personal

Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Fren(2/6)

ETH m/44'/60'/0'/0/0: 0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
BTC m/84'/0'/0'/0/0: bc1q9yscq3l2yfxlvnlk3cszpqefparrv7tk24u6pl

1 friar	8 harvest	15 soul
2 garlic	9 epidemic	16 smoking
3 beard	10 fishing	17 alcohol
4 romp	11 emerald	18 document
5 company	12 violence	19 script
6 traveler	13 float	20 secret
7 society	14 overall	

SLIP39 Fam(1/4) for: Personal

Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Fren(2/6)

ETH m/44'/60'/0'/0/0: 0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
BTC m/84'/0'/0'/0/0: bc1q9yscq3l2yfxlvnlk3cszpqefparrv7tk24u6pl

1 friar	8 dryer	15 response
2 garlic	9 ordinary	16 exchange
3 ceramic	10 golden	17 square
4 roster	11 declare	18 wisdom
5 daughter	12 viral	19 blind
6 speak	13 eyebrow	20 desire
7 editor	14 muscle	

SLIP39 Fam(2/4) for: Personal

Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Fren(2/6)

ETH m/44'/60'/0'/0/0: 0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
BTC m/84'/0'/0'/0/0: bc1q9yscq3l2yfxlvnlk3cszpqefparrv7tk24u6pl

1 friar	8 webcam	15 faint
2 garlic	9 identify	16 fantasy
3 ceramic	10 task	17 energy
4 scared	11 increase	18 slice
5 adorn	12 eraser	19 rapids
6 brave	13 prevent	20 duration
7 theater	14 repeat	

Figure 1: SLIP-39 Cards PDF (from `--secret ffff...`)

```
2021-12-25 11:10:38 slip39          Wrote SLIP-39-encoded wallet for 'Personal' to:\
  Personal-2021-12-22+15.45.36-0xb44A2011A99596671d5952CdC22816089f142FB3.pdf
```

The resultant PDF will be output into the designated file.

This PDF file can be printed on 3x5 index cards, or on regular paper or card stock and the cards can be cut out (`--card credit` , `business`, `half` (page) and `third` (page) are also available, as well as custom `"(<h>,<w>),<margin>"`).

To get the data printed on the terminal as in this example (so you could write it down on cards instead), add a `-v` (to see it logged in a tabular format), or `--text` to have it printed to stdout in full lines (ie. for pipelining to other programs).

2.1.1 Paper Wallets

The Trezor hardware wallet natively supports the input of SLIP-39 Mnemonics. However, most software wallets do not (yet) support SLIP-39. So, how do we load the Crypto wallets produced from our Seed into software wallets such as the Metamask plugin or the Brave browser, for example?

The `slip39.gui` (and the macOS/win32 SLIP-39.App) support output of standard BIP-38 encrypted wallets for Bitcoin-like cryptocurrencies such as BTC, LTC and DOGE. It also outputs encrypted Ethereum JSON wallets for ETH. Here is how to produce them (from a test secret Seed; exclude `--secret ffff...` for yours!):

```
$ slip39 -c ETH -c BTC -c DOGE -c LTC --secret ffffffffffffffffffffffffffffffff \
    --wallet password --wallet-hint 'bad:pass...'
```

And what they look like:

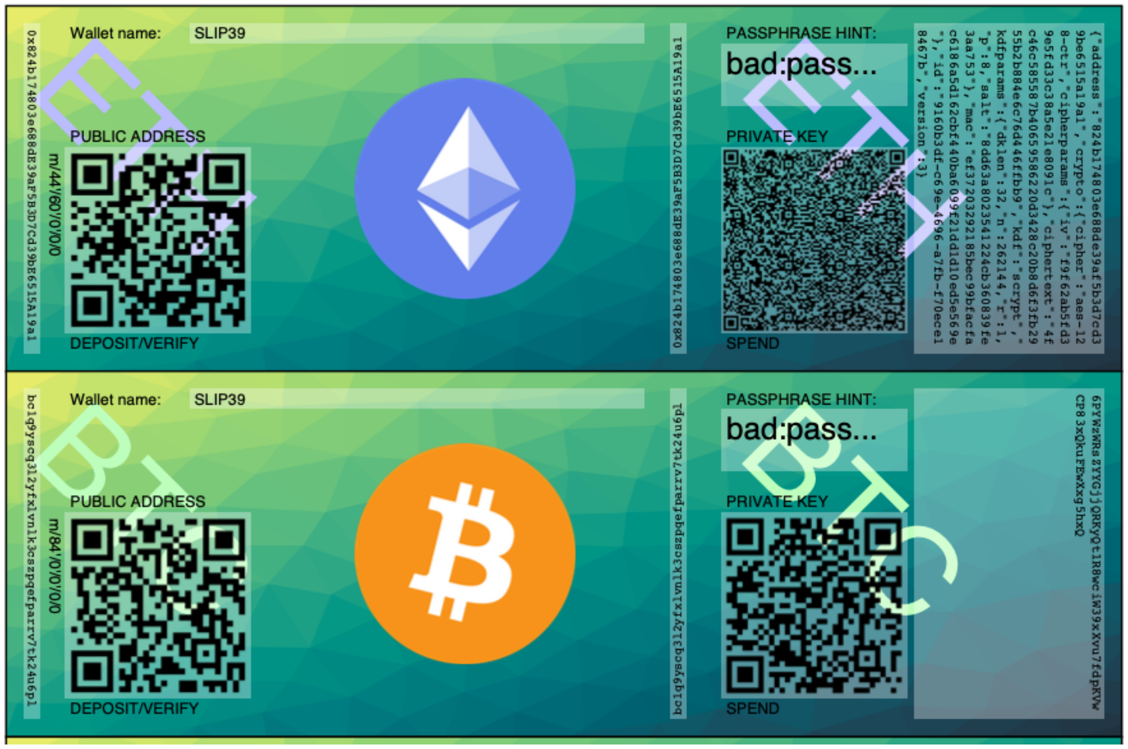


Figure 2: Paper Wallets (from `--secret ffff...`)

2.1.2 Supported Cryptocurrencies

While the SLIP-39 seed is not cryptocurrency-specific (any wallet for any cryptocurrency can be derived from it), each type of cryptocurrency has its own standard derivation path (eg. `m/44'/3'/0'/0/0` for DOGE), and its own address representation (eg. Bech32 at `m/84'/0'/0'/0/0` for BTC eg. `bc1qcupw7k8enymvvsa7w35j5hq4ergtvus3zk8a8s`.

When you import your SLIP-39 seed into a Trezor, you gain access to all derived HD cryptocurrency wallets supported directly by that hardware wallet, and **indirectly**, to any coin and/or blockchain network supported by any wallet software (eg. Metamask).

Crypto	Semantic	Path	Address <
ETH	Legacy	m/44'/60'/0'/0/0	0x...
BNB	Legacy	m/44'/60'/0'/0/0	0x...
CRO	Bech32	m/44'/60'/0'/0/0	crc1...
BTC	Legacy	m/44'/ 0'/0'/0/0	1...
	SegWit	m/44'/ 0'/0'/0/0	3...
	Bech32	m/84'/ 0'/0'/0/0	bc1...
LTC	Legacy	m/44'/ 2'/0'/0/0	L...
	SegWit	m/44'/ 2'/0'/0/0	M...
	Bech32	m/84'/ 2'/0'/0/0	ltc1...
DOGE	Legacy	m/44'/ 3'/0'/0/0	D...

1. ETH, BTC, LTC, DOGE

   These coins are natively supported both directly by the Trezor hardware wallet, and by most software wallets and "web3" platforms that interact with the Trezor, or can import the BIP-38 or Ethereum JSON Paper Wallets produced by `python-slip39`.

2. BNB on the Binance Smart Chain (BSC): binance.com

   The Binance Smart Chain uses standard Ethereum addresses; support for the BSC is added directly to the wallet software; here are the instructions for adding BSC support for the Trezor hardware wallet, using the Metamask wallet. In `python-slip39`, BNB is simply an alias for ETH, since the wallet addresses and Ethereum JSON Paper Wallets are identical.

3. CRO on Cronos: crypto.com

   The Cronos chain (formerly known as the Crypto.org chain). It is the native chain of the crypto.com CRO coin.

   Cronos also uses Ethereum addresses on the `m/44'/60'/0'/0/0` derivation path, but represents them as Bech32 addresses with a "crc" prefix, eg. `crc19a6r74dvfxjyvjzf3pg9y3y5rhk6rds2c9265n`.

   As with BNB, CRO is an alias for ETH, but changes the default wallet address representation to Bech32 prefixed with `crc`.

2.2 The macOS/win32 `SLIP-39.app` GUI App

If you prefer a graphical user-interface, try the macOS/win32 SLIP-39.App. You can run it directly if you install Python 3.9+ from python.org/downloads or using homebrew `brew install python-tk@3.10`. Then, start the GUI in a variety of ways:

```
slip39-gui
python3 -m slip39.gui
```

Alternatively, download and install the macOS/win32 GUI App .zip, .pkg or .dmg installer from github.com/pjkundert/python-slip-39/releases.

2.3 The Python `slip39` CLI

From the command line, you can create SLIP-39 seed Mnemonic card PDFs.

2.3.1 `slip39` Synopsis

The full command-line argument synopsis for `slip39` is:

```
    slip39 --help              | sed 's/^/: /' # (just for output formatting)

usage: slip39 [-h] [-v] [-q] [-o OUTPUT] [-t THRESHOLD] [-g GROUP] [-f FORMAT]
              [-c CRYPTOCURRENCY] [-p PATH] [-j JSON] [-w WALLET]
              [--wallet-hint WALLET_HINT] [--wallet-format WALLET_FORMAT]
              [-s SECRET] [--bits BITS] [--passphrase PASSPHRASE] [-C CARD]
              [--paper PAPER] [--no-card] [--text]
              [names ...]

Create and output SLIP-39 encoded Seeds and Paper Wallets to a PDF file.

positional arguments:
  names                 Account names to produce

options:
  -h, --help            show this help message and exit
  -v, --verbose         Display logging information.
  -q, --quiet           Reduce logging output.
  -o OUTPUT, --output OUTPUT
                        Output PDF to file or '-' (stdout); formatting w/
                        name, date, time, crypto, path, address allowed
  -t THRESHOLD, --threshold THRESHOLD
                        Number of groups required for recovery (default: half
                        of groups, rounded up)
  -g GROUP, --group GROUP
                        A group name[[<require>/]<size>] (default: <size> = 1,
                        <require> = half of <size>, rounded up, eg.
                        'Frens(3/5)' ).
  -f FORMAT, --format FORMAT
                        Specify crypto address formats: legacy, segwit,
                        bech32; default BTC:bech32, DOGE:legacy, ETH:legacy,
                        LTC:bech32
  -c CRYPTOCURRENCY, --cryptocurrency CRYPTOCURRENCY
                        A crypto name and optional derivation path (eg.
                        '../<range>/<range>'); defaults: BTC:m/84'/0'/0'/0/0,
                        DOGE:m/44'/3'/0'/0/0, ETH:m/44'/60'/0'/0/0,
                        LTC:m/84'/2'/0'/0/0
  -p PATH, --path PATH  Modify all derivation paths by replacing the final
                        segment(s) w/ the supplied range(s), eg. '.../1/-'
                        means .../1/[0,...)
  -j JSON, --json JSON  Save an encrypted JSON wallet for each Ethereum
                        address w/ this password, '-' reads it from stdin
                        (default: None)
  -w WALLET, --wallet WALLET
                        Produce paper wallets in output PDF; each wallet
                        private key is encrypted this password
  --wallet-hint WALLET_HINT
                        Paper wallets password hint
  --wallet-format WALLET_FORMAT
                        Paper wallet size; half, third, quarter or
                        '(<h>,<w>),<margin>' (default: quarter)
  -s SECRET, --secret SECRET
                        Use the supplied 128-, 256- or 512-bit hex value as
                        the secret seed; '-' reads it from stdin (eg. output
                        from slip39.recover)
  --bits BITS           Ensure that the seed is of the specified bit length;
                        128, 256, 512 supported.
  --passphrase PASSPHRASE
                        Encrypt the master secret w/ this passphrase, '-'
                        reads it from stdin (default: None/'')
  -C CARD, --card CARD  Card size; index, credit, business, half, third,
                        quarter, photo or '(<h>,<w>),<margin>' (default:
                        index)
  --paper PAPER         Paper size (default: Letter)
  --no-card             Disable PDF SLIP-39 mnemonic card output
  --text                Enable textual SLIP-39 mnemonic output to stdout
```

2.4 Recovery & Re-Creation

Later, if you need to recover the wallet seed, keep entering SLIP-39 mnemonics into `slip39-recovery` until the secret is recovered (invalid/duplicate mnemonics will be ignored):

```
$ python3 -m slip39.recovery   # (or just "slip39-recovery")
Enter 1st SLIP-39 mnemonic: ab c
Enter 2nd SLIP-39 mnemonic: veteran guilt acrobat romp burden campus purple webcam uncover ...
Enter 3rd SLIP-39 mnemonic: veteran guilt acrobat romp burden campus purple webcam uncover ...
Enter 4th SLIP-39 mnemonic: veteran guilt beard romp dragon island merit burden aluminum worthy ...
2021-12-25 11:03:33 slip39.recovery  Recovered SLIP-39 secret; Use:  python3 -m slip39 --secret ...
383597fd63547e7c9525575decd413f7
```

Finally, re-create the wallet seed, perhaps including an encrypted JSON wallet file for import of some accounts into a software wallet:

```
slip39 --secret 383597fd63547e7c9525575decd413f7 --json password 2>&1
```

```
2022-03-10 09:54:43 slip39          It is recommended to not use '-s|--secret <hex>'; specify '-' to read from input
2022-03-10 09:54:43 slip39          The SLIP-39 Standard Passphrase is not compatible w/ the Trezor hardware wallet; use its 'h
2022-03-10 09:54:43 slip39          It is recommended to not use '-j|--json <password>'; specify '-' to read from input
2022-03-10 09:54:43 slip39.layout    ETH    m/44'/60'/0'/0/0    : 0xb44A2011A99596671d5952CdC22816089f142FB3
2022-03-10 09:54:43 slip39.layout    BTC    m/84'/0'/0'/0/0     : bc1qcupw7k8enymvvsa7w35j5hq4ergtvus3zk8a8s
2022-03-10 09:54:44 slip39.layout    Wrote JSON SLIP39's encrypted ETH wallet 0xb44A2011A99596671d5952CdC22816089f142FB3 derived
```

2.4.1 slip39.recovery Synopsis

```
    slip39-recovery --help         | sed 's/^/: /' # (just for output formatting)

usage: slip39-recovery [-h] [-v] [-q] [-b] [-m MNEMONIC] [-p PASSPHRASE]

Recover and output secret seed from SLIP39 or BIP39 mnemonics

options:
  -h, --help            show this help message and exit
  -v, --verbose         Display logging information.
  -q, --quiet           Reduce logging output.
  -b, --bip39           Recover 512-bit secret seed from BIP-39 mnemonics
  -m MNEMONIC, --mnemonic MNEMONIC
                        Supply another SLIP-39 (or a BIP-39) mnemonic phrase
  -p PASSPHRASE, --passphrase PASSPHRASE
                        Decrypt the master secret w/ this passphrase, '-'
                        reads it from stdin (default: None/'')

If you obtain a threshold number of SLIP-39 mnemonics, you can recover the original
secret seed, and re-generate one or more Ethereum wallets from it.

Enter the mnemonics when prompted and/or via the command line with -m |--mnemonic "...".

The master secret seed can then be used to generate a new SLIP-39 encoded wallet:

    python3 -m slip39 --secret = "ab04...7f"

BIP-39 wallets can be backed up as SLIP-39 wallets, but only at the cost of 59-word SLIP-39
mnemonics.  This is because the *output* 512-bit BIP-39 seed must be stored in SLIP-39 -- not the
*input* 128-, 160-, 192-, 224-, or 256-bit entropy used to create the original BIP-39 mnemonic
phrase.
```

2.4.2 Pipelining slip39.recovery | slip39 --secret -

The tools can be used in a pipeline to avoid printing the secret. Here we generate some mnemonics, sorting them in reverse order so we need more than just the first couple to recover. Observe the Ethereum wallet address generated.

Then, we recover the master secret seed in hex with `slip39-recovery`, and finally send it to `slip39 --secret -` to re-generate the same wallet as we originally created.

```
   ( python3 -m slip39 --text --no-card -v \
       | sort -r \
       | python3 -m slip39.recovery \
       | python3 -m slip39 --secret - --no-card -q ) 2>&1
```

```
   2022-03-10 09:54:45 slip39          The SLIP-39 Standard Passphrase is not compatible w/ the Trezor hardware wallet; use its
   2022-03-10 09:54:46 slip39          First(1/1): Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Frens(3/6)
   2022-03-10 09:54:46 slip39          1st  1 strike     8 learn     15 cultural
   2022-03-10 09:54:46 slip39               2 steady     9 tadpole   16 dominant
   2022-03-10 09:54:46 slip39               3 acrobat   10 budget    17 being
   2022-03-10 09:54:46 slip39               4 romp      11 brave     18 suitable
   2022-03-10 09:54:46 slip39               5 document  12 python    19 activity
   2022-03-10 09:54:46 slip39               6 jury      13 inform    20 resident
   2022-03-10 09:54:46 slip39               7 screw     14 oasis
   2022-03-10 09:54:46 slip39          Second(1/1): Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Frens(3/6)
   2022-03-10 09:54:46 slip39          1st  1 strike     8 describe  15 diagnose
   2022-03-10 09:54:46 slip39               2 steady     9 domain    16 station
   2022-03-10 09:54:46 slip39               3 beard     10 finance   17 tolerate
   2022-03-10 09:54:46 slip39               4 romp      11 bumpy     18 cubic
```

```
2022-03-10 09:54:46 slip39                5 dominant  12 friar     19 buyer
2022-03-10 09:54:46 slip39                6 focus     13 declare   20 demand
2022-03-10 09:54:46 slip39                7 findings  14 military
2022-03-10 09:54:46 slip39           Fam(2/4): Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Frens(3/6)
2022-03-10 09:54:46 slip39           1st  1 strike     8 lamp      15 tolerate
2022-03-10 09:54:46 slip39                2 steady     9 glad      16 ancestor
2022-03-10 09:54:46 slip39                3 ceramic   10 subject   17 diet
2022-03-10 09:54:46 slip39                4 roster    11 rebuild   18 pleasure
2022-03-10 09:54:46 slip39                5 cradle    12 pancake   19 level
2022-03-10 09:54:46 slip39                6 acrobat   13 volume    20 patent
2022-03-10 09:54:46 slip39                7 usher     14 raisin
2022-03-10 09:54:46 slip39           2nd  1 strike     8 making    15 training
2022-03-10 09:54:46 slip39                2 steady     9 mouse     16 story
2022-03-10 09:54:46 slip39                3 ceramic   10 trash     17 fiber
2022-03-10 09:54:46 slip39                4 scared    11 capacity  18 deal
2022-03-10 09:54:46 slip39                5 chew      12 teacher   19 public
2022-03-10 09:54:46 slip39                6 taste     13 minister  20 install
2022-03-10 09:54:46 slip39                7 desktop   14 dynamic
2022-03-10 09:54:46 slip39           3rd  1 strike     8 multiple  15 worthy
2022-03-10 09:54:46 slip39                2 steady     9 simple    16 cage
2022-03-10 09:54:46 slip39                3 ceramic   10 rhyme     17 radar
2022-03-10 09:54:46 slip39                4 shadow    11 mailman   18 club
2022-03-10 09:54:46 slip39                5 dynamic   12 method    19 member
2022-03-10 09:54:46 slip39                6 physics   13 junk      20 ruin
2022-03-10 09:54:46 slip39                7 bishop    14 replace
2022-03-10 09:54:46 slip39           4th  1 strike     8 geology   15 velvet
2022-03-10 09:54:46 slip39                2 steady     9 dramatic  16 smith
2022-03-10 09:54:46 slip39                3 ceramic   10 march     17 stadium
2022-03-10 09:54:46 slip39                4 sister    11 ceiling   18 response
2022-03-10 09:54:46 slip39                5 desert    12 snake     19 reunion
2022-03-10 09:54:46 slip39                6 isolate   13 capture   20 blanket
2022-03-10 09:54:46 slip39                7 snake     14 debut
2022-03-10 09:54:46 slip39           Frens(3/6): Recover w/ 2 of 4 groups First(1), Second(1), Fam(2/4), Frens(3/6)
2022-03-10 09:54:46 slip39           1st  1 strike     8 maximum   15 suitable
2022-03-10 09:54:46 slip39                2 steady     9 warn      16 lyrics
2022-03-10 09:54:46 slip39                3 decision  10 always    17 peaceful
2022-03-10 09:54:46 slip39                4 round     11 harvest   18 parking
2022-03-10 09:54:46 slip39                5 drink     12 trust     19 organize
2022-03-10 09:54:46 slip39                6 squeeze   13 pleasure  20 goat
2022-03-10 09:54:46 slip39                7 favorite  14 advance
2022-03-10 09:54:46 slip39           2nd  1 strike     8 mortgage  15 swing
2022-03-10 09:54:46 slip39                2 steady     9 true      16 crisis
2022-03-10 09:54:46 slip39                3 decision  10 permit    17 increase
2022-03-10 09:54:46 slip39                4 scatter   11 machine   18 parking
2022-03-10 09:54:46 slip39                5 detailed  12 activity  19 reward
2022-03-10 09:54:46 slip39                6 kind      13 mustang   20 thank
2022-03-10 09:54:46 slip39                7 orange    14 prize
2022-03-10 09:54:46 slip39           3rd  1 strike     8 gesture   15 grasp
2022-03-10 09:54:46 slip39                2 steady     9 aluminum  16 nervous
2022-03-10 09:54:46 slip39                3 decision  10 pajamas   17 craft
2022-03-10 09:54:46 slip39                4 shaft     11 flea      18 merchant
2022-03-10 09:54:46 slip39                5 beam      12 vitamins  19 medal
2022-03-10 09:54:46 slip39                6 keyboard  13 short     20 domain
2022-03-10 09:54:46 slip39                7 fluff     14 group
2022-03-10 09:54:46 slip39           4th  1 strike     8 jacket    15 glance
2022-03-10 09:54:46 slip39                2 steady     9 burden    16 domain
2022-03-10 09:54:46 slip39                3 decision  10 armed     17 wavy
2022-03-10 09:54:46 slip39                4 skin      11 rescue    18 merchant
2022-03-10 09:54:46 slip39                5 breathe   12 cage      19 problem
2022-03-10 09:54:46 slip39                6 sprinkle  13 voice     20 repair
2022-03-10 09:54:46 slip39                7 military  14 sidewalk
2022-03-10 09:54:46 slip39           5th  1 strike     8 energy    15 iris
2022-03-10 09:54:46 slip39                2 steady     9 already   16 example
2022-03-10 09:54:46 slip39                3 decision  10 shrimp    17 flavor
2022-03-10 09:54:46 slip39                4 snake     11 pecan     18 boundary
2022-03-10 09:54:46 slip39                5 capital   12 verify    19 dynamic
2022-03-10 09:54:46 slip39                6 category  13 float     20 flash
2022-03-10 09:54:46 slip39                7 thunder   14 galaxy
```

```
2022-03-10 09:54:46 slip39          6th  1 strike     8 frost     15 idle
2022-03-10 09:54:46 slip39               2 steady     9 biology   16 universe
2022-03-10 09:54:46 slip39               3 decision  10 grumpy    17 loud
2022-03-10 09:54:46 slip39               4 spider    11 enforce   18 boundary
2022-03-10 09:54:46 slip39               5 body      12 browser   19 careful
2022-03-10 09:54:46 slip39               6 mailman   13 grief     20 standard
2022-03-10 09:54:46 slip39               7 custody   14 vegan
2022-03-10 09:54:46 slip39.layout    ETH    m/44'/60'/0'/0/0    : 0xAc0aE959A931a28550D9F4AE696ae8300F61acB2
2022-03-10 09:54:46 slip39.layout    BTC    m/84'/0'/0'/0/0     : bc1qhq3dnas499w62hejs854j0pawydj97zmmvrx3w
2022-03-10 09:54:46 slip39.recovery  Recovered 128-bit SLIP-39 secret with 5 (1st, 2nd, 3rd, 7th, 8th) of 8 supplied mnemonic
```

2.5 Generation of Addresses

For systems that require a stream of groups of wallet Addresses (eg. for preparing invoices for clients, with a choice of cryptocurrency payment options), `slip-generator` can produce a stream of groups of addresses.

2.5.1 `slip39-generator` Synopsis

```
    slip39-generator --help --version         | sed 's/^/: /' # (just for output formatting)

usage: slip39-generator [-h] [-v] [-q] [-s SECRET] [-f FORMAT]
                        [-c CRYPTOCURRENCY] [-p PATH] [-d DEVICE]
                        [-b BAUDRATE] [-e ENCRYPT] [--decrypt ENCRYPT]
                        [--enumerated] [--no-enumerate] [--receive]
                        [--corrupt CORRUPT]

Generate public wallet address(es) from a secret seed

options:
  -h, --help            show this help message and exit
  -v, --verbose         Display logging information.
  -q, --quiet           Reduce logging output.
  -s SECRET, --secret SECRET
                        Use the supplied 128-, 256- or 512-bit hex value as
                        the secret seed; '-' (default) reads it from stdin
                        (eg. output from slip39.recover)
  -f FORMAT, --format FORMAT
                        Specify crypto address formats: legacy, segwit,
                        bech32; default BTC:bech32, DOGE:legacy, ETH:legacy,
                        LTC:bech32
  -c CRYPTOCURRENCY, --cryptocurrency CRYPTOCURRENCY
                        A crypto name and optional derivation path (default:
                        "ETH:{Account.path_default('ETH')}"), optionally w/
                        ranges, eg: ETH:../0/-
  -p PATH, --path PATH  Modify all derivation paths by replacing the final
                        segment(s) w/ the supplied range(s), eg. '.../1/-'
                        means .../1/[0,...)
  -d DEVICE, --device DEVICE
                        Use this serial device to transmit (or --receive)
                        records
  -b BAUDRATE, --baudrate BAUDRATE
                        Set the baud rate of the serial device (default:
                        115200)
  -e ENCRYPT, --encrypt ENCRYPT
                        Secure the channel from errors and/or prying eyes with
                        ChaCha20Poly1305 encryption w/ this password; '-'
                        reads from stdin
  --decrypt ENCRYPT
  --enumerated          Include an enumeration in each record output (required
                        for --encrypt)
  --no-enumerate        Disable enumeration of output records
  --receive             Receive a stream of slip.generator output
  --corrupt CORRUPT     Corrupt a percentage of output symbols

Once you have a secret seed (eg. from slip39.recovery), you can generate a sequence
of HD wallet addresses from it.  Emits rows in the form:

    <enumeration> [<address group(s)>]
```

```
If the output is to be transmitted by an insecure channel (eg. a serial port), which may insert
errors or allow leakage, it is recommended that the records be encrypted with a cryptographic
function that includes a message authentication code.  We use ChaCha20Poly1305 with a password and a
random nonce generated at program start time.  This nonce is incremented for each record output.

Since the receiver requires the nonce to decrypt, and we do not want to separately transmit the
nonce and supply it to the receiver, the first record emitted when --encrypt is specified is the
random nonce, encrypted with the password, itself with a known nonce of all 0 bytes.  The plaintext
data is random, while the nonce is not, but since this construction is only used once, it should be
satisfactory.  This first nonce record is transmitted with an enumeration prefix of "nonce".
```

2.5.2 Producing Addresses

Addresses can be produced in plaintext or encrypted, and output to stdout or to a serial port.

```
    slip39-generator --secret ffffffffffffffffffffffffffffffff --path '../-3' | sed 's/^/: /' # (just for output formatting)

0: [["ETH", "m/44'/60'/0'/0/0", "0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1"], ["BTC", "m/84'/0'/0'/0/0", "bc1q9yscq3l2yfxlvnlk3
1: [["ETH", "m/44'/60'/0'/0/1", "0x8D342083549C635C0494d3c77567860ee7456963"], ["BTC", "m/84'/0'/0'/0/1", "bc1qnec684yvuhfrmy3q8
2: [["ETH", "m/44'/60'/0'/0/2", "0x52787E24965E1aBd691df77827A3CfA90f0166AA"], ["BTC", "m/84'/0'/0'/0/2", "bc1q2snj0zcg23dvjpw7m
3: [["ETH", "m/44'/60'/0'/0/3", "0xc2442382Ae70c77d6B6840EC6637dB2422E1D44e"], ["BTC", "m/84'/0'/0'/0/3", "bc1qxwekjd46aa5n0s3dt
```

To produce accounts from a BIP-39 or SLIP-39 seed, recover it using slip39-recovery.

Here's an example of recovering a test BIP-39 seed; note that it yields the well-known ETH `0xfc20...1B5E` and BTC `bc1qk0...gnn2` accounts associated with this test Mnemonic:

```
    slip39-recovery --bip39 --mnemonic 'zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong' \
        | slip39-generator --secret - --path '../-3'                          | sed 's/^/: /' # (just for output formatting)

0: [["ETH", "m/44'/60'/0'/0/0", "0xfc2077CA7F403cBECA41B1B0F62D91B5EA631B5E"], ["BTC", "m/84'/0'/0'/0/0", "bc1qk0a9hr7wjfxeenz9n
1: [["ETH", "m/44'/60'/0'/0/1", "0xd1a7451beB6FE0326b4B78e3909310880B781d66"], ["BTC", "m/84'/0'/0'/0/1", "bc1qkd33yck74lg0kaq4t
2: [["ETH", "m/44'/60'/0'/0/2", "0x578270B5E5B53336baC354756b763b309eCA90Ef"], ["BTC", "m/84'/0'/0'/0/2", "bc1qvr7e5aytd0hpmtaz2
3: [["ETH", "m/44'/60'/0'/0/3", "0x909f59835A5a120EafE1c60742485b7ff0e305da"], ["BTC", "m/84'/0'/0'/0/3", "bc1q6t9vhestkcfgw4nut
```

We can encrypt the output, to secure the sequence (and due to integrated MACs, ensures no errors occur over an insecure channel like a serial cable):

```
    slip39-recovery --bip39 --mnemonic 'zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong' \
        | slip39-generator --secret - --path '../-3' --encrypt 'password'     | sed 's/^/: /' # (just for output formatting)



nonce: 2bed51891030482019634345f490515722f467eb817de0de7559b716
    0: 546f975ac40174c801b325759d18351694d86577493f9ba96cc2530874bf03030b066f47084d310cb609fb2fa507e3a4854dbf2f0cff827ff0b79fe4f
    1: 3b6ec5a935f41a781c0828c94de3f9a2991a2dacf07456c8ca4139c0a301ccc0125bea4572e1047bd27cfde3cd4ed53e683515c84c11a55b7f6e5fb57
    2: f14d85730d42a63db4a4710ea34b84414206581817a9186db8b136c8c86d6258d3f2e021a90ae9af6fc2d580db6beb42ee439d58752b4e3a11ca9ee11
    3: 7f54abf0553a44d8bc287c1cd09be7533fc4819b33b7542a3c1887956f754a615d4ced80d09d17c8e198ae1398c9ea7935861c5afbdd057de45ee6887
```

On the receiving computer, we can decrypt and recover the stream of accounts from the wallet seed; any rows with errors are ignored:

```
    slip39-recovery --bip39 --mnemonic 'zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong' \
        | slip39-generator --secret - --path '../-3' --encrypt 'password' \
        | slip39-generator --receive --decrypt 'password'                     | sed 's/^/: /' # (just for output formatting)

0: [["ETH", "m/44'/60'/0'/0/0", "0xfc2077CA7F403cBECA41B1B0F62D91B5EA631B5E"], ["BTC", "m/84'/0'/0'/0/0", "bc1qk0a9hr7wjfxeenz9n
1: [["ETH", "m/44'/60'/0'/0/1", "0xd1a7451beB6FE0326b4B78e3909310880B781d66"], ["BTC", "m/84'/0'/0'/0/1", "bc1qkd33yck74lg0kaq4t
2: [["ETH", "m/44'/60'/0'/0/2", "0x578270B5E5B53336baC354756b763b309eCA90Ef"], ["BTC", "m/84'/0'/0'/0/2", "bc1qvr7e5aytd0hpmtaz2
3: [["ETH", "m/44'/60'/0'/0/3", "0x909f59835A5a120EafE1c60742485b7ff0e305da"], ["BTC", "m/84'/0'/0'/0/3", "bc1q6t9vhestkcfgw4nut
```

2.6 The `slip39` module API

Provide SLIP-39 Mnemonic set creation from a 128-bit master secret, and recovery of the secret from a subset of the provided Mnemonic set.

2.6.1 `slip39.create`

Creates a set of SLIP-39 groups and their mnemonics.

Key	Description
name	Who/what the account is for
group_threshold	How many groups' data is required to recover the account(s)
groups	Each group's description, as {"<group>":(<required>, <members>), …}
master_secret	128-bit secret (default: from secrets.token_bytes)
passphrase	An optional additional passphrase required to recover secret (default: "")
iteration_exponent	For encrypted secret, exponentially increase PBKDF2 rounds (default: 1)
cryptopaths	A number of crypto names, and their derivation paths]
strength	Desired master_secret strength, in bits (default: 128)

Outputs a `slip39.Details` namedtuple containing:

Key	Description
name	(same)
group_threshold	(same)
groups	Like groups, w/ <members> = ["<mnemonics>", …]
accounts	Resultant list of groups of accounts

This is immediately usable to pass to `slip39.output`.

```
import codecs
import random

#
# NOTE:
#
# We turn off randomness here during SLIP-39 generation to get deterministic phrases;
# during normal operation, secure entropy is used during mnemonic generation, yielding
# random phrases, even when the same seed is used multiple times.
#
import shamir_mnemonic
shamir_mnemonic.shamir.RANDOM_BYTES = lambda n: b'\00' * n

import slip39

cryptopaths         = [("ETH","m/44'/60'/0'/0/-2"), ("BTC","m/44'/0'/0'/0/-2")]
master_secret       = b'\xFF' * 16
passphrase          = b""
create_details      = slip39.create(
    "Test", 2, { "Mine": (1,1), "Fam": (2,3) },
    master_secret=master_secret, passphrase=passphrase, cryptopaths=cryptopaths )
[
    [
        f"{g_name}({g_of}/{len(g_mnems)}) #{g_n+1}:" if l_n == 0 else ""
    ] + words
    for g_name,(g_of,g_mnems) in create_details.groups.items()
    for g_n,mnem in enumerate( g_mnems )
    for l_n,(line,words) in enumerate(slip39.organize_mnemonic(
            mnem, label=f"{g_name}({g_of}/{len(g_mnems)}) #{g_n+1}:" ))
]
```

0	1	2	3
Mine(1/1) #1:	1 academic	8 safari	15 standard
	2 acid	9 drug	16 angry
	3 acrobat	10 browser	17 similar
	4 easy	11 trash	18 aspect
	5 change	12 fridge	19 smug
	6 injury	13 busy	20 violence
	7 painting	14 finger	
Fam(2/3) #1:	1 academic	8 prevent	15 dwarf
	2 acid	9 mouse	16 dream
	3 beard	10 daughter	17 flavor
	4 echo	11 ancient	18 oral
	5 crystal	12 fortune	19 chest
	6 machine	13 ruin	20 marathon
	7 bolt	14 warmth	
Fam(2/3) #2:	1 academic	8 prune	15 briefing
	2 acid	9 pickup	16 often
	3 beard	10 device	17 escape
	4 email	11 device	18 sprinkle
	5 dive	12 peanut	19 segment
	6 warn	13 enemy	20 devote
	7 ranked	14 graduate	
Fam(2/3) #3:	1 academic	8 dining	15 intimate
	2 acid	9 invasion	16 satoshi
	3 beard	10 bumpy	17 hobo
	4 entrance	11 identify	18 ounce
	5 alarm	12 anxiety	19 both
	6 health	13 august	20 award
	7 discuss	14 sunlight	

Add the resultant HD Wallet addresses:

```
[
    [ account.path, account.address ]
    for group in create_details.accounts
    for account in group
]
```

0	1
m/44'/60'/0'/0/0	0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
m/44'/0'/0'/0/0	bc1qm5ua96hx30snwrwsfnv97q96h53l86ded7wmjl
m/44'/60'/0'/0/1	0x8D342083549C635C0494d3c77567860ee7456963
m/44'/0'/0'/0/1	bc1qwz6v9z49z8mk5ughj7r78hjsp45jsxgzh29lnh
m/44'/60'/0'/0/2	0x52787E24965E1aBd691df77827A3CfA90f0166AA
m/44'/0'/0'/0/2	bc1q690m430qu29auyefarwfrvfumncunvyw6v53n9

2.6.2 `slip39.produce_pdf`

Key	Description
name	(same as `slip39.create`)
group_threshold	(same as `slip39.create`)
groups	Like groups, w/ <members> = ["<mnemonics>", ...]
accounts	Resultant { "path": Account, ...}
card_format	'index', '(<h>,<w>),<margin>', ...
paper_format	'Letter', ...

Layout and produce a PDF containing all the SLIP-39 details on cards for the crypto accounts, on the paper_format provided. Returns the paper (orientation,format) used, the FPDF, and passes through the supplied cryptocurrency accounts derived.

```
(paper_format,orientation),pdf,accounts = slip39.produce_pdf( *create_details )
pdf_binary = pdf.output()
[
    [ "Orientation:",orientation ],
    [ "Paper:",paper_format ],
    [ "PDF Pages:",pdf.pages_count ],
    [ "PDF Size:",len( pdf_binary )],
]
```

0	1
Orientation:	landscape
Paper:	Letter
PDF Pages:	1
PDF Size:	12985

2.6.3 slip39.write_pdfs

Key	Description
names	A sequence of Seed names, or a dict of { name: <details> } (from slip39.create)
master_secret	A Seed secret (only appropriate if exactly one name supplied)
passphrase	A SLIP-39 passphrase (not Trezor compatible; use "hidden wallet" phrase on device instead)
group	A dict of {"<group>":(<required>, <members>), ...}
group_threshold	How many groups are required to recover the Seed
cryptocurrency	A sequence of ["<crypto>", "<crypto>:<derivation>", ...] w/ optional ranges
edit	Derivation range(s) for each cryptocurrency, eg. "../0-4/-9" is 9 accounts first 5 change addresses
card_format	Card size (eg. "credit"); False specifies no SLIP-39 cards (ie. only BIP-39 or JSON paper wallets)
paper_format	Paper size (eg. "letter")
filename	A filename; may contain "...{name}..." formatting, for name, date, time, crypto path and address
filepath	A file path, if PDF output to file is desired; empty implies current dir.
printer	A printer name (or True for default), if output to printer is desired
json_pwd	If password supplied, encrypted Ethereum JSON wallet files will be saved, and produced into PDF
text	If True, outputs SLIP-39 phrases to stdout
wallet_pwd	If password supplied, produces encrypted BIP-38 or JSON Paper Wallets to PDF (preferred vs. json_pwd)
wallet_pwd_hint	An optional passphrase hint, printed on paper wallet
wallet_format	Paper wallet size, (eg. "third"); the default is 1/3 letter size

For each of the names provided, produces a separate PDF containing all the SLIP-39 details and optionally encrypted BIP-38 paper wallets and Ethereum JSON wallets for the specified cryptocurrency accounts derived from the seed, and writes the PDF and JSON wallets to the specified file name(s).

```
slip39.write_pdfs( ... )
```

2.6.4 slip39.recover

Takes a number of SLIP-39 mnemonics, and if sufficient `group_threshold` groups' mnemonics are present (and the options `passphrase` is supplied), the `master_secret` is recovered. This can be used with `slip39.accounts` to directly obtain any `Account` data.

Note that the passphrase is **not** checked; entering a different passphrase for the same set of mnemonics will recover a **different** wallet! This is by design; it allows the holder of the SLIP-39 mnemonic phrases to recover a "decoy" wallet by supplying a specific passphrase, while protecting the "primary" wallet.

Therefore, it is **essential** to remember any non-default (empty) passphrase used, separately and securely. Take great care in deciding if you wish to use a passphrase with your SLIP-39 wallet!

Key	Description
mnemonics	["<mnemonics>", ...]
passphrase	Optional passphrase to decrypt secret

```
recoverydecoy       = slip39.recover(
    create_details.groups['Mine'][1][:] + create_details.groups['Fam'][1][:2],
    passphrase=b"wrong!"
)
recoverydecoyhex    = codecs.encode( recoverydecoy, 'hex_codec' ).decode( 'ascii' )

recoveryvalid       = slip39.recover(
    create_details.groups['Mine'][1][:] + create_details.groups['Fam'][1][:2],
    passphrase=passphrase
)
recoveryvalidhex    = codecs.encode( recoveryvalid, 'hex_codec' ).decode( 'ascii' )

[[ f"{len(recoverydecoy)*8}-bit secret w/ decoy password recovered:" ]] + [
 [ f"{recoverydecoyhex[b*32:b*32+32]}" ]
    for b in range( len( recoverydecoyhex ) // 32 )
] +  [[ f"{len(recoveryvalid)*8}-bit secret recovered:" ]] + [
 [ f"{recoveryvalidhex[b*32:b*32+32]}" ]
    for b in range( len( recoveryvalidhex ) // 32 )
]
```

```
0
128-bit secret w/ decoy password recovered:
2e522cea2b566840495c220cf79c756e
128-bit secret recovered:
ffffffffffffffffffffffffffffffff
```

3 Conversion from BIP-39 to SLIP-39

If we already have a BIP-39 wallet, it would certainly be nice to be able to create nice, safe SLIP-39 mnemonics for it, and discard the unsafe BIP-39 mnemonics we have lying around, just waiting to be accidentally discovered and the account compromised!

3.1 BIP-39 vs. SLIP-39 Incompatibility

Unfortunately, it is **not possible** to cleanly convert a BIP-39 derived wallet into a SLIP-39 wallet. Both of these techniques preserve "entropy" (random) bits, but these bits are used **differently** – and incompatibly – to derive the resultant Ethereum wallets.

The best we can do is to preserve the 512-bit **output** of the BIP-39 mnemonic phrase as a set of 512-bit SLIP-39 mnemonics.

3.1.1 BIP-39 Entropy to Mnemonic

BIP-39 uses a single set of 12, 15, 18, 21 or 24 BIP-39 words to carefully preserve a specific 128 to 256 bits of initial entropy. Here's a 128-bit (12-word) example using some fixed "entropy" `0xFFFF..FFFF`:

```
from mnemonic import Mnemonic
bip39_english       = Mnemonic("english")
entropy             = b'\xFF' * 16
entropy_mnemonic    = bip39_english.to_mnemonic( entropy )
[
 [ entropy_mnemonic ]
]
```

```
                                                  0
zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong
```

Each word is one of a corpus of 2048 words; therefore, each word encodes 11 bits (2048 = `2**11) of entropy.  So, we provided 128 bits, but 12*11` = 132. So where does the extra 4 bits of data come from?

It comes from the first few bits of a SHA256 hash of the entropy, which is added to the end of the supplied 128 bits, to reach the required 132 bits: 132 / 11 == 12 words.

This last 4 bits (up to 8 bits, for a 256-bit 24-word BIP-39) is checked, when validating the BIP-39 mnemonic. Therefore, making up a random BIP-39 mnemonic will succeed only 1 / 16 times on average, due to an incorrect checksum 4-bit (16 == 2**4) . Lets check:

```
def random_words( n, count=100 ):
    for _ in range( count ):
        yield ' '.join( random.choice( bip39_english.wordlist ) for _ in range( n ))

successes           = sum(
    bip39_english.check( m )
    for i,m in enumerate( random_words( 12, 10000 ))) / 100

[[ f"Valid random 12-word mnemonics:" ]] + [
 [ f"{successes}%" ]] + [
 [ f"~ 1/{100/successes:.3}" ]]
```

```
0
Valid random 12-word mnemonics:
6.14%
~ 1/16.3
```

Sure enough, about 1/16 random 12-word phrases are valid BIP-39 mnemonics. OK, we've got the contents of the BIP-39 phrase dialed in. How is it used to generate accounts?

3.1.2 BIP-39 Mnemonic to Seed

Unfortunately, we do **not** use the carefully preserved 128-bit entropy to generate the wallet! Nope, it is stretched to a 512-bit seed using PBKDF2 HMAC SHA512. The normalized **text** (*not the entropy bytes*) of the 12-word mnemonic is then used (with a salt of "mnemonic" plus an optional passphrase, "" by default), to obtain the seed:

```
seed               = bip39_english.to_seed( entropy_mnemonic )
seedhex            = codecs.encode( seed, 'hex_codec' ).decode( 'ascii' )
[
 [ f"{len(seed)*8}-bit seed:" ]] + [
 [ f"{seedhex[b*32:b*32+32]}" ]
 for b in range( len( seedhex ) // 32 )
]
```

0
512-bit seed:
b6a6d8921942dd9806607ebc2750416b
289adea669198769f2e15ed926c3aa92
bf88ece232317b4ea463e84b0fcd3b53
577812ee449ccc448eb45e6f544e25b6

3.1.3 BIP-39 Seed to Address

Finally, this 512-bit seed is used to derive HD wallet(s). The HD Wallet key derivation process consumes whatever seed entropy is provided (512 bits in the case of BIP-39), and uses HMAC SHA512 with a prefix of b"Bitcoin seed" to stretch the supplied seed entropy to 64 bytes (512 bits). Then, the HD Wallet **path** segments are iterated through, permuting the first 32 bytes of this material as the key with the second 32 bytes of material as the chain node, until finally the 32-byte (256-bit) Ethereum account private key is produced. We then use this private key to compute the rest of the Ethereum account details, such as its public address.

```
path               = "m/44'/60'/0'/0/0"
eth_hd = slip39.account( seed, 'ETH', path )
[
 [ f"{len(eth_hd.key)*4}-bit derived key at path {path!r}:" ]] + [
 [ f"{eth_hd.key}" ]] + [
 [ "... yields ..." ]] + [
 [ f"Ethereum address: {eth_hd.address}" ]
]
```

0
256-bit derived key at path "m/44'/60'/0'/0/0":
7af65ba4dd53f23495dcb04995e96f47c243217fc279f10795871b725cd009ae
... yields ...
Ethereum address: 0xfc2077CA7F403cBECA41B1B0F62D91B5EA631B5E

Thus, we see that while the 12-word BIP-39 mnemonic careful preserves the original 128-bit entropy, this data is not directly used to derive the wallet private key and address. Also, since an irreversible hash is used to derive the seed from the mnemonic, we can't reverse the process on the seed to arrive back at the BIP-39 mnemonic phrase.

3.1.4 SLIP-39 Entropy to Mnemonic

Just like BIP-39 carefully preserves the original 128-bit entropy bytes in a single 12-word mnemonic phrase, SLIP-39 preserves the original 128-bit entropy in a *set* of 30-word mnemonic phrases.

```
name,thrs,grps,acct = slip39.create(
    "Test", 2, { "Mine": (1,1), "Fam": (2,3) }, entropy )
[
 [ f"{g_name}({g_of}/{len(g_mnems)}) #{g_n+1}:" if l_n == 0 else "" ] + words
 for g_name,(g_of,g_mnems) in grps.items()
 for g_n,mnem in enumerate( g_mnems )
 for l_n,(line,words) in enumerate(slip39.organize_mnemonic(
         mnem, rows=7, cols=3, label=f"{g_name}({g_of}/{len(g_mnems)}) #{g_n+1}:" ))
]
```

0	1	2	3
Mine(1/1) #1:	1 academic	8 safari	15 standard
	2 acid	9 drug	16 angry
	3 acrobat	10 browser	17 similar
	4 easy	11 trash	18 aspect
	5 change	12 fridge	19 smug
	6 injury	13 busy	20 violence
	7 painting	14 finger	
Fam(2/3) #1:	1 academic	8 prevent	15 dwarf
	2 acid	9 mouse	16 dream
	3 beard	10 daughter	17 flavor
	4 echo	11 ancient	18 oral
	5 crystal	12 fortune	19 chest
	6 machine	13 ruin	20 marathon
	7 bolt	14 warmth	
Fam(2/3) #2:	1 academic	8 prune	15 briefing
	2 acid	9 pickup	16 often
	3 beard	10 device	17 escape
	4 email	11 device	18 sprinkle
	5 dive	12 peanut	19 segment
	6 warn	13 enemy	20 devote
	7 ranked	14 graduate	
Fam(2/3) #3:	1 academic	8 dining	15 intimate
	2 acid	9 invasion	16 satoshi
	3 beard	10 bumpy	17 hobo
	4 entrance	11 identify	18 ounce
	5 alarm	12 anxiety	19 both
	6 health	13 august	20 award
	7 discuss	14 sunlight	

Since there is some randomness used in the SLIP-39 mnemonics generation process, we would get a **different** set of words each time for the fixed "entropy" `0xFFFF..FF` used in this example (if we hadn't manually disabled entropy for `shamir_mnemonic`, above), but we will **always** derive the same Ethereum account `0x824b..19a1` at the specified HD Wallet derivation path.

```
[
 [ "Crypto", "HD Wallet Path:", "Ethereum Address:" ]
] + [
 [ account.crypto, account.path, account.address ]
 for group in create_details.accounts
 for account in group
]
```

0	1	2
Crypto	HD Wallet Path:	Ethereum Address:
ETH	m/44'/60'/0'/0/0	0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1
BTC	m/44'/0'/0'/0/0	bc1qm5ua96hx30snwrwsfnv97q96h53l86ded7wmjl
ETH	m/44'/60'/0'/0/1	0x8D342083549C635C0494d3c77567860ee7456963
BTC	m/44'/0'/0'/0/1	bc1qwz6v9z49z8mk5ughj7r78hjsp45jsxgzh29lnh
ETH	m/44'/60'/0'/0/2	0x52787E24965E1aBd691df77827A3CfA90f0166AA
BTC	m/44'/0'/0'/0/2	bc1q690m430qu29auyefarwfrvfumncunvyw6v53n9

3.1.5 SLIP-39 Mnemonic to Seed

Lets prove that we can actually recover the **original** entropy from the SLIP-39 recovery mnemonics; in this case, we've specified a SLIP-39 group_threshold of 2 groups, so we'll use 1 mnemonic from Mine, and 2 from Fam:

```
_,mnem_mine         = grps['Mine']
_,mnem_fam          = grps['Fam']
recseed             = slip39.recover( mnem_mine + mnem_fam[:2] )
recseedhex          = codecs.encode( recseed, 'hex_codec' ).decode( 'ascii' )
[
 [ f"{len(recseed)*8}-bit seed:" ]
] + [
 [ f"{recseedhex[b*32:b*32+32]}" ]
    for b in range( len( recseedhex ) // 32 )
]
```

0
128-bit seed:
ffffffffffffffffffffffffffffffff

3.1.6 SLIP-39 Seed to Address

And we'll use the same style of code as for the BIP-39 example above, to derive the Ethereum address **directly** from this recovered 128-bit seed:

```
receth = slip39.account( recseed, 'ETH', path )
[
 [ f"{len(receth.key)*4}-bit derived key at path {path!r}:" ]] + [
 [ f"{receth.key}" ]] + [
 [ "... yields ..." ]] + [
 [ f"Ethereum address: {receth.address}" ]
]
```

0
256-bit derived key at path "m/44'/60'/0'/0/0":
6a2ec39aab88ec0937b79c8af6aaf2fd3c909e9a56c3ddd32ab5354a06a21a2b
... yields ...
Ethereum address: 0x824b174803e688dE39aF5B3D7Cd39bE6515A19a1

And we see that we obtain the same Ethereum address `0x824b..1a2b` as we originally got from `slip39.create` above. However, this is **not** the Ethereum wallet address obtained from BIP-39 with exactly the same `0xFFFF...FF` entropy, which was `0xfc20..1B5E`. This is due to the fact that BIP-39 does not use the recovered entropy to produce the seed like SLIP-39 does, but applies additional one-way hashing of the mnemonic to produce the seed.

3.2 BIP-39 vs SLIP-39 Key Derivation Summary

At no time in BIP-39 account derivation is the original 128-bit mnemonic entropy used directly in the derivation of the wallet key. This differs from SLIP-39, which directly uses the 128-bit mnemonic entropy recovered from the SLIP-39 Shamir's Secret Sharing System recovery process to generate each HD Wallet account's private key.

Furthermore, there is no point in the BIP-39 entropy to account generation where we **could** introduce a known 128-bit seed and produce a known Ethereum wallet from it, other than as the very beginning.

3.2.1 BIP-39 Backup via SLIP-39

There is one approach which can preserve an original BIP-39 wallet address, using SLIP-39 mnemonics.

It is clumsy, as it preserves the BIP-39 **output** 512-bit stretched seed, and the resultant 59-word SLIP-39 mnemonics cannot be used (at present) with the Trezor hardware wallet. They can, however, be used to recover the HD wallet private keys without access to the original BIP-39 mnemonic phrase – you could generate and distribute a set of more secure SLIP-39 mnemonic phrases, instead of trying to secure the original BIP-39 mnemonic.

We'll use `slip39.recovery --bip39 ...` to recover the 512-bit stretched seed from BIP-39:

```
( python3 -m slip39.recovery --bip39 \
    --mnemonic "zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong"
) 2>&1
```

```
2022-03-10 09:54:56 slip39.recovery  Recovered 512-bit BIP-39 secret from english mnemonic
b6a6d8921942dd9806607ebc2750416b289adea669198769f2e15ed926c3aa92bf88ece232317b4ea463e84b0fcd3b53577812ee449ccc448eb45e6f544e25b6
```

Then we can generate a 59-word SLIP-39 mnemonic set from the 512-bit secret:

```
( python3 -m slip39.recovery --bip39 \
    --mnemonic "zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo zoo wrong" \
  | python3 -m slip39 --secret - --no-card
) 2>&1
```

```
2022-03-10 09:54:56 slip39.recovery  Recovered 512-bit BIP-39 secret from english mnemonic
2022-03-10 09:54:56 slip39           The SLIP-39 Standard Passphrase is not compatible w/ the Trezor hardware wallet; use its 'h
2022-03-10 09:54:56 slip39.layout    ETH    m/44'/60'/0'/0/0    : 0xfc2077CA7F403cBECA41B1B0F62D91B5EA631B5E
2022-03-10 09:54:56 slip39.layout    BTC    m/84'/0'/0'/0/0     : bc1qk0a9hr7wjfxeenz9nwenw9flhq0tmsf6vsgnn2
```

This `0xfc20..1B5E` address is the same Ethereum address as is recovered on a Trezor using this BIP-39 mnemonic phrase.

4 Building & Installing

The `python-slip39` project is tested under both homebrew:

```
$ brew install python-tk@3.9
```

and using the official python.org/downloads installer.

Either of these methods will get you a `python3` executable running version 3.9+, usable for running the `slip39` module, and the `slip39.gui` GUI.

4.1 The `slip39` Module

To build the wheel and install `slip39` manually:

```
$ git clone git@github.com:pjkundert/python-slip39.git
$ make -C python-slip39 install
```

To install from Pypi, including the optional requirements to run the PySimpleGUI/tkinter GUI, support serial I/O, and to support creating encrypted BIP-38 and Ethereum JSON Paper Wallets:

```
$ python3 -m pip install slip39[gui,paper,serial]
```

4.2 The `slip39` GUI

To install from Pypi, including the optional requirements to run the PySimpleGUI/tkinter GUI:

```
$ python3 -m pip install slip39[gui]
```

Then, there are several ways to run the GUI:

```
$ python3 -m slip39.gui     # Execute the python slip39.gui module main method
$ slip39-gui                # Run the main function provided by the slip39.gui module
```

4.2.1 The macOS/win32 `SLIP-39.app` GUI

You can build the native macOS and win32 `SLIP-39.app` App.

This requires the official python.org/downloads installer; the homebrew python-tk@3.9 will not work for building the native app using either `PyInstaller`. (The `py2app` approach doesn't work in either version of Python).

```
$ git clone git@github.com:pjkundert/python-slip39.git
$ make -C python-slip39 app
```

4.2.2 The Windows 10 `SLIP-39` GUI

Install Python from `https://python.org/downloads`, and the Microsoft C++ Build Tools via the Visual Studio Installer (required for installing some `slip39` package dependencies).

To run the GUI, just install `slip39` package from Pypi using pip, including the `gui` and `wallet` options. Building the Windows `SLIP-39` executable GUI application requires the `dev` option.

```
PS C:\Users\IEUser> pip install slip39[gui,wallet,dev]
```

To work with the python-slip39 Git repo on Github, you'll also need to install Git from git-scm.com. Once installed, run "Git bash", and

```
$ ssh-keygen.exe -t ed25519
```

to create an `id_ed25519.pub` SSH identity, and import it into your Git Settings SSH keys. Then,

```
$ mkdir src
$ cd src
$ git clone git@github.com:pjkundert/python-slip39.git
```

1. Code Signing

   The MMC (Microsoft Management Console) is used to store your code-signing certificates. See stackoverflow.com for how to enable its Certificate management.

5 Dependencies

Internally, python-slip39 project uses Trezor's python-shamir-mnemonic to encode the seed data to SLIP-39 phrases, python-hdwallet to convert seeds to ETH, BTC, LTC and DOGE wallets, and the Ethereum project's eth-account to produce encrypted JSON wallets for specified Ethereum accounts.

5.1 The `python-shamir-mnemonic` API

To use it directly, obtain , and install it, or run `python3 -m pip install shamir-mnemonic`.

```
$ shamir create custom --group-threshold 2 --group 1 1 --group 1 1 --group 2 5 --group 3 6
Using master secret: 87e39270d1d1976e9ade9cc15a084c62
Group 1 of 4 - 1 of 1 shares required:
merit aluminum acrobat romp capacity leader gray dining thank rhyme escape genre havoc furl breathe class pitch location render
Group 2 of 4 - 1 of 1 shares required:
merit aluminum beard romp briefing email member flavor disaster exercise cinema subject perfect facility genius bike include say
Group 3 of 4 - 2 of 5 shares required:
merit aluminum ceramic roster already cinema knit cultural agency intimate result ivory makeup lobe jerky theory garlic ending s
merit aluminum ceramic scared beam findings expand broken smear cleanup enlarge coding says destroy agency emperor hairy device
merit aluminum ceramic shadow cover smith idle vintage mixture source dish squeeze stay wireless likely privacy impulse toxic mo
merit aluminum ceramic sister duke relate elite ruler focus leader skin machine mild envelope wrote amazing justice morning voca
merit aluminum ceramic smug buyer taxi amazing marathon treat clinic rainbow destroy unusual keyboard thumb story literary weapo
Group 4 of 4 - 3 of 6 shares required:
merit aluminum decision round bishop wrote belong anatomy spew hour index fishing lecture disease cage thank fantasy extra often
merit aluminum decision scatter carpet spine ruin location forward priest cage security careful emerald screw adult jerky flame
merit aluminum decision shaft arcade infant argue elevator imply obesity oral venture afraid slice raisin born nervous universe
merit aluminum decision skin already fused tactics skunk work floral very gesture organize puny hunting voice python trial lawsu
merit aluminum decision snake cage premium aide wealthy viral chemical pharmacy smoking inform work cubic ancestor clay genius f
merit aluminum decision spider boundary lunar staff inside junior tendency sharp editor trouble legal visual tricycle auction gr
```