TREZOR
The Hardware Bitcoin Wallet

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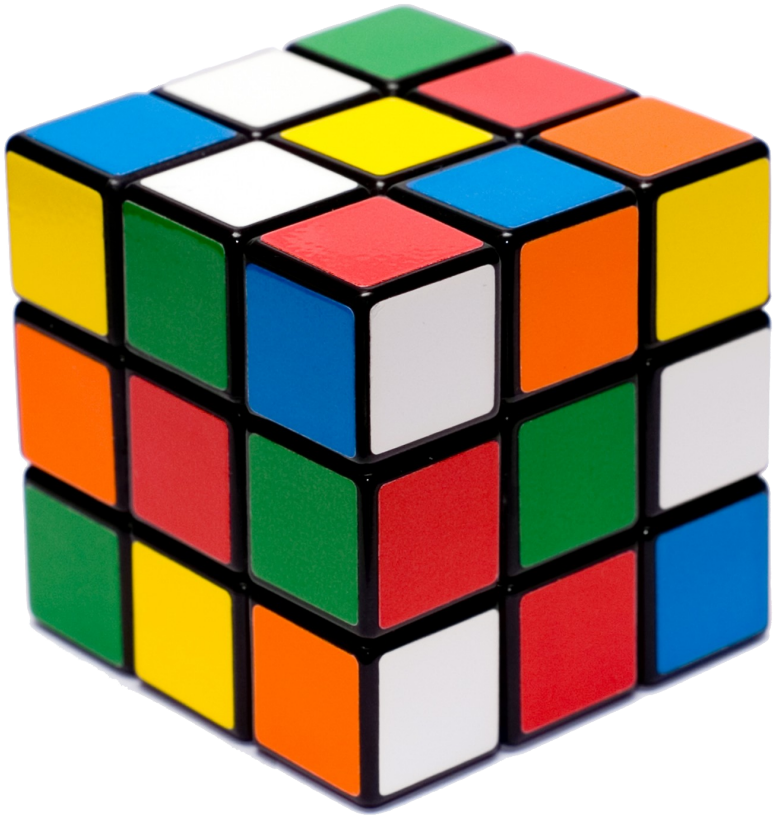
Problem: private keys security/safety

- end user computer security
  - compromised computers
  - untrusted computers
  - rigged clients
- data (wallet) loss
  - disasters, hard-drive failures
  - naive reinstalls
  - failing to do proper backups



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Solution

HARDWARE

WALLETS!

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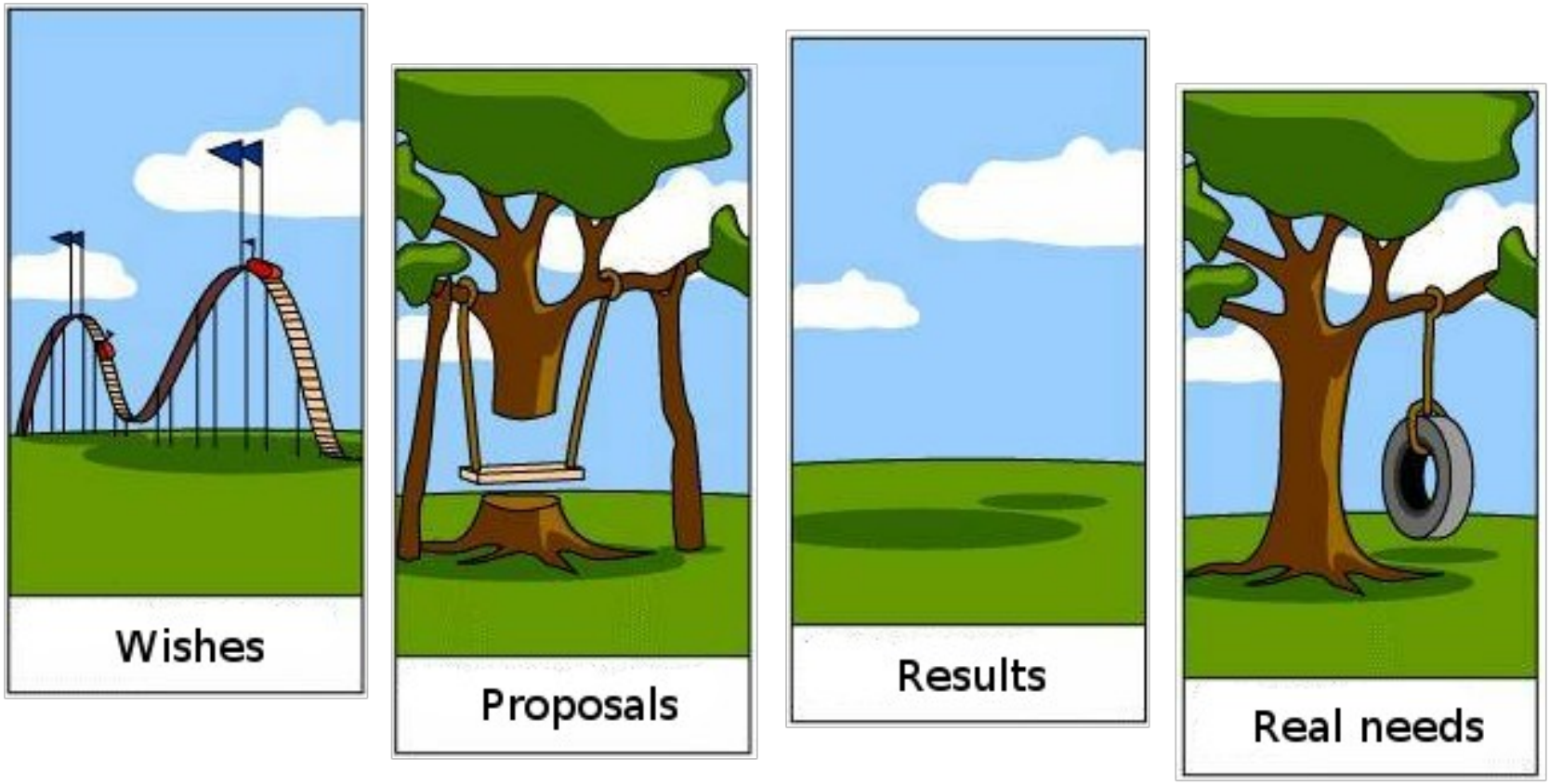
Hardware Wallet Ideas



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KISS

- USB gadget (HID)
- OLED display
- ok/cancel buttons
- no batteries
- no radio

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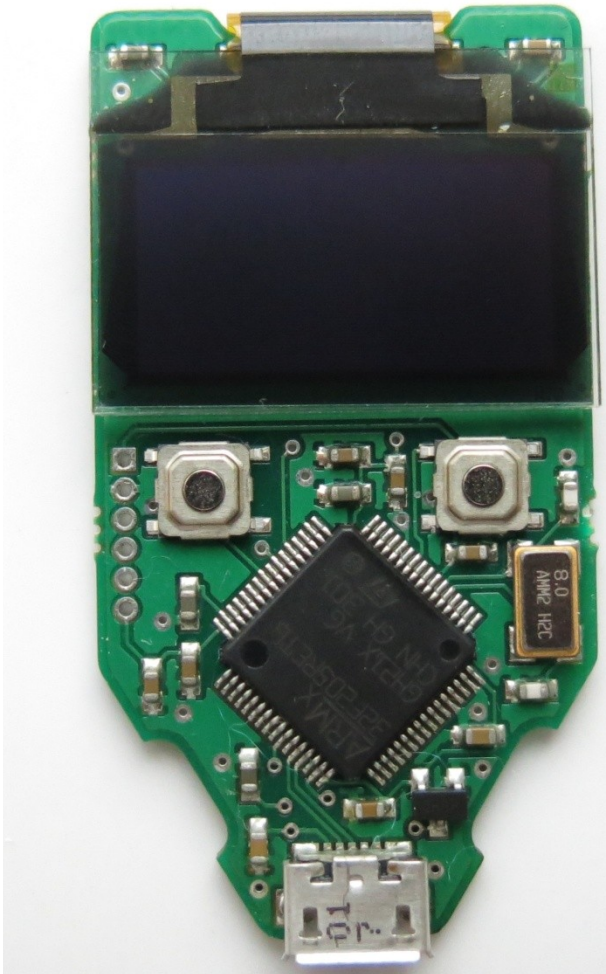
What's inside?

- ARM Cortex-M3 microcontroller
  - STM32F205
  - 120 MHz
  - 512 KiB Flash
  - 128 KiB RAM
  - HW RNG *
- 128x64 0.96“ OLED display



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Raspberry Pi

- same OLED display
- USB HID to Serial
- prototyping platform
  - Python
  - rapid development
  - follows the same logic

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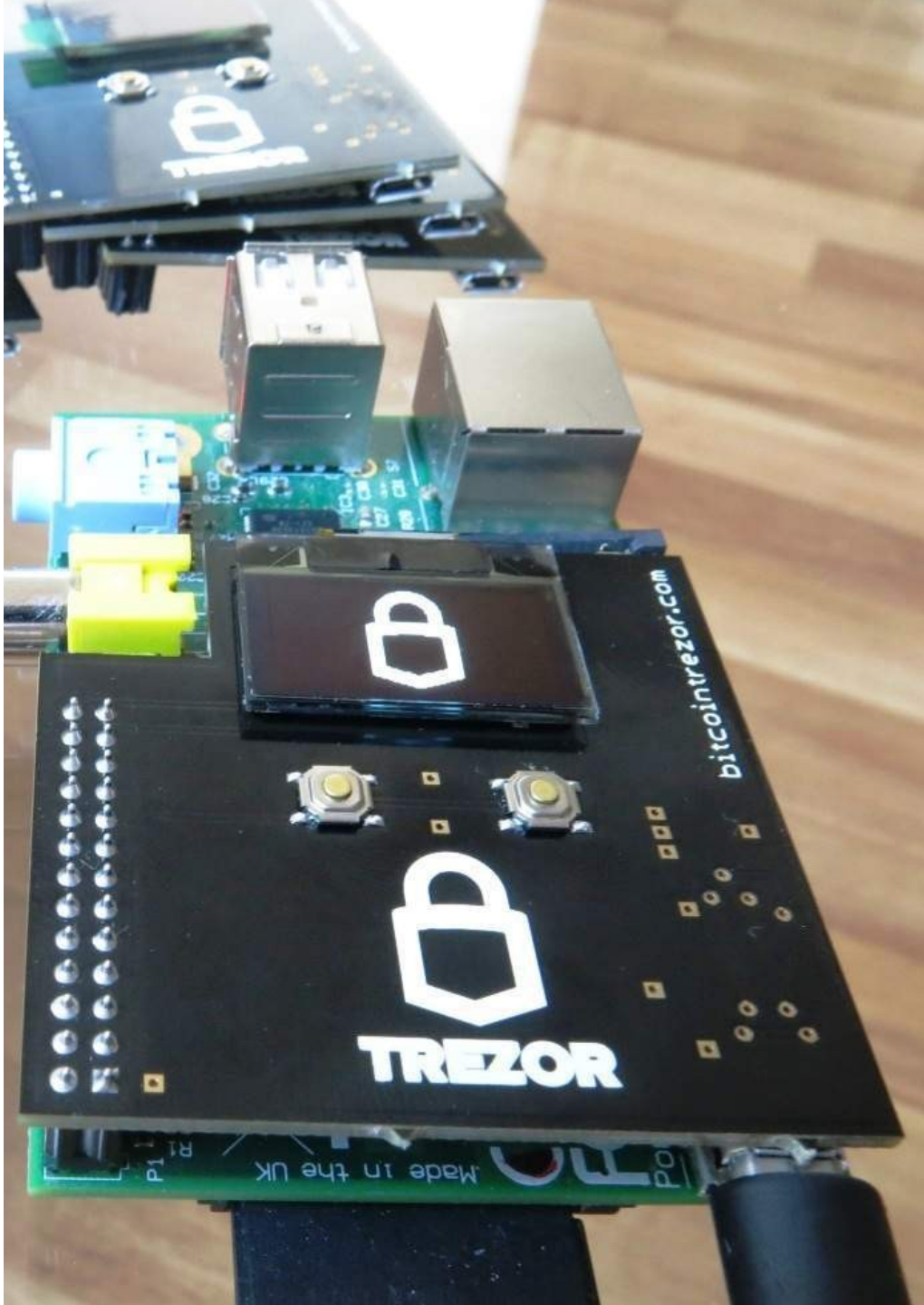

Modus Operandi (1)

- generate initial entropy
- allow its easy backup
- use this entropy to derive master private key and master public key

  „generators“
- send master public key to computer

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Modus Operandi (2)

- computer prepares transaction and sends to TREZOR
  - (gaps with keys indices instead of signatures)
- TREZOR uses master private key to generate needed private keys from indices
- TREZOR sends signed transaction back to computer
  - which will broadcast it to the network
- **private keys never leave the device!**

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Generate Entropy

- use HW RNG to generate entropy A (e.g. 256 bits)
- request entropy B from computer (e.g. 256 bits)
- use both entropies to generate final entropy while proving that external entropy was used - e.g. E = SHA256(A || B)
- more complex schemas suggested by Timo Hanke & Ilja Gerhardt

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Mnemonic code (for backups)

- convert entropy to string of words aka „mnemonic sentence“

  "immense uphold skin recall avoid cricket brush pill next home require friend"

- use entropy directly to generate master private key

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Mnemonic code BIP-0039

- convert entropy to string of words aka „mnemonic sentence“

  "immense uphold skin recall avoid cricket brush pill next home require friend"

- ~~use entropy directly to generate master private key~~
- use PBKDF2 to generate master private key
  - PRF = HMAC-SHA512
  - Password = mnemonic sentence
  - Salt = „mnemonic“ || user's secret
  - c = 4096 ; dkLen = 512 bits

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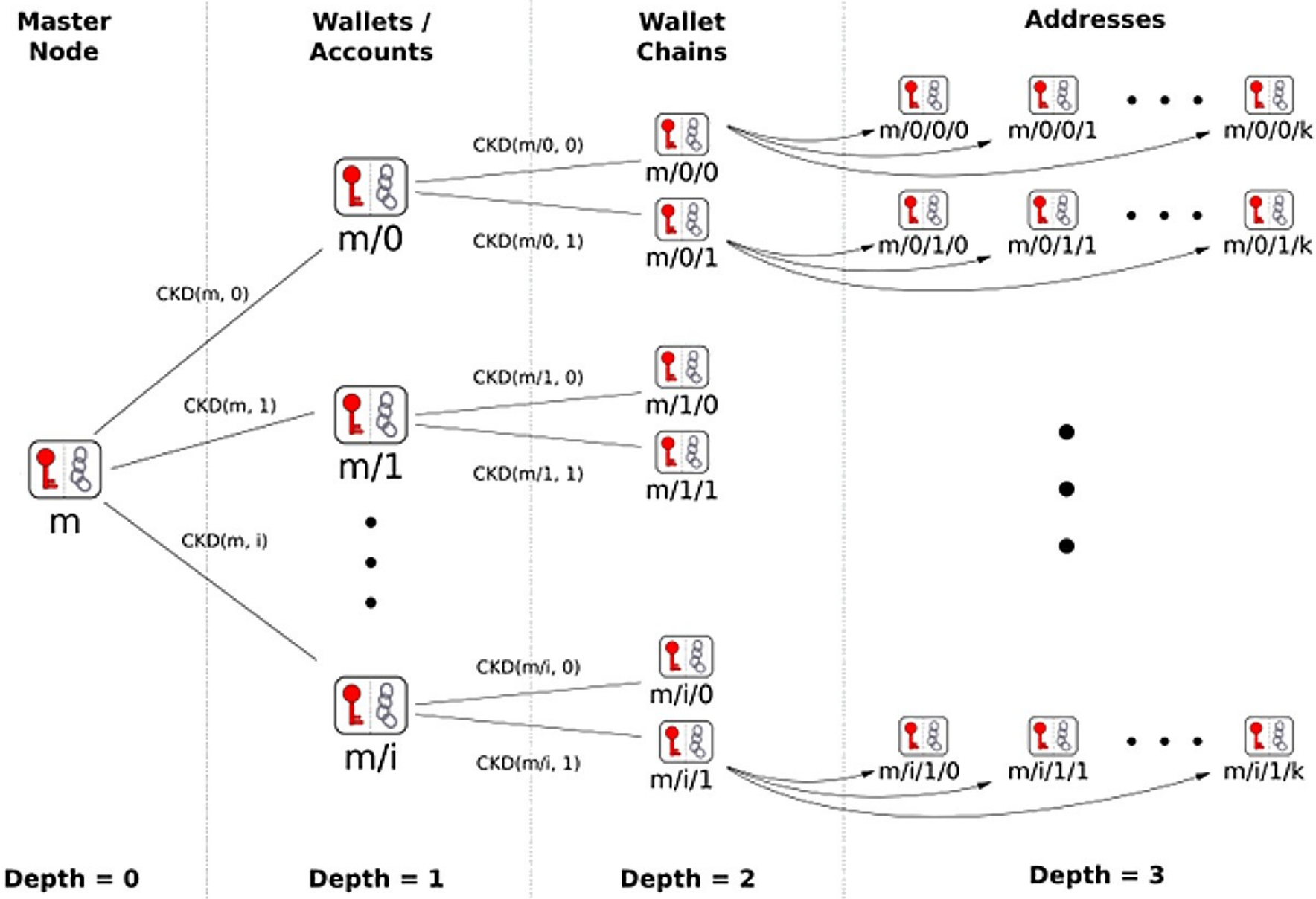
Hierarchical Deterministic Wallets



Hierarchical Deterministic Wallets

- BIP-0032 by Pieter Wuille ; CKD uses HMAC-SHA512
- abstract concept, lots of possibilities
  - master node – accounts – chains – addresses
  - master node – cointype – accounts - addresses
  - master node – HQ – local branches – accounts – addresses
  - master node – cryptocoins / SSH / FDE / challenge response / etc.
- wallet token => identity token !

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ECDSA Signatures

- ECDSA requires random nonce during signing (256-bit for Bitcoin)
- using same nonce twice for signing different messages using the same particular key => leak
- 27c3 fail0verflow: Console Hacking – PS3 hack
- August 2013: Android Java RNG vulnerability in SecureRandom
  - 59+ BTC stolen

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Deterministic ECDSA Signatures

- August 2013: RFC 6979 (Java, Go, python-ecdsa since 0.9)
- HMAC_DRBG seeded with private key and message
- great news!
  - avoids problem described in the previous slide
  - enables unit testing of signatures
  - proof that TREZOR does not leak master private key in nonce

Integration

- existing desktop clients
  - Multibit, Electrum, Armory
- mobile clients
- webwallets via native browser plugin

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Thank you !

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