Blockstream

Secure protocols on BIP-taproot

2019-06-08 Jonas Nick jonasd.nick@gmail.com https://nickler.ninja @n1ckler

GPG: 36C7 1A37 C9D9 88BD E825 08D9 B1A7 0E4F 8DCD 0366

Disclaimer

It’s not at all certain that a BIP-taproot softfork activates in its current form or at all. This depends on community consensus.

BIP-taproot address generation (witness version 1)

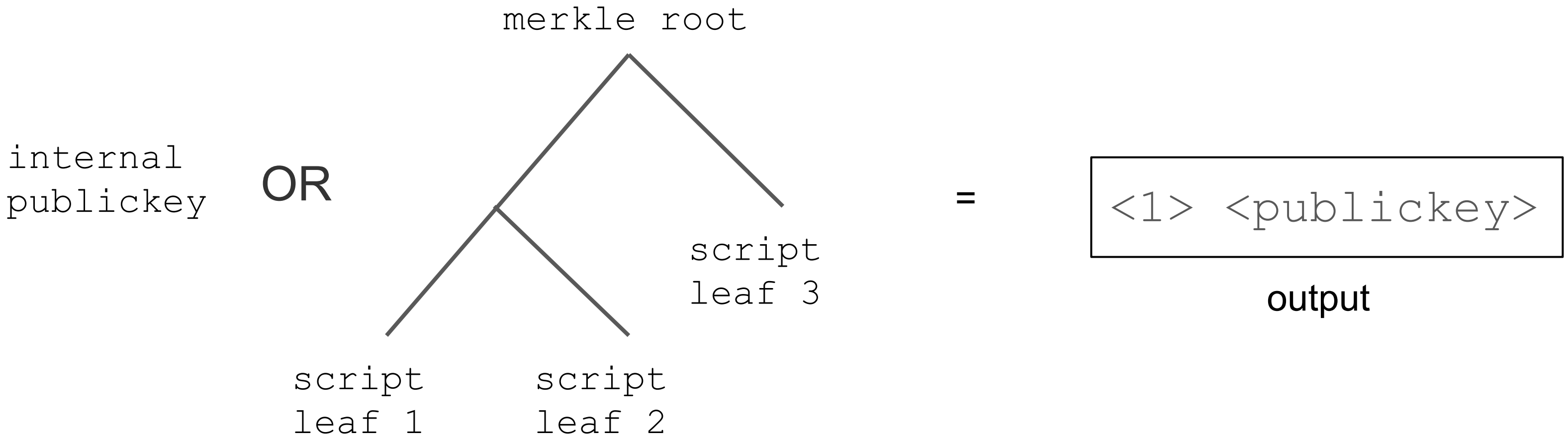
Policy: single key

```
<1> <publickey>
```

output

BIP-taproot address generation (witness version 1)

Policy: single key OR script1 OR script2 OR script3



BIP-taproot spending

output

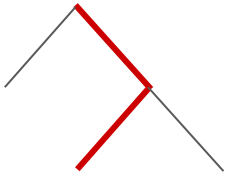
`<1> <publickey>`

Key spend

(BIP-schnorr) signature

Script spend (Script 2)

Script 2 inputs



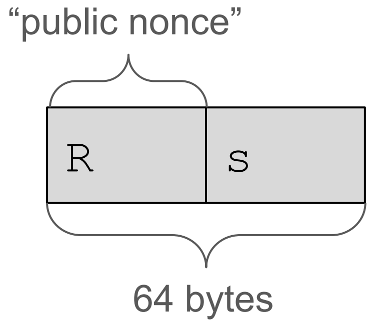
Script 2

bitcoin-core/secp256k1

- “Difficult to use insecurely”
  - Well reviewed and tested
  - Fast and portable
  - Free of timing sidechannels
- rust-bitcoin/rust-secp256k1 type-safe rust bindings (`no_std`)
- Will provide cryptographic primitives for bip-taproot
  - minimum required: schnorrsig module
- elementsproject/libsecp-zkp
  - fork of secp256k1 with rangeproofs, surjectionproofs, schnorrsig, musig, …
  - just released: rust-secp256k1-zkp beta (schnorrsig, optional `no_std`)
- HOWTO
  - read the docs before using it (`include/secp256k1_*.h`)

schnorrsig module

[secp256k1 PR #558](#)
[secp256k1-zkp module](#)
[rust-secp256k1-zkp module](#)

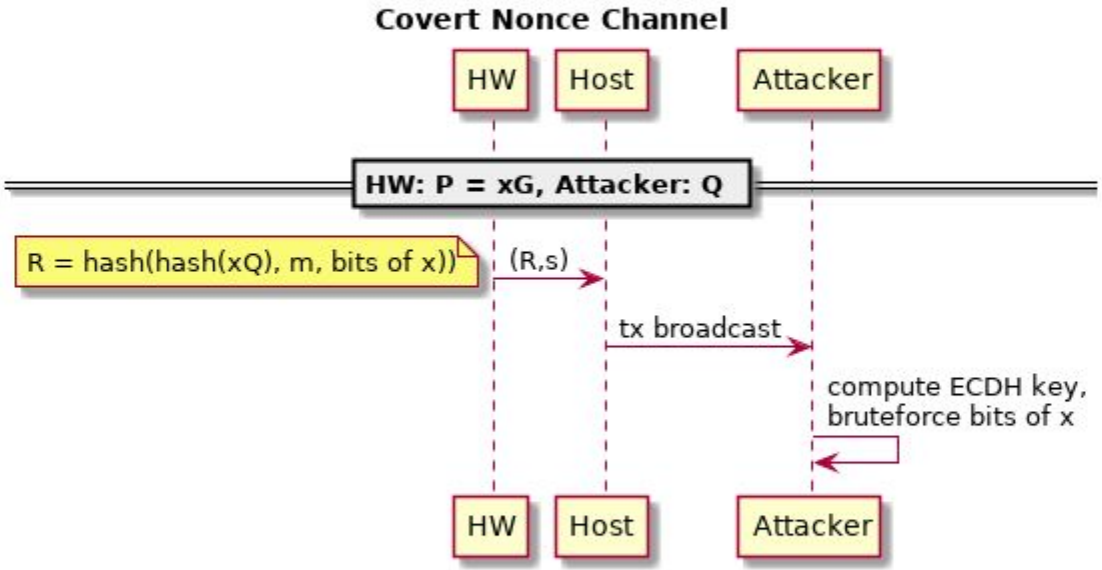


nonce = Number used ONCE

- Deterministic nonce derivation as per BIP-schnorr
  - Picking a specific nonce is unnecessary
- Batch verification
  - 400 sigs can be verified in half the time
  - Don’t know which exact sig was invalid
  - May not reduce worst case cost

Covert nonce channel

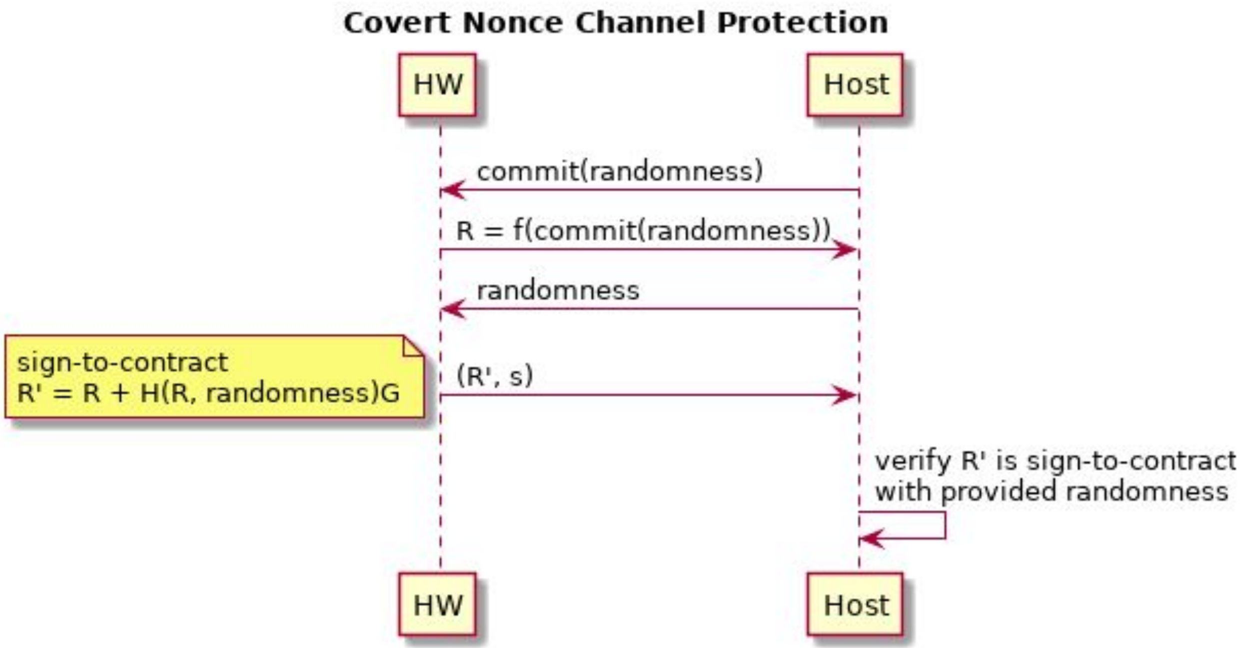
- Problem: malicious HWW can exfiltrate secret key through nonce



secp256k1 PR #590

Covert nonce channel protection

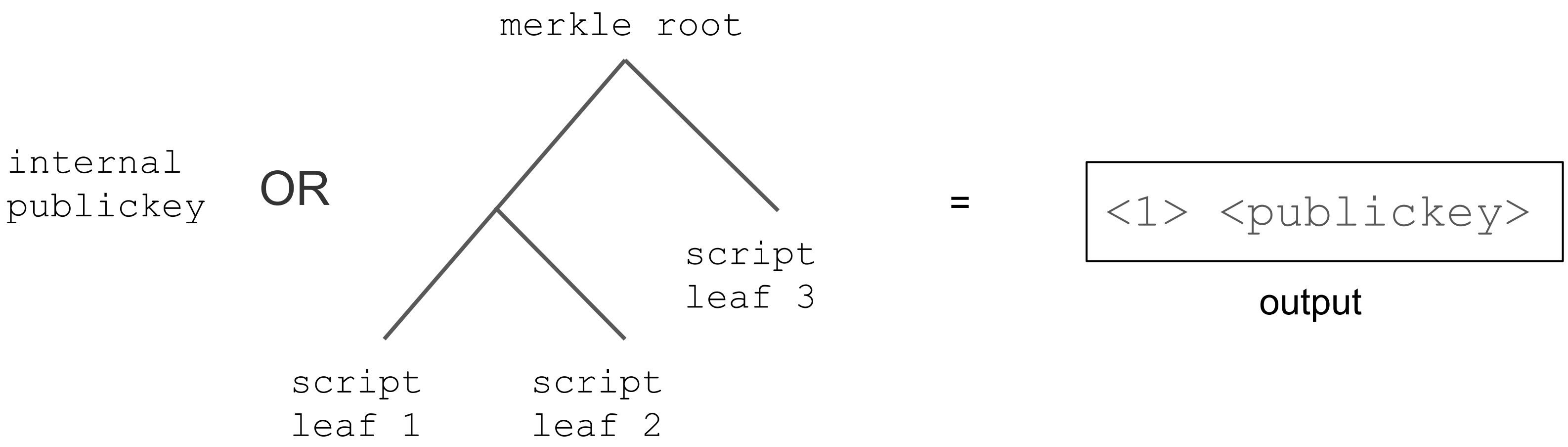
Solution: enforce putting host-supplied randomness in nonce with *sign-to-contract*



Alternative: MuSig key aggregation but that's currently difficult for hardware wallets secp256k1

Tweak Add

- Create taproot commitment if there’s a script path

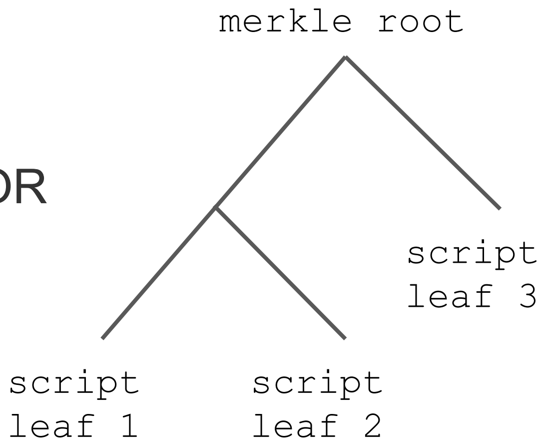


[secp256k1]

Tweak Add

- Create taproot commitment if there’s a script path

internal publickey OR



=

`<1> <publickey>`

output

`P + hash(prefix, P, root)G = Q`

secp256k1

Tweak Add

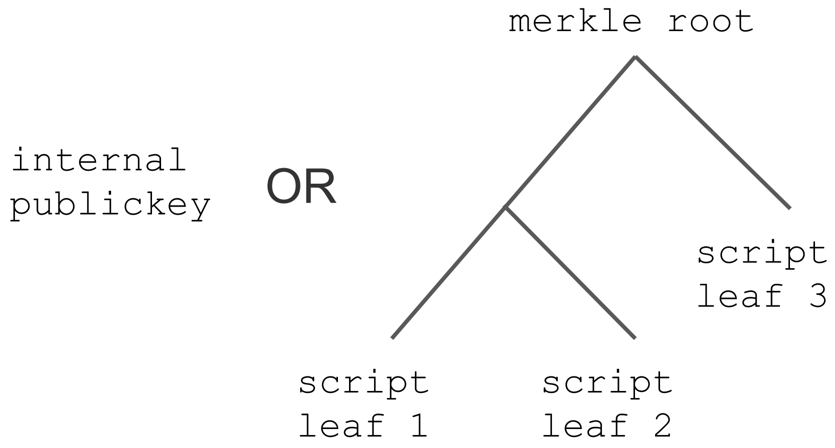
- Create taproot commitment if there’s a script path

```
int secp256k1_ec_pubkey_tweak_add(
    const secp256k1_context* ctx,
    secp256k1_pubkey *pubkey,
    const unsigned char *tweak)
```

```
P            + hash(prefix, P, root)G      =      Q
```

Tweak Add Fungibility

- Try avoiding the script path
  - in multi-party contracts use “happy” case
- Don’t reuse keys
  - internal keys and leaf keys
- Using script path basically leaks wallet
  - Depth of tree, script, …
- Ensure sufficient leaf entropy

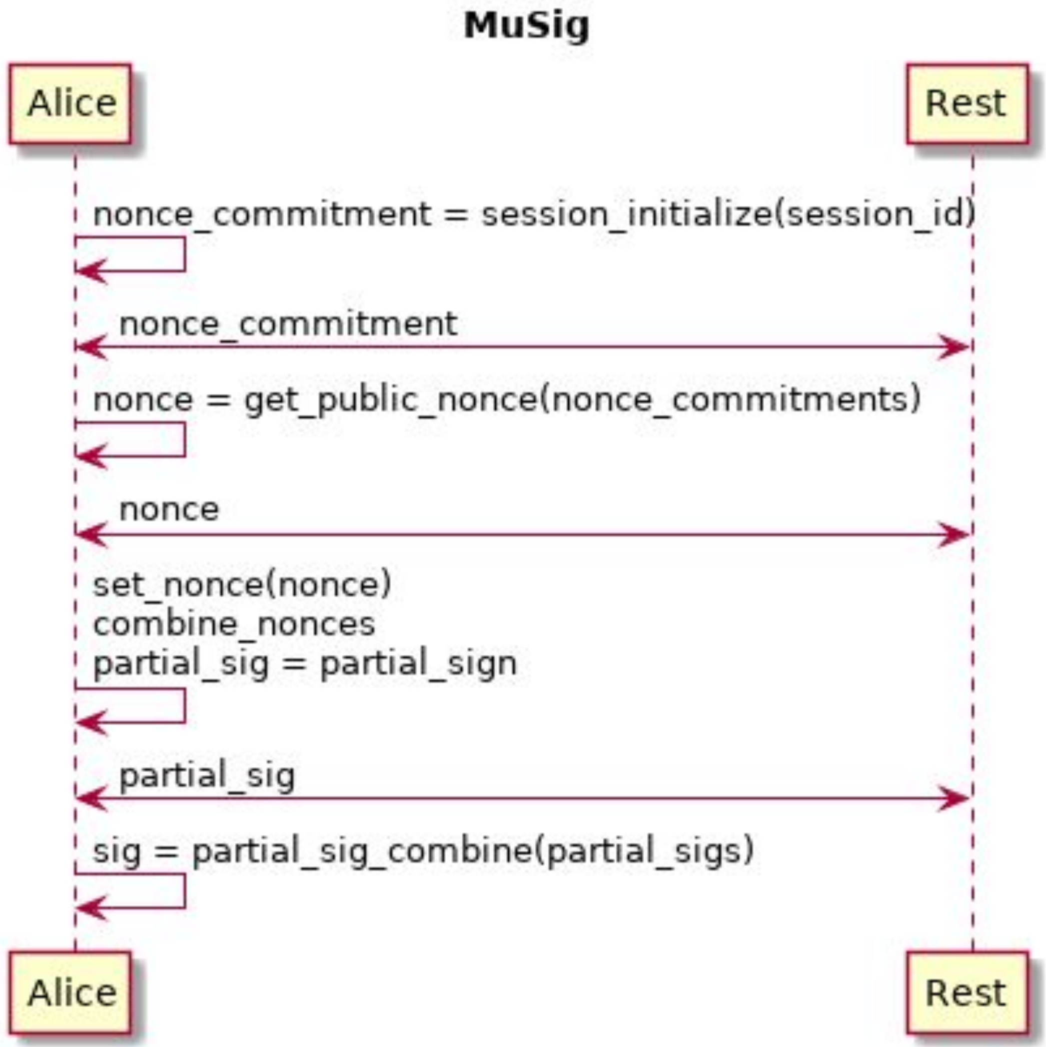


Multisignature Options with BIP-taproot

1. use `CHECKMULTISIG` replacement opcode `CHECKSIGADD`
   - uses BIP-schnorr and is batch verifiable
2. Key aggregation
   - Encode n-of-n signing policy in single public key and single BIP-schnorr signature
   - more fungible, cheaper
   - interactive protocol

Key Aggregation Options

1. **“Legacy”:** p2wpkh key aggregation
   - complicated and [80 bits security]
2. **BIP-taproot:** MuSig key aggregation
   - `P = hash(P1, P2, 1)P1 + hash(P1, P2, 2)P2`
3. **BIP-taproot:** Non-MuSig key aggregation
   - `P = P1 + P2`, and proof of knowledge to avoid key cancellation
   - But one party can add taproot tweak!
   - `P1 = P1’ + hash(prefix, P, root)G`


MuSig
Alice
Rest
nonce_commitment = session_initialize(session_id)
nonce_commitment
nonce = get_public_nonce(nonce_commitments)
nonce
set_nonce(nonce)
combine_nonces
partial_sig = partial_sign
partial_sig
sig = partial_sig_combine(partial_sigs)
Alice
Rest

[secp256k1-zkp musig module]

MuSig Implementation

using libsecp-zkp is safe if you

1. Never reuse a session id
    - need randomness or atomic counter
2. Never copy the state
    - otherwise: Nonce reuse and active attacks

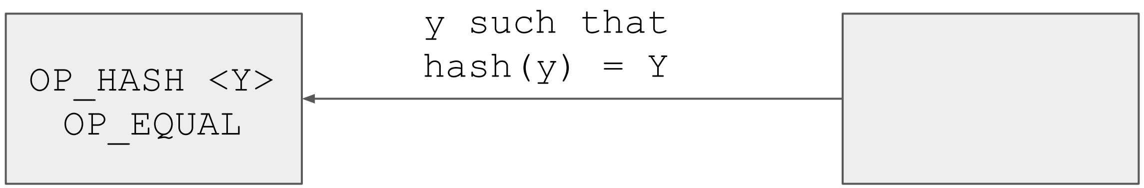
MuSig: Reducing Communication

- Can attach the nonce (commitment) to already existing messages in protocol
  - old message: `ClientHello`
  - new message: `(ClientHello, nonce_commitment)`
- Can run multiple sessions in parallel ("pre-sharing nonces")
- Three parallel sessions get one sig per round
  - `(partial_sig_i, nonce_i+1, nonce_commitment_i+2)`

MuSig with Offline/Hardware Wallets is hard

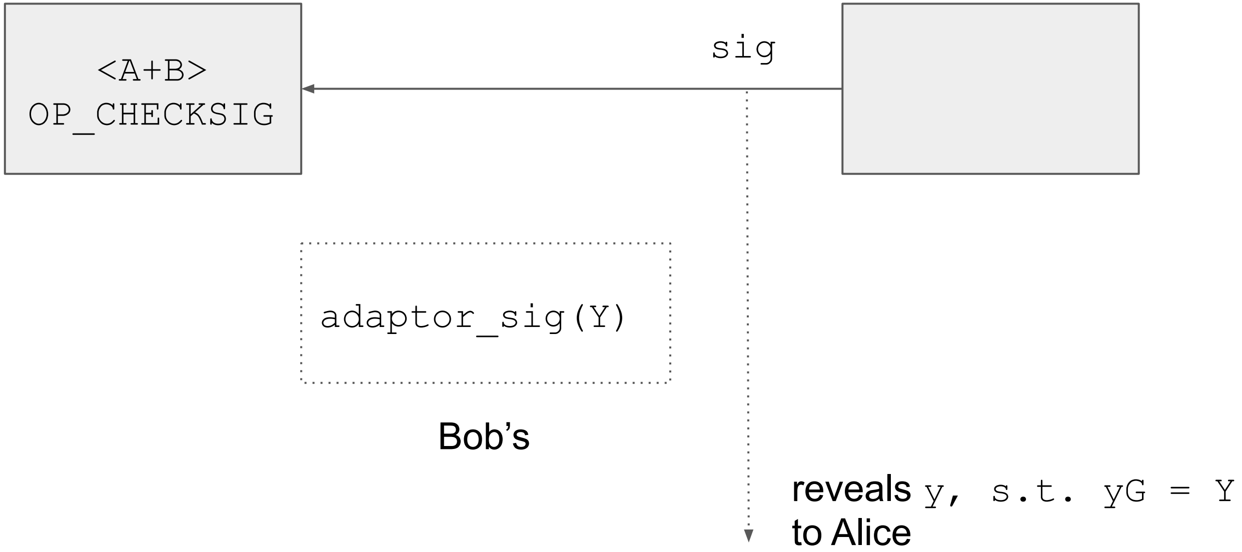
- Storing state on persistent medium is a copy (**dangerous**)
- Therefore, serializing state not supported right now in our implementation
- Just have a “single” session?
  - Need to travel to your HWW vault for every single signature
- Hope: deterministic nonce derivation
  - no randomness, no state, two rounds
  - but must be efficient
  - adds code complexity

Hash locks



secp256k1-zkp

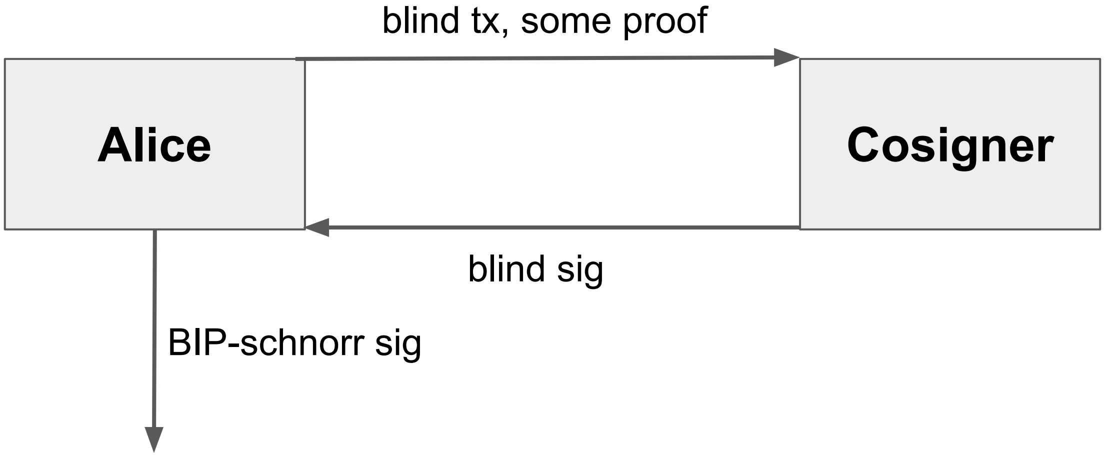
MuSig Adaptor Signatures



- **DANGER**: partial verification required
- Bonus: works with n-of-n, where n>=2

Blind Schnorr Signatures

- Interactive protocol between client and signing server
- Signer does not know the message being signed
- Result is a BIP-schnorr signature



Blind Schnorr Signatures Problems

- Vulnerable to Wagner's attack
  - 65536 parallel signing sessions can forge a signature with only `O(2^32)` work
- Moreover, they can't be proven secure in the Random Oracle Model

Blind Schnorr Signatures

1. If you just need blind signatures (f.e. ecash)
   - Don’t use blind Schnorr signatures
2. If you need blind signatures for Bitcoin transactions
   - Need to use blind Schnorr signatures
   - Idea to prevent Wagner’s attack
      i. Client blinds message with 128 different blinding factors and sends them to server
      ii. Server picks only one of those to blindly sign

Conclusion

- BIP-taproot is a substantial efficiency & fungibility improvement
- Simple sending remains simple
- Can use libsecp256k1 ecosystem for cryptography
- DL assumption is nice (fast, studied)
    - but requires interactive protocols, creates new challenges
- TODO: k-of-n threshold signatures
- Please try to break it!
- Slides at nickler.ninja/slides/2019-breaking.pdf

GPG: 36C7 1A37 C9D9 88BD E825 08D9 B1A7 0E4F 8DCD 0366