Replacing Weary Crypto: Upgrading the I2P network with stronger primitives

str4d
https://geti2p.net
str4d@i2pmail.org
@str4d

2016-01-08

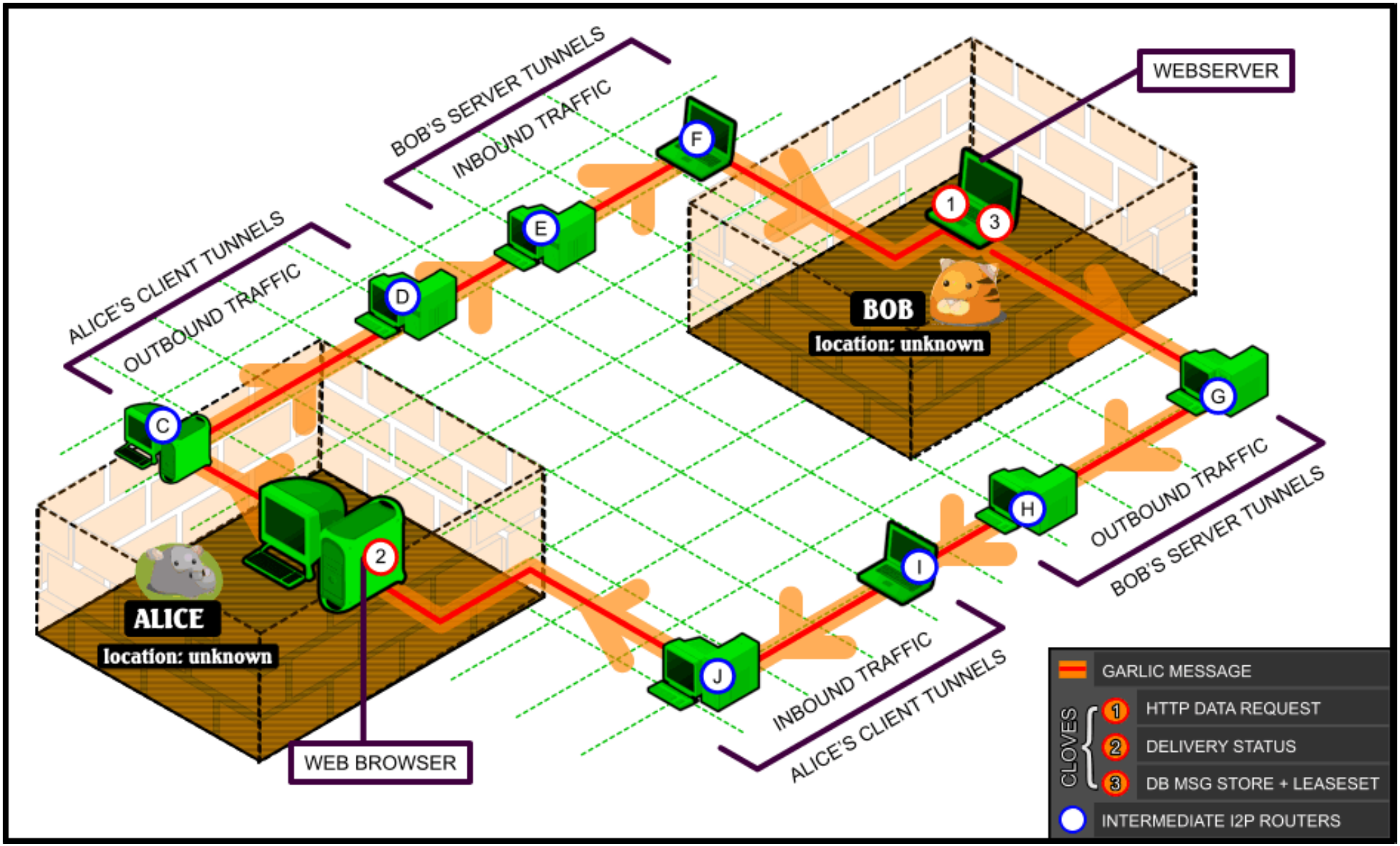
Tor and I2P have several similarities...

- Both started circa 2003
- Location anonymity
  - Onion routing
- Low-latency
  - Vulnerability to traffic confirmation attacks!

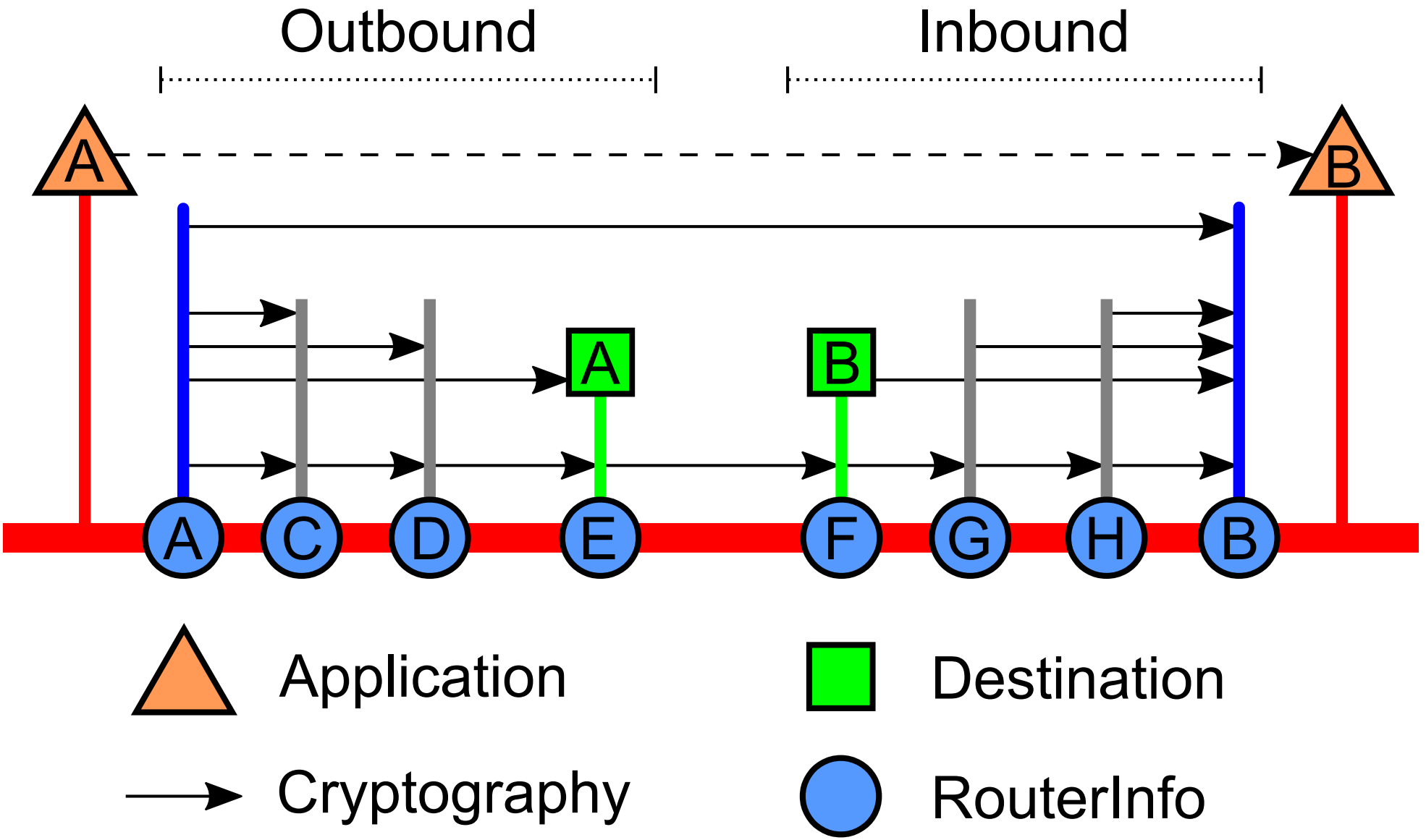
… but also significant differences

Tor	I2P
• Centralized*	• Decentralized*
• Asymmetric design – ~8,000 relays – Millions of users	• Symmetric design – ~40,000 routers
• TCP	• TCP, UDP, RAW, ...
• Bidirectional tunnels	• Unidirectional tunnels

Tunnel layout



I2P uses three layers of crypto



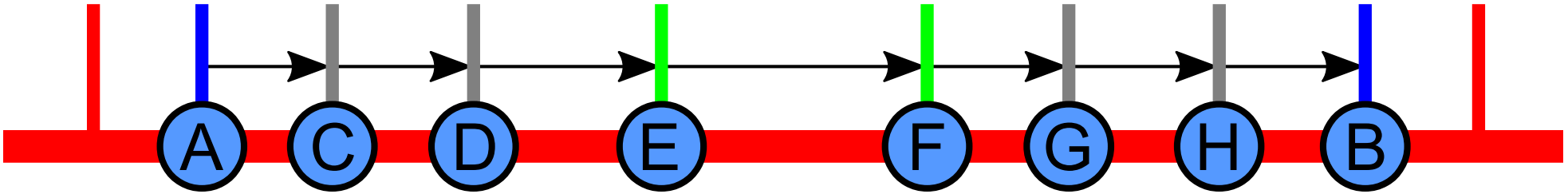
Link encryption

NTCP (2006) - TCP

- 2048-bit DH
- 2-way auth
- AES-256/CBC with last 16 bytes of prev. message as IV

SSU (2005) - UDP

- 2048-bit DH
- 2-way auth
- AES-256/CBC with random IV and MAC (HMAC-MD5-128*)



Tunnel encryption

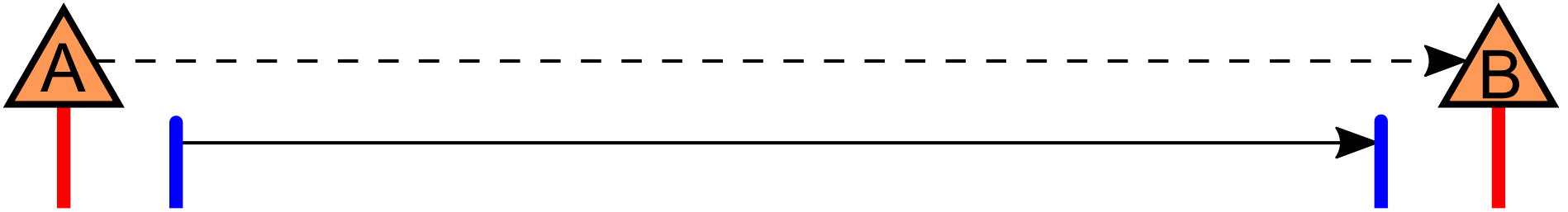
AES-256/CBC + truncated SHA256

Packet: 4-byte Tunnel ID + 16-byte IV + Ciphertext

IV encrypted before and after each hop with AES-256/ECB (ie. one block)

End-to-end encryption

ElGamal/AES+SessionTags



First packet:

- 514-byte ElG(PK_B, (sk, pre-IV))
- AES-CBC(sk, SHA256(pre-IV)[:16], (list of 32-byte nonces + payload))

Subsequent packets:

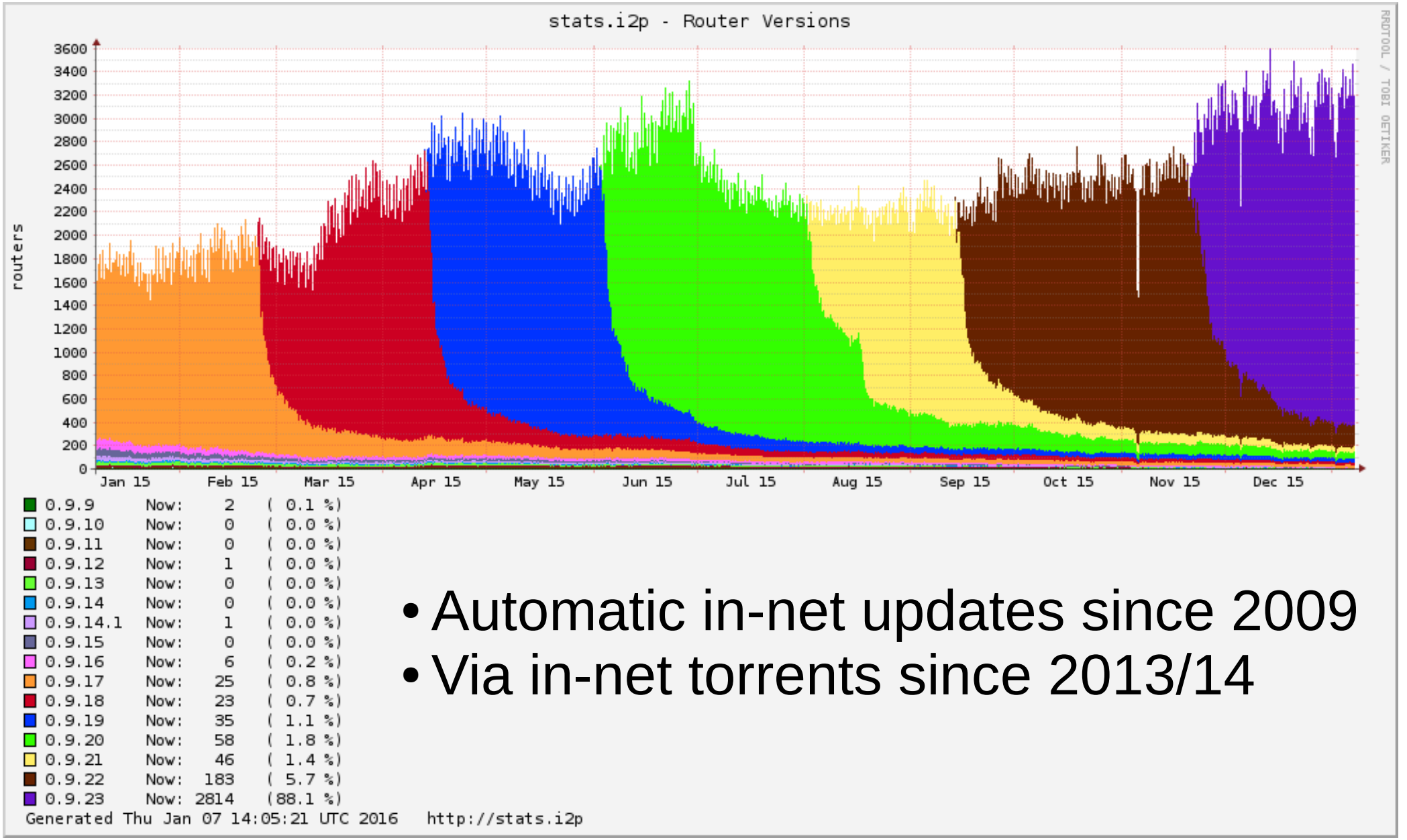
- 32-byte nonce
- AES-CBC(sk, SHA256(nonce)[:16], payload)

Original primitives

- ElGamal-2048
  - Using Oakley primes
  - Use short exponent [1] on non-(64-bit x86) hardware
- DSA-1024
- AES-256/CBC
- SHA256
- Non-standard HMAC-MD5-128 (only for SSU)

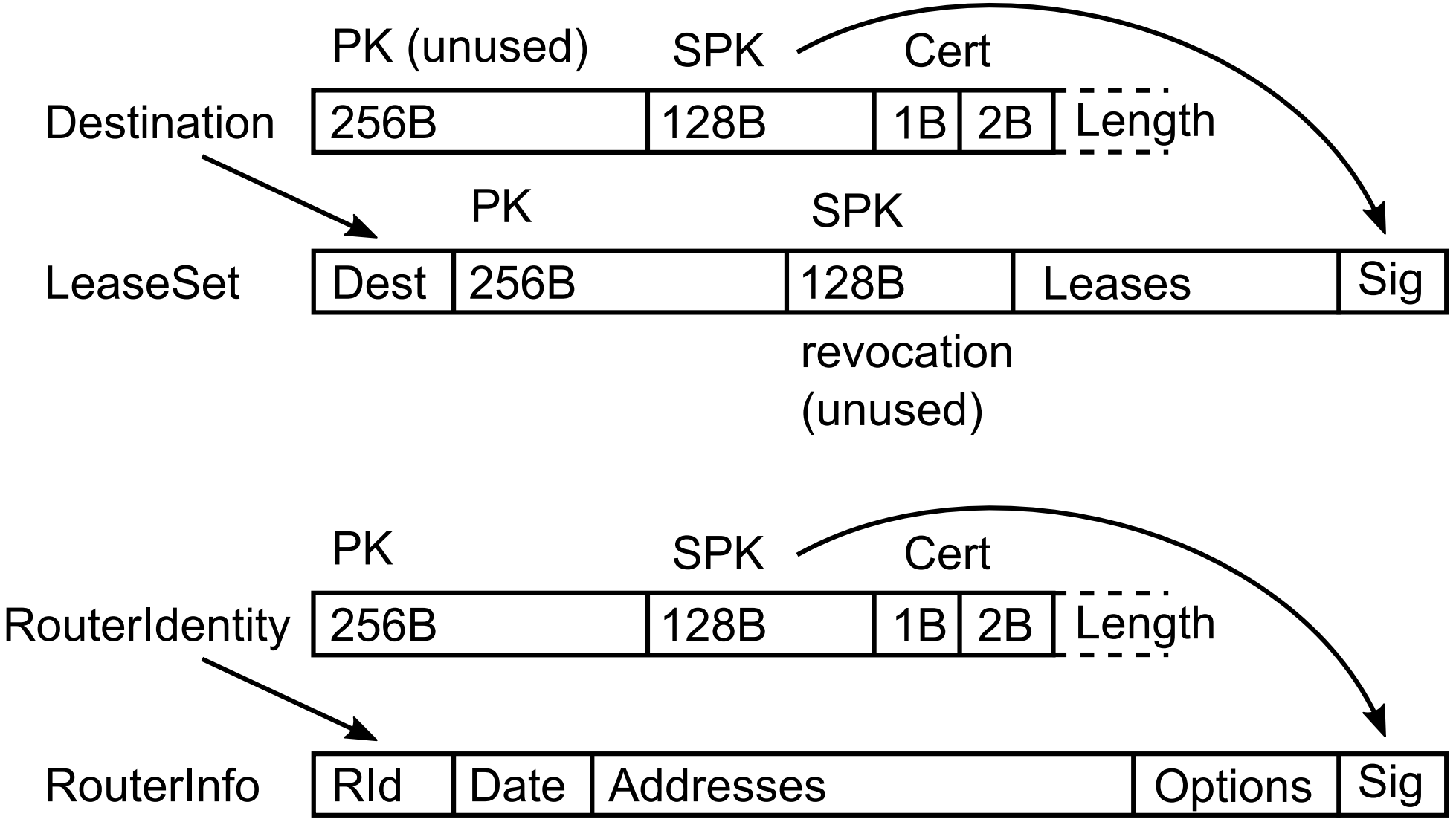
[1] On Diffie-Hellman Key Agreement with Short Exponents - van Oorschot, Weiner at EuroCrypt 96

We have good update propagation



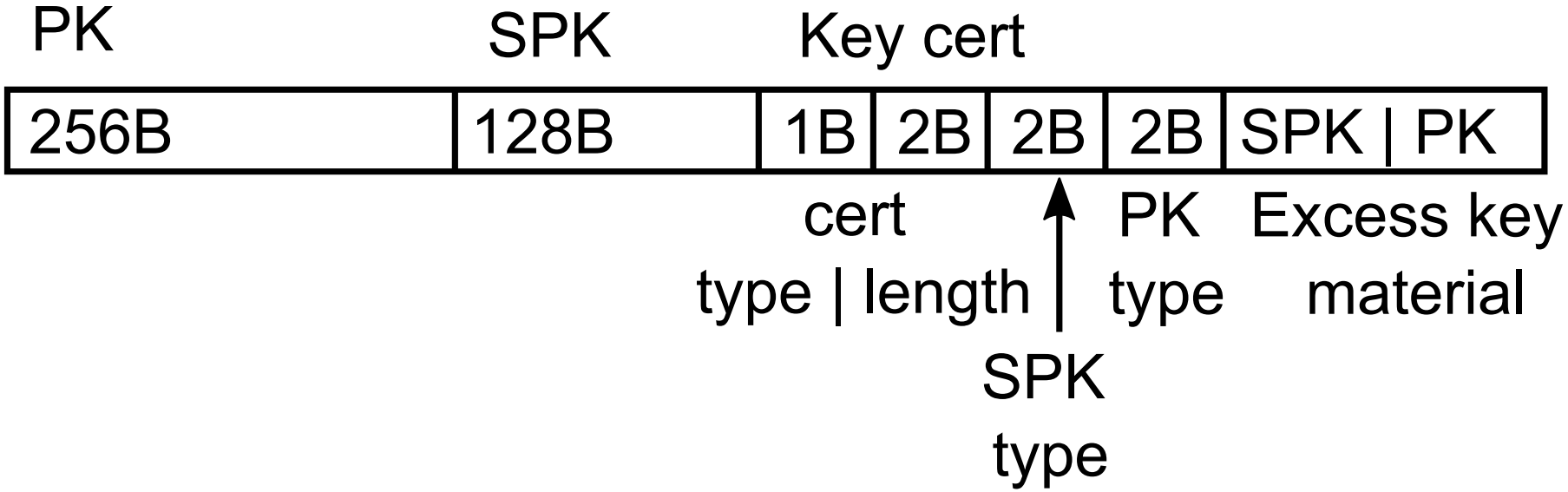
- Automatic in-net updates since 2009
- Via in-net torrents since 2013/14

Legacy data structures...



Don't break third-party software!

Key Certificate



We now have full flexibility for future key types
(up to 64,000 each, 7 SPK defined)

(Relatively) good uptake

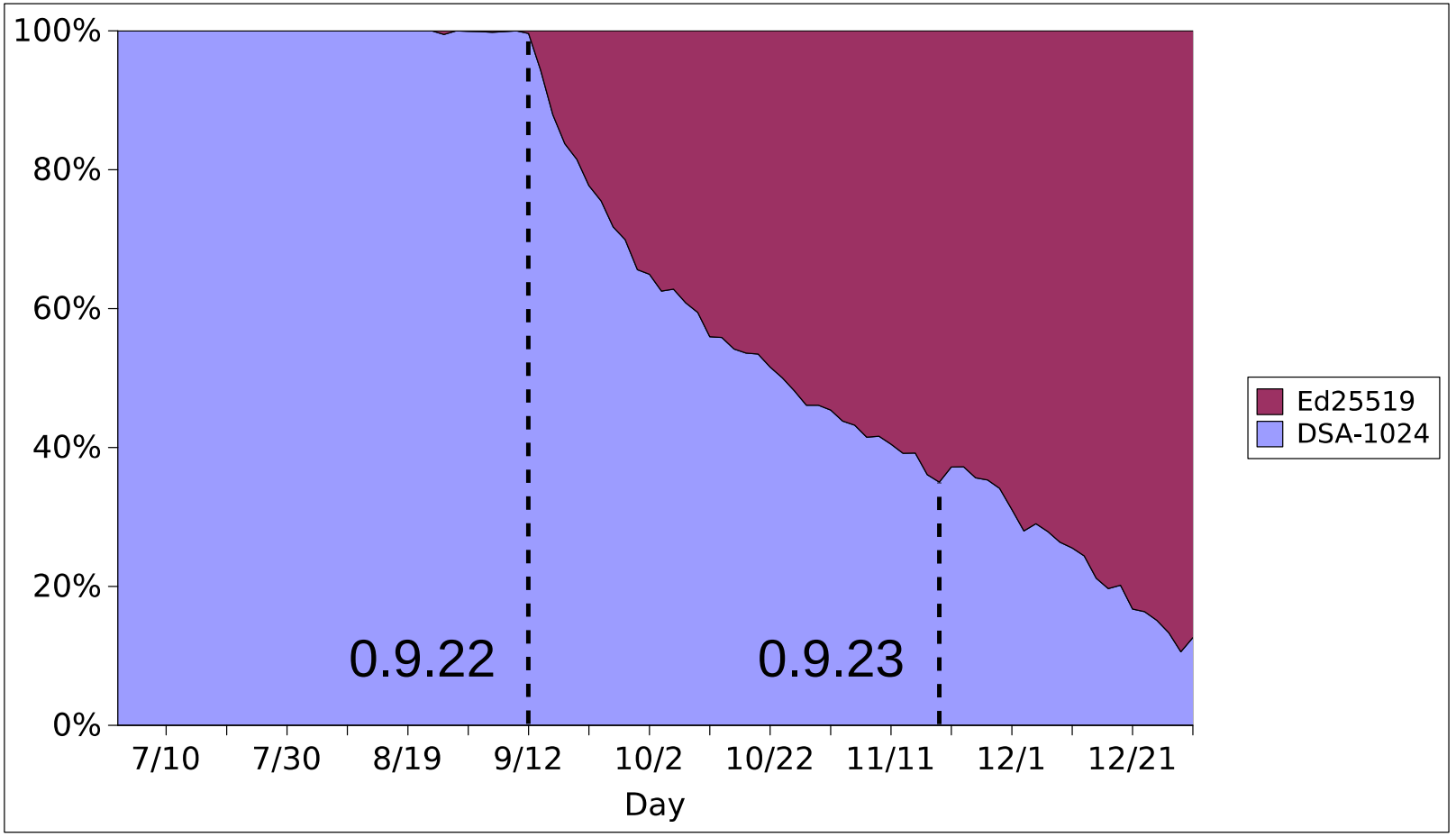
Type	Usage
DSA_SHA1	73%
ECDSA_SHA256_P256	6%
EdDSA_SHA512_Ed25519	21%

We get router key upgrades for free!

- Can change signing and encryption type
  - (becomes “new” router)
- But no backup for routers without support for new types

→ Cut backwards compatibility

RI signature upgrade is rolling out



We are continuing the migration

- E2E crypto: LeaseSet has no free bits → LS2
  - Easy to handle, doesn't change address
  - Take opportunity to redesign both netDb and LS
- NTCP is very identifiable → NTCP2
  - Based on nTor? Ace?
  - We require 2WAKE

Design help appreciated!