Cryptographic directions in Tor

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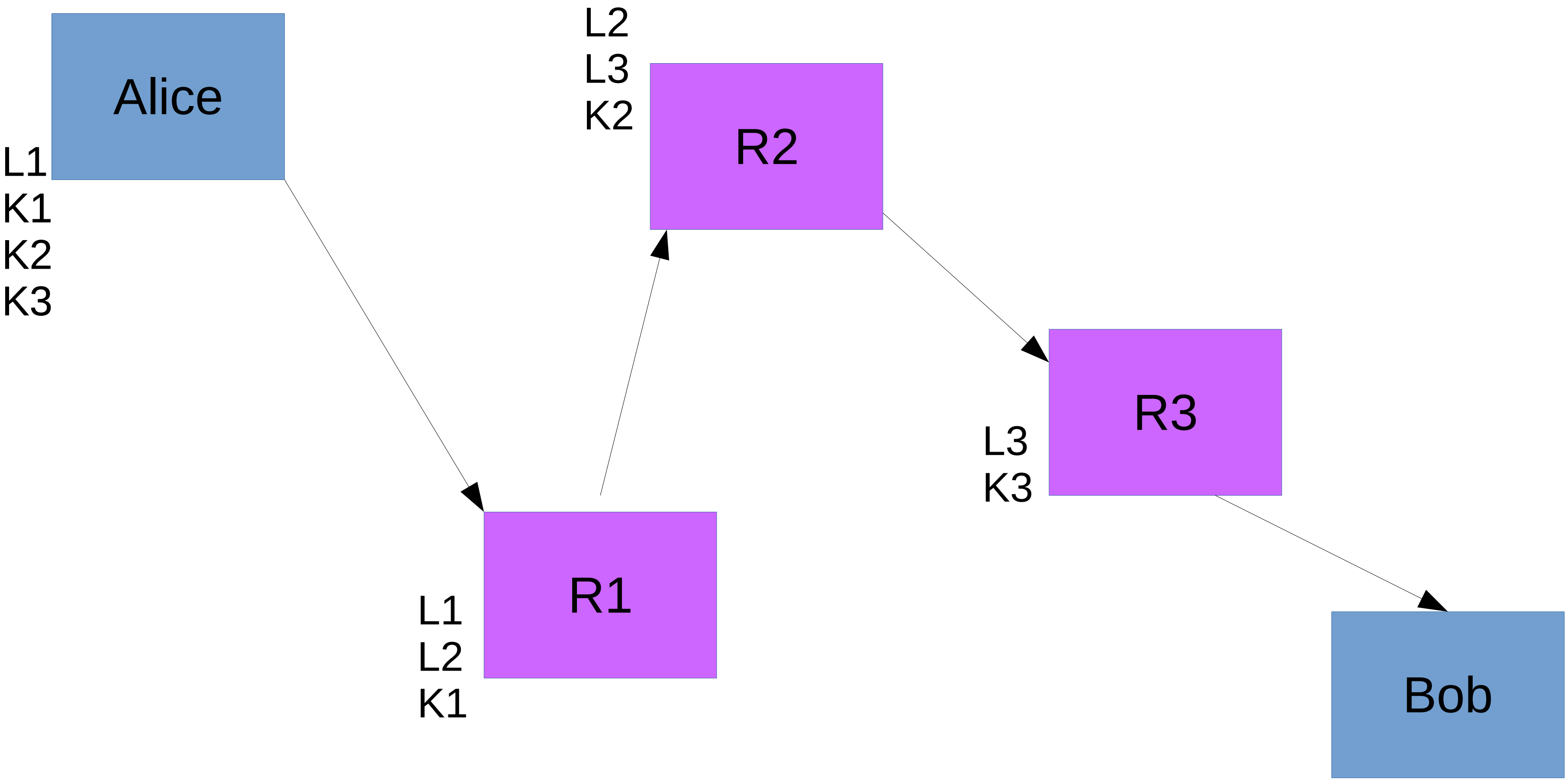
Outline

- Where we started
- Where we are
- Where we're going – maybe.

Let's oversimplify Tor, in 1 slide.



We chose some reasonable-looking crypto in 2004...

- Relay encryption: AES-CTR + Truncated SHA1
  - End-to-end only

- Key negotiation: “ ”.
  - (RSA1024 + DH1024 + AES-CTR)

- Links: TLS1.0
  - With DH1024, RSA1024, AES-CBC, SHA1.

...and we've replaced a lot of it...

- Relay encryption: AES-CTR + Truncated SHA1
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- Key negotiation: “~~TAP~~” “ntor”
  - ~~(RSA1024 + DH1024 + AES-CTR)~~
  - Curve25519 + SHA256
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- Links: ~~TLS1.0~~ TLS >= 1.0...
  - ~~With DH1024, RSA1024, AES-CBC, SHA1.~~
  - With ECDH (P256), RSA1024, AES-GCM

But work remains!

- Relay encryption: AES-CTR + Truncated SHA1
  - End-to-end only

Too Malleable!

- Key negotiation: “~~TAP~~” “ntor”
  - ~~(RSA1024 + DH1024 + AES-CTR)~~
  - Curve25519 + SHA256

Not Postquantum Enough!

- Links: ~~TLS1.0~~ TLS >= 1.0...
  - ~~With DH1024, RSA1024, AES-CBC, SHA1.~~
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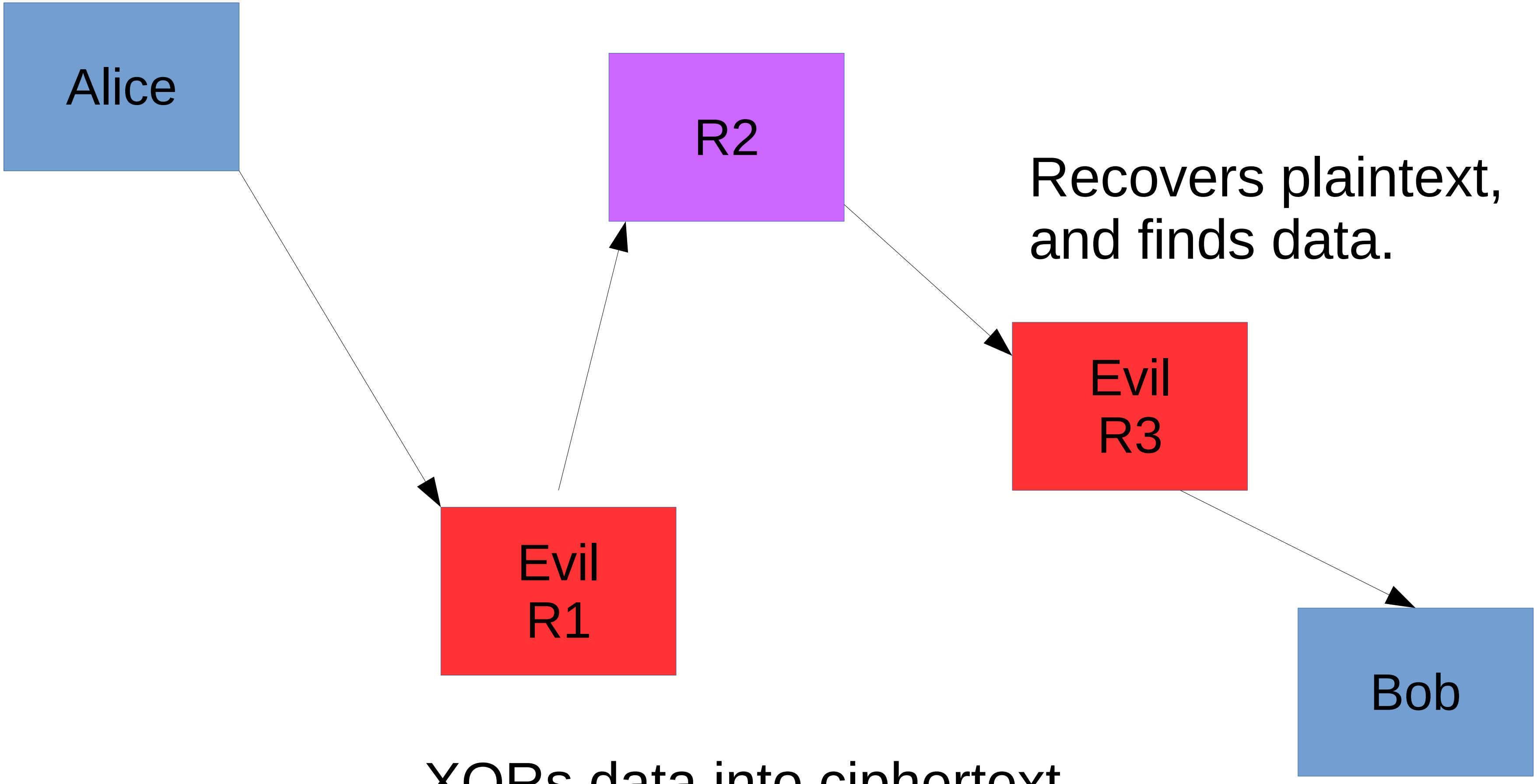
Just no.

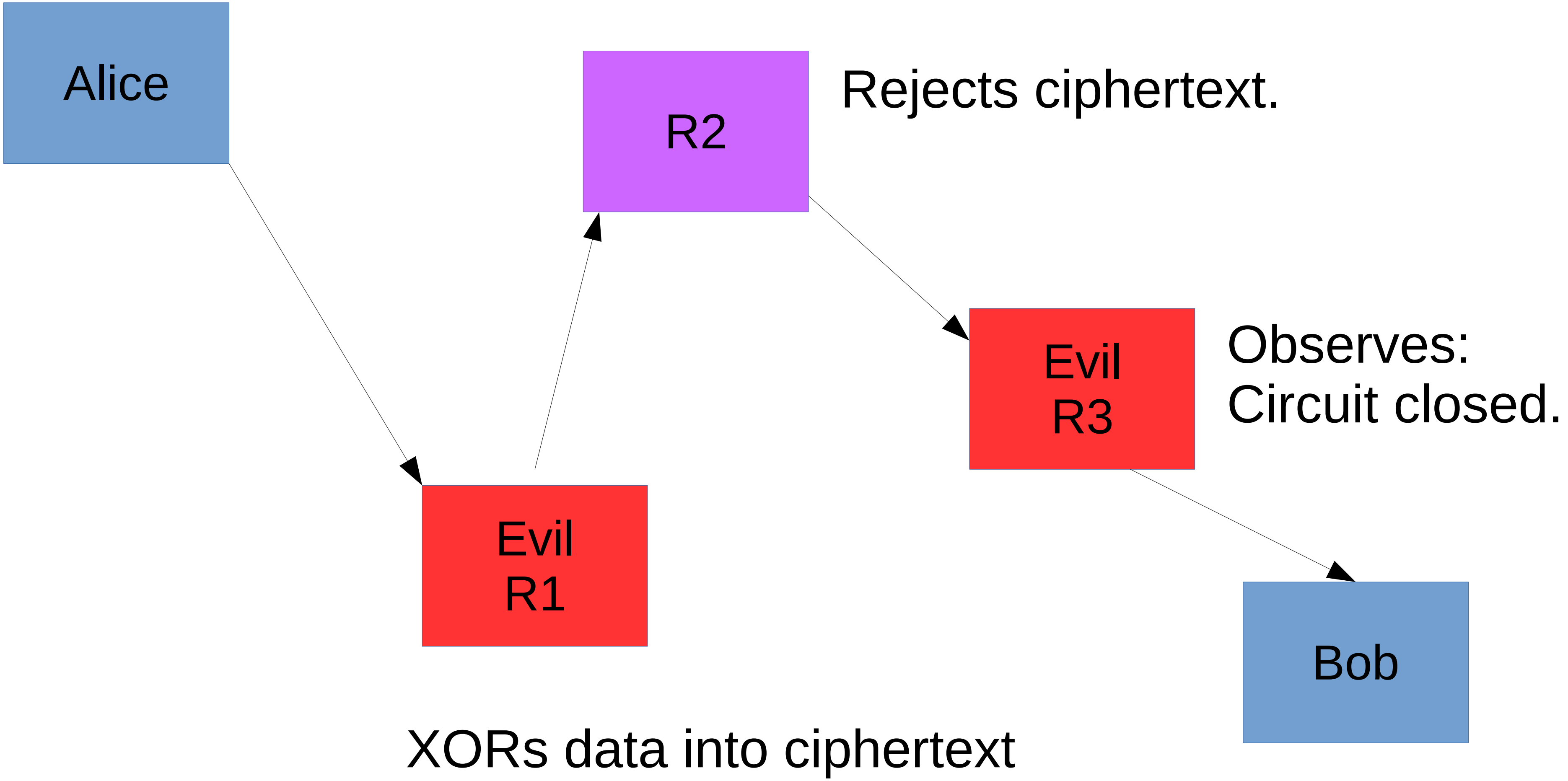
Malleable AES-CTR + end-to-end MAC allows tagging attacks.



Recovers plaintext, and finds data.

XORs data into ciphertext

Solution: Add a MAC at each hop?



Alice

R2

Rejects ciphertext.

Evil R3

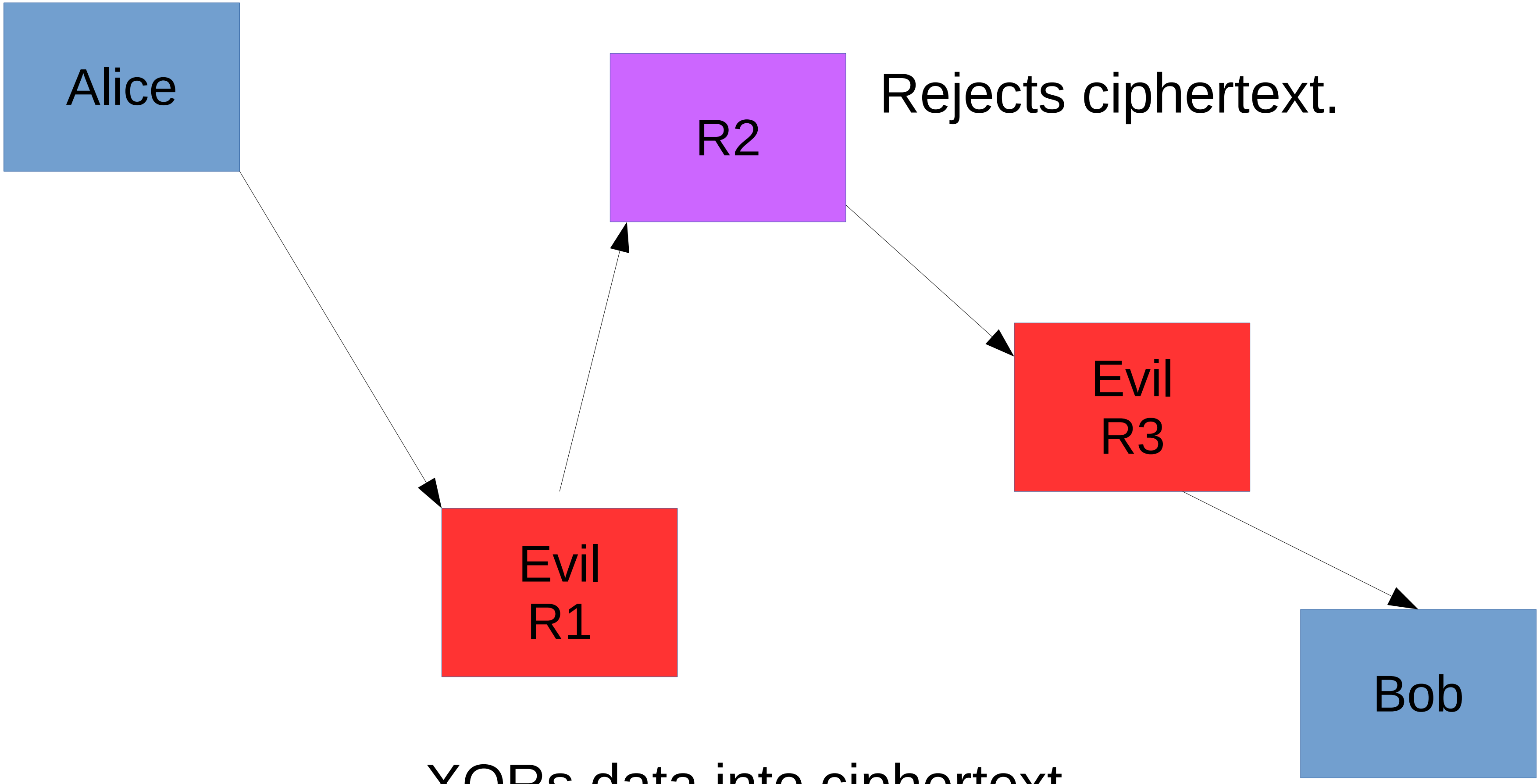
Observes: Circuit closed.

Evil R1

Bob

XORs data into ciphertext

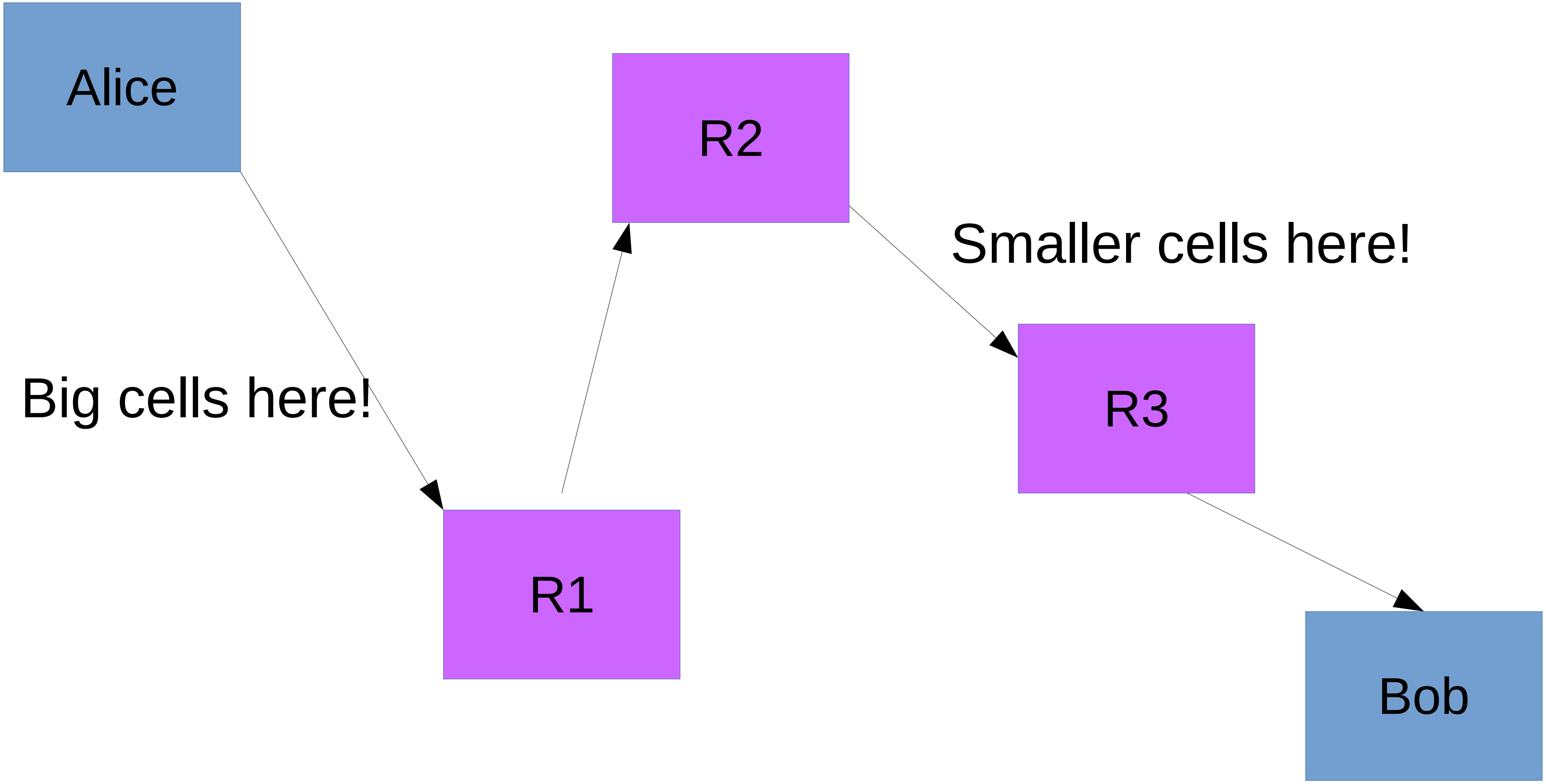
Solution: Add a MAC at each hop?



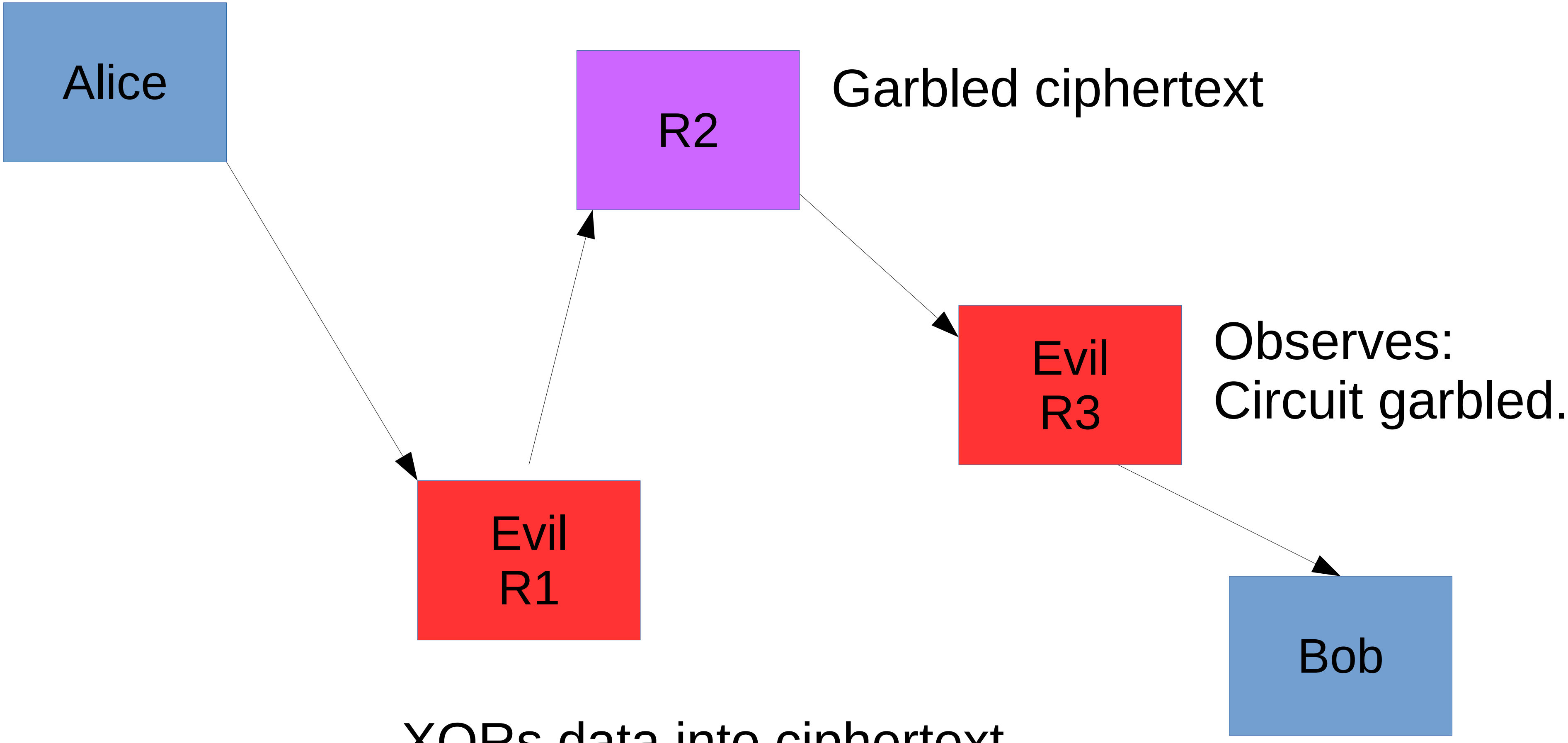
Rejects ciphertext.

XORs data into ciphertext

But that leaks path length/position.



Solution:
Chained wide-block SPRP?



XORs data into ciphertext

Single anonymity tool seeks SPRP for good times, encryption.

- AEZ? (rogaway et al)
  - CAESAR candidate
  - Based on AES round function—complex.
  - Fast with AESNI; less so if not??
- HHFHFH? (djb et al)
  - Feistel construction: simple, has proofs.
  - Instantiate with GF25519 / XChaCha20?
  - Slower than AEZ?? Need more data!
- Help?

Also let's do PQ circuit extension!

- Forward secrecy matters most.
- Needs to be fast-ish and small-ish.
- No less secure than current ntor approach.

  (approximately:)

  - Alice → Bob: “g^x, Bob.”
  - Bob → Alice: “g^y, H1(g^xy, g^xb….)”.
  - Keys are: KDF(g^xy, g^xb….)

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- Forward secrecy matters most.
- Needs to be fast-ish and small-ish.
- No less secure than current ntor approach.

  (approximately:)

  - Alice → Bob: “g^x, Bob, PQKey ”
  - Bob → Alice: “g^y, H1(g^xy, g^xb….), E(PQKey, N)”.
  - Keys are: KDF(g^xy, g^xb, N ….)

Current candidates

- ntru?
- newhope?
- ___________ ?

Questions?

- Also see tor-dev mailing list for more discussion!
- Targeting 2016 deployment.
- Also, ask me about hidden service crypto.