[matrix]

Decentralised Communication: The challenge of balancing interoperability and privacy.

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Privacy in Matrix

Two basic types of privacy:

1. Can attackers see what you're saying?

2. Can attackers see who you're talking to, and when?

Matrix can protect the contents of what you're saying using end-to-end encryption.

Neither the servers nor the network can decrypt the data; only invited clients.

End to End Crypto with Olm

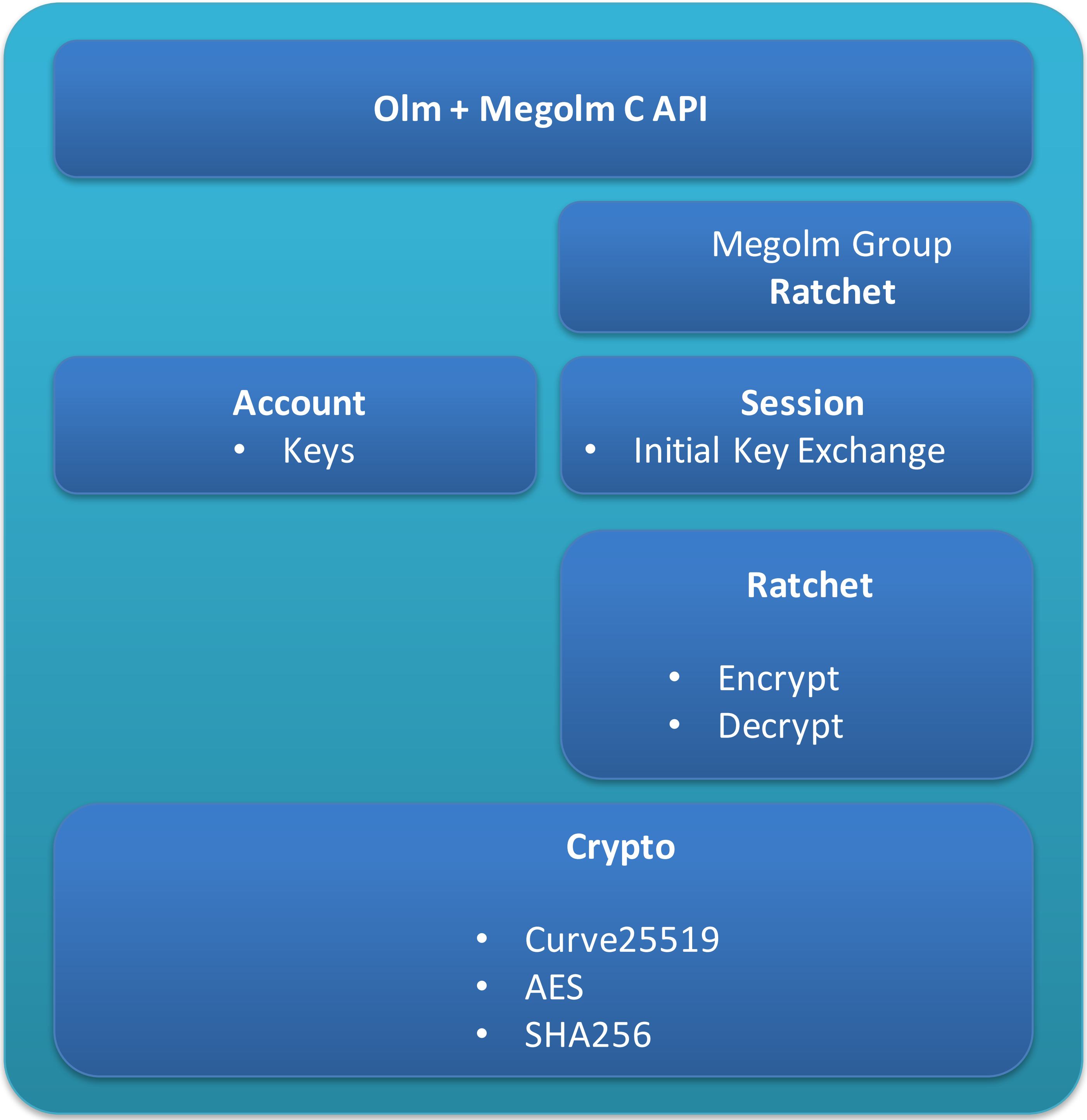
https://matrix.org/git/olm

End to End Encryption

- Based on Open Whisper Systems' "Double Ratchet" algorithm as used in Signal etc.
- Public audit by NCC Group
- Started beta roll-out in Sept 2016 on Web
- Beta launched Nov 21 2016 on iOS+Android
- Keys are per-device, not per-user (currently)
- So encryption is per-device.
- Supports flexible history privacy per-room.

Olm

- Apache License C++11 implementation of Double Ratchet, exposing a C API.
- Supports encrypted asynchronous 1:1 communication.
- “Megolm” layer adds group communication too.
- ~150KB x86-64 .so, or ~250KB of asm.js



Olm + Megolm C API

Megolm Group **Ratchet**

Account

- Keys

Session

- Initial Key Exchange

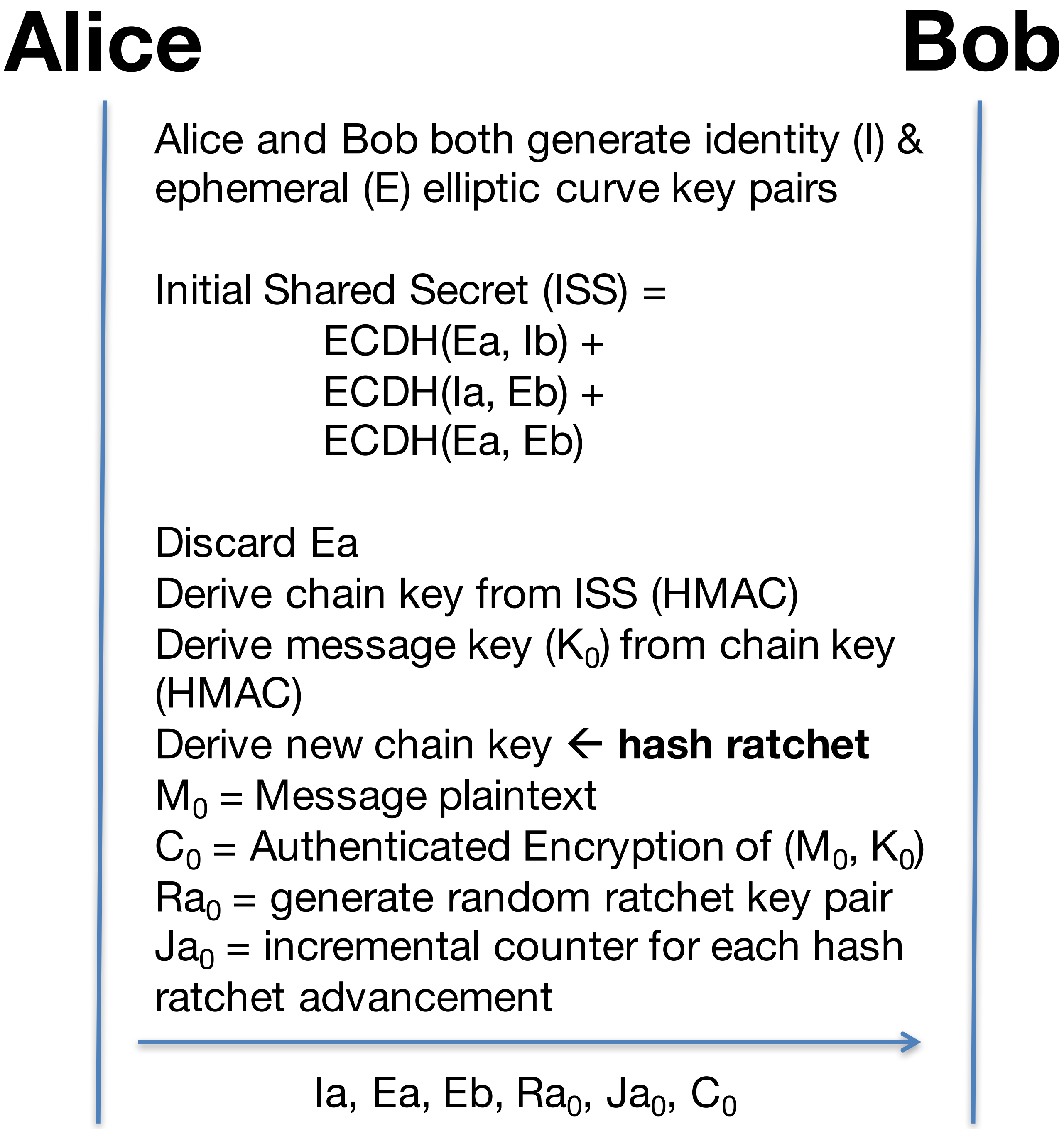
Ratchet

- Encrypt
- Decrypt

Crypto

- Curve25519
- AES
- SHA256

A Double ratchet.
Kinda sorta.



Alice

Bob

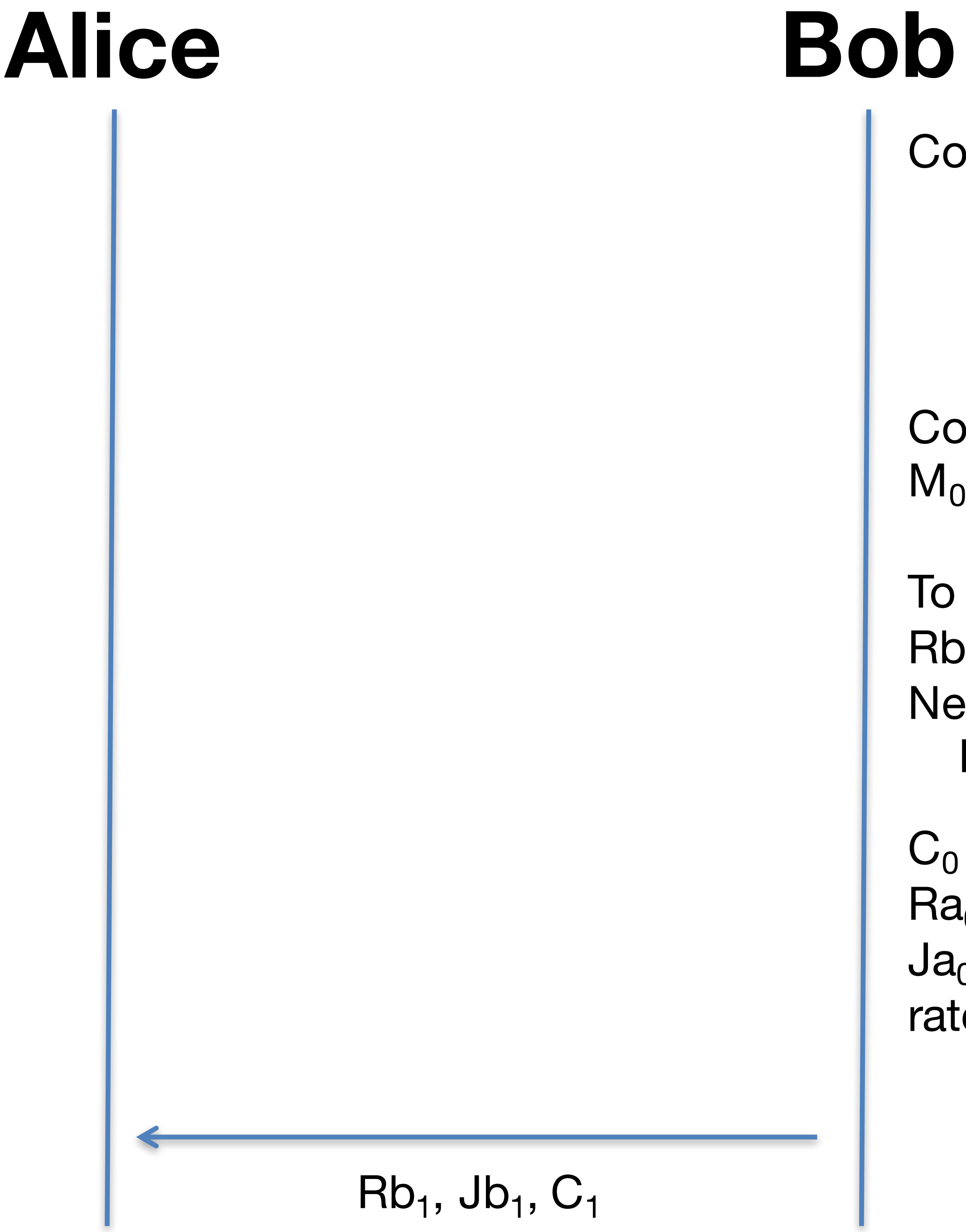
Alice and Bob both generate identity (I) & ephemeral (E) elliptic curve key pairs

Initial Shared Secret (ISS) =
ECDH(Ea, Ib) +
ECDH(Ia, Eb) +
ECDH(Ea, Eb)

Discard Ea
Derive chain key from ISS (HMAC)
Derive message key (K_0) from chain key (HMAC)
Derive new chain key ← **hash ratchet**
M_0 = Message plaintext
C_0 = Authenticated Encryption of (M_0, K_0)
Ra_0 = generate random ratchet key pair
Ja_0 = incremental counter for each hash ratchet advancement

Ia, Ea, Eb, Ra_0, Ja_0, C_0

A Double ratchet. Kinda sorta.



Alice

Bob

Rb_1, Jb_1, C_1

Compute same Initial Shared Secret =
ECDH(Ea, Ib) +
ECDH(Ia, Eb) +
ECDH(Ea, Eb)

Compute same K_0
M_0 = Authenticated decryption of (C_0, K_0)

To respond, B starts new ratchet chain:
Rb_1 = generate random ratchet key pair
New Initial Shared Secret =
ECDH(Ra_0, Rb_1) ← **ECDH Ratchet**

C_0 = Authenticated Encryption of (M, K_0)
Ra_0 = generate random ratchet key
Ja_0 = incremental counter for each hash ratchet advancement

```
              Alice

    Sending     |     Receiving

MK      CK      RK      CK      MK
--      --      --      --      --
            ECDH(A0,B0)
                |
                |
    ECDH(A1,B0) +
               /|
              / |
             /  + ECDH(A1,B1)
     CK-A1-B0   |\
         |      | \
MK-0 ----+      |  \
         |      |   CK-A1-B1
MK-1 ----+      |       |
         |      |       +---- MK-0
MK-2 ----+      |       |
                |       +---- MK-1
    ECDH(A2,B1) +
               /|
              / |
             /  |
     CK-A2-B1   |
         |      + ECDH(A2,B2)
MK-0 ----+       \
                  \
                   \
                    CK-A2-B2
                        |
                        +---- MK-0
                        |
                        +---- MK-1
```

Group chat

- Adds a 3rd type of ratchet: “**Megolm**”, used to encrypt group messages.
- Simple hash ratchet, which can be fast-forwarded to ease sharing ratchet details.
- Each sender maintains its own ratchet per room
- Establish 'normal' 1:1 ratchets between all participant devices in order to share the initial secret for a sender’s group ratchet session.
- Ratchets are replaced when users leave, on demand, or every N messages

Flexible privacy with Megolm

- Rooms can be configured to have:
  - No ratchet (i.e. no crypto)
  - Full PFS ratchet
  - Selective ratchet
    - Deliberately share megolm ”session keys” to support paginating partial eras of history.
    - Up to participants to trigger the ratchet (e.g. when a member joins or leaves the room)

Olm: What’s next?

- Debugging!
- Backing up & restoring megolm session ratchet data
- Sharing session ratchet data with new devices or new room participants
- Cross-signing device keys?
- Better device verification
- Better push notification UX for E2E rooms
- Better primitives & performance
- Turning on E2E by default for rooms with private history
- Negotiating E2E with legacy clients(?)

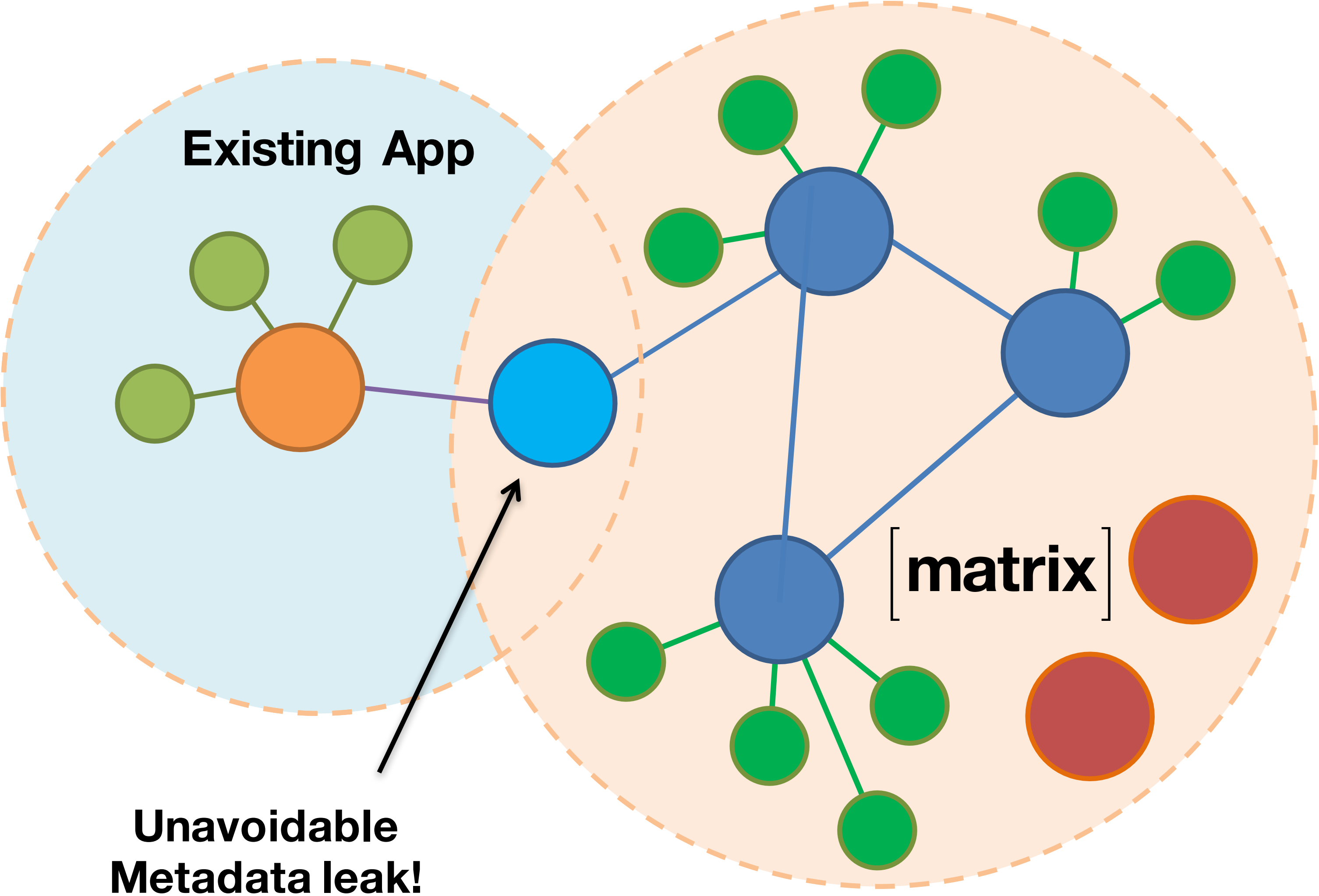
So, what about protecting metadata?

(i.e. hiding who's talking to who and when?)

Matrix is all about pragmatically fixing today's vendor lock-in problem.

You can't bridge existing networks without exposing who's talking to who.

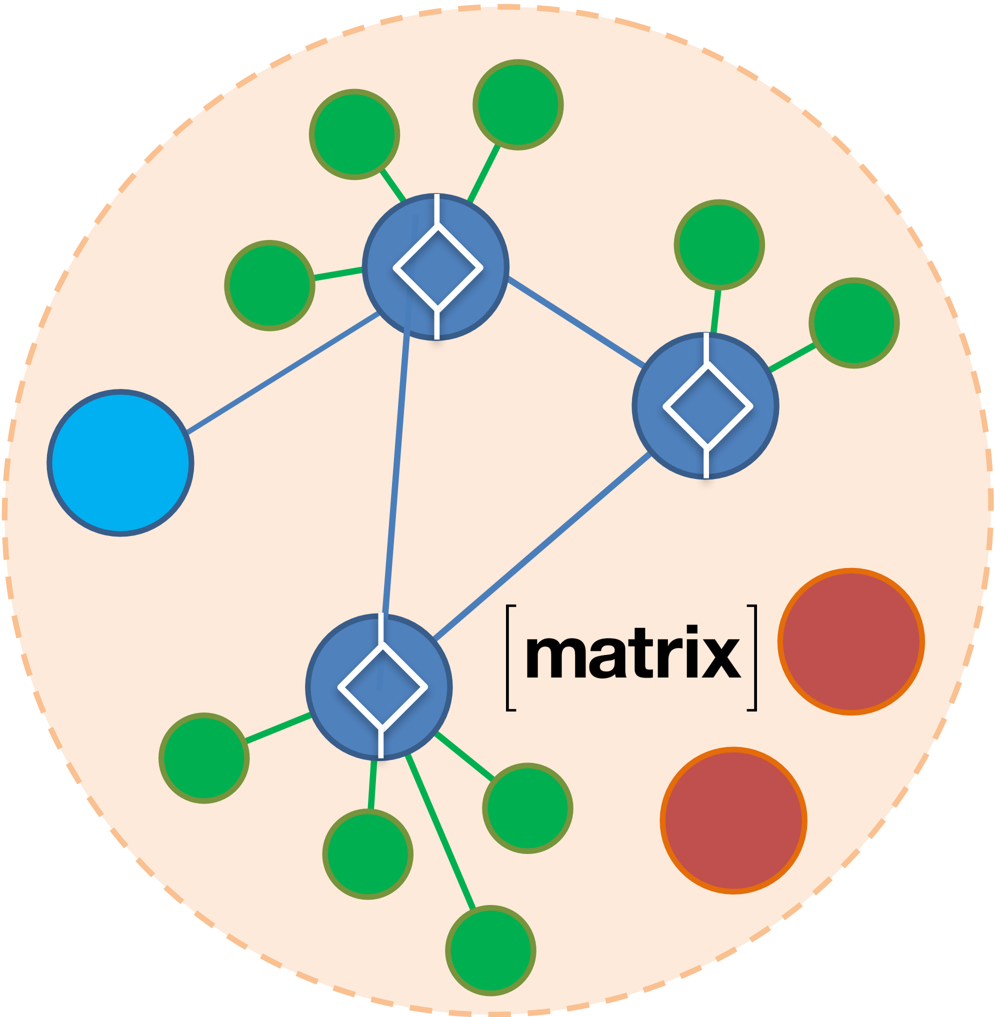
Bridges expose metadata



Unavoidable
Metadata leak!

That said, Matrix also exposes metadata on Home Servers:

Home Servers expose metadata too



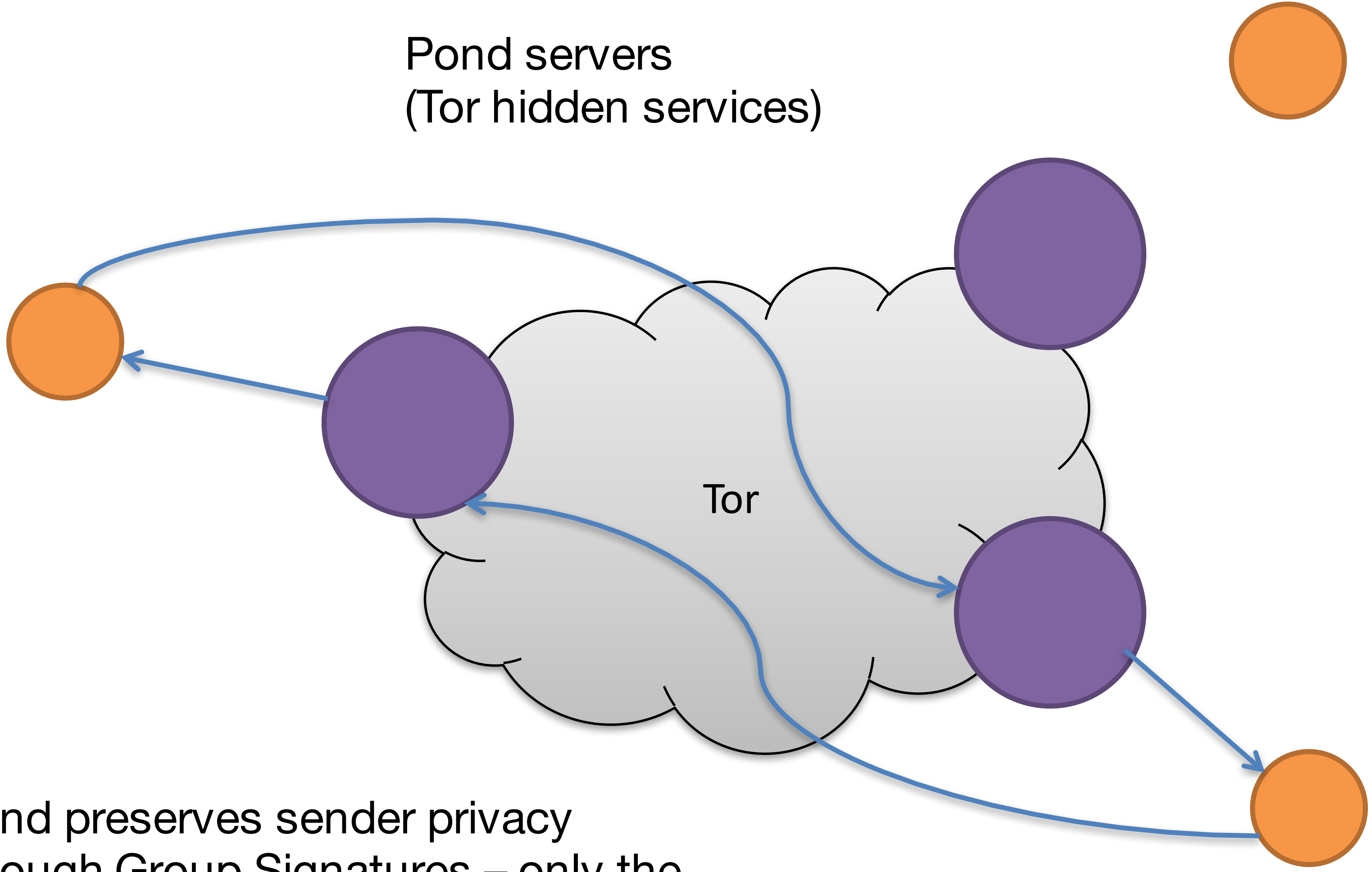
Can we do better?

Apps like Pond show that you can obfuscate metadata quite effectively:

Pond

Pond clients,
storing encrypted
history

Pond servers
(Tor hidden services)



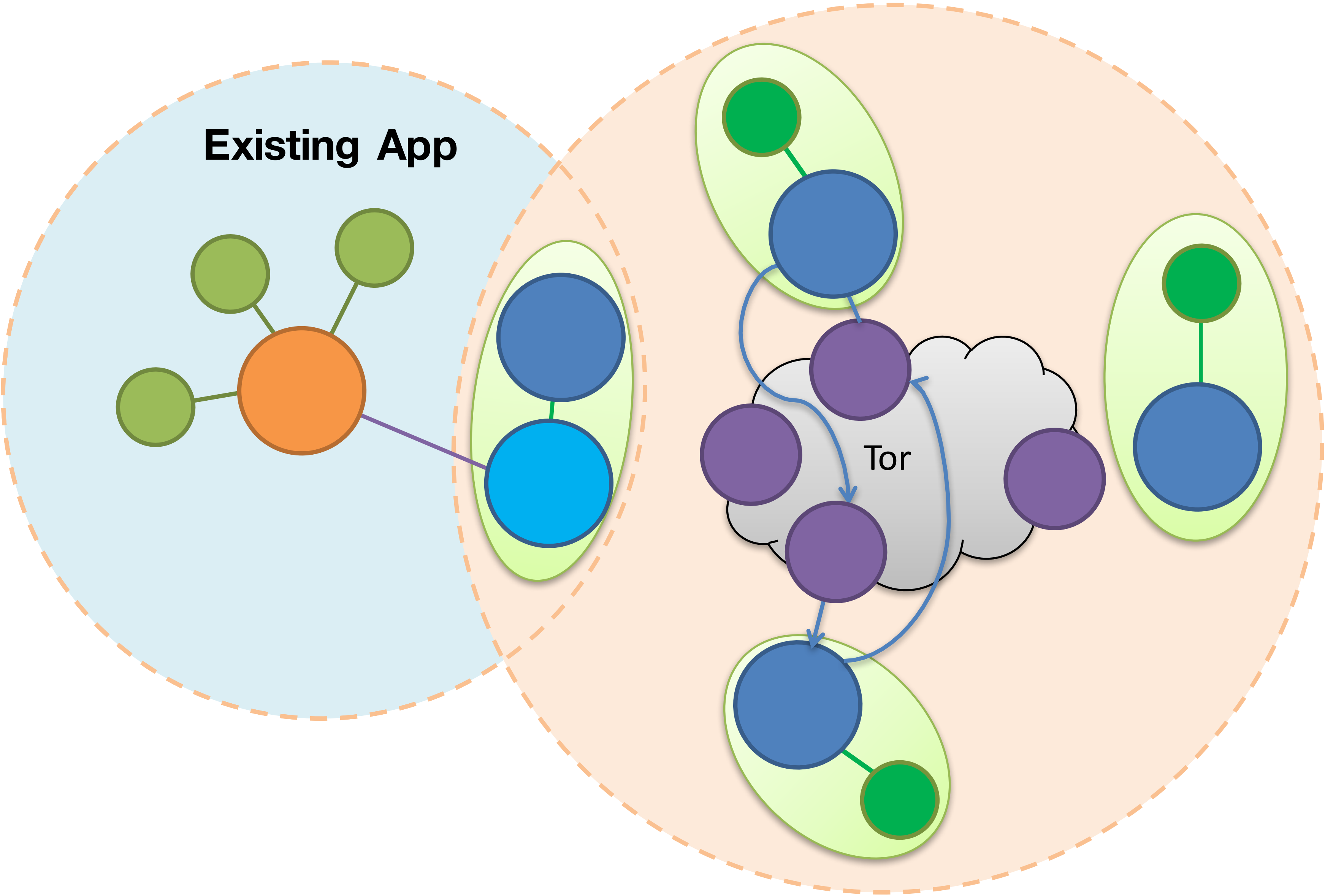
Pond preserves sender privacy through Group Signatures – only the client can decrypt who the message was from.

Matrix was designed to evolve and support future network architectures and privacy strategies.

Thought Experiment: Could Matrix adopt a Pond-like strategy?

- **Move home servers onto the client.**
- **Use pond-style Tor hidden services for store-and-forward of encrypted messages.**
- **Migrate incrementally from 'classic' DAG federation.**

Matrix with Pond strategy



Advantages over pure Pond

- Supports any and all Matrix clients via the existing standard client-server API
- Supports decentralised conversation history by tunnelling HS federation over Pond
- Supports bridging to other networks via existing Matrix AS API or classic Matrix Federation – at expense of privacy. Mitigated by disabling bridging/federation per-room.

matrix

Thank you!

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