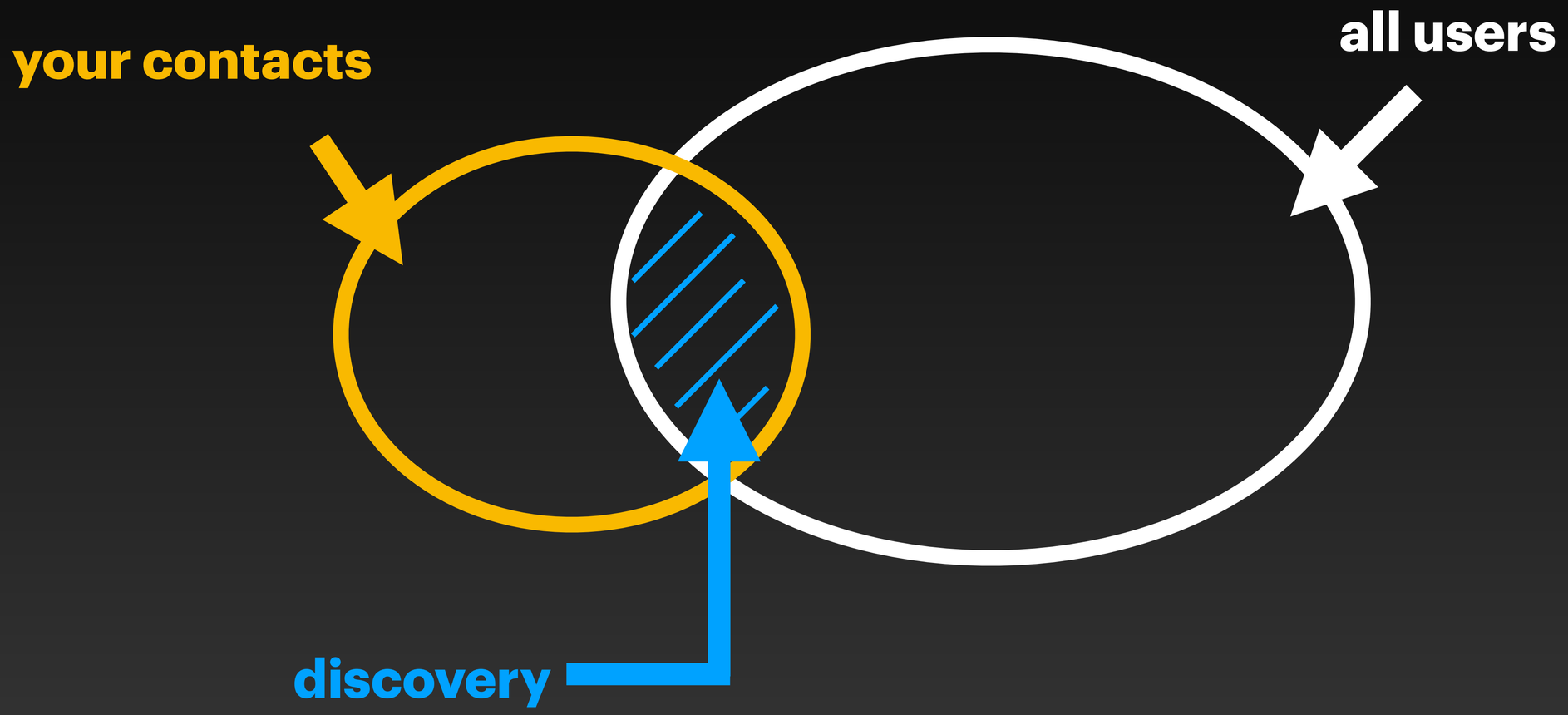
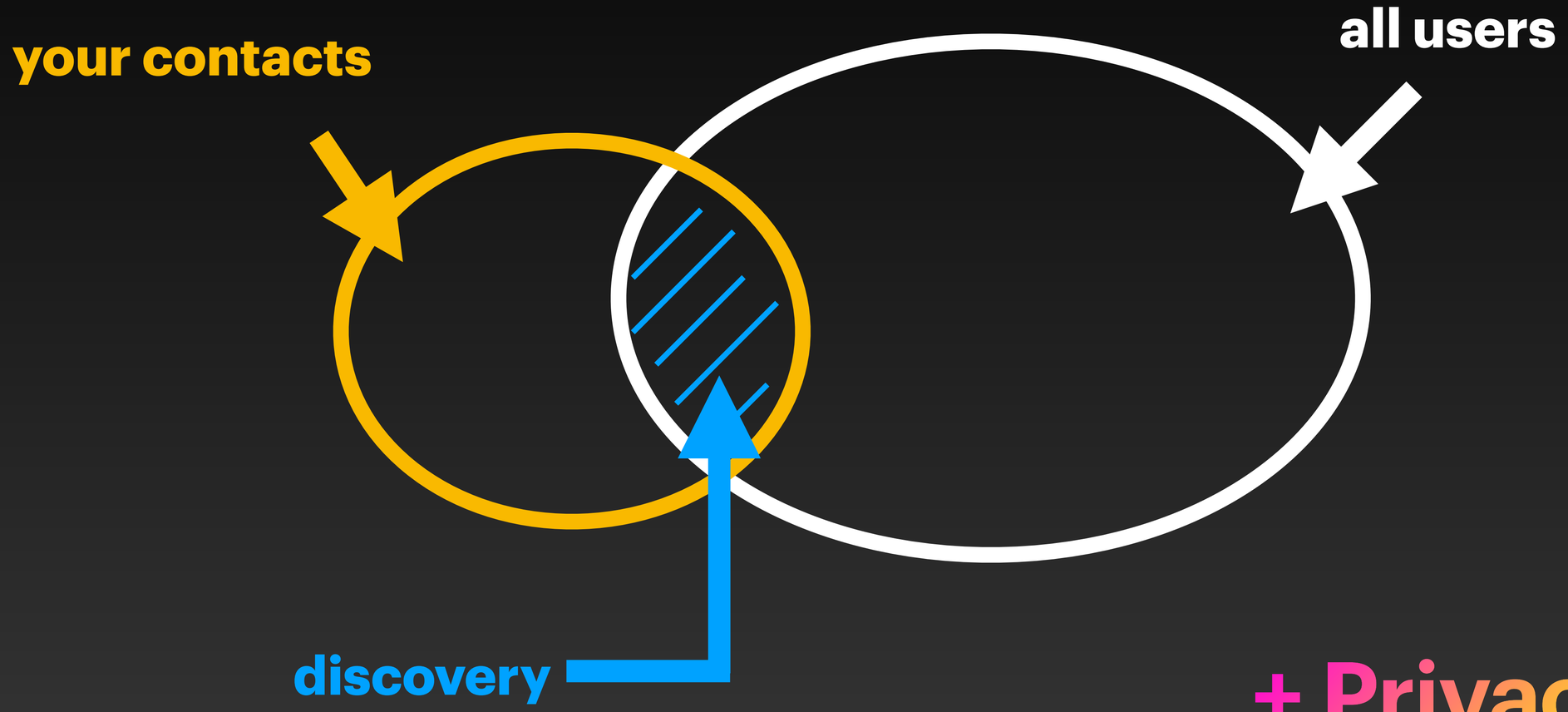
Arke

Scalable and Byzantine Fault Tolerant Privacy-Preserving Contact Discovery

Alberto Sonnino


your contacts
all users
discovery



+ Privacy

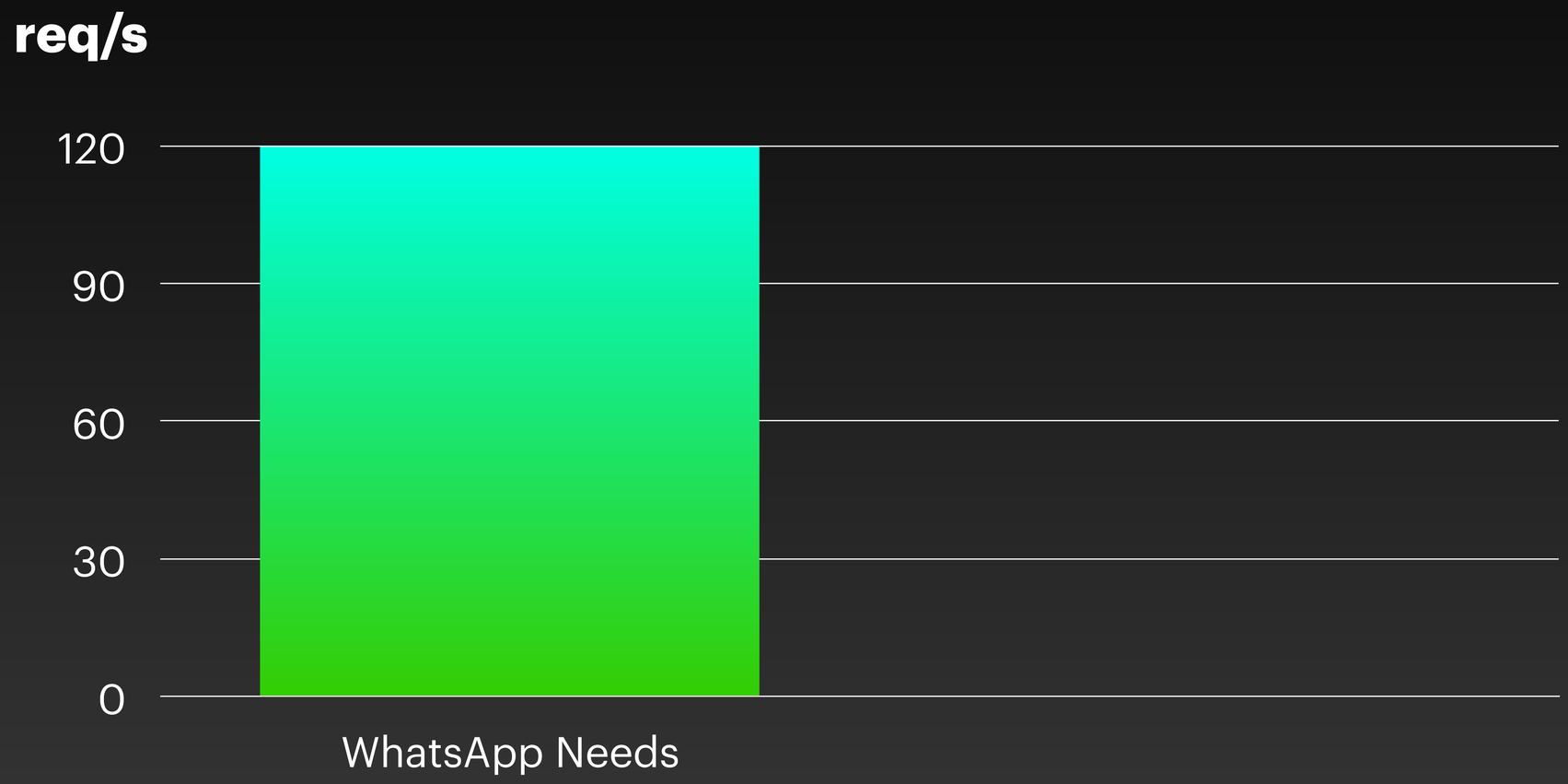
Web2 Needs

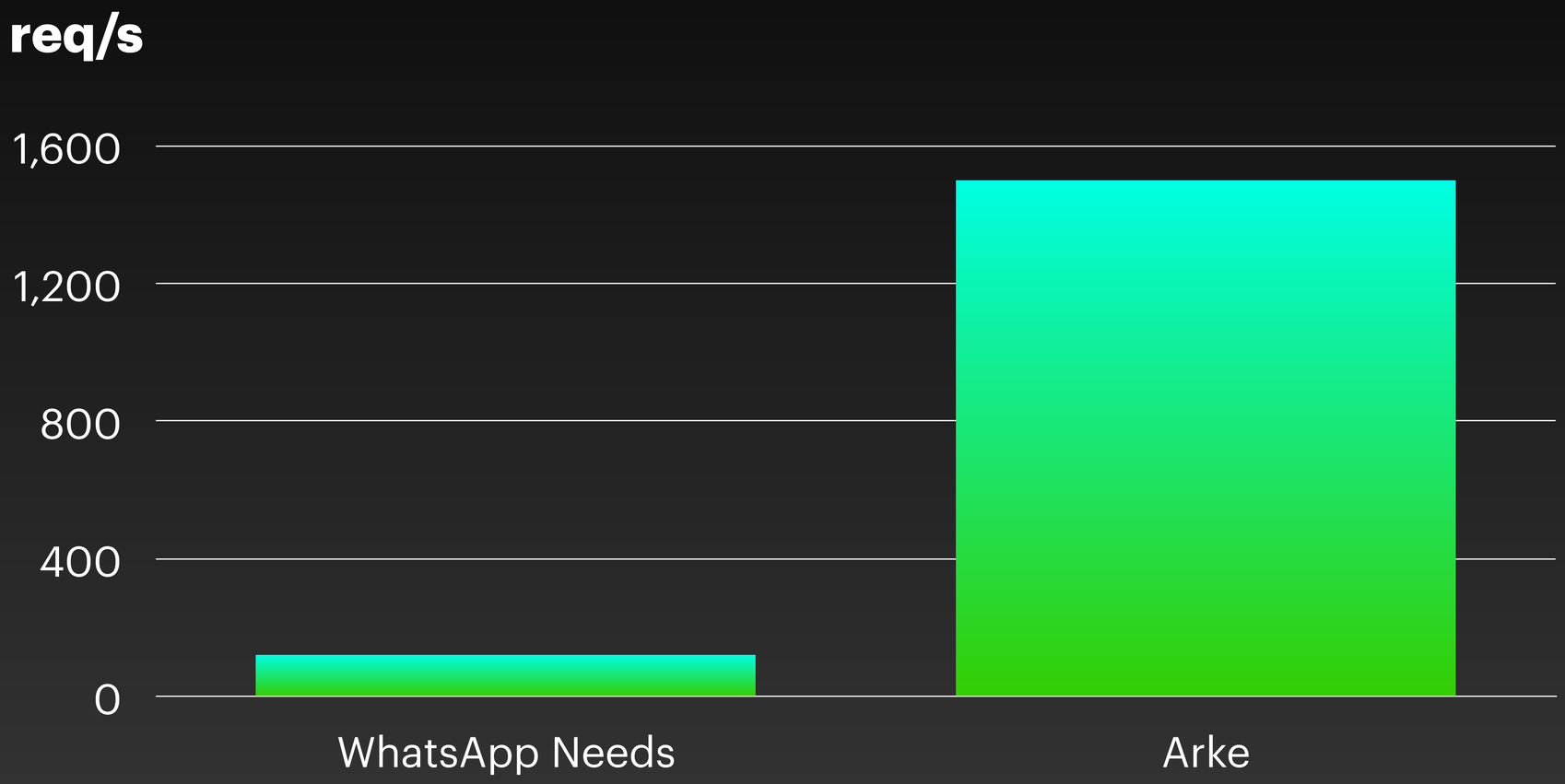
- 10 Million requests / day

Web3 Needs

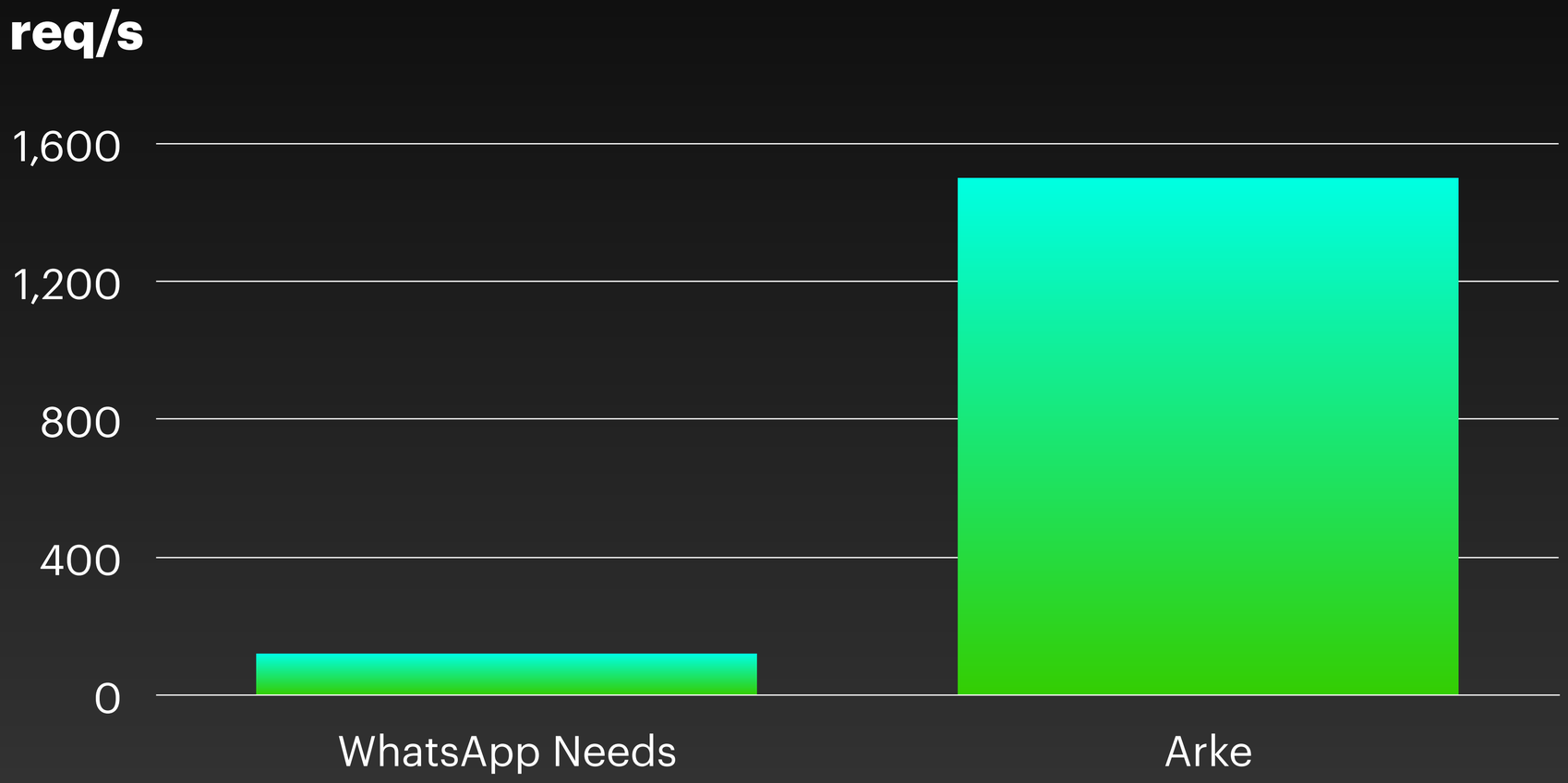
- Decentralisation

- O(1) — independent of the total number of users
- Byzantine Fault Tolerant

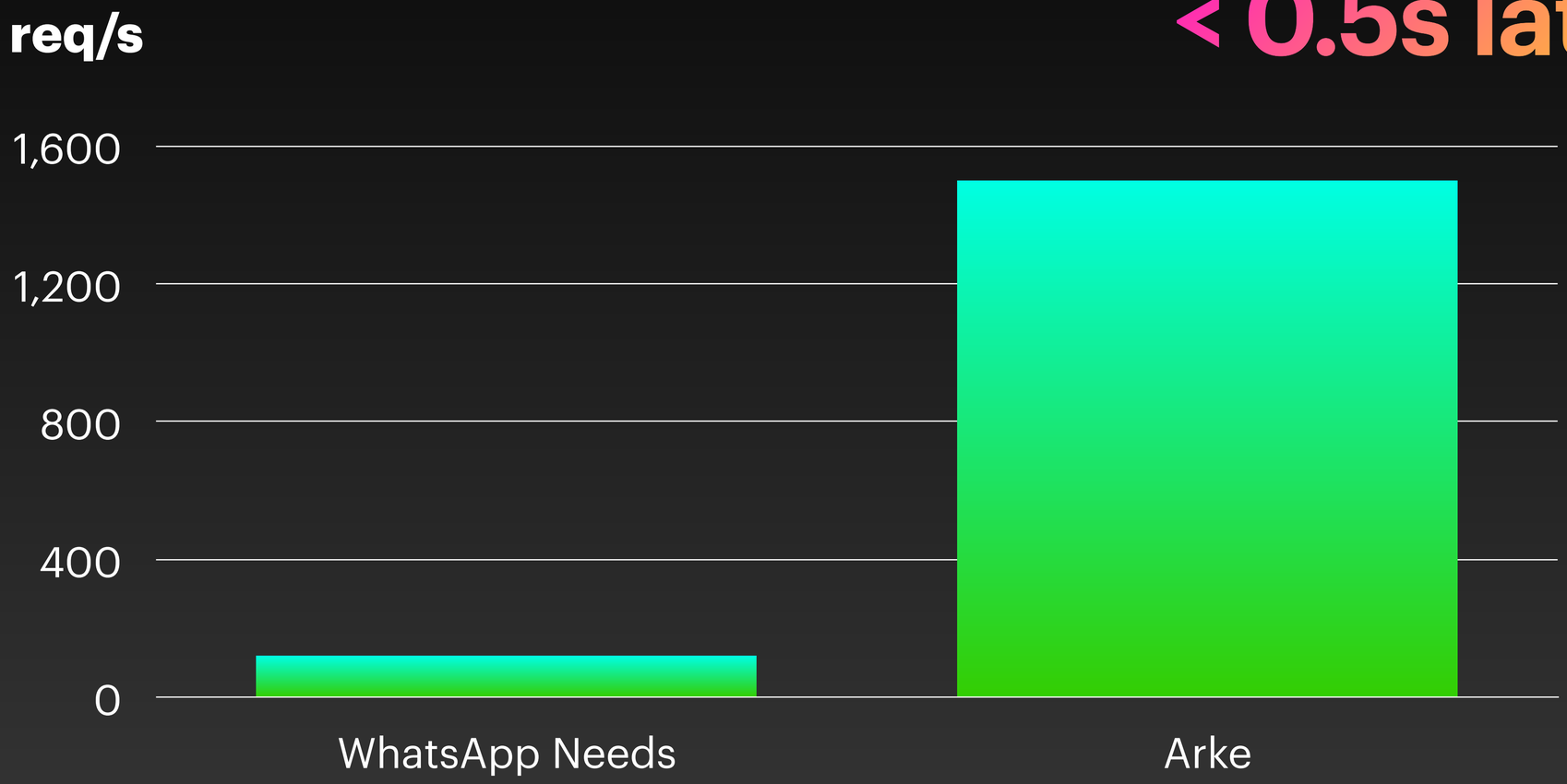

req/s
120
90
60
30
0
WhatsApp Needs

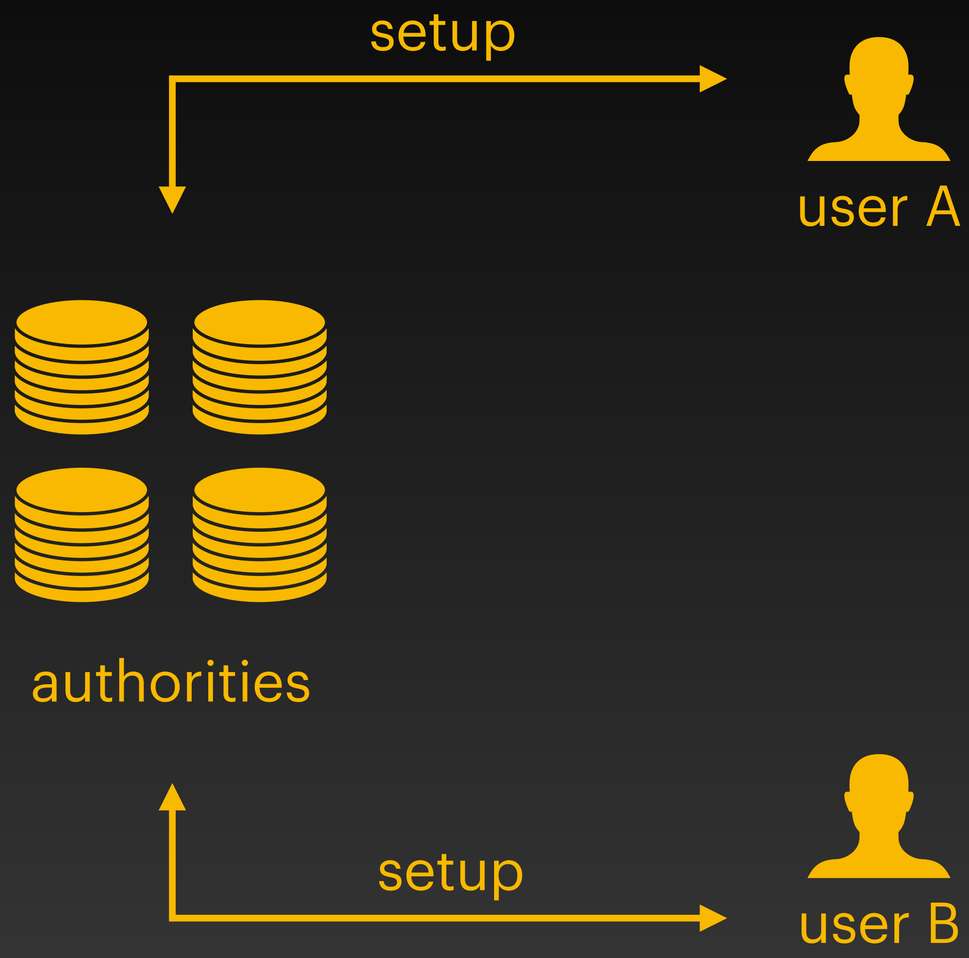

req/s
1,600
1,200
800
400
0
WhatsApp Needs
Arke

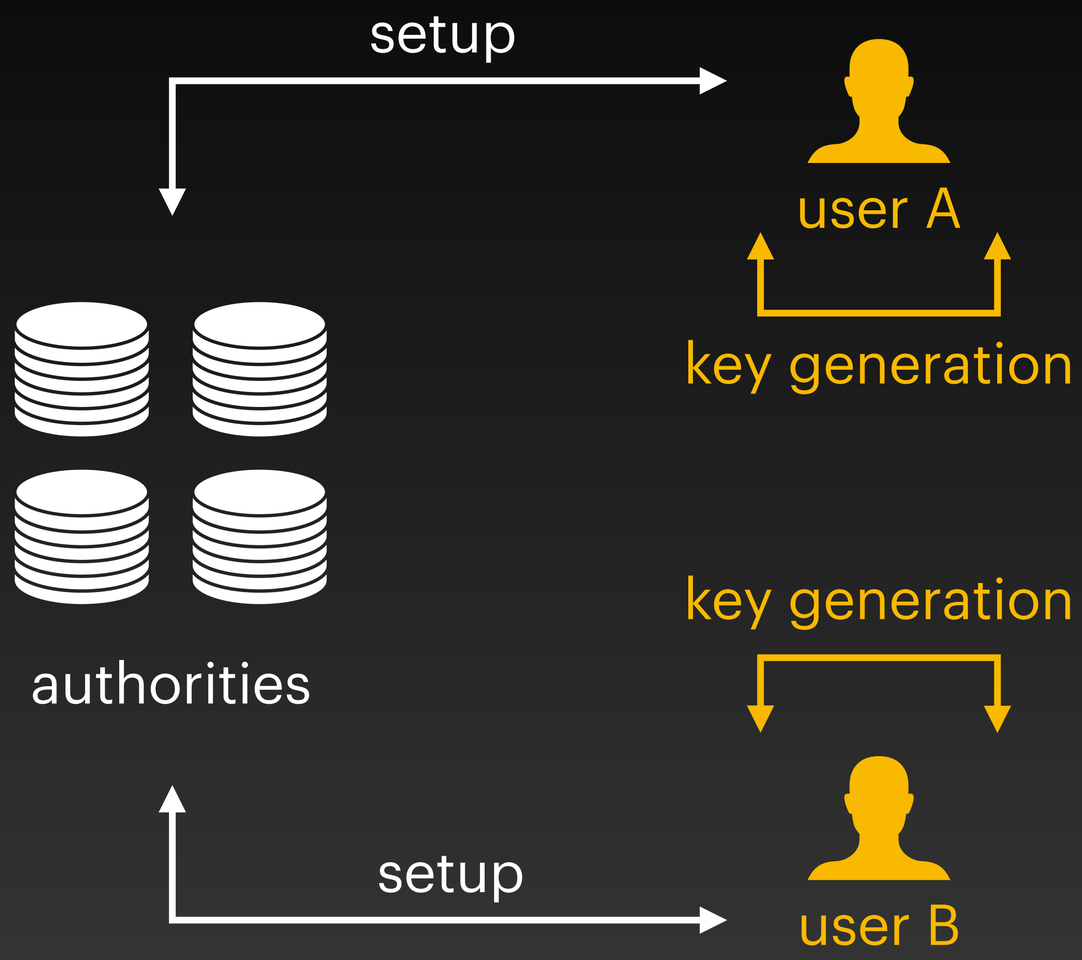
50 nodes

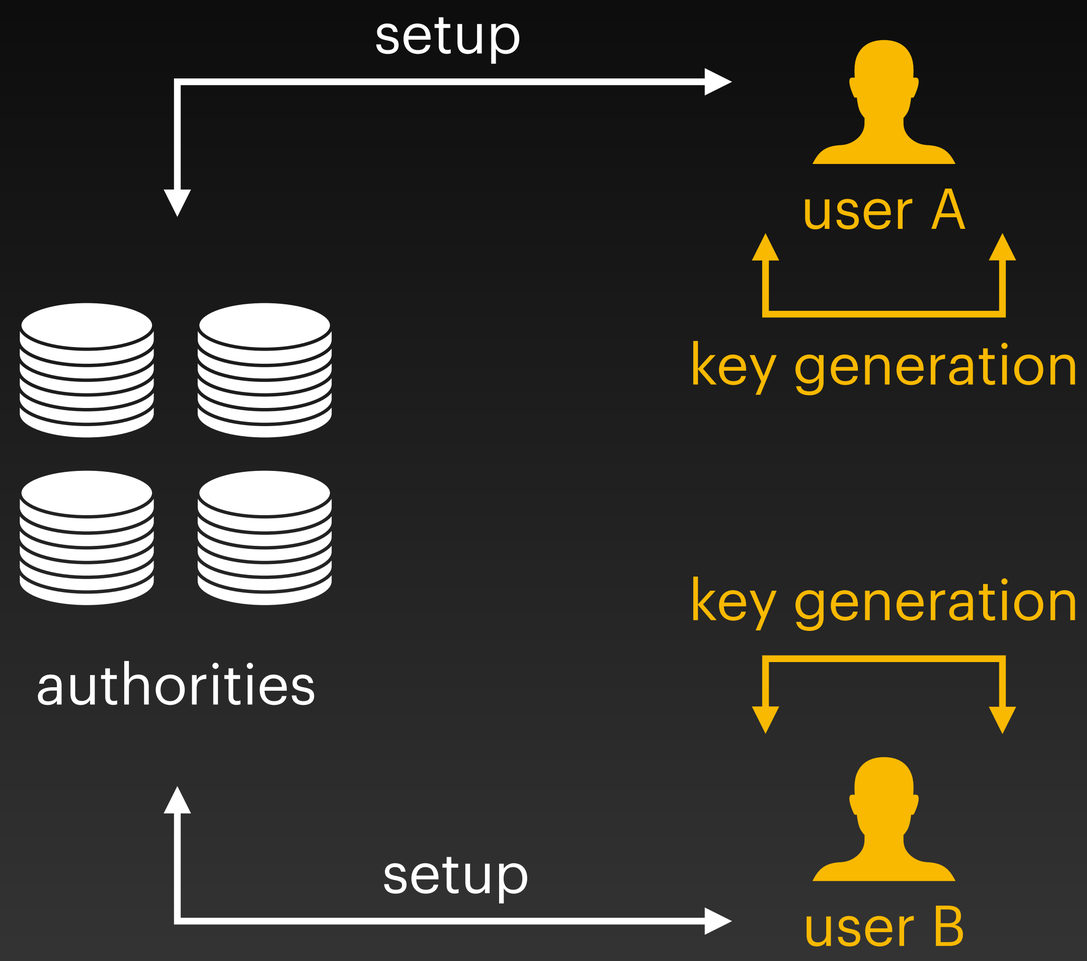


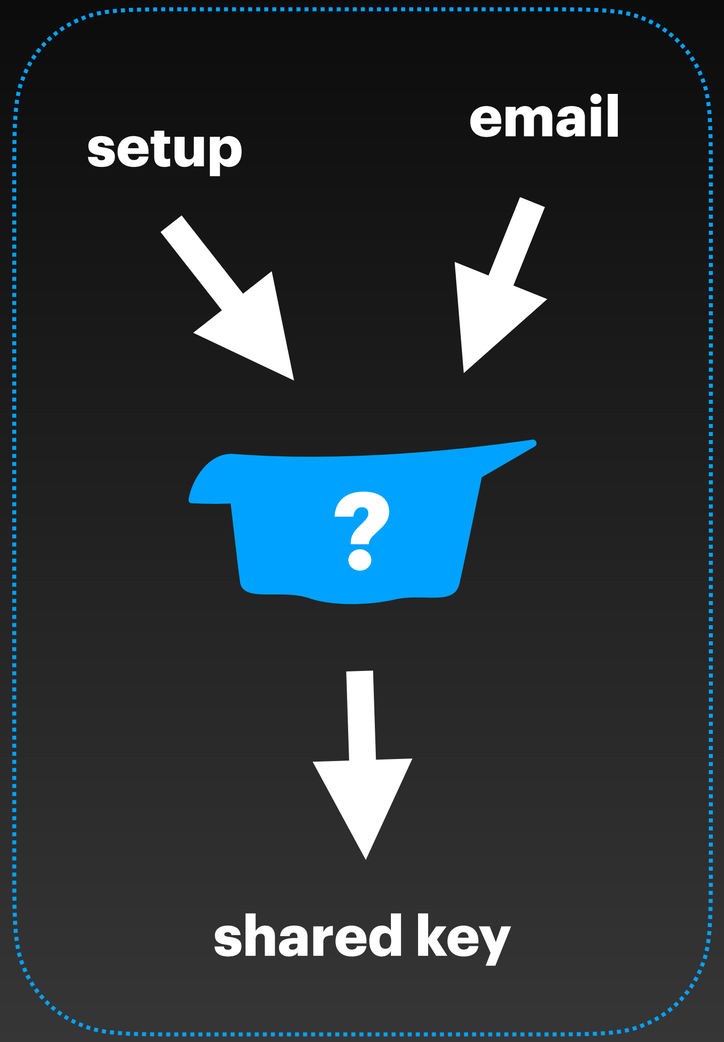
50 nodes
< 0.5s latency

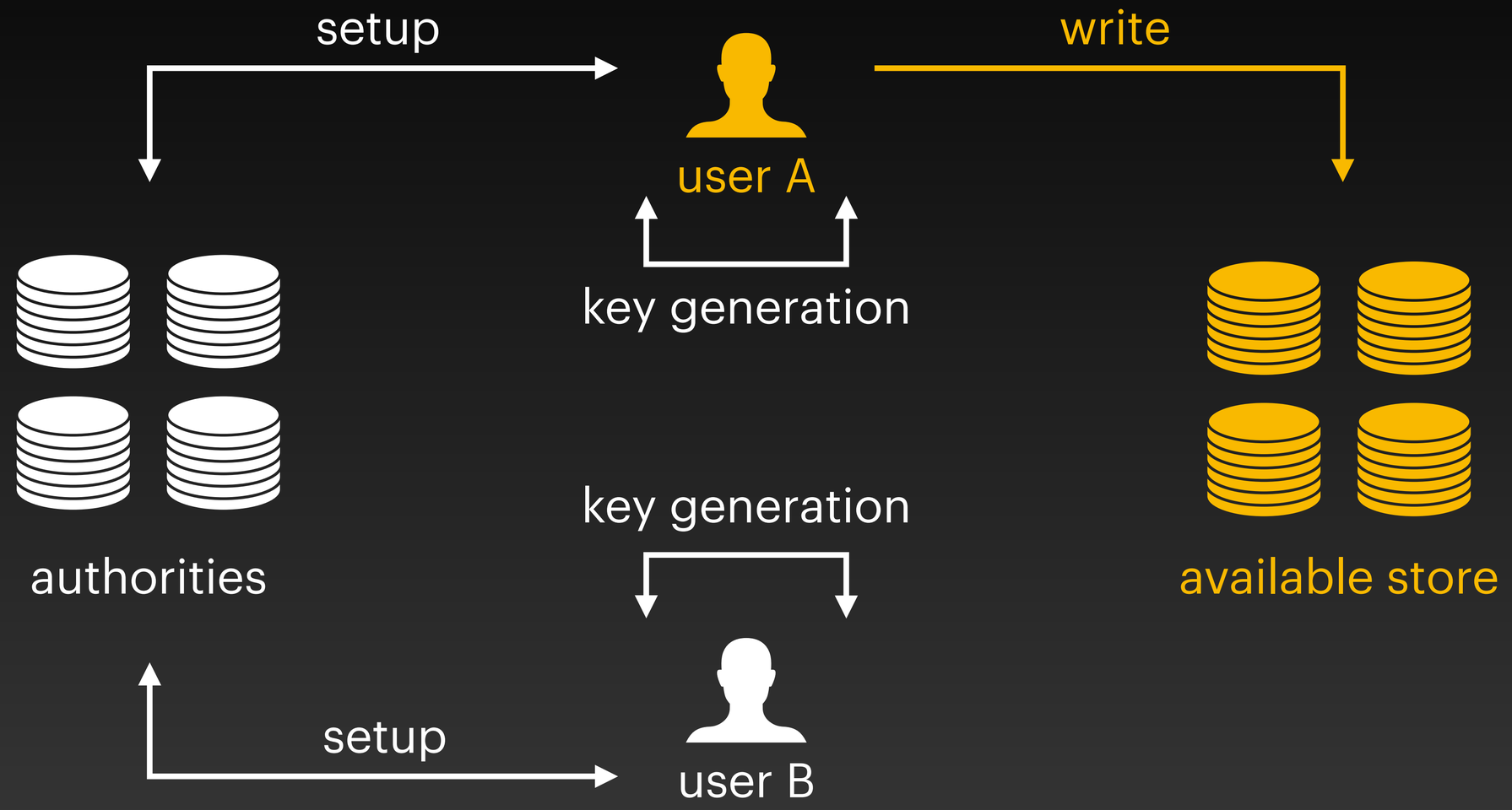


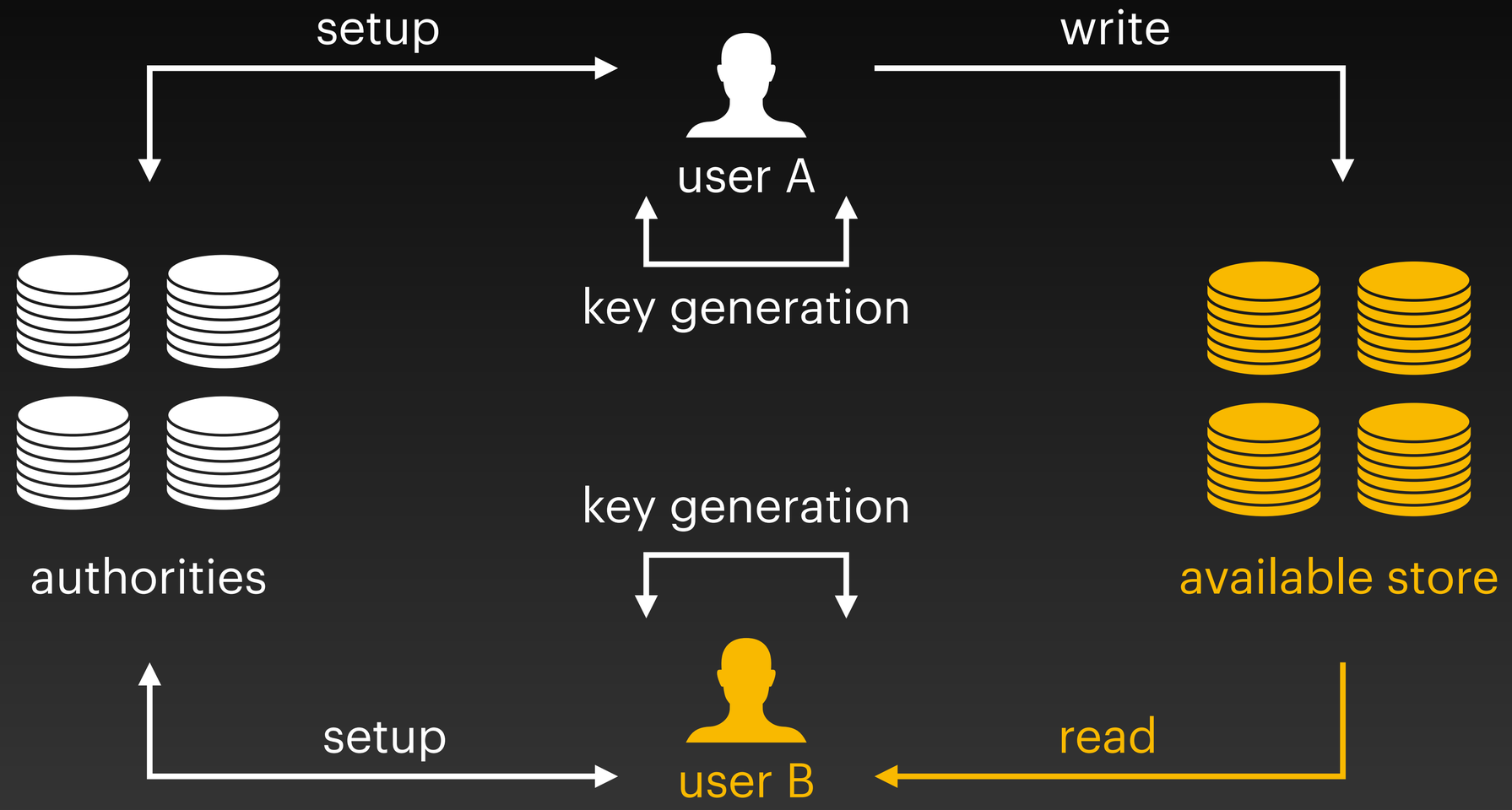

setup
user A
authorities
setup
user B


setup
user A
key generation
key generation
authorities
setup
user B

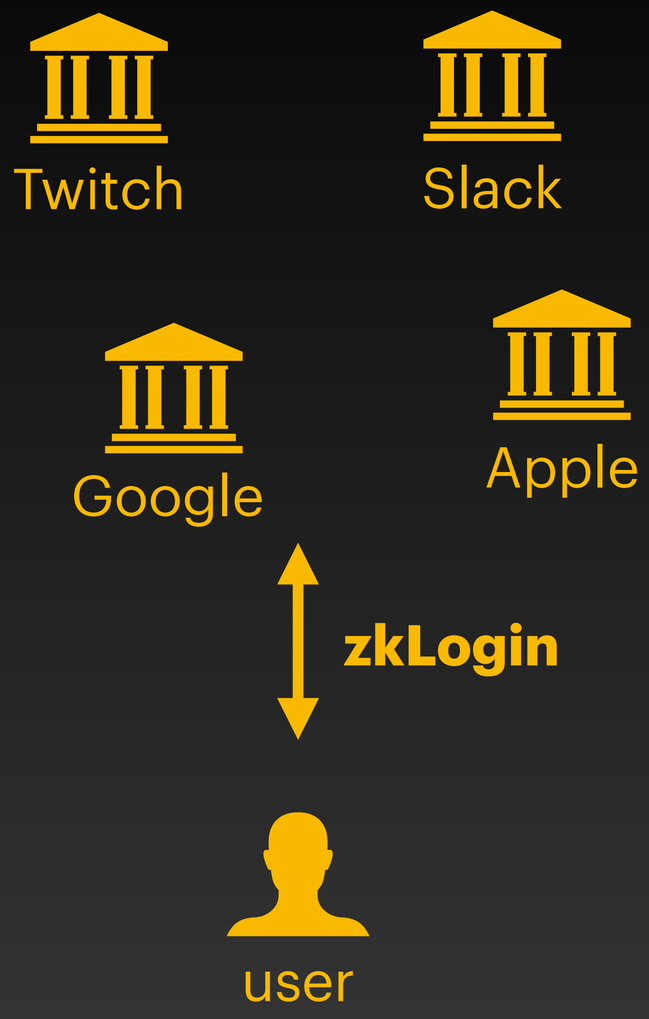

setup
user A
key generation
authorities
key generation
setup
user B

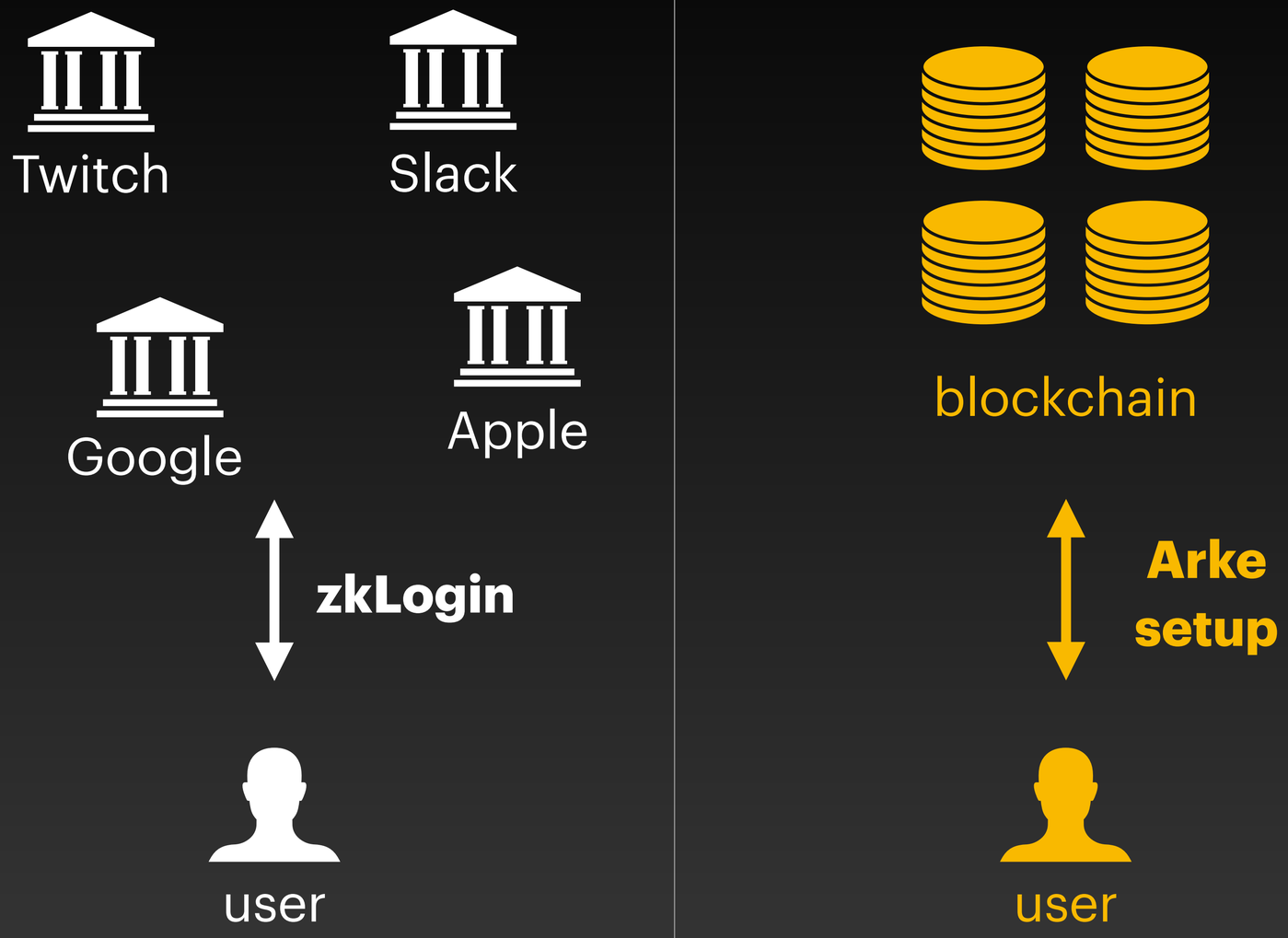

setup
email
?
shared key

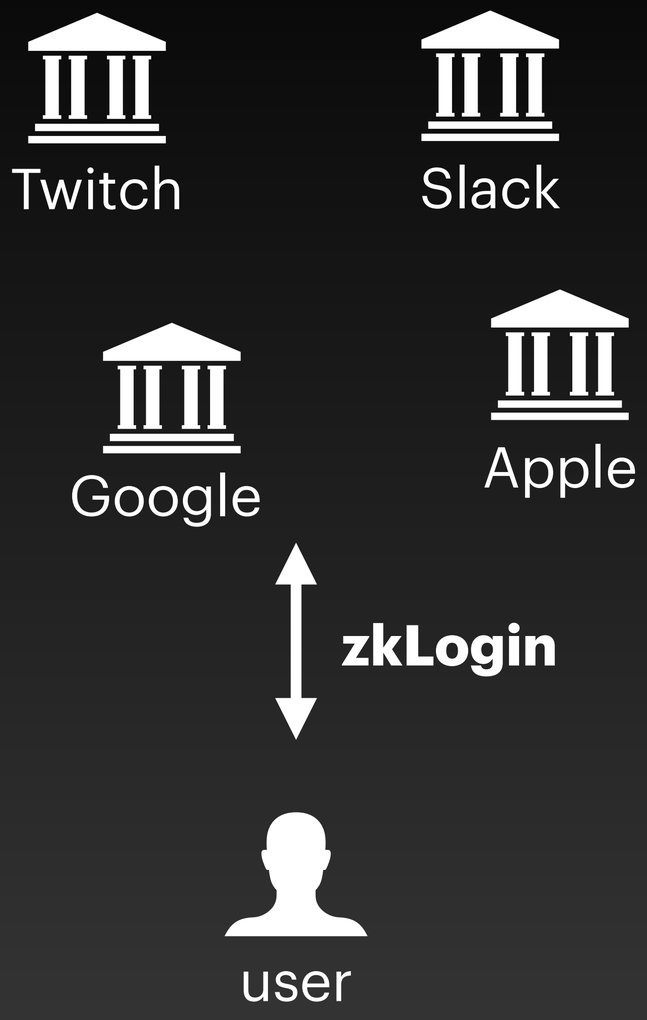

setup
write
user A
key generation
authorities
key generation
available store
setup
user B

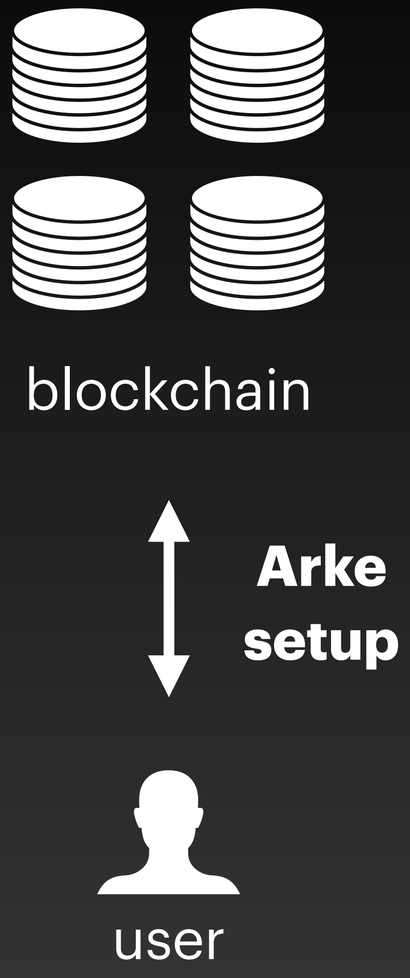

setup
write
user A
key generation
authorities
key generation
available store
setup
user B
read

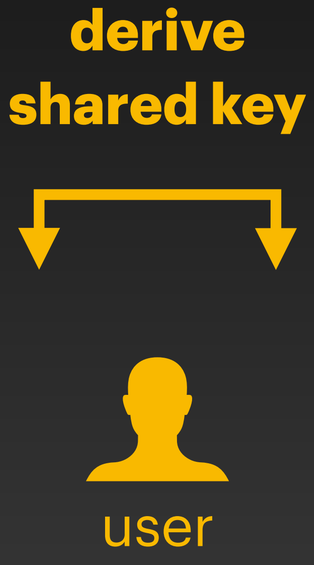
What about blockchains?


Twitch
Slack
Google
Apple
zkLogin
user


Twitch
Slack
Google
Apple
zkLogin
user
blockchain
Arke
setup
user


Twitch
Slack
Google
Apple
zkLogin
user


blockchain
Arke
setup
user


derive
shared key
user

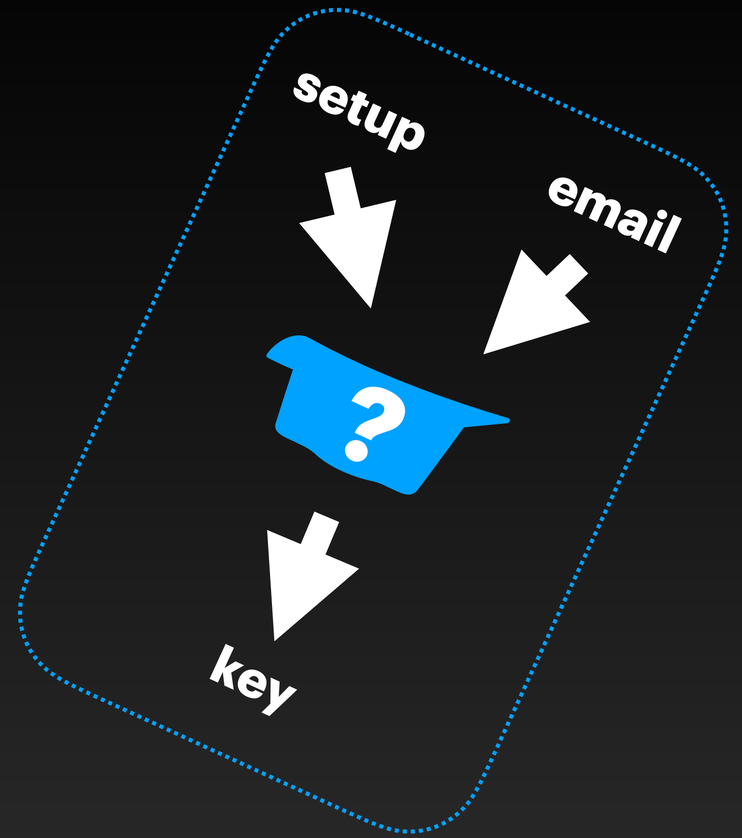
More than private chats

- Decentralised messaging
- Bootstrap multi-user gaming sessions
- Airdrops / payments even before recipient has an account

Paper

alberto@mystenlabs.com

Paper



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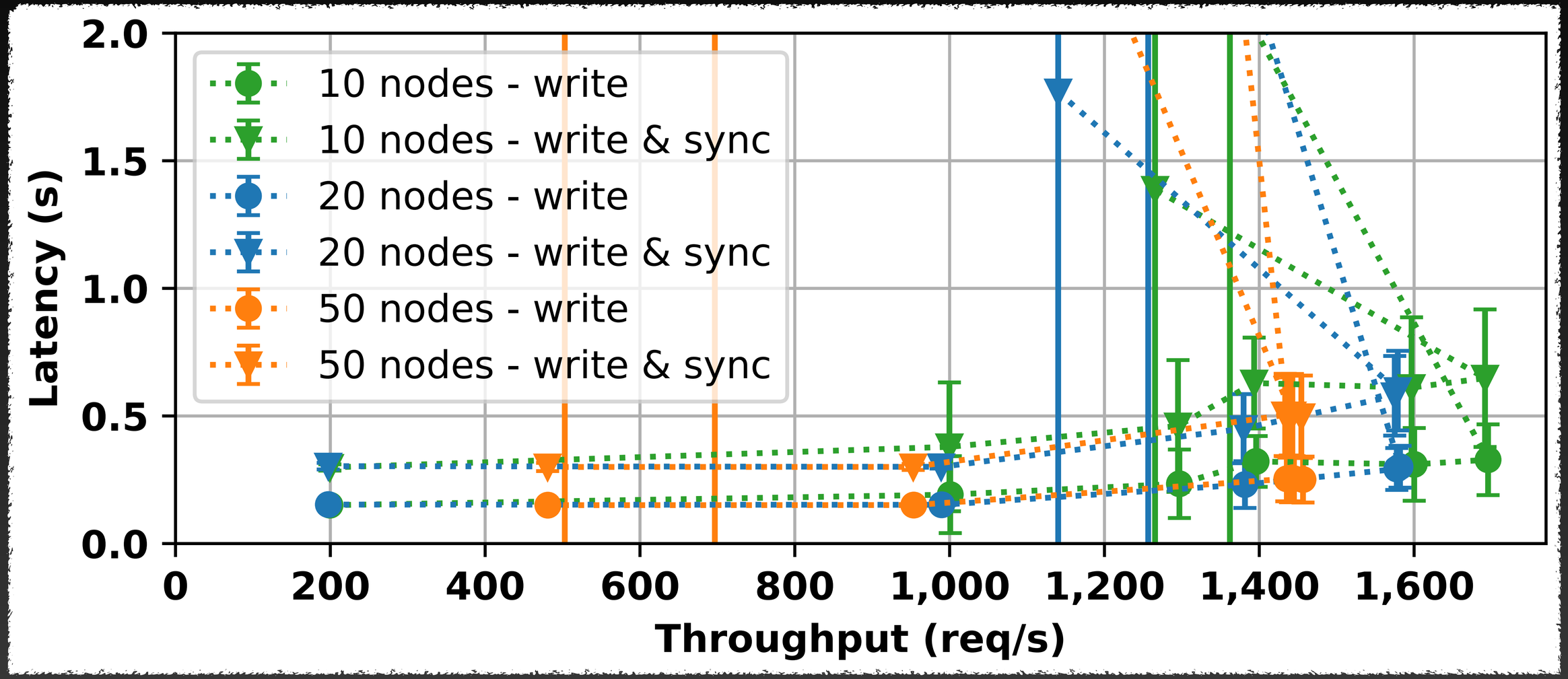
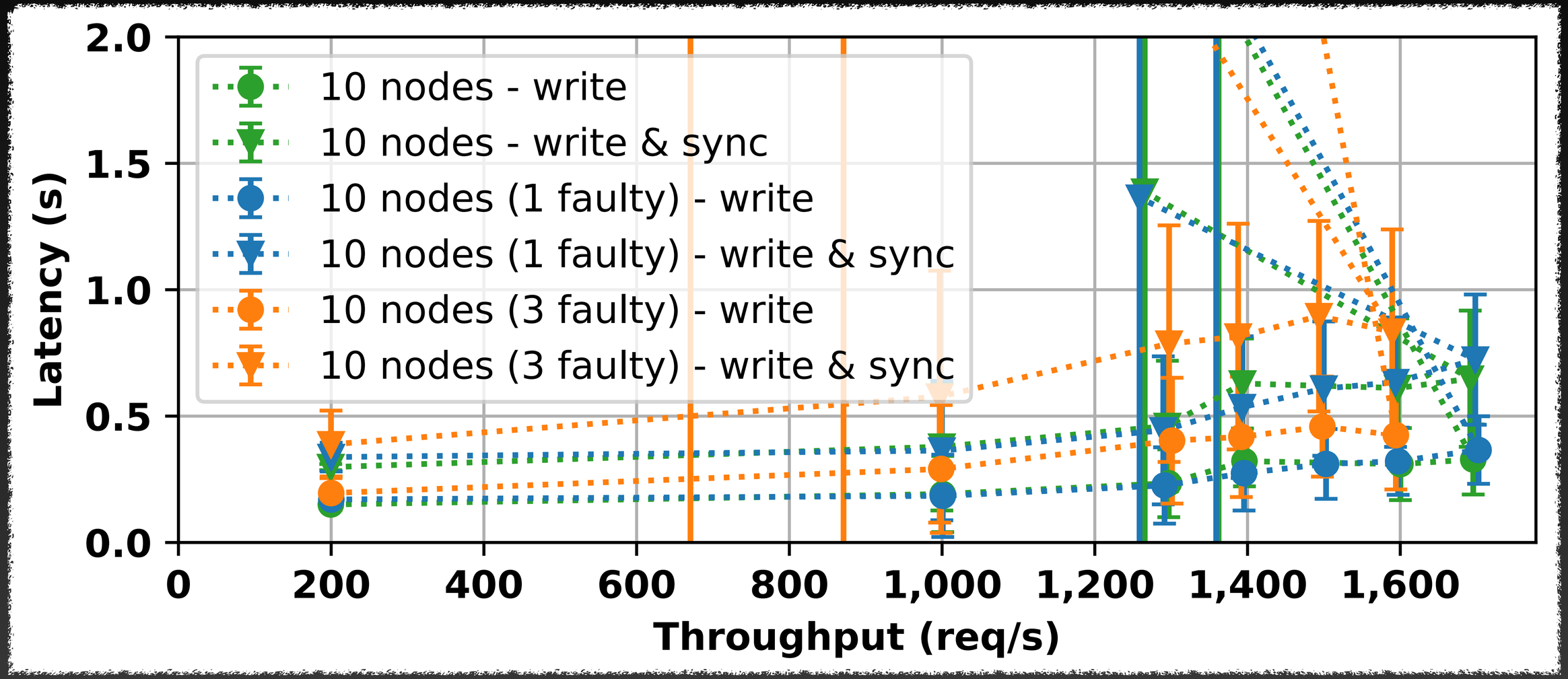
L-Graphs

Performance



Performance



The Crypto

Setup

$w\ ,\ pk_{w_1} \in G_1\ ,\ pk_{w_2} \in G_2$

IdP

$t_1 = H_1(n_A)^w \in G_1$

$t_2 = H_2(n_A)^w \in G_2$

Prove ownership of email/phone number n_A

user

user

$a \leftarrow Z_q$

$\sigma_1 = t_1^a\ ,\ \ m_1 = H_1(n_A)^a$

$\sigma_2 = t_2^a\ ,\ \ m_2 = H_2(n_A)^a$

$s\ ,\ pk_{s_1} \in G_1\ ,\ pk_{s_2} \in G_2$

Blockchain

$BLS\ .\ vrfy(\sigma_1, m_1, pk_{w_1})$

$SLB\ .\ vrfy(\sigma_2, m_2, pk_{w_2})$

$m_1^s = H_1(n_A)^{as}$

$m_2^s = H_2(n_A)^{as}$

user

$k_1 = H_1(n_A)^s = (m_1^s)^{-a}$

$k_2 = H_2(n_A)^s = (m_2^s)^{-a}$

Key Derivation

user A

$$S_{AB} = e(k_1, H_2(n_B)) = e(H_1(n_A)^s, H_2(n_B))$$
$$S_{BA} = e(H_1(n_B), k_2) = e(H_1(n_B), H_2(n_A)^s)$$

$$k_{AB} = KDF(S_{AB}\ XOR\ S_{BA})$$

$$key = g_1^{t_{AB}}\ ,\ \ t_{AB} = H(s_{AB})$$
$$val = c_{AB} = AEAD_k(pk_A)$$

user B

$$S_{AB} = e(H_1(n_A), k_2) = e(H_1(n_A), H_2(n_B)^s)$$
$$S_{BA} = e(k_1, H_2(n_A)) = e(H_1(n_B)^s, H_2(n_A))$$

$$k_{AB} = KDF(S_{AB}\ XOR\ S_{BA})$$

$$key = g_1^{t_{BA}}\ ,\ \ t_{BA} = H(s_{BA})$$
$$val = c_{BA} = AEAD_k(pk_B)$$

Sui is special

user A

$$S_{AB} = e(k_1, H_2(n_B)) = e(H_1(n_A)^s, H_2(n_B))$$
$$S_{BA} = e(H_1(n_B), k_2) = e(H_1(n_B), H_2(n_A)^s)$$

$$k_{AB} = KDF(S_{AB}\ XOR\ S_{BA})$$

$$key = g_1^{t_{AB}}\ ,\ \ t_{AB} = H(s_{AB})$$
$$val = c_{AB} = AEAD_k(addr_A)$$

1. Create a new owned object with owner *hash(key)*
2. The object/event contains a single field: *val*
3. Readers gather all objects owned by a public key
4. Single-owner object structure remains because there is a single writer for every key