SDDR: Light-Weight, Secure Mobile Encounters

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Mobile Social Applications

Services based on user context:

① **location** ② **activity** ③ **nearby peers**

Latitude

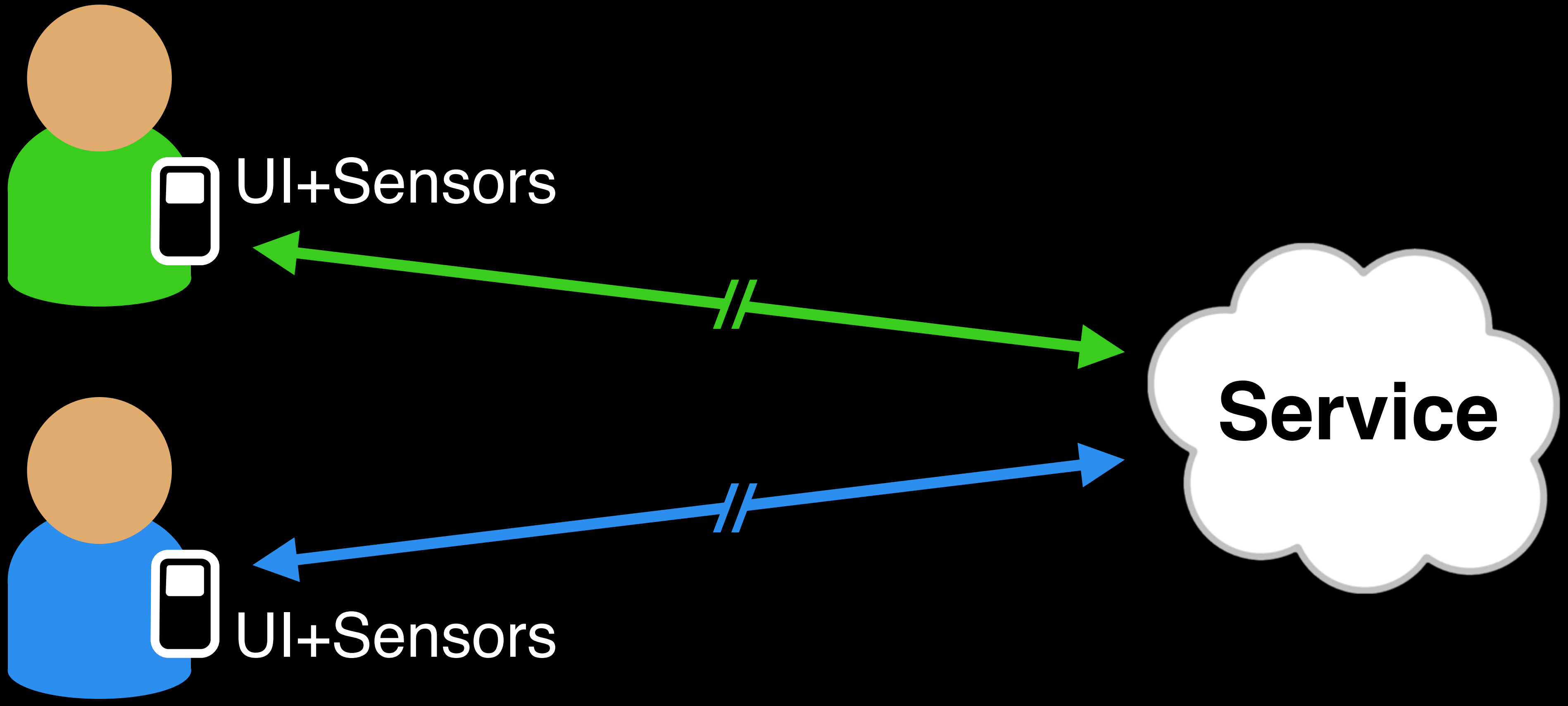
Foursquare

FireChat

Haggle

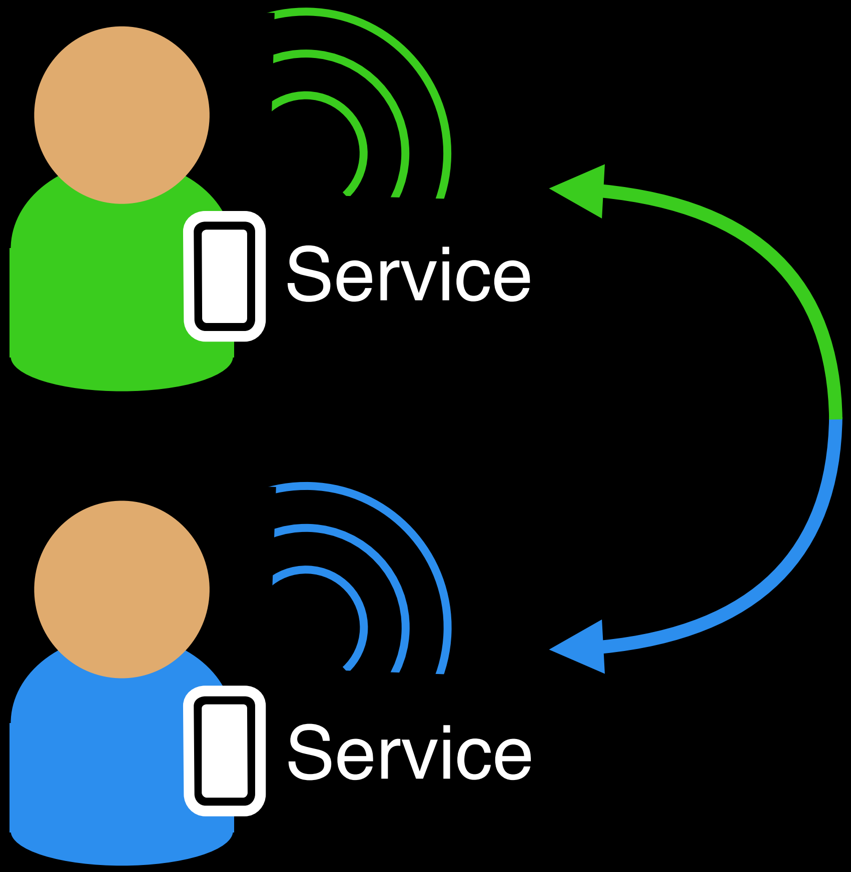
Highlight

Common: Centralized Service



Involves a trusted third party

Alternate: Device-to-Device



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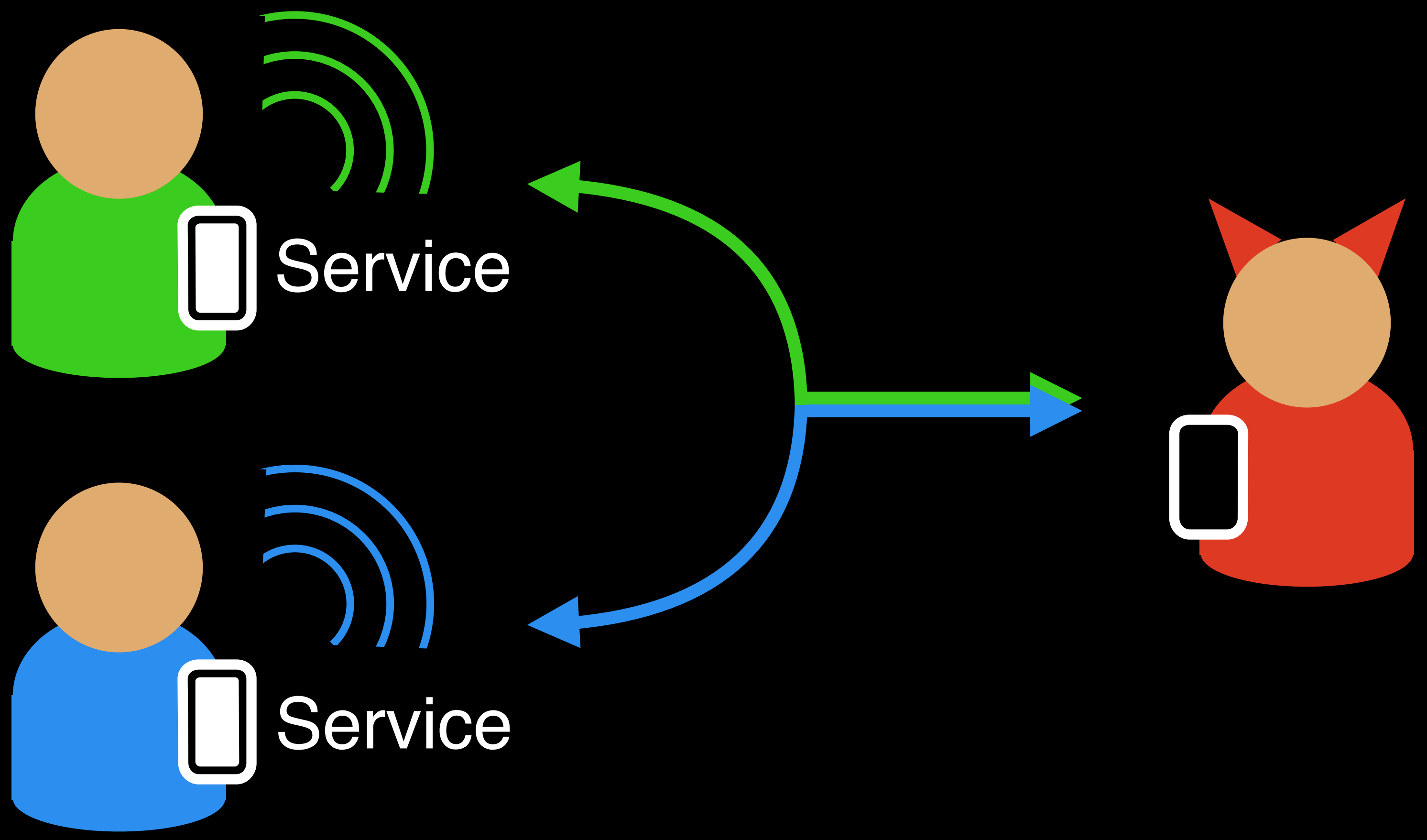

Enables tracking by adversaries

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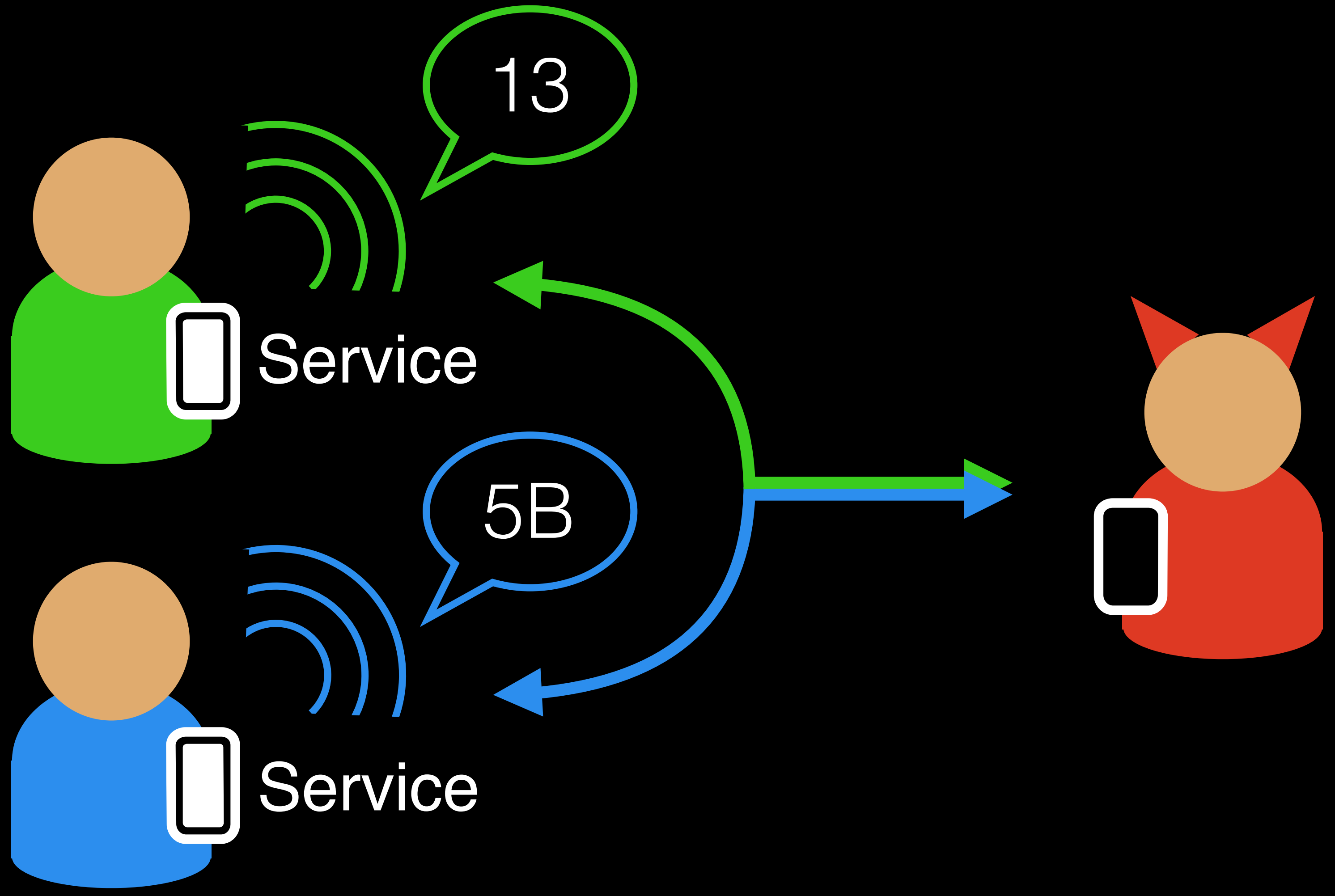

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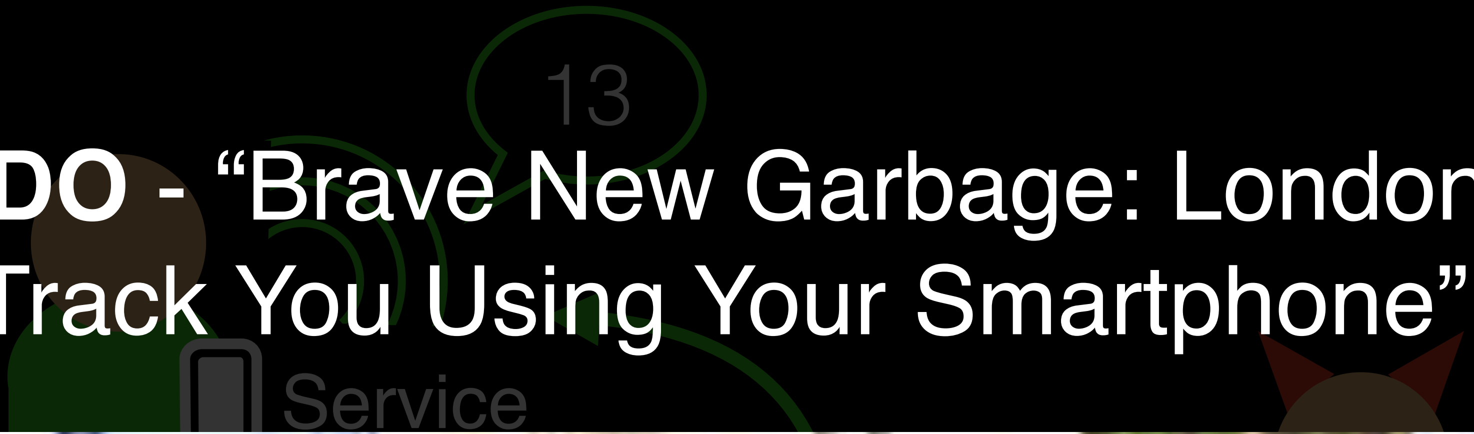
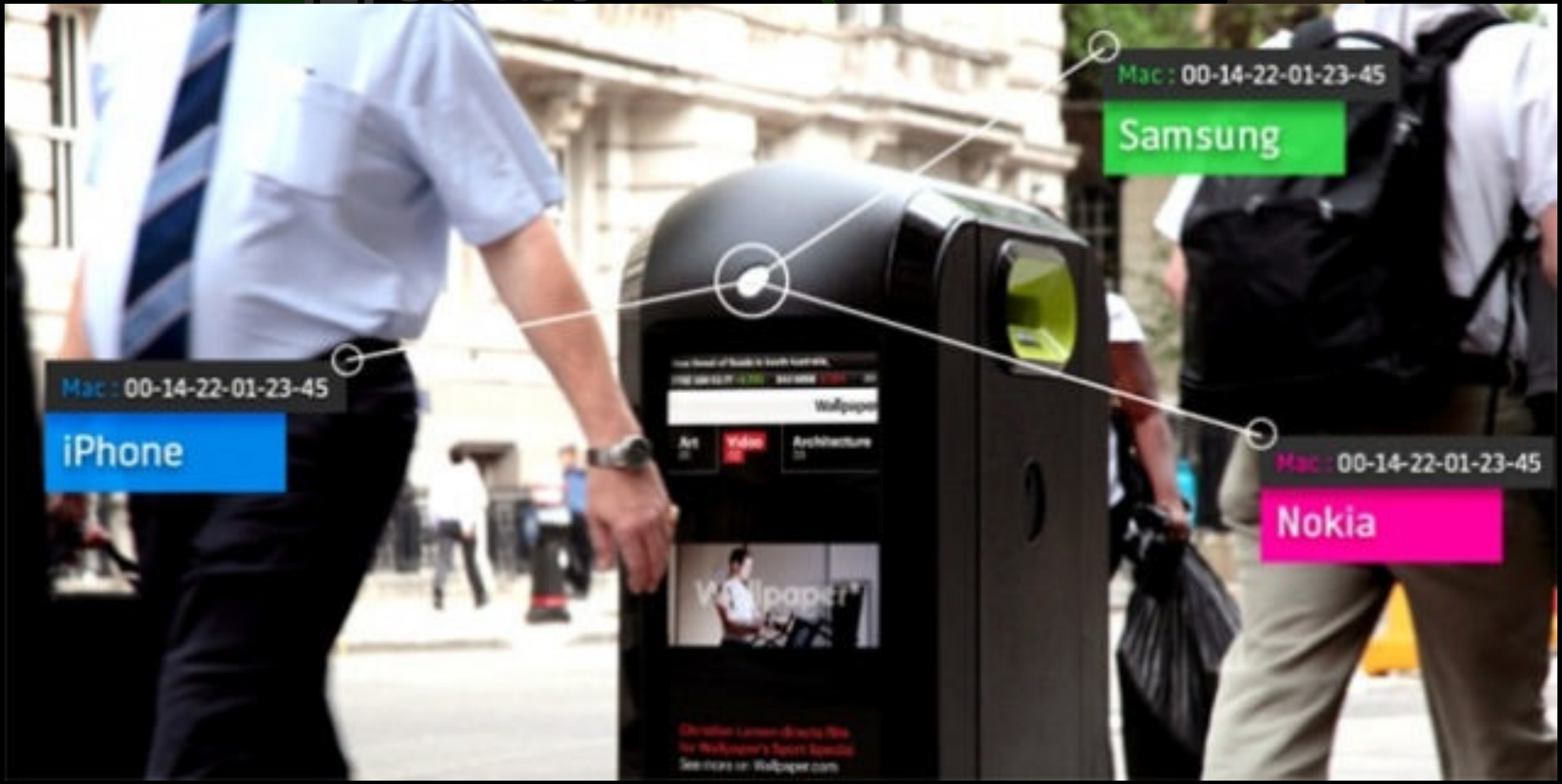
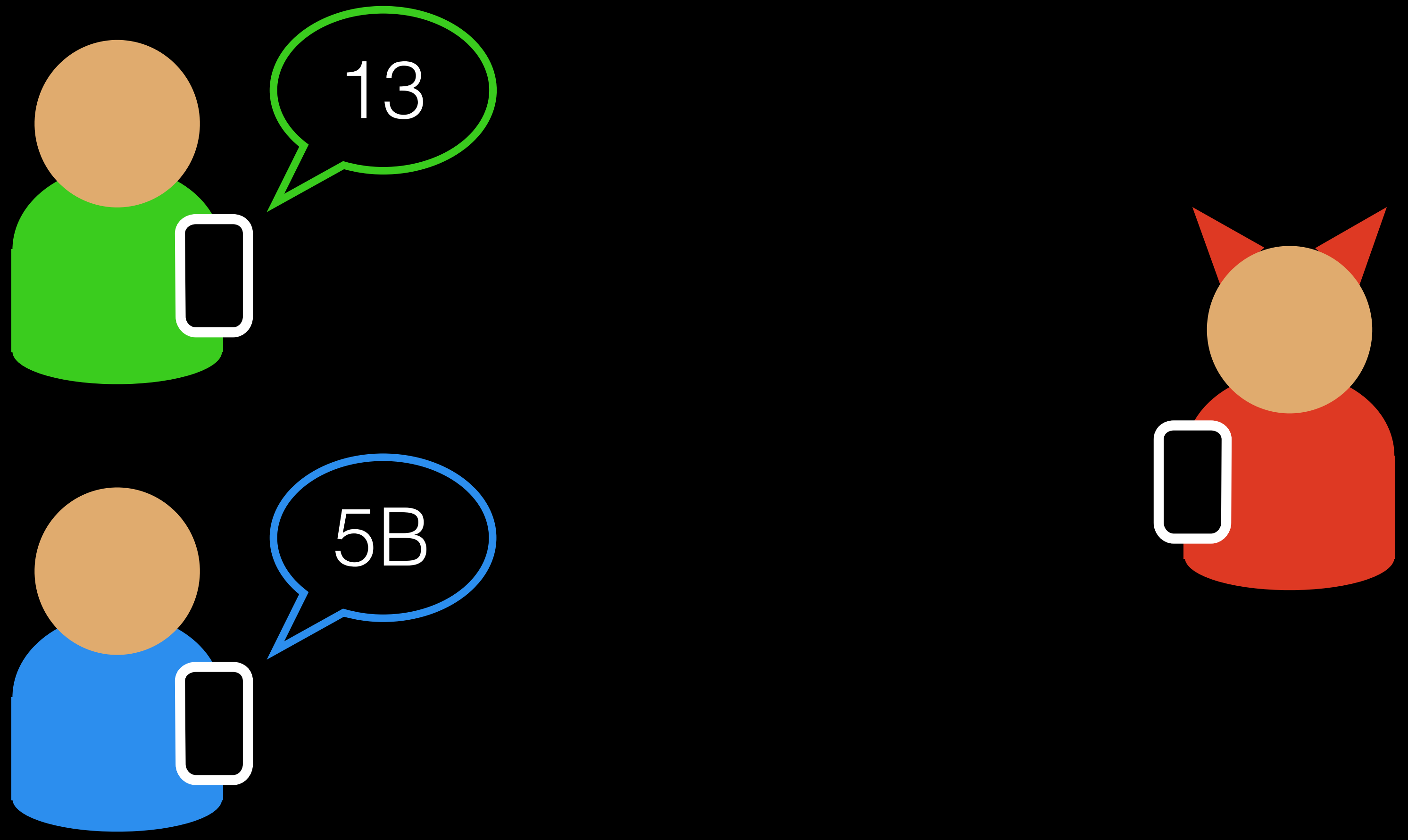


GIZMODO - “Brave New Garbage: London’s Trash Cans Track You Using Your Smartphone” (2013)



Credit: http://gizmodo.com/brave-new-garbage-londons-trash-cans-track-you-using-1071610114

Randomize Addresses?



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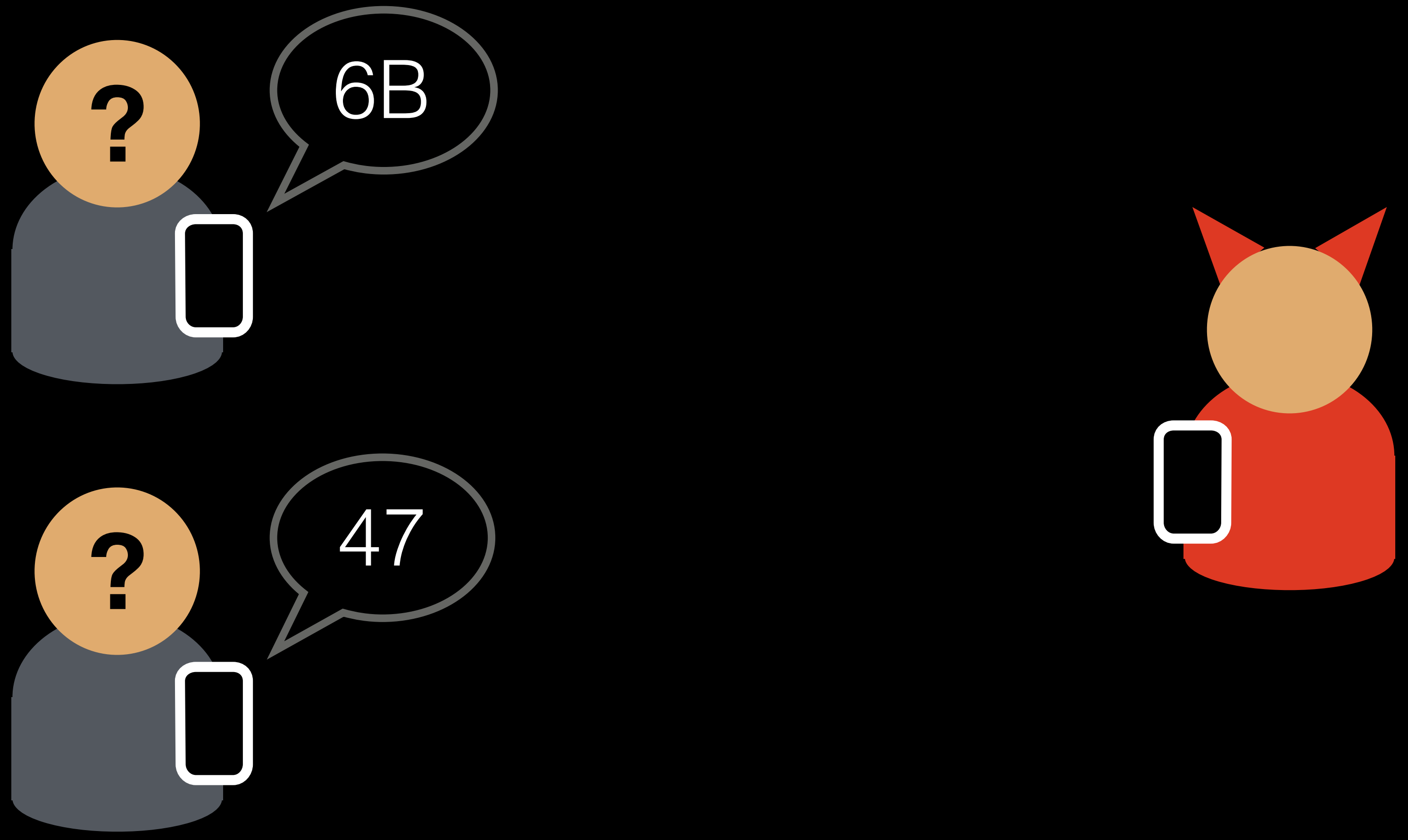
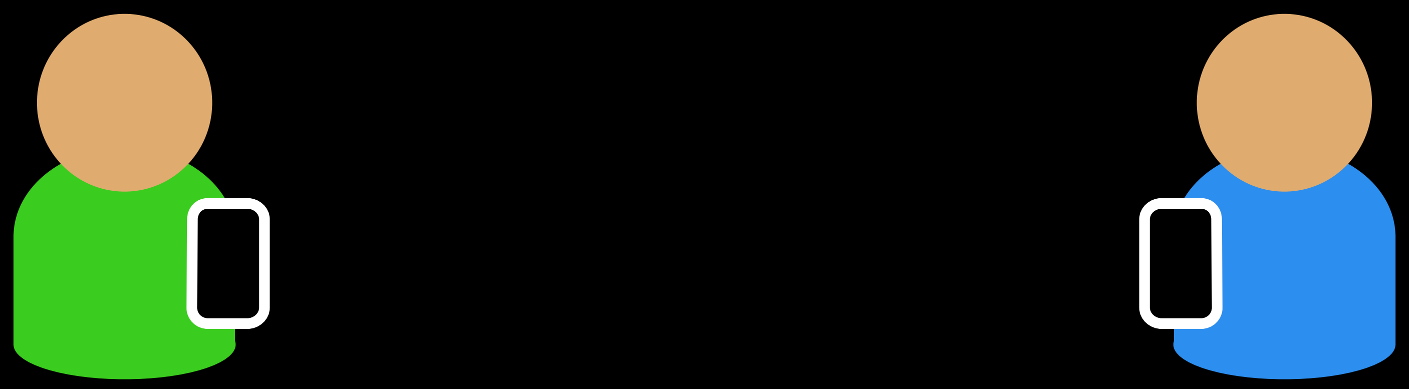


Unlinkable, but does not support **recognition**!

Secure Device Discovery and Recognition

1. Secure Encounter Primitive
2. Strawman Protocol
3. System Goals and SDDR Protocol
4. Evaluation and Concurrent Work

Secure Encounters



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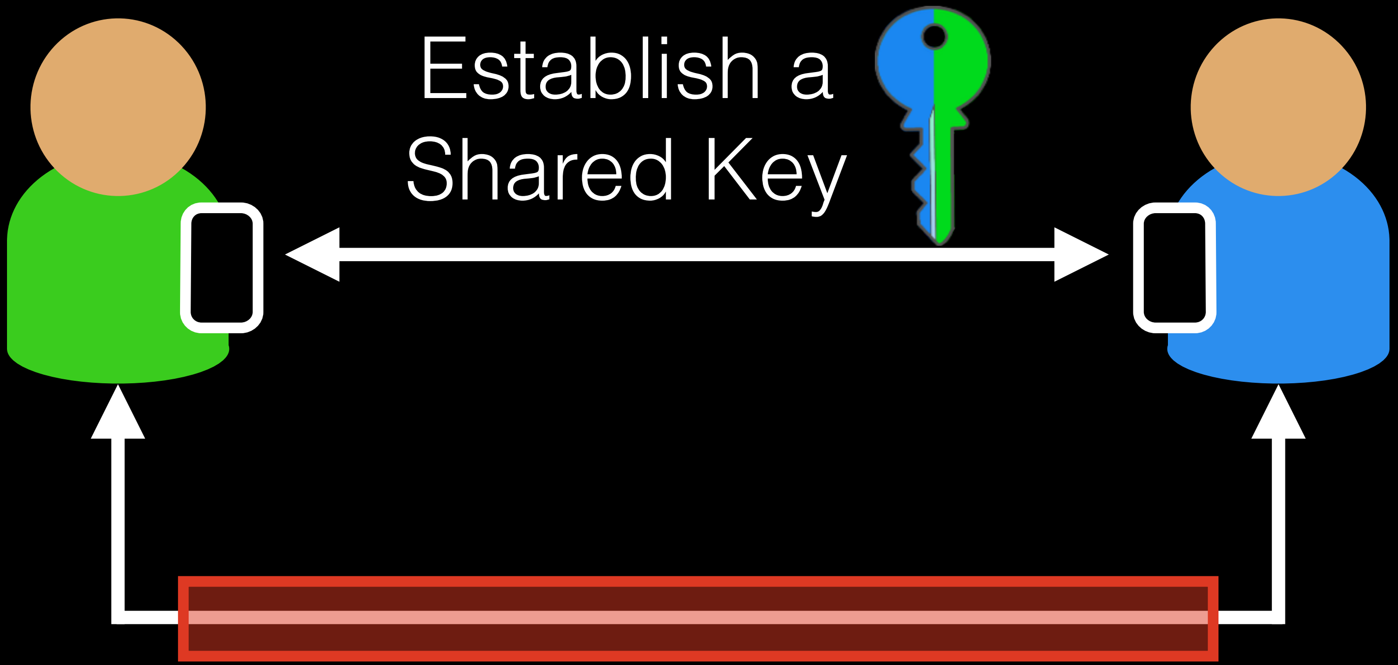
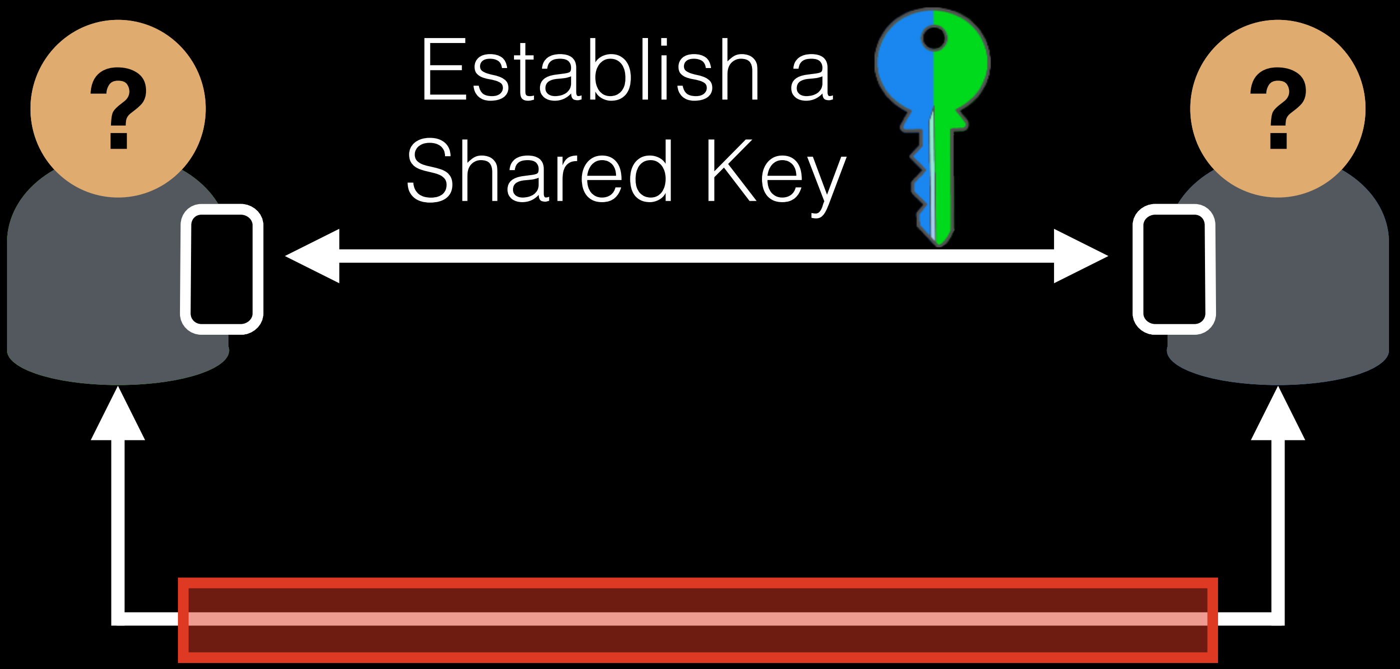


Establish a Shared Key

Secure communication through untrusted channel (e.g., pseudonymous email)

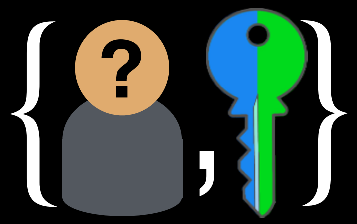
Secure Encounters



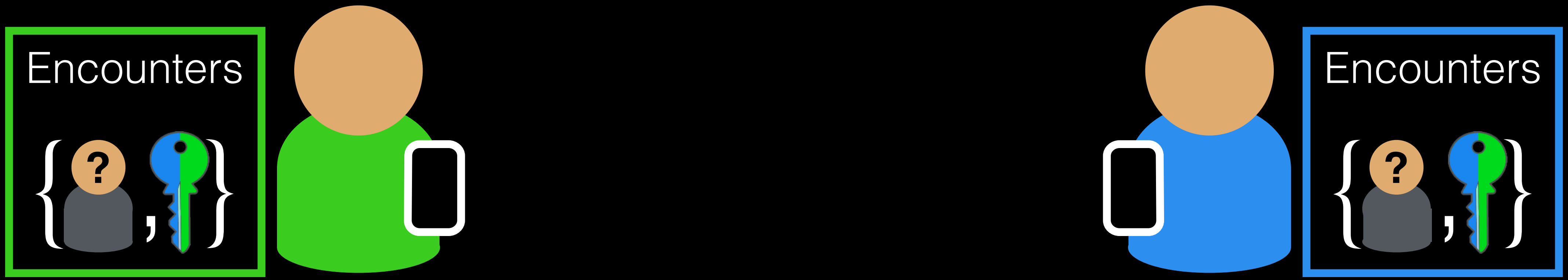
Establish a Shared Key

Secure communication through untrusted channel (e.g., pseudonymous email)

Unlinkable by default

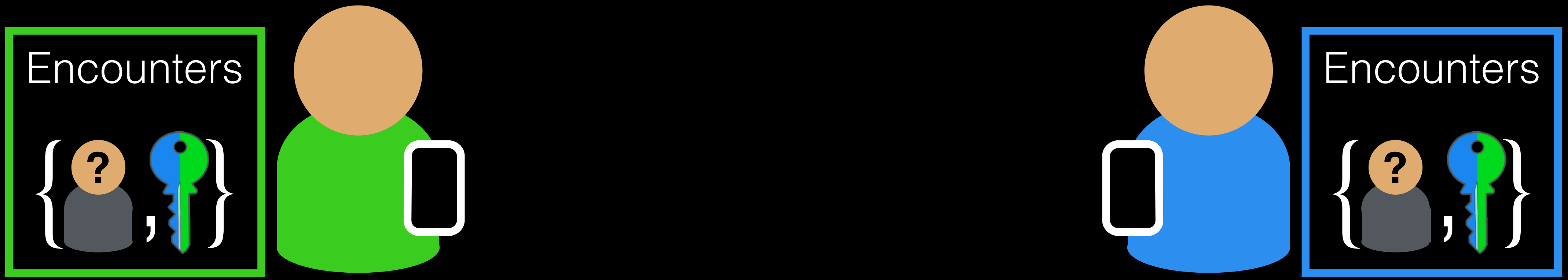


Recognition



Want to **recognize** each other in encounters

Recognition



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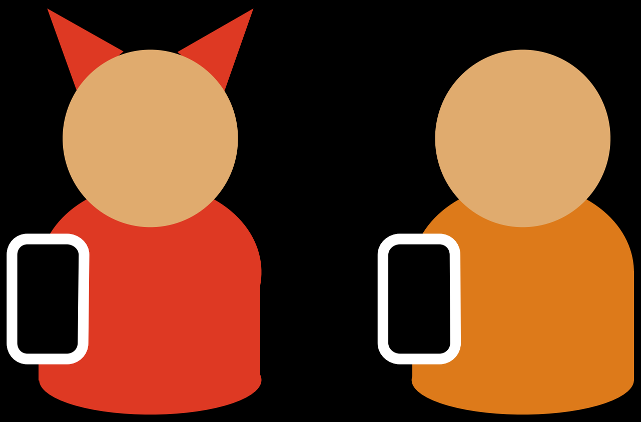
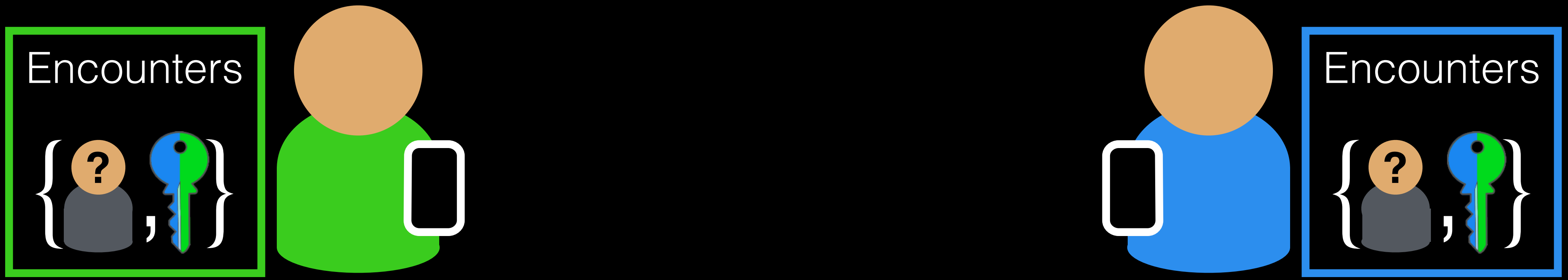


… while remaining **unlinkable** by others

Recognition



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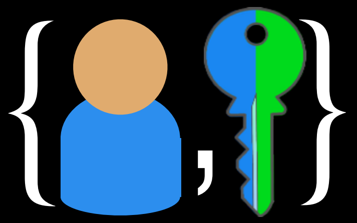
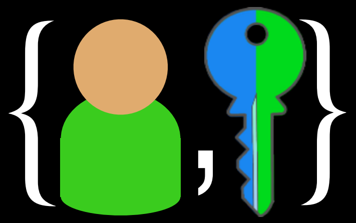


Map ephemeral pseudonyms to long-lived identities



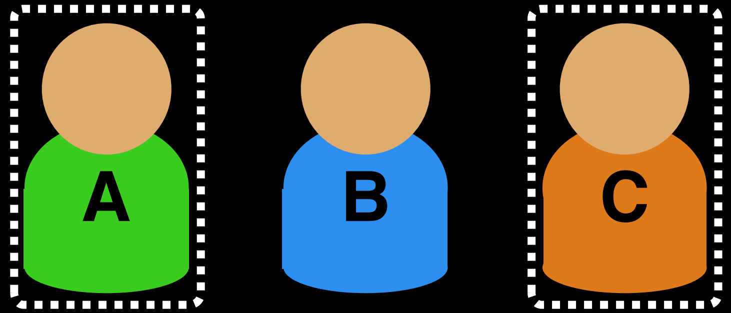
Revocation and Scoping

No Longer Friends

Temporary Friends

Only At Work

Only After 8pm



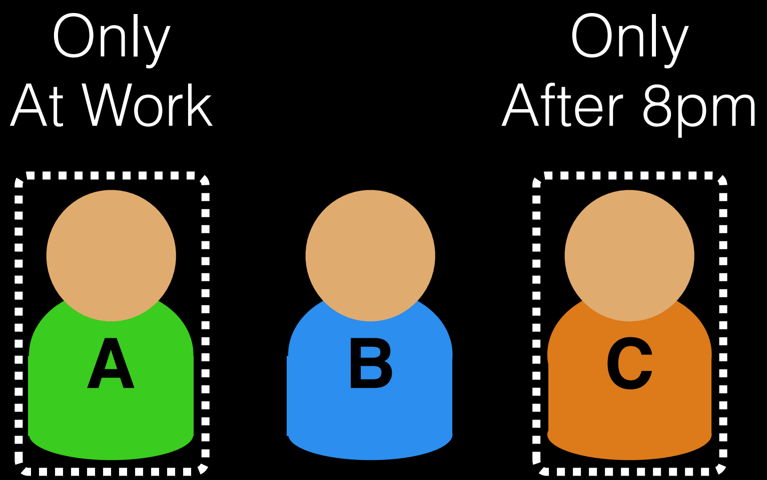
Context-based Scoping

Allow recognizability by friends using context-based constraints

Revocation and Scoping

No Longer Friends

Temporary Friends



Context-based Scoping

Allow recognizability by friends using context-based constraints

Efficient and **unilateral** revocation is required

Security Properties

Discover devices while preserving user privacy

Secure communication between encounter peers

Recognize peers with prior trust relations
and support efficient, unilateral **revocation**

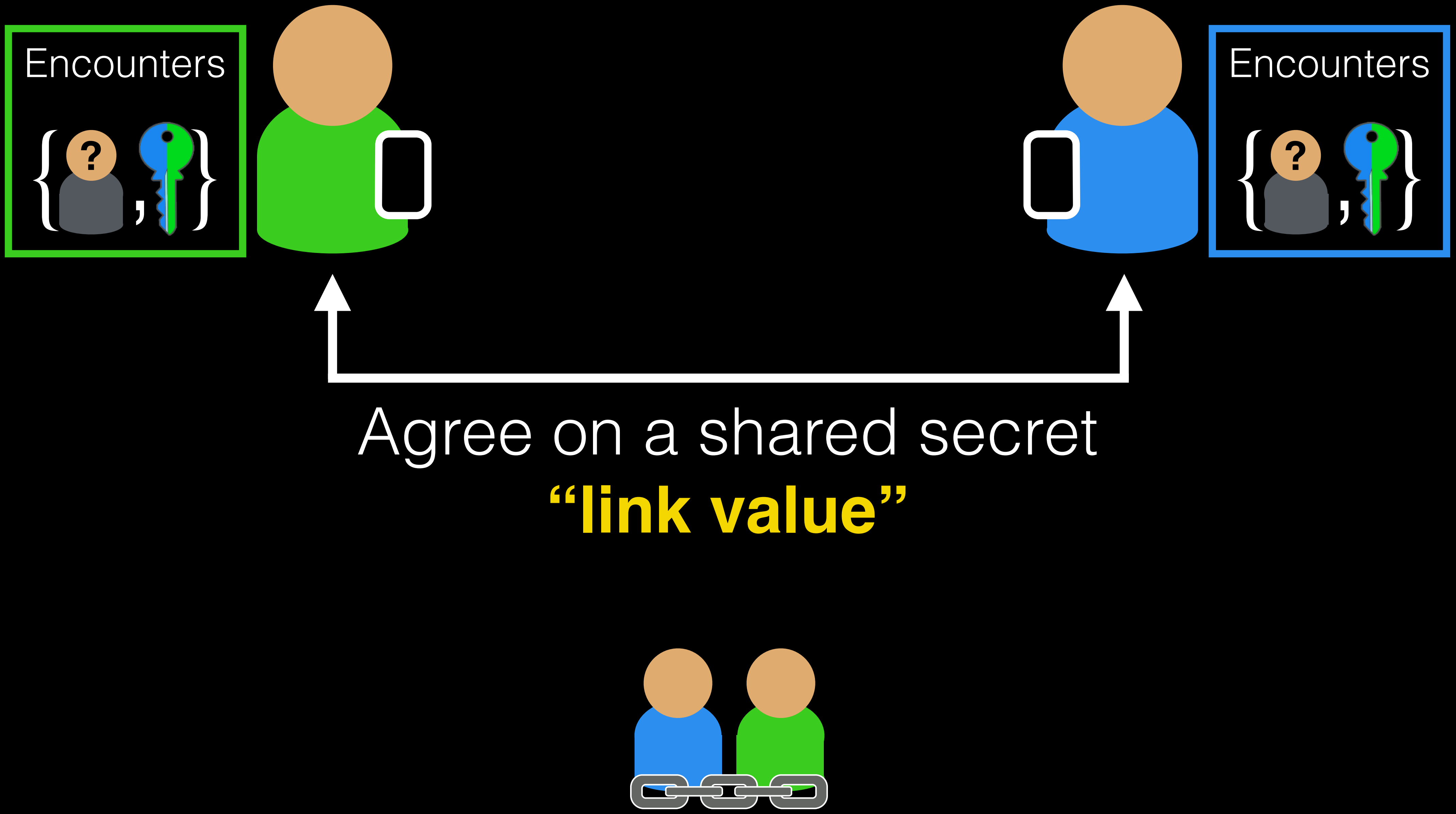
Threat Model

Trust OS and apps on your phone

No PHY layer attacks considered

Participate with all nearby devices
(*arbitrary* subset of colluding attackers)

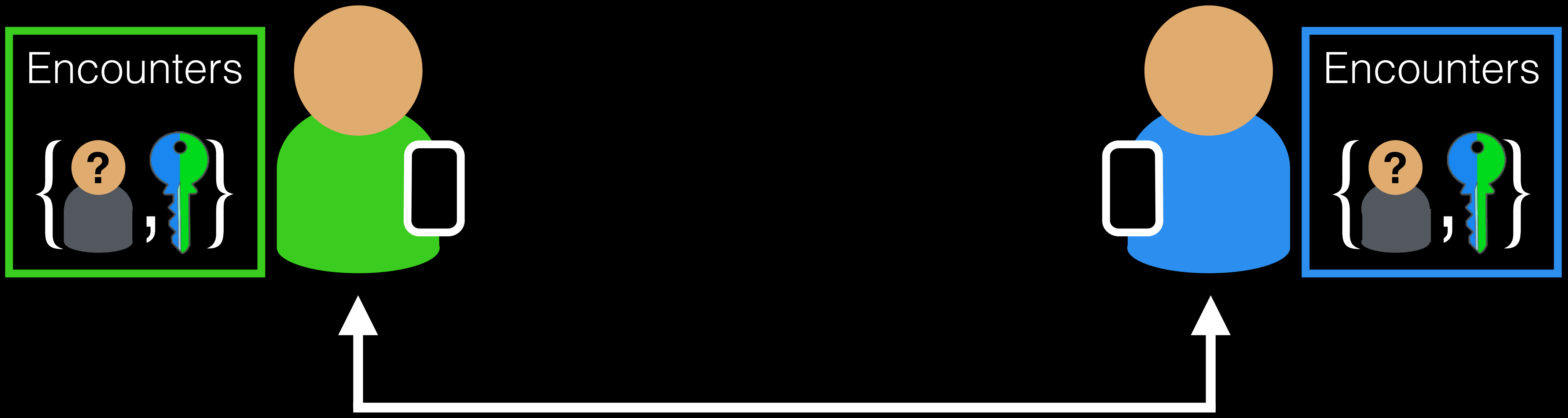
Enabling Recognition



Agree on a shared secret

“link value”

Enabling Recognition



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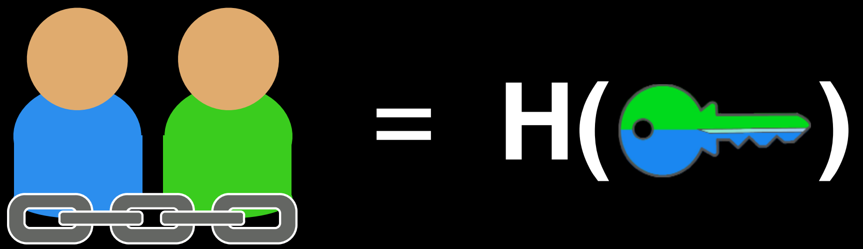
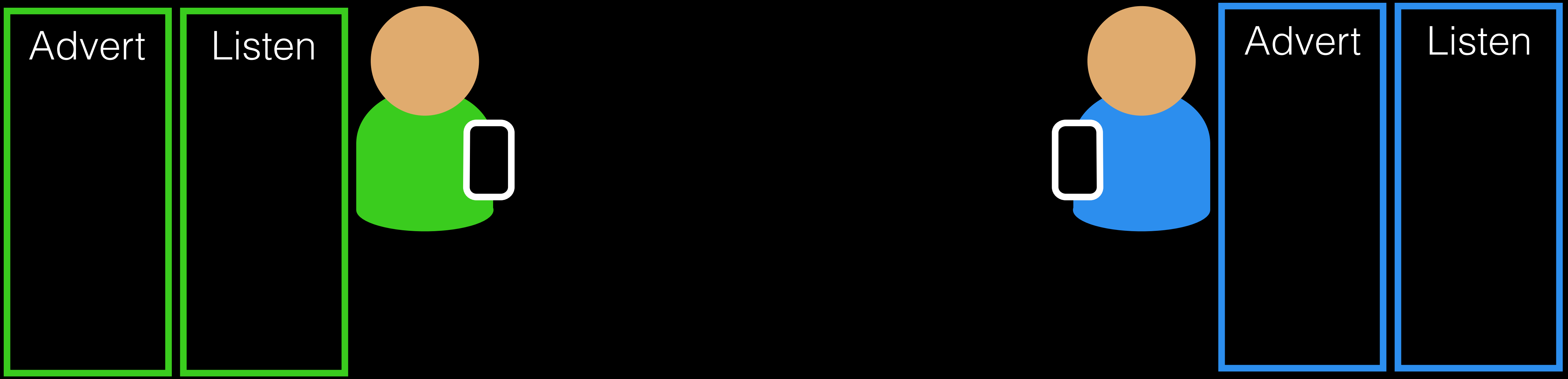


Recognition and Revocation



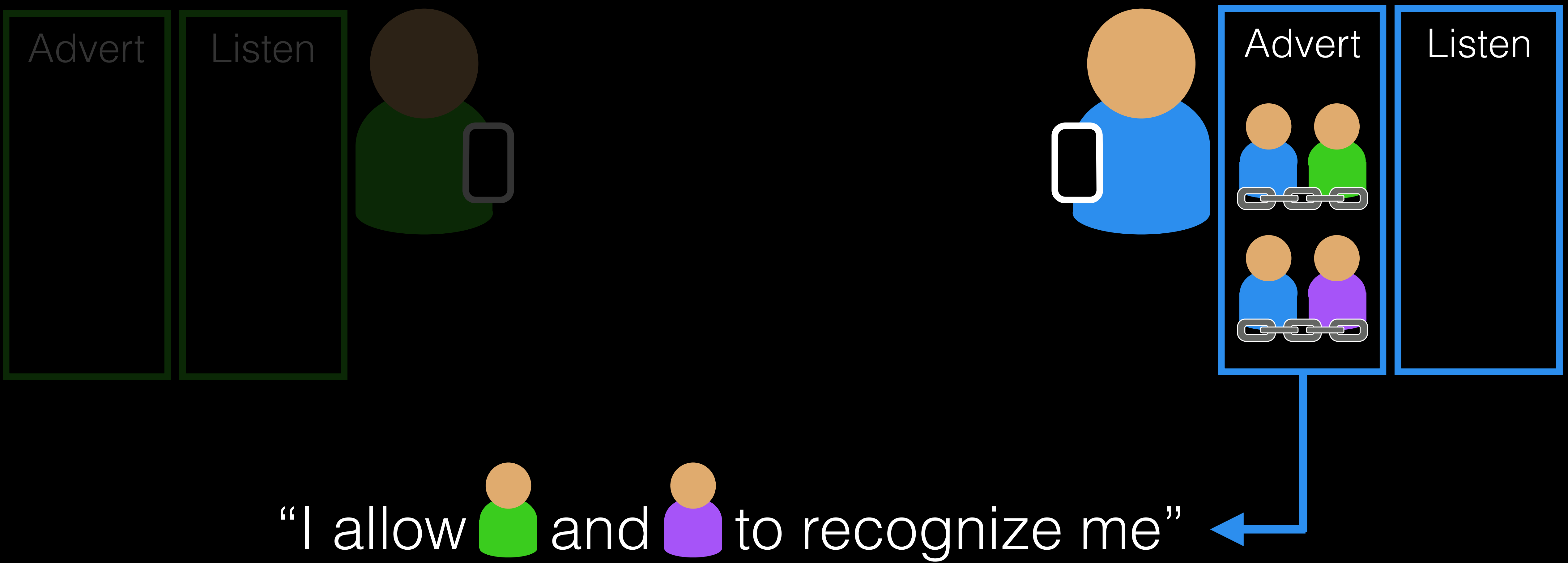
Advert

Listen

Advert

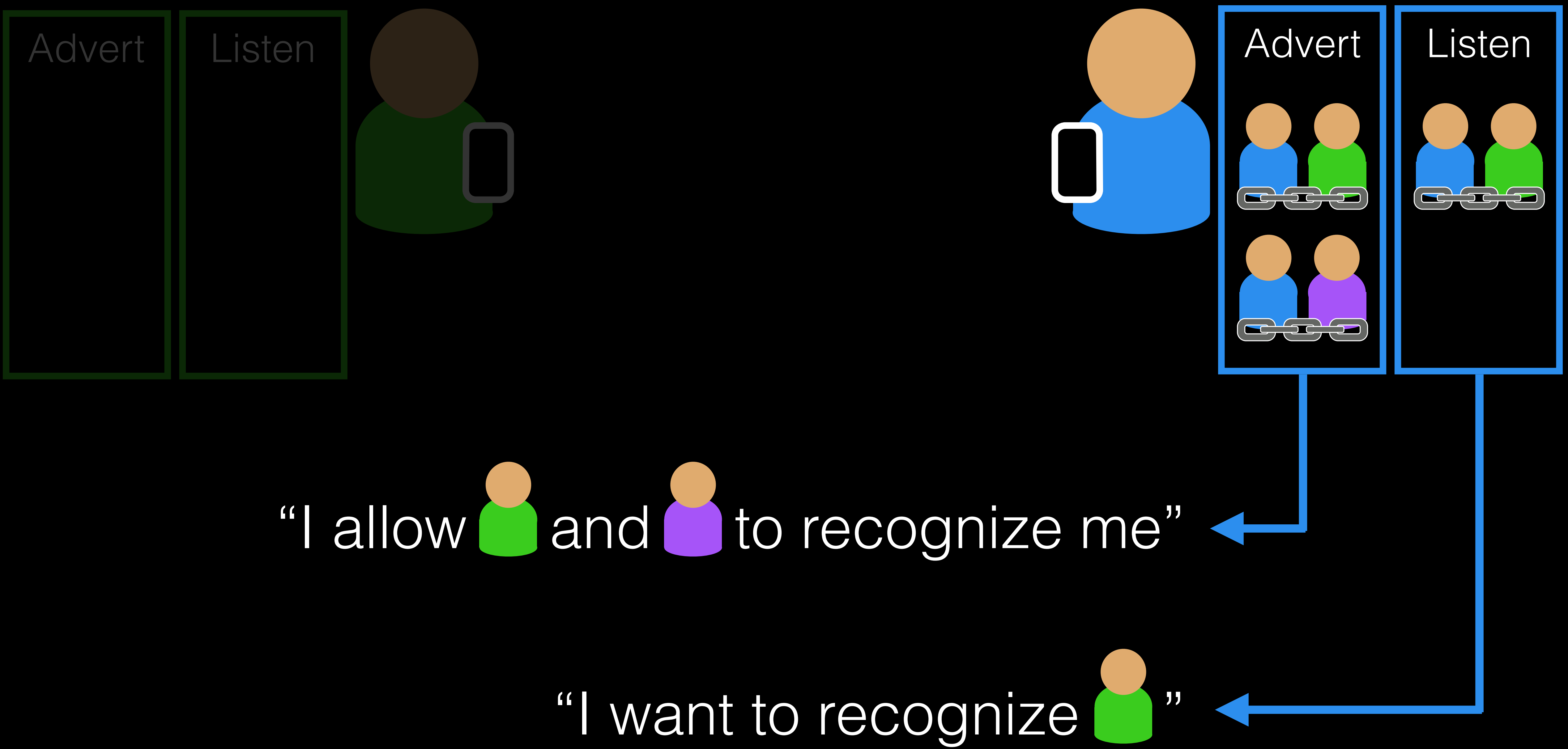
Listen

Recognition and Revocation



“I allow 🟩 and 🟪 to recognize me”

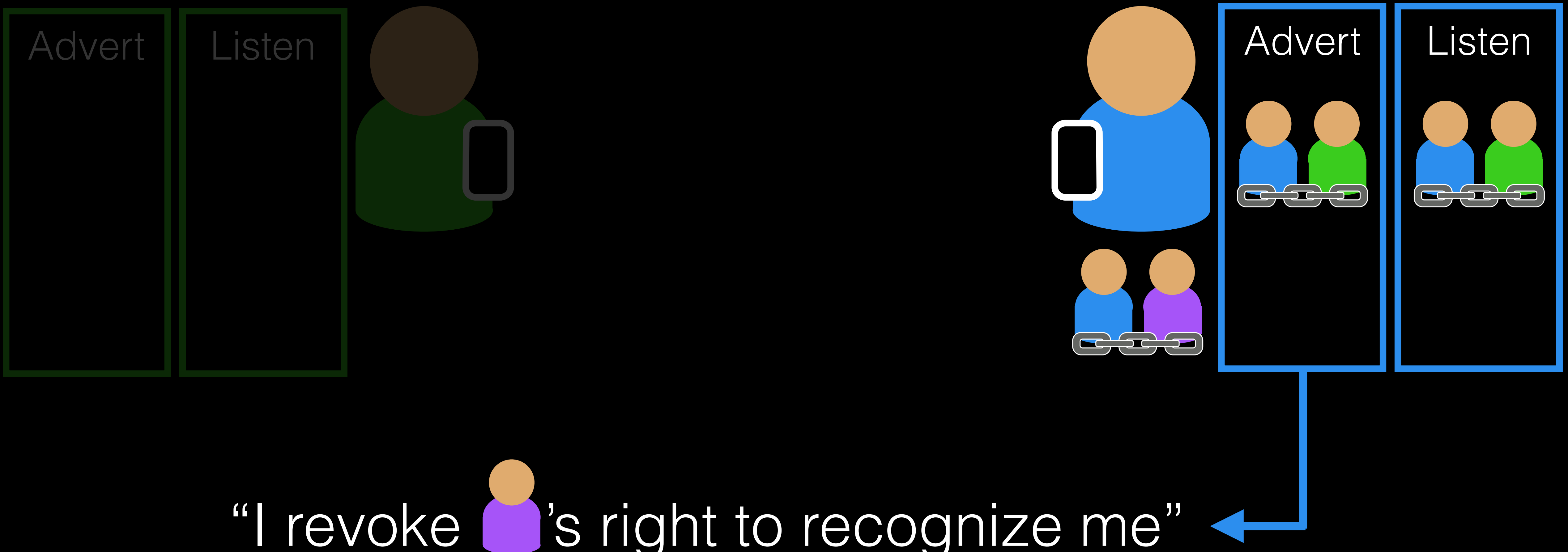
Recognition and Revocation



"I allow 🟩 and 🟪 to recognize me"

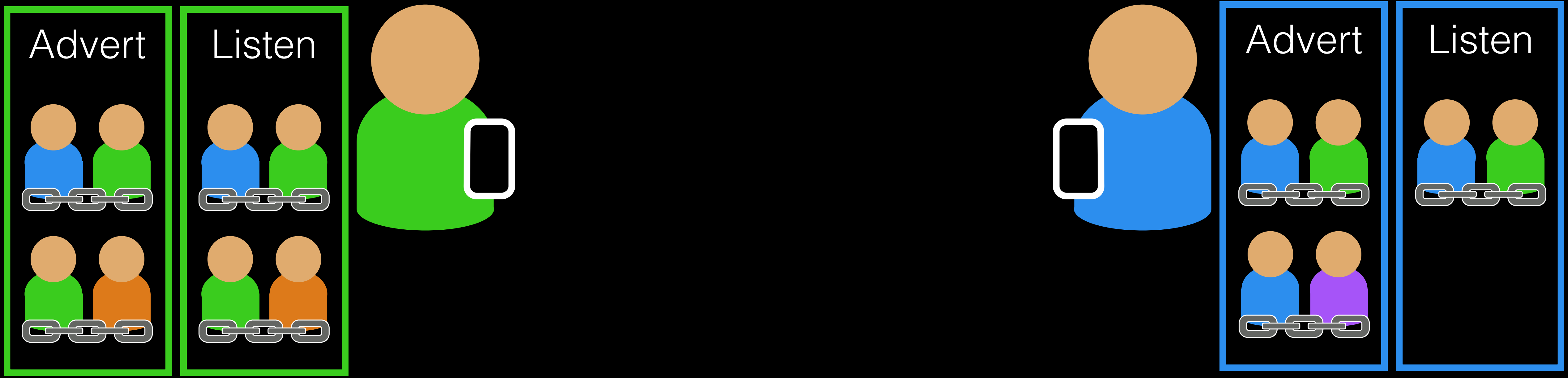
"I want to recognize 🟩"

Recognition and Revocation

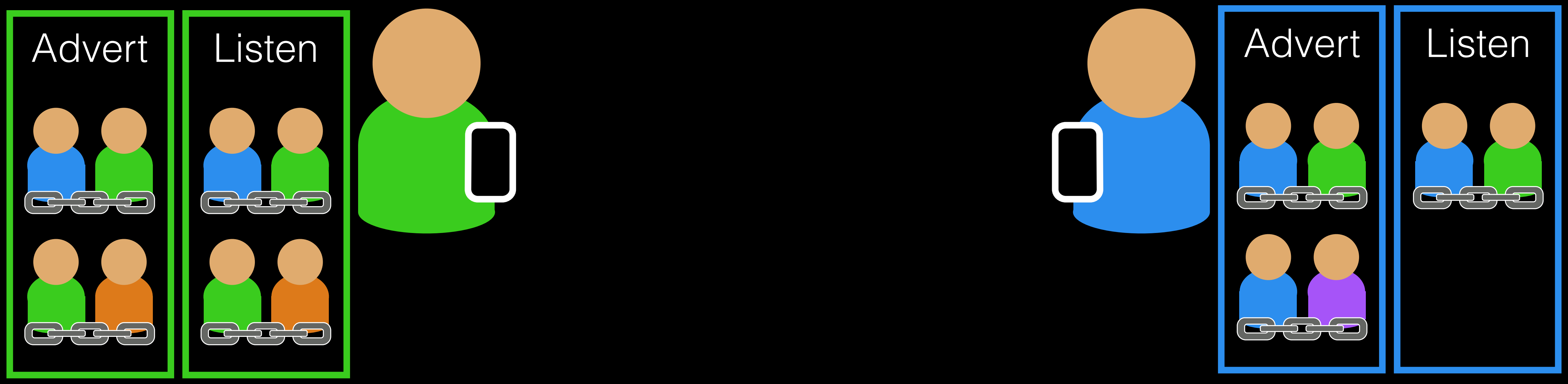


“I revoke 👤’s right to recognize me”

Recognition and Revocation



Recognition by Intersecting Sets



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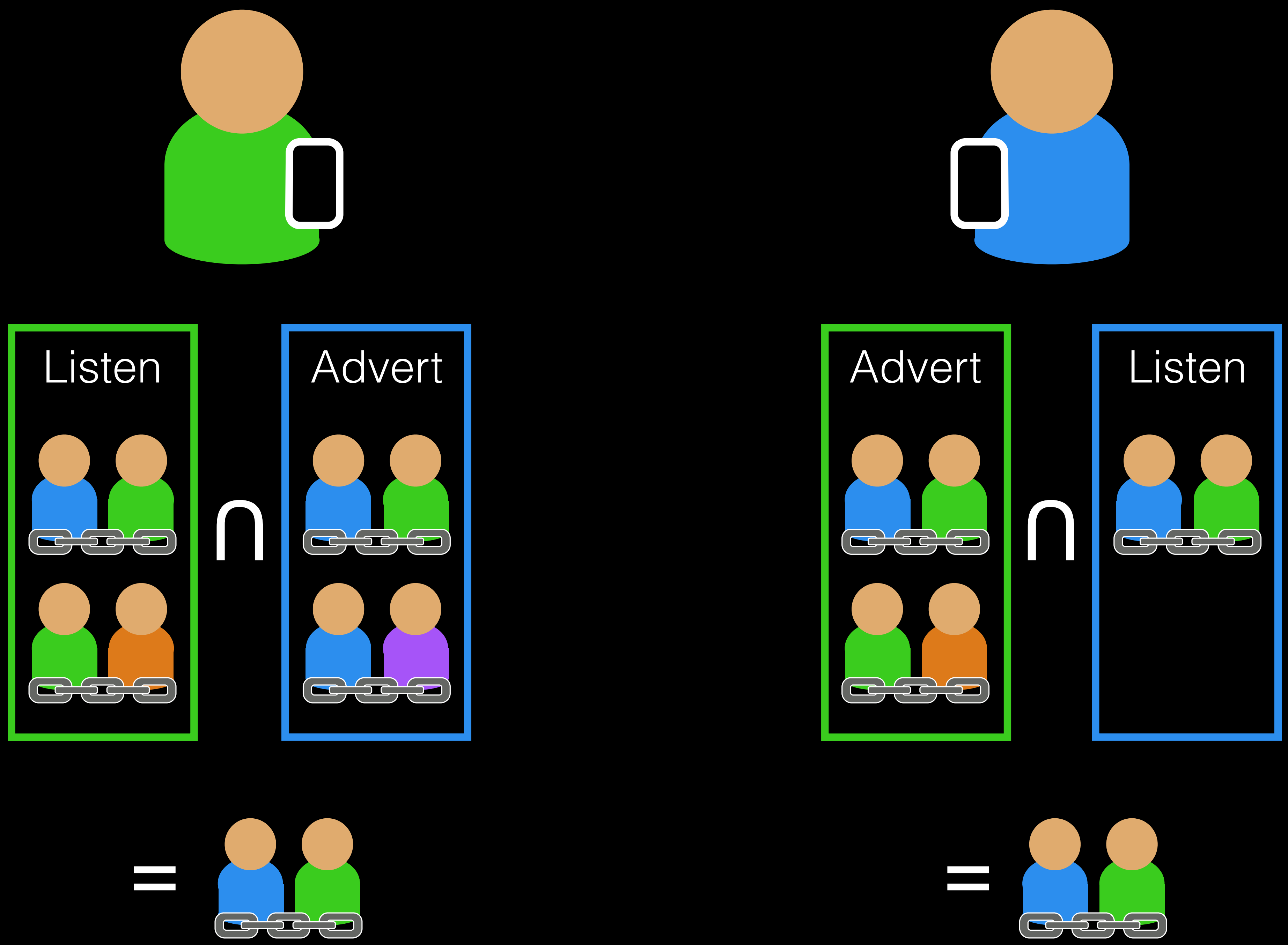
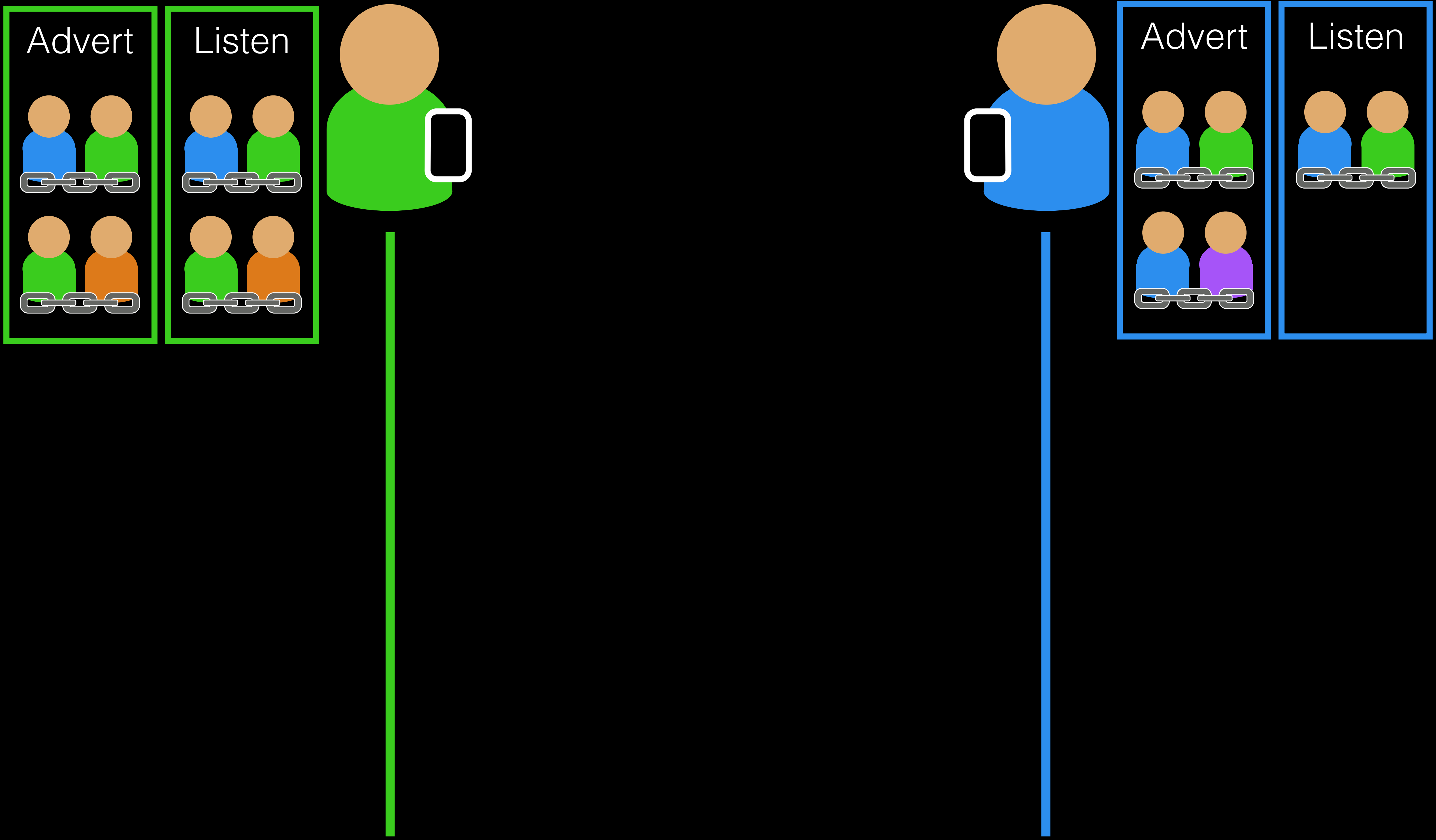


Strawman Protocol



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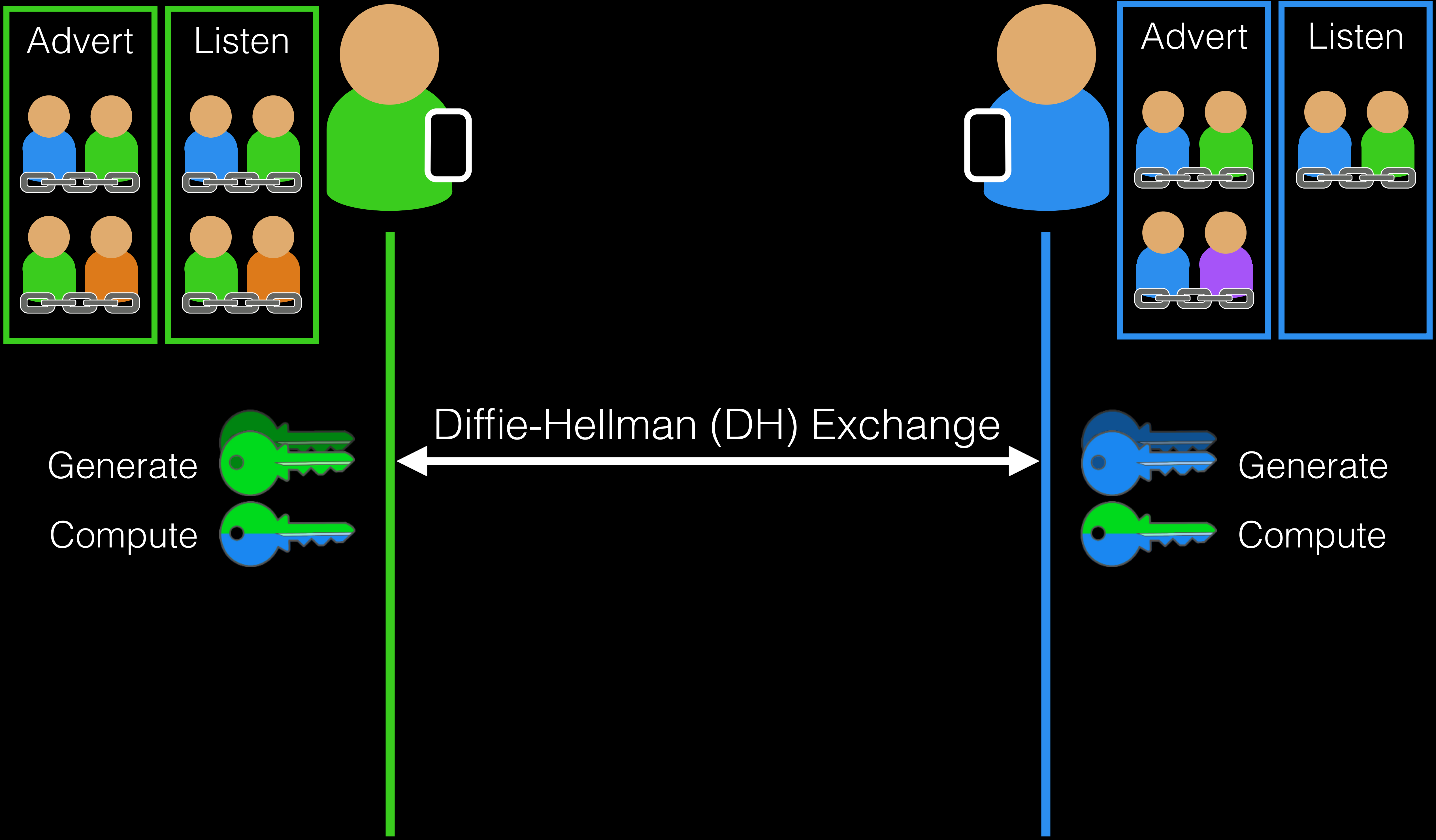

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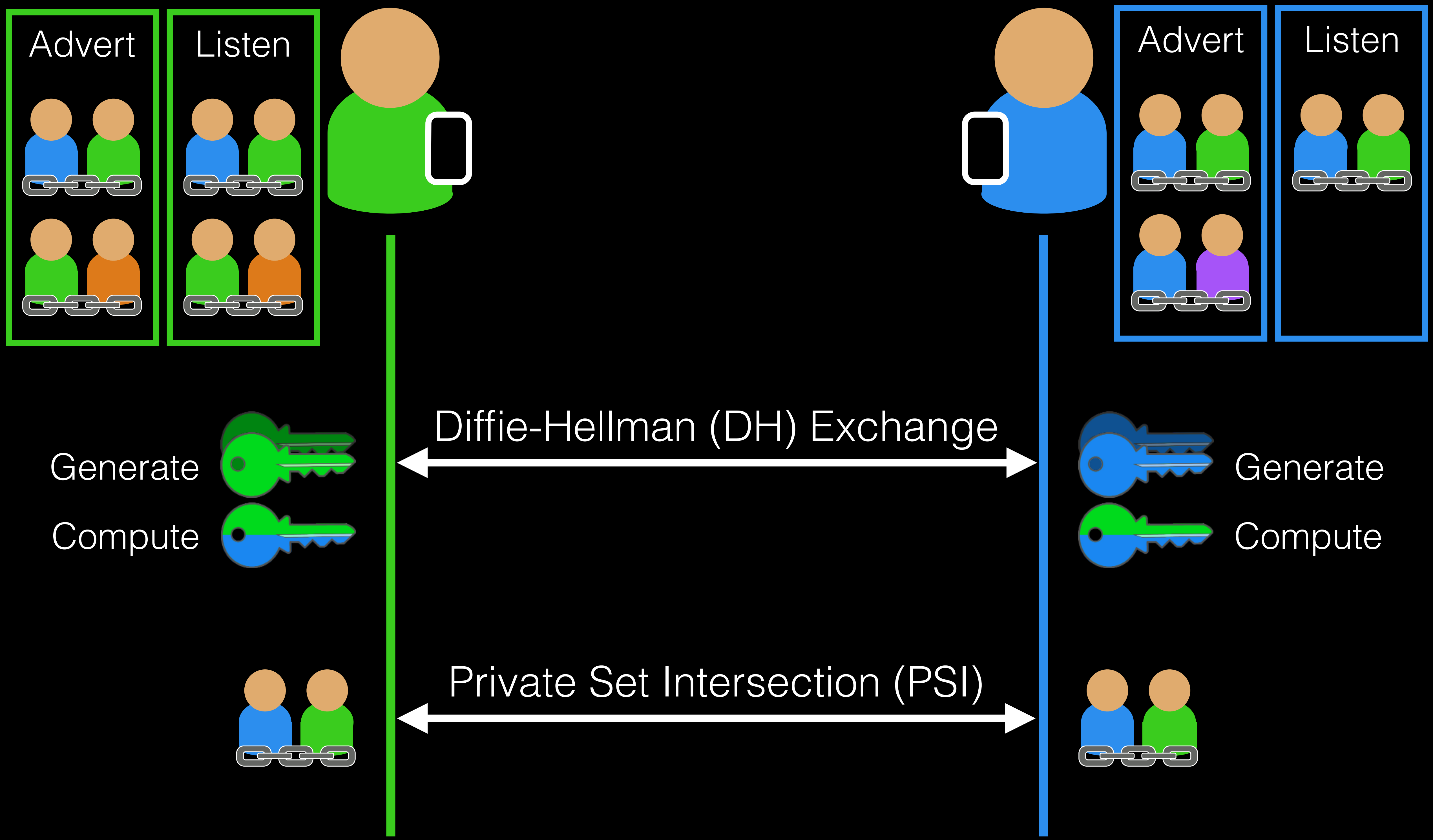

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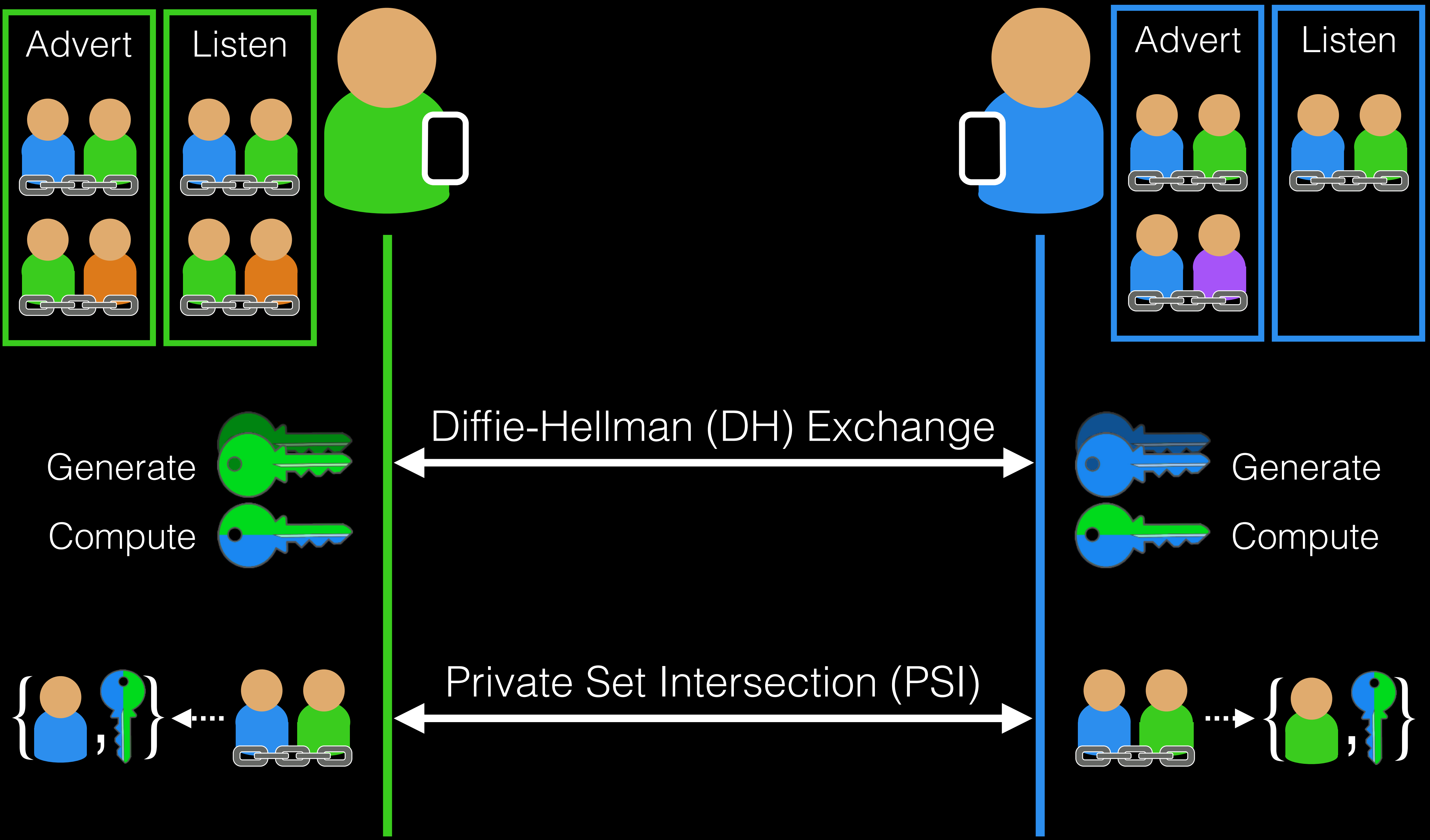


Advert

Listen

Advert

Listen

Diffie-Hellman (DH) Exchange

Generate

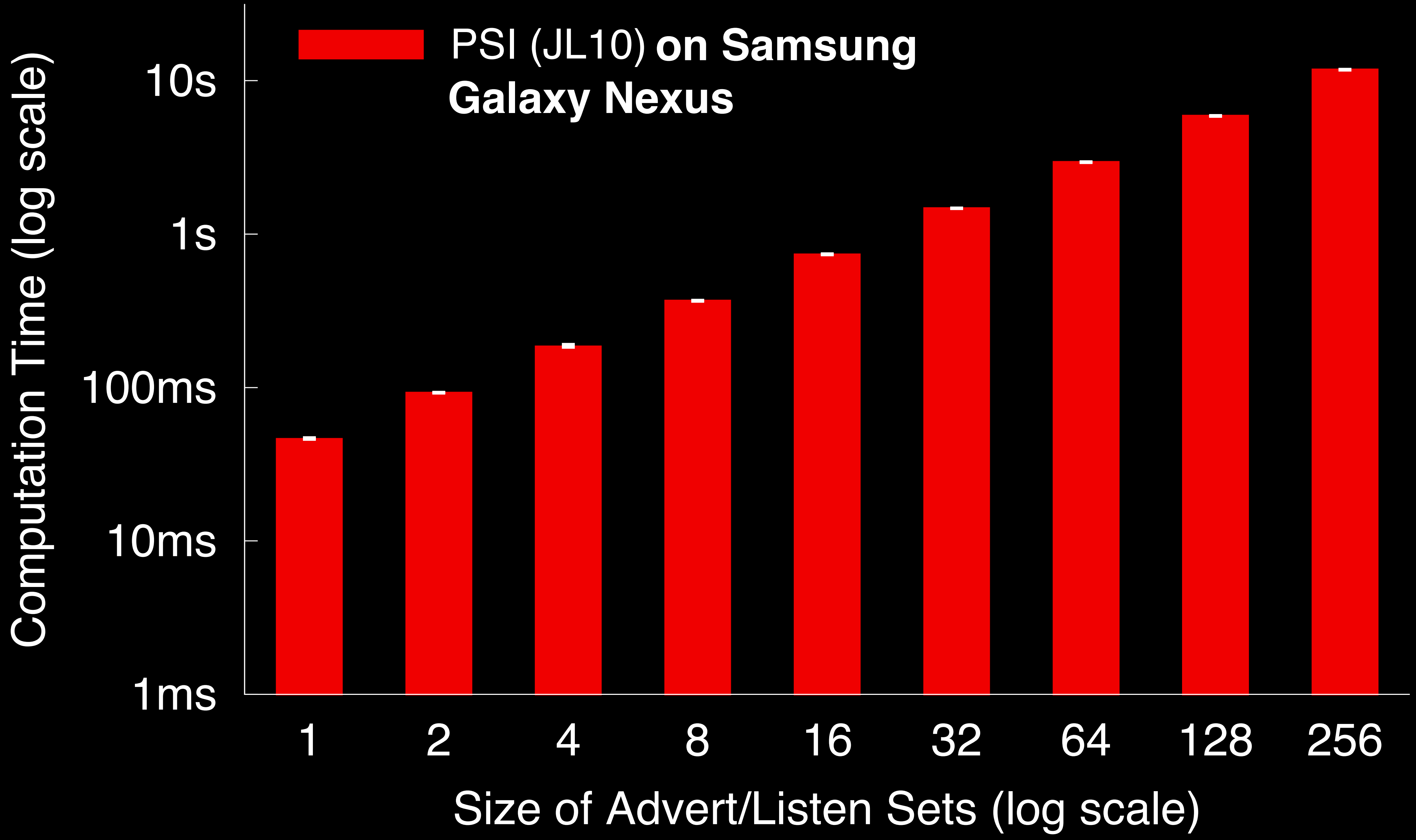
Compute

Generate

Compute

Private Set Intersection (PSI)

PSI is Prohibitively Slow



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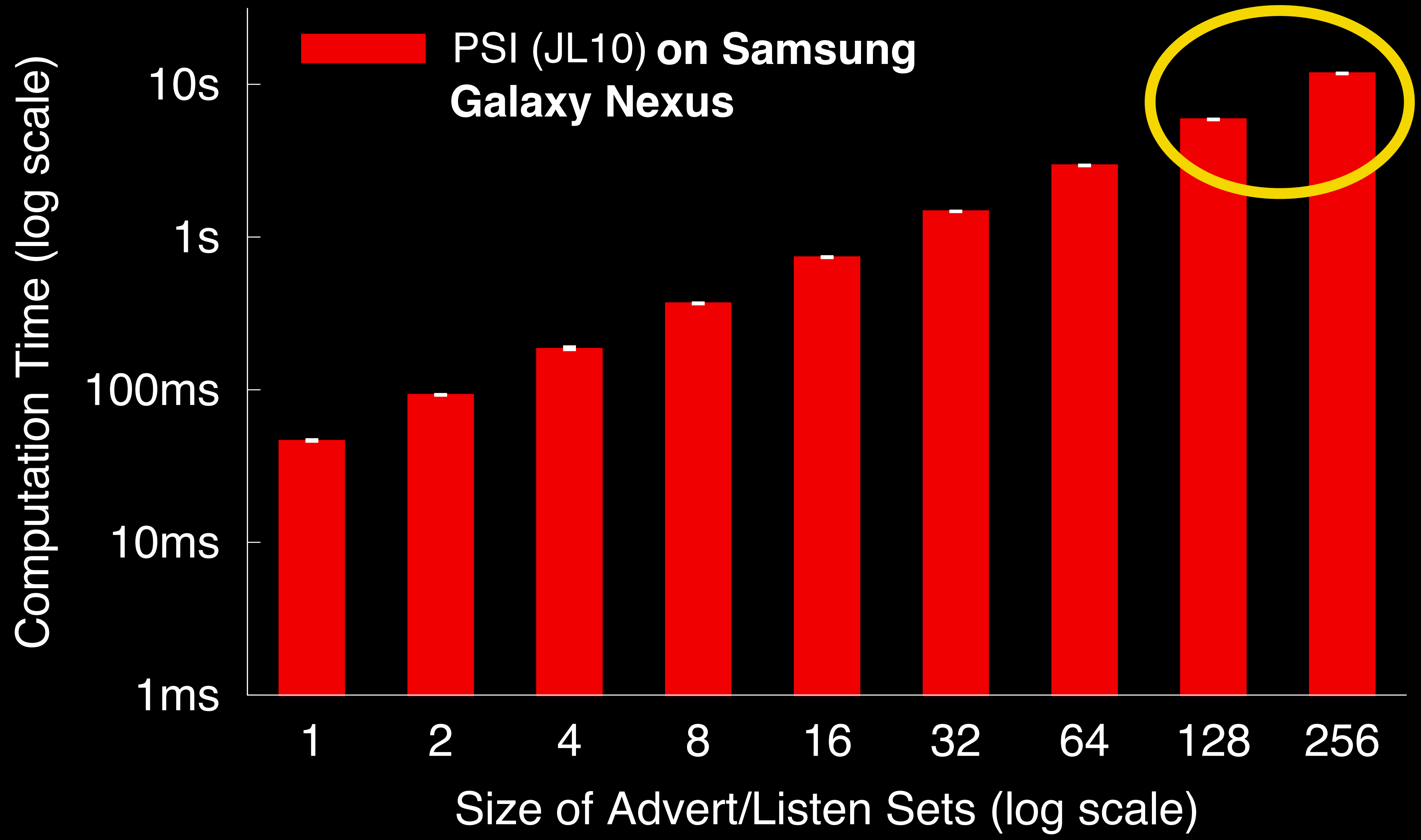

System Goals

Efficiency - Practical for resource-constrained devices

Scalability - Handle many peers (e.g., stadium)

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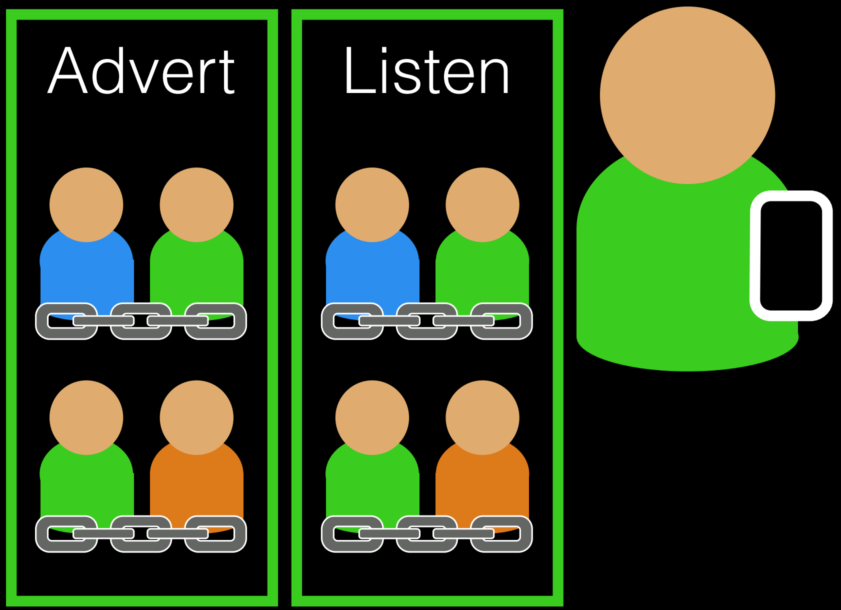
Scalability - Handle many peers (e.g., stadium)

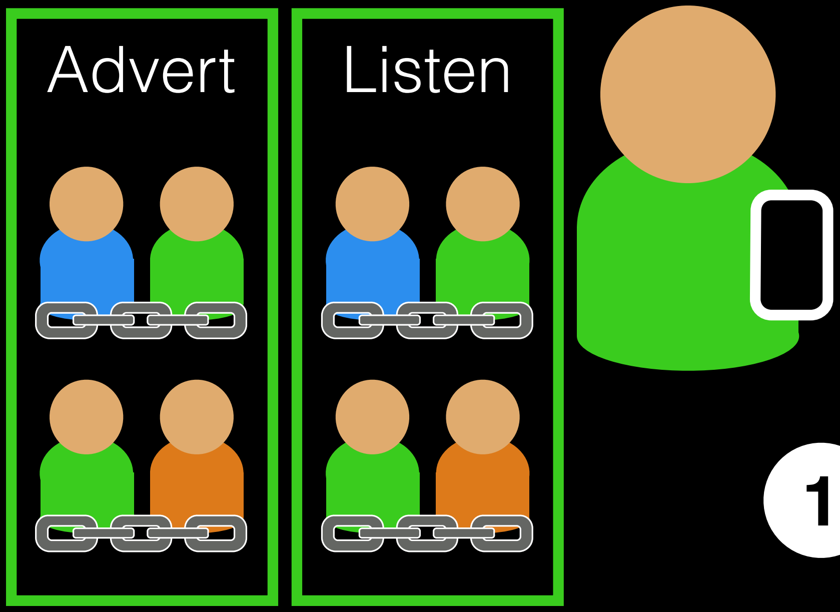
Need to develop secure protocols with energy efficiency as a first order goal

SDDR Protocol State



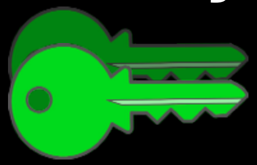
Divide time into discrete **epochs**, across which user is unlinkable.

SDDR Protocol State

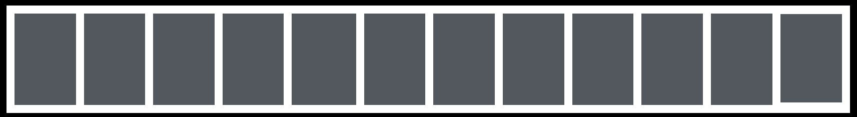


In each **epoch**, generate:

1 **DH Key Pair**



2 **Bloom Filter**



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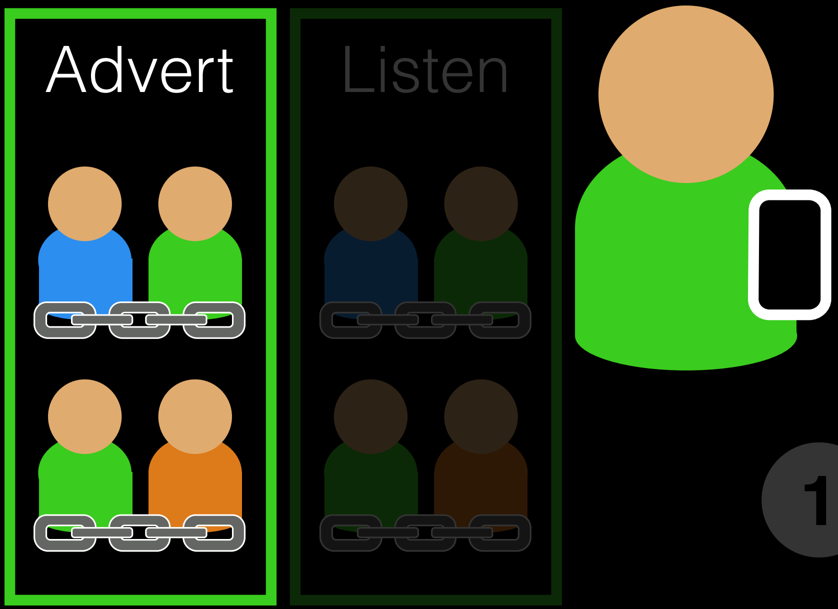

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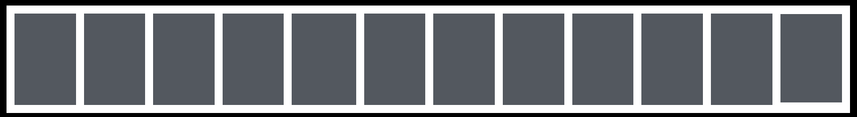
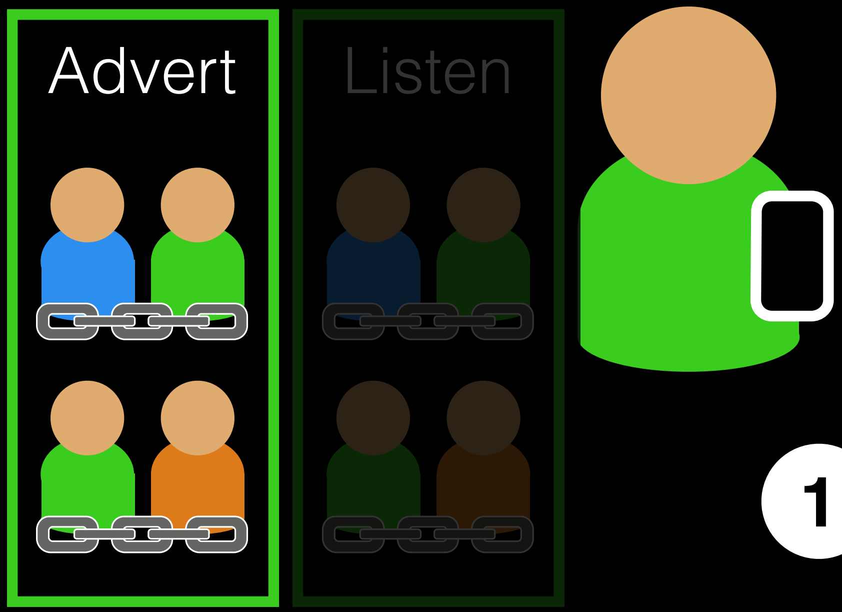


Probabilistic set digest for advertised link values

We use them for compactness, *not* security

SDDR Protocol State



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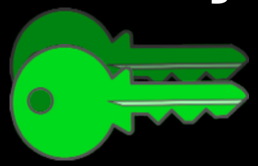

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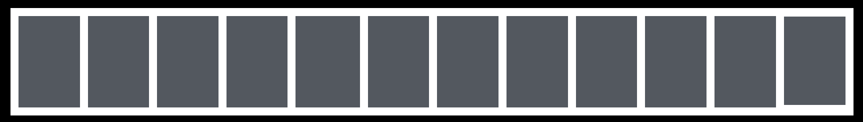

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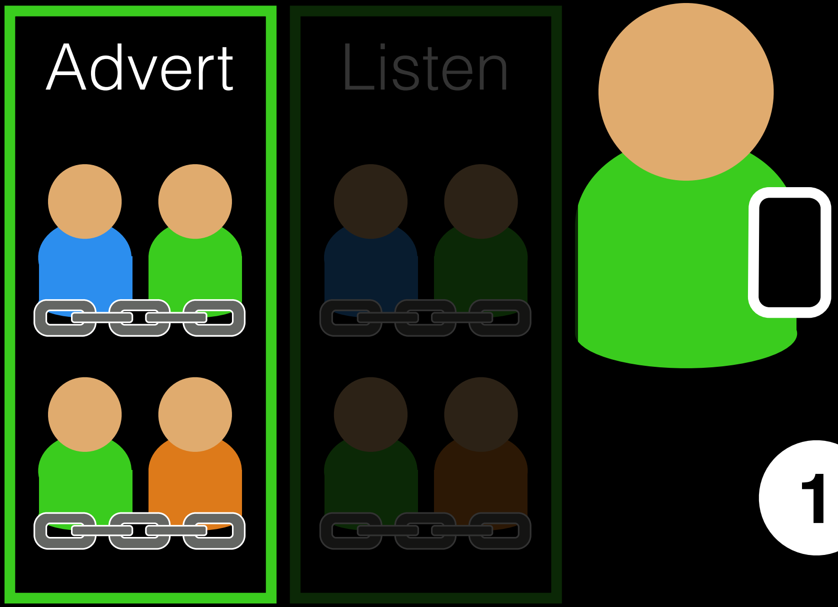

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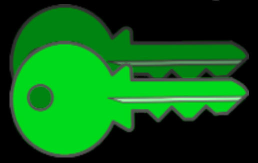

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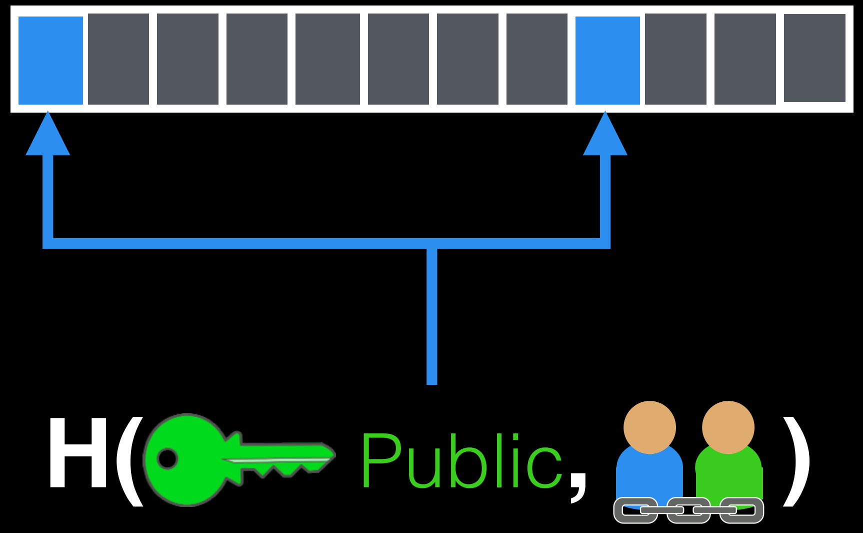

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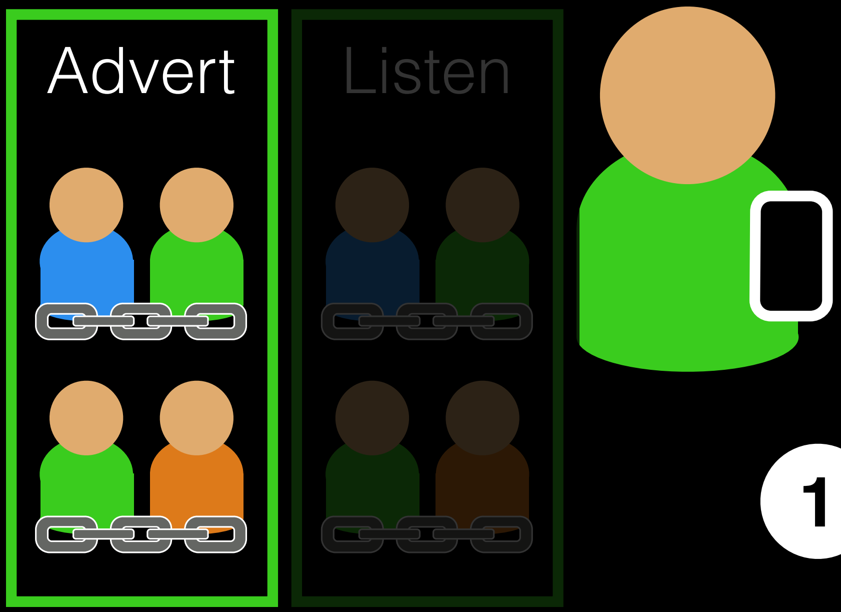

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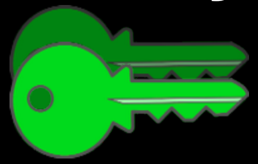

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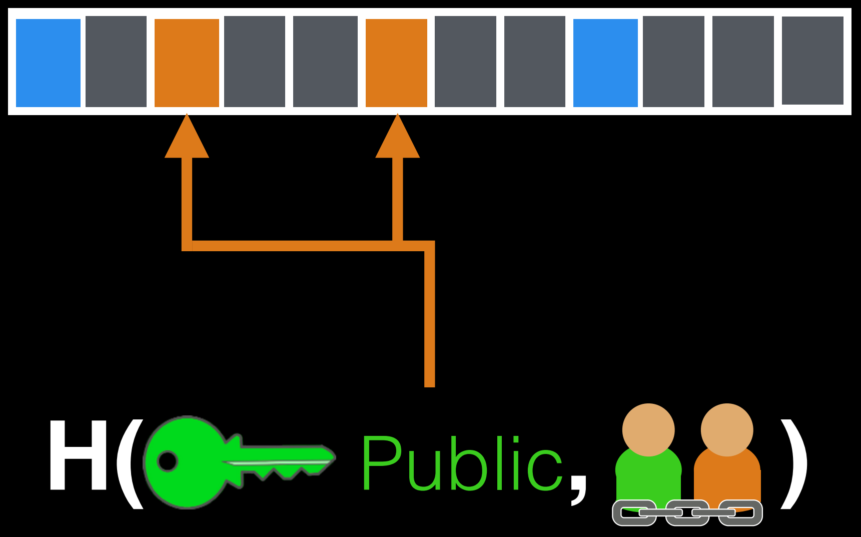

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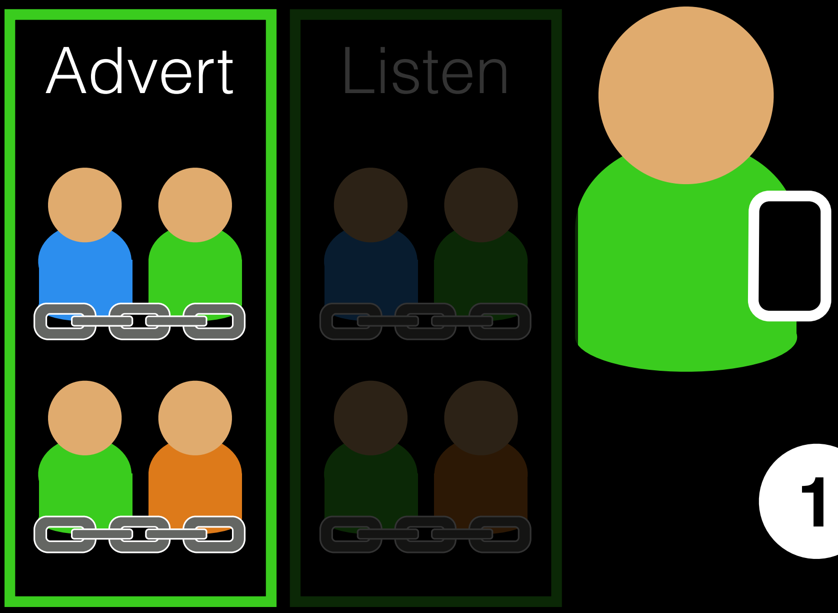

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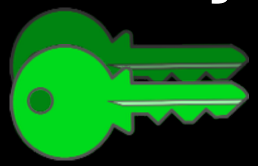

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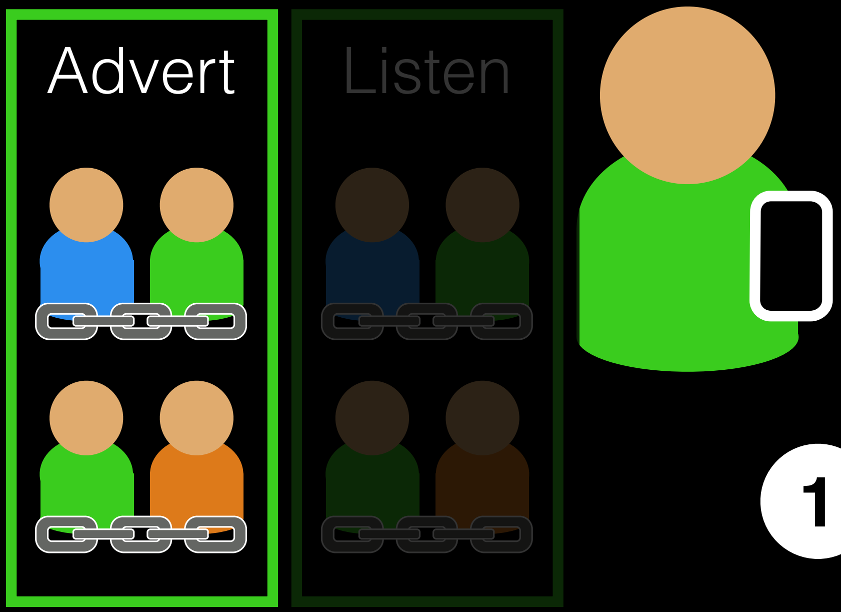
SDDR Protocol State



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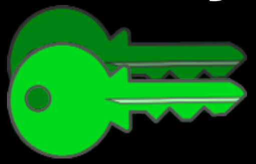

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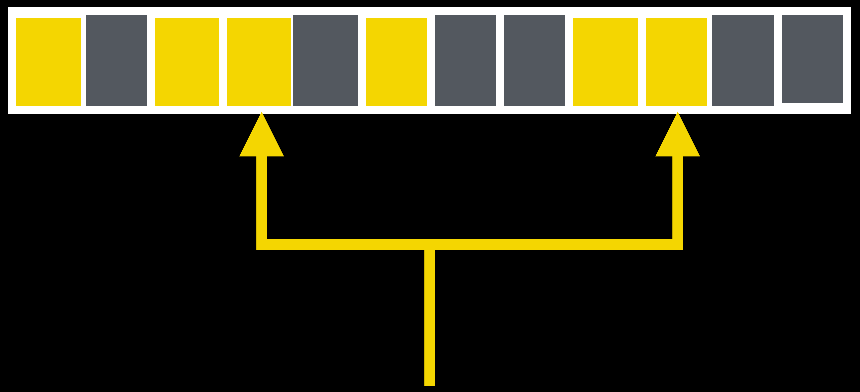
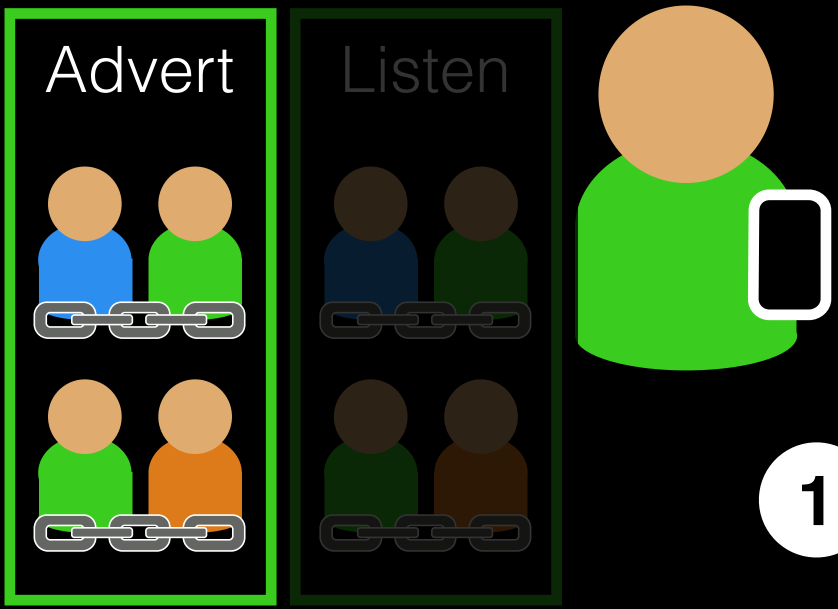


Random padding to global maximum size

SDDR Protocol State



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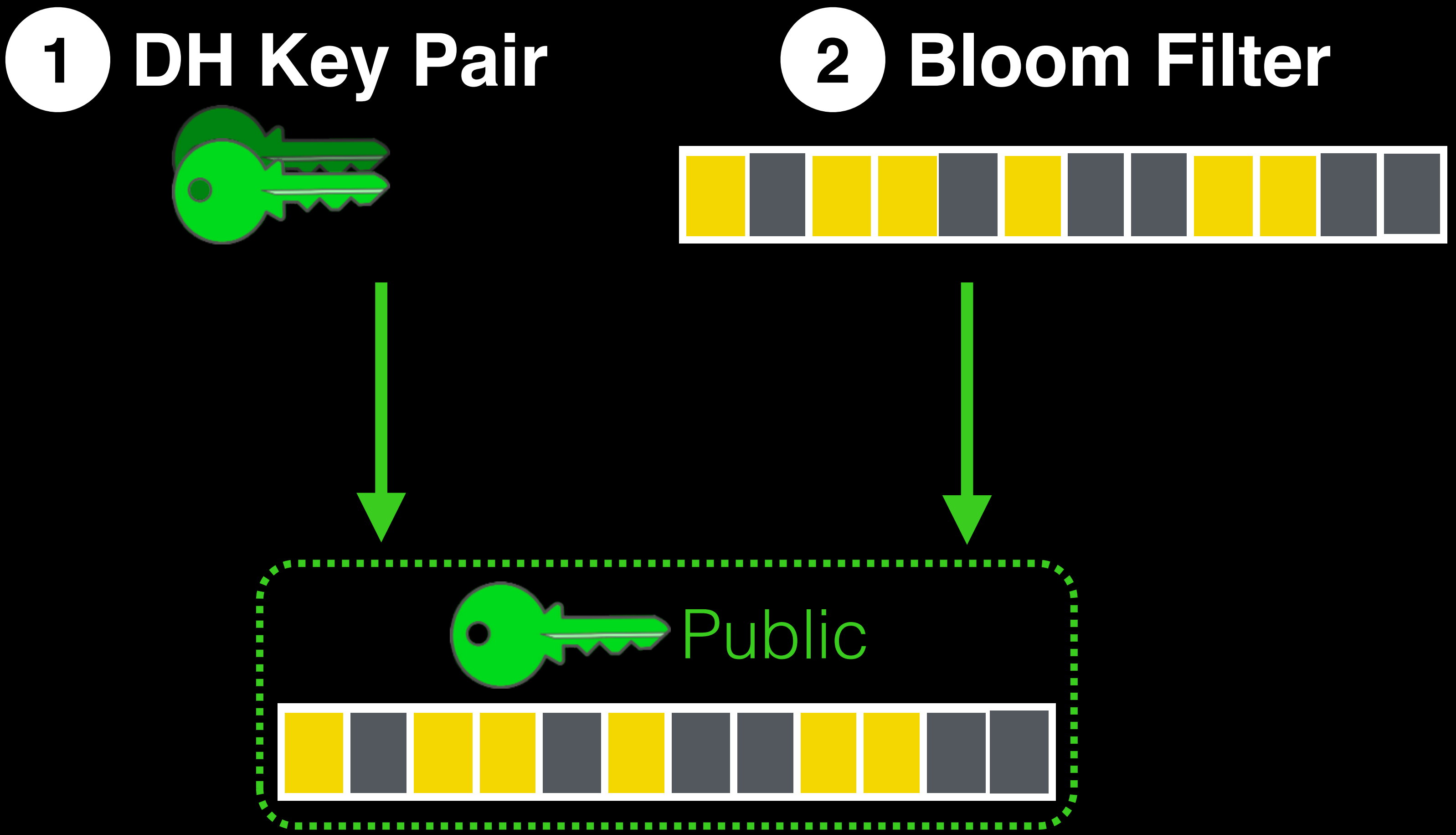
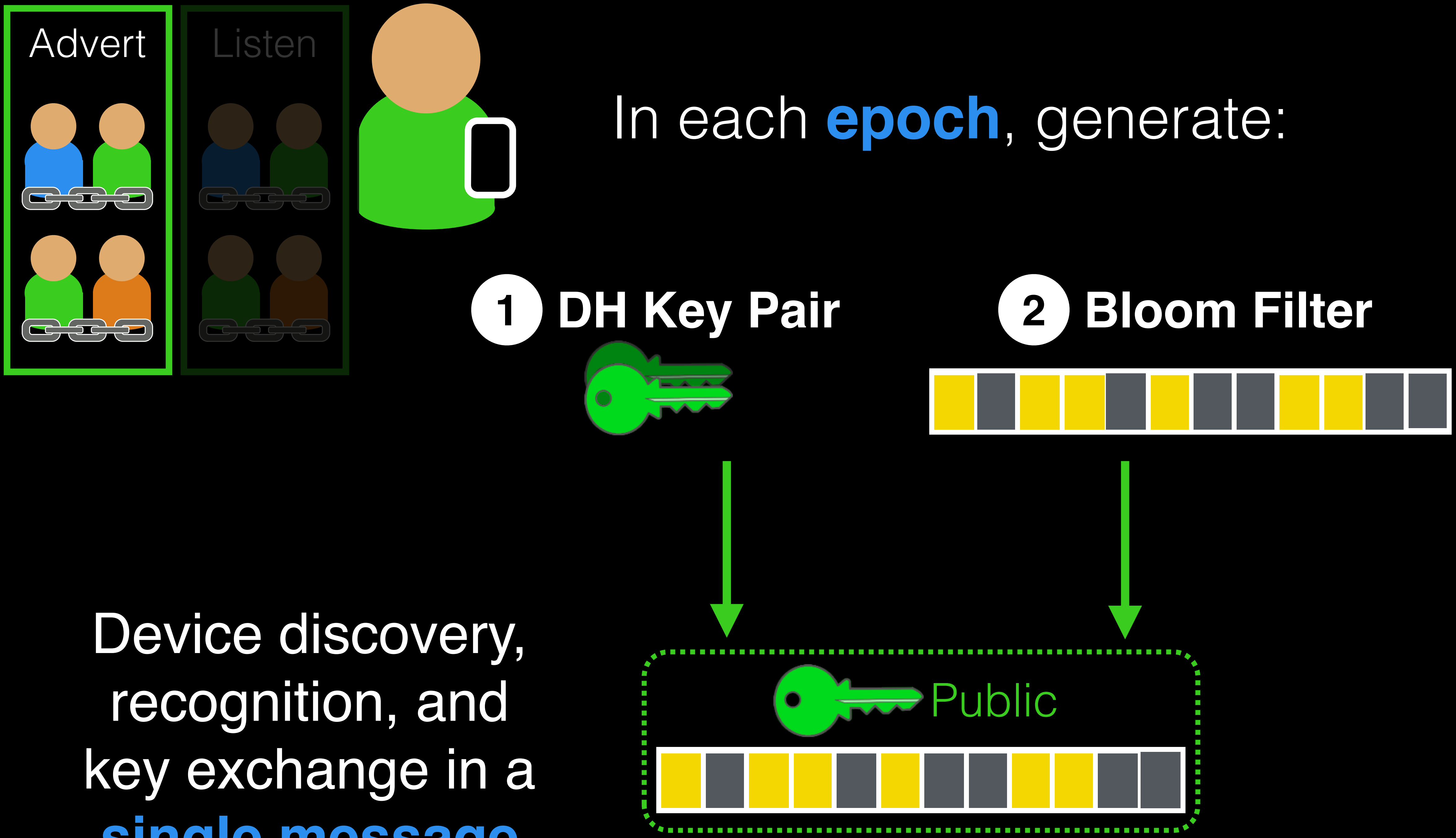


1. **DH Key Pair**
2. **Bloom Filter**

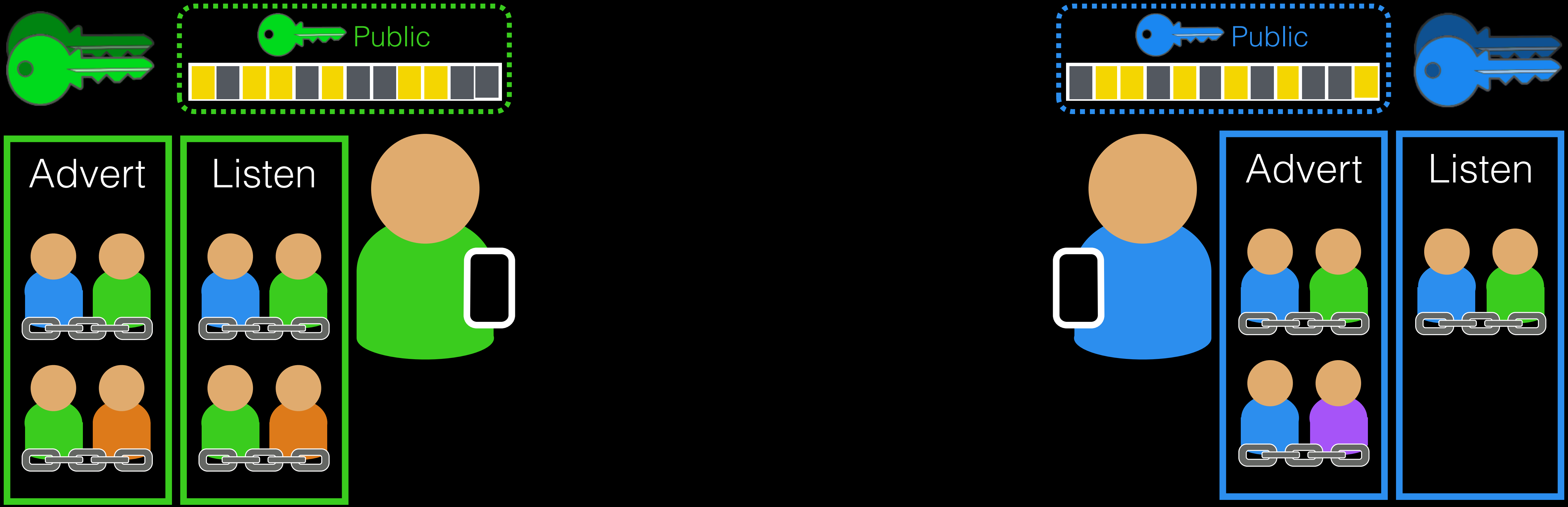
SDDR Protocol State



In each **epoch**, generate:

Device discovery, recognition, and key exchange in a **single message**

SDDR Protocol



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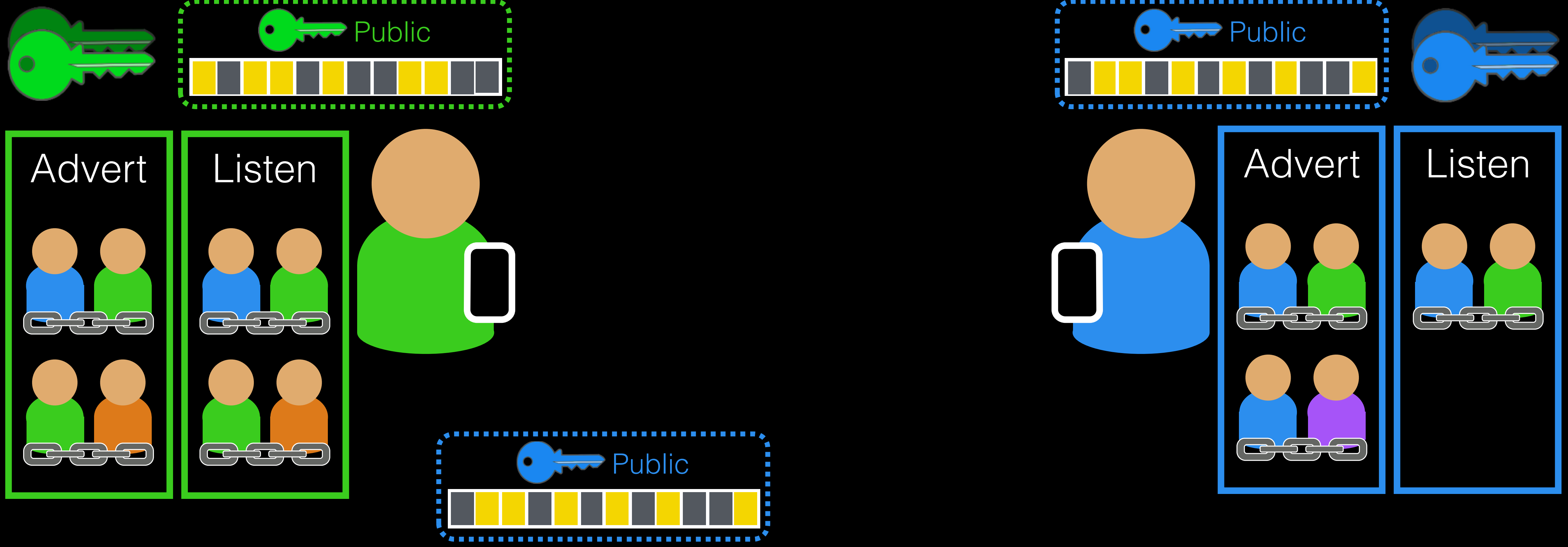

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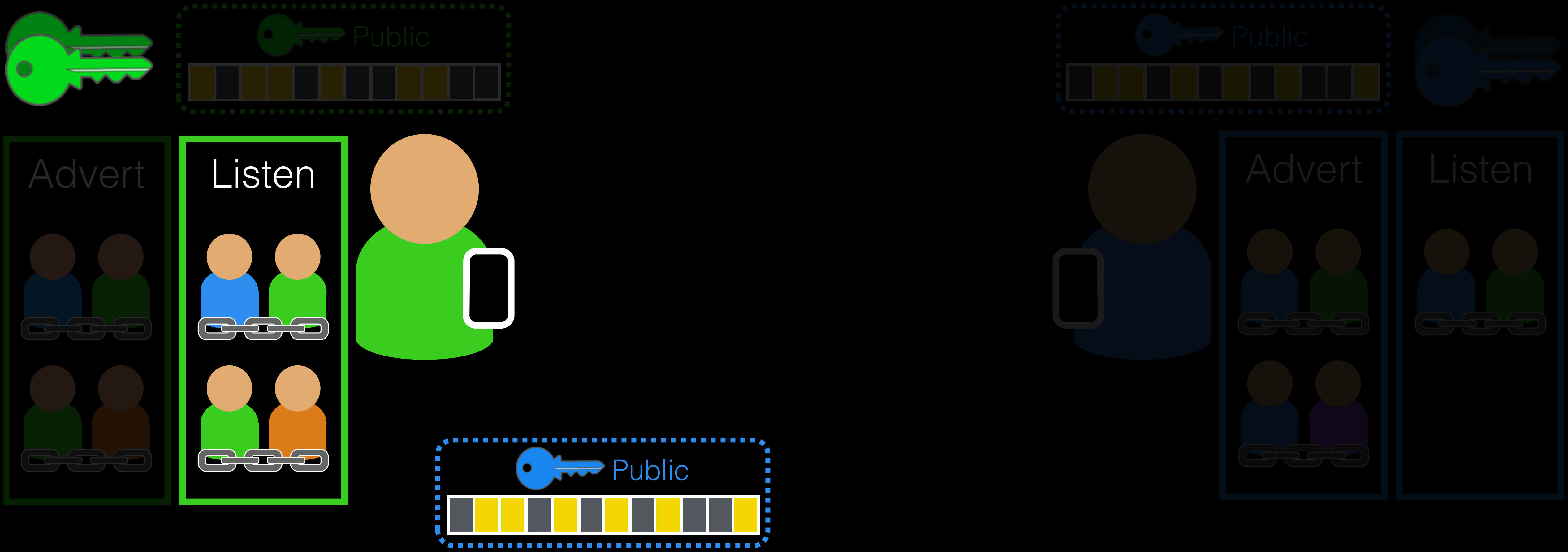

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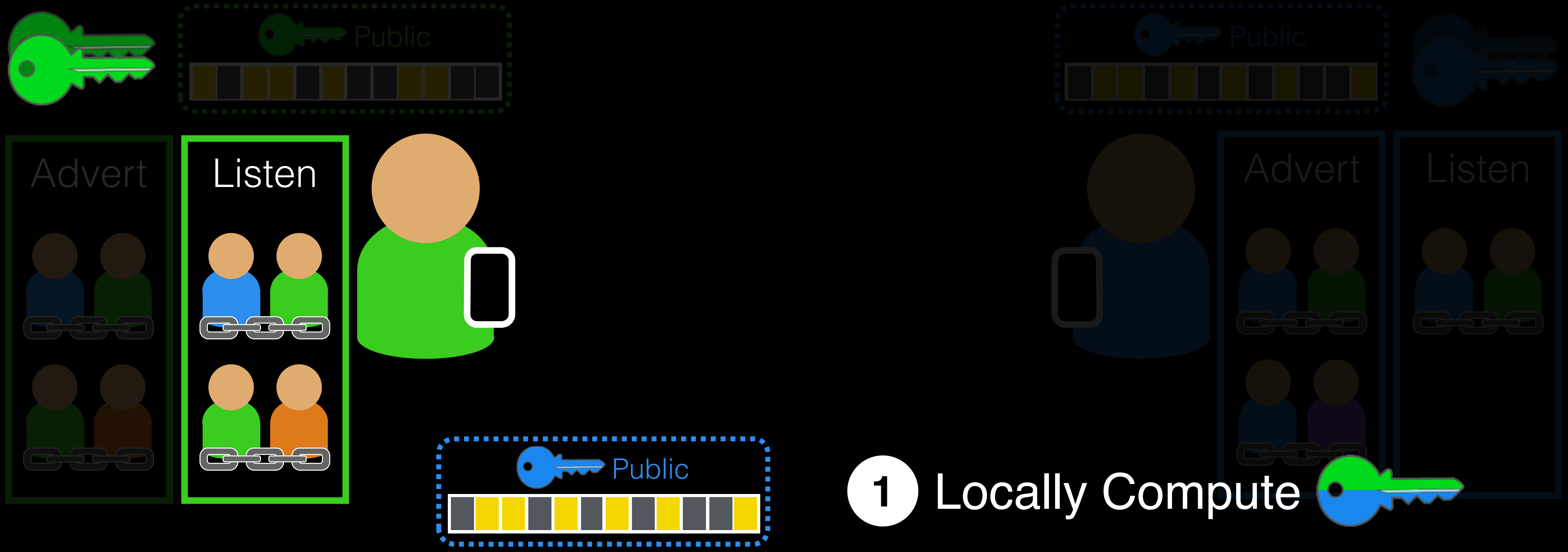
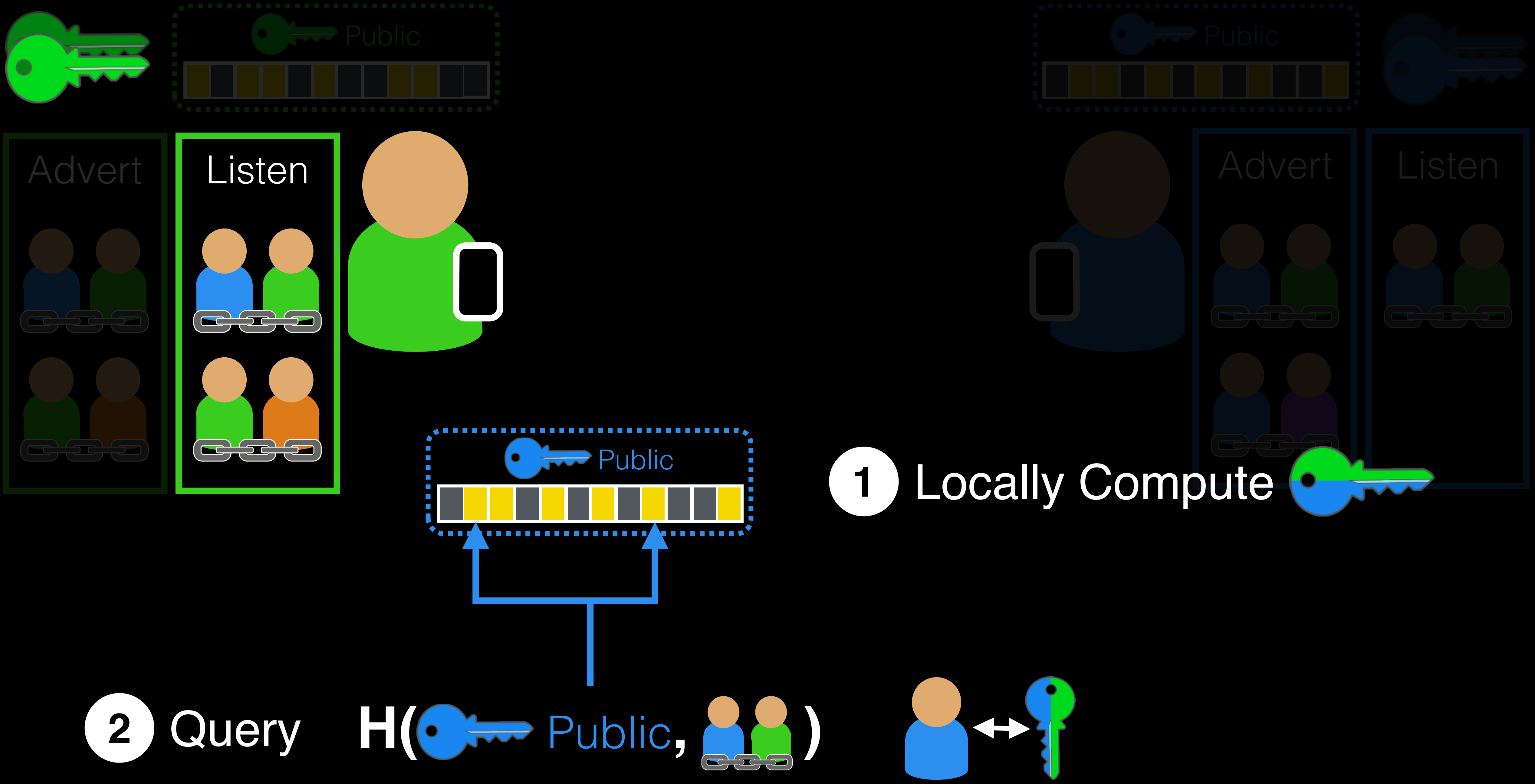


1 Locally Compute

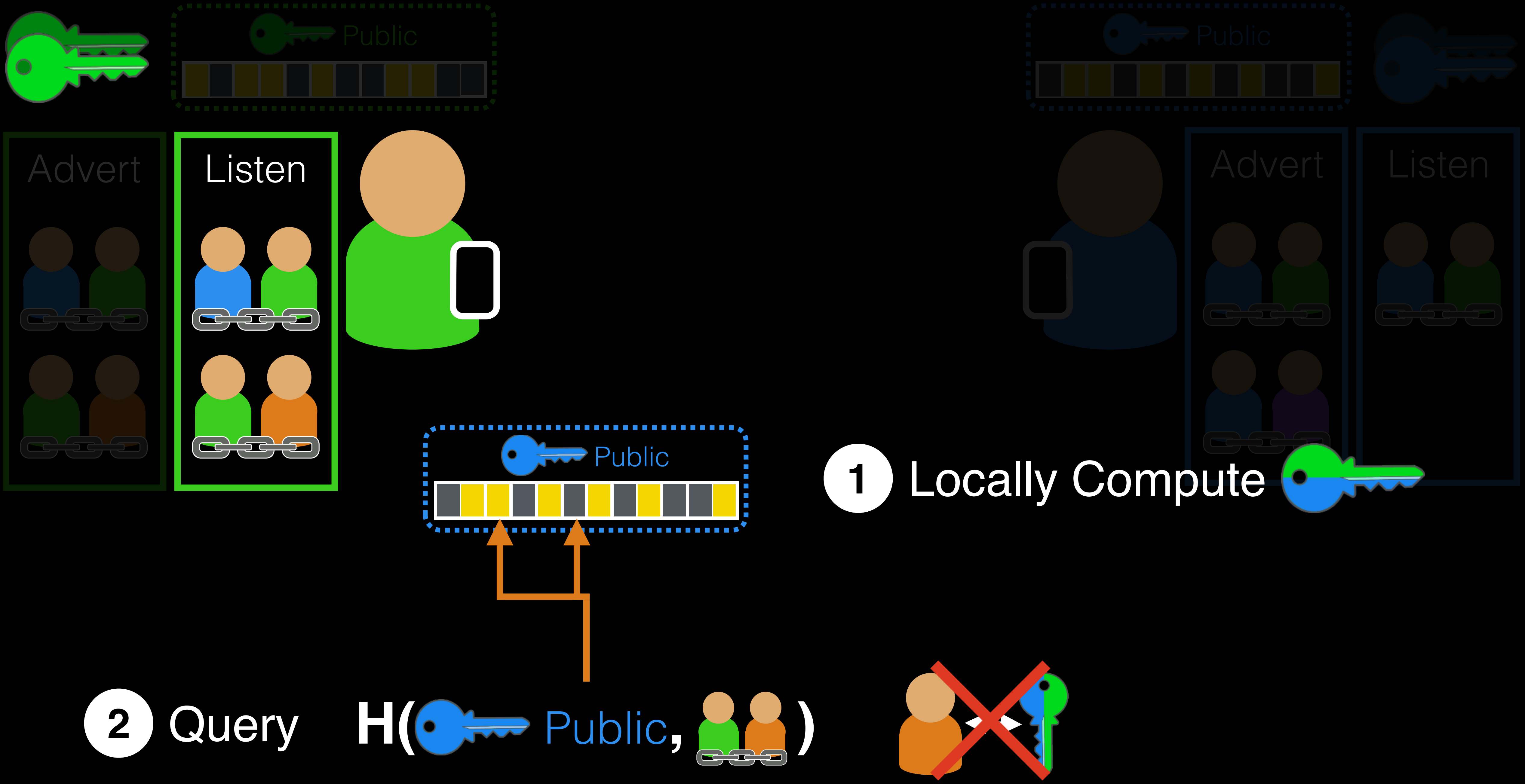
SDDR Protocol



1 Locally Compute

2 Query H(Public,)

SDDR Protocol



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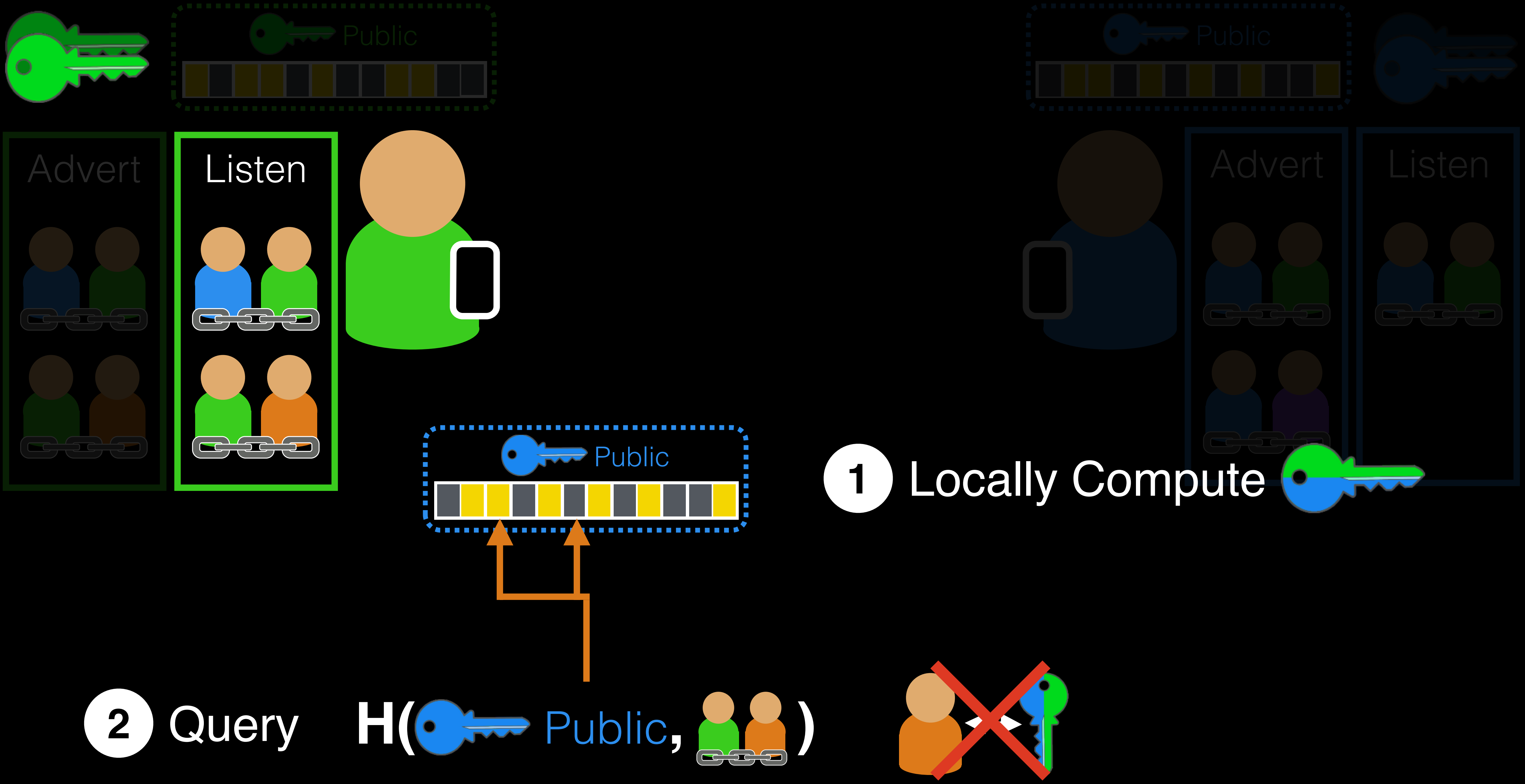
2 Query H(Public,)

SDDR Protocol

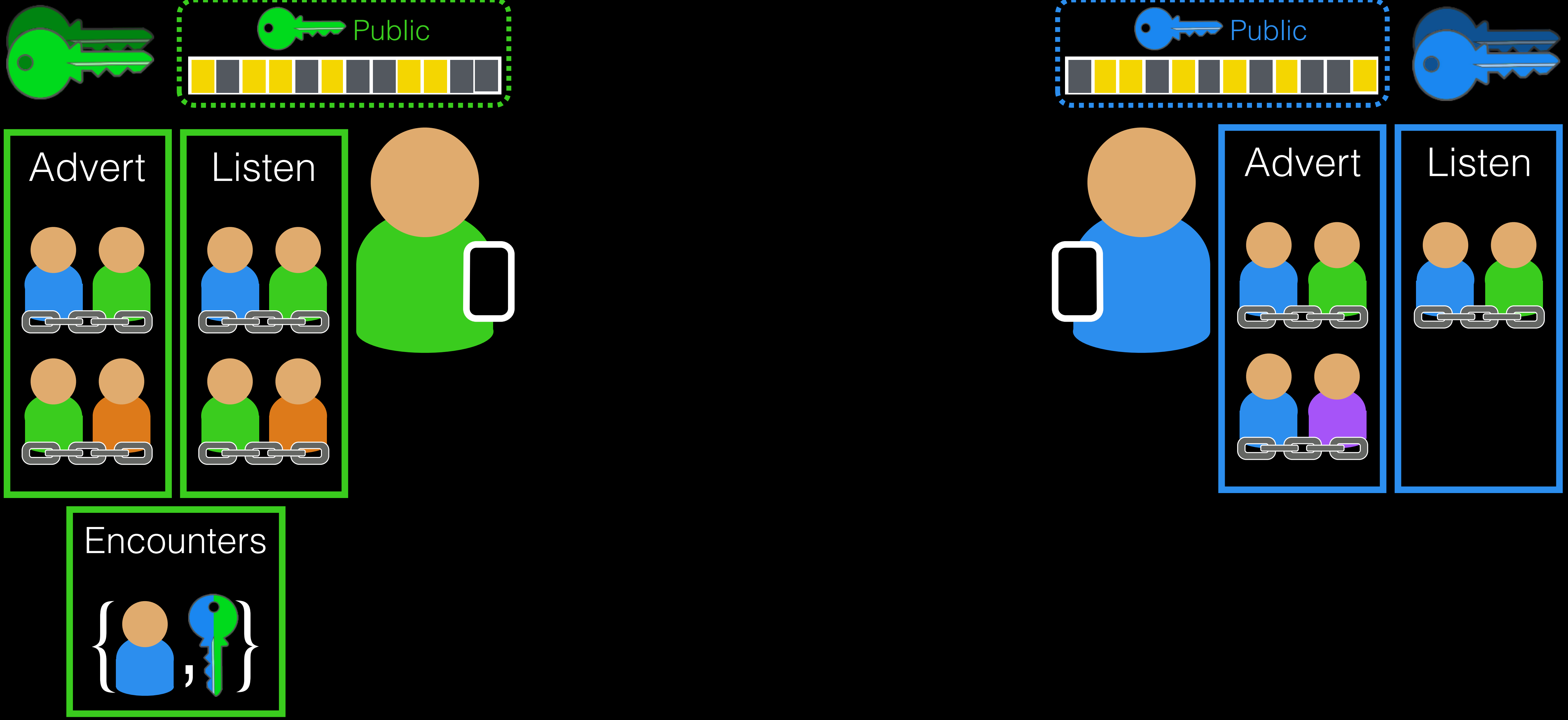


1 Locally Compute

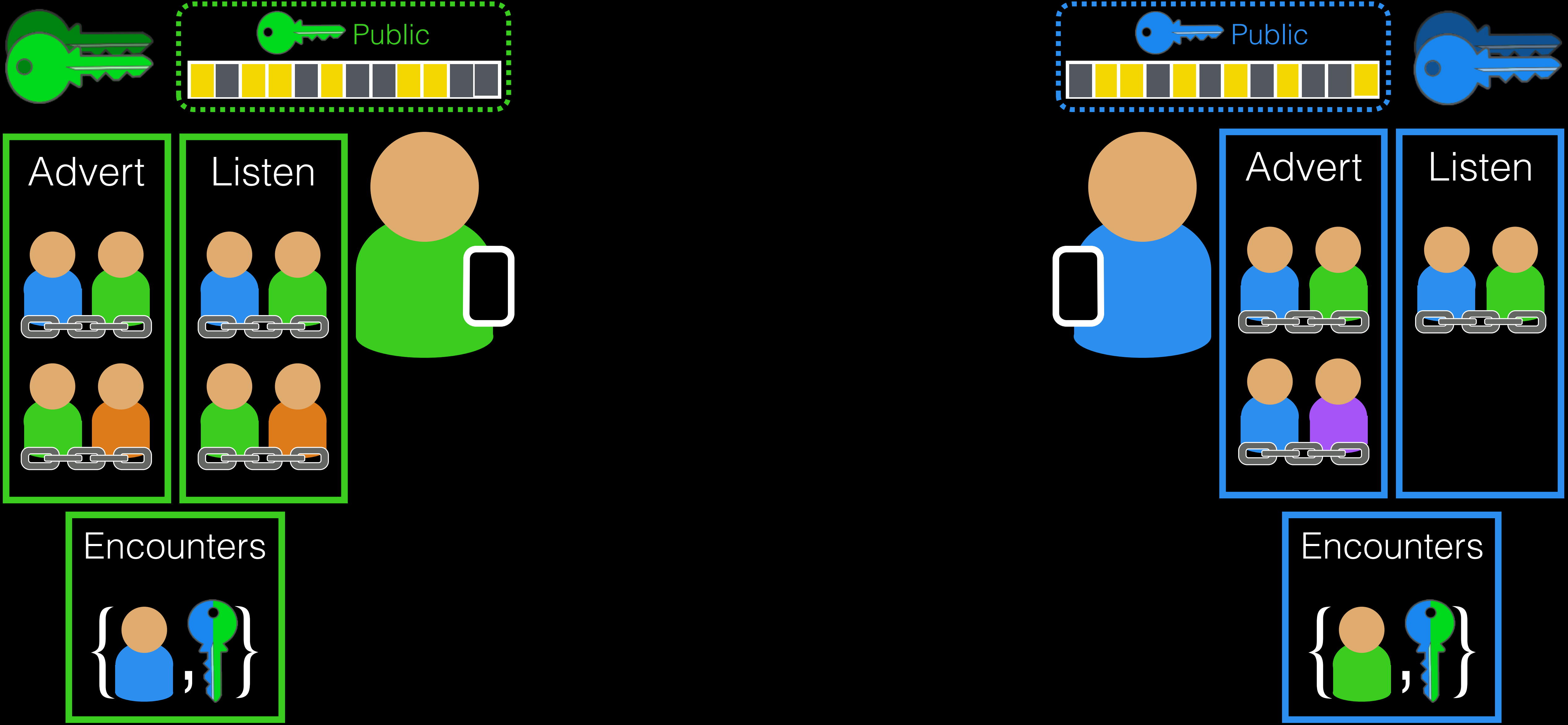
2 Query H(Public,)

Can mitigate false positives (Details in paper)

SDDR Protocol



SDDR Protocol



Public

Advert

Listen

Encounters

Public

Advert

Listen

Encounters

SDDR Implementation

Prototype for Android using Bluetooth 2.1

Developed/Evaluated on
Samsung Galaxy Nexus

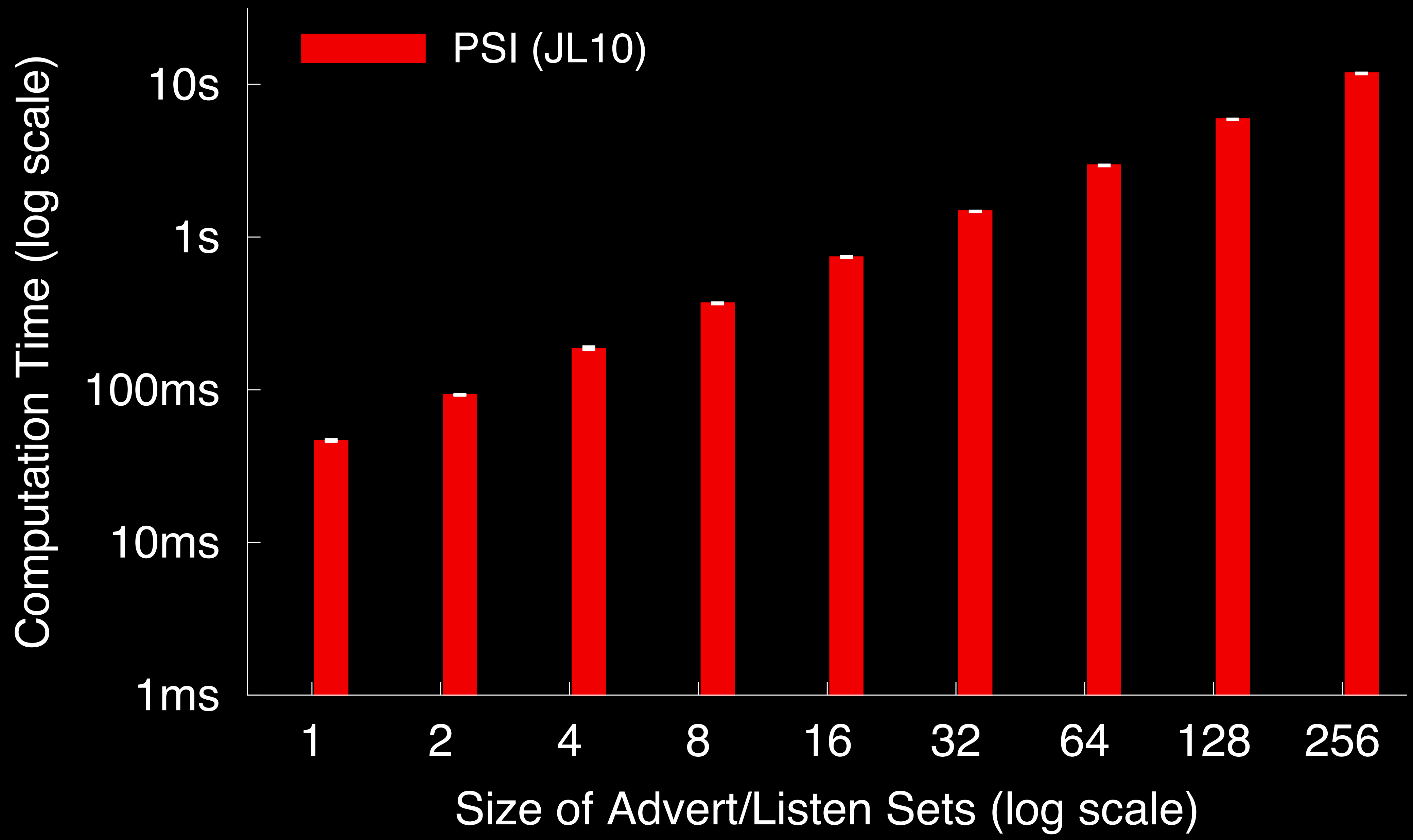
BattOr for Power
Measurements

System Goals

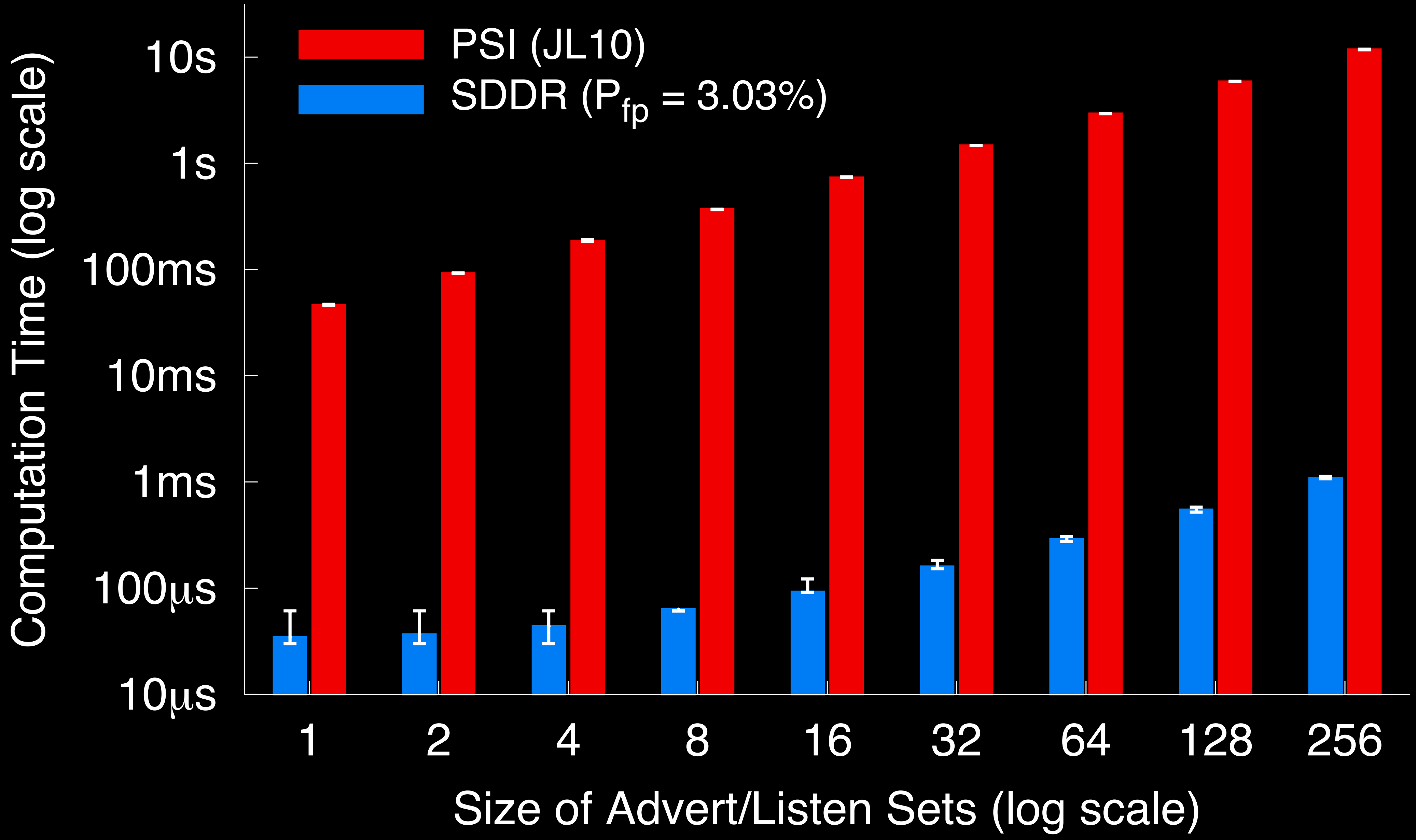
Efficiency - Practical for resource-constrained devices

Scalability - Handle many peers (e.g., stadium)

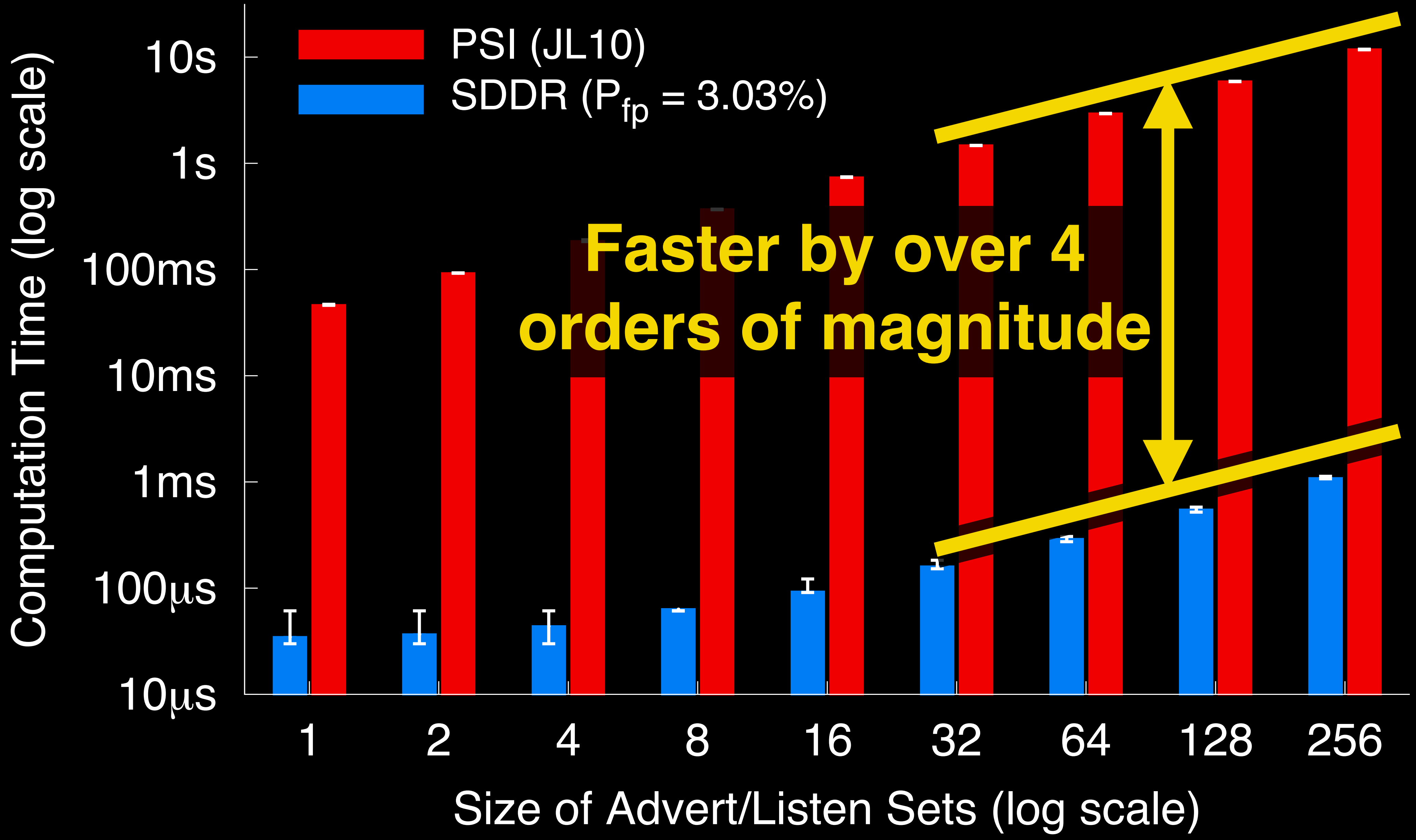
SDDR vs PSI - Computation



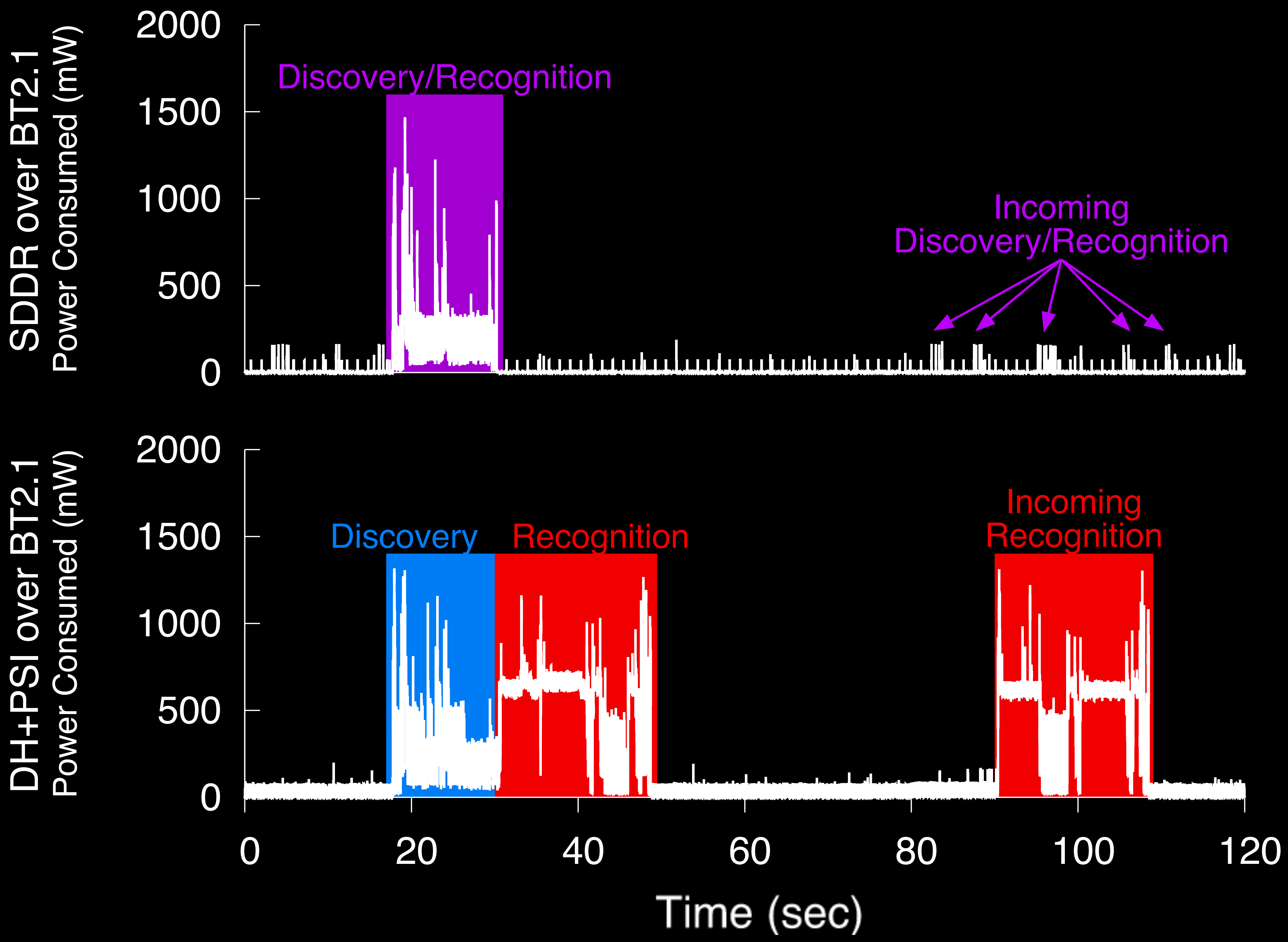
SDDR vs PSI - Computation



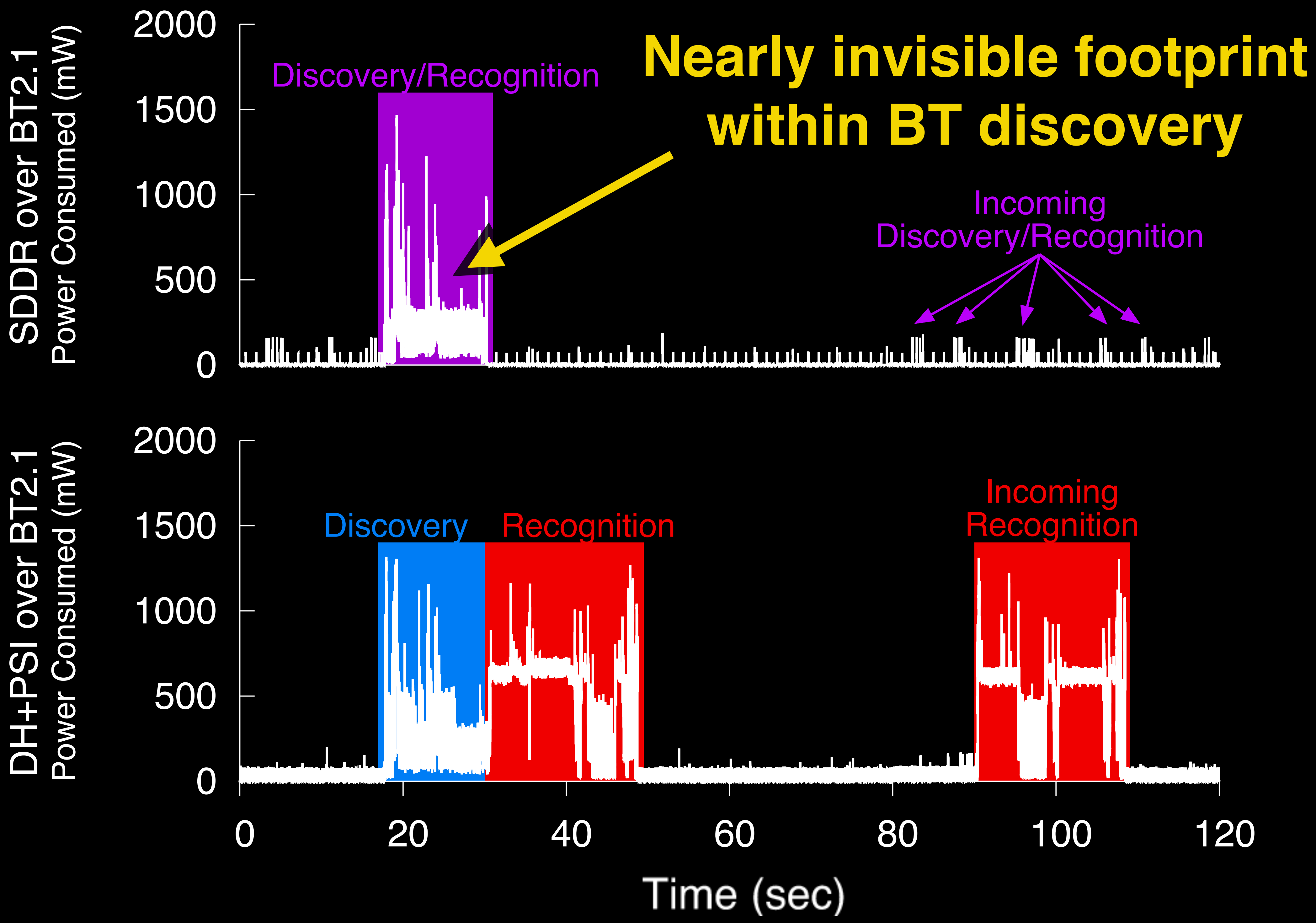
SDDR vs PSI - Computation



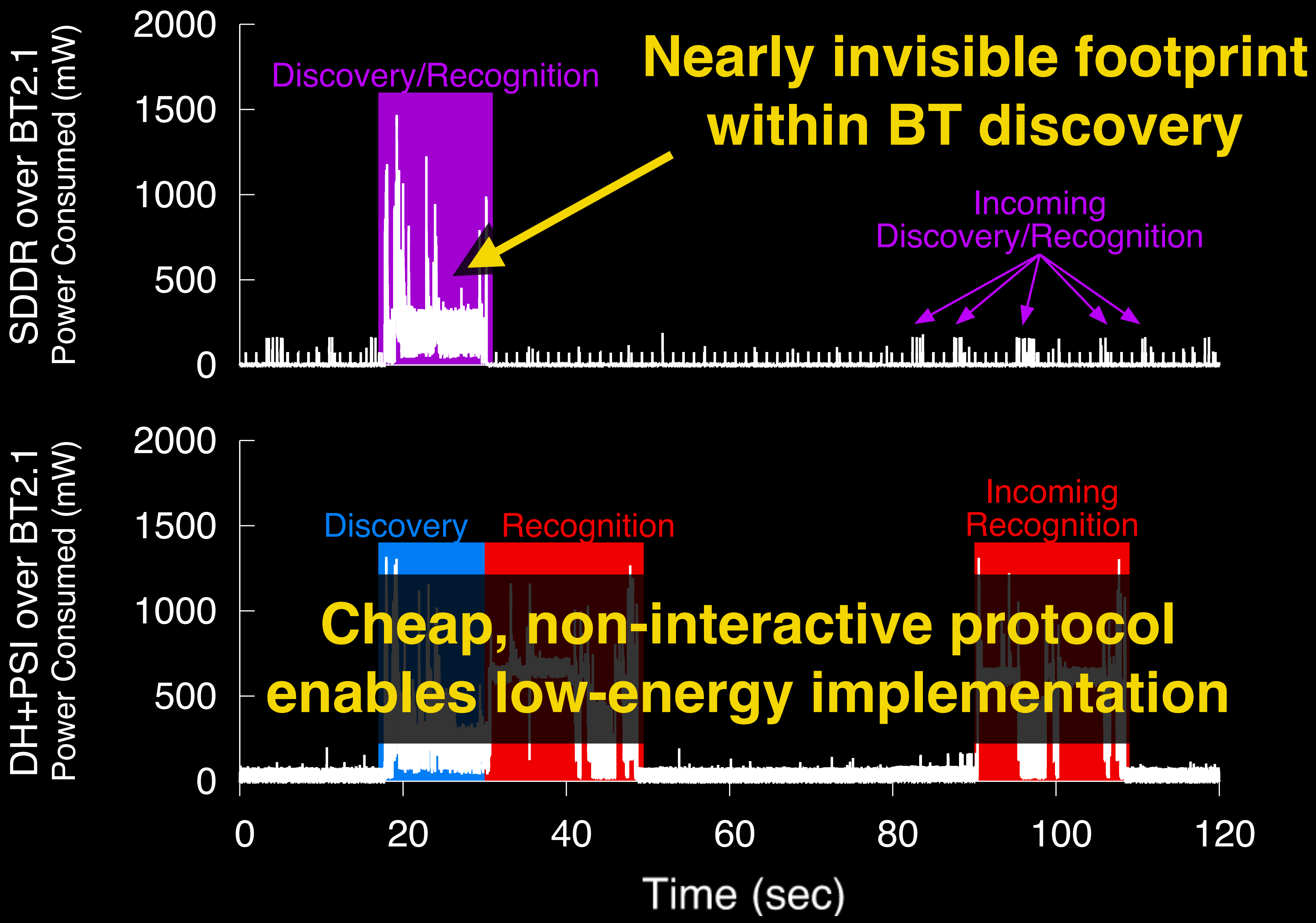
SDDR vs PSI - Power Traces



SDDR vs PSI - Power Traces



SDDR vs PSI - Power Traces



Nearly invisible footprint within BT discovery

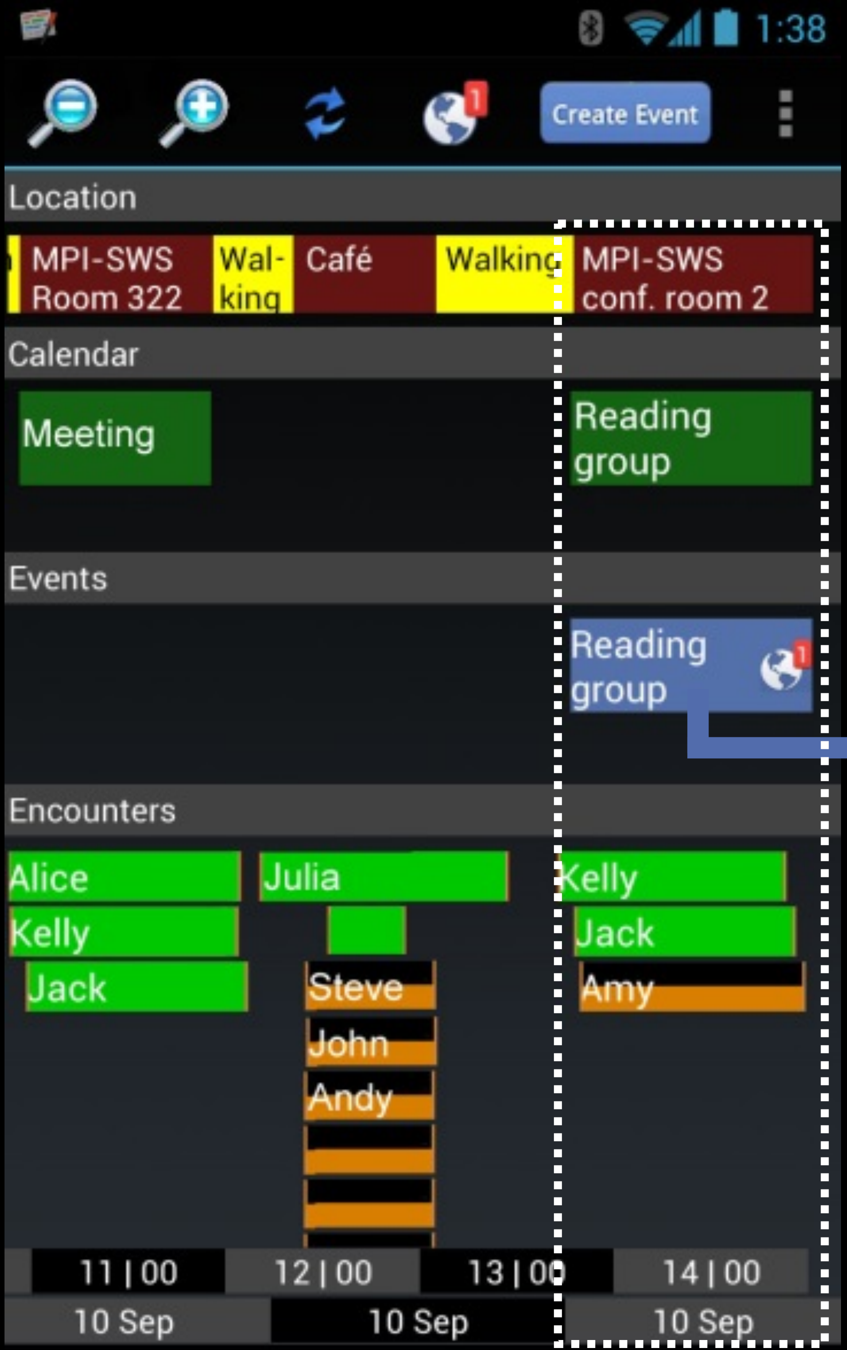
Cheap, non-interactive protocol enables low-energy implementation

SDDR Evaluation

- ✓ Time to Compute Recognizability
- ✓ Energy Consumption - Power Traces
- Energy Consumption - Micro-benchmarks
- Battery Life vs. # Nearby Devices

EnCore - Communication Platform

Appeared in MobiSys '14



Supports content sharing for groups of socially meaningful encounters

"Great discussion!" - Amy

Summary

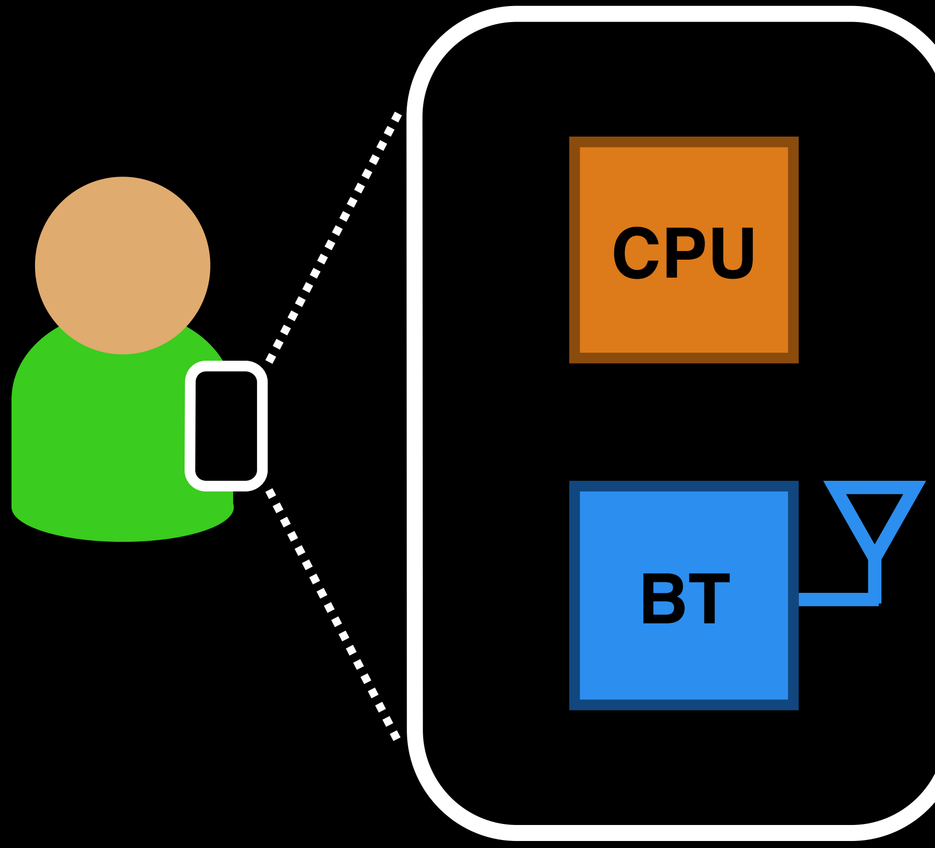
Mobile social applications have significant privacy challenges

SDDR provides secure encounter primitive

runs efficiently on mobile devices

www.cs.umd.edu/projects/ebn

SDDR over Bluetooth 2.1



Discoverable B

Responds to inquiry scan with address and beacon

Inquirer C B

Performs inquiry scan, receiving and processing nearby devices’ beacons

Change MAC address each epoch