Kintsugi 🔑🏺

Decentralized E2EE Key Recovery

Emilie Ma & Martin Kleppmann

Slides available at emilie.ma/fosdem2025 ◦ hello@emilie.ma

I lost my phone. What now?

- with non-E2EE apps: log in with the same username/password
- with E2EE apps: server doesn’t store a copy of key
    - recovery PIN
    - recovery contact
    - recovery codes
    - recovery files
    - and more…

Existing schemes have tradeoffs.

Recovery PINs	**Recovery Contacts**	**Recovery Codes/ Files**
• e.g. Signal SVR, WhatsApp • Requires secure hardware for rate-limiting guesses (otherwise, brute-forceable)	• e.g. Apple iCloud, PreVeil • Have to totally trust contacts • Usually can collude to gain access to your account	• e.g. LastPass, Bitcoin • Protects against brute-force/guessing because high-entropy, but requires keeping a copy

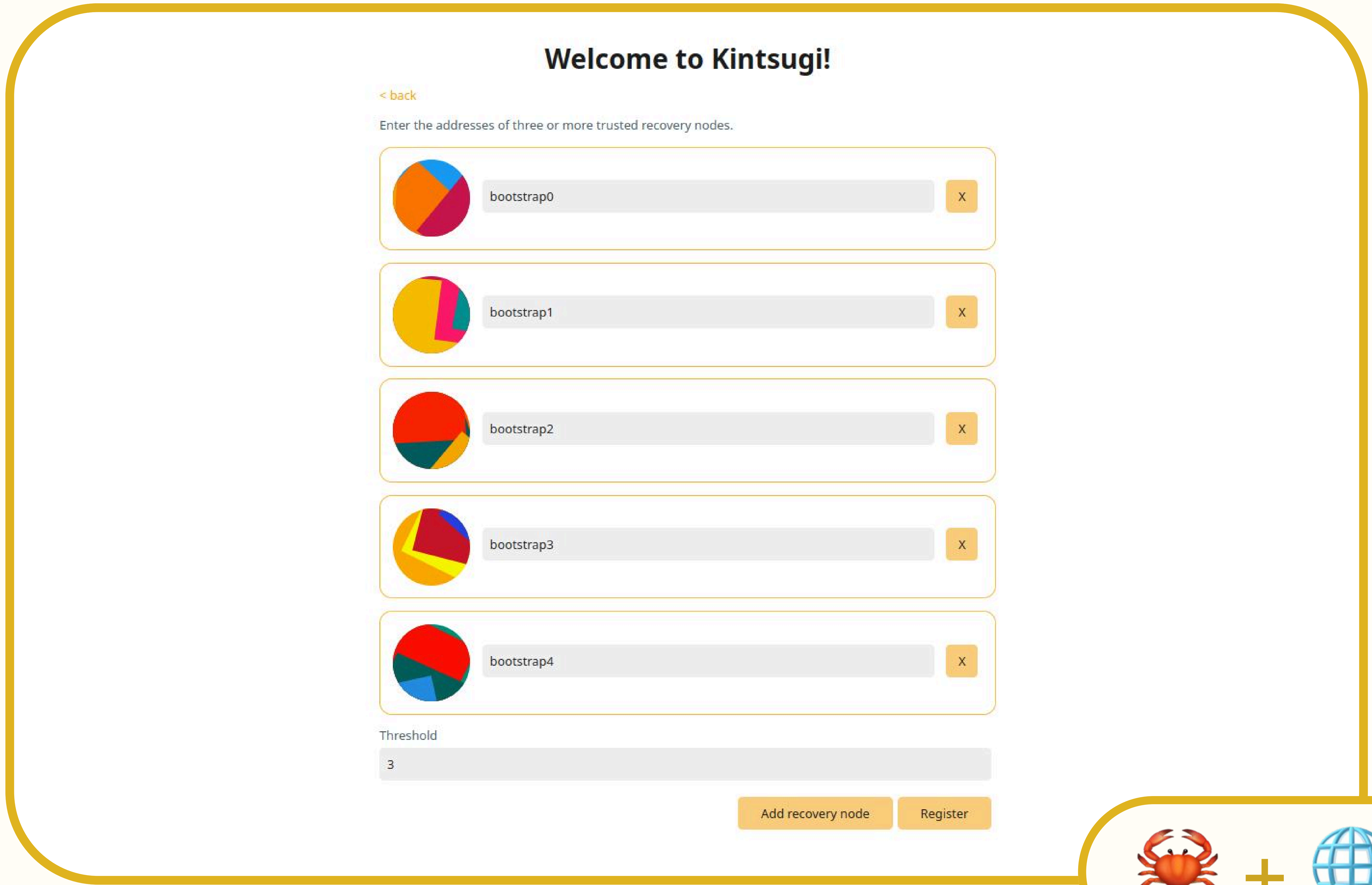
Centralization doesn’t always work.

- some applications require metadata privacy (e.g. Tor)
- others may have infrastructure shut down (e.g. sanctioned activists)
- services may lack/want to avoid central authority group
- infrastructure can be cost-prohibitive
- other issues: single point of trust, infra availability

Introducing Kintsugi!

- decentralized key recovery protocol based on P2P network
  - recovery servers + contacts’ devices + a mix
- recovery by contacting some threshold *t+1* of recovery nodes
  - each hold share of secret for user to recover key
- users can update recovery nodes at any time
- protects against brute-forcing low-entropy password
- also protects against colluding, “honest-but-curious” recovery nodes

Demo



Welcome to Kintsugi!

< back

Enter the addresses of three or more trusted recovery nodes.

bootstrap0

bootstrap1

bootstrap2

bootstrap3

bootstrap4

Threshold

3

🦀 + 🌐 + ⚛️

github.com/kewbish/kintsugi

What’s an OPRF?

- Oblivious Pseudo-Random Function
    - user keeps a secret value, *U*
    - server keeps a secret value, *S*
    - user learns the result F(U, S) (but **not S**), server learns nothing

👤 🎩

User

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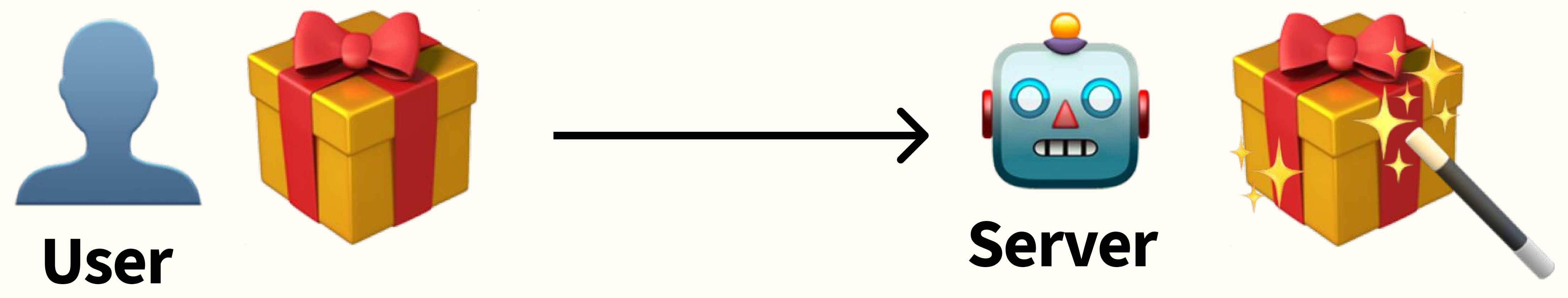

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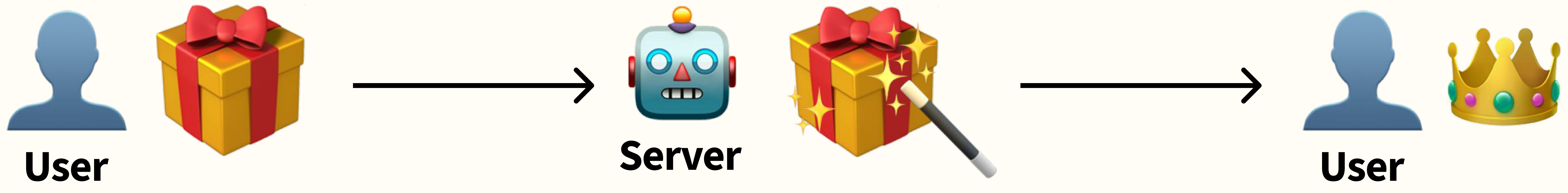
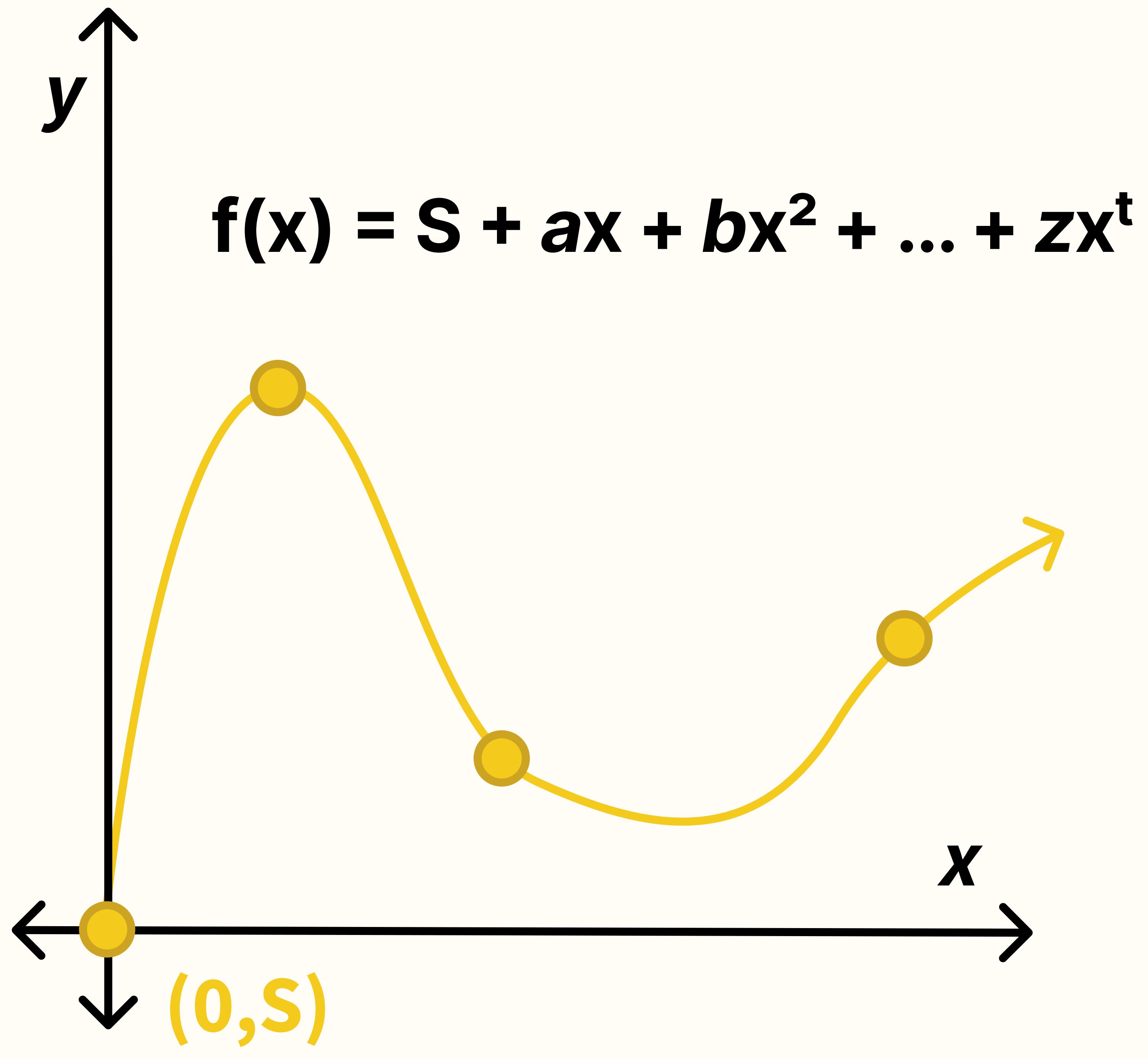


Shamir Secret Sharing

- have a secret *S* that you want to split up into *shares*
- require at least *t+1* shares to reconstruct *S*



- each of these points is a share
- can "connect the dots" with enough shares to find the unique function (Lagrange interpolation)
- then can compute f(0) = S

Protocols Used

- combination of:
    - threshold OPRFs (TOPPSS by Jarecki et al.)
        - imagine an OPRF but with multiple “servers”, where you need to reach at least *t+1*
    - dynamic, proactive secret sharing (Honey Badger by Das et al.)
        - recovery nodes can be changed on demand
        - imagine SSS but you can exchange nodes’ shares while keeping *s* the same

Registration Flow

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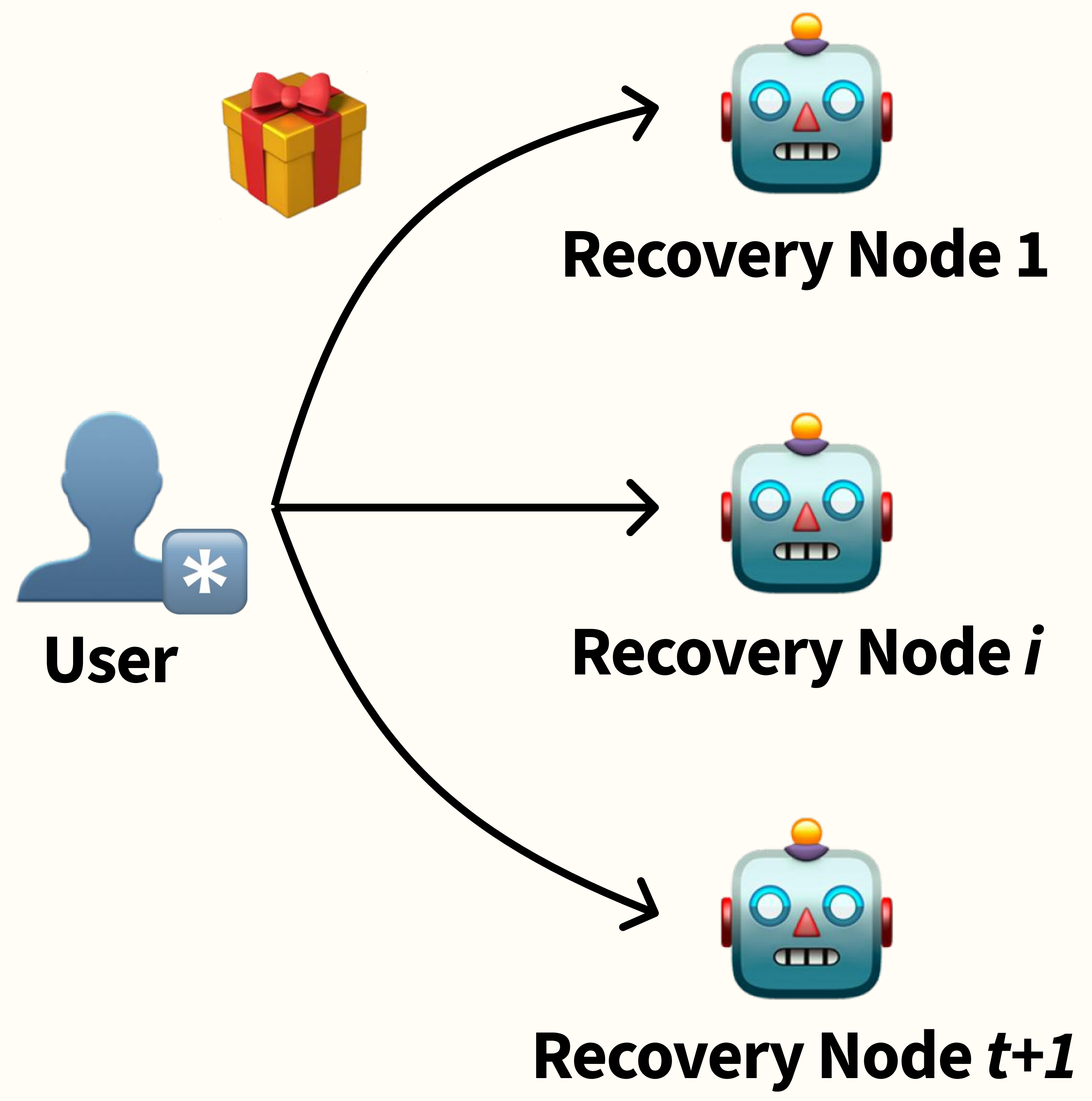
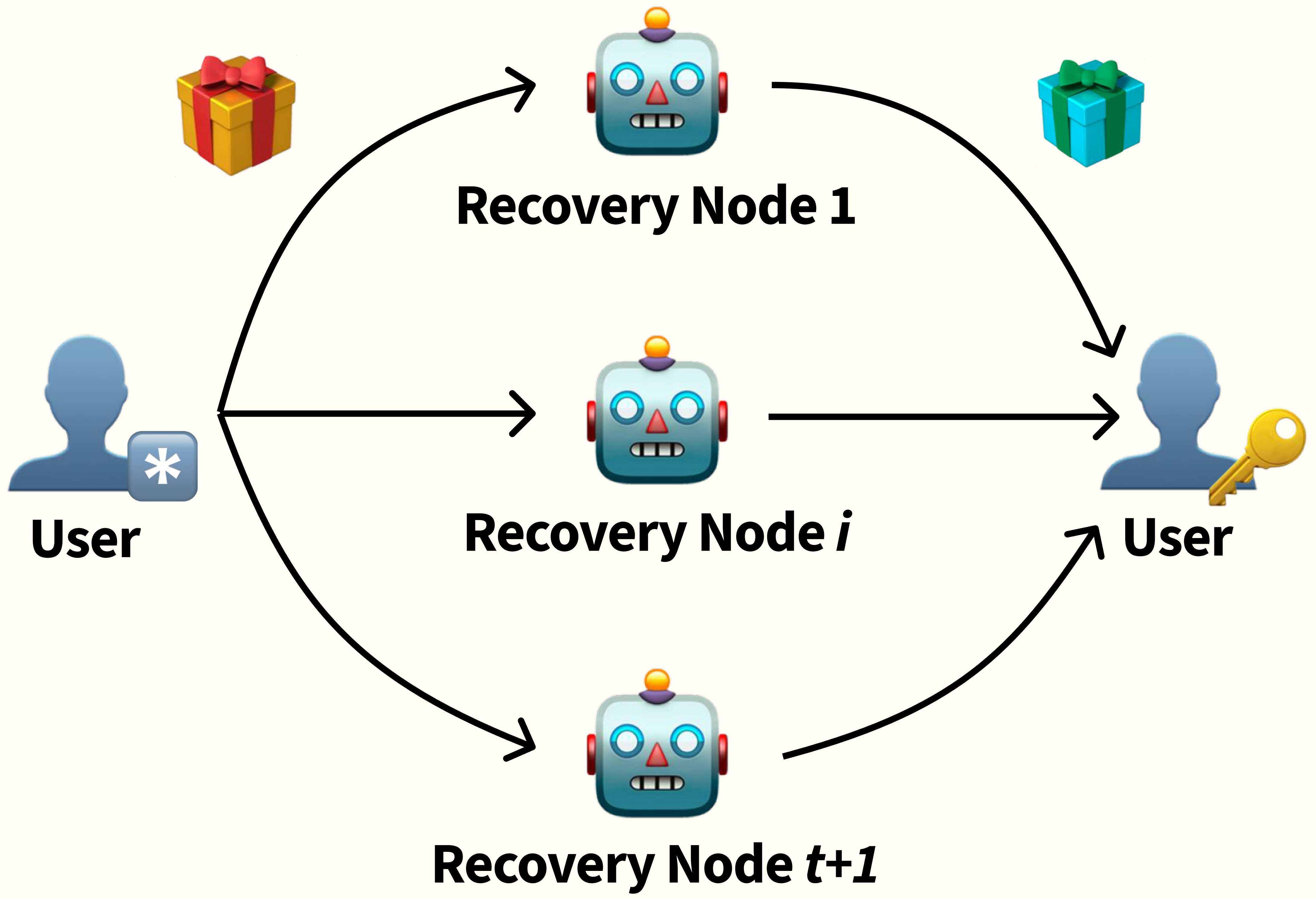
User

Registration Flow

Registration Flow



Registration Flow



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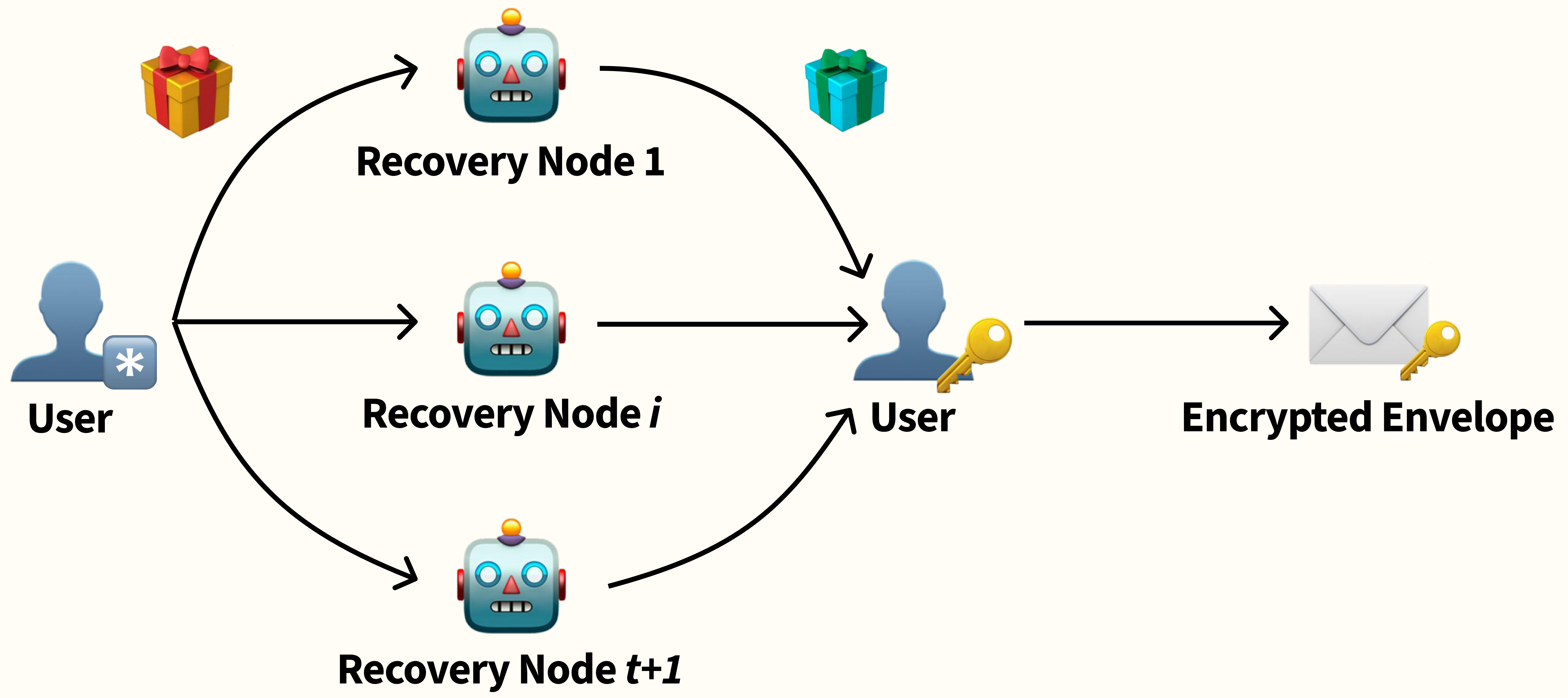

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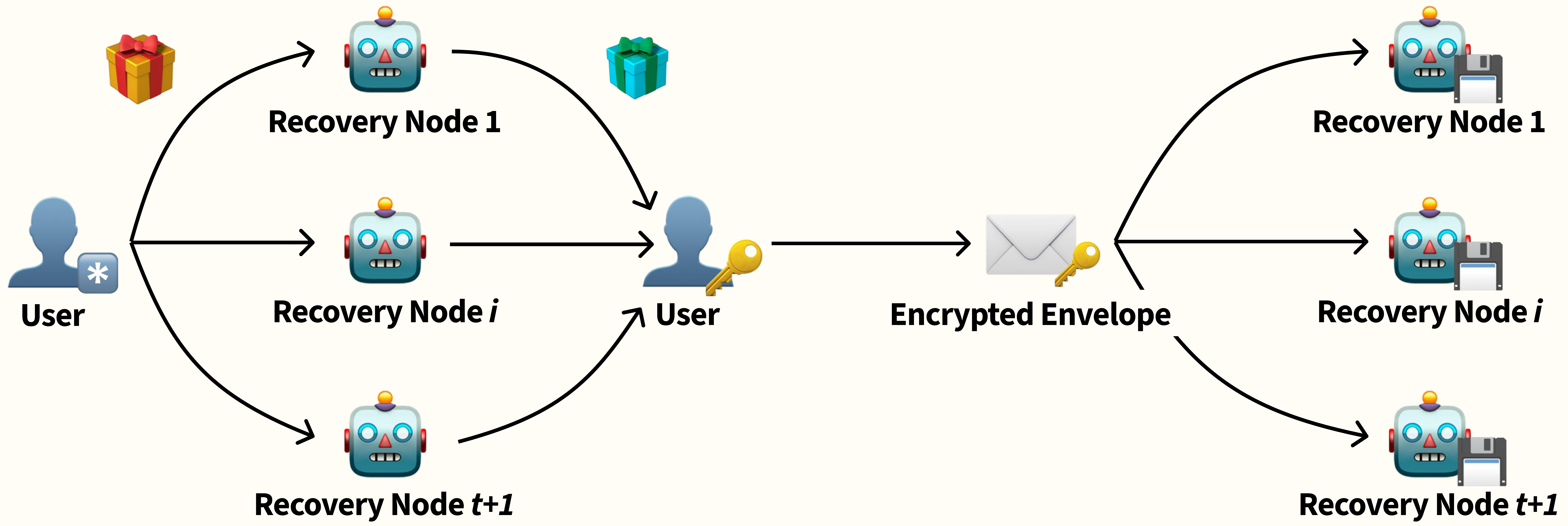
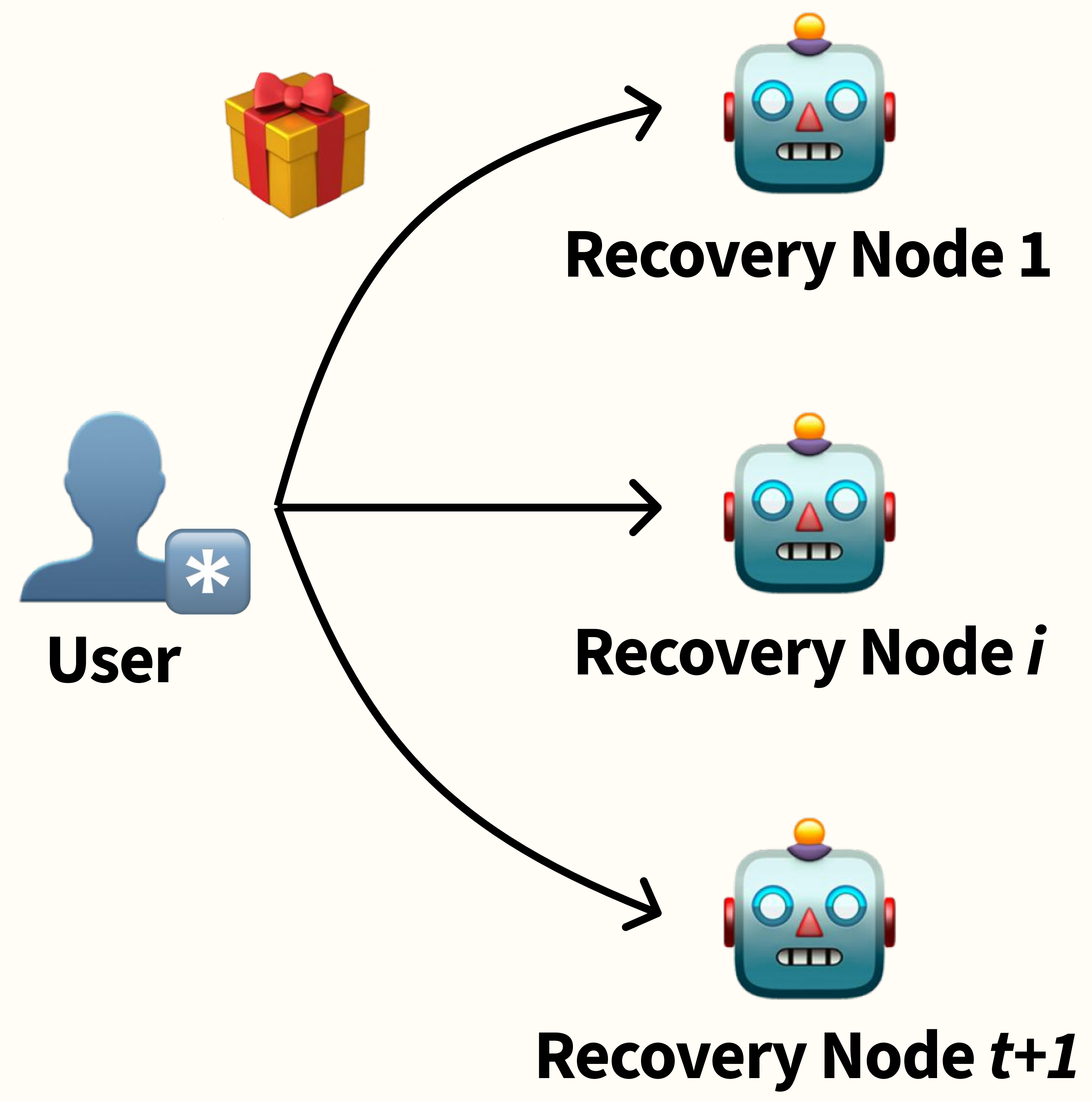


Recovery Flow



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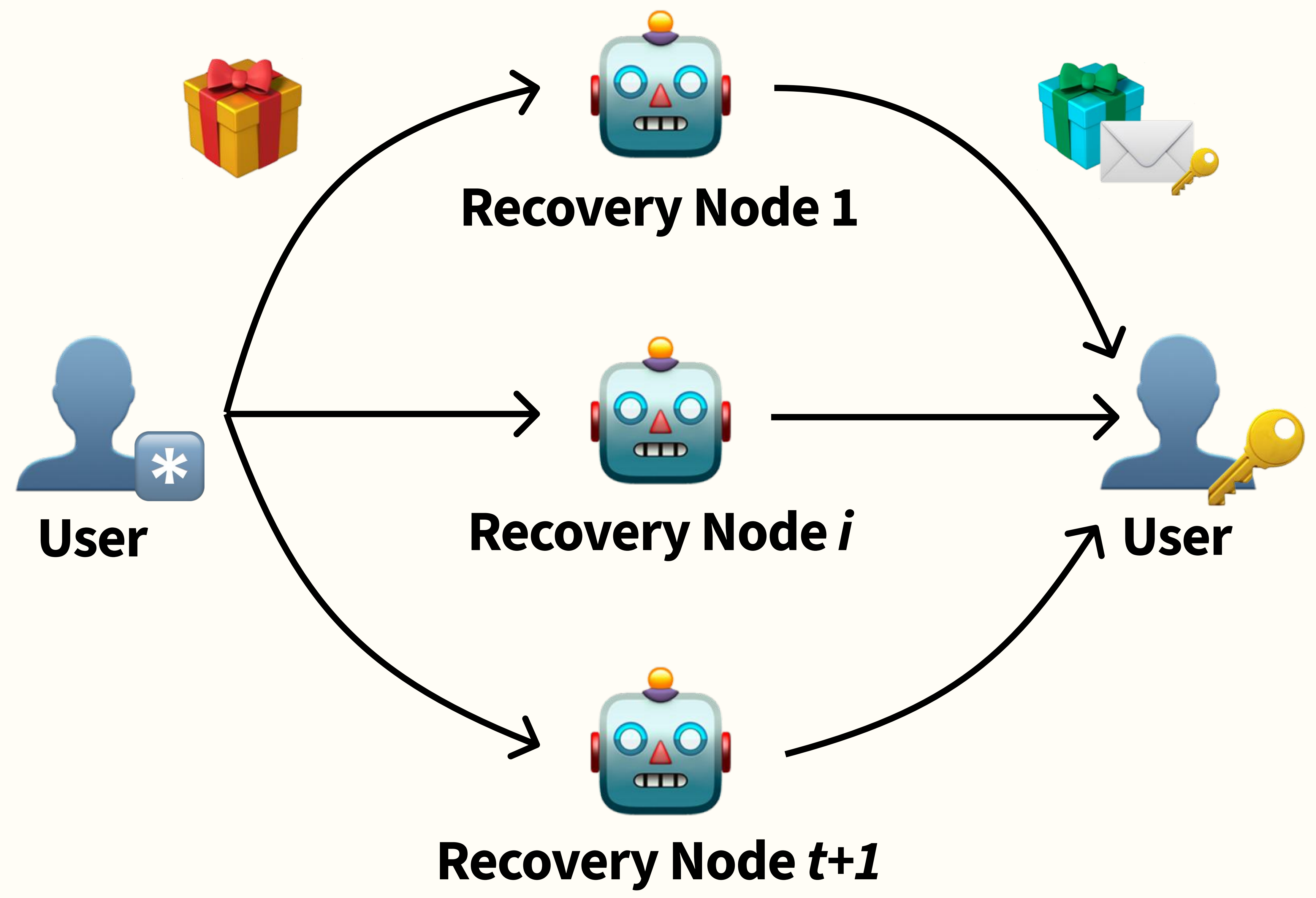

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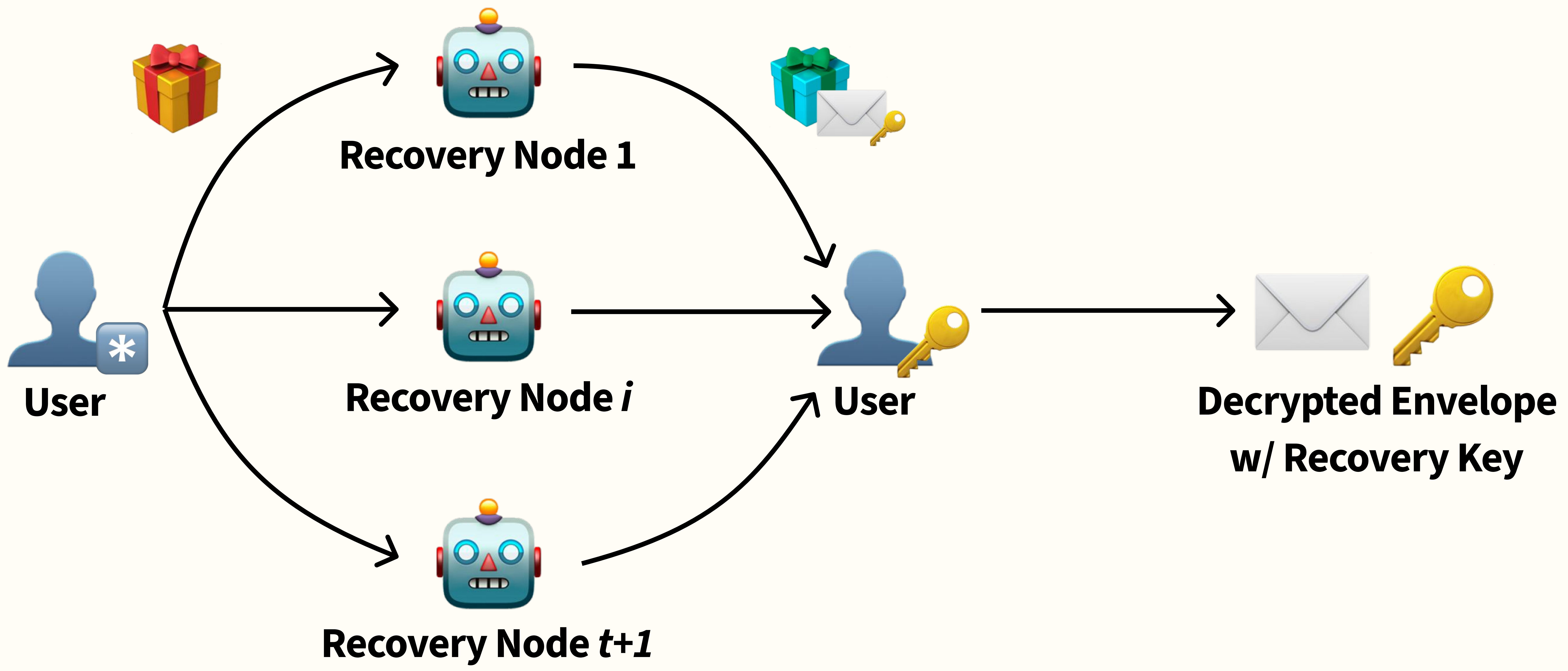

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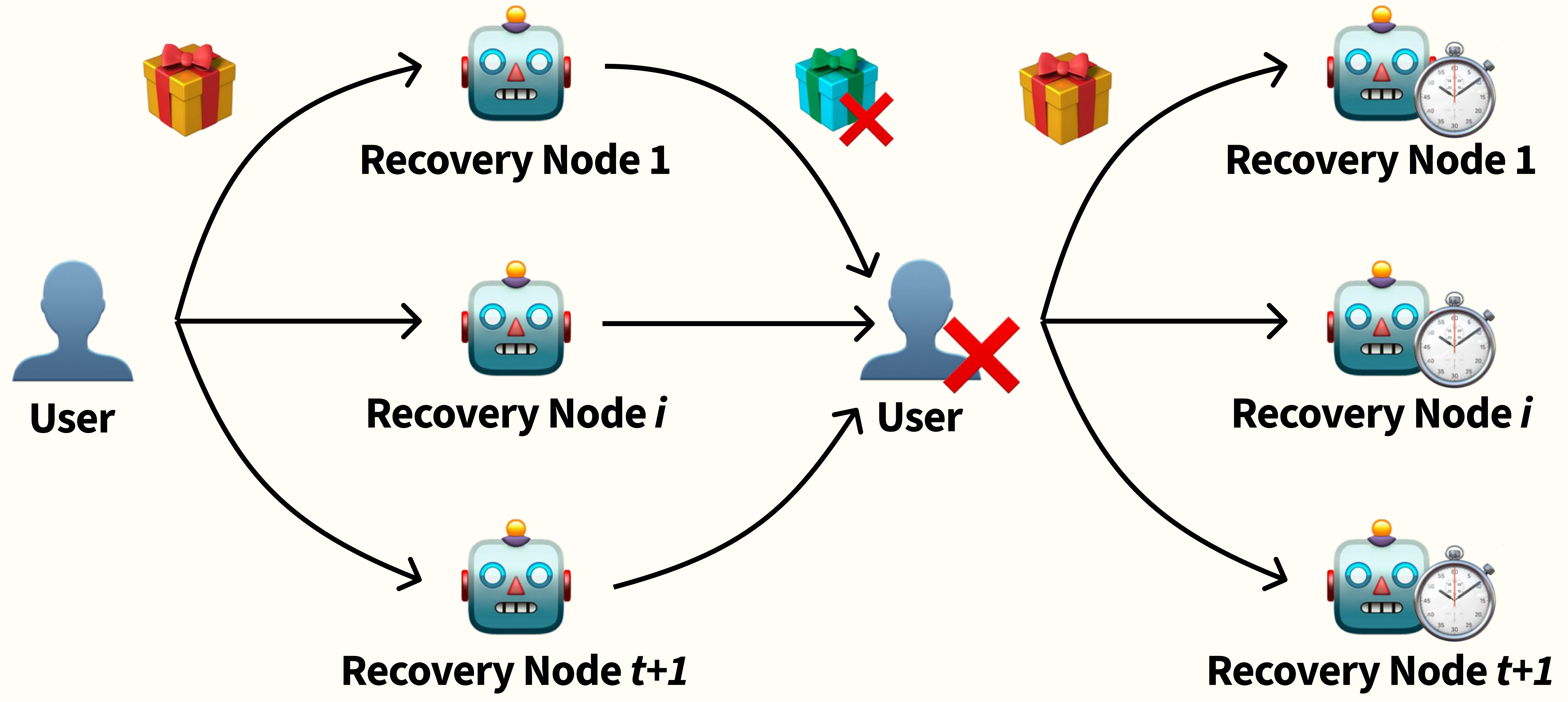
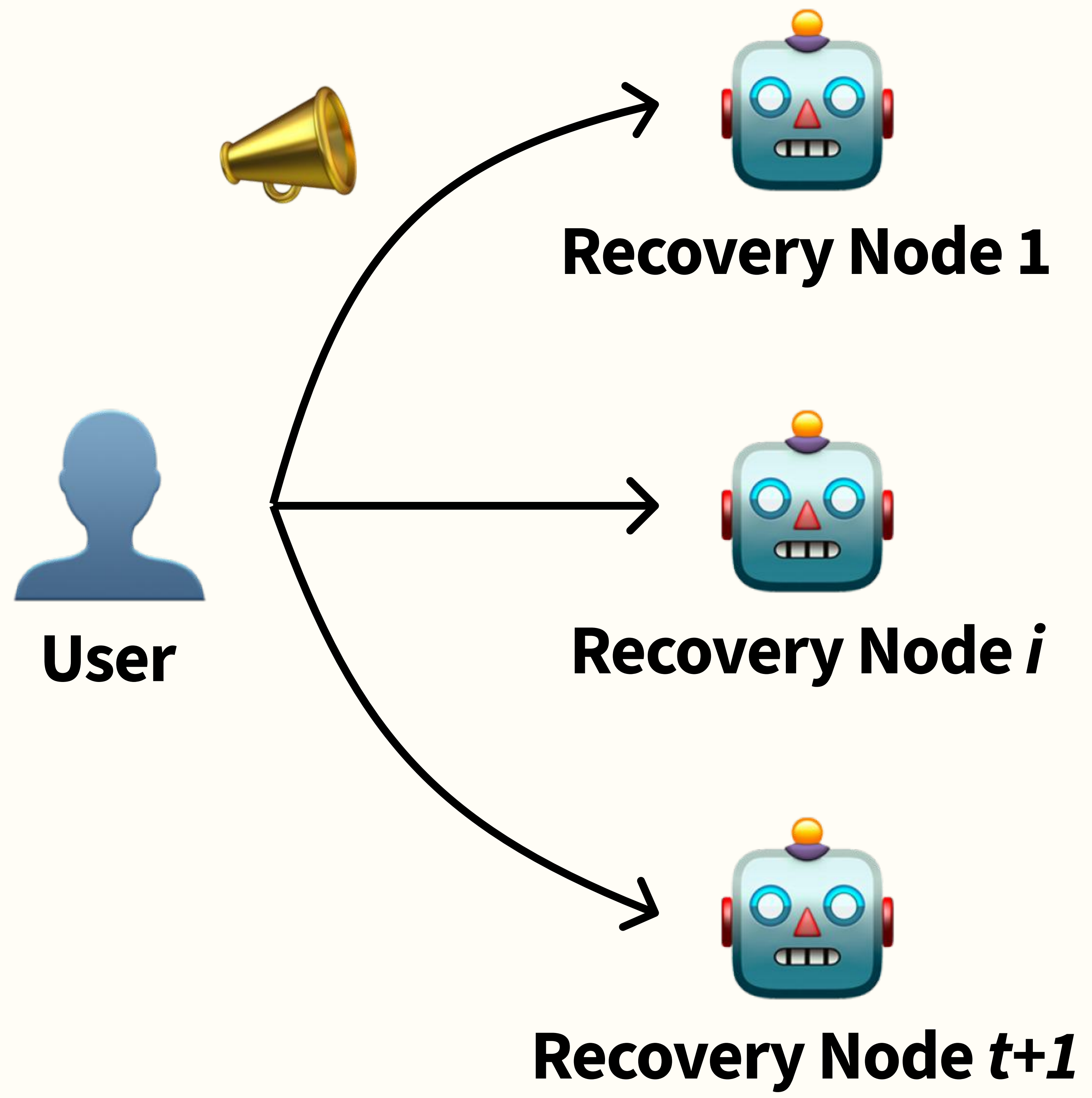


Recovery Node Update Flow



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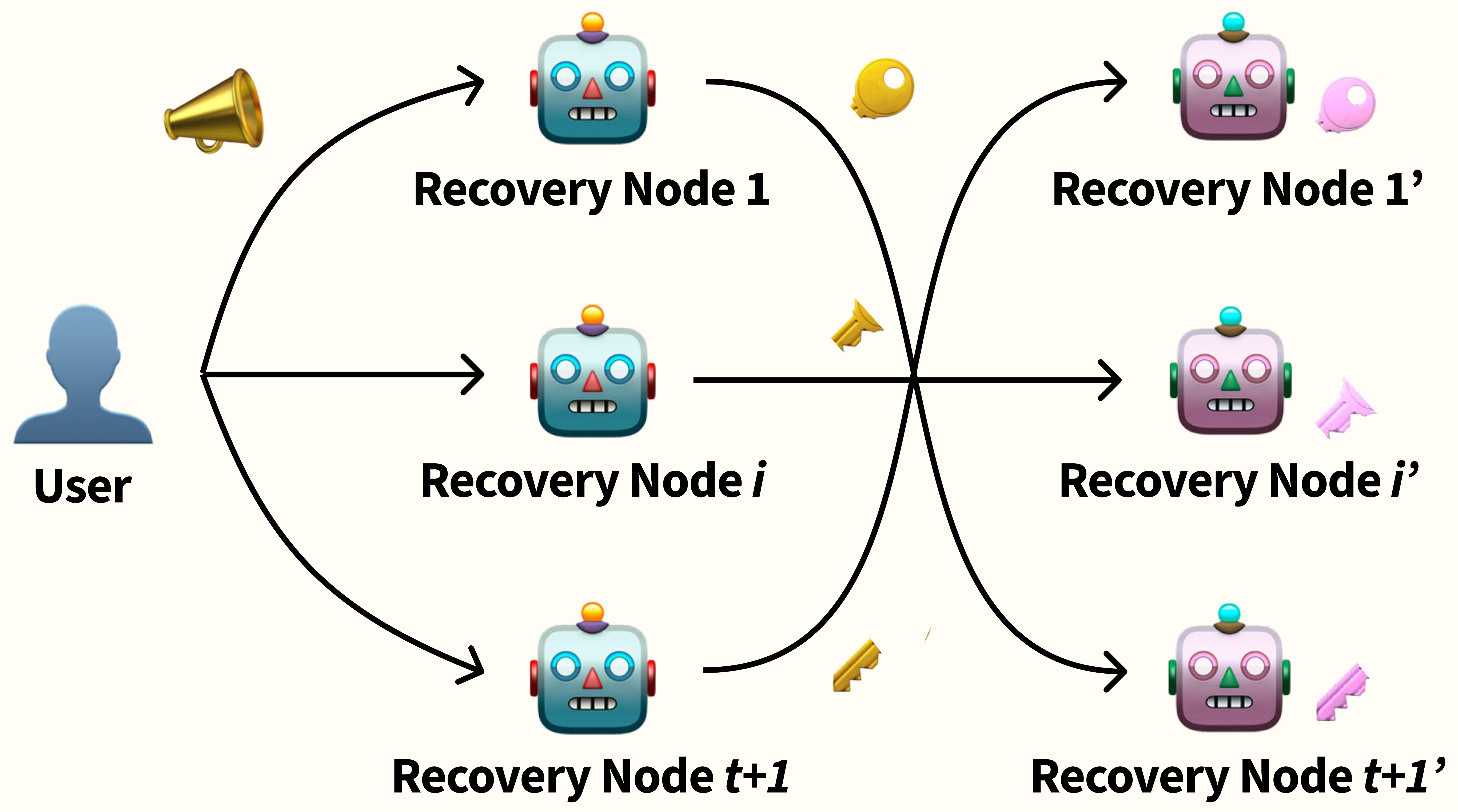

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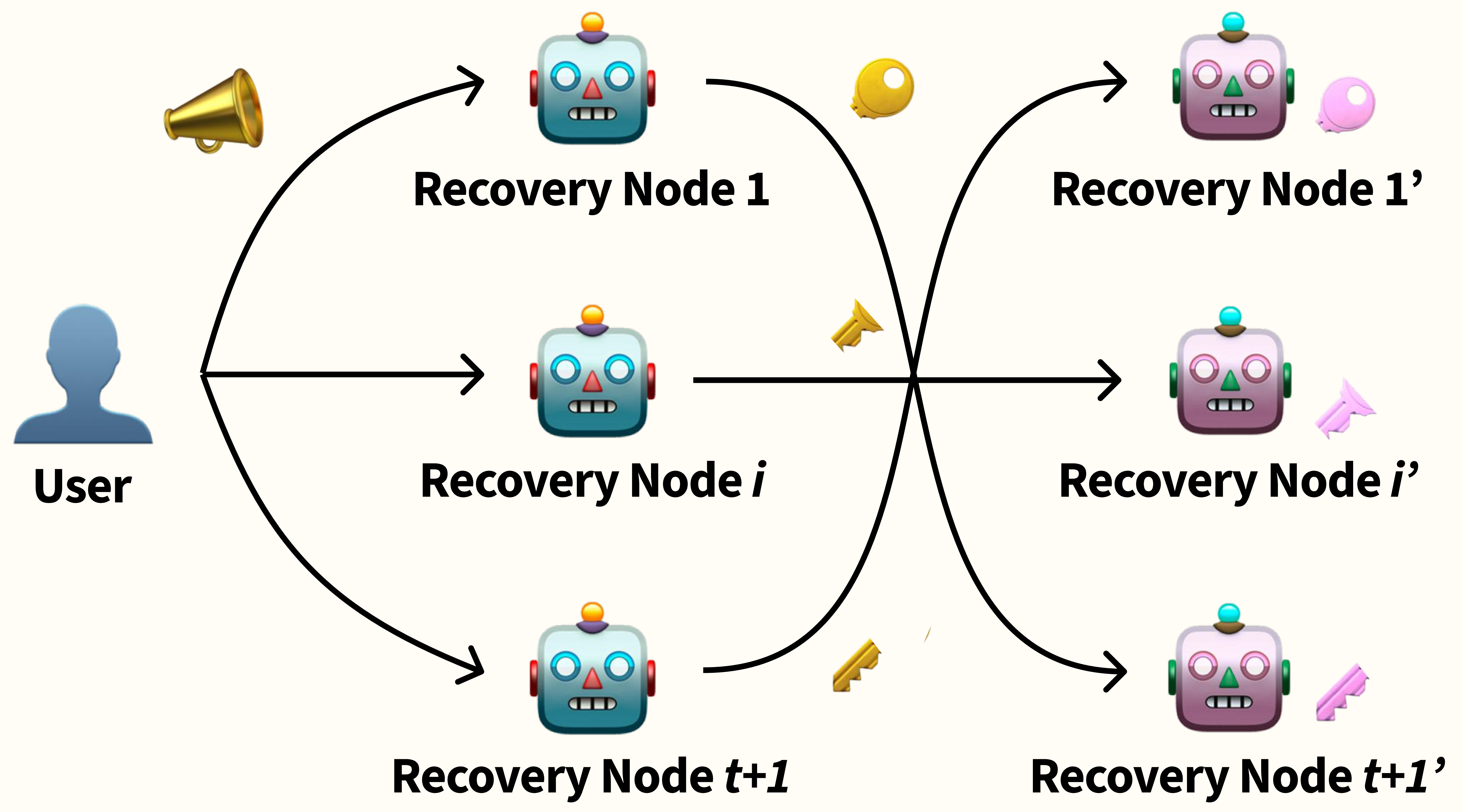

https://emilie.ma/blog/posts/241229/

TL;DR: Kintsugi provides decentralized secure recovery.

- improvements on existing methods:
  - decentralized!
  - no expensive hardware required
  - works in the case of device loss
  - protects against brute-force + colluding recovery nodes
- currently: initial implementation finished
- next: integrating w/ Ink & Switch Beehive project, polishing

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