Introduction to UCAN

User Controlled Authorization Networks

Brooklyn Zelenka

@expede

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- CTO at Fission
  - https://fission.codes / @FISSIONCodes
  - SDK: local-first, E2EE/EAR, distributed, passwordless

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https://lu.ma/distributed-systems

Cryptography is a tool for turning lots of different problems into key management problems

Dr. Lea Kissner, Google's Global Lead of Privacy Technologies

Intro

What We're Going to Cover

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- Dependencies
- Intuition for ACL vs Cap
- UCAN Anatomy
- Delegation
- Nontrivial Example

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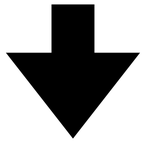
- Dependencies
- Intuition for ACL vs Cap
- UCAN Anatomy
- Delegation
- Nontrivial Example

- Not going to cover
  - Deep theory
  - Design considerations
  - Full-Blown Object Capabilities
  - UCAN-Based Auth Recovery
  - WebCrypto API Subtleties

UCAN Teaser Token


```
eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a2V5Ono2TWtzWFFCZkw4b3d6dFRDSlRt
N2hOUmY2YjE4WXhYUHAzaTY2b0pIbThMM1lHSiIsImF0dCI6W3sid25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvbm90
ZXMvIiwiY2FwIjoiT1ZFUldSSVRFIn1dLCJleHAiOjkyNTY5Mzk1MDUsImlzcyI6ImRpZDprZXk6ejZNa3A1RXN6OXMyTUhzcVl2TG9j
Y3lId1g1U2V5WktwcTc5R3Q0NWZGR0VaUjk5IiwibmJmIjoxNjM5NjA4MjkzLCJwcmYiOltdfQ.MgYarLqy7RmQ1AIrqYL6cFy9z7a5W
IAU--TYARPSgirOSszvar3_DNr25rbPretHbnT0mMVKyoaQXruR7KbrBg
```


```
{
  "iss": "did:key:z6Mkp5Esz9s2MHsqYvLoccyHwX5SeyZKpq79Gt45fFGEZR99",
  "aud": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "exp": 9256939505,
  "nbf": 1639608293,
  "att": [
    {
      "with": "wnfs://demouser.fission.name/public/notes/",
      "can": "OVERWRITE"
    }
  ]
}
```

Preamble

DIDs

Decentralized Digital Identity

DIDs

EXAMPLE 2: Minimal self-managed DID Document

```
{
  "@context": "https://w3id.org/did/v1",
  "id": "did:example:123456789abcdefghi",
  "publicKey": [{
    "id": "did:example:123456789abcdefghi#keys-1",
    "type": "RsaVerificationKey2018",
    "owner": "did:example:123456789abcdefghi",
    "publicKeyPem": "-----BEGIN PUBLIC KEY...END PUBLIC KEY-----\r\n"
  }],
  "authentication": [{
    // this key can be used to authenticate as DID ...9938
    "type": "RsaSignatureAuthentication2018",
    "publicKey": "did:example:123456789abcdefghi#keys-1"
  }],
  "service": [{
    "type": "ExampleService",
    "serviceEndpoint": "https://example.com/endpoint/8377464"
  }]
}
```

Decentralized Digital Identity

DIDs

- Interoperable format
- One or more public keys
- Agnostic about backing
  - Self-attesting
  - Trad. Database
  - Blockchain
- For users, devices, and more
- Relates to verifiable credentials

EXAMPLE 2: Minimal self-managed DID Document

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{
  "@context": "https://w3id.org/did/v1",
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    "type": "RsaVerificationKey2018",
    "owner": "did:example:123456789abcdefghi",
    "publicKeyPem": "-----BEGIN PUBLIC KEY...END PUBLIC KEY-----\r\n"
  }],
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    // this key can be used to authenticate as DID ...9938
    "type": "RsaSignatureAuthentication2018",
    "publicKey": "did:example:123456789abcdefghi#keys-1"
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  "service": [{
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Decentralized Digital Identity

Variety

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- Raw Public Keys, Microsoft ION, Ceramic, Sovrin, did:key, >500 others

Decentralized Digital Identity

Variety

- Raw Public Keys, Microsoft ION, Ceramic, Sovrin, did:key, >500 others
- Can federate, but early so rarely done in the wild
  - DIF has a JVM-based "Universal Resolver"
  - Custom e.g. did:key + ION

Decentralized Digital Identity

did:key & UCAN

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- “Just” a public key (e.g. RSA, EdDSA)

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Decentralized Digital Identity

did:key & UCAN

- “Just” a public key (e.g. RSA, EdDSA)
- Self-certifying, extremely flexible
- Well suited to capabilities/authZ (vs identity/authN)
- UCANs — "transfer authority without transferring keys"
  - did:key → authN
  - UCAN → authZ

DIDs say who you are

DIDs say who you are
UCANs show what you can do

User Controlled, Local-First, Universal Auth & ID

UCAN

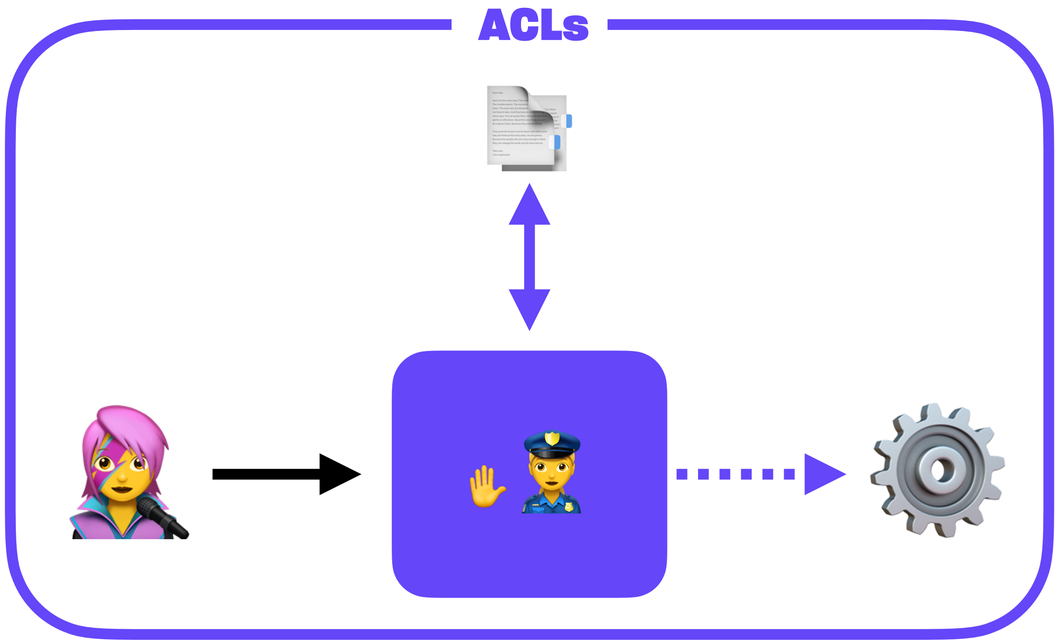
UCAN

Capability Model

UCAN

Capability Model

- ACLs are “reactive auth”



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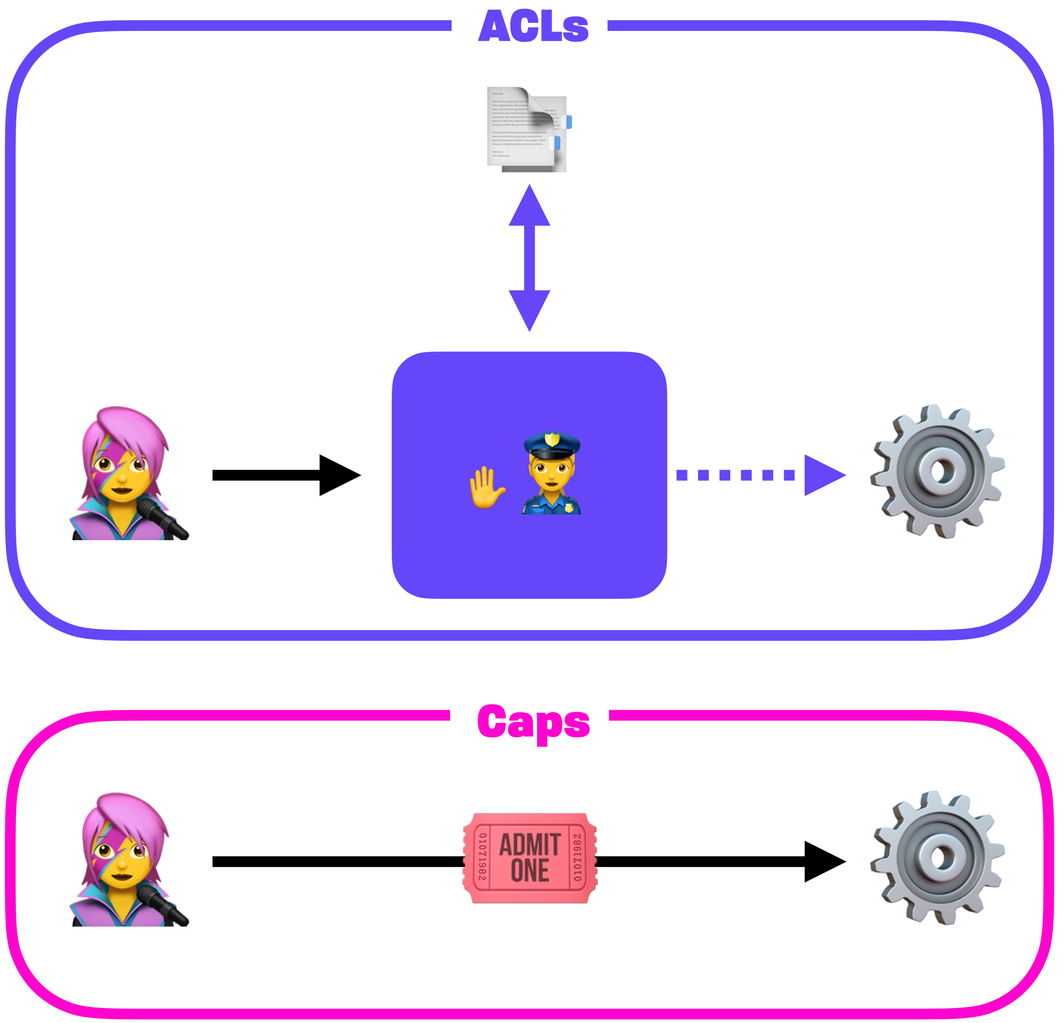
Capability Model

- ACLs are “reactive auth”
- Capabilities are “proactive auth”
  - Contains all the info about access
  - Any guarding done up front (e.g. time limiting)
  - Generally some reference, proof, or key
    - Anything directly created (parenthood 🐣)
    - Delegate subset to another (introduction 🤝)
  - Long history (e.g. X.509, SPKI/SDSI, Macaroons)



UCAN

ACL Read & Write

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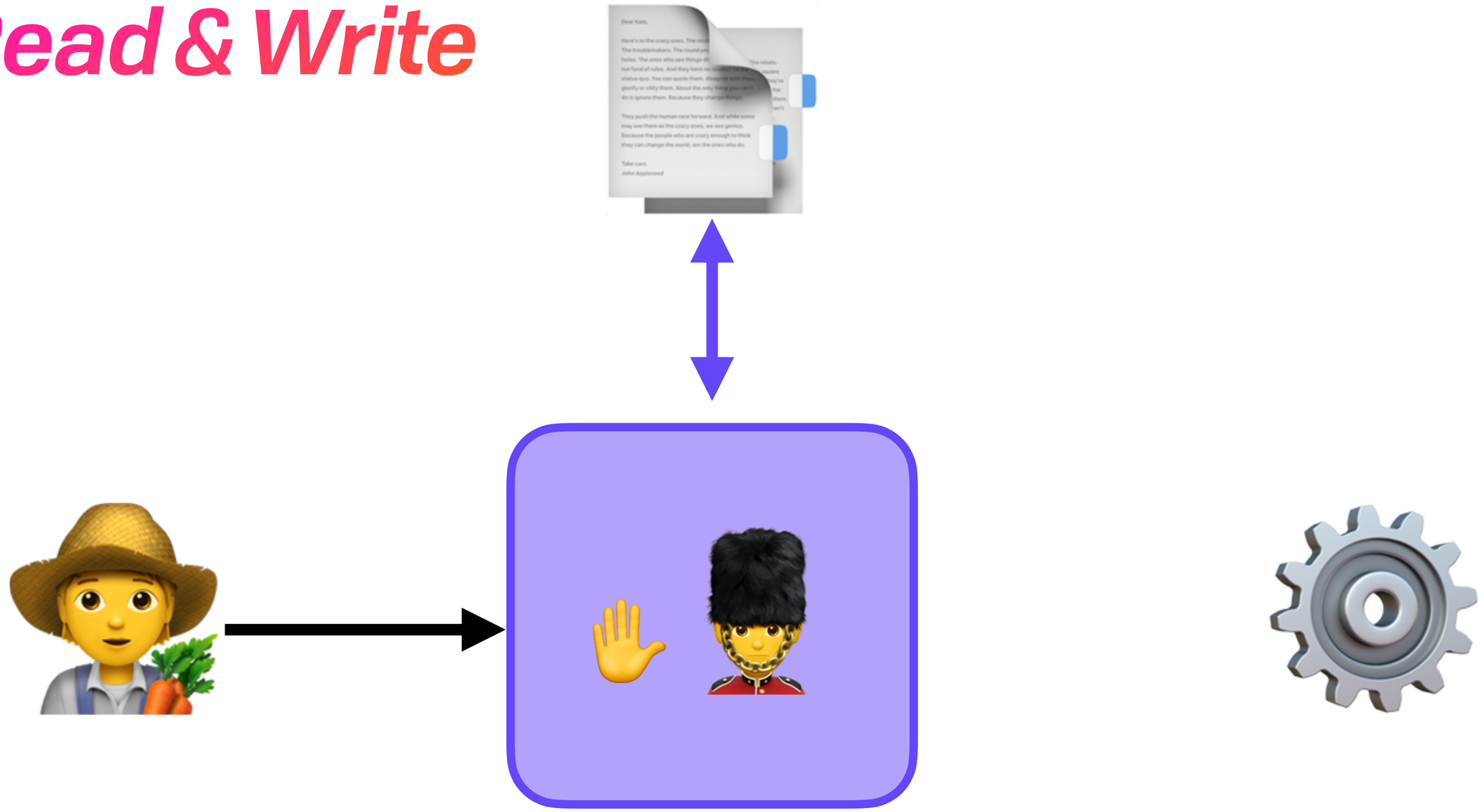

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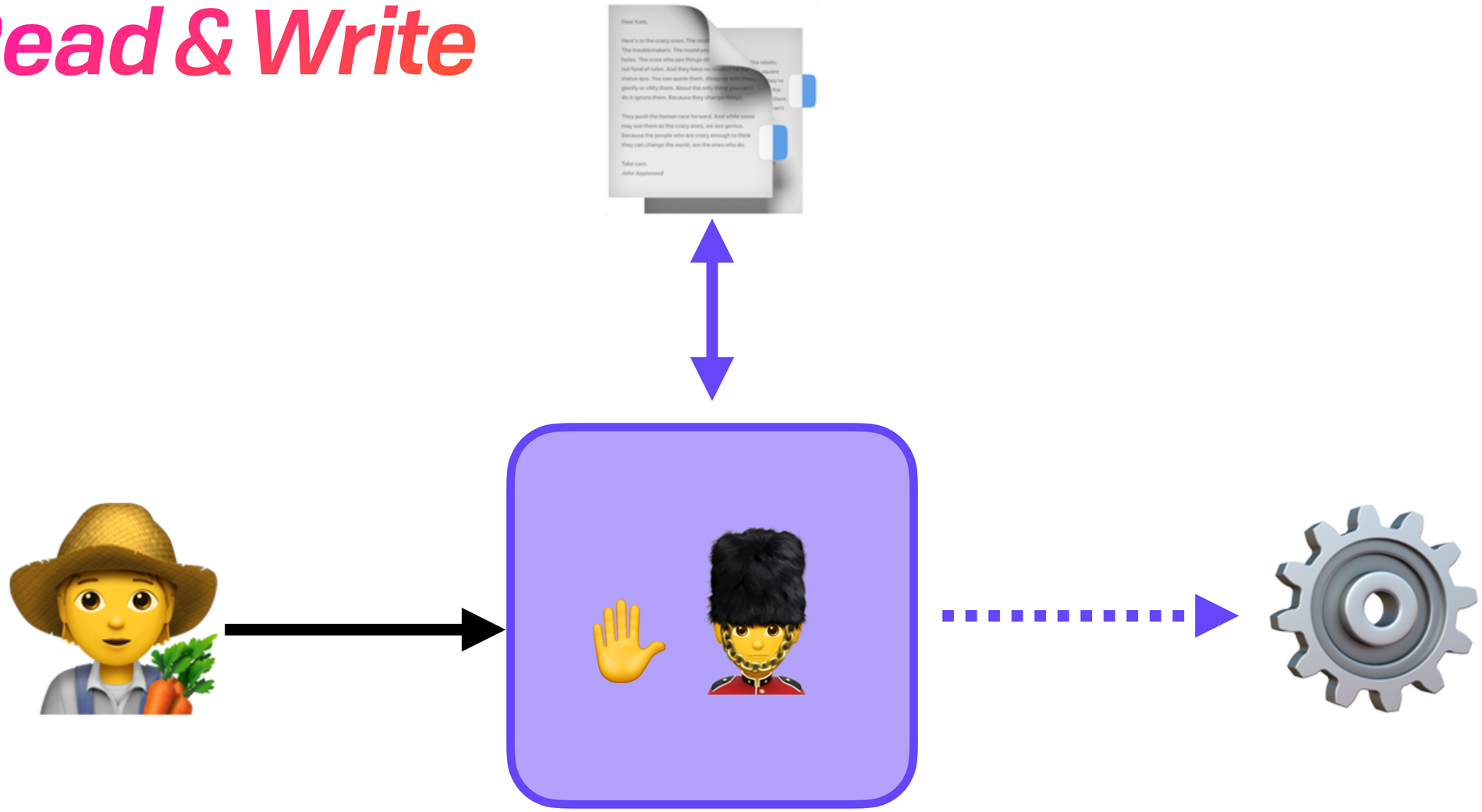

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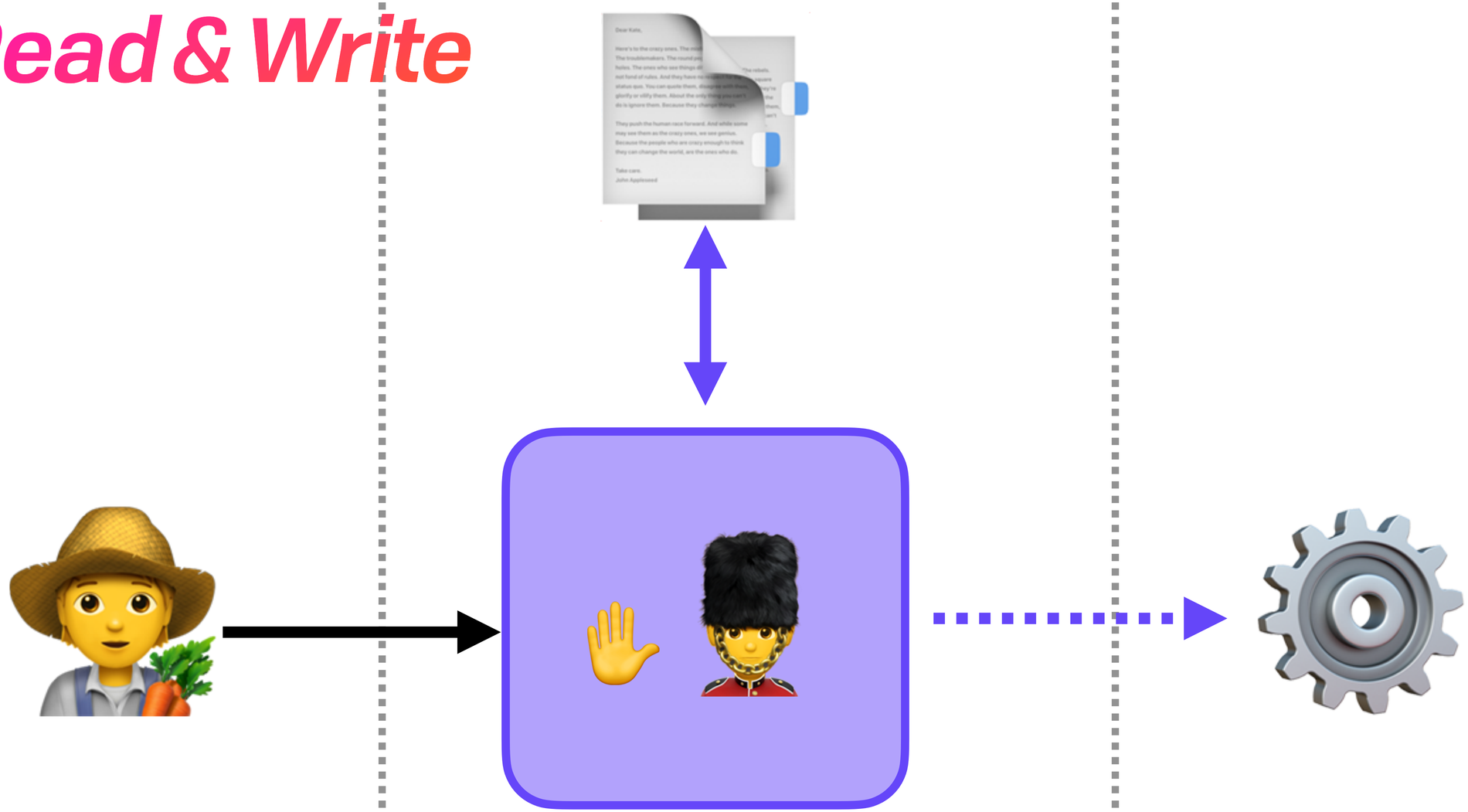

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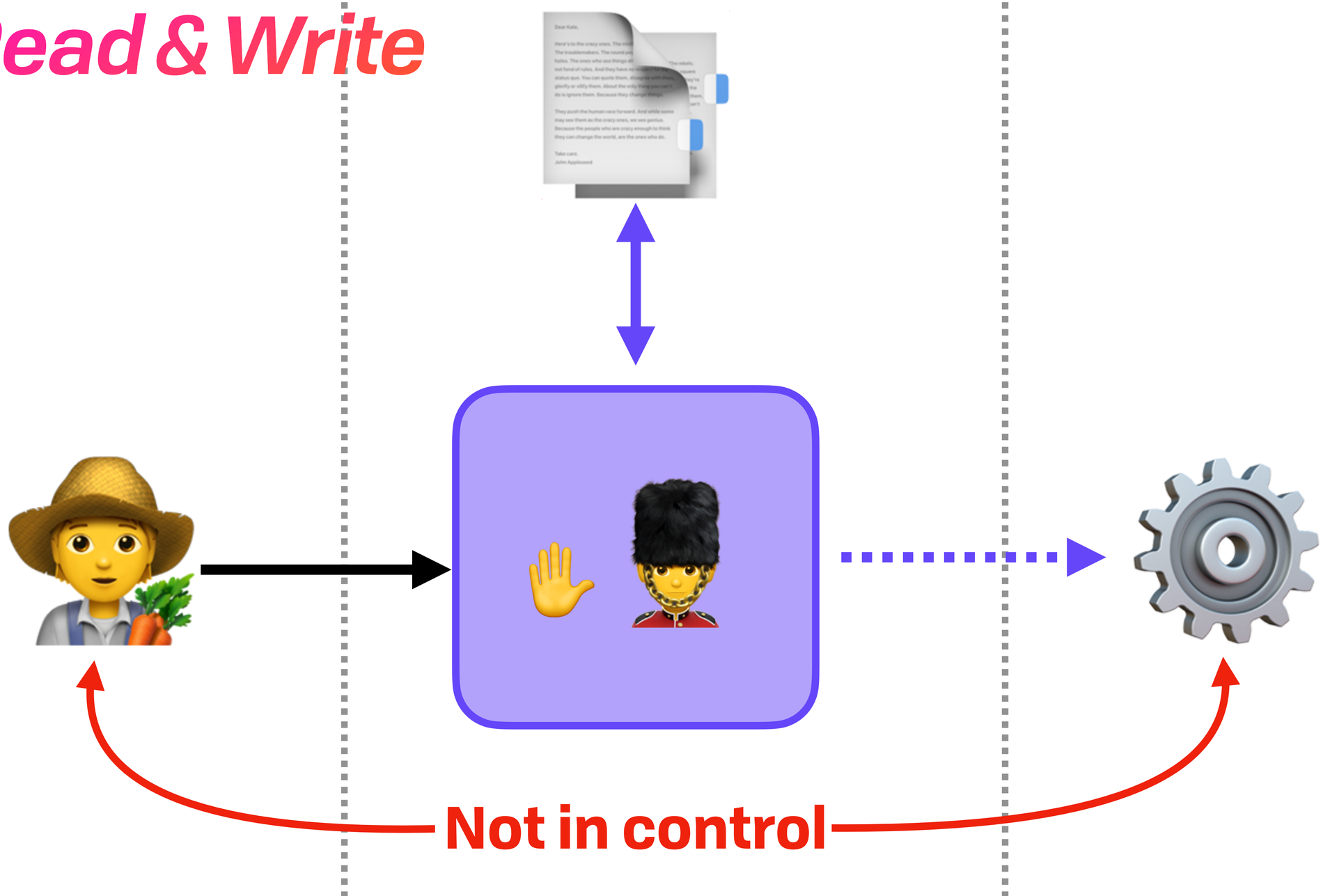

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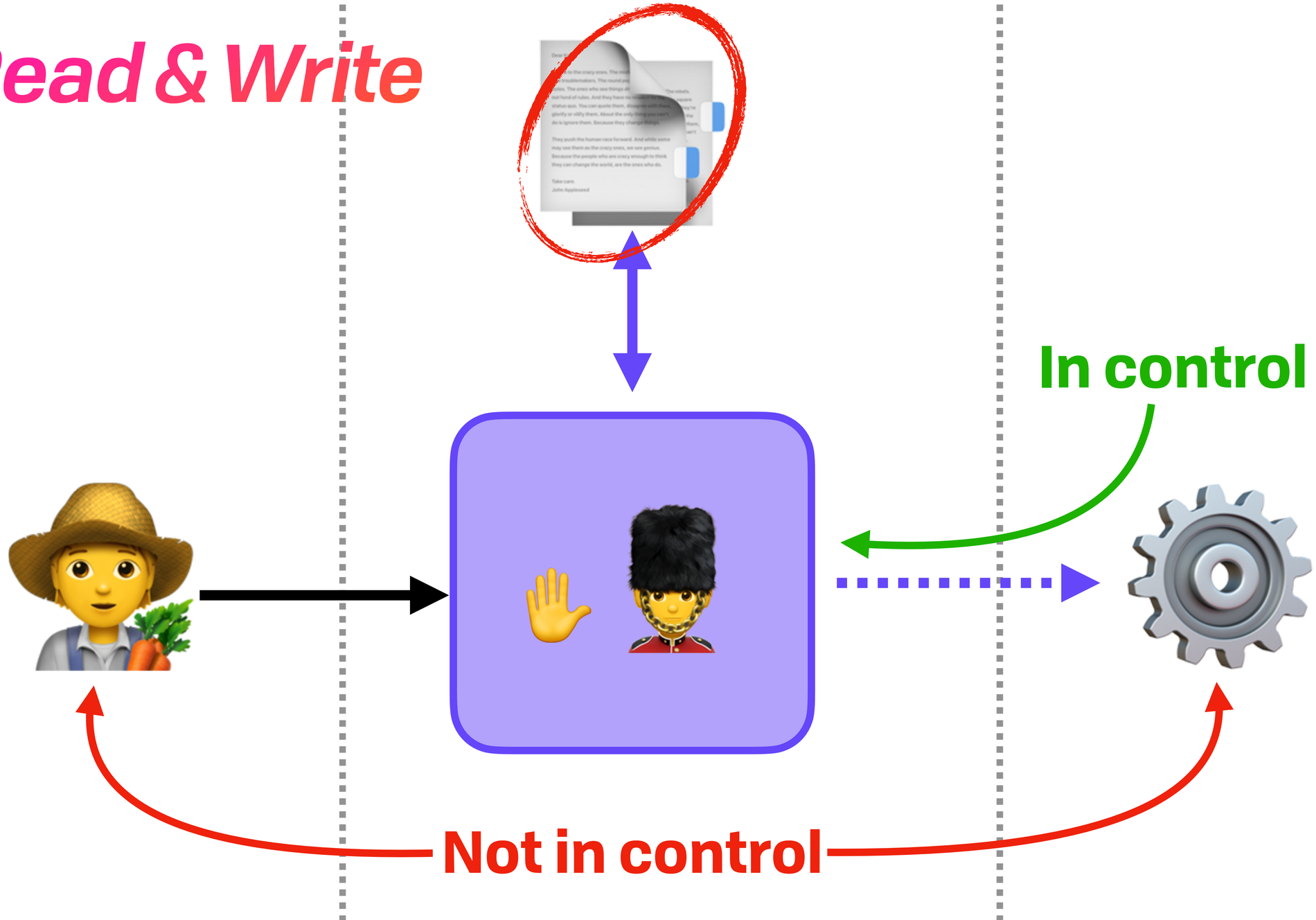
ACL Read & Write

In control

Not in control

UCAN

ACL Read & Write



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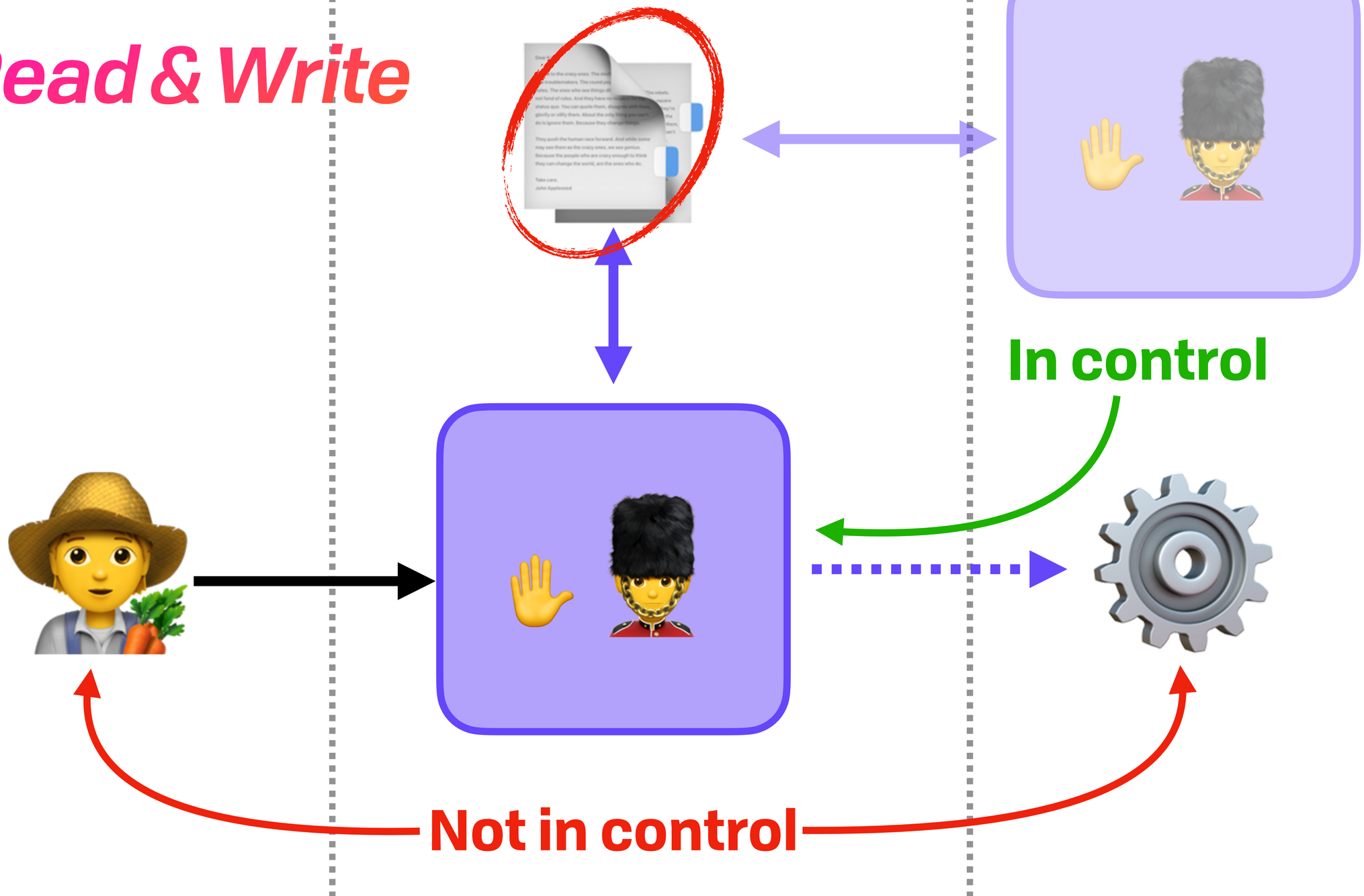

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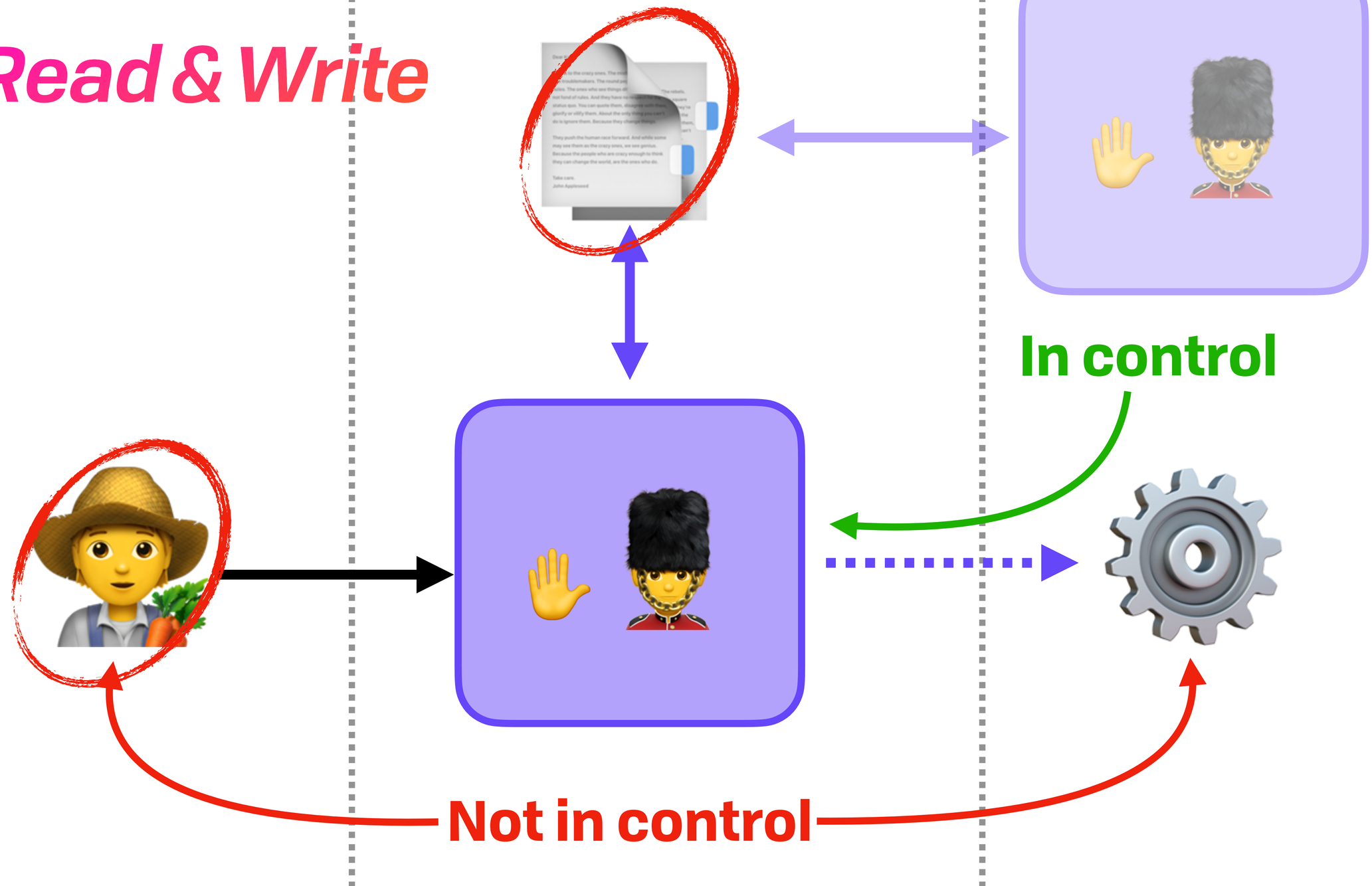

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From Actors to Capabilities

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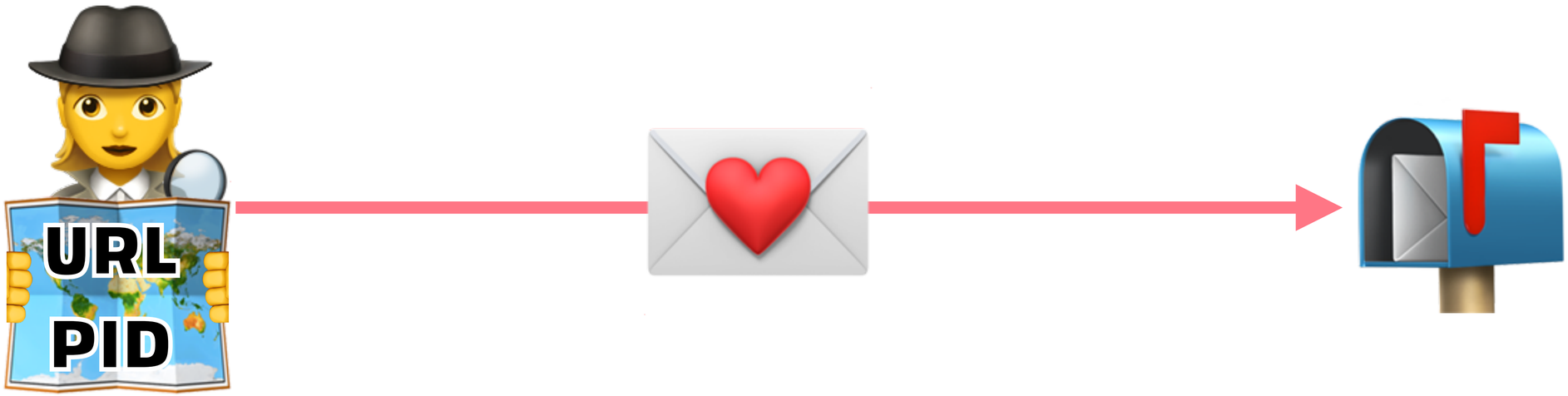

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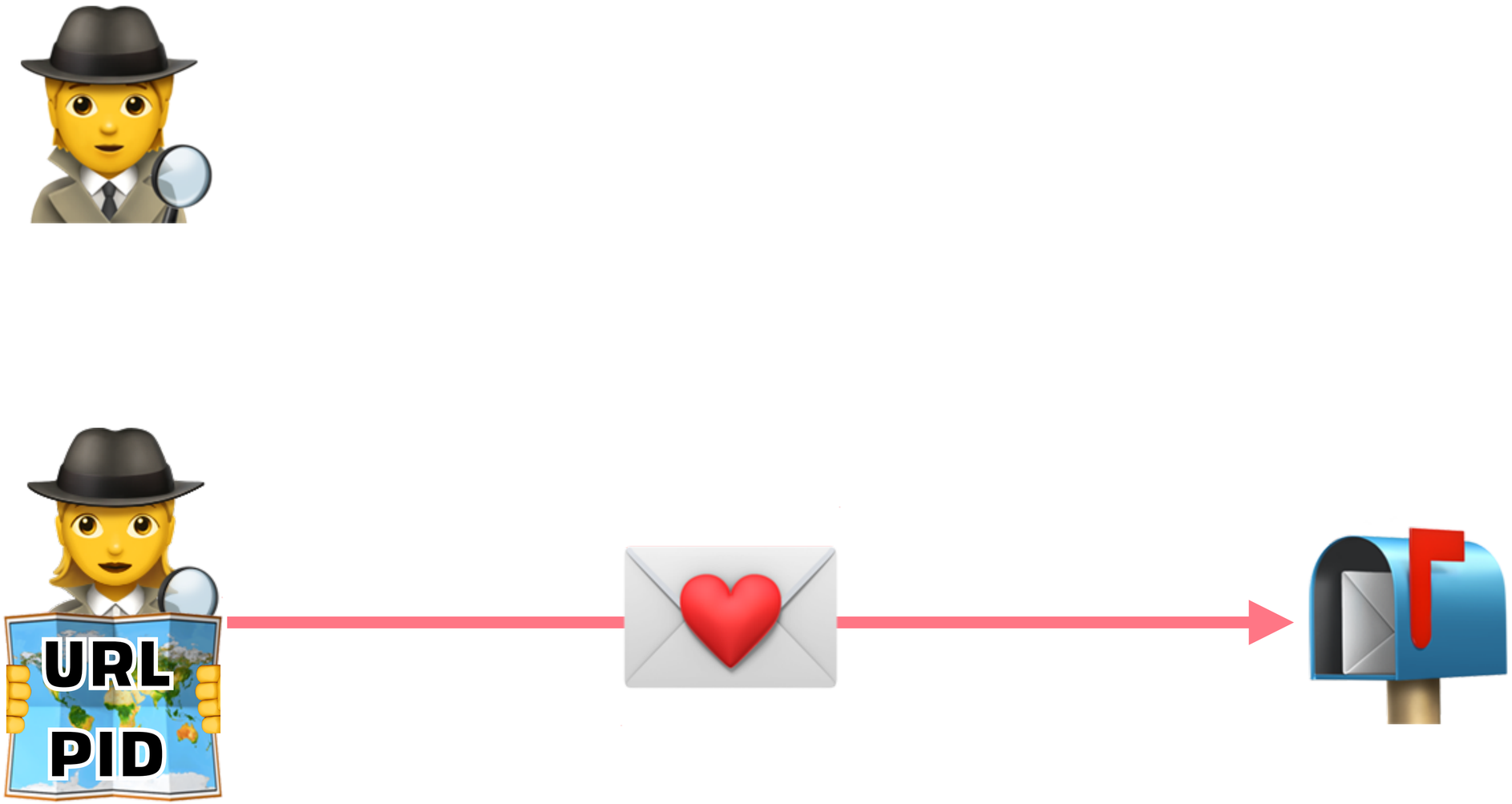

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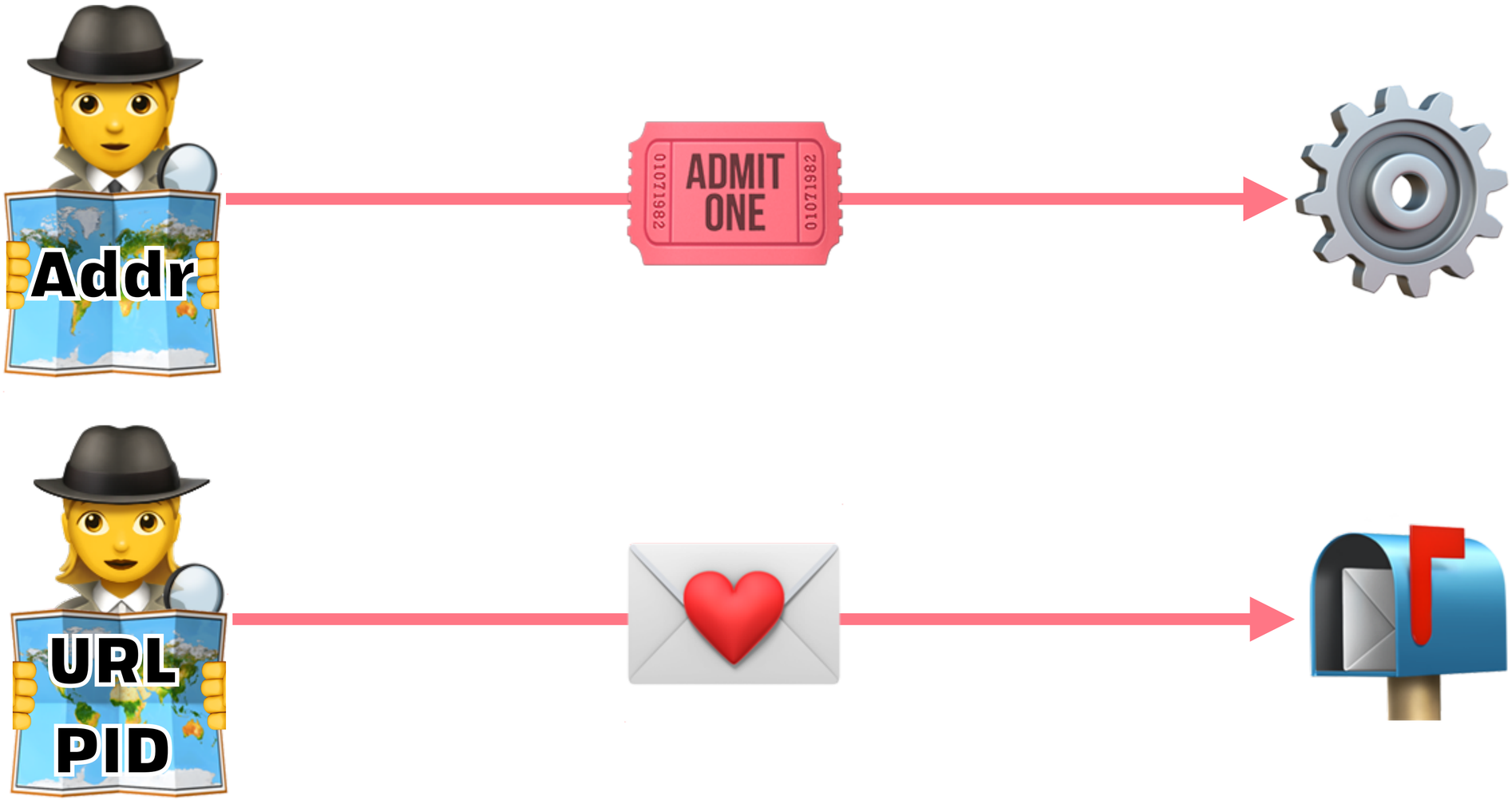

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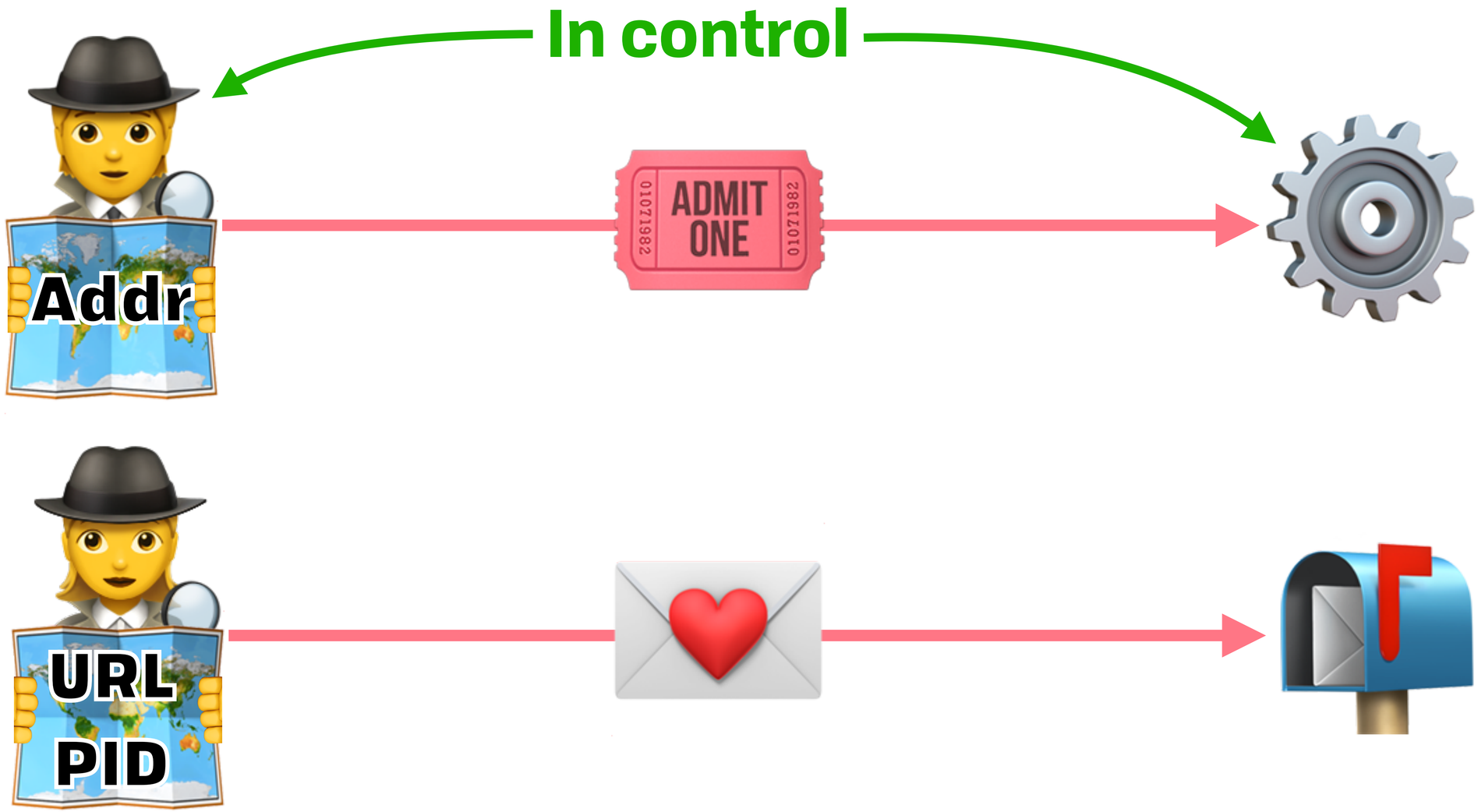

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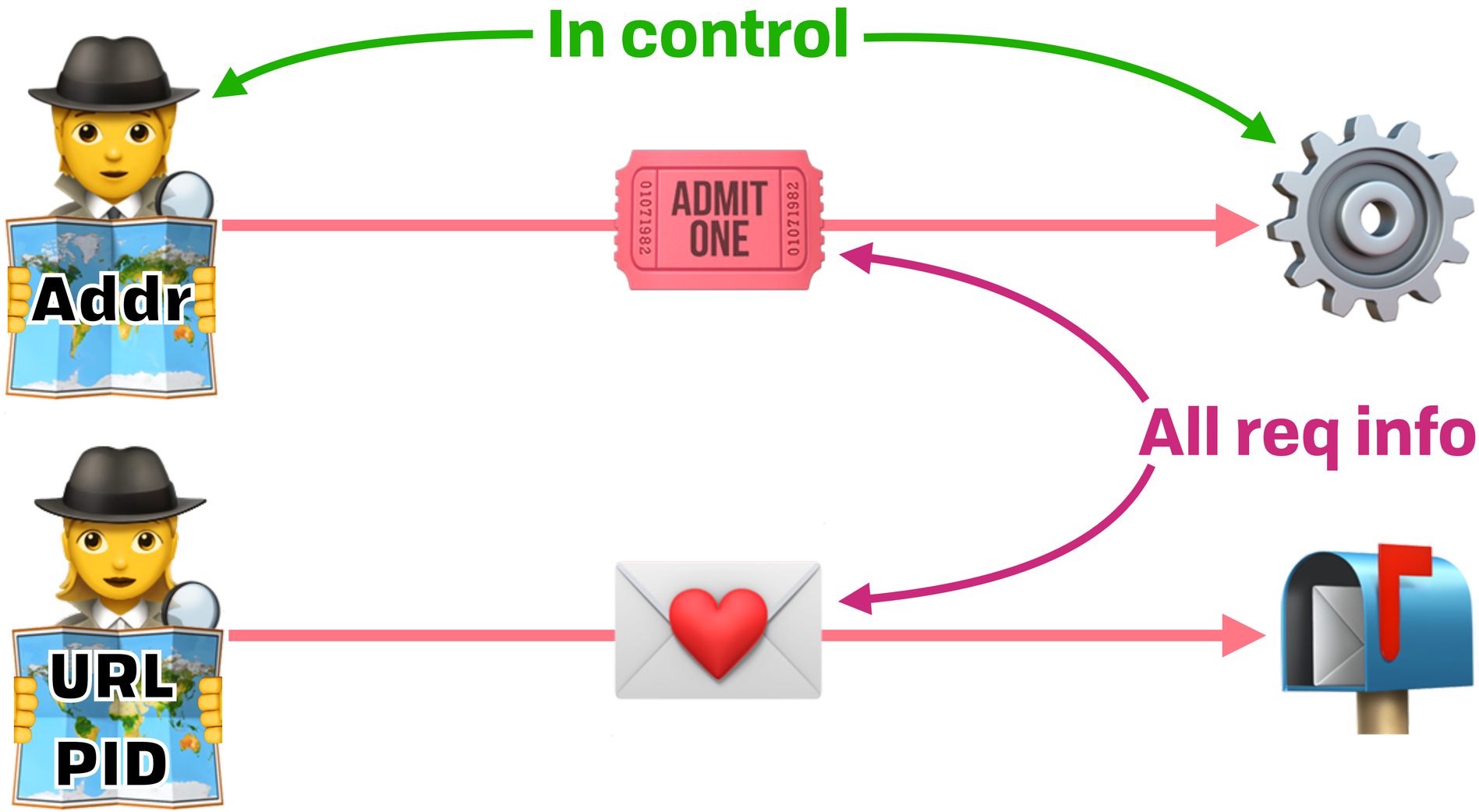

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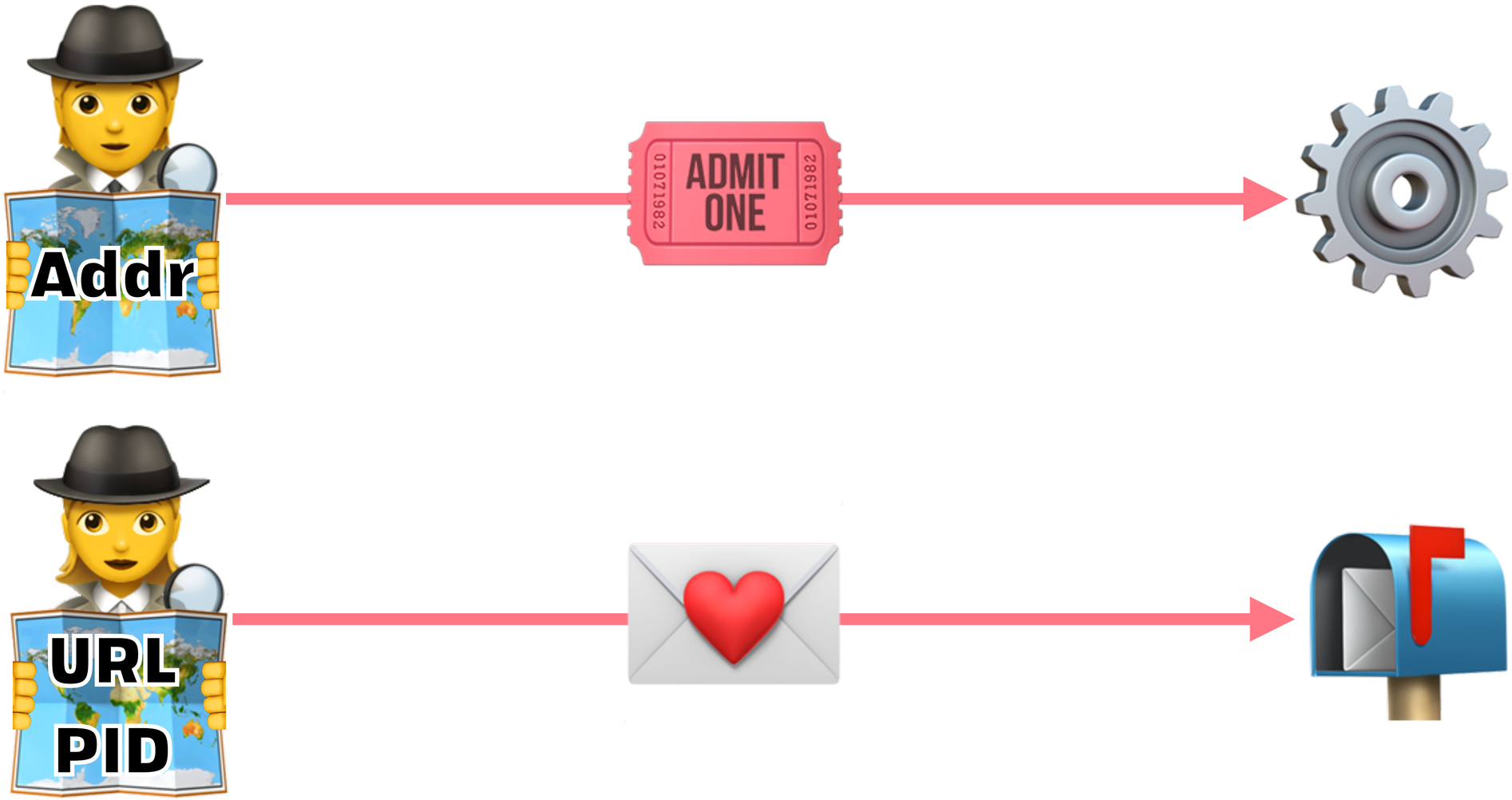

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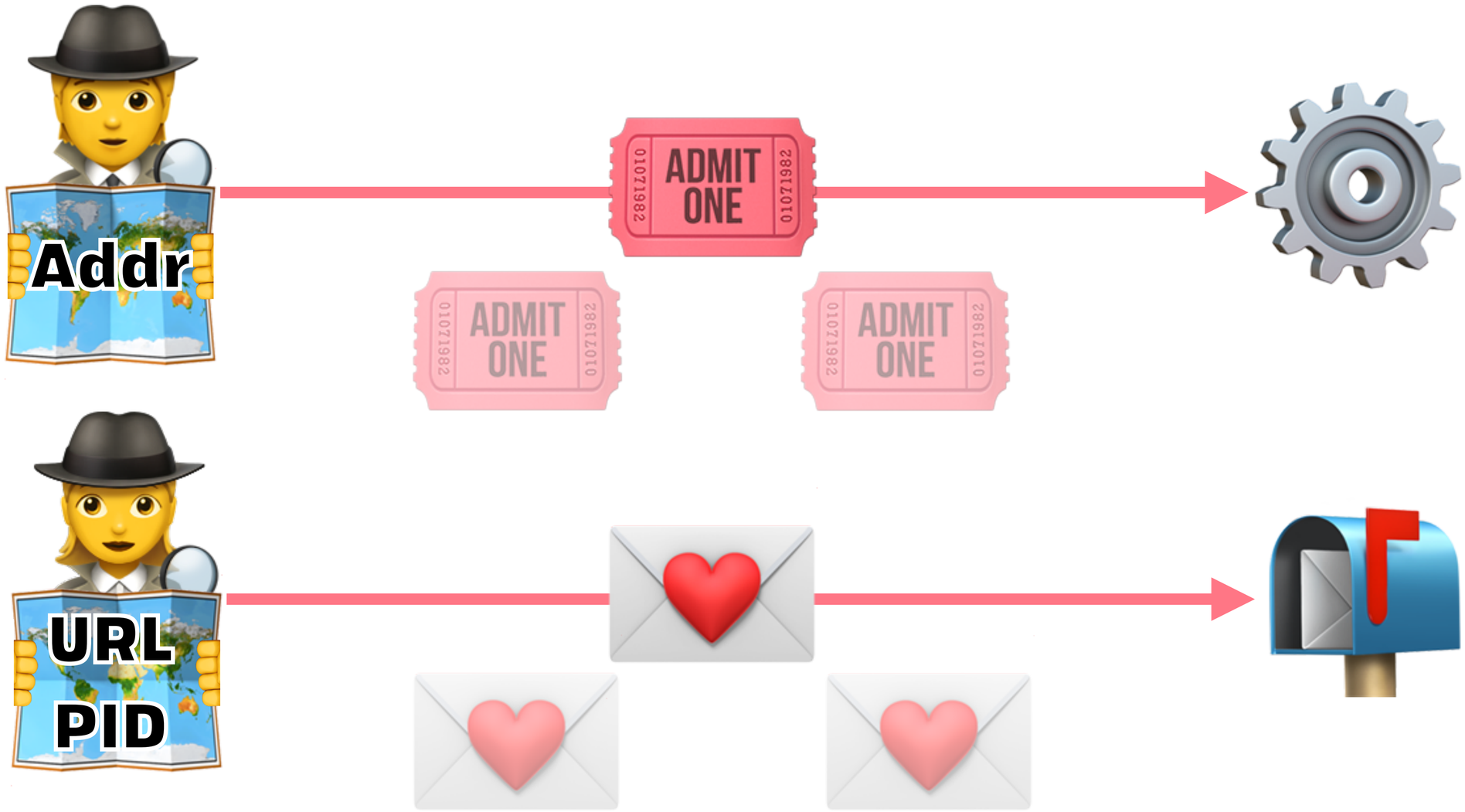

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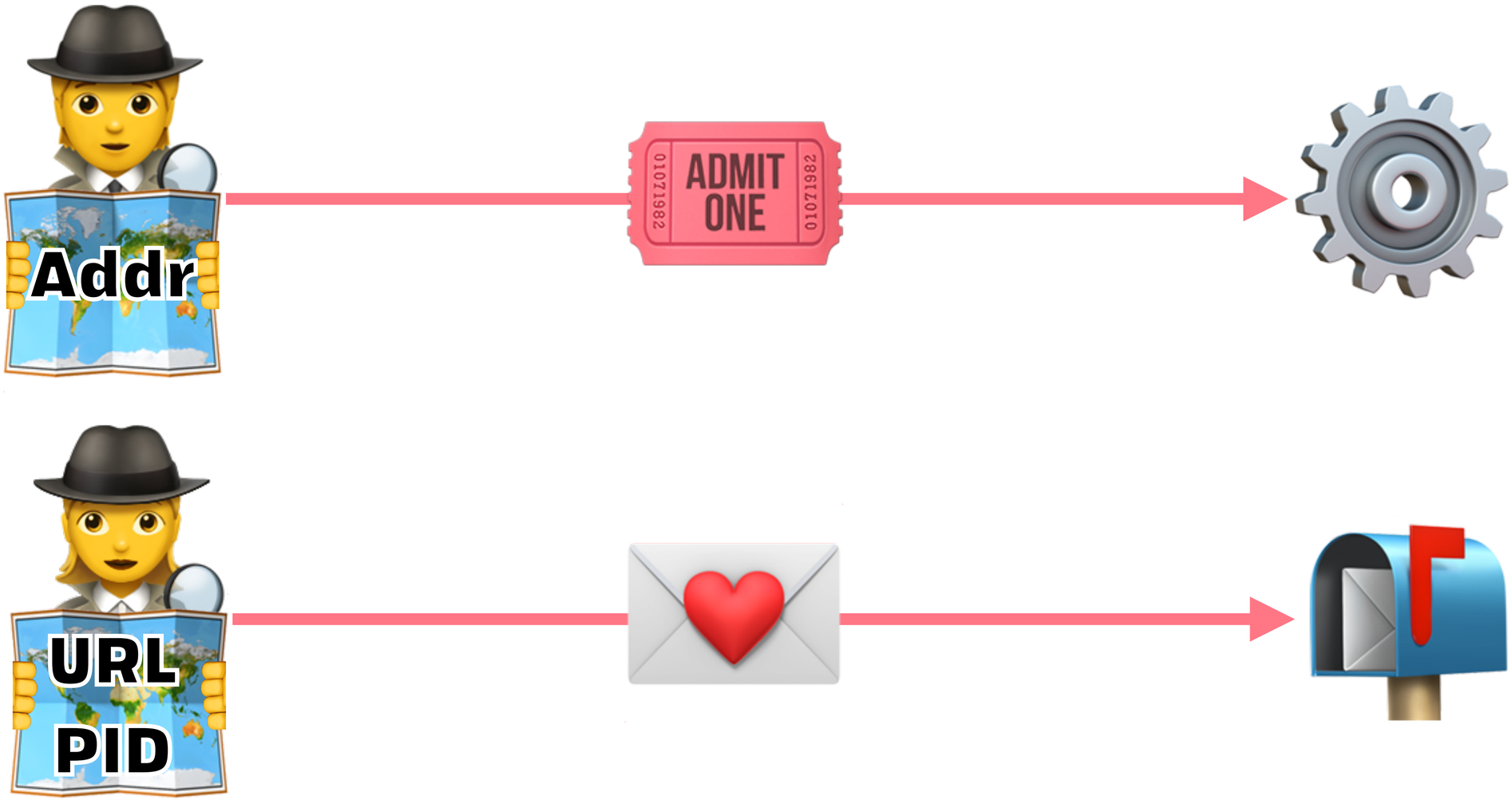

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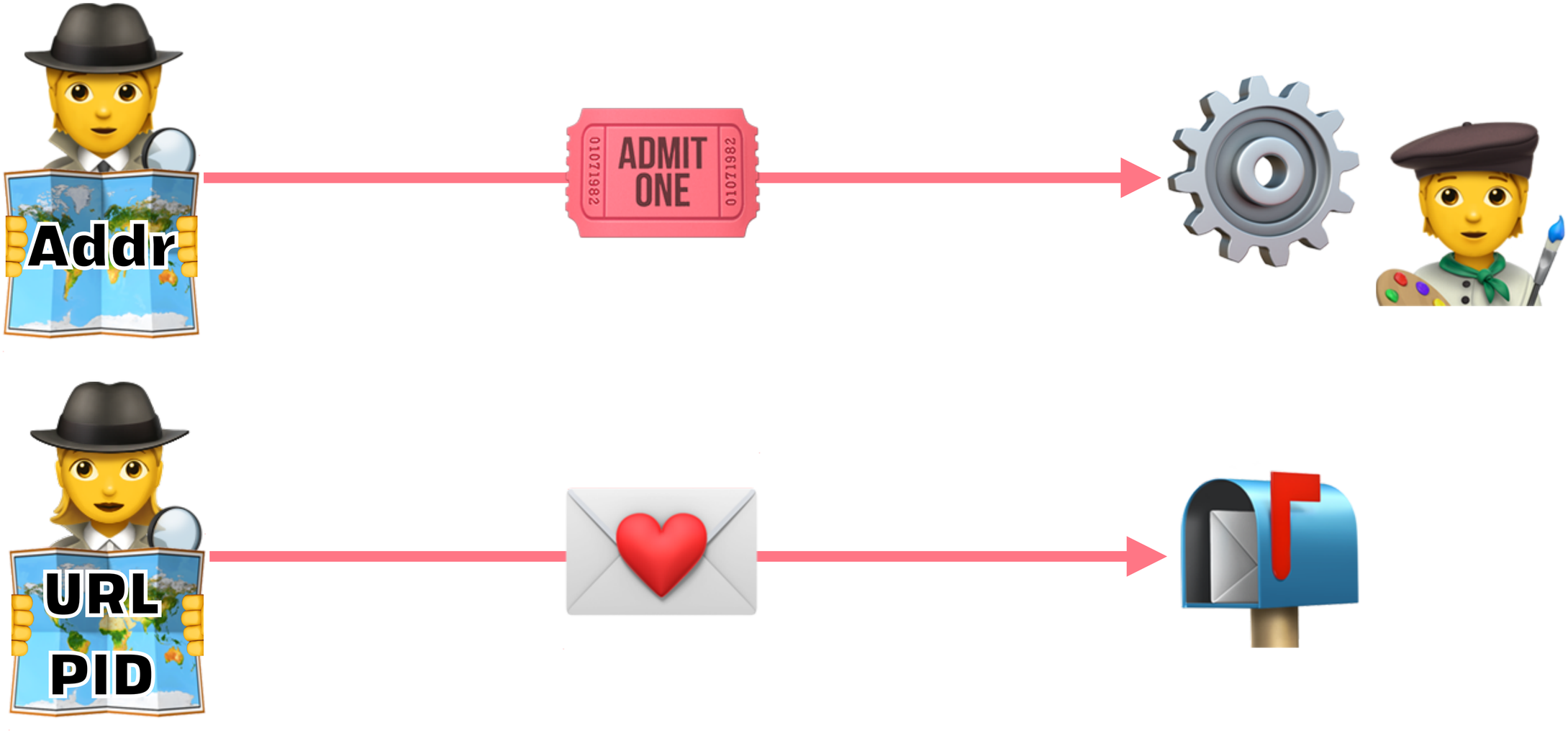

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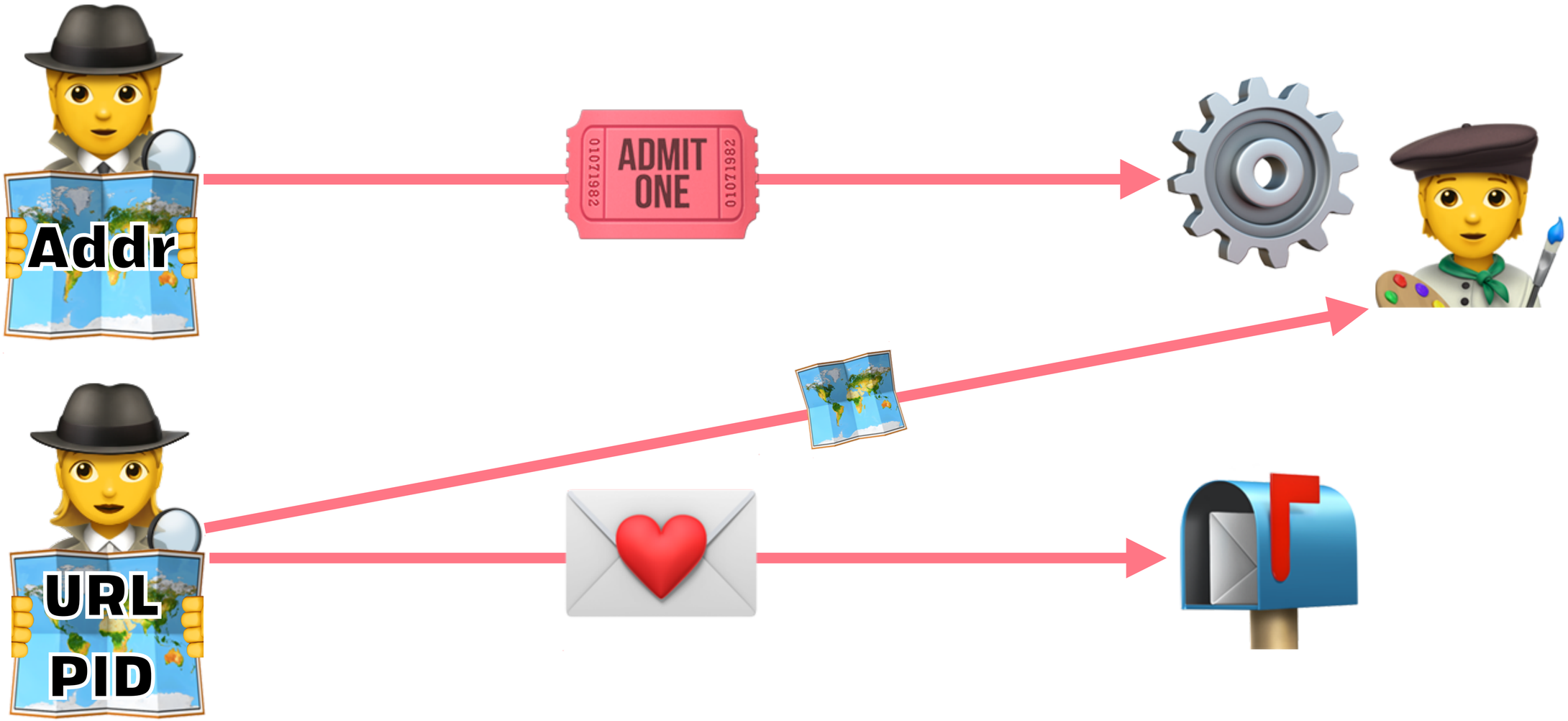

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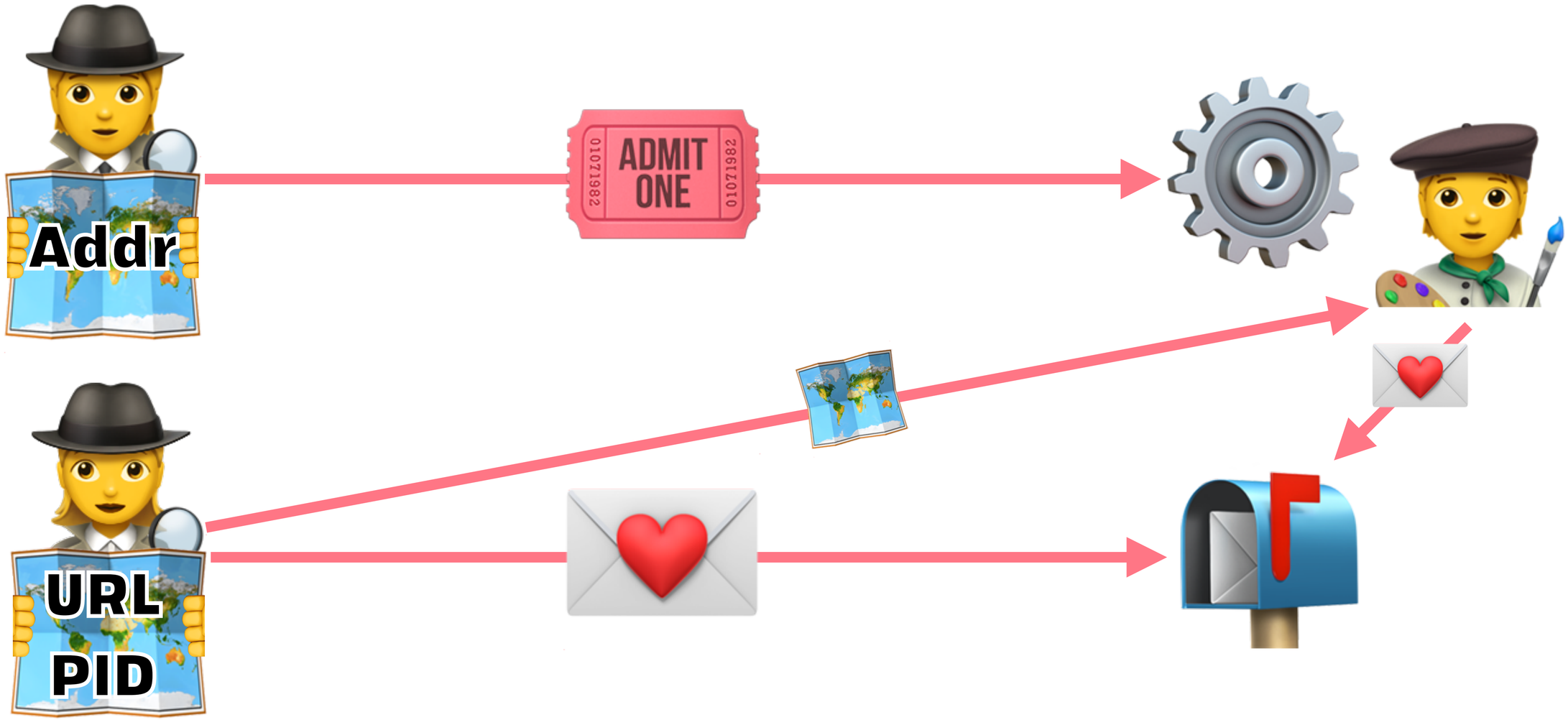

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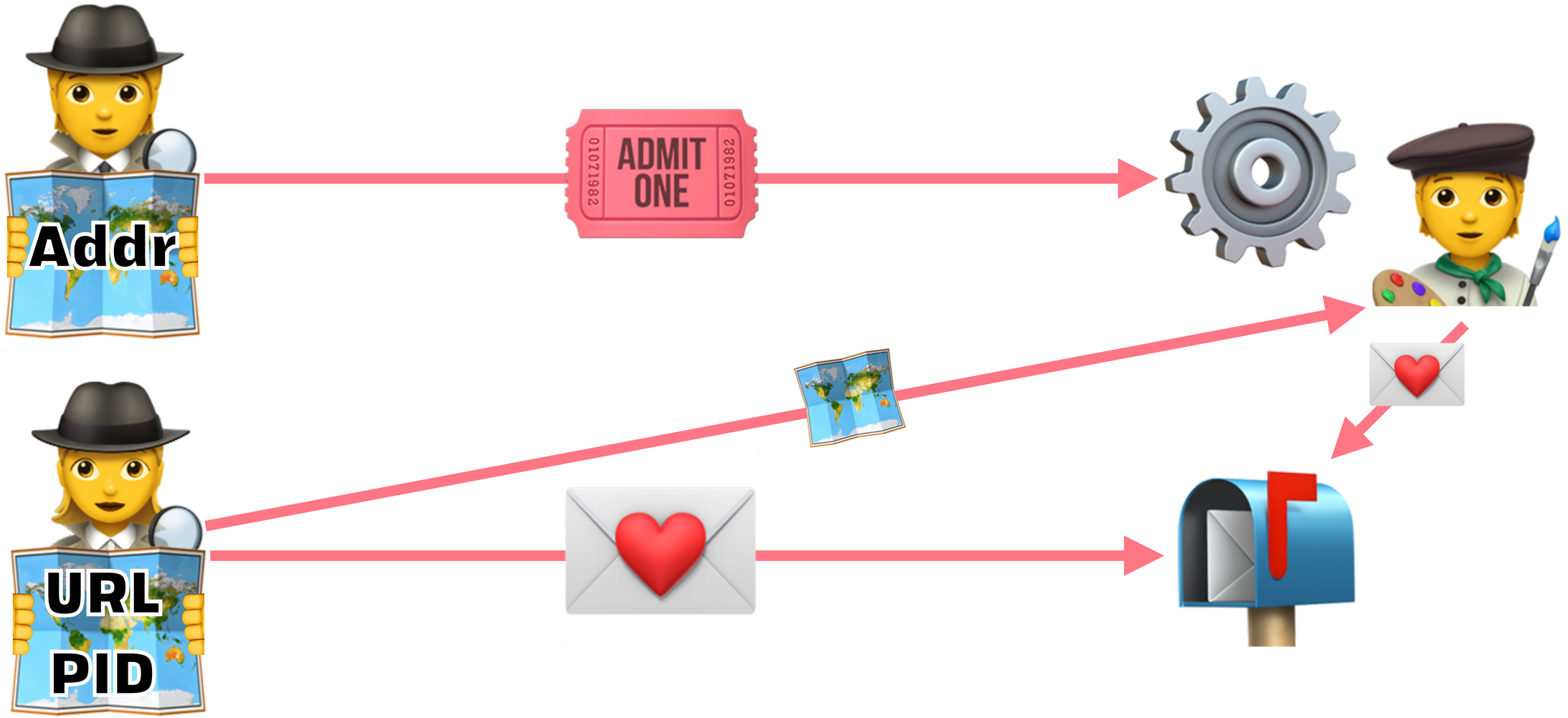

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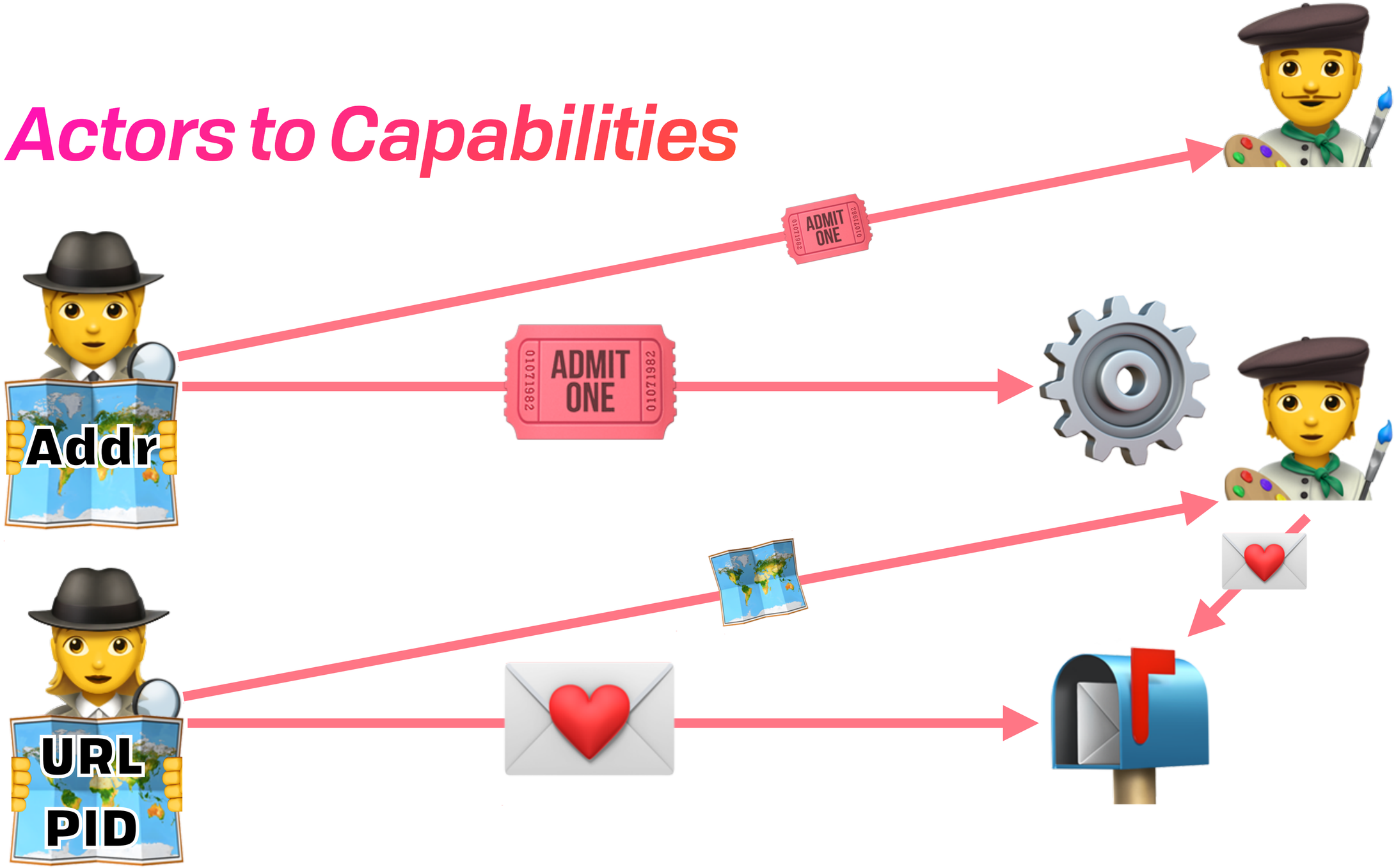

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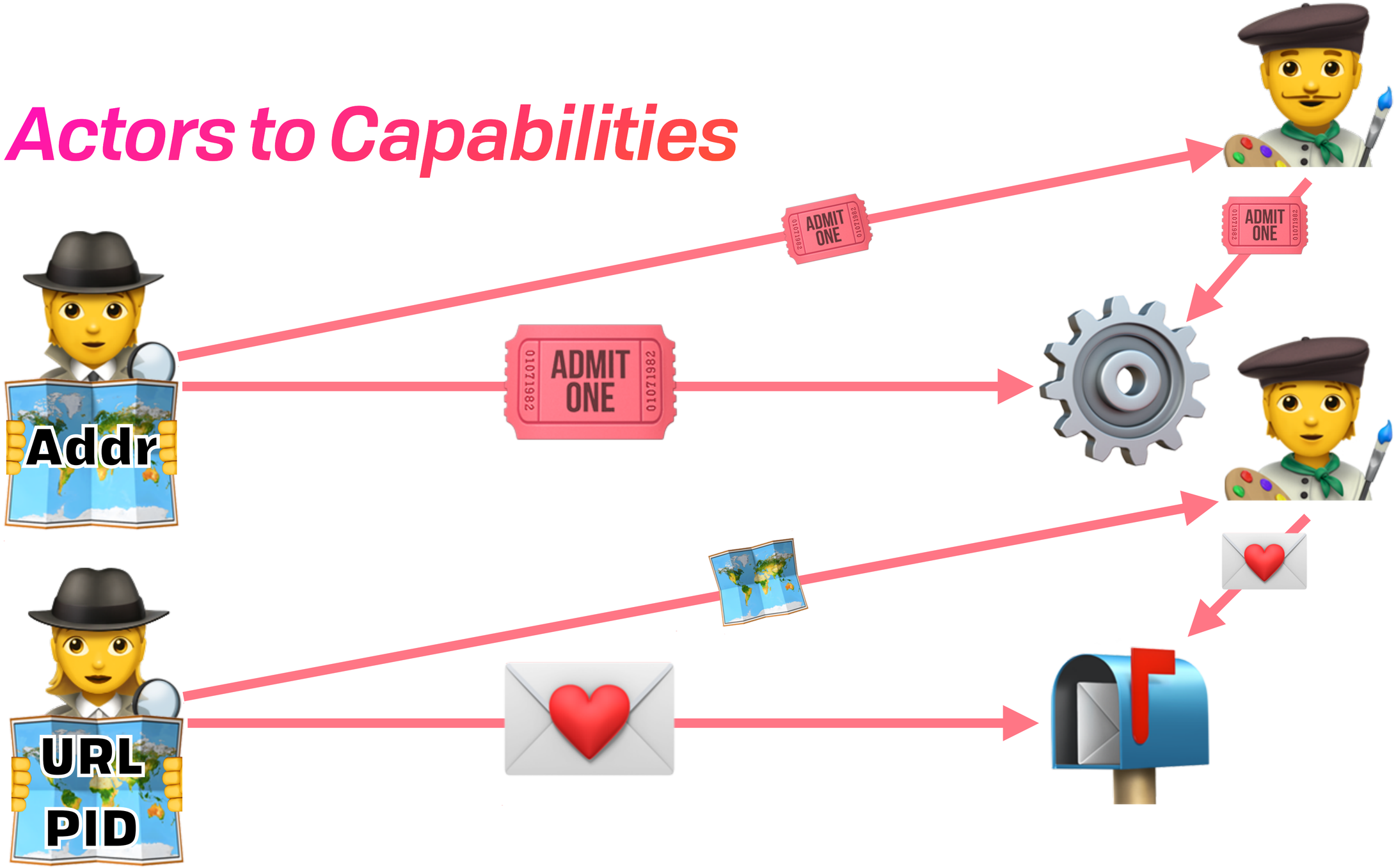

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Rights Amplification

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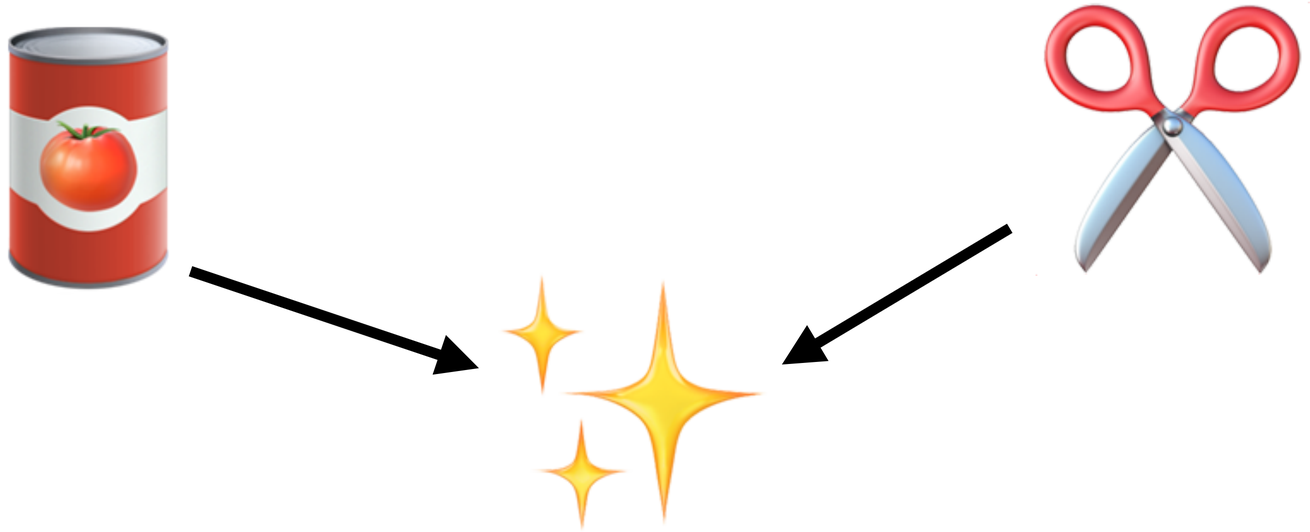

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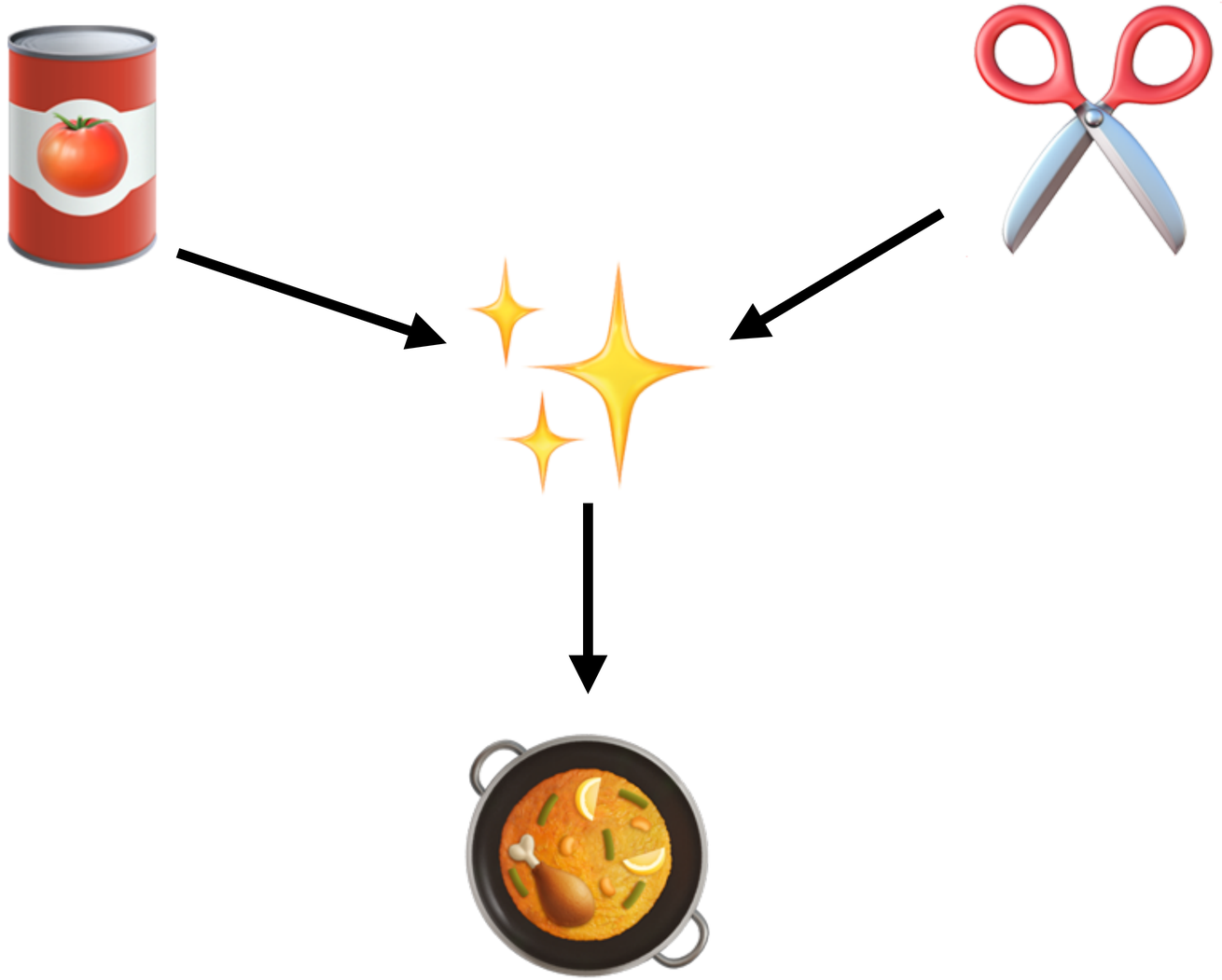

UCAN

JWT → UCAN

UCAN

JWT → UCAN

Header

```
{
  "alg": "EdDSA",
  "typ": "JWT",
  "ucv": "0.8.0"
}
```

UCAN

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Payload

```
{
  "iss":
"did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "aud":
"did:key:z6MkvXfPUv8bxtsVQiGo7Ntk4qKJNcgK2it52pc73teUpRLT",
  "nbf": 1639608293,
  "exp": 9256939505,
  "att": [
    {
      "with": "wnfs://demouser.fission.name/public/photos/",
      "can": "OVERWRITE"
    },
    {
      "with": "wnfs://demouser.fission.name/public/notes/",
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    },
    {
      "with": "wnfs://demouser.fission.name/public/notes/",
      "can": "APPEND"
    }
  ]
}
```

Signature

```
kwRdqPN74pkcpXGgdk7Z7FW3M1mRR
YaDE5ZgkG6srAuu6V6mvMVRdBLnD5
CWid-X4tDIKpliVjlCSLTntB4pCw
```

UCAN

JWT → UCAN

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    }
  ]
}
```

✅

Signature

```
kwRdqPN74pkcpXGgdk7Z7FW3M1mRR
YaDE5ZgkG6srAuu6V6mvMVRdBLnD5
CWid-X4tDIKpliVjlCSLTntB4pCw
```

UCAN

Anatomy of a Capability

UCAN

Anatomy of a Capability

```
[
  {
     "with": "http://example.com/alice/photos/",
     "can": "GET"
  },
  {
    "with": "mailto:boris@fission.codes",
    "can": "SEND",
    "to": "/.*@fission.codes/"
  }
]
```

UCAN

Anatomy of a Capability

Resource / "noun"

```
[
  {
    "with": "http://example.com/alice/photos/",
    "can": "GET"
  },
  {
    "with": "mailto:boris@fission.codes",
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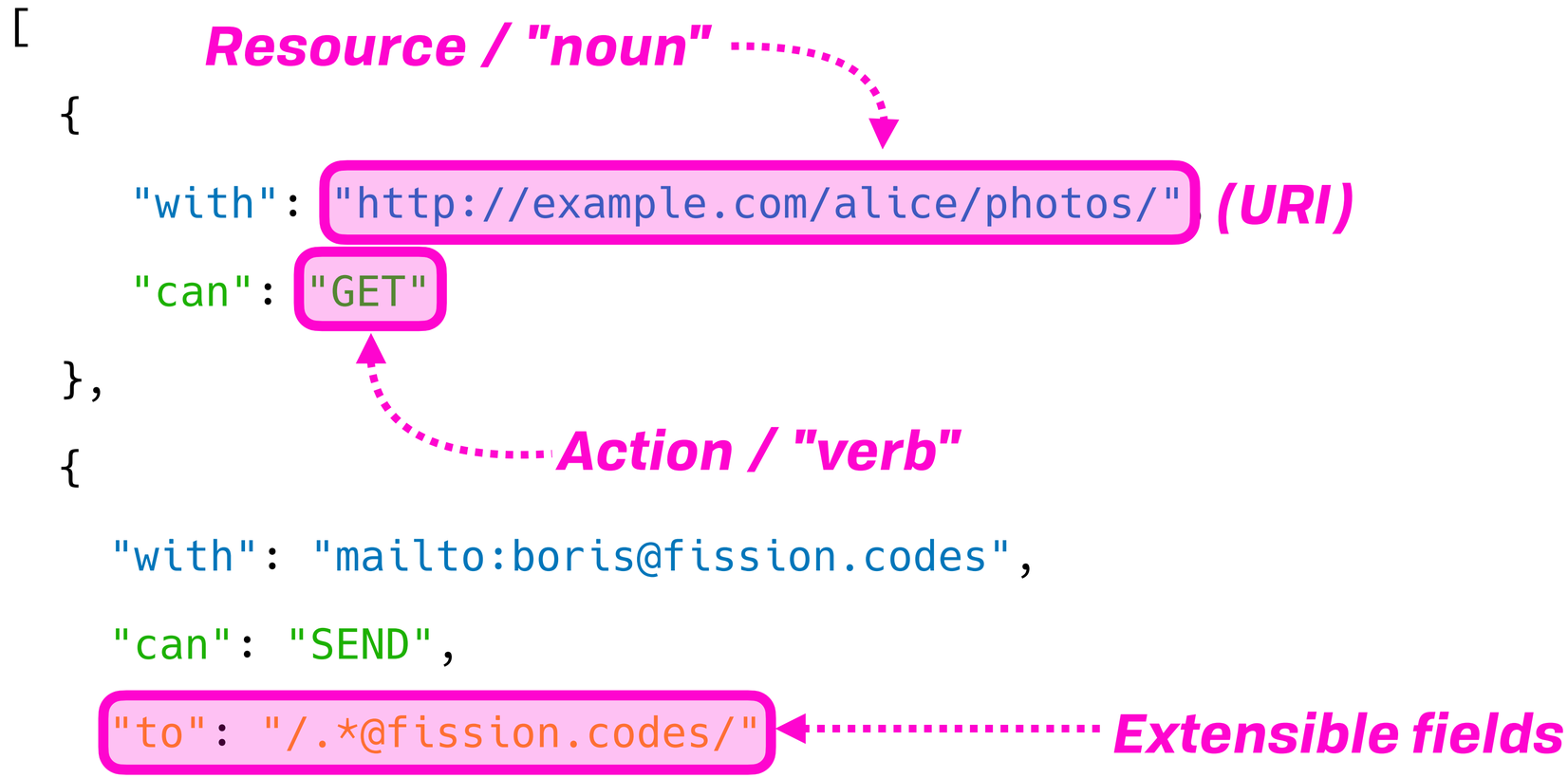
(URI)

UCAN

Anatomy of a Capability

UCAN

Anatomy of a Capability



UCAN

Chain Witnesses

UCAN

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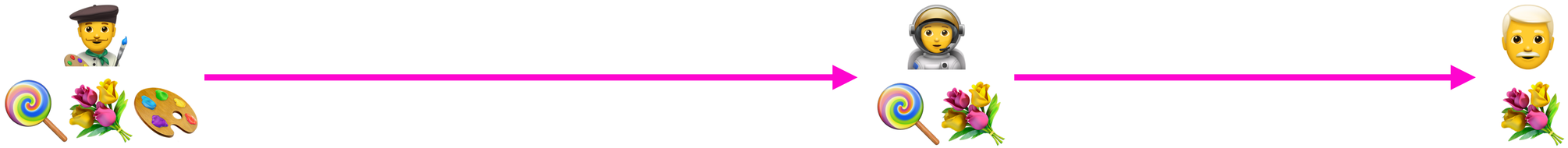
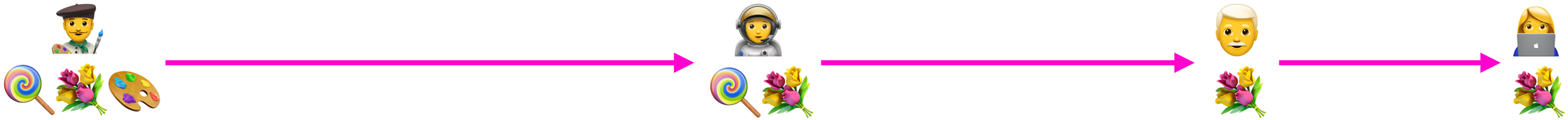


UCAN

Chain Witnesses

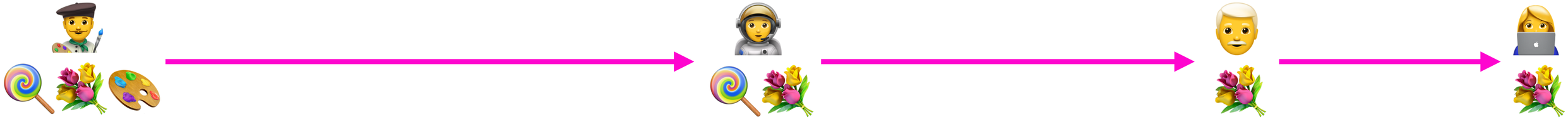


UCAN

Chain Witnesses

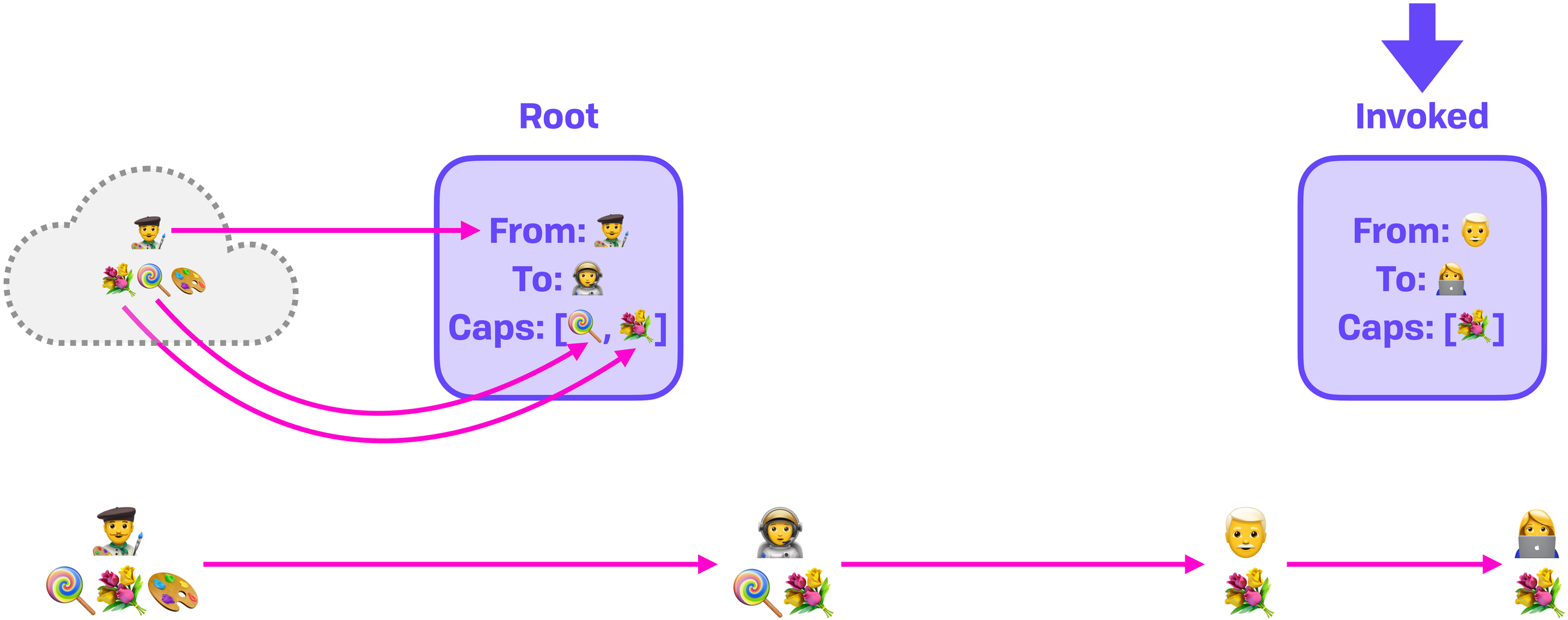
Invoked

From: 👴
To: 👩‍💻
Caps: [💐]



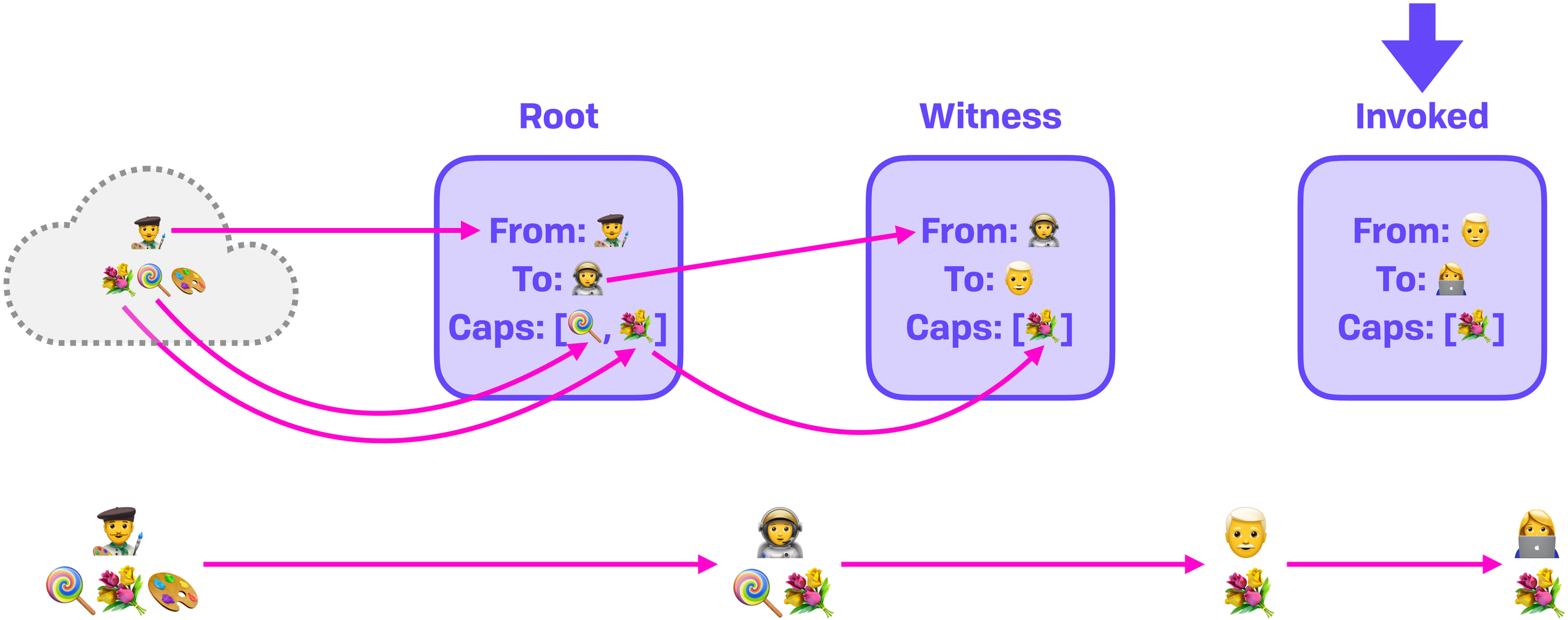
UCAN

Chain Witnesses



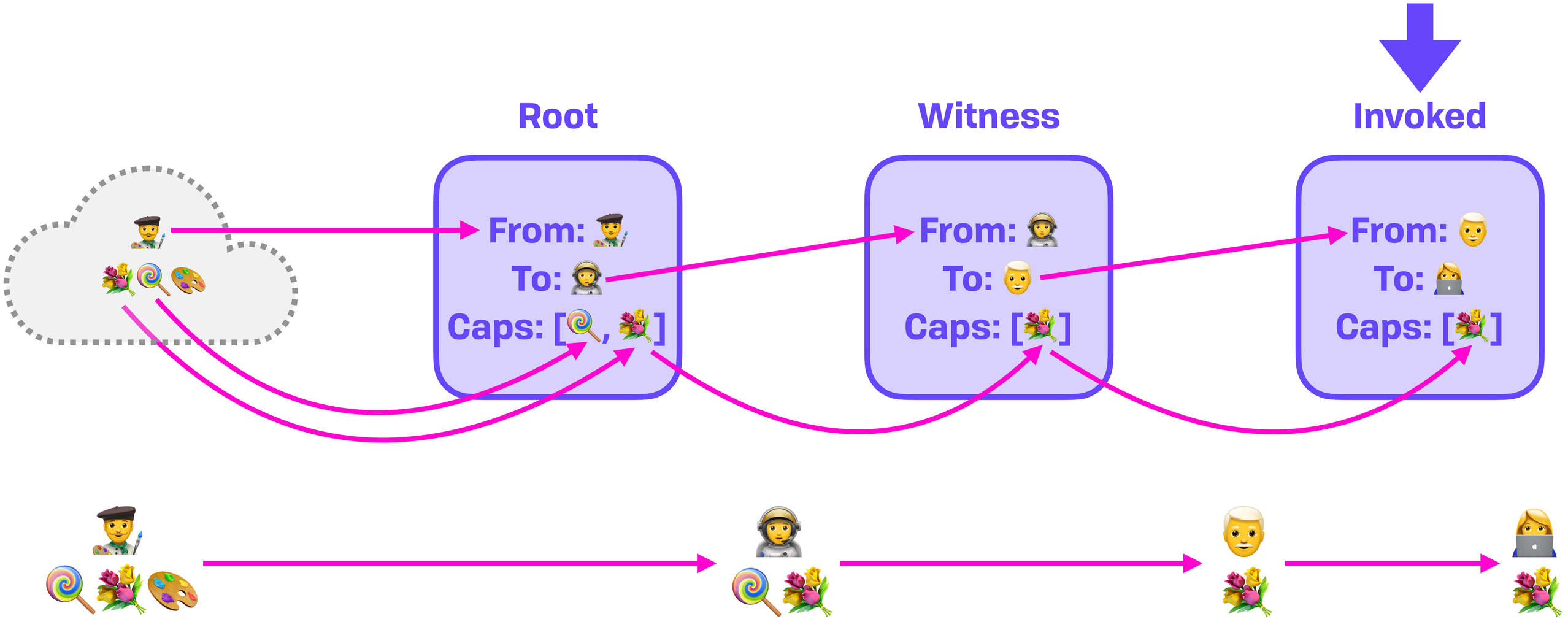
UCAN

Chain Witnesses



UCAN

Chain Witnesses



UCAN

Zoomed Out

UCAN

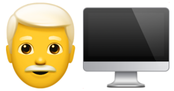
Zoomed Out

UCAN

Zoomed Out

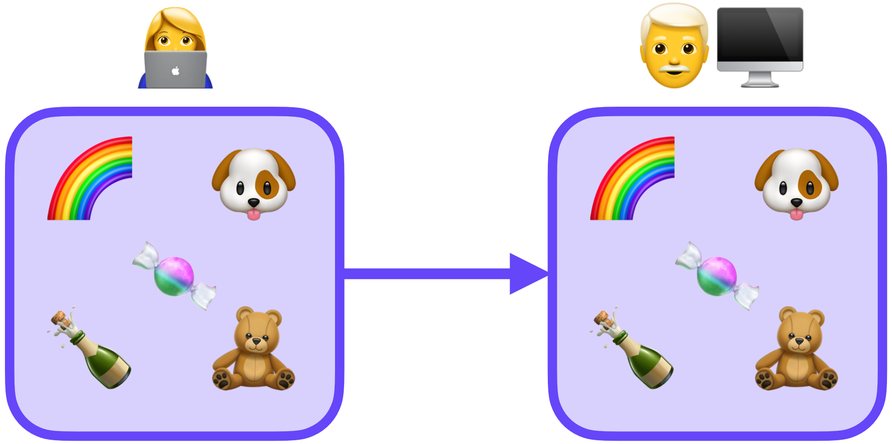
UCAN

Zoomed Out



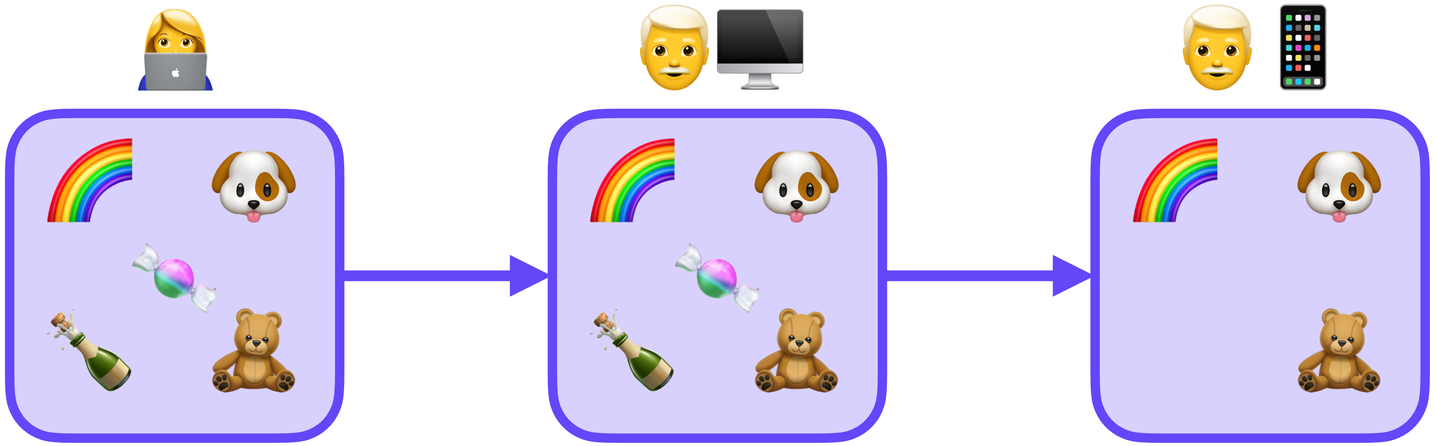
UCAN

Zoomed Out



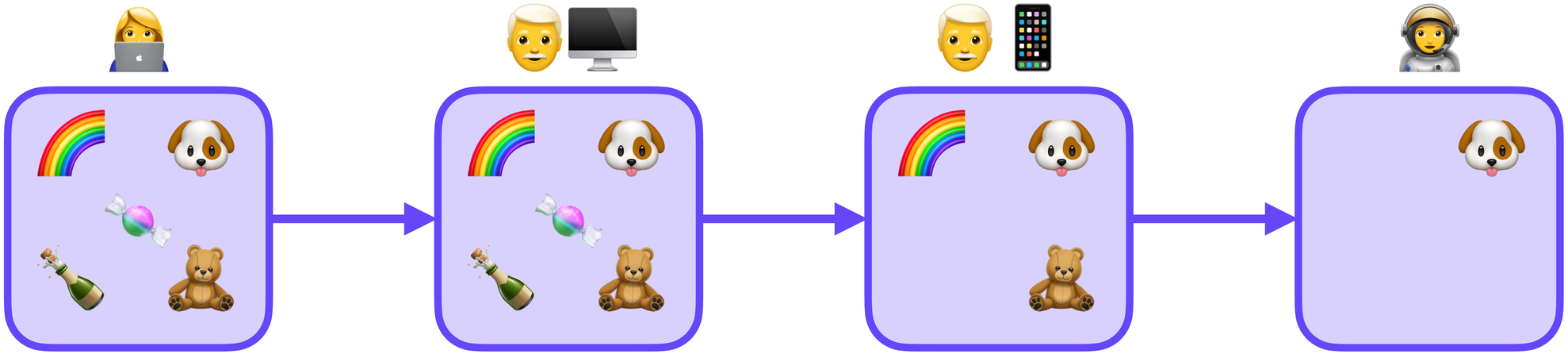
UCAN

Zoomed Out



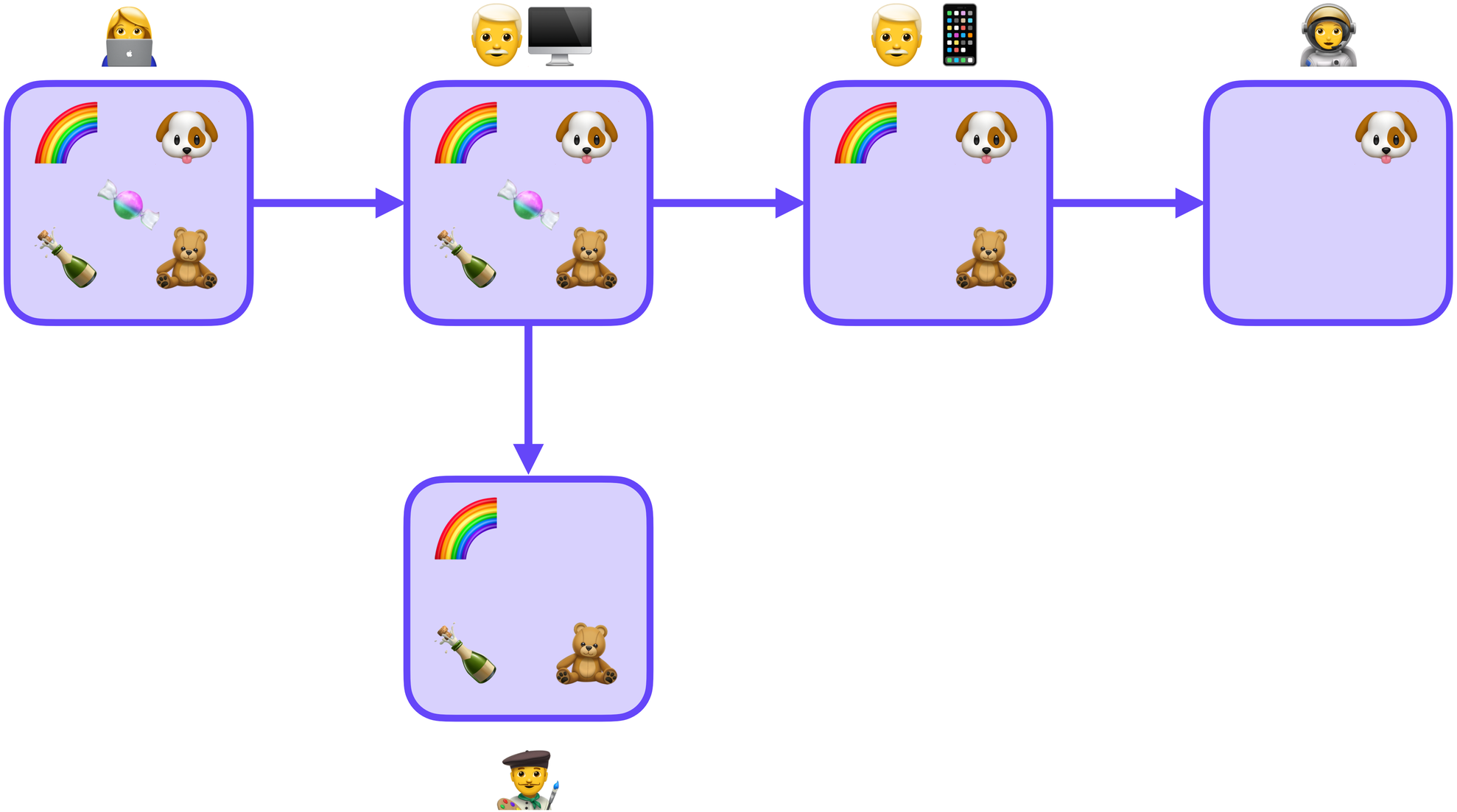
UCAN

Zoomed Out



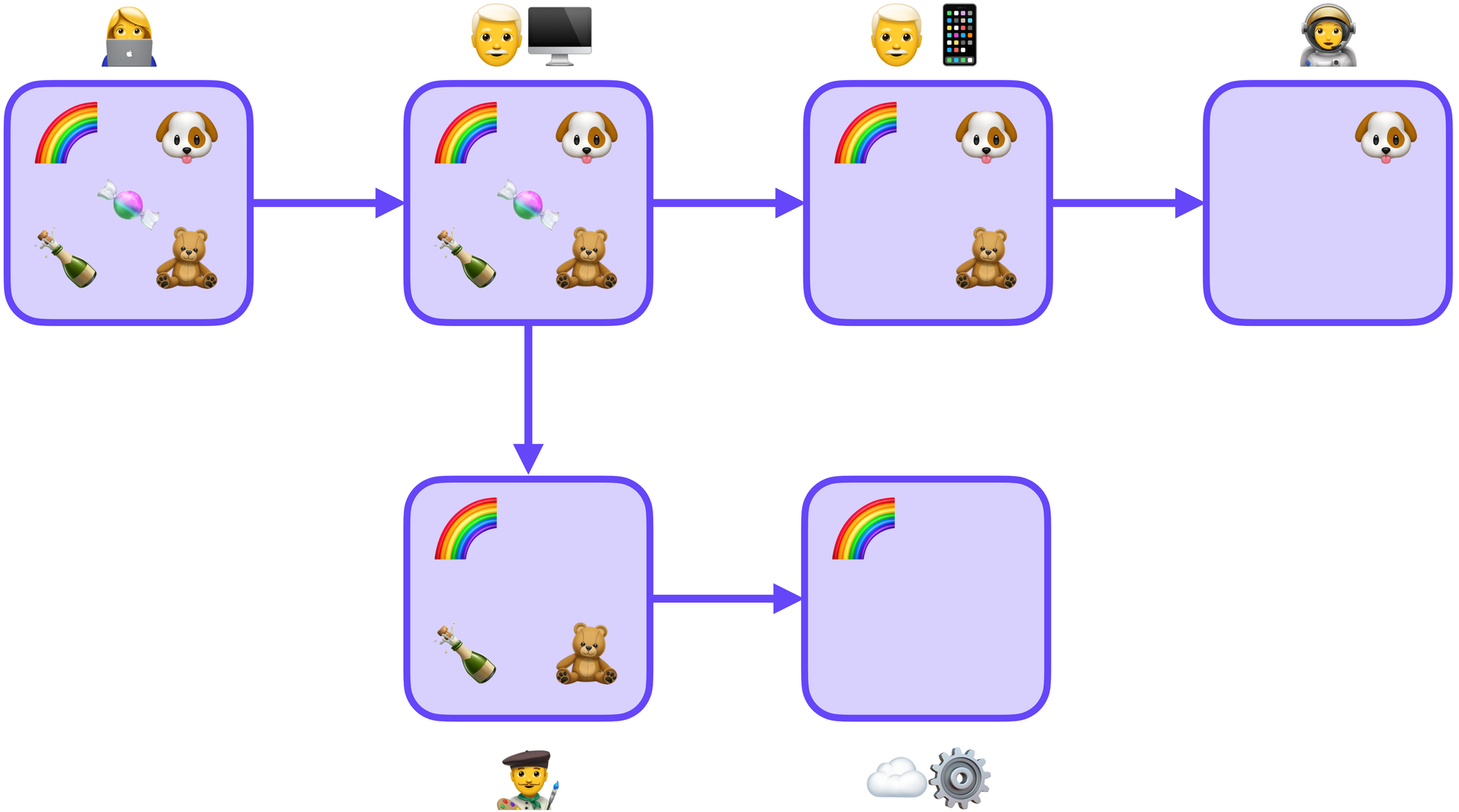
UCAN

Zoomed Out



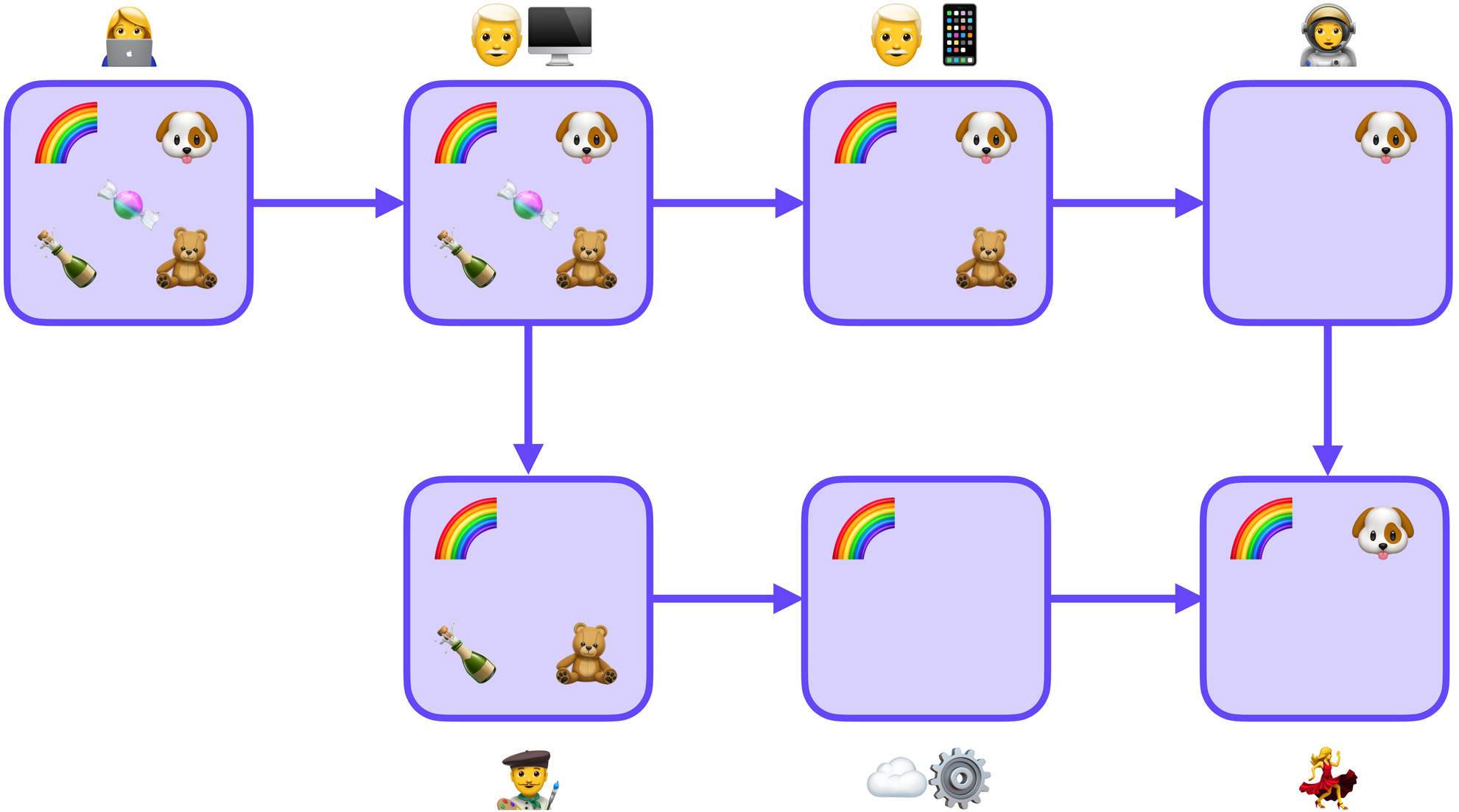
UCAN

Zoomed Out



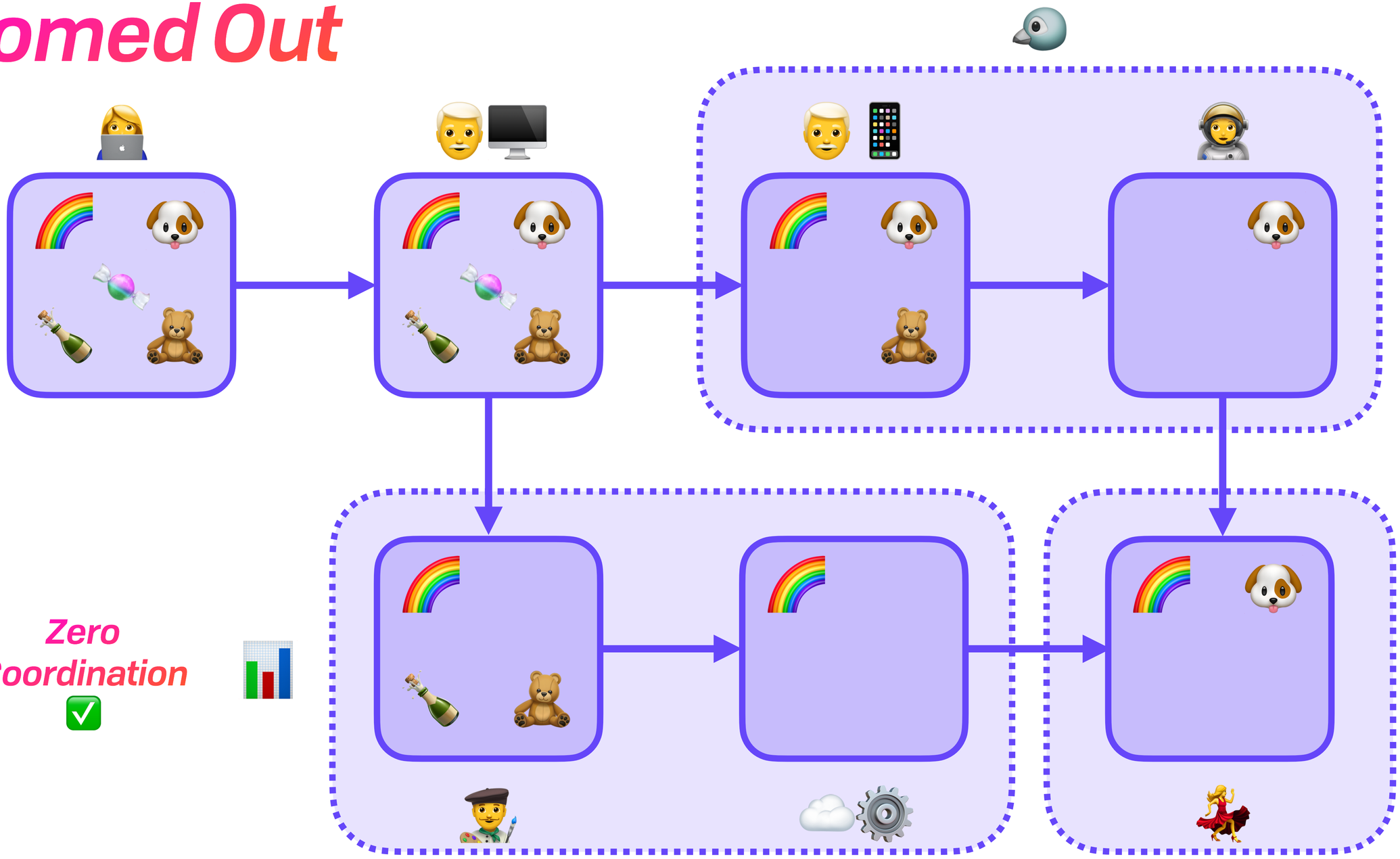
UCAN

Zoomed Out



UCAN

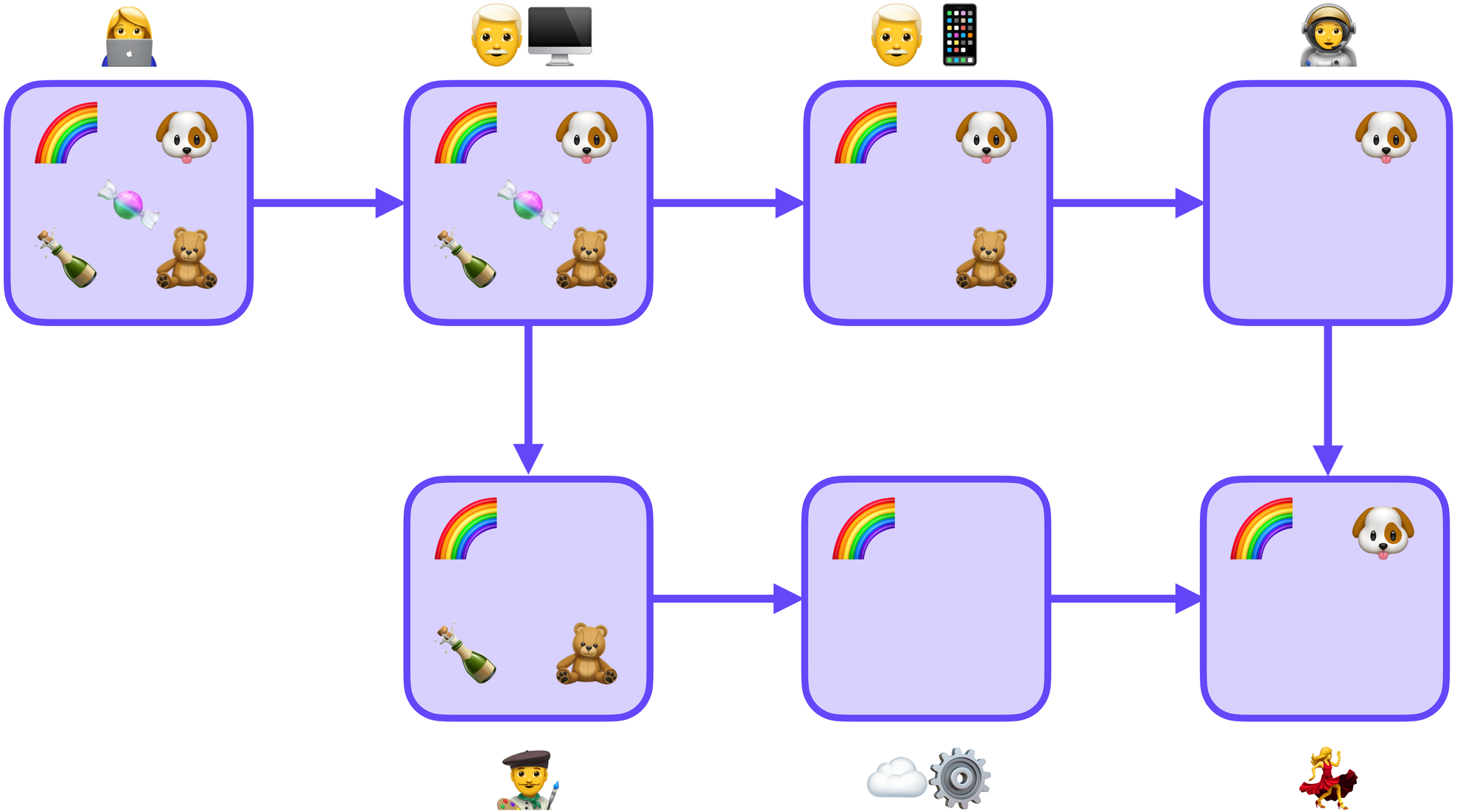
Zoomed Out



Zero Coordination ✅

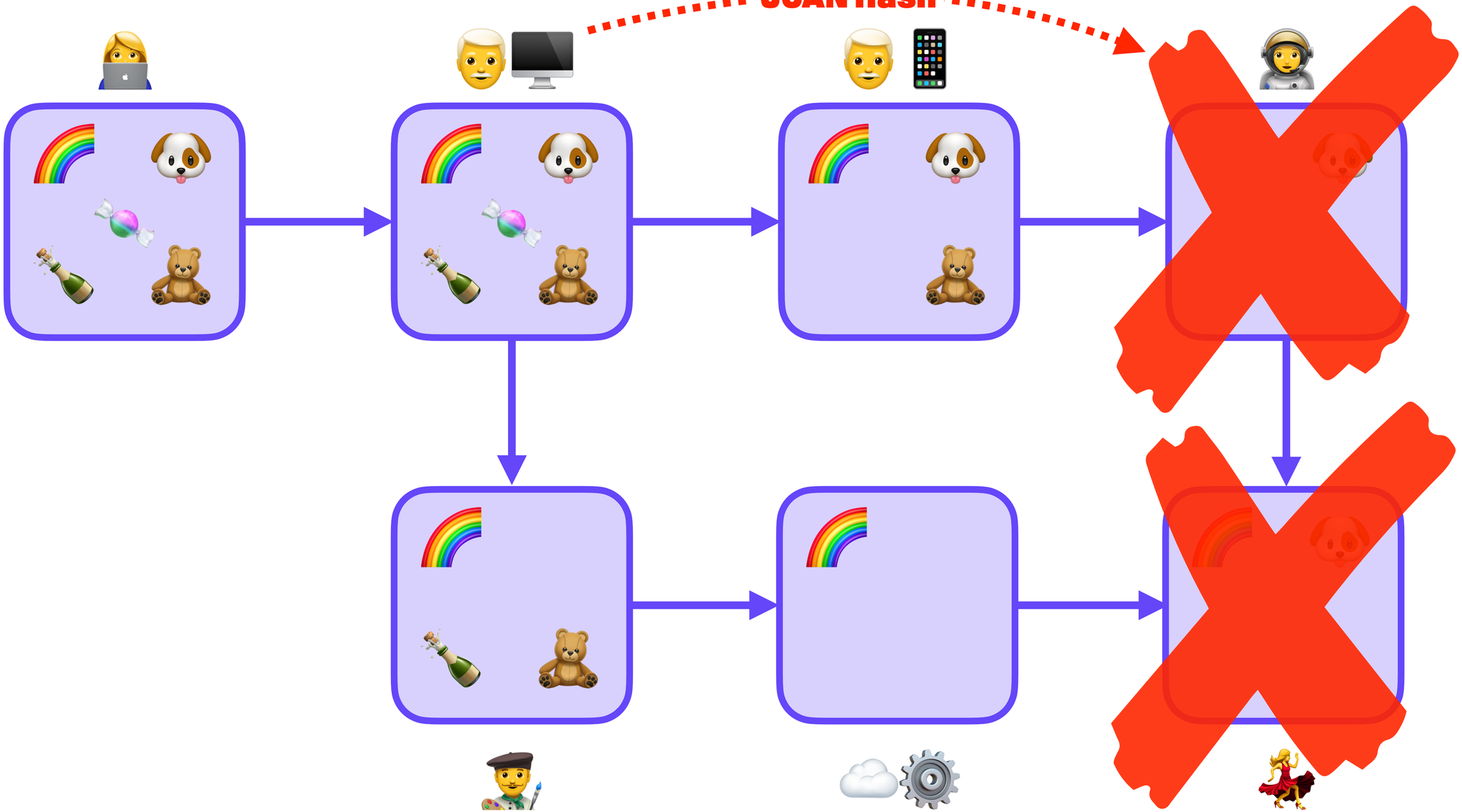
UCAN

Revocation Cascade



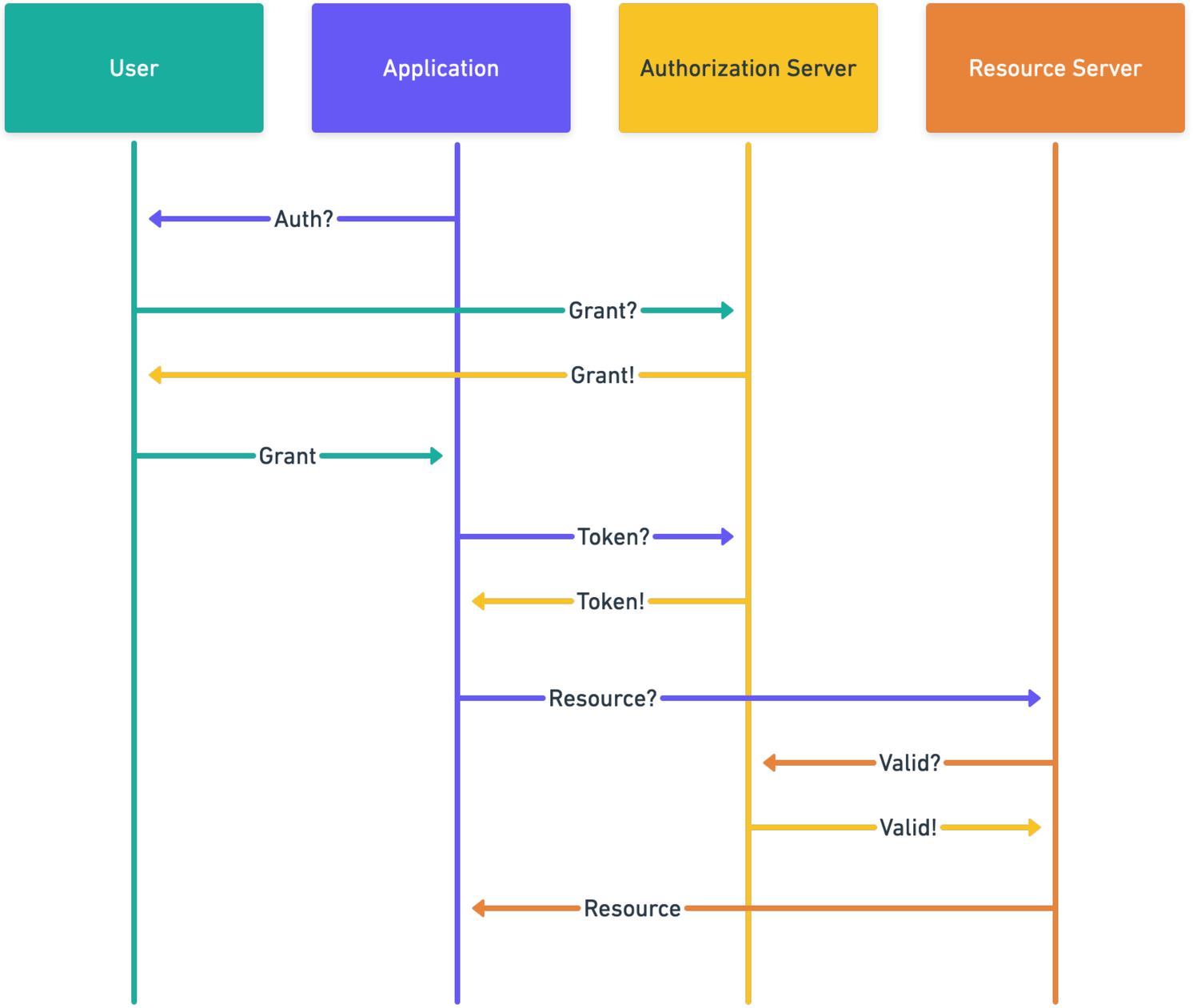
UCAN

Revocation Cascade



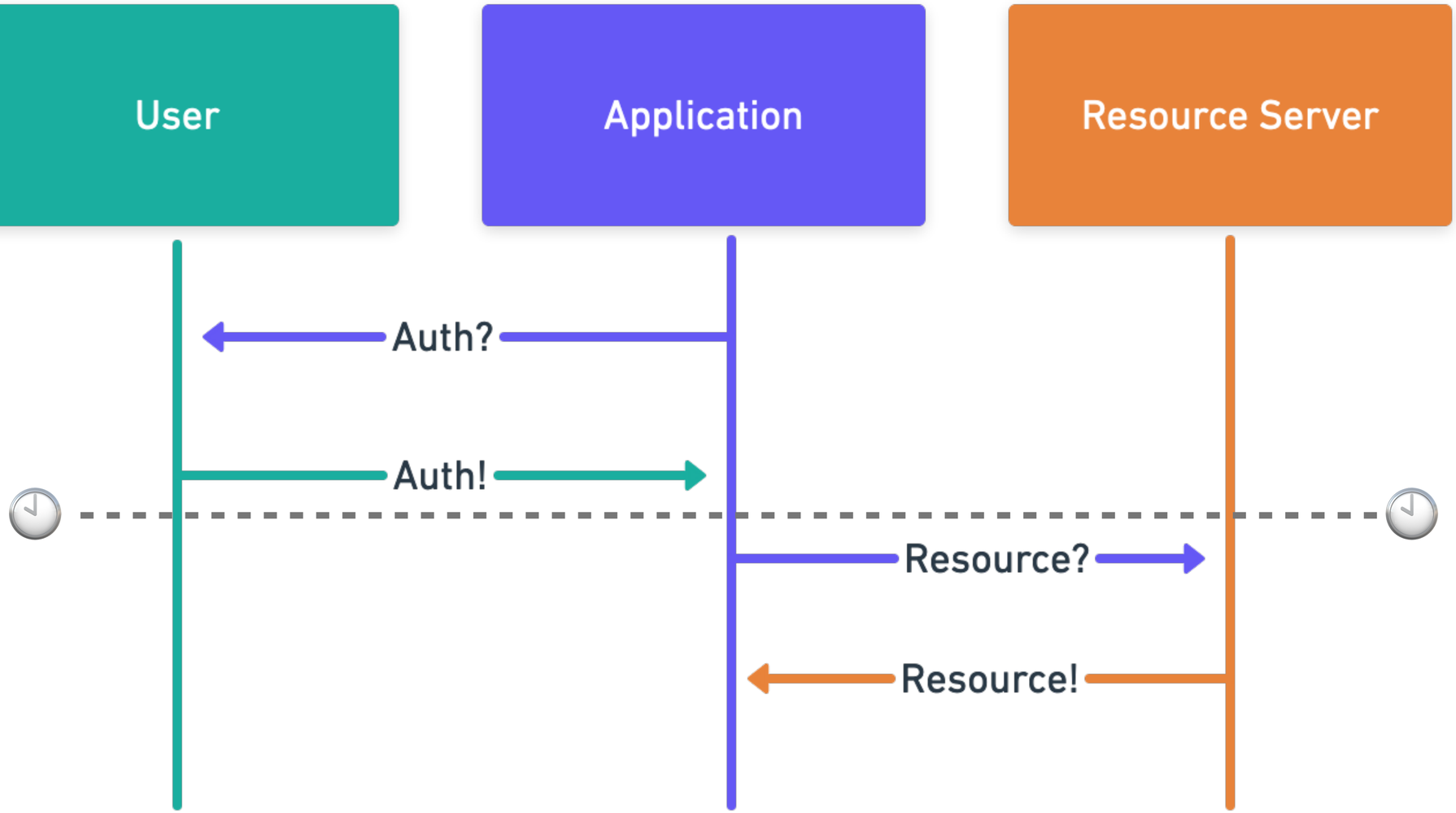
UCAN

OAuth Sequence



UCAN

UCAN Sequence



Nontrivial Example

Nontrivial Example

Encoded

Nontrivial Example

Encoded


```
eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a2V5Ono2T
Wt2WGZQVXY4Ynh0c1ZRaUdvN050azRxS0pOY2dLMml0NTJwYzczdGVVcFJMVCIsImF0dCI6W3sid25mcy
I6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvcGhvdG9zLyIsImNhcCI6Ik9WRVJXUklURSJ9LHs
id25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvbm90ZXMvIiwiY2FwIjoiT1ZFUldSSVRF
In1dLCJleHAiOjkyNTY5Mzk1MDUsImlzcyI6ImRpZDprZXk6ejZNa3NYUUJmTDhvd3p0VENKVG03aE5SZ
jZiMThZeFhQcDNpNjZvSkhtOEwzWUdKIiwibmJmIjoxNjM5NjA4MjkzLCJwcmYiOlsiZXlKaGJHY2lPaU
pGWkVSVFFTSXNJblI1Y0NJNklrcFhWQ0lzSW5WamRpSTZJakF1Tnk0d0luMC5leUpoZFdRaU9pSmthV1E
2YTJWNU9ubzJUV3R6V0ZGQ1prdzRiM2Q2ZEZSRFNsUnROMmhPVW1ZMllqRTRXWGhZVUhBemFUWTJiMHBJ
YlRoTU0xbEhTaUlzSW1GMGRDSTZXM3NpZDI1bWN5STZJbVJsYlc5MWMyVnlMbVpwYzNOcGIyNHVibUZ0W
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pVMk9UTTVOVEExTENKcGMzTWlPaUprYVdRNmEyVjVPbm8yVFd0d05VVnplamx6TWsxSWMzRlpka3h2WTJ
ONVNIZFlOVk5sZVZwTGNIRTNPVWQwTkRWbVJrZEZXbEk1T1NJc0ltNWlaaUk2TVRZek9UWXdPREk1TXl3
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kFNb0Z3VHVwdEcwWEZnTkl2SHVsUHBsVnpaWURWRGV4bzc2a0F3IiwiZXlKaGJHY2lPaUpGWkVSVFFTSX
NJblI1Y0NJNklrcFhWQ0lzSW5WamRpSTZJakF1Tnk0d0luMC5leUpoZFdRaU9pSmthV1E2YTJWNU9ubzJ
UV3R6V0ZGQ1prdzRiM2Q2ZEZSRFNsUnROMmhPVW1ZMllqRTRXWGhZVUhBemFUWTJiMHBJYlRoTU0xbEhT
aUlzSW1GMGRDSTZXM3NpZDI1bWN5STZJbVJsYlc5MWMyVnlMbVpwYzNOcGIyNHVibUZ0WlM5d2RXSnNhV
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VzSW1semN5STZJbVJwWkRwclpYazZlalpOYTNBMVJYTjZPWE15VFVoemNWbDJURzlqWTNsSWQxZzFVMlY
1V2t0d2NUYzVSM1EwTldaR1IwVmFVams1SWl3aWJtSm1Jam94TmpNNU5qQTRNamt6TENKd2NtWWlPbHRk
ZlEuTWdZYXJMcXk3Um1RMUFJcnFZTDZjRnk5ejdhNVdJQVUtLVRZQVJQU2dpck9Tc3p2YXIzX0ROcjI1c
mJQcmV0SGJuVDBtTVZLeW9hUVhydVI3S2JyQmciXX0.kwRdqPN74pkcpXGgdk7Z7FW3M1mRRYaDE5ZgkG
6srAuu6V6mvMVRdBLnD5CWid-X4tDIKpliVjlCSLTntB4pCw
```

Nontrivial Example

Decoded

Header


```
{
  "alg": "EdDSA",
  "typ": "JWT",
  "ucv": "0.8.0"
}
```


Payload


```
{
  "iss": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "aud": "did:key:z6MkvXfPUv8bxtsVQiGo7Ntk4qKJNcgK2it52pc73teUpRLT",
  "nbf": 1639608293,
  "exp": 9256939505,
  "att": [
    {
      "with": "wnfs://demouser.fission.name/public/photos/",
      "can": "OVERWRITE"
    },
    {
      "with": "wnfs://demouser.fission.name/public/notes/",
      "can": "APPEND"
    }
  ],
  "prf": [
"eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a
2V5Ono2TWtzWFFCZkw4b3d6dFRDSlRtN2hOUmY2YjE4WXhYUHAzaTY2b0pIbThMM1lHSiIsImF
0dCI6W3sid25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvcGhvdG9zLyIsImNhc
CI6Ik9WRVJXUklURSJ9XSwiZXhwIjo5MjU2OTM5NTA1LCJpc3MiOiJkaWQ6a2V5Ono2TWtwNUV
zejlzMk1Ic3FZdkxvY2N5SHdYNVNleVpLcHE3OUd0NDVmRkdFWlI5OSIsIm5iZiI6MTYzOTYwO
DI5MywicHJmIjpbXX0.4TNhuHRrPG9aHo869HXlsNK8_FmlShQ5GzG4itN2NKk-
yKTbAMoFwTuptG0XFgNIvHulPplVzZYDVDexo76kAw",

"eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a
2V5Ono2TWtzWFFCZkw4b3d6dFRDSlRtN2hOUmY2YjE4WXhYUHAzaTY2b0pIbThMM1lHSiIsImF
0dCI6W3sid25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvbm90ZXMvIiwiY2FwI
joiT1ZFUldSSVRFIn1dLCJleHAiOjkyNTY5Mzk1MDUsImlzcyI6ImRpZDprZXk6ejZNa3A1RXN
6OXMyTUhzcVl2TG9jY3lId1g1U2V5WktwcTc5R3Q0NWZGR0VaUjk5IiwibmJmIjoxNjM5NjA4M
jkzLCJwcmYiOltdfQ.MgYarLqy7RmQ1AIrqYL6cFy9z7a5WIAU--
TYARPSgirOSszvar3_DNr25rbPretHbnT0mMVKyoaQXruR7KbrBg"
  ]
}
```


Signature


```
kwRdqPN74pkcpXGgdk7Z7FW3M1mRR
YaDE5ZgkG6srAuu6V6mvMVRdBLnD5
CWid-X4tDIKpliVjlCSLTntB4pCw
```

Nontrivial Example

Decoded

Header


```
{
  "alg": "EdDSA",
  "typ": "JWT",
  "ucv": "0.8.0"
}
```


Payload


```
{
  "iss": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "aud": "did:key:z6MkvXfPUv8bxtsVQiGo7Ntk4qKJNcgK2it52pc73teUpRLT",
  "nbf": 1639608293,
  "exp": 9256939505,
  "att": [
    {
      "with": "wnfs://demouser.fission.name/public/photos/",
      "can": "OVERWRITE"
    },
    {
      "with": "wnfs://demouser.fission.name/public/notes/",
      "can": "APPEND"
    }
  ],
  "prf": [
    "eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a
    2V5Ono2TWtzWFFCZkw4b3d6dFRDSlRtN2hOUmY2YjE4WXhYUHAzaTY2b0pIbThMM1lHSiIsImF
    0dCI6W3sid25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvcGhvdG9zLyIsImNhc
    CI6Ik9WRVJXUklURSJ9XSwiZXhwIjo5MjU2OTM5NTA1LCJpc3MiOiJkaWQ6a2V5Ono2TWtwNUV
    zejlzMk1Ic3FZdkxvY2N5SHdYNVNleVpLcHE3OUd0NDVmRkdFWlI5OSIsIm5iZiI6MTYzOTYwO
    DI5MywicHJmIjpbXX0.4TNhuHRrPG9aHo869HXlsNK8_FmlShQ5GzG4itN2NKk-
    yKTbAMoFwTuptG0XFgNIvHulPplVzZYDVDexo76kAw",
    "eyJhbGciOiJFZERTQSIsInR5cCI6IkpXVCIsInVjdiI6IjAuNy4wIn0.eyJhdWQiOiJkaWQ6a
    2V5Ono2TWtzWFFCZkw4b3d6dFRDSlRtN2hOUmY2YjE4WXhYUHAzaTY2b0pIbThMM1lHSiIsImF
    0dCI6W3sid25mcyI6ImRlbW91c2VyLmZpc3Npb24ubmFtZS9wdWJsaWMvbm90ZXMvIiwiY2FwI
    joiT1ZFUldSSVRFIn1dLCJleHAiOjkyNTY5Mzk1MDUsImlzcyI6ImRpZDprZXk6ejZNa3A1RXN
    6OXMyTUhzcVl2TG9jY3lId1g1U2V5WktwcTc5R3Q0NWZGR0VaUjk5IiwibmJmIjoxNjM5NjA4M
    jkzLCJwcmYiOltdfQ.MgYarLqy7RmQ1AIrqYL6cFy9z7a5WIAU--
    TYARPSgirOSszvar3_DNr25rbPretHbnT0mMVKyoaQXruR7KbrBg"
  ]
}
```


Signature


```
kwRdqPN74pkcpXGgdk7Z7FW3M1mRR
YaDE5ZgkG6srAuu6V6mvMVRdBLnD5
CWid-X4tDIKpliVjlCSLTntB4pCw
```

Nontrivial Example

Decoded Witness #1

Header

```
{
  "alg": "EdDSA",
  "typ": "JWT",
  "ucv": "0.8.0"
}
```

Payload

```
{
  "iss": "did:key:z6Mkp5Esz9s2MHsqYvLoccyHwX5SeyZKpq79Gt45fFGEZR99",
  "aud": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "nbf": 1639608293,
  "exp": 9256939505,
  "att": [
    {
      "with": "wnfs://demouser.fission.name/public/photos/",
      "can": "OVERWRITE"
    }
  ],
  "prf": []
}
```

Signature

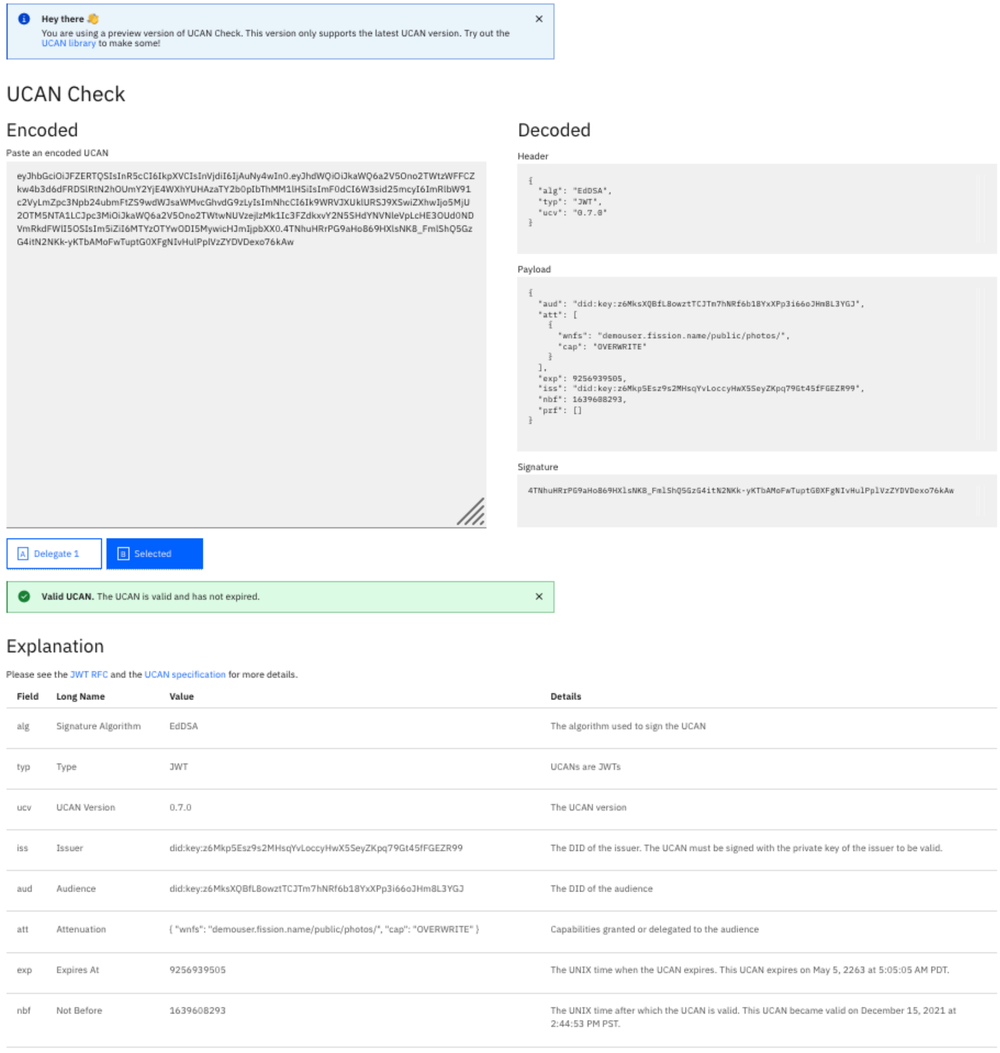
```
4TNhuHRrPG9aHo869HXlsNK8_FmlShQ5GzG
4itN2NKk-
yKTbAMoFwTuptG0XFgNIvHulPplVzZYDVDe
xo76kAw
```

Nontrivial Example

ucan.xyz — Online Explorer / Validator

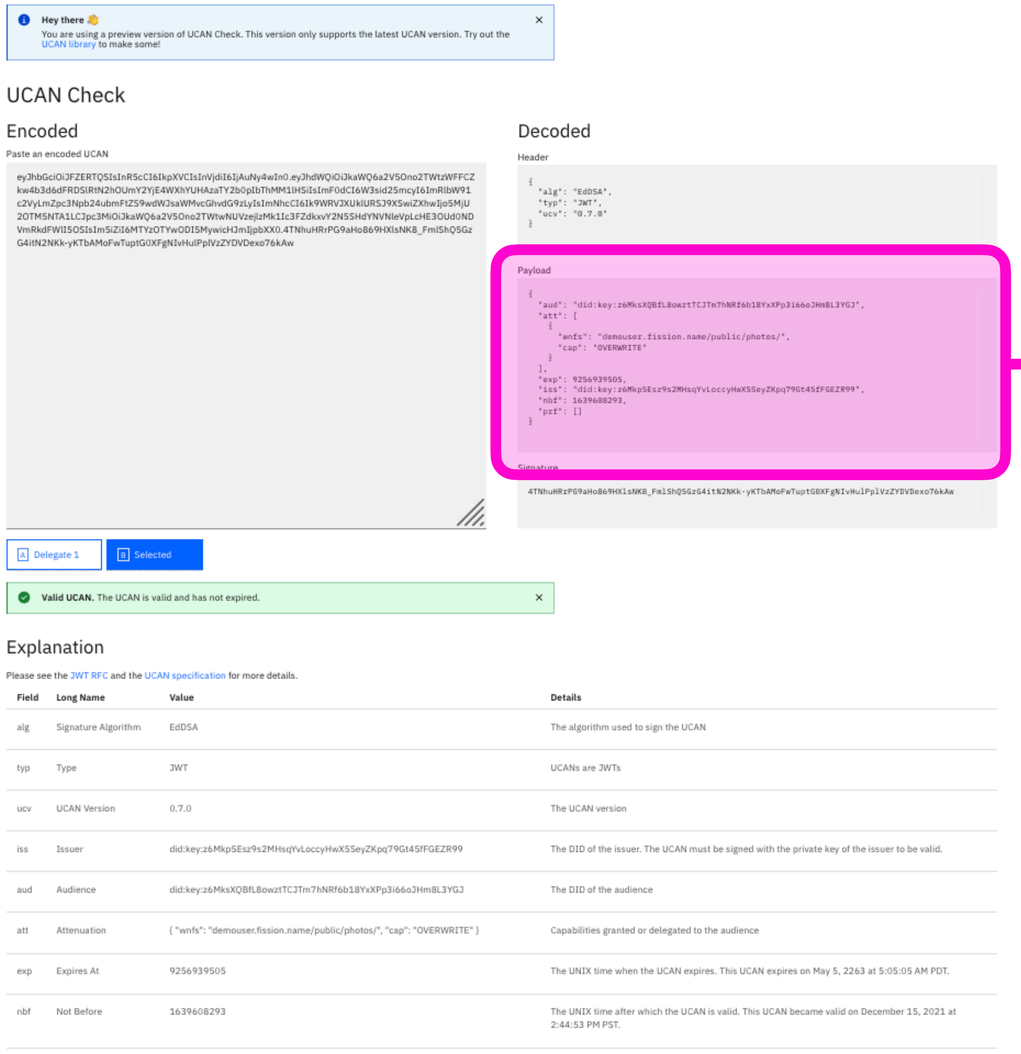
Nontrivial Example

ucan.xyz — Online Explorer / Validator



Nontrivial Example

ucan.xyz — Online Explorer / Validator

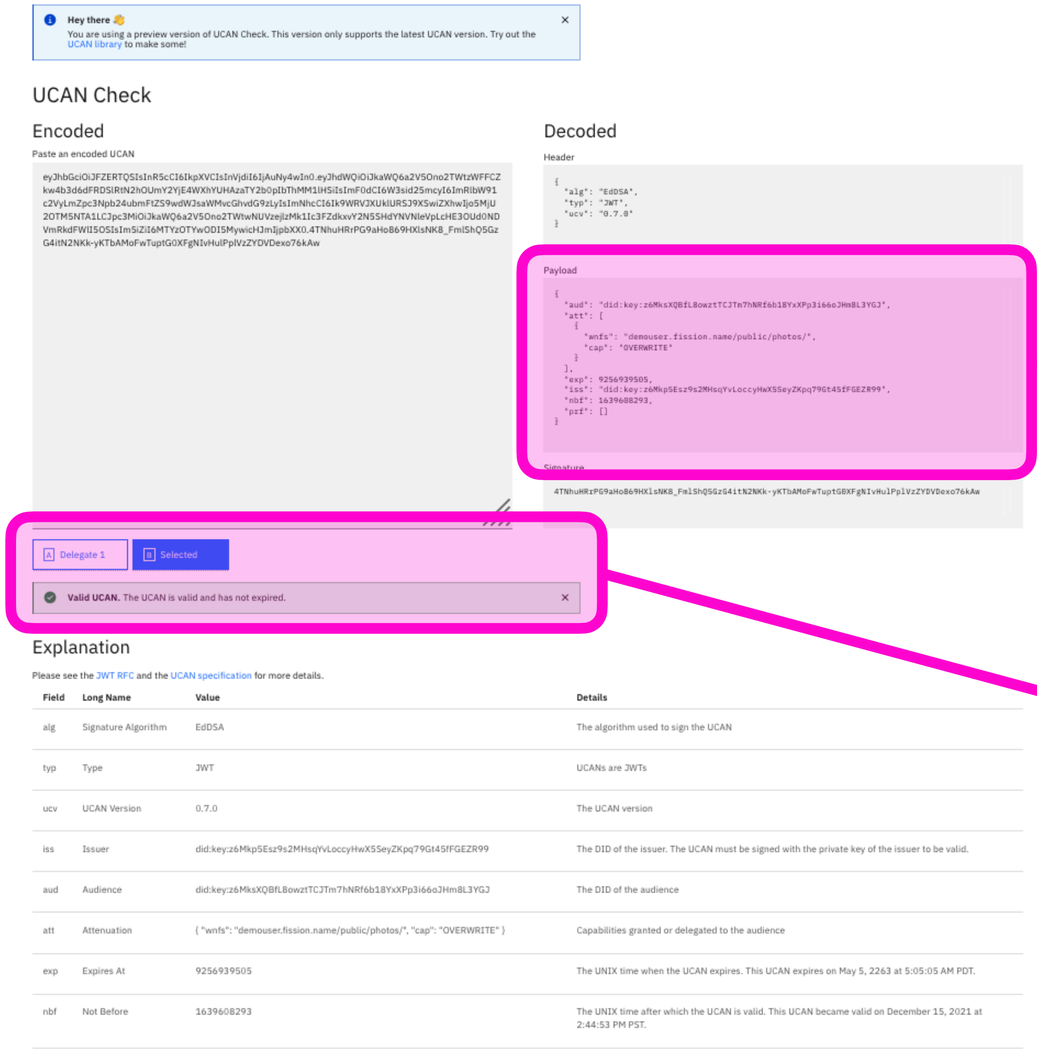


Payload


```
{
  "aud": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "att": [
    {
      "wnfs": "demouser.fission.name/public/photos/",
      "cap": "OVERWRITE"
    }
  ],
  "exp": 9256939505,
  "iss": "did:key:z6Mkp5Esz9s2MHsqYvLoccyHwX5SeyZKpq79Gt45fFGEZR99",
  "nbf": 1639608293,
  "prf": []
}
```

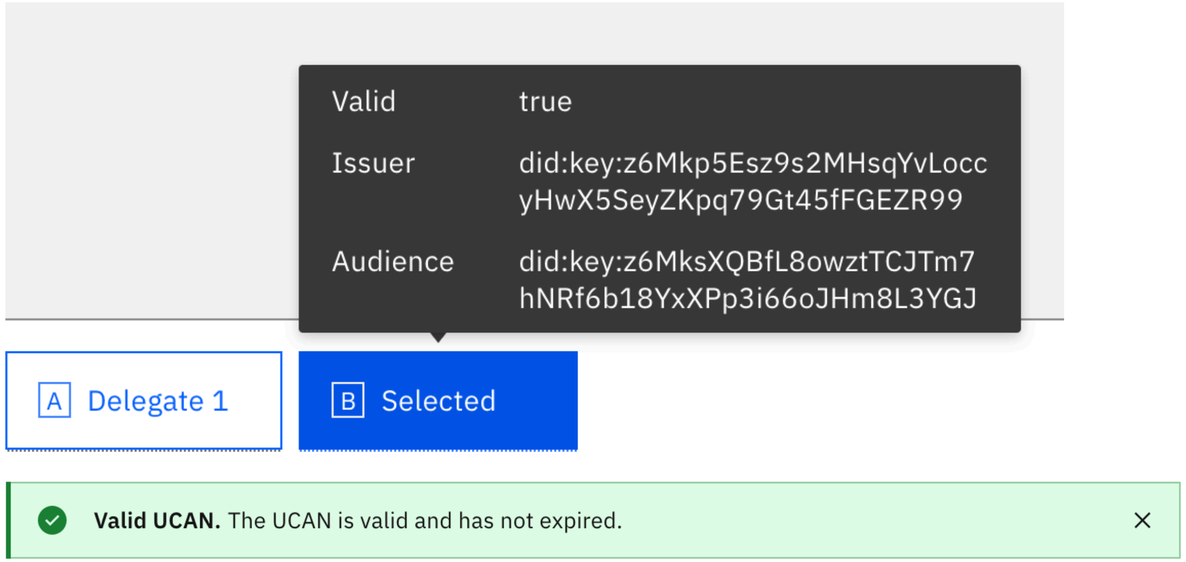
Nontrivial Example

ucan.xyz — Online Explorer / Validator



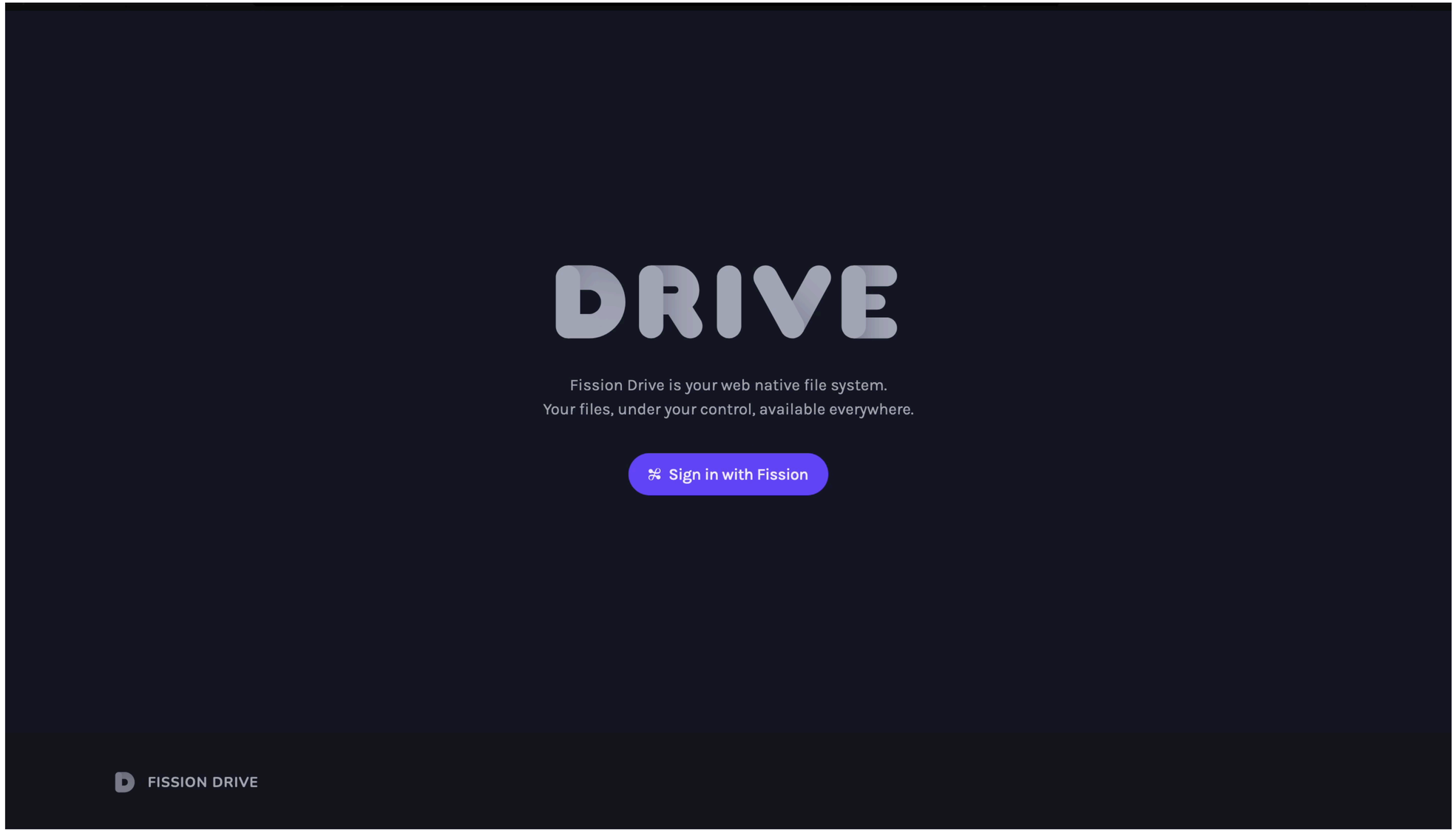
Payload


```
{
  "aud": "did:key:z6MksXQBfL8owztTCJTm7hNRf6b18YxXPp3i66oJHm8L3YGJ",
  "att": [
    {
      "wnfs": "demouser.fission.name/public/photos/",
      "cap": "OVERWRITE"
    }
  ],
  "exp": 9256939505,
  "iss": "did:key:z6Mkp5Esz9s2MHsqYvLoccyHwX5SeyZKpq79Gt45fFGEZR99",
  "nbf": 1639608293,
  "prf": []
}
```

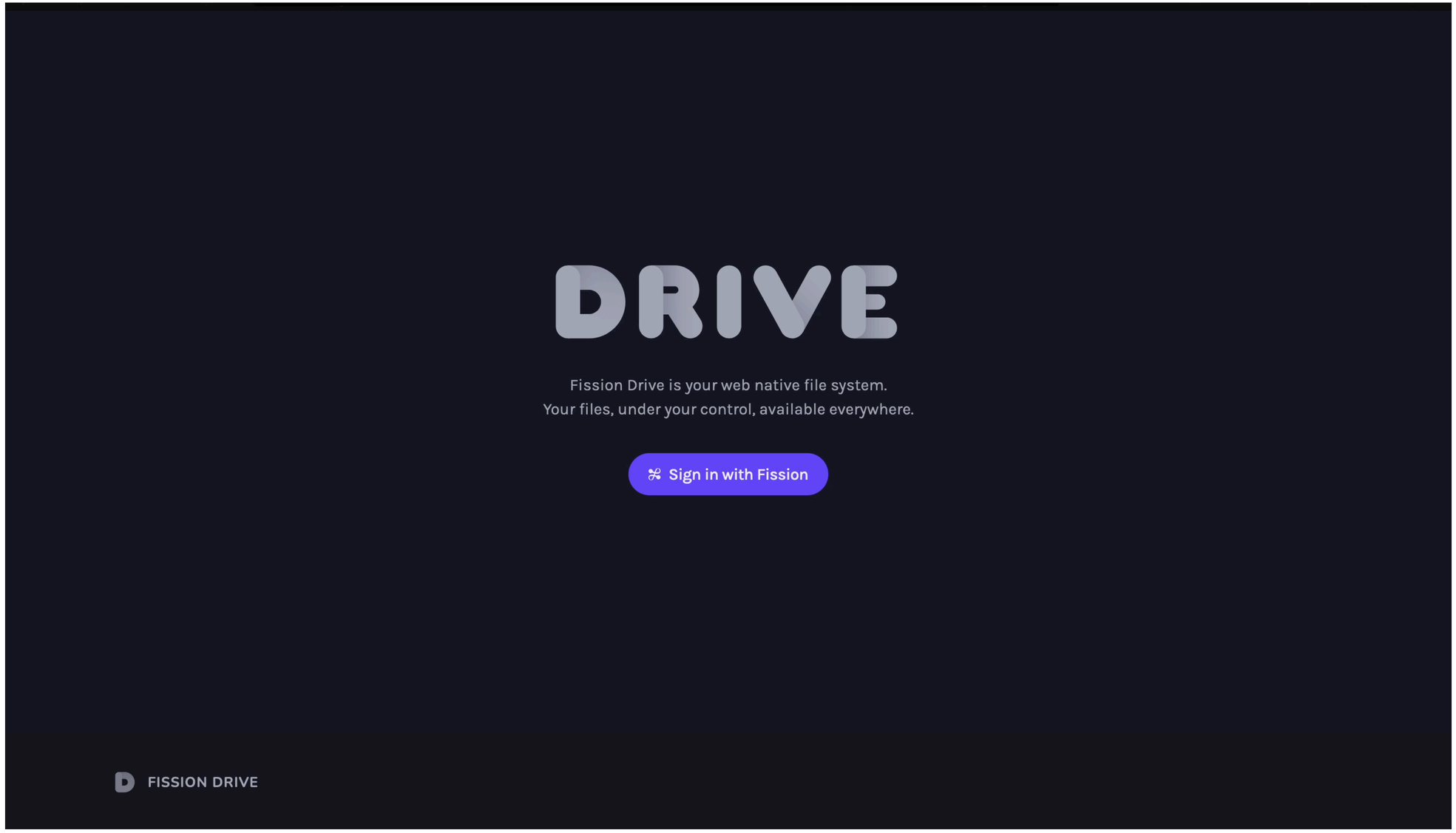
Nontrivial Example

Auth Should be Boring!



Nontrivial Example

Auth Should be Boring!



Resources

Resources

Further Reading

Resources

Further Reading

- https://talk.fission.codes/t/user-controlled-authorization-networks-ucan-resources/1122
- https://github.com/ucan-wg/
  - Spec, Improvement Proposals
  - Libraries: TypeScript, Golang, Haskell, (Rust soon)
- Capability Myths Demolished (https://srl.cs.jhu.edu/pubs/SRL2003-02.pdf)
- ACLs Don't (http://waterken.sourceforge.net/aclsdont/current.pdf)
- https://erights.org
- https://theworld.com/~cme/html/spki.html

https://ucan.xyz

https://github.com/ucan-wg

Thank You, Ink & Switch

brooklyn@fission.codes

https://fission.codes

github.com/expede

@expede