
IPVM
Seamless Services
—For an Open World—
🌈 Light Cones, User Agency, & Connecting Everything 🧩
github.com/ipvm-wg
fission.codes

Seamless Services for an Open World

We cannot sow seeds with clenched fists.
To sow we must ***open our hands***.

– **Adolfo Perez Esquivel**

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Jesper, I have this idea in which we'll connect all of the worlds Erlang systems to each other, imagine if ***every process could talk to every other process***, world-wide!

– **Joe Armstrong,** email to Jesper L. Andersen

Seamless Services for an Open World

Brooklyn Zelenka @expede

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`github.com/expede`

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- Cofounder & CTO at Fission Codes
  - https://fission.codes
- PLT and DSys are my jam 🤘
- Witchcraft, UCAN, WNFS, Rhizome, Multiformats, EIPs, &c

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- PLT and DSys are my jam 🤘
- Witchcraft, UCAN, WNFS, Rhizome, Multiformats, EIPs, &c
- 🦀 Rust IPVM implementation (mainly) by *Zeeshan Lakhani*
- Joint work with Protocol Labs, Expanso, and others

github.com/zeeshanlakhani

Seamless Services for an Open World

Rolling Weight

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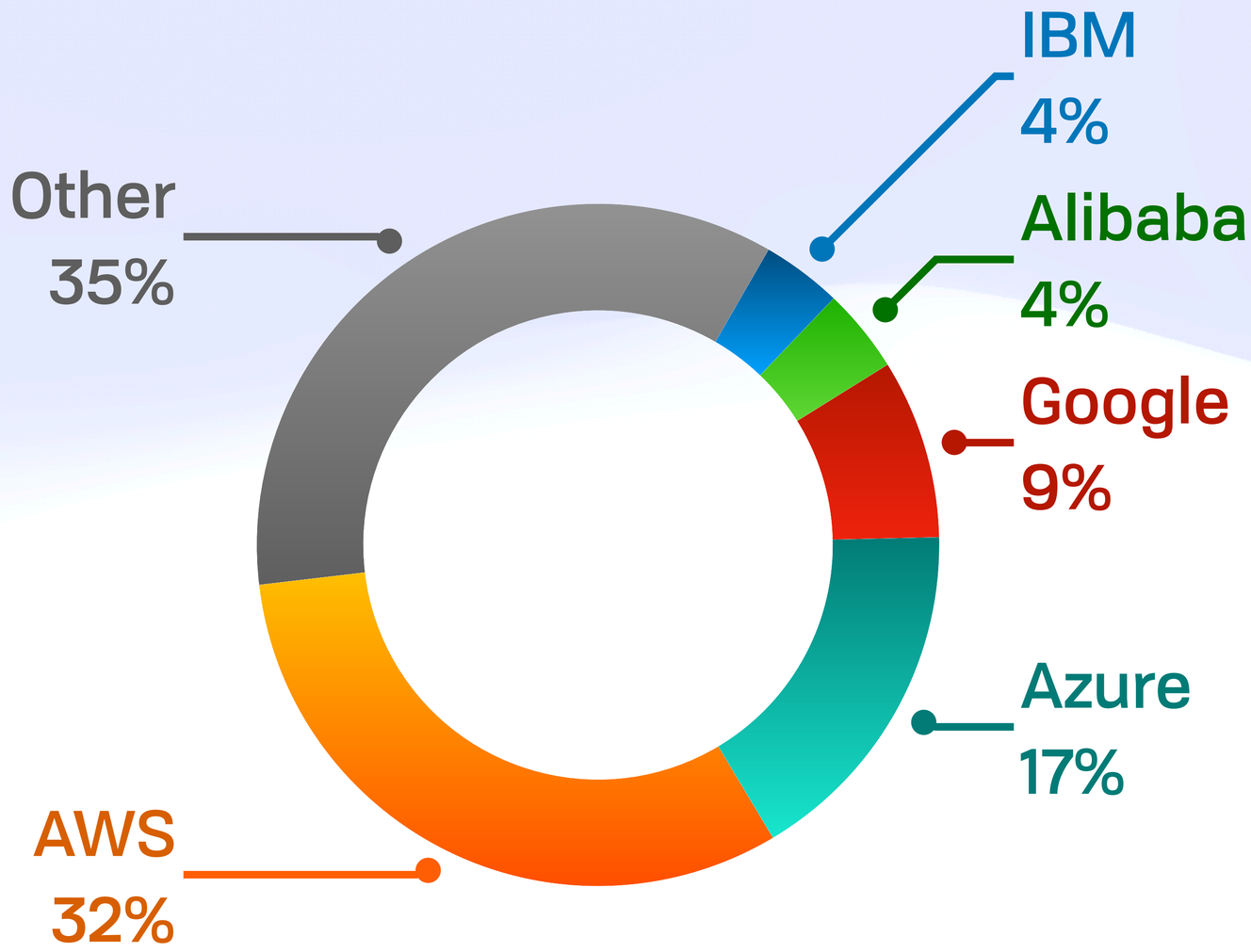
Rolling Weight



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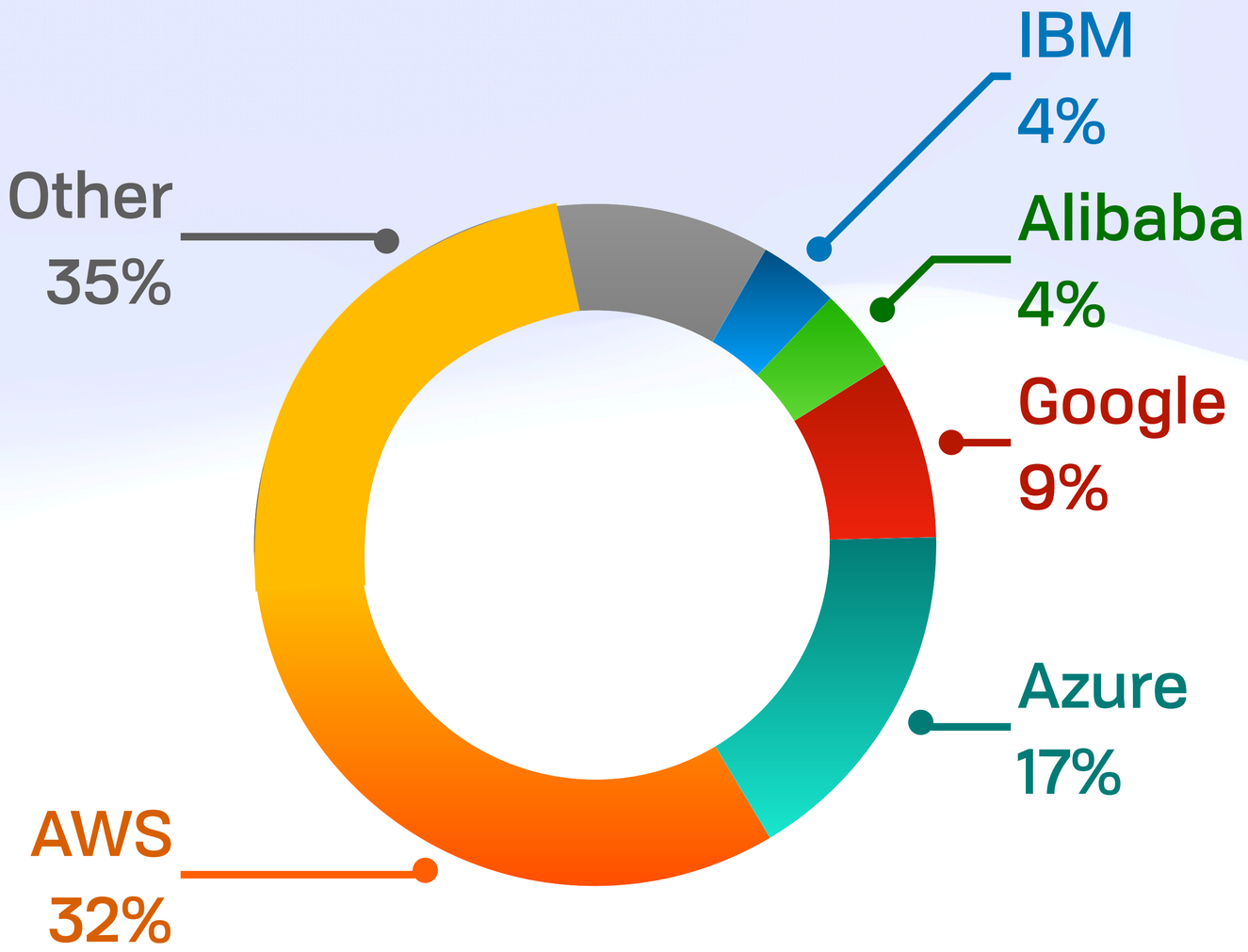

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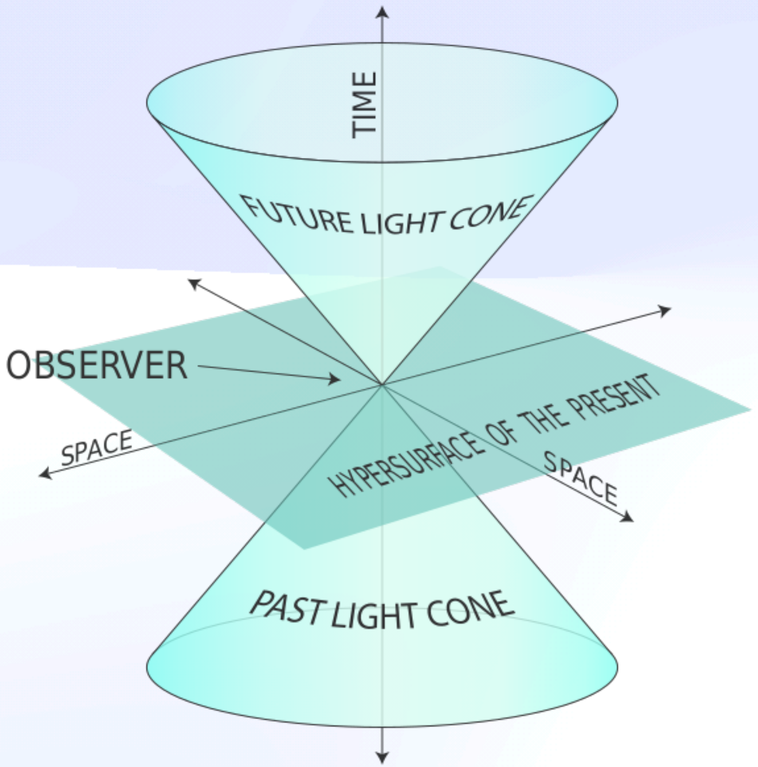

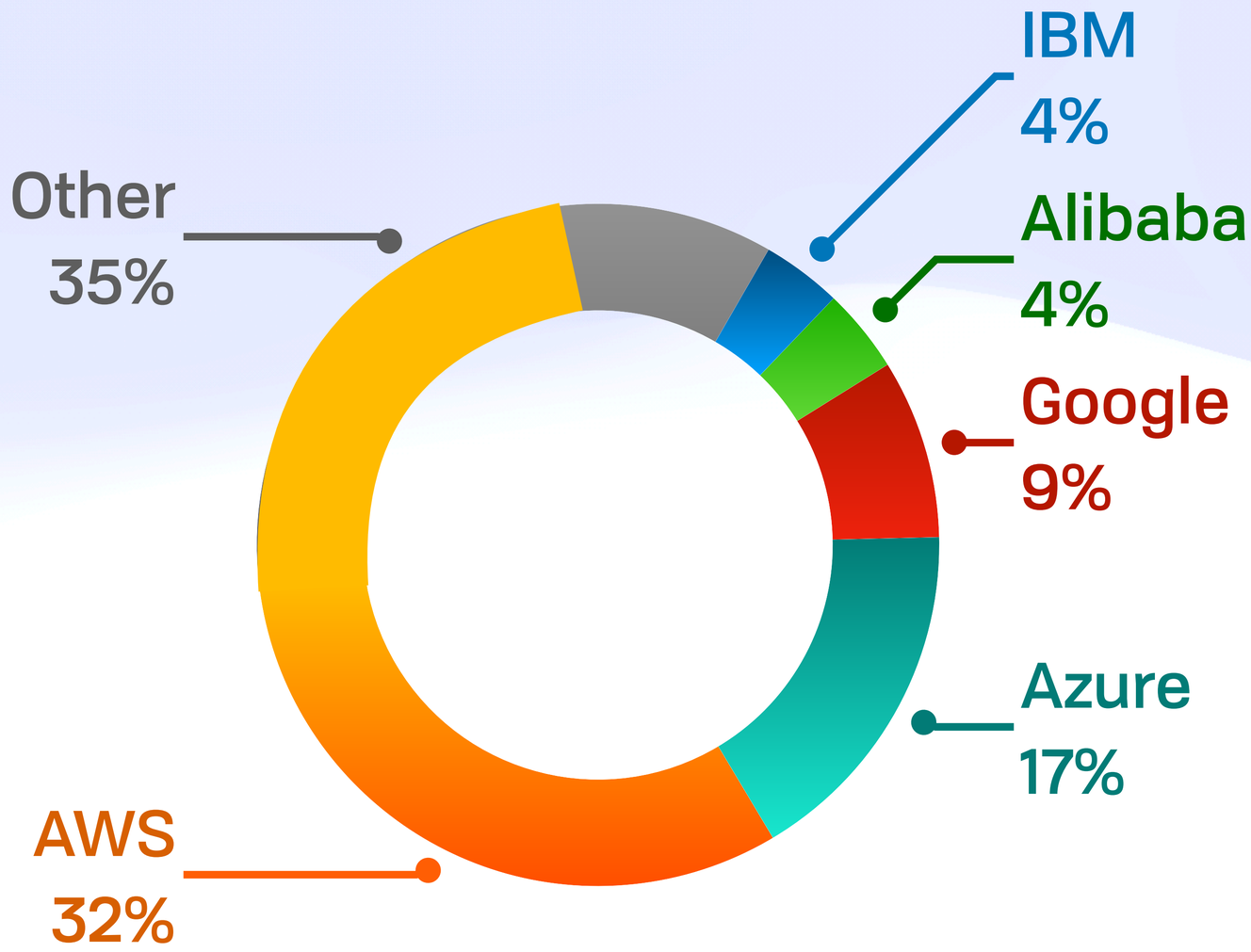

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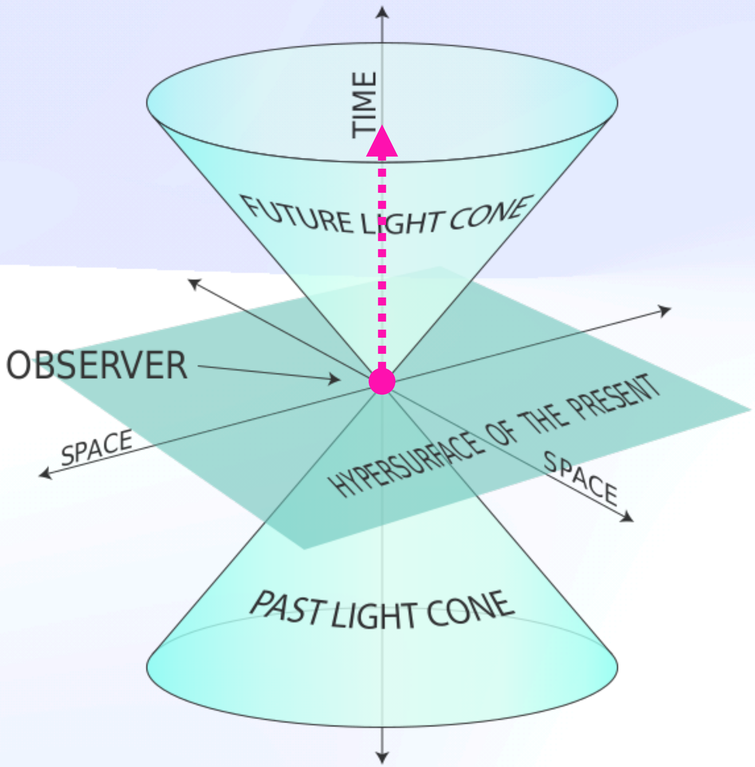

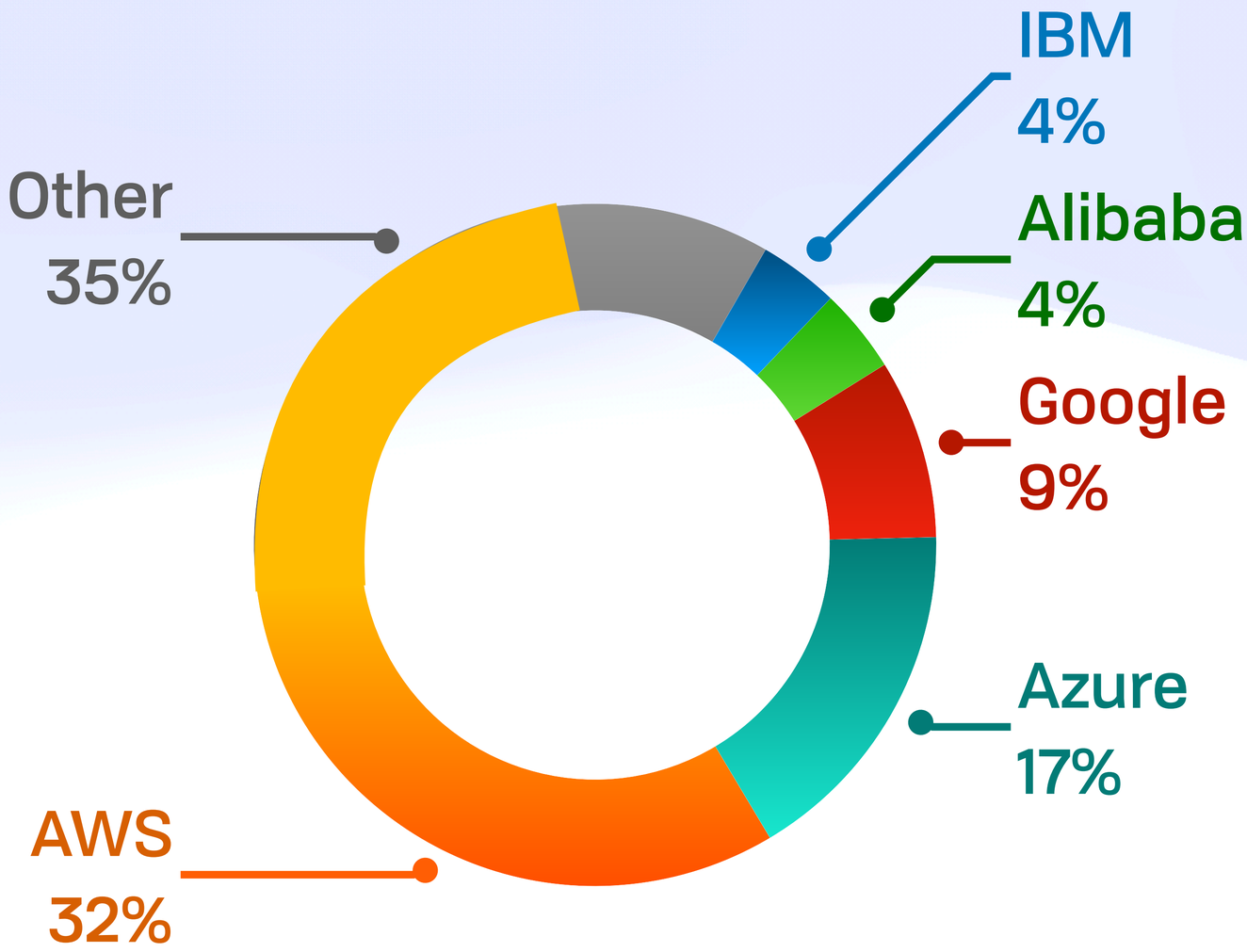

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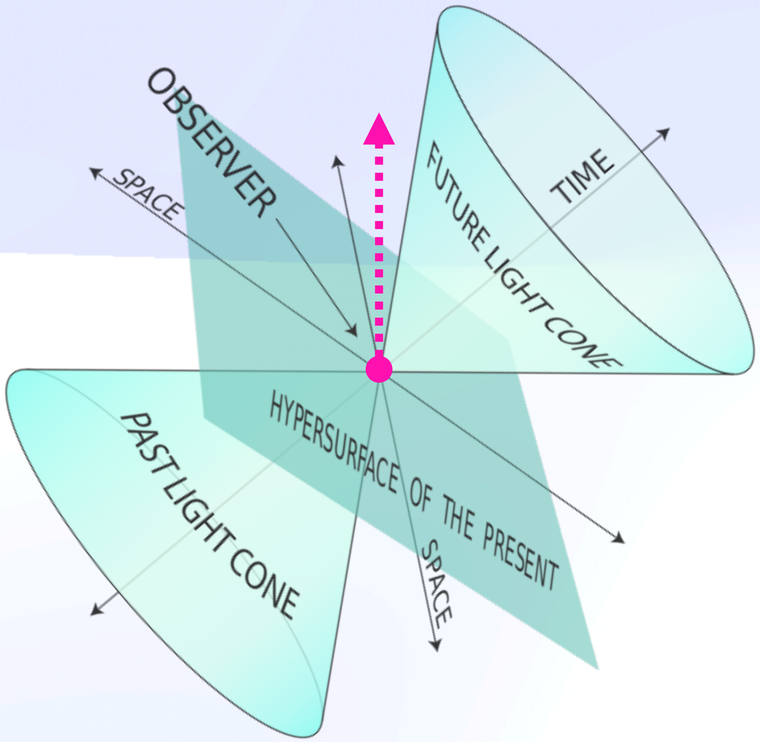

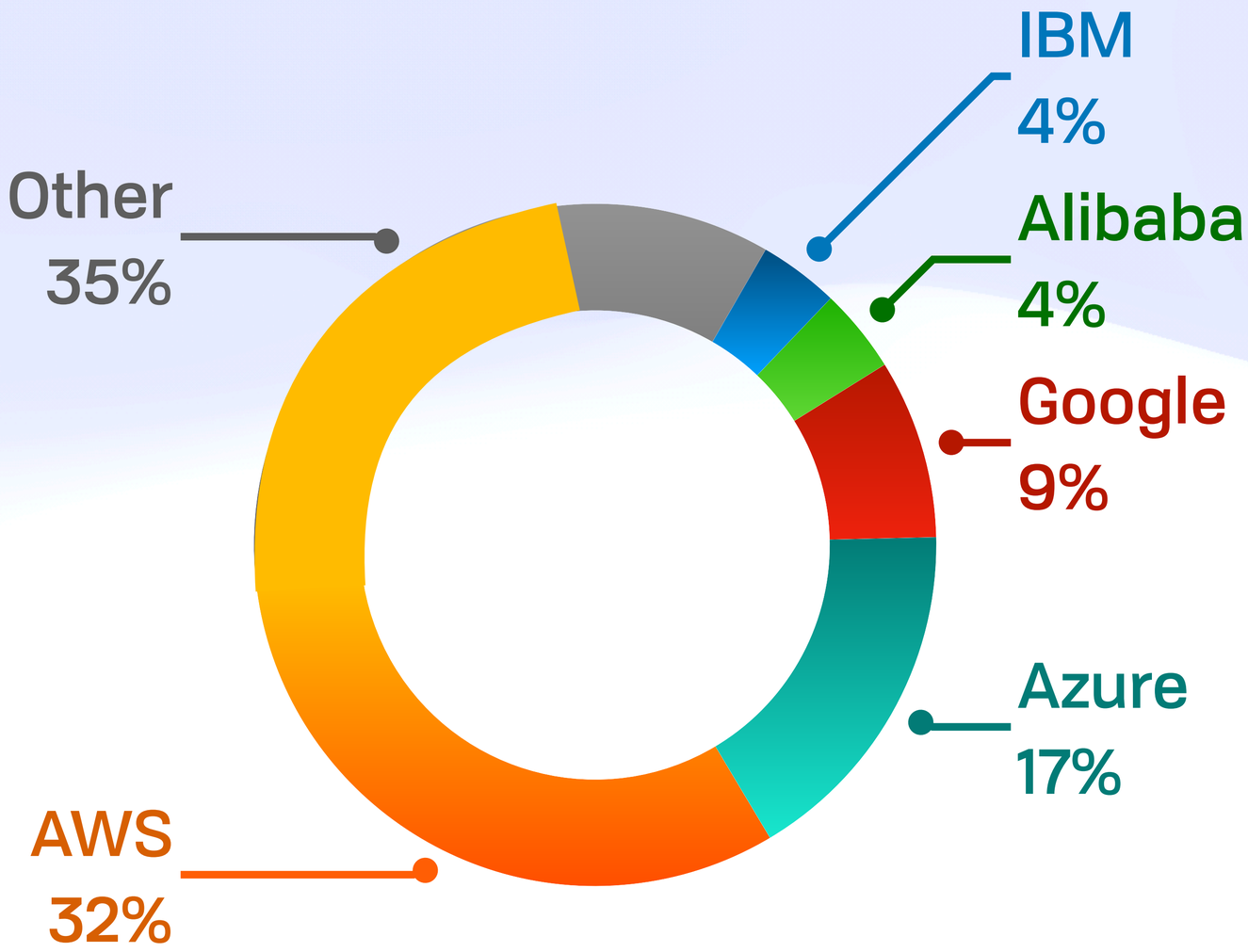

Seamless Services for an Open World

Everything, Everywhere, All At Once

Seamless Services for an Open World

Everything, Everywhere, All At Once

Nothing less than connecting
all of the world's users & services.

The "HTTP" storage and compute equivalent:
open, interoperable, & everywhere.

Must be ***substantially*** better
than the status quo.

Seamless Services for an Open World

Dependency Stack

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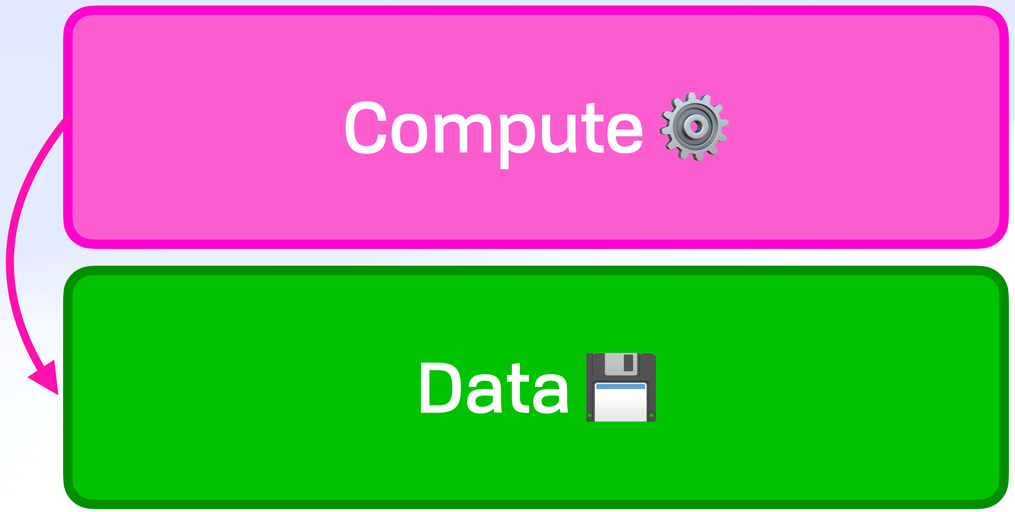
Dependency Stack

Compute ⚙️

Seamless Services for an Open World

Dependency Stack



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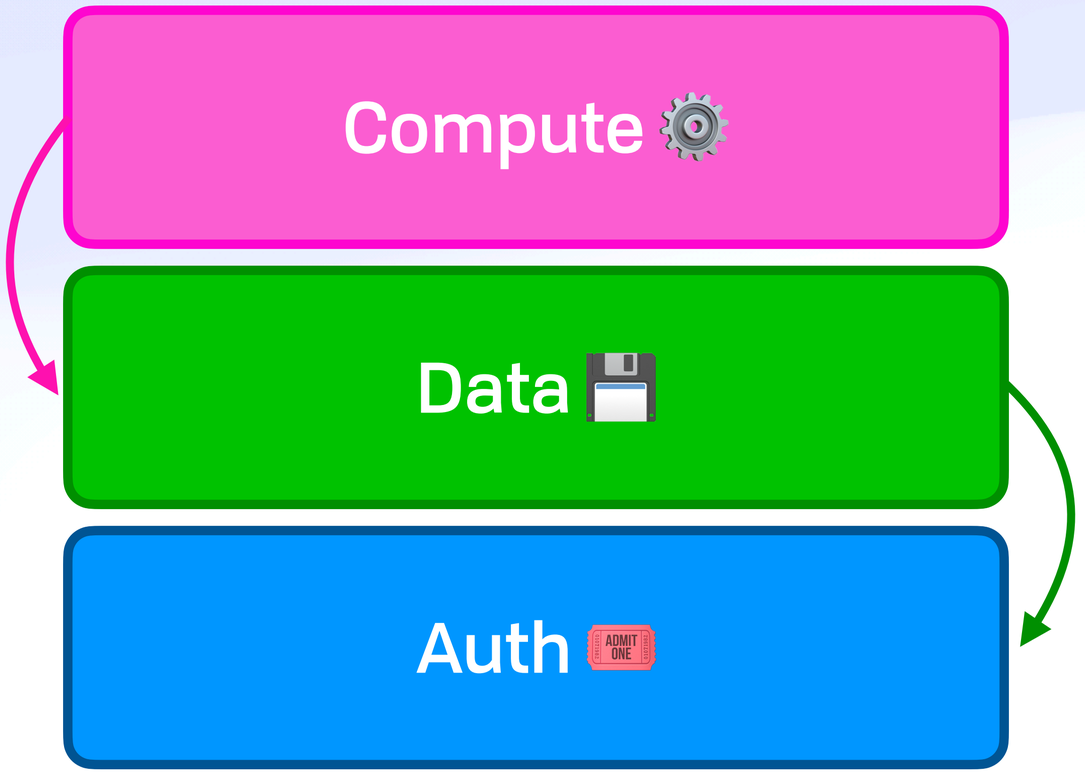
Dependency Stack




— A Series of Very Reasonable Steps —
How We Got Here

How We Got Here

One-to-One

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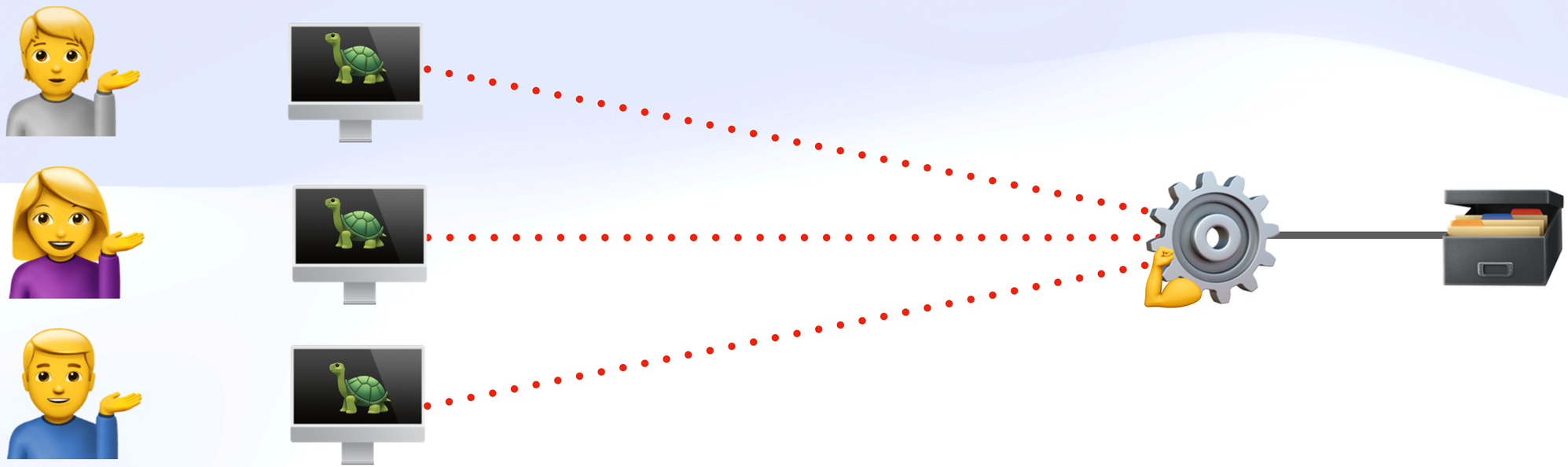

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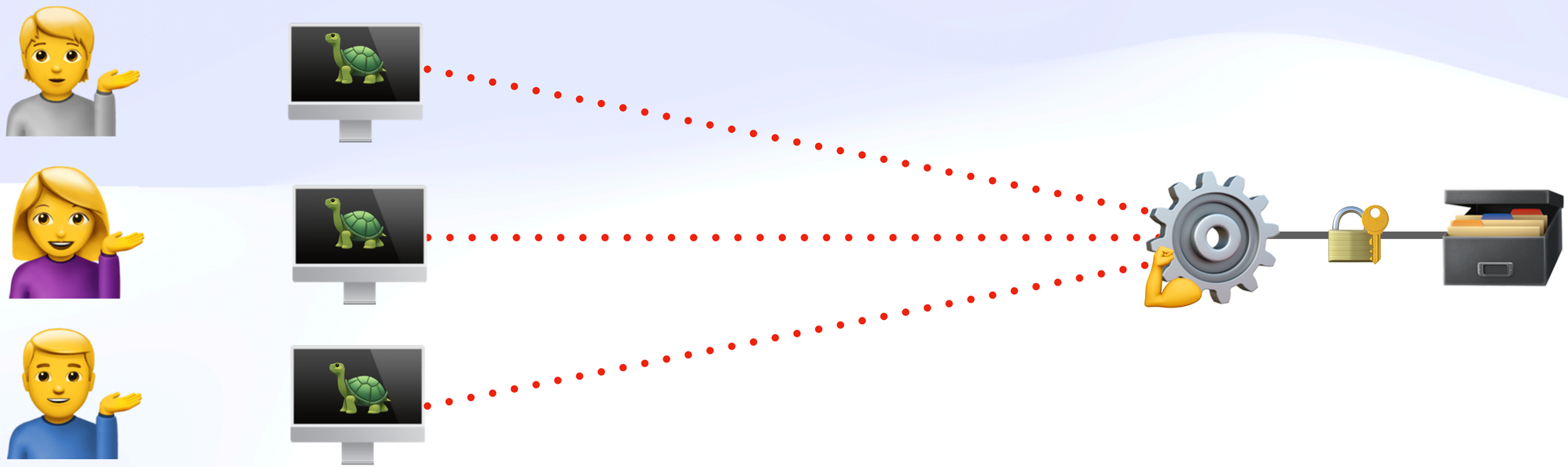
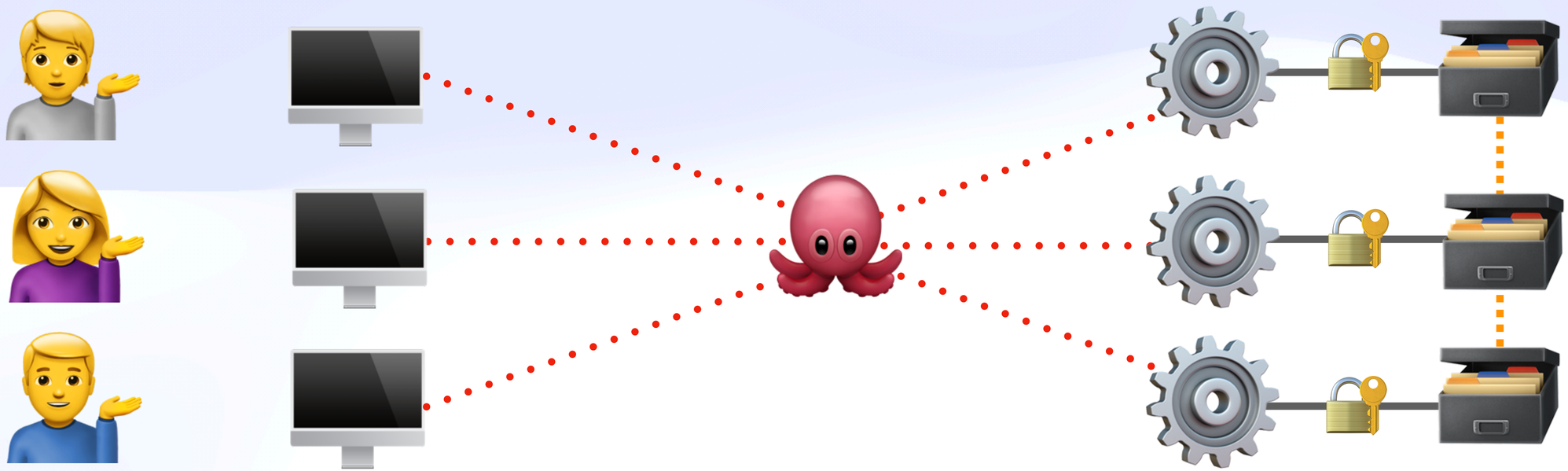


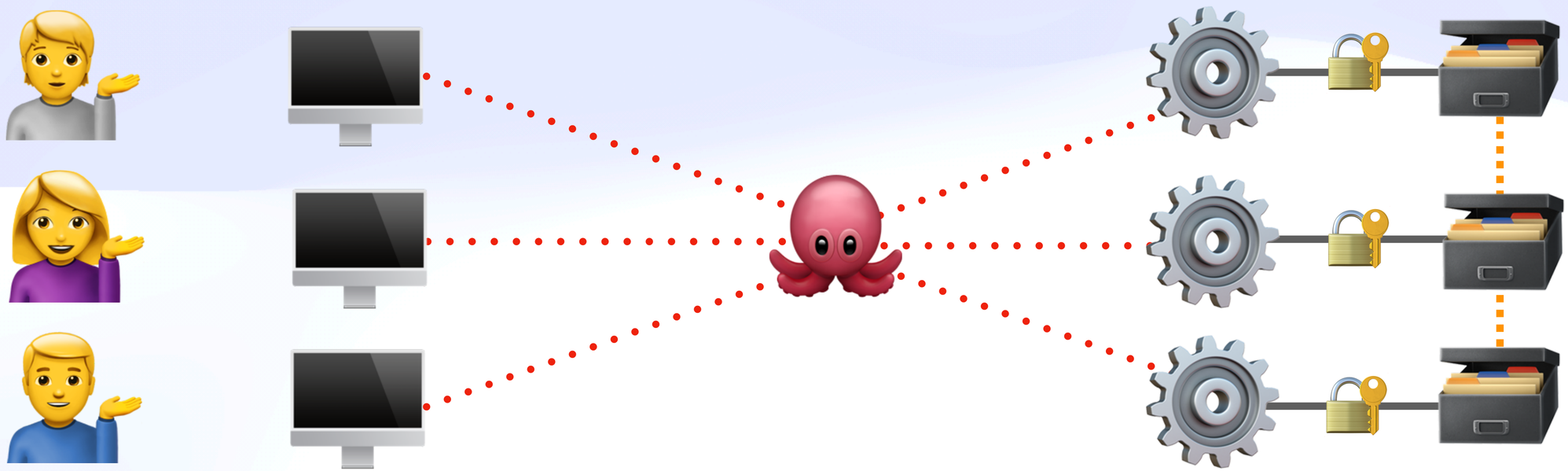
How We Got Here

Hidden Many-to-Many



How We Got Here

Invisible Many-to-Many



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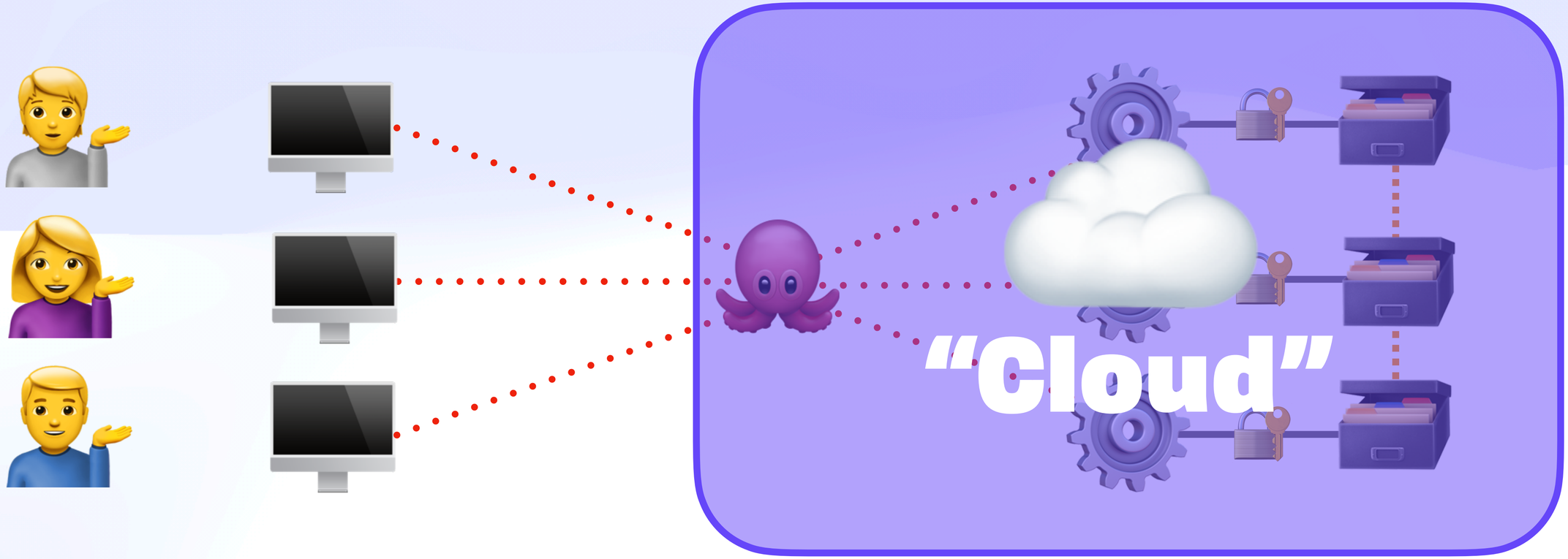
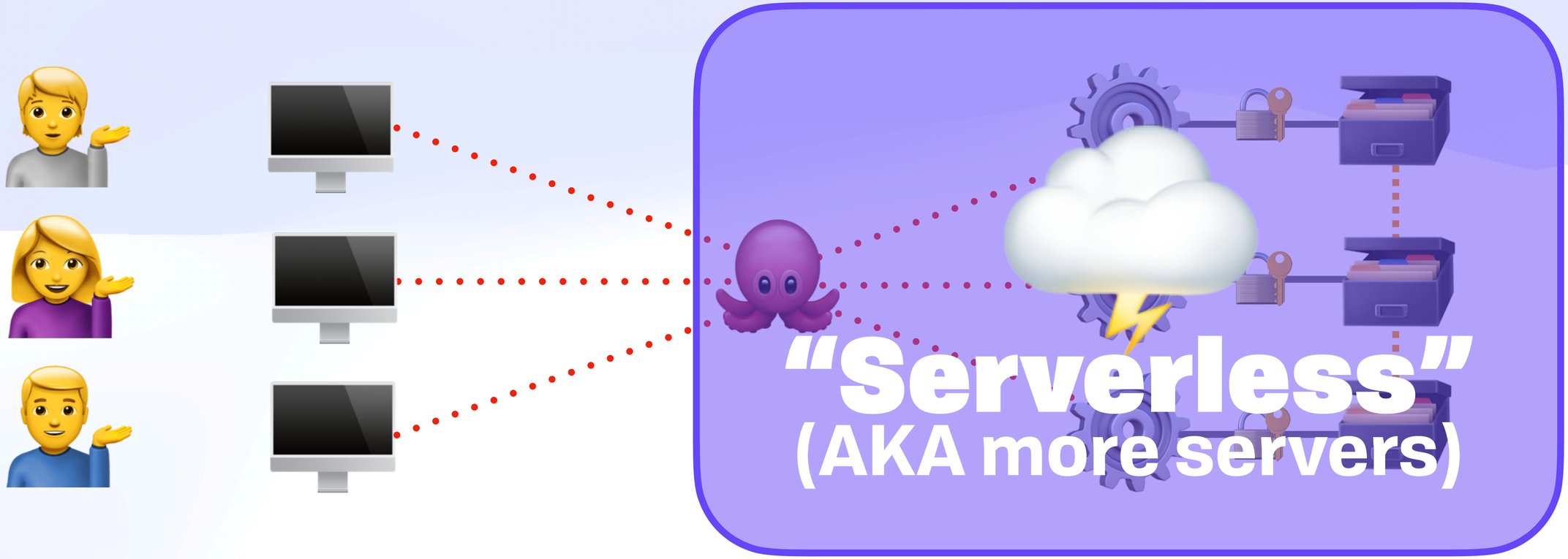


How We Got Here

Abstract Many-to-Many



How We Got Here

...and so it was for many years...

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How We Got Here

Consequences 🍂

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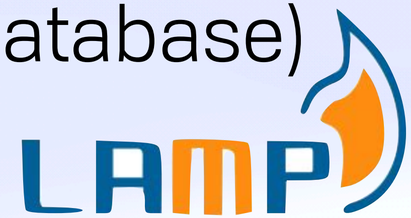
- Single source of truth ("**the**" database)

How We Got Here

Consequences

- Single source of truth ("**the**" database)
- Server-centric
  - "Full stack development"
  - DevOps, Docker, k8s, IaC
  - How to train enough engineers?



How We Got Here

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Random Walk

Image by Pradyumna Yadav

How We Got Here

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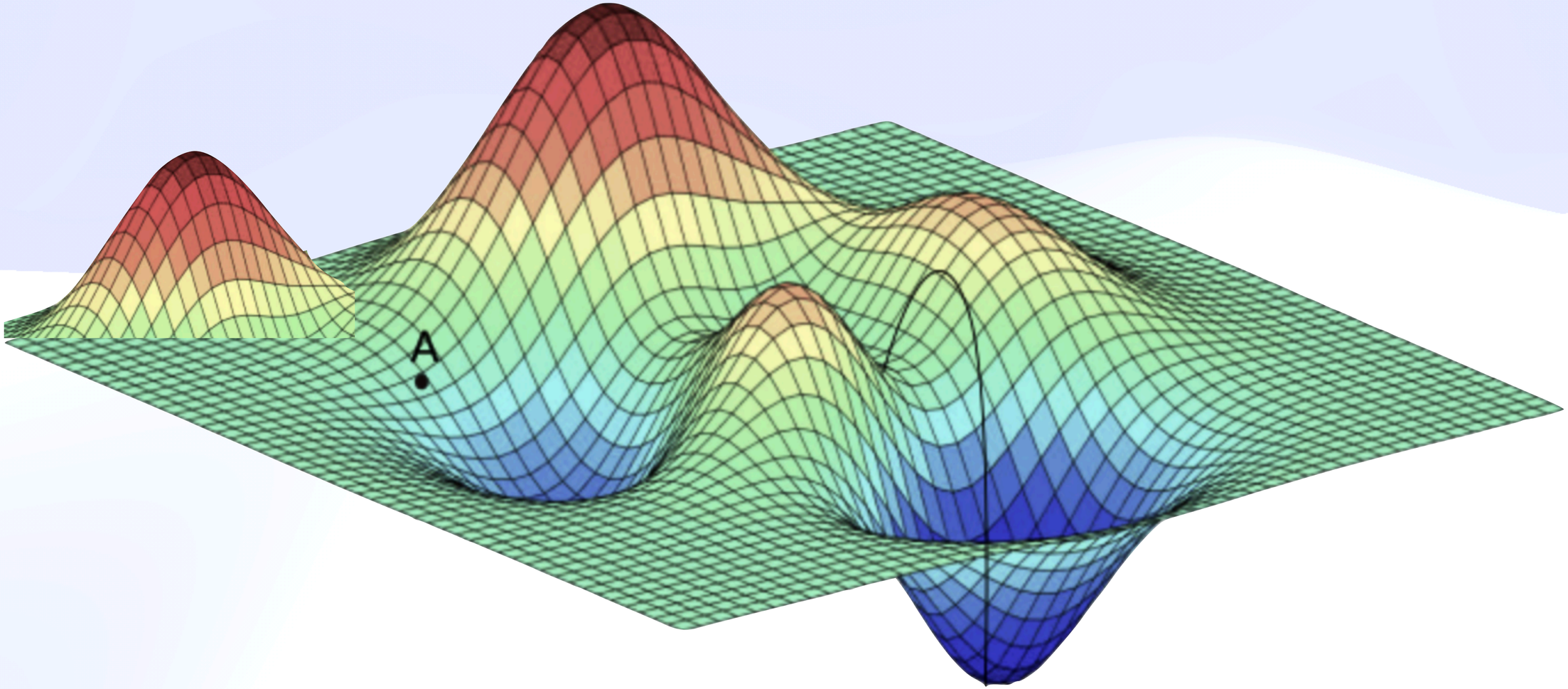

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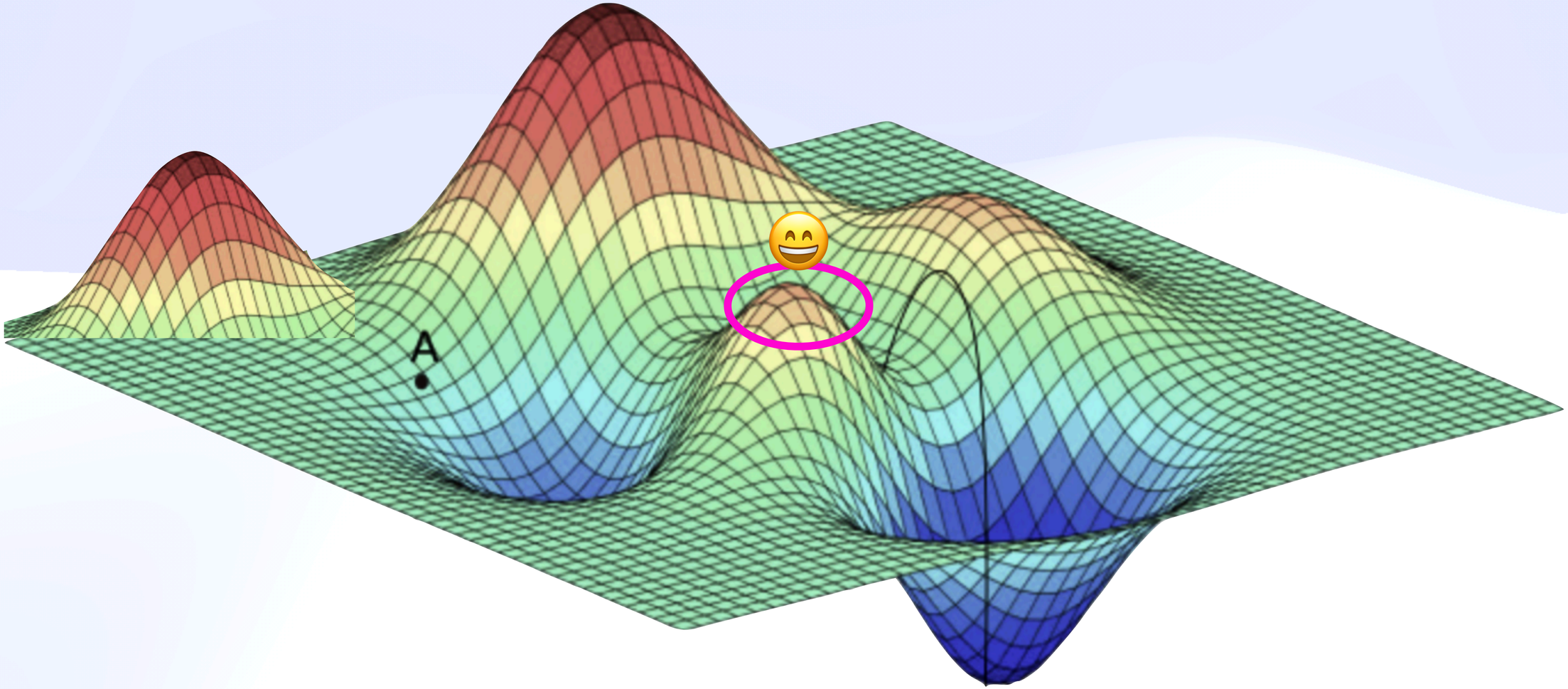

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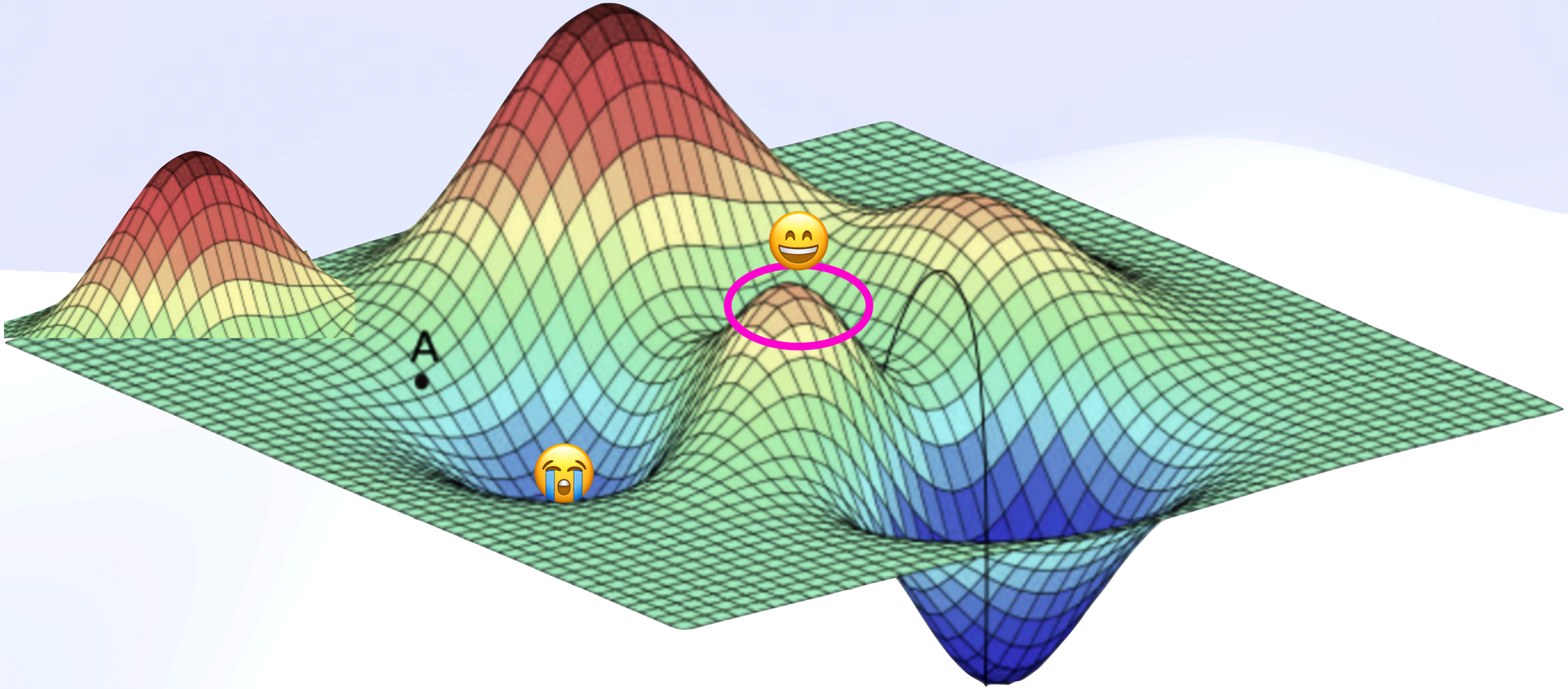

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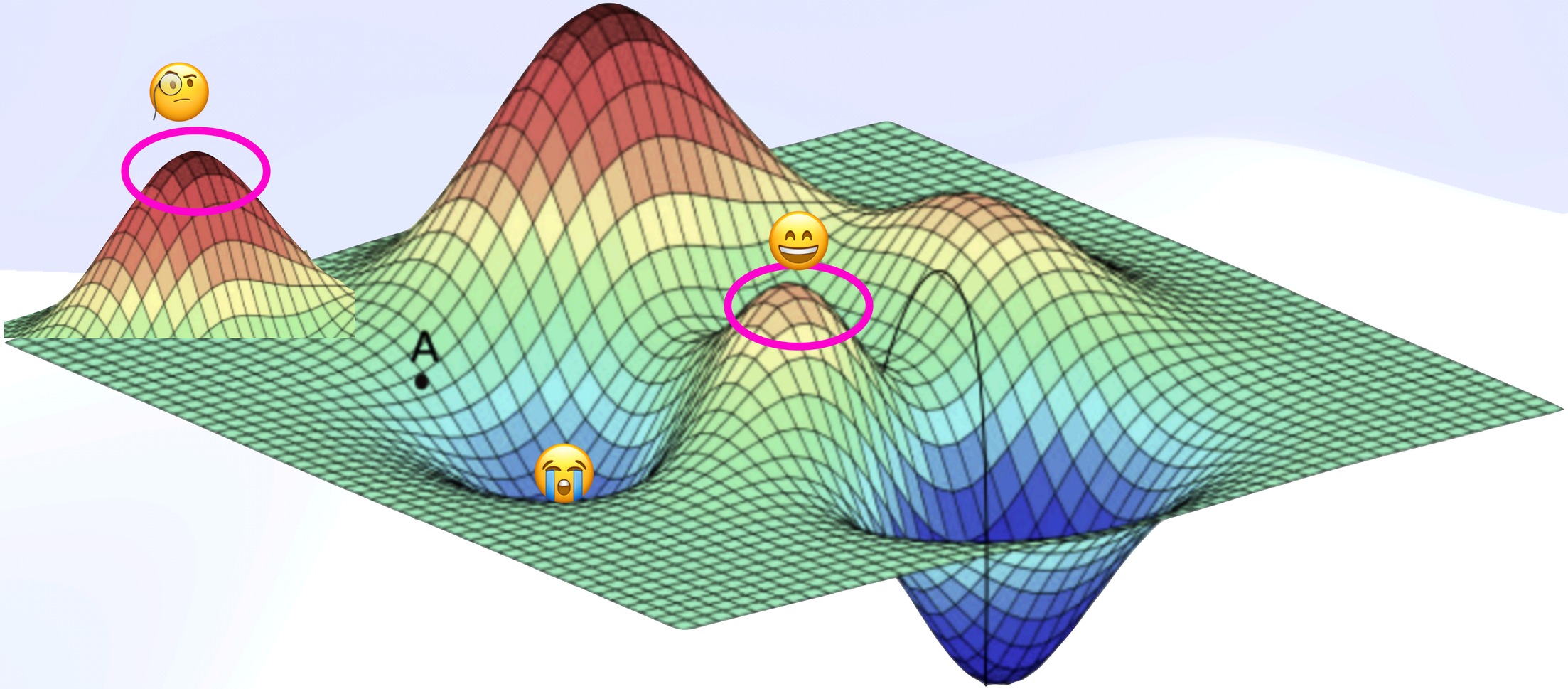

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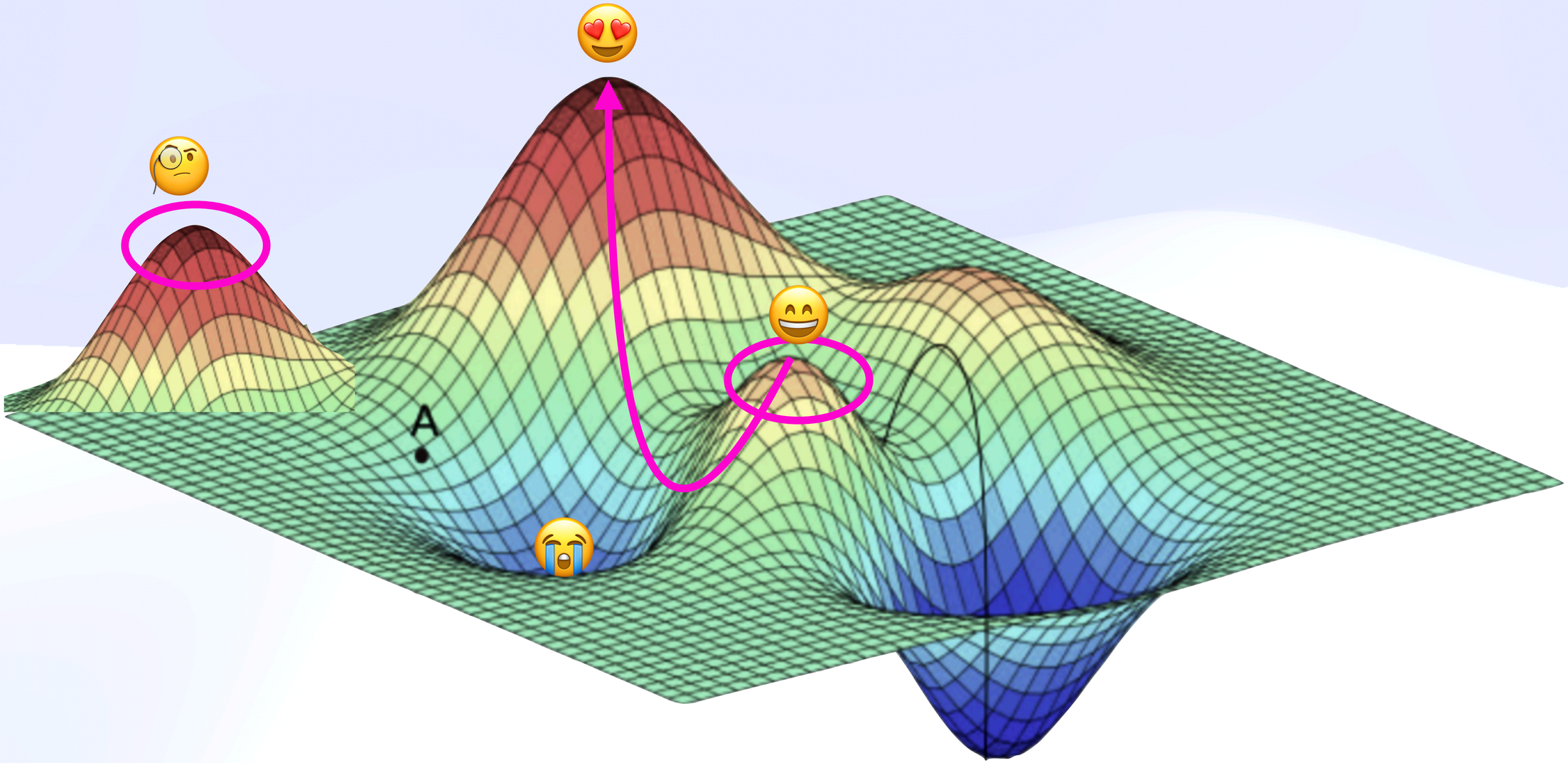

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How We Got Here

How We Got Here

Not to be bound by certain ‘obvious’ methodological rules [...] is both reasonable and ***absolutely necessary for the growth of knowledge***. [...] There are always circumstances when it is advisable not only to ignore the rule, but to ***adopt its opposite.***

– **Paul Feyerabend**, Against Method

How We Got Here

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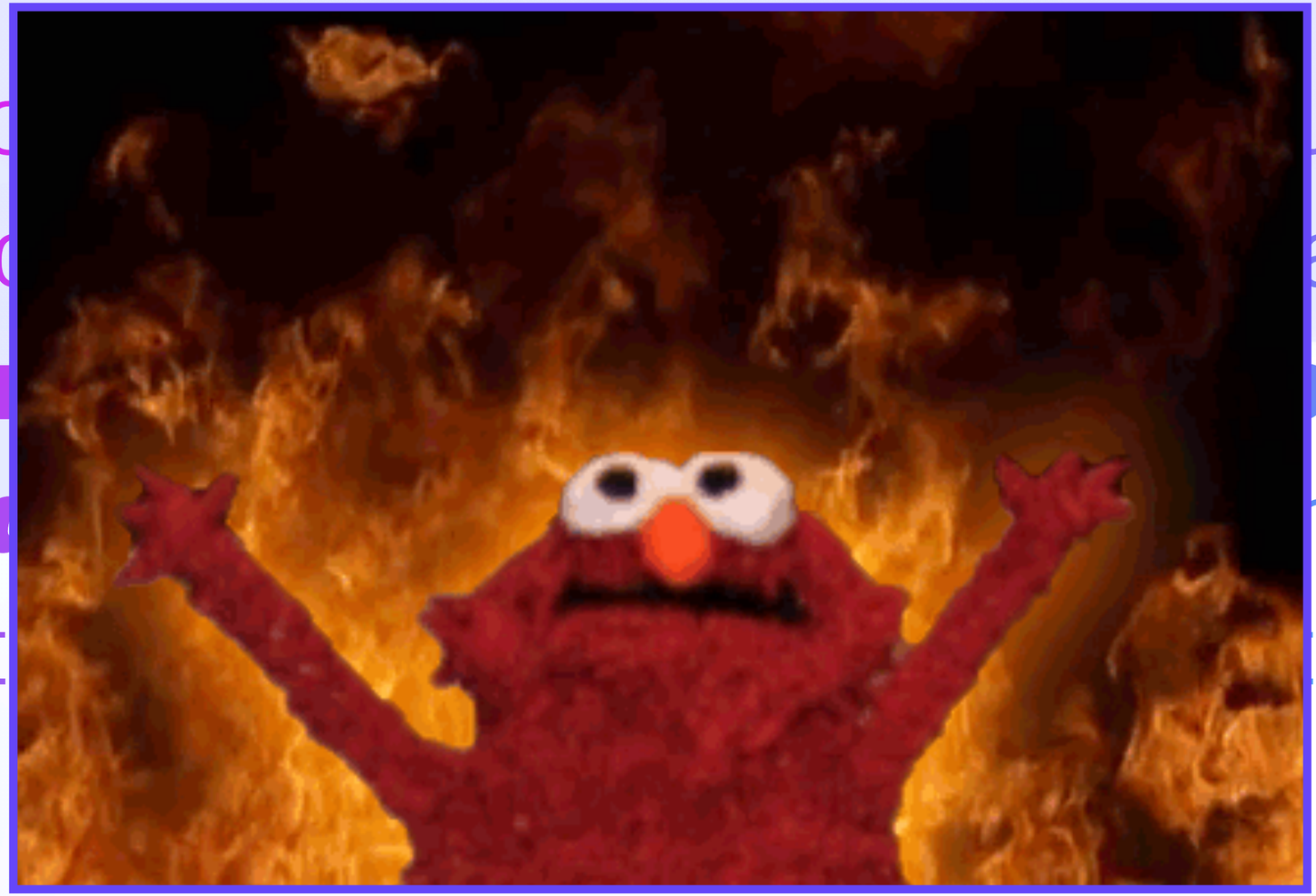

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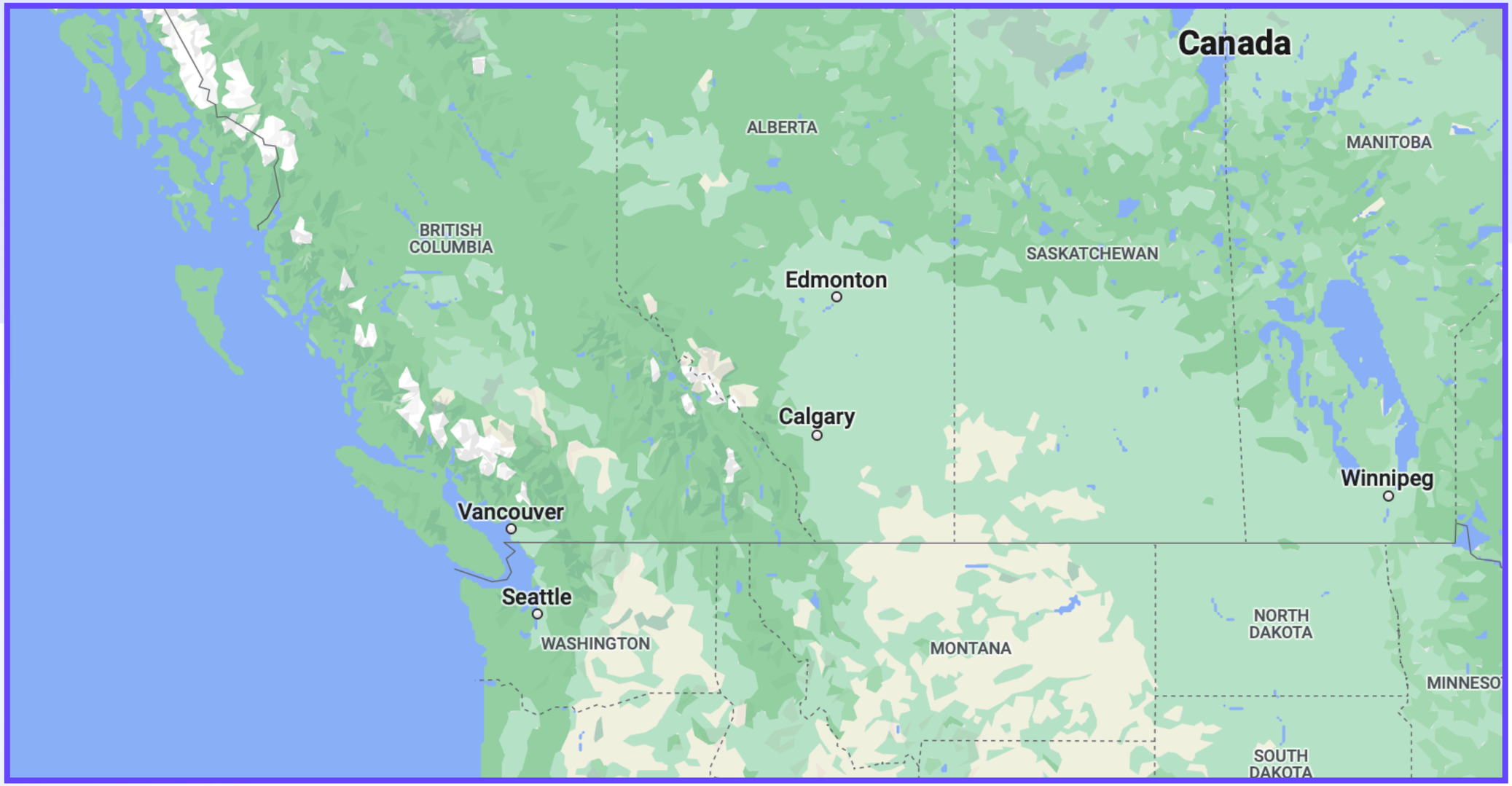
— We're Not On Dial-Up Anymore —
A New Environment

A New Environment

Sending a "Direct" Message



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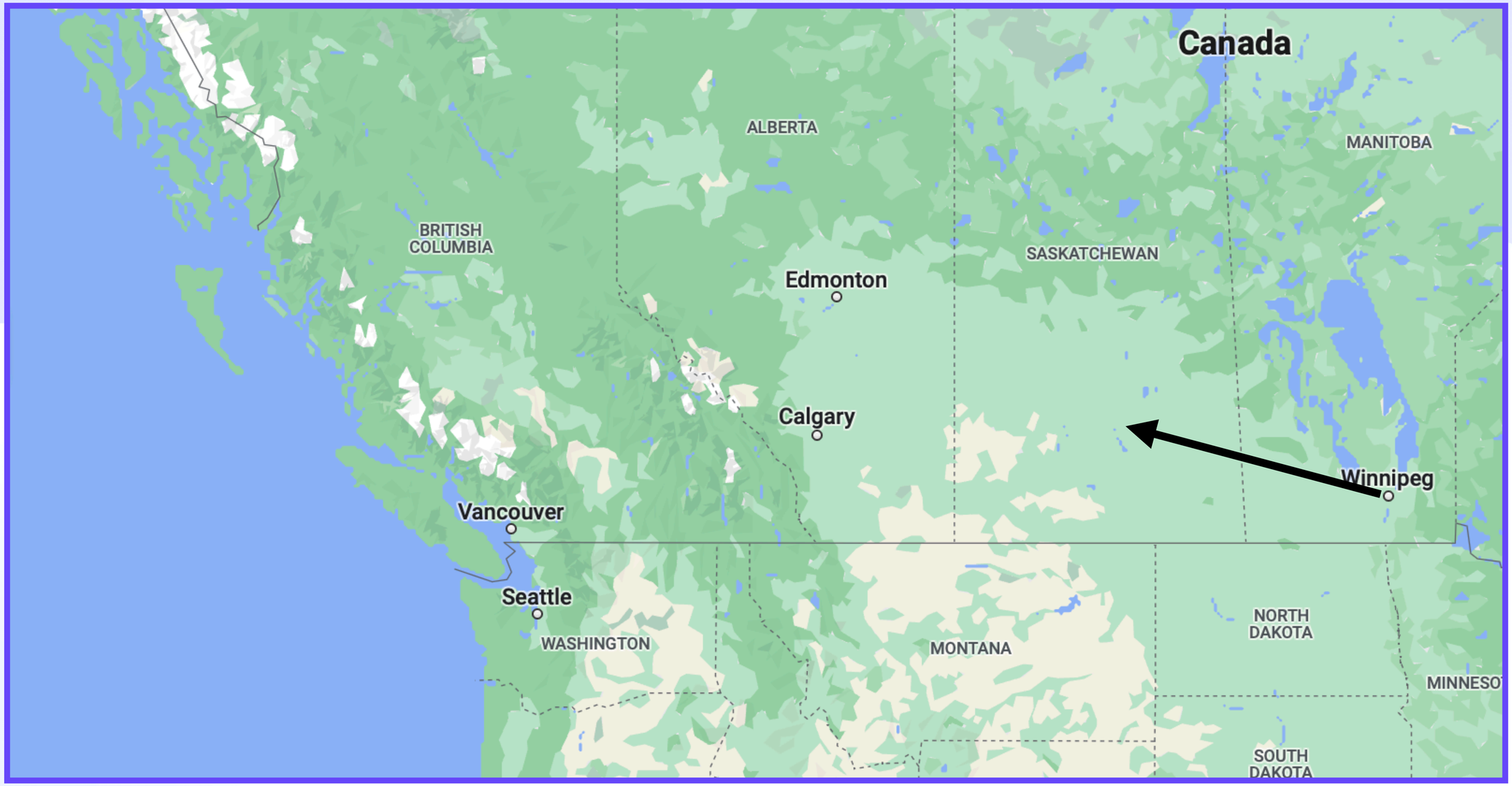

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Sending a "Direct" Message

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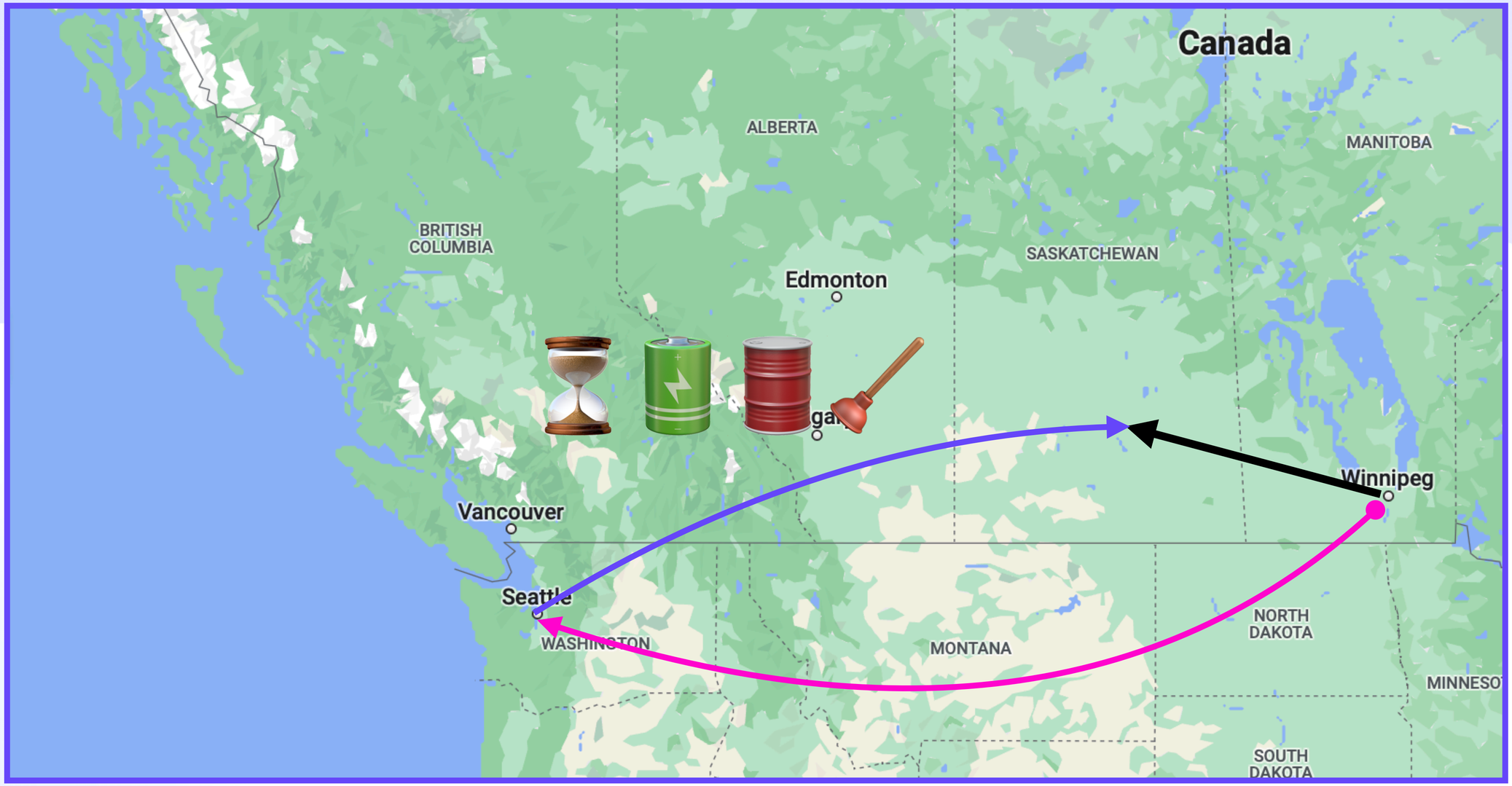
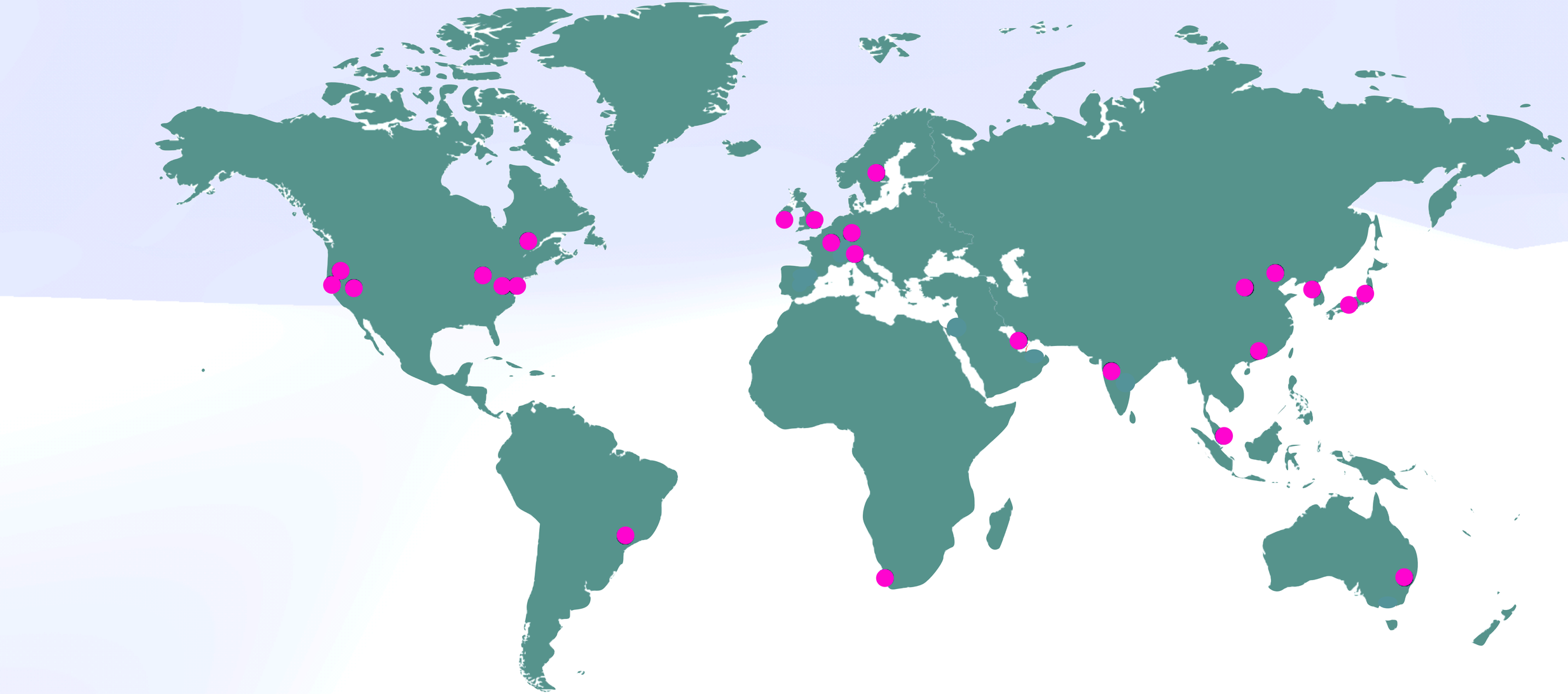


A New Environment

Users vs Cloud Infra



Source: AWS

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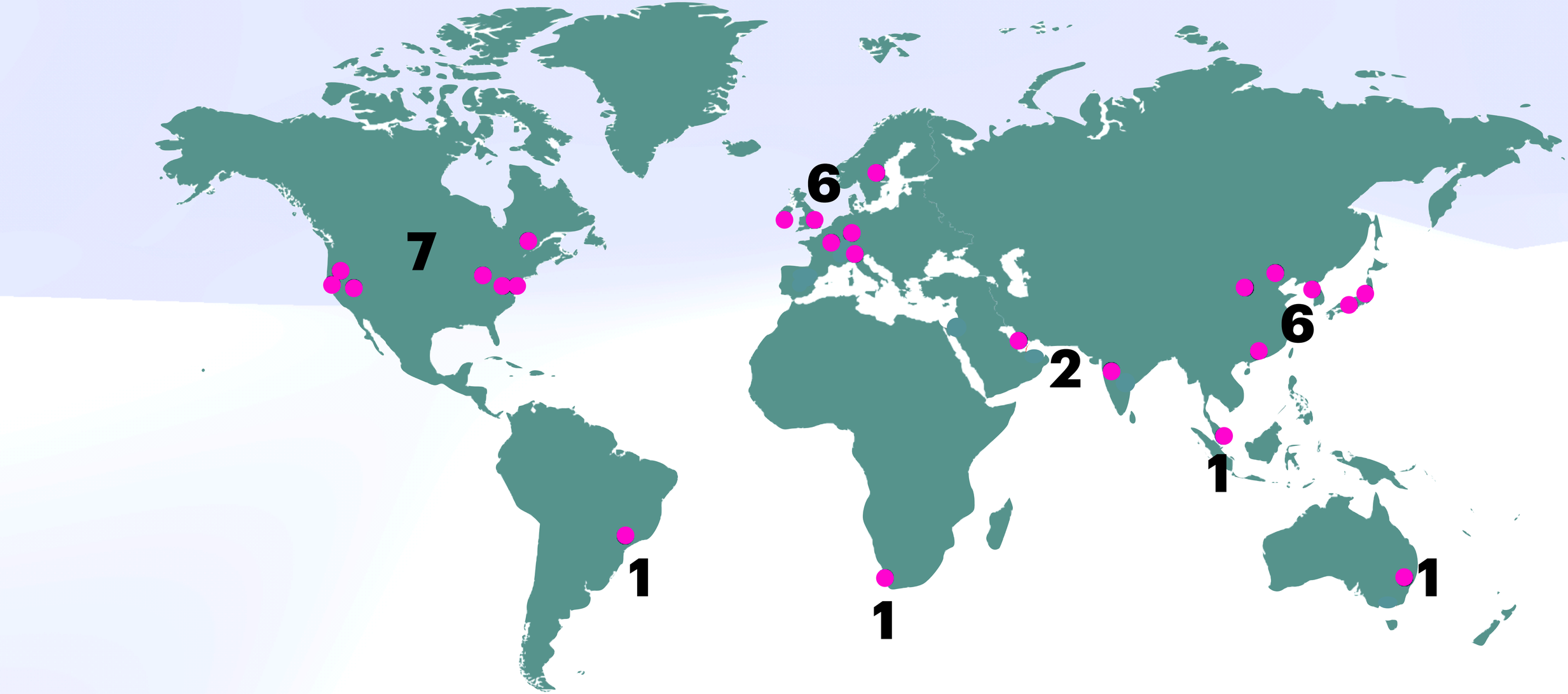

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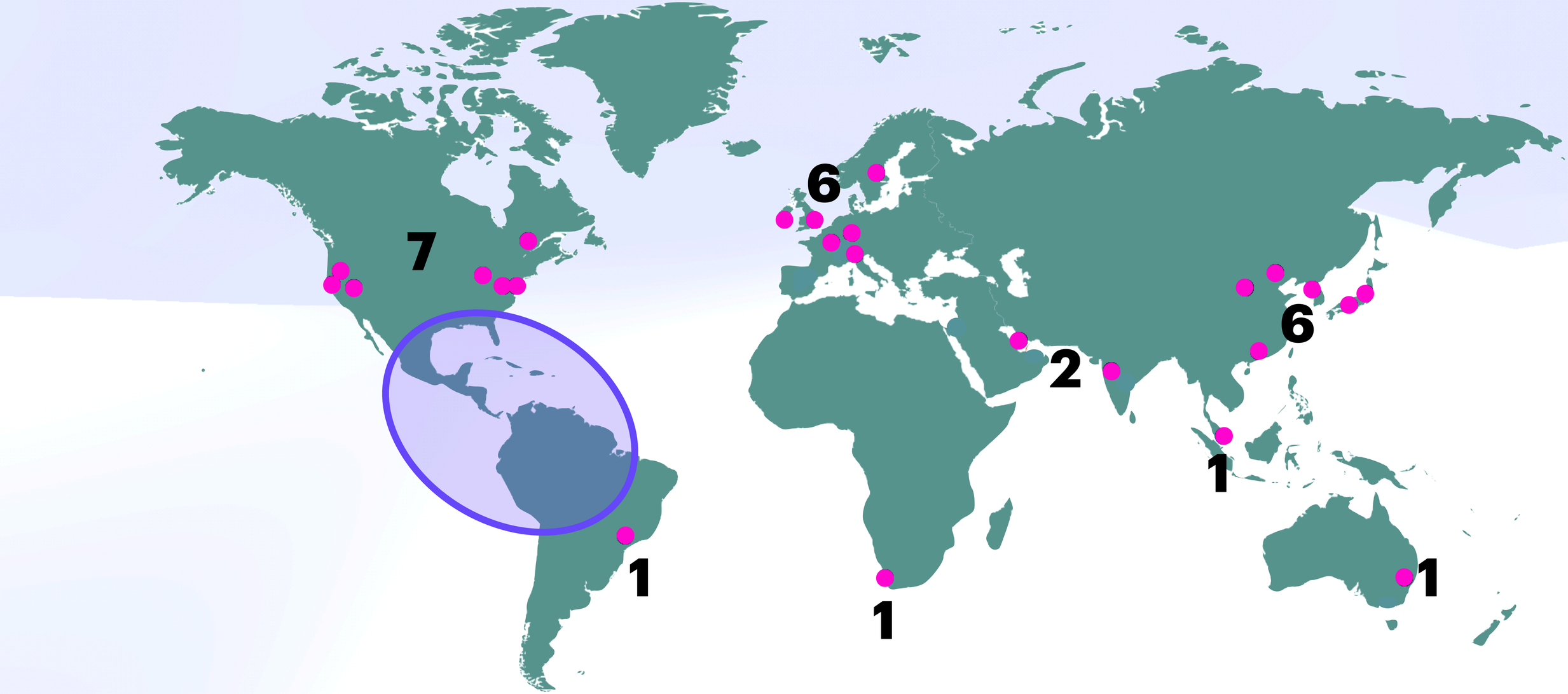

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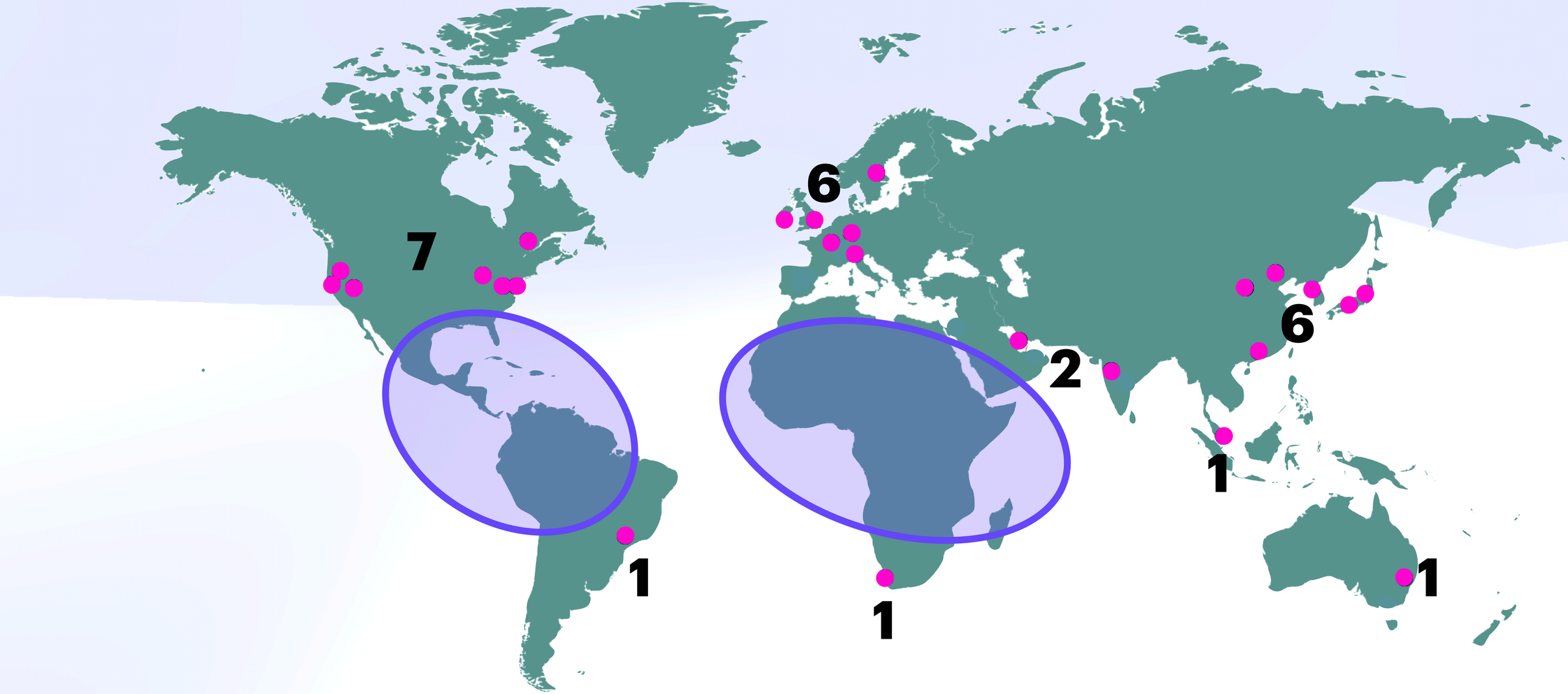

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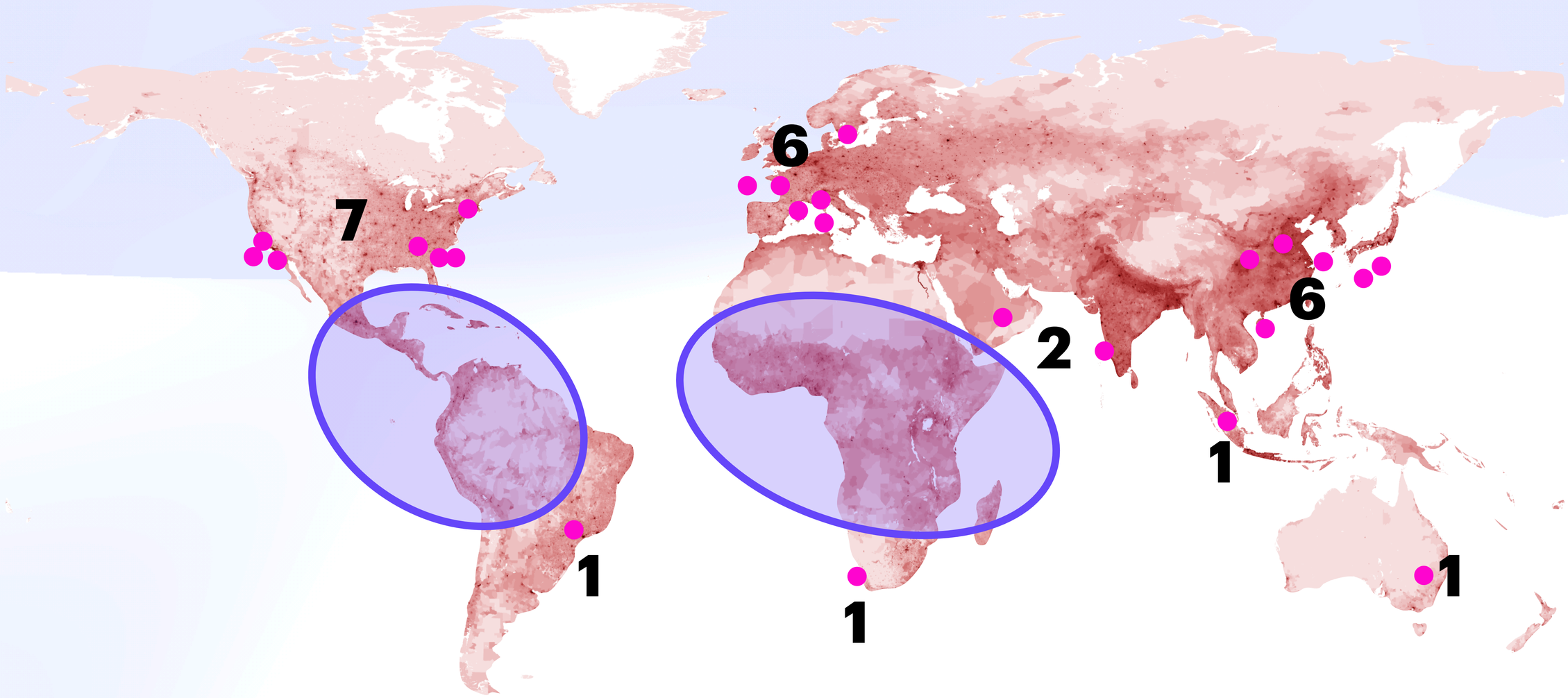

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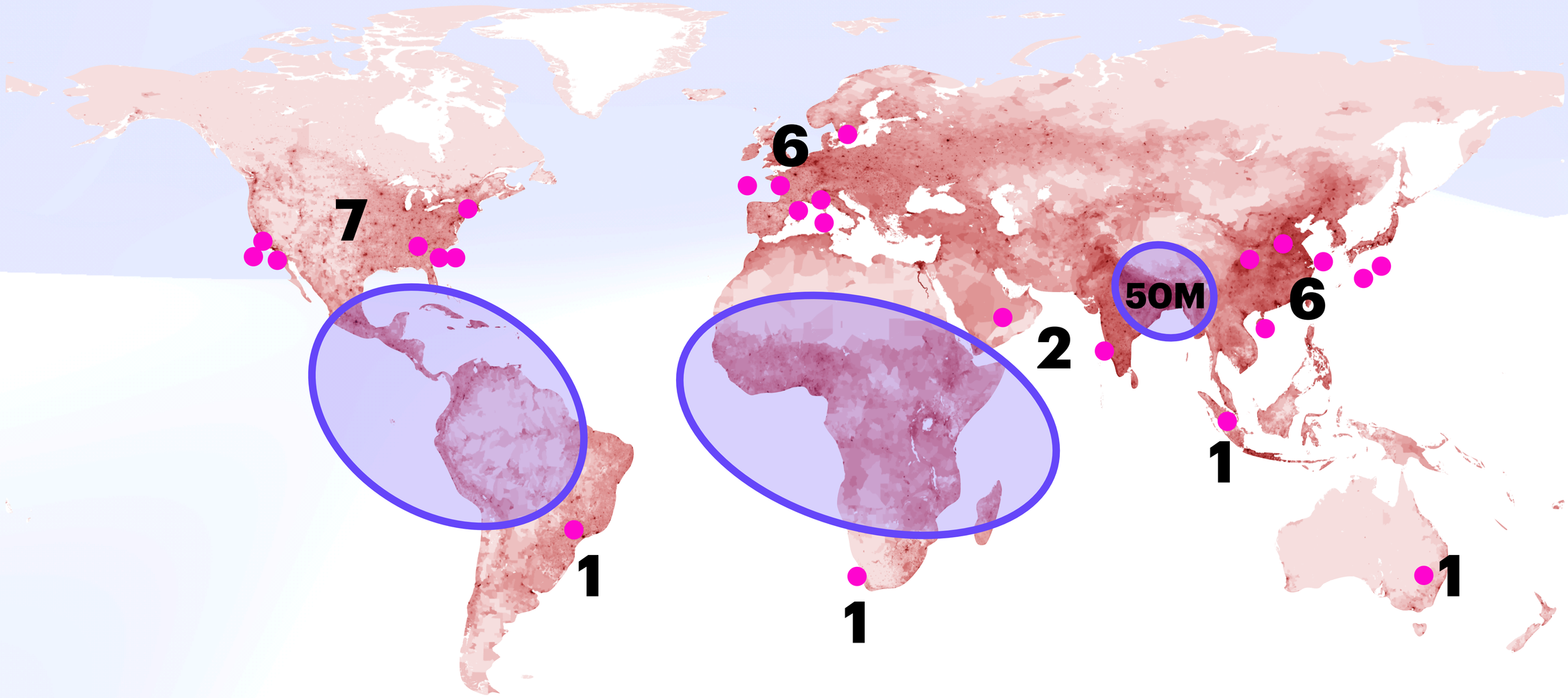

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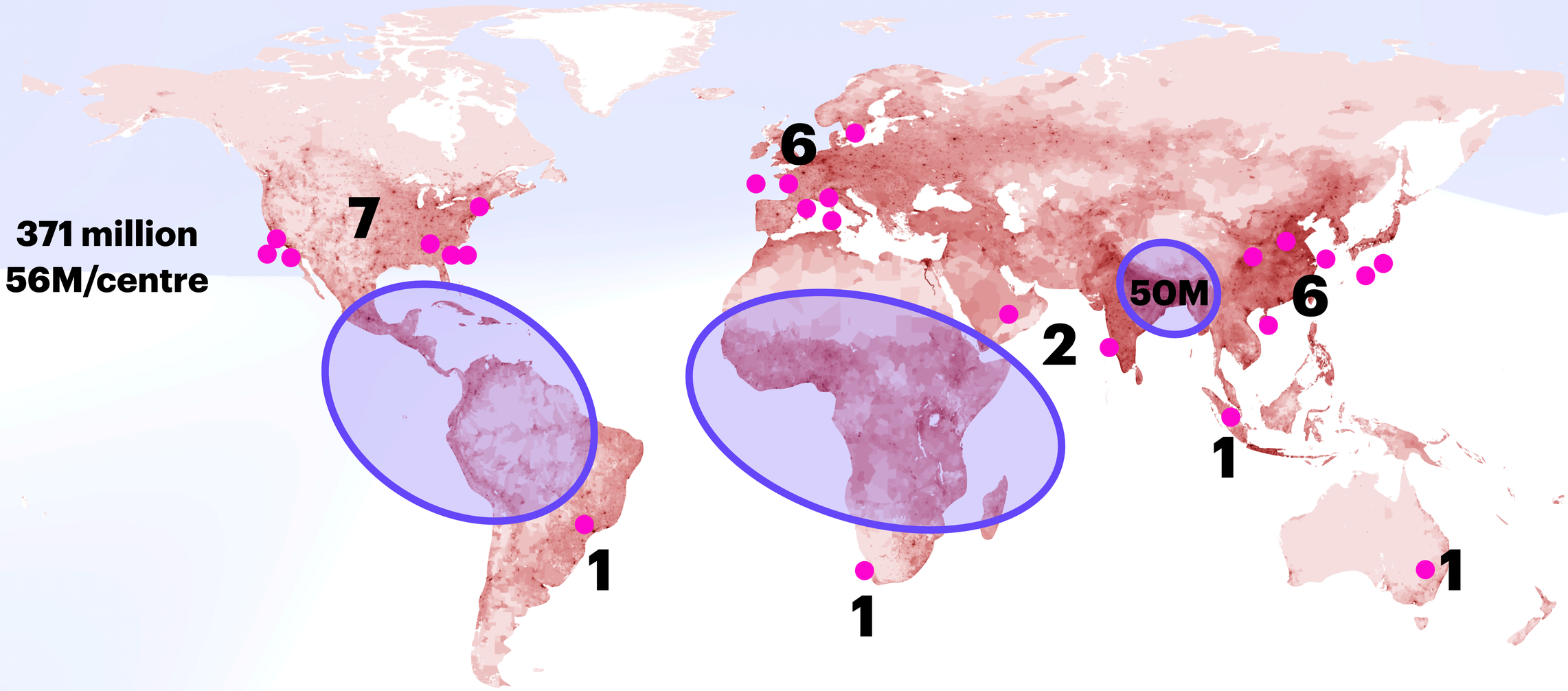

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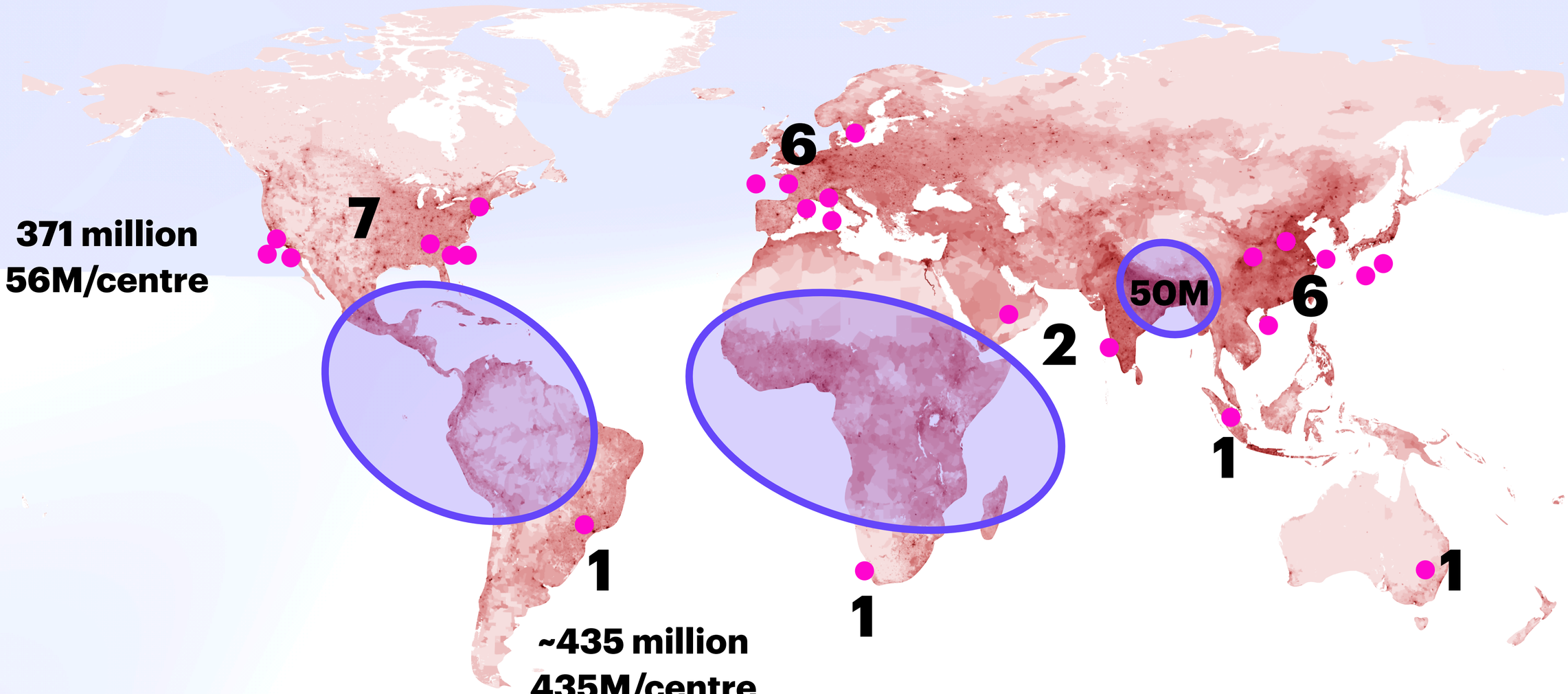

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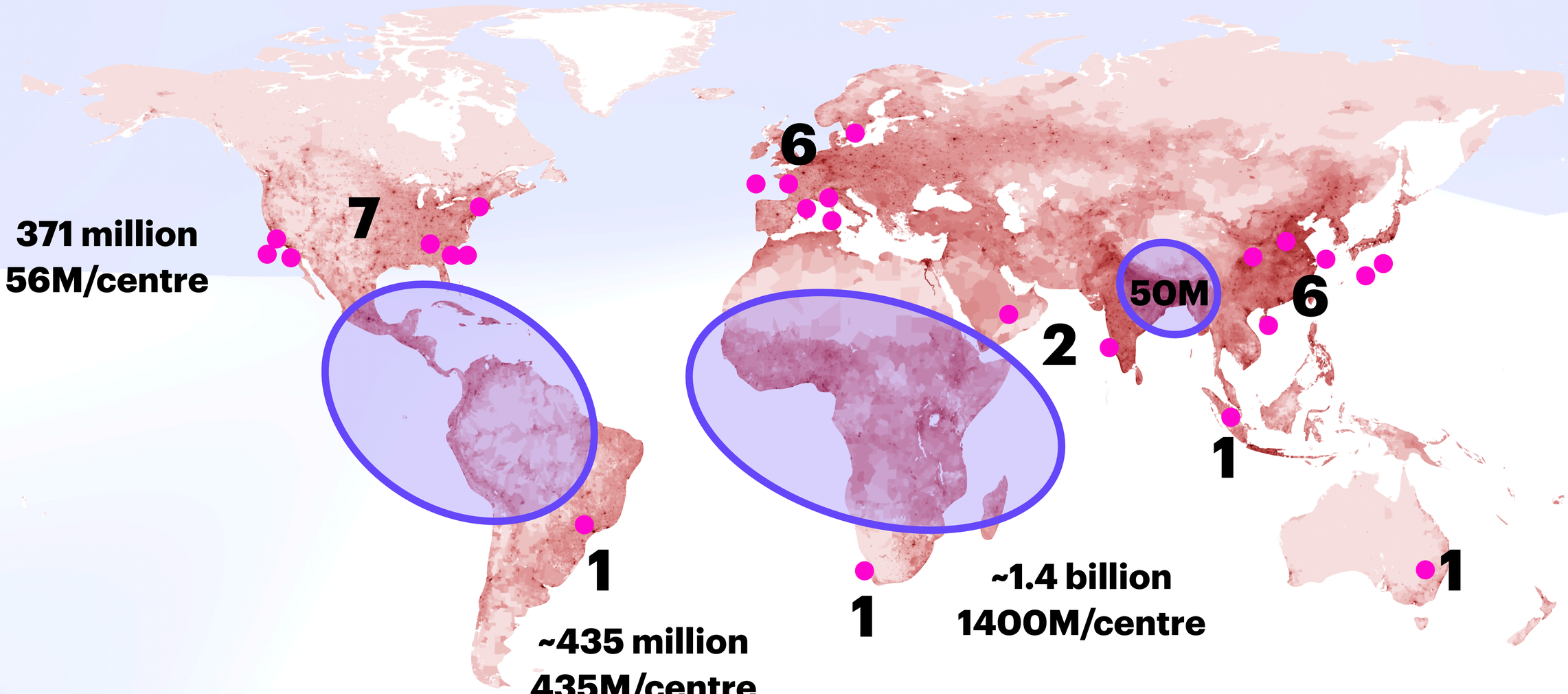

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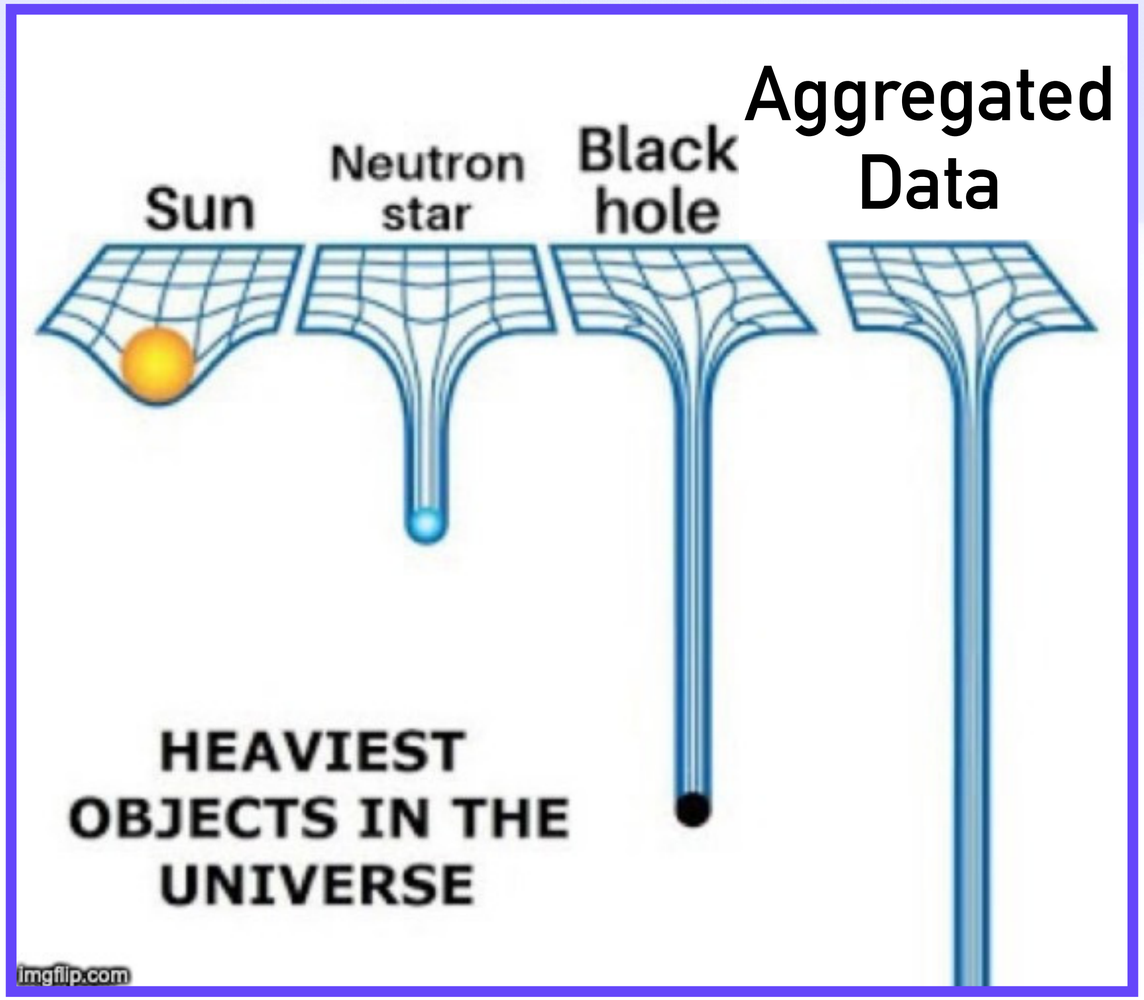
A New Environment

Data Gravity



A New Environment

What 8ms Looks Like

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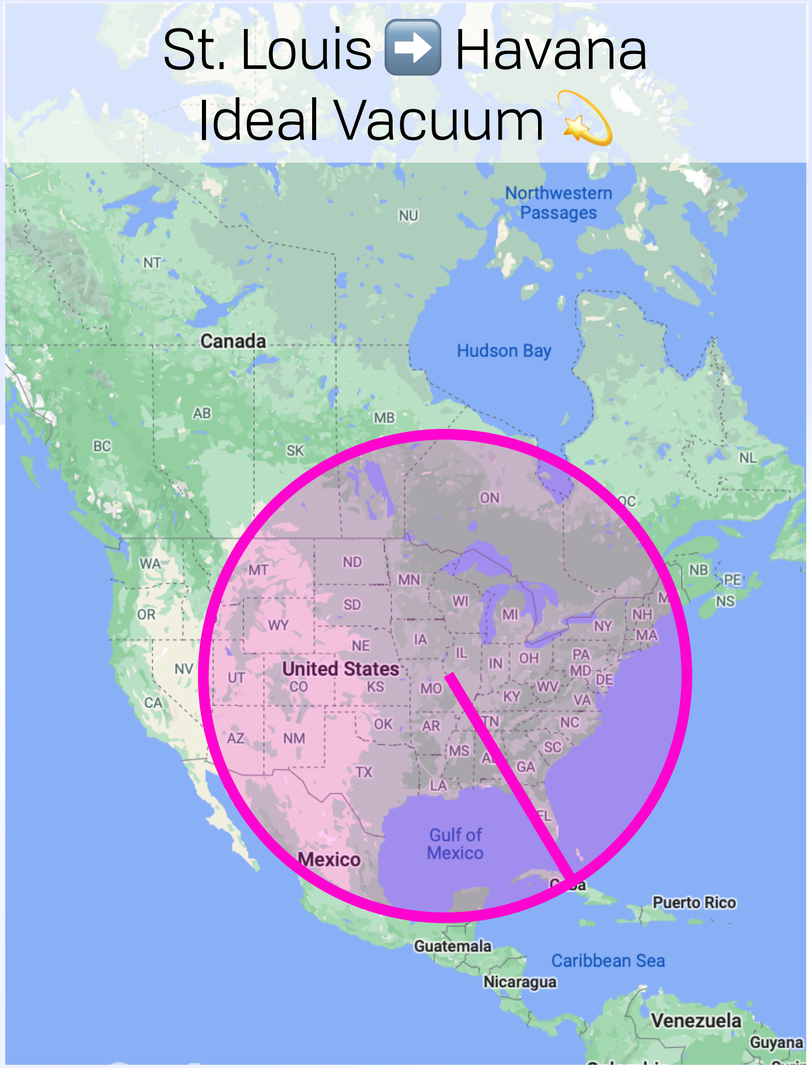
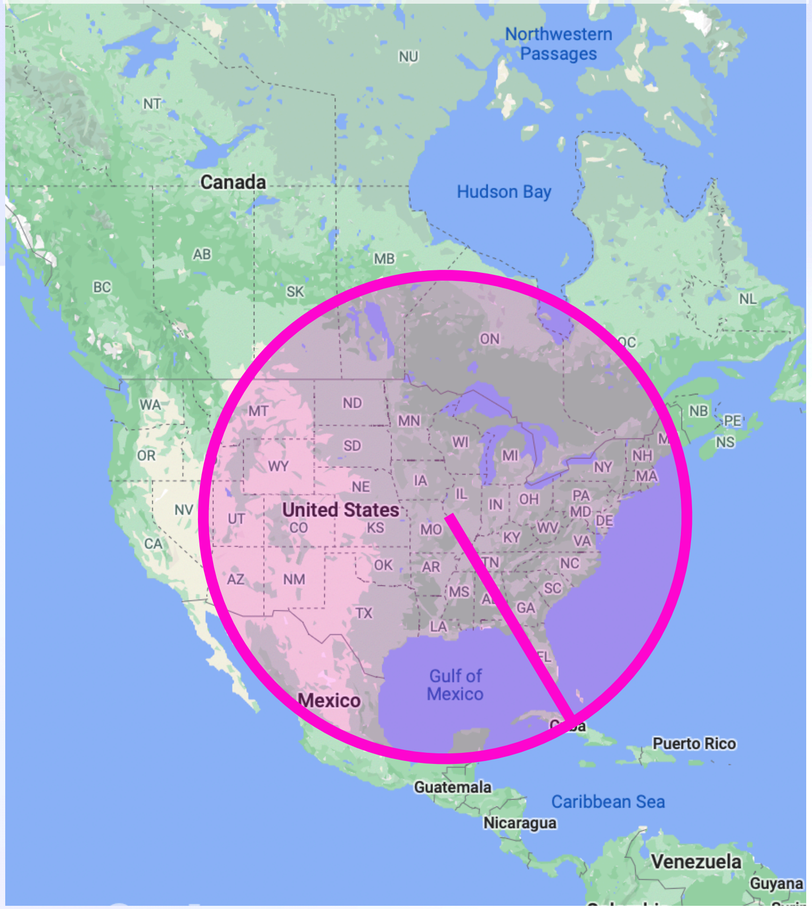


A New Environment

What 8ms Looks Like

St. Louis ➡️ Havana
Ideal Vacuum 💫



St. Louis 🔁 NYC
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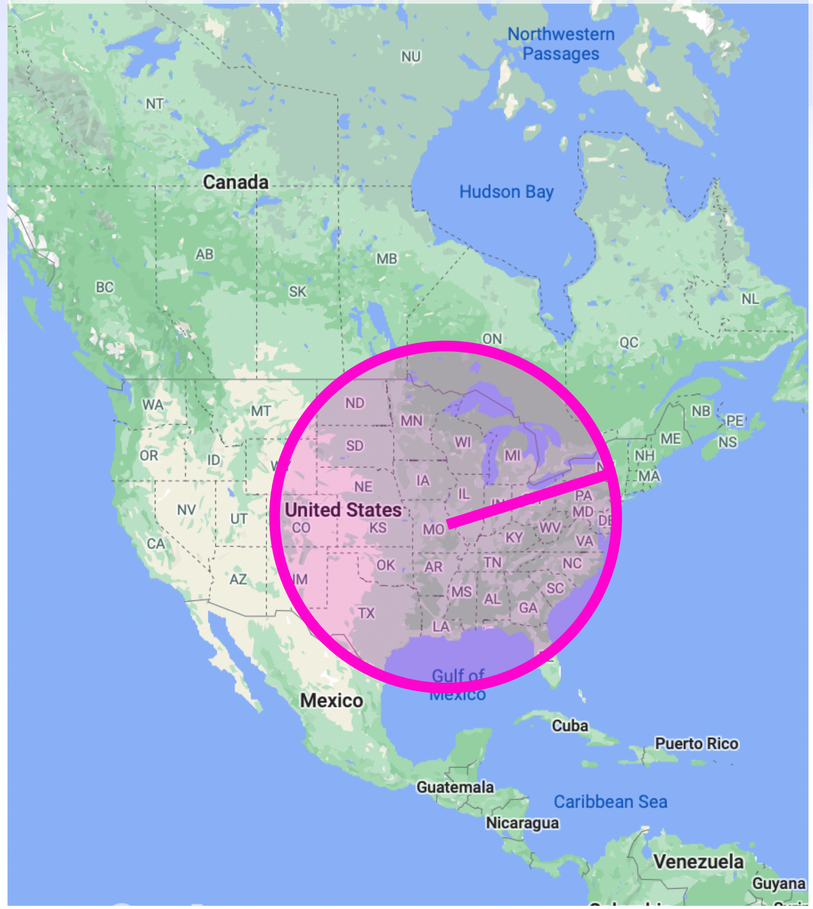

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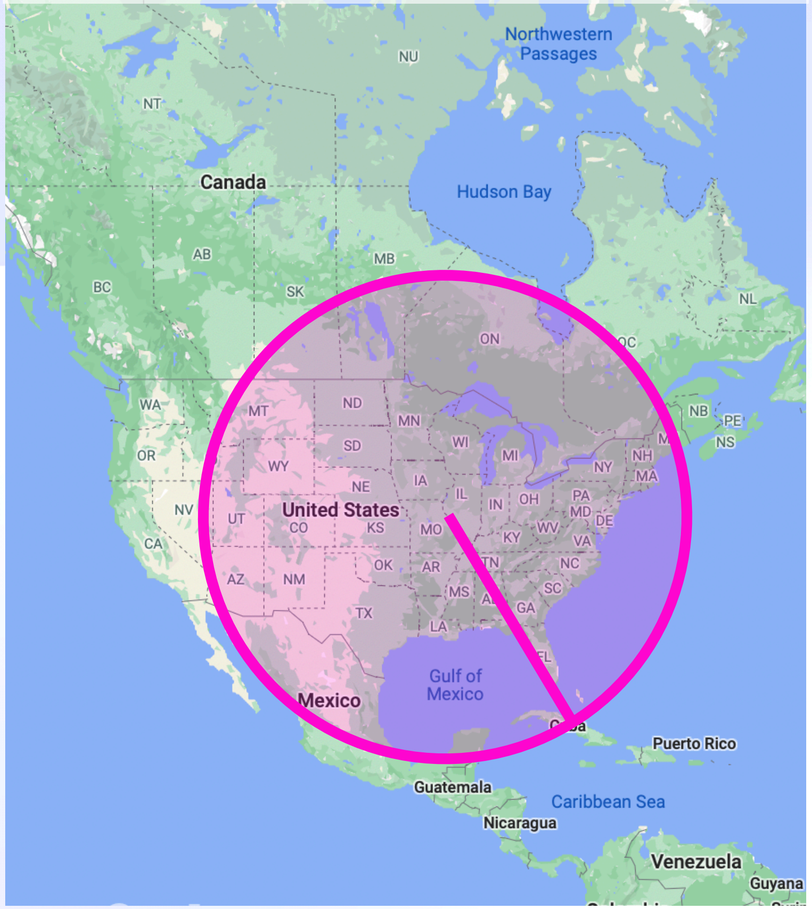

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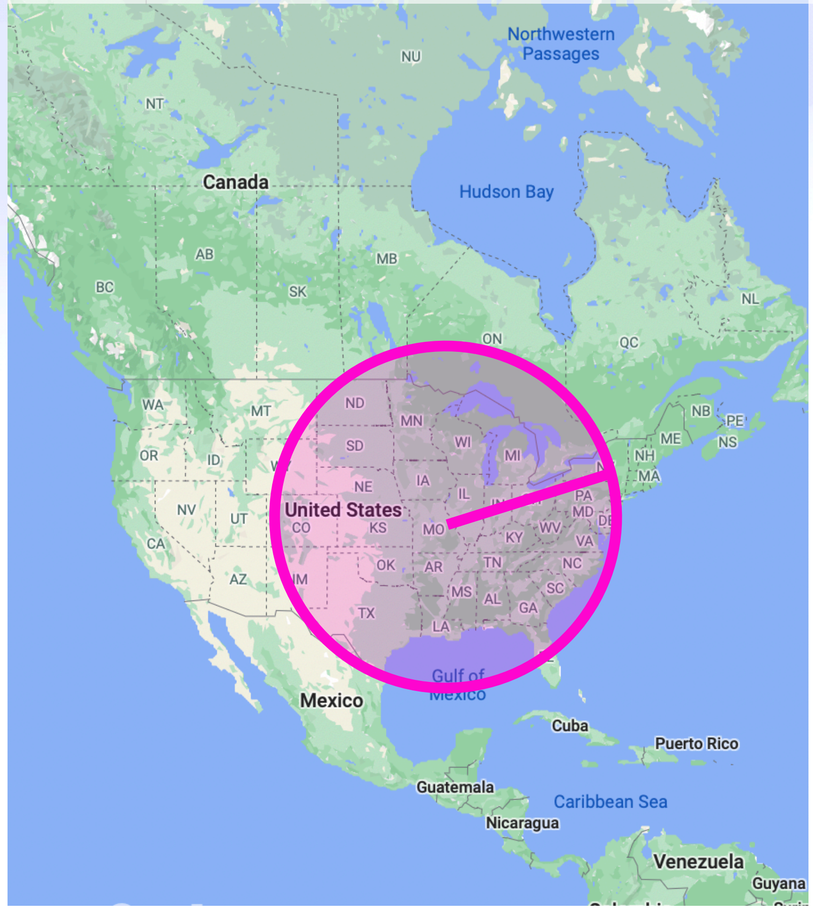
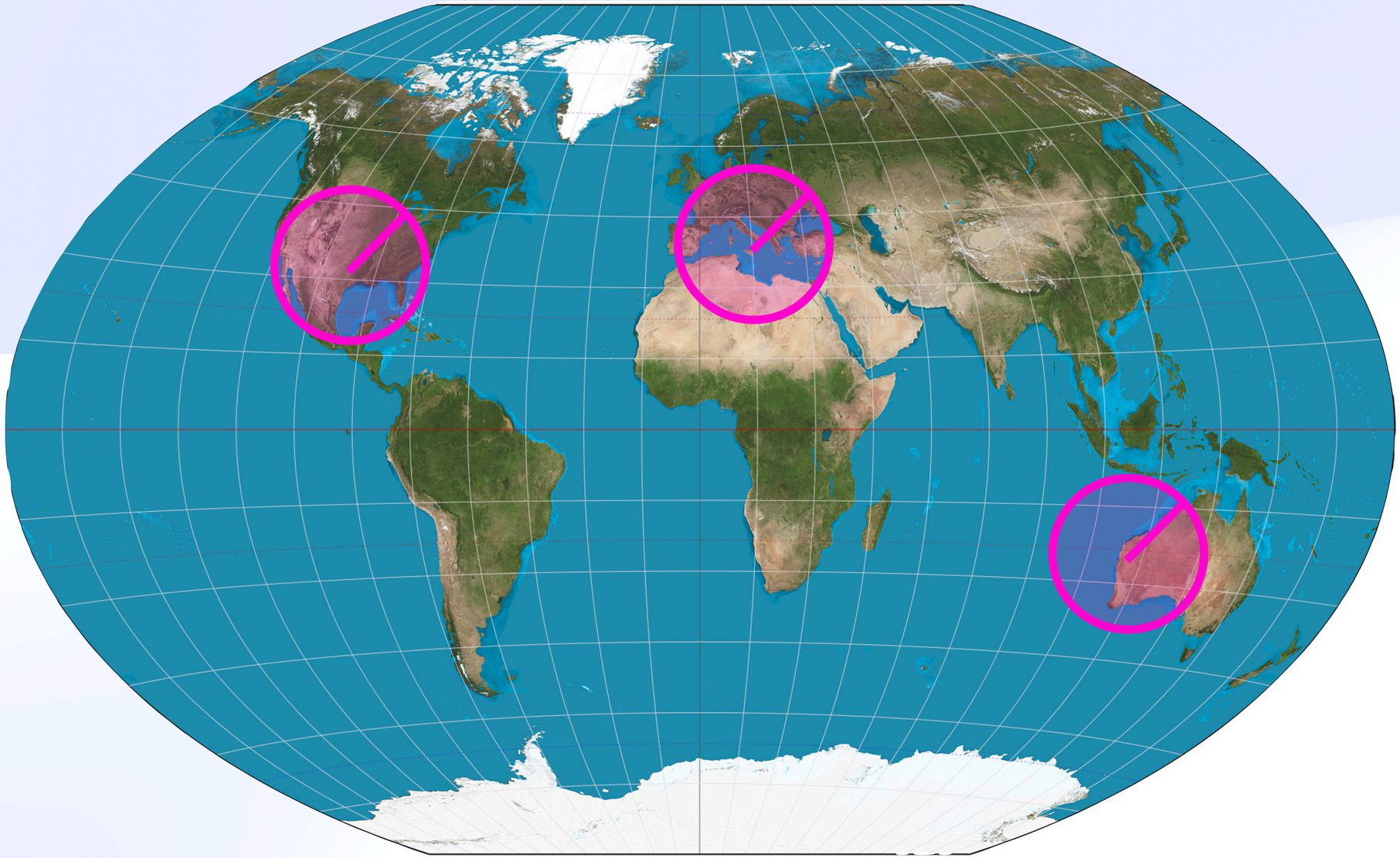


St. Louis 🔁 Detroit
Ideal Fibre 🧶

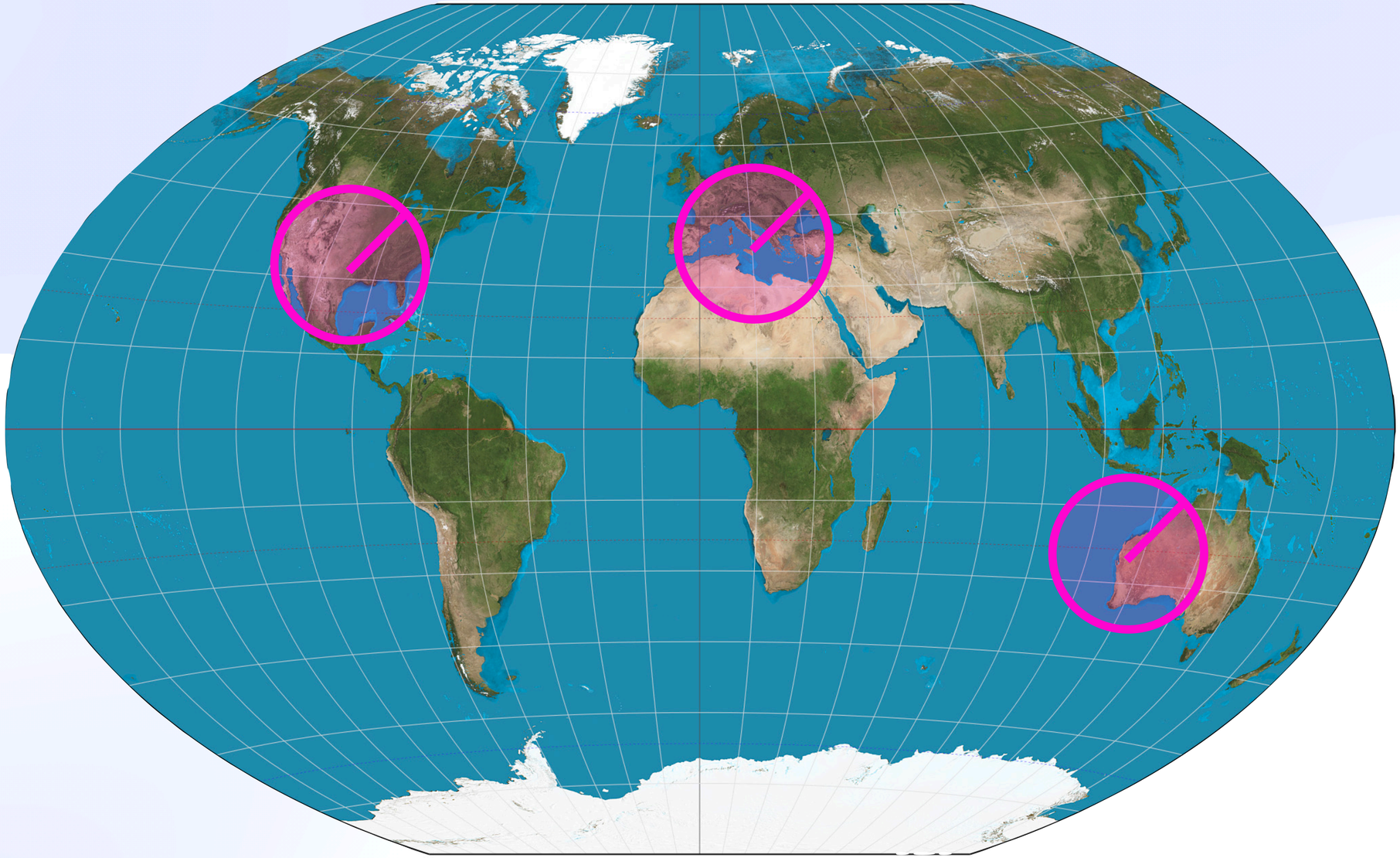
A New Environment

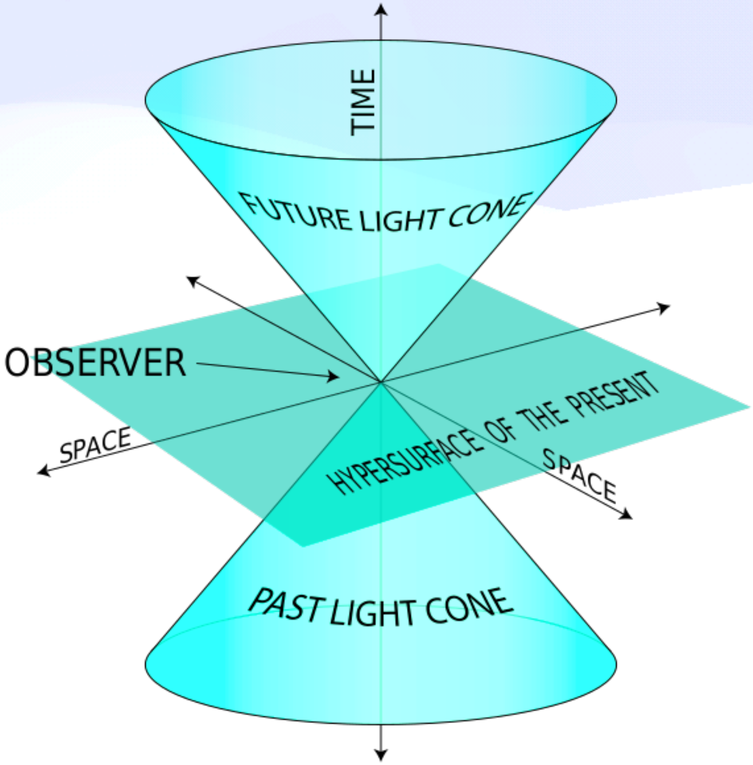
Causal Islands 🏝️🌴



A New Environment

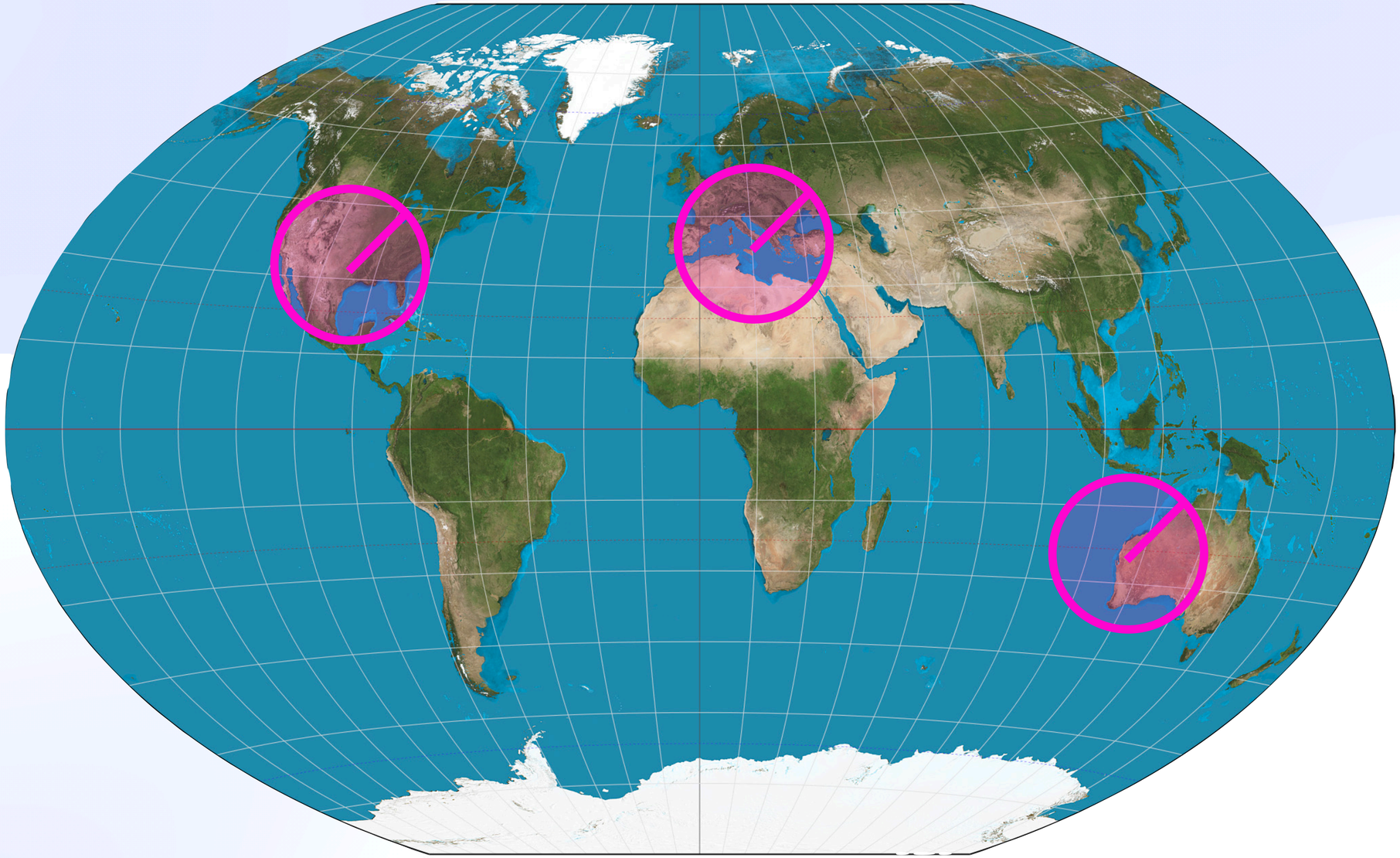
Causal Islands 🏝️🌴

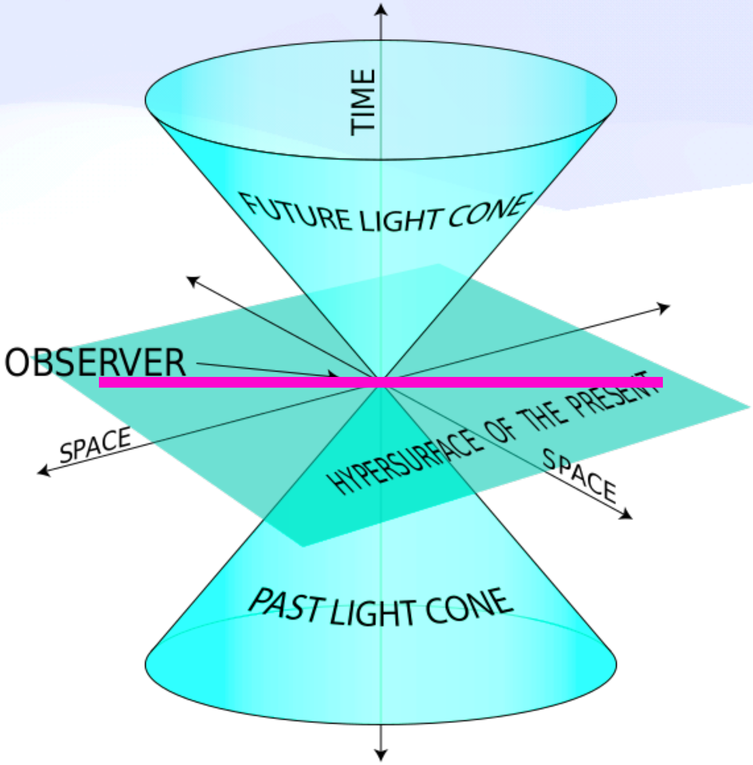




A New Environment

Causal Islands 🏝️🏝️





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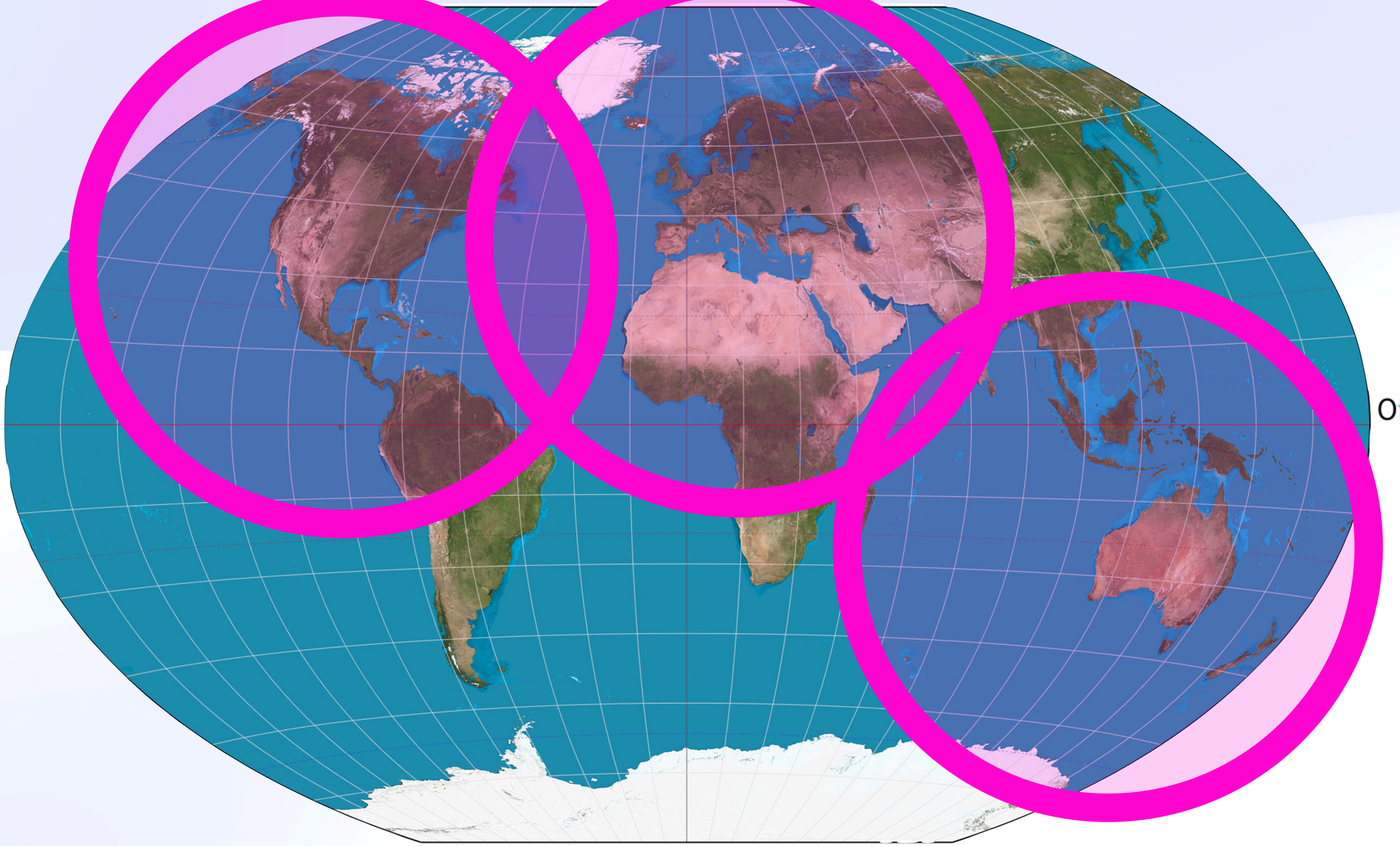

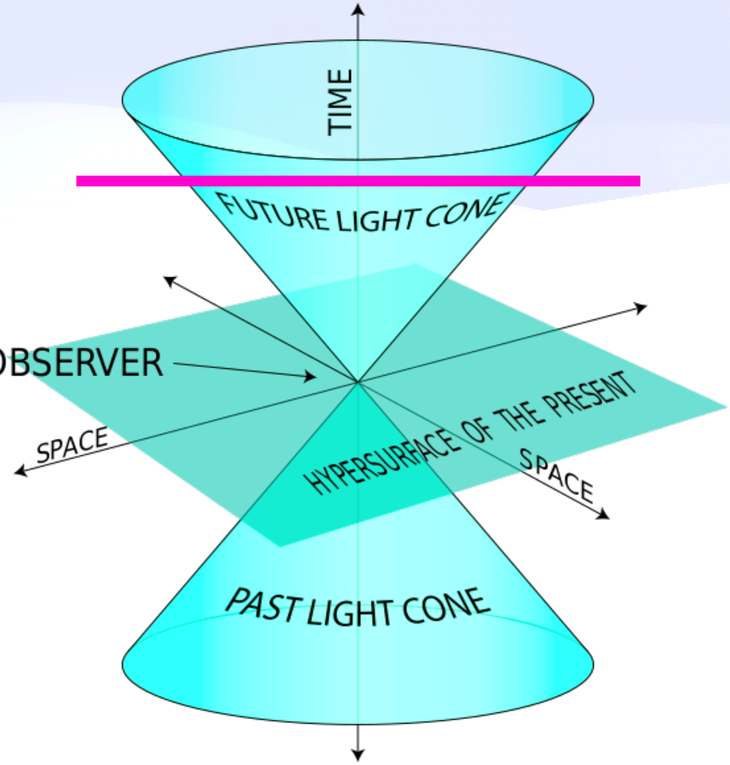

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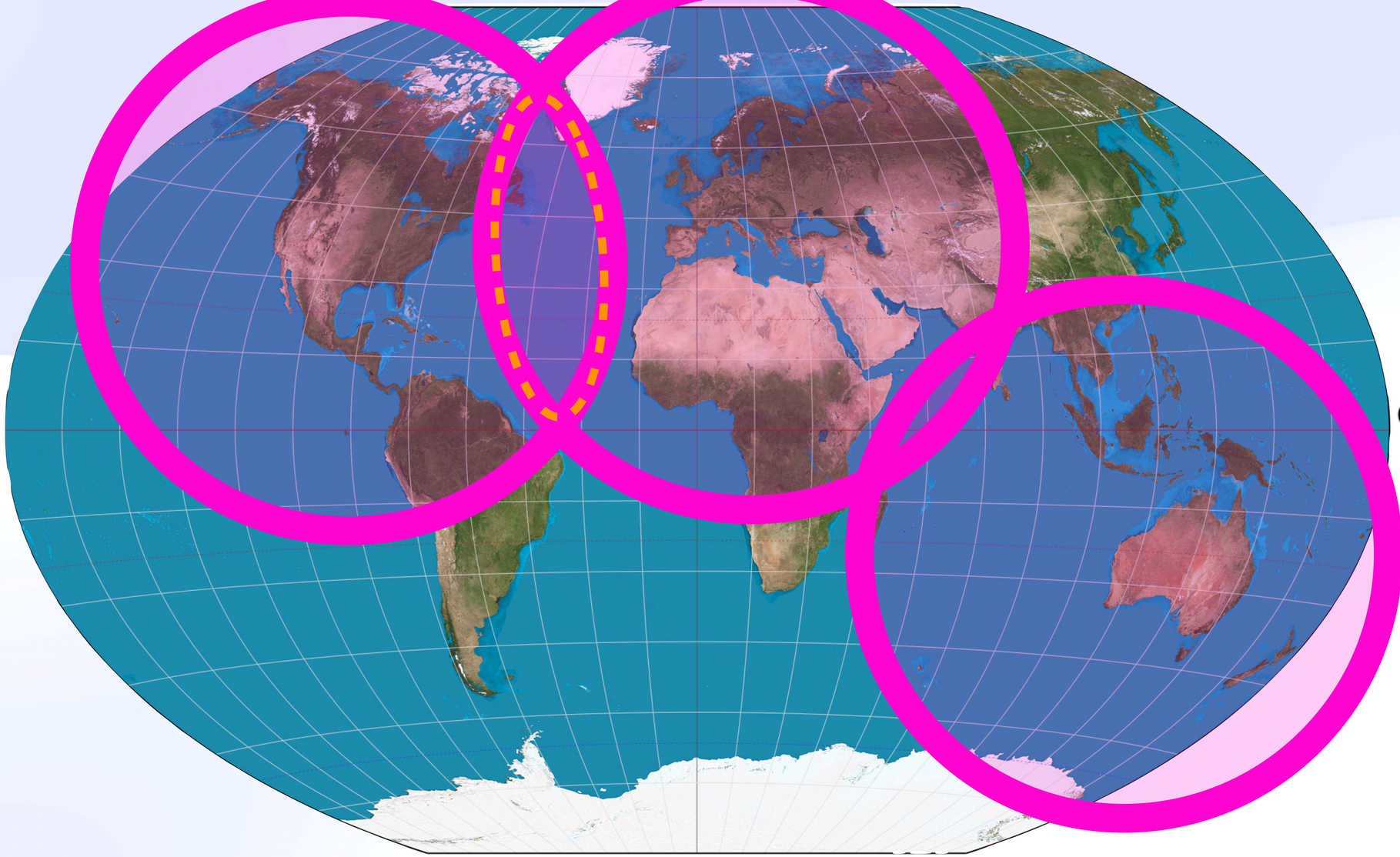
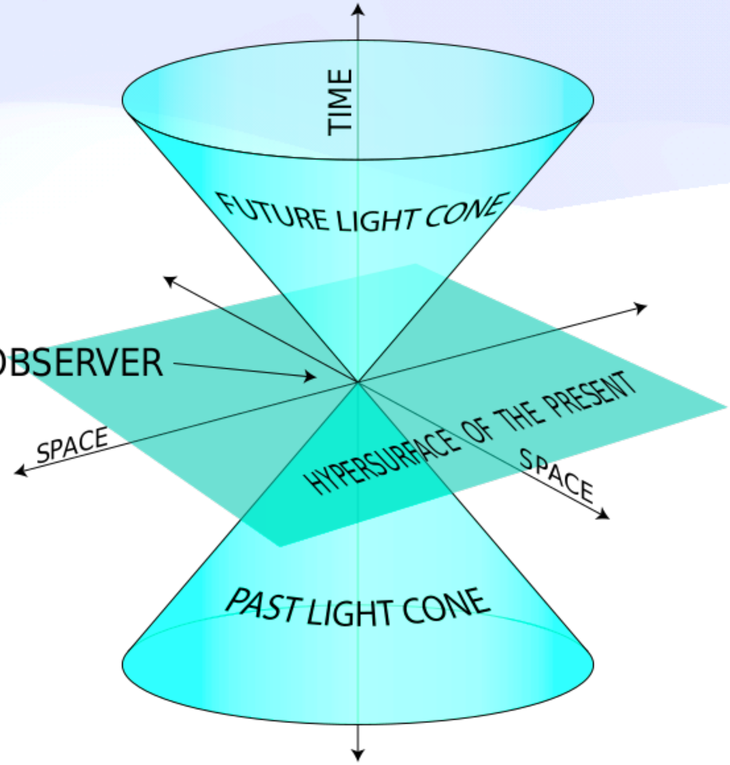
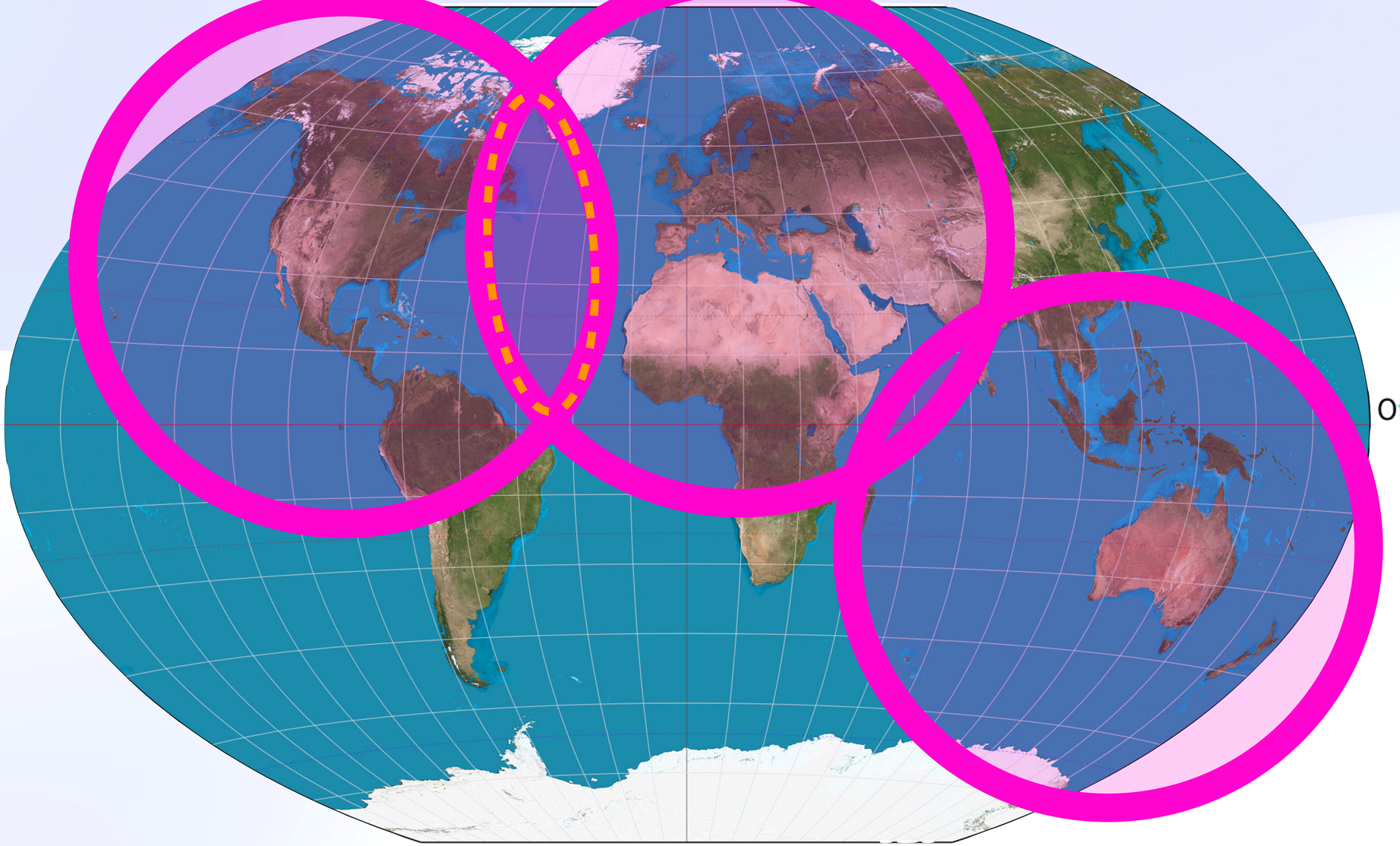
Causal Islands 🏝️🌴

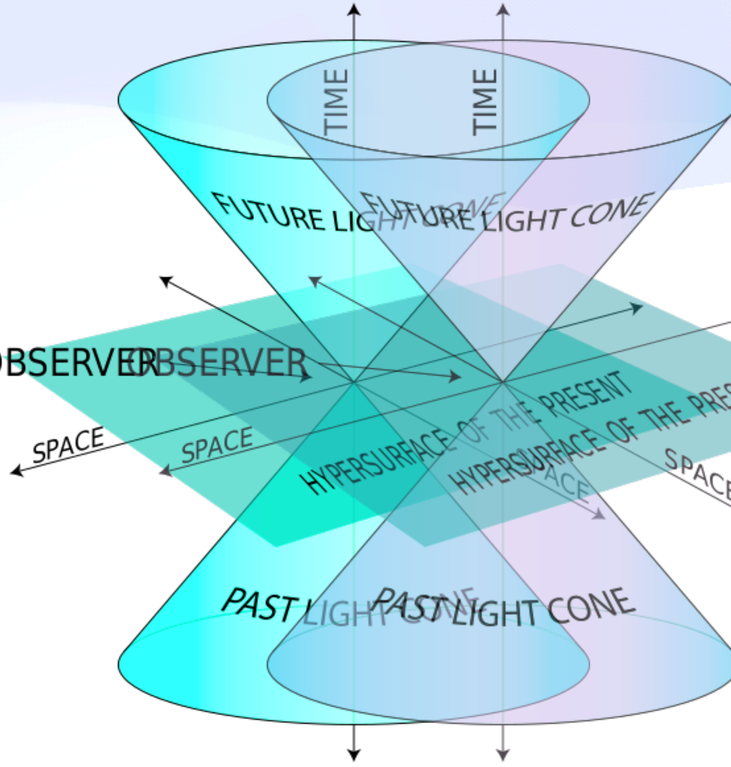




A New Environment

Causal Islands 🏝️🌴





A New Environment

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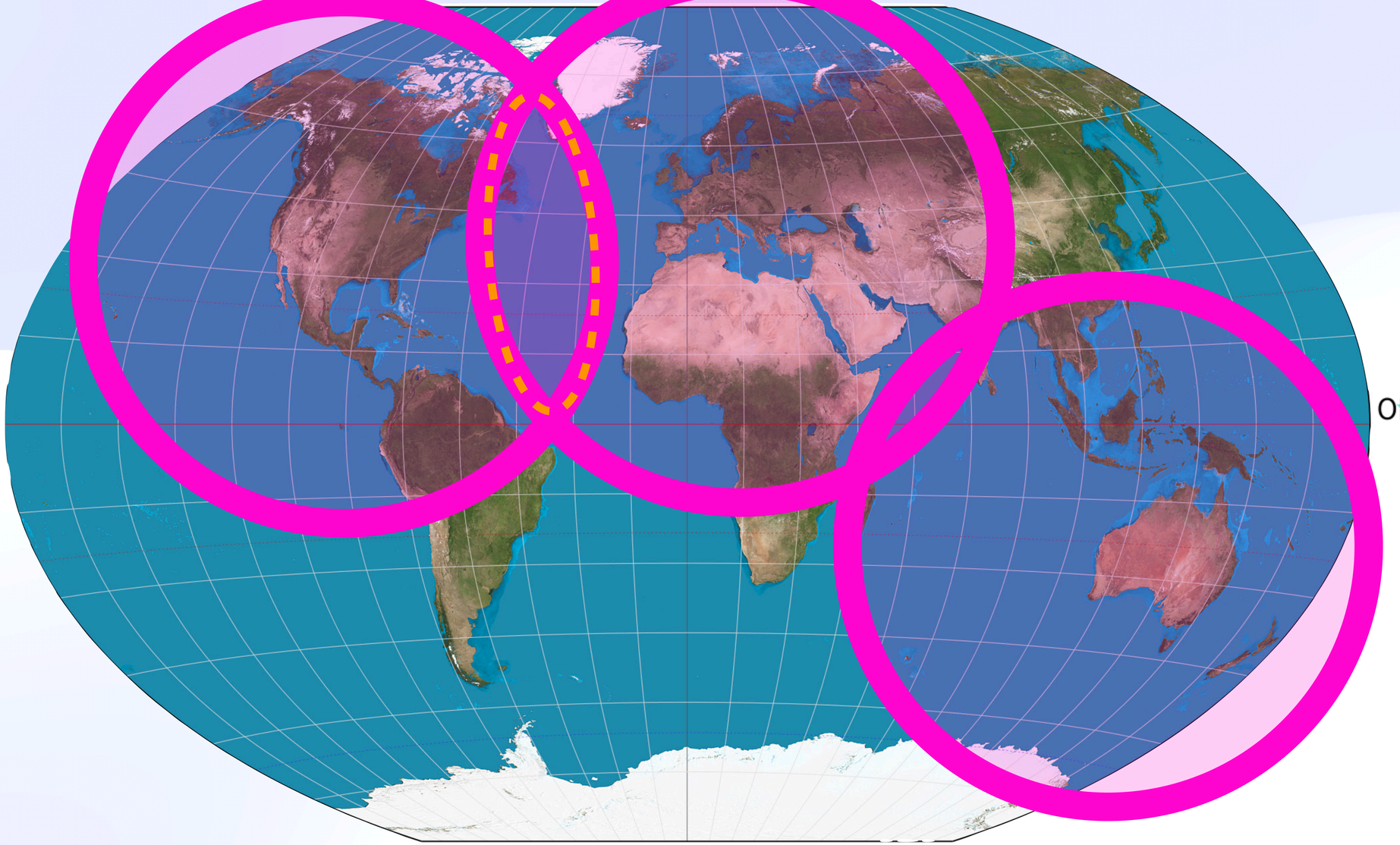
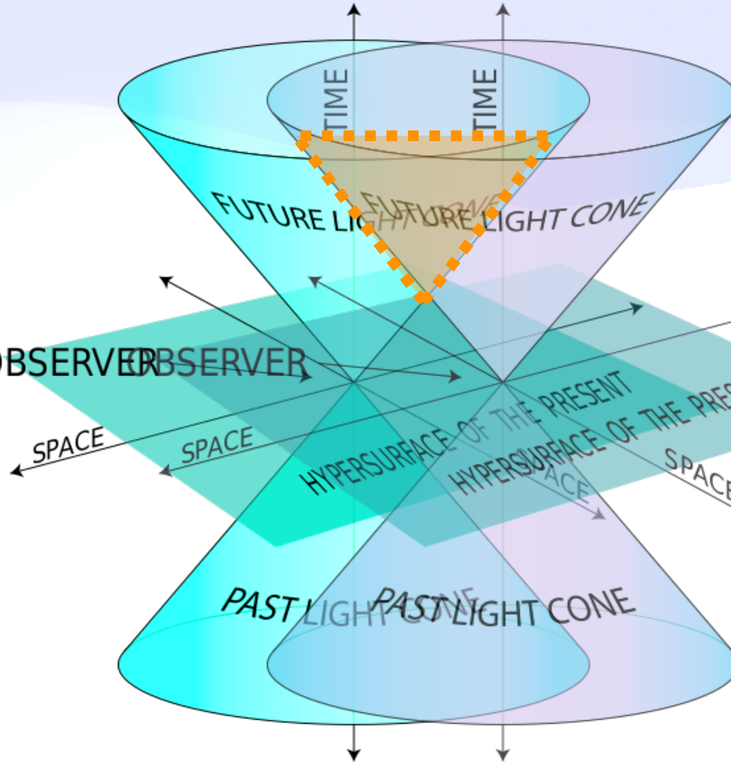




A New Environment

A New Environment

As we continue to increase the number of globally connected devices, we ***must embrace a design that considers every single member in the system as the primary site*** for the data that it is generates.

It is ***completely impractical*** that we can look at a single, or a small number, of globally distributed data centers as the ***primary site for all global information*** that we desire to perform computations with.

– **Meiklejohn**, A Certain Tendency Of The Database Community

A New Environment

Everything, Everywhere

A New Environment

Everything, Everywhere

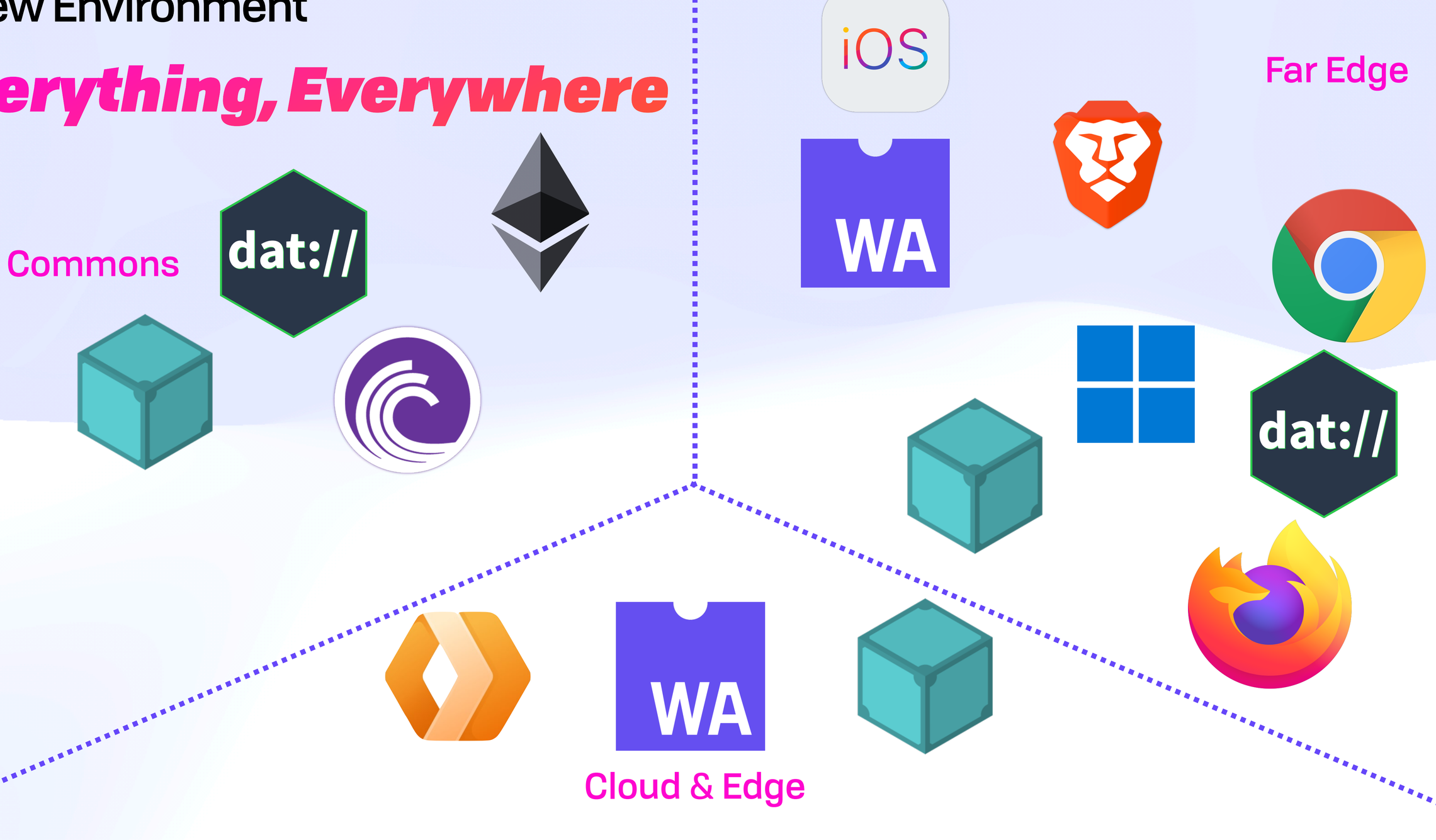
Commons

Far Edge

Cloud & Edge

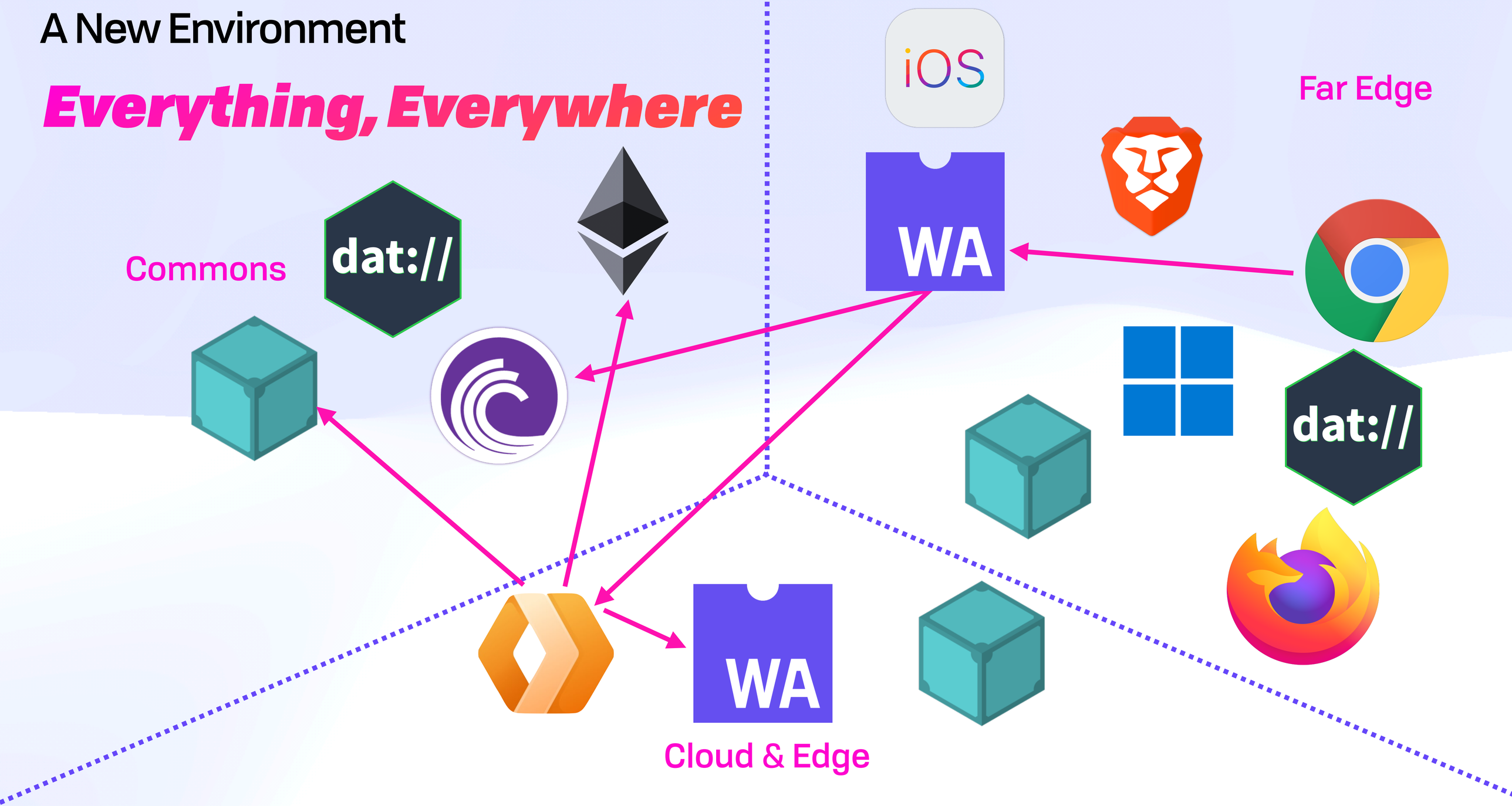
A New Environment

Everything, Everywhere



A New Environment

Everything, Everywhere



A New Environment


— Getting Back to Our Roots —
Networks for Good

Networks for Good

Back to Our Roots

Networks for Good

Back to Our Roots

1. Decentralisation
2. Non-discrimination
3. Bottom-up Design
4. Universality
5. Consensus

– **The Web Foundation**, History of the Web

Networks for Good

Back to Our Roots

1. Decentralisation
2. Non-discrimination
3. Bottom-up Design
4. Universality
5. Consensus

Layer			Protocol data unit (PDU)
Host layers	7	Application	Data
	6	Presentation	
	5	Session	
	4	Transport	Segment, Datagram
Media layers	3	Network	Packet
	2	Data link	Frame
	1	Physical	Bit, Symbol

en.wikipedia.org/wiki/OSI_model

– **The Web Foundation**, History of the Web

Networks for Good

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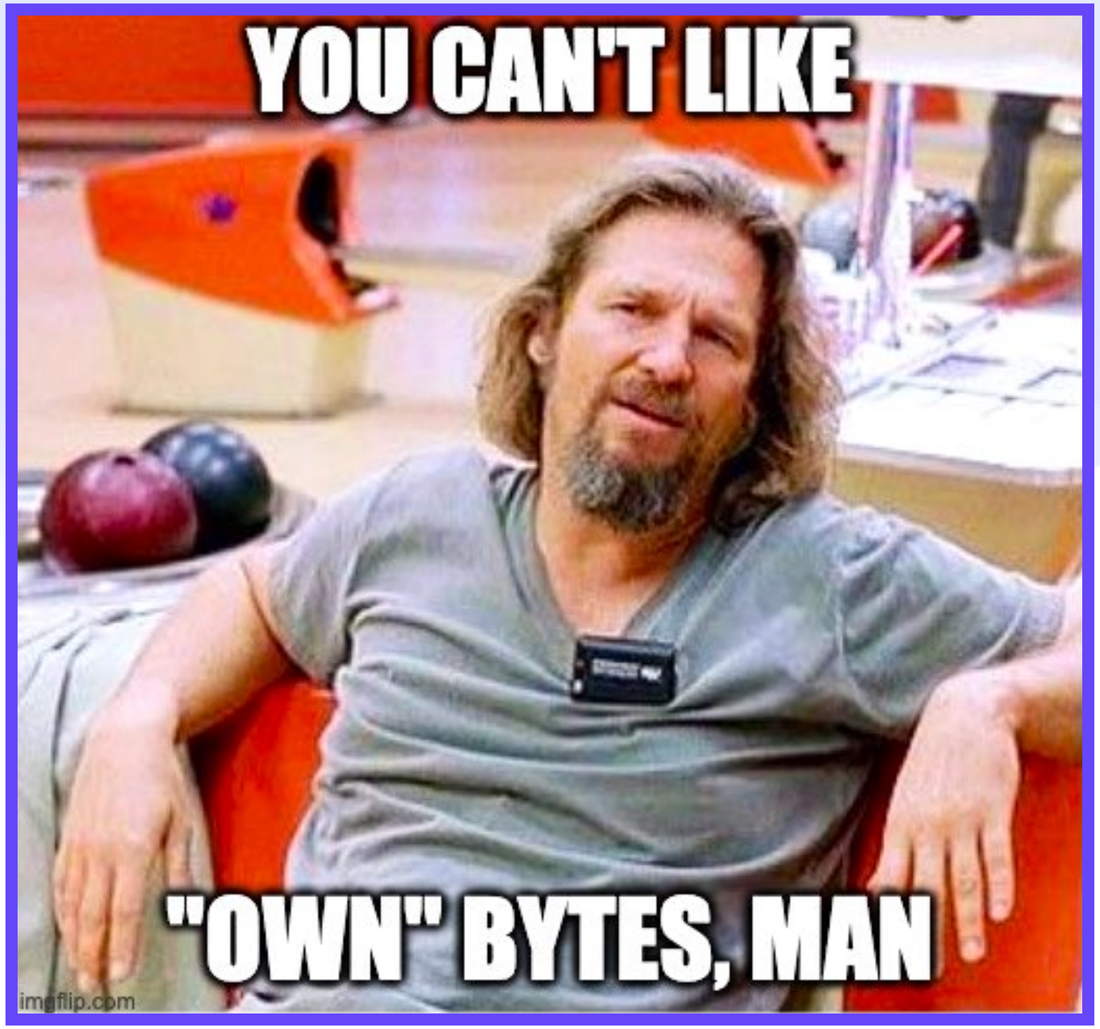
– **The Web Foundation**, History of the Web

Networks for Good

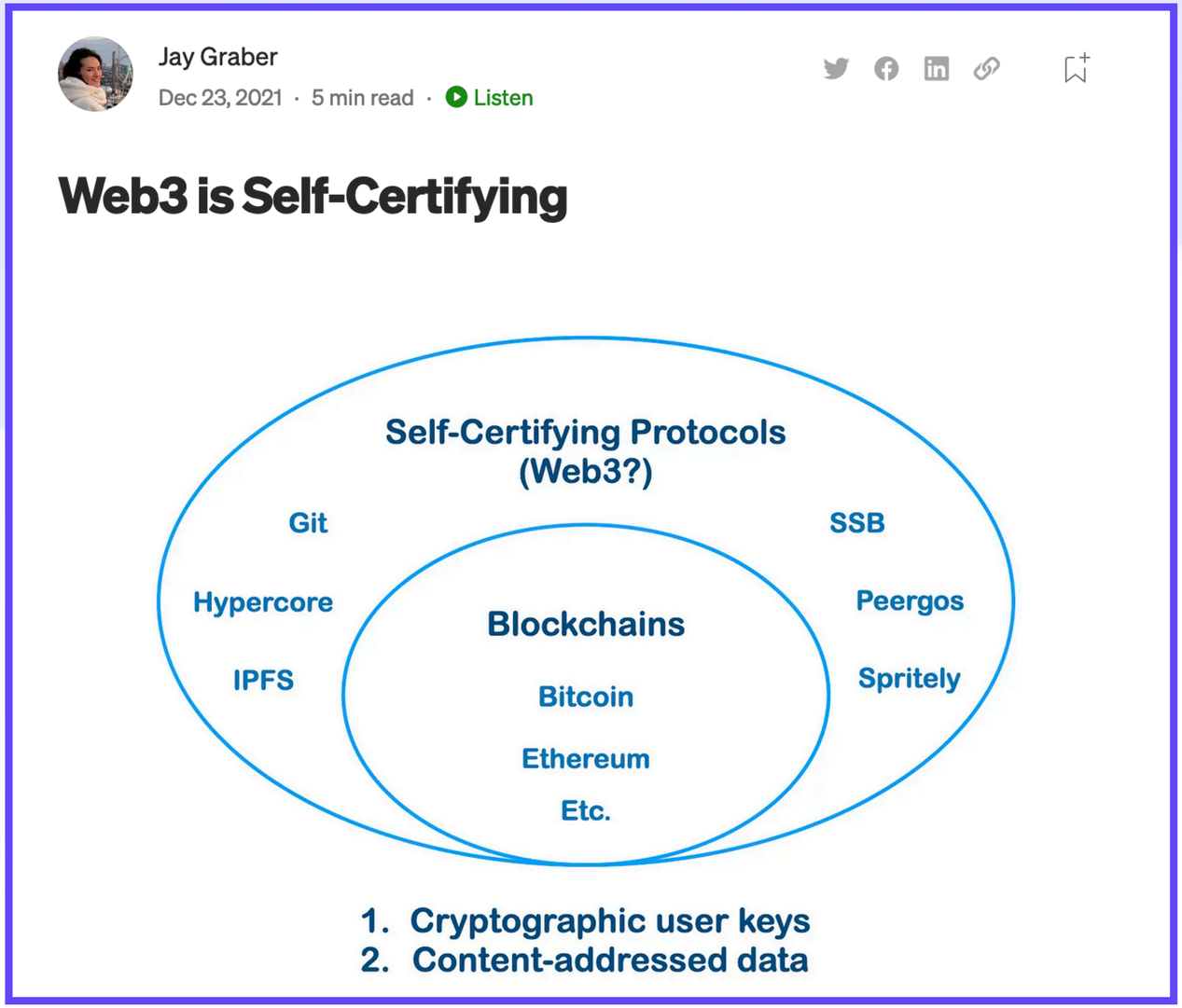
User Agency

- **Entry:** Empower users to participate
- **Exit:** Option to move or leave
- **Safety:** Control access to *your* data
- **Serve:** Provide capacity to others



Signs of a Way Out

Emerging Definitions



Jay Graber

Dec 23, 2021 · 5 min read · Listen

Web3 is Self-Certifying

1. Cryptographic user keys
2. Content-addressed data

Signs of a Way Out

ACL Redux

Signs of a Way Out

ACL Redux

Signs of a Way Out

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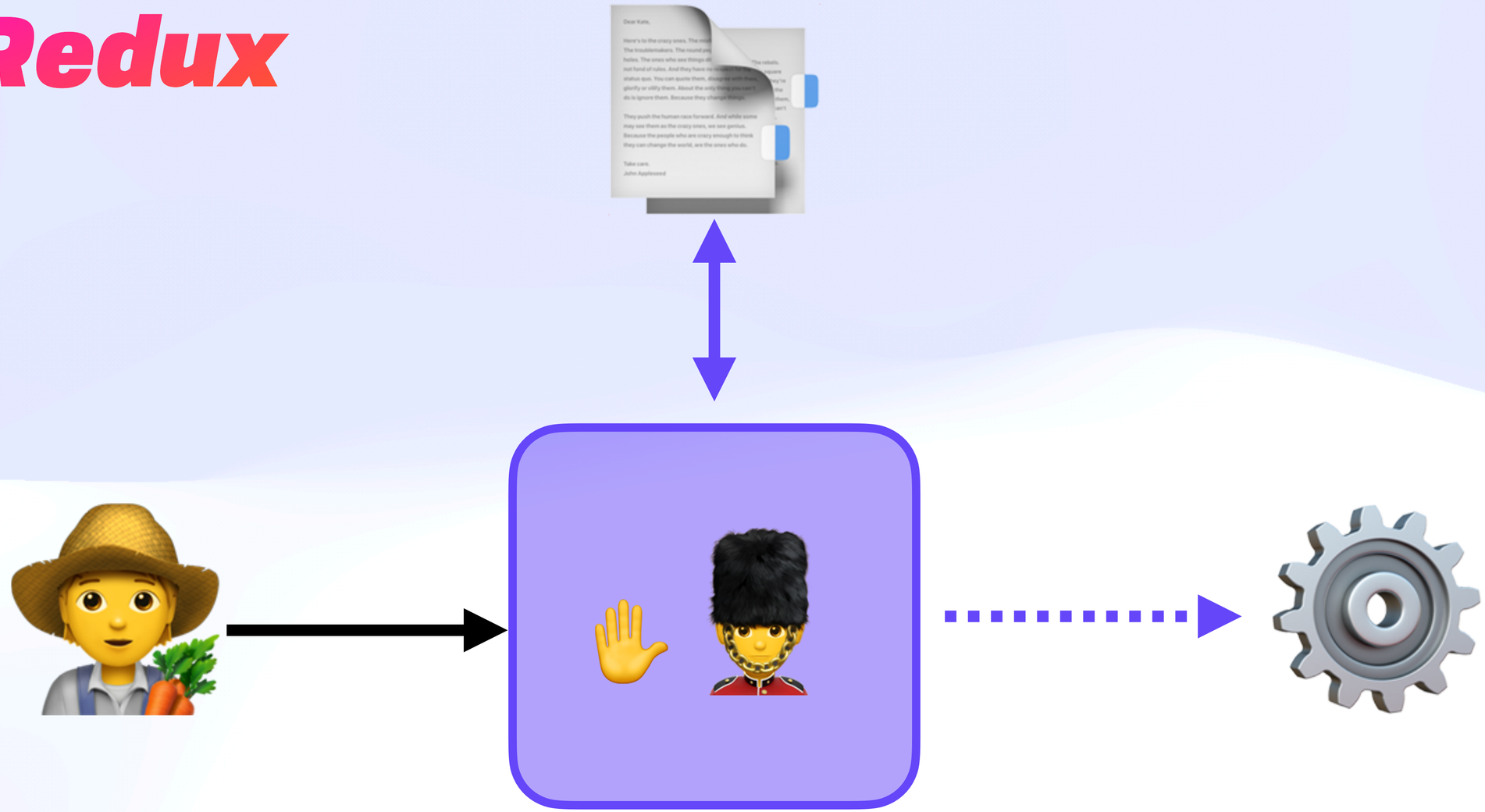
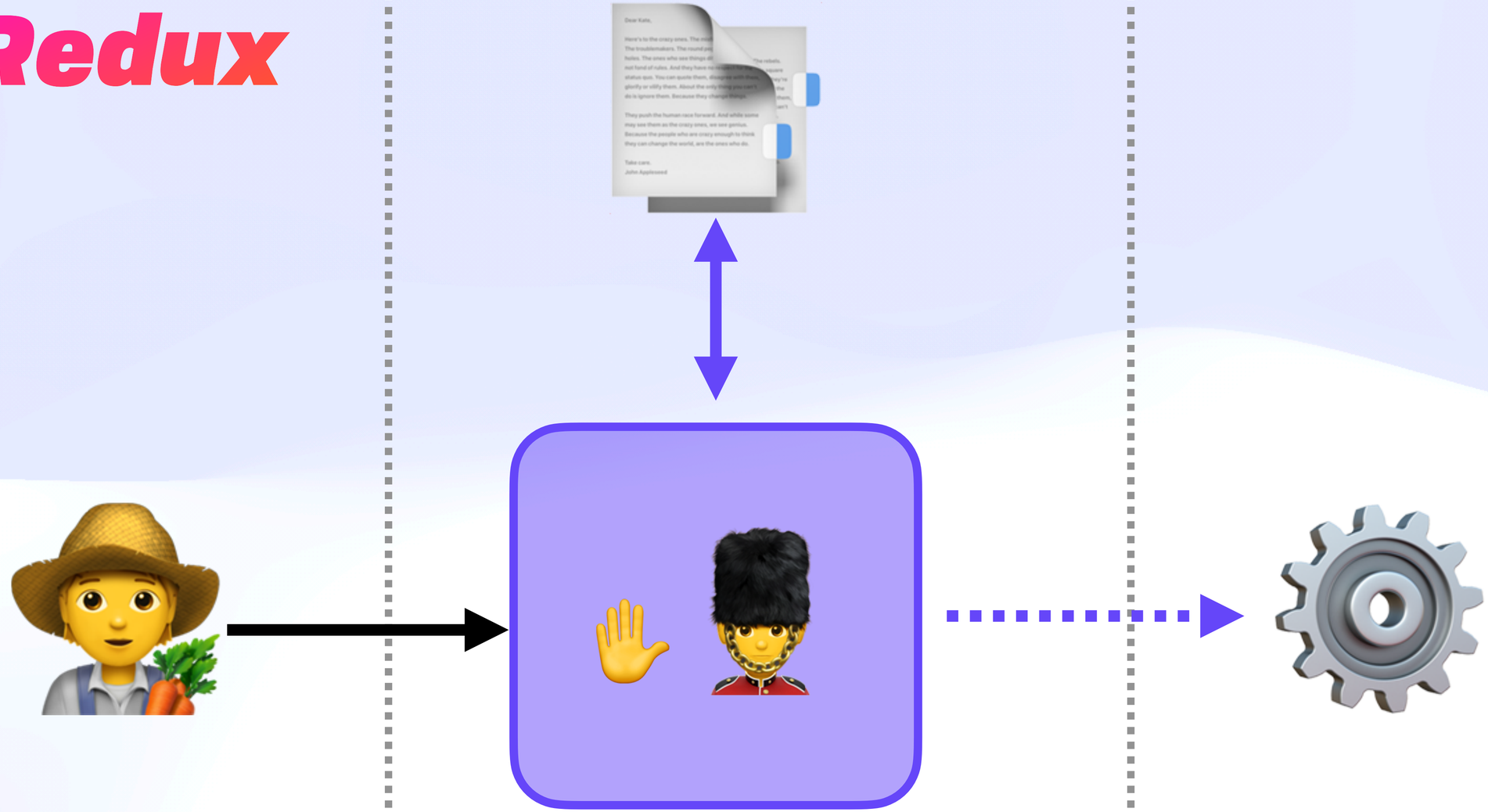
ACL Redux



Signs of a Way Out

ACL Redux



Signs of a Way Out

ACL Redux

Not in control

Signs of a Way Out

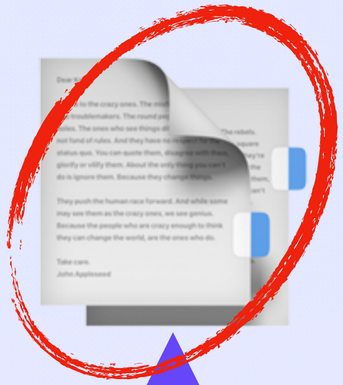
ACL Redux

In control

Not in control

Signs of a Way Out

ACL Redux



In control

Not in control

Signs of a Way Out

Capabilities

Signs of a Way Out

Capabilities

Signs of a Way Out

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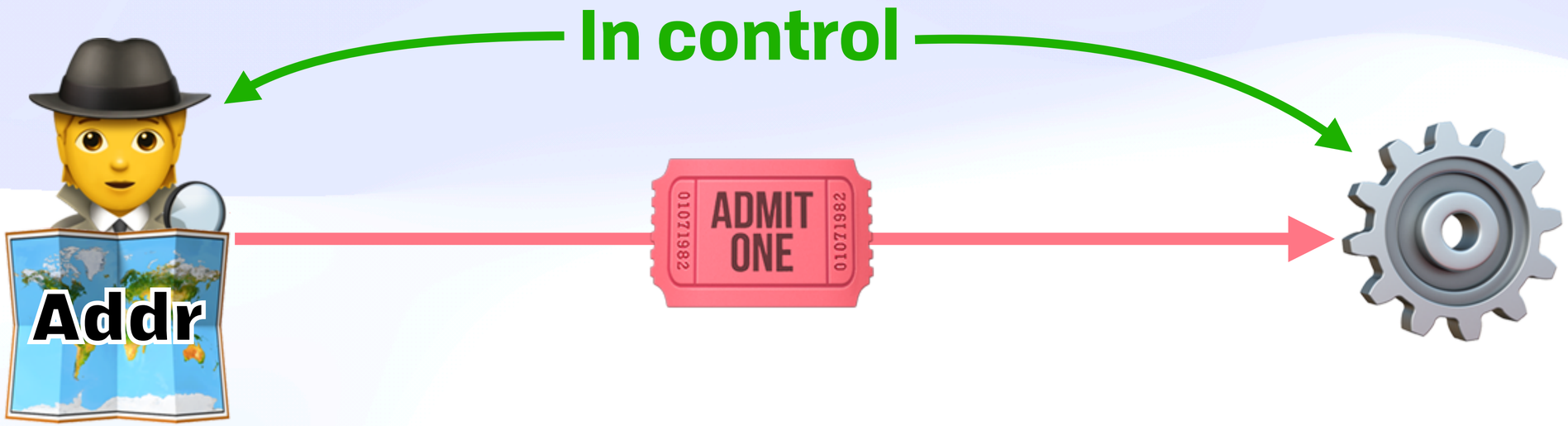
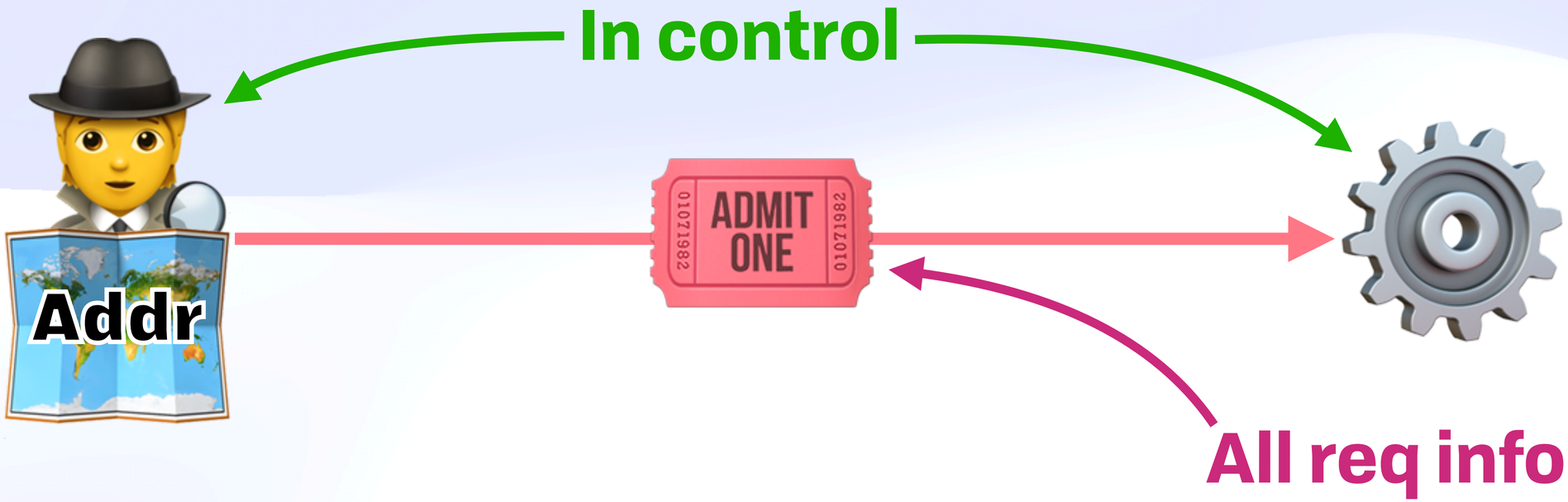


Signs of a Way Out

Capabilities



Signs of a Way Out

Capabilities

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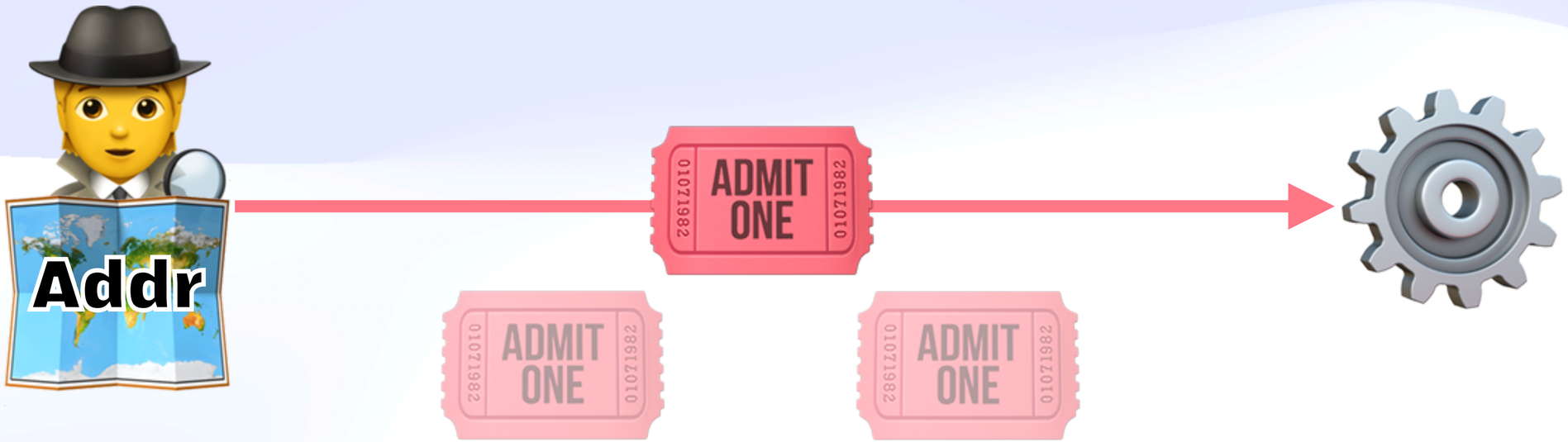

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Capabilities

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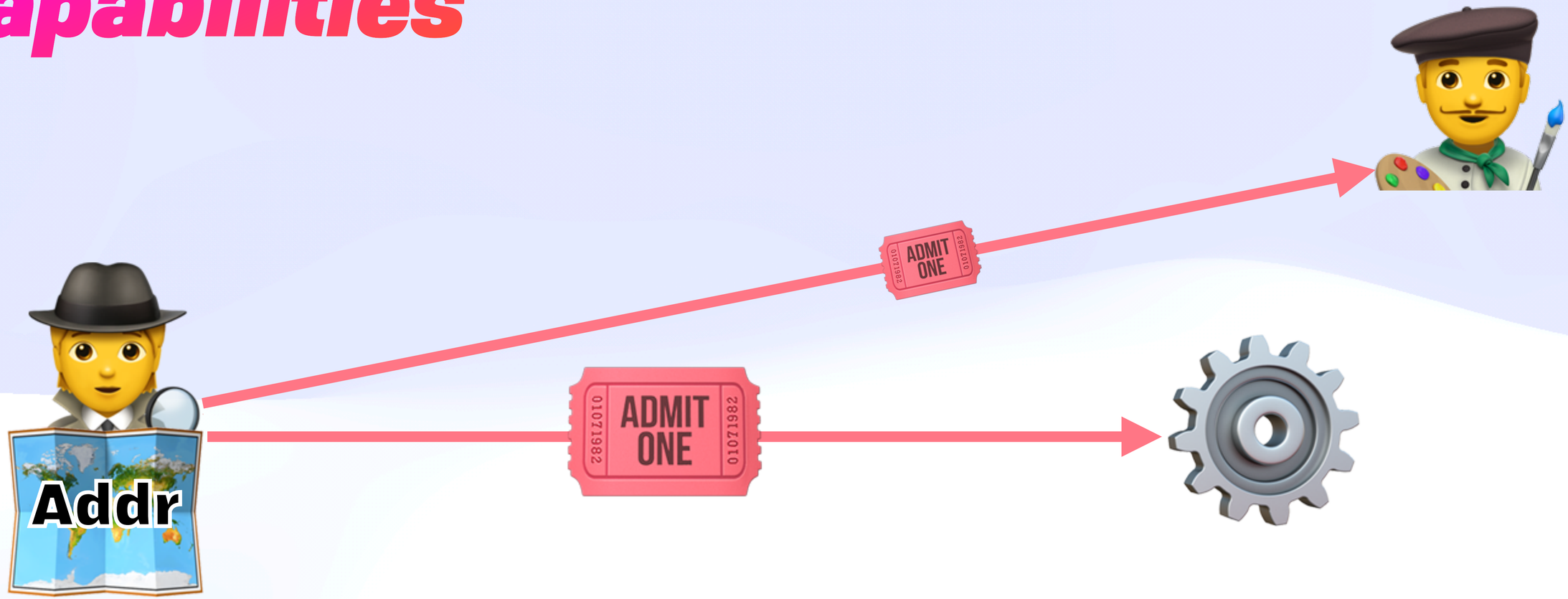

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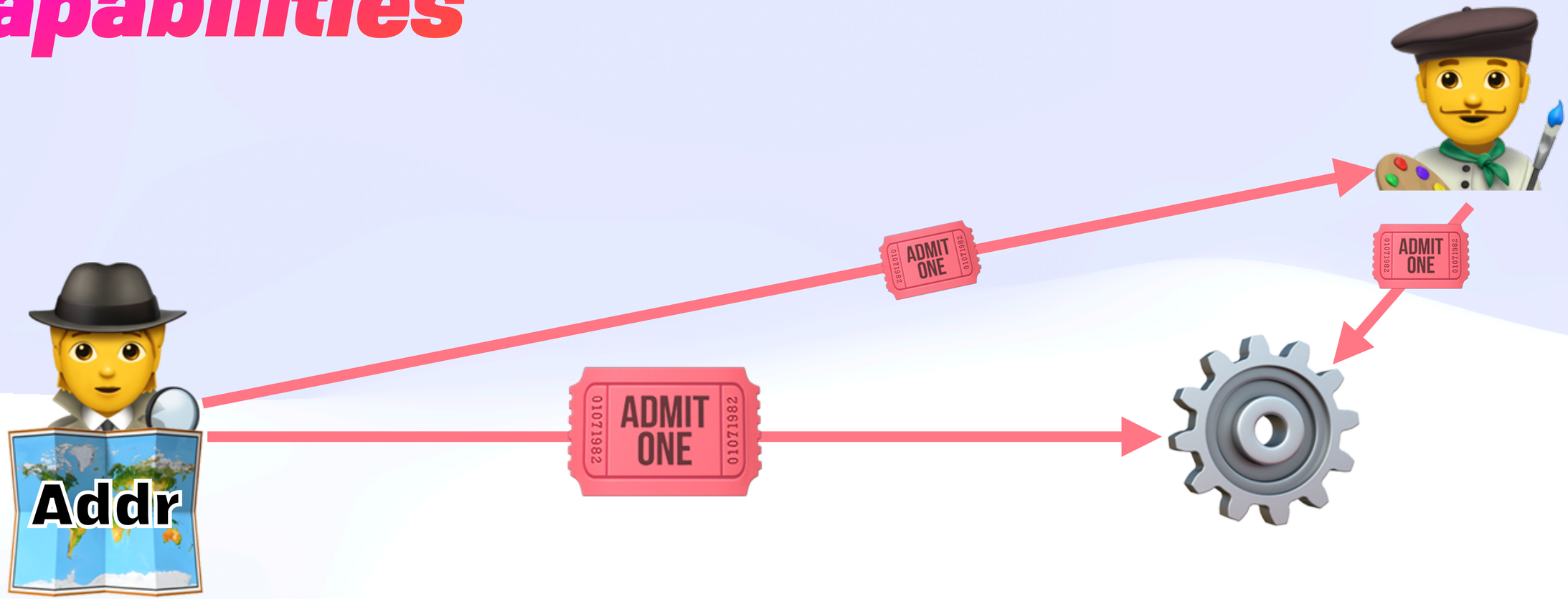
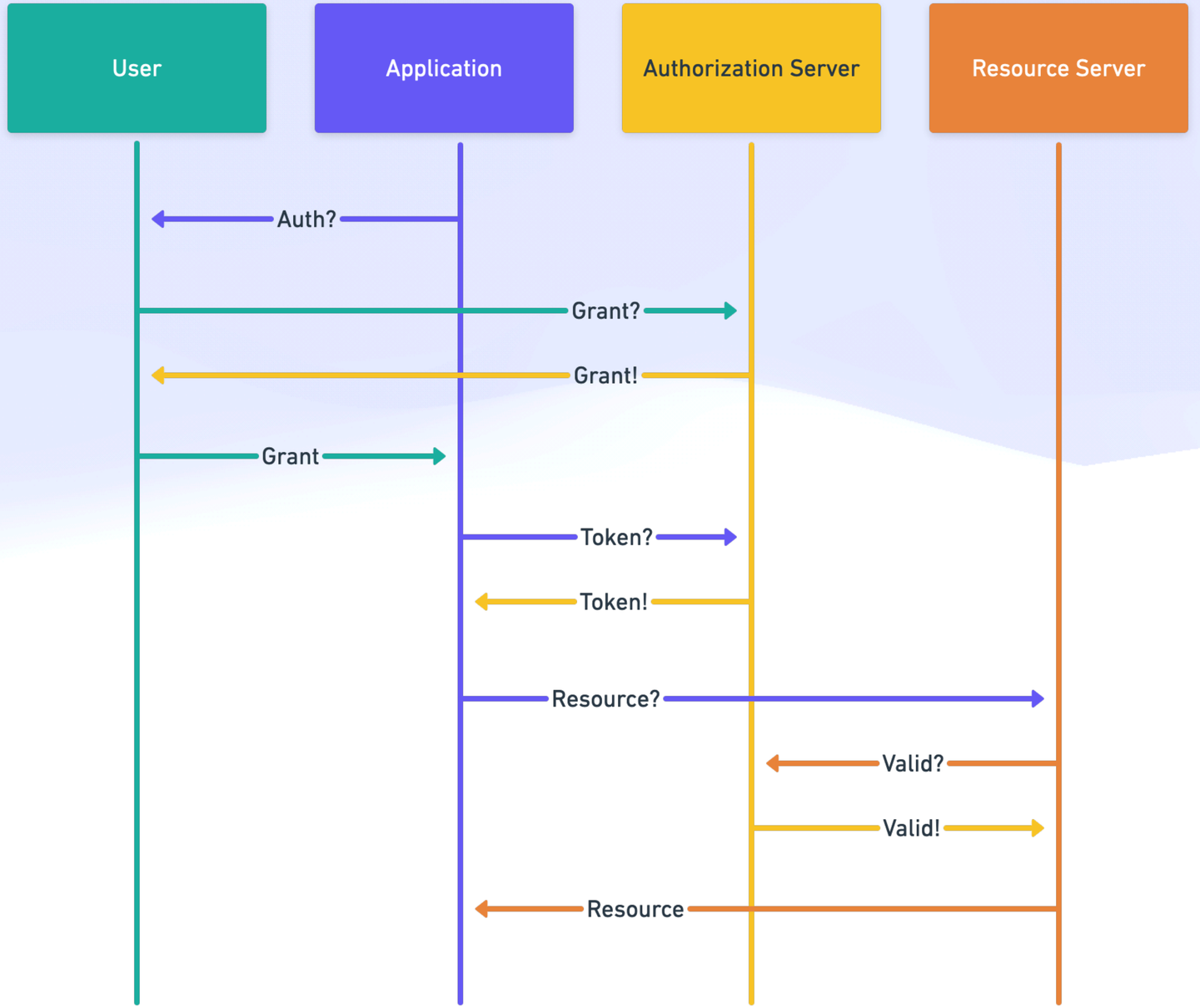


Signs of a Way Out

OAuth Sequence



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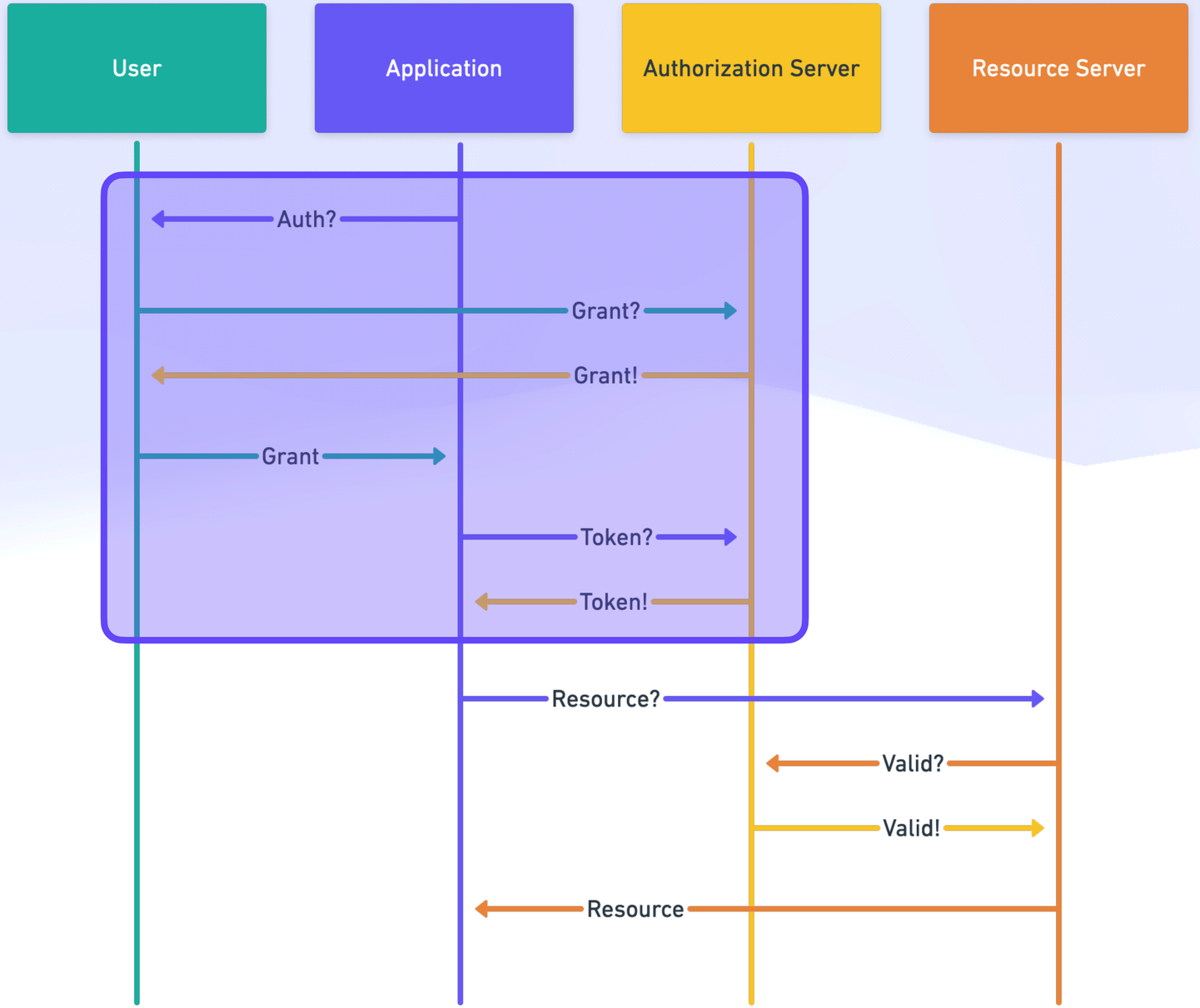

Signs of a Way Out

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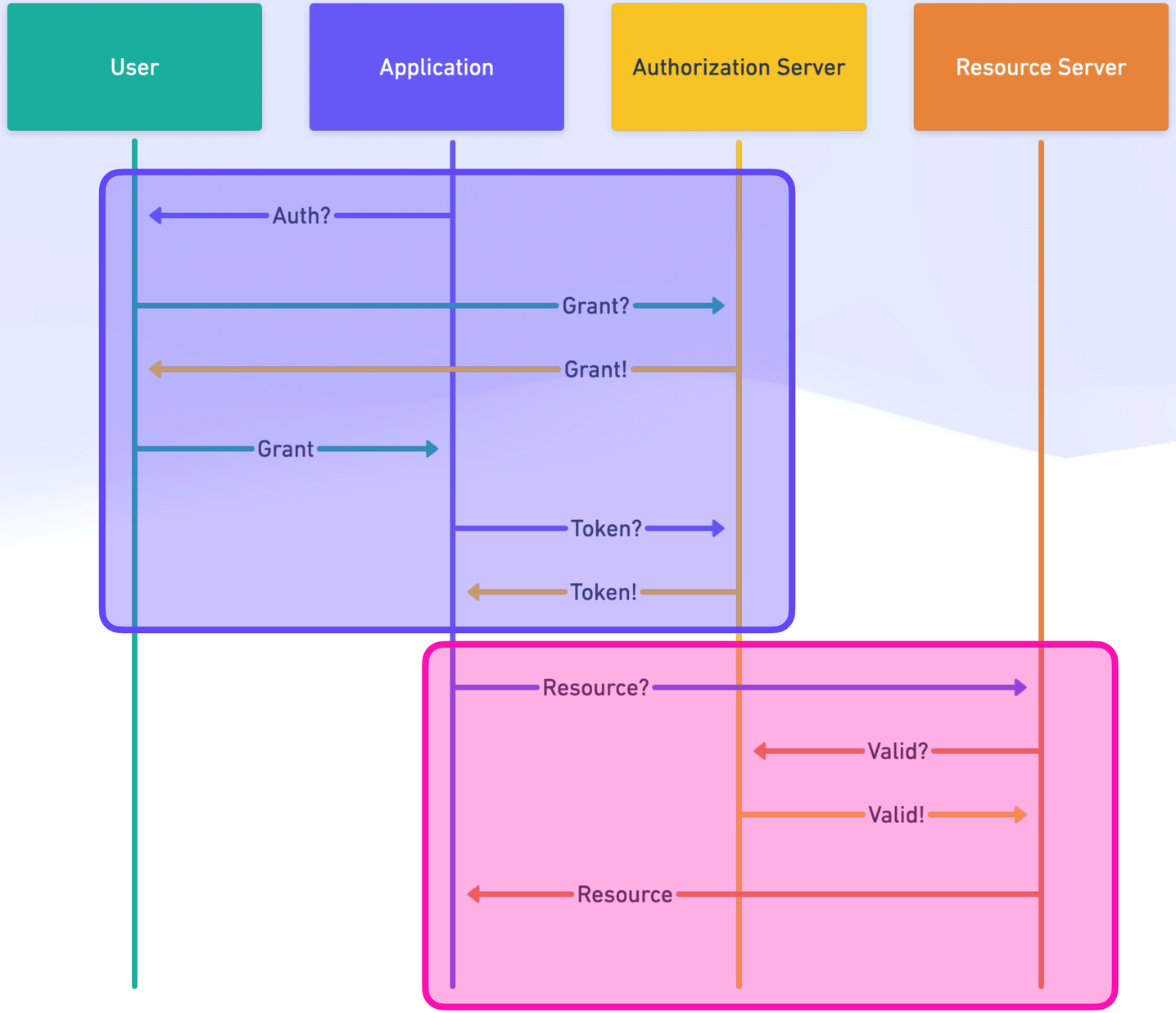

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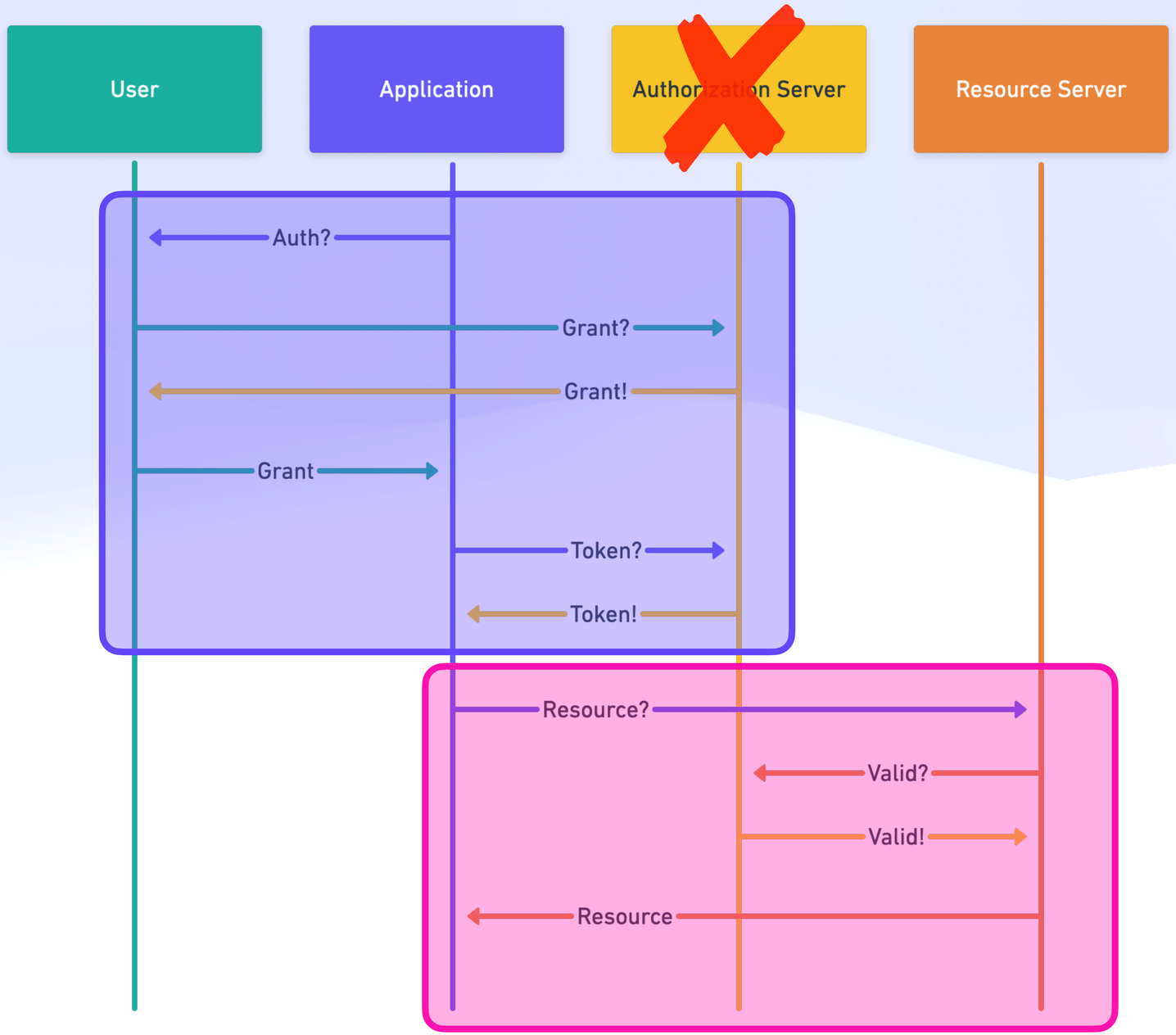
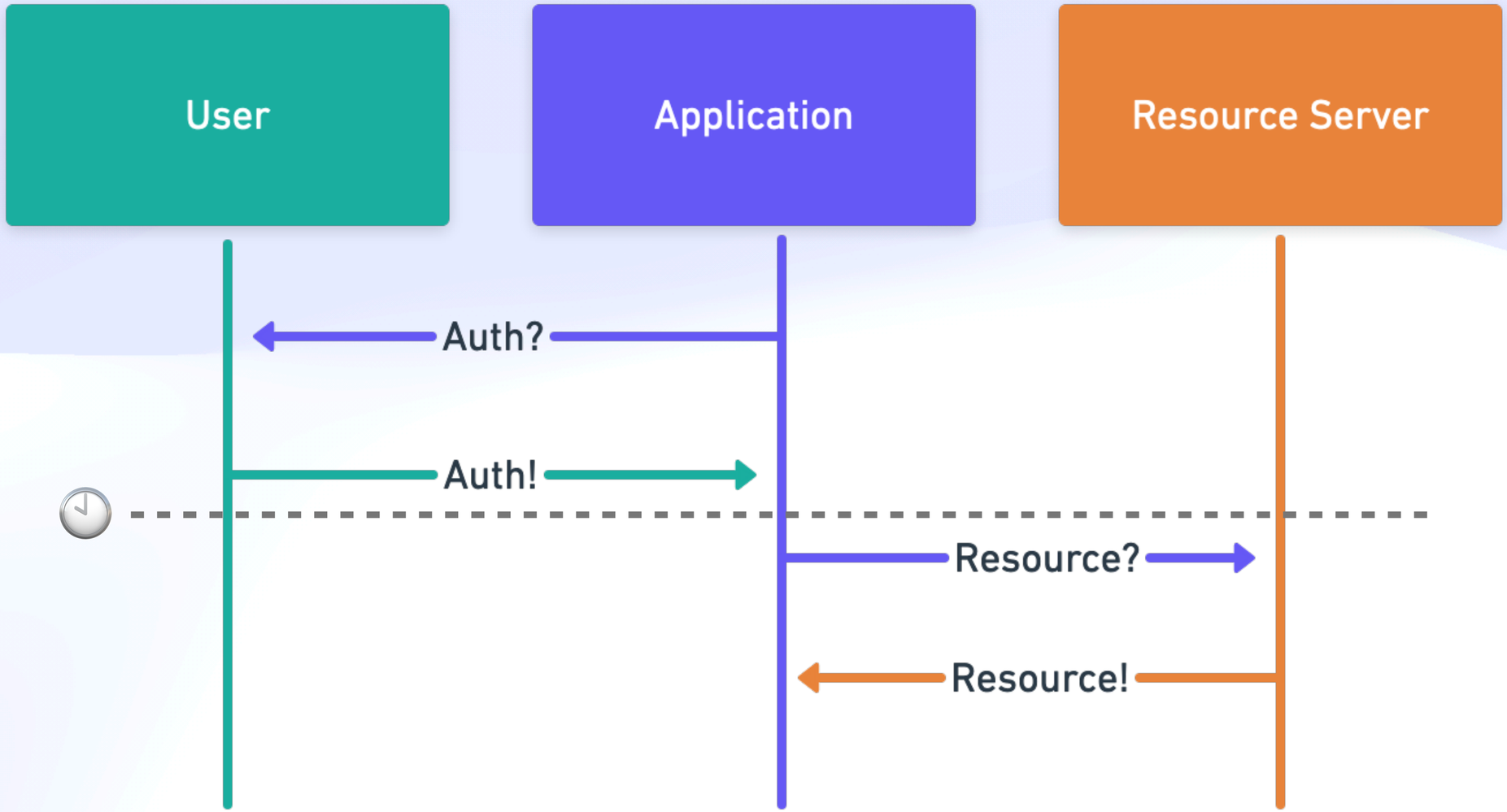


Signs of a Way Out

UCAN Sequence



Signs of a Way Out

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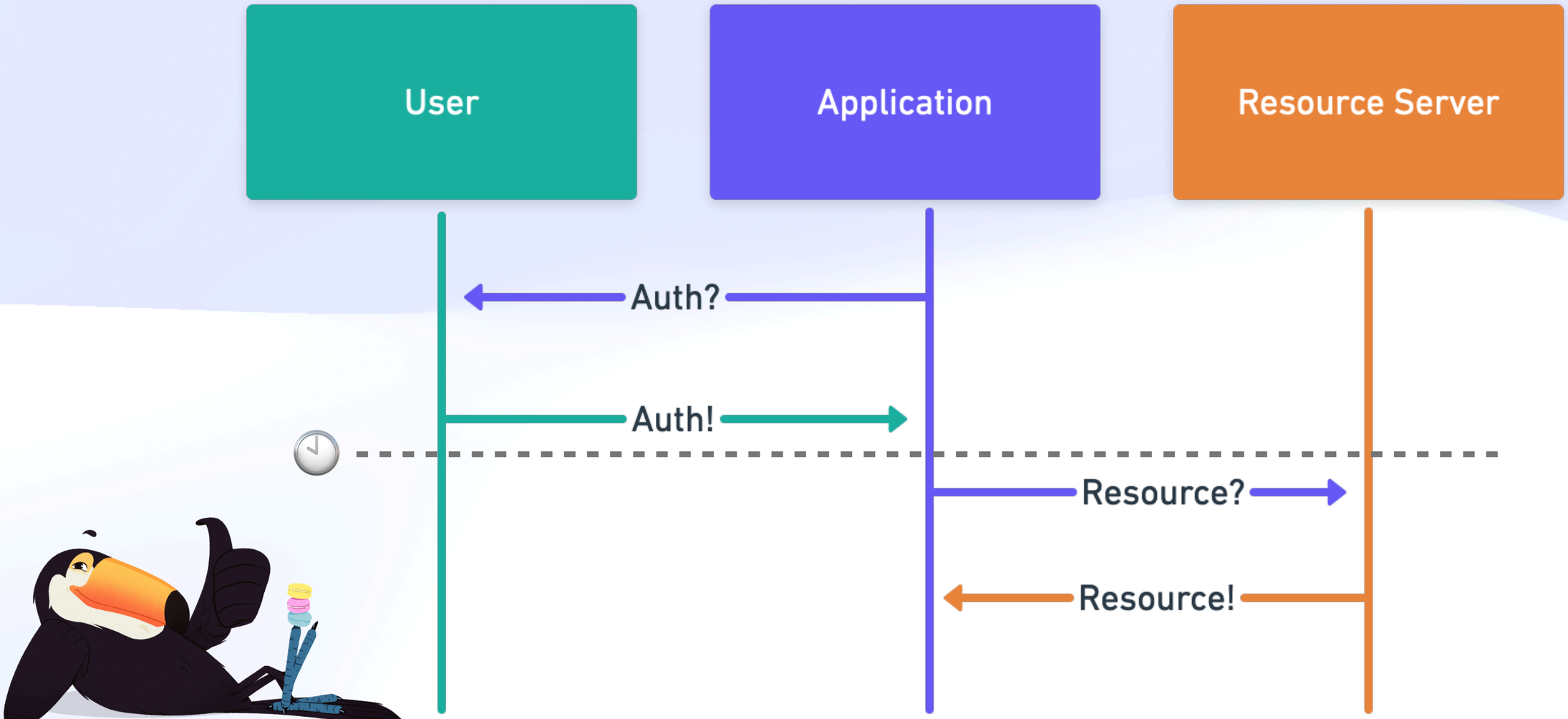

Signs of a Way Out

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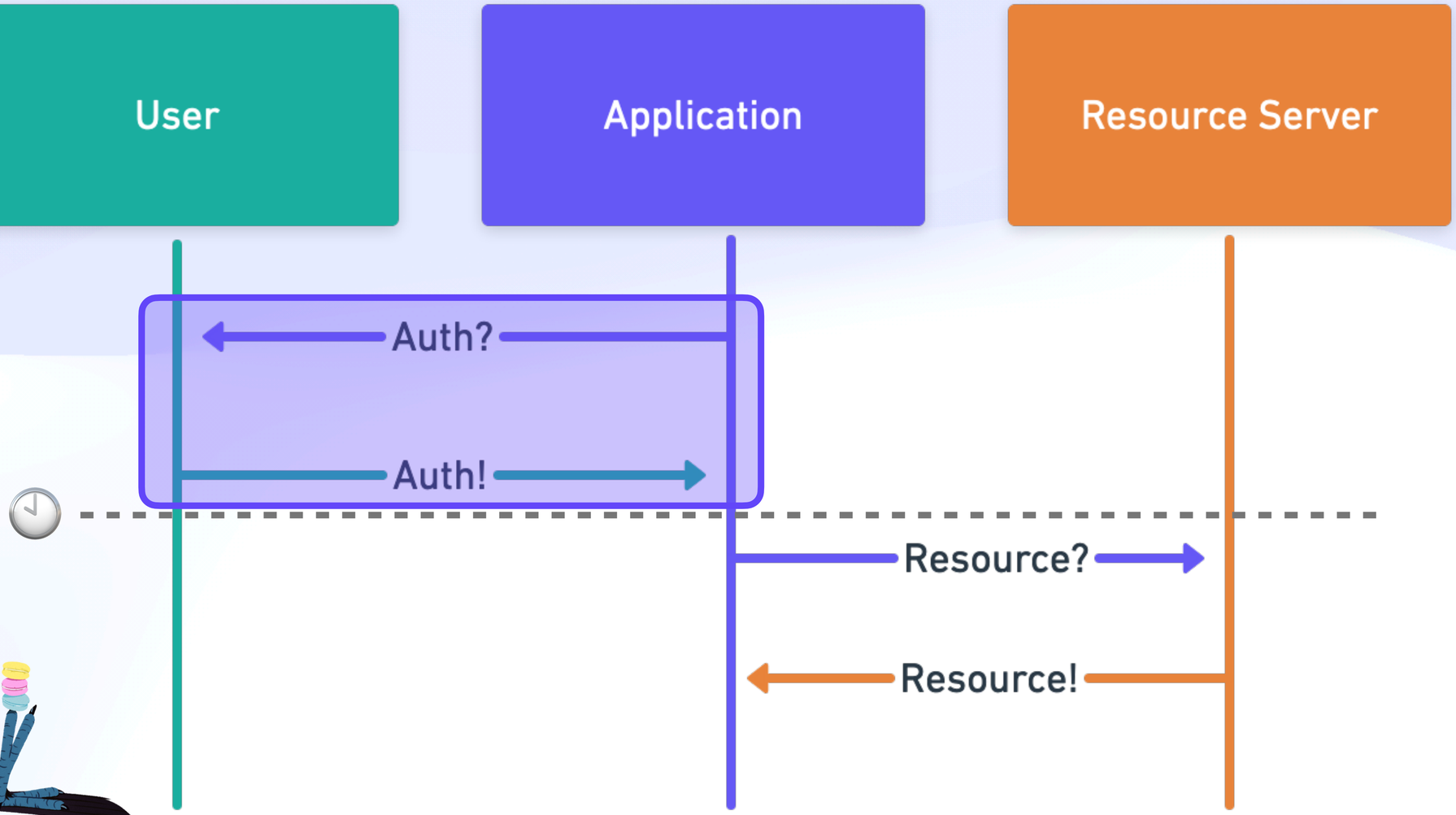

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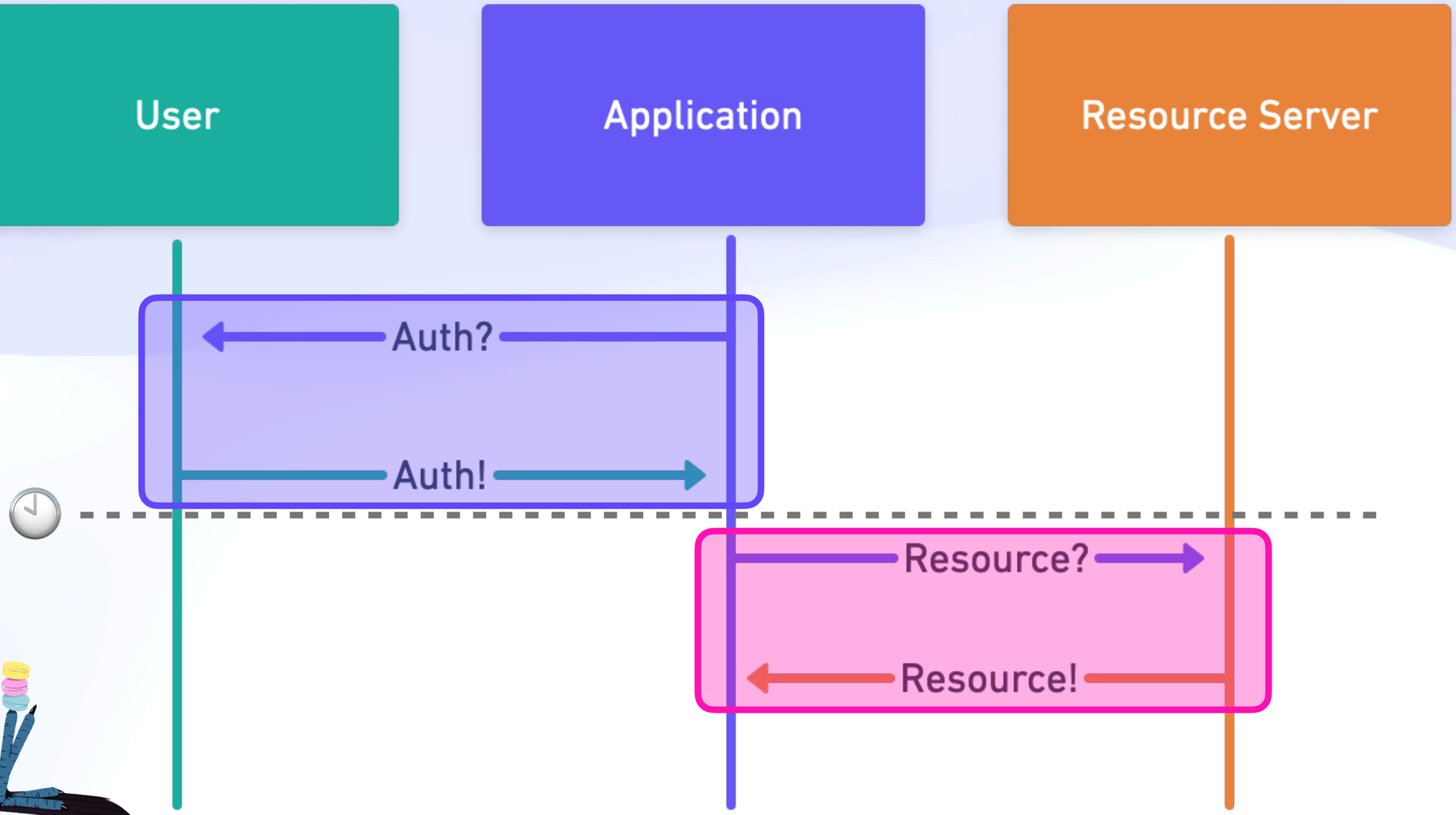

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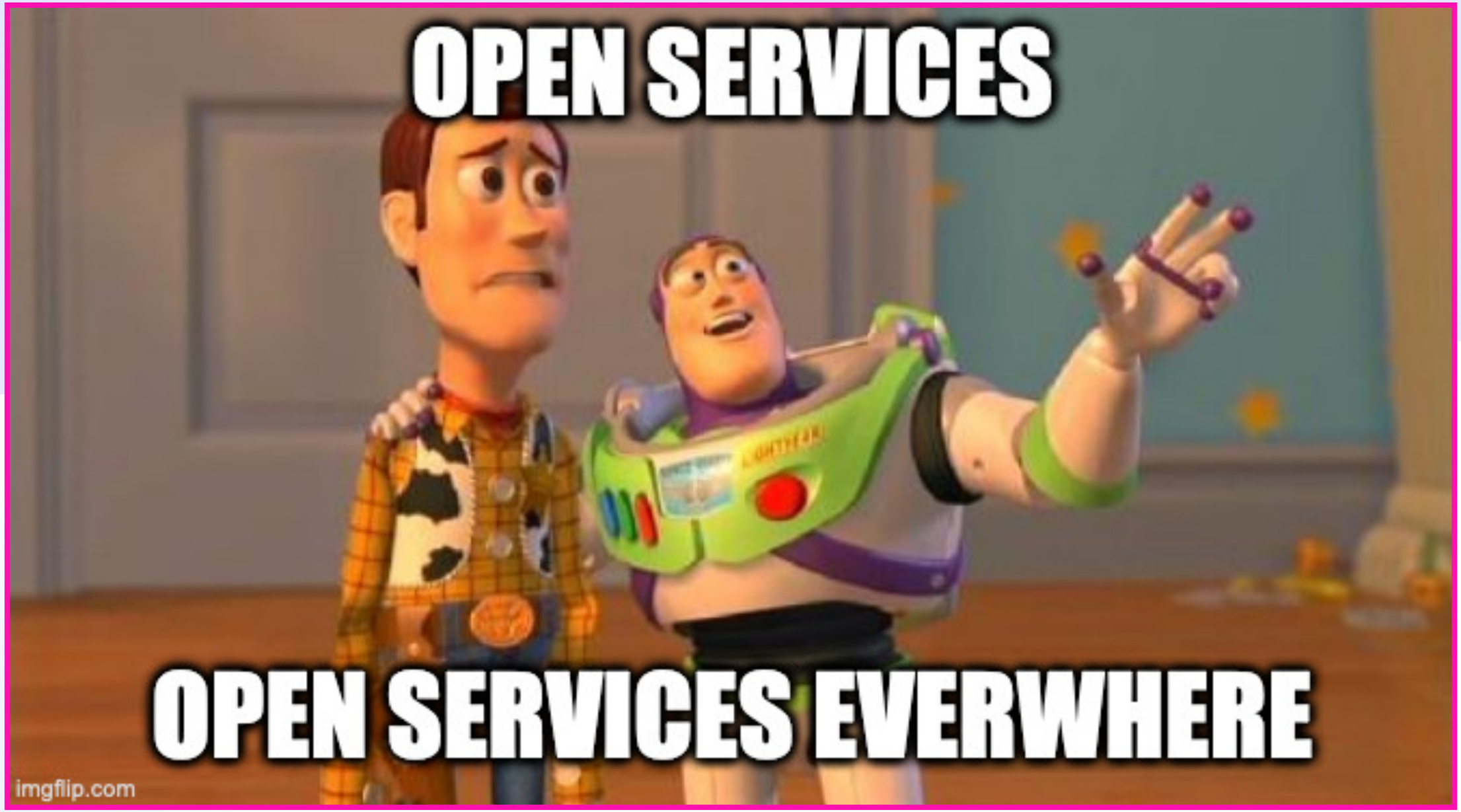
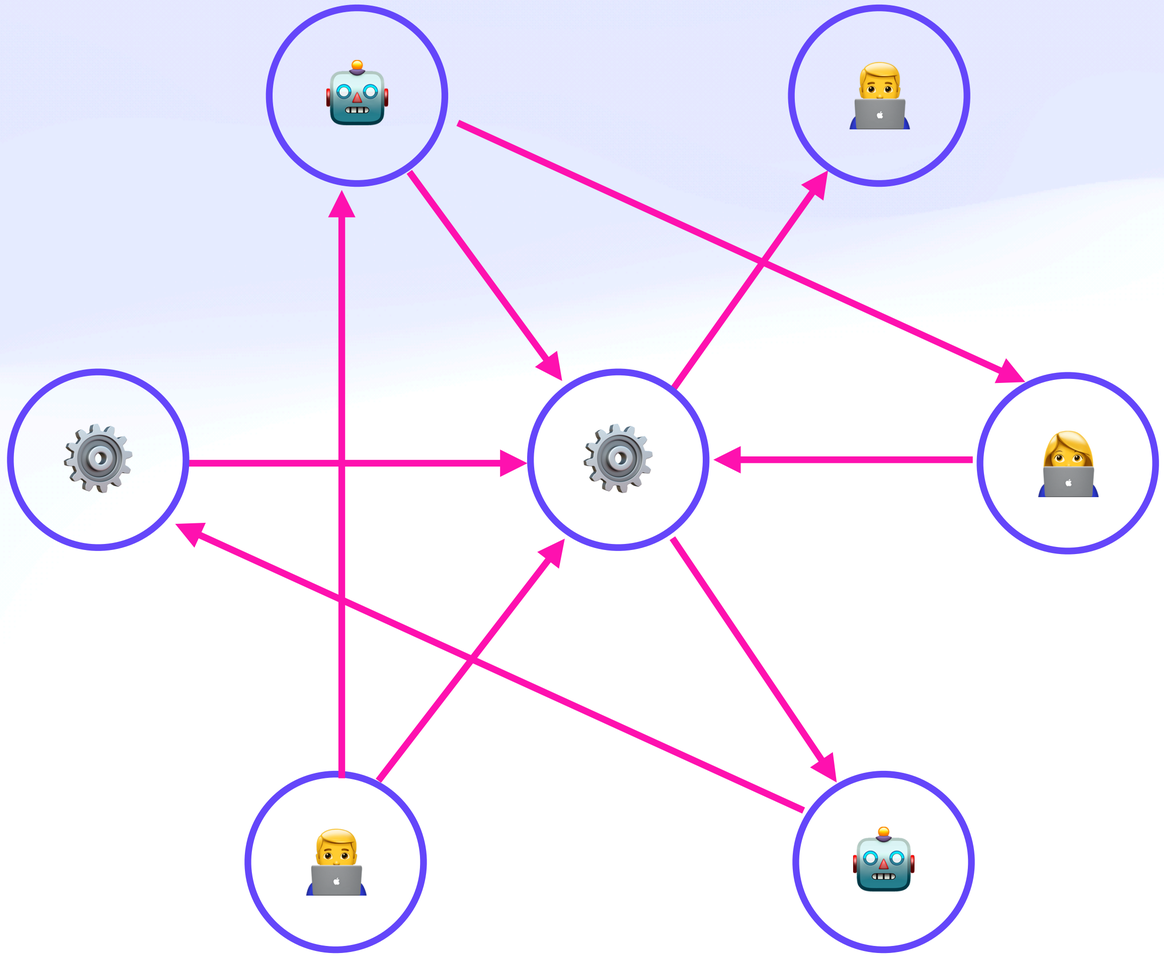


Signs of a Way Out

Disorderly Programming

Signs of a Way Out

Disorderly Programming



Signs of a Way Out

Don't Make Me Think

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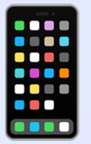

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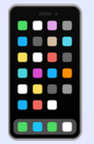

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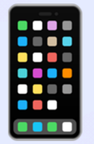

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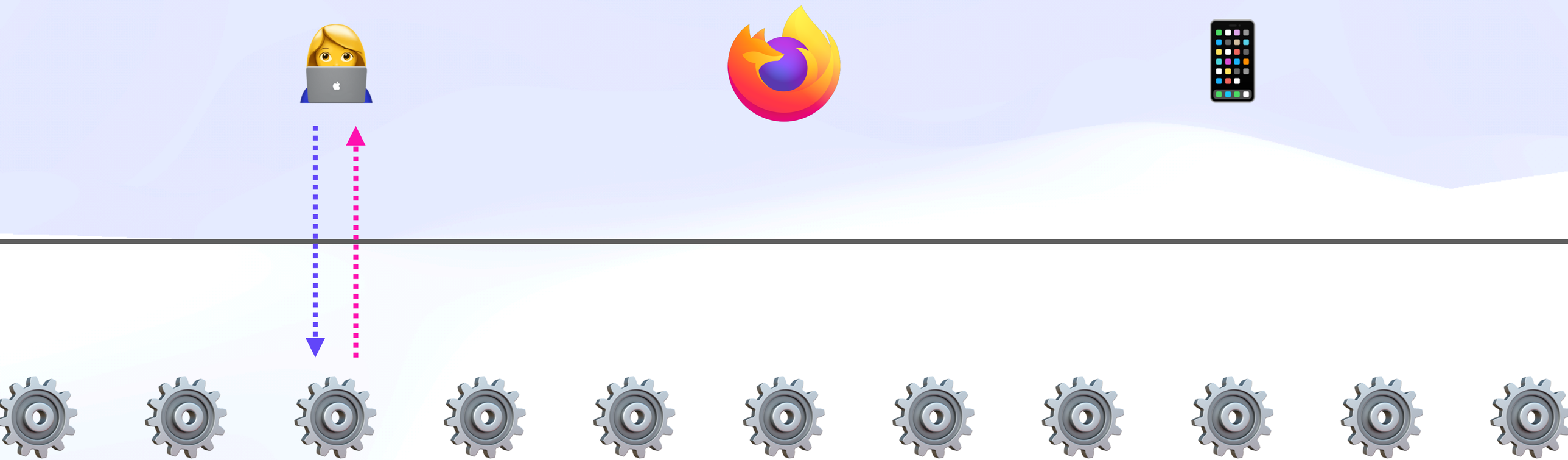

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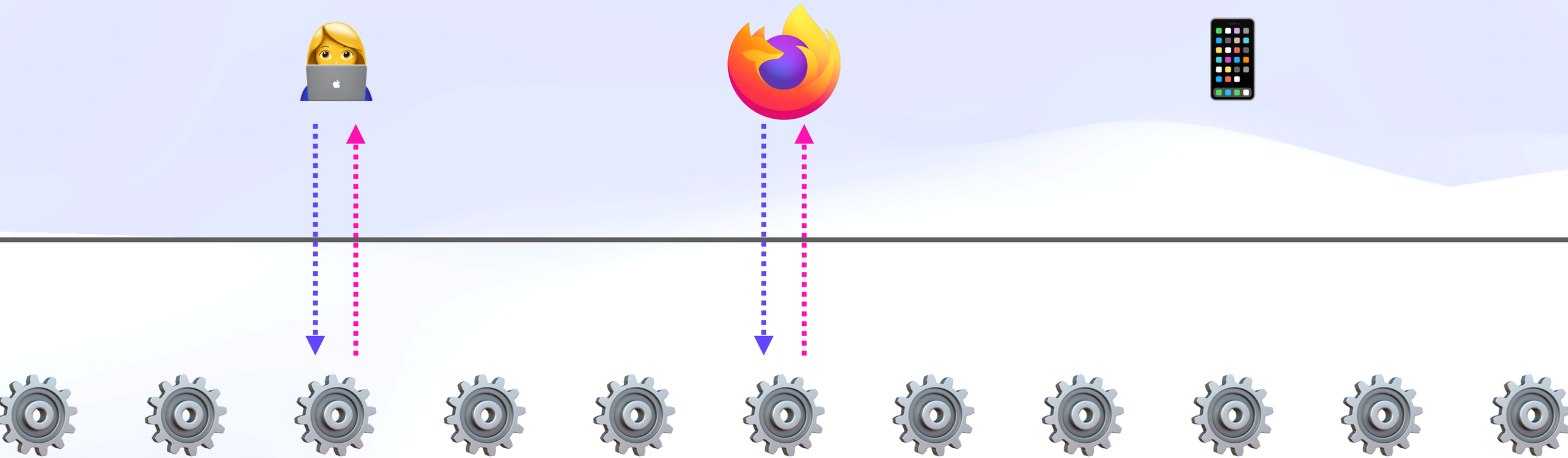

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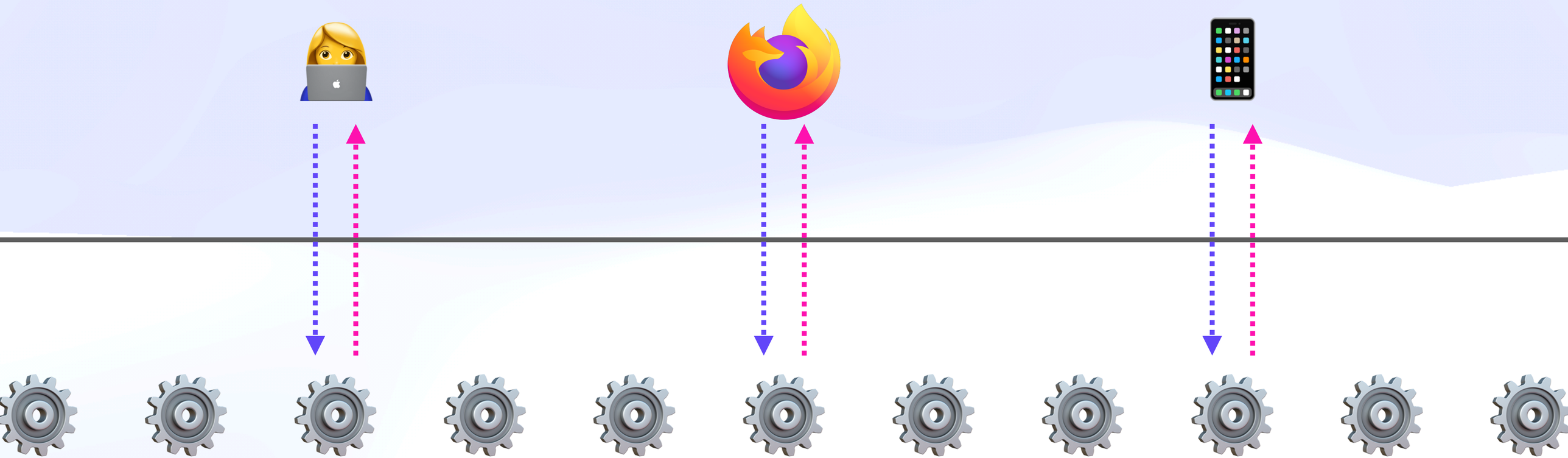



Compute Substrate
— Schedule. Execute. Verify. Reuse —

Compute Substrate

Wasm Eats the World 🤤

Compute Substrate

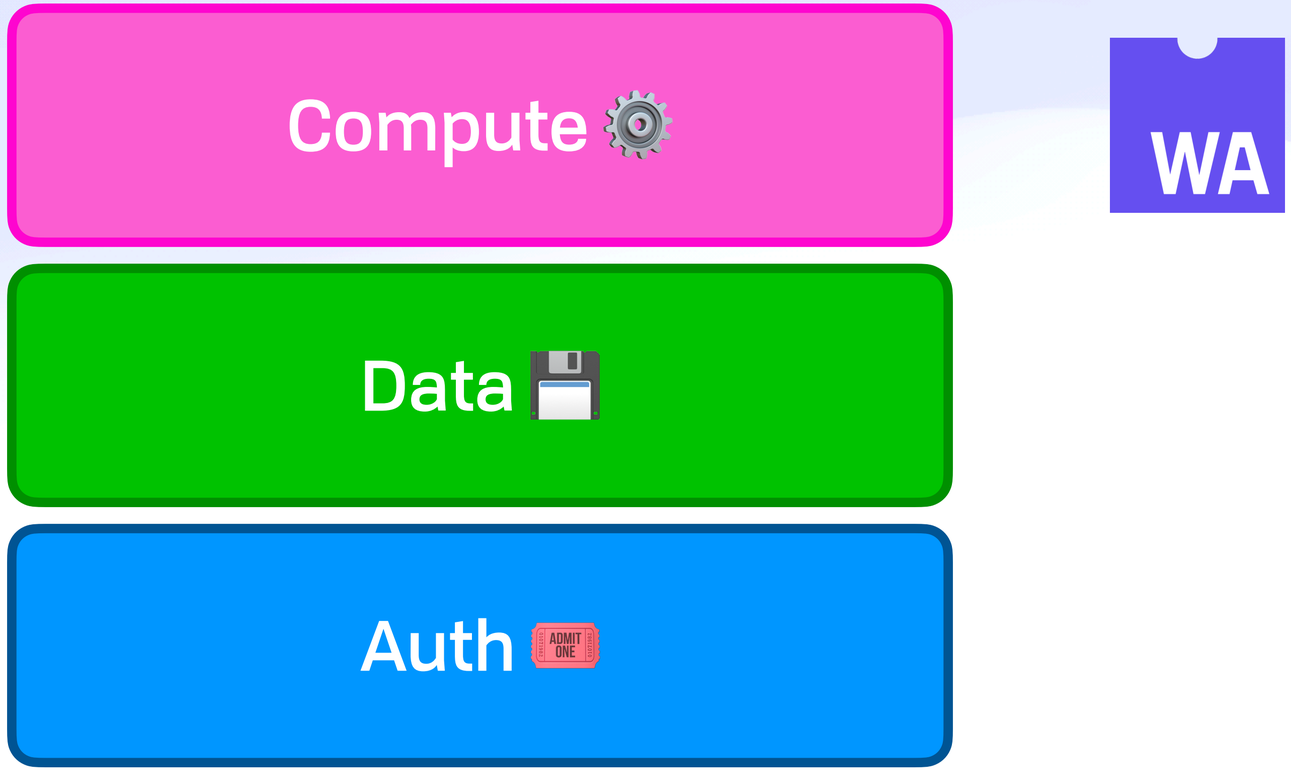
Wasm Eats the World 🤤

Compute Substrate

With Their Powers Combined!

Compute Substrate

With Their Powers Combined!



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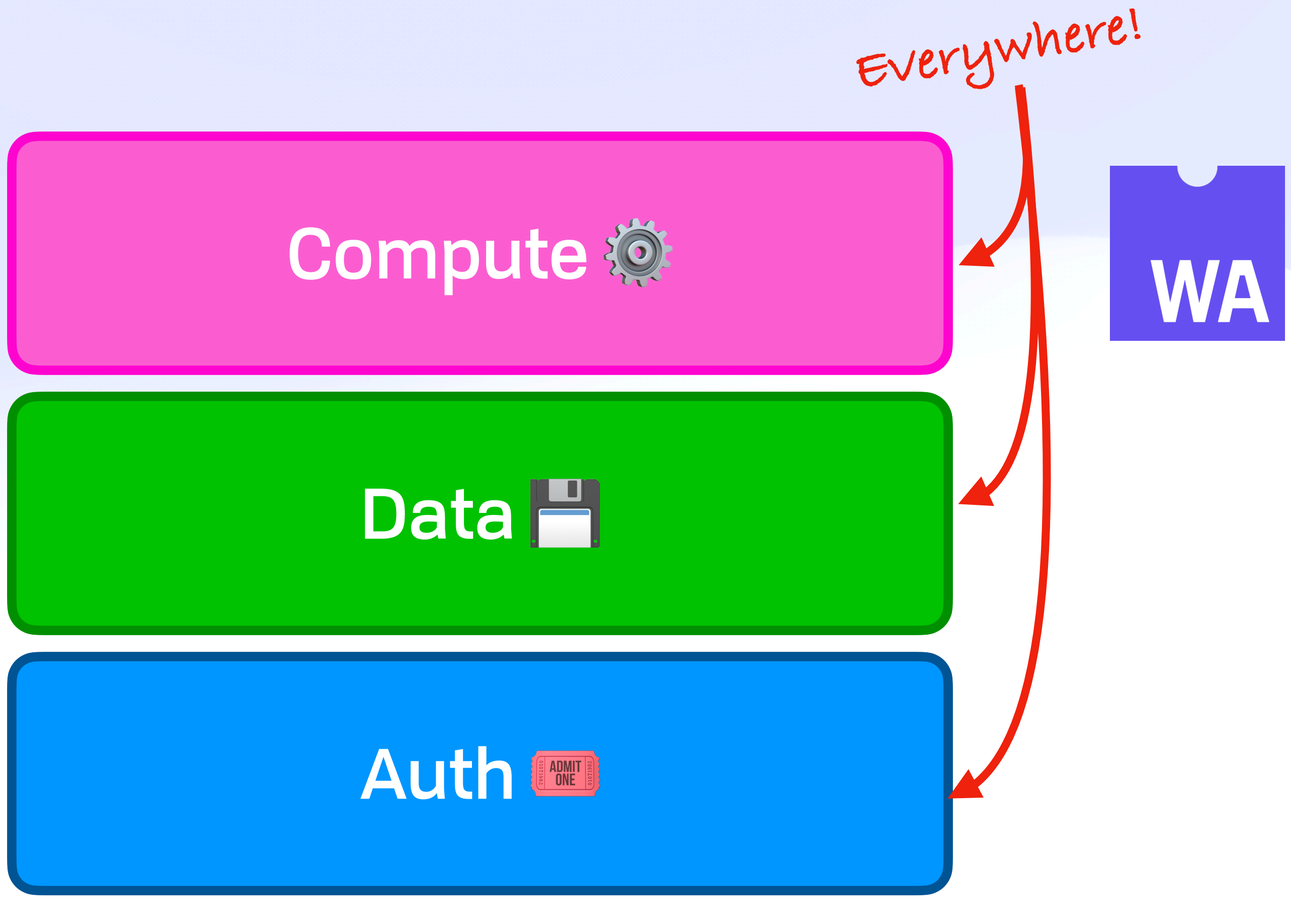
With Their Powers Combined!



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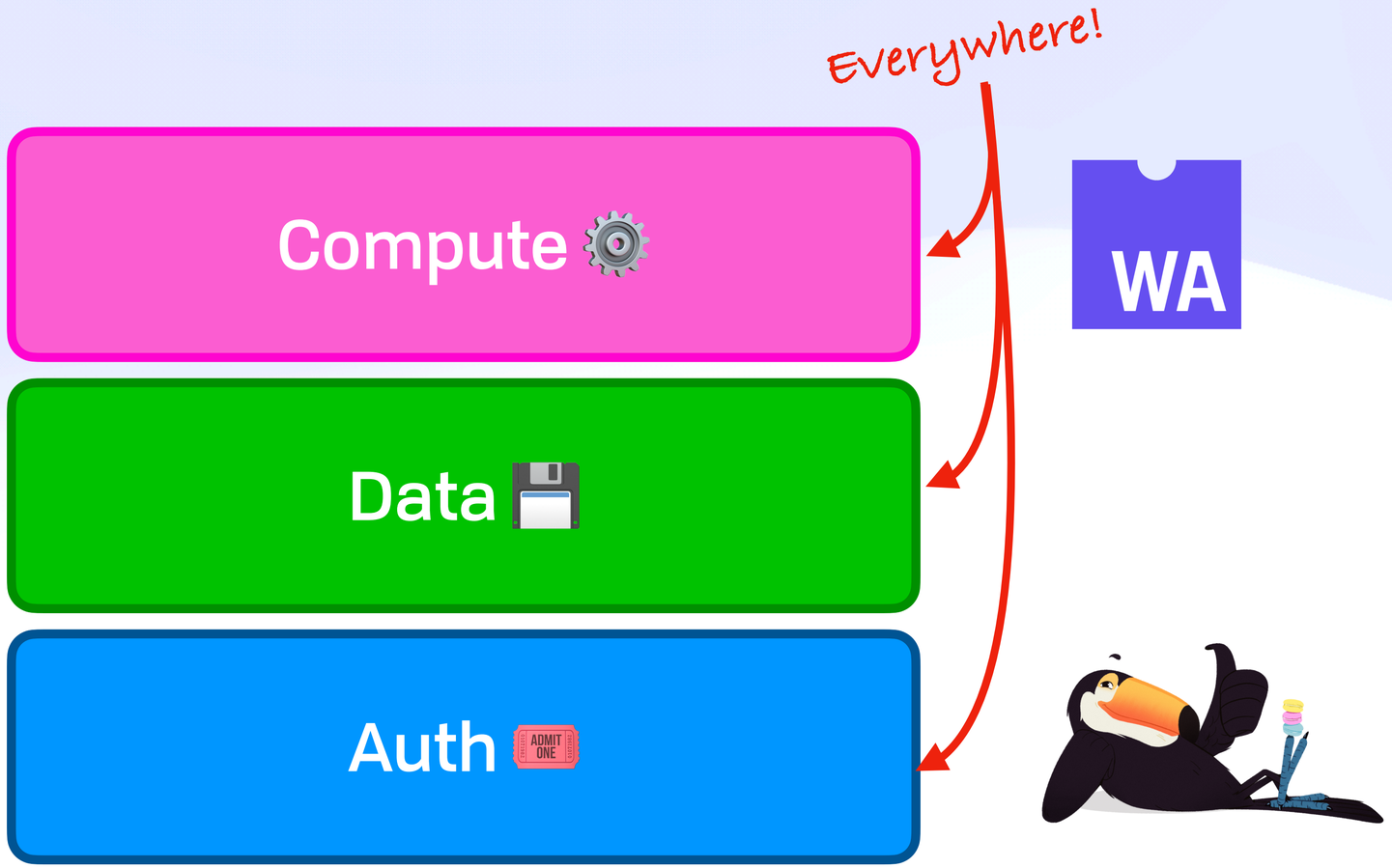

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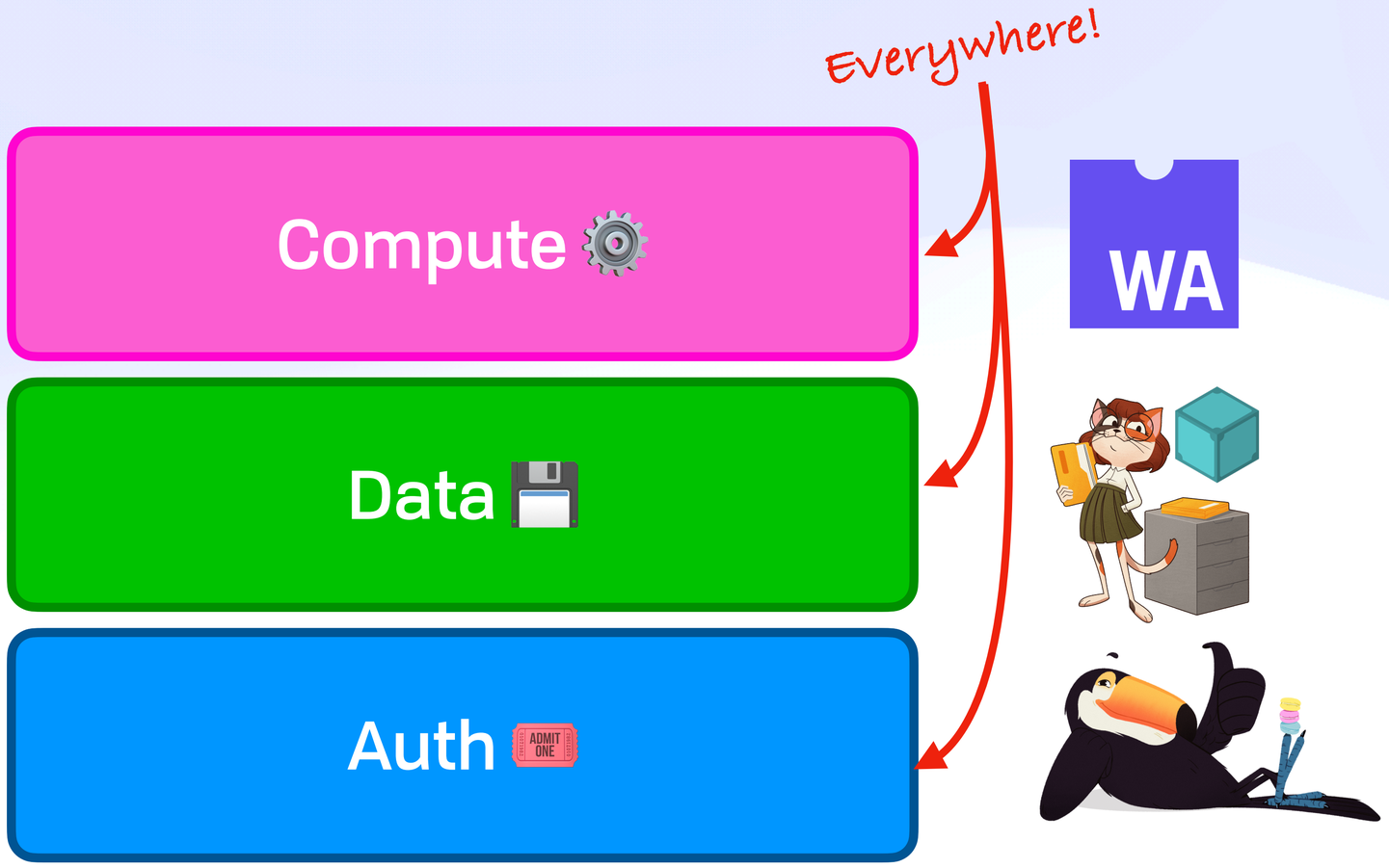

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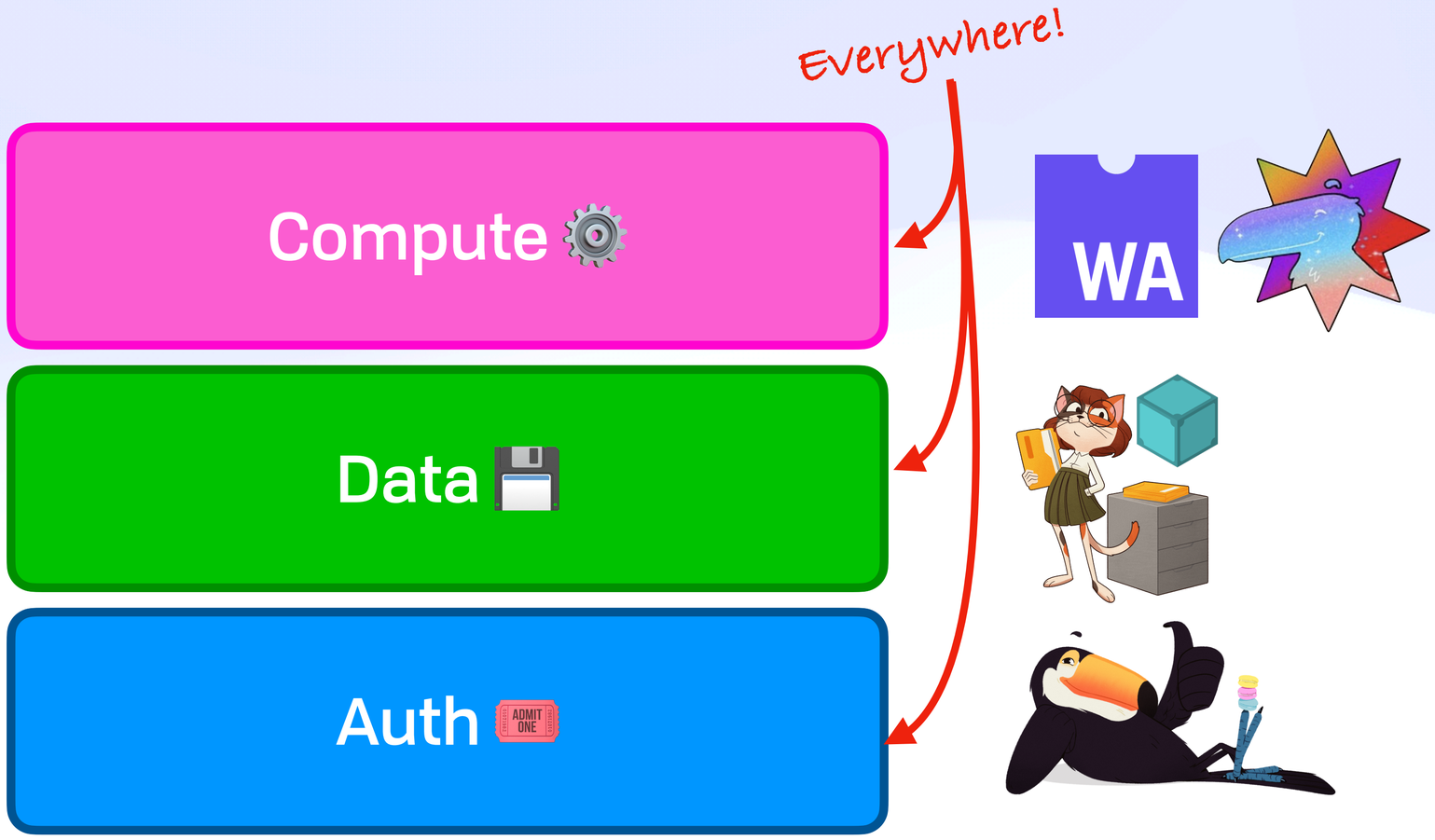


Compute Substrate

With Their Powers Combined!

Everywhere!

IPVM

Compute ⚙️

Data 💾

Auth 🎟️

Compute Substrate

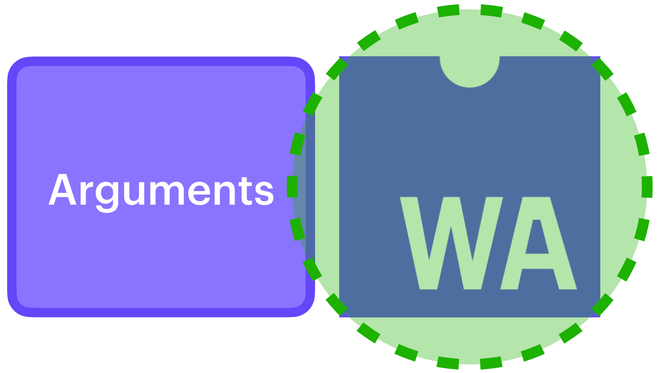
Code-as-Data

Compute Substrate

Code-as-Data

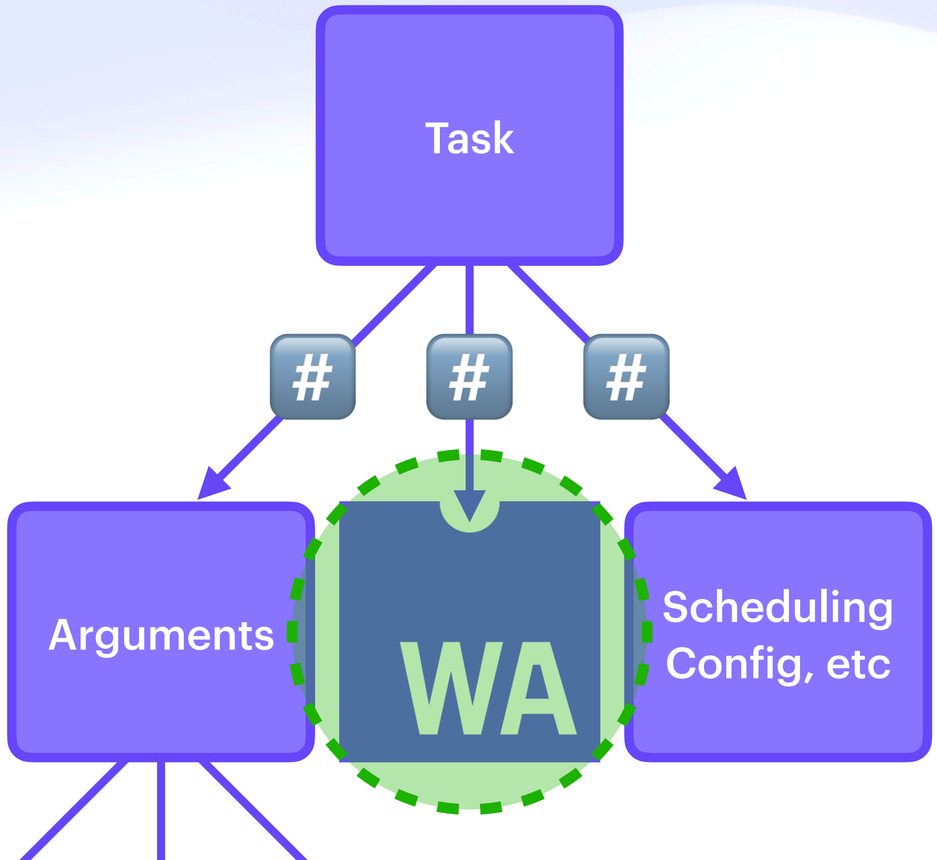
Compute Substrate

Code-as-Data



Compute Substrate

Code-as-Data



Compute Substrate

Code-as-Data

```
const message = () ⇒ alert("hello world")
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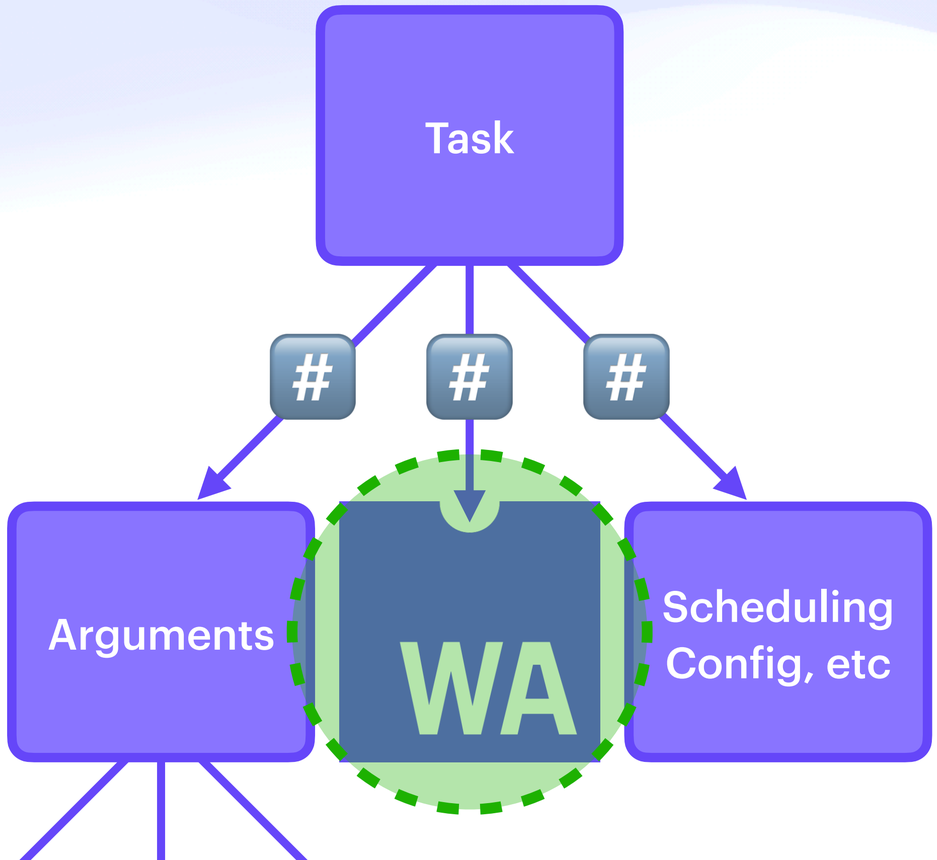
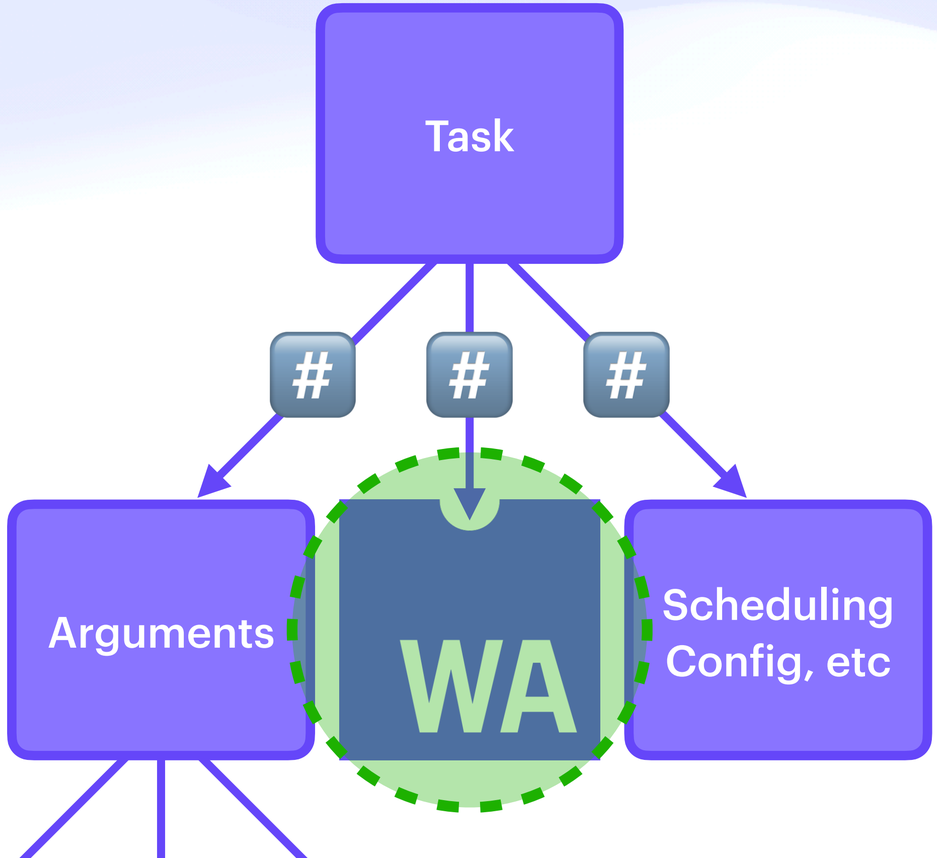


Compute Substrate

Code-as-Data

```
const message = () ⇒ alert("hello world")

message // Nothing happens
```



Compute Substrate

Code-as-Data

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message // Nothing happens

message() // A message interrupts the user
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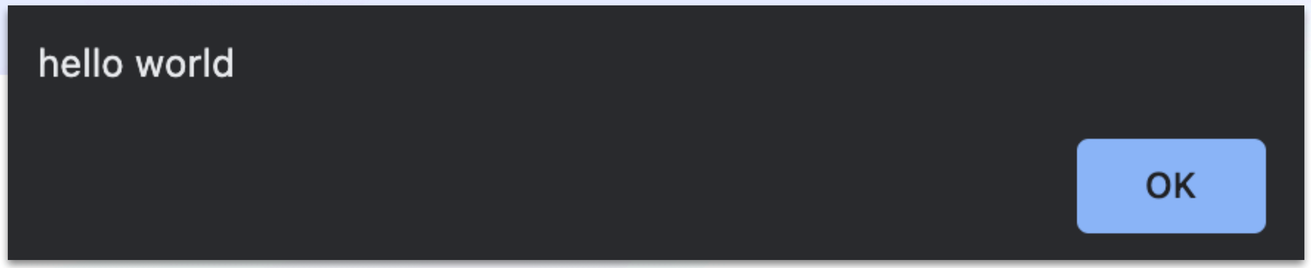

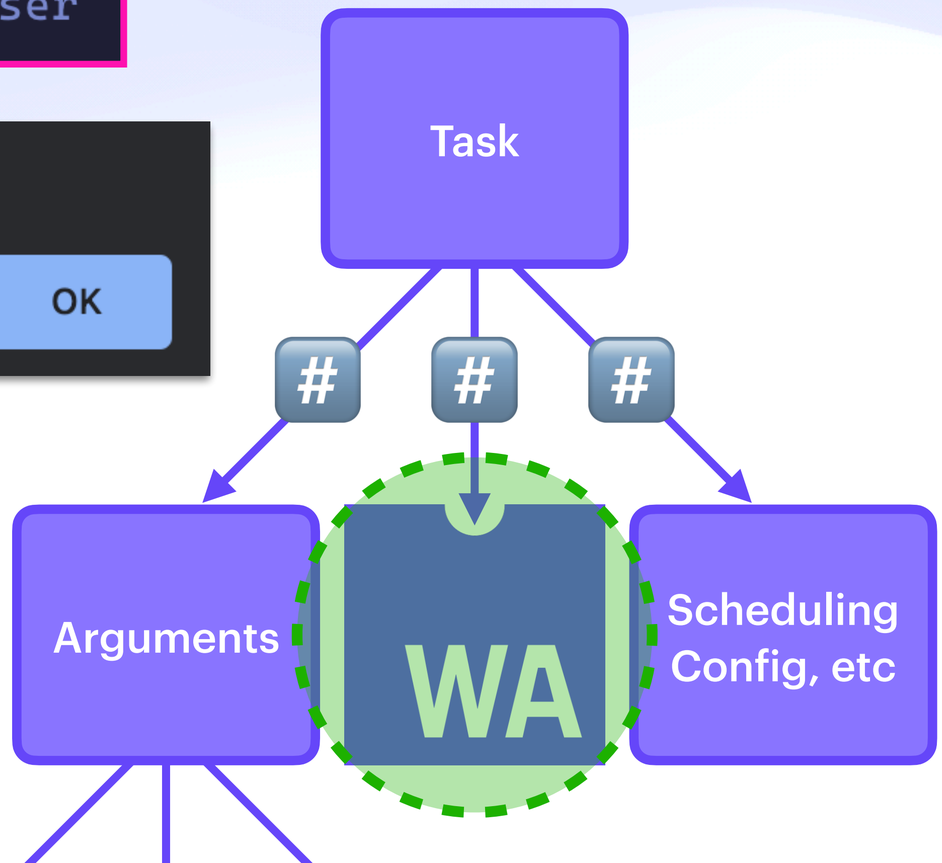

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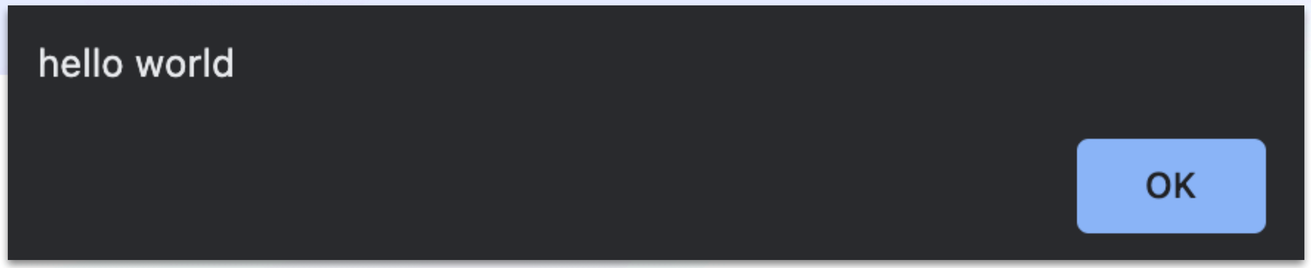

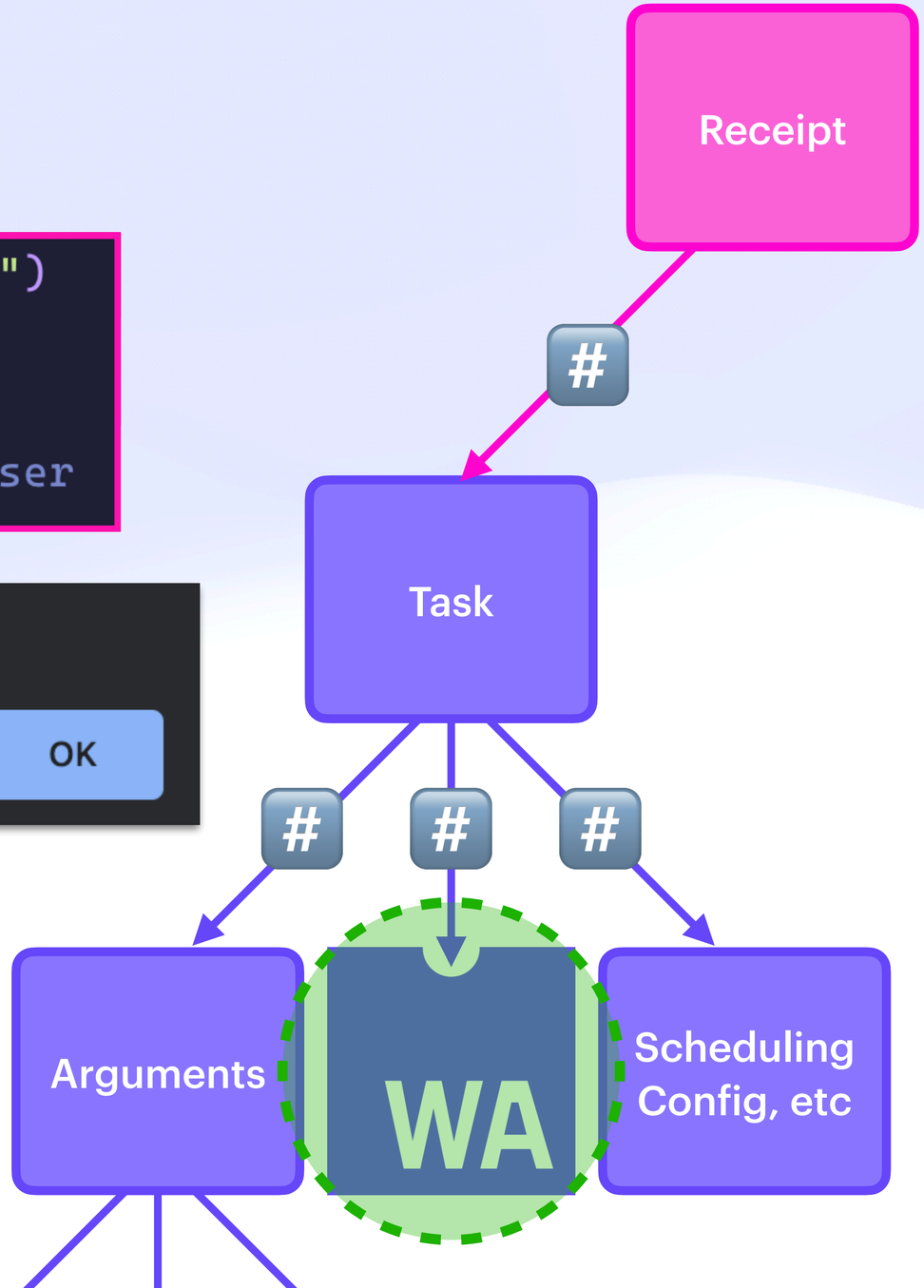

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```
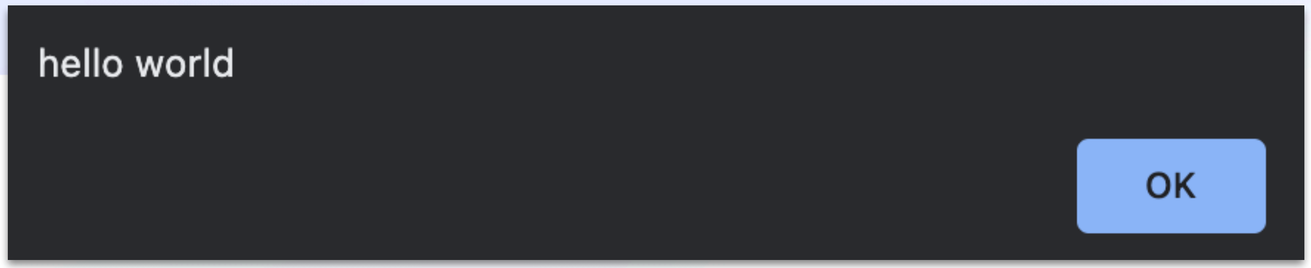
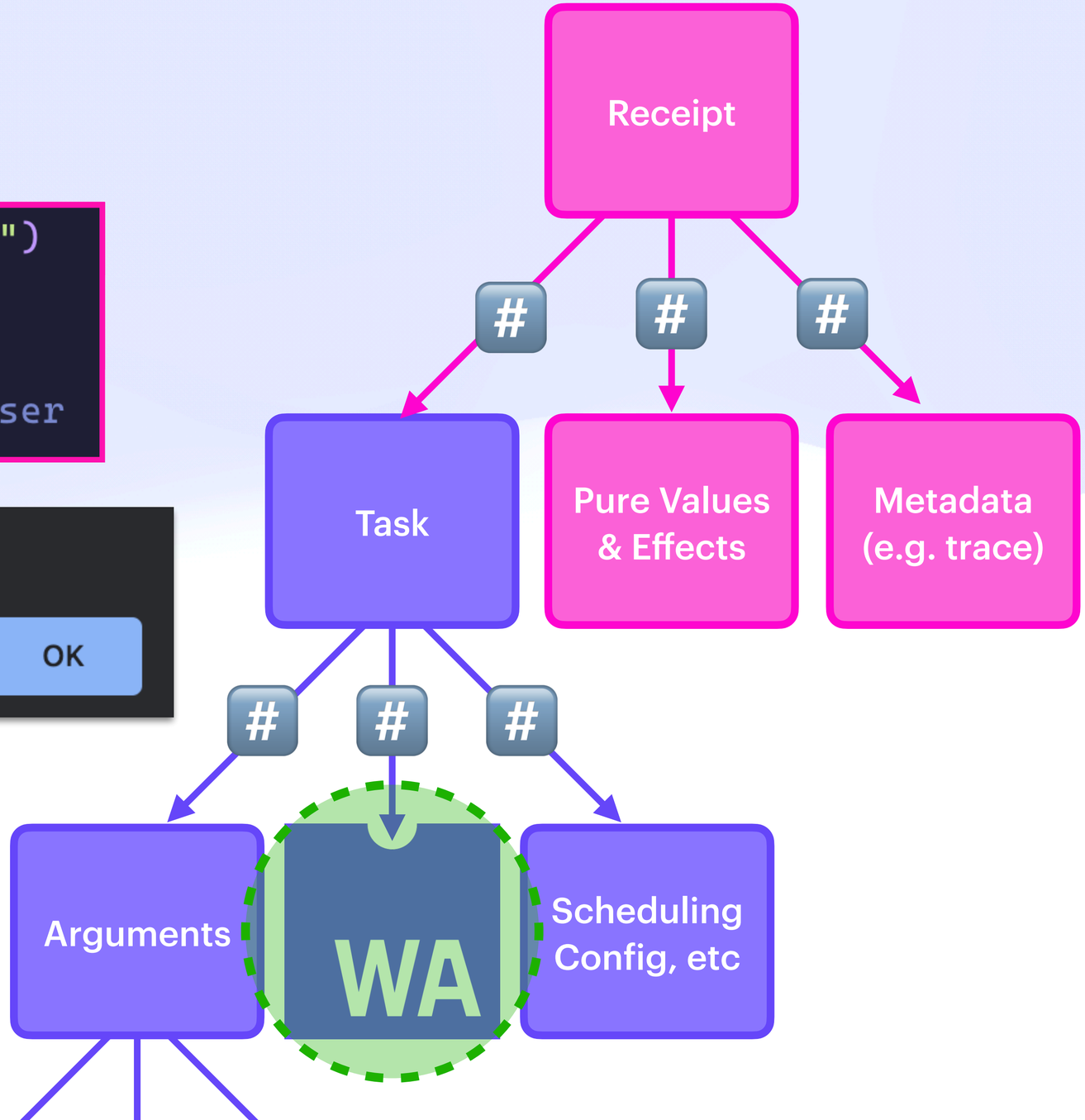





Compute Substrate

Invocation & Distributed Promises

Compute Substrate

Invocation & Distributed Promises

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [42]
    }
}
```

Compute Substrate

Invocation & Distributed Promises

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [42]
    }
}
```

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [{"await/ok": {"/": "bafkreiauharffox63dv2iakndymassol3ryznr32tqii6ijw6ter3ksleu"}}]
    }
}
```

Compute Substrate

Invocation & Distributed Promises

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [42]
    }
}
```

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [{"await/ok": {"/": "bafkreiauharffox63dv2iakndymassol3ryznr32tqii6ijw6ter3ksleu"}}]
    }
}
```

Compute Substrate

Invocation & Distributed Promises

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [42]
    }
}
```

```
{
    "uri": "ipfs://bafkreibmj5zo6x2g7kuzcqpsikr5q34rnzgbjkxk6rjf5ibu5szmx74hxy",
    "call": "wasm/run",
    "input": {
        "func": "add_one",
        "args": [{"await/ok": {"/": "bafkreiauharffox63dv2iakndymassol3ryznr32tqii6ijw6ter3ksleu"}}]
    }
}
```

Compute Substrate

Distributed Invocation

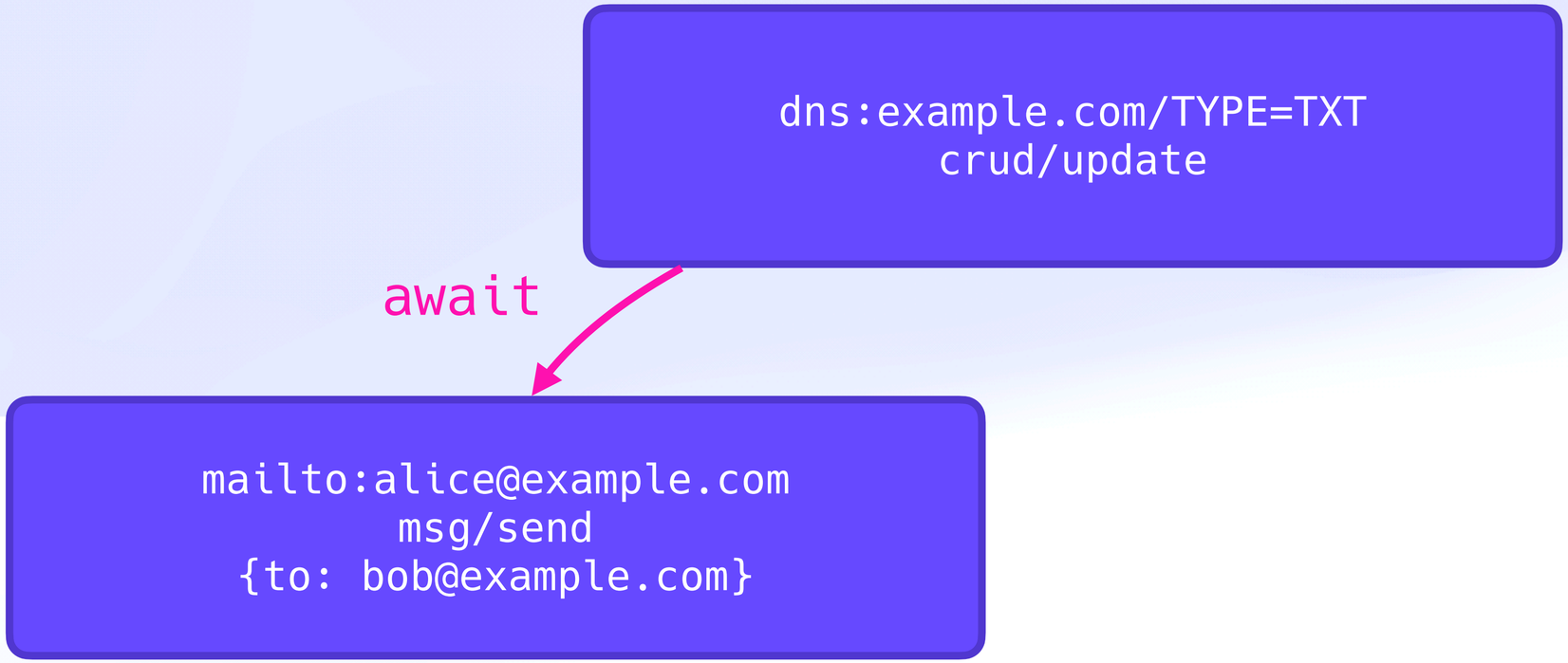
Compute Substrate

Distributed Invocation

```
dns:example.com/TYPE=TXT
crud/update
```

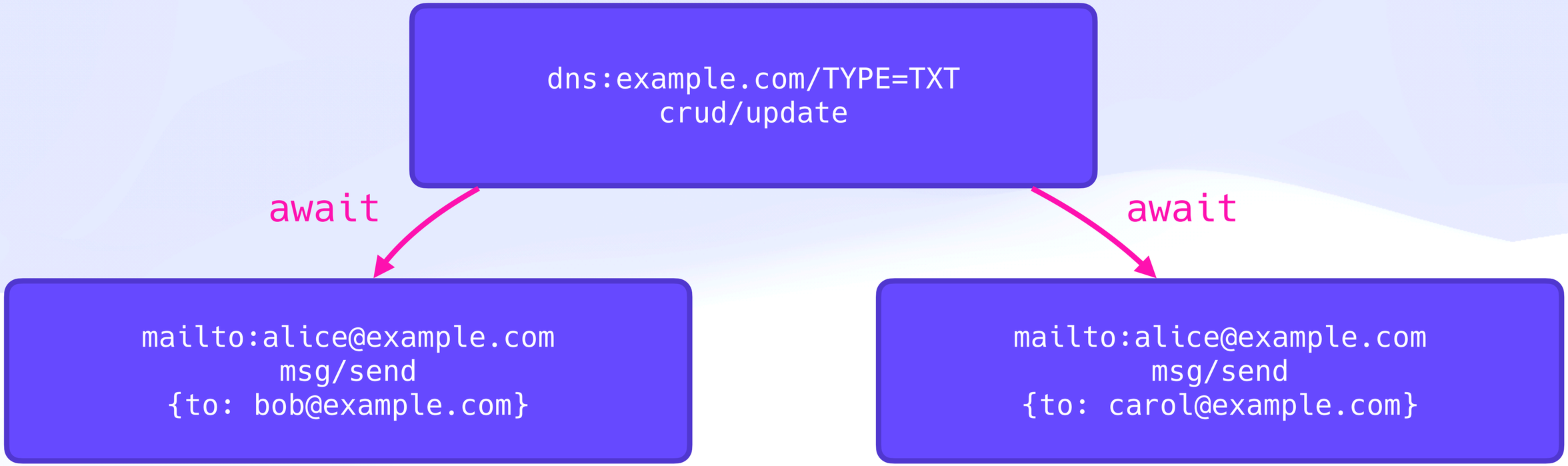
Compute Substrate

Distributed Invocation



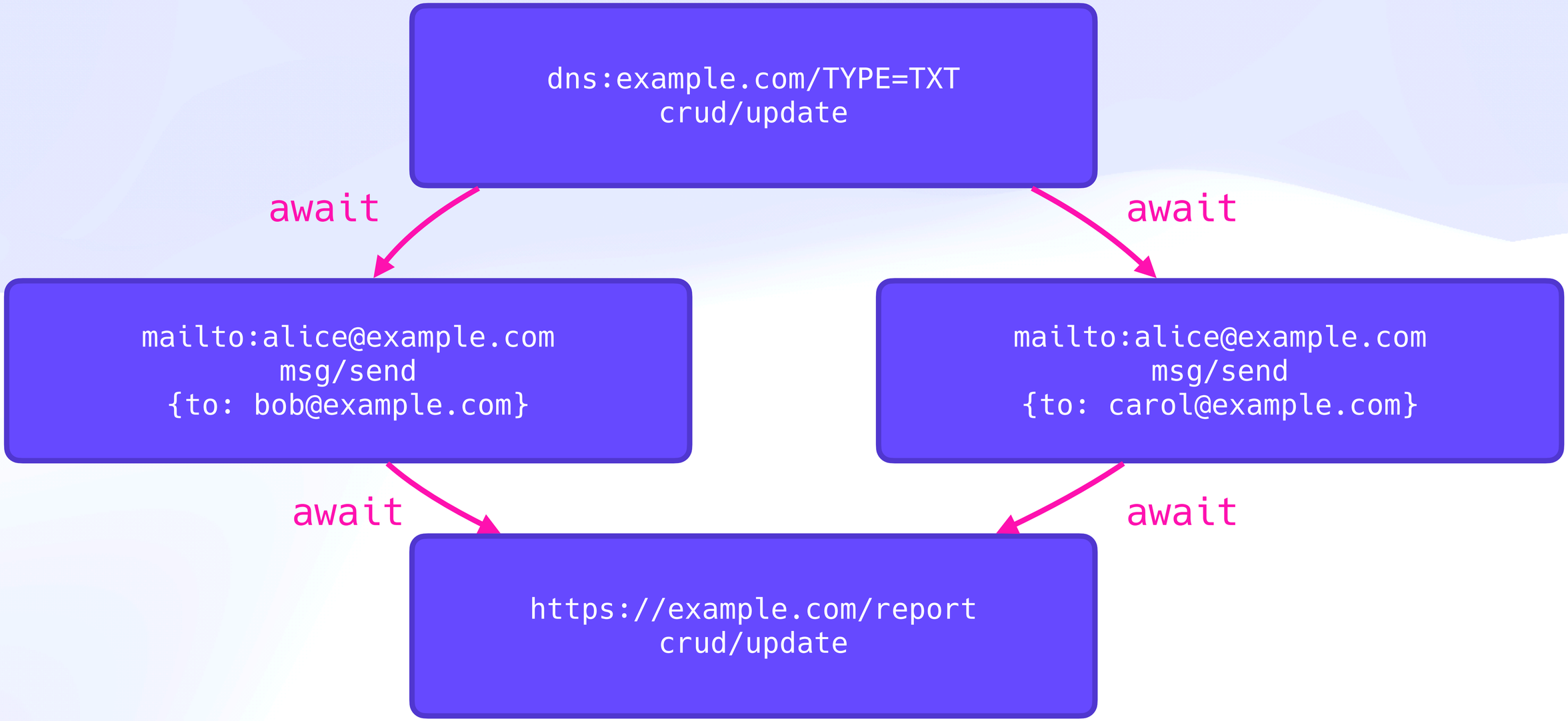
Compute Substrate

Distributed Invocation



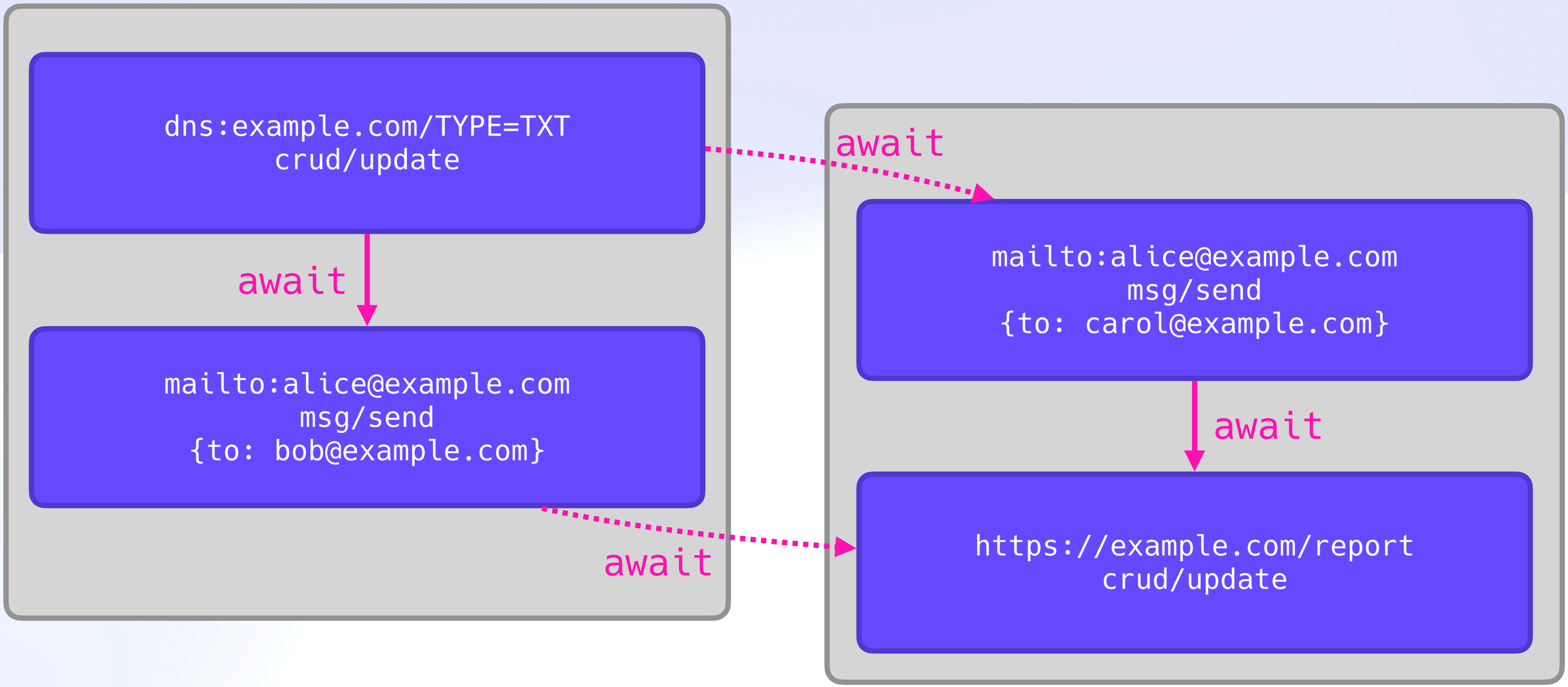
Compute Substrate

Distributed Invocation



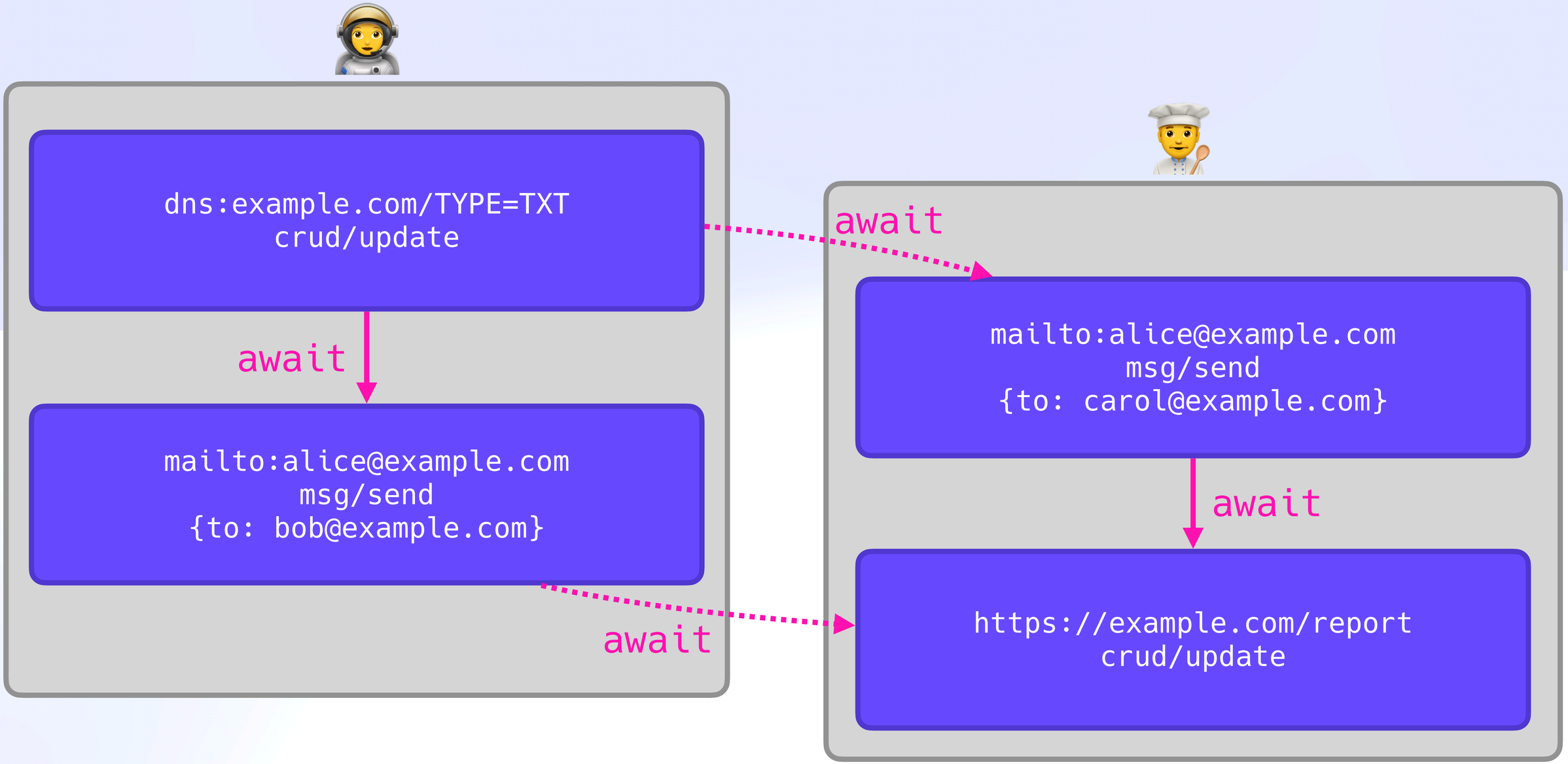
Compute Substrate

Distributed Invocation



Compute Substrate

Distributed Invocation



Compute Substrate

Matchmaking

Compute Substrate

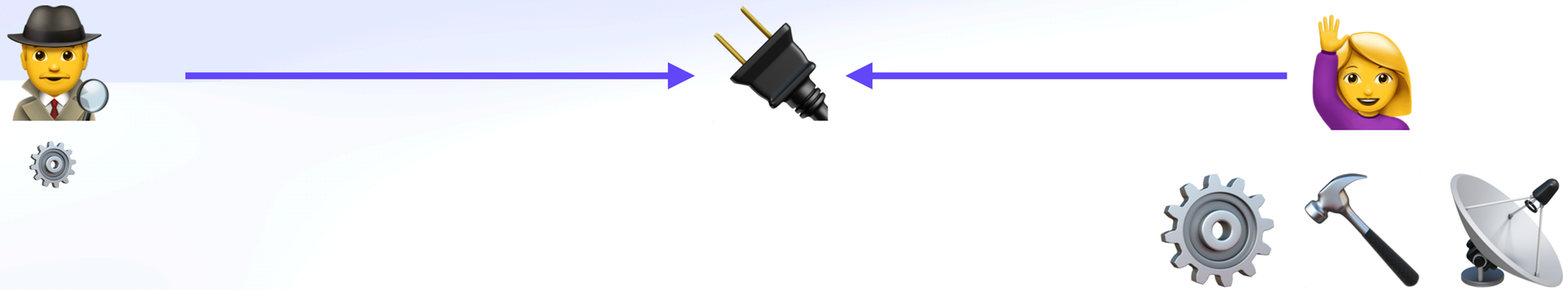
Matchmaking

Compute Substrate

Matchmaking

Compute Substrate

Matchmaking



Compute Substrate

"Nine Nines" Is So 1999

Compute Substrate

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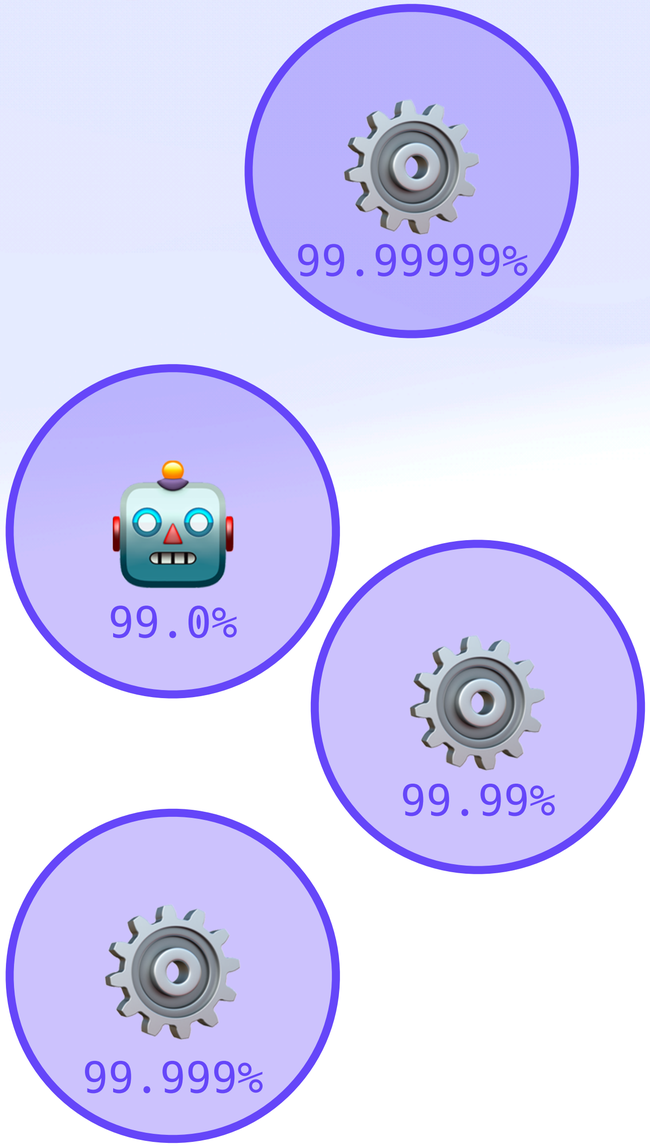
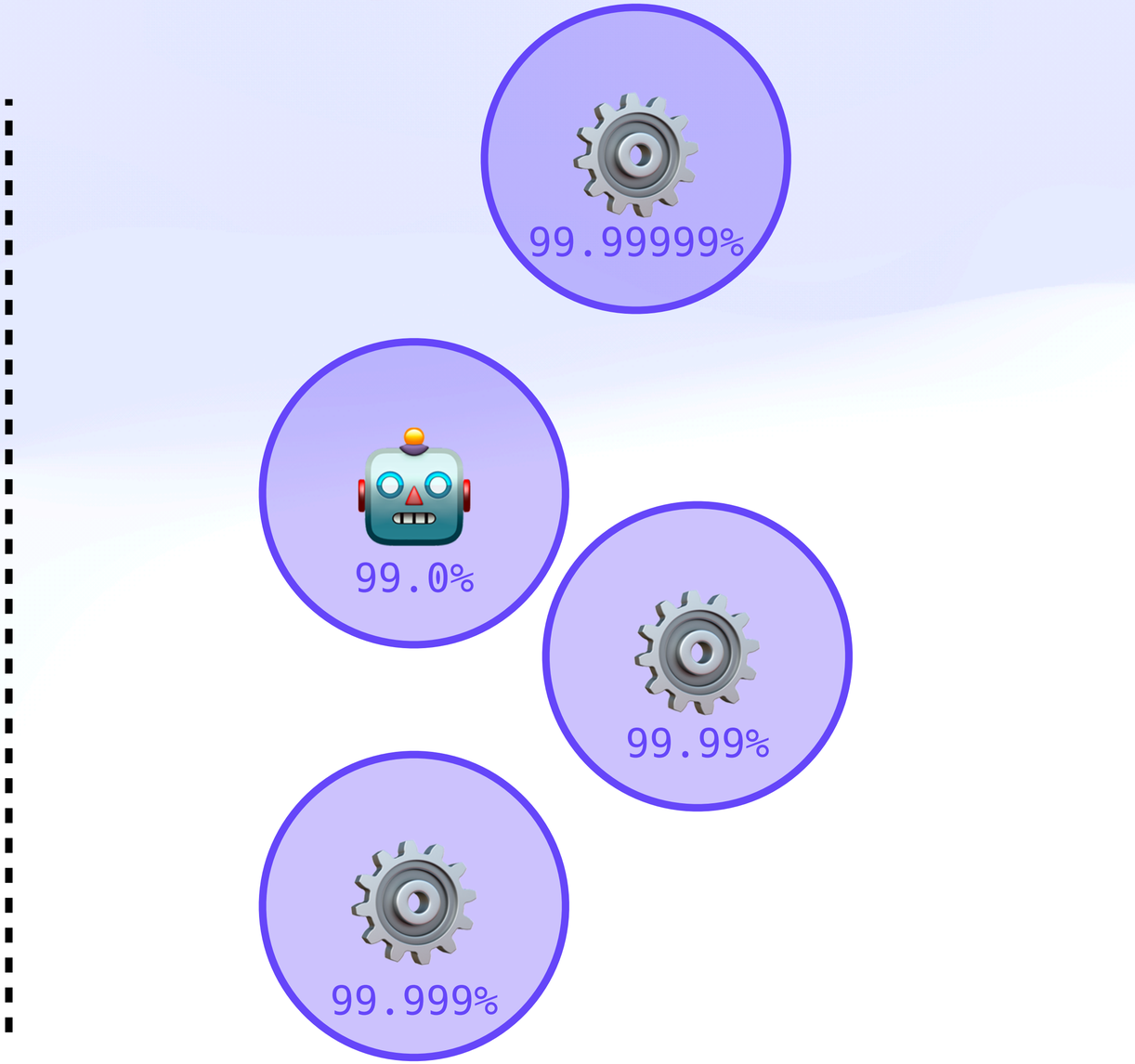
Compute Substrate

"Nine Nines" Is So 1999



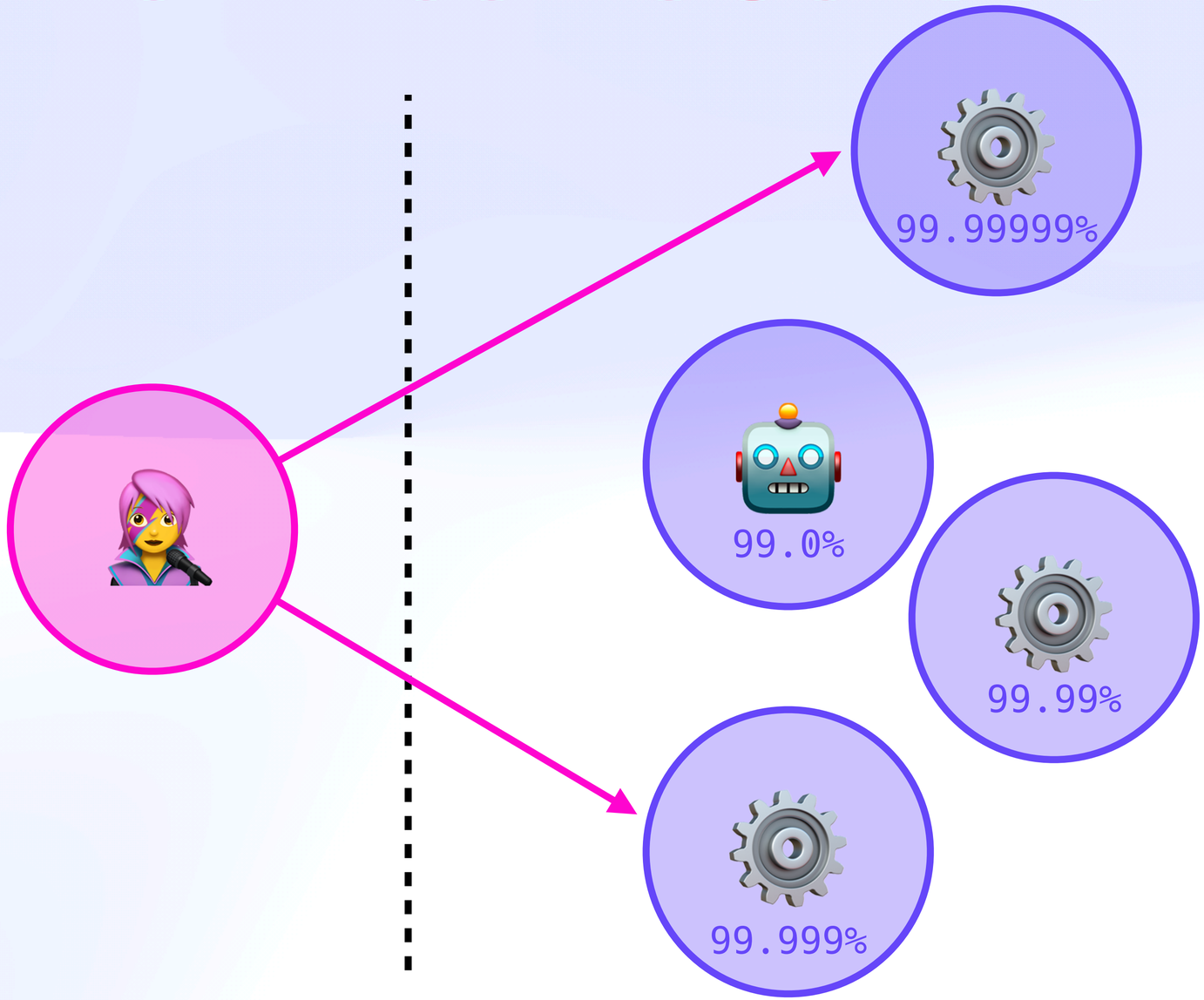
Compute Substrate

"Nine Nines" Is So 1999



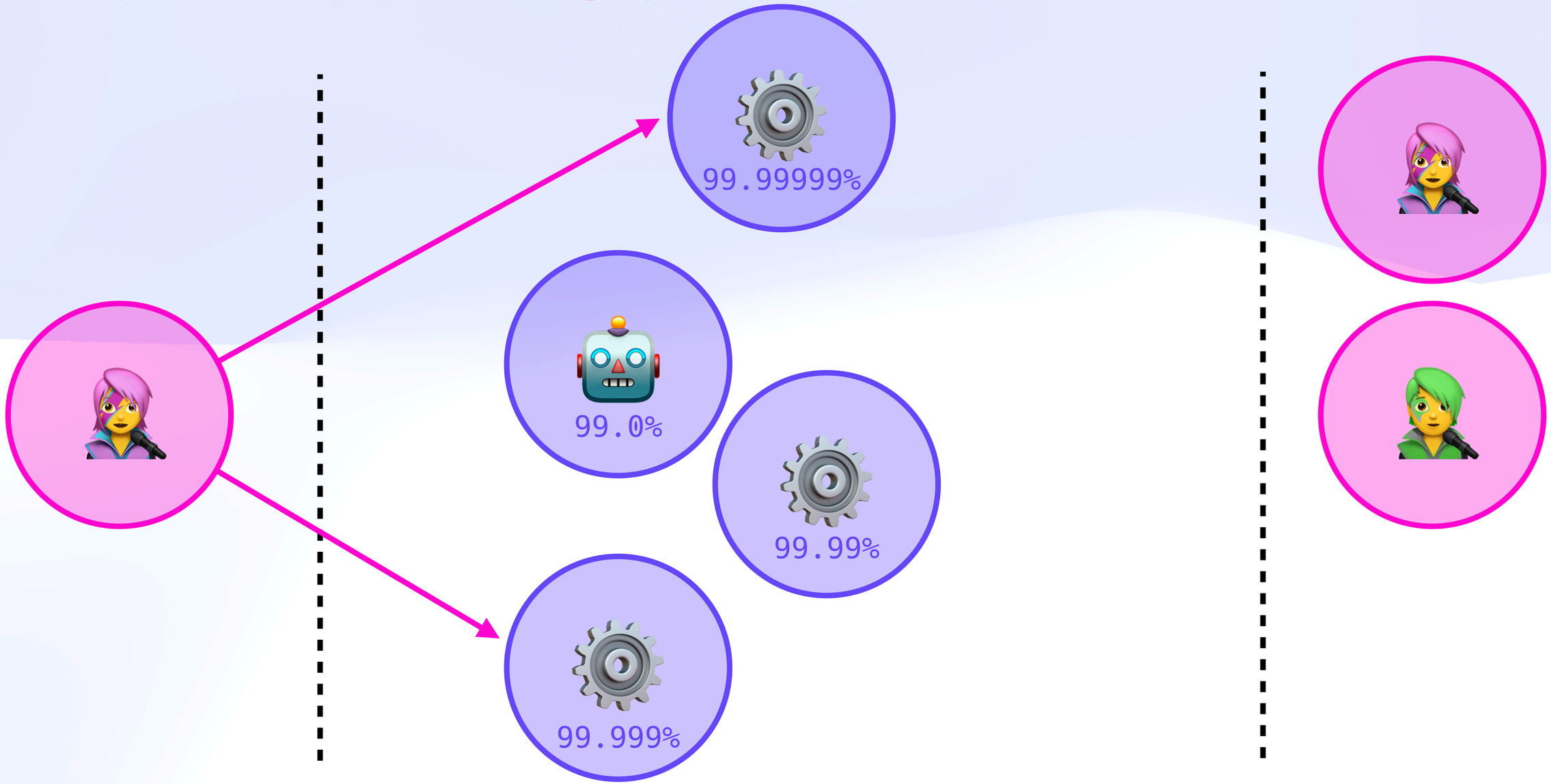
Compute Substrate

"Nine Nines" Is So 1999



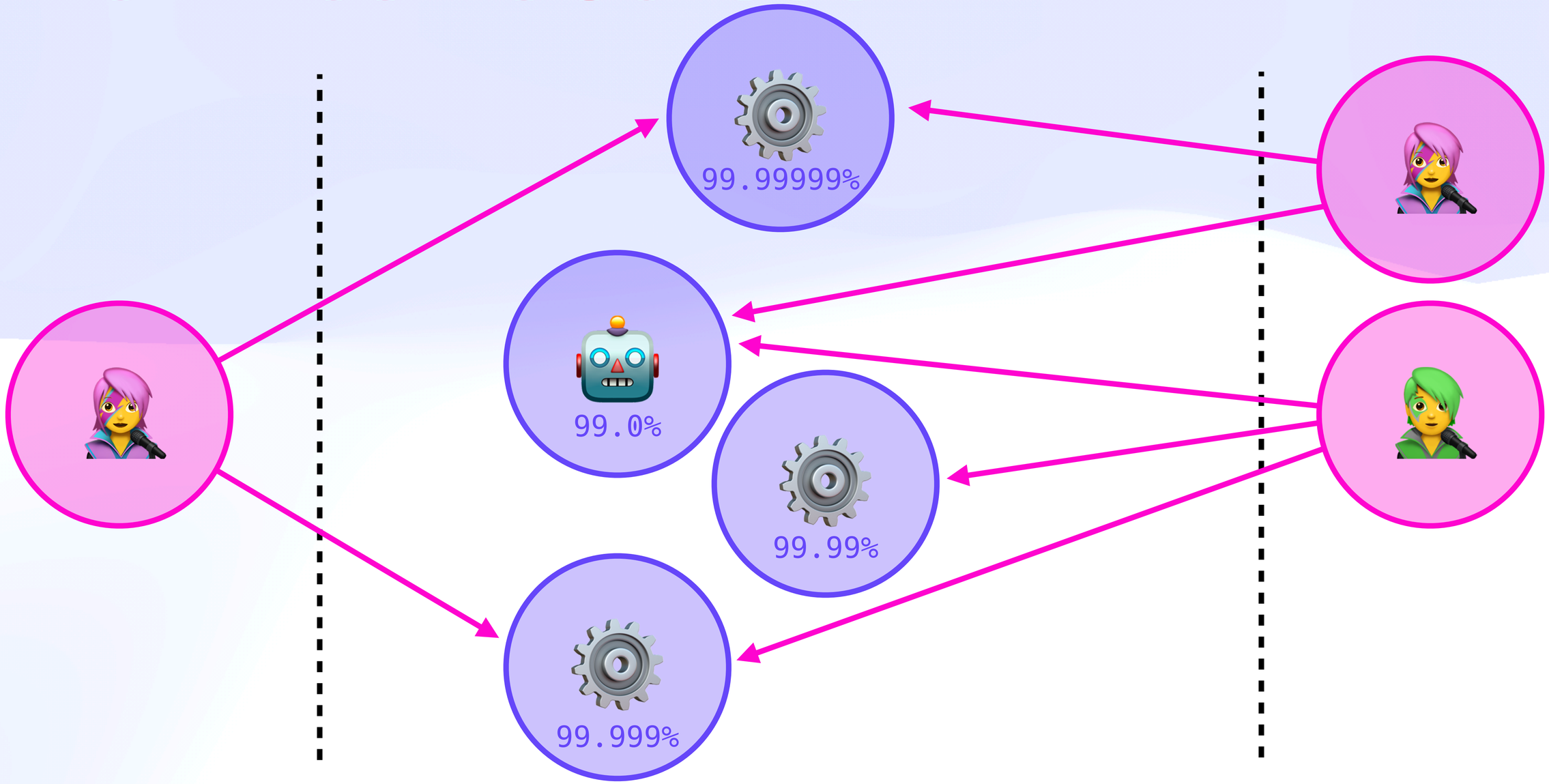
Compute Substrate

"Nine Nines" Is So 1999



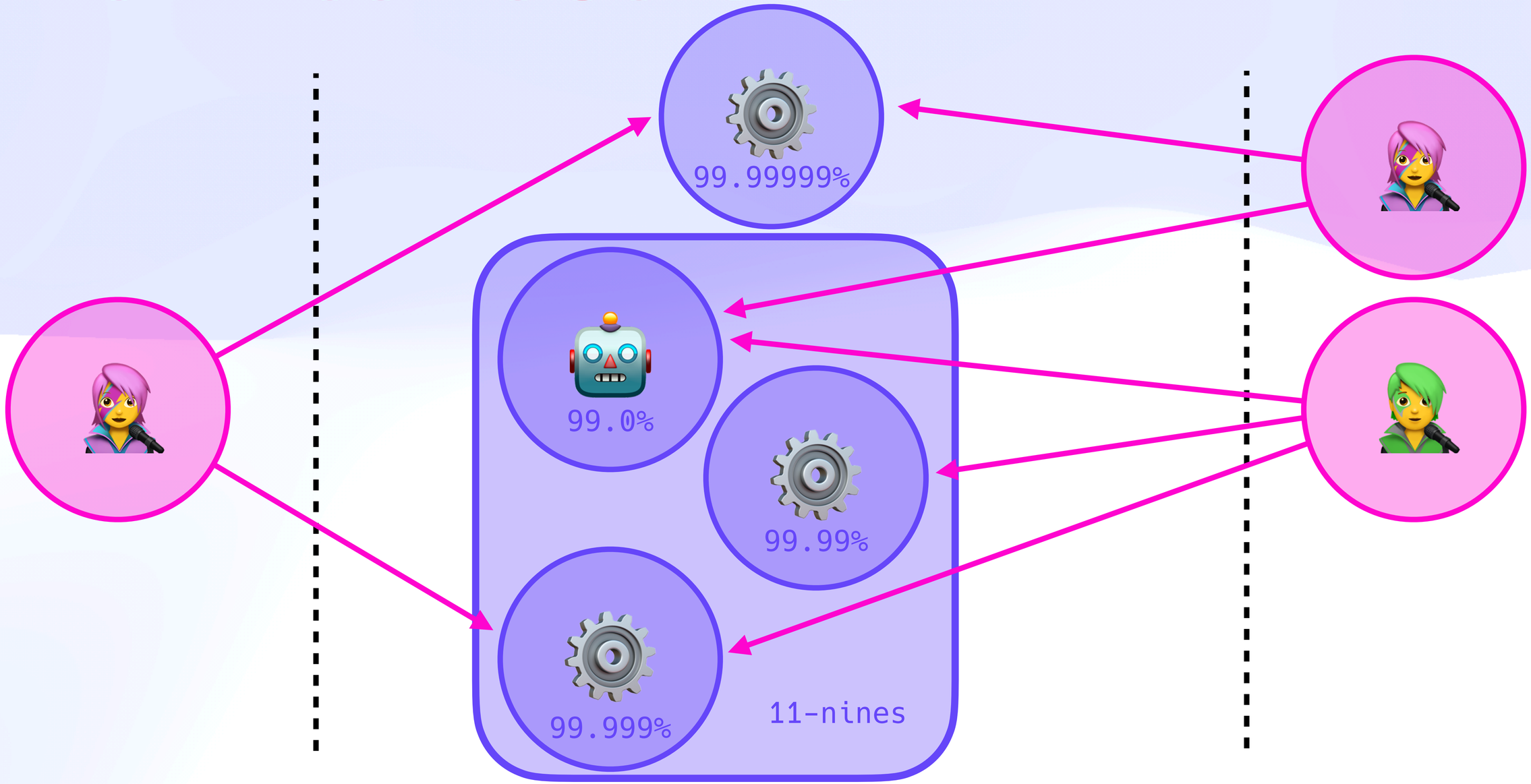
Compute Substrate

"Nine Nines" Is So 1999



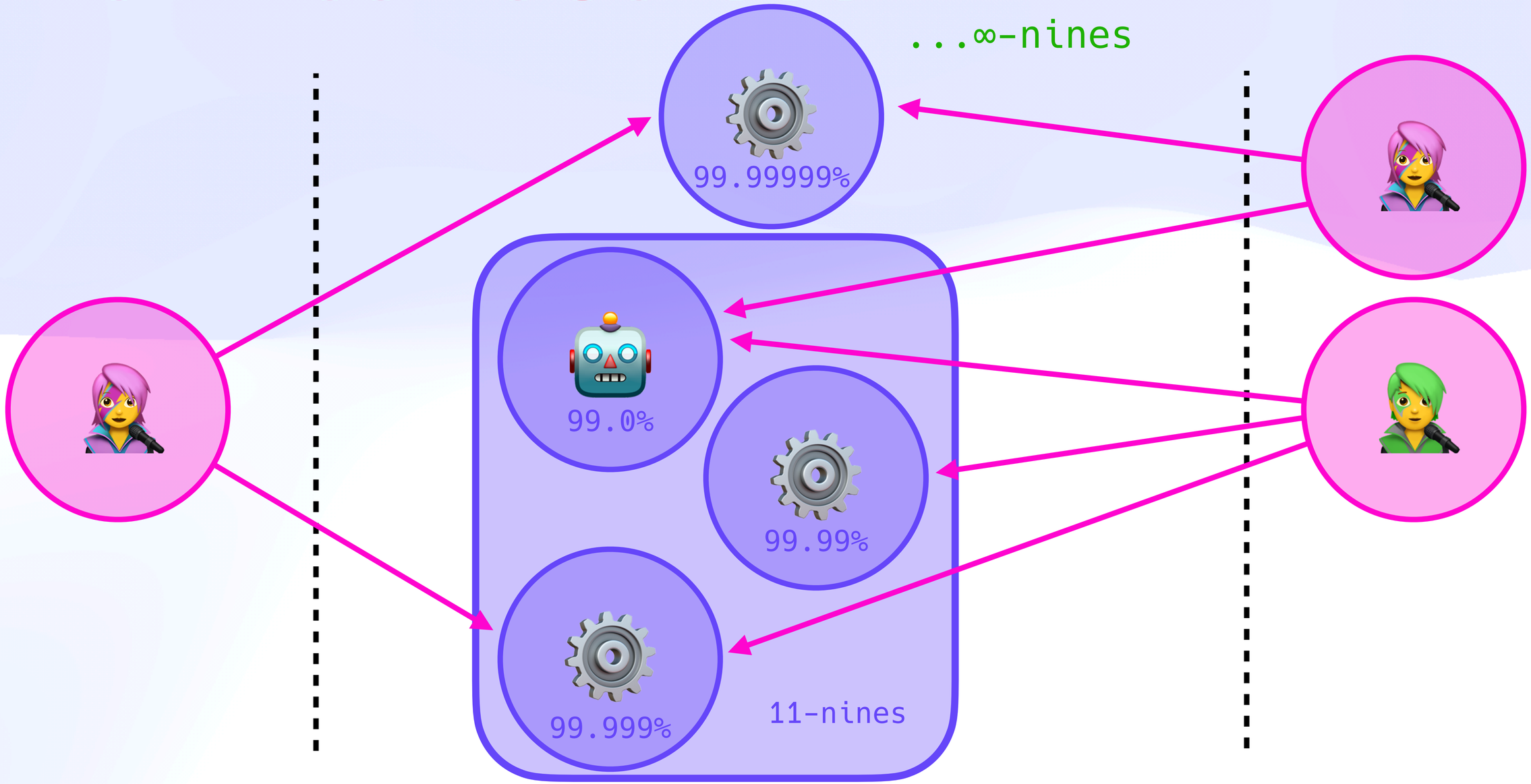
Compute Substrate

"Nine Nines" Is So 1999



Compute Substrate

"Nine Nines" Is So 1999

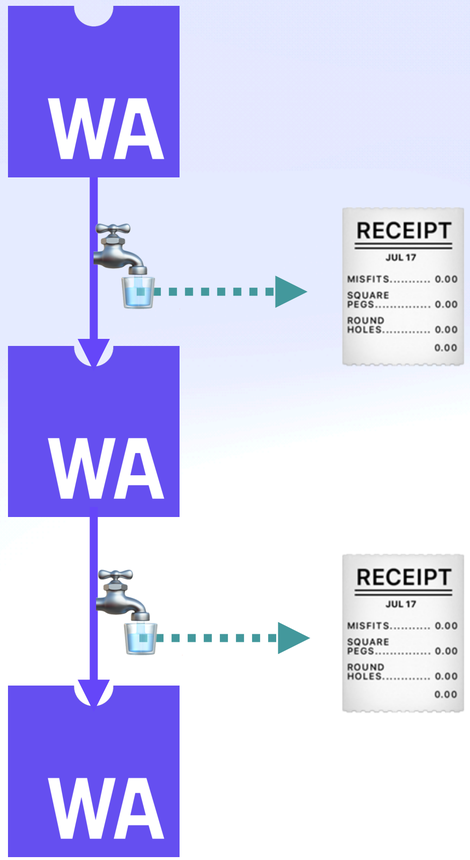


Compute Substrate

Cache, Suspend, Move, Verify

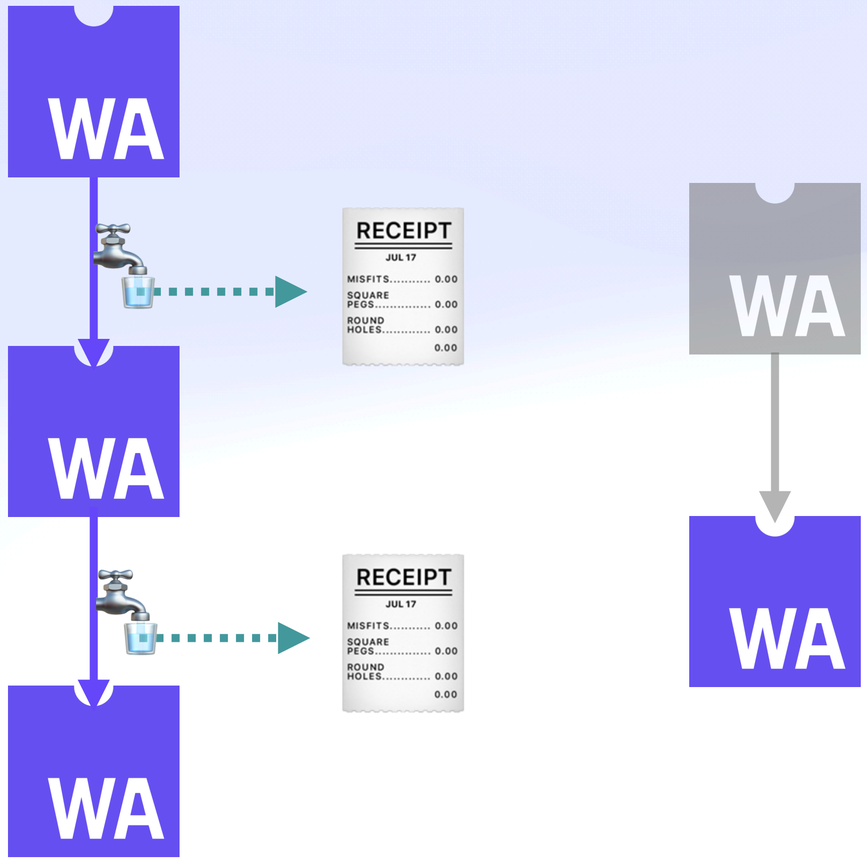
Compute Substrate

Cache, Suspend, Move, Verify



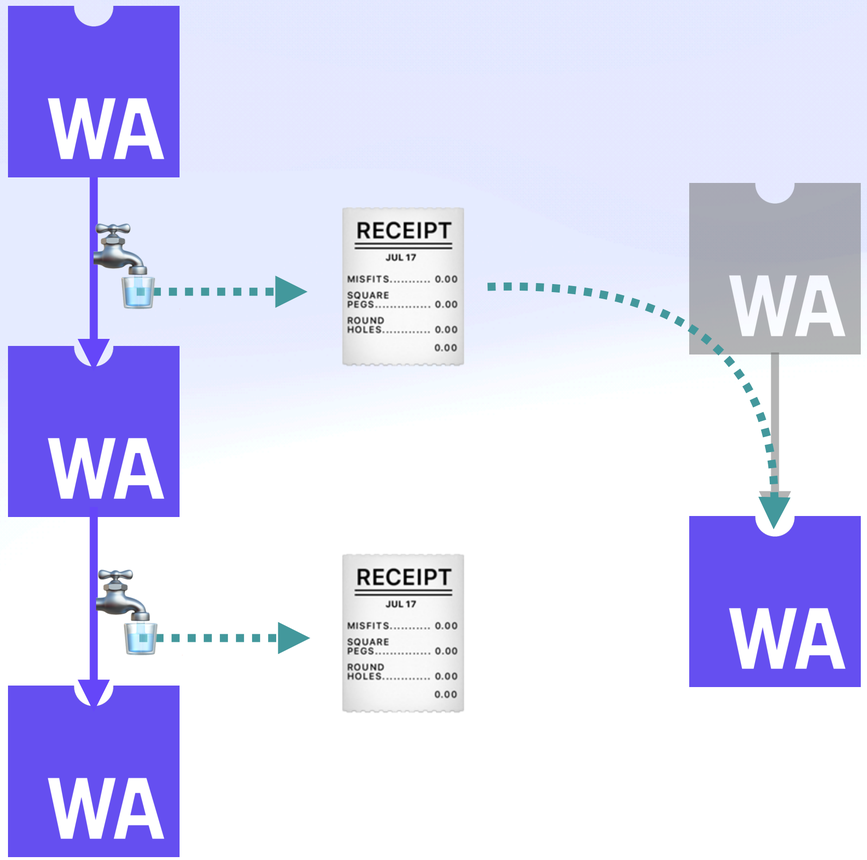
Compute Substrate

Cache, Suspend, Move, Verify



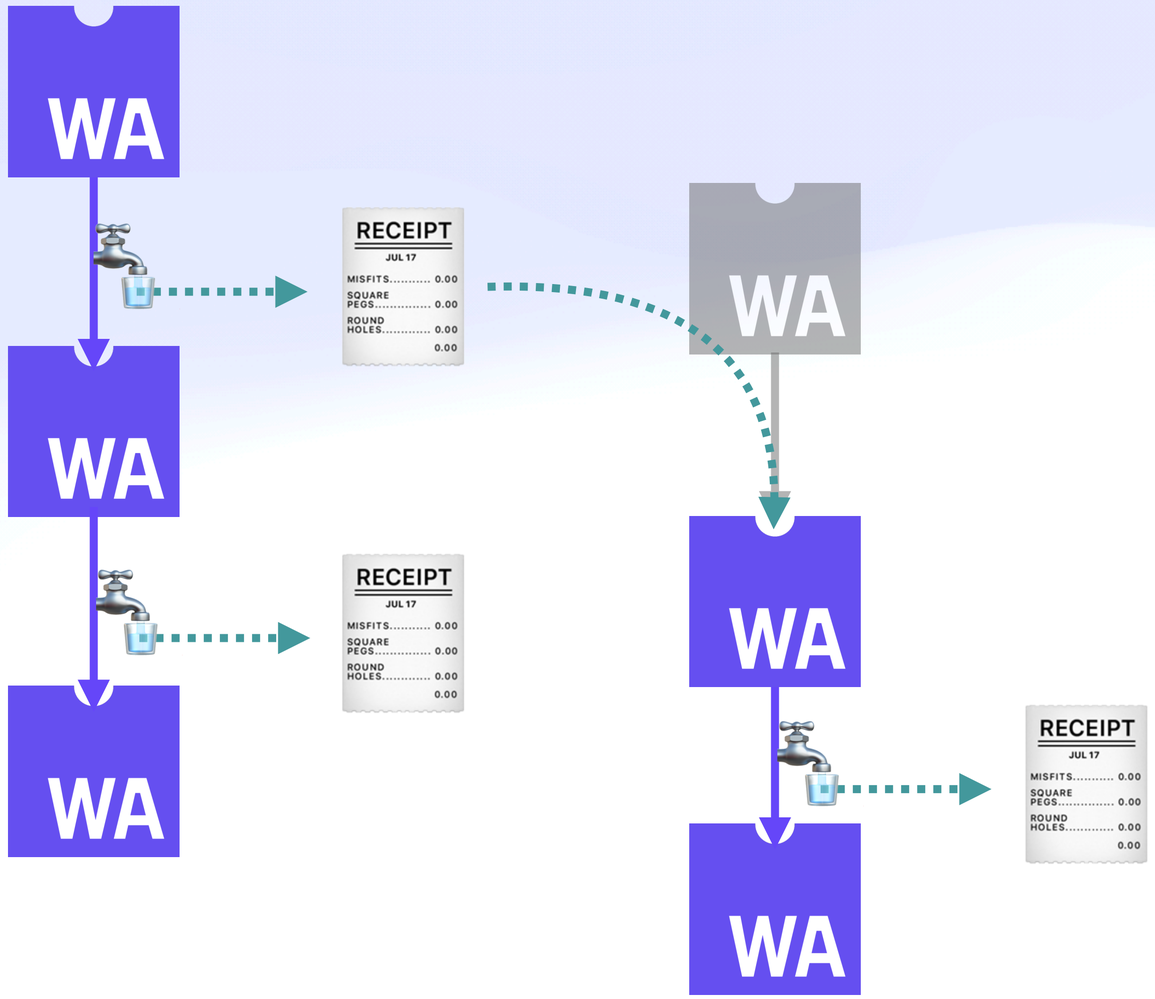
Compute Substrate

Cache, Suspend, Move, Verify



Compute Substrate

Cache, Suspend, Move, Verify

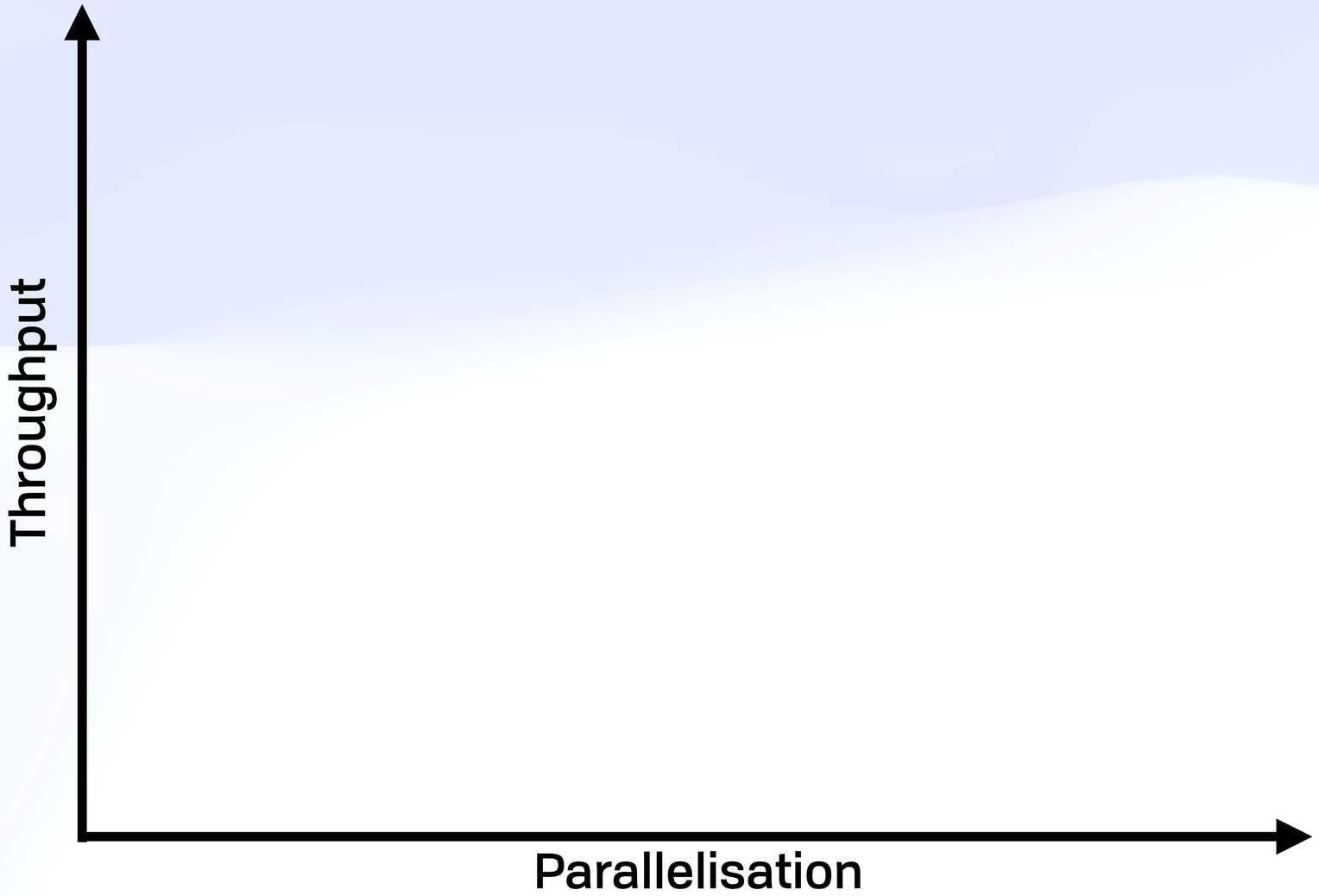


Compute Substrate

With a Little Help From My Friends

Compute Substrate

With a Little Help From My Friends



Compute Substrate

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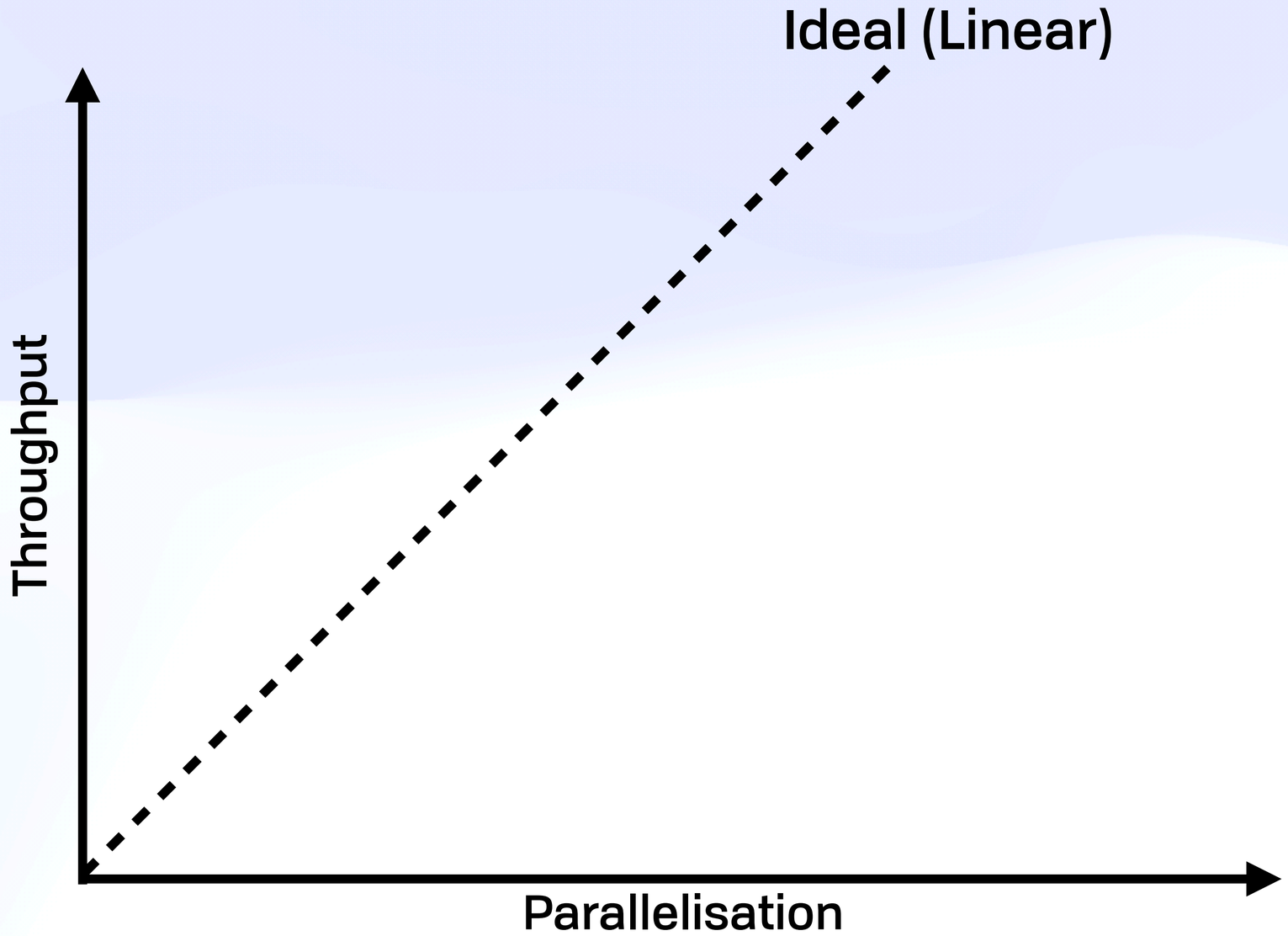
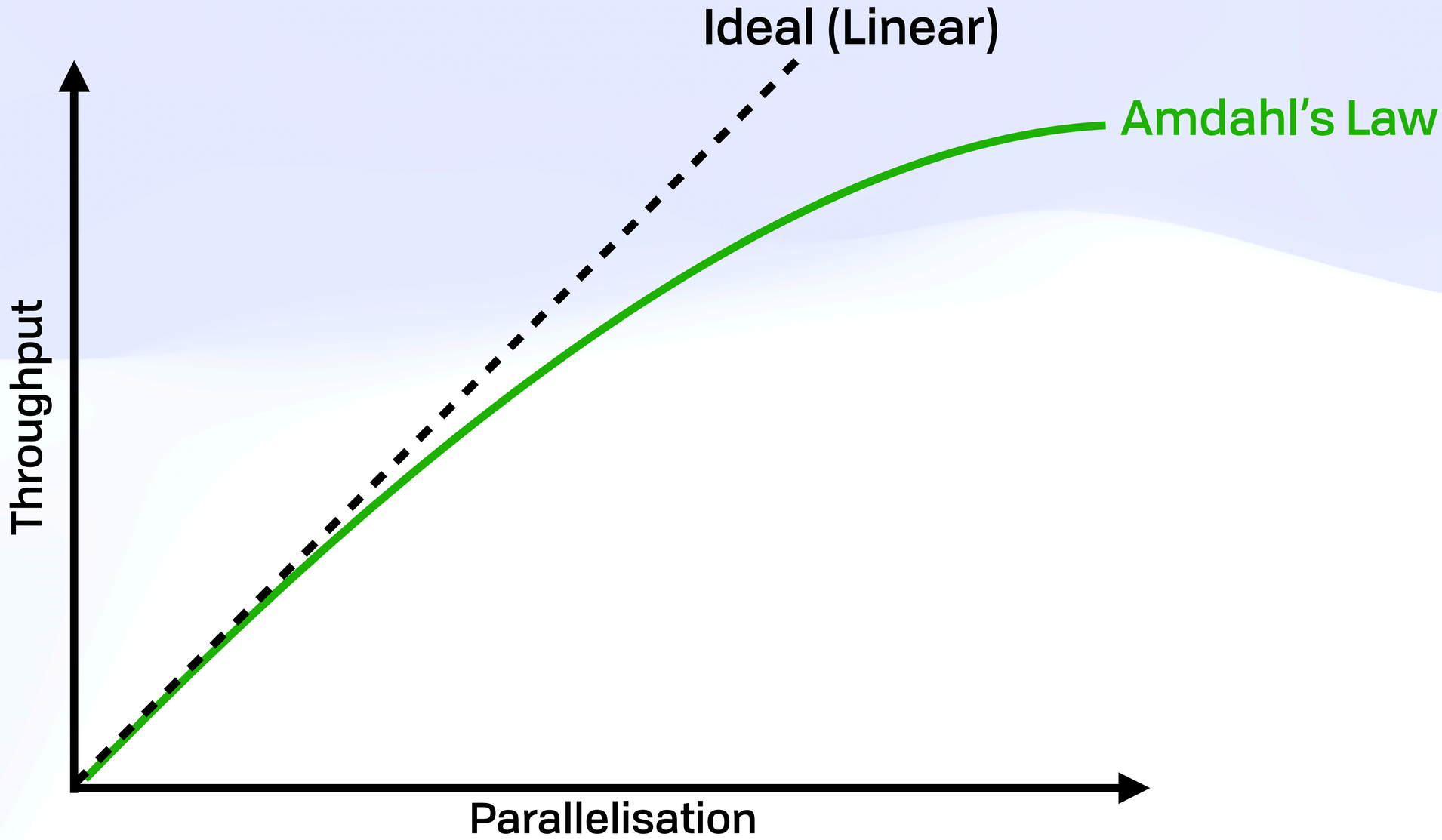


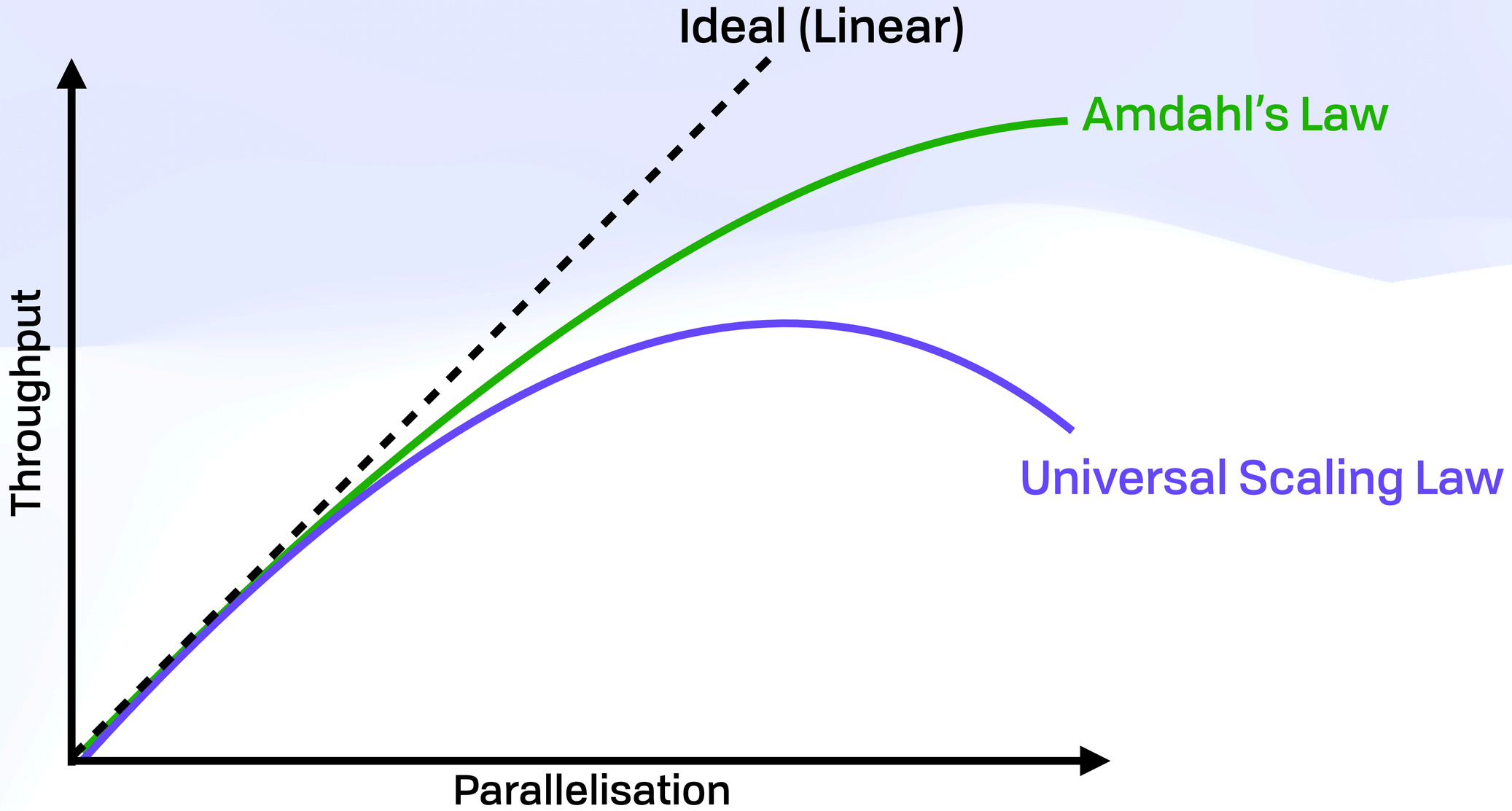
Compute Substrate

With a Little Help From My Friends



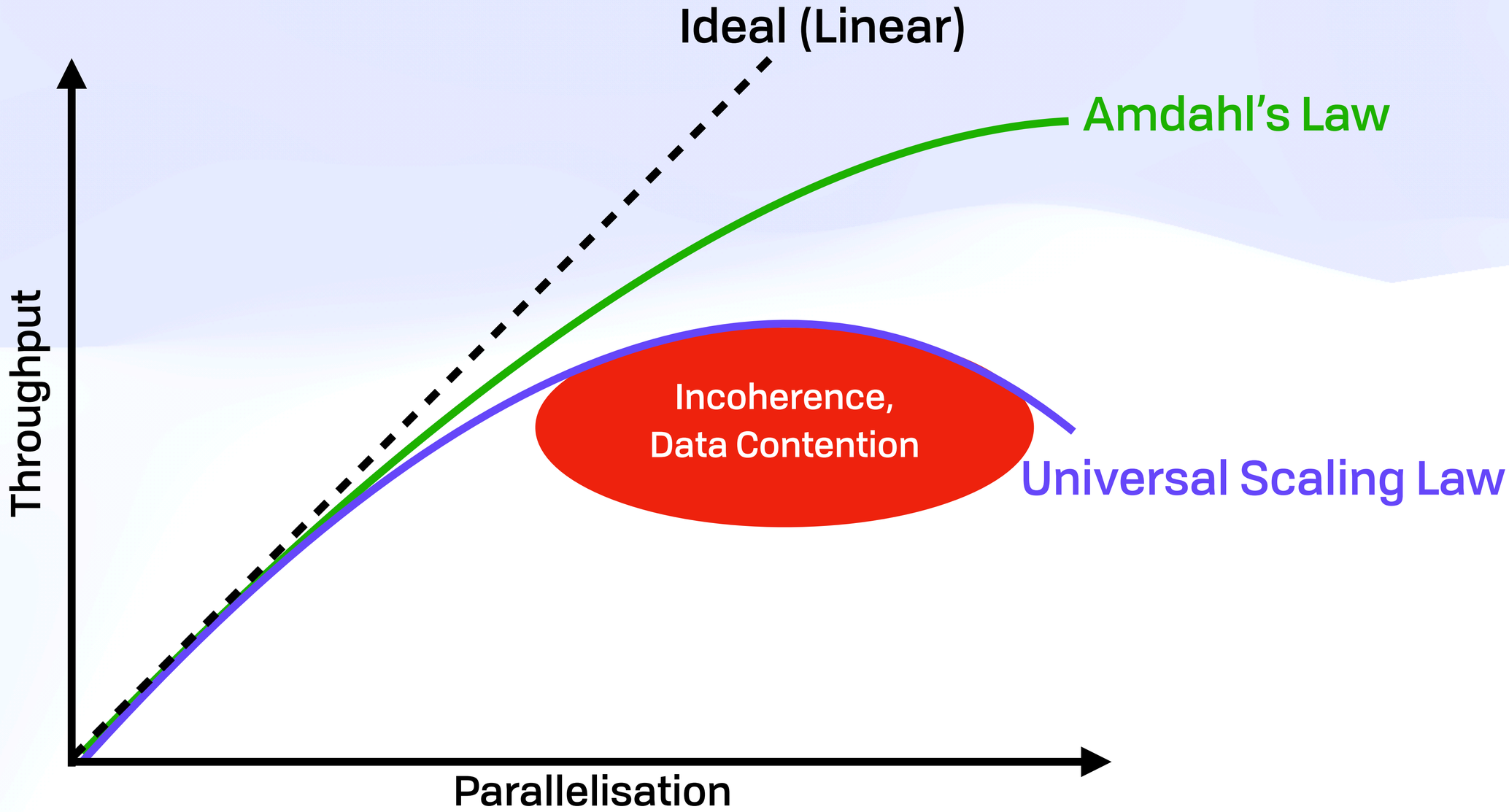
Compute Substrate

With a Little Help From My Friends



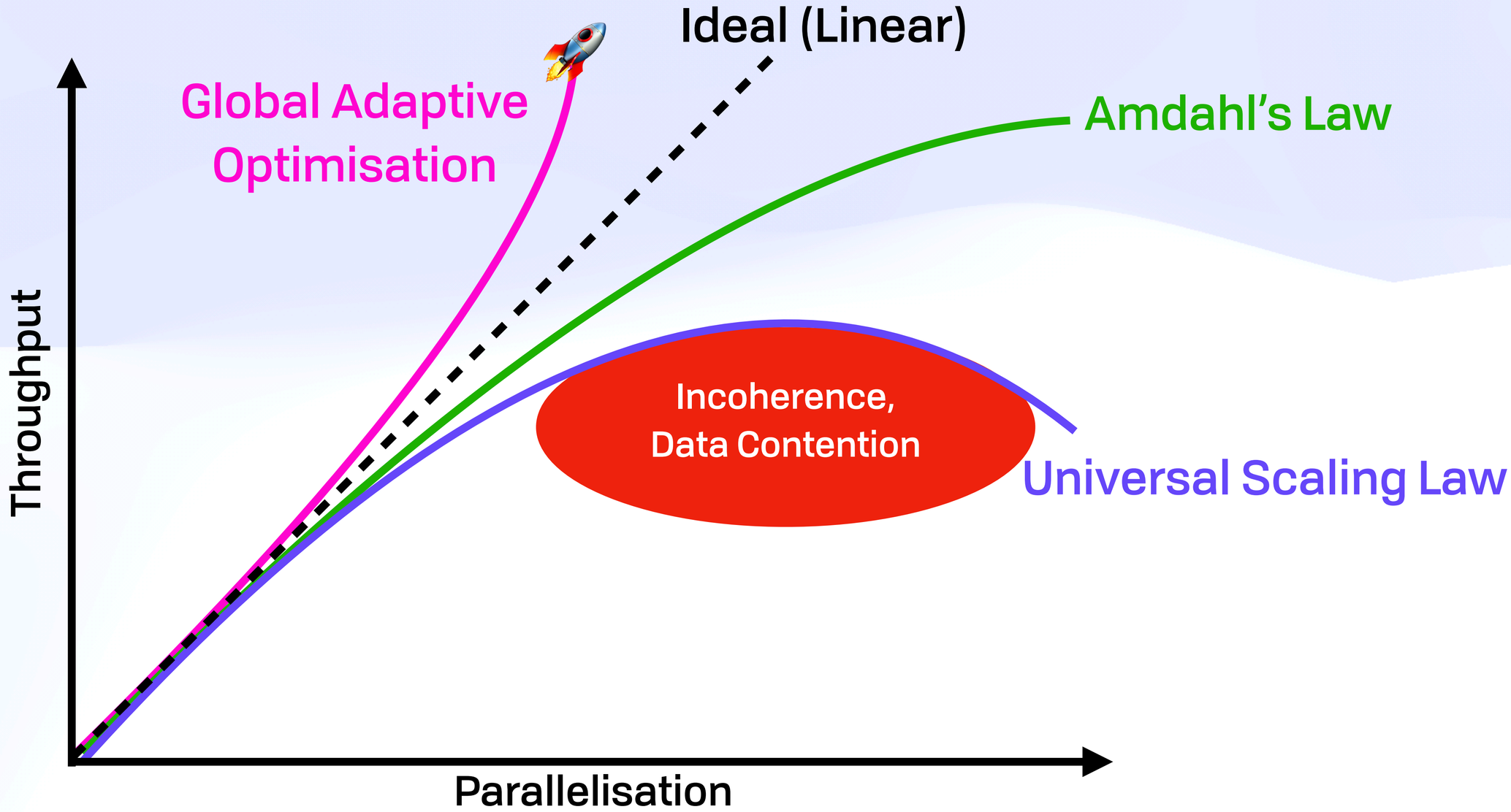
Compute Substrate

With a Little Help From My Friends



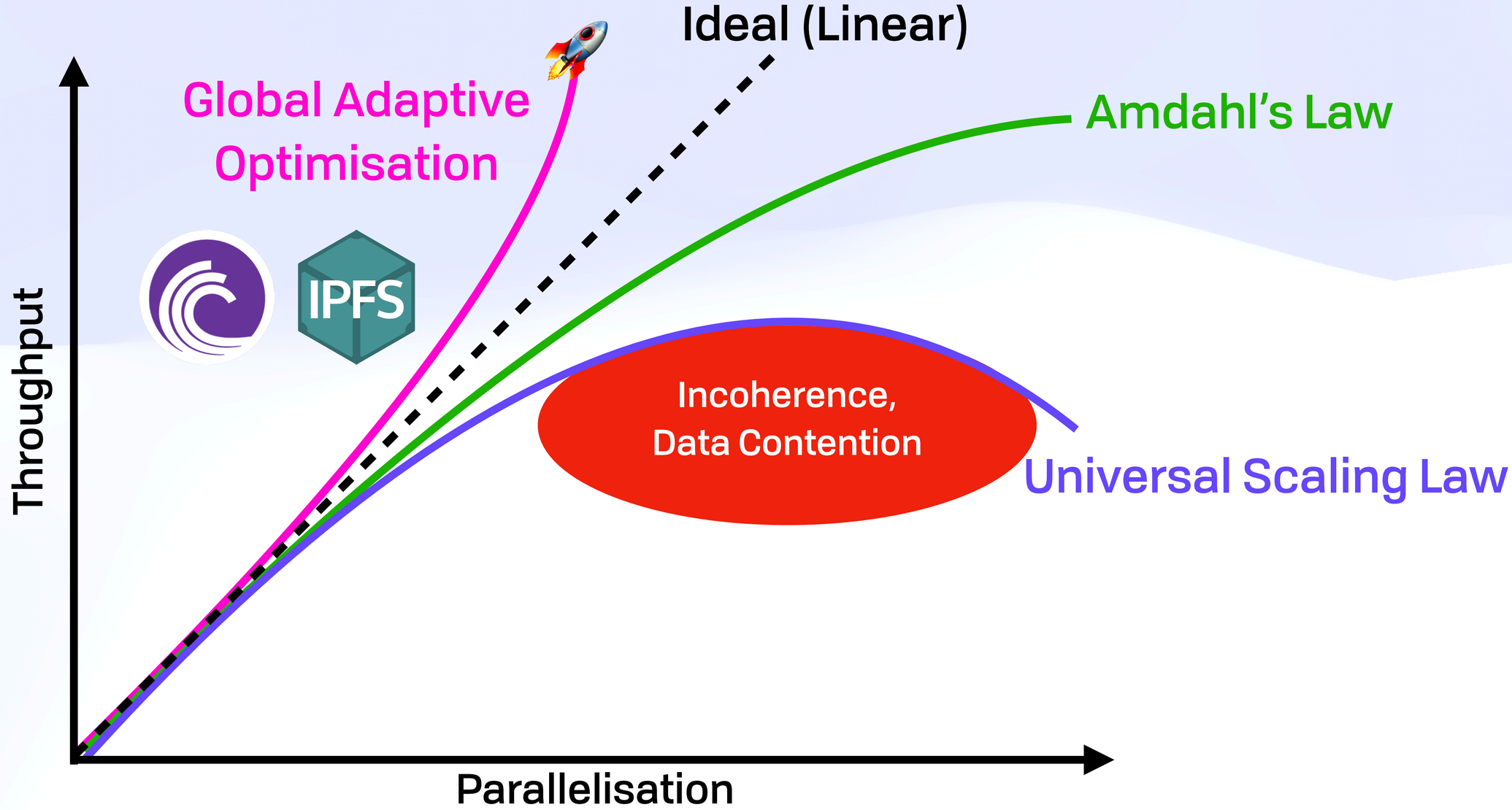
Compute Substrate

With a Little Help From My Friends



Compute Substrate

With a Little Help From My Friends



Compute Substrate

Run Once, And Never Again

Compute Substrate

Run Once, And Never Again

- **Input Hash → Cached Output**

Compute Substrate

Run Once, And Never Again

- **Input Hash → Cached Output**
  - AI moderation & tagging

Compute Substrate

Run Once, And Never Again

- **Input Hash → Cached Output**
  - AI moderation & tagging
  - Distributed JWT/DID validation

Compute Substrate

Run Once, And Never Again

- **Input Hash → Cached Output**
  - AI moderation & tagging
  - Distributed JWT/DID validation
  - Transitive trust

Compute Substrate

Run Once, And Never Again

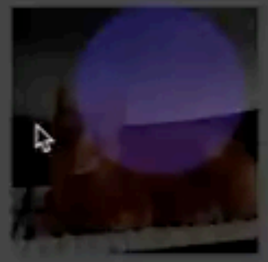
- **Input Hash → Cached Output**
  - AI moderation & tagging
  - Distributed JWT/DID validation
  - Transitive trust
  - Thumbnails, cropping

127.0.0.1:5173

PWLConf 2022 -... zeeshanlakhani/p... fission Distributed Syste... cmu pwlzoho Google Drive Pittsburgh Events... Game Thread and... Programming Lan... Other Bookmarks

IPVM Homestar Demo

- Workflow One
  - Crop
  - Rotate90
  - Blur
- Workflow Two
  - Crop
  - Rotate90
  - Grayscale



0:00

Loom – Screen Recorder & Screen Capture is sharing your screen. Stop sharing Hide

127.0.0.1:5173

PWLConf 2022 -... zeeshanlakhani/p... fission Distributed Syste... cmu pwlzoho Google Drive Pittsburgh Events... Game Thread and... Programming Lan... Other Bookmarks

IPVM Homestar Demo

- Workflow One
  - Crop
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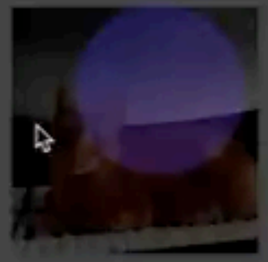
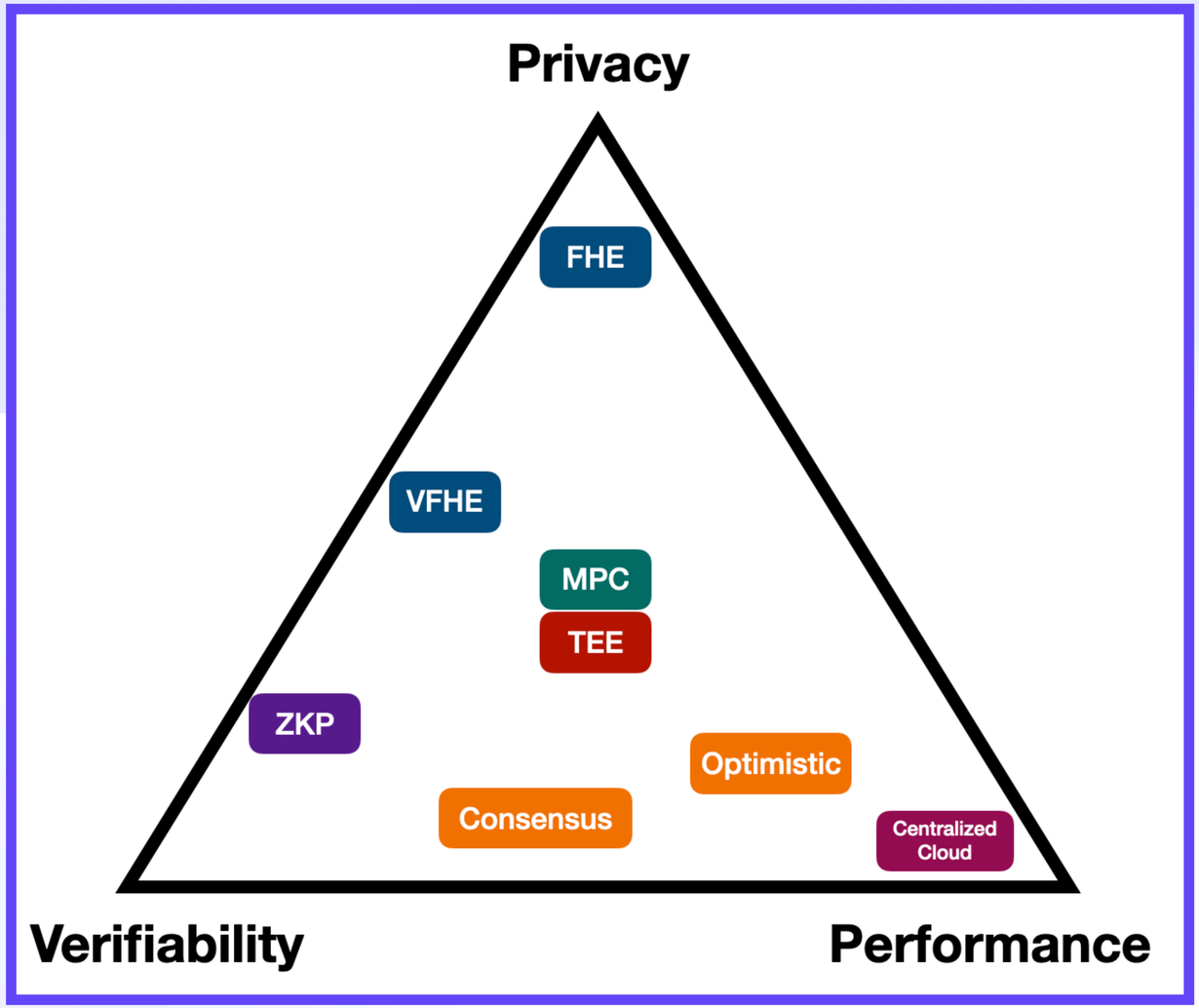


0:00

Loom – Screen Recorder & Screen Capture is sharing your screen. Stop sharing Hide

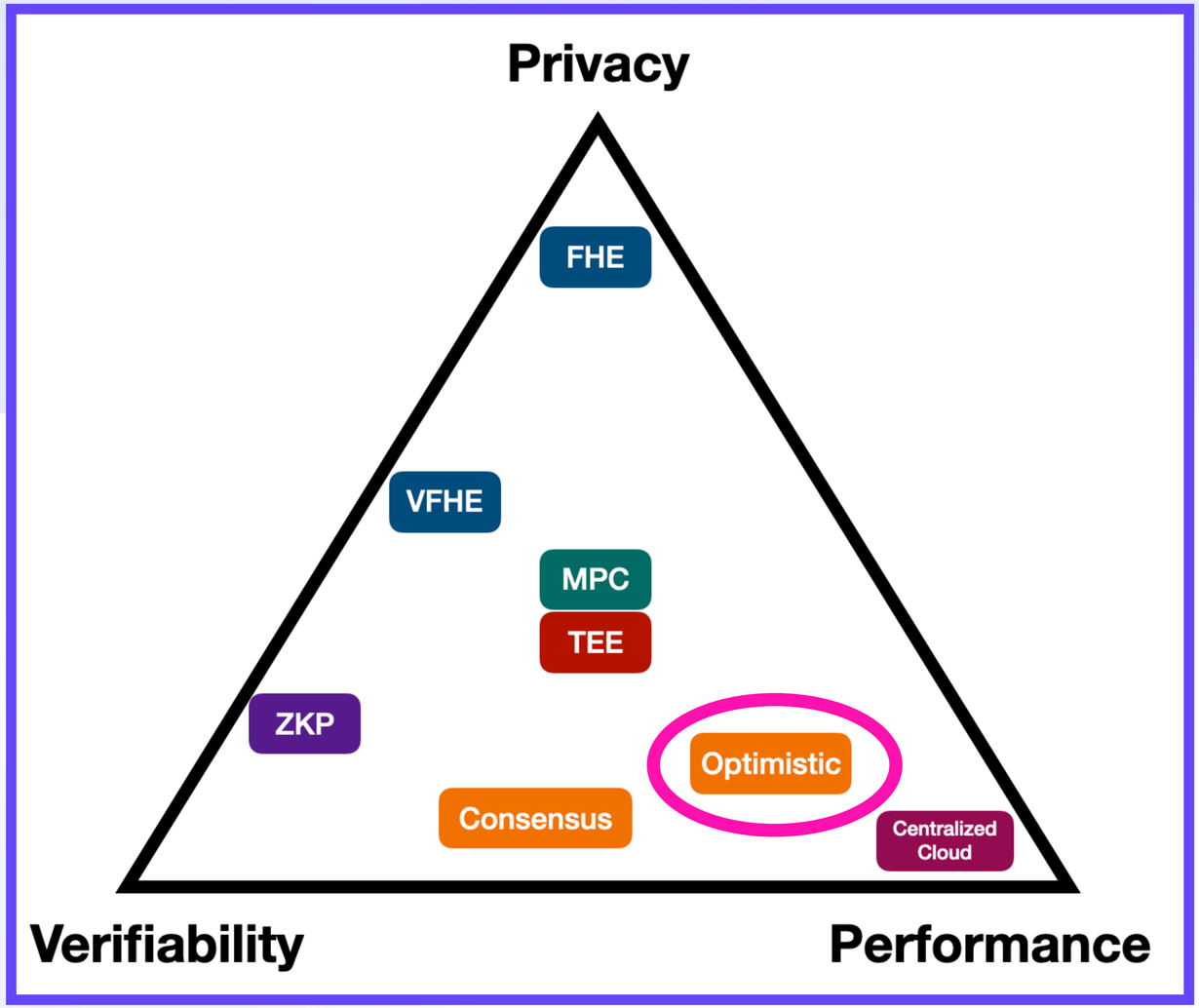
Compute Substrate

Determinism = Verifiable Computation



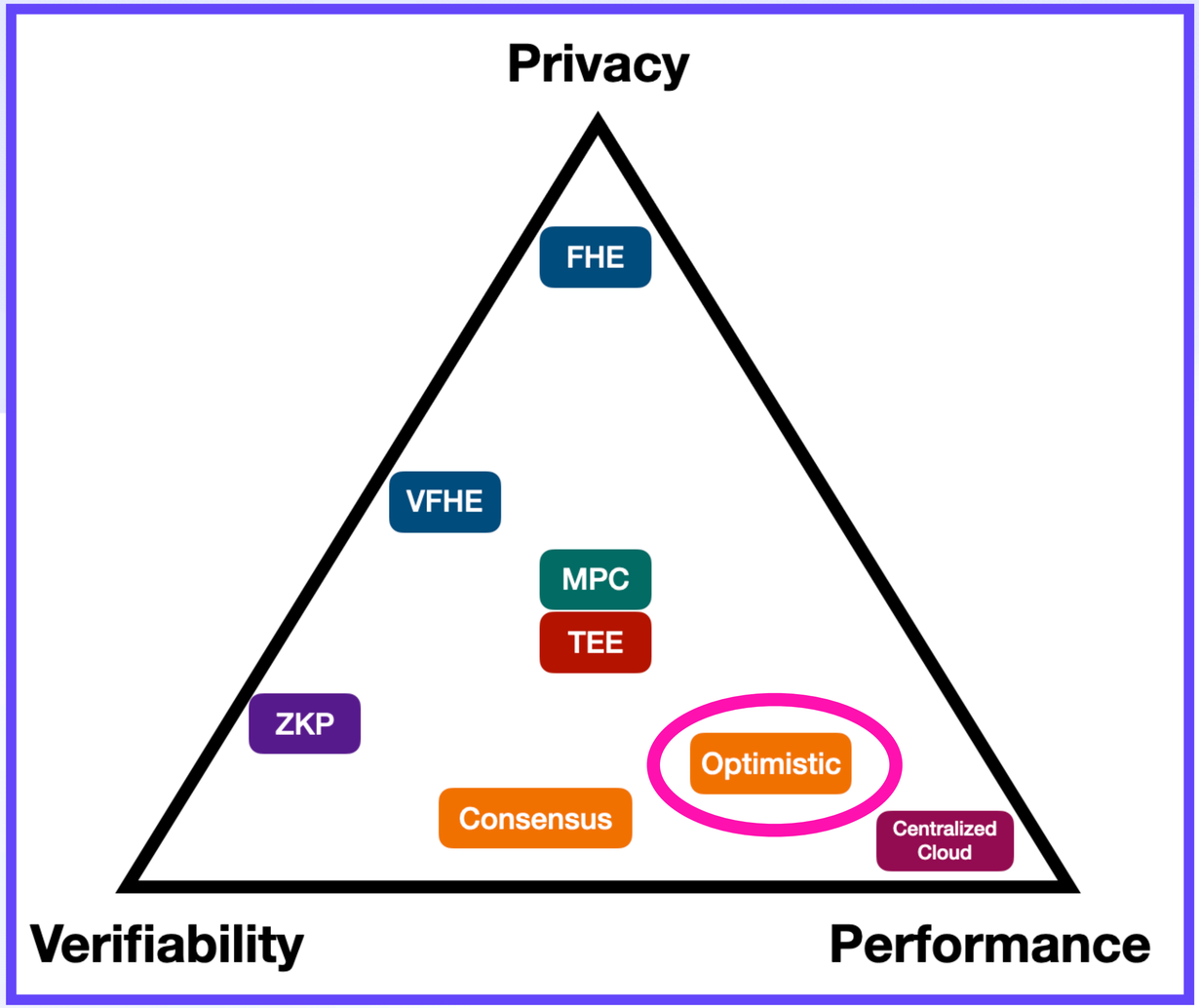
Compute Substrate

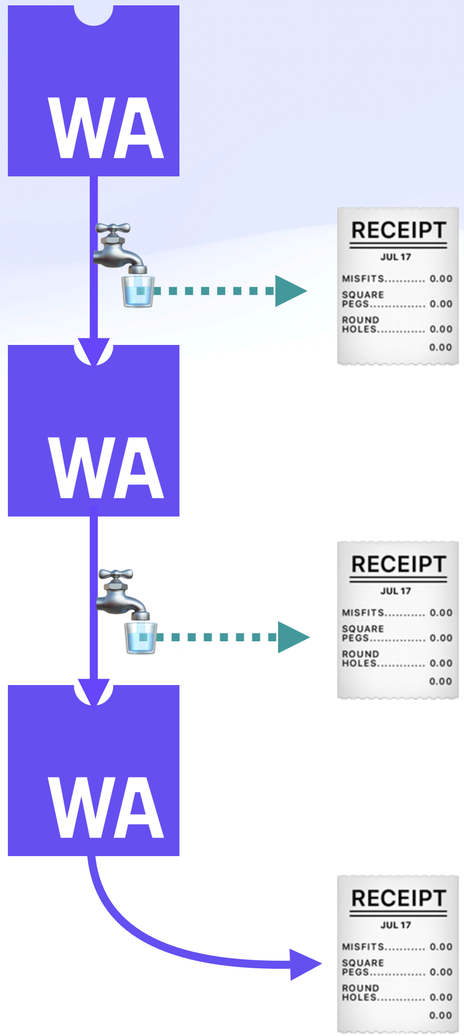
Determinism = Verifiable Computation



Compute Substrate

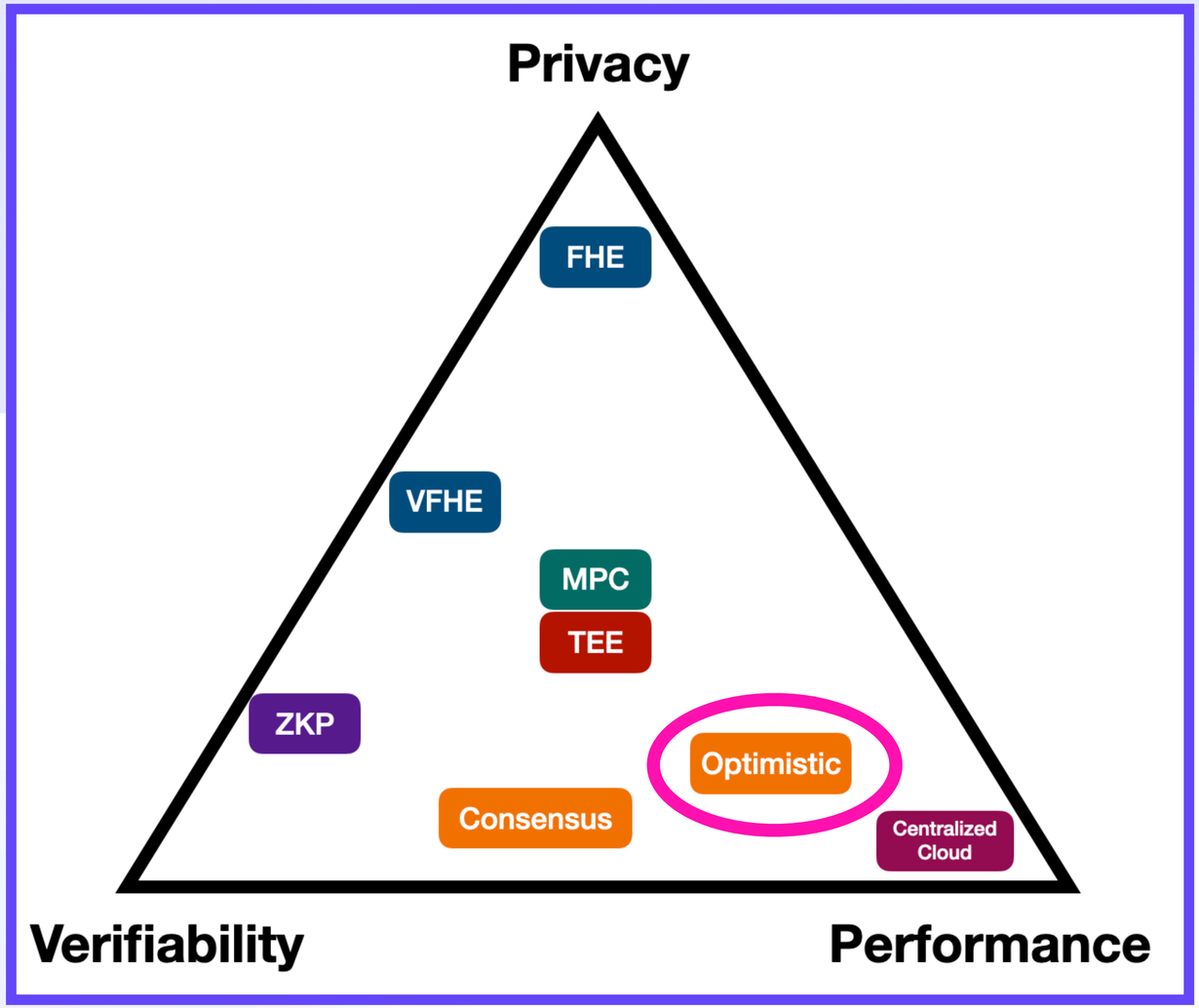
Determinism = Verifiable Computation

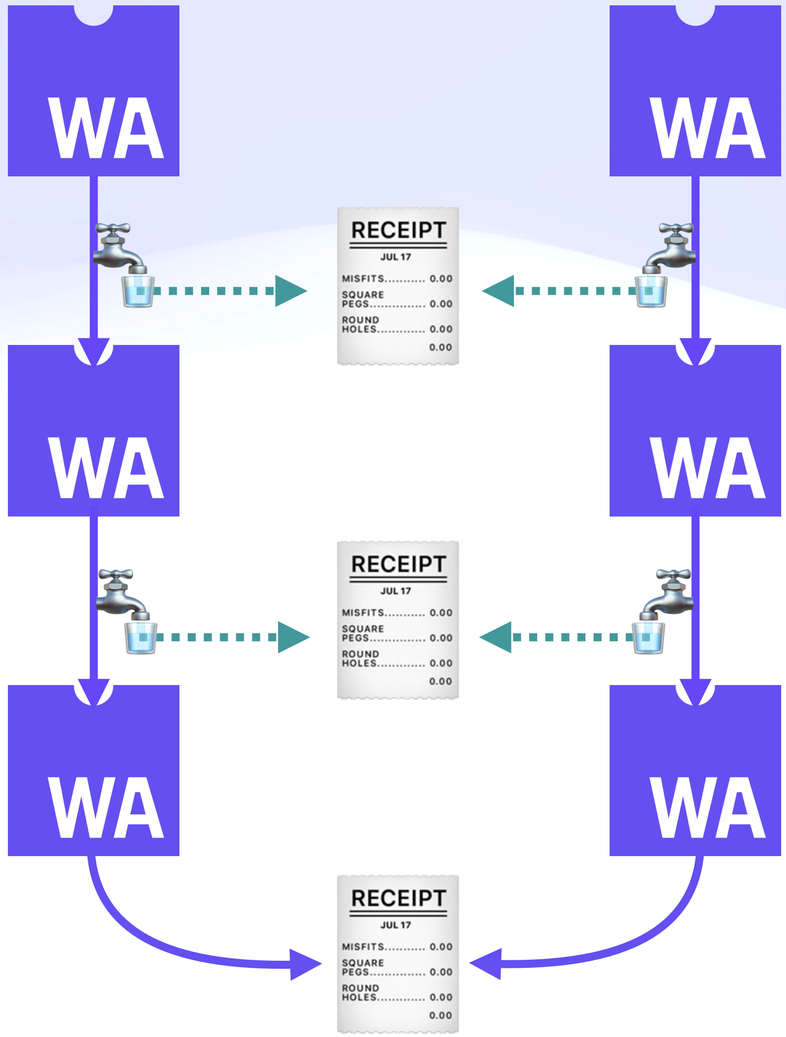




Compute Substrate

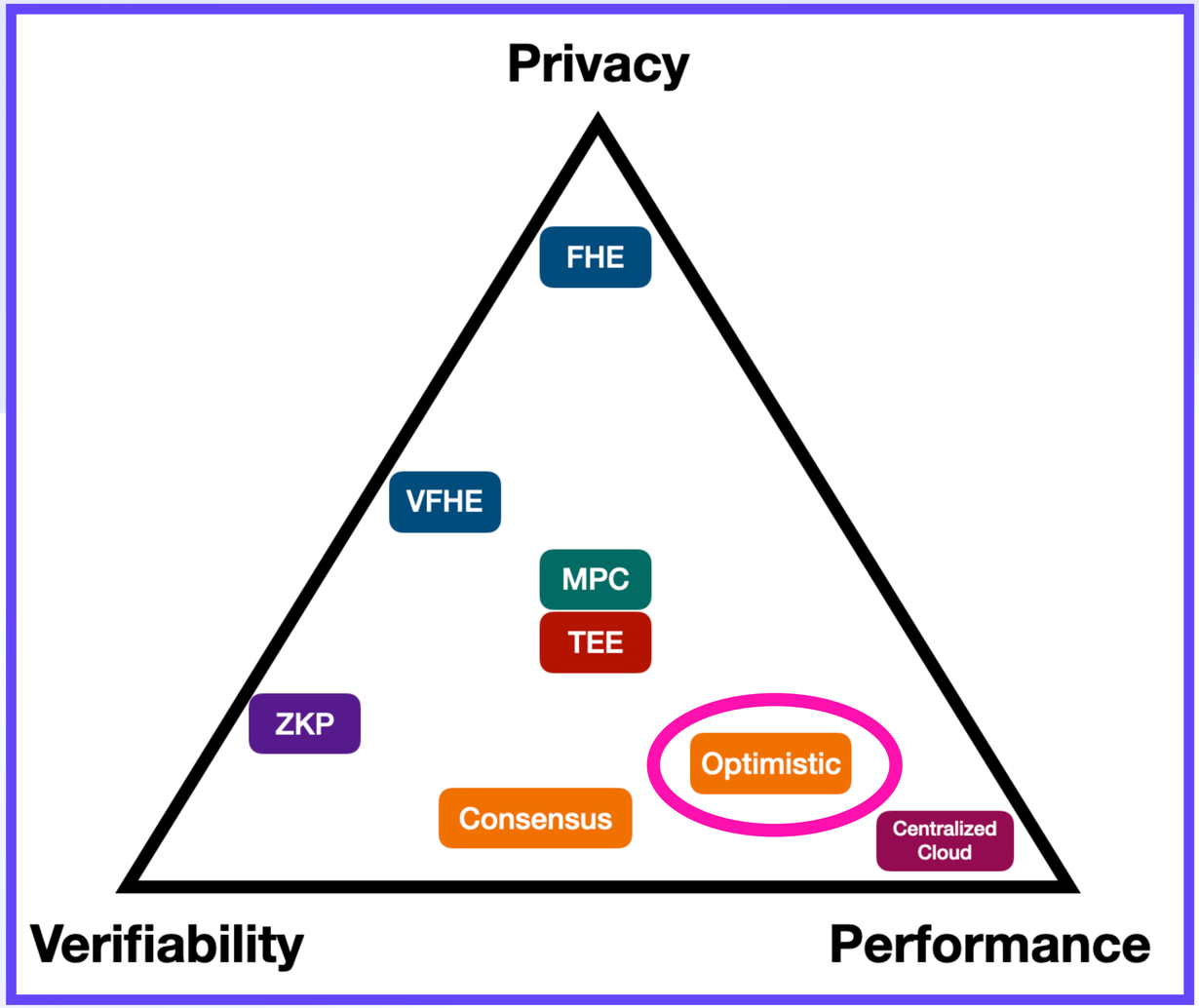
Determinism = Verifiable Computation

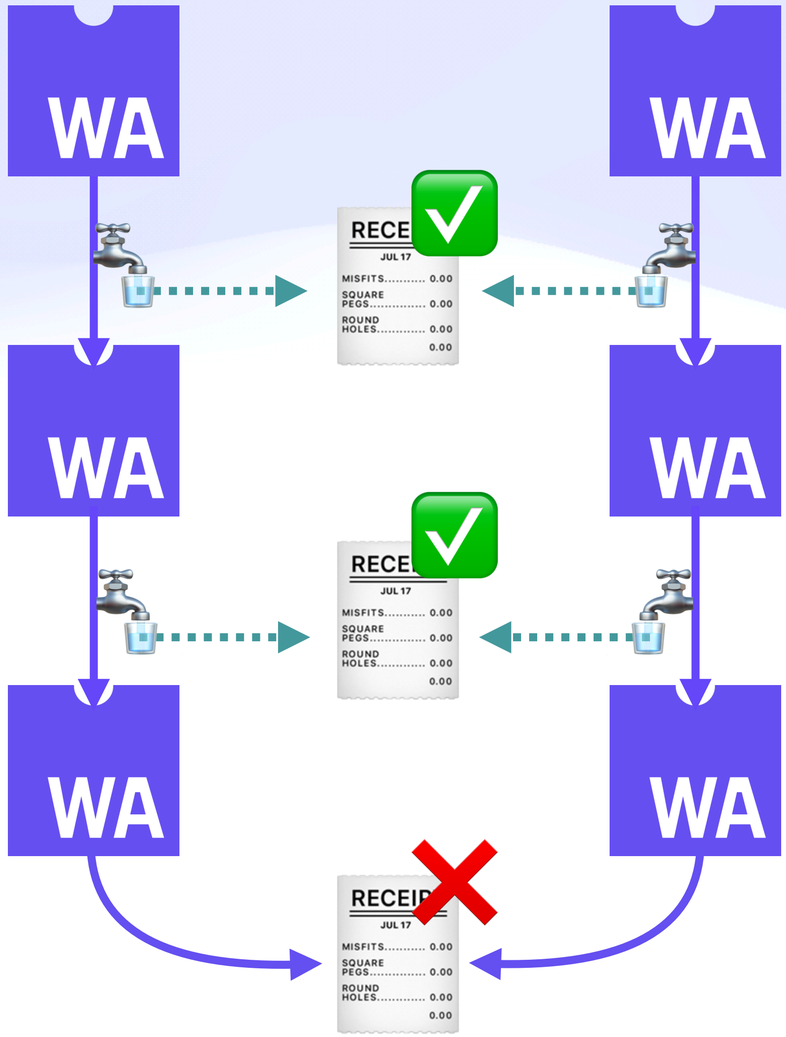




Compute Substrate

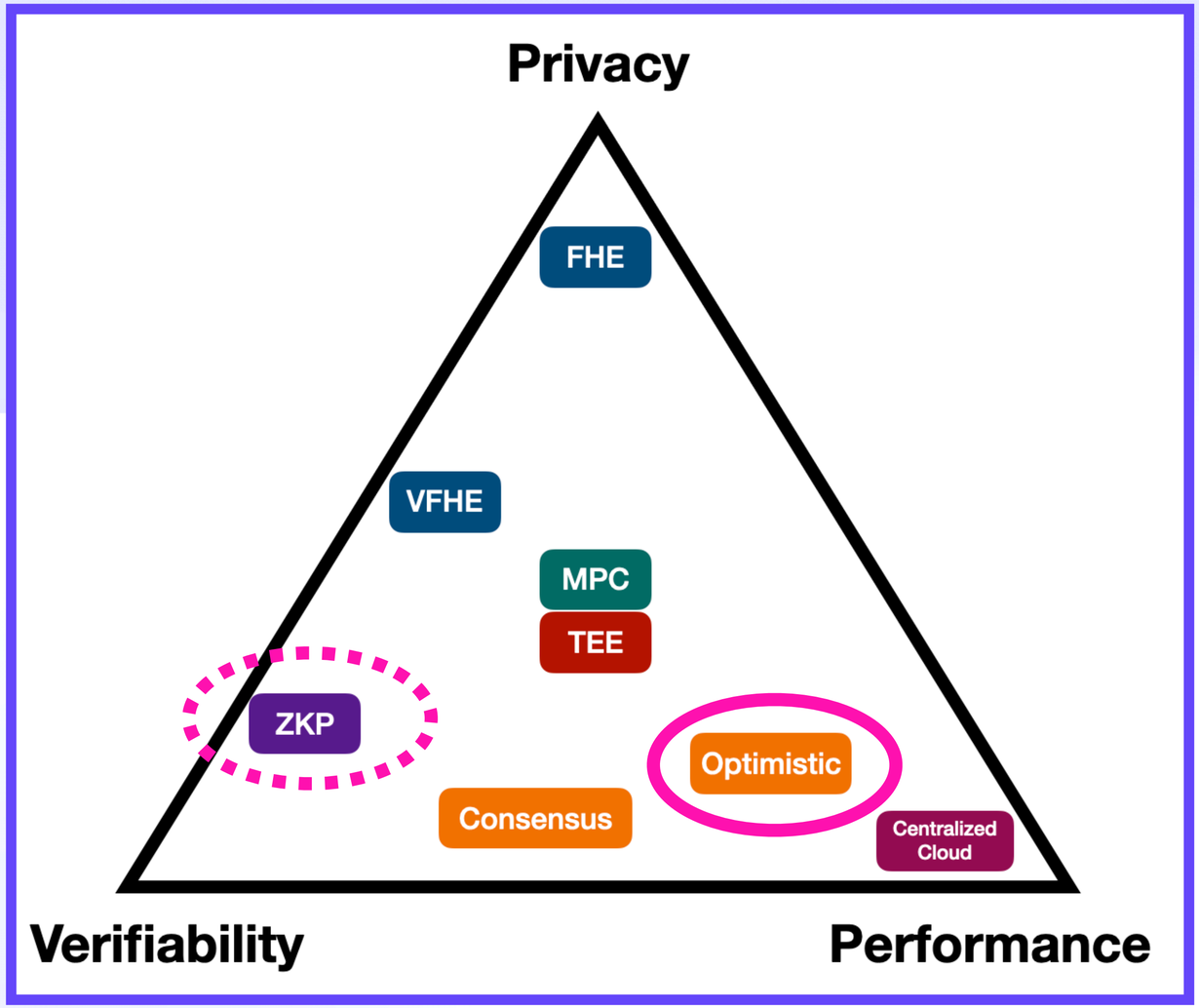
Determinism = Verifiable Computation

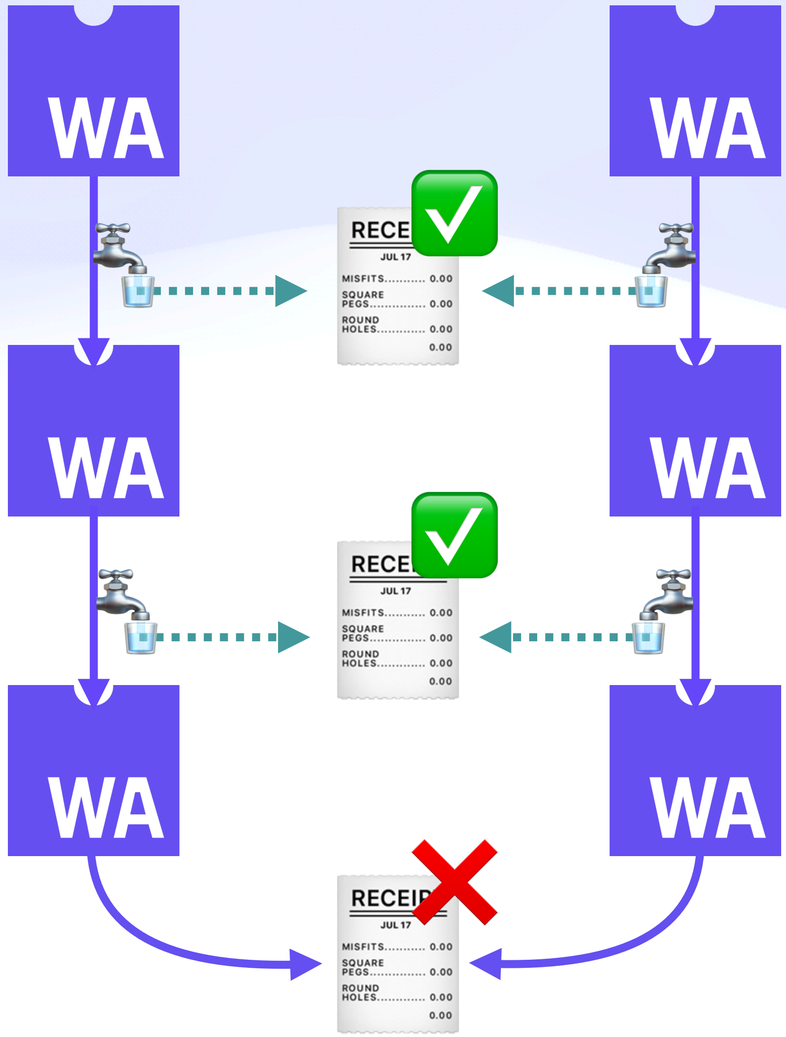




Compute Substrate

Determinism = Verifiable Computation






The Safety Dance
— Semantics to Climb Out of the Tar Pit —

The Safety Dance 🕺

Description vs Invocation

The Safety Dance 🦹

Description vs Invocation

Impure functions produce ***side effects***
Pure functions manipulate ***data***

Side effects → ***managed*** effects

The Safety Dance 🕺

Description vs Invocation

Impure functions produce ***side effects***
Pure functions manipulate ***data***

Side effects → ***managed*** effects

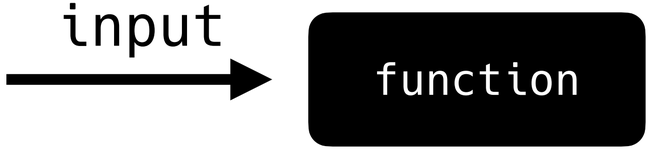
```
function
```

The Safety Dance 🦹

Description vs Invocation

Impure functions produce ***side effects***
Pure functions manipulate ***data***

Side effects → ***managed*** effects



The Safety Dance 🦹

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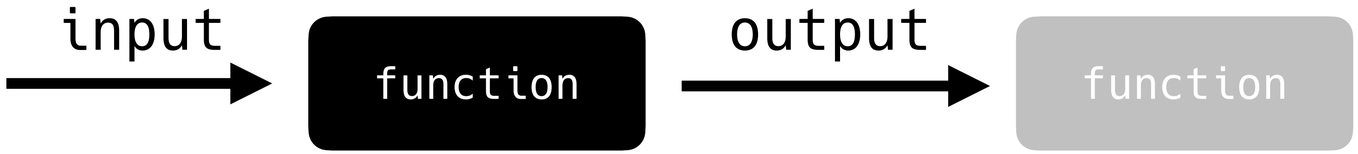

The Safety Dance 🕺

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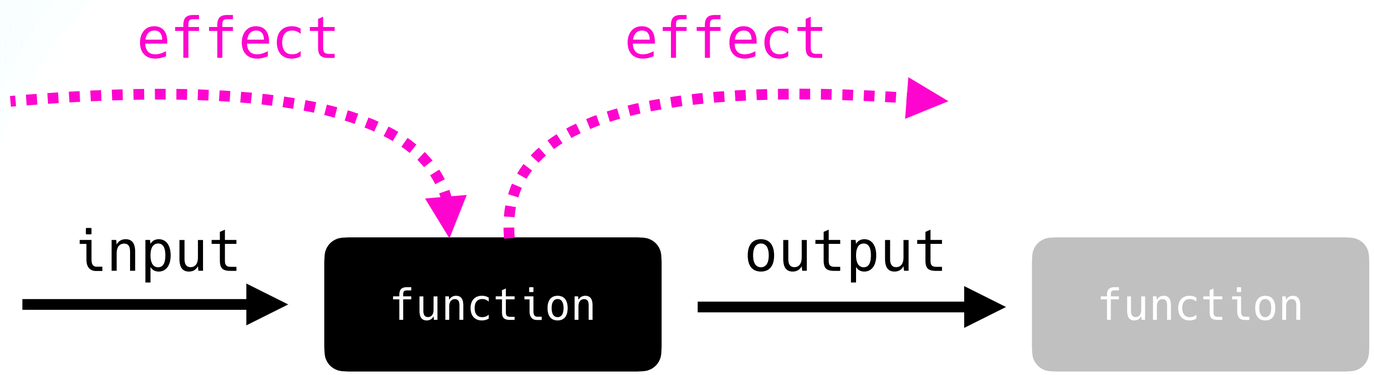
Side effects → ***managed*** effects



The Safety Dance 🦹

Description vs Invocation

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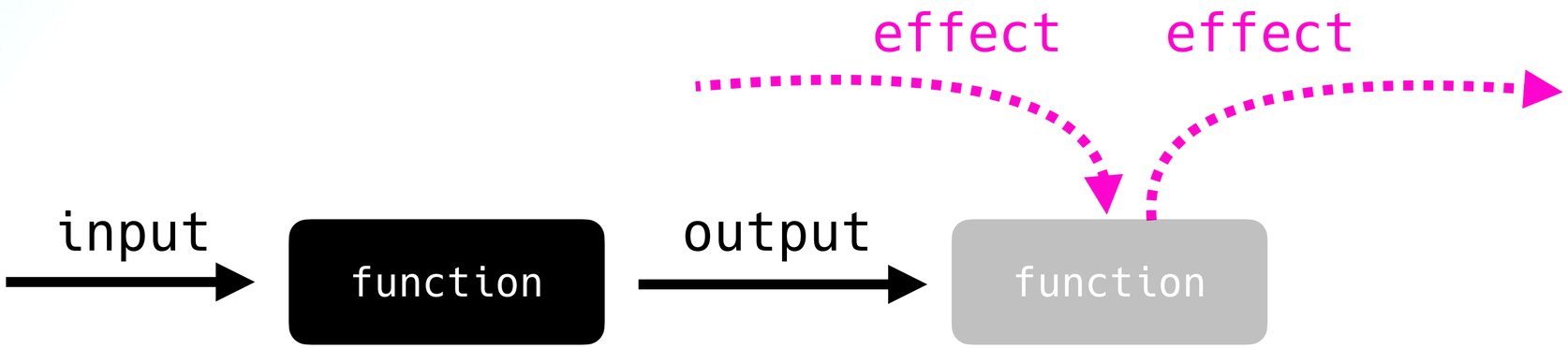
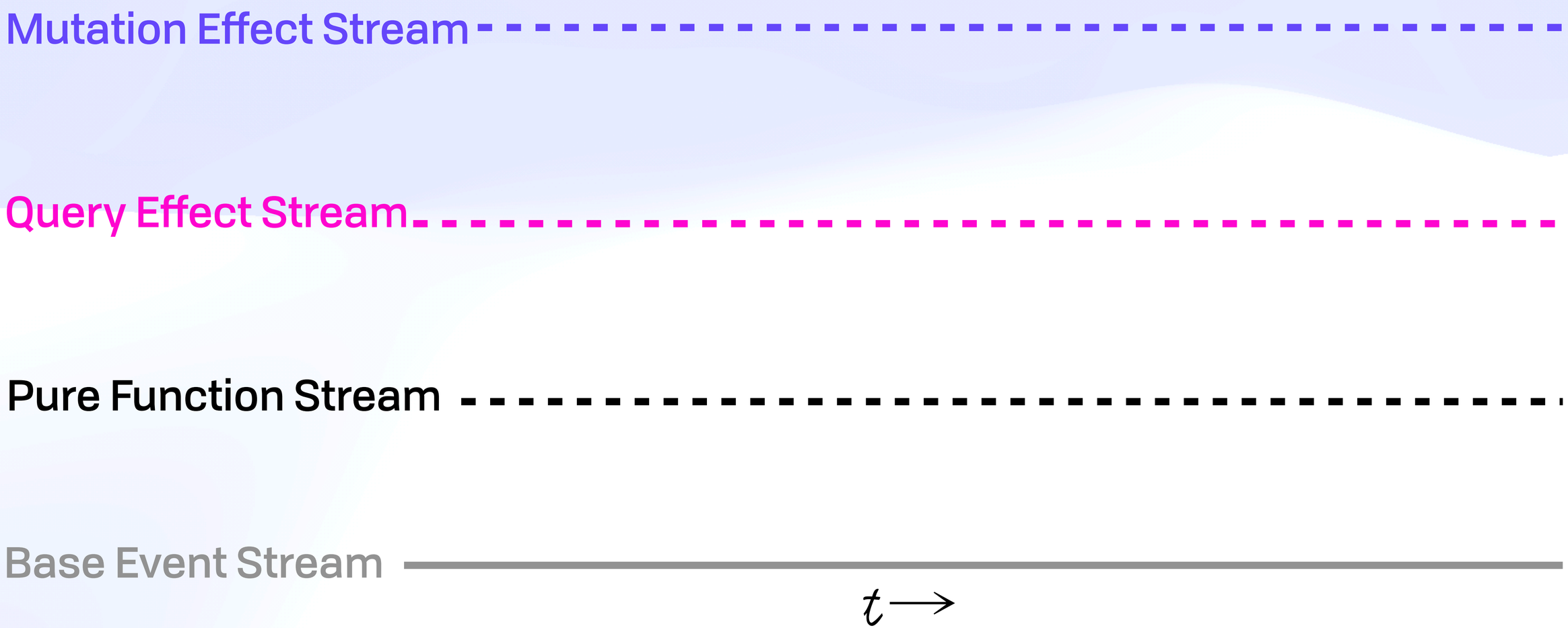
Side effects → ***managed*** effects



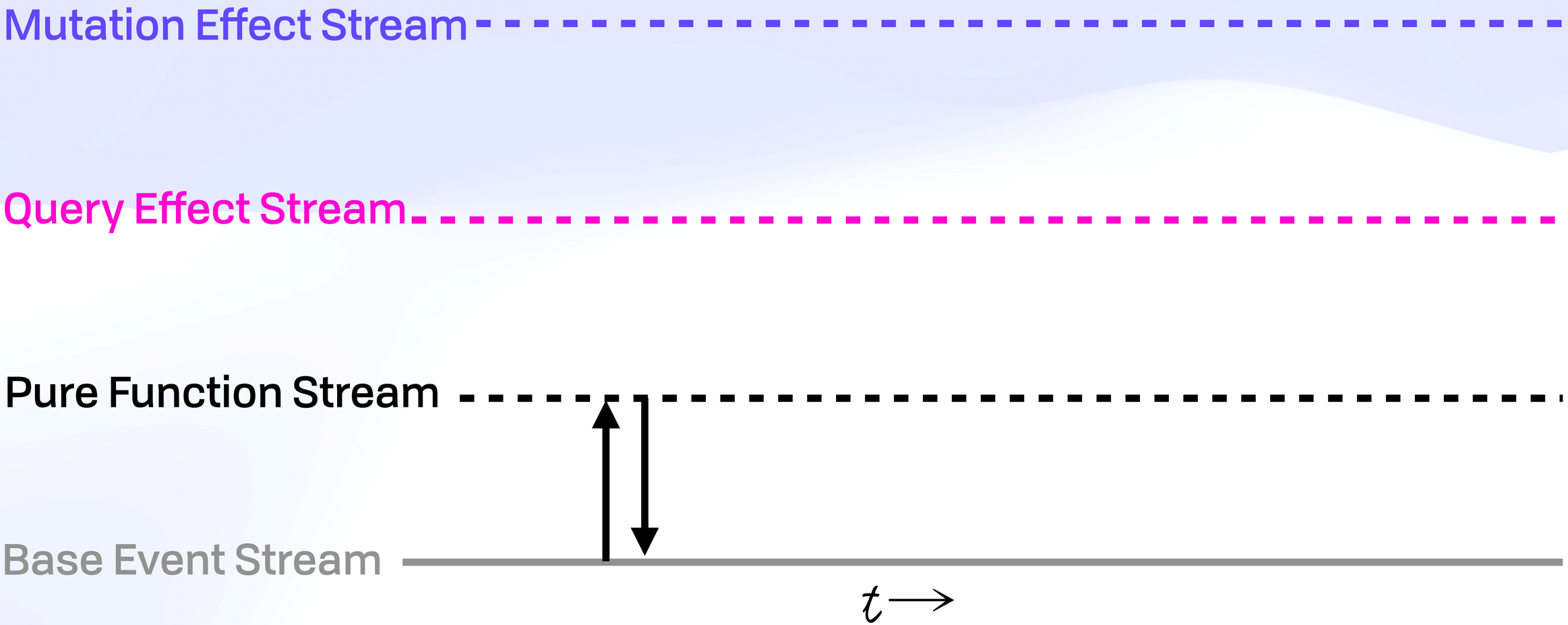
The Safety Dance 🦹‍♀️

Managed Effects



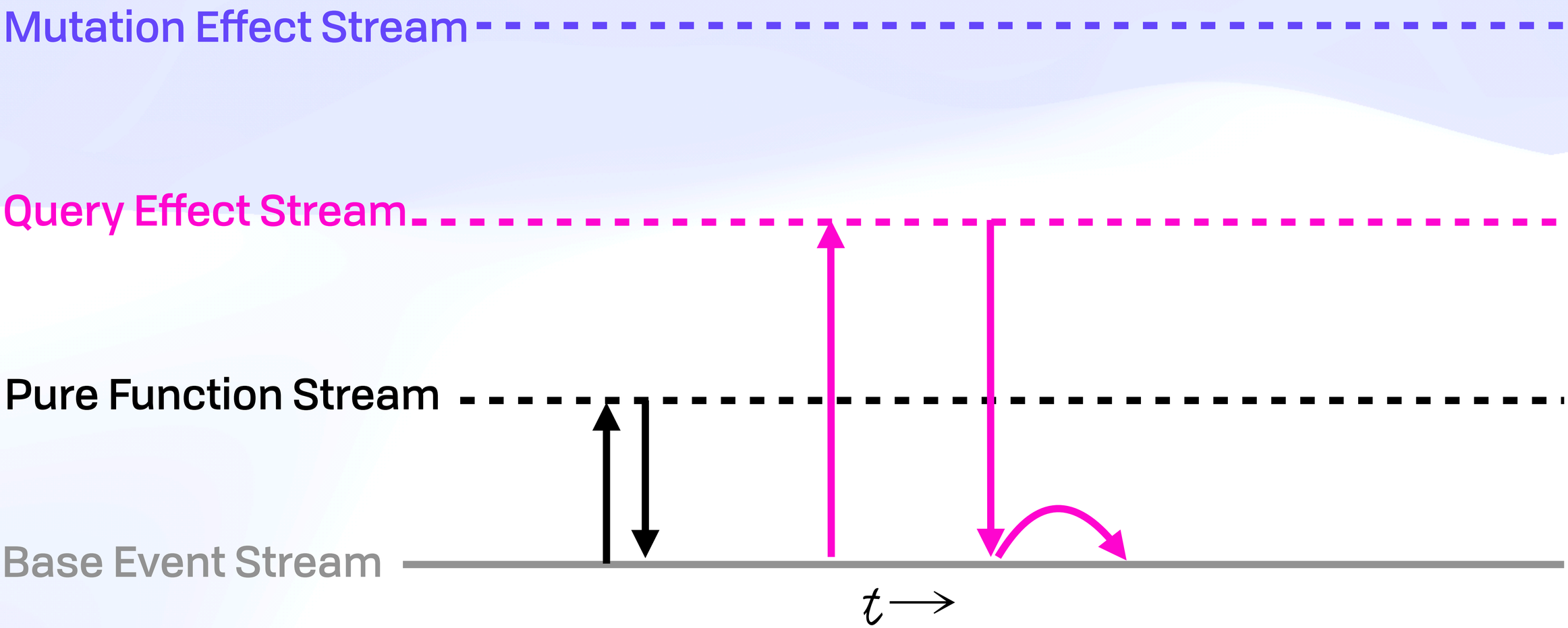
The Safety Dance 🦹‍♀️

Managed Effects



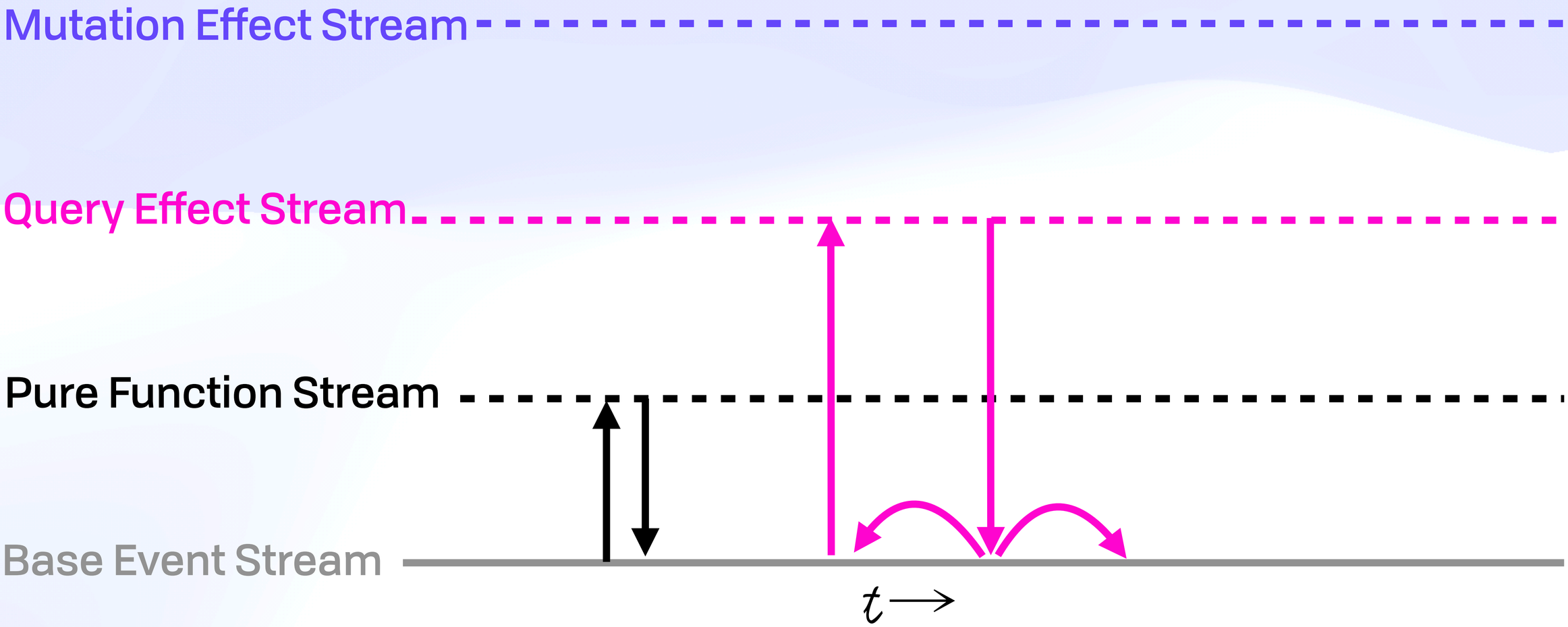
The Safety Dance 🕺

Managed Effects



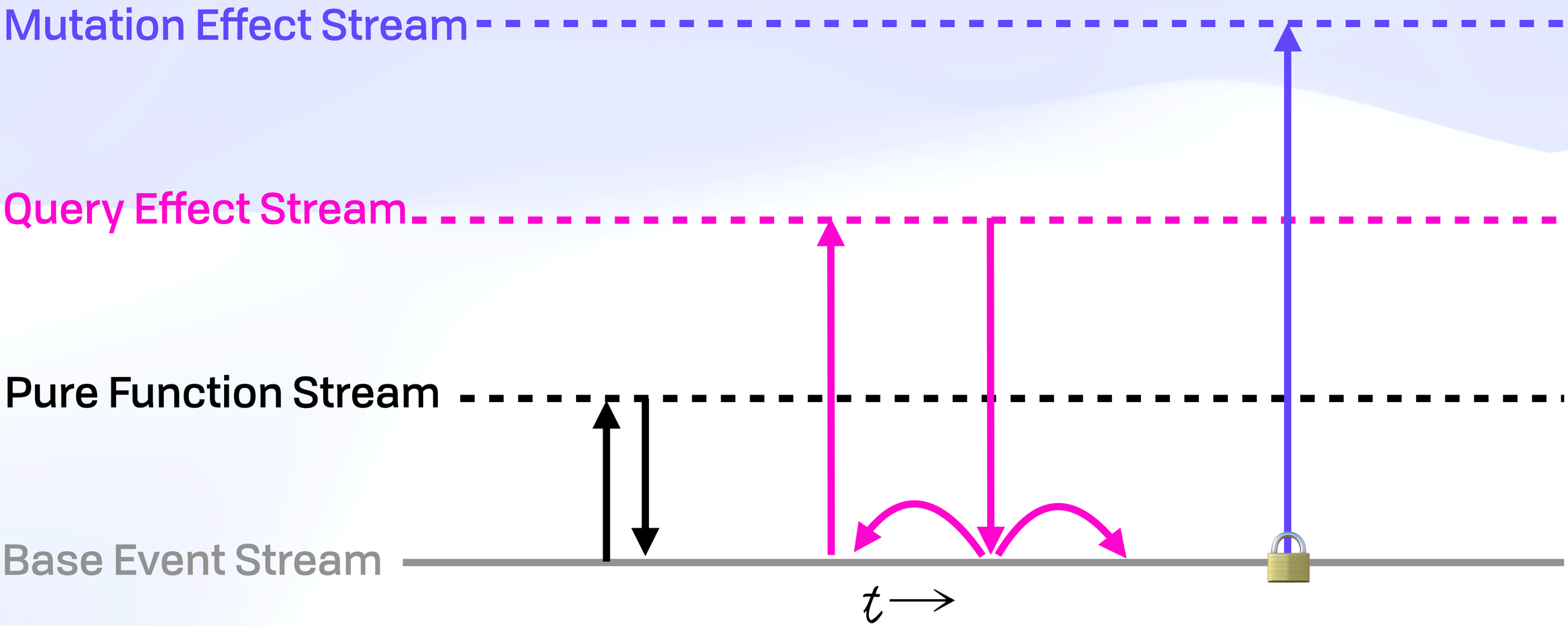
The Safety Dance 🦹‍♀️

Managed Effects



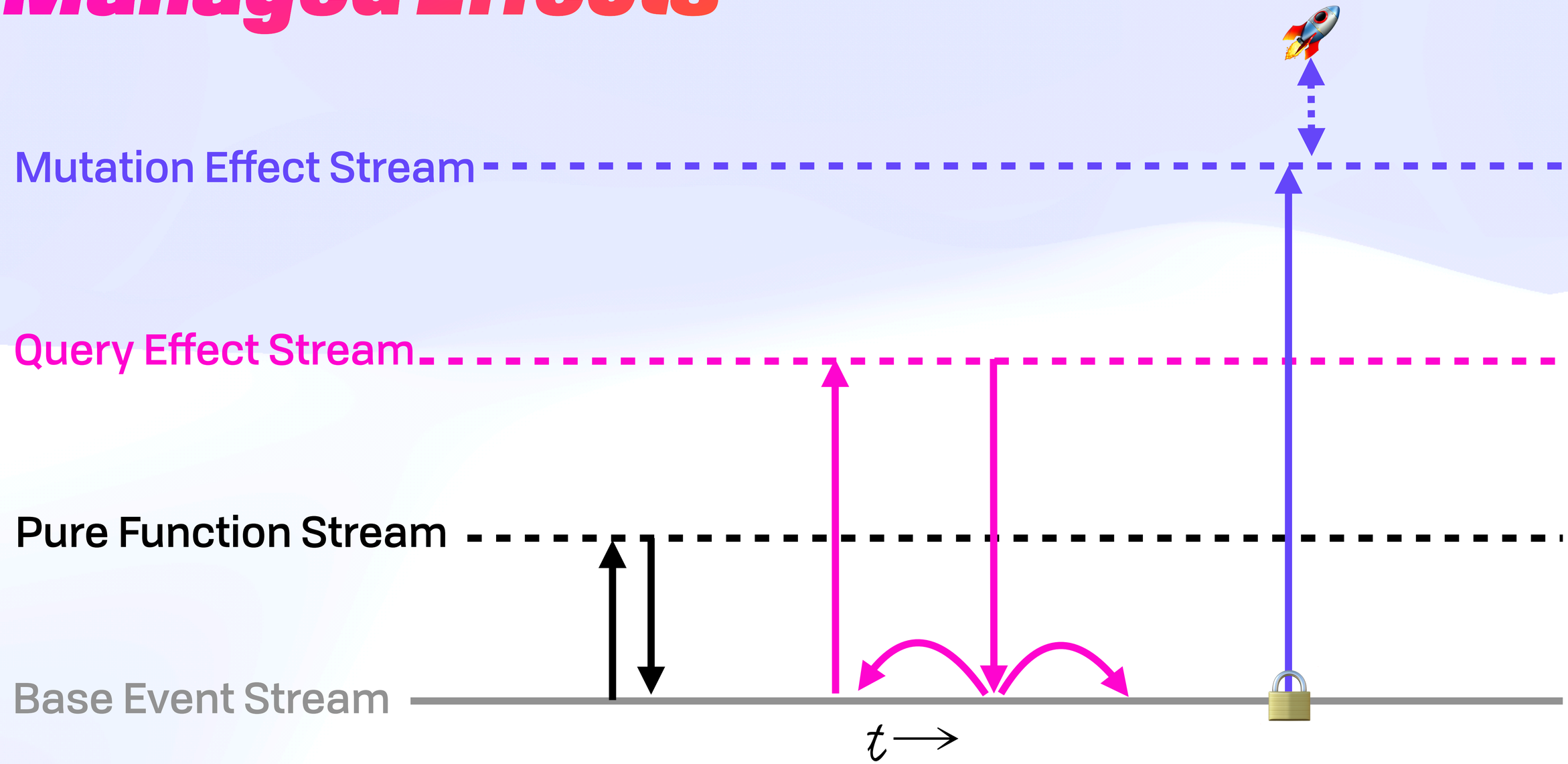
The Safety Dance 🕺

Managed Effects



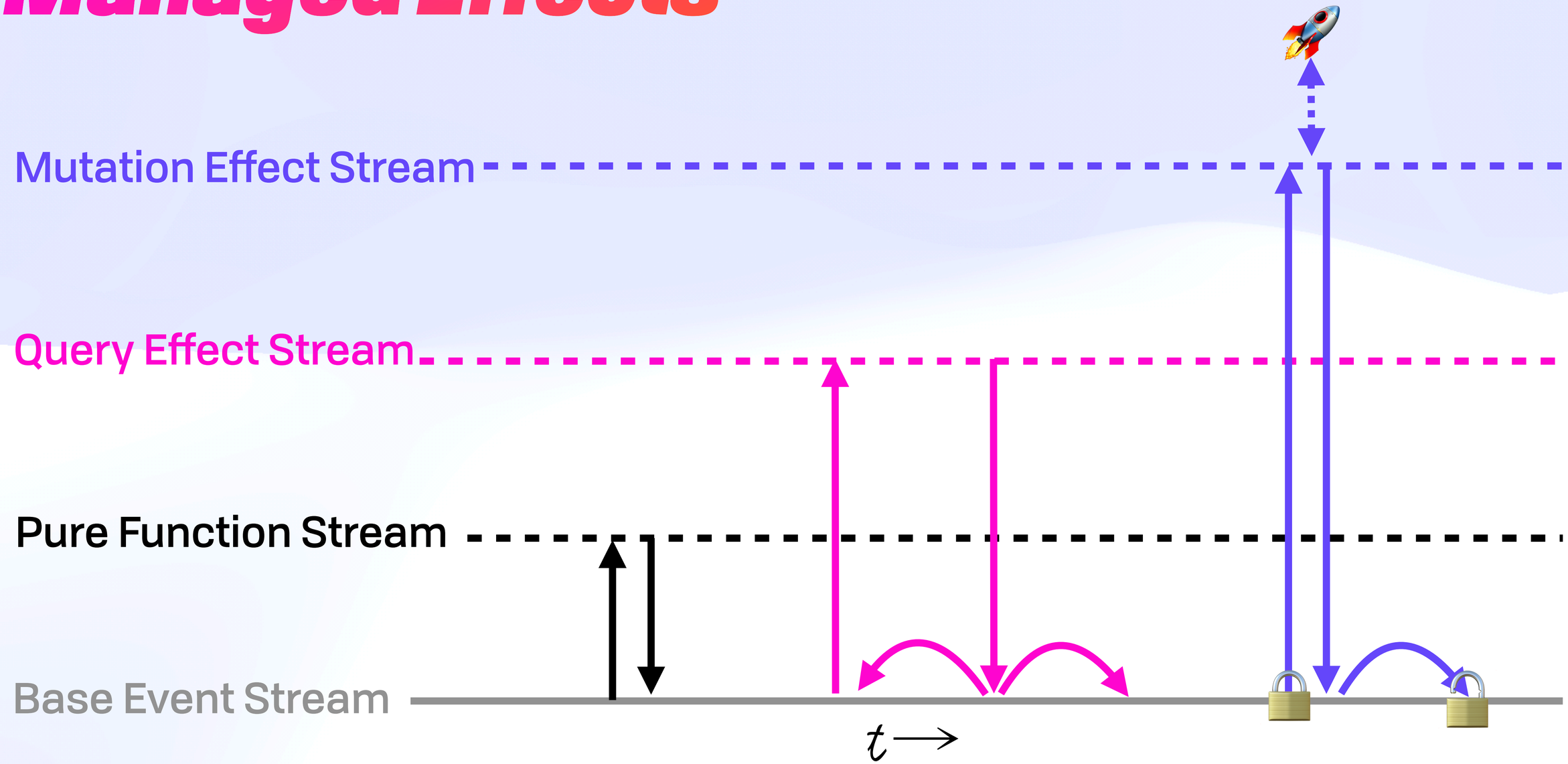
The Safety Dance 🦹‍♀️

Managed Effects



The Safety Dance 🕺

Managed Effects



The Safety Dance 🕺

Virtual Resiliency

The Safety Dance 🕺

Virtual Resiliency

- Mutable 🦋
- Idempotent 🔂
- Deterministic 📆

The Safety Dance 🕺

Virtual Resiliency

Query A

Query B

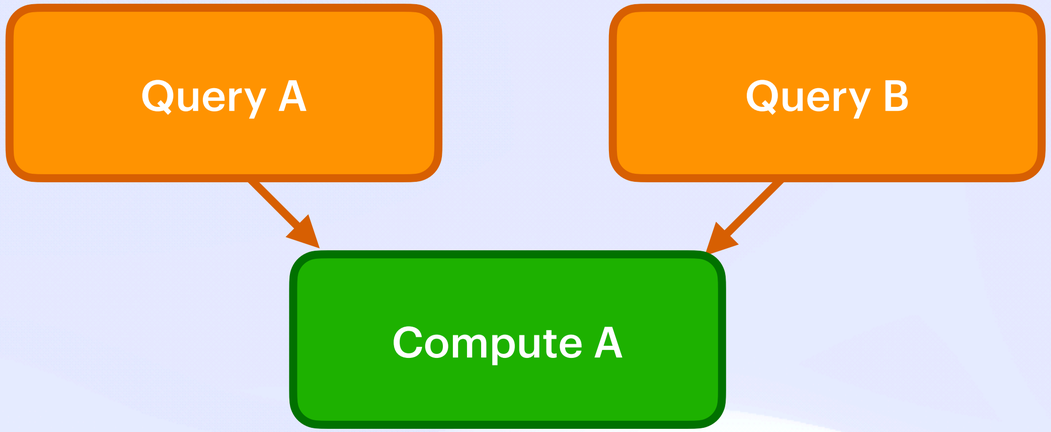
Mutable 🦋

Idempotent 🔂

Deterministic 📆

The Safety Dance 🕺

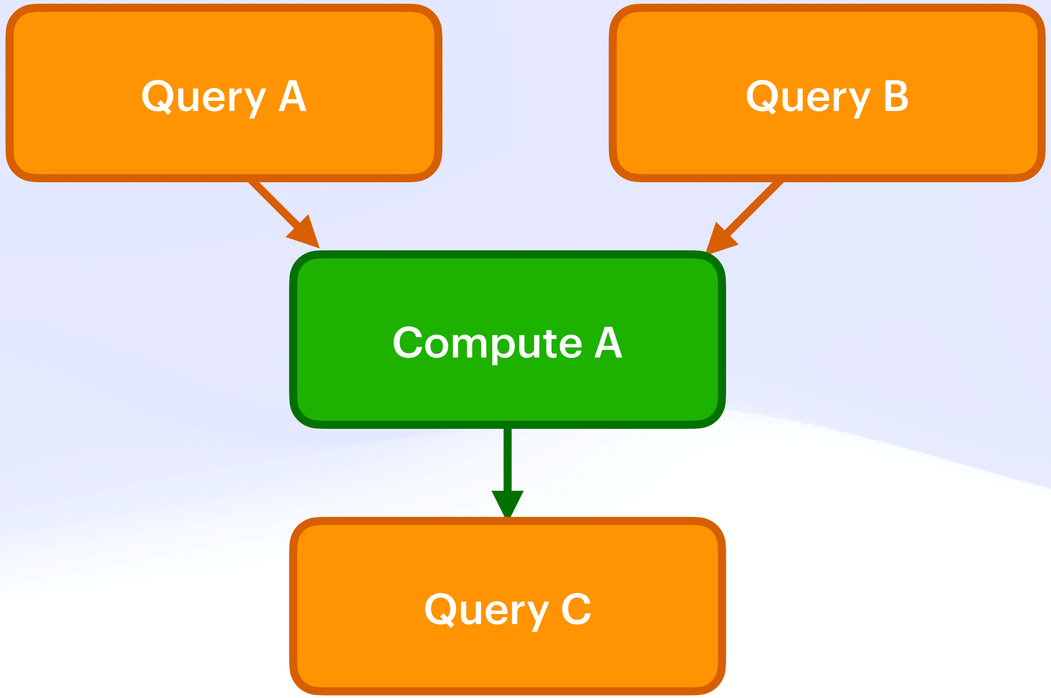
Virtual Resiliency



- Mutable 🦋
- Idempotent 🔂
- Deterministic 📆

The Safety Dance 🕺

Virtual Resiliency

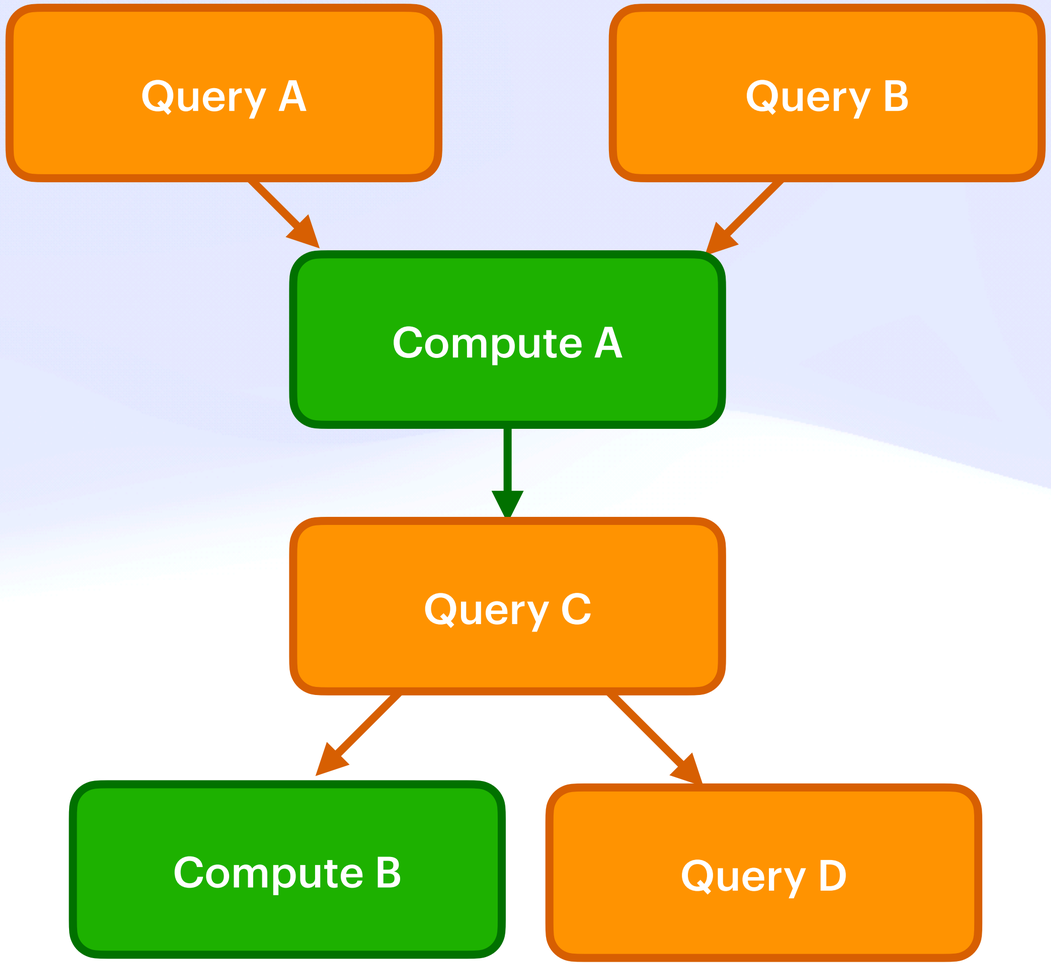


- Mutable 🦋
- Idempotent 🔂
- Deterministic 📆

The Safety Dance 🕺

Virtual Resiliency

- Mutable 🦋
- Idempotent 🔂
- Deterministic 📆



The Safety Dance 🕺

Virtual Resiliency

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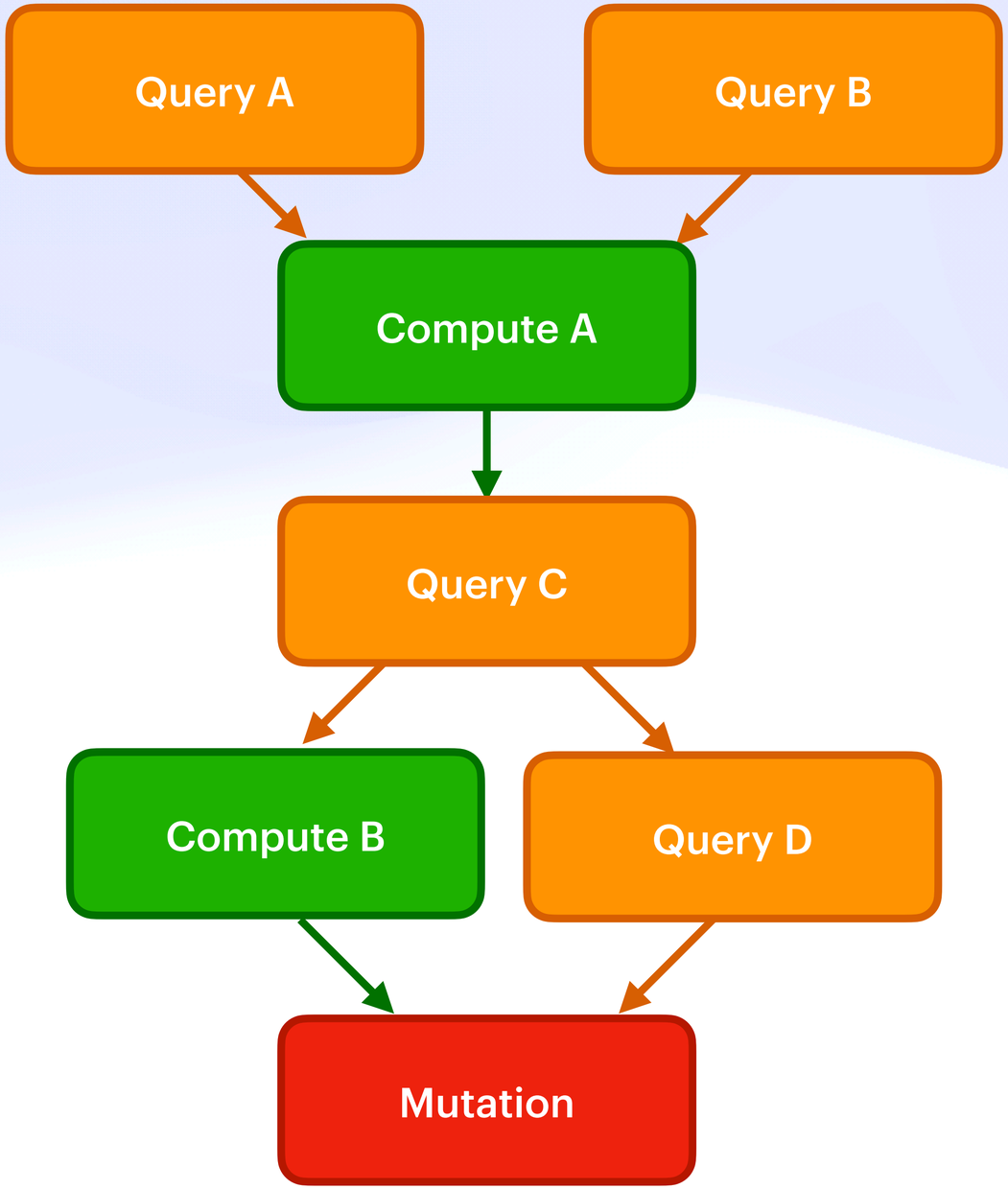

The Safety Dance 🕺

Virtual Resiliency

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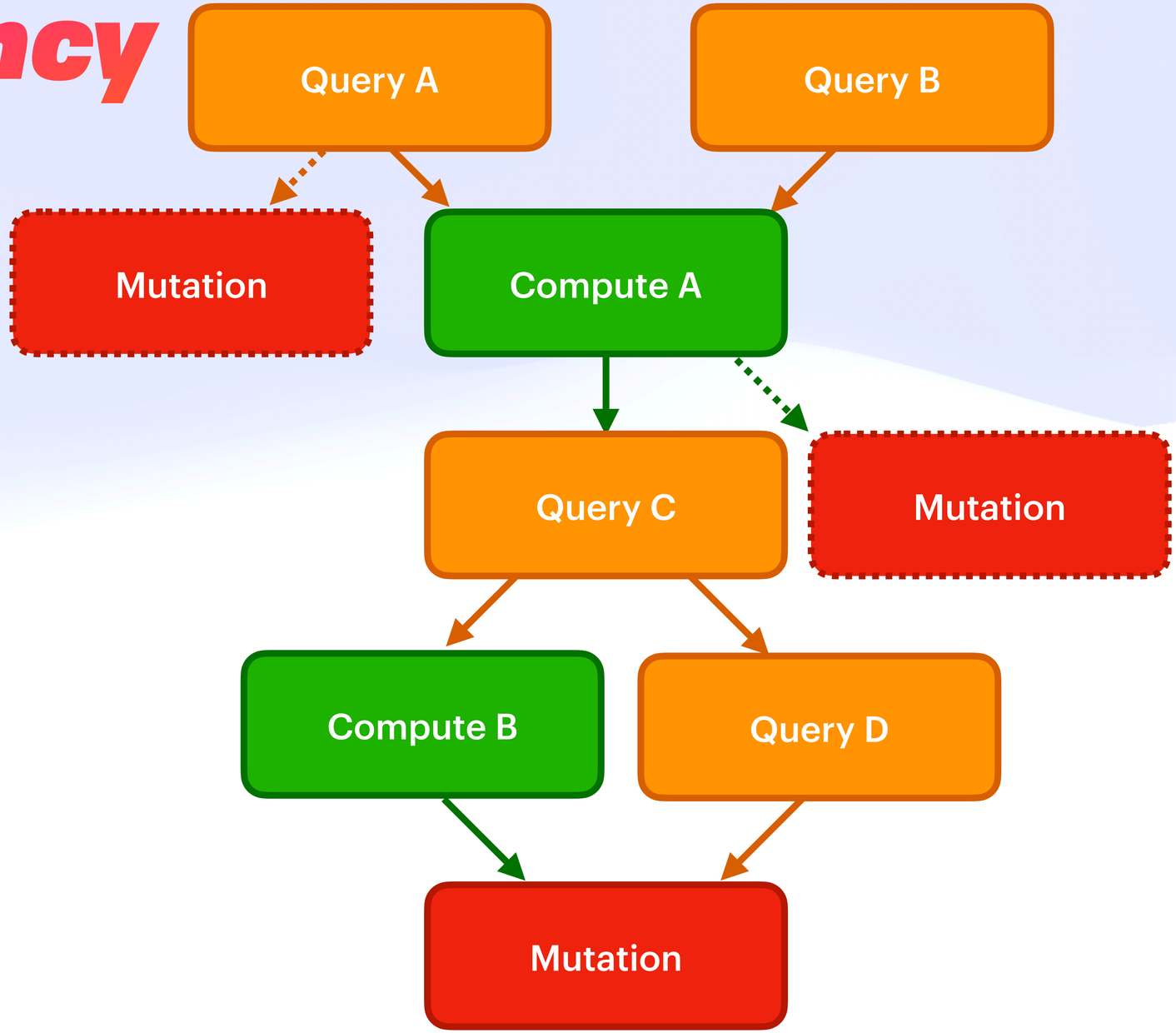


The Safety Dance 🕺

The Safety Dance 🕺

If their application can be cast as ***pure data processing***, they benefit from the past 40-50 years of work form the database community, [and] ***completely isolate the developer from the possibility of failure***

— **Goldstein et al,** AMBROSIA: Providing Performant Virtual Resiliency for Distributed Applications

The Safety Dance 🕺

Simplified Safe Layout

The Safety Dance 🕺

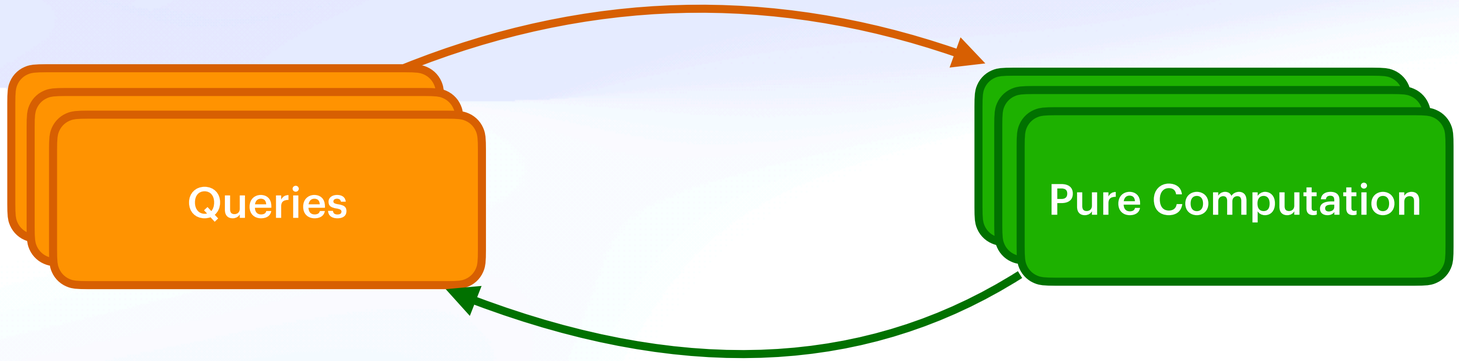
Simplified Safe Layout

The Safety Dance 🦹

Simplified Safe Layout

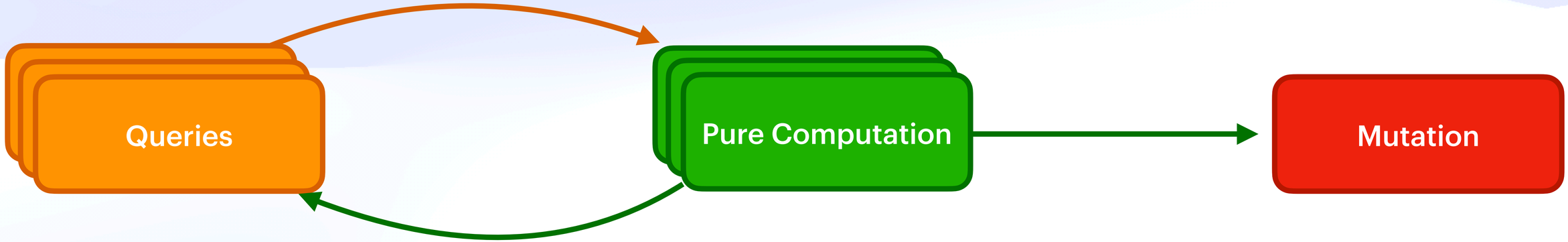
The Safety Dance 🕺

Simplified Safe Layout



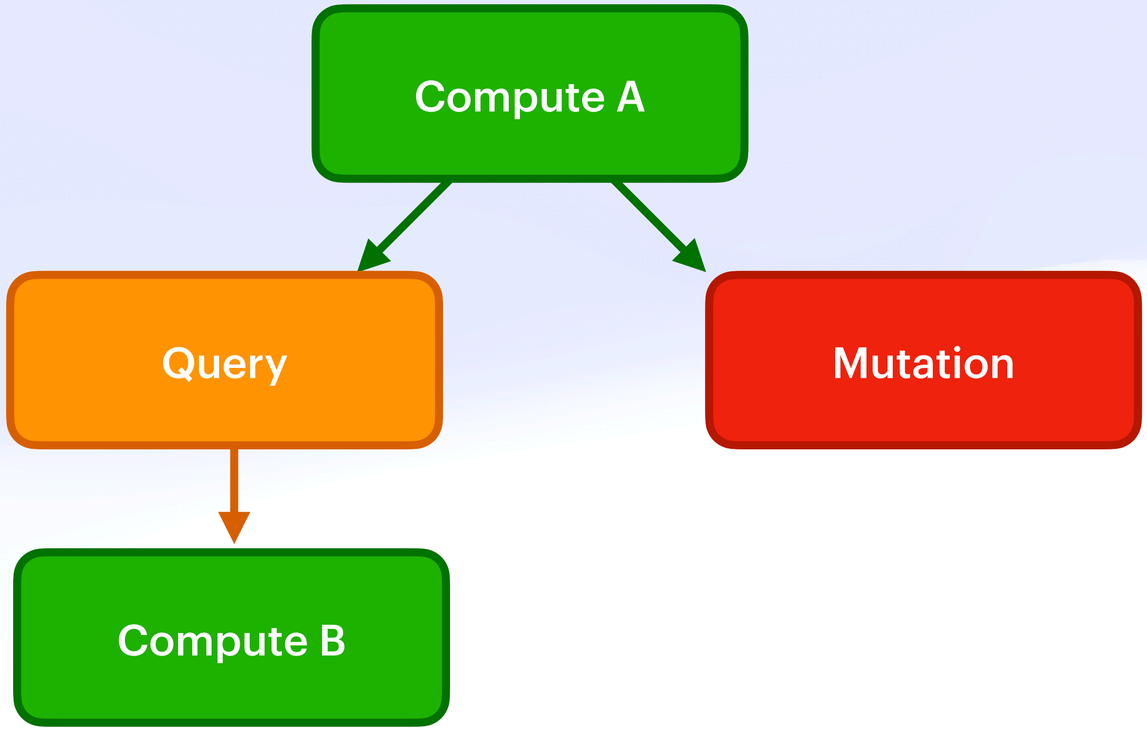
The Safety Dance 🕺

Simplified Safe Layout



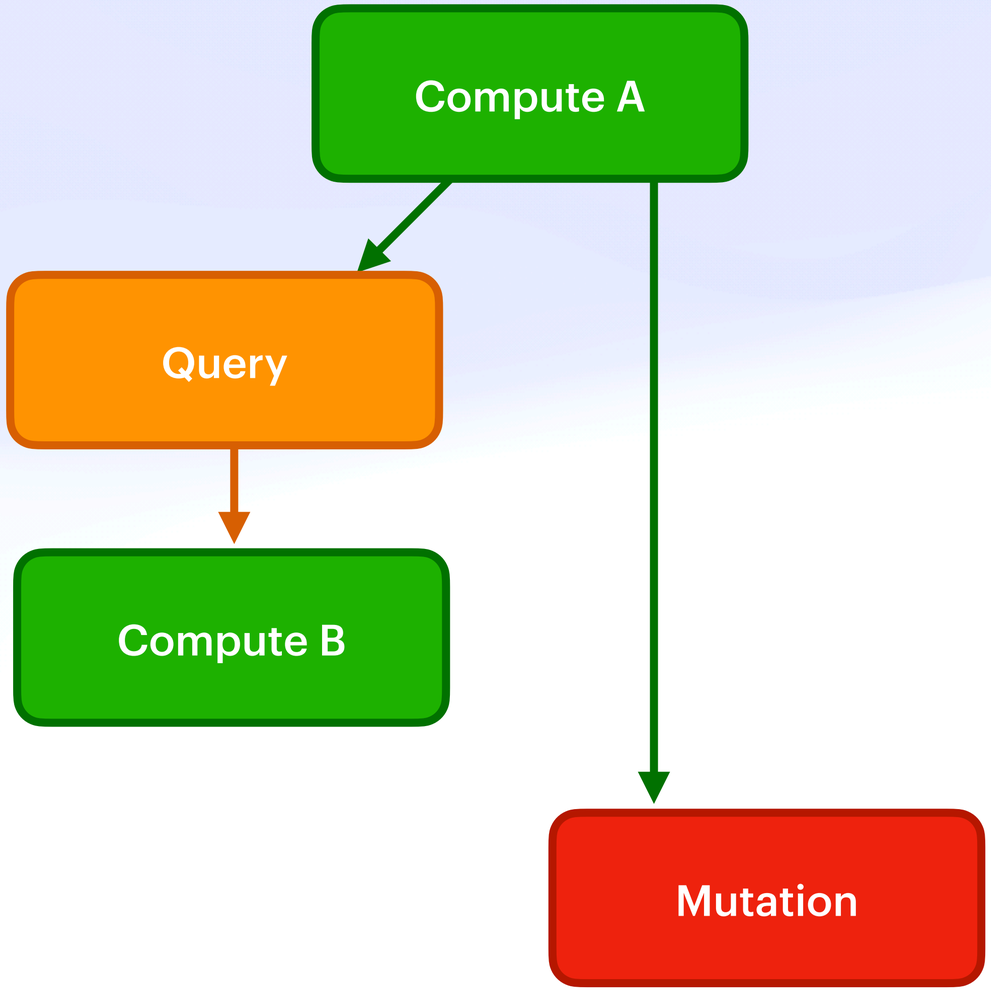
The Safety Dance 🕺

Simple Example



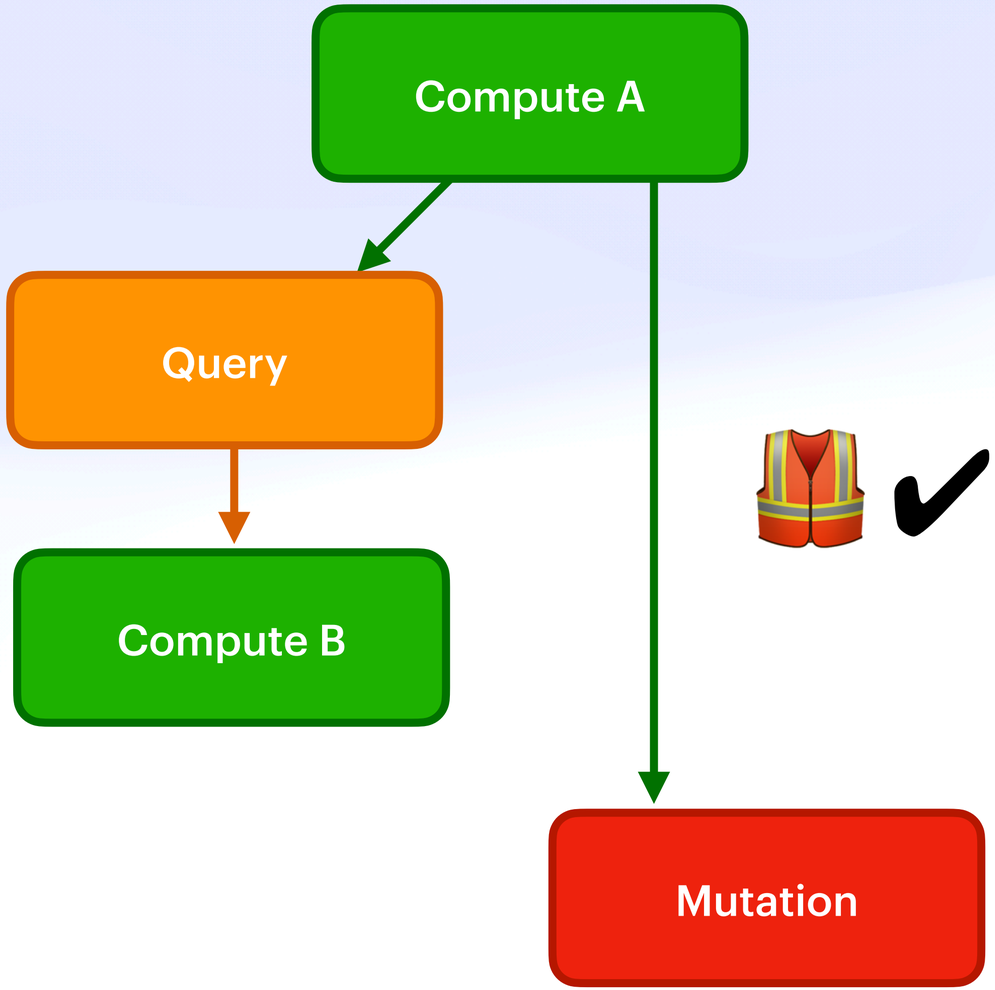
The Safety Dance 🕺

Simple Example



The Safety Dance 🕺

Simple Example



🦺 ✔


Wrap Up

Wrap Up

Reusable / Remixable Specs

Wrap Up

Reusable/Remixable Specs

IPVM Workflow 🎛️

Transactions, Error Handling, Defaults

IPVM Task ⚙️

VM Config, Verification, etc

UCAN Pipeline 🌊

Call Graph, Awaits, etc

UCAN-Chan / ユーキャンちゃん

Consumable Channels

Receipts

Attestation, Memoization, etc

UCAN Invocation 🪄

Input Addressing, Execution, etc

UCAN Core 🎟️

Distributed Authority

IPLD-WIT ⚙️

IDL

Varsig ✍️

Self-Describing Signatures

github.com/ucan-wg

github.com/ipvm-wg

🎉 Thank You, Strange Loop ♾️

📄 https://fission.codes

📧 brooklyn@fission.codes

🦣 @expede@octodon.social

🦋 bsky.app/profile/expede.wtf