Rethinking General-Purpose Decentralized Computing

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EPFL

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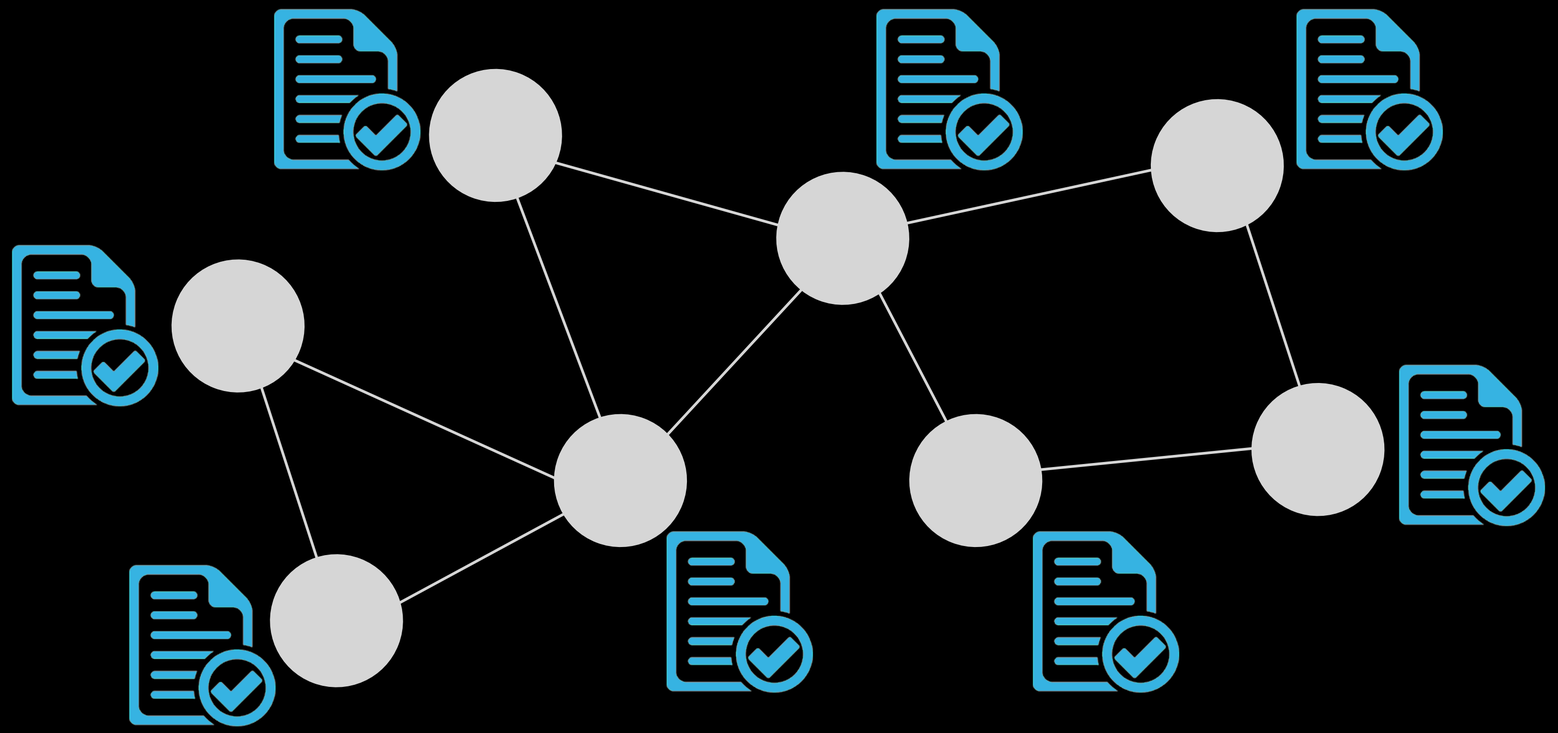
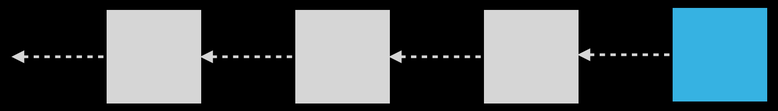
MORE BLOCKCHAIN

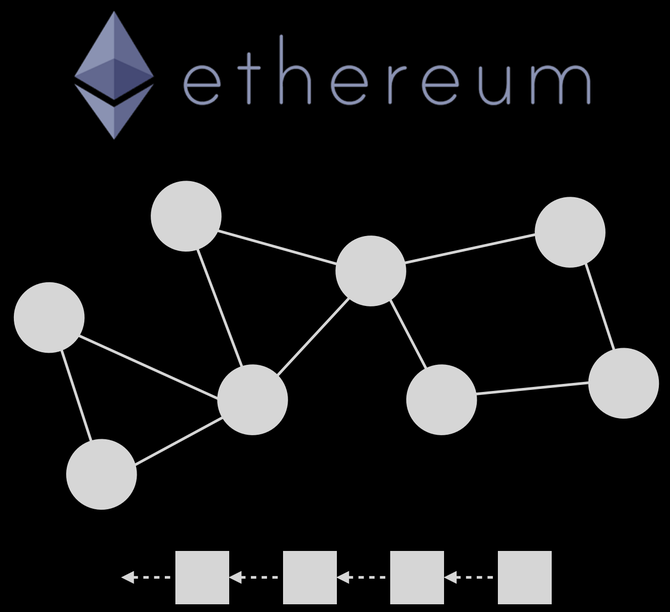
MORE BLOCKCHAIN

Smart contracts





Ethereum



- 2nd largest cryptocurrency
- ~445M transactions processed
- ~1.5M contracts deployed
- “The world computer”

BUT…

What’s wrong?

😔 Limited functionality

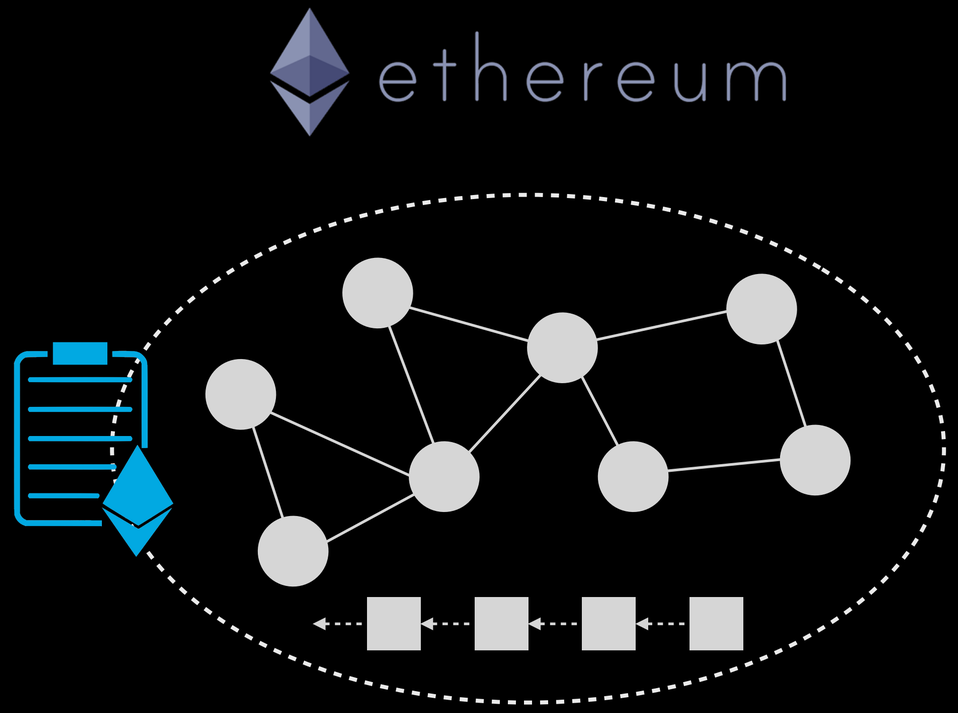
- ❖ No support for non-determinism
- ❖ Cannot securely operate on private data

😔 Difficulty of system upgrades

😔 Poor performance

- ❖ Every node runs every contract

Running example: Betting application



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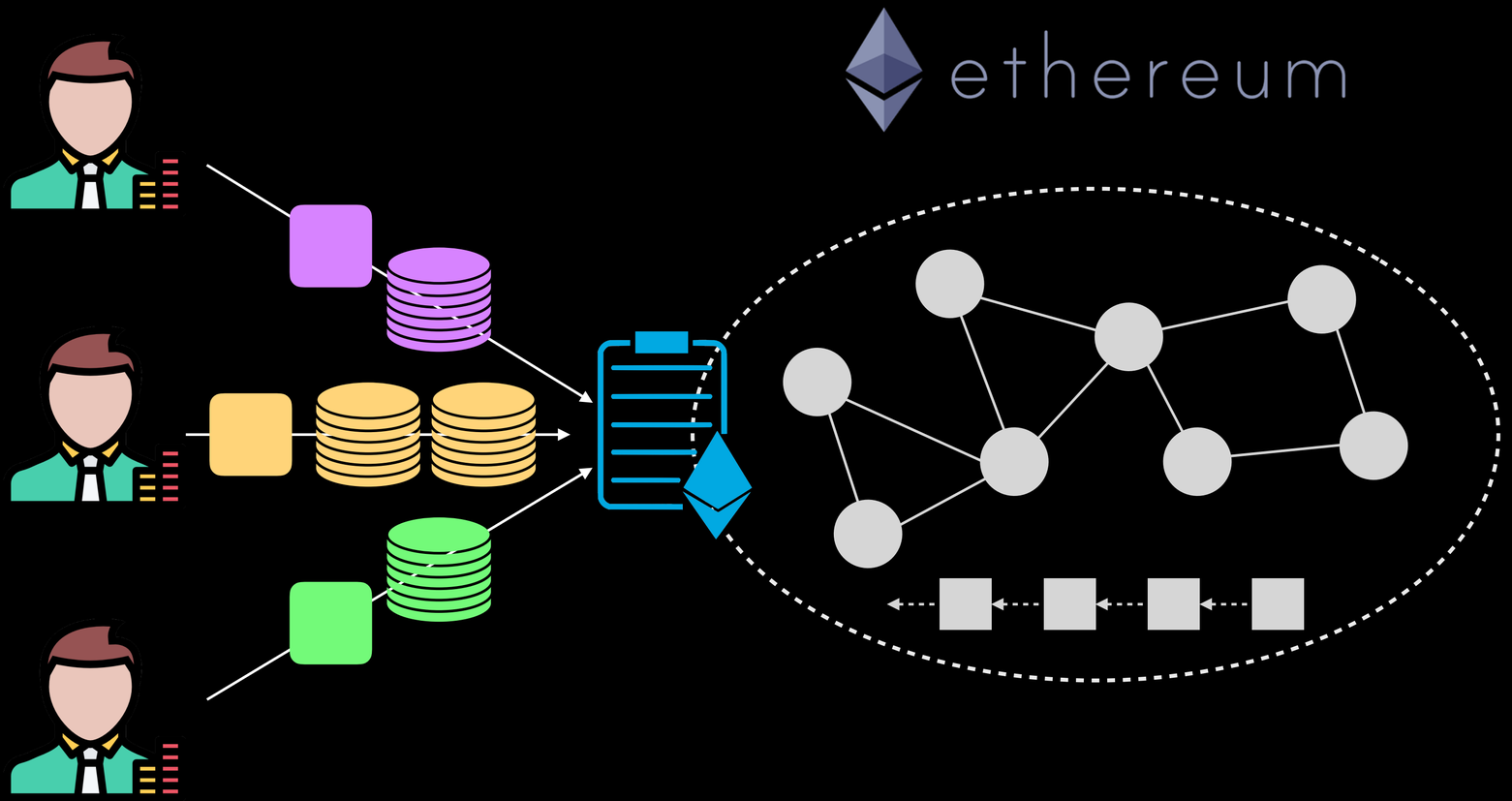

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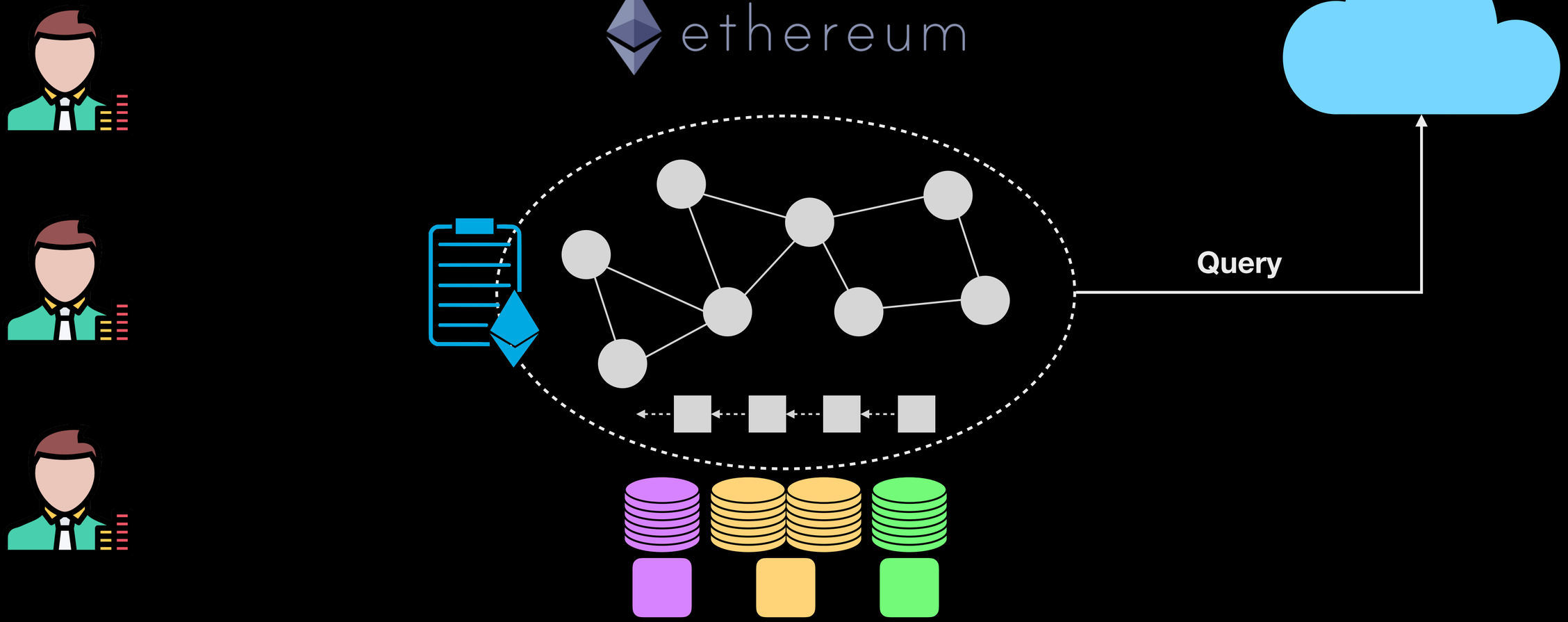

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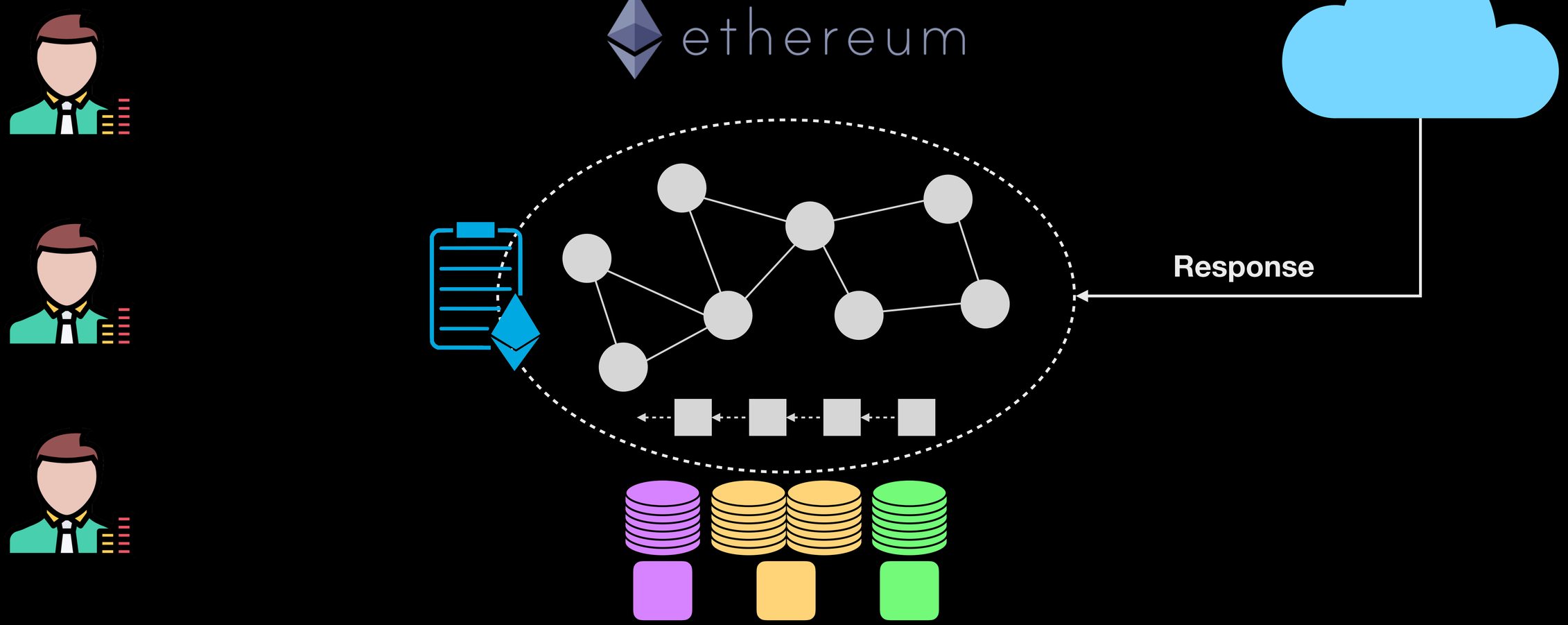

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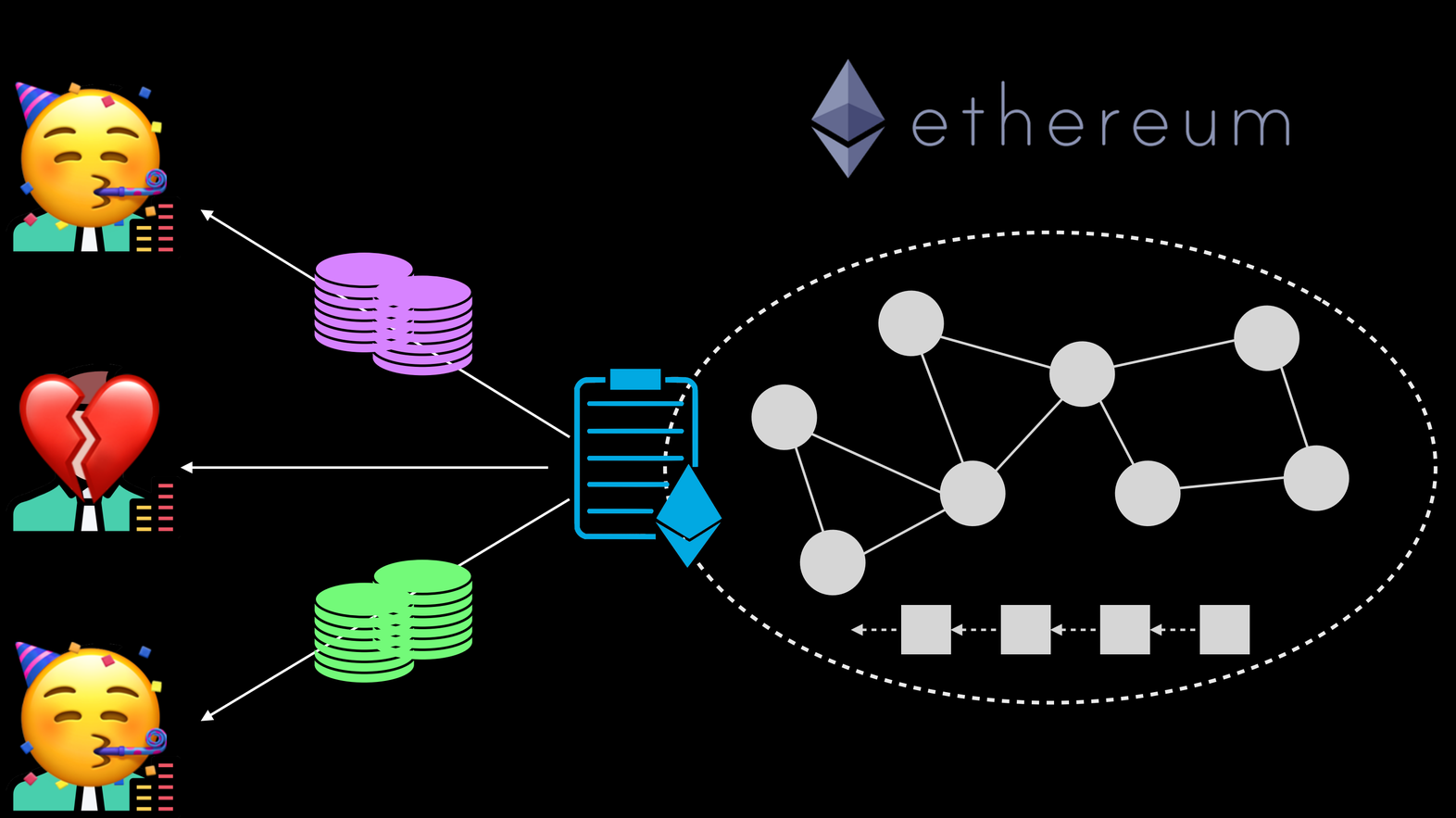


Challenges

Hide predictions until release time

Store data off-chain

Access to reliable real-world data

Third-party oracle services

Challenges

Hide predictions until release time

Access to reliable real-world data

Upgrade for new functionalities

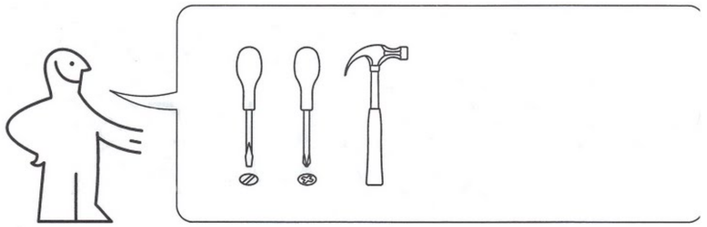
Challenges

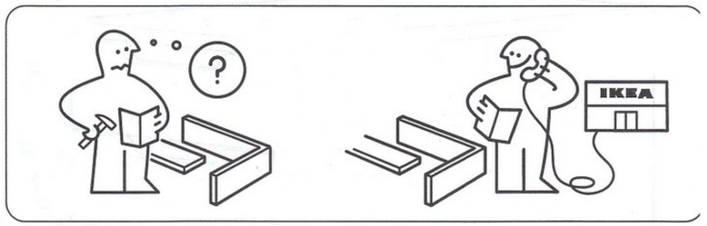
Hide predictions until release time

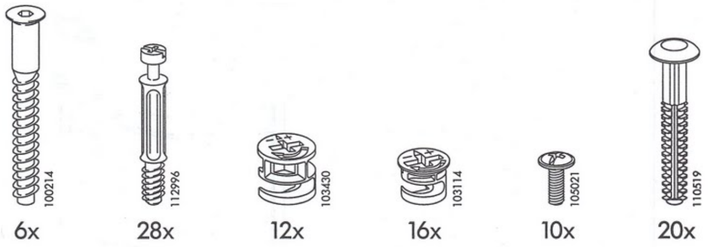
Access to reliable real-world data

Monolithic architecture

Consensus and **code execution**
are **tightly coupled**




?
IKEA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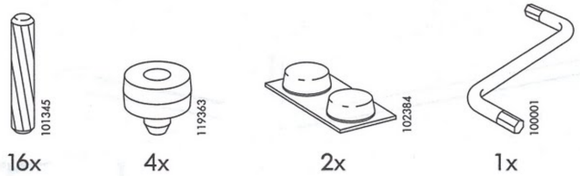
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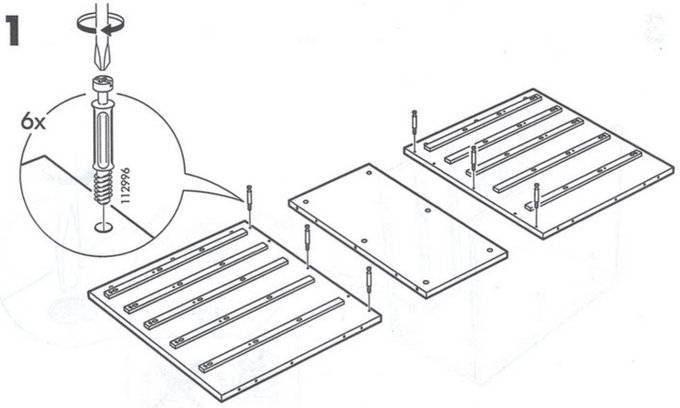
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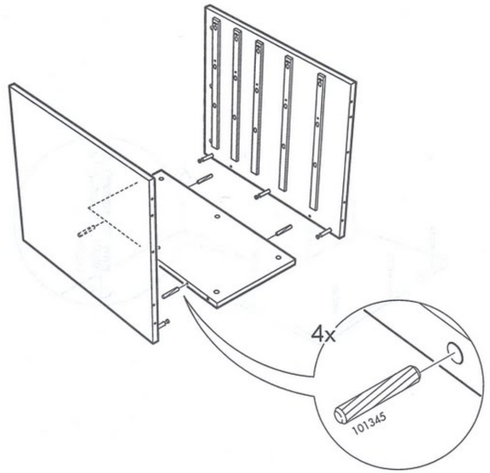
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PROTEAN

A modular architecture for general-purpose decentralized computing

Functional separation of nodes into special-purpose modules

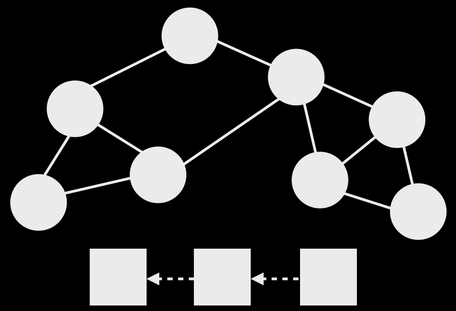
Functional units

- Distributed systems that provide distinct specialized computations
- Similar to **microservices** architecture in cloud computing

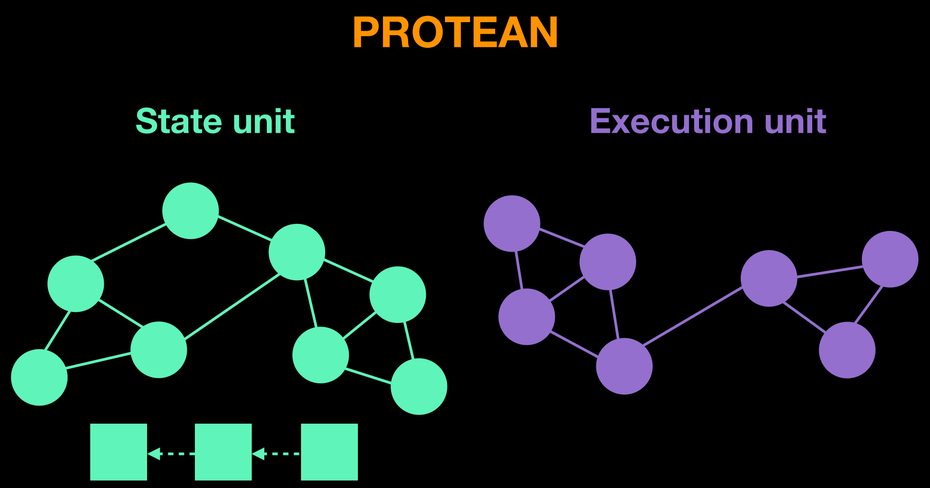
Functional units

Ethereum

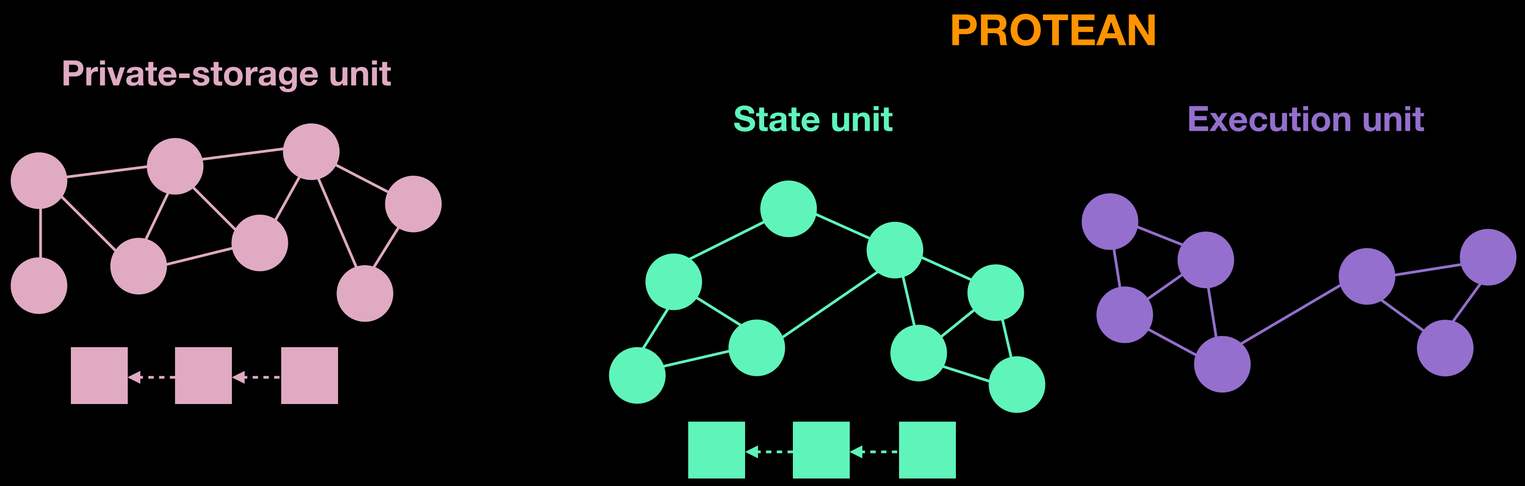
State & Execution unit



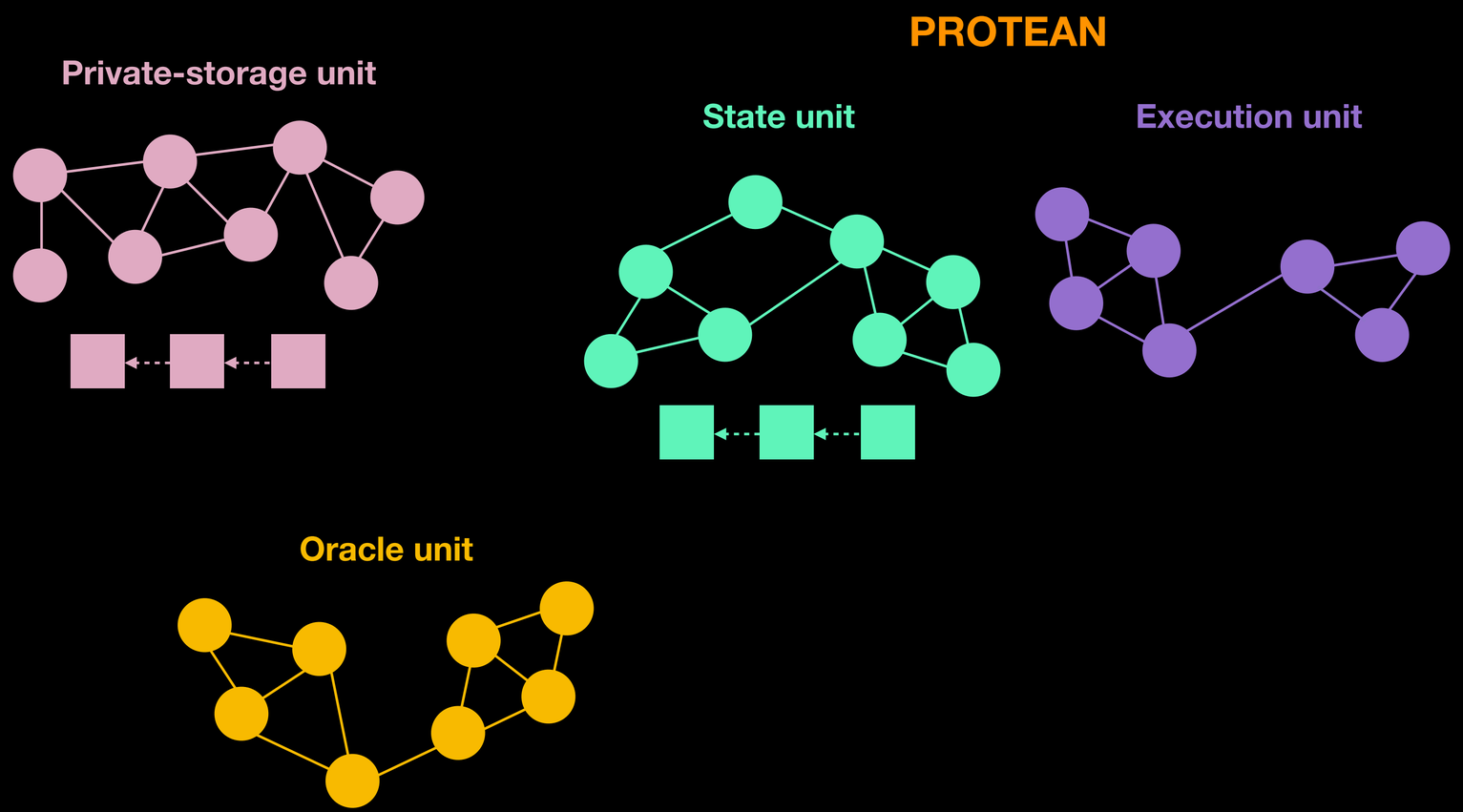
Functional units



Functional units



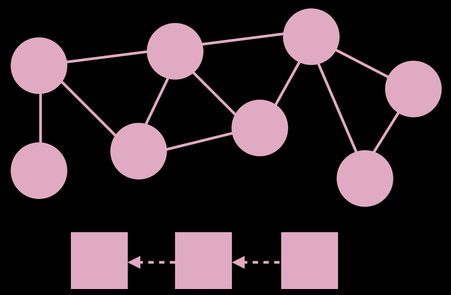
Functional units



Functional units

PROTEAN

Private-storage unit



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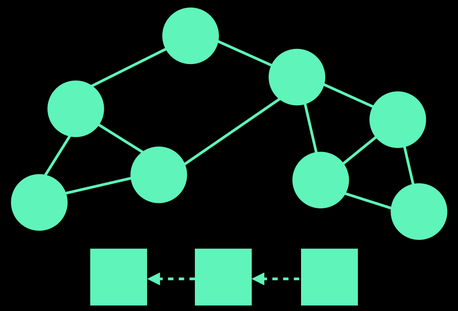

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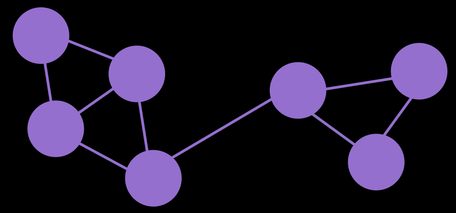
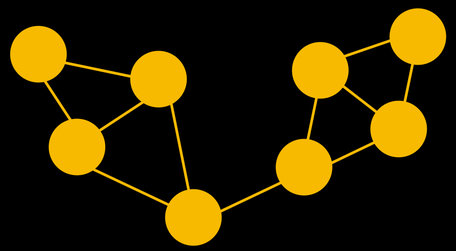


Oracle unit



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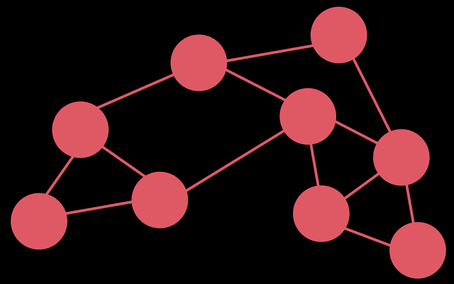

Functional units

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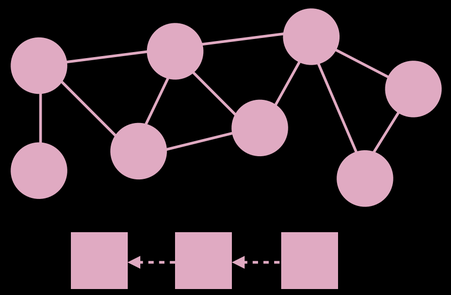

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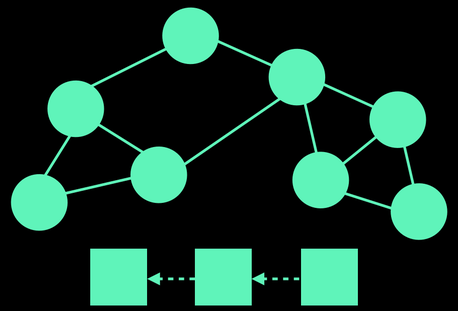

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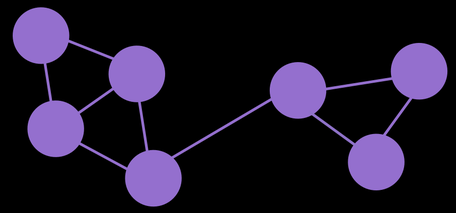
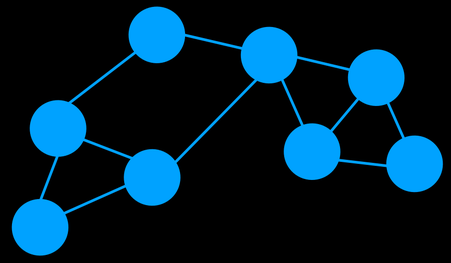


Shuffler unit



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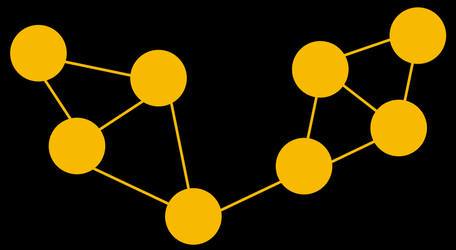

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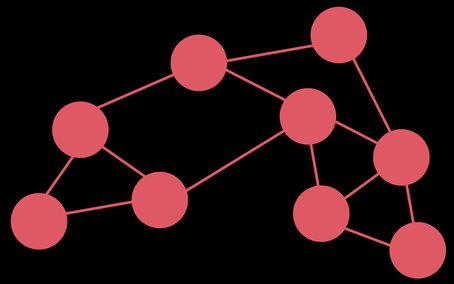

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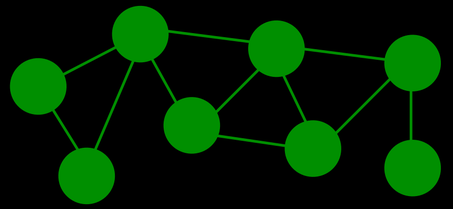

Functional units

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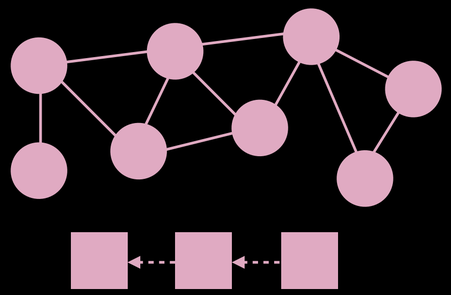
Private-storage unit



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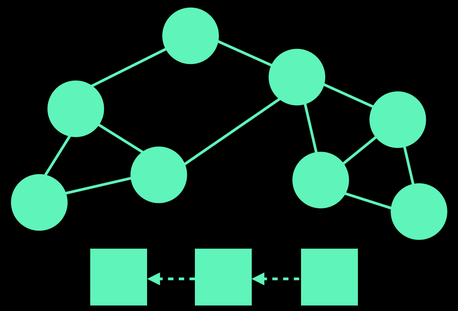

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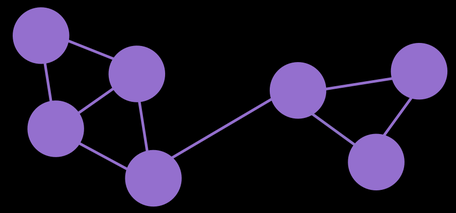
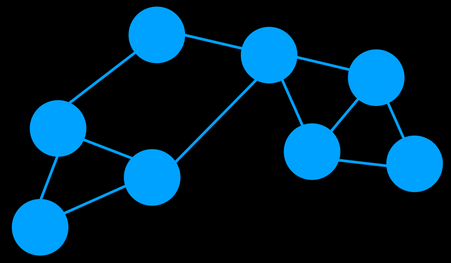
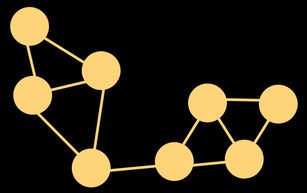


Shuffler unit



OU1-v2



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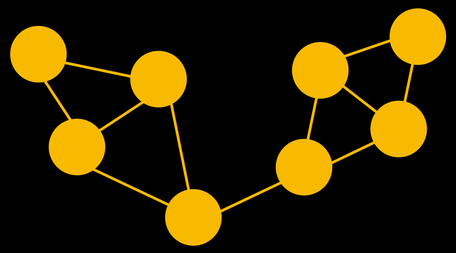

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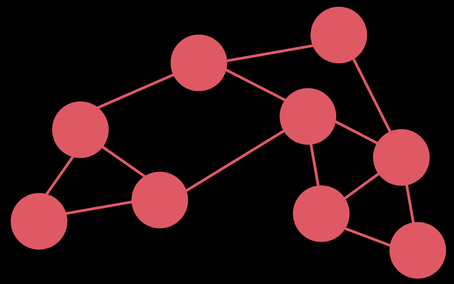

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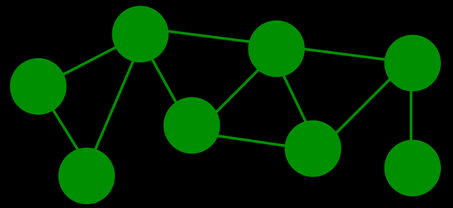
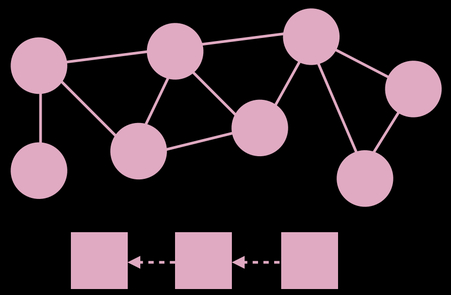


Functional units

PROTEAN

Private-storage unit



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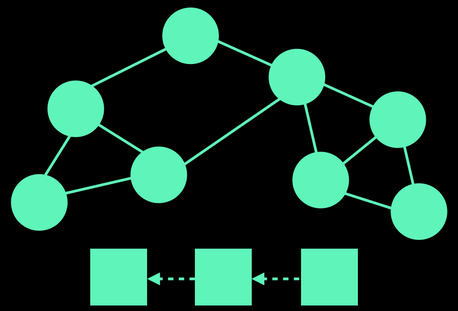

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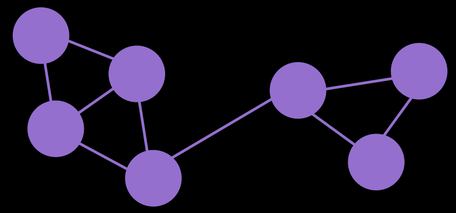

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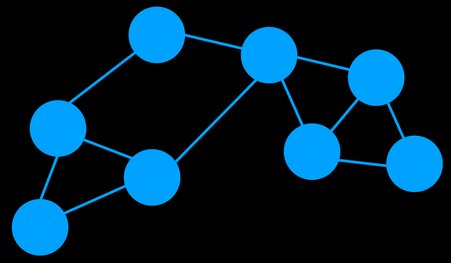

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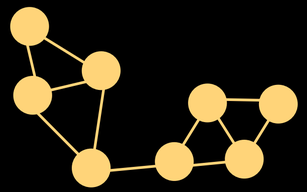

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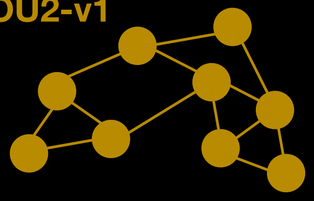

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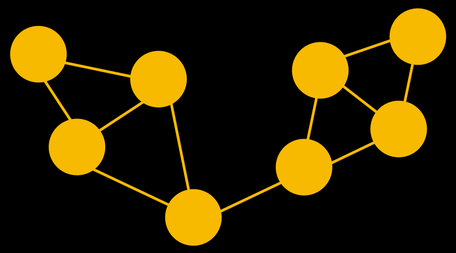
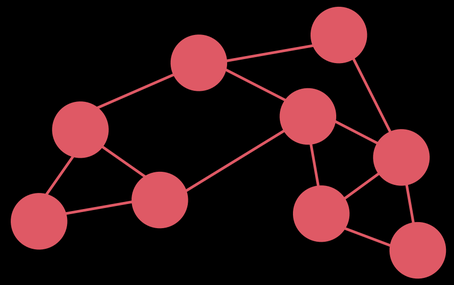


OU1-v1

Randomness unit



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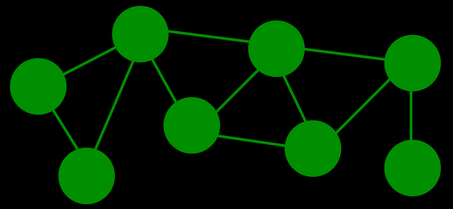
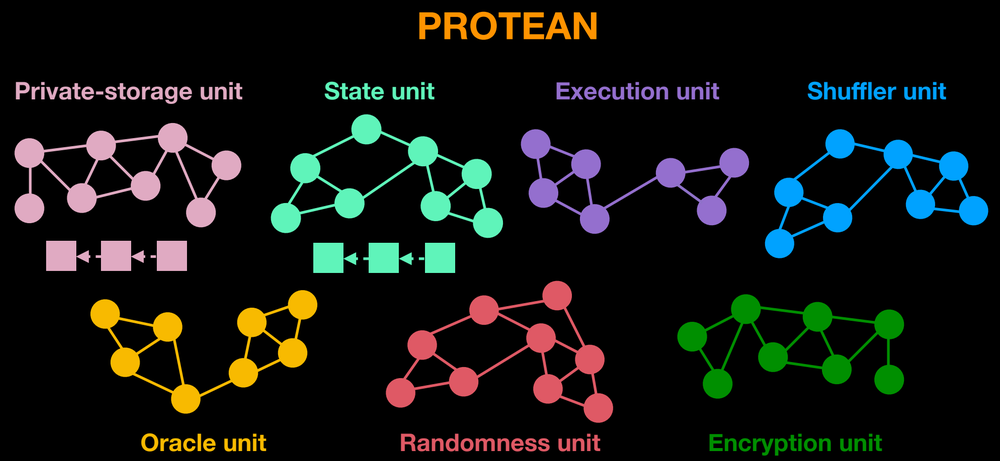


Functional units



Richer set of functionalities

Permissionless evolution

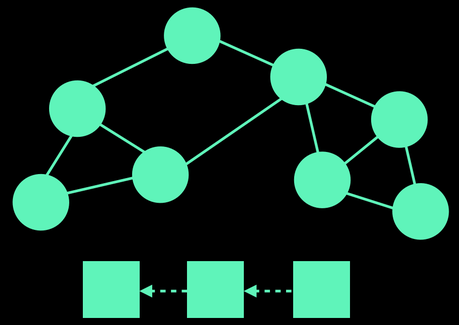
Functional units

- Expose a set of **transactions**
  - ❖ Building blocks for decentralized applications
  - ❖ Well-defined semantics and API
  - ❖ Executed atomically by the unit
- Provide cryptographic proof of successful execution

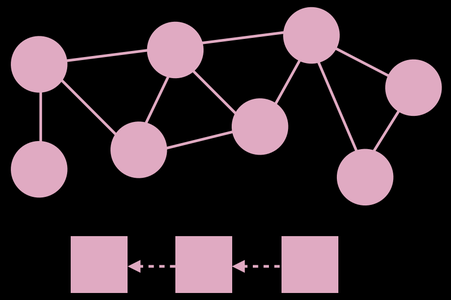
Building applications

Bet

State unit

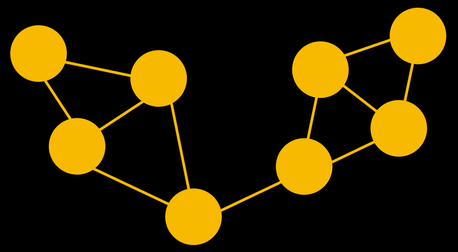


Private-storage unit



Reveal

Oracle unit



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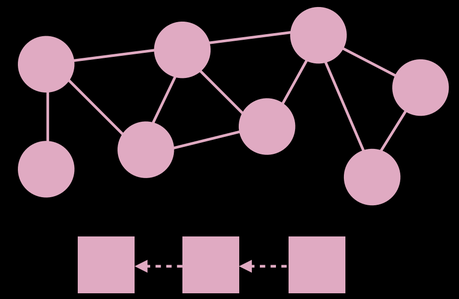

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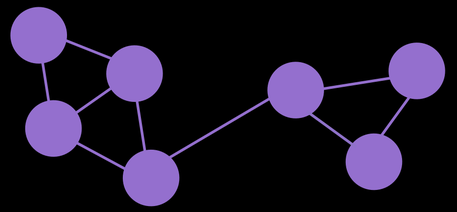

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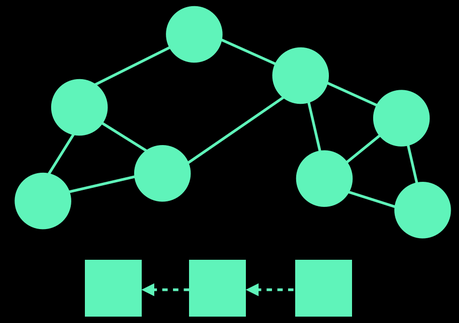
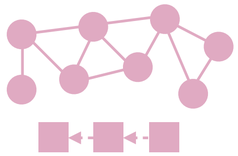


Private-storage unit



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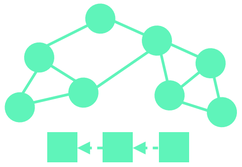
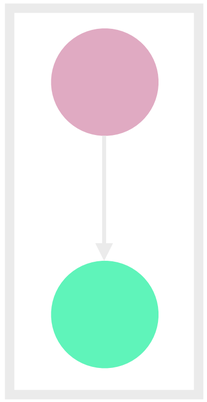


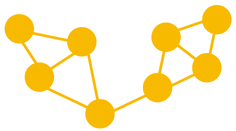
Workflow



store_secret

update_state

Oracle unit



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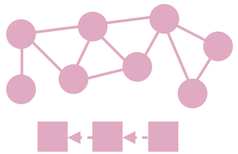
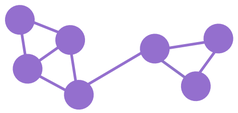


Execution unit



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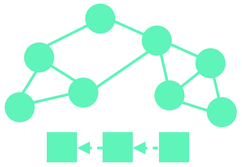
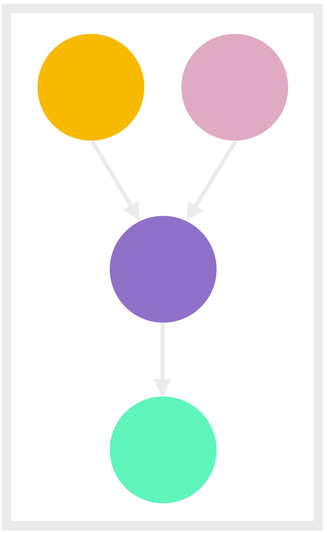


oracle_query

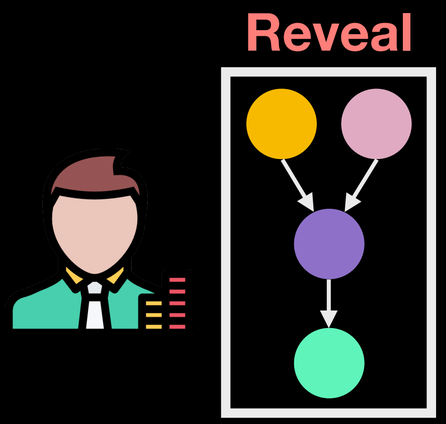
execute

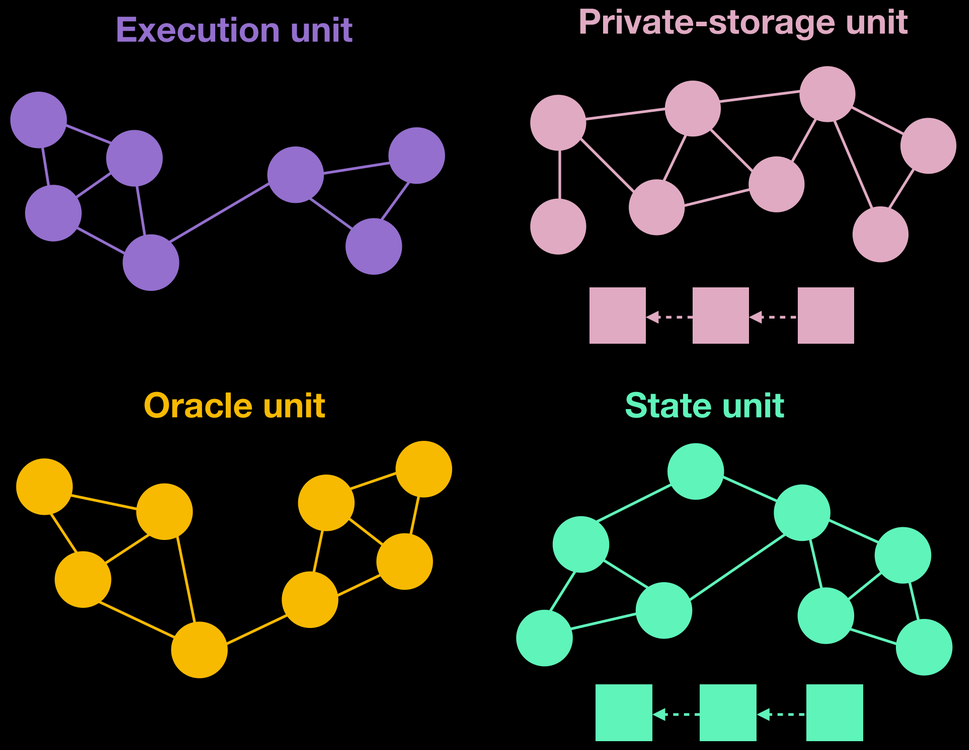
update_state



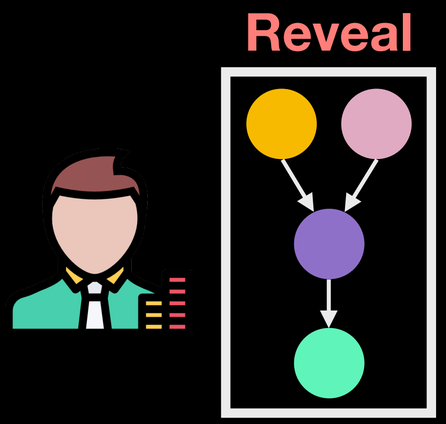
get_secret

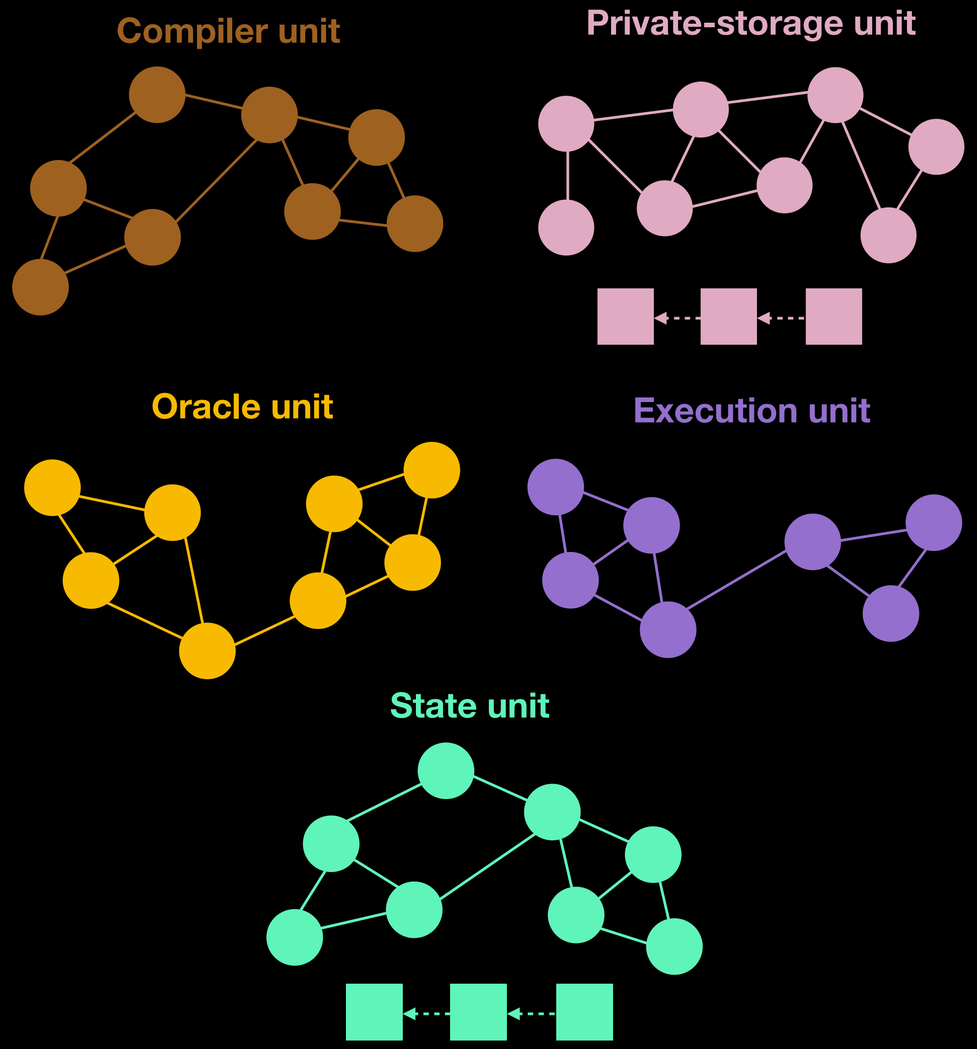
Executing applications





Executing applications





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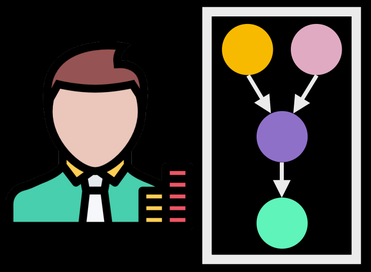
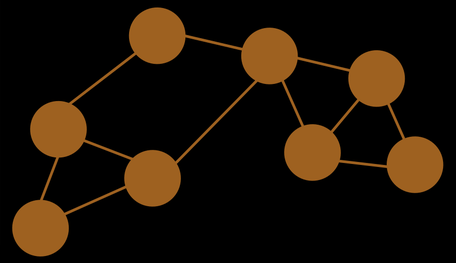
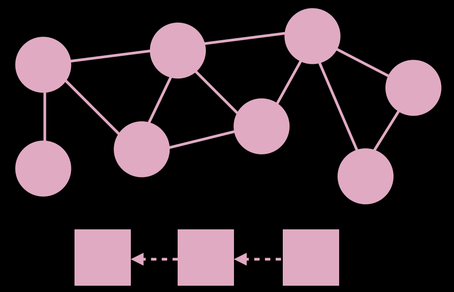
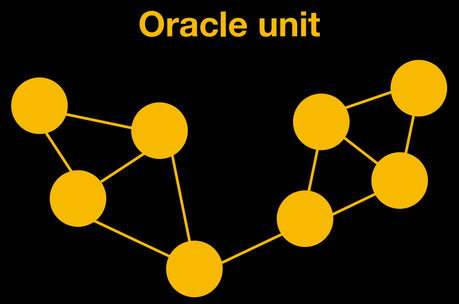
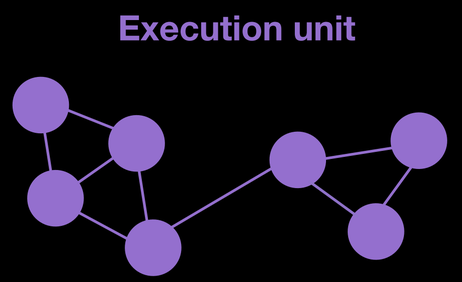
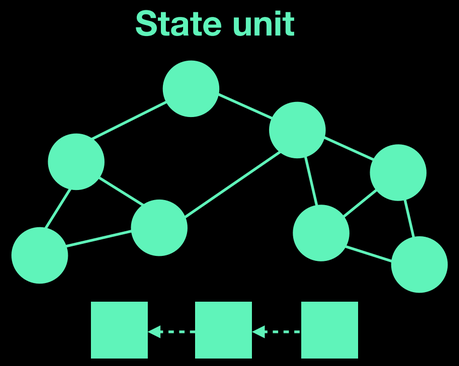




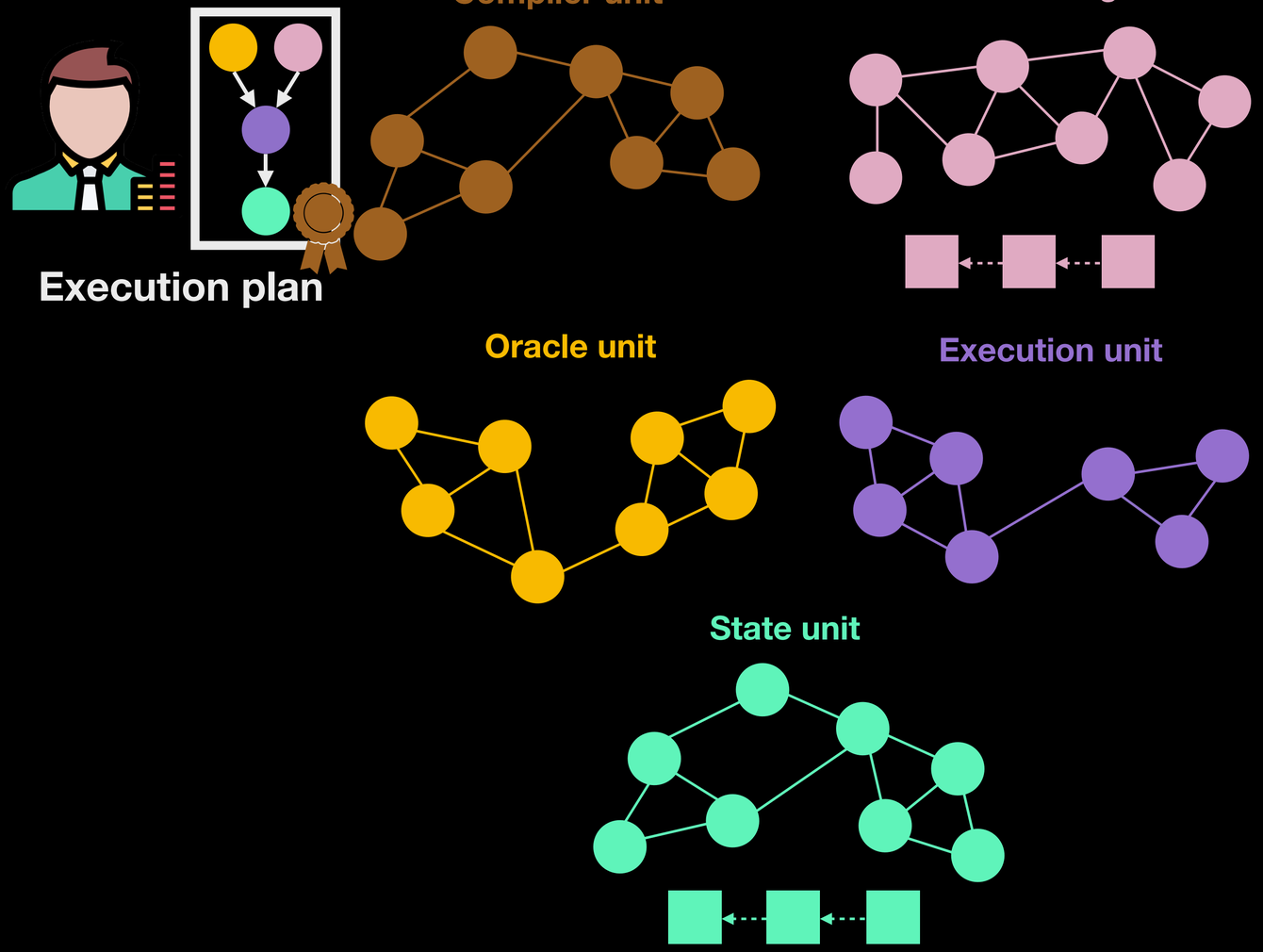








Executing applications



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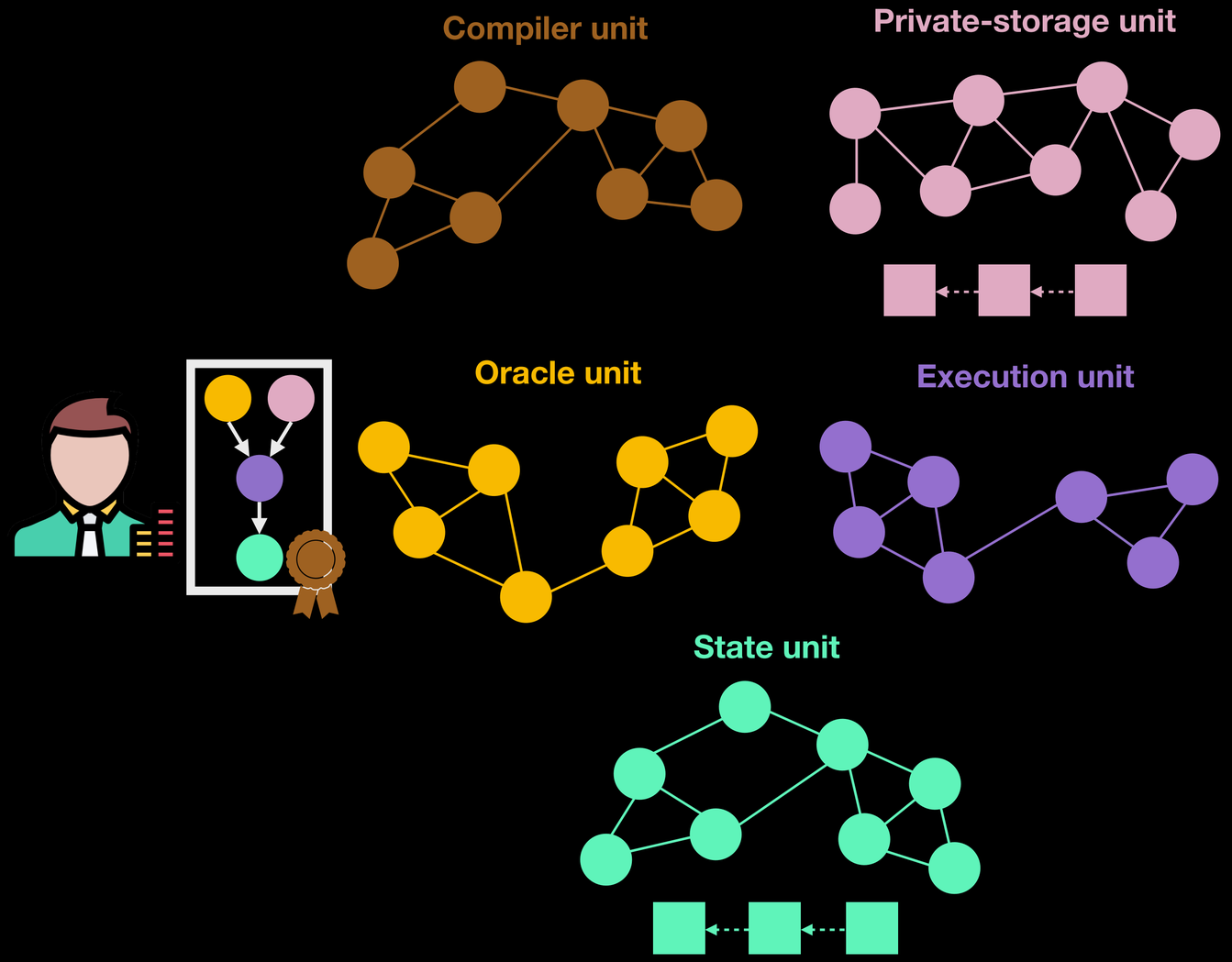

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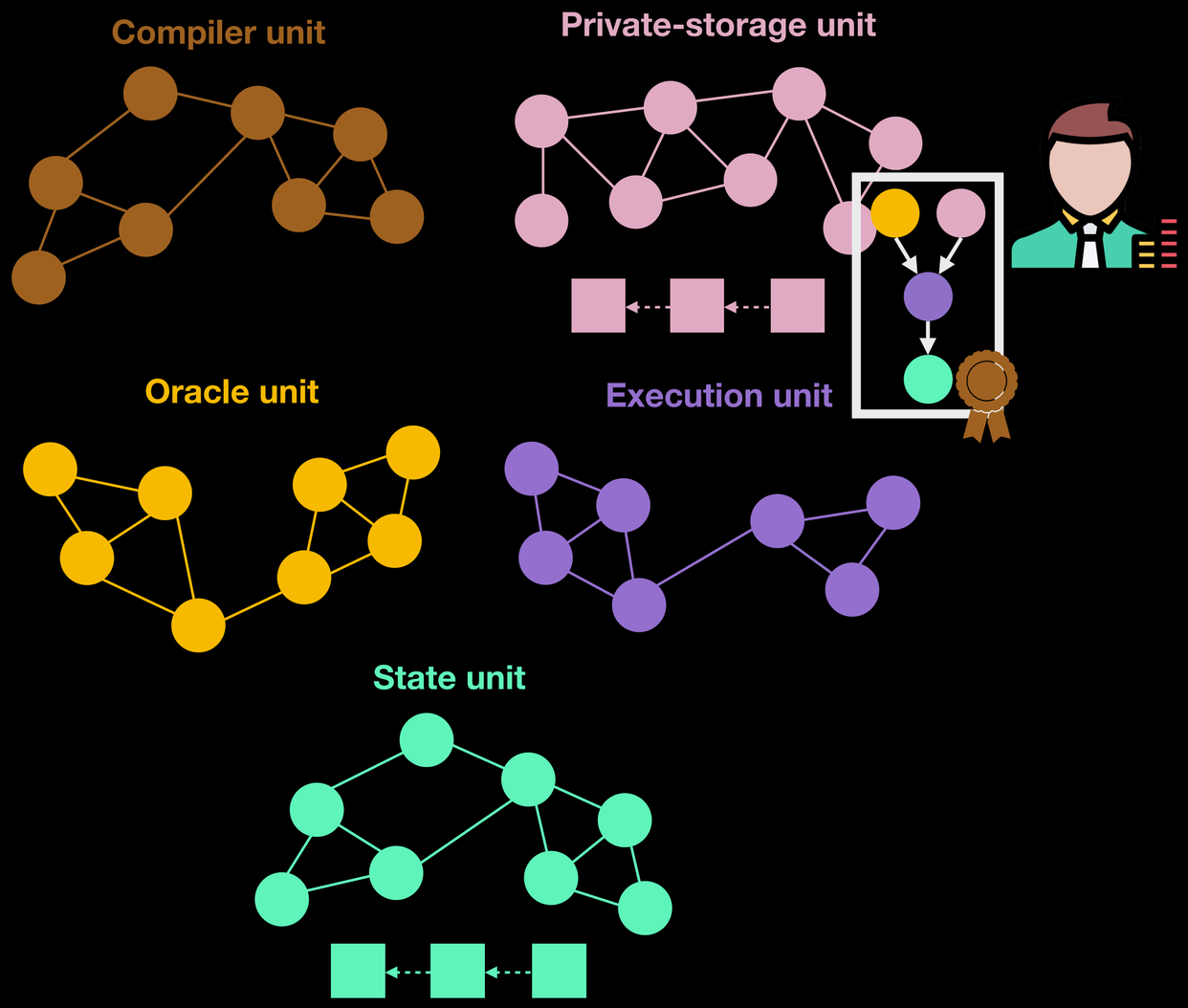
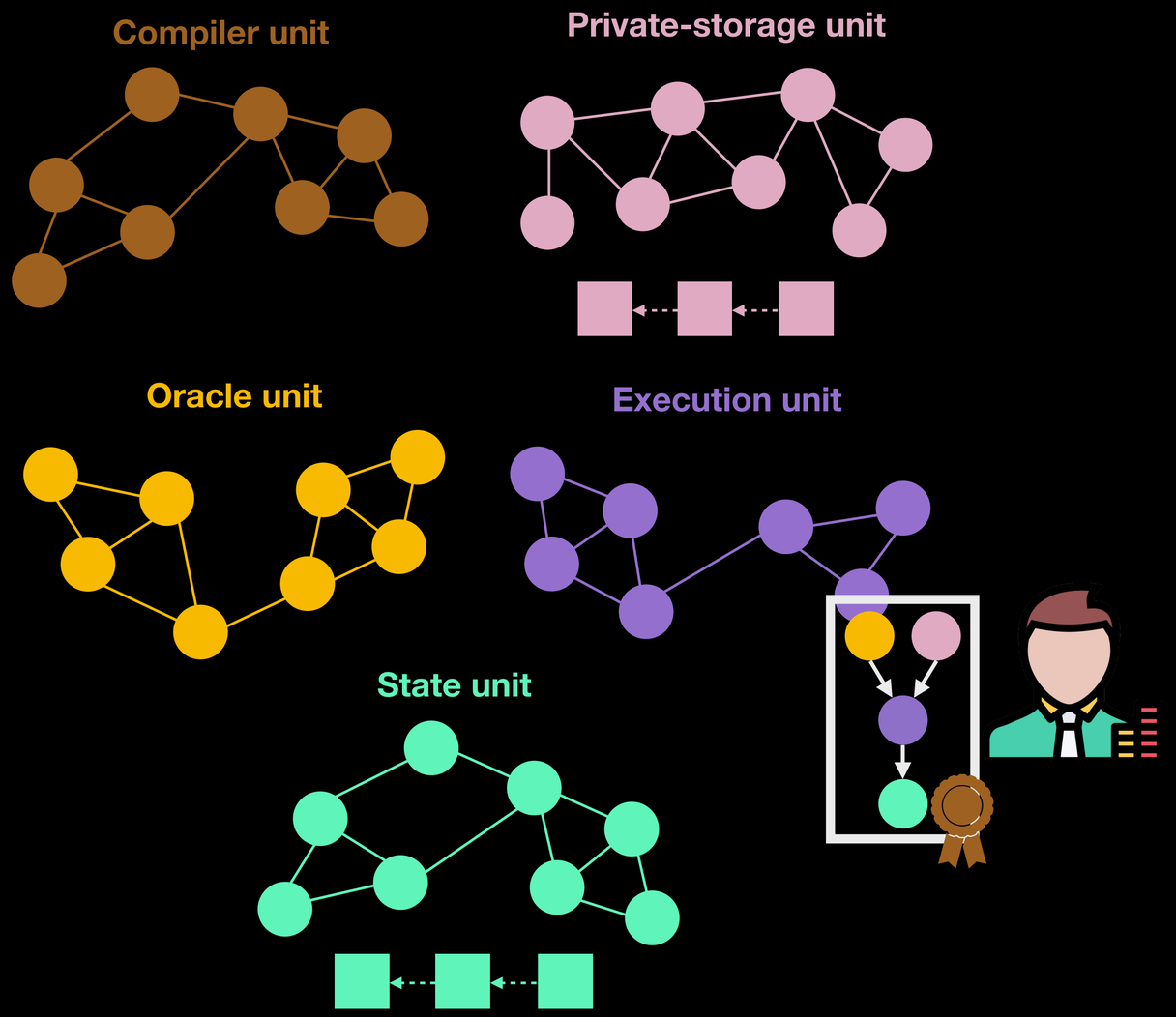
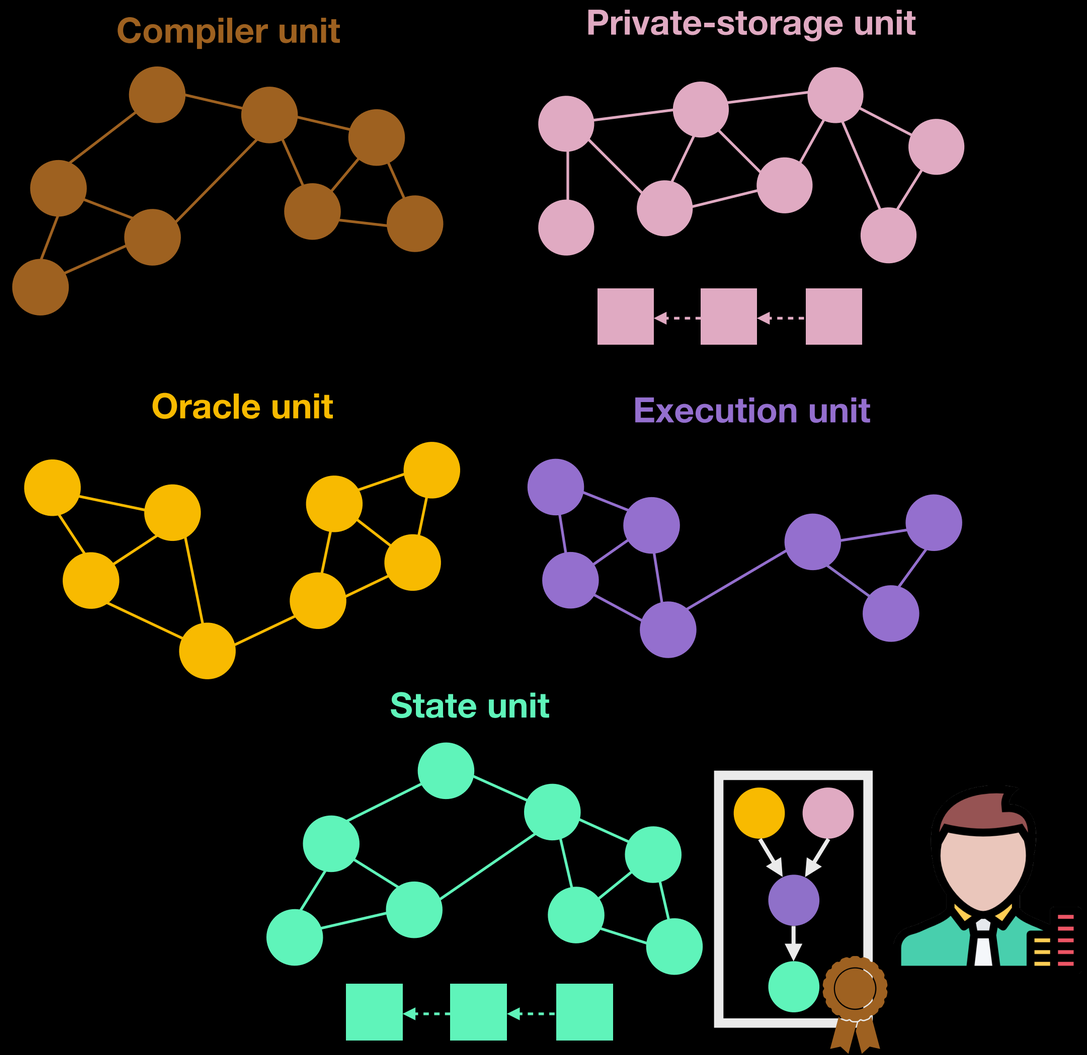


Executing applications

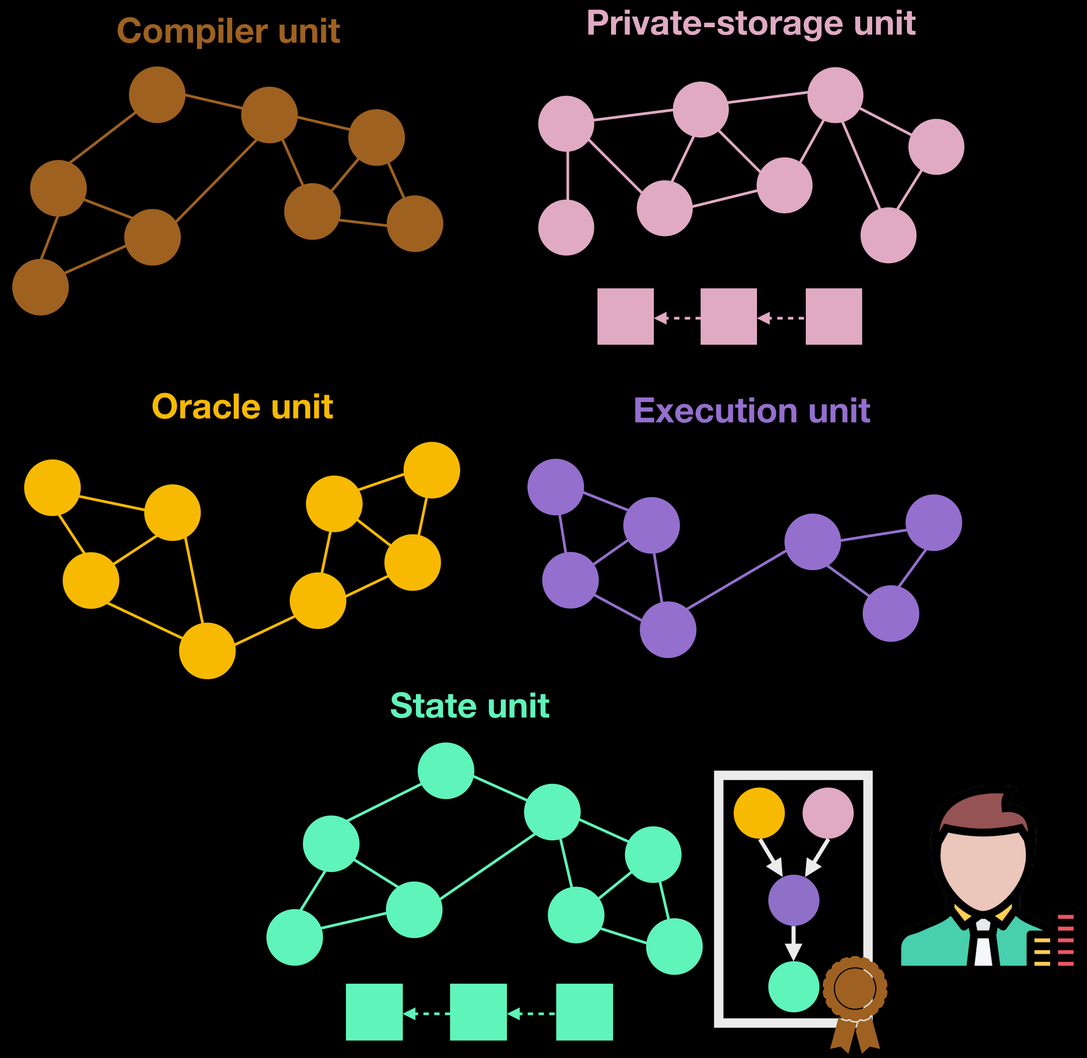


Executing applications



Executing applications

Inadvertently or maliciously deviate from the execution plan

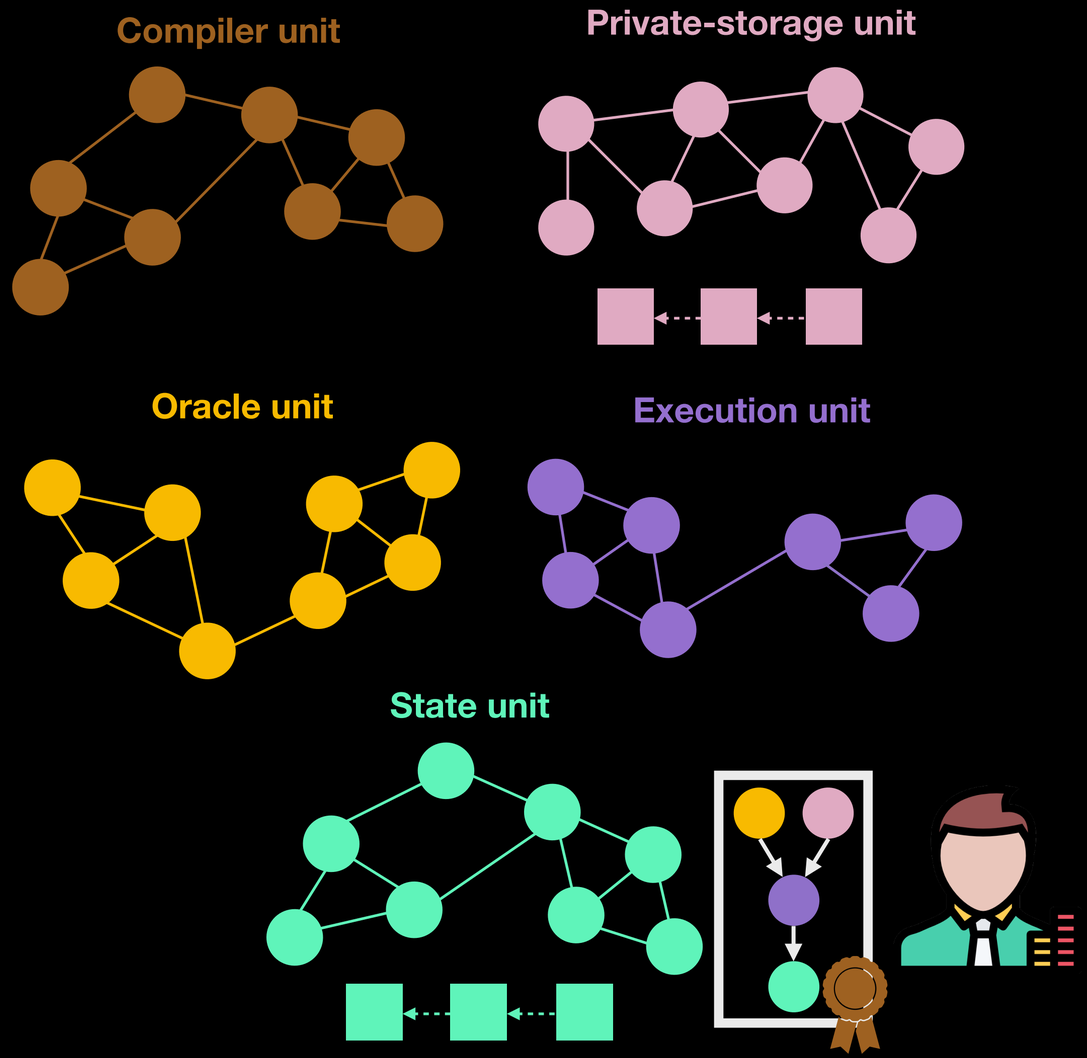


Executing applications

Inadvertently or maliciously deviate from the execution plan

Collective witnessing

- Collectively sign the execution plan
- Check signatures from parents are present



Summary

- PROTEAN: A modular architecture for building general-purpose decentralized applications
- Functional separation of nodes into special-purpose modules
- Enables applications currently insecure/impossible in smart contracts
- Permissionless evolution: easy/modular addition of new functionality
- Opportunity for node specialization for efficient execution

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