blockchain.lab

Uses of Blockchain in Supply Chain Traceability

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Agenda

- Cryptographic Foundations
- Blockchain (what is, notable use cases)
- An Abstract Traceability Use case
- Ontologies for Blockchain Application design
- Traceable Resource Units (TRU)
- Prototype Traceability Smart Contract
- Standardization
- Some key questions

Cryptographic Principles

- Cryptographic encryption and signature
  - Each Actor has their own set of Keys
  - Public (others can create an encrypted message only the Actor can read, and verify signed messages)
  - Private (used by Actor to sign messages, and decrypt or read messages encrypted with the public key)
- Hashing functions (message digest)
  - Hashing operations produce a much shorter digest (hash) of data or a document.
  - original data cannot be reconstructed from the hash
  - probability of different data producing same hash ≅ 0

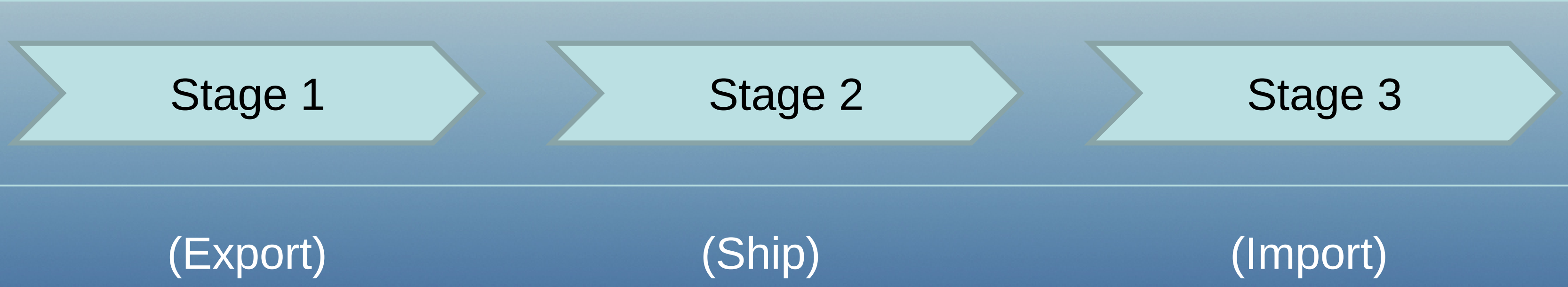
Blockchain

- A blockchain is a decentralized shared ledger, where a network of peers—rather than a centralized intermediary—maintain copies of one truthful ledger.
- New ledger entries are "chained" to the end of the blockchain using the hash-digest of the previous block within the current block.
- Previous entries cannot be readily modified nor deleted.
- Security ≠ Privacy
  - Many Blockchain implementations consider data to be public (e.g. Bitcoin)
- *Potential Niche: in regulatory environment, the cost (trust) of maintaining a central database can instead be spread across a network of stakeholders*

Blockchain

- Blockchain is a useful buzzword referring to a family of technologies like “the cloud”
- True value could be as part of a *Digital Transformation* story.
- Federated Technologies include:
  - low-cost ubiquitous networked sensors (Internet of Things, IoT)
  - Business & Data analytics – allows us to make sense of all this, big picture
  - Content addressable storage
- “Smart Contract” has come to mean a program which is executed on a blockchain and it’s state is secured by the blockchain. Can be used to encode business logic and carry out transactions (hence contract) → decentralized applications
- Multiple decentralized applications can be run on the same blockchain

A Hypothetical “Pipeline”



Stage 1

Stage 2

Stage 3

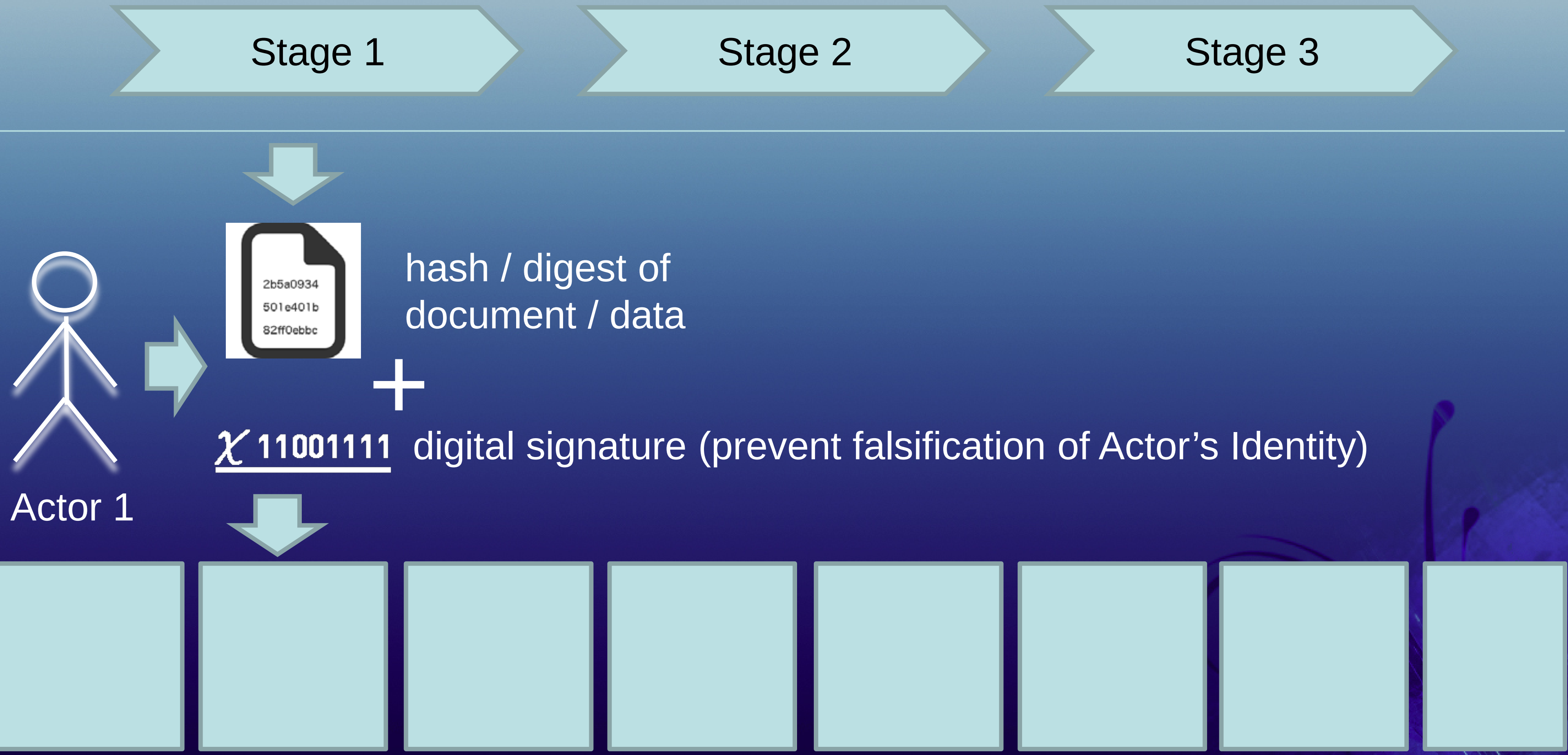
(Export)

(Ship)

(Import)

- Deliberately abstract
- Could correspond to:
  - supply chain activities
  - import/export documentation
  - Shipping
  - bills of lading
  - various certificates (quality etc.)

Blockchain "1.0" (ex. Bitcoin)



Stage 1

Stage 2

Stage 3

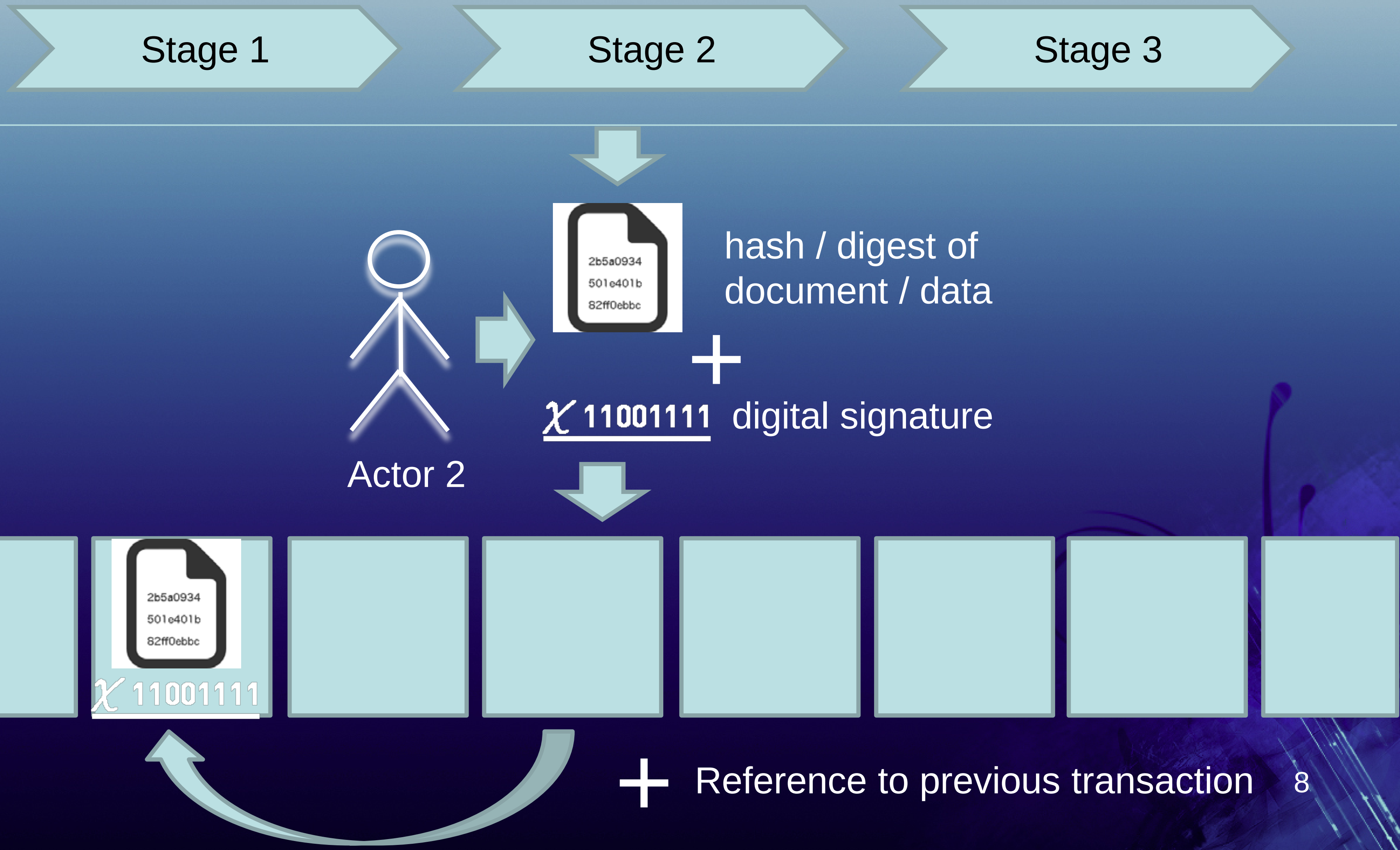
hash / digest of document / data

+

digital signature (prevent falsification of Actor's Identity)

Actor 1

Blockchain “1.0”



Stage 1

Stage 2

Stage 3

hash / digest of document / data

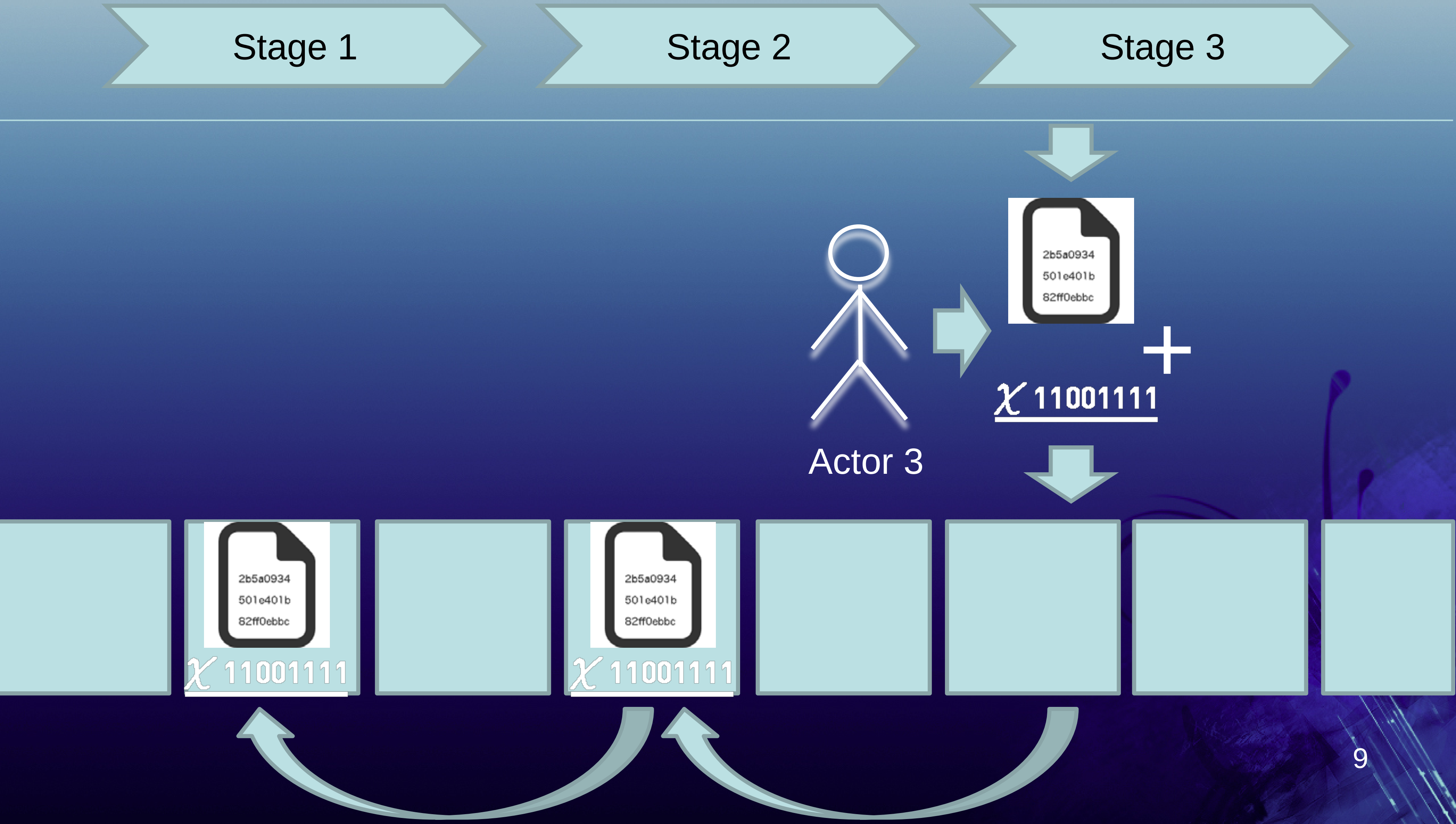
+

digital signature

Actor 2

+ Reference to previous transaction

Blockchain “1.0”

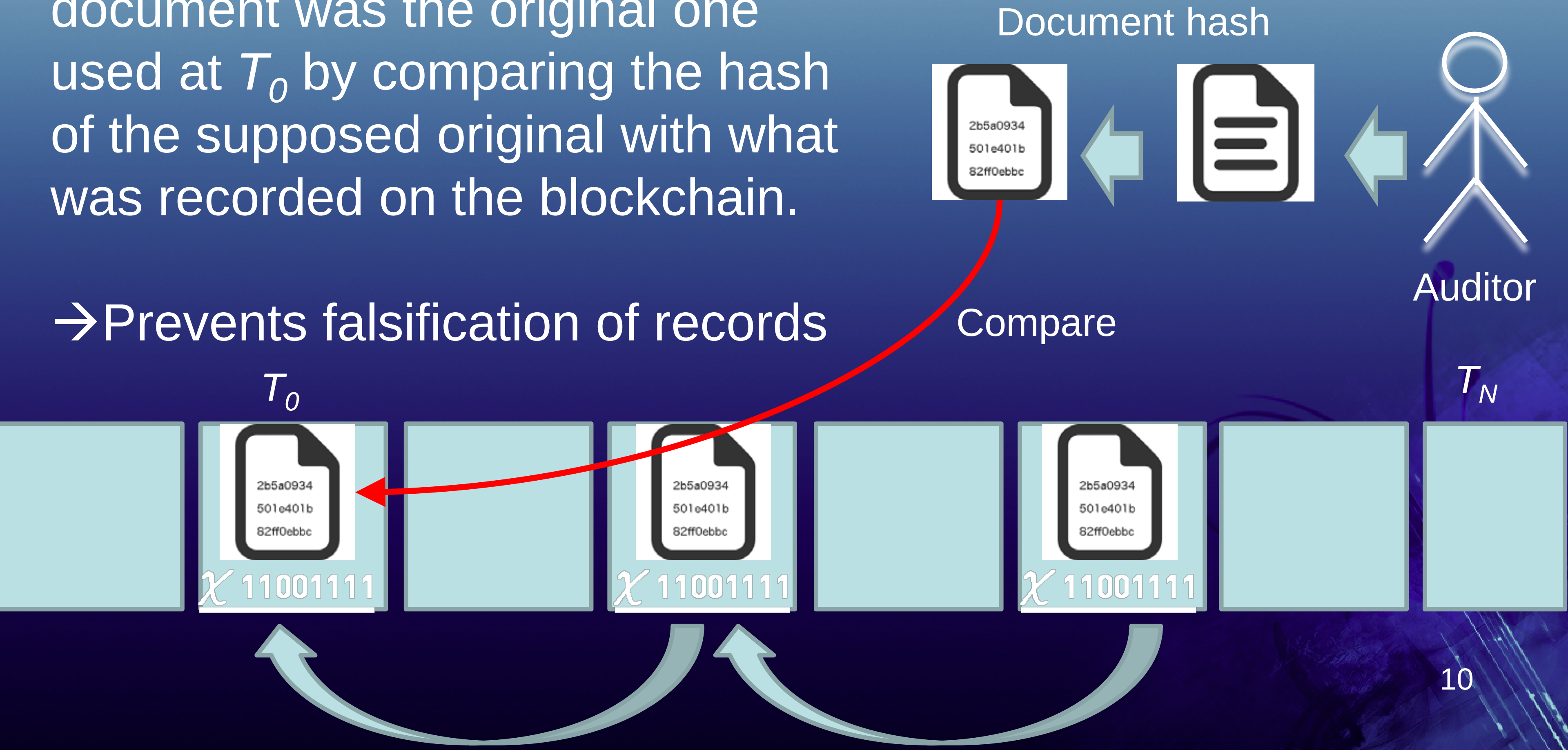


Blockchain “1.0”

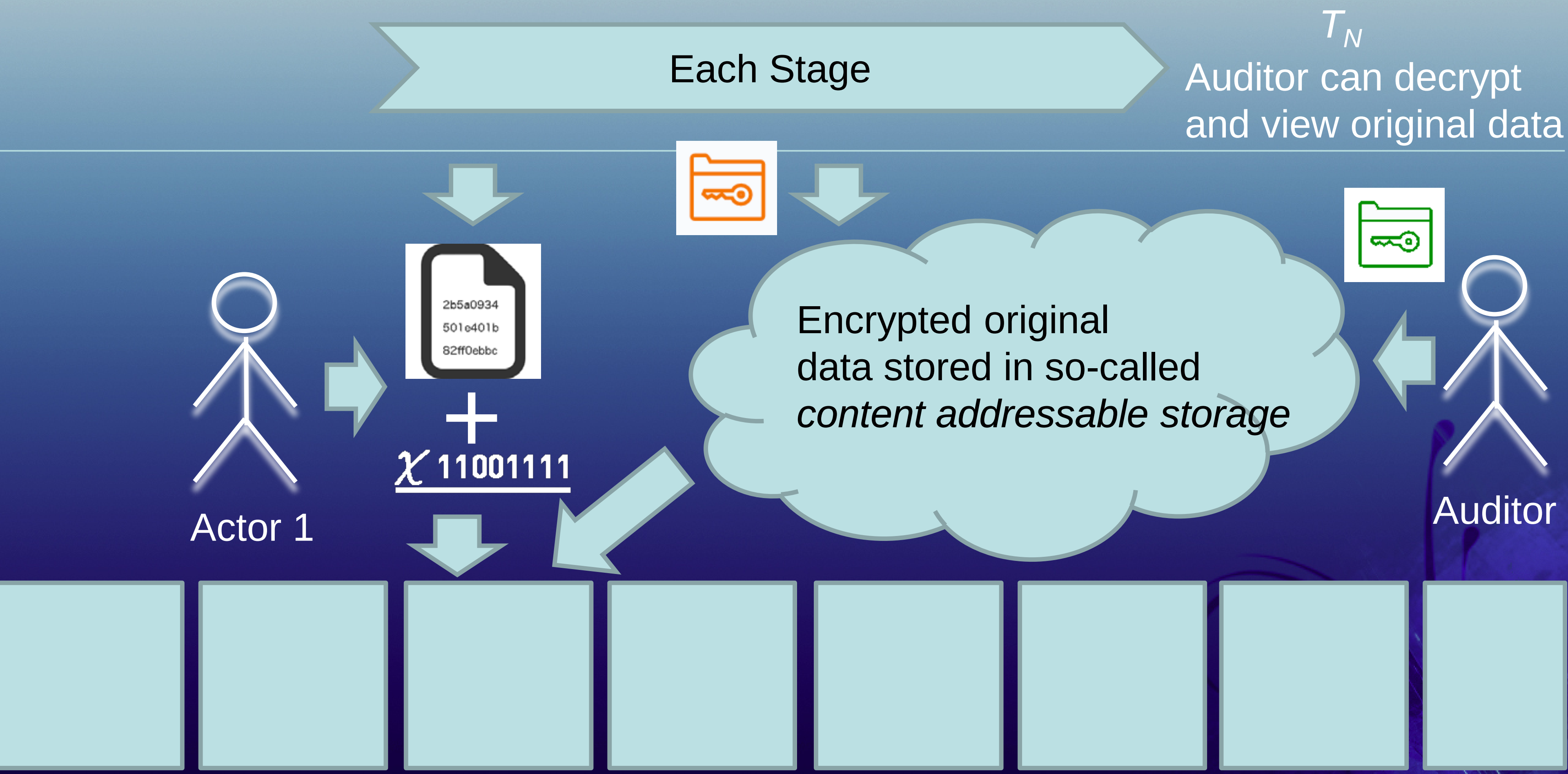
*Blocks are time-stamped

Later, at T_N we can prove a document was the original one used at T_0 by comparing the hash of the supposed original with what was recorded on the blockchain.

→Prevents falsification of records



Blockchain “1.5” ex. Bitcoin + IPFS



Each Stage

T_N
Auditor can decrypt and view original data

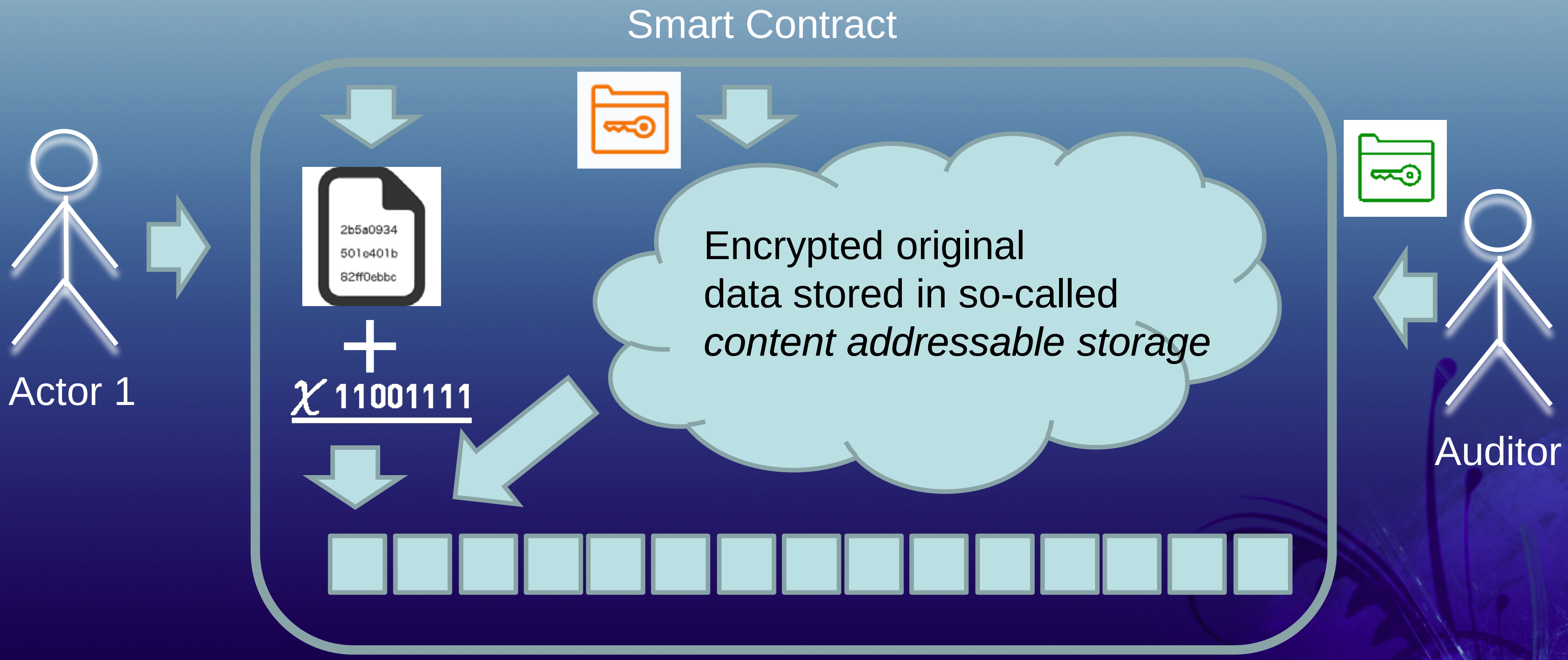
Encrypted original data stored in so-called *content addressable storage*

Actor 1

Auditor

+ Hash of Encrypted document also stored on-chain

Blockchain "2.0" ex. Smart Contracts (Ethereum) + IPFS

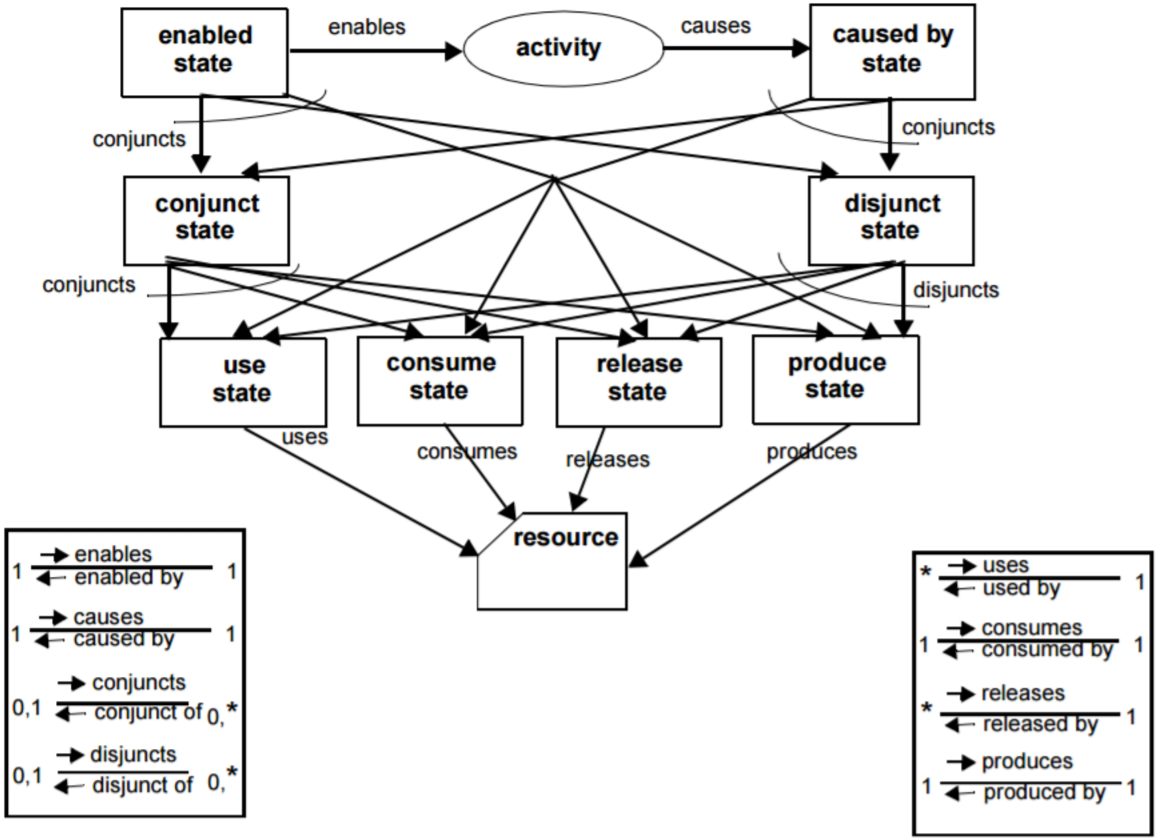


* Interaction with the blockchain is mediated through a Smart Contract that encodes business logic; can be used to *drive* the process

An example ontology: for Enterprise Modelling

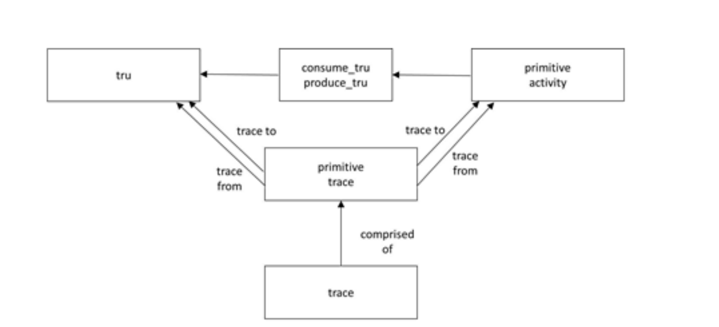
Ontology ≈ Domain Specific Data Model + Business Rules + Formalism + Philosophy

Activity Cluster: An Object-Oriented Model of Activities, States, Causality, Time, and Resources

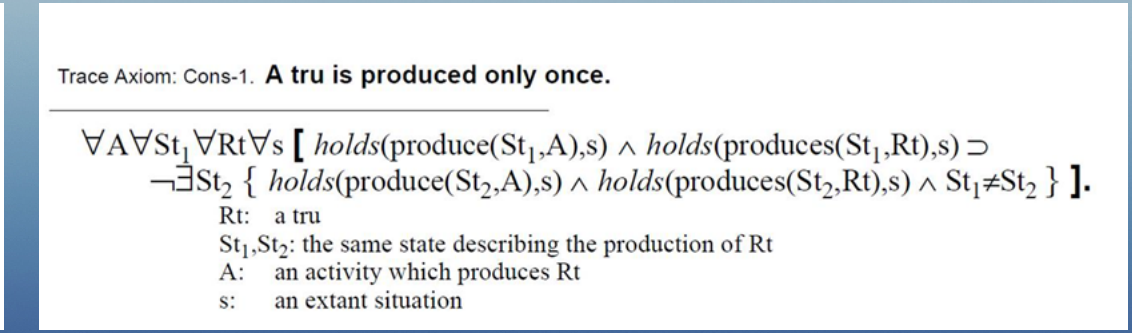


Traceability Ontology (TOVE)

Data Model



Axioms

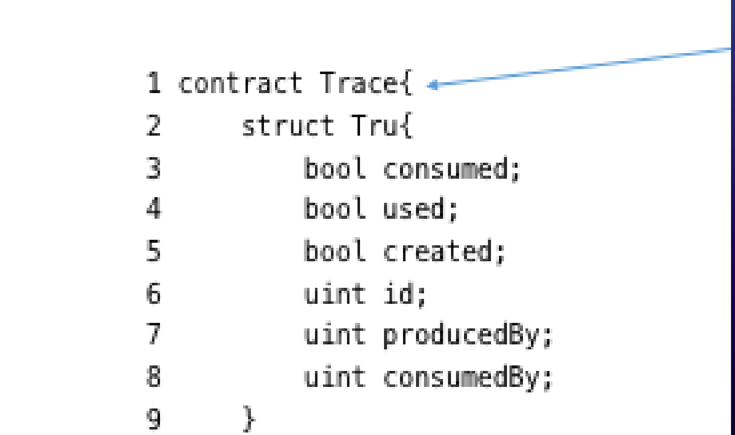


Trace Axiom: Cons-1. **A tru is produced only once.**

$$\forall A \forall St_1 \forall Rt \forall s\ [\ \textit{holds}(\text{produce}(St_1,A),s) \wedge \textit{holds}(\text{produces}(St_1,Rt),s) \supset \neg\exists St_2\ \{\ \textit{holds}(\text{produce}(St_2,A),s) \wedge \textit{holds}(\text{produces}(St_2,Rt),s) \wedge St_1 \neq St_2\ \}\ ].$$

Rt: a tru
St_1,St_2: the same state describing the production of Rt
A: an activity which produces Rt
s: an extant situation

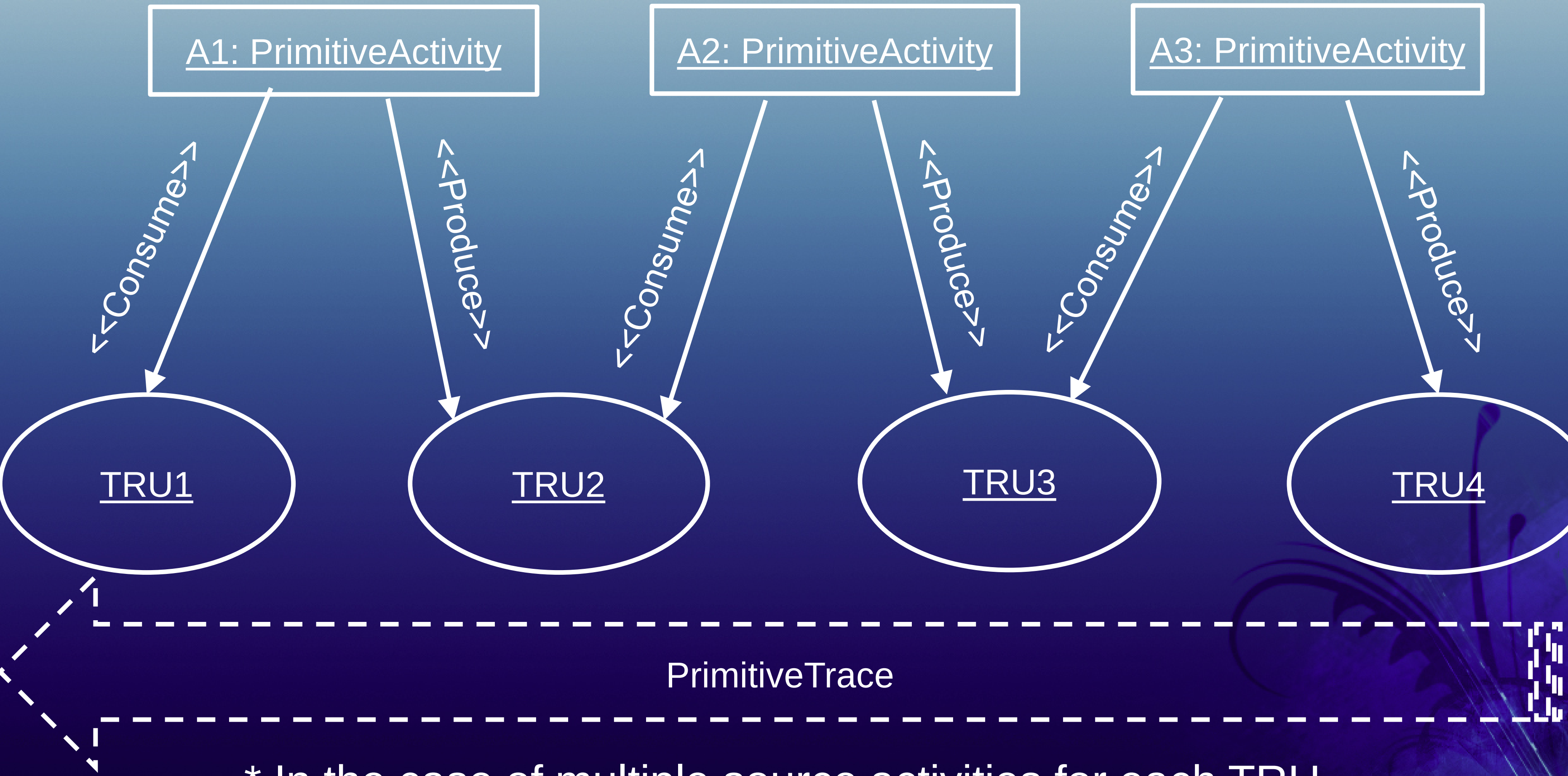
Definition: A Traceable Resource Unit (TRU) is a collection of one or more Objects (goods) that cannot be individually traced further



```
contract Trace{
    struct Tru{
        bool consumed;
        bool used;
        bool created;
        uint id;
        uint producedBy;
        uint consumedBy;
    }
```

Smart Contract

An example primitive trace



* In the case of multiple source activities for each TRU, each branch would have to be searched

Regarding Standardization

- Networks become more valuable with more users → interoperability
- Numerous efforts are underway to standardize blockchain and distributed ledger
- Interoperability at a *protocol* level
- Interoperability at a *semantic* level
- Both must be addressed.
- *Now is the time!*

Semantic Interoperability

- Blockchain Lab currently trialing Smart Contract “meta standard”
- Permit inspection of a Smart Contract’s underlying *Data Model*
- It can be reasoned whether two Data Models are compatible
- Would become necessary if new versions of a Data Model are introduced or modified over time.

Some Questions

- How to implement Key Management?
- How to manage Identification on the blockchain?
- How to scale blockchain applications?
- Can blockchain be used to implement Single Window?

Recent Headlines

- ISO starts Blockchain standardization process
- UN World Food Programme using blockchian for tracking food aid
- Alibaba building blockchain solution for food traceability and provenance to fight ”fake food”
- IBM launches commercial blockchain effort for identity with 6 Canadian Banks; Carbon Credits in China & more…
- CreditEase / Yixin launches blockchain solution for supply chain

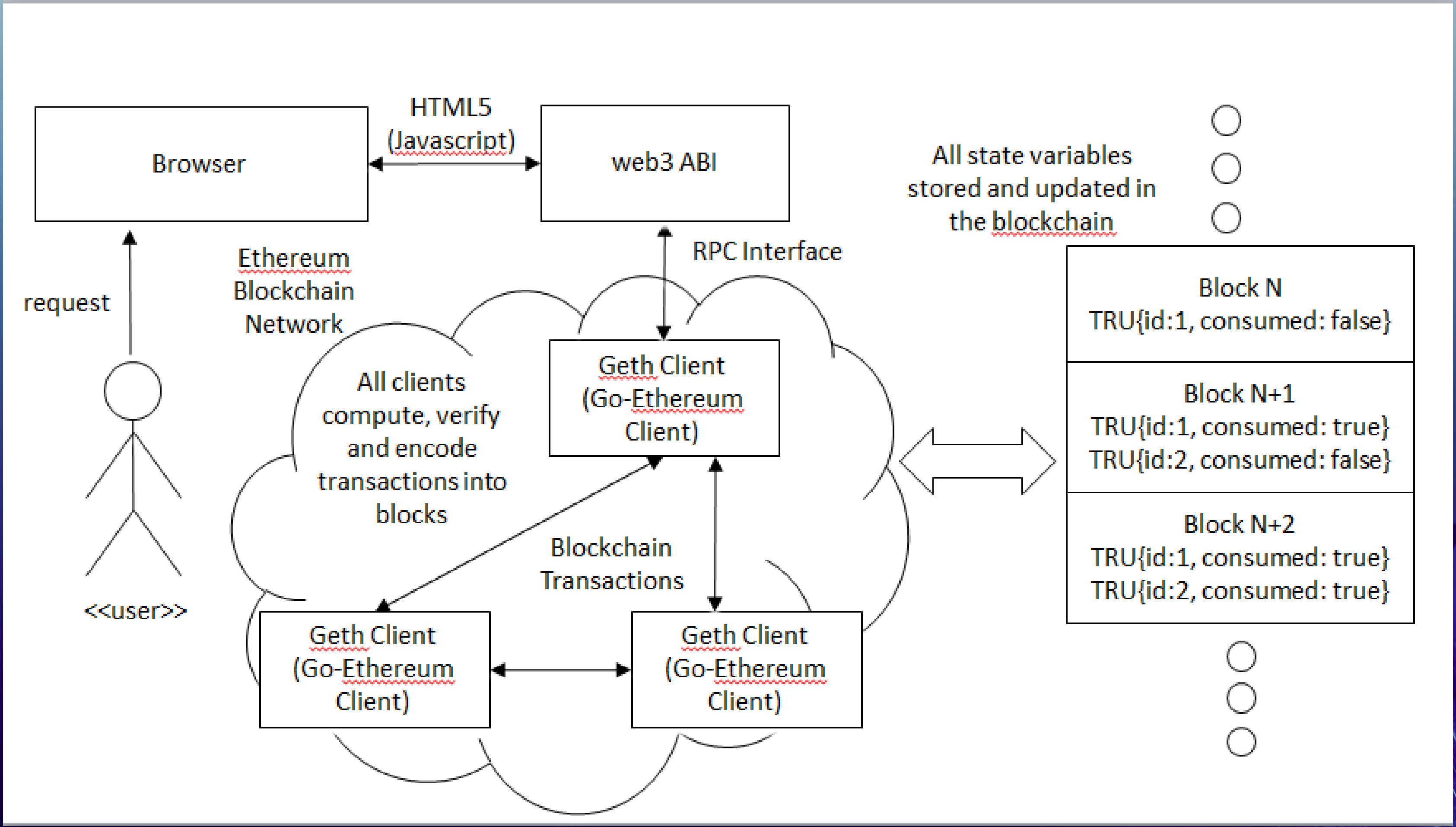
Recent Headlines

- Enterprise Ethereum Alliance Releases Goals for 2017:
- Develop a sufficiently modular Ethereum implementation to separate and define clear interfaces between networking and storage layers - that is a prototype for pluggable consensus that minimizes the code changes required to switch consensus algorithms.
- Experiment with potential consensus algorithms, along with data privacy and permissioning frameworks.

Recent Headlines

- Enterprise Ethereum Alliance Releases Goals for 2017 (continued):
- Develop a clear set of capabilities:
  - 100 transactions per second, across a 10 party network
  - High volume and value use cases
  - High availability/reliability
  - Parallelization and horizontal scaling
- Produce a reference implementation.
- Leverage a robust governance process to ensure alignment and agreement on approaches

Prototype: Ontologies and Blockchain for Supply Chain Traceability



Browser

HTML5 (Javascript)

web3 ABI

All state variables stored and updated in the blockchain

request

Ethereum Blockchain Network

RPC Interface

<<user>>

All clients compute, verify and encode transactions into blocks

Geth Client (Go-Ethereum Client)

Blockchain Transactions

Geth Client (Go-Ethereum Client)

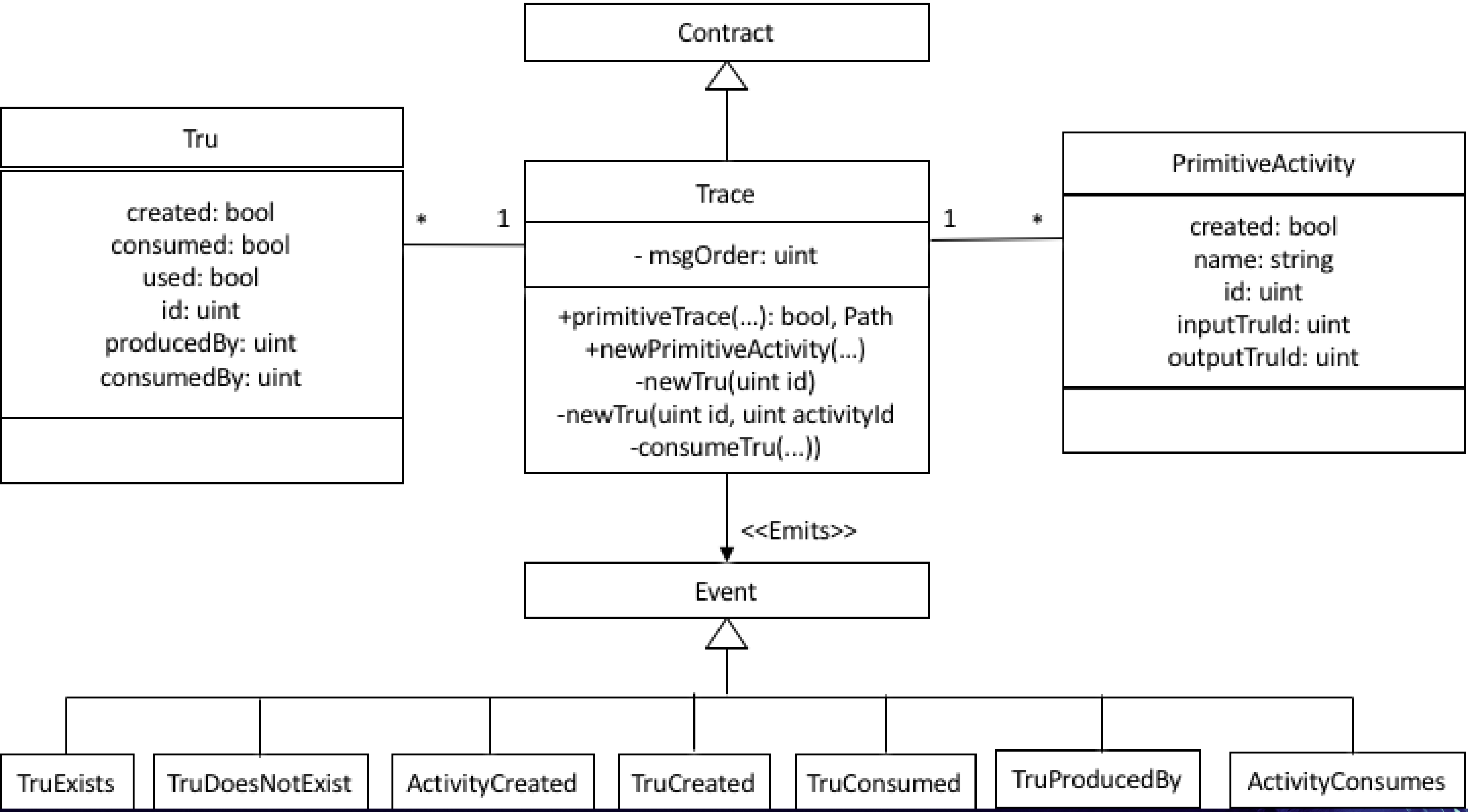
Geth Client (Go-Ethereum Client)

Block N
TRU{id:1, consumed: false}

Block N+1
TRU{id:1, consumed: true}
TRU{id:2, consumed: false}

Block N+2
TRU{id:1, consumed: true}
TRU{id:2, consumed: true}

UML Model Used to develop traceability smart contract



Contract

Tru

created: bool
consumed: bool
used: bool
id: uint
producedBy: uint
consumedBy: uint

Trace

- msgOrder: uint

+primitiveTrace(...): bool, Path
+newPrimitiveActivity(...)
-newTru(uint id)
-newTru(uint id, uint activityId
-consumeTru(...))

PrimitiveActivity

created: bool
name: string
id: uint
inputTruId: uint
outputTruId: uint

Event

TruExists
TruDoesNotExist
ActivityCreated
TruCreated
TruConsumed
TruProducedBy
ActivityConsumes