Towards Understandable Smart Contracts

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Distributed Ledgers and Smart Contracts

- Distributed Ledger Technology (aka “blockchain”) enables trustworthy sharing and updating of tamper-proof data between untrusting parties
  - Currencies, digital (or tokenized) assets, …
- Smart contracts enable flexible and expressive logic to govern updates
- Combination enables exciting new use cases
  - Payment triggered by agreed conditions (on-time delivery, IoT device confirms shipping conditions within agreed parameters)
  - …
  - Decentralized Autonomous Organization (DAO)
    - Crowd funding, proposals approved via voting by token holders, no (biased, corruptible) humans
    - Proposals can generate income for the DAO, effectively a decentralized investment fund

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“The” DAO

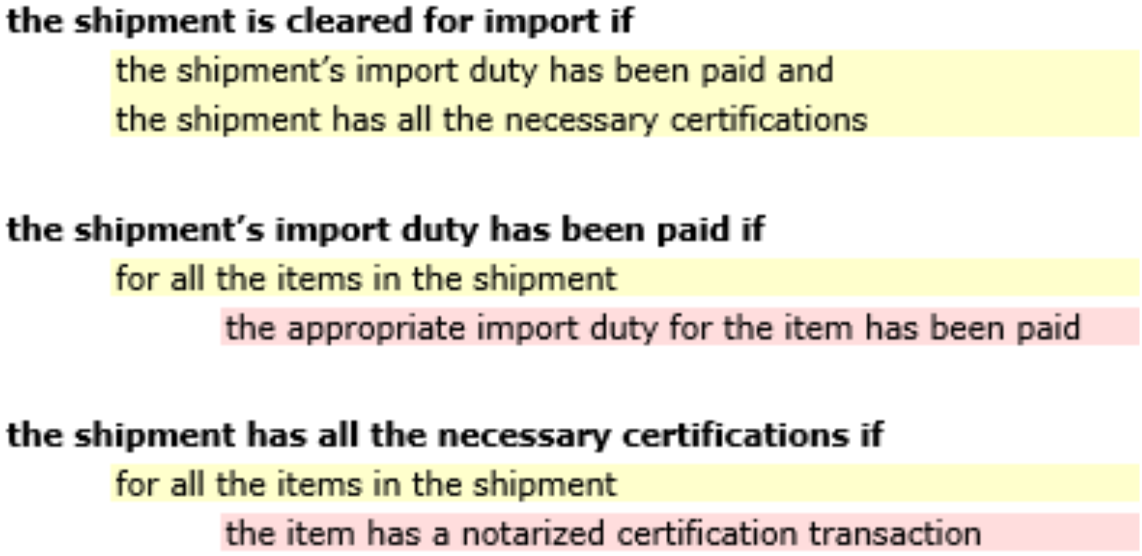
- Launched on public Ethereum platform in May 2016
- Raised equivalent of > US $160M
- Quickly attacked, resulting (kind of) in loss of > US $50M
- (Subset of) community rallied to create “hard fork” that special-cased recovery of lost funds
- Now we have two Ethereums (Etherea?)

Ooops! What went wrong with the DAO?

- Ethereum platform behaved correctly, as specified
- DAO smart contract contained multiple bugs, did not reflect authors' intent or (presumably) investors' understanding
- Written in Solidity (new Javascript-like language) for Ethereum VM
- Choice and design of programming language can be debated, but…
- … **any** general-purpose language is difficult to understand for most people
- If experts did not catch bugs, what hope is there for a human (e.g. potential investor) to understand exactly **what** s/he is trusting?

Oracle ® Policy Automation (OPA)

- Express business rules and policies in **human-readable** language
- Rules compiled to machine-readable format
- OPA engine applies rules to data
  - Input attributes + inference => Goal attributes



the shipment is cleared for import if

- the shipment’s import duty has been paid and
- the shipment has all the necessary certifications

the shipment’s import duty has been paid if

- for all the items in the shipment
  - the appropriate import duty for the item has been paid

the shipment has all the necessary certifications if

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Top-Level Conditions for Approving Imports

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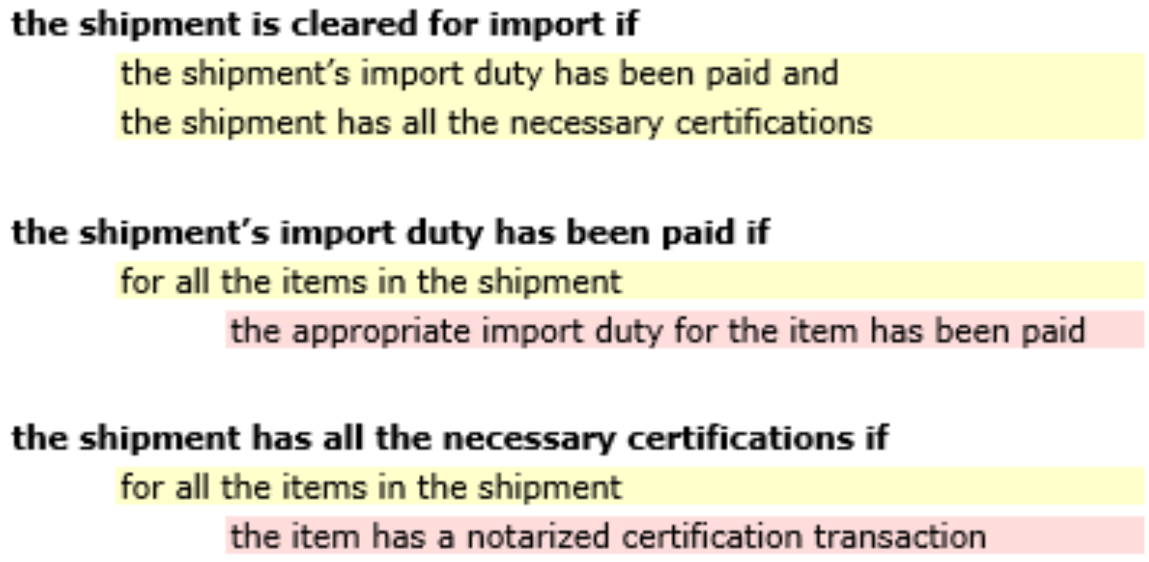

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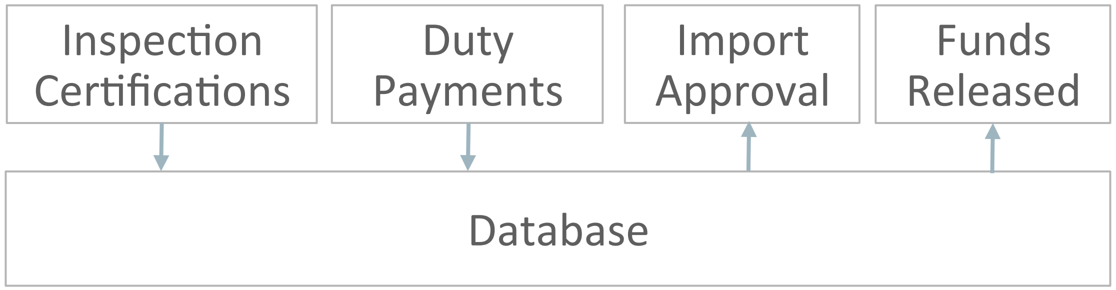

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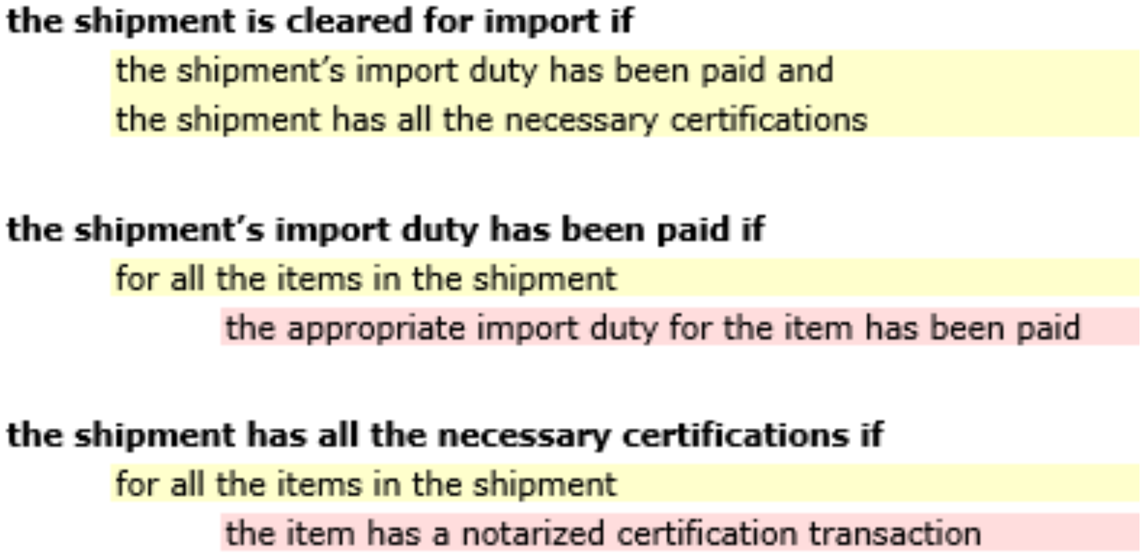
- We explore integration to enable OPA rules as smart contracts



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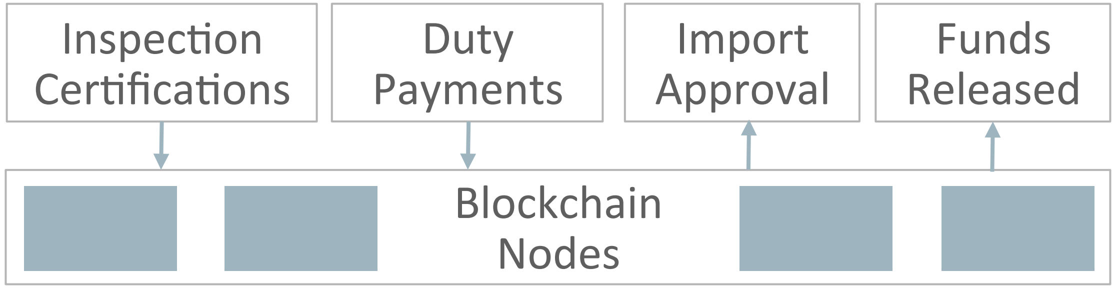

OPA as Smart Contract Language?

- Human readable
- Deterministic
- Guaranteed to terminate
  - may not reach conclusion if configured to stop too soon, but deterministic
- These qualities address significant challenges for smart contracts

Juno

- Open source blockchain platform
- Implemented in Haskell
- “BFT hardened” Raft protocol for consensus
- Built-in DSL for money transfers

Generalizing Juno

- We modified Juno to support “pluggable” smart contract engines
  - Engine defines ledger state type, initial state, command processor for updating state
- Smart contract engine for OPA
  - State: key-value map
  - Command processor:
    - Sends input attributes and metadata from application command to “servlet”
    - To be continued…

OPA Servlet

- Has registered OPA rule set
- Receives a request containing:
  - Rule set ID
  - Input attributes
  - Scope ID (e.g., identify customer, case, etc.)
- Invokes OPA engine via Java API, provides input attributes
- Receives result from OPA engine, including inferred goal attributes(s)
- Produces transaction and sends it back to Juno:
  - read set contains input attributes, write set contains goal attributes
  - keys derived from data model, attribute names, scope ID, etc.

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  - Command processor:
    - Sends input attributes and metadata from application command to “servlet”
    - Receives results from servlet in form of a transaction (read and write sets)
    - Validates read set against key-value store; if successful…
    - … updates key-value store based on write set

Benefits

- Tamper-proof record of transaction in blockchain
- Transactions driven by human-understandable policies
- OPA can “explain” reasoning, providing valuable audit trail
  - Can be reproduced on demand after the fact, as OPA is stateless
- No trusted party, no single point of failure

Concluding Remarks

- This is an experimental prototype for research
- Demonstrates feasibility of integrating human-readable policies with a blockchain platform
- More work needed to achieve/assess practicality for real use cases

Questions?

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