Digital Asset

Functional Modelling of Contractual Workflows

DAML and the DLT Architectural Style

Who am I

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Engineer working at Digital Asset

Part of the Digital Asset team that in 2017, built the first existence proof that DLT can simultaneously meet the HA, DR, throughput, and functionality requirements of the CHESS+ replacement system.

Currently working on the production version of CHESS+, the replacement Clearing and Settlement system for ASX

Legal Requirements of Contractual Workflows

Legal Contracts

Legal requirements for formation and execution

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- Multiple autonomous parties
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+ 2 non-technical requirements: (Intent to be legally bound, and Consideration)

Technical Requirements of Contractual Workflows

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  Model of obligation
- Privacy
  Perfect forward secrecy
- Monitoring of performance
  Guaranteed notification

Digital (smart) Legal Contracts (Requirements)

So, to support real world legal contracts, a smart contract language must be:

A *distributed multi-party system* that crosses *autonomous trust boundaries,* supporting *deterministic evolution of consensus of belief* that is *independently validatable;* supported by formal models of *authorization (consent, delegation, and obligation).*

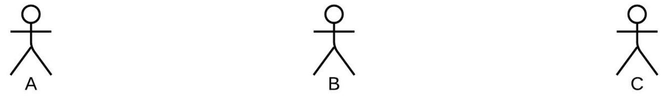
It should also simultaneously guarantee *perfect forward secrecy*, and *notification* of relevant events.

Oh, and if you're modeling financial contracts: it needs to scale to billions of individual contracts, and millions of contract events per minute.

Architectural Style supporting Contractual Workflows

Distributed Multi-Party

Consensus of Belief
Deterministic Certainty
Core Architecture Style (CQRS)
Trust Boundaries
Validatable
Modeling Consent
Modeling Delegation
Modeling Privity
Stepwise Determinism
Privacy
Notifications
Final Architecture Style



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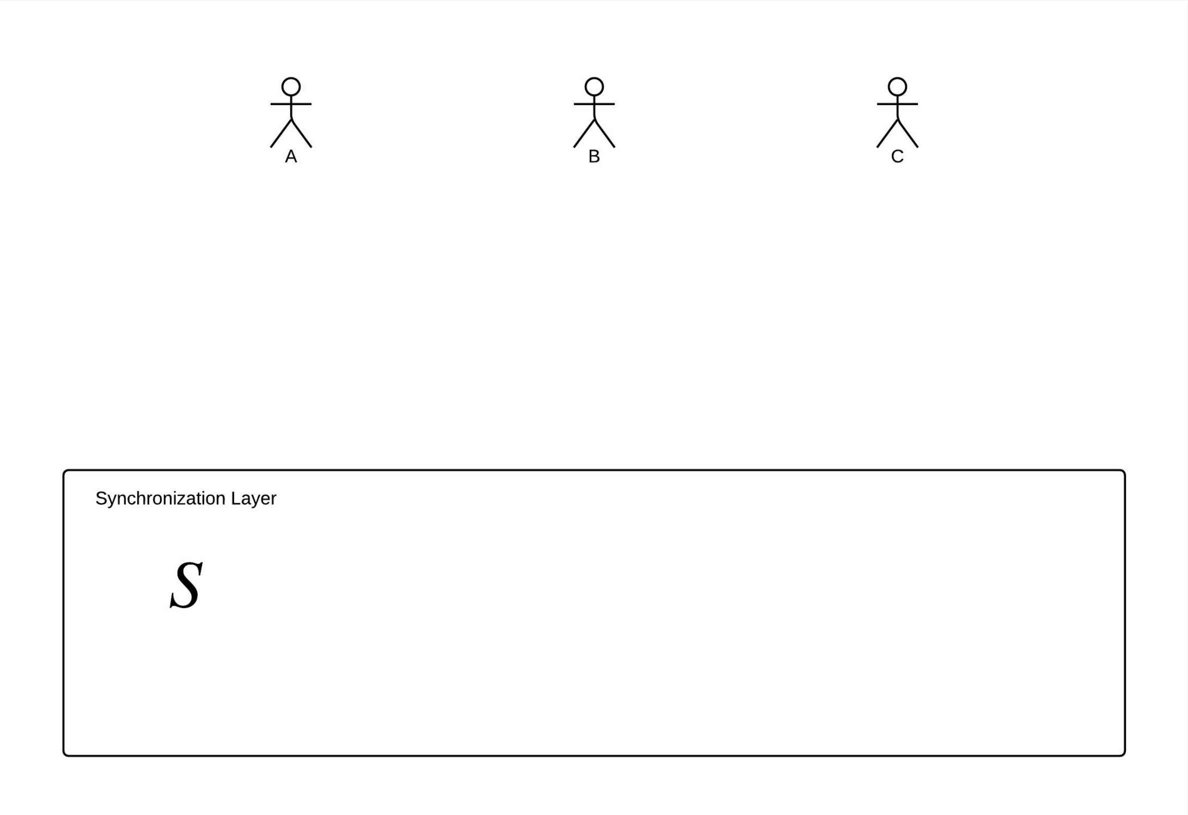

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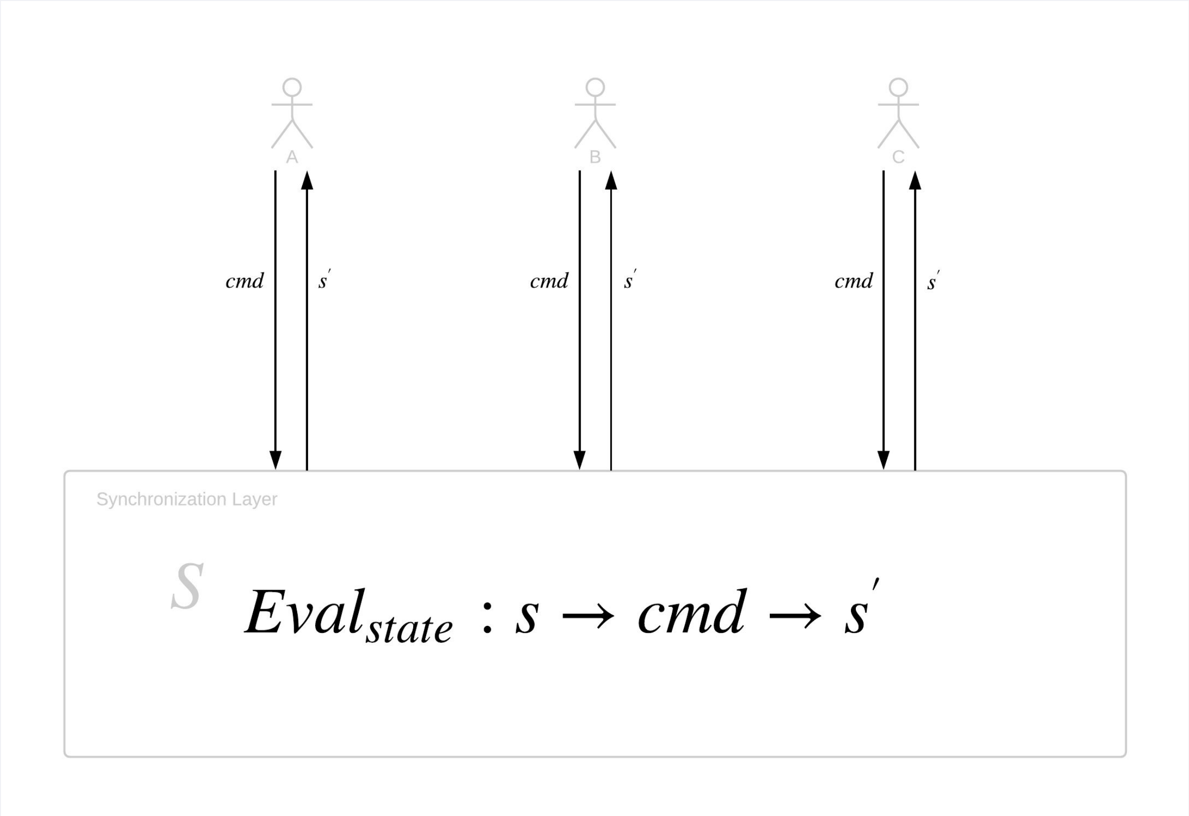

$$Eval_{state} : s \rightarrow cmd \rightarrow s'$$

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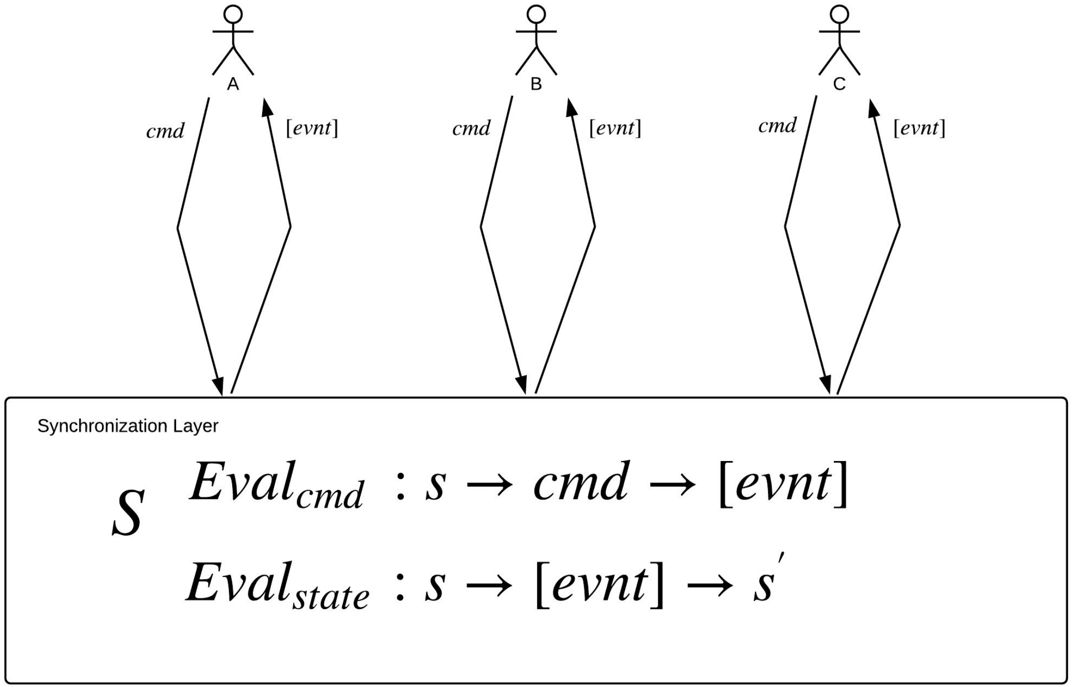

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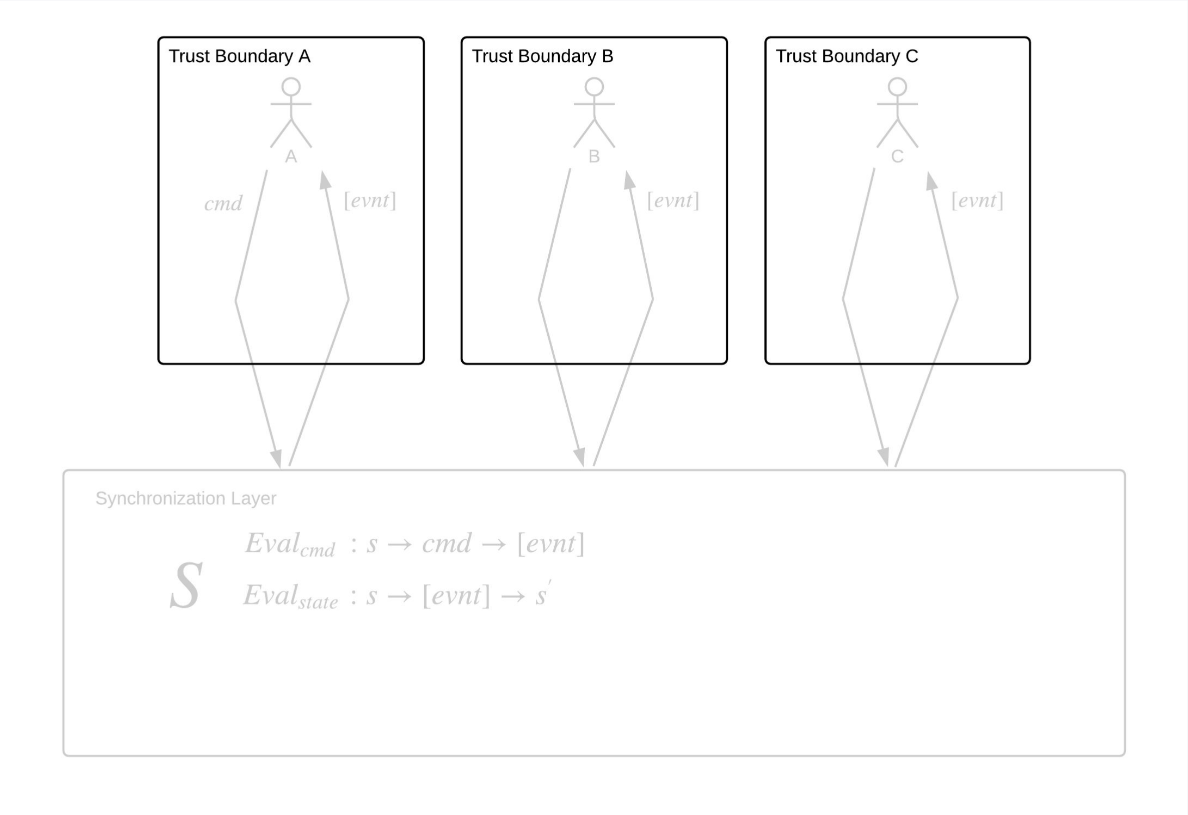

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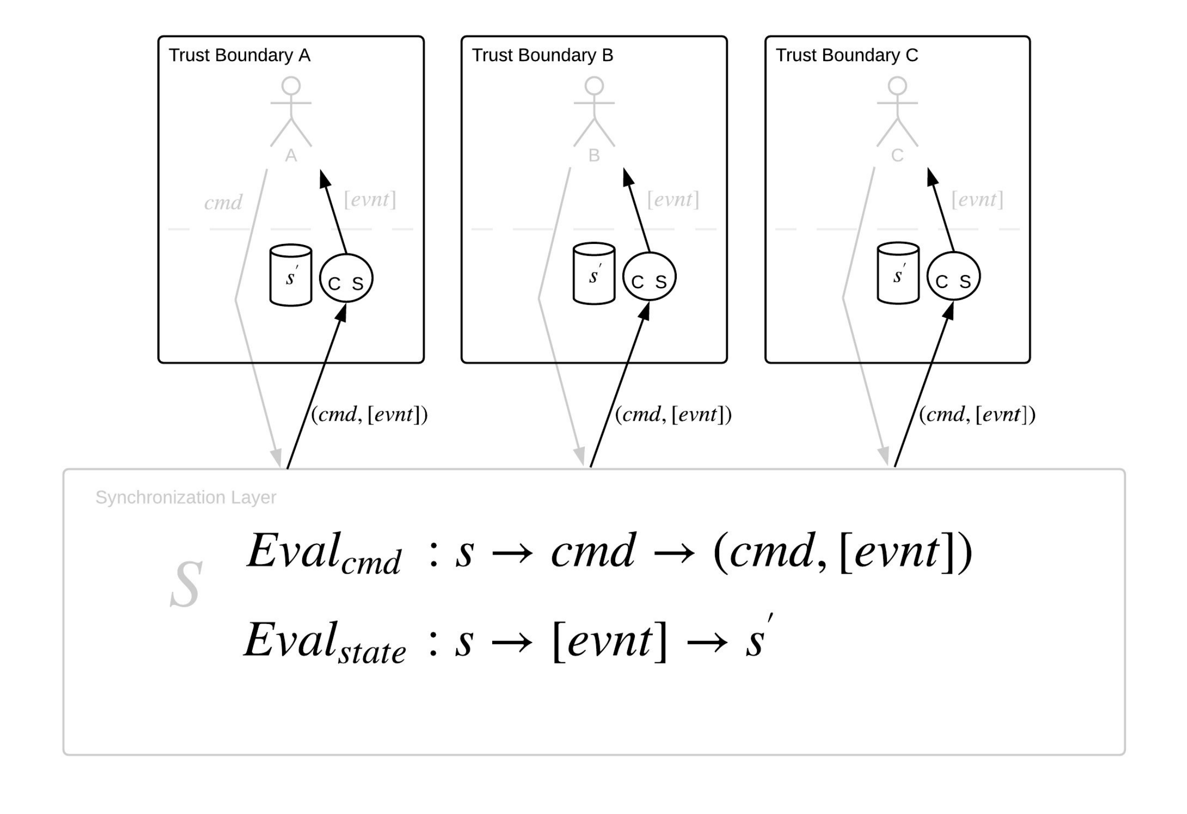

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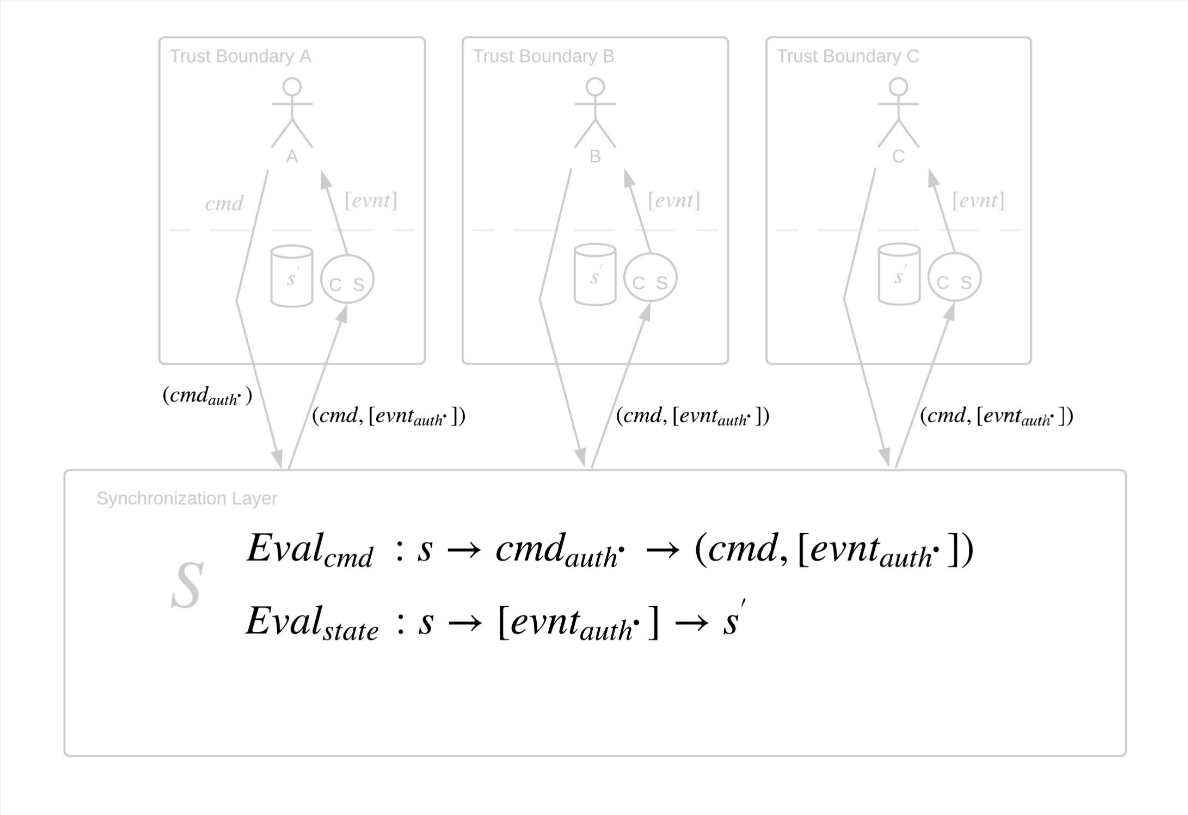

$$Eval_{cmd} : s \rightarrow cmd_{auth'} \rightarrow (cmd, [evnt_{auth'}])$$

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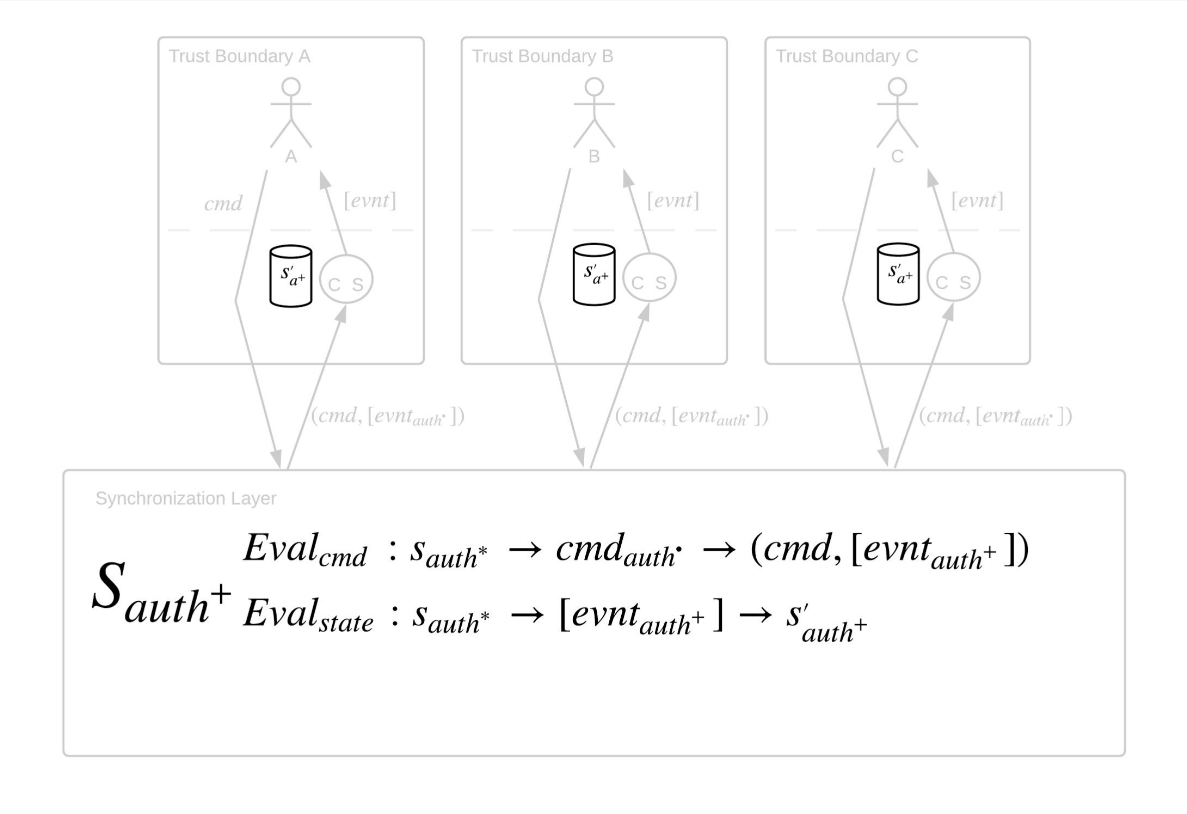

$$S_{auth^+} \begin{array}{l} Eval_{cmd} : s_{auth^*} \to cmd_{auth^\cdot} \to (cmd, [evnt_{auth^+}]) \\ Eval_{state} : s_{auth^*} \to [evnt_{auth^+}] \to s'_{auth^+} \end{array}$$

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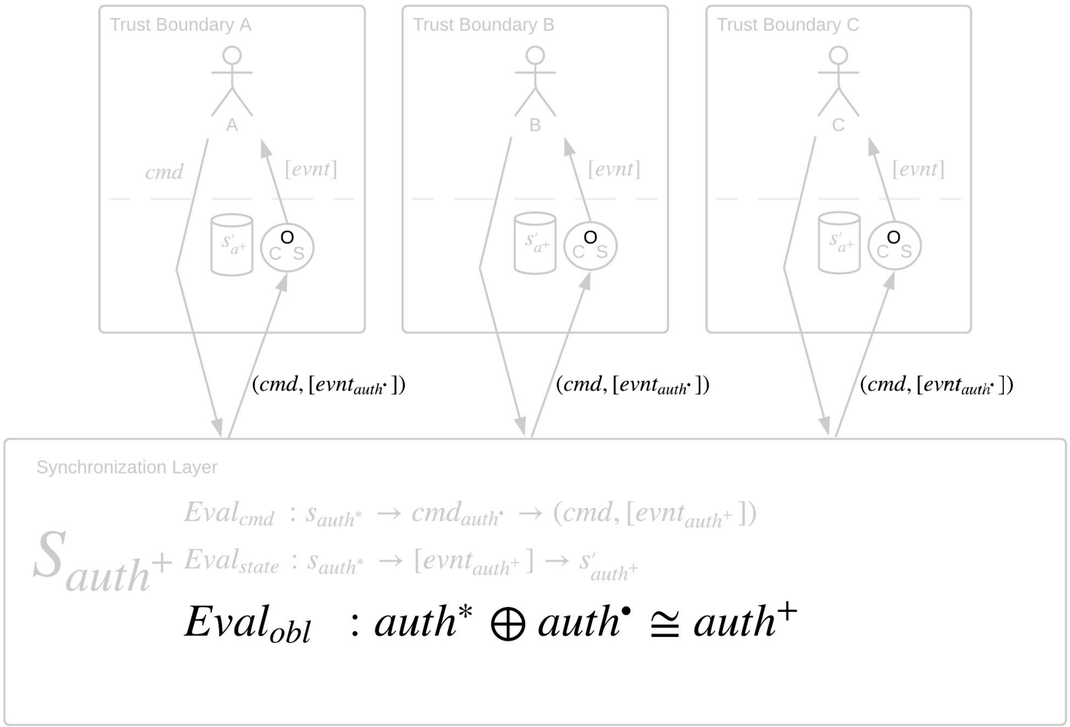

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$$Eval_{obl} : auth^* \oplus auth^\bullet \cong auth^+$$

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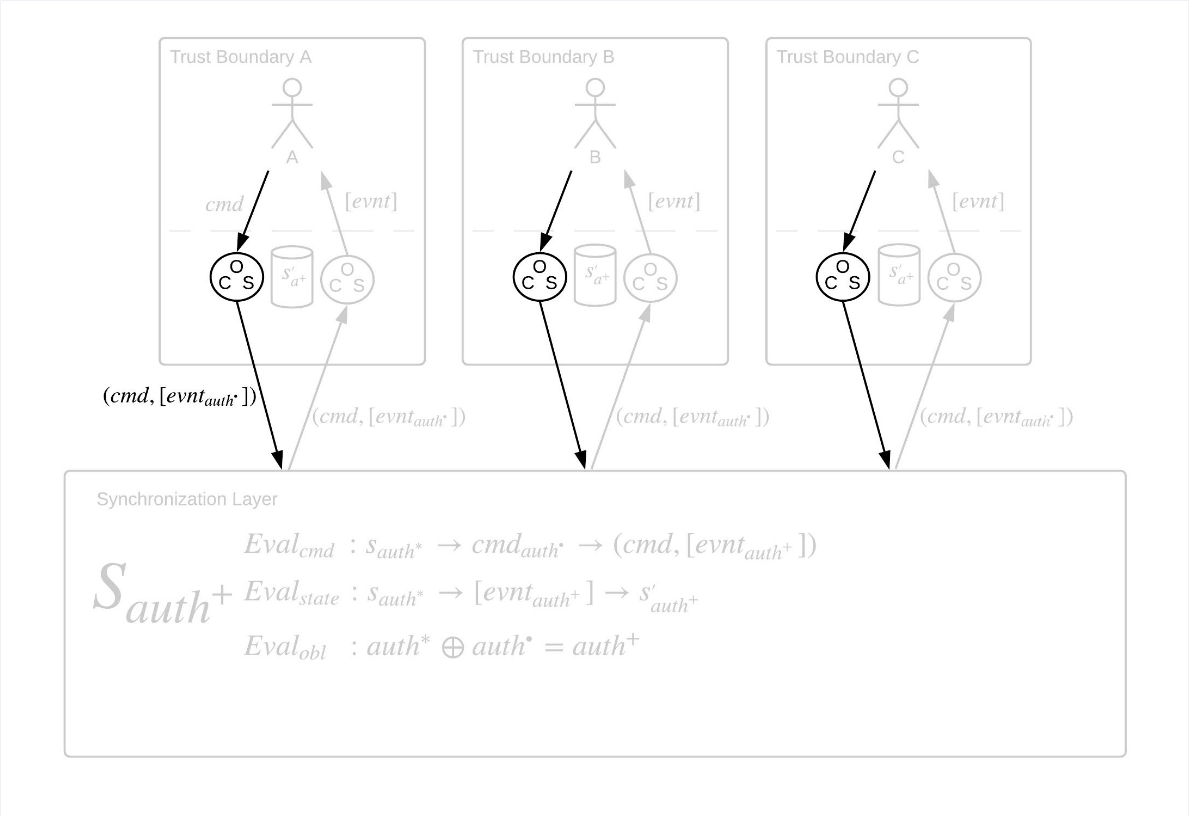
Trust Boundary A
A
cmd
$[evnt]$
O C S
s'_{a^+}
O C S
Trust Boundary B
B
$[evnt]$
O C S
s'_{a^+}
O C S
Trust Boundary C
C
$[evnt]$
O C S
s'_{a^+}
O C S
$(cmd, [evnt_{auth^\bullet}])$
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Synchronization Layer
S_{auth^+}
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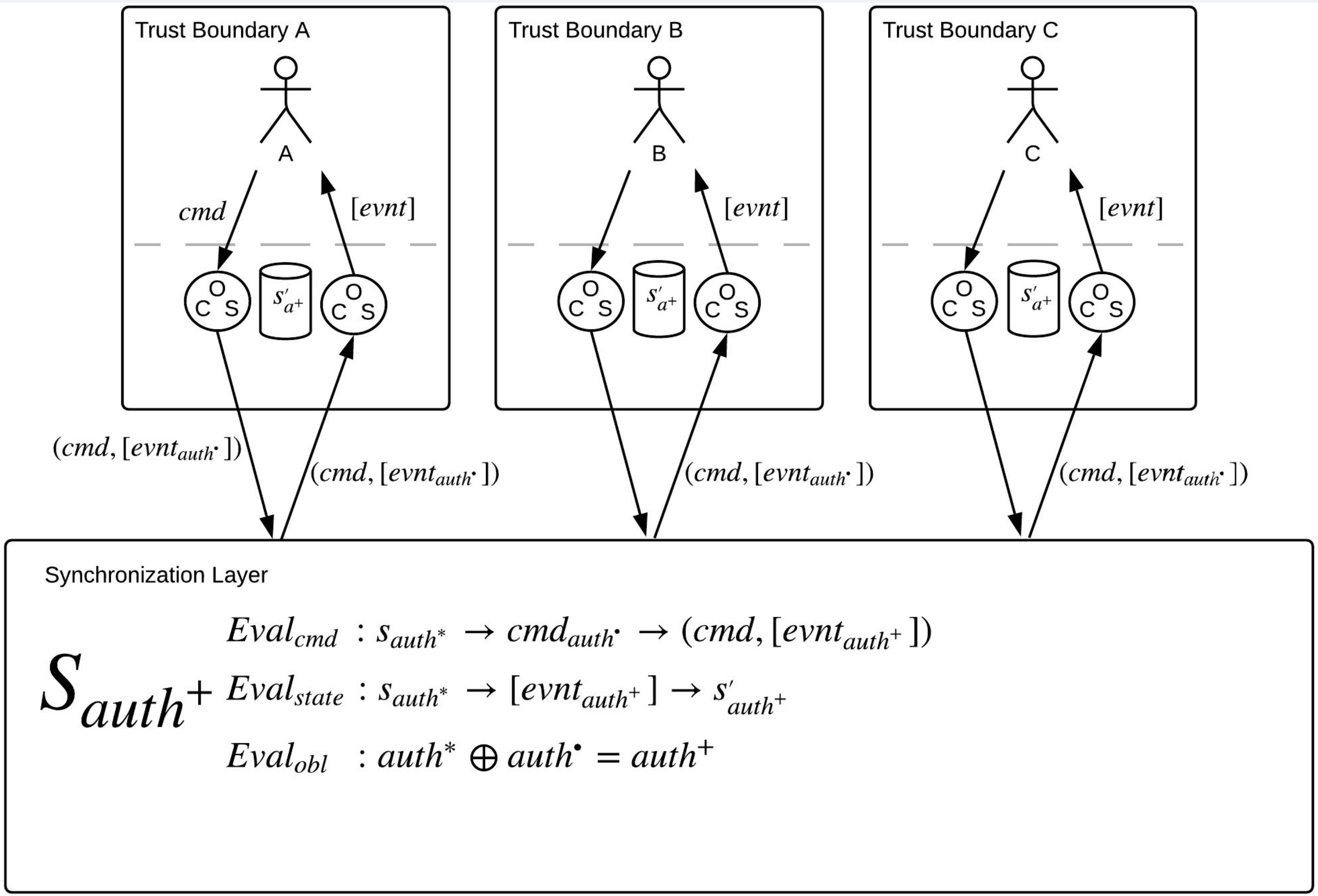
$Eval_{obl} : auth^* \oplus auth^\bullet = auth^+$



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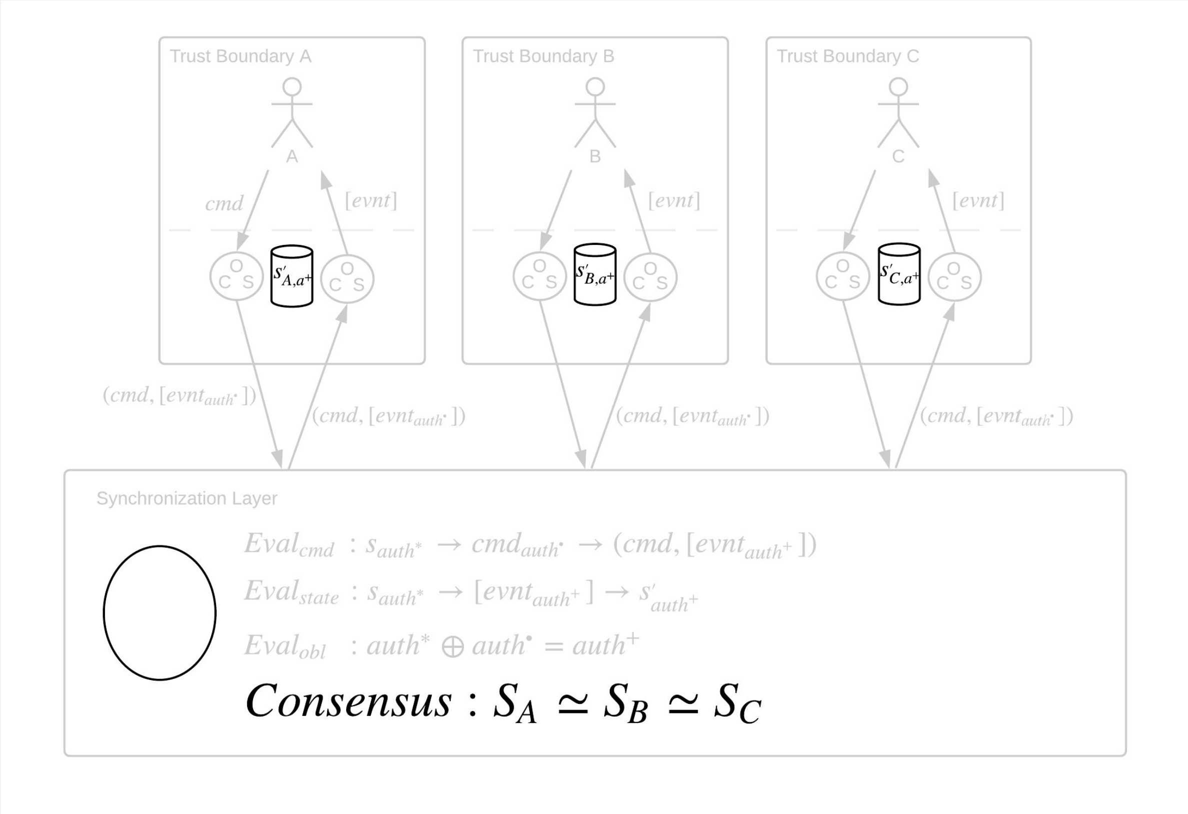

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$$Consensus : S_A \simeq S_B \simeq S_C$$

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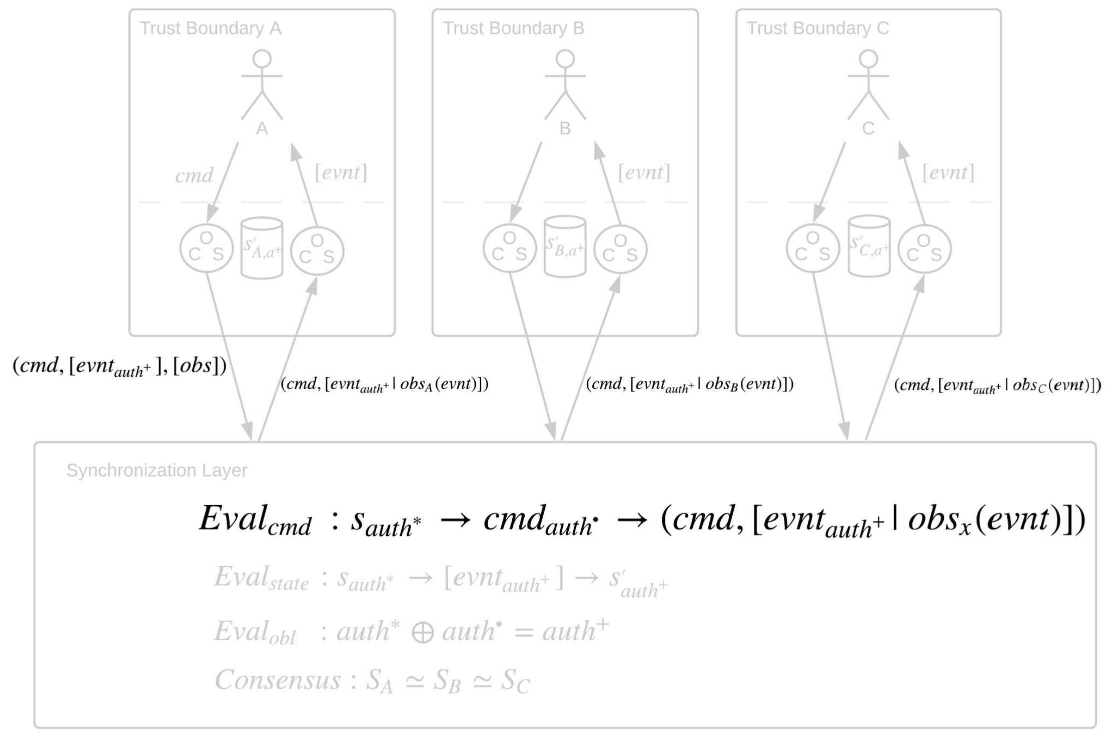

$$Eval_{cmd} : s_{auth^*} \rightarrow cmd_{auth^\bullet} \rightarrow (cmd, [evnt_{auth^+} \mid obs_x(evnt)])$$

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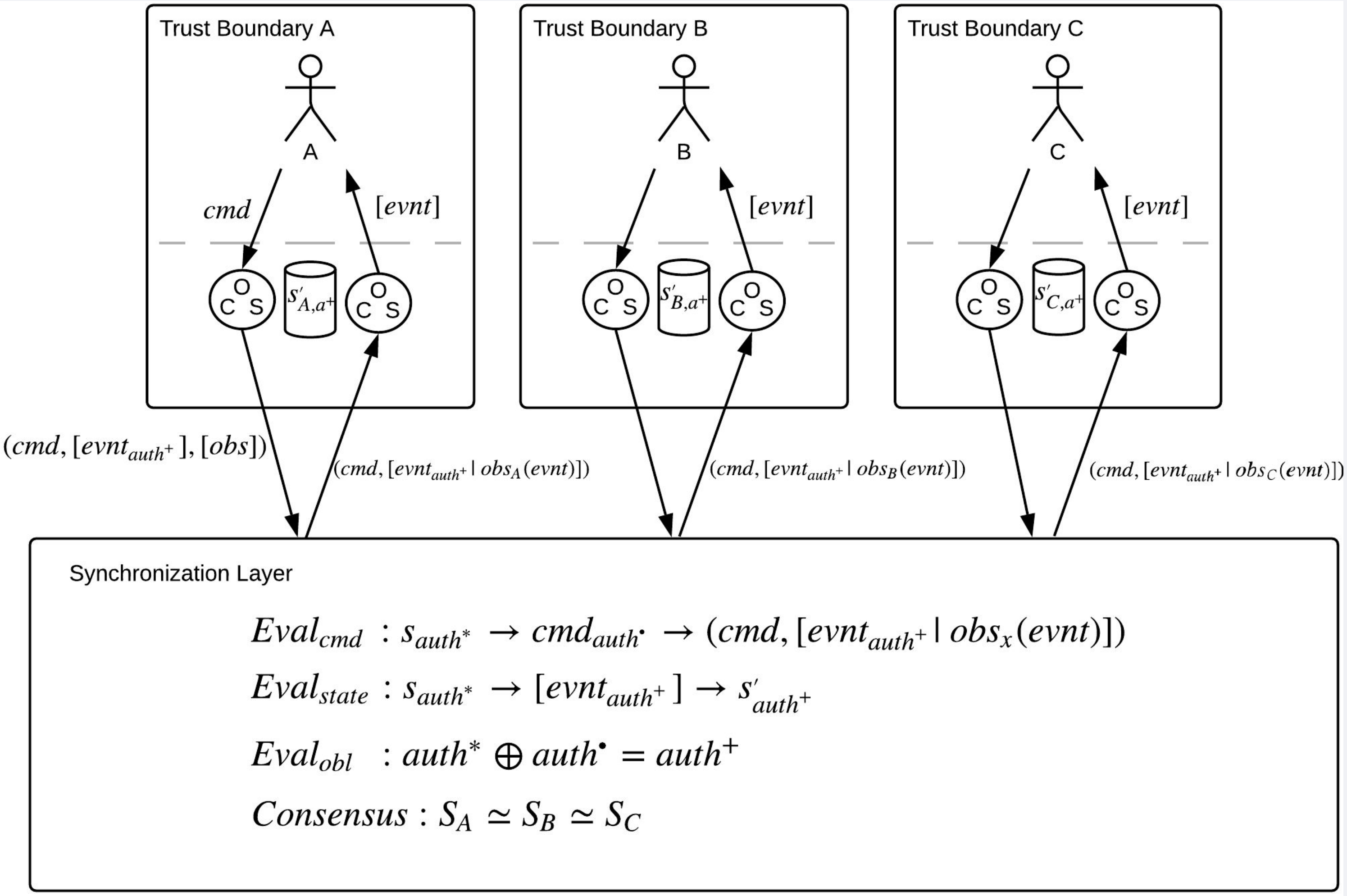

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CardMarket.daml

DAML (Digital Asset Modeling Language)

- Pure-Functional Haskell dialect
- Formal Operational Semantics that provides
  - Technology-neutral ledger model
  - Privacy and Disclosure
  - Authorization and Consent
  - Completely deterministic evaluation
- Digital Asset SDK provides
  - DAML IDE support (Visual Studio plugin)
  - DAML/DLT sandbox suitable for testing/debugging/PoC-dev
  - DAML compiler to intermediate canonical form
  - DAML interpreter
- Open-Source (https://github.com/digital-asset/daml)

Synchronization/Consensus Layer

- Distributed Consensus via
  - Total ordering on Commands
  - All multi-party coordination is via the Transaction Log
- Predicated Transactions (Commands + Expected Events)
  - Commands (Create + Exercise)
  - Events (Created + Archived)
  - Aggregated State := events ⇒ filter (valid) ⇒ fold (created - archived)

DAML (Modelling)

- We model Rights to act (ie. “Gates” or “Choices”) NOT data
- A digital ledger is not a database — we aren’t using CRUD
  Rather, it is a distributed transaction log of choices made by parties

  (this is intension vs. extension)
  Not: "This state exists" or "Party A possesses token T"
  Rather: "Party A chose act M, now Party B now has right to chose act N"

  ie. "A makes offer to B":
  Not: "Party B is now in possession of an 'Offer' from Party A"
  Rather: "Party A chose to make offer”, now
  “Party B how has the choice of 'Accept Offer' or 'Reject Offer'"

DAML (Proving facts/beliefs)

Each contract on the ledger represents a formal proof that the signatories to the contract have agreed that a particular fact is true.

or more formally: an observer of a contract has a justified basis for belief that the signatories reached a consensus of belief: that a predicate holds for the lifetime of the contract

CardTrader.daml

DAML Resources

DA Website:	https://digitalasset.com/
DAML:	https://daml.com/
DAML API Hoogle:	https://hoogle.daml.com/
DAML source code:	https://github.com/digital-asset/daml
Further Reading:	https://medium.com/daml-driven
Public Slack:	https://damldriven.slack.com
Code + slides:	http://github.com/recurse/CardMarket

Andrae Muys
e: andrae.muys@digitalasset.com
t: @etymon

Questions

For details on the CHESS Replacement:

https://www.asx.com.au/services/chess-replacement.htm

mailto:CHESSReplacement@asx.com.au