Harmony

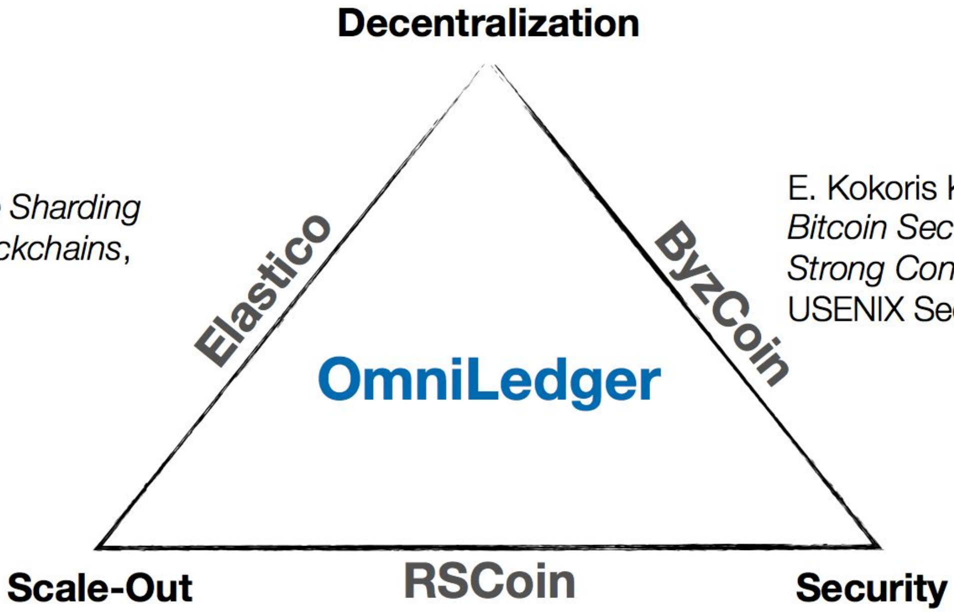
Open Consensus for 10B People

Scaling via Systems and Language Design

Stephen Tse
harmony.one/talk

Bring Research Results to Production!

L. Luu et al., *A Secure Sharding Protocol for Open Blockchains*, CCS 2016

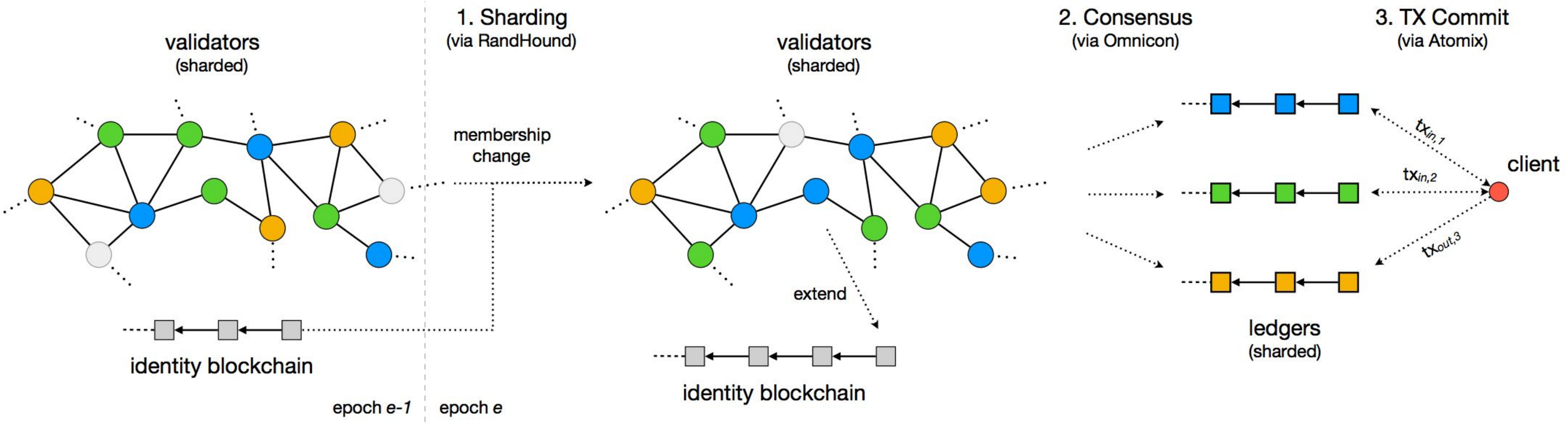


E. Kokoris Kogias et al., *Enhancing Bitcoin Security and Performance with Strong Consistency via Collective Signing*, USENIX Security 2016

G. Danezis and S. Meiklejohn, *Centrally Banked Cryptocurrencies*, NDSS 2016

Backtesting with historical data?
Adversarial simulation, **parameter optimizations**?

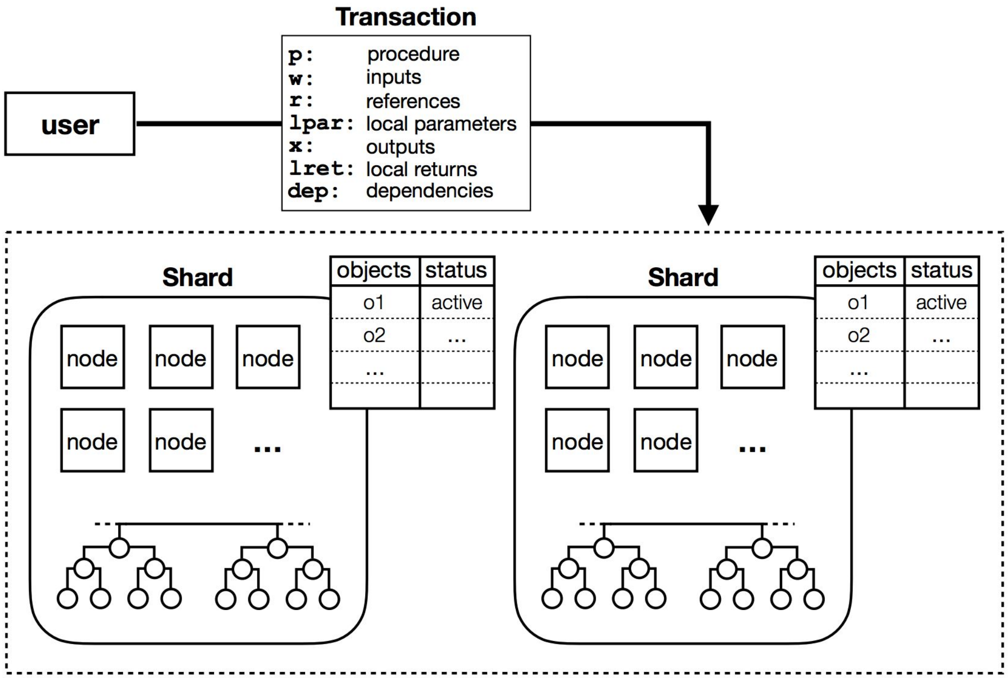
Harmony: Production Network of 100k Nodes



A high-performance blockchain demands ***10x innovations*** in transport networks, consensus protocols & systems tools.

We bring proven innovations to *large-scale* production [OmniLedger*, RapidChain, Blockmania, Avalanche].

Sharding Contracts with Static Types



Transaction

p:	procedure
w:	inputs
r:	references
lpar:	local parameters
x:	outputs
lret:	local returns
dep:	dependencies

objects	status
o1	active
o2	...
...	

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o1	active
o2	...
...	

Age of Open Development: a *core team* to **productionize** research with protocol + application *communities*

[Chainspace*, Scilla, Fraud Proofs].

Scaling Trust to 10B people & 100B devices

Can we *agree* now but foresee **inconsistency** in practice?

Can we *rely* on **intuition** when expressing terms & conditions?

Can we *iterate* without lawyers, regional laws, or **penalties**?

Can smart contracts be safe, easy, fast?

Trusting Contracts: As **SAFE** as Java

Java Virtual Machine makes web applications so *boringly* reliable for teams of 100+ developers

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Run-time checks maintain **global constraints** (termination, resource consumption, balance flow)

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Tse/TOPLAS: Verified interoperable implementations of security protocols
Tse/IEEE-SP: Run-time principals in information-flow type systems

Writing Contracts: As **EASY** as Python

Minimal syntax (no distraction!), human has limited cognitive focus for abstractions such as *invariants* & *isomorphism*

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Functional and *process calculi* to avoid managing states, type inference as theorem proving to tame structures & complexity

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Understand theories behind dependencies (information flow) & **parametricity** (higher-order polymorphism) vs “fat languages”

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Tse/Penn: Concise concrete syntax (generalized LR parser), min-lang.com
Tse/ICFP: Translating dependency into parametricity

Running Contracts: As **FAST** as OCaml

Compile to native code & run tests in 200 ms

Tezos, Zilliqa’s Scilla, Coda’s SNARK, **Coq** are written in OCaml

Declarative style leaves freedom for memory management, parallelism strategies, graph executions, sharding algorithms

Beautiful and Secure Code

```
black_scholes
    s : ℝ # stock price
    x : ℝ # strike price
    t : ℝ # expiration time in years
    r : ℝ # risk-free interest rate
    σ : ℝ # volatility
    : ℝ
 = s ϕ(d1) - x e^(-r t)ϕ(d2) @
  ϕ = Normal.cdf
  d0 = log s/x + (r + σ²/2)t
  d1 = d0 / σ√t
  d2 = d1 - σ√t
```

harmony.one/type-checks

Join **Harmony** team! Bring Empathy, Passion, Excellence

Rust engineers, protocol researchers, compiler writers to **s@harmony.one**

See harmony.one/talk, /sharding and /tgi

Stephen: security protocols PhD

Nicolas: VR startup founder

Alok: **Apple Siri** ML

Rongjian: Google search

Minh: **Google infrastructure**

Nick: Stanford AI masters

Sahil: Harvard MBA

Eugene: Amazon networking

Leo: **Amazon Phone OS**

Hakwan: Rhode Scholars

Kayuet: Oxford PhD

OmniLedger: Principles & Optimizations for Scaling

Representative sharding

O(1)-size multi-signatures for 10k nodes vs 16-node PBFT. Crypto sortition via randoness from multi-party computation and commit-then-reveal step.

Gradual transition

Sybil-resistant identities to maintain liveness when swapping. A sliding window from a fixed permutation to ensure ⅔ honest majority.

Atomic shard-commit

Each shard uses O(log n) *multicast tree-based BFT* to unanimously accept cross-shard transactions with O(1)-size *coordination.*

Parallelizing blocks

Acyclic graphs to capture transaction *dependencies transitively*. Divide each shard into groups to replace faulty nodes with a view-change.

Pruning checkpoints

State blocks for storage and bootstrapping against Byzantine DoS. Multi-hop, collectively signed back -pointers, 100x space savings.

Optimistic confirms

Trust but verify low-value transactions with shard deposits. Guarantee finality in ~1s with *penalty linear to loss* and detection in minutes.