Cardano

The Secret of Success of one of the Leading Cryptocurrencies

DISTRIBUTE Hamburg
2018-06-28

Well-Typed
The Haskell Consultants

PREDICTABLE NETWORK SOLUTIONS

About myself

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- Leading Incentives team.

Agenda

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Cardano

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- Proof of Stake blockchain

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- Cryptocurrency Ada

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PoW vs PoS

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- Leader selection based on Hashing Power: “One CPU, one vote!”

- Leader selection based on Stake: “Follow the Satoshi!”

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- Huge energy consumption to guarantee security.

- Leader selection based on Stake: “Follow the Satoshi!”
- Consensus is relatively cheap.

PoW vs PoS

- Leader selection based on Hashing Power: “One CPU, one vote!”
- Huge energy consumption to guarantee security.
- Well established and provably secure.

- Leader selection based on Stake: “Follow the Satoshi!”
- Consensus is relatively cheap.
- Provably secure, but hotly debated.

Ouroboros

First Provably Secure PoS Protocol

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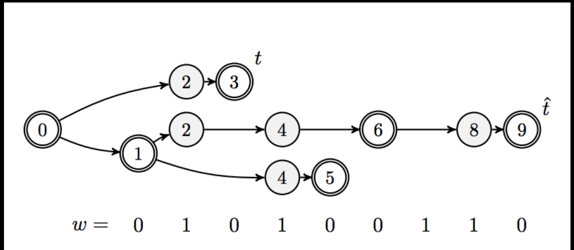
- Stakeholders agree on randomness for next epoch.
- Running in production in Cardano since October 2017.
- Provably secure against adversary with less than 50% stake.



Adversary	BTC	OB Covert	OB General
0.10	50	3	5
0.15	80	5	8
0.20	110	7	12
0.25	150	11	18
0.30	240	18	31
0.35	410	34	60
0.40	890	78	148
0.45	3400	317	663

Ouroboros Praos

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- Deals gracefully with message delays.
- Currently being implemented for future versions of Cardano.

Ouroboros Genesis

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- No checkpointing: New Players can safely join the protocol without any trusted advice.
- Security Proof in the UC-framework, making it easier to compare with Bitcoin (and other PoW systems).

Formal Methods

From Mathematical Paper...

Ouroboros Praos: An adaptively-secure, semi-synchronous proof-of-stake blockchain

Bernardo David*, Peter Gaži**, Aggelos Kiayias***, and Alexander Russell†

October 6, 2017

Abstract. We present "Ouroboros Praos", a proof-of-st[a] the first time, provides security against *fully-adaptive cor* *setting*: Specifically, the adversary can corrupt any parti[c] population of stakeholders at any moment as long the st[a] an honest majority of stake; furthermore, the protocol tol[e] message delivery delay unknown to protocol participants. To achieve these guarantees we formalize and realize in th[e] suitable form of forward secure digital signatures and a new that maintains unpredictability under malicious key genera[tion] a general combinatorial framework for the analysis of se[mi] may be of independent interest. We prove our protocol sec[ure] assumptions in the random oracle model.

Protocol π_{SPoS}

The protocol π_{SPoS} is run by stakeholders $U_1, \ldots, U_n$ interacting among themselves and with ideal functionalities $\mathcal{F}_{\mathsf{INIT}}, \mathcal{F}_{\mathsf{VRF}}, \mathcal{F}_{\mathsf{KES}}, \mathcal{F}_{\mathsf{DSIG}}, \mathsf{H}$ over a sequence of slots $S = \{sl_1, \ldots, sl_R\}$. Define $T_i \triangleq 2^{\ell_{\mathsf{VRF}}} \phi_f(\alpha_i)$ as the threshold for a stakeholder U_i, where α_i is the relative stake of U_i, ℓ_{VRF} denotes the output length of $\mathcal{F}_{\mathsf{VRF}}$, f is the active slots coefficient and ϕ_f is the mapping from Definition 1. Then π_{SPoS} proceeds as follows:

1. **Initialization.** The stakeholder U_i sends $(\mathsf{KeyGen}, sid, U_i)$ to $\mathcal{F}_{\mathsf{VRF}}$, $\mathcal{F}_{\mathsf{KES}}$ and $\mathcal{F}_{\mathsf{DSIG}}$; receiving $(\mathsf{VerificationKey}, sid, v_i^{\mathrm{vrf}})$, $(\mathsf{VerificationKey}, sid, v_i^{\mathrm{kes}})$ and $(\mathsf{VerificationKey}, sid, v_i^{\mathrm{dsig}})$, respectively. Then, in case it is the first round, it sends $(\mathsf{ver\_keys}, sid, U_i, v_i^{\mathrm{vrf}}, v_i^{\mathrm{kes}}, v_i^{\mathrm{dsig}})$ to $\mathcal{F}_{\mathsf{INIT}}$ (to claim stake from the genesis block). In any case, it terminates the round by returning $(U_i, v_i^{\mathrm{vrf}}, v_i^{\mathrm{kes}}, v_i^{\mathrm{dsig}})$ to $\mathcal{Z}$. In the next round, U_i sends $(\mathsf{genblock\_req}, sid, U_i)$ to $\mathcal{F}_{\mathsf{INIT}}$, receiving $(\mathsf{genblock}, sid, \mathbb{S}_0, \eta)$ as the answer. U_i sets the local blockchain $\mathcal{C} = B_0 = (\mathbb{S}_0, \eta)$ and its initial internal state $st = H(B_0)$.
2. **Chain Extension.** After initialization, for every slot $sl_j \in S$, every online stakeholder U_i performs the following steps:
   (a) U_i receives from the environment the transaction data $d \in \{0,1\}^*$ to be inserted into the blockchain.
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Fig. 4: Protocol π_{SPoS}.

From Mathematical Paper...

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Ouroboros Praos: An adaptively-secure, semi-synchronous proof-of-stake blockchain

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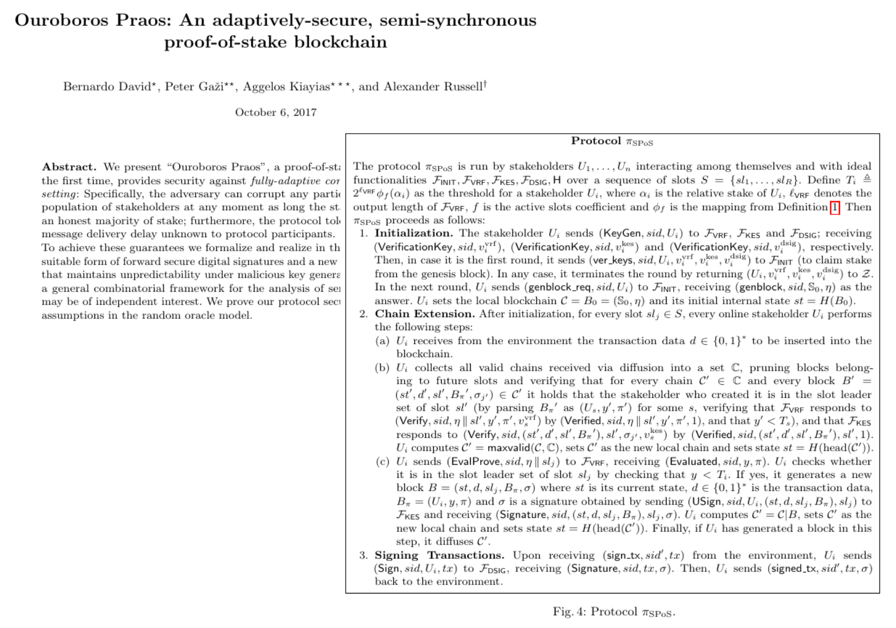

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   (c) U_i sends $(\mathsf{EvalProve}, sid, \eta \,\|\, sl_j)$ to $\mathcal{F}_{\mathsf{VRF}}$, receiving $(\mathsf{Evaluated}, sid, y, \pi)$. U_i checks whether it is in the slot leader set of slot sl_j by checking that $y < T_i$. If yes, it generates a new block $B = (st, d, sl_j, B_\pi, \sigma)$ where st is its current state, $d \in \{0,1\}^*$ is the transaction data, $B_\pi = (U_i, y, \pi)$ and σ is a signature obtained by sending $(\mathsf{USign}, sid, U_i, (st, d, sl_j, B_\pi), sl_j)$ to $\mathcal{F}_{\mathsf{KES}}$ and receiving $(\mathsf{Signature}, sid, (st, d, sl_j, B_\pi), sl_j, \sigma)$. U_i computes $\mathcal{C}' = \mathcal{C}|B$, sets $\mathcal{C}'$ as the new local chain and sets state $st = H(\mathrm{head}(\mathcal{C}'))$. Finally, if U_i has generated a block in this step, it diffuses $\mathcal{C}'$.
3. **Signing Transactions.** Upon receiving $(\mathsf{sign\_tx}, sid', tx)$ from the environment, U_i sends $(\mathsf{Sign}, sid, U_i, tx)$ to $\mathcal{F}_{\mathsf{DSIG}}$, receiving $(\mathsf{Signature}, sid, tx, \sigma)$. Then, U_i sends $(\mathsf{signed\_tx}, sid', tx, \sigma)$ back to the environment.

Fig. 4: Protocol π_{SPoS}.

- Written in English.
- Written by Mathematicians.
- Very abstract.

...To Efficient Code

```haskell
-- CHECK: @verifyEncShare
-- | Verify encrypted shares
verifyEncShares
    :: MonadRandom m
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    -> Scrape.Threshold
    -> [(VssPublicKey, EncShare)]
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Scientific Paper

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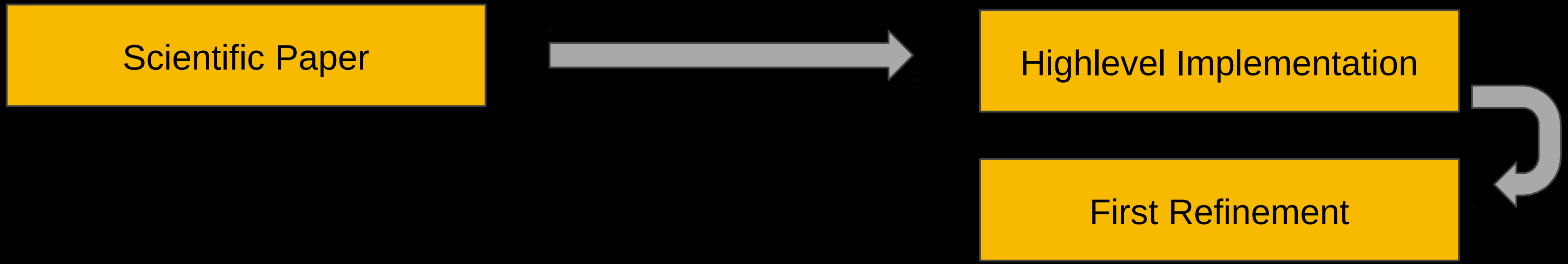
Scientific Paper → Highlevel Implementation

The Solution: Formal Methods



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Highlevel Implementation → First Refinement → Second Refinement

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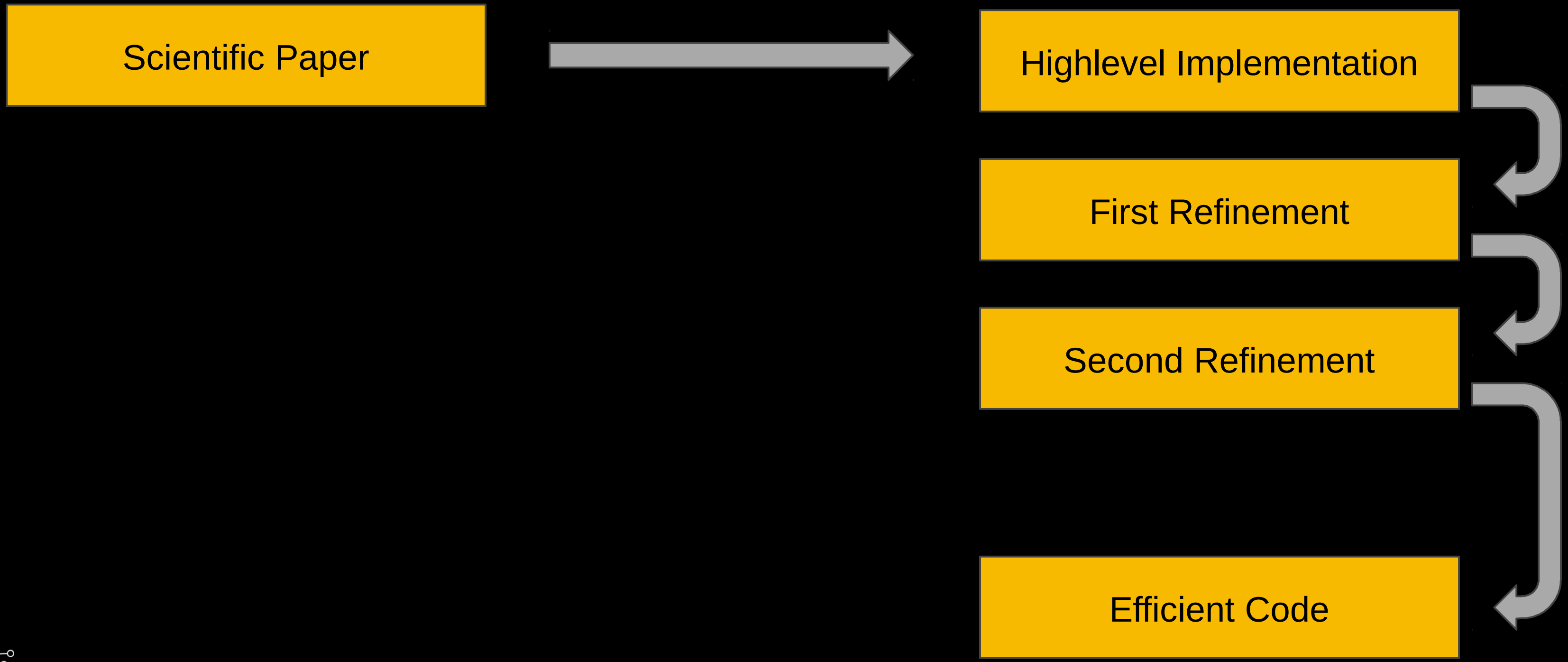

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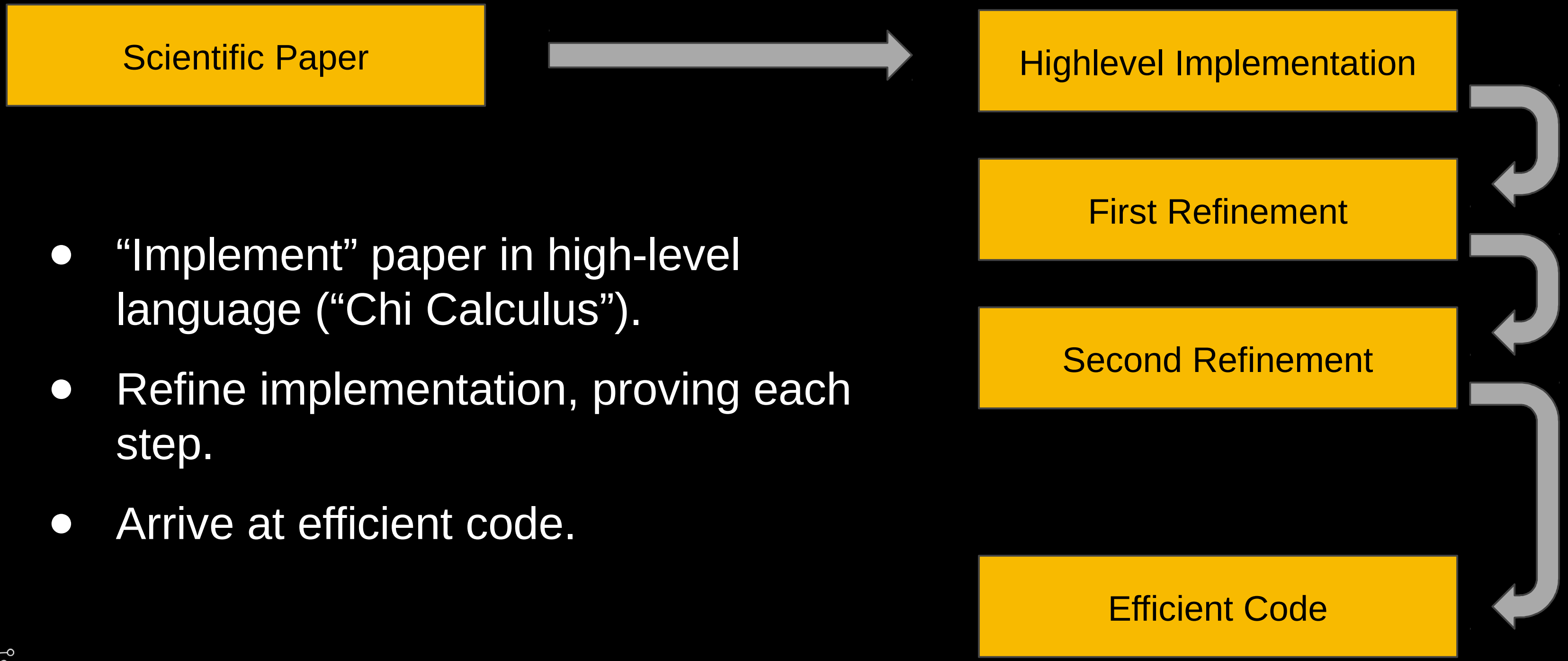

- “Implement” paper in high-level language (“Chi Calculus”).
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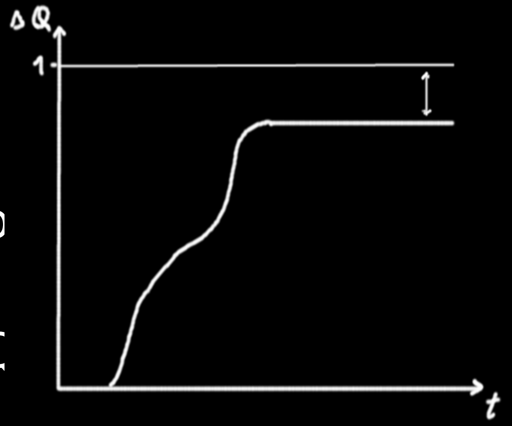

Incentives

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- In the case of Cardano, it means being online and creating a block when they have been elected slot leader and to participate in the election process.

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- **Ideally, monetary and moral incentives should align perfectly.**

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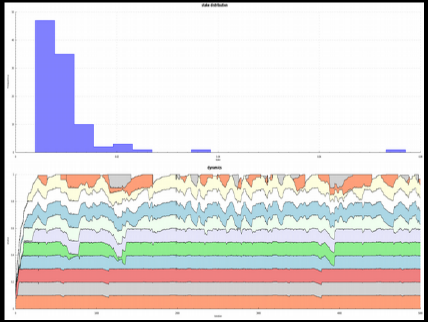
- In Cardano, we strive for perfect alignment of incentives.
- We use Game Theory and Simulations to develop and test our model.



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- Questions?
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