Validating Smart Contract Execution Across a Heterogenous Collection
A Proposal

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Agenda

• Background
• Challenges
• Proposal and Open Problems
• Q & A
Background

• Distributed consensus not new
  – Fischer Lynch Paterson : 1985 JACM
  – Presence of malicious users: Byzantine Fault-tolerance

• Blockchain: A particular architecture for distributed consensus
  – Also handles malicious users

• Distributed protocols enforce some desired property

• Cryptographic proof of work
  – Dwork/Naor 1992
Background

• **Bitcoin**: Enforces application specific properties
  – Prevent double spending
  – Privacy preservation

• **Ethereum**
  – Transaction based state machine
  – GHOST protocol for consensus
  – Transitions between the states expressed as a program
  – EVM: Stack based virtual machine
  – Programming languages like Solidity
Challenges

• **Scalability**
  – Number of participants
  – Transactions costs
  – Size of block and maximum length of chain,

• **Security assurance**

• **Heterogenous systems**
  – Need single “truth”
  – Different implementations
Challenges

• Is the smart contract correct?
  – Does it meet the desired properties
  – Very similar to program verification

• Are all the participants executing the same contract?
  – Is there any tampering?
  – Are integrity constraints satisfied?

• Is the downloaded code correct?
Proposal

• Can ideas such as
  – Proof carrying code or Proof carrying data be useful?
  – Proof carrying code was proposed in 1998 by Necula and Lee

• The key idea
  – Generator of new state generates a proof that the transition is valid
  – The user of the new state checks that the proof is valid before accepting state

• Premise
  – Generating proof is harder than verifying the proof
  – The onus is on generator to demonstrate “correctness”
Proof Carrying Code

Architecture
Open Problems

• Can Turing complete languages be supported in practice?
• What are the logics to express the desired properties?
  – Do we need tools such as Coq or Isabelle?
• Are there decidable subsets where automated techniques can be used?
  – What are the tradeoffs between expressive power, security guarantees and applicability?
  – What is the tradeoff between the costs of proof generation and proof checking?
Open Problems

• What are the sizes of typical proofs?
  – Can the proof be converted to a ‘tactic’?

• Can they be stored on the chain?
  – If not do we need to use trusted entities?
  – What is the level of trust required?

• Can a class of proof-checkers be used?
Open Problems

- Can such ideas be used with state channels?
- Do the proofs need to be history sensitive or do they apply only to transitions?
- Can other techniques such as probabilistic proof-systems or approximate algorithms suffice?
  - They may not give 100% guarantee but at an acceptable risk level
Q&A
Integrated Cloud
Applications & Platform Services