Validating Smart Contract Execution Across a Heterogenous Collection

A Proposal

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July 2018

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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

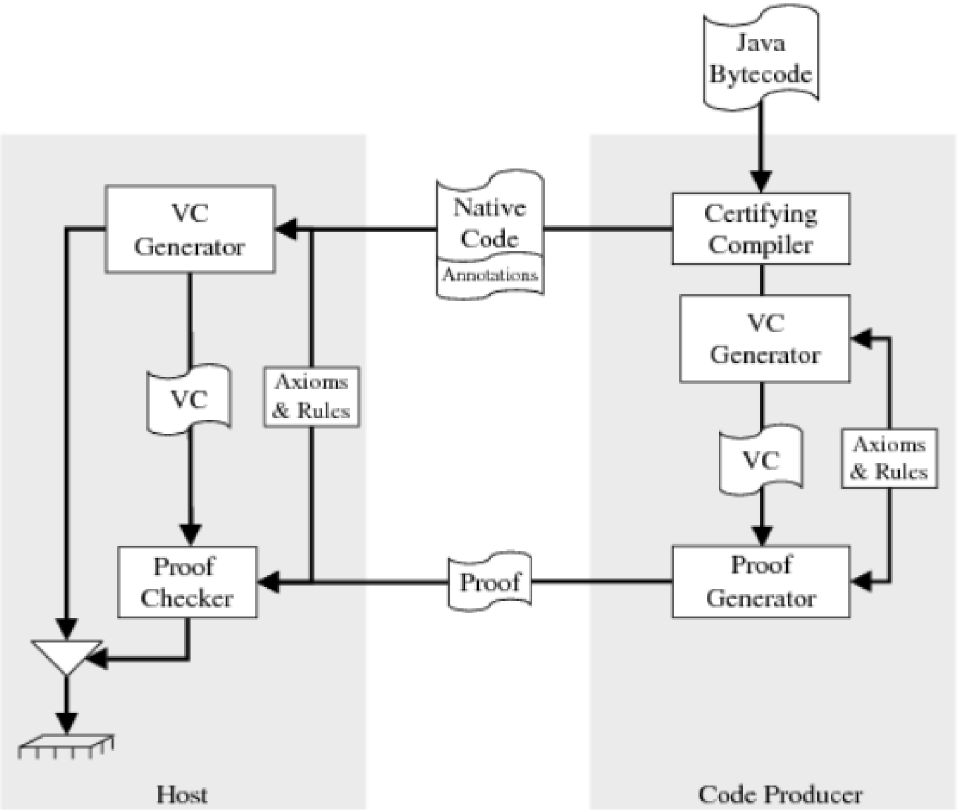
- **Is the smart contract correct?**
  - **Does it meet the desired properties**
  - **Very similar to program verification**
- **Are all the participants executing the same contract?**
  - **Is there any tampering?**
  - **Are integrity constraints satisfied?**
- **Is the downloaded code correct?**

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

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