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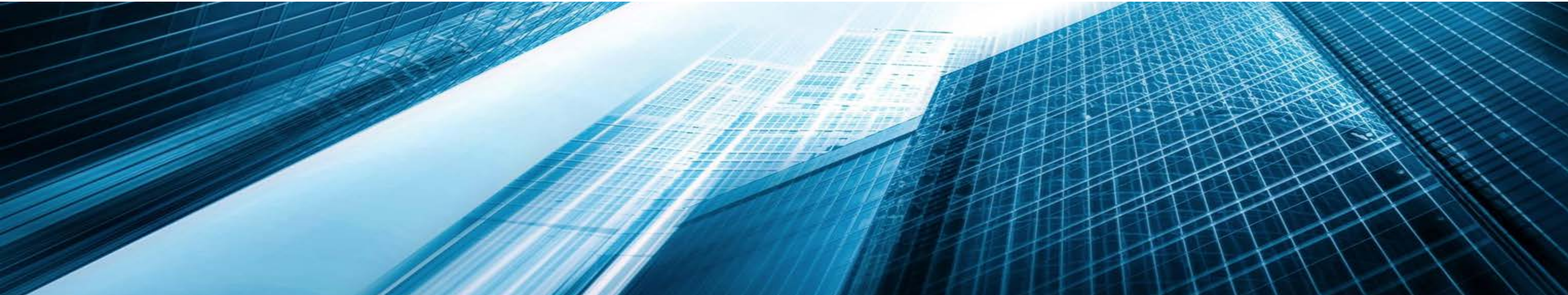
TESTING OF DISTRIBUTED LEDGER SYSTEMS



INTRODUCTION

- CTO of RISE Financial Technologies

- London-based technology provider
- Bringing DLT infrastructure to the post-trade industry

- First product focused on issuance, settlement, and record keeping
- Past and current projects with SWIFT, CSDs, banks etc

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SWIFT

Blockchain Startup 2016
Lifecycle of a bond on
the blockchain

IF YOU DON'T GET IT RIGHT...

- 2010 Bitcoin: Two critical validation bugs
  - Spend money from any account
  - Create unlimited money

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- 2016 Ethereum DAO: Critical smart-contract bug
  - Lost $53M
  - Mistake made not by user but by creator of system

OVERVIEW

- Focus on:
  - Software testing
  - Challenges rather than established testing strategies

- Two main areas:
  - DLT system itself
  - Validation rules and smart contracts

DLT? BLOCKCHAINS?

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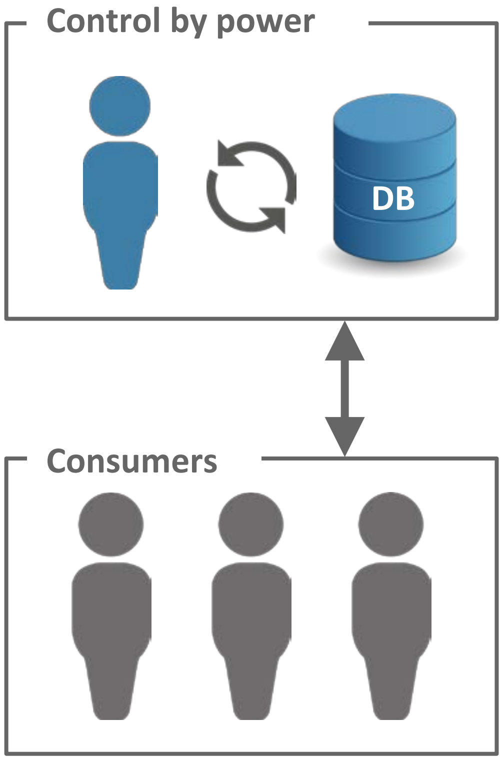
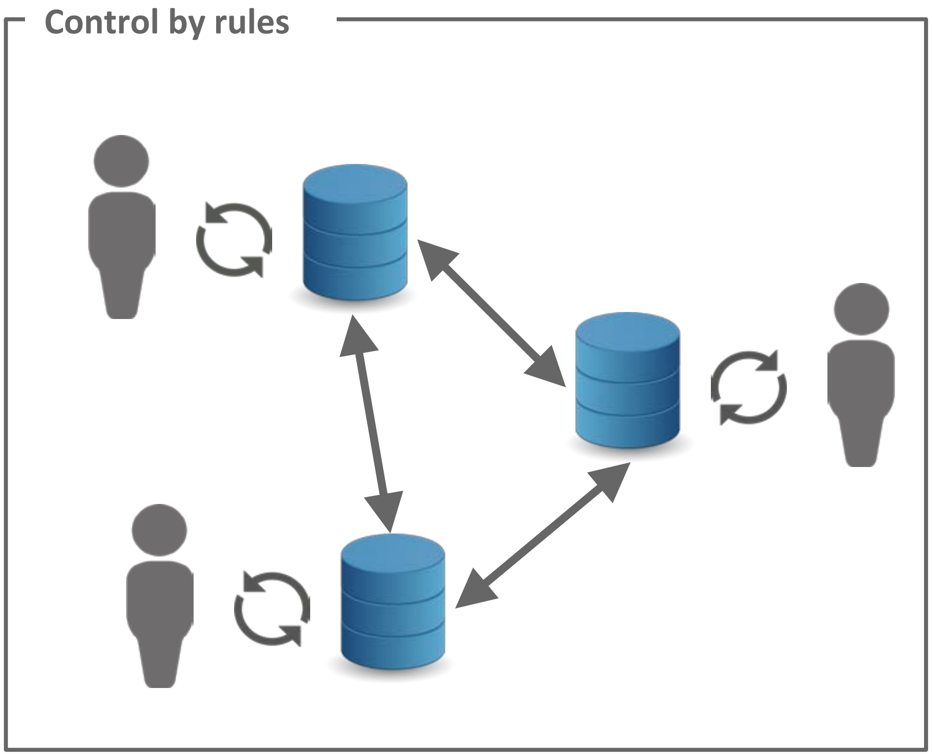
“Distributed ledgers are systems that enable parties who don’t fully trust each other to form and maintain consensus about the existence, status and evolution of a set of shared facts”

- Blockchain is essentially a distributed database with **shared control**
- What’s new is that this can now be done with **limited trust**
- Participants agree on validity of changes to the system according to a set of rules (*consensus*)

SHARED CONTROL





DLT SYSTEM

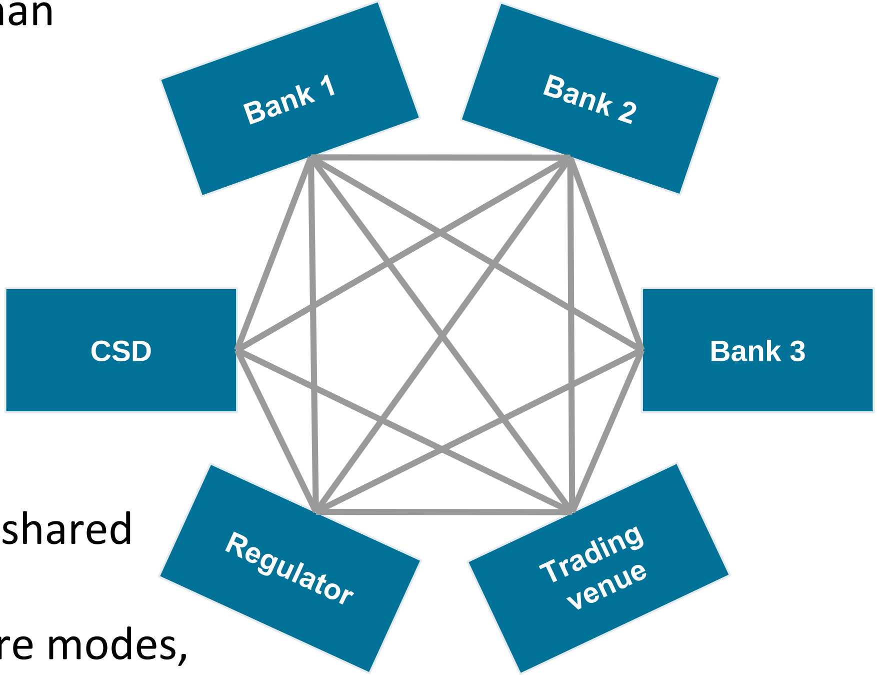
IT'S A DISTRIBUTED SYSTEM!

Distributed systems are a **great deal harder** than conventional tx processing systems.

Testing of distributed systems is **notoriously difficult**.

Analogous to a massively inter-connected banking system:

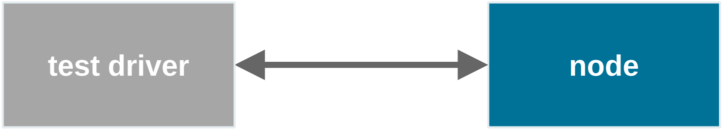
- Delays, frequent lags, connection losses, shared but diverging data
- Concurrent execution, independent failure modes, no global time



DS TEST STRATEGIES

- Isolate
- Make it deterministic
- Inject faults

1) Test each component in isolation



DS TEST STRATEGIES

- Isolate
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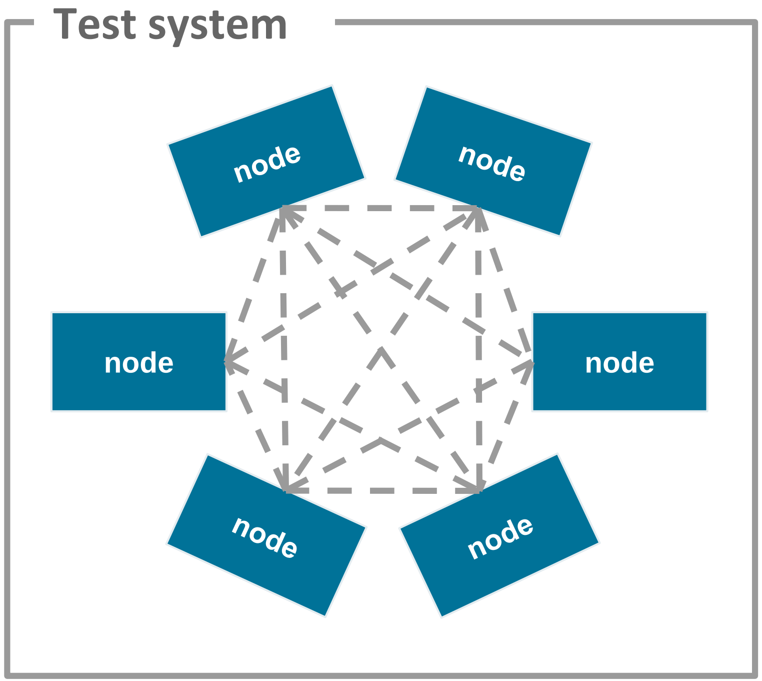
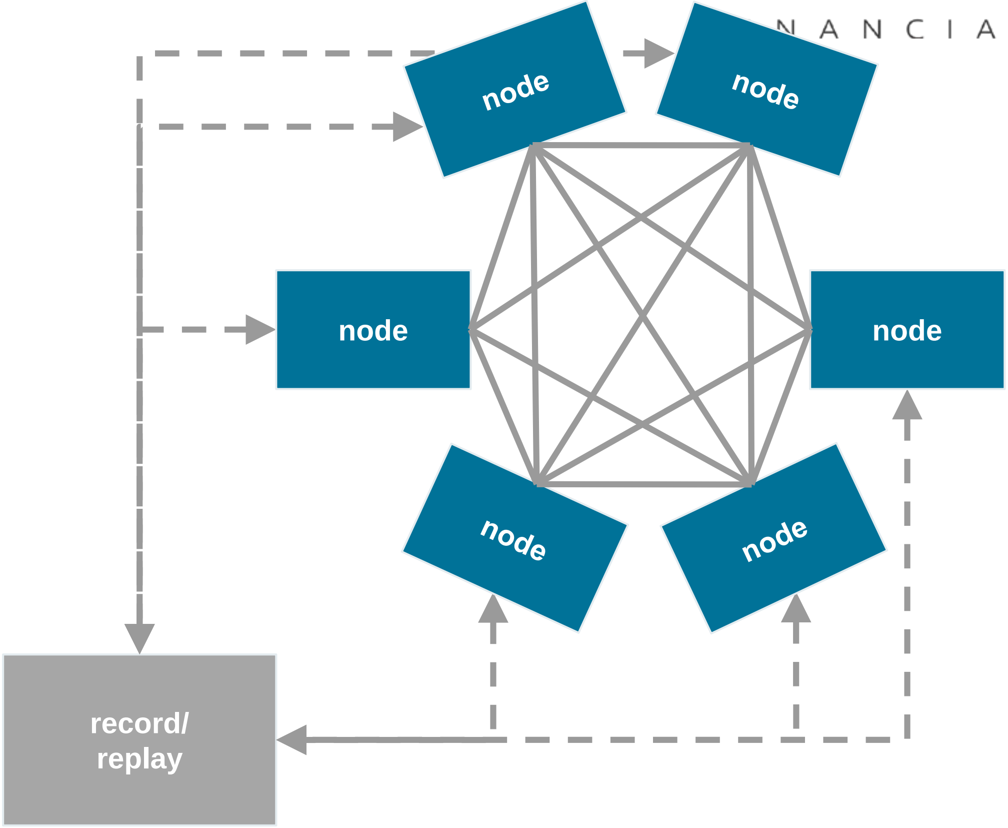
1) Test each component in isolation
2) Test system in a tightly controlled environment



DS TEST STRATEGIES

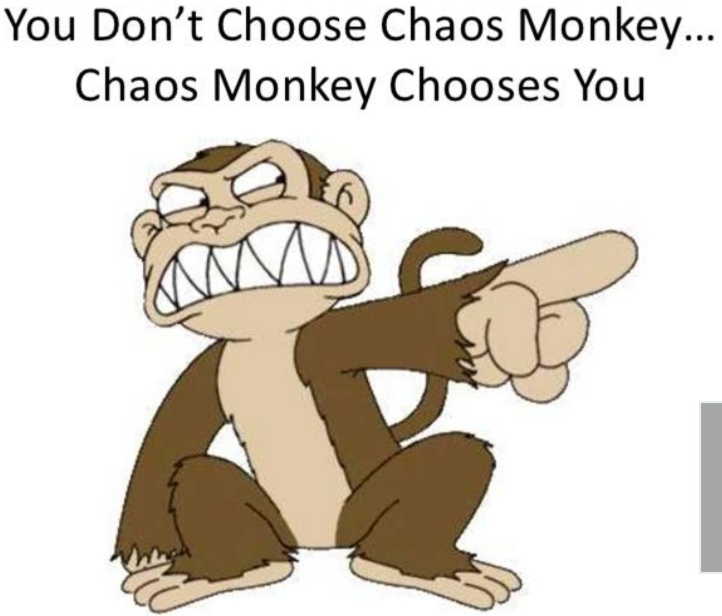
- Isolate
- Make it deterministic
- Inject faults

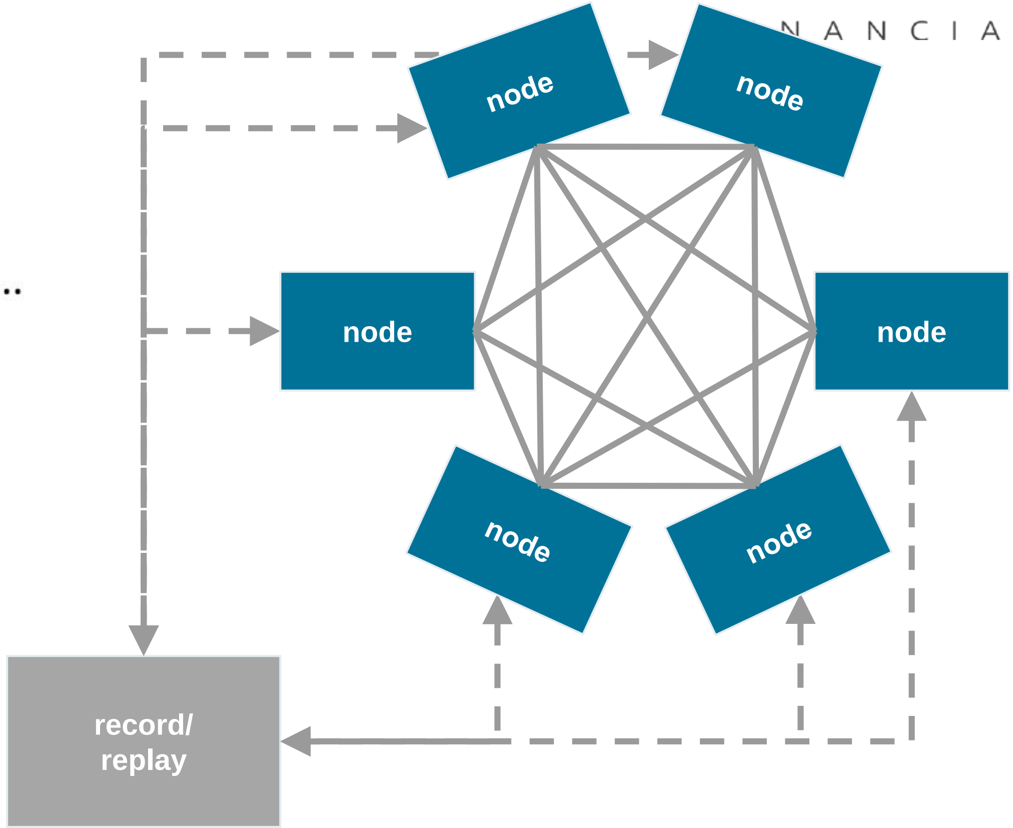
1) Test each component in isolation
2) Test system in a tightly controlled environment
3) Deal with non-determinism



DS TEST STRATEGIES

- Inject **random** faults!





FURTHER CHALLENGES

- Adversarial environments
  - DLT systems intended for networks with limited trust
- Non-functional testing
  - Ensuring non-functional requirements is hard in a distributed system
- Security testing
  - A DLT is essentially a cryptographic system
- Version and change management
  - Backwards compatibility

VALIDATION RULES

VALIDATION RULES

- Network participants agree on what’s valid and what’s not valid
- They follow a set of shared rules, the **validation rules**
- Rules can be hard-coded or ad-hoc (“smart contracts”)

- Tradeoffs between complexity, flexibility and security
  - Complexity is caused by flexibility
  - Simplicity favors security
- Heavily influences testability and QA

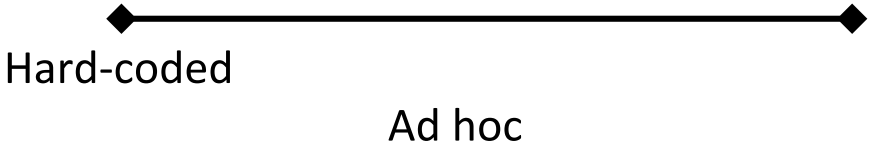
VALIDATION RULES

- Challenges:
  - Make absolutely consistent across diverse systems/architectures
  - The more complex the rules, the larger the state space

- Can be tackled with the usual testing/QA methods
  - Model/black-box testing
  - Unit testing, regression testing, etc

- Some tips:
  - Keep it simple
  - Keep it self-contained
  - Keep it stateless

HARD-CODED VS. AD HOC

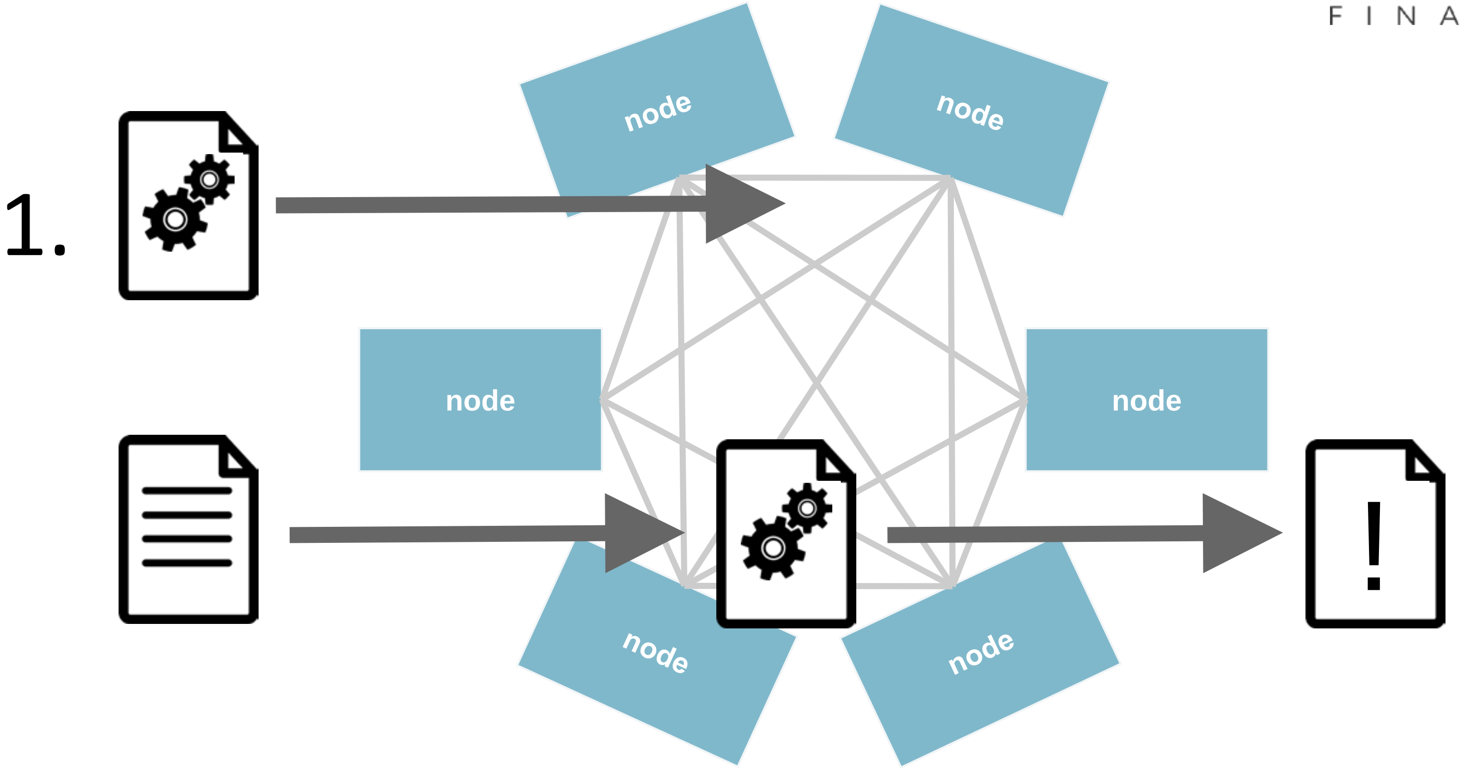


- Encode validation rules in blockchain engine
  - Tight control on rule implementation
  - Thoroughly reviewed and tested

- More flexible are extensions using scripting languages
  - Bitcoin uses a very limited stack-based language

- Smart contracts

SMART CONTRACTS



SMART CONTRACTS

- Smart contracts **transfer risk** from the DLT provider to the DLT user
  - User has to do testing and QA

- Most smart contract languages are Turing complete
  - High complexity
  - Infinite state space

- Additional complexity from interactions between smart contracts
  - These might be from different providers

SMART CONTRACTS

From the user’s perspective:

- Testing/QA of a (Turing complete) program...
  - ...that potentially interacts with other programs
  - ...in a distributed, non-deterministic system
  - ...on a dynamically changing and expanding network
  - ...using evolving rules and features

SUMMARY

TESTING CHALLENGES

- Distributed systems are really hard to test
  - DLT systems are even harder

- Testing/QA of validation rules is crucial
  - Complexity makes testing hard

- Smart contracts testing is unsolved
  - Risk lies with the user

RECOMMENDATIONS

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Stay focused:

- Limit scope, chose the right use-case

Test components:

- Isolate, inject faults!

Test non-deterministically:

- Record/replay
- Unleash the Chaos Monkey

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