

Blockchain Security in 30 Minutes (not a cryptocurrency investment talk)

Parsia Hakimian
March 12th 2018

Who is this guy

- **Appsec Consulting @ Synopsys**
 - EDA software company you have not heard of
 - Software Integrity Group (SIG)
 - Cigital <-- I was here
 - Blackduck
 - Coverity
 - Defensics

What this is NOT!

- How can I get rich with Bitcoin? **Time travel.**



- How do I keep my private keys safe? **Paper wallet.**
- What should I mine? **Doge coin.**

First!

- Do I need a blockchain? **Not Really!**
- Reinventing databases; a tragedy in two parts

A decentralized git repositories registry on blockchain could save us all. Is anyone working on something similar?

1:10 AM - 28 Feb 2018

- GitHub goes down.
- I push my repo on another origin, even self hosted.
- I update the blockchain registry.
- The dev that included my library asks the distributed registry where to pull the code.
- The registry provides the new git repo.
- Everything still builds.

6:32 AM - 1 Mar 2018

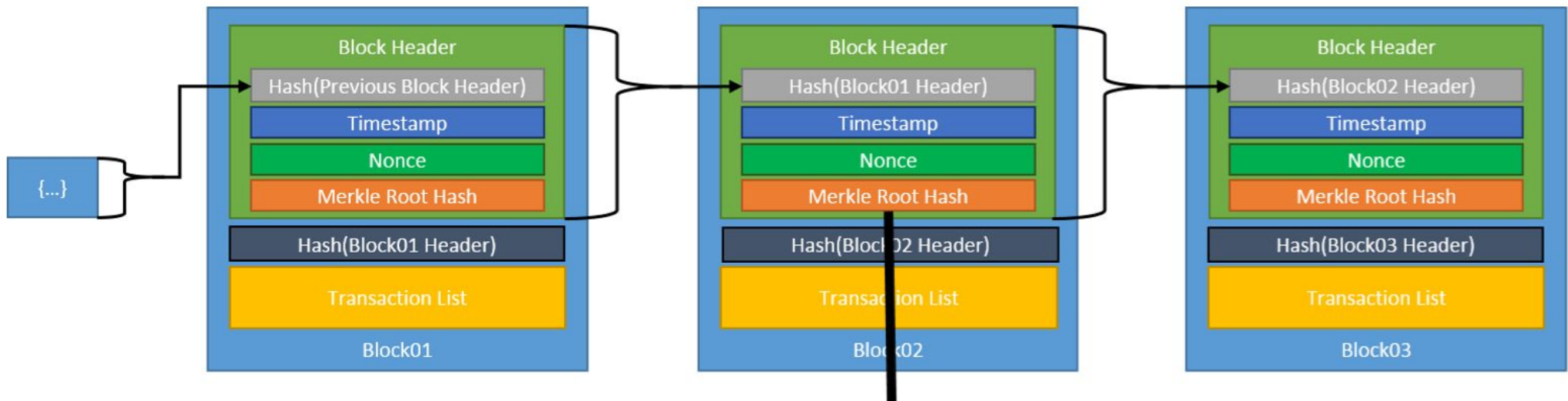
Blockchain or Glorified Distributed DB?

- **Data you want to store:**
 - Dank memes, events, transactions, network logs, etc.
- **Ledger:**
 - Event log
- **Distributed Ledger:**
 - Distributed and updated event log
- **Blockchain**
 - An implementation of a distributed ledger

Most important slide

- **Blockchain System == Distributed Network**
 - Solves some problems
 - Introduces new challenges
- **Attacks/Concerns from literature apply**
 - Sybil attack
 - Fault tolerance
 - CAP theorem

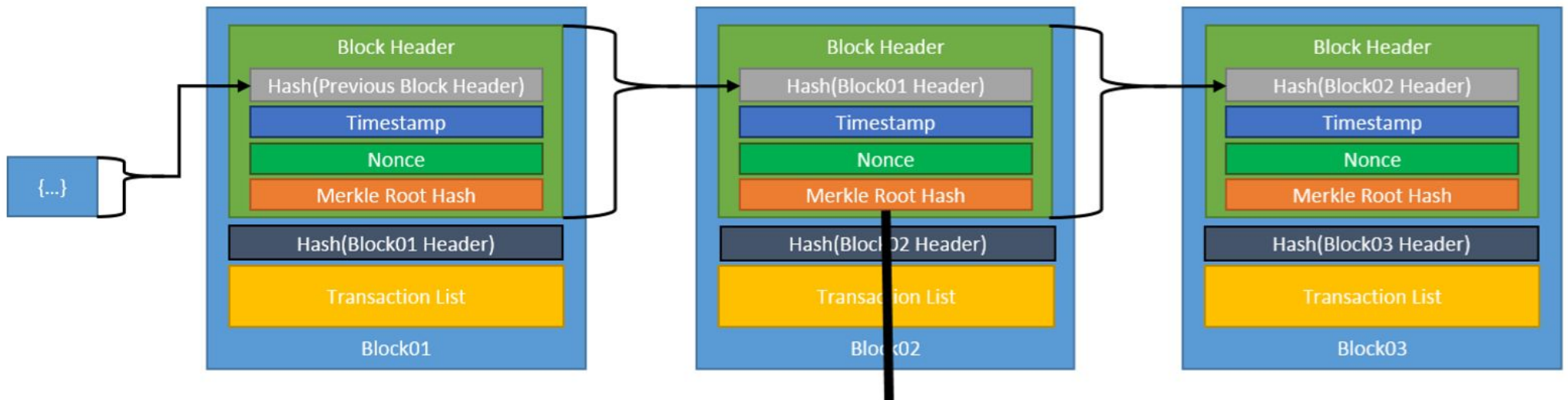
Blockchain



Source: NISTIR 8202 - Blockchain Technology Overview - January 2018 Draft

- **Write-once distributed ledger**
- **History is verifiable**
- **HashChain**

Problem 0-0: Integrity



- **HashChain does the trick**
- **Good hash function:**
 - SHA/Scrypt/Ethash/Equihash/etc...

Hash Function

- **Any-length input > fixed-length output**
 - **Diffusion**
 - Smallest change in input > completely different output.
 - **Pre-image resistant**
 - Hard to predict input that results in a specific output.
 - **Collision resistant**
 - Hard to find two inputs that produce in the same output.
 - **Second pre-image resistant**
 - Having one specific input, it should be hard to find a collision.

Problem 0-1: Integrity of Transactions



Merkle Tree Root Hash

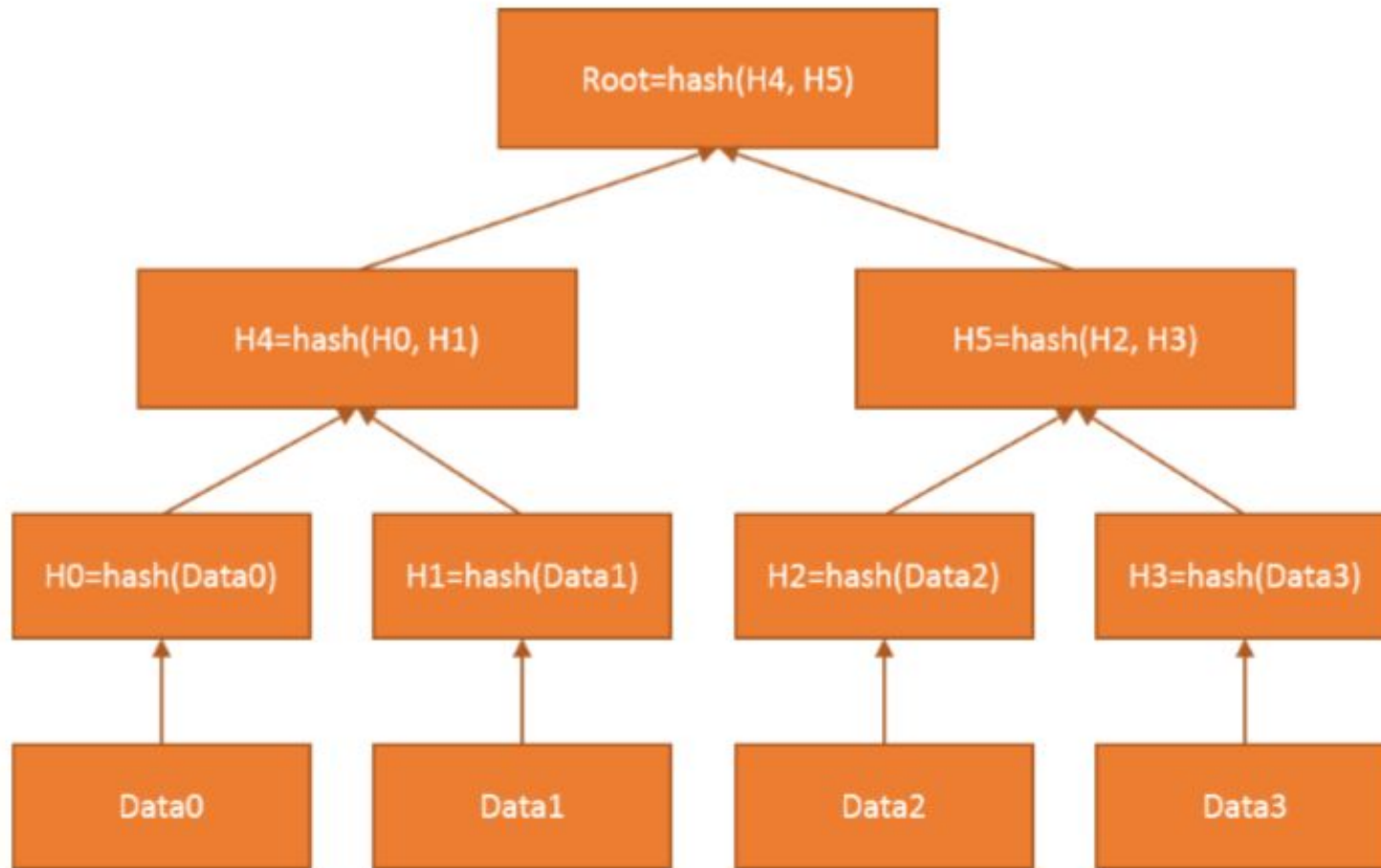


Figure 5: Example of a Merkle Tree

Source: NISTIR 8202 - Blockchain Technology Overview - January 2018 Draft

Problem 1: Who can join?

- **Permissioned**

- Central authority vets nodes
- Not all nodes can do everything
- Enterprise blockchains
 - Hyperledger Fabric – IBM & Linux foundation
 - Quorum – JPMC

- **Permissionless**

- Everyone can submit/read/write
- Most Cryptocurrencies

Federal Register on a Blockchain



- **Federal Register**

- Data: Rules and regulations
- Submit transaction: Office of the Federal Register
- Writer: Government Publishing Office or GPO
- Reader/Verifier: Everyone

- **Public permissioned blockchain**

- **This is a horrible idea!**

Problem 2: Who's who?

- **Permissioned**

- Central vetting authority
- Certificates

- **Permissionless**

- Private/Public key
- Public key > hash > stringify > address
 - Stringify: Base56
- Wallets/transactions can be traced

Problem 3-0: Verifying Transactions

- **Verify validity**
 - Sign transaction with private key
 - Verify with public key
 - Use public key to derive address
- **Verify balance**
 - Calculate $(\text{in} - \text{out}) \times \text{coins}$

Problem 3-1: Theft

- **Private key access == Owner**
- **No undo - SFYL**
 - Immutable ledger
- **Exchange theft**
 - Bitconnect (straight up Ponzi scheme) -
- **Solution:**
 - 2FA
 - Paper wallets/Multi-signature wallets



“Bitconnect Guy”

Nodes

- **Full Node**

- Store complete history of blockchain

- **Mining Node**

- Full node + maintain blockchain
 - Create new blocks

- **Lightweight Node**

- No mining or storing
- Submit transactions
- Pass data around

Problem 4: Distributed Backups

- **Solution**

- Full/Mining nodes store everything

- **Challenge**

- Waste of bandwidth
- Bitcoin blockchain 110+ GB

Problem 5: Maintaining the Network

- **Permissioned**

- Out-of-band incentives
 - Law: GPO
 - Business agreements: Banks

- **Permissionless**

- Award Cryptocurrency
 - How bitcoin is created
- New challenge
 - Who gets to create new blocks?

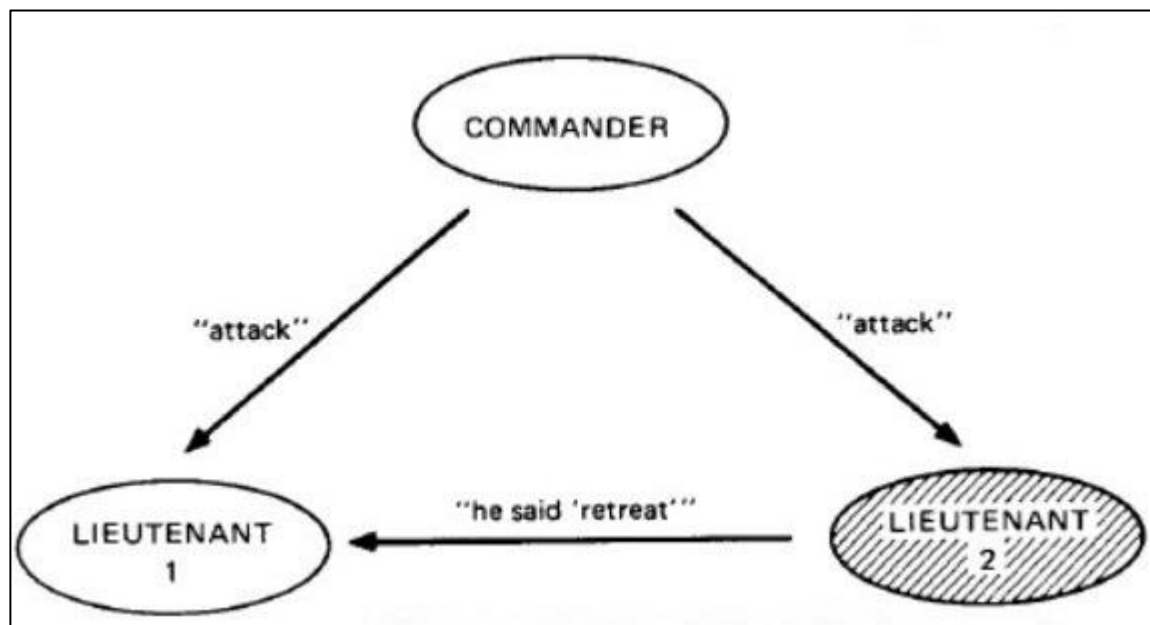
Problem 6: Malicious Nodes

- **Permissioned**
 - Nodes can go rogue/malicious
 - Nodes can be faulty
- **Permissionless**
 - Untrusted nodes
 - Everyone is malicious
- **Solutions?**
 - Distributed Networks literature

Academic Ivory Tower

Byzantine Generals

- **Byzantine Generals' Problem (1982)**
 - Leslie Lamport, Robert Shostak, and Marshall Pease
 - Reaching Consensus == Network agreeing on something



- **Game of Telephone**

- Malicious node: Evil me
- Faulty node: Non-native speaker me

- **Byzantine Nodes**

- Nodes with Byzantine Fault
- Display different symptoms to different observers
 - Unintentional: Faulty nodes
 - Intentional: Malicious nodes

- **Byzantine Failure**

- A network requiring consensus, failing to perform its service because of Byzantine nodes.

- **Game of Telephone – Order Pizza**

- First person decides toppings
- Whisper
- Last person orders
- Failure: Ordered pizza does not have correct toppings

Academic Ivory Tower

Byzantine Fault Tolerance

- **Reaching consensus with Byzantine Nodes**
- **Evading Byzantine Failures**
- **Impossible in our Telephone game**
 - One path from source to destination
- **Solution: Ensure message integrity**
 - Checksums (e.g. CRC32)
 - Works with non-malicious nodes (e.g. electronics)
 - Cryptographic Signing
 - Prevent tampering by malicious nodes

Problems 5 and 6 Revisited

- Nodes in Blockchain: **Byzantine Nodes**
- Consensus: **Who mines next block**
- Not agreeing on next miner: **Byzantine Failure**
 - Blockchain will not be maintained
- **Consensus Mode: Byzantine Fault Tolerance**
 - Proof of Work (PoW)
 - Proof of Stake
 - Round-Robin

Proof of Work (PoW) Consensus Model

- **Nodes compete to solve a puzzle**
- **Puzzle**
 - Difficult to solve but easy to verify (NP problem?)
 - Previous puzzles solves must not help with new ones
- **First node to solve makes new block**
- **Challenge**
 - Waste of time and energy

Bitcoin PoW

- **Puzzle**

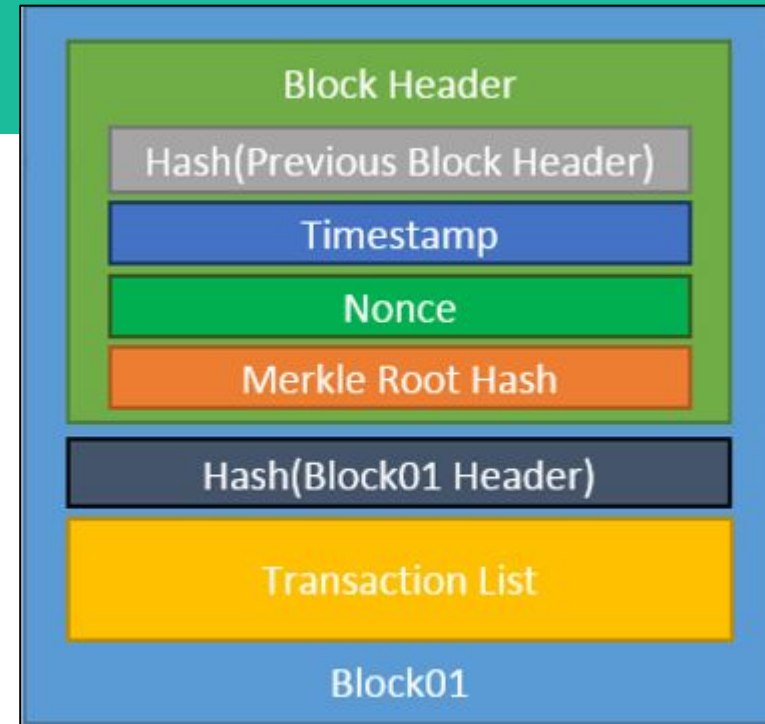
- Hash(block header) < 0000xxxxxxx
- Hash starting with 4 zeros or more

- **Mining**

- Create candidate block
 - Choose & verify transactions from **unspent transaction pool**
 - Transaction fees
- Choose nonce -> Calculate hash -> Check hash

- **Adjustable difficulty**

- Change number of zeros



Problem 7: Conflicts

- **Decentralized networks have lag**
 - Different unspent transaction pools
- **Two valid blocks mined > Two blockchains**
 - Longer is chosen
 - If same length, wait for next block
 - Incentivizes nodes to accept valid blocks and mine on top of them

Problem 8: Sybil Attack – Double Spend

- **Also Majority Attack or 51% Attack**
- **Ignore valid blocks by others**
 - Keep cryptocurrency rewards
 - Fix: Conflict resolution strategy
- **Create longer chain with invalid transactions**
 - Double spend

Sybil Attack - Double Spend Fix

- **Computing: Proof of Work**
 - Hard to gain control of 51% hash rate
 - Hashing is a constrained resource
- **Ownership / Commercial Interest: Proof of Stake**
 - More stake in system == invested in its success
- **Hierarchical Trust: Authority**
 - Law and order - Federal Register

Current and Future Work

- **Enterprise blockchains**

- Hyperledger: Fabric
- Quorum

- **Smart contracts**

- Ethereum - Quorum
 - Solidity/LLL/etc.
 - Ethereum Virtual Machine (EVM)
- Hyperledger: Fabric
 - ChainCode (Golang)

Questions?

- **More reading:**

- NISTIR 8202 Blockchain Technology Overview
- “Do you need a blockchain?” by Karl Wüst, Arthur Gervais
- <https://parsiya.net/categories/blockchain/>
- Hyperledger: Fabric
 - <https://github.com/hyperledger/fabric>
- Quorum
 - <https://github.com/jpmorganchase/quorum>