Introduction to Blockchain

2018. 07. 26
Samuel Hyun
1. Essence of Blockchain: Infrastructure for Trust
2. Bitcoin, Ethereum
3. Private Blockchain
4. Blockchain Applications
5. Next Generation Blockchain
Trust Network

VS.

Centralised Ledger vs. Distributed Ledger
Key Factors of Blockchain

By design, no one party can modify, delete, or even append any record to the ledger without the consensus, making the system useful for ensuring the immutability of transaction, contract, and other legal documents.

- Append-only system of record shared across business network
- Distributed DB

- Shared Ledger
- Cryptography
  - Hash, PKI
  - Ensuring secure, authenticated & verifiable transactions

- Consensus
- Smart Contract
  - Business terms embedded in transaction database & executed with transactions
  - P2P, Consensus

Broader participation, lower cost, increased efficiency
**Current view:** Individual ledgers and organizational silos complicate how information and incidents are managed in the network.

**Future view:** A shared ledger built on blockchain offers visibility, trust, and permanence.

Source: IBM Institute for Business Value analysis.
Symmetric Key Encryption

Original data → Encryption with Symmetric key → Scrambled data → Decryption with Symmetric key → Original data

Public Key Encryption

Original data → Encryption with Public key → Scrambled data → Decryption with Private key → Original data
P2P Protocol & Consensus Algorithm

Distributed P2P Network

PROOF-OF-WORK

- The probability of mining a block is dependent on how much work is done by the miner.

PROOF-OF-STAKE

- Person can "mine" depending on how many coins they hold.

- Payouts becomes smaller and smaller for Bitcoin miners, there is less incentive to avoid a 51% attack.

- The POS systems make any 51% attack more expensive.

- POS systems are more decentralized - but must work hard to build communities around their coins.

POW systems have powerful mining communities - but tend to become centralized over time.
Blockchain: Infrastructure of Trust

“Blockchain: Distributed Trust Network”

Blockchain's Big Innovation is **Trust**, Not Money

- immutability
- transparency
- autonomy
Evolution of Blockchain

Blockchain 1.0:
Blockchain for Digital Currency

Blockchain 2.0:
Blockchain as a Platform

Smart contract
(Ethereum...)

Private blockchain
(Public → Private)

blockchain based services
(bitcoin → blockchain)

Ethereum is a "world computer" you can't shut down

Leading consortia

Brokering business relationships

Providing software

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Bitcoin: A Peer-to-Peer Electronic Cash System

Satoshi Nakamoto
satoshi@gmx.com
www.bitcoin.org

Abstract. A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution. Digital signatures provide part of the solution, but the main benefits are lost if a trusted third party is still required to prevent double-spending. We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work. The longest chain not only serves as proof of the sequence of events witnessed, but proof that it came from the largest pool of CPU power. As long as a majority of CPU power is controlled by nodes that are not cooperating to attack the network, they'll generate the longest chain and outpace attackers. The network itself requires minimal structure. Messages are broadcast on a best effort basis, and nodes can leave and rejoin the network at will, accepting the longest proof-of-work chain as proof of what happened while they were gone.
“Tamper-Proof Distributed Ledger”
Bitcoin Transaction

“UTXO”

Transaction 7957a35fe64f80d234d76d83a2a8f1a0d8149a41d81de548f0a65a8a99996f18

Inputs From:
From (previous transactions Joe has received):
Joe
0.1005 BTC

Outputs To:
Output #1 Alice's Address
Transaction Fees: 0.0005 BTC
0.100 BTC (spent)

Transaction 0627052b6f28912f2f703066a912ea577f2ce4da4ea5a5fbd8a57286c345c2f2

Inputs From:
Alice
0.1000 BTC

Outputs To:
Output #0 Bob's Address
Output #1 Alice's Address (change)
Transaction Fees: 0.0845 BTC (unspent)
0.0150 BTC (spent)
0.0005 BTC

Transaction 2bba88bb3a57a2363407ac8c16a67015ed2e88a4388af58cf90299e0744d3de4

Inputs From:
Bob
0.0150 BTC

Outputs To:
Output #0 Gopesh's Address
Output #1 Bob's Address (change)
Transaction Fees: 0.0845 BTC (unspent)
0.0100 BTC (unspent)
0.0005 BTC

“Verification”

Transaction

Hash
Owner 1's Public Key
Owner 0's Signature
Verify

Transaction

Hash
Owner 2's Public Key
Owner 1's Signature
Verify

Transaction

Hash
Owner 3's Public Key
Owner 2's Signature
Verify

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How Bitcoin Works

How a blockchain works

1. A wants to send money to B
2. The transaction is represented online as a 'block'
3. The block is broadcast to every party in the network
4. Those in the network approve the transaction is valid
5. The block then can be added to the chain, which provides an indelible and transparent record of transactions
6. The money moves from A to B
11684 NODES

24-hour charts »

Top 10 countries with their respective number of reachable nodes are as follow:

<table>
<thead>
<tr>
<th>RANK</th>
<th>COUNTRY</th>
<th>NODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>3247</td>
</tr>
<tr>
<td>2</td>
<td>Germany</td>
<td>1951</td>
</tr>
<tr>
<td>3</td>
<td>France</td>
<td>810</td>
</tr>
<tr>
<td>4</td>
<td>China</td>
<td>769</td>
</tr>
<tr>
<td>5</td>
<td>Netherlands</td>
<td>525</td>
</tr>
<tr>
<td>6</td>
<td>Canada</td>
<td>501</td>
</tr>
<tr>
<td>7</td>
<td>United Kingdom</td>
<td>443</td>
</tr>
<tr>
<td>8</td>
<td>Russian Federation</td>
<td>395</td>
</tr>
<tr>
<td>9</td>
<td>n/a</td>
<td>350</td>
</tr>
<tr>
<td>10</td>
<td>Singapore</td>
<td>242</td>
</tr>
</tbody>
</table>

More (101) »

Map shows concentration of reachable Bitcoin nodes found in countries around the world.
Smart Contract

Blockchain 1.0 - Bitcoin

Evolution of Paradigm

Blockchain 2.0 - e.g. Ethereum, ...

Transaction 0x012BCFG4512
From: Bob Bitcoin Address
To: Sally Bitcoin Address

Bob (Buyer)

Sally (Seller)

Transaction Details

Nick Szabo

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In 2014, Vitalik launched Ethereum project and successfully funded 20 mil worth of Ether by ICO.

While the goal of bitcoin is to build a platform that makes the digital currency to be exchanged safely on the internet without any interfering with governments or financial institutions, the goal of Ethereum is to build a platform that makes a genuine free web by expanding the territory of blockchain to encompass real-world applications.

Gas, Ethereum Virtual Machine

“World Computer”
Smart Contract on Blockchain

**Smart contract**

- **Agreement**
  - A → B
  - Smart contract

- **Trigger & execution**
  - A = Data
  - B = Data

- **Consensus**
  - A → B
  - Output
  - Data

**Non-blockchain world**

- Business rules
  - Subject to existing rules & regulations
  - Edited by a service provider or one of the parties to the agreement

- Trigger
  - Smart contract execution can be triggered by an event on the blockchain or outside

- Output
  - The execution of a contract can produce an output supposed to impact another blockchain (cash ledger) or another system
# Ethereum Transaction

<table>
<thead>
<tr>
<th><strong>“Transaction”</strong></th>
<th><strong>“Message”</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nounce</strong></td>
<td>How many times the sender has sent a transaction</td>
</tr>
<tr>
<td><strong>Sender</strong></td>
<td>Address of sender</td>
</tr>
<tr>
<td><strong>Recipient</strong></td>
<td>Address of smart contract account</td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>Amount of ether to send</td>
</tr>
<tr>
<td><strong>Gasprice</strong></td>
<td>Amount of ether the sender pay per unit gas</td>
</tr>
<tr>
<td><strong>Gaslimit</strong></td>
<td>Maximum units of gas to consume</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Message to smart contract</td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td>Signature of sender</td>
</tr>
</tbody>
</table>
Block of Ethereum
Gas

- Maximum transaction execution cost = gasLimit * gasPrice
- Min gasLimit: 21,000
- Max gasLimit per a block: 6,700,000
Scalability Improvements

Casper's checkpointing

Miners

One Epoch

RAIDEN

SHARDING

GROUP 1

GROUP 2

GROUP 3

Plasma Contract (Decentralized Exchange)

Plasma Contract (Social Network)

Plasma Contract (Private Blockchain)

Root Chain (e.g., Ethereum)

Plasma Contract (Micropayments)
Global Ethereum network

<table>
<thead>
<tr>
<th>Country</th>
<th>Nodes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>14846</td>
<td>100%</td>
</tr>
<tr>
<td>United States</td>
<td>5090</td>
<td>34.29%</td>
</tr>
<tr>
<td>China</td>
<td>1712</td>
<td>11.53%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>886</td>
<td>5.97%</td>
</tr>
<tr>
<td>Germany</td>
<td>841</td>
<td>5.66%</td>
</tr>
<tr>
<td>Canada</td>
<td>812</td>
<td>5.47%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>520</td>
<td>3.50%</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>436</td>
<td>2.94%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>374</td>
<td>2.52%</td>
</tr>
<tr>
<td>France</td>
<td>333</td>
<td>2.24%</td>
</tr>
<tr>
<td>Ukraine</td>
<td>287</td>
<td>1.93%</td>
</tr>
</tbody>
</table>
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Public Blockchain vs. Private Blockchain

**Public blockchain**
- Public structure enables wide variety of applications
- Decentralised data storage & verification performed by P2P network
- No ex-post revisions possible
- Higher operating costs
- No operator fees

**Private blockchain**
- Anonymous
- Free access
- Invitation-based
- Know-your-customer controls
- Contracts are made between customers through operator’s platform
- Centralised data storage & verification performed by operator
- Ex-post revisions possible (e.g. in the case of legal dispute)
- Lower operating costs
- Operator fees

Registration

Smart contract preparation

Blockchain

Manipulation

Costs
Hosted by Linux Foundation & IBM

Open source collaborative effort to advance cross-industry blockchain platform

+100 startups, companies, organizations joined throughout the world
Hyperledger Fabric

Hyperledger-fabric model

Permission Issuer

Transaction (defining contracts)

Transaction (invoking contracts)

Client

End-user Alice

End-user Bob

Peer

Validating Entities

Peer

Peer

Peer

Peer

Ledger

Ledger

Ledger

Ledger

IBM
➢ World first blockchain-based global bank consortium project
➢ Founders: David Rutter, Jesse Edwards, Todd McDonald
➢ +80 banks joined throughout the world
➢ Distributed ledger platform for recording and processing financial agreement
Corda Network

Name: Bob
Services: Cash Issuer, bond Issuer
Address: 192.168.0.4:10005
Public key: 5hw03nnk43jknk4n

Name: Network Map
Services: Network map service
Address: 192.168.0.2:10005
Public key: t453wv84bvt3cj5w3h

Name: Alice
Services: Cash Issuer, bond Issuer
Address: 192.168.0.3:10005
Public key: 5h54h5wv632vhy55
Enterprise Ethereum Project

Trust, Privacy & Performance

Ethereum’s intrinsically trusted system is the most promising solution for enterprise Blockchain adoption, given its maturity and multi-purpose design. Privacy and Performance improvements will be mandatory to achieve enterprise-ready status and will be the focus of Enterprise Ethereum’s roadmap.

Community & Resources

In partnership with the dedicated and robust Ethereum community, Enterprises are coming together to produce the industry standard, open source, free to use blockchain solutions that will be the foundation for businesses going forward.
Full Blockchain, Common Public State, Divergent Private State

Participant 1
- Single Blockchain
- Public State
- Private State

Regulator
- Single Blockchain
- Public State
- Private State

Participant 2
- Single Blockchain
- Public State
- Private State

Participant n
- Single Blockchain
- Public State
- Private State

Participant 3
- Single Blockchain
- Public State
- Private State

Participant 4
- Single Blockchain
- Public State
- Private State

J.P. Morgan
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32 global consortiums
18 in financial services
24 started in 2016
Average # of members in each: 30
Largest memberships: 100
R3 Is the World’s Largest Distributed Ledger Consortium

The 50+ Member initiative is focused exclusively on developing a next generation financial transaction network and commercial applications based on DLT.
SBI Fintech Consortium

+30 Japanese fintech firms joined, Led by SBI Ripple Asia

SBI FinTech Consortium Objectives

[Objective] Through a combination of participant companies’ technologies and a reduction of initial introductory costs, will endeavor to establish Japan’s first globally accepted FinTech services in various financial sectors

“SBI FinTech Consortium” Participant Companies Today
Chinese Blockchain Consortium

**Chinaledger Alliance**
- Led by Wanxiang Group
- +11 financial institutions are joined

**Blockchain Shenzhen Consortium**
- Led by Ping An Bank and Tencent
- +31 technology and financial firms in China are joined
European banks’ consortium for blockchain-based trade finance platform

- Consortium members: Duetsche Bank, HSBC, Natixis, Rabobank, Societe Generale, UniCredit, KBC
- DTC: Digital Trading Chain
- Facilitate cross-border commerce for European small and medium-sized enterprises
- Leveraging distributed ledger technology to connect all parties involved in international trade transactions
- We.trade: digital platform for managing, tracking and protecting trade transactions between SMEs
- Registers entire trade process from order to payment, fully automated
Member: Aegon, Allianz, Munich Re, Swiss Re, Zurich, Achmea, Ageas, Generali, Hannover Re, RGA, Liberty Mutual, SCOR, Sompo Japan Nipponkoa Insurance, Tokio Marine Holdings, XL Catlin  
Streamlining insurance contract & settlement process using blockchain-based smart contract  
Acceleration of information & fund flow, Audit process improvement  
Developing new types of insurance service such as P2P insurance, microinsurance, parametric insurance  
Codex 1: Blockchain-based smart contract prototype to automate catastrophic reinsurance processes
Tech Giants and start-ups have joined to form a consortium that will look to build a trusted IoT ecosystem with enhanced security and trust protocol

- Consortium includes Bank New York Mellon, Bosch, Cisco, Gemalto, Foxconn, BitSE, Chronicled, Consensys, Filament, Ledger, Skuchain, Slock.it, IOTA, Oaken Innovation, Chain of Things, BigChain DB
- Completed PoCs for trusted odometer, luxury goods identity verification, router firmware verification, trade finance automation, supply chain event logging, smart vehicle charging, deed of title registration, data logger provenance
- Value propositions for IoT product identity and provenance, Secure and transferable digital identities, Payments-enabled devices/machines, Immutable attestation of sensor data and event logs, Automation of business logic with smart contracts, Neutral support for business ecosystem, Elimination of silos in current IoT model
Maersk has joined forces with IBM to deploy blockchain technology for global cross-border supply chain applications

➢ Provide immutable, transparent visibility of the progress of goods through the supply chain, location of containers, status of customs, documents, BOL, and other data
➢ Provide efficiencies by reducing fraud and errors, improving inventory management, ultimately reducing cost and time
➢ Collaborating with shippers, freight forwarders, ocean carriers, ports, custom authorities
➢ Building global trade digitisation solution
➢ Completed PoC for tracking a container of flowers
➢ Custom administration of Netherlands, US Department of Homeland Security Science and Technology Directorate, US Customs and Border Protection
Major food suppliers’ blockchain consortium for food safety initiative

- Consortium includes Walmart, Kroger, Driscoll’s, Doll, Golden State Food, McCormick and Co., McLane Co., Nestle, Tyson Foods, Unilever
- Explore and test blockchain technology as a solution for enhanced food safety across the business
- Provide benefits to customers with greater transparency and traceability in the supply chain
Blockchain in Energy Industry

Indigo Stakeholder Activity Taxonomy - Blockchain in Energy and Utilities

- P2P Trading & Connected Home
  - POWER LEDGER Vector
  - alliander Fortum

- EV Charge / Share
  - oxygen ze innogy
  - Lock. it

- Consortia and Research
  - ENERGY X FOUNDATION
  - WANGXANG BLOCKCHAIN LABS
  - endesa

- Bitcoin Meter Payments
  - Marubeni
  - bitpay BAS PEY bankymoon

- Solar Cryptocurrencies
  - smappee

- Notable Startups
  - Volt Markets M-PAYG
  - Gem

- Wholesale Trading & Smart Markets
  - Qiwi NEW 4.0
  - yus PRIoGEN
  - BTL Wien Energie

- CHRONICLED
  - Adpteve
  - FILAMENT
  - theSunExchange

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Blockchain in Healthcare

Blockchain challenges for clinical health data exchange and interoperability, drug supply chain integrity and provenance

Blockchain Technology – Promising Use Cases for Healthcare Industry

- Clinical data sharing improvement
- Public health improvement
- Better and secured research and clinical trials
- More precise medicine
- Administrative and financial information
- Patient and provider identity

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- Public health improvement
- Better and secured research and clinical trials
- More precise medicine
- Administrative and financial information
- Patient and provider identity
Blockchain for Trade Finance

Key stakeholders in the trade finance ecosystem

Current open account trading process

(Source: ASTRI Report)
Blockchain for Trade Finance

Current process inefficiencies:
- No standardised structure of a PO
- No way to verify the latest version of a PO
- Low visibility of contract terms and amendments to banks
- High error rate due to manual mistakes
- Inefficient and costly due to:
  - Handling of paper-based documents
  - Difficulty in authentication by banks
- Risk of fraud

Improvements achieved by applying DLT:
- Digitised and standardised PO
- Deployment of smart contract automates trade execution
- Facilitate cross-border trade finance by collaboration with overseas DLT projects
- Financing to customer is faster and enable stage financing along the supply chain
- Lower risk of financing and avoid double financing

(Source: ASTRI Report)
Blockchain for P&C Claim Processing

Current-state process description

- Complicated claim submission
- Cost for intermediaries
- Manual claim processing
- High potential for fraud and errors

(Source: World Economic Forum)
Blockchain for P&C Claim Processing

- Simplified claim submission
- Streamlined transfer of information
- No intermediaries
- Automated claim processing
- Reduction in fraud and error
- Streamlined payment processing

(Source: World Economic Forum)
In Estonia, Digital Identity Card in connection with Blockchain

Australian Postal Office is developing Blockchain-based digital ID platform
Dubai Wants All Government Documents on Blockchain By 2020

The Crown Prince of Dubai announced a strategic plan today that would see all government documents secured on a blockchain by 2020.

Revealed at an event hosted by the Dubai Future Foundation and the Smart Dubai Office, the final goal of the government-led initiative is to open the blockchain platform to other cities around the world.

In remarks, Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum explained the effort is part of a larger bid by the emirate, one of seven in the larger UAE, to set the "standard" for smart cities.

He said:

➢ Dubai government announced to register all public documents on the Blockchain until 2020

The Russian Government is Testing Blockchain for Document Storage

An anti-trust agency within the Russian government is testing a blockchain-based document management system.

Dubbed “Digital Ecosystem”, the project is aimed at developing tools that can “increase the speed, reliability and quality of interaction during document exchange”.

The country’s Federal Antimonopoly Service (FAS) is working alongside Sberbank to develop it. Other companies, including Aeroflot, Russia’s largest airline carrier, are also involved, Sberbank said today.

In statements, FAS deputy chief Andrey Tsarikovsky said that the project points to a potential reduction in the cost of managing and exchanging documents.

➢ Russian government in the process of testing feasibility of Blockchain as a public document depository
Government officials in Moscow today revealed plans to investigate applications of blockchain technology. According to a report by Gazeta.ru, Deputy Head of the Department of Information Technologies (DIT) of Moscow Andrey Belozerov said that the agency is now exploring how to apply blockchain to various use cases, including voting fraud.

One proposal, according to the news source, would find Moscow incorporating blockchain into Active Citizen, an in-progress e-government effort aimed at getting citizens more involved in local decision-making.

- Russian government is developing Blockchain-based E-Voting system

A new Australian political party has proposed the introduction of a token-based political system based on the concept of decentralised blockchain technology.

Called the Flux Party, the new entity has already attracted more than 500 members. It needs to potentially place senate candidates on ballots in all the country's states. However, the party's immediate goal is to try and elect six senators, according to Reuters.

Notably, the Flux Party will be free of its own policies, instead opting for its senators to vote for or against legislation at the bidding of token holders.

- Australian political party proposed Blockchain-based E-Voting system
Georgia government is developing Blockchain-based platform to register land ownership and verify the transition of ownership.

Sweden completed the test for Smart Contract-based Land registration and transition record.

Honduras is developing Blockchain-based land registration system to prevent land registry fraud.
UK government is looking for the way to increase the transparency of pension payment using blockchain technology

Denmart government in research of applying Blockchain to oversea aids program
➢ Alibaba announced the project to develop Blockchain-based donation platform

➢ Dutch non-profit organization is developing Blockchain-based charity management platform
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Proof of Stake (PoS)

In **Proof of Stake**, each validator owns some stake in the network, and has to lock it in order to be selected.

1. Anyone who holds the base cryptocurrency can become a **validator**, although sometimes a locked up deposit is required.

2. A validator’s chance of mining a block is based on how much of a stake (or cryptocurrency) they have. For example, if you owned 1% of the cryptocurrency, you would be able to mine 1% of all its transactions.

3. The PoS protocol will randomly assign the right to create a block in between selected validators, based upon the value of their stakes. The chosen validator is rewarded by a part or the whole of the transaction fee.
Delegated Proof of Stake (DPoS)

“PoS”
- Direct Democracy
- Voters: stakeholder with minimally required stake
- Voter’s duty: validate transactions, generate a block

“DPoS”
- Indirect Democracy
- Witness (Delegate): elected by stakeholder.
- Witness’s duty: validate transactions, generate a block

- Fast, efficient
- No need to purchase a tremendous amount of coin
- Higher participation rate – 99%
- Witness’s pledge
  - Return a portion of mining compensation (ARK, RISE)
  - Exempt transfer fee (EOS, Steem)
EOS vs. NEO

- **Scalable**
  - Support 1000s of commercial scale DAPPs
  - Parallel execution
  - Asynchronous communication
  - Separation of authentication from action

- **Flexible**
  - Freeze and fix broken applications
  - Publish source code not assembly
  - Generalized role-based permissions
  - Multiple virtual machines (Wren & Web assembly)

- **Usable**
  - Web toolkit for interface development
  - Self describing interfaces
  - Self describing database schemas
  - Declarative permission scheme

- **Governance**
  - Elected block producers
  - Legally binding constitution
  - Dispute resolution
  - Self funded community benefit apps

- **Neo vs. Gas**
  - Neo Contract, NeoFS, NeoQS
  - Consensus mechanism - DBFT
  - Block time - 15 second
  - Fast tps, immediate finality

- Parallel computing
- Inter-app communication
- Consensus mechanism - DPoS
- Block time - 3 second
- Protocol update & constitution
Aion facilitates inter-blockchain communication via a high-performance bridging mechanism. Multiple bridges between pairs of chains allow both data and value to transfer between chains.

Aion addresses the issues of scalability and performance by introducing a new high-performance virtual machine, and by enabling applications to operate across multiple chains.

Aion allows custom blockchain design, including different consensus algorithms and virtual machines, without sacrificing interoperability with other blockchains.

“Integrate dissimilar blockchain systems in a multi-tier hub-and-spoke model”
Thank You!