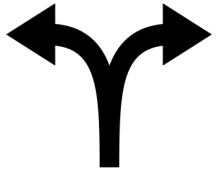
TEZOS
BLOCKCHAIN CAMP
BUSAN

테조스 플랫폼

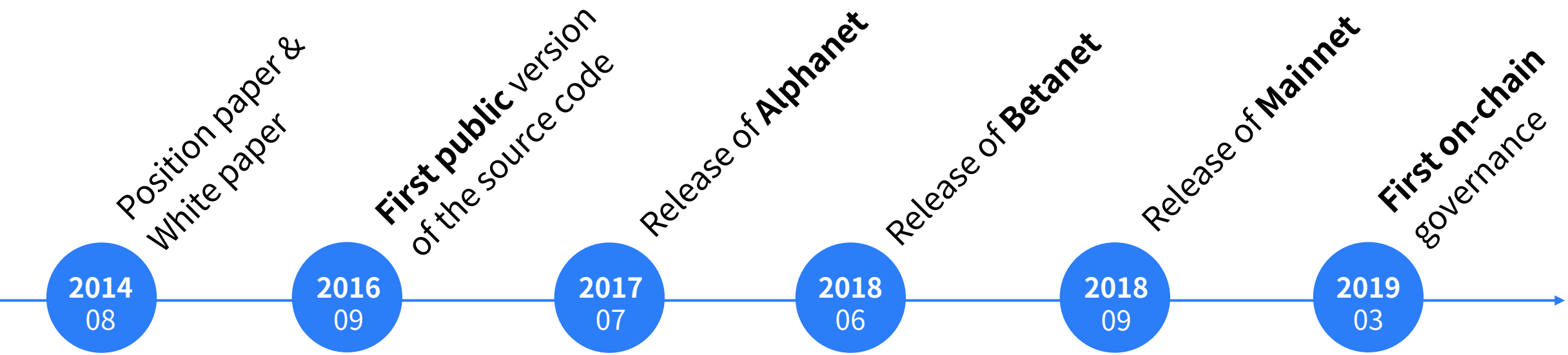
Formal verification
오류가 최소화된 스마트 컨트랙트



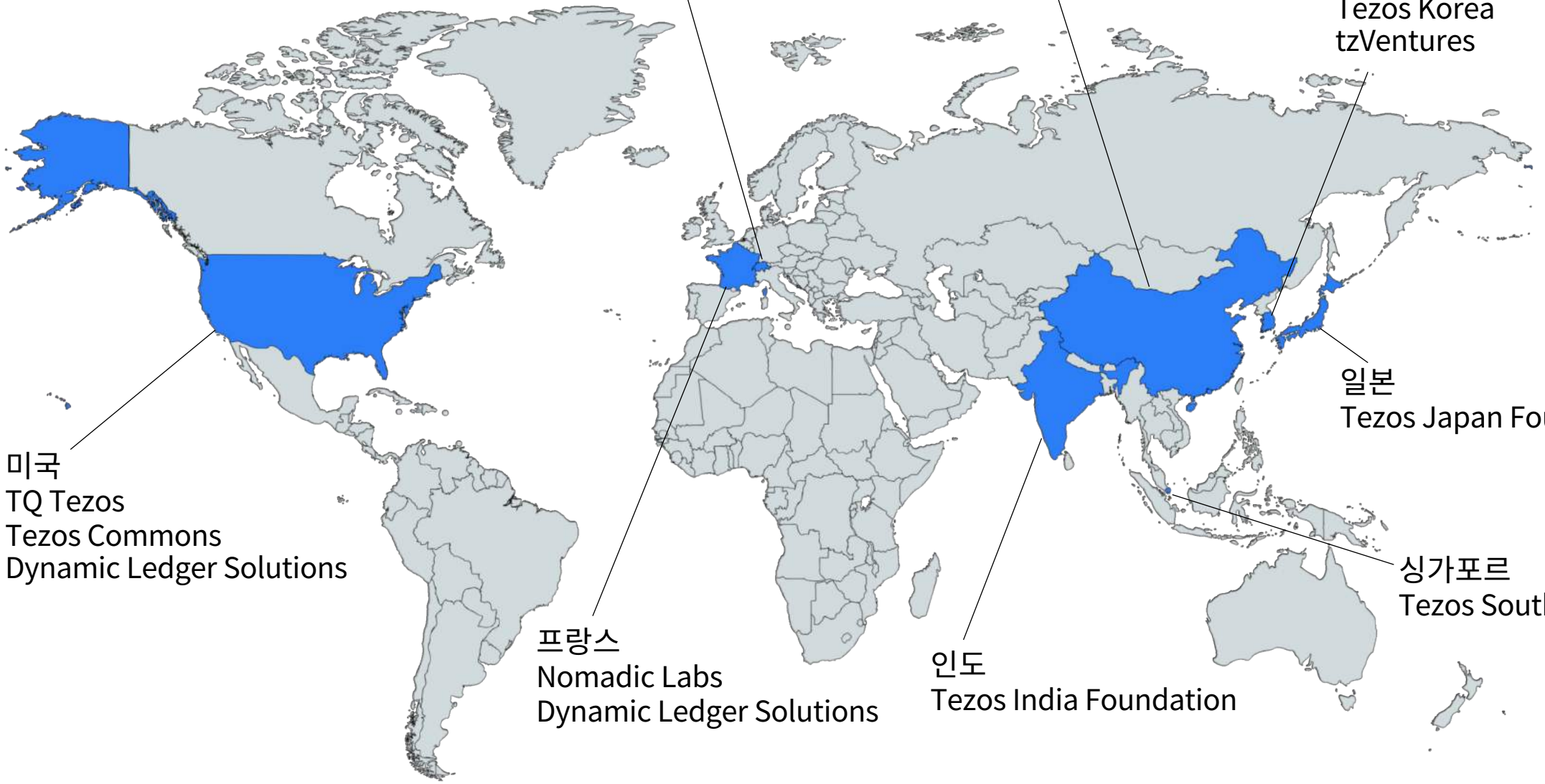
On-chain Governance
하드 포크의 위험성이 최소화

Business Logic Automation
비지니스 스마트 컨트랙트 플랫폼

테조스 네트워크 연혁


Position paper &
White paper
2014
08
First public version
of the source code
2016
09
Release of Alphanet
2017
07
Release of Betanet
2018
06
Release of Mainnet
2018
09
First on-chain
governance
2019
03

테조스 글로벌 생태계


스위스
Tezos Foundation
중국
Tezos HK-China Foundation
한국
Tezos Korea Foundation
Tezos Korea
tzVentures
일본
Tezos Japan Foundation
미국
TQ Tezos
Tezos Commons
Dynamic Ledger Solutions
프랑스
Nomadic Labs
Dynamic Ledger Solutions
인도
Tezos India Foundation
싱가포르
Tezos Southeast Asia

테조스 메인 네트워크*

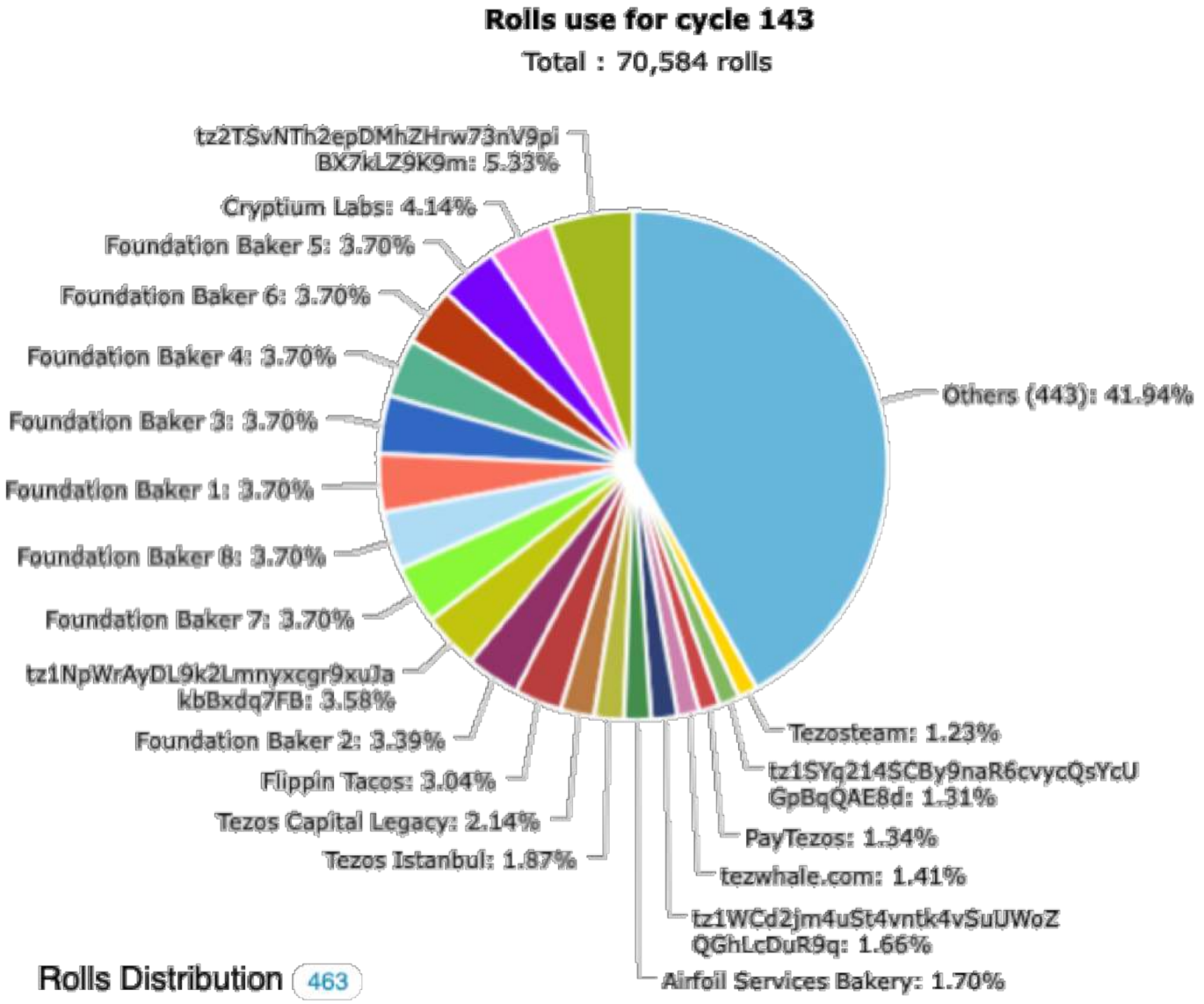
463 Bakers

8,546 Nodes

565,519 Blocks

804,110,000 ꜩ in total

564,672,000 ꜩ in staking



* As of 19.08.15

한국 내 테조스 조직 소개

테조스 한국 재단 (Tezos Korea Foundation)

한국 내 테조스 생태계 조성

교육 프로그램, 학계 지원

밋업, 컨퍼런스 기획 및 주최

(주)테조스코리아 (Tezos Korea Inc.)

테조스 한국 재단 산하 영리 기업

블록체인 컨설팅 및 기술 지원

tzVentures

글로벌 테조스 인큐베이터

스타트업 발굴, 지원, 데모 데이

Advisors & MOUs

김기천 교수, 박진하 교수 건국대학교 정보통신대학원 블록체인전공

- 정보통신 산업 발전 및 블록체인전공 교육과정 개발 협약

이광근 교수 서울대학교 컴퓨터공학, 소프트웨어 무결점 연구소

- Tezos 스마트 컨트랙트 Formal Verification 및 Audit

이재원 교수 KAIST/세종대 경영학과

- 블록체인 비즈니스 모델 및 인큐베이팅

정호진 교수 홍익대학교 경영학과

- 토큰 이코노미 및 Boundary / Allocation

박선주 교수 연세대학교 경영학과, 디지털 사회 연구센터

- 블록체인 인재양성 교육

(주)테조스코리아

서비스

스마트 컨트랙트 작성 및 검증(Formal verification)

비즈니스 모델 및 토큰 이코노미 설계

거래소 상장 및 스테이킹 기술 지원

블록체인 특강(기업, 공공기관, 학교)

테조스 장외(OTC) 거래

STO 플랫폼

파트너

서울대학교 SEOUL NATIONAL UNIVERSITY

연세대학교 YONSEIUNIVERSITY

KU 건국대학교 KONKUK UNIV.

ROSAEC center Research On Software Analysis for Error-free Computing 소프트웨어 무결점 연구센터 NRF ERC

산업과 예술의 만남 홍익대학교

엘티캠퍼스 The Best HR Service Partner

TEZOS SOUTHEAST ASIA

NOMADIC LABS

SEUM 법무법인 세움

테조스코리아 교육 프로그램

멀티캠퍼스
The Best HR Service Partner

KU 건국대학교 KONKUK UNIV.

sba

멀티캠퍼스 정규 과정 개설

10월 말 개설

블록체인 이론 및 실습

Tezos 스마트 컨트랙트

2019년 2학기 건국대학교

정보통신대학원 블록체인전공

석사과정 정규 강의 (2학점)

합의 알고리즘 개론 및 응용

캠퍼스 CEO 과정

서울산업진흥원 주관

19년 2학기, 20년 1학기

블록체인 기술 및 창업 과정 (3학점)

참고 자료

https://bit.ly/2KXcrKm

커뮤니티

https://tezoskoreacommunity.org

공모전

https://tezoskorea.co.kr/innovators

목차

TEZOS BLOCKCHAIN CAMP BUSAN

CHAPTER1 블록체인 기본

블록체인이란 무엇인가?

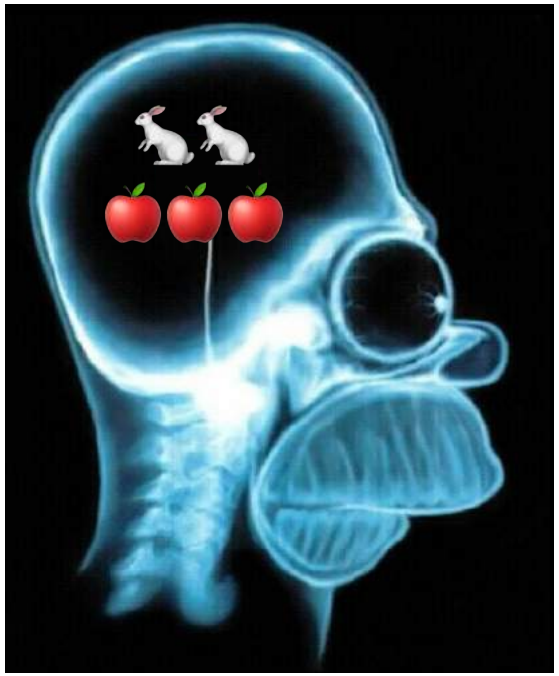
Blockchain is an **open distributed ledger**

Open Distributed Ledger

Open 누구에게나 공개되어 있고
Distributed 분산되어 있는
Ledger (거래의 기록을 담는) 장부
= Open Shared Database

기록 방식의 발전은 **효율성**을 위한 노력의 결과

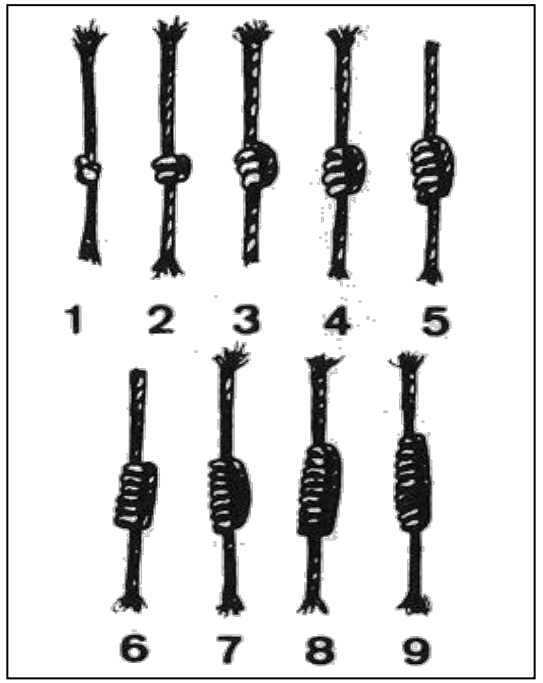
생산력의 발전
기존 방식의 한계



Memory

Cuneiform

새로운 기록 방식

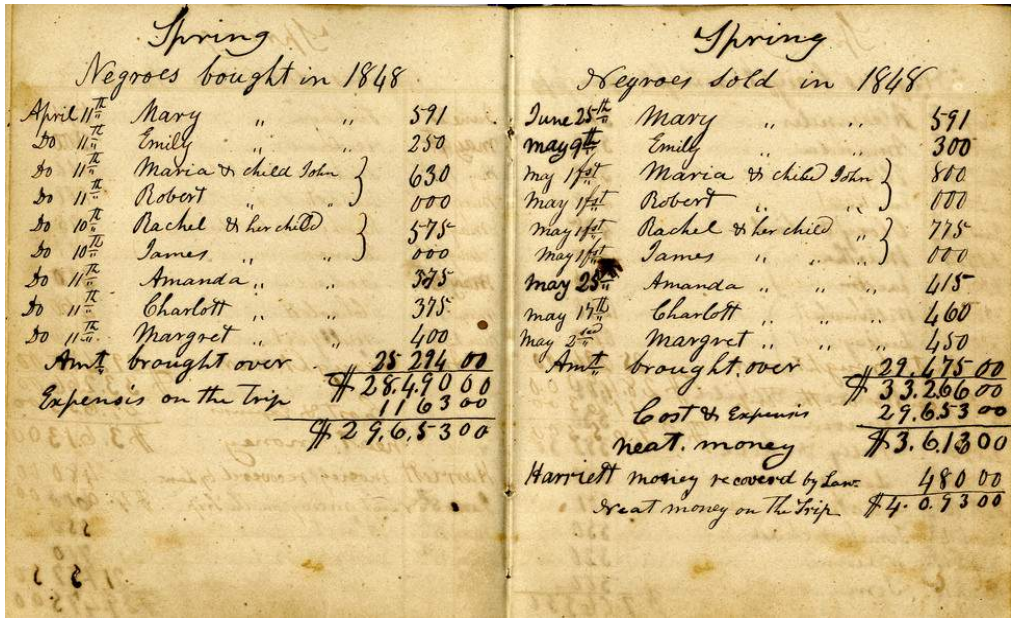


Knots

기록 방식의 발전은 **효율성**을 위한 노력의 결과

기업의 등장
소유/경영 분리

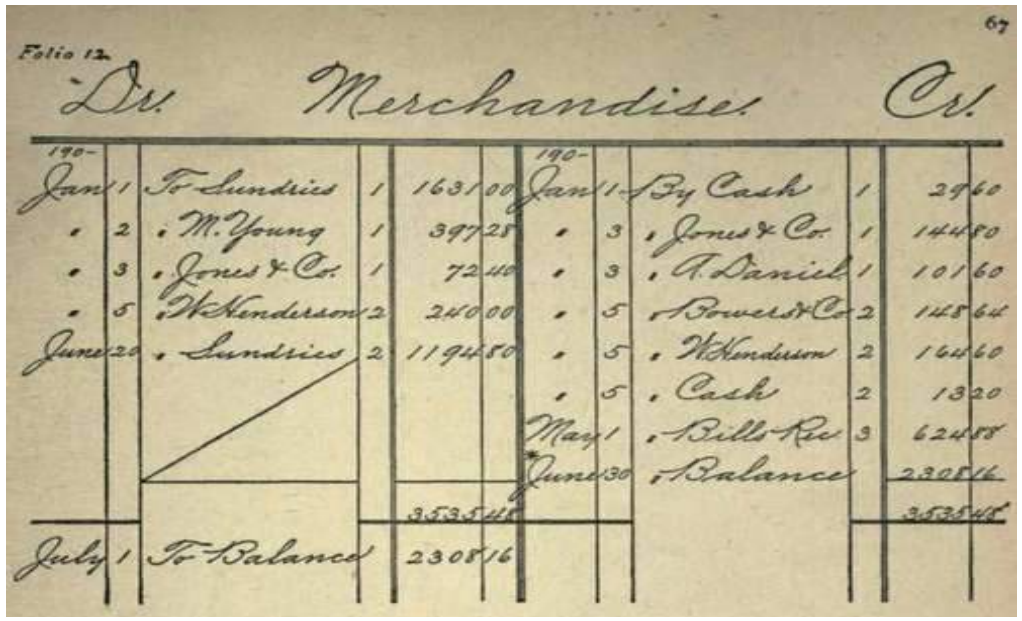
기록 관리인


Spring
Negroes bought in 1848

April 11th	Mary	" "	591
Do 11th	Emily	" "	250
Do 11th	Maria & child John		630
Do 11th	Robert	" "	000
Do 10th	Rachel & her child		575
Do 10th	James	" "	000
Do 11th	Amanda	" "	375
Do 11th	Charlott	" "	375
Do 11th	Margret	" "	400
Amt brought over			25 294 00
Expenses on the Trip			$28.490 00
			1163 00
			$29.653 00

Spring
Negroes sold in 1848

June 25th	Mary	" "	591
may 9th	Emill	" "	300
may 1st	Maria & child John		810
may 1st	Robert	" "	100
may 1st	Rachel & her child	"	775
may 1st	James	" "	000
may 28th	Amanda	" "	415
may 15th	Charlott	" "	460
may 2nd	Margret	" "	450
Amt brought over			29.475 00
			$33.266 00
Cost & Expenses			29.653 00
neat money			$3.613 00
Harriett money recovered by Law			480 00
Neat money on the Trip			$4.093 00


Folio 12. 67

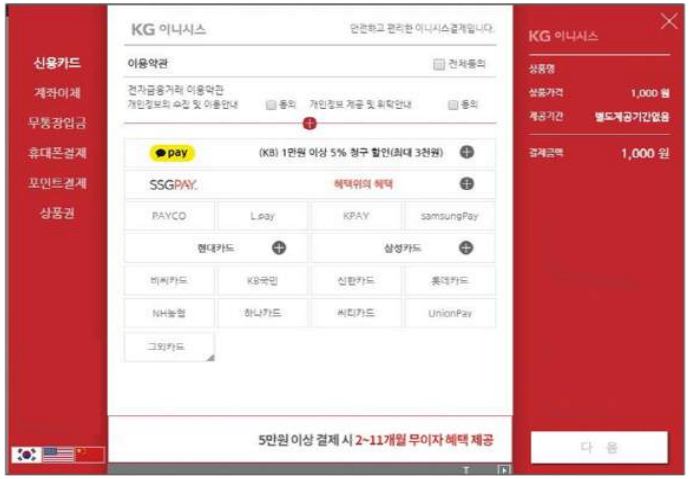
Dr. Merchandise Cr.

190-						190-				
Jan	1	To Sundries	1	1631 00	Jan	1	By Cash	1		29 60
"	2	" M. Young	1	397 25	"	3	" Jones & Co.	1		144 80
"	3	" Jones & Co.	1	72 40	"	3	" A. Daniel	1		101 60
"	5	" W. Kenderson	2	240 00	"	5	" Bowel & Co	2		145 64
June	20	" Sundries	2	1194 50	"	5	" W. Kenderson	2		164 60
					"	5	" Cash	2		1320
					May	1	" Bills Rec	3		624 88
					June	30	" Balance			2308 16
				3535 48						3535 48
July	1	To Balance		2308 16						

Single entry bookkeeping

Double entry bookkeeping

거래: 현대적, 효율적 삶을 위한 수단



거래의 기본은 **신뢰**

신뢰 비용의 증가

빈도
규모
지역

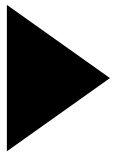
신탁

Middle man
TTP
Central authority

중앙화된 시스템은 많은 문제를 **해결**

금융시스템

신뢰가 없는 사람들
사이에 **신뢰**를 만들어
거래가 가능하게 함



믿을 수 있고
효율적이고
편리하고
문제가 최소화

거래 비용 감소

국가와 사회가 안정되고 제도와 규제가 정비됨에 따라 거래의 많은 문제가 해결되었다.

오늘날 우리는 인터넷을 통해 지구 반대편의 상품을 편하게 구매할 수 있다.

간편 결제, 간편 송금 서비스 등의 등장으로 거래 방식이 더욱 편리해졌다.

가끔 해킹, 피싱 등으로 피해가 발생하지만 전체 거래 규모에 비하면 매우 사소한 부분이며, 보안은 점점 발전 중이다.

…

블록체인이란 무엇인가? Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화

비트코인의 등장

비트코인, **P2P 전자화폐** 시스템의 출현 (ref #1)

2008년 10월 31일

Cryptography Mailing List

2009년 1월 SW 배포 및 네트워크 가동

Bitcoin: A Peer-to-Peer Electronic Cash System

Satoshi Nakamoto
satoshin@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.

1. Introduction

Commerce on the Internet has come to rely almost exclusively on financial institutions serving as trusted third parties to process electronic payments. While the system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust based model.

거인의 어깨 위에 서 있는 비트코인

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.

거래가 **전자 서명**으로 보호되고, **타임스탬프**와 함께 **체인** 형태로 기록된다.

체인은 **작업**의 결과인 **해시** 값으로 연결되어 있다.

대다수의 컴퓨팅 파워가 **정직**하게 사용된다면, 기록이 **안전**하게 유지된다.

누구나 노드로 참여할 수 있고, **언제든** 그만둘 수 있다.

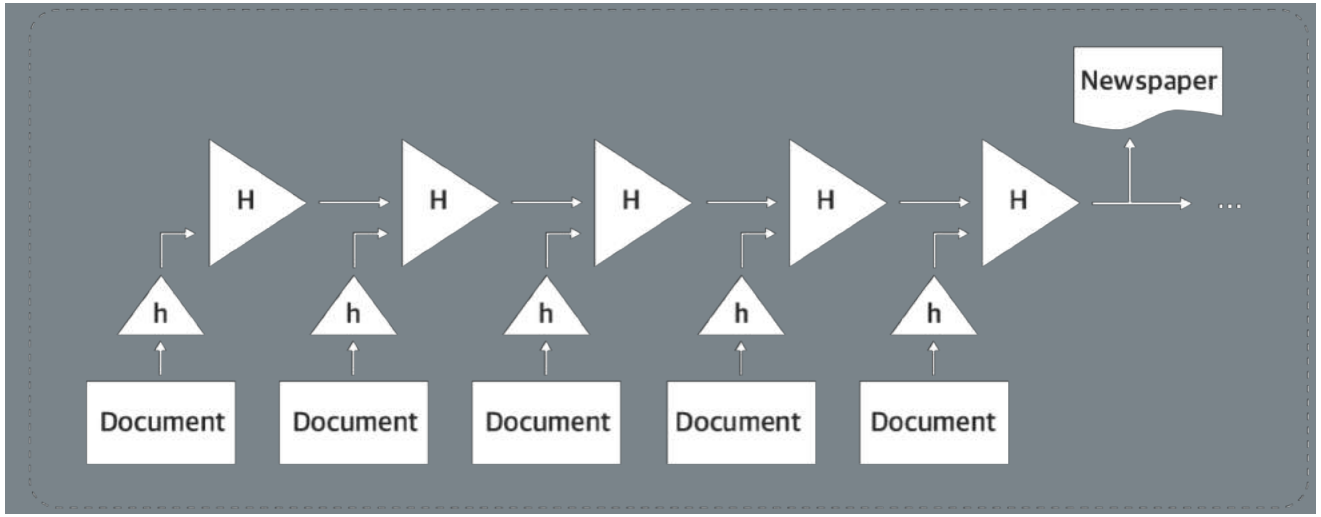
비트코인 탄생의 배경

1982 **Byzantine Generals Problem**
임의의 장애를 견딜 수 있는 (Byzantine fault tolerant) 분산 시스템(Synchronous)을 구현하기 위한 해결책 제시

1985 **FLP Impossibility**
비동기 분산 시스템에서, 하나의 프로세서라도 crash될 경우 safety와 liveness를 동시에 만족하는 알고리즘은 존재하지 않는다.

1989 **Paxos**
비동기(Asynchronous) 분산 시스템에서 Safety를 보장하는 합의 알고리즘 제시

1991 **A chain of cryptographically secured blocks**
디지털 정보를 조작이 불가능하도록 안전하고(hash pointer) 효율적으로(grouped into batches) 저장하는 방법 제시.
1992년에 Merkel Trees(1979) 추가



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1992년에 Merkel Trees(1979) 추가

1992 **A concept of proof of work**
디지털 서명을 이용해 서비스 요청자의 자원을 소모하도록 요구. 네트워크 자원 남용(Spam, Ddos)에 대한 해결책 제시

1997 **Hashcash**
효율적인 해시 함수 기반의 작업 증명 시스템. 여러 암호 화폐 채굴(PoW) 알고리즘의 일부

1999 **Proof of Work**
‘작업 증명’ 용어 등장 및 개념 정리(formalization)

2004 **A CHAIN OF BLOCKS 특허 만료**

Papers

Byzantine Generals Problem | Byzantine Generals Problem (L. Lamport)

FLP Impossibility | Impossibility of Distributed Consensus with One Faulty Process (MJ. Fischer)

Paxos | The Part-Time Parliament (L. Lamport)

A chain of cryptographically secured blocks | How to time-stamp a digital document (S. Haber)

A concept of proof of work | Pricing via Processing, Or, Combatting Junk Mail, Advances in Cryptology (C. Dwork)

Hashcash | A partial hash collision based postage scheme (A. Beck)

Proof of Work | Proof of Work and Bread Pudding Protocols (M. Jakobsson)

Digital Cash

1983 **Ecash (David Chaum)**
Anonymous cryptographic electronic money (Blind Signatures for untraceable payments)

1997 **Hashcash (Adam Beck)**
Proof of work to aid the generation and distribution of new coins

1998 **B-Money (Wei Dai)**
Anonymous, distributed electronic cash system

1998 **Bit Gold (Nick Szabo)**
Proof of work system. Aimed to avoid centralized authorities

2004 **RPOW Token (Hal Finney)**
Reusable PoW + Hashcash

Cryptography

1985 **ECDSA**
Elliptic Curve Digital Signature Algorithm. 256-bit ECC = 3072-bit RSA

1996 **RIPEME-160**
RIPE Message Digest of 160 bits used to make bitcoin addresses

2002 **SHA256**
Secure Hash Algorithm of 256 bits used to hash a block header and find nonce

블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain

WHY

비트코인 개발 동기에 대한 추측: **금융 위기**

비트코인 개발 동기에 대한 추측: **금융 위기**

RAW HEX VERSION

```
01 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00 00 00 00 3B A3 ED FD  7A 7B 12 B2 7A C7 2C 3E  ....;£íýz{.²zÇ,>
67 76 8F 61 7F C8 1B C3  88 8A 51 32 3A 9F B8 AA  gv.a.È.Ã^ŠQ2:Ÿ¸ª
4B 1E 5E 4A 29 AB 5F 49  FF FF 00 1D 1D AC 2B 7C  K.^J)«_Iÿÿ...¬+|
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비트코인 **제네시스(Genesis)** 블록

"두 번째 **구제 금융**을 앞두고 있는 재무 장관"

THE TIMES

Saturday January 3 2009 timesonline.co.uk No 69523 £1.50

Eat Out from £5

More than 900 great restaurants, including four Gordon Ramsay favourites from £15

Start collecting tokens today Pullout inside

Israel prepares to send tanks and troops into Gaza

Michael Sheen Frost, Nixon and me

Working mums So that's how she does it

Detox in style The best spas on the planet

Salman Rushdie I won't marry again

Giant killing? Guide to the FA Cup third round

Chancellor on brink of second bailout for banks

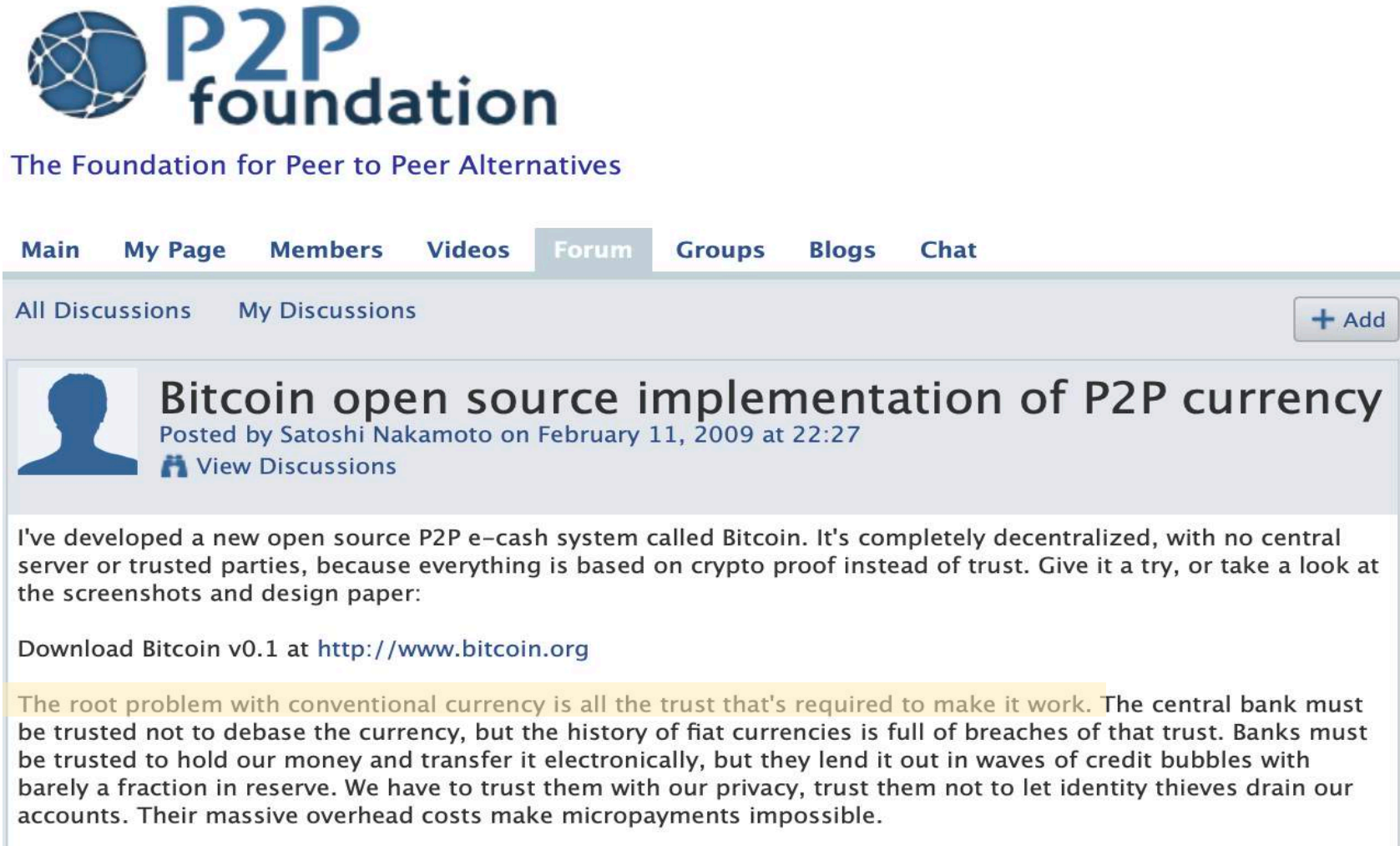
Billions may be needed as lending squeeze tightens

99p

비트코인 개발 동기에 대한 추측: **Cyberpunk**

2008년 10월 31일 **Cryptography Mailing List**에 **백서** 공개

"전통적인 화폐의 **근본적인 문제**는 그것을 운용하기 위해 필요한 **신뢰 그 자체**이다."



Cyberpunk: **기술**을 통해 **자치, 자유**를 추구

정보 독점 사회

1980~90 급격한 기술 발전

정부 권력의 강화 (규제)

다국적 거대 기업의 등장

VS

사이버 펑크

개인 사생활 보호

자치를 위한 투쟁

Bitcoin open source implementation of P2P currency

Posted by Satoshi Nakamoto on February 11, 2009 at 22:27

View Discussions

(ref #2)

I've developed a new open source P2P e-cash system called Bitcoin. It's completely decentralized, with no central server or trusted parties, because everything is based on crypto proof instead of trust. Give it a try, or take a look at the screenshots and design paper: Download Bitcoin v0.1 at http://www.bitcoin.org

The root problem with conventional currency is all the trust that's required to make it work. The central bank must be trusted not to debase the currency, but the history of fiat currencies is full of breaches of that trust. Banks must be trusted to hold our money and transfer it electronically, but they lend it out in waves of credit bubbles with barely a fraction in reserve. We have to trust them with our privacy, trust them not to let identity thieves drain our accounts. Their massive overhead costs make micropayments impossible.

A generation ago, multi-user time-sharing computer systems had a similar problem. Before strong encryption, users had to rely on password protection to secure their files, placing trust in the system administrator to keep their information private. Privacy could always be overridden by the admin based on his judgment call weighing the principle of privacy against other concerns, or at the behest of his superiors. Then strong encryption became available to the masses, and trust was no longer required. Data could be secured in a way that was physically impossible for others to access, no matter for what reason, no matter how good the excuse, no matter what.

It's time we had the same thing for money. With e-currency based on cryptographic proof, without the need to trust a third party middleman, money can be secure and transactions effortless.

One of the fundamental building blocks for such a system is digital signatures. A digital coin contains the public key of its owner. To transfer it, the owner signs the coin together with the public key of the next owner. Anyone can check the signatures to verify the chain of ownership. It works well to secure ownership, but leaves one big problem unsolved: double-spending. Any owner could try to re-spend an already spent coin by signing it again to another owner. The usual solution is for a trusted company with a central database to check for double-spending, but that just gets back to the trust model. In its central position, the company can override the users, and the fees needed to support the company make micropayments impractical.

Bitcoin's solution is to use a peer-to-peer network to check for double-spending. In a nutshell, the network works like a distributed timestamp server, stamping the first transaction to spend a coin. It takes advantage of the nature of information being easy to spread but hard to stifle. For details on how it works, see the design paper at http://www.bitcoin.org/bitcoin.pdf

The result is a distributed system with no single point of failure. Users hold the crypto keys to their own money and transact directly with each other, with the help of the P2P network to check for double-spending.

Satoshi Nakamoto http://www.bitcoin.org

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블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain
개발 동기	제네시스 블록(금융위기), Cyberpunk, 중앙화, 신뢰, 프라이버시, 암호학

중앙화의 문제

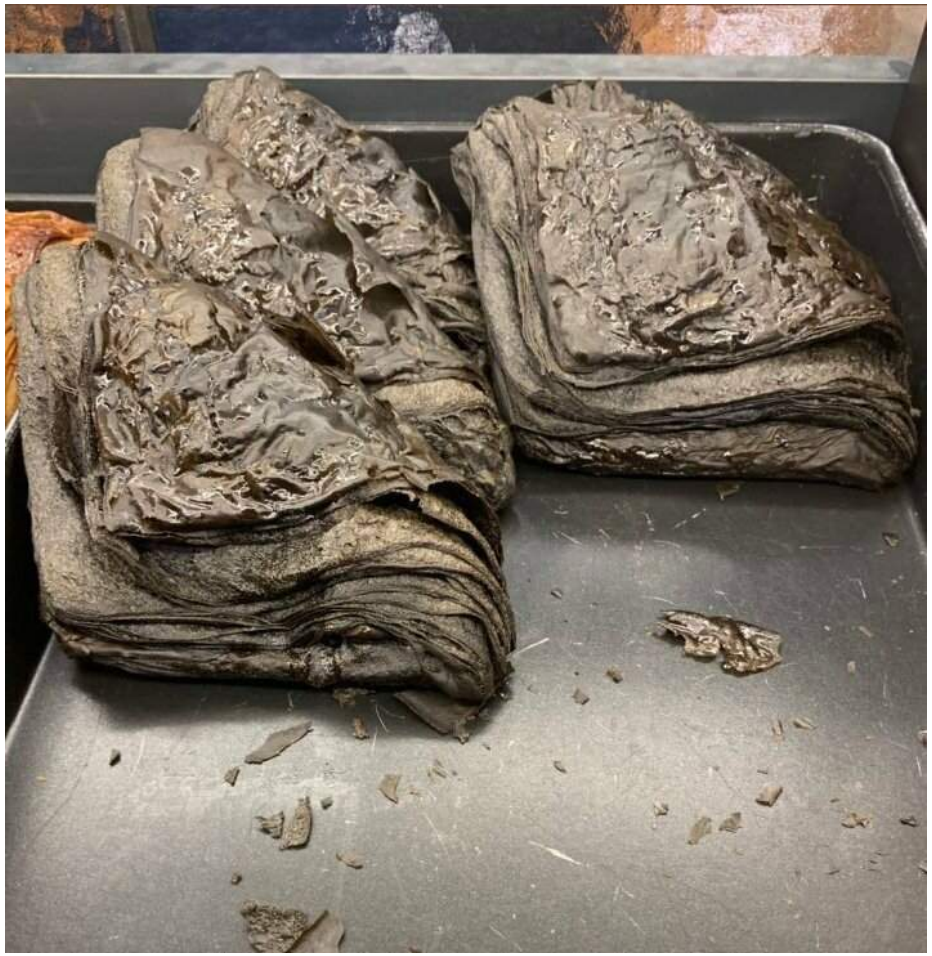
중앙화의 문제: **Trust**

중앙화의 문제: **Trust**

김미영 팀장입니다.
고객님께서는 최저 이율로 최고
3,000만원까지 30분 이내
통장 입금 가능합니다.

중앙화의 문제: **Single point of failure**

화재로 인한 문화재 손실



중앙화의 문제: **Single point of failure**

먹물퐁당 감자치즈

중앙화의 문제: **Single point of failure**

1995 **Citibank**
러시아 해커 Vladimirr Levin이 시티뱅크 전산망을 해킹하여 천만달러를 전세계로 송금함.

2000 **Mafia Boy**
캐나다 10대 소년 Michel Calce에 의해 ahoo, Dell, CNN 등 다국적 기업들의 서비스가 중단(DoS)됨

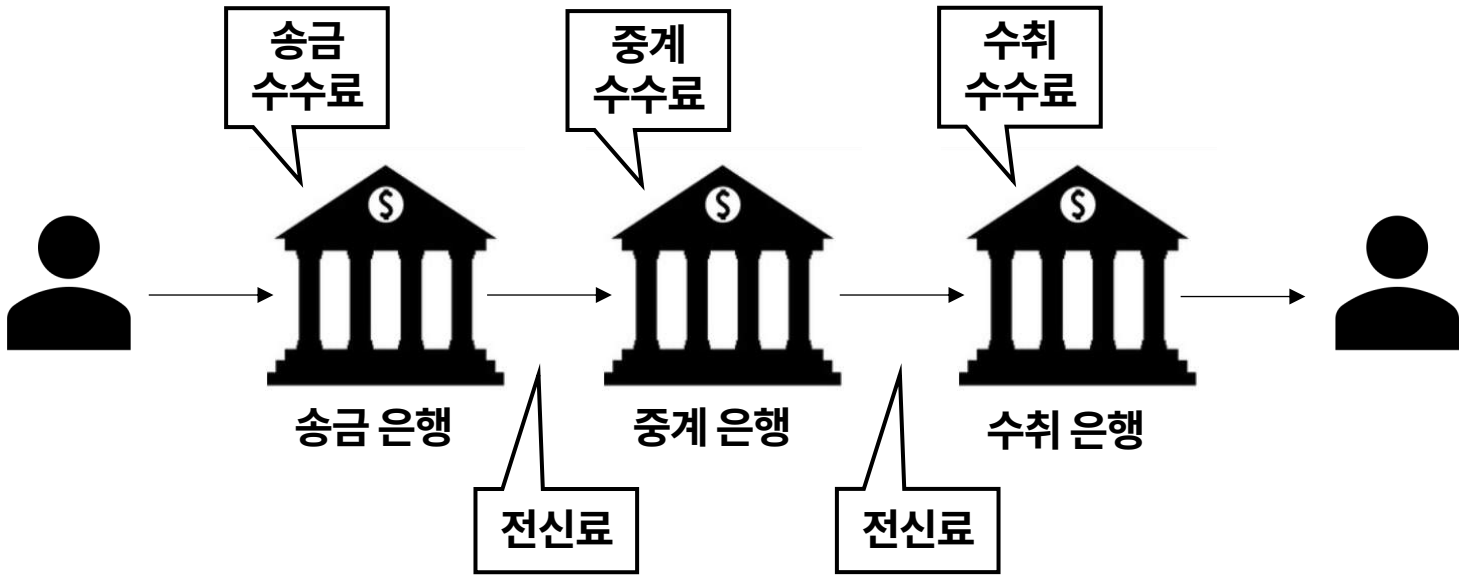
2004 **Delta Airline**
Sven Jaschan(당시 18세)가 델타 항공사의 운항 노선의 일부를 취소 시킴

2016 **Bangladesh Bank Heist**
방글라데시아 은행이 사용하는 SWIFT 시스템(국제 은행 간 송금 표준)이 해킹당해 8,100만 달러 손실

2017 **WannaCry**
‘비트코인을 요구하는 랜섬 웨어. 텔레포니카, 영국 국민 건강 서비스, 페덱스 등 150개 이상 국가의 대기업, 기관이 피해를 입음

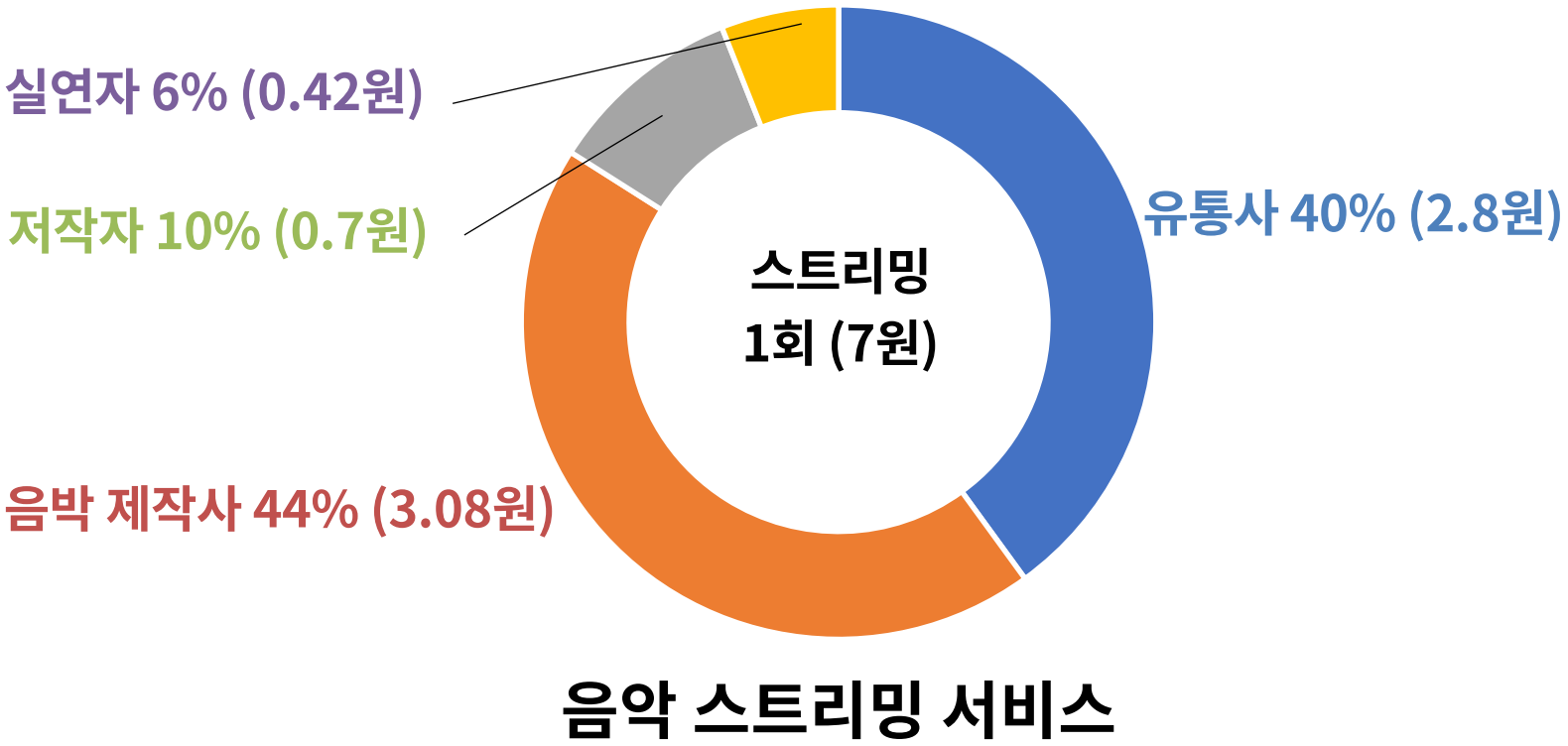
2018 **Facebook**
페이스북 서버 해킹으로 5천만명의 개인정보가 유출

중앙화의 문제: **Tyranny**



국제 송금

중앙화의 문제: **Tyranny**



중앙화의 문제

Trust

Efficiency, Authority, License

Single point of failure

Ownership of data

Tyranny

Network effect, Platform power

Overhead cost

Availability, Security, Regulation

블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain
개발 동기	제네시스 블록(금융위기), Cyberpunk, 중앙화, 신뢰, 프라이버시, 암호학
중앙화의 문제	Trust, Single point of failure, Tyranny, Overhead cost

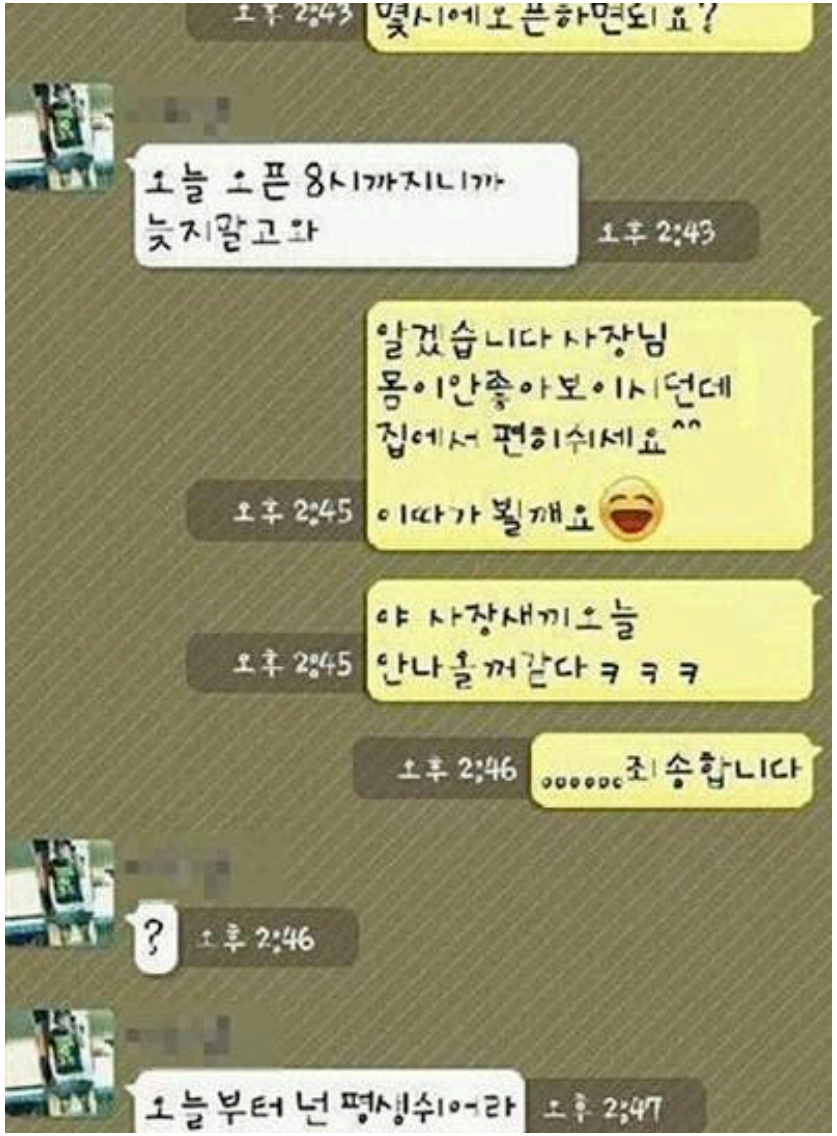
중개자 없는 P2P 거래

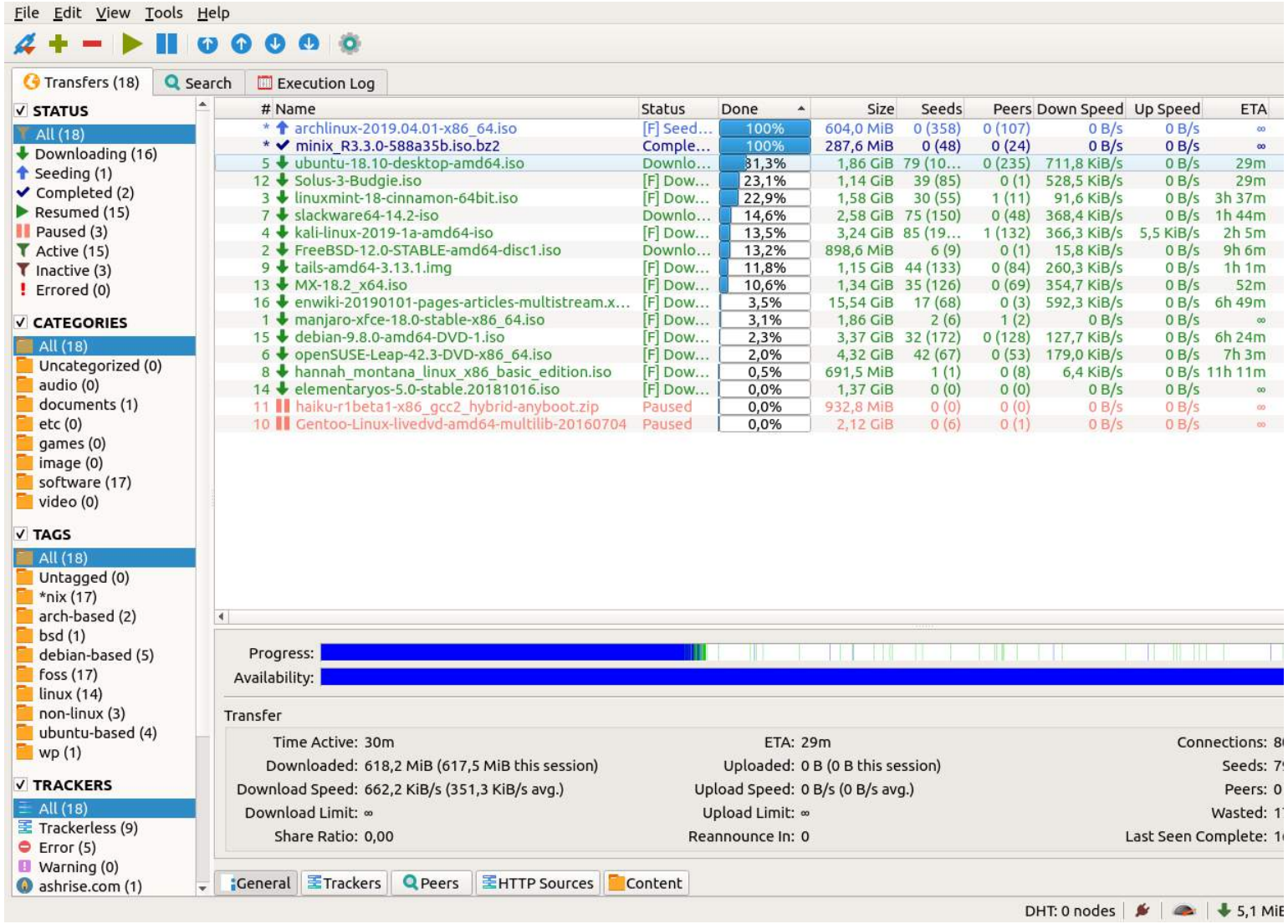
중개자 없는 P2P 거래

I’ve developed a new open source **P2P** e-cash system called Bitcoin. It's completely **decentralized, with no central server or trusted parties**.

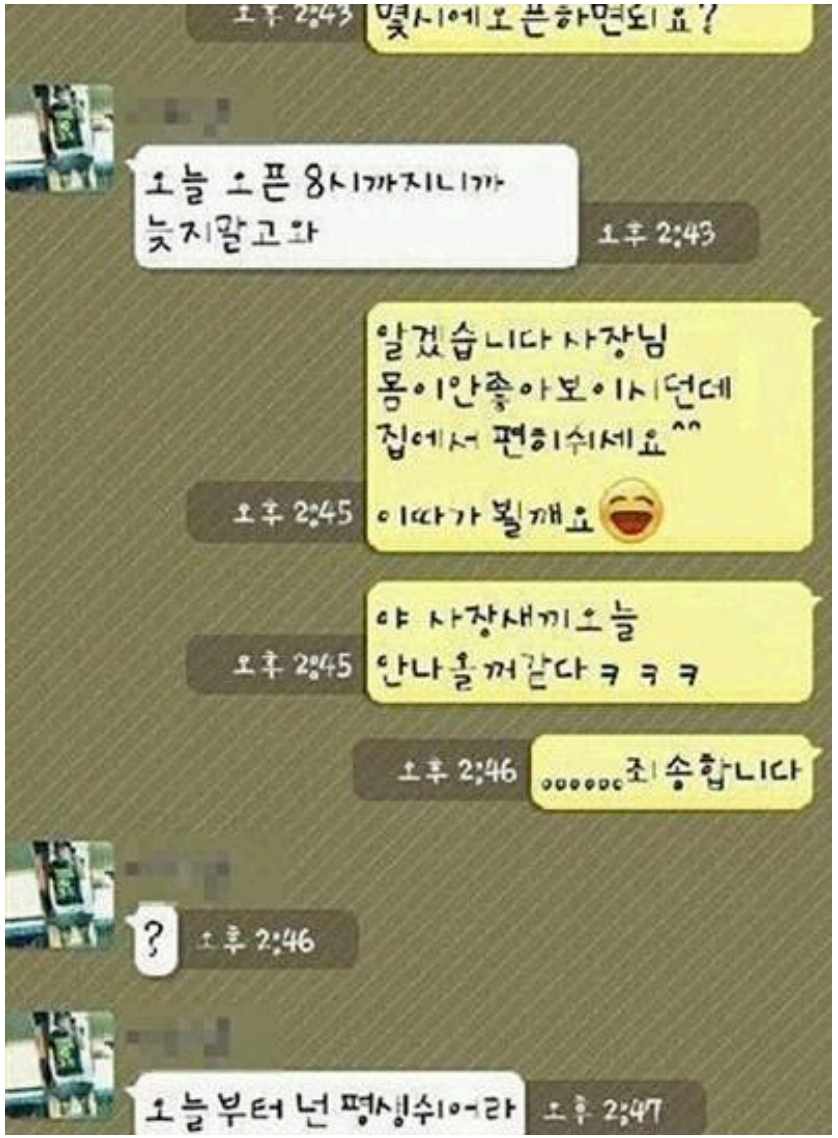
Users hold the crypto keys to their own money and **transact directly with each other**, with the help of the P2P network to check for double-spending.

Server-client vs. Peer-to-Peer

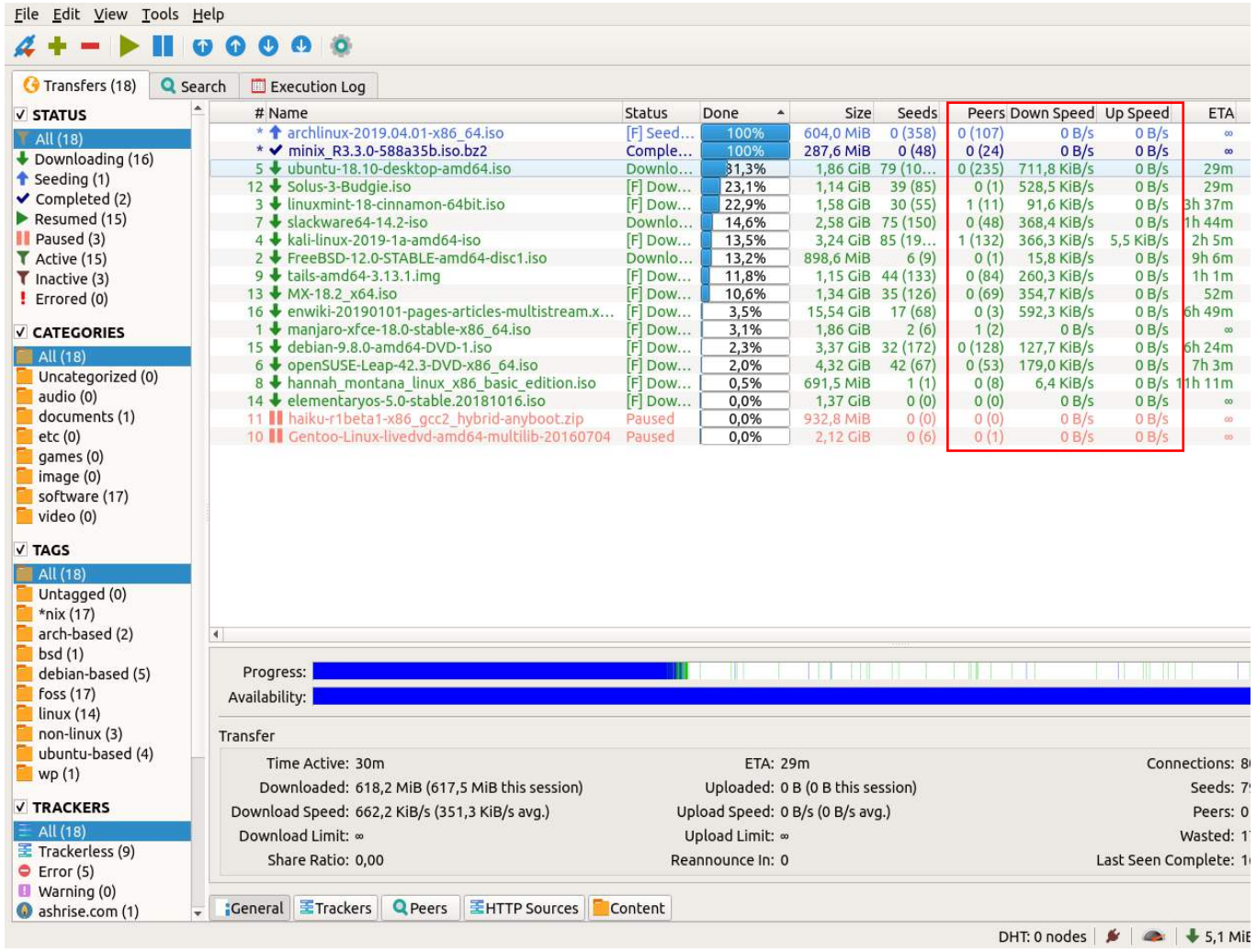


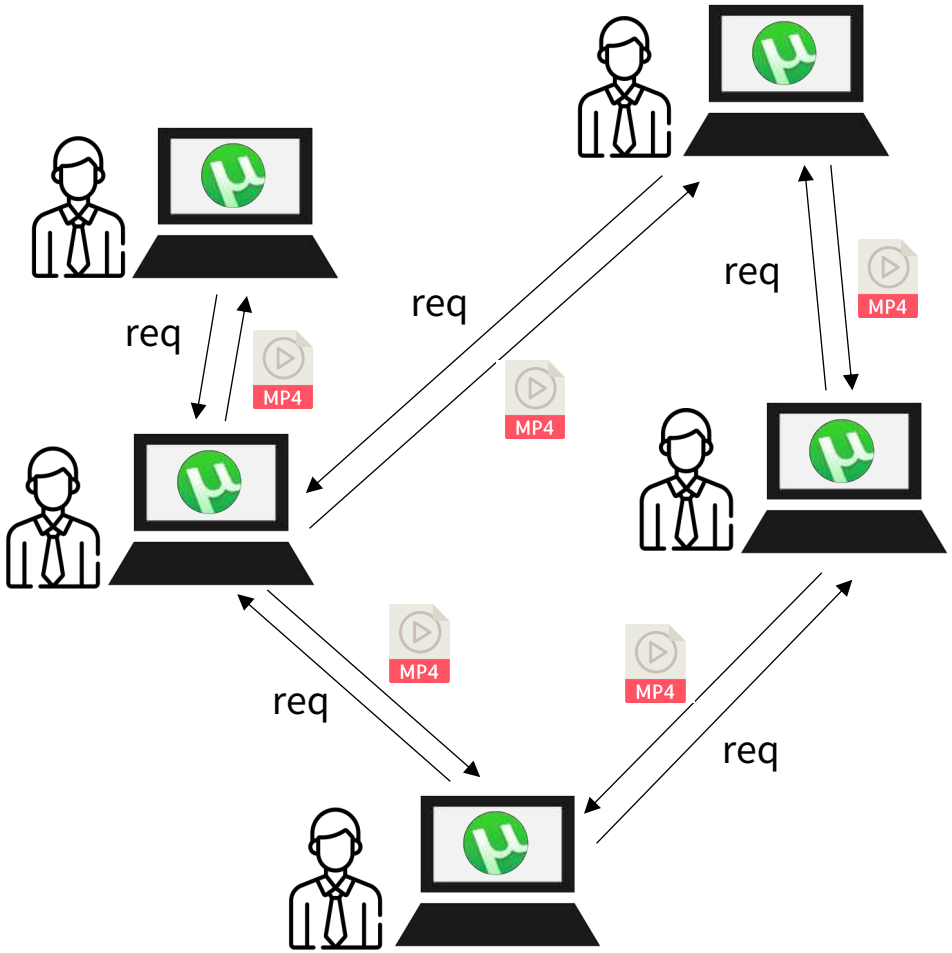


Server-client

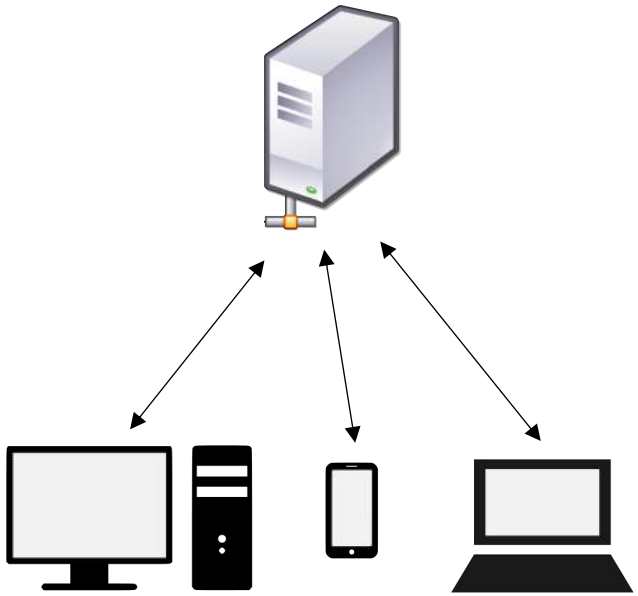


Peer-to-Peer (ref #3)

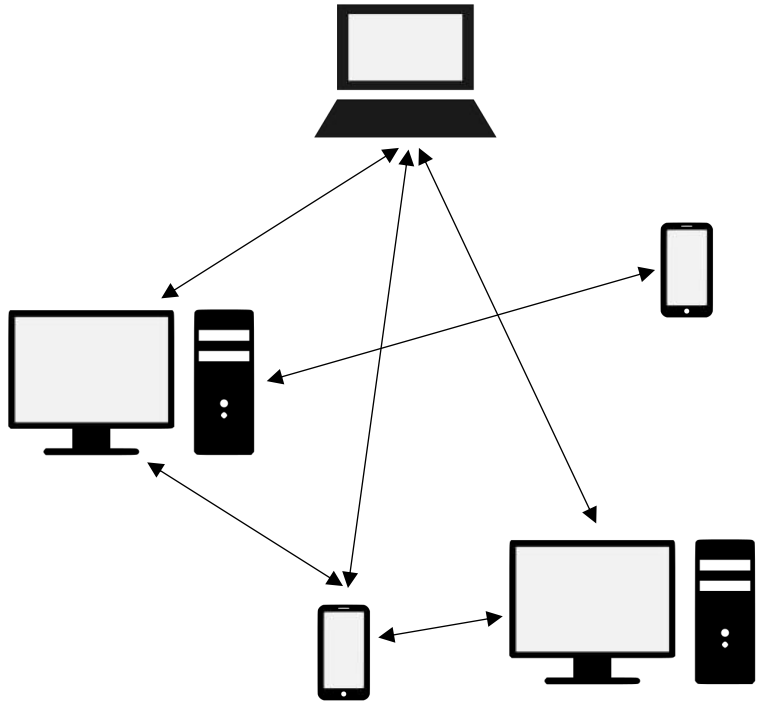




Server-client vs. Peer-to-Peer



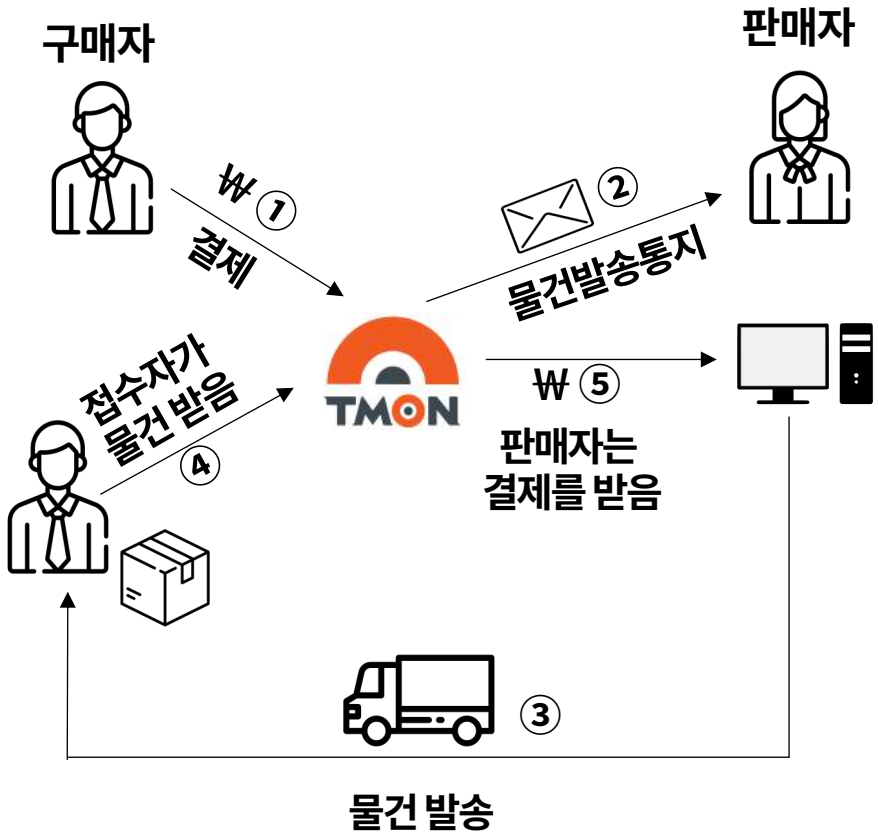
VS



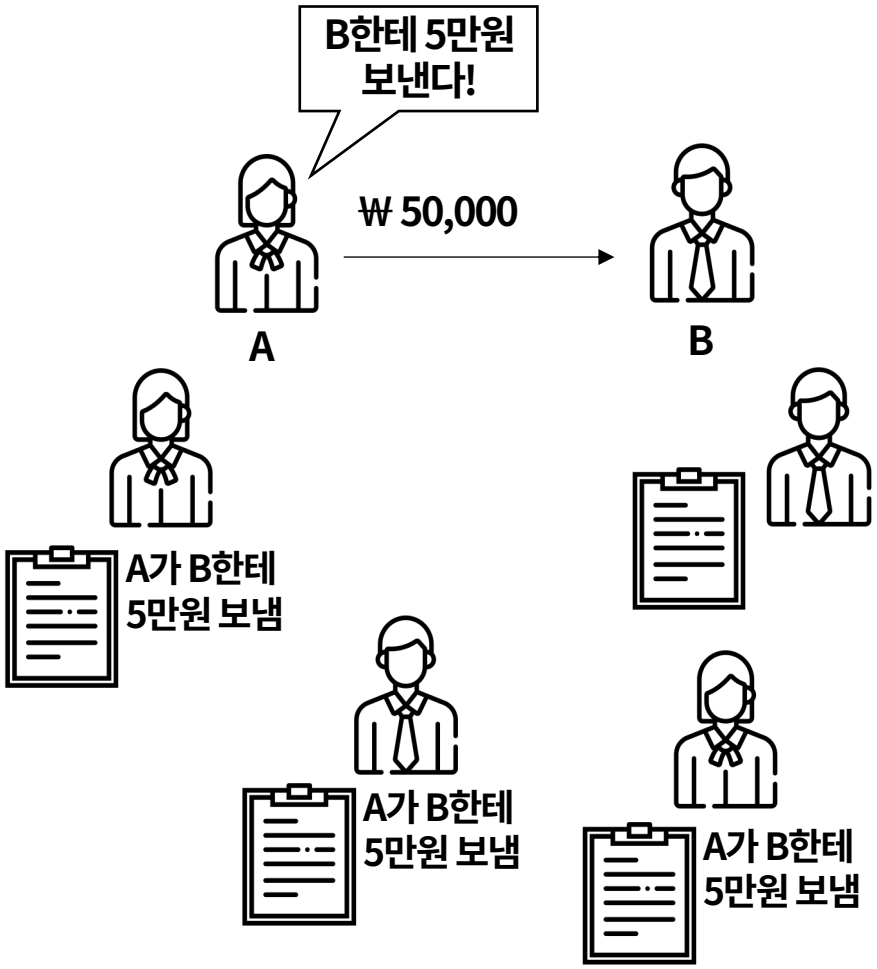
Clients request
A server responses

Each peer request as a client
Each peer responses as a server

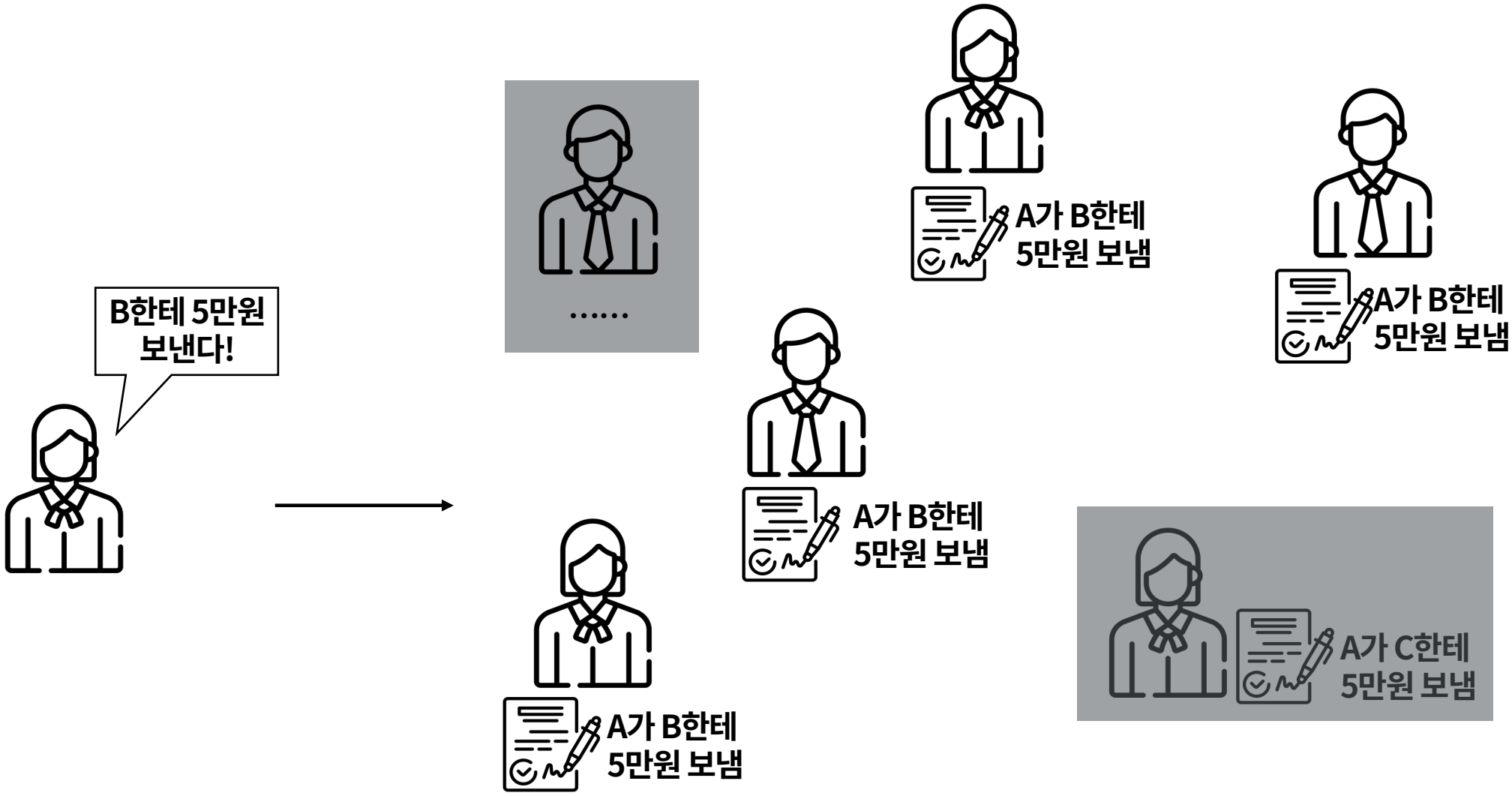
Server-client vs. Peer-to-Peer



VS



분산화의 장점: **대다수가 정직**한 경우



분산 장부의 목표: **동일한 장부**의 유지

언제나 대다수의 노드가 **동일한 장부에 합의**

합의를 위해서는 투표와 같은 **다수결 규칙**이 필요

합의 알고리즘

폐쇄 네트워크 vs. 공개 네트워크

소문과 평판

???

나카모토의 해결책

컴퓨팅 파워로 투표를 대체

보상 **인센티브**

Proof of Work

Bitcoin: 1st generation of blockchain

사이버 펑크 운동

2008년 금융위기

기술의 발전

컴퓨터 과학 + 암호학 + 경제학(게임이론)

블록체인을 활용한 애플리케이션

최초의 성공한 암호 화폐

Ethereum: Beyond Bitcoin

Vitalik Buterin

초기 비트코인 개발 기여

Bitcoin Magazine 공동 설립자 (11년 9월)

비트코인의 한계 극복 시도

13년 이더리움 백서 발표

14년 11월 월드 테크놀로지 어워드 IT/SW 수상

15년 7월 30일 이더리움 메인넷 런칭

Ethereum: 2nd generation of blockchain

비트코인의 한계 : Scripts, DDoS(서비스 거부 공격)

스마트 컨트랙트

닉 자보에 의해 처음 제안 (1994)

계약을 프로그래밍 언어로 작성

Not by court, but code

블록체인에 저장된 프로그램

가스 모델로 DDoS 방지

디지털 암호 화폐 -> 블록체인 플랫폼

블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain
개발 동기	제네시스 블록(금융위기), Cyberpunk, 중앙화, 신뢰, 프라이버시, 암호학
중앙화의 문제	Trust, Single point of failure, Tyranny, Overhead cost
중개자 없는 P2P 거래	직접 거래, 대다수가 정직, 다수결, 합의 알고리즘, 컴퓨팅 파워, 보상 인센티브

SO WHAT

Key features

Decentralization → Disintermediation

Immutability → Verifiability

Transparency → Auditability

Programmability → Automation

Key advantages

Replacement of existing trust system

Reducing transaction cost by **standardization**

Cost cutting by **automation**

New business model of a form of **direct participation**

Considerations

Not (**yet**) for high transaction frequency & strict finality

Not only for fin-tech → New **transaction** models

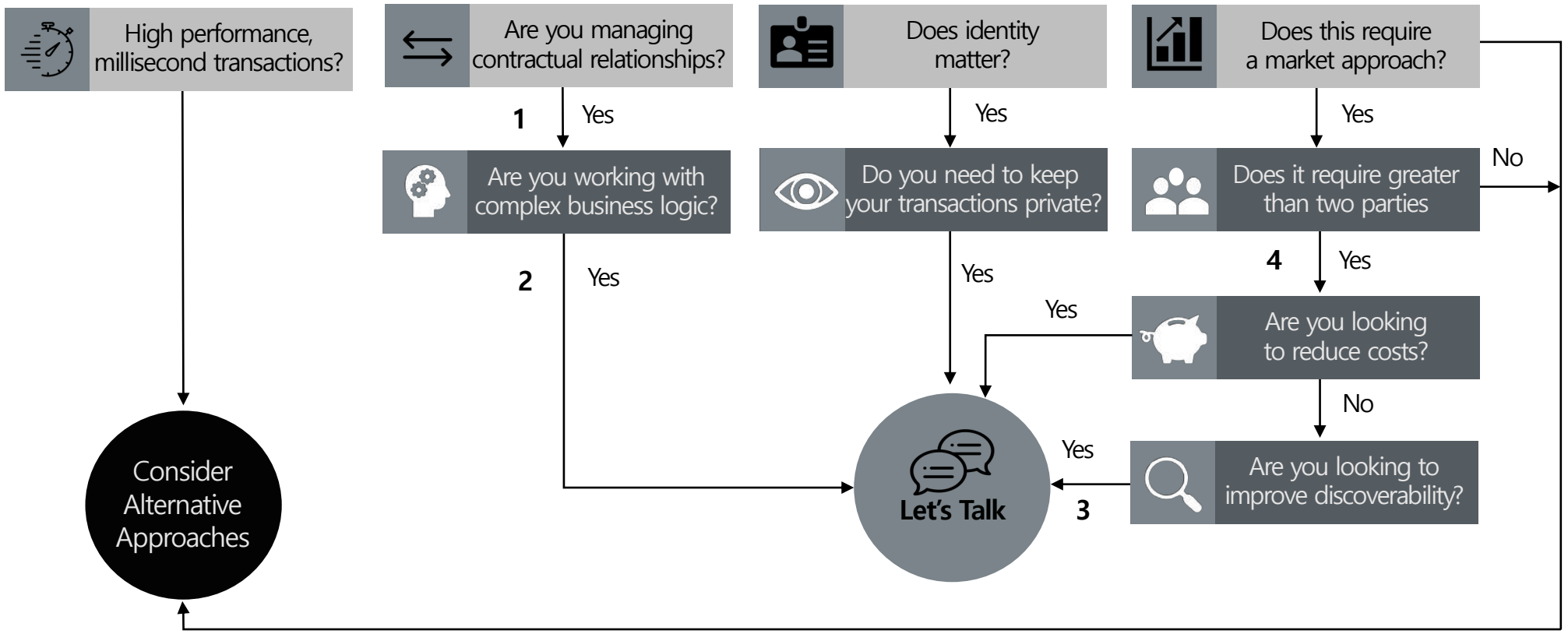
DLT-based applications in financial sector (WBG, ref #4)

Money & Payments	- Digital currencies - Payment authorization, clearance & settlement - International remittances and cross-border payments - Foreign exchange - Micropayments
Financial Services & Infrastructure	- Capital markets: digital issuance, trading & settlements of securities - Commodities trading - Notarization services (e.g. for mortgages) - Collateral / movable asset registries - Syndicated loans - Crowdfunding (as initial coin offerings) - Insurance for automating payouts and validation of occurrence of insured event
Collateral registries & ownership registers	- Land registries, property tiles & other collateral registries
Internal systems of financial service provider	- Replacing internal ledgers maintained by large, multinational financial service providers that record information across different departments, subsidiaries, or geographies

DLT-based applications in other sectors (WBG)

Identity	- Digital identity platforms - Storing personal records: birth, marriage & death certificates
Trade & Commerce	- Supply chain management (management of inventory and disputes) - Product provenance & authenticity (e.g. artworks, pharmaceuticals, diamonds) - Trade finance and Post-trade processing - Rewards & loyalty programs - Invoice management - Intellectual property registration - Internet of Things
Agriculture	- Financial services in the agricultural sector like insurance, crop finance and warehouse receipts - Provenance of cash crops - Safety net programs related to delivery of seeds, fertilizers and other inputs
Governance	- E-voting systems and E-Residence - Government record-keeping, e.g. criminal records - Reducing fraud and error in government payments and tax fraud - Protection of critical infrastructure against cyberattacks
Healthcare	- Electronic medical records
Humanitarian & Aid	- Tracking delivery & distribution of food, vaccinations, medications, etc. - Tracking distribution and expenditure of aid money

How to decide whether to use it? (IBM, ref #5)



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

2 Smart contracts aim to provide security superior to traditional contract and reduce other Tx costs associated with contracting.

3 When everyone on an exchange can view the same ledger, it is easy to broadcast an intention (or offer) by appending it. For example, in a trading network, all ask and bids would be visible to every network participant.

4 Blockchain networks allow each participant to create customized solutions using their own proprietary business logic while running on the same common ledger.

블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain
개발 동기	제네시스 블록(금융위기), Cyberpunk, 중앙화, 신뢰, 프라이버시, 암호학
중앙화의 문제	Trust, Single point of failure, Tyranny, Overhead cost
중개자 없는 P2P 거래	직접 거래, 대다수가 정직, 다수결, 합의 알고리즘, 컴퓨팅 파워, 보상 인센티브
특징	Decentralization, Transparency, Programmability, Immutability

다양한 관점들

Blockchain is a particular type of **Distributed Ledger Technology**

Distributed Ledger Technology

The Internet of Value

Decentralized Autonomous Organization

Trustless

Bootstrapped

Protocol is fat

Anti-fragile

Blockchain is a particular type of **Distributed Ledger Technology**

Blockchain is a particular type of **Distributed Ledger Technology**

Blockchain gave rise to **The Internet of Value**

Blockchain is a **Decentralized Autonomous Organization**

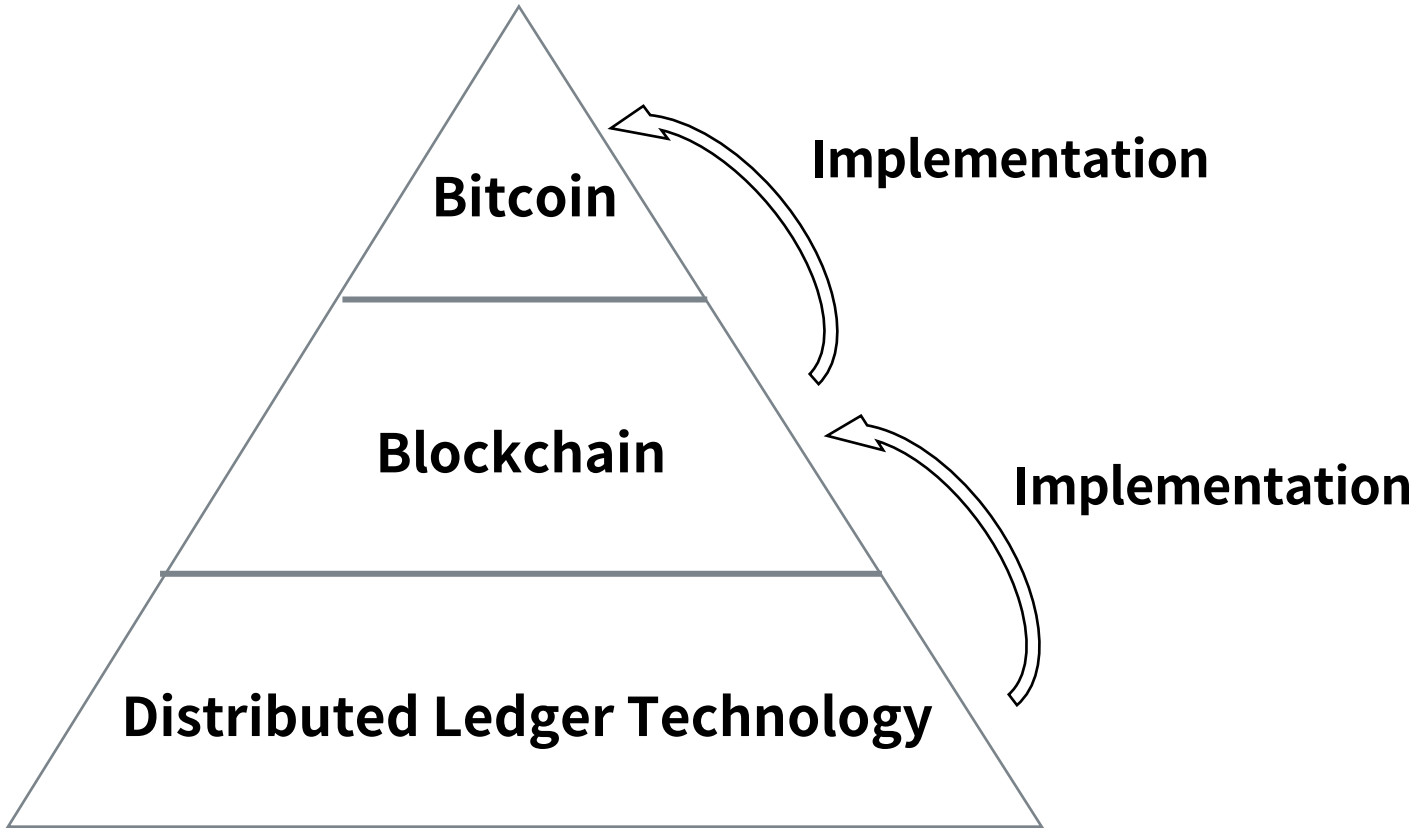
Blockchain is **Trustless**

Bitcoin is **bootstrapped**

Blockchain **protocol is fat**

Bitcoin is **anti-fragile**

Blockchain is a particular type of **Distributed Ledger Technology**



Blockchain is a particular type of **Distributed Ledger Technology**

Bitcoin ≠ Blockchain

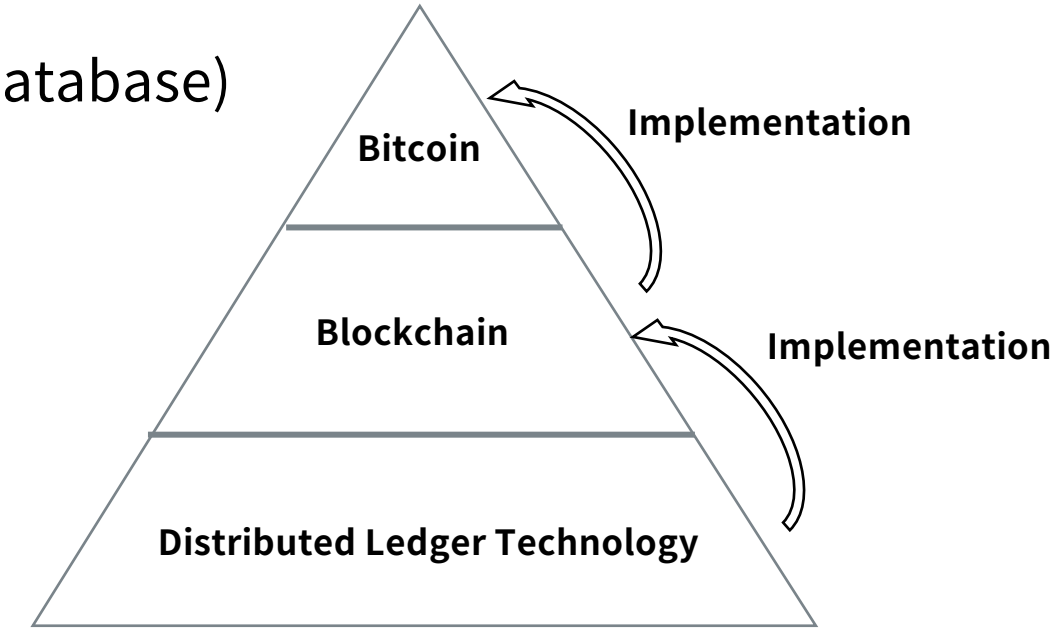
Bitcoin is a **cryptocurrency** implemented on top of blockchain

Blockchain is an **append-only data structure**

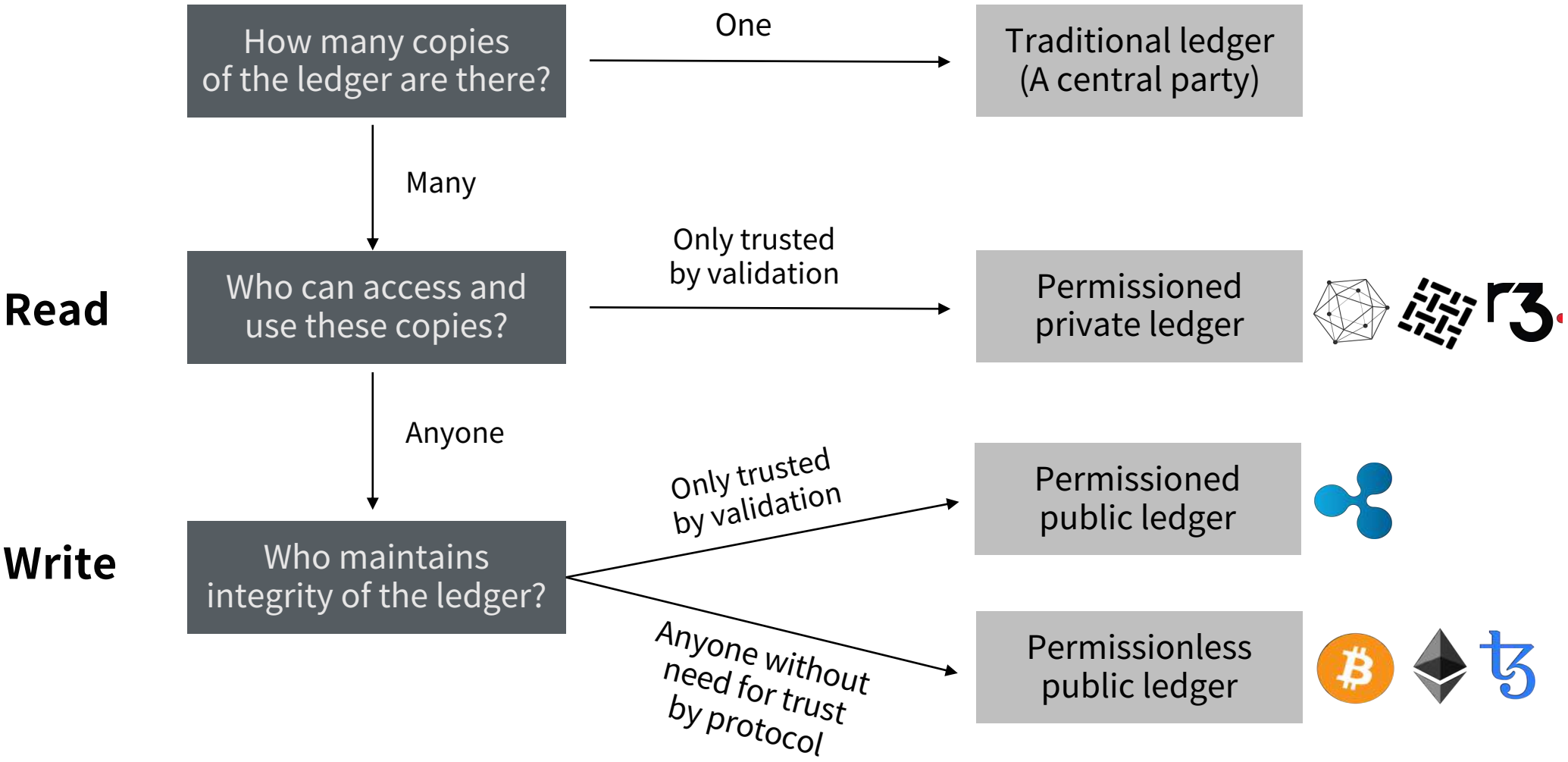
Some blockchains are open distributed ledgers (database)

Distributed ledger → Blockchain X

Blockchain → Distributed X



Types of blockchain (WBG)



Blockchain gave rise to **The Internet of Value**

정보는 순식간에 전 세계로 이동 가능

가치의 이전과 교환은 여전히 신뢰 시스템에 의존

The Internet of Information

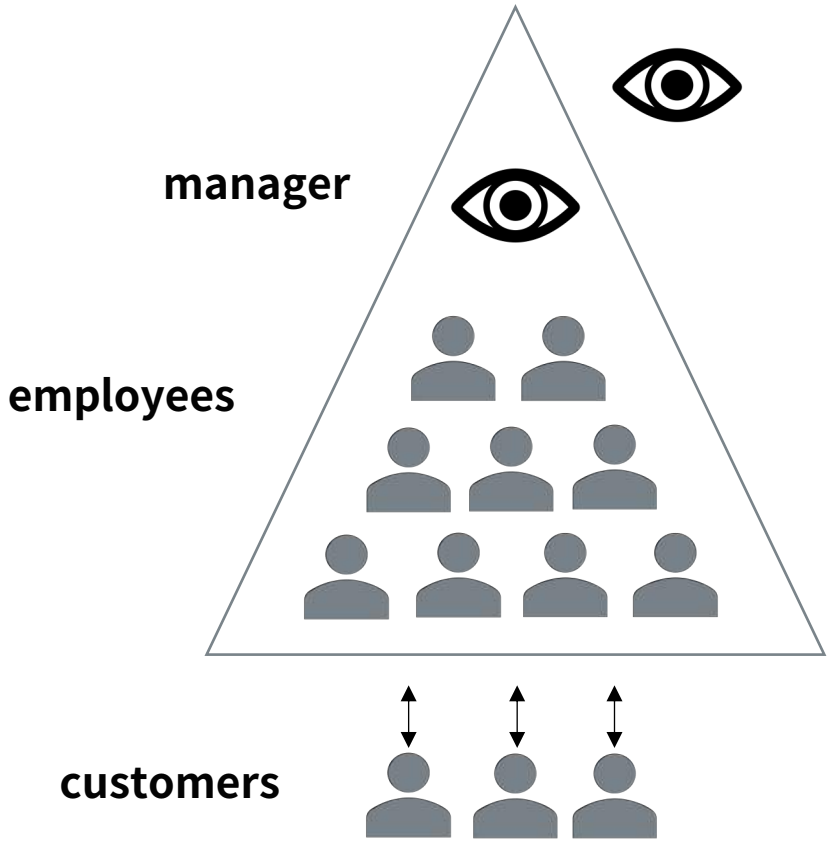
The Internet of Value

Bitcoin = Internet-like money

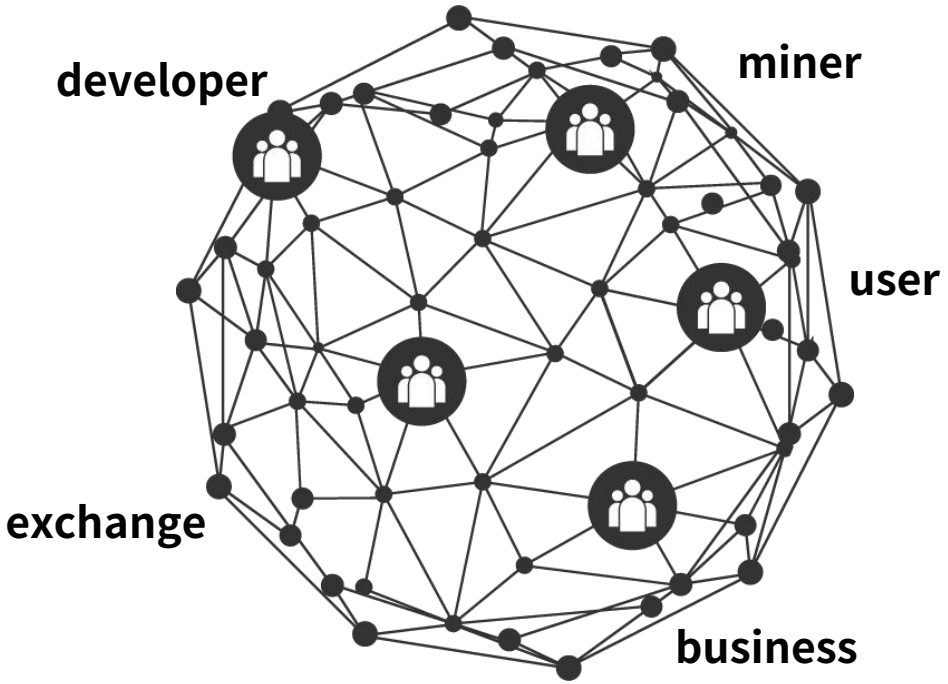
인터넷을 통해 모든 자산을 자유롭게 교환 가능

Blockchain is a **Decentralized Autonomous Organization**

Management by people
Automation by machine

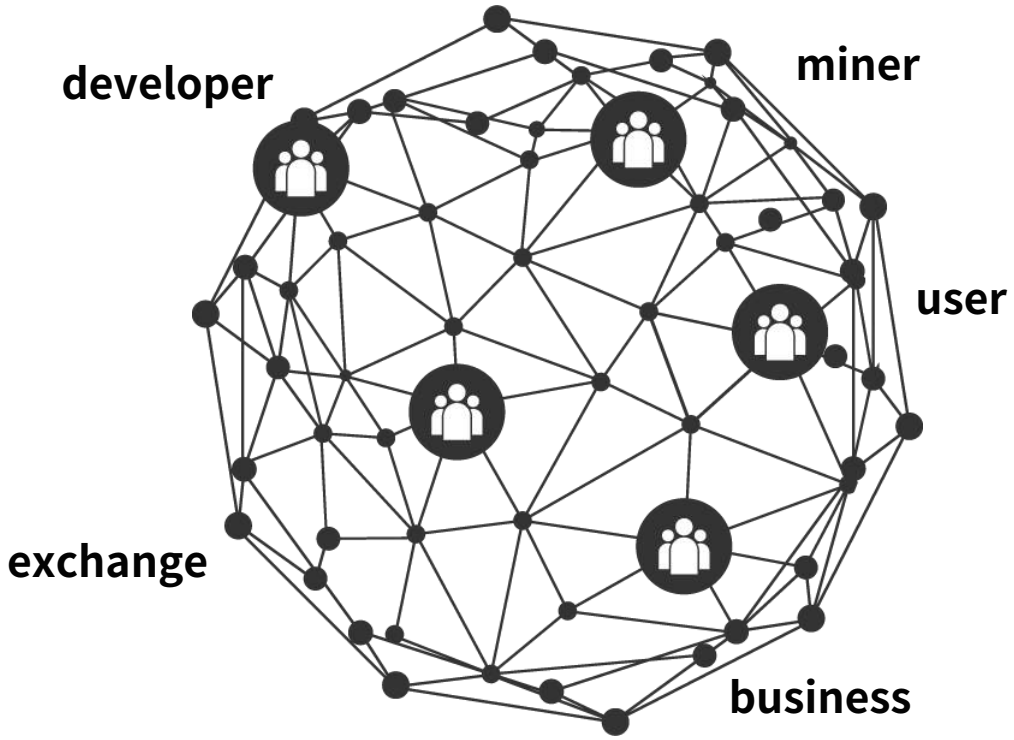


Watching each other
Governed by protocol



Blockchain is a **Decentralized Autonomous Organization**

Bitcoin network as a world biggest auto payment service



CEO / Managers:

Employees:

Salary:

Customers:

Stockholders:

Stocks:

Stock listing:

Capital gain:

Blockchain is **Trustless**

Trust

제삼자에 대한 신용을 전제

리스크, 신용 증명 비용

규제, 감독, 처벌

제삼자에 의한 강제 집행

측정 가능한 신뢰의 범위

= 사회 발전의 범위

VS

Trustless

신용이 필요 없음

신용 자체가 존재 X

부정행위 자체가 불가능

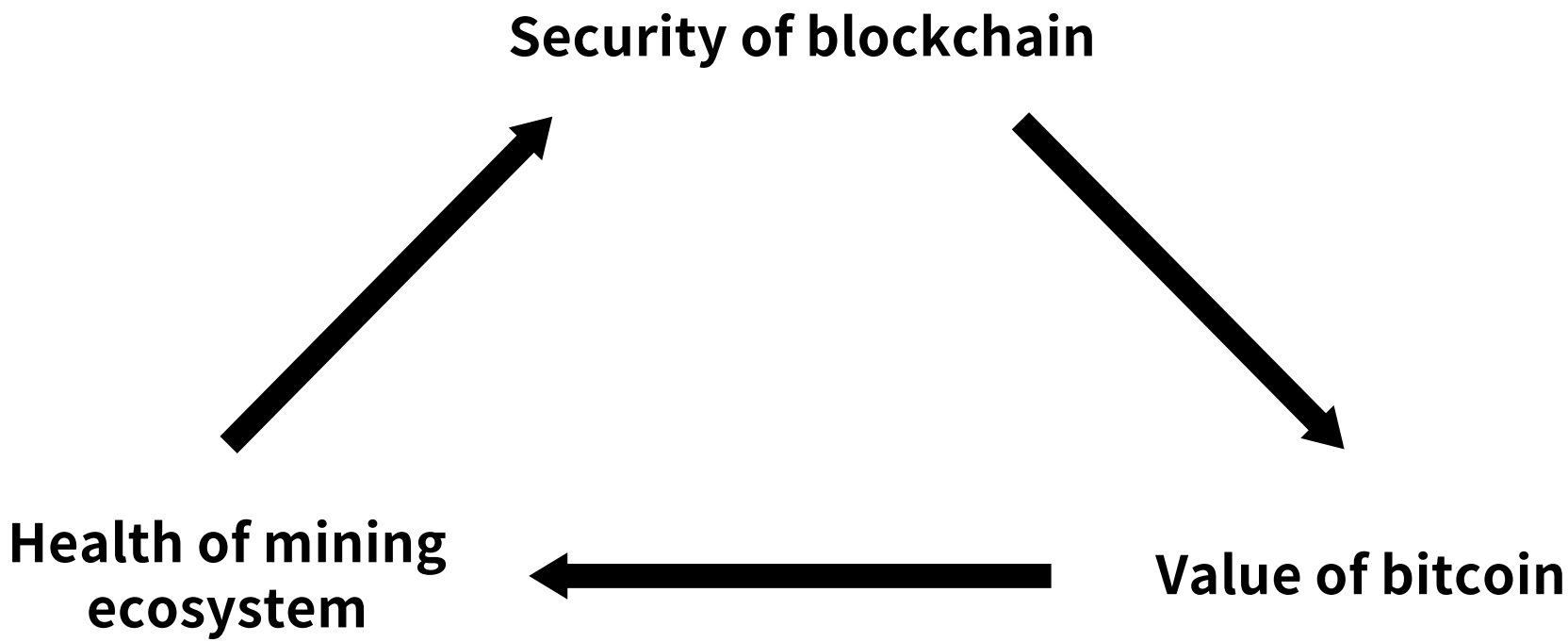
프로토콜에 의한 자동 집행

시스템의 분산

자율, 자치

Bitcoin is **bootstrapped** : from NOTHING to ALL

Interlocking interdependencies in Bitcoin



Blockchain **protocol is fat**

Protocol

통신이 가능한 네트워크 장비 사이에서 데이터, 메시지를 주고 받는 **규칙**

신호 체계, 인증, 오류 감지 및 수정

표준으로서 역할 (HTTP, TCP/IP, SMTP 등)

Blockchain protocol

네트워크에 참여한 **노드**들이 **연결**되는 **방식**

기록(트랜잭션, 블록)에 대한 노드들의 **검증과 합의**를 통해 블록 추가

예. 블록 사이즈, 트랜잭션 조건, 이중 지불 금지

Blockchain **protocol is fat**

Fat protocol*

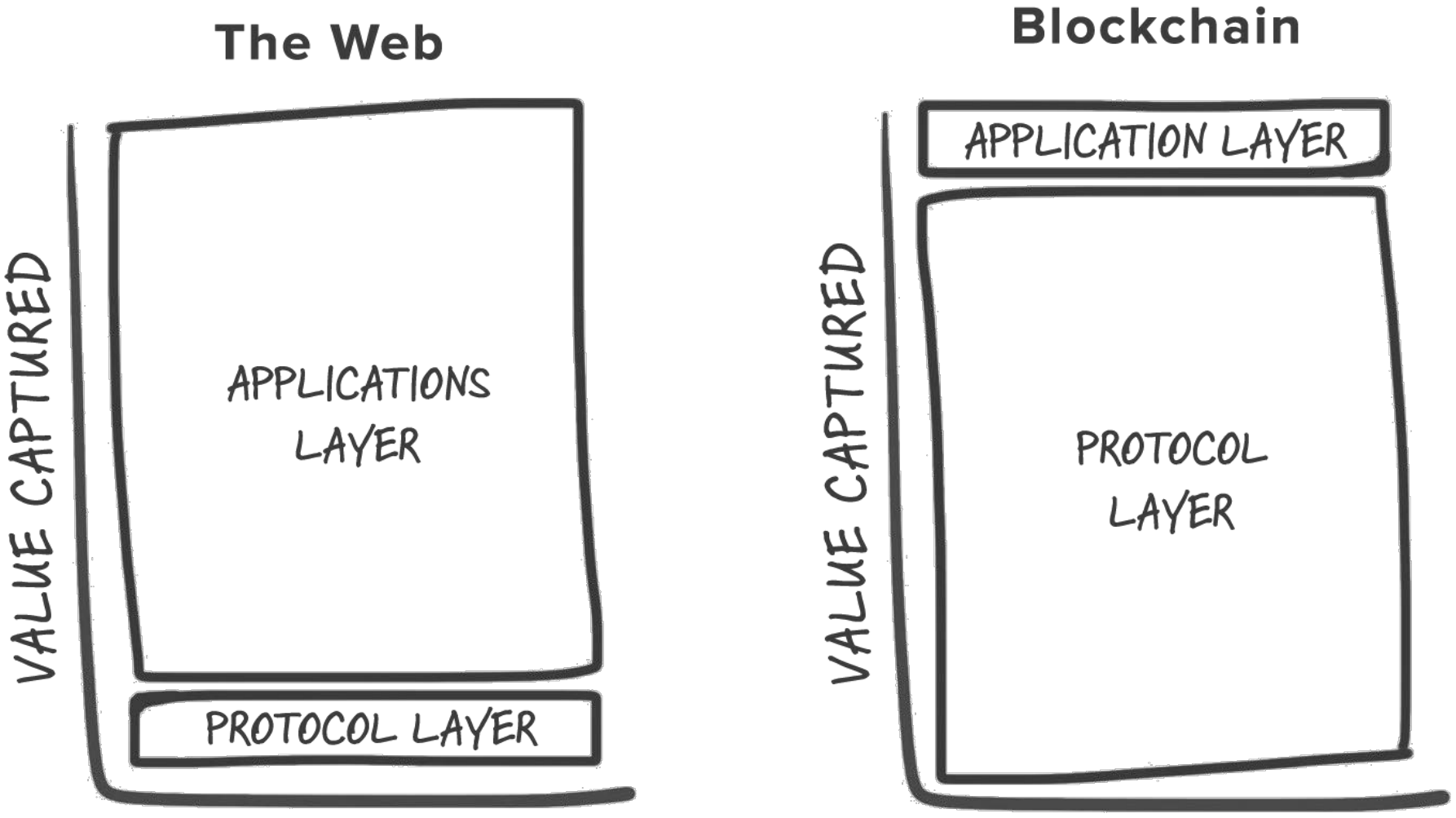
웹: 애플리케이션(아마존, 구글, 페이스북)에 가치가 집중

블록체인: dApp을 위한 **인프라****로서 프로토콜에 가치가 집중

* Joel Monégro

** Shared data, Cryptographic access token

Blockchain **protocol is fat**

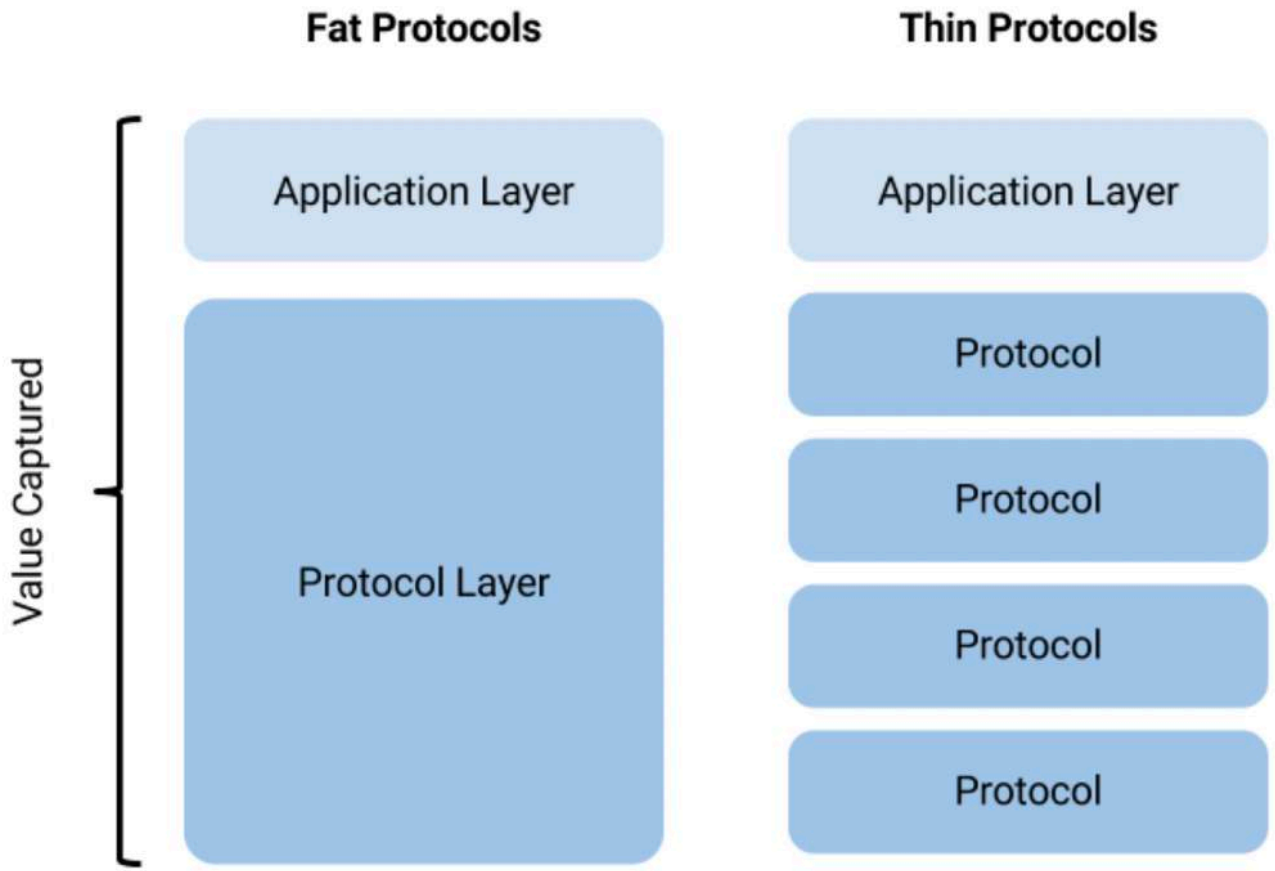


Thin protocol (Teemu Paivinen)

Protocols in aggregate is fat

Divided by **multiple protocols**

Forking competitive market



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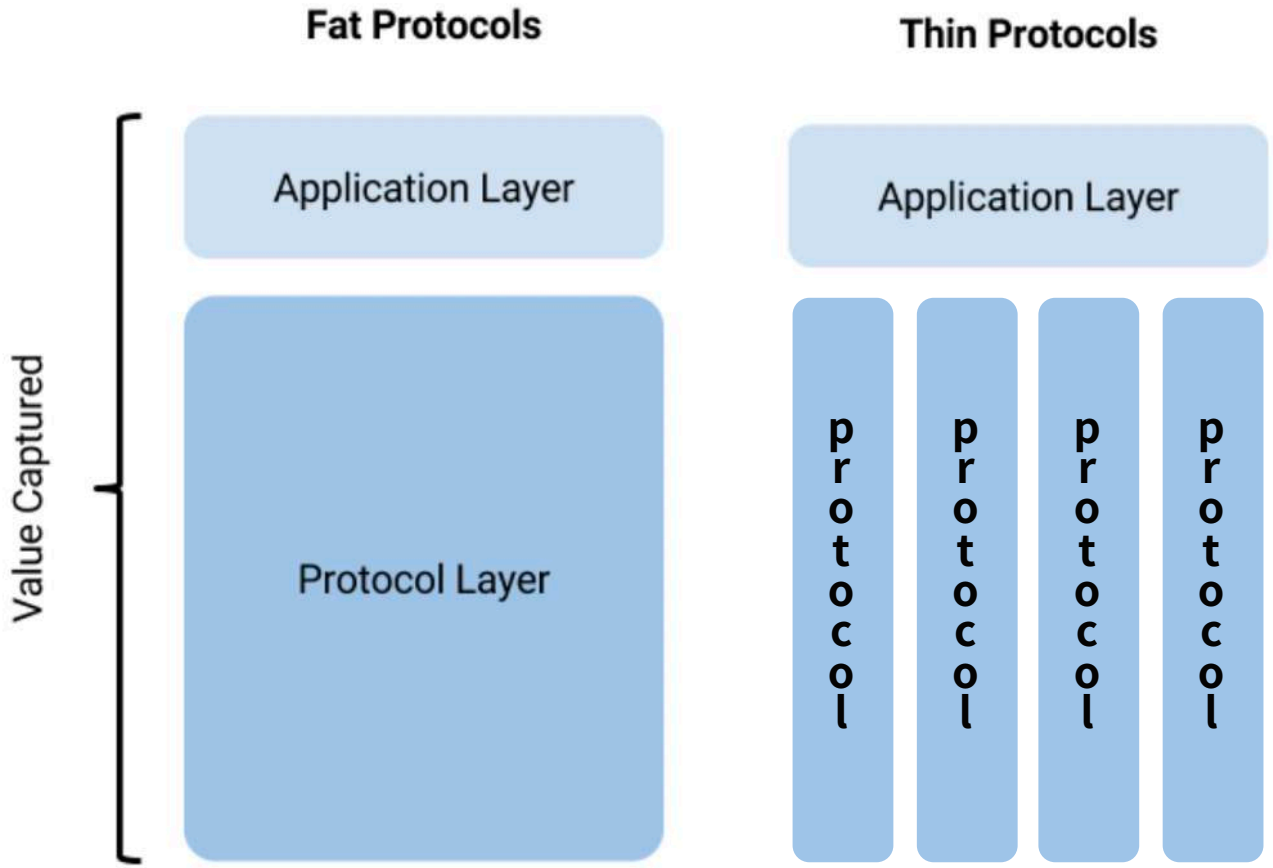


Bitcoin is **anti-fragile**

마운트곡스 파산

14년 2월 85만개의 비트코인 도난

(4억7400만 달러, 5천억)

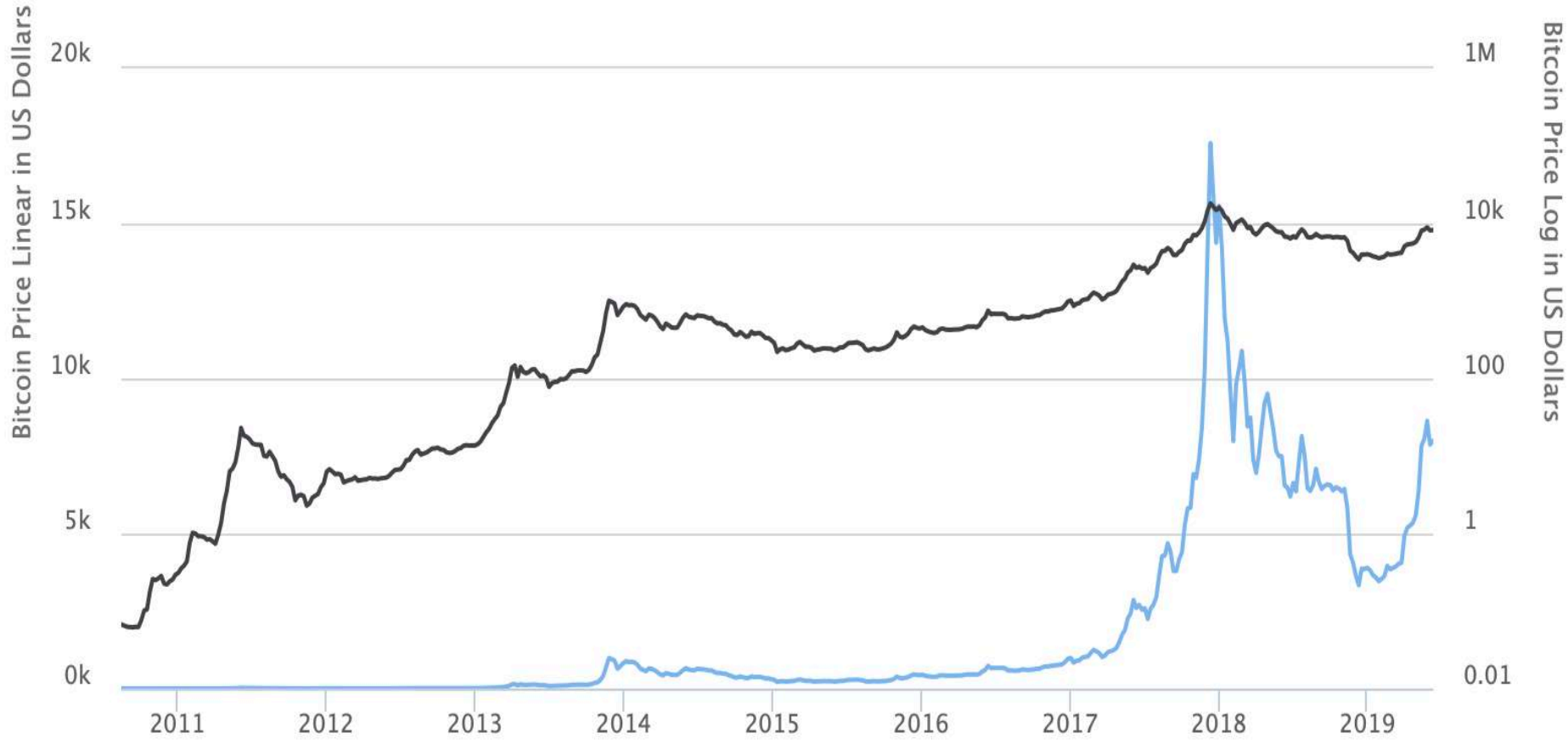
비트코인 네트워크 자체에 영향 X

일반 투자자는 기피

VC들은 투자

(14년 3.6억 달러, 15년 6.5억 달러)

Bitcoin is **anti-fragile**



블록체인이란 무엇인가?	Open Distributed Ledger, 거래, 효율성, 신뢰, 중앙화
비트코인의 등장	거인의 어깨, Byzantine generals, Hash, Digital signature, Chain
개발 동기	제네시스 블록(금융위기), Cyberpunk, 중앙화, 신뢰, 프라이버시, 암호학
중앙화의 문제	Trust, Single point of failure, Tyranny, Overhead cost
중개자 없는 P2P 거래	직접 거래, 대다수가 정직, 다수결, 합의 알고리즘, 컴퓨팅 파워, 보상 인센티브
특징	Decentralization, Immutability , Transparency, Programmability
의의	DLT, IoV, DAO, Trustless, Bootstrapped, Fat protocol, Anti-fragile

HOW

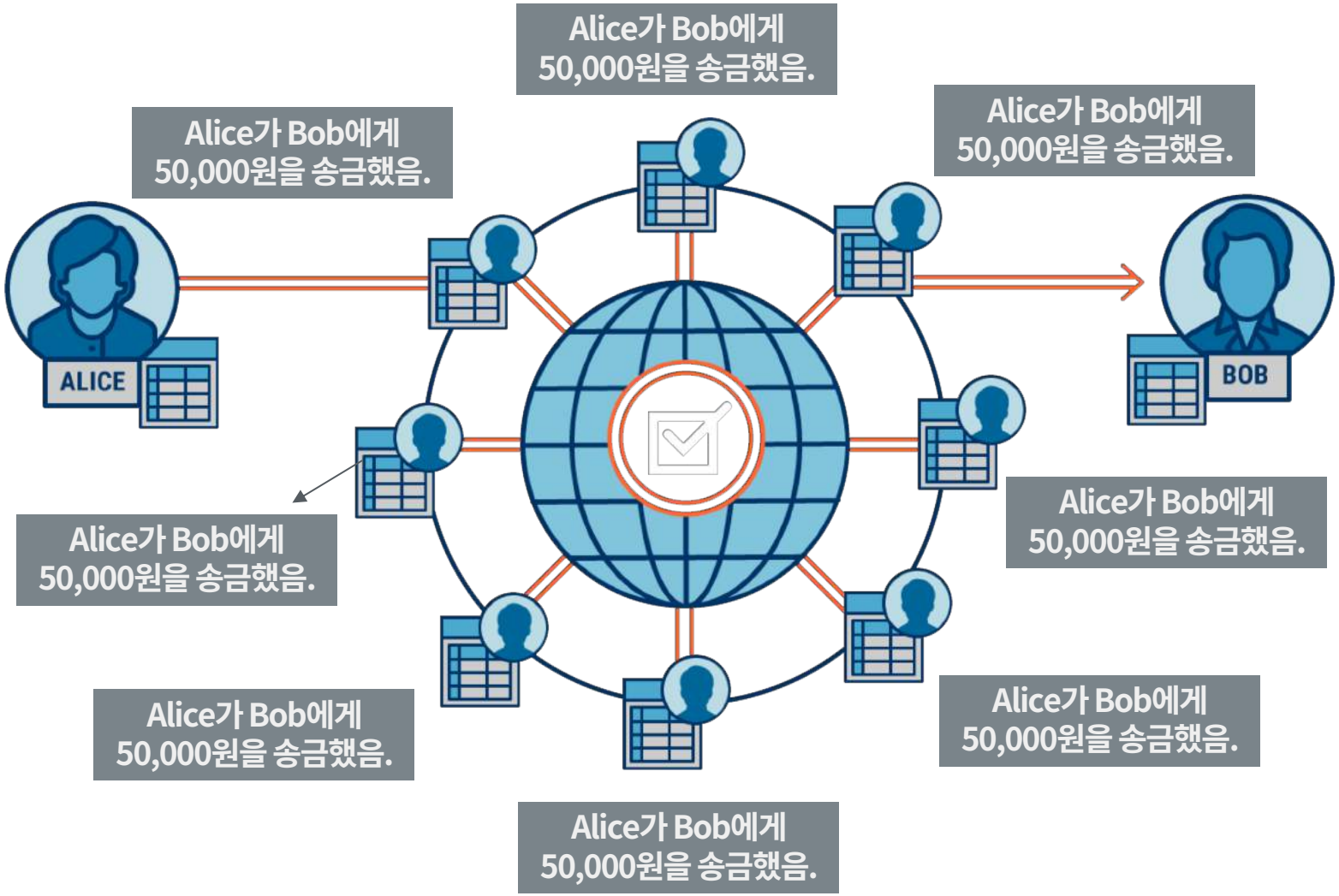
CHAPTER2 합의 알고리즘과 거버넌스

중개자 없는 P2P 거래: **Trustless**

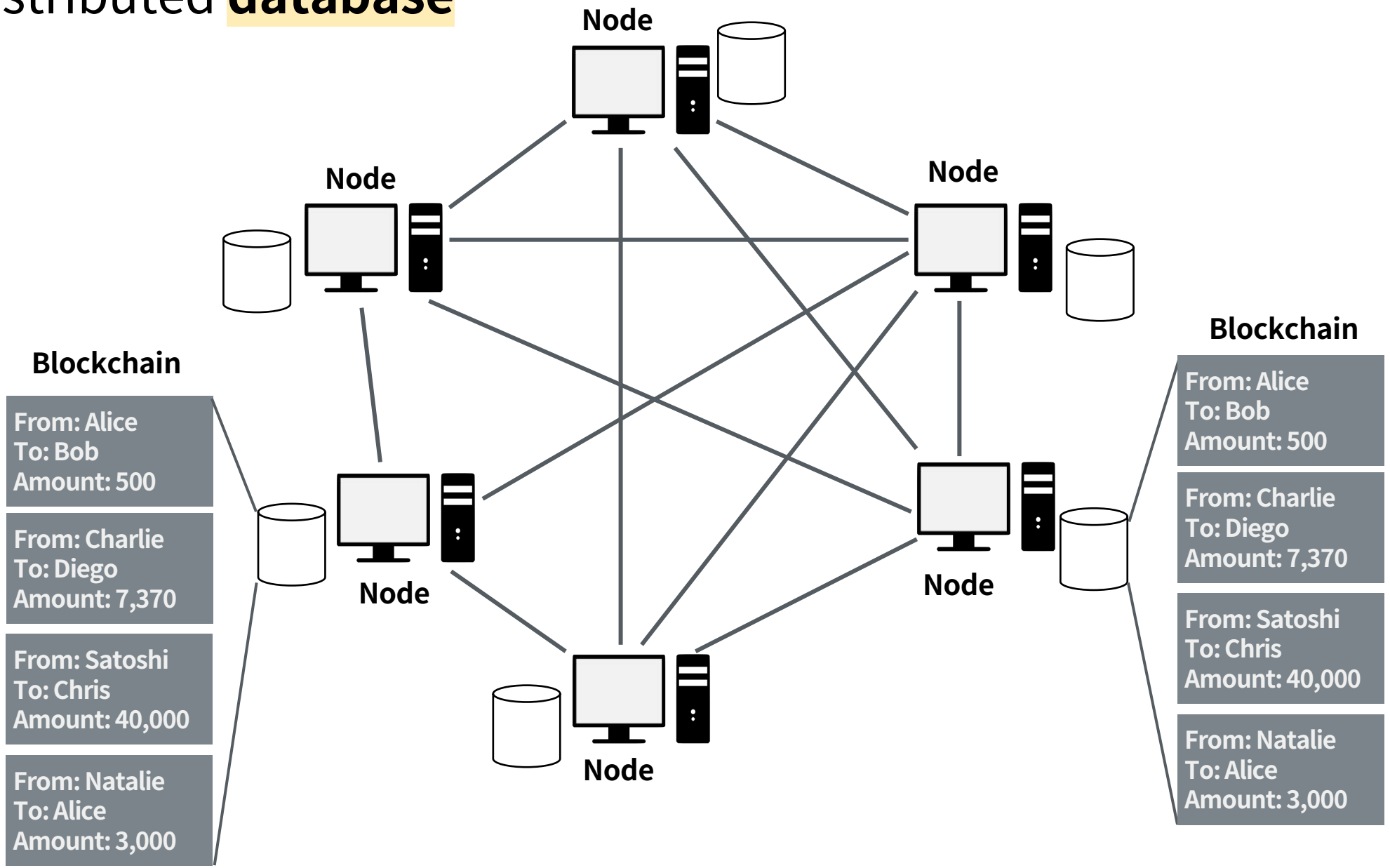
I’ve developed a new open source **P2P** e-cash system called Bitcoin. It's completely **decentralized, with no central server or trusted parties**.

Users hold the crypto keys to their own money and **transact directly with each other**, with the help of the **P2P network to check for double-spending**.

Open distributed **ledgers**



Open distributed **database**



분산 장부의 목표: **동일한 장부**의 유지

언제나 대다수의 노드가 **동일한 장부에 합의**

합의를 위해서는 투표와 같은 **다수결 규칙**이 필요

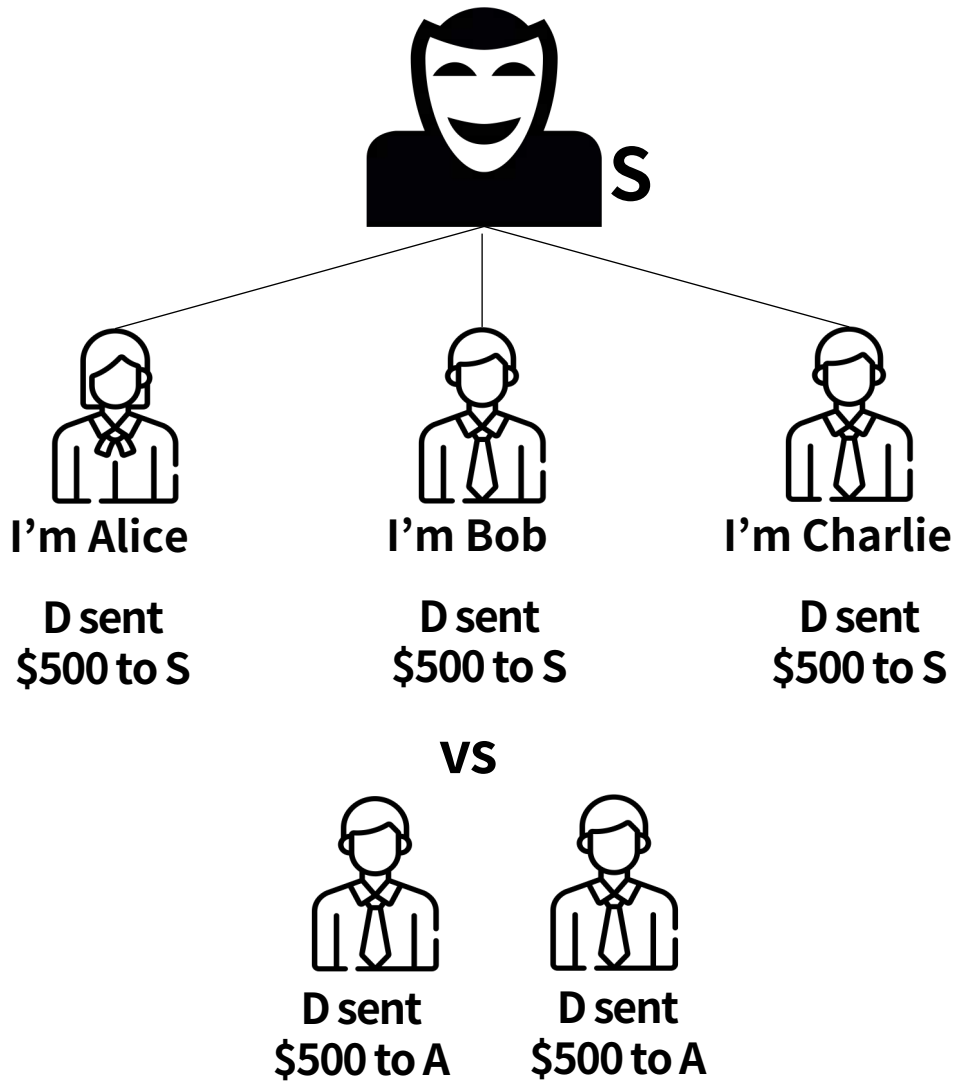
제한된 (폐쇄, 소규모) 네트워크에서 해결

합의 알고리즘

분산 장부의 목표: **동일한 장부**의 유지

Sybil attack

공개 네트워크의 한계



규칙이 필요

Blockchain protocol

누군가가 내 돈을
함부로 쓰지는 않을까

기록하려는 사람이
아무도 없으면?

진짜 동일한 기록일까
아니라고 발뺌하면?

RULES

1.

2.

3.

해결책: 암호학 + 게임이론 + 컴퓨터 과학

누군가가 내 돈을 함부로 쓰지는 않을까	**디지털 서명**
기록하려는 사람이 아무도 없으면?	**기록에 대한 보상**
진짜 동일한 기록일까 아니라고 발뺌하면?	**해시 함수 + PoW**

해결책: 암호학 + 게임이론 + 컴퓨터 과학

누군가가 내 돈을
함부로 쓰지는 않을까

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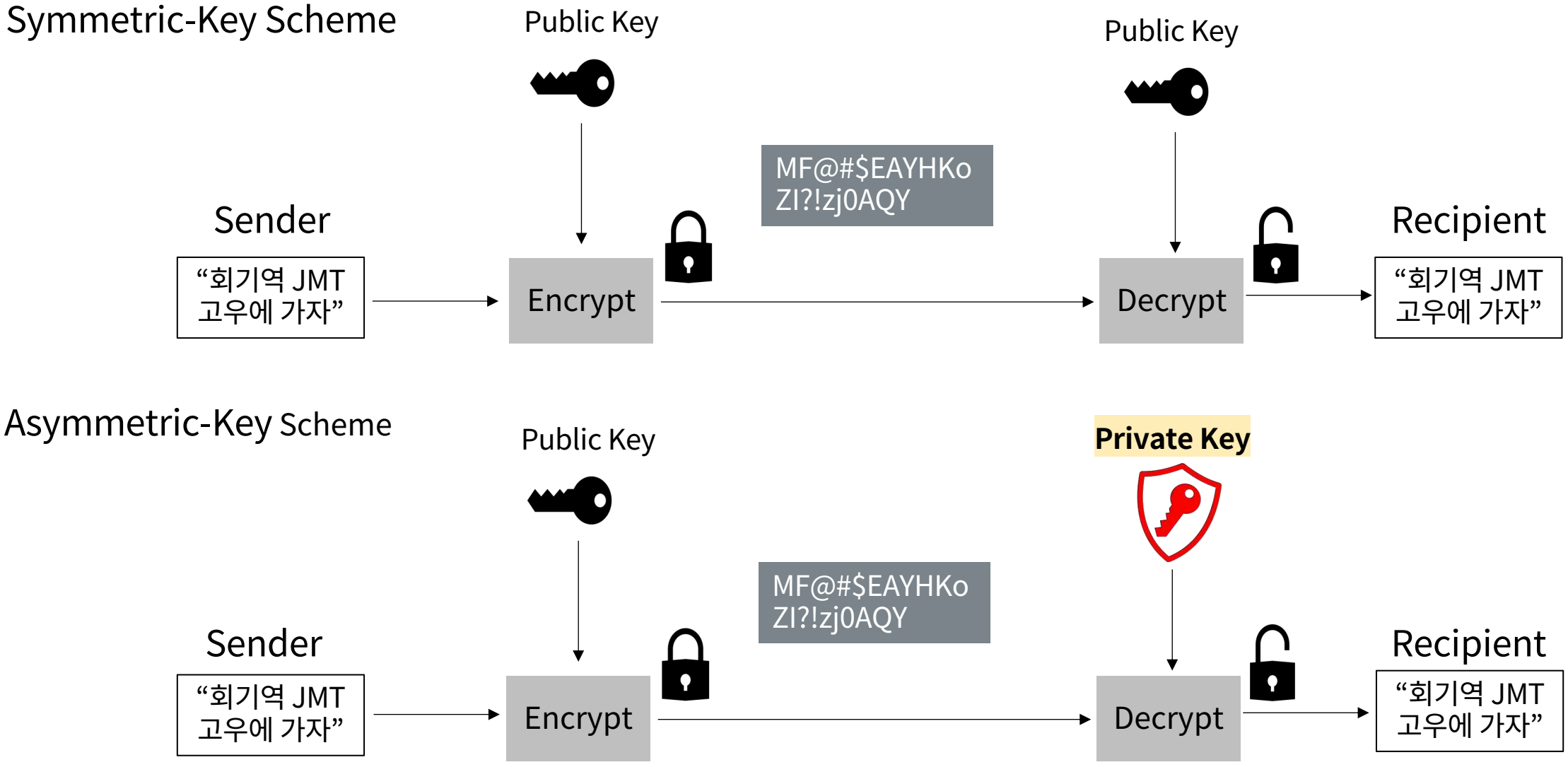
기록하려는 사람이
아무도 없으면?

기록에 대한 보상

진짜 동일한 기록일까
아니라고 발뺌하면?

해시 함수 + PoW

Encryption and Key Scheme (ref #6)

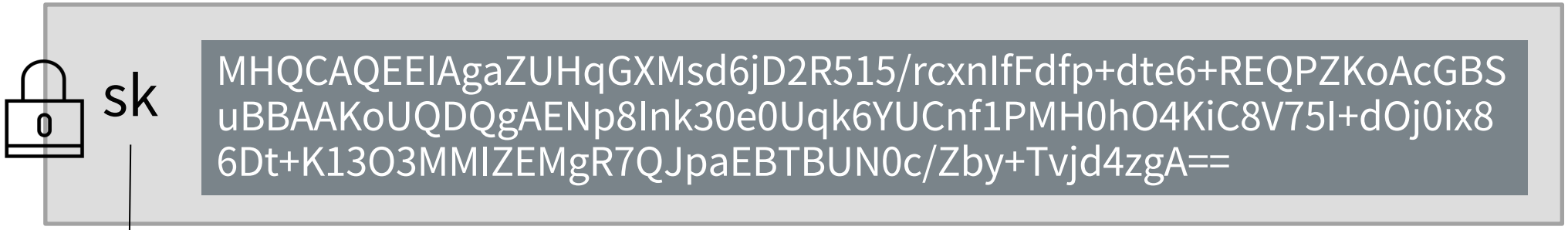


Encryption and Key Scheme

Symmetric-Key Scheme

Asymmetric-Key Scheme

Digital signature: Pk는 Sk로부터 (거의) 유일하게 계산된다 (ref #7)



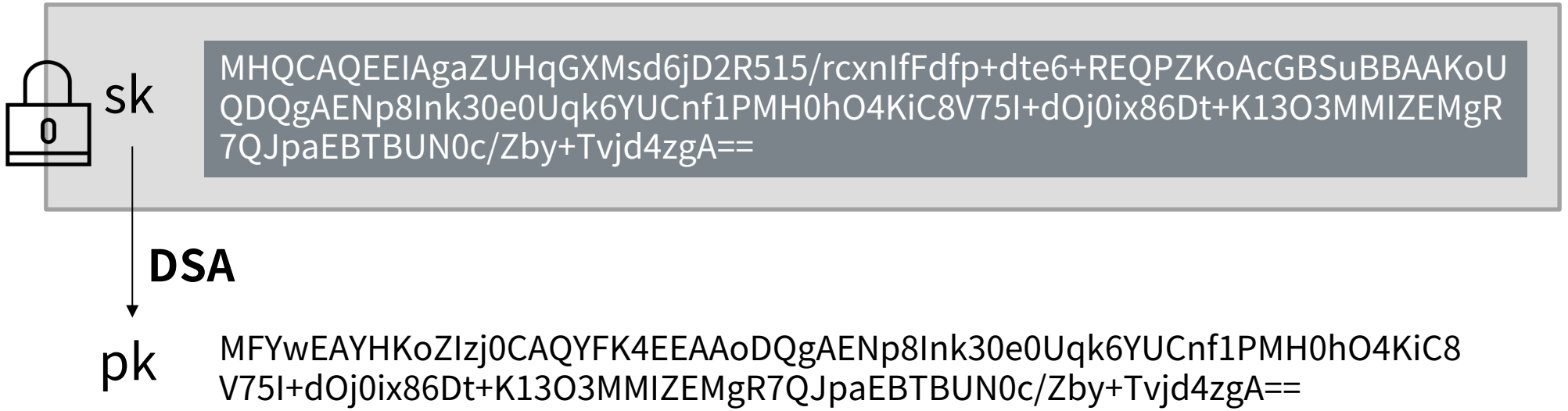
Digital Signature Algorithm

ed25519, secp256k1, secp256r1(P-256)

pk

MFYwEAYHKoZIzj0CAQYFK4EEAAoDQgAENp8Ink30e0Uqk6YUCnf1PM
H0hO4KiC8V75I+dOj0ix86Dt+K13O3MMIZEMgR7QJpaEBTBUN0c/Zby+
Tvjd4zgA==

Digital signature: Sk로 서명하고, 이 서명과 Pk로 검증한다 (ref #7)



Sign(Message, **sk**) = **Signature**

Verify(Message, **Signature**, **pk**) = T/F

Digital signature: 서명은 메시지마다 (거의) 유일하게 결정된다 (ref #7)

Sign(Message, **sk**) = *Signature*

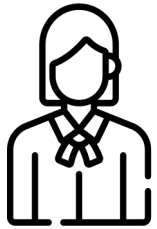
I will give you **500** dollars

MEUCIQD1/HQHlNLUjuUgtcsGU6w/lU9X
uuX7bFPT5BOXOCiA3wIgCfcKeWuwVUOL
u4aIk20C+AfTff/4u2LJLnNquL4NOLs=

I will give you **5000** dollars

MEQCIHGa+a4M4f+BuKmhZqaOFWRzUps
Q3LHti83lSpDHkhQUAiBcZ17eopOlltMuW
ZzFXnxo9AzQT60Y2mQpP39WbDW2Vg==

Digital signature: 동일한 메시지를 다른 Sk로 서명하면 결과가 다르다 (ref #7)



Alice

Pk_A

Sk_A

Bob

Pk_B

Sk_B

Alice sends Bob **500** dollars

Sk_A

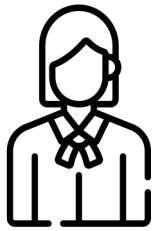
MEUCIQD1/HQHlNLUjuUgtcsGU6w/lU
9XuuX7bFPT5BOXOCiA3wIgCfcKeWuw
VUOLu4aIk20C+AfTff/4u2LJLnNquL4N
OLs=

Alice sends Bob **500** dollars

Sk_B

EMASJAKQa+a4M4f+(^GmhZqaOFWRz
UpsQ3LHti890a7sdkGhQUqwwZ17eop
OlltM56hb!@ADAzQT60Yo98ads21DAD

Digital signature: 서명에 사용된 Sk에 대응하는 Pk만이 True를 리턴한다 (ref #7)



Pk_A
Sk_A

Pk_B
Sk_B

Sign(Message, Sk_A) = *Signature*

Verify(Message, *Signature*, Pk_A) = **True**

Verify(Message, *Signature*, Pk_B) = **False**

Digital signature

서명은 메시지마다 (거의) 유일하게 결정된다.

동일한 메시지를 다른 Sk로 서명하면 결과가 (거의) 다르다.

서명에 사용된 Sk에 대응하는 Pk만이 True를 리턴한다.

나만이 내 행동(돈)에 대해 서명할 수 있다.
이미 서명한 이상 반박할 수는 없다.

거의 유일하게 = 그렇지 않은 경우가 현실적으로 불가능 (**Infeasible**)

$$2^{256} = (2^{32})^8$$

1600경

≒ (40억) (40억) (40억) (40억) (40억) (40억) **(40억) (40억)**

최고급 GPU ≒ 초당 약 10억 번

GPU 4대(**40억 번**) 장착한 PC **40억 개**

40억 명

40억 개의 지구

40억 초 ≒ 126.8년

126.8년 * **40억** ≒ 5,070억 년

거의 유일하게 = 그렇지 않은 경우가 현실적으로 불가능 (**Infeasible**)

$$2^{256} = (2^{23})^{11.xx} = (2^{18})^{14.xx}$$

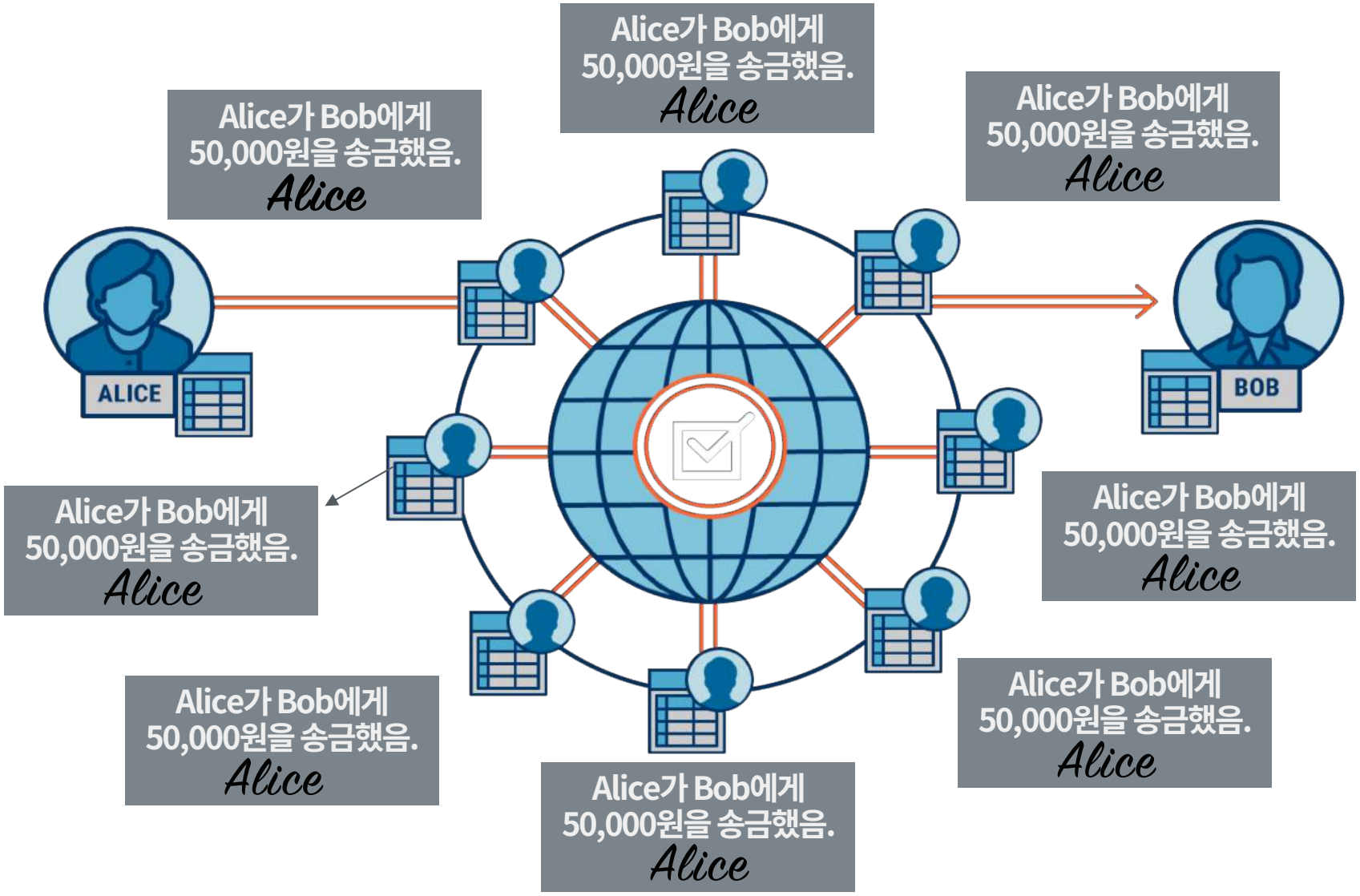
로또 1등 맞을 확률 = 1 / 8,145,060 ≒ 1/ 2^{23}

로또 1등을 연속으로 **11번** 당첨될 확률

벼락 맞을 확률 ≒ 1/ 280,000 ≒ 1 / 2^{18}

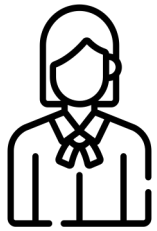
벼락을 연속으로 14번 맞을 확률

Distributed ledgers with digital signature



RULES

1. 비트코인을 송금하는 사람은 거래에 자신의 디지털 서명을 포함시켜야 한다.



Pk_A
Sk_A

Sign('Alice sends 10 btc to Bob', Sk_A) = *Alice's Signature*

해결책: 암호학 + 게임이론 + 컴퓨터 과학

누군가가 내 돈을
함부로 쓰지는 않을까

디지털 서명

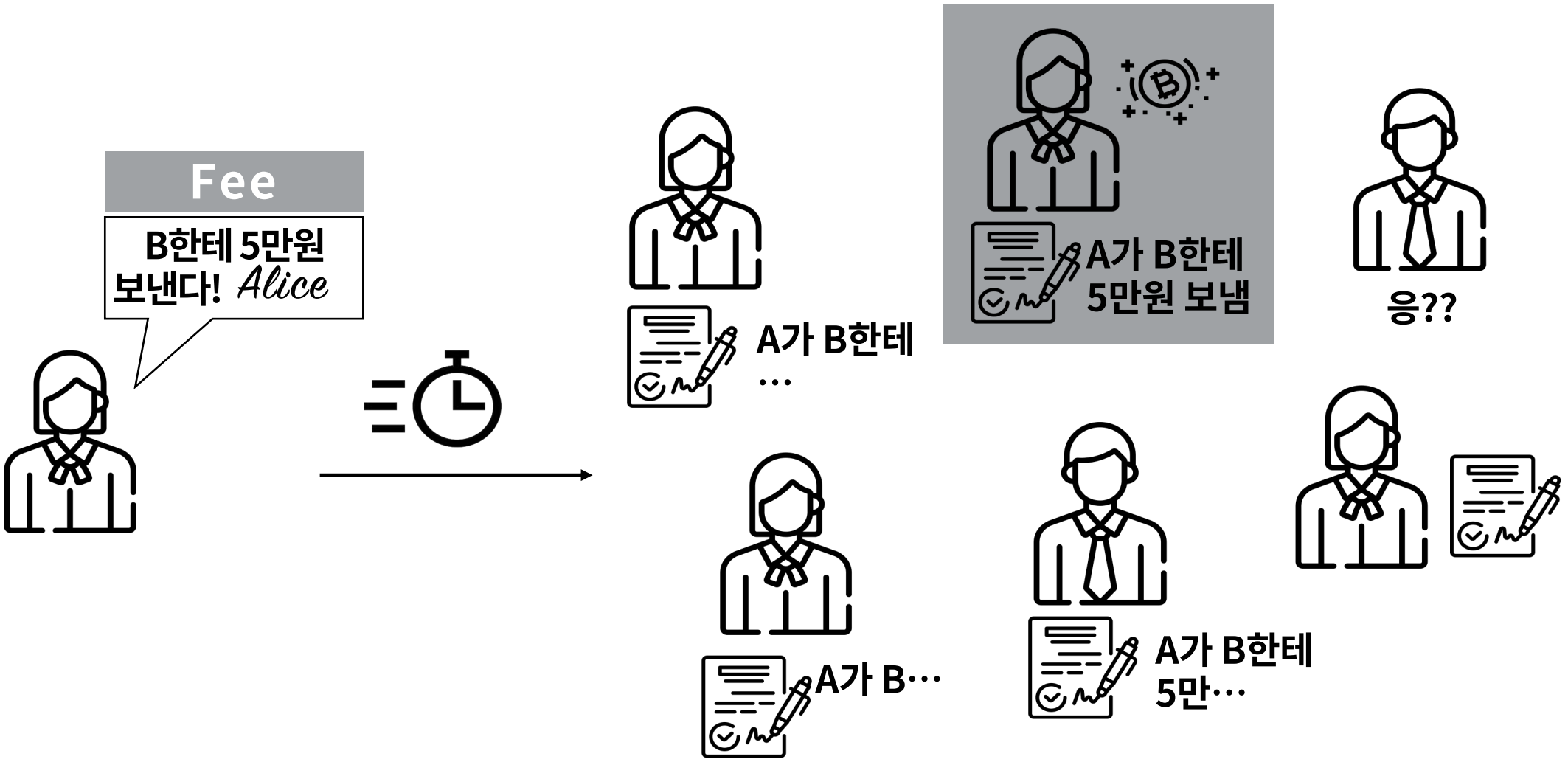
기록하려는 사람이
아무도 없으면?

기록에 대한 보상

진짜 동일한 기록일까
아니라고 발뺌하면?

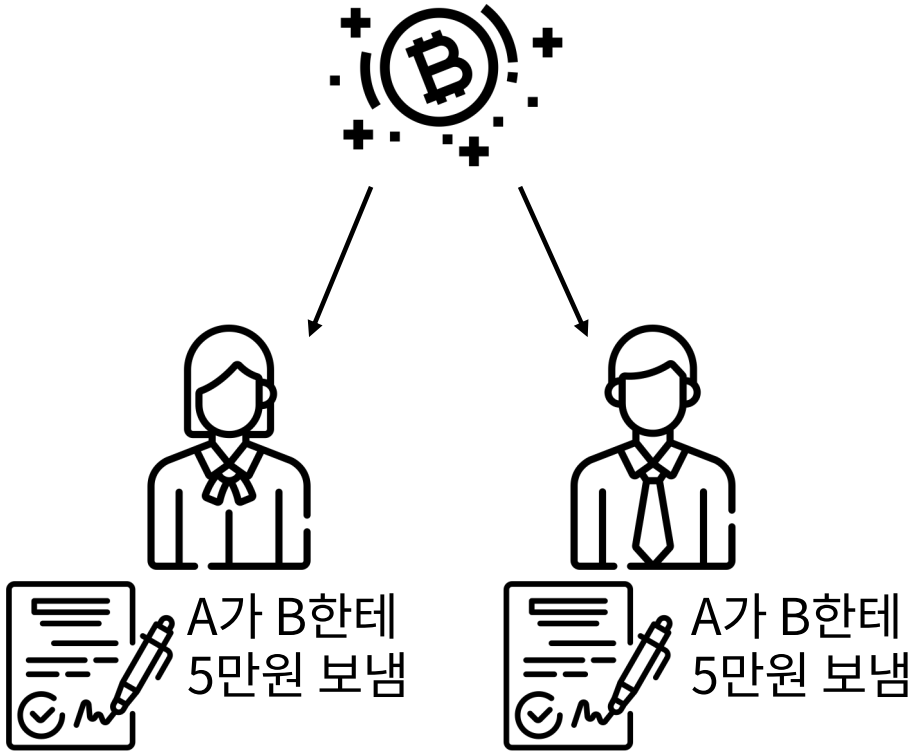
해시 함수 + PoW

제일 먼저 기록한 사람이 보상을 가져간다



제일 먼저 기록한 사람이 보상을 가져간다

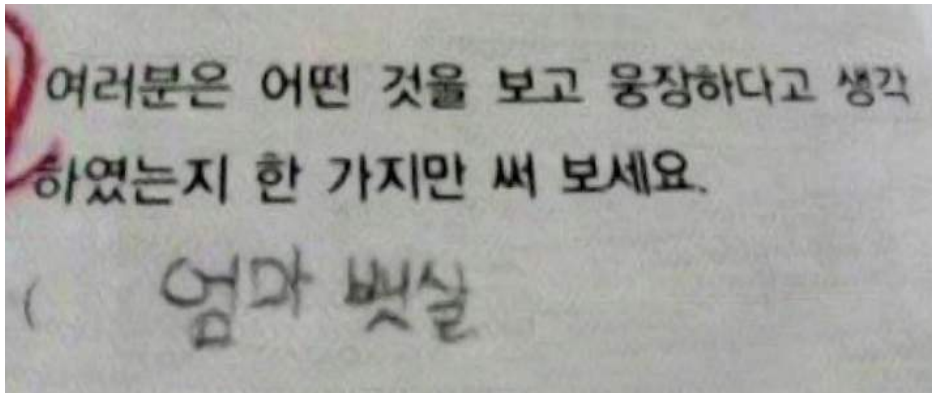
제일 먼저???



경쟁

문제를 **가장 빨리**

맞춘 사람이 승리



RULES

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2. 문제를 가장 빨리 맞춘 사람이 기록이 공식 기록으로 인정되고,
기록의 대가로 보상을 받는다.

RULES

1. 비트코인을 송금하는 사람은 거래에 자신의 디지털 서명을 포함시켜야 한다.
2. 문제를 가장 빨리 맞춘 사람이 기록이 공식으로 인정되고, 그 대가로 보상을 받는다.

해결책: 암호학 + 게임이론 + 컴퓨터 과학

누군가가 내 돈을
함부로 쓰지는 않을까

디지털 서명

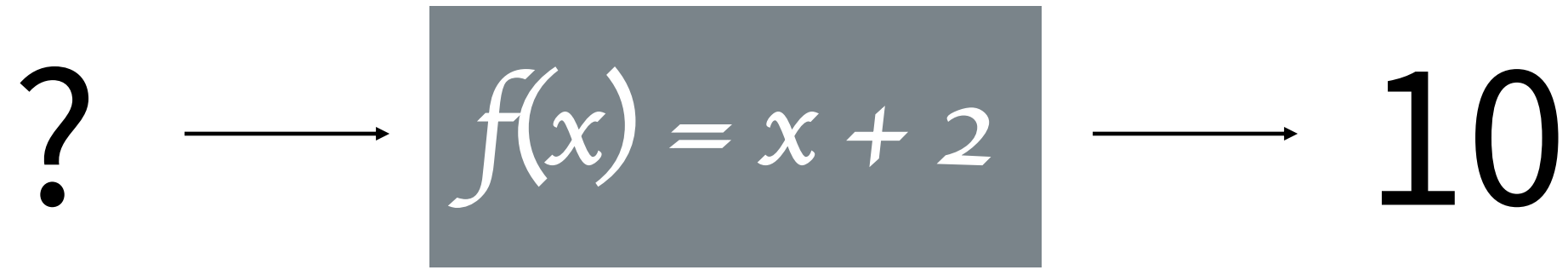
기록하려는 사람이
아무도 없으면?

기록에 대한 보상

진짜 동일한 기록일까
아니라고 발뺌하면?

해시 함수 + PoW

함수의 **결과값**을 보고 **입력값** 맞추기



함수의 **결과값**을 보고 **입력값** 맞추기 (**Hash Puzzle**)

(Cryptographic) Hash Function (ref #8)

임의의 길이의 데이터를 **고정된 길이**의 데이터로 매핑하는 함수

Deterministic

$x = y \Rightarrow h(x) = h(y)$

Cryptographic Hash Function

Collision resistance

같은 결과값을 갖는 서로 다른 입력값을 찾기가 **실질적으로 불가능**

$x \neq y \Rightarrow h(x) \neq h(y)$

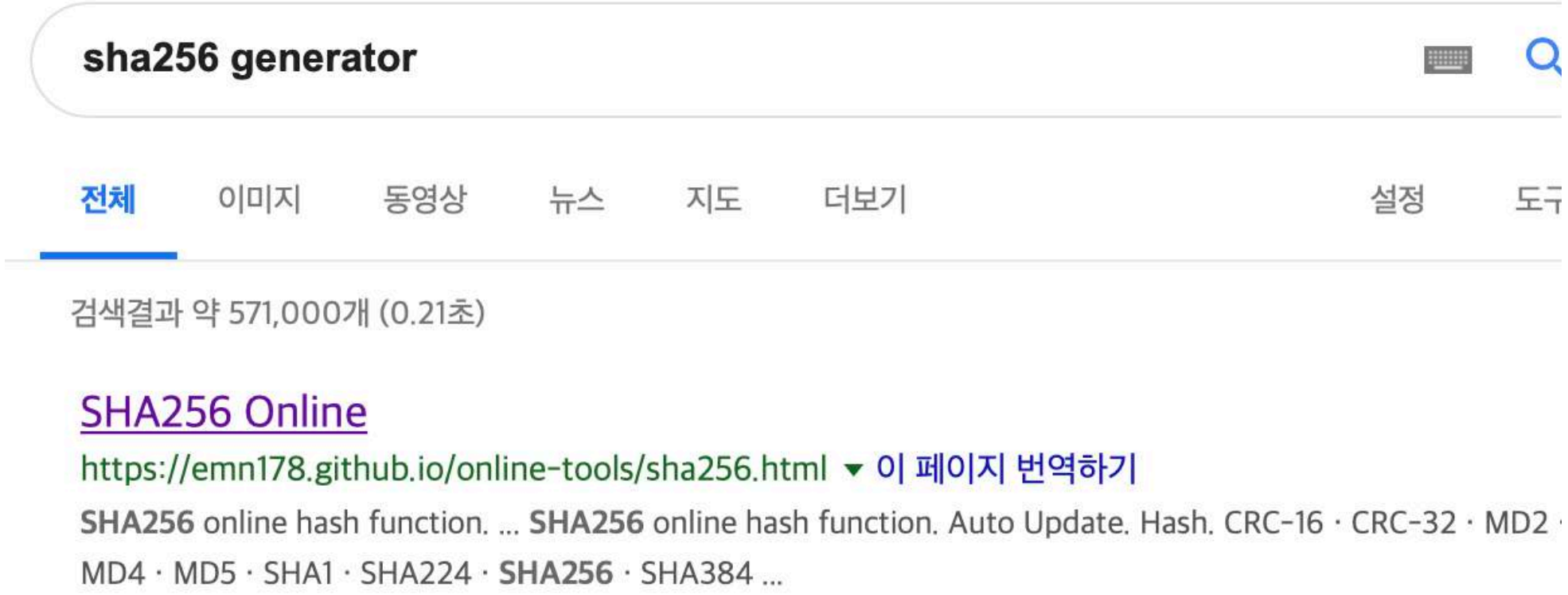
Hiding

결과값을 가지고 입력값을 찾기가 **실질적으로 불가능**

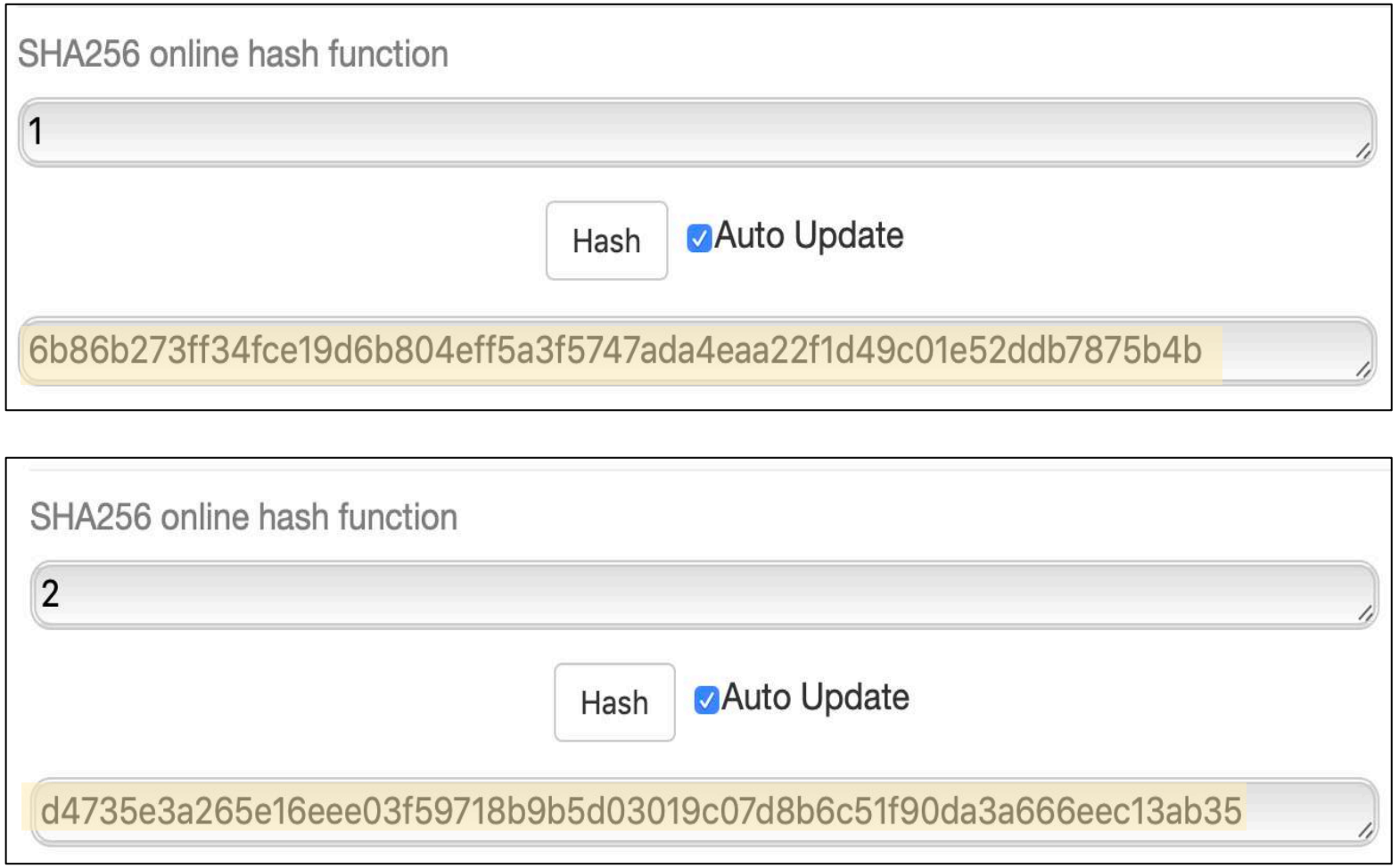
Puzzle friendliness

무작위로 찾는게 **현재로선 최선**

Secure Hash Algorithm with 256 bits (ref #8)



Secure Hash Algorithm with 256 bits (ref #8)



Applications of SHA: Digital fingerprint, Message digest (ref #8)

내 전 재산 중 **5%**를 ㅇㅇㅇ에 기부한다.

→

6BC1820A9BC0EB207F86741A22DCE5460
C959655A73FB3BDF2581B62FEF631CF

내 전 재산 중 **95%**를 ㅇㅇㅇ에 기부한다.

→

7A32C64C3AE19CEC3809E6DAC5B10A59F
58AEFF127907446F59A8375830D573A

고대 근처 맛집 리스트
대성집: 해장국 핵존맛, 수육 캬
고른햇살: 김혜자 쓰앵님 이상의 가성비 분식
형제집: 아재감성 술집쓰. 오돌뼈, 닭도리탕...
용초수: 꿔바로우 하... 토마토볶음 오...
유자유: 김치떡볶이 + 비빔밥
오샬: 인도커리 냠냠
춘자: 핵 저렴한 술집
회기역 근처 이자카야 고우 꼭 가세요. JMT!
회기역 근처 이자카야 고우 두 번 가세요!!!
...

→

9DC44C08F26189C2DB2ECB5B0711348D
CDE76DAC6227F39ACB33CB0882BD3A6E

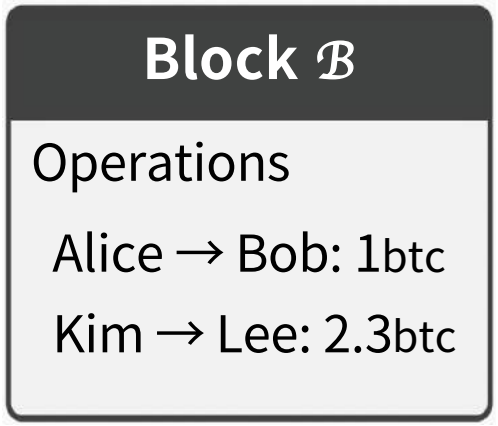
Hash puzzle in Bitcoin

블록의 해시 값이 **특정 조건**을 만족해야 적법한(**valid**) 블록으로 인정

특정 조건을 만족하도록 블록을 만들자!

Hash puzzle in Bitcoin

블록의 해시 값이 **특정 조건**을 만족해야 적법한(**valid**) 블록으로 인정



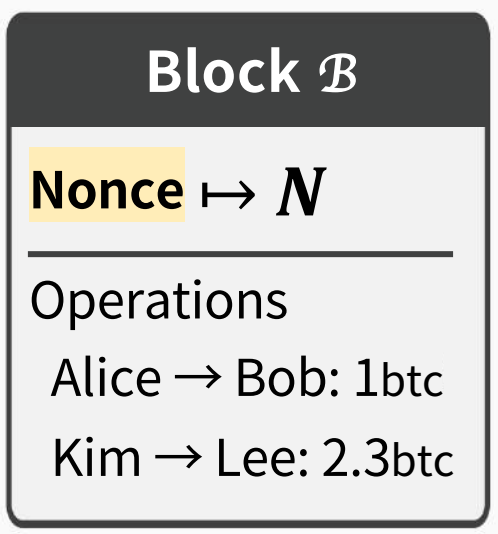
$\mathcal{H}ash(\mathcal{B})$ = 0347C308D64E2DF...D0C23B625031980089 1C3E6D2

$\mathcal{H}ash(\mathcal{B})$ = 0000 0011 0100 0111 ...

$\mathcal{H}ash(\mathcal{B})$가 홀수인가?
$\mathcal{H}ash(\mathcal{B})$를 7로 나눈 나머지가 2인가?
...

Hash puzzle in Bitcoin

블록의 해시 값이 **특정 조건**을 만족해야 적법한(**valid**) 블록으로 인정



$\mathcal{B}_i$ = Block $\mathcal{B}$ with i as a nonce:

$\mathcal{H}ash(\mathcal{B}_0)$ = 0110 1011 0110 1101 ...

$\mathcal{H}ash(\mathcal{B}_1)$ = 0011 0011 0100 0111 ...

...

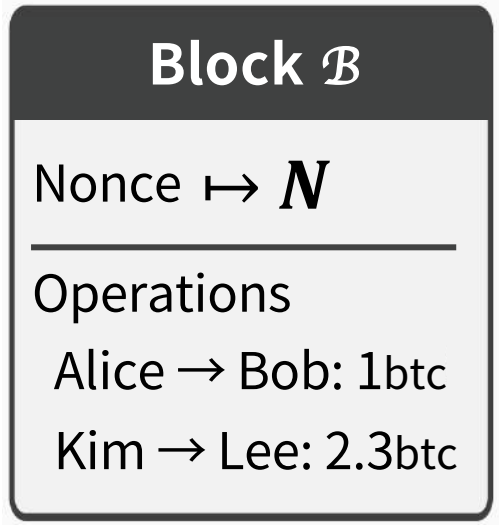
$\mathcal{H}ash(\mathcal{B}_{98})$ = 0000 0110 0110 0101 ...

...

$\mathcal{H}ash(\mathcal{B}_i)$이 5개의 0으로 시작하는 i를 찾아라

Hash puzzle in Bitcoin

$\mathcal{H}ash(\mathcal{B}_i)$이 n개의 0으로 시작하는 i를 찾아라



$\mathcal{B}_i$ = Block $\mathcal{B}$ with i as a nonce

256 0s and 1s

$\mathcal{H}ash(\mathcal{B}_i)$ = 0110 1011 0110 1101 ... 0110 1101 1111

n이 충분히 커지면, 확률적으로 i 역시 커진다

RULES

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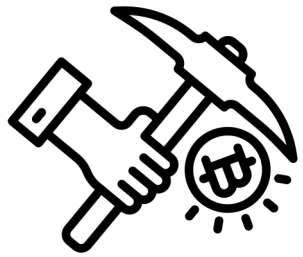
2. 블록의 해시가 n개의 0으로 시작하도록 만드는 논스를 가장 먼저 찾은 사람이 기록이 공식으로 인정되고, 그 대가로 보상을 받는다.
3. 각 블록은 오퍼레이션과 논스로 구성된다.

Mining competition & Coinbase Tx



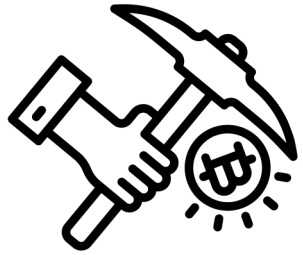
Miner A

Block $\mathcal{B}$

Nonce
2345678999
Operations
Miner A gets 12.5btc
Alice → Bob: 1btc
Kim → Lee: 2.3btc

SHA256

0010101001111100010011101101010010100100011
01001101010000101011000110101110110000111 10
10111000011100111000001100010000011100111 01
11001011011011101000010001011011000111111 10
10101100110001101111001001001100111110101 00
00101011110100000001001111111001011101101



Miner B

Block $\mathcal{B}$

Nonce
6876678999
Operations
Miner A gets 12.5btc
Alice → Bob: 1btc
Kim → Lee: 2.3btc

SHA256

0000000001110010100111110001001110110101001
01001000110100110101000010101100011010111 01
10000000011100111000001100010000011100111 01
11001011011011101000010001011011000111111 10
10101100110001101111001001001100111110101 00
00101011110100000001001111111001011101101

Mining difficulty

n개의 bit로 나타낼 수 있는 경우의 수

$$\overbrace{\boxed{\mathbf{11111...11111}}}^{n} = 2^n$$

Mining difficulty

n개의 bit 중 앞 i개가 0일 때,
나타낼 수 있는 경우의 수

$$\underbrace{0000}_{i}\underbrace{1\ldots11111}_{n-i} \quad (n) = 2^{n-i}$$

Mining difficulty

256개의 bit 중 앞 96개가 0일 때

Output space of SHA256

000000000011111111...11111111

target space

2^{96}

probability

2^{160}

2의 160승도 여전히 매우 큰 수

2^{160} 비트코인 지갑의 개수 (RIPE-MD160)

= 1,460,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

2,045년, 지구 인구 **90억**명

모든 사람이 비트코인 주소 **천만개** 씩 소유

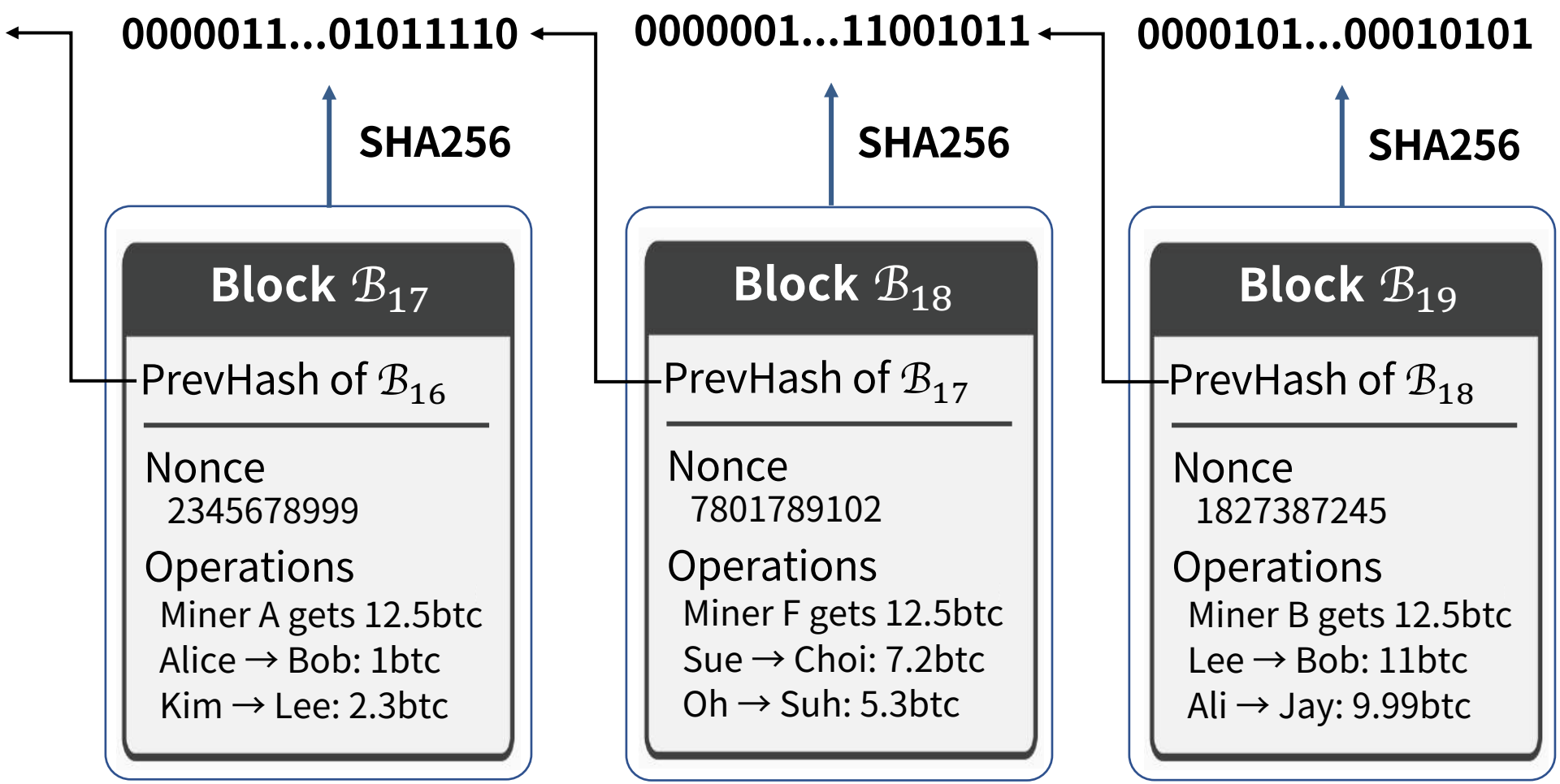
총 **90,000,000,000,000,000개**의 지갑

90,000,000,000,000,000 / 2^{160}

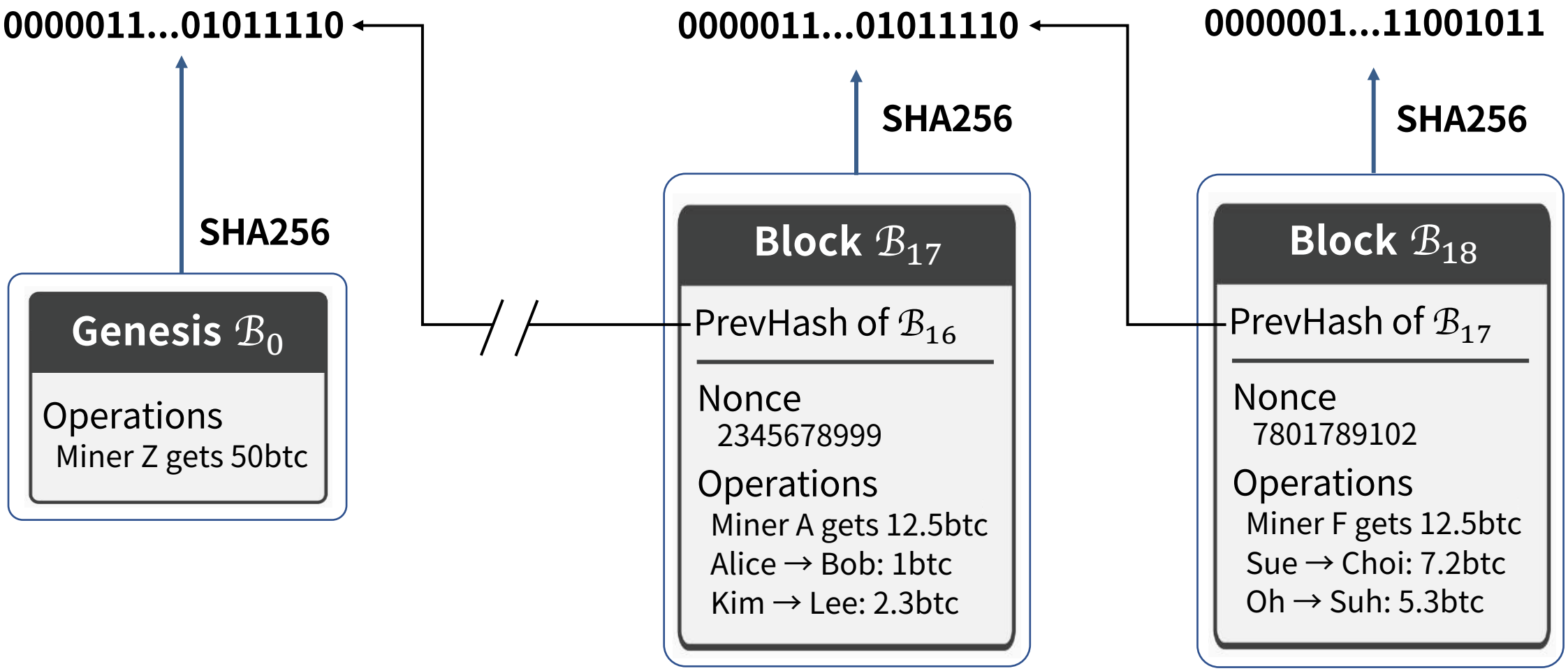
= **0.000000000000000000000000000000615%**

= 전기세, 실제 비트코인이 들어있는지, 얼마나 들어있는지 등은 고려 안 됨

Blockchain = A chain of blocks



Blockchain = A chain of blocks



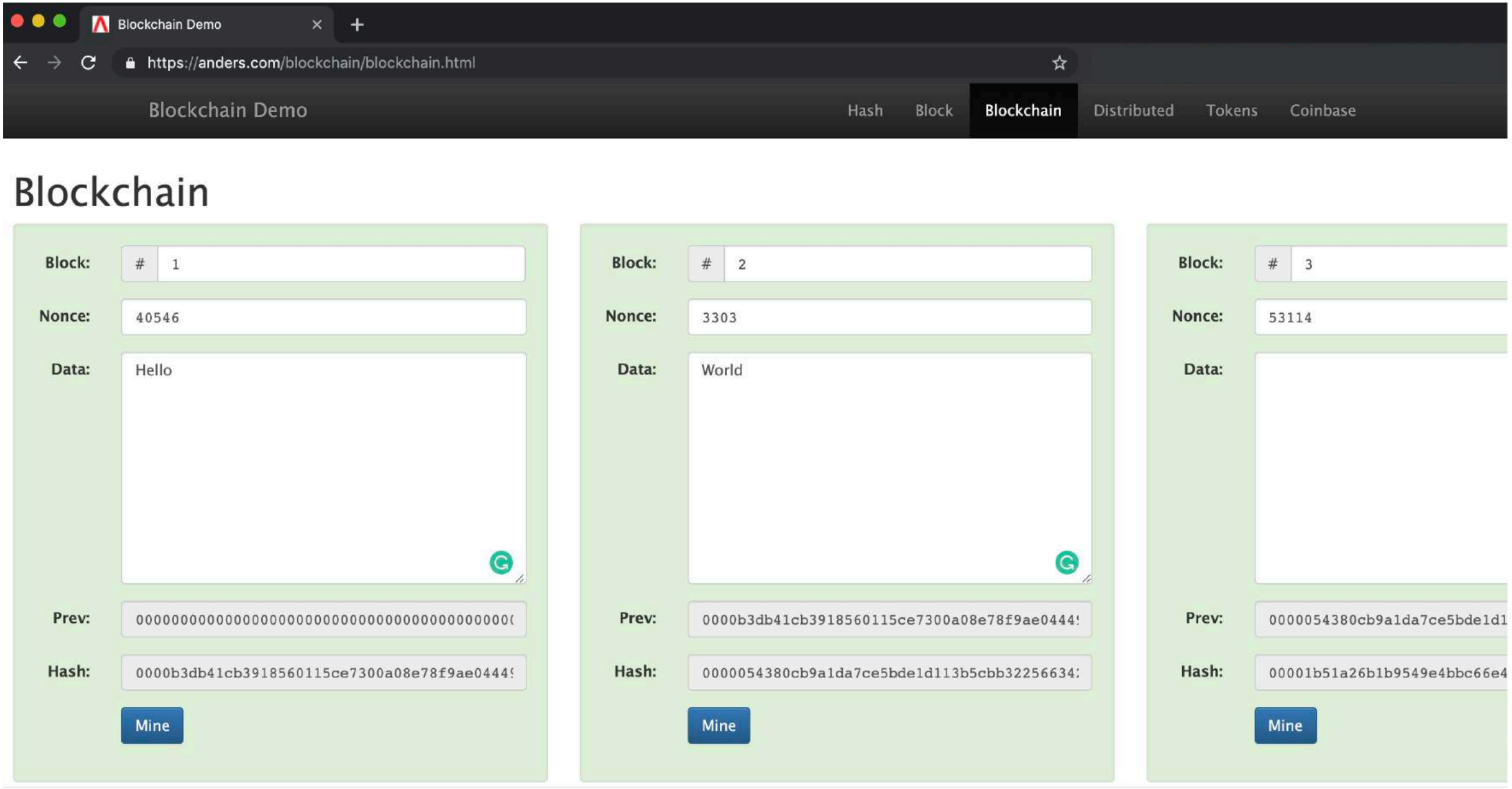
bitcoin/src/chainparams.cpp

```
42   * Build the genesis block. Note that the output of its generation
43   * transaction cannot be spent since it did not originally exist in the
44   * database.
45   *
46   * CBlock(hash=000000000019d6, ver=1, hashPrevBlock=00000000000000, hashMerkleRoot=4a5e1e, nTime=1231006505, nBits=1d00ffff, nNonc
47   *   CTransaction(hash=4a5e1e, ver=1, vin.size=1, vout.size=1, nLockTime=0)
48   *     CTxIn(COutPoint(000000, -1), coinbase 04ffff001d0104455468652054696d65732030332f4a616e2f3230303920436861696e63656c6c6f72206f6
49   *     CTxOut(nValue=50.00000000, scriptPubKey=0x5F1DF16B2B704C8A578D0B)
50   *   vMerkleTree: 4a5e1e
51   */
52  static CBlock CreateGenesisBlock(uint32_t nTime, uint32_t nNonce, uint32_t nBits, int32_t nVersion, const CAmount& genesisReward)
53  {
54      const char* pszTimestamp = "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks";
55      const CScript genesisOutputScript = CScript() << ParseHex("04678afdb0fe5548271967f1a67130b7105cd6a828e03909a67962e0ea1f61deb64
56      return CreateGenesisBlock(pszTimestamp, genesisOutputScript, nTime, nNonce, nBits, nVersion, genesisReward);
57  }
```

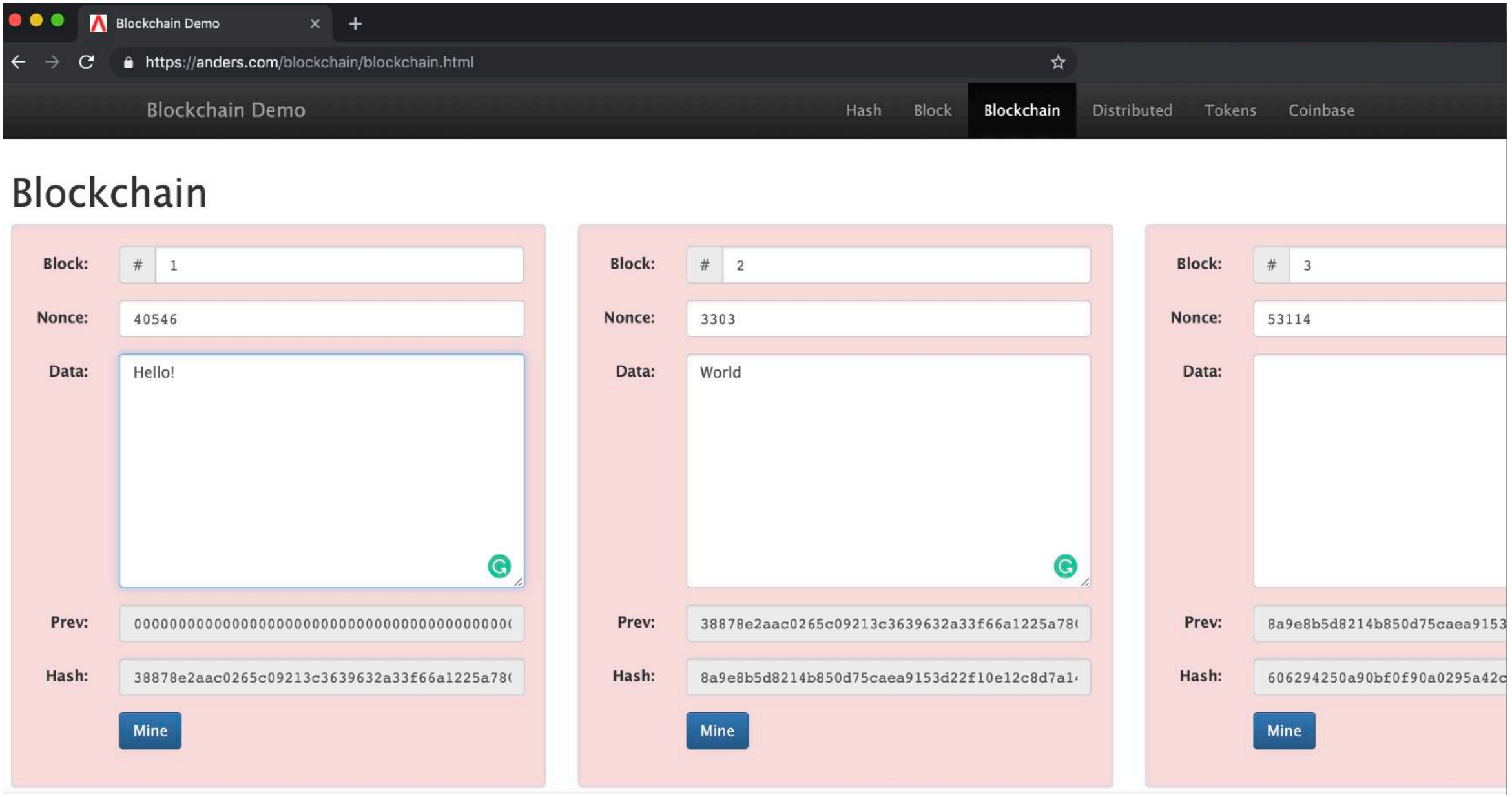
bitcoin/src/chainparams.cpp

```
 *
 * CBlock(hash=000000000019d6, ver=1, hashPrevBlock=00000000000000, hashMerkleRoot=4a5e1e, nTime=1231006505, nBits
 *   CTransaction(hash=4a5e1e, ver=1, vin.size=1, vout.size=1, nLockTime=0)
 *     CTxIn(COutPoint(000000, -1), coinbase 04ffff001d0104455468652054696d65732030332f4a616e2f32303039204368616e6
 *     CTxOut(nValue=50.00000000, scriptPubKey=0x5F1DF16B2B704C8A578D0B)
 *   vMerkleTree: 4a5e1e
 */
static CBlock CreateGenesisBlock(
    uint32_t nTime,
    uint32_t nNonce,
    uint32_t nBits,
    int32_t nVersion,
    const CAmount& genesisReward) {
      const char* pszTimestamp = "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks";
      const CScript genesisOutputScript = CScript() \
        << ParseHex(
            "04678afdb0fe5548271967f1a67130b7105cd6a828e03909a67962e0ea1f61deb649f6bc3f4cef38c4f35504e51ec112de5c384
        << OP_CHECKSIG;
      return CreateGenesisBlock(pszTimestamp, genesisOutputScript, nTime, nNonce, nBits, nVersion, genesisReward);
}
```

Blockchain Demo: Finding nonce (ref #9)



Blockchain Demo: Finding nonce (ref #9)



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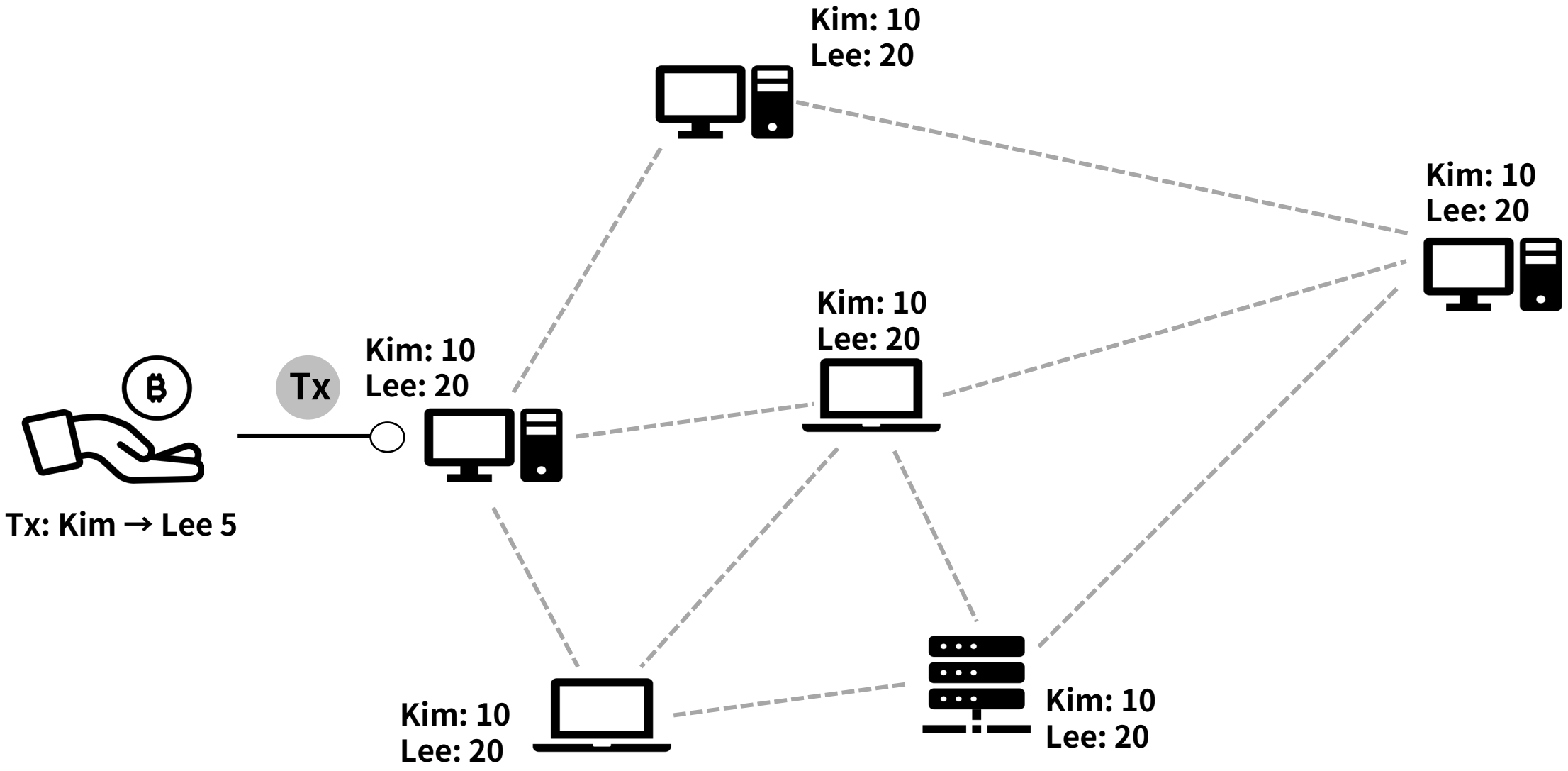
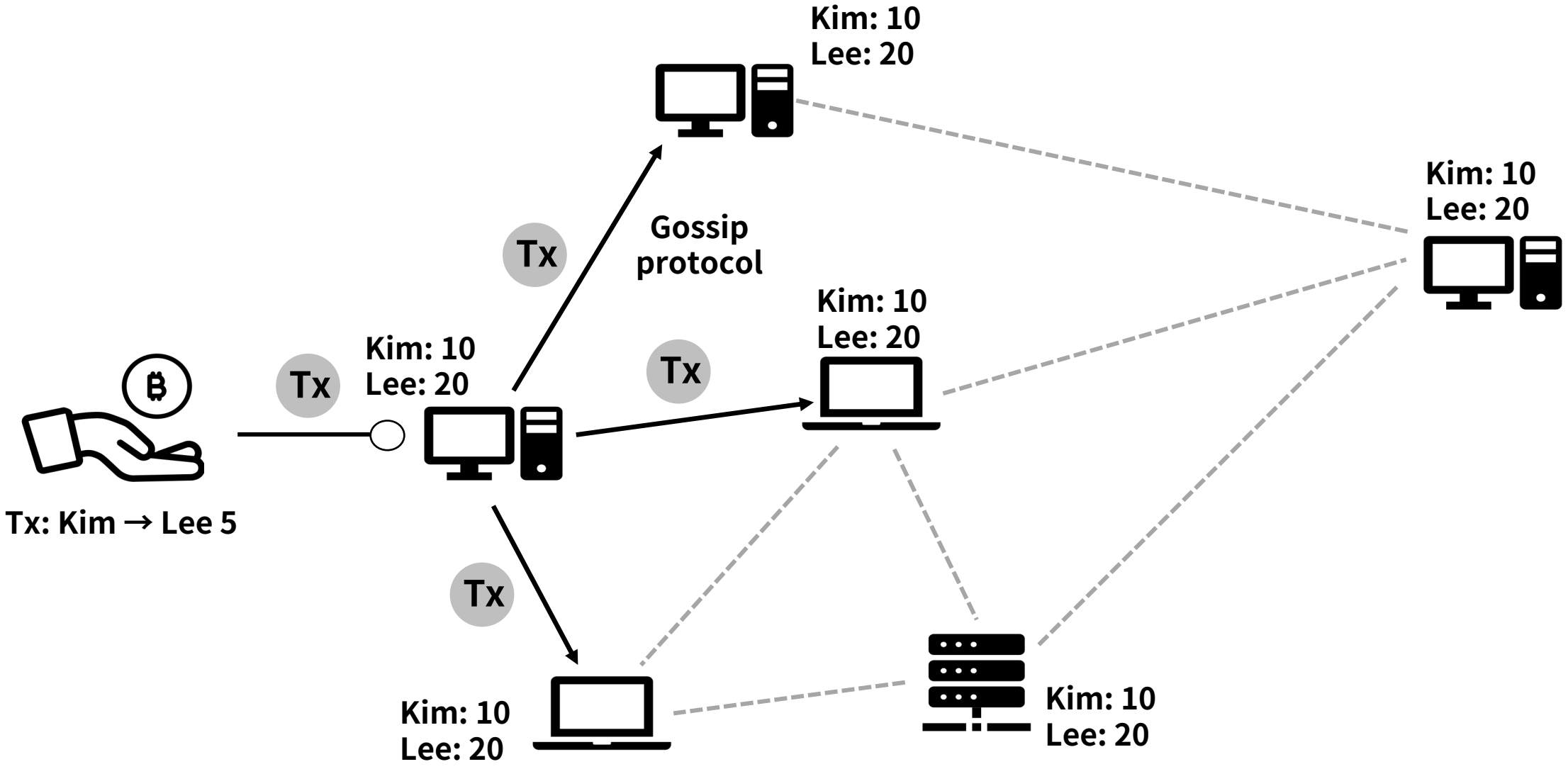
2. 각 블록은 이전 블록의 해시, 오퍼레이션, 이전 블록의 해시, 논스로 구성된다.
3. 제일 먼저 블록의 해시를 난이도보다 낮게 만든 채굴자가 보상을 받는다.
4. 채굴자는 블록에 보상(코인베이스 트랜잭션)을 포함시킨다.
5. 새 블록의 해시는 $\mathcal{H}ash$(이전 블록의 해시 + 오퍼레이션 + 논스)이며, 논스를 바꿔가며 목표 해시를 찾는다.

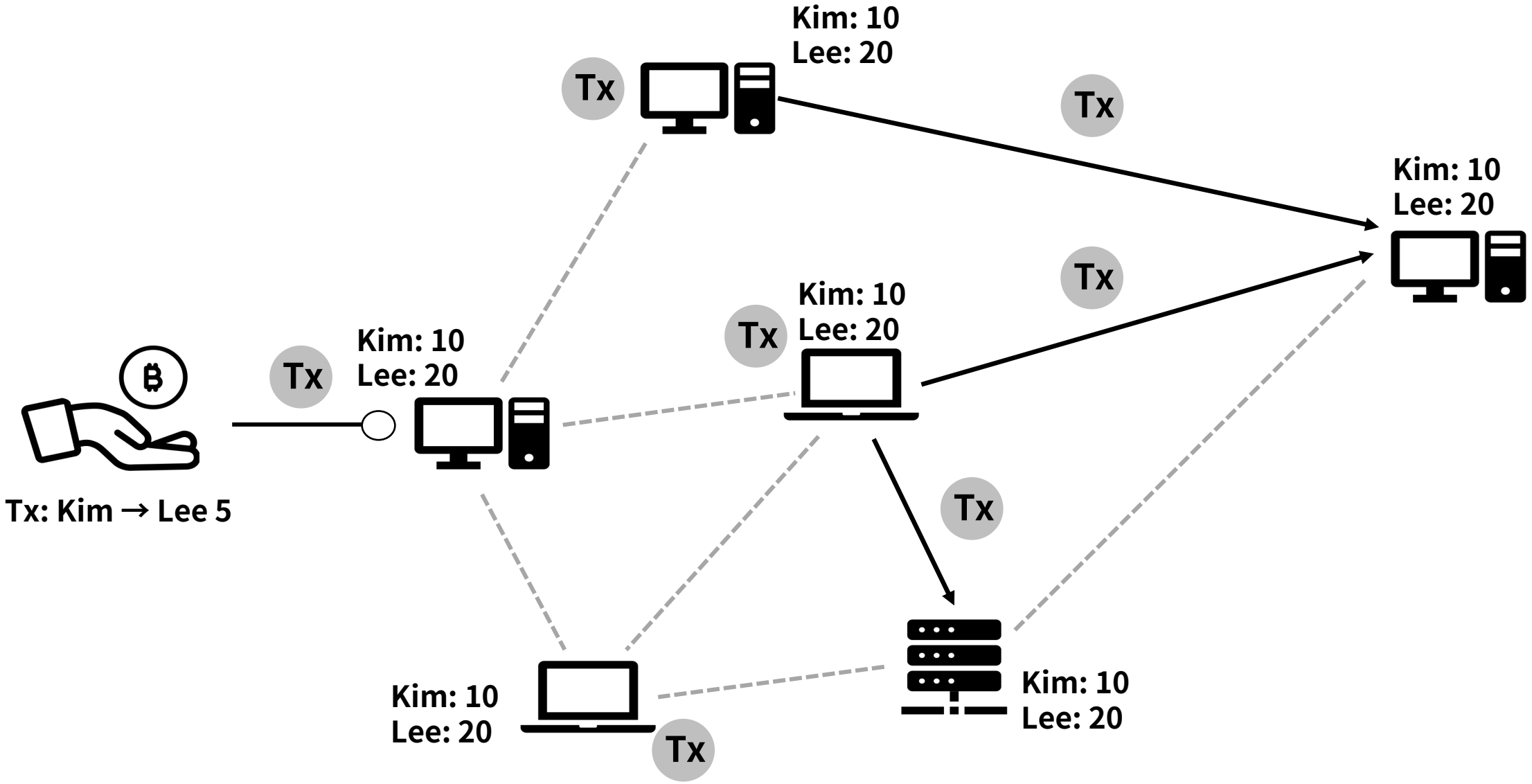
Life cycle of transaction



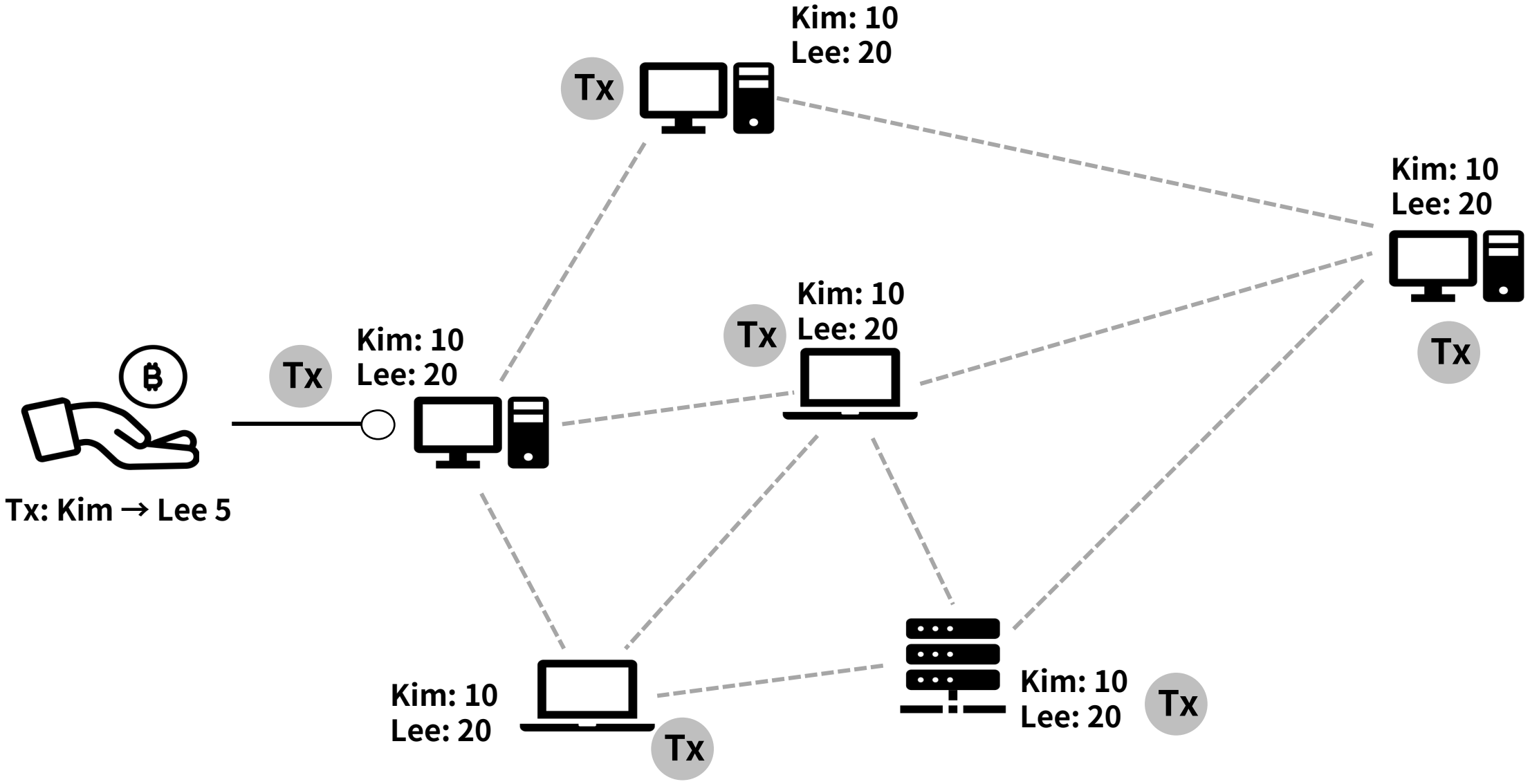
Life cycle of transaction



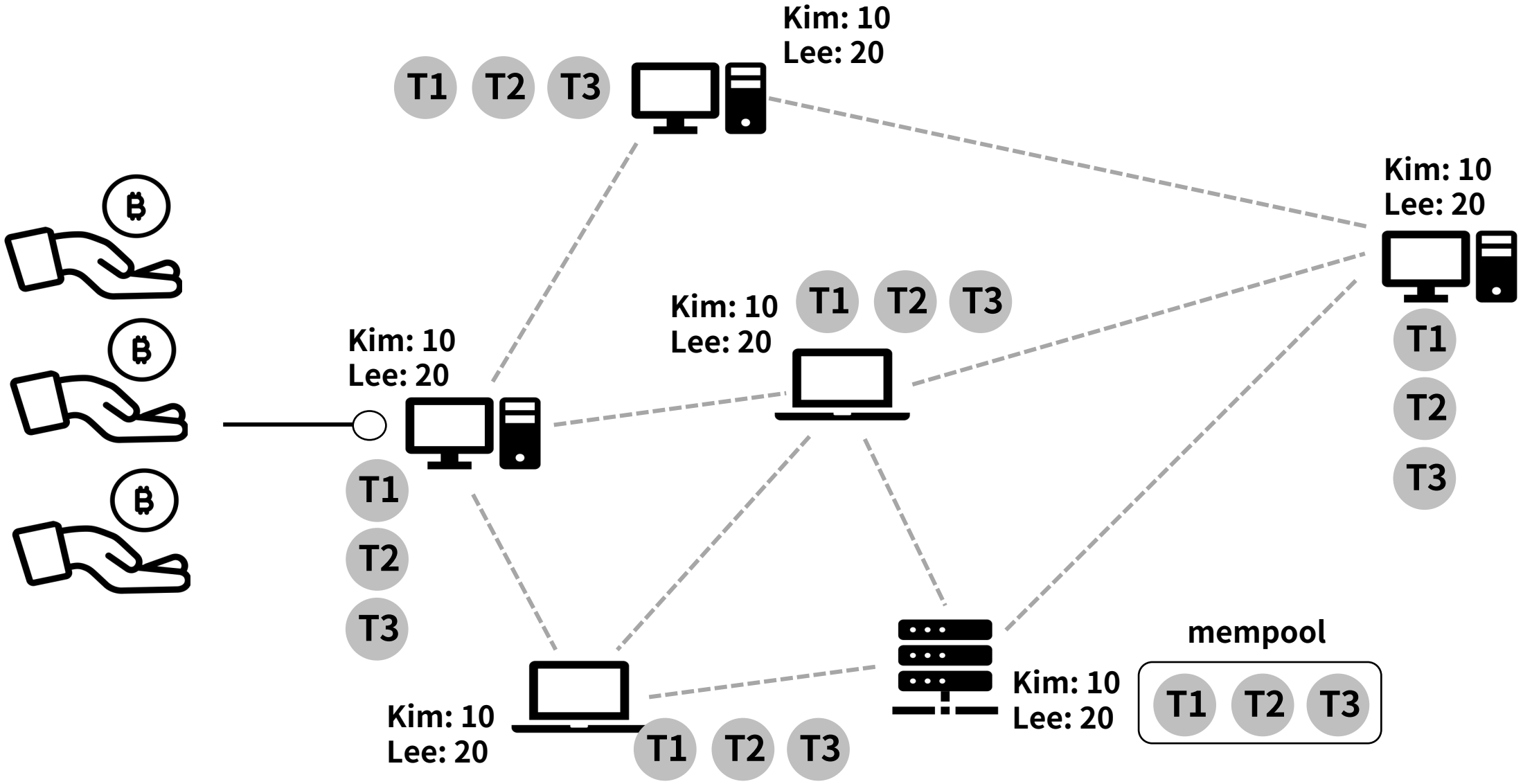
Life cycle of transaction



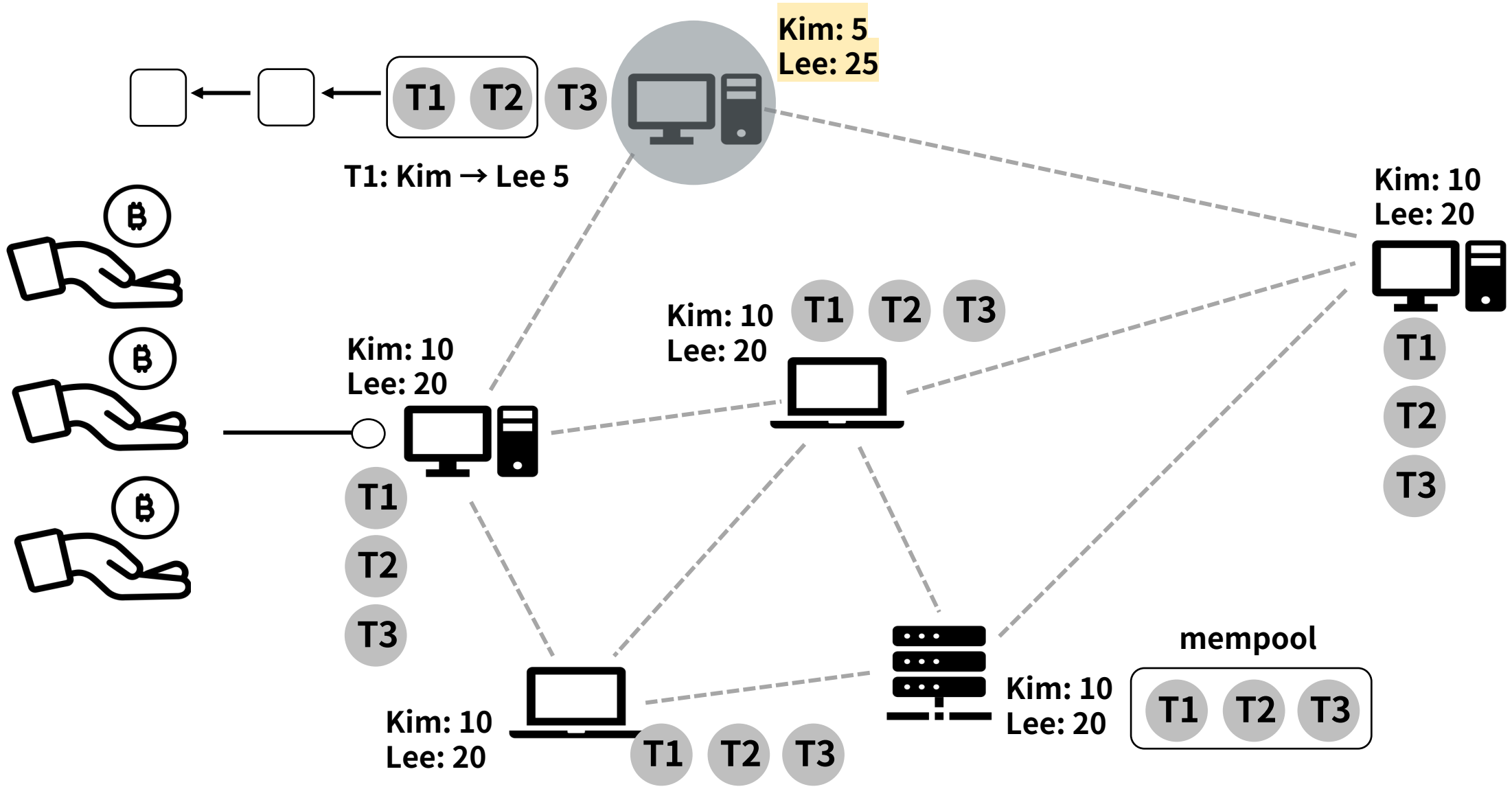
Life cycle of transaction



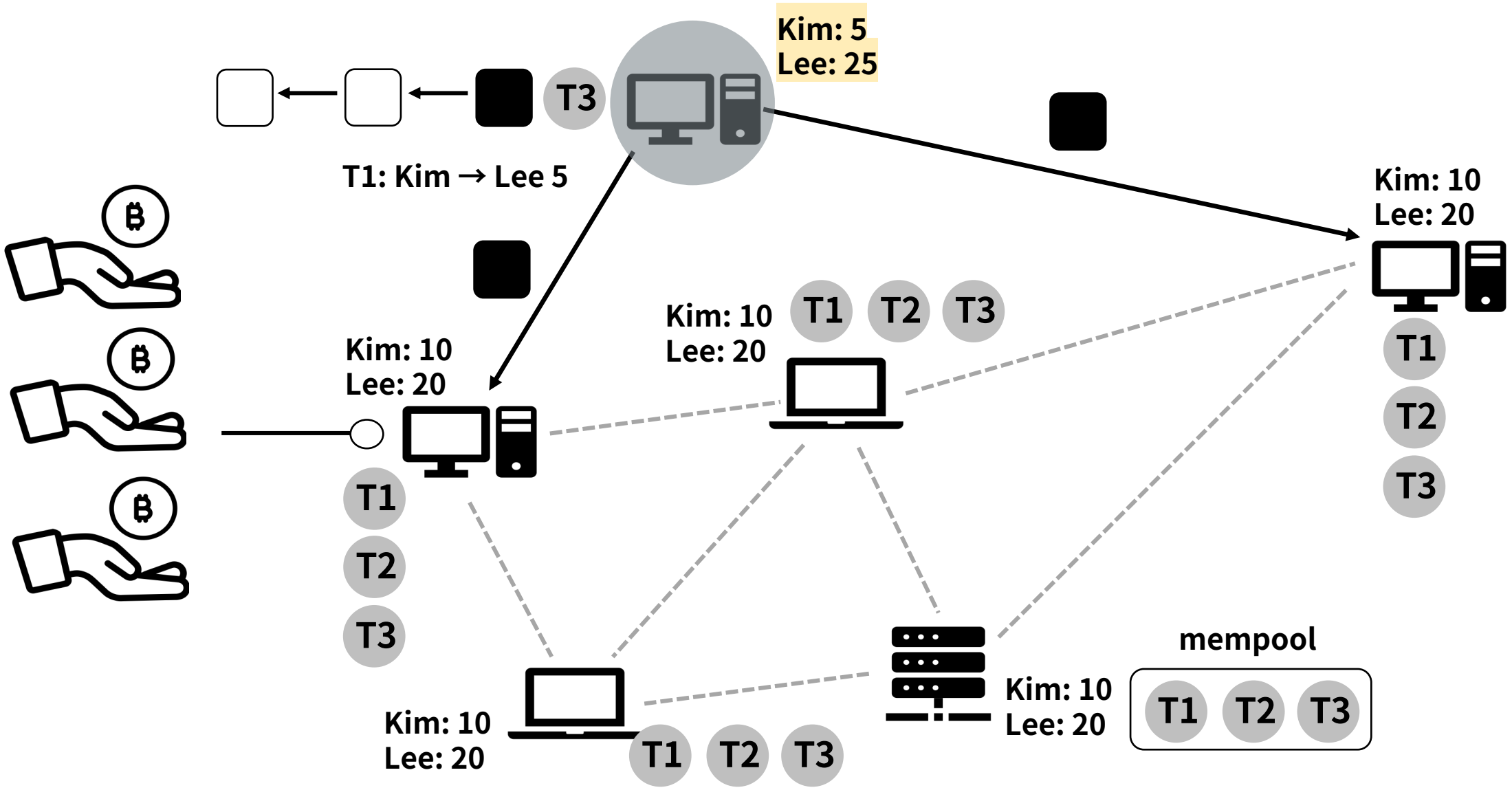
Life cycle of transaction



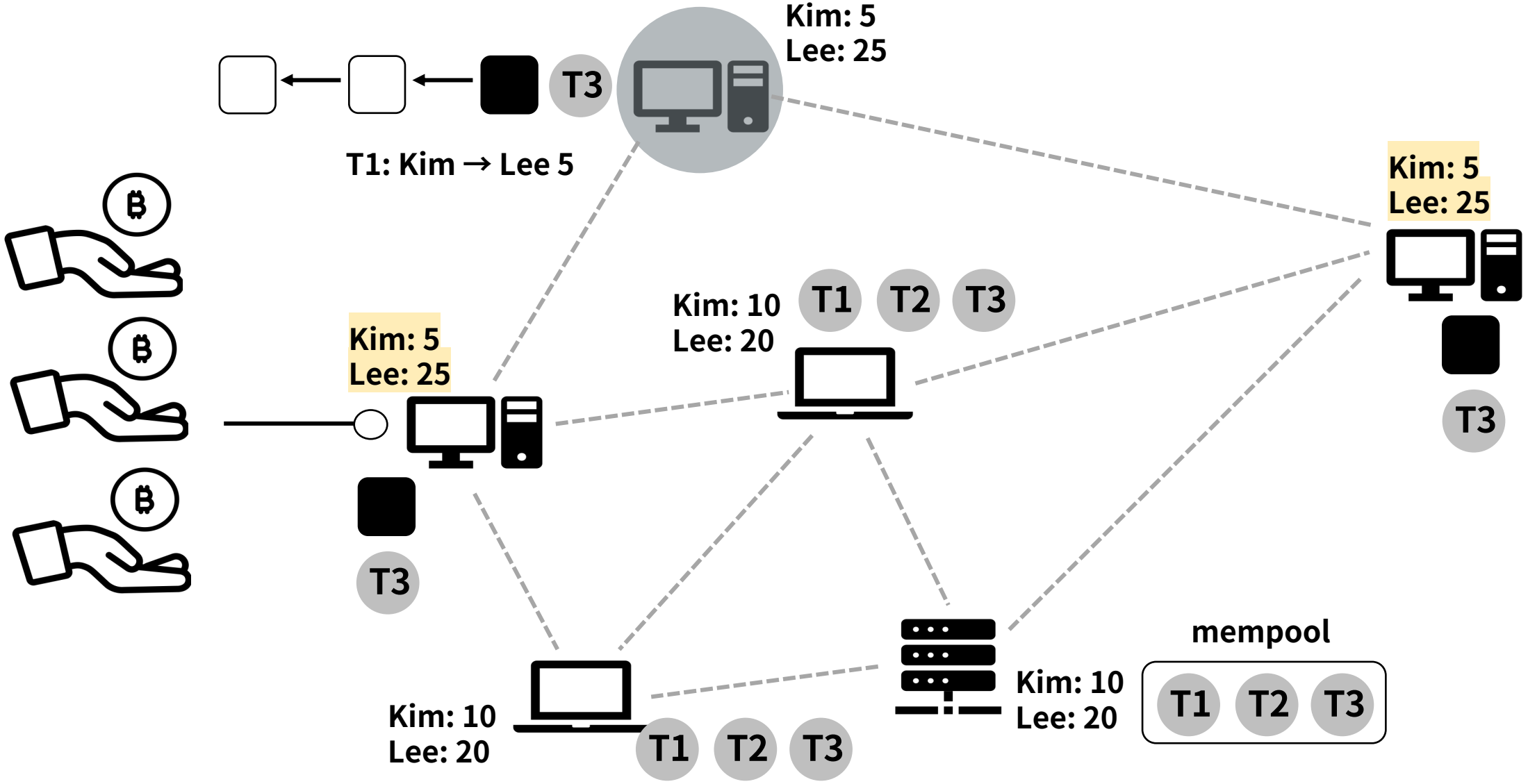
Life cycle of transaction



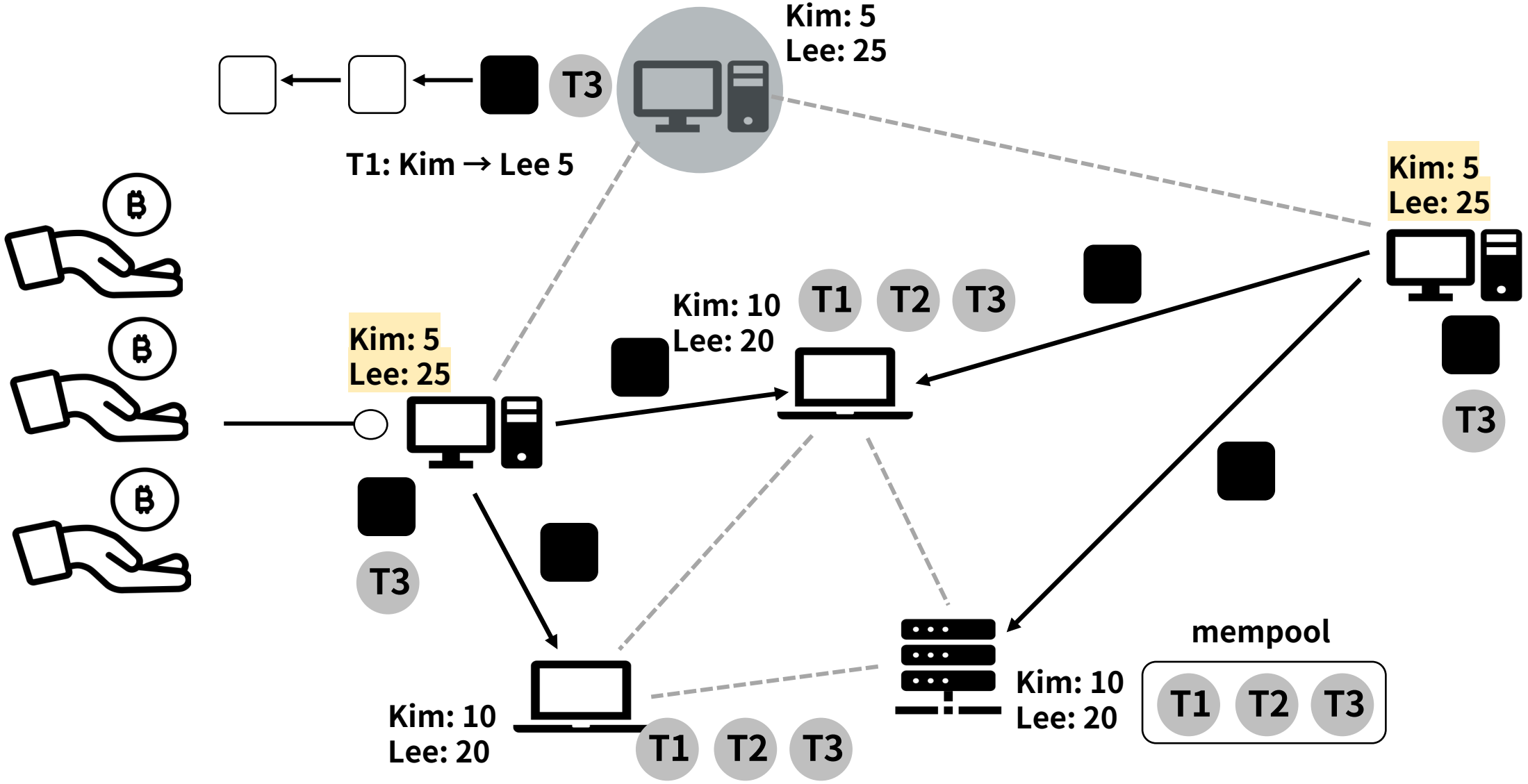
Life cycle of transaction



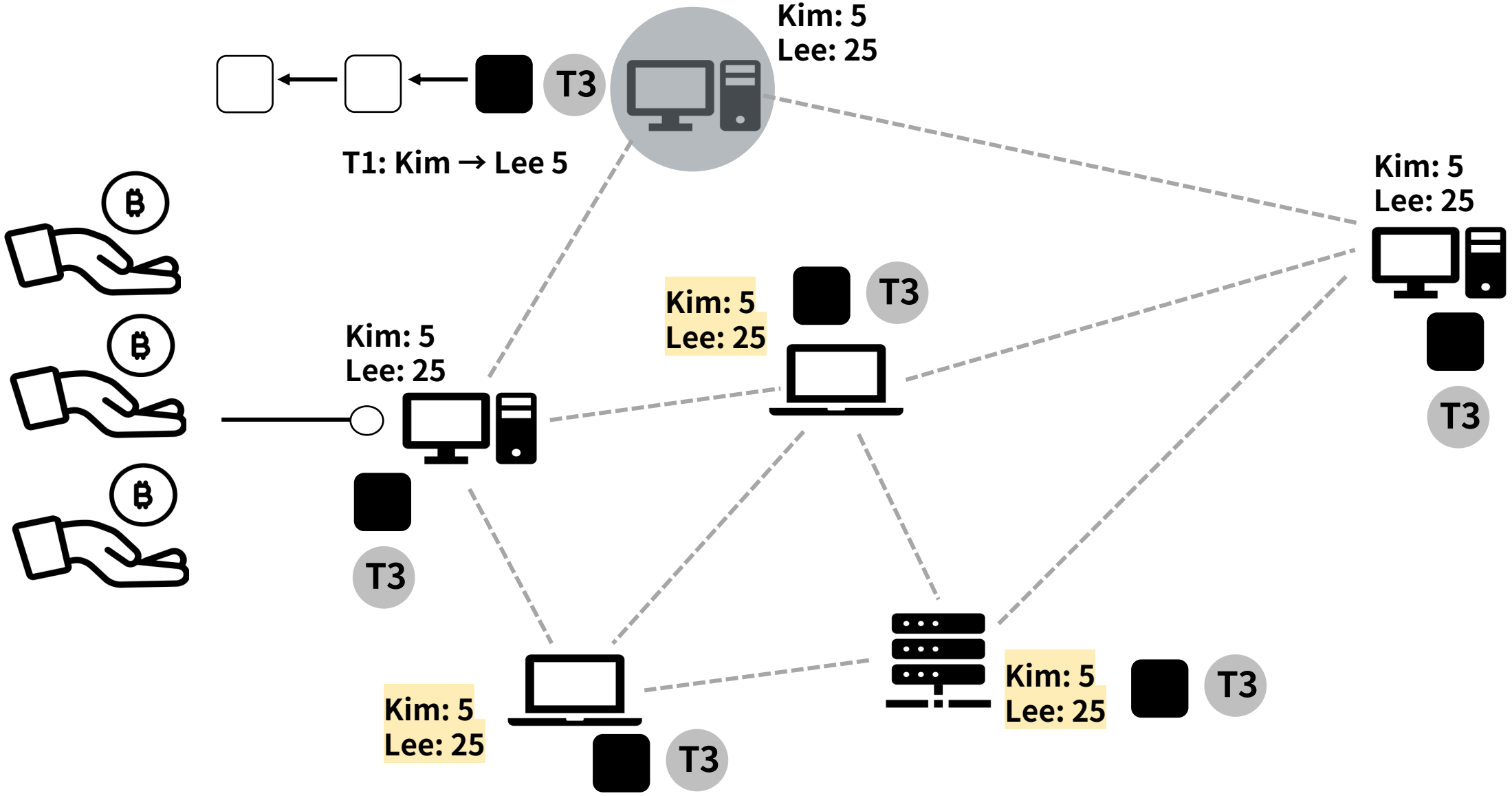
Life cycle of transaction



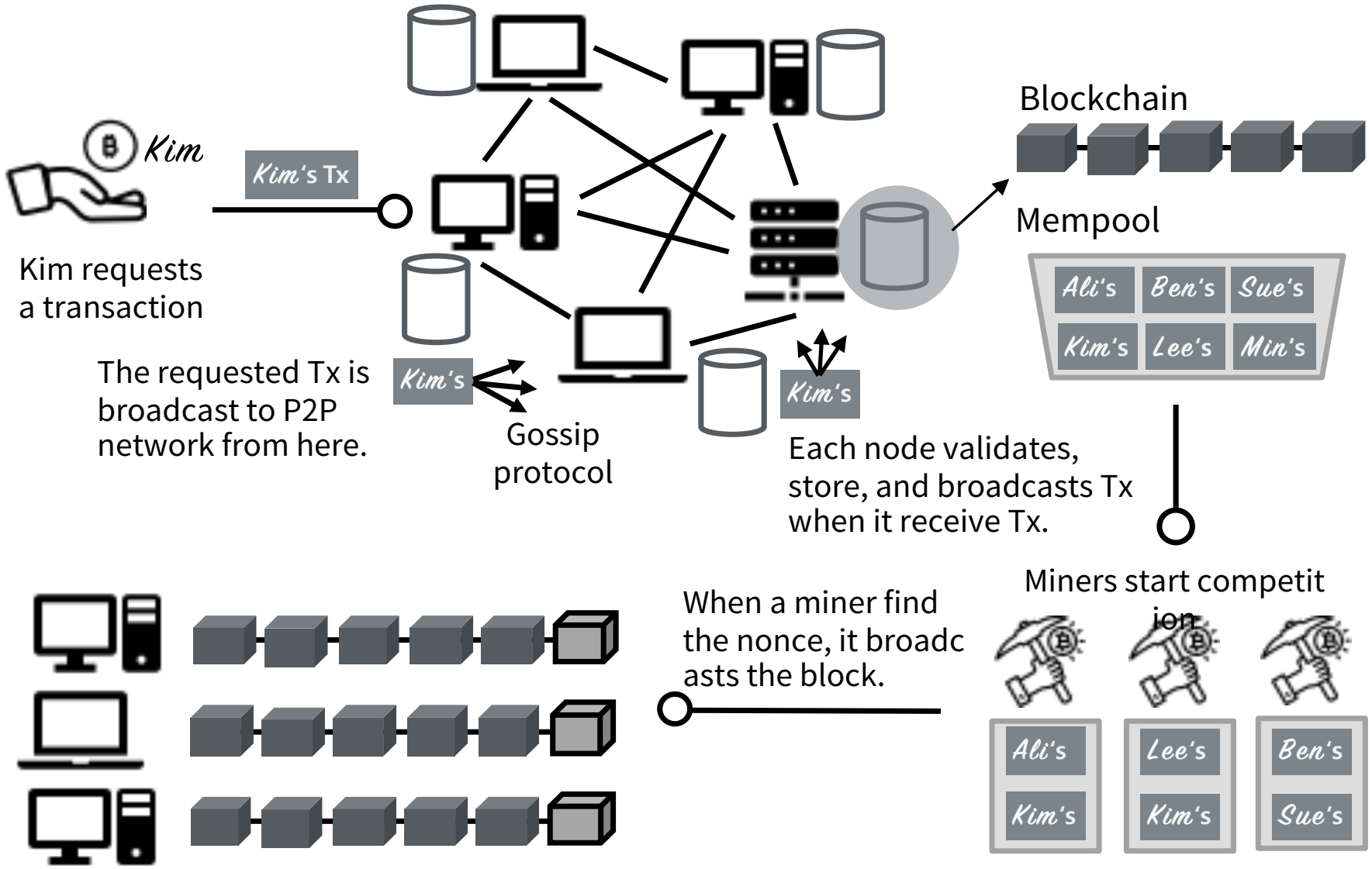
Life cycle of transaction



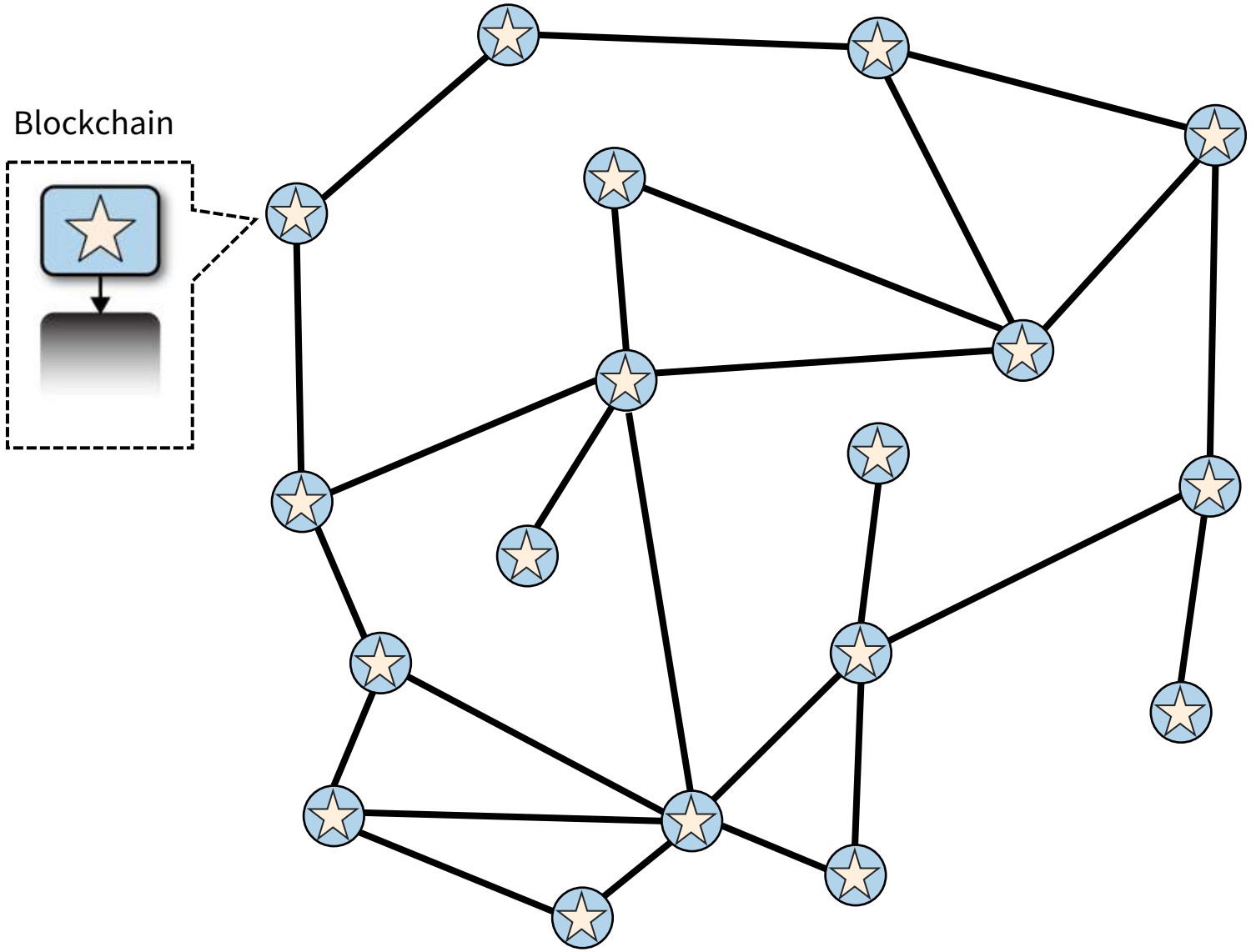
Life cycle of transaction



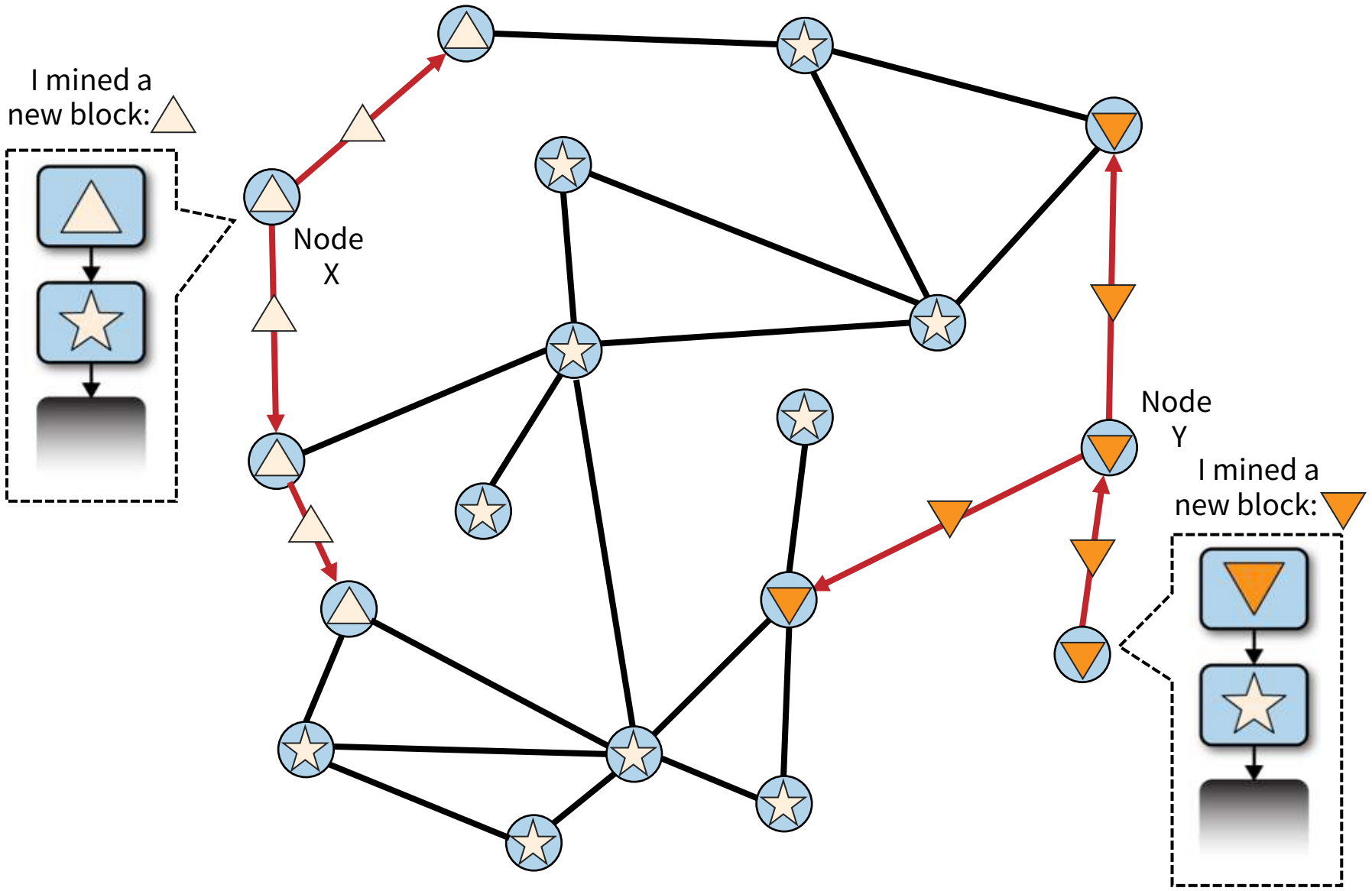
블록체인 충돌 해소 과정


Kim
Kim's Tx
Kim requests
a transaction
The requested Tx is
broadcast to P2P
network from here.
Kim's
Gossip
protocol
Kim's
Each node validates,
store, and broadcasts Tx
when it receive Tx.
Blockchain
Mempool
Ali's
Ben's
Sue's
Kim's
Lee's
Min's
Miners start competit
ion
When a miner find
the nonce, it broadc
asts the block.
Ali's
Kim's
Lee's
Kim's
Ben's
Sue's

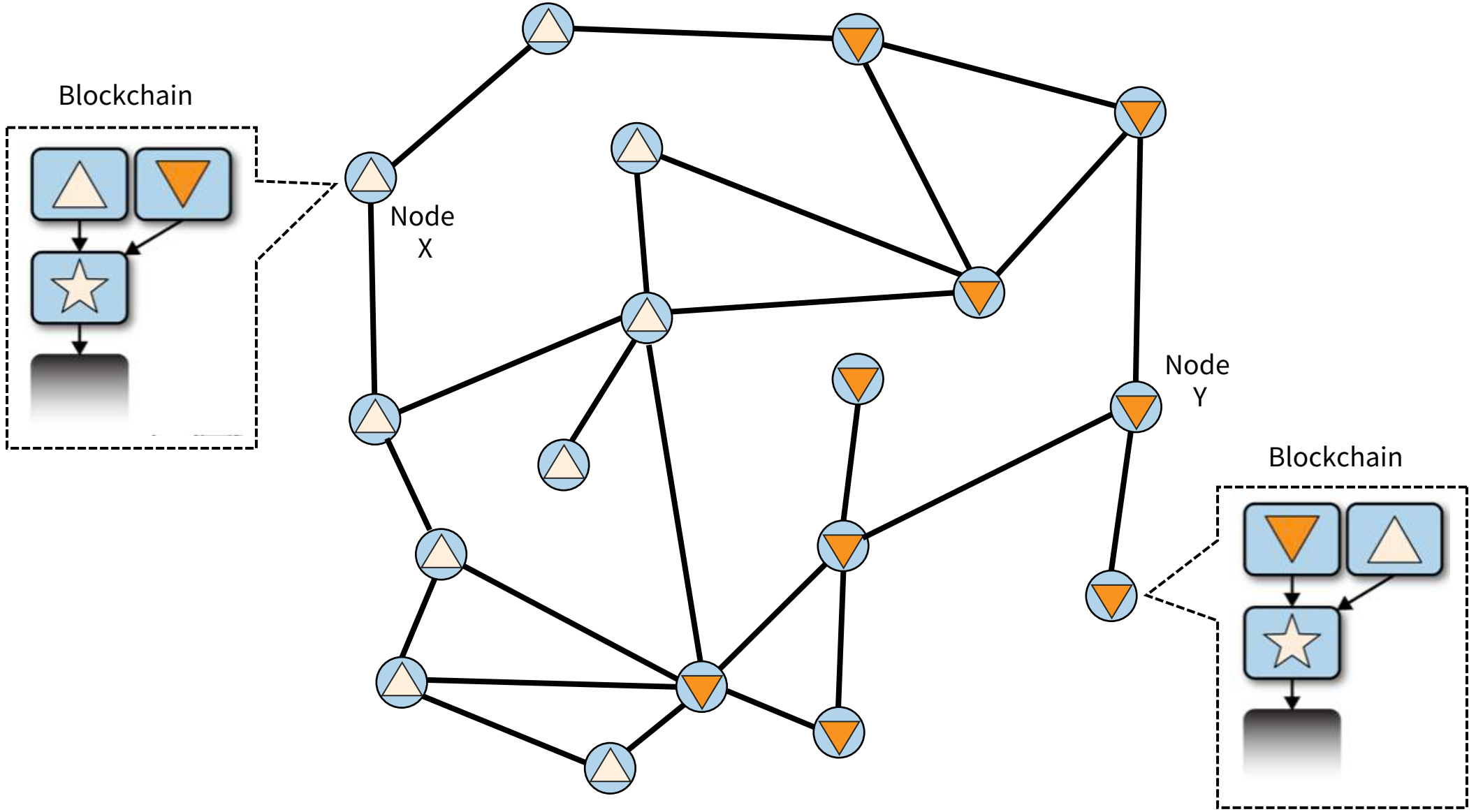
블록체인 충돌 해소 과정 (Mastering Bitcoin)



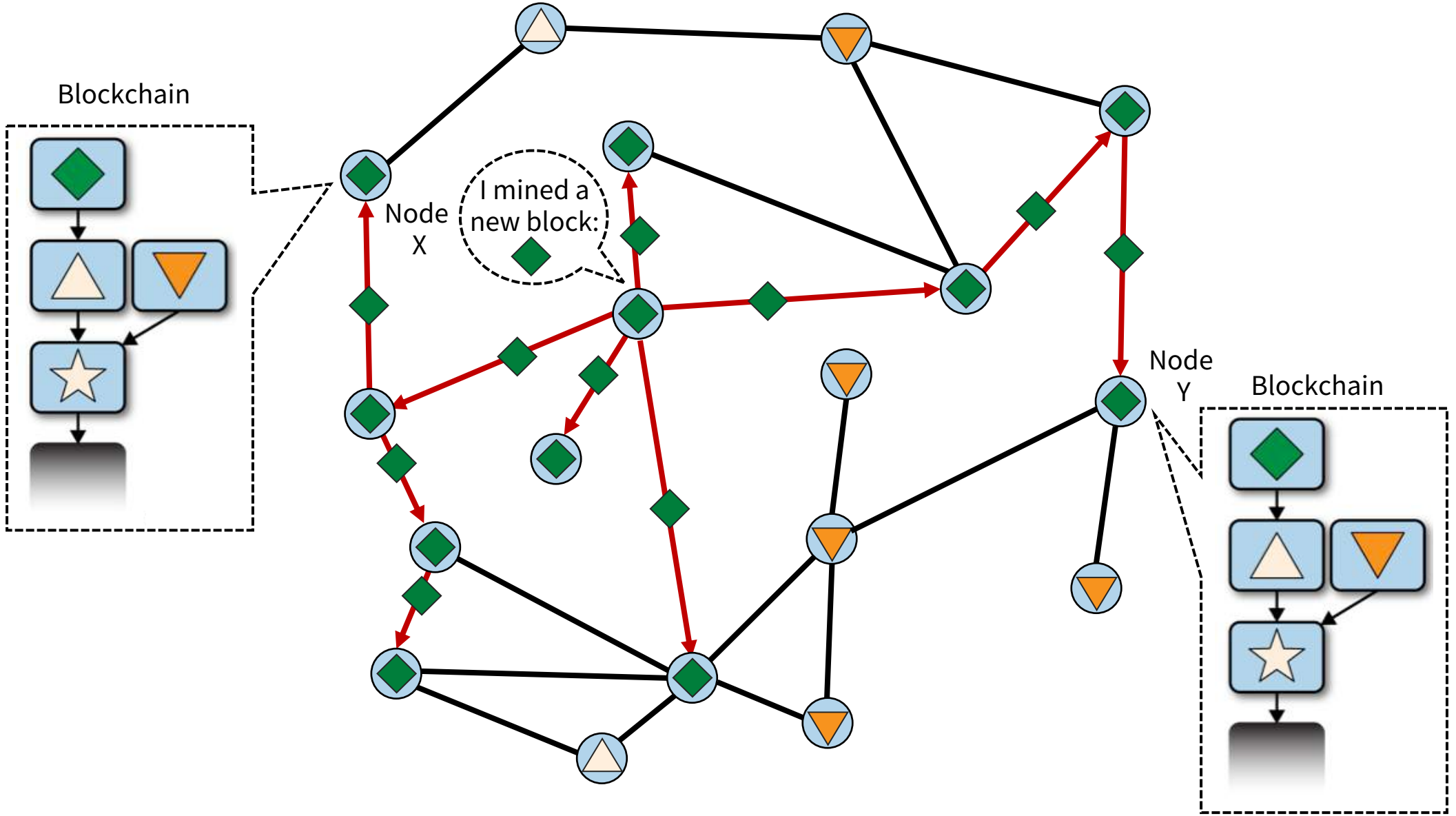
블록체인 충돌 해소 과정 (Mastering Bitcoin)



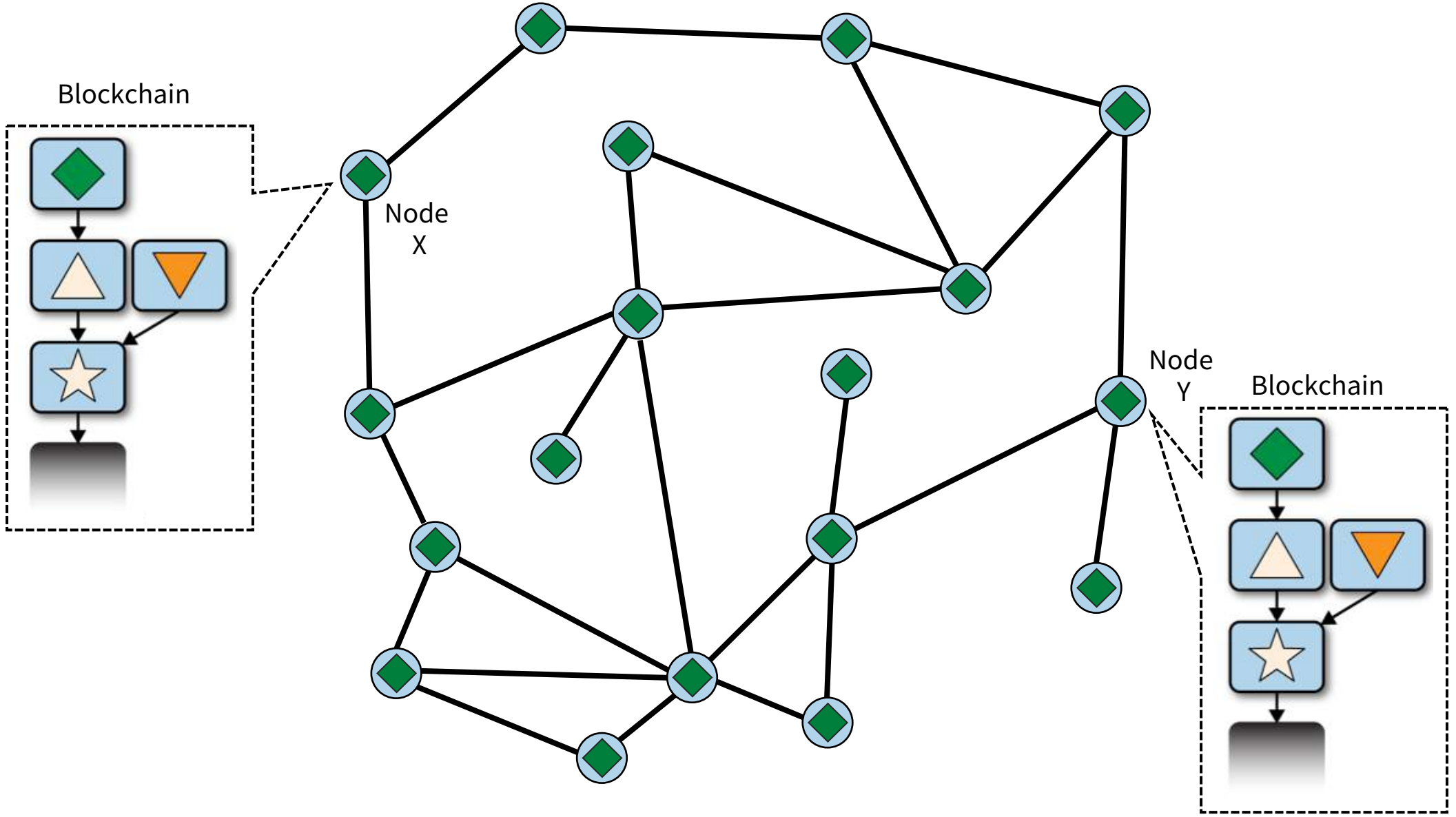
블록체인 충돌 해소 과정 (Mastering Bitcoin)



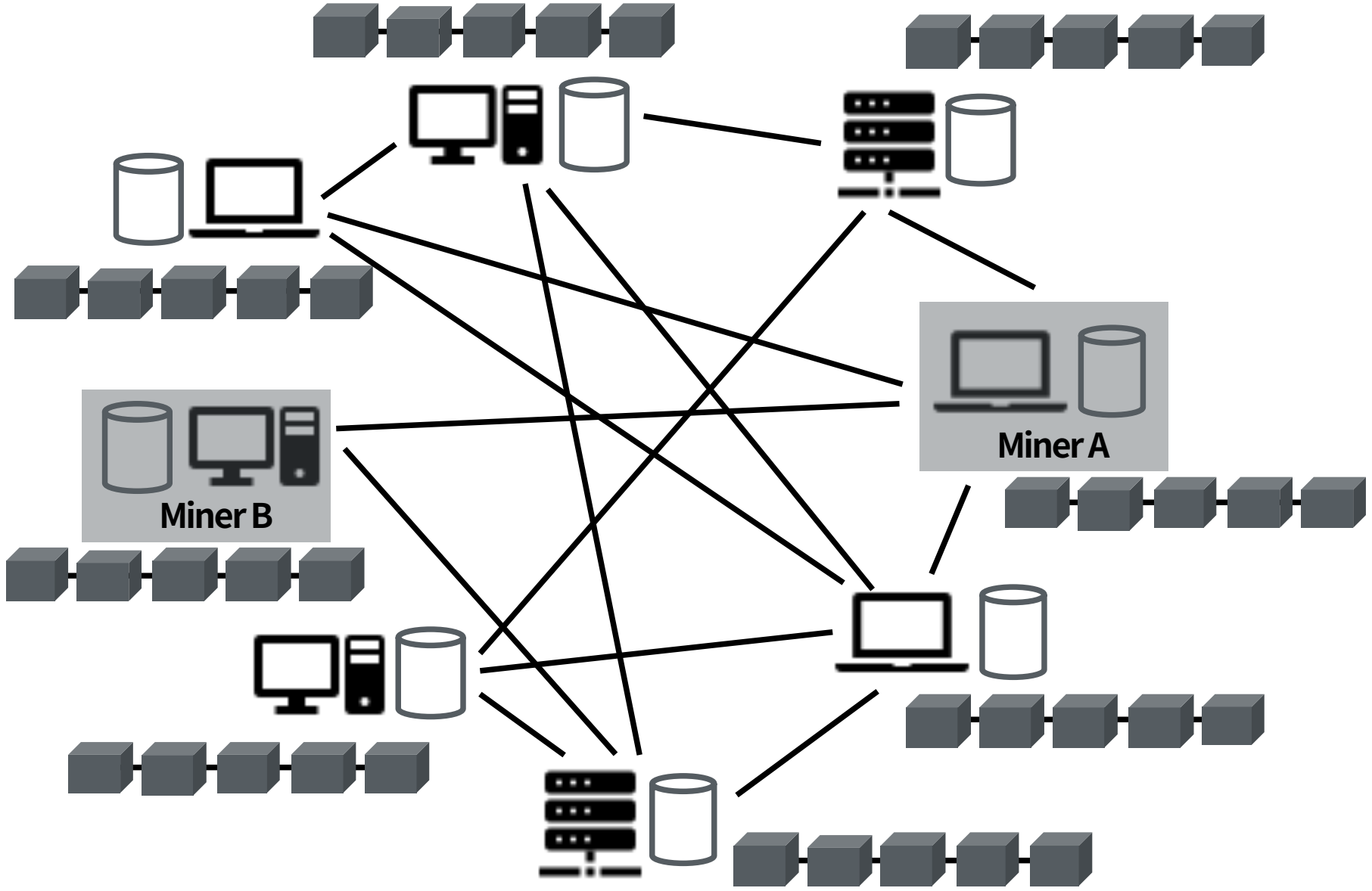
블록체인 충돌 해소 과정 (Mastering Bitcoin)



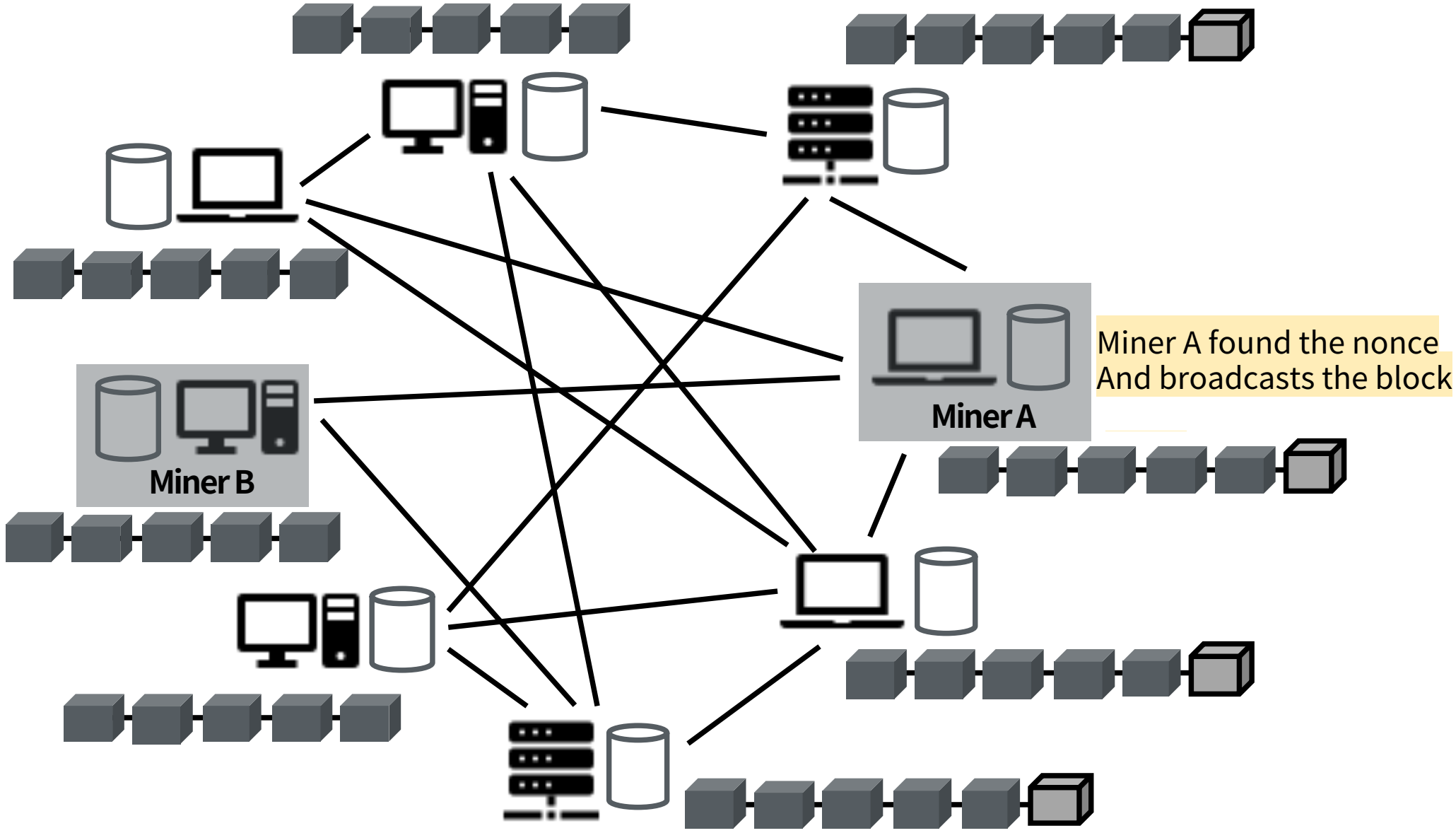
블록체인 충돌 해소 과정 (Mastering Bitcoin)



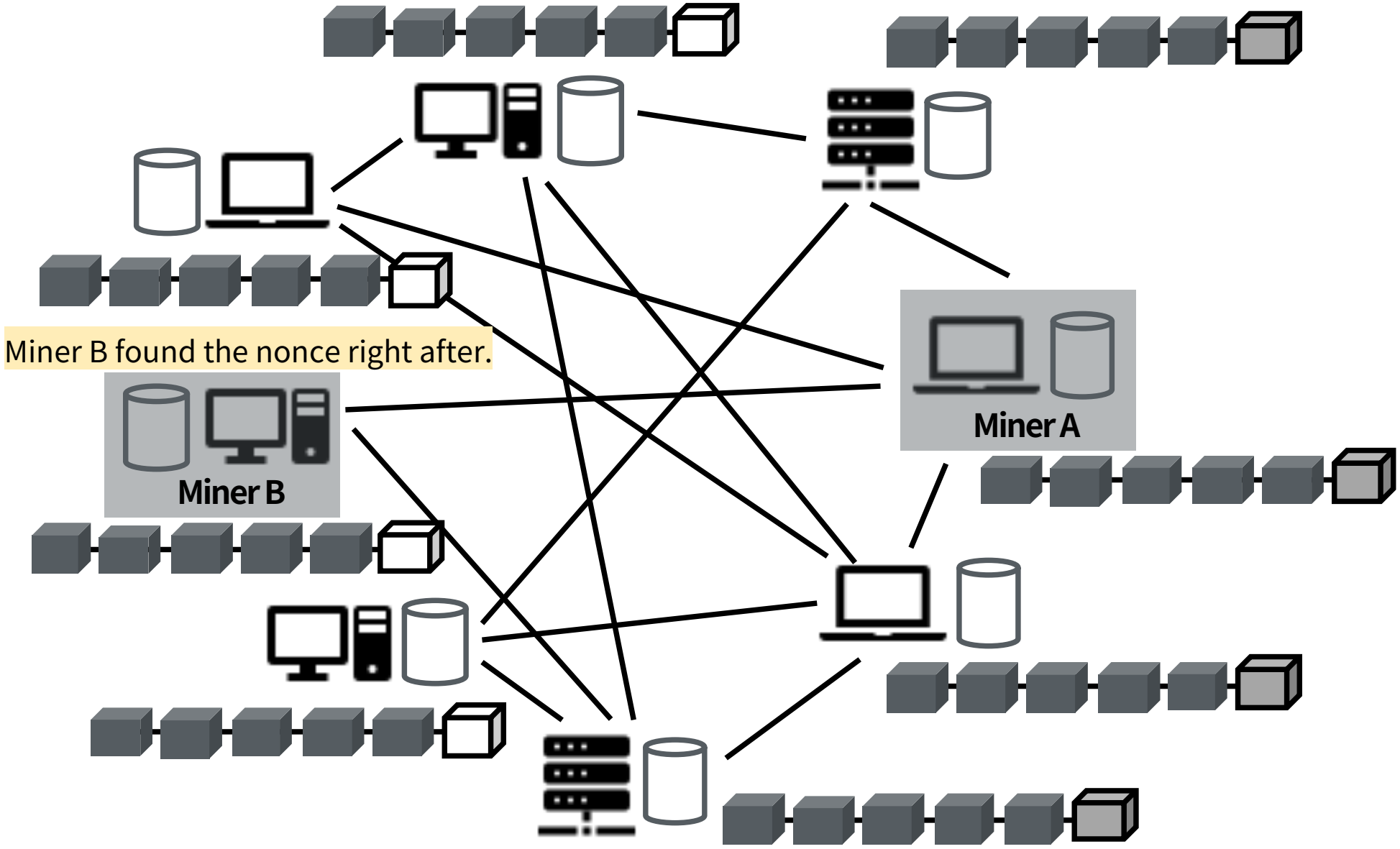
블록체인 충돌 해소 과정



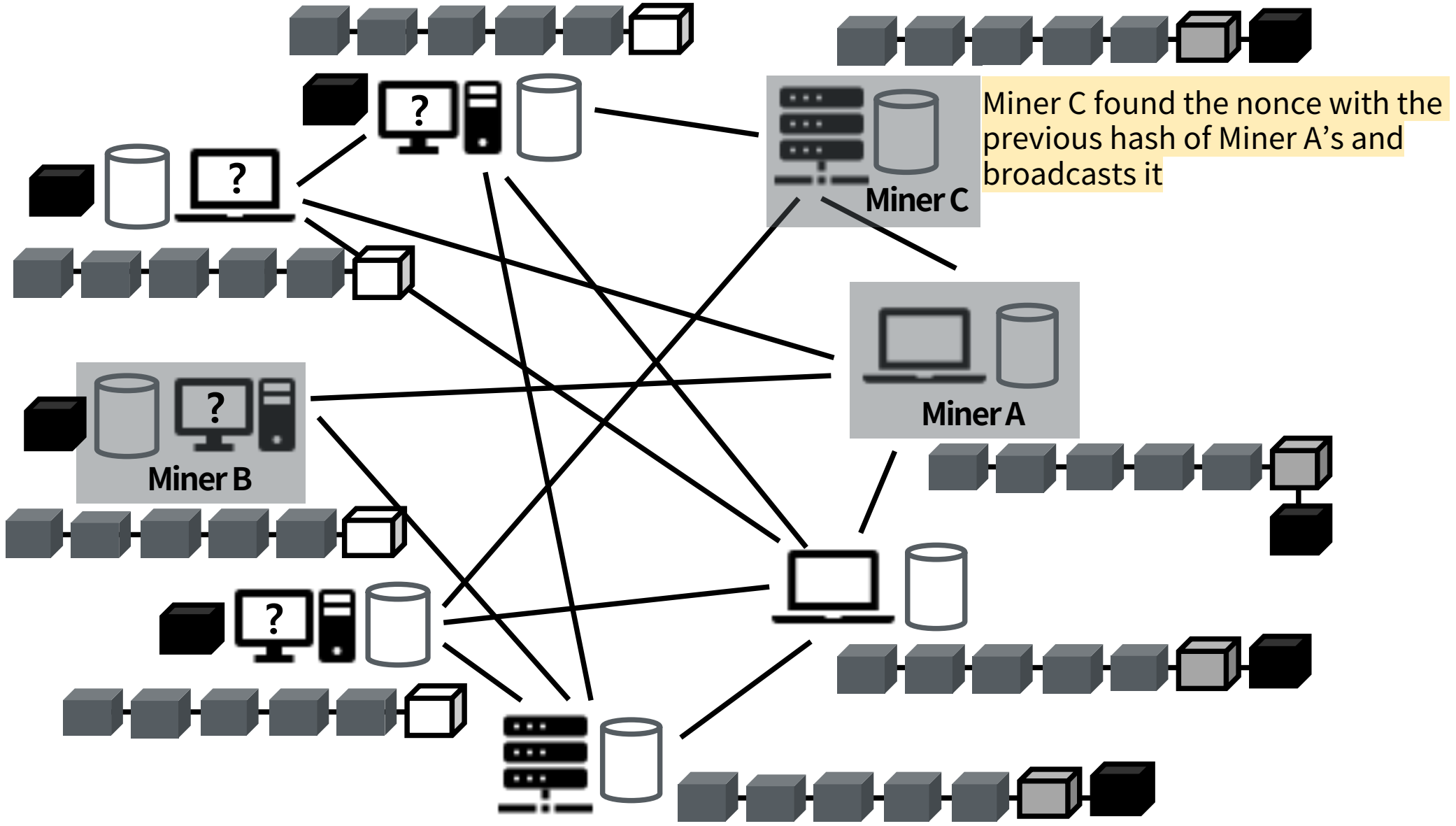
블록체인 충돌 해소 과정


Miner A found the nonce
And broadcasts the block
Miner A
Miner B

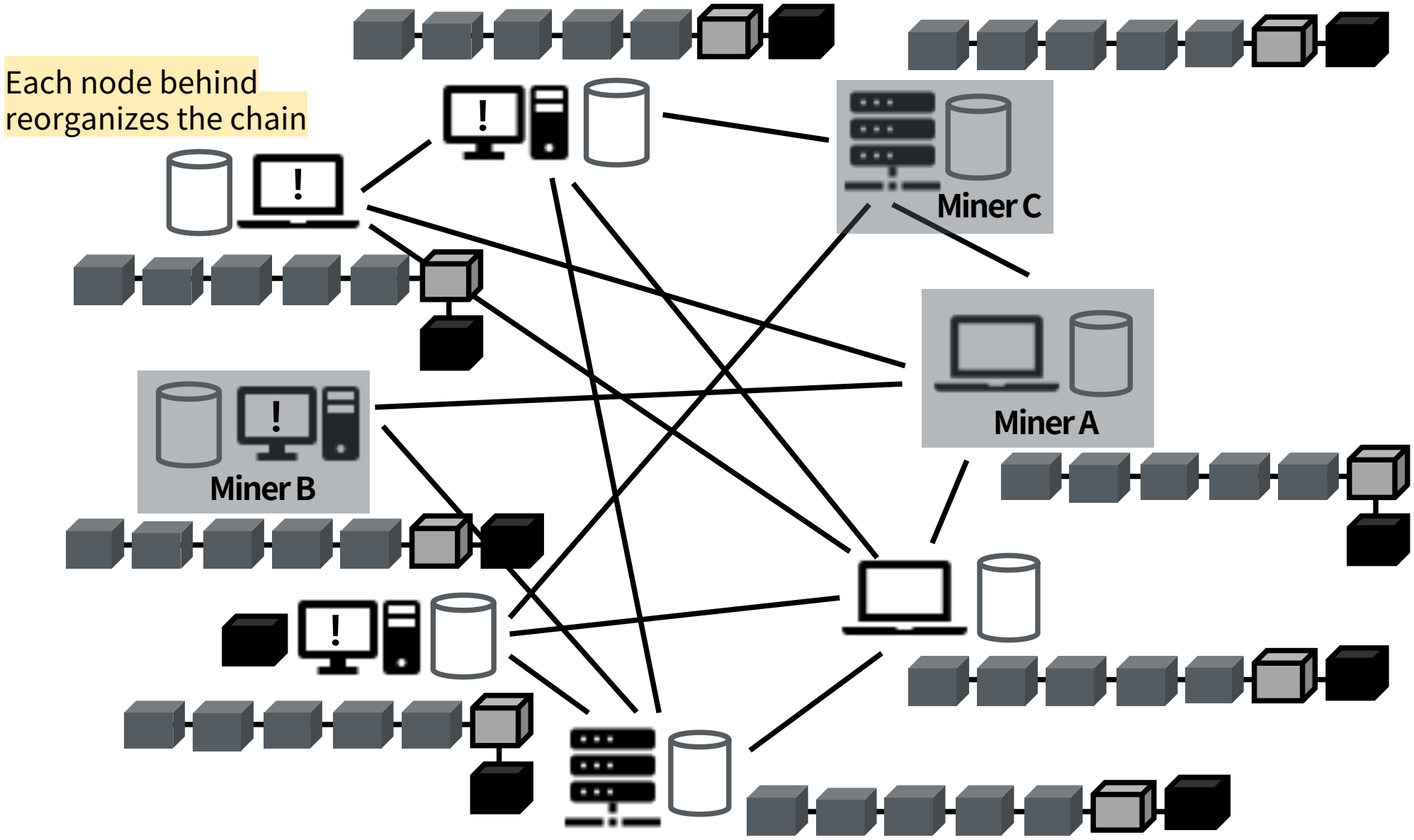
블록체인 충돌 해소 과정



블록체인 충돌 해소 과정


Miner C found the nonce with the previous hash of Miner A's and broadcasts it
Miner C
Miner A
Miner B

블록체인 충돌 해소 과정


Each node behind
reorganizes the chain
Miner C
Miner A
Miner B

블록체인 충돌 해소 과정

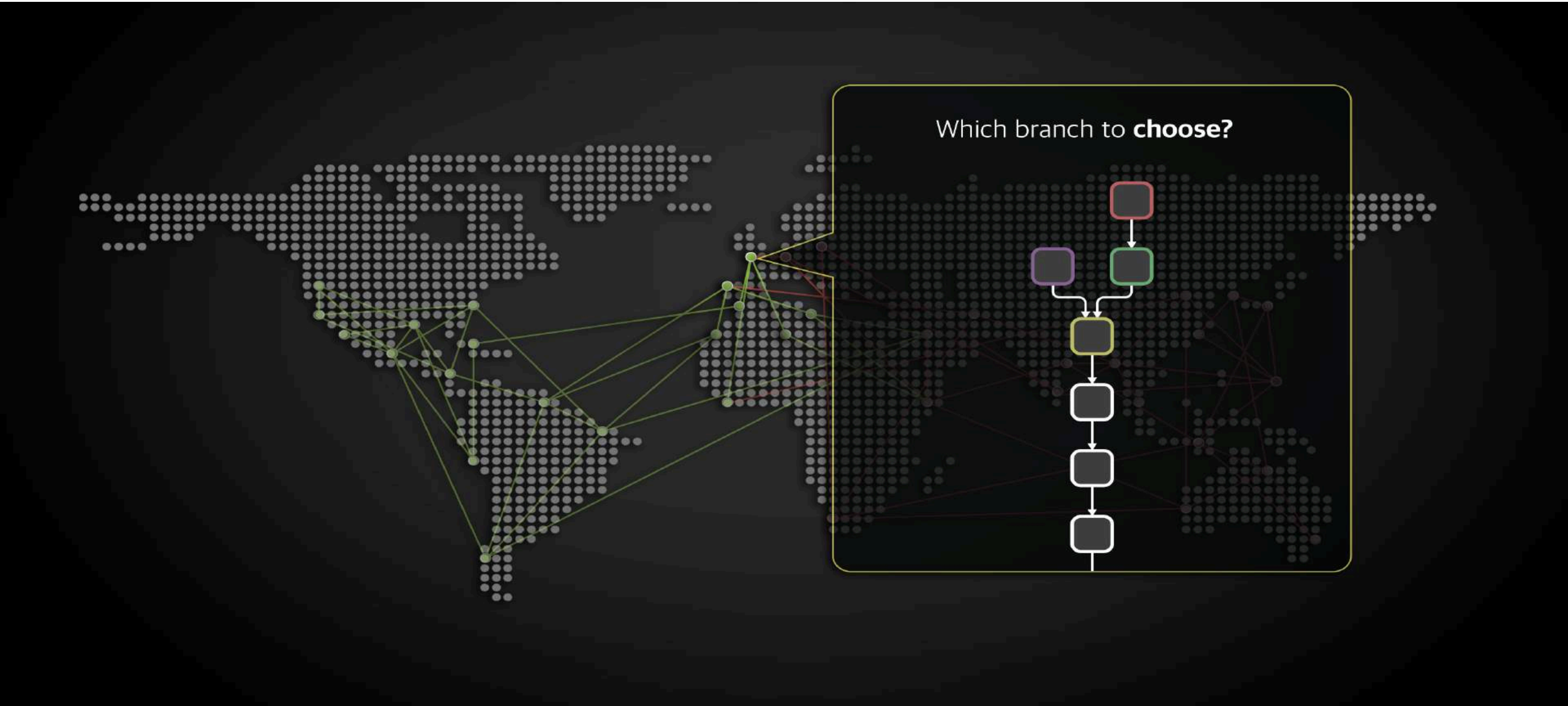
블록체인 충돌 해소 과정


BLOCK
A
BLOCK
P
BLOCK CHAIN HEIGHT
BLOCK
B
BLOCK
A
BLOCK
P
BLOCK CHAIN HEIGHT

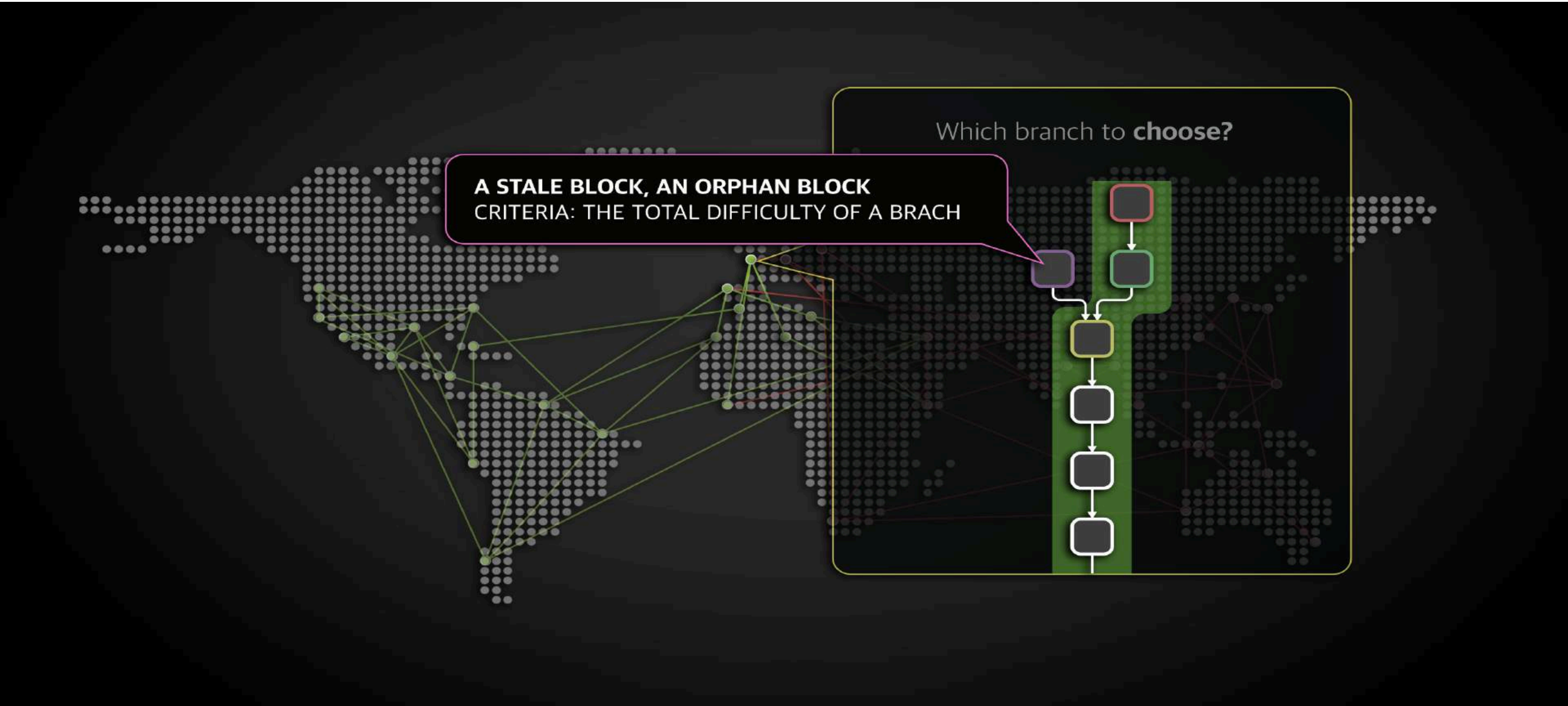
블록체인 충돌 해소 과정


BLOCK C
BLOCK A
BLOCK P
BLOCK CHAIN HEIGHT
BLOCK B
BLOCK A
BLOCK P
BLOCK CHAIN HEIGHT

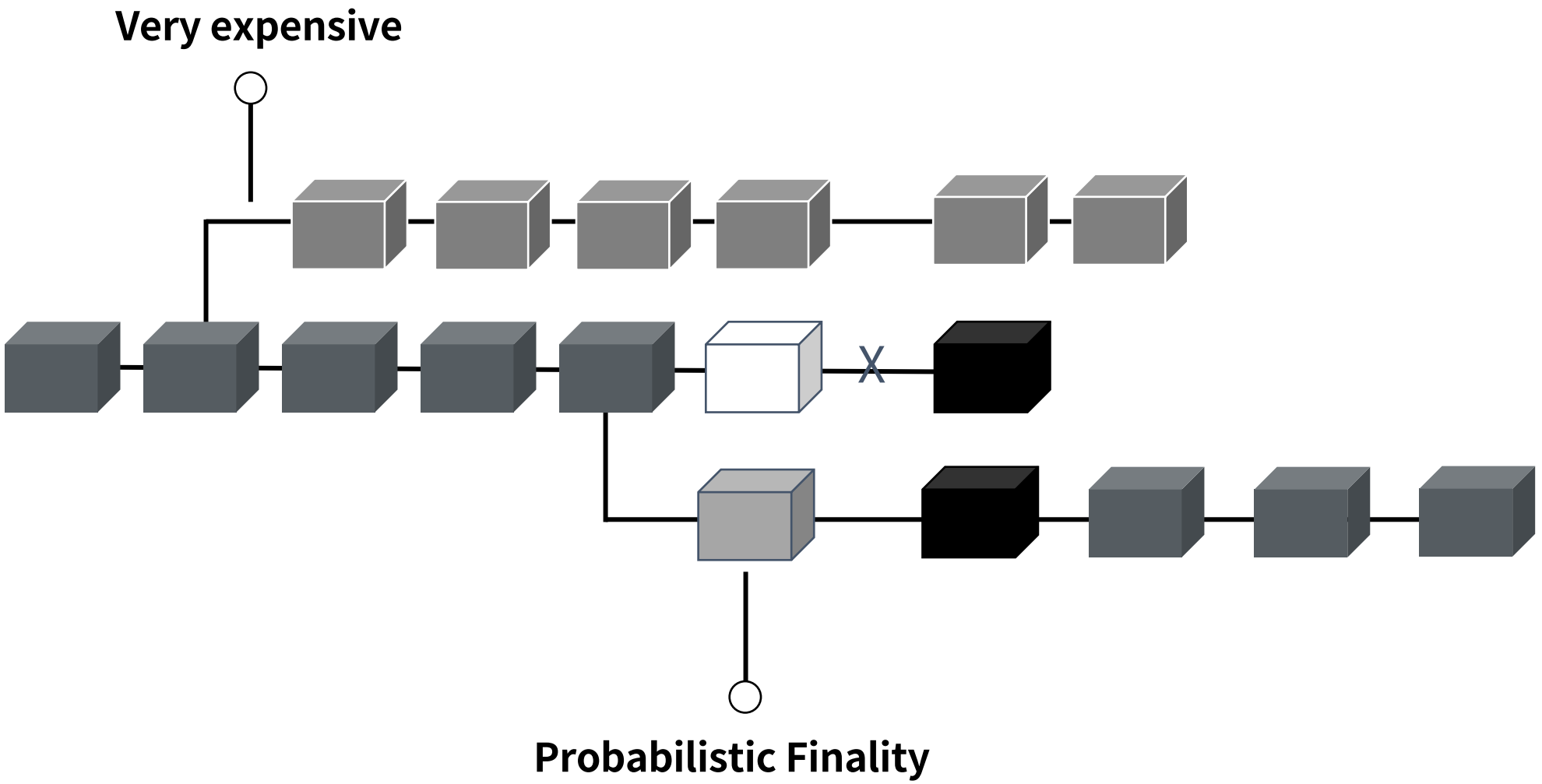
블록체인 충돌 해소 과정



블록체인 충돌 해소 과정


Which branch to **choose?**
A STALE BLOCK, AN ORPHAN BLOCK
CRITERIA: THE TOTAL DIFFICULTY OF A BRACH

블록체인 충돌 해소 과정

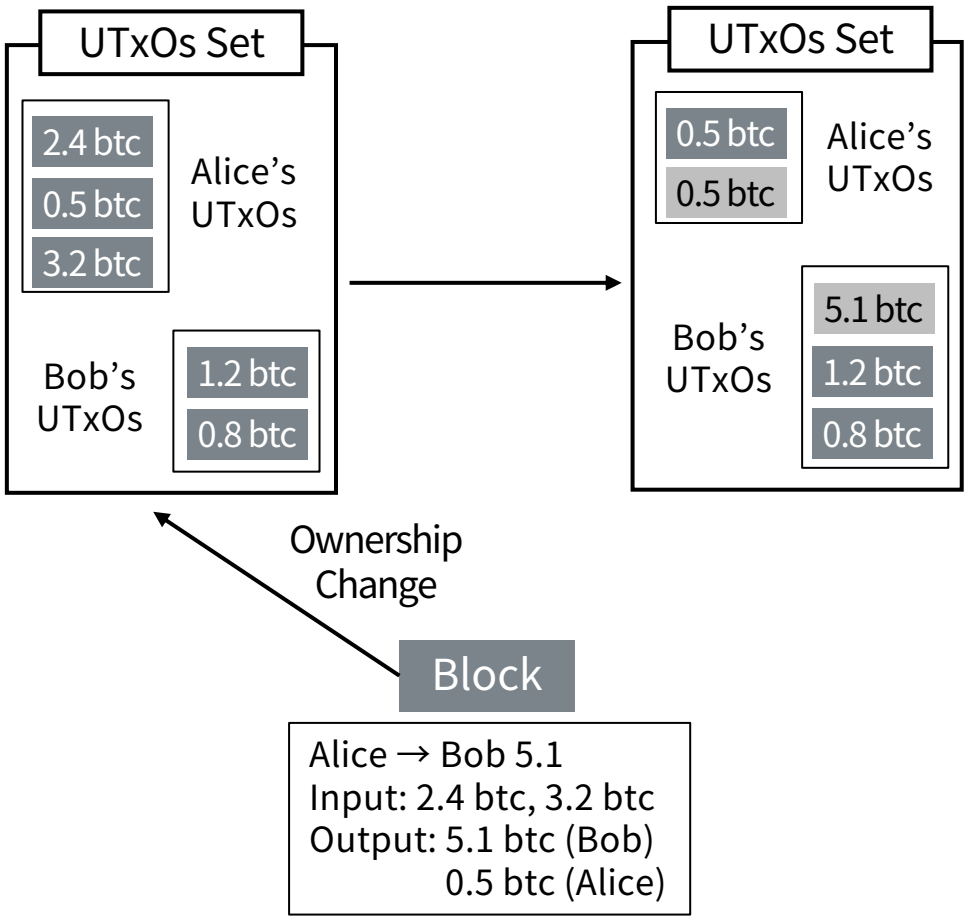


RULES

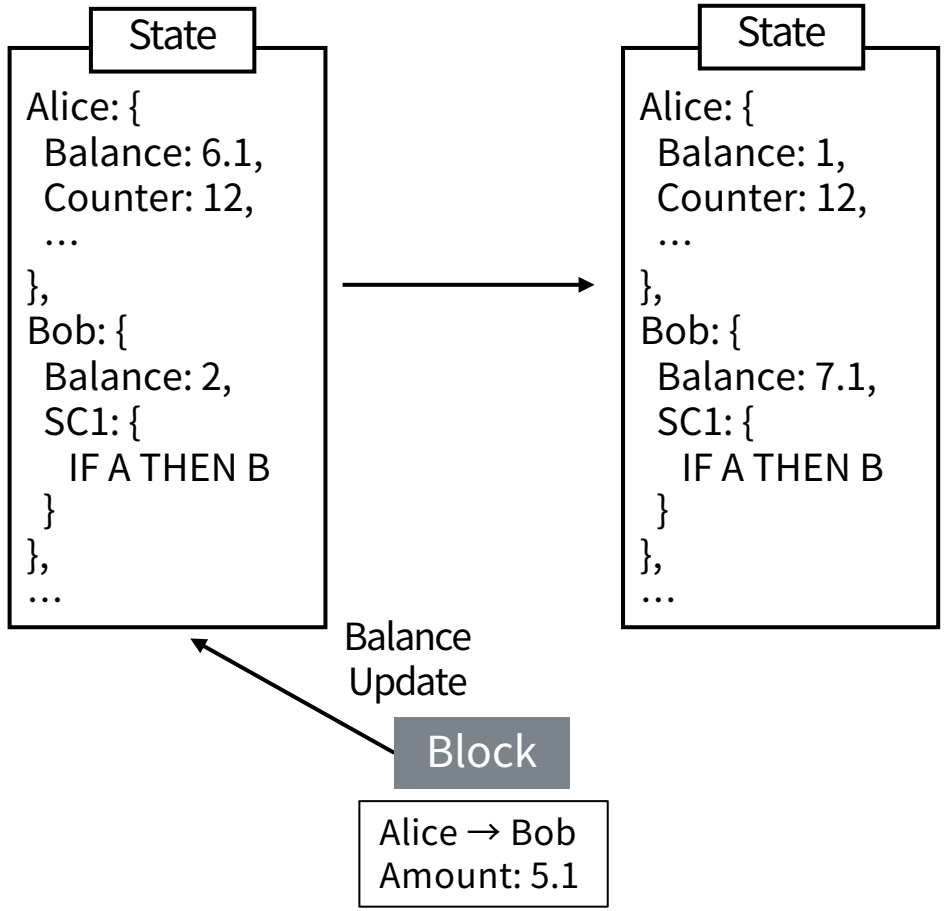
1. 비트코인을 송금하는 사람은 거래에 자신의 디지털 서명을 포함시켜야 한다.
2. 각 블록은 이전 블록의 해시, 오퍼레이션과 논스로 구성된다.
3. 제일 먼저 블록의 해시를 난이도보다 낮게 만든 채굴자가 보상을 받는다.
4. 채굴자는 블록에 보상(코인베이스 트랜잭션)을 포함시킨다.
5. 새 블록의 해시는 $\mathcal{H}ash$(이전 블록의 해시 + 오퍼레이션 + 논스)이며, 논스를 바꿔가며 목표 해시를 찾는다.
6. 누적 난이도 총합이 가장 큰 체인이 적법한 체인이다.

Abstract Blockchain

UTxO vs. Account-based Model

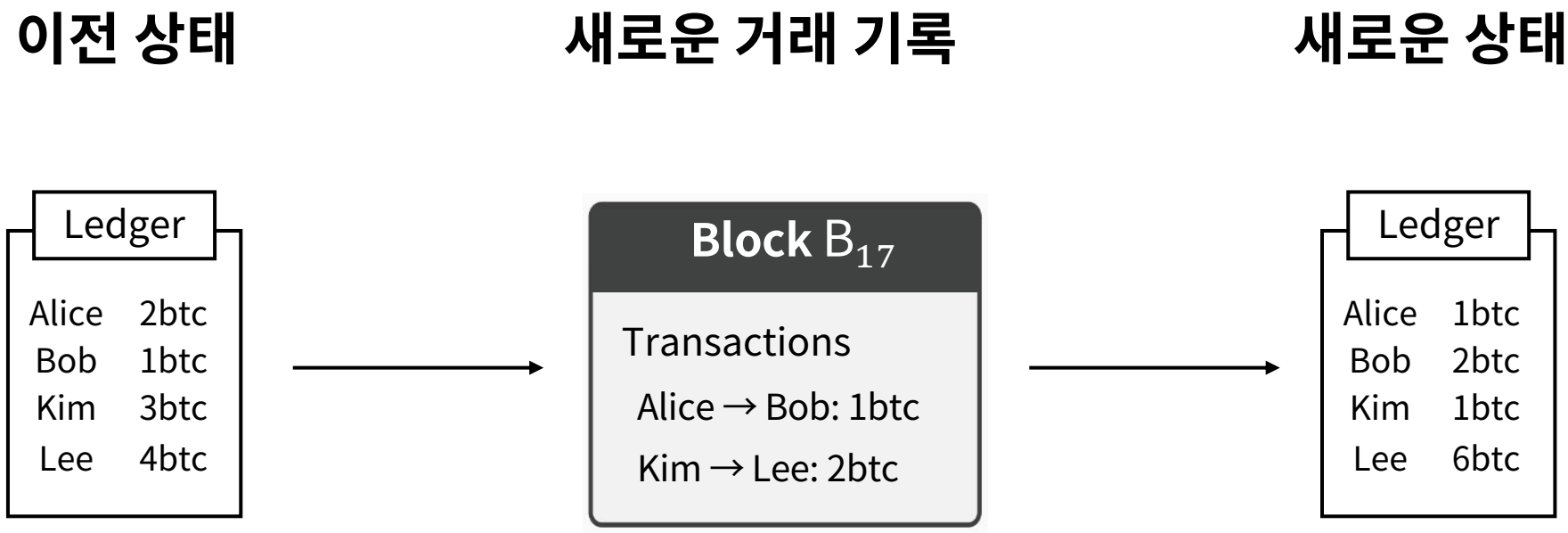


The current **sum of UTxOs** of Alice?



The current **value of balance** in Alice's account?

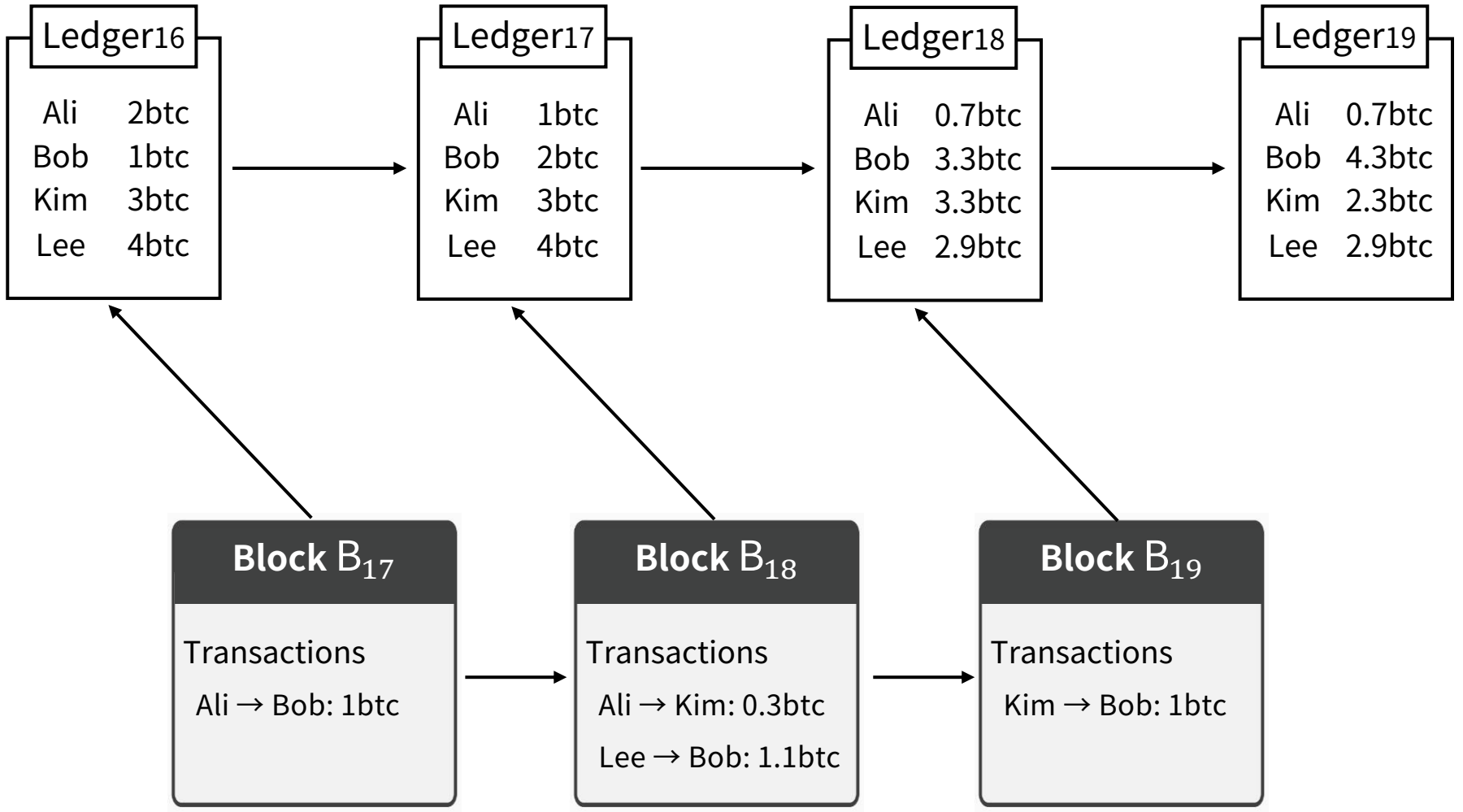
Block as an **Operator**



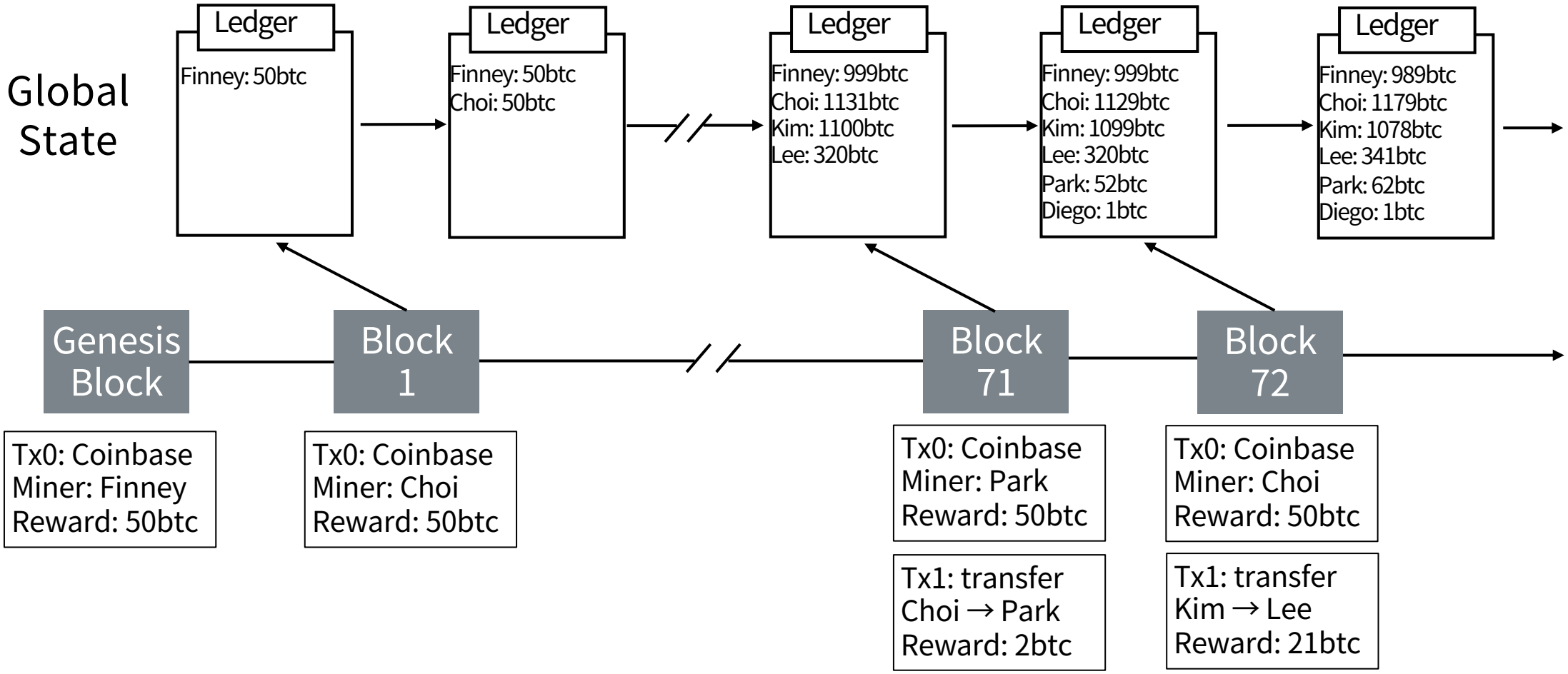
Blockchain = A chain of blocks

거래의 결과 (상태 값)

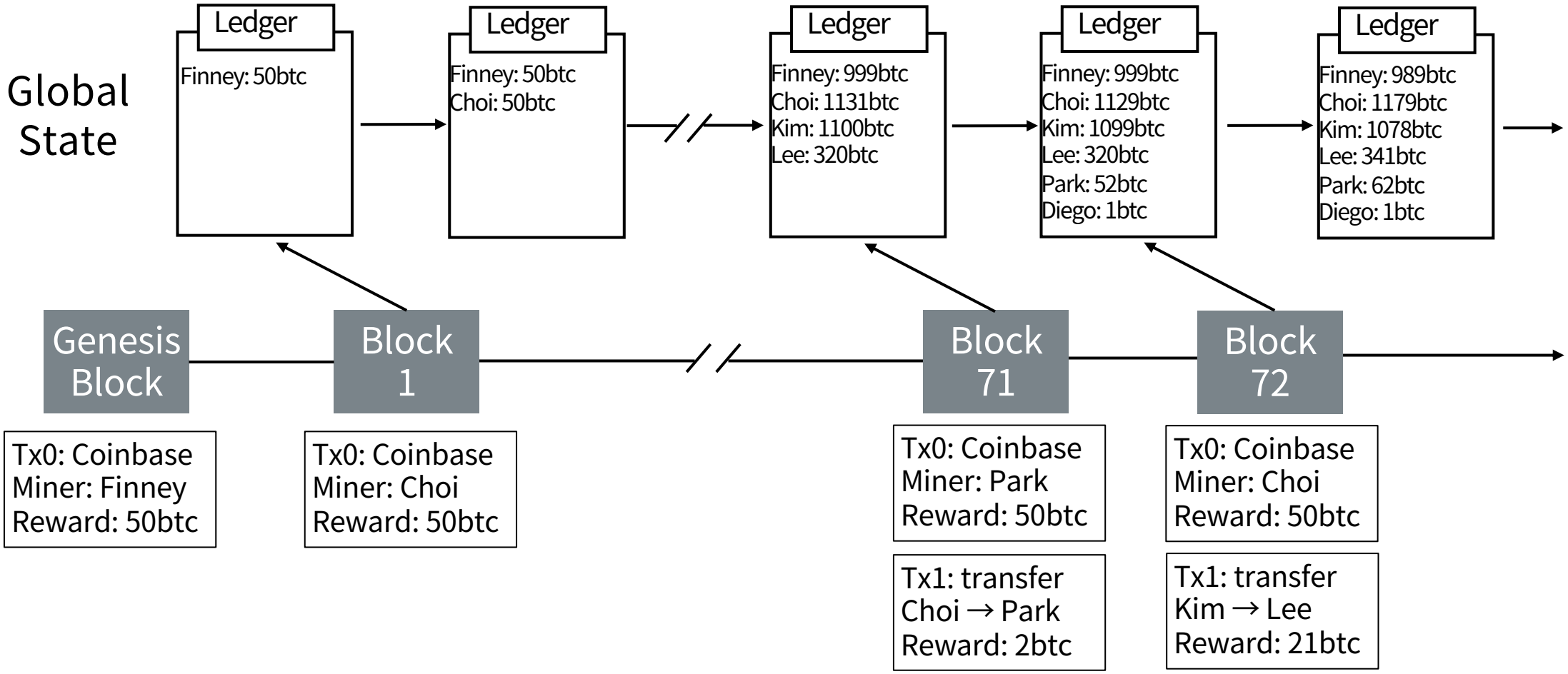
거래 기록들 (블록체인)



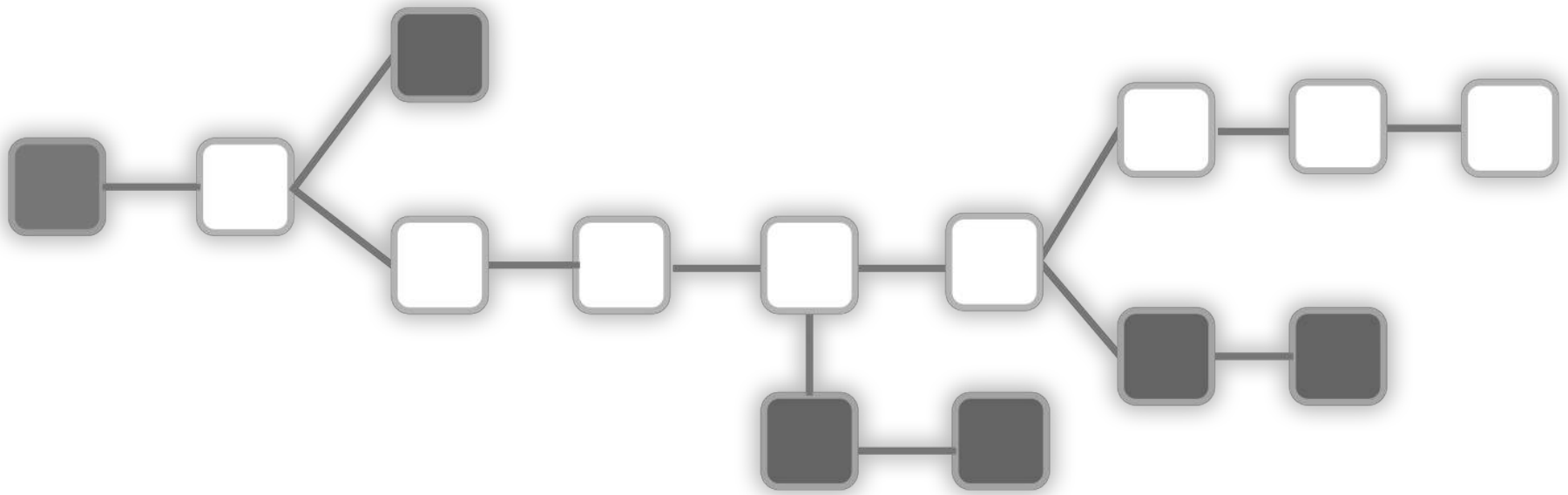
Block as an **Operator**



Block as an **Operator**



Abstract Blockchain



A blockchain

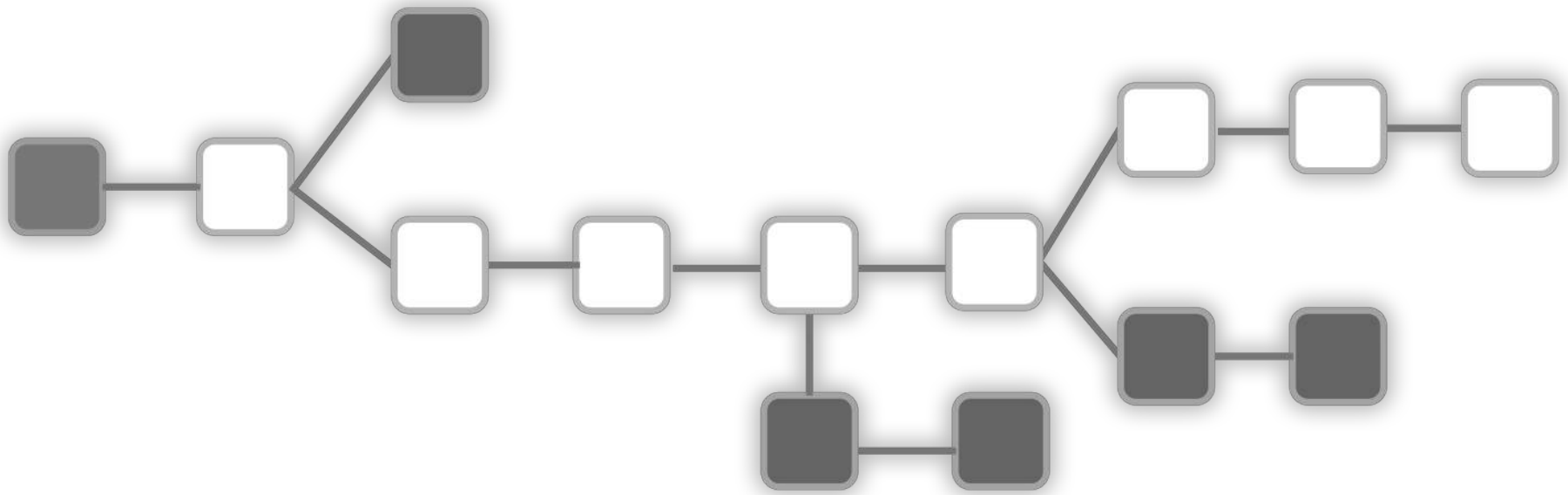
represents **a single state** being concurrently edited and

keeps the state as **a shared ledger** to avoid conflicts

as a series of **transformations** applied to an initial state (genesis state).

A set of blocks, each bundling together multiple operations in it.

Abstract Blockchain

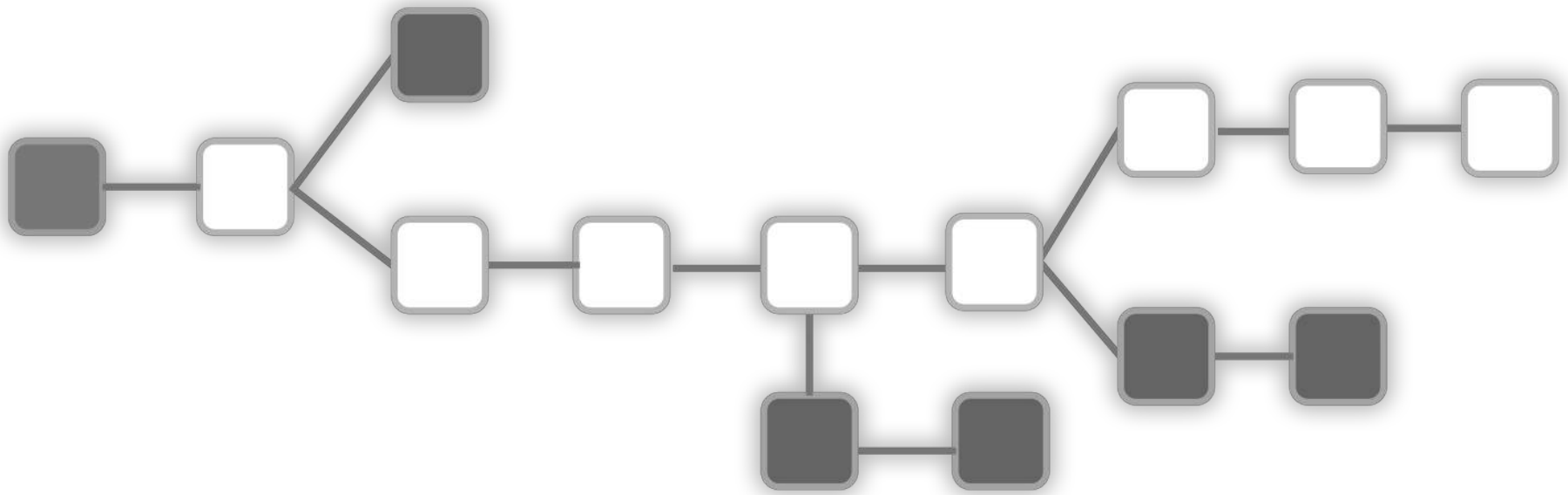


A blockchain protocol

is a monadic implementation of **concurrent mutations** of **a global state** through a series of operations such that blocks are defined as operators.

apply: $S \mapsto O \mapsto S$ or $S' = f(S, O)$

Abstract Blockchain



Blocks

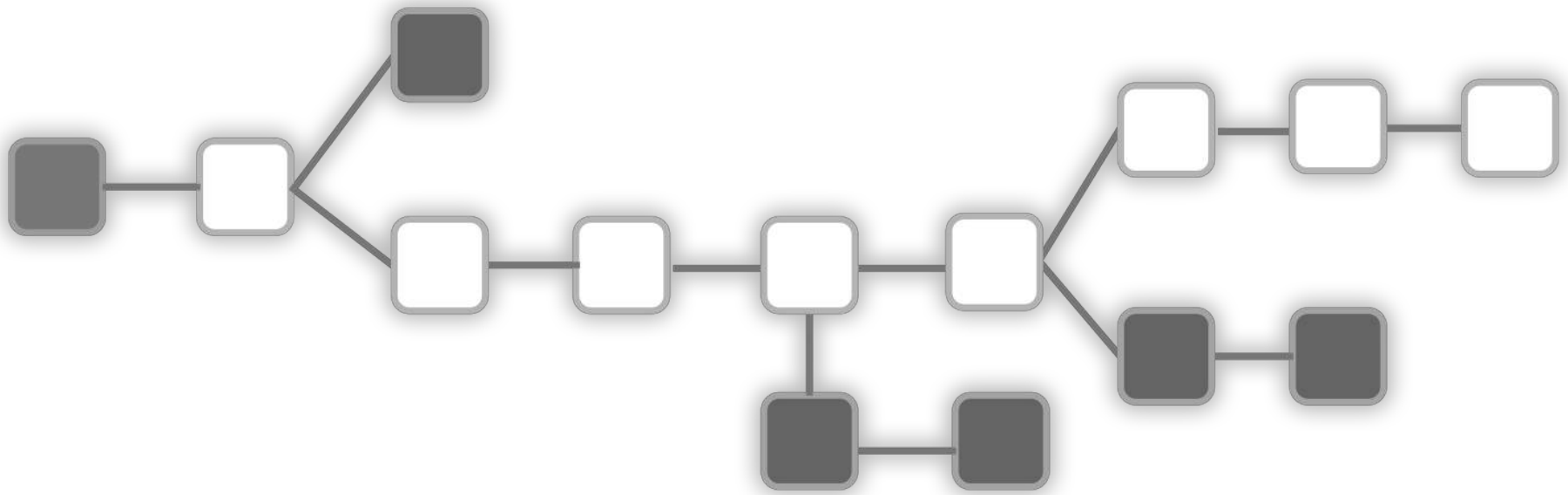
are created asynchronously by many concurrent nodes

forms a **tree structure**,

which needs **well-ordering** for choosing **the valid one** (unique, canonical).

score : $S \mapsto N$ or $N = f(S)$

Abstract Blockchain

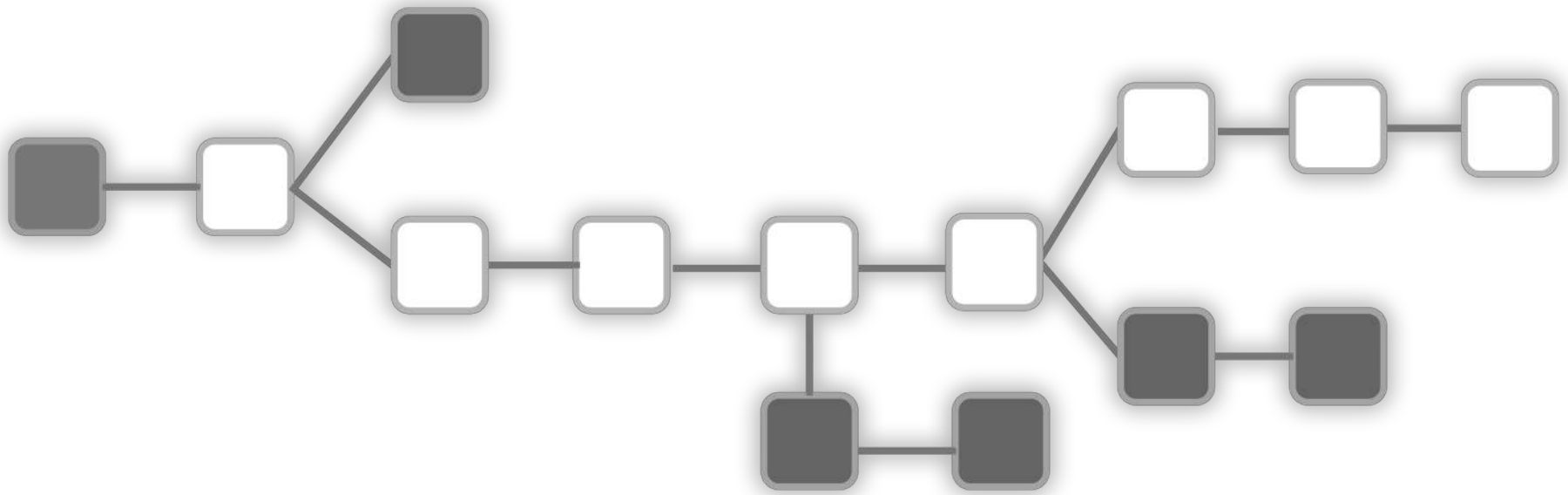


All existing block chain implementation generally

apply: $S \mapsto O \mapsto S$ or $S' = f(S, O)$

score: $S \mapsto N$ or $N = f(S)$

Abstract Blockchain



Bitcoin

State = A set of UTxOs + total work + block index

Operations = transactions

Score = the one with the greatest total difficulty

테조스 플랫폼

Tezos , **the last** crypto currency

Tezos: A Self-Amending Crypto-Ledger Position Paper (2014)

Conclusion

We've presented issues with the existing cryptocurrencies and offered Tezos as a solution. While the irony of preventing the fragmentation of cryptocurrencies by releasing a new one does not escape us, Tezos truly aims to be the *last* cryptocurrency.

No matter what innovations other protocols produce, it will be possible for Tezos stakeholders to adopt these innovations. Furthermore, the ability to solve collective action problems and easily implement protocols in OCaml will make Tezos one of the most reactive cryptocurrency.

Tezos , **the last** crypto currency

Problems

The Protocol Fork Problem

Shortcomings of Proof-of-Work

Smart Contracts

Correctness

Contents

Tezos , **the last** crypto currency

Problems

- **The Protocol Fork Problem**
- **Shortcomings of Proof-of-Work**
- **Smart Contracts**
- **Correctness**

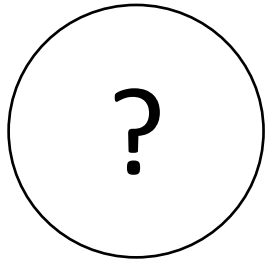
Solutions

- **Self-Amending & On-chain governance**
- **LPoS**
- **Smart Contracts**
- **Formal Verification**
- **Abstract Blockchain**

Tezos , **the last** crypto currency

1st Gen. Bitcoin
First ever Cryptocurrency
and blockchain

2nd Gen. Ethereum
Turing complete
Smart contract



Who's the next?
Scalability
Inter-operability
Sustainability

Motivations
Protocol fork
Proof of Work
Smart Contract
Correctness

Abstract blockchain
Self-Amending
On-chain governance
LPoS
Smart contract
Formal Verification
Abstract Blockchain

PoS 합의 알고리즘

Why PoS? No more PoW

Inefficient

PoW의 지나친 에너지 소모와 환경 파괴

Hash puzzle 경쟁으로 인한 중복 계산

Centralization

ASIC과 마이닝 풀의 등장

Mis-alignment of interest

채굴자의 동기는 채굴 보상

(ex. 자동 해시 파워 이동 서비스)

Not scalable

Hash puzzle 경쟁으로 인한 중복 계산

Not solved by just shorter block interval (more stale blocks)

But why PoW is still the King?

Time Tested

Old-school blockchains (Bitcoin, Litecoin, Ethereum) are using PoW

Bitcoin network has never been hacked

Secure

Real proof by burning physical resources

Hard to attack

(Dis)Incentive – Block reward and computing power is a kind of stake

Fair

Very fair guaranteed by cryptography

What is PoS?

PROOF

블록에 포함된 트랜잭션과 해당 블록이 적법하다는 증거 또는 증명

STAKE

특정 퍼블릭 키 해시(주소)가 보유한 지분의 상대적 가치

특정 주소의 staking 토큰 수 / 네트워크 전체 staking 토큰 수

PROOF OF STAKE

지분의 비율에 따라 선택된 주체가 새 블록을 생성

FOLLOW-THE-SATOSHI (Follow-the-coin)

새롭게 생성(mined, minted)된 토큰의 **모든 최소 단위에** 고유한 시리얼 넘버를 부여

시리얼 넘버 한 개를 (무작위로) 선택하고, 이 토큰을 보유한 주소가 블록을 생성함

더 많은 토큰을 보유할수록, 블록 생성 확률이 높음

PoS also should be **fair** and **secure**

Fair & Secure

블록 생성의 기회가 지분의 비율에 따라 공정하게 주어져야 함

스케줄 생성에 개인이 큰 영향을 끼쳐서는 안 됨

이미 정해진 스케줄이 변경되어서도 안 됨

악의적인 행동을 효과적으로 막을 수 있어야 함 (Nothing at stake, Long range attack)

PoS also should be **fair** and **secure**

Validator selection rule

Disincentive for malicious behavior

Incentive for honest behavior

PoS also should be **fair** and **secure**

Validator selection rule

Disincentive for malicious behavior

Incentive for honest behavior

PoS of Tezos, **A mix of several ideas**

Validator Selection Rule	**Multiple snapshots** **Random seed**
Dis-incentive for Malicious Behavior	**Safety deposit** **Plenitude rule**
Incentive for Honest Behavior	**Block reward** **Accussing reward**

PoS of Tezos, **A mix of several ideas**

Validator Selection Rule	**Multiple snapshots Random seed**
Dis-incentive for Malicious Behavior	**Safety deposit Plenitude rule**
Incentive for Honest Behavior	**Block reward Accussing reward**

용어 정리

Baking

Block producing , Staking

Baker

Block producer, validator, miner, forger

Delegation

Only staking right, NOT ownership

Cycle

Period defined in protocol

4,096 Blocks (1 block = 1 min)

Validator selection rule = Roll snapshot + Random seed

Follow the roll

1 roll = 8,000 xtz (베이커 보유분 + 위임 받은 수량)

베이킹 파워가 롤 단위로 내림(Rounded down)

8,000 ~ 15,999 xtz = 1 roll

FTS 알고리즘 측면에서는 효율적

Roll snapshot을 통해 베이킹 파워를 측정

PoS with Optional Delegation

Validator selection rule = Roll snapshot + Random seed

Random seed

베이커들이 결정

예측이 사실상 불가능한 무작위 숫자열

Validator selection rule = Roll snapshot + Random seed

Roll snapshot

지분을 얼마나 보유하고 있는가

+

Random seed

예측이 사실상 불가능한 무작위 숫자열

Baking rights

블록 B는 베이커 A가 생성한다

Validator selection rule = Roll snapshot + Random seed

Cycle

1 Cycle = 4,096 블록 = 4,096분 = 2일 20시간 16분 (best case)

사이클 단위로 베이킹 스케줄이 **미리** 결정됨

Baking rights in cycle 1

Block 4,097: 베이커(Alice, Diego, Arthur, Charlie, Satoshi, ...)

Block 4,098: 베이커(Satoshi, Charles, Dan, Vitalik, Kwon, ...)

Block 4,099: 베이커(Justin, Kate, Arthur, Satoshi, Satoshi, ...)

…

Block 8,192: 베이커(Alice, Diego, Arthur, Charlie, Satoshi, ...)

Validator selection rule = Roll snapshot + Random seed

Block 8,192: 베이커(Alice, Diego, Arthur, Charlie, Satoshi, ...)

가장 높은 우선순위의 베이커는 이전 블록 생성 후 **1분** 후 베이킹 가능

2번째 우선순위의 베이커는 이전 블록 생성 후 **2분** 후 베이킹 가능

…

16분이 지난 경우, **보증금 없이** 베이킹 가능

체인별 블록 생성 시간을 통해서 체인의 score를 가늠할 수 있음

Validator selection rule = Roll snapshot + Random seed

Roll snapshot in **Cycle N**

지분을 얼마나 보유하고 있는가

+

Random seed in **Cycle N+1**

예측이 사실상 불가능한 무작위 숫자열

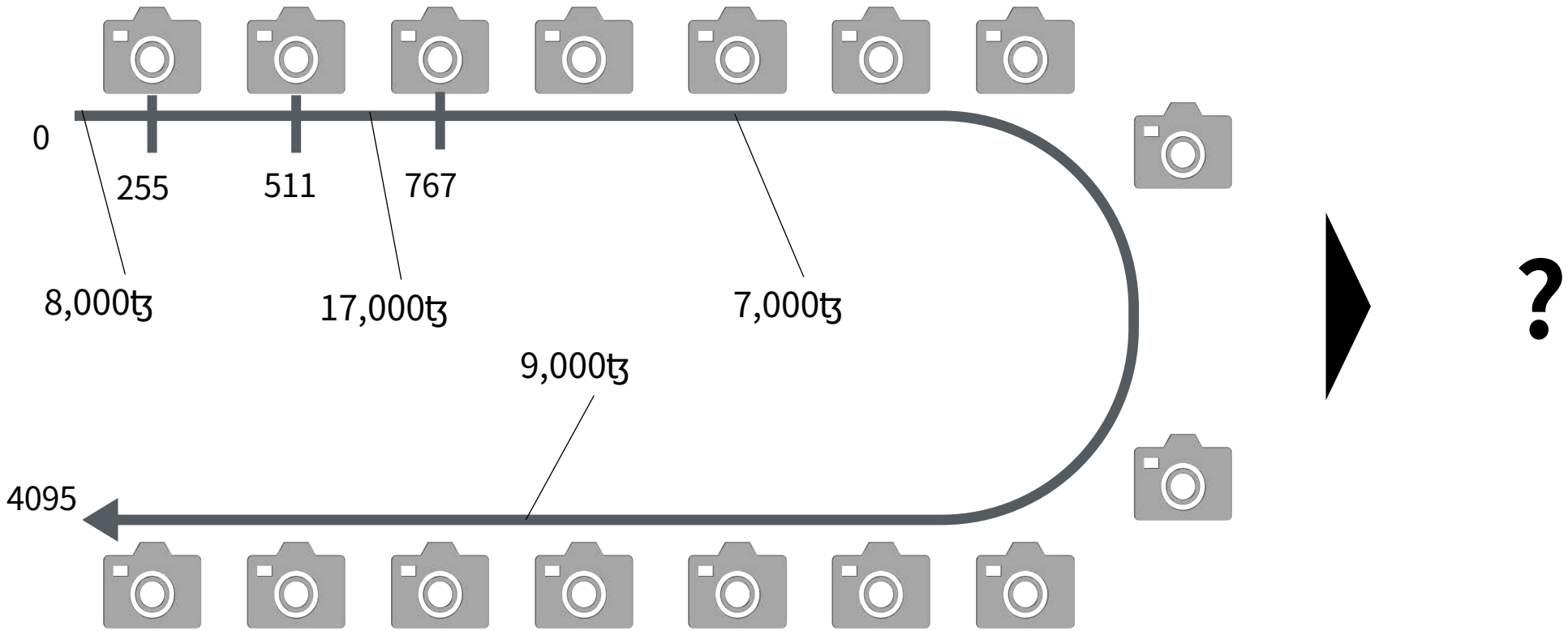
Baking rights in **Cycle N+7**

블록 B는 베이커 A가 생성한다

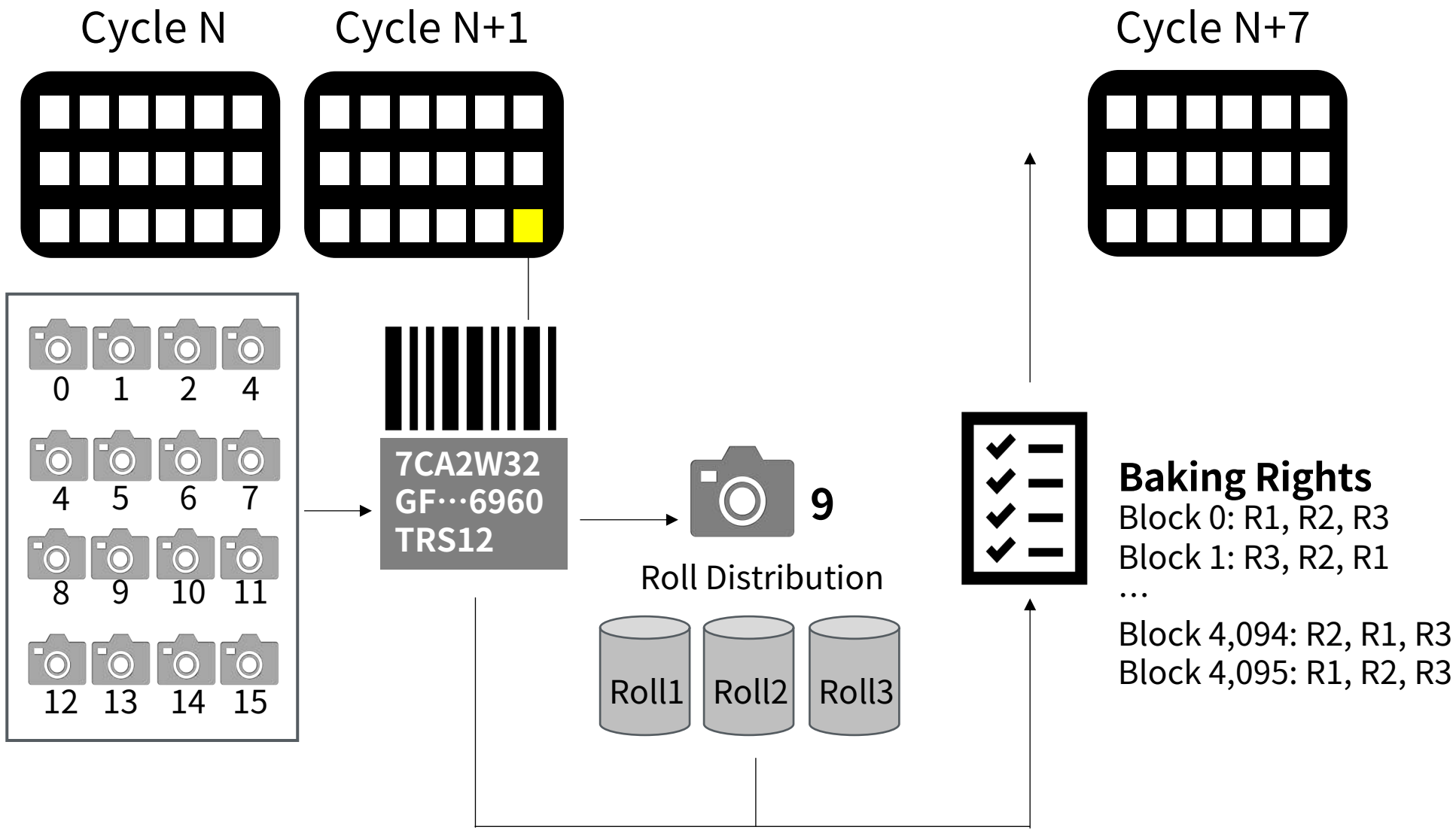
Validator selection rule = Roll snapshot + Random seed

Multiple snapshots (16 in a cycle) and random selection

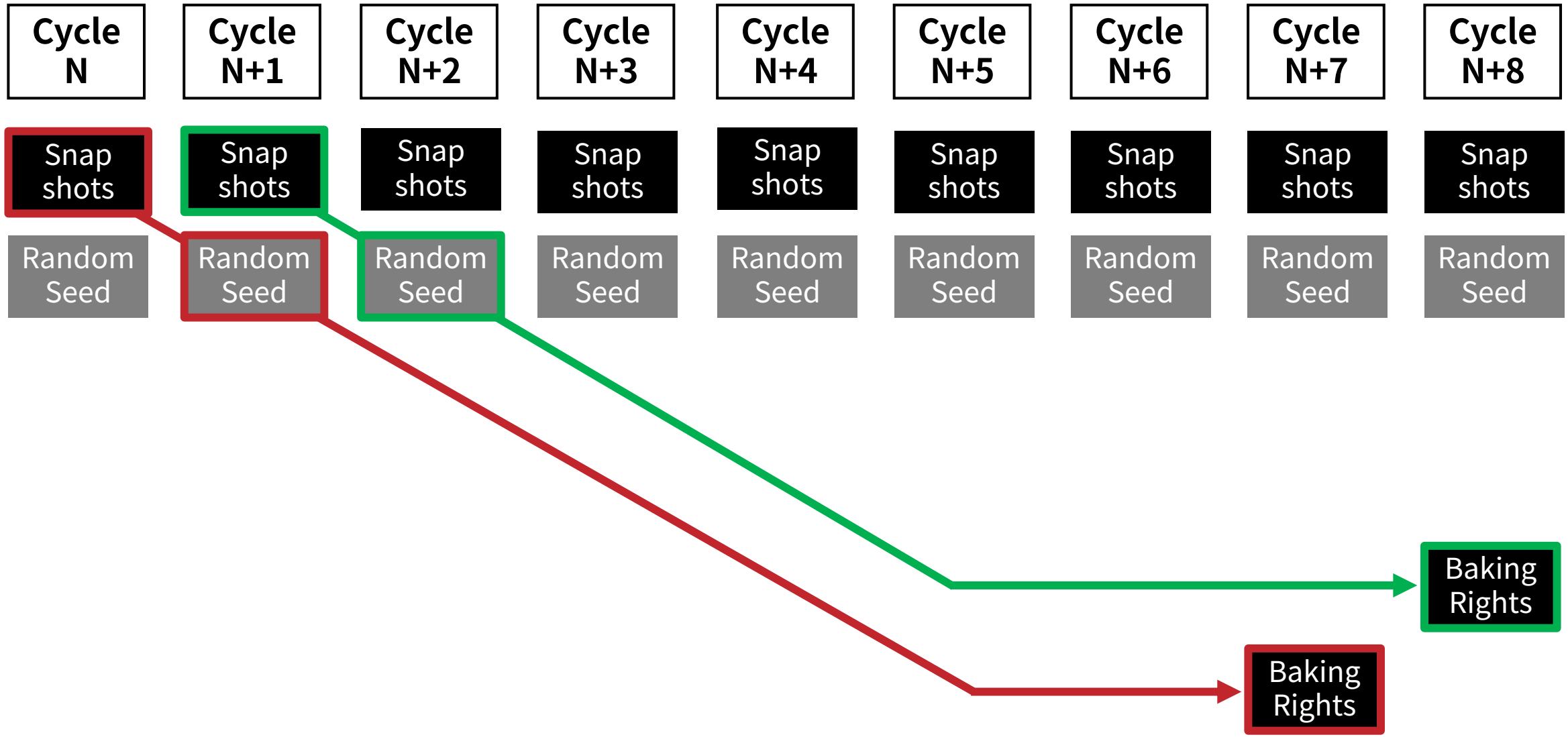
Proof of **STAKING**



Validator selection rule = Roll snapshot + Random seed



Validator selection rule = Roll snapshot + Random seed



Validator selection rule = Roll snapshot + Random seed

Random seed

베이커는 미리 정해진 베이킹 스케줄에 따라 블록B를 생성

임의의 숫자를 암호화(**hash commitment**)하여 블록B에 포함

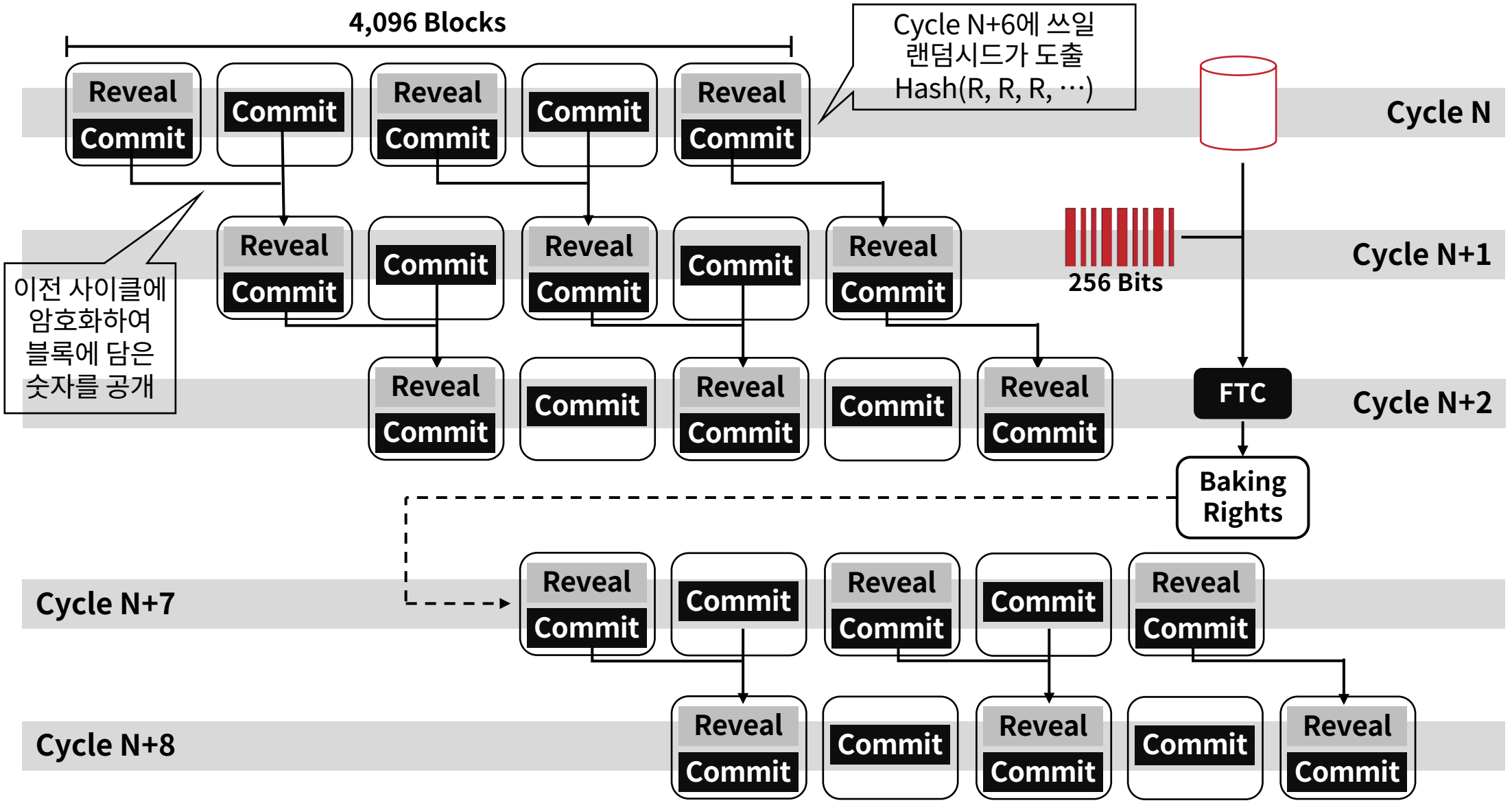
이 숫자는 다음 사이클에 공개(**reveal**)해야 함

숫자를 공개하지 않은 경우, 블록B의 보상과 수수료 몰수

매 사이클 마지막에 공개된 숫자를 모두 결합, 해싱하여 랜덤 시드 생성

공개는 32블록마다 자유롭게 가능

Validator selection rule = Roll snapshot + Random seed



PoS of Tezos, **A mix of several ideas**

Validator Selection Rule	Multiple snapshots Random seed
Dis-incentive for Malicious Behavior	**Safety deposit** **Plenitude rule**
Incentive for Honest Behavior	Block reward Accussing reward

Disincentive = Deposit + Endorsement

Endorsement

블록당 **32명**의 Endorser가 **미리** 정해짐 (Roll snapshot + Random seed)

이전 블록에 **투표**(endorse, notarize)

$\mathcal{B}lock_i$ 가 베이킹 된 후, 인도서들은 $\mathcal{B}lock_i$ 에 대해 서명을 제출함

$\mathcal{B}lock_i$ 베이커가 이 투표를 블록에 포함

체인의 score(fitness) = 인도스먼트의 합

인도싱이 블록에 담기고, Canonical chain이 되어야 보상

보상 = 최대 2ꜩ (2 / dT)

Disincentive = Deposit + Endorsement

Safety Deposit

베이킹, 인도싱에 요구되는 조건

5사이클 동안 동결(locked, frozen)

악의적인 행동 시 몰수(forfeit, slashed)

Baking	Number	Deposits	Rewards
Baking	1	**512 ꜩ**	16 ꜩ
Endorsing	Up to 32	**64 ꜩ**	2/dT ꜩ

PoS with Optional Delegation

Chain-based PoS consensus with a use of endorsements to speed-up confirmation times and reduce selfish baking

PoS of Tezos, **A mix of several ideas**

Validator Selection Rule	Multiple snapshots Random seed
Dis-incentive for Malicious Behavior	Safety deposit Plenitude rule
Incentive for Honest Behavior	**Block reward Accussing reward**

Incentive

Baking reward

Steal: 후순위 베이커가 베이킹 하는 경우

Endorsing reward

최대 2 ꜩ (2 / dT)

Accusing reward

악의적인 행동을 신고

악의적인 행동이 적발된 베이커는 Safety deposit 몰수

몰수된 토큰의 절반은 소각(proof of burn), 절반은 신고자에게 지급