# BITCOIN PROTOCOL AND CONSENSUS: A HIGH LEVEL OVERVIEW

Max Fang & Viget

# TERMINOLOGY
## BLOCKCHAIN FUNDAMENTALS

### Bitcoin is the technology that started it all

- Bitcoin is a cryptocurrency

### Blockchain is the technology underlying Bitcoin

- Enables distributed consensus

### Community terminology

- **"crypto"**, **"cryptocurrency"** - Bitcoin, Ethereum, more technical
- **"private blockchains"**, **"permissioned ledgers"**, or just **"blockchain"**
- **"distributed tech"** or **"decentralized tech"** - umbrella term

AUTHOR: MAX FANG

# BITCOIN AND CONSENSUS

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# Blockchain fundamentals

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## Blockchain is the technology underlying Bitcoin: Enables distributed consensus

## Community terminology

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BLOCKCHAIN AT BERKELEY

# SATOSHI NAKAMOTO'S INNOVATION

BLOCKCHAIN FUNDAMENTALS

**Bitcoin was created by Satoshi Nakamoto in 2009**

- Decentralized, trustless system for transactions
  - A low cost financial system that only requires an internet connection
- Nakamoto solved the Double Spending problem
  - Prevent someone from spending the same asset twice
  - Solution? The blockchain + Proof-of-Work

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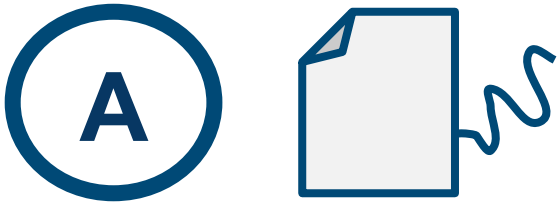
# 1. Alice writes and signs a message describing her transaction




“I, Alice, am giving Bob one bitcoin.”

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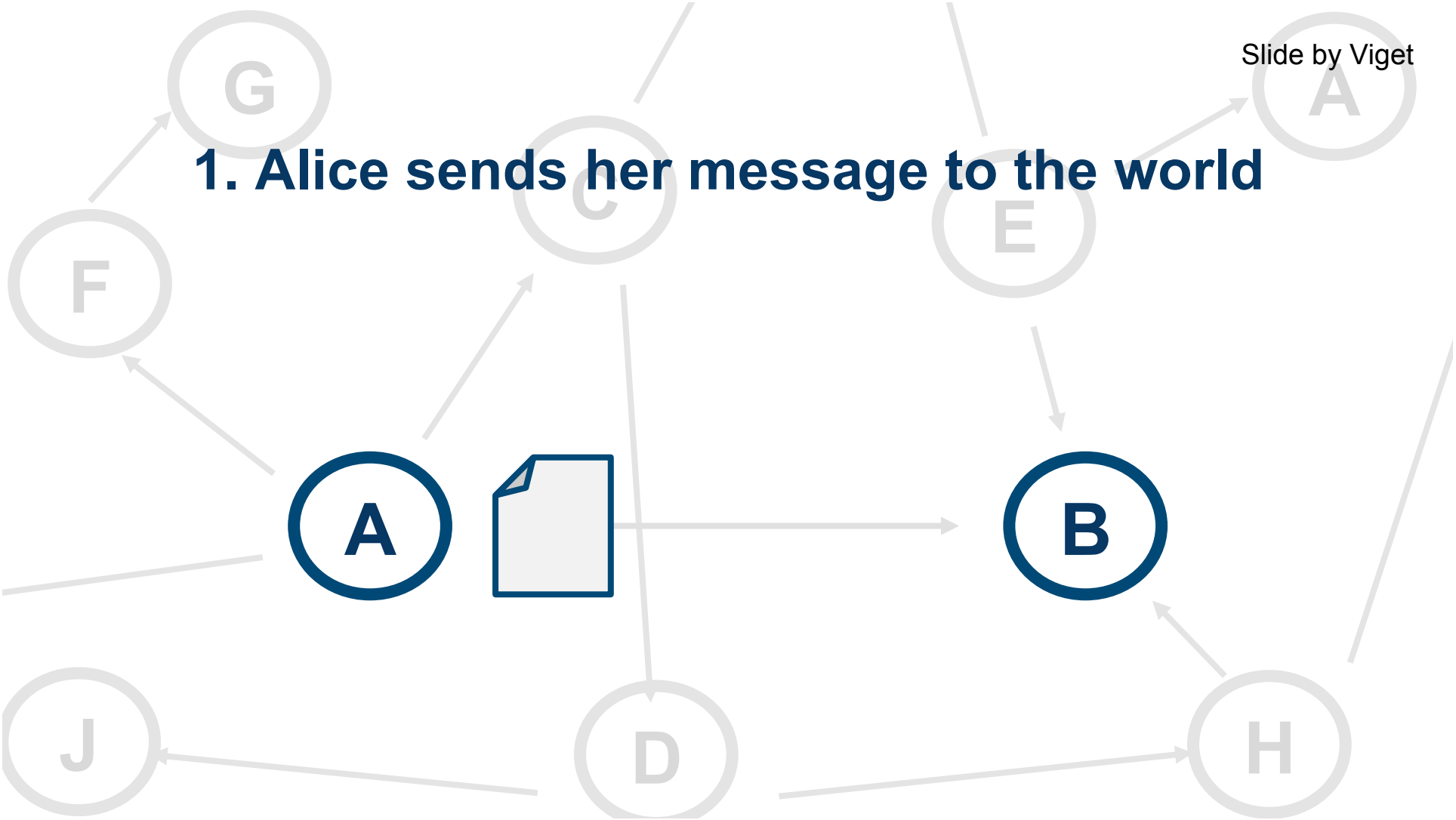
# 1. Alice sends her message to the world



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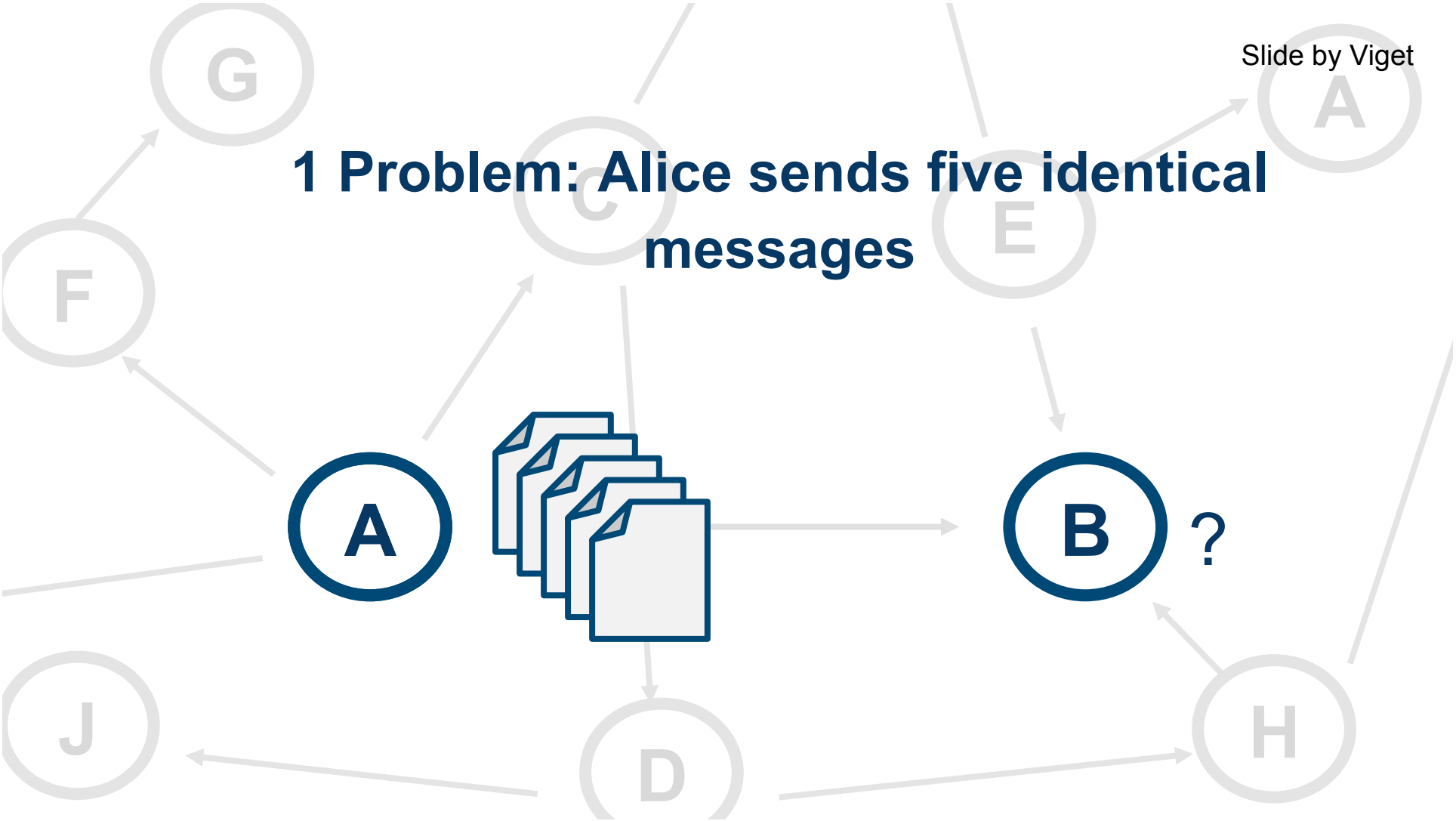
# 1 Problem: Alice sends five identical messages



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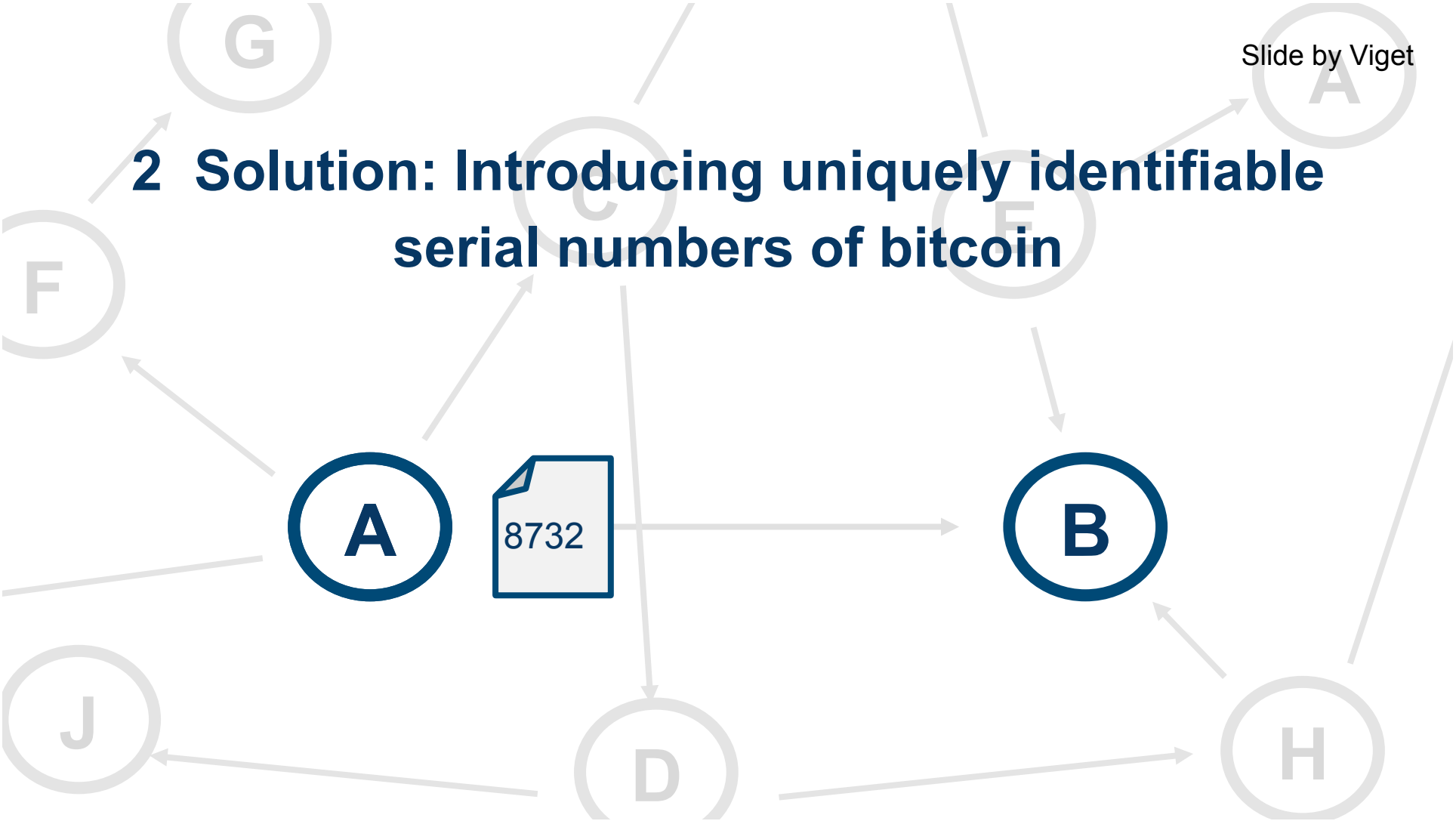
# 2 Solution: Introducing uniquely identifiable serial numbers of bitcoin



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# 2 Where do serial numbers come from?

?

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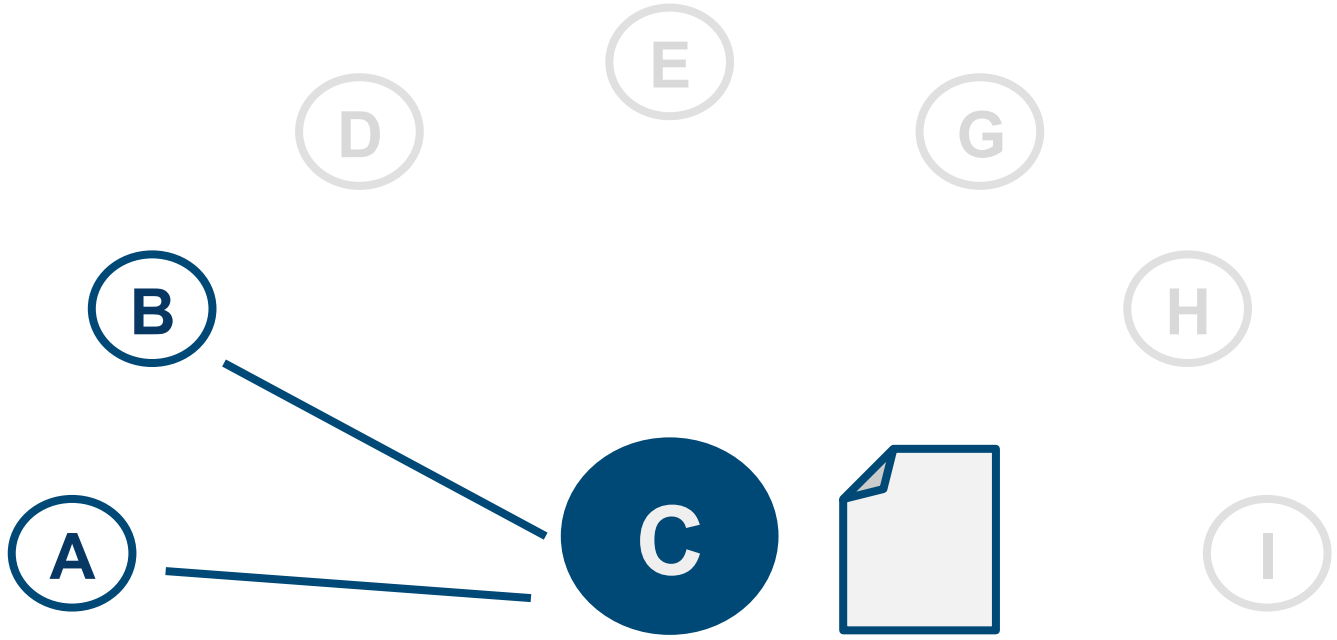
# 2 Usual solution (centralized): A central bank manages transactions and balances each banknote has a serial number



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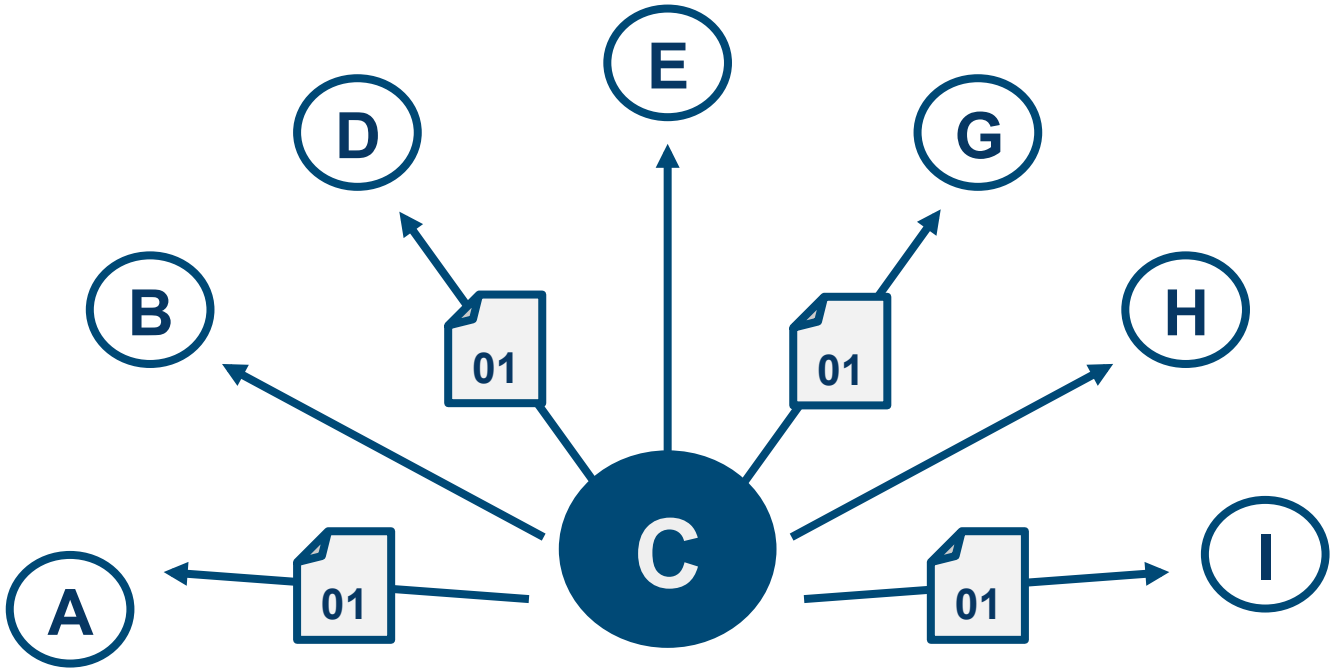
# 2 Central bank: Centralization



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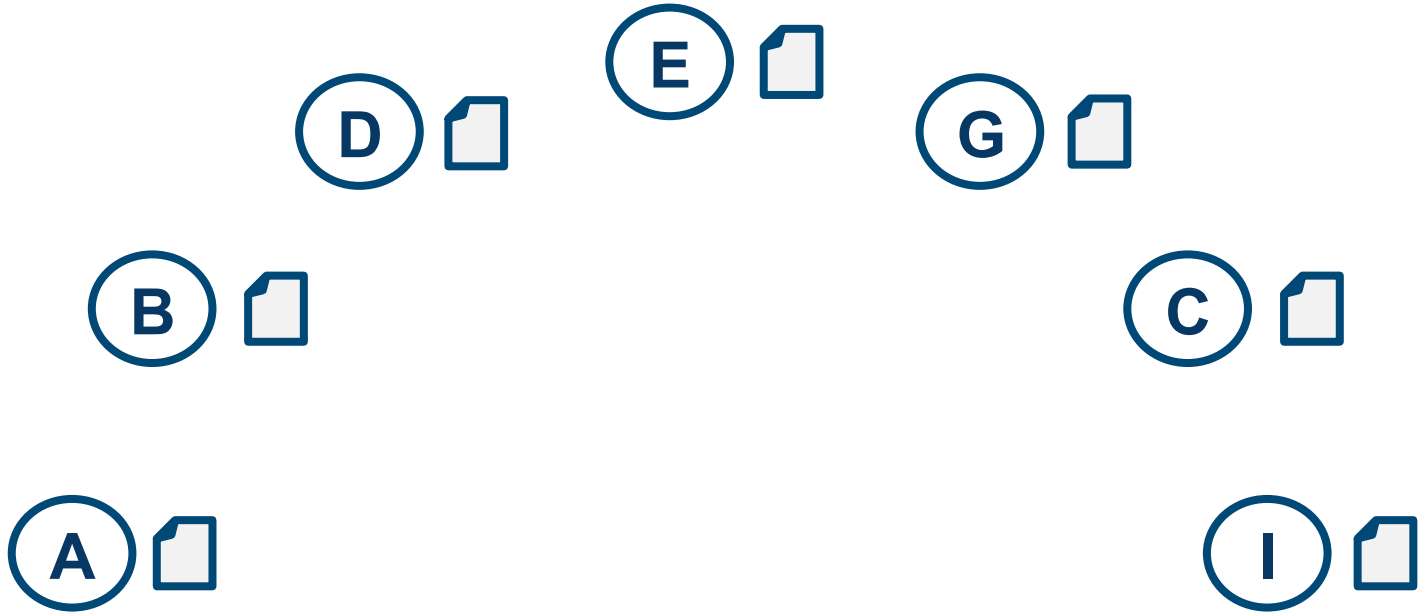
# 3 Distributed: Making everyone the bank
# Everyone has a complete record of transactions



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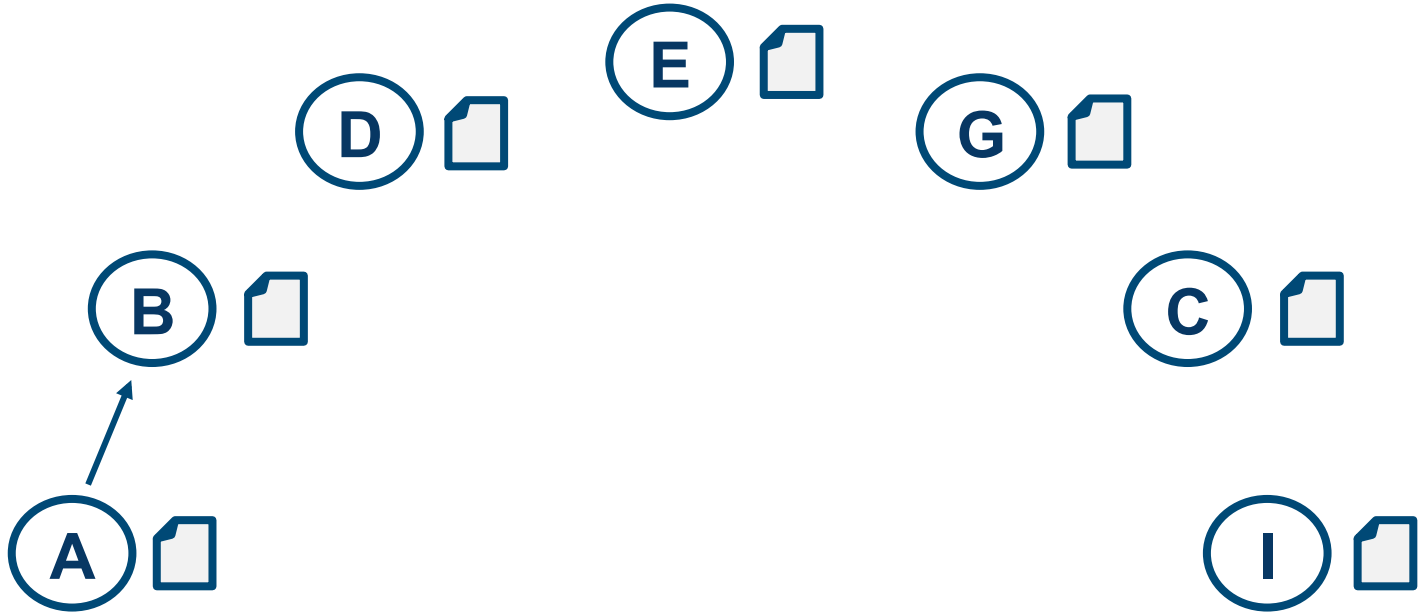
# 3. Making everyone the bank

## 3.1 Alice sends her transaction to Bob



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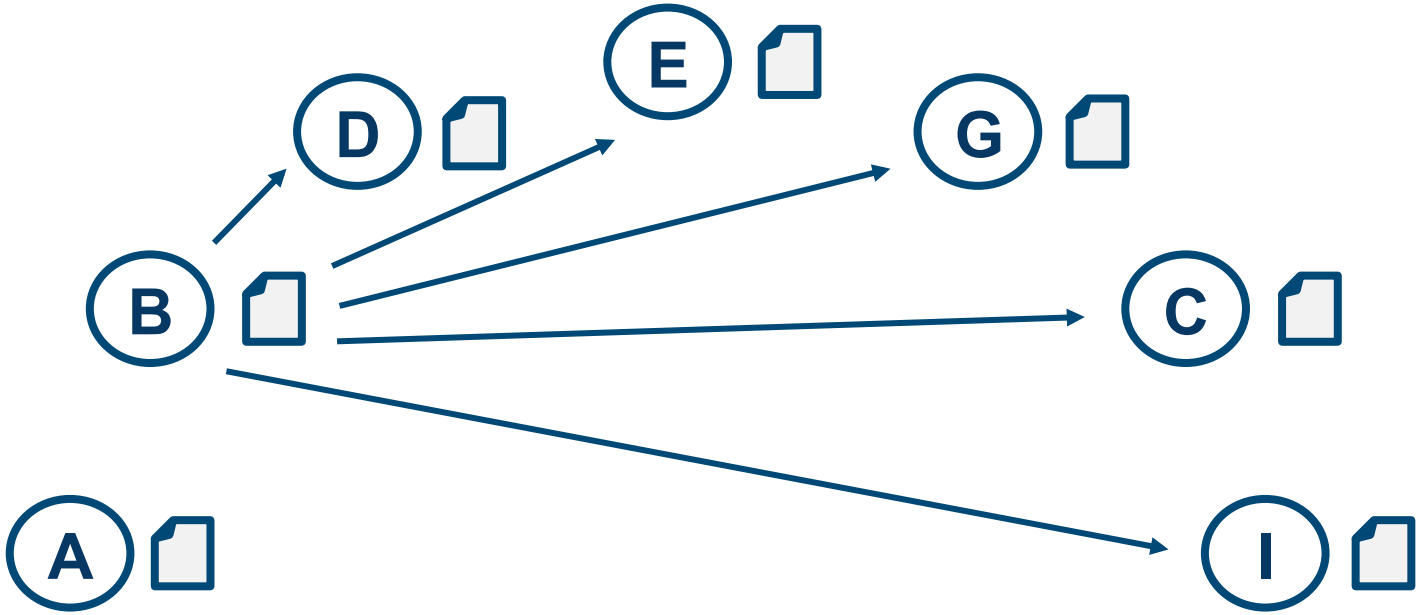
# 3. Making everyone the bank

## 3.2 Bob announces the transaction to the world



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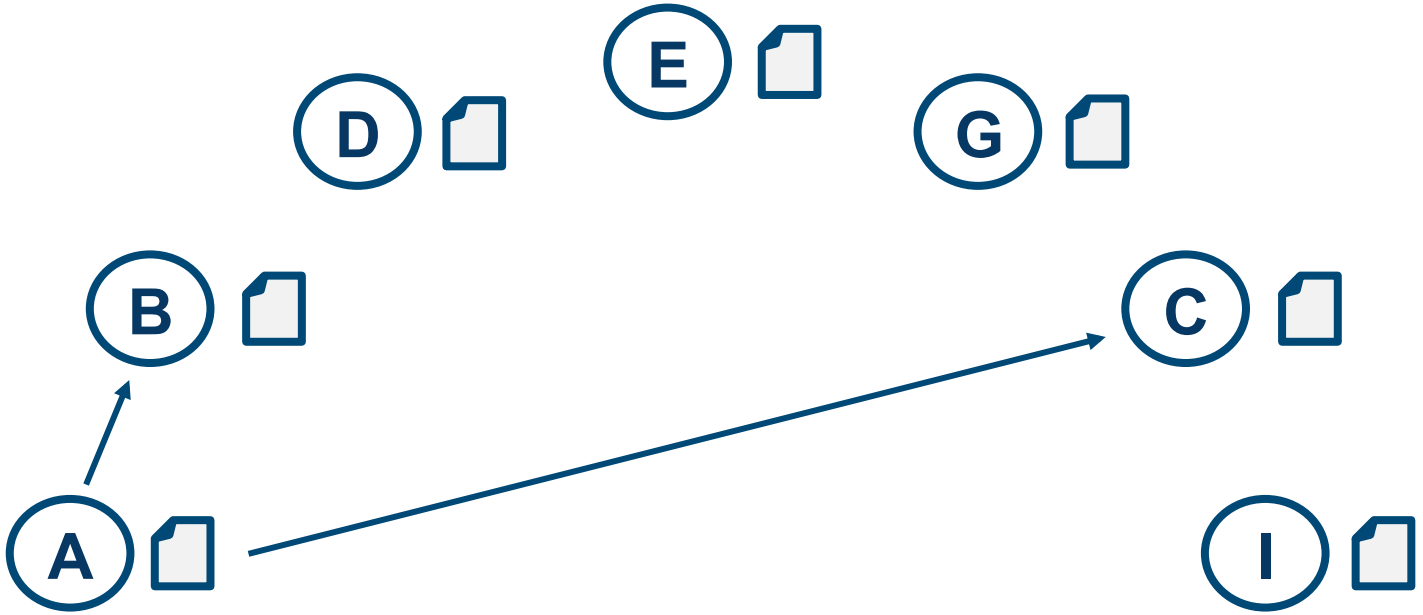
# 3. Making everyone the bank : Problem

## 3.3 Alice double spends on Bob and Charlie



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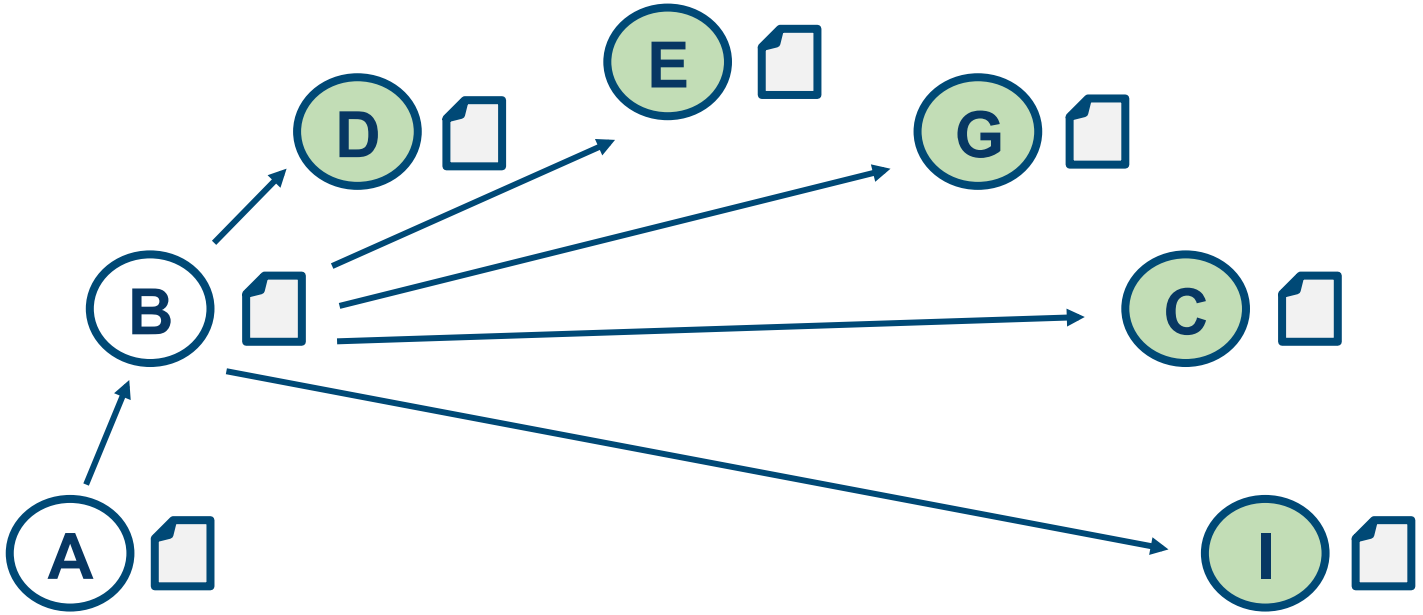
# 3. Making everyone the bank

## 3.4 Everyone verifies transactions

### A transaction is accepted if everybody accepts



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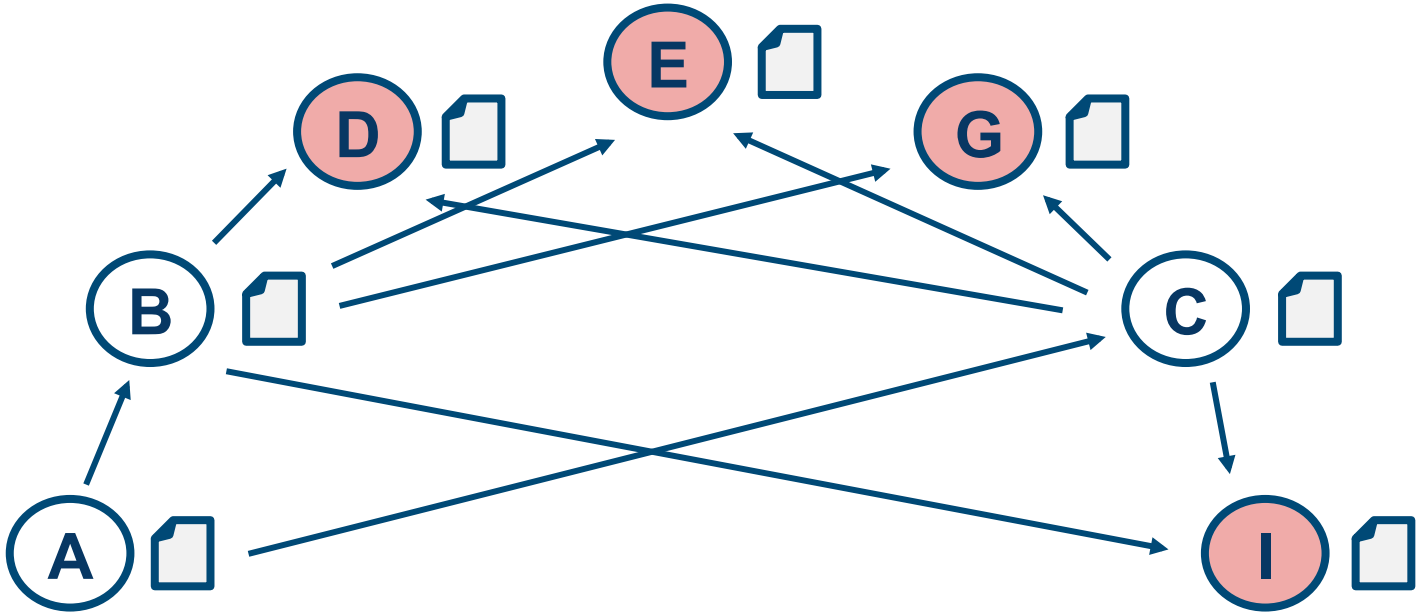
# 3. Making everyone the bank

## 3.4 Everyone verifies transactions therefore Alice is prevented from double spending



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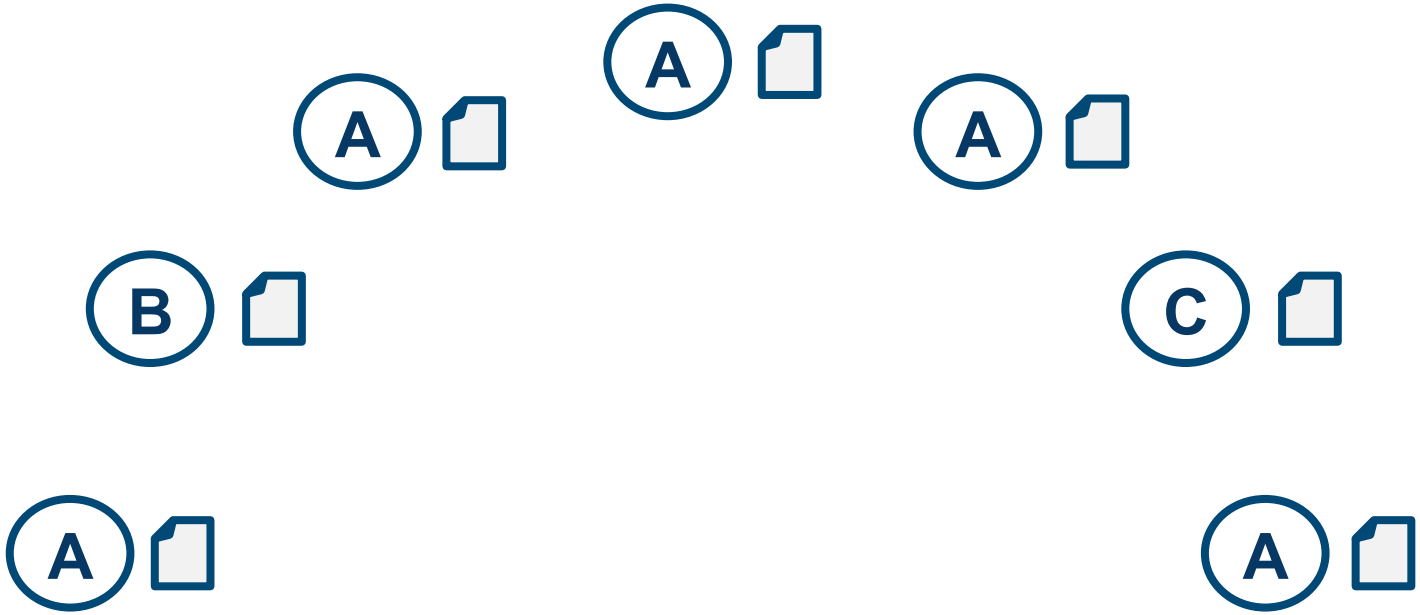
# 3. Making everyone the bank

## 3.5 Alice sets up multiple identities



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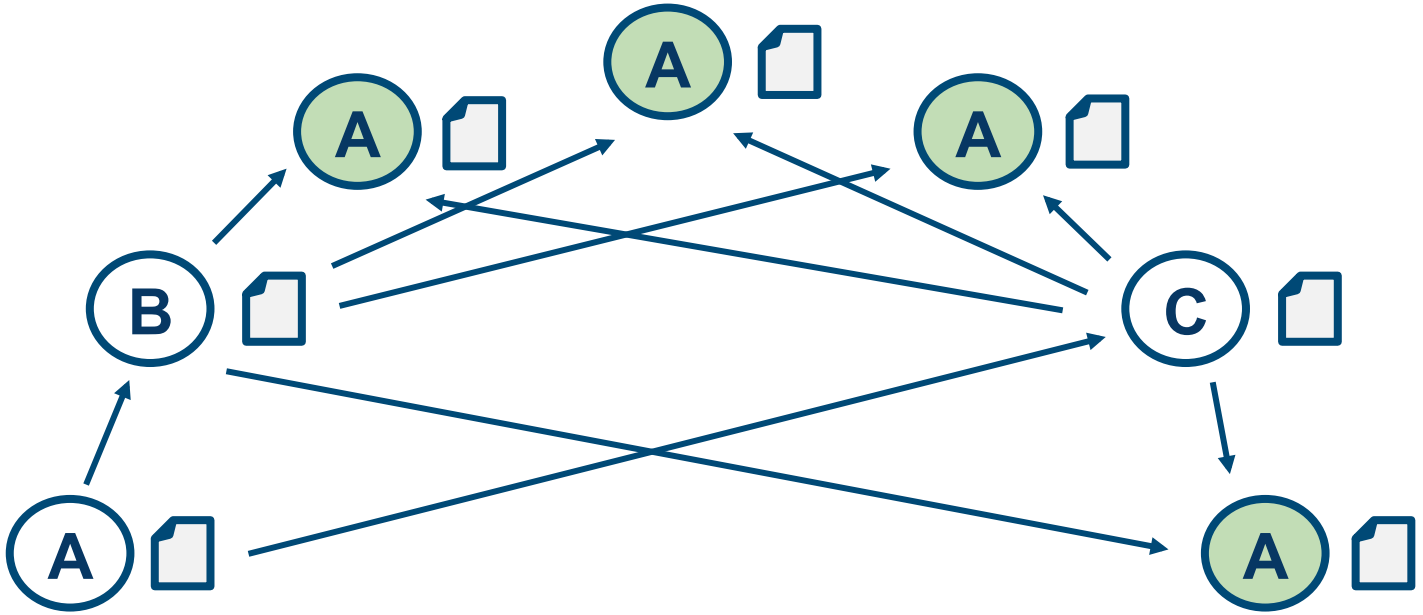
# 3.5 Alice double spends using multiple identities

## Sybil Attack: Creating many fake identities to subvert a system



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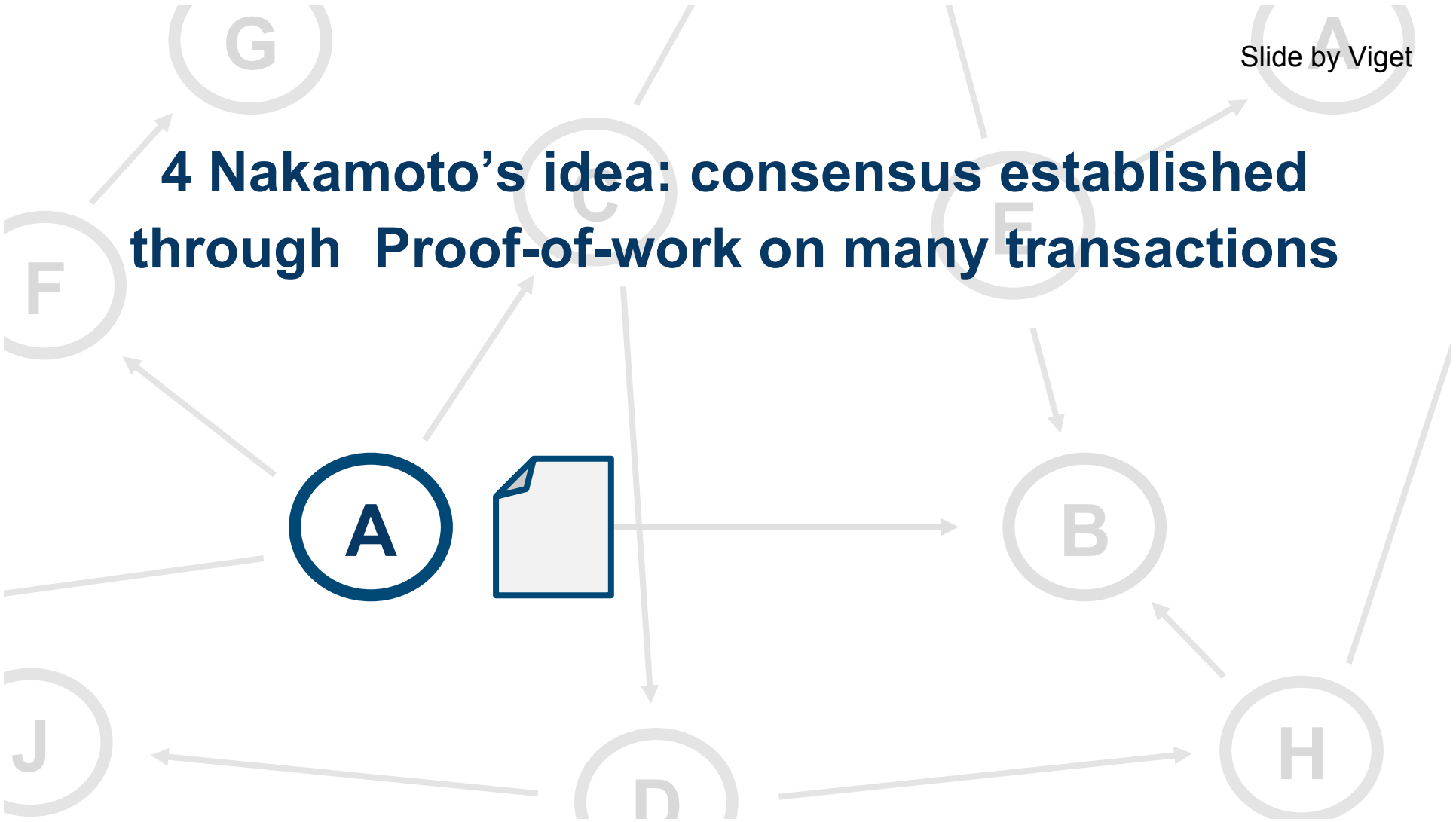
# 4 Nakamoto’s idea: consensus established through  Proof-of-work on many transactions



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# 4.1 Block: verify a block of transitions

## Many users add to list of pending transactions

**Block: a set of transactions**

1. I, Tom, am giving Sue one bitcoin, with serial number 3920.
2. I, Sydney, am giving Cynthia one bitcoin, with serial number 1325.
3. I, Alice, am giving Bob one bitcoin, with serial number 1234

**All transactions since Bitcoin started are stroed using as data structures a list (chain) of blocks**

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# 4.1 Verifying transactions

0 Form block

1 Check block is correct

2 Solve puzzle

3 Announce block to all users

4 users verify correctness

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# 5 Nakamoto’s idea:
# Solve the puzzle using Mathematics
# Why the math?

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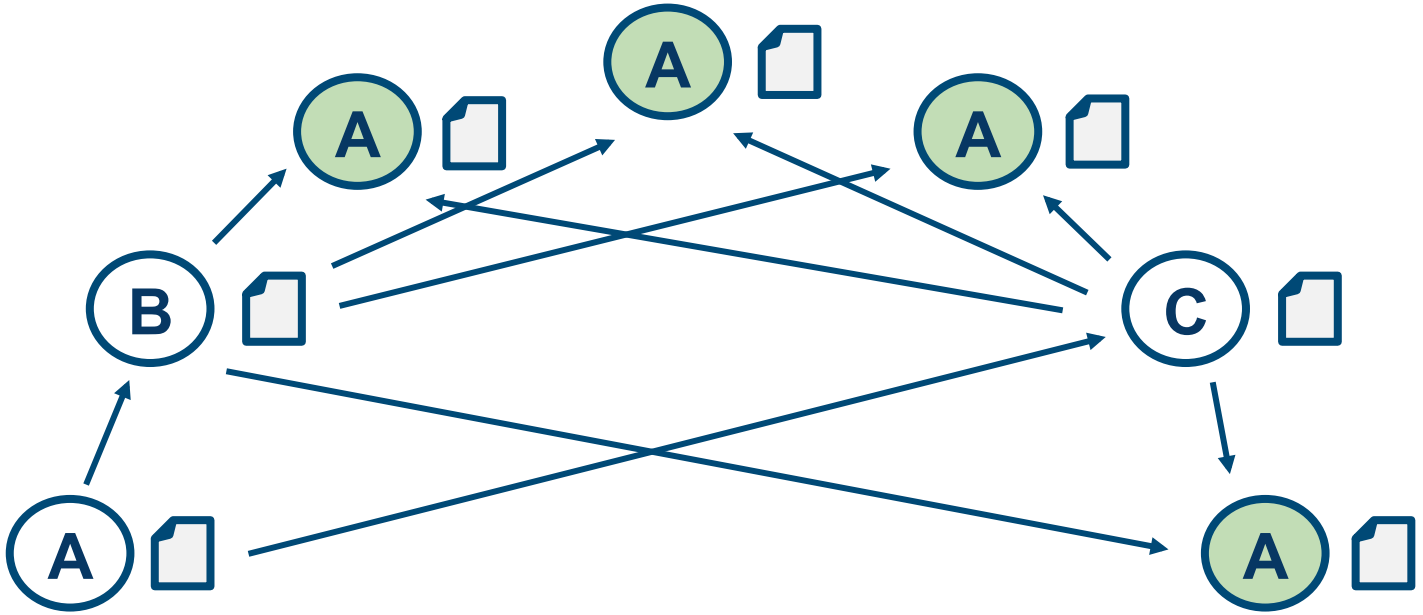
# 5.1 Why the math?

## We want to make it costly for Alice to double spends with her multiple identities



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# 5.2 How is the math?
# Proof-of-work as a competition
# who wins the competition is paid with Bitcoins

# 5.2 Proof-of-work as a competition

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- the winner is the first that solves a puzzle on the new block to be added to the blockchain
- the winner is paid with Bitcoins
- the rule of the game favour honest behaviour: there is an incentive to recognize the winner also for those that are not winner

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# Summary

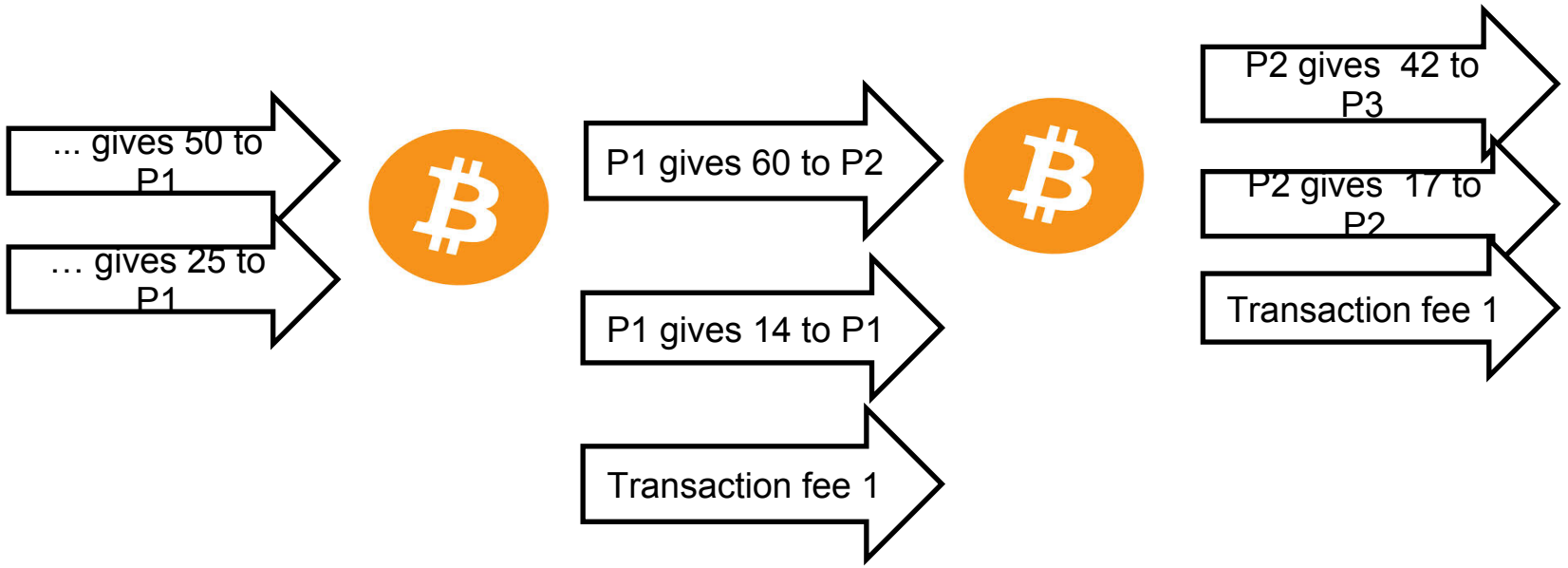
| | **Major feature** | **Value added** |
|---|---|---|
| 1 | Signed messages announced to the network | Basis of entire system |
| 2 | Serial numbers | Uniquely identifiable transactions |
| 3 | The block chain | Shared record of transactions |
| 4 | Everyone verifies transactions | Increased security |
| 5 | Proof-of-work | Prevents double spending |

# How is money created in Bitcoin?

- New block **every ~10 mins**
  - **d** adjusted every ~2000 blocks
- H = **2-SHA2**
- d number of leading zeros of hash (difficulty)
- R random number, L new block
- Initial reward: **50 BTC**
  - Halved every ~4 years (now **12.5 BTC**)

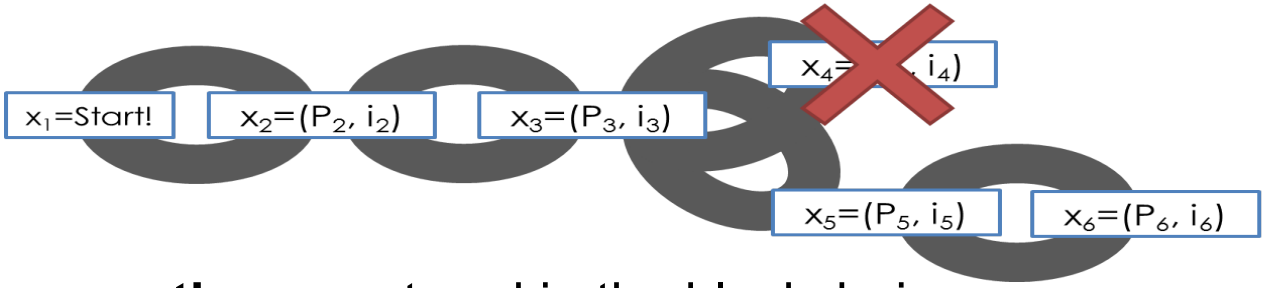
# How is money transferred in Bitcoin?

**Example**: P1 wants to give 60 to P2



# How is money stored in Bitcoin?

- Transaction in **orphaned blocks** are invalid
  - **Wait 6 blocks** (~1 hour) before accepting transaction.
  - **Checkpoints** to prevent complete history rollback




- **All transaction** are stored in the blockchain
  - (Currently ~170 GB)