



# Hedera™ Hashgraph

THE TRUST LAYER OF THE INTERNET

# Hello Future

## The trust layer of the internet

**Cooper Kunz**

Developer Evangelist

 cooper\_kunz

# Agenda

- I. Overview of the Hedera Hashgraph public network
- II. Foundations of the Hashgraph Consensus Algorithm
- III. Users / projects building on Hedera
- IV. How to start building your own applications
- V. Q&A



# Part 1 - Overview of the Hedera Hashgraph Public Network

 @hashgraph

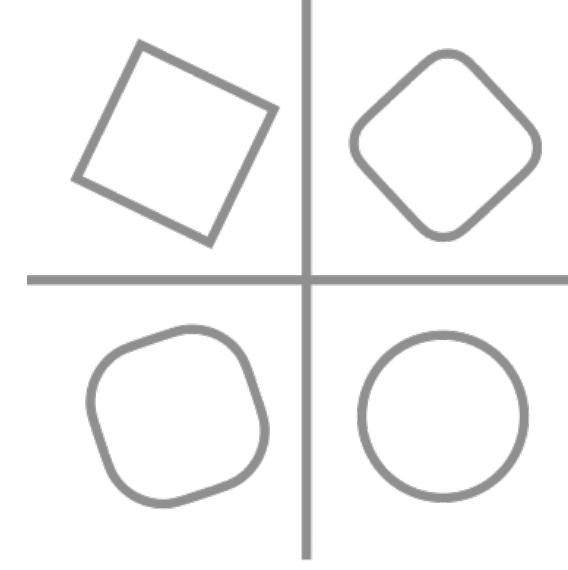
# Enterprise adoption of public distributed ledgers



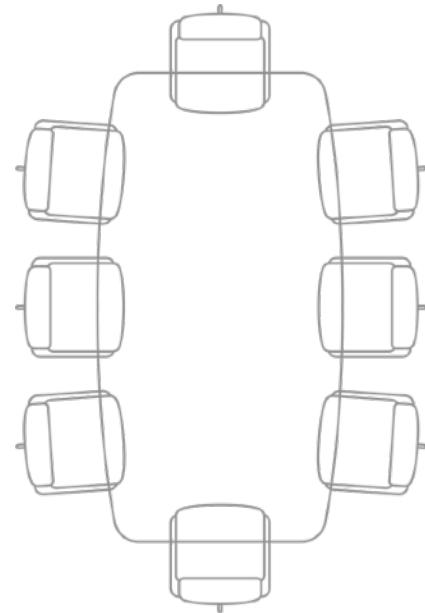
Performance



Security



Stability



Governance

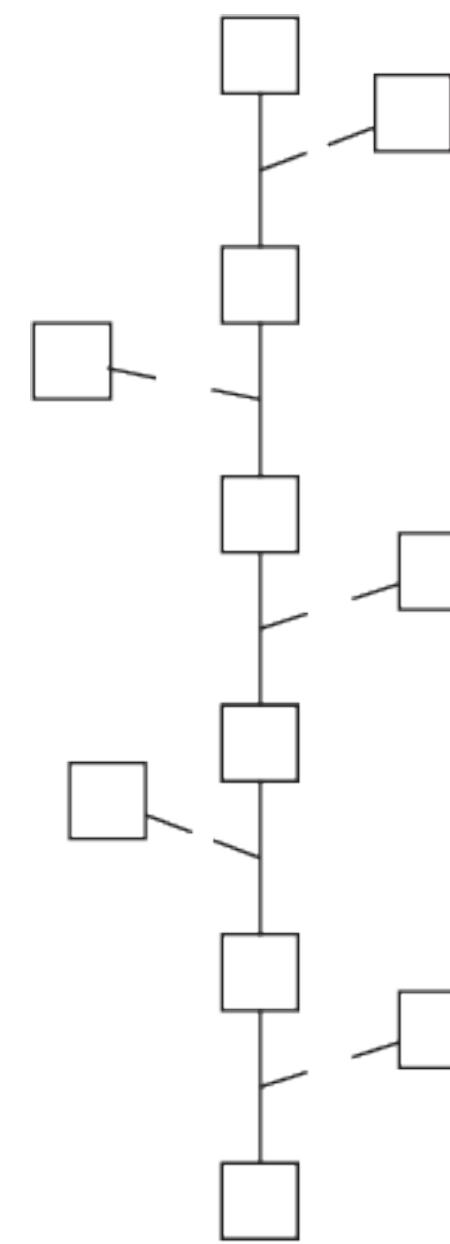
# Technology Overview

HASHGRAPH CONSENSUS & HEDERA NETWORK SERVICES



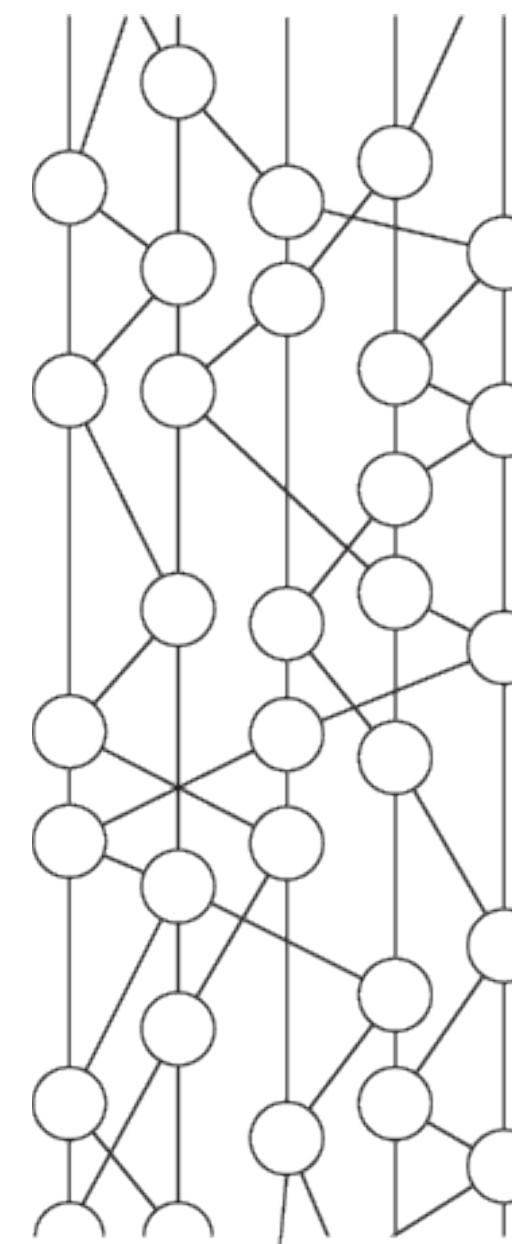
# BLOCKCHAIN VS. HASHGRAPH

## BLOCKCHAIN

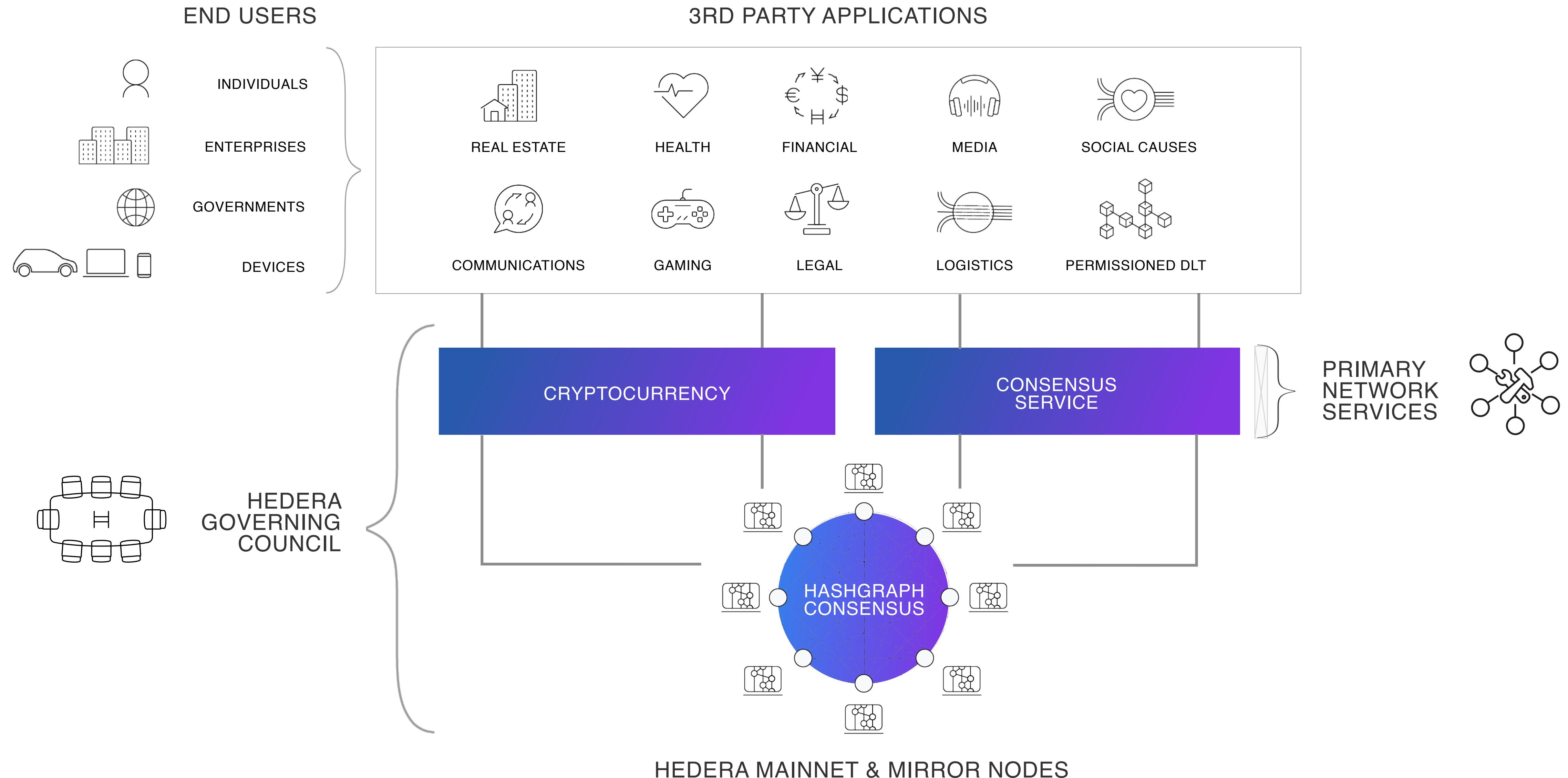


- Blockchain is designed to be slow, as a security measure
- Proof-of-work puzzle adjusts to keep the system at a specific speed, as time is needed to determine which block of transactions to add to the chain
- Efforts to speed up blockchain all make security sacrifices
- Requires heavy electricity usage

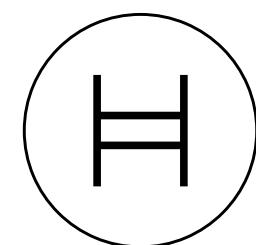
## HASHGRAPH



- Hashgraph is a distributed ledger, but not a blockchain
- Combines a gossip protocol with virtual voting algorithm to efficiently and quickly achieve network consensus on transactions
- Asynchronous Byzantine fault tolerant (highest level of security for distributed networks)
- Does not require heavy electricity usage

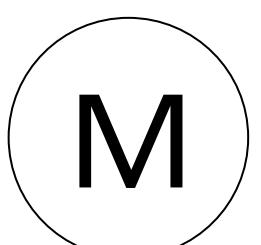
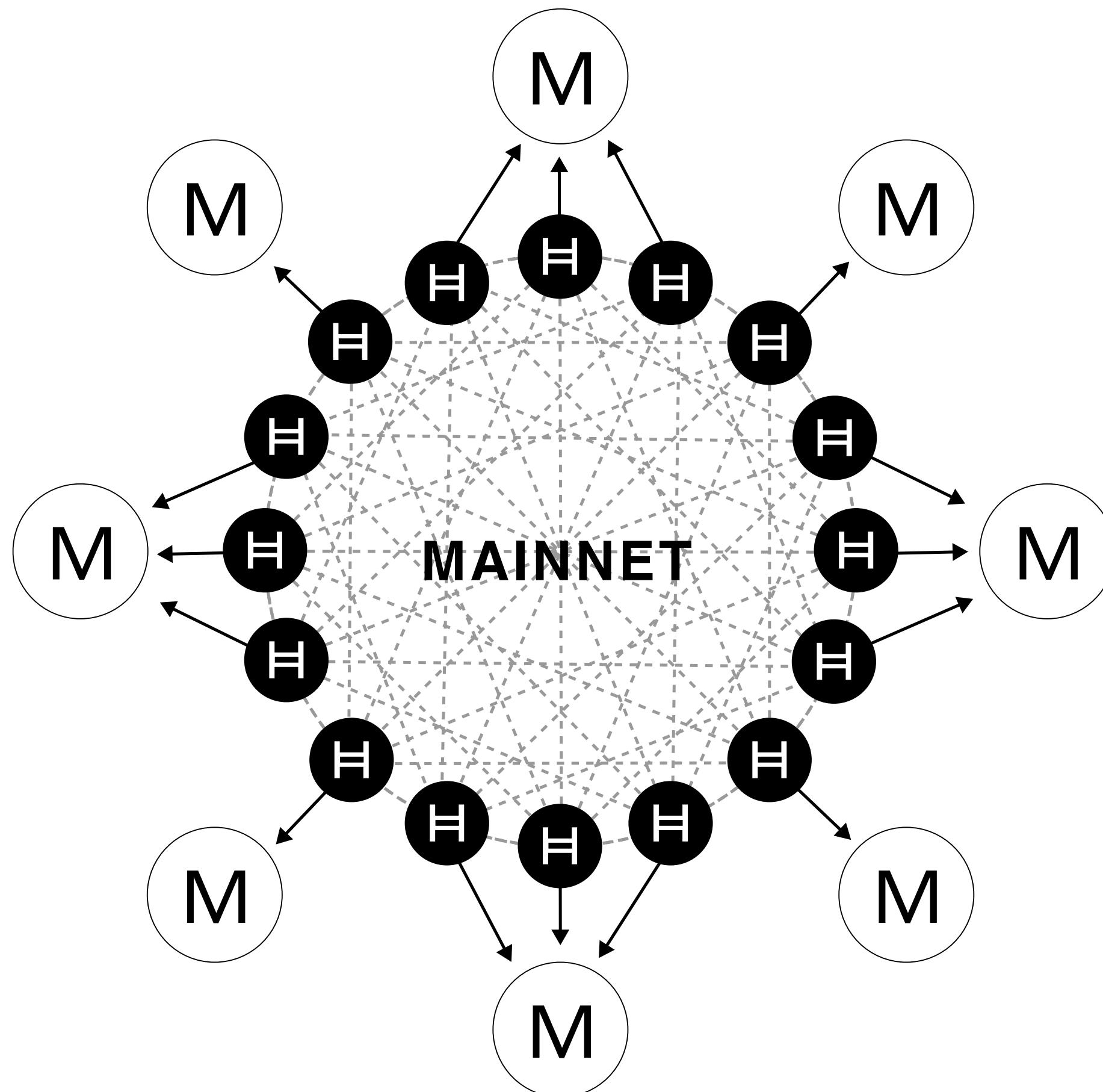


# HEDERA MAINNET & MIRRORNET



## MAINNET

- Can submit HAPI (Hedera API) transactions to the Hedera network
- Contributes to consensus on transactions
- Creates events on the Hedera network
- Requires HBAR cryptocurrency payment for transactions & queries

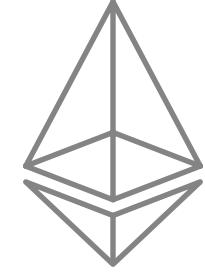


## MIRRORNET

- Maintains a history of some or all of the Hedera network state and ledger of transactions
- Value-added services (managed read-only node, etc.)
- Enables analytical insight into an application's state / transactions
- Publish and subscribe capabilities



# A third generation public distributed ledger

	1ST GENERATION 	2ND GENERATION 	3RD GENERATION 
TRANSACTIONS PER SECOND	3+ TPS	12+ TPS	10,000+ TPS
AVERAGE TRANSACTION FEE	\$0.20 USD	\$0.13 USD	\$0.0001 USD
AVERAGE TRANSACTION CONFIRMATION	10-60 MINUTES	10-20 SECONDS	3-5 SECONDS (W/ FINALITY)

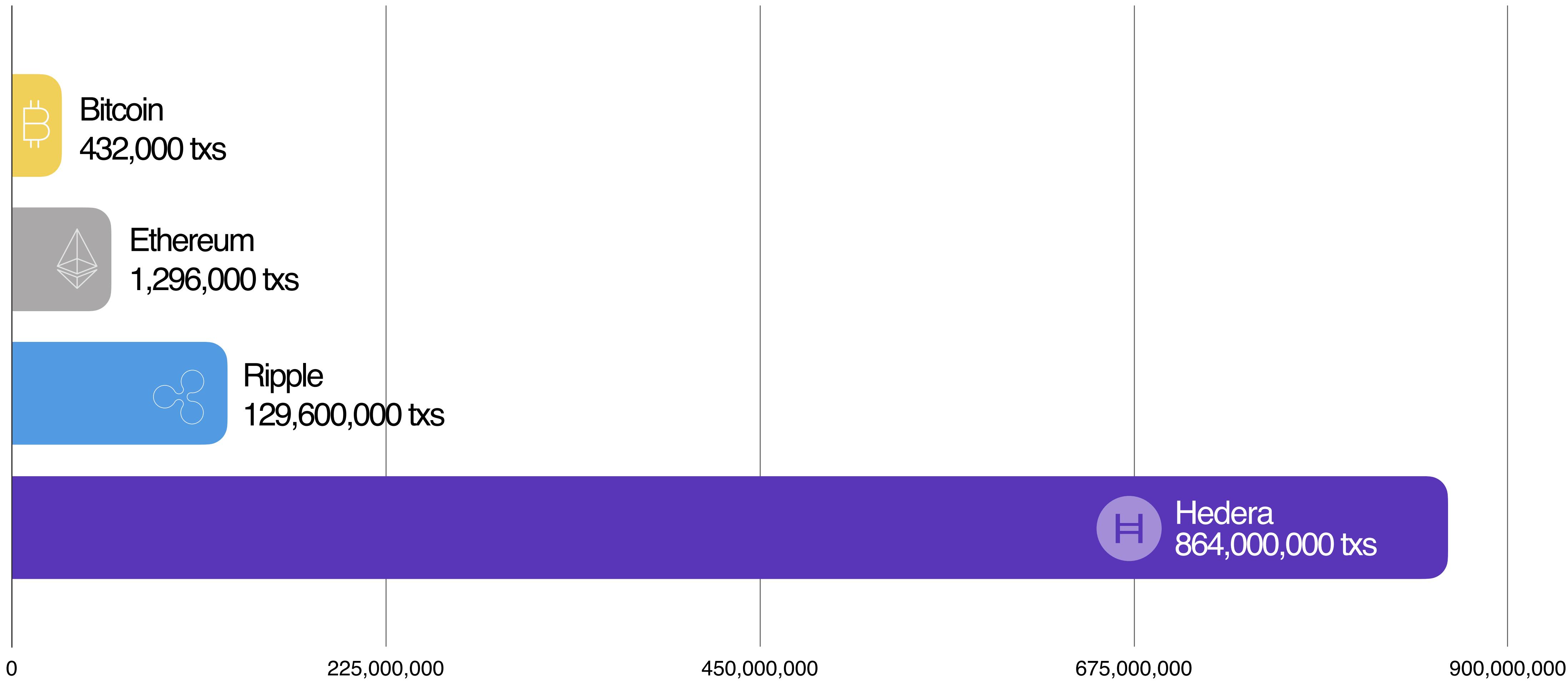
• Cryptocurrency transactions. For Hedera, range shown for transactions not requiring a transaction record, but can receive a transaction receipt.

• Avg. Bitcoin tx fee from 9/26/18 - 3/26/19 from <https://bitcoinfees.info/>

• Avg. Ethereum tx fee from 9/26/18 - 3/26/19 from <https://blockchair.com/ethereum/charts/average-transaction-fee-usd>

# DAILY TRANSACTION POTENTIAL

Single shard, on-ledger





# Data Integrity

*“Using Hedera Consensus Service, advertisers can be more confident that their data is both accurate and tamper-proof, aiding in the fight to reduce ad-fraud and recover the billions of dollars lost each year in wasted ad spend.”*

Ian Mullins | CEO

**AdsDaX**

## REAL-TIME DATA

Transactions on Hedera are logged in real-time, making data accessible to applications and analytical tools.

## VERIFIABLE TRANSACTIONS

Grant auditors, regulators, and partners the ability to verify application events with a transparent set of records.

## LOW FEES

Logging events to Hedera costs just a fraction of a penny per event, ensuring access for web-scale applications without impacting the bottom line.



# Micropayments

*“Hedera is the only platform we’ve seen that can cope with the volume of split-second transactions that need to take place.”*

Jiro Olcott | Director



## CUSTOMIZABLE

Transactions of value in Hedera’s native cryptocurrency HBAR are expressed as code, enabling unique application experiences.

## SCALABLE TRANSACTIONS

The efficiency of hashgraph yields extremely fast cryptocurrency transactions with finality in seconds.

## LOW FEES

Operationally efficient, resulting in low and predictable cryptocurrency transaction fees.

# Decentralized Identity

*"The success of a self-sovereign identity solution is driven by the platform it's built upon. While choosing the underlying platform, we compared many options, and decided to build Earth.Id on Hedera."*

Shiv Aggarwal | Co-Founder



## OPEN STANDARDS

Hedera's credentials follow the decentralized identifier and verifiable credentials standards under development at the W3C.

## EMPOWER USERS

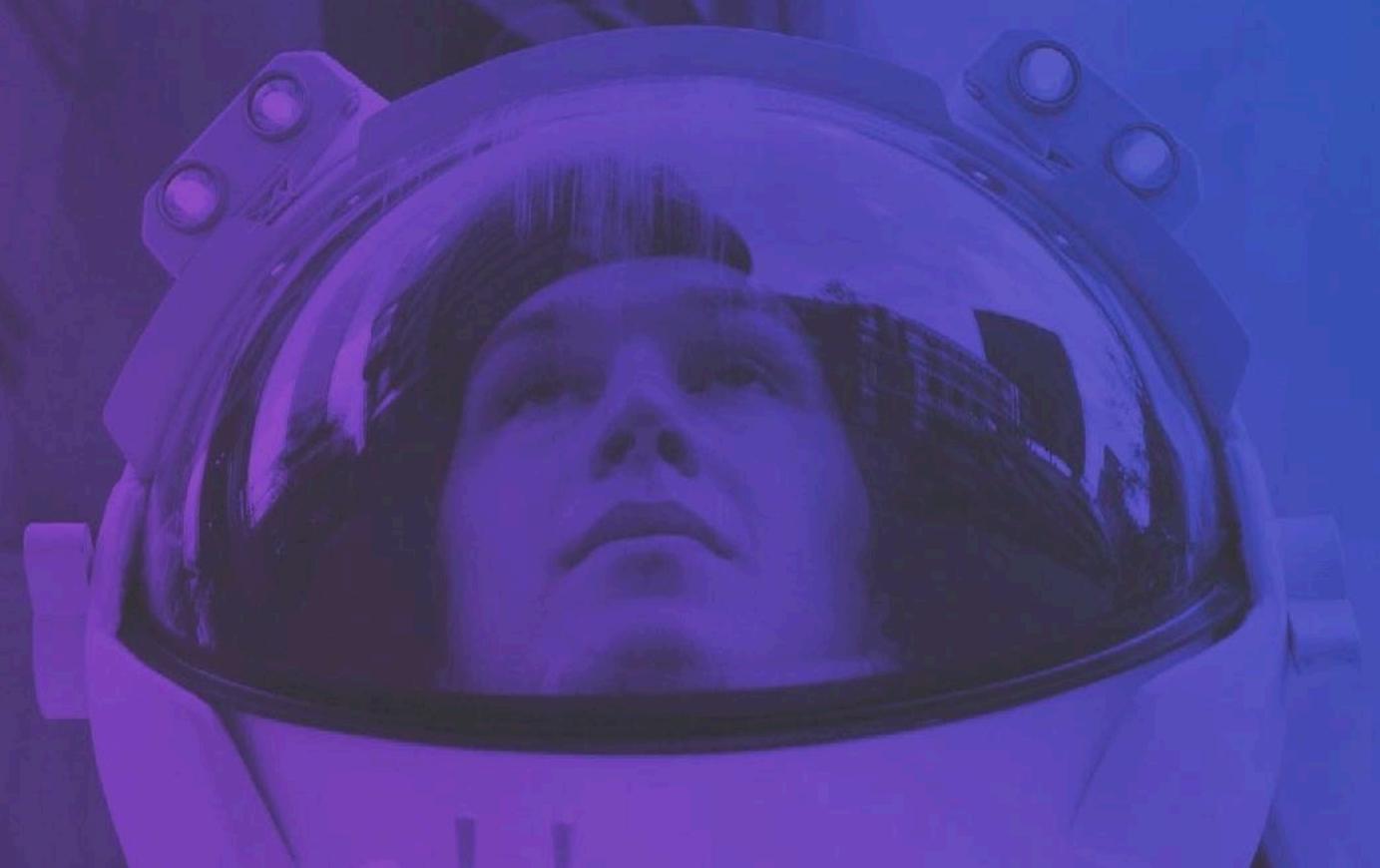
Credentials on a decentralized network can give users greater control over when and to whom their identity attributes are shared.

## SCALE TO DEVICES

Hedera Consensus Service can scale to support high-volume device identity use cases.

# Governance

THE HEDERA GOVERNING COUNCIL





# The Hedera Governing Council

Building the future  
together.

Up to **39** leading global organizations

**11** unique industries, **1** university, and **1** non-profit across major markets

Every member required to run a network node

Members not compensated beyond network node payments

**2.6%** influence per member (equal vote)

**5** committees:  
Membership, Technical Steering & Product, Treasury Management & Coin Economics, Legal/Regulatory, Marketing

**3**-year maximum term, with up to 2 consecutive terms

First **38** additional members selected by Hedera; council membership committee will find replacements



# The Hedera Governing Council

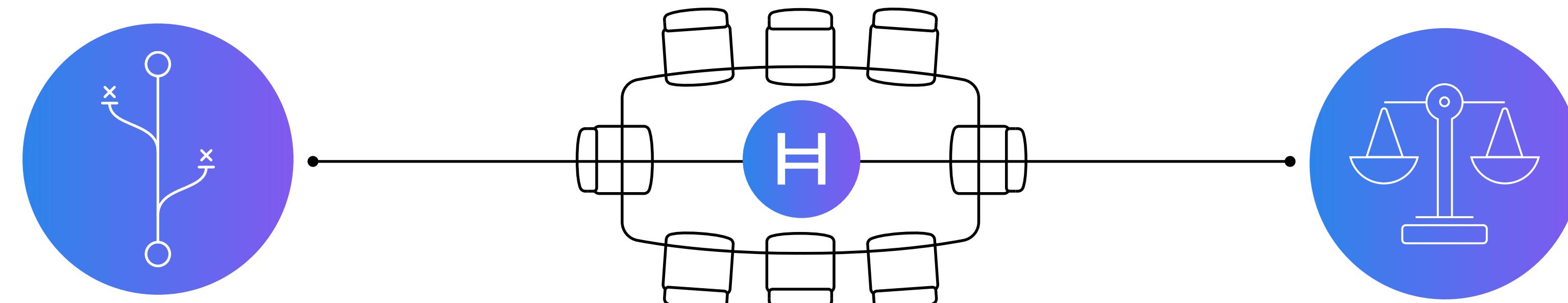
Building the future  
together.



## Network decisions:

- Feature decisions (what)
- Product roadmap (when)
- Fee model
- Node incentives
- Manage treasury

# Hedera's Strong Governance



## Technical Controls

- No Forks
- Ensures simultaneous software upgrade

## Legal Controls

- Patents & IP protections
- No license required to use network
- Open code review



H

# The Hedera Governing Council

Building the future  
together.



Deutsche  
Telekom



# Google



# magalu

NOMURA

*Swirls*

# TATA

UCL



# zain

# Meet the Team

CO-FOUNDERS & EXECUTIVE TEAM MEMBERS



# The Founders



**Mance Harmon**  
CO-FOUNDER & CEO

Mance is Co-Founder and CEO of Hedera. His prior experience includes serving as the Head of Architecture at Ping Identity, Program Manager program for the Missile Defense Agency, Course Director for Cybersecurity at the US Air Force Academy, and research scientist in Machine Learning at Wright Laboratory. Mance received a MS in Computer Science from the University of Massachusetts and a BS in Computer Science from Mississippi State University.



**Dr. Leemon Baird**  
CO-FOUNDER & CHIEF SCIENTIST

Leemon is the inventor of the hashgraph distributed consensus algorithm, and is the Co-Founder and Chief Scientist of Hedera. Previously in his career he was Professor of Computer Science and has been the Co-Founder of several startups, including two identity-related startups. Leemon received his PhD in Computer Science from Carnegie Mellon University and has multiple patents and publications in computer security, machine learning, and mathematics.

# Company Facts:



**55+ employees**



## Funding

- **\$124M** raised from institutions and accredited crowdsale



## HBAR

- Total supply: **50B**



## Developer Community

- Mainnet applications: **33+**
- Testnet developers: **8,000+**
- Discord chat: **8,000+**

# The Executive Team



**Dr. Leemon Baird**  
CO-FOUNDER  
& CHIEF SCIENTIST



**Mance Harmon**  
CO-FOUNDER  
& CEO



**Christian Hasker**  
CHIEF MARKETING  
OFFICER



**Natalie Furman**  
GENERAL  
COUNSEL



**Lionel Chocron**  
CHIEF PRODUCT  
OFFICER



**Zenobia Godschalk**  
SENIOR VP  
COMMUNICATIONS



**Jordan Fried**  
SENIOR VP, BUSINESS  
DEVELOPMENT



**Mehernosh Mody**  
SENIOR VP  
ENGINEERING



**Atul Mahamuni**  
SENIOR VP  
PRODUCT



**Brett McDowell**  
EXEC DIRECTOR,  
GOVERNING COUNCIL



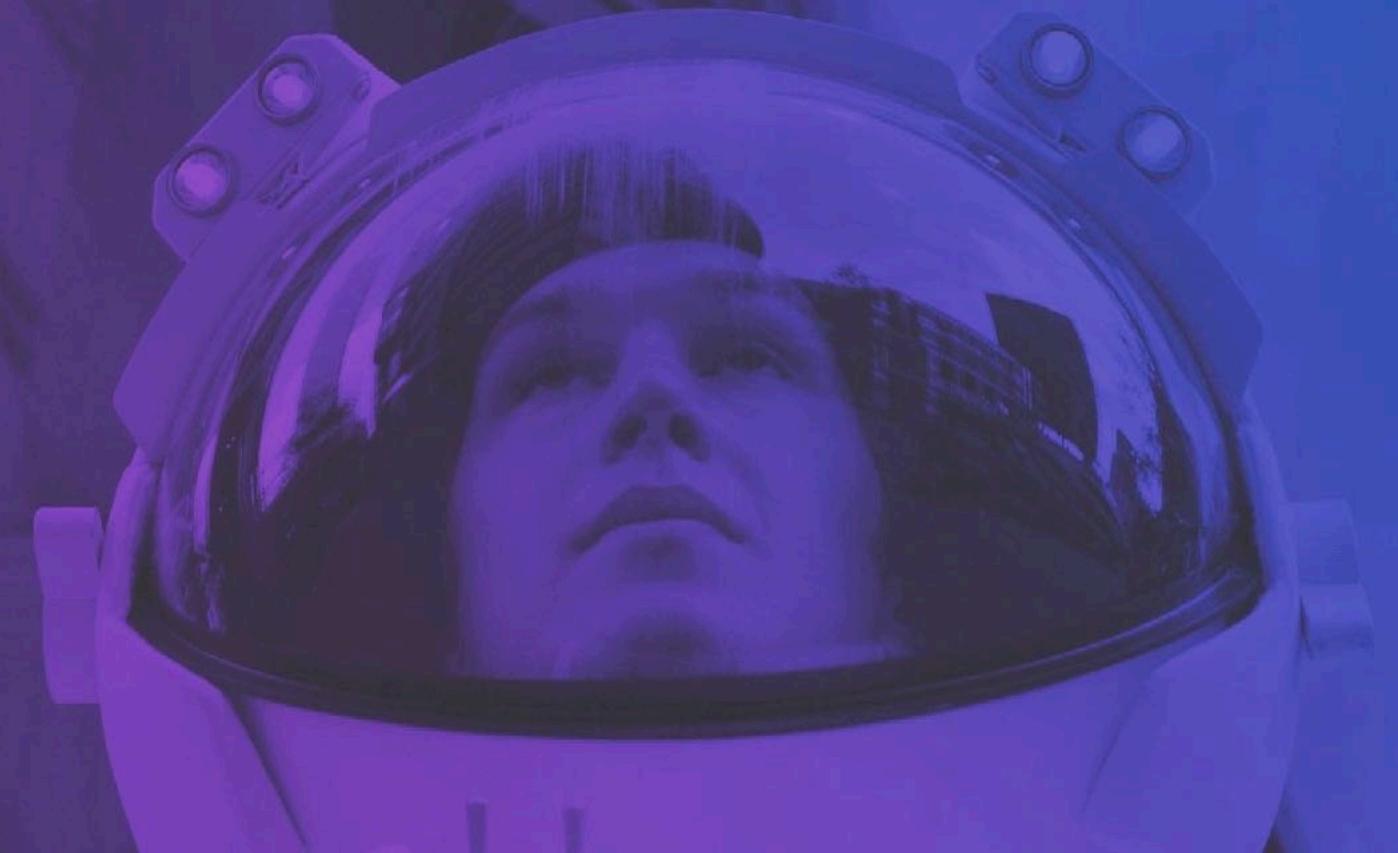
**Ken Anderson**  
CHIEF DEVELOPER  
ADVOCATE



**Nigel Clark**  
SENIOR VP,  
INDUSTRIES  
& PARTNERS

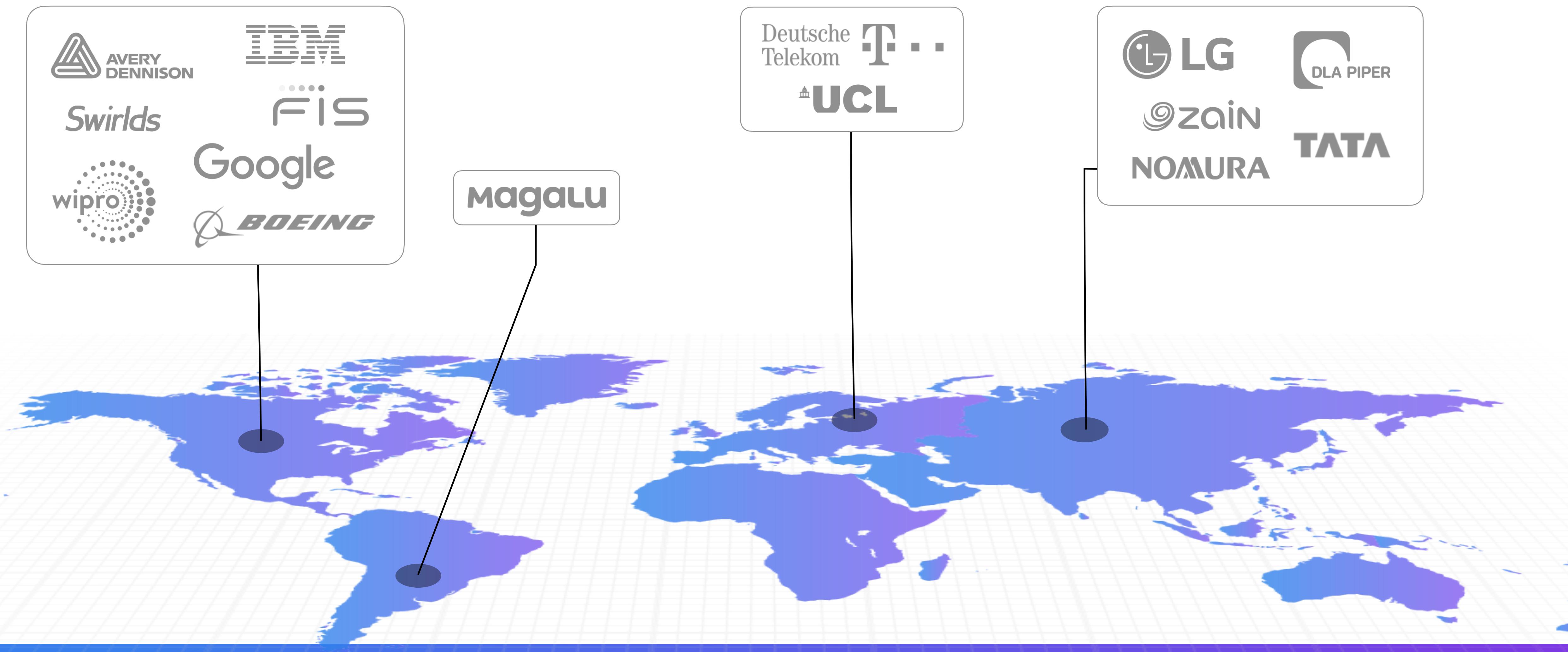
# Network Growth

HEDERA'S PATH TO A FULLY DECENTRALIZED NETWORK



# NETWORK GROWTH OVER TIME

PHASE 1: Up to 39 council members

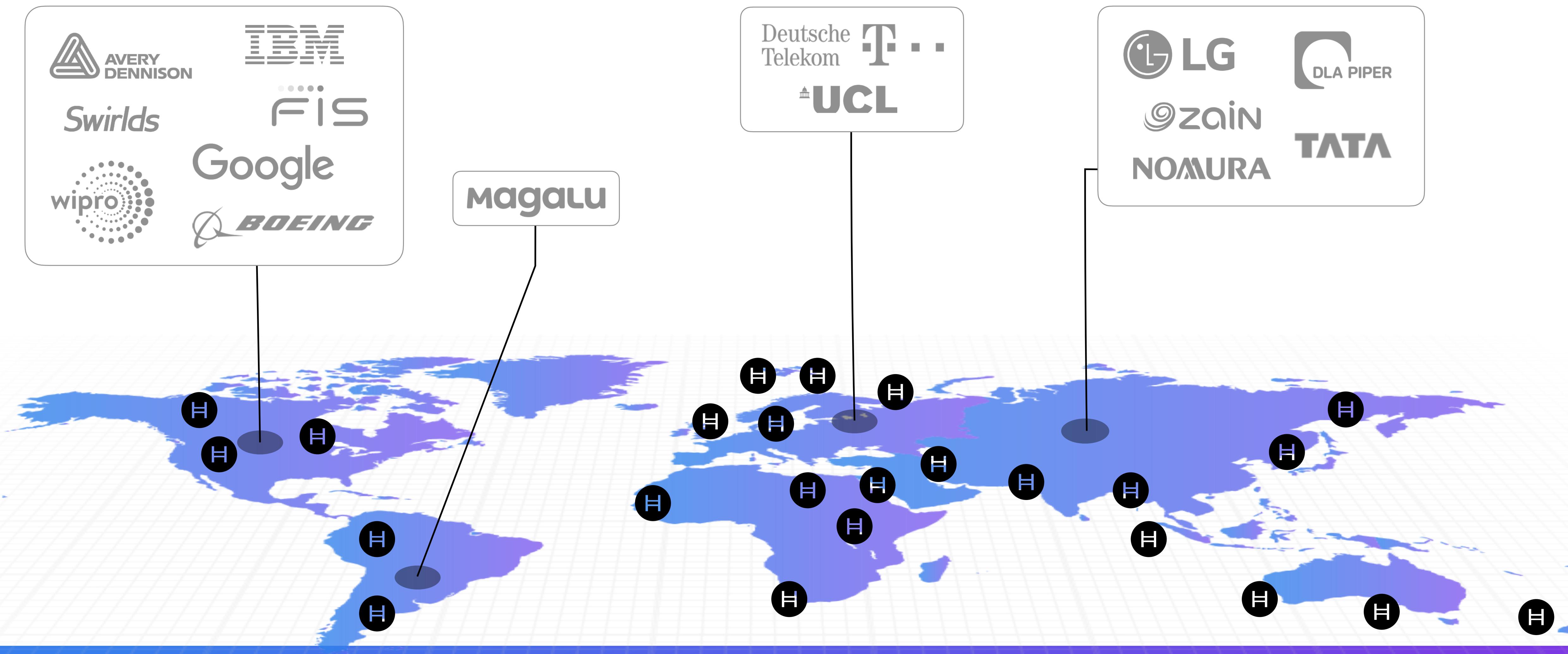


Hedera™ Hashgraph

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# NETWORK GROWTH OVER TIME

PHASE 2: 100s of KYC'd permissioned nodes

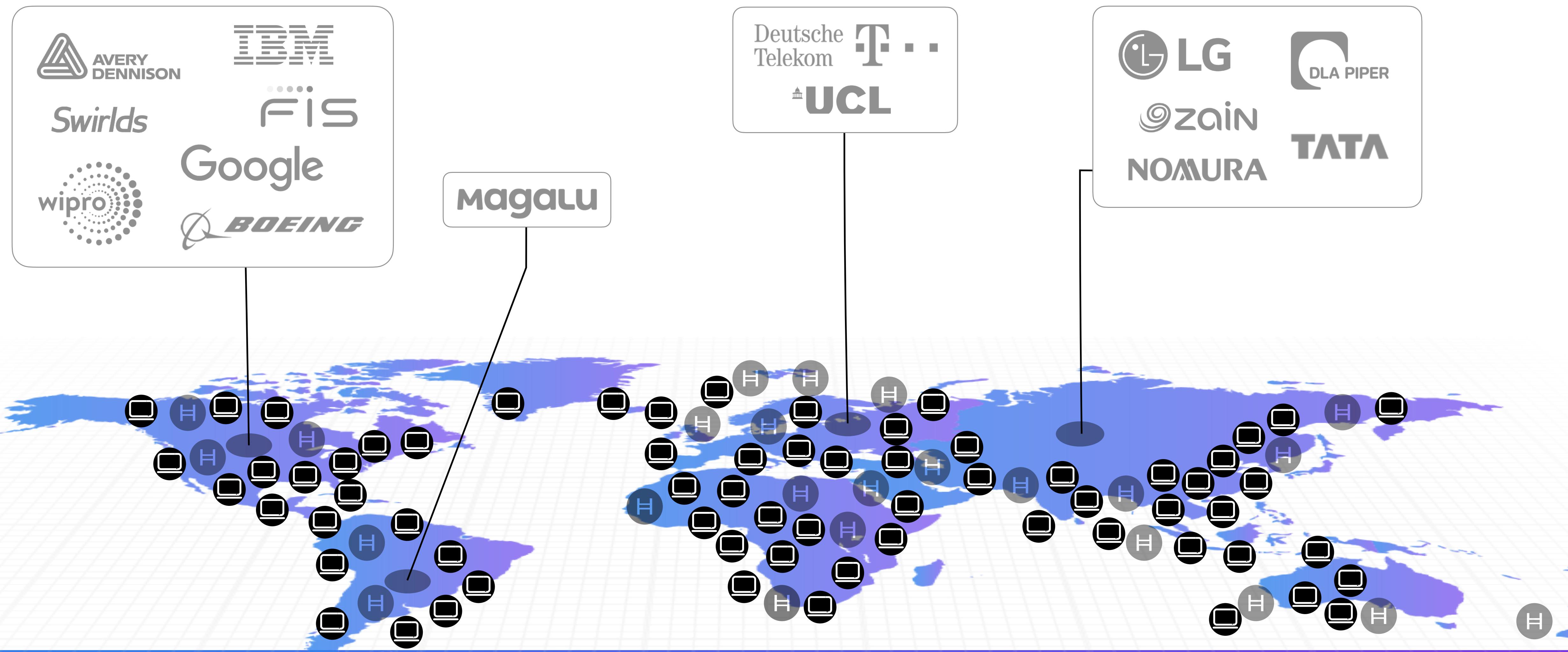


Hedera™ Hashgraph

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# NETWORK GROWTH OVER TIME

PHASE 3: 1000s of permissionless nodes

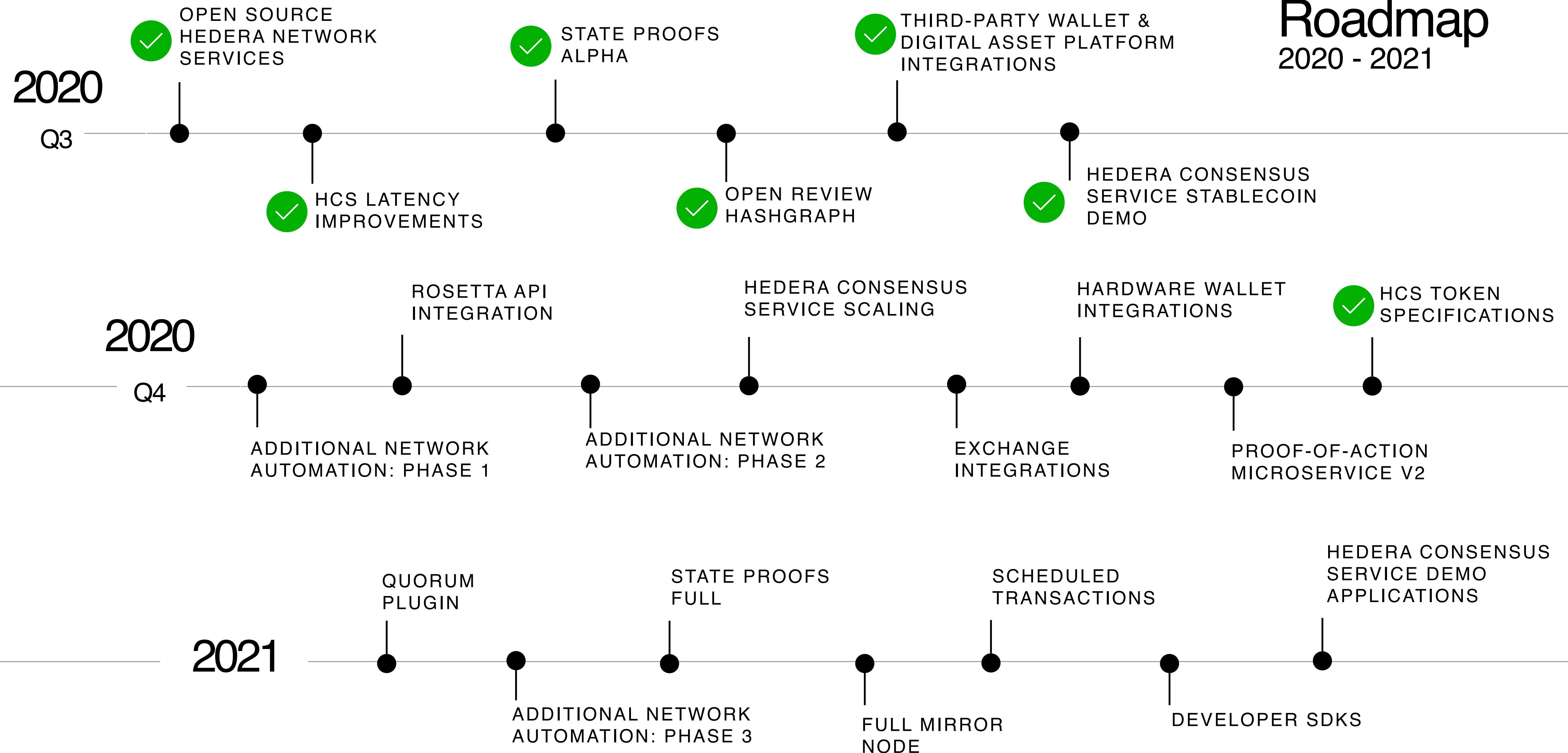


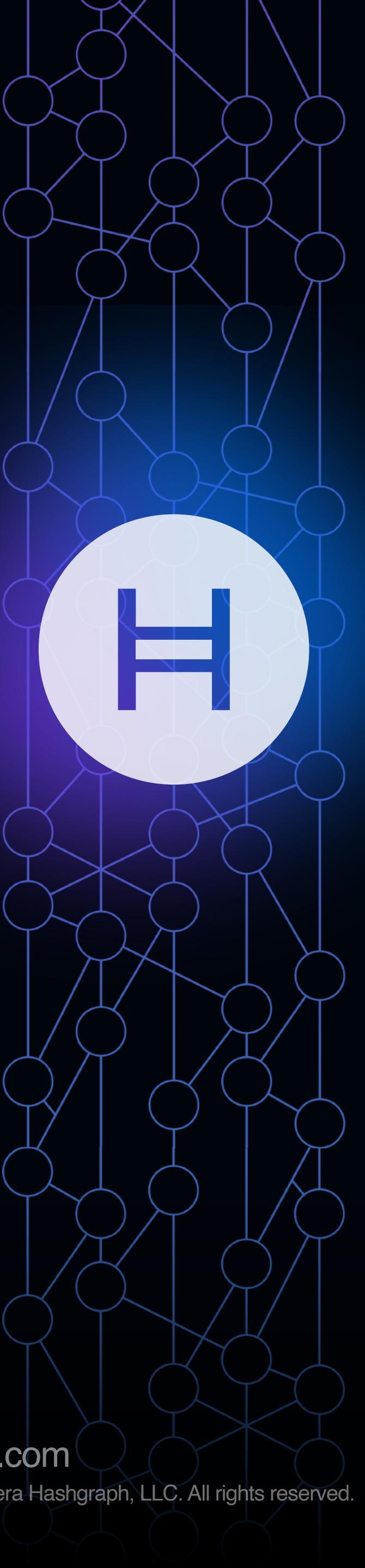
# Roadmap

UPCOMING FEATURES & FUNCTIONALITY



# Roadmap 2020 - 2021





# Part 2 - Foundations of the Hashgraph Consensus Algorithm

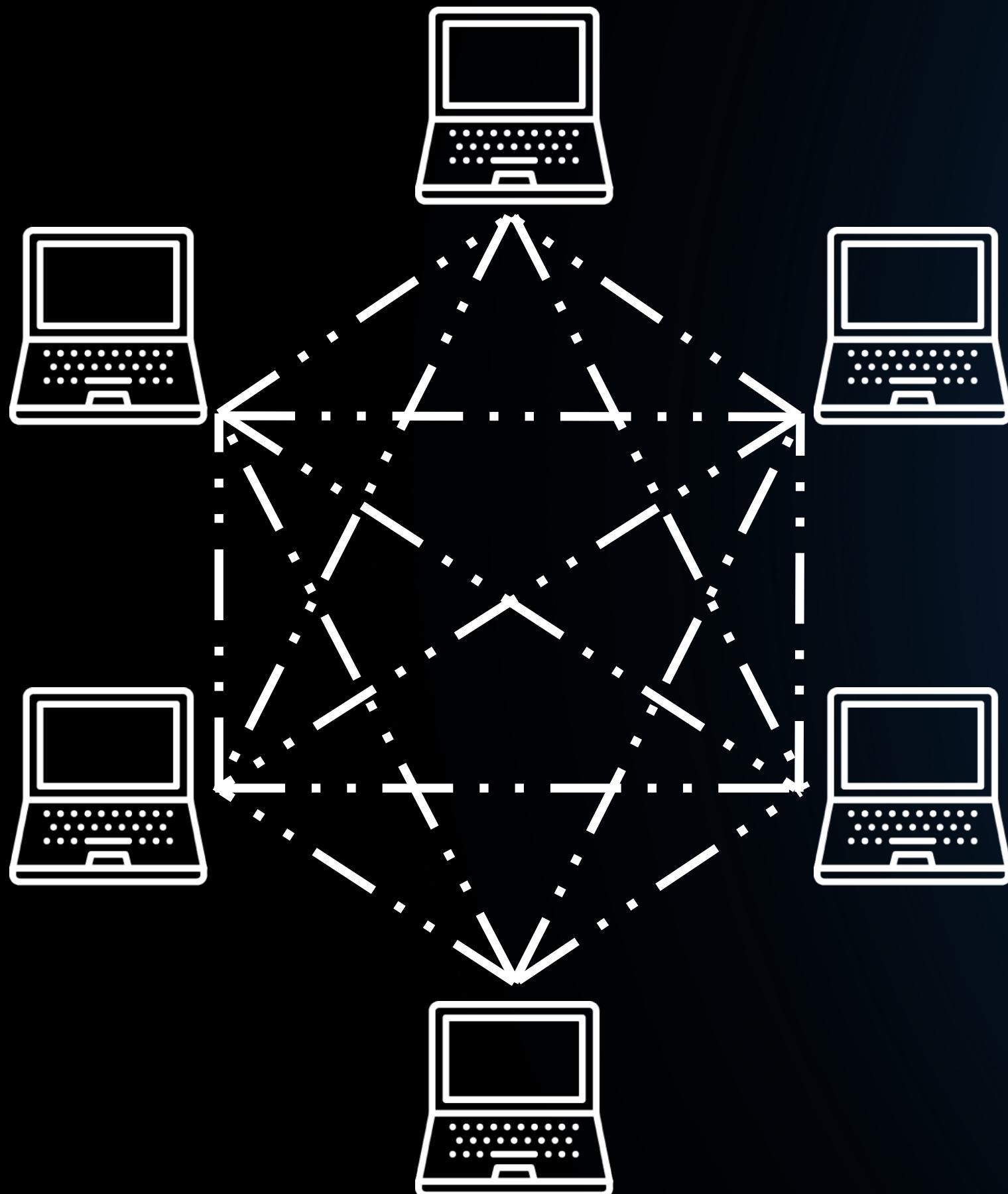


@hashgraph

# Virtual Voting

An algorithm that calculates (in a Byzantine resistant manner) the timestamp of transactions from 2/3 of the network or more

# Voting Based Consensus



## ADVANTAGES

- Byzantine
- Immutable Audit
- DDoS Resilient
- Firewall / virus attack resilient
- Low computation (No PoW)
- High Availability

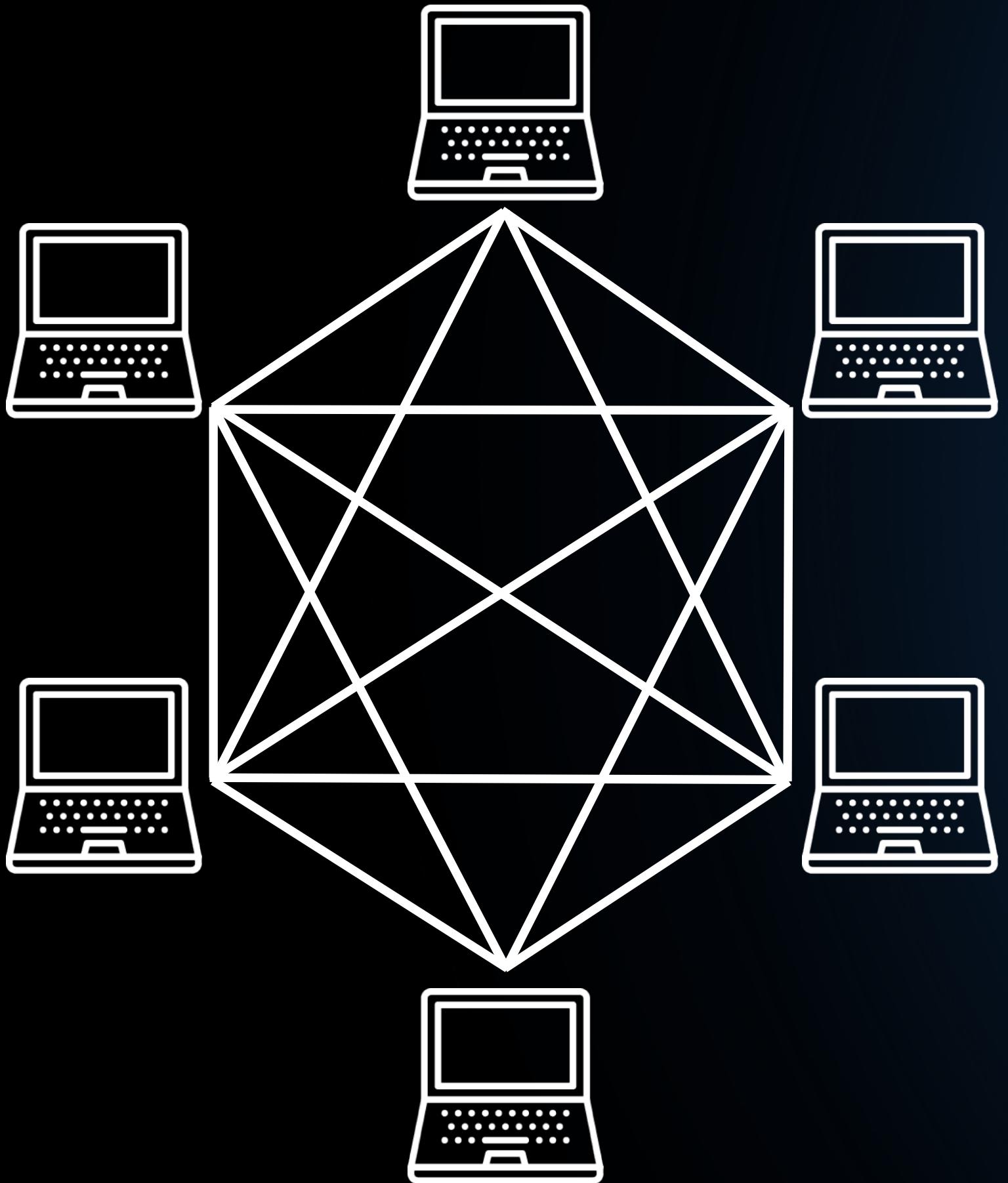
## DISADVANTAGES

- Poor scalability (Impractical bandwidth requirements)
- Individual members can influence transaction access and order
- Low throughput

## EXAMPLES

- None – not practical

# Hashgraph Virtual Voting Consensus



## ADVANTAGES

- Byzantine
- High Throughput (100,000s tps)
- Immutable Audit
- DDoS Resilient
- Firewall / virus attack resilient
- Fairness of transaction access and order
- Fair Timestamps
- Low computation (No PoW)
- High Availability
- Scalable

## EXAMPLES

- Hedera Hashgraph

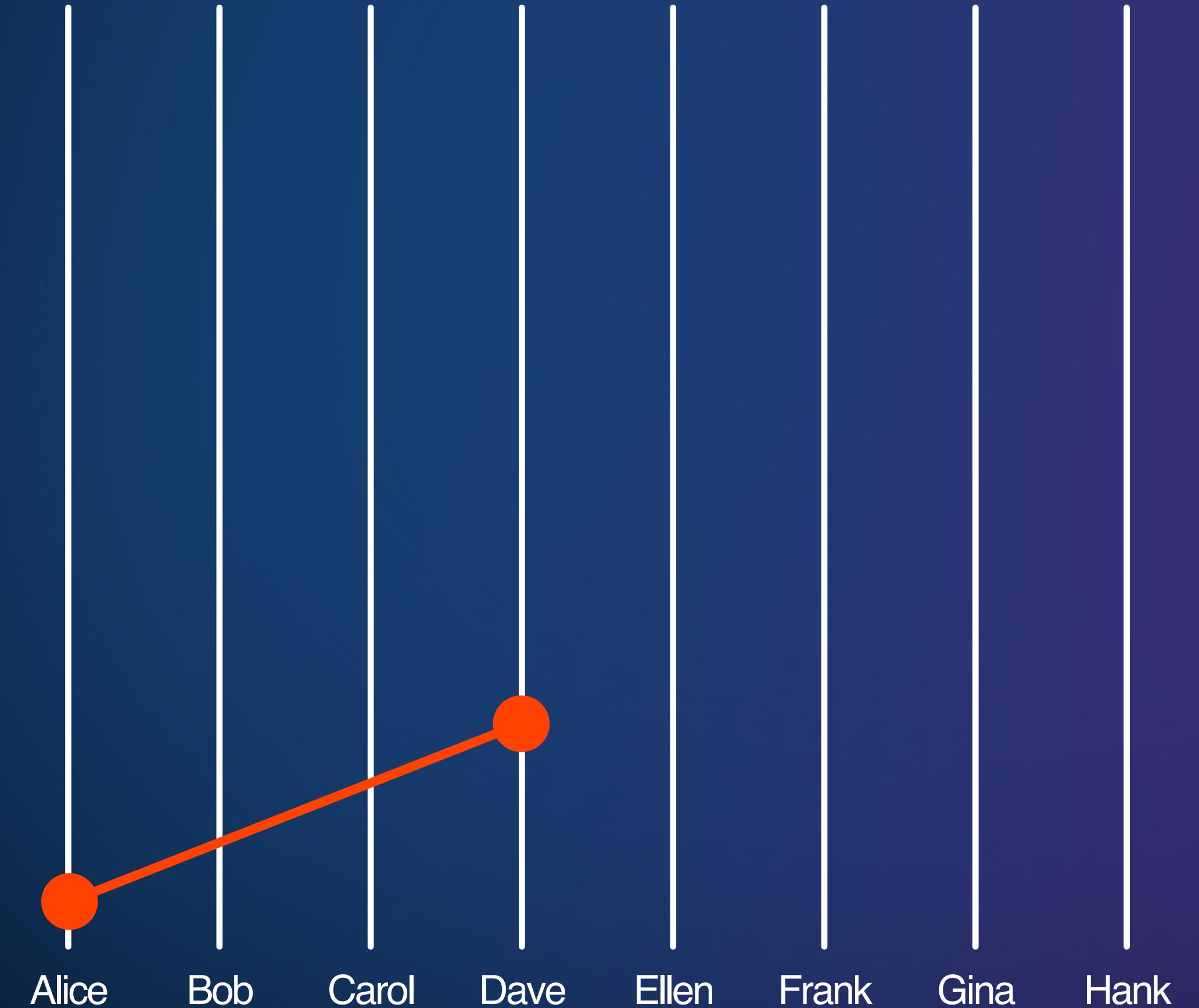
# Gossip about Gossip

Talking about the history of how nodes have talked to each other

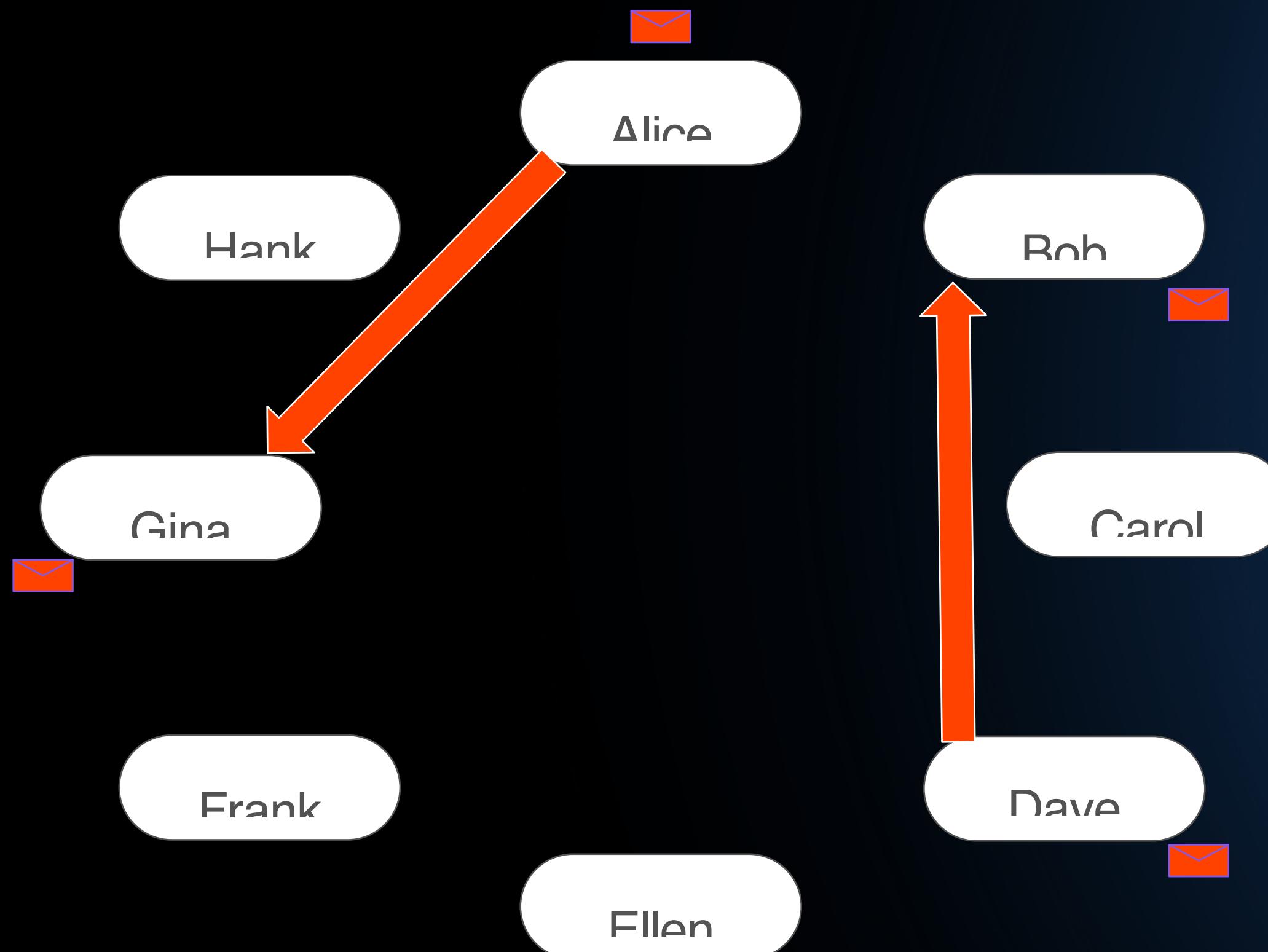
# Gossip about gossip



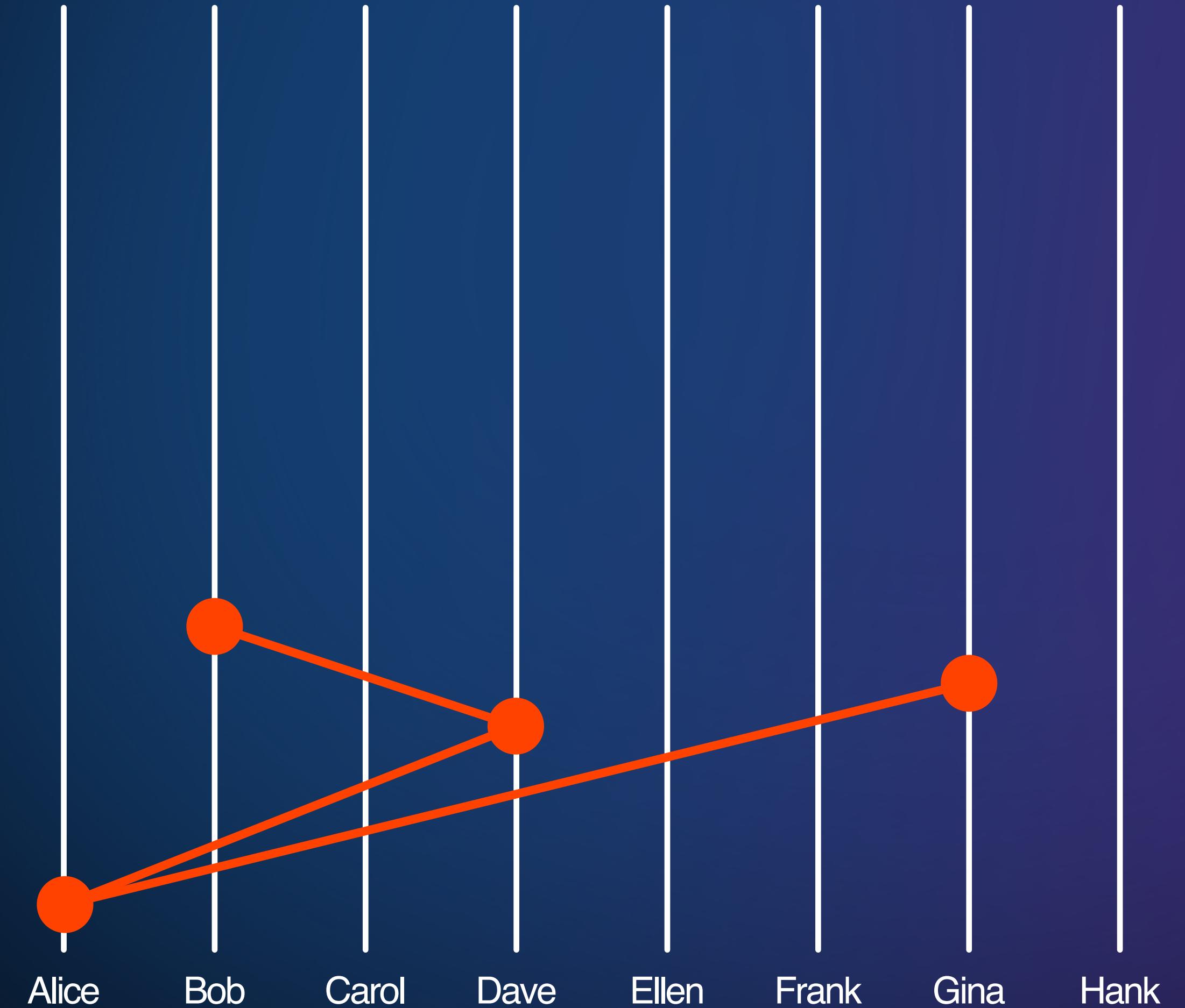
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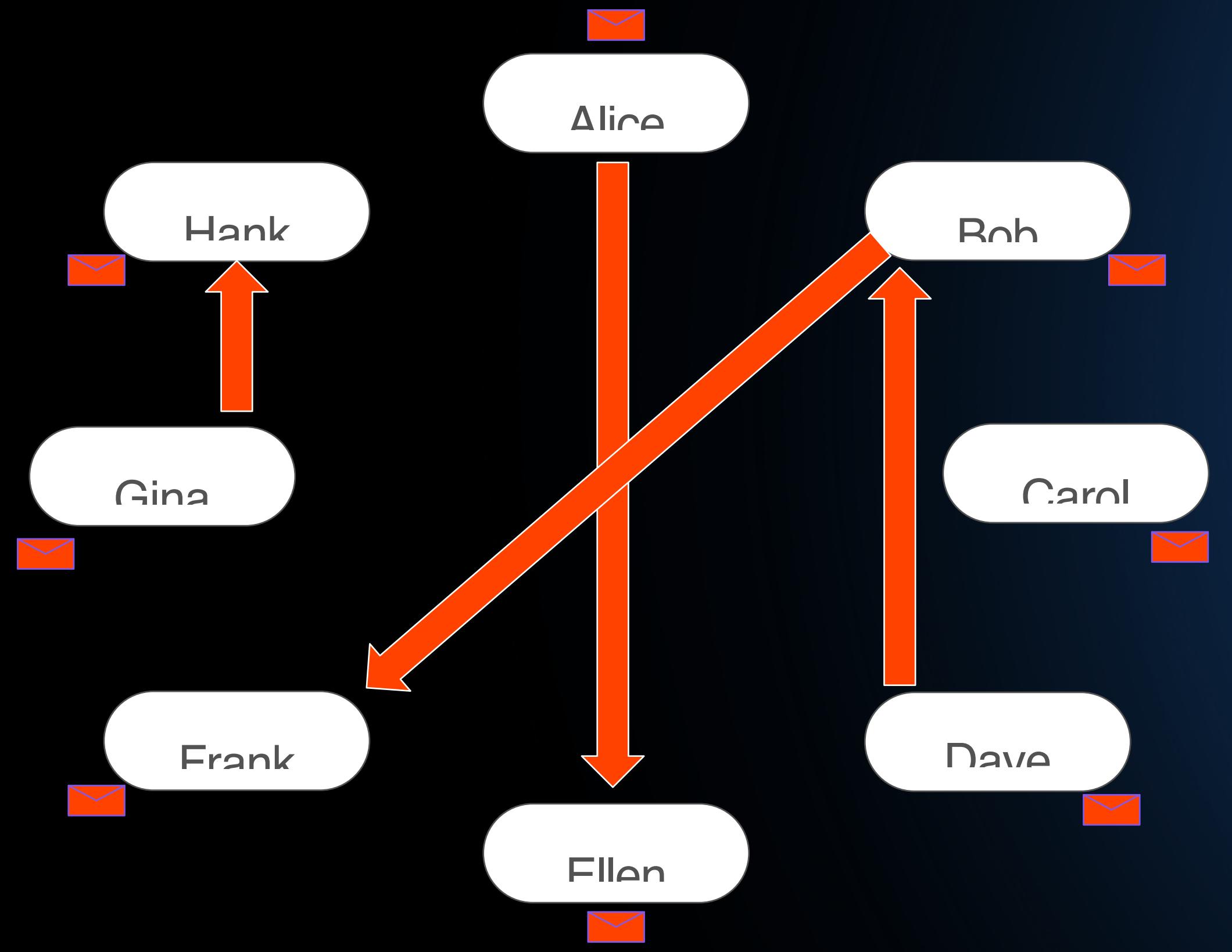
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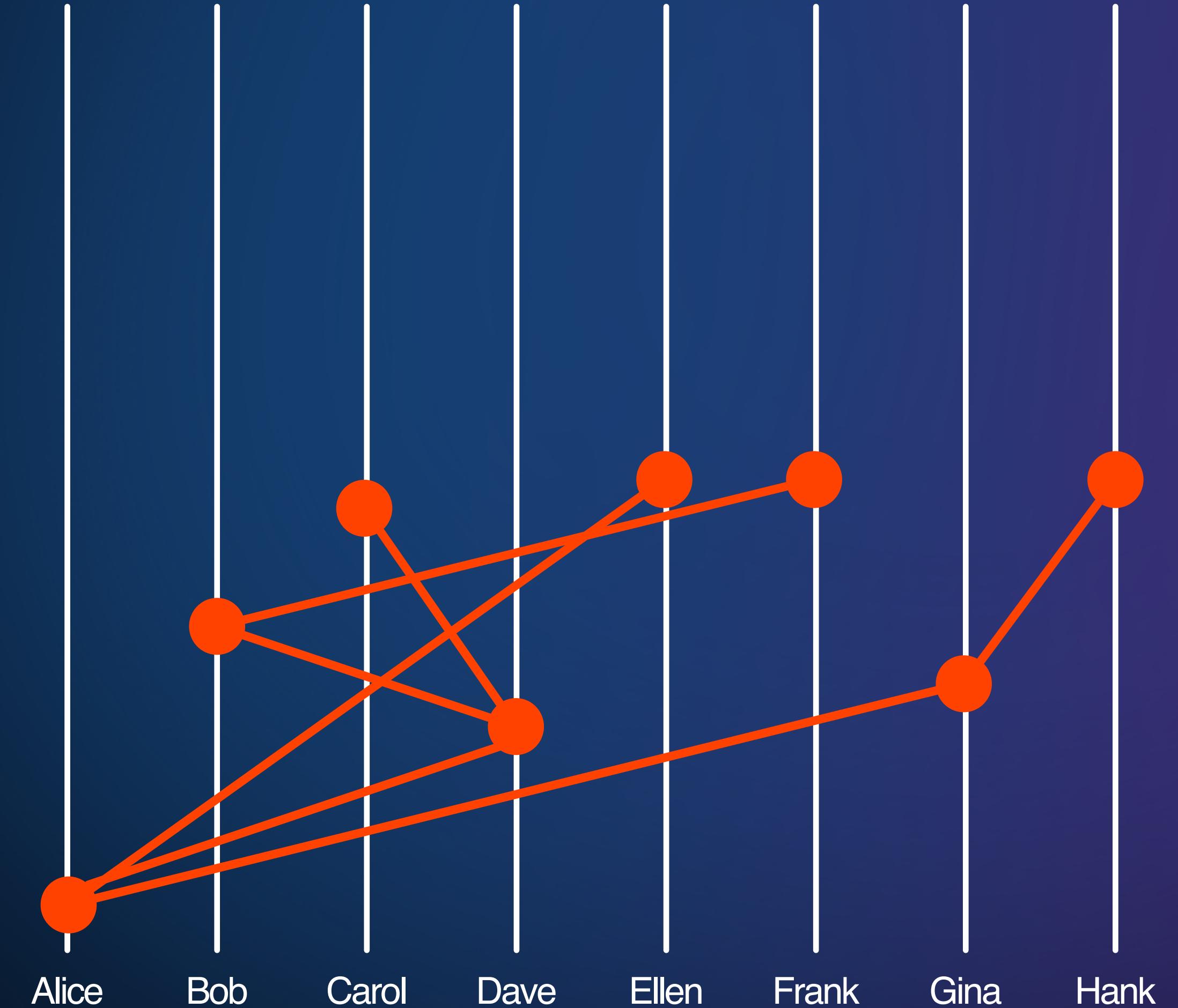
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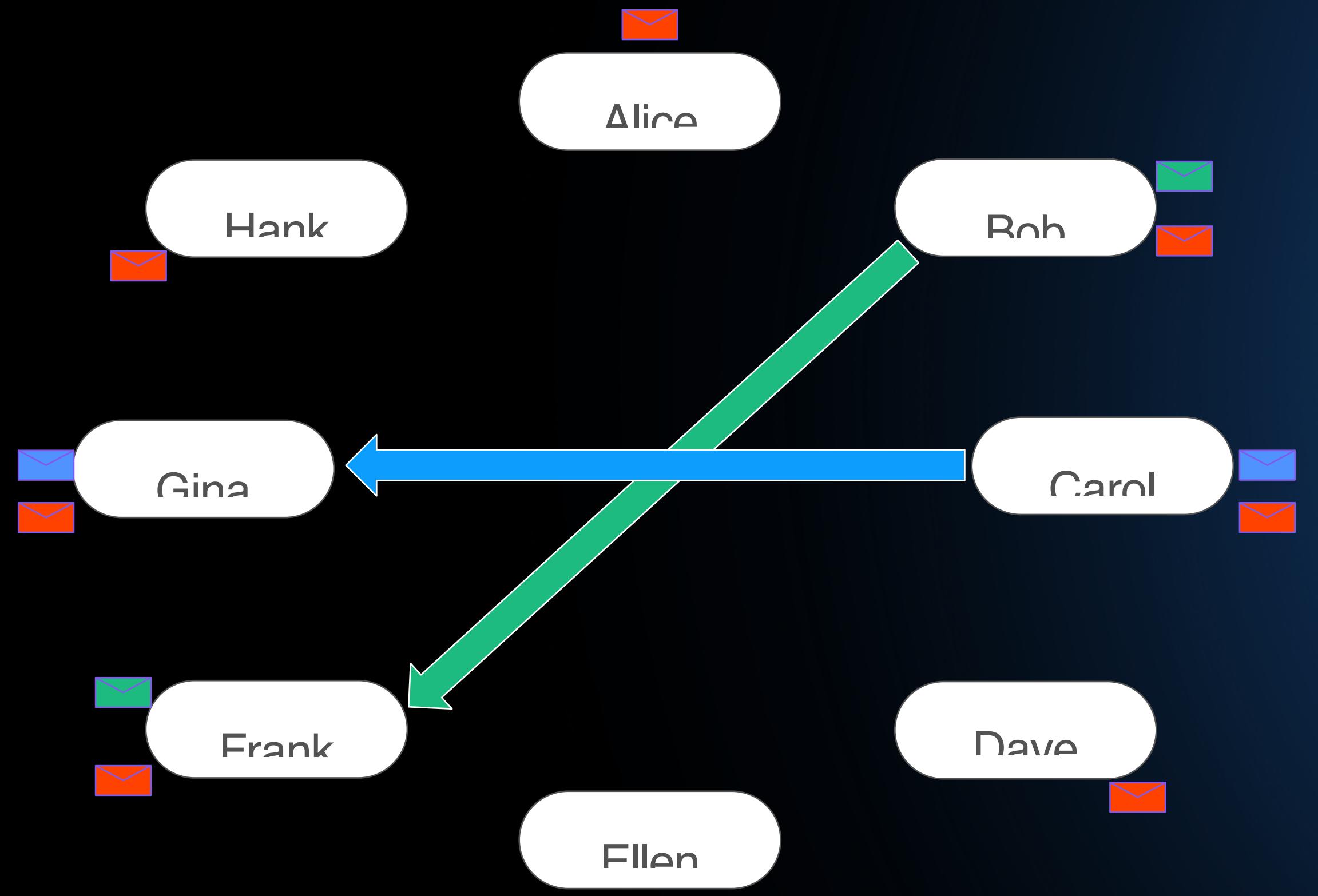
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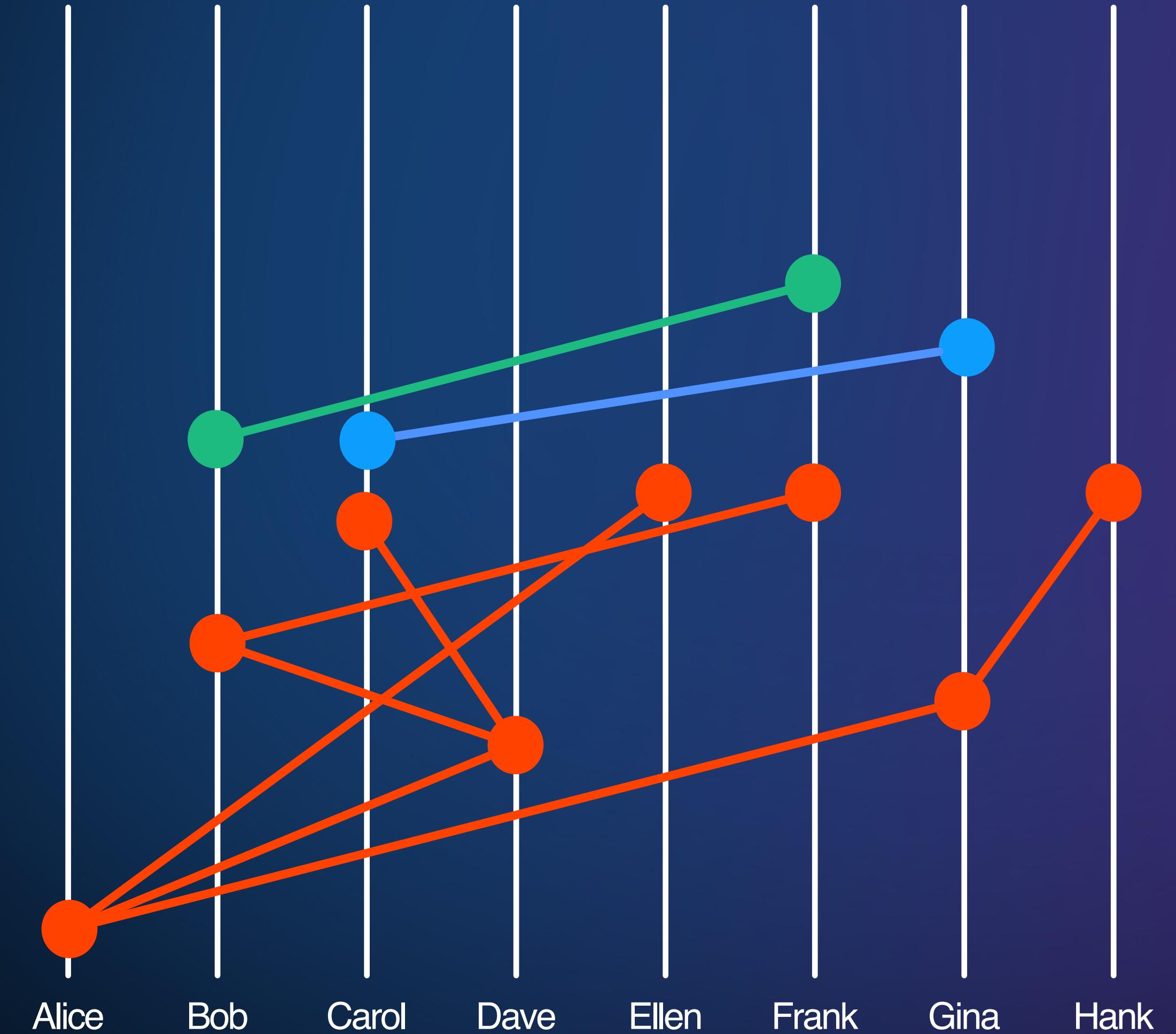
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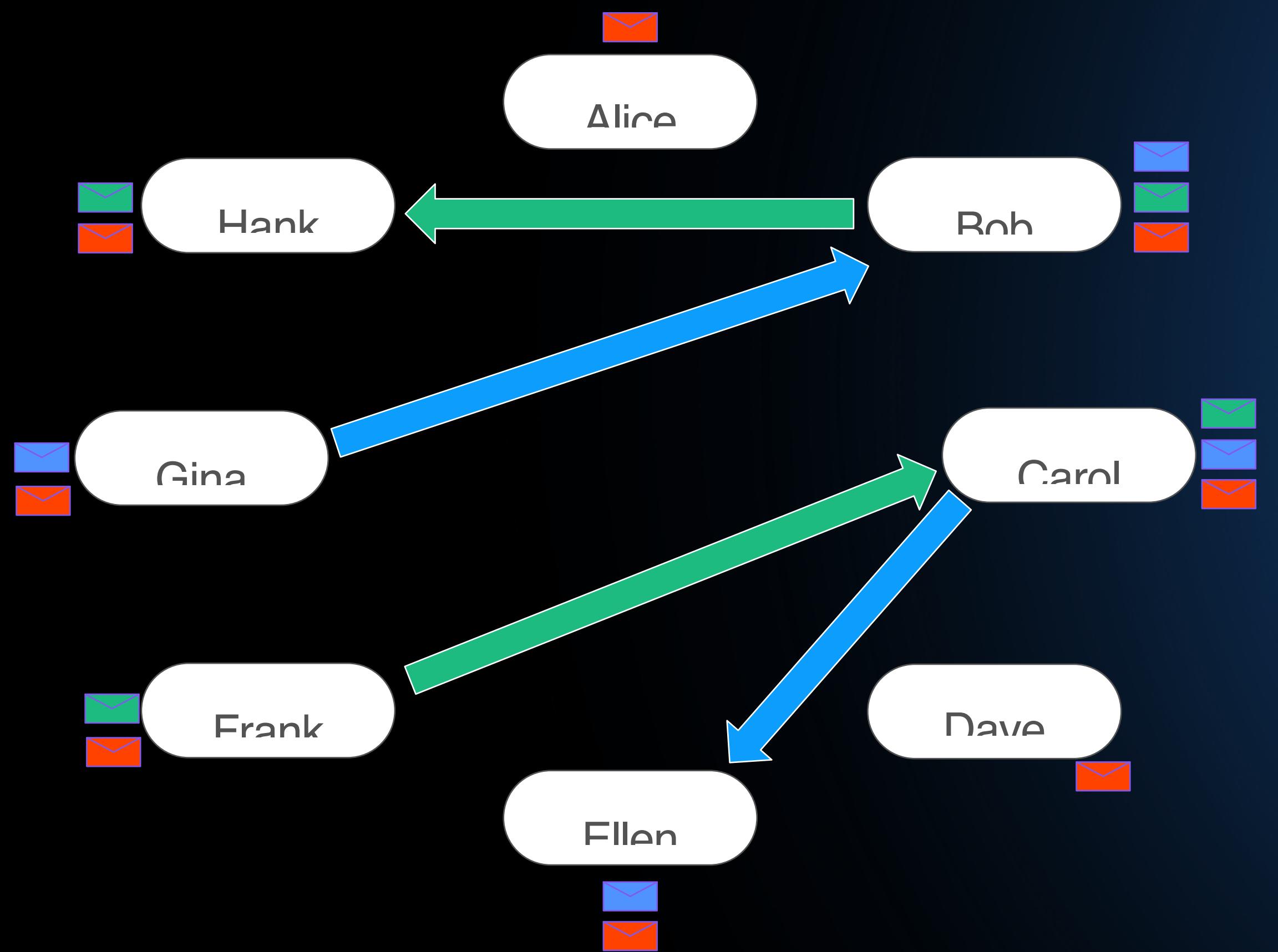
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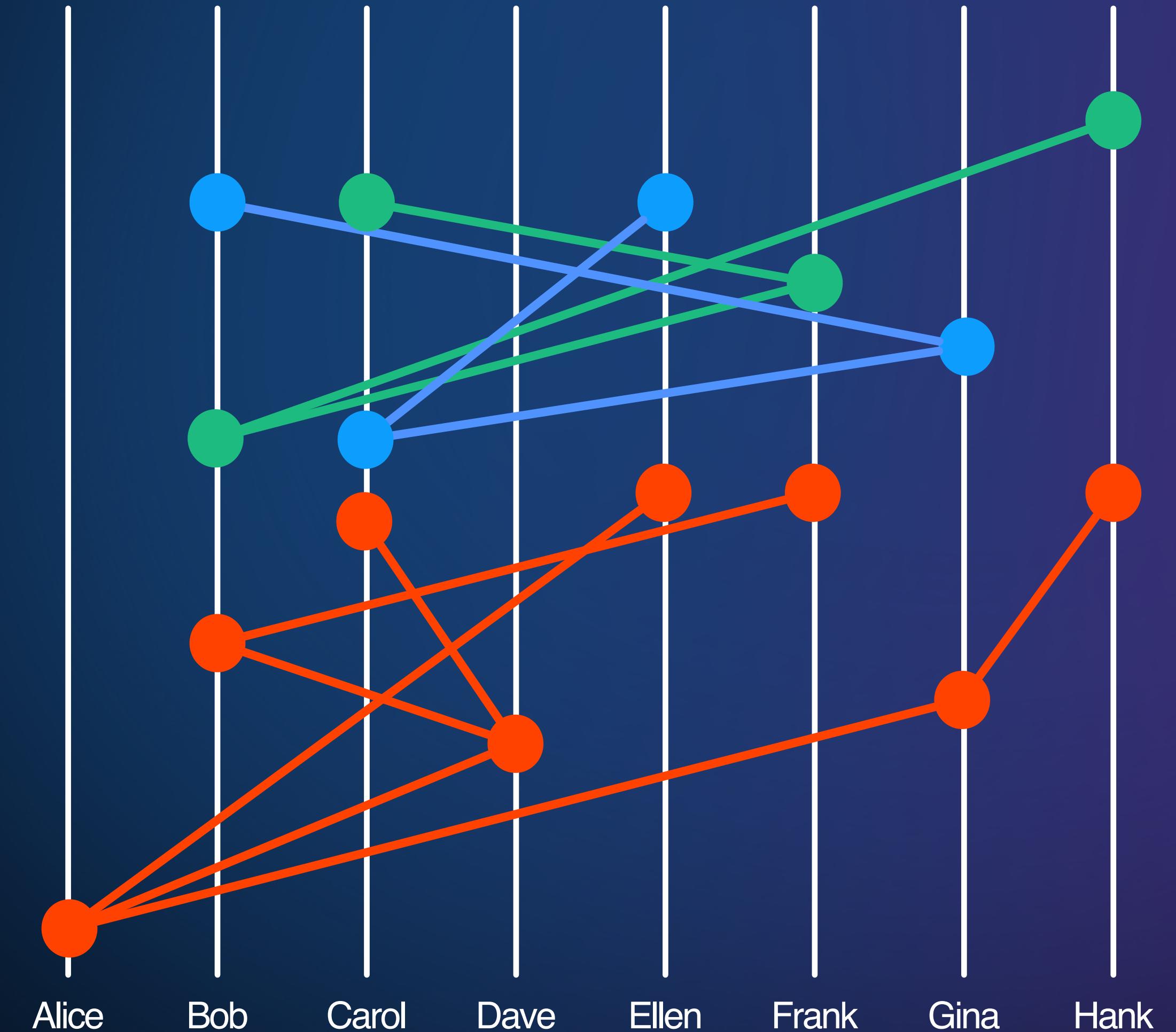
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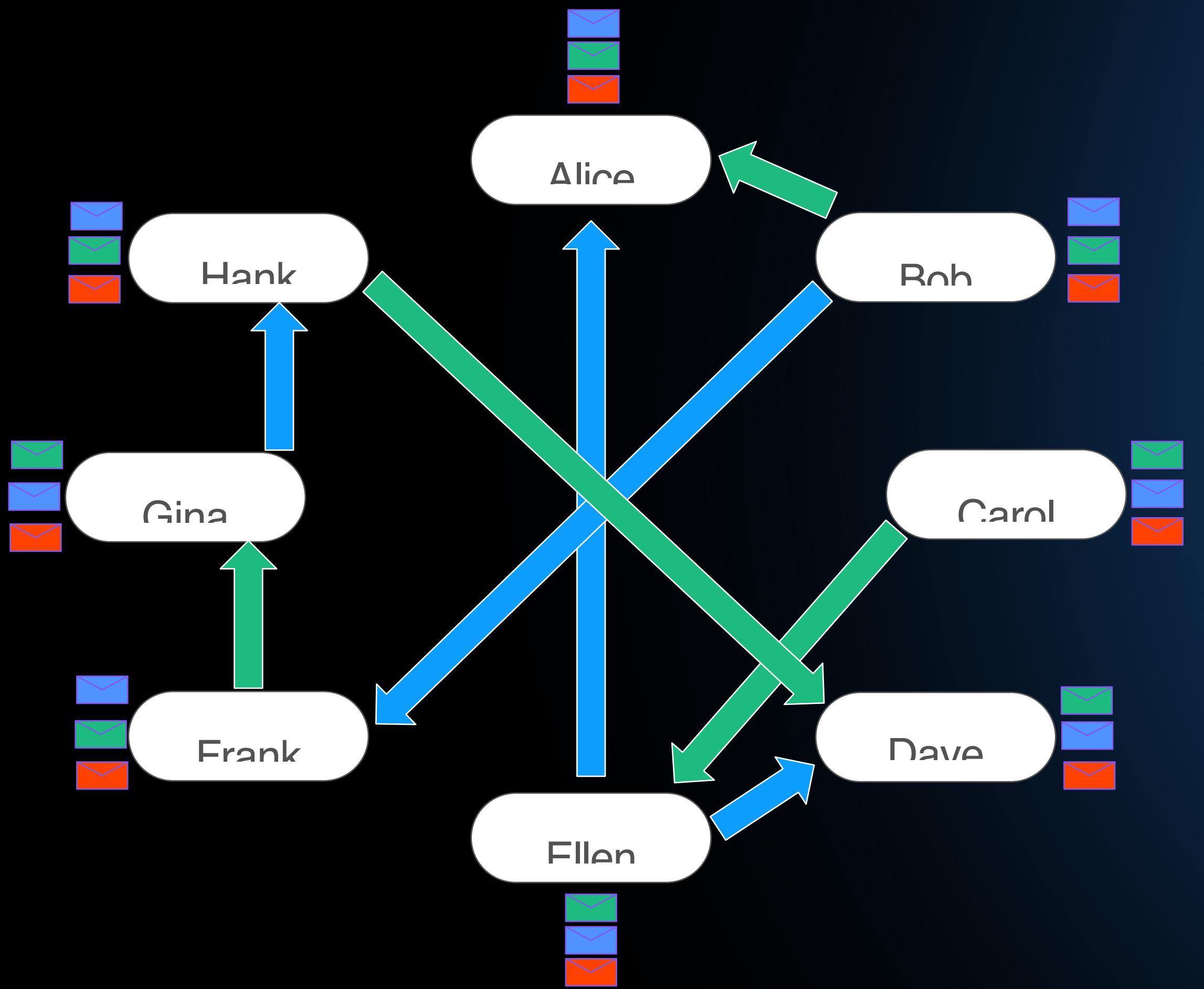
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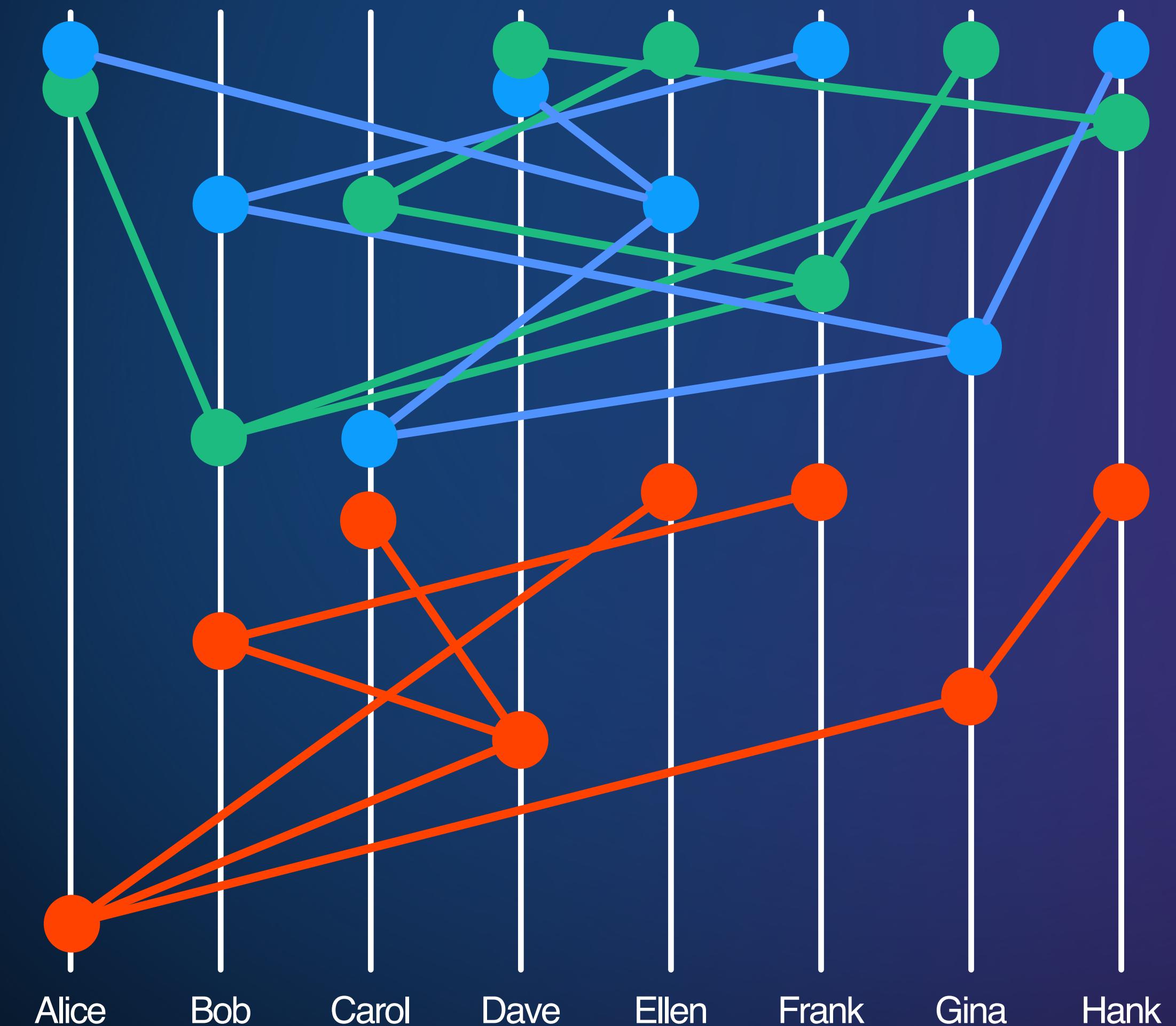
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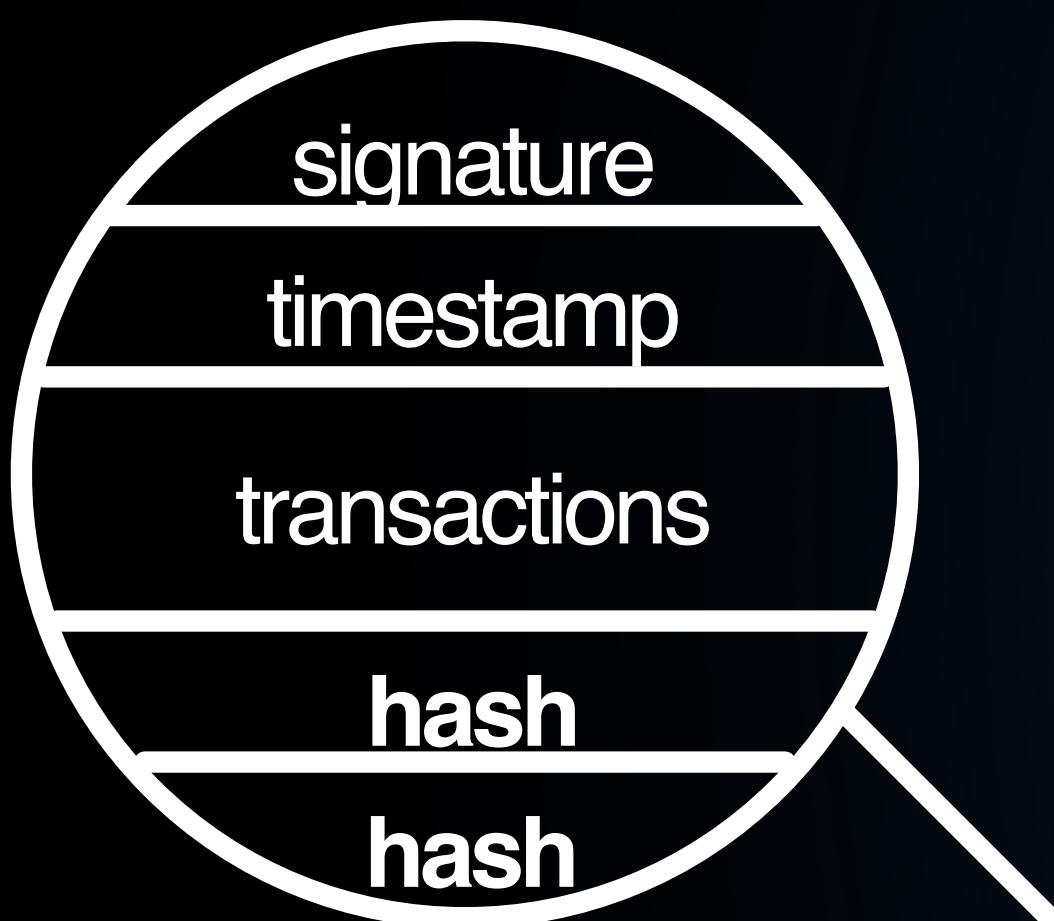
# Gossip about gossip



# Gossip about Gossip

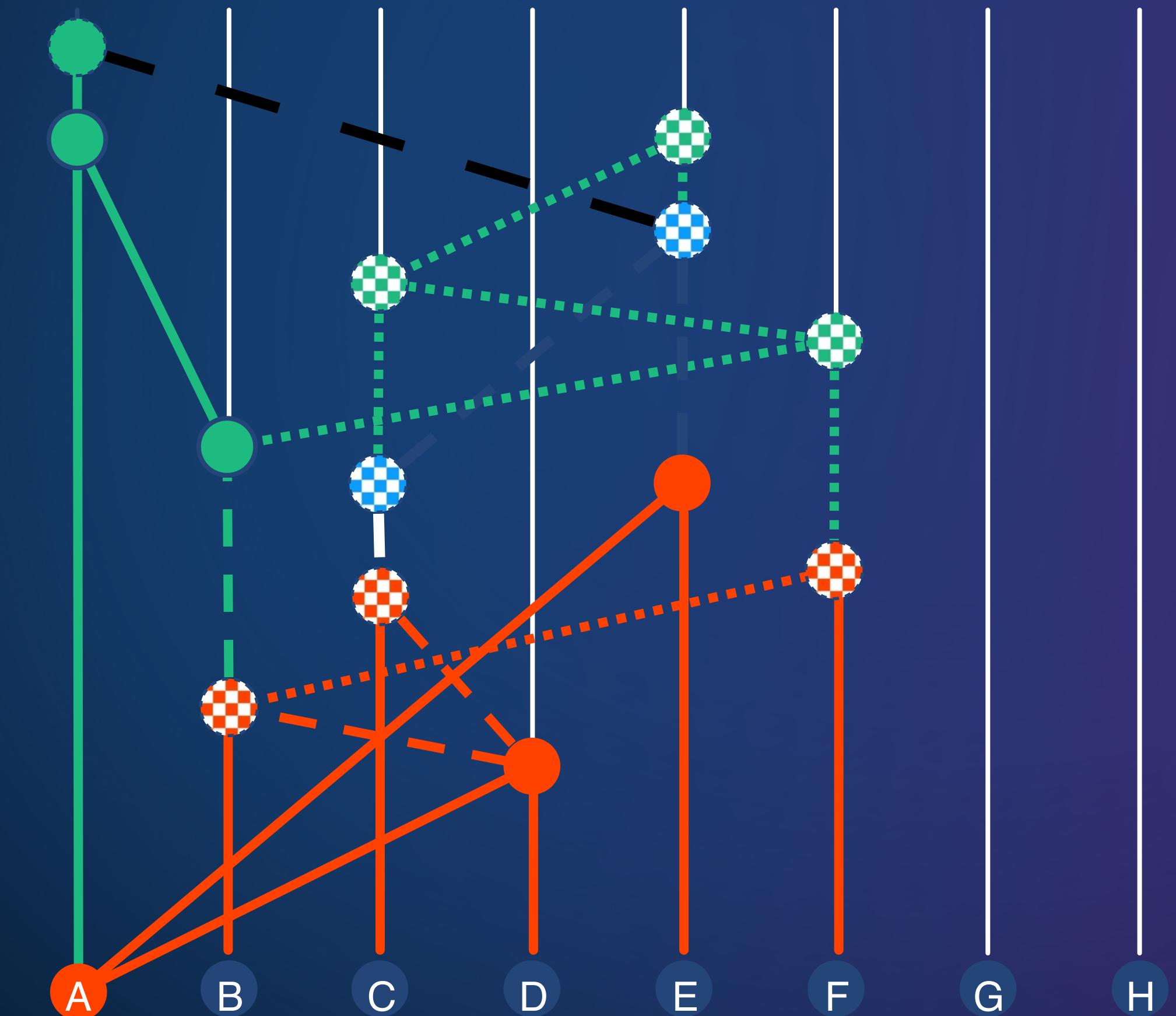


## GOSSIP ABOUT GOSSIP

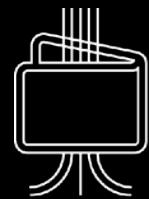


Share events unknown to each other  
during gossip

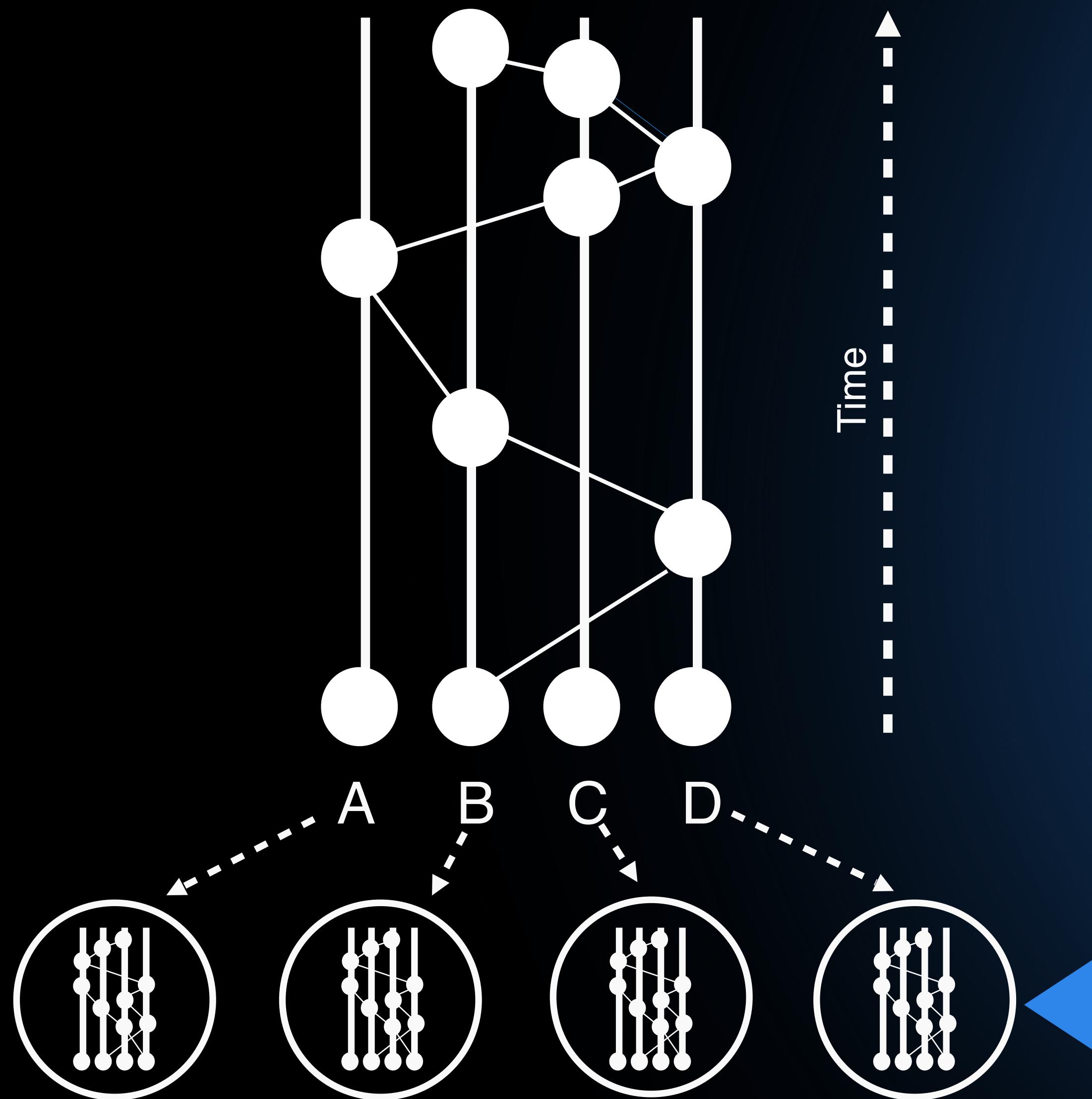
## Gossip about Gossip



- — — Alice learns through gossip about gossip
- ..... Alice doesn't yet know
- Alice already knows



## GOSSIP ABOUT GOSSIP



## Gossip about Gossip

The hashgraph gives each node the entire history of who has talked to who and when.

- Each node can put themselves in the place of any other node just by looking at their own hashgraph
- Each node runs the same consensus algorithm, using the hashgraph as an input
- Because all nodes use the same algorithm and inputs, the community reaches a consensus on order and timestamp
- No need to send multiple ballots and receipts over the network as in historical voting models

All nodes have the same picture of the hashgraph, except for the very latest events which will eventually sync.



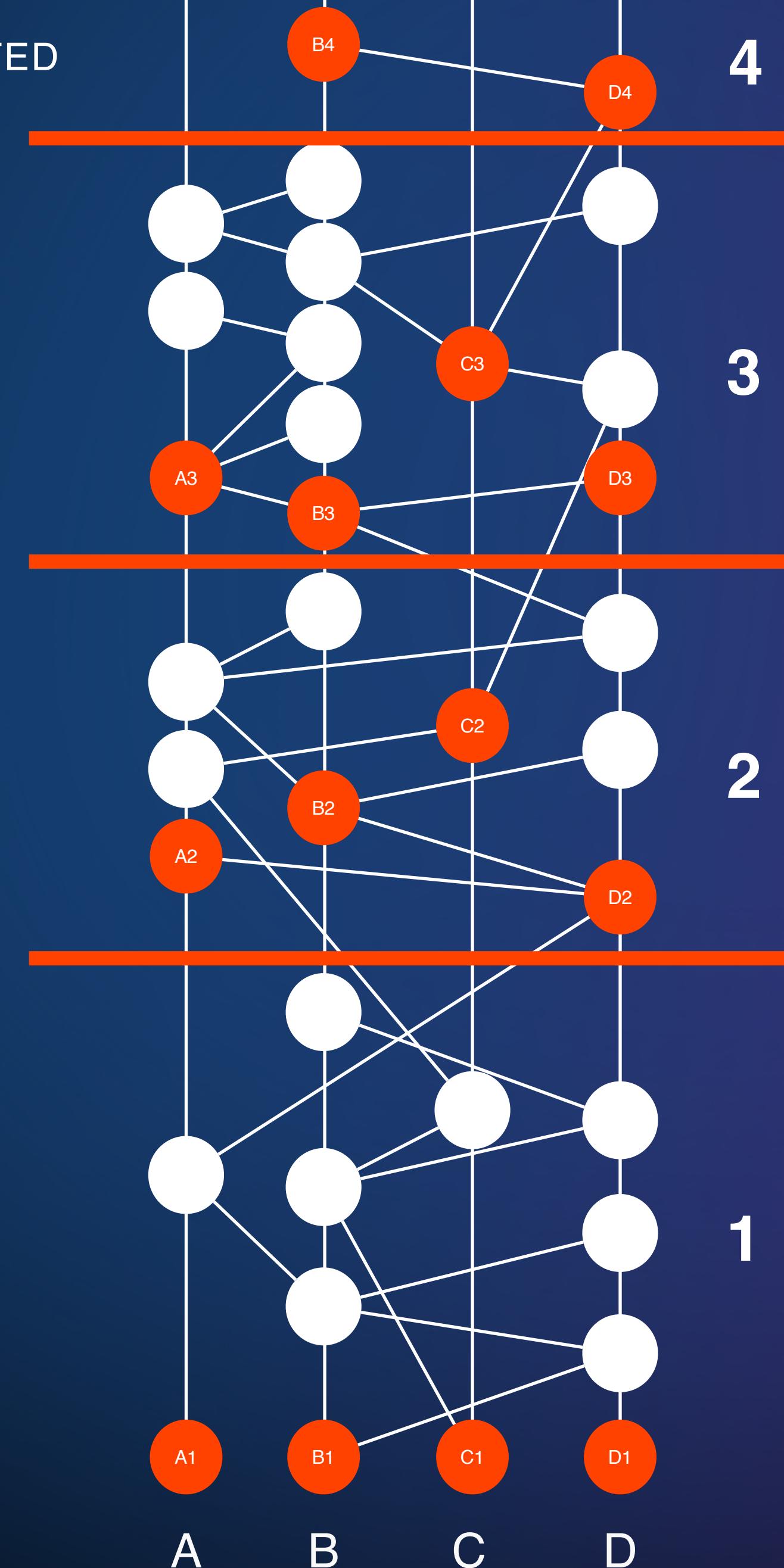
# Virtual Voting

Within the context of the hashgraph

## Rounds and witnesses

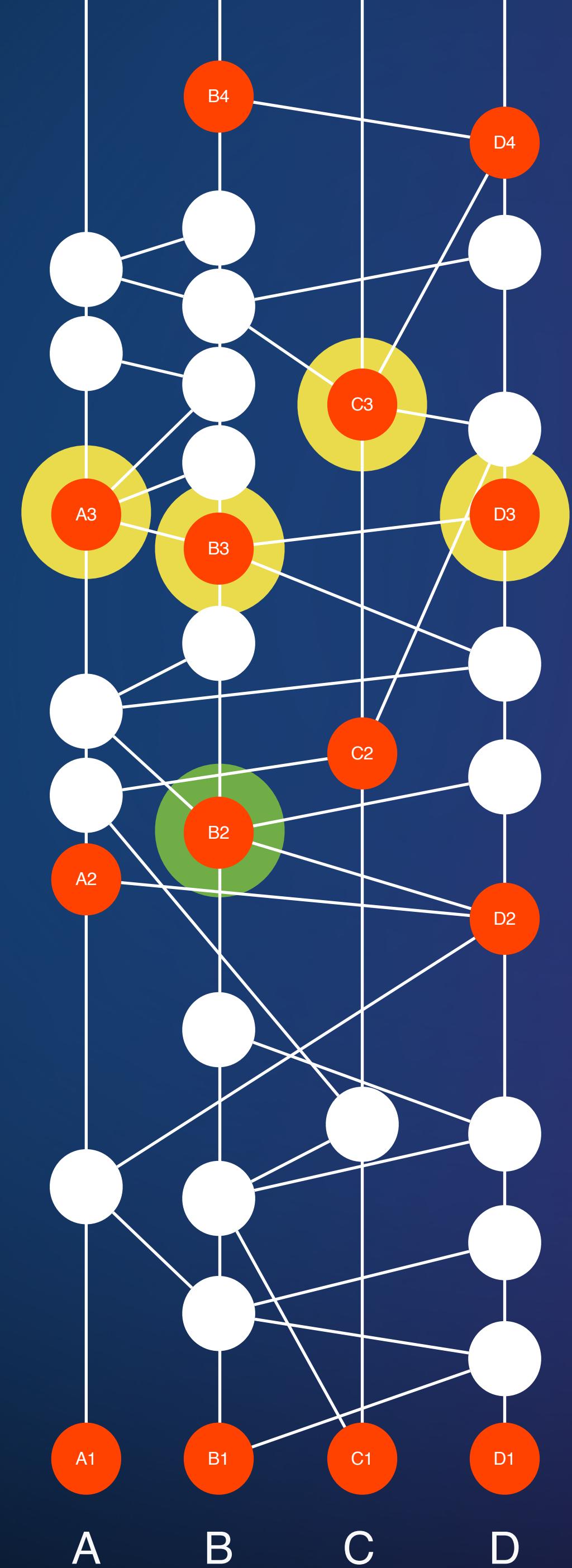
- Round: Created when the supermajority of witnesses in the previous round can be strongly seen
- Witness: First event in a round for a given node
- Red events are witnesses

ROUND CREATED



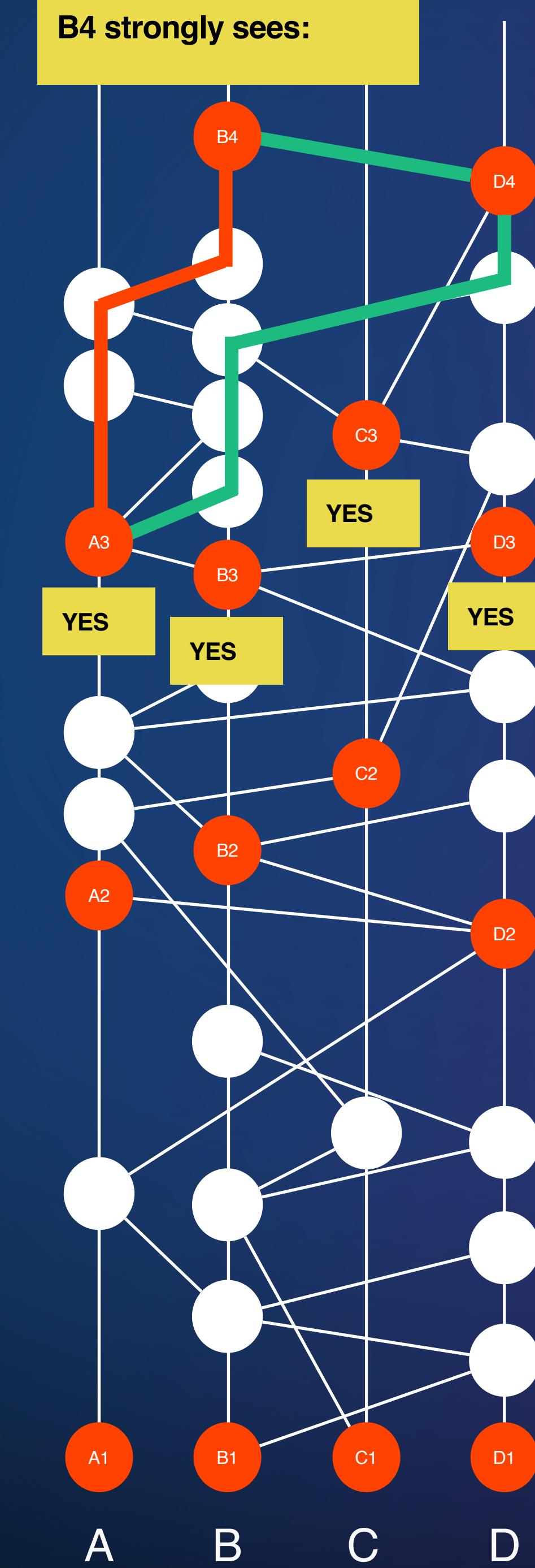
## Famous witnesses

- Famous witnesses: means lots of people see it in the next round
- B2 is seen by A3 (through B3)
- B2 is also seen by C3 (via D3 and B3)
- Seen by A3 + B3 + C3 + D3 means it's **famous** (unanimously so)
- This is repeated for all witness events
- But this "fame" is only the opinion of each event



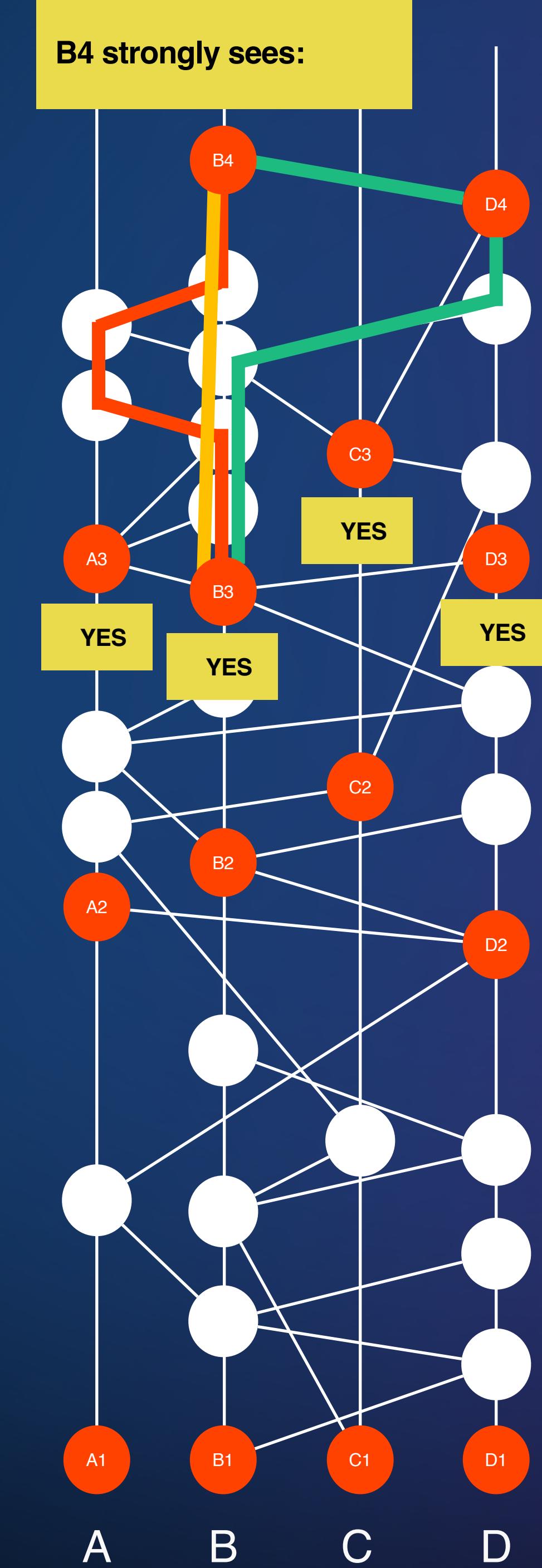
## Counting votes

- Strongly seen: To strongly see someone, you have to see them through a supermajority. That means more than two-thirds of the population (or stake as we will see later)
- Vote counting is performed by witness events
- B4 can strongly see A3 via paths through A, B and D which is a supermajority



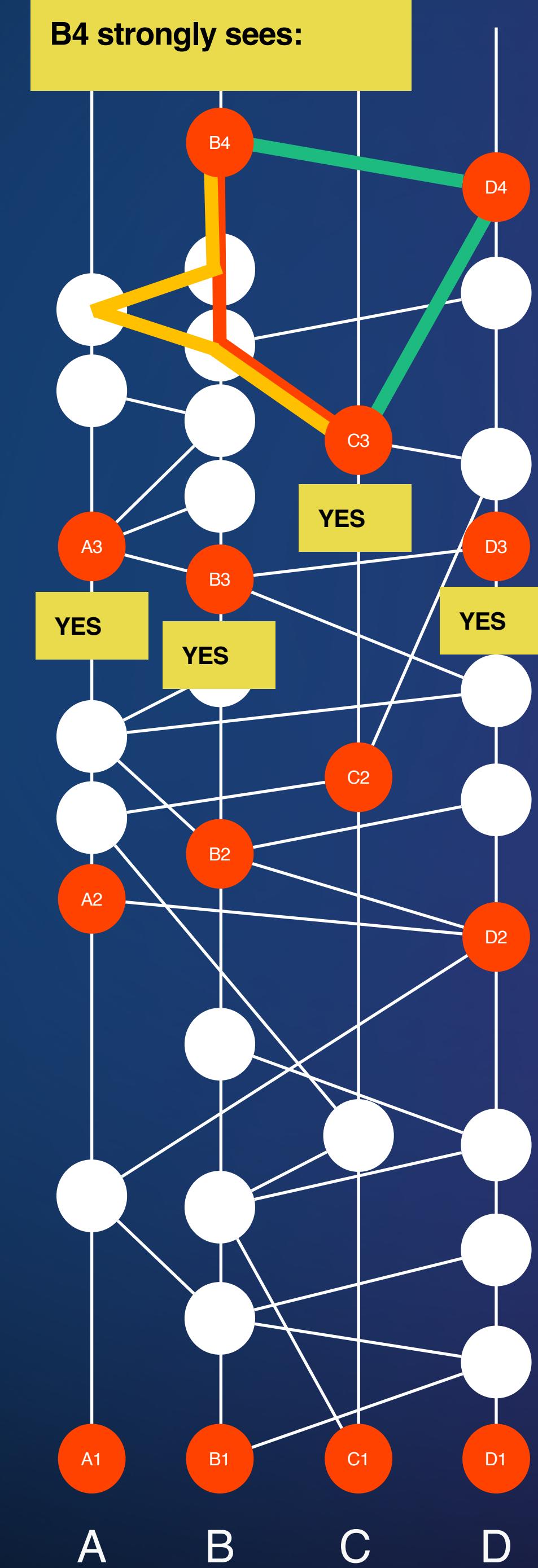
## Counting votes

- Strongly seen: To strongly see someone, you have to see them through a supermajority. That means more than two-thirds of the population (or stake as we will see later)
- B4 can also strongly see B3 through A, B and D



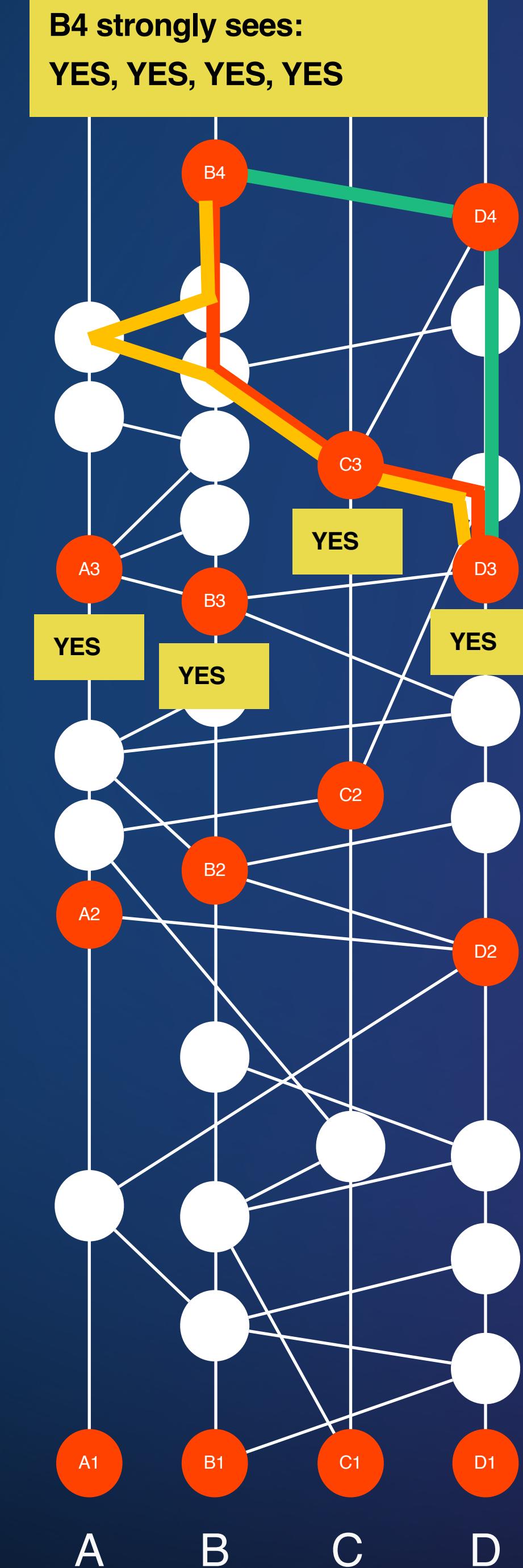
## Counting votes

- Strongly seen: To strongly see someone, you have to see them through a supermajority. That means more than two-thirds of the population (or stake as we will see later)
- And C3 through A, B and D



## Counting votes

- Strongly seen: To strongly see someone, you have to see them through a supermajority. That means more than two-thirds of the population (or stake as we will see later)
- And finally D3 through A, B, C and D
- We can therefore conclude that B2 is indeed famous after vote counting



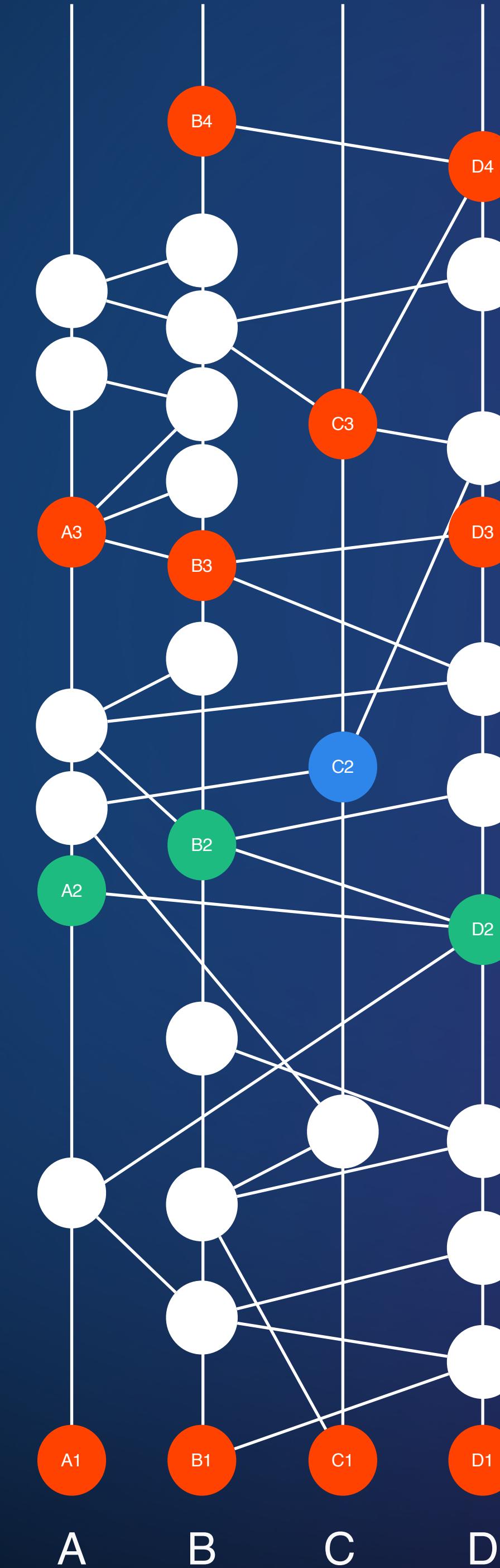
## VIRTUAL VOTING

## Famous Witnesses

After a few rounds of voting, we've determined which events are famous (green) and which aren't (blue)

If a decision cannot be made in a round, we try again in the following round

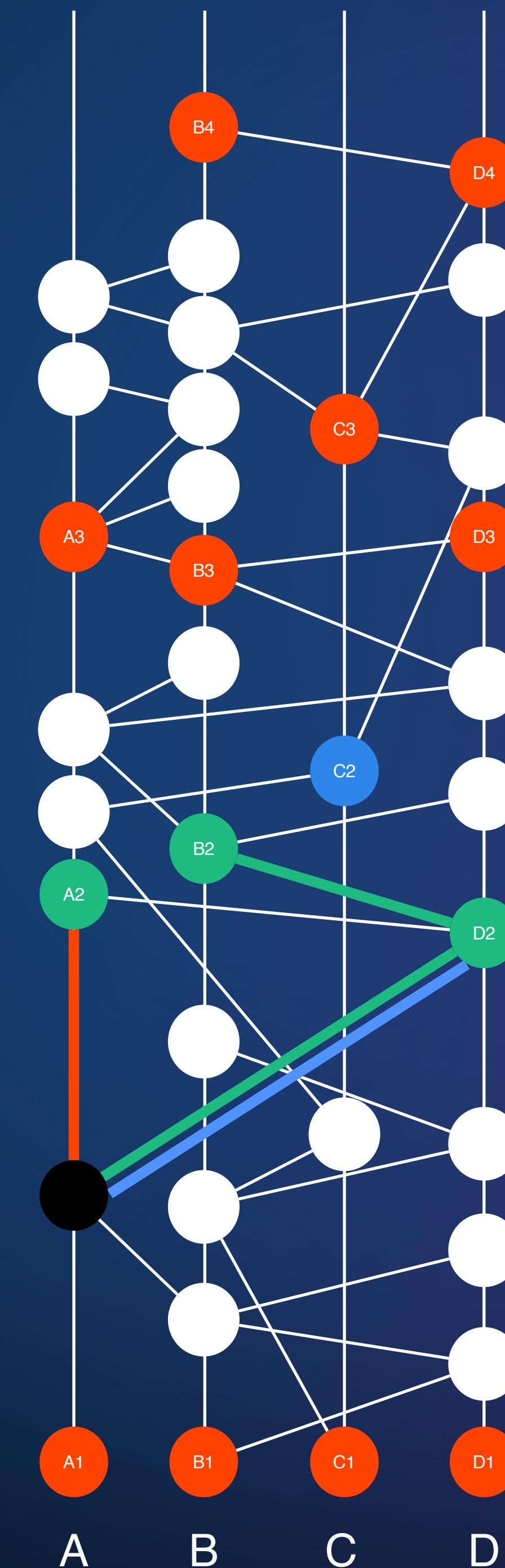
Every node performs this calculation **independently**, and they all come to the same result



## VIRTUAL VOTING

## Transaction ordering

- Any event may contain transactions to process, even non-witness events
- Consensus timestamp of black event is median of earliest time other events could see the black one (median of D2, B2 and the black event)
- Events are thus put in order for transaction processing



# Proof of Stake with Proxying

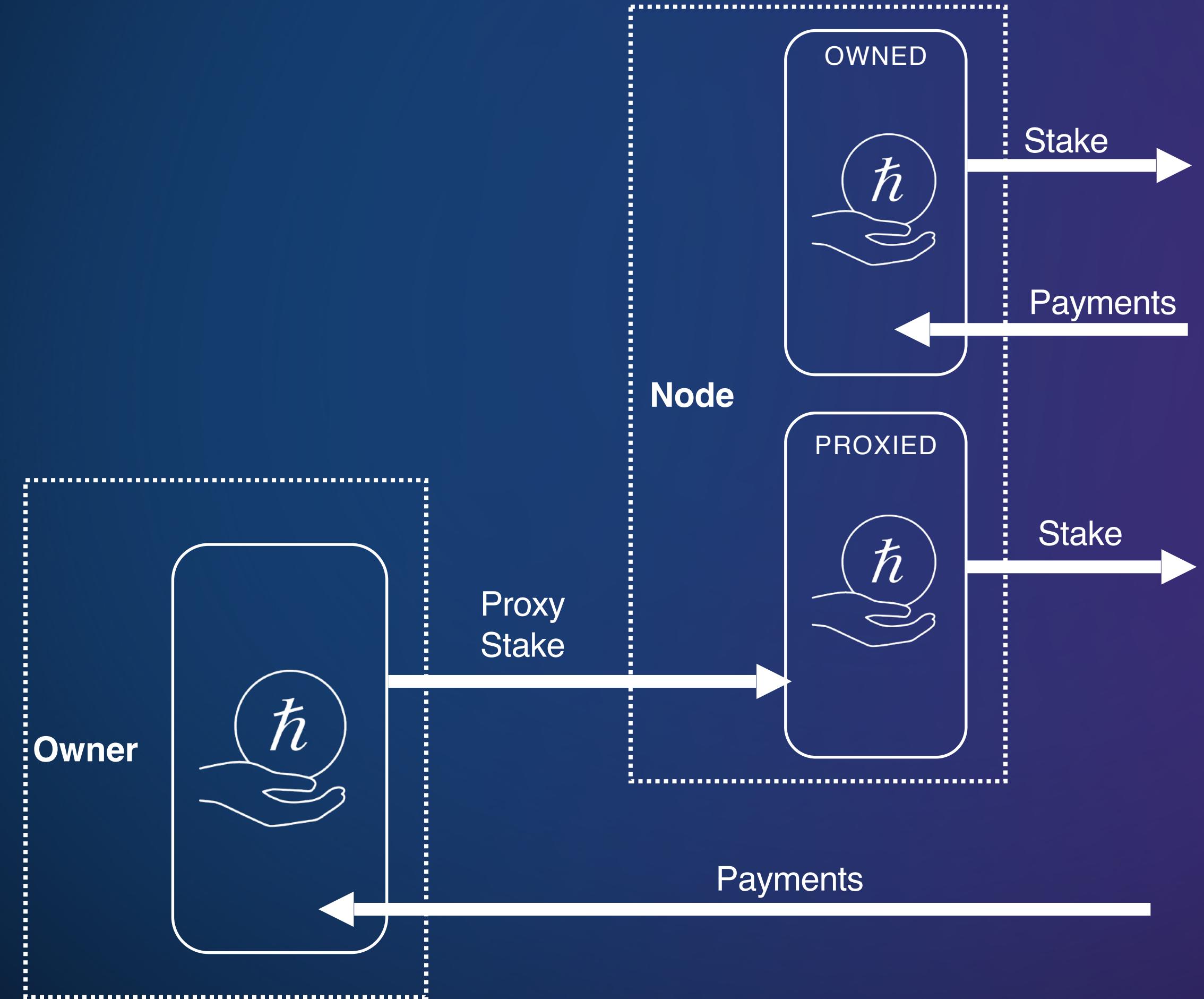
" an algorithm that calculates (in a Byzantine resistant manner) the timestamp of transactions from 2/3 of the network or more"

What defines "the network" ?

# Hint: It's not node(s)

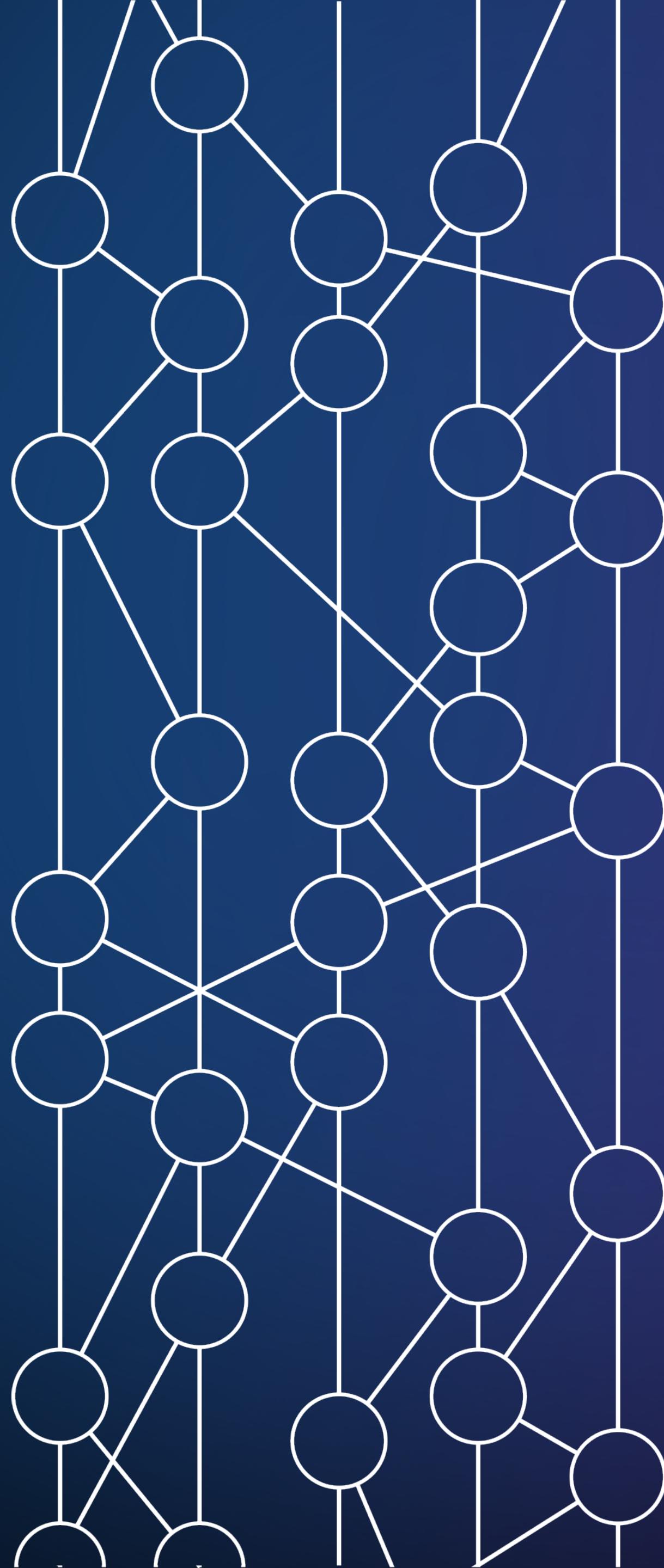
# Proxy Staking with Proxying

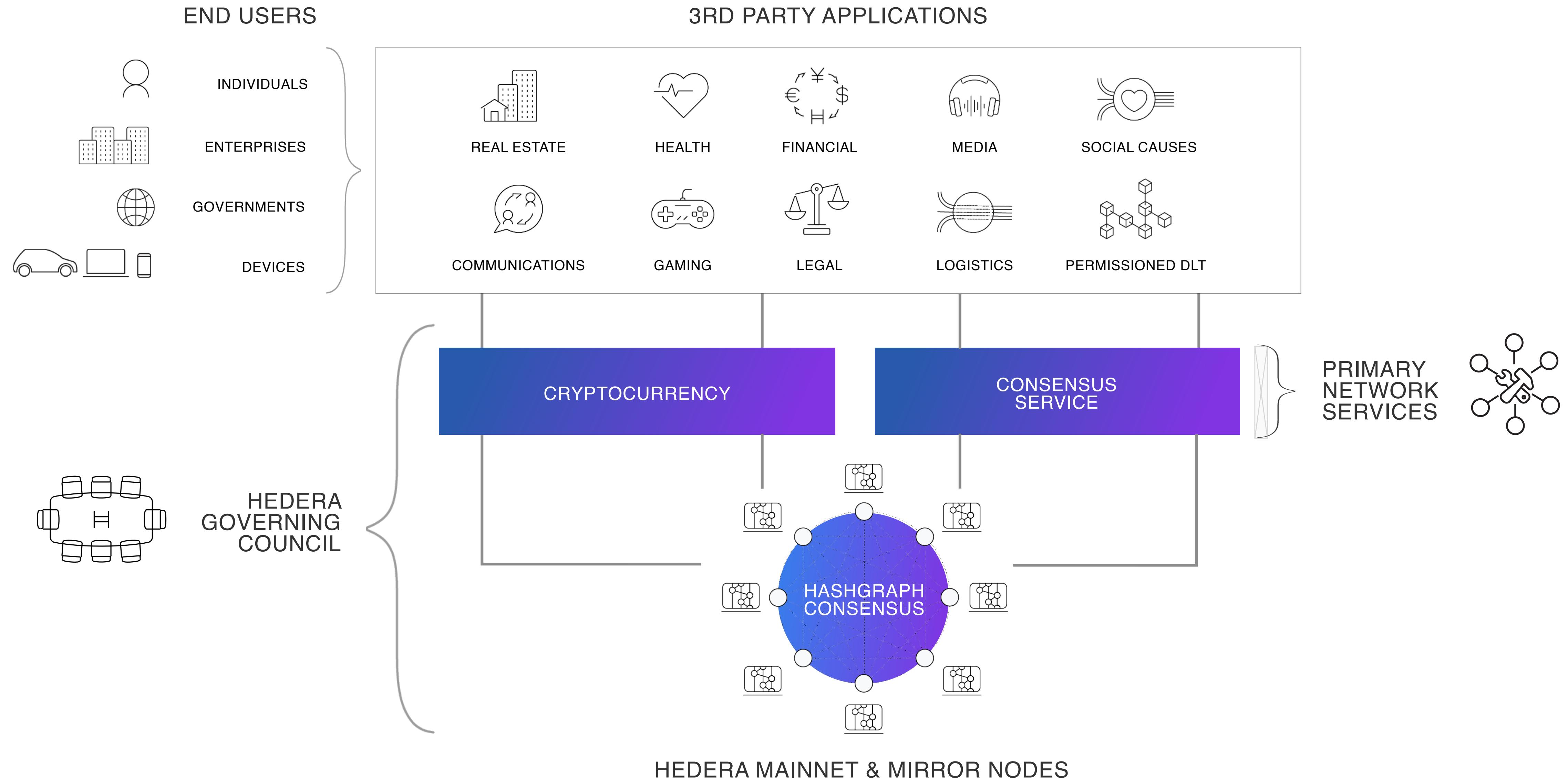
- No Leader or Delegate Election
- Number of nodes is irrelevant... stake held by nodes is
- No deposits / locking / slashing / bonding
- Any account can proxy its tokens to another account / node (and continue spending / earning tokens)
- Voting weight = (node's own stake + proxied stake) ÷ total hbar
- Every node participates in consensus
- Protects network against Sybil attacks



# Hashgraph is a consensus algorithm

- Architected from ground up to be fast, fair, and secure
- Achieves gold standard of security without performance trade-offs
- Gossip about gossip with virtual voting to quickly achieve consensus with 100% certainty
- Efficient in bandwidth and computation (no PoW)
- Leaderless







## Part 3 - Users / Projects That Are Building on Hedera



@hashgraph

# Hedera Today

APPLICATIONS, DEVELOPERS, & NETWORK ACTIVITY





The  
**CHOPRA  
FOUNDATION**

GEN<sup>omic</sup>Bank.io

tune.fm

Chainlink

eftpos

ECL<sup>osia</sup>

OTRAFY

SAFE

hedera.com

THE COUPON BUREAU

EARTH.ID

earthtile

HASHING SYSTEMS

Manetu

power transition

AD PROV

CLINK

CARBON

COINSQUAD

DIAMOND STANDARD

DRAGONGLASS

hash-hash.

HEX

zabo inara

KABUTO

HUMAN KIND

KPAY

LONESTAR DATA TECHNOLOGIES

L

PLAY HASH

Public  
est  
Network

RED SWAN

Rejolut

SEUN

SKY PEOPLE

zeug

ZIMBALI

## 8,000+ DEVELOPERS

Attending global hackathons, meetups, and active in Discord.

## 35+ APPLICATIONS

In production on Hedera mainnet, since open access on Sept. 2019

## ~1,000,000 MILLION TXS/DAY

Surpassing the daily transaction volume of Ethereum.

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INDUSTRY & USE CASE

ADVERTISING | REAL-TIME FRAUD DETECTION



Real-time auditing at scale to eliminate advertising fraud and remove costly intermediaries.

*"Hedera has proven it has the scale, speed and reliability to handle all of the live advert tracking data and programmatic event data that we have been handling in recent campaigns."*

IAN MULLINS | FOUNDER & CEO

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QUICK FACTS

MITIGATE AD FRAUD by providing a full, auditable trail of events, programmatically verified by a 3rd party to create trust between brands and media buyers.

LOW COST FOR CONSENSUS on transactions (\$0.0001) means AdsDax can create a viable and scalable business model for the advertising industry.

HIGH TRANSACTION THROUGHPUT with fast finality handles millions of daily advertising events.

CHRONOLOGICAL ORDERING OF TRANSACTIONS with timestamps enables analytical insight & transparency for both fraud detection and remittance.

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MORE INFORMATION

[HEDERA.COM/USERS/ADSDAX](https://hedera.com/users/adsdax)

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INDUSTRY & USE CASE

RETAIL | TRACKING AND REDEMPTION



Develops and maintains the Universal Positive Offer File for manufacturer coupons using the Hedera Consensus Service.

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*"Only Hedera Hashgraph was able to provide the real-time, tamper-proof logging capabilities that we needed to bring transparency, trust, agnosticism and industry oversight to a platform that connects all coupon industry stakeholders"*

BRANDI JOHNSON | CEO

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QUICK FACTS

CHALLENGE

Coupon and associated promotional data is fragmented, non-standardized, and rife with fraud. Without the necessary controls, transparency or trust, the industry usage of this promotional vehicle has decreased in recent years.

SOLUTION

The Coupon Bureau can bring its standardization and added efficiencies to the marketplace with transparency and trust. By allowing 3rd party validation and audit capabilities among authorized stakeholders, the industry will be able to have confidence in this centralized, agnostic solution.

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MORE INFORMATION

[HEDERA.COM/USERS/COUPON-BUREAU](https://hedera.com/users/COUPON-BUREAU)

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INDUSTRY & USE CASE

HEALTHCARE | SUPPLY CHAIN TRACK & TRACE



Real-time, public, scalable platform to address key clinical research, regulatory reporting and supply chain challenges.

*"Public ledgers provide a good option for regulators, allowing them to achieve the compliance and transparency they need in a secure, high-performance network designed for collaboration."*

JIM NASR | VP, TECHNOLOGY & INNOVATION

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QUICK FACTS

REDUCE THE FREQUENCY OF DRUG SHORTAGES and offer better predictability, with an end-to-end transparent trail of events across all supply chain parties.

HIGH TRANSACTION THROUROUGHPUT & FINALITY in seconds makes it easy to handle changes in supply chain velocity.

FAIR (CHRONOLOGICAL) ORDERING of transactions and timestamps enables tracking, tracing, and auditing, with precision.

LIVE HEALTH APPLICATION for tracking the deadly coronavirus in real-time with Hedera Hashgraph's public distributed ledger.

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MORE INFORMATION

[HEDERA.COM/USERS/ACOER](https://hedera.com/users/acoer)

# Deepak Chopra Leverages Blockchain To Fight Covid-19 Mental Health Crisis



Jason Brett Contributor ⓘ

Crypto &amp; Blockchain

I write about blockchain regulation and policy.

If you are having thoughts of suicide, please know that you are not alone. If you are in danger of acting on suicidal thoughts, call 911. For support and resources, call the National Suicide Prevention Lifeline at 1-800-273-8255 or text 741-741 for the Crisis Text Line.

Today, Deepak mental health a of Health websi preventing suic “There is some 19 influenza pa acute respirator

[DLA Piper and Aldersgate DLS launch TOKO, a fast, secure and cost effective solution for buying and selling high value assets using blockchain technology](#)



Share this



5 November 2020

Global law firm DLA Piper in collaboration with Aldersgate DLS (Digital Ledger Solutions), has launched TOKO, a unique tokenisation engine and vital component in the digital asset ecosystem. Developed with Aldersgate DLS, TOKO provides smart contract functionality and digital asset creation functionality and assurance.



# Brooklyn Nets' Spencer Dinwiddie Is Launching Galaxy, A Blockchain-Based App For Influencers



Shlomo Sprung Senior Contributor ⓘ

SportsMoney

I'm a senior contributor covering the NBA, MLB, NFL, NHL, soccer, esports and more.

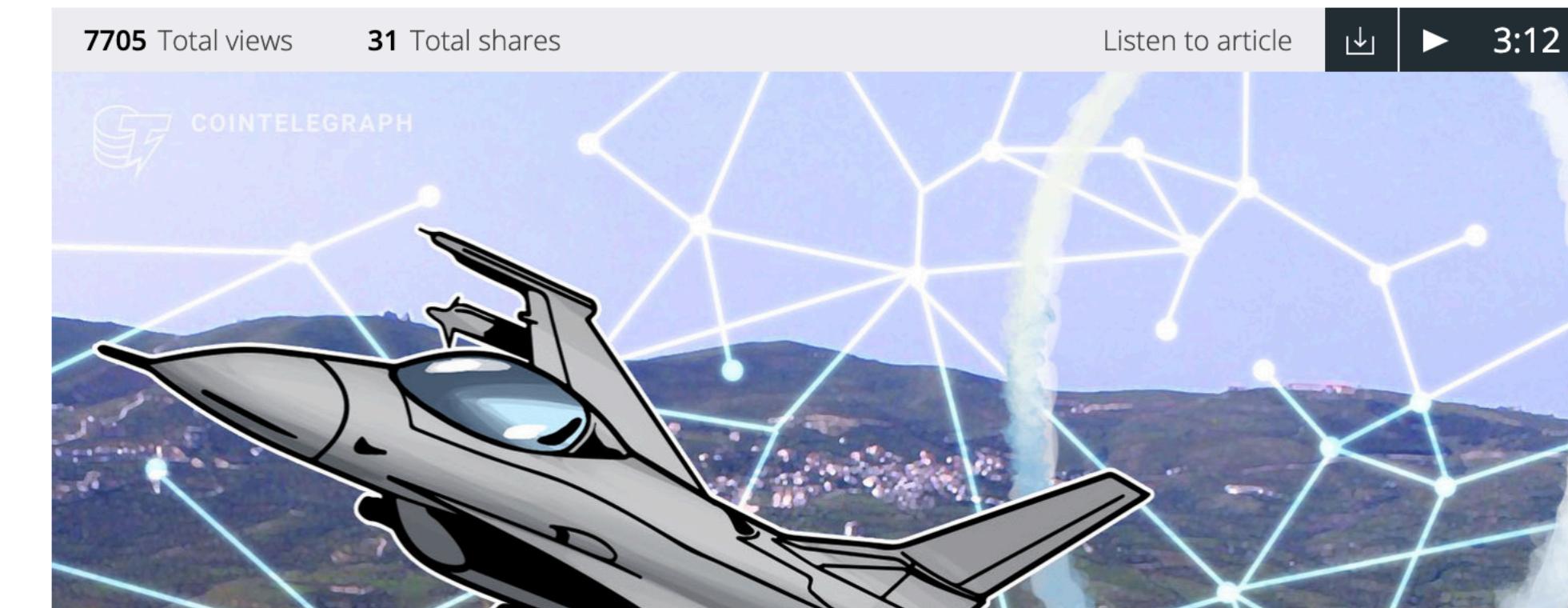
[f](#)
  
[t](#)
  
[in](#)


MARIE HUILLET

10 HOURS AGO

## Hedera Hashgraph to be used for crowdsourced airstrike warning app in Syria

An app that has been used for years to help civilians to access better real-time information about airstrikes has switched from using Ethereum to Hedera Hashgraph.

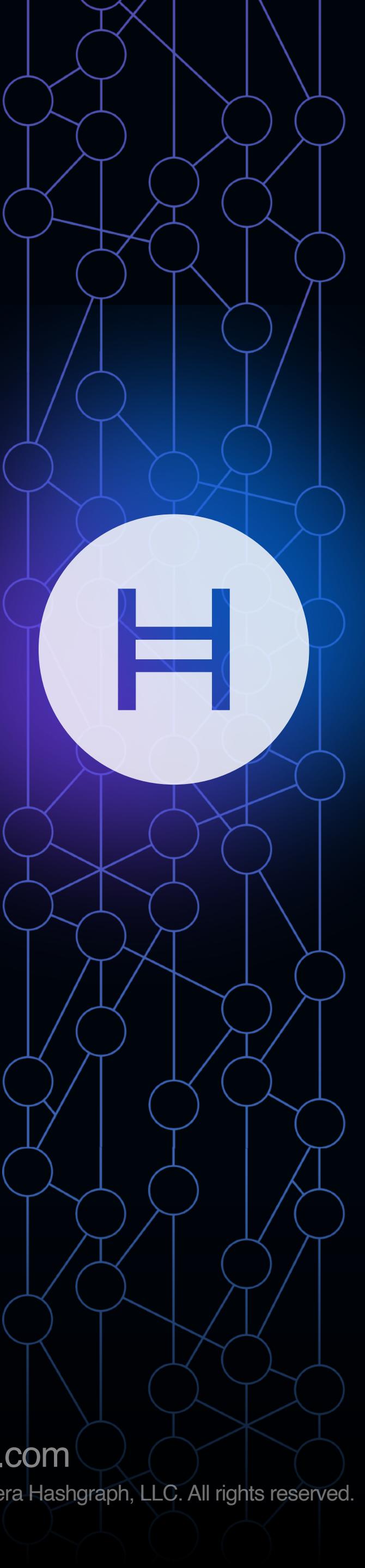


7705 Total views

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# Part 4 - How To Get Started Building Your Own Applications on Hedera



@hashgraph



## Part 5 - Q&A

## Additional Resources -

Sign up for a test account - [portal.hedera.com](https://portal.hedera.com)

Getting started guides - [hedera.com/get-started](https://hedera.com/get-started)

Discord chat - [hedera.com/discord](https://hedera.com/discord)

Tutorials - [youtube.com/channel/UCIhE4NYpaX9E9SssFnwrjww](https://youtube.com/channel/UCIhE4NYpaX9E9SssFnwrjww)

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