Hedera™ Hashgraph

THE TRUST LAYER OF THE INTERNET

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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

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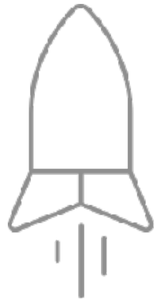
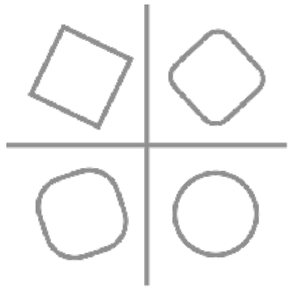
Enterprise adoption of public distributed ledgers

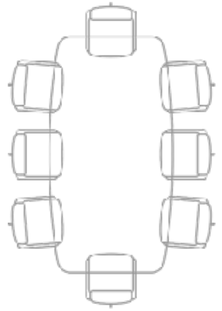


Performance

Security



Stability



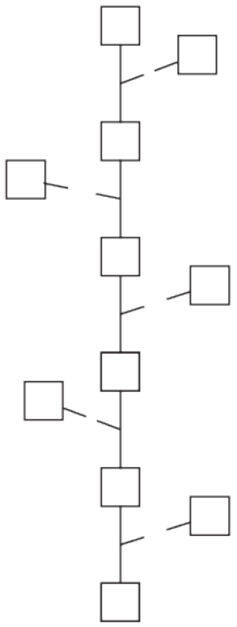
Governance

Technology Overview

HASHGRAPH CONSENSUS & HEDERA NETWORK SERVICES

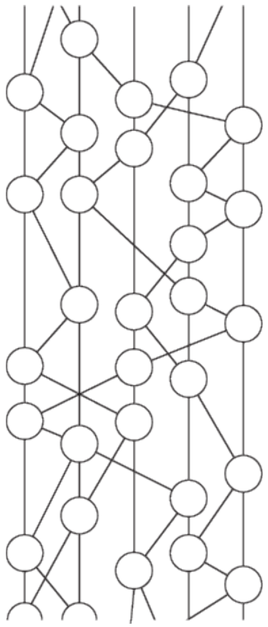
BLOCKCHAIN VS. HASHGRAPH

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

END USERS

INDIVIDUALS

ENTERPRISES

GOVERNMENTS

DEVICES

3RD PARTY APPLICATIONS

REAL ESTATE

HEALTH

FINANCIAL

MEDIA

SOCIAL CAUSES

COMMUNICATIONS

GAMING

LEGAL

LOGISTICS

PERMISSIONED DLT

CRYPTOCURRENCY

CONSENSUS SERVICE

PRIMARY NETWORK SERVICES

HEDERA GOVERNING COUNCIL

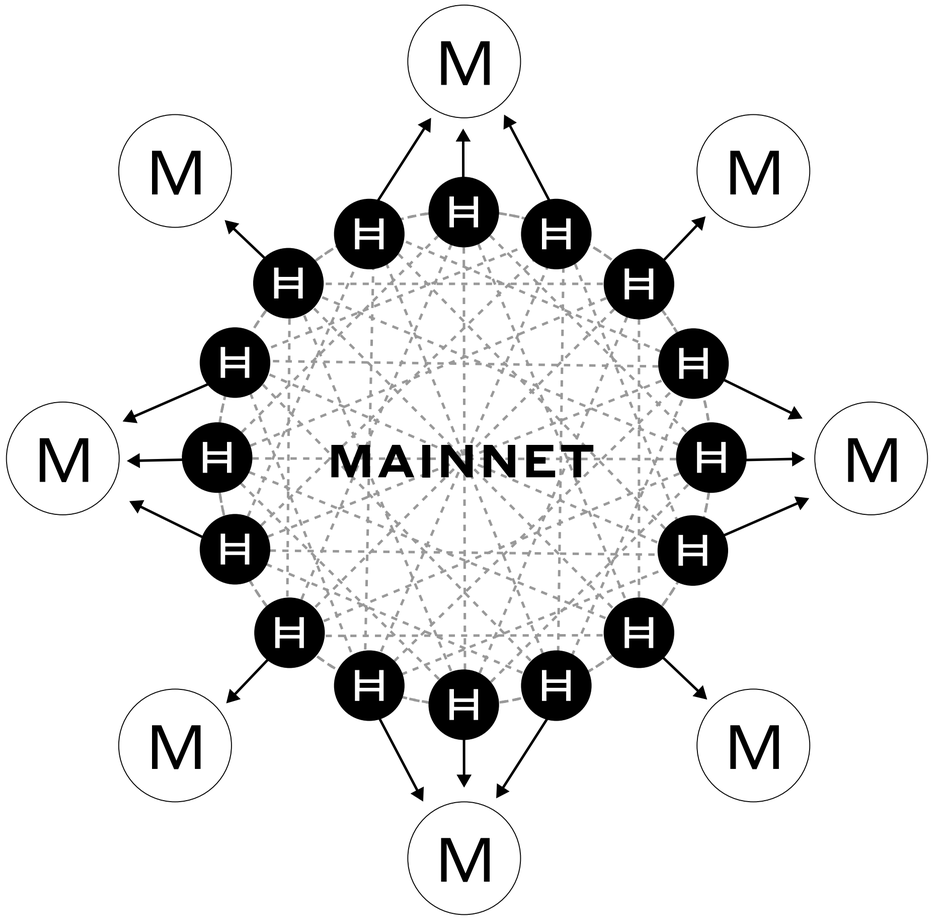
HASHGRAPH CONSENSUS

HEDERA MAINNET & MIRROR NODES

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

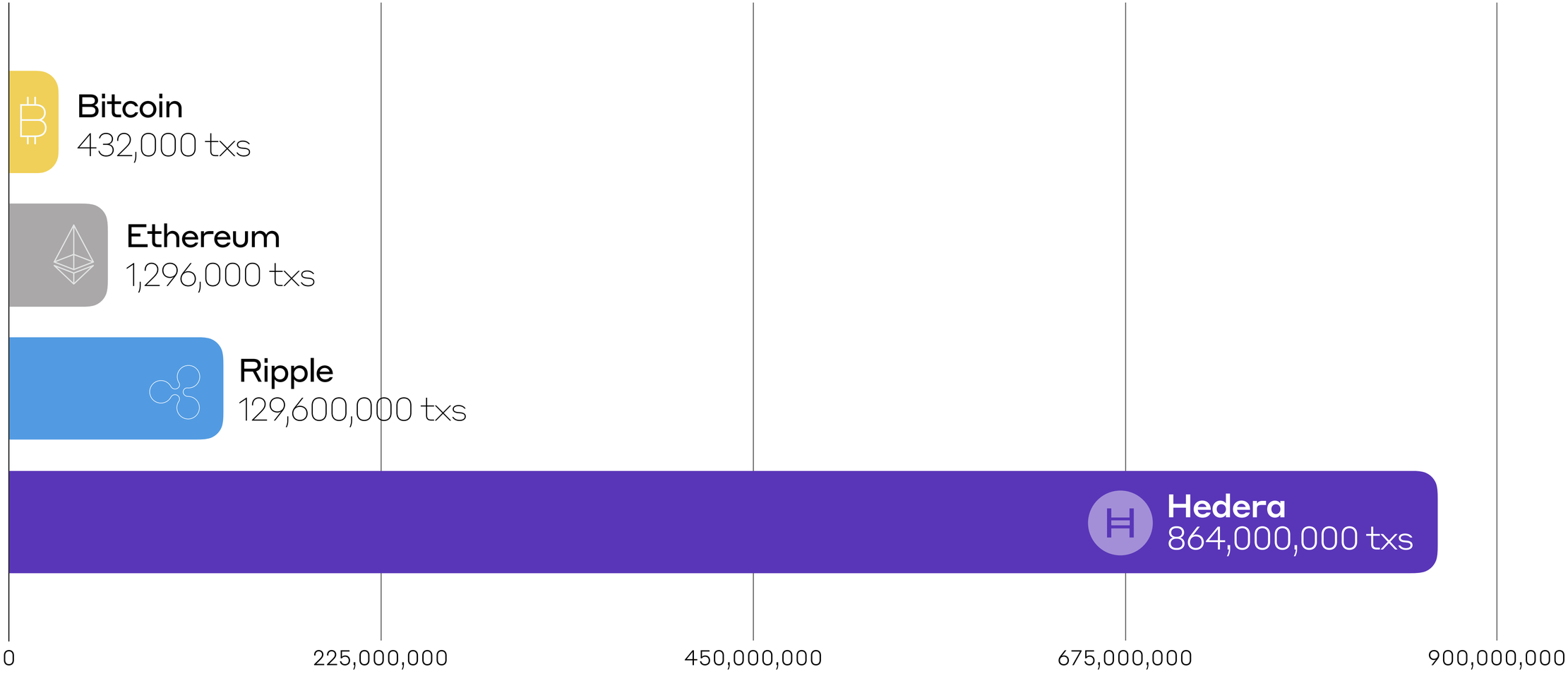
A third generation public distributed ledger

	1ST GENERATION	2ND GENERATION	3RD GENERATION
	Bitcoin Blockchain	Ethereum Blockchain	Hedera™ Hashgraph
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

power transition

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

EARTH.ID

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

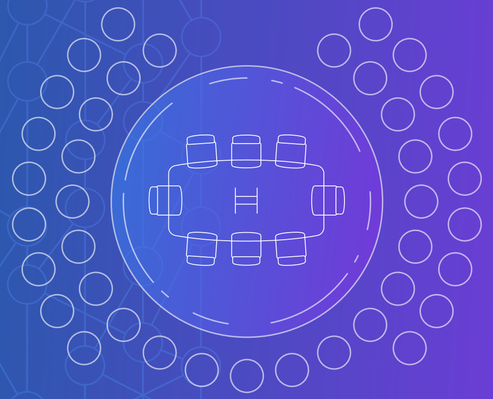
Hedera Consensus Service can scale to support high-volume device identity use cases.

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

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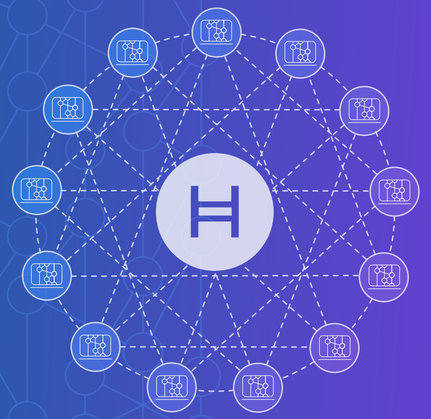
The Hedera **Governing Council**

Building the future together.



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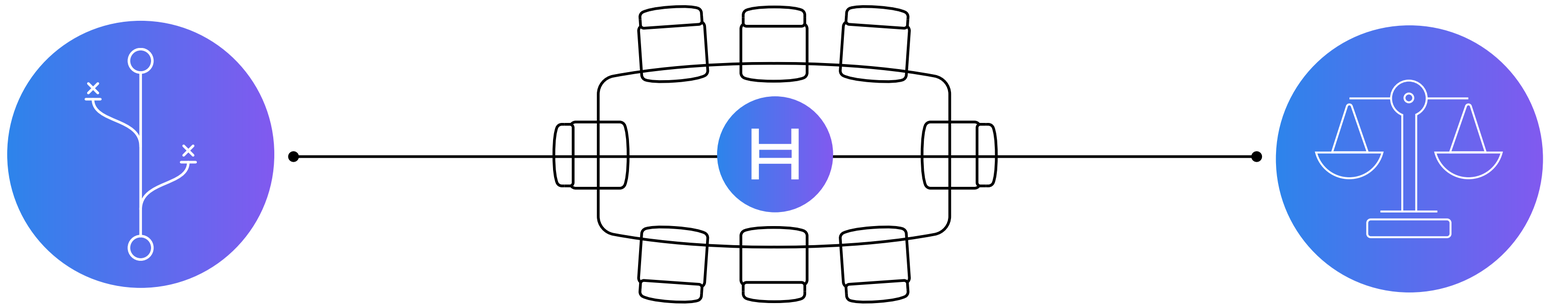
Network decisions:

- 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

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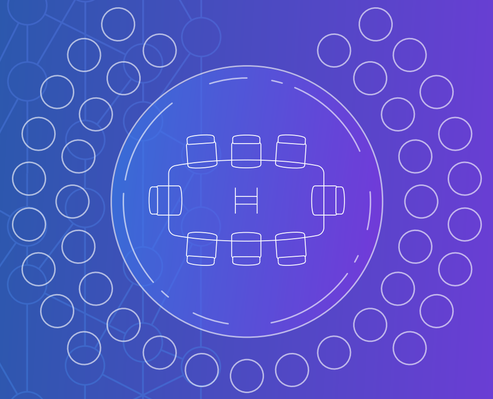
Building the future together.



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Avery Dennison
Boeing
DLA Piper
Deutsche Telekom
FIS
Google
IBM
LG
Magalu
Nomura
Swirlds
TATA
UCL
wipro
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+**

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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

JordanFried
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

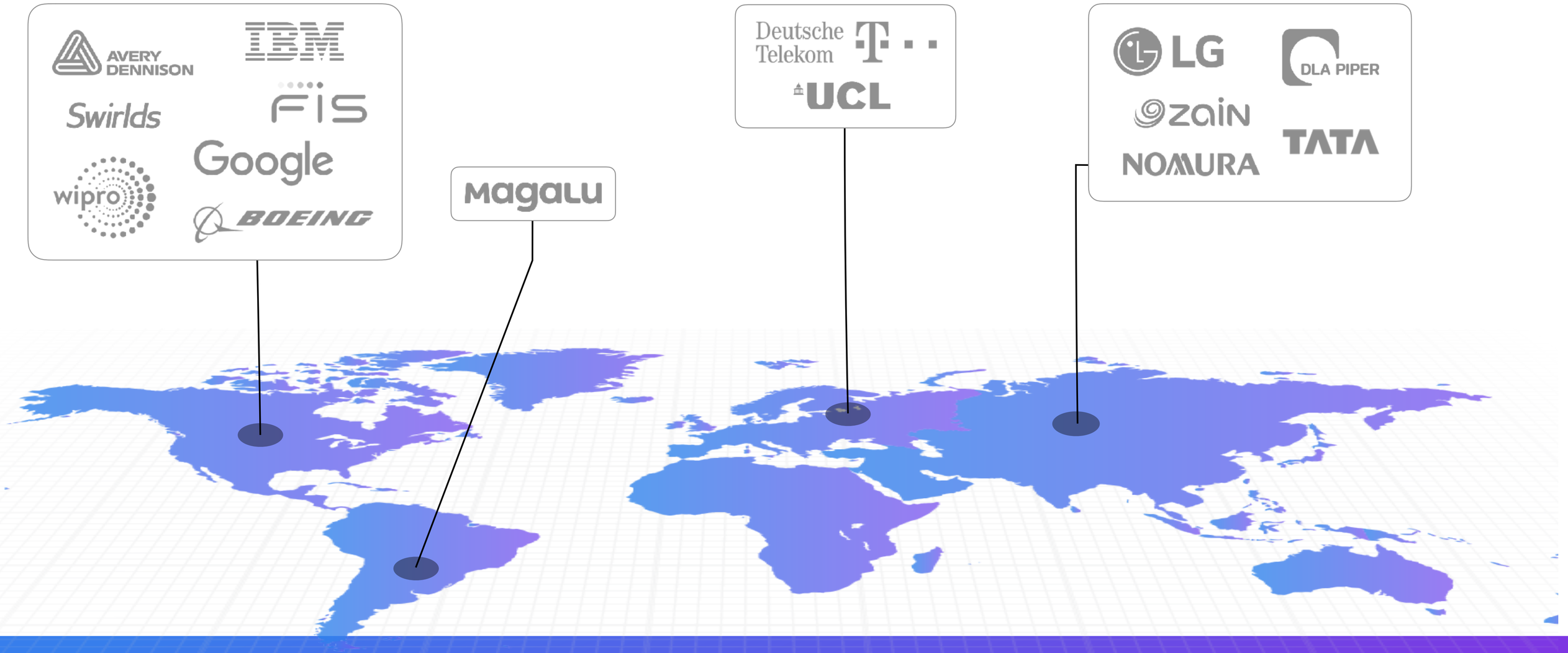
Nigel Clark
SENIOR VP, INDUSTRIES & PARTNERS

Network Growth

HEDERA'S PATH TO A FULLY DECENTRALIZED NETWORK

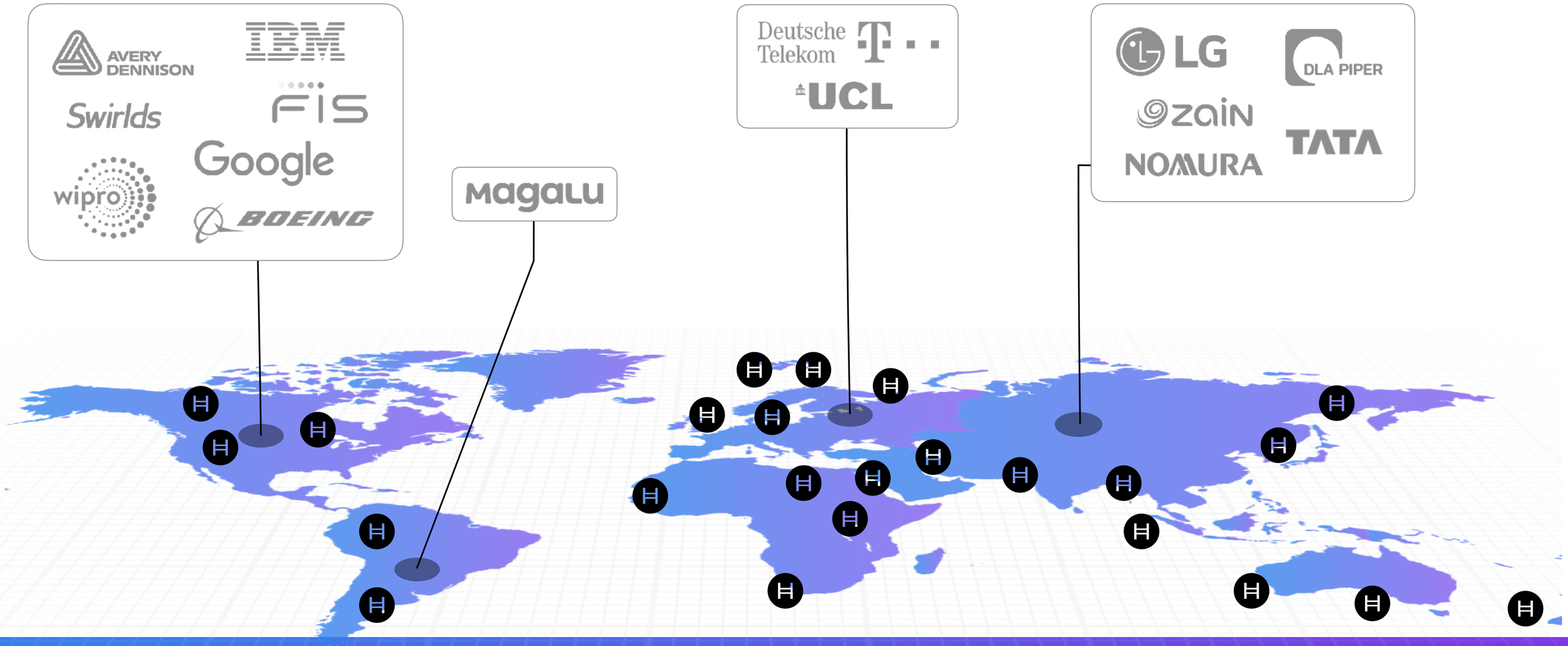
NETWORK GROWTH OVER TIME

PHASE 1: Up to 39 council members



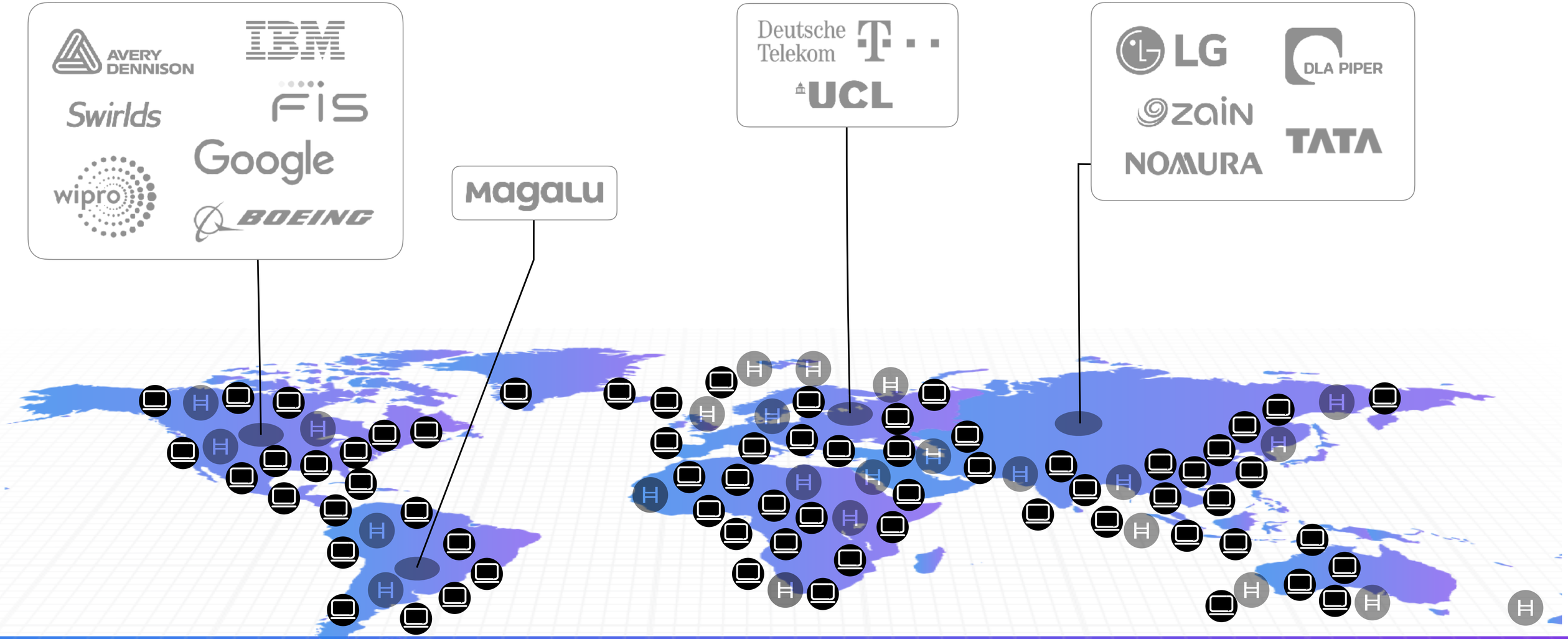
NETWORK GROWTH OVER TIME

PHASE 2: 100s of KYC'd permissioned nodes



NETWORK GROWTH OVER TIME

PHASE 3: 1000s of permissionless nodes

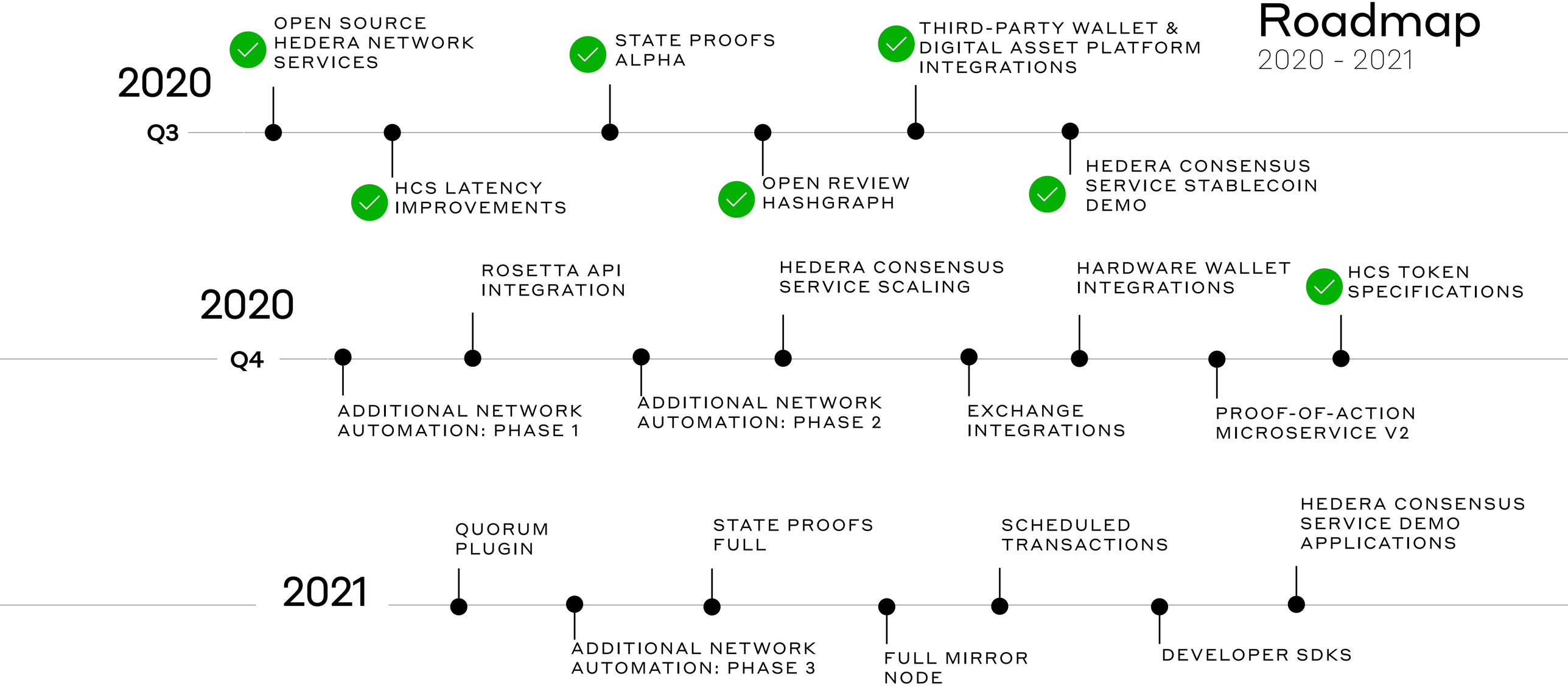


Roadmap

UPCOMING FEATURES & FUNCTIONALITY

Roadmap

2020 - 2021



Part 2 - Foundations of the Hashgraph Consensus Algorithm

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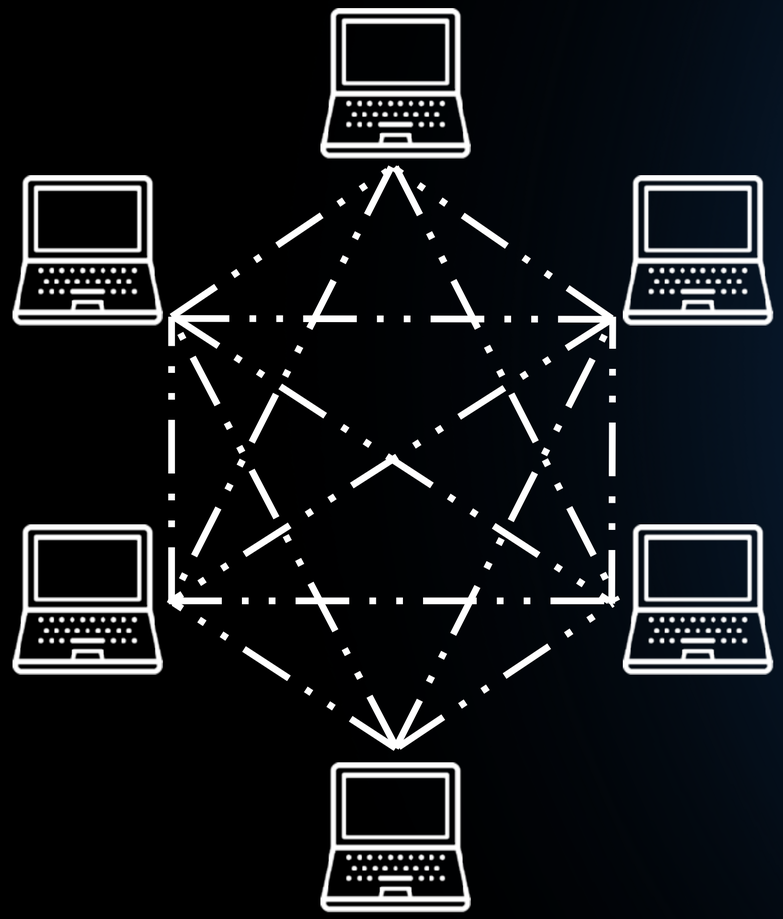
Virtual Voting

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

VOTING-BASED

Voting Based Consensus



ADVANTAGES

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

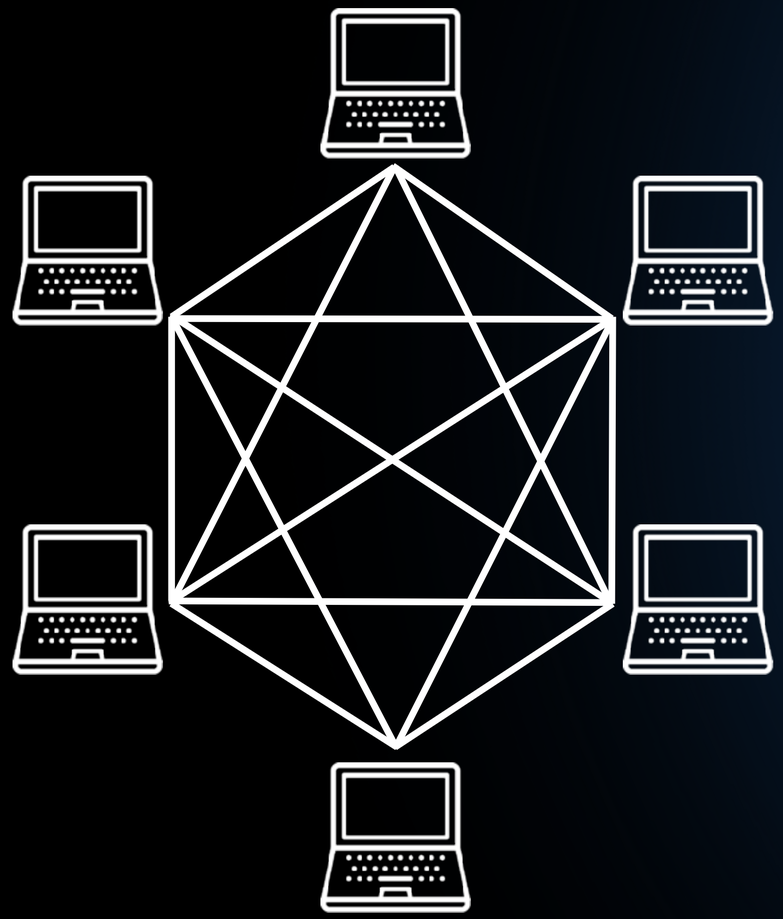
DISADVANTAGES

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

EXAMPLES

- None – not practical

VIRTUAL VOTING



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

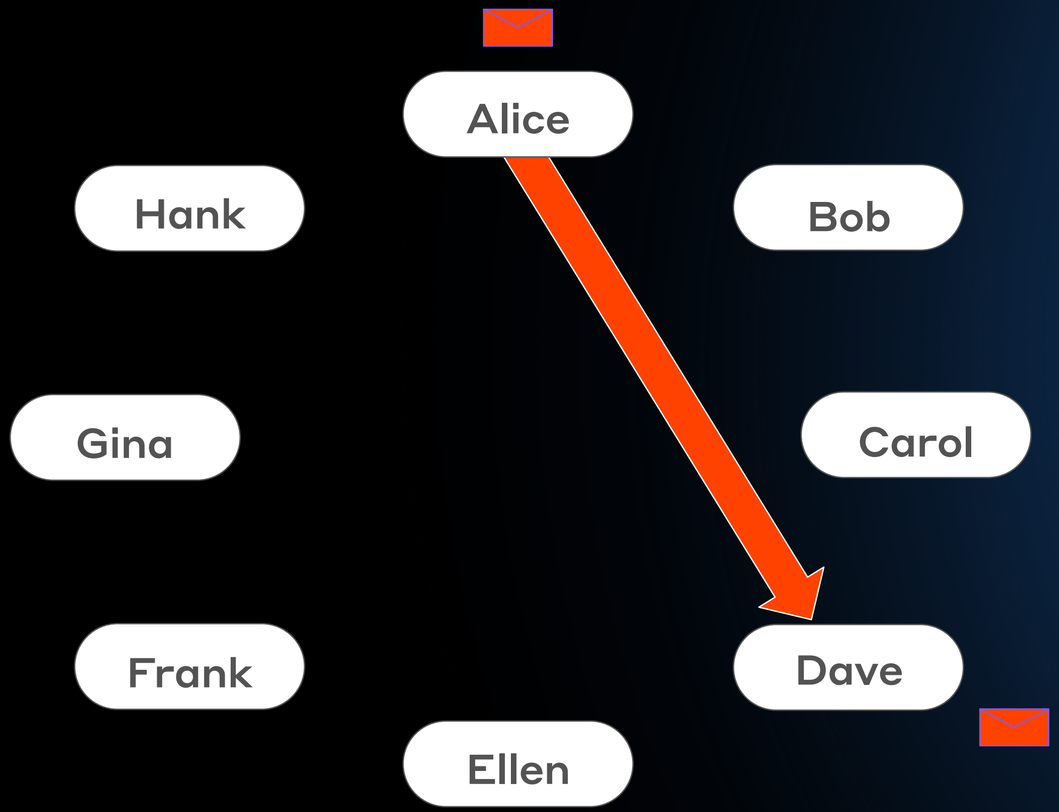
EXAMPLES

- Hedera Hashgraph

Gossip about Gossip

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

Gossip about gossip



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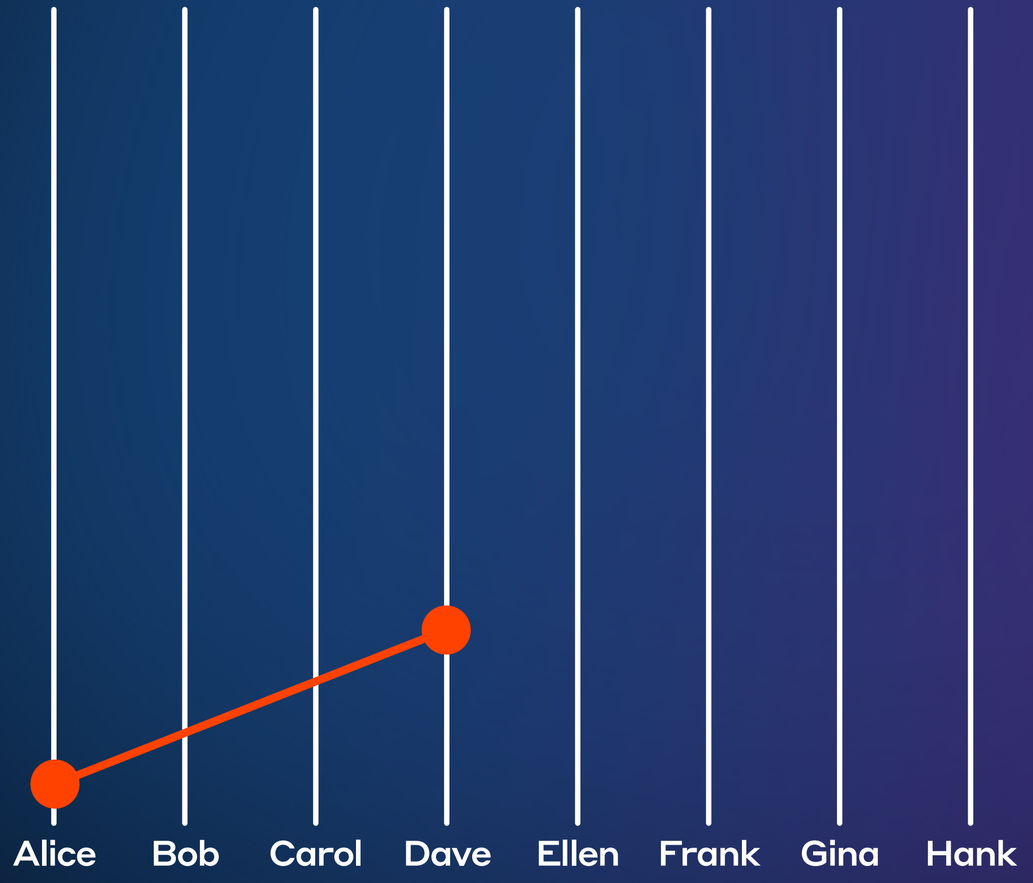

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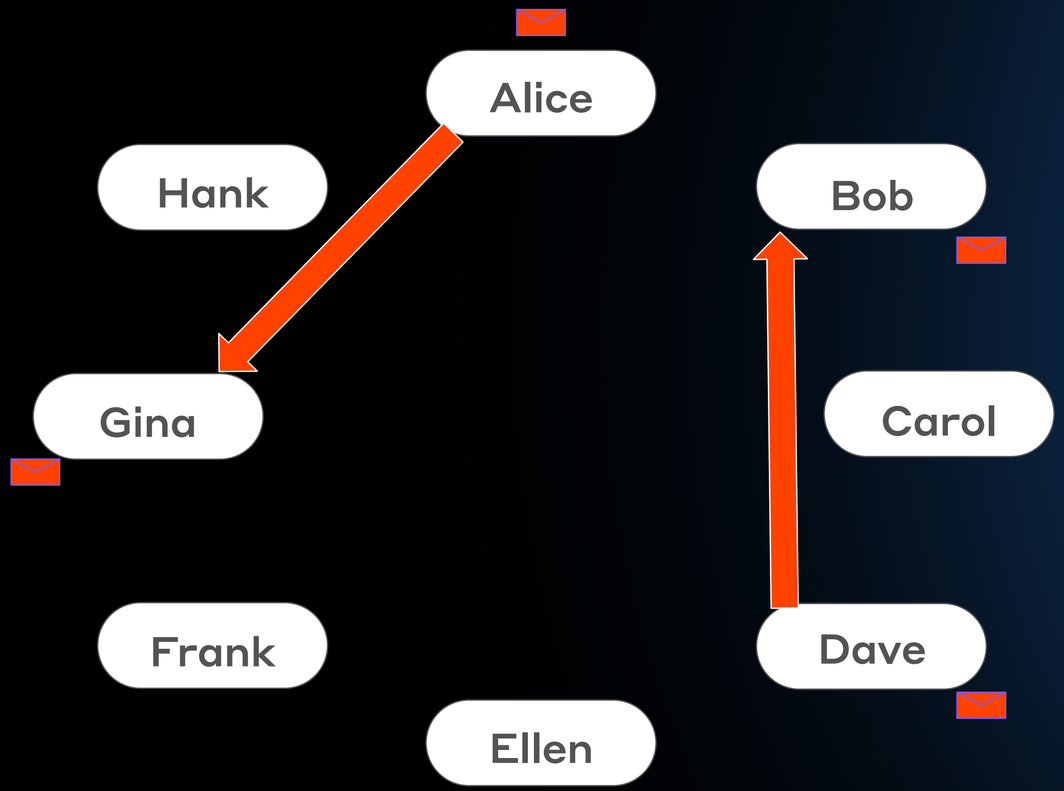

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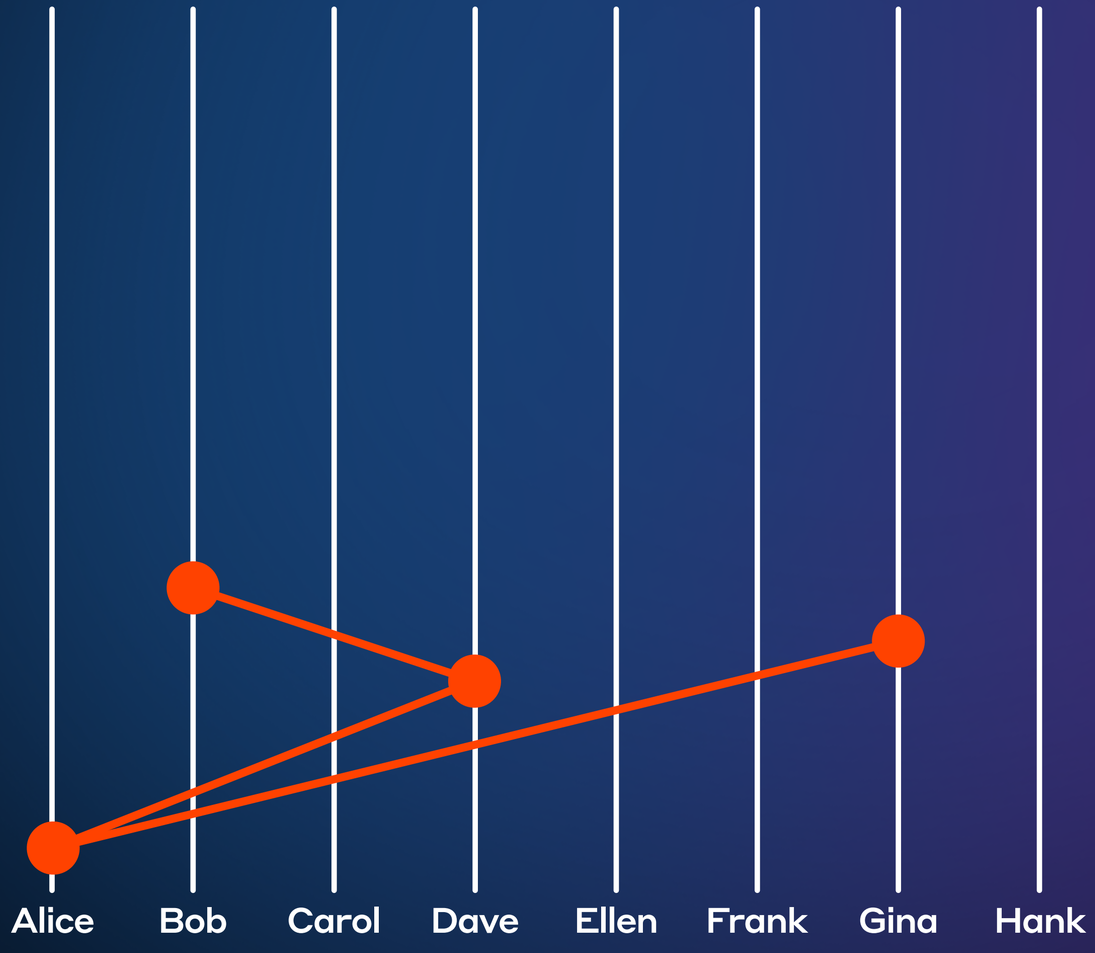

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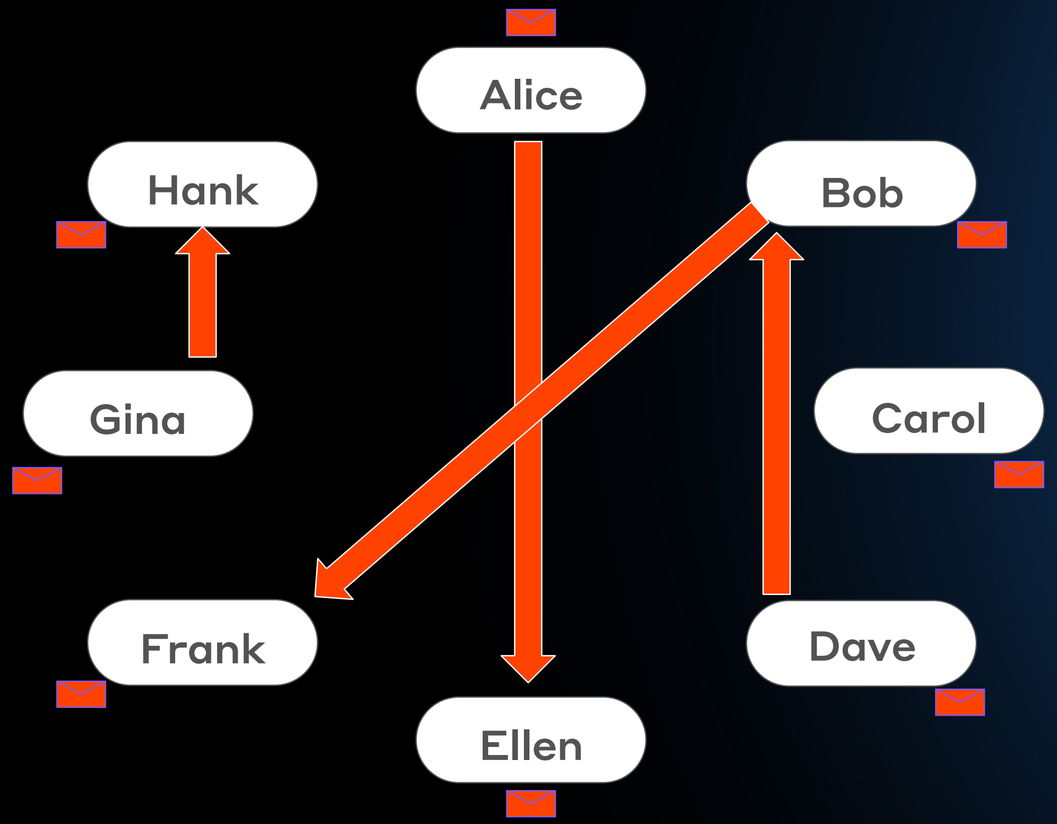

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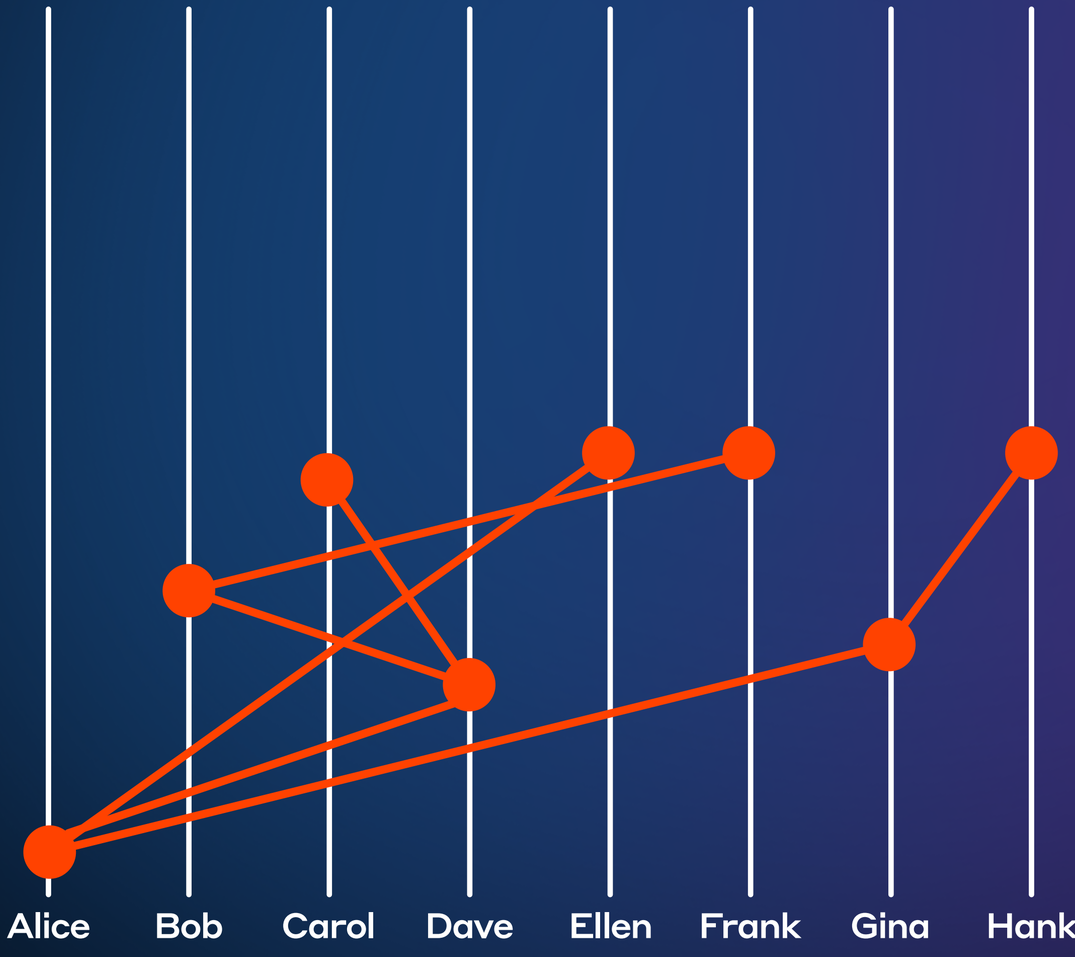

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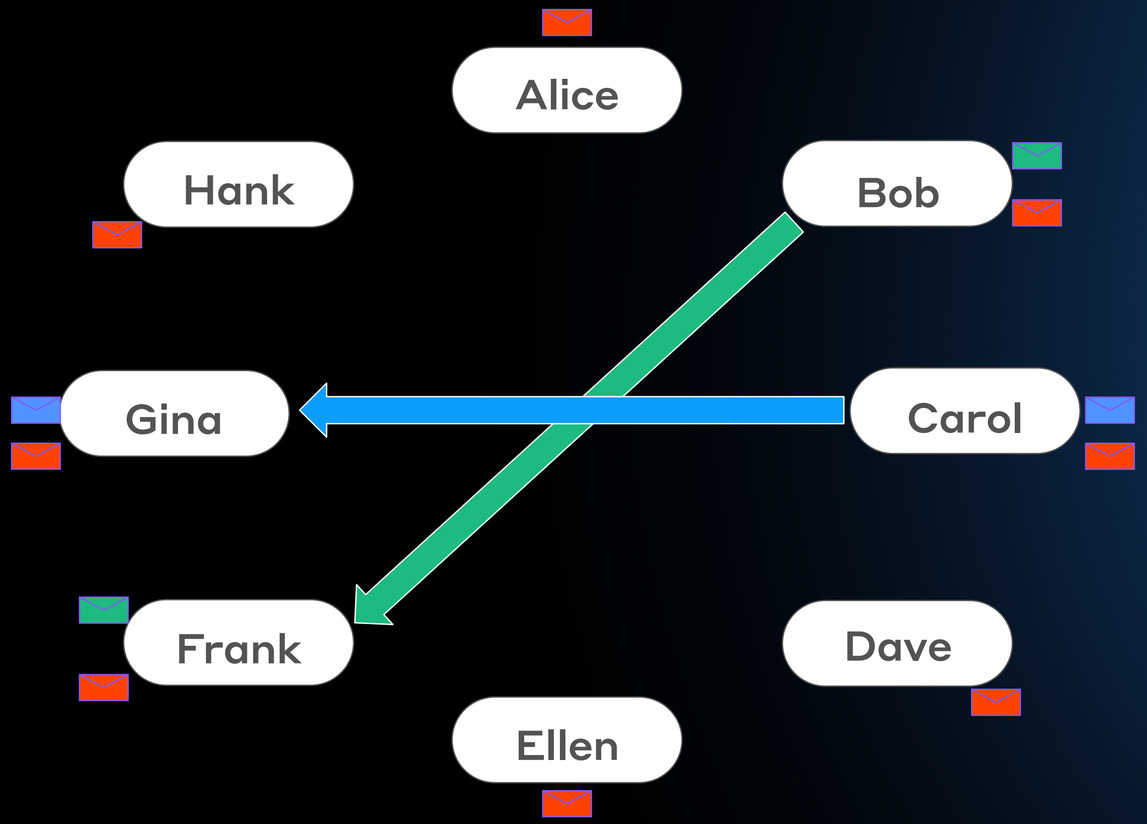

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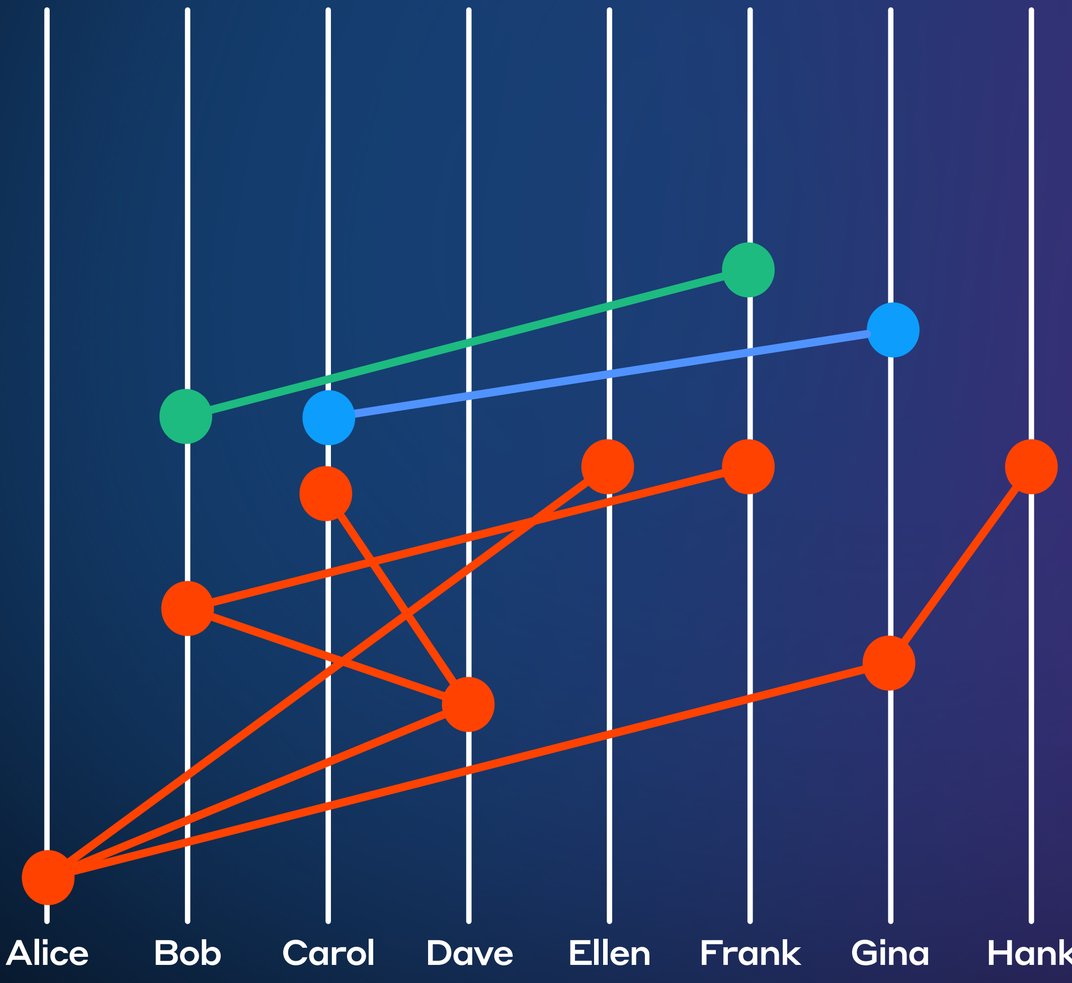

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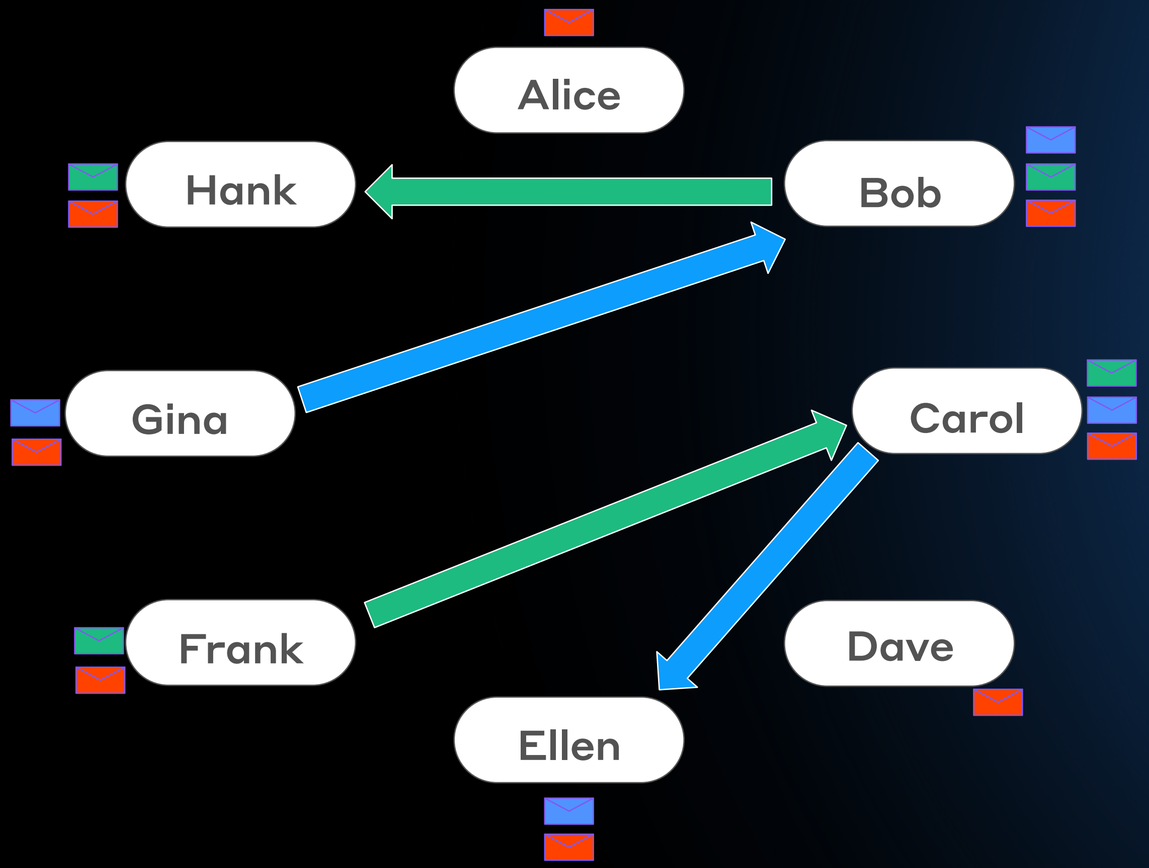

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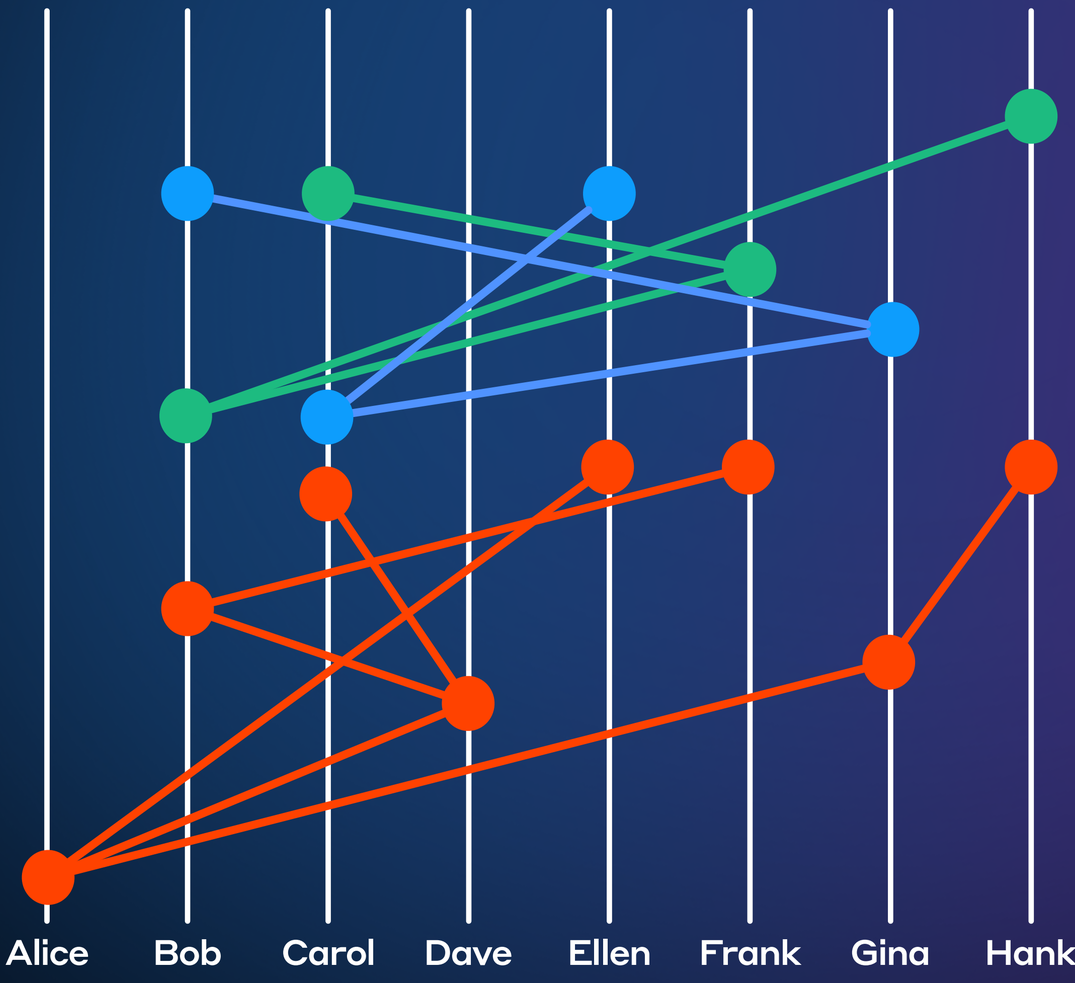

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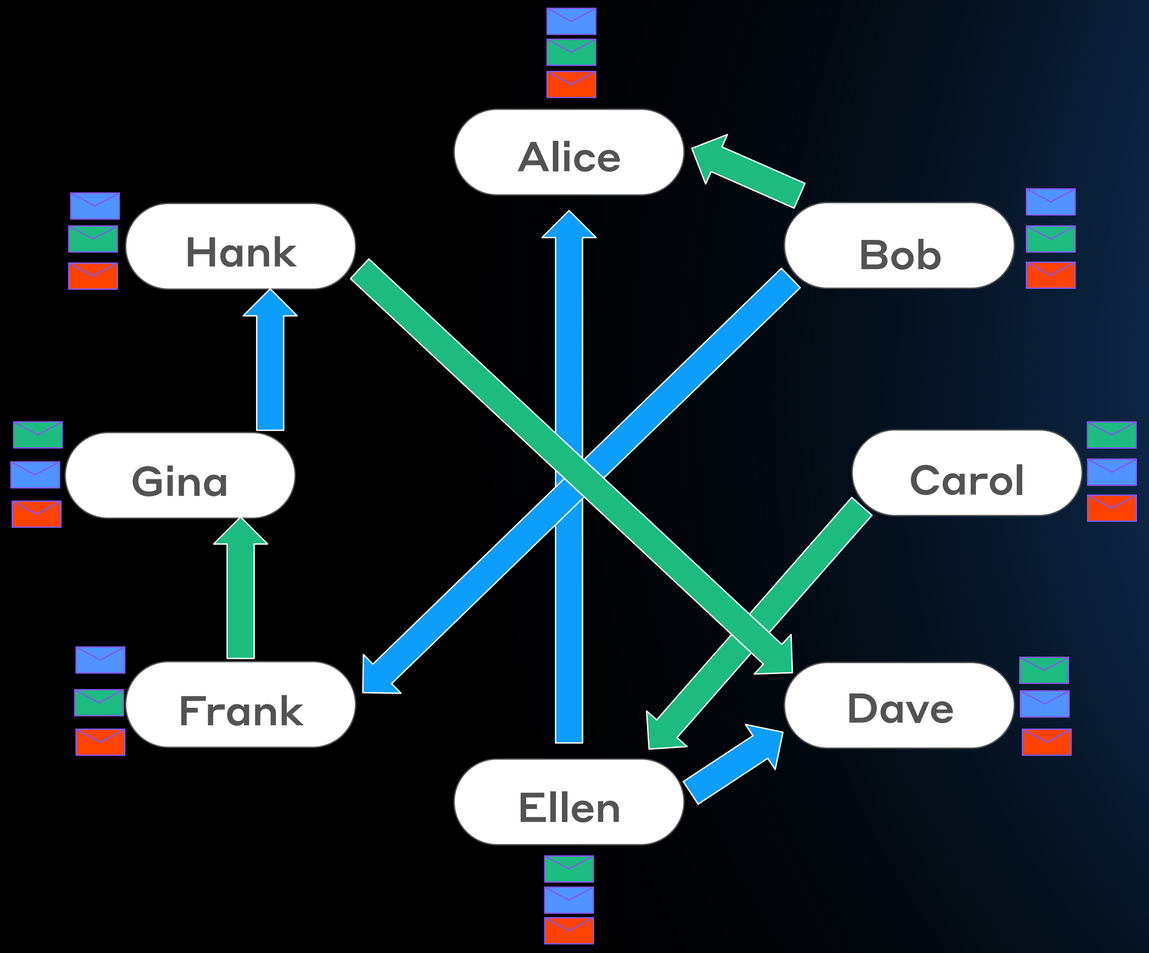
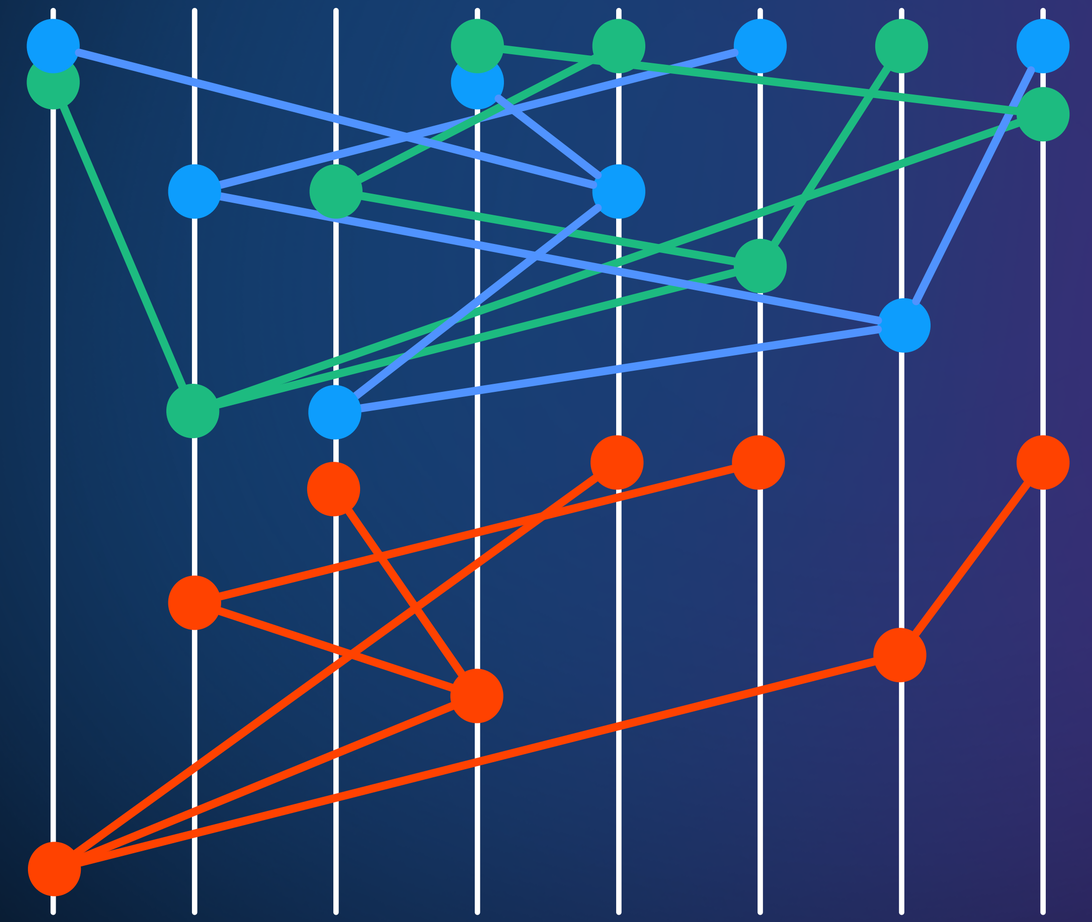
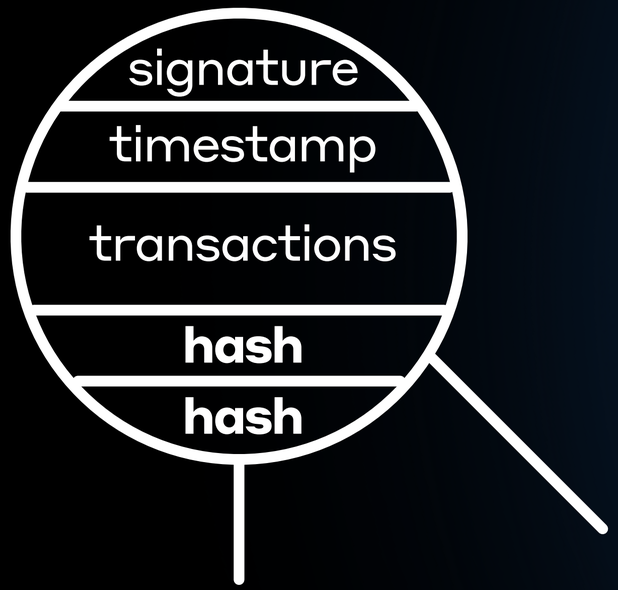


Gossip about Gossip

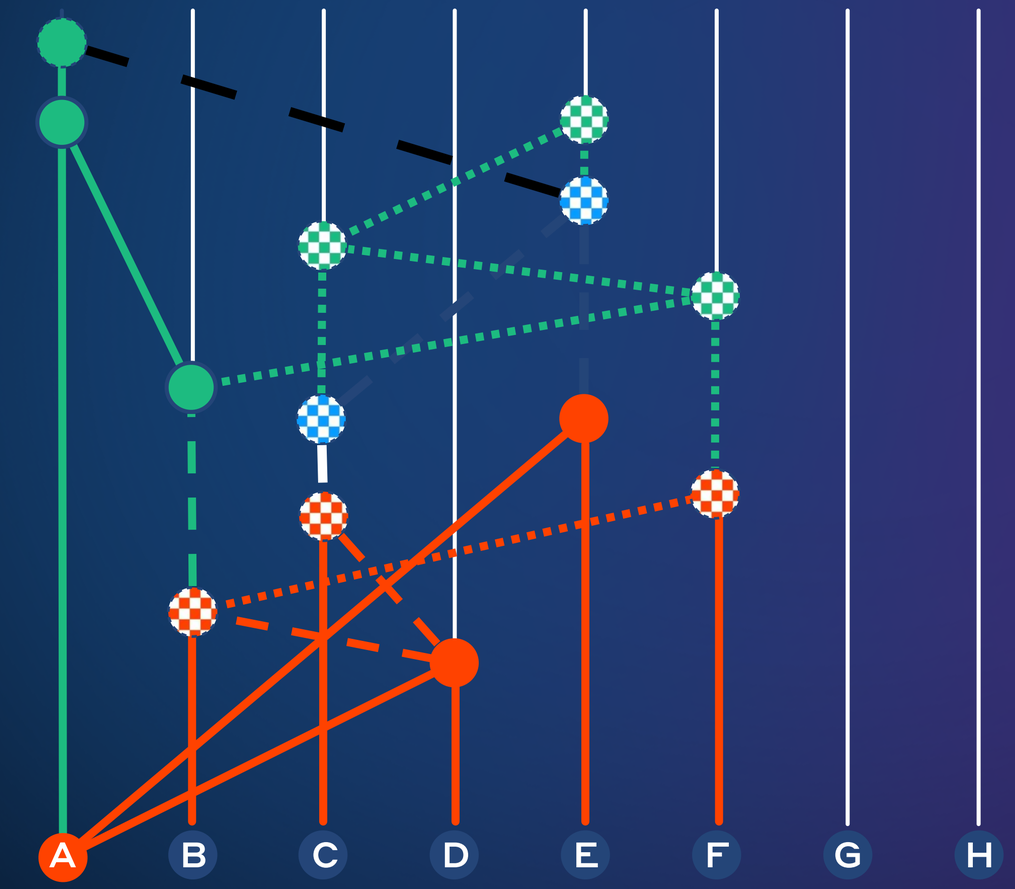


GOSSIP ABOUT GOSSIP

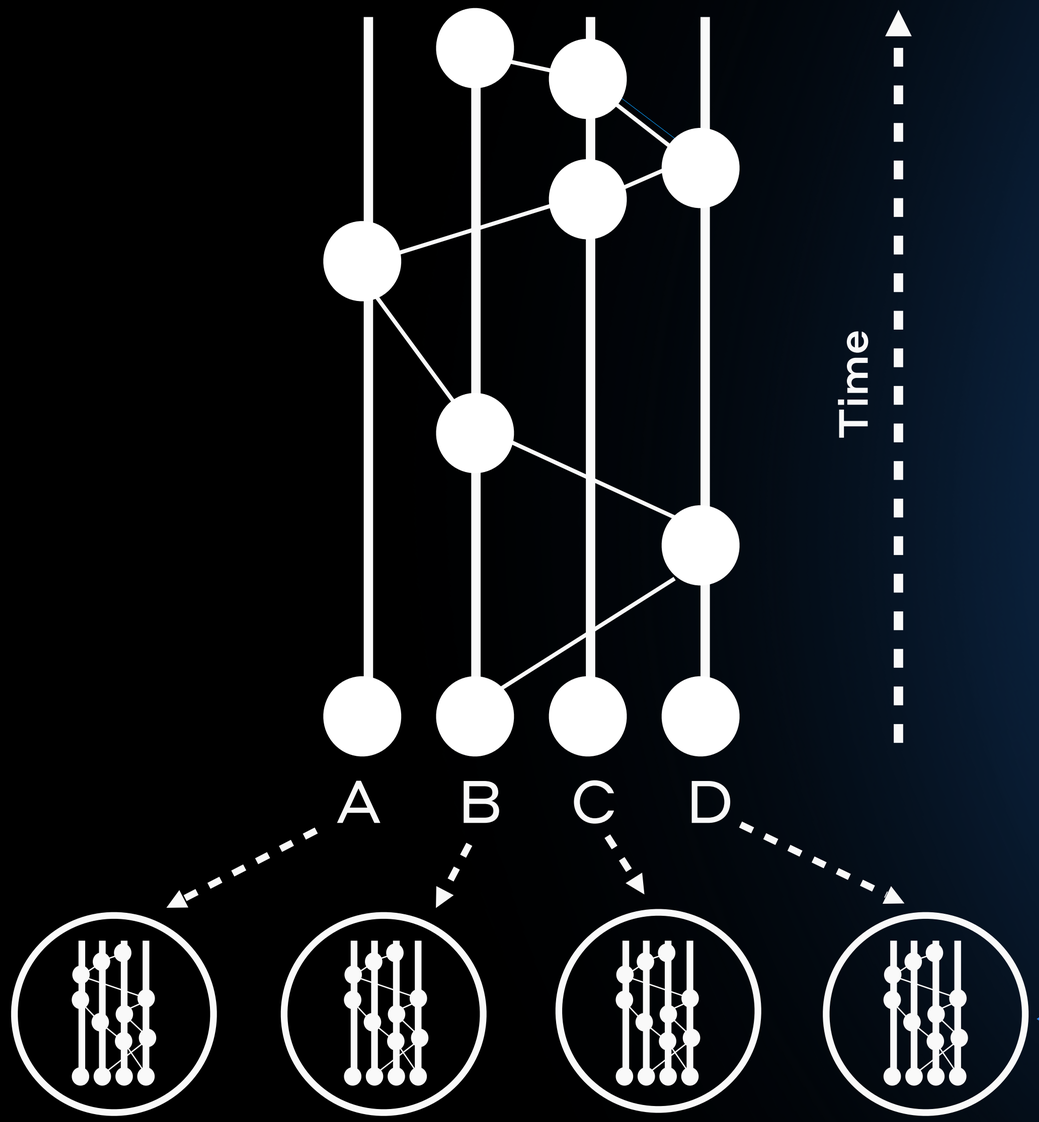


Share events unknown to each other during gossip

Gossip about Gossip



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



Gossip about Gossip

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.

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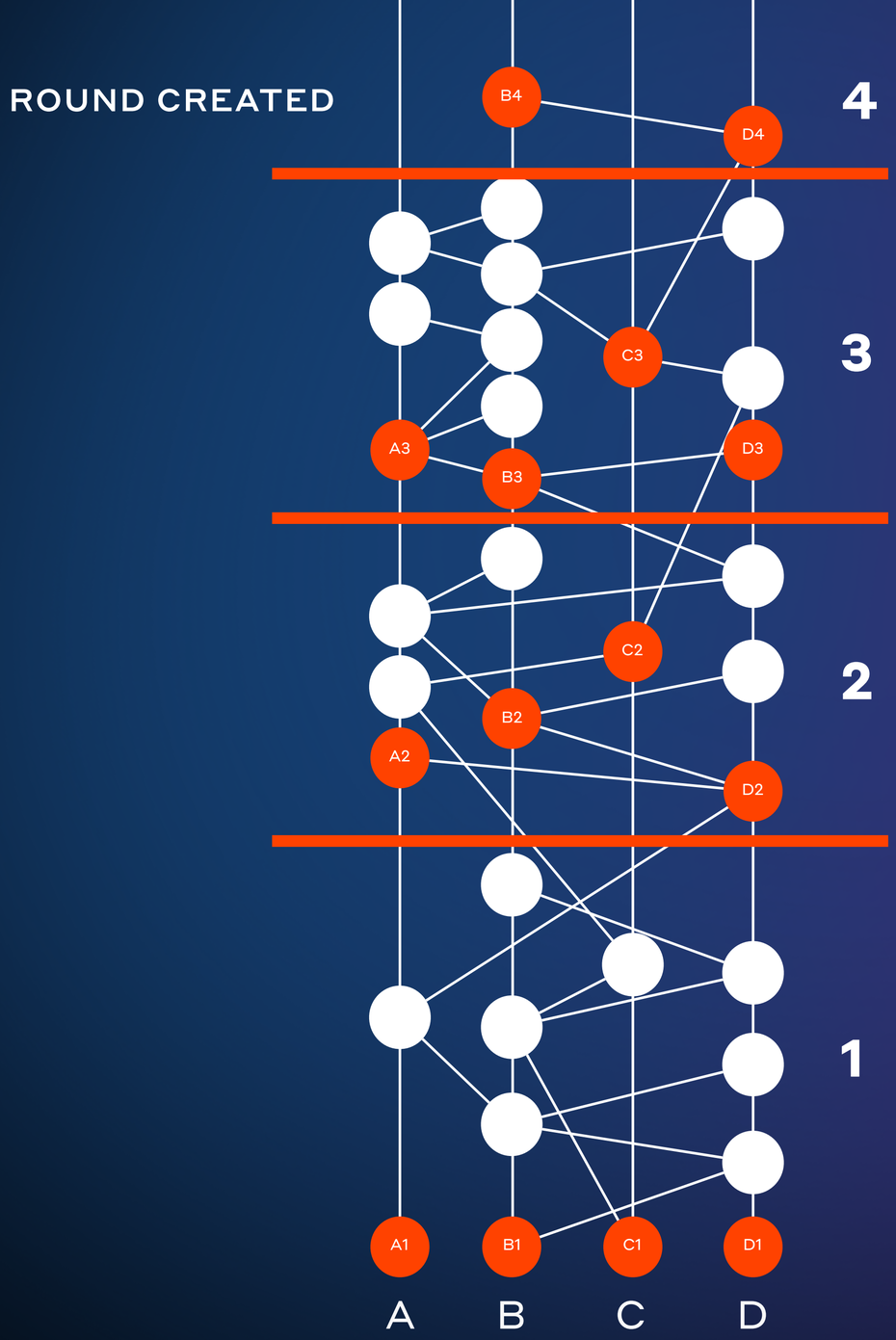
Virtual Voting

Within the context of the hashgraph

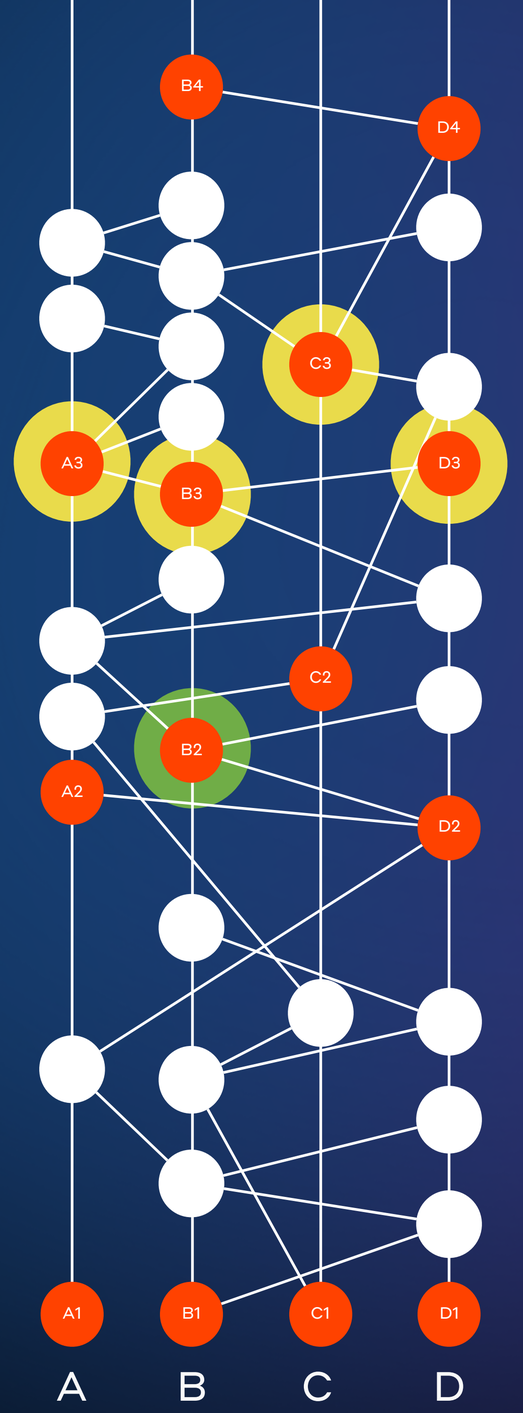
Rounds and witnesses

- 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



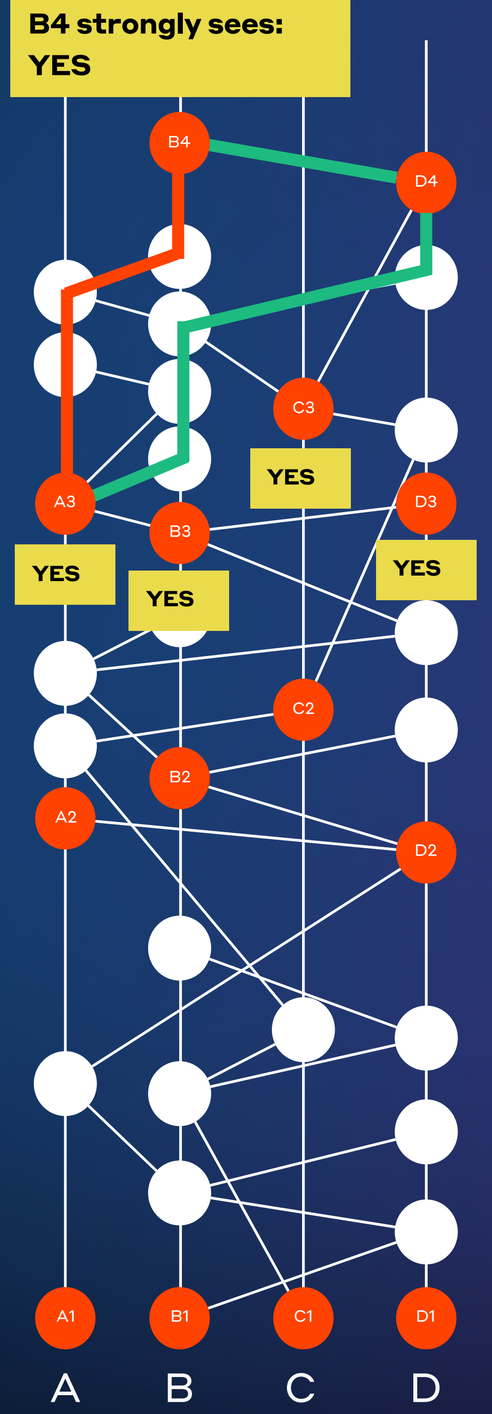
Famous witnesses

- 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



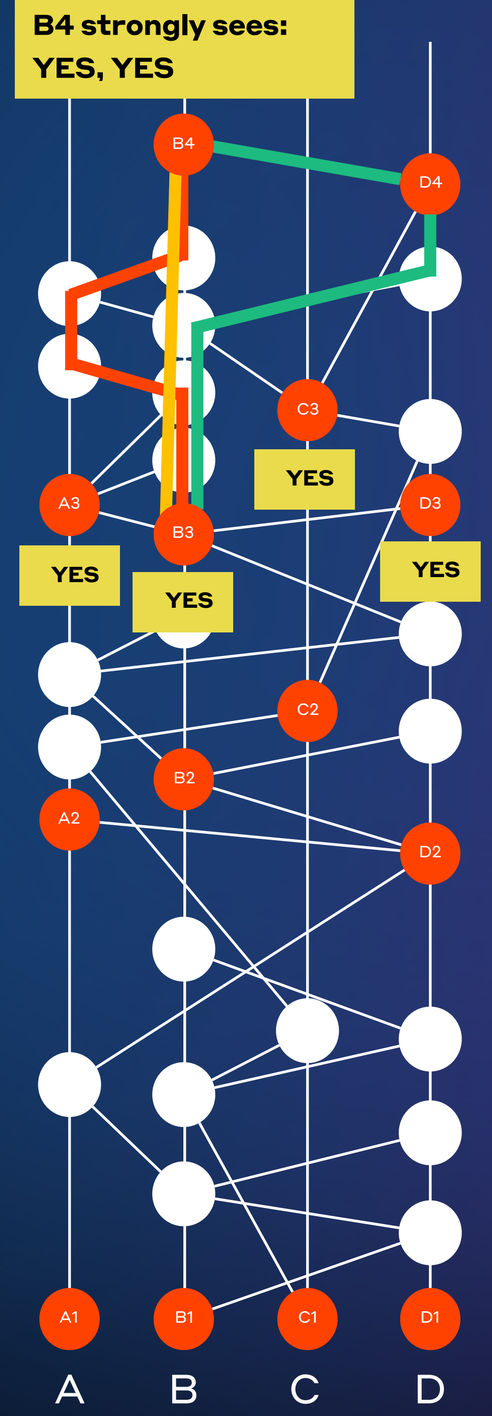
Counting votes

- 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



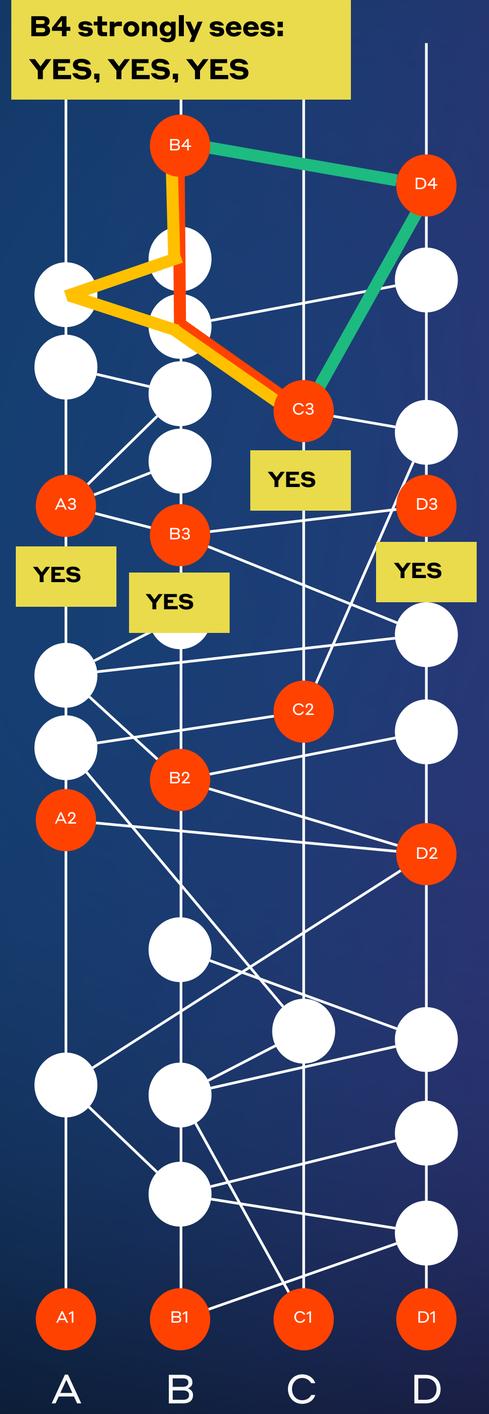
Counting votes

- 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



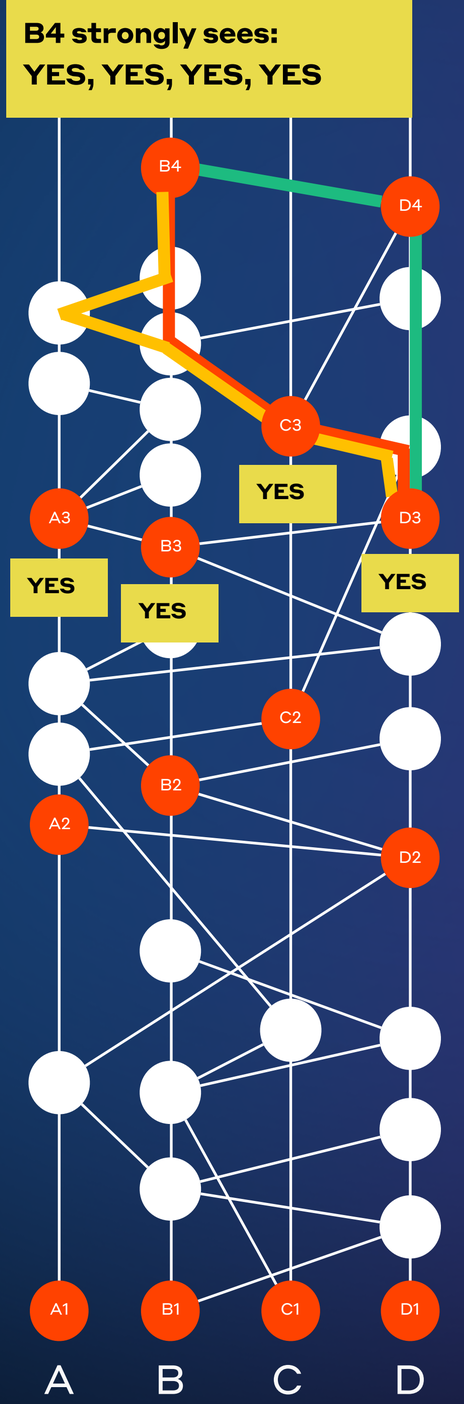
Counting votes

- 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

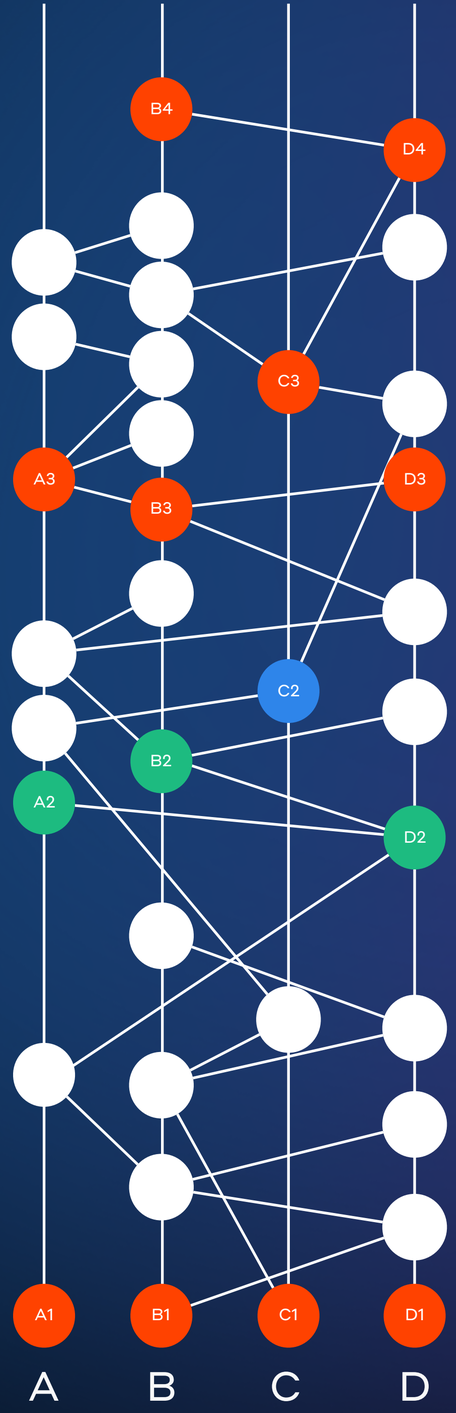


Famous Witnesses

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

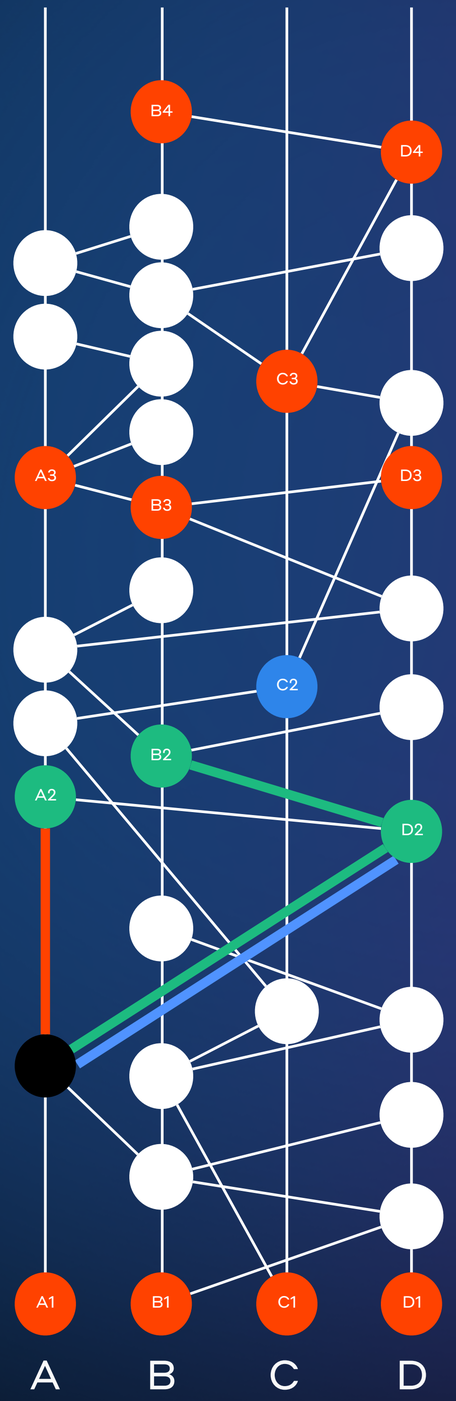
If a decision cannot be made in a round, we try again in the following round

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



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

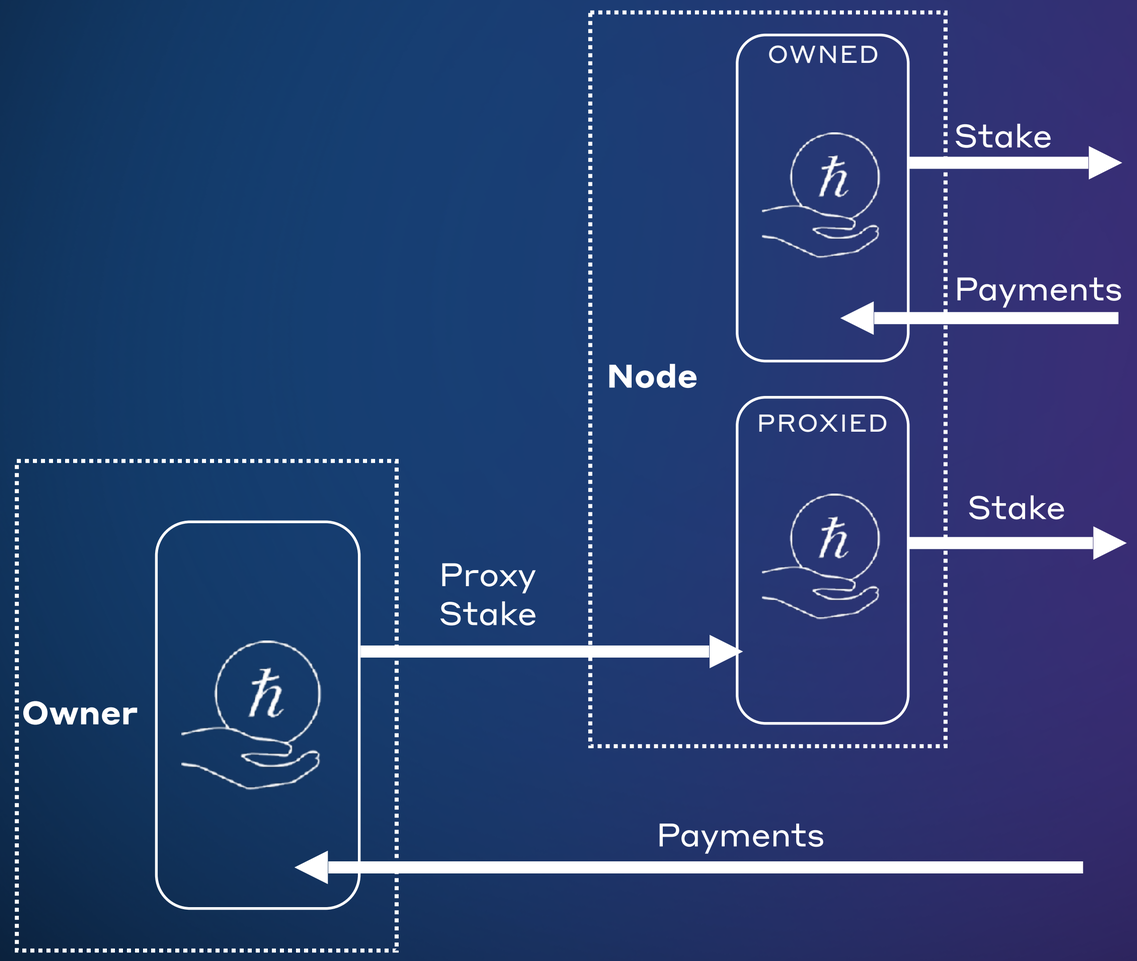
” an algorithm that calculates (in a Byzantine resistant manner) the timestamp of transactions from 2/3 of the network or more”

What defines “the network” ?

Hint: It’s not node(s)

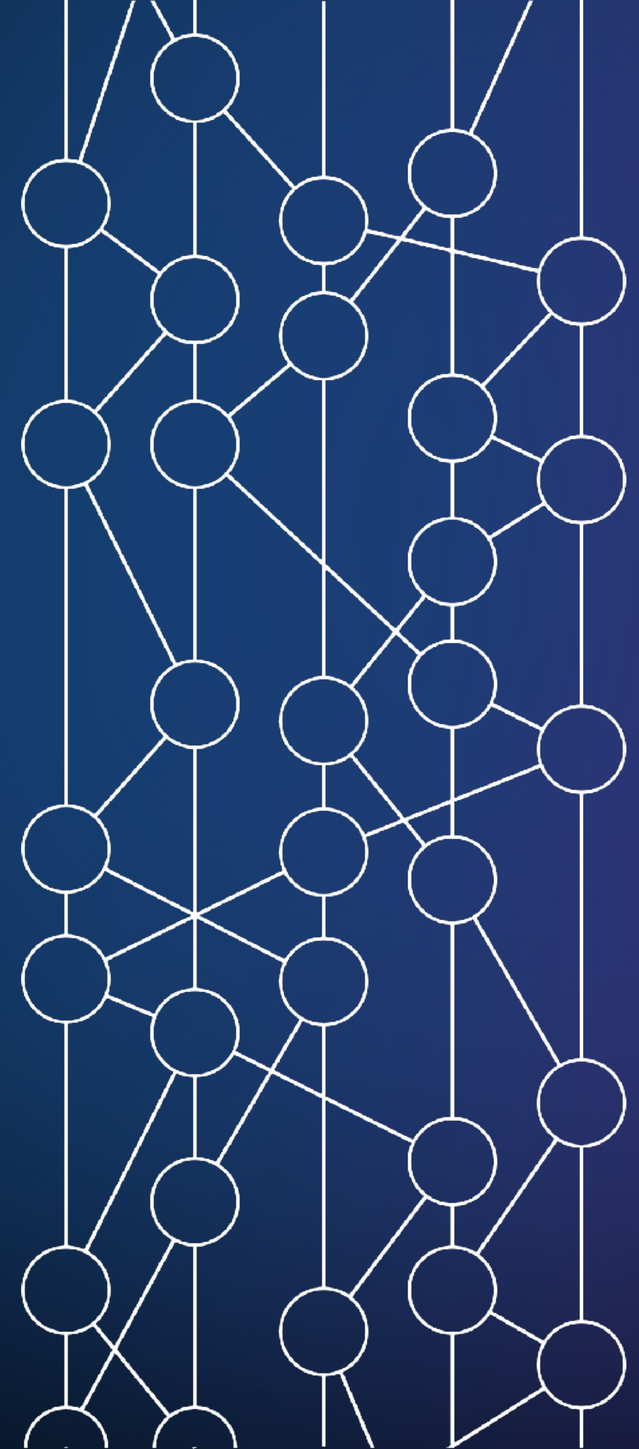
Proxy Staking with Proxying

- 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



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END USERS

INDIVIDUALS

ENTERPRISES

GOVERNMENTS

DEVICES

3RD PARTY APPLICATIONS

REAL ESTATE

HEALTH

FINANCIAL

MEDIA

SOCIAL CAUSES

COMMUNICATIONS

GAMING

LEGAL

LOGISTICS

PERMISSIONED DLT

CRYPTOCURRENCY

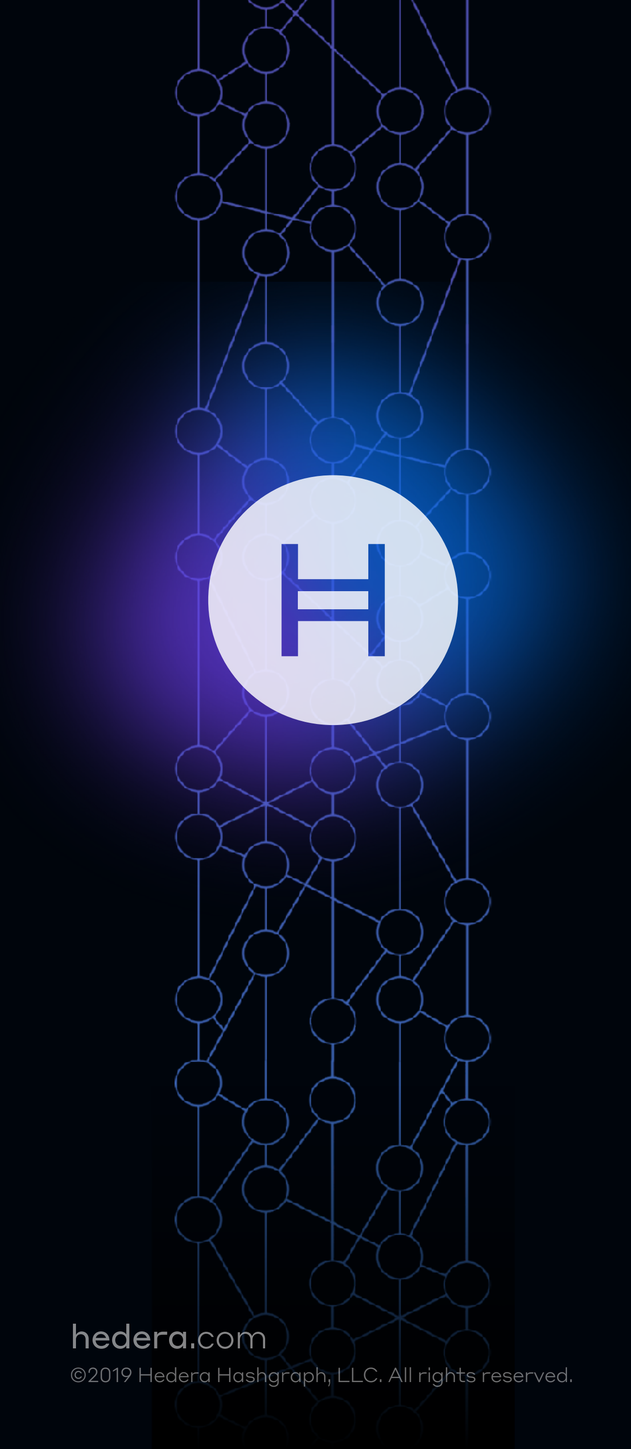
CONSENSUS SERVICE

PRIMARY NETWORK SERVICES

HEDERA GOVERNING COUNCIL

HASHGRAPH CONSENSUS

HEDERA MAINNET & MIRROR NODES



Part 3 - Users / Projects That Are Building on Hedera

@hashgraph

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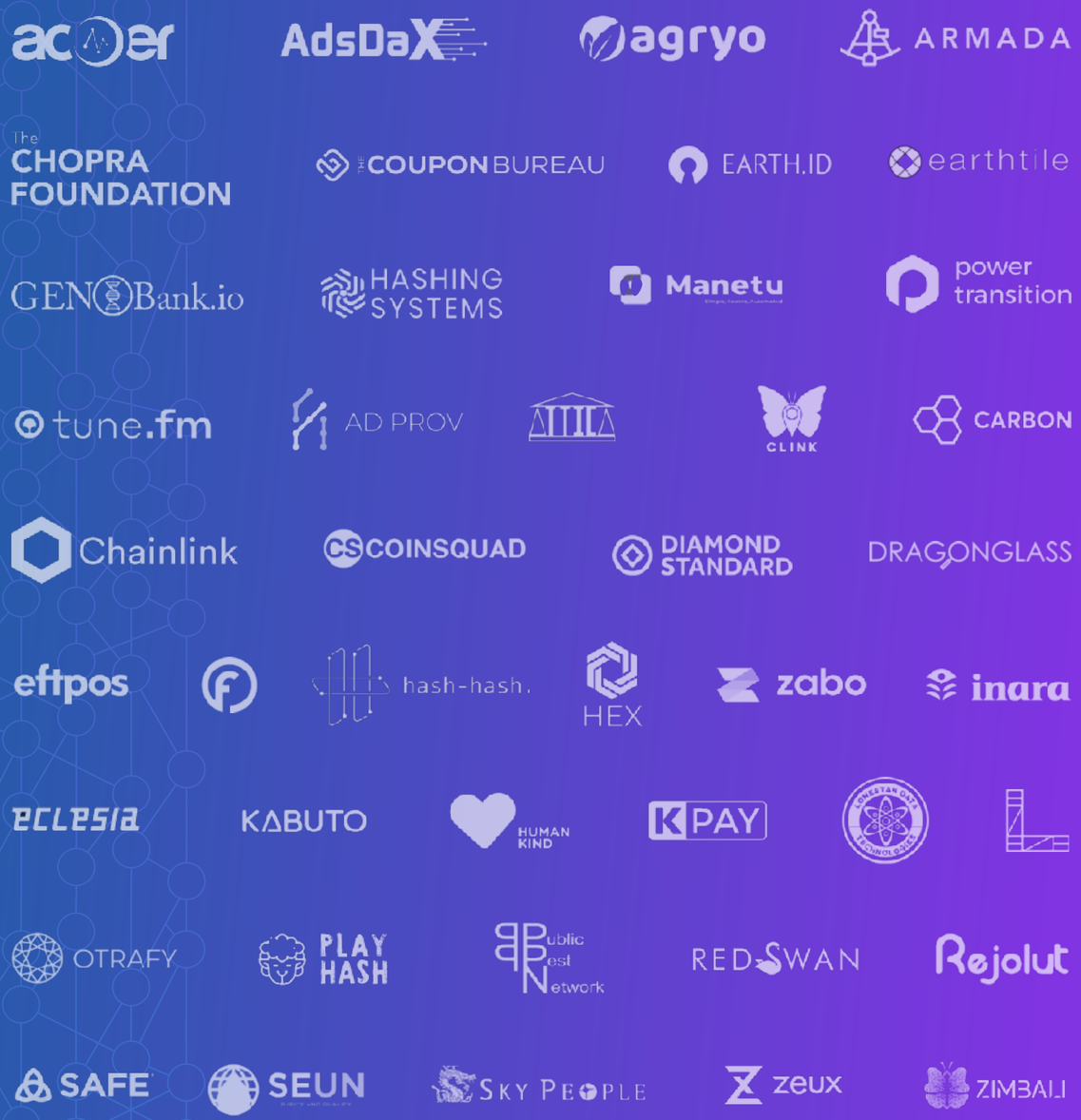
Hedera Today

APPLICATIONS, DEVELOPERS, & NETWORK ACTIVITY



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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.

INDUSTRY & USE CASE

ADVERTISING | REAL-TIME FRAUD DETECTION

AdsDaX

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

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.

MORE INFORMATION

HEDERA.COM/**USERS**/**ADSDAX**

INDUSTRY & USE CASE

RETAIL | TRACKING AND REDEMPTION

THE COUPON BUREAU

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

"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

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.

MORE INFORMATION

HEDERA.COM/**USERS**/**COUPON-BUREAU**

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

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 THROUGHPUT & 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.

MORE INFORMATION

HEDERA.COM/**USERS**/**ACOER**

Forbes

6,586 views | Aug 20, 2020, 09:02am EDT

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

Jason Brett Contributor ⓘ
Crypto & 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 respirato

Brooklyn Nets' Spencer Dinwiddie Is Launching Calaxy, 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.

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

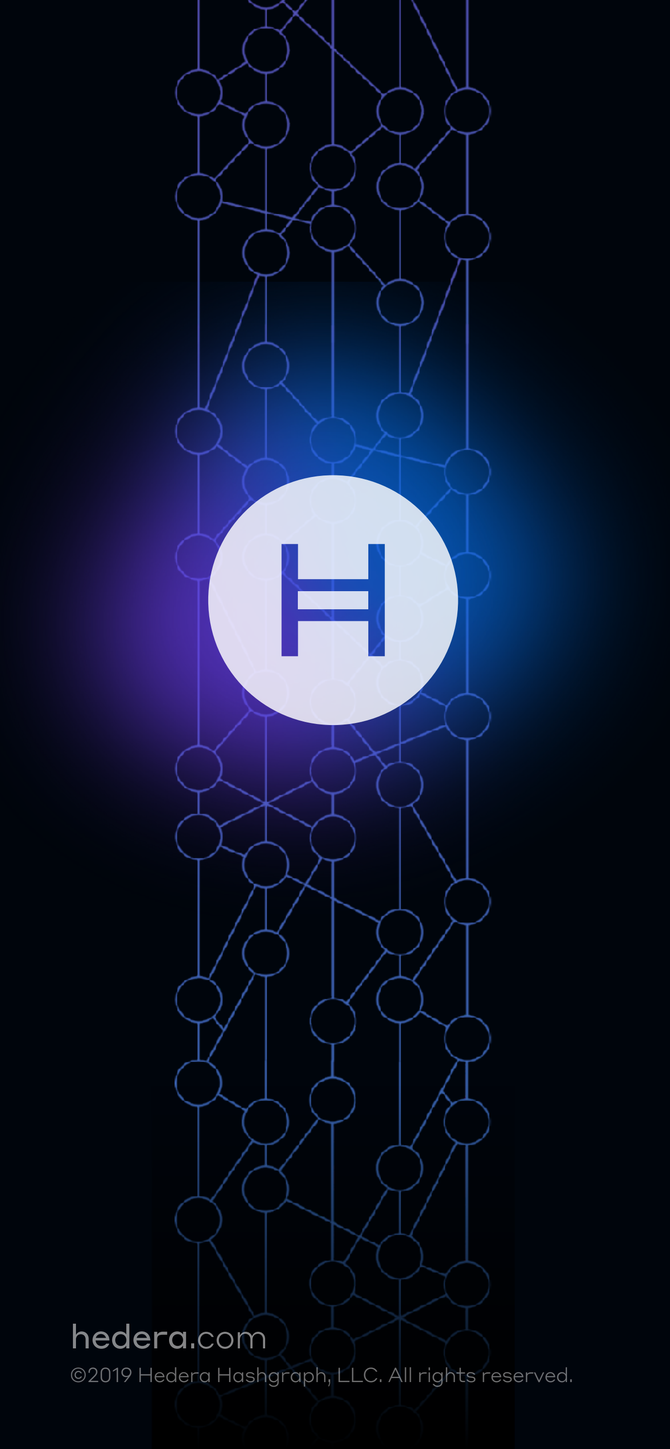
5 November 2020

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.

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.



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

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Part 5 - Q&A

Additional Resources -

Sign up for a test account - portal.hedera.com
Getting started guides - hedera.com/get-started
Discord chat - hedera.com/discord
Tutorials - youtube.com/channel/UCIhE4NYpaX9E9SssFnwrjww
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Email - cooper@hedera.com

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