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# SymbIoT: Towards an Extensible Blockchain Testbed for IIoT

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# The great promise

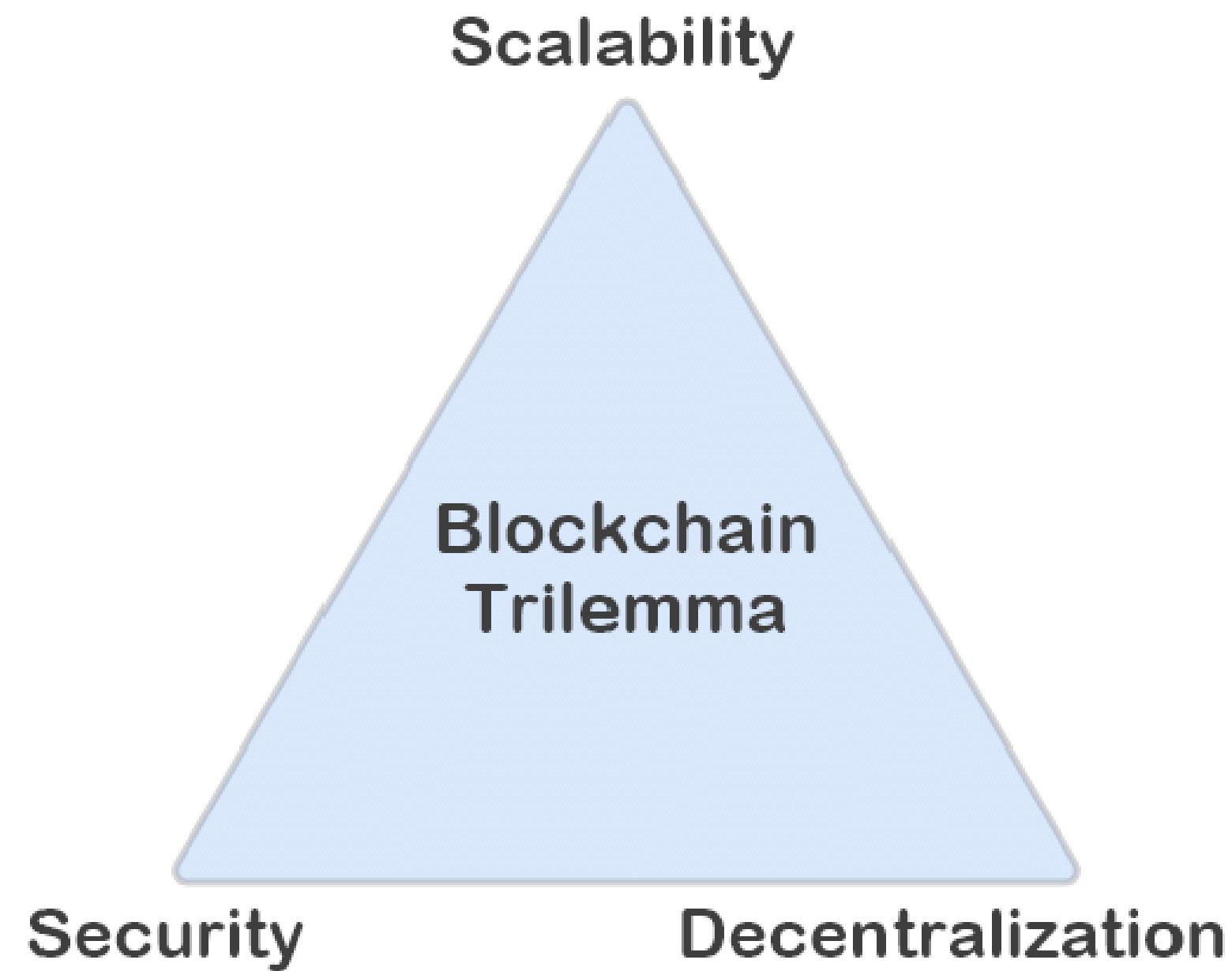
- Decentralization: In industrial settings, decentralization can prevent single points of failure in critical systems, ensuring continuous operation even if one node goes offline.
- Transparency for Stakeholders: Allows manufacturers, suppliers, and end-users to track the lifecycle of products, from raw materials to end products, fostering trust in the supply chain.
- Traceability in Supply Chains: For industries with complex supply chains, blockchain can provide a detailed and unalterable record of every component's origin, processing, and journey.
- Smart Contracts for Automation: Smart contracts can automate processes like payment upon delivery or triggering maintenance when certain conditions are met by IIoT sensors..
- Data Integrity for Critical Decisions: Decisions often have significant financial or safety implications. Blockchain ensures that the data driving these decisions hasn't been tampered with.



# The great hurdle

- Scalability: IIoT can involve thousands to millions of devices. Handling transactions and data from all these devices can strain blockchain networks, leading to scalability concerns.
- Latency: Real-time operations are crucial in many IIoT applications. The time taken to validate and add transactions to the blockchain can introduce unacceptable delays.
- Energy Consumption: Proof-of-work, used in many blockchains, can be energy-intensive, which might not be sustainable for large-scale IIoT networks.
- Standardisation: The lack of standardized protocols for blockchain in IIoT can lead to interoperability issues between different systems and devices.
- Lack of Emulation Testbed: There's a notable absence of a comprehensive emulation testbed for blockchain in IIoT. Such a testbed is crucial for simulating real-world scenarios, testing solutions, and conducting full empirical studies before actual deployment

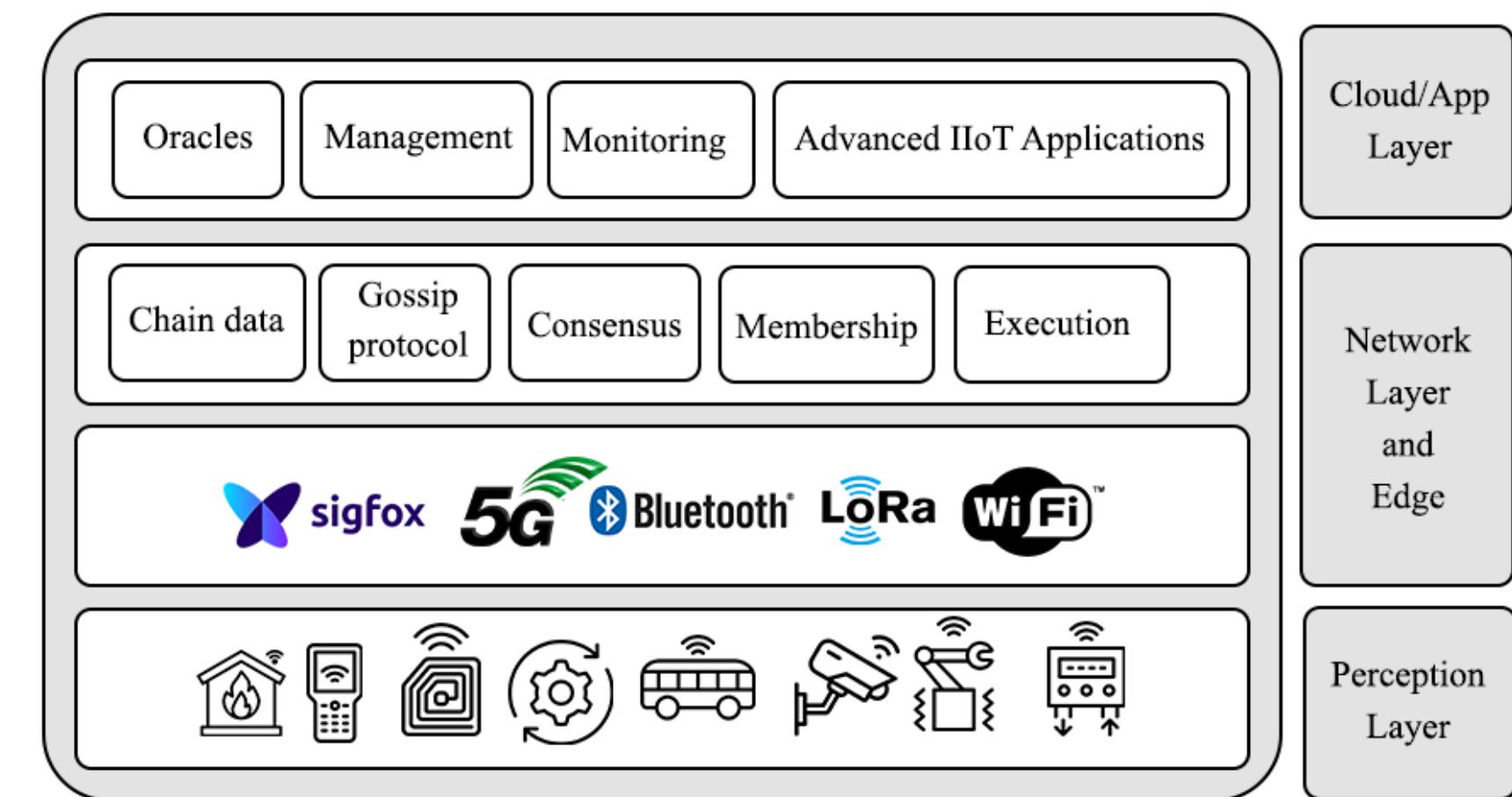
# The Trilemma!



# How do we evaluate real-world Blockchain viability?

# Framework

- We consider a multi-layer deployment, with customisable parameters at each, representative of real-world scenarios
- Throughputs of a variety of common communication protocols have been considered
- A range of "external" services are also considered, including Oracles
- Facilitates multi-layer analysis and optimisation



# Framework

- Extensive suite of consensus protocols can be deployed within the framework, enabling diverse comparison
- Based on the corresponding standards and open-source implementations
- Critical for valuable empirical study!

Property	PoW	PoS	DPoS	PoET	Ripple	Tendermint	PBFT and Variants	Federated BFT
Blockchain Type	Open/ Permissionless	Open/ Both	Open	Both	Open	Permissioned	Permissioned	Permissionless
Energy Saving	No	Partial	Partial	Yes	Yes	Yes	Yes	Yes
Tolerated power of advisory	<=25% Computing power	<51% stake (Depends on specific algorithm used )	<51% validators	Unknown	<51% faulty nodes in UNL	<33.3% byzantine voting power	<=33.3% faulty replicas	<=33.3%
Example	Bit coin	Peer coin	Bitshares	Coin desk, Hyper ledger Saw tooth	Ripple	Tendermint	Hyper ledger Fabric	Stellar, Ripple
Transaction finality	Probabilistic	Probabilistic	—	Probabilistic	—	—	Immediate	Immediate
Transaction Rate	Low	High	Medium	Medium	High	High	High	High
Token needed?	Yes	Yes	Yes	No	—	—	No	No
Cost of participation	Yes	Yes	Yes	No	—	—	No	No
Scalability of peer network	High	High	High	High	—	High	Low	High
Trusted Model	Untrusted	Untrusted	Untrusted	Untrusted	Semi-trusted	—	Semi-trusted	Semi-trusted

# Implementation

## Blockchain

Modular Python-based framework with configurable parameters. Expose HTTP API for monitoring, configuration, interaction.

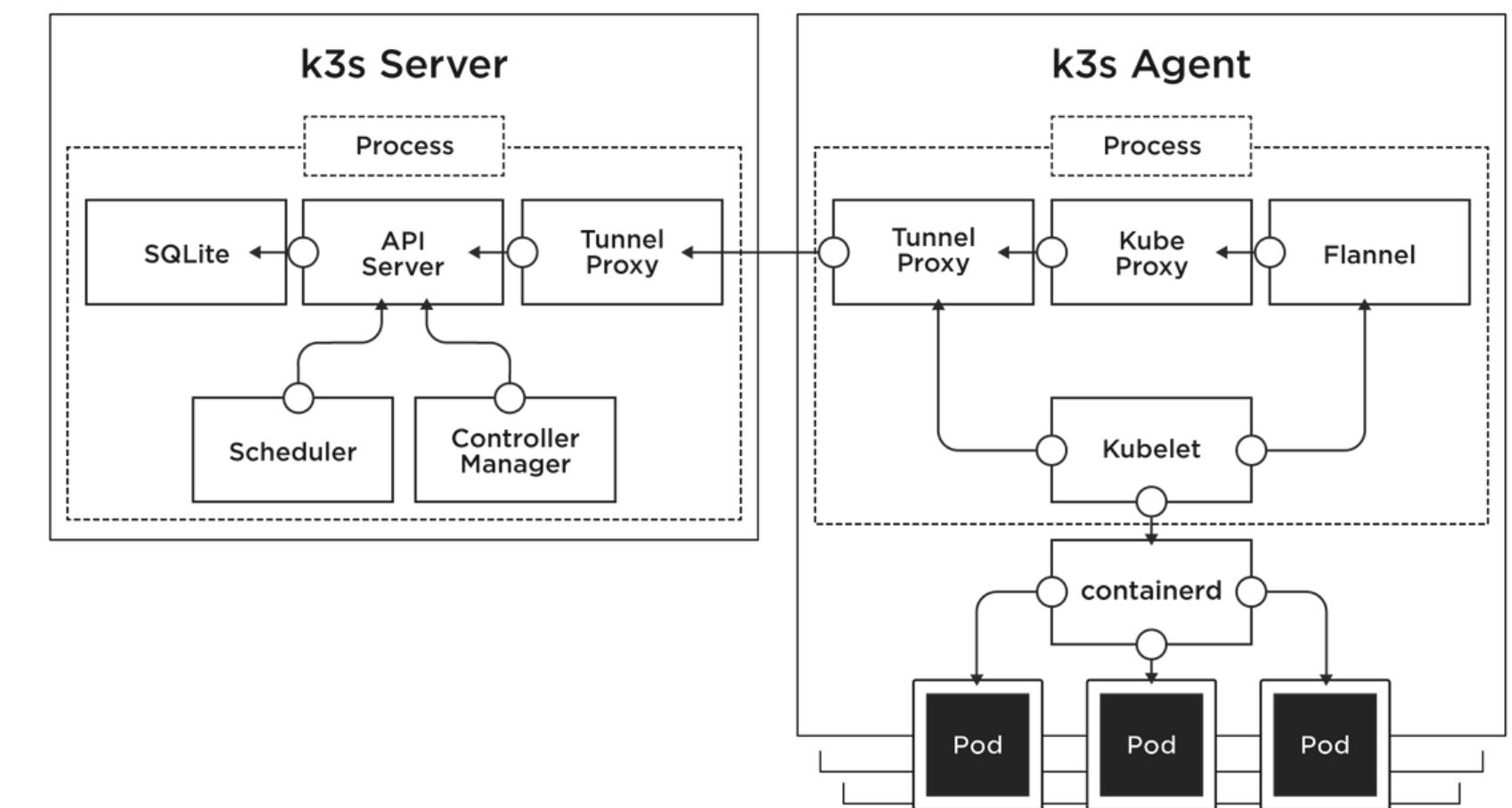
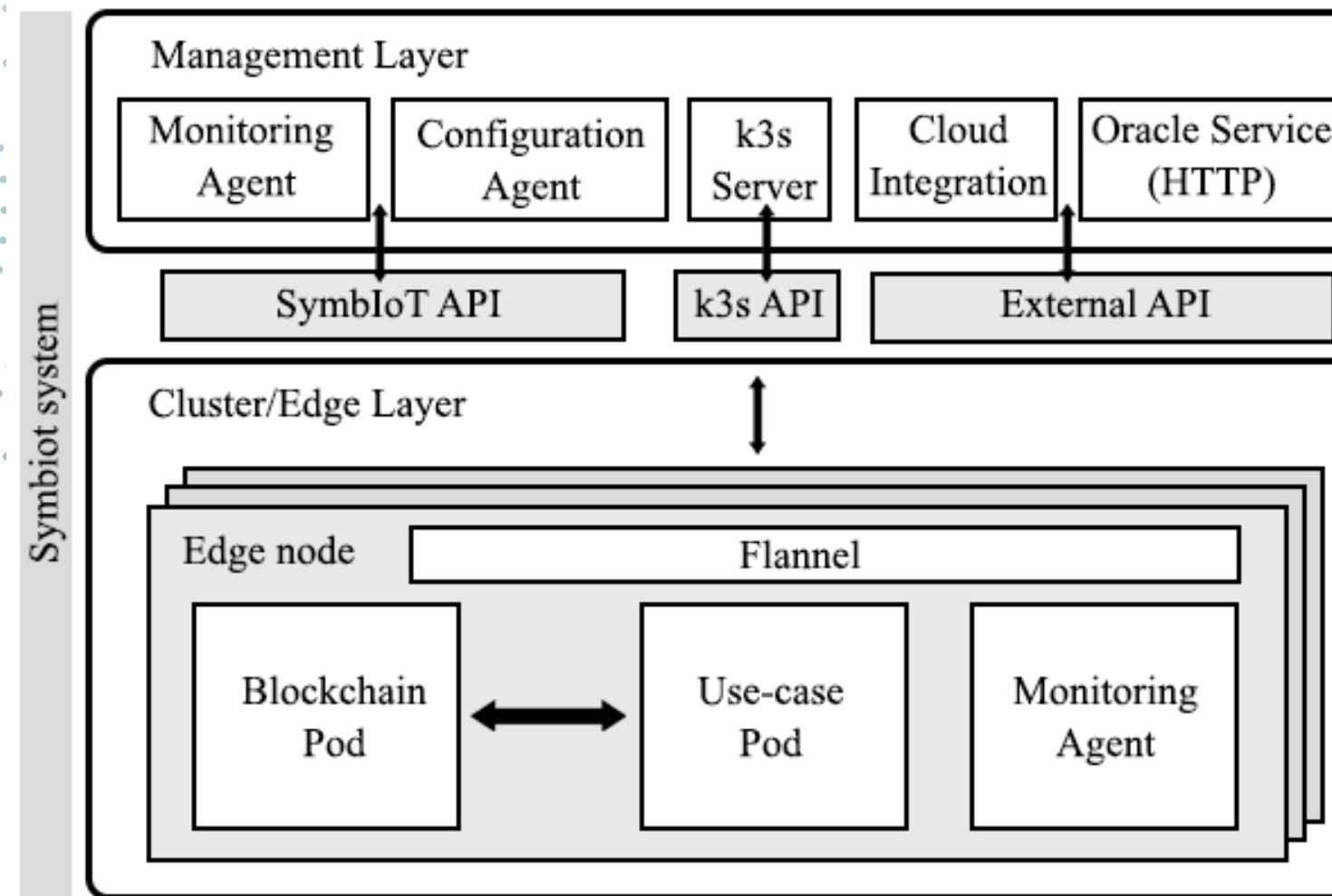
## Use-Case

Interacts with the exposed local blockchain API for producing and interacting with transactions, generates data based on scenario.

## Monitoring

Provides detailed metrics to evaluate network performance and status, including block height, TPS, etc. (specific params consensus dependent)

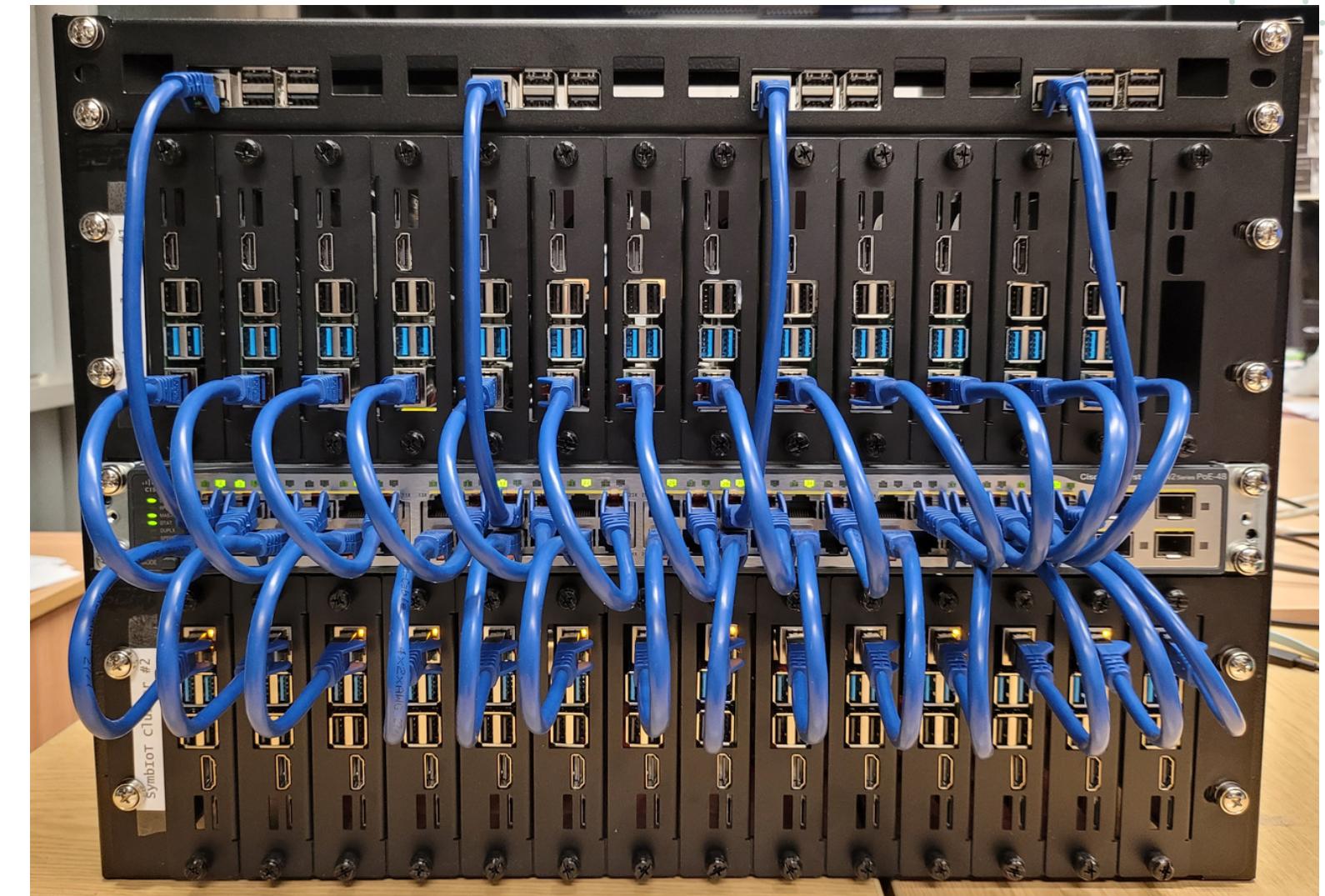
# Implementation



# Testbed

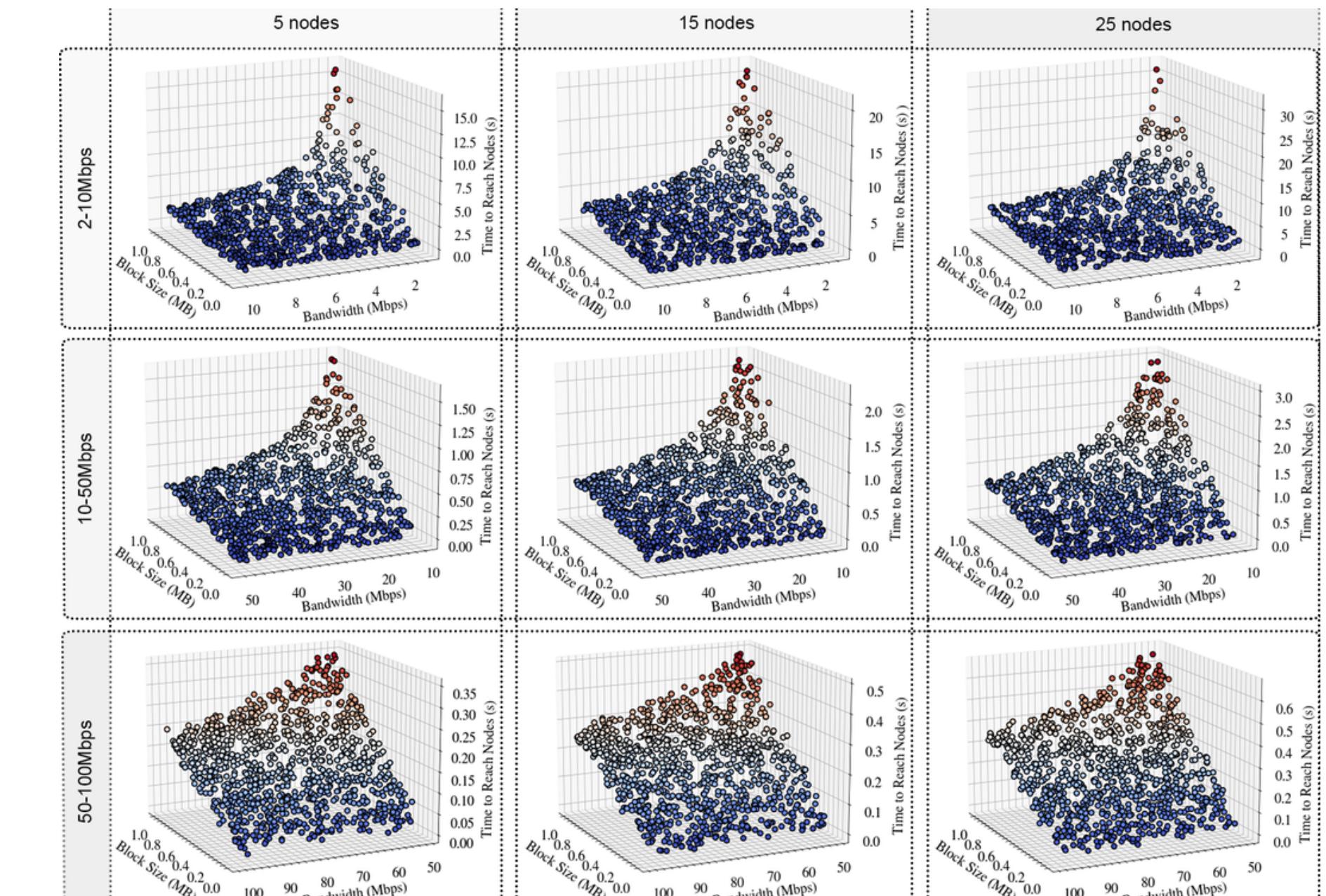
- 32 Raspberry Pi 4B 8GB
  - 4 reserved for "management" with 28 available for Blockchain network emulation, each node can run 2 chain pods, extending capability to 56 node configurations
  - peer/neighbour relationships are configurable (typically 2 or 3)
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- Rudimentary power usage monitoring using USB digital meter (not ideal but effective!)
  - Egress bandwidth capped on switch
  - Configurable via HTTP API:

Management	Monitoring	Interaction
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# Latency Results

- We present preliminary results concerning total convergence/finality time given a variety of block sizes and data rates.
- In our sample use-case, we provide transactions containing data corresponding to machine status. Unsurprisingly a significant but non-linear correlation due to processing time.



# Future work



We are working to extend the capacity and capability of the testbed to provide a more extensive suite of consensus algorithms for analysis. Additionally, expanding analysis metrics for great empirical analysis capability.

Allow the provision of multiple/hybrid consensus algos - arguably the future of public chains.

Open access to our research students for diverse use-case analysis (IIoT and beyond), open source full solution.

# Contact

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