TP 01: Protocols and Consensus (180 minutes)

In this workshop, you will analyze key performance and decentralization metrics of major blockchain networks, specifically Bitcoin, Ethereum, and Solana. You will gain hands-on experience gathering data, interpreting metrics, and drawing conclusions on the efficiency, scalability, and decentralization of these systems.

By the end of the workshop, you will:

- Understand critical blockchain performance metrics and their relevance to system scalability.
- Compare and contrast the performance and decentralization of different consensus mechanisms (PoW vs. PoS).
- Learn how to use blockchain data to evaluate the health and fairness of blockchain networks.

Duration:

3 hours (with breaks included)

Initial Setup: Data Architecture (20 minutes)

Before starting the analysis, you will need to know, for each blockchain, which block you want to start the analysis from. Use a blockchain data explorer service such as **QuickNode** to fetch data for **1000 blocks** from each of the three blockchains.

- For **Bitcoin**, any starter block - 1000 the most recent is fine.
- For **Ethereum**, ensure you use a starter block that were staked after the **Ethereum Merge** (post-September 15th) for a valid comparison of Proof of Work (PoW) versus Proof of Stake (PoS) metrics.
- For **Solana**, same as Bitcoin.

/!\ Advices

- You can do the whole workshop blockchain by blockchain, so you don't lost yourself in all of the different blocks specifications and fields. First start with the easiest, Bitcoin, then Ethereum, then Solana.
- Notice that with QuickNode you can only have one Endpoint at the time, so ensure to archive a blockchain when it is done, then create a new Endpoint for having a new API key for the next blockchain you want to track the activity.

QuickNode API:

- Bitcoin
- Ethereum JSON RPC API
- Solana JSON RPC API - HTTP Methods

Part 1: Blockchain Metrics Collection (100-120 minutes)

Introduction to Metrics

In this part, you will gather and analyze data on the blockchain networks: **Bitcoin, Ethereum, and Solana**. You will focus on measuring performance and understanding the implications of various metrics on the network's efficiency, scalability, and security.

1.1 Average Block Latency

- **Task:** Compute the average block latency by analyzing the time difference between consecutive blocks.
- **Concept:** Block latency can be influenced by network propagation delays, mining times, and other factors. A lower latency suggests quicker confirmations, while higher latency could indicate potential delays in block propagation.
- **Guidance:** Consider how different blockchains manage block propagation and validation time.

1.2 Transaction Count per Block

- **Task:** Calculate the average number of transactions per block for the analyzed datasets.
- **Concept:** This metric reflects the blockchain's ability to handle high throughput. The ideal blockchain network should utilize available block space efficiently.
- **Guidance:** Low transaction count could indicate either lower demand for the network or under-utilized space. Think about what happens when blocks are not fully utilized.

1.3 Transaction Fees

- **Task:** Analyze the average transaction fees across blocks.
- **Concept:** Transaction fees vary based on network demand. A higher fee may indicate network congestion, whereas a lower fee could suggest that transaction volume is not high enough.
- **Guidance:** In proof-of-work blockchains, higher fees can be a mechanism to prioritize transactions when blocks fill up. Think about how fee dynamics might affect user behavior.

1.4 Block Size Variance

- **Task:** Calculate the variance in block sizes to understand how efficiently the blockchain uses available space.
- **Concept:** Block size variance tells you how the blockchain handles varying transaction volumes and how well it adapts to scaling demands.
- **Guidance:** A high variance can indicate inefficient use of block space, which might be a signal for improving scalability. For Solana, computing average block size is optional.

1.5 Orphaned or Uncle Blocks

- **Task:** Analyze orphaned (Bitcoin) or uncle (Ethereum) blocks and their impact on blockchain propagation.
- **Concept:** These blocks are valid but not included in the main chain due to a race condition in block selection. Their frequency can reveal insights into the efficiency of the consensus protocol and network stability.
- **Guidance:** High orphan block rates suggest issues with network synchronization or inefficiencies in block propagation.

Part 2: Decentralization and Distribution Analysis (45 minutes)

In this part, you will assess the level of decentralization in the blockchain networks by analyzing the distribution of validators, stakers, and miners.

2.1 Staking Validators for Ethereum and Solana

- **Task:** Assess the distribution of Ethereum and Solana validators. Consider the concentration of power within these networks.
- **Concept:** In Proof of Stake (PoS), validators have the power to propose blocks and validate transactions. If a small group controls most of the staking power, the network becomes more centralized.
- **Guidance:** Research validator distribution and calculate metrics such as the **Gini coefficient** to evaluate the fairness of the power distribution.

2.2 Miner Distribution for Bitcoin

- **Task:** Assess the distribution of Bitcoin miners and their mining power.
- **Concept:** In Proof of Work (PoW), miners control block creation and validate transactions. A few large mining pools could control the network, undermining its decentralization.
- **Guidance:** Research the number of mining pools and their hash rate share. A network with only a few dominant miners could face risks in terms of censorship and security.

Part 3: Discussion and Conclusions (20 minutes)

3.1 Discussion of Findings

- **Task:** Based on the data collected in Part 1 and Part 2, draw conclusions on the performance and decentralization of the analyzed blockchains.
- **Guidance:** Consider the trade-offs between different consensus mechanisms, such as the throughput and latency of PoW blockchains like Bitcoin and Ethereum versus the lower energy consumption and potential decentralization benefits of PoS blockchains like Solana.

3.2 Comparison Before and After Ethereum Merge (Bonus)

- **Task:** If you're analyzing Ethereum, compare the metrics before and after the Ethereum network transitioned from Proof of Work (PoW) to Proof of Stake (PoS).
- **Concept:** The Ethereum merge has drastically changed the way blocks are validated, with PoS replacing PoW. This transition affects block times, fees, and decentralization.
- **Guidance:** Discuss how these changes could impact the overall performance and scalability of the Ethereum network in the future.

Resources and Tools

You will need the following tools and datasets:

1. **Quicknode API Documentation**: To access blockchain data for Ethereum, Solana, and Bitcoin.
   - Quicknode API: https://blog.quicknode.com/
2. **Solana Explorer**: Use the explorer to check validator distribution.
   - Solana Explorer: https://explorer.solana.com/
3. **Bitcoin Core and Bitcoin Wiki**: To study Bitcoin block data.
   - Bitcoin Core: https://bitcoin.org/en/bitcoin-core/
   - Bitcoin Wiki: https://en.bitcoin.it/wiki/Block
4. **Ethereum Explorer (Etherscan)**: For Ethereum transaction and staking data.
   - Etherscan: https://etherscan.io/
5. **Consensus and Blockchain Papers**:
   - *Proof of Work vs Proof of Stake: A Survey*: https://arxiv.org/pdf/1907.06599
   - *Bitcoin Whitepaper*: https://bitcoin.org/bitcoin.pdf

Assessment and Expected Outcomes

At the end of the workshop, you should:

- Have a deep understanding of how to measure blockchain performance using real-world data.
- Be able to assess the decentralization of blockchain networks and the concentration of power in different consensus mechanisms.
- Have experience working with blockchain APIs and interpreting raw data to uncover trends, bottlenecks, and inefficiencies.