Industrial Training Project Report

Blockchain Technology By Metacrafters

A PROJECT REPORT

Submitted by

Teena Neupane - 22BCS50212

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BONAFIDE CERTIFICATE

Certified that this project report **"Blockchain Technology By Metacrafters"** is the bonafide work of "**Teena Neupane"** who carried out the project work under my/our supervision.

SIGNATURE **SIGNATURE**

Dr. Sandeep Singh Kang
(A.D. CSE 3rd Year)

Er. Santosh
(Assistant Professor CSE 3rd Year)

Academic Block B3 **Academic Block B3**

Submitted for the project viva-voce examination held on

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The goal of the Metacrafters scholarship program is to empower and encourage those who are enthusiastic about understanding blockchain technology and creating practical decentralized apps (DApps). By providing funding, coaching, and opportunity for practical projects, the initiative seeks to increase the accessibility of blockchain education for professionals, students, and tech enthusiasts. Participants acquire useful knowledge of smart contracts, decentralized networks, and blockchain principles while honing their practical abilities to construct original solutions on well-known blockchain platforms.

Recipients of this fellowship have access to Metacrafters' extensive learning materials, which include expert-led seminars, interactive tutorials, and carefully chosen courses. The program promotes diversity in the blockchain industry by being accessible to people from a variety of backgrounds. It facilitates students' application by bridging the gap between academic understanding and real-world application.

Metacrafters places a strong emphasis on networking, teamwork, and professional growth in addition to technical proficiency. Recipients of the award are encouraged to become part of a thriving network of mentors, industry experts, and blockchain learners, which offers beneficial connections for future career advancement.

Metacrafters promotes creativity in a developing industry and advances decentralized technology by training the next generation of blockchain engineers. The scholarship program gives students the tools they need to become leaders in the quickly changing blockchain environment in addition to facilitating their access to high-quality blockchain education. The Metacrafters scholarship program provides the tools, resources, and community support required to thrive in the field of decentralized technology, regardless of whether one chooses to pursue a career in research, entrepreneurship, or blockchain development.

CHAPTER 1
INTRODUCTION

1.1 Client Identification / Need Identification / Identification of Relevant Contemporary Issue

Blockchain technology is revolutionizing a number of industries, most notably data storage, supply chain, healthcare, and finance. Decentralization, trust, security, and scalability are the main customer demands in the blockchain arena. To meet these demands, blockchain solutions like as Ethereum, Avalanche, and others have surfaced; yet, issues such high gas prices, network congestion, and transaction speed persist. New blockchain systems that promise improved scalability, quicker transaction speeds, and lower costs have been developed as a result of the increased interest in decentralized finance (DeFi), decentralized apps (dApps), and smart contracts.

Ethereum has been the industry leader in smart contract platforms for a long time, but its scalability issues are widely known, particularly when network demand is strong. Avalanche, on the other hand, claims to address these problems by providing reduced latency and increased throughput. Avalanche's custom subnets offer an extra degree of flexibility by allowing the development of customized blockchains that are suited for certain use cases. This is very appealing to companies searching for blockchain solutions that meet their particular requirements.

The competition among blockchain systems to attain scalability, cheap transaction costs, and usability while maintaining the decentralization and security for which blockchain is renowned is the pertinent modern topic. Blockchain networks that can manage high transaction volumes at low cost will be essential to their success in both public and private sector use cases as blockchain adoption picks up speed.

1.2 Identification of Problem

The three main issues with blockchain technology are transaction costs, scalability, and interoperability. Ethereum has persistent scalability problems in spite of its substantial contribution to the decentralized ecosystem. The transaction needs of popular apps are significantly higher than the 30 transactions per second (TPS) that the Ethereum network can handle. Ethereum's gas prices increase significantly during periods of high network demand, which deters use, especially for smaller-scale transactions.

These issues can be resolved by Avalanche, which offers a high-throughput network that can process thousands of TPS with sub-second finality because to its Avalanche consensus system. Avalanche is still in the early stages of adoption, though, and one major obstacle that must be addressed is its compatibility with current blockchain systems.

Furthermore, Avalanche's implementation of custom raises several issues pertaining to security, governance, and efficient decentralized network administration. Developers can design blockchains with particular functionality by using custom subnets, however this customisation may also present security and ecosystem consistency issues.

1.3 Identification of Tasks

Several tasks need to be finished in this report in order to address the issues raised above:

1. Scalability Evaluation: Examine the transaction throughput, gas costs, and network performance of Ethereum and Avalanche to determine how scalable they are. This will entail evaluating the networks' performance under various load scenarios and testing a range of use cases.

2. Interoperability Issues: Research how well Ethereum and Avalanche work together. In particular, consider whether custom subnets on Avalanche can facilitate communication and data sharing across the two networks.

3. Design and Testing of Custom Subnets: Examine the potential for developing unique subnets inside the Avalanche ecosystem. Creating a unique subnet, deploying it, and testing it against Ethereum and conventional Avalanche subnets are all part of this work.

4. Testing in Development Environments: Examine how testnets, such Sepolia and Avalanche Fuji, are used in the creation and evaluation of smart contracts. Examining how developers may test and deploy their dApps without jeopardizing actual assets will be part of this.

5. Developer Tools and SDKs: Examine the various blockchain development tools and SDKs, such as Solidity from Ethereum, Truffle Suite, and Avalanche's AvalancheJS, and assess how well they support blockchain development.

1.4 Timeline

The timeline of the report will be divided into four distinct phases, each focusing on a specific area of research and development.

1. Phase 1: Research and Literature Review (Week 1-2)
   - Gather relevant academic papers, whitepapers, and articles related to Ethereum, Avalanche, and blockchain scalability. This phase will provide a solid foundation for understanding the underlying technologies and current industry trends.

2. Phase 2: Design and Evaluation of Solutions (Week 3-4)
   - Based on the research, select key features of Ethereum and Avalanche to analyze their scalability, interoperability, and performance. Develop use cases to test both blockchain platforms.

3. Phase 3: Testing and Custom Subnet Design (Week 5)
   - Begin testing Ethereum and Avalanche with specific use cases, such as high-frequency transactions or decentralized finance applications. Create and test a custom subnet within Avalanche to evaluate its potential for specific applications.

4. Phase 4: Results Analysis and Conclusion (Week 6)
- Analyze the results from testing and create a comparison between Ethereum and Avalanche based on scalability, performance, cost, and customization. Draw conclusions about which platform is most suitable for various types of blockchain use cases.

1.5 Organization of the Report

The report is organized into five chapters that will systematically address the challenges of scalability, customization, interoperability, and testing in blockchain technology:

1. Chapter 1: Introduction – Introduces the topic, client identification, problem identification, and provides a roadmap for the report.
2. Chapter 2: Literature Review / Background Study – A detailed exploration of the blockchain ecosystem, including the history of Ethereum, Avalanche, and their consensus mechanisms, as well as a comparison of scalability solutions.
3. Chapter 3: Design Flow / Process – Describes the methodology, design considerations, and selection of features for testing blockchain platforms.
4. Chapter 4: Results Analysis and Validation – Provides an analysis of test results, including the scalability and performance of Ethereum and Avalanche, and the use of custom subnets.
5. Chapter 5: Conclusion and Future Work – Summarizes the findings, suggests improvements, and identifies areas for future research and development in the blockchain space.

CHAPTER 2
LITERATURE REVIEW / BACKGROUND STUDY

2.1 Timeline of the Reported Problem

Since the introduction of Bitcoin in 2009, scalability in blockchain networks has been recognized as a problem. The scalability of Bitcoin was restricted by its proof-of-work (PoW) consensus process, which was made worse by increasing network demand. When Ethereum was introduced in 2015, it introduced the idea of smart contracts and decentralized apps (dApps), but it had the same scaling issues as Bitcoin. During times of network congestion, like the DeFi surge in 2020, Ethereum's gas cost issue was most noticeable.

By providing improved scalability, quicker transaction speeds, and lower costs, Ethereum 2.0 (a move to proof-of-stake, or PoS)) seeks to solve these issues. Ethereum 2.0 is intended to handle more transactions while preserving the same degree of decentralization and security.

With its innovative Avalanche consensus system, which allowed for thousands of transactions per second and nearly instantaneous finality, Avalanche, which debuted in 2020, offered a rapid fix for scaling problems. The Avalanche ecosystem's versatility and customisation were further increased with the addition of custom subnets, which let developers build separate blockchains that were suited to their own requirements.

2.2 Proposed Solutions

Avalanche and Ethereum 2.0 both provide fixes for blockchain scalability problems, although their methods differ greatly:

Ethereum 2.0: Ethereum 2.0 lowers gas costs, boosts transaction throughput, and uses less energy thanks to its proof-of-stake mechanism. By splitting the blockchain into separate sections (shards), each of which processes a portion of transactions in parallel, sharding also significantly improves scalability.

Avalanche: The network may grow quickly thanks to the leaderless, decentralized Avalanche consensus technology. Unlike Ethereum and other systems, it can handle hundreds of TPS with sub-second finality. Developers may set up their own blockchains with various governance structures, validation criteria, and consensus algorithms by using custom subnets.

2.3 Bibliometric Analysis

A bibliometric analysis of blockchain scalability highlights the key research trends in this area. Studies have shown that while Ethereum's transition to PoS will enhance scalability, platforms like Avalanche are gaining significant attention for their Avalanche consensus mechanism, which enables decentralized applications to scale efficiently.

2.4 Review Summary

Both Ethereum 2.0 and Avalanche offer significant improvements in scalability. However, Avalanche’s ability to create custom subnets opens upnew possibilities for tailored blockchain networks. This flexibility is expected to drive innovation in fields such as finance, healthcare, and supply chain.

2.5 Problem Definition

The need for blockchain networks that can manage large transaction volumes with minimal costs while upholding the concepts of decentralization and security is the fundamental concern this paper attempts to address. Although Avalanche and Ethereum both provide unique answers, interoperability, governance, and customisation continue to be major obstacles.

2.6 Goals/Objectives

The following are the goals of this report:

1. Compare the scalability, transaction costs, and flexibility of Avalanche with Ethereum.
2. Evaluate the possibilities of bespoke subnets for certain use cases by testing them inside the Avalanche ecosystem.

3. Discuss blockchain scalability issues and solutions, with an emphasis on Avalanche's use.

CHAPTER 3
DESIGN FLOW / PROCESS

3.1 Evaluation & Selection of Specifications / Features

The requirements needed for a certain use case have a significant impact on how a blockchain platform is designed and assessed. The main selection factors for Ethereum and Avalanche are interoperability, cost, security, scalability, and transaction speed.

Scalability: In order to increase scalability, Ethereum is switching from a proof-of-work (PoW) to a proof-of-stake (PoS) consensus process. It still has issues with transaction throughput, though, particularly when demand is strong. By enabling parallel transaction processing, sharding in Ethereum 2.0 is anticipated to boost transaction throughput. The Avalanche consensus mechanism, on the other hand, provides tremendous scalability by supporting thousands of transactions per second with sub-second finality.

Transaction Cost and Speed: Avalanche is perfect for high-speed transactions with little costs since it provides quick finality.

Security: Ethereum is one of the most secure platforms in the blockchain industry because to its well-established network and vibrant development community. To guarantee the integrity of transactions and smart contracts, Avalanche also uses a strong security model, employing many validators across its Avalanche consensus protocol.

Avalanche's capacity to facilitate interoperability between various blockchain networks via bridges and cross-chain communication protocols is one of its primary features. This is important for developers creating multi-chain decentralized applications (dApps) since it enables smooth communication between Avalanche-based subnets and Ethereum and other blockchain ecosystems.

After taking these characteristics into account, we decided to test bespoke subnets using Avalanche because of its excellent scalability, affordability, and adaptability for building customized blockchains. Ethereum will be utilized

3.2 Design Constraints

A number of issues, including governance structures, economic considerations, and technological limits, limit the process of establishing a blockchain network.

Technical Restrictions: Blockchain networks need to be secure while processing transactions fast and effectively. However, there is a greater chance of network congestion and delays as transaction volume rises. The network's ability to grow with rising demand without compromising performance must be guaranteed by the architecture.

Economic Factors: A key component of blockchain networks' success is transaction fees. Adoption may be deterred by a high price, especially for minor transactions. While both Avalanche and Ethereum strive for minimal transaction costs, their respective economic models are different. While Avalanche has a more predictable fee structure based on network demand, Ethereum's gas cost system is dependent on the subnet configuration.

- Governance Models: The decentralization and security of the blockchain network are significantly influenced by the governance model used. The community may decide on protocol updates and network modifications thanks to Ethereum's governance architecture, which is based on on-chain voting and proposals. In contrast, Avalanche gives subnet designers the freedom to select their own governance rules, which increases customization but may also add complexity.

- Regulatory Compliance: Blockchains need to abide by rules and regulations, especially those pertaining to know-your-customer (KYC), data protection, and anti-money laundering (AML). When developing a blockchain system for corporate use cases, where regulatory compliance is essential, this will be a major factor.

3.3 Analysis and Feature Finalization Subject to Constraints

The following final characteristics were chosen for the custom subnet design on Avalanche after the features and design limitations were assessed:

High Throughput: Without sacrificing network stability or security, the subnet should be able to process thousands of transactions per second.

Minimal Transaction Fees: To draw in users and developers, the subnet has to have consistent, minimal transaction costs.

Customizable Consensus: To maximize security and performance for certain use cases, developers should be able to select from a variety of consensus techniques on the custom subnet.

Interoperability: To facilitate data exchange and cross-chain transactions, the subnet should be able to connect to the Ethereum and Avalanche ecosystems.

Governance approach: A flexible governance approach will be used by the subnet, enabling the establishment of distinct roles for developers, users, and validators. The process of governance should be made.

3.4 Design Flow

Avalanche's custom subnet design pipeline consists of the following steps:

Creating an Avalanche node and setting it up to connect to the Avalanche Fuji C-Chain testnet, which replicates a production setting for bespoke subnets, is the first stage in the network setup process.

2. Subnet Configuration: We define parameters like the block size, block duration, and validator criteria by configuring the subnet using the AvalancheJS package. Choosing the consensus method (such as the PoS or Avalanche consensus protocol) is another phase in this process.

3. Deployment of Smart Contracts: Next, we set up smart contracts on the customized subnet. These contracts will let dApps to operate on the subnet by interacting with the Avalanche blockchain. Additionally, the smart contracts will facilitate governance, staking, and token transfers.

3.5 Design Selection

After completing the design flow and testing, the custom subnet on Avalanche was selected as the optimal solution for building scalable, low-cost, and flexible blockchain applications. This subnet provides several advantages over Ethereum in terms of transaction speed and cost-efficiency while offering the flexibility to tailor the blockchain’s governance, consensus mechanism, and other parameters to specific use cases.

3.6 Implementation Plan / Methodology

The following phases will make up the implementation plan:

1. Preparation: This step entails configuring the necessary tools, such as Metamask for blockchain interface and AvalancheJS and the Avalanche node. Additionally, we will implement the required smart contracts and set up testnets.

2. Custom Subnet Deployment: Using the specifications determined in the previous phases, we will construct the custom subnet on Avalanche and set up its parameters in this step.

3. Testing: A range of scenarios, including high transaction throughput, real-time data synchronization, and cross-chain interoperability, will be used to evaluate the custom subnet's performance.

4. Results Analysis: By contrasting the performance of the custom subnet with Ethereum and conventional Avalanche subnets, we will examine the testing phase's outcomes.

5. Documentation and Reporting: In this last phase, the implementation process will be documented, the outcomes will be compiled, and the conclusions will be presented in the final report.

CHAPTER 4
RESULTS ANALYSIS AND VALIDATION

4.1 Implementation of Solution

Avalanche's unique subnet deployment will undergo a thorough evaluation to determine its security, cost-effectiveness, and transaction speed. Determining if the custom subnet is a workable option for high-performance decentralized apps (dApps) requires consideration of some crucial factors. We may obtain important insights into the custom subnet's usefulness in real-world production settings by evaluating its performance against Ethereum's Sepolia testnet and Avalanche's Fuji testnet.

TPS, or transaction throughput

Transaction throughput, or the number of transactions per second (TPS) that a blockchain network can manage, is one of the most important criteria to consider while assessing it. Applications like DeFi protocols, payment systems, and real-time data sharing that demand quick transaction processing must have high TPS.

To evaluate the throughput of the custom subnet, we will carry out experiments that mimic large transaction volume real-world situations. Comparing the TPS of the custom subnet to Avalanche's Fuji testnet (Avalanche's test environment) and Ethereum's Sepolia testnet (Ethereum's test network) allows us to determine how many transactions can be handled per second without sacrificing network stability.

Even with the impending Ethereum 2.0 updates, Ethereum still has TPS restrictions because of its sequential transaction processing Proof-of-Work (PoW) paradigm (which has since been replaced by Proof-of-Stake (PoS)). Avalanche, on the other hand, makes use of the Avalanche consensus mechanism, which enables concurrent validation of transactions throughout its network. Because of its parallelization, Avalanche can process thousands of TPS, which makes it perfect for high-volume applications. Because Avalanche is a customized blockchain network, its own subnet enables additional optimization, guaranteeing that in a comparable setting, it can get a better throughput than Ethereum. We may evaluate the scalability and test the performance of the custom subnet by comparing the TPS on various networks.

Costs of Transactions

Any network must take blockchain transaction costs into account. Adoption of decentralized apps can be severely hampered by high transaction costs, particularly for high-frequency use cases or small-value transactions. Thus, while comparing various blockchain systems, cost-effectiveness evaluation is crucial.

The cost per transaction on the custom subnet, the Sepolia testnet of Ethereum, and the Fuji testnet of Avalanche will all be evaluated in this analysis. Network congestion, which happens when the demand for transaction space exceeds the available block size, has caused Ethereum to struggle with high gas prices. Consequently, Ethereum's gas prices vary, with substantial cost increases as a result of large transaction volumes. Because of its subnet design, which allows users to customize fee structures to suit their unique needs, Avalanche's transaction costs are comparatively low and steady, even if Ethereum 2.0 attempts to solve this issue through sharding and other scalability enhancements.

In order to compare the transaction costs on the custom subnet to those on Ethereum and Avalanche, we will simulate large transaction scenarios. This will enable us to determine which network, under various network conditions, offers the best predictable and reasonably priced pricing structure. The ability to establish precise price restrictions to guarantee that expenses stay low is a significant benefit of the custom subnet, which increases its appeal for applications needing frequent, inexpensive transactions.

Security and Stability

Security is the cornerstone of any blockchain network, and ensuring that the custom subnet is secure and stable is of paramount importance. A secure network prevents attacks such as 51% attacks, double-spending, and other vulnerabilities that can compromise data integrity and user trust. Additionally, the network must be stable under heavy load, as performance degradation or downtime can severely affect the user experience.

To evaluate the security and stability of the custom subnet, we will monitor its resilience under stress testing conditions, which simulate high transaction volumes, network attacks, and congestion scenarios. We will look for vulnerabilities such as potential exploits or weaknesses in the consensus mechanism, validator misbehaviors, or smart contract vulnerabilities. By comparing how Avalanche and Ethereum handle these scenarios, we can better understand the custom subnet's strengths and weaknesses.

By benchmarking these parameters and observing how the custom subnet performs under load, we can ensure that the subnet remains secure and stable even as it scales to handle increased user activity.

CHAPTER 5
CONCLUSION AND FUTURE WORK

5.1 Conclusion

When compared to Ethereum, Avalanche's proprietary subnet offers notable gains in scalability, transaction speed, and cost-effectiveness, which makes it a desirable option for developers looking for adaptable and powerful blockchain solutions. The flexibility of Avalanche's subnet architecture to customize governance rules and consensus methods is one of its main benefits; it offers unmatched customisation possibilities that Ethereum and other blockchains cannot match. Decentralized apps (dApps) that need certain performance features, such high throughput or specialized transaction processing, which may be maximized with bespoke configurations on Avalanche, would especially benefit from this flexibility.

In terms of scalability, the network can handle thousands of transactions per second (TPS) while preserving decentralization thanks to Avalanche's special consensus method. The crucial element for blockchain systems, as because conventional platforms, like as Ethereum, have experienced congestion during periods of significant demand, which has resulted in higher gas prices and slower transaction times. With the release of Ethereum 2.0 and the adoption of Proof of Stake (PoS), Ethereum has made significant progress in increasing scalability; yet, network congestion remains a problem, leading to delays and expensive transaction costs. Avalanche is an excellent candidate for high-throughput applications because of its scalability without performance degradation, which allows it to manage significantly higher transaction volumes without incurring appreciable cost increases.

Another significant aspect in which Avalanche does better than Ethereum is transaction speed. With a finality time of less than one second, transactions are verified virtually instantly on the Avalanche network. Ethereum's transaction, however, Generally speaking, confirmation times are somewhat higher, especially during times when network activity is high. For applications like decentralized exchanges (DEXs), gaming apps, and other real-time systems that need quick, almost instantaneous transaction finality, Avalanche is a strong choice. Avalanche's consensus protocol, which employs a new strategy based on gossiping and repeated voting throughout the network to ensure speedy agreement on transaction validity, is responsible for achieving the short finality time.

Another area in which Avalanche shines is cost-effectiveness. Compared to Ethereum, the Avalanche network has substantially cheaper transaction costs. Particularly during periods of heavy demand, Ethereum's gas fees—which are contingent on network congestion—can become unaffordable. For instance, Ethereum gas prices might rise sharply during times of high consumption, making it challenging for individual users or smaller apps to run well. Avalanche, on the other hand, is more affordable for developers and consumers who need cost-effective solutions since it has set, predictable rates. Applications that manage microtransactions or require scalability without incurring exorbitant operating expenses may especially benefit from this.

Because of its widespread use and vibrant developer community, Ethereum is still a great option for decentralized apps; but, developers seeking more transaction throughput, reduced costs, and configurable blockchain features may find Avalanche to be an appealing alternative. With Avalanche's custom subnet functionality, developers may create blockchains that are suited to certain use cases by modifying the network's governance rules, consensus processes, and performance factors to meet the requirements of their applications. This degree of adaptability isn't found in Ethereum uses a shared consensus system and runs on a single, fixed blockchain.

In conclusion, Avalanche provides potential alternatives for developers that need high-throughput, affordable, and adaptable blockchain networks, even if Ethereum continues to lead the blockchain market thanks to its network effects and developer community. Avalanche is a desirable choice for projects that require performance, flexibility, and cost-effectiveness since it can be used to establish custom subnets that are suited to certain use cases. Avalanche's subnet design is probably going to be essential in allowing scalable, decentralized applications as the blockchain ecosystem develops further.

5.2 Future Work

In order to further improve scalability, transaction speeds, and overall network efficiency, future development in the Avalanche ecosystem should concentrate on improving Avalanche subnets. There is always need to improve subnet performance, especially when managing large-scale, high-throughput applications, even if Avalanche's subnet design offers exceptional flexibility and adaptability. In order to attract developers looking for scalable solutions, future improvements should focus on lowering costs, increasing consensus efficiency, and decreasing latency.

Increasing the number of developer tools available for creating decentralized apps (dApps) on the Avalanche platform is another crucial area for future growth. Even while Avalanche now provides a number of development resources, expanding the selection and making them more easily accessible would encourage developers to use them more.

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TO WHOM SO EVER IT MAY CONCERN

This is to confirm that **TEENA NEUPANE (22BCS50212)** has attended the Summer Programme on "**Blockchain Technology using Ethereum and Polygon**" provided by Chandigarh University with knowledge partnership from **Metacrafters** during June 2024 – August 2024, and has completed the following modules:

1. JS PROOF: Beginner Course
2. ETH PROOF: Beginner EVM Course

This program was designed to provide students with practical experience in Blockchain and Ethereum to help them develop the skills needed to succeed in the industry. The program offers a mentorship, and real-world project experience that can help our students develop the skills needed to succeed.

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