THE UNIVERSITY OF HONG KONG

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Faculty of Engineering

Department of Computer Science

COMP4801 Final Year Project
Project Plan

Blockchain Ticketing System

Date	:	1st October 2023	
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1   Project Background

1.1   Background

Hong Kong, a major metropolis with a diverse population, annually hosts a variety of concerts and music festivals. In 2023, world-known artists and groups such as DJ Alan Walker, BLACKPINK, Charlie Puth, and Jay Chou chose Hong Kong as part of their world tour [1]. Traditional ticketing systems are commonly used to facilitate ticket sales and distribute tickets for various events. However, these systems are fundamentally flawed by vicious speculation, which poses harm to both Event Organizers and Ticket Purchasers.

1.2   Problem Statement

1.2.1   Ticket Scalping

Due to the immense popularity of numerous prestigious events, scalpers purchase large quantities of tickets from traditional ticketing platforms, thereby decreasing the number of tickets available to other Ticket Purchasers and increasing overall demand. Subsequently, scalpers proceed to resell these tickets at an inflated price for profit [2].

1.2.2   Ticket Fraud

Traditional tickets are commonly available in two formats: physical or electronic. However, these tickets lack adequate security safeguards and are susceptible to forgery. Due to the lack of regulations on online resale, victims frequently incur losses by not being able to receive a legitimate and valid ticket after the completion of payment [3].

1.2.3   Single Functionality of Tickets

Tickets distributed by current ticketing systems have limited usage after the conclusion of the event; waste is generated and the environment is rapidly degraded.

1.3   Project Motivation

Both Ticket Purchasers and Event Organizers are negatively affected by ticket scalping and fraud. For Ticket Purchasers, the phenomenon of ticket scalping causes them to capitulate to scalpers, resulting in the purchase of overpriced tickets and the risk of purchasing fraudulent tickets. This hinders their enthusiasm to participate in future events, hence posing a threat to the sustainability of the industry. For Event Organizers, they may suffer reputational harm due to ticket scalping. It creates a negative perception among consumers regarding the arrangements, resulting in customer dissatisfaction.

To tackle the problems associated with traditional ticketing systems, Event Organizers have used various management strategies, such as limiting the number of transactions per individual and enhancing measures to combat ticket fraud, etc. [4]. Nevertheless, the aforementioned issues persist and have no indication of diminishing. Therefore, it is imperative to undertake a comprehensive revamp of the existing ticketing system to address the problems and ensure sustainable development within the industry.

1.4   Project Solution

To find a suitable solution to the aforementioned problems, we aim to develop a system that can bring improvements and benefits in critical domains, namely: 1) Enhanced security, 2) Transparency and 3) Trust, 4) Increased management capabilities, and 5) Sustainability.

The utilization of blockchain technology allows a distinctive and secure way to purchase tickets. From customers engaging in transactions to organizers hosting events, user satisfaction and effectiveness can be boosted due to its stable and dependable environment. Hence, a more robust and secure environment should be established to crack down on ticket scalping while enhancing data privacy protection.

2   Project Objective

This project aims to develop a blockchain-based ticketing platform that revolutionizes the ticketing industry by addressing two key objectives: preventing ticket scalping and enhancing the functionality of tickets.

2.1   Prevent Ticket Scalping

- By leveraging blockchain's immutable and transparent feature, the platform allows secure documentation and effortless traceability of ticket transactions. It eliminates the possibility of scalpers engaging in fraudulent activities.
- By implementing Smart Contracts on the platform, ticket issuance and transferal can be automated, reducing the involvement of third parties and minimizing the risk of unauthorized reselling.

2.2   Improve Functionality of Ticket

- Through the platform, Event Organizers can leverage the platform's dashboard function to gain valuable insights into users' behavior and preferences, allowing them to tailor their offerings and marketing strategies accordingly.
- Through the platform, existing participants and Event Organizers can benefit from improved convenience and personalized experiences. For instance, the system can offer discounts to customers who repeatedly purchase tickets, incentivizing their continued engagement and fostering a good client relationship.

3 Project Methodology

3.1 Roles

3.1.1 Ticket Purchaser

A **Ticket Purchaser** is an individual who purchases tickets for events. They access and interact with the Ticket Purchaser-facing website to browse events, choose tickets, and submit online payments using their crypto wallet.

3.1.2 Event Organizer

The **Event Organizer** is the individual responsible for utilizing the Event Organizer-facing website to distribute event tickets to **Ticket Purchasers**. They submit event details and establish ticket inventories through the website to seek approval from the **Super Admin**. Additionally, they can oversee the ticket sales process through an interactive dashboard.

3.1.3 Super Admin

The **Super Admin** plays a crucial role in having a full overview of the system and managing any requests from **Ticket Purchasers** and **Event Organizers**. They are the administrators of the whole Blockchain Ticketing System to maintain system configurations and smooth operation.

3.2   Deliverables

Figure 1 illustrates the interaction between 1) end users, 2) front-end websites and applications, 3) back-end data storage, and 4) Ethereum blockchain.
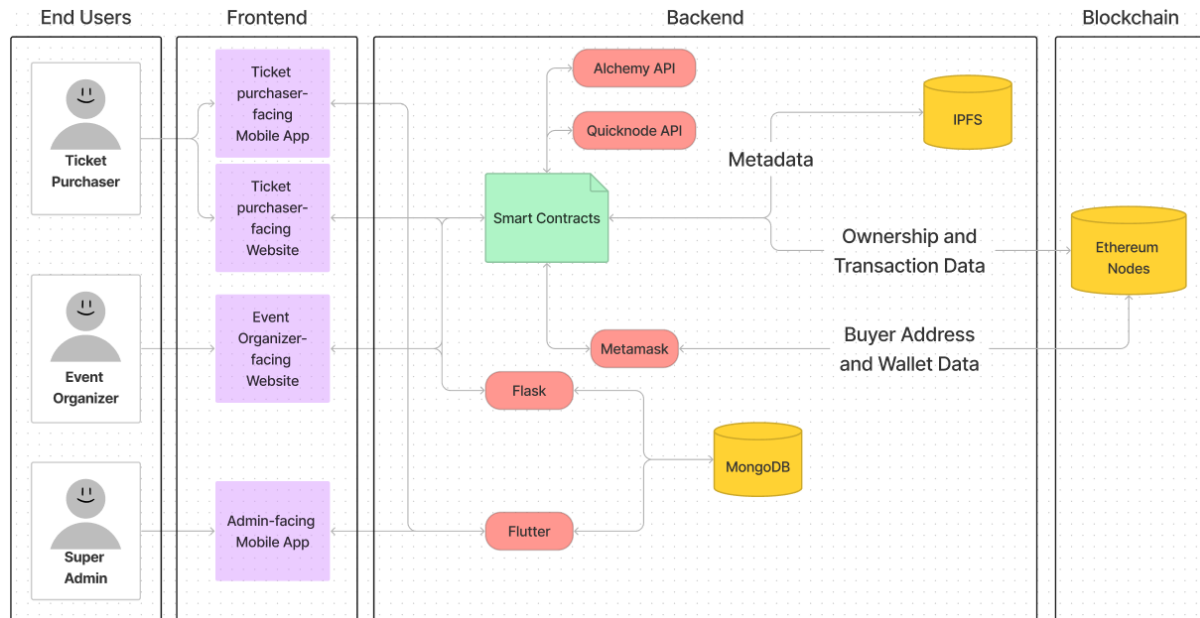

Figure 1: *High-level Overview of Technical Implementations of the Blockchain Ticketing System*

By implementing Smart Contracts for identity verification, Ticket Purchasers will be able to connect the Ticket Purchaser-facing Website with their crypto wallet (MetaMask). The Smart Contract will be linked with MetaMask to fetch relevant information from the cryptocurrency wallet of the Ticket Purchasers. Then, Ticket Purchasers may trigger the minting button to mint the NFT Tickets, which indicates a purchase of event tickets.

Ticket Purchasers will be able to connect their cryptocurrency wallet with the Ticket Purchaser-facing Mobile App. Purchased NFT Tickets will be shown in the App upon the establishment of a successful connection. After selecting the NFT Ticket, a QR code will be generated for the purpose of ticket authentication. This QR code automatically refreshes every minute to enhance security and prevent unauthorized sharing. The activation of the Smart Contract will be initiated after the QR code is scanned by the Admin-facing App, resulting in the deactivation of the NFT Ticket that has been utilized.

Event Organizers could use the Event Organizer-facing Website to access and review the NFT Ticket sales data. Data of the NFT Tickets will be fetched from the Ethereum blockchain and shown on the Dashboard. Besides, Event Organizers could use the website to submit details of the events and tickets to be onboarded. The final approval of the submitted details will be made by the Super Admin.

3.2.1   NFT Tickets

NFT Tickets in the Ethereum blockchain with the ERC-721 Non-Fungible Token (NFT) Standard will be created and minted through the implementation of Smart Contracts. Each unique NFT ticket will consist of on-chain transaction data and off-chain Metadata:

- On-chain Transaction Data:
  1) Token ID
  2) Contract Address
  3) Owner Address
  4) Creator Address
- Off-chain Metadata:
  1) Event Date
  2) Event Time
  3) Event Organizer
  4) Event Name
  5) Event Venue
  6) Gate
  7) Section
  8) Row
  9) Seat

3.2.2   Websites

3.2.2.1   Ticket Purchaser-facing Website

The Ticket Purchase Website will serve the purpose of general ticket purchase for the Ticket Purchaser. It will consist of the following functions:

1) User Log-in by Crypto Wallet Connection
2) Event Listing
3) Ticket Buying Confirmation
4) Ticket Minting Smart Contract
5) User Ticket Collection Listing

3.2.2.2   Event Organizer-facing Dashboard

The Dashboard will serve the purposes of data analytics and event details submission for the Event Organizer. It will consist of the following functions:

1) User Registration
2) User Log-in
3) User Account Reset
4) Event Details Submission
5) Ticket Details Submission
6) Data Analytics Dashboard
7) Event and Ticket Details Confirmation by Super Admin

3.2.3   Mobile Application

3.2.3.1   Ticket Purchaser-facing Ticket Authentication Application

The Ticket Purchaser-facing Ticket Authentication Application will serve the purpose of generating QR code tickets for the Ticket Purchaser. It will consist of the following functions:

1) User Log-in by Crypto Wallet Connection
2) Event Listing
3) User Ticket Listing
4) QR Code Ticket Generation from NFT Ticket
5) Auto-refresh QR Code Ticket in the Regular Time Frame

3.2.3.2   Ticket Authenticator-facing Ticket Authentication Application

The Ticket Authenticator-facing Ticket Authentication Application will serve the purpose of authenticating QR code tickets generated by the Ticket Purchaser-facing Ticket Authentication Application for the Ticket Authenticator. It will consist of the following functions:

1) Scanning QR Code Tickets by Mobile Camera
2) Ticket Burning Smart Contract

3.3 Technology Implementation

3.3.1 Front-end Development

Before starting on the front-end code development, our own design system will be created in Figma to visualize the layout of the websites and the mobile applications. To reduce design and development time, we plan to utilize the pre-styled CSS framework Bootstrap rather than starting from scratch.

3.3.1.1 Ticket Purchaser-facing Website and Event Organizer-facing Dashboard

As our project is based heavily on Python, a Python templating engine Jinja2 will be used to integrate with our backend. It allows simplicity in producing dynamic HTML content with JavaScript while optimizing web applications for improved performance.

3.3.1.2 Ticket Purchaser-facing and Admin-facing Ticket Authentication Application

The two mobile applications will be implemented based on Flutter, a cross-platform framework that allows us to deploy the application on various platforms such as Android and iOS. Flutter can deliver high-quality applications while executing them very fast, this high and efficient performance benefits us in terms of the main usage of the applications, which is to allow generating and scanning of QR code in a short period of time.

3.3.2 Back-end Development

3.3.2.1 Flask

Flask will be used for developing our Python-based websites and Web Server Gateway Interface (WSGI) [5] will be used to run the websites. As a powerful backend infrastructure and lightweight web micro-framework [5, 6], it even has great compatibility with Python which allows us to connect to the blockchain ecosystem seamlessly.

3.3.3   Database

3.3.3.1   MongoDB

MongoDB is a document database for storing and managing data [7]. Data in MongoDB is in JSON-like format [7]. This feature allows the database to directly map the current programming language with ease and convenience. MongoDB could be used in the Blockchain Ticketing System to store the login information of Event Organizers, as well as the sales data that is not included in the Ethereum blockchain.

3.3.3.2   IPFS

InterPlanetary File System (IPFS) is a protocol to store and transfer data through peer-to-peer networking in a decentralized way similar to blockchain technology [8]. In the Ethereum blockchain, the block size is limited and not large enough to store all the data of an NFT, IPFS will be used to store the Metadata of the NFT Tickets of the Blockchain Ticketing System. The decentralized feature of IPFS allows the Metadata can be stored in IPFS nodes securely and ensures the Metadata is tamper-proof.

3.3.4   Crypto Wallet

3.3.4.1   MetaMask

To connect Ticket Purchasers' crypto wallet, MetaMask will be used in both the Ticket Purchaser-facing Ticket Purchase Website and Ticket Authentication Application. MetaMask will be able to connect Ticket Purchasers' crypto wallet and blockchain to interact such as storing the NFT Tickets minted by the Ticket Purchasers and amending the NFT Tickets used.

3.3.5   Blockchain

The decentralized, traceable, and transparent feature of blockchain [9] will play an essential role in the Blockchain Ticketing System to fulfill the objective of the system. The NFT Tickets sold by the system should be 1) tamper-proof to prevent counterfeit tickets, 2) able to limit the resale price to control the ticket scalping on secondary sales, and 3) traceable on ticket resale history for the ease of data analysis.

3.3.5.1 Ethereum

To decide which blockchain to use in the system, there will be a list of features to be considered, including 1) popularity, 2) transaction fees, 3) scalability, and 4) level of decentralization. Therefore, a comparison between several blockchains has been done to evaluate the benefits and downsides. The following table shows the comparison of features between Ethereum, Solana, Polygon PoS, and Polygon zkEVM.

	Ethereum	Solana	Polygon PoS	Polygon zkEVM
Start Year	2015 [10]	2020 [11]	2021 [12]	2023 [13]
Gas Fee (per transaction)	26 ETH Gwei (0.86 USD) [14]	0.0001 SOL (0.000027 USD) [15]	88.6 MATIC Gwei (0.00097 USD) [16]	0.6997 MATIC Gwei (0.0000076 USD) [17]
Scalability (1st = Highest)	4th	1st	3rd	2nd
Transaction Speed	12.8 TPS [14]	4739 TPS [18]	29.4 TPS [16]	0.2 TPS [19]
No. of Validators	945,129 [20]	3,400 [21]	100 [22]	Permissionless Sequencer and Aggregator [23]
Security	High security but potential risk from PoS	A newer platform with security risks & vulnerabilities	Lower security than Ethereum as it is developed on layer 2	Low security in off-chain transactions but high security in on-chain transactions
Decentralization (1st = Highest)	1	3	4	2
No. of Unique Address in Blockchain	245,342,698 [24]	39,750,000 [25]	354,695,682 [26]	441,723 [27]
Consensus Algorithm	Proof of Stake (PoS) [28]	Proof of History (PoH) [29]	Proof of Stake (PoS) [30]	Proof of Efficiency (PoE) [31]
Development Language	Solidity [32]	Rust, C, C++ [33]	Solidity [34]	Solidity [34]
Cryptocurrency	ETH [35]	SOL [36]	MATIC [37]	MATIC [37]

3.3.5.2 Smart Contract

Smart Contracts in the Solidity language will be developed to interact with the Ethereum blockchain to perform the main functions in the Blockchain Ticketing System. Several APIs will be used in the Smart Contracts to interact with the Ethereum blockchain such as Alchemy NFT API to fetch NFT data [38] and MetaMask API to request Ticket Purchasers' wallet address [39].

4   Project Schedule and Milestones

The following table summarizes the milestones of the project.

Date	Milestones
September 4, 2023	• Finalize Topic and Methodology • Conduct initial research
October 1, 2023	• **Deliverable 1:** Detailed Project Plan • **Deliverable 1:** Project Webpage
October 18 – November 27, 2023	• Design Front-end Layout (Web page for Ticket Purchaser and Event Organizer) • Smart Contract Development • Literature Review
November 28 – January 15, 2023	• Integration of Blockchain and Platform Back-end • Front-end Implementation (Webpage)
December 28, 2023	• Preparation for the First Presentation
January 8 – January 12, 2024	• First Presentation
January 21, 2024	• **Deliverable 2**: Preliminary Implementation • **Deliverable 2**: Detailed Interim Report
February 30, 2024	• Front-end Implementation (Mobile App) • Build Relevant Test Cases for Trials
March 15, 2024	• Final Review and Improvement • Implementation to the Live Market for the Final Result
March 30, 2024	• Preparation of the Project Poster • Preparation of the Final Presentation • Final Review of the Project
April 15 – April 19, 2024	• Final Presentation
April 23, 2024	• **Deliverable 3**: Final report • **Deliverable 3**: Finalized Tested Implementation
April 26, 2024	• Project Exhibition

5   References

[1] am730. "演唱會經濟｜新加坡又贏成亞洲第一勝香港　吸巨星開個唱一場賺多少？" am730.

Jul. 12, 2023. [Online]. Available: https://www.am730.com.hk/財經/演唱會經濟-新加坡又贏成亞洲

第一勝香港-吸巨星開個唱一場賺多少-/387759

[2] C. F. Cheung. "Ticket Scalping." Legislative Council of the Hong Kong Special Administrative
Region. Accessed: Jan. 30, 2019. [Online]. Available: https://www.legco.gov.hk/research-
publications/english/essentials-1819ise04-ticket-scalping.htm

[3] Anti-Deception Coordination Centre. "Beware of Online Concert Ticket Trading Fraud." Anti-
Deception Coordination Centre. Nov. 23, 2022. [Online]. Available: https://www.adcc.gov.hk/en-
hk/alerts-detail/alerts-1595362836003168257.html

[4] J. Jeffers. "How Enterprises Can Protect Against Ticket Scalping**.**" Security Boulevard. Jan. 18,
2023. [Online]. Available: https://securityboulevard.com/2023/01/how-enterprises-can-protect-against-
ticket-scalping/

[5] Hemanthhari2000. "Introduction To Micro Web Framework Flask." Medium. April. 04, 2021.
[Online]. Available: https://medium.com/featurepreneur/introduction-to-micro-web-framework-flask-
78de9289270b

[6] T. Nandam. "Implementing Flask Application Using Object Oriented Programming (OOP's) [Part-
1]." Hashnode. Nov. 15, 2021. [Online]. Available: https://nandamtejas.hashnode.dev/implementing-
flask-application-using-object-oriented-programming-oops-part-1

[7] MongoDB. "Why Use MongoDB and When to Use It?" MongoDB. Accessed: Sep. 28, 2023.
[Online]. Available: https://www.mongodb.com/why-use-mongodb

[8] IPFS. "What Is IPFS." IPFS. Accessed: Sep. 27, 2023. [Online]. Available:
https://docs.ipfs.tech/concepts/what-is-ipfs/

[9] IBM. "Benefits Of Blockchain." IBM. Accessed: Sep. 26, 2023. [Online]. Available:
https://www.ibm.com/topics/benefits-of-blockchain

[10] Ethereum.org. "The History Of Ethereum." Ethereum.org. Sep. 22, 2023. [Online]. Available:
https://ethereum.org/en/history/

[11] CoinMarketCap. "Solana Price Today, SOL To USD Live Price, Marketcap And Chart." CoinMarketCap. Accessed: Sep. 26, 2023. [Online]. Available: https://coinmarketcap.com/currencies/solana/#About

[12] OKX. "Polygon 2.0 Deep Dive: Exploring Blockchain's Game-Changing New Platform." OKX. Jul. 7, 2023. [Online]. Available: https://www.okx.com/learn/polygon-2

[13] Polygon Labs. "To Ethereum, With Love: Announcing Polygon ZkEVM Mainnet Beta On March 27th." Polygon Labs. Feb. 14, 2023. [Online]. Available: https://polygon.technology/blog/to-ethereum-with-love-announcing-polygon-zkevm-mainnet-beta-on-march-27th#:~:text=As the leading EVM-equivalent,journey to the future begins

[14] Etherscan. "Ethereum (ETH) Blockchain Explorer." Etherscan. Accessed: Sep. 26, 2023. [Online]. Available: https://etherscan.io/

[15] Parcl. "What Are Blockchain Gas Fees? A Comprehensive Guide To Gas Fees On The Solana Blockchain." Parcl. Mar. 20, 2023. [Online]. Available: https://www.parcl.co/blog/what-are-blockchain-gas-fees#:~:text=As of March 2023%2C the,equivalent to a few cents

[16] PolygonScan. "Polygon PoS Chain Explorer." PolygonScan. Accessed: Sep. 26, 2023. [Online]. Available: https://polygonscan.com/

[17] Polygon zkEVM. "Polygon ZkEVM Blockchain Explorer Average Gas Price Chart." Polygon zkEVM. Accessed: Sep. 26, 2023. [Online]. Available: https://zkevm.polygonscan.com/chart/gasprice

[18] Solana Explorer. "Explorer | Solana." Solana Explorer. Accessed: Sep. 26, 2023. [Online]. Available: https://explorer.solana.com/

[19] Polygon zkEVM. "Polygon ZkEVM Explorer." Polygon zkEVM. Accessed: Sep. 26, 2023. [Online]. Available: https://zkevm.polygonscan.com/

[20] BeaconScan. "Statistics - Validators." BeaconScan. Accessed: Sep. 26, 2023. [Online]. Available: https://beaconscan.com/stat/validator

[21] Solana Foundation. "Solana Foundation Validator Health Report: March 2023." Solana Foundation. Mar. 23, 2023. [Online]. Available: https://solana.com/news/validator-health-report-march-2023

[22] Polygon Labs. "Validator Decentralization: Protecting The Network, Securing The Future." Polygon Labs. Nov. 9, 2022. [Online]. Available: https://polygon.technology/blog/validator-decentralization-protecting-the-network-securing-the-future

[23] Polygon Labs. "Polygon ZkEVM Protocol." Polygon Labs. Accessed: Sep. 26, 2023. [Online]. Available: https://wiki.polygon.technology/docs/zkEVM/protocol/protocol-components/

[24] Etherscan. "Ethereum Unique Addresses Chart." Etherscan. Accessed: Sep. 26, 2023. [Online]. Available: https://etherscan.io/chart/address

[25] A. Zirojevic. "Solana Smashes $20 Barrier As Active Users Surge; What's Next For SOL Price?" Finbold. May. 29, 2023. [Online]. Available: https://finbold.com/solana-smashes-20-barrier-as-active-users-surge-whats-next-for-sol-price/

[26] PolygonScan. "Polygon PoS Chain Unique Addresses Chart." PolygonScan. Accessed: Sep. 26, 2023. [Online]. Available: https://polygonscan.com/chart/address

[27] Polygon zkEVM. "Polygon zkEVM Unique Addresses Chart." Polygon zkEVM. Accessed: Sep. 26, 2023. [Online]. Available: https://zkevm.polygonscan.com/chart/address

[28] Ethereum.org. "Consensus Mechanisms." Ethereum.org. Jan. 14, 2023. [Online]. Available: https://ethereum.org/en/developers/docs/consensus-mechanisms/

[29] Solana Foundation. "Proof of History: How Solana Brings Time To Crypto." Solana Foundation. Nov. 30, 2021. [Online]. Available: https://solana.com/news/proof-of-history

[30] Polygon Labs. "What is Polygon PoS?" Polygon Labs. Accessed: Sep. 26, 2023. [Online]. Available: https://wiki.polygon.technology/docs/pos/what-is-polygon-pos/

[31] Polygon Labs. "What is Polygon ZkEVM?" Polygon Labs. Accessed: Sep. 26, 2023. [Online]. Available:
https://rise.articulate.com/share/p8w6t759TahpdxqMUrUI6tvPWaF8YcBJ#/lessons/EvHYIjRjrV_2GLkhNpZMeBdFv3tPpTaG

[32] Ethereum.org. "Smart Contract Languages." Ethereum.org. Sep. 2, 2022. [Online]. Available: https://ethereum.org/en/developers/docs/smart-contracts/languages/

[33] Solana Foundation. "Getting Started With Solana Development." Solana Foundation. Aug. 20, 2021. [Online]. Available: https://solana.com/news/getting-started-with-solana-development

[34] SettleMint. "Smart Contracts IDE" SettleMint. Accessed: Sep. 27, 2023. [Online]. Available: https://console.settlemint.com/documentation/docs/blockchain-guides/Polygon/polygon-integration-tools/

[35] Ethereum.org. "What Is Cryptocurrency?" Ethereum.org. Accessed: Sep. 27, 2023. [Online]. Available: https://ethereum.org/en/what-is-ethereum/

[36] Coinbase. "Solana (SOL) Price, Charts, and News." Coinbase. Accessed: Sep. 27, 2023. [Online]. Available: https://www.coinbase.com/price/solana#WhatisSolana

[37] Crypto.com. "Polygon Price | MATIC Price, USD Converter, Charts." Crypto.com. Accessed: Sep. 27, 2023. [Online]. Available: https://crypto.com/price/polygon

[38] Ethereum.org. "Javascript API Libraries." Ethereum.org. Accessed: Jul. 12, 2023. [Online]. Available: https://ethereum.org/en/developers/docs/apis/javascript/

[39] MetaMask. "Home | MetaMask Developer Documentation." MetaMask. Accessed: Sep. 27, 2023. [Online]. Available: https://docs.metamask.io/