SilkViser - A Visual Explorer of Blockchain-based Cryptocurrency Transaction Data

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ABSTRACT

SilkViser, a pioneering research project developed as part of the Spring 2024 CSE 578 Data Visualization course at Arizona State University, aims to enhance the accessibility and comprehension of blockchain-based cryptocurrency transaction data. By introducing innovative visualization tools into traditional blockchain explorers, SilkViser empowers users to understand and interact with cryptocurrency transaction mechanisms more effectively. Through aesthetically pleasing visualizations inspired by paper ledgers and ancient copper coins, SilkViser offers intuitive representations on web-based pages dedicated to blockchain, blocks, transactions, addresses, and a specialized choropleth map. Leveraging geographical information associated with each transaction, the choropleth map provides valuable insights into network relay activity, enabling users to identify areas that more resilient to attacks. SilkViser aims to cater to both novice and experienced users, paving the way for enhanced user engagement and comprehension in the evolving landscape of blockchain technology.

1 INTRODUCTION

The landscape of cryptocurrency has evolved significantly in recent years, propelled by the emergence of blockchain technology[4]. Since the first real-world Bitcoin transaction in 2010, cryptocurrencies have relied on blockchain variations as their foundational infrastructure. Central to this technology is the blockchain, a decentralized ledger that transparently records and validates all transactions within a network. Over time, the accessibility of transaction data has become increasingly important, leading to the development of tools like Blockchain Explorers.

However, conventional blockchain explorers predominantly present transaction data in textual and tabular formats, which can be challenging for both newcomers and seasoned users to comprehend fully. Recognizing these limitations, our project, SilkViser, expands upon the SilkViser [5] research paper to introduce innovative visualization tools into traditional blockchain explorers. Our aim is to enhance user experience and accessibility by providing intuitive visualizations that facilitate a deeper understanding of cryptocurrency transaction data.

SilkViser is a web-based platform designed to revolutionize the exploration of blockchain-based cryptocurrency transaction data. Our platform comprises distinct pages dedicated to blockchain, blocks, transactions, addresses, and a specialized choropleth map [3]. Each page offers visually intuitive representations aimed at empowering users to gain deeper insights into the intricacies of Bitcoin transactions.

The addition of the choropleth map feature is a significant enhancement, offering users valuable geographical insights into network relay activity. By leveraging geographical information associated with each transaction, this visualization tool enables users to identify areas that are more resilient to attacks.

Built using HTML, CSS, JavaScript, and d3.js, SilkViser utilizes various datasets, including block details, daily summaries of block and transaction counts, IP geolocation data, and GeoJSON files for plotting geographical distributions. The platform also incorporates live API calls to fetch real-time transaction and address data, ensuring up-to-date information for users.

In summary, SilkViser offers a comprehensive suite of visualizations tailored to enhance user understanding of blockchain-based cryptocurrency transaction data. From visualizing daily generation trends to exploring transaction details and geographical distribution, SilkViser caters to both novice and experienced users, providing a user-friendly interface for navigating the complexities of cryptocurrency transaction[2].

2 VISUALIZATION DESIGN

2.1 BlockChain Page

The blockchain page [Fig.1] contains a Double Axis Bar Chart and Line Chart. It shows daily generation trends of blocks and transactions over a 3-month period. It also has custom block glyphs[Fig. 2] representing connected blocks. Information on these blocks include block height, confirmation number, generation time, block hash, previous block hash, and number of transactions. Clicking on the custom block glyphs would redirect users to the Block Page.

2.2 Block Page

The block page[Fig. 3] features a Coin Glyph[Fig. 4] encoding essential information about the transactions of that block. The opacity of the coin represents the transaction size. The size of the square center represents the transaction fee. The left and right arcs represent the number of input and output addresses respectively. The histograms below these glyphs display the size, addresses and fees of all the transactions in the block for easier visual comparisons. Clicking on the coin glyphs would redirect the users to the transaction page with details of the selected transaction.

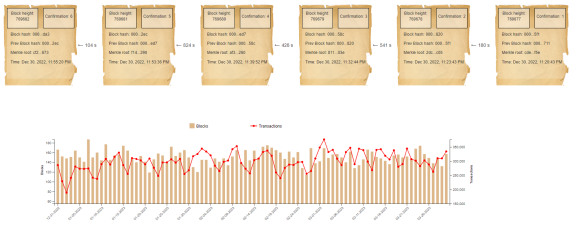

Figure 1: Glyphs and Double axis Bar chart on the block page.

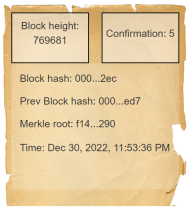

Figure 2: Block glyph that contains the high level details of the block.

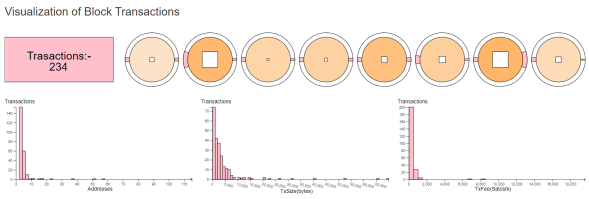

Figure 3: Glyphs and bar charts to display the transaction details.

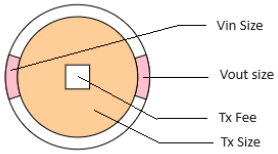

Figure 4: Details of the coin glyph.

We implemented a brushing feature [Fig. 5] on the histograms displayed on the page to give users the autonomy to filter the data to understand and compare. When a user brushes over any histogram, the glyphs and the histograms would update to display only the selected data.

The table below these graphs would display the entire list of transaction details which the user could sort based on the sorting. This would also update the glyphs and show the top transactions from the table

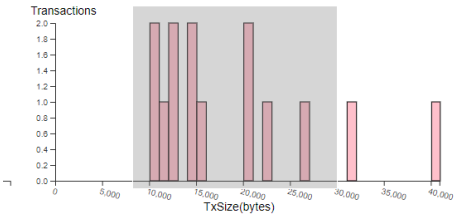

Figure 5: Histogram showing the brushing feature to filter data.

2.3 Transaction Page

The transaction page includes a custom coin sankey chart[Fig. 6] depicting incoming and outgoing addresses along with the amount involved in transactions. This helps gives the user and idea on how the amount is being segregated in each transaction. Below this are two tables with incoming and outgoing addresses along with the transaction amount. Users can click on an address and see more information about that address.

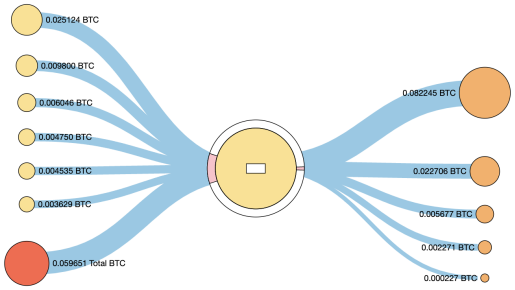

Figure 6: Sankey chart displaying the input and output addresses and sizes.

2.4 Address Page

The address page contains information about that address, such as balance, no of transactions, etc. Below that would be the Bar Chart[Fig. 7] which enables users to explore no of transactions grouped by date of the last hundred transactions. The user also sees a detailed table of all transactions that address is involved in.

2.5 Network Relay Page(Extension)

The Choropleth map[Fig. 8] displays a map offering a unique perspective on the geographical distribution of blockchain relay activity across U.S. states. Each state is color-coded based on the frequency of IP addresses relaying block information.

3 DATASET DESCRIPTION

SilkViser's dataset leverages the Blockchain.com Blockchain Explorer API[1], providing a granular view into cryptocurrency transactions. Unlike conventional downloadable datasets, this API acts as a programmatic interface (API) to the blockchain, a decentralized

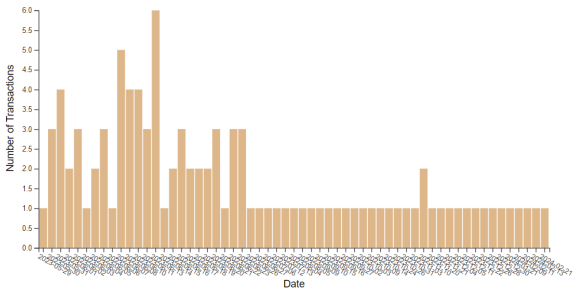

Figure 7: Bar chart showing transaction activity for addresses.

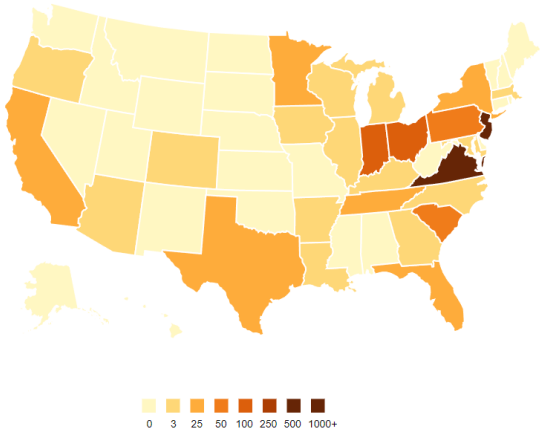

Figure 8: Choropleth graph displaying the frequency of network relay activity in each state.

ledger that persistently records all cryptocurrency transactions. Our queries to the API function as targeted extractions of specific data points, akin to filtering a large database.

The datasets derived[Table 1] from this API encompasses numerous facets of blockchain activity, comprising semi-structured datasets with hierarchical organization.

'Blockdetails.json' offers quantitative and temporal attributes, featuring both sequential and ordered data elements essential for understanding block specifics. 'Dailysummary.json' presents daily summaries of block and transaction counts, providing ordered quantitative insights aligned with temporal markers. Additionally, we integrate IP geolocation data, correlating IP addresses with categorical geographical information such as country, state, and city, along with quantitative counts. This geographical context is pivotal for analyzing the spatial distribution of network relay activity. We further leverage GeoJSON files containing boundary data for U.S. states to facilitate visualization of this distribution.

DataSet	Attribute	Type
BlockDetails	hash	Alphanumeric
	height	Quantitative
	prev_block	Alphanumeric
	mrkl_root	Alphanumeric
	time	Temporal
	n_tx	Quantitative
	size	Quantitative
DailySummary	dateInUnix	Temporal
	blockCount	Quantitative
	transactionCount	Quantitative
Transaction	hash	Alphanumeric
	size	Quantitative
	fee	Quantitative
	v_out	Quantitative
	v_in	Quantitative
IPGeolocation	ip	Alphanumeric
	country	Categorical
	state	Categorical
	city	Categorical
	zip	Alphanumeric
	count	Quantitative

Table 1: Dataset Description

4 CASE STUDIES

4.1 Case Study 1: Identifying Busy Transaction Periods

By analyzing the double axis bar chart on the Blockchain page, users can gain insights into daily transaction volume trends. For instance, a surge in transaction volume on a specific date might indicate a significant event impacting the cryptocurrency market. This visualization allows users to visually identify periods of high transaction activity and investigate the underlying factors.

4.2 Case Study 2: Geopolitical Analysis of Transaction Relays

The choropleth map on the Network Relay page offers a unique perspective on the geographical distribution of block information relays. By color-coding each state based on the frequency of IP addresses relaying block information, users can identify regions with a higher resilience to attacks. This visualization can potentially aid in identifying the strong relay node areas.

4.3 Case Study 3: Generating Coinbase Transactions

The transaction with the hash shown below serves as a pertinent example of a coinbase transaction. This transaction is identifiable as a coinbase transaction due to its distinct characteristics: absence of inputs and the presence of outputs.

Understanding the Transaction:

The absence of inputs in the coinbase transaction signifies that it is the first transaction in a block, created by the miner who

Attributes	Value
Hash	9d02a...11e0d
Timestamp	12-30-2022
Block Height	769682
Transaction Fee	0 BTC
Inputs	None
Outputs	3

Table 2: A coinbase transaction.

successfully mined the block. Coinbase transactions play a pivotal role in incentivizing miners to dedicate computational resources to the network. Upon successfully mining a block, the miner is rewarded with newly created bitcoins, forming the bulk of the outputs in the coinbase transaction.

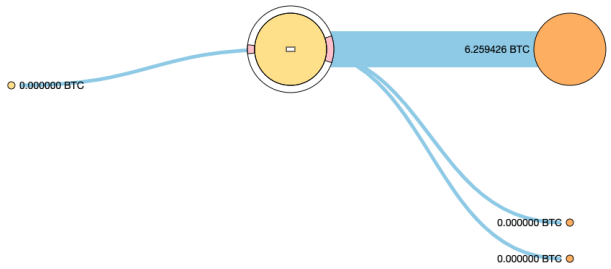

Figure 9: Generating Coinbase Transactions.

5 DISCUSSION

5.1 Lessons learnt

From this project we learnt about the critical role of data collection, pre-processing, and filtering in creating effective visualizations. Initially, due to constraints, we collected data over a short duration. However, this limited dataset did not provide enough insights through the visualizations. Recognizing this, we expanded our data collection efforts to cover a period of three months. With this larger dataset, we were able to create visualizations that offered deeper insights and a more comprehensive understanding of the data.

This project provided us with an opportunity to delve deeper into the utilization of D3.js for data visualization and to explore its potential in analyzing blockchain data. Through this process, we gained valuable insights into the capabilities and intricacies of D3.js. We were able to explore and implement features we had not utilised before this such as creating custom glyphs, choropleth graphs, histogram brushing.

Moreover, we gained a deeper appreciation for the importance of storytelling in data visualization. We ensured that our visualizations were designed to cater to all types of users, including both experts and novices. By incorporating storytelling techniques, we were able to provide context and meaning to the data, making it more accessible and understandable to a wider audience.

Additionally, this project served as a valuable lesson in project planning. We adopted a systematic approach by dividing the work into smaller, manageable parts that could be tackled individually. This not only improved efficiency but also allowed for better coordination and collaboration among team members. Overall, these insights have greatly enhanced our approach to data visualization projects and have equipped us with valuable strategies for future endeavors.

5.2 Future improvements

Currently, our data is represented using static charts. To enhance interactivity, we can considering implementing animations and control panels. The following are a few ideas:

(1) Instead of simply appearing when loaded, charts could fade in or grow gradually.
(2) When updating the glyphs while brushing the histograms, we could either move the current glyphs to new positions or animate them to display updated values.
(3) As users navigate between pages, which are linked together, we could incorporate animations to signify a deeper level of detail in relation to previously selected items. This would enhance the storytelling aspect.
(4) Since the graphs, such as the double bar chart and glyphs, display multiple parameters, it would be beneficial to include a control panel. This would allow users to select exactly which parameters they want to view, providing them with more control and autonomy over the visualizations.
(5) Currently the visualizations do not work well with smaller screens such as mobile phones and tablet screens. We can develop the charts to be responsive and adapt to different screen sizes and devices.
(6) The current theme gives a rustic look to the charts which may not appeal to all types of users. We can allow users to customize the theme(eg, modern look, different colours) giving them a sense of autonomy while appealing to their style.

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