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**A Comparison of
State-of-the-Art
Blockchain Bridges**

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Head of Research and Insights
Henry Hon PhD, CFA



Research Editor
Joy Zhou

Research Intern
Bowen Liu

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Contents

Executive Summary	5
1. Introduction	6
2. Overview	7
3. Comparison	8
3.1 Net Inflows	8
3.2 Market Shares	9
3.3 Distribution of Bridge Assets	10
3.4 Layer-1 Transactions	11
3.5 Pros/Cons + Transfer Charges	12
4. Analysis of Polygon, Avalanche, and Anyswap Bridges	14
4.1 Polygon	14
4.2 Avalanche	15
4.3 Anyswap	16
5. Conclusion	17
References	18

Executive Summary

- **Polygon and Avalanche are the top two Ethereum bridges in terms of TVL as of October 2021.** More than USD 4.87B and \$4.86B were locked in Polygon and Avalanche, respectively. Arbitrum (\$2.35B), Fantom (\$2.04B), and RenBridge (\$1.07B) are other popular bridge platforms with large TVLs.
- **Polygon, Avalanche, Arbitrum, Fantom, and Ren boast relatively large market shares.** Polygon and Avalanche bridges currently occupy around 30.3% and 30.2% of the overall values locked. Meanwhile, Arbitrum and Fantom are the other two major Ethereum bridges with market shares of 14.7% and 12.7%, respectively. RenBridge is also substantial, with a share of 6.6%.
- **WETH is the most popular bridged token on Ethereum bridges.** There are more than 20 assets on Ethereum bridges. The most popular bridged token was WETH, representing 43.6% of total bridged tokens. Other major tokens are as follows: 15.3% (WBTC), 11.8% (USDC), 7.7% (USDT), and 6.8% (Polygon Matic token), respectively.
- **The rise of alternate Layer-1 solutions does not necessarily divert liquidity from the Ethereum mainnet, suggesting that new money has flown into the entire blockchain ecosystem.** Solana recorded the largest number of transactions since launch (34B in total), while Ethereum processed 1.33B transactions as of 26 October 2021. However, the net inflows (TVLs) from Ethereum to Solana through Wormhole bridge were only \$211.04M, ranked 7th in our study.

1. Introduction

Bridges are moving the promise of the blockchain ecosystem a step further. Blockchain has established itself as one of the greatest innovations of the past few years, forming the backbone of web 3.0. After years of mainly academic contributions and industrial development, a wide range of different blockchains have emerged. Nowadays, there are more than 100 active public blockchains with their own use cases and target markets. As a result, chain interoperability is seen as a critical factor that may help boost current ecosystems by allowing assets from distinct blockchains to be bridged easily.

Despite the need for a means of communication between chains, this function is still somewhat limited due to the different technology and native tokens implemented on various chains. For instance, it is hard or unrealistic to build a pipe between the Bitcoin network and the Ethereum platform. **For greater adaptation and scaling of the crypto ecosystem to be achieved, the issue of cross-chain communication has to be addressed.**

Fortunately, the community has realised this. **In the past year, we have experienced an explosion in cross-chain development.** Generally speaking, cross-chain initiative acts as a bridge connecting multiple chains, e.g., Filecoin and ETH. Token holders from two chains can start trading their distinct tokens through the bridge. Normally, the cross-chain bridge platforms will hardcode a set of regulations to guarantee the security of every transaction. Bridges may be seen as a practical approach to extending the promise of existing blockchains, moving it a step further.

In this article, we aim to provide an overview of current bridges in the market, including a comparison of multiple metrics and potential drawbacks. The remainder of this article is organised as follows: Section 2 presents an overview of popular bridges and their comparisons. We plan to sketch a bridge workflow introduction and a bridge taxonomy. Section 3 describes several data-driven comparisons of market shares, TVLs, distributions of bridged assets, total transaction numbers, and transfer fees. Section 4 analyses the key features of selected popular bridges based on the findings in Section 3. Section 4 reviews our findings and concludes the article.

2. Overview

Current bridges usually include four necessary processes which are involved in a bridge implementation between a source chain and destination chain, as depicted below:

Process	Monitor	Relay	Agreement	Sign
Objective	Constantly monitor states/events	Deliver the message from source chain to destination chain	Ensure the message has been delivered	Generate signatures (if necessary)

Let's assume that a user wants to invoke a cross-chain transaction. By design, an entity called a "monitor" is introduced who acts as an oracle and constantly monitors the states or events on the source chain. In practice, a number of monitors are incentivised to contribute. Once a cross-chain request is invoked, a monitor is able to capture this event and subsequently fulfil his obligations by relaying information to the destination chain. An agreement is required among the system monitors in order to transmit information from the source chain to the destination chain.

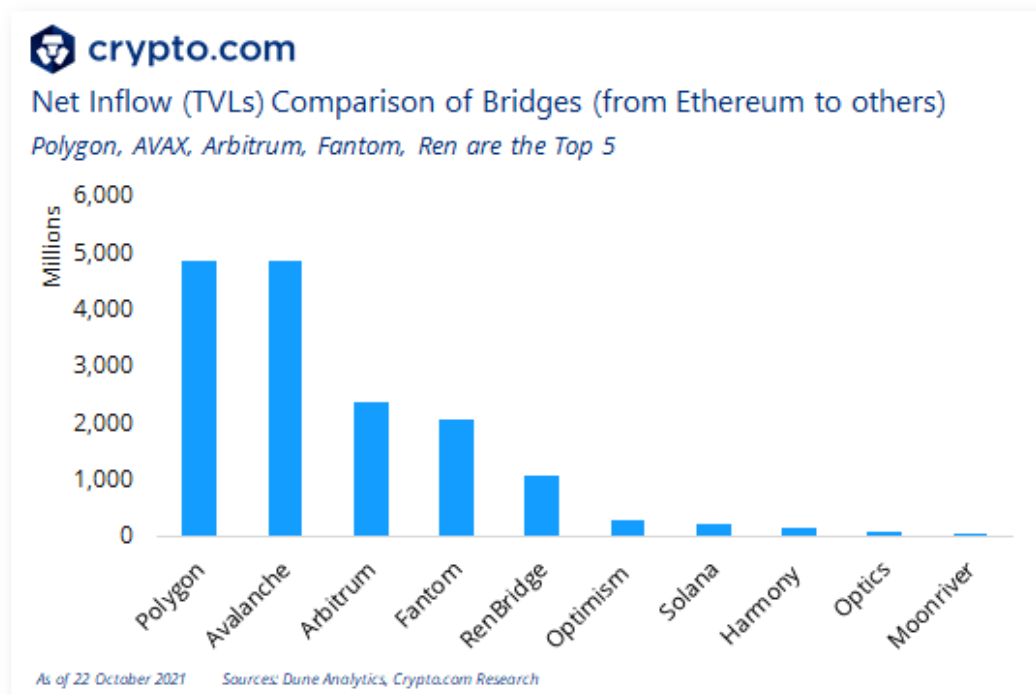
Several mainstream consensus protocols like PoS, PoW, PoA, or BFT-based have been adopted by bridges in their agreement components. Like many secure multi-party computation systems, the information is signed by monitors, which creates a cryptographic binding of a valid monitor and is sent to the destination chain. Eventually, the destination chain will notify the incoming request and proceed with the corresponding mint or burn actions.

3. Comparison

This section highlights the comparison of several important metrics for popular bridges.

3.1 Net Inflows

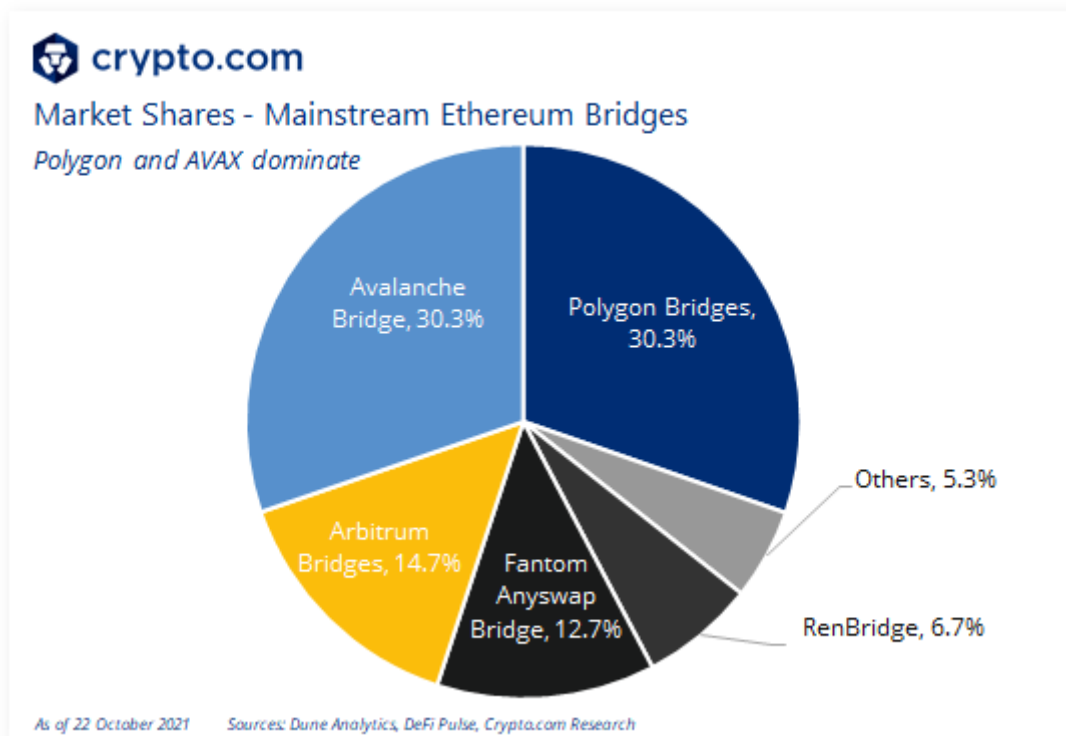
Polygon and Avalanche have captured the highest TVLs as of 22 October 2021. Total value locked (TVL), also known as net inflow, is a useful metric that shows the total amount of assets locked in a bridge application. TVL is now used as a key metric for various blockchain incentive programmes. As for the DeFi benchmark index, the DeFi pulse index, TVL is used to calculate the weight of each DeFi protocol. [DeFi Pulse](#) has popularised the metric since 2019, listing TVLs for a number of DeFi platforms. However, it doesn't integrate the data of all popular bridges. Hence, in our TVL measurement, we leverage both DeFi Pulse and [Dune Analytics](#) as data sources. Note that Ethereum ecosystems and their DeFi applications are the most popular (in terms of TVL, as of 29 October 2021, accounted for more than 67% of total TVL across blockchains) in the market. Therefore, we mainly focus on net inflows (TVLs) from Ethereum to other blockchains in this article.



The figures above show the TVL ranking among ten popular Ethereum bridges in the market (the data were retrieved between 1 January and 22 October 2021). It was found that more than \$4.87 billion were currently locked/deposited in the Polygon bridge, ranking 1st out of a total of ten platforms in our study. **Next in line, Avalanche (\$4.86B), Arbitrum (\$2.35B), Fantom (\$2.04B), and RenBridge (\$1.07B) are the other main bridge platforms with high net inflows.**

3.2 Market Shares

Polygon, Avalanche, Arbitrum, Fantom, and Ren are the top 5 bridges in terms of market share. In this section, we discuss the market share of various popular Ethereum bridges. As with the TVL comparison, we are primarily looking at Ethereum bridges here. The extracted data is current as of 22 October 2021.



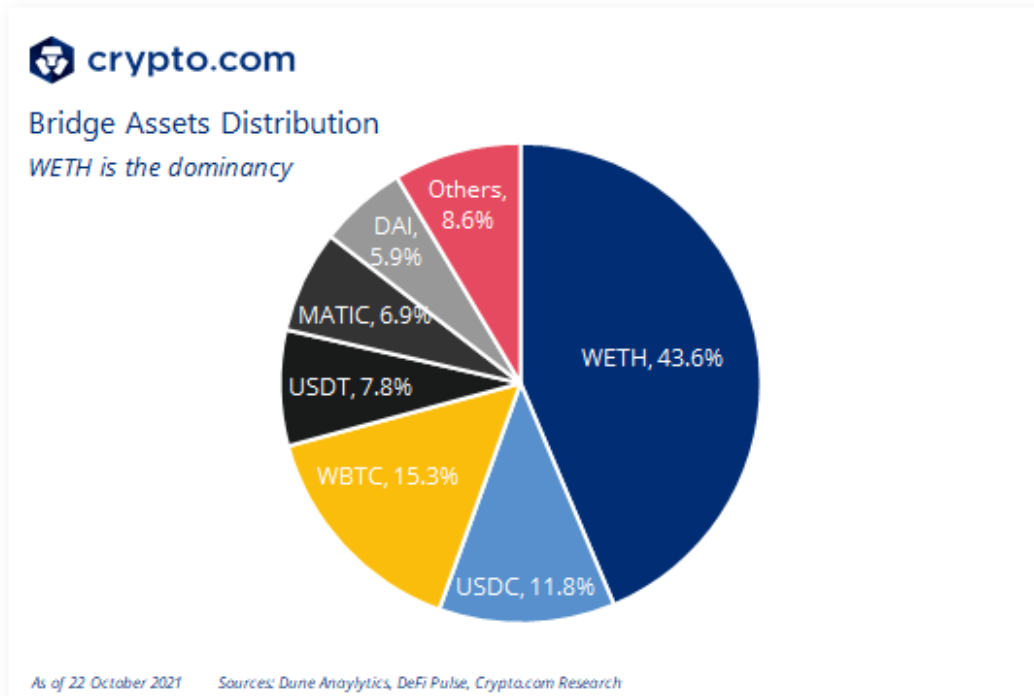
We measured the market share comparison among popular bridges, such as Arbitrum, Avalanche, Anyswap, Harmony, Near, Optimism, Polygon, and Solana. As shown, the Polygon and Avalanche bridges currently dominate bridge market shares, with around 30.3% and 30.2% of overall market caps in USD, and a value locked of more than \$4.8B. Arbitrum and Fantom were the other two major Ethereum bridges, with market shares of 14.7% and 12.7%,

respectively. Finally, we found the market share of RenBridge substantial, ranking 5th in our study.

The metric of market share can imply the popularity of a bridge platform to some extent. We thus conclude that Polygon and Avalanche are the top two most popular Ethereum bridges in the current market.

3.3 Distribution of Bridge Assets

WETH is among the most popular Ethereum-based bridged tokens. In general, asset distribution reflects what kind of tokens are being bridged on Ethereum-based bridges. To gain insights on this, we evaluated the different tokens that are bridged in popular Ethereum bridge platforms. Due to the measurement being based on Ethereum bridges, the most commonly bridged token was WETH or ETH, which made up around 43.6% of total assets. The percentages of other major tokens were relatively even, and their corresponding ratios were 15.3% (for WBTC), 11.8% (for USDC), 7.7% (USDT), and 6.8% (Polygon Matic token). **There were around 20 assets involved in total, indicating that current bridges can support assets of multiple blockchains.**



3.4 Layer-1 Transactions

We compared the total transactions among popular Layer-1 solutions to show that the net inflows (in terms of TVL) of bridges does not necessarily correlate with the popularity of Layer-1 solutions.

Solana posted the largest number of transactions (34.02B) since launch, which is somewhat surprising given that the platform is only 18 months old. Solana is the fastest blockchain globally and the fastest-growing ecosystem in crypto, with over 400 projects spanning DeFi, NFTs, Web3, and more.

The total number of transactions on the Binance Smart Chain was the second largest (1.50B) among mainstream Layer-1 solutions. Another EVM compatible Layer-1 solution - Fantom, was ranked 4th in transaction numbers since launch, standing at 102.96M in total. Meanwhile, Avalanche also processed a large number of transactions, more than 19.81M.

Thus, we conclude that the rise of alternate Layer-1 solutions does not necessarily divert liquidity from the largest player - Ethereum mainnet, and that new money has flown into the entire blockchain ecosystem.

Blockchain	# of Total Transactions Since Launch
Solana	35.44B
Binance Smart Chain	1.50B
Ethereum	1.33B
Fantom	102.96M
Avalanche	19.81M
Terra	48.16K

As of 26 October 2021

Sources: Crypto.com Research, Dune Analytics

In the next section, we will compare the advantages and drawbacks of existing bridge designs, in addition to their transfer fees.

3.5 Pros/Cons + Transfer Charges

Different bridges have individual strengths and limitations. In this section, we will elaborate on the pros and cons of mainstream bridges. Furthermore, we give insights into the actual transfer charges.

Polygon bridge is compatible with ZKrollup's sidechains and Optimistic Layer-2 solutions, but its contract governance could withdraw all users' balance.

Avalanche bridge has the most robust security guarantees compared to other bridges as its team has leveraged trusted hardware technology (i.e. Intel SGX) for transaction validation (Avalanche). The downside is that AVAX currently only supports a small number of token types.

Anyswap provides optimisation on blockchain scalability. Therefore, it has a fast finalisation period when a party wants to withdraw assets. However, the process may be rather slow (up to 24 hours) under large assets exchange scenarios.

RenBridge is well known for its good compatibility with BTC on Ethereum and BSC. In terms of its drawbacks, one possible limitation is that its price experiences high volatility.

Arbitrum bridge is one of the most popular Layer-2 bridges. Minimised data is required to be sent into the blockchain, which is more efficient (Ivan). However, Arbitrum bridge requires multi-round interactions when bridge exchanges are compared to other platforms (Offchain Labs).

Overall, as discussed above, **Solana** recorded the largest number of transactions among bridges, as it focuses on fast transaction confirmations.

Bridge	Upside	Downside	Transfer Fees (if any)
Polygon	Good compatibility	Contract governance	<u>0.1%, 0.15% or 0.25%</u>
Avalanche	Strongest security guarantee	Supported tokens	<u>Base Fee (25-1000 Gwei) + Dynamic Fee</u>
AnySwap	Fast exit/finalisation	Slow for large asset exchange	<u>Transaction Fee (0.1%)</u>
RenBridge	Good compatibility with Bitcoin on ETH or BSC	1) Ren team dominates many Greycore nodes 2) Ren's token is volatile	<u>Transaction Fee (~3 USD) + Protocol Fee (0.15%)</u>
Arbitrum	1) Less data needed to proceed on chain 2) Reduces blockchain cost	1) Multi-round interaction 2) Long waiting period	<u>Normal Transaction Fee (~ \$20-30)</u>
Solana	Fastest transactions	Users limited to a particular network	<u>\$0.00025</u>

The following section will look into a few top bridges and dig out more metrics based on further analysis.

4. Analysis of Polygon, Avalanche, and Anyswap Bridges

Based on the findings in Section 3, we have selected three representative bridges to provide further measurements.

4.1 Polygon

Polygon’s daily transaction number dropped after September 2021.

Polygon aims to create the first cross-chain platform for Ethereum scaling. Using Polygon, users can create Optimistic Rollup/ZK Rollup/stand-alone chains, effectively transforming Ethereum into a fully-fledged multi-chain system. It has become the most popular Ethereum bridge with a high market volume, large TVL and high transaction volume.

In addition to the common metrics discussed above, we charted the overall transaction number of the Polygon network in the past 30 days (as of 20 October 2021), which can be seen below.



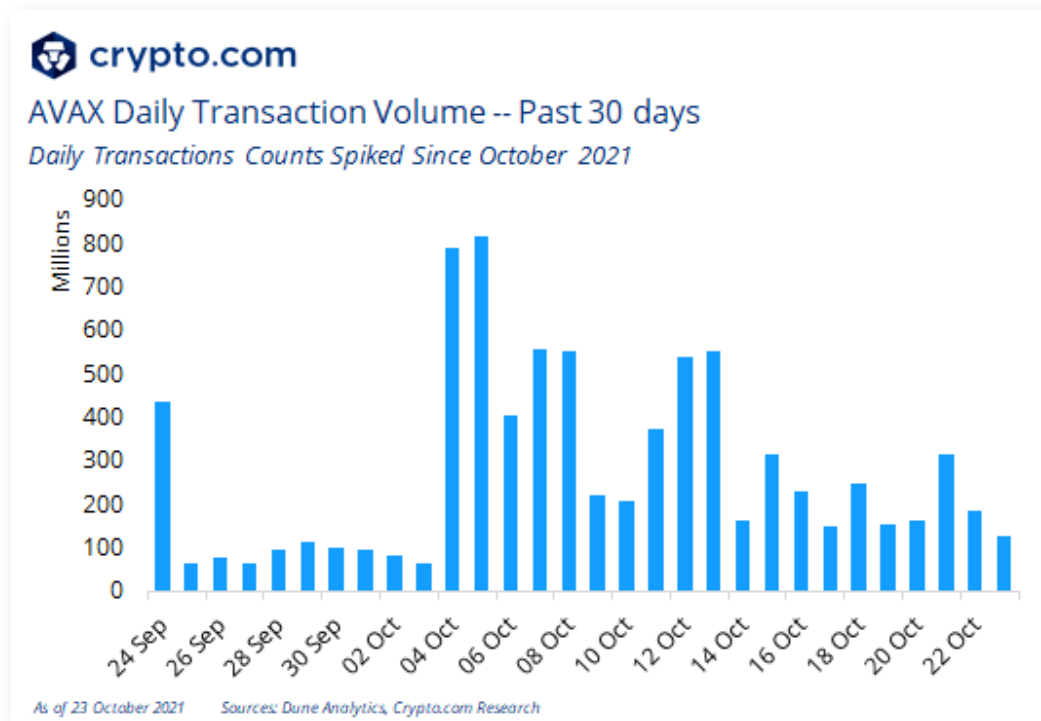
Polygon saw large daily transaction numbers during this time period, with the typical daily transaction count clocking in at over 5 million in September. When AVAX and Fantom launched their incentive programs, the number of transactions in Polygon went down significantly.

4.2 Avalanche

On 4 and 5 October 2021, Avalanche’s transaction volume surged from 100M to 800M. Avalanche features three built-in blockchains: Exchange Chain (X-Chain), Platform Chain (P-Chain), and Contract Chain (C-Chain). Avalanche uses a proof-of-stake consensus mechanism to achieve high throughput, estimated to reach over 4500 transactions per second.

Compared to other cross-chain solutions, Avalanche provides significantly stronger security due to the integration with trusted hardware technology (i.e., Intel SGX enclave). By design, any bridge transfer is to be audited or computed inside the SGX enclave to ensure security.

In Section 3, we measured the number of daily transactions for Avalanche. In the following, we charted the transaction volumes as of 23 October 2021.



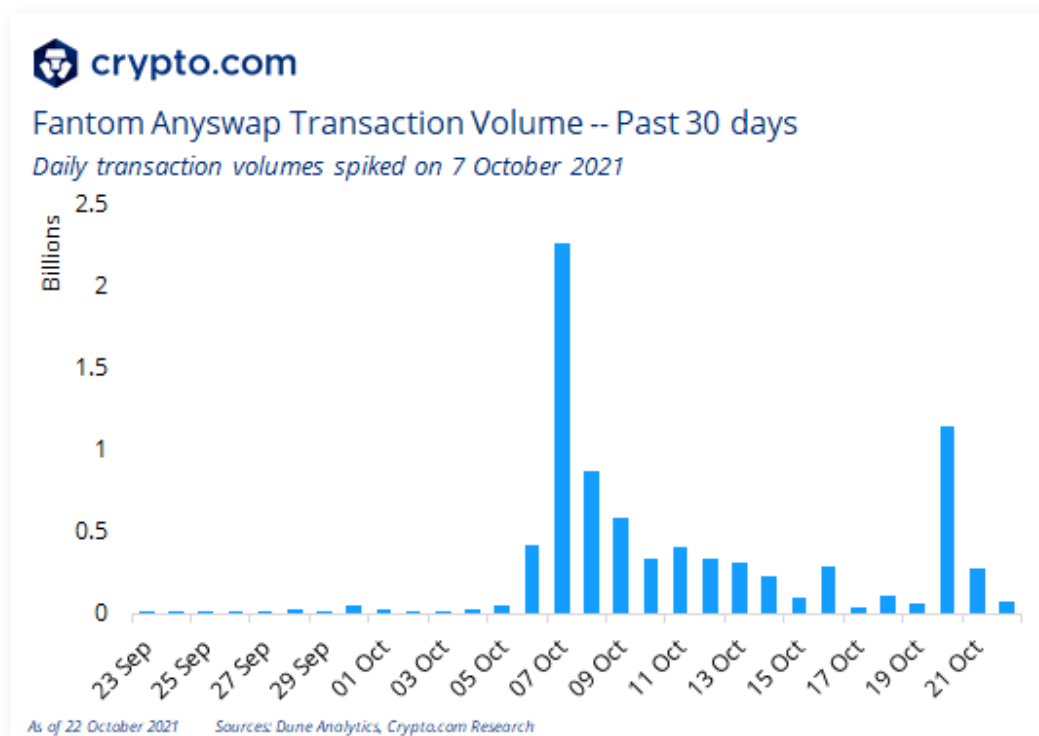
From the chart, we can observe a surge in the transaction volume on 4 and 5 October 2021, rising to around 800M on both days due to an AVAX price surge.

4.3 Anyswap

Transaction volume spiked from 400M to over 2000M on 7 October 2021.

Anyswap allows users to exchange assets between Ethereum, BSC, Fantom, Avalanche, HECO, and KCC, among others. It also provides a cross-chain solution Multichain in addition to supporting the Fusion, Heco, Polygon, and xDAI networks.

We selected the Fantom Anyswap bridge in our analysis as it boasts the largest transaction number of all Anyswap bridges (recall Section 3.1). As shown below, we can see that transaction volume was volatile. For instance, the volume on 7 October 2021 spiked to more than 2 billion, while most days saw volumes below 0.5 billion.



5. Conclusion

In this article, we provided an overview of mainstream bridges in the market. We first sketched the high-level workflow of existing bridge designs. Next, we presented a comprehensive comparison of popular bridges by four metrics, including market shares, net inflow, bridge assets distribution, and the total transaction numbers across several Layer-1 solutions. We concluded that the rise of alternate Layer-1 solutions does not necessarily divert liquidity from the largest player - Ethereum mainnet, suggesting that new money had been flowing into the entire blockchain ecosystem. Lastly, we further analysed the top platforms and discussed the pros/cons and their corresponding cross-chain transfer fees.

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