Exploring Dynamics of NFT Life Cycles Through Simulation

The internet emerged as a powerful force in the late 90's, allowing communication across the planet at the speed of light and promising more decentralized power structures. However, as the founder of some of the first Internet browsers, Marc Andreesen, notes, "The original sin of the internet was not having a native way of transferring value in the browser." Andreesen makes the case that many of the exploitative features of the internet (advertisement, collecting of data, lack of privacy) are rooted from the fact that payment was not embedded into the browser from genesis. The early internet looks nothing like the internet of modern times., iInformation was static and users could only read from it. With the introduction of JavaScript, the next phase of the internet (Web 2.0) was dominated by interactive platforms, where users now had the ability to read and write to the internet. While many of the biggest technology companies like Google, Facebook, Twitter were built in this era, the users were still relatively passive participants in these new platforms. Users didn't own their own data, were locked in to the platforms they spent their time on, and were even tricked into giving up privacy rights to freemium products like Facebook and Google.

Through massive scale and bolstering global connectivity, the modern internet increases the variance of many things that are built on top of it. Many things are stress tested more rigorously and society is learning that trusted third parties can be security holes. Some examples include negligent custody of the data of hundreds of millions of customers by trusted parties like Equifax, Facebook, and Google**.** The next wave of the internet (Web 3.0) emerged as an answer to the fallout from the 2008 Global Financial Crisis caused by greedy banks. The first technology to gain traction in the Web 3.0 era was Bitcoin, a blockchain based technology, which aimed to remove the need for trusted third parties. Bitcoin is a distributed immutable ledger that facilitates the process of recording transactions and tracking assets in a peer to peer network. The goal of blockchains is to find innovative new ways of organizing society and they use distributed consensus algorithms to remove counterparty risk. The blockchain movement is all about self-sovereignty in a trustable, verifiable, permissionless, and censorship resistant way. Assets are protected by public-key cryptography and are stored in software or hardware wallets in the user's control.

Ethereum emerged in 2014 as a decentralized blockchain platform that has an application layer to process autonomous objects known as smart contracts and functions as a global computer. Under the hood is the Ethereum Virtual Machine (EVM) which is Turing Complete. The EVM is fully expressive and allows for composability in a way no gated centralized platform (Facebook, Twitter, Instagram) community could. Composability is a key feature of the open source software movement that allows participants to build off of the work of others - instead of burning resources on a redundant task. What's needed is an innovative, transparent, and tamper proof way to transfer digital value using an internet native, a digital approach empowered by cryptography.

As the world moves to a higher proportion of digital interactions these will get represented in an internet native way. A non-fungible token (NFT) is a way of enforcing digital scarcity and creates a system of digital property rights that represents tokenization of real-world objects like art, music, in-game items and videos. If you can make programmable instruments and programmable agreements and contracts then you can build social contracts on top of that and create rights. NFTs are the building blocks of an ownership economy by providing the ability to describe interactions in a verifiable way. Web 3.0 is about ownership, membership, and voice (governance). This is a fundamentally different world than what we have in Web 2.0. This allows a digital world with a permissionless self-sovereign identity. NFTs are generally traded through a centralized marketplace like OpenSea (similar to Ebay) or community owned marketplaces like Rarible. Before blockchains there was no verifiable canonical version of digital content, making it difficult to sell such content. There is no marginal cost to reproduce these digital goods.This represents a shift from fabricated scarcity (paywalled content, sell your time) to selling scarce digital goods (NFTs) which introduces pricing power to suppliers allowing monetization in a way that was never possible.

Most interactions are now happening over the internet and every facet of the human experience is at least partially virtual if not entirely. Creators were responsible for creating a lot of value in Web 2.0 but were not beneficiaries of value creation (instead profit was siphoned off by platform owners). In Web 2.0 creators were building on top of rented land. Many of the top platforms like Twitter and Facebook have been known to change the rules and pull the rug out from under developers. Over time, the best entrepreneurs, developers, and investors have learned to not build on top of centralized platforms. This has stifled innovation. It is a goal of an ownership economy platform to distribute value to users as a mechanism for growth. The internet is trending to more user generated content and social connectivity. Many believe NFTs can serve as the atomic unit that this digital world will leverage to increase the velocity of connection.

Finally users can establish some sort of rights on platforms and these can be made intrinsic to the layers of the internet. Many NFT projects provide extra utility that traditional art pieces never could: access to communities, real-world events like concerts, and direct channel to the original creator. This allows the owner to leverage the power of programmable assets and bootstrap an entire economy around it. Web 3.0 redistributes wealth and power by creating platforms that are balanced and don't tilt. This is a profound opportunity to address wealth inequality.

This paper will follow the lifecycle of many NFT projects known as profile pics (PFP). In this digital first world, we are moving towards using a pseudonymous identity (email ids, social network screen names). Many PFP projects use on-chain generative art to mint collections of a fixed number of pieces (typically 10,000). When a user submits a transaction to the blockchain during the minting period, the hash of the transaction provides a source of randomness for that art to output a unique PFP. PFP projects are interesting because users identify with their avatar by using it to represent themselves to the world. Using a

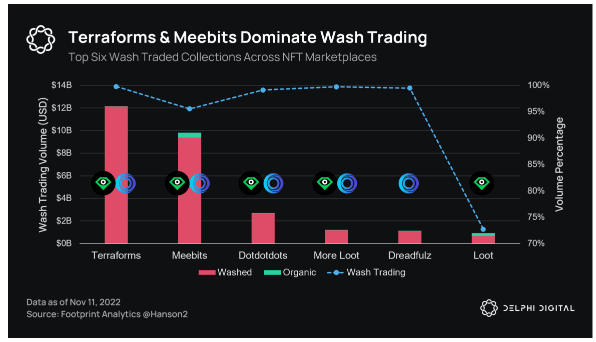
PFP unlocks utility and many are beginning to build companies and communities around these identities. This taps into the missing formula of centralized web services which is the ability to interact with a community you have created in an economic way that's frictionless and decentralized.

What's missing in the Web 3.0 revolution is one of the biggest revenue generators of the traditional internet world: target advertising, based on your on-chain activity or what NFTs are held in your cryptocurrency wallet. Additional high level analytics such as recent purchase history, statistics for categories/pieces, and understanding who is buying a product will make for a better product experience for users and developers. Unfortunately, the structure of the blockchain makes retrieving this information or any arbitrary queries very difficult. Queries are relatively expensive due to the cost of collecting the information and many redundant operations. The achieved goal of this paper was to use a service to retrieve relevant transaction data so that NFT projects could be analyzed. The first service considered for this analysis was the Graph Protocol.

The Graph Protocol is an indexing protocol for querying blockchain data that enables the creation of fully decentralized applications. Indexing blockchains is difficult for a few reasons. First, algorithms running on blockchains are much more difficult to deal with than classical distributed computing such as PageRank where the graph is distributed among multiple machines for efficiency. Here the multiple machines are only seeing part of the problem and the system requires trust between all these machines. Also, centralized Search Engines don't allow users to verify the results produced by a query. This creates a counterparty risk which goes against one of the principles mentioned earlier about blockchains. The lack of trust is an added difficulty for anything to do with the blockchain. Thus you add the condition that the work done by the machine needs to be sufficiently hard to fake, or sufficient economic incentive against fake it, and it is easily verifiable. Second, a blockchain is a chain of blocks containing transaction histories with an immutable history. A naive implementation would have to start from the beginning of the chain and iterate through all the blocks to find the relevant information. This leads to a lot of redundant work.

There are many centralized services known as blockchain explorers that are able to transform the data from a blockchain into a format that can be queried by users. This paper uses a blockchain explorer, EtherScan, to gather all of the data for the experiments. However, this doesn't avoid the counterparty risk discussed earlier. The Graph uses an open source querying language, Graph QL, to organize data into subgraphs. The Graph also provides an explorer to easily find subgraphs of the most protocols. This protocol back end has curators proposing subgraphs, indexers/delegators supporting those subgraphs through indexing services and economic stake. Users pay for these services using the native token (GRT). If there are disputes, challenging the validity of services provided by indexers, then Fisherman and Arbitrators provide game theoretic checks to backstop the security of the system.

The protocol uses a native token (GRT) to incentivize services provided by Curators and Indexers. Indexers are node operators who index relevant subgraphs. They earn rewards by indexing subgraphs and earn fees for serving queries on those subgraphs. They compete against other indexers in a marketplace to keep prices competitive. Consumers pay indexers for the services with the GRT token. Also, staying consistent with core blockchain principles of transparency and verifiability the Graph allows users to inspect queries. Quality is maintained on the protocol by holding reserves by Indexers who have their stake slashed for providing incorrect or very bad indexing. Curators use the GRT token to signal what subgraphs are worth indexing (like authorities in the authority-hub model). They are incentivized because they receive rewards proportional to how popular a subgraph is. Delegators, fisherman, and arbitrators provide security to the network. The Graph operates like a social network involving interactions between network participants (Users, Indexers, Curators, Delegators etc) codified by transactions between wallets. This is notably different from services like Google that were developed and maintained with top-down control. The Graph Protocol requires consuming a lot of resources to extract the entire transaction graph so the centralized free equivalent EtherScan was used in this paper to collect the data about the NFT projects.



The trading volume of the two NFT projects (Terraforms, Meebits) tracked in this paper are dominated by wash trading. Wash trading is a type of price manipulation that generally happens for two reasons. Some platforms such as LooksRare incentivize users with trading rewards. Wash traders conduct fake trades to win the rewards from the competitions. The second reason users will wash trade is to artificially inflate the trading volume so that projects seem more popular than they are.

Methods

NFT transaction graphs

Using the NetworkX package in python all the transaction data was read in to construct graphs where the users (represented by a wallet address) are nodes and the interactions are captured by edges. As the script conducted BFS on the entire transaction graph and saw wallets it had not seen before, they were added to the constructed graph. The EtherScan API rate limits users so the graph sleeps if it processes transactions faster than 0.2 seconds. There is also a limit of 200K total API calls allowed per day.

A random graph was separately constructed as a benchmark to see if the data taken from the NFT graphs was more than noise and specifically gave insight to how these NFT communities operated. The random graph was made with a similar density as the graph representing the Union of all the projects (excluding washtraded projects). The graph had a similar number of nodes, and edges were randomly distributed. If the NFTs were randomly traded between people then the Union graph should be similar to the random graph.

The majority of the NFT volume in many of the projects was dominated by an address controlled by an autonomous contract (batching for companies). Removing these contracts so the only transactions were between Externally Owned Addresses (users) proved beyond the scope of the current project.

Path Statistics

There were several steps taken to calculating path statistics over these graphs.

Step 1: Path Analysis (WCC,SCC)

First, the graph was filtered down to a weakly connected component (WCC), where all pairs of vertices in the graph have a path between them when ignoring the direction of edges. The search through the data was motivated by **Graph Structure of Web by Broder** paper that constructed a strongly connected component (SCC) and ran breadth first search (BFS) algorithms to measure which nodes interacted with the SCC by: only going into it, only leaving it, and finally nodes that were only in the WCC but not in the SCC (tendrils). The only difference here is that depth first search (DFS) was used to achieve the results for this paper. Using a Monte Carlo approach some of the path statistics extracted were the diameter (width) of the graph, the average path length, and the connectivity of the graph (fraction of nodes that had a path between them). Please note the diameters found were consistent and biased to be lower. They were biased because the maximum element was found by sampling the distribution and returning the maximum element that was seen. The diameters are consistent because in the limit we would get the exact size. The out_from_in and in_from_out nodes represent how many nodes were seen exploring away from the SCC. These sections make up the bowtie from the Graph Structure of the Web paper and the authors of that paper discovered the out_from_in nodes are an order of magnitude larger than the in_from_out nodes.

Step 2: Network Flow

Next, the Ford Fulkerson algorithm was run to compute the maximum flow in the network to test how many transactions could be removed to keep the graph connected. On the first pass, from the source to the sink node, two random nodes were chosen. This statistic is consistent and biased to be higher for the same reasons given for the biased diameter. The next pass the source nodes were restricted to the top N nodes ranked by out-degree and the sink nodes were restricted to the top N nodes ranked by in-degree. This statistic is exact because all pairs are computed between the restricted node list. The degree counts calculated were consistent with a power law distribution (**cite lognormal paper)** so it made sense to be able to get the same statistics mentioned on a graph that removes any nodes over a degree threshold, and the top N nodes.

Results

Union graph (Moonbirds, Azuki, BAYC, MAYC, Doodles), num_samples=10000, num_iter=5000
all_graphs (SCC): {1: 23792, 2: 963, 3: 165, 4: 44, 5: 18, 6: 5, 7: 3, 9: 2, 8: 2, 18: 1, 59: 1, 43371: 1}
all_graphs (WCC): {1: 61, 2: 53, 3: 12, 6: 2, 5: 2, 4: 2, 69759: 1, 20: 1}
Path statistics: (degree = 206, avg_path_length = 8.436915133914153, connectivity = 0.6198)
Path Analysis: ({'in': 0.019, 'out': 0.3526, 'tendrils': 0.006, 'scc': 0.6224}, {'out_from_in_nodes': 2.0315789473684203, 'in_from_out_nodes': 1.9013045944412972}

Network flow (num_iter=50, num_nodes=5):
Random Nodes: Average max flow, Min max flow = (1.3800000000000001, 1)
Top n Node only (source by out-degree, sink by in-degree): Average max flow, Min max flow = (789.3181818181819, 513)

Network flow (num_iter=50, num_nodes=10):
Random Nodes: Average max flow, Min max flow = (1.2400000000000004, 1)
Top n Node only (source by out-degree, sink by in-degree): (404.9032258064516, 202)

Highest degree address:
0x620b70123fb810f6c653da7644b5dd0b6312e4d8

Random graph, num_samples=10000, num_iter=5000
random_graph (SCC): {1: 5667, 64345: 1}
random_graph (WCC): {1: 98, 69912: 1, 2: 1}
Path statistics: (degree = 17, avg_path_length = 10.367651835011317, connectivity = 0.9237)
Path Analysis: {'in': 0.0388, 'out': 0.0344, 'tendrils': 0.0008, 'scc': 0.926}, {'out_from_in_nodes': 1.1546391752577319, 'in_from_out_nodes': 1.1686046511627919}

Network flow (num_iter=50, num_nodes=5):
Random Nodes: Average max flow, Min max flow = (2.08, 1)
Top n Node only (source by out-degree, sink by in-degree): (12.200000000000001, 12)

Network flow (num_iter=50, num_nodes=10):
Random Nodes: Average max flow, Min max flow = (2.2799999999999994, 1)
Top n Node only (source by out-degree, sink by in-degree): (11.849999999999998, 11)

Discussion of Results

A look over the path analysis reveals some clear directional trends about the lifecycle of NFT assets. The WCC ended up ~99% of the activity in the transaction graph for this study, this is why all the graphs were constructed on the WCC (ignoring small inactive parts of the graph). The percentage of transactions that were in the SCC ranged from 53% to 72%. This implies the communitiesy forming around these projects are very insular and the majority of transactions occur within the core community. Also there is an incentive to hold these assets because NFTs are collectible art with cultural value; they are already a speculative asset that can appreciate very quickly. This effect is shown by the substantial (~25-55%) out subgraph for all of the real NFT graphs. Most transactions occur within the SCC, so once a transaction leaves the SCC it's likely a collector who plans to hold the asset. It is worth noting that the in subgraph was very small in all graphs ranging from 1% to 4.2%. This indicates that a very small proportion of non-regular traders entered into the higher velocity part of the community. There are several important factors that may contribute to this effect: supply is limited because NFT owners like to hold on to the assets in anticipation of a much higher price in the future, and the group of users that is not the most frequent user by definition is not likely to be involved in a transaction with the community. It is possible but not probable that a random user will interact with this community. Because the in subgraph is very small and is dominated by the SCC and out subgraph it is quite rare to just be in the WCC but not interact with the rest of the community. This is why the tendrils hover around a very small fraction of total activity.

From the results it can be shown that the probability of a random node interaction (by plurality) is most likely to be a SCC member sending to an address that doesn't further interact with the SCC. Notably, even though a substantial fraction of the graph is in the out subgraph (~25-55%), the exploration out path (out_from_in nodes) was extremely shallow (~1-3 nodes). This low depth and traversal path indicate a transaction ending with a user who bought an NFT and never sold it – in other words, a collector.

To understand how NFTs can generate value beyond price speculation one can look at Costly Signaling theory from Game Theory. Why do consumers pay for luxury goods like a Rolex or designer clothing item when a substitute for a fraction of the price will satisfy the same basic function? First, we make the assumption that wealthier partners are more coveted as business collaborators, romantic partners, and acquaintances. Paying a high price for a luxury good is a good signal. Second, "Some signals, for instance, tend to indicate that not only is the individual relatively wealthy, but they also had a good upbringing or have high cultured friends. " (**EY and MH**) Similar to the high-end art market, having a strong aesthetic taste sends strong social signals about the ability to curate cultural artifacts and integrate with a community.

Most collectors are generally concerned with evaluating the cultural premium of an NFT. When a collector makes a purchase there is an implicit bet that they value the item more than what they perceive the cultural premium to be. What do people find interesting today and what will interest people in the future? How will this collection be remembered in the future? Collecting NFTs is an asymmetric bet on culture, and the ability to curate a culturally relevant and lucrative NFT portfolio is a strong social signal in the NFT niche of the Web 3.0 community. The hope is that sending such signals will connect you with more desirable business collaborators, romantic partners, and acquaintances. The ability for the receiver of a signal to easily differentiate a high quality sender from a low quality sender leads to a ‘separating’ equilibrium. (**EY and MH)** The costly signal forms as a reliable filtering mechanism to differentiate the quality of the sender - in this simplistic model.

When looking over the Ford Fulkerson results it is shown the average number of nodes to disconnect the random graph was 1 node - very small relative to the total number of nodes. This is much smaller than the number of nodes needed to disconnect the actual NFT graphs, implying the real graphs have stronger connections between nodes. Stronger connections between nodes implies that NFT graphs have reasonably dense communities when compared with the random graph. When analyzing how many nodes can disconnect the graph when the top 10 highest (out subgraph or in subgraph) nodes were chosen for source and sink, the collection of graphs that wasn't manipulated by wash trading peaked at around 2:1. The ratio of minimum nodes to remove versus average nodes to remove and was as close as 1:1. The wash-traded graphs hovered around a 3:1 ratio of minimum nodes to remove versus average nodes to remove. This is intuitive because the measurements of the wash traded graphs are very sensitive to the volume of the accounts exploiting the system by artificially inflating the volume. Stronger connections between graphs imply that if you removed the top few washtraders the graph would still be connected. If the washtraders were the majority of the volume then the graph would quickly be disconnected.

When going over all of the data a clear pattern emerged: most NFT projects (removing wash traded accounts) have very similar statistics. They have large SCCs, relatively large out sections, very small in sections, and most vertices not part of SCC were reachable from SCC. The random graph and wash traded graphs looked a little different. The random graph was important to check the statistics against because it gives some evidence that the results of this paper are significant and are not completely random**.** In the random graph the diameter (17) is much lower than that of the simulated actual graphs but the average path length is a little bit longer. The average path lengths are likely longer because the SCC is quite broad and there are only a few nodes in the diameter. This implies there is a giant loop running out through this SCC where an NFT was directly traded with several accounts before being traded with some sort of service account. Overall, the distribution of vertex degrees was consistent with a power law distribution (**powerlaw paper)**. The NFT projects had a fairly large diameter compared with the path lengths. For example, BAYC was ~3x smaller than the random graph but still had a larger diameter. Overall, the data seemed fairly consistent (large SCC, large out subgraph, small in subgraph, small tendril) across NFT projects showing a difference between the random graph and the washtraded NFT graphs.

Appendix: NFT Collections

Bored Ape Yacht Club (BAYC):
BAYC is the most popular NFT Collection in the world and it was minted by Yuga Labs on April 23, 2021. BAYC is a PFP project with a collection of 10,000 apes. Each ape is unique in the traits that it has such as different types of fur, facial expressions, or clothing. The floor price is $86.5k, average price is $112k and it has a market cap of $863mm. Yuga labs has a grand vision for this project and is trying to create an entire interactive universe to go along with the project. This project is quite unique in the crypto space because Yuga Labs has given intellectual property, commercial, and exclusive licensing rights to all members of the BAYC club. A lot of the value of owning a BAYC comes from interacting with the community in Discord and special BAYC only events.

Mutant Ape Yacht Club (MAYC):
MAYC is a collection of 20,000 mutant themed ape NFTs minted on August 28,2021 by Yuga Labs. This project was developed as a way to grow the Board Ape universe and has grown to become one of the most coveted PFPs in the NFT Market. MAYC are the product of introducing an existing BAYC to a mutant serum, this is where they get their unique traits. The mutant serum is an NFT that was first airdropped to existing BAYC members. They can also only be applied by BAYC members, or they can be held to be sold. There are 3 levels of mutant serum that have increasingly rare traits (M1: 7500, M2: 2492, M3: 8). The floor price is $18k and the

market cap of MAYC is $356mm. Some of the rare Mega Mutant NFTs (M3) can go for millions of dollars.

Moonbirds:

Moonbirds is a collection of 10,000 owl NFTs and it was minted by Proof Collective on April 16, 2022. The Proof Collective is an members-only exclusive NFT community that consists of 1,000 NFT collectors and artists. The Proof Collective was founded by prominent investor and podcaster Kevin Rose. 2,000 of the NFTs were distributed to Proof Collective Members and the rest were distributed in 3 batches. Moonbirds is one of the fastest growing PFP collections and within a few days had generated $300mm in secondary sales. Moonbirds has a unique feature that allows the owner to “Nest” the bird in a vault and earn interest based on how long the bird has been staked in this vault. This is good for the community because it allows the developers of the project to distribute any rewards to the community scaled by how committed the owner is to the project. The commitment is measured by how long the NFT has been nested.

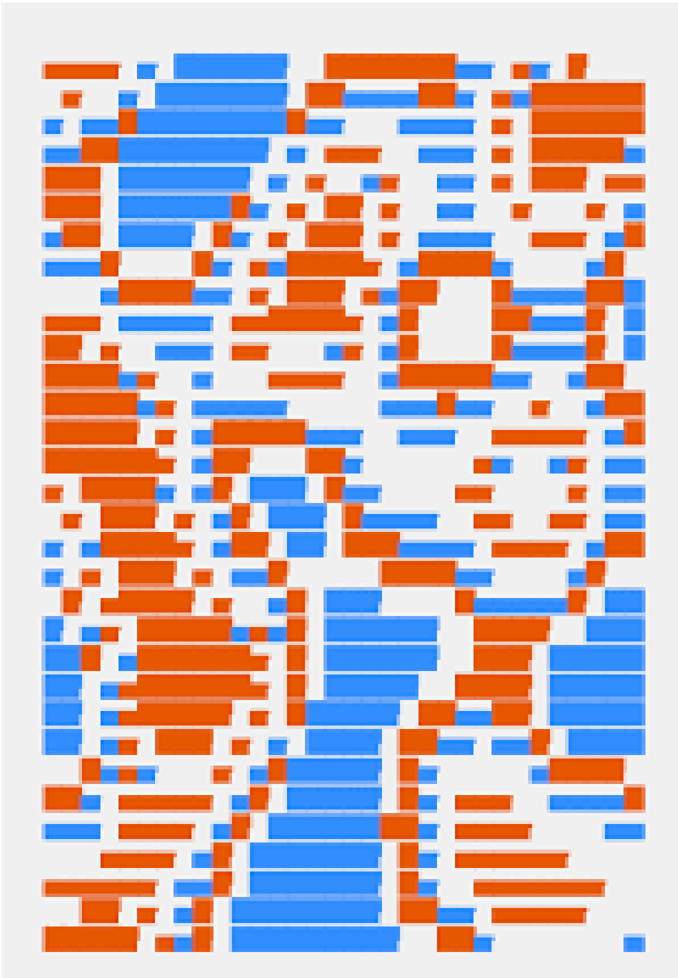
Doodles:
Doodles was minted on October 17, 2021 and is a collection of 10,000 generative NFTs consisting of different animals, humans and aliens. The developers were part of the team that developed the original iconic NFT CryptoKitties in 2017. The floor price is $9.5k and the market cap of the project is $85mm.

Azuki:
Azuki is a collection of 10,000 anime-inspired NFTs that was mined on January 12, 2022. Due to the high mint price and aggressive roadmap by the team it became one of the fastest growing projects in the PFP space. The avatars are a unique mix between the 3D action role-playing game, “The World Ends with You” and the epochal skateboarding magazine Thraser. The floor price is 16.5k and the market cap is $165mm. The project became embroiled in a scandal when the pseudonymous creator was found to have been involved in a few NFT projects that had scammed users.

The trading volume of the next two NFT projects is dominated by wash trading. Wash trading is a type of price manipulation that generally happens for two reasons. Some platforms such as LooksRare incentivize users with trading rewards. Wash traders conduct fake trades to win the rewards from the competitions. The second reason users will wash trade is to artificially inflate the trading volume so that projects seem more popular than they are.

Meebits (High Washtrading):
Meebits is a 20,000 NFT collection project developed by Larva Labs and minted in May 2021. Larva Labs is famous for creating the project that kicked off the PFP NFT Revolution with the collection Crypto Punks. While Crypto Punks are made for a 2D Avatar format, Meebits are made for the 3D VR/AR Avatar format. The floor price is 3.6k and the market cap is $72mm with some of the rarest Meebits going for over $1mm.

Terraforms (High Washtrading):
Terraforms are a 9909 NFT collection of on-chain land art that have been generated from a dynamic 3D World. The floor price is $2.4k and the market cap is $23mm.



Appendix: Experimental Results (cont.)

Union graph with Washtraded NFTs(Moonbirds, Azuki, BAYC, MAYC, Doodles, Meebits, Terraforms)), num_samples=10000, num_iter=5000

All Washed (Meebits, Terraforms)), num_samples=10000, num_iter=5000
all_washed (SCC): {1: 7536, 2: 327, 3: 40, 4: 20, 5: 6, 6: 4, 9: 3, 7: 2, 31: 2, 13: 1, 14: 1, 33: 1, 45: 1, 10: 1, 10205: 1}
all_washed (WCC): {1: 54, 2: 25, 3: 5, 4: 2, 18740: 1}
Path statistics: (degree = 63, avg_path_length = 9.29686065724247, connectivity = 0.5447)
Path Analysis: {'in': 0.0302, 'out': 0.416, 'tendrils': 0.012, 'scc': 0.5418}, {'out_from_in_nodes': 2.059602649006624, 'in_from_out_nodes': 3.333173076923076}

Network flow (num_iter=50, num_nodes=5):
Random Nodes: Average max flow, Min max flow = (1.2800000000000002, 1)

Top n Node only (source by out-degree, sink by in-degree): (846.3181818181819, 534)

Network flow (num_iter=50, num_nodes=10):
Random Nodes: Average max flow, Min max flow = (1.3000000000000005, 1)
Top n Node only (source by out-degree, sink by in-degree): (427.67741935483866, 205)

Highest degree address: 0x620b70123fb810f6c653da7644b5dd0b6312e4d8

Union of washtraded NFTs (Meebits, Terraforms), num_samples=10000, num_iter=5000
all_washed (SCC): {1: 7536, 2: 327, 3: 40, 4: 20, 5: 6, 6: 4, 9: 3, 7: 2, 31: 2, 13: 1, 14: 1, 33: 1, 45: 1, 10: 1, 10205: 1}
all_washed (WCC): {1: 54, 2: 25, 3: 5, 4: 2, 18740: 1}
Path statistics: (degree = 63, avg_path_length = 9.146656950264072, connectivity = 0.5489)
Path Analysis: {'in': 0.0332, 'out': 0.4152, 'tendrils': 0.0154, 'scc': 0.5362}, {'out_from_in_nodes': 2.1987951807228914, 'in_from_out_nodes': 3.513969171483623}

Network flow (num_iter=50, num_nodes=5):
Random Nodes: Average max flow, Min max flow = (1.2400000000000004, 1)
Top n Node only (source by out-degree, sink by in-degree): 101.13636363636363, 33)

Network flow (num_iter=50, num_nodes=10):
Random Nodes: Average max flow, Min max flow = (1.1400000000000003, 1)
Top n Node only (source by out-degree, sink by in-degree): (74.88541666666666, 32)

Highest degree address: 0x83c8f28c26bf6aaca652df1dbbe0e1b56f8baba2

BAYC, num_samples=10000, num_iter=5000
Bayc (SCC): {1: 7863, 2: 491, 3: 125, 4: 27, 5: 11, 6: 3, 9: 1, 7: 1, 12708: 1}
Bayc (WCC): {2: 7, 3: 5, 5: 2, 1: 2, 22058: 1, 6: 1, 20: 1}
Path statistics: (degree = 28, avg_path_length = 7.884801381692535, connectivity = 0.579)
Path Analysis: {'in': 0.0094, 'out': 0.4076, 'tendrils': 0.0042, 'scc': 0.5788}, {'out_from_in_nodes': 1.851063829787234, 'in_from_out_nodes': 2.3842001962708546}

Network flow (num_iter=50, num_nodes=5):
Random Nodes: Average max flow, Min max flow = (1.22, 1)
Top n Node only (source by out-degree, sink by in-degree): 226.00000000000003, 139)

Network flow (num_iter=50, num_nodes=10):
Random Nodes: Average max flow, Min max flow = (1.34, 1)

Top n Node only (source by out-degree, sink by in-degree): (139.84375000000003, 92)

Highest degree address: 0xc310e760778ecbca4c65b6c559874757a4c4ece0

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