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# DiLeNA: Distributed Ledger Network Analyzer

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# Graphs



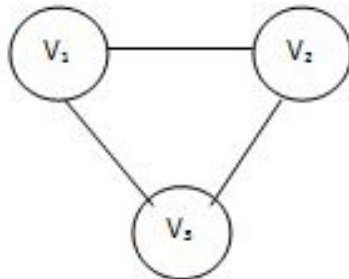
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A graph consists of a set of nodes and edges (links between two nodes).

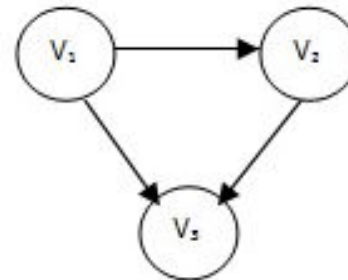
A graph can have multiple meanings, for example nodes can be entities and the edges can represent interactions between two entities.

Graphs can either be directed or undirected.

**Undirected Graph**



**Directed Graph**



# Metrics on the graphs



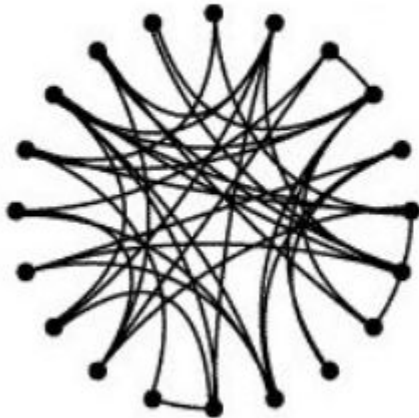
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- **Degree Distribution**, it indicates which is the percentage of nodes having a certain number of connections. In directed graphs one can refer to in-degree, out-degree or total degree.
- **Average shortest path length**, it indicates the average shortest path between any two couples of nodes. Shortest paths can be computed with Dykstra algorithm
- **Average clustering coefficient**, that is the average of the clustering coefficients of all the nodes. The clustering coefficient of a node is the fraction that indicates how many edges between his neighbors exist among all the possible ones.

# Graphs Topologies



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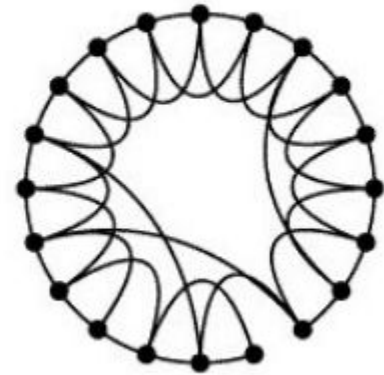
Random graph



Scale-free graph



K-regular graph



Small world graph

# Erdos - Renyi Model



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Erdos Renyi Model is the most used technique to generate a random graph of a given size.

There are two variants of the algorithm:

1. The user inserts the number of nodes and edges to be created.
2. The user inserts the number of nodes and the probability that there is a connection between two nodes.

# Small World Graph



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Small world graphs are a graph topology where most of the nodes are not connected to each other, but most of the vertices can be reached by other nodes through a short number of hops.

To investigate if a graph has small world properties, it is necessary to make a comparison with a random graph of the same size.

The analyzed graph must have:

- A similar or minor average shortest path length compared to the random graph
- A significantly higher average clustering coefficient

# DILENA



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DILENA is a software tool for the analysis of the graphs based on networks' transactions. It is structured in two parts:

- Graph Generator: the transactions of a certain blockchain referring to a specified period of time are downloaded and the corresponding directed graph is created.
- Graph Analyzer: some metrics are calculated on the graph, in order to determine whether it has small world properties or it doesn't.

# Setup and Methodologies



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Blockchains analyzed: **Bitcoin** and **Ethereum**



**bitcoin** ethereum

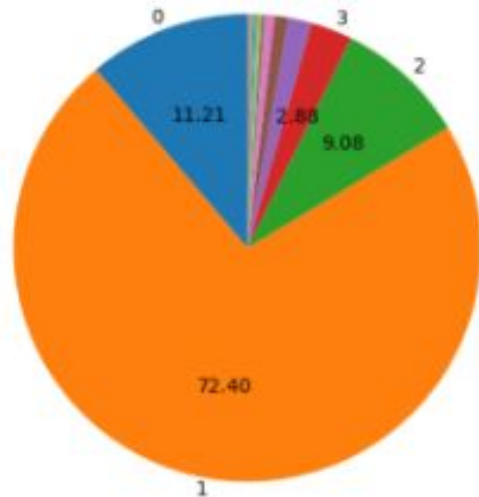
Period of time considered: december 2010 for Bitcoin, December 2016 for Ethereum. The aim was to analyze a full month in the second year of life of the cryptocurrencies.



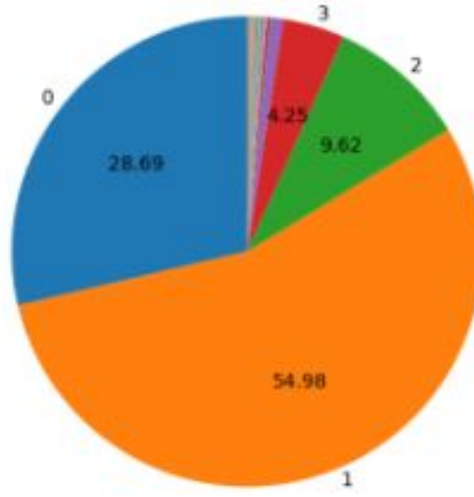
# Ethereum Degree Distribution



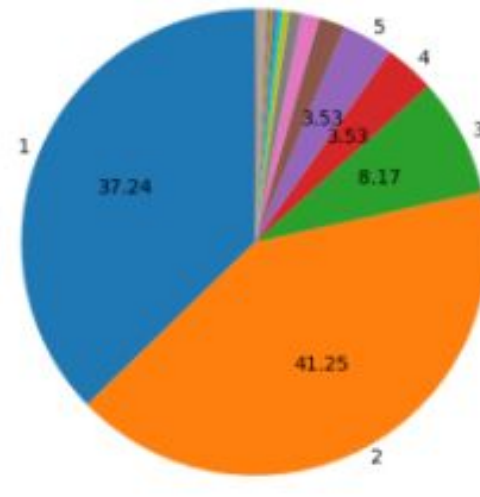
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(a) Ethereum in degree distribution



(b) Ethereum out degree distribution



(c) Ethereum total degree distribution



The node with the highest degree showed an amount of connections with almost the 10% of the node set.

Around 10 nodes with a degree higher than 2000



# Metrics on Ethereum

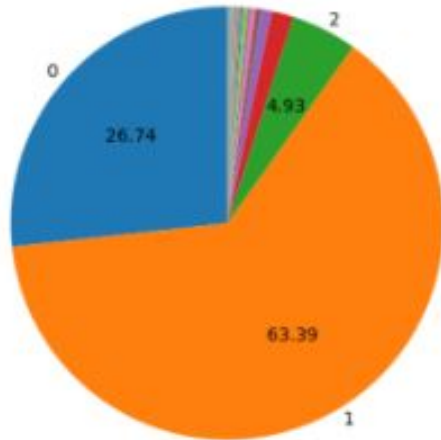
Graph	Graph ACC	Main Component ASPL	Main Component ACC
<i>Ethereum</i>	0.02099	1.4256	0.02134
<i>Random</i>	0.000014	10.3584	0.000015

- The ratio of the average clustering coefficient between the Ethereum and the random generated graph is 1469 
- The ratio of the average shortest path length between the Ethereum and the random generated graph is 0.14 

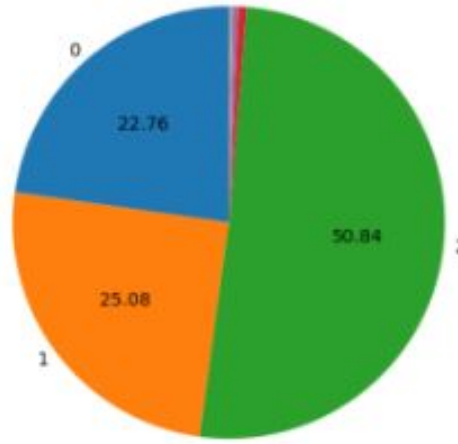
# Bitcoin Degree Distribution



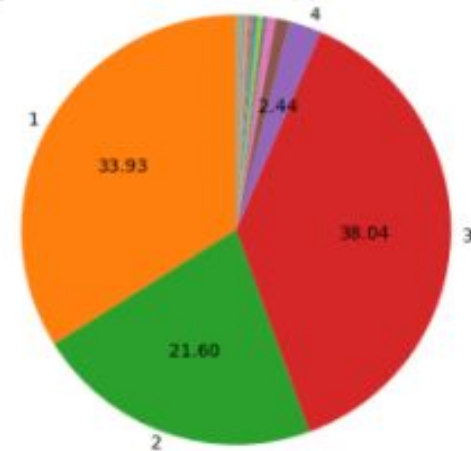
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(a) Bitcoin in degree distribution



(b) Bitcoin out degree distribution



(c) Bitcoin total degree distribution



Almost 1/2 of the nodes has either 0 in-degree or 0 out-degree

Few nodes with a very high degree, acting as hubs of the network

# Metrics on Bitcoin



Graph	Graph ACC	Main Component ASPL	Main Component ACC
<i>Bitcoin</i>	0.0235	190.4879	0.024
<i>Random</i>	0.000026	6.461	0.000029

- The ratio of the average clustering coefficient between Bitcoin and the random generated graph is 828 
- The ratio of the average shortest path length between Bitcoin and the random generated graph is 29.5 

# Possible Extensions to DILENA



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- Analyze other distributed ledgers



- Increase the level of parallelization

# Conclusions



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Ethereum transactions graph has small world properties, while the Bitcoin's one has not.

## WHY?

- Presence of smart contract in Ethereum (many interactions among groups of users are performed through smart contracts, that thus become common network neighbors to all these users).
- Consistent presence of anonymous accounts.