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# A VISUAL LANGUAGE FOR CRYPTOCURRENCY TECHNOLOGIES EXPLORATION

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***Abstract.*** — In this report I describe some early work investigation on how to represent a massive complex graph, the Bitcoin blockchain network. Through visual clues and topology analysis, I explore different representation of the 130 GB connected graph as long as educational material to make the learning of Blockchain based technologies more easy to understand and pass on. This includes the development of an abstract visual language for design integrated in some gamification and videos, focusing on mining and block per block visualization.

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## 1. Introduction

Distributed Ledgers technologies are now well known by the public as Bitcoin price skyrocketed to 16000 USD per BTC early December 2017. Yet, even if everybody has heard about them, few understand what is behind the scene.

This paper is the opportunity not only to explore the different uses of different ledgers through different use cases such as anonymity, money laundering

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***Key words and phrases.*** — blockchain, bitcoin, graph, visual language.

on coin mixing services and exchanges but also to develop some resources to make the explanation of such a sophisticated system easier. The motivation to start this project is coming from a course that I followed last semester called COMP 6111C - Blockchain and Cryptocurrency Technologies on which the focus was on describing research issues related to Bitcoin exploration.

As visualization is key for explanation in this field, I started to aggregate all the interesting visual resources I found on the way, leading me to create a new platform with new resources that I could create on my own.

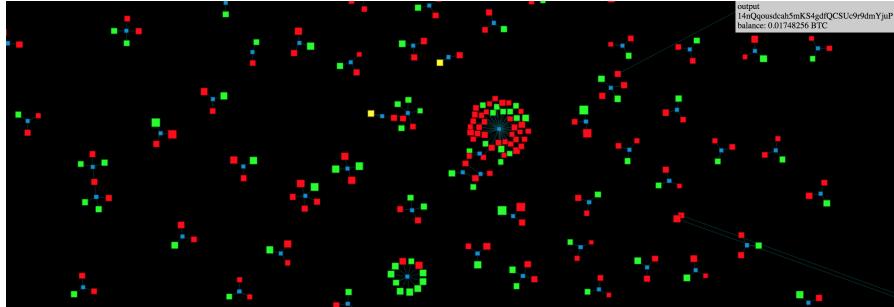
The Princeton course for example is one of the best open examples of Blockchain technology I bumped into: <http://bitcoinbook.cs.princeton.edu>. There is probably no need to go too much into details here about how it works, as we're going to see it along this report.

## 2. Awesome Blockchain Visualisation Initiative

The Awesome Blockchain Visualisation repo is a public domain (license 0) initiative to aggregate a curated list of interesting visualisations around the blockchain ecosystem. It can be found at <https://github.com/xpfio/awesome-blockchain-visualisation> and guidelines for contributing are included in <https://github.com/xpfio/awesome-blockchain-visualisation/blob/master/CONTRIBUTING.md>. In this section we are going to explore the different subsection of existing work on Blockchain visual language and we'll later explore what was built on top of it.

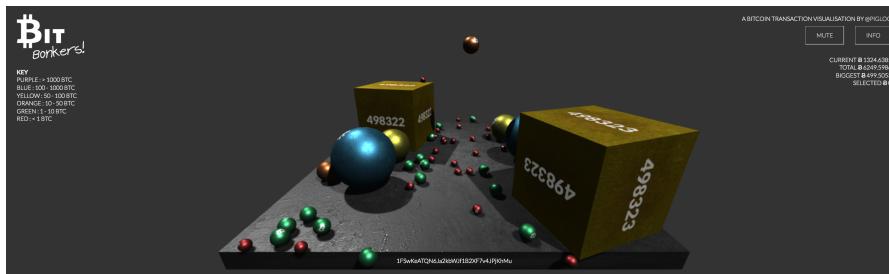
### 2.1. Transactions

The first category we are going to explore are transactions visualisation. The Bitcoin blockchain allows users to transfer some funds (bitcoin) from a public address to another. The whole point of the system is to make it in a secure manner, where every workers, miners, will verify the transactions to avoid unwanted spendings, such as stealing or double spending. Daily Blockchain is an interesting real time visualisation of transactions added to the Mempool, here the color encoding is relatively straight forward: green is an input, red is an output and blue is a transaction between inputs and outputs. This lead to this very interesting visualisation that inspired the block visualisation we are going to see later.



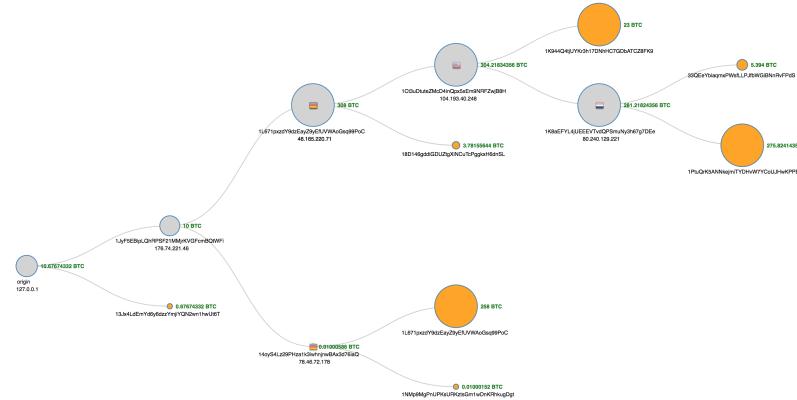
Daily Blockchain Transaction Visualisation

BitBonkers choose a different approach, representing only the amount of bitcoin that are exchanged in real-time, giving us a sense of how big those transactions are. For example, in the example below, blue balls represent transaction between 100 and 1000 BTC, between 1.6 and 16 million USD, and seeing them is fairly common, just like seeing a purple ball (a transaction of more than 16 million USD, as of the 9th December 2017)



BitBonkers Transaction Visualisation

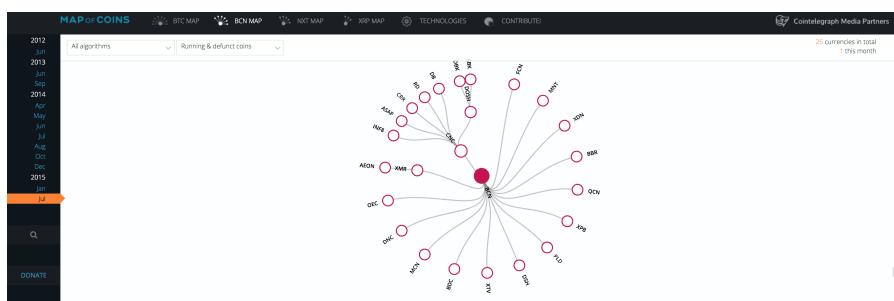
Blockchain.info has a very interesting tree view to explore the data, with a lot of interactions, giving us a great sense of where and how the money flows, transactions after transactions.



Blockchain.info Transaction Visualisation

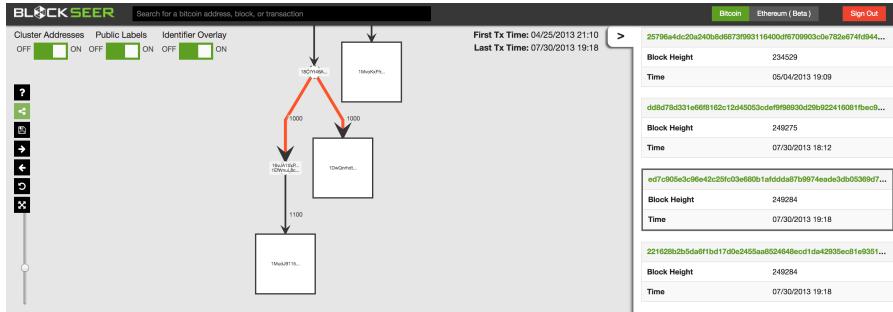
## 2.2. Exploration Tools

Exploration tools are very powerful and gives an idea about the history of a given coin. This is what MapCoin did, tracing all the forks for a given cryptocurrency and the result is very interesting.



Map Coin History Exploration

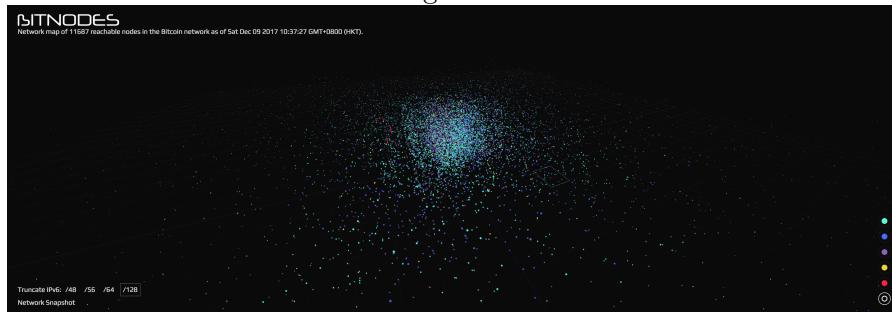
BlockSeer is just like Blockchain.info exploration, with more features that allows the user to get a nice overview of what happened for a given account and follow up the transactions.



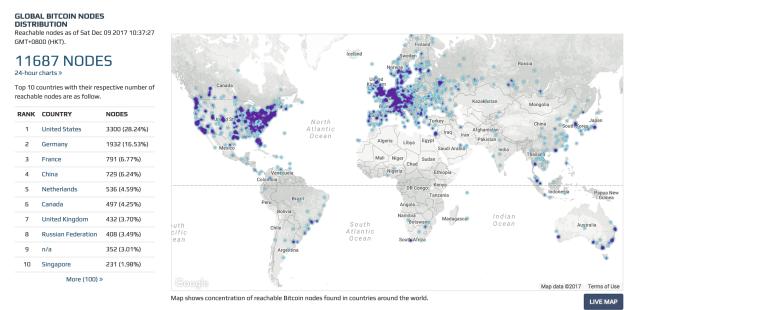
Block Seer Exploration Tools

### 2.3. Nodes and Blockchain Status

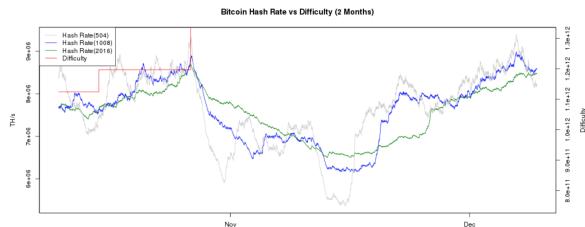
To validate transactions, the blockchain network miners are trying to solve a puzzle which difficulty depends on the total computation power of the network, illustrations below from bitnodes give us an idea of how the miners are working.



BitNodes System Overview



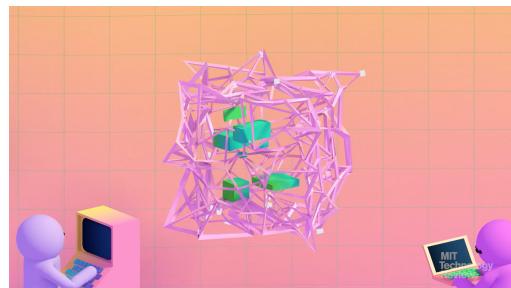
BitNodes Map



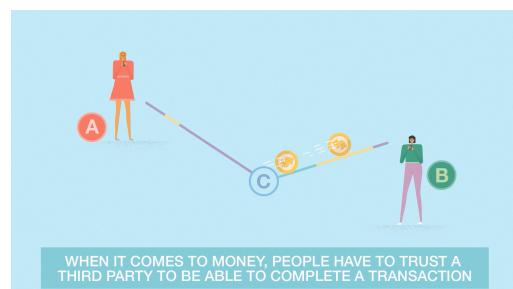
Difficulty Chart

## 2.4. Video

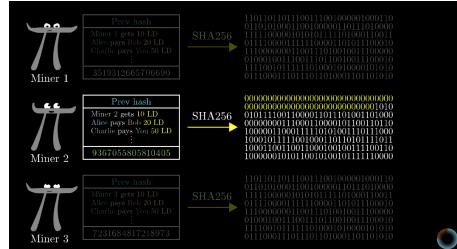
Videos are a great way to convey a convincing message, and some developed very interesting way to explain and visualize how blockchain was working, here are 3 very interesting videos that are worth watching to get a sense about what it means to conceptualize the technologies.



Blockchain Explainer - MIT Technology Review



WEF: Blockchain



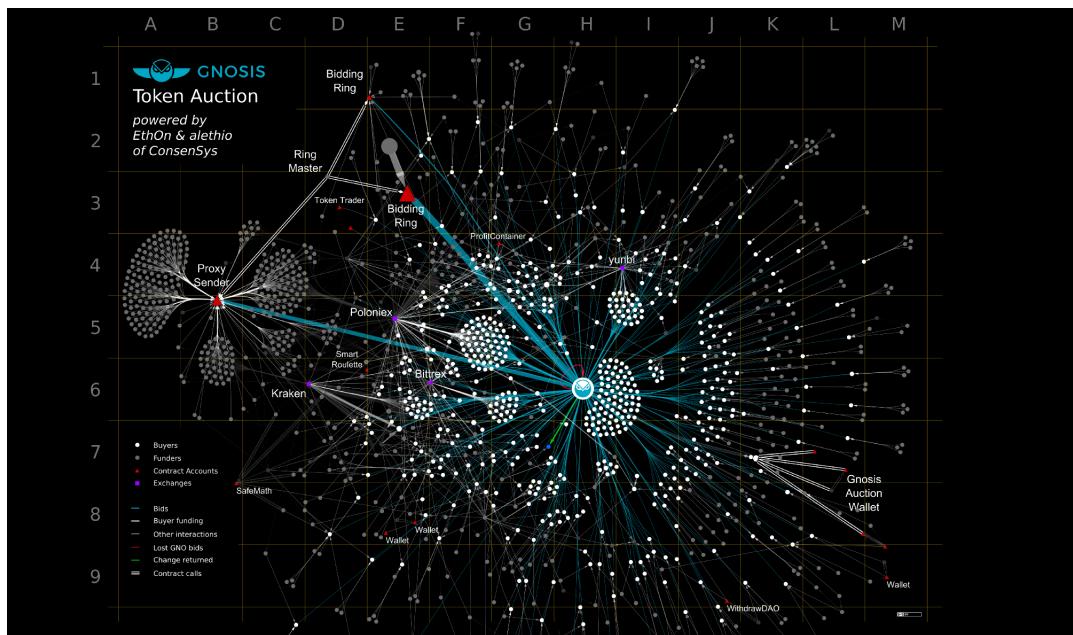
3Blue1Brown - Ever wonder how Bitcoin (and other cryptocurrencies) actually work?

## 2.5. Articles

Two very interesting papers were published regarding Bitcoin visualisation: Visualizing Dynamic Bitcoin Transaction Patterns and BitConeView: Visualization of Flows in the Bitcoin Transaction Graph, they are worth reading and provide interesting directions to explore.

## 2.6. Other

Many other great works around visualising blockchain technology has been done, if you know any, feel free to contribute, I'll just add some here that are worth looking at but don't add much to what has already been said.



Ethereum - The Gnosis Token Auction



Elliptic.co

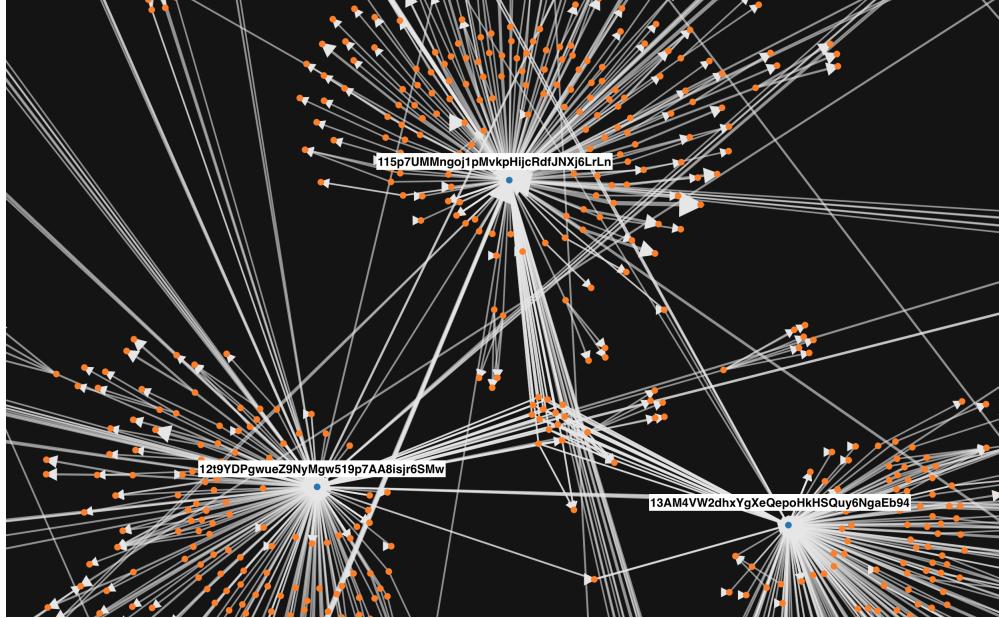


Cryptowatch

### 3. Transaction Visualisation

Code for this section available at [https://github.com/xpfio/blockchain\\_viz](https://github.com/xpfio/blockchain_viz)

I built the kick-off of a visualisation of the bitcoin blockchain. The transactions stored in each block create a large oriented graph that we wanted to explore in-depth. I focused on a particular ransomware, WannaCry, which used bitcoin for money transactions. From the 12 May 2017, infected people transferred around 300 USD to 3 particular bitcoin addresses: 115p7UMMnogoj1pMvkpHjcRdfJNXj6LrLn, 12t9YDPgwueZ9NyMgw519p7AA8isjr6SMw and 13AM4VW2dhxYgXeQepoHkHSQuy6NgaEb94. The graph built provide the tools to understand where to money was coming from and where it went, potentially identifying hackers as the money was withdrawn at some point.



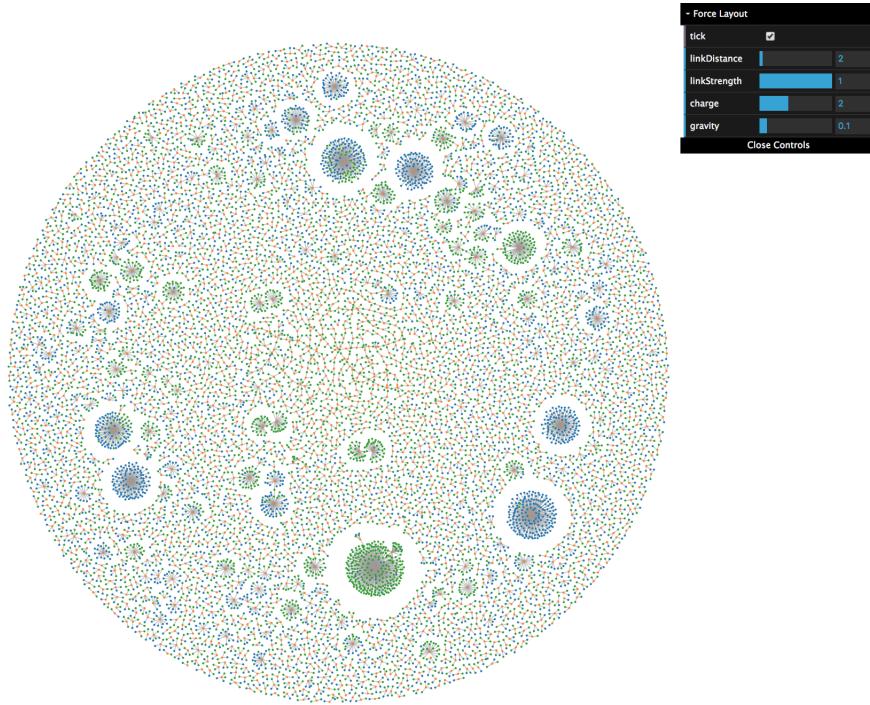
This visualisation is giving us a powerful tool to explore the network, yet as the time is not involved, there is a big part of it that is missing. This is what I explored in a second time with block visualisation.

#### 4. Block Visualisation

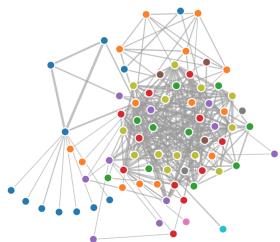
Code for this section available at [https://github.com/xpfio/blockchain\\_block\\_visualisation](https://github.com/xpfio/blockchain_block_visualisation)

A block contains a large number of transactions and are later added to the blockchain when validated and when a nonce produces a block hash that matches current difficulty. They contain precious information and explain some of the Blockchain history, like the block chain size controversy, which lead to some DDoS attacks on the blockchain itself as demonstration, or money laundering patterns, which are well explained in the precedent paper mentioned.

I choose a new visual encoding for block visualisation, using a force directed layout in d3js, and some fine tuned parameters with a new interface to choose them carefully. This project has been open sourced recently and can be found at <https://xpfio.github.io/d3-force-visual/>.



Regular Block and its editor

**D3 Force Layout****d3.forceCenter**

Active

Name

force.x  237

force.y  250

**d3.forceCollide**

Active

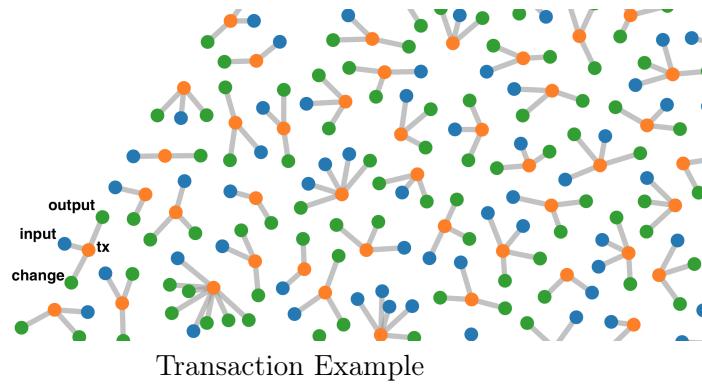
Name

radius  11

Open sourced General Force Layout Editor

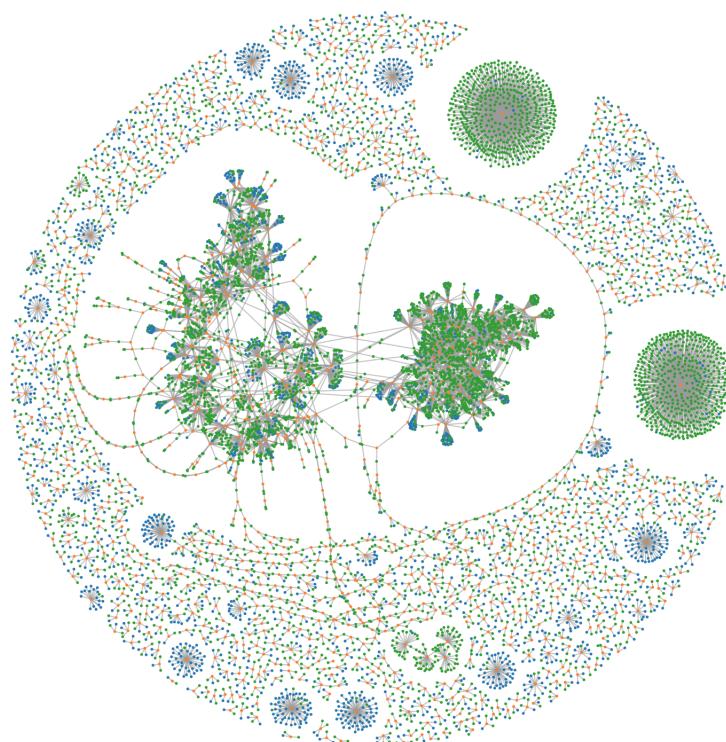
The encoding scheme for the layout is inspired from the existing work. Inputs are blue, outputs are green and transactions are represented in orange. This reveals very interesting patterns when displayed on a force layout. To represent each block, I wrote a simple Javascript web app that take as input a graph generated in Python from the blockchain.info API, and applied 3

forces: a gravity force to center the graph, a link force to make the nodes come closer if they are linked with each other and a collision force for the nodes to repeal each other. Fine tuning the visualisation with different parameters that evolves over time to find the best (visual) layout. Once this part was automated, I used a Selenium web driver to render multiple graphs and ran about 1000 renderings over night ( 40/60 seconds to render the layout on my computer). I aggregated some interesting results and created a video around this visualisation with some nice screenshots available on the README.



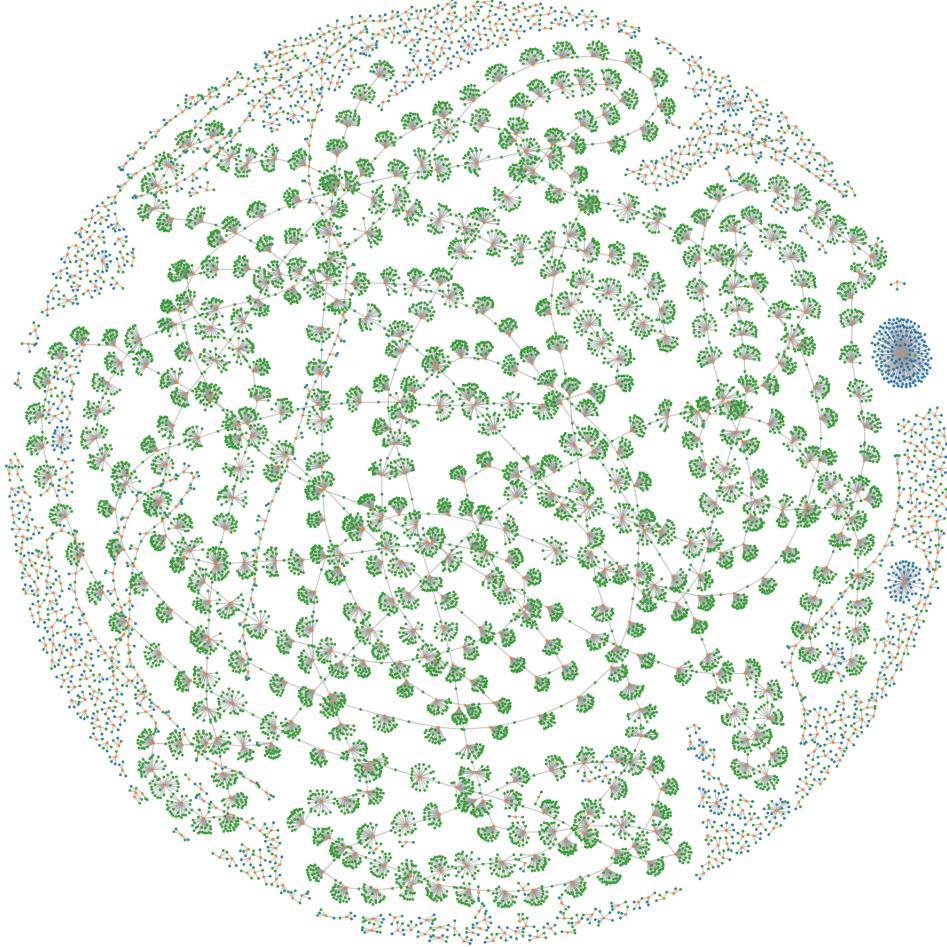
The next visualisation describes abnormal blocks, some attacks were observed during some specific periods of time and I just focus on them, knowing that abnormalities were going to be found there. It might be very interesting in future work, to study the degree or longest paths between nodes inside a block to find similar blocks automatically. Next pictures are describing two blocks, an unknown attack and a parasite

attack, where small amounts of bitcoin were exchanged between similar nodes to overload the network, we can see it as a DDoS attack.



Block

00000000000000000000549f8d5cf9037b4b2f10cbba695a40e537b179af8d6fae



Block  
000000000000000000a529be68d2cfb3eb80cf91ce75c4e0aacd388fbe2aa883  
(Parasite Attack)

## 5. UI Elements

The code for this section is available at <https://github.com/xpfio/bitcoin-clicker>

To describe the blockchain features, I studied some visualisation and created a small game around it that can be used as real-time visualisation of the network status or educational material. Those elements includes: a network visualisation and the propagation of information over its nodes, SHA256 hash function and its link to the difficulty (target) of block mining,

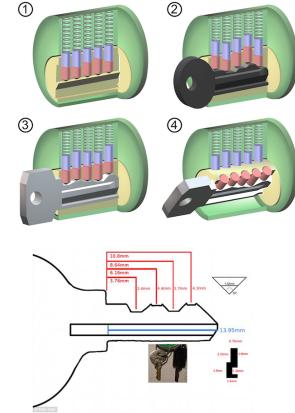
the mining ecosystem and some examples of tools that can be used to mine, cool down computers and electricity related, the merkle tree used to verify and check efficiently the transactions, the coinbase that generated new bitcoins as rewards, the UTXO (unspent transactions outputs) which is a database of the bitcoin that can be used as inputs for new transaction and the mempool, containing the transactions to be included in the blocks.



UI Elements of Blockchain technology

The inspiration for the layout is coming for different sources, I aggregate some of the prevalent sources for reference below, this gives an overview of the design process and constitutes a first attempt to develop a visual language around the blockchain technology ecosystem. The game is playable already but is far away to be in its final version, any feedback will be greatly appreciated! Next step will include, as described before, graph mining on the blockchain to find key blocks/wallets/transactions to visualise, and a global view of what

happened and what is happening on the blockchain.



References for UI Design

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