Distributed Ledger Technology Workshop
1 - 02 - 2018

An analysis of the Bitcoin Users Graph: Detecting Artificial Behaviours

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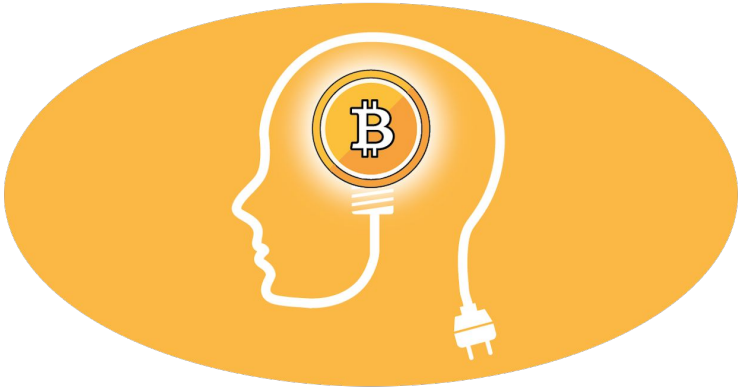
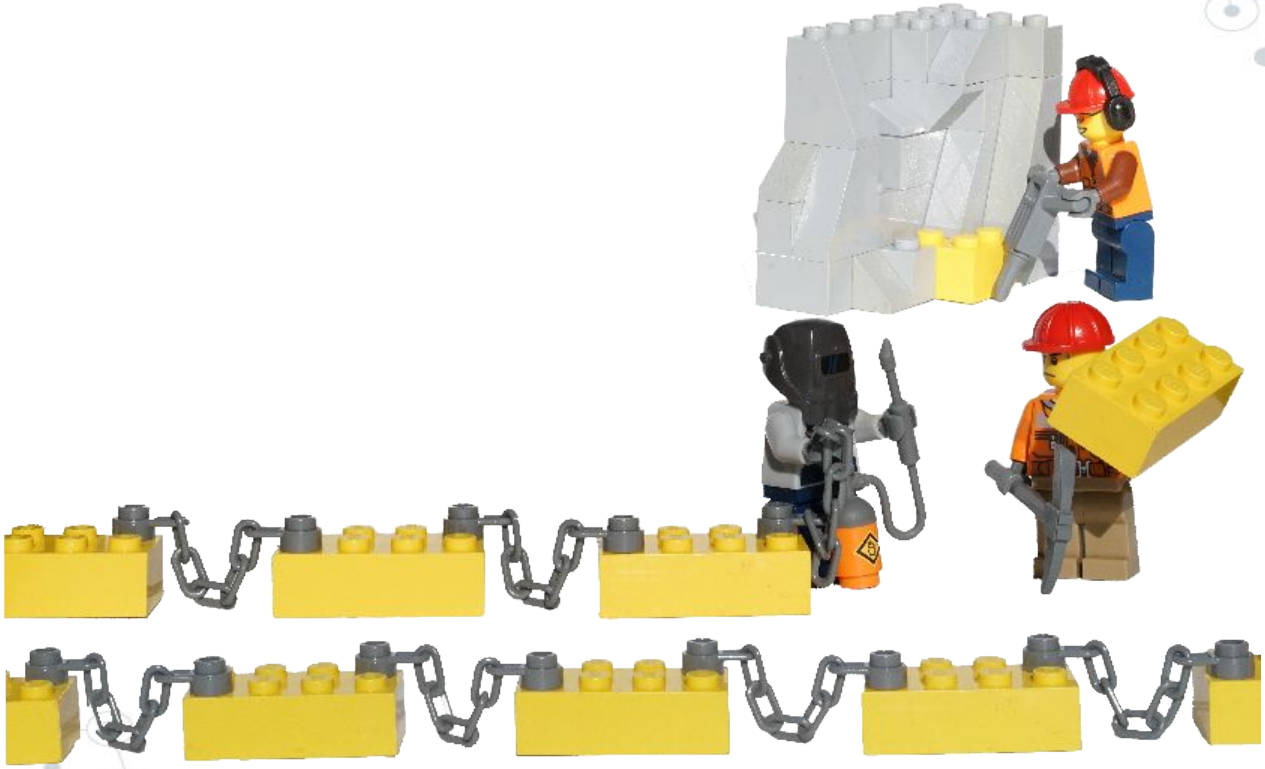
Key words

Bitcoin



Users Graph

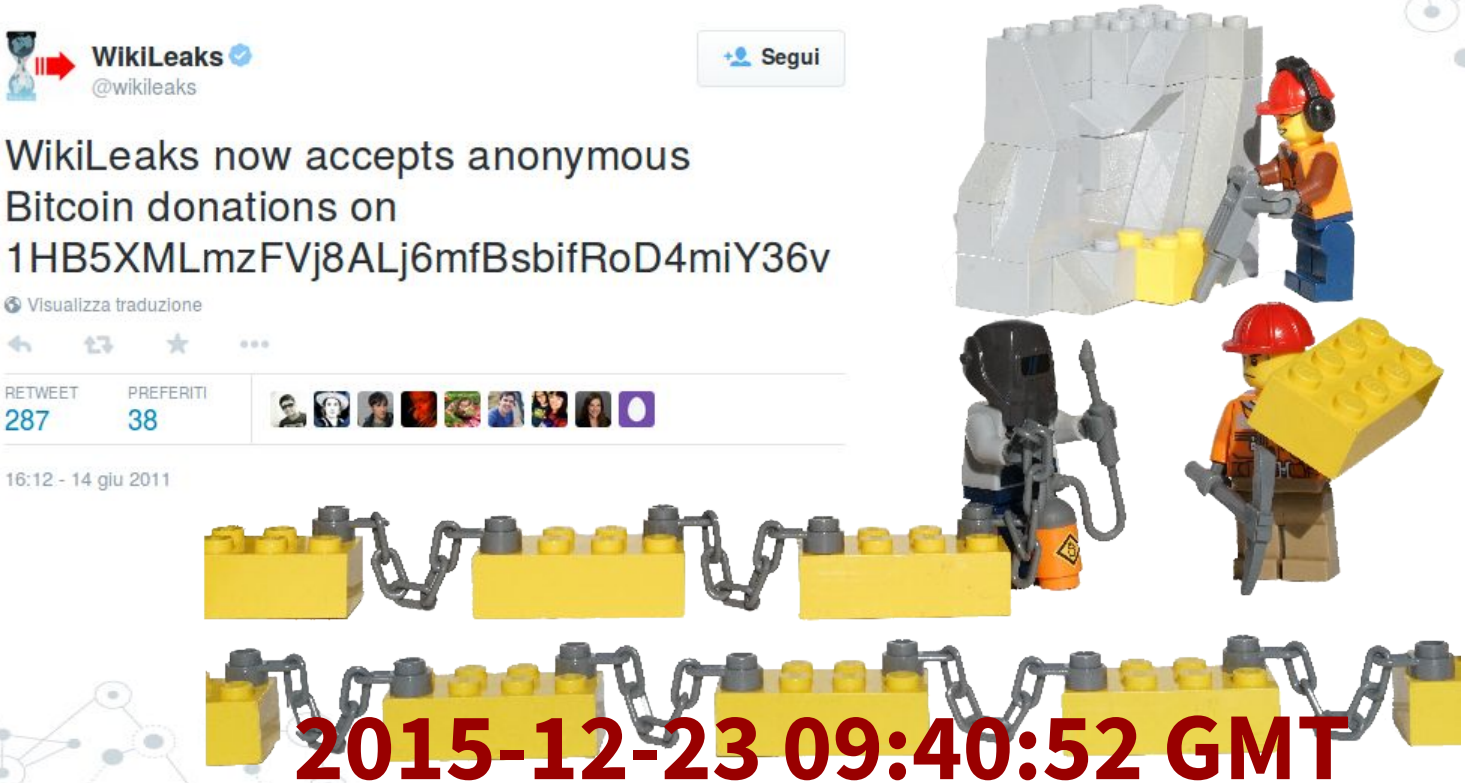
Data:



Data: Bitcoin Blockchain

2015-12-23 09:40:52 GMT

Data: Bitcoin Blockchain + External Informations



2015-12-23 09:40:52 GMT

Deanonymization Attack

blockchain

⇩

transactions graph

heuristic based clustering

⇩

users graph

external informations

⇩

identities graph

Pseudonymity

1Ez69SnzzmePmZX3WpEzMKTrcBF2gpNQ55

Pseudonymity

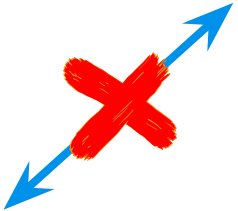
1A1zP1eP5QGefi2DMPTfTL5SLmv7DivfNa

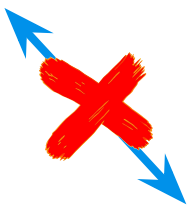
1Ez69SnzzmePmZX3WpEzMKTrcBF2gpNQ55

1XPTgDRhN8RFnzniWCddobD9iKZatrvH4

Pseudonymity

Pseudonymity



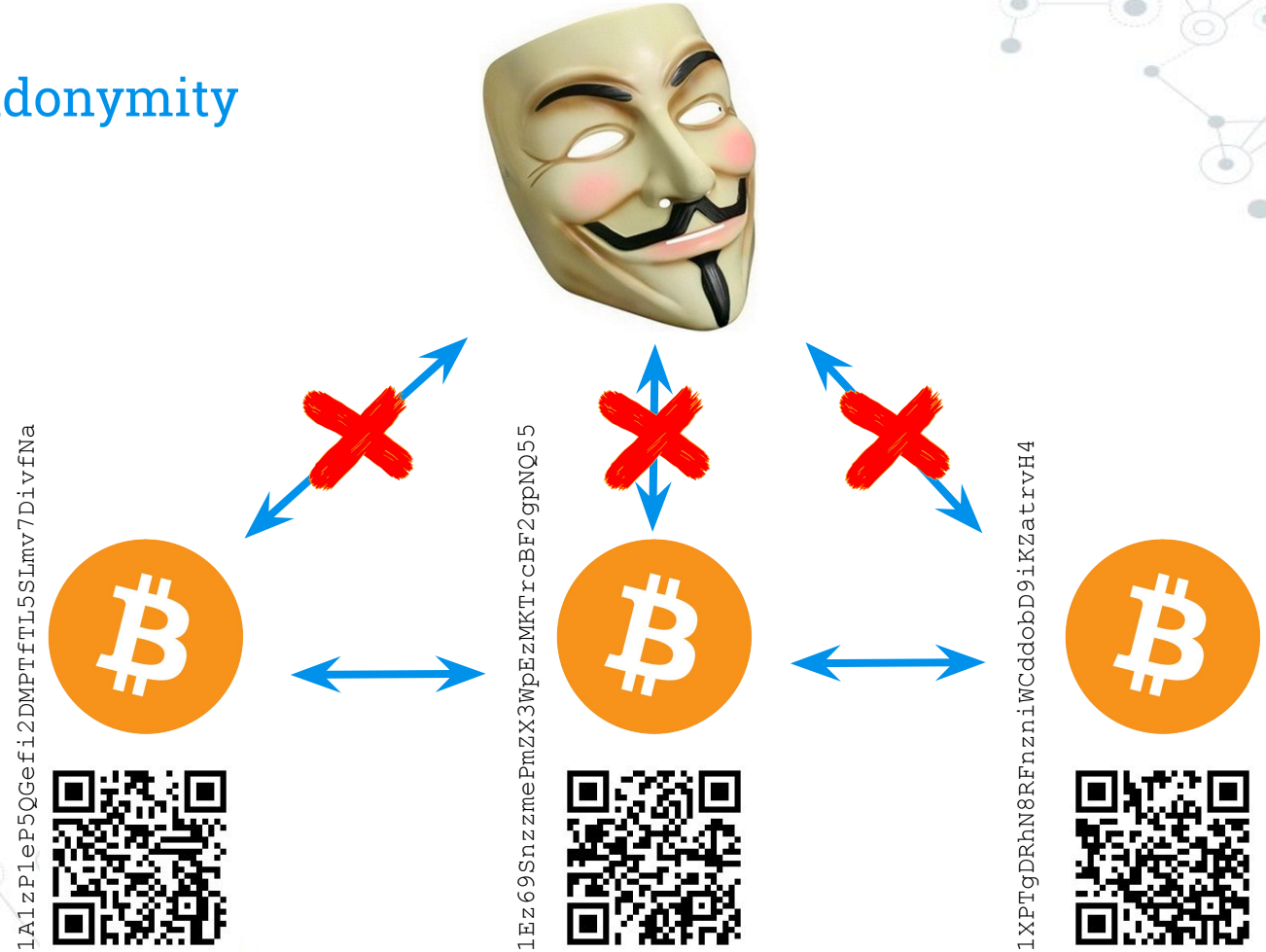


1A1zP1eP5QGefi2DMPTfTL5SLmv7DivfNa

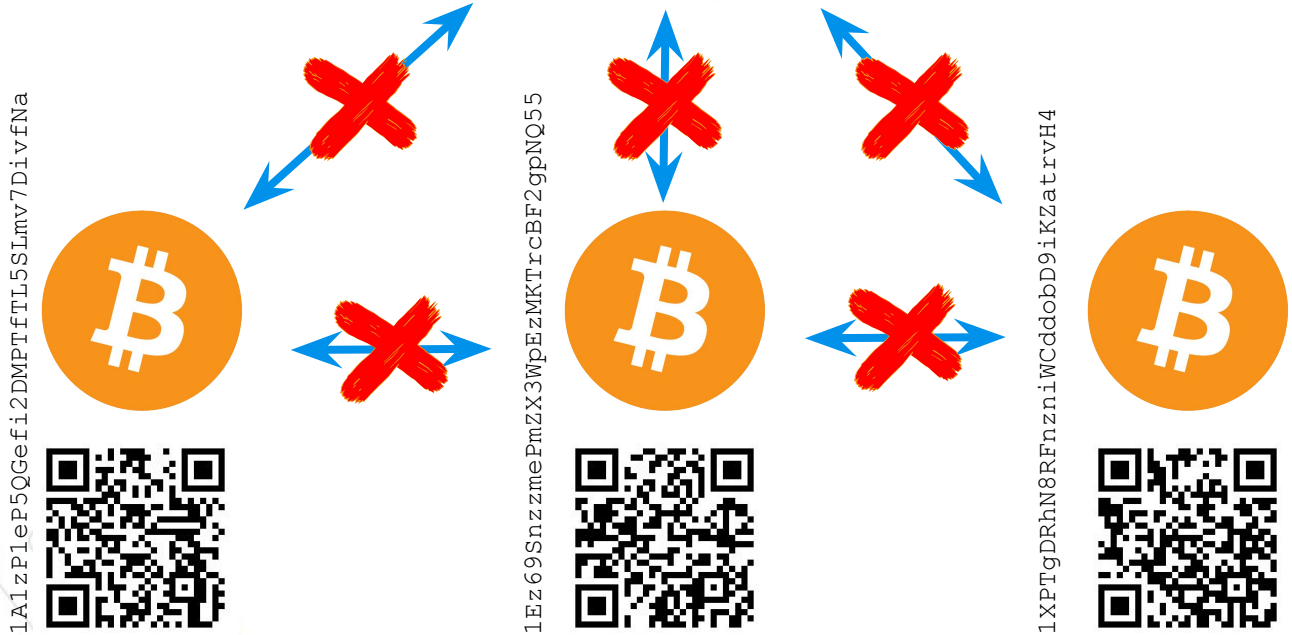
1Ez69SnzzmePmZX3WpEzMKTrcBF2gpNQ55

1XPTgDRhN8RFnzniWCddobD9iKZatrvH4

Pseudonymity



Pseudonymity



Deanonymization Attack

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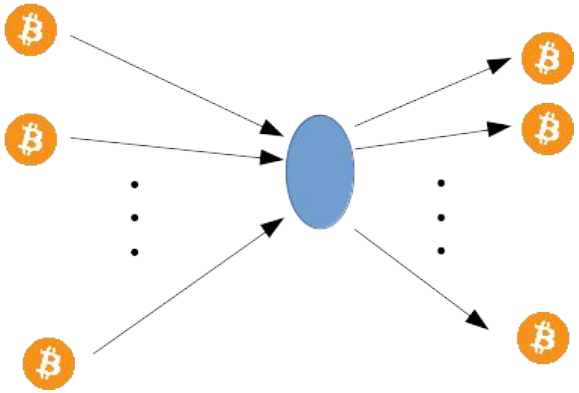
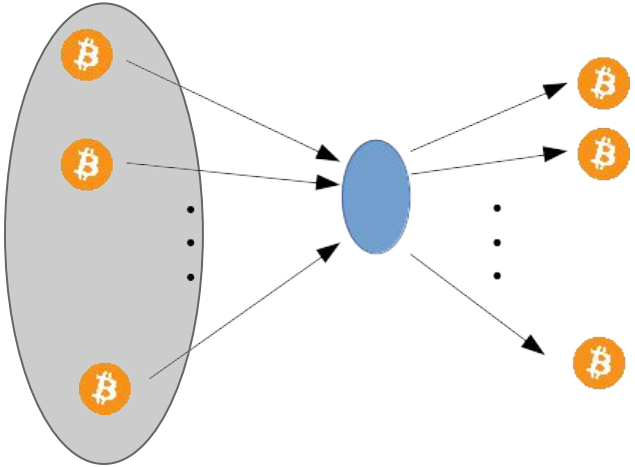
Common inputs heuristic clustering



Common inputs heuristic clustering



$$O(|A| + \sum_{(A_1,A_2)\in T} (|A_1| + |A_2|))$$

Users Graph:

Weighted directed multigraph

- **46,144,246** Nodes
- **294,705,549** Edges

Densification, distance analysis, degree distribution, clustering coefficient and several centrality measures

WebGraph

Definition of richness:

$$d^t(u) = |\{(v,u) \ : \ (v,u) \in E^t\}|$$

Definition of richness:

$$b^t(u) = \sum_{(v,u)\in E^t} w(v,u) - \sum_{(u,v)\in E^t} w(u,v) - \phi^t(u) + \beta^t(u)$$

$$d^t(u) = |\{(v,u) \ : \ (v,u) \in E^t\}|$$

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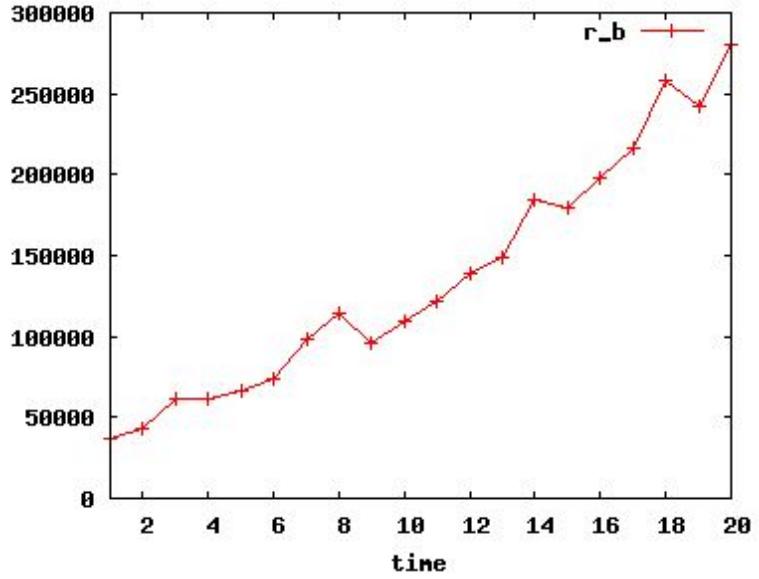
$$d^t(u) = |\{(v,u) \ : \ (v,u) \in E^t\}|$$

Rich get Richer:

- The richest users at time *t* are richer than the richest users at time *t'*<*t*.

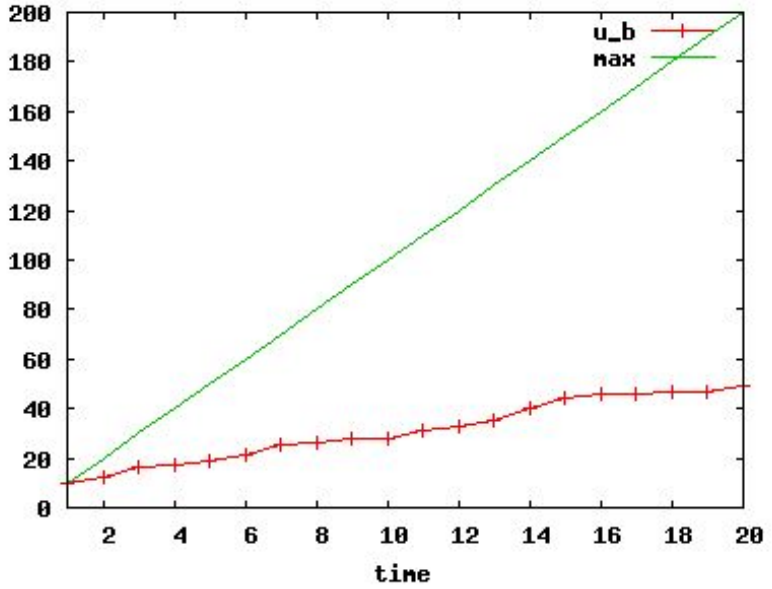
$$r_b^t = \frac{\sum_{u \in B_k^t} b^t(u)/k}{\sum_{u \in V^t} b^t(u)/|V^t|}$$



Rich get Richer:

- The richest users at a certain time *t* tend to remain the richest at time *t'*>*t*.

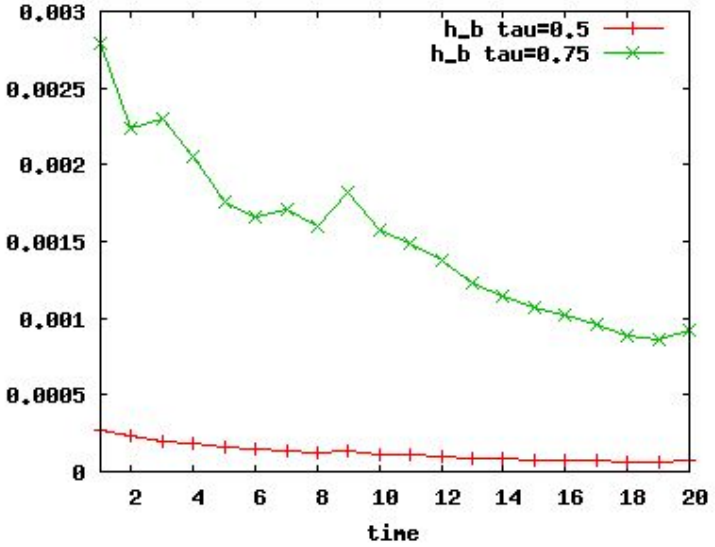
$$u_b^t = |\bigcup_{i=1}^{t} B_k^i|$$



Rich get Richer:

- The richness gets more concentrated with the progression of time.

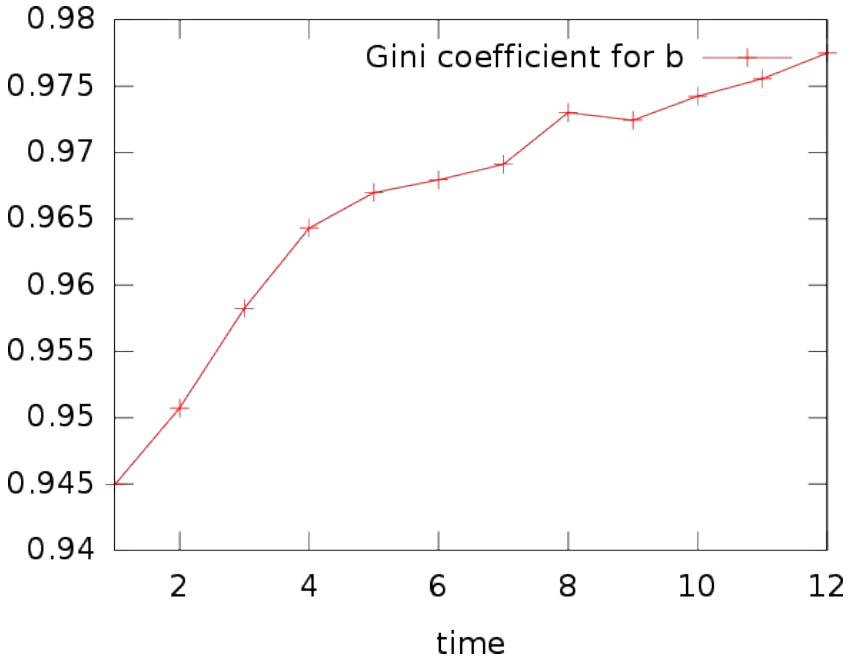
$$h_b^t = min\left\{ k \ : \ \frac{\sum_{u \in B_k^t} b^t(u)}{\sum_{u \in V^t} b^t(u)} > \tau \right\} / |V^t|$$

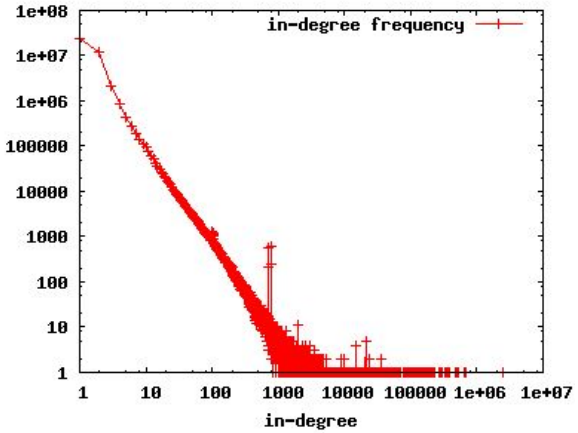


Rich get Richer:

- Gini coefficient.

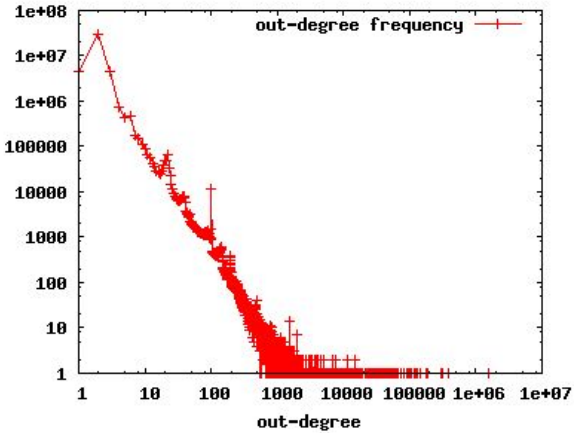
$$G = \frac{2\sum_{i=1}^{n} i x_i}{n\sum_{i=1}^{n} x_i} - \frac{n+1}{n}$$



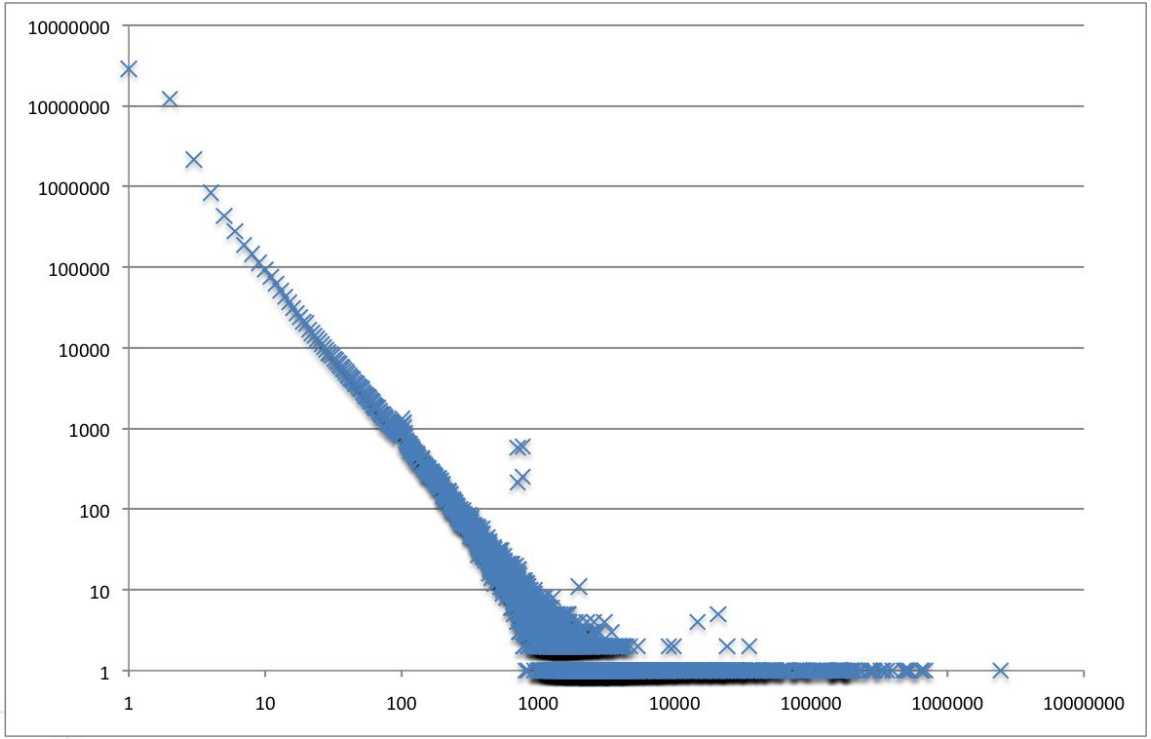


Small World Anomalies

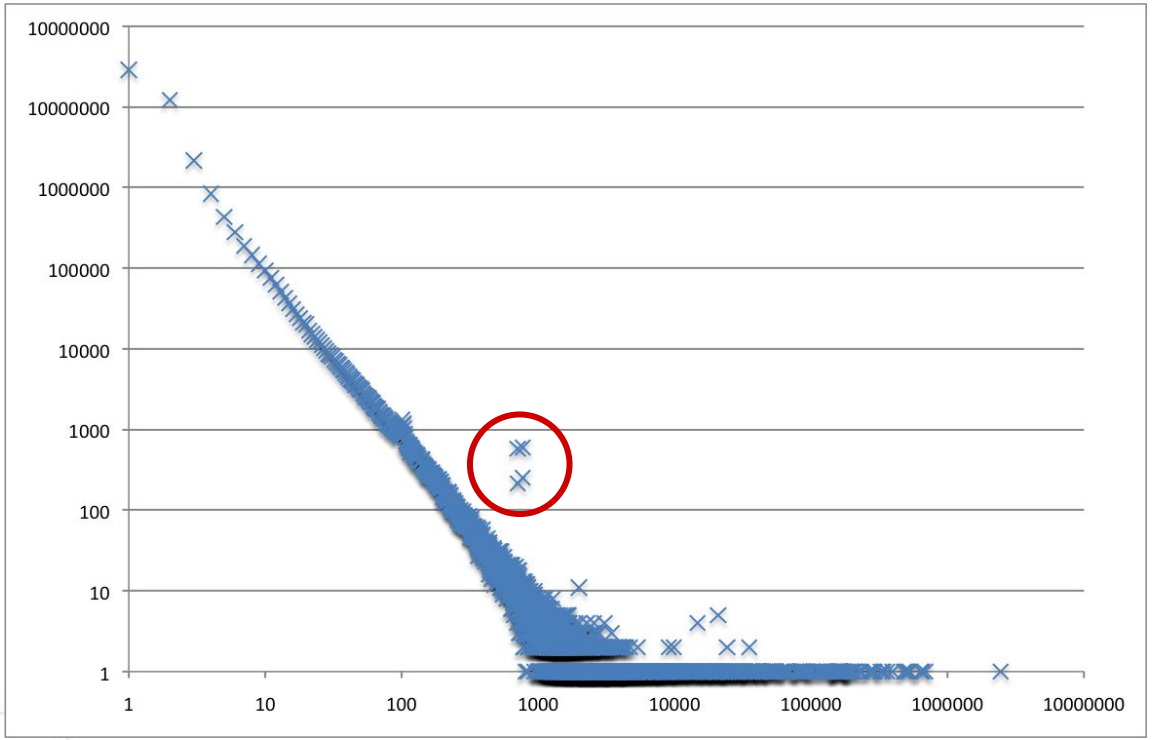
(whole graph)



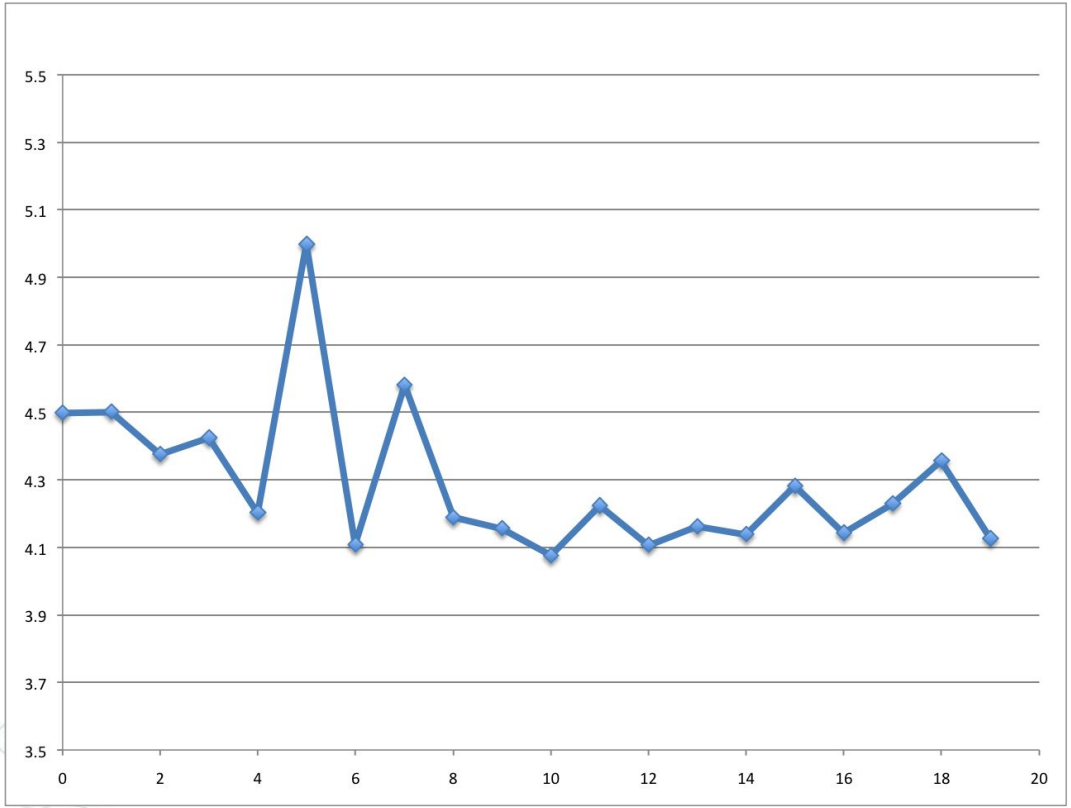
Indegree Distribution



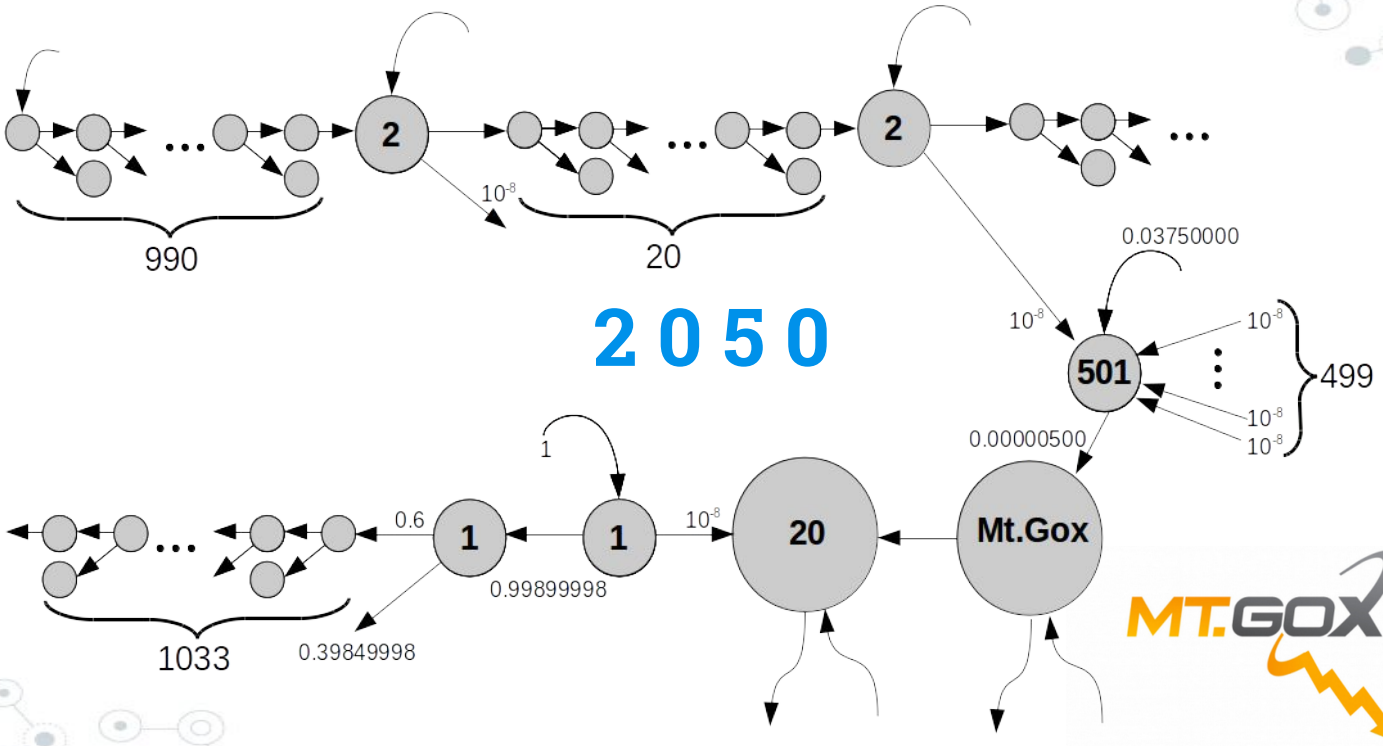
Indegree Distribution



Average Distance



Diameter


2
2
990
20
10^{-8}
0.03750000
10^{-8}
501
499
10^{-8}
10^{-8}
10^{-8}
0.00000500
2050
1
1
0.6
1
10^{-8}
20
Mt.Gox
0.99899998
1033
0.39849998
MT.GOX

An interesting transaction: 35dead89c059e846e2013a06a70cd84a7ba0f80da7741c283d6efd573e0a7319

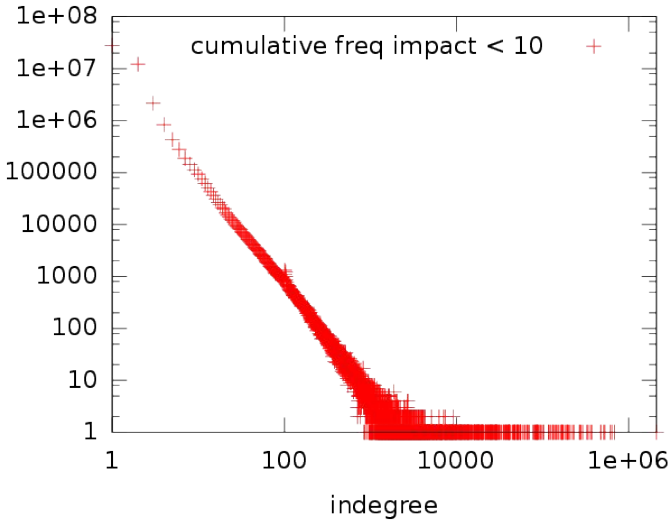
13hBbRdWGLCDNkDR8Pyf6jw3wM3q4EwbTF (0.0929742 BTC - Output)

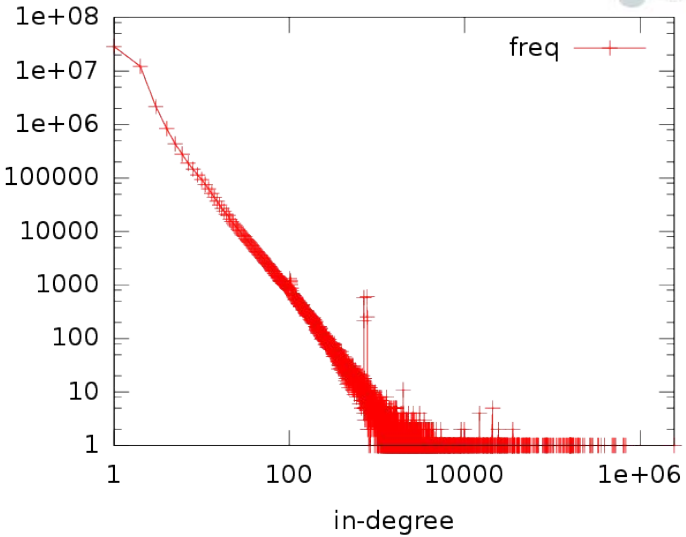
1G8zjUzeZBfJpeC...	(Jay_Pal) - (Unspent)	0.00001 BTC
14bFbRFJQXZTPG...	(jaronm) - (Unspent)	0.00001 BTC
1C3NNQ8Y7Qa7Q...	(Jambo) - (Spent)	0.00001 BTC
1DhFR2vR8w17BV...	(jarly) - (Unspent)	0.00001 BTC
14B3GFdtBZqxgNp...	(jarekb) - (Unspent)	0.00001 BTC
1MAVk5dcd3v9m8...	(Jameson) - (Unspent)	0.00001 BTC
19V4ITPAYUPT7Lx...	(jaredk) - (Unspent)	0.00001 BTC
143SikKpjzwhBy5Z...	(Jan) - (Unspent)	0.00001 BTC
12ZyGLt2ps2Agpy6...	(jak0b) - (Unspent)	0.00001 BTC
1PxBSHEZ3EbyZ4...	(jake262144) - (Unspent)	0.00001 BTC
1KseGadiZnuFoHo...	(jalidi) - (Unspent)	0.00001 BTC
1JadeSJWfvCuMA...	(Jade-) - (Unspent)	0.00001 BTC
1JALLENn5SAy4F...	(jallen	
1GsNNdHjYFSf5mBgHRwqJ	LEYiMcHYTA - (Spent)	0.0912558 BTC
1BgKdr9cZc2yFpX...	(jaken	
1EPY398Xk6cgqP...	(jabberwok) - (Unspent)	0.00001 BTC
19QkqAza7BHFTu...	(jackjack) - (Unspent)	0.00001 BTC
1jackkHHCLtxryJF...	(jackmanlnov) - (Unspent)	0.00001 BTC
17tqSDHshYLthDv...	(jacoder) - (Unspent)	0.00001 BTC
1CXwyYjrc9Vock5...	(jacroe) - (Unspent)	0.00001 BTC
16jVo7Vj7QdZ4Ap...	(jziHost.tk) - (Unspent)	0.00001 BTC
1FzcqruNwbXgkDk...	(ixne) - (Unspent)	0.00001 BTC
1MZVFA1VZmYTP...	(ixlpixl) - (Unspent)	0.00001 BTC
1BSGbFq4G8r3uck...	(JA37) - (Unspent)	0.00001 BTC
1aombYbEyggW4u...	(iyeman) - (Unspent)	0.00001 BTC
1FkN3XYsvuNdd2i...	(J.) - (Unspent)	0.00001 BTC
1DbQYvpXSVB7G...	(itsybitsy) - (Unspent)	0.00001 BTC
1CmUQsc87rByVi...	(itsmine) - (Unspent)	0.00001 BTC
19e3fcoLTu8YVFA...	(ivica) - (Unspent)	0.00001 BTC
1Lhifrdmq563mZxY...	(ivanish) - (Unspent)	0.00001 BTC
16Zo6werKP4akoTt...	(ItsASpork) - (Unspent)	0.00001 BTC

Classification:

- Pseudo Spam Transactions and Chains
- Generic Pseudo Spam Transactions and Chains
- Economical meaning

PSchains & GPSchains pruning

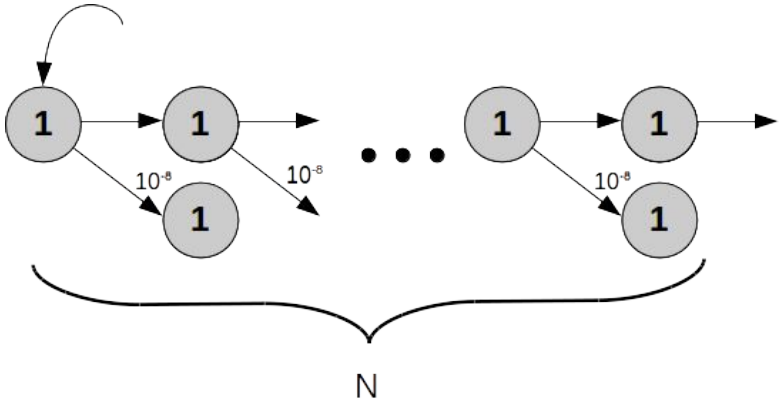




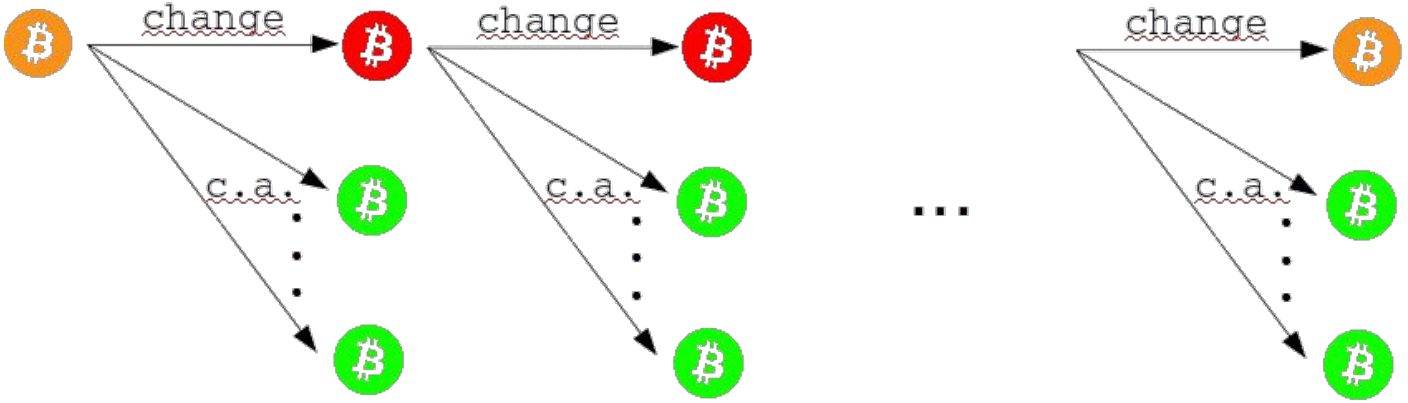
9 (575)

2050

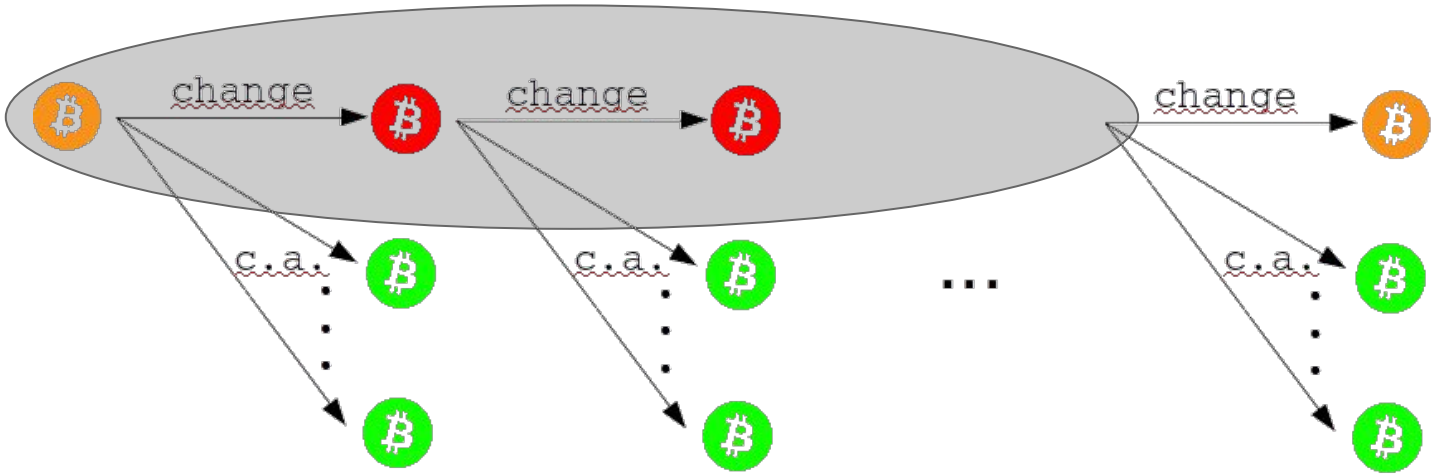
Detecting Patterns



Chain Heuristic:



Chain Heuristic:



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blockchain

transactions graph

heuristic based clustering

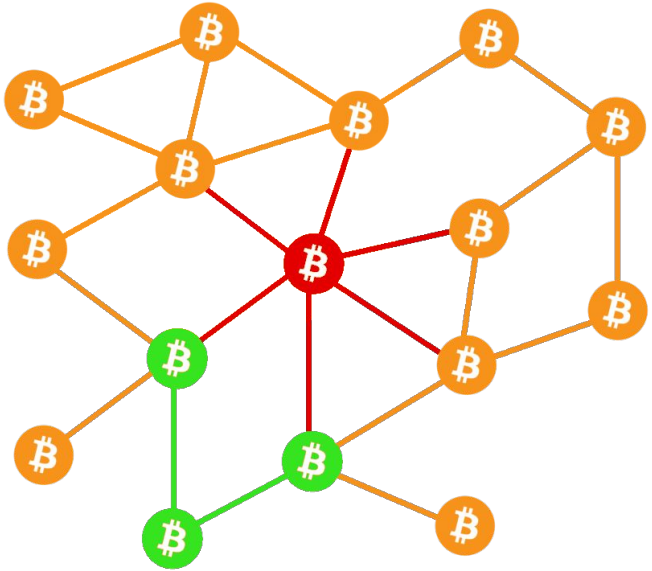
users graph

external informations

identities graph

External Informations

Network Listener (IP)



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