

PROJECT PRESENTATION

PROJECT OBJECTIVE

- We have in a database all transactions between addresses and all transactions between actors from the beginning of bitcoin to the beginning of 2021 (We can get 2022)
- Choose and obtain a small subset of this network that you consider interesting
 - Around a particular transaction (illegal activity ...)
 - About some actors
 - About a period
 - ...

PROJECT OBJECTIVE

- Apply tools you learned about during the class to better understand this network
- Write a report about what you learnt, and what you could learn with more time/data
 - If possible, a single Jupyter notebook with code and text
 - A separate report in PDF is also possible if relevant

PROJECT OBJECTIVE

- Recommendations:
- I recommend to limit yourself to a few thousand nodes, and less than 10.000 edges (filtering). Comparing a few graphs of this size can be relevant.
- The goal of the project is to interact!
 - Ask me if something is possible, how to do it... we are doing the project together.

DATA DESCRIPTION

SUMMARY OF THE PROCESS

1. Run a Bitcoin Node to download the full Blockchain
 - =>January 2021: **366 Go**
2. Use a tool (*bitcoin-etl*) to extract transactions as .json files
 - =>Until January 2018: **862G**
 - =>Total: **1.5 To**
3. Use co-spending heuristic to identify clusters
4. Use walletpexplorer.com data to identify clusters of large actors
5. Create an Actor to Actor transaction records

ACTOR TO ACTOR TRANSACTION RECORDS

- Each transaction has a single actor in input
- It can have one or several actors in output.
 - Actors are identified by their names
 - Clusters are identified by an integer
 - Singleton addresses are identified by their address

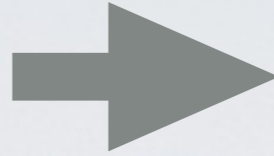
SOME IDEAS

ONCHAIN ACTIVITY ANALYSIS EXAMPLE

1

Traditional Bank

Transfer (€)



→ deposited 75.00 € processed 2/10/2017

Operations

Account	Name	Amount	Date
available	operation	+75.00 €	2/10/2017 - 3:28 PM

2

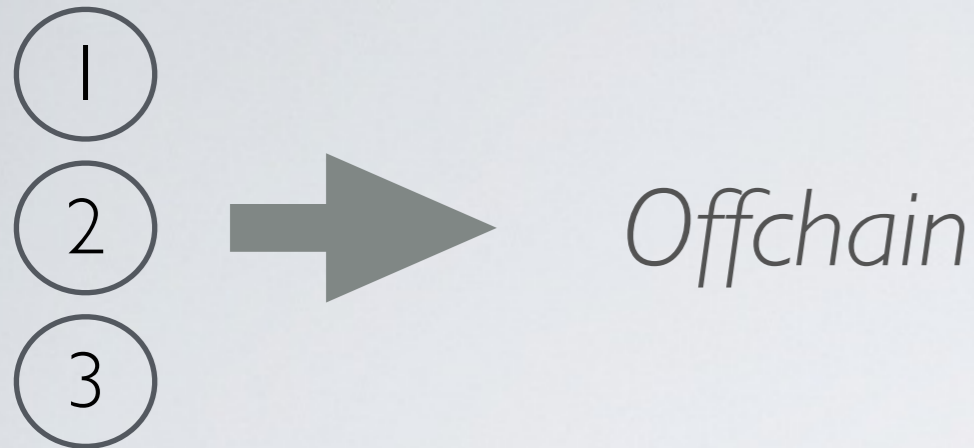
Initial Bitcoin purchase (trading)

↑ bought 0.05423052 btc for 921.99 € average filled 2/10/2017

3

“Trading”

↓ sold	0.07130000 btc	for 1,059.00 €	average	filled	2/22/2017
↑ bought	0.07136414 btc	for 1,008.91 €	average	filled	2/18/2017
↓ sold	0.07400000 btc	for 980.17 €	average	filled	2/18/2017
↑ bought	0.05076142 btc	for 985.00 €	average	filled	2/17/2017
↓ sold	0.02600000 btc	for 975.01 €	average	filled	2/16/2017



- How it works (probably)

- ▶ The exchange company owns a stock of Bitcoin
- ▶ It maintains a list of customer accounts, and how much each customer owns at time t
- ▶ When customer $c1$ buys btc to a customer $c2$, change in the internal database of the company (scripture)
 - Goal: no transaction fees, easier to manage
- ▶ The company itself certainly buy and sell on the market to ensure liquidity
 - Success= \Rightarrow more customers who want to buy= \Rightarrow need to provide fresh coins
 - Need of buying/selling on the blockchain
- ▶ The company needs enough reserve since customers can order bitcoin transactions from their (*virtual*) account to a *real bitcoin wallet*

bought

0.05417748 btc for 1,974.99 € average

filled 5/28/2017

9:23GMT+1

timestamp	sender	receiver	value	date	value_btc	
619503540	1495929670	-192947146 Paymium.com	4276511	2017-05-28 00:01:10	0.042765	
619622203	1495940615	35172026 Paymium.com	21408870	2017-05-28 03:03:35	0.214089	
619627952	1495940615	36676998 Paymium.com	1278580	2017-05-28 03:03:35	0.012786	
619641058	1495941084	320110 Paymium.com	2889754	2017-05-28 03:11:24	0.028898	
619678470	1495946218	234 Paymium.com	50000000	2017-05-28 04:36:58	0.500000	
619720731	1495953357	21 Paymium.com	500000000	2017-05-28 06:35:57	5.000000	
619724954	1495954071	Poloniex.com Paymium.com	90000000	2017-05-28 06:47:51	0.900000	
619734802	1495953492	15195288 Paymium.com	563100	2017-05-28 06:38:12	0.005631	
619742071	1495956403	32328334 Paymium.com	300000000	2017-05-28 07:26:43	3.000000	
619749598	1495956760	Bitstamp.net Paymium.com	500000000	2017-05-28 07:32:40	5.000000	
619773769	1495962103	Poloniex.com Paymium.com	5990000	2017-05-28 09:01:43	0.059900	
619813537	1495968880	Poloniex.com Paymium.com	299990000	2017-05-28 10:54:40	2.999900	
619814805	1495969178	-193097249 Paymium.com	5000000	2017-05-28 10:59:38	0.050000	
619816324	1495969665	-193098289 Paymium.com	501097	2017-05-28 11:07:45	0.005011	
619859643	1495972870	Bitstamp.net Paymium.com	99900000	2017-05-28 12:01:10	0.999000	
619870536	1495971407	-193116479 Paymium.com	4113900	2017-05-28 11:36:47	0.041139	
619874781	1495972455	5224442 Paymium.com	1373550	2017-05-28 11:54:15	0.013735	
619877124	1495973819	-193121122 Paymium.com	365283	2017-05-28 12:16:50	0.003653	
619880471	1495972455	-193122823 Paymium.com	59539	2017-05-28 11:54:15	0.000595	
619880482	1495972455	-193122827 Paymium.com	58606	2017-05-28 11:54:15	0.000586	
619882043	1495973387	Paymium.com	16096	620000	2017-05-28 12:09:47	0.006200
619882044	1495973387	Paymium.com	222	680000	2017-05-28 12:09:47	0.068000

Paymium on-chain activity on 2017-05-28

Hard to say what it corresponds too...
But my exact transaction is not there

... (153 total)

4 Sending 0.005 btc from Paymium exchange to my personal wallet



transferred 0.00500000 btc processed 2/10/2017

Hash	2017-02-10 19:48
1431198bef5645bcce667c11f988257292c...	
1FNhjTqbogGenAtiVn... 0.03000000 BTC	1FBov1eSTzbEWFhNP... 0.04811430 BTC
1FNhjTqbogGenAtiVn... 0.29980000 BTC	1FnJ7ifPVs6pVzPAHj... 0.15385554 BTC
1ChT8jHwnu28S8Gse... 0.00552015 BTC	1PLS2uFx9RCXj6y7o... 0.03240000 BTC
134JTcD1rwYzf3mJh... 0.01066365 BTC	1JPDfDbpYu7ZMN54... 0.11000000 BTC
1F2DnSngMqhx3Bc5t... 0.00102304 BTC	1Acekhv2vRYE8JUY... 0.10000000 BTC
1PmJouprMuWvnuz1... 0.00060627 BTC	125UVAGTHgRpUWu... 5.00000000 BTC
1CNKsJdKEGAfk7A6... 0.02800000 BTC	1LCy45fGKy5DDyLX7... 0.19080000 BTC
1Jv324ZskcMwVaHo... 0.04971298 BTC	1JQAJC1as3zqGvh3R... 0.10780000 BTC
1Jv324ZskcMwVaHo... 0.02700664 BTC	1uQWT55a31oXbG7y... 0.06000000 BTC
1FyJw1oF7ojJVfb... 200.00000000 BTC	1AtG2dZL2QT9Anob... 0.26000000 BTC
Load more inputs... (1 remaining)	19P2i6fCFLyhsZWVd... 0.05476170 BTC
	1NAr6doa9jzdAtjfcED... 0.00100000 BTC
	1GZjj8XvbdVvMgiSm... 0.21500000 BTC
	32SRuobXXWbxRYeLt... 0.11180000 BTC
	1DtnwrYpuj2AviHBKL... 0.31386546 BTC
	1mxx5bDua8844zAik... 0.03416878 BTC
	1X9rcMVx8SvZ5uPz... 0.00500000 BTC
	1Hxm69VGPXfGu7kK... 0.01000000 BTC
	1CEoEkc1xzb5mBhpa... 0.00547958 BTC
	3ErsNJgohjZ9DeJcz... 0.56630000 BTC
	13sSQcEjasD7S5PZn... 0.01185000 BTC
	17McVX1jhiEMg5Mnt... 0.85516806 BTC
	1LHY6mAeqHVYbpZ... 0.37096600 BTC
	15Gw27cNPkqgUxqe... 0.26954988 BTC
	15wgdrhi64ZuV8QY... 0.26955280 BTC
	1KbB2KsEV2wUkAAx... 0.10780000 BTC
	1Bjkr17q2TF37nvTdC... 1.00000000 BTC
	16zFtGxAF7RWNpZay... 0.10712284 BTC
	14qiXwDXJLUM5P7h... 0.04280000 BTC
	1FyJw1oF7ojJVfbM... 193.37661929 BTC
Fee	0.00150000 BTC (55.310 sat/B - 13.827 sat/WU - 2712 bytes)
	+0.00500000 BTC

4

The screenshot shows a Bitcoin transaction interface. At the top, the hash '1431198bef5645bcce667c11f988257292c...' and the date '2017-02-10 19:48' are visible. The transaction is divided into two columns of inputs and outputs. A red circle highlights the first input: '1FNhjTqbogGenAtiVn... 0.03000000 BTC'. Another red circle highlights the first output: '1FBov1eSTzbEWFhNP... 0.04811430 BTC'. A third red circle highlights the final output: '1FyJw1oF7ojJVfbM... 193.37661929 BTC'. At the bottom left, the fee is '0.00150000 BTC (55.310 sat/B - 13.827 sat/WU - 2712 bytes)'. At the bottom right, a green box shows '+0.00500000 BTC'. A green arrow points from the first input to the first output.

Hash	Amount	Unit
1431198bef5645bcce667c11f988257292c...		
1FNhjTqbogGenAtiVn...	0.03000000	BTC
1FNhjTqbogGenAtiVn...	0.29980000	BTC
1ChT8jHwnu28S8Gse...	0.00552015	BTC
134JTcD1rwYzf3mJh...	0.01066365	BTC
1F2DnSngMqhx3Bc5t...	0.00102304	BTC
1PmJouprMuWvnuz1...	0.00060627	BTC
1CNKsJdKEGafk7A6...	0.02800000	BTC
1Jv324ZskcMwVaHo...	0.04971298	BTC
1Jv324ZskcMwVaHo...	0.02700664	BTC
1FyJw1oF7ojJVfb...	200.00000000	BTC
Load more inputs... (1 remaining)		
1FBov1eSTzbEWFhNP...	0.04811430	BTC
1FnJ7ifPVs6pVzPAHj...	0.15385554	BTC
1PLS2uFx9RCXj6y7o...	0.03240000	BTC
1JPDfDbpYu7ZMN54...	0.11000000	BTC
1Acehkhv2vRYE8JUJ...	0.10000000	BTC
125UVAGTHgRpUWu...	5.00000000	BTC
1LCy45fGKy5DDyLX7...	0.19080000	BTC
1JQAJC1as3zqGvh3R...	0.10780000	BTC
1uQWT55a31oXbG7y...	0.06000000	BTC
1AtG2dZL2QT9Anob...	0.26000000	BTC
19P2i6fCFLyhsZWVd...	0.05476170	BTC
1NAr6doa9jzdAtjfcED...	0.00100000	BTC
1GZjj8XvbdVvMgiSm...	0.21500000	BTC
32SRuobXXWbxRYeLt...	0.11180000	BTC
1DtnwrYpuj2AviHBKL...	0.31386546	BTC
1MXx5bDua8844zAiK...	0.03416878	BTC
1X9rcMVx8SvZ5uPz...	0.00500000	BTC
1Hxm69vGPXrGu7kB...	0.01000000	BTC
1CEoEkc1xzb5mBhpa...	0.00547958	BTC
3ErsNJgohjZ9DeJcz...	0.56630000	BTC
13sSQcEjasD7S5PZn...	0.01185000	BTC
17McVX1jhiEMg5Mnt...	0.85516806	BTC
1LHY6mAeqHVVYbpZ...	0.37096600	BTC
15Gw27cNPkqgUxqe...	0.26954988	BTC
15wgdri64ZuV8QY...	0.26955280	BTC
1KbB2KsEV2wUkAAx...	0.10780000	BTC
1Bjkr17q2TF37nvTdC...	1.00000000	BTC
16zFtGxAF7RWNpZAY...	0.10712284	BTC
14giYwDXJLUM3P7i...	0.04280000	BTC
1FyJw1oF7ojJVfbM...	193.37661929	BTC
Fee	0.00150000	BTC
(55.310 sat/B - 13.827 sat/WU - 2712 bytes)		
		+0.00500000 BTC

The exchange do not write on-chain transaction for each custom activity, but instead factorize them.

It reduces individual transaction fees.

Same for inputs.

Note the change address with a large amount

5

Sending back **0.001** from Wallet to Paymium Exchange

Address I received payment to

Address provided by Paymium

Hash	40a08e1ff76d8133c151705f816bec87c75a8d7dd0957b4bd1ecd...	2017-02-11 07:56
	1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB 0.00500000 BTC	1NdhZ1TBi1dE8uk1qzUqYR2x7dRi52j5wr 0.00100000 BTC
	1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf	0.00380700 BTC
Fee	0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes)	0.00480700 BTC

High fees:
20% of the amount sent

Change
(My address in my wallet)

What happens with coins sent at this address?

Hash	40a08e1ff56d8133c151705f816bec87c75a8d7dd0957b4bd1ecd...	2017-02-11 07:56
	1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB 0.00500000 BTC	→ 1NdhZ1TBi1dE8uk1qzUqYR2x7dRi52j5wr 0.00100000 BTC
		1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf 0.00380700 BTC
Fee	0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes)	0.00480700 BTC

Hash	59c821350e1291c55ae8e0286b05e3627...	2017-02-11 14:09
	1HsSSUvaMuL3VUw... 0.72080588 BTC	→ 1544JSQRTLckfhJ1E... 0.05040000 BTC
	1NdhZ1TBi1dE8uk1qz... 0.00100000 BTC	1HzGDkZN7fe4rAmW... 0.04910000 BTC
	1KM3b551HzSQ4MQ... 0.00951400 BTC	128DsHfMjaeCDunze... 0.44900000 BTC
	1HUxJ5kTqLNhuMZy... 0.45732080 BTC	1NCe8eAhHzyZPneYh... 0.11000000 BTC
	1BoBVfPfk3BxaN1M1... 0.03900991 BTC	1CjcXagRZviJwWSH... 0.06900000 BTC
	1MgQhKRk4QqMTgeY... 0.01447889 BTC	1A4wdSpiToSc3rw1G... 2.30000000 BTC
	1FyJw1oF7ojJVfbM... 193.18850960 BTC	19DBZUM62sYv66up... 0.05344623 BTC
		1PKmMMR7S26Usjrkj... 0.34257068 BTC
		17puCgUUALRV222V... 2.09300000 BTC
		1HoEKSQfmCebgcKo... 0.04000000 BTC
		Load more outputs... (19 remaining)
Fee	0.00150000 BTC (72.886 sat/B - 18.222 sat/WU - 2058 bytes)	-0.00100000 BTC

“My” coins have been spent the same day, and not by me!

=> 1Ndh... Is not “my” address, it’s paymium’s address.

It’s just that when coins are sent to this address, Paymium *credit* my customer account of the same amount.

6

Using my wallet coins to buy some real things (Amazon gift card)

Hash: 40a08e1ff56d8133c151705f816bec87c75a8d7dd0957b4bd1ecd... 2017-02-11 07:56

1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB 0.00500000 BTC → 1NdhZ1Tbi1dE8uk1qzUqYR2x7dRi52j5wr 0.00100000 BTC
1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf 0.00380700 BTC

Fee: 0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes) **0.00480700 BTC**

Hash: 1650dd5cd9233705193aa83e42d8460d... 2021-01-27 23:16

1ArvJf54cVwJ2Y6gH... 0.00380700 BTC → bc1qcp8uuxkx48ylrg... 0.00060200 BTC
3JnJU19y21FgySKoX... 0.00300300 BTC

Fee: 0.00020200 BTC (91.403 sat/B - 22.851 sat/WU - 221 bytes) **-0.00380700 BTC**

Company selling gift card

Hash: 7578596ecc510bb93d662d97d8bf6c8b7... 2021-01-28 05:08

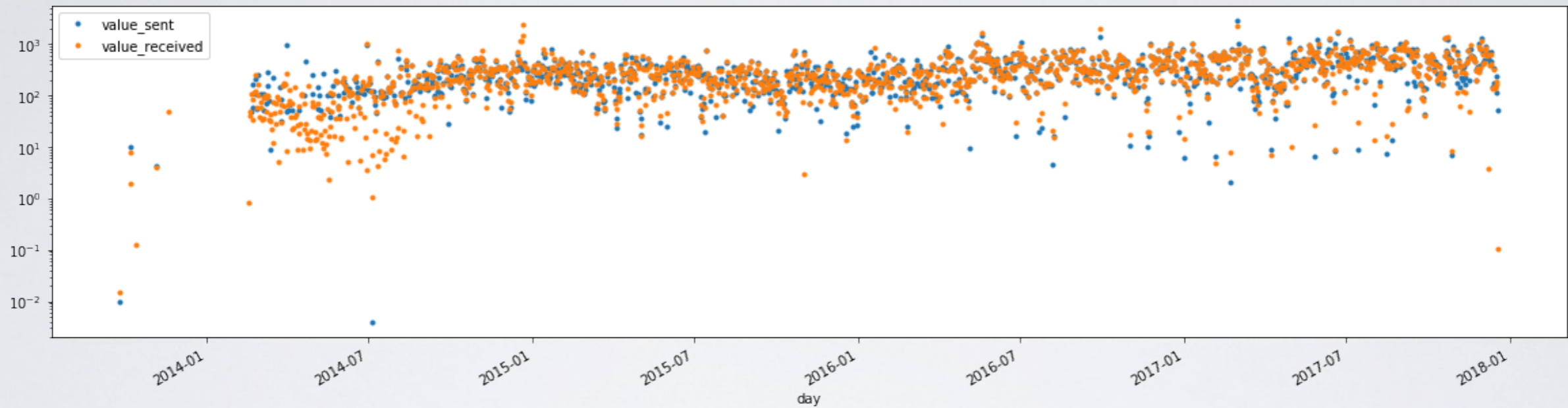
3PxxW8ghgJuC4J5y1... 0.00438600 BTC → bc1qj4zp28m9r3elw5... 7.00529441 BTC
3Q2xe5JyvuL5mvxn... 0.01404900 BTC
38LwzsRkxqXe3jfSD... 0.00806700 BTC
3C8i2YX1EWurpK9qt... 0.00318400 BTC
34Z85bRMu4jE5mRm... 0.00212500 BTC
35zcYgpERQo9SUUo... 0.01549100 BTC
3GZ2PMcvphAiYdA2... 0.00325000 BTC
349AFe7DdK4bfJZ7R... 0.00212600 BTC
3N3W124kvbjPQ89u... 0.02365300 BTC
32dkoFUb5bh9ECPG... 0.00314300 BTC

Load more inputs... (776 remaining)

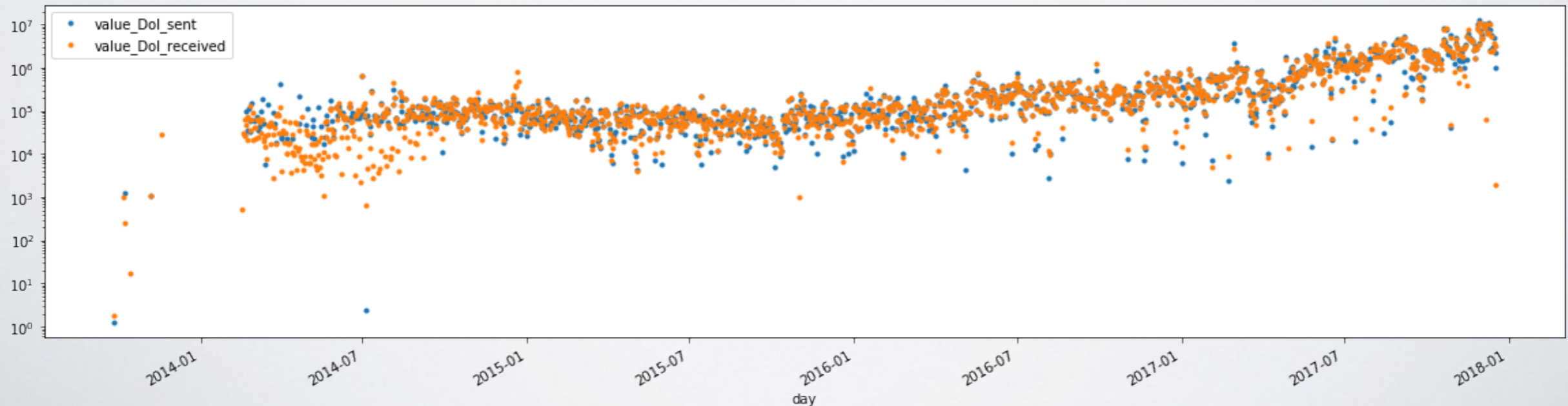
Fee: 0.00163316 BTC (1.211 sat/B - 0.571 sat/WU - 134825 bytes) **-0.00300300 BTC**

PAYMIUM ACTIVITY

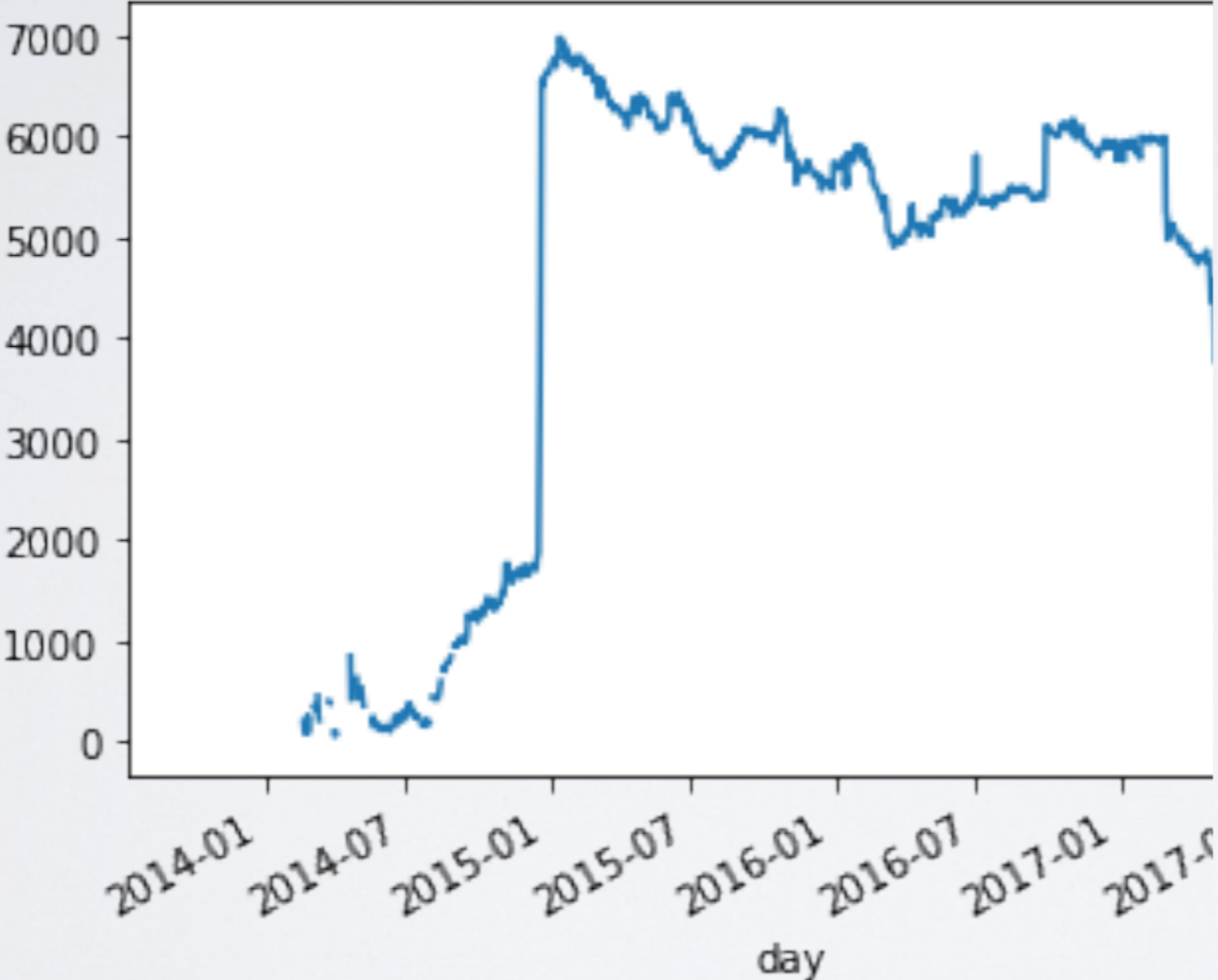
Dayly sent/received amounts in btc



Dayly sent/received amounts in \$



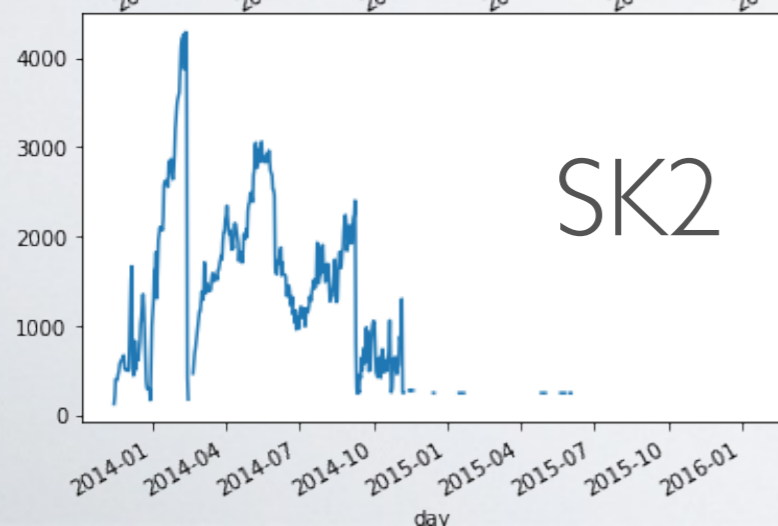
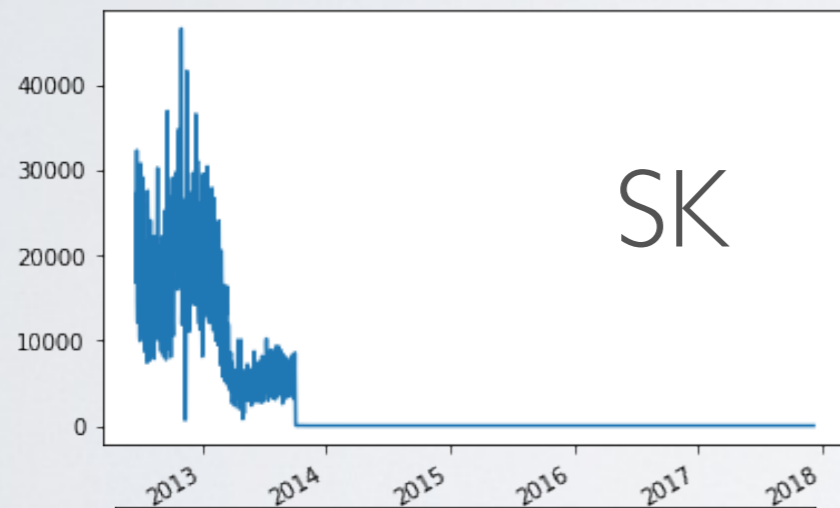
Cumulative of the difference between amounts
received and sent
(Btc owned)



SILK ROAD

Silk Road was a website infamous for illegal product selling (drugs, etc.)

Daily transactions
Amounts (btc)



Top 10 actors who
Sent/Received the most to/from Silk-Road

(Mostly
anonymous
eWallet and
Mixing services)

SilkRoadMarketplace	6.393444e+06
ePay.info	5.057304e+05
Instawallet.org	1.785853e+05
Bitcoin.de-old	6.506796e+04
Bitstamp.net-old	4.965712e+04
10666	4.130923e+04
89090	3.998100e+04
363	3.533352e+04
BTC-e.com-old	3.511806e+04
LocalBitcoins.com-old	3.451882e+04

SilkRoadMarketplace	6.393601e+06
BitcoinFog	1.791251e+05
Instawallet.org	1.615579e+05
ePay.info	1.478182e+05
Bitstamp.net-old	1.451114e+05
2077410	1.445200e+05
89090	1.137133e+05
223978	7.453770e+04
28928788	5.878110e+04
-6337253	5.000000e+04

SILK ROAD

Some of the last transactions made by SR2...
Same private Wallet, same amounts...

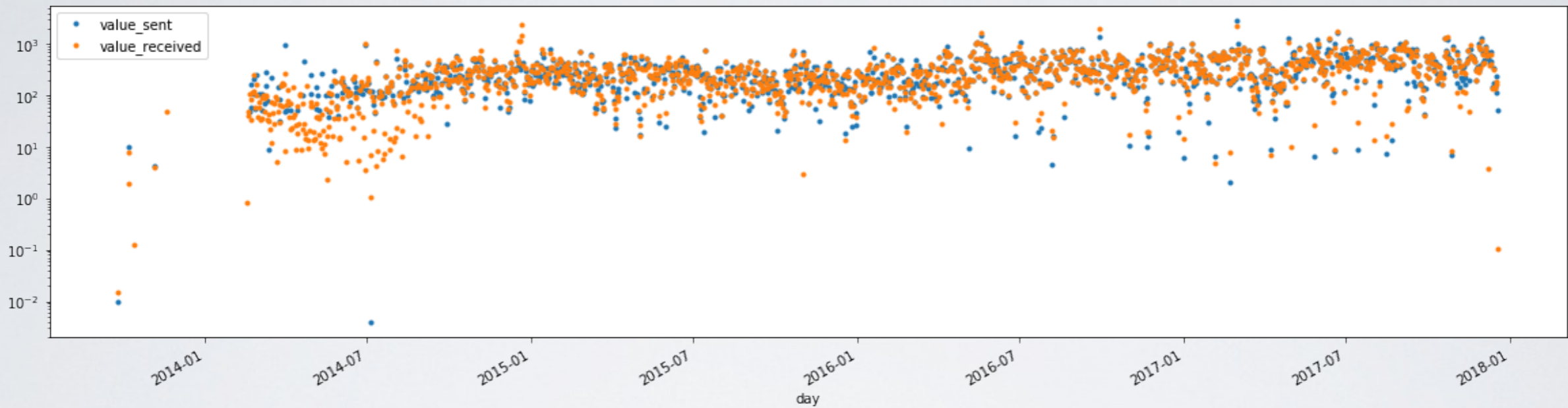
138077500	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081140	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081181	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081229	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081666	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081914	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081996	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082018	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082050	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082069	1415256435	SilkRoad2Market	35339862	2500000000	2014-11-06 06:47:15	2014-11-06
138082087	1415256435	SilkRoad2Market	35339862	2500000000	2014-11-06 06:47:15	2014-11-06
138082134	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082146	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082166	1415256435	SilkRoad2Market	35339862	5000000000	2014-11-06 06:47:15	2014-11-06
138082206	1415256435	SilkRoad2Market	35339862	5000000000	2014-11-06 06:47:15	2014-11-06
138082248	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06

And then...

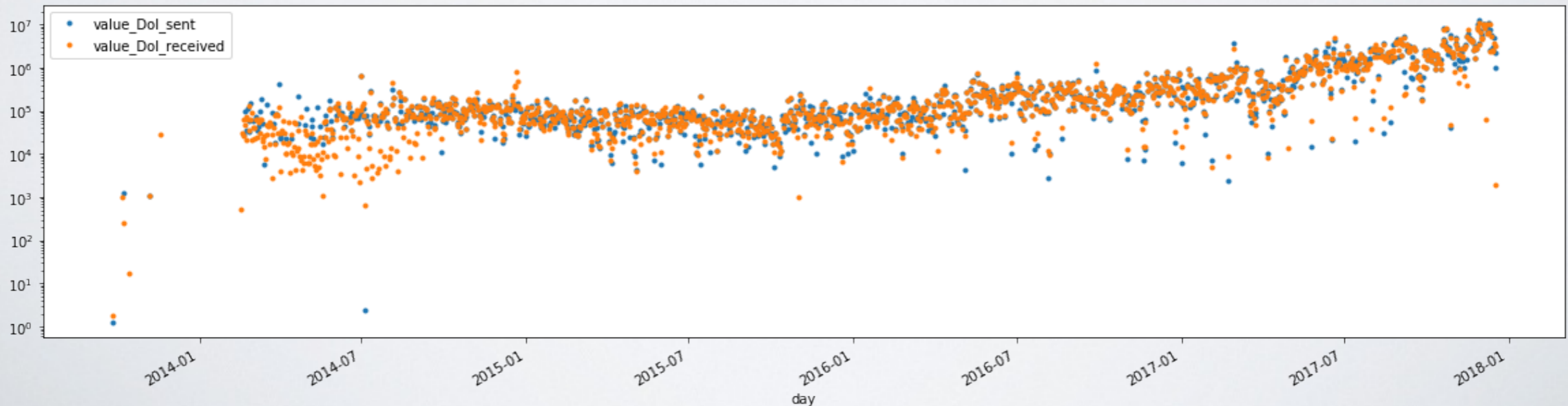
	timestamp	sender	receiver	value	date	day
588090783	1492427923	35339862	-177532360	146799545224	2017-04-17 11:18:43	2017-04-17

PAYMIUM ACTIVITY

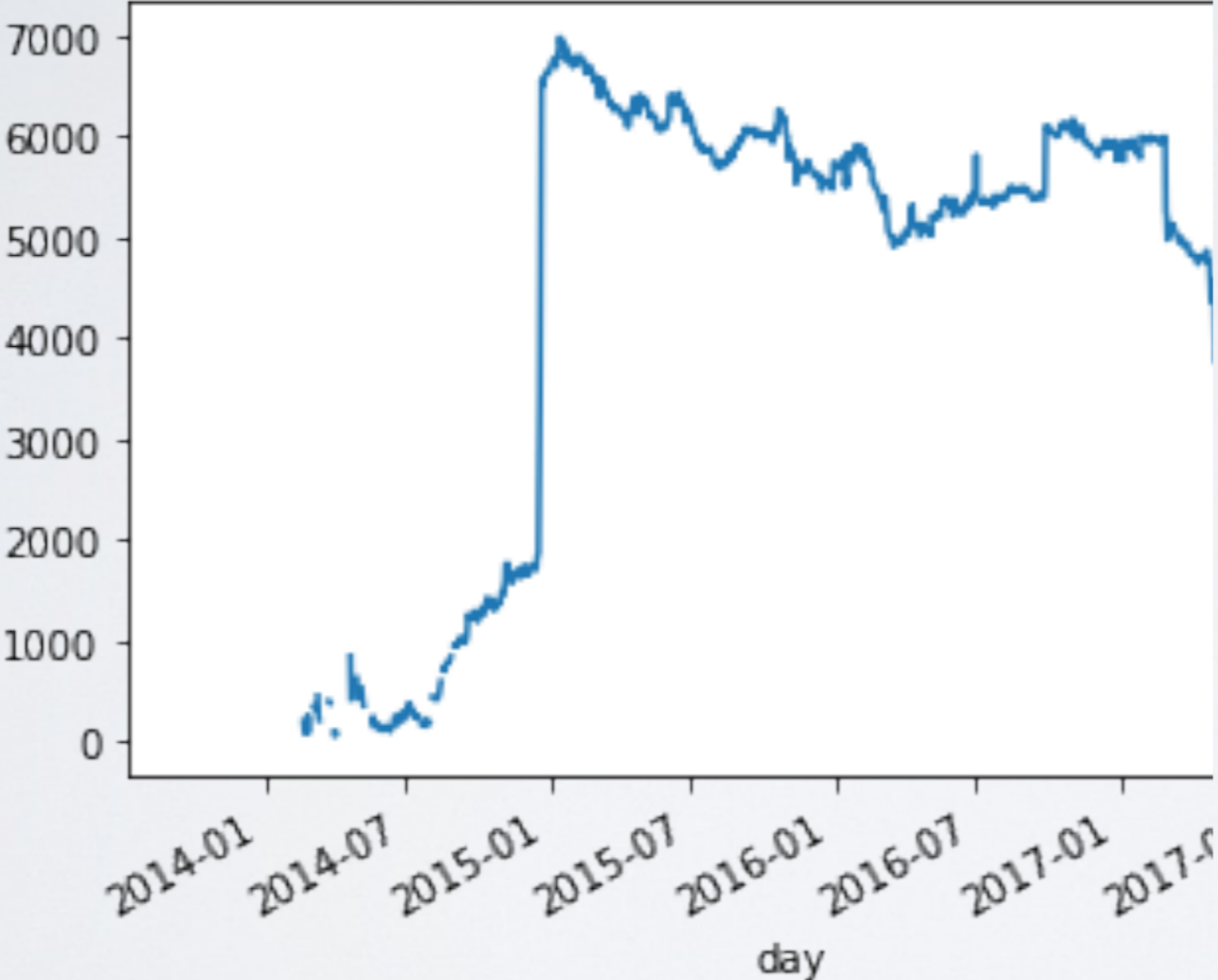
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Dayly sent/received amounts in \$



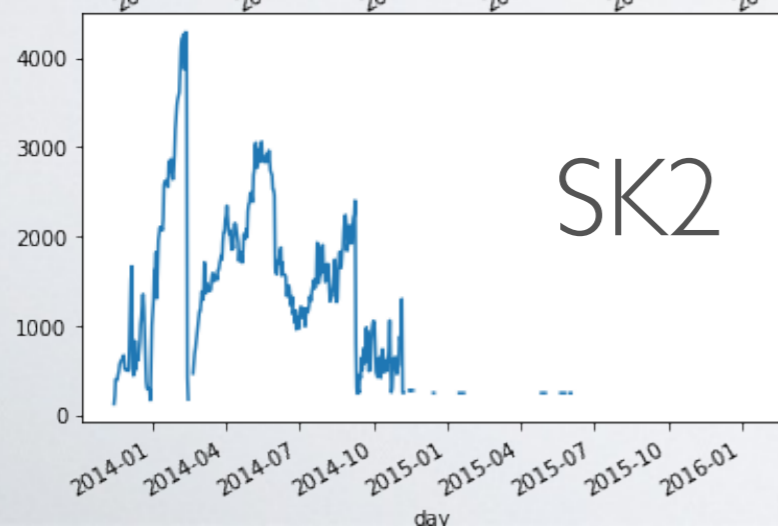
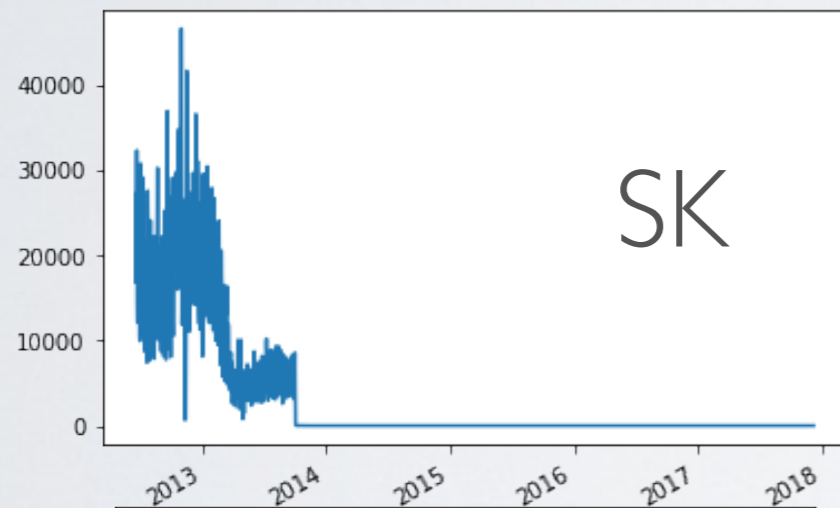
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eWallet and
Mixing services)

SilkRoadMarketplace	6.393444e+06
ePay.info	5.057304e+05
Instawallet.org	1.785853e+05
Bitcoin.de-old	6.506796e+04
Bitstamp.net-old	4.965712e+04
10666	4.130923e+04
89090	3.998100e+04
363	3.533352e+04
BTC-e.com-old	3.511806e+04
LocalBitcoins.com-old	3.451882e+04

SilkRoadMarketplace	6.393601e+06
BitcoinFog	1.791251e+05
Instawallet.org	1.615579e+05
ePay.info	1.478182e+05
Bitstamp.net-old	1.451114e+05
2077410	1.445200e+05
89090	1.137133e+05
223978	7.453770e+04
28928788	5.878110e+04
-6337253	5.000000e+04

SILK ROAD

Some of the last transactions made by SR2...
Same private Wallet, same amounts...

138077500	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081140	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081181	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081229	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081666	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081914	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138081996	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082018	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082050	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082069	1415256435	SilkRoad2Market	35339862	2500000000	2014-11-06 06:47:15	2014-11-06
138082087	1415256435	SilkRoad2Market	35339862	2500000000	2014-11-06 06:47:15	2014-11-06
138082134	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082146	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06
138082166	1415256435	SilkRoad2Market	35339862	5000000000	2014-11-06 06:47:15	2014-11-06
138082206	1415256435	SilkRoad2Market	35339862	5000000000	2014-11-06 06:47:15	2014-11-06
138082248	1415256435	SilkRoad2Market	35339862	1000000000	2014-11-06 06:47:15	2014-11-06

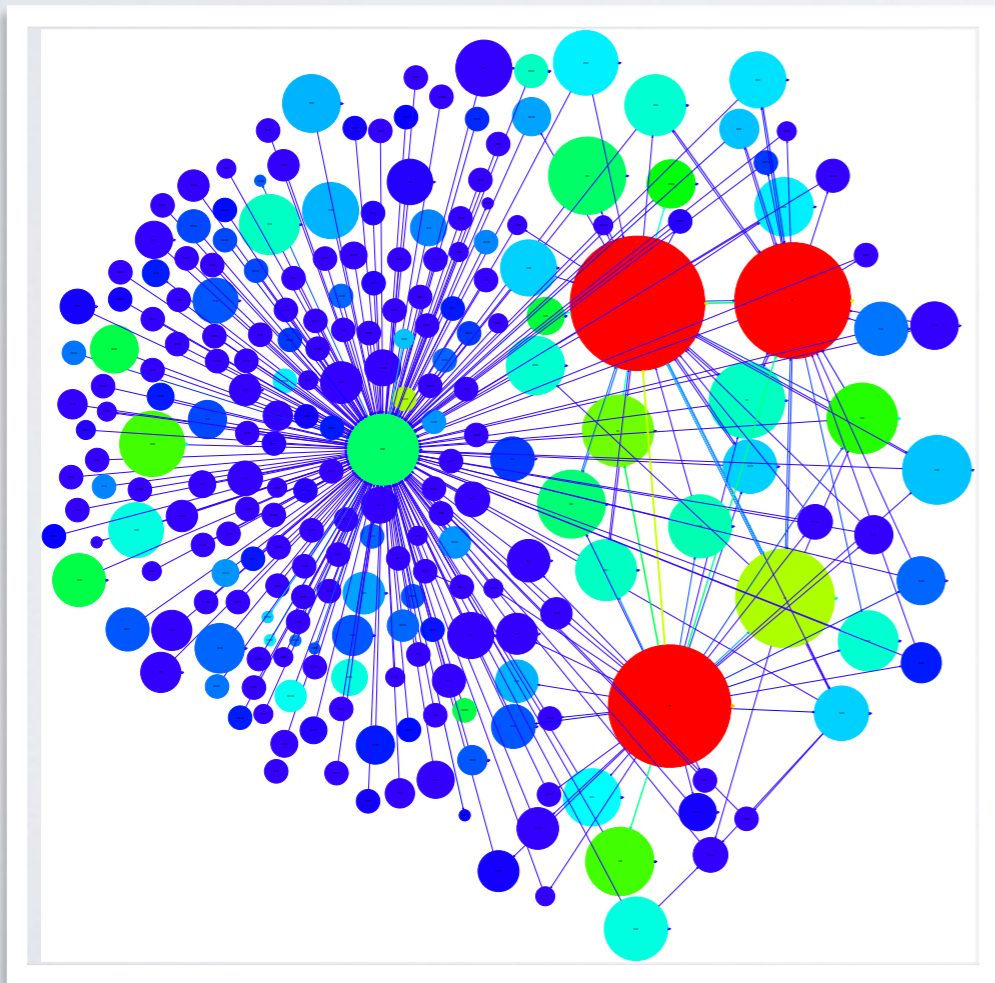
And then...

	timestamp	sender	receiver	value	date	day
588090783	1492427923	35339862	-177532360	146799545224	2017-04-17 11:18:43	2017-04-17

EXAMPLES FROM THE SCIENTIFIC LITERATURE

EGO-CENTERED NETWORK

- Wikileaks



Green in the center : wikileaks

MONEY LAUNDERING

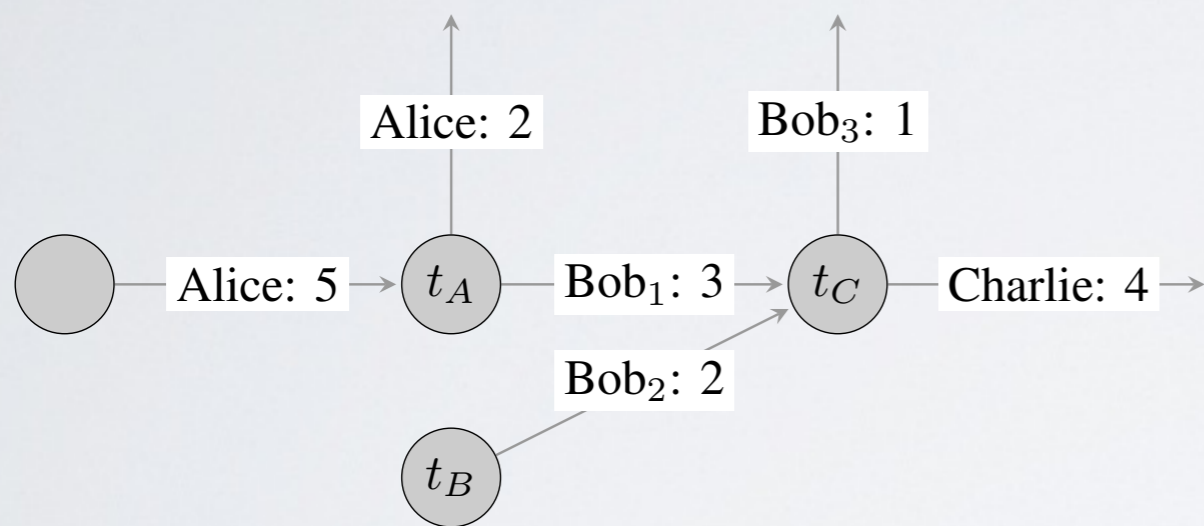


Figure 1. Example of a partial transaction graph

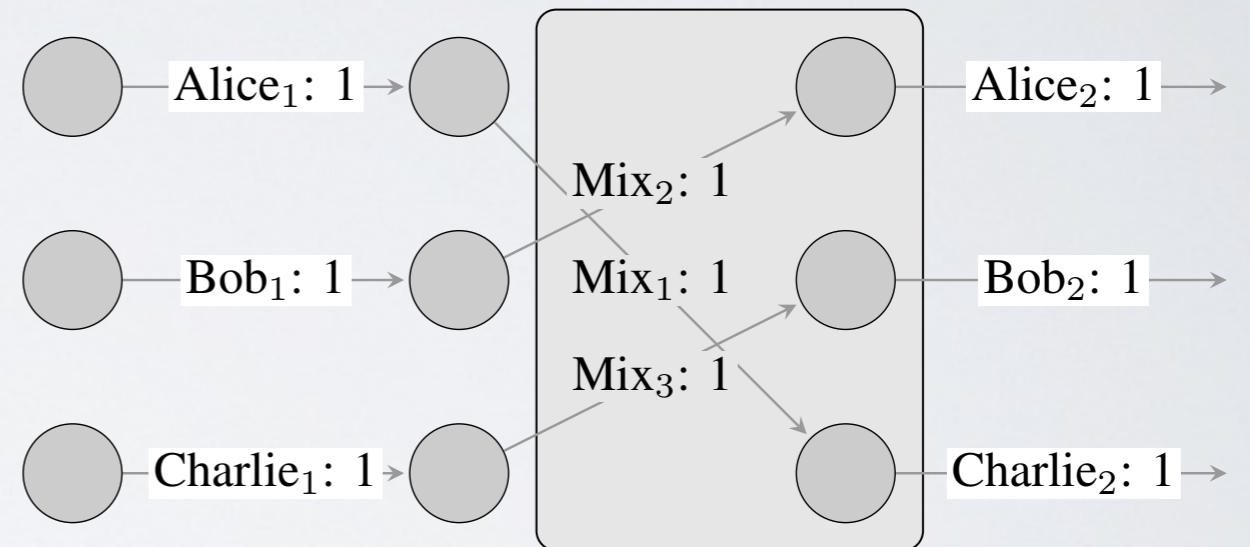
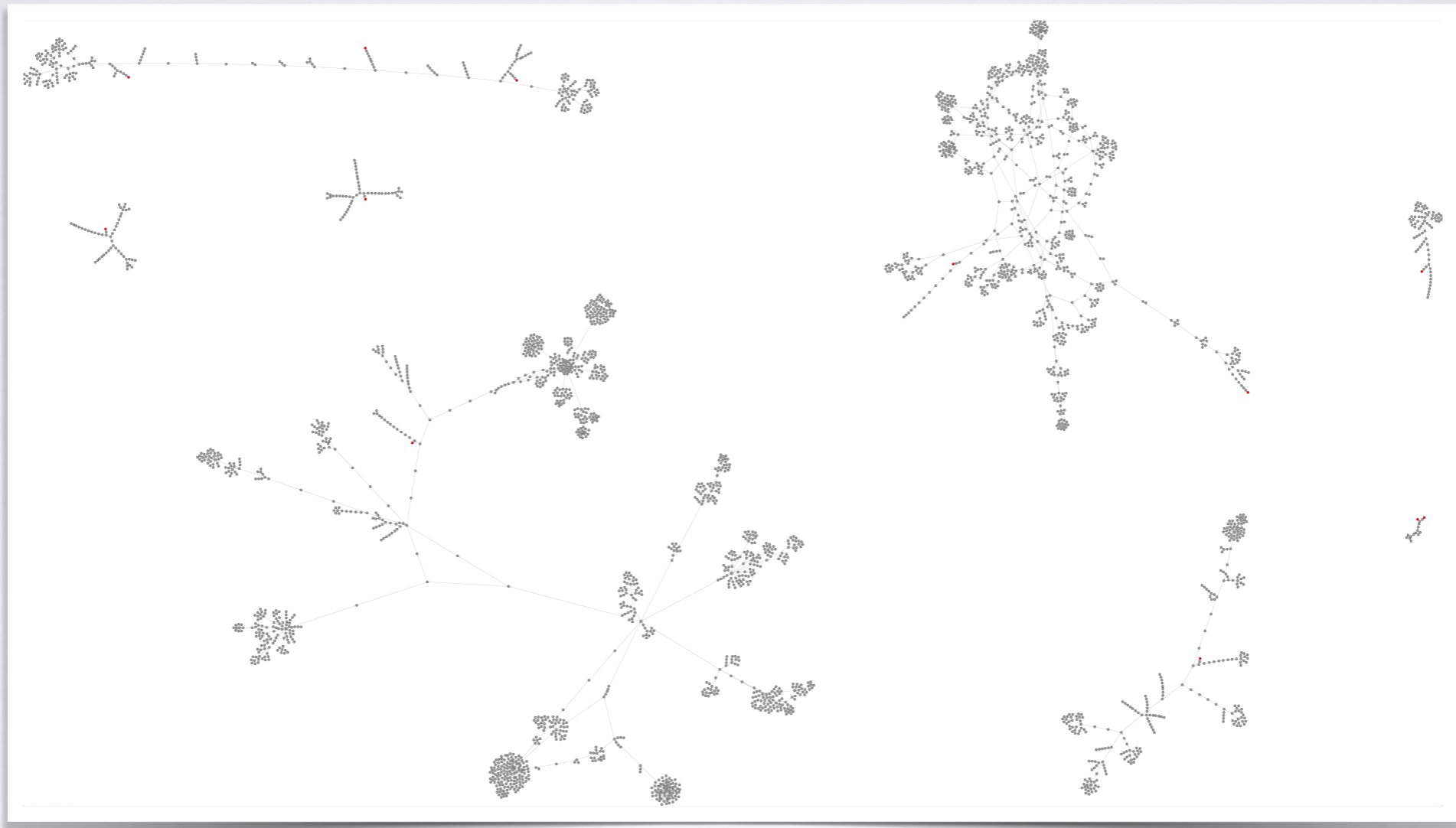


Figure 2. Block diagram of a hypothetical Bitcoin mixing service

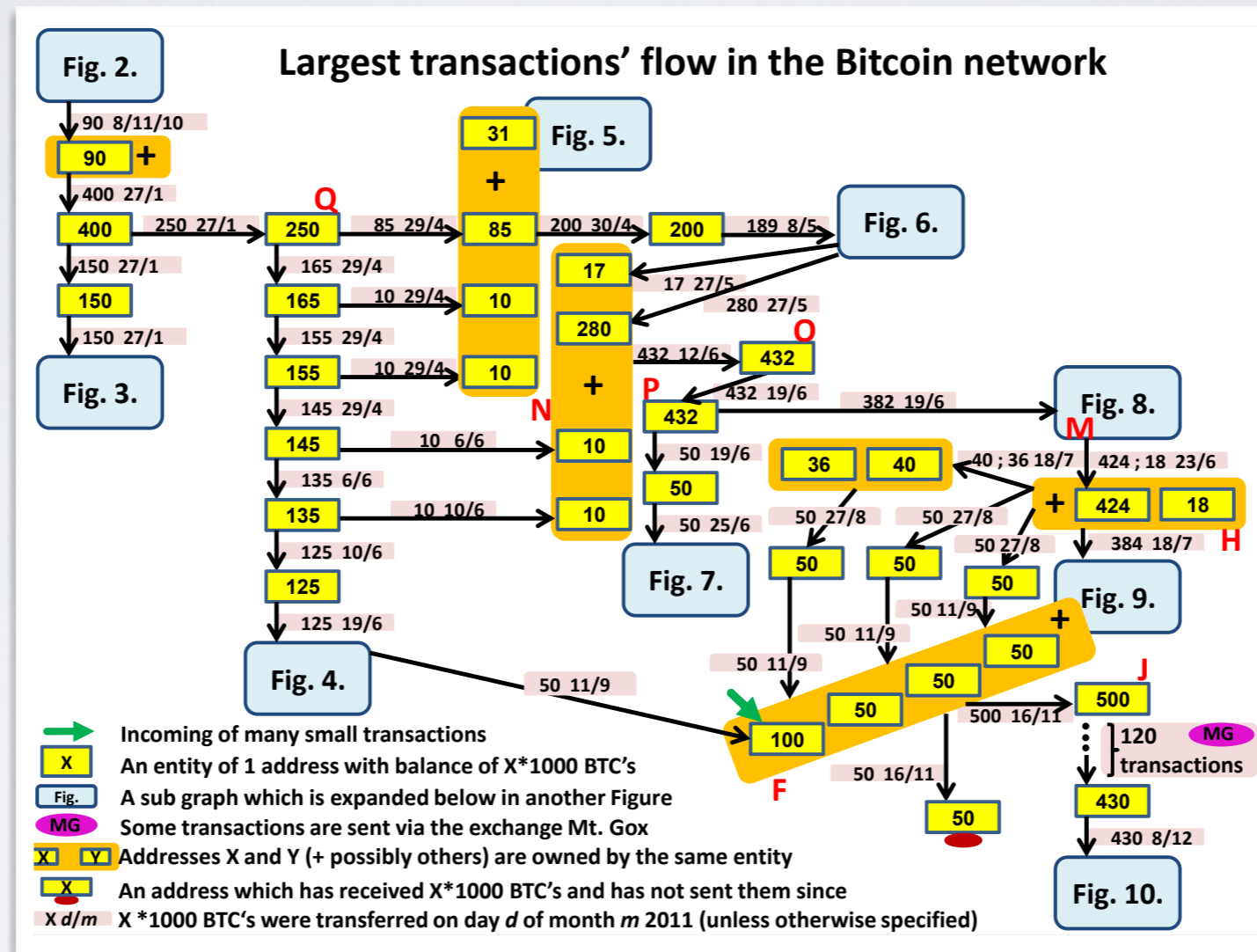
[Möser & Böhme]

MONEY LAUNDERING



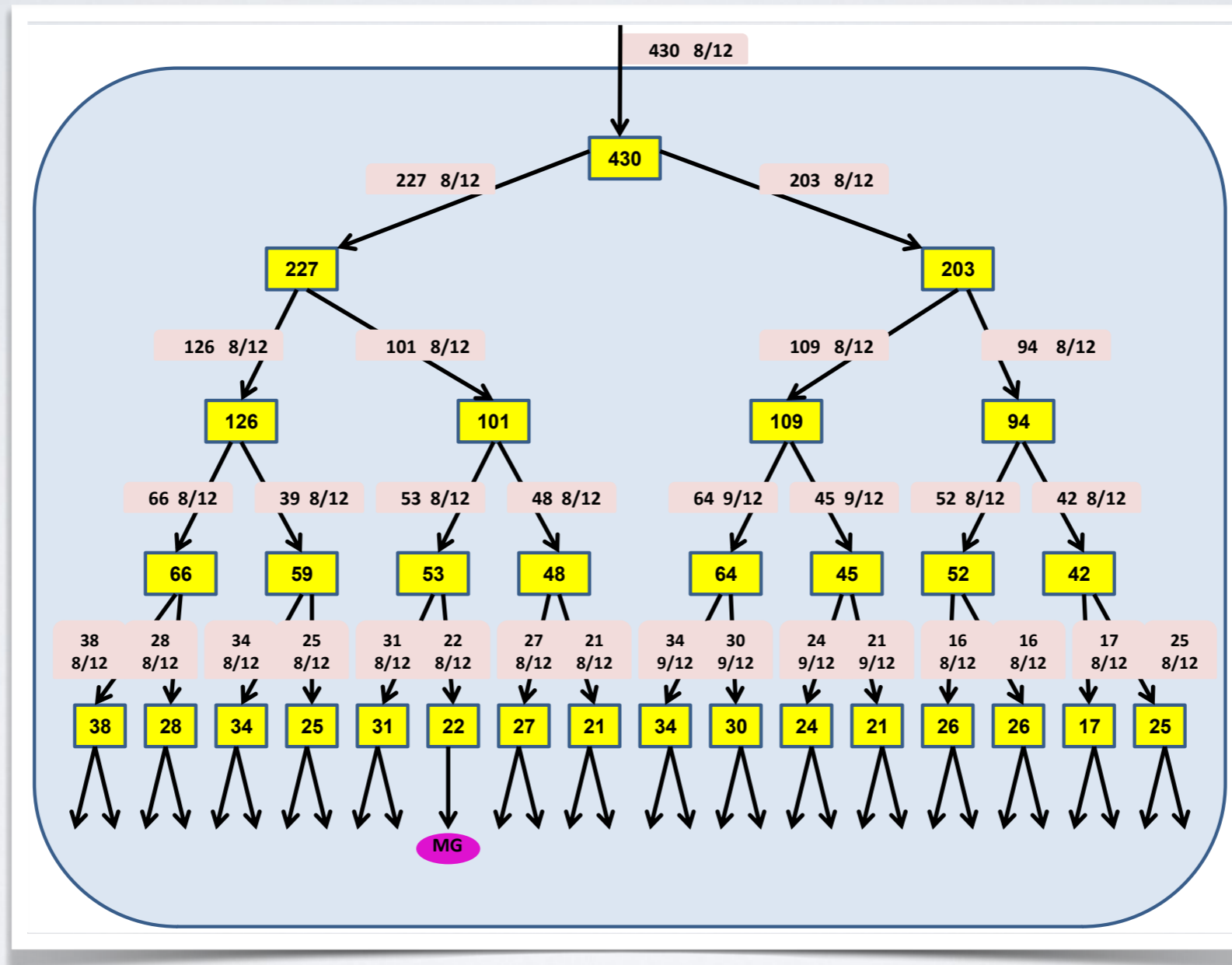
[Möser & Böhme]

EXCEPTIONAL TRANSACTIONS ANALYSIS



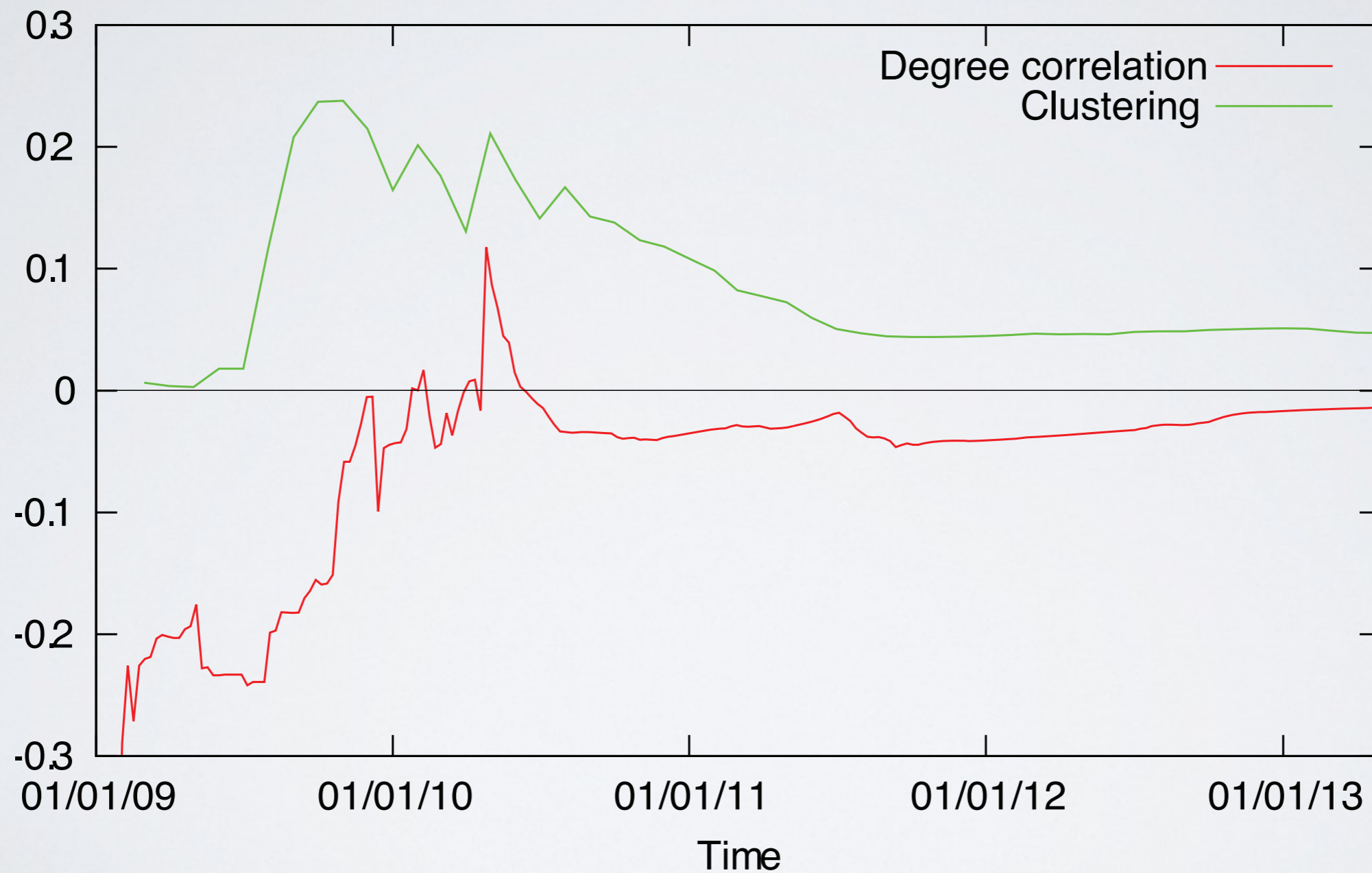
[Ron & Shamir]

EXCEPTIONAL TRANSACTIONS ANALYSIS



[Ron & Shamir]

ANALYSIS OF NETWORK PROPERTIES



[Kondor et al]