Cryptocurrencies
from technology to economy

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ETH Zurich – Distributed Computing Group

Hacker stahlen ETH-Doktoranden Bitcoin für 9 Millionen

Diebstahl Hacker erbeuteten bei einem Mitarbeiter der ETH Zürich 9222 Bitcoin. Heute sind die virtuellen Münzen 9 Millionen Franken wert. Der Fall liegt nun bei der Kantonspolizei.

VON CHRISTIAN BÜTIKOFER 06.12.2013

Cryptocurrencies

#	Name	Market Cap	Price	Available Supply	Volume (24h)
1	Bitcoin	$ 8,981,243,870	$ 574.31	15,638,375 BTC	$ 71,004,500
2	Ethereum	$ 1,172,919,101	$ 14.51	80,853,613 ETH	$ 9,933,140
3	Litecoin	$ 216,171,881	$ 4.68	46,149,551 LTC	$ 5,031,230
4	Ripple	$ 201,593,968	$ 0.005782	34,868,679,462 XRP *	$ 552,597
5	The DAO	$ 162,984,082	$ 0.138973	1,172,775,159 DAO *	$ 1,502,090
6	Dash	$ 51,232,986	$ 7.87	6,510,786 DASH	$ 248,316
7	Lisk	$ 46,560,900	$ 0.465609	100,000,000 LSK *	$ 2,472,480
8	Dogecoin	$ 27,584,159	$ 0.000263	104,686,099,387 DOGE	$ 506,232
9	MaidSafeCoin	$ 25,406,247	$ 0.056140	452,552,412 MAID *	$ 421,888
10	DigixDAO	$ 20,670,600	$ 10.34	2,000,000 DGD *	$ 65,517

What is Bitcoin?

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«Satoshi Nakamoto»

Technology

The Bank of Bitcoin

The Bank of Bitcoin

User	Balance
A	2
B	5
C	8

The Bank of Bitcoin

TX

$B \rightarrow A$

User	Balance
A	2
B	5
C	8

The Bank of Bitcoin

TX

B $\rightarrow$ A

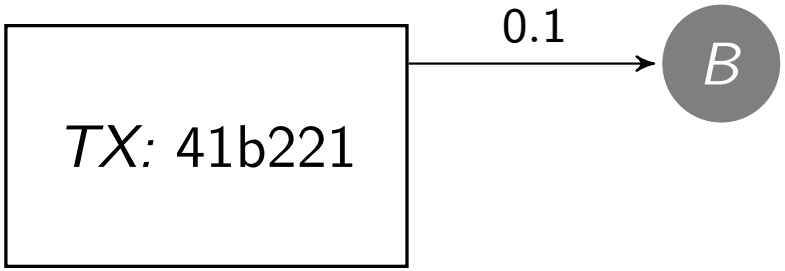
User	Balance
A	~~2~~ 4
B	~~5~~ 3
C	8

Opening an Account in Bitcoin

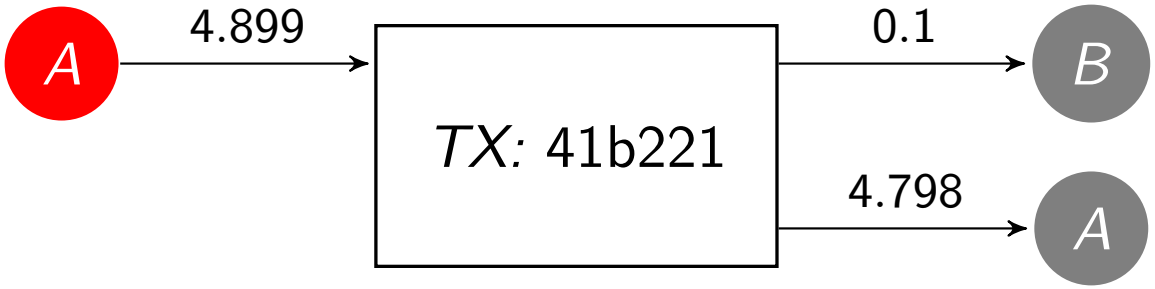
Transferring Bitcoins

TX: 41b221

Transferring Bitcoins



Transferring Bitcoins



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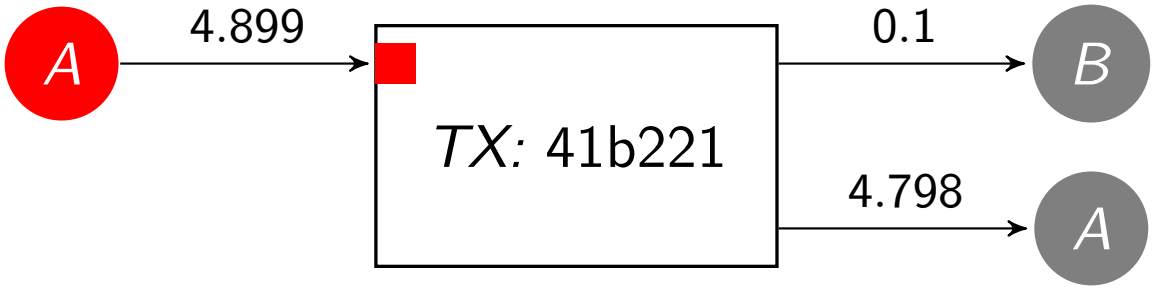

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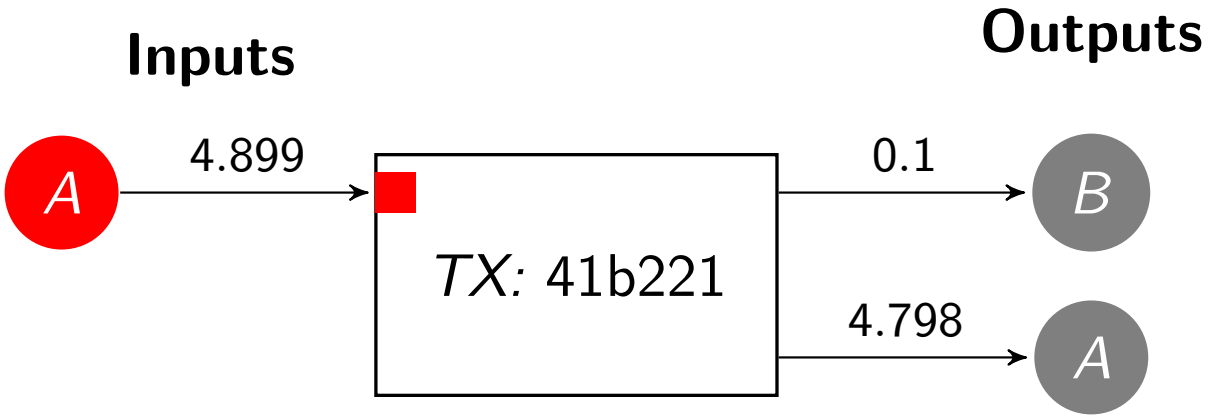

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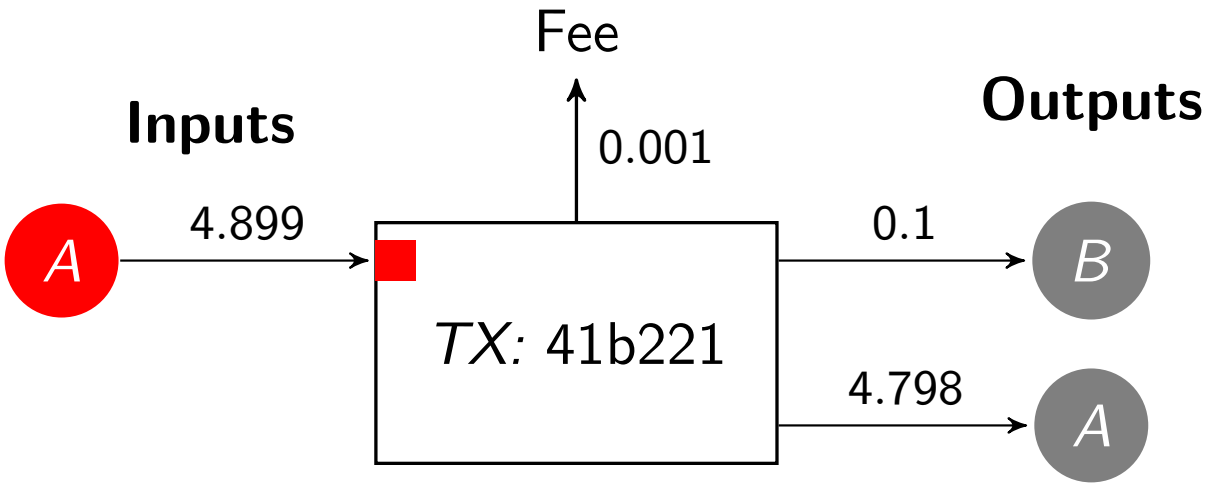

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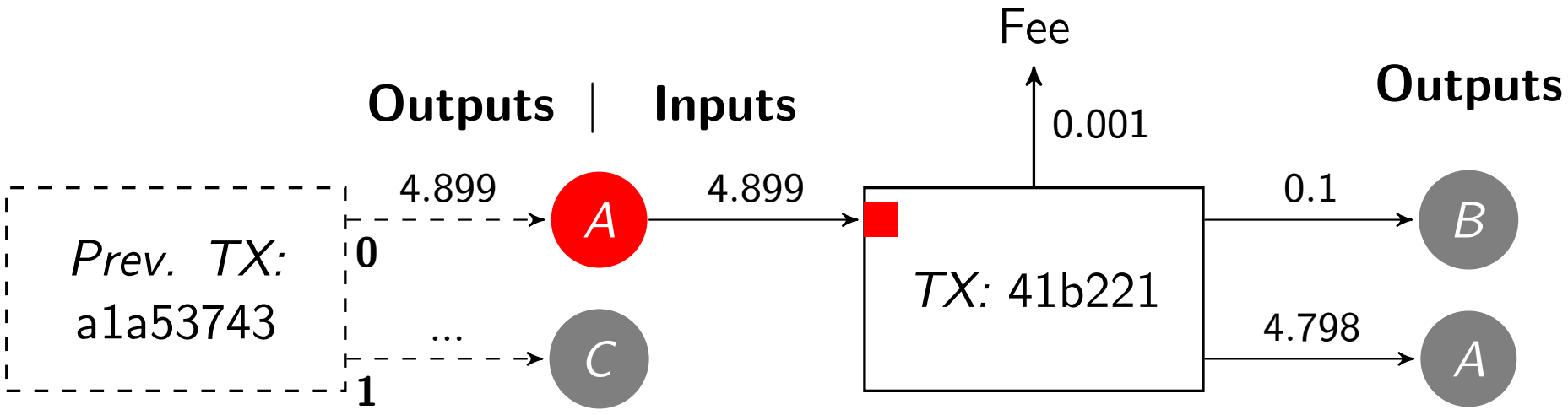
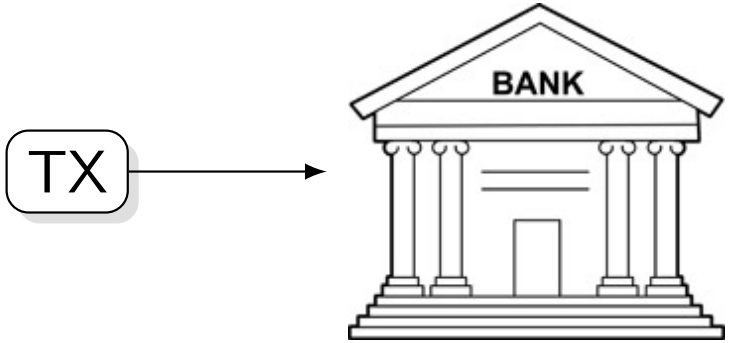
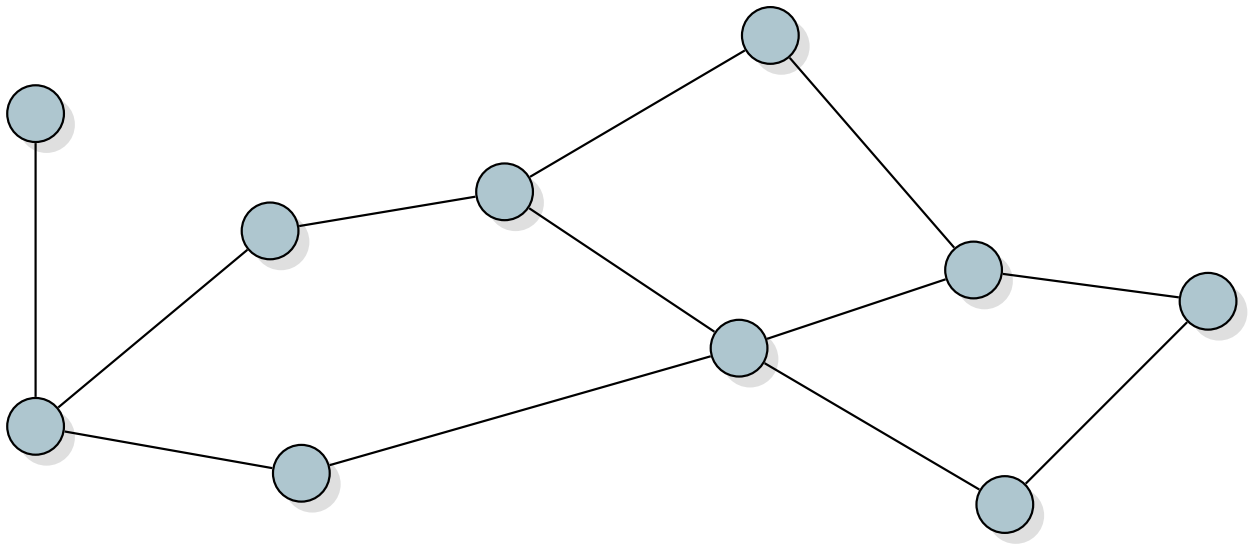


Distributing the Bank

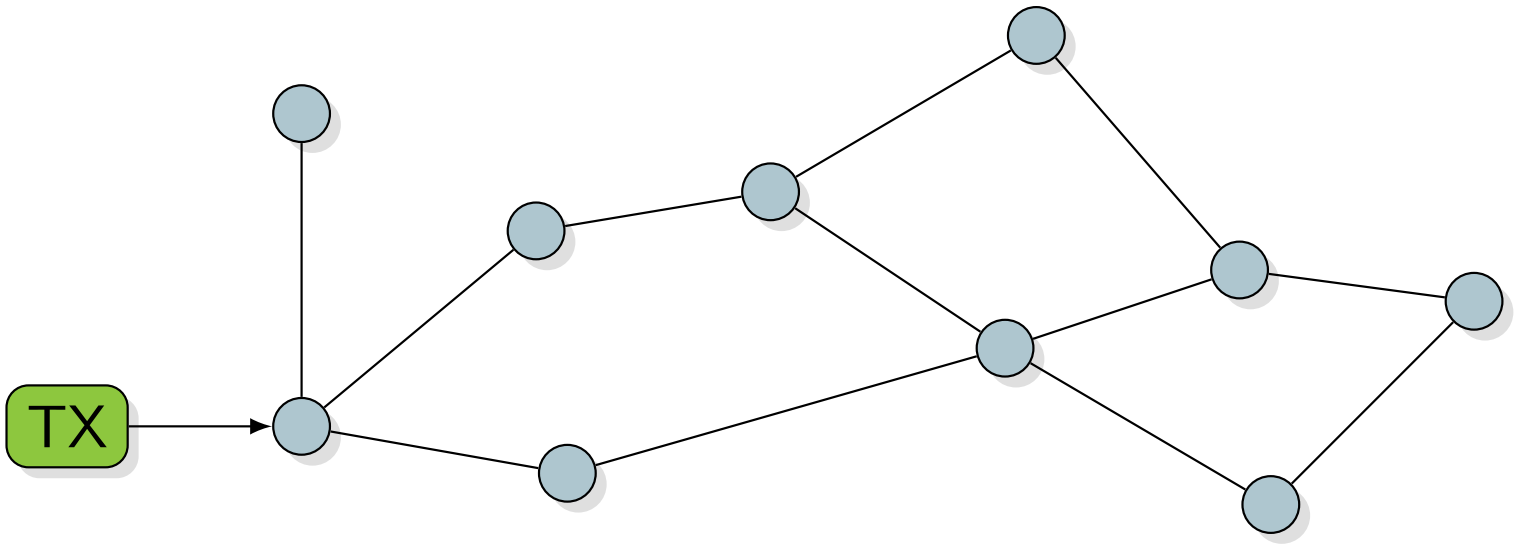


User	Balance
A	2
B	5
C	8

Distributing the Bank



Distributing the Bank



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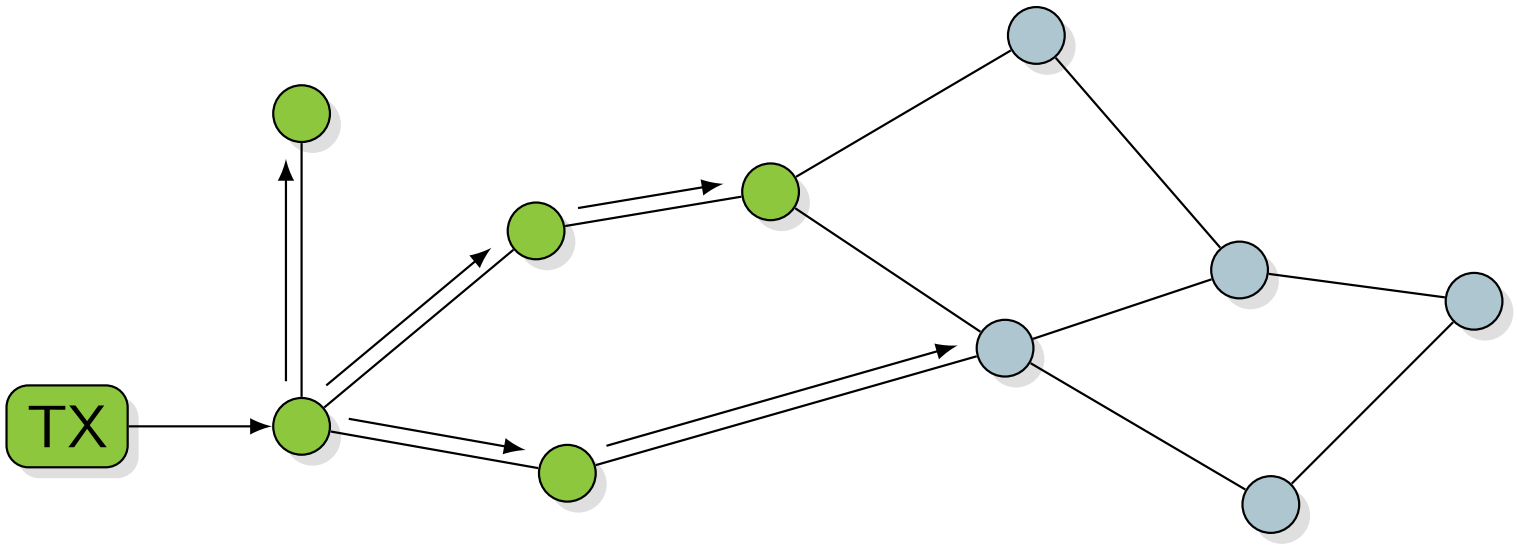

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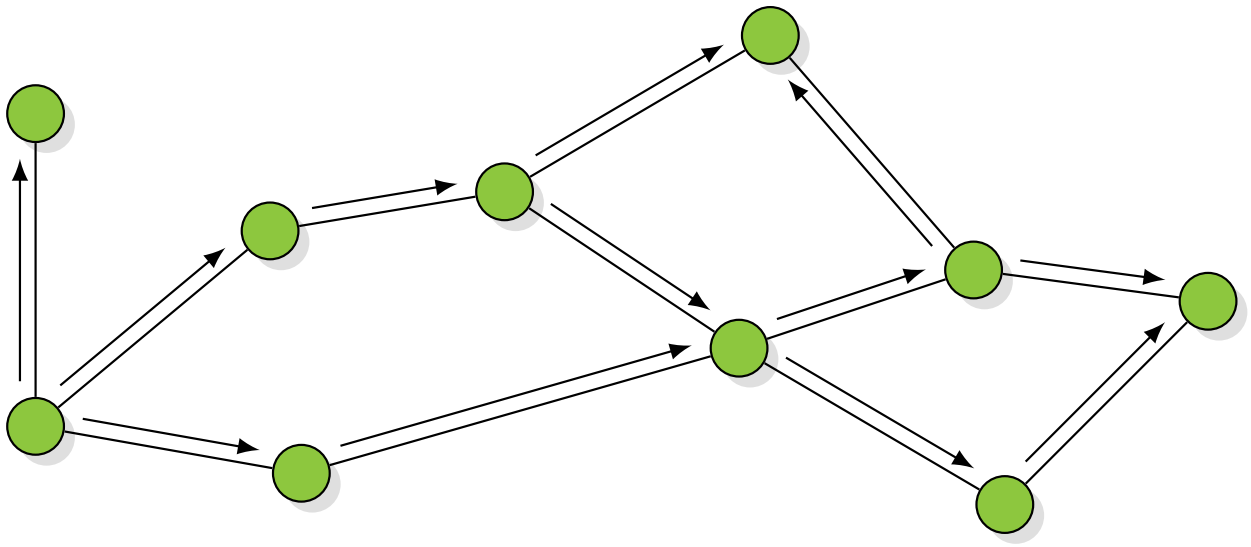

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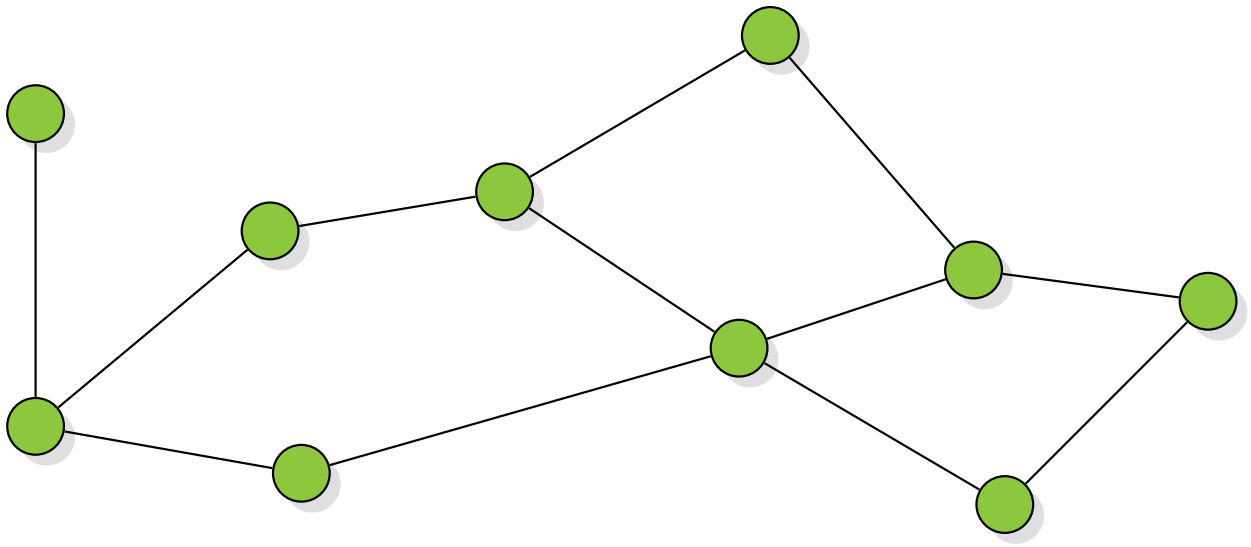
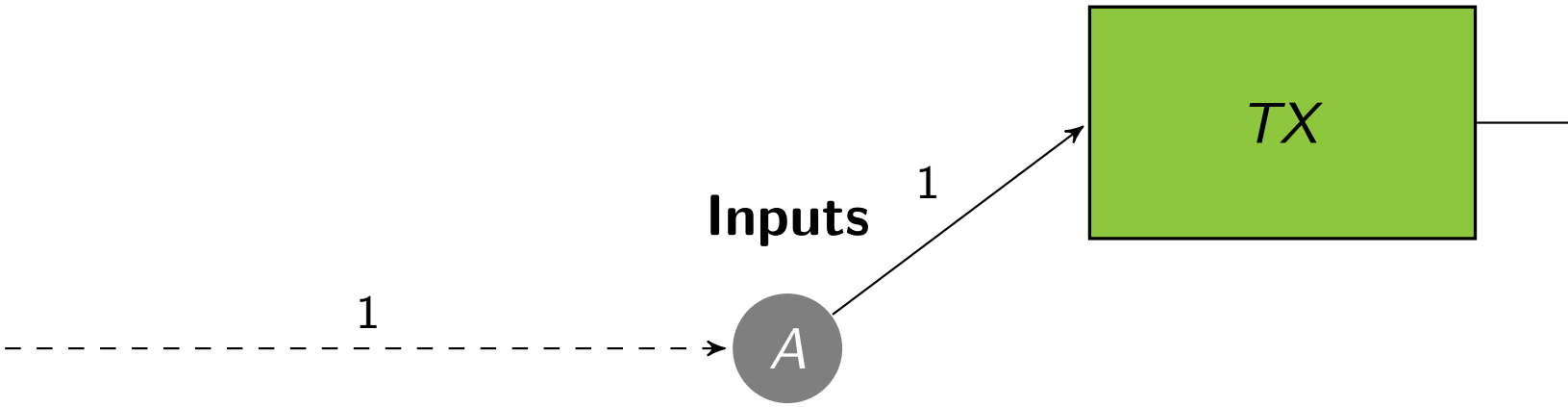


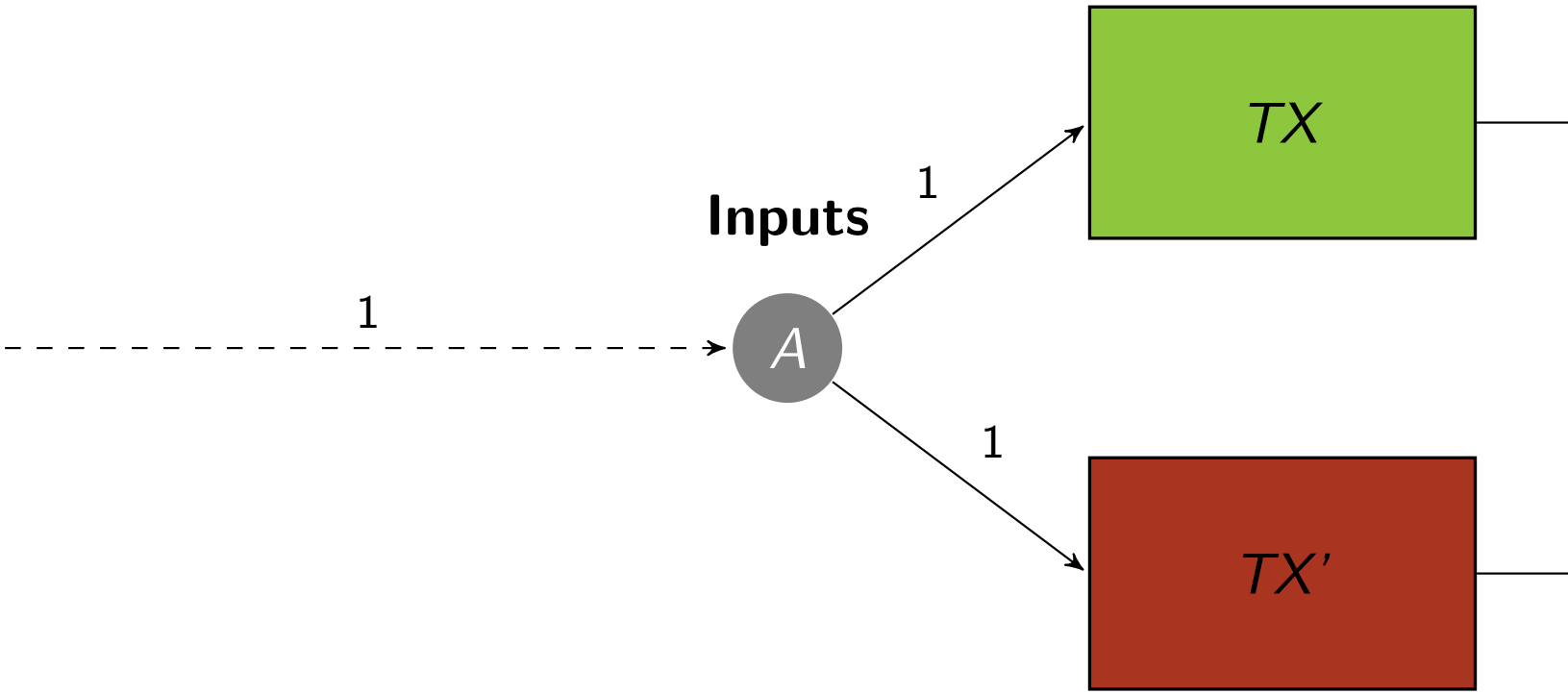
Let's Buy a Snack

[Bamert, Decker, Elsen, W, Welten, 2013]

Doublespending



Doublespending



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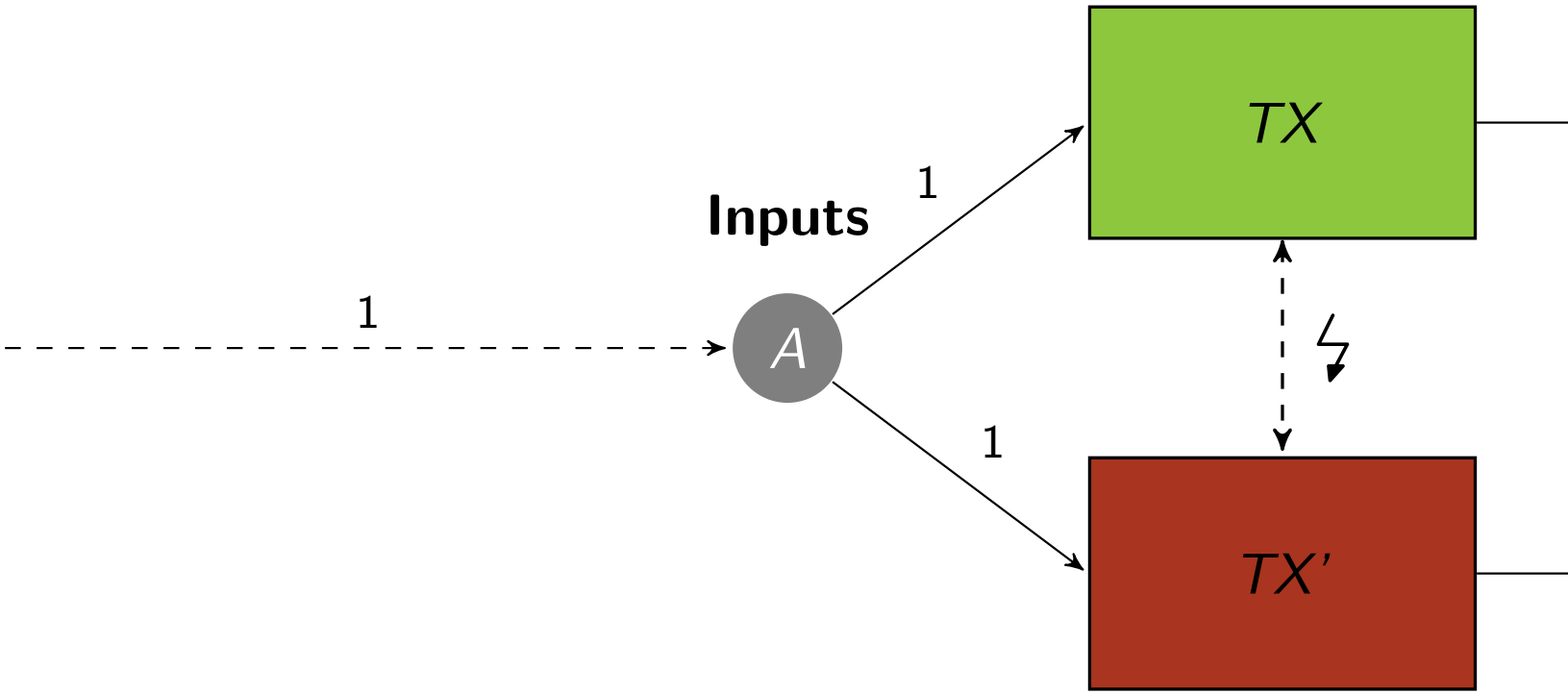
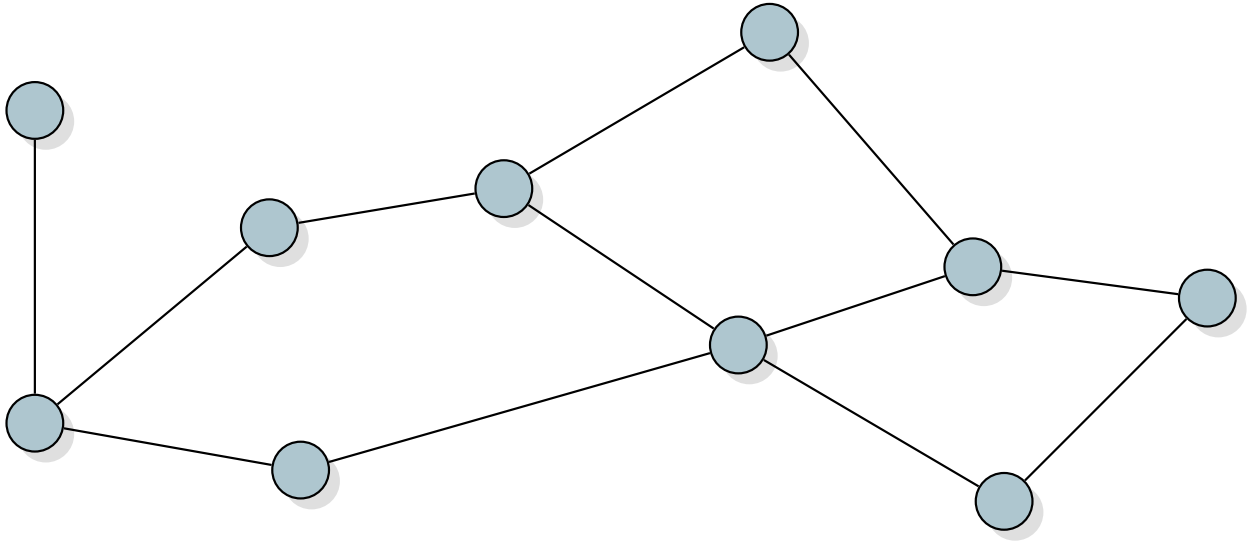


Transaction Conflicts



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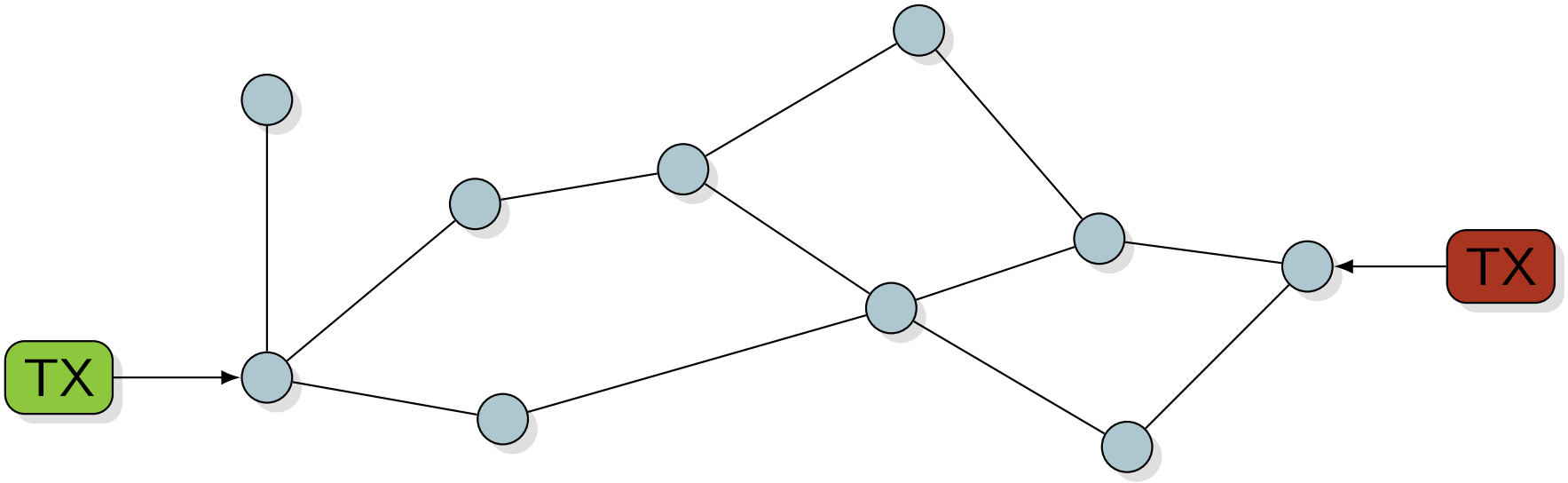

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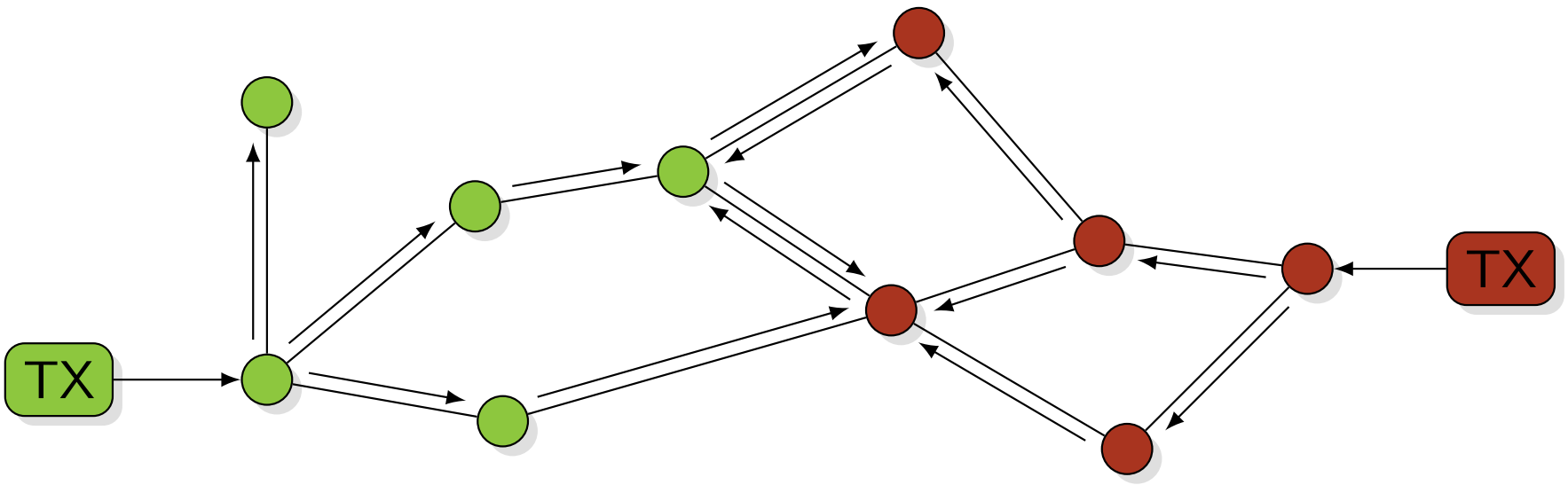

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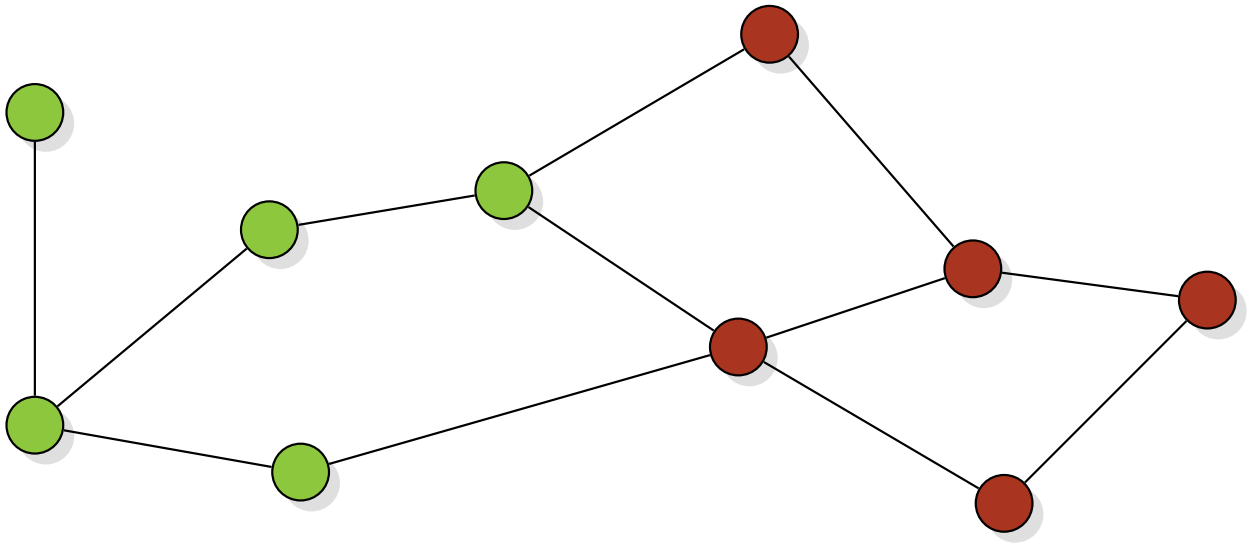
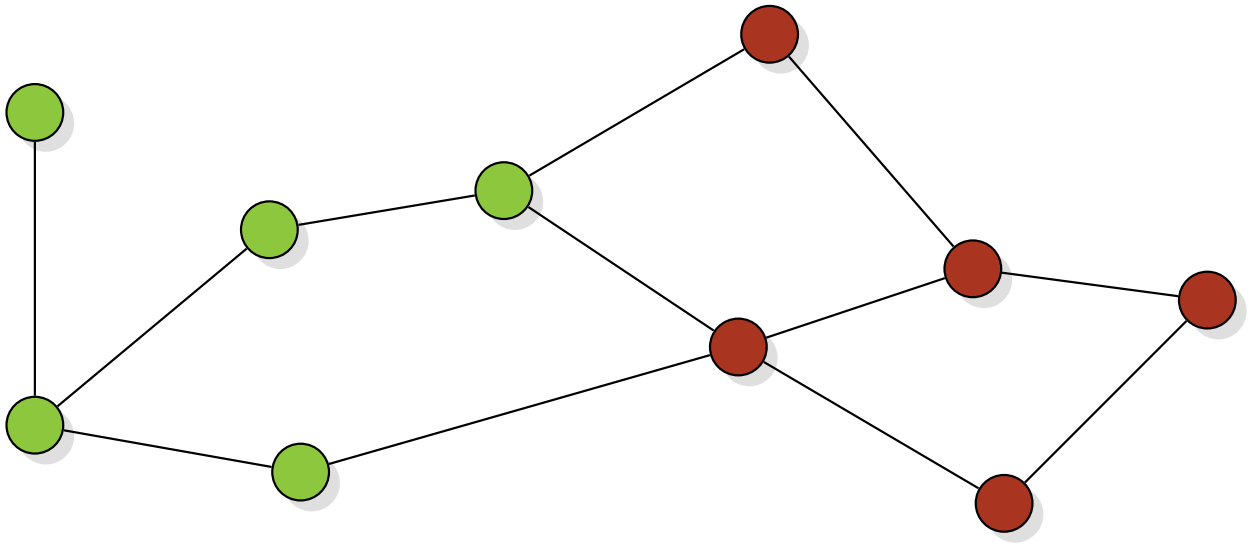


Resolving Conflicts



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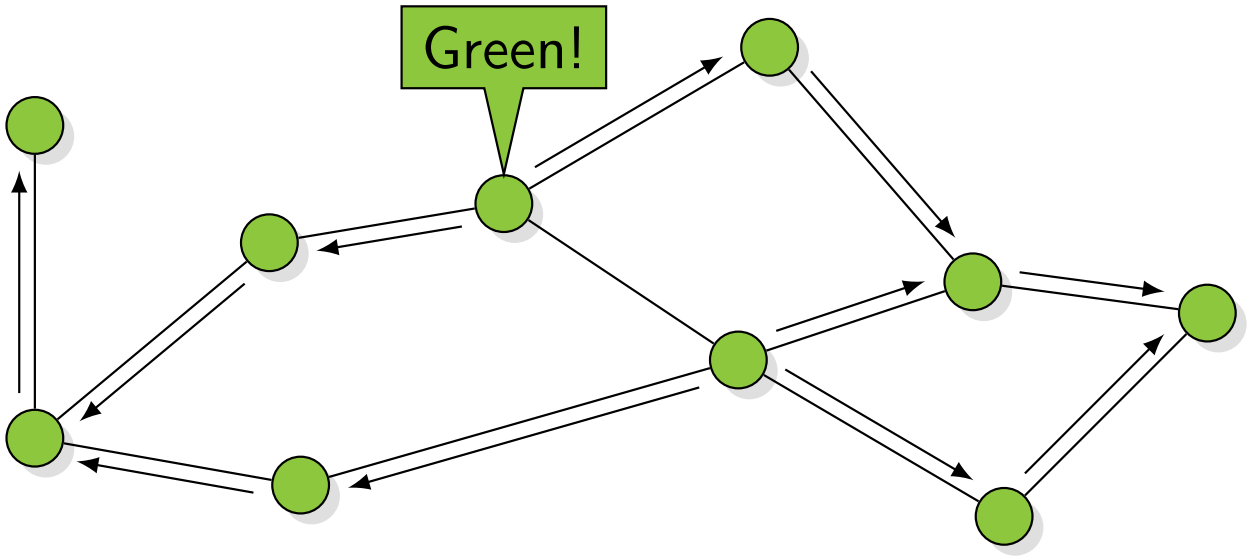
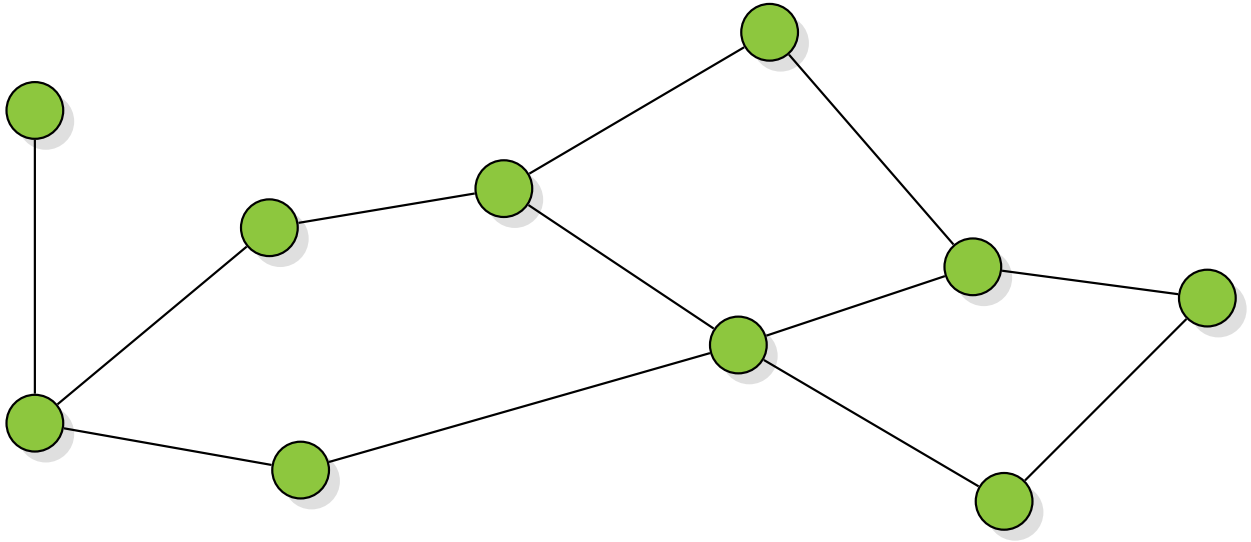
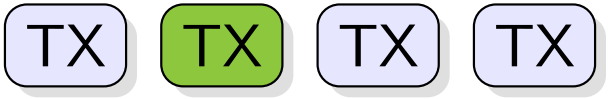


Resolving Conflicts

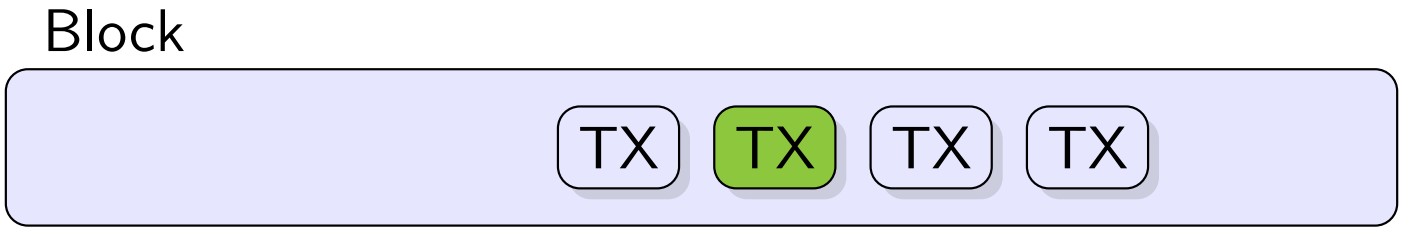


How to Choose a Leader?

Proof-of-Work



Proof-of-Work



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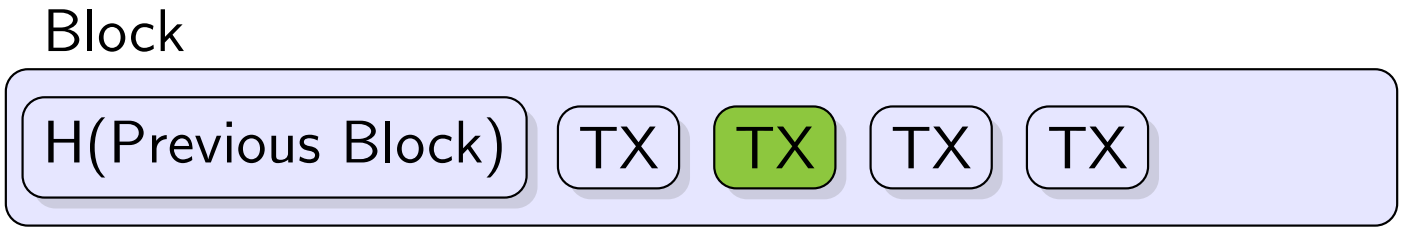

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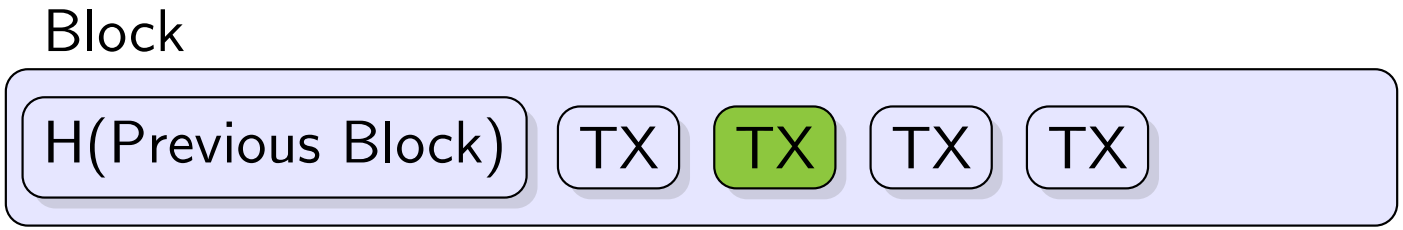
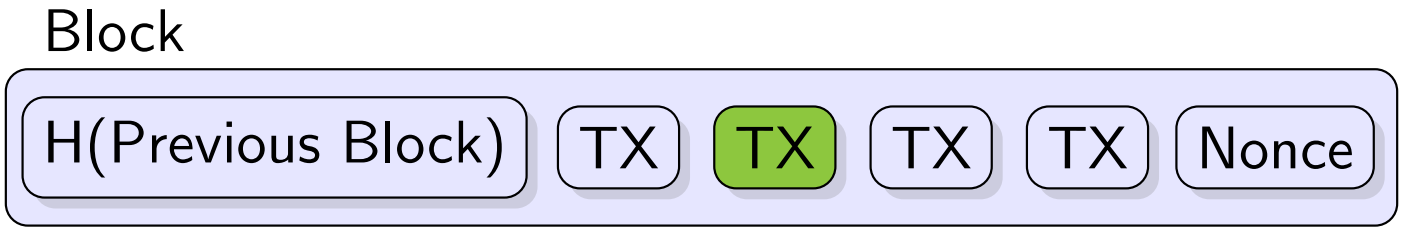


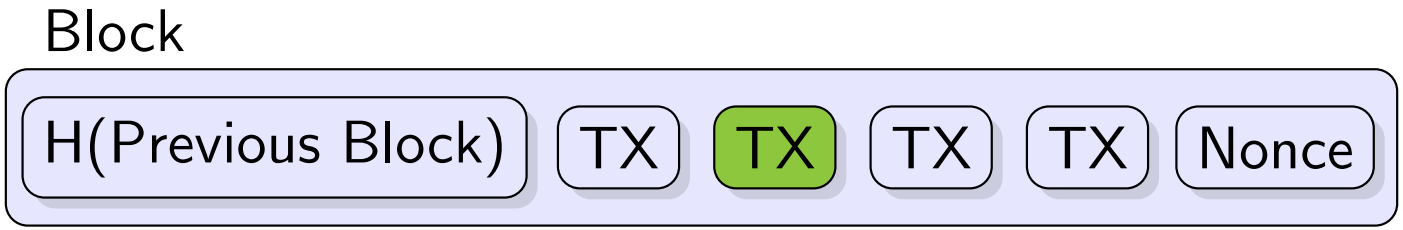
- H(Block) $\rightarrow$ fd2e2055f117bfa261b5a6c7e11df367...

Proof-of-Work



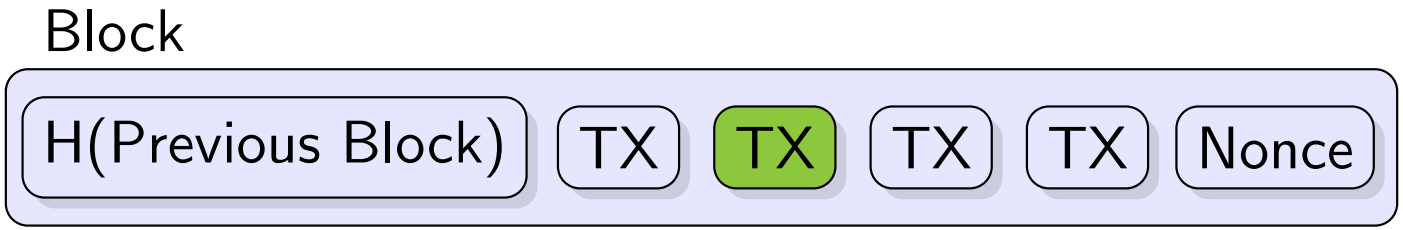
- $H(\text{Block}|0) \rightarrow 094d66aa7c844a9dbb516a41259b5877\ldots$

Proof-of-Work



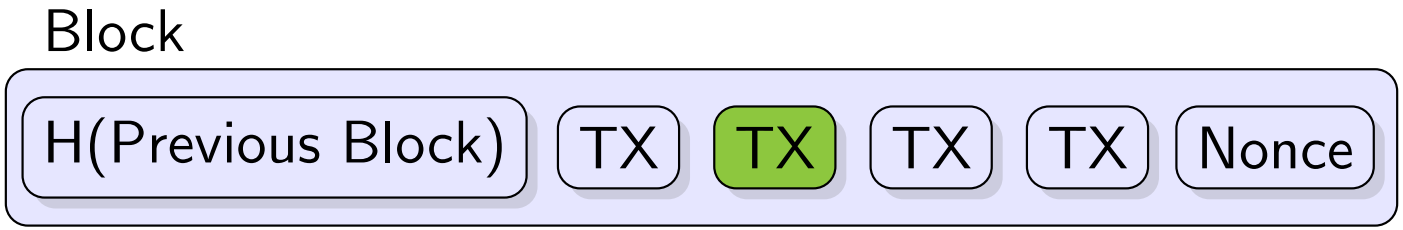
- $H(\text{Block}|0) \rightarrow$ 094d66aa7c844a9dbb516a41259b5877...
- $H(\text{Block}|1) \rightarrow$ f2496854af8bf989171587a9259f634f...

Proof-of-Work



- H(Block|0) → 094d66aa7c844a9dbb516a41259b5877...
- H(Block|1) → f2496854af8bf989171587a9259f634f...
- H(Block|2) → aec87c0ca2e5eb3f23111092f1089ada...

Proof-of-Work

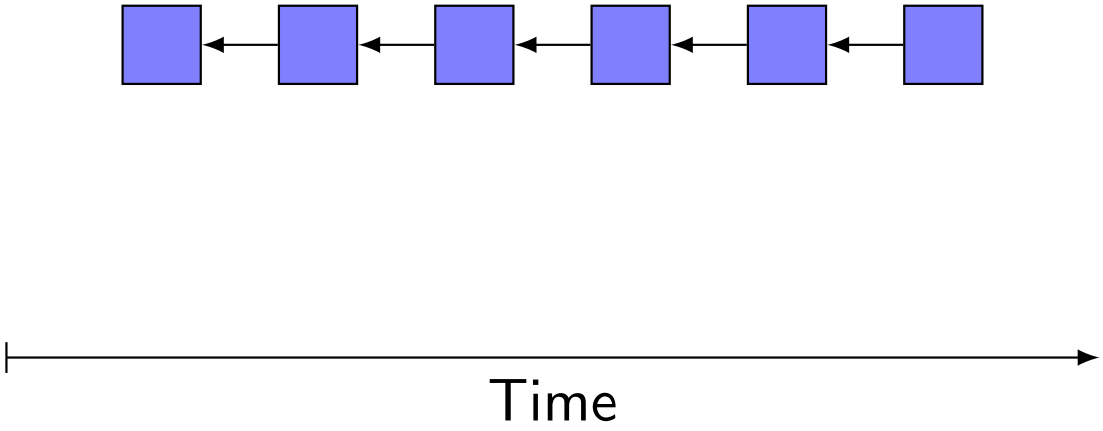


- $H(\text{Block}|0) \rightarrow$ 094d66aa7c844a9dbb516a41259b5877...
- $H(\text{Block}|1) \rightarrow$ f2496854af8bf989171587a9259f634f...
- $H(\text{Block}|2) \rightarrow$ aec87c0ca2e5eb3f23111092f1089ada...
- $H(\text{Block}|3) \rightarrow$ 777f75b2a8ecfdc8026c236fc1d2ffa0...

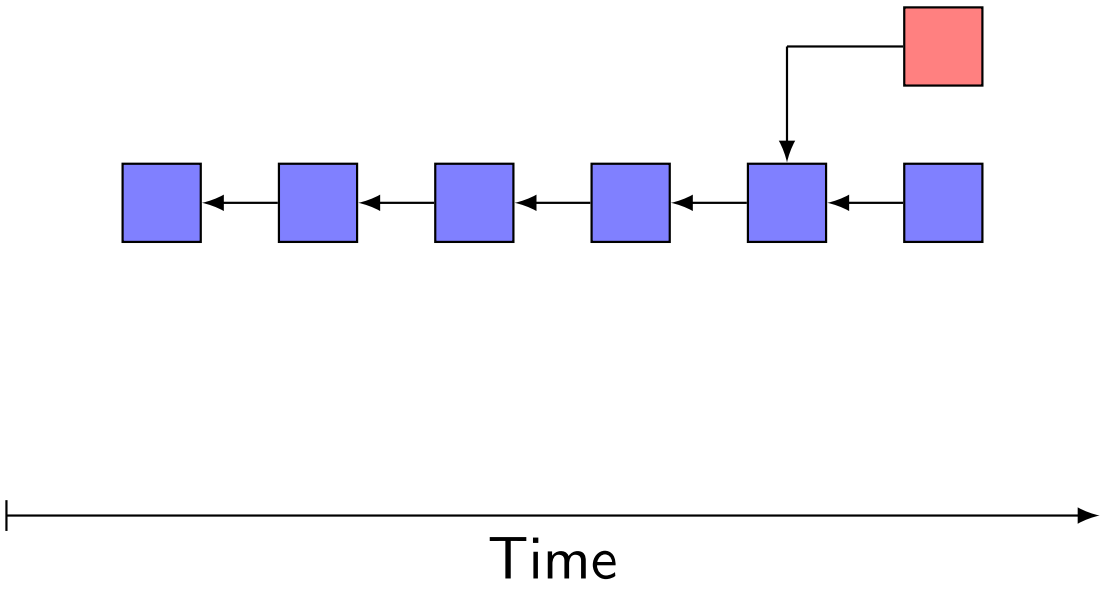
  ⋮

- $H(\text{Block}|961127) \rightarrow$ 000001482341962 2d4c133672a7d657e...

The Blockchain

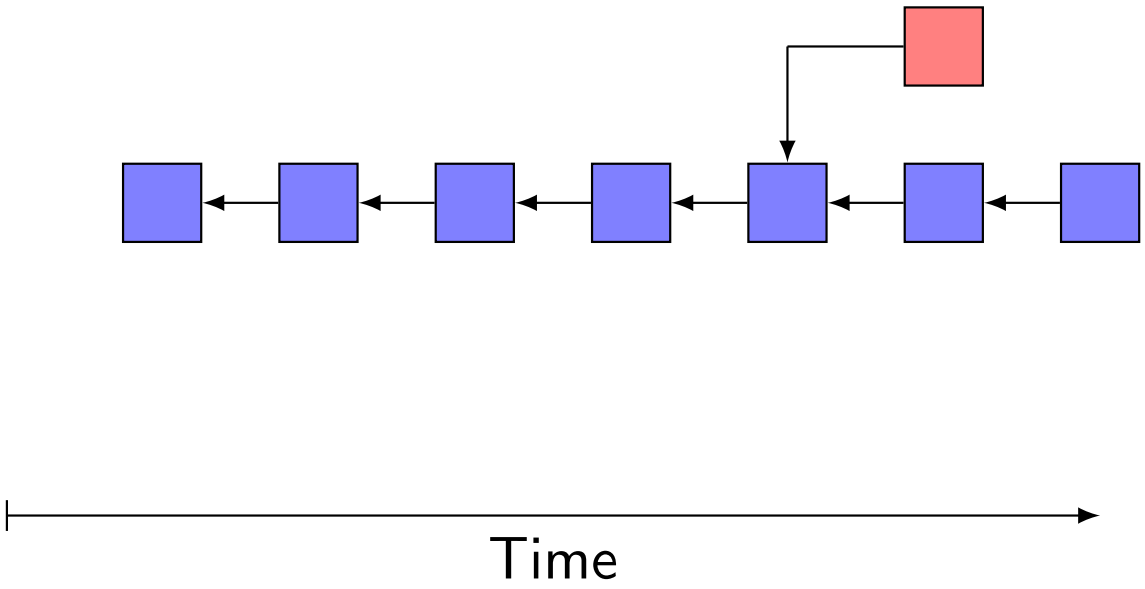


The Blockchain

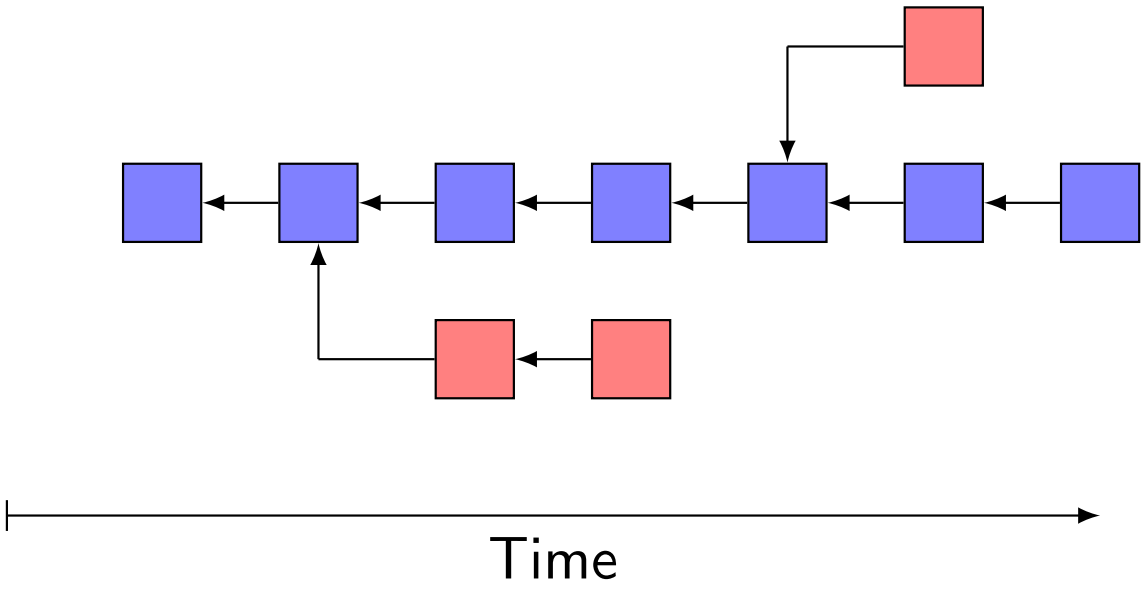


Is Bitcoin stable?

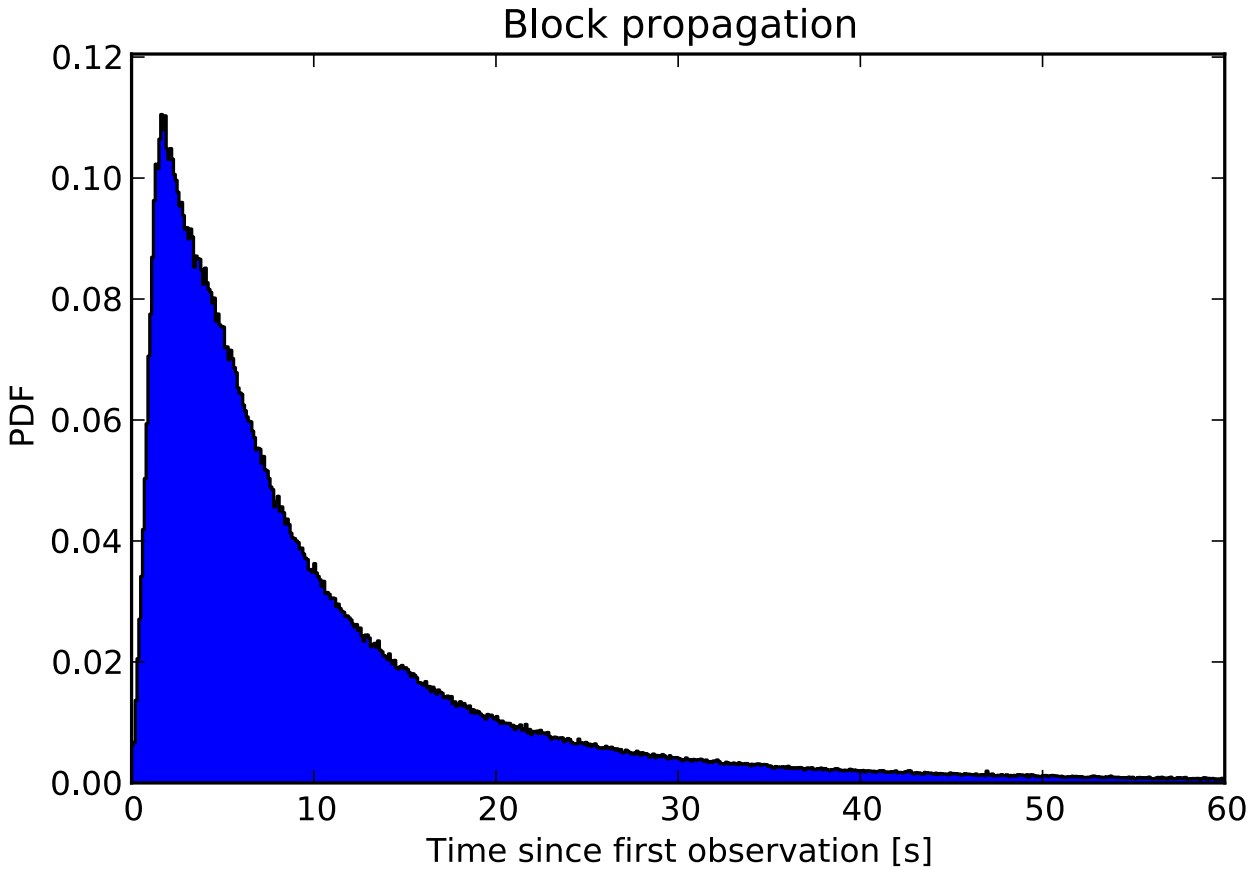
The Blockchain



The Blockchain



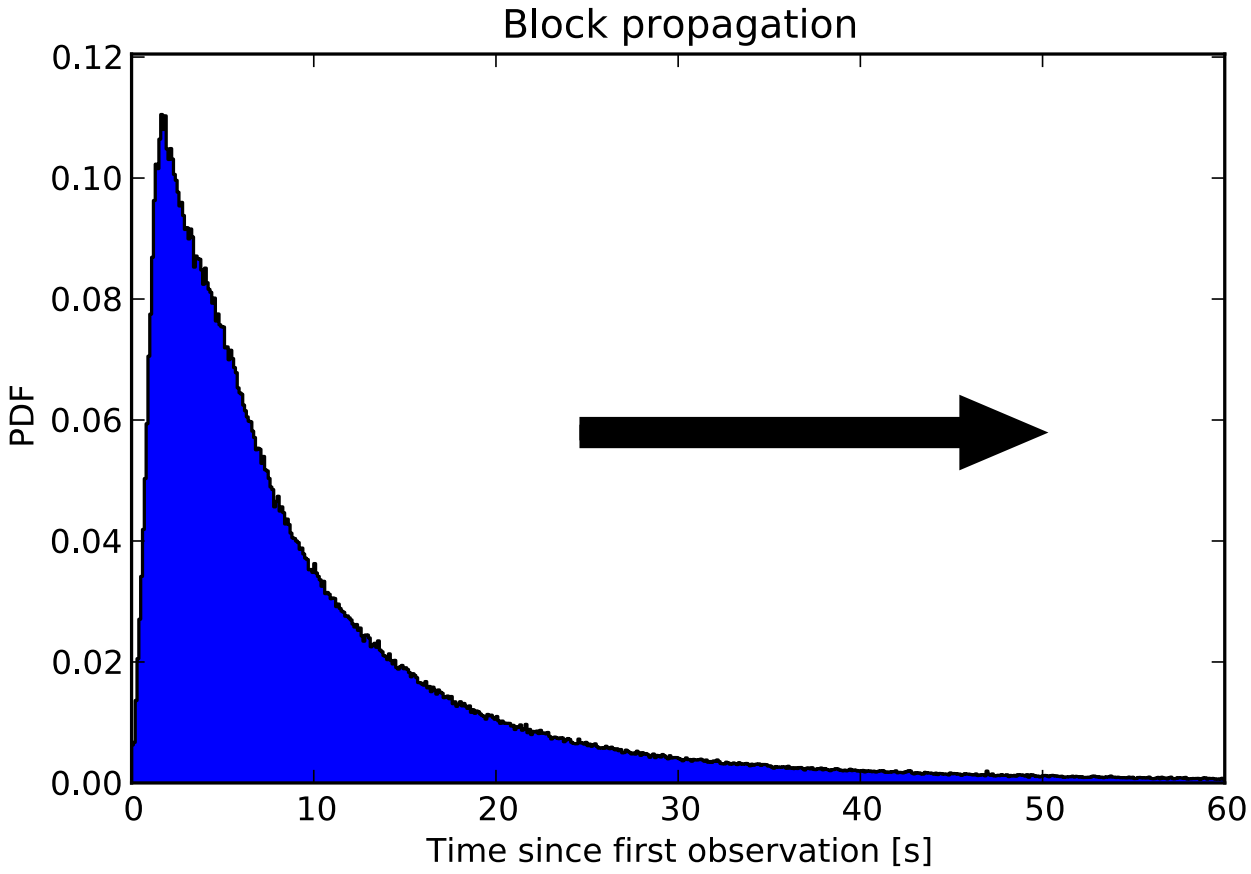
Propagation Speed



http://bitcoinstats.com

[Decker, W, 2013]

Propagation Speed



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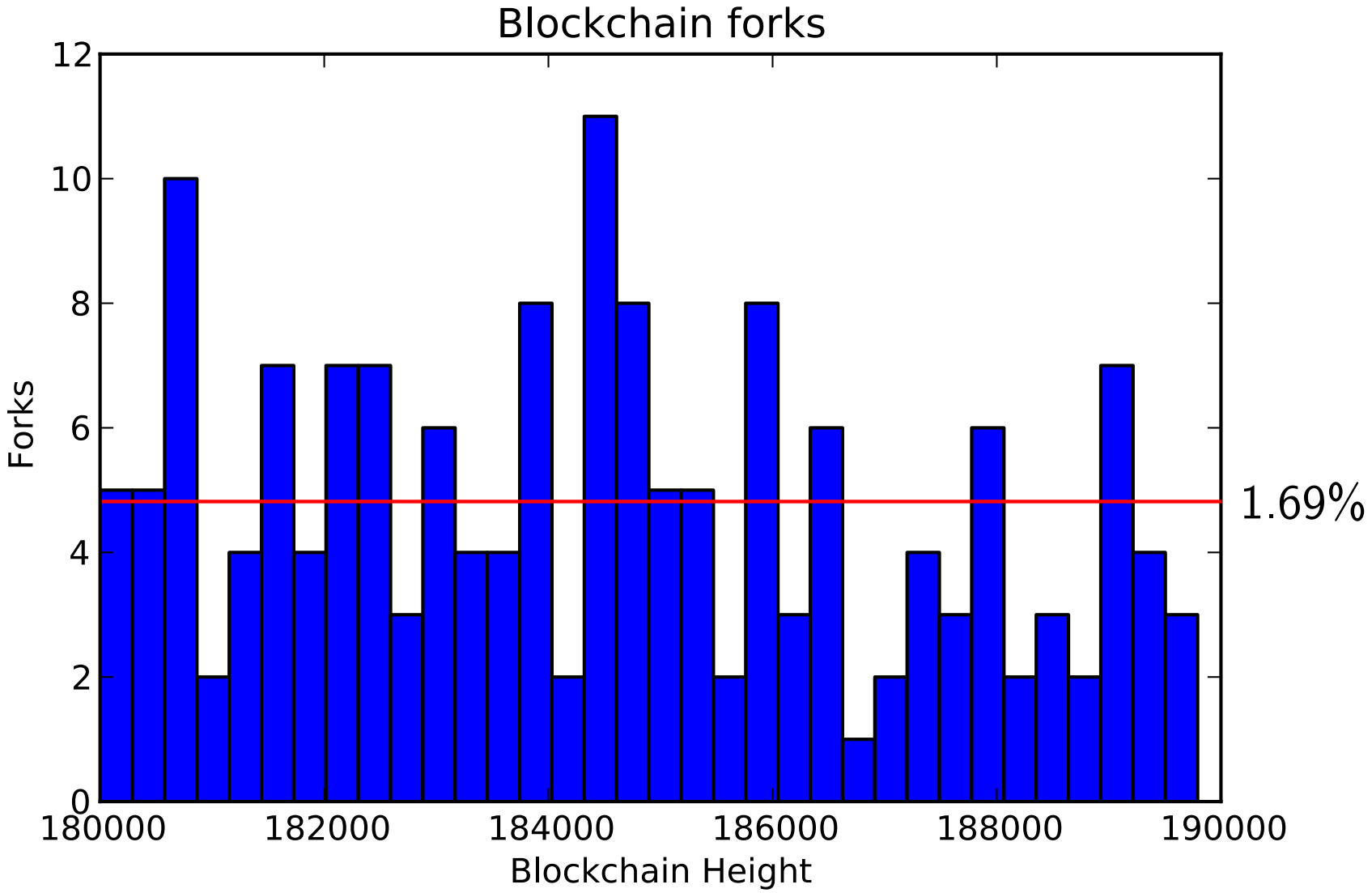
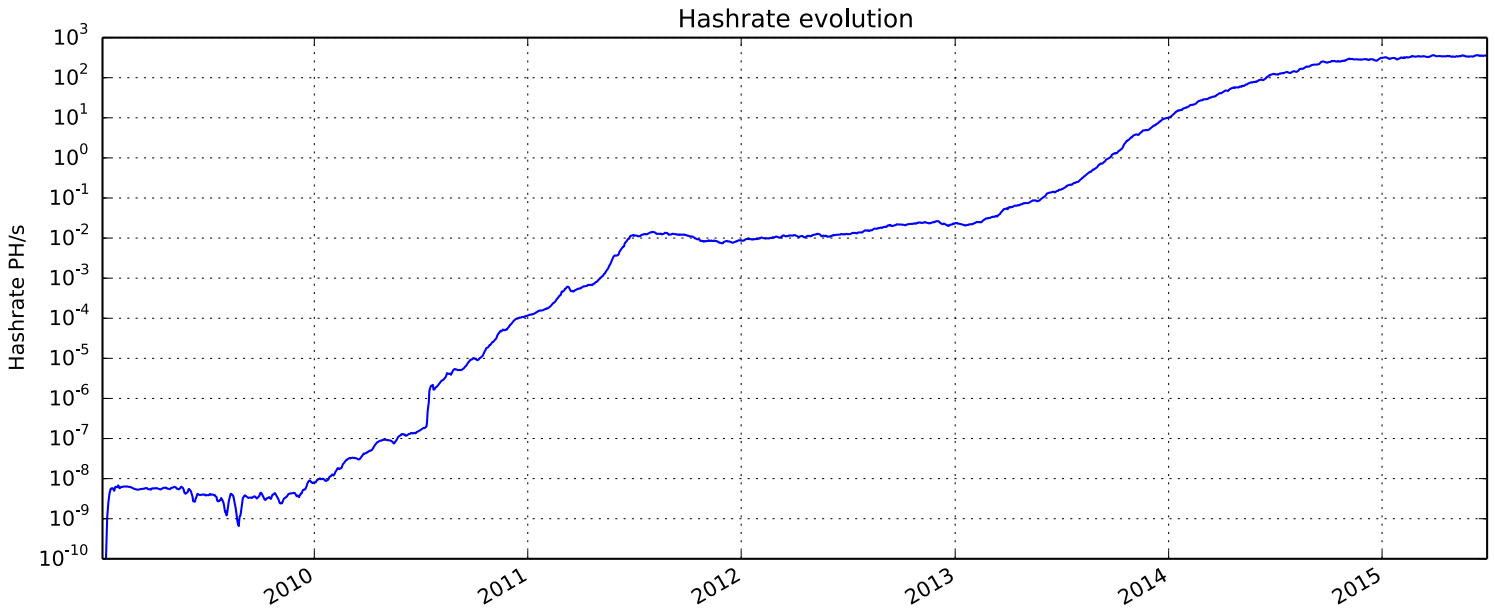
[Decker, W, 2013]

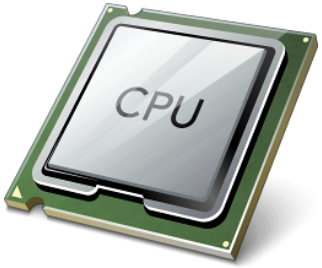
Blockchain Forks



[Decker, W, 2013]

Aside: Mining Evolution





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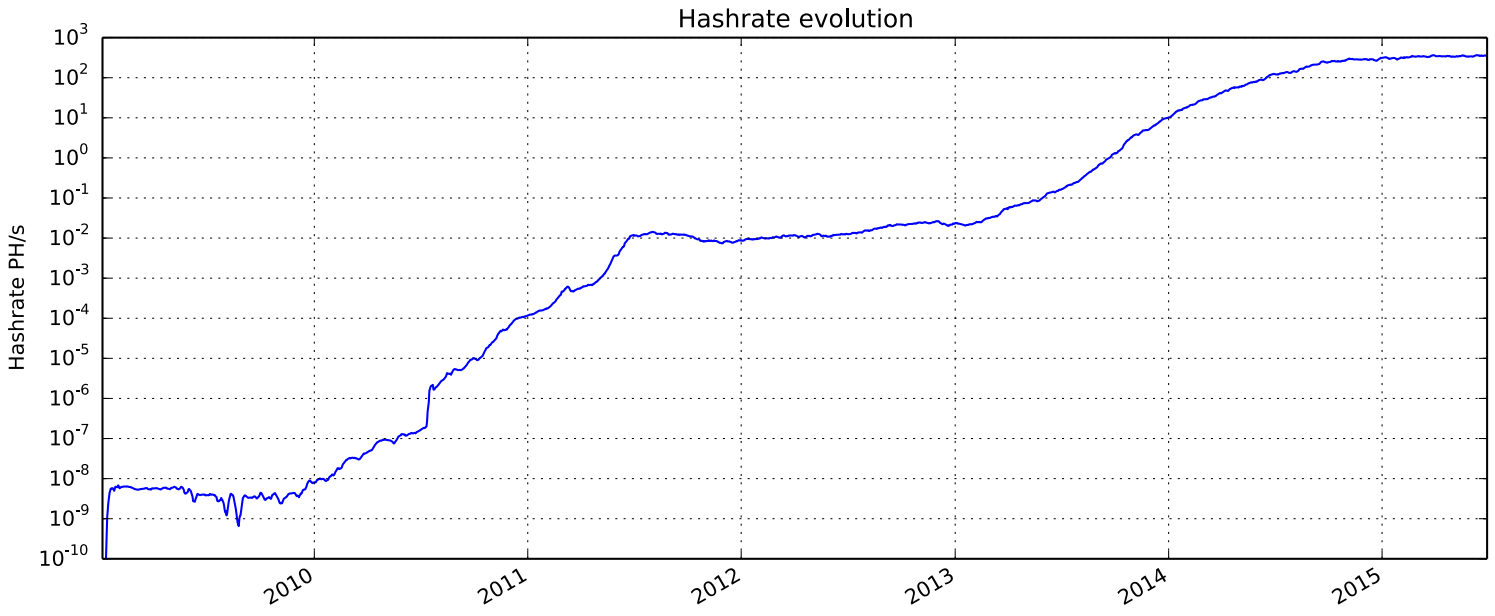
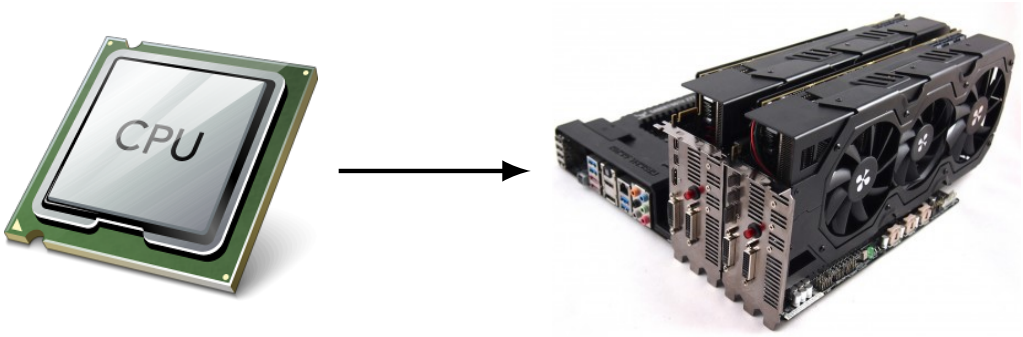
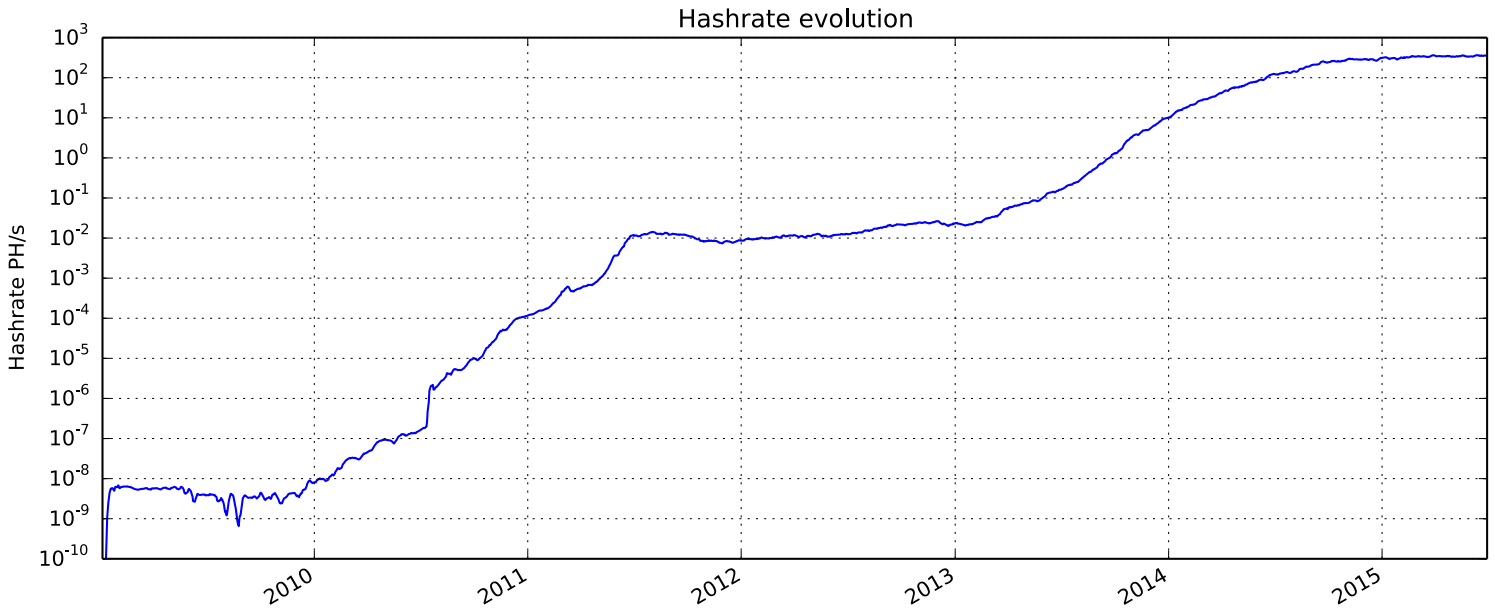


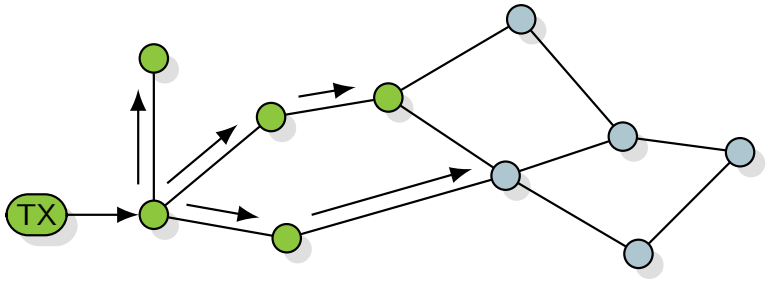


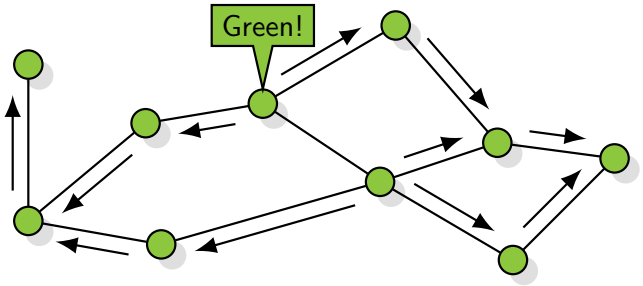
Aside: Mining Evolution

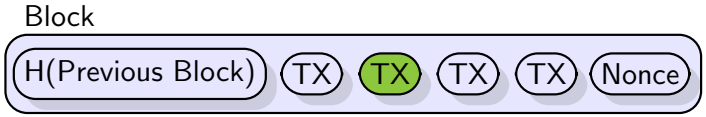


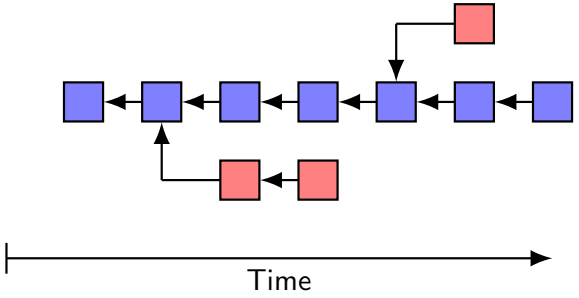
500 MW

Summary









Stories

How to Lose $500M

Addressing Transaction Malleability: MtGox has detected unusual activity on its Bitcoin wallets and performed investigations during the past weeks.

The MtGox Incident

- July 2010: First trade on MtGox
- May 2011: Transaction malleability identified as low priority issue
- February 7, 2014: MtGox halts withdrawals
- February 10, 2014: MtGox announces loss of 850,000 bitcoins (620 millio USD) and cites transaction malleability as root cause
- February 28, 2014: MtGox files for bankruptcy
- March 7 2014: MtGox finds 200,000 bitcoins
- August 2015: MtGox CEO is arrested

Signatures

61 af bb 4d e9 f8 b8 74 86 1e

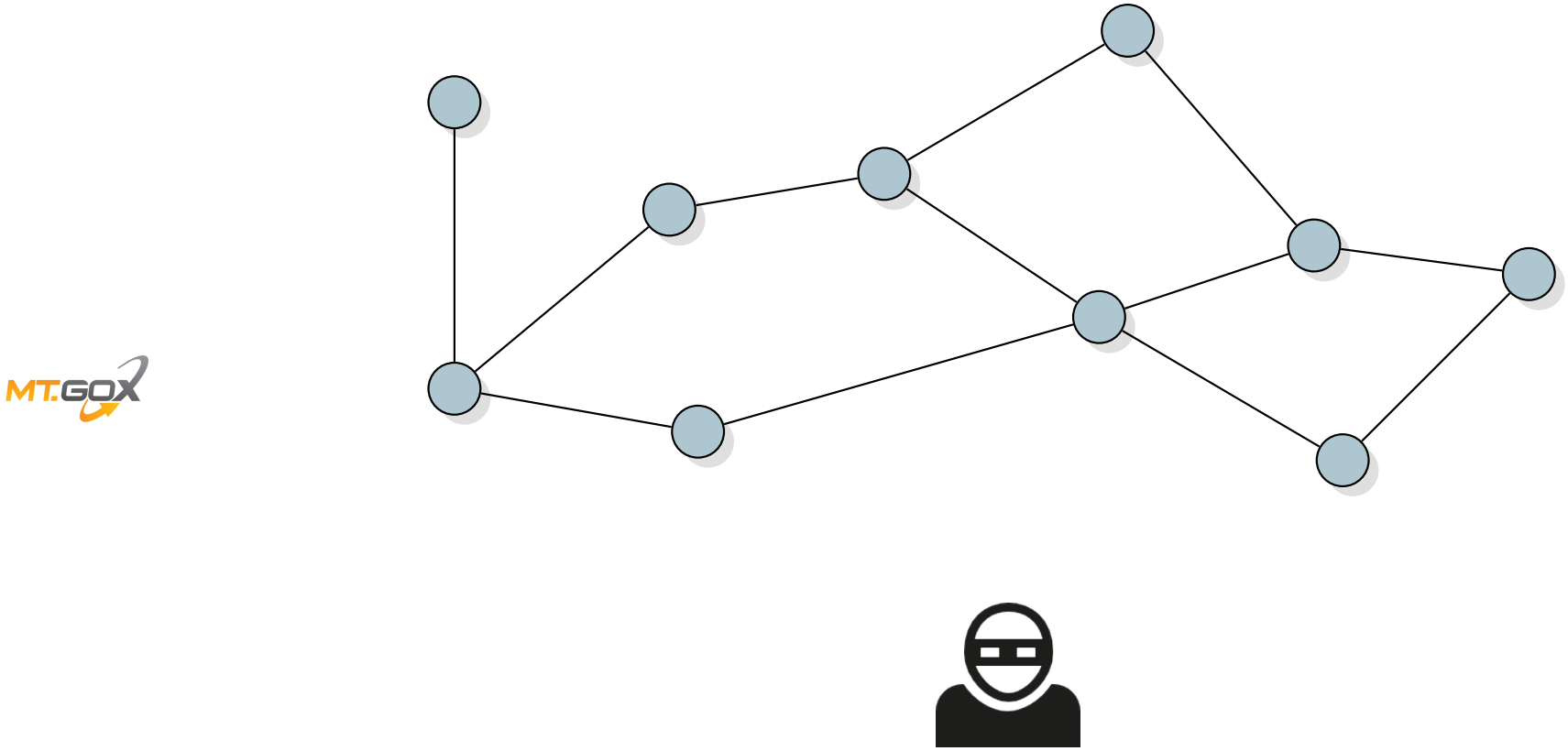
Signatures

00 00 61 af bb 4d e9 f8 b8 74 86 1e

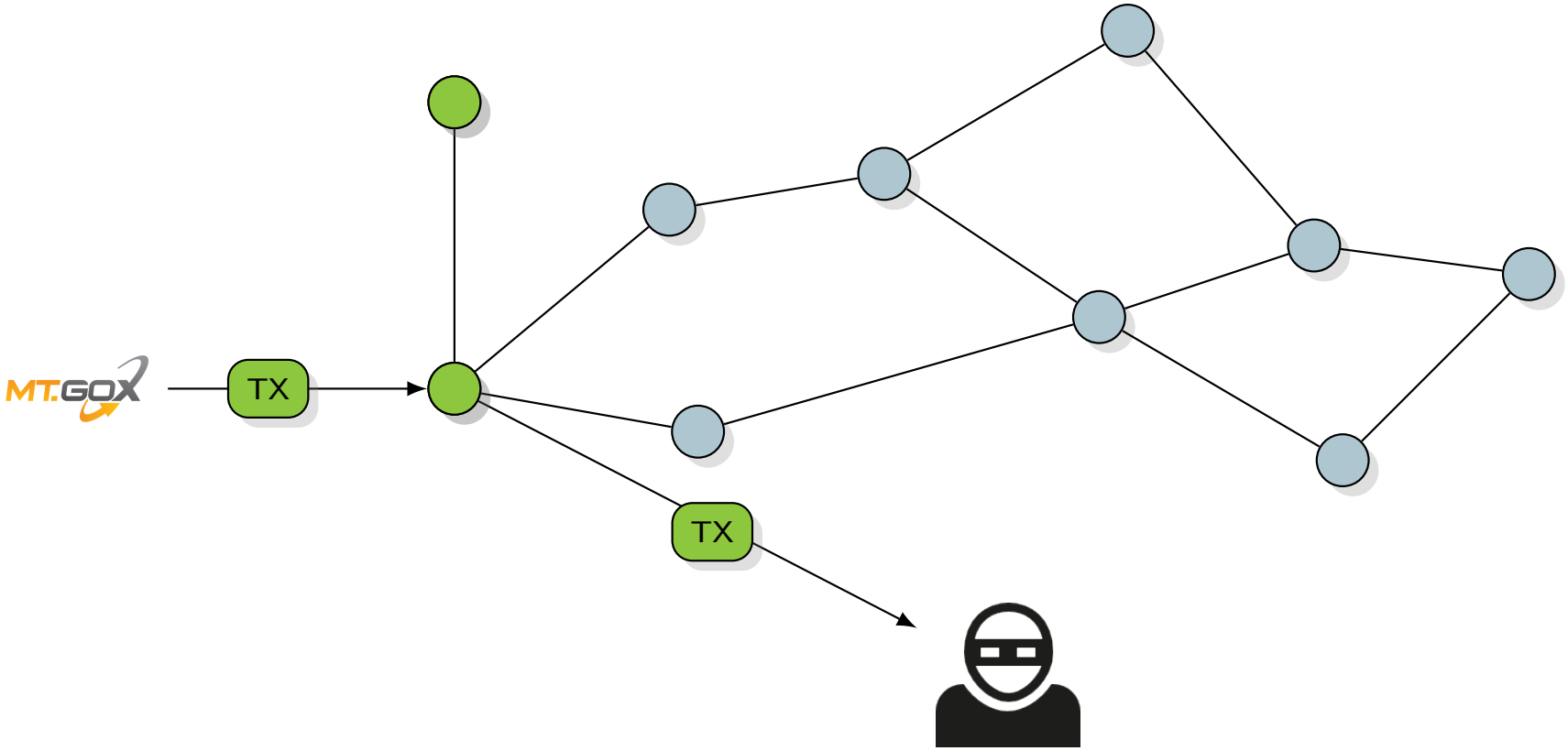
There are multiple ways to serialize a signature:

- Multiple push operations (1 byte, 2 byte, 4 byte)
- Non-canonical DER encodings
- Padding
- ...

Transaction Malleability Attack



Transaction Malleability Attack



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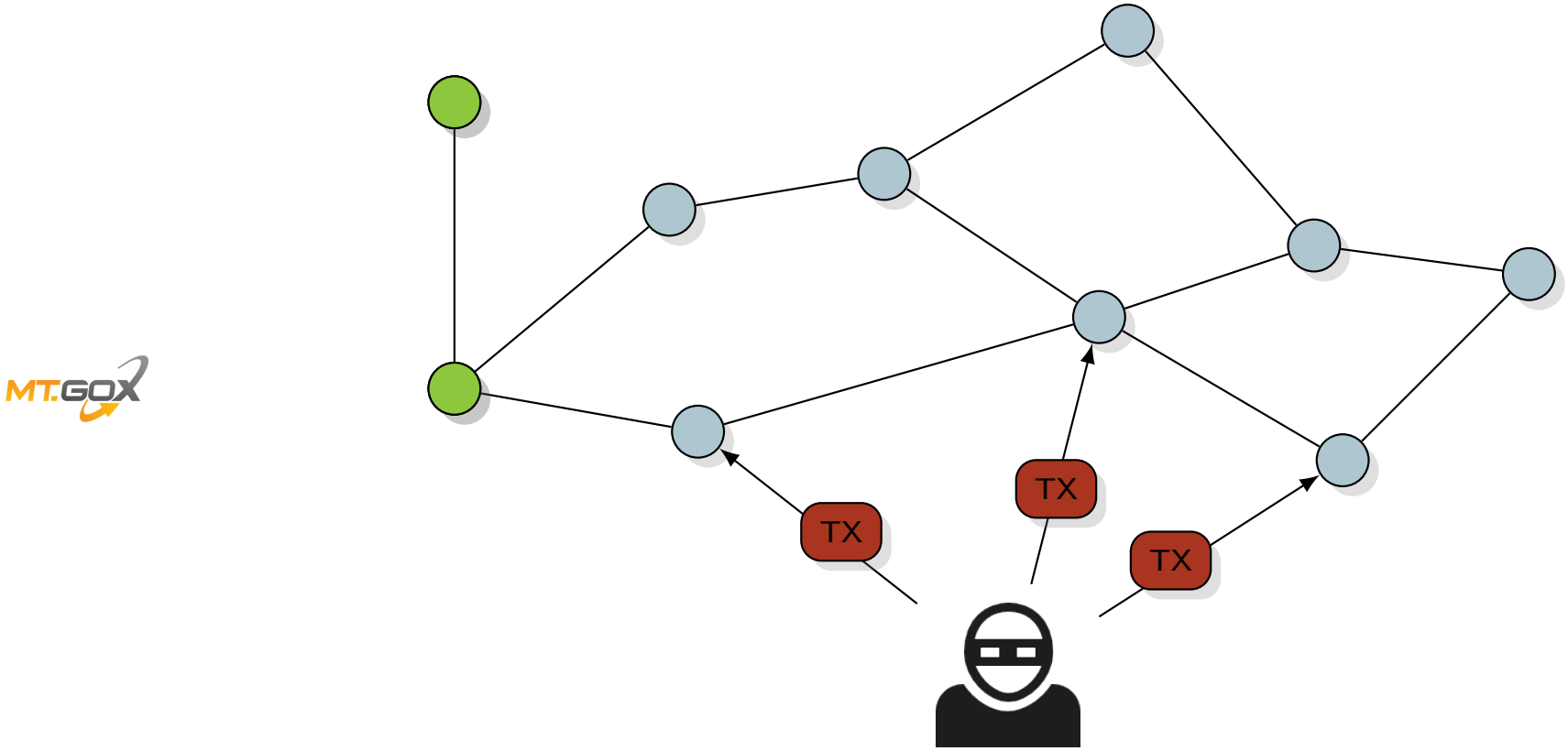
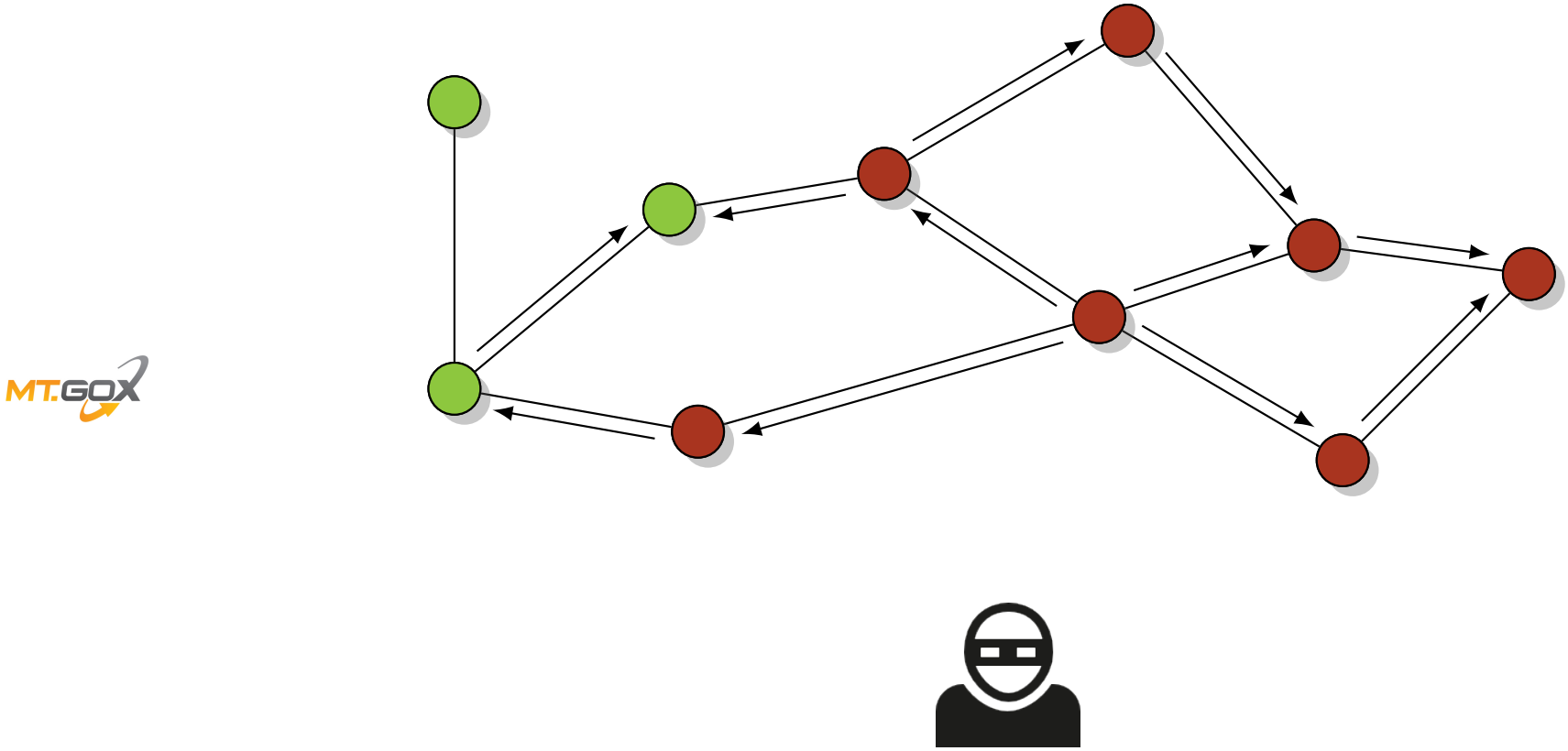
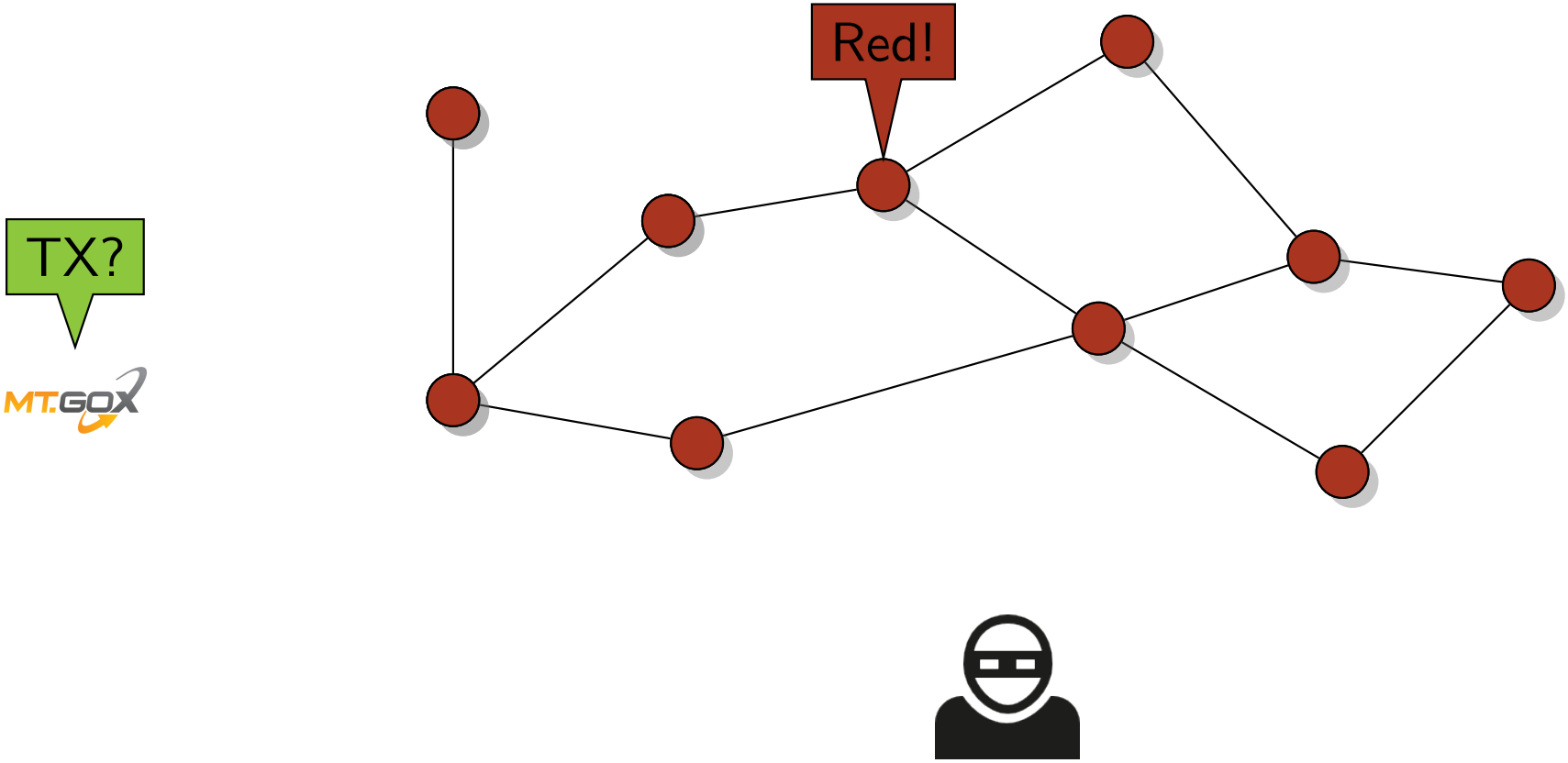


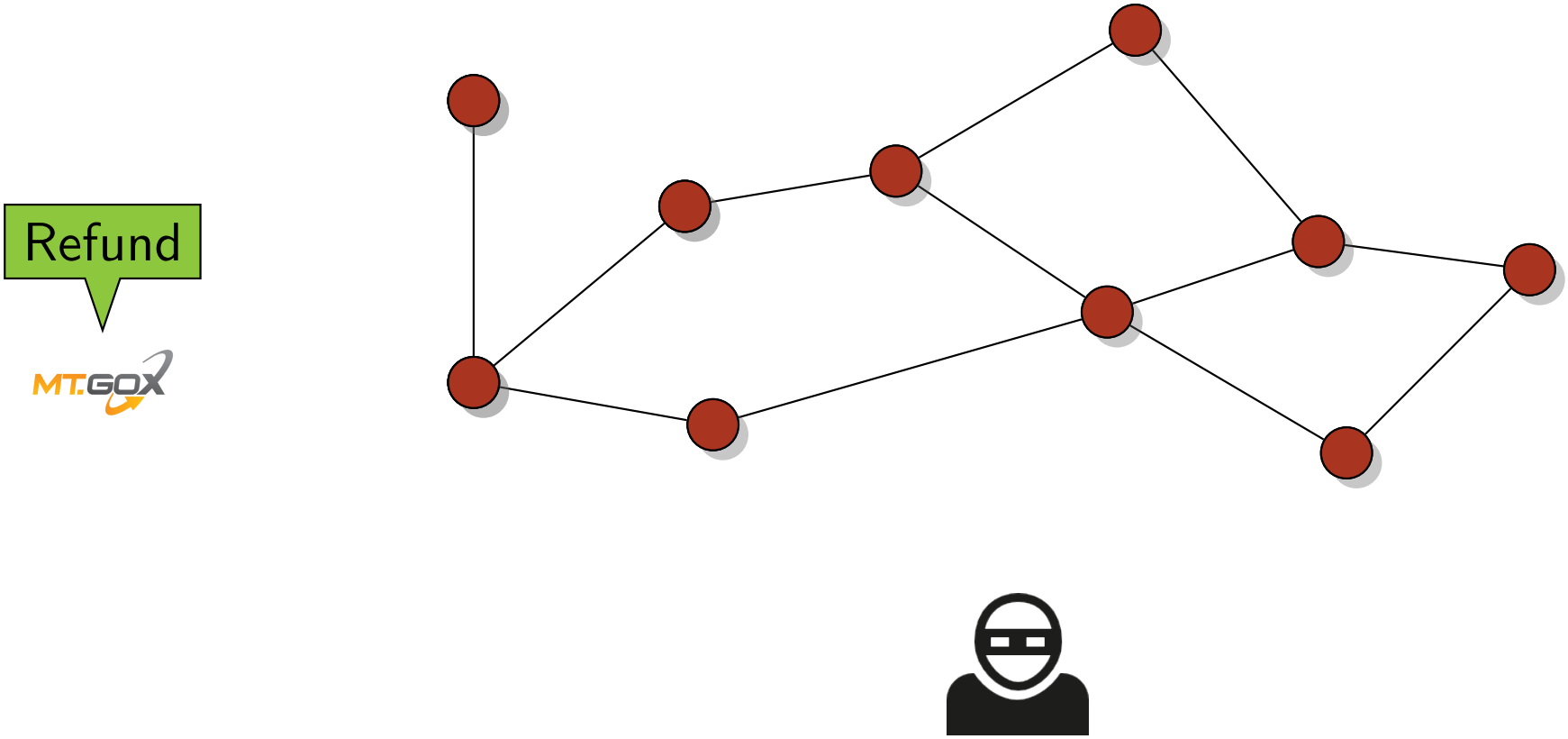
Transaction Malleability Attack



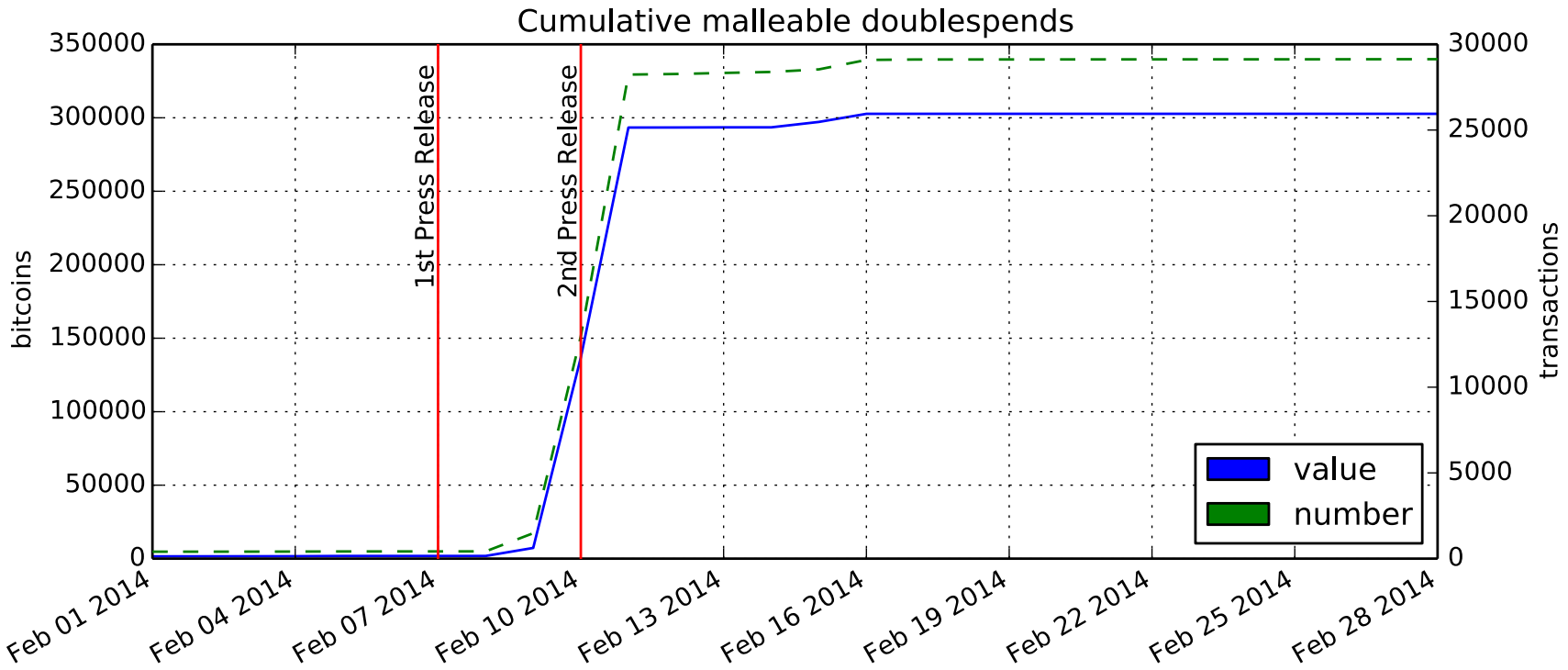
Transaction Malleability Attack



Transaction Malleability Attack

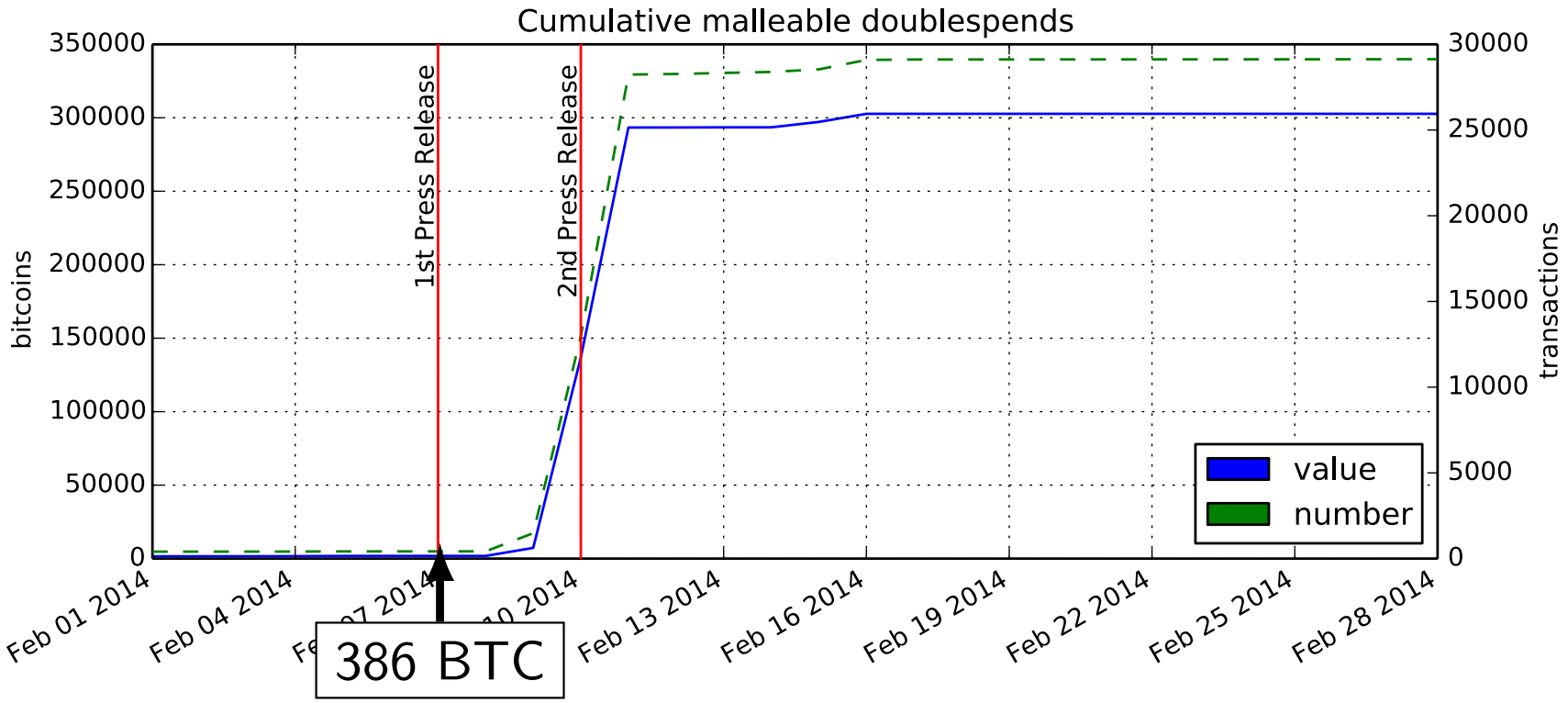


Incident Timeline



[Decker, W, 2014]

Incident Timeline



[Decker, W, 2014]

Mt. Gox Seeks Bankruptcy After $480 Million Bitcoin Loss

By Carter Dougherty and Grace Huang | Feb 28, 2014 8:59 PM GMT+0100 | **95 Comments** **Email** **Print**

Mt. Gox, once the world's largest Bitcoin exchange, filed for bankruptcy in **Japan** saying about $480 million in Bitcoins belonging to its customers and the firm were missing.

"The company believes there is a high possibility that the Bitcoins were stolen," Mt. Gox said in a statement.

The filing follows three weeks of speculation about the fate of the Tokyo-based exchange, which suspended withdrawals on Feb. 7. Since Bitcoins exist as bits of software, they can be stolen if a hacker gains access to the computers and servers used to run online exchanges, where the virtual currency can be traded for dollars, euros and other currencies.

Mark Karpeles, CEO of Mt. Gox, the world's largest bitcoin exchange, bows for an... **Read More**

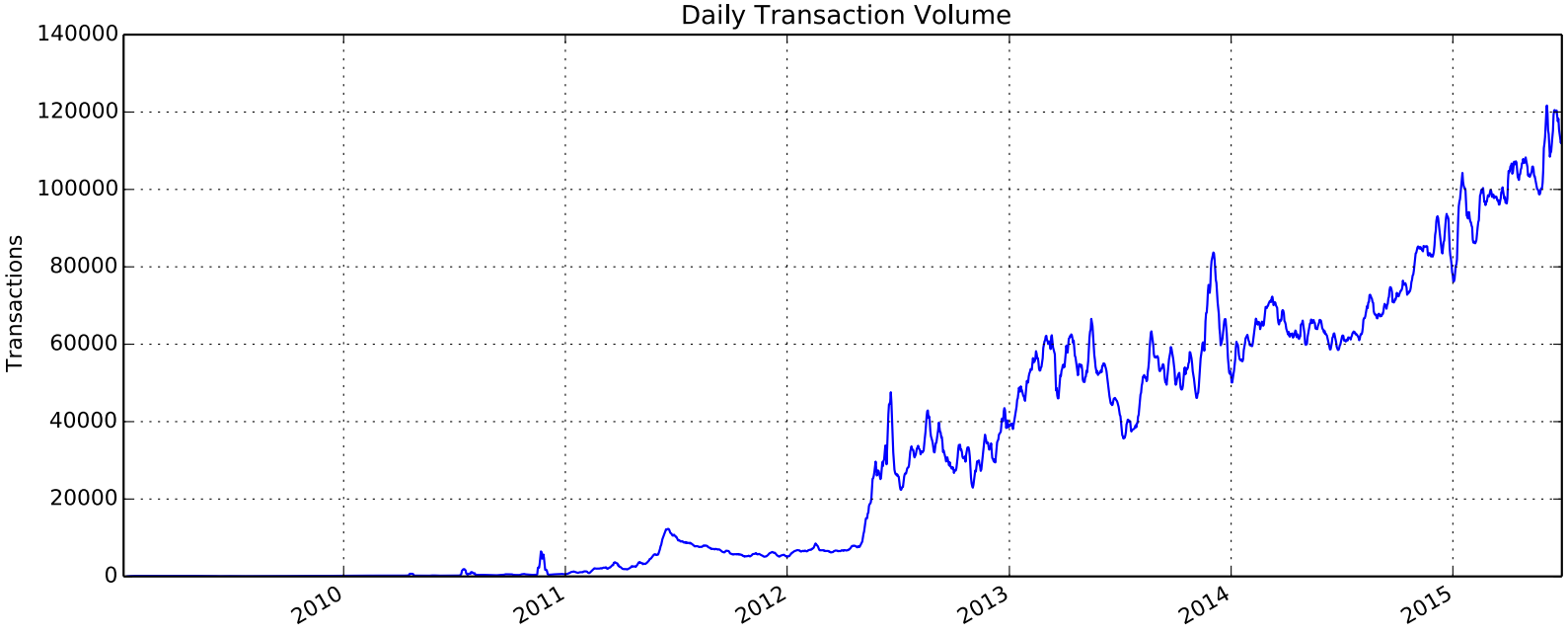
Is Bitcoin Secure?

Securing Your Bitcoins

[Bamert, Decker, W, 2013]

Does Bitcoin Scale?

The Bitcoin Ecosystem is Growing



Scalability Limits

- Disk space: < 500 transactions per second

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- Disk space: < 500 transactions per second
- Processing power: < 200 transactions per second

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- Processing power: < 200 transactions per second
- Network bandwidth: < 100 transactions per second

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- Network bandwidth: < 100 transactions per second
- Artificial 1MB limit: < 3 transactions per second

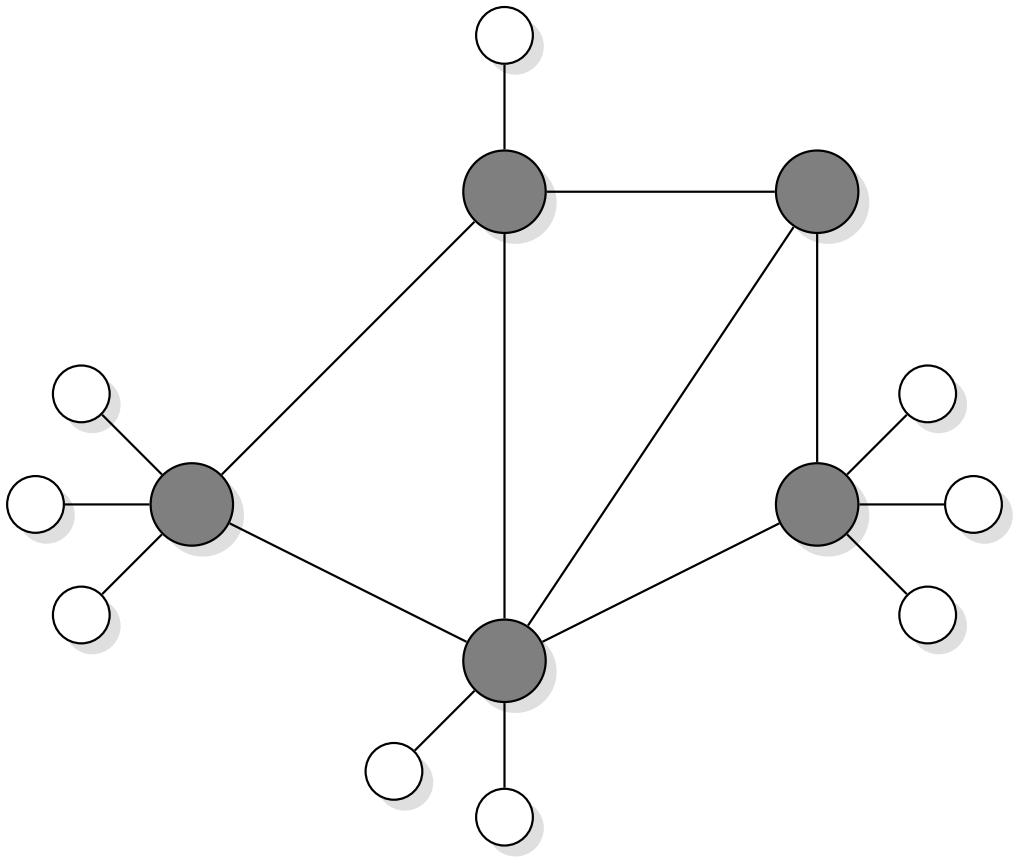
Scalability Limits

- Disk space: < 500 transactions per second
- Processing power: < 200 transactions per second
- Network bandwidth: < 100 transactions per second
- Artificial 1MB limit: < 3 transactions per second

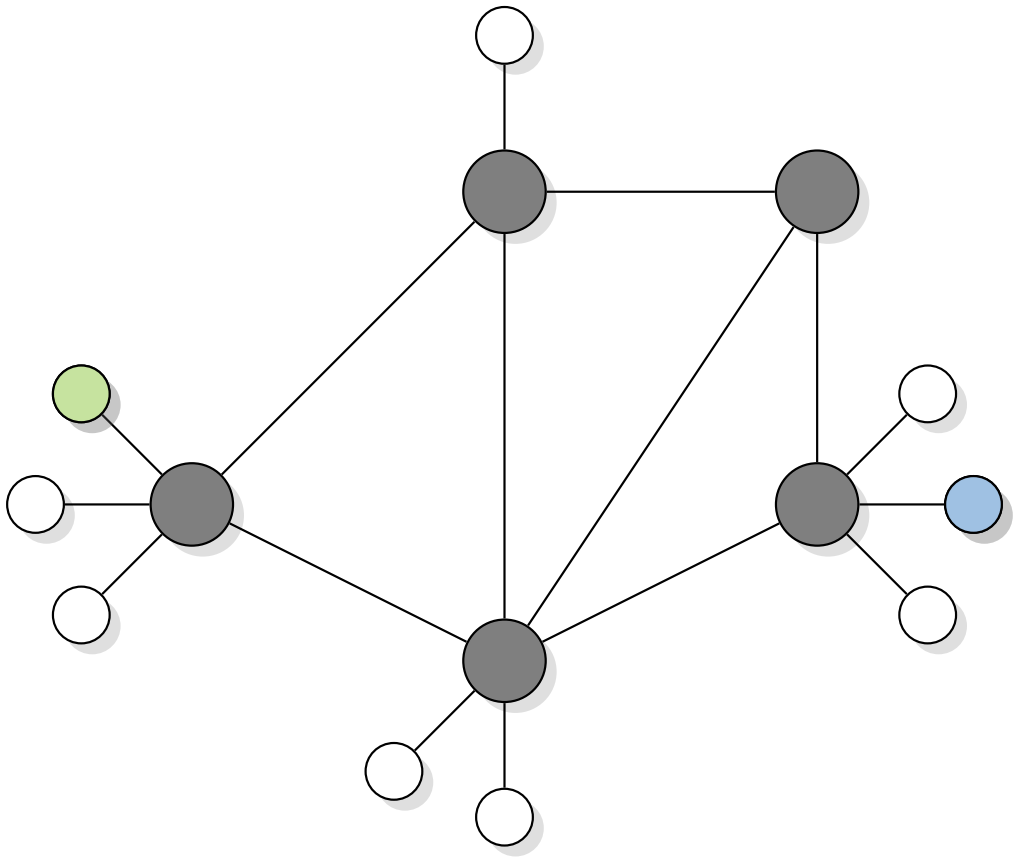
Today:

- Bitcoin: 1 transaction per second
- Credit Cards: $> 10,000$ transactions per second

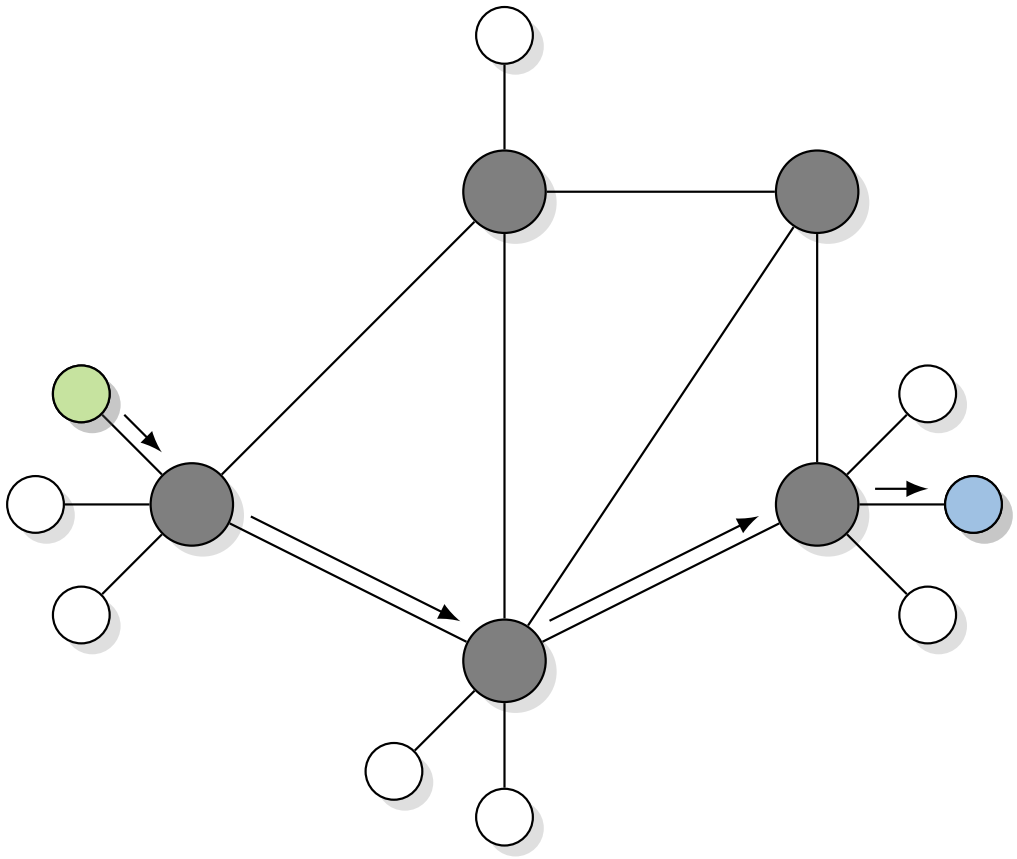
Payment Network



Payment Network



Payment Network

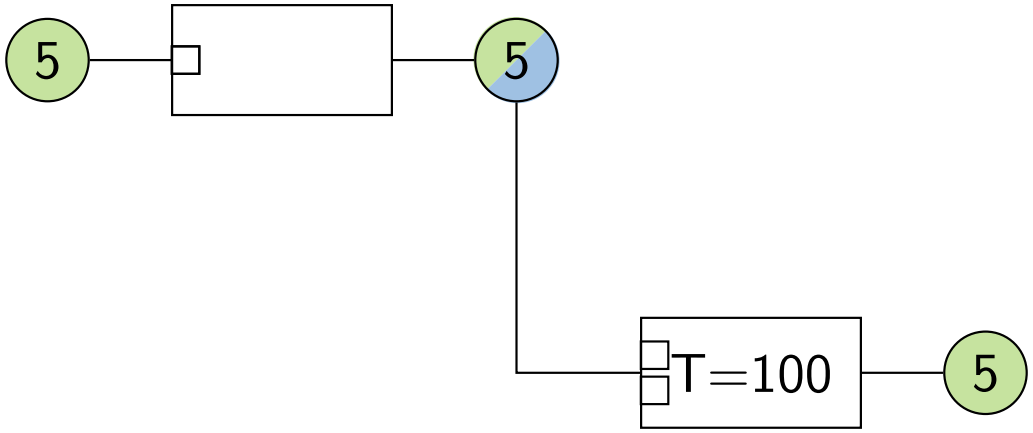


Micropayment Channels

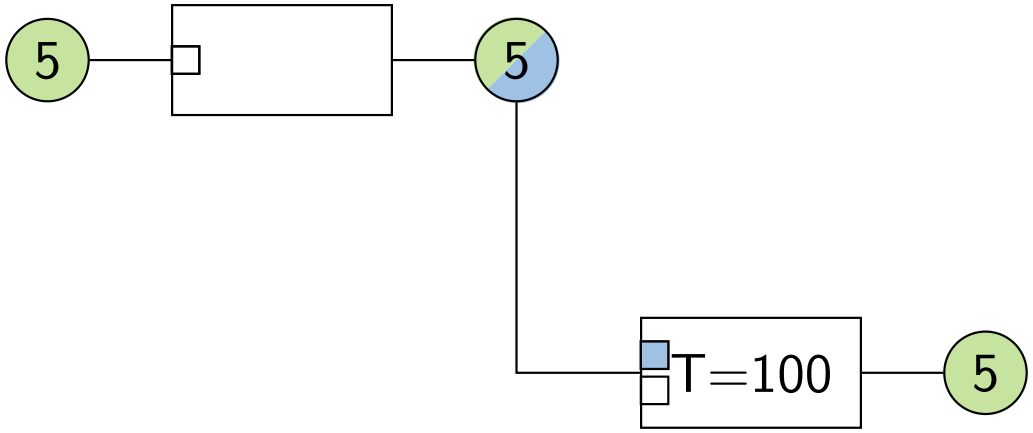
5

Micropayment Channels

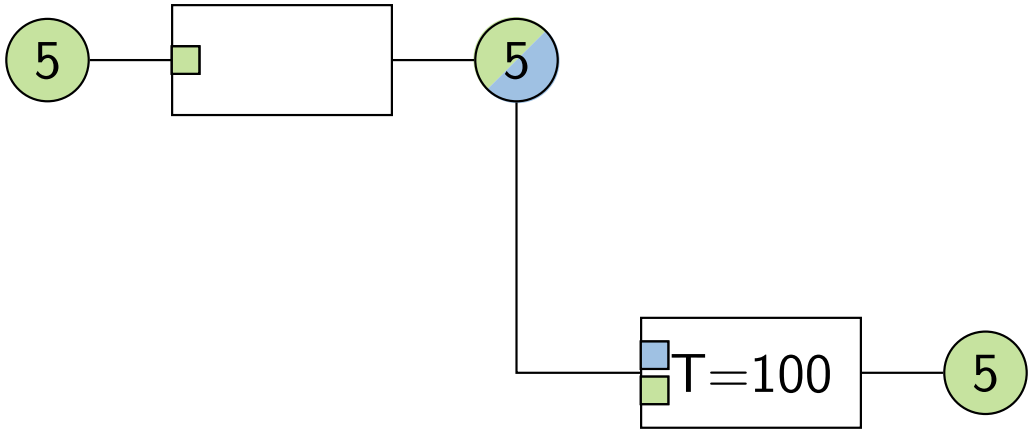
Micropayment Channels



Micropayment Channels



Micropayment Channels



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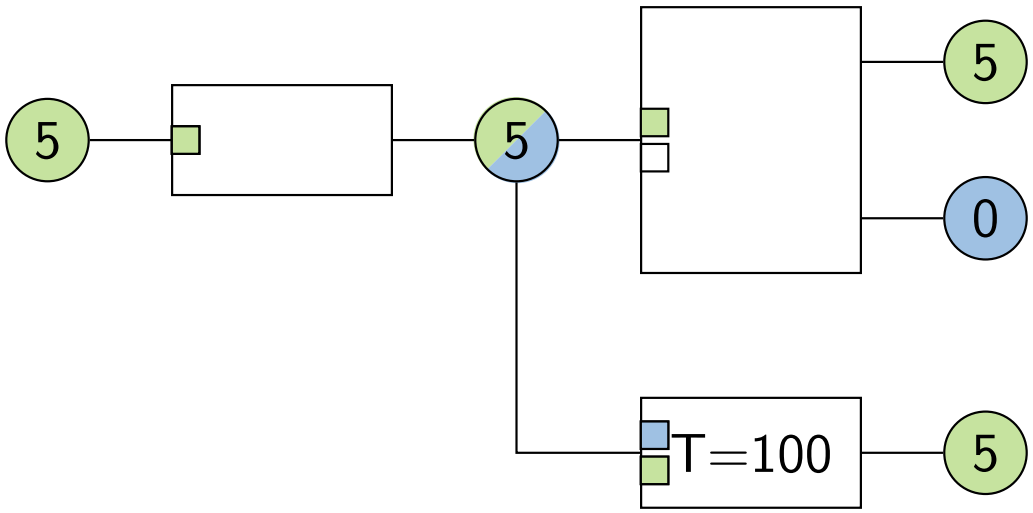
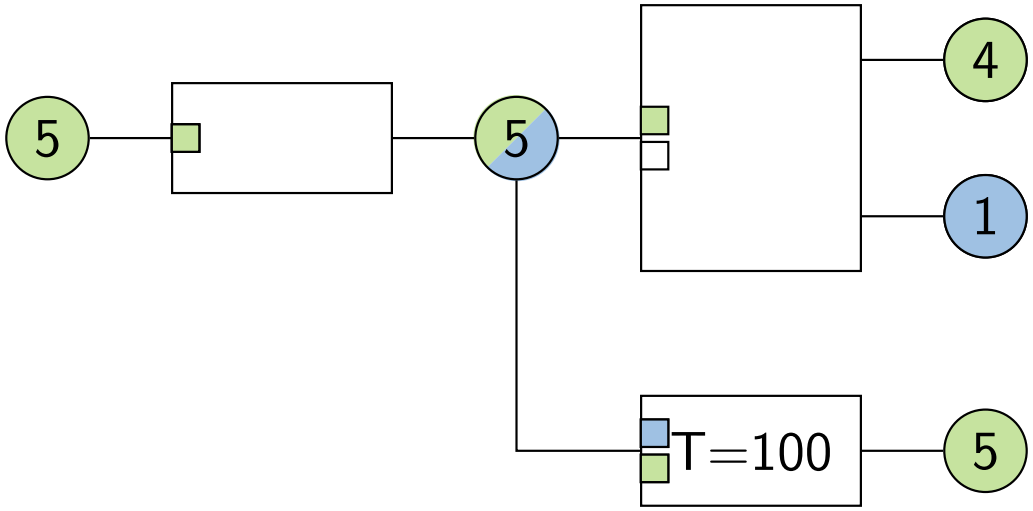


Micropayment Channels



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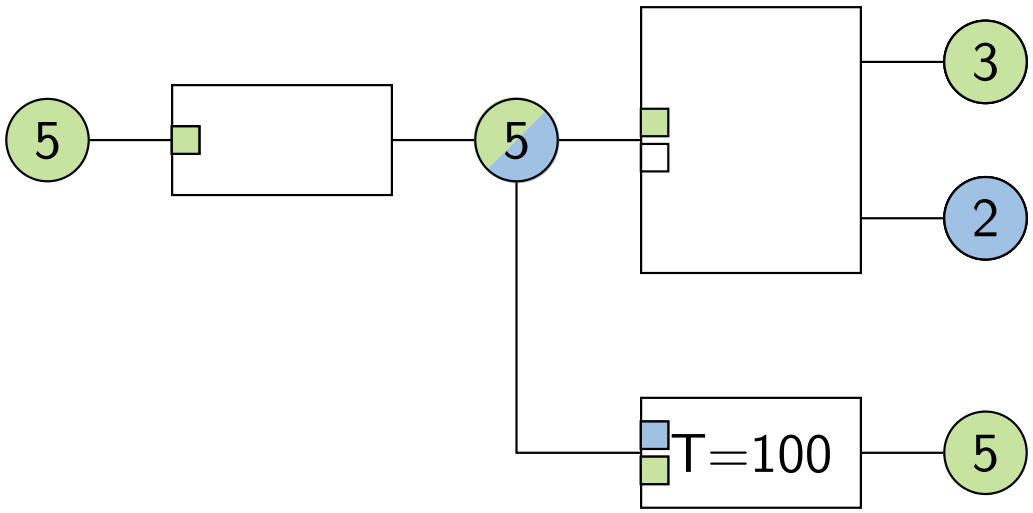
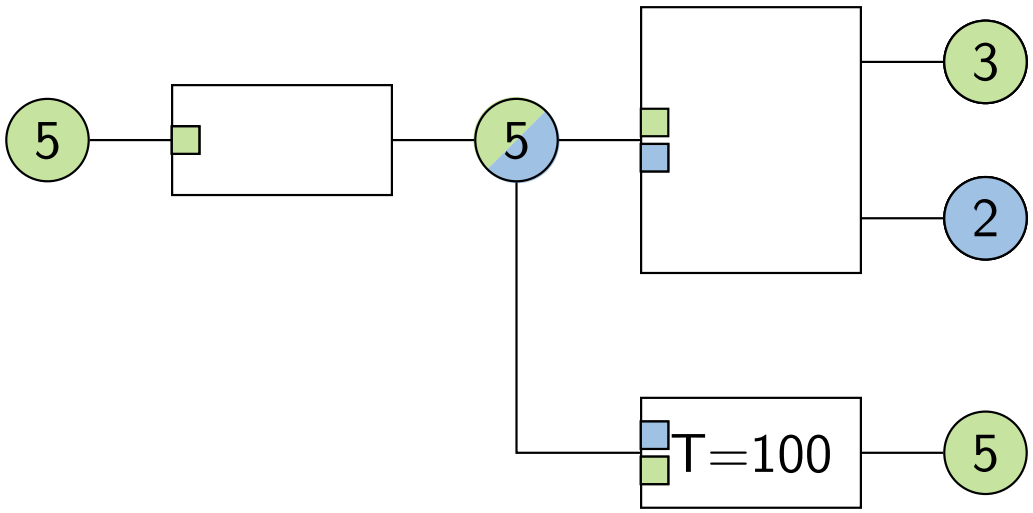
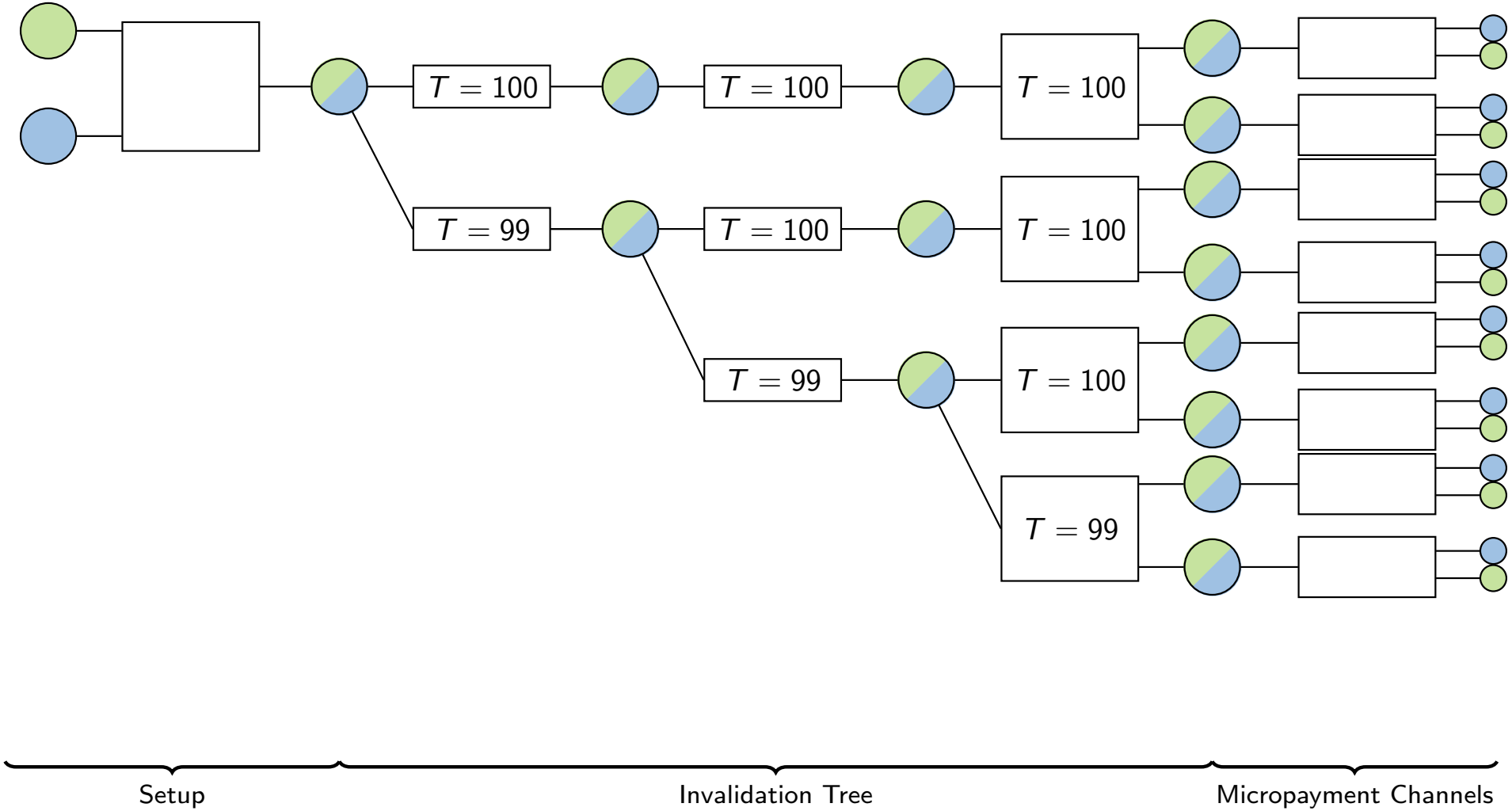


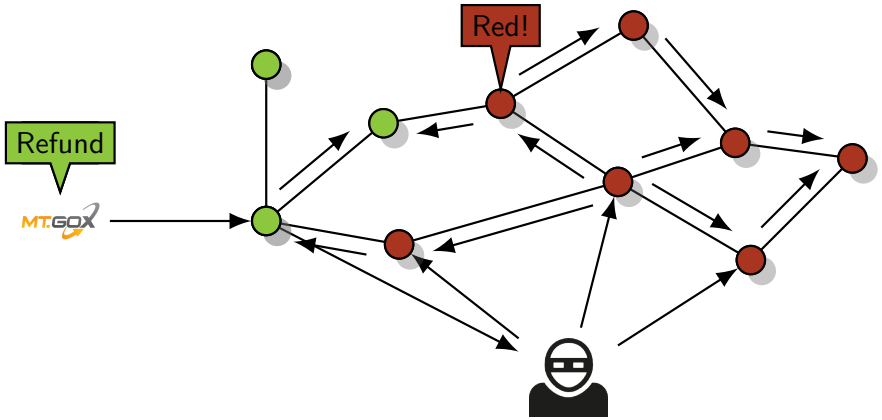
Micropayment Channels

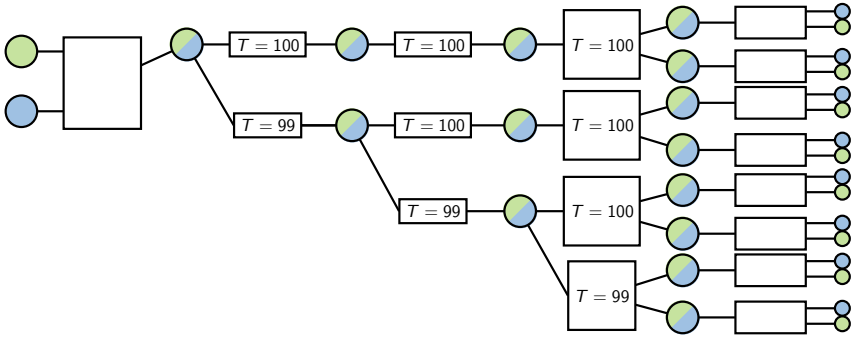


Duplex Micropayment Channels



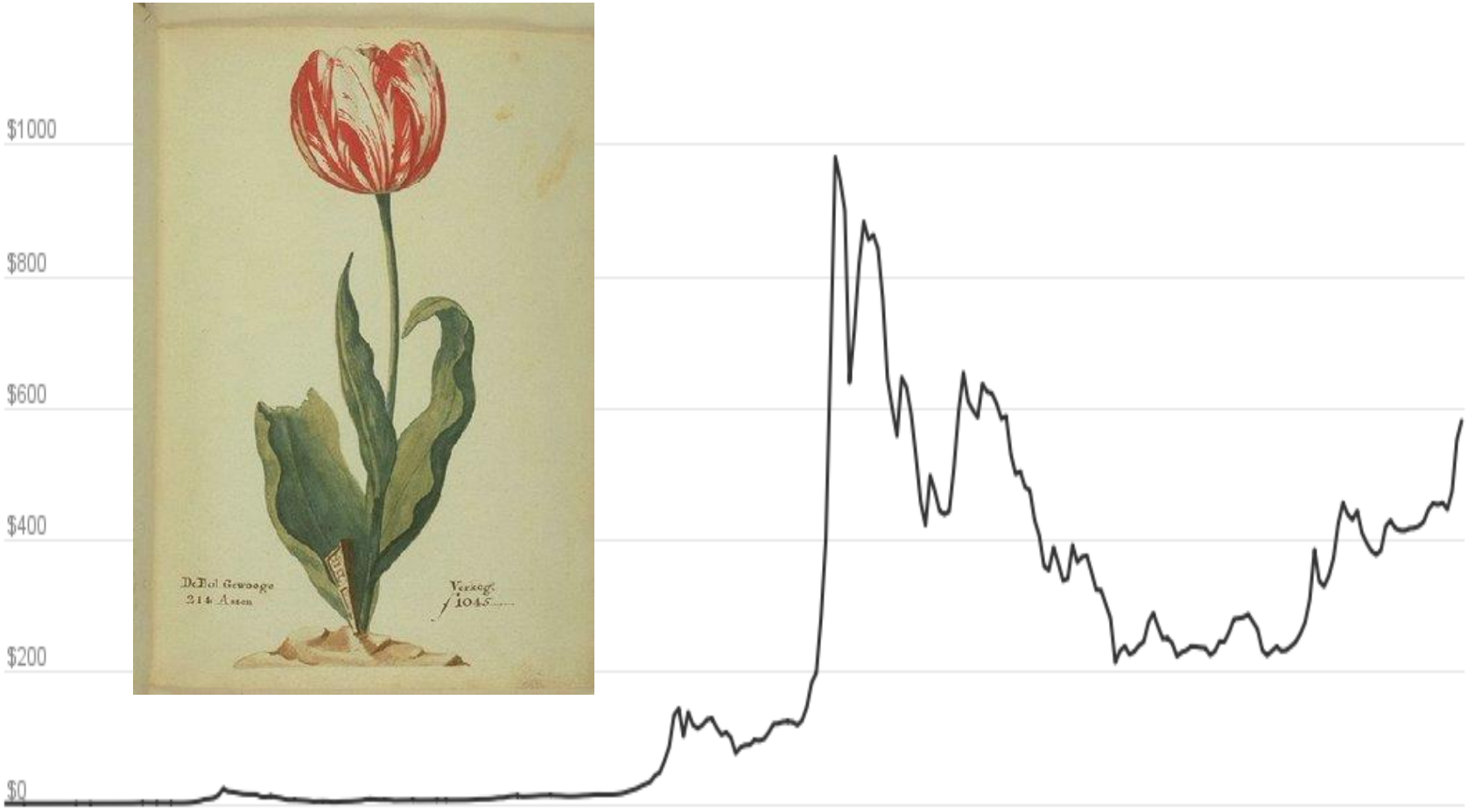
Summary



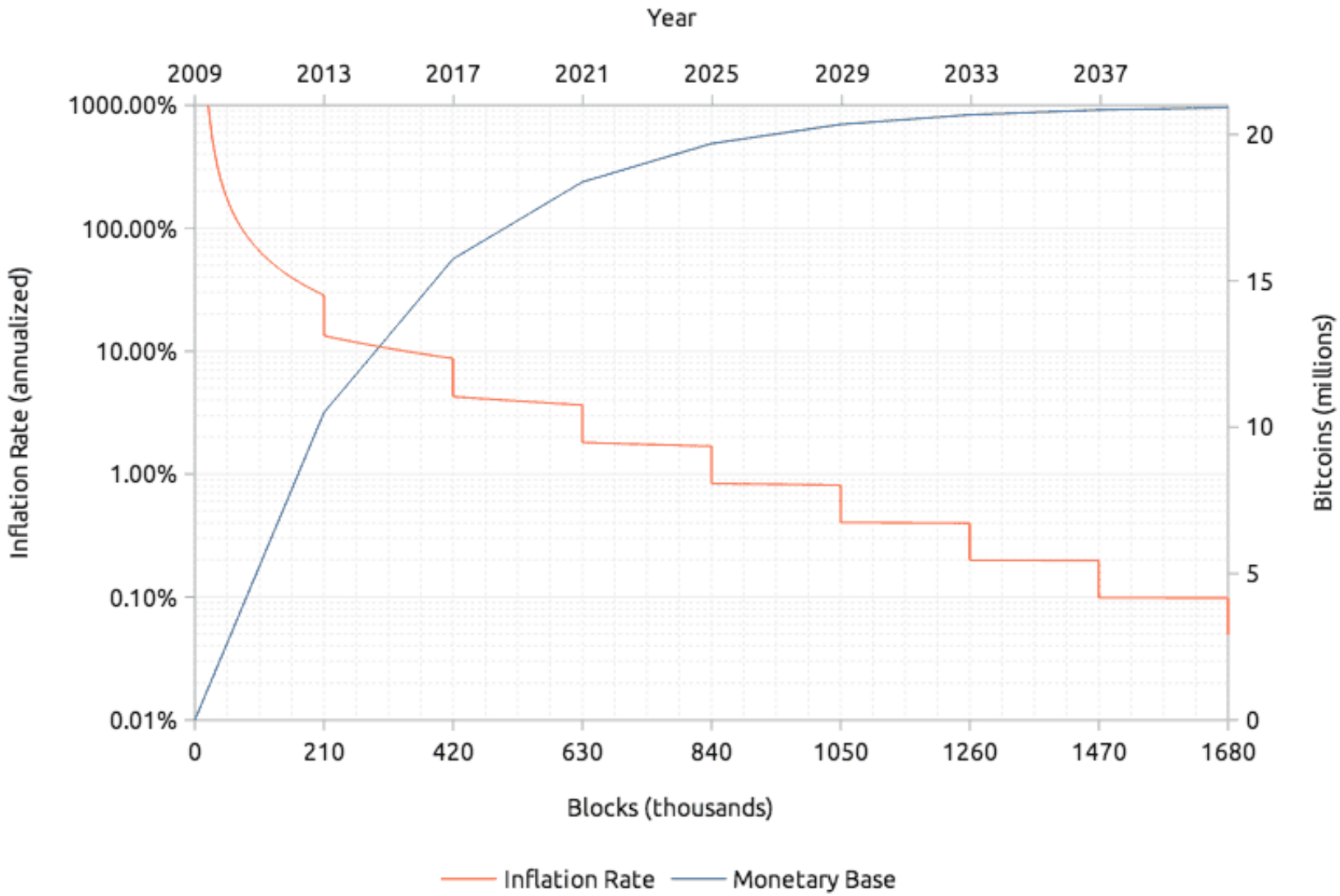


Economy

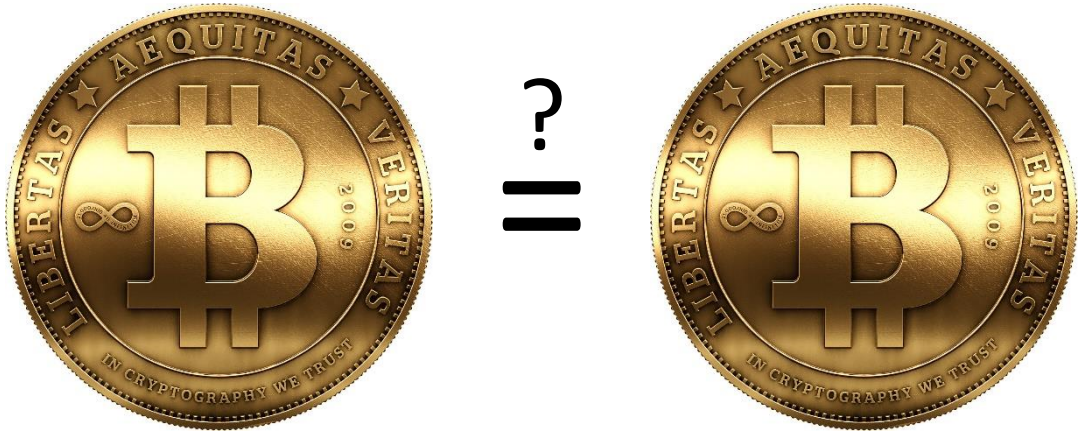
BTC in USD



Inflation


Year
2009
2013
2017
2021
2025
2029
2033
2037
1000.00%
100.00%
10.00%
1.00%
0.10%
0.01%
Inflation Rate (annualized)
20
15
10
5
0
Bitcoins (millions)
0
210
420
630
840
1050
1260
1470
1680
Blocks (thousands)
Inflation Rate
Monetary Base

Fungibility



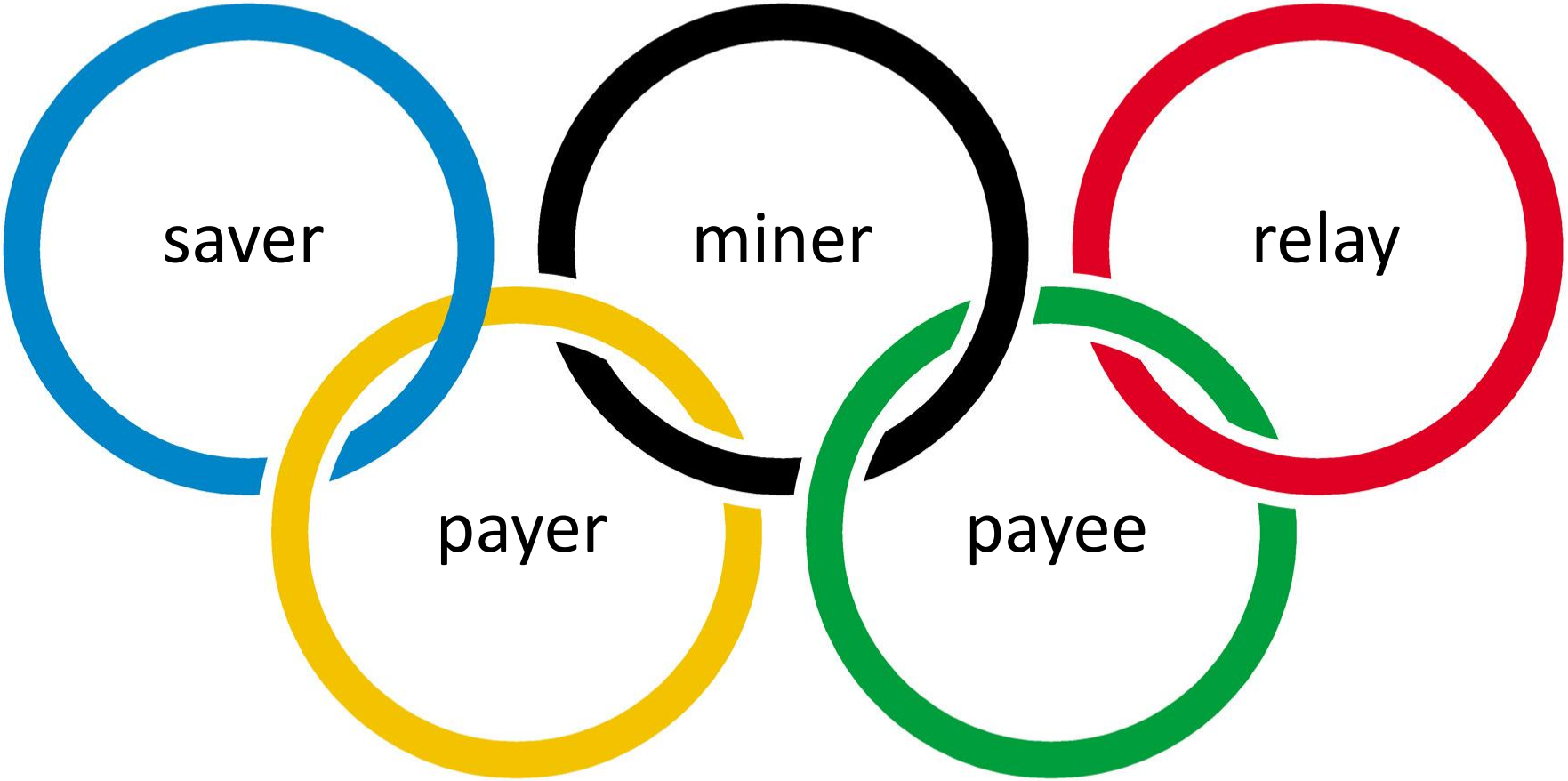
18

Looking to buy an old 50 BTC block. Where to buy? (self.Bitcoin)

submitted 7 months ago by blockCollector

I'll pay in bitcoin. No FIAT/Alt coin. Willing to pay premium.

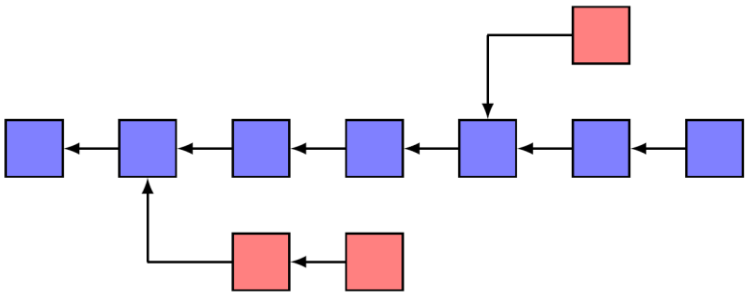
Improving Bitcoin?

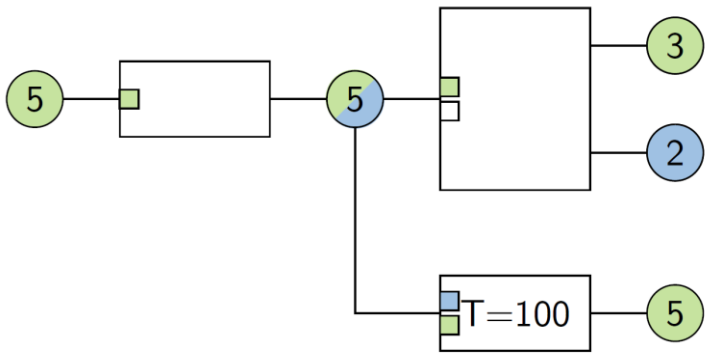


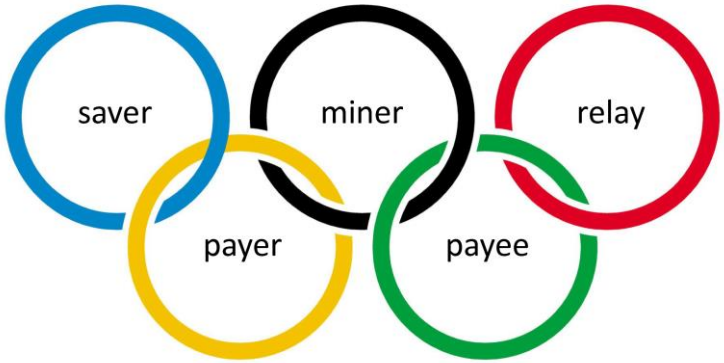
What is Money?

What is Money?

Summary







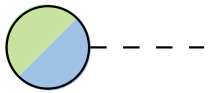
Thank You!

Questions & Comments?

Thanks to my co-author
Christian Decker

www.disco.ethz.ch

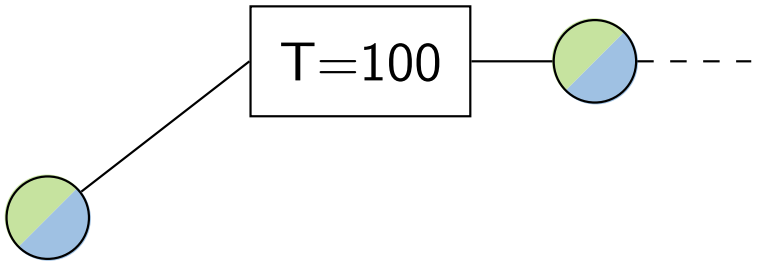
Atomic Multiparty Opt-In



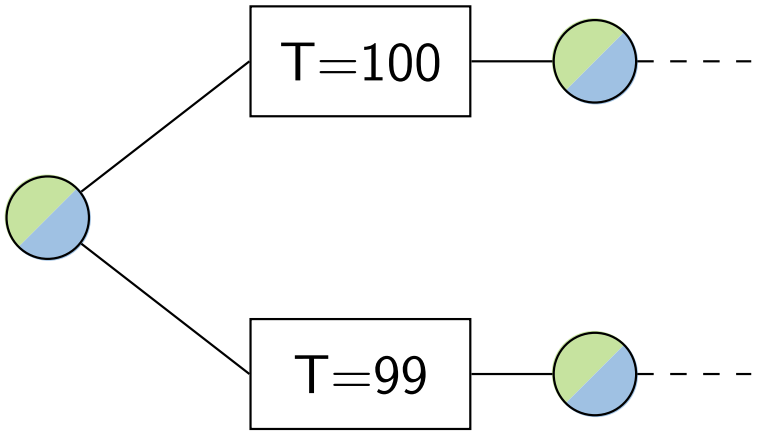
Atomic Multiparty Opt-In

Atomic Multiparty Opt-In

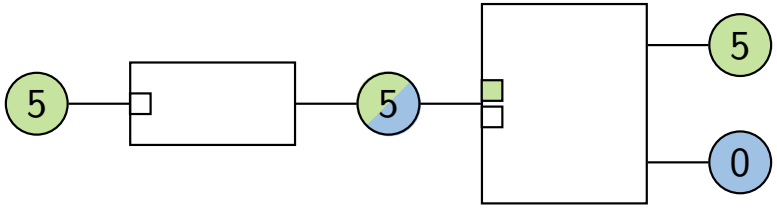
Invalidating Transactions

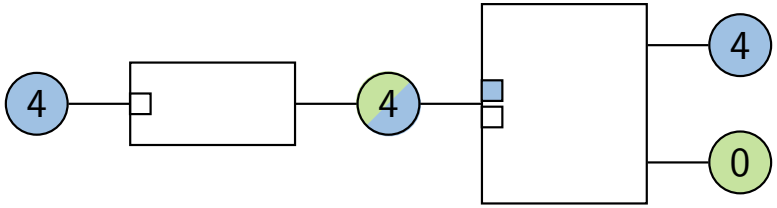


Invalidating Transactions

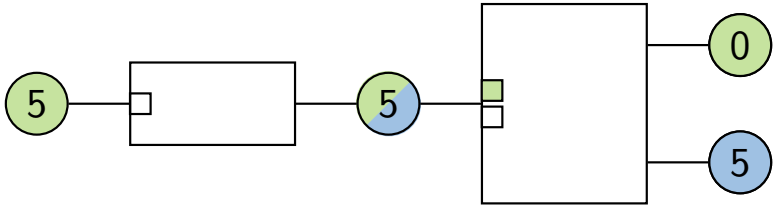


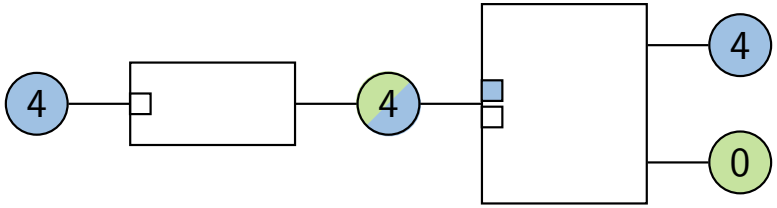
Bidirectional Transfers





Bidirectional Transfers





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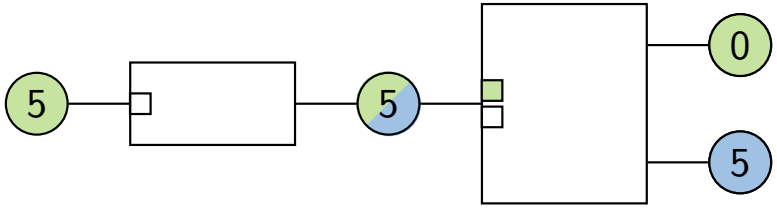
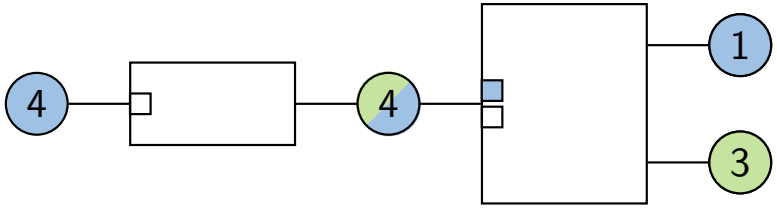
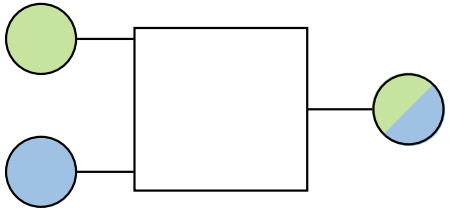


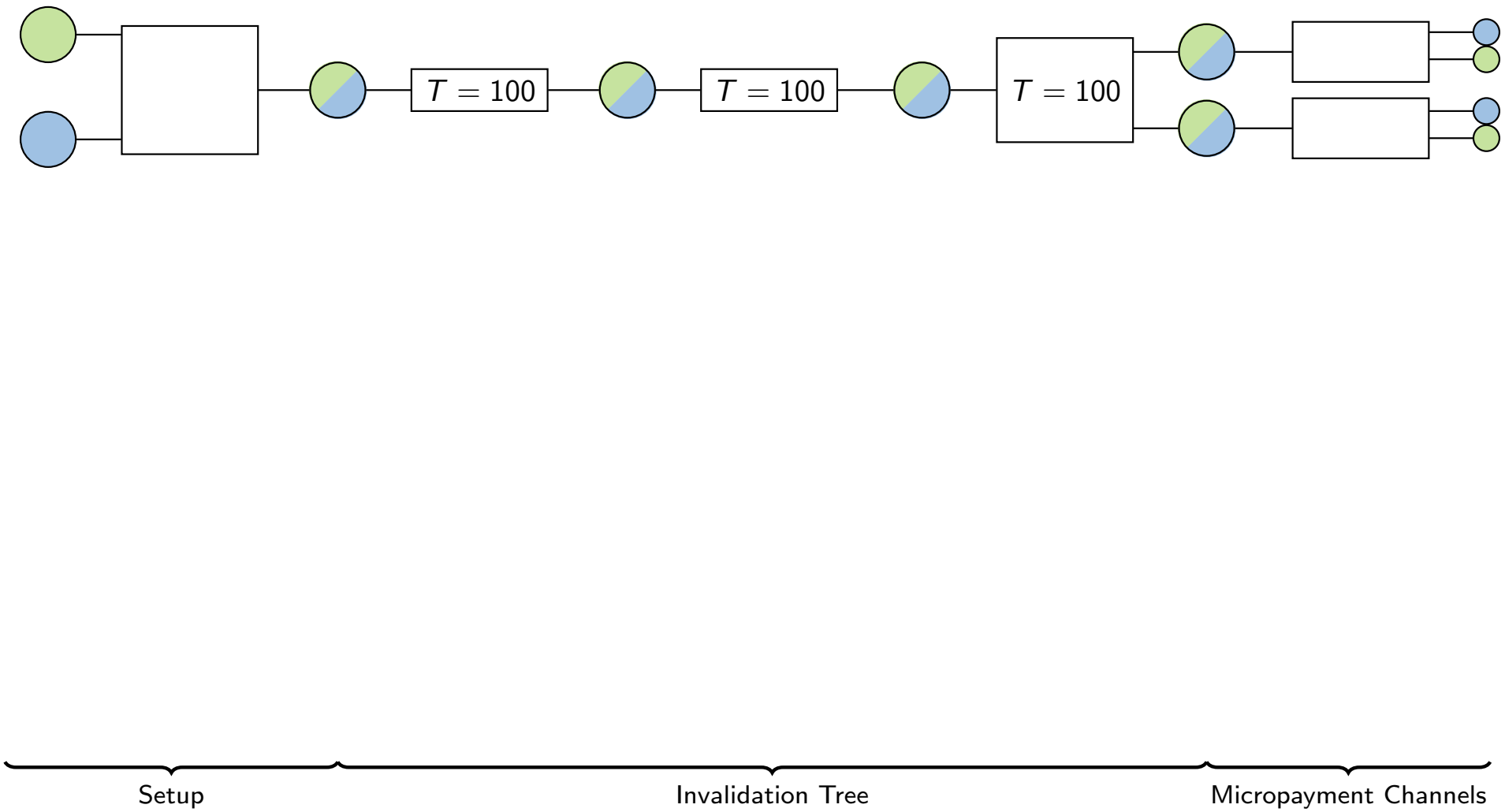


Duplex Micropayment Channels

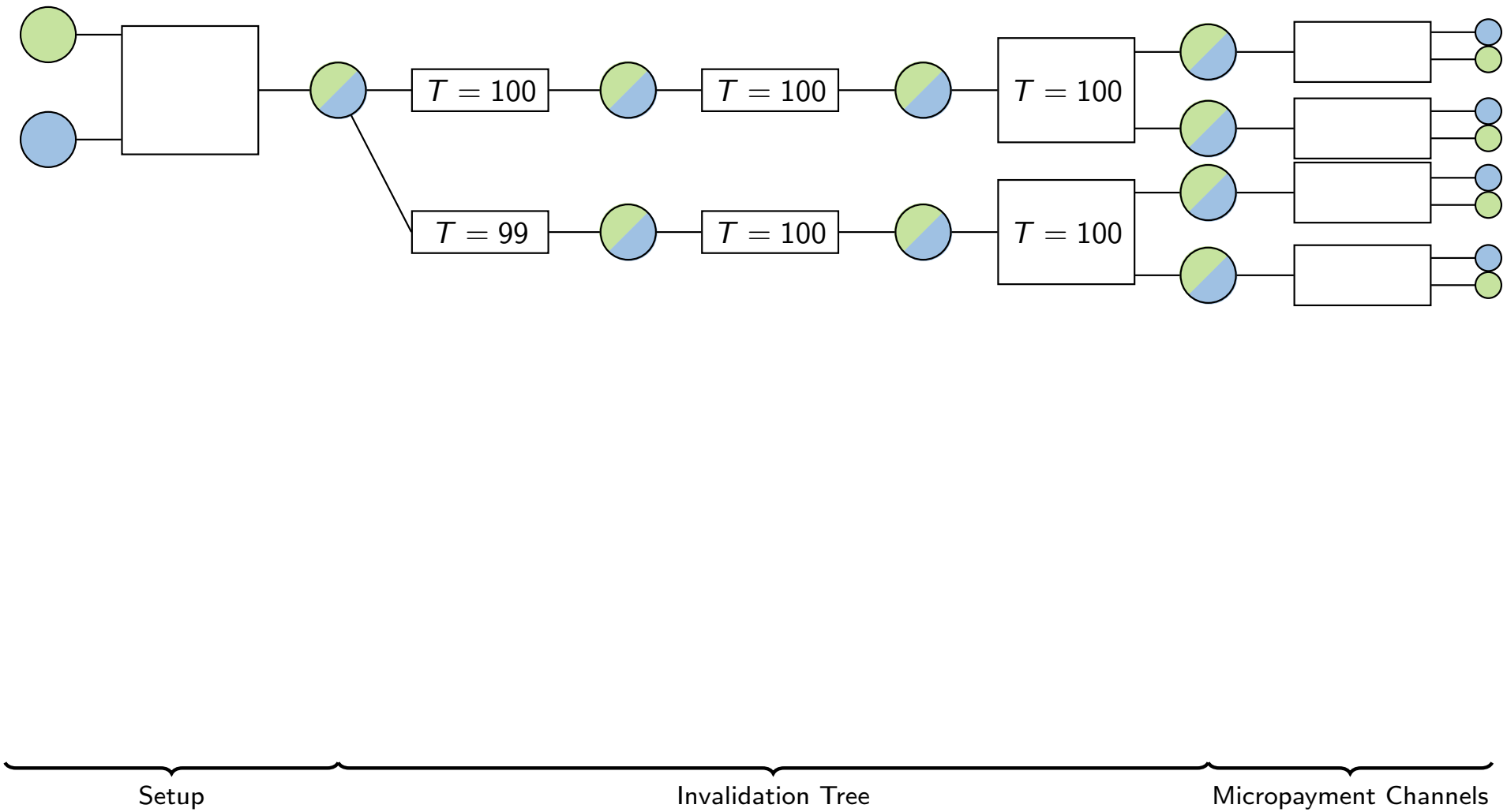


Setup | Invalidation Tree | Micropayment Channels

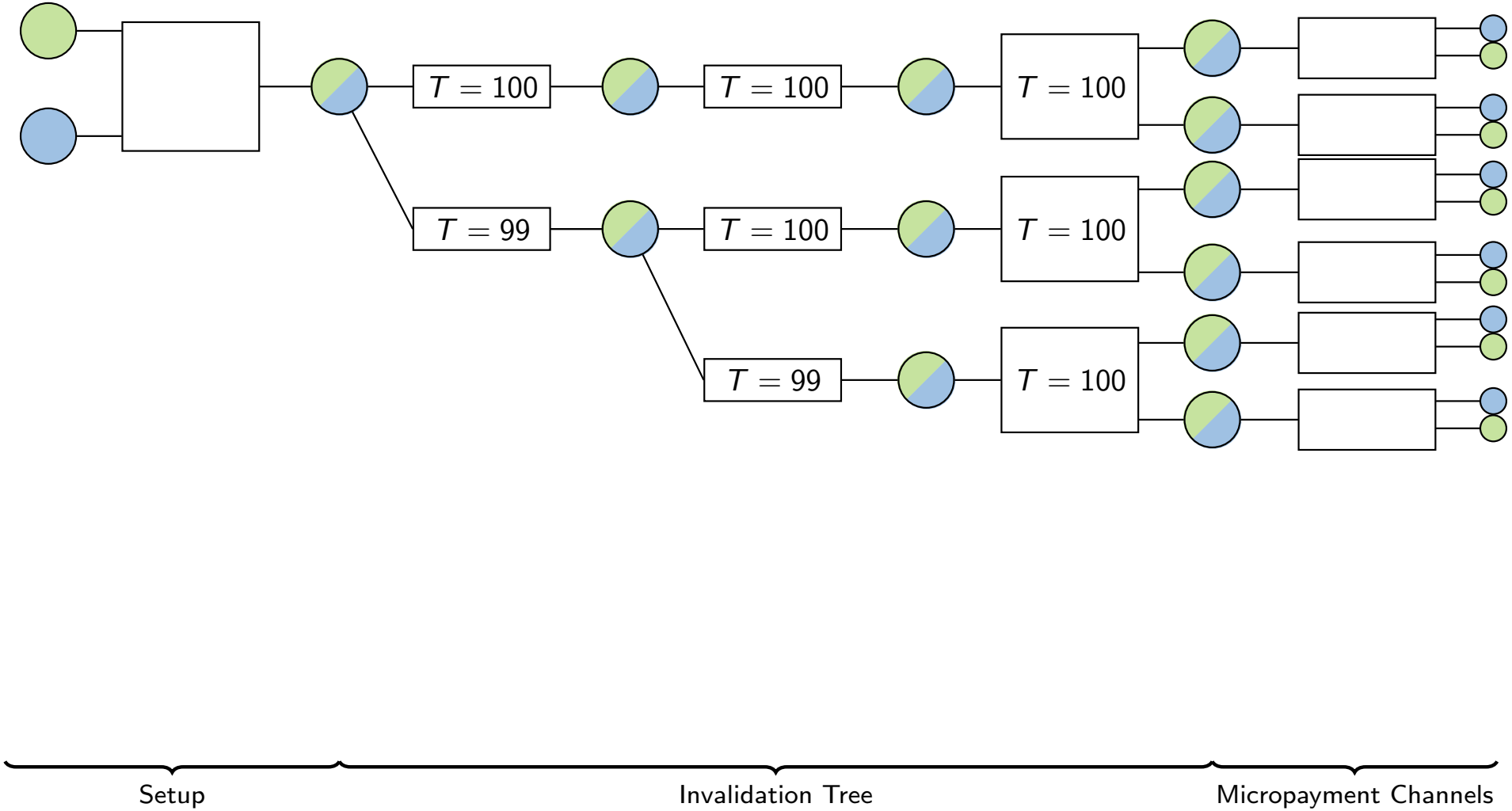
Duplex Micropayment Channels



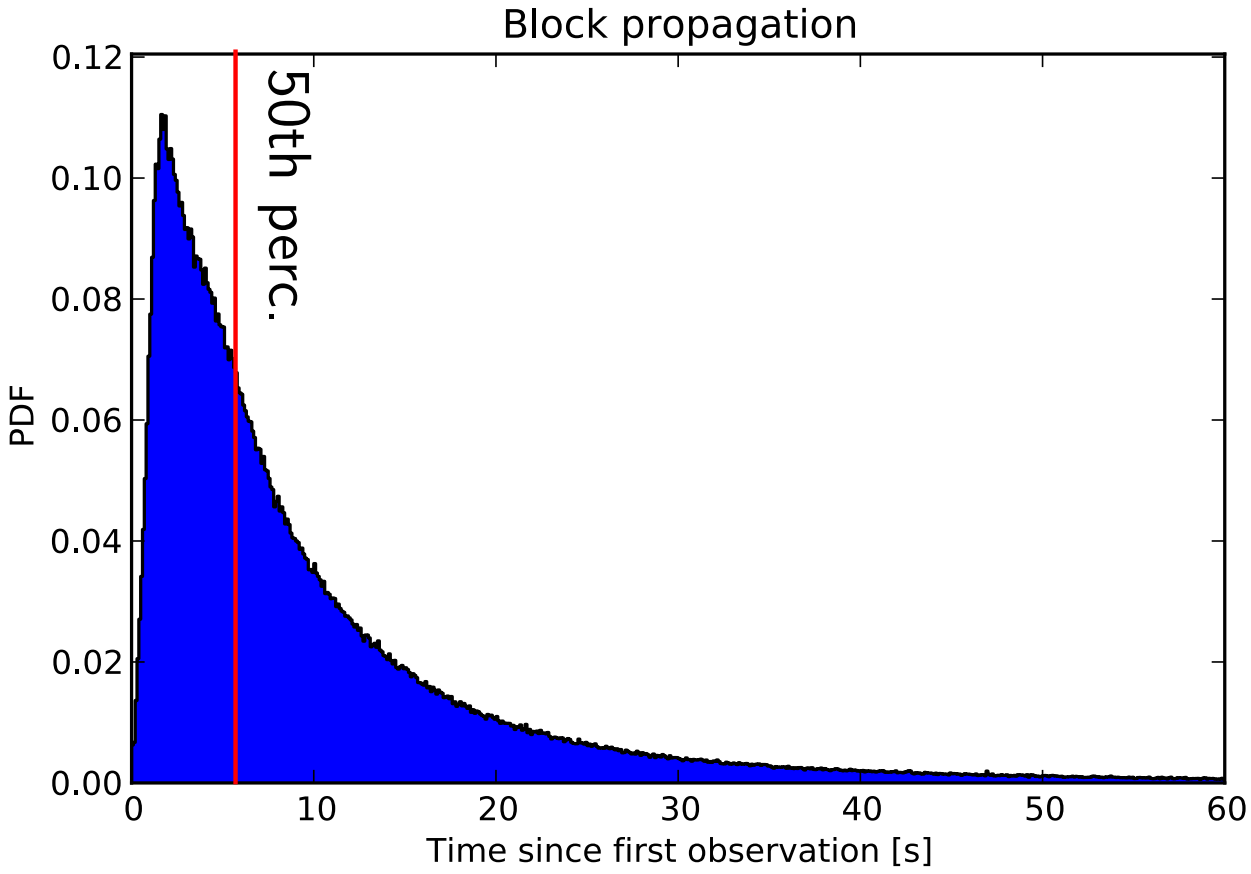
Duplex Micropayment Channels



Duplex Micropayment Channels



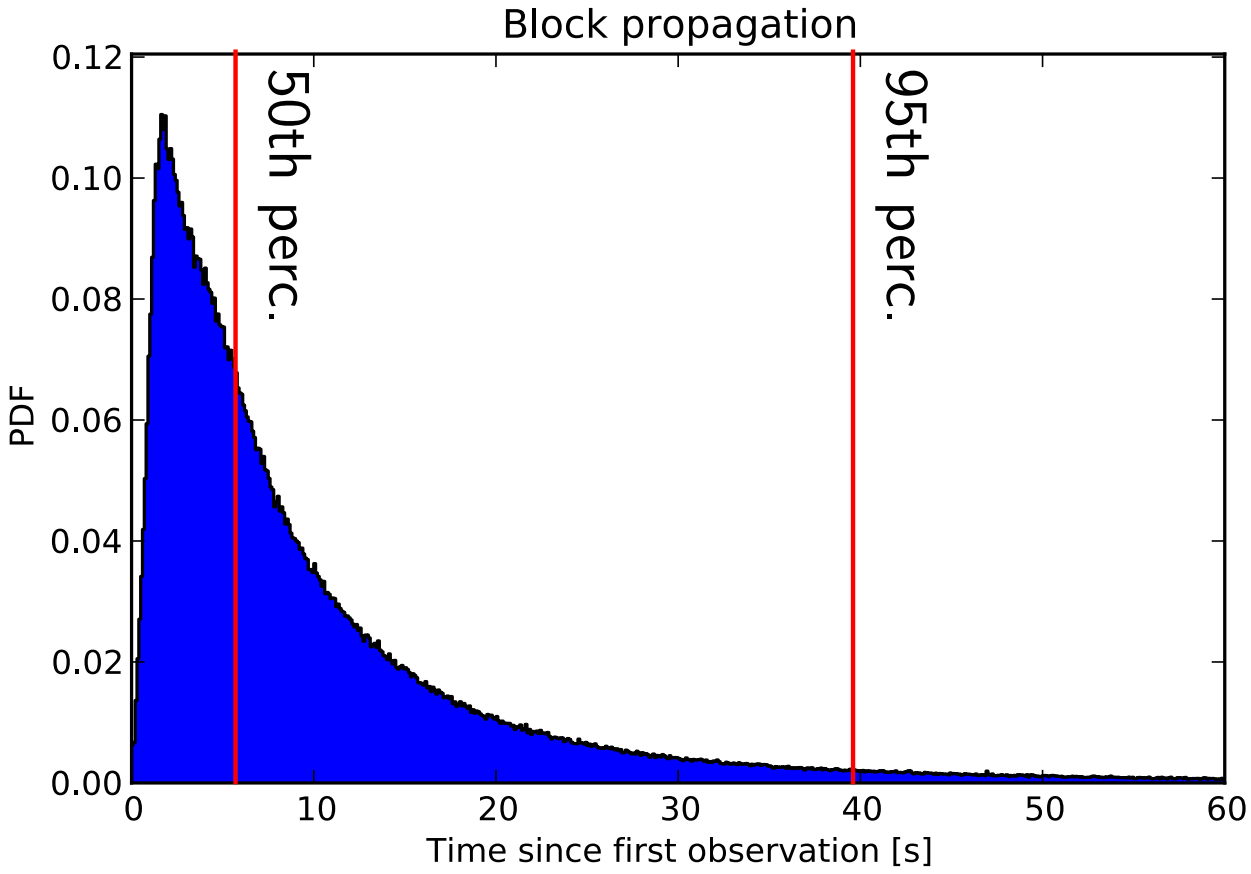
Propagation Speed



http://bitcoinstats.com

[Decker, W, 2013]

Propagation Speed



http://bitcoinstats.com

[Decker, W, 2013]

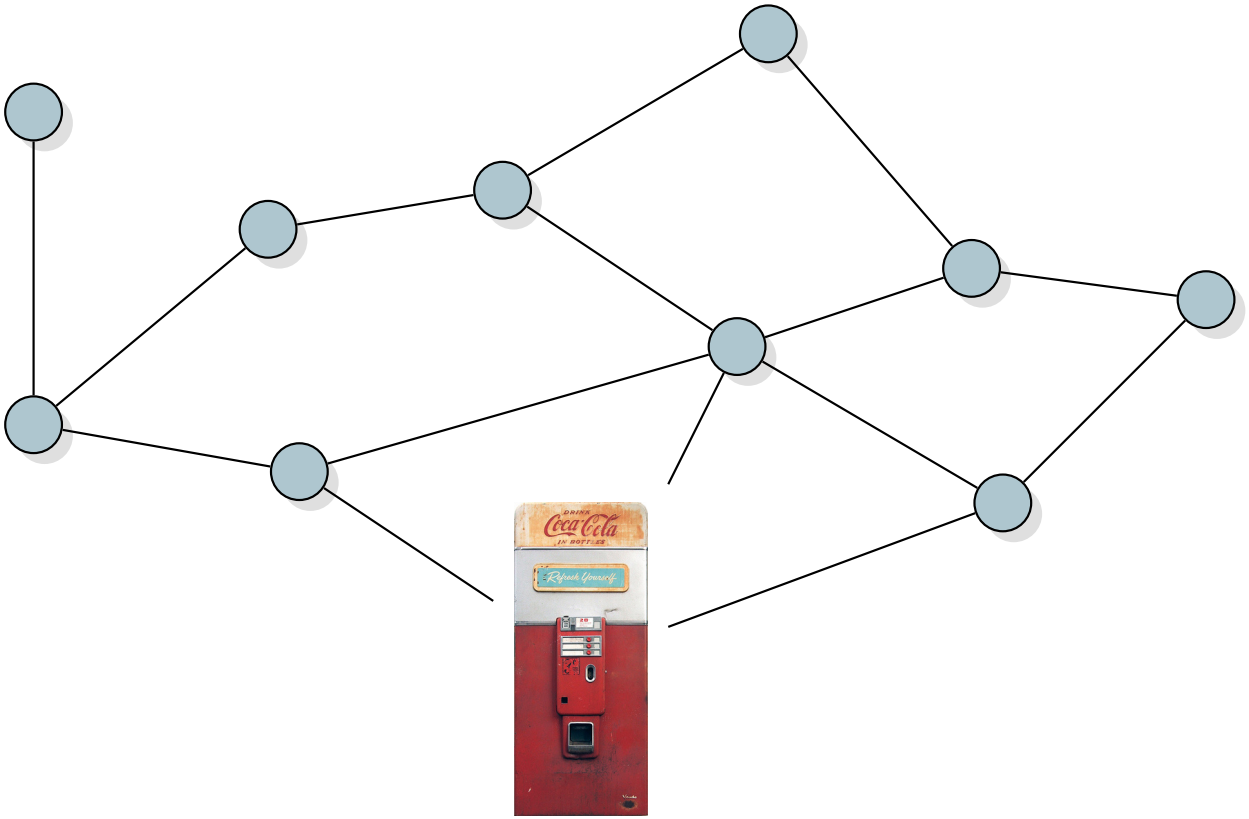
500 MW

Securing Fast Payments

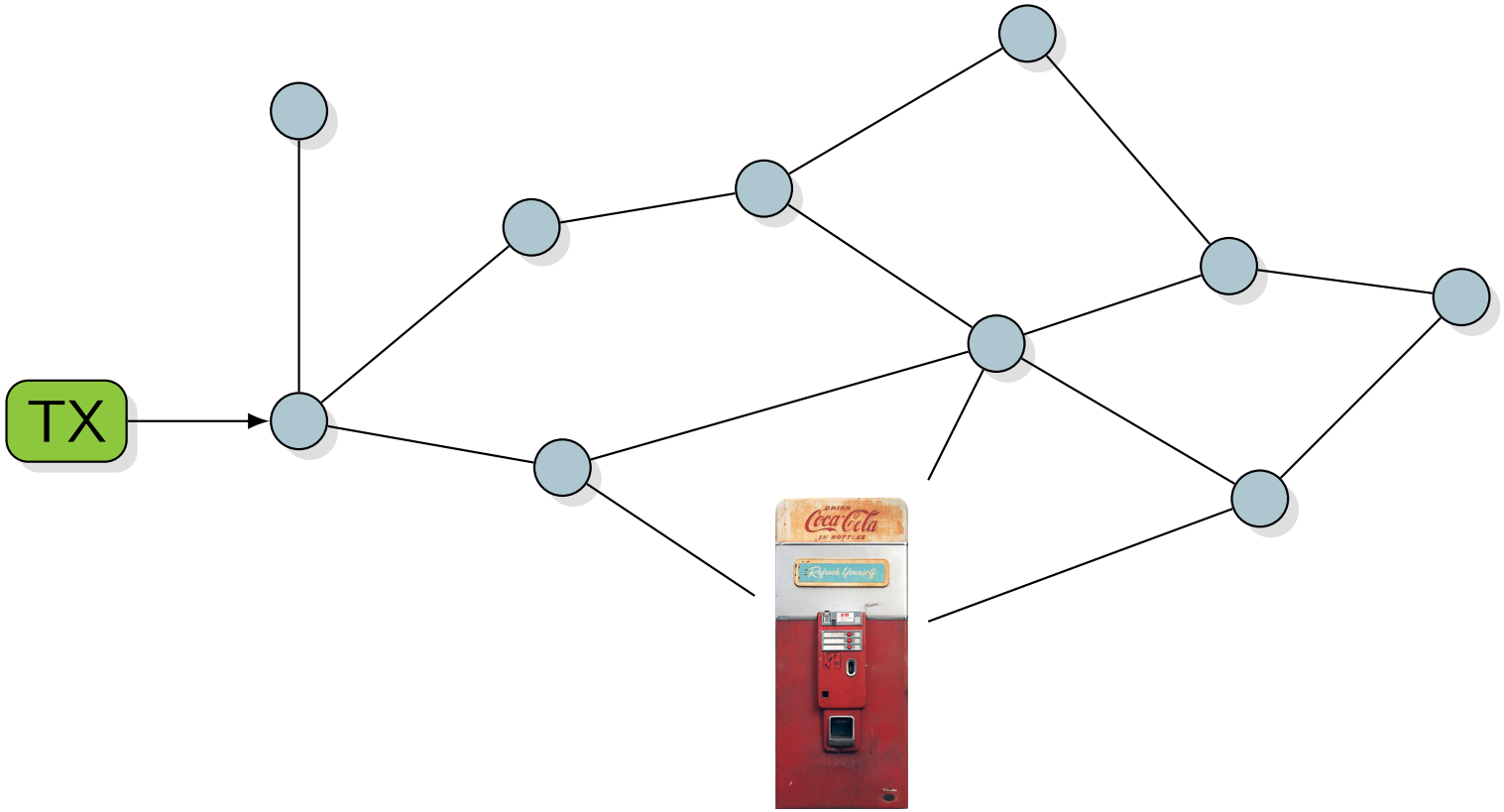
Let's Buy a Snack

[Bamert, Decker, Elsen, W, Welten, 2013]

Transaction Confidence

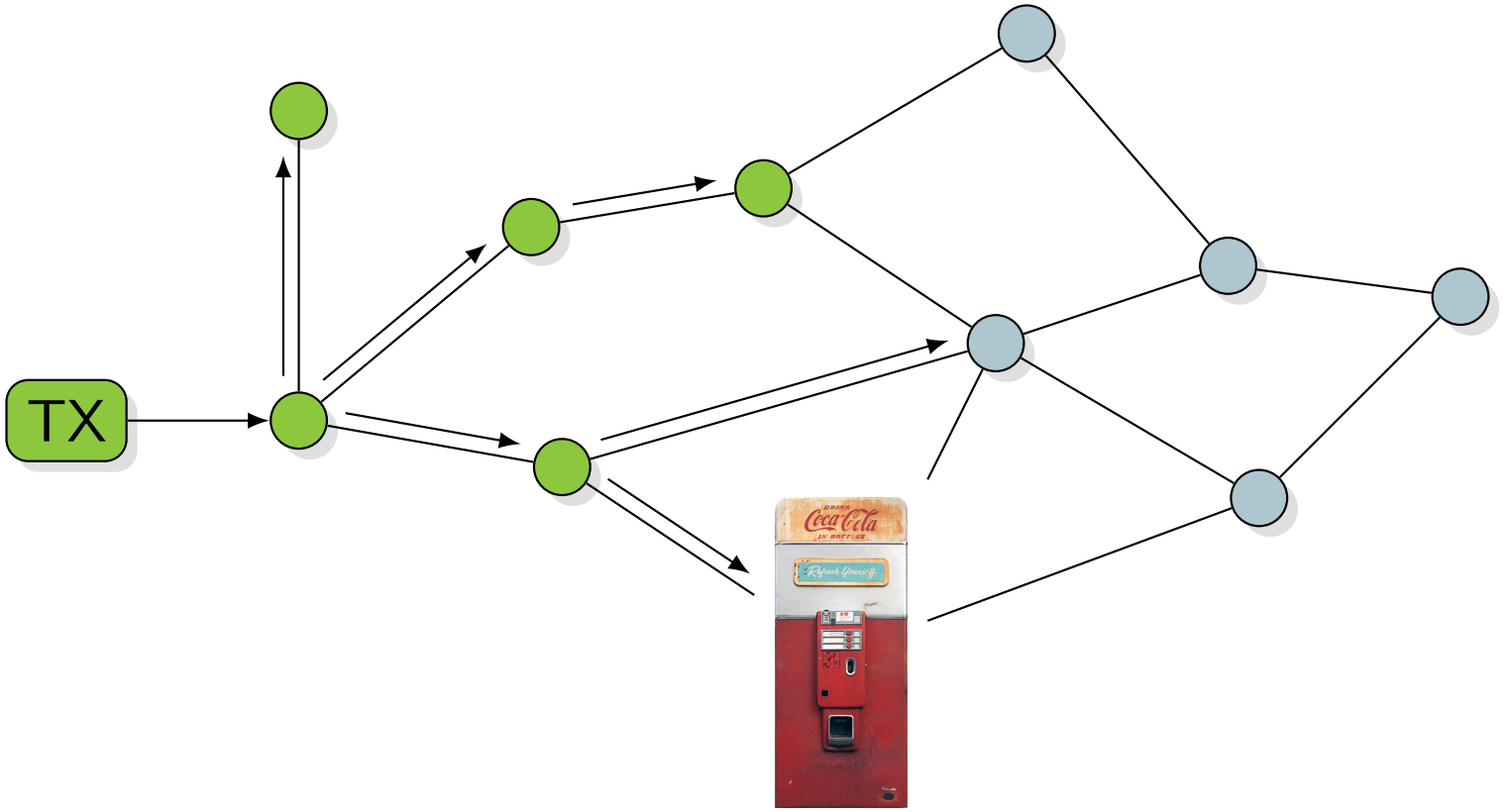


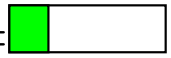
Transaction Confidence



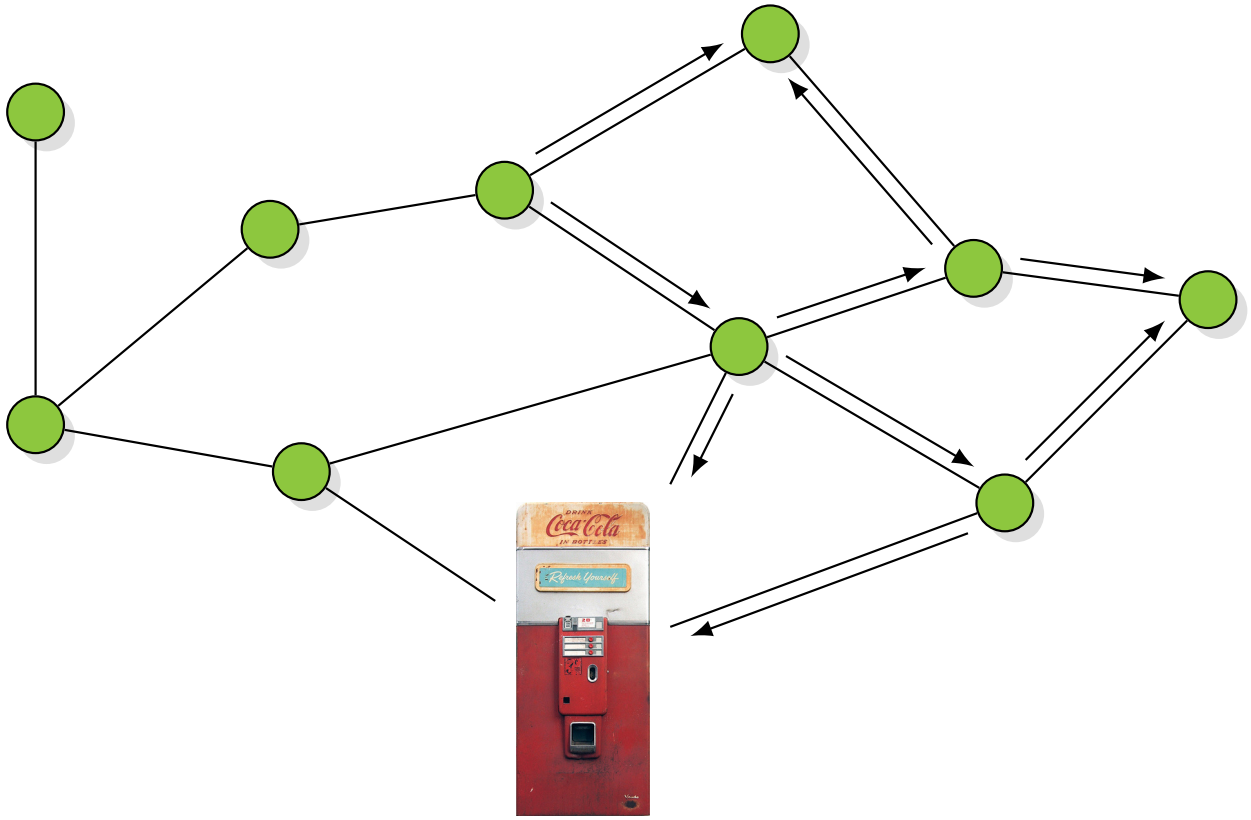
$$confidence(TX) = \boxed{}$$

Transaction Confidence



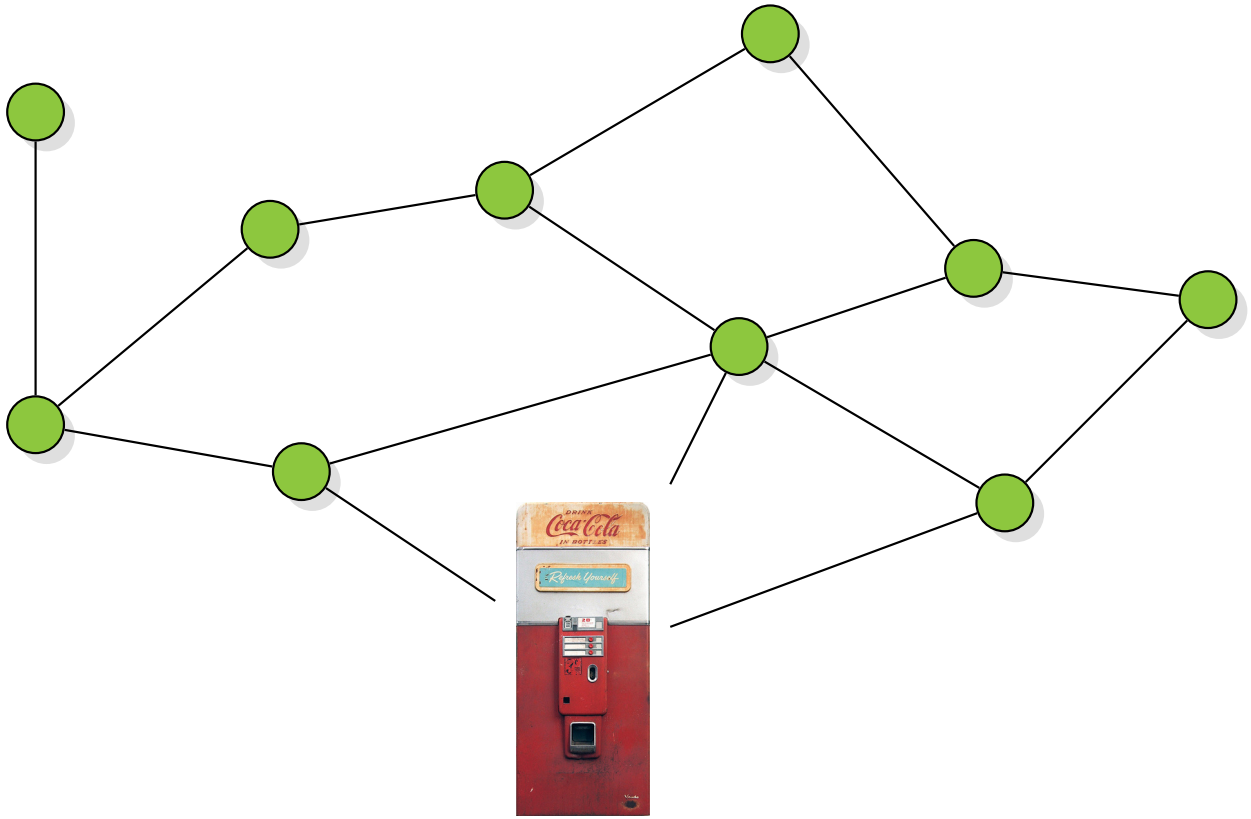
$confidence(TX) =$ 

Transaction Confidence



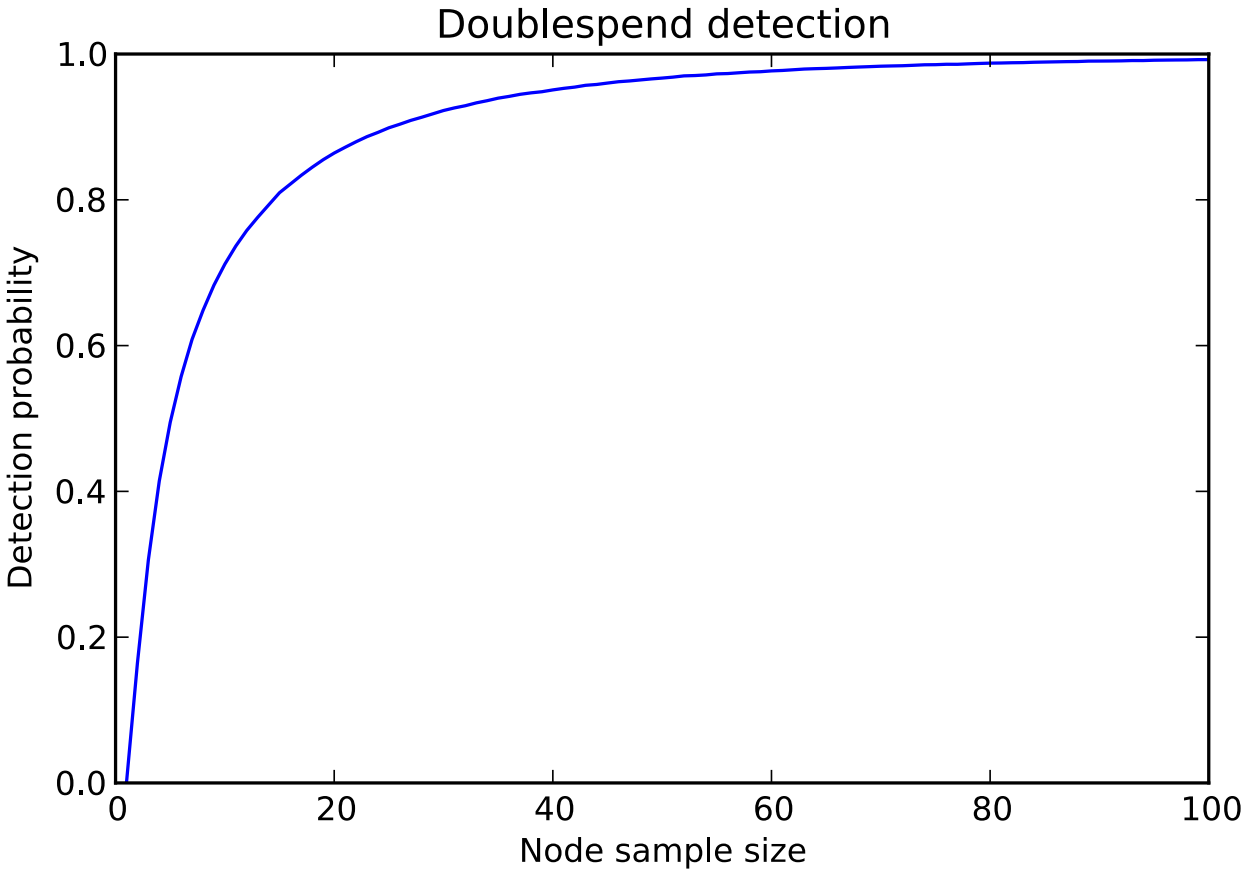
$confidence(TX) =$

Transaction Confidence



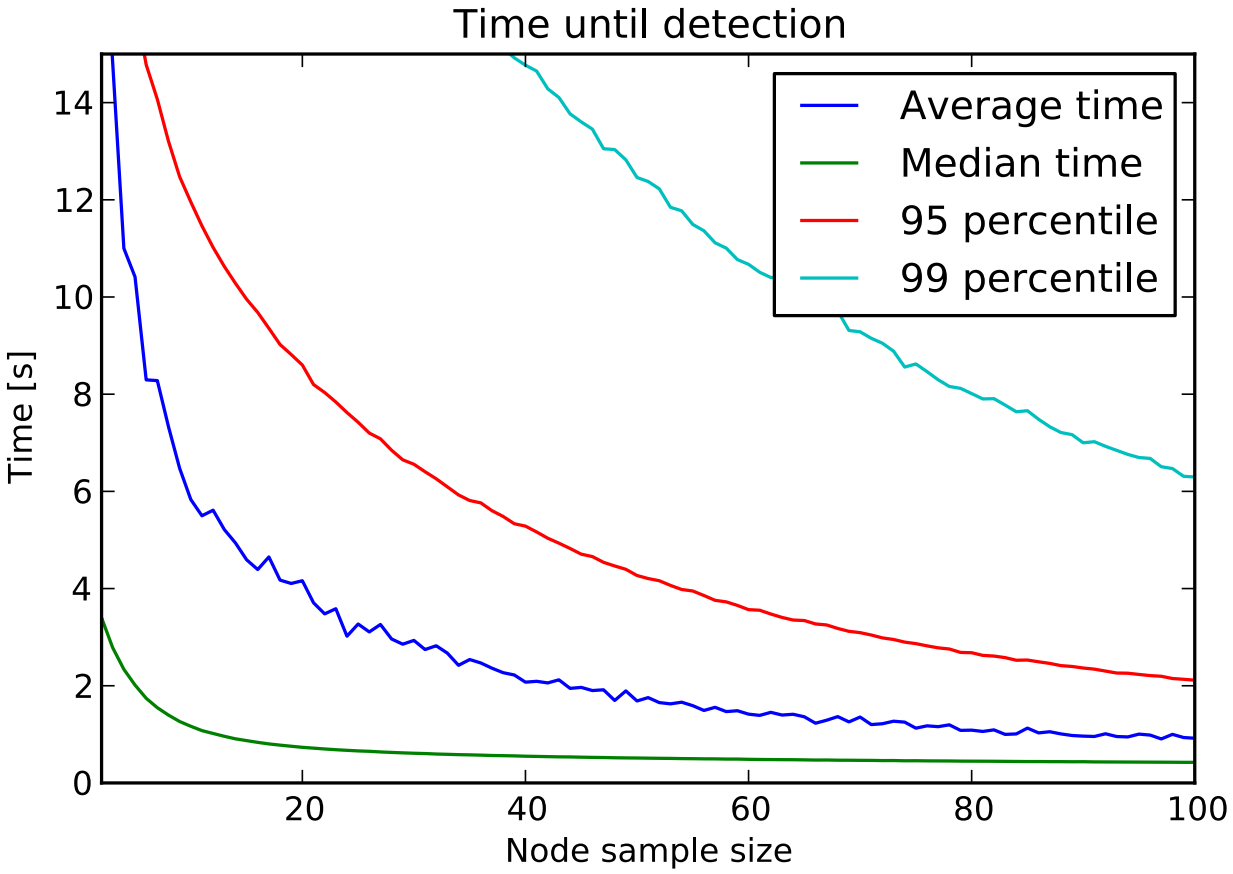
$confidence(TX) =$

Doublespend Detection



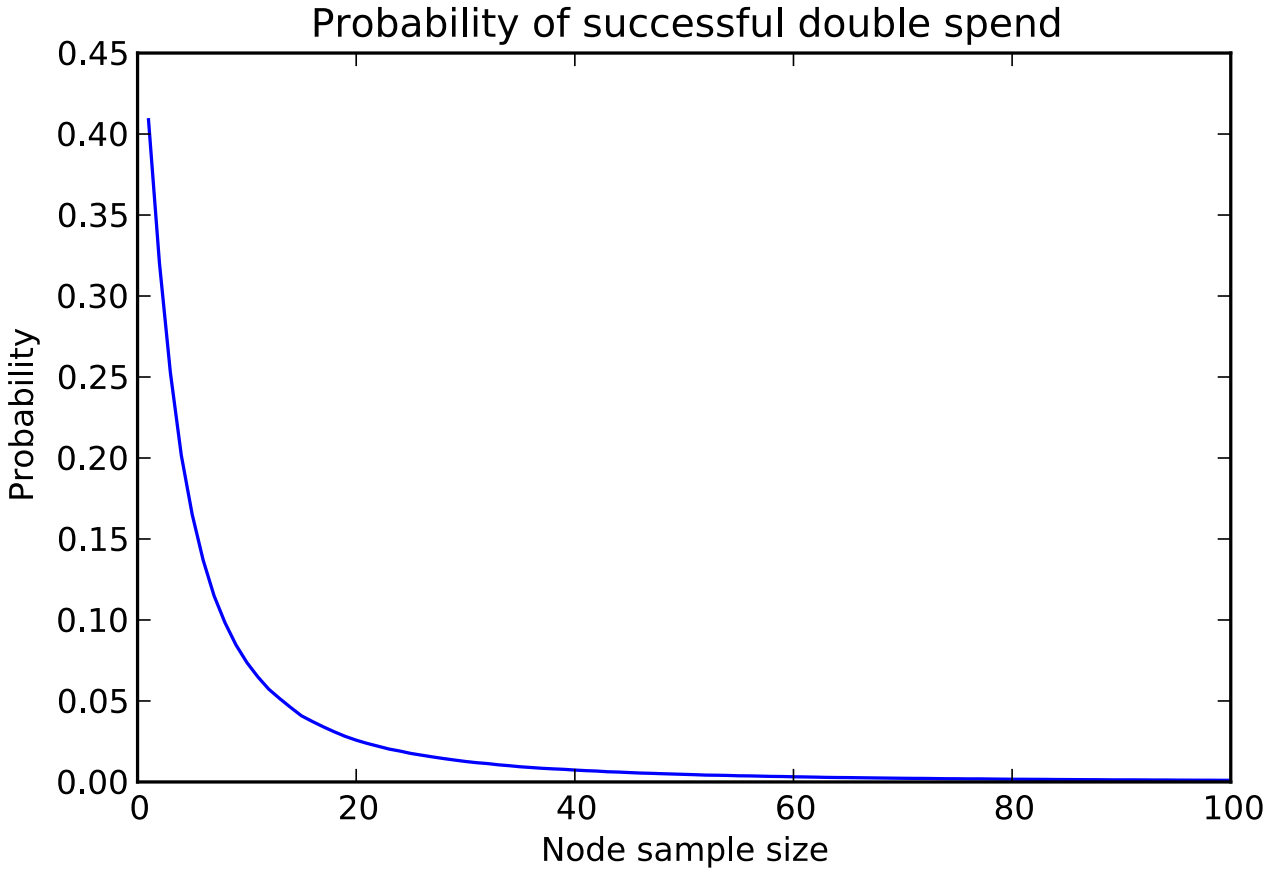
[Bamert, Decker, Elsen, W, Welten, 2013]

Time to Detection



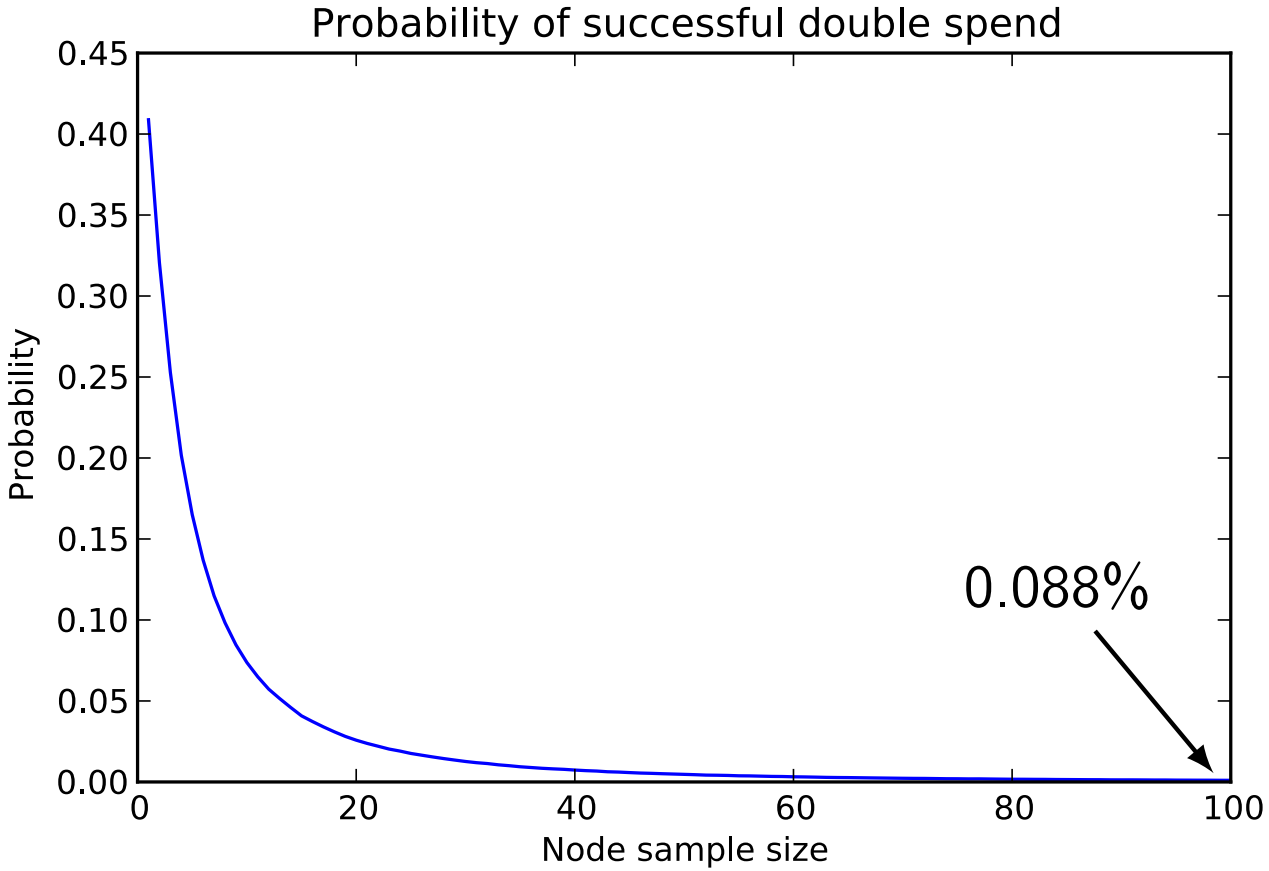
[Bamert, Decker, Elsen, W, Welten, 2013]

Successful Doublespend



[Bamert, Decker, Elsen, W, Welten, 2013]

Successful Doublespend



[Bamert, Decker, Elsen, W, Welten, 2013]