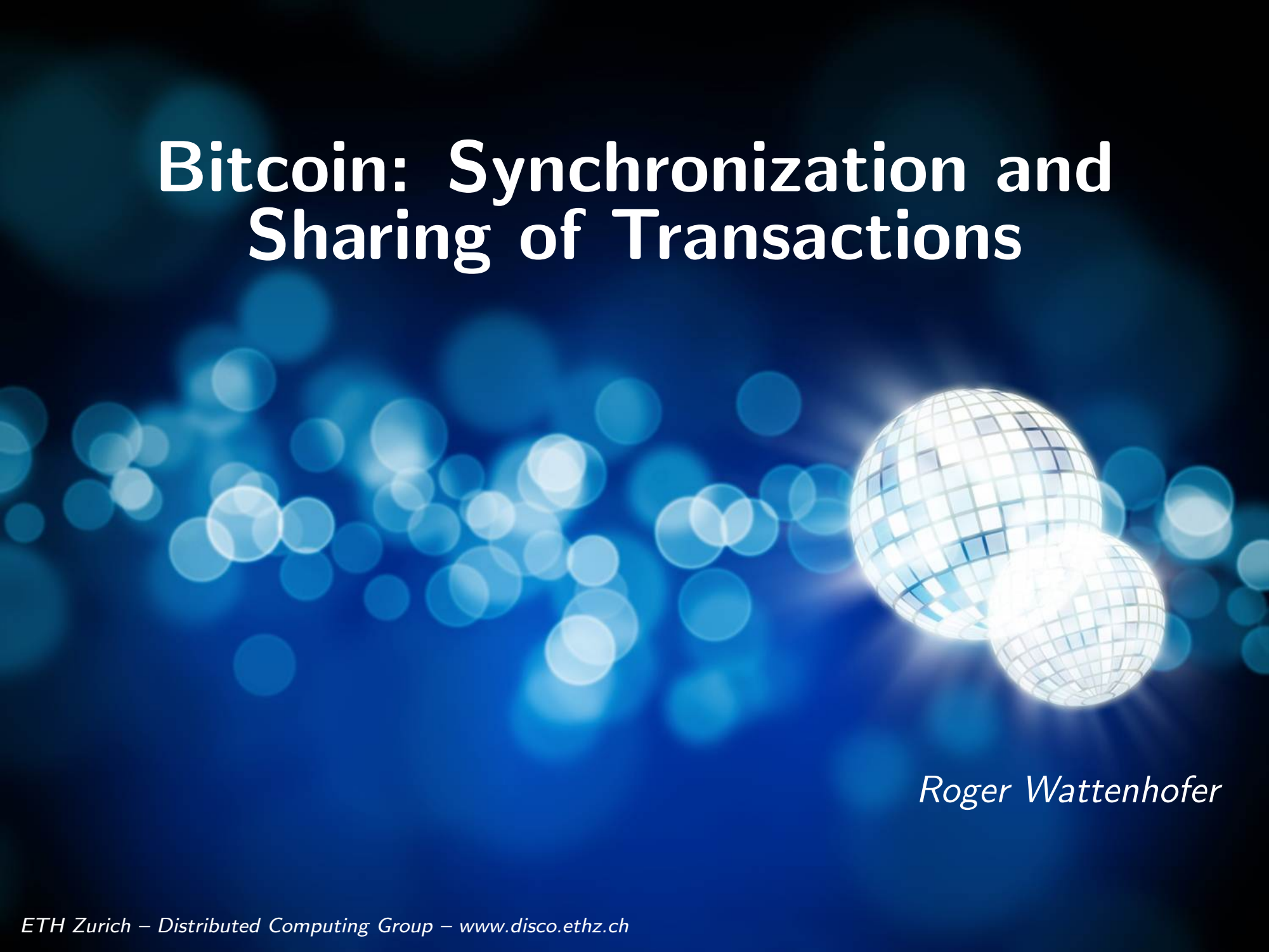
Bitcoin: Synchronization and Sharing of Transactions



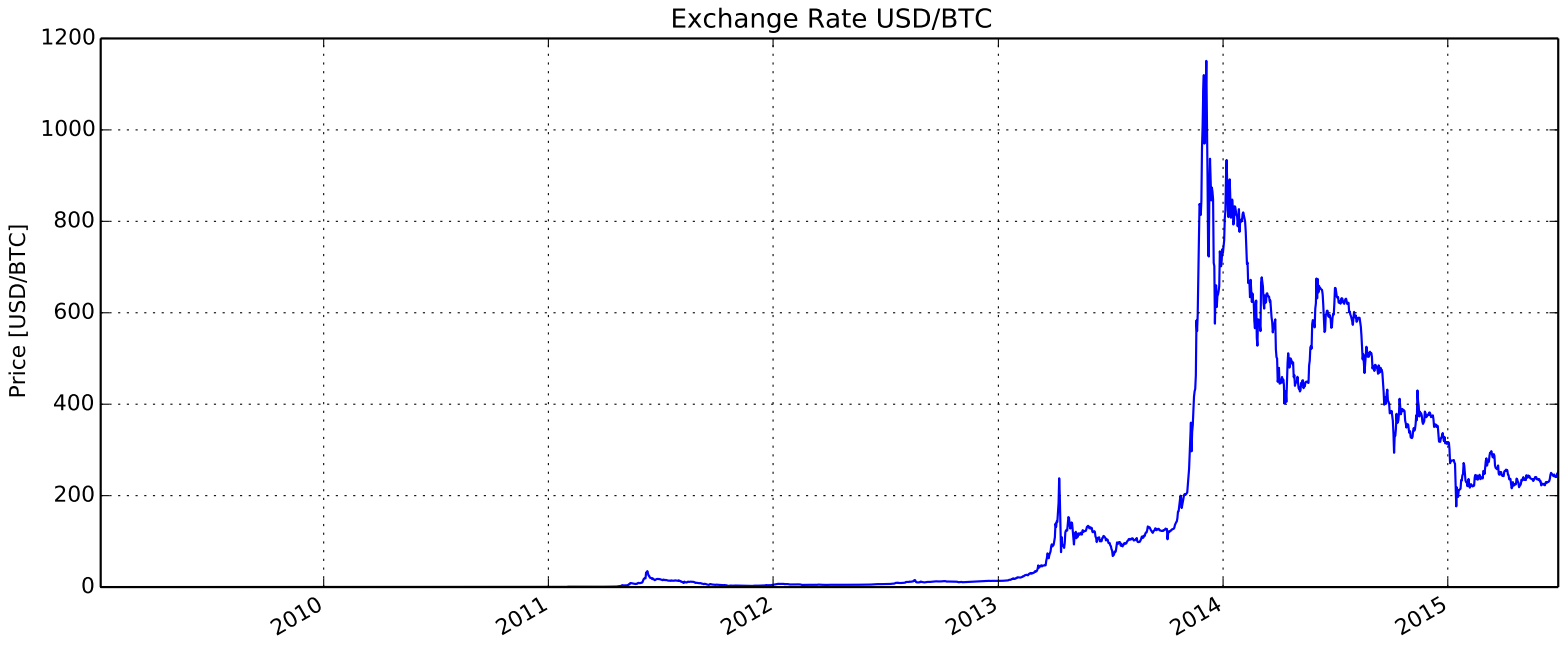
Roger Wattenhofer

ETH Zurich – Distributed Computing Group – www.disco.ethz.ch

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


Exchange Rate USD/BTC
Price [USD/BTC]
1200
1000
800
600
400
200
0
2010
2011
2012
2013
2014
2015

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**

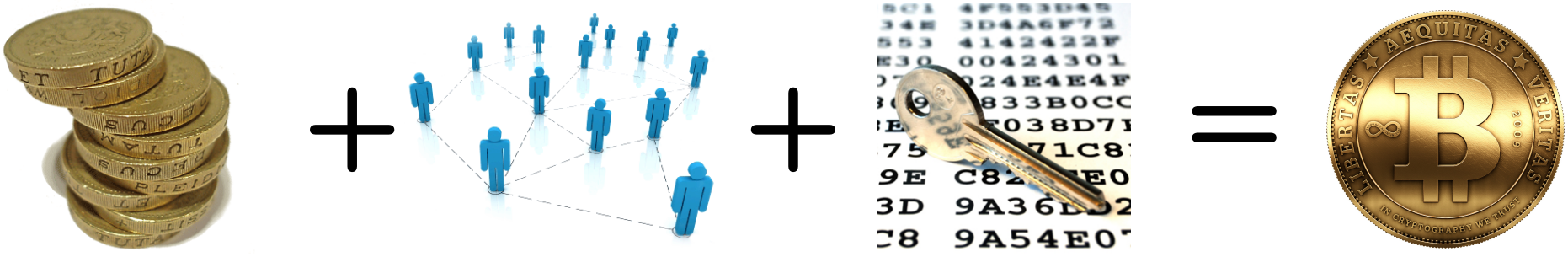
Mt. Gox, once the world's largest Bitcoin exchange, filed for bankruptcy in **Japan** saying about $480 million in Bitcoins belonging to its customers and the firm were missing.

"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

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

What is Bitcoin?



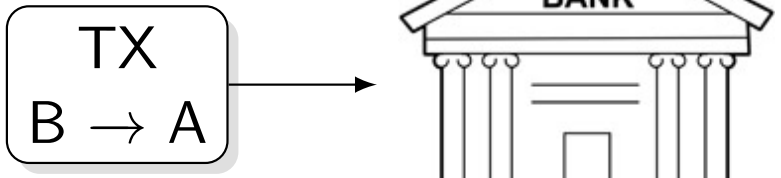
Bitcoin Basics

The Bank of Bitcoin

The Bank of Bitcoin

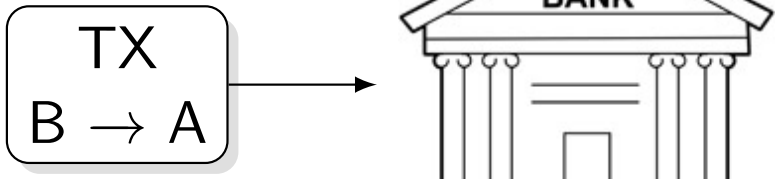
User	Balance
A	2
B	5
C	8

The Bank of Bitcoin



User	Balance
A	2
B	5
C	8

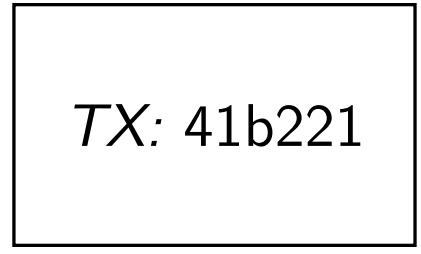
The Bank of Bitcoin



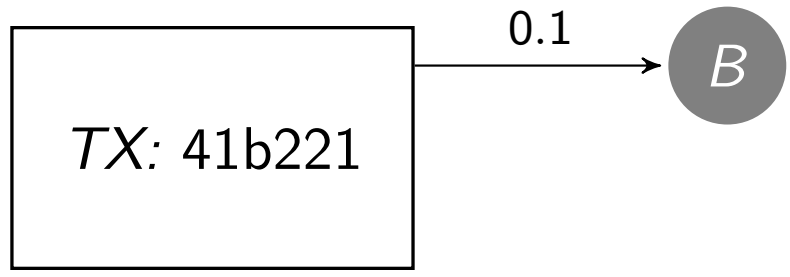
User	Balance
A	~~2~~ 4
B	~~5~~ 3
C	8

Opening an Account in Bitcoin

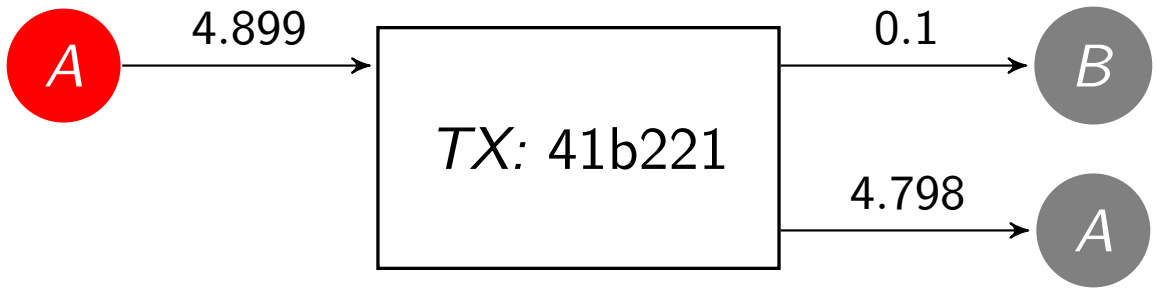
Transferring Bitcoins



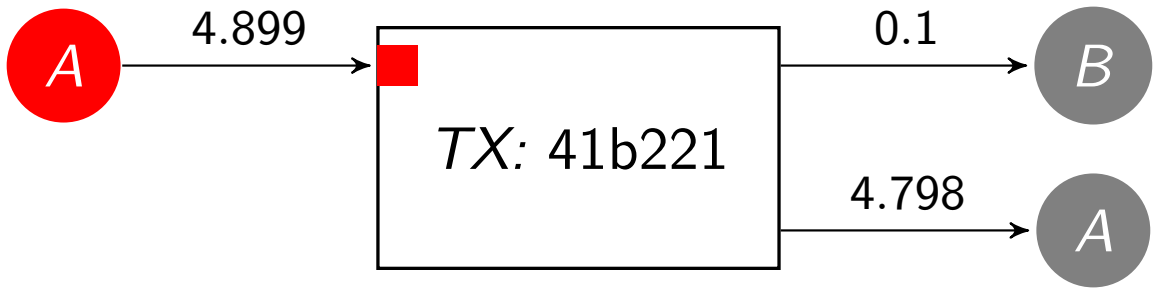
Transferring Bitcoins



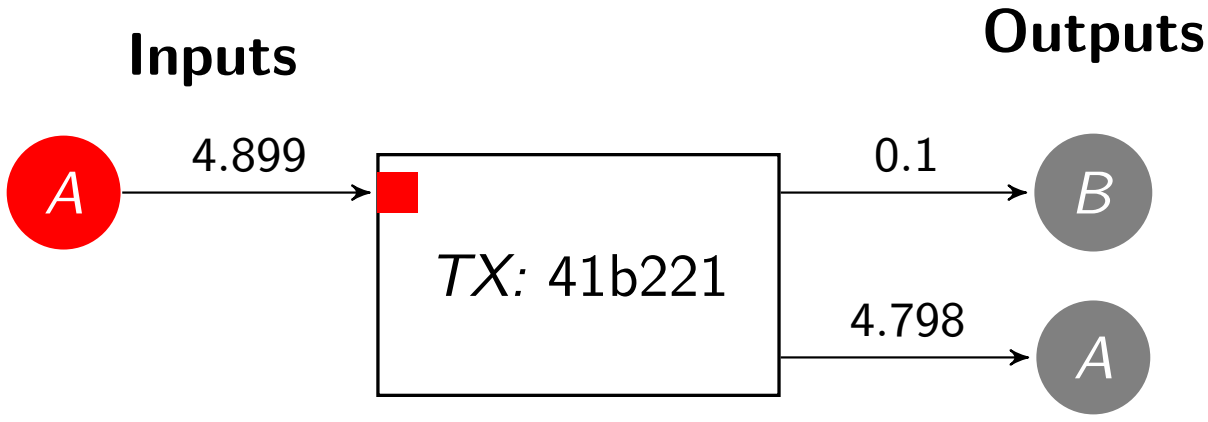
Transferring Bitcoins



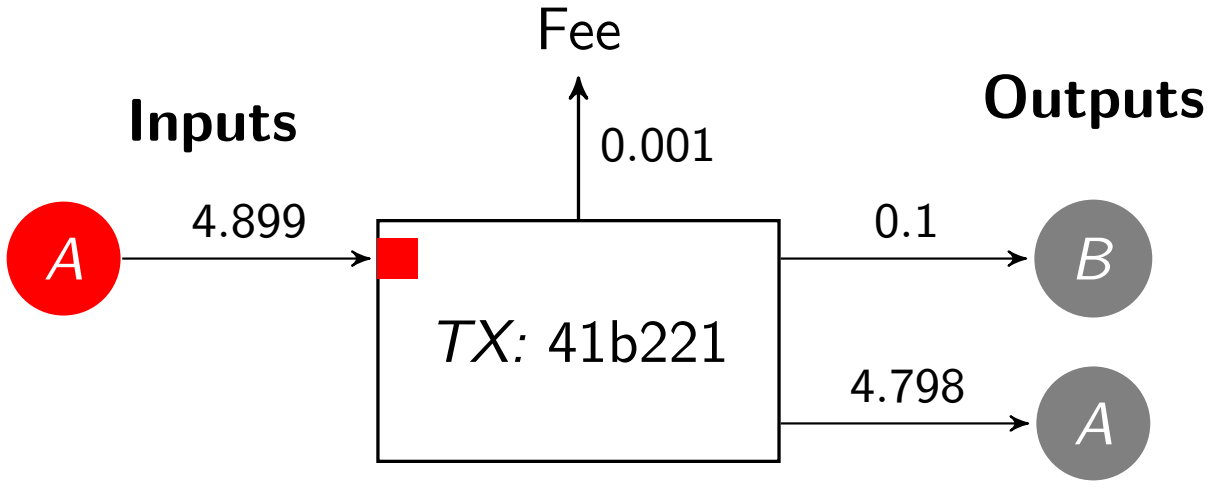
Transferring Bitcoins



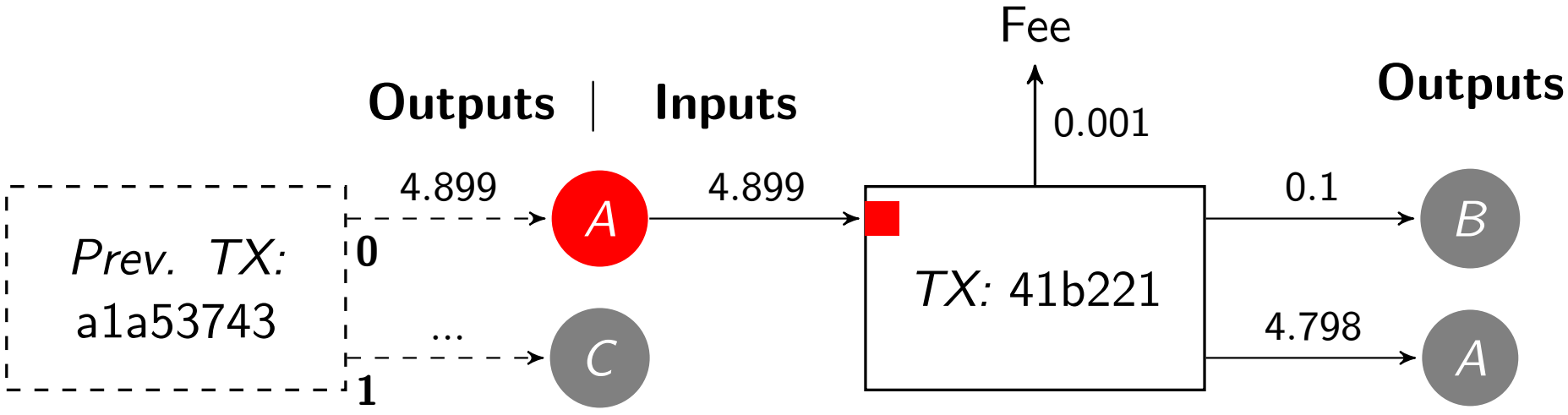
Transferring Bitcoins



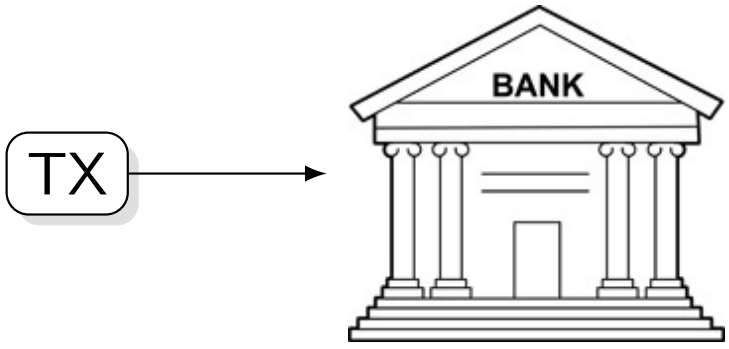
Transferring Bitcoins



Transferring Bitcoins

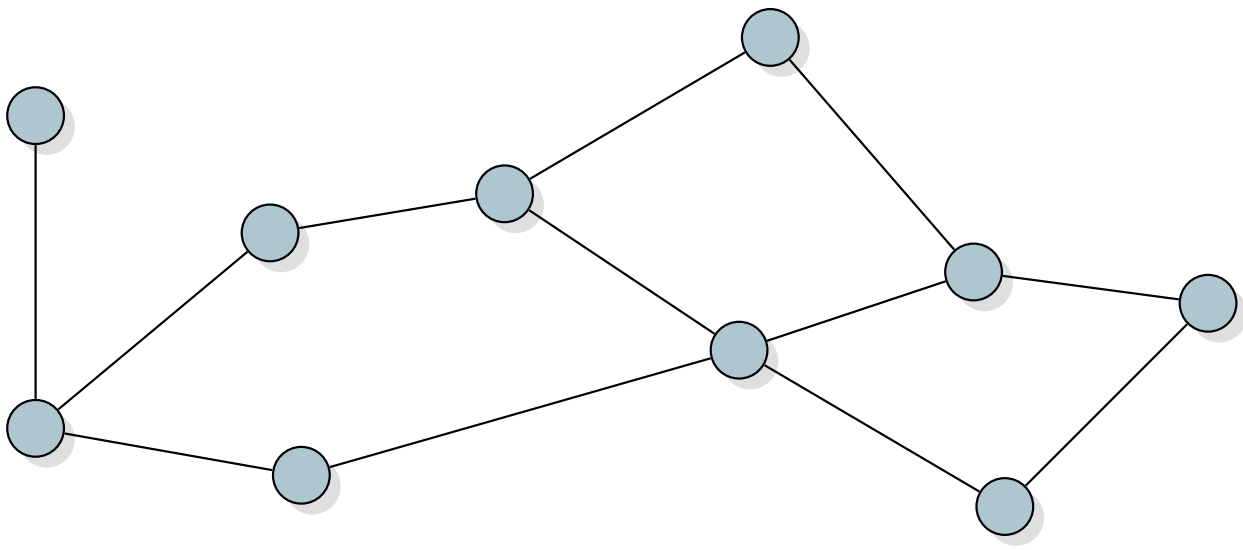


Distributing the Bank

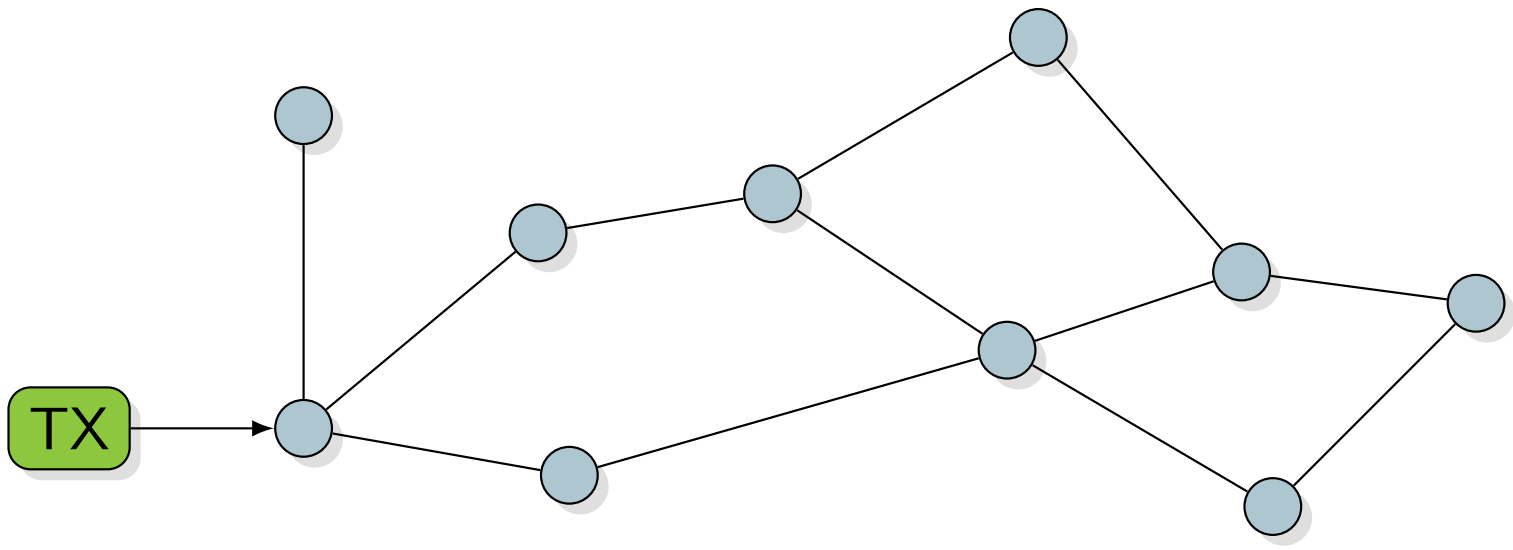


User	Balance
A	2
B	5
C	8

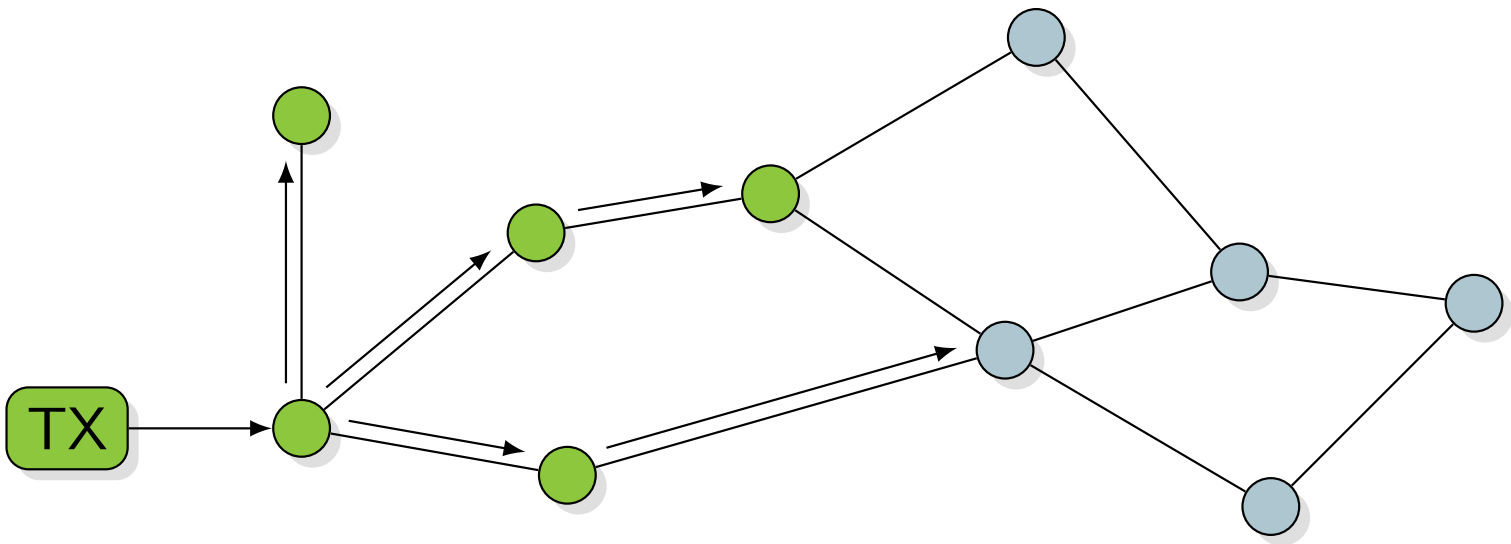
Distributing the Bank



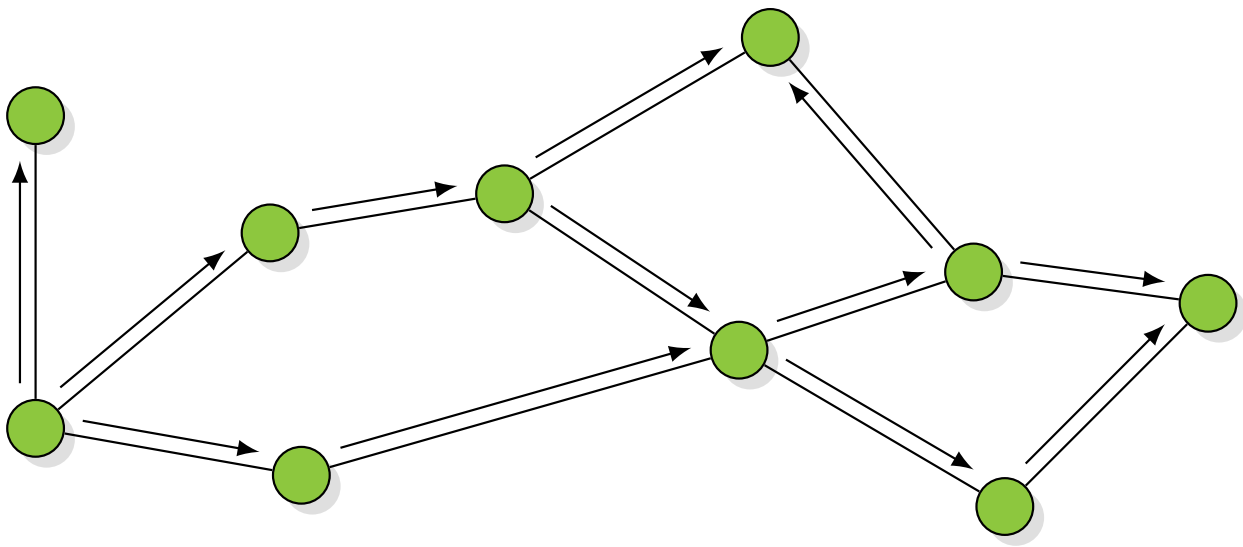
Distributing the Bank



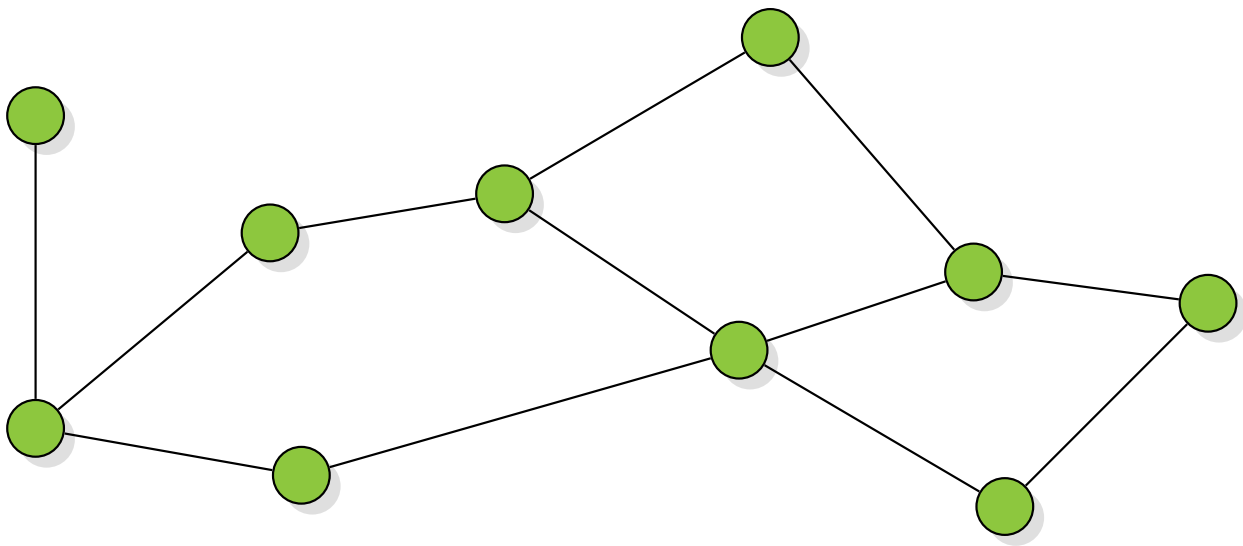
Distributing the Bank



Distributing the Bank



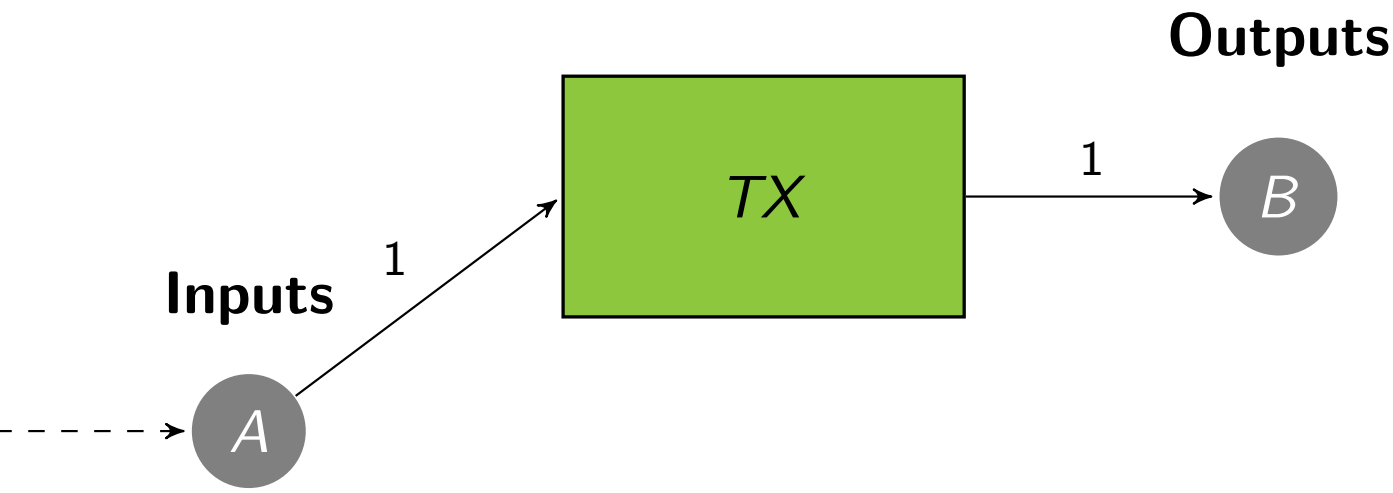
Distributing the Bank



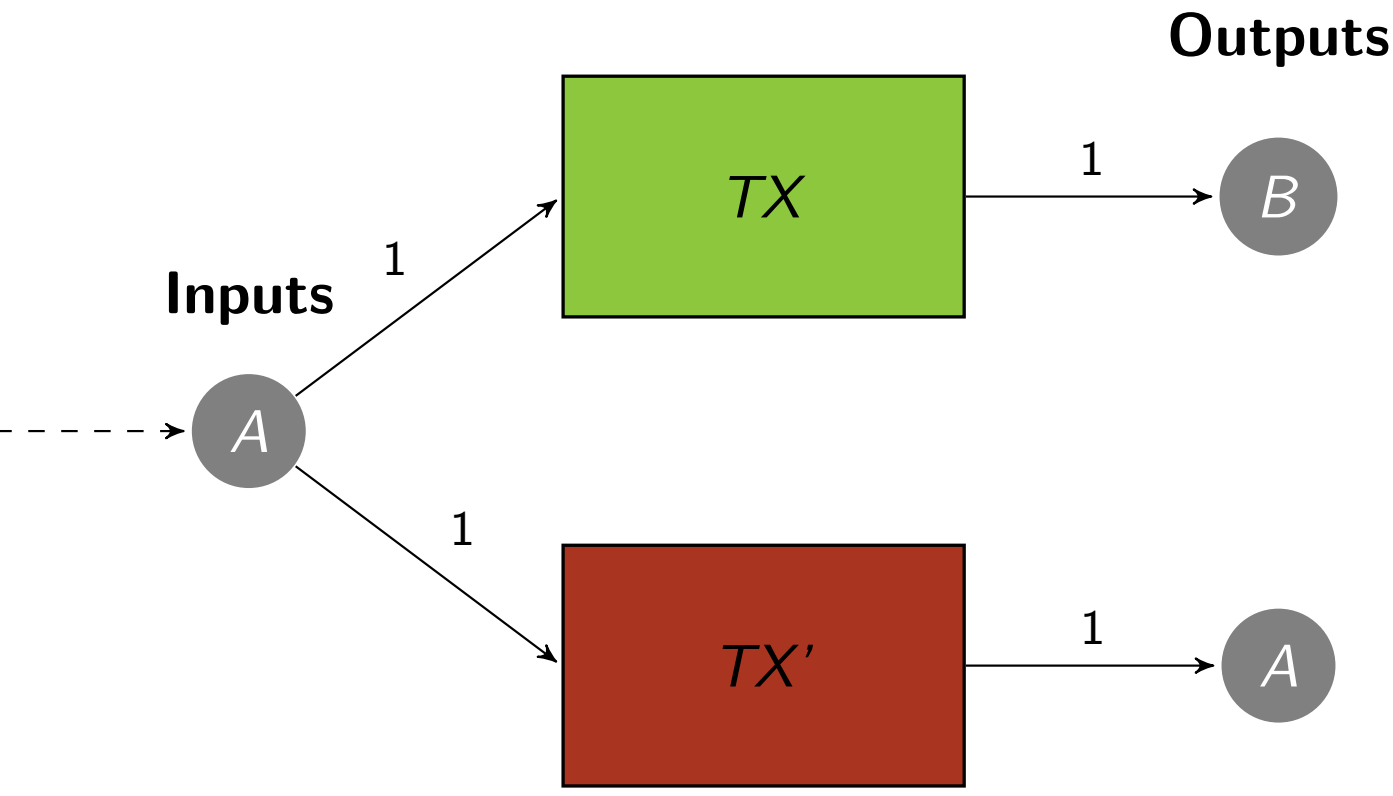
Let's Buy a Snack

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

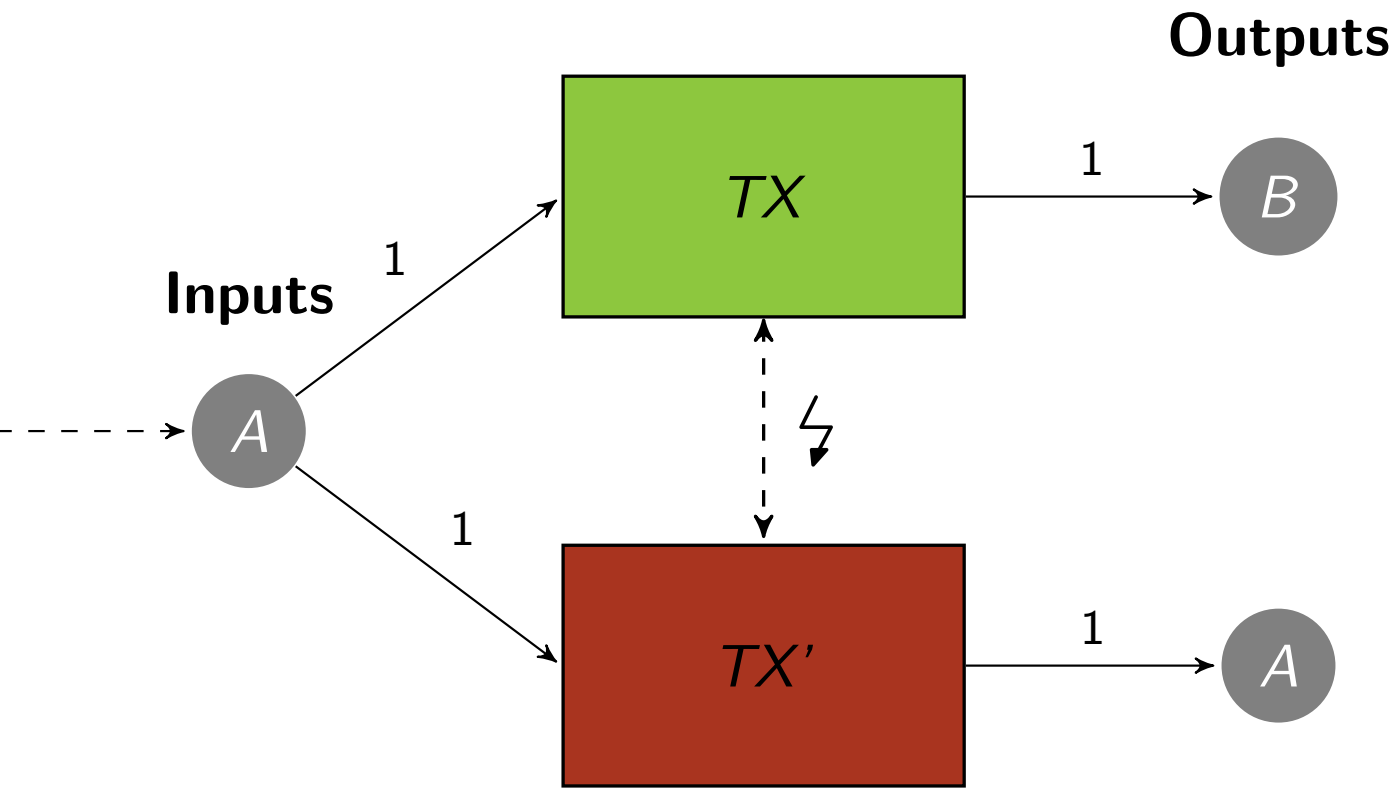
Doublespending



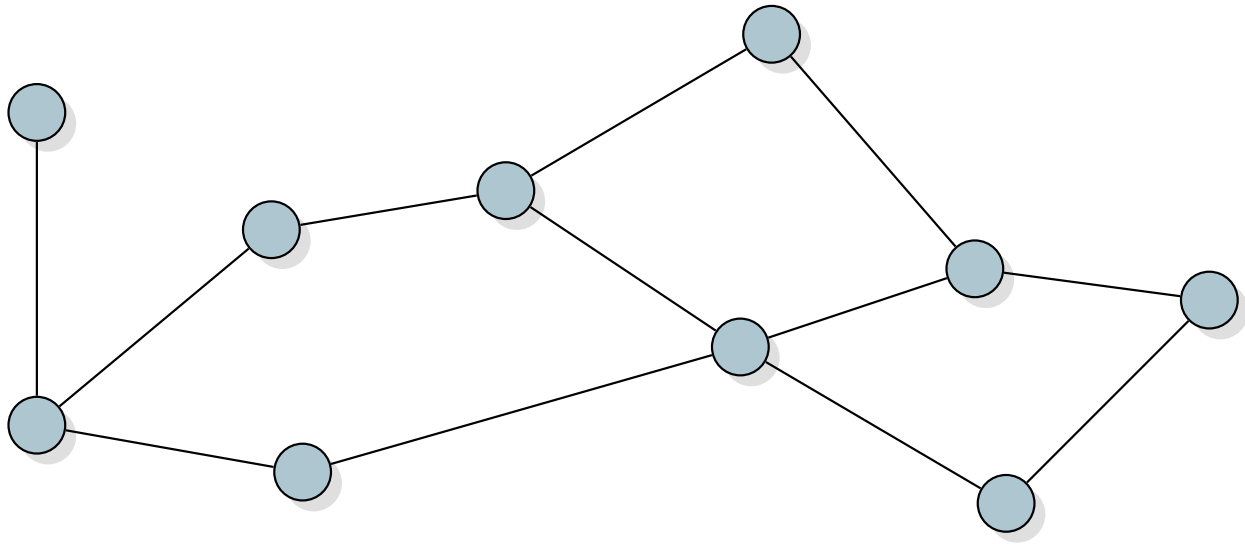
Doublespending



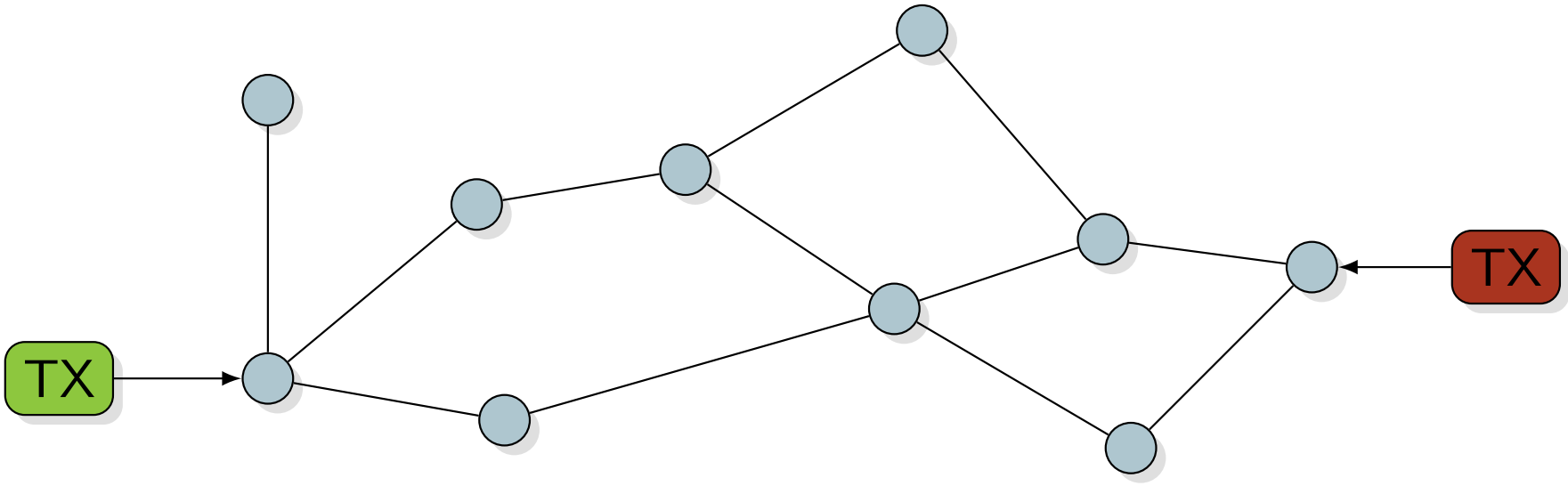
Doublespending



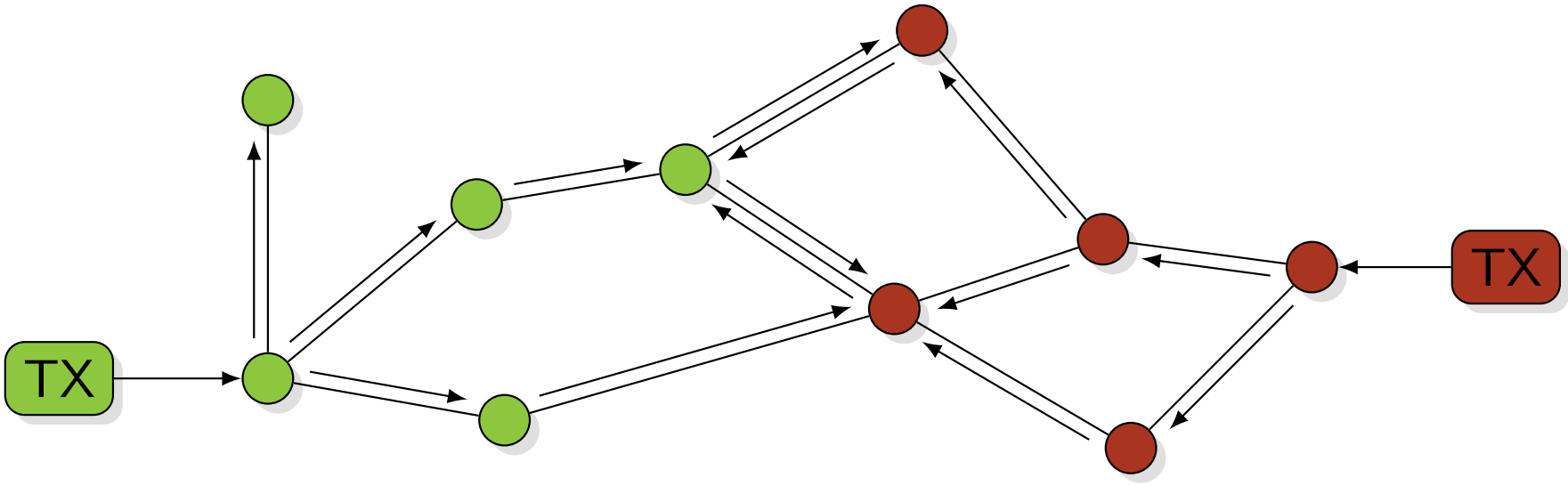
Transaction Conflicts



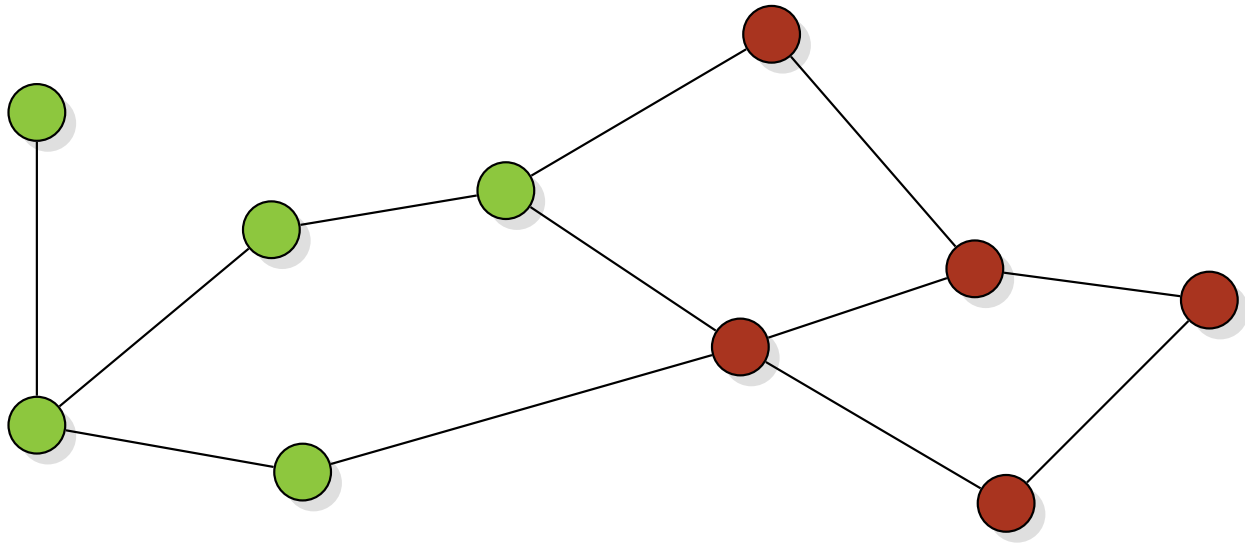
Transaction Conflicts



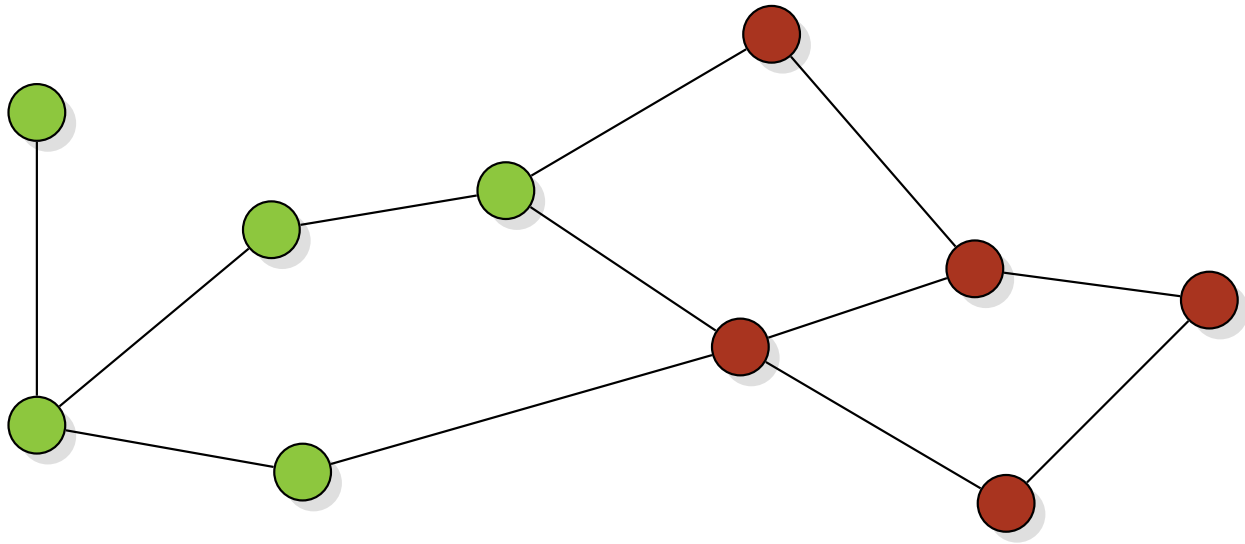
Transaction Conflicts



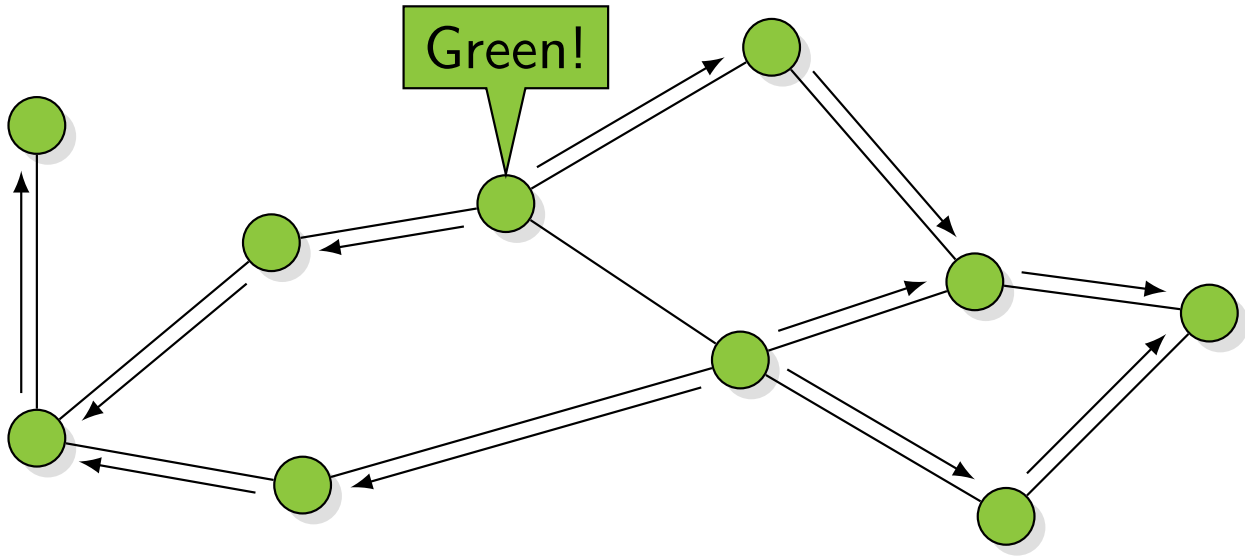
Transaction Conflicts



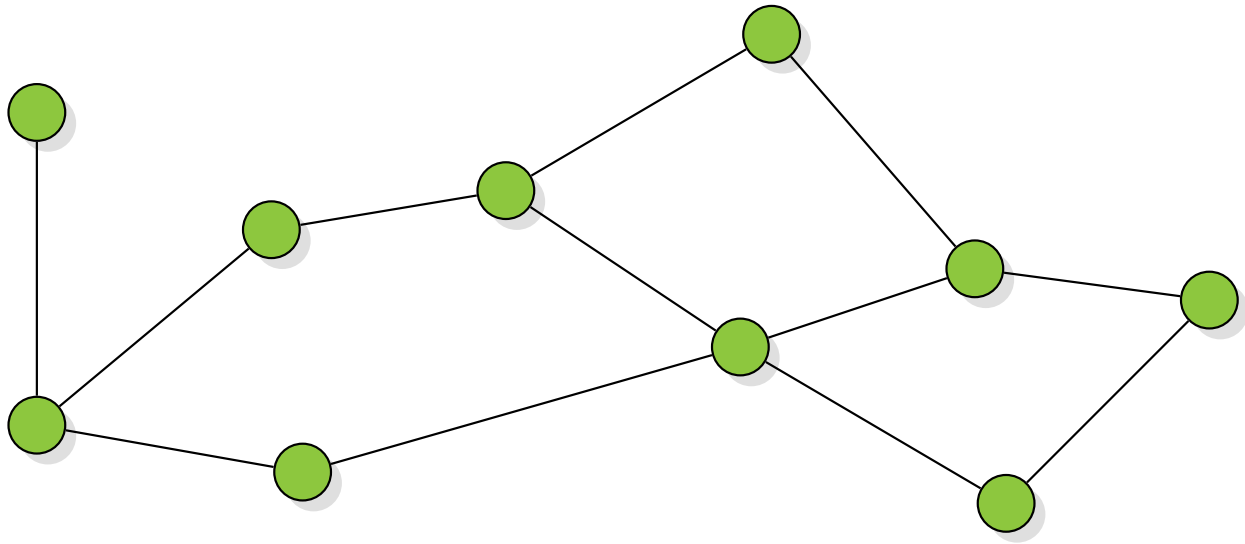
Resolving Conflicts



Resolving Conflicts

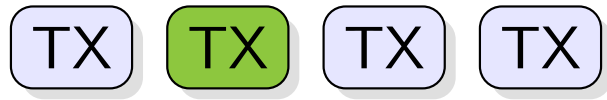


Resolving Conflicts

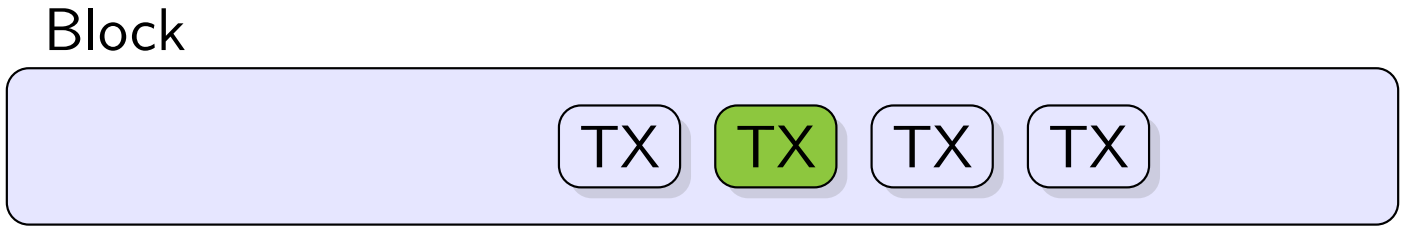


How to Choose a Leader?

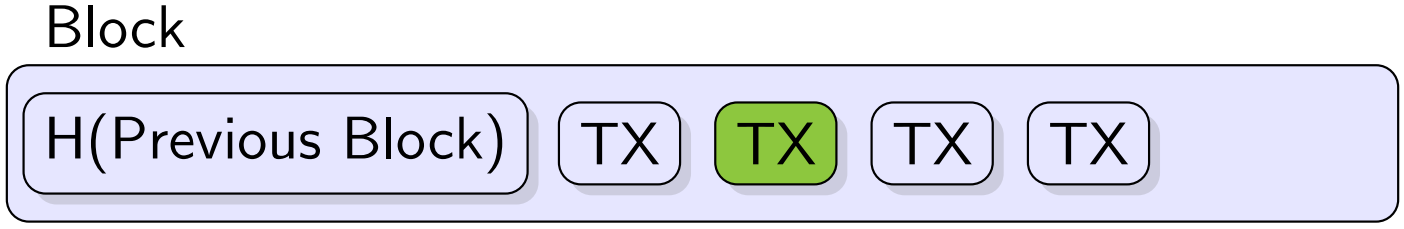
Proof-of-Work



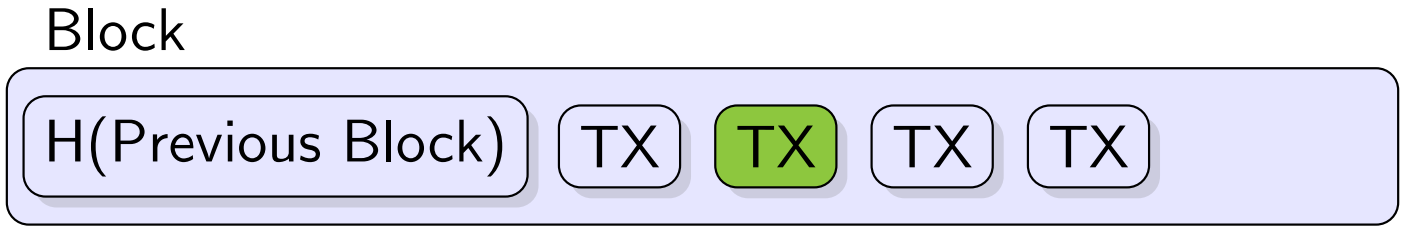
Proof-of-Work



Proof-of-Work

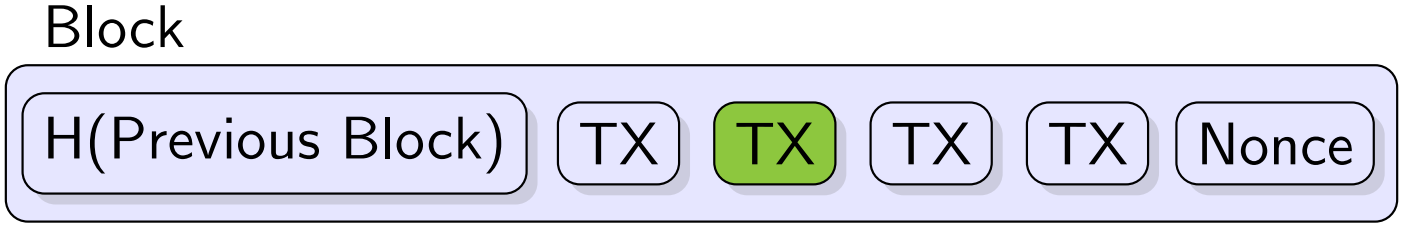


Proof-of-Work



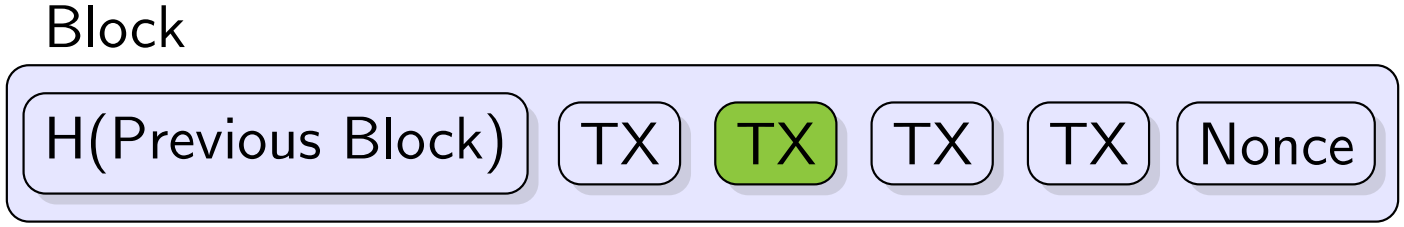
- H(Block) $\rightarrow$ fd2e2055f117bfa261b5a6c7e11df367...

Proof-of-Work



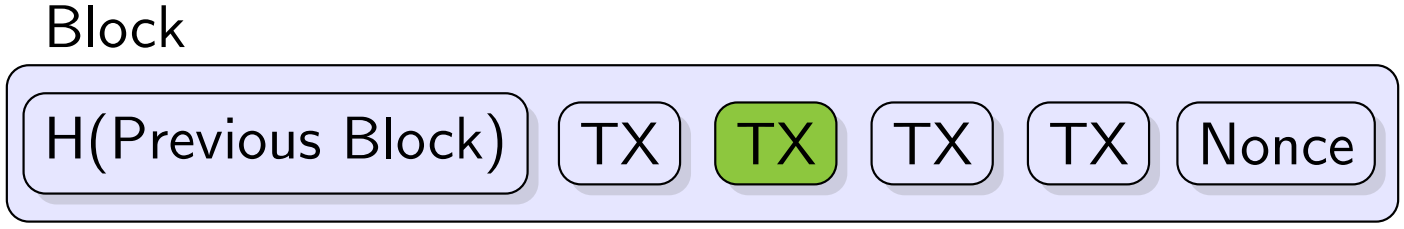
- H(Block|0) $\rightarrow$ 094d66aa7c844a9dbb516a41259b5877...

Proof-of-Work



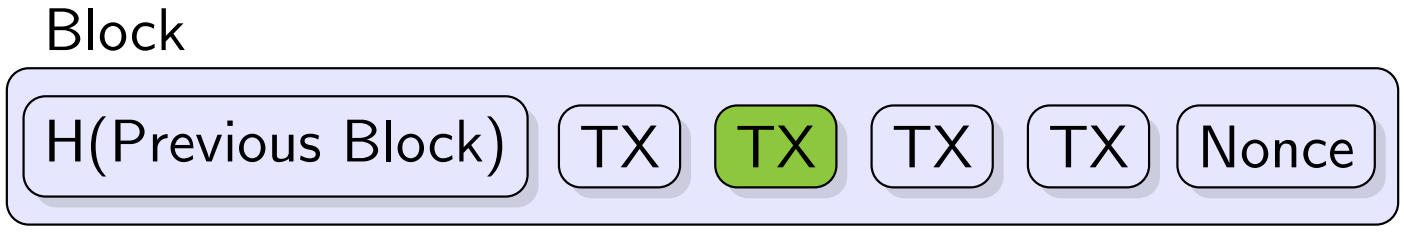
- H(Block|0) $\rightarrow$ 094d66aa7c844a9dbb516a41259b5877...
- H(Block|1) $\rightarrow$ f2496854af8bf989171587a9259f634f...

Proof-of-Work



- H(Block|0) $\rightarrow$ 094d66aa7c844a9dbb516a41259b5877...
- H(Block|1) $\rightarrow$ f2496854af8bf989171587a9259f634f...
- H(Block|2) $\rightarrow$ aec87c0ca2e5eb3f23111092f1089ada...

Proof-of-Work

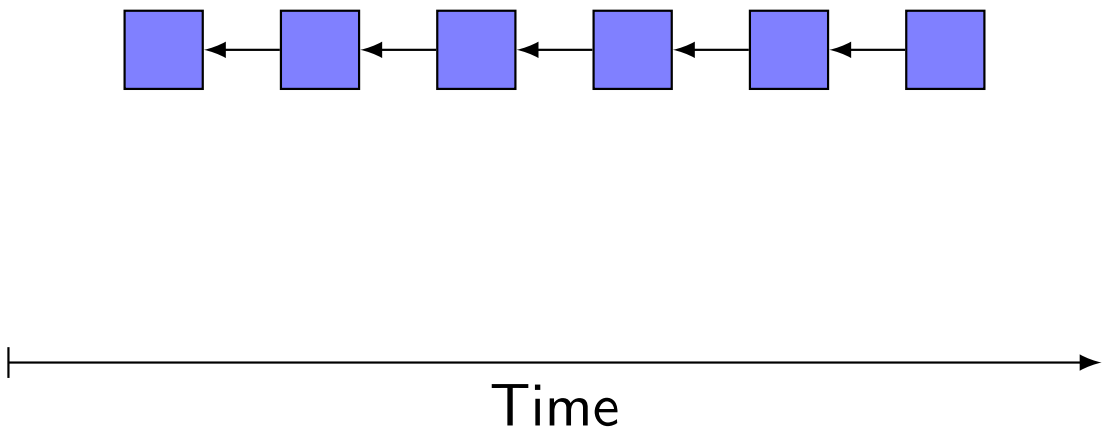


- H(Block|0) $\rightarrow$ 094d66aa7c844a9dbb516a41259b5877...
- H(Block|1) $\rightarrow$ f2496854af8bf989171587a9259f634f...
- H(Block|2) $\rightarrow$ aec87c0ca2e5eb3f23111092f1089ada...
- H(Block|3) $\rightarrow$ 777f75b2a8ecfdc8026c236fc1d2ffa0...

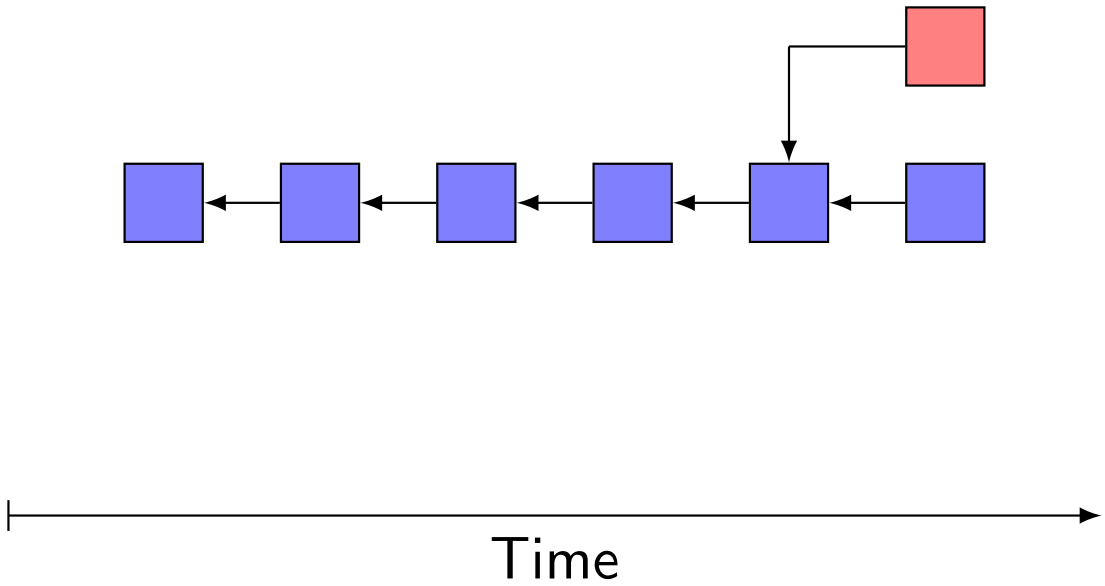
  $\vdots$

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

The Blockchain

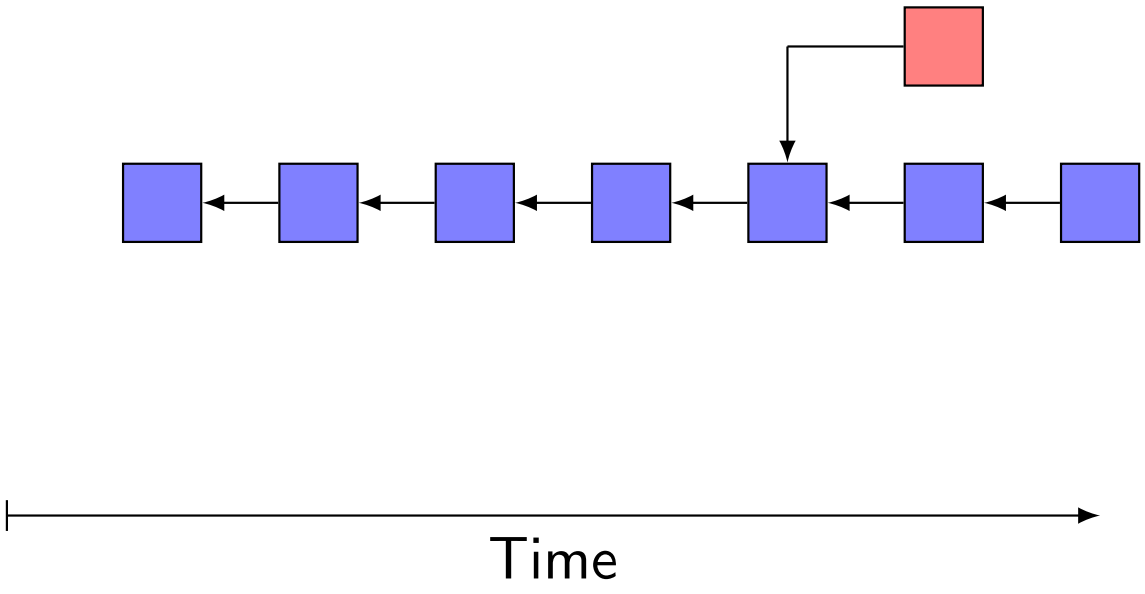


The Blockchain

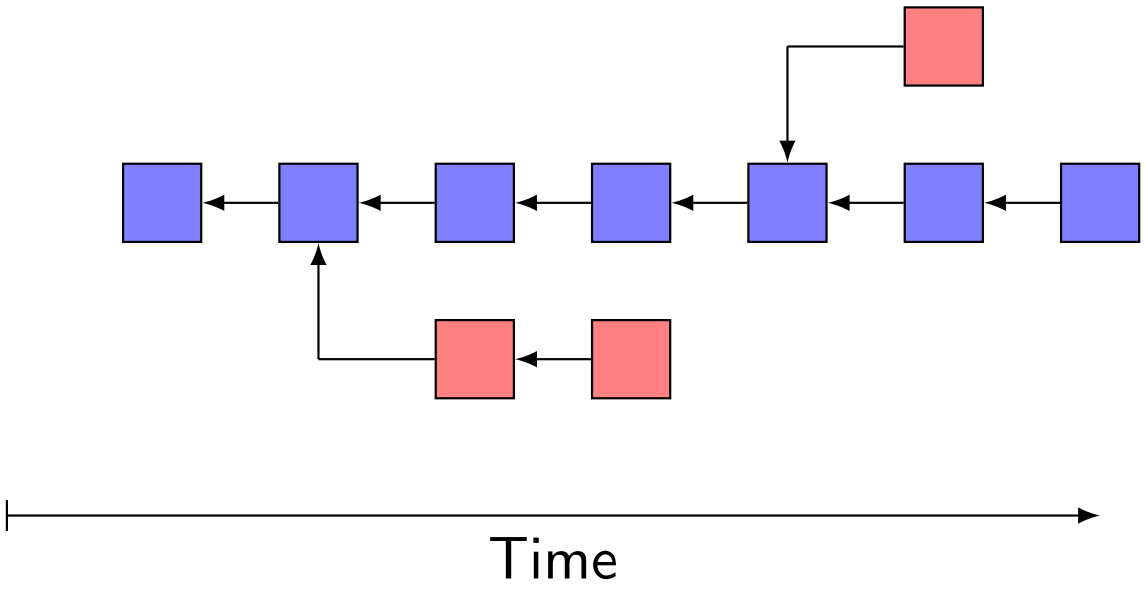


Is Bitcoin stable?

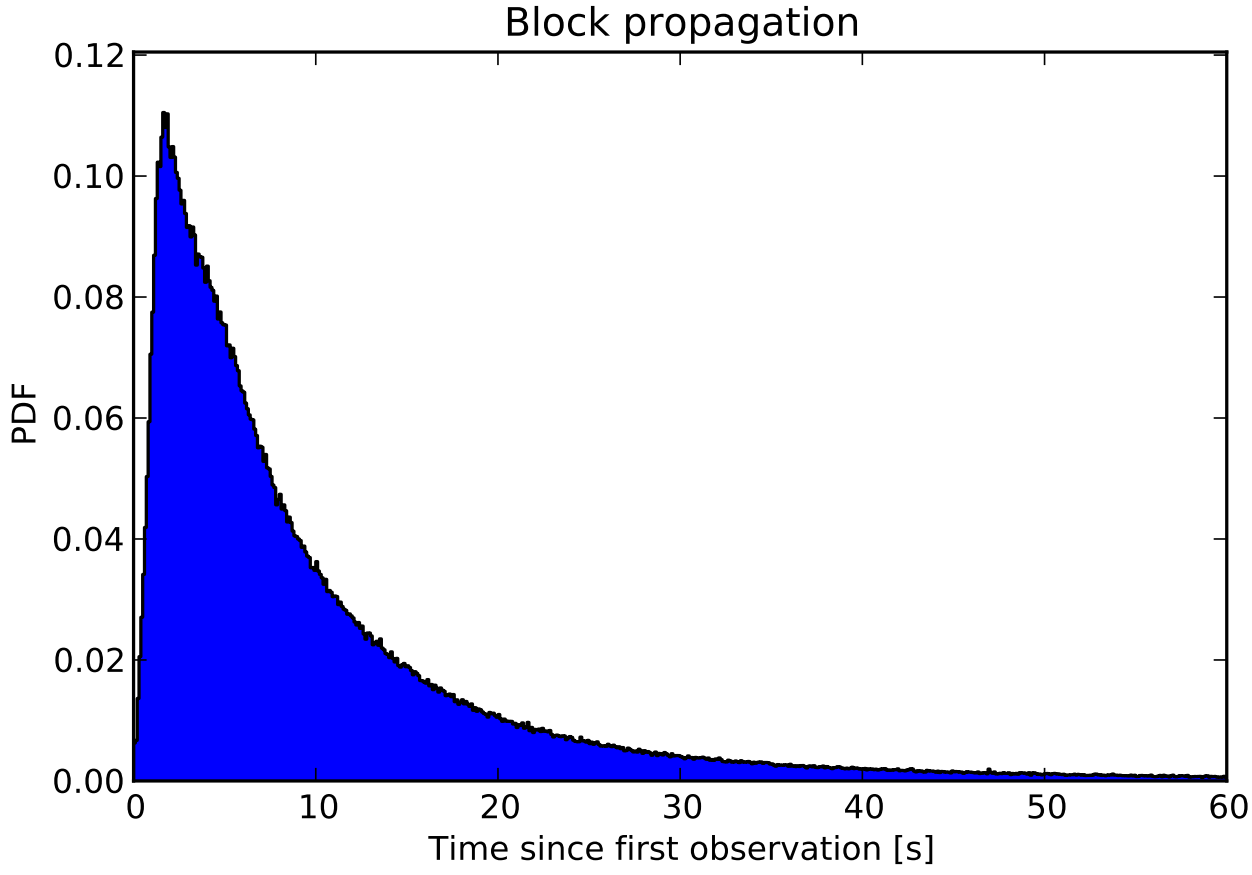
The Blockchain



The Blockchain



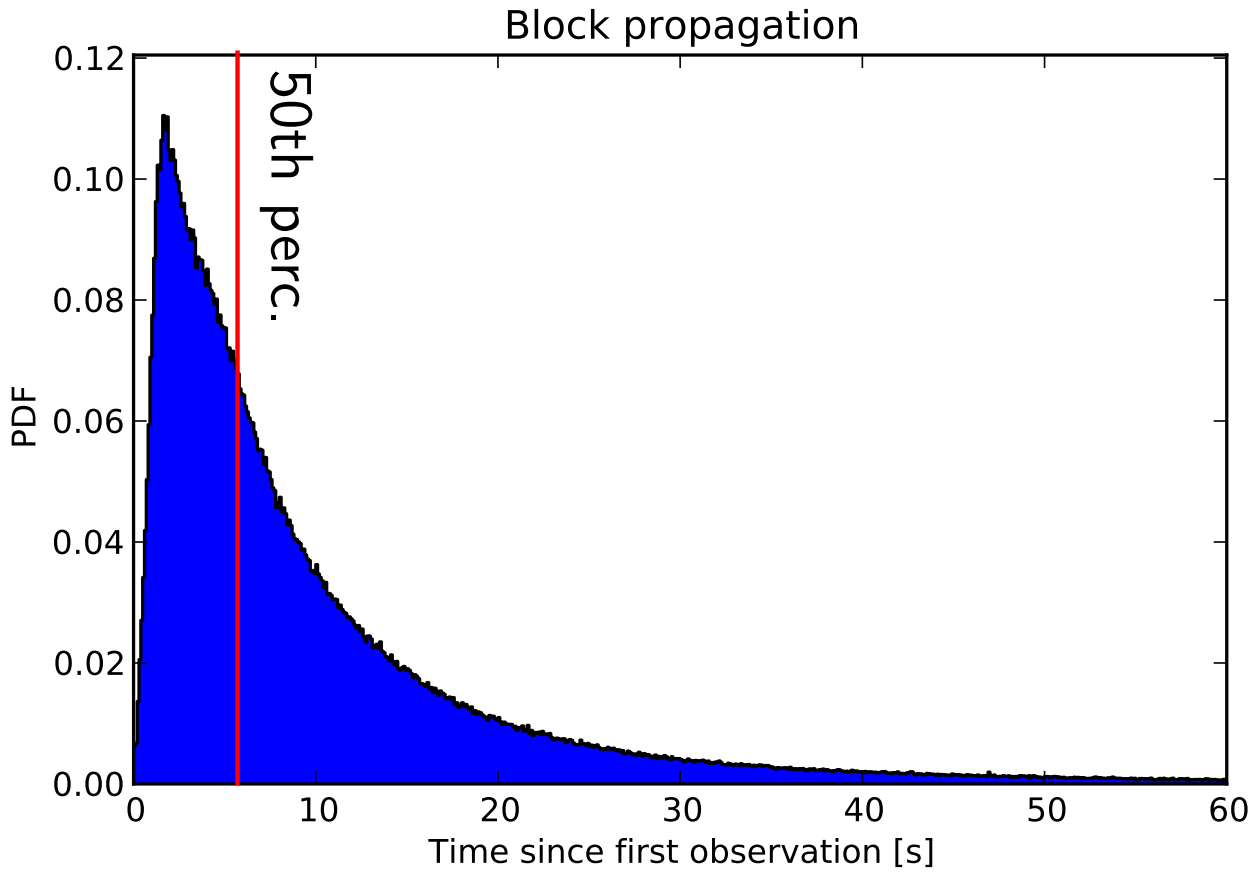
Propagation Speed



`http://bitcoinstats.com`

[Decker, W, 2013]

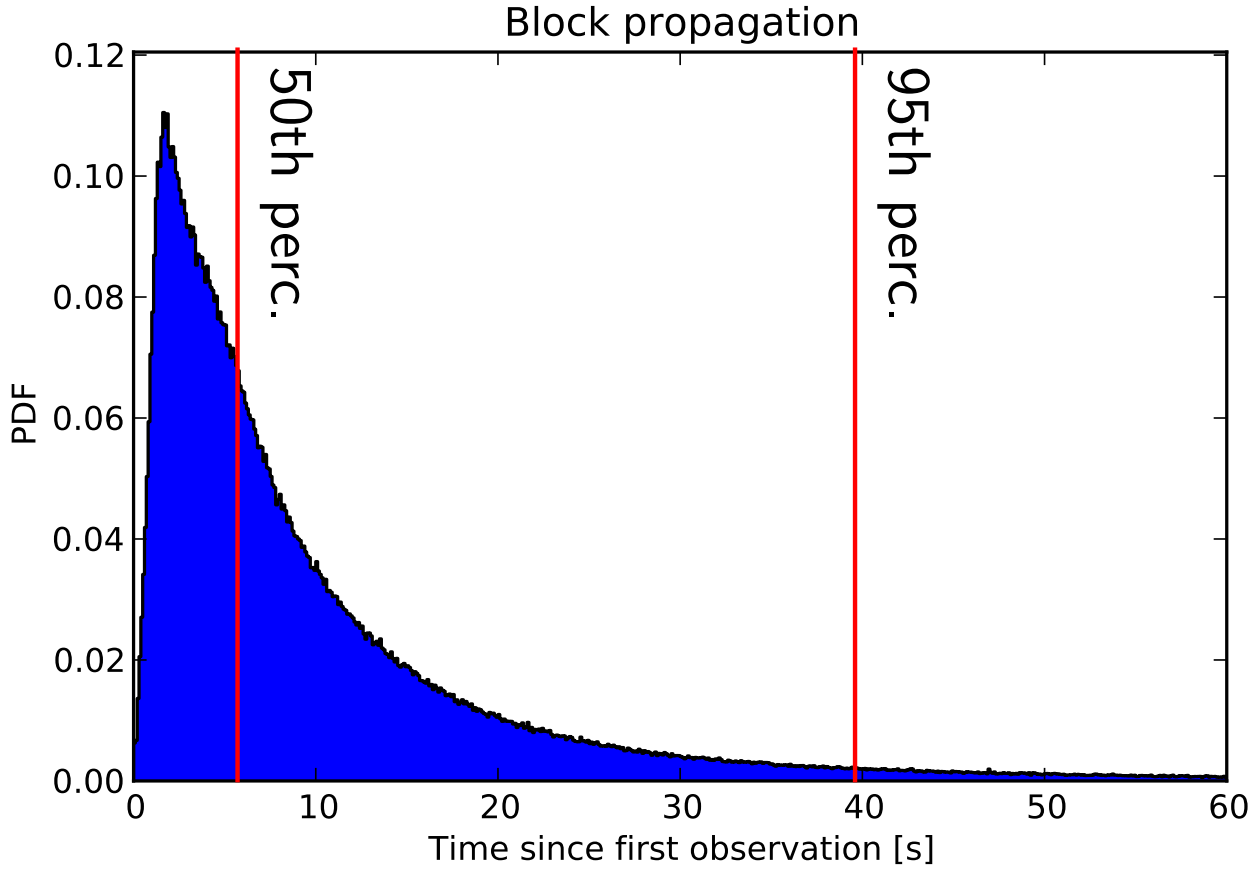
Propagation Speed



`http://bitcoinstats.com`

[Decker, W, 2013]

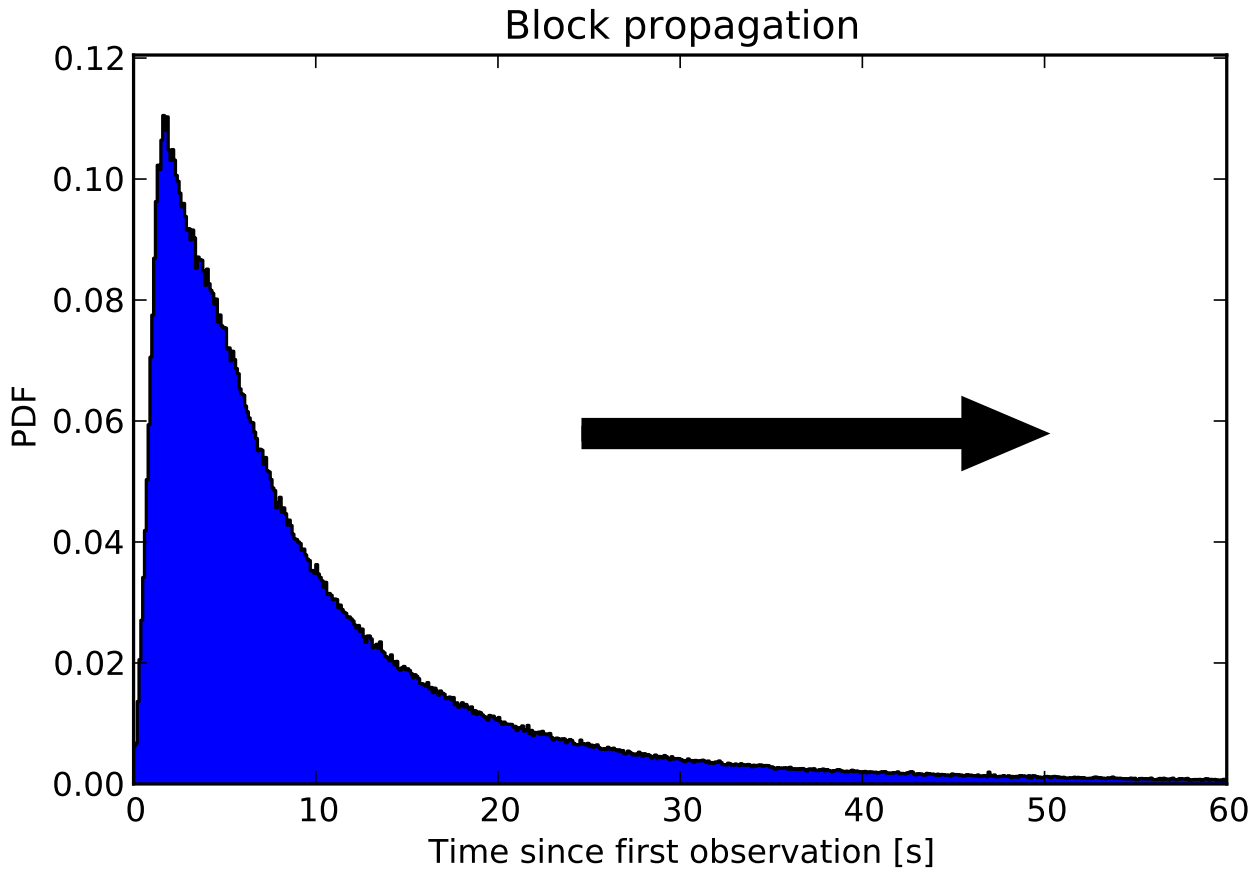
Propagation Speed



`http://bitcoinstats.com`

[Decker, W, 2013]

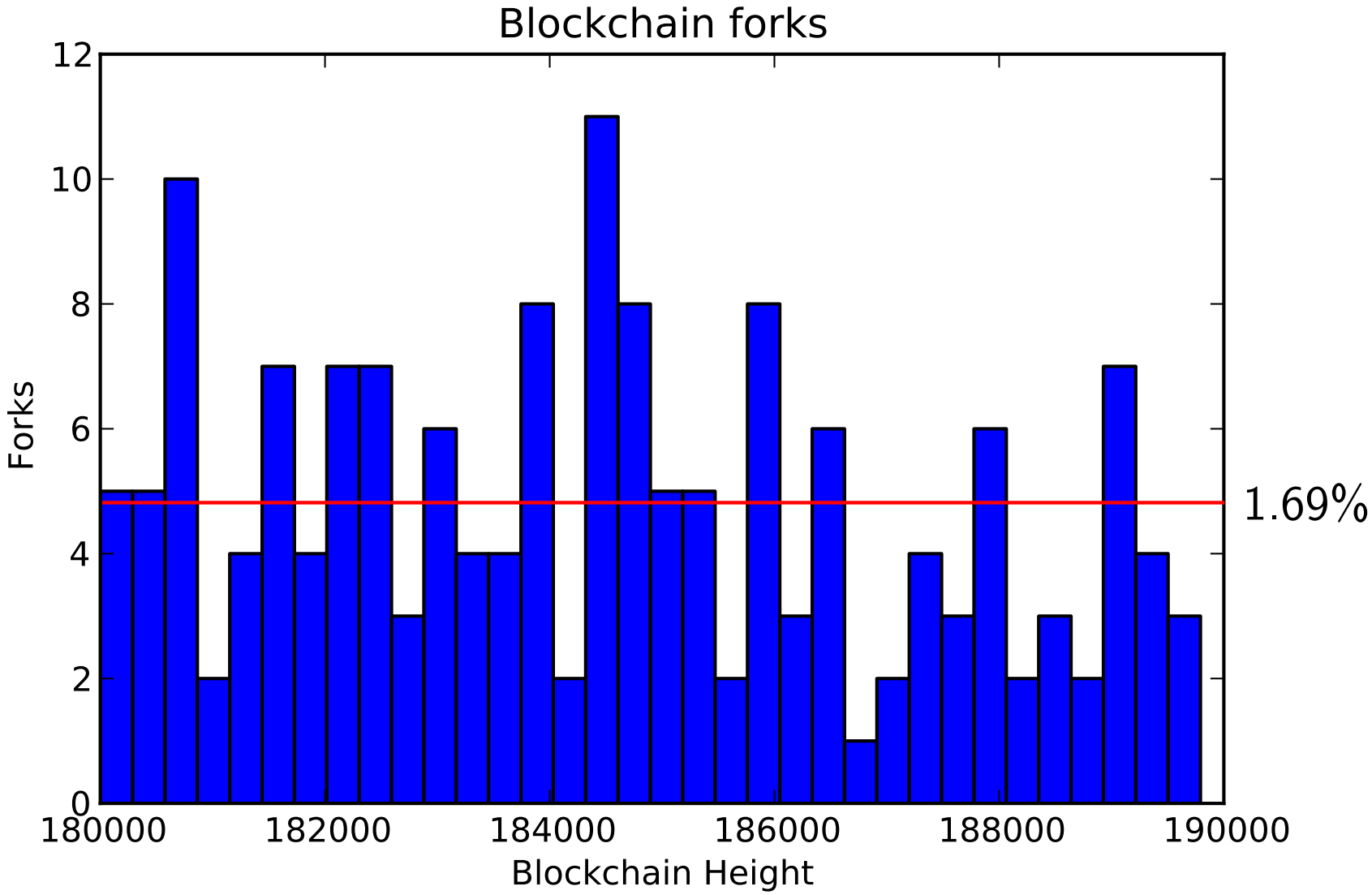
Propagation Speed



`http://bitcoinstats.com`

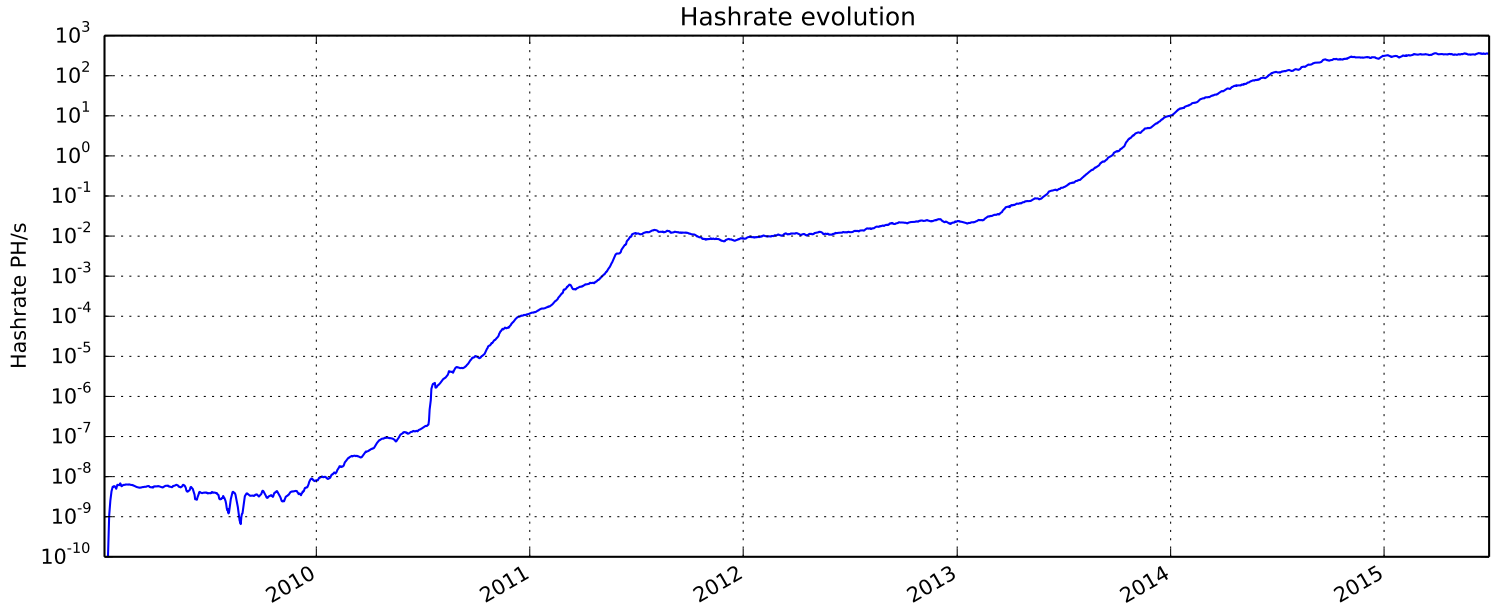
[Decker, W, 2013]

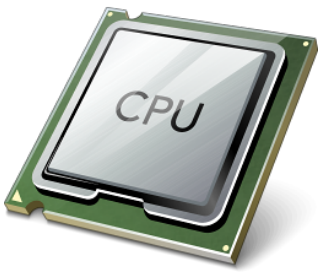
Blockchain Forks



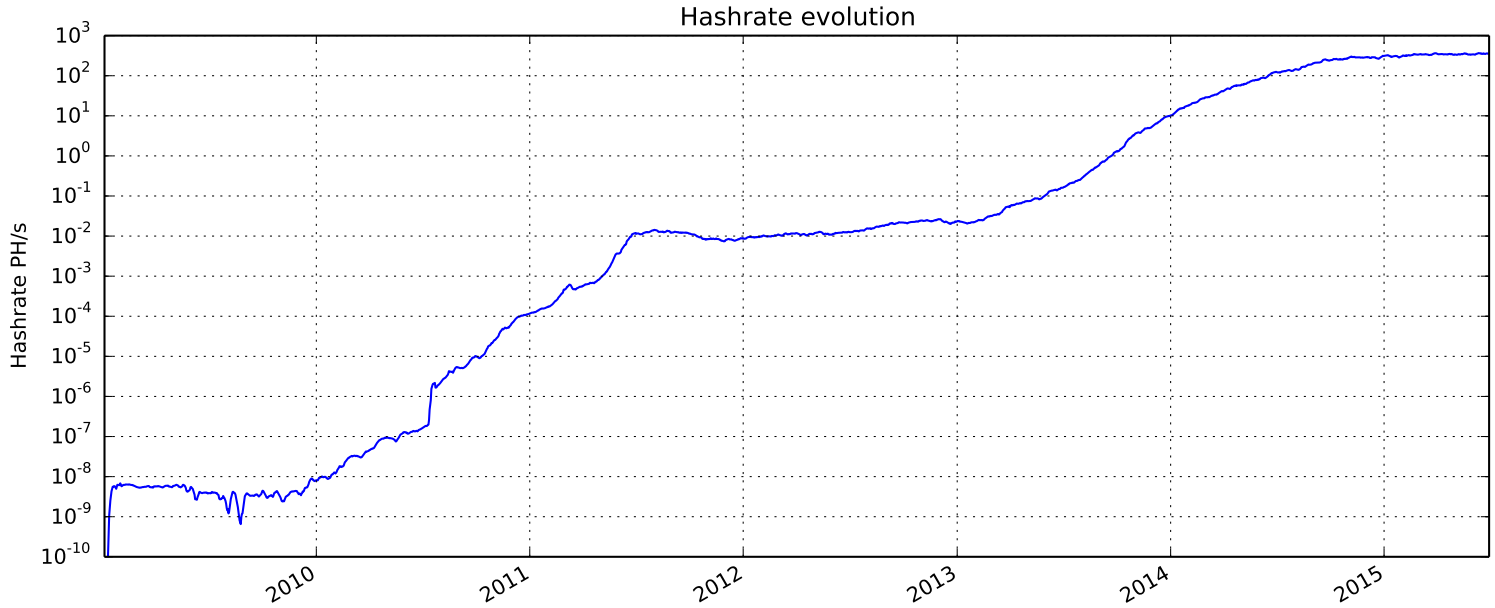
[Decker, W, 2013]

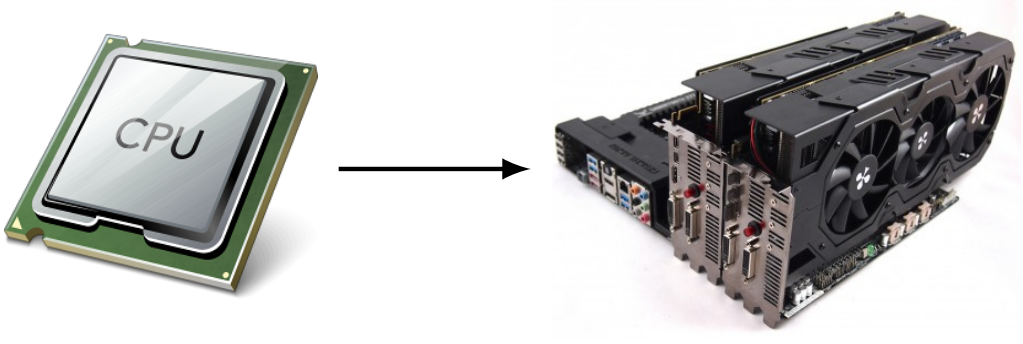
Aside: Mining Evolution



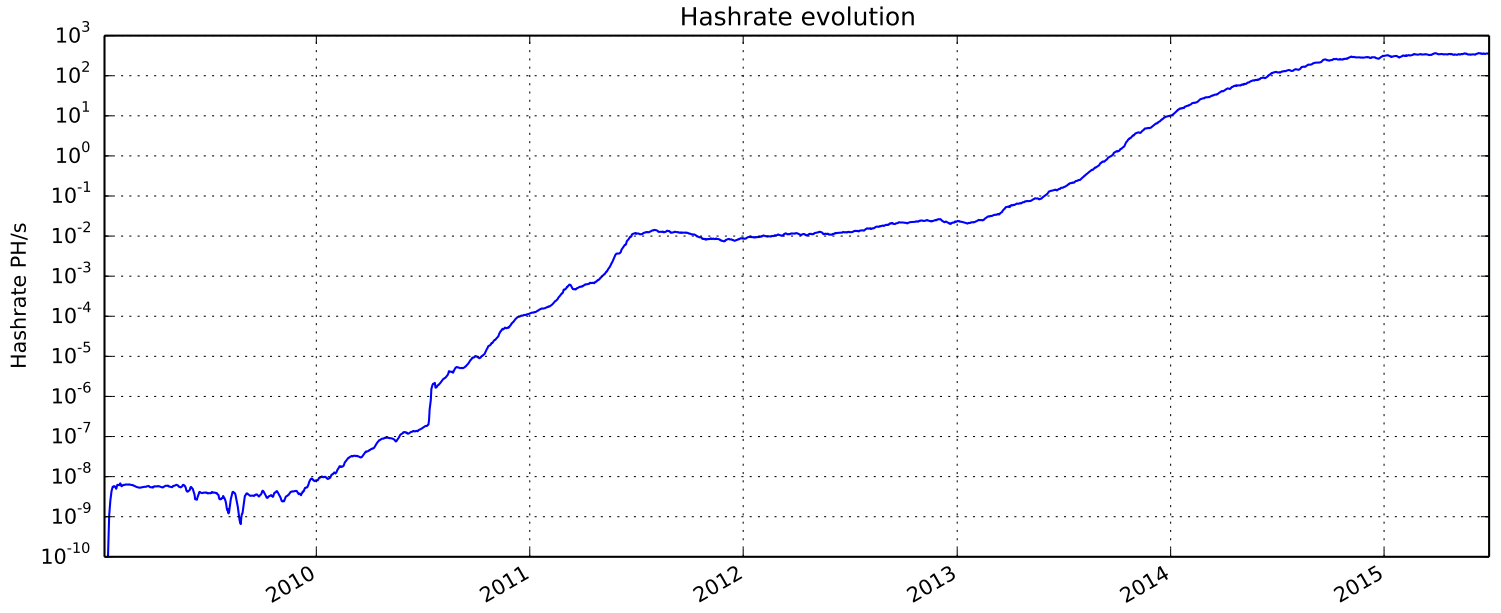


Aside: Mining Evolution

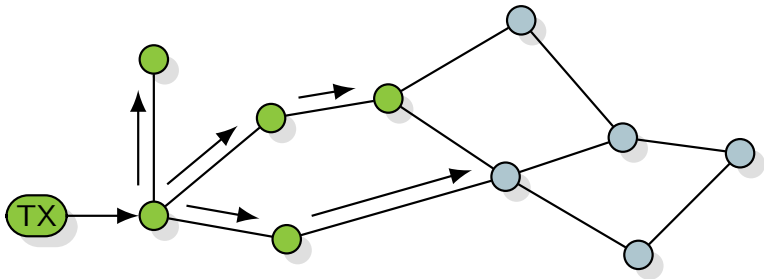


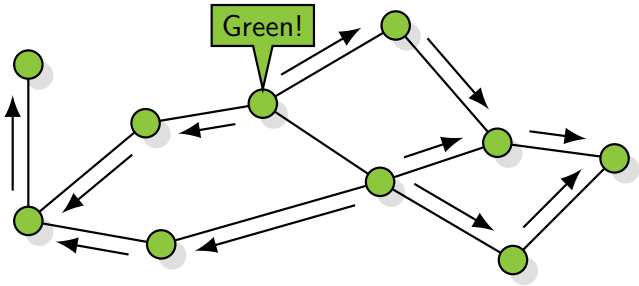


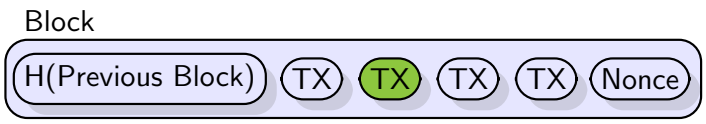
Aside: Mining Evolution

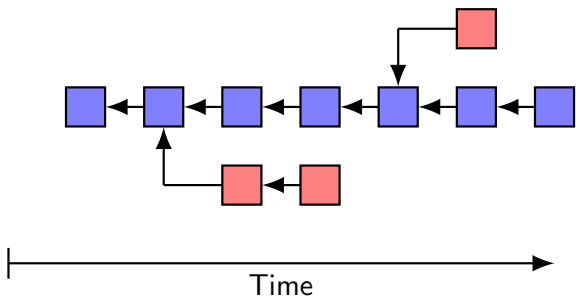


Summary









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

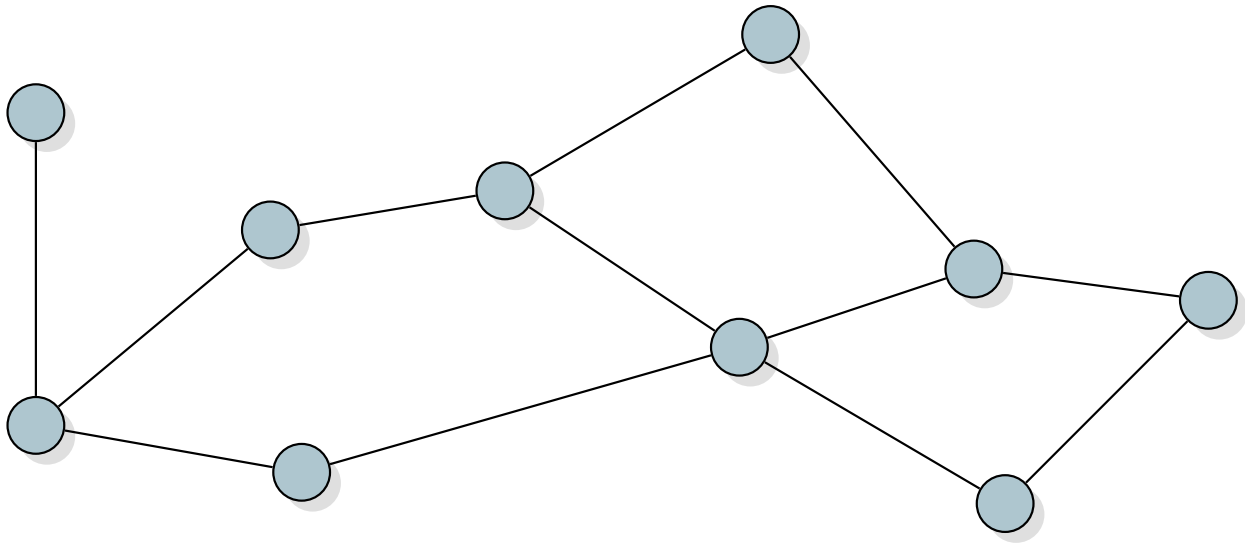
Signatures

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

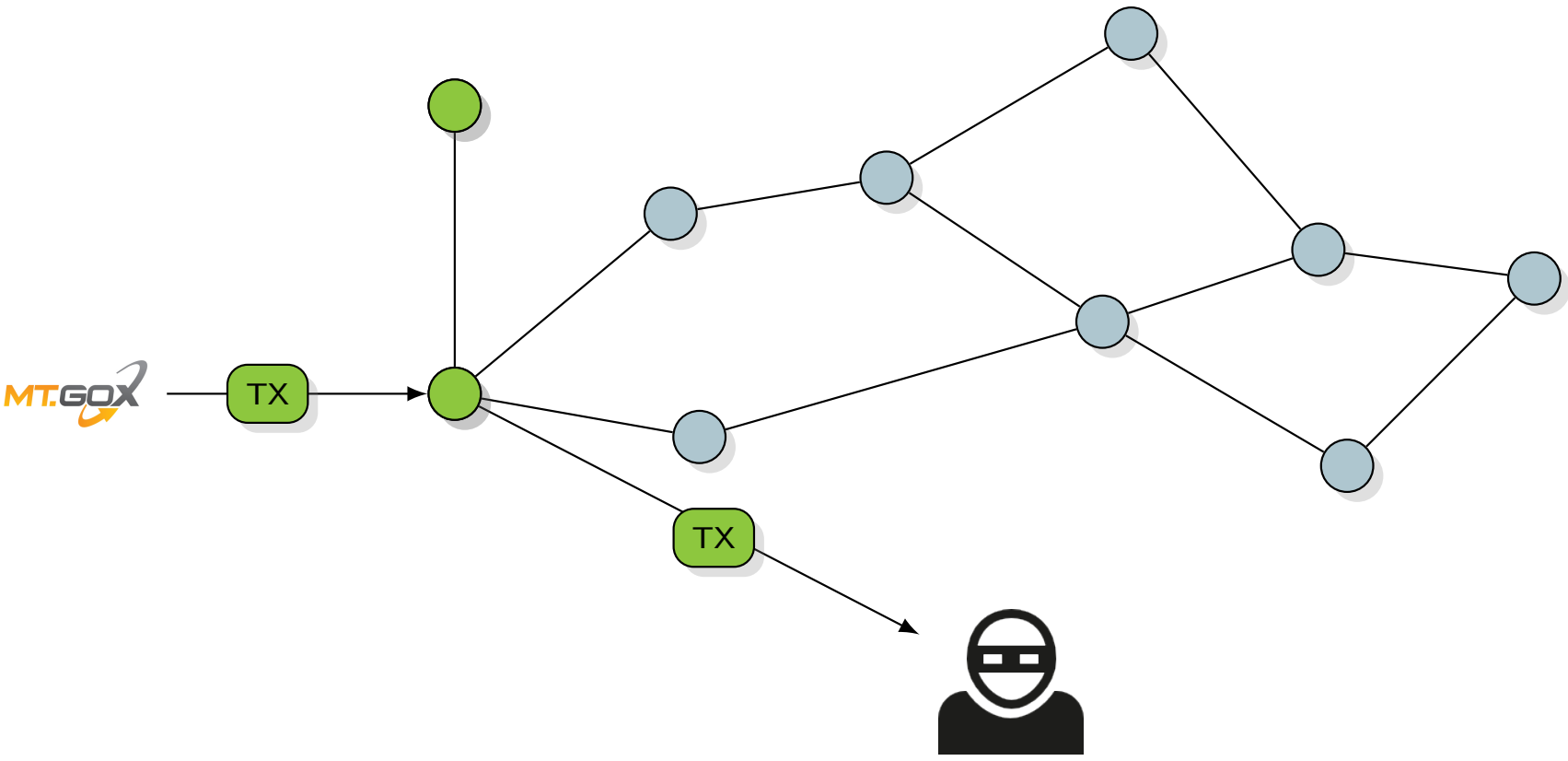
There are multiple ways to serialize a signature:

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

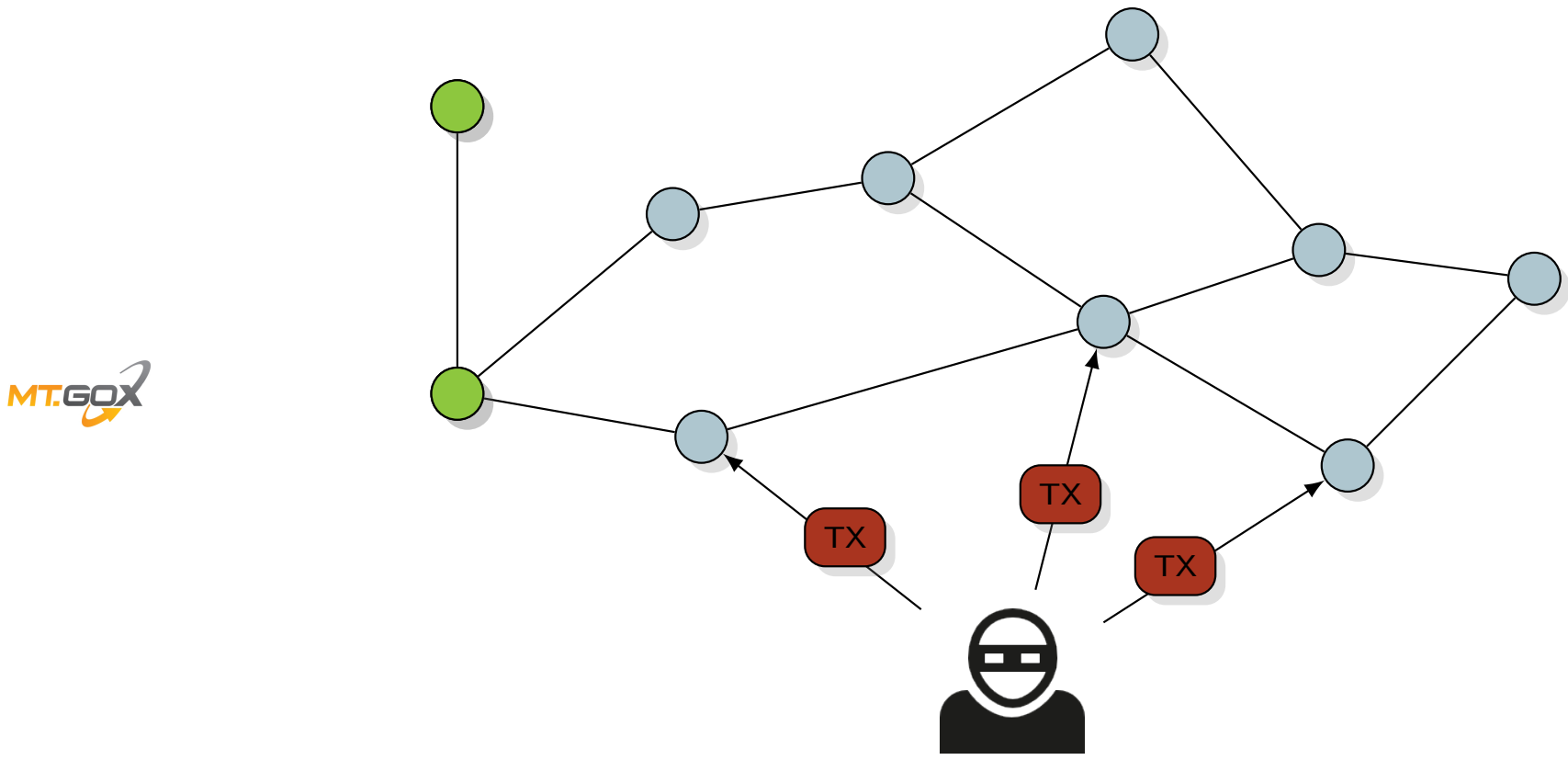
Transaction Malleability Attack



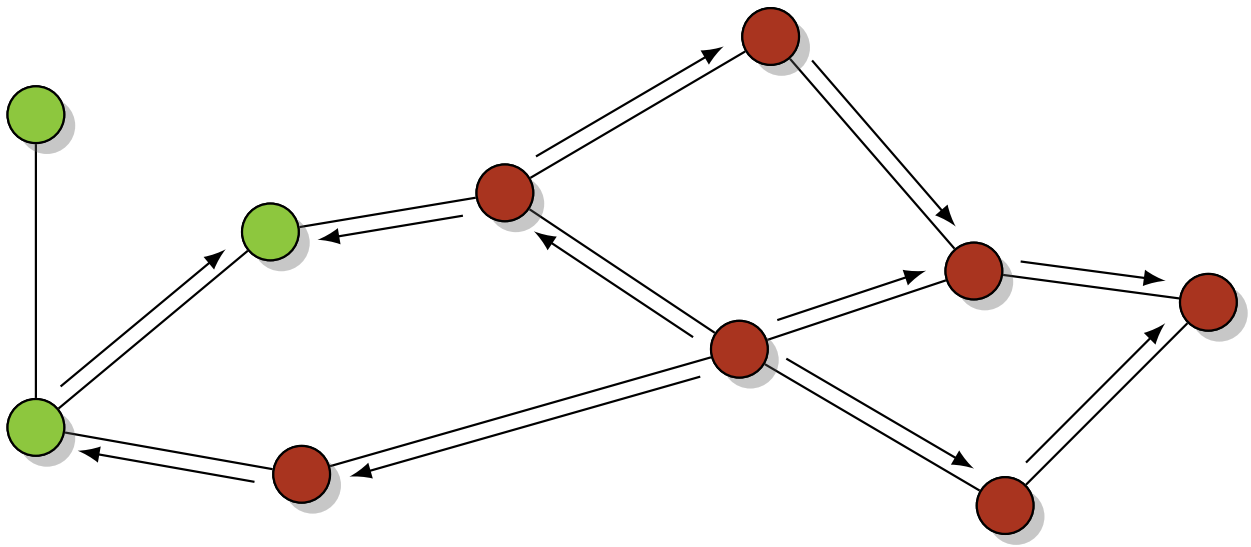
Transaction Malleability Attack



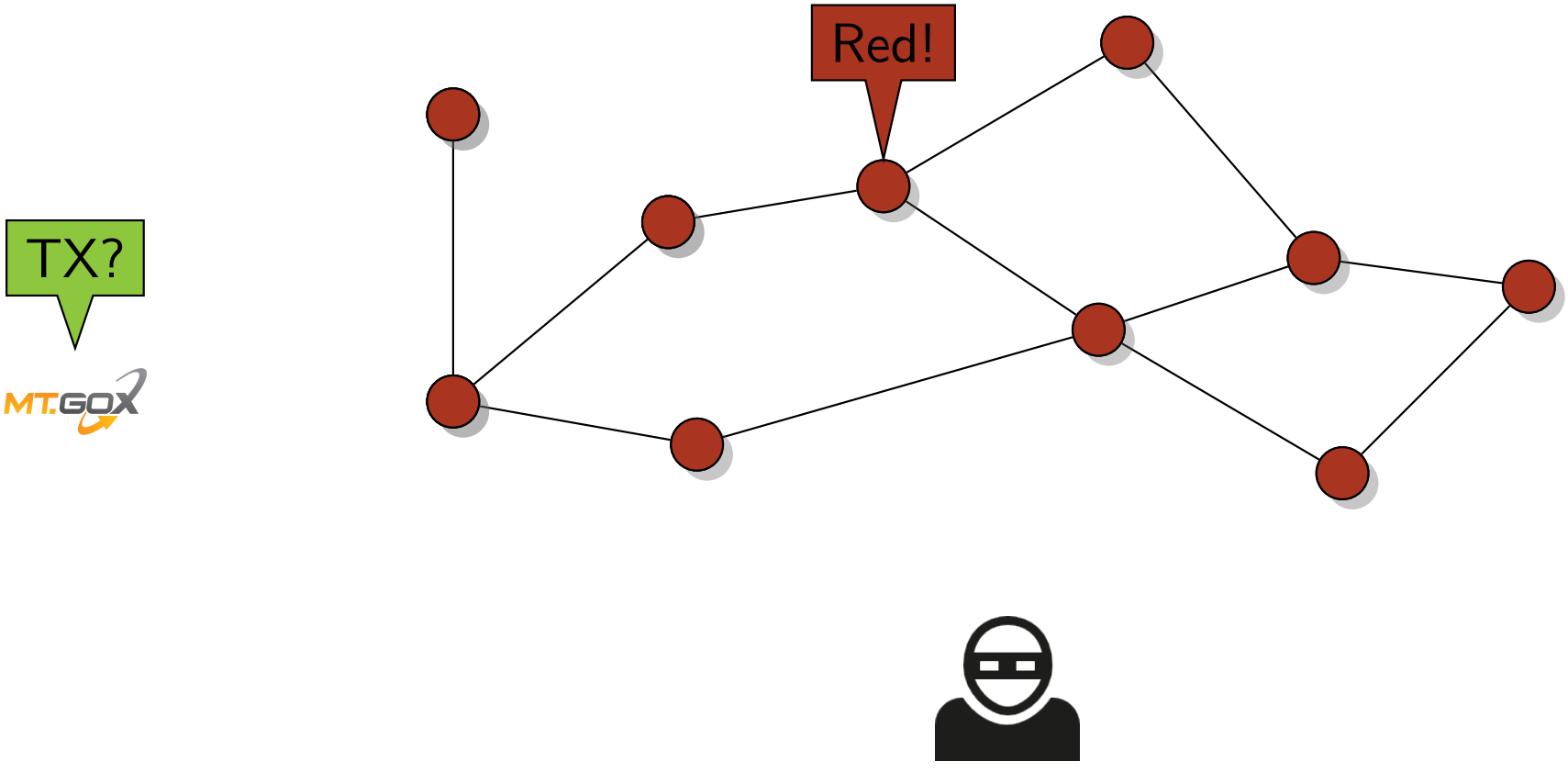
Transaction Malleability Attack



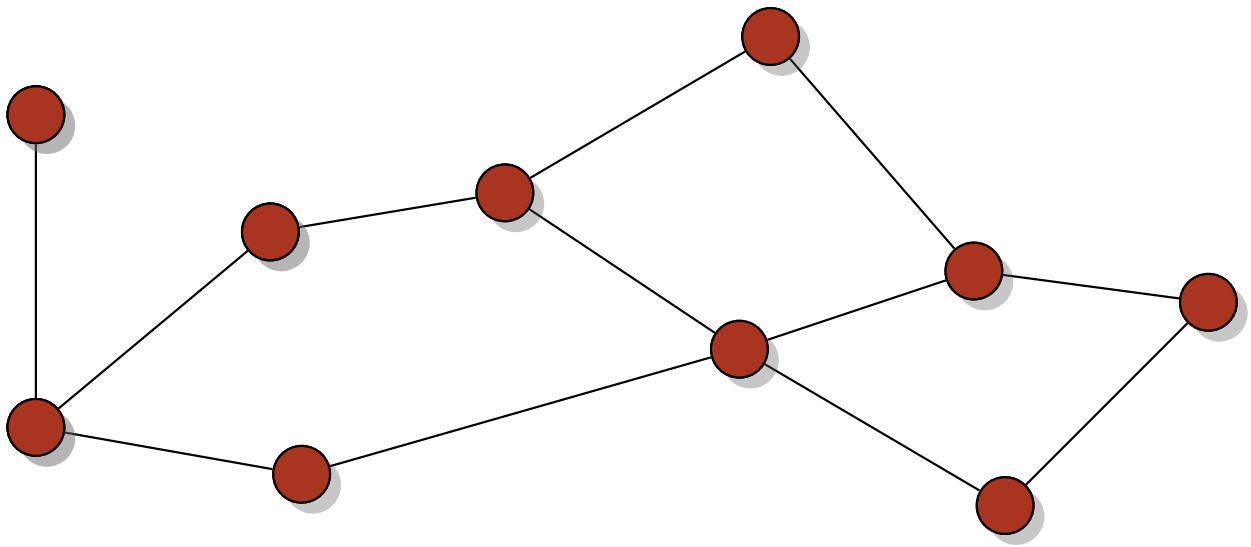
Transaction Malleability Attack



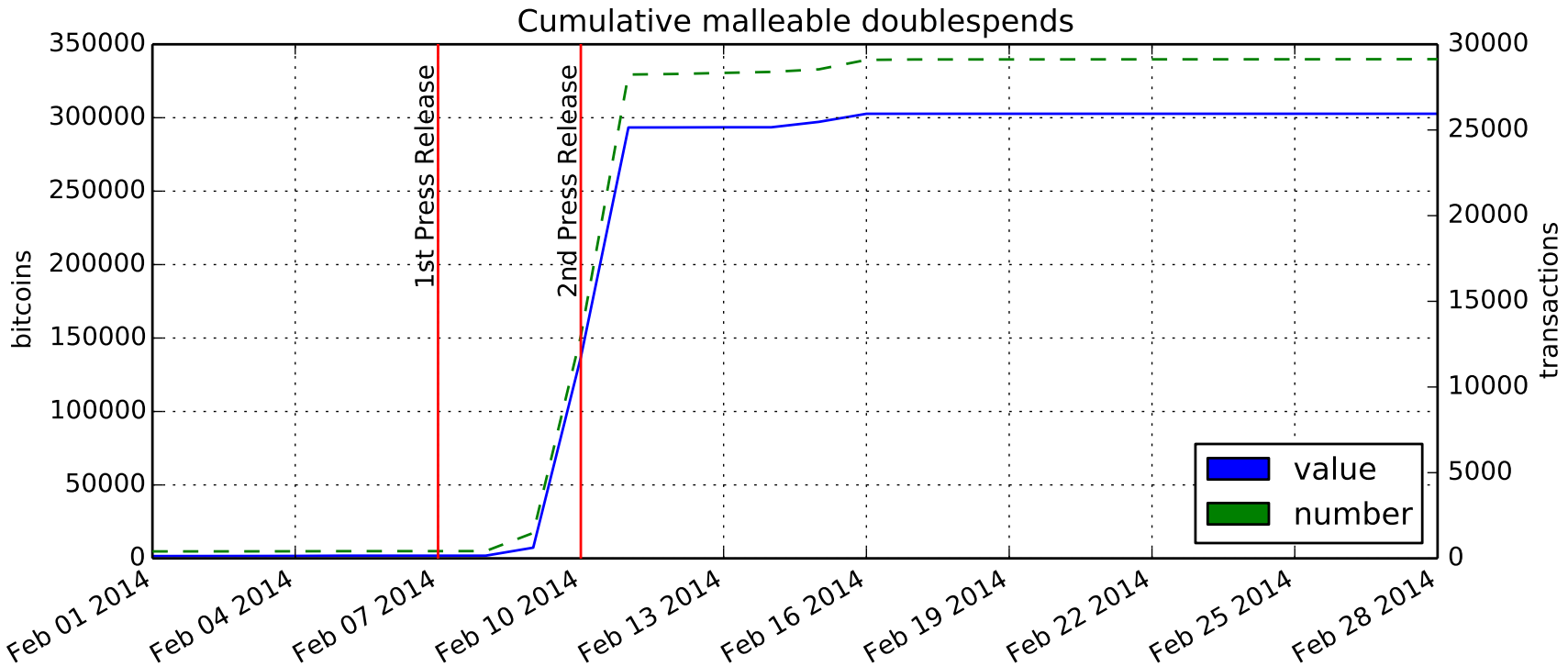
Transaction Malleability Attack



Transaction Malleability Attack

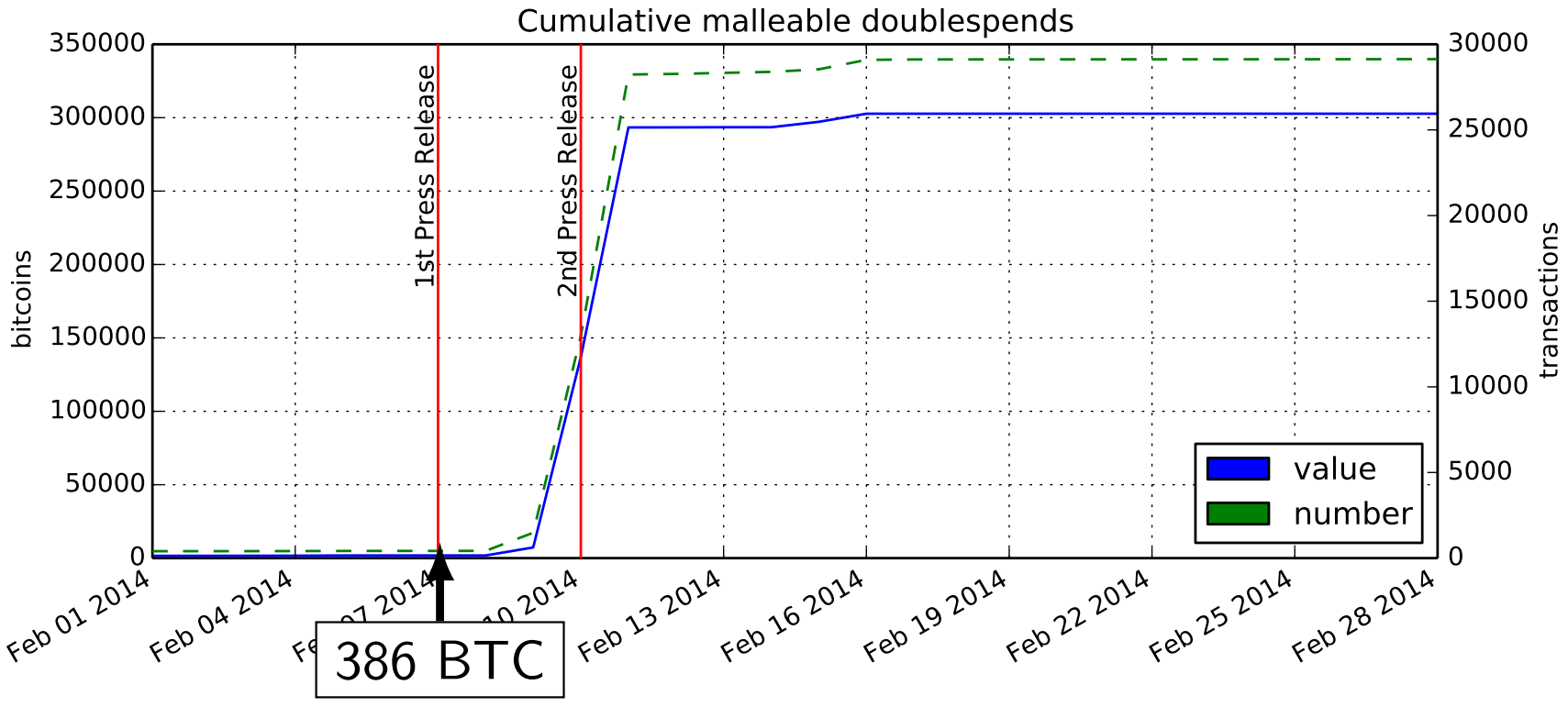


Incident Timeline



[Decker, W, 2014]

Incident Timeline



[Decker, W, 2014]

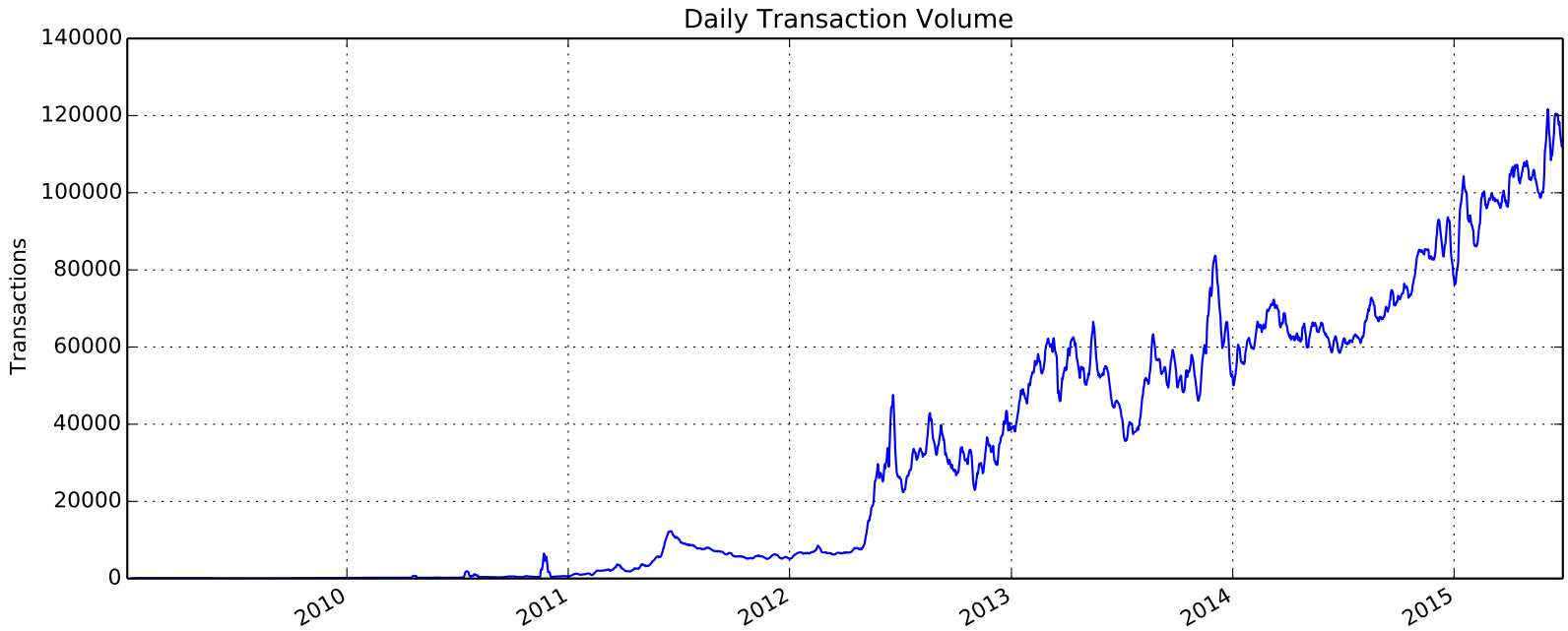
Is Bitcoin Secure?

Securing Your Bitcoins

[Bamert, Decker, W, 2013]

Does Bitcoin Scale?

The Bitcoin Ecosystem is Growing



Scalability Limits

- Disk space: $<$ 500 transactions per second

Scalability Limits

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

Scalability Limits

- Disk space: < 500 transactions per second
- Processing power: < 200 transactions per second
- Network bandwidth: < 100 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

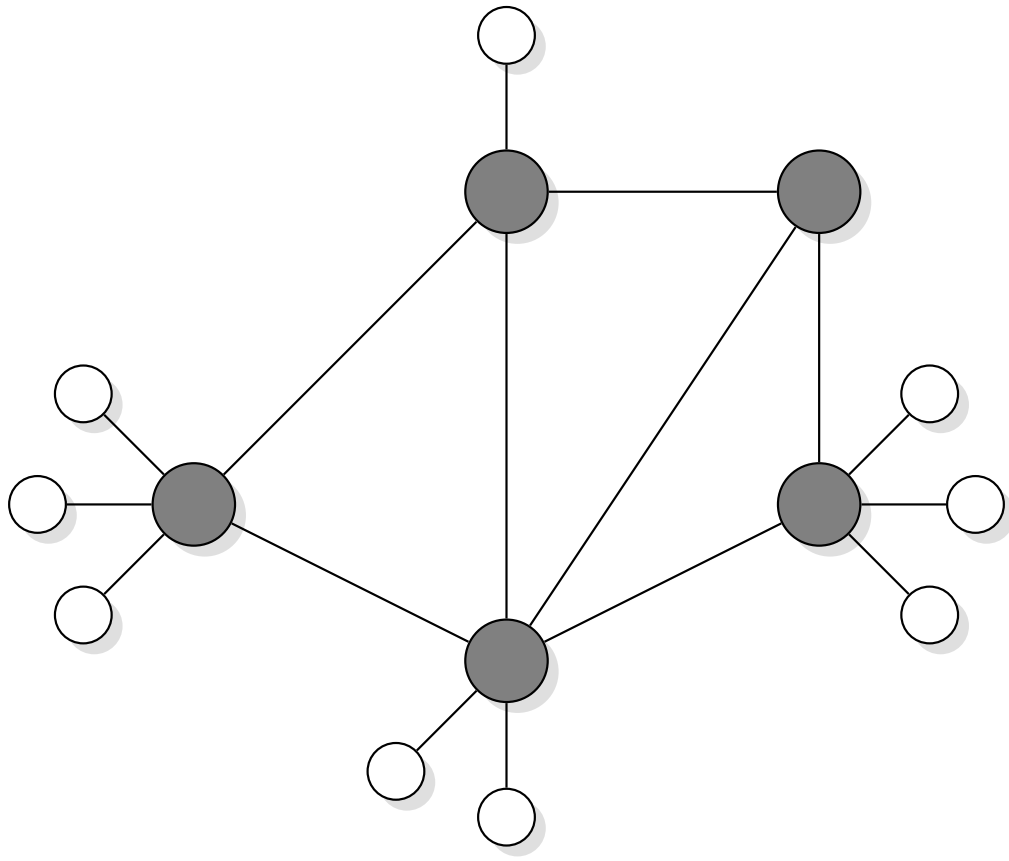
Scalability Limits

- 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

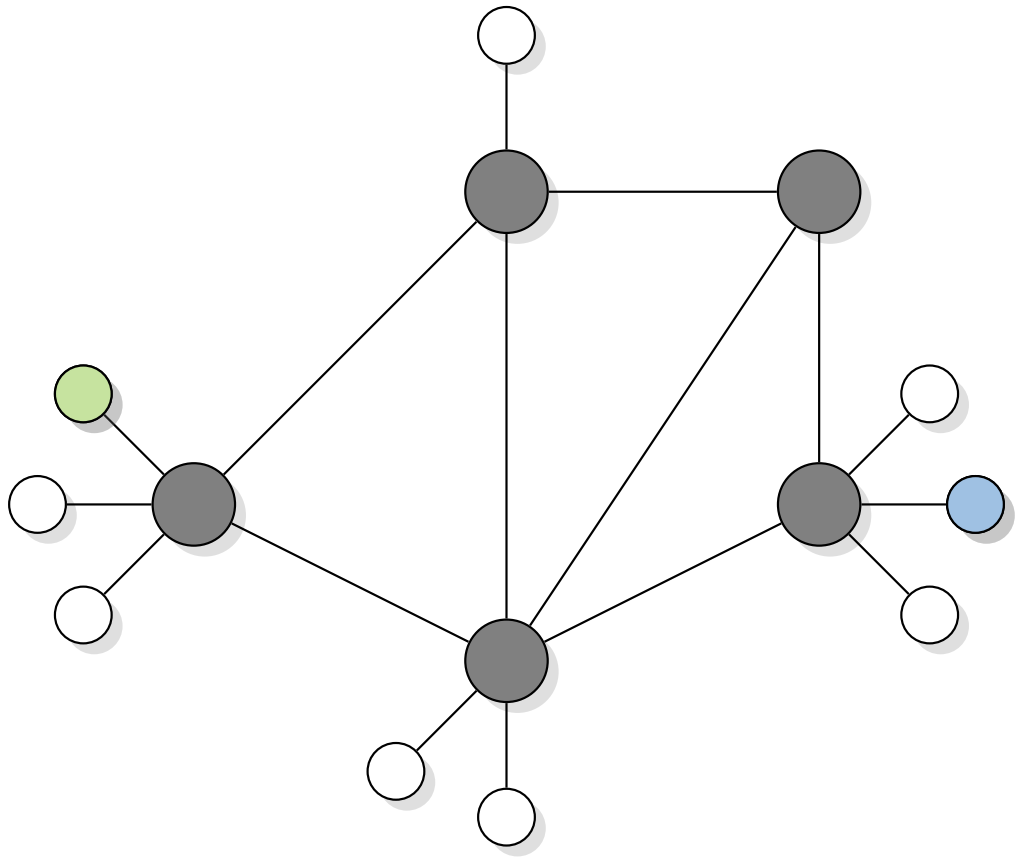
Today:

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

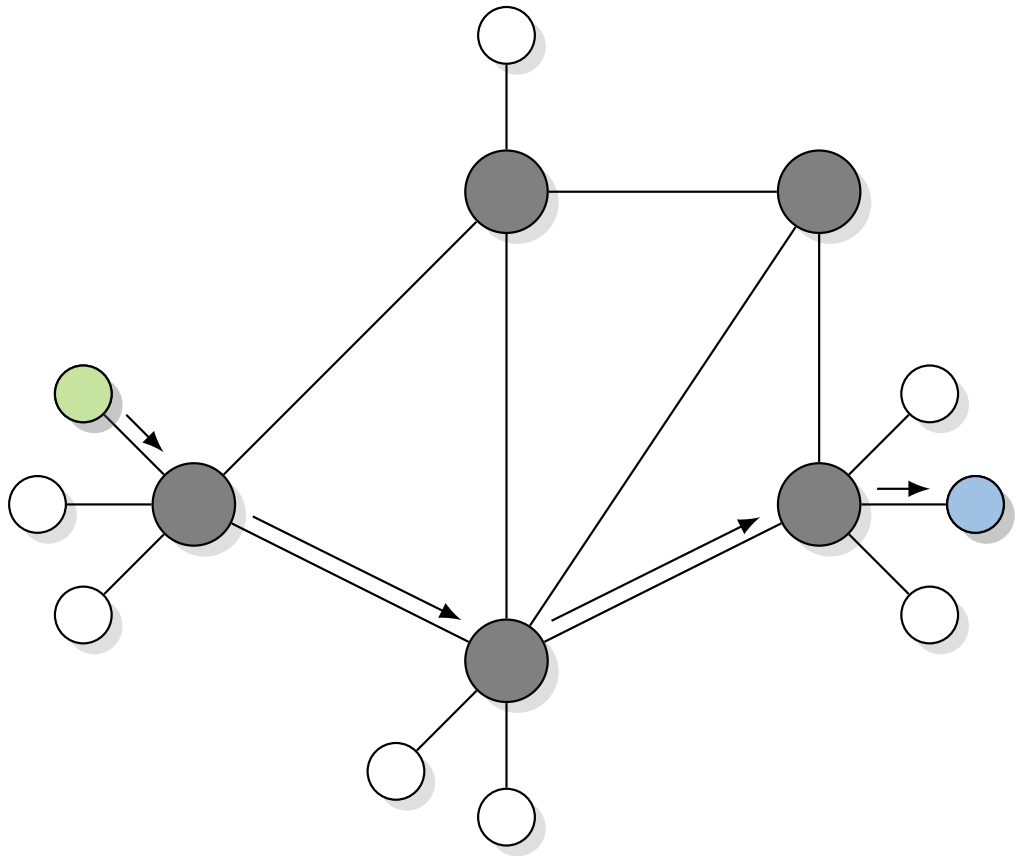
Payment Network



Payment Network



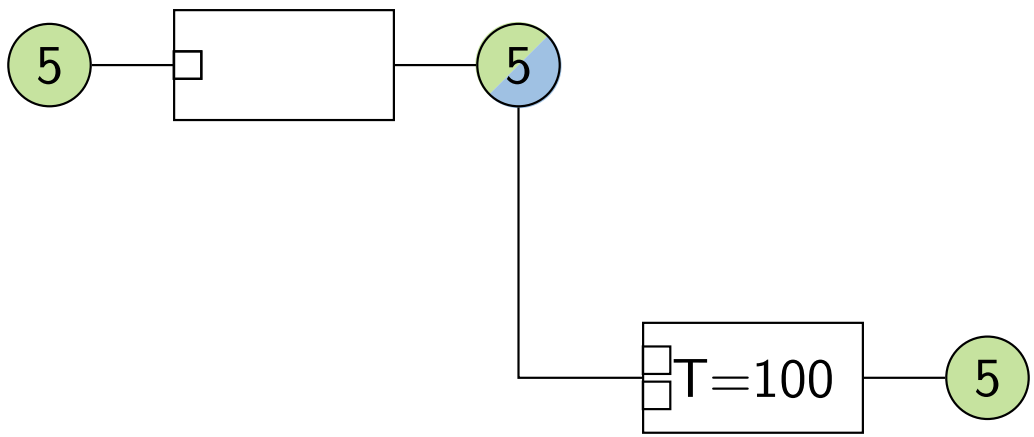
Payment Network



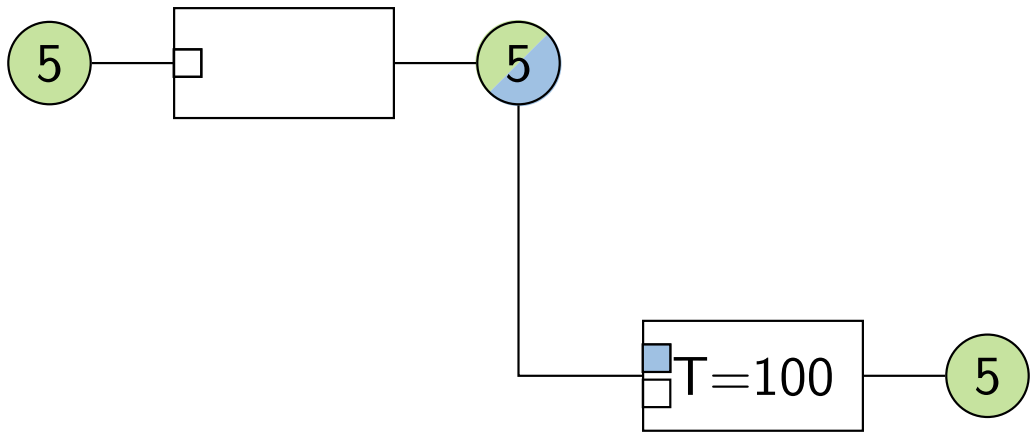
Micropayment Channels

Micropayment Channels

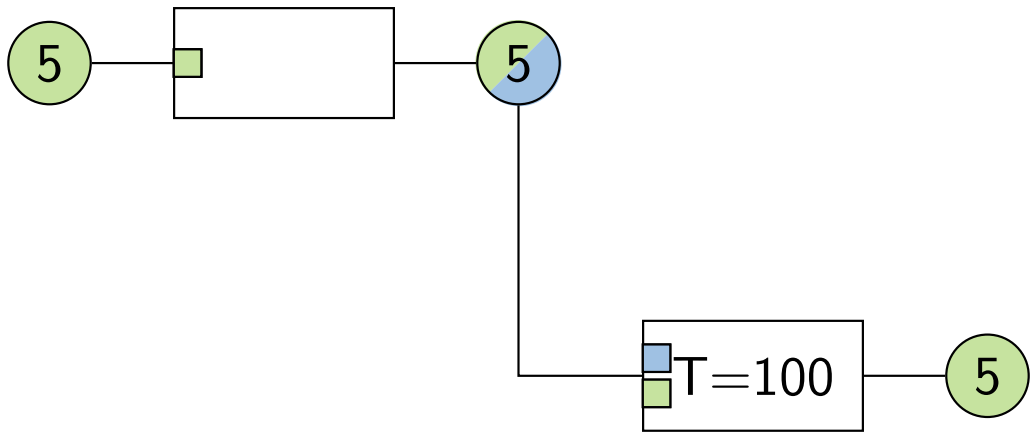
Micropayment Channels



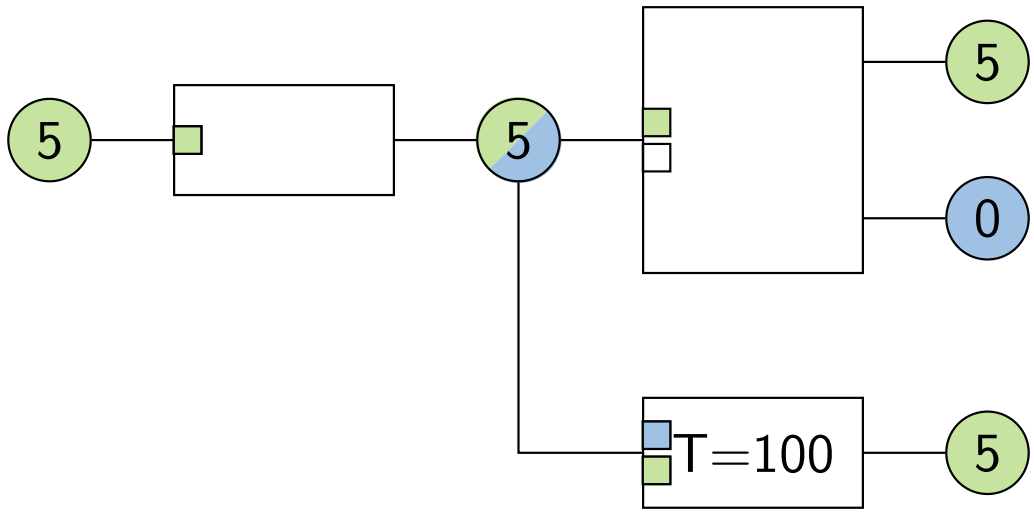
Micropayment Channels



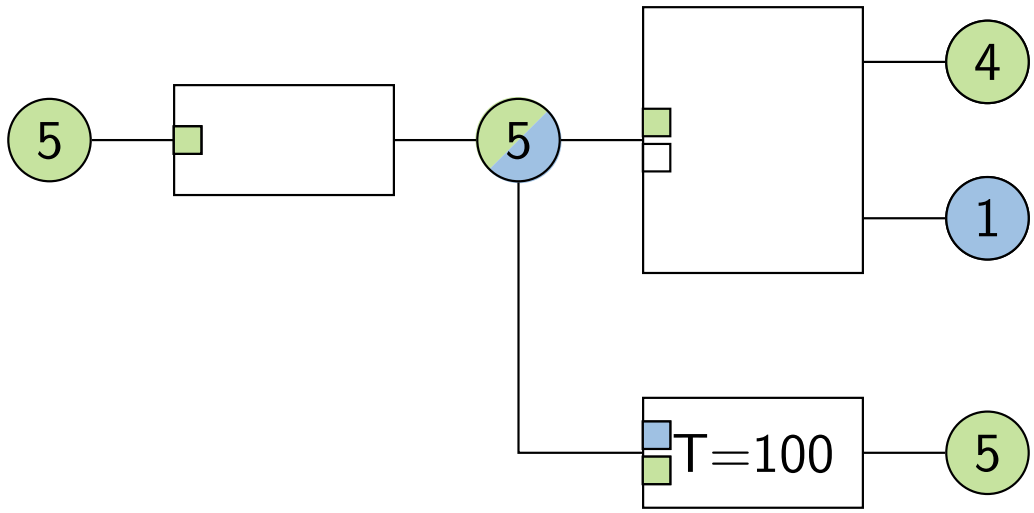
Micropayment Channels



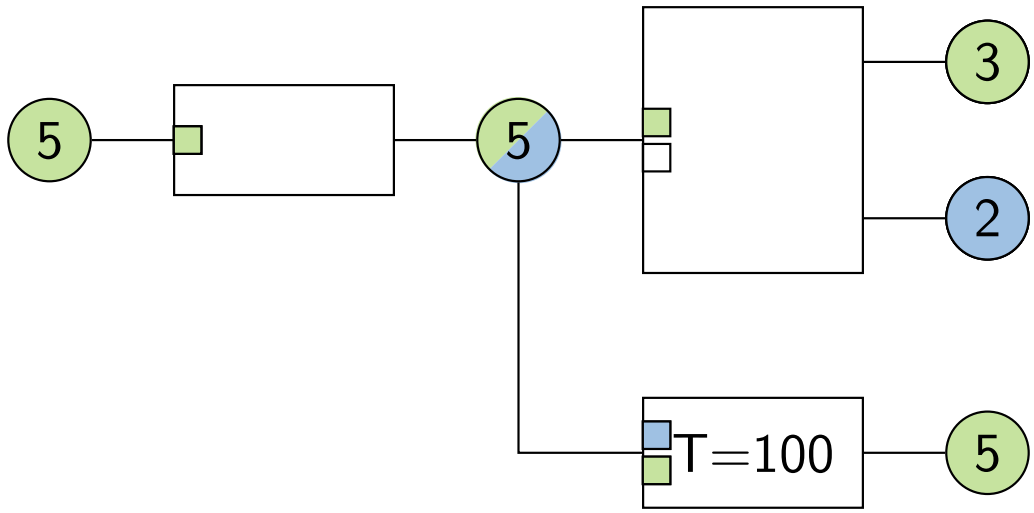
Micropayment Channels



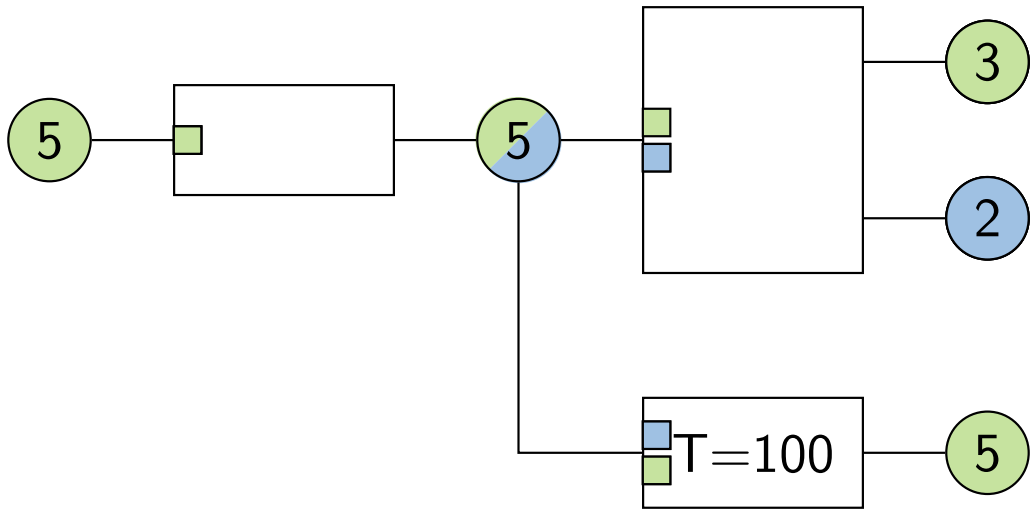
Micropayment Channels



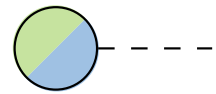
Micropayment Channels



Micropayment Channels



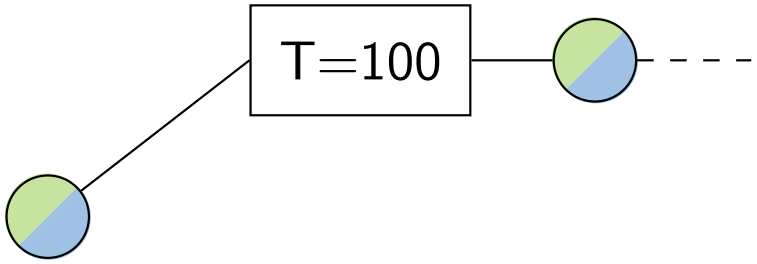
Atomic Multiparty Opt-In



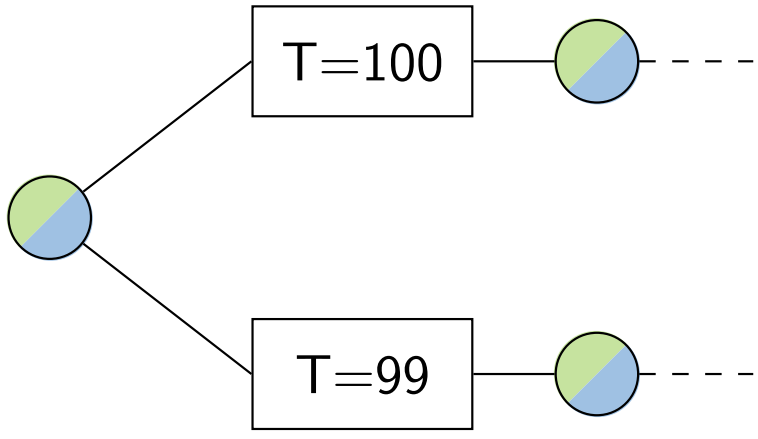
Atomic Multiparty Opt-In

Atomic Multiparty Opt-In

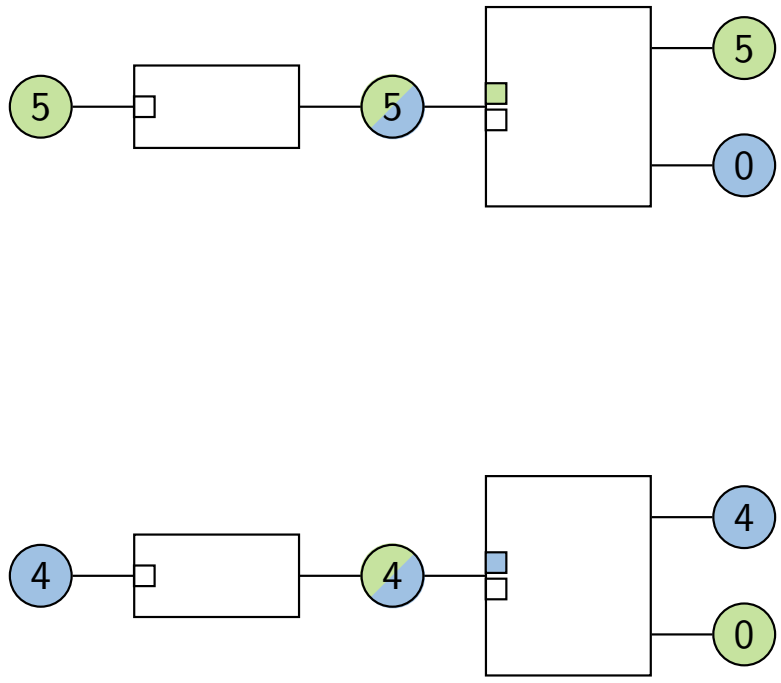
Invalidating Transactions



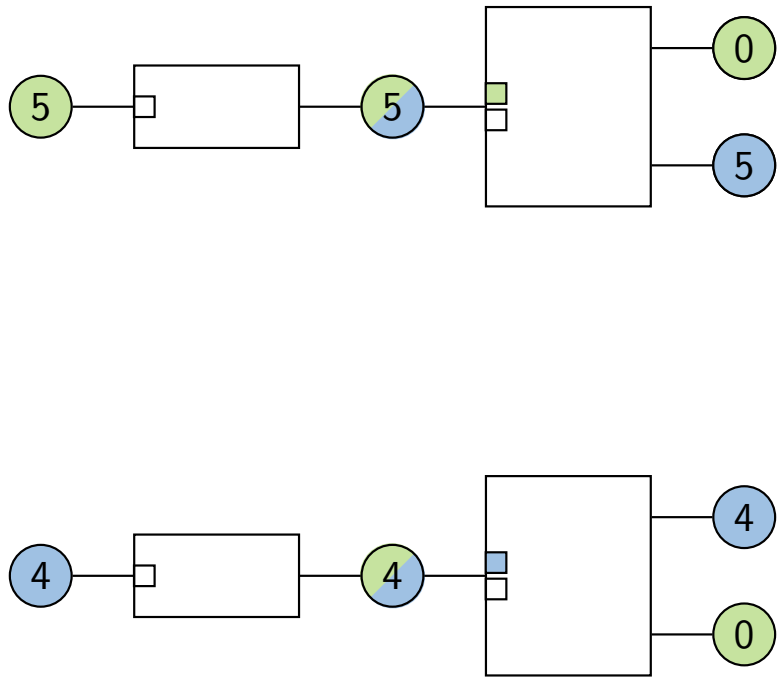
Invalidating Transactions



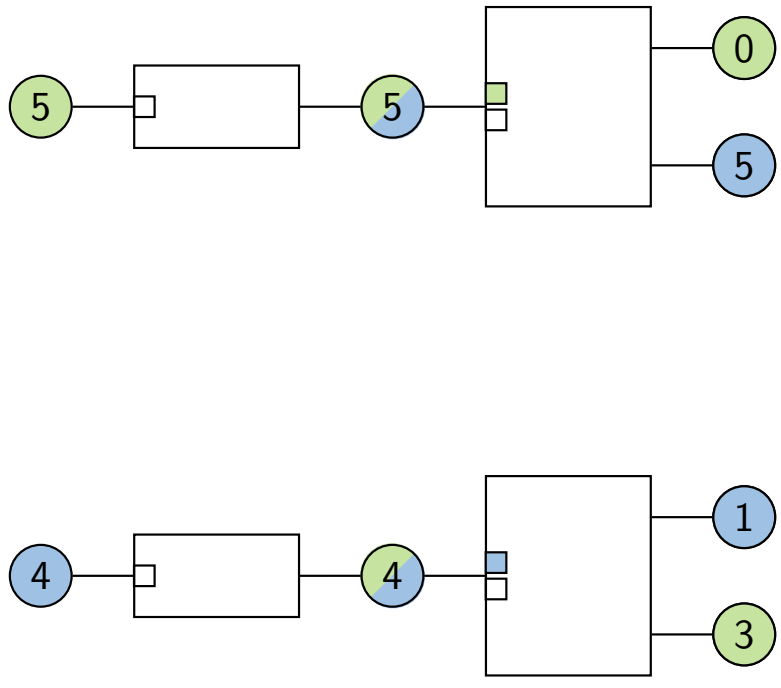
Bidirectional Transfers



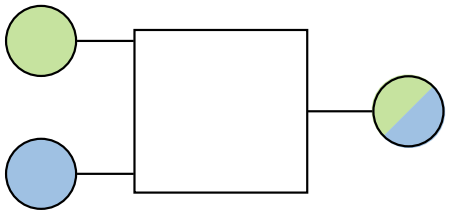
Bidirectional Transfers



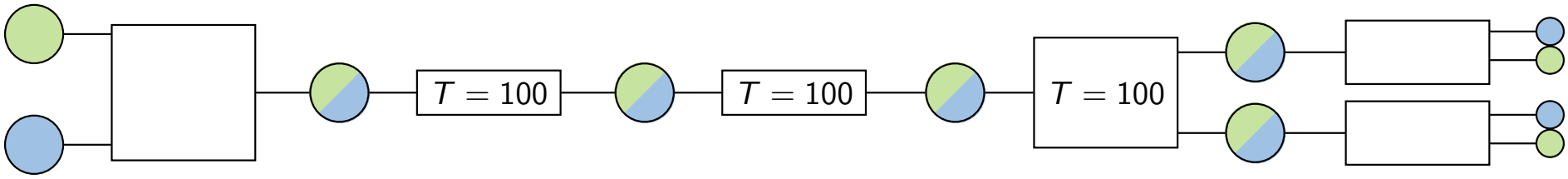
Bidirectional Transfers



Duplex Micropayment Channels

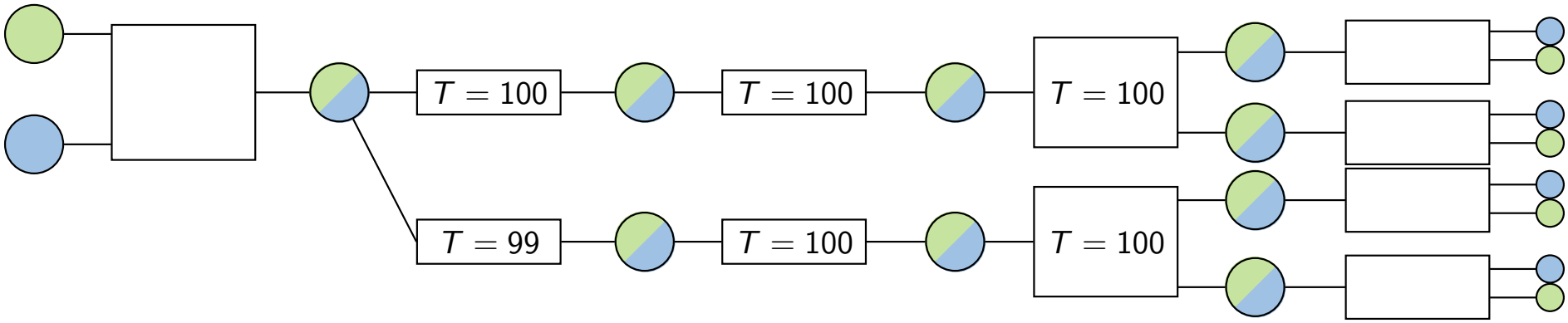


Duplex Micropayment Channels



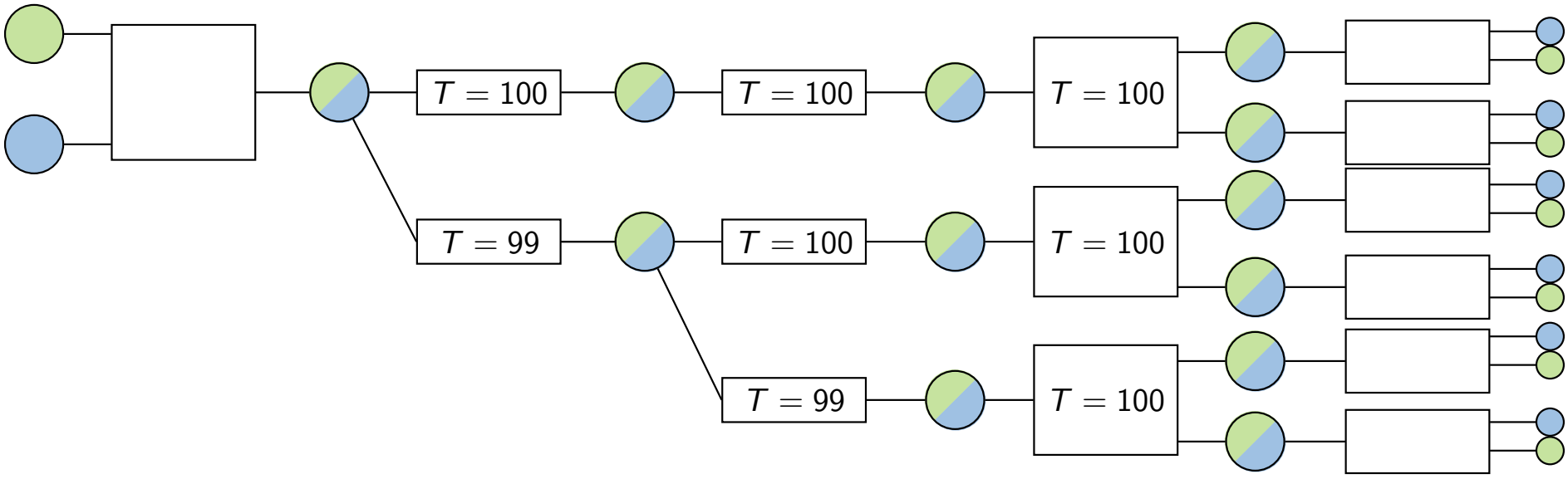
Setup | Invalidation Tree | Micropayment Channels

Duplex Micropayment Channels



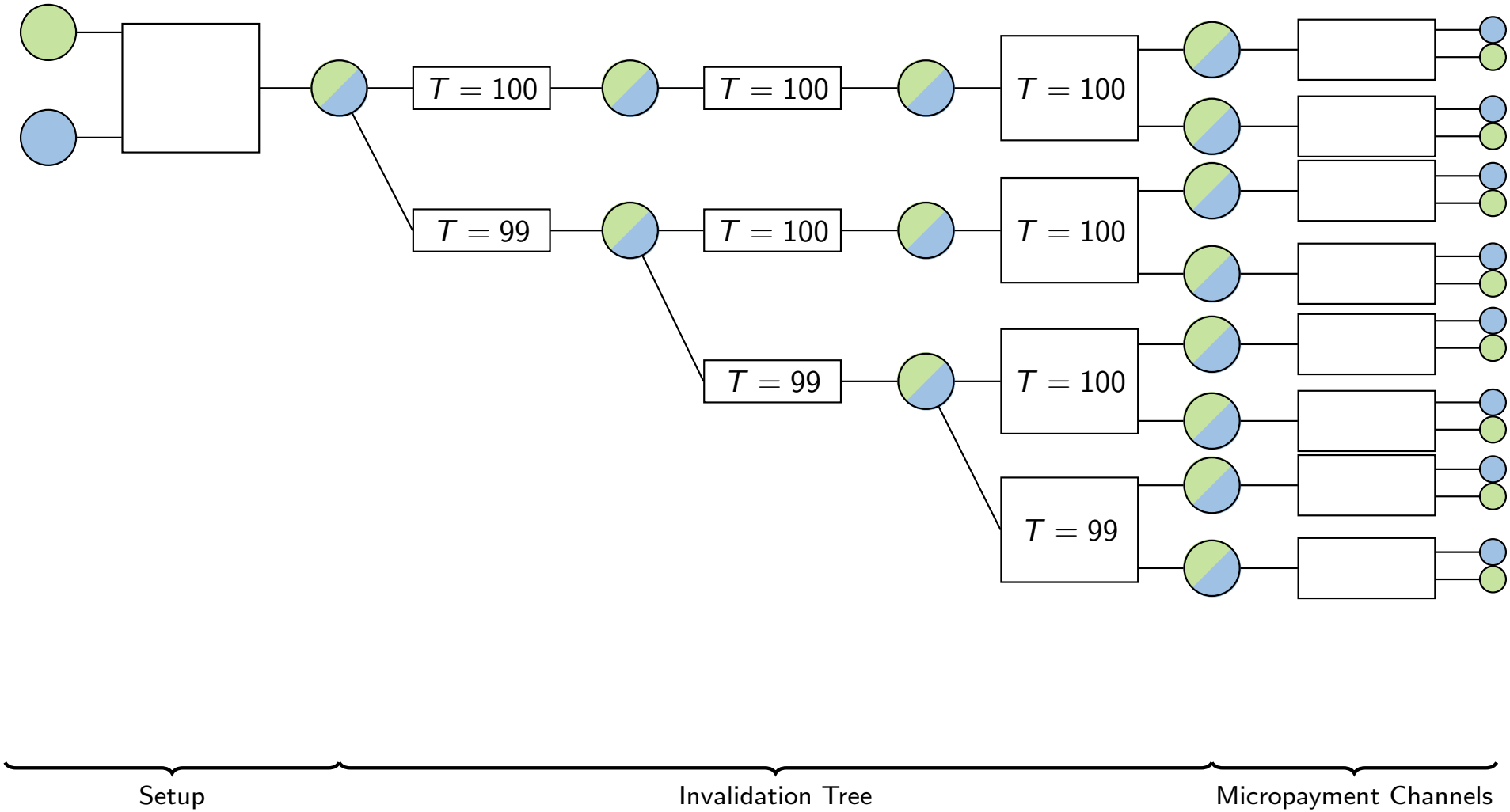
Setup | Invalidation Tree | Micropayment Channels

Duplex Micropayment Channels

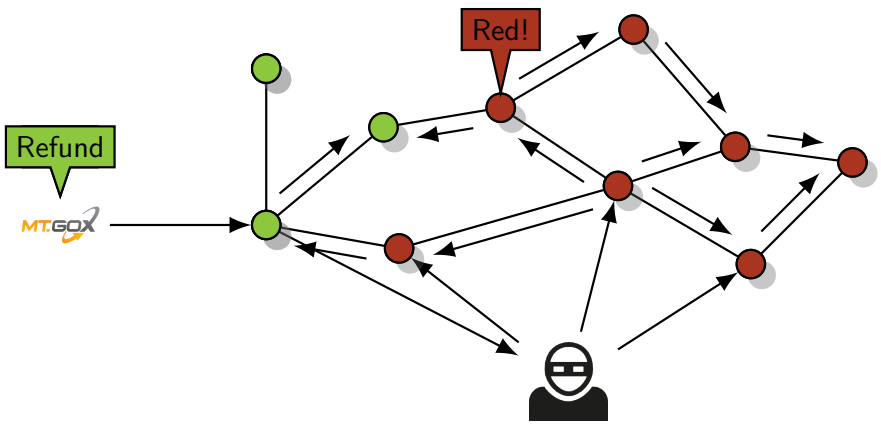


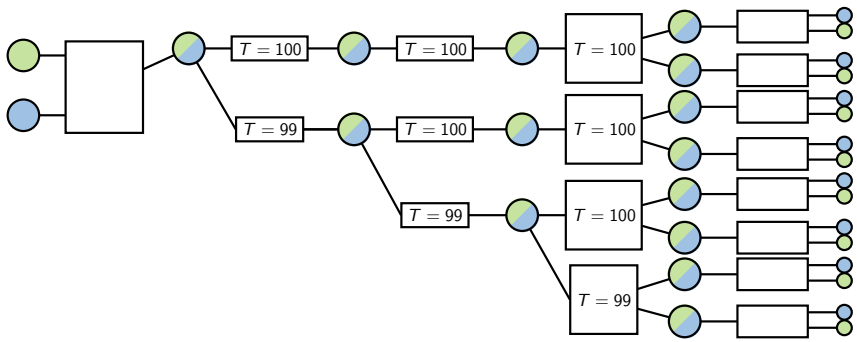
Setup | Invalidation Tree | Micropayment Channels

Duplex Micropayment Channels



Summary





Thank you, questions?

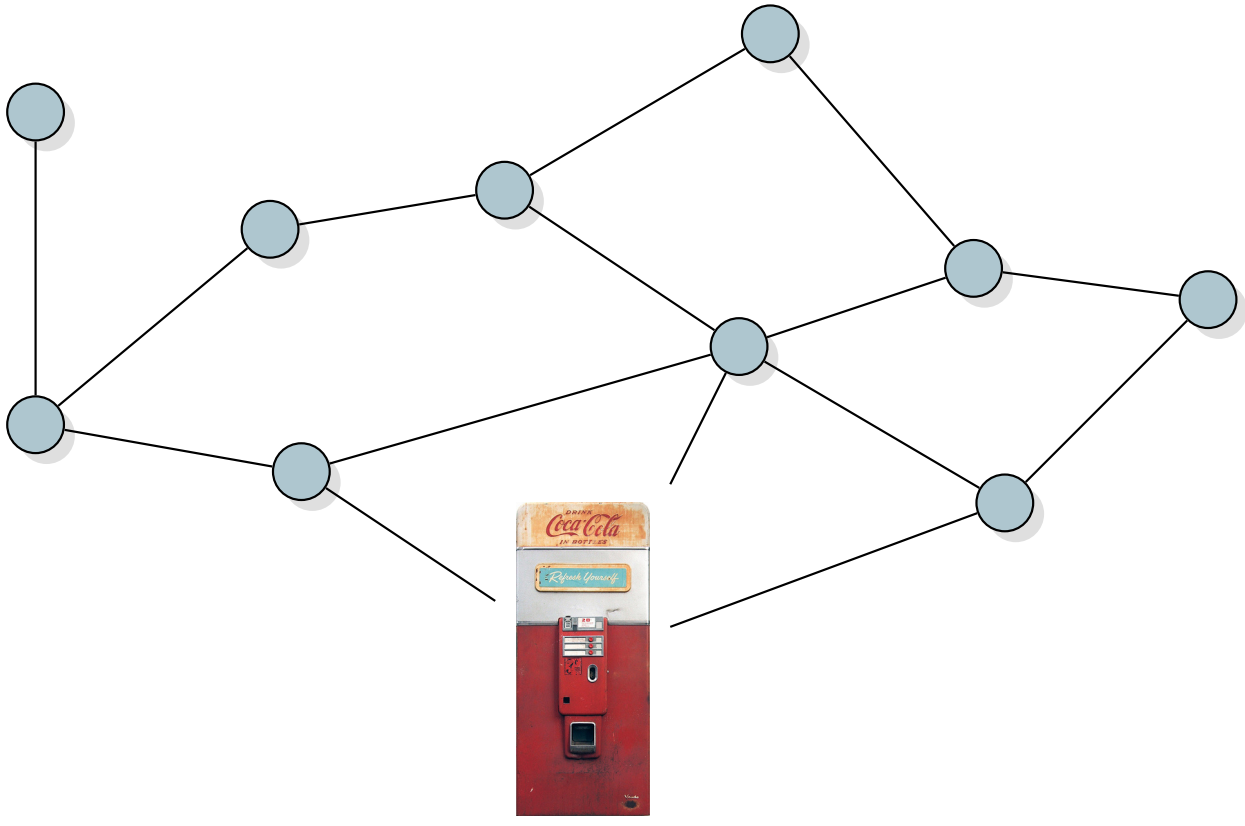
Thanks to Christian Decker

Securing Fast Payments

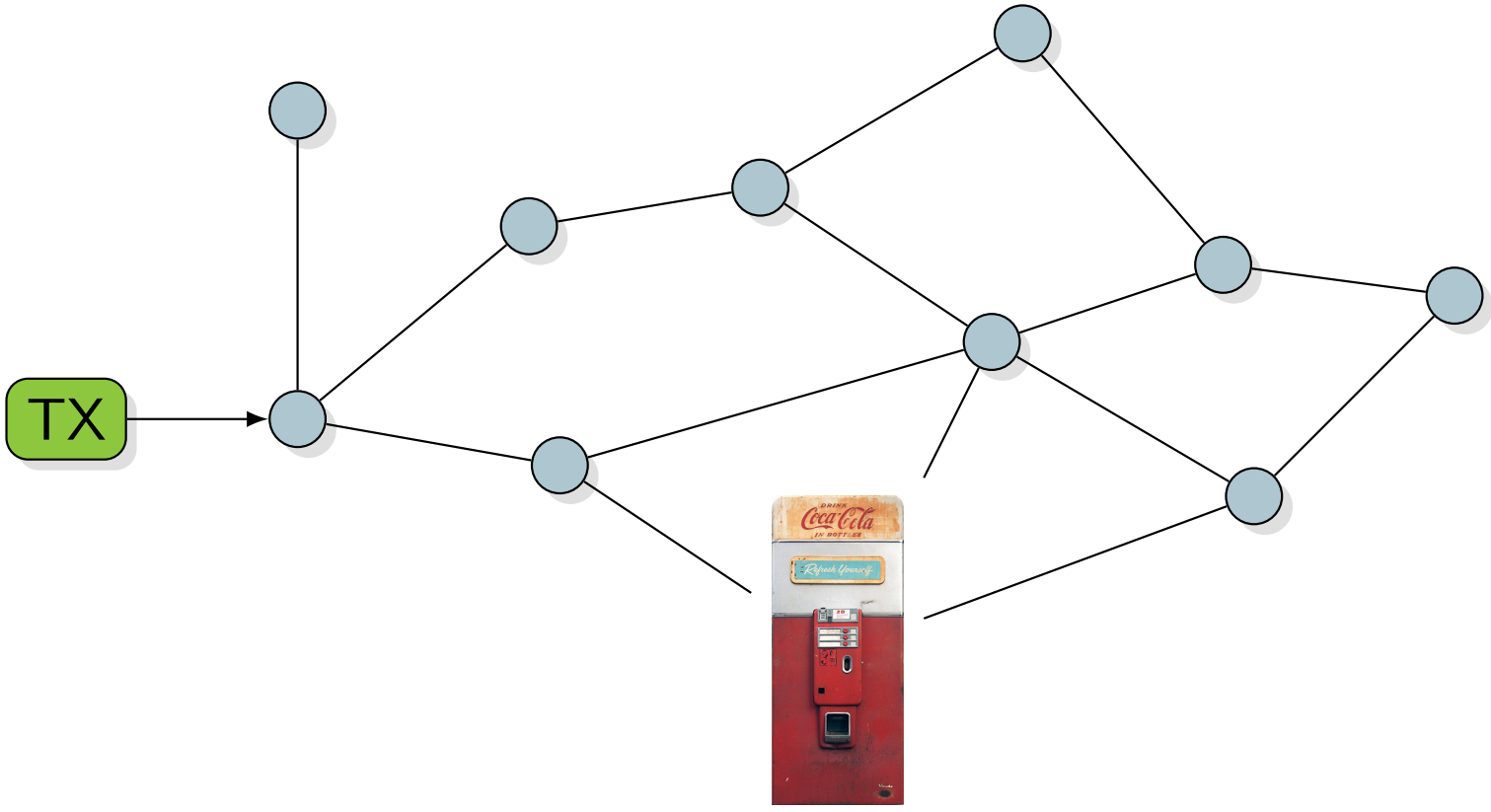
Let's Buy a Snack

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

Transaction Confidence

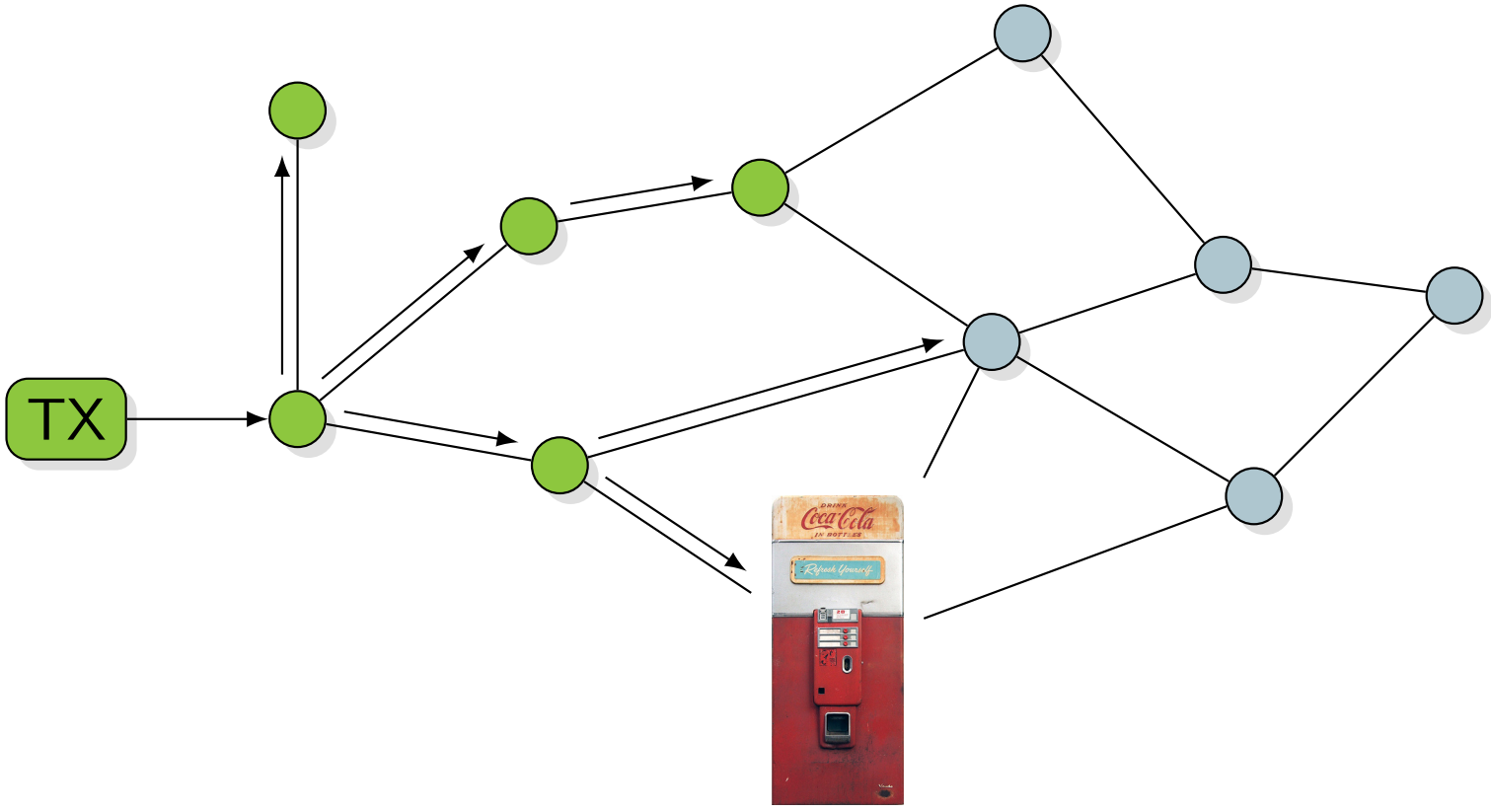


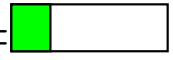
Transaction Confidence



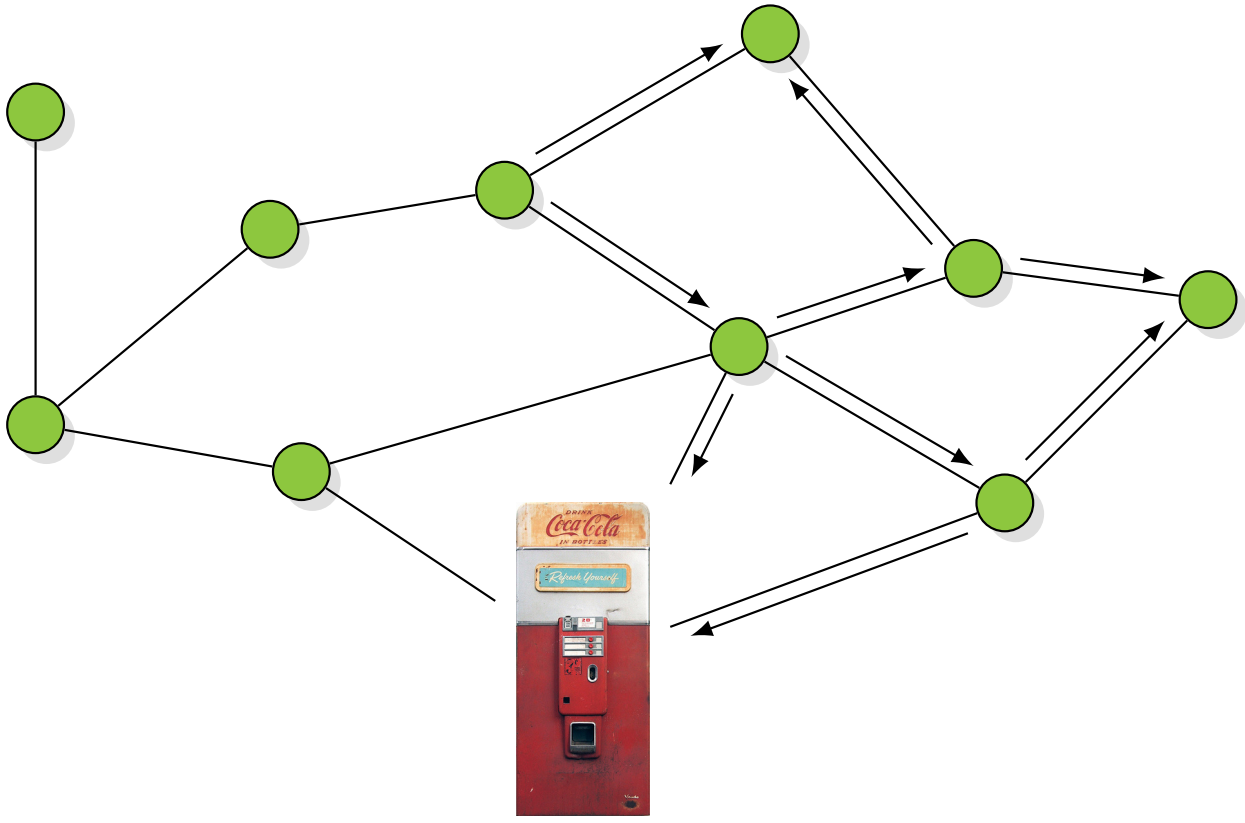
$$confidence(TX) = \square$$

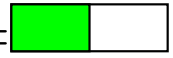
Transaction Confidence



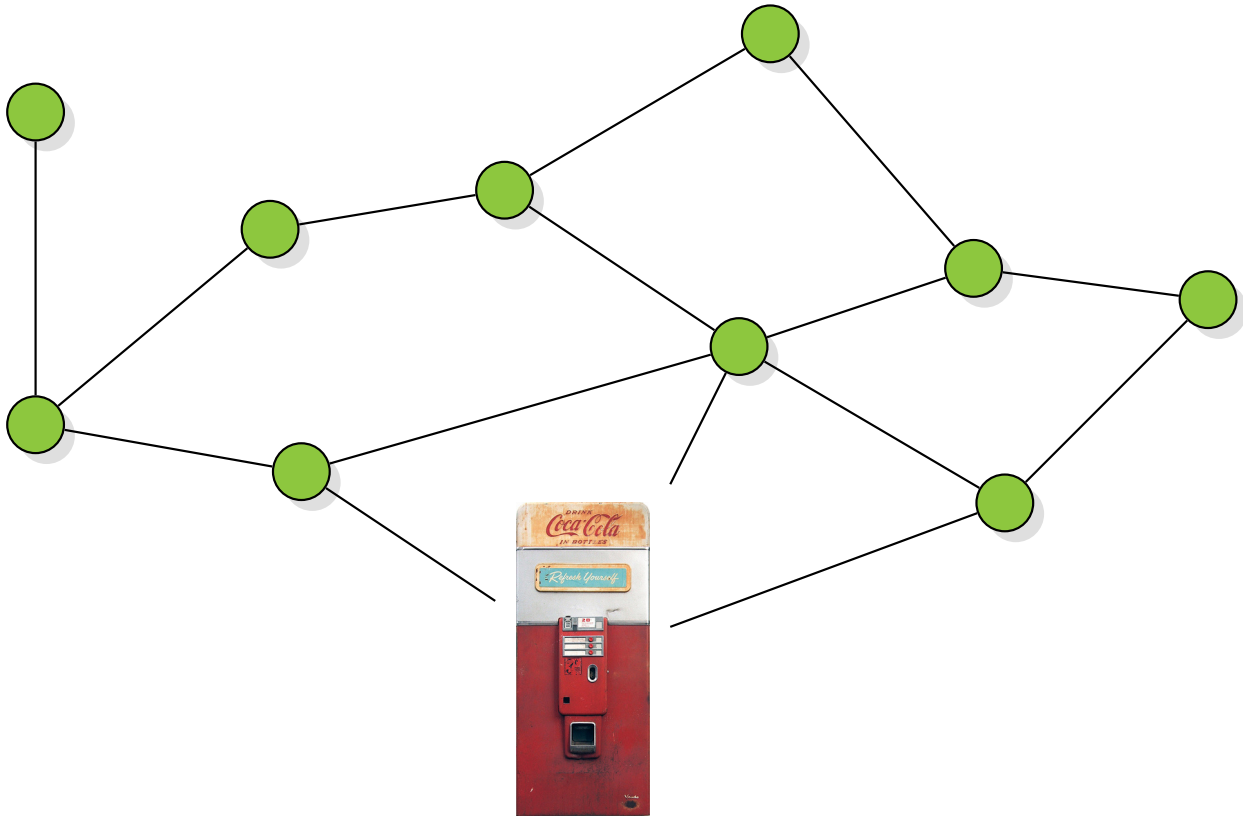
$confidence(TX) =$ 

Transaction Confidence



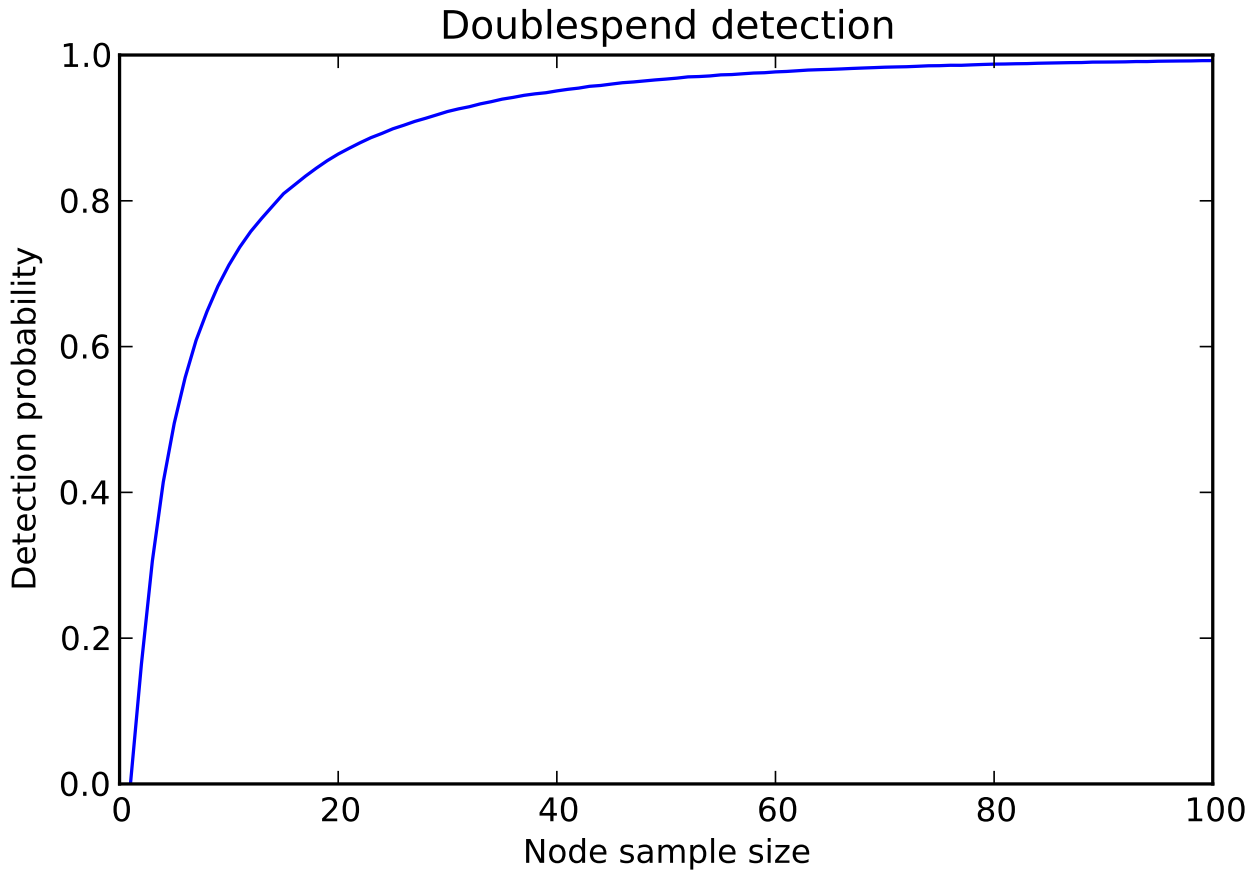
$confidence(TX) =$ 

Transaction Confidence



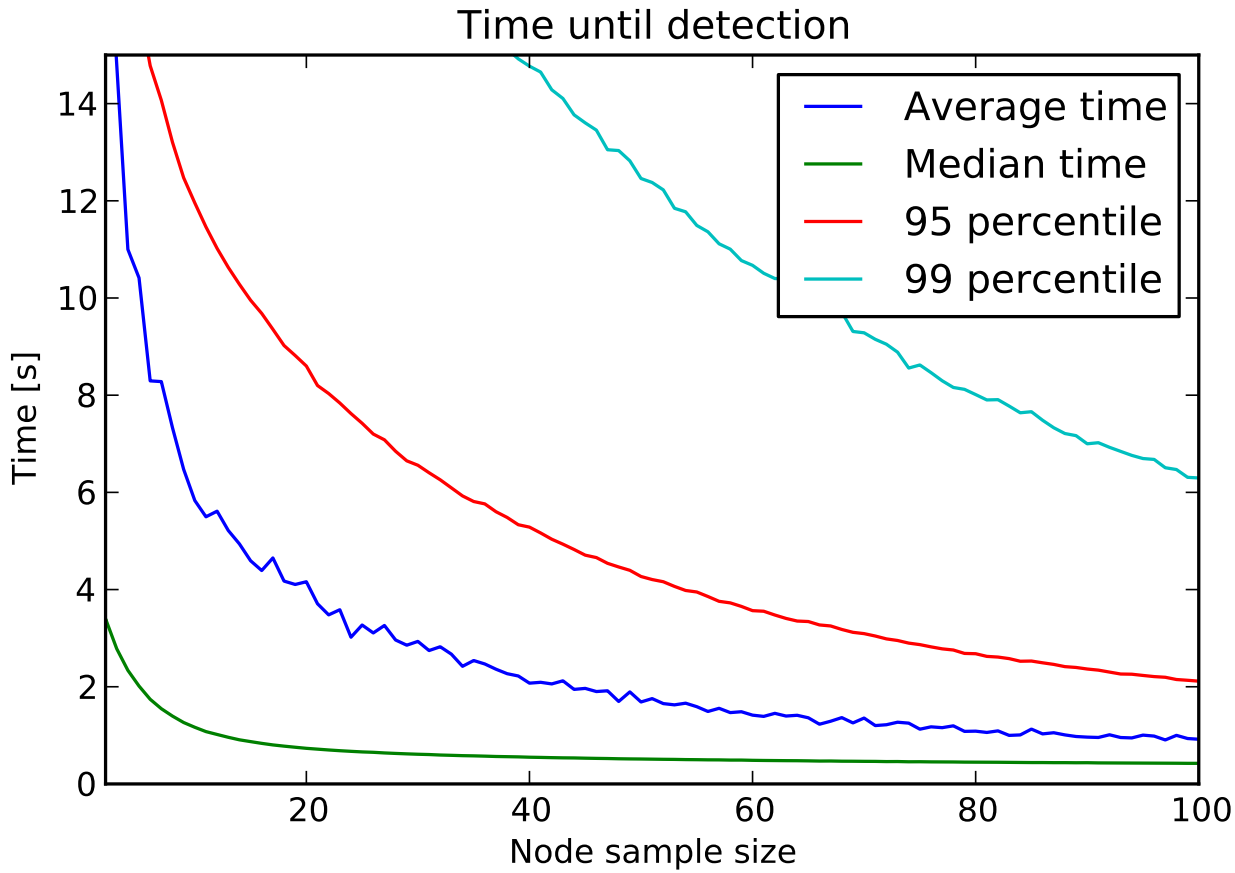
$confidence(TX) =$ 

Doublespend Detection



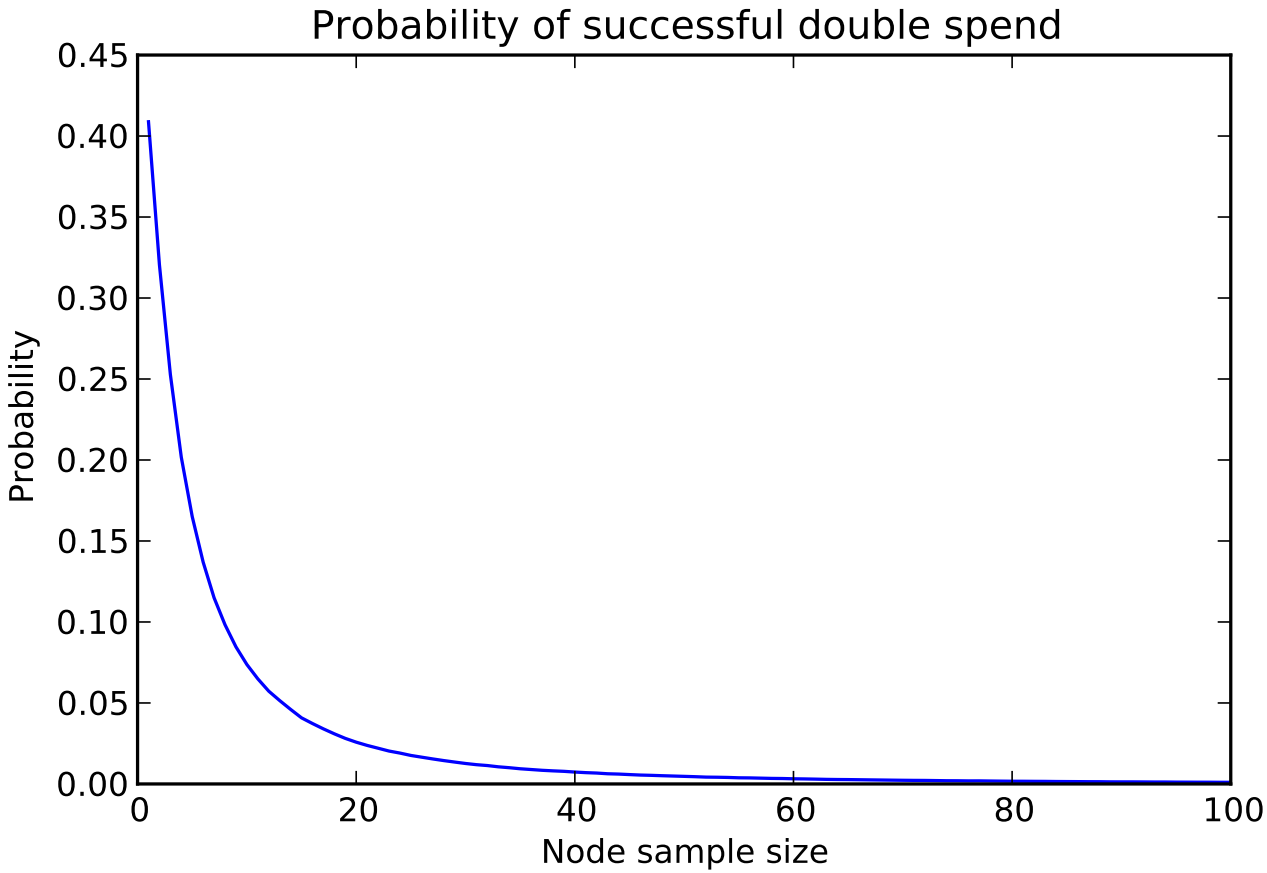
[Bamert, Decker, Elsen, W, Welten, 2013]

Time to Detection



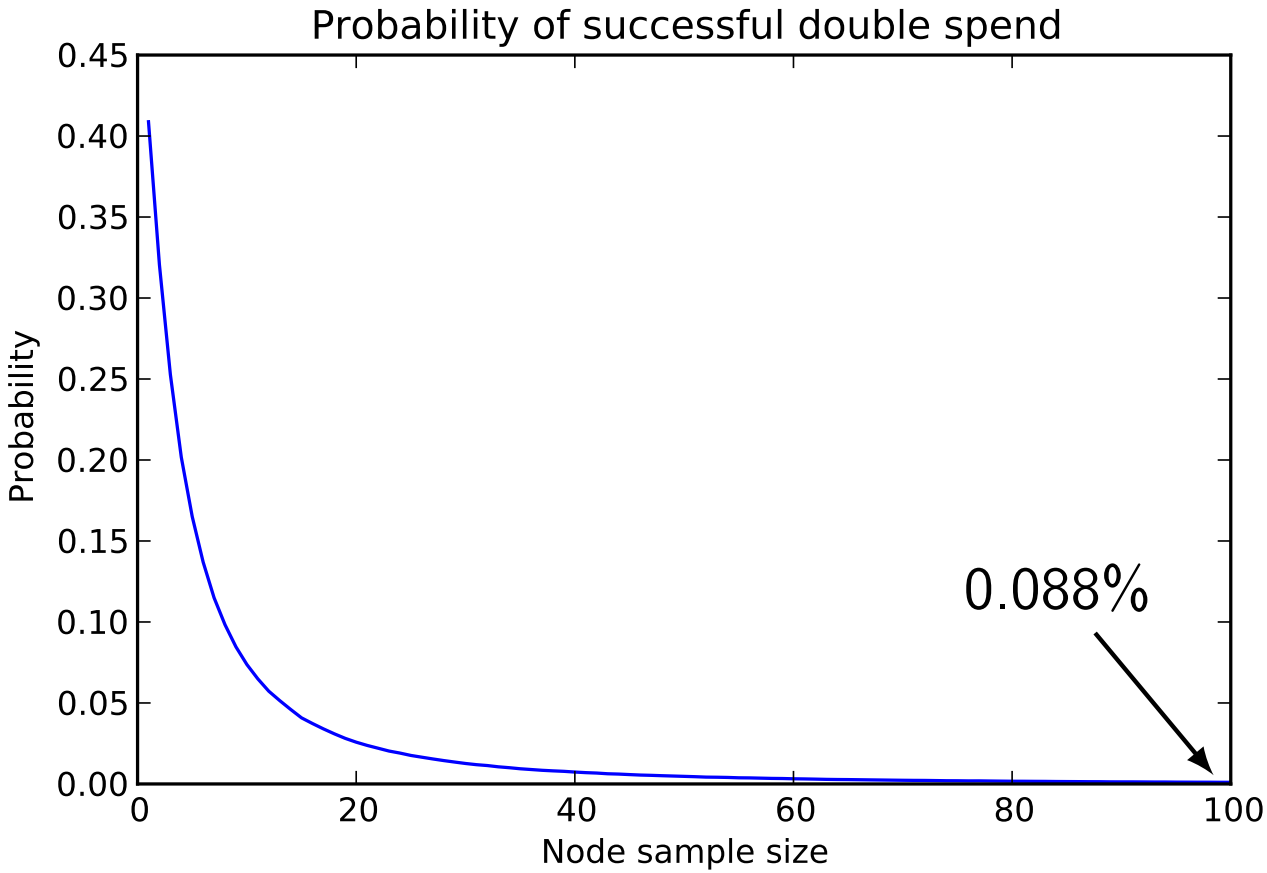
[Bamert, Decker, Elsen, W, Welten, 2013]

Successful Doublespend



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

Successful Doublespend



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