Group Meeting 07.20

Tampering with the Delivery of Blocks and Transactions in Bitcoin

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Speaker: LING Xiang

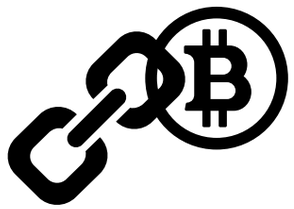
CCS 2015

Bitcoin

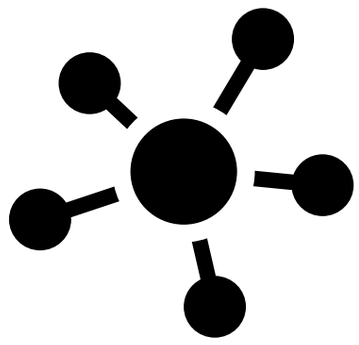
- Peer-to-peer decentralized currency

- No trusted third parties

- Blockchain: distributed DB
  - Transactions
  - Blocks

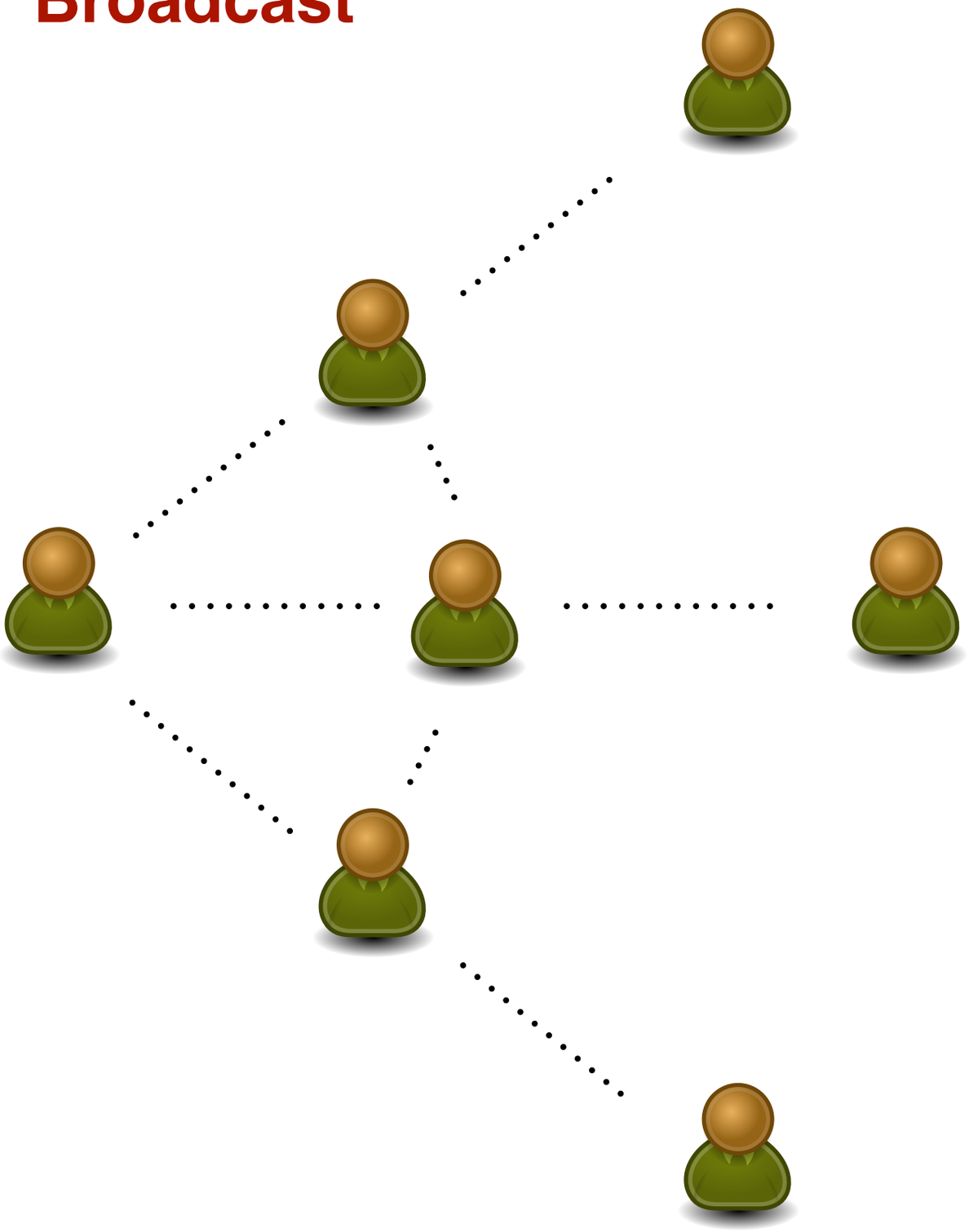


- Broadcast protocol



ETH zürich

Broadcast



ETH zürich

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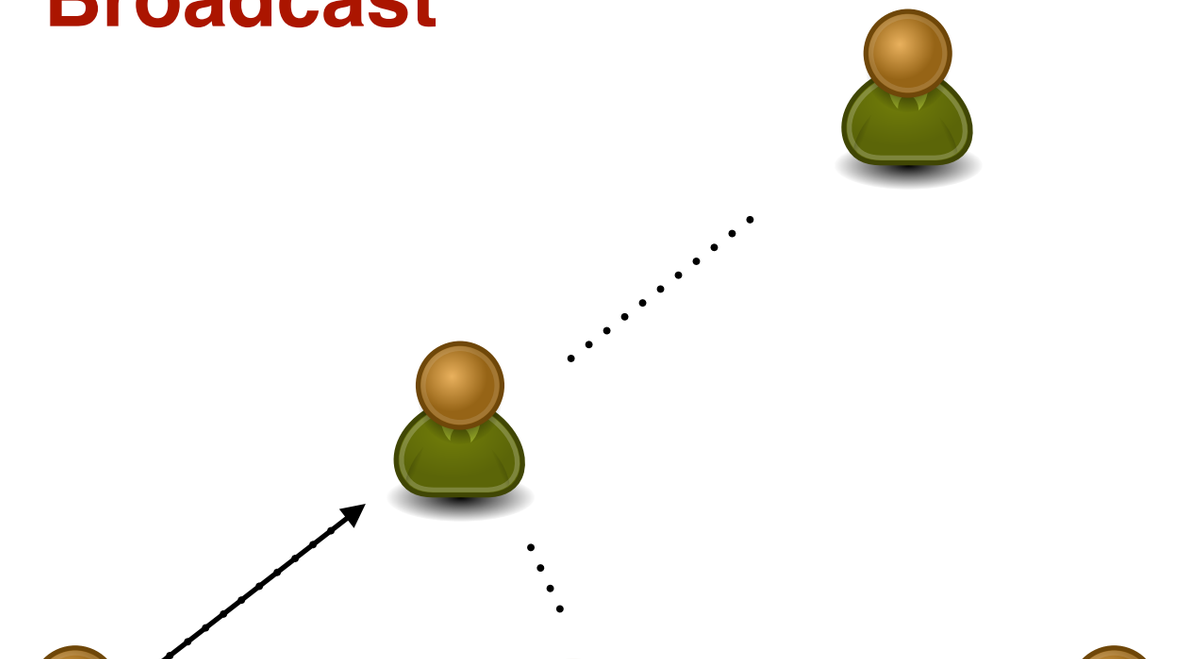

ETH zürich

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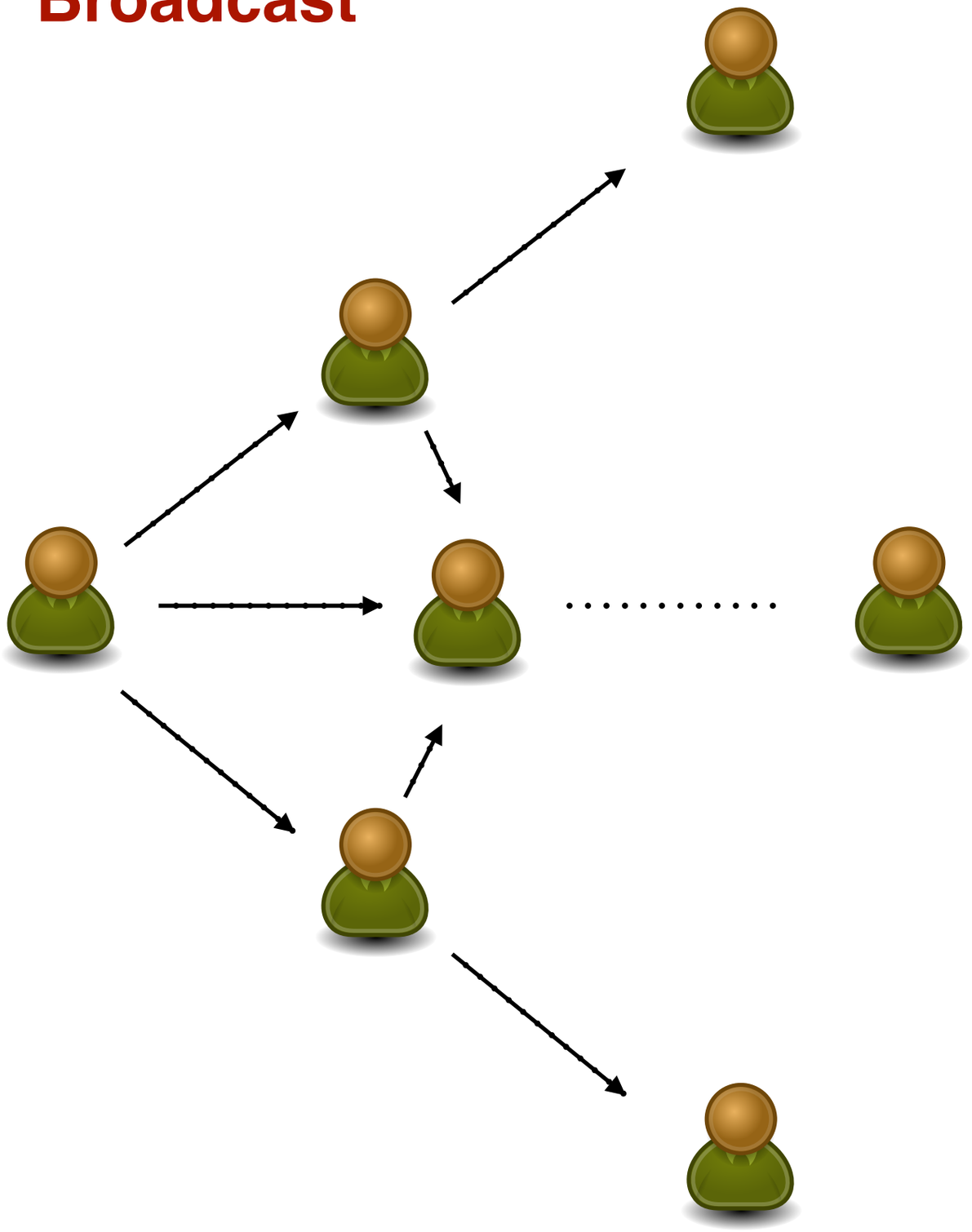

ETH zürich

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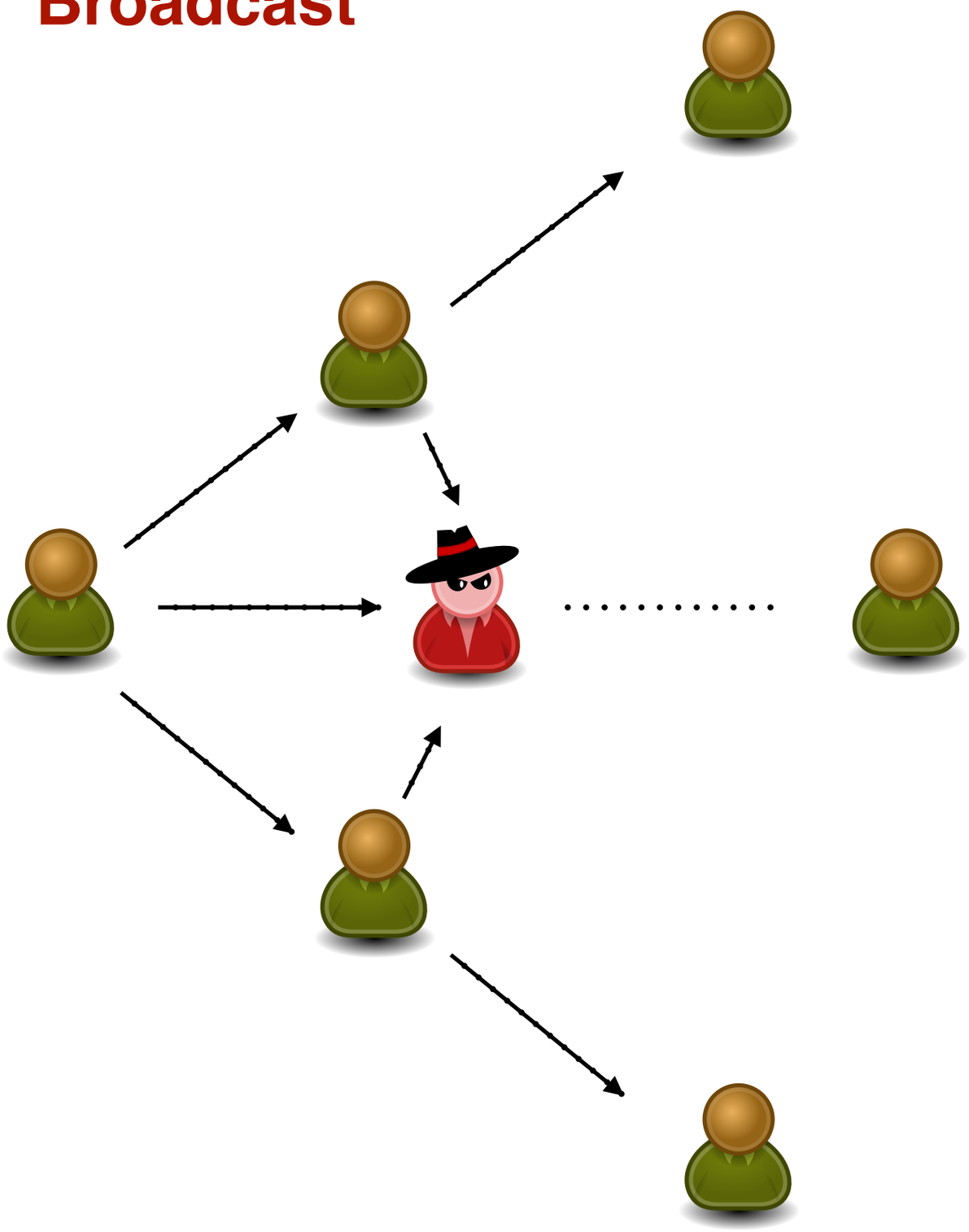

ETH zürich

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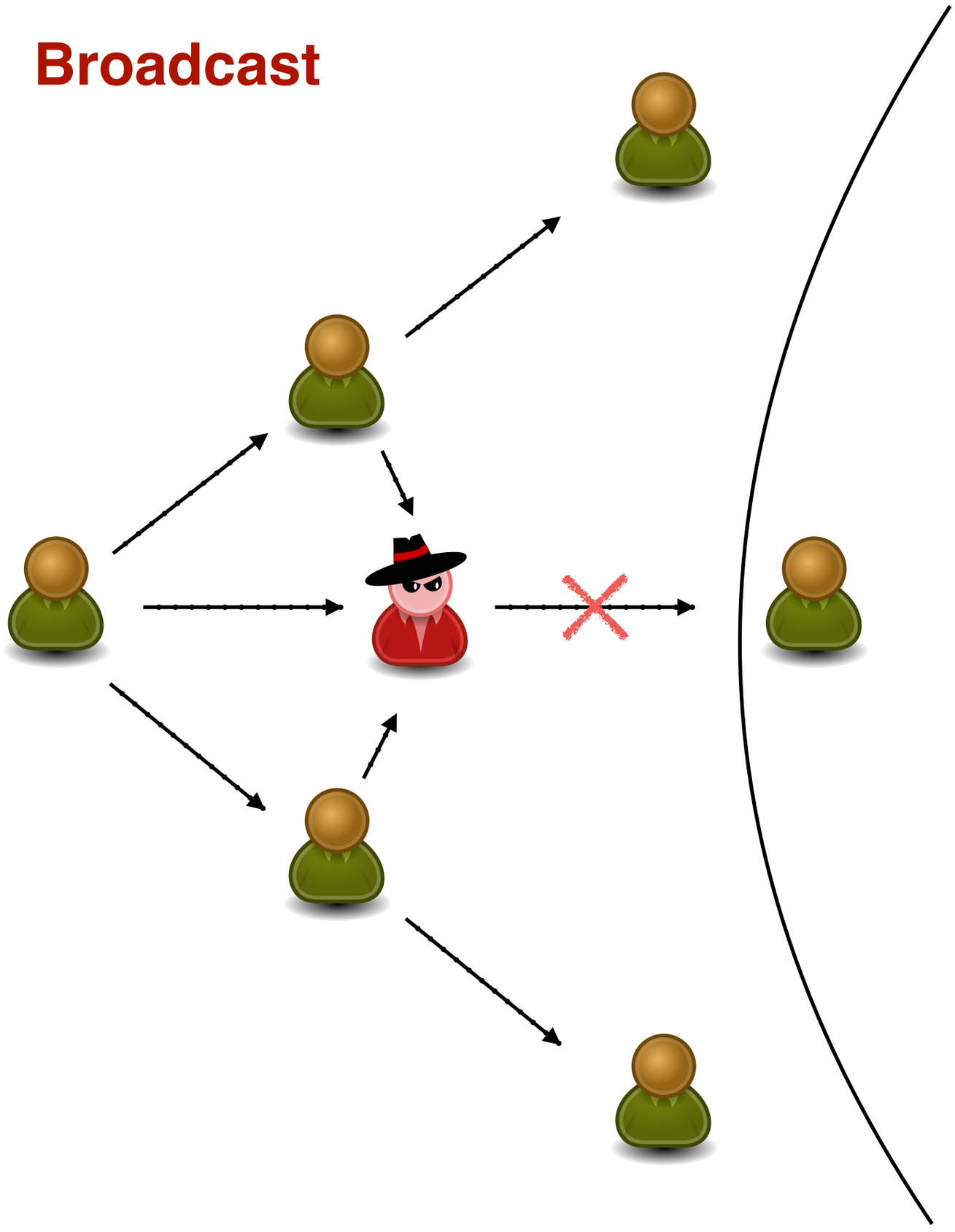

ETH zürich

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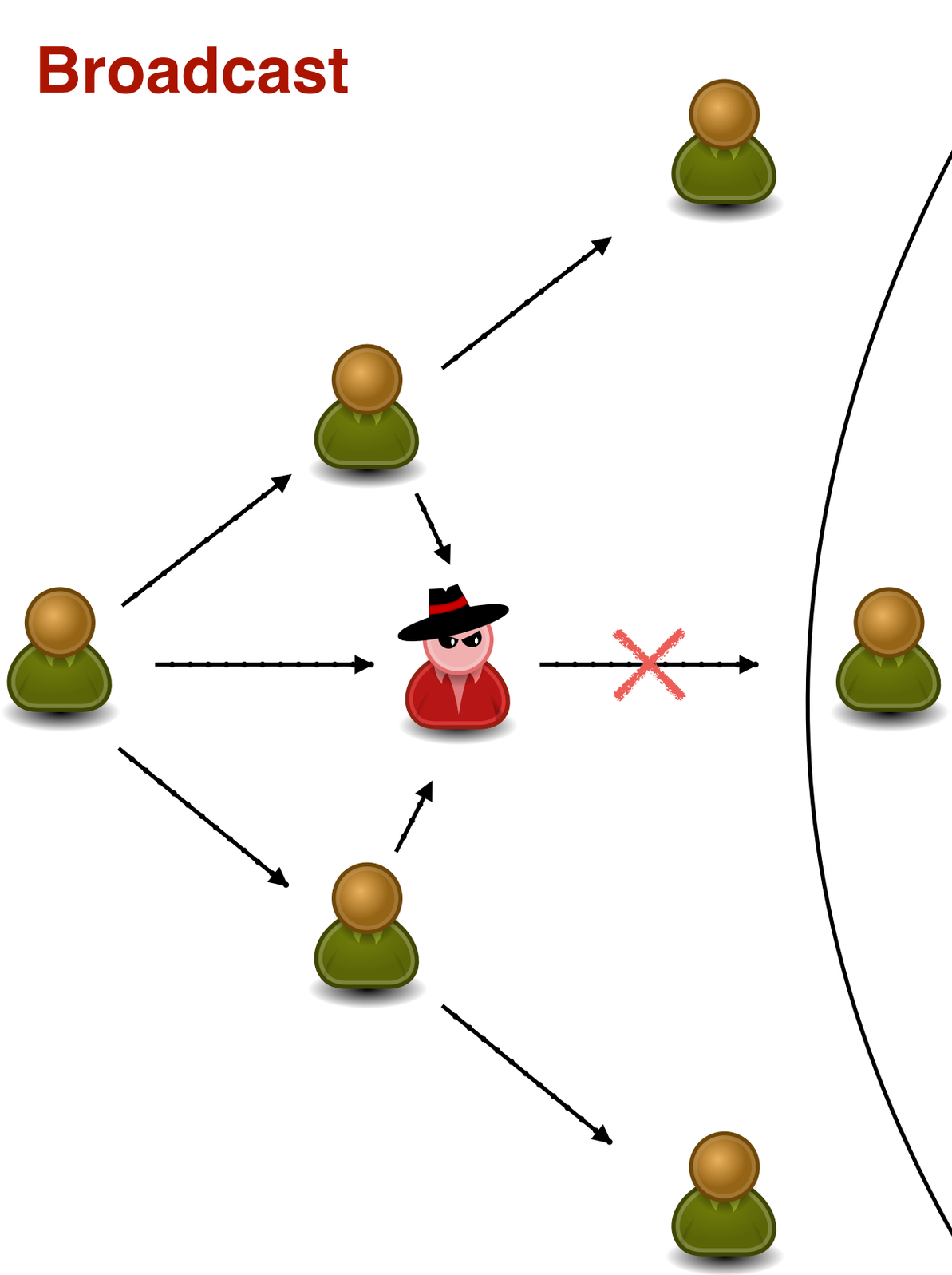
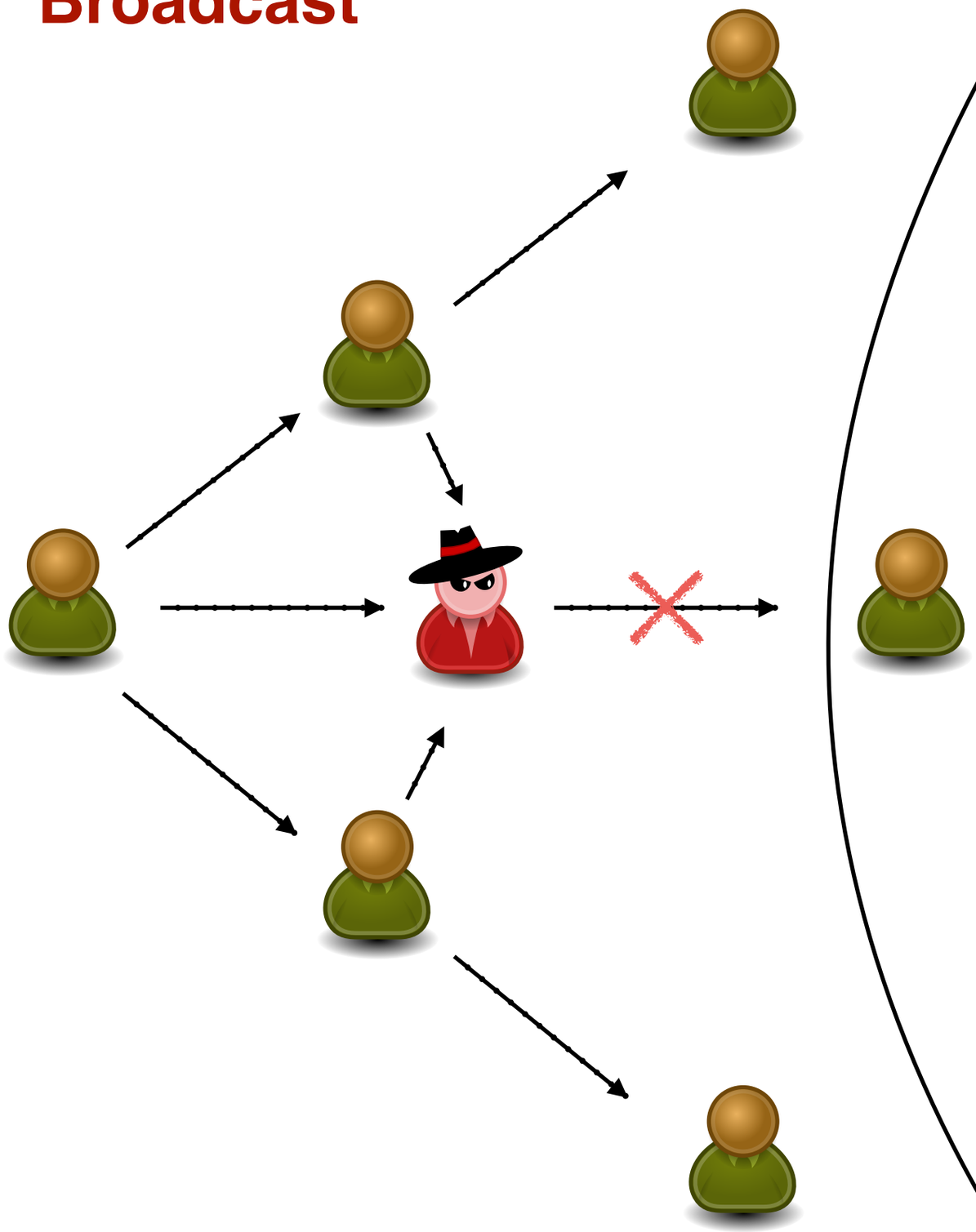


Denial of Service

Double Spending

Broadcast

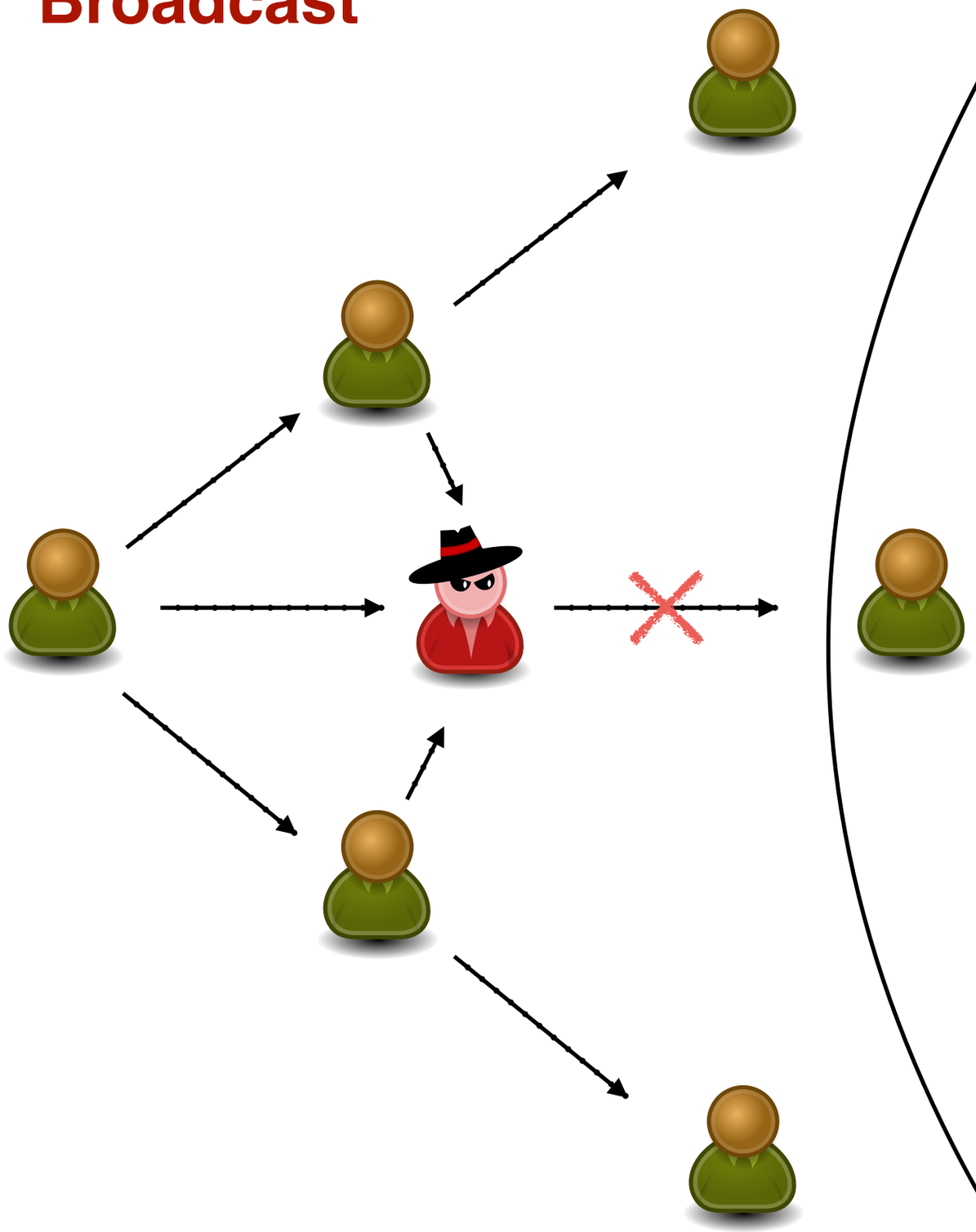


Eclipse attacks
Heilman et al., Usenix ’15

Denial of Service

Double Spending

Broadcast



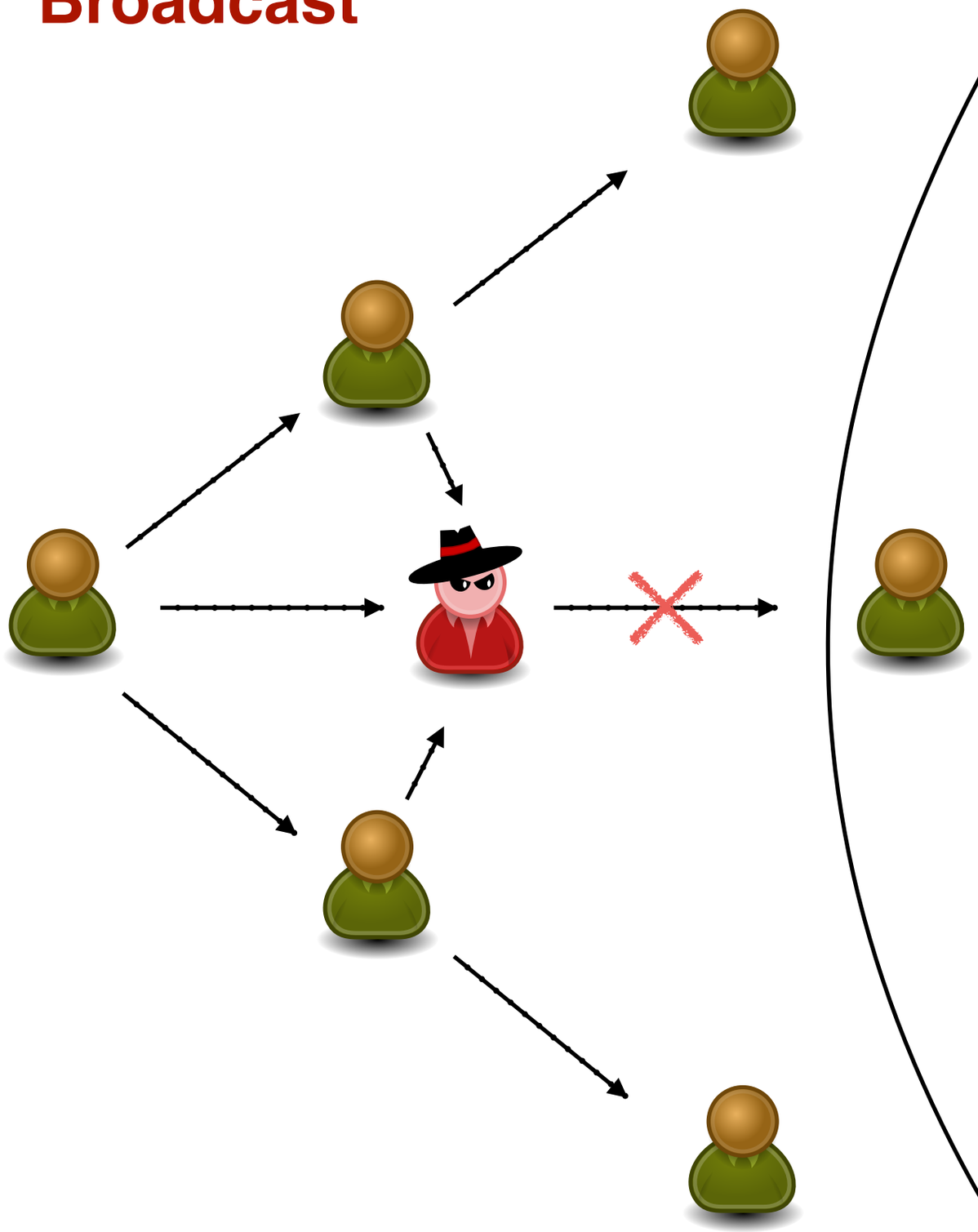
Eclipse attacks
Heilman et al., Usenix ’15

- Monopolize connections
- Spamming addresses
- Forcing node restart
- Requires many bots

Denial of Service

Double Spending

Broadcast



This paper

1 connection sufficient

No victim restart necessary

Eclipse attacks

Heilman et al., Usenix ’15

Monopolize connections

Spamming addresses

Forcing node restart

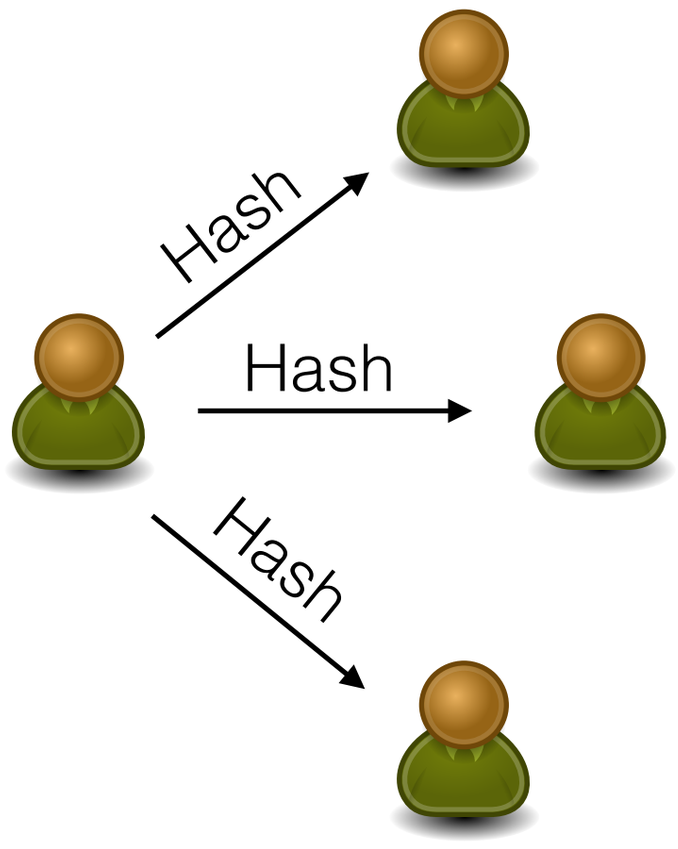
Requires many bots

Denial of Service

Double Spending

Transaction/Block advertisement

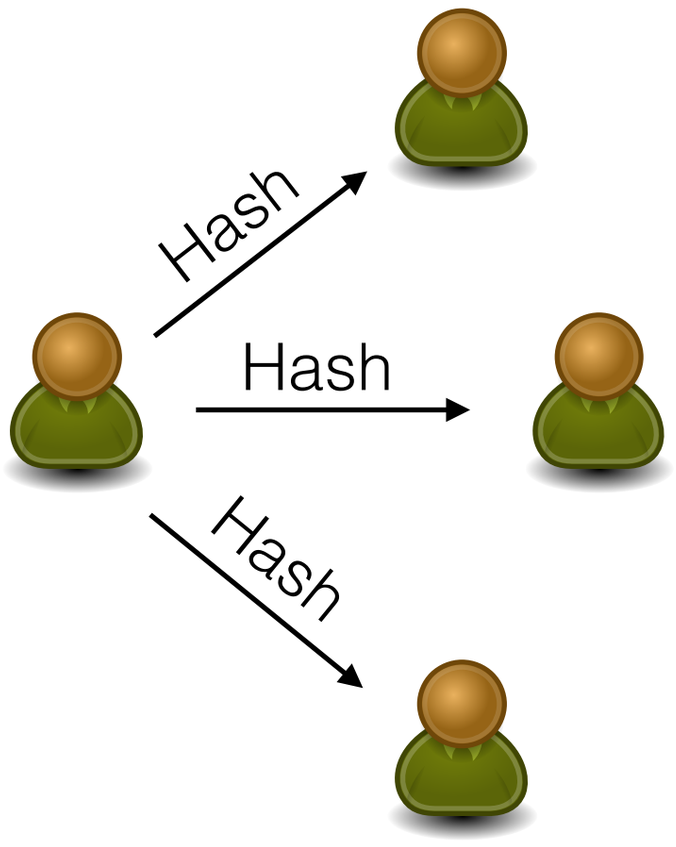
1. Transaction/Block
   hash broadcast



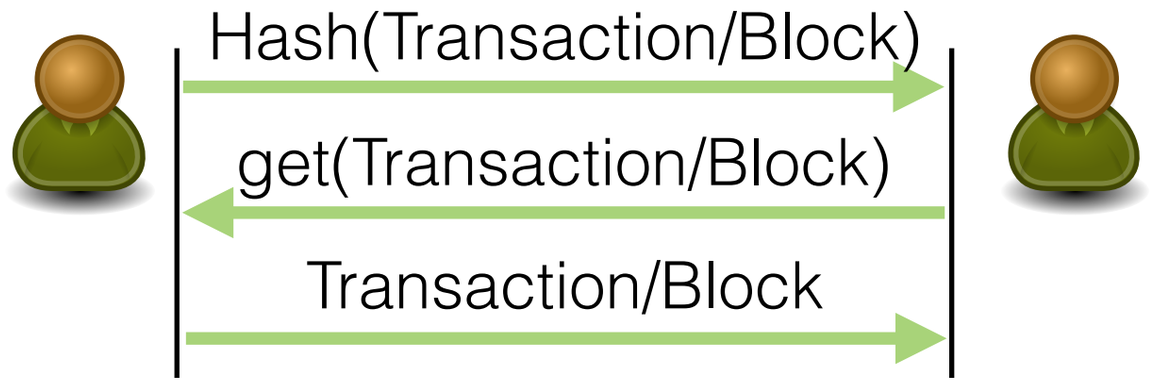
Broadcast

Transaction/Block advertisement

1. Transaction/Block hash broadcast
2. Transaction/Block request



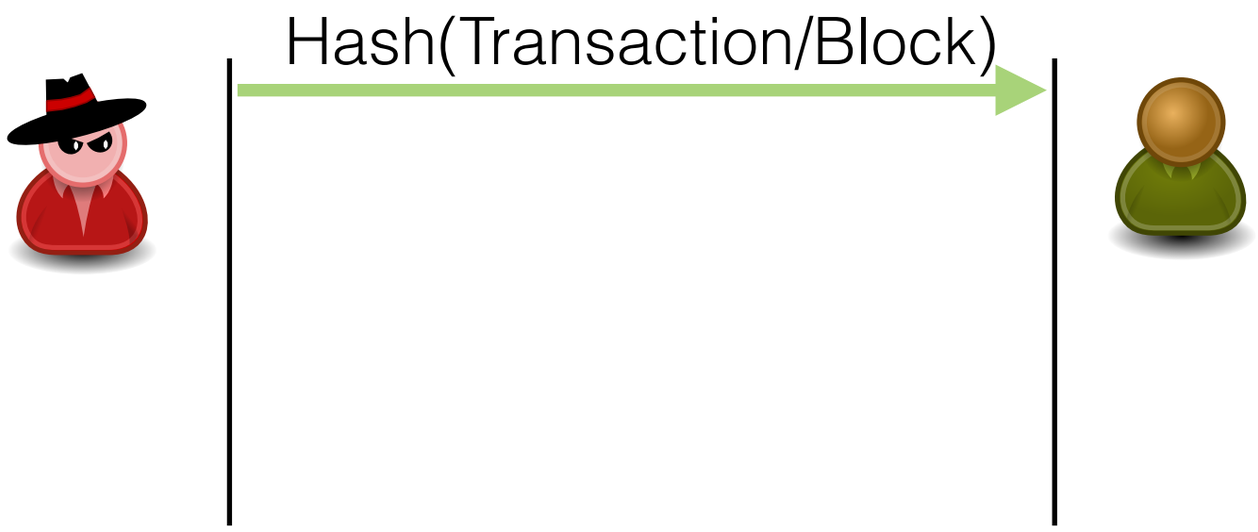
Broadcast



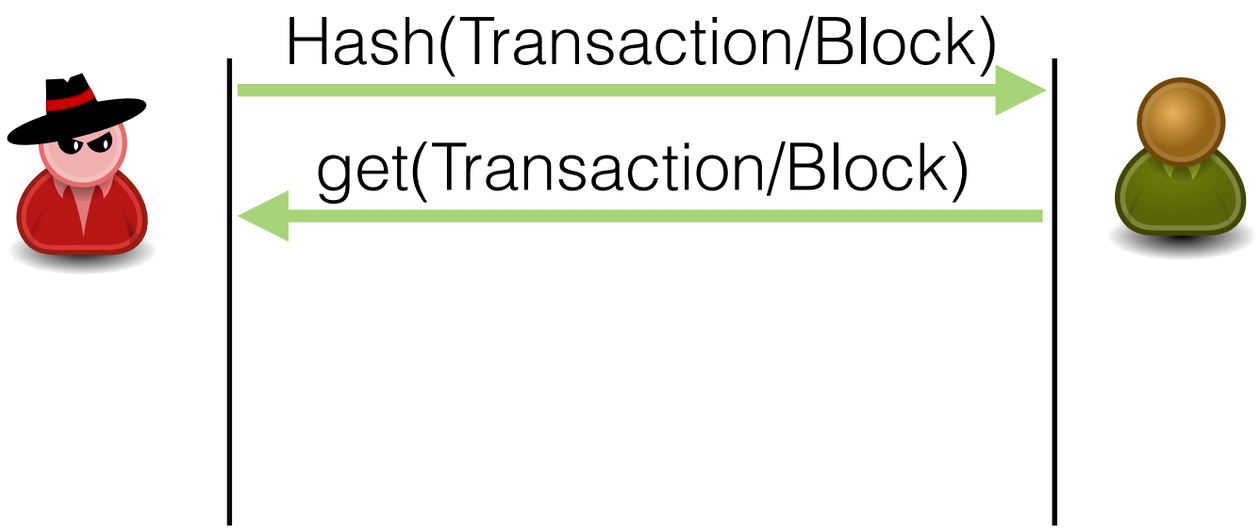
Request from only 1 peer!

Request timeouts

Request timeouts



Request timeouts



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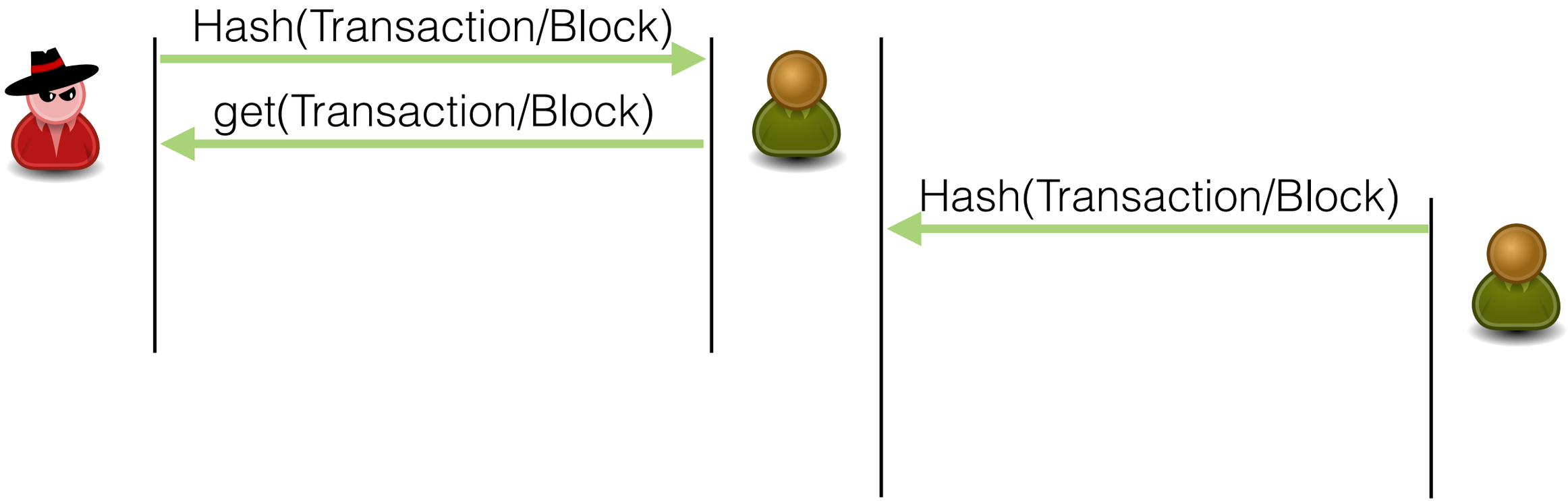
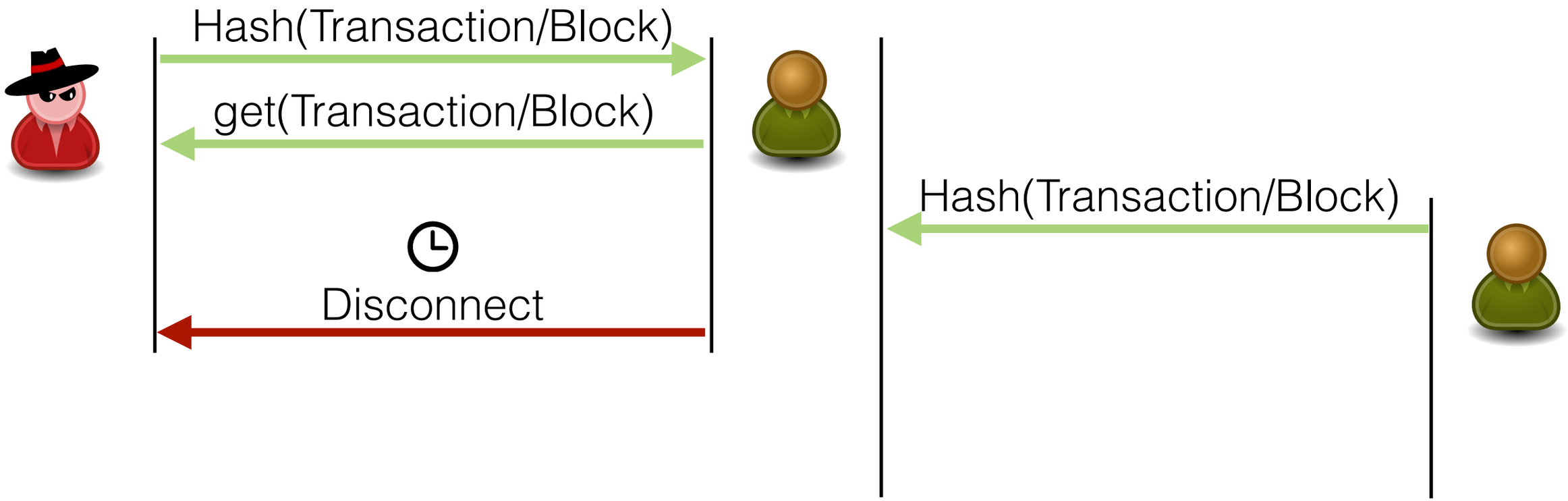
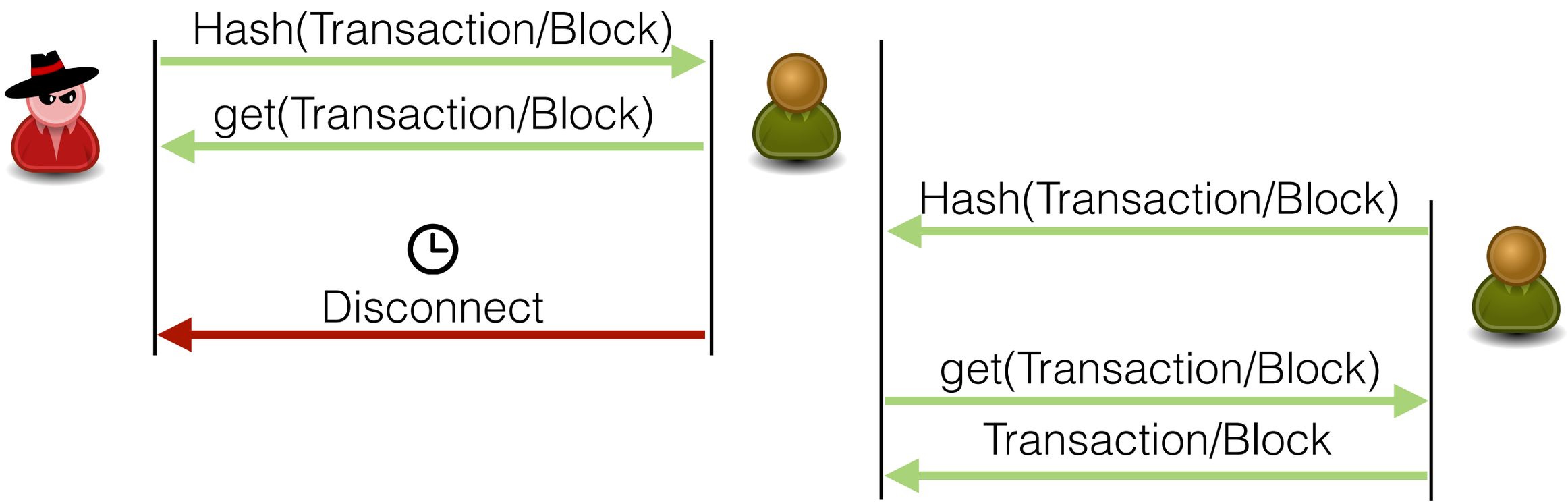


Request timeouts



Request timeouts



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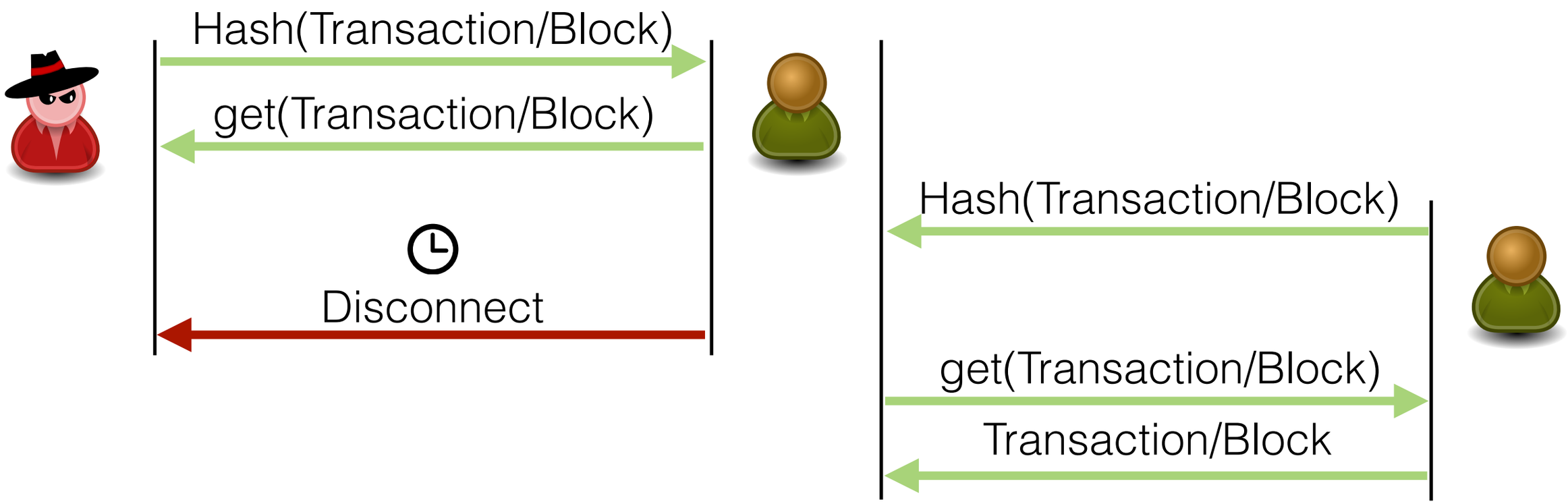


Block timeout: 20 minutes
Transaction timeout: 2 minutes

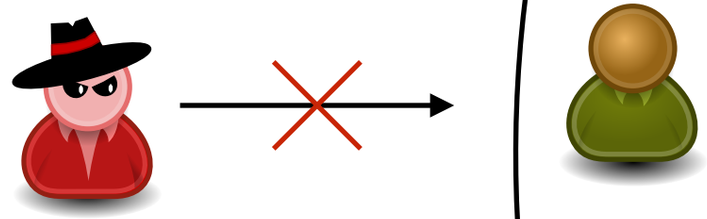
Contributions

Adversary

- Blinds victim from blocks and transaction > 20 min
- Experimental validation

Impact

- **Double spend transactions**
- Aggravated selfish mining
- **Network wide Denial of Service**

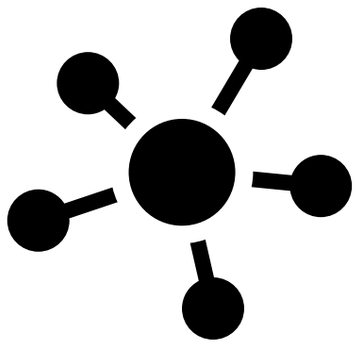


Mitigations

- **Hardening measures**
- Estimate waiting time for secure transactions

Necessary requirements

1. Must be **first** peer to advertise Transaction/Block



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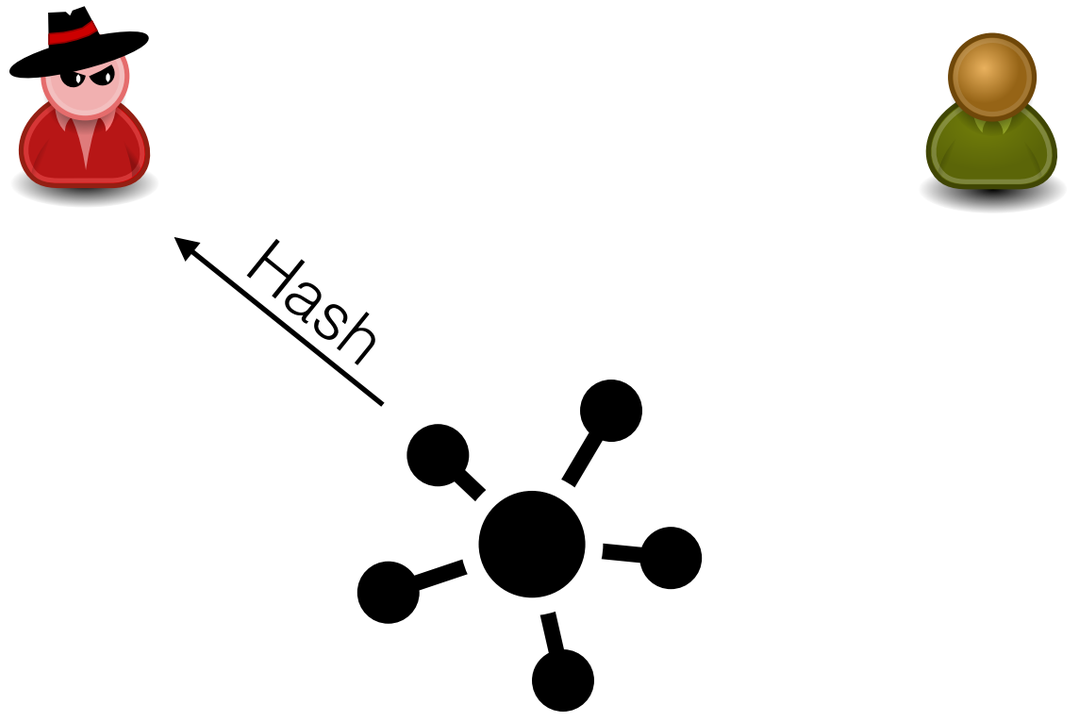

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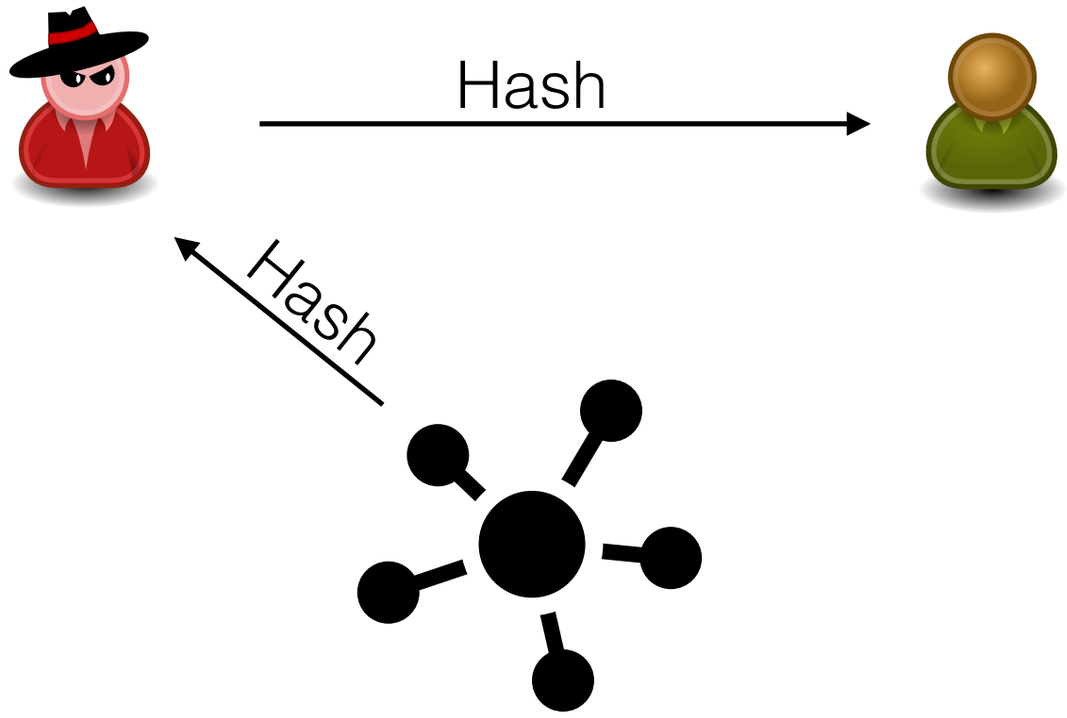

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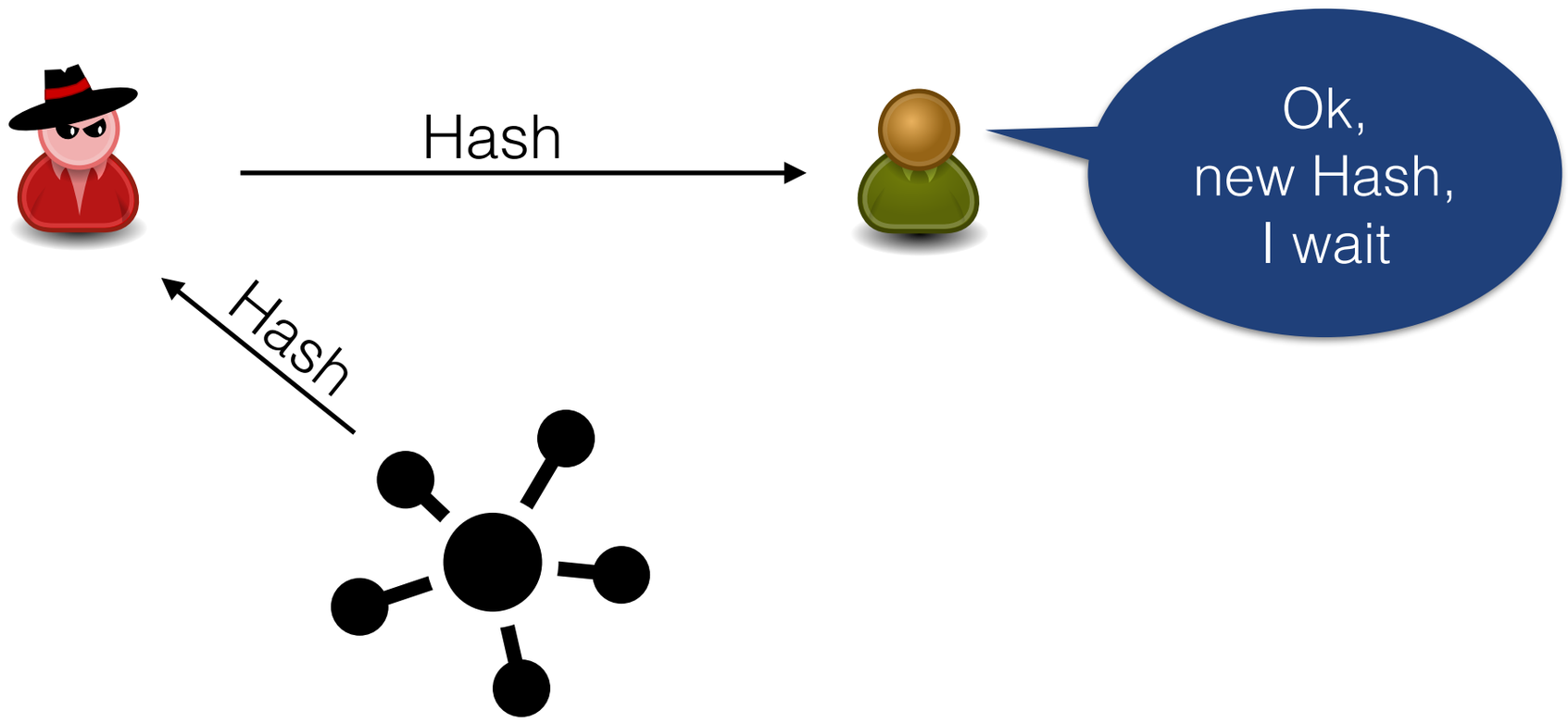

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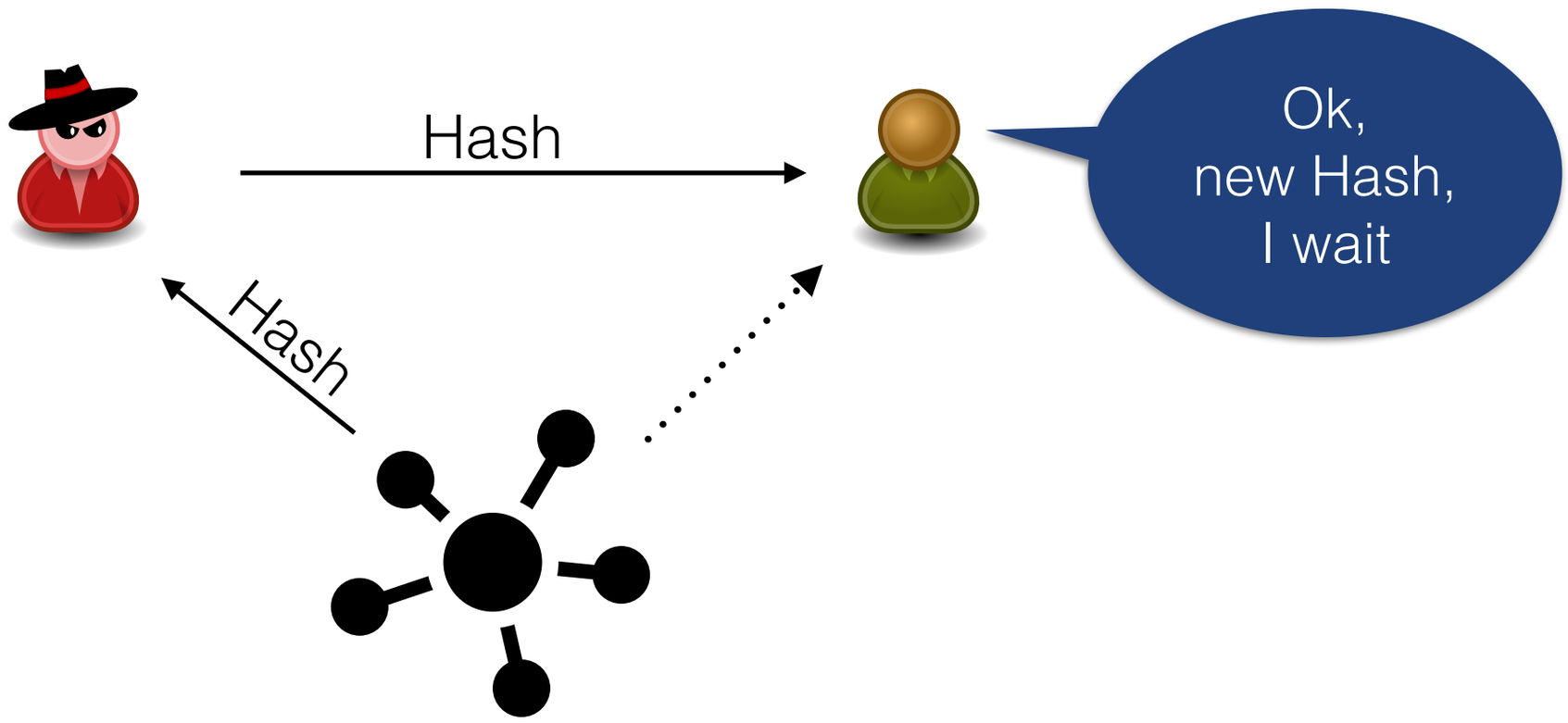

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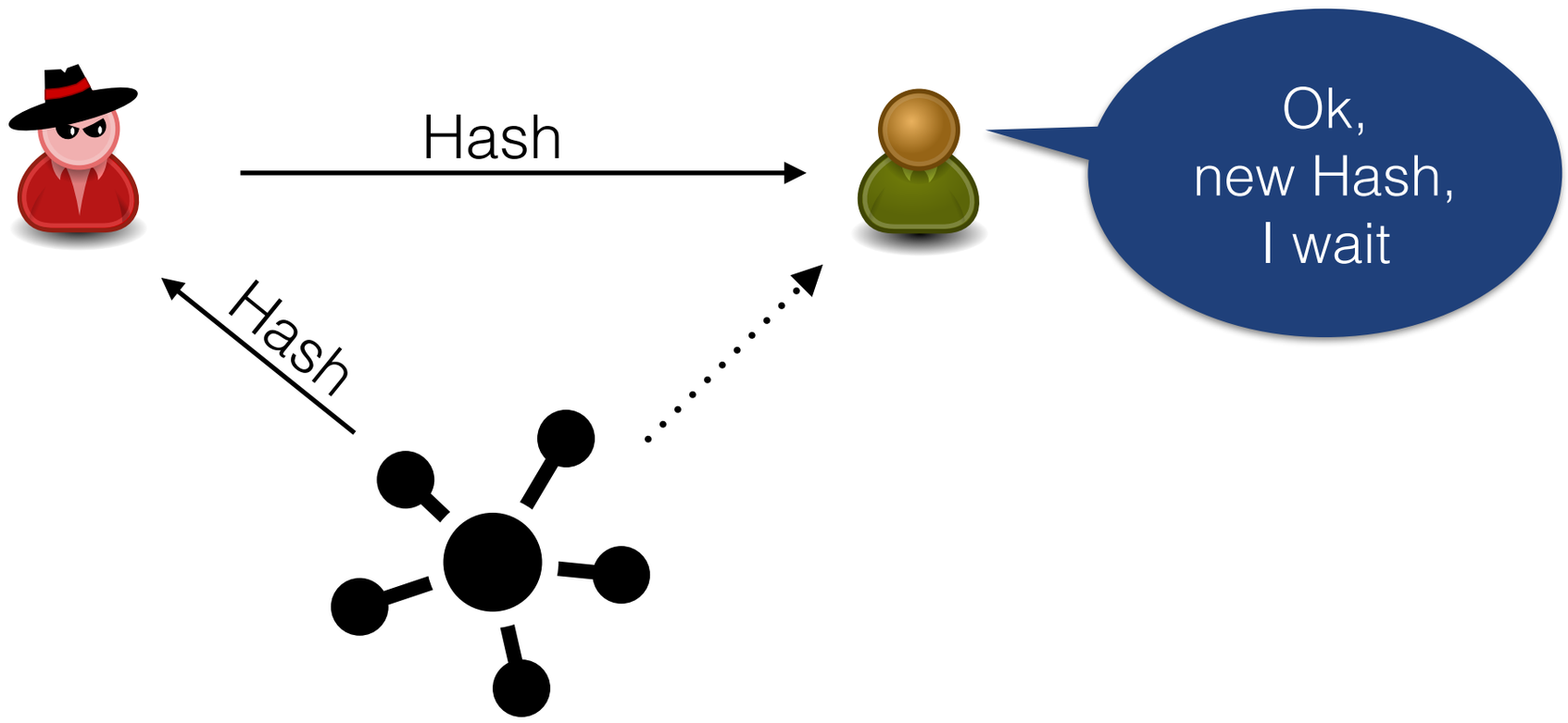
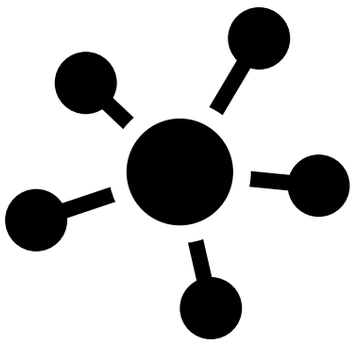


2. Victim should wait
   - Block timeout: 20 minutes
   - Transaction timeout: 2 minutes

Being First

Zurich



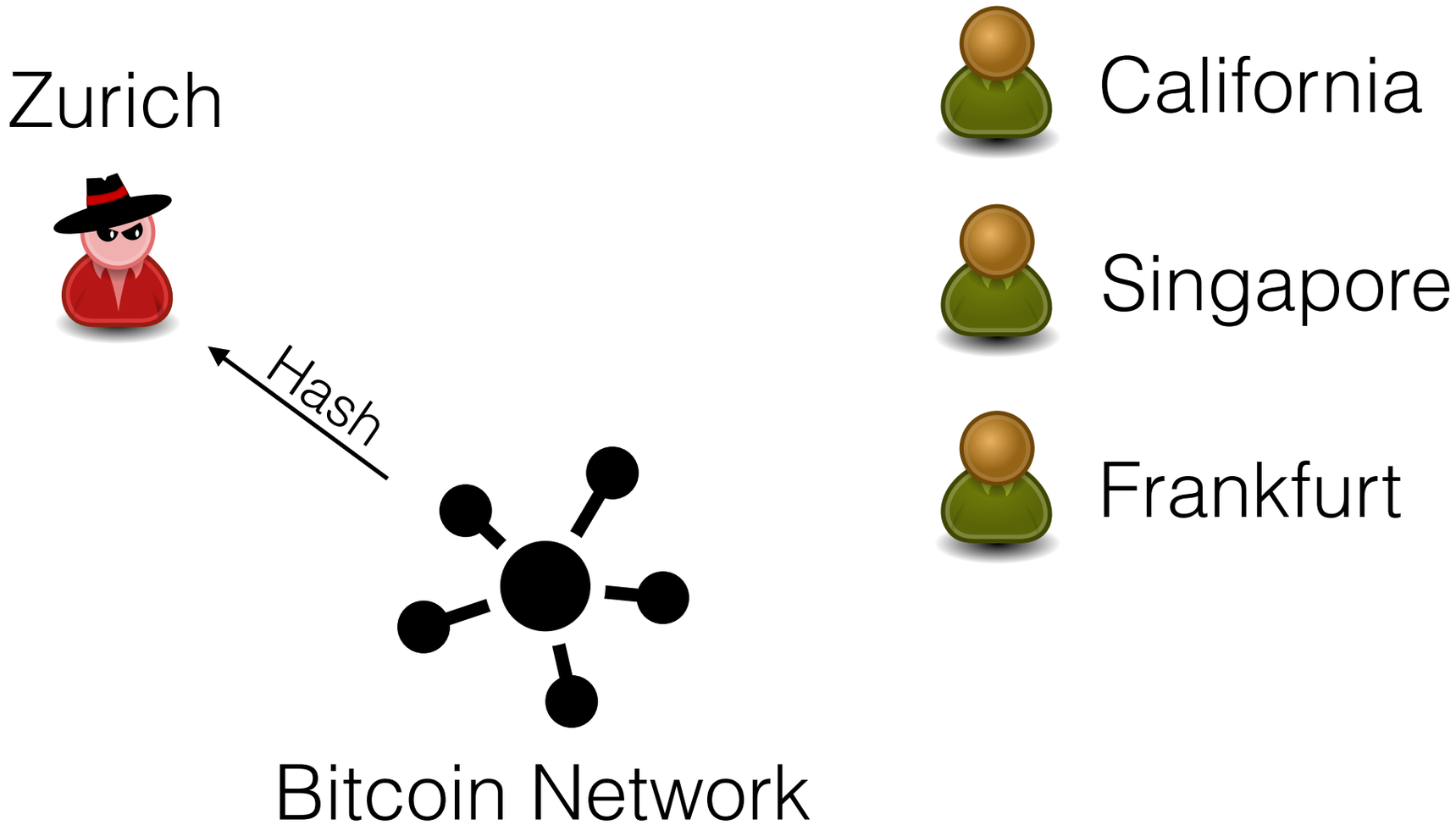
Bitcoin Network

California

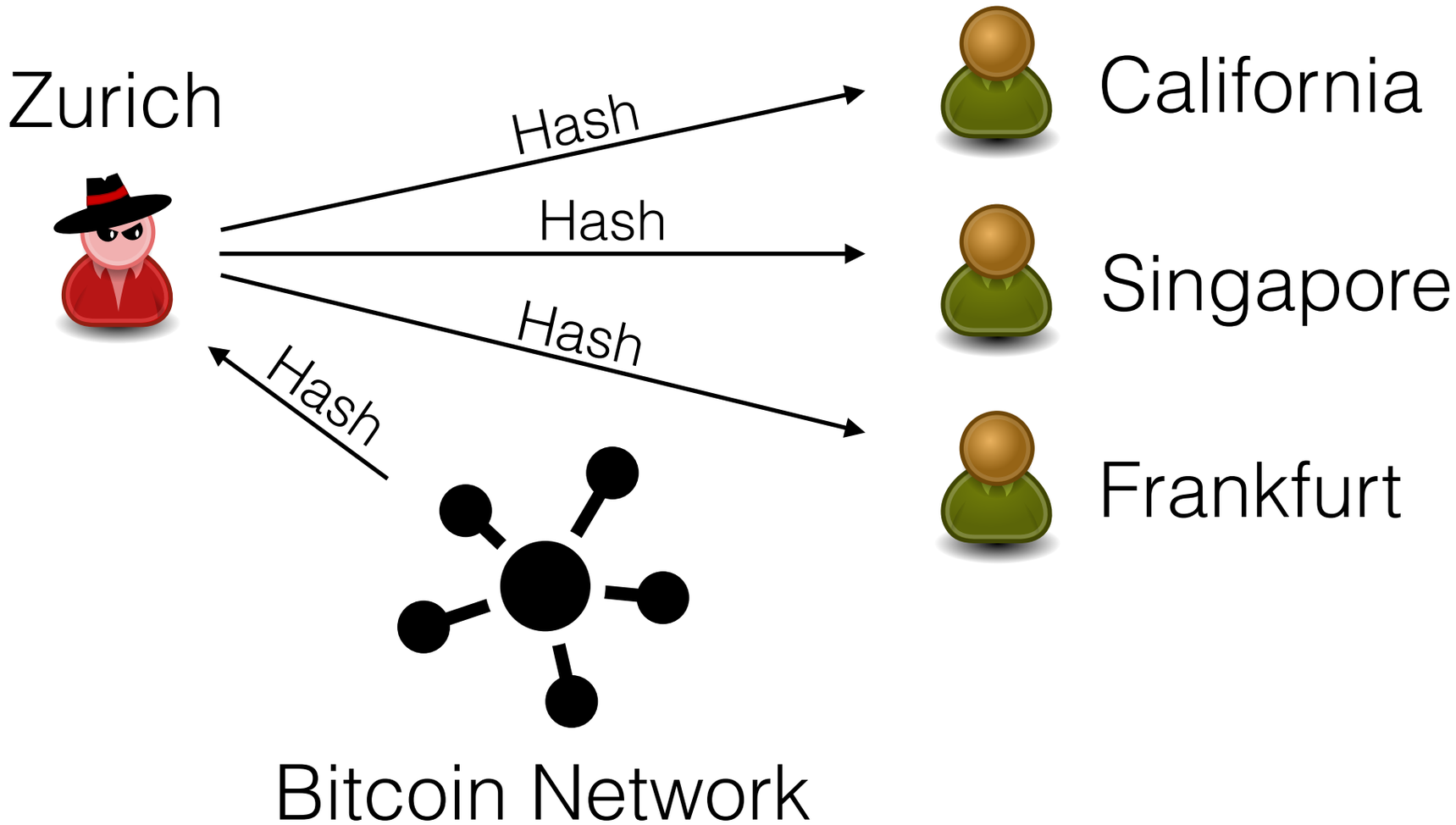
Singapore

Frankfurt

Being First


Zurich
Hash
Bitcoin Network
California
Singapore
Frankfurt

Being First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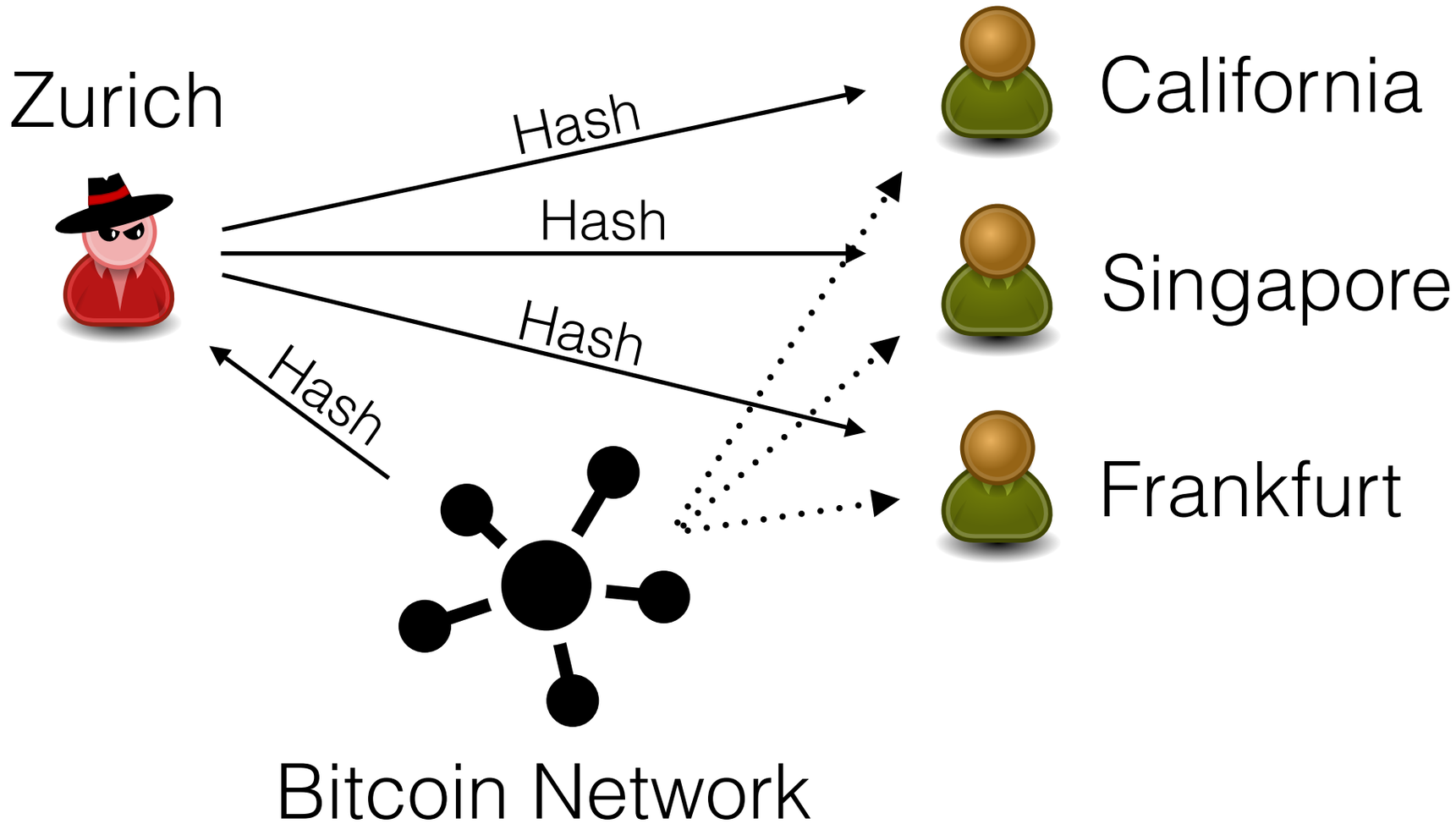
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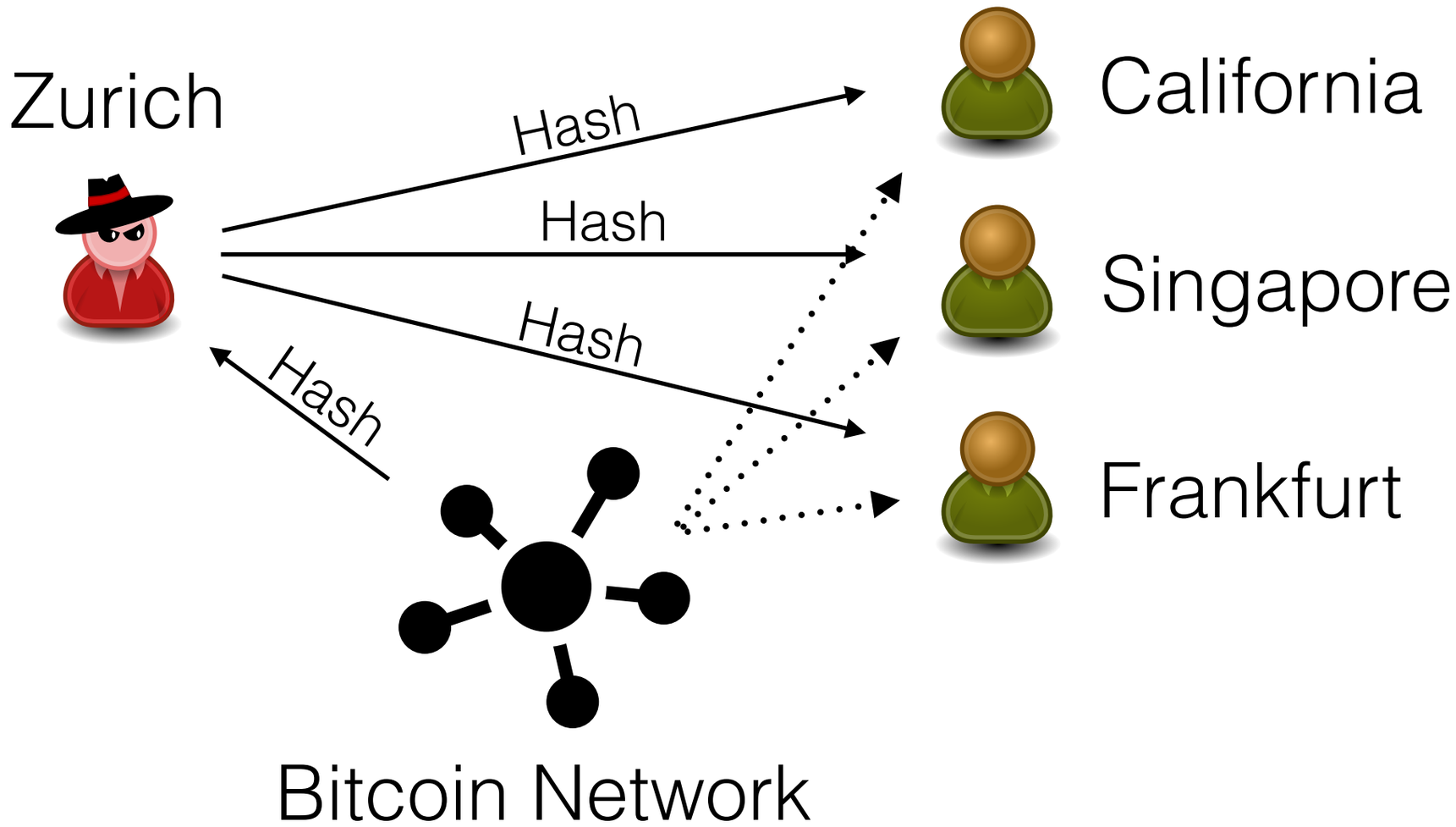


Connections of Adversary	40	80	200	800
Connections of Victim	40	40	40	40
Average success in being first	0.44± 0.14	0.57± 0.20	0.80± 0.14	**0.89± 0.07**

Waiting

Transactions

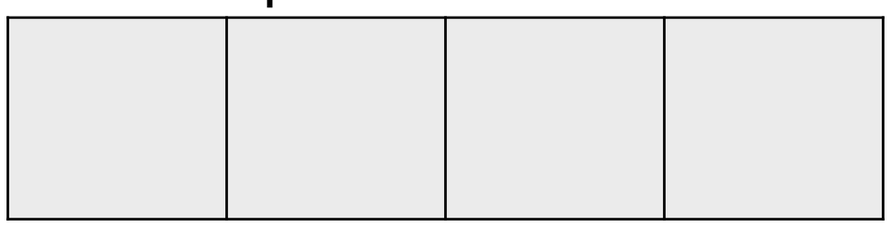
- After 2 minutes request from other peer (FIFO)

Waiting

Transactions

- After 2 minutes request from other peer (FIFO)

FIFO queue



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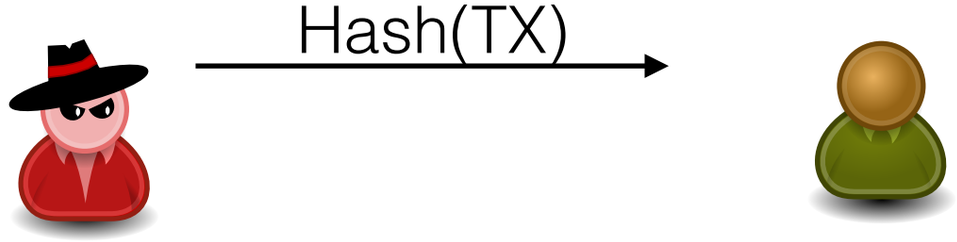

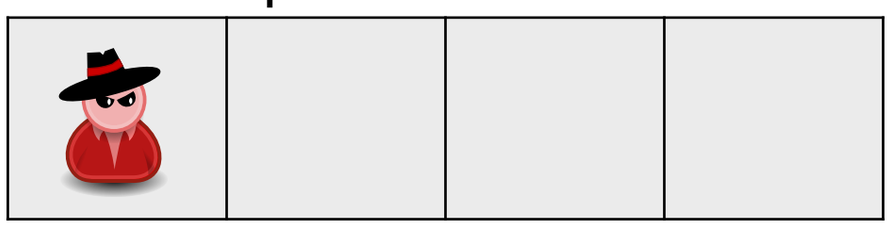

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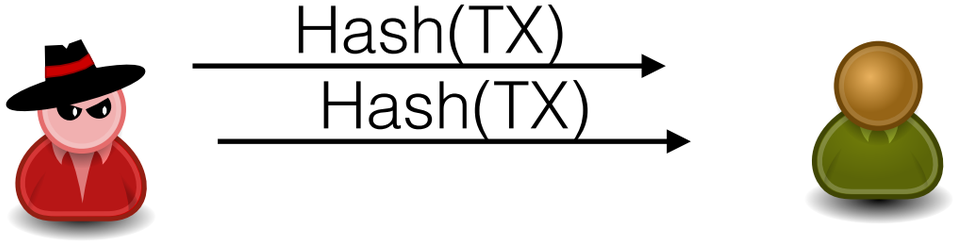

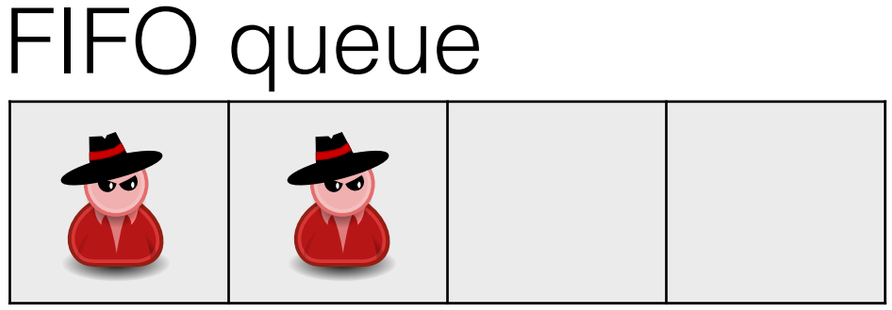

Waiting

Transactions

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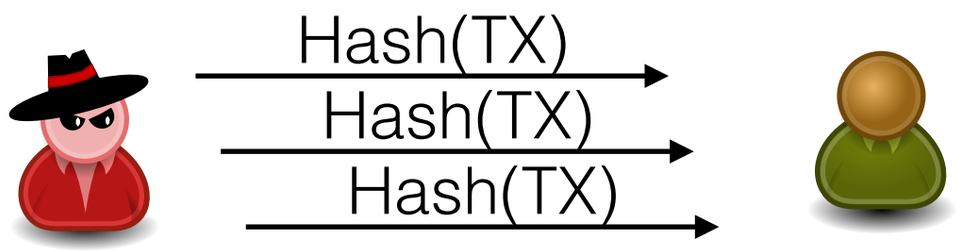

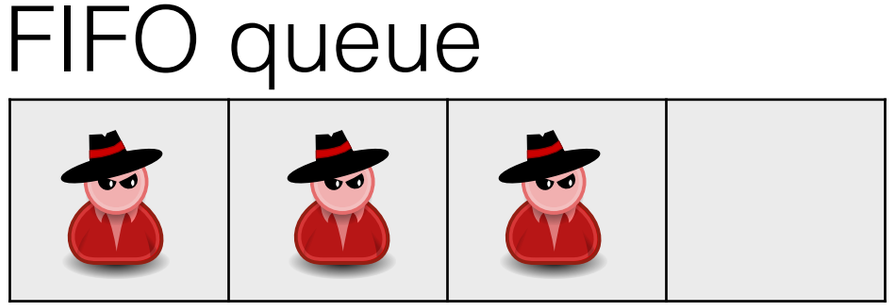

Waiting

Transactions

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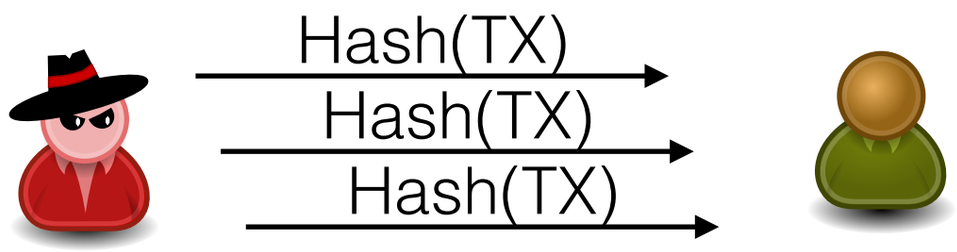
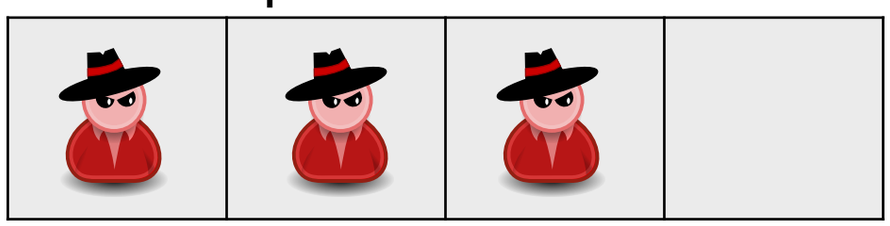
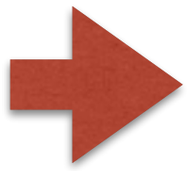


FIFO queue



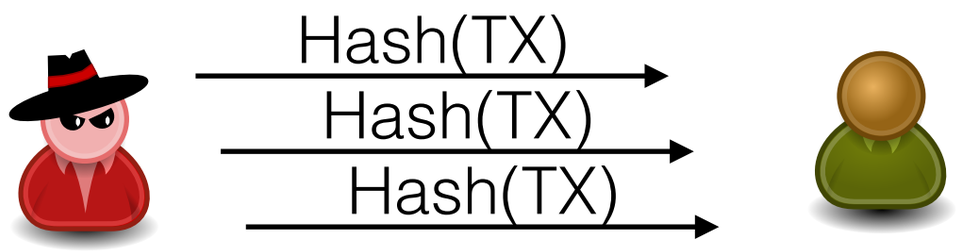


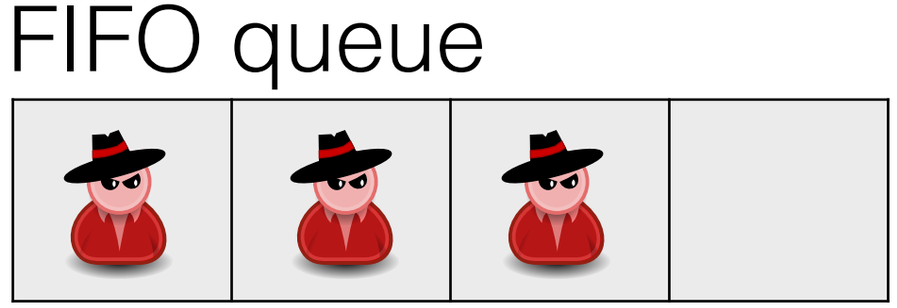
6 minutes timeout

Waiting

Transactions

- After 2 minutes request from other peer (FIFO)





Blocks

- After 20 minutes disconnect and do nothing
- If received header, disconnect and request block from another peer

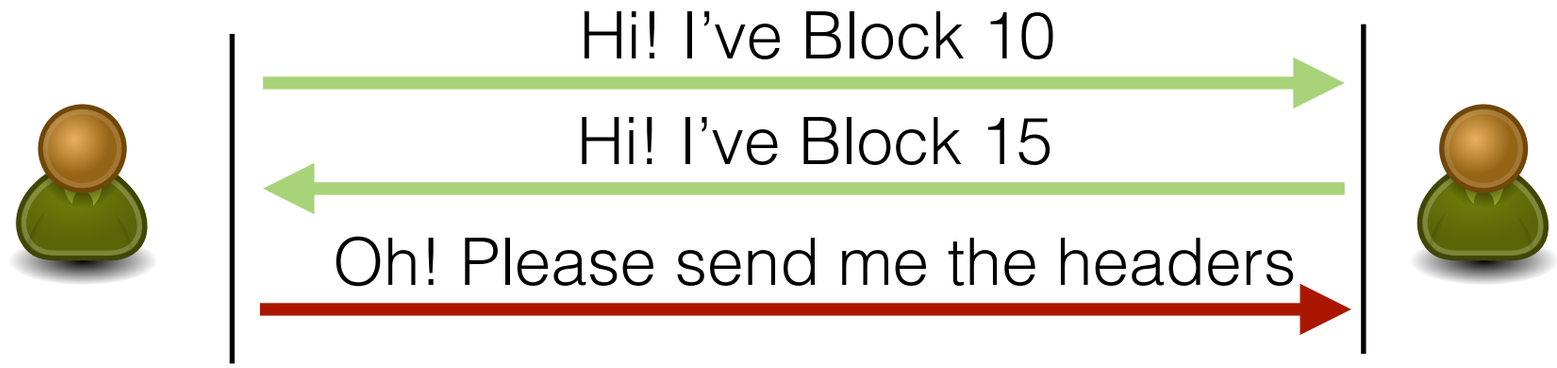
Block delivery time > 20 min

1. Requirement for victim 

    - Must not receive block header
    - Must not receive version message

Block delivery time > 20 min

Version message exchange
on connection initiation



Occupy all open connection slots
No new connections

Block delivery time > 20 min

1. Requirement for victim 

    - Must not receive block header
    - Must not receive version message

Block delivery time > 20 min

1. Requirement for victim 

    - Must not receive block header
    - Must not receive version message

2. Requirements for adversary 

    - Must be first relayer for all blocks
    - Should perform connection depletion

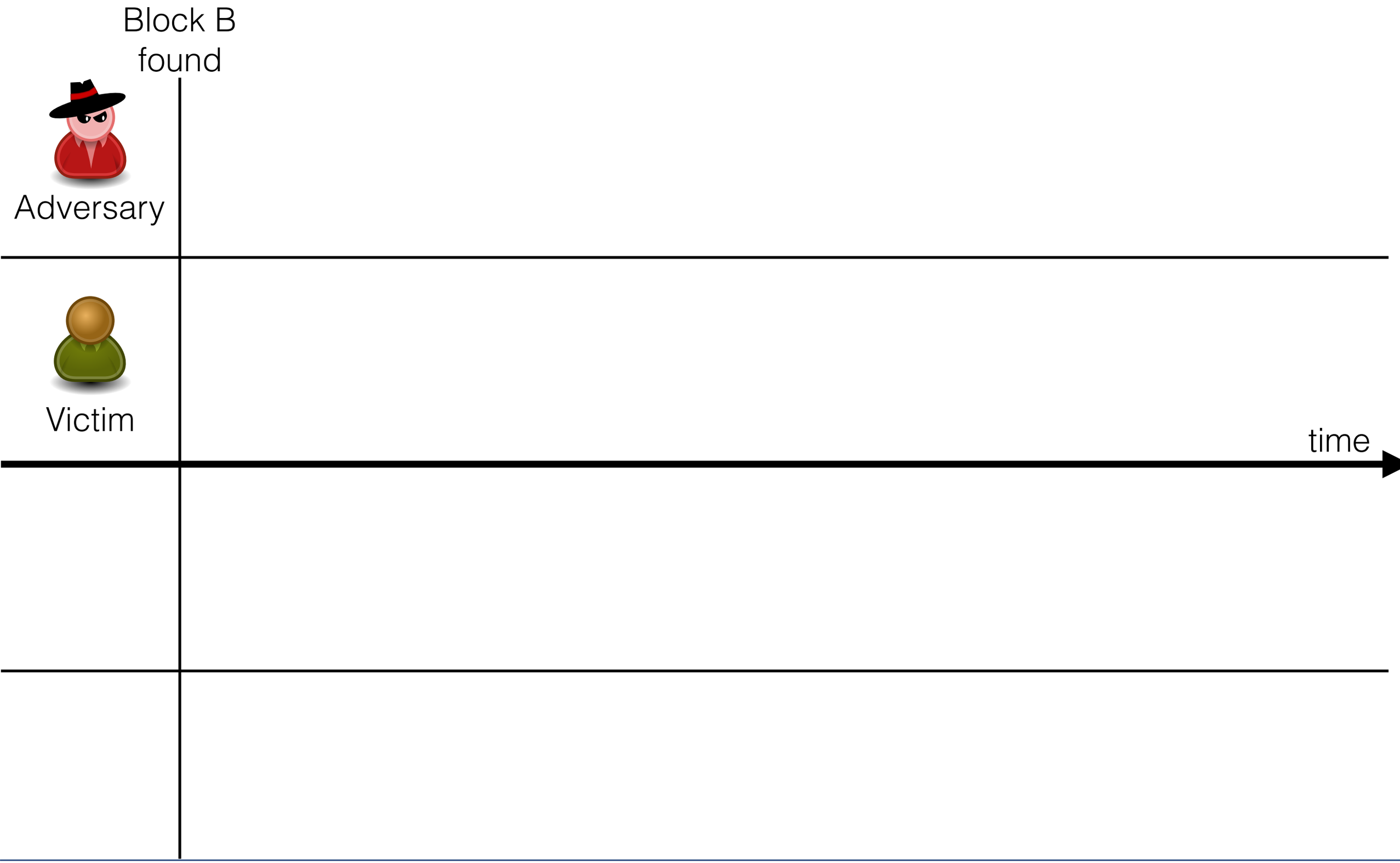
Extending the block delivery time - Example

Adversary

Victim

time

Extending the block delivery time - Example



Extending the block delivery time - Example

Block B found

Adversary

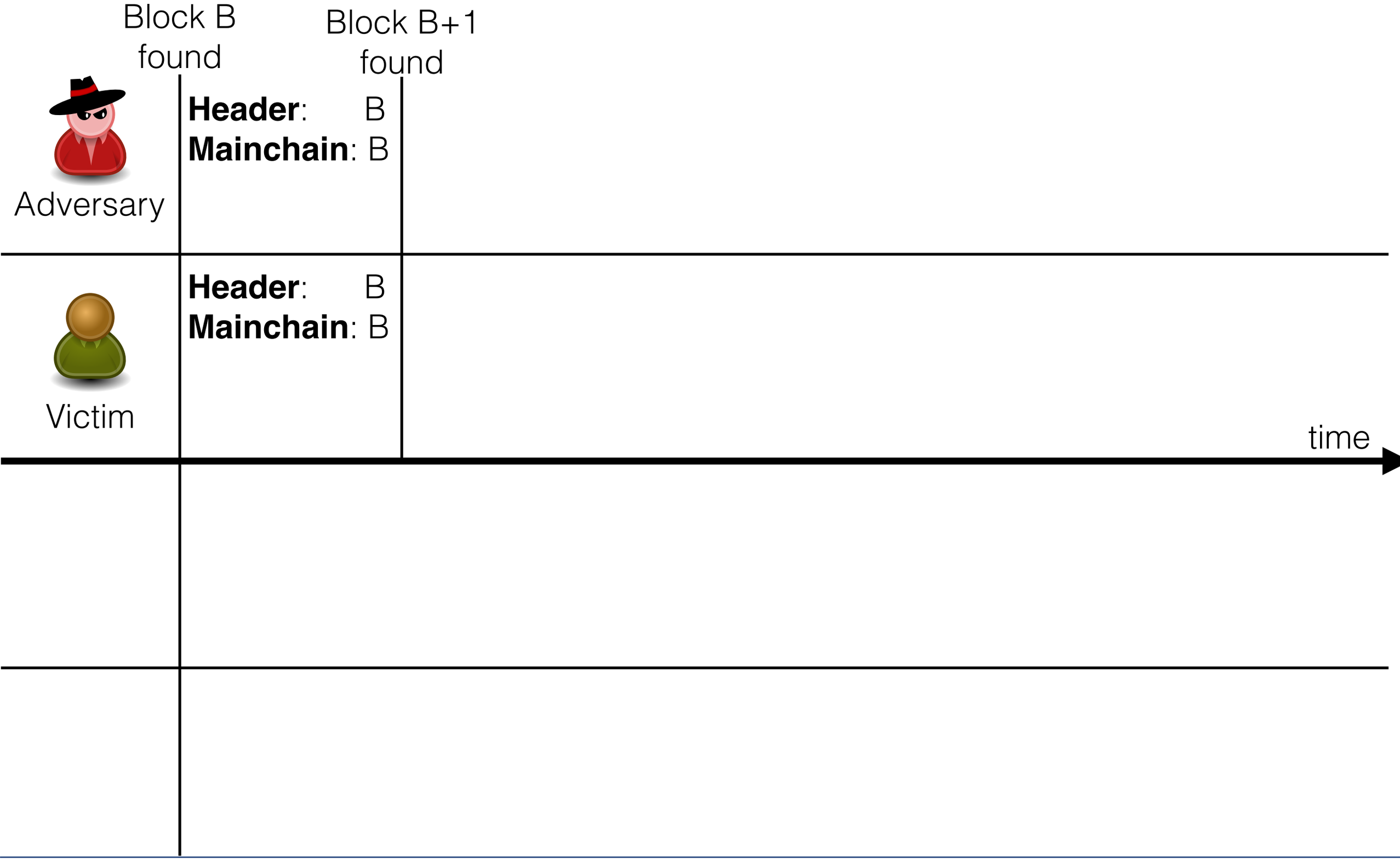
Header: B
Mainchain: B

Victim

Header: B
Mainchain: B

time

Extending the block delivery time - Example



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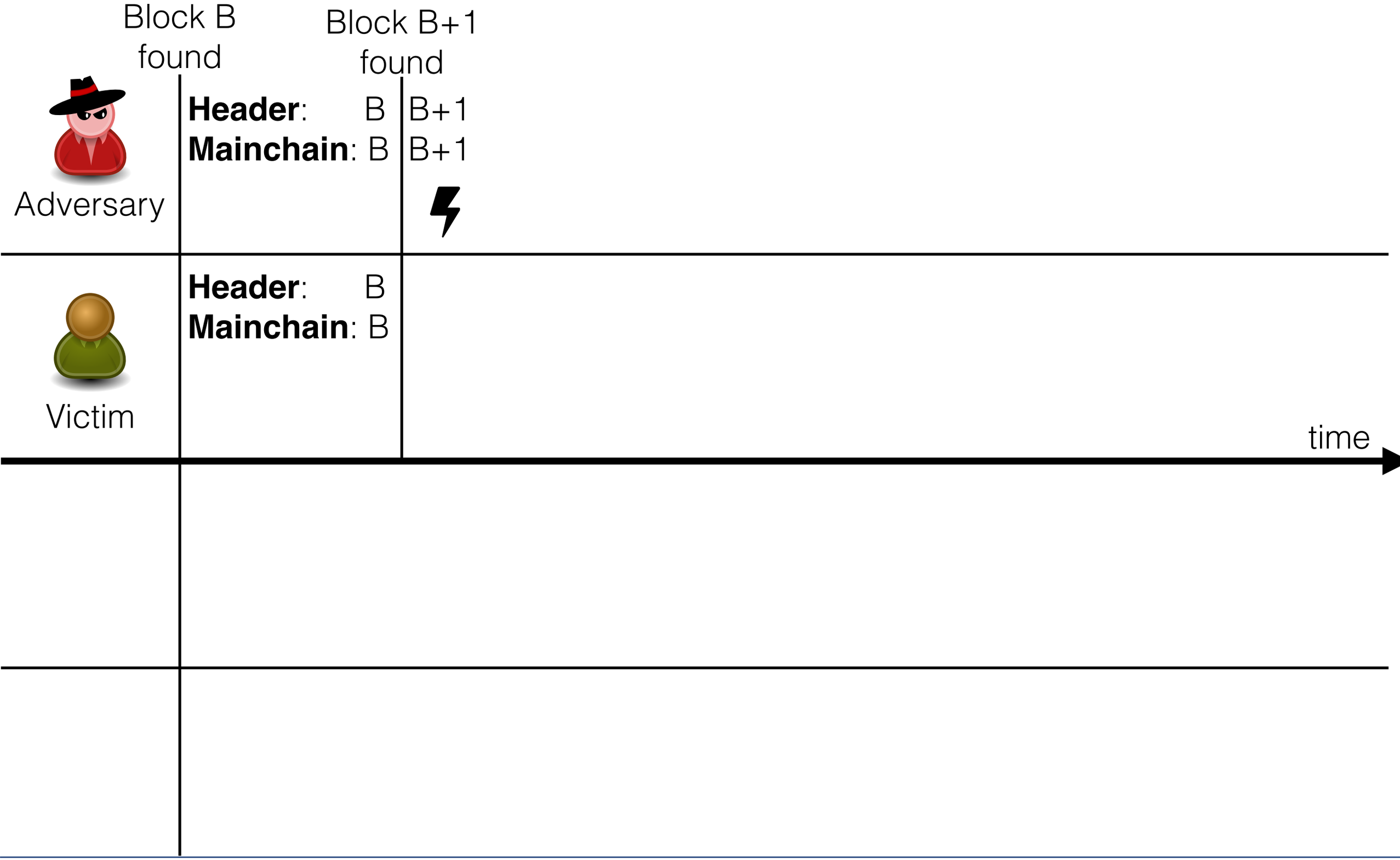

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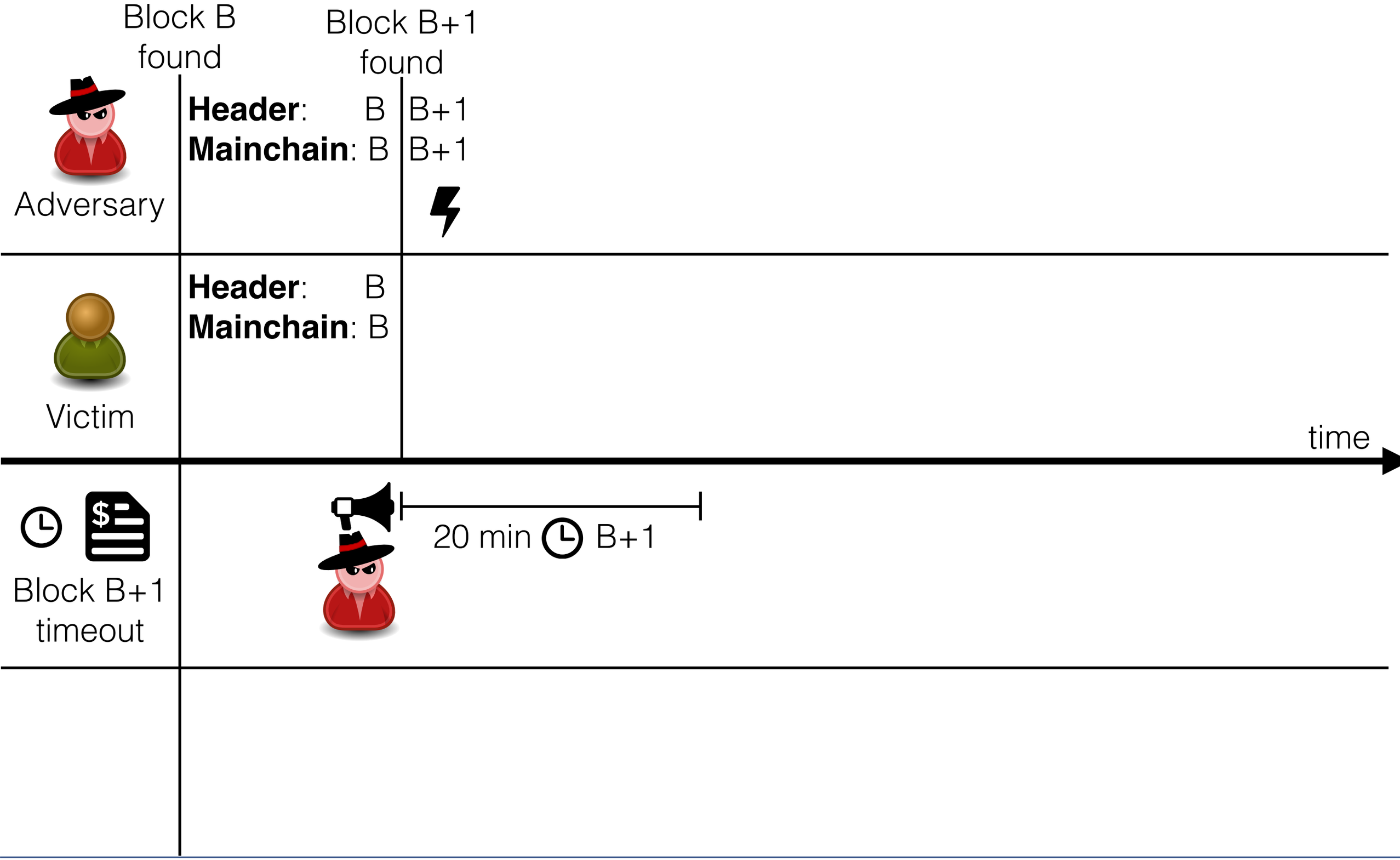

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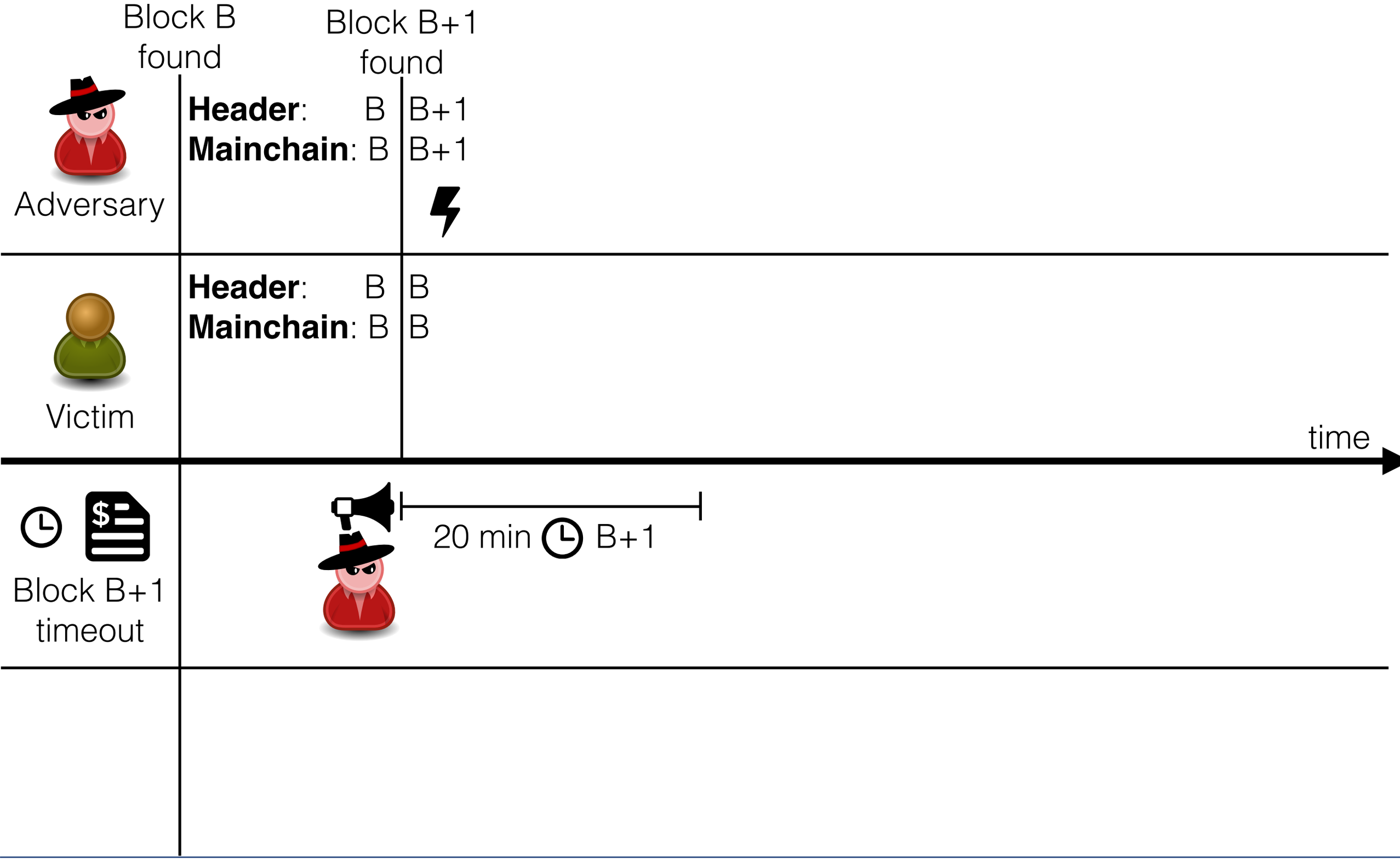

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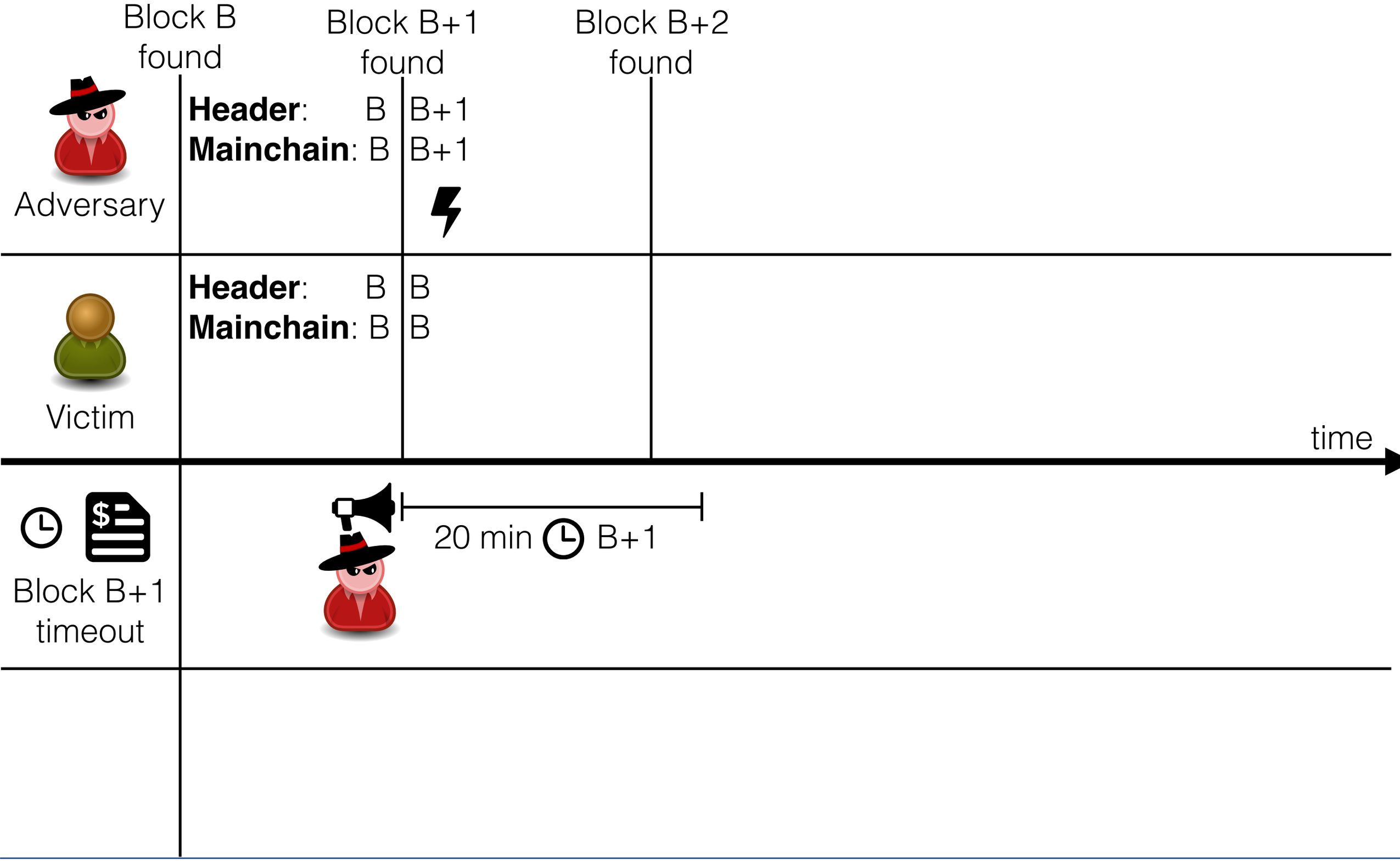

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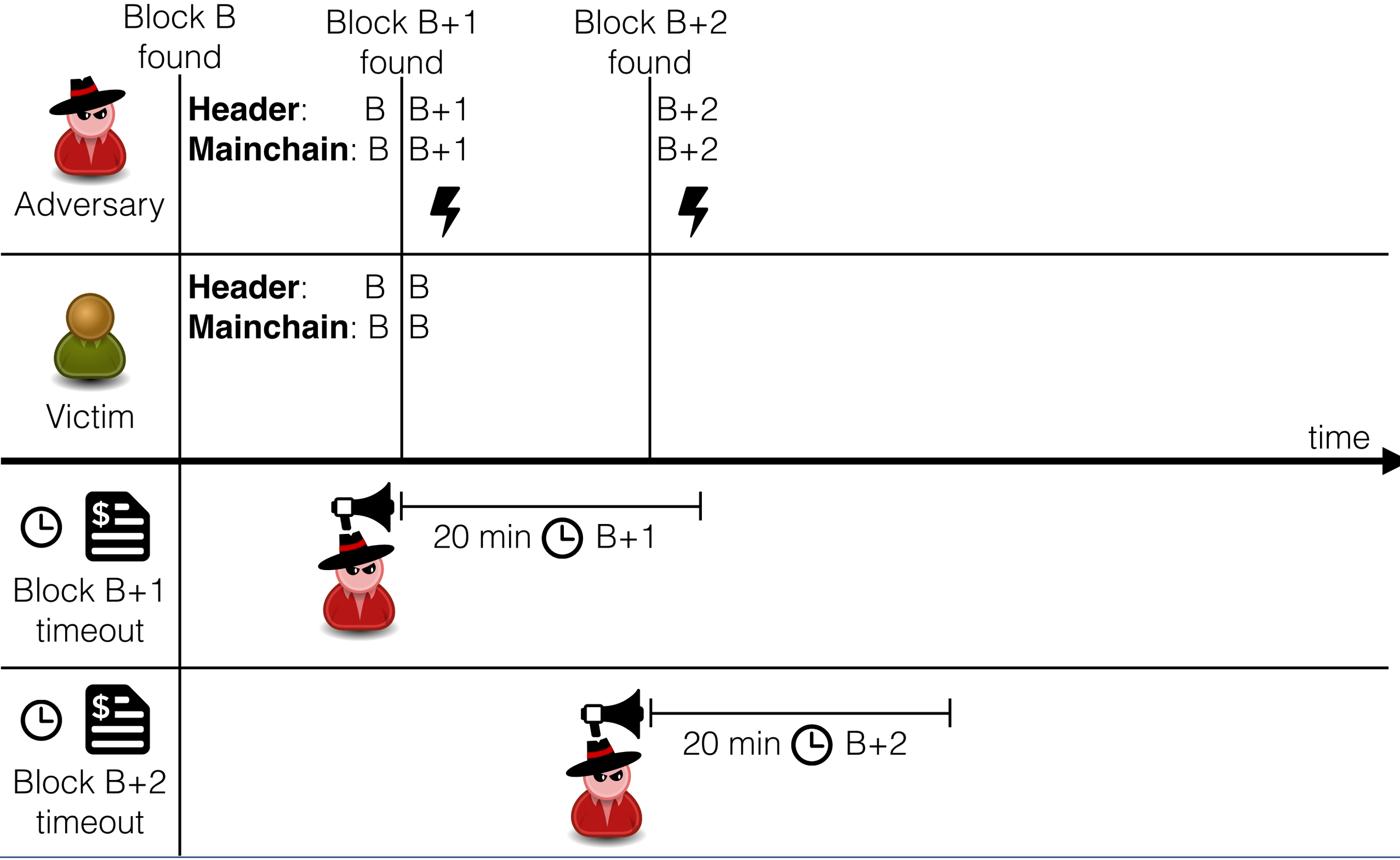


Extending the block delivery time - Example

	Block B found	Block B+1 found	Block B+2 found
Adversary	**Header**: B **Mainchain**: B	B+1 B+1	B+2 B+2
Victim	**Header**: B **Mainchain**: B	B B	B B

time

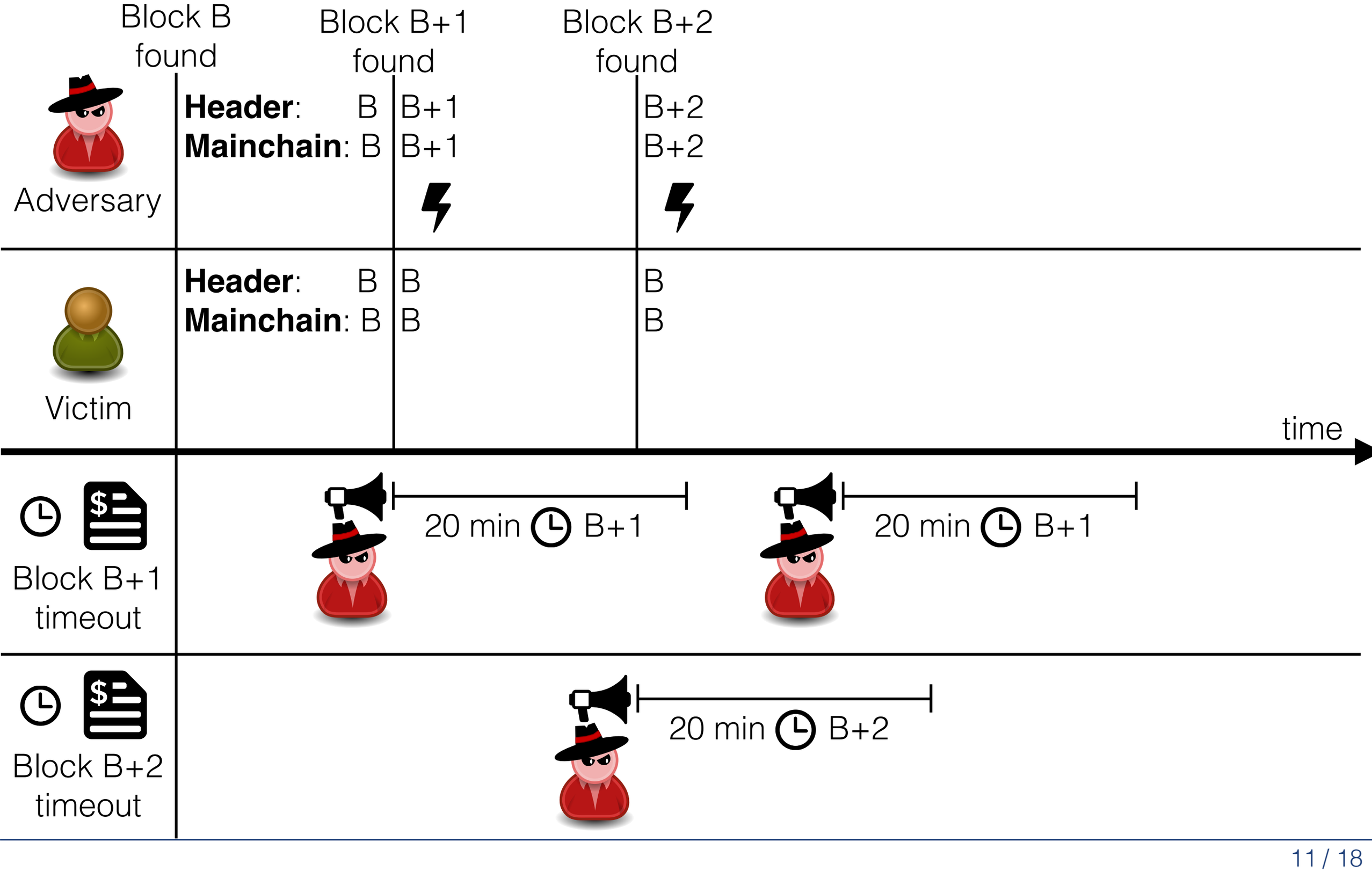
Block B+1 timeout

20 min B+1

Block B+2 timeout

20 min B+2

Extending the block delivery time - Example



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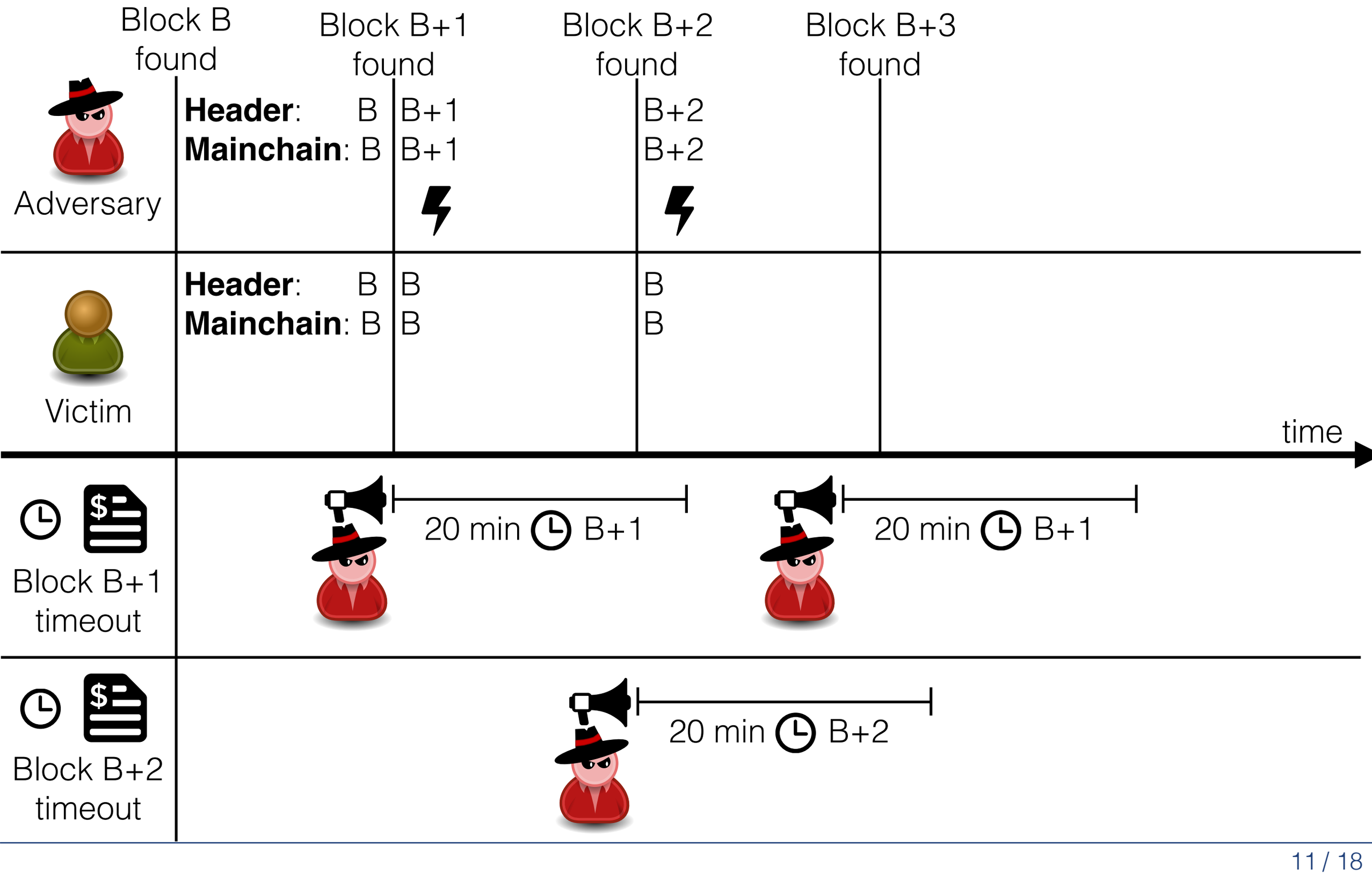

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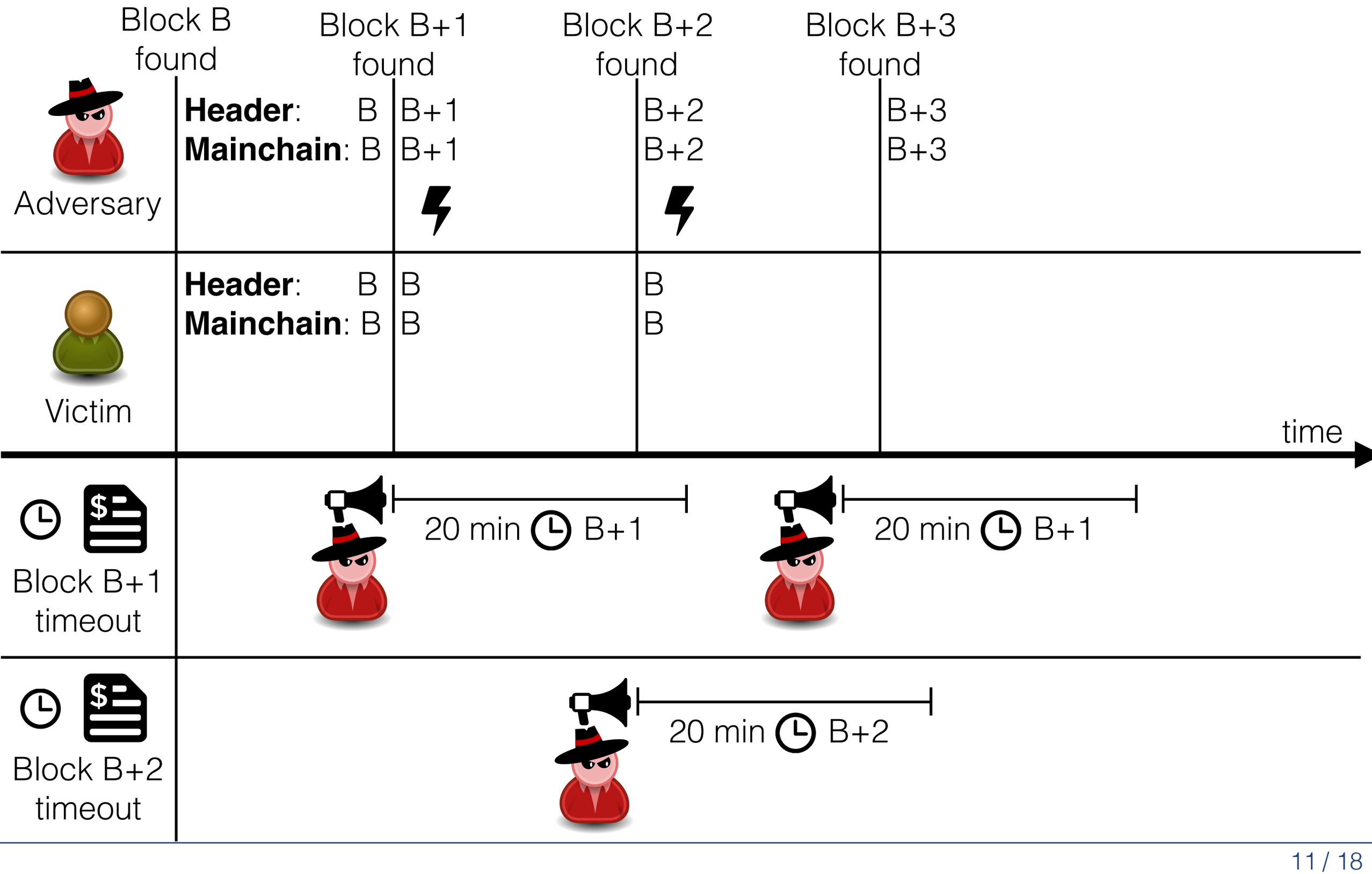

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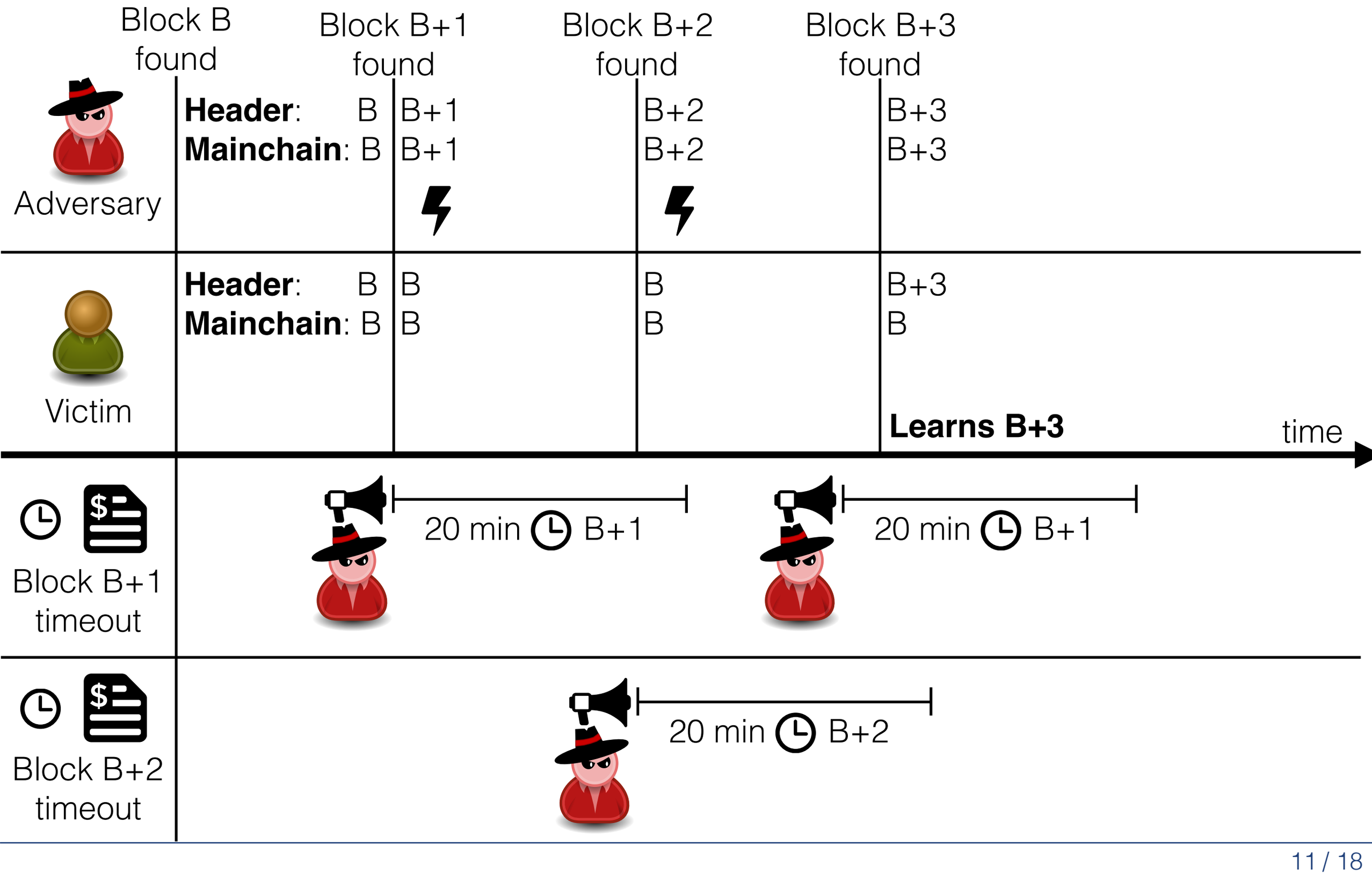

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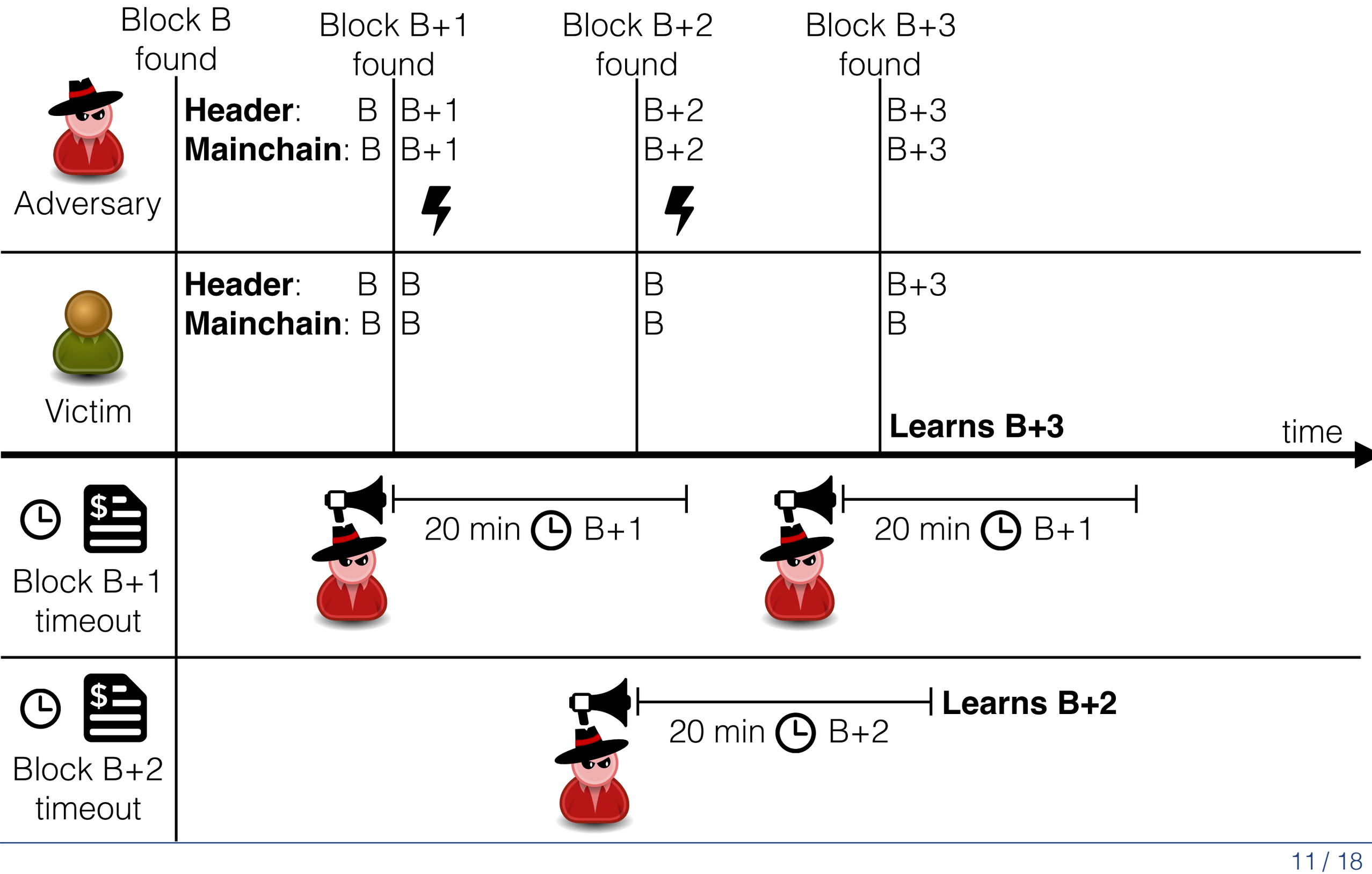

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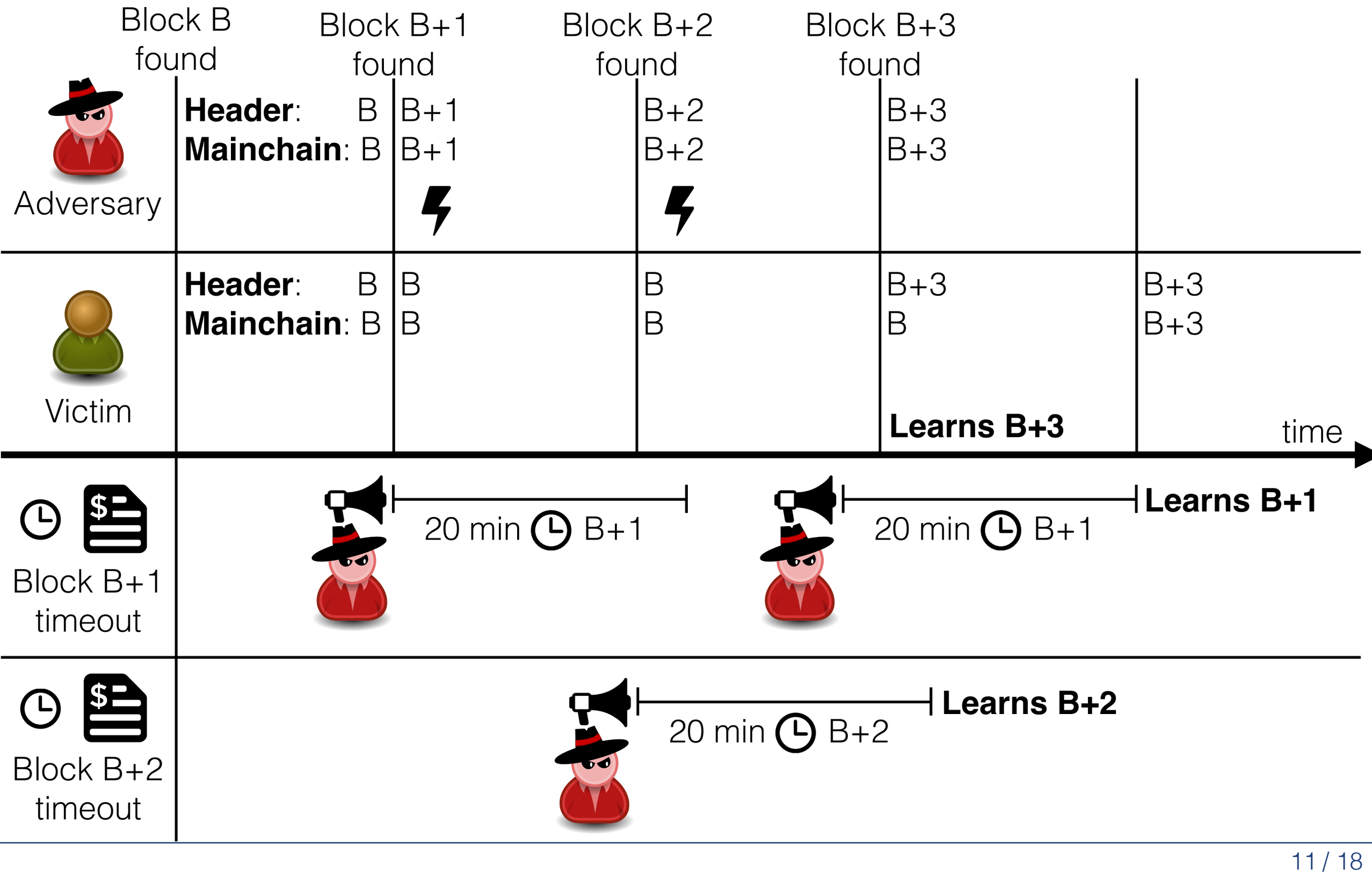
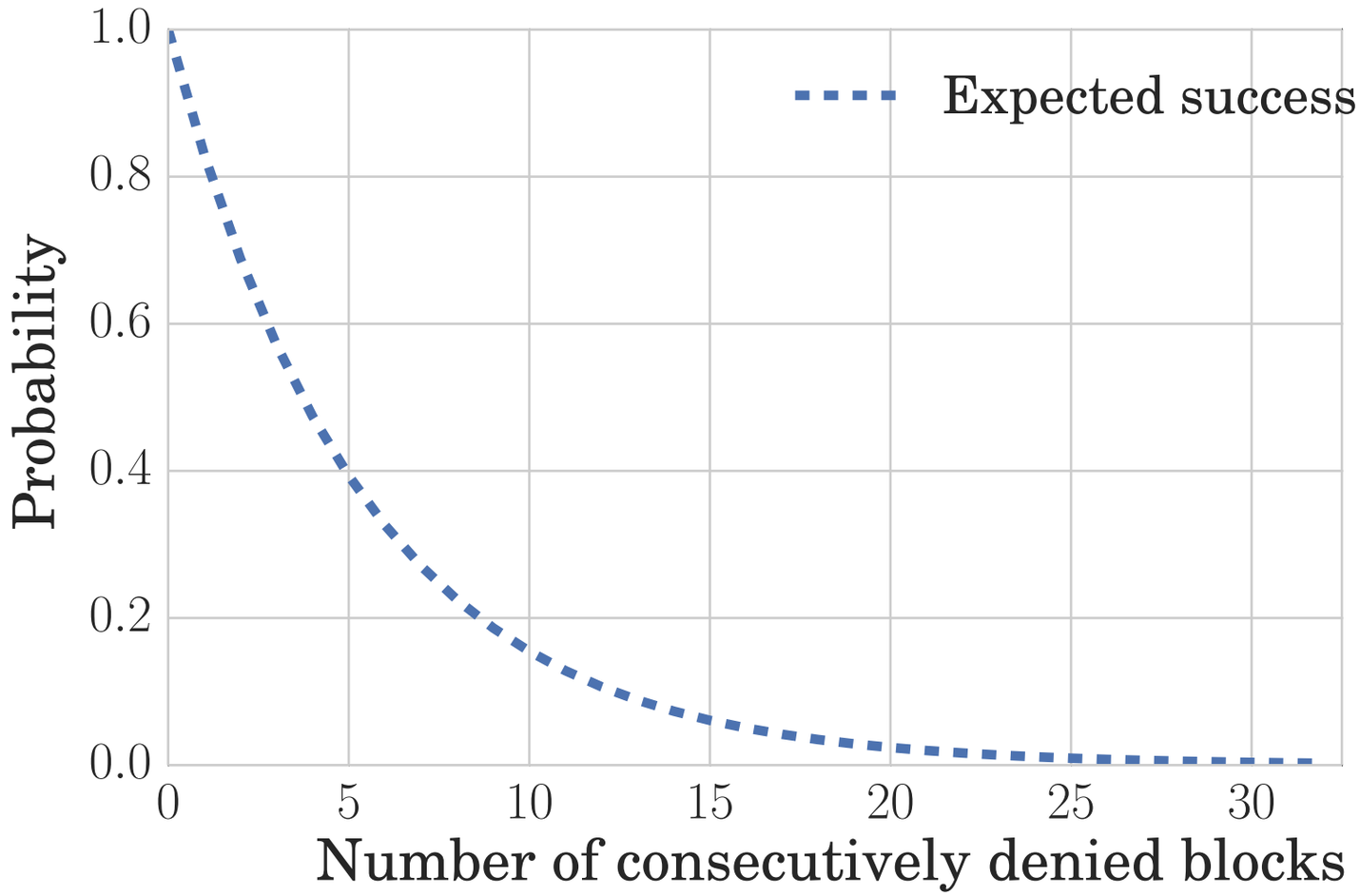


Experimental validation - Continuous block denial



Probability for N blocks = P^N

based on P = 0.83

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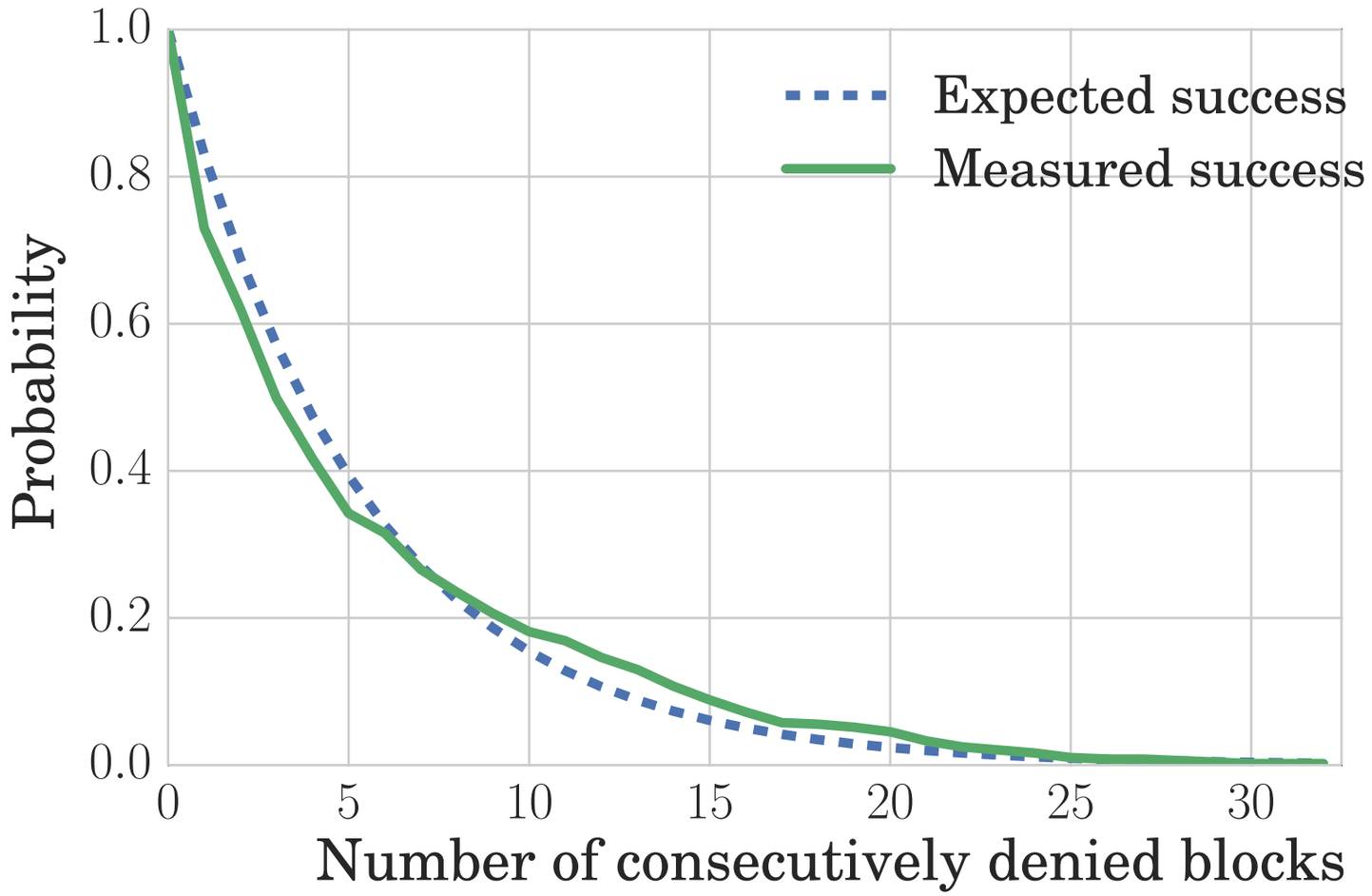

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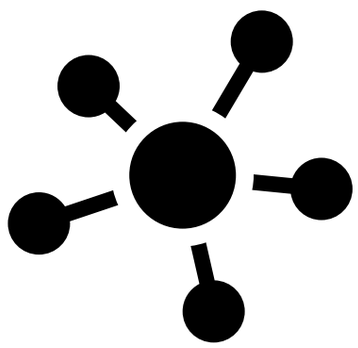
What is Double Spending?

Spending money more than once

$TX_{legitimate}$ - Pays the vendor

$TX_{doublespend}$ - Pays the adversary



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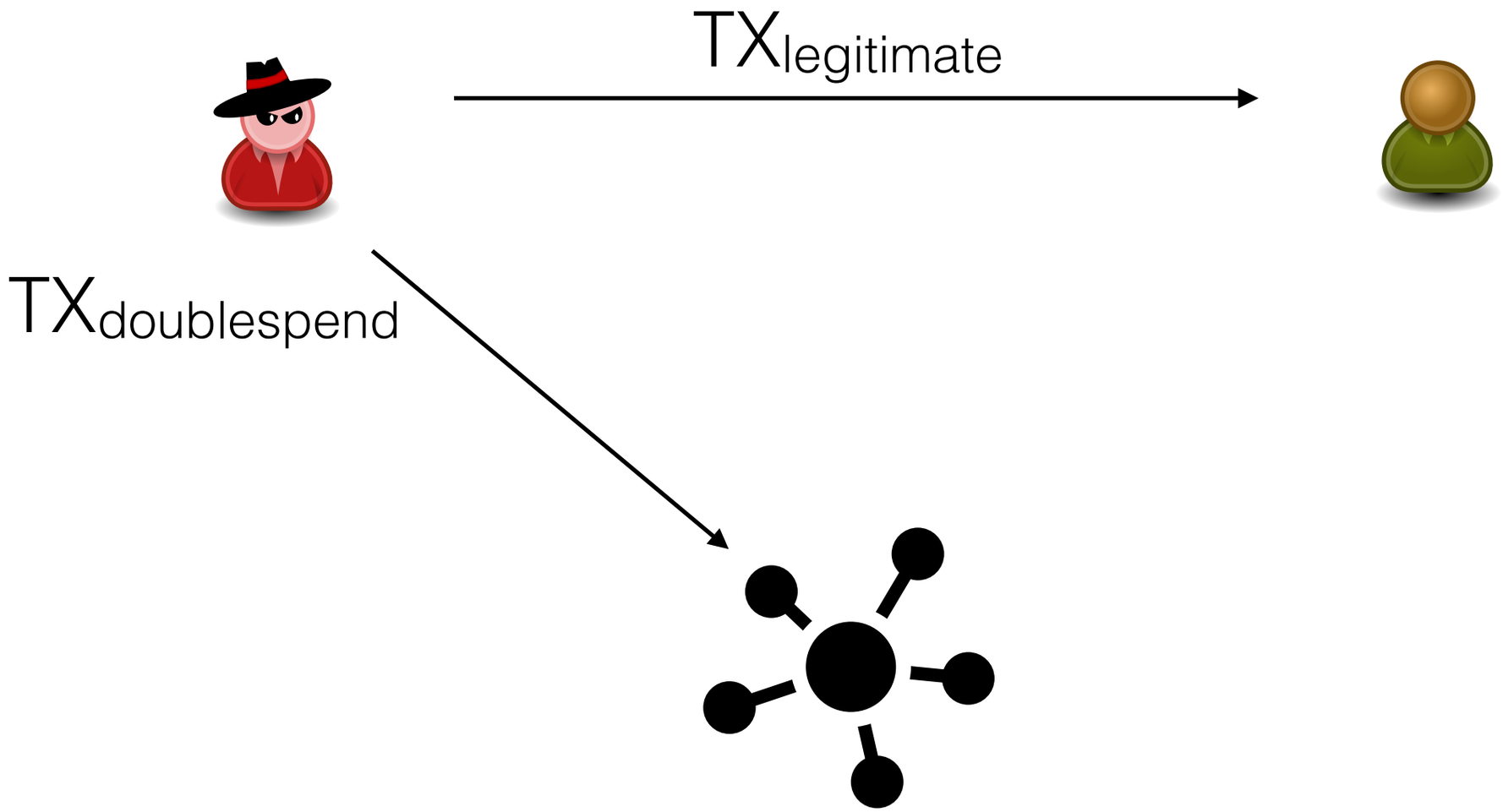

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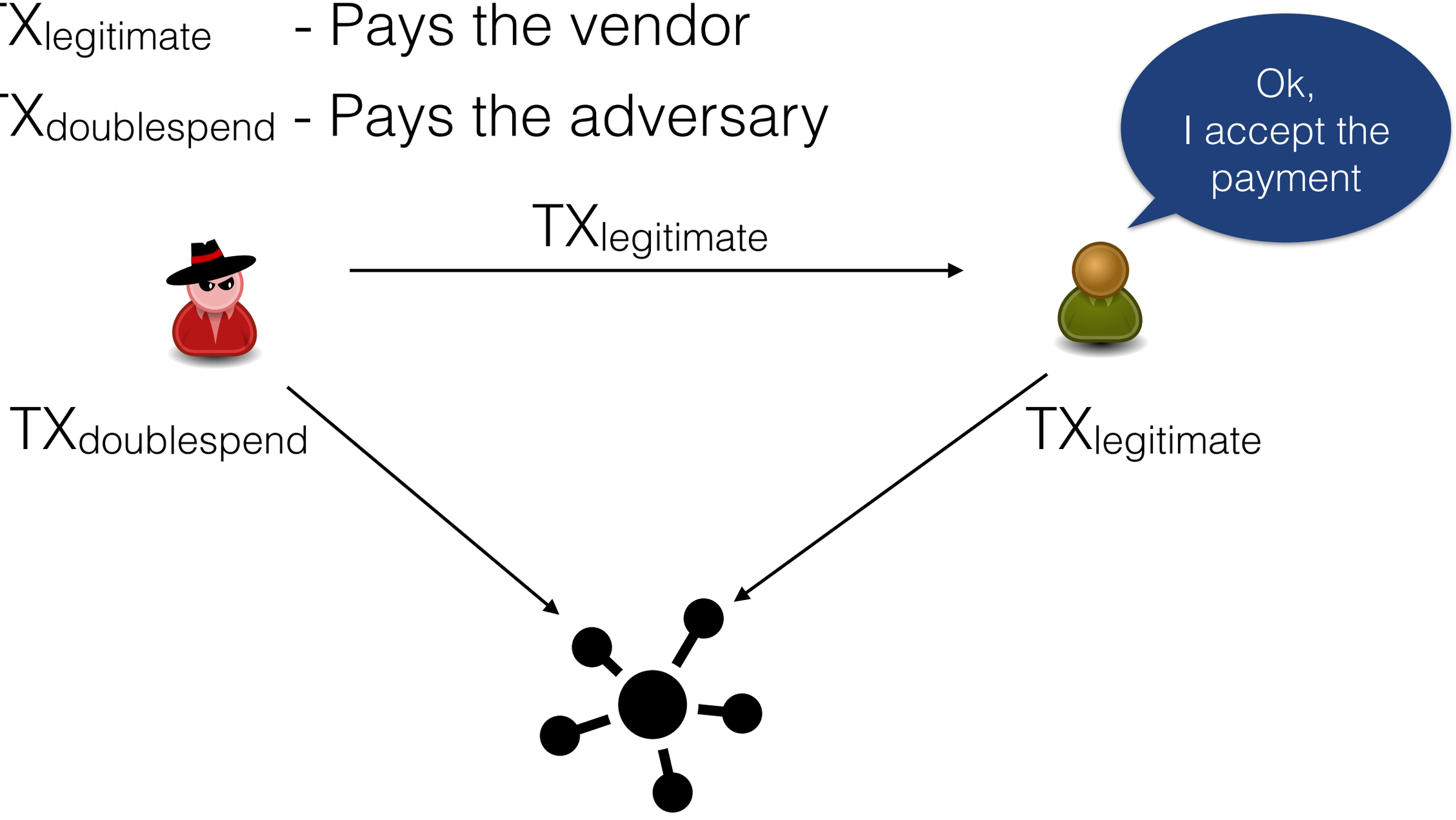

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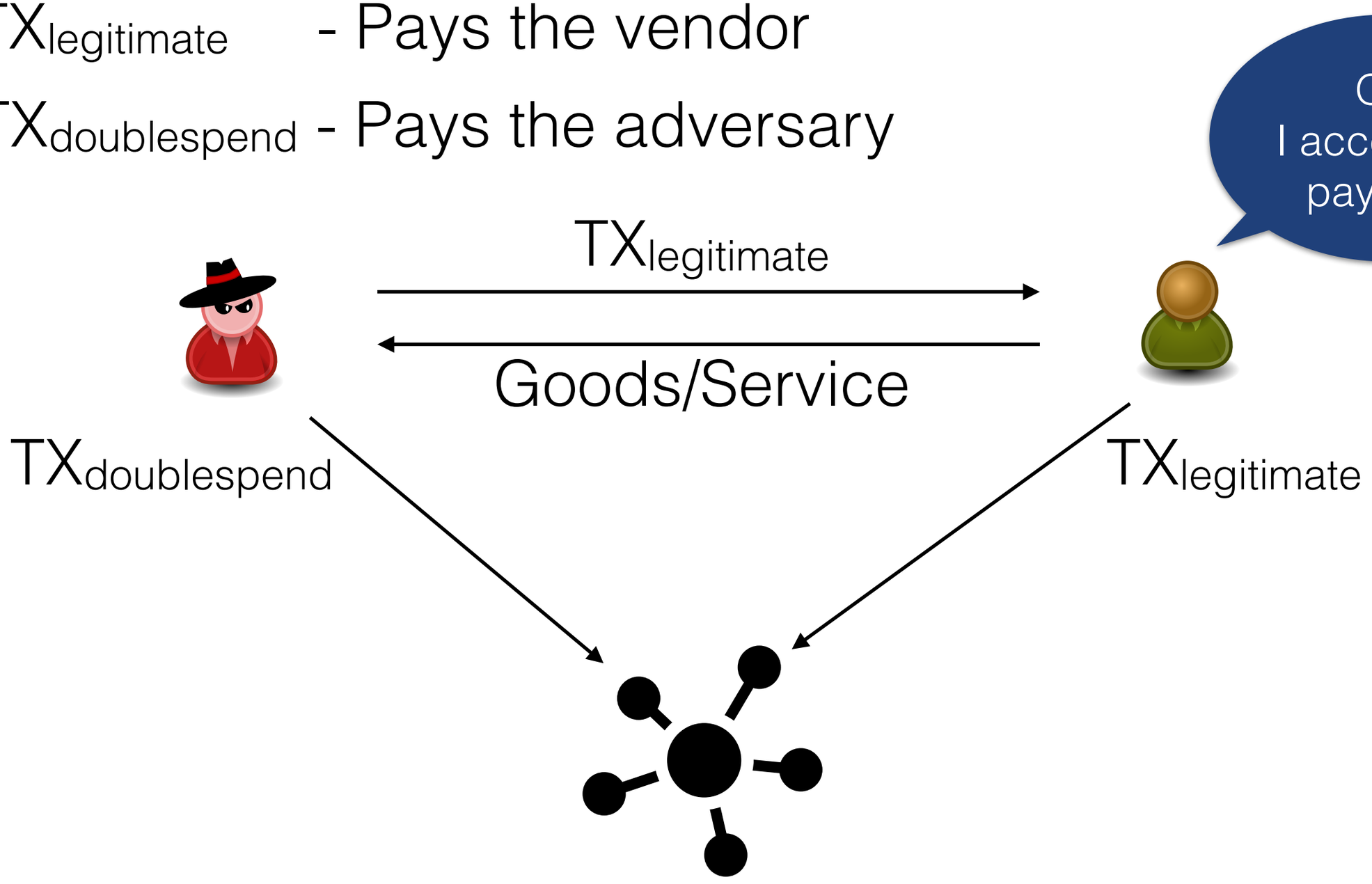

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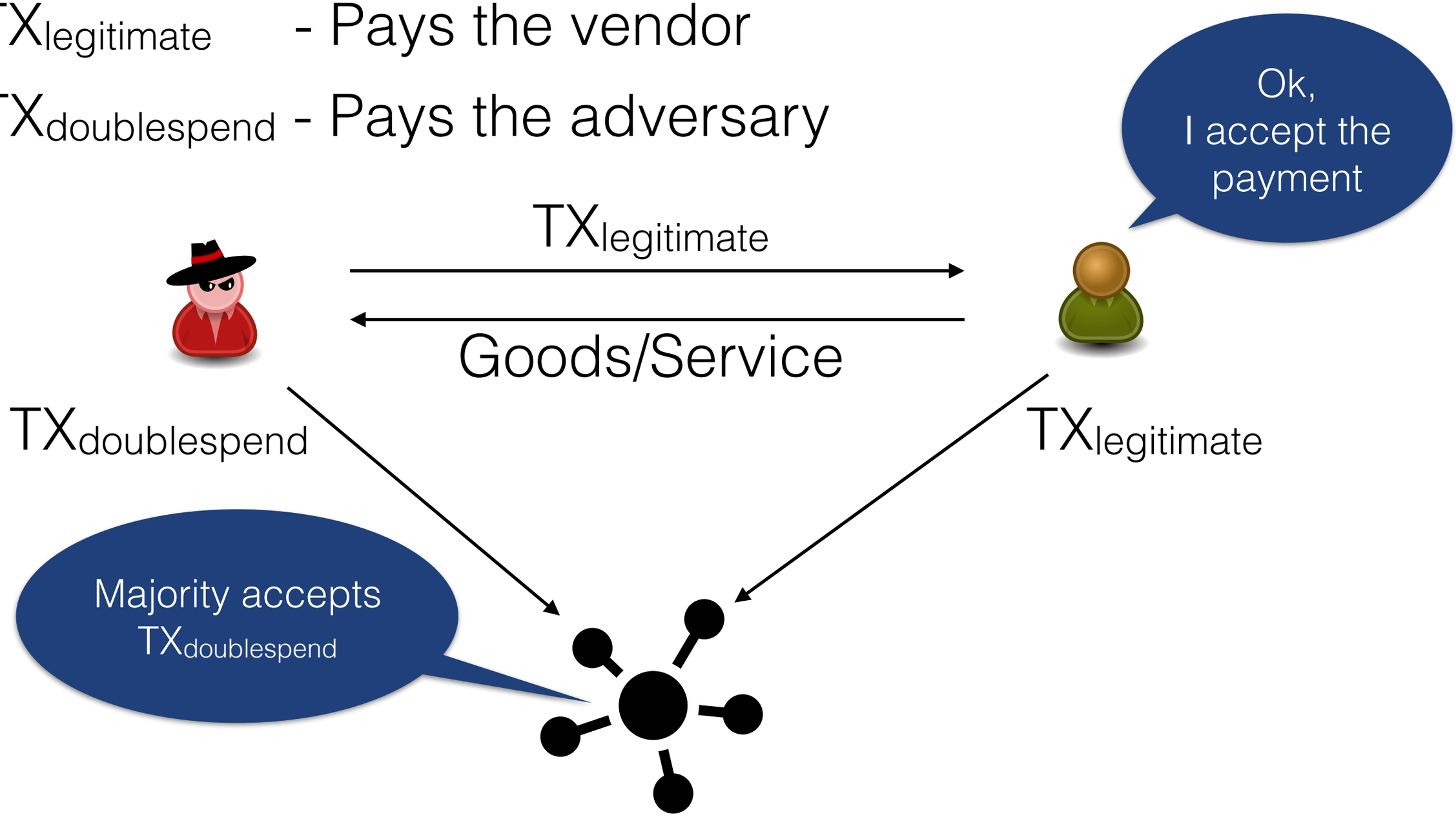

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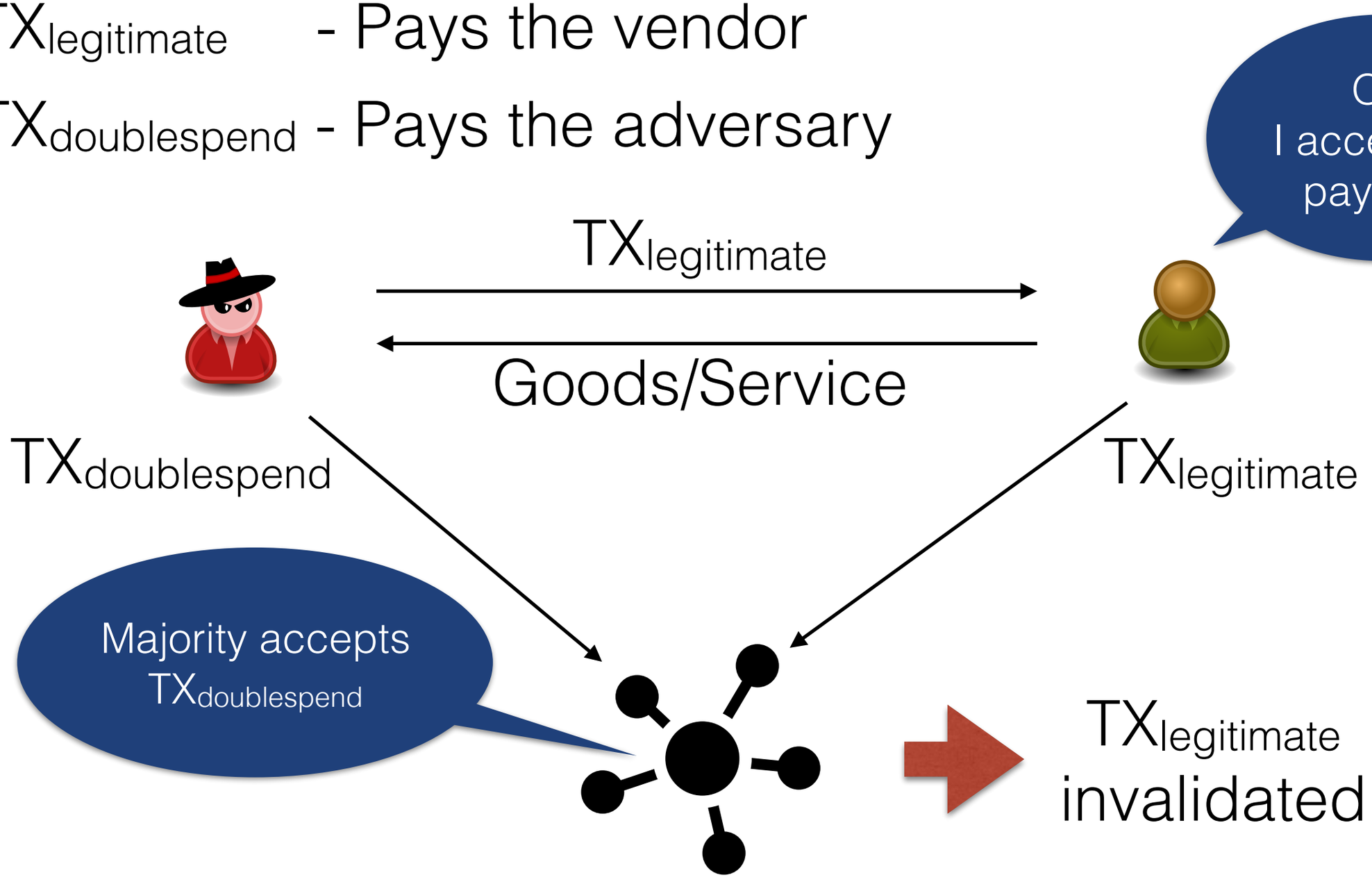
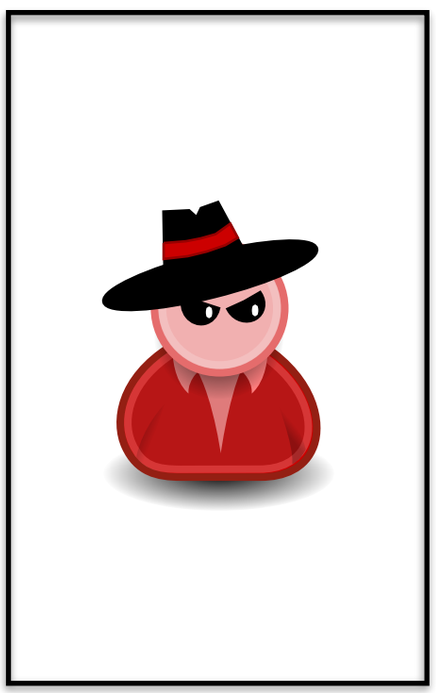
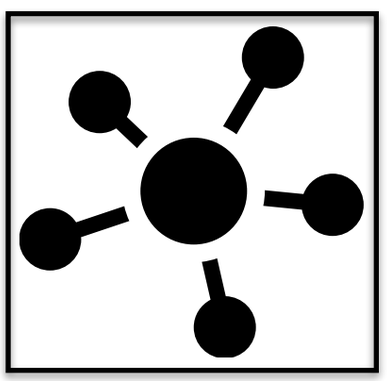


Double Spending 0 Confirmation Transactions

- Very reliable attack
- Regardless of protection (double spend relay)



Vendor



Bitcoin Network

Double Spending 0 Confirmation Transactions

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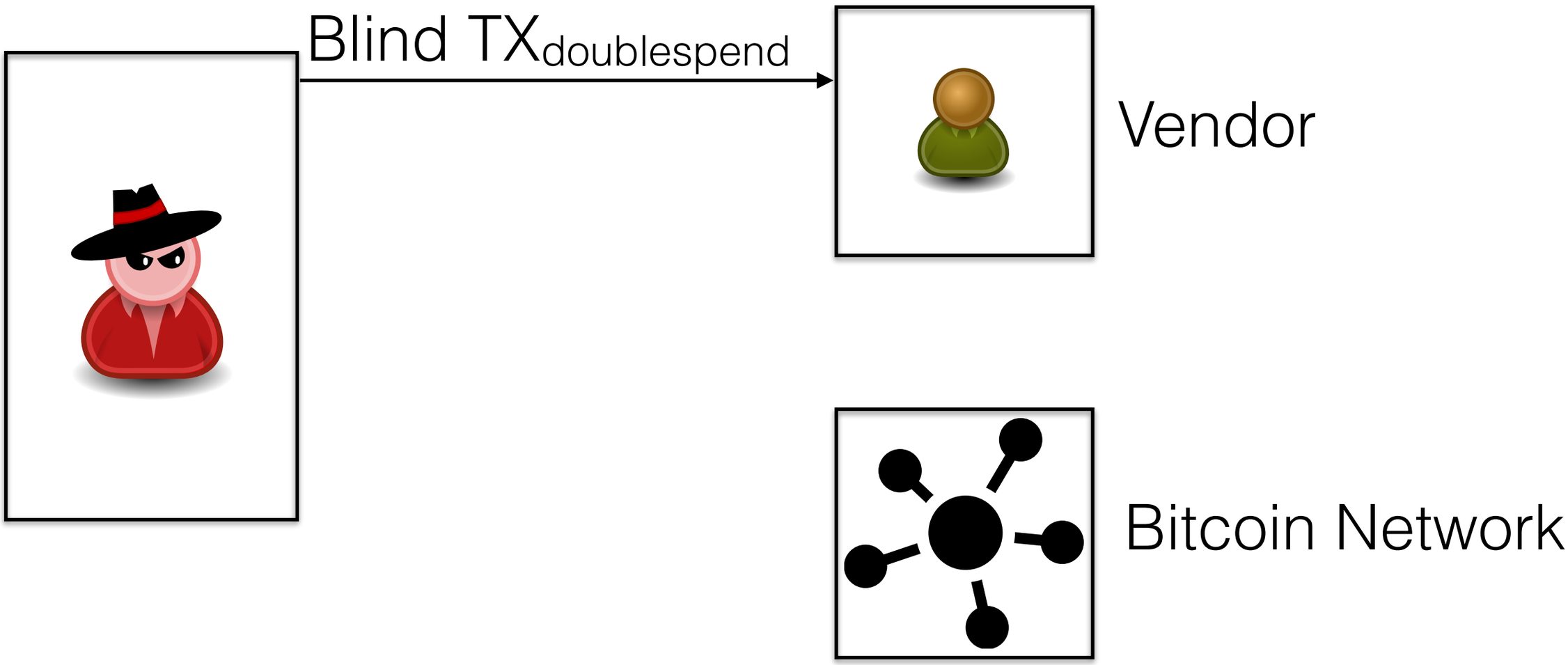

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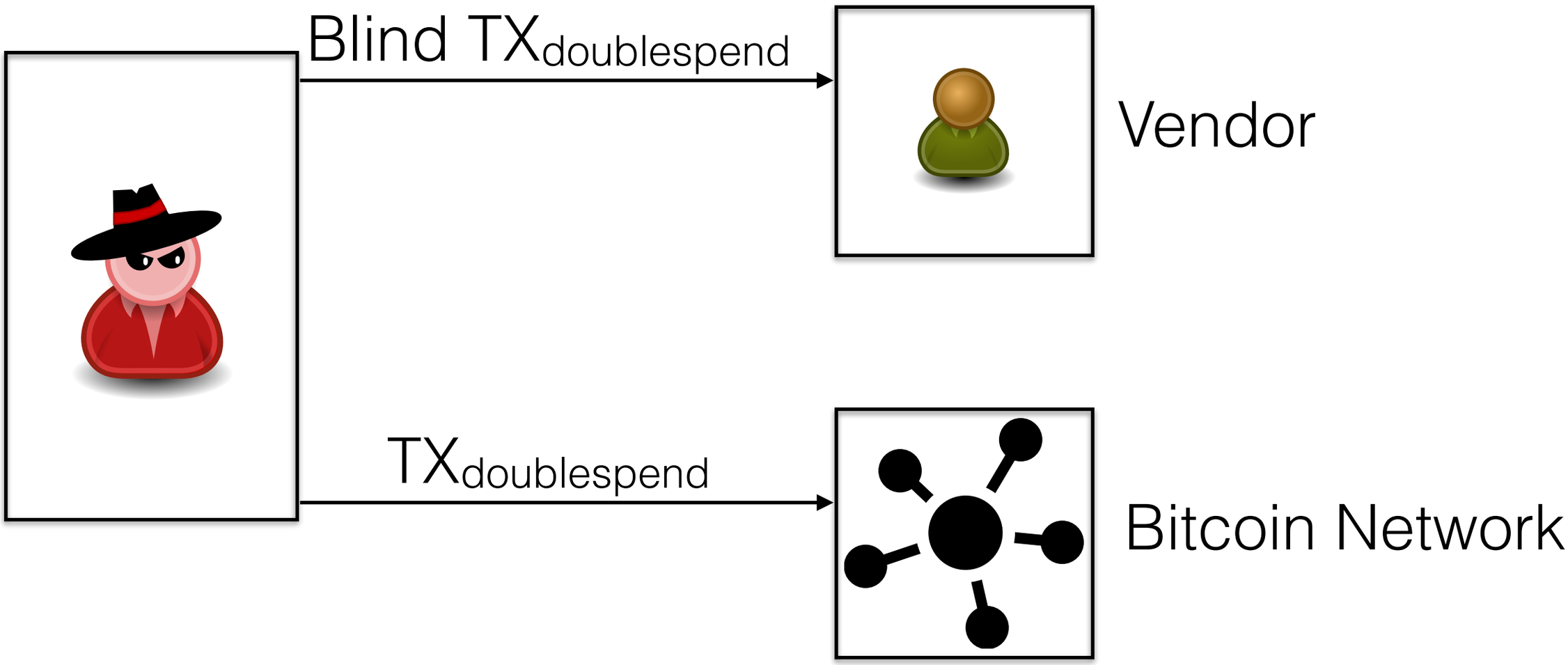

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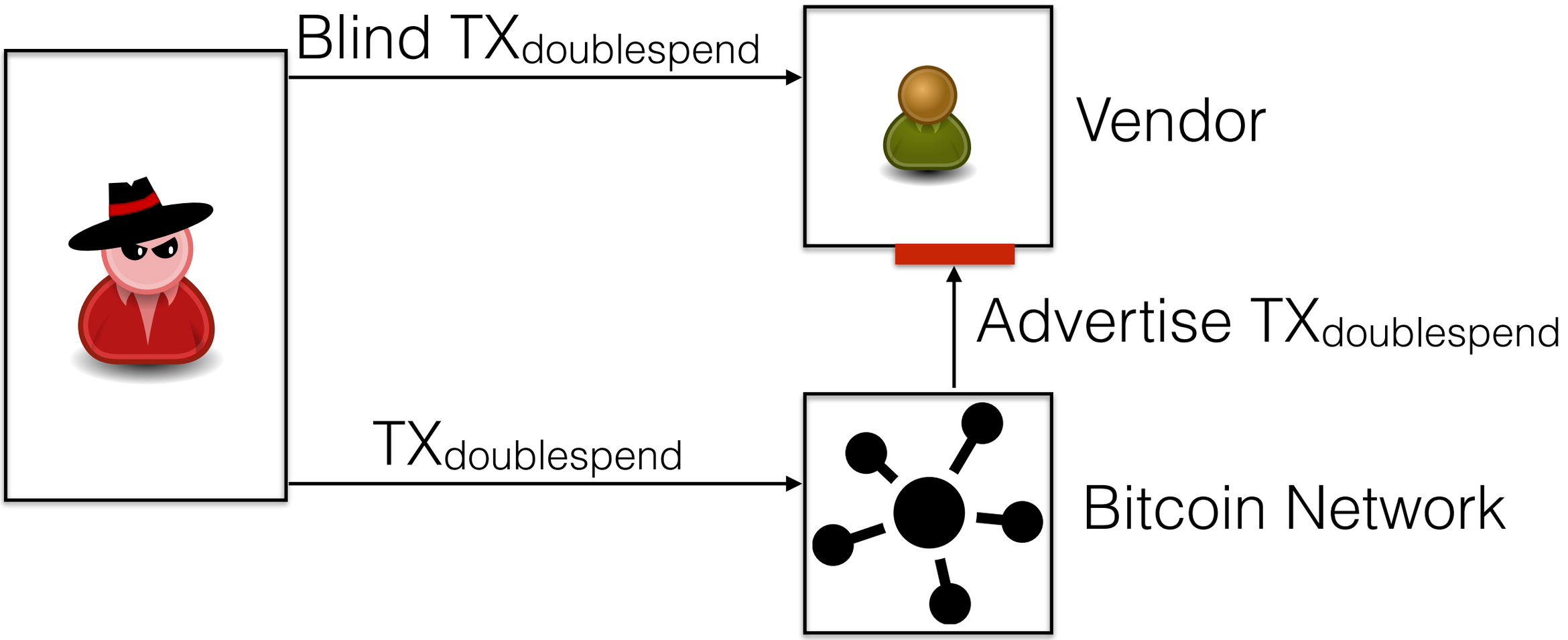

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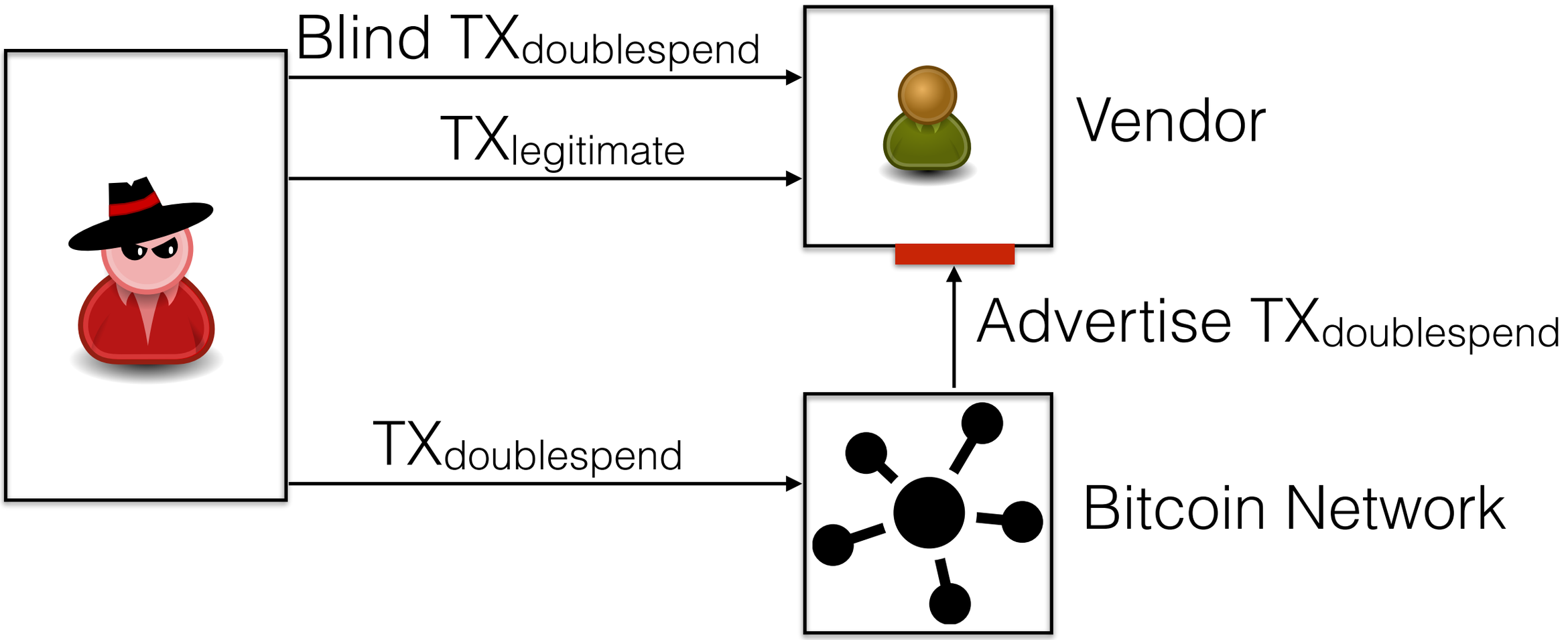

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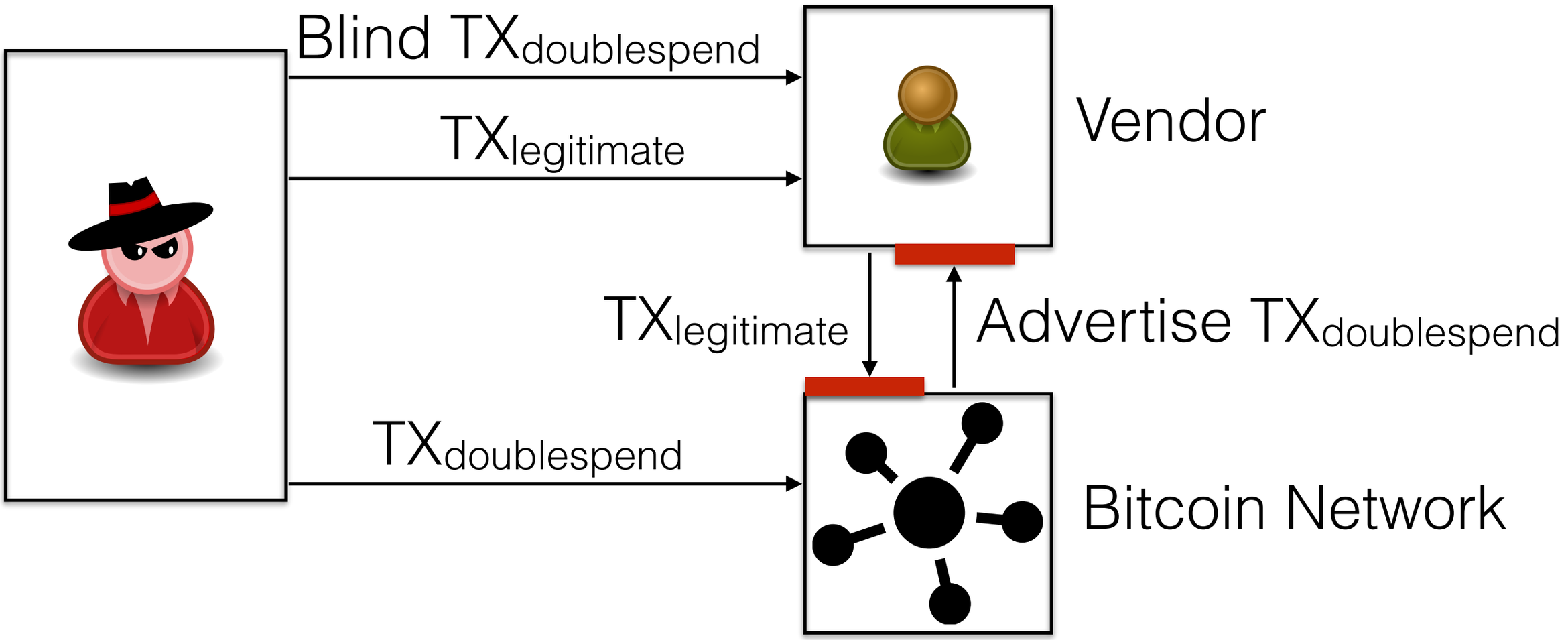

Denial of Service

6000 reachable Bitcoin nodes

Preventing the delivery of blocks to these

- 450 000 TCP connections required
- 600 KB of advertisement / block / 20 min

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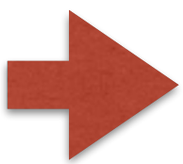


Network wide Denial of Service

Hardening the P2P overlay network

1. Why not smaller static timeouts?

2. Why not requesting from multiple peers?

3. What about alternative relay networks?

Security vs Scalability tradeoffs

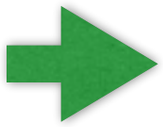
Hardening the P2P overlay network

1. Dynamic timeouts

Hardening the P2P overlay network

1. Dynamic timeouts

2. Handling Transaction Advertisements
   - **Filtering by IP address**
   - Randomly choosing sender



First request from one peer, then two, then three…

Hardening the P2P overlay network

1. Dynamic timeouts

2. Handling Transaction Advertisements
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   ➡ First request from one peer, then two, then three…

3. Updating Block Advertisements:
   - **Broadcast header instead of hash**
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Summary

Scalability measures impact security

Blind victim from blocks and transactions

- Minimum 20 minutes
- 1 connection sufficient per target

Summary

ETH zürich

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Show impact

- Double Spending
- Aggravated selfish mining
- Affordable Denial of Service

Summary

ETH zürich

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Proposal to harden the network

- Hardening measures
- Estimation of waiting time for secure transactions

Summary

Scalability measures impact security

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Thank you!

Show impact

- Double Spending
- Aggravated selfish mining
- Affordable Denial of Service

Proposal to harden the network

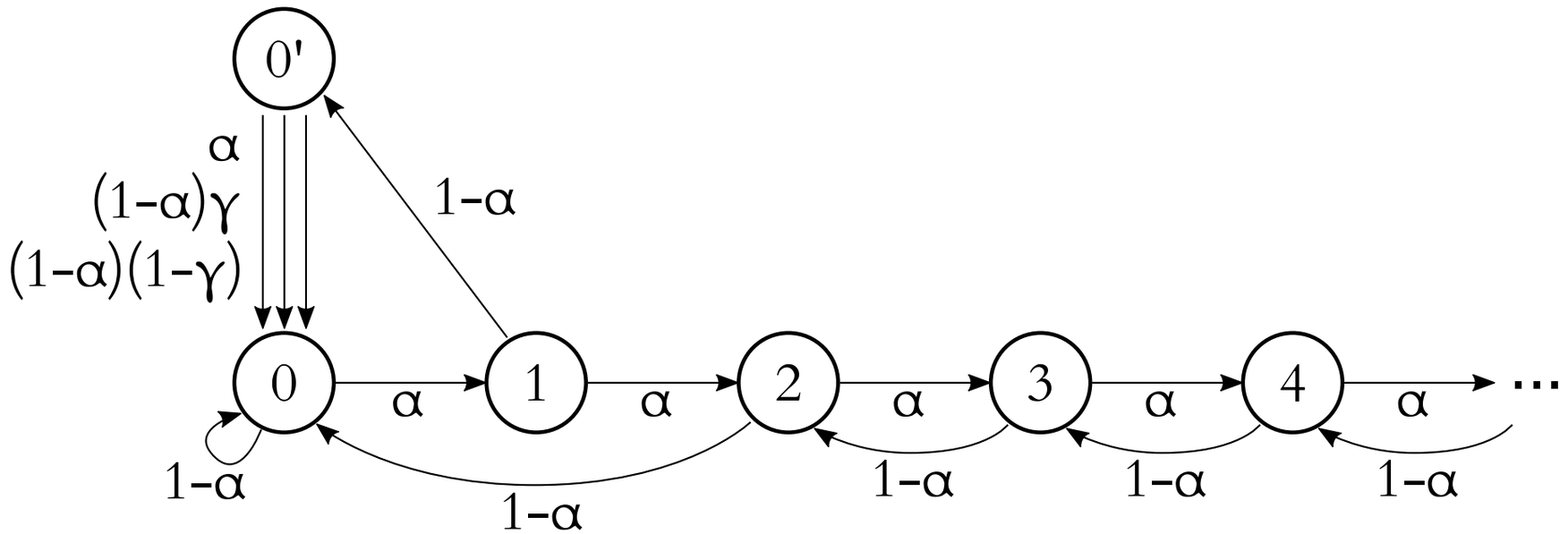
- Hardening measures
- Estimation of waiting time for secure transactions

Implications - Increasing Mining Advantage

Idea from Eyal et. al:

- Instead of publishing, keep a block private

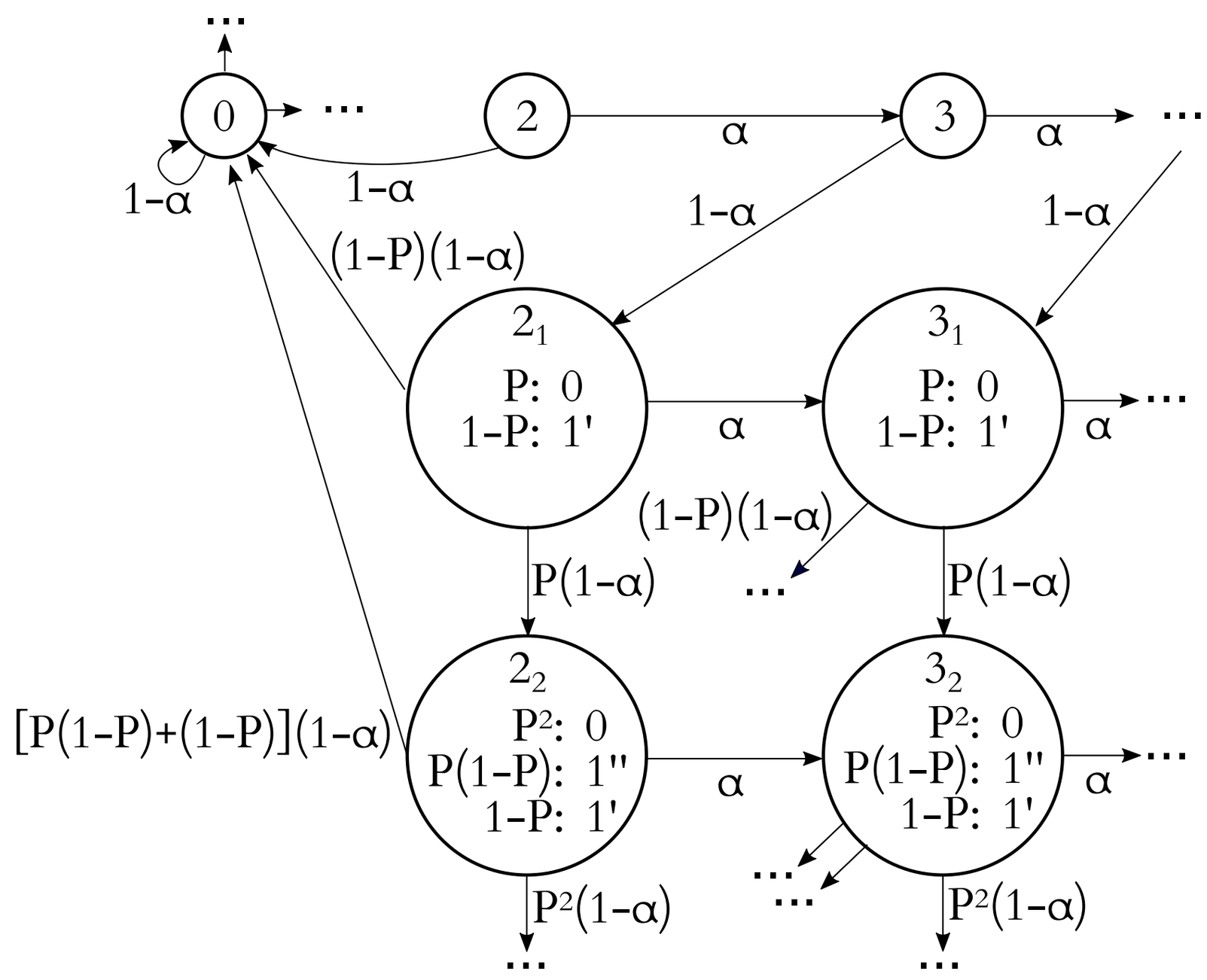
➡ Other miners will perform wasteful computations



α : hashing power of adversary

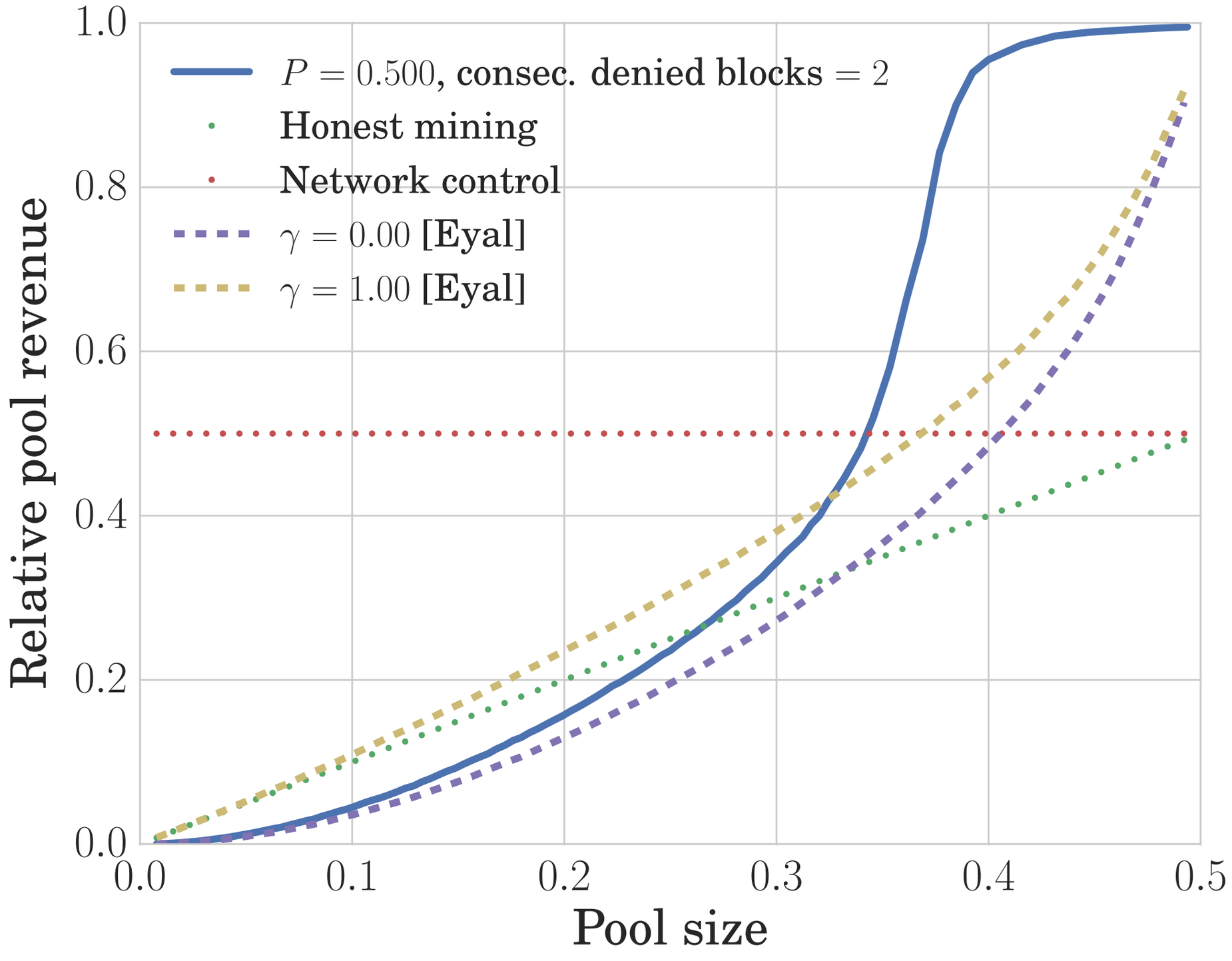
γ : propagation parameter

Implications - Increasing Mining Advantage

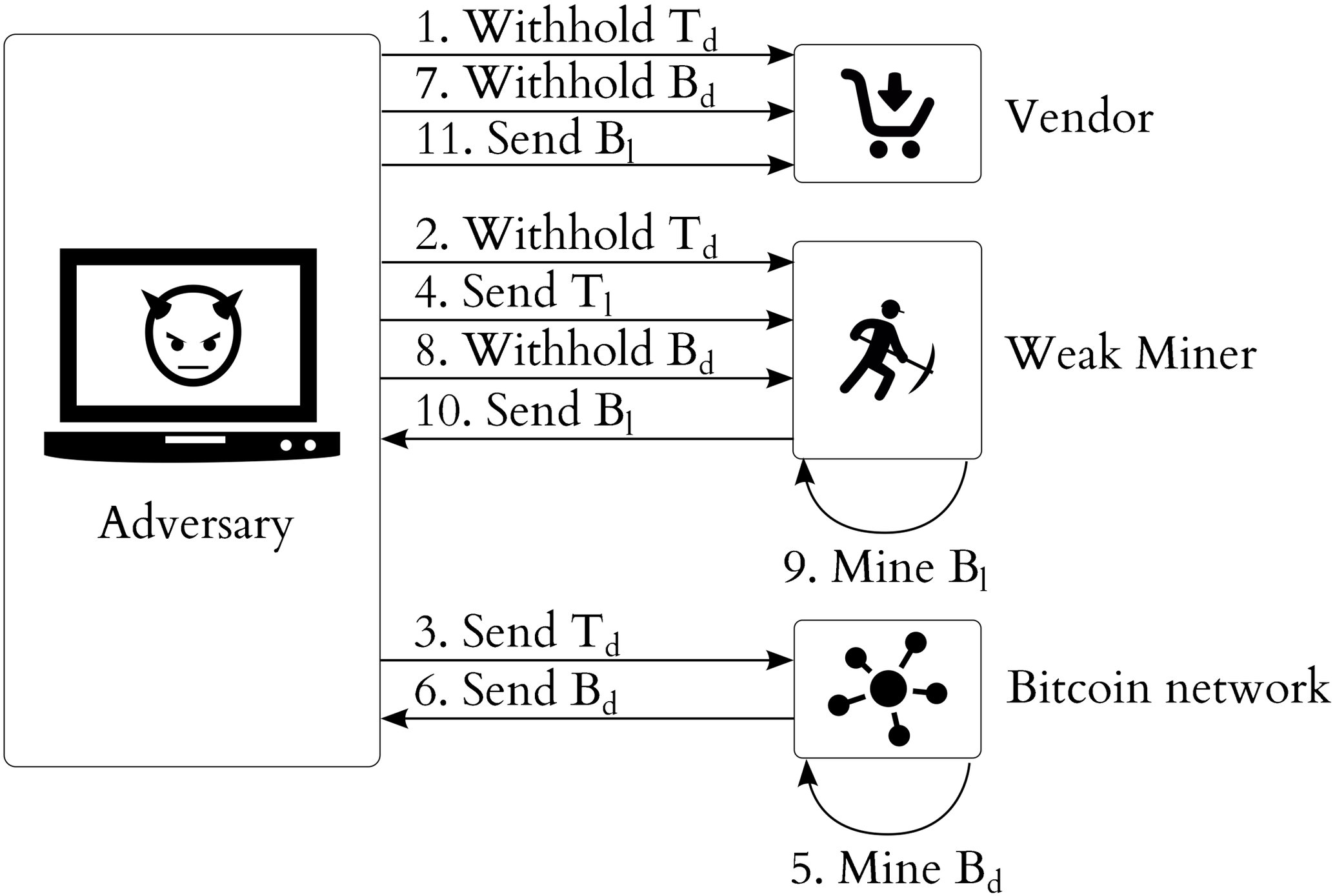


P: probability to deny a block to a miner

Implications - Increasing Mining Advantage



Implications - Double Spending 1 Confirmation Transactions



X**l** = legitimate
X**d** = double spend attempt

Hardening the P2P overlay network

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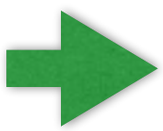
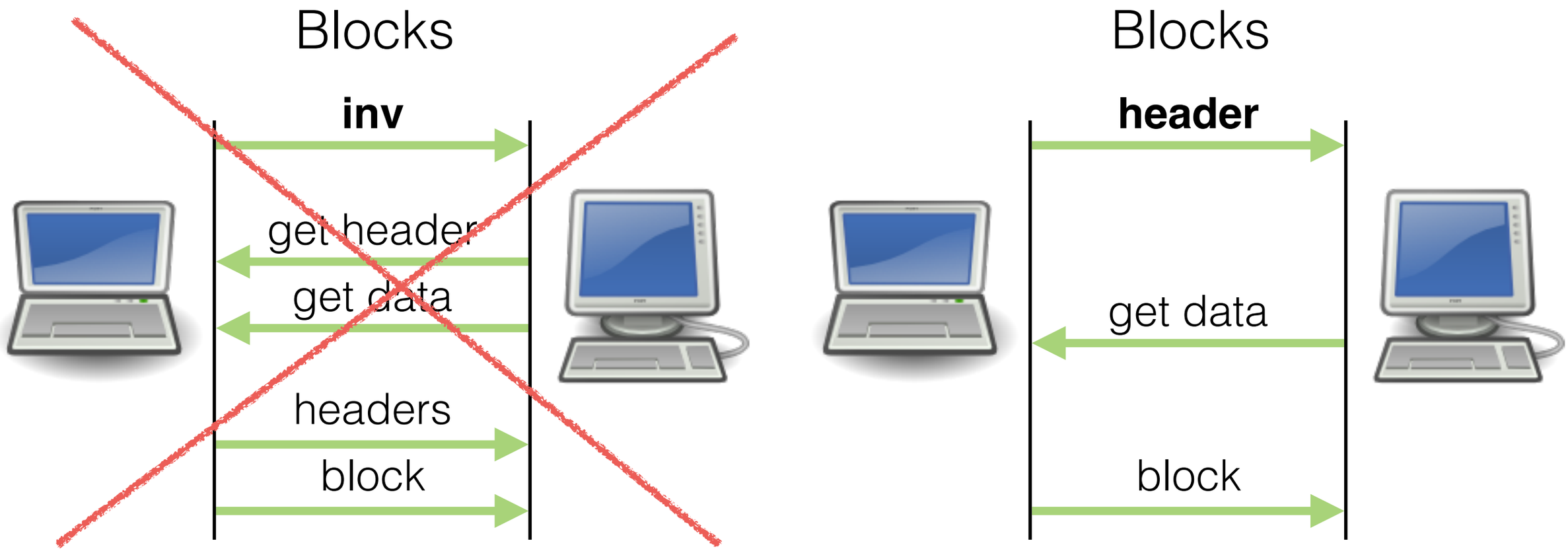


First request from one peer, then two, then three…

Hardening the P2P overlay network

Better Block request management



size(inv) = 36 bytes
size(header) = 80 bytes

Hardening the P2P overlay network

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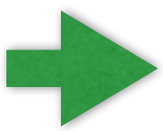

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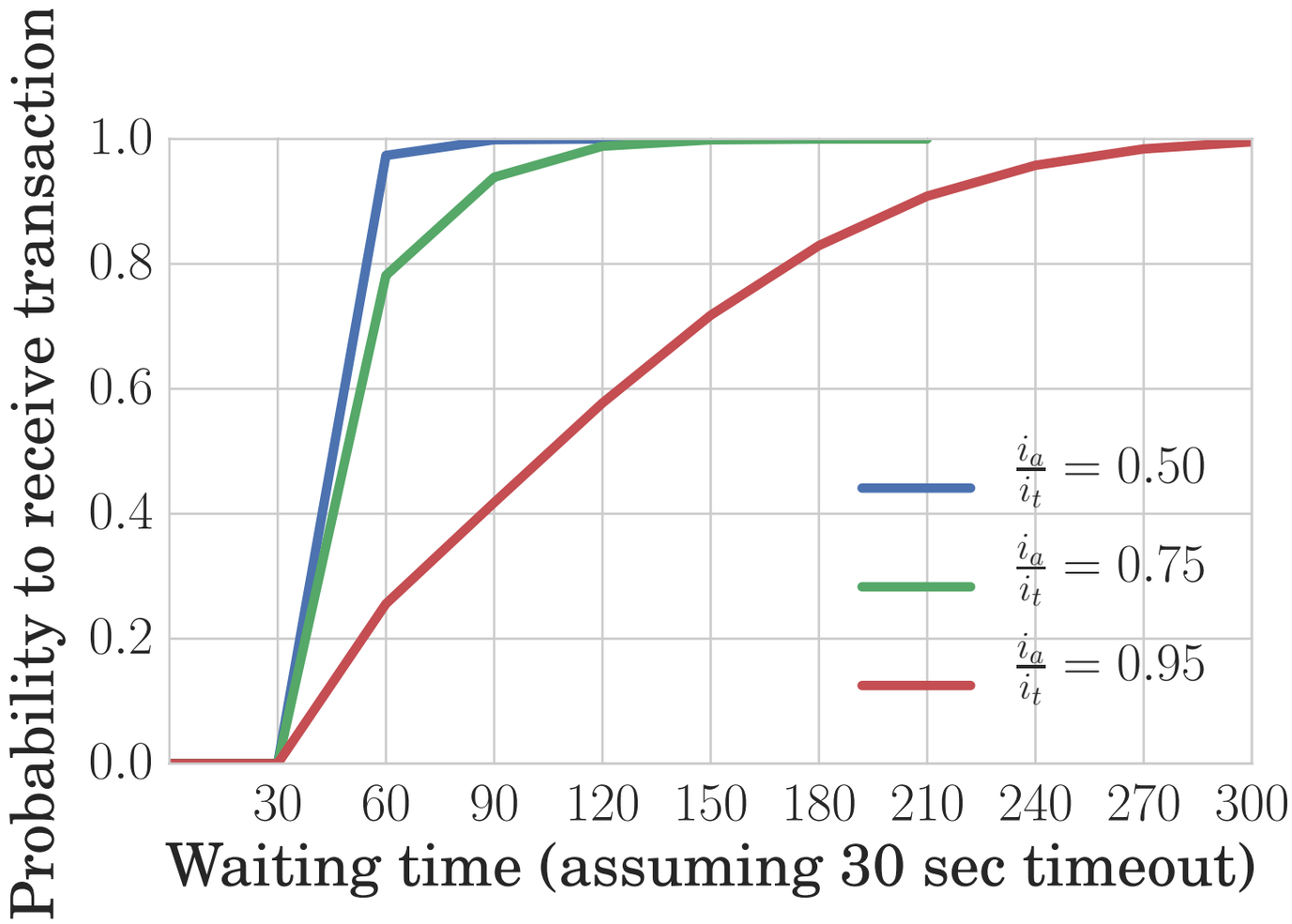
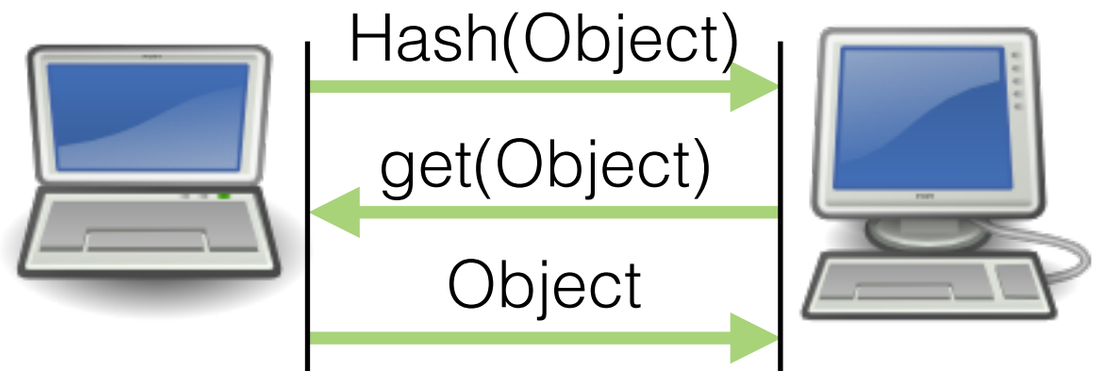


i_a = **inv** messages sent by adversary

i_t = total **inv** messages

After 5 minutes, transaction is received, even if the adversary controls 95% of the inv

Advertisment-based request request management system



Blocks

Transactions

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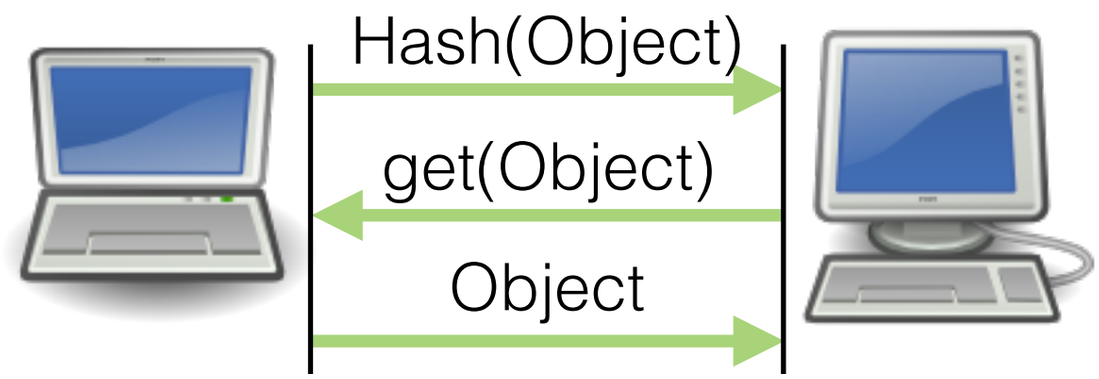

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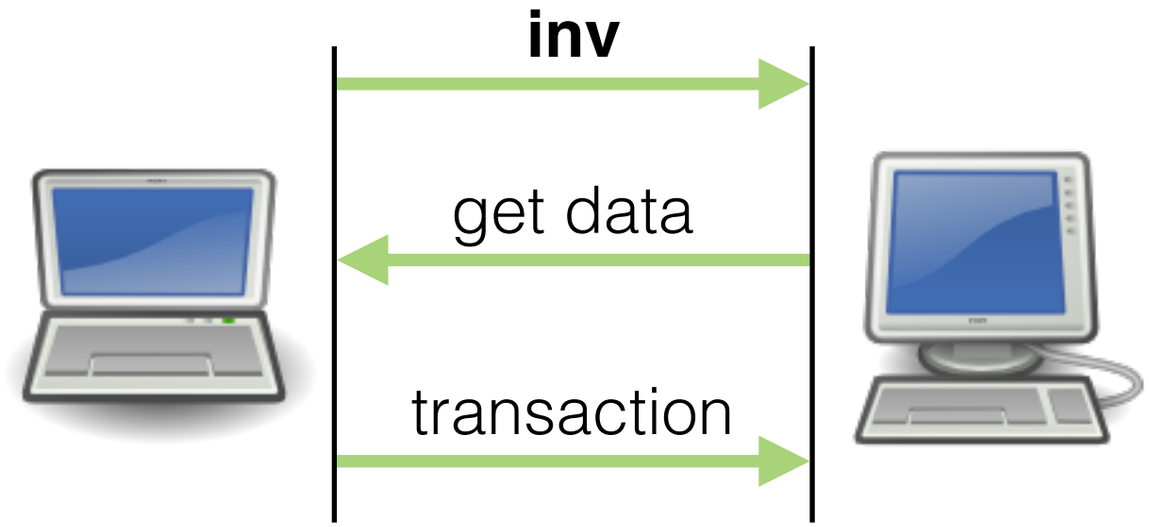

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