The Lightning Network

Machine-to-machine Payments

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Hong Kong, January 4, 2019

Bitcoin

Decentralized, open and free global financial network

- Slow (~10 min block intervals)
- Expensive (~HK$2-30)
- Limited capacity (~4-7 tx/s)
- Volatile exchange rate (~2% per hour)

Blockchain

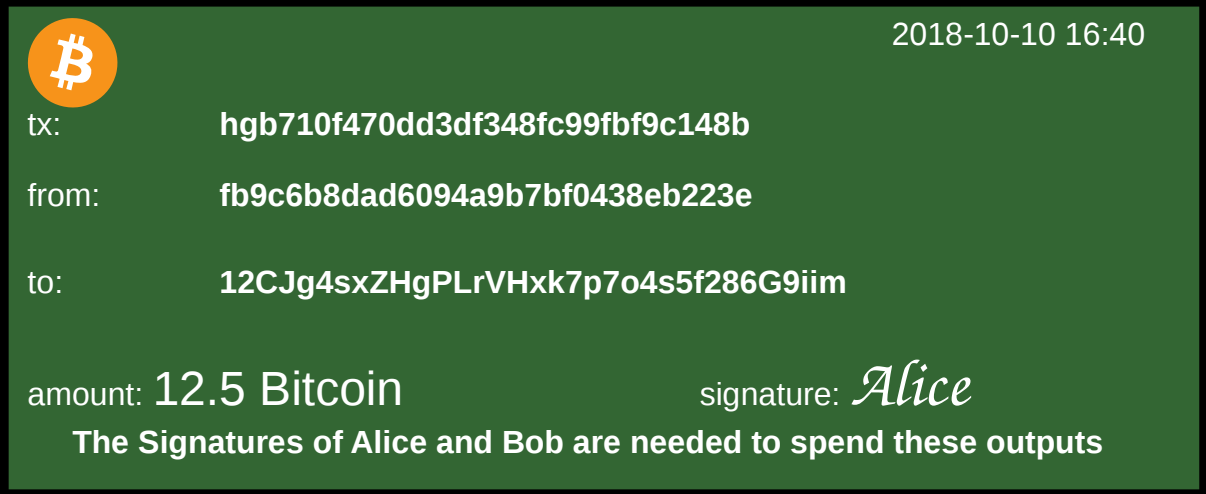
- Does not scale
- Broadcast model
- High external costs (Memory, bandwidth, computing power)

  - > Dangerous conflicts between throughput and decentralization

A New Network

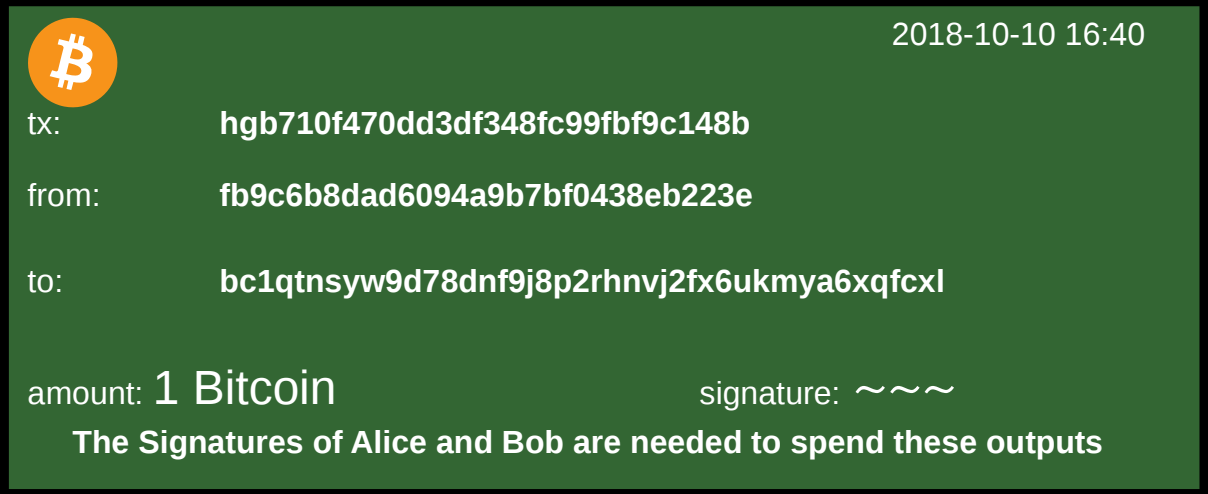
- Bitcoin as the settlement layer
- Lightning as the payment layer
- Scaling without compromising the security of the base layer
- Lightning is not a Blockchain!

Bitcoin Transaction



- Every transaction references a previous transaction
- Every transaction is signed
- Complicated rules can be defined (→ Smart Contracts)

Payment Channel



1) Payment Channel is being opened
1 BTC is sent to a 'multisig' address
Alice and Bob control this address together

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Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

amount: 1 Bitcoin signature: ~~~

The Signatures of Alice and Bob are needed to spend these outputs

2) Alice only signs her transaktion after she receives Bob's signature on a refund transaction. This way her funds can't be stuck.

2018-10-10 16:40

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p6ts2nzcg**
amount: **1 Bitcoin**

to: **bc1qj93n553npnsumygn4sqfch9qlkv34d82sjxzdf**
amount: **0 Bitcoin**

LOCAL MEMORY

signature: *Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

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Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

SETTLED

amount: 1 Bitcoin

signature: *Alice*

The Signatures of Alice and Bob are needed to spend these outputs

2) Alice signs both transactions, but keeps the second transaction in her local memory

2018-10-10 16:40

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p6ts2nzcg**
amount: **1 Bitcoin**

to: **bc1qj93n553npnsumygn4sqfch9qlkv34d82sjxzdf**
amount: **0 Bitcoin**

LOCAL MEMORY

signature: *Alice, Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

SETTLED

amount: 1 Bitcoin

signature: *Alice*

The Signatures of Alice and Bob are needed to spend these outputs

2018-10-10 16:41

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p[illegible]ts2nzcg**

amount: 0.9 Bitcoin

to: bc1qj93n553npnsumygn4sqfch9qlkv[illegible]82sjxzdf

amount: 0.1 Bitcoin

LOCAL MEMORY

signature: *Alice, Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

3) Alice pays 0.1 Bitcoin to Bob by signing a new transaction that sends 0.1 BTC to Bob. This transaction is kept in local memory by both.

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Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

SETTLED

amount: 1 Bitcoin

signature: *Alice*

The Signatures of Alice and Bob are needed to spend these outputs

4) Bob can also send funds this way.

2018-10-10 16:42

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p9ts2nzcg**

amount: 0.95 Bitcoin

to: bc1qj93n553npnsumygn4sqfch9qlkv94u82sjxzdf

amount: 0.05 Bitcoin

LOCAL MEMORY

signature: *Alice, Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

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Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

SETTLED

amount: 1 Bitcoin

signature: *Alice*

The Signatures of Alice and Bob are needed t

2018-10-10 16:43

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p[illegible]ts2nzcg**

amount: 0.85 Bitcoin

to: bc1qj93n553npnsumygn4sqfch9qlkv[illegible]4u82sjxzdf

amount: 0.15 Bitcoin

LOCAL MEMORY

signature: *Alice, Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

5) An infinite number of transactions can be sent between Alice and Bob.

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Payment Channel

2018-10-10 16:40

tx: **hgb710f470dd3df348fc99fbf9c148b**

from: **fb9c6b8dad6094a9b7bf0438eb223e**

to: **bc1qtnsyw9d78dnf9j8p2rhnvj2fx6ukmya6xqfcxl**

SETTLED

amount: 1 Bitcoin

signature: *Alice*

The Signatures of Alice and Bob are needed t

2018-10-10 16:43

tx: **283e4f581e1bb73d8d47a5072471f7**

from: **hgb710f470dd3df348fc99fbf9c148b**

to: **bc1qsrr3pv86v8ftxh8nmgrdt9rda7vl4p6ts**

amount: 0.85 Bitcoin

to: bc1qj93n553npnsumygn4sqfch9qlkv94a82sjxzdf

amount: 0.15 Bitcoin

SETTLED

signature: *Alice, Bob*

The Signatures of Alice and Bob are needed to spend these outputs. This money can only be spent two days after this transaction is confirmed unless the secret to hash 2325005714a7 is revealed.

6) Alice and Bob can close their Payment Channel anytime, even if the other party is unavailable.

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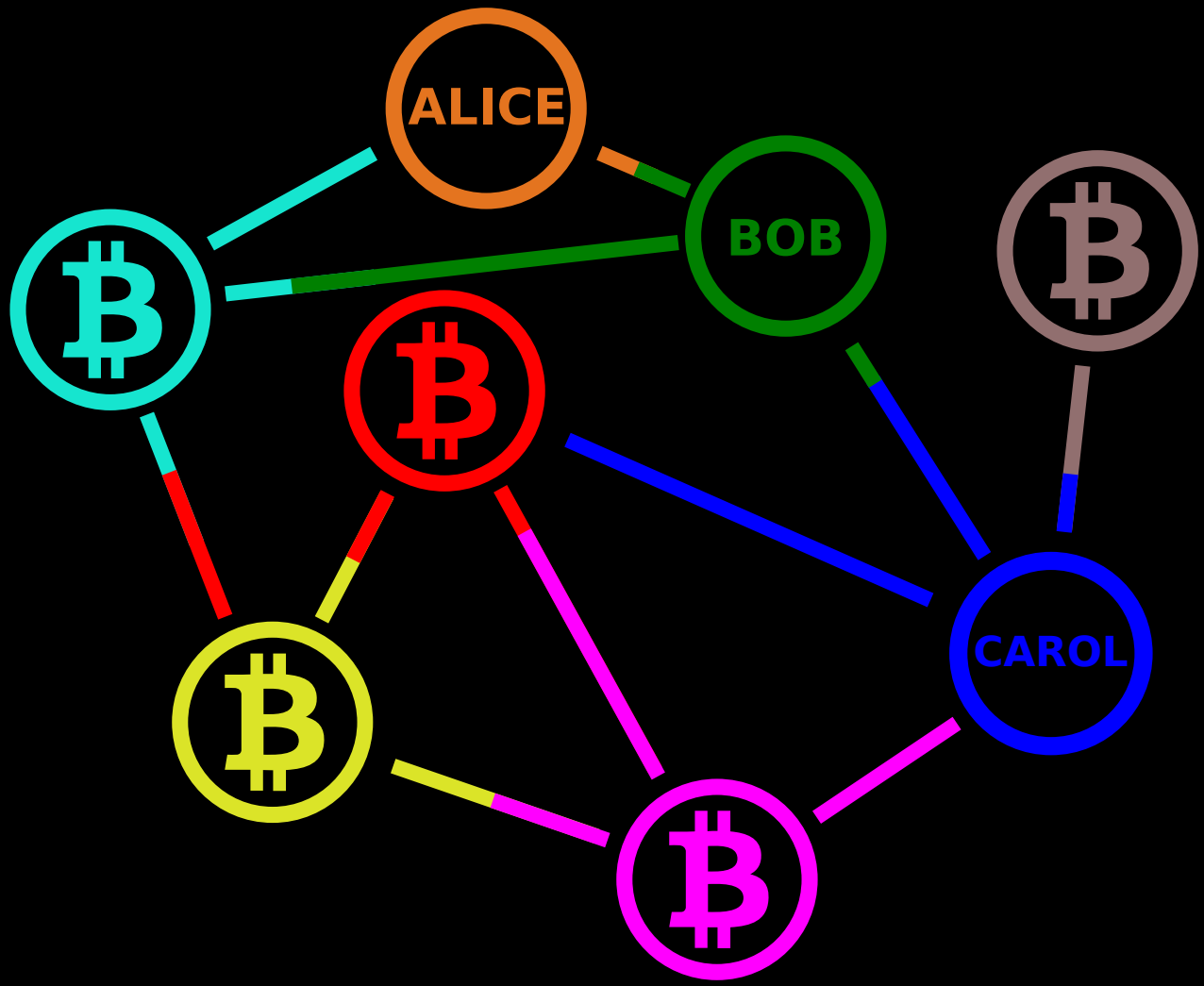
A Network of Channels

- Hash Time-Locked Contracts (HTLC)
  - Alice sends Bitcoin to a HTLC address
  - Bob only receives the funds if he reveals a secret 'key'
  - Otherwise the payment does not become valid
- Alice → Bob → Carol
  - Carol generates secret key
  - Alice makes payment to Bob dependent on this key
  - Bob makes payment to Carol dependent on the same key
  - Carol needs to reveal her key to receive the payment
- The transfer is made atomically. Either it succeeds completely, or it never happens

A Network of Channels



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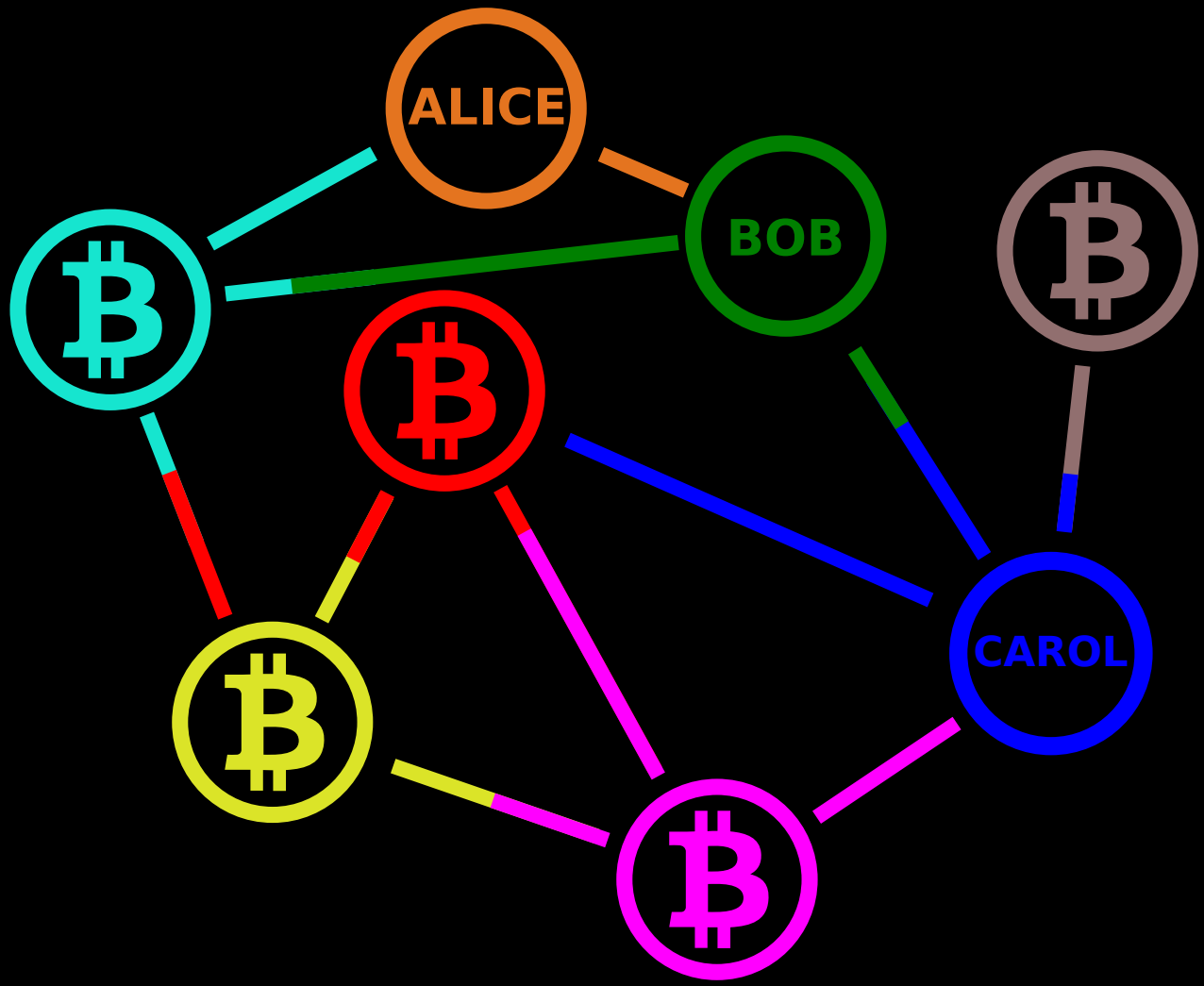
A Network of Channels



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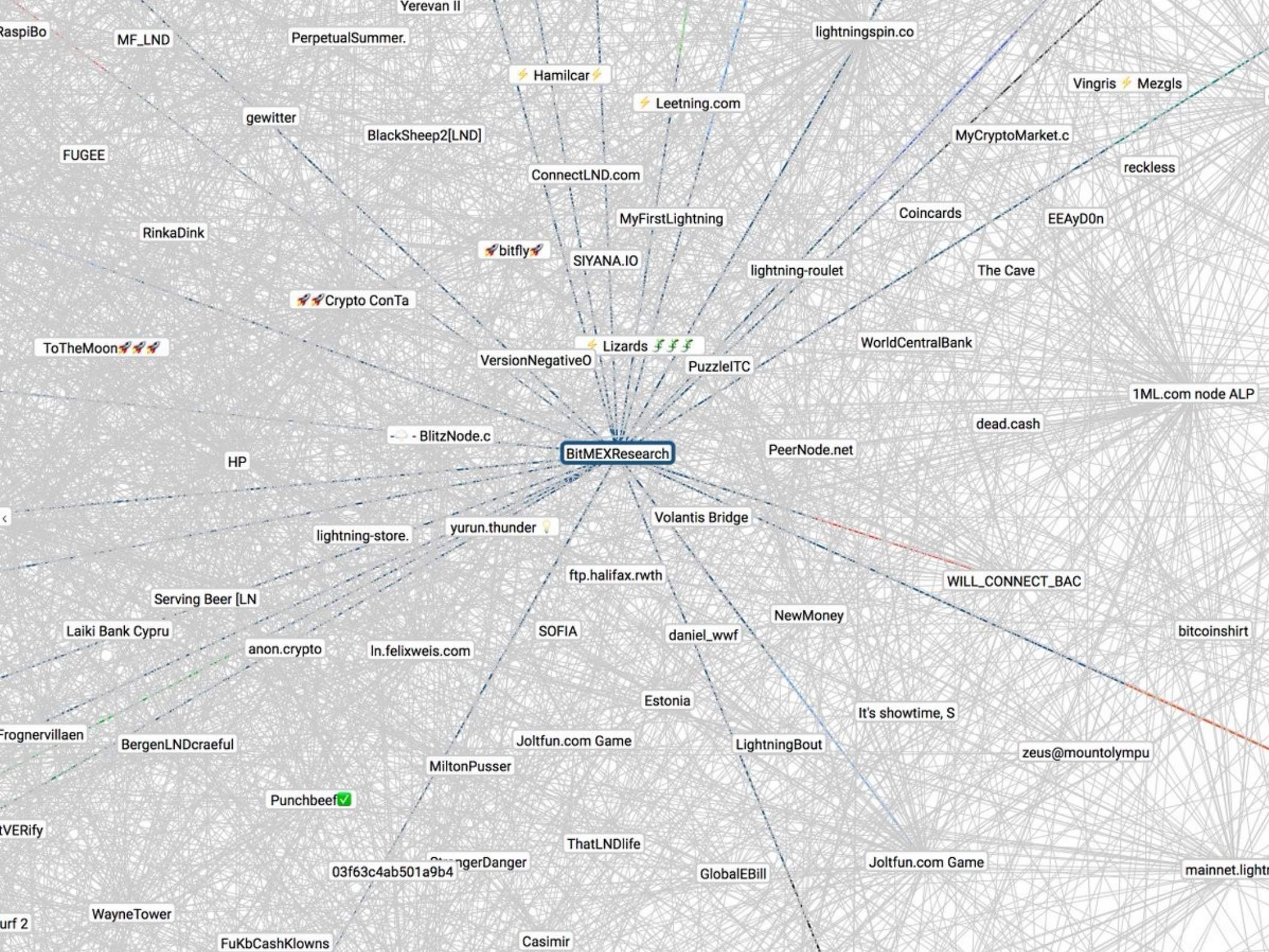
Yerevan II
RaspiBo
MF_LND
PerpetualSummer.
lightningspin.co
⚡ Hamilcar ⚡
Vingris ⚡ Mezgls
⚡ Leetning.com
gewitter
BlackSheep2[LND]
MyCryptoMarket.c
FUGEE
ConnectLND.com
reckless
MyFirstLightning
Coincards
EEAyD0n
RinkaDink
🚀bitfly🚀
SIYANA.IO
lightning-roulet
The Cave
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ToTheMoon🚀🚀🚀
⚡ Lizards ⚡⚡⚡
WorldCentralBank
VersionNegativeO
PuzzleITC
1ML.com node ALP
dead.cash
- BlitzNode.c
BitMEXResearch
PeerNode.net
HP
Volantis Bridge
lightning-store.
yurun.thunder
ftp.halifax.rwth
WILL_CONNECT_BAC
Serving Beer [LN
NewMoney
Laiki Bank Cypru
SOFIA
daniel_wwf
bitcoinshirt
anon.crypto
ln.felixweis.com
Estonia
It's showtime, S
Frognervillaen
BergenLNDcraeful
Joltfun.com Game
LightningBout
zeus@mountolympu
MiltonPusser
Punchbeef✅
ThatLNDlife
03f63c4ab501a9b4
GlobalEBill
Joltfun.com Game
WayneTower
FuKbCashKlowns
Casimir

Benefits

- Infinite payments within the network
- Payments can be arbitrarily small (<1 Satoshi)
- Instant Payments
- Based on invoices, not addresses
- Easier to protect the users' privacy, as payments aren't public
- Unicast und Anycast are easier to scale
- Bitcoin can be liquidated in real-time

Limitations

- Liquidity of the channels is limited
- Finding routes can be complicated
- Participants have to always be online
- Channels cannot be opened and closed frequently (Bitcoin ~7 tx/s)

Demos

- Lightning Roulette
  - Roulette with Micropayments
- LND Work
  - Automatic Turk
- Y'alls
  - Paywall for articles
- Bitcoin.org.hk
  - Generic payment

Applications

- Efficient market for microservices
  - APIs (e.g. Time tables, ticket sales)
  - AI (e.g. Routing, image recognition)
  - Sensors (e.g. Traffic, weather)
  - Computing power (e.g. CGI animations)
  - Memory (z.B. Amazon S3)
- No Accounts necessary
  - Security
  - Privacy
  - Identification through asymmetric keys

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PGP: 9185 B1FD 625A 1AD0 CCFE F451 C073 56F5 BB4D D1B7

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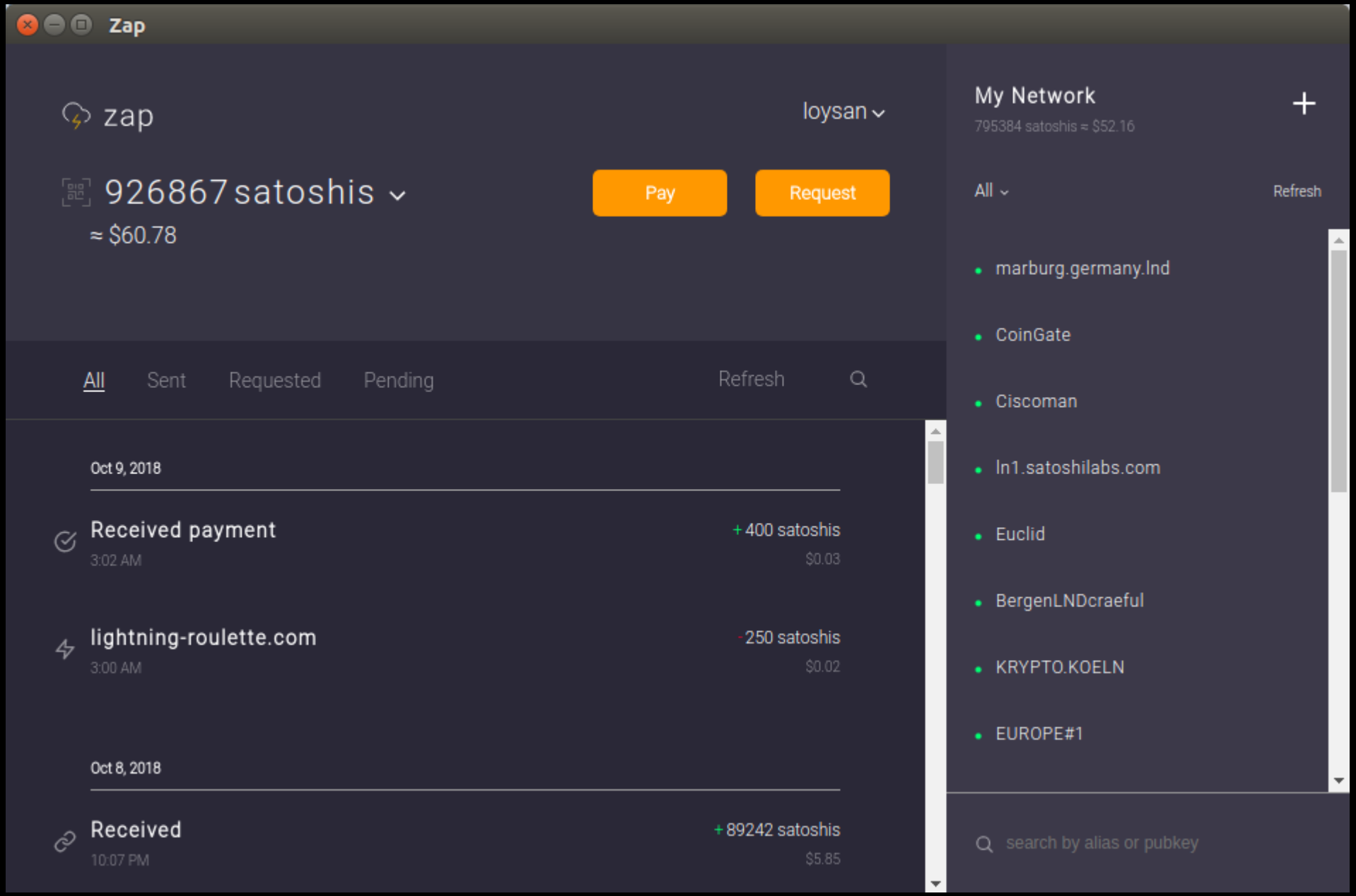

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Lightning Roulette

https://lightning-roulette.com

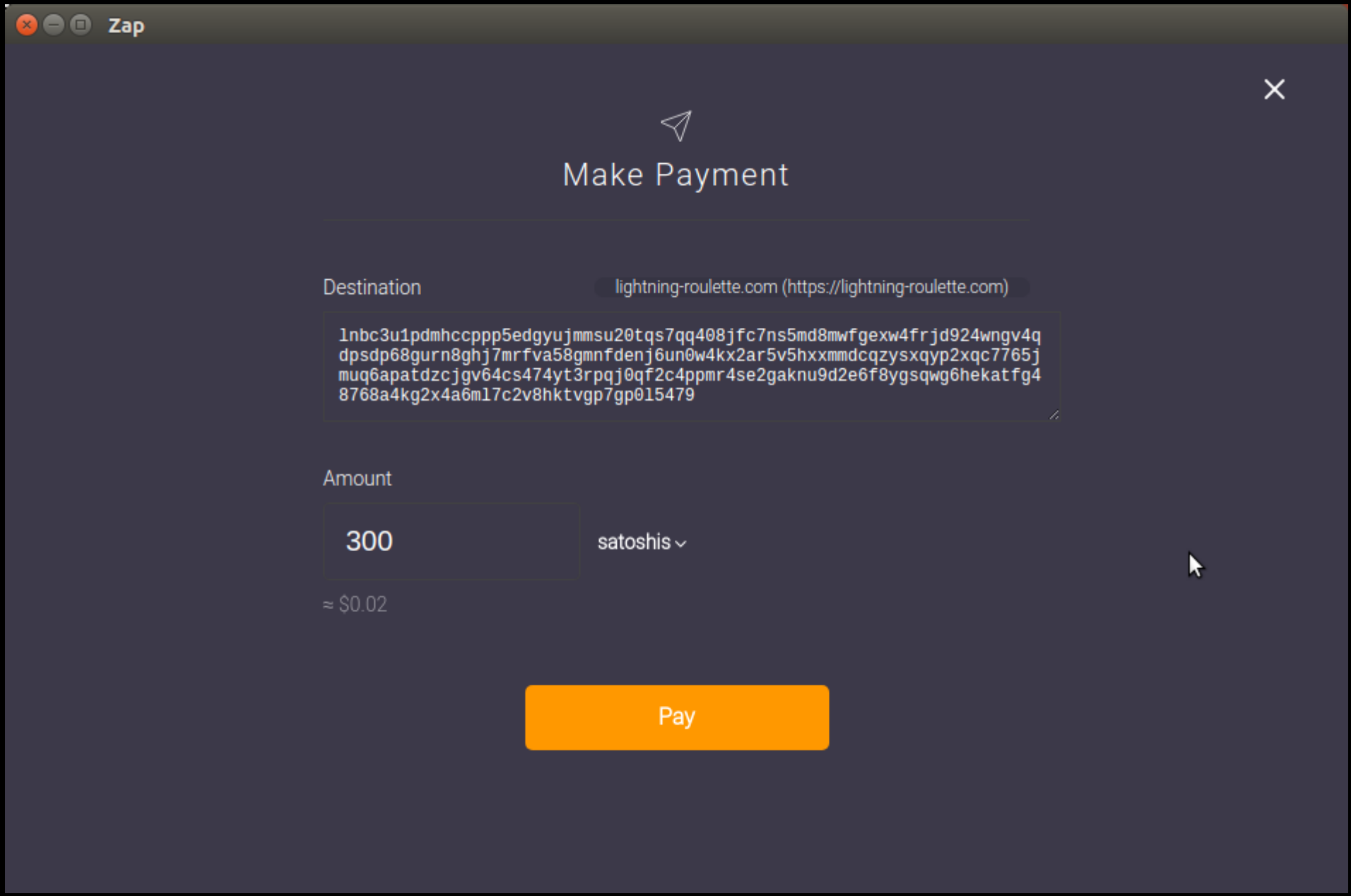
BALANCE
0

BET
300

PROFIT
0

0	3	6	9	12	15	18	21	24	27	30	33	36	2:1
	2	5	8	11	14	17	20	23	26	29	32	35	2:1
	1	4	7	10	13	16	19	22	25	28	31	34	
	1ST 12				2ND 12				3RD 12				
	1 - 18		EVEN						ODD		19 - 36		

1 5 10 20 50 100 500 1000 2000 5000



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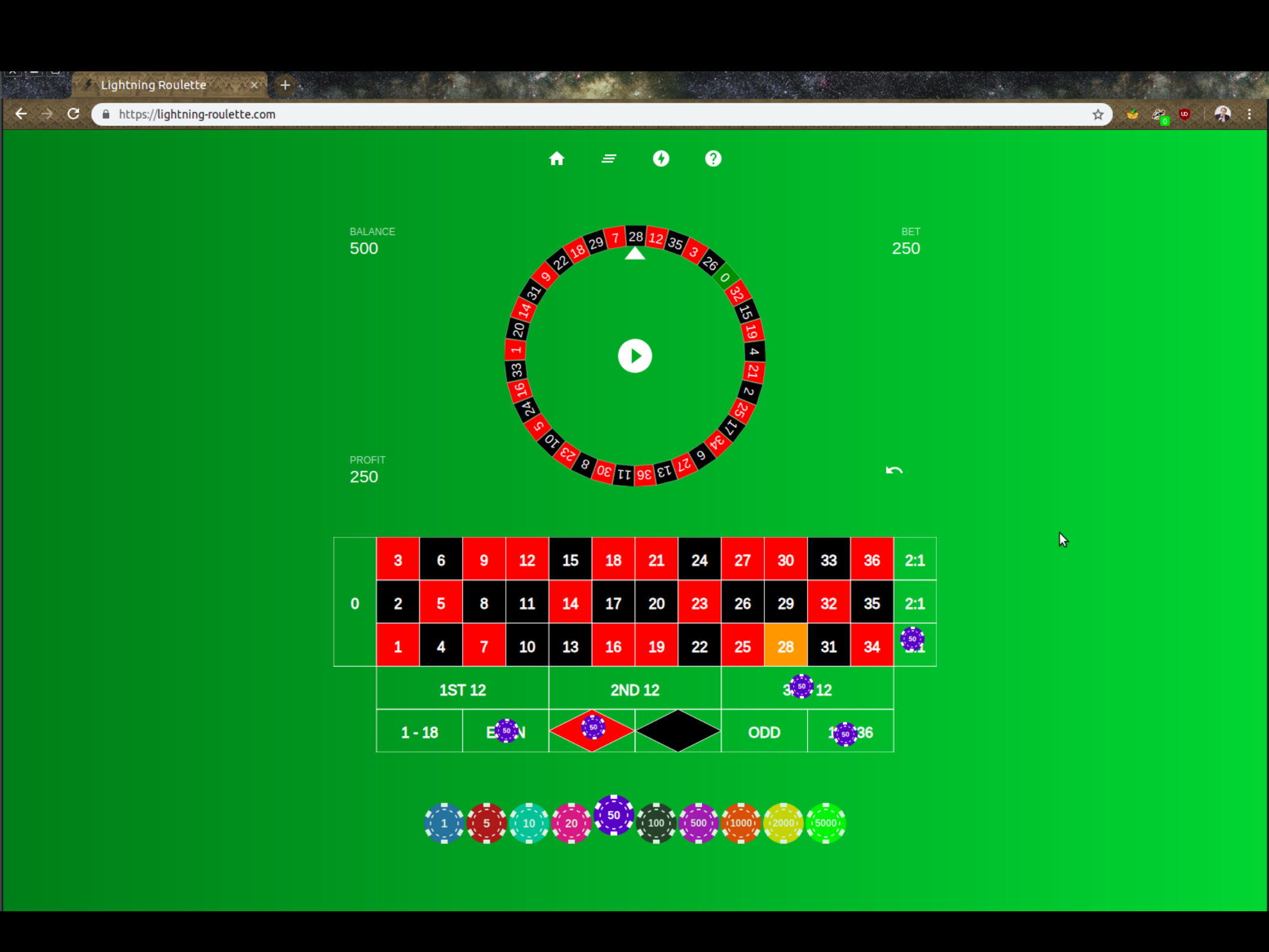
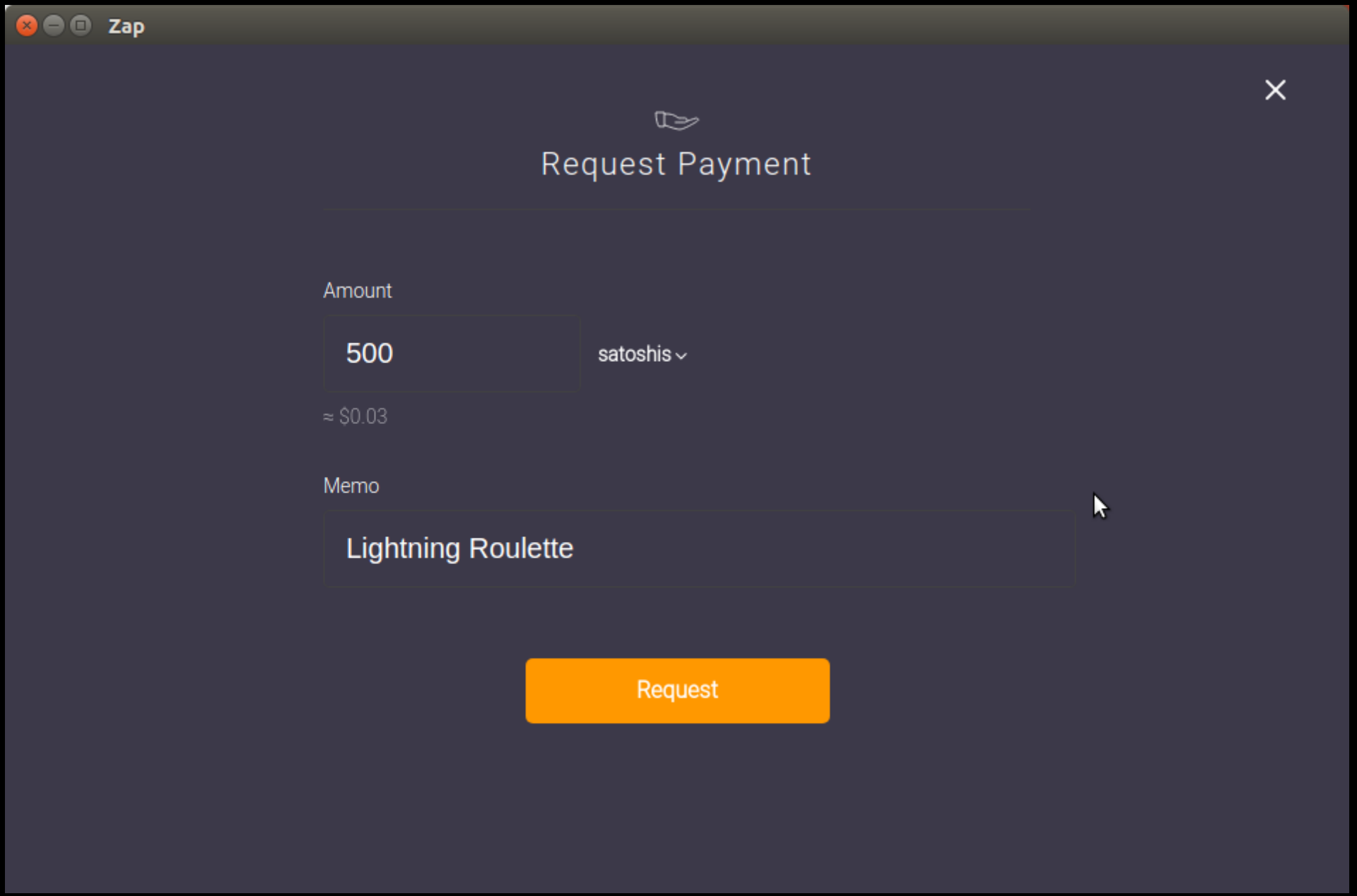

Lightning Roulette
https://lightning-roulette.com
BALANCE
500
BET
250
PROFIT
250
0
3 6 9 12 15 18 21 24 27 30 33 36 2:1
2 5 8 11 14 17 20 23 26 29 32 35 2:1
1 4 7 10 13 16 19 22 25 28 31 34
1ST 12
2ND 12
12
1 - 18
ODD
36
1 5 10 20 50 100 500 1000 2000 5000



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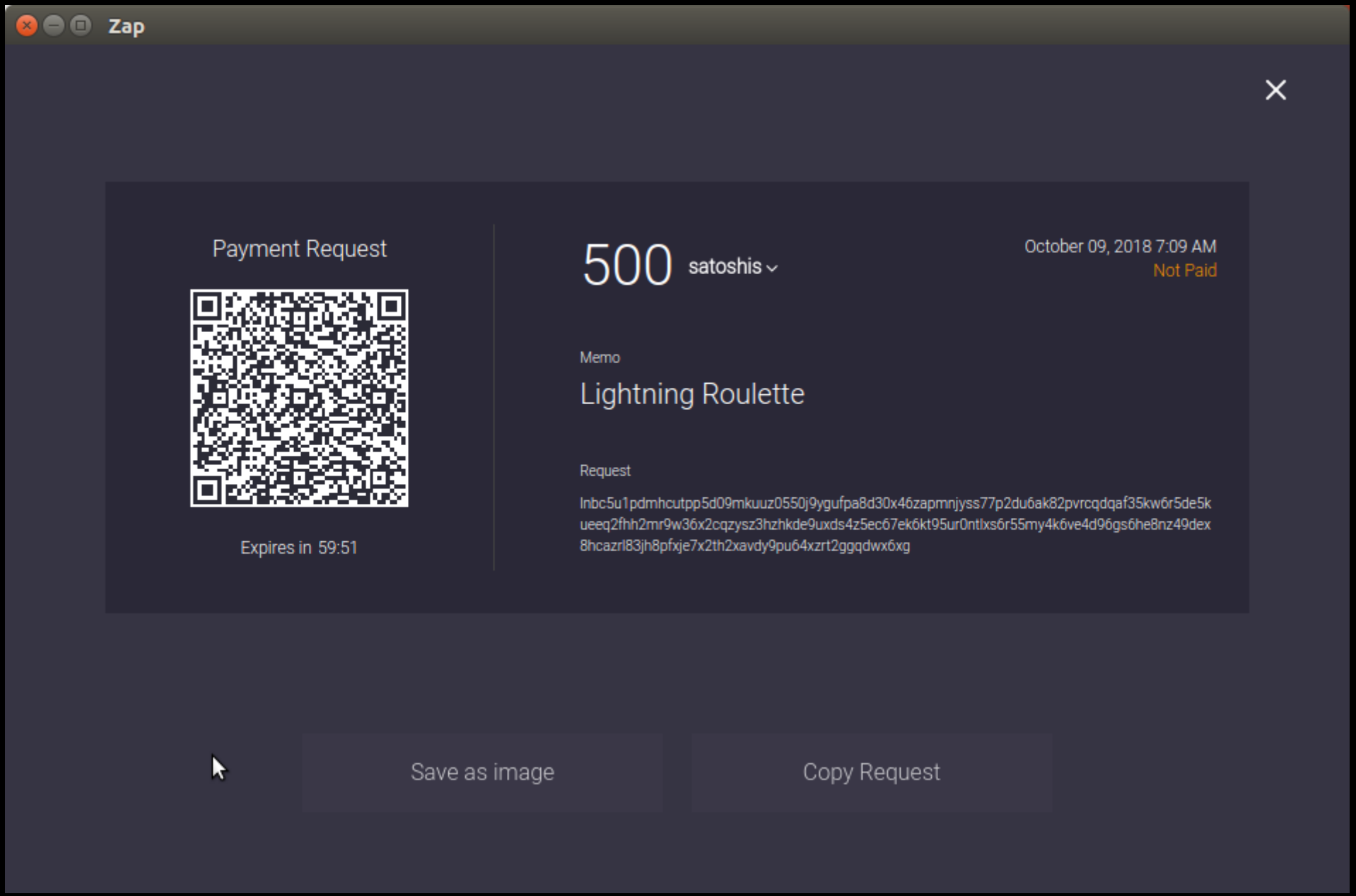

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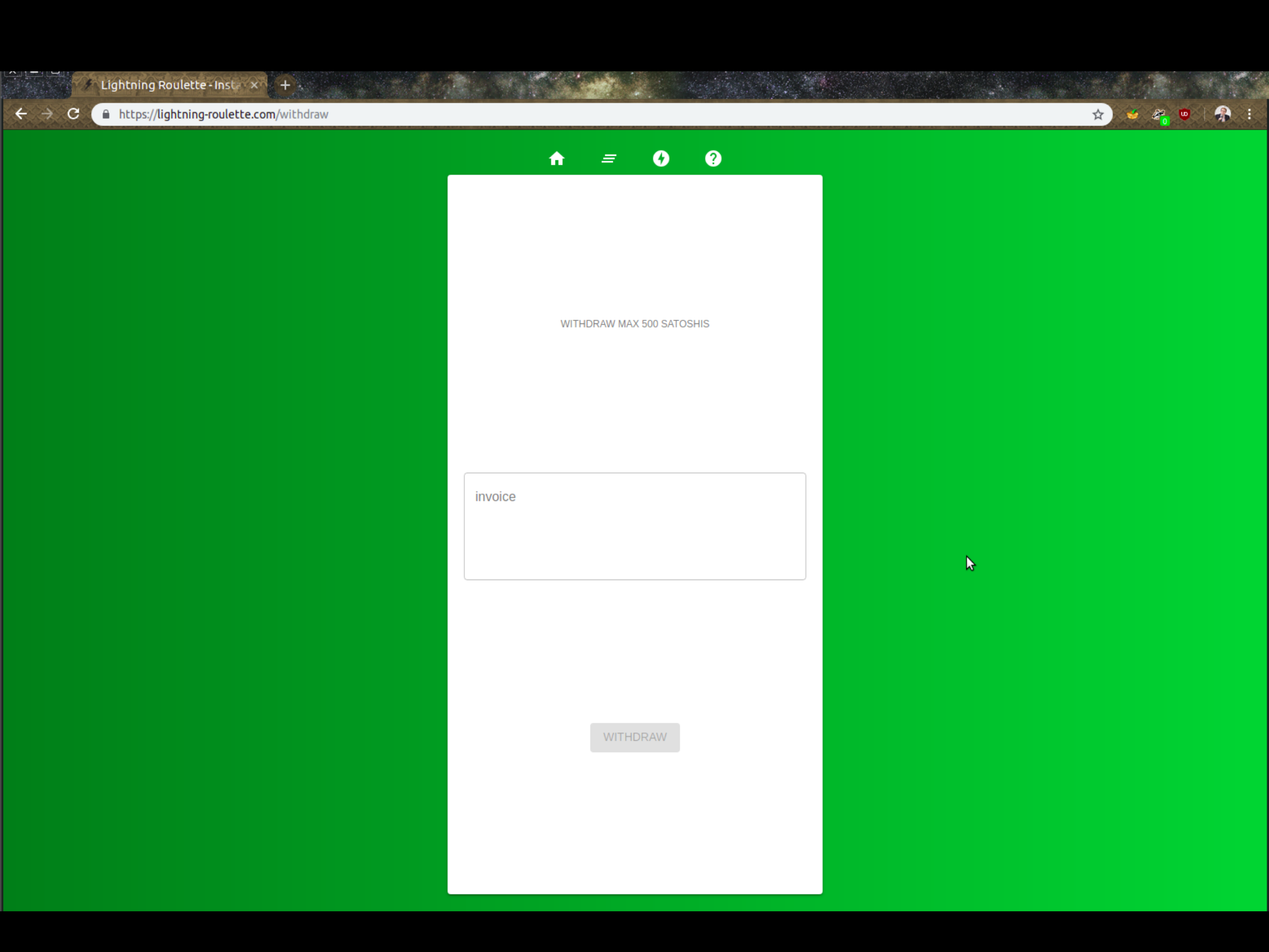
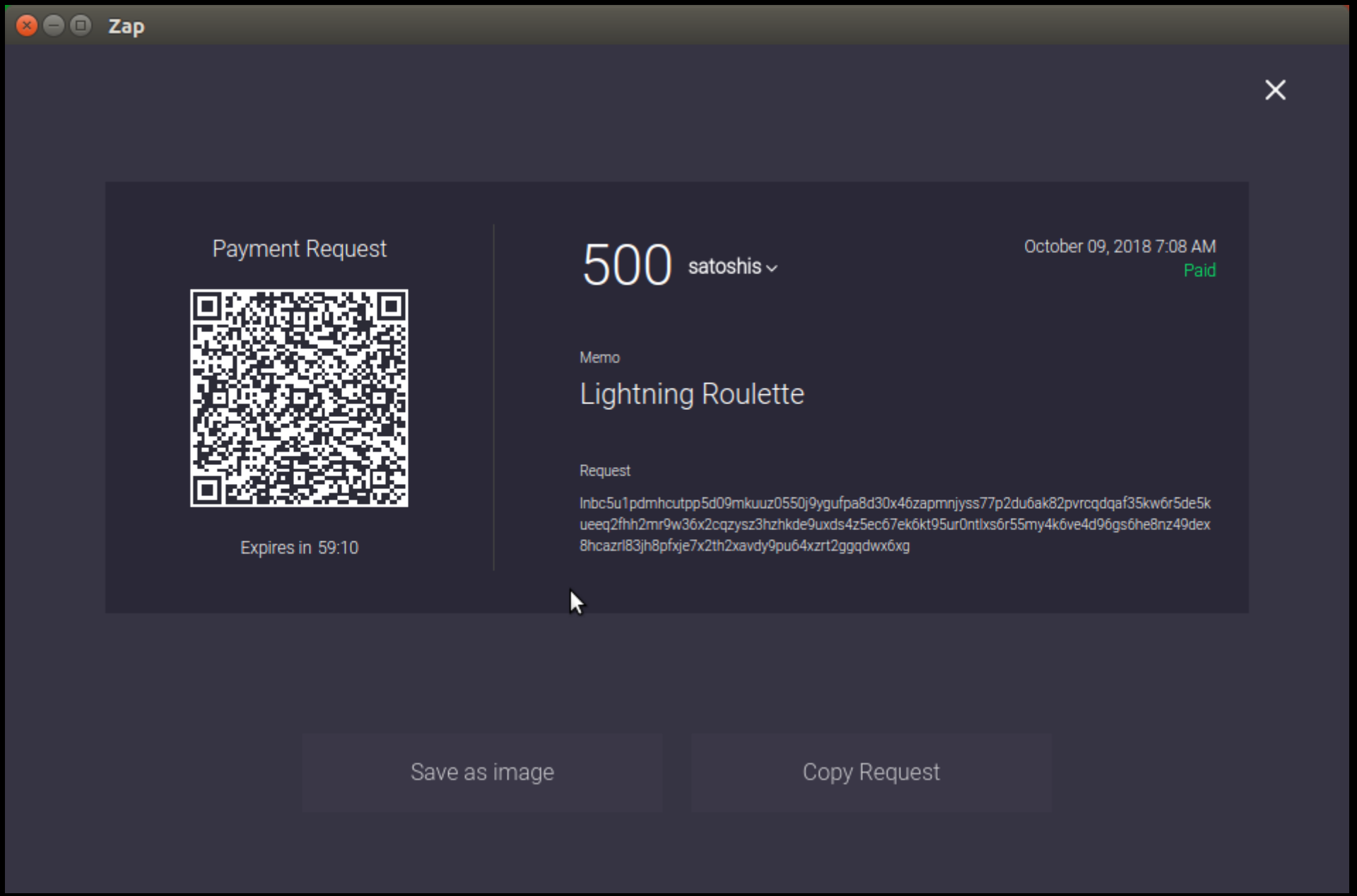

Lightning Roulette - Inst
https://lightning-roulette.com/withdraw
WITHDRAW MAX 500 SATOSHIS
invoice
WITHDRAW



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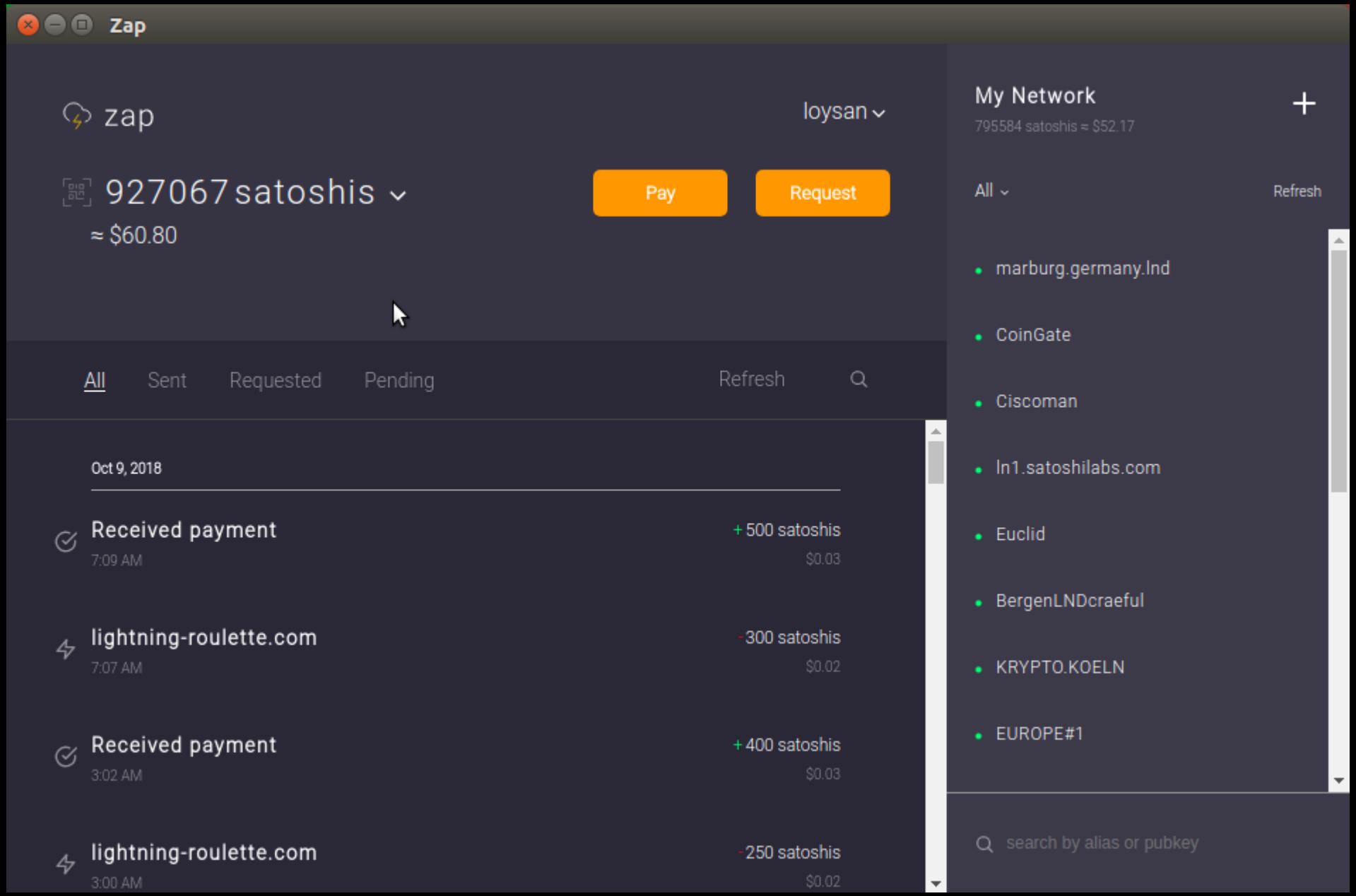

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