GAS AND GAS SPONSORSHIP IN CONFLUX

TOPICS WE WILL COVER TODAY

- transaction fee in Bitcoin
- transaction fee in Ethereum
- transaction fee in Conflux
- transaction sponsorship
- blockchain applications and tools

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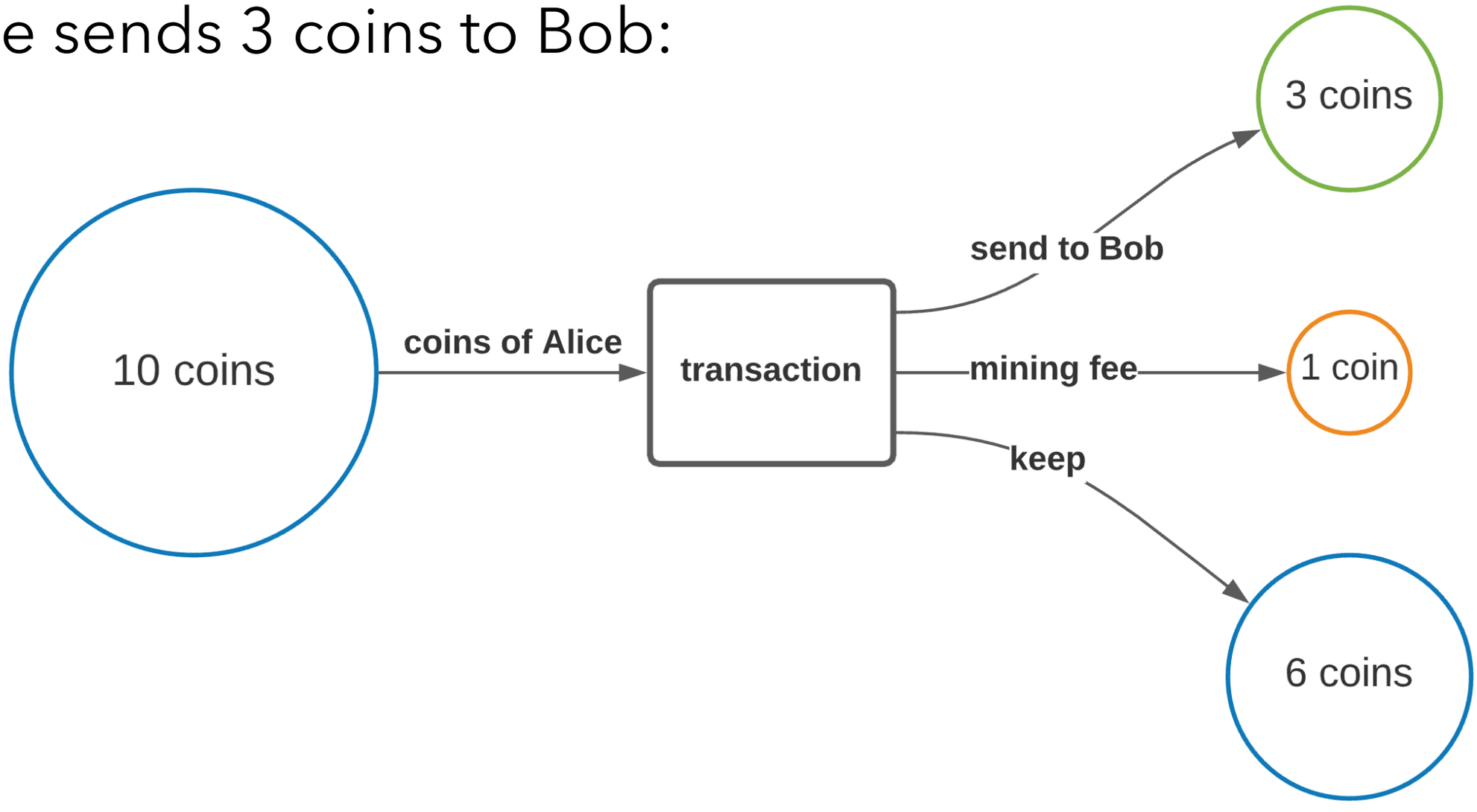
TRANSACTION FEE IN BITCOIN

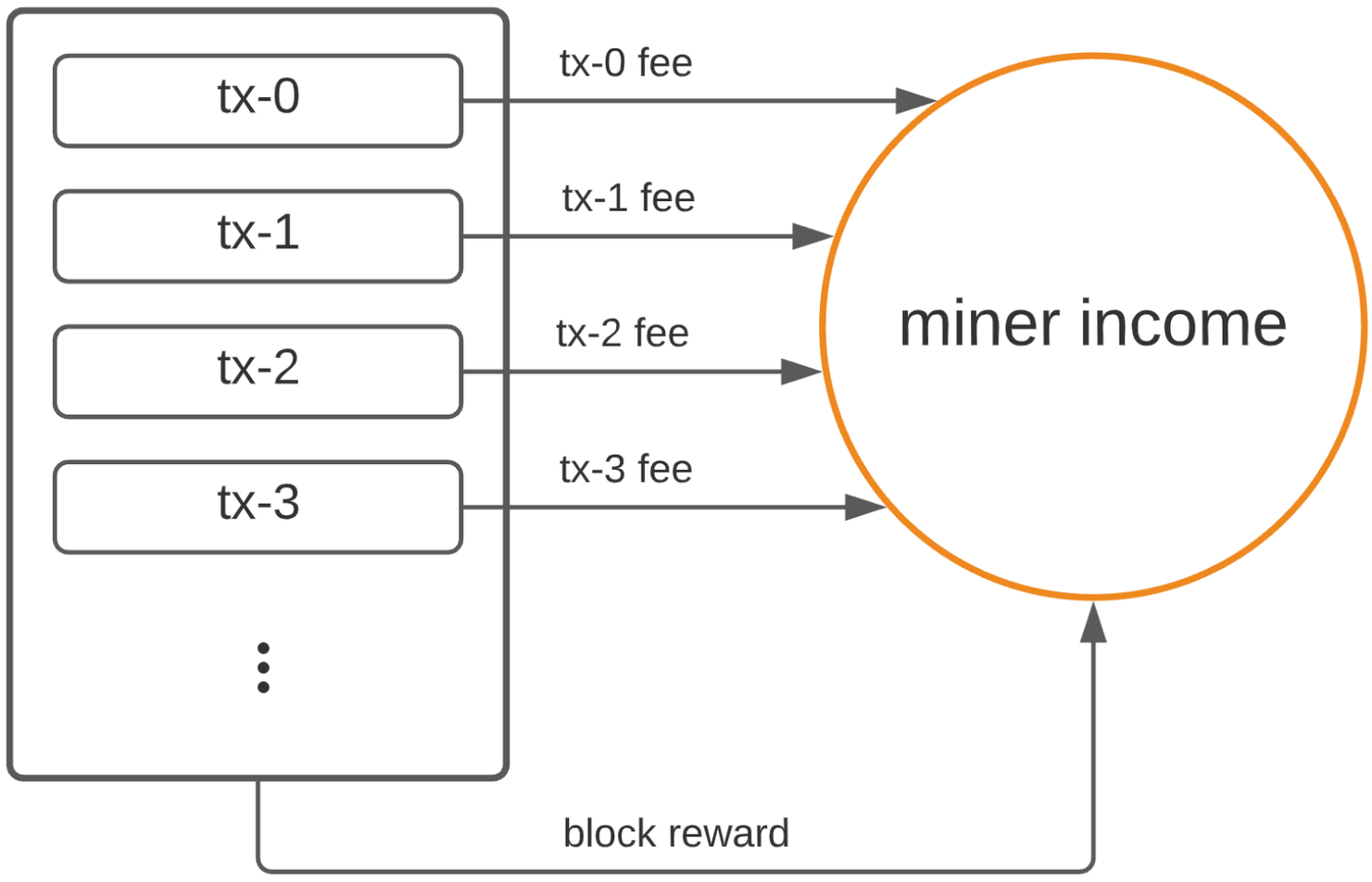
- Bitcoin, created by Satoshi Nakamoto, is the first blockchain system
- the main innovation of Bitcoin is incentive alignment
- miners make money by processing transactions (transaction fee) and by creating blocks (block reward)

HOW DOES TRANSACTION FEE WORK?

- Alice sends 3 coins to Bob:



MINER INCOME

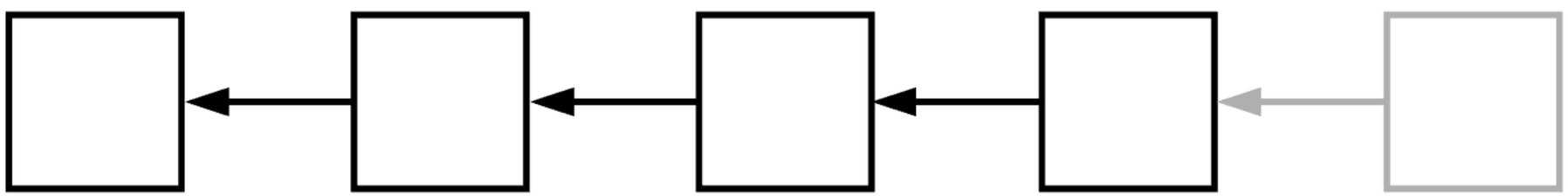


WHAT IS INCENTIVE ALIGNMENT?

- if you deviate from the rules, you will lose money
- instead of attacking the system, you can earn more money by actually participating (as a miner)
- this is the reason a native currency is necessary for permissionless blockchains like Bitcoin and Conflux

TRANSACTION FEE AS AN AUCTION

- the transaction fee market is basically an auction
- you are competing for the limited slots in the next block
- rational miners will prioritize transactions with higher fees
- as a result, the transaction fee also expresses the urgency



BITCOIN'S INCENTIVES ARE NOT PERFECT

- transaction fee market is not fully incentive compatible
- selfish mining might allow miners to earn more
- there is no direct incentive for validating the ledger and propagating transactions
- the mining algorithm and low block creation rate incentivizes miner centralization

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THE COST OF ETHEREUM TRANSACTIONS

- Ethereum has smart contracts
- before creating a block, the miner has to execute all the transactions it wants to include in that block
- but two smart contract calls can be very different!

  execution cost: maybe it will run a loop for millions of cycles

  storage cost: maybe it will write millions of items to disk

THE PROBLEM OF TRANSACTION TERMINATION

- the halting problem: just by looking at the transaction, you cannot decide if it will ever finish running
- how to address this?

THE PROBLEM OF TRANSACTION TERMINATION

- the halting problem: just by looking at the transaction, you cannot decide if it will ever finish running
- how to address this?
  - limit the language so that you cannot even write such code (Bitcoin)
  - this works but might severely limit the types of applications you are able to express

THE PROBLEM OF TRANSACTION TERMINATION

- the halting problem: just by looking at the transaction, you cannot decide if it will ever finish running
- how to address this?
  - run for a fixed duration then terminate (Hyperledger)
  - this might harm determinism: code that timeouts on one machine might terminate on another, any they will be unable to reach consensus

THE PROBLEM OF TRANSACTION TERMINATION

- the halting problem: just by looking at the transaction, you cannot decide if it will ever finish running
- how to address this?
  - terminate after a certain number of steps (a certain amount of computation) has been performed
  - you pay for each computational unit so that miners get properly compensated

GAS IN ETHEREUM

- Ethereum: “pay-per-computational-step” model
- instead of pricing instructions directly in ETH (the price of which fluctuates), we use another metric: GAS
- each EVM instruction has a predefined GAS cost that is independent of the value of ETH
- the gas cost of a transaction is the sum of the cost for each instruction executed

GAS IN ETHEREUM -- INSTRUCTION GAS COSTS

ADD	3
SLOAD	200
LOG	375 + 8 * (number of bytes in log data)
SSTORE	20000 / 5000
CREATE	32000

source: https://github.com/djrtwo/evm-opcode-gas-costs/blob/master/opcode-gas-costs_EIP-150_revision-1e18248_2017-04-12.csv

GAS IN ETHEREUM -- GAS LIMIT

- when you send a transaction, you specify a **gas limit**: the maximum amount of GAS you are willing to spend
- if the execution reaches this limit before finishing, the transaction is reverted and you pay the corresponding fee
- if the gas used by the execution is below the limit, the remaining gas is refunded to your account
- this basically solves the halting problem: you can write infinite loops but you'll have to pay for them

GAS IN ETHEREUM -- GAS PRICE

- when you send a transaction, you specify a **gas price**: the amount of ETH you're willing to pay per gas
- you are free to choose what gas price to set, similarly to Bitcoin where you can set the transaction fee freely
- the miner is free to choose which transactions to include. it is likely to choose transactions with higher gas price.

GAS IN ETHEREUM -- HOW MUCH DO WE PAY?

- Let's say you can a transaction with

  gas limit: 50000

  gas price: 0.00000008 Ether (80 Gwei)

- you will have to make an up-front payment of

  50000 x 0.00000008 = 0.004 ETH

- if execution uses 41172 gas, after refund you'll effectively pay

  41172 x 0.00000008 = 0.00329376 ETH

GAS IN ETHEREUM -- EXAMPLE

- let us discuss this example contract:

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1;
        num_b += 1;




    }
}
```

GAS IN ETHEREUM -- EXAMPLE

- let us discuss this example contract:

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1;
        num_b += 1;

        // incrementing is essentially equivalent to:
        // uint256 current_value = number;
        // uint256 new_value = current_value + 1;
        // number = new_value;
    }
}
```

GAS IN ETHEREUM -- EXAMPLE

- let us discuss this example contract:

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1;
        num_b += 1;

        // solc compiles it like this:
        // SLOAD ADD SWAP3 POP POP DUP2 SWAP1 SSTORE POP PUSH1 0x1 DUP1
        // PUSH1 0x0 DUP3 DUP3 SLOAD ADD SWAP3 POP POP DUP2 SWAP1 SSTORE

    }
}
```

GAS IN ETHEREUM -- EXAMPLE

- let us discuss this example contract:

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1;
        num_b += 1;

        // we will simply treat it like this:
        // SLOAD ADD SSTORE SLOAD ADD SSTORE
        // gas cost: 2 x (3 + 200 + 5000) = 10406 GAS

    }
}
```

GAS IN ETHEREUM -- EXAMPLE

- what happens if we provide a gas limit of **5203** GAS?

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1; // this succeeds
                    // <- we run out of gas at this point
        num_b += 1;

        // the whole transaction is reverted
        // neither num_a nor num_b is updated
        // the sender pays for the executed 5203 GAS
    }
}
```

GAS IN ETHEREUM -- EXAMPLE

- what happens if we provide a gas limit of **12000** GAS?

example.sol

```
contract Test {
    uint256 num_a = 0;
    uint256 num_b = 0;

    function increment() public {
        num_a += 1; // this succeeds
        num_b += 1; // this also succeeds
                    // we finish the execution

        // the whole transaction succeeds
        // both num_a and num_b will be updated
        // the sender pays for the executed 10406 GAS, 1594 is refunded
    }
}
```

GAS IN ETHEREUM -- BASE COST

- transactions actually have a base cost of 21000 GAS
- covers checking the signature, storing the transaction, etc.
- sending a simple payment transaction will cost 21000 gas

WHY THE GAS ANALOGY?

- gasoline is what really moves your car, just as it moves the execution of smart contracts
- your car's gas consumption is roughly static, while the price of gasoline changes
- you could try stuffing dollar bills into the fuel tank of your car, but instead you buy gasoline using dollars, and use that to run it

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GAS IN CONFLUX

- Conflux inherited the same fee mechanism from Ethereum, with a few changes:
  - limited gas refund
  - separate payment for execution and storage
  - gas can be sponsored

GAS IN CONFLUX -- LIMITED GAS REFUND

- the cost of a contract call might change, depending on when you call it. consider the following example:

example.sol

```
contract MaybeExpensive {
    uint256 num = 0;
    event E(uint8 n);

    function increment() public { num += 1; }

    function foo() public {
        if (num == 0) {
            for (uint8 ii = 0; ii < 1000; ii++) {
                emit E(ii);
            }
        }
    }
}
```

GAS IN CONFLUX -- LIMITED GAS REFUND

- triggering `foo()` might do almost nothing, or it might also emit 1000 events, depending on the current value of **`num`**

example.sol

```
contract MaybeExpensive {
    uint256 num = 0;
    event E(uint8 n);

    function increment() public { num += 1; }

    function foo() public {
        if (num == 0) {
            for (uint8 ii = 0; ii < 1000; ii++) {
                emit E(ii);
            }
        }
    }
}
```

GAS IN CONFLUX -- LIMITED GAS REFUND

- in Conflux, miners cannot know for sure the state on which the transaction is executed
- this makes it impossible to accurately estimate the profits of including certain transactions
- to make this estimation easier, at most 1/4 of the whole gas is refunded
- e.g. if gas limit is 10000 and the transaction execution used 6000 gas, the account will still be charged for 7500

GAS IN CONFLUX -- PAY SEPARATELY FOR STORAGE

- in Ethereum paying for storage is a one-time fee (gas for SSTORE), even though miners might have to store it forever
- consider this example: that 13 has to be stored on each machine maintaining the blockchain.

storage.sol

```
contract Storage {
    mapping (address => uint256) data;

    constructor() {
        data[msg.sender] = 13;
    }
}
```

GAS IN CONFLUX -- PAY SEPARATELY FOR STORAGE

- in Conflux, you need to deposit CFX for storage entries. this deposit is called storage collateral.
- miners earn interest on the collateralized storage
- if someone deletes or overwrites your entry, you get back your collateral

GAS IN CONFLUX -- PAY SEPARATELY FOR STORAGE

- so what you will pay is

(gas_used x gas_price) + *(1/16 CFX x storage_collateralized)*

… minus the refund of at most *1/4 x gas_used x gas_price*

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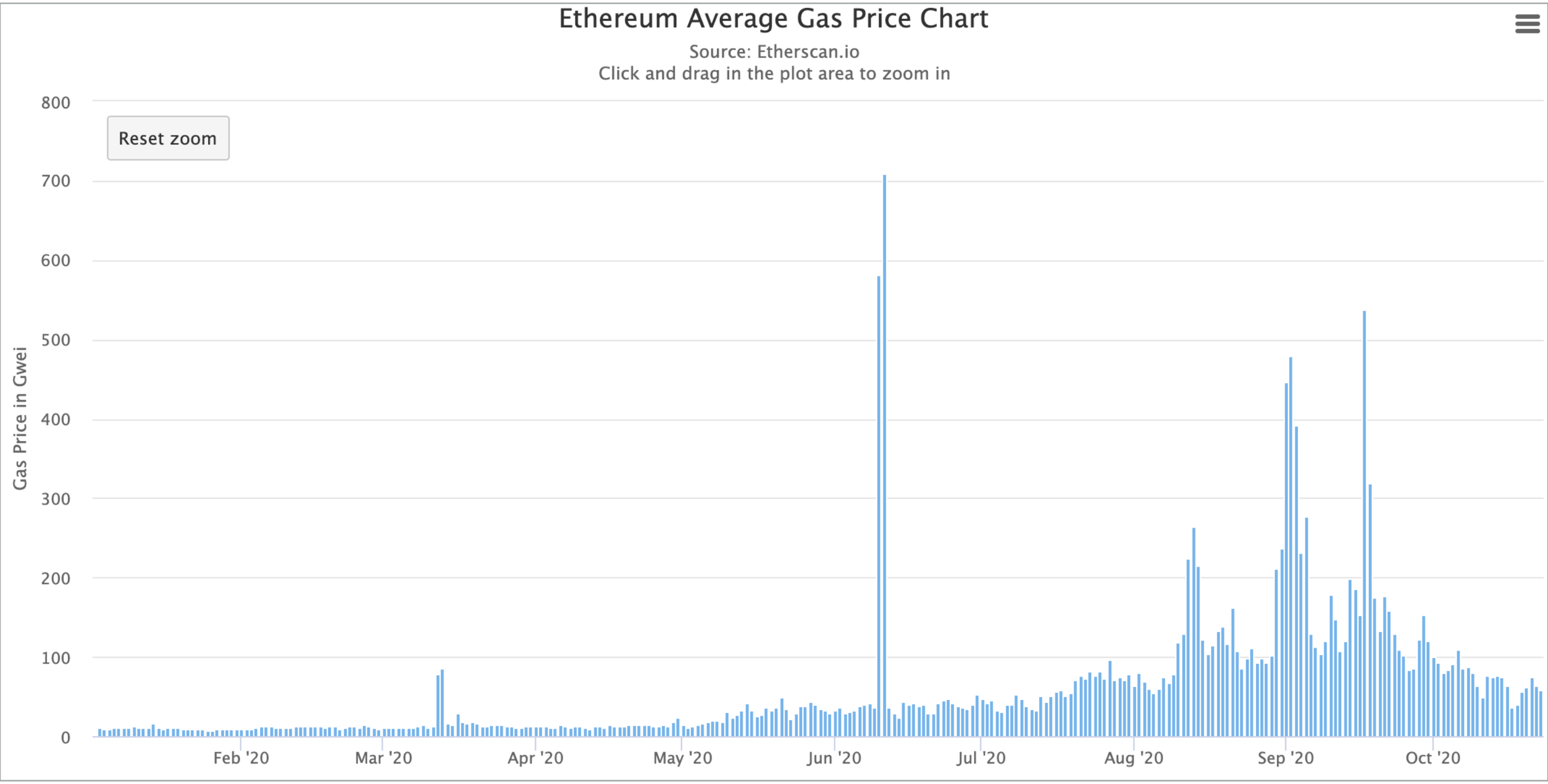
THE PROBLEMS WITH GAS -- USER EXPERIENCE

- Ethereum dapps: high entry barrier
  - get a wallet, acquire some ETH, …
- are people willing to pay for each transaction?
  - web 2.0: you have to pay for your server’s uptime but you don’t directly push this onto your customers; you have other revenue streams

THE PROBLEMS WITH GAS -- PRICES ON ETHEREUM



SPONSORSHIP MECHANISM IN CONFLUX

- someone can choose to sponsor transactions to a smart contract, i.e. pay on the sender's behalf
- example use case: MoonSwap
  - UniSwap: if you swap ETH for USDT, fees are around $4.1 at the time of writing
  - MoonSwap: would cost $0.4 at current price but in practice it's $0 because the transaction is sponsored

SPONSORSHIP MECHANISM IN CONFLUX

- there is a built-in contract called *SponsorWhitelistControl* address: `0x0888000000000000000000000000000000000001`
- **sponsor** calls `setSponsorForGas(...)` to become the sponsor of a smart contract. they will also send some CFX along that will be used to cover the gas costs.
- **contract** calls `addPrivilege(...)` to *"whitelist"* accounts (or use `0x0000000000000000000000000000000000000000`)

SPONSORSHIP MECHANISM IN CONFLUX

- let's say Alice deploys the following contract for her dapp

dapp.sol

```
contract MyCoolDapp {
    constructor() {
        address addr = 0x0888000000000000000000000000000000000001;
        SponsorWhitelistControl swc = SponsorWhitelistControl(addr);

        address[] memory a = new address[](1);
        a[0] = 0x0000000000000000000000000000000000000000;
        swc.add_privilege(a);
    }

    function doSomething() public {
        // ...
    }
}
```

SPONSORSHIP MECHANISM IN CONFLUX

- when Bob calls `doSomething()`, he has to cover gas and storage

dapp.sol

```
contract MyCoolDapp {
    constructor() {
        address addr = 0x0888000000000000000000000000000000000001;
        SponsorWhitelistControl swc = SponsorWhitelistControl(addr);

        address[] memory a = new address[](1);
        a[0] = 0x0000000000000000000000000000000000000000;
        swc.add_privilege(a);
    }

    function doSomething() public {
        // ...
    }
}
```

SPONSORSHIP MECHANISM IN CONFLUX

- at some point, Alice sends 10 CFX to the SWC contract through this call:

set_sponsor

```
swc.setSponsorForGas(
    0x8caddbc9f0360b6b96e32fc0a37ffa275ee139f6, // contract
    10000000000000000, // upper limit per transaction: 0.1 CFX
)
```

- she will most likely do this using the JavaScript SDK, or directly from Conflux Studio
- this means that at least 100 transactions will be sponsored

SPONSORSHIP MECHANISM IN CONFLUX

- when Bob calls `doSomething()` again, he does not need to pay anymore

dapp.sol

```
contract MyCoolDapp {
    constructor() {
        address addr = 0x0888000000000000000000000000000000000001;
        SponsorWhitelistControl swc = SponsorWhitelistControl(addr);

        address[] memory a = new address[](1);
        a[0] = 0x0000000000000000000000000000000000000000;
        swc.add_privilege(a);
    }

    function doSomething() public {
        // ...
    }
}
```

TRANSACTION SPONSORSHIP -- DEMO

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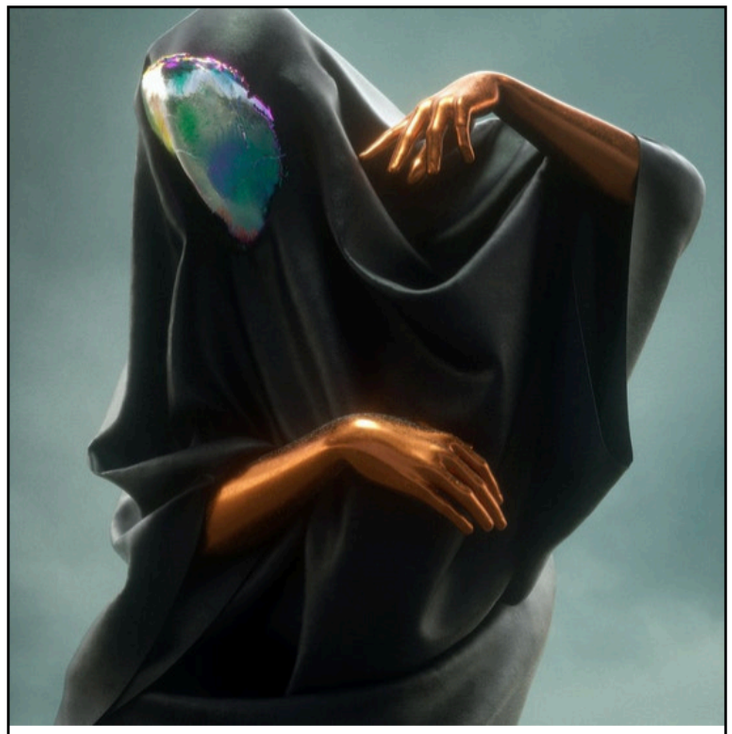
BLOCKCHAIN APPLICATIONS AND TOOLS

- tokens (ERC-20, NFT)
  - stablecoin
  - tokenized art
  - tokenized real-world assets

Skip Tracer

52.53Ξ ($20,97...
List price

ARTIST aeforia
OWNER cryptojack2



Ivy

–
List price

6Ξ ($2,467)
Current bid by @fafafofo

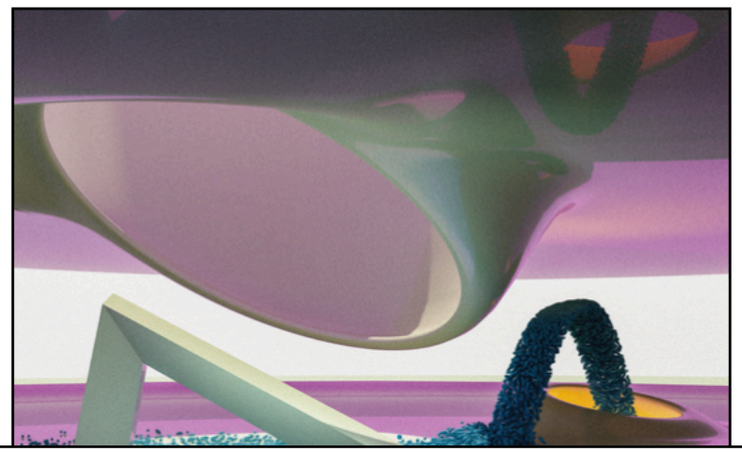
ARTIST aeforia
OWNER aeforia

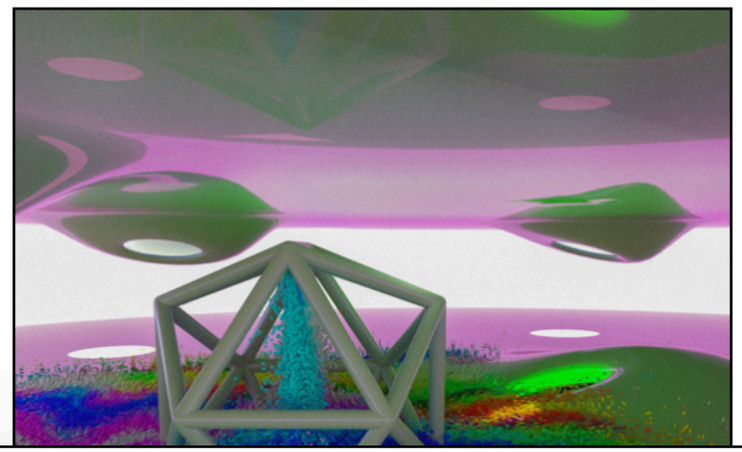
Paranoid

–
List price

17Ξ ($6,991)
Current bid by @doodl...

ARTIST etienecrau...
OWNER fafafofo





BLOCKCHAIN APPLICATIONS AND TOOLS

- DeFi
  - MoonDex
  - MoonSwap
- ShuttleFlow
  - a building block for DeFi applications
  - move tokens from other chains to Conflux
  - e.g. ETH -> cETH, BTC -> cBTC

MOONSWAP

0x1dBD...7636

Swap Pool Wallet

From Balance: 0

0.0 MAX cETH

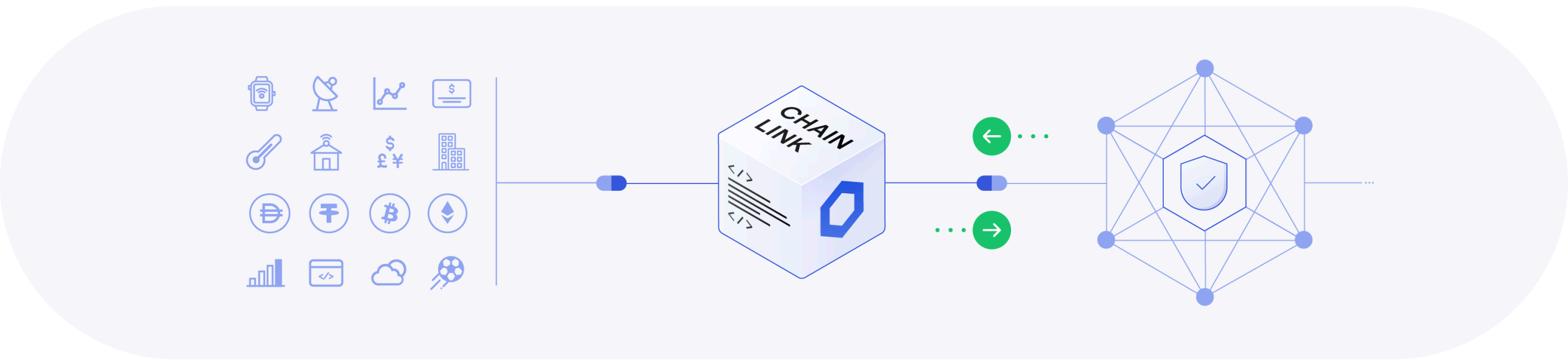
To Balance: 0

0.0 cUSDT

Enter an amount

BLOCKCHAIN APPLICATIONS AND TOOLS

- Oracles: allow your smart contract to interact with the world



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RESOURCES

- ETH Gas Station
  ethgasstation.info
- Bitcoin's Underlying Incentives
  queue.acm.org/detail.cfm?id=3168362
- Zohar et al. Redesigning bitcoin’s fee market. 2019.
  arxiv.org/abs/1709.08881
- Eyal, Sirer. Majority is not Enough: Bitcoin Mining is Vulnerable. 2013.
  www.cs.cornell.edu/~ie53/publications/btcProcFC.pdf

RESOURCES

- What is Ethereum Gas?
  blockgeeks.com/guides/ethereum-gas
- Staking & Collateral For Storage On Conflux Network
  medium.com/conflux-network/conflux-economic-model-staking-collateral-for-storage-on-conflux-network-cb4c8c150e3
- Block Reward Components Under the Network's Mining Incentive Model
  medium.com/conflux-network/conflux-networks-economic-model-block-reward-components-under-the-network-s-mining-incentive-ceadd8f8408f