Threat model of blockchain applications

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Overview

- What is a blockchain
- Why is it important for IoT
- What are the security challenges
- Some past exploits

What is the scope of a blockchain?

The Problem

Create an electronic cash-like payment system

Goals

- p2p transactions

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- Censorship resistant

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- Censorship resistant
- Permission-less
- Bonus: store of value
- Bonus 2: privacy-aware

Decomposing the problem

- **WHO** is transacting?

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- **WHERE** do I keep track of the transaction?
- **WHAT** is the object of the transaction?
- **WHEN** is the transaction occurring?

The PayPal model

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- Everything is controlled by a centralized server
- Easy to be censored and shut down
- Security hole and reliability risks
- No control on the total supply

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- Using digital signatures you can easily identify the actors in the system
- The receiver of the transaction can verify that the sender is actually the owner of a balance
- No need to rely on a central party to manage identities

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- Instead of keeping everything on a central server, each user keeps a local copy of the transactions that are relevant to him

- Less trust required through the central party, more difficult to censor transactions

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- To send an email, you were required to calculate the hash of the text + a nonce, and keep hashing changing the nonce until an hash with the required number of 0 was found

- The receiver could easily verify that a work was done in order to send the email

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- Users have the guarantee that their wealth cannot be easily diluted without an effective work done
- The object of the transaction has a value since a work was done to create a coin

WHAT - The Proof of Work to issue money

50 btc to Alice/ nonce

4389051bbab1a0a176caca15c7fc33bbeb8b04a060436a1685b68e20e311b364
34da93ee3b196a998cab98b889c041ad503bf21af46059a84adcefeedf53e905
C06b4e4b8e35e49f09fe2d5cef82eb56666a98b00097cf4c785918c54bca7fc5
A7de28cfe908ec9801c5e42220545e9d93c6113344166611ee70f3f73705f485
3439c0226bc243d4fa1e816b560851df1c9ecb4ad5bb356d333d6e78716be996
.
.
.
028511490652c7a4ffb0a0a4c7b4a6e764600ea96682f54d15beba5e6293edf2

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- If the double spending is not forbidden, users can create new money at 0 costs

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- An easy solution would be to have a central coordinator to decide which transaction came first
- This of course this causes censorship resistance and reliability problems
- Everybody needs to have a **full copy of the ledger** (to detect double spending) and a consensus on the state of the ledger has to be achieved

WHEN - PoW for transaction validation

- The PoW is already applied for issuing transaction (mining), to decide which transactions are valid it can be applied also to other people non-issuing transactions

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- A PoW algorithm is applied to a block of transaction, the first one to find an hash with the required difficulty get the issuing transaction (reward) and decides the validity of other people transactions

WHEN - The Proof of Work to issue money

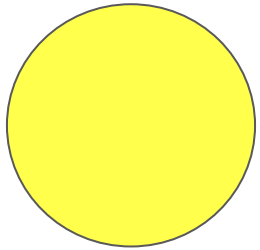
50 btc to Alice/ nonce

1 btc from Bob to Carol
5 btc from Dave to Frank
2.3 btc from Ted to Chuck

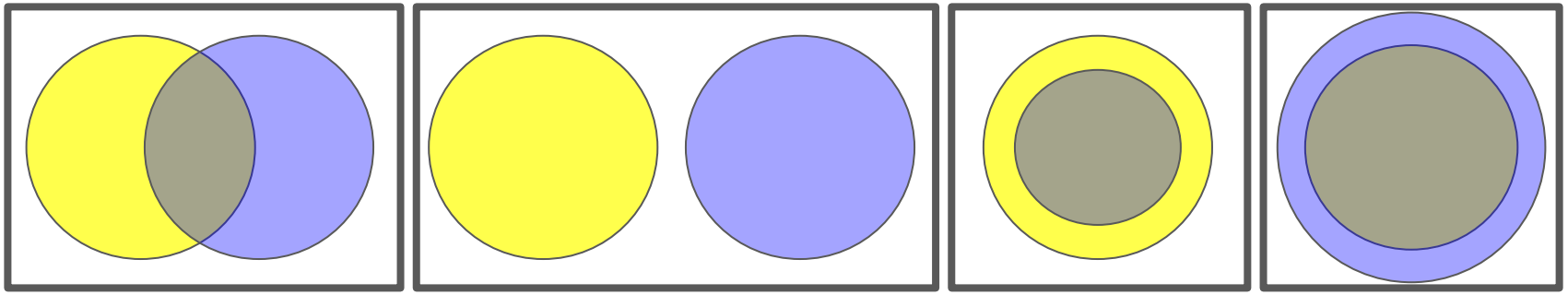
0de8c5eadad506ec3e777a25ebc5982d22364e987ac759d5ce685731b798e627

Consensus rules

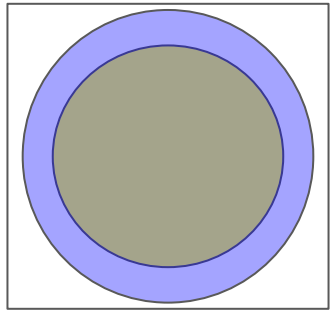
In any consensus-based system, nodes follow the same set of rules

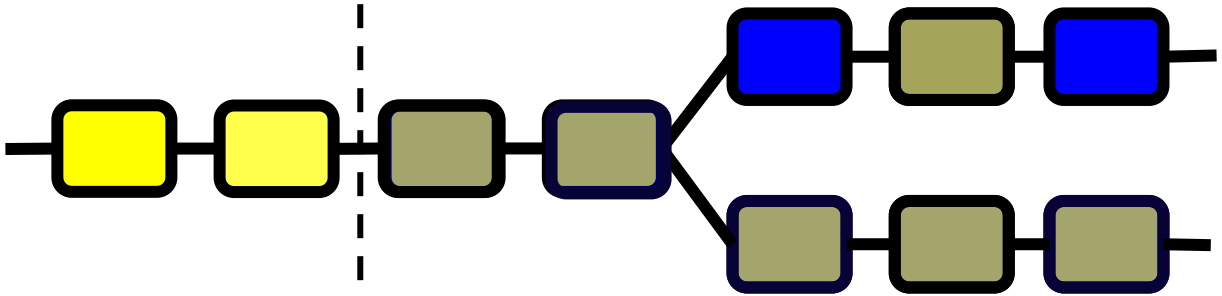


What happens if nodes follow different rules?



Hard fork





As soon as a blue block appears, there is no way to recover the split

Blockchain and IoT

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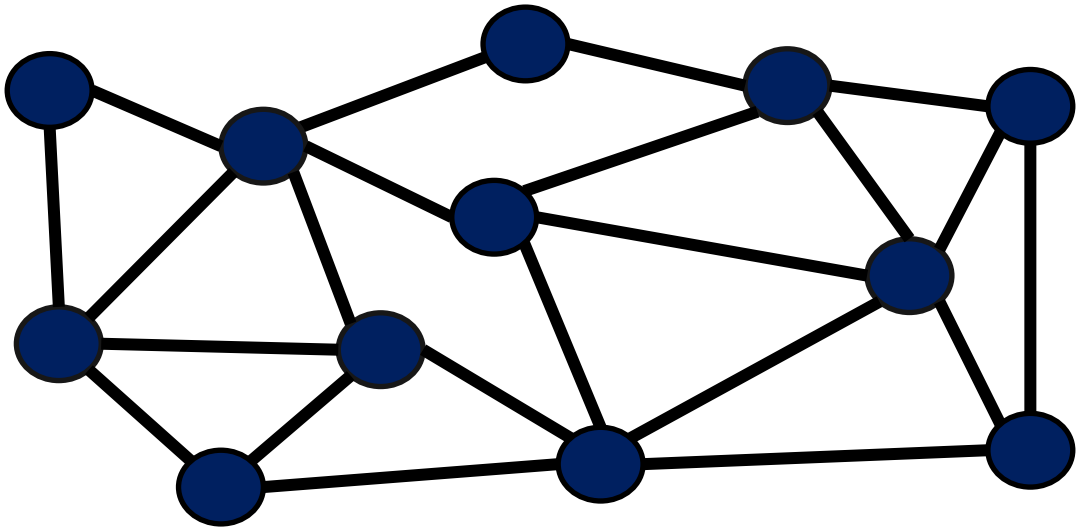
- **Data notarization:** IoT sensors generated data can be notarized on the blockchain making them verifiable for future auditing, something extremely valuable in the insurance industry

Smart contracts



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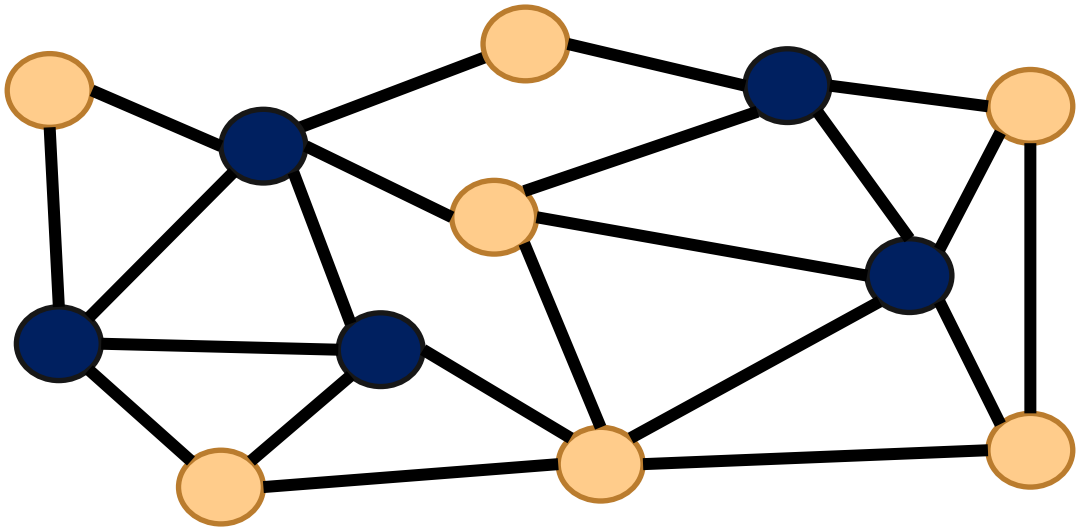

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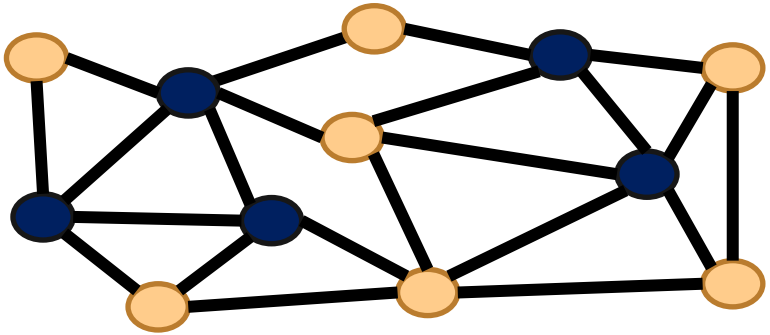
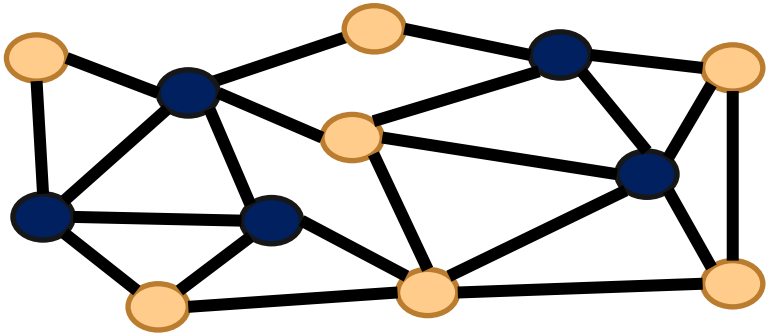


Smart contracts accepted by yellow nodes

Smart contracts accepted by blue nodes

Smart contracts



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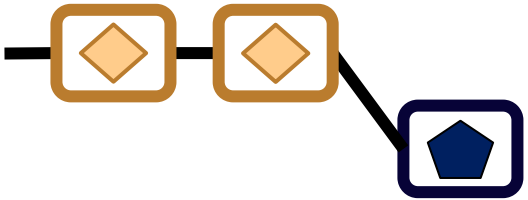

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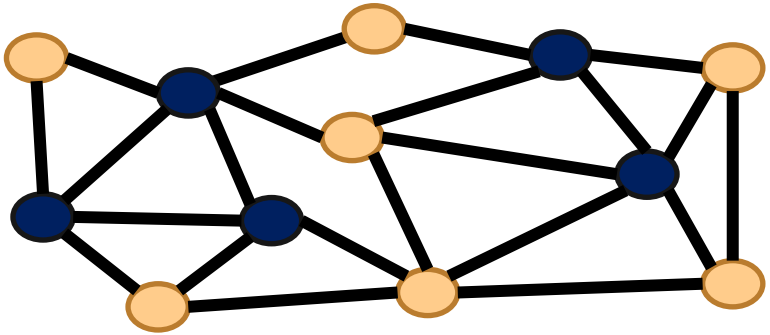

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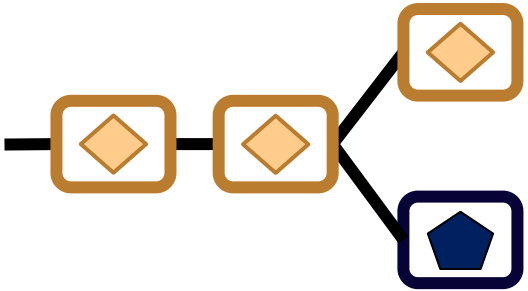

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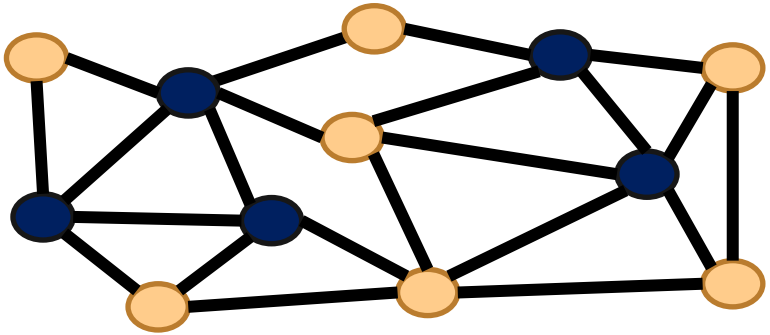

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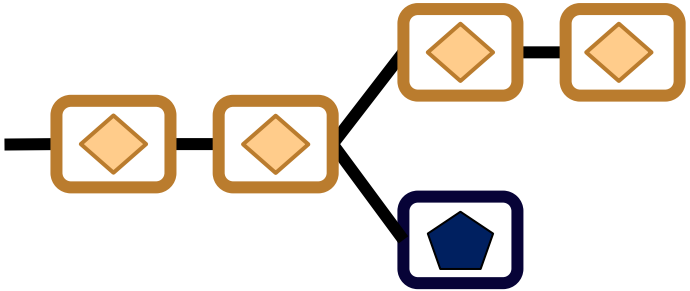

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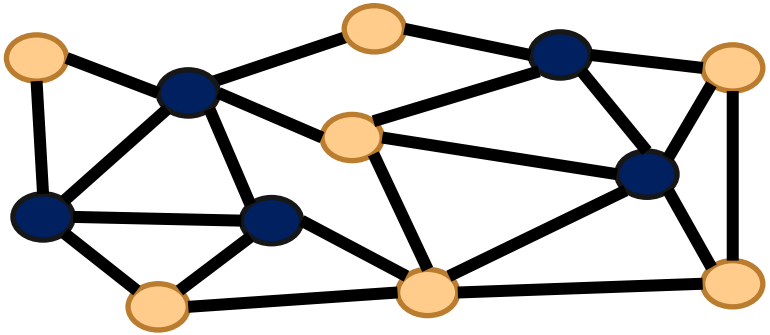

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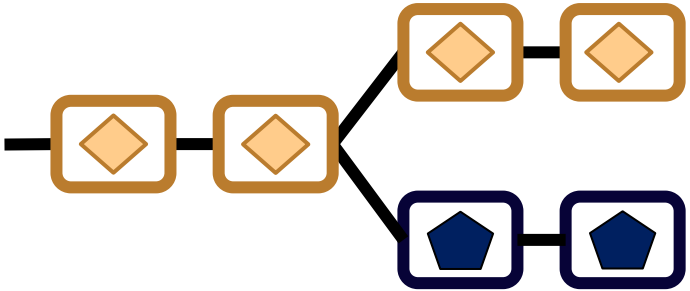

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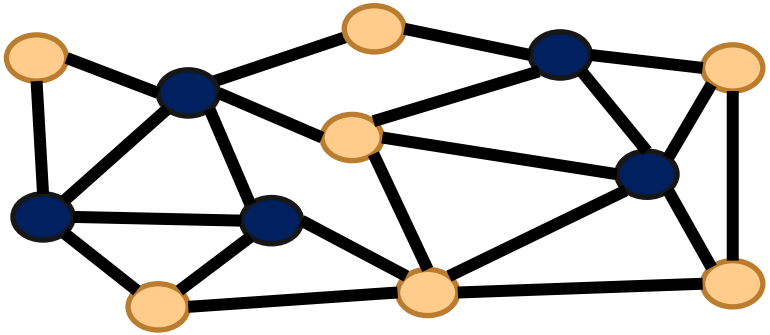

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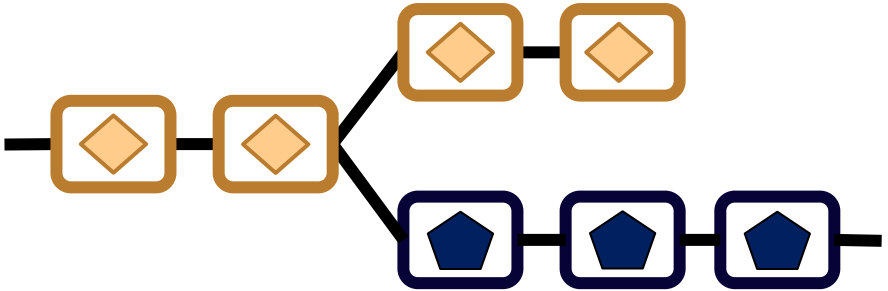

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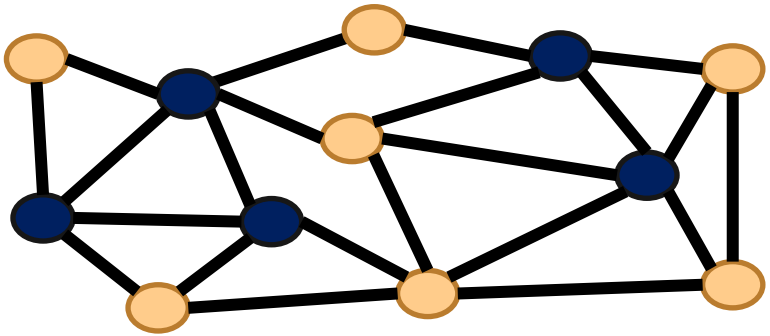

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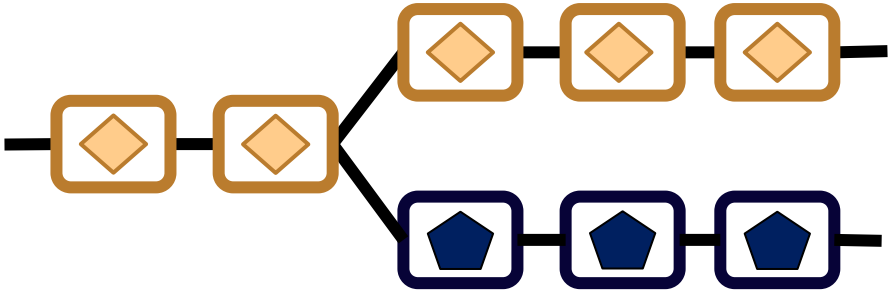
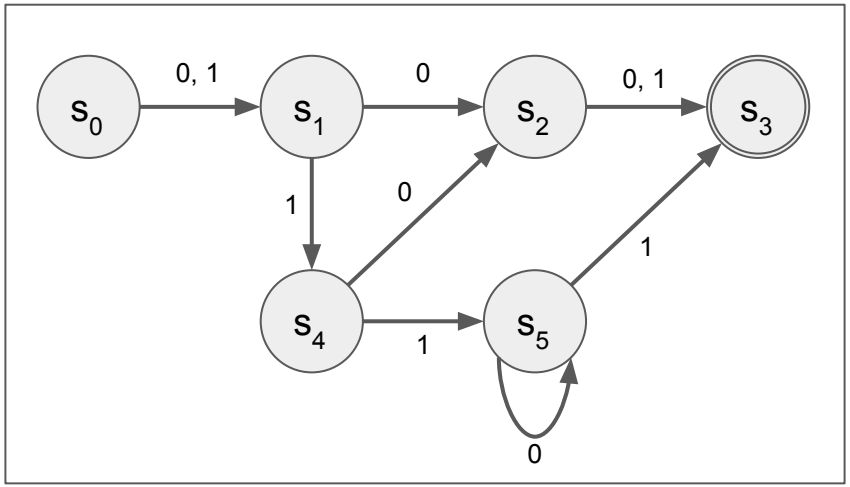
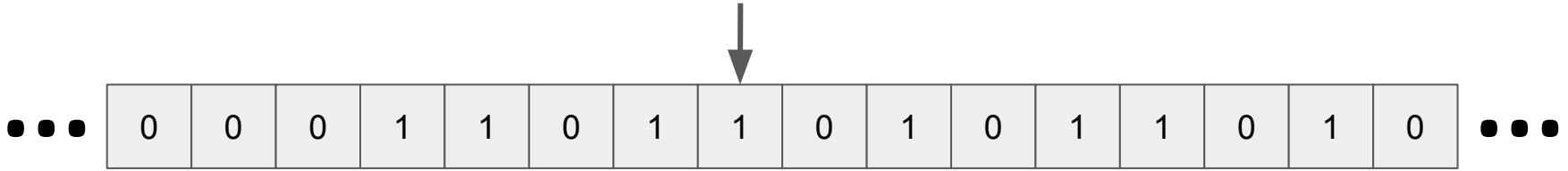


Turing completeness - General concept

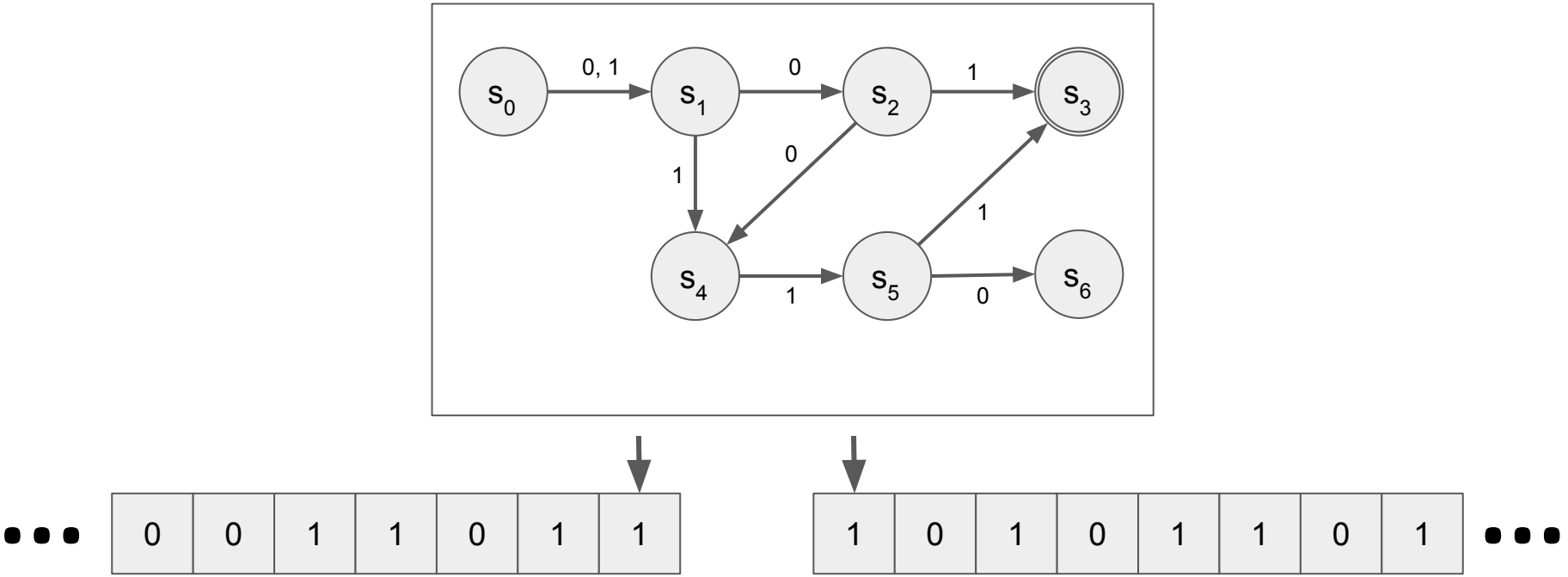




Turing completeness - In real life

```
 1
 2a = int(input())
 3
 4if a > 10:
 5
 6    while a < 100:
 7        a = a + 1
 8        print(a)
 9
10else:
11    print(a + 10)
12
```

Turing completeness - Bitcoin formalisation



Turing completeness - Bitcoin in real life

```
IF
    HASH160 <hashed_data> EQUAL

    <pubk1> CHECKSIG

ELSE

    <timestamp> CHECKLOCKTIMEVERIFY

    2 <pubk2> <pubk3> <pubk4> 3 CHECKMULTISIG

ENDIF
```

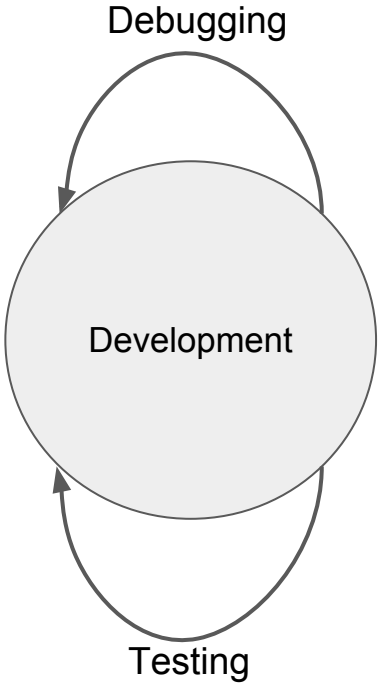
Turing completeness - Problems

find the bug!

```
    sorted_currencies = sorted(currencies)
    for gateway in [g.replace('/','-') for g in Account.known_users]:
        for field in ('from_users','from_gateways'):
            with open('trust_by_gateway/%s/%s' % (field,gateway), 'w') as outfile:
                outfile.write('time ')
                for curr in sorted_currencies:
                    outfile.write('{0}_amount {0}_volume '.format(curr))
                outfile.write('overall_amount overall_volume\n')
    for ledg in ledger_gen(START,LAST+1,STEP,True):
        time = ledg.close_time(True)
        output = {user:{'from_users':{c:0.0 for c in currencies+['overall']}, 'from_gateways':{c:0.0 for c in currencies+['overall']}}
for user in Account.known_users}
        received = {user:{'from_users':{c:set() for c in currencies+['overall']}, 'from_gateways':{c:set() for c in currencies
+['overall']}} for user in Account.known_users}
        for edge in ledg.trustlines(lambda x: x.dest.known and converter.convertible_in_time(x.amount.currency)):
            name = edge.dest.get_name().replace('/','-')
            currency = edge.amount.currency
            if edge.orig.known:
                field = 'from_gateways'
            else:
                field = 'from_users'
            converted_value =  converter.convert_in_time(edge.amount.value,currency,conversion,time)
            if currency in currencies:
                output[name][field][currency] += converted_value
                received[name][field][currency].add(edge.orig.get_name())
            output[name][field]['overall'] += converted_value
            received[name][field]['overall'].add(edge.orig.get_name())
        for gateway in output:
            for field in ('from_gateways', 'from_users'):
                with open('trust_by_gateway/%s/%s' % (field,gateway), 'a') as outfile:
                    outfile.write("%s " % (time.strftime("%Y%m%d%H%M%S"),))
                    outfile.write(' '.join(["%s %d" % (str(output[gateway][field][sorted_currencies[i]]), len(received[gateway][field]
[sorted_currencies[i]])) for i in xrange(len(sorted_currencies))]))
                    outfile.write(" %s %d\n" % (str(output[gateway][field]['overall']), len(received[gateway][field]['overall'])))
```

Turing completeness - Problems

- Classical software development process



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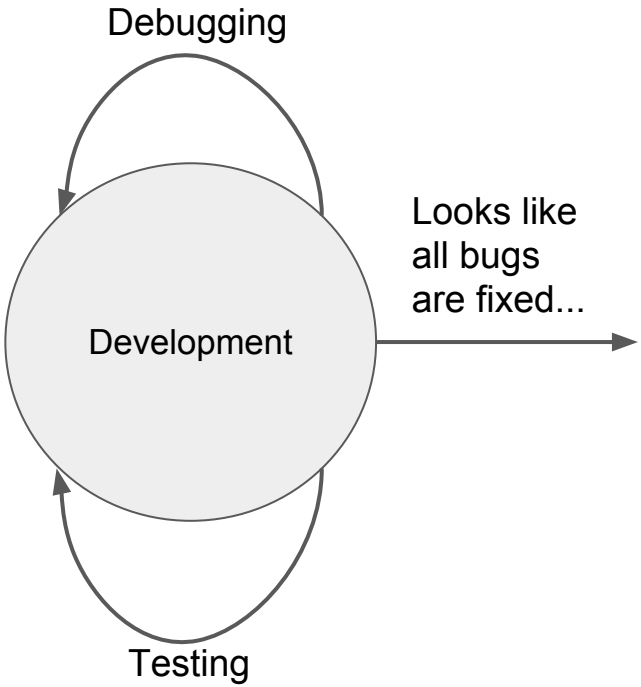

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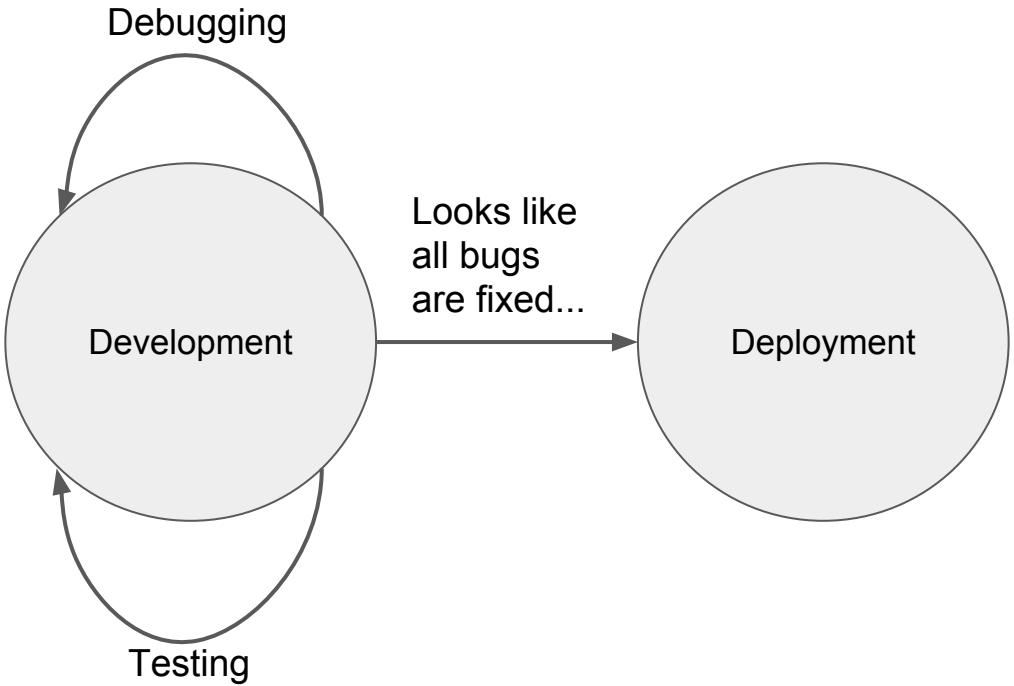

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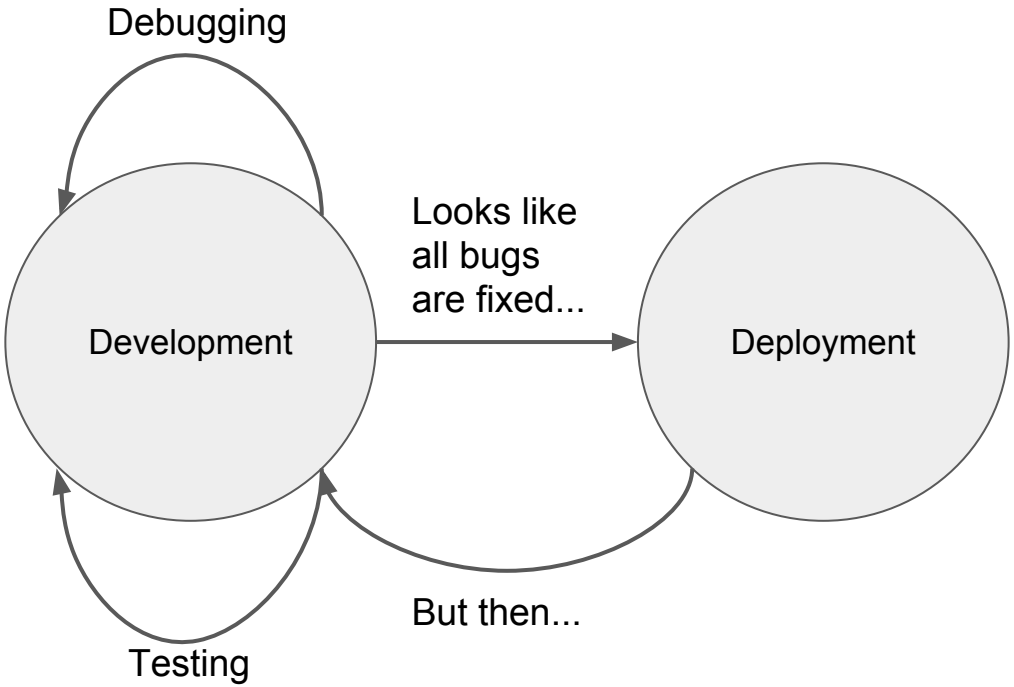
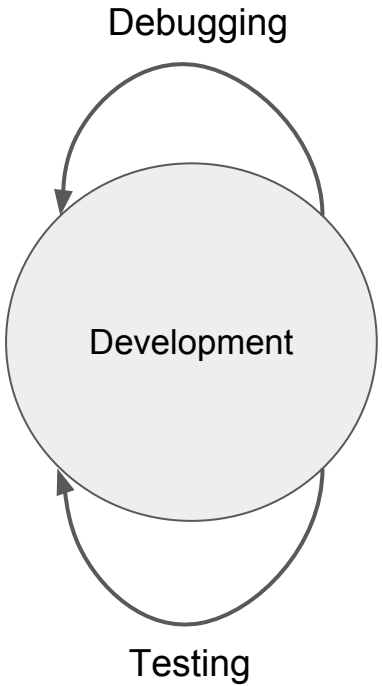


Immutability!

- Software development process on smart contracts



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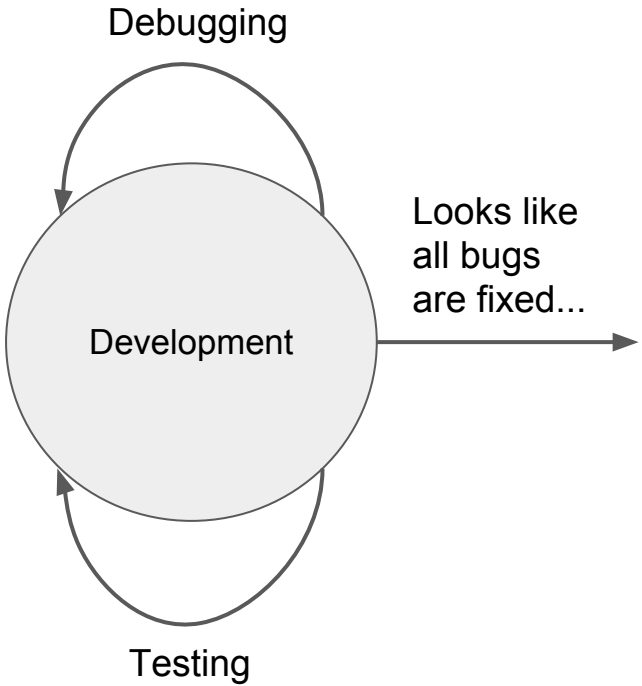

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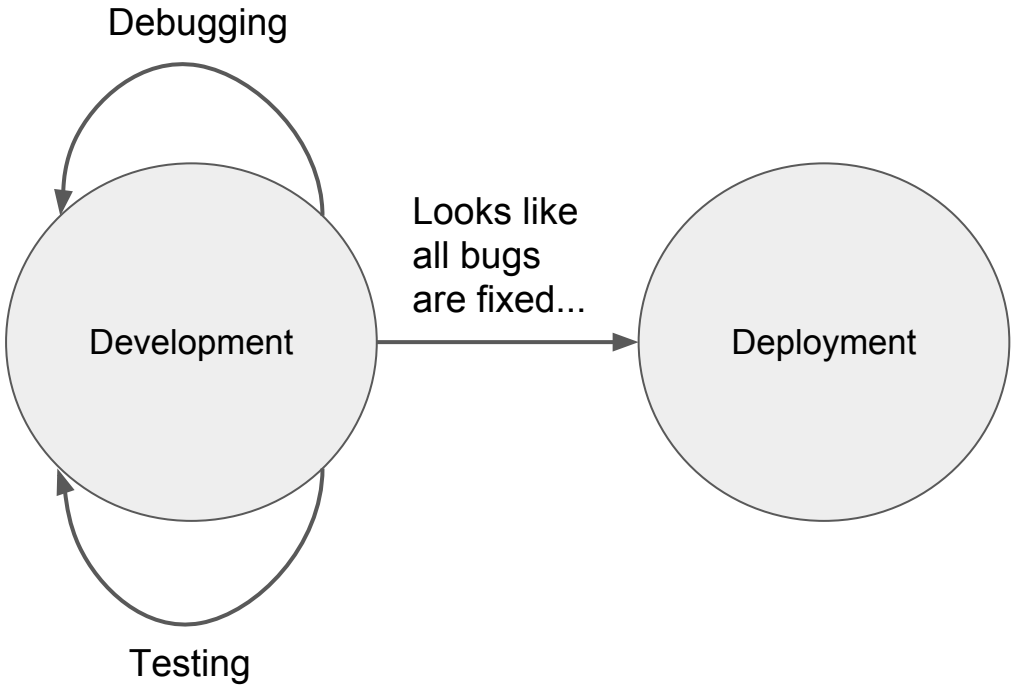

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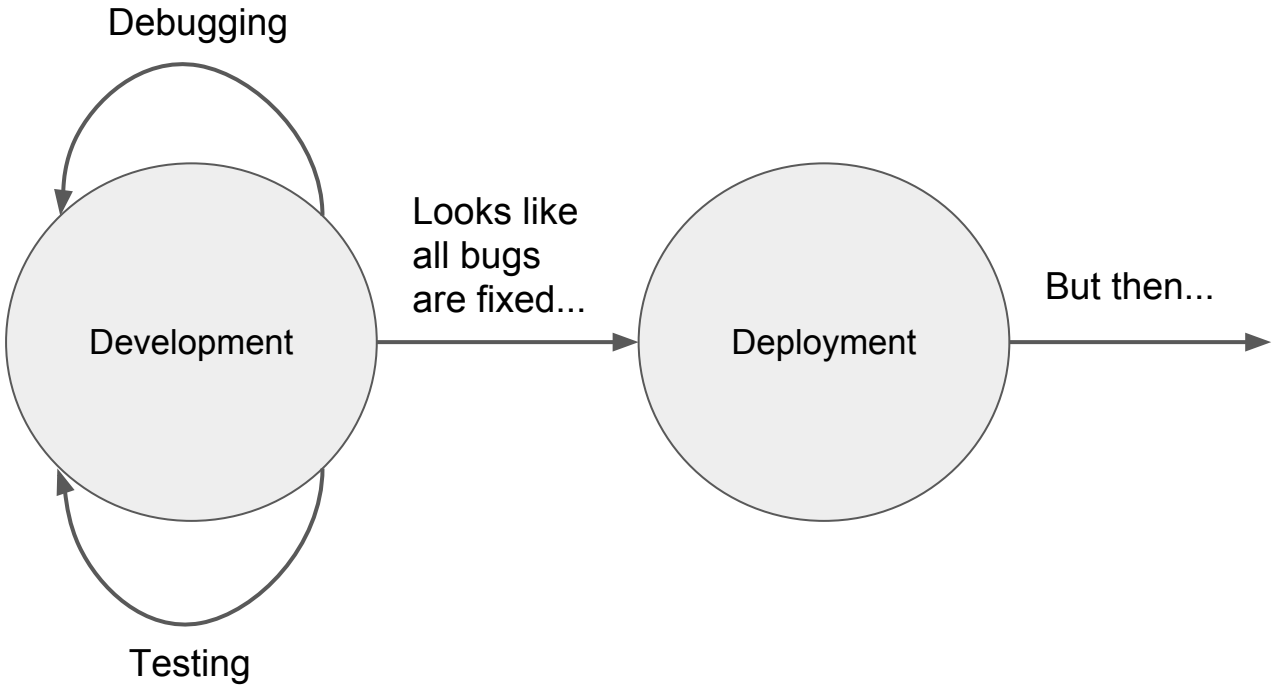

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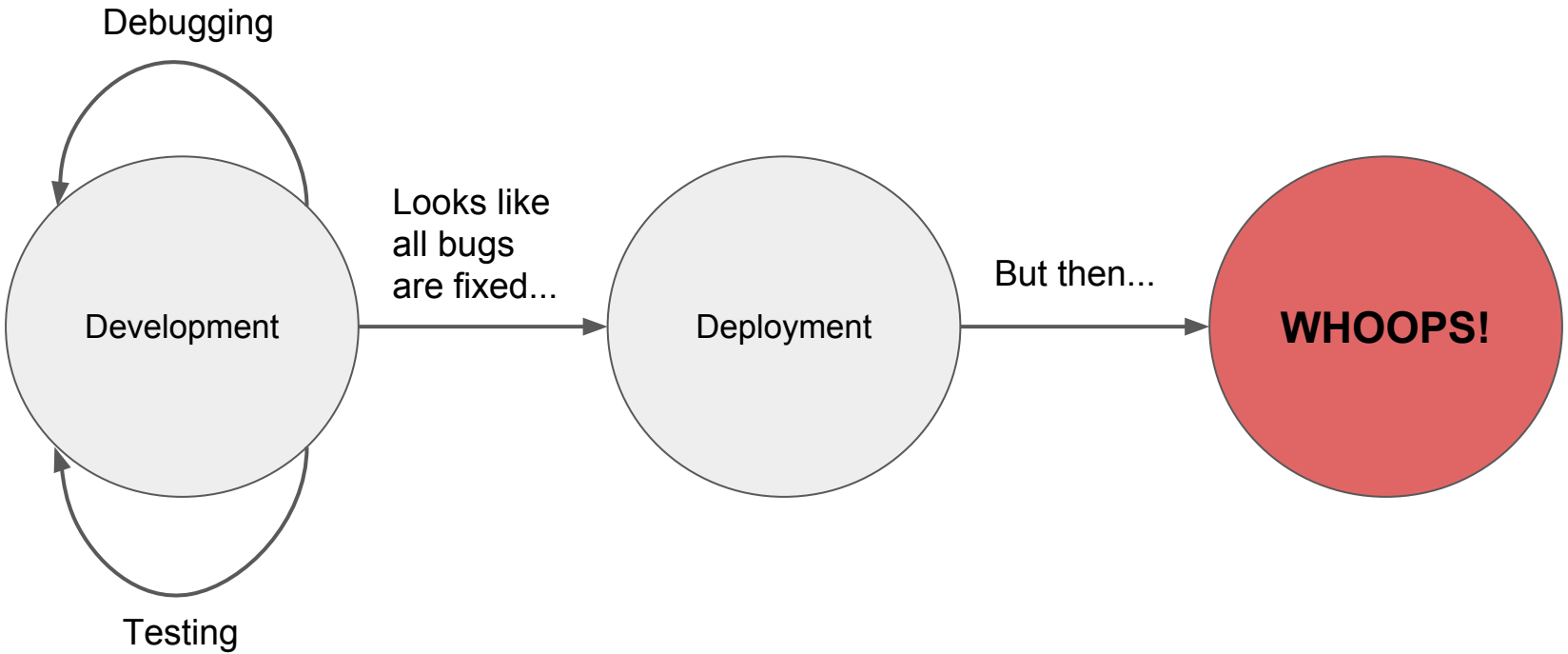
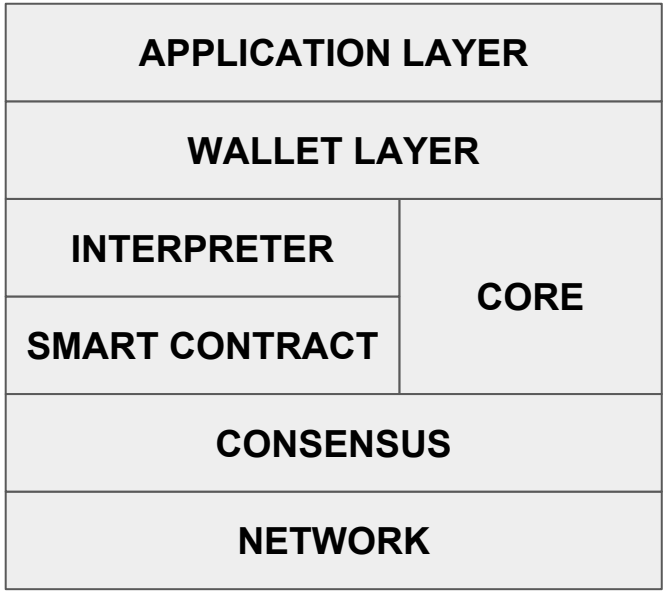
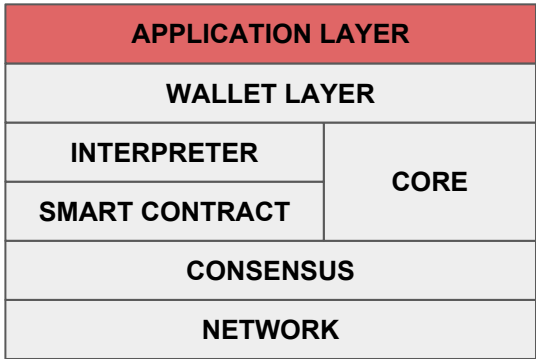


Attack surfaces



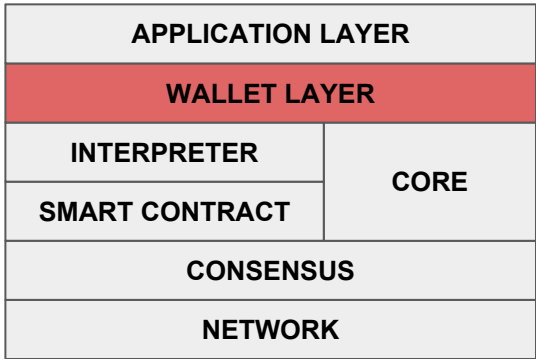
Brainwallets

- Brainwallets are wallets that generate the private keys using few words chosen by the user as source of entropy
- With this technique users don’t have to securely store their private keys as they are able to regenerate them at anytime
- Unfortunately the lack of entropy in this key generation system make it easy for attackers to brute force the private keys and steal the funds



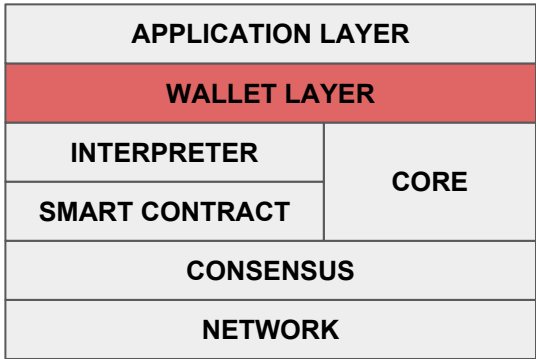
Mt Gox

- In Bitcoin transactions are identified by the TXID, but unfortunately it was possible for third parties to change the TXID of a transaction without making it invalid
- MtGox used the TXID to track deposits and withdrawals of its users
- Attacker could request a withdraw, malleate the withdrawing transaction and contact MtGox support claiming that the transaction didn’t occur
- MtGox would then send a second withdraw transaction to the user



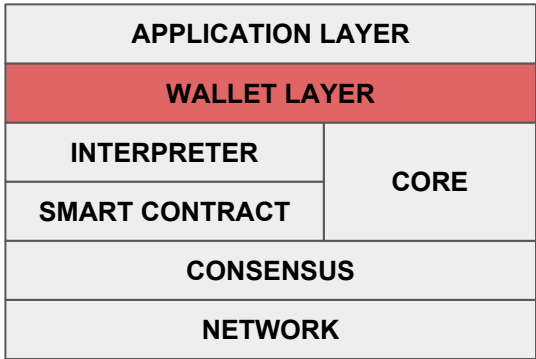
Blockchain.info

- On December 8th 2014, for few hours the random number generator responsible for private keys creation was mistakenly altered
- The key generated in that period were exposed, compromising the bitcoins they held
- Few hundreds bitcoins were stolen, but Blockchain.info reimbursed the users affected by the loss



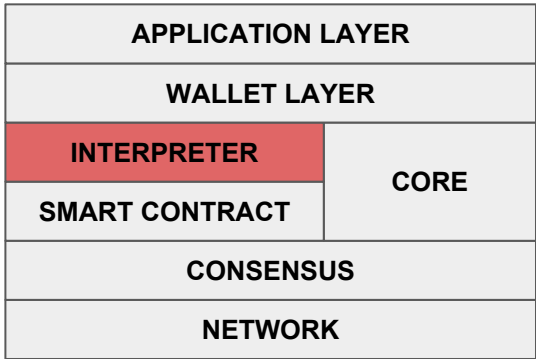
Bitcoin - Value overflow incident

- On August 15 2010, it was discovered that block 74638 contained a transaction that created 184,467,440,737.09551616 bitcoins
- This happened because the code used for checking transactions before including them in a block didn't account for the case of outputs so large that they overflowed when summed
- A new version of the client was published, containing a soft forking change to the consensus rules that rejected output value overflow transactions
- The blockchain forked until the “good” chain eventually became the longest



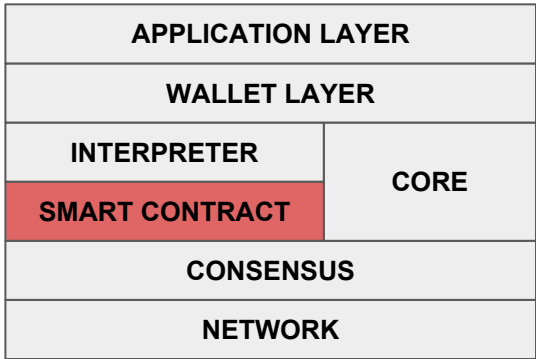
Bitcoin - Multisig evaluation

- In its first version, bitcoin operation `OP_CHECKMULTISIG` expected N+1 values as an input to validate N signatures
- This meant that providing the correct number of signatures had the interpreter crash
- The solution was actually easy (just provide one more dummy parameter)
- To this day we still add a dummy parameter to multisig scripts



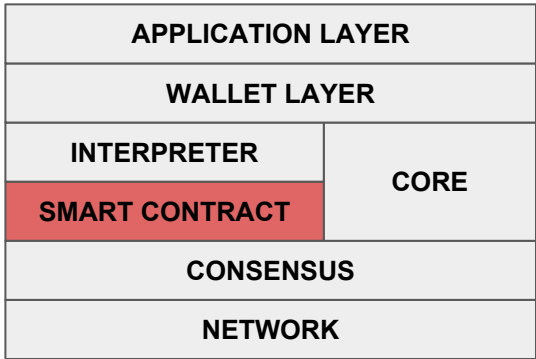
Parity 1

- Parity provided a multisig wallet smart contract which was probably overcomplicated (hundreds of lines of code)
- In the contract there was a bug that allowed third parties to change the ownership of the contract, stealing the funds inside
- $31M dollars were stolen, and other $100M were taken by white hat hackers and later given back to the owners



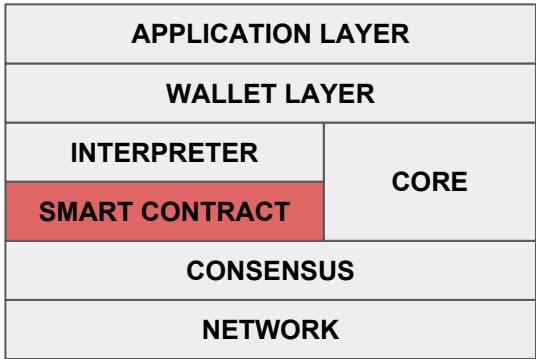
Parity 2

- Parity multisig wallet contract refers to a “library” contract to save gas on the deployment of the wallet logic
- The “library” contract however was actually an unutilized wallet contract, and it could be initialized by anyone
- Somebody did it, and as the new owner of the contract was able to kill it, freezing the funds of all the other wallets depending on it



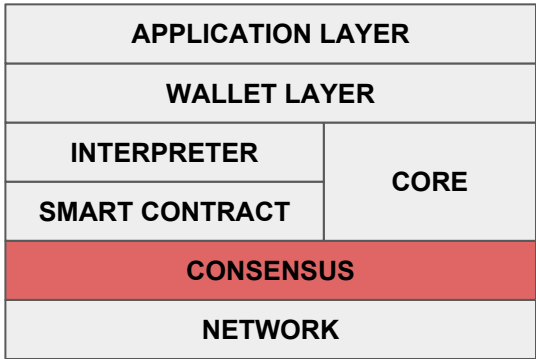
DAO (1)

- The DAO was a complex Ethereum-based smart contract that was supposed to act as a decentralised investment fund and collected over $150M
- Due to a bug in its code, it was possible for an attacker to withdraw more money than deposited, draining funds out of the DAO



DAO (2)

- To fix the issues, miners agreed to operate a hard fork and give the money back to the DAO investors
- As a result of the hard fork, the Ethereum network split and still today there are two incompatible versions of the chain



devops199 @devops199 07:49

will i get arrested for this? 😟

0x642483b7936b505dbe2e735cc140f29ddfddb3f3e39efa549707d98e0298de6e4dea99a30da4872869e36322c9dfcdd06d9aa389e746dc6b92fdc0414e0b18421b

0xae7168deb525862f4fee37d987a971b385b96952

Tienus @Tienus 07:51

@devops199 you are the one that called the kill tx?

devops199 @devops199 07:51

yes

i'm eth newbie..just learning

qx133 @qx133 07:52

you are famous now haha

devops199 @devops199 07:52

sending kill() destroy() to random contracts

you can see my history

😟(((((((((((((((((((((((((((((

Xavier @n3xco 07:52

can't make an omelet without breaking some eggs

i guess

Tienus @Tienus 07:53

Let me know next time you decide to kill some contracts so I can sell my E

1 UNREAD

Conclusions

- Blockchains are a very powerful tool, but:
  - Using them is very complex
  - Mistakes can cost millions
  - There is a huge need for experts
  - There is a huge lack of experts

QUESTIONS?