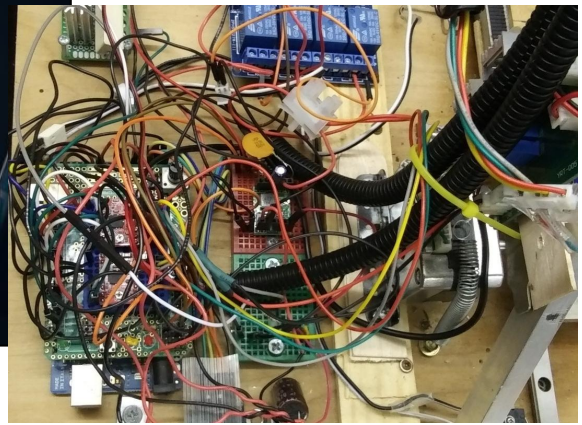
Bitcoin & BigQuery

Introduction to fraud detection

About me

- nam
- city:
- occu
- in th
- lang
- duri
  - family
  - offshore sailing
  - finding solution

ment: **>10 years**



Story of my life

TODOs

Cryptography 101

Bitcoin Data Model

Google Bitcoin Public Dataset Overview

Simple Fraud Detection

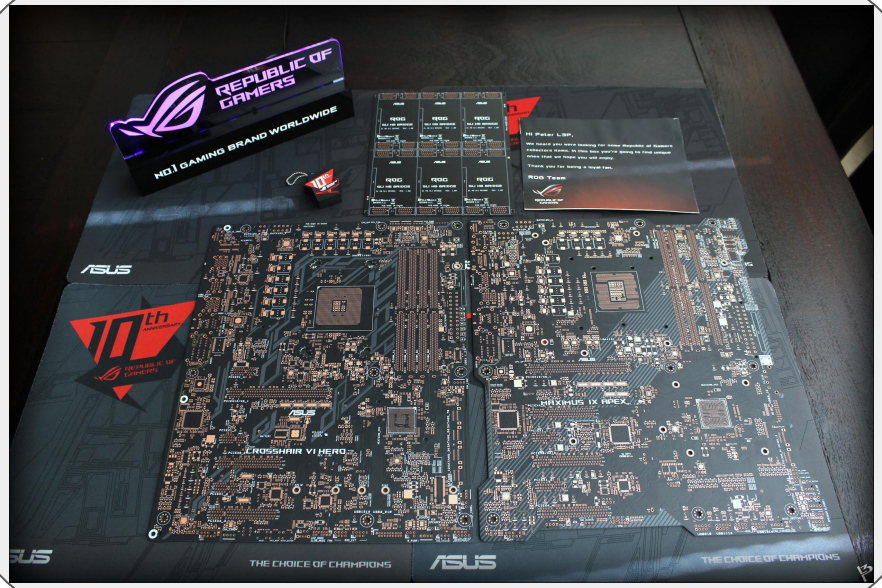
Chapter 0:

Cryptography 101

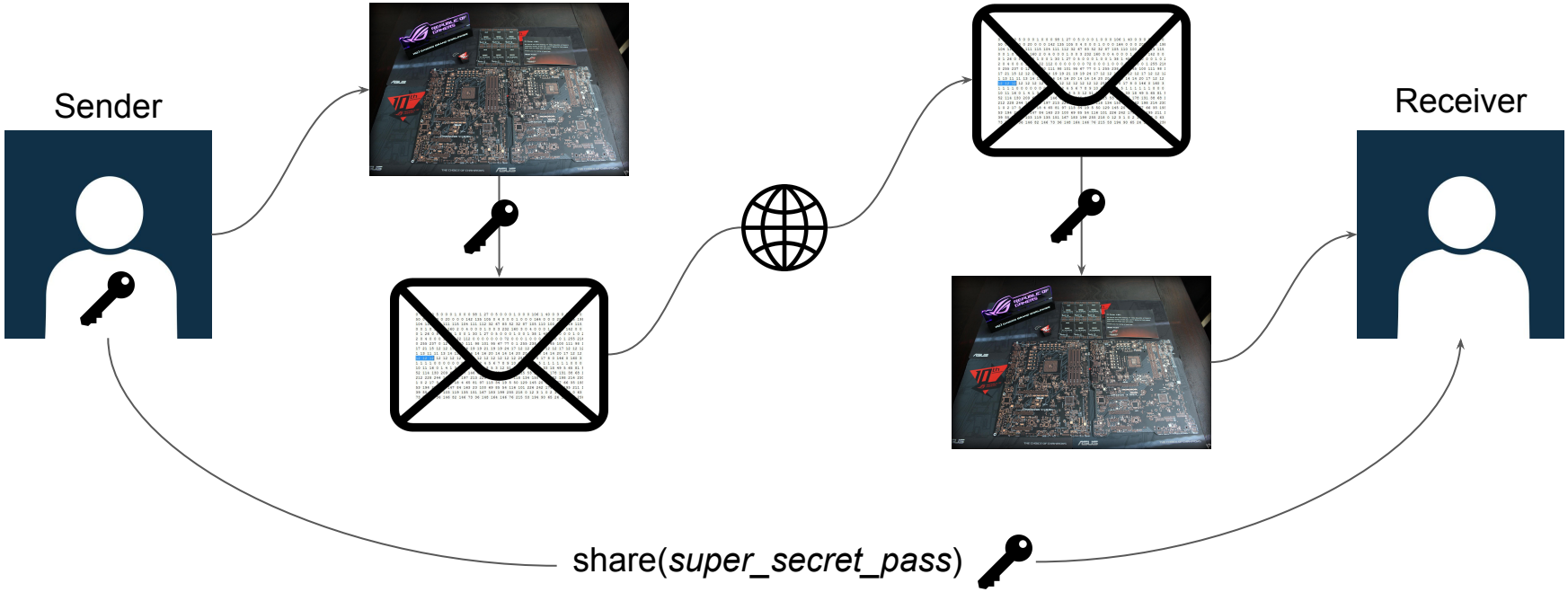
Chapter 0: Cryptography 101 - use cases

Send nudes

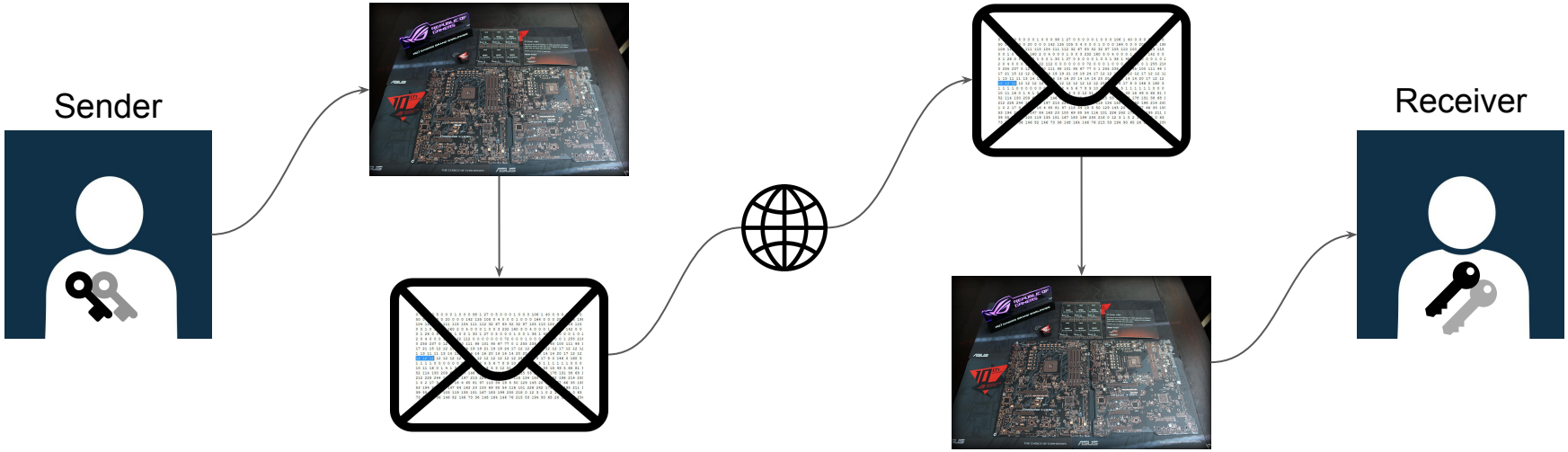
Sure!



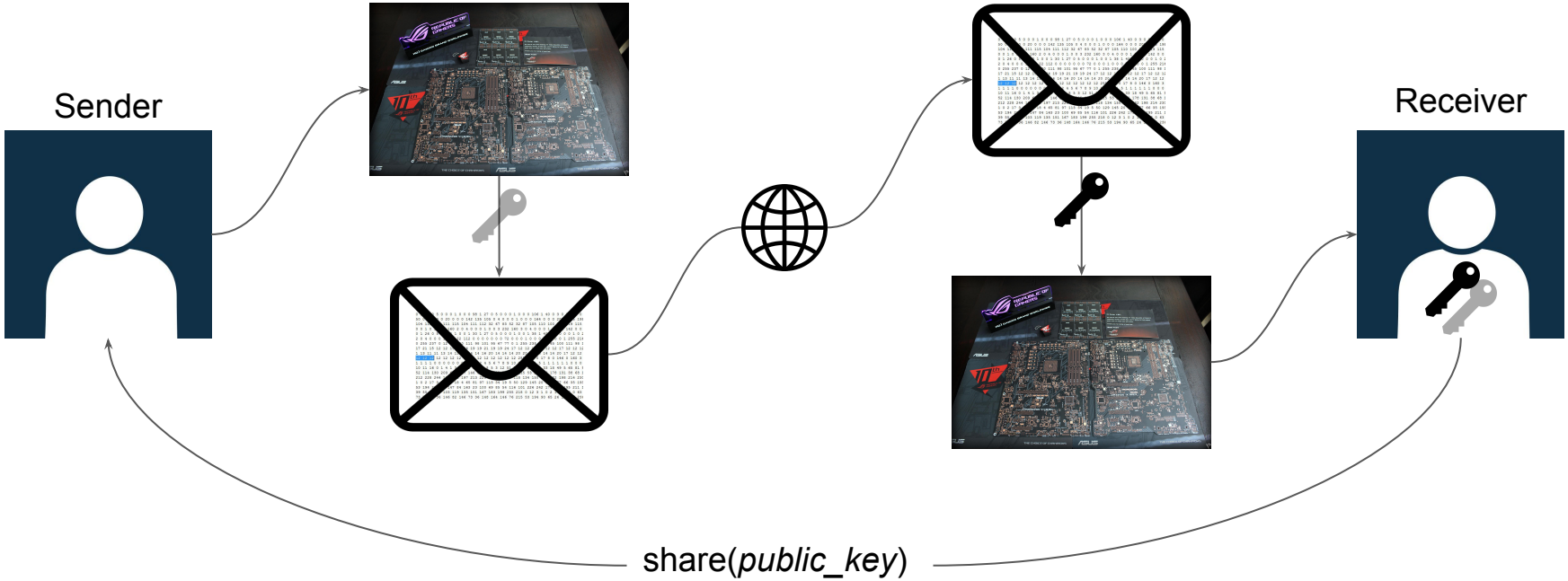
Chapter 0: Cryptography 101 - symmetric



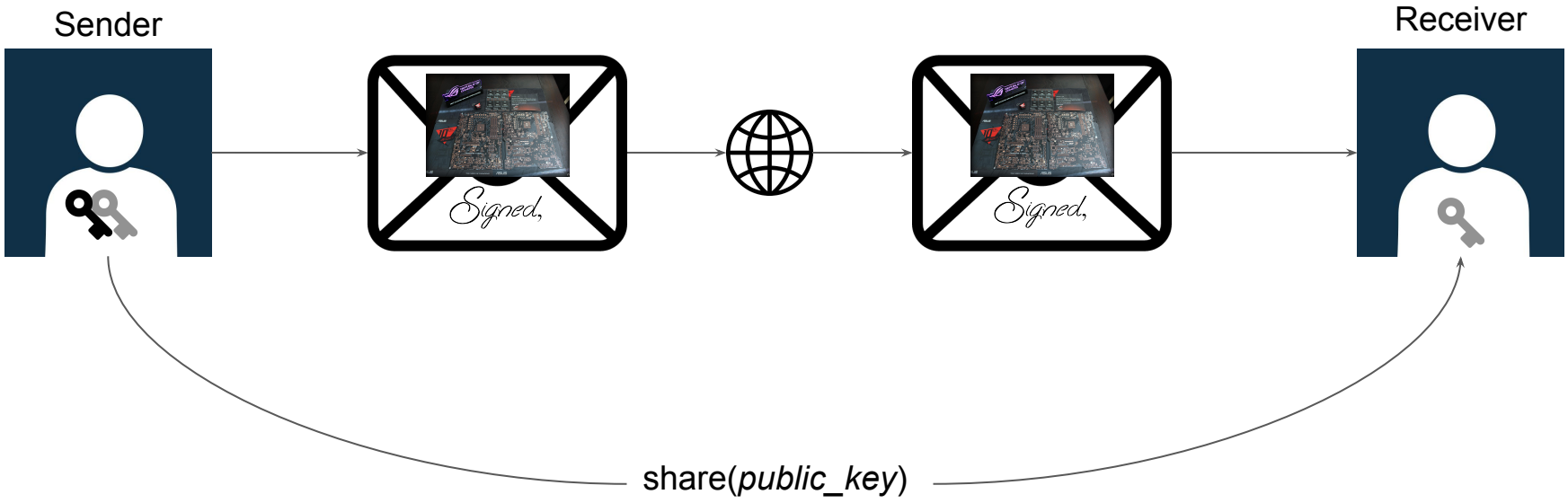
Chapter 0: Cryptography 101 - test question



Chapter 0: Cryptography 101 - asymmetric



Chapter 0: Cryptography 101 - signing



Chapter 0: Cryptography 101 - summary

- Symmetric cryptography

- Asymmetric cryptography
  - Encrypting & Decrypting
  - **Signing**

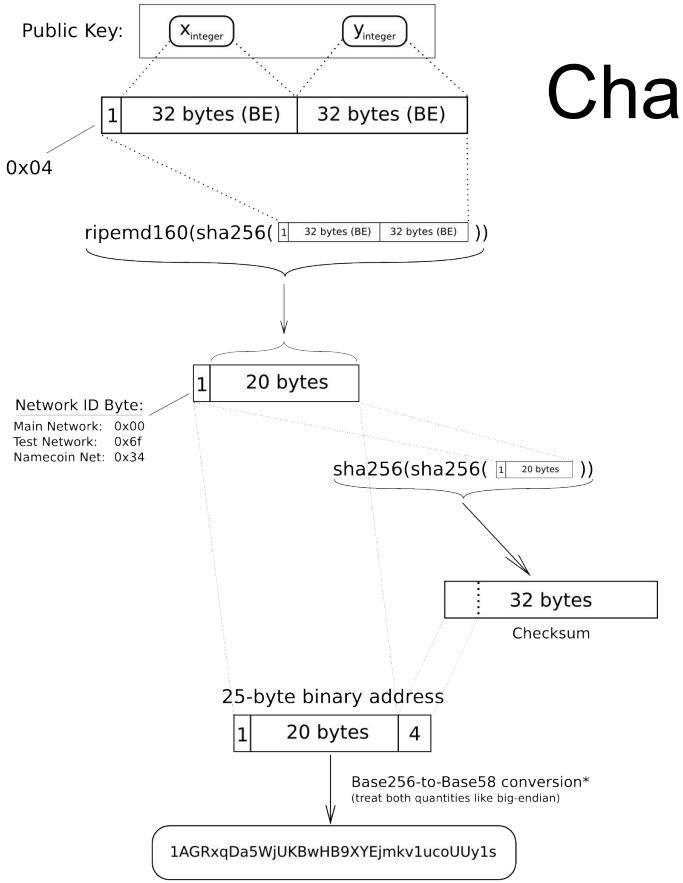
Chapter 1:

Bitcoin Model

Chapter 1: Bitcoin Model - address

https://www.blockchain.com/btc/address/1DBqpfptUMizLDACvMVsrJFPdMtbgmZCk1

Chapter 1: Bitcoin Model - address



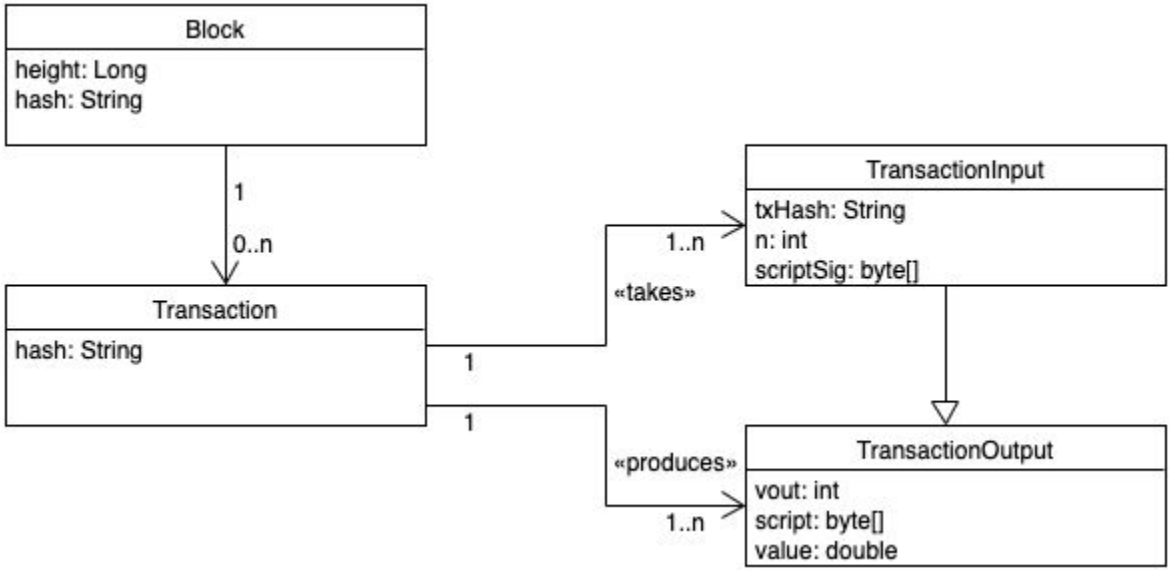
https://en.bitcoin.it/wiki/Technical_background_of_version_1_Bitcoin_addresses

Chapter 1: Bitcoin Model - value

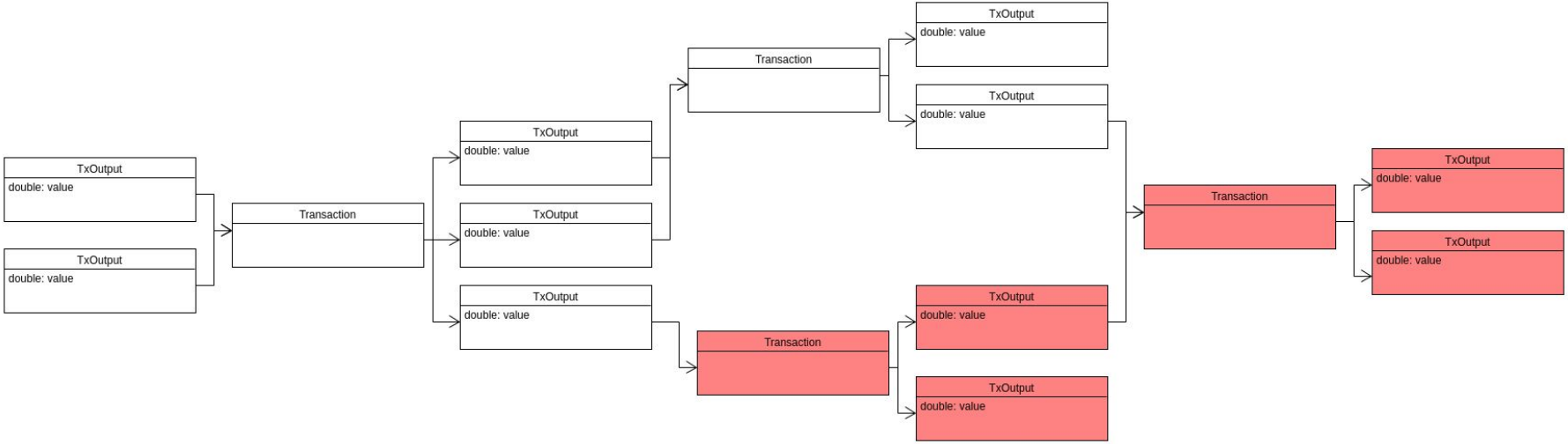
1 BTC = 100,000,000 Satoshi ~ 6,940.00$ ~ 26,364.85zł

TxOutput!

Chapter 1: Bitcoin Model - UML like a pr0; part: I

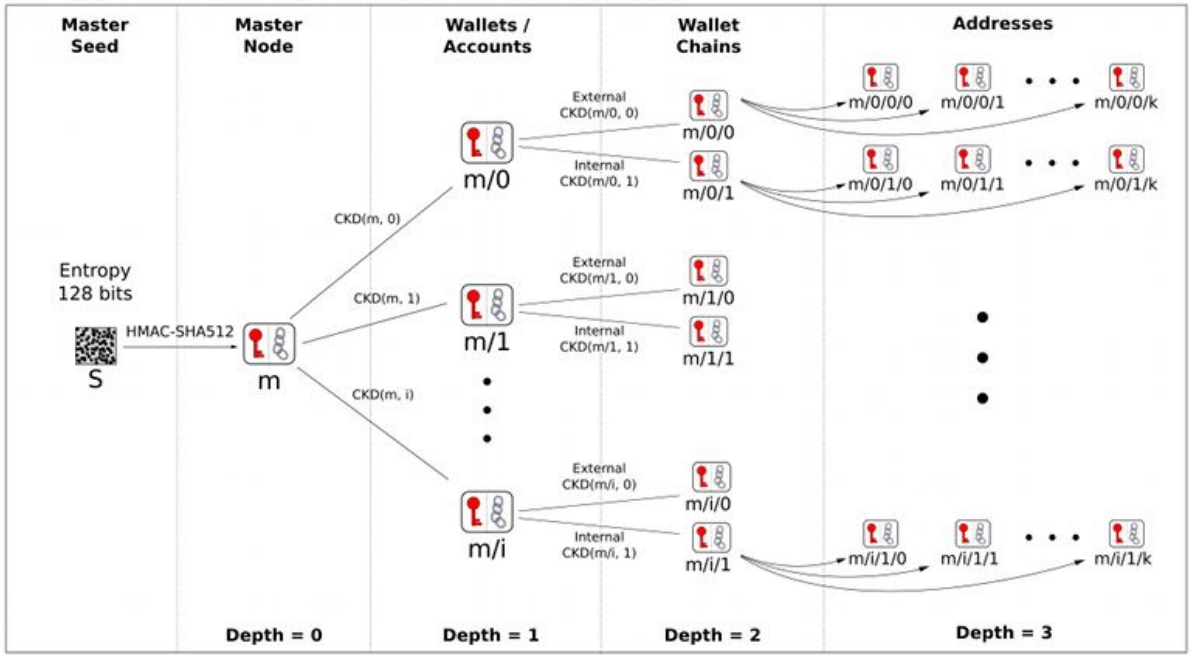


Chapter 1: Bitcoin Model - UML like a pr0; part: II



Chapter 1: Bitcoin Model - hd wallets

BIP 32 - Hierarchical Deterministic Wallets



Child Key Derivation Function ~ $CKD(x,n) = HMAC\text{-}SHA512(x_{Chain}, x_{PubKey} || n)$

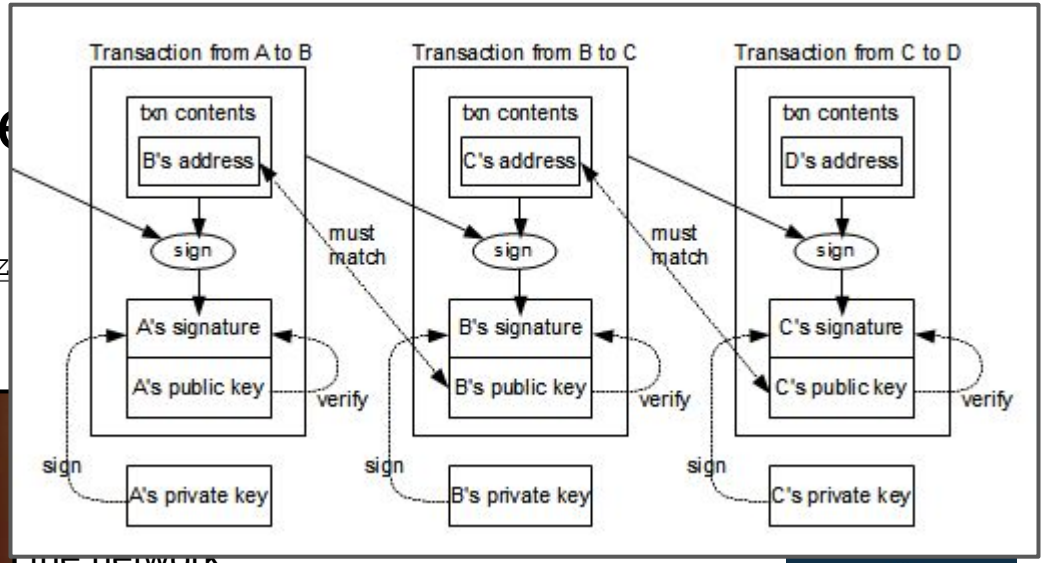
https://medium.com/@harshagoli/hd-wallets-explained-from-high-level-to-nuts-and-bolts-9a41545f5b0

https://iancoleman.io/bip39/

Chapter 1: Bitcoin Mode

1DBqpfptUMiz

- takes tx x out



the network

Owns: **1DBqpfptUM[...]**

Chapter 1: Bitcoin Model - dawn of the devs

It turns out that actually using the Bitcoin protocol is harder than I expected. As you will see, the protocol is a bit of a jumble: it uses big-endian numbers, little-endian numbers, fixed-length numbers, variable-length numbers, custom encodings, DER encoding, and a variety of cryptographic algorithms, seemingly arbitrarily. As a result, there's a lot of annoying manipulation to get data into the right format. [7]

FFFF

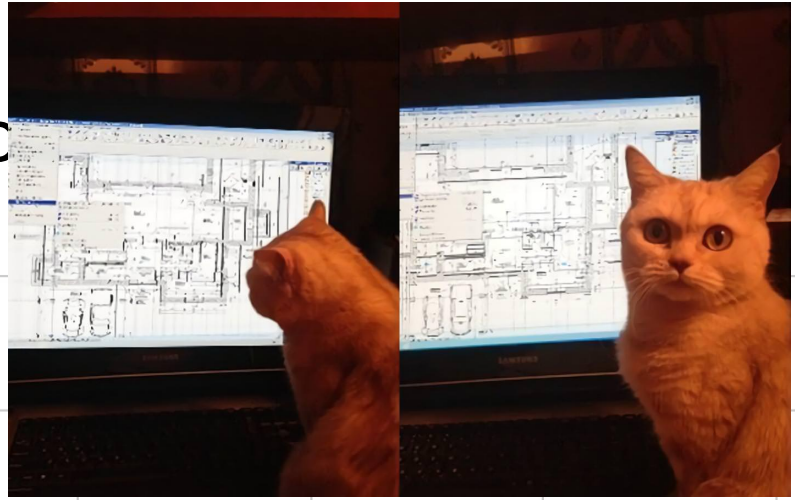
Chapter 1: Bitcoin Model - getting dirty

How to check where the coins came from?

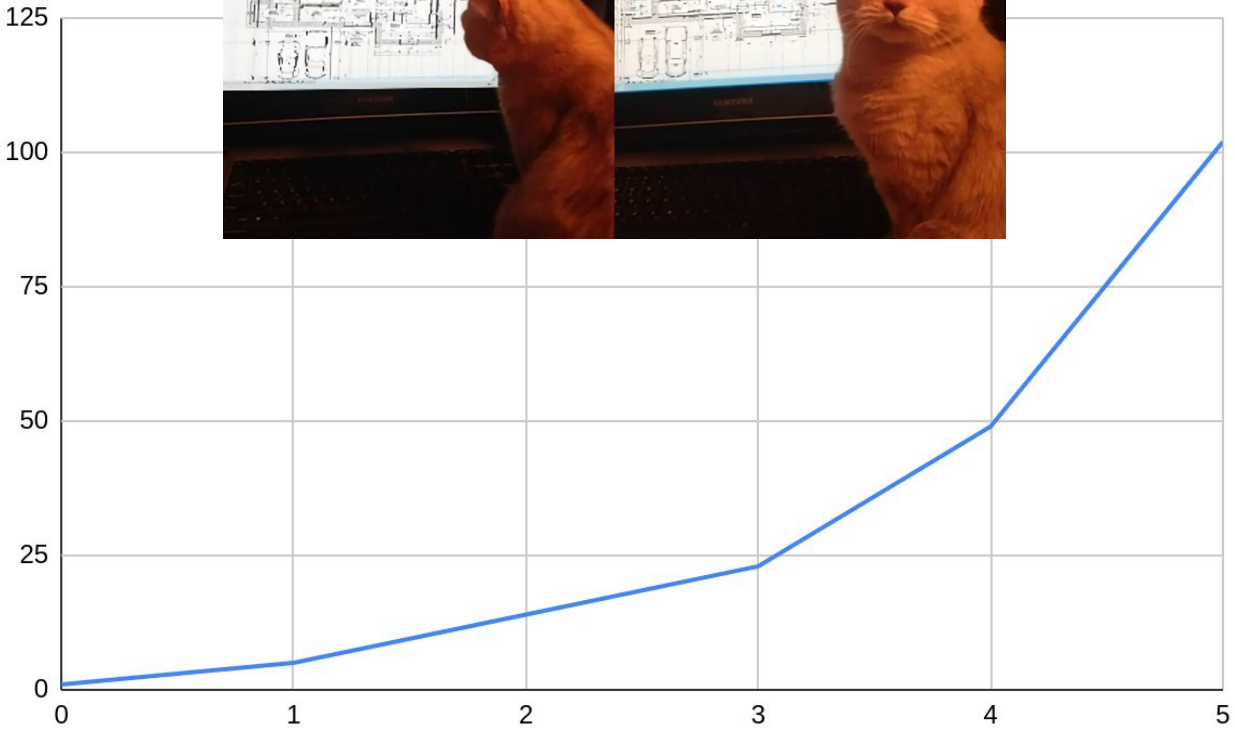
Chapter 1: Bitcoin Model - querying public apis

```
import requests
import time

desired_depth = 5

def deeper(txhash, depth):
    isFraud(txhash)
    print('Going to: ' + txhash + ' at depth: ' + str(depth))
    if depth < desired_depth:
        r = requests.get("https://api.blockcypher.com/v1/btc/main/txs/" + txhash)
        inputs  = r.json()['inputs']
        for inp in inputs:
            try:
                deeper(inp['prev_hash'], depth+1)
            except:
                return

def isFraud(txhash):
    if txhash == '3d0b134570101fbb1d61370c0c122c219d130ae3760fb072309f6f2b2eeaec7b':
        print('FRAUD!!!!')


deeper("f854aebae95150b379cc1187d848d58225f3c4157fe992bcd166f58bd5063449?token=9d56627bbe214a19a82141a0c645768d", 0)
```

Chapter 1: Bitcoin Mo is



Depth	No Of Txs
0	1
1	5
2	14
3	23
4	49
5	102



Chapter 1: Bitcoin Model - standard approach summary

- It’s slow (50reqs in 12s)
- It’s expensive (1.500.000reqs cost 650$)
- It’s not secure

Chapter 1: Bitcoin Model - alternatives for traversals

- Real time
  - Self hosted bitcoin-core node
  - PostgreSQL (with indexed addresses)
  - Mongo
  - JanusGraph

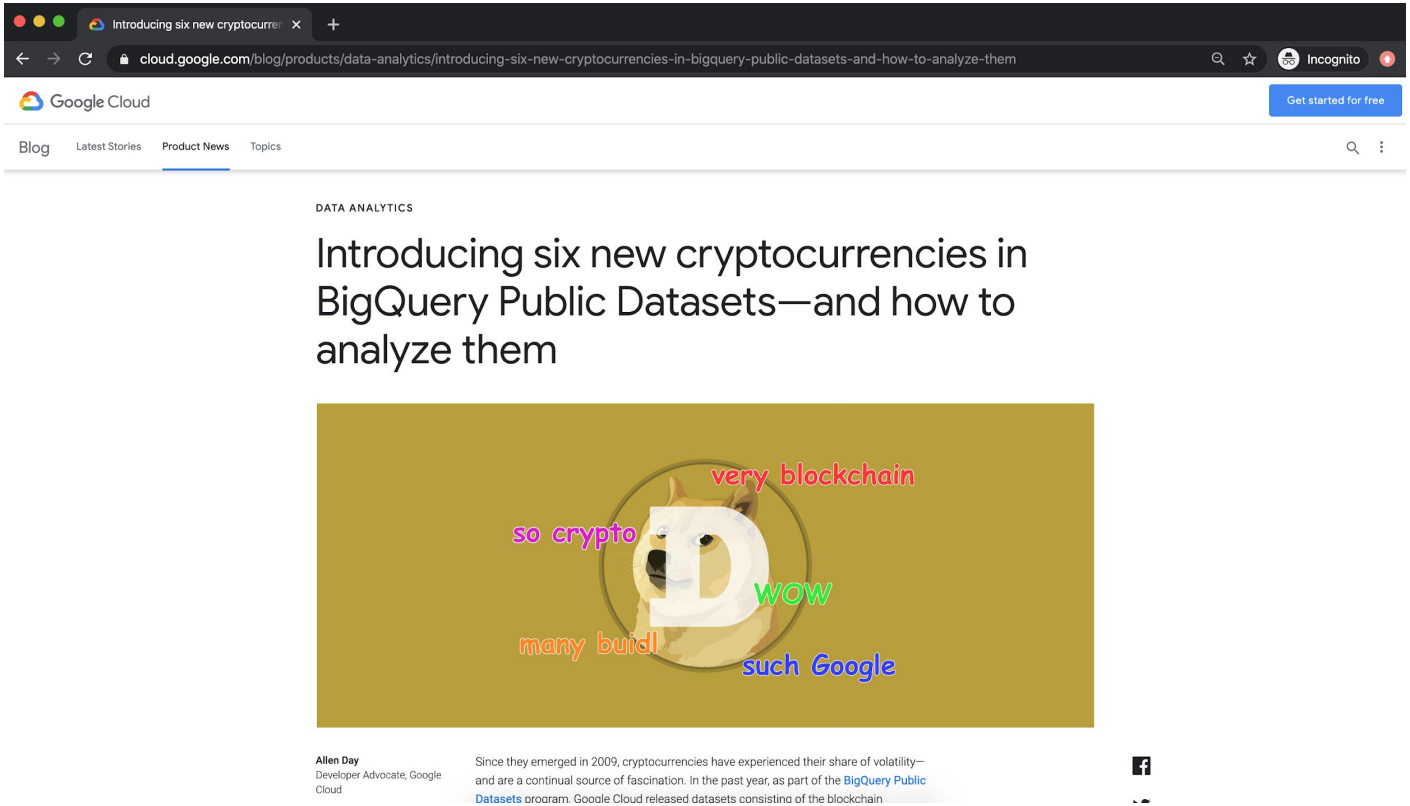
- Batch
  - Dataflow
  - **BigQuery!**

Chapter 2: BigQuery to the rescue

Chapter 2: BigQuery to the rescue

A public dataset is any dataset that is stored in BigQuery and made available to the general public through the Google Cloud Public Dataset Program. The public datasets are datasets that BigQuery hosts for you to access and integrate into your applications. Google pays for the storage of these datasets and provides public access to the data via a project. You pay only for the queries that you perform on the data. The first 1 TB per month is free, subject to query pricing details.

Chapter 3: BigQuery to the rescue



https://cloud.google.com/blog/products/data-analytics/introducing-six-new-cryptocurrencies-in-bigquery-public-datasets-and-how-to-analyze-them

Chapter 2: Bitcoin Public Dataset Schema

https://console.cloud.google.com/bigquery?project=telemetry-233915&folder&organizationId&p=bigquery-public-data&d=crypto_bitcoin&t=transactions&page=table

- Tables: blocks, **transactions**
- Views: inputs, outputs

Schema Details Preview

Field name	Type	Mode	Description
hash	STRING	REQUIRED	The hash of this transaction
size	INTEGER	NULLABLE	The size of this transaction in bytes
virtual_size	INTEGER	NULLABLE	The virtual transaction size (differs from size for witness transactions)
version	INTEGER	NULLABLE	Protocol version specified in block which contained this transaction
lock_time	INTEGER	NULLABLE	Earliest time that miners can include the transaction in their hashing of the Merkle root to attach it in the latest block of the blockchain
block_hash	STRING	REQUIRED	Hash of the block which contains this transaction
block_number	INTEGER	REQUIRED	Number of the block which contains this transaction
block_timestamp	TIMESTAMP	REQUIRED	Timestamp of the block which contains this transaction
block_timestamp_month	DATE	REQUIRED	Month of the block which contains this transaction
input_count	INTEGER	NULLABLE	The number of inputs in the transaction
output_count	INTEGER	NULLABLE	The number of outputs in the transaction
input_value	NUMERIC	NULLABLE	Total value of inputs in the transaction
output_value	NUMERIC	NULLABLE	Total value of outputs in the transaction
is_coinbase	BOOLEAN	NULLABLE	true if this transaction is a coinbase transaction
fee	NUMERIC	NULLABLE	The fee paid by this transaction
inputs	RECORD	REPEATED	Transaction inputs
inputs. **index**	INTEGER	REQUIRED	0-indexed number of an input within a transaction
inputs. **spent_transaction_hash**	STRING	NULLABLE	The hash of the transaction which contains the output that this input spends
inputs. **spent_output_index**	INTEGER	NULLABLE	The index of the output this input spends
inputs. **script_asm**	STRING	NULLABLE	Symbolic representation of the bitcoin's script language op-codes
inputs. **script_hex**	STRING	NULLABLE	Hexadecimal representation of the bitcoin's script language op-codes
inputs. **sequence**	INTEGER	NULLABLE	A number intended to allow unconfirmed time-locked transactions to be updated before being finalized; not currently used except to disable locktime in a transaction
inputs. **required_signatures**	INTEGER	NULLABLE	The number of signatures required to authorize the spent output
inputs. **type**	STRING	NULLABLE	The address type of the spent output
inputs. **addresses**	STRING	REPEATED	Addresses which own the spent output
inputs. **value**	NUMERIC	NULLABLE	The value in base currency attached to the spent output
outputs	RECORD	REPEATED	Transaction outputs
outputs. **index**	INTEGER	REQUIRED	0-indexed number of an output within a transaction used by a later transaction to refer to that specific output
outputs. **script_asm**	STRING	NULLABLE	Symbolic representation of the bitcoin's script language op-codes
outputs. **script_hex**	STRING	NULLABLE	Hexadecimal representation of the bitcoin's script language op-codes
outputs. **required_signatures**	INTEGER	NULLABLE	The number of signatures required to authorize spending of this output
outputs. **type**	STRING	NULLABLE	The address type of the output
outputs. **addresses**	STRING	REPEATED	Addresses which own this output
outputs. **value**	NUMERIC	NULLABLE	The value in base currency attached to this output

Chapter 3:

Chapter 3: BigQuery - Bitcoin’s unique IDs

```
select t.hash, count(*)
  from `bigquery-public-data.crypto_bitcoin.transactions` t
  group by t.hash
  having count(*) > 1
```

Chapter 3: BigQuery - Bitcoin’s unique IDs

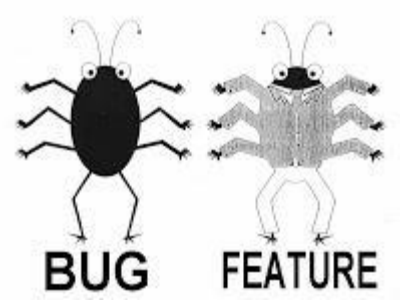
```
select t.hash, count(*)
  from `bigquery-public-data.crypto_bitcoin.transactions` t
  group by t.hash
  having count(*) > 1
```

Chapter 3: Unique IDs

```
select t.hash, count(*)
  from `bigquery-public-data.crypto_bitcoin.transactions` t
  group by t.hash
  having count(*) > 1
```

Job information | Results | JSON | Execution details

Row	hash
1	d5d27987d2a3dfc724e359870c6644b40e497bdc0589a033220fe15429d88599
2	e3bf3d07d4b0375638d5f1db5255fe07ba2c4cb067cd81b84ee974b6585fb468



Chapter 3: How much coins I have?

```
WITH
ins AS (
  SELECT SUM(outs.value) AS value FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.outputs) AS outs
  JOIN UNNEST(outs.addresses) AS addrs
  WHERE addrs = '1DBqpfptUMizLDACvMVsrJFPdMtbgmZCk1'),
outs AS (
  SELECT SUM(ins.value) AS value FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.inputs) AS ins
  JOIN UNNEST(ins.addresses) AS addrs
  WHERE addrs = '1DBqpfptUMizLDACvMVsrJFPdMtbgmZCk1')
SELECT
  (ins.value - outs.value)/100000000.0*7445.87
FROM
  ins,outs
```

Chapter 3: How much coins I have?

```
WITH
ins AS (
  SELECT SUM(outs.value) AS value FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.outputs) AS outs
  JOIN UNNEST(outs.addresses) AS addrs
  WHERE addrs = '1DBqpfptUMizLDACvMVsrJFPdMtbgmZCk1'),
outs AS (
  SELECT SUM(ins.value) AS value FROM `bigquery-pub
  JOIN UNNEST (t.inputs) AS ins
  JOIN UNNEST(ins.addresses) AS addrs
  WHERE addrs = '1DBqpfptUMizLDACvMVsrJFPdMtbgmZ
SELECT
  (ins.value - outs.value)/100000000.0*7445.87
FROM
  ins,outs
```

Row	f0_
1	20.978738725

Chapter 3: How much coins I have?

```
WITH
active_addrs as (
  SELECT distinct(addrs) AS addr FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.outputs) AS outs
  JOIN UNNEST(outs.addresses) AS addrs where t.block_timestamp_month = '2019-12-01' ),
ins AS (
  SELECT addrs, SUM(outs.value) AS value FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.outputs) AS outs
  JOIN UNNEST(outs.addresses) AS addrs
  group by addrs  ),
outs AS (
  SELECT addrs, SUM(ins.value) AS value FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.inputs) AS ins
  JOIN UNNEST(ins.addresses) AS addrs
  group by addrs )
SELECT
  active_addrs.addr, (ins.value - outs.value)/100000000.0*7445.87 as val
FROM
  active_addrs join ins on ( active_addrs.addr = ins.addrs )
  join outs on (active_addrs.addr = outs.addrs) order by val desc
```

Row	addr	val
1	35hK24tcLEWcgNA4JxpvbkNkoAcDGqQPsP	1902435728.968829836
2	3JZq4atUahhuA9rLhXLMhhTo133J9rF97j	933995195.286528686
3	3CgKHXR17eh2xCj2RGnHJHTDjPpqaNDgyT	832881958.685483666
4	3M6UcBNGZAW1HRjiFDMRcY5aXFrQ4F9E1y	667777685.169873268
5	3D2oetdNuZUqQHPJmcMDDHYoqkyNVsFk9r	572536905.077642759
6	34xp4vRoCGJym3xR7yCVPFHoCNxv4Twseo	545495104.140982197
7	1HQ3Go3ggs8pFnXuHVHRytPCq5fGG8Hbhx	516520976.980904968
8	385cR5DM96n1HvBDMzLHPYcw89fZAXULJP	488701521.174904326
9	38UmuUqPCrFmQo4khkomQwZ4VbY2nZMJ67	406167510.858920128
10	3FDWNdFxrJxXoF4hWXF4dkc1FFxsNyKAHh	403286288.515758849

Chapter 3: Am I the bad guy?

```
haystack as (
  SELECT * FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  WHERE t.block_timestamp_month >= '2018-01-01' ),
```

```
my_addresses as (
  SELECT distinct addrs AS addr FROM `bigquery-public-data.crypto_bitcoin.transactions` t
  JOIN UNNEST (t.outputs) AS outs
  JOIN UNNEST(outs.addresses) AS addrs WHERE t.block_timestamp_month = '2020-01-01'
```

```
received_transactions as (
  SELECT distinct h.hash, addrs FROM haystack h
  JOIN unnest(h.outputs) AS outs JOIN unnest(outs.addresses) AS addrs
  RIGHT JOIN my_addresses ON addrs = my_addresses.addr LIMIT 10000),
```

Chapter 3: Am I the bad guy?

```
adjacency_list AS (
  SELECT h.hash AS root, inputs.spent_transaction_hash AS prev from haystack h
  JOIN unnest(h.inputs) AS inputs),
```

```
graph AS (
  SELECT l0.root AS l0, l1.root AS l1, l2.root AS l2, l3.root AS l3, l4.root AS l4
    FROM adjacency_list l0
    JOIN adjacency_list l1 ON l0.prev = l1.root
    JOIN adjacency_list l2 ON l1.prev = l2.root
    JOIN adjacency_list l3 ON l2.prev = l3.root
    JOIN adjacency_list l4 ON l3.prev = l4.root)
```

```
SELECT rt.addrs, g.* FROM received_transactions rt JOIN graph g ON (rt.hash = g.l0 )
  WHERE
    g.l0 IN (SELECT * FROM potential_fraud ) OR
    g.l1 IN (SELECT * FROM potential_fraud ) OR
    g.l2 IN (SELECT * FROM potential_fraud ) OR
    g.l3 IN (SELECT * FROM potential_fraud ) OR
    g.l4 IN (SELECT * FROM potential_fraud )
```

Row	addrs	l0	l1	l2	l3	l4
1	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	c8f30f87035ae5d15332e79ba4ce8a752bbf46df286f428eee0561452ad6515d	df5339e7d03a4653a3b43278f29a1d779c628f276a66dd5df6702b7f2e6a03d	d640e7ea82d16a4711fcf3ca878c09e5055ff3ec6990f19d3b8adb448183f5f11	042f3409fce0070addaf1bd57d2ac501f1aa301fada9a6ae92f6ee03447255b6	339fe0979f13b5dca354bc4f3daea8d6399f86ba36357c0e491d4494e6bf6f5a
2	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	43e3ac5c7e82af1700e8aabb93374ec26d9acdfac8981505eee0bf29505f6b08	da5cb64abbe793a215171657f250821321b4bdb4ad2dde083e62d71f39cc728e	dc3a32950dcb0e353a6c5ce7a10b4de3ec33078ca0d844caaa6f45639ef1145e	6071b056d05d2a82223216668580413fddb4cd95fcab204ebfafa48a9df87fc9	f80dfef7be86b14ccf4e18087fd49cba75cb874ee9485d7de1a02f0b944e63a1
3	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	43e3ac5c7e82af1700e8aabb93374ec26d9acdfac8981505eee0bf29505f6b08	da5cb64abbe793a215171657f250821321b4bdb4ad2dde083e62d71f39cc728e	dc3a32950dcb0e353a6c5ce7a10b4de3ec33078ca0d844caaa6f45639ef1145e	6071b056d05d2a82223216668580413fddb4cd95fcab204ebfafa48a9df87fc9	f80dfef7be86b14ccf4e18087fd49cba75cb874ee9485d7de1a02f0b944e63a1
4	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	1a2038dcccbde5c5c46bc2902c0b26c8191d0b4e9d247b24b5b204a459f60a3e	7d9a8b0f387e24e5d3f83e3d29a3b5f11eabb52c938d4f0f8f050f22dffcac923d	a496a53fae06ee985c4f1f554be6edc3ab225d396915756b02a3c6066264c0d7	49bcae579891b90df5b6478cf5b3eea46df54ea28e384659fe776ce51dc9c40b	d1ec070c272d240ad879fd9bb4e0fde13e38842d624e7a1d7a1f7194d3fc34df
5	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	2b98863032e65e2174927acab23af54078bc9015cab52a43d6b4cc9cbbcdc6d	2d293480b6a6bc5fa56e927cdffe2ba6f4c808a14c22cc0976fd91fa4d366e99	0b24bdf522a90bcf46fa791a3c3b0427df54a1464eca2cfba7c5dde798d5d62b	aa8d948a70f66f98ba01ba347dc828f172f0076da8a0f911e3a25441ffe985b	99d318ccc26e2b822b5bc963dfde5b568daf443f9ed1b5f3e57866e500b
6	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	a30f144f79db7a734ba4adac61fd2a213b4f7eb0091f499874c9fa84b984e583	5273288bfa19e32b5a91c878563629fe83cc96fe0d0393f313c37d4a943a0f1b	92a2ca92708e0fceb2633791a14348717c6b1ee2501ac550203df8a6eefdb245	b4f3f864c3130611b3aeb522604a2cd50def69d8b99bfcd59037b49577ff973a	613845747a13105491109b0aaddb1c3e33ba63785138c34202cbca86d6f50d69
7	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	c8f30f87035ae5d15332e79ba4ce8a752bbf46df286f428eee0561452ad6515d	b7e0b2974d1906b9ef42d4ee9a314ac0217792be9bc22f4212e621afe61da43d	fef37382a21af70655abb612738d25375c03d5994c4f5ebe4d8de004b147beffe	02ce7a4054dd2a1f8e8ab9040032fb35eaddca9cf674fc37bfe9bf69a89d233d	528ef4af6021f0b2877a9cc36a22da73cf965a3b7dfa28908421914b3fa01030
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40	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	1a2038dcccbde5c5c46bc2902c0b26c8191d0b4e9d247b24b5b204a459f60a3e	7d4faebe5387e8c84798a0795a960f3e6e43d28cb898a0f5f0e76b840d8d5842	472c3f7e493d9ec16194eb89662028ff24c3df071bf43b2d621cac8014f8394c	f248b048580a58b5adee982e3cce98ff1b16ee34ae983cf68502c0768a9e1025	bfc9adb17f9516f308f0a5ca8e12a42325b0d92c4df978426169 7b45f1c43a2e
41	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	1a2038dcccbde5c5c46bc2902c0b26c8191d0b4e9d247b24b5b204a459f60a3e	57d028c77c97f01f4fdedad18c1000be5464988cacba8002b0cc777c31a9ab6442	43ca1bdb9800624469 11e72da489c797f3b4d738076e204c76a6cd80220dc0c42e	27ea32d8fe5e51673891a9a8b7a74432cd2ee20249255f83e9f78c30199bb4369	b4f27cae1f2f0d1f1f2446da107e568ad66eb397c7e
42	1FH6NBSJyuAEML3oCMkizn1N4U1vX4Lrv9	deca2b7625669b37a2608c95ccdae1de5a906a72bcab945 14b64d6e54861e05b	e7614451d71642e9ab369999d8039679fc96d345824367 3bdeb90a8a8a38f9d8	0f87d58f2164ae2d1d2fbb0232f76d94566e8a5a88a78c40571e9bedddae3731	d2334e2f6e5d67d1b2194043 9d3a1ea7bc3fd97631e0cb053d4d212924fd69de	f7fc232d02a1d2a24154087d7c883dcff68b82b87586755f7ff2280bf909db13
43	1G47mSr3oANXMafVrR8UC4pzV7FEAzo3r9	2aedb3ee766539aaa1b417e234c6bb55024056e686e2c165733cbd05e421af35	6bc5aa30e055dfff96520dc558d947092baba3bcd3ea3803b504368efa6f1569	5144f58126dfea06e2962117b6dfa69d0434e55fc80aae369047af262fd87b86	7fd97d075db58e5feb2ec1363b38aac57156e6f616461d44c0ceb506a7c1aea0	9f9818fe98a8e4e0d48fd146fea8ed5b1cb9a79a9748aa8c17a31839c53da07
44	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	c8f30f87035ae5d15332e79ba4ce8a752bbf46df286f428eee0561452ad6515d	d7fc53f271618dc6b64c3a4c373dfc0e5891c214591feb51ffcf760461f7973d	0f1334029eebbd1ff3ad1989a46fd0ad0976cd53c742de138650397291f10977	a54f3b4d44adeb1df9c01a01d8b78bba61cc12e3adf2afefe53bd81eb6f6bb544	6c6433974ab92b6b1196f6816b0e39ef2ad86f53a202d9c1e13056bcf5a60b5b5
45	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	1a2038dcccbde5c5c46bc2902c0b26c8191d0b4e9d247b24b5b204a459f60a3e	d6950bc43078f95c7513e93cb7de4a986dfb1b8185ebd4820f934e1b9644e42	e5aae02b6e0877831e46abad33571dcead51b614fcb35a4845129 0530e59a85	8a8be42e7232957a30b5131adda75bac4000c472953084d502149df2c8723704	02e260c30d4937c7a4a22869058cba9a99830dec1b2268945cc5761bd2dcc1e
46	1FoWyxxPXuj4C6abqwhjDWdz6D4PZgYRjA	2b98863032e65e2174927acab23af54078bc9015cab52a43d6b4cc9cbbcdc6d	2d293480b6a6bc5fa56e927cdffe2ba6f4c808a14c22cc0976fd91fa4d366e99	0b24bdf522a90bcf46fa791a3c3b0427df54a1464eca2cfba7c5dde798d5d62b	2e69bef594bdf7dce9df307df586e26e096f83f344beec2d0dd9f38eb641e50	23f99aaa6030a1546295 4e78ee5ae96599df4eb73fcd59ab9fc81da8366c14c

Chapter 3: BigQuery graph traversal - summary

+ It’s super cheap (60Gb/query)
+ Requires no maintenance

- Dataset is updated only once per day :(
- Could be faster

Chapter 3: Ideas to improve

How to achieve deeper traversals

- Address/Transaction clustering
- Fraudulent transactions/addresses preprocessing

How to achieve real-time validation

- Key-value result storages
- Hybrid solutions

Chapter 4: Questions

Chapter 5: Thank you!

Some papers

https://www.ifca.ai/fc14/papers/fc14_submission_11.pdf

https://github.com/mikebocian/talks/tree/master/20200108-warsaw_meetup