Lero THE IRISH SOFTWARE RESEARCH CENTRE

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Blockchain for Government

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Research Areas

Internet Voting

Cryptocurrencies

Authentication

Identity Mgt

Efficient Consensus Mechanisms

KYC

Healthcare & IoT

Online Lotteries

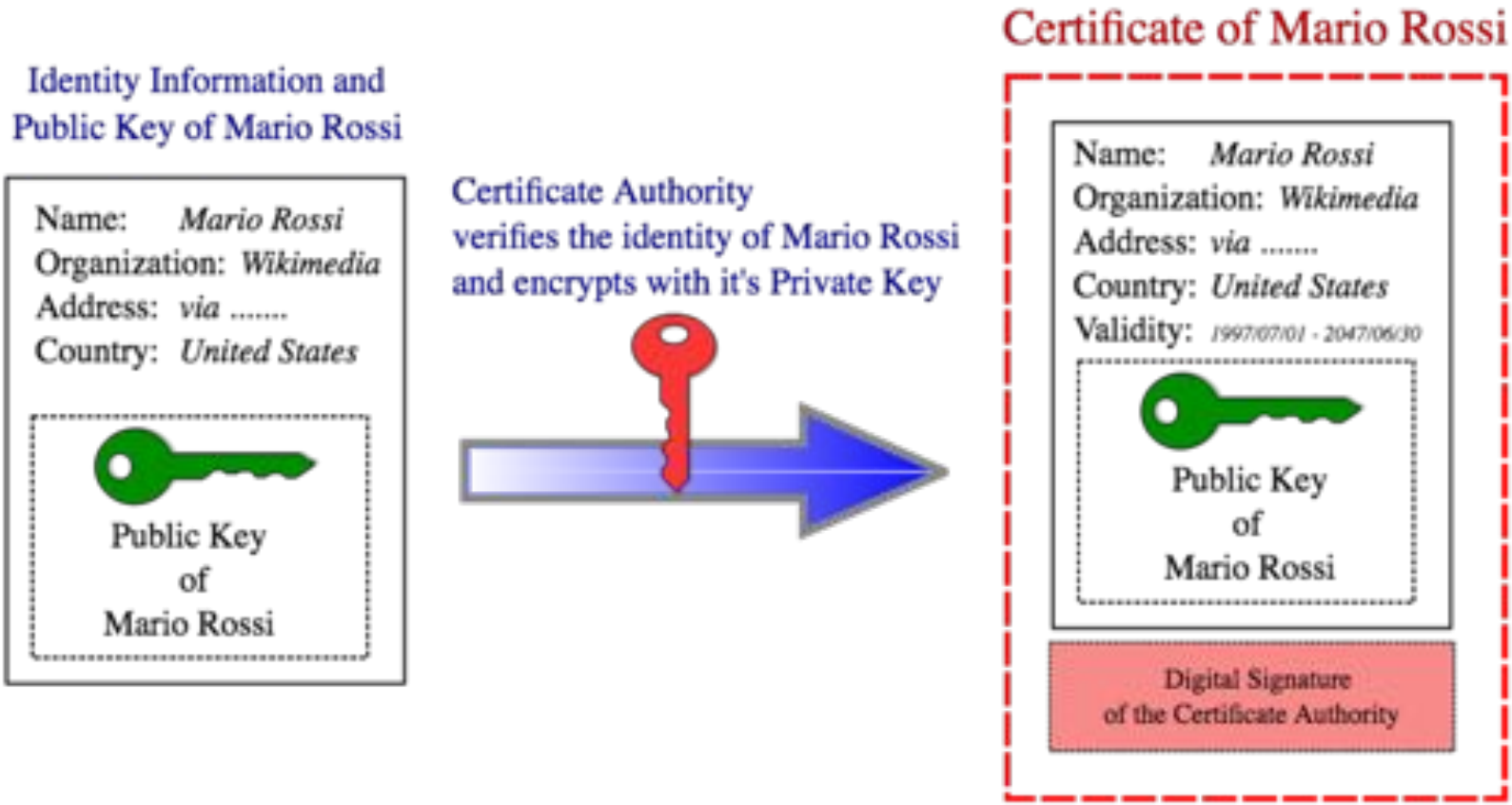
Secure Email

Issue a public key certificate to every citizen at "zero cost"

Digital Identity

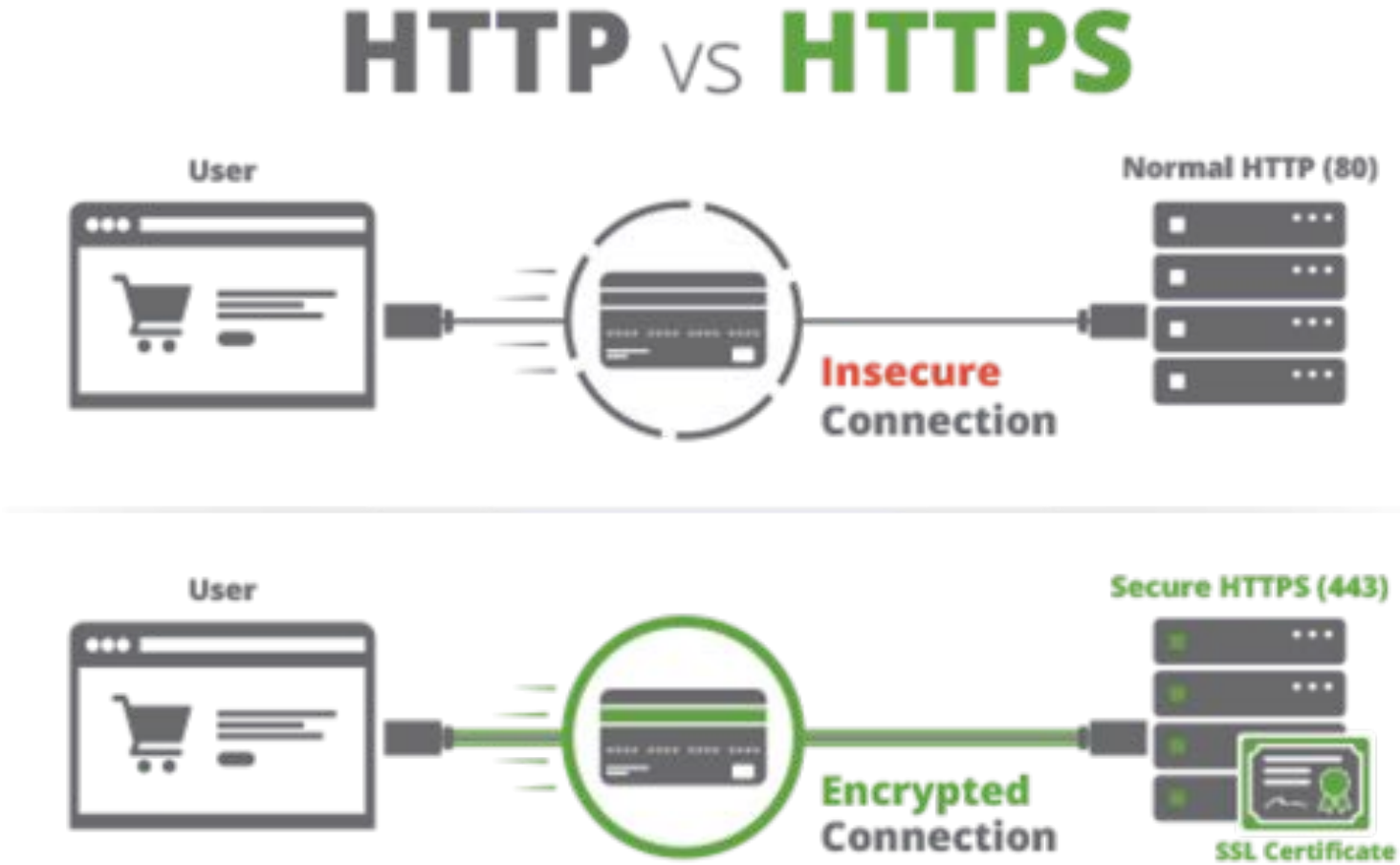
Public Key (SSL) Certificate

What is a SSL Certificate?



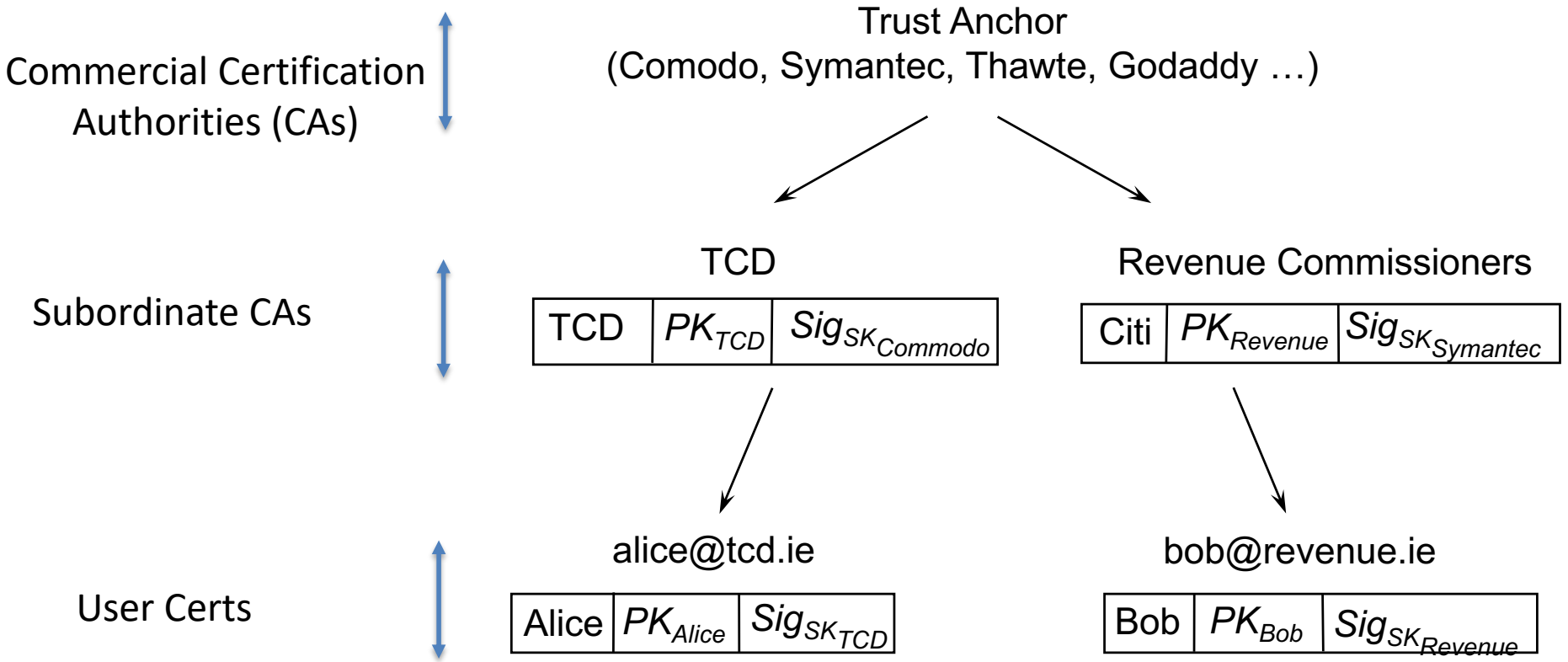
Binds a public key to an identity

Who Buys SSL Certs?



SSL certs cost €200-2000 per annum!!

Public Key Infrastructure (PKI)



Make use of blockchain technology for storage and dissemination of certs

Certificate Issuance

Alice
(alice@tcd.ie)

2. Request cert from organizational CA

5. Certificate

TCD CA Server

1. Generate public key pair (PK_A, SK_A)

3. Create and broadcast new cert to P2P network

4. CAs verify and lock certs into blockchain

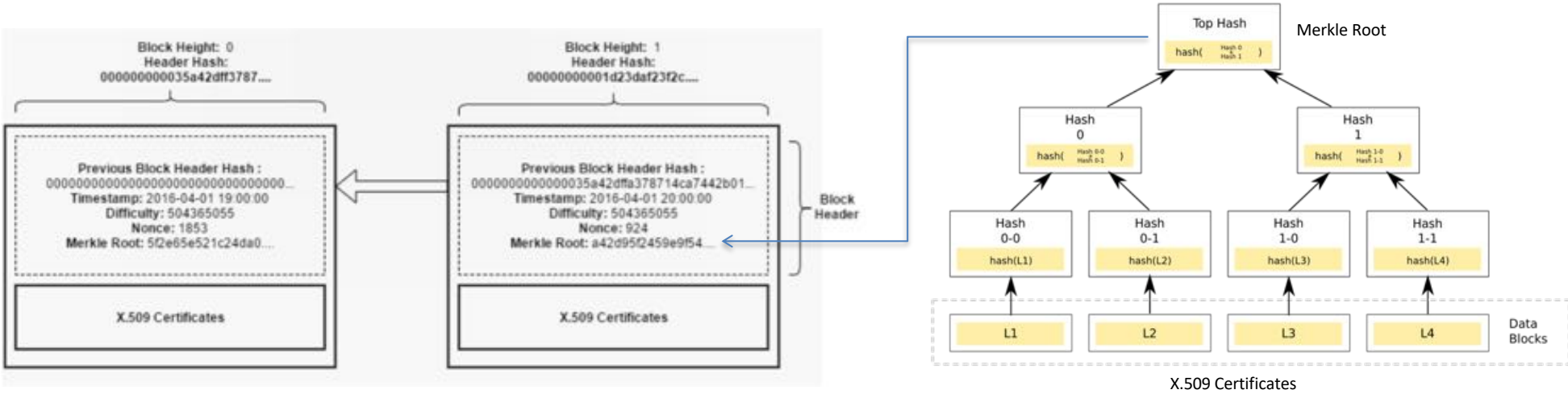
Internet

Revenue CA Server

BoI CA Server

CAs are equivalent of "miners" - collectively verify certs

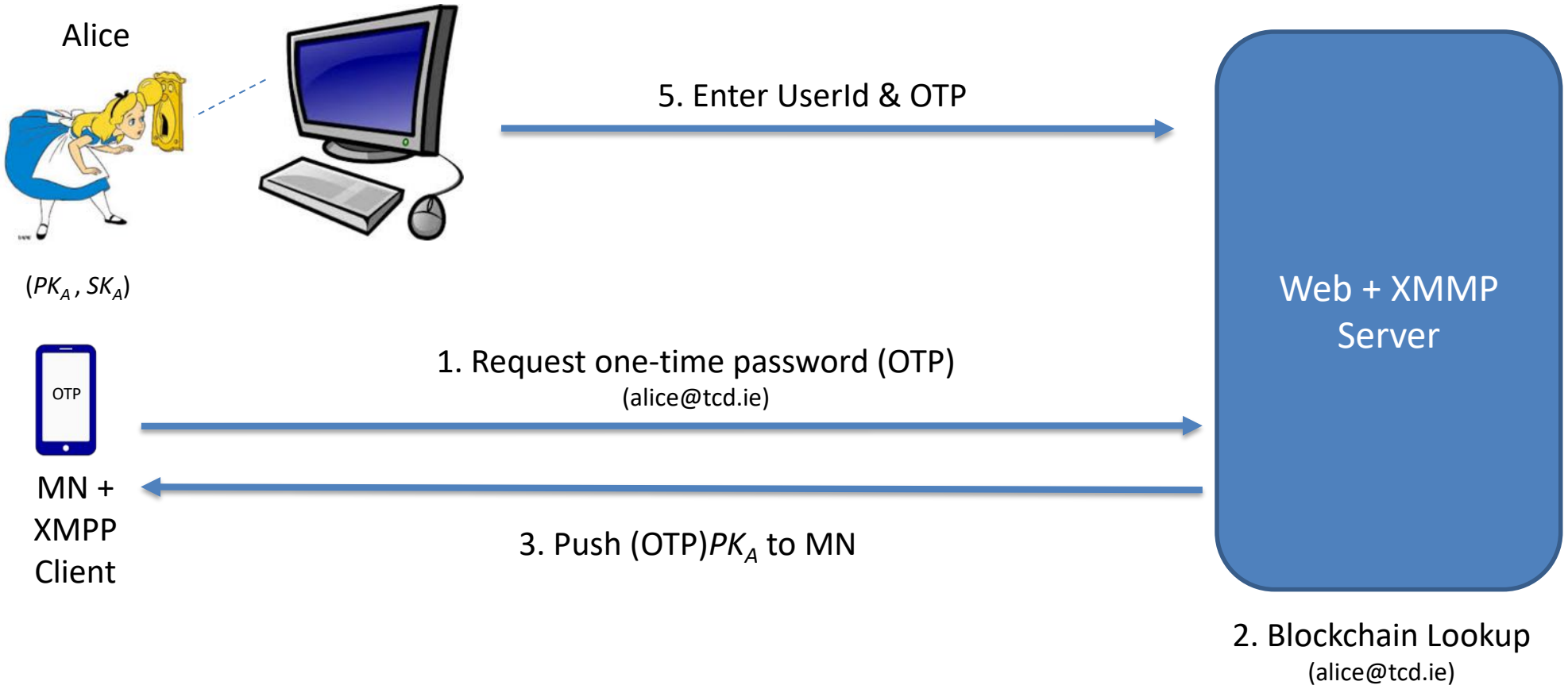
Blockchain Structure



- Certs replace monetary transactions on the blockchain
  - Indexed via an email address
- On average we require 1K of storage per cert
  - 1 million certs require 1GB
- Individuals can have more than one cert
  - e.g. employer cert, government cert …

No more weak passwords!!

Two Factor Authentication



Minimal changes to login process – password replaced with OTP

XMPP – Instant Messaging Protocol e.g. WhatsApp

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Verified Social Media Accounts

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Stop Abuse on Social Media

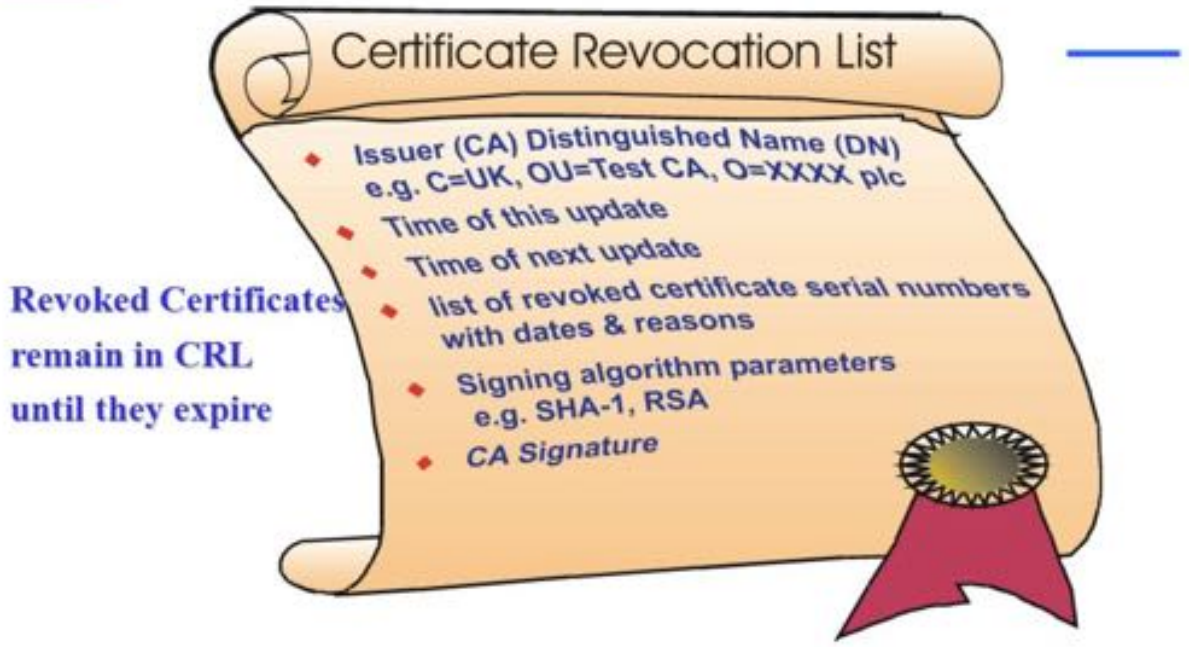
- Users authenticated using their public key cert
  - Account can be traced back to a ***real*** person

- Required to use the same identity across *all* sites
  - Prevents users from setting up fake accounts etc.

- Abusive posts will result in a user's cert being revoked
  - Prevent further access to *all sites instantly*

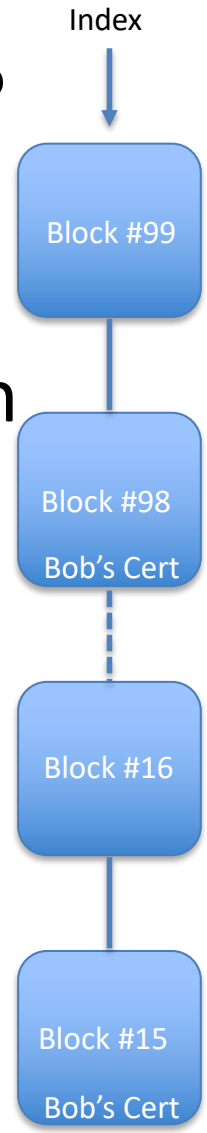
No Need for CRLs!!

Certificate Revocation List



Lost or Revoked Certs

- What happens if a user's keys are compromised?
  - Ask organization to issue new cert
- Can be more than one cert for a user in the chain
  - Indexed using newest block in the chain
- If an employee leaves an organization/dismissed
  - Issue a cert on their behalf
    - Instantly preventing access to company servers!!



Reduce Spam Mail

Alice
(PK_A, SK_A)

1. Compose email

4.Digitally **Signed** and **Encrypted** email

Email Server

2. Lookup Bob's cert
(bob@revenue.)

3. Bob's cert

X509Cloud Service
or Local Blockchain

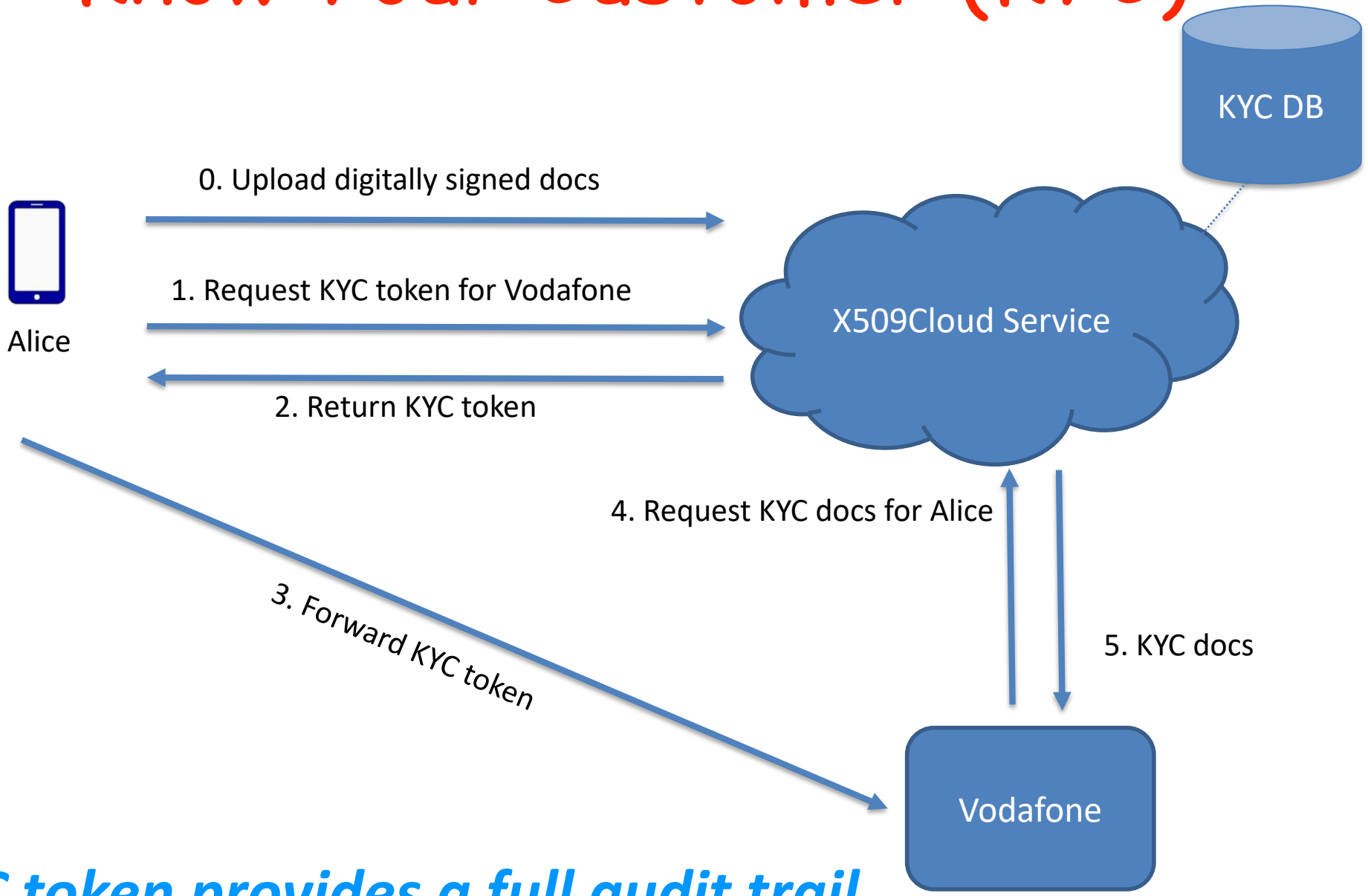
5. Lookup Alice's cert
(alice@tcd.ie)

6. Alice's cert

Bob
(PK_B, SK_B)

X509Cloud Service could be maintained by a govt. agency

Know Your Customer (KYC)

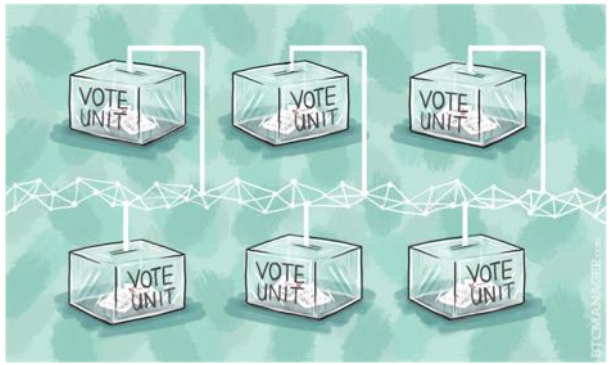


KYC token provides a full audit trail

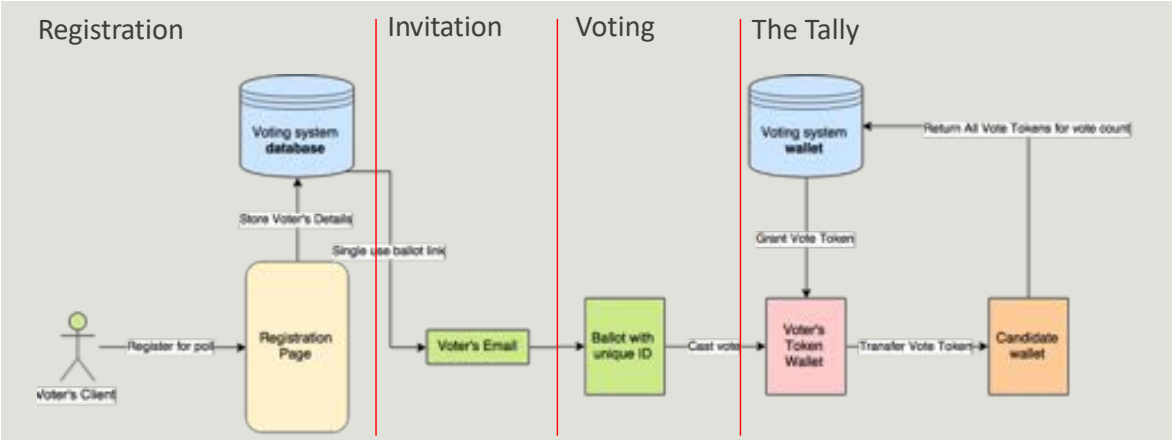
e-voting

Internet Voting

- e-voting protocols to date have been too complicated to deploy!!
- Easier and more *transparent* alternatives required
  - Blockchains allow for observers to ***verify in real-time*** the casting and counting of votes
- Allow citizens to vote using their mobile devices
  - More young people will exercise their franchise



Internet Voting Using Zcash



- Zcash can be thought of as an *anonymous* version of Bitcoin
  - Makes use of zero coins (ZEC) as currency
- Provides a full *audit trial* of spent tokens
  - Total **input** values = Total **output** values in a transaction
- Make use of low-value ZECs as voting tokens!!
  - Potential voters sent a ZEC at the start of an election
    - Candidate crypto wallet that receives most ZECs wins election

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National Healthcare Blockchain

Managing Lifetime Healthcare Data on the Blockchain

- Enable *all* medical records pertaining to a citizen to be stored on the blockchain

- IoT enabled devices will *automatically* load patient test results onto the blockchain
  - e.g. Blood tests, X-rays, CT scans

Data Storage and Retrieval

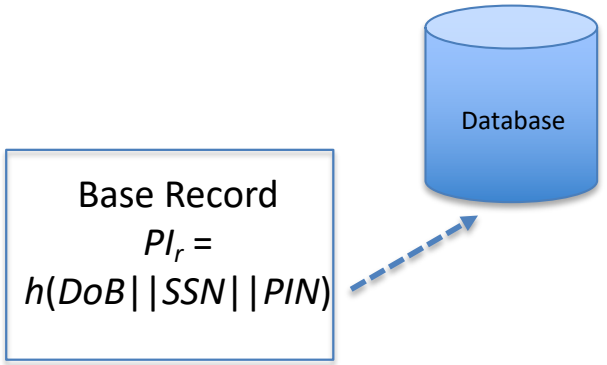
Two competing requirements

- *Pseudonymisation* of patient data stored on databases and indexed via the blockchain
  - Enable mining by external organizations

- Allow *authorised users* to view all records for particular individual on the blockchain
  - Given knowledge of certain security params

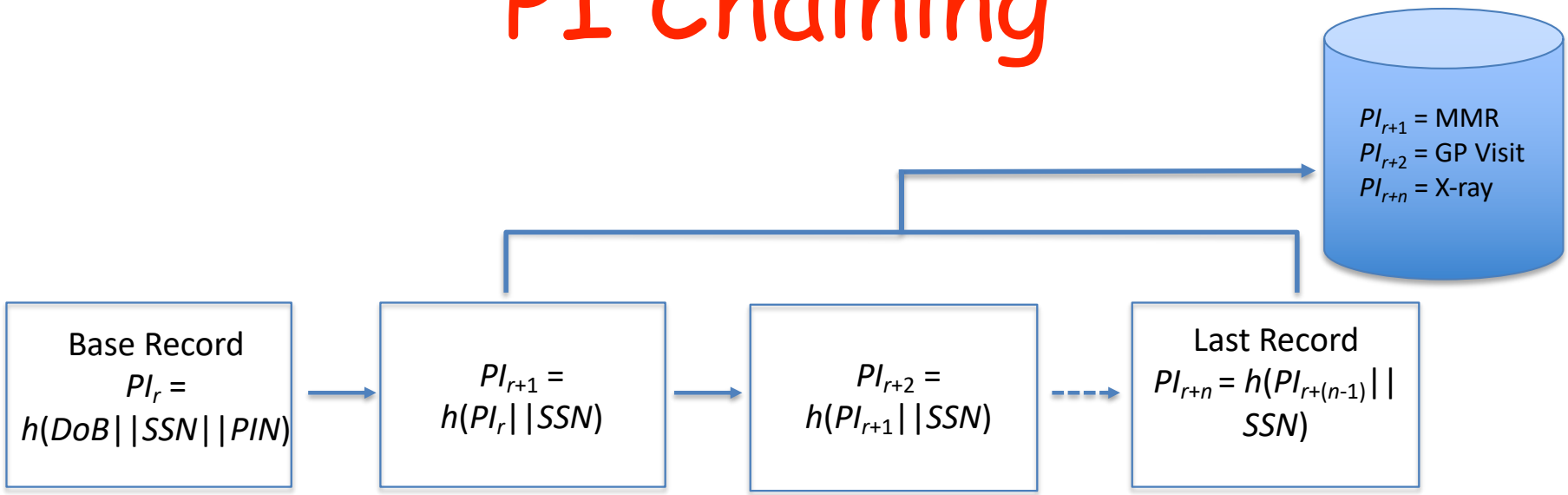
Pseudo-Anonymous Identifier (PI)

- Initial *base record* (PI_r) entry created on the blockchain for each child at time of birth cert issuance
- Generated by passing the following parameters through a hash algorithm
  - Date of Birth (DoB)
  - Social Security Number (SSN)
  - Secret Seed (PIN)
    - e.g. last four digits of the birth cert serial number



- Individuals can retrieve their base record from a web portal
  - Can be stored as a QR code on a mobile device

PI Chaining



- Each subsequent record on the blockchain for an individual will be linked to their base record (PI_r)
- Records belonging to a patient spread over many blocks in the blockchain
  - Logically chained together

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Cryptocurrencies & Distributed Consensus

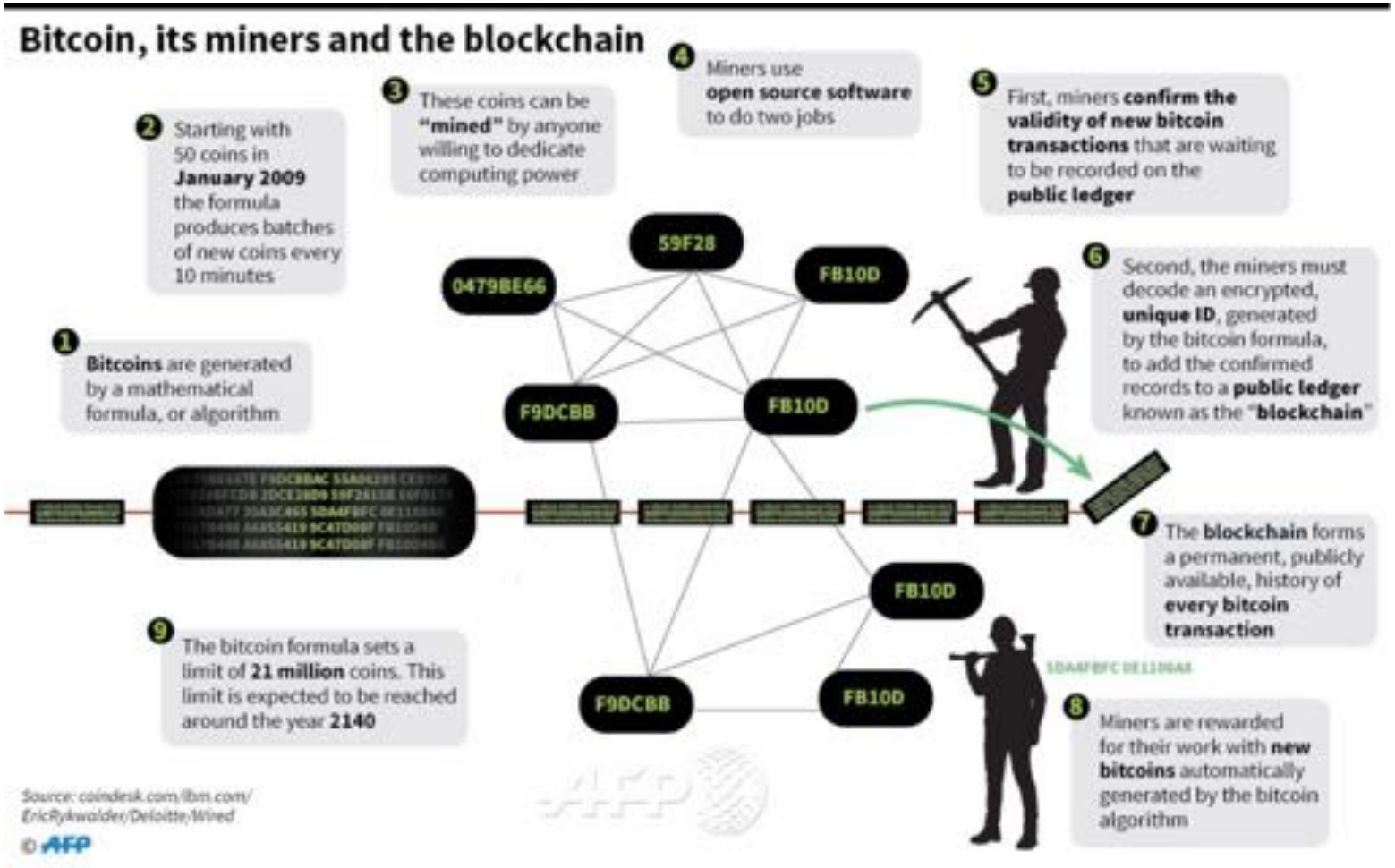
Fiat Backed Cryptocurrencies

- Cryptocurrencies are being used as an “asset” class
  - Not as a means of exchange for goods and services

- Require cryptos to be backed by fiat currency
  - Prevent hoarding of coins etc.

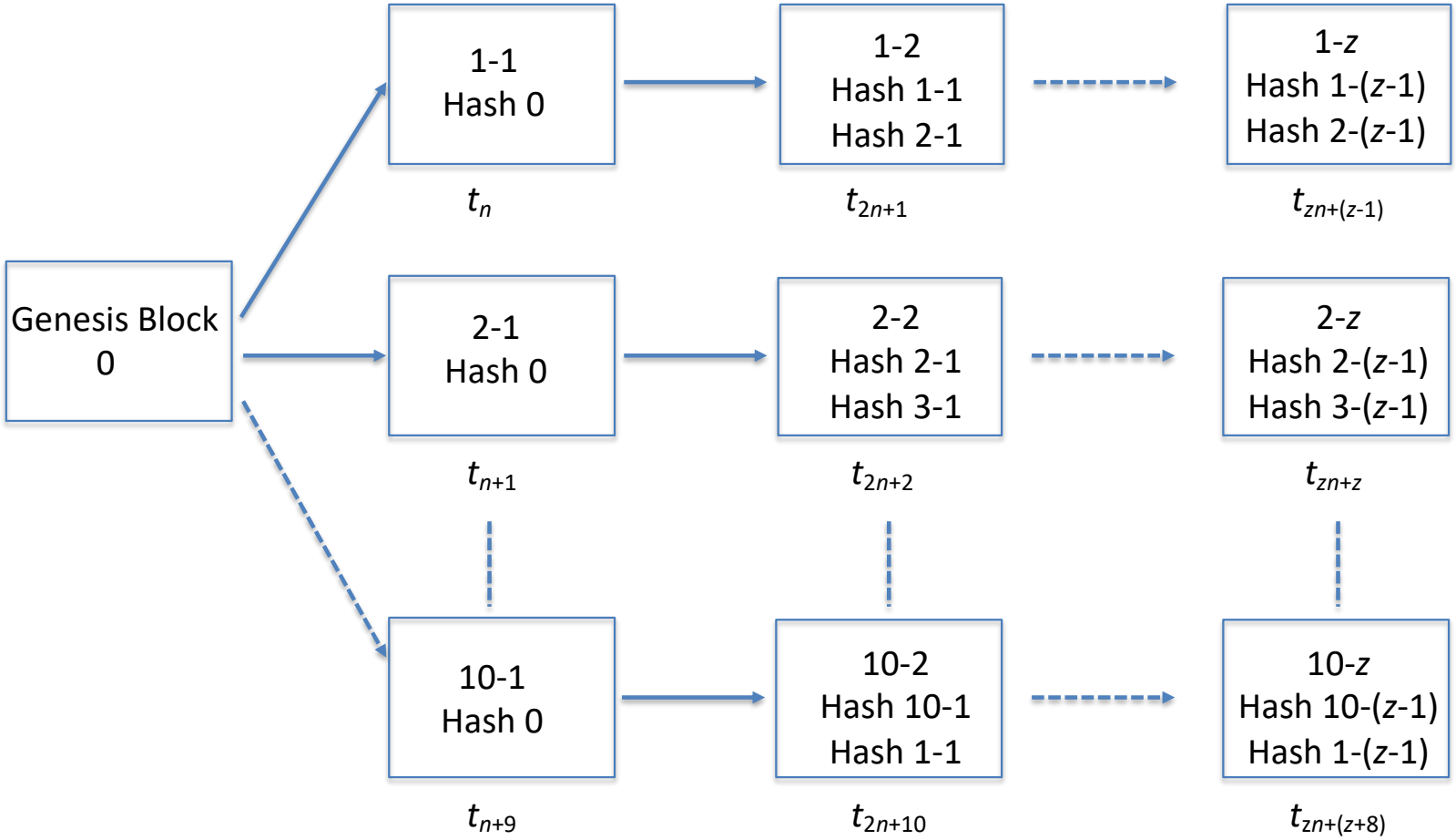
- Also need better *distributed consensus* mechanisms
  - Faster transaction processing and real-time point-of-sale

Mining



On average the Bitcoin network processes 7 transactions per second - as opposed to 2,000 on the Visa network!

Efficient Mining



Sub-chains mined in a sequential but overlapping manner - allows for parallel mining of blocks

Thank You

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