

# TRUST IN THE AGE OF BLOCKCHAIN

 @michelenati  
 <https://www.linkedin.com/in/michelenati/>  
 <https://medium.com/@michele.nati>

**Michele Nati, PhD**  
**Digital Trust Lead**  
**Technologist**

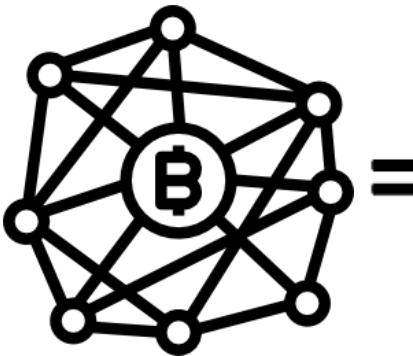
# WHO AM I?



+



+



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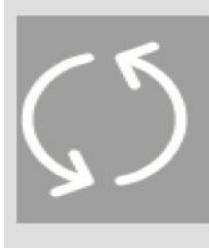
# THE SERIOUS STUFF

The screenshot shows a website for 'CATAPULT Digital'. On the left, a woman wearing a VR headset is shown against a purple digital background. The text 'Demonstrating the potential of immersive' and 'Immersive Labs' is overlaid. In the center, there's a large image of a futuristic city skyline with glowing nodes connected by lines, representing IoT innovation. The text 'Build and test IoT innovations that solve real world problems' and 'Innovation facilities and an open P2WAN network for UK businesses to experiment and prototype new IT solutions' is overlaid. On the right, a man is shown working at a computer, with the text 'Machine Intelligence' and 'Machine Intelligence' overlaid. The overall theme is advanced technology and innovation.



The screenshot shows the homepage of the 'European Blockchain Association'. The background features a dark, abstract pattern of glowing orange and yellow lines resembling a neural network or blockchain structure. The title 'European Blockchain Association' is prominently displayed in large, white, sans-serif font. Below the title, a subtitle reads: 'We are a Non-Profit Organisation that connects quality Blockchain Projects with Investors around the World'. At the bottom, a yellow button says 'Submit a Project'.

# Technology Layers



## FUTURE NETWORKS

Internet of Things  
5G  
LPWAN



## AI and ML

Artificial Intelligence  
Machine Learning  
Big Data



## AR and VR

Augmented Reality  
Virtual Reality  
Mixed Reality



## LIVE PROJECTS

IoTUK  
5G Brighton  
Things Connected

## LIVE PROJECTS

MI Garage  
Rolls-Royce  
British Oxygen Co.  
Hack&Pitch

## LIVE PROJECTS

Immersive Lab  
Volumetric Studio  
Augmentor  
CreativeXR

# OUTLINE

1. Why trust is important?
2. Building Digital Trust
3. Decentralizing trust
  - a. Examples
4. GDPR: Something to keep in mind
5. What are we working on?
  - a. H2020 Synchronicity
  - b. PoC
6. Few ideas to work on
  - a. CET - A Community Engagement Token

# FEW EXAMPLES - RENTING A PROPERTY



# WHY DID THIS HAPPEN?

## Urban Appeal

China is trying facilitate migration to cities, where people can often earn higher salaries.

### Annual household income



Note: 1,000 yuan = \$165  
Source: National Bureau of Statistics

## Urban growth

By 2025, China will have

23  
cities

More than  
5 million  
people

22  
cities

More than  
10 million  
people

15  
cities

More than  
25 million  
people

► The 15 cities  
include:

Chengdu

Chongqing

Beijing

Tianjin

Shanghai

Wuhan

Shenzhen

Guangzhou



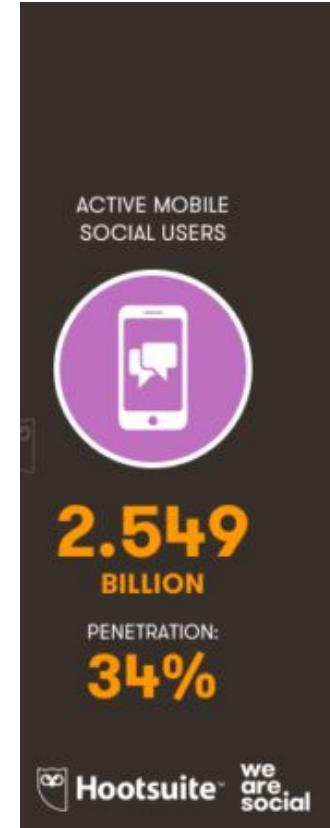
# WHERE THE TRUST GOT BROKEN?

- Lack of a notary
- Proof of ownership
- Lack of verified identity

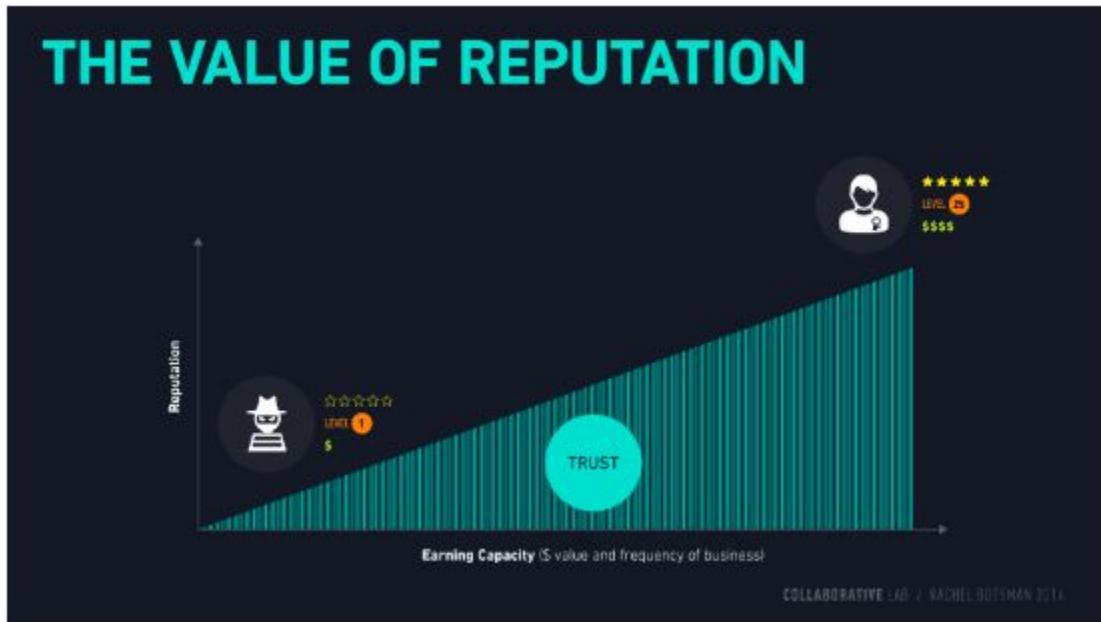
# THE SIZE OF THE PROBLEM



## 2018 *This Is What Happens In An Internet Minute*



# TRUST-BASED ECONOMY



- 450 billions transaction per days on the Internet expected by 2020
- Value of transaction depending on the trust
- Lack of trust might hinder this opportunity

# HOW TO UNLOCK THIS VALUE?



## BUILDING DIGITAL TRUST

# FROM HUMAN TO DIGITAL TRUST

**Trust:** is the result of one (or multiple) relations where one party (trustor) is willing to rely on the actions of another party (trustee).

->>> When results meet expectation the **trust of the trustor towards the trustee is likely to increase**

This works well in real-life and with 1-to-1 relations

# GOING FURTHER

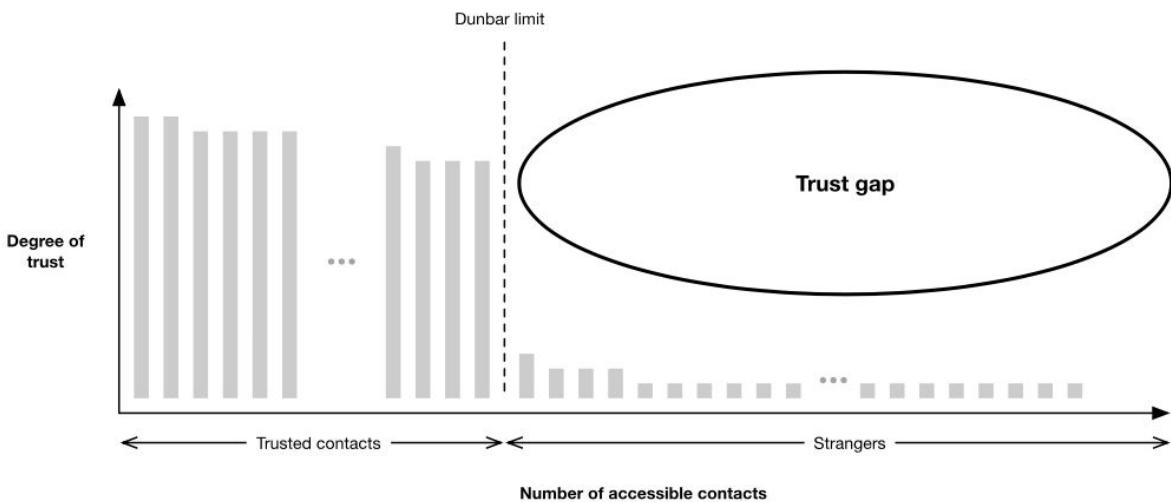
**Trust metrics:** is a measurement of the degree to which one social actor (an individual or a group) trusts another social actor

**Reputation** is a trust metric and is a concept that helps to build trust on others

**where**

reputation is a measure on how good is somebody in performing required actions

# TRUST-AT-A-DISTANCE



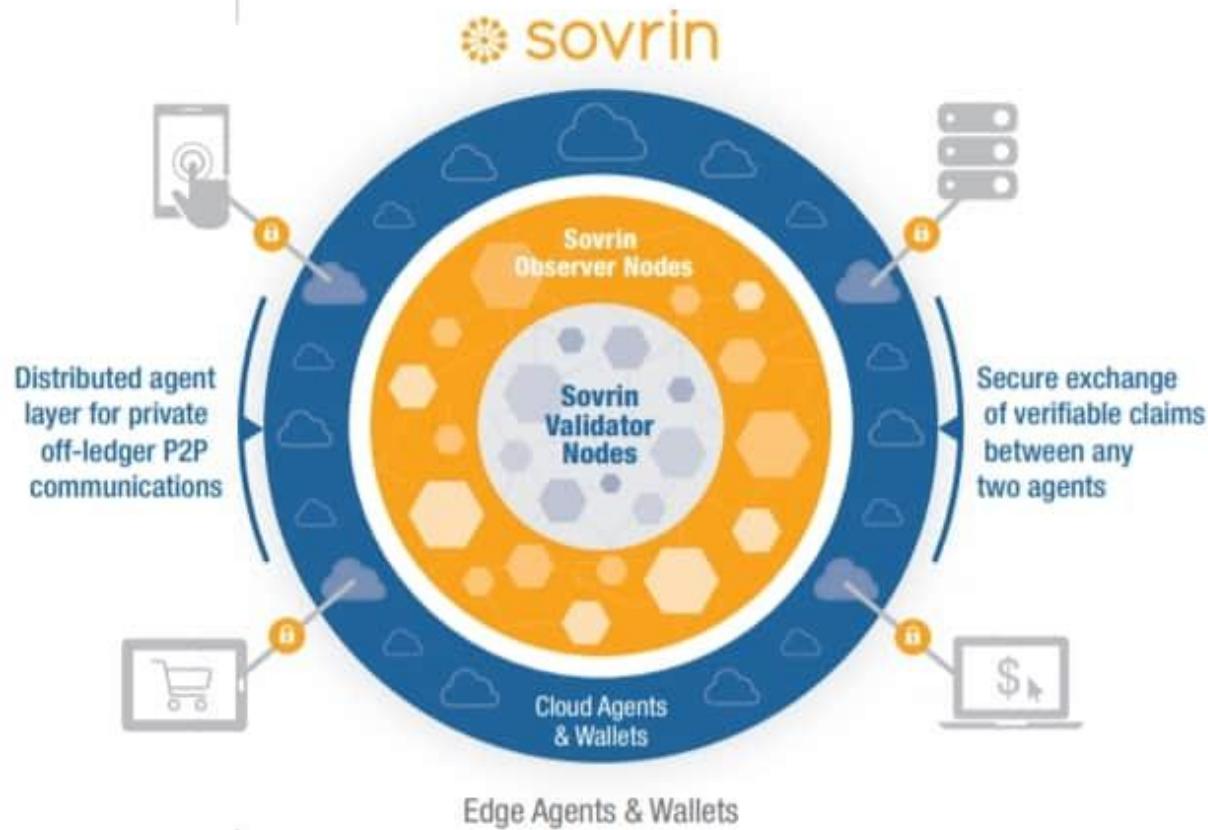
- Social-connection based trust limited to 150
- Trust gap increases as more and more people transact on Internet
- Low quality information distribution

# MITIGATING THE RISK: IS IDENTITY ENOUGH?



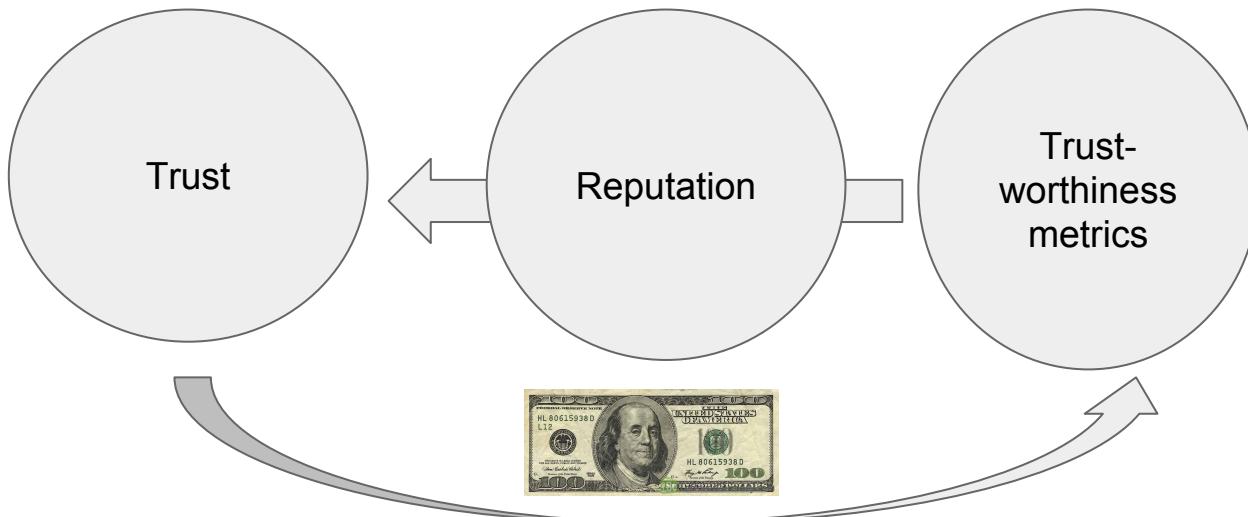
- Transaction can be still at risk
- Resolution can be eased
- Costs are still high

# DIGITAL IDENTITY



t  
n  
all

# HOW TO BUILD REPUTATION?



In the digital world should be:

- measurable
- replicable
- defined as digital contract

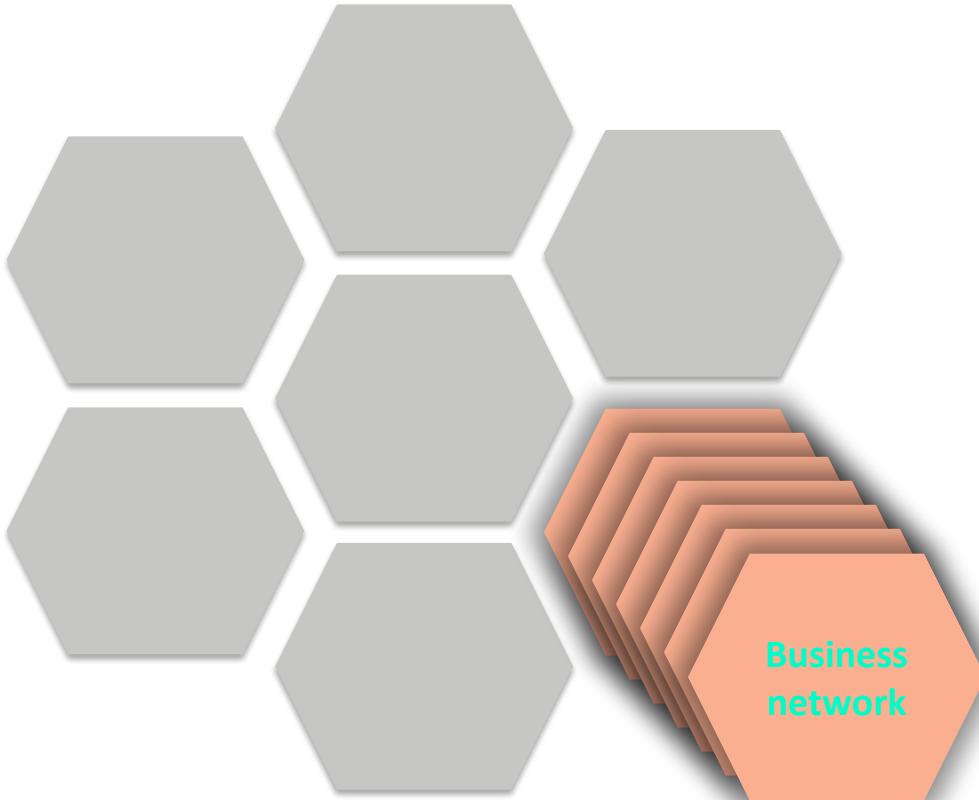
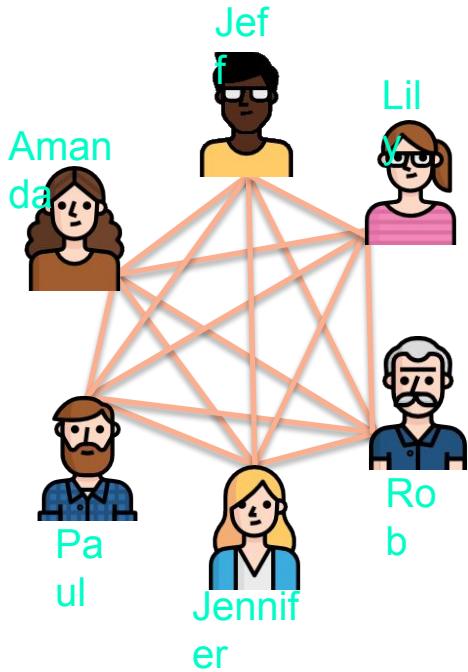
# TODAY ONLINE REPUTATION



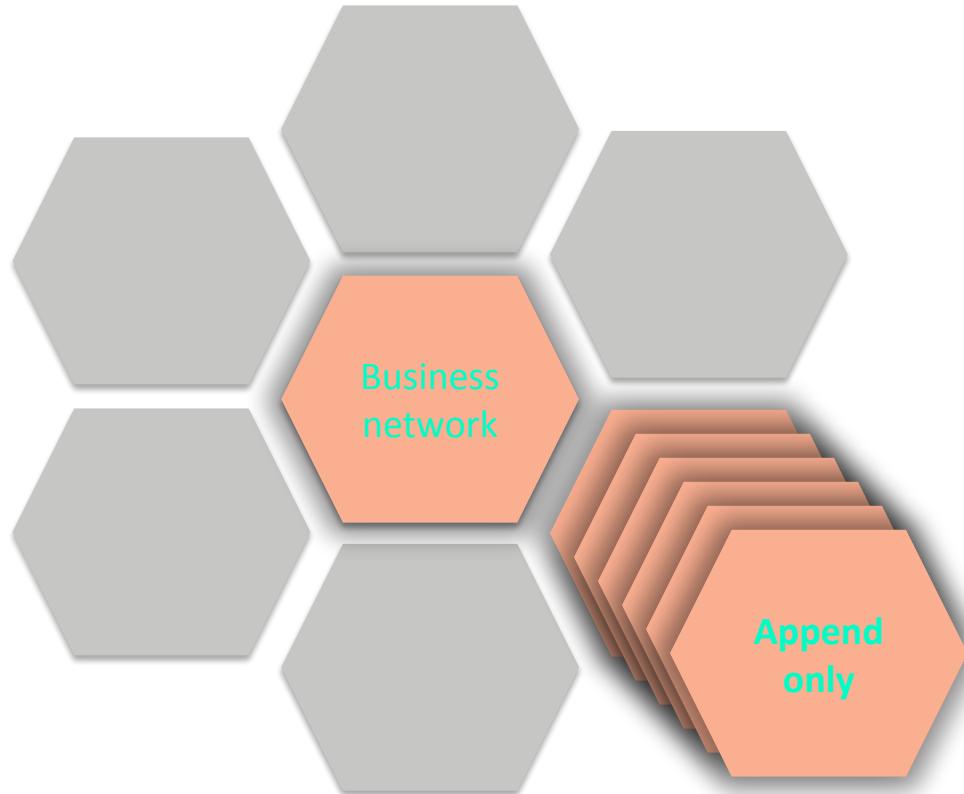
- Not owned
- Highly segmented
- Not portable

HOW TO  
DECENTRALIZE TRUST?

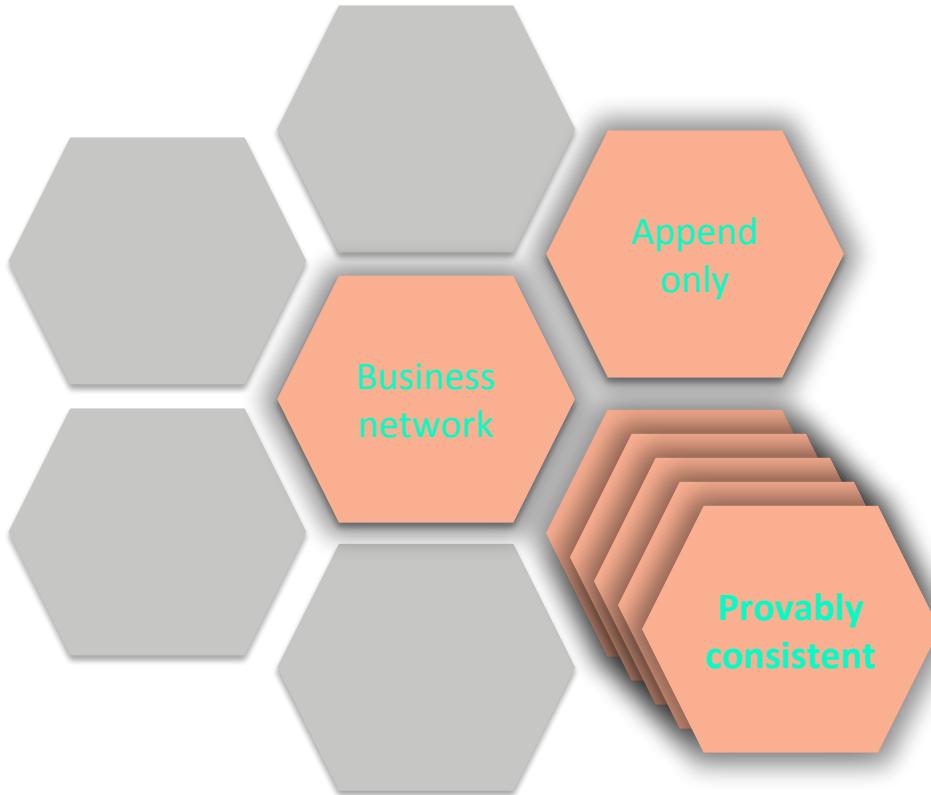
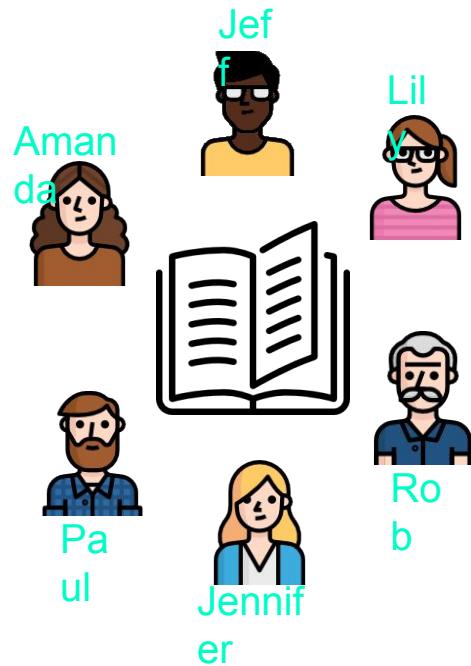
# LEVERAGING BLOCKCHAIN



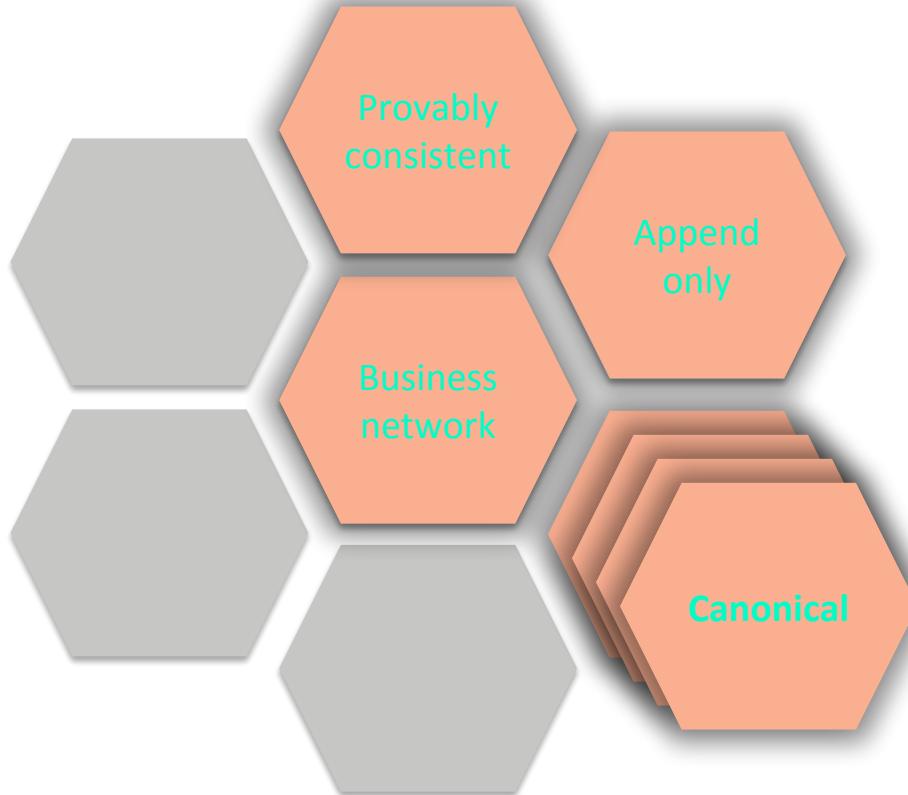
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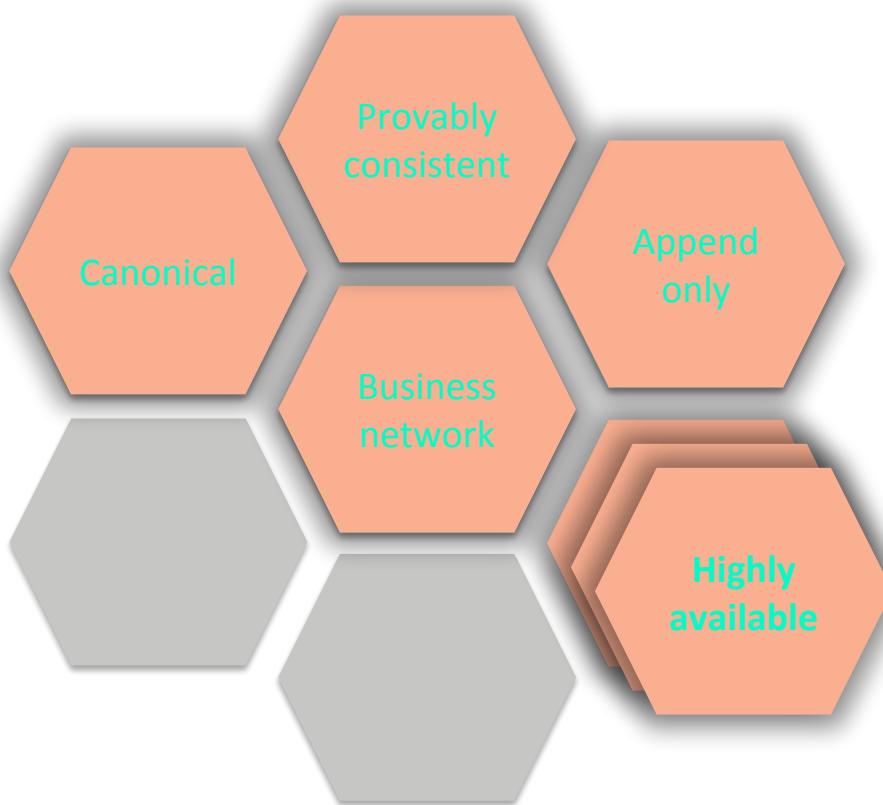
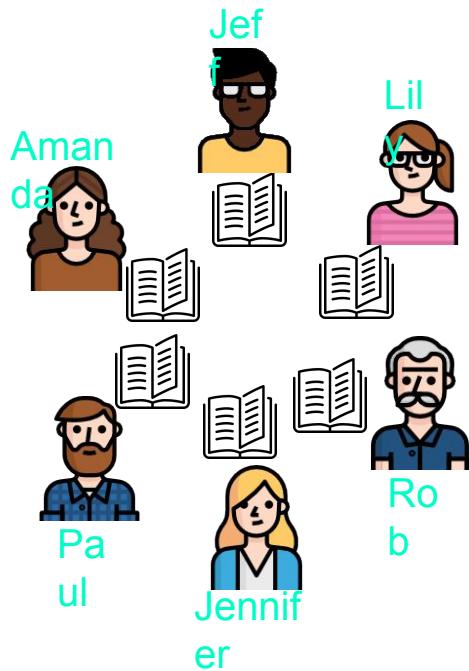
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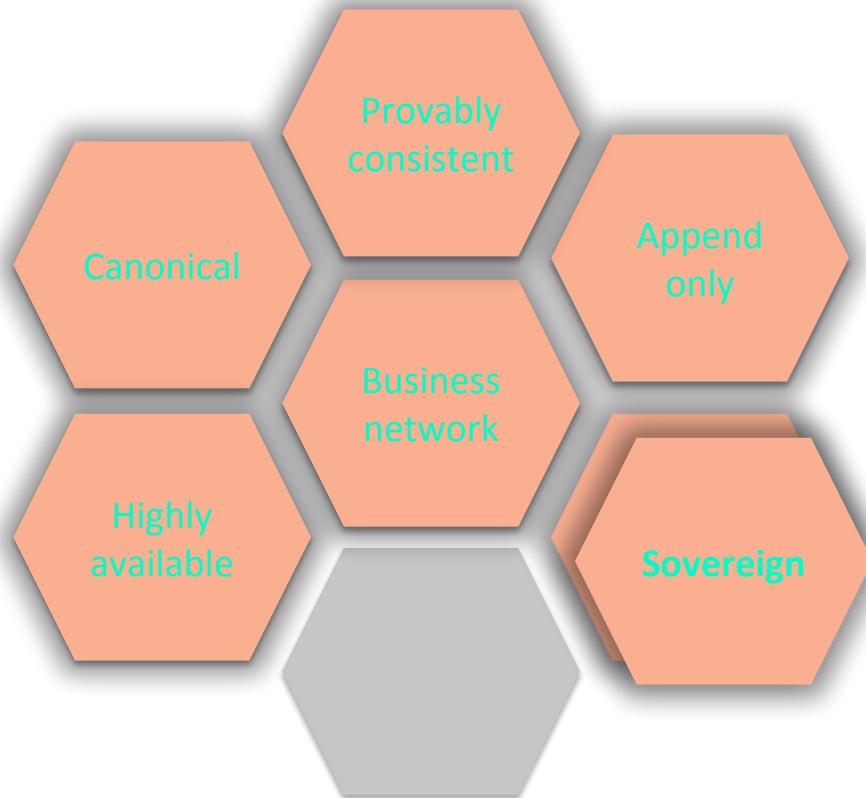
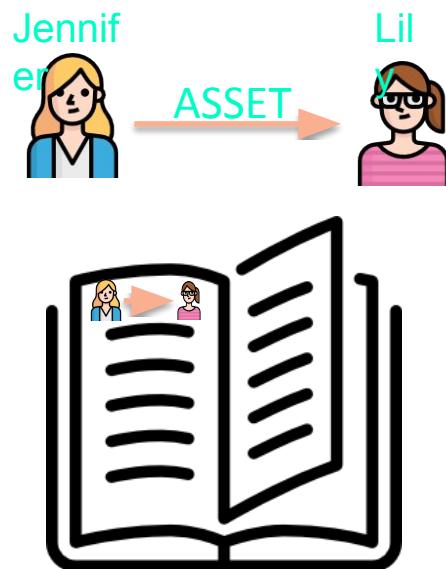
# LEVERAGING BLOCKCHAIN



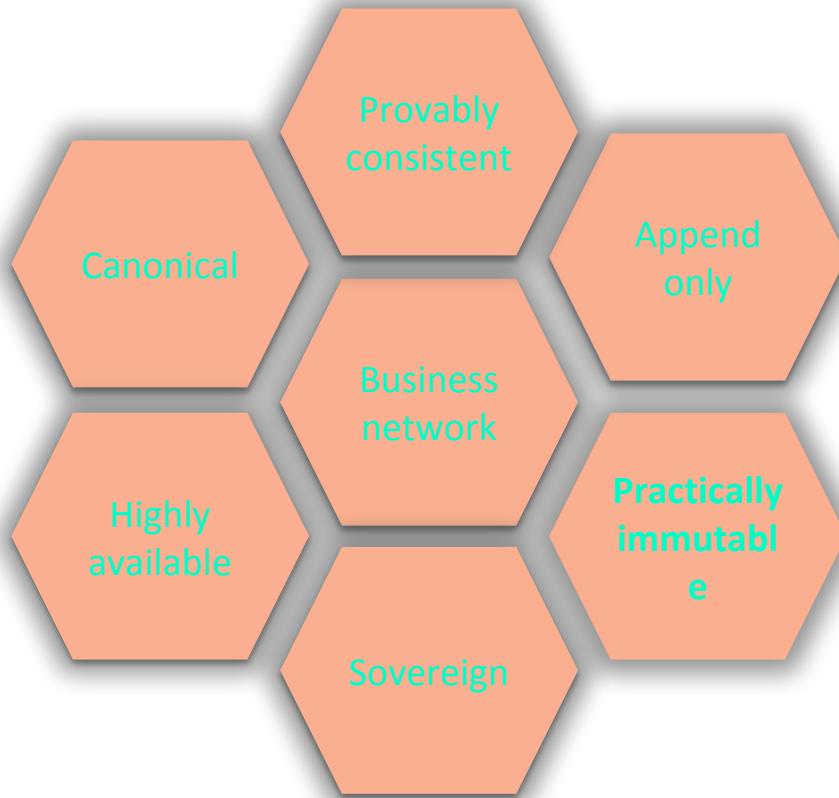
# LEVERAGING BLOCKCHAIN



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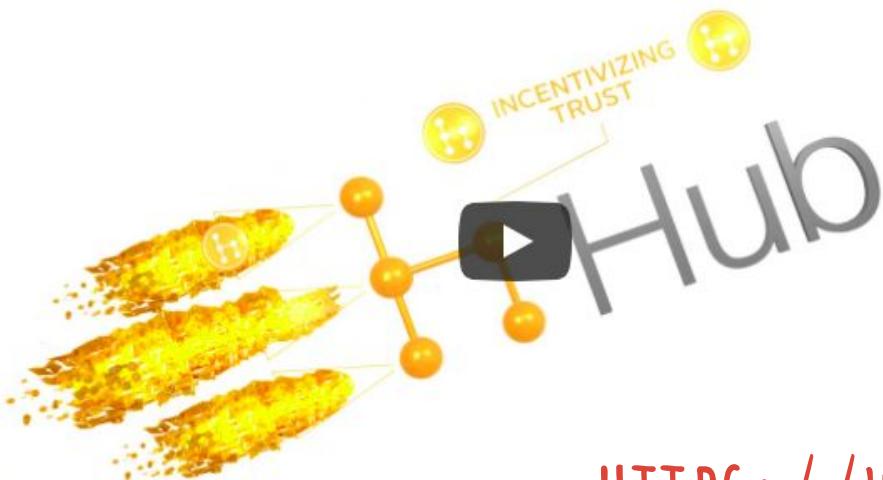


# DECENTRALIZED REPUTATION

- Sovereign
  - Owned by the subject -> It's an individual asset
- Create incentive
  - An asset with real value
- Measurable, verifiable and consistent
  - Result of one or multiple transaction
  - Immutable
- Can be utual but not symmetric
  - Escrow service
- Interoperable
  - It can be used in different networks -> global network or possibility to exchange assets

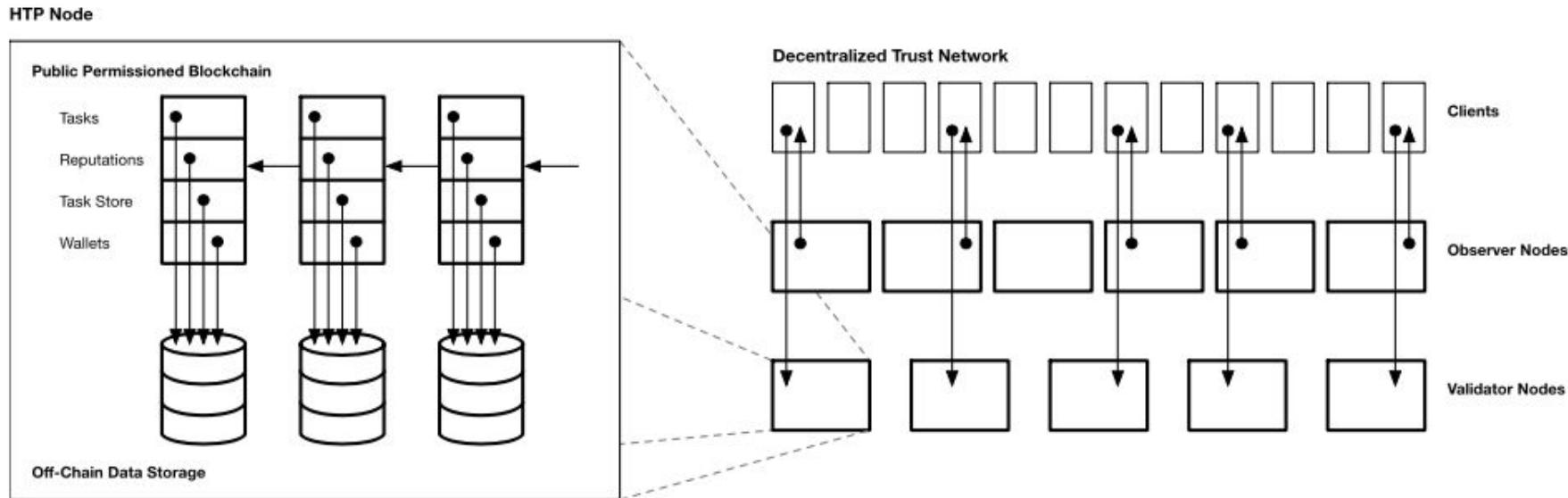
# Human Trust Protocol

Billions of users on the Internet interact with each other every day on messengers, online communities, social networks and peer-to-peer marketplaces, making contact with people they never met let alone trust.



[HTTPS://WWW.HUBTOKEN.ORG](https://www.hubtoken.org)

# HOW TO BUILD A TRUST NETWORK: HUMAN TRUST PROTOCOL



# TASKS

- A contract between parties
- They express the way to measure outcomes (e.g., work to be done)
- A template is provided and further extended
  - Need to define actors
  - Need to define conditions for payment
  - Need to define arbiter to resolve dispute
  - Need to have a reference to the template creator

# TRUST STAKE FOUNDATIONS AND EXMAPLES

*In this game theoretic mechanism, an “entrepreneur” incentivizes “agents” (or players) to contribute to produce a “public good” as long as a sufficient number of players pledge to contribute.*

# TRUST ECONOMY

Trust Stake: *the tokens pledged by a task participant that is at risk when the task's outcome does not go as planned*



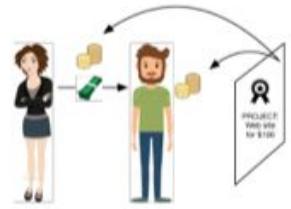
# RULES TO BUILD (AND INCENTIVISE) TRUST

1. Participants pledge a meaningful Trust Stake when they collaborate on interactions
2. There are well-defined rules on how the pool of Trust Stake is redistributed depending on the outcome of the Task
3. The summary of the Task and outcome is kept in reputation histories for future evaluation of trust-at-a-distance
4. Trust Stake is different than *payment(s)*. Stakes are always involved with Tasks, but Tasks do not always involve payment(s)

# TRUST STAKE REQUIREMENTS

1. Tasks should be *fully-staked*
  - a. *nothing-at-stake problem*
2. *Partially-staked* tasks are still possible

BACK US NOW ON  
**KICKSTARTER**



Katie is happy with  
Sam's design

1. Katie pays Sam for the project
2. Sam's Stake is returned
3. Katie's Stake is returned

The project and its outcome is recorded and goes into Sam's and Katie's reputation profiles



Katie is not satisfied with Sam's design

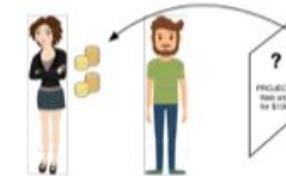
- Katie & Sam agree to an arbitrator to resolve their dispute



The arbitrator decides in favor of Sam

The arbitrator decides in favor of Katie

1. Katie does not pay Sam
2. Sam's Stake is distributed to Katie
3. Katie's Stake is returned



The project and its outcome is recorded and goes into Sam's (and Katie's) reputation profile



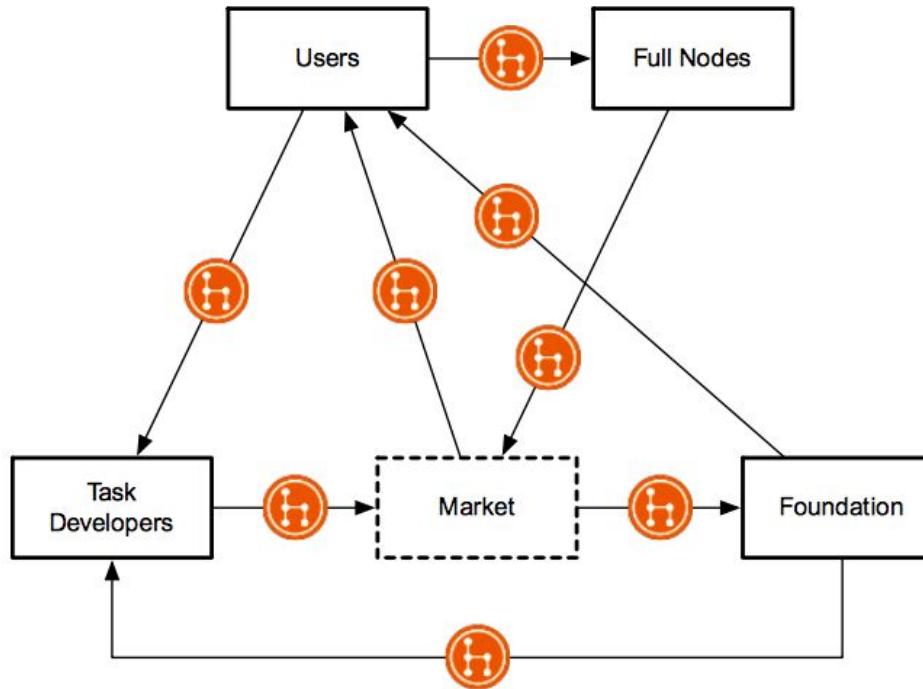
# ARBITRATORS

- Serves as an oracle for the Task
- Their judgement is a Task itself (*chained Task*)
- They need to be compensated
  - Using the trust stakes
  - Or with extra fees
- Their reputation can be assessed too

# TOKEN ECONOMY

- Digitazing and decentralizing trust creates an ecosystem
- Ecosystem needs incentives
- For Users:
  - Successful tasks increase trust-at-a-distance
  - Unsuccessful tasks reduce trust-at-a-distance and result in economic loss
- Need a Token to fuel this ecosystem (developers, arbitrators, miner, etc)

# TOKEN ECONOMY



# REPUTATION: SECURITY AND PRIVACY

- Reliable to attacks:
  - Collusion:
    - central authority/verified identity; resource testing and web-of-trust networks
  - Dishonest raters & Dynamic Personalities
    - Arbitrators
  - Dishonest mining of stake rewards
    - Cost of performing tasks
- Protect the privacy:
  - Multi-faced
  - Share the outcome but protect the details



KEEP  
CALM  
AND  
COMPLY WITH  
GDPR

# WHAT IS GDPR?

*A regulation for the treatment of personal data in Europe, superseding previous DPA (in force on May 25<sup>th</sup> 2018, after a two years grace period)*

**Whose personal data:** All EU citizen

**Who has to comply:** All organizations processing data of EU citizens

# PERSONAL DATA - WT...K ?

According to GDPR: '*Personal data*' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person

**Reputation data are most likely personal**

- If in doubt, be conservative!

# DATA PROTECTION 101

**Data Subject:** the person whom data are collected and processed for the provisioning of a service

**Data Controller:** who sets the purpose of the processing  
*(either collected directly or acquired from other sources)*

**Data Processor:** who processes the data for the purpose of providing a service (might be the same as the Controller)

# GDPR: LEVEL OF CONTROL

## Article 17-19

*The right to be informed* -> provide information notice

*The right of access* -> free of charge, within a month

*The right to rectification* -> within one (or two months)

*The right to erasure* -> some exceptions are possible

*The right to restrict processing* -> retain information but stop processing

*The right to data portability* -> free of charge, within a month, no hindrance

*The right to object* -> marketing and research unless legal basis

*Rights in relation to automated decision making and profiling.*

# BLOCKCHAIN PROPERTIES: RECAP

- **Transactional data are personal**
  - Anonymization -> Hashing is not anonymization
  - Pseudonymization -> Keys are not anonymous
- **Unpermissioned vs permissioned**
  - Decentralized network, who runs it?
  - Append-only
  - High-redundancy of data

# IS BLOCKCHAIN COMPLIANT?

- **Personal/Reputation data**
  - What data to store?
- **Jurisdiction**
  - Who is the data controller?
- **Digital rights enforcement**
  - Minimization?
  - Erasure?
  - Update? What update means?
  - Access request? To who?
- **Possible solutions?**
  - Think about your network first
  - Think about what you store
  - Consider off-chain data store, store consent but consider carefully meta-data

EXAMPLES: FROM  
GENERAL TO SINGLE  
PURPOSE

# INK PROTOCOL: REPUTATION ON EXCHANGING GOODS

[HTTPS://PAYWITHINK.COM](https://paywithink.com)

## Ink Protocol Decentralizes Marketplaces

### Buyers

View any seller's reputation across multiple marketplaces, pay with escrow, and leave feedback for completed transactions.

### Sellers

Reputation is decentralized and public, so it is available anywhere. Bring it with you and never worry about rebuilding it from scratch.



### Any marketplace

Ink Protocol can be integrated into new or existing marketplaces and can also be used in marketplaces that don't directly handle payments.

### Any transaction

Ink Protocol doesn't require a marketplace. It can be used for any peer-to-peer transaction.

Reputation of sellers is attached to transactions

### Benefits:

- From Listia to Ink Token
- Portable to other marketplace

### Cons:

- Not generic
- Spendable in Ink Token

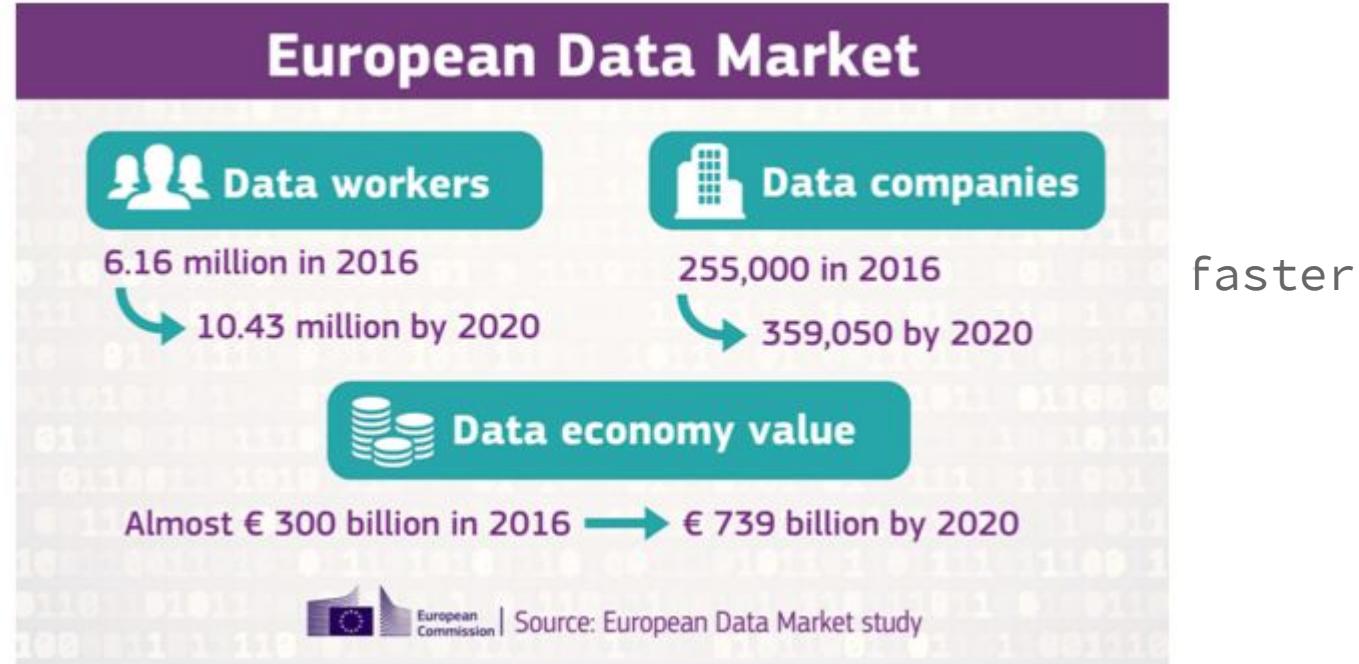
NOT ONLY PEOPLE  
NEED TRUST AND  
REPUTATION

# SHARING DATA: BENEFITS AND BARRIERS

- Data are...
  - Current
- More dat
- Better c  
training

We need bui

- Data sha
- Data qua





Gems

Team

Blog

FAQs

Twitter

Alpha

Whitepaper

Join the Telegram

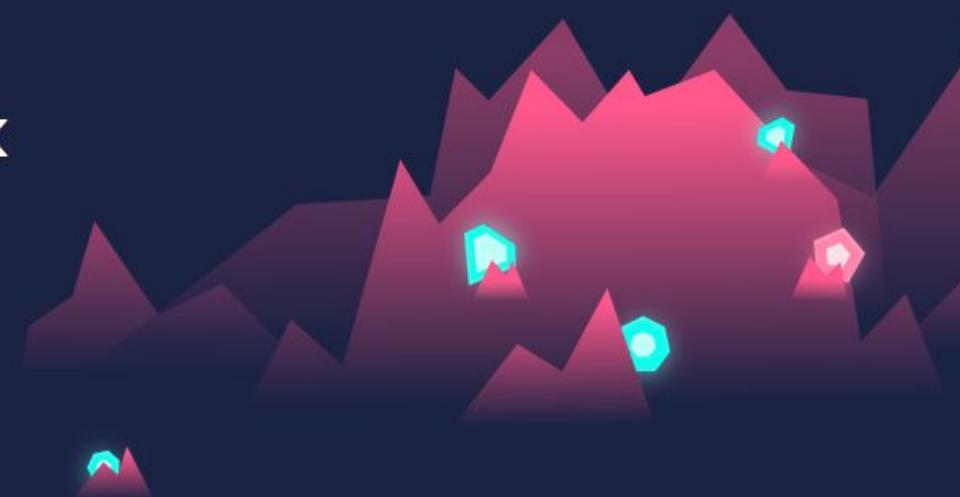
# Decentralized Mechanical Turk

Powered by Ethereum

Join our mailing list for updates

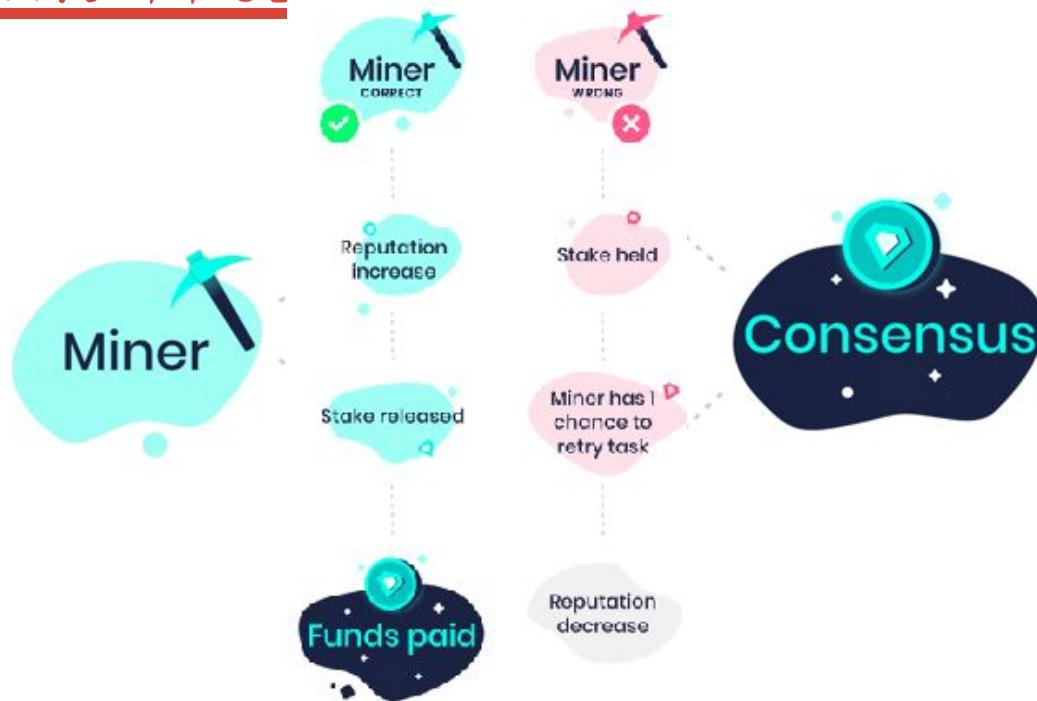
Enter your email

Join



# GEMS: REPUTATION FOR MICROTAKS WORKERS

[HTTPS://GEMS.ORG](https://gems.org)



Decentralized MTurk network:

- no fees per task
- open to unbanked
- initial focus on AI labelling

Reputation of workers:

- can be generic, covers different tasks
- not (ex-)portable at the moment

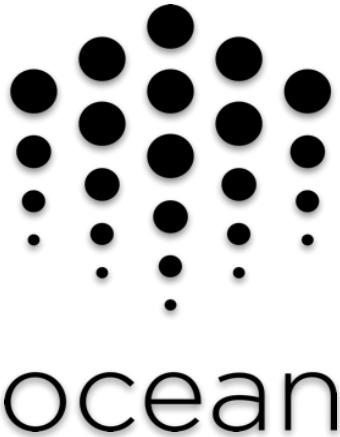
# A Decentralized Data Exchange Protocol to Unlock Data for AI

POWERED BY

BIGCHAIN<sup>DB</sup>  DEX



# Ocean Protocol solves data sharing for all Stakeholders



- a **decentralized data exchange protocol** to unlock data for AI
- uses **blockchain technology** that allows data to be **shared** and **transferred** in a **safe, secure** and **transparent** manner
- enables a **decentralized platform** and network connecting **providers** and **consumers** of valuable data, and providing open access for **developers** to **build services**

# The Ocean Protocol Ecosystem and Network

## Data Providers

- Private Data
- Not free
- Public Data
- Free



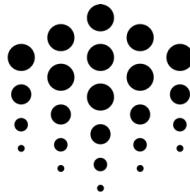
Data+  
Stake



Reputation  
+Stake

## Foundation

Governance  
Ecosystem  
Partnerships



ocean

## Keepers

Validation  
Storage  
Network

Pricing  
Control  
Security  
Transparency  
Compliance

Tokens



Data  
Tokens

## Consumer

Discover  
Select  
Buy  
Analytics & AI



## Marketplace or Exchange

GUI  
Discovery  
Compliance  
Pricing

# Key Ecosystem Participants

## Publishers

- Own rights to data assets
- Publish assets on Ocean
- Earn tokens for asset usage

## Consumers

- Harness data assets and services
- Use their own choice of tools
- Pay tokens for consumption



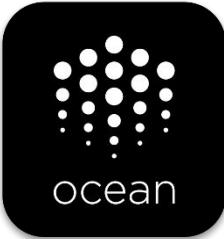
Ocean Protocol & Network

## Providers

- Offer data services (storage, compute AI)
- Provide proofs of service provision and trust compliance
- Earn tokens for service provision

## Marketplaces

- Enable discovery of relevant assets
- Facilitate data transactions
- Verify trusted data rules
- Earn tokens for transactions and services



The Ocean Protocol Token (OCN)  
is the means of value exchange and  
network incentivization

### Earn OCN for selling Data

- Publish data for sale with a variety of **pricing mechanisms**
- Maintain **full control**
- Comply with **regulation**

### Data marketplaces earn OCN

- Curate and publish data to Ocean Protocol to find new buyers
- An open source protocol that democratizes access for **new data market places**

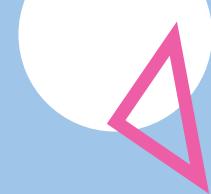
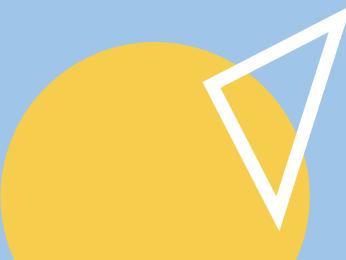
### Earn OCN for supporting the network

- Provide **validation** and **verification** services for the network
- Store blockchain **history of transactions**

### Earn OCN for publishing public data

- **Publish, curate** and **conserve** public data to earn minting rewards

WHAT ARE WE  
WORKING ON?



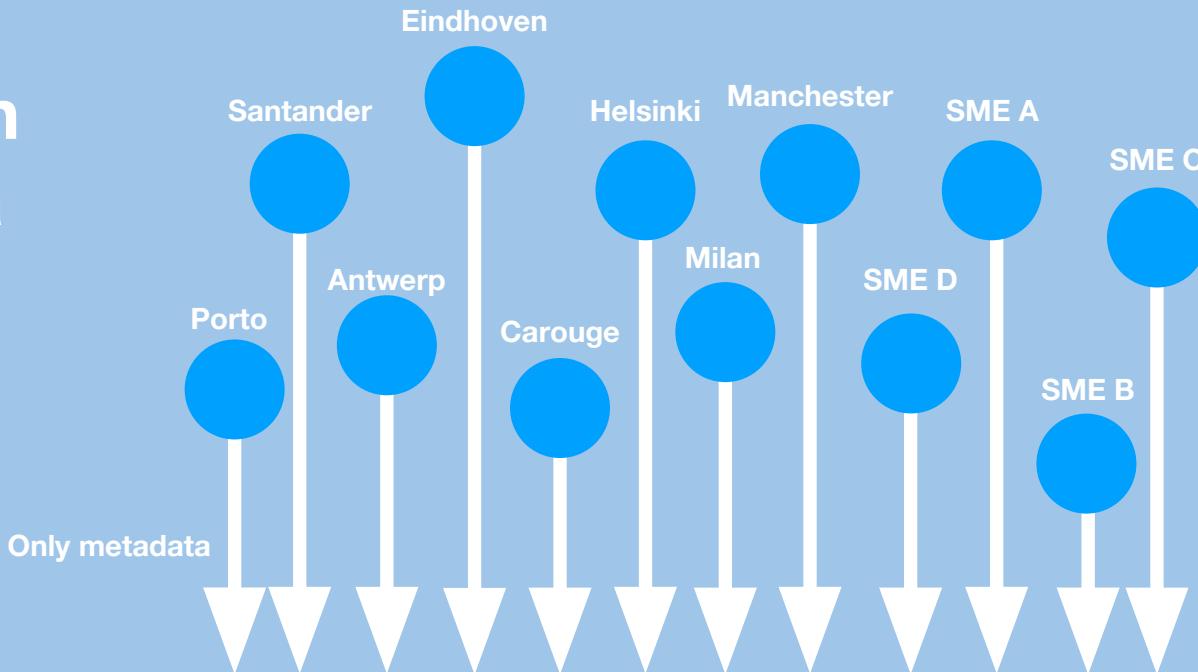
**What about (non personal) smart cities data?**

- 1 City vendor lock-in**
- 2 Developer city lock-in**
- 3 Infrastructure is not an asset**
- 4 City data silos**
- 5 Only share Open data**

# SmartCities data economy: The Opportunity

Open  
data

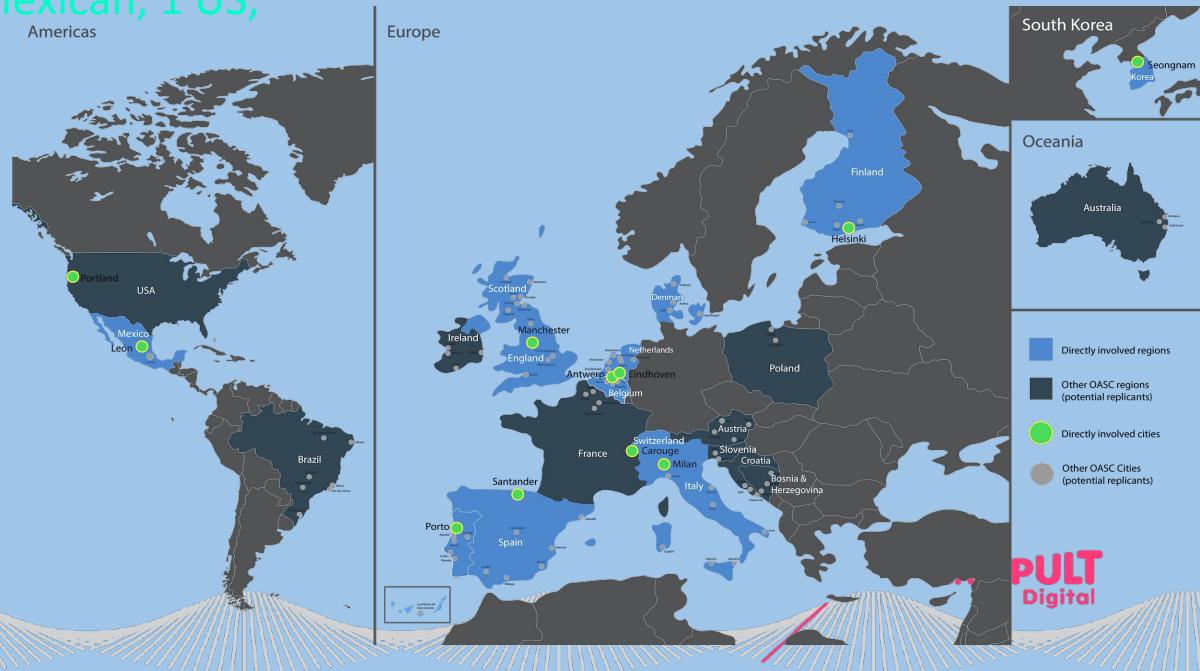
Closed  
data

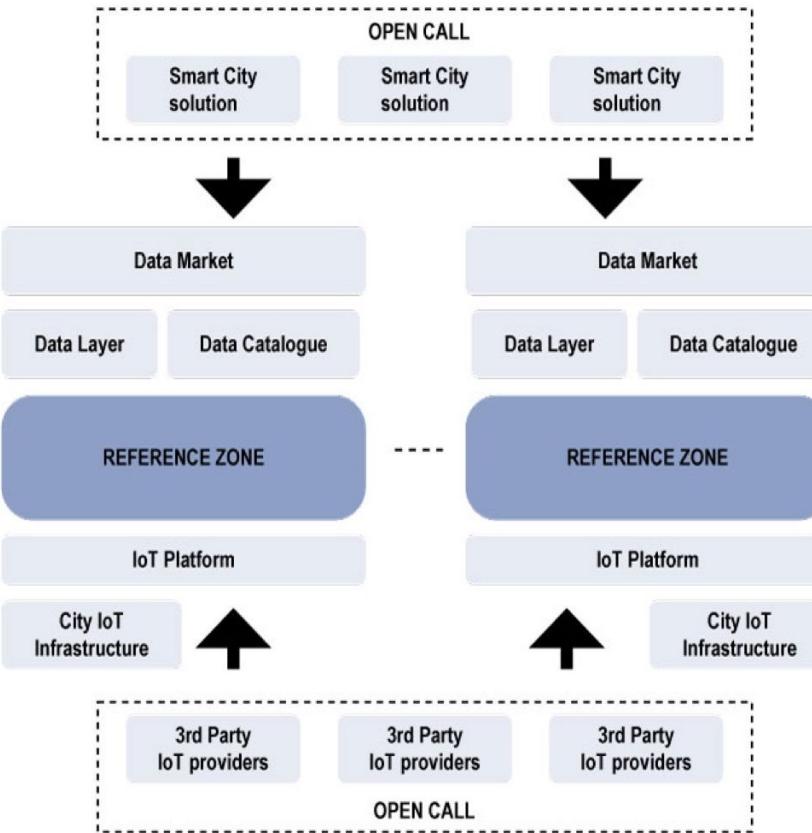


IoT Data Marketplace

# The Synchronicity project

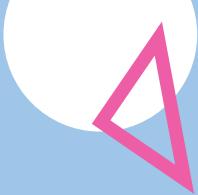
- 35 Partners
  - 15 different countries
  - 11 Cities - 7 EU, 1 Swiss, 1 Mexican, 1 US,  
1 South Korean
- EU H2020 funding
  - €15 Mio funding
  - €3 Mio for open calls





# IoT Data Marketplace

Enablers for IoT Data Monetisation



# SmartCities data economy: The Barriers

## 1 Lack of trust

- Data providers are typically required to hand over control of their data in order to share them
- Data consumers need guarantees of the trustworthiness of the data and its providers

## 2 Lack of flexible licenses and SLAs

- IoT data licenses and SLAs are typically provided as inflexible static text which is hard to be effectively understood by data consumers and machines

# SynchroniCity's trust requirements



1

## Liability

Cities do not want to be liable for potential disputes related to data exchange

2

## Governance consortium

Cities want to jointly run the process of governing the marketplace

3

## Fairness

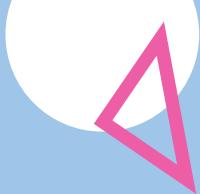
Marketplace should not favour any participant

4

## Transparency

Participants' behaviour should be tracked to enable auditing



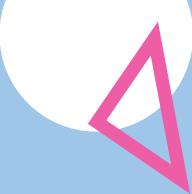


# Challenges

How can we make it easier for data providers and consumers to express and settle suitable agreements (pricing, license, SLA)?

How can we track the behaviour of involved parties with respect to the settled agreement?





## Our Solutions

Express



Define customisable and  
machine readable  
agreements

Settle



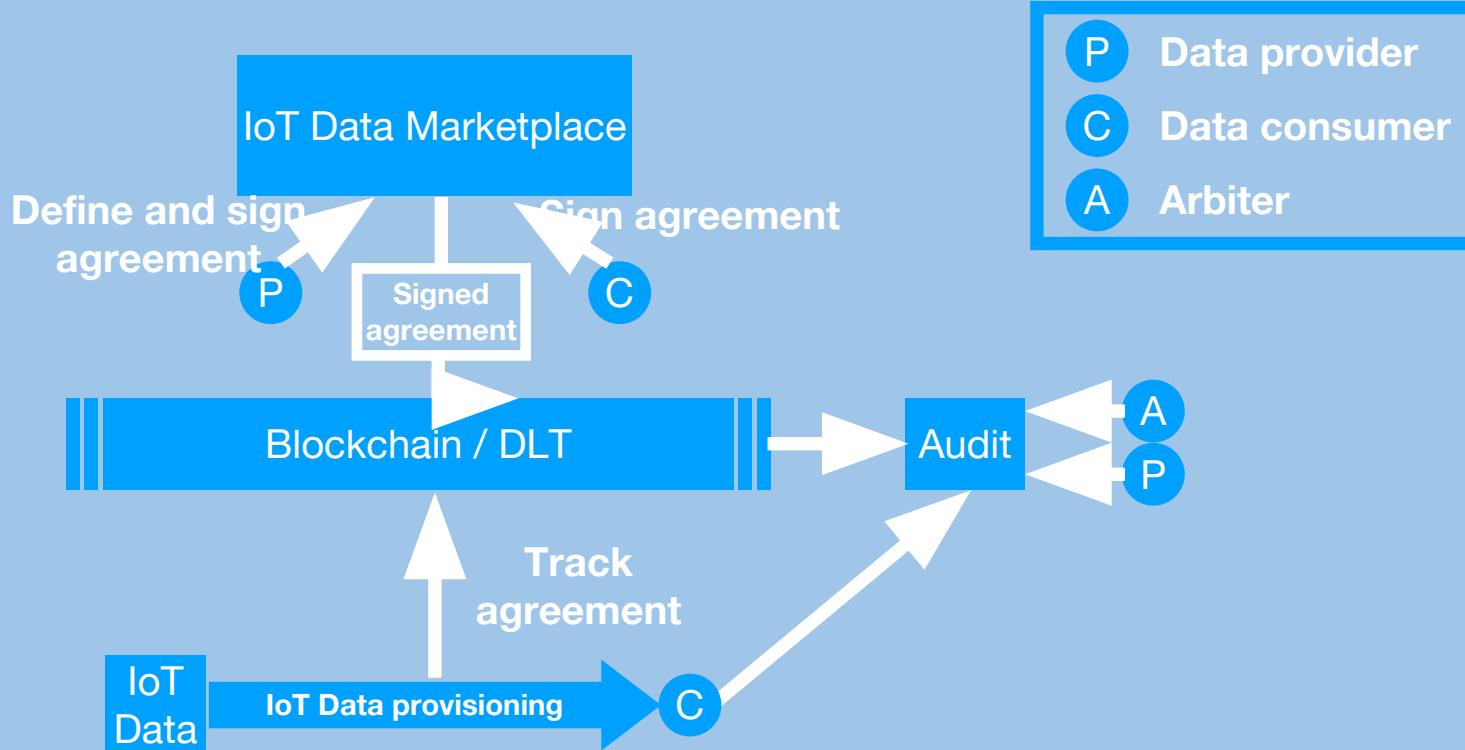
Digitally sign the agreement

Track



Create tamper proof audit  
trails

# High-level conceptual view



*Mind My Value:  
A decentralised infrastructure  
for fair and trusted IoT data trading*

Paolo Missier

Shaimaa Bajoudah

{firstname.lastname}@ncl.ac.uk

School of Computing, Newcastle  
University, UK

Angelo Capossele

Andrea Gaglione

Michele Nati

{firstname.lastname}@digitalcatapult.org.uk

Digital Catapult Centre

London, UK

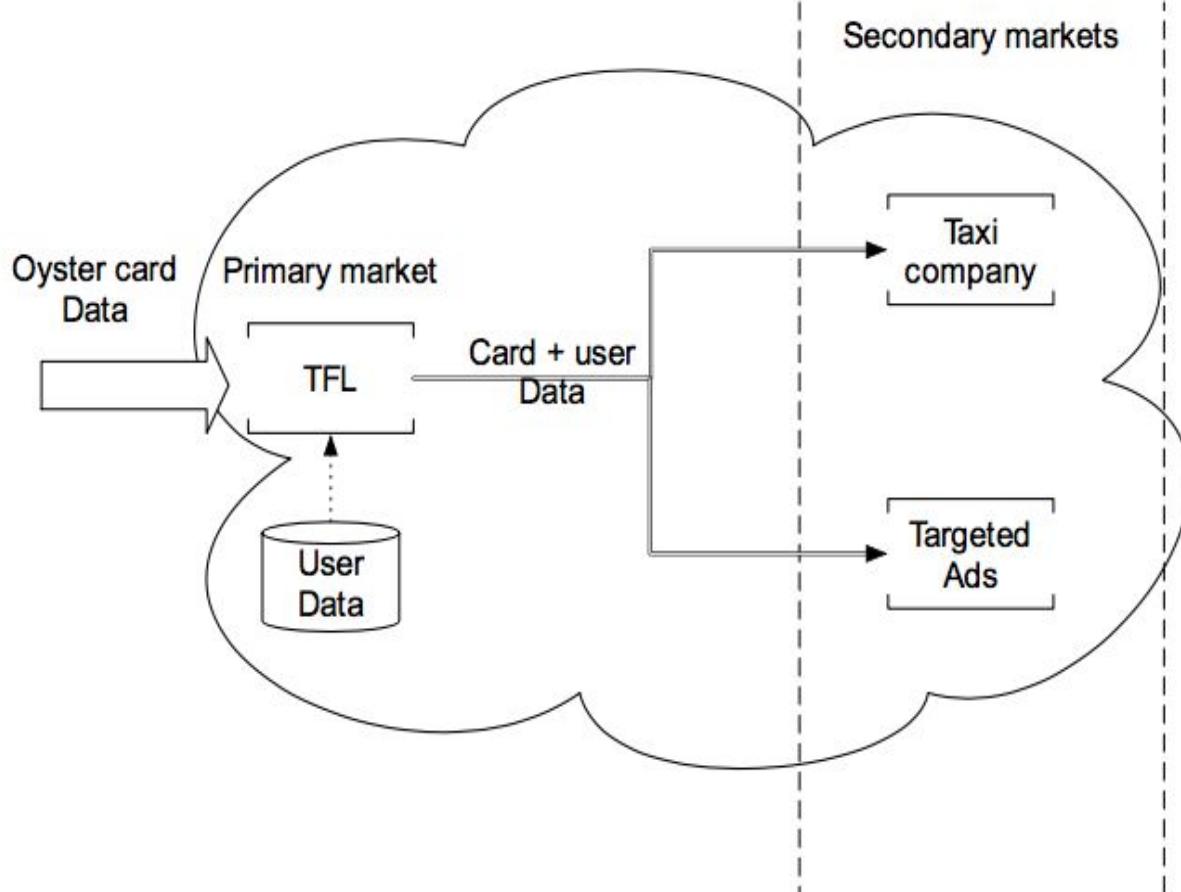
IoT Conference

Linz, Austria

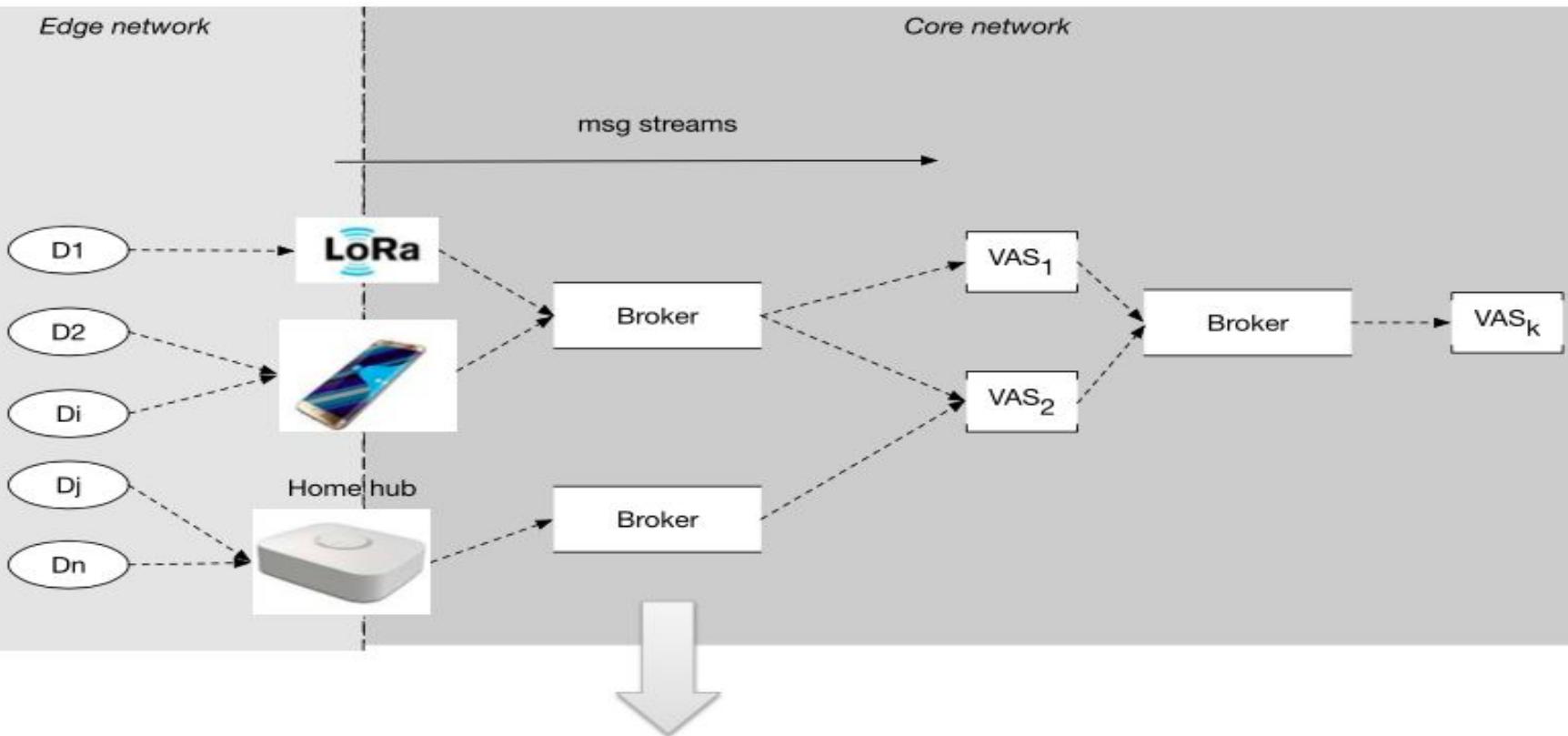
Oct. 24<sup>th</sup>, 2017

# Data re-use

Tube stations gates

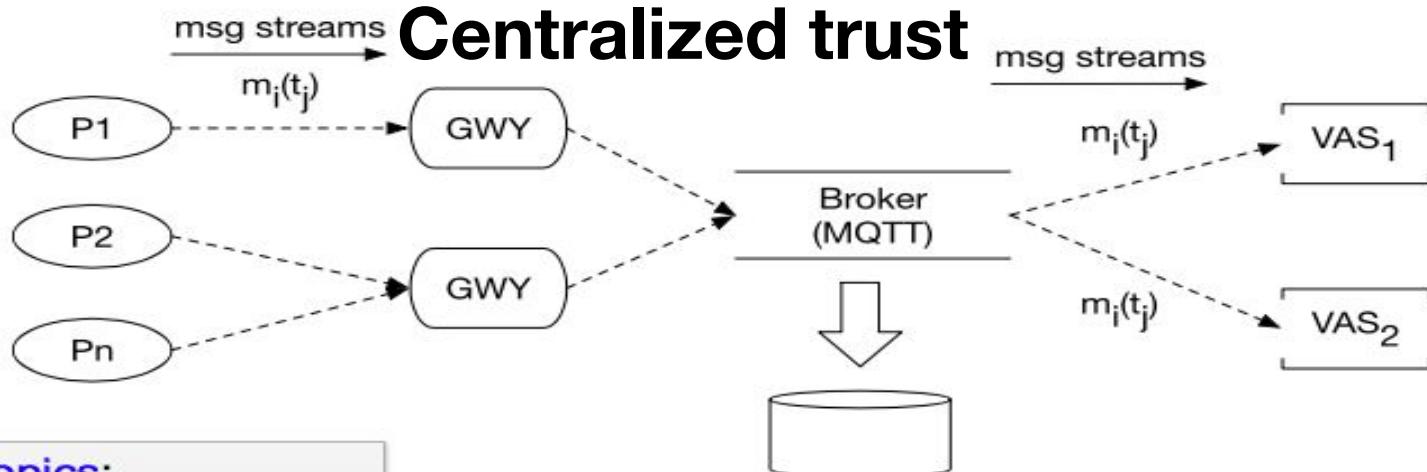


## An IoT pub/sub setting (eg MQTT)



Observable IoT data streams  
- Simply count messages: <from, to, topic>

# Centralized trust



## Example Topics:

- Heart rate
- Speed
- GPS trace
- Glucose level
- Gait
- Home water consumption
- Vehicle driving data
- ...

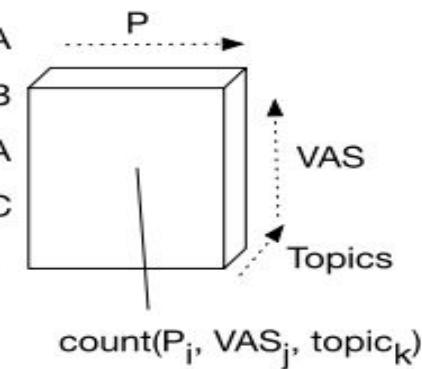
$P_1 \rightarrow VAS_1$ , topic A

$P_2 \rightarrow VAS_2$ , topic B

$P_1 \rightarrow VAS_2$ , topic A

$P_3 \rightarrow VAS_1$ , topic C

*message count cubes  
Only contain metadata*



$$\text{cube}(W) = \{\langle p_i, c_j, t_k, N_{ijk}(W) \rangle\}_{p_i \in P, c_j \in C, t_k \in T}$$

# Settlement

$$\text{cube}(W) = \{\langle p_i, c_j, t_k, N_{ijk}(W) \rangle\}_{p_i \in P, c_j \in C, t_k \in T}$$

At the end of each  $W$ :

Total fee owed by each  $c_j$  to each  $p_i$  computed by aggregating counts in the cube:

$$\text{fee}(c_j, p_i, W) = \sum_{t_k \in T} N_{ijk}(W) \cdot \underbrace{\text{val}(t_k)}_{\substack{\text{Unit cost} \\ \text{for topic } k \text{ messages}}}$$

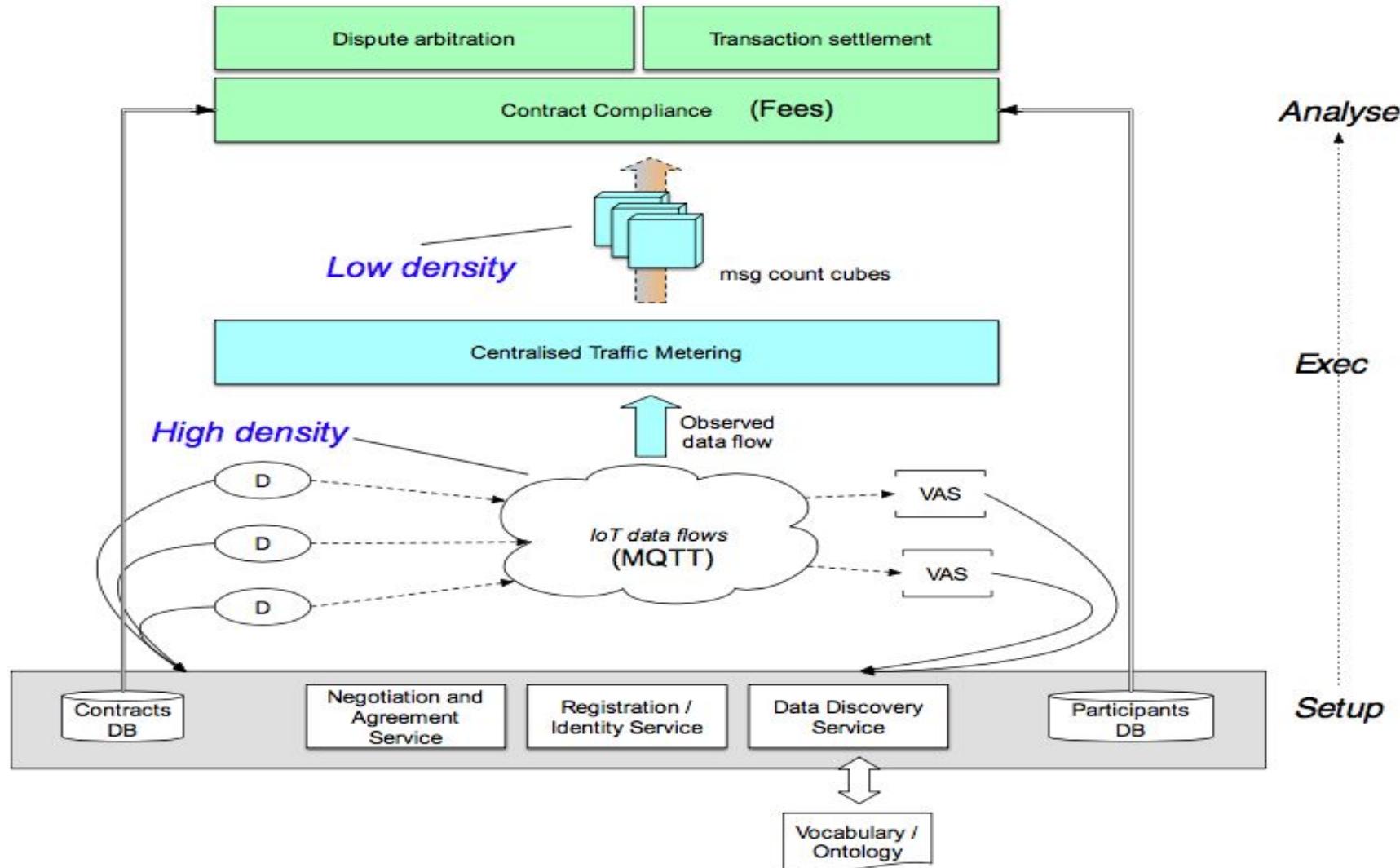
$p_i$  revenue after  $W$ :

$$\text{revenue}(p_i, W) = \sum_{c_j \in C} \text{fee}(c_j, p_i, W)$$

if we assume:

- Complete and correct traffic metering
- A trusted authority to compute revenues

Problem solved?



# Decentralizing Trust

Trusted broker provides

- Accountability (accurate, complete counts)
- Dispute resolution
- Revenue distribution

Can we remove the trust assumption and still fulfill these functions?

- 1) **Accountability**: Each participant is responsible for reporting their own counts of messages sent / received
- 2) **Transparency**: Reports become part of blockchain transactions

**Unilateral** count cubes:

- Provided by each participant
- Partial – reflect a participant's point of view

$$\text{cube}(W) = \{\langle p_i, c_j, t_k, N_{ijk}(W) \rangle\}_{p_i \in P, c_j \in C, t_k \in T}$$

**Provider cube**:

$$\text{cube}^p(W, p_i) = \{\langle t_k, N_{ik}^s(W) \rangle\}_{t_k \in T}$$

*Count of messages sent by  $p_i$  about  $t_k$*

**Subscriber cube**:

$$\text{cube}^s(W, c_j) = \{\langle p_i, t_k, N_{ijk}(W) \rangle | c_j \in \text{sub}(t_k)\}_{p_i \in P, t_k \in T}$$

*Count of messages received by  $c_j$  from  $p_i$  about  $t_k$*

Cubes collected at the end of  $W$ :

$$\{ \text{cube}^p(W, p_i) \}_{p_i \in P} \cup \{ \text{cube}^s(W, c_j) \}_{c_j \in C}$$

**Consistency constraint:**

For each  $t_k$ , for each subscriber  $c_j$  to  $t_k$ :

Number of messages sent by  $p_i$  = number of messages received by  $c_j$  from  $p_i$

$$\begin{aligned}\text{cube}^p(W, p_i)[t_k] &= N_{ik}^s(W) = \\ \text{cube}(W)[p_i, t_k, c_j] &= N_{ijk}(W) = \\ \text{cube}^s(W, c_j)[p_i, t_k]\end{aligned}$$

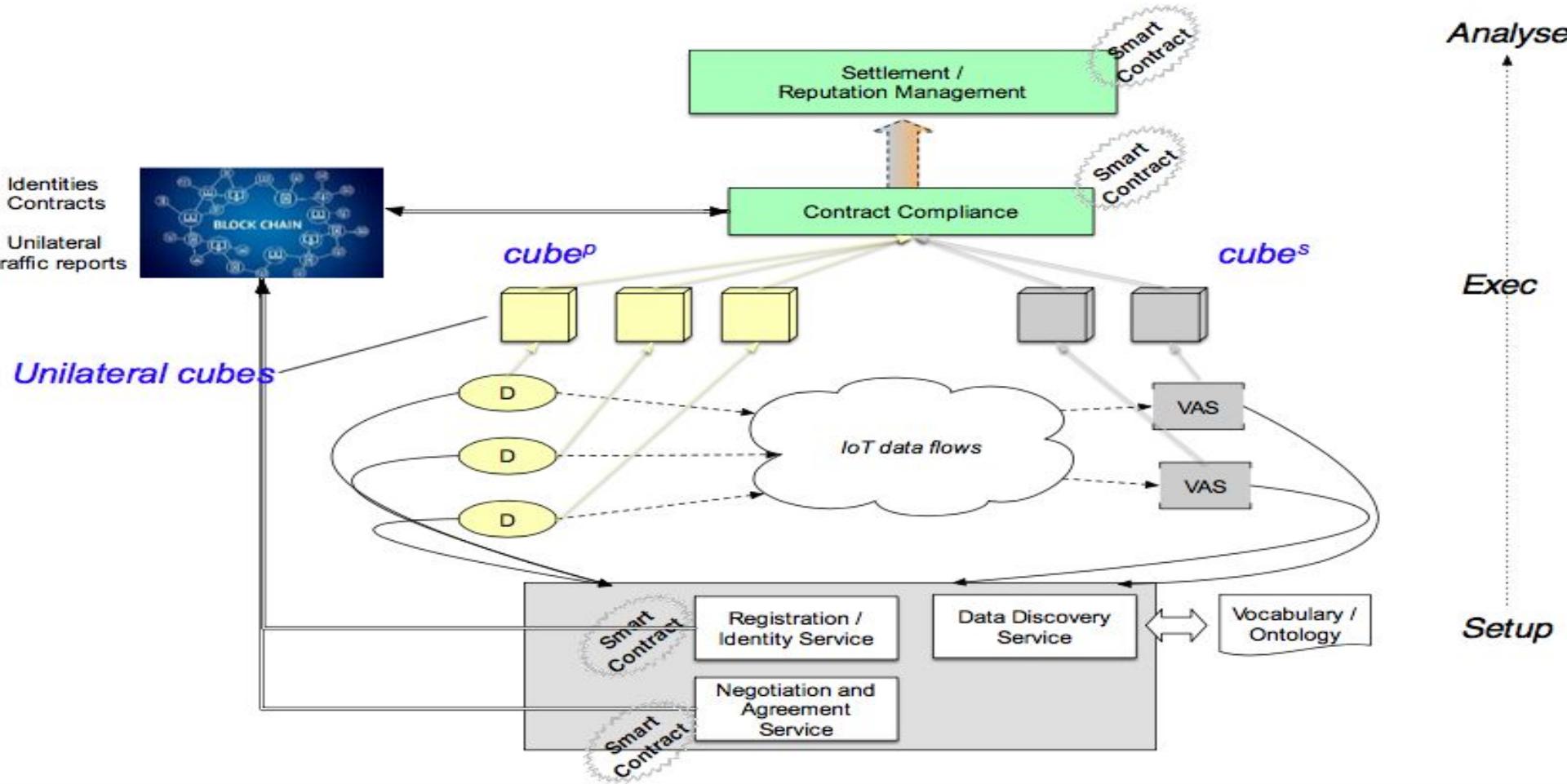
But:

- Producers have an incentive to over-report the data they send
- VAS have an incentive to under-report the data they receive

Thus for some combination of  $p_i$ ,  $c_j$ ,  $t_k$  we may expect:

$$\text{cube}^p(W, p_i)[t_k] > \text{cube}^s(W, c_j)[p_i, t_k]$$

broker-controlled “message count cubes” → each participant unilaterally reports data sent / received



## How much does it cost to run the settlement smart contract?

Execution cost of cube  
settlement operations

Operation	Gas used	
	w/o Oraclize	w Oraclize
Contract deployment	175000	2061490
Update	41000	120000
Callback	23000	70000
Transfer	21000	21000

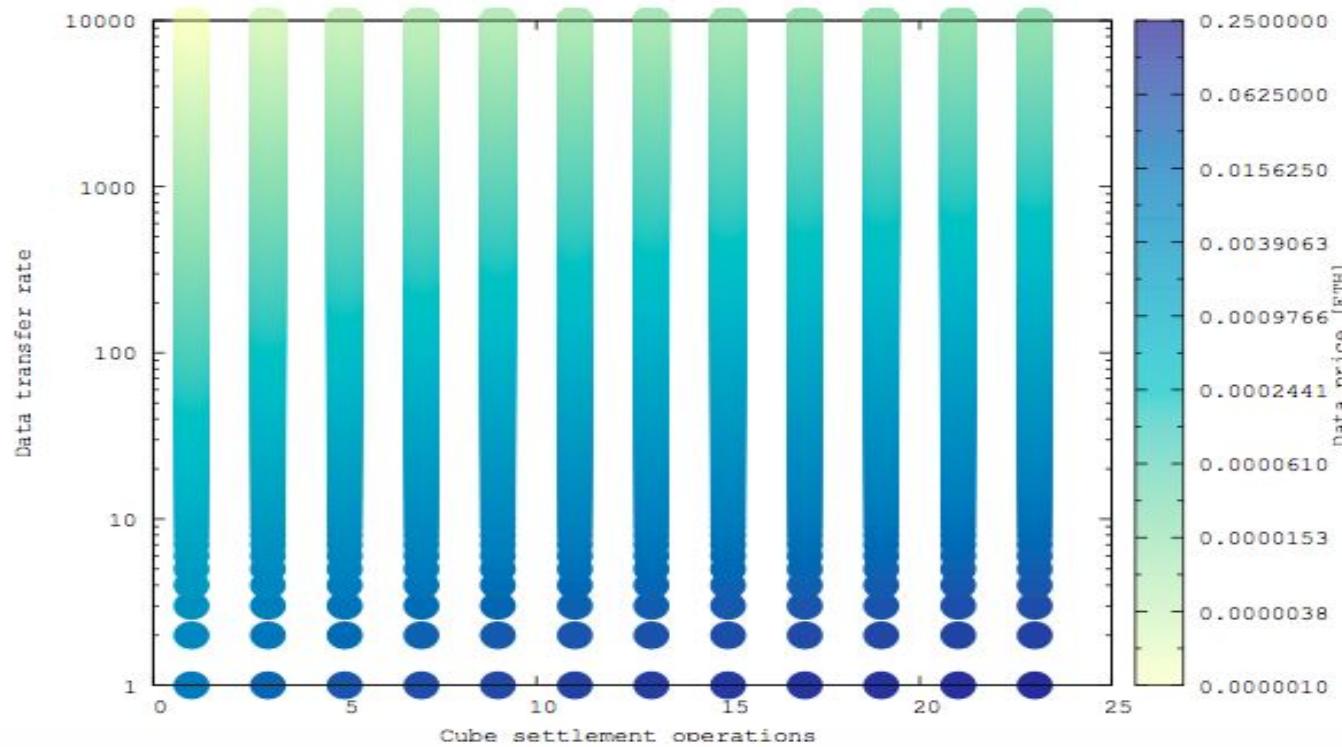
Where should cubes data live?

- **Off chain:** cubes remain natively located within participants' trusted zones
- Oraclize (Ethereum-specific mechanism)
- Adds to cost of Smart Contract execution
- guarantees the authenticity and integrity of the retrieved data.
- Oraclize requires a query fee: 0.01\$ to 0.04\$
  
- **On chain:** transactions embed the cubes in the blockchain
- No cost but adds to transaction size

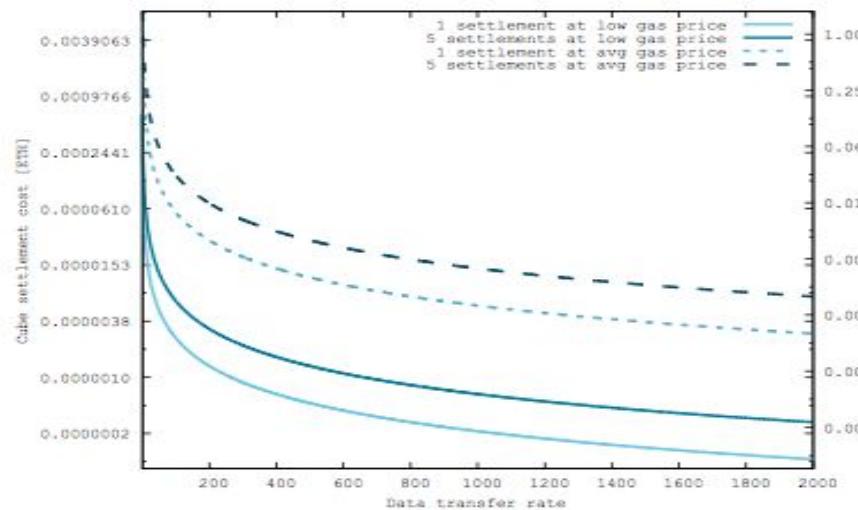
**Overhead:** (cost of contract execution) x (settlement rate)

- cost of contract execution → cube size) → #PROD X #CONS x #TOPICS (possibly compressed)

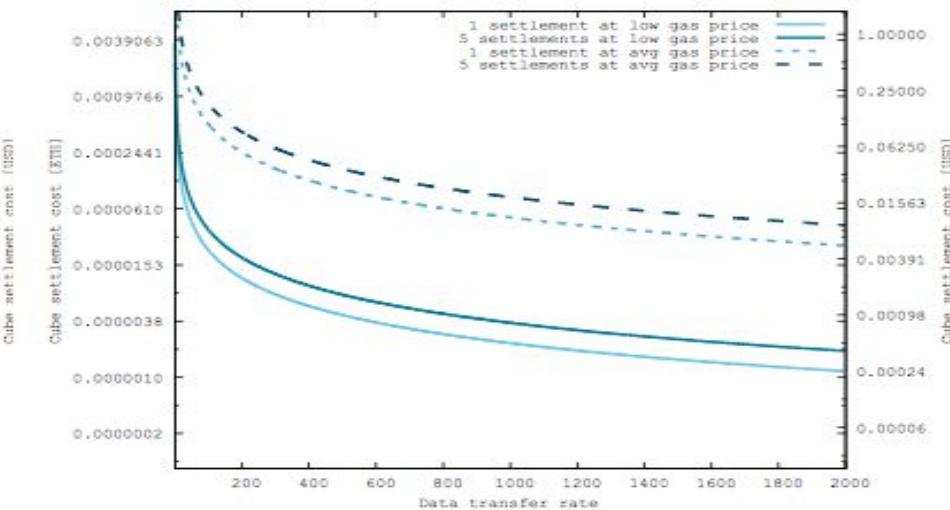
Impact of overhead on unit cost for varying settlement rate and data transfer rate



# Cost per message for varying data volume, settlement rate, gas price



on-chain data



off-chain data  
(retrieved using Oracle with additional cost overhead)

Estimated data prices

Data rate	Data price			
	w/o Oracle		w Oracle	
	ETH	USD	ETH	USD
high	5.73e-8	1.26e-5	2.09e-7	4.59e-5
medium	3.44e-6	7.56e-4	1.25e-5	2.76e-3
low	2.06e-4	4.54e-2	7.52e-4	1.65e-1

**Fairness** in the presence of malicious behaviour

→ reputation model:

based on history of disagreements on past transactions

**What's in a trading agreement?**

- From atomic data trading (single message) to complex SLA  
    Think “follow-your-runner”

**System challenges:**

- Evolving Smart Contract technology: Ethereum vs Hyperledger
- Public vs permissioned blockchains
- Scalability

EXERCISE - CEL  
REPUTATION FOR  
MEETUP  
PARTICIPATION

|THIS PAPER IS OPEN TO COMMENTS. PLS BE  
CONSTRUCTIVE AND DON'T ABUSE THIS  
DOCUMENT WITH SPAM OR PROFANITY.

BEST COMMENTS WILL BE REWARDED WITH CEL<sup>1</sup> TOKEN AIRDROP, LEAVE YOUR  
ETH ADDRESS AS SIGNATURE OF COMMENT.

A COMBO OF 3 COMMENTS ACCEPTED BY AUTHORS WILL ENTITLE 0.2 CEL

CHEERS

## A blockchain token for community engagement

Davide Carboni and Michele Nati  
Draft: 16 APR 2018

<https://goo.gl/TgNe9Q>

# FOMO-FE: FEAR OF MISSING OUT (A FREE EVENT)

Meetup organization benefits:

- Organizers earn respect and reputation
- Speakers shine on the stage and advertise themselves
- Hosts reuse some space in off-peak hours in exchange of visibility
- Participants?????

**Are payment or deposit the right solution?**

**What about a virtual token?**

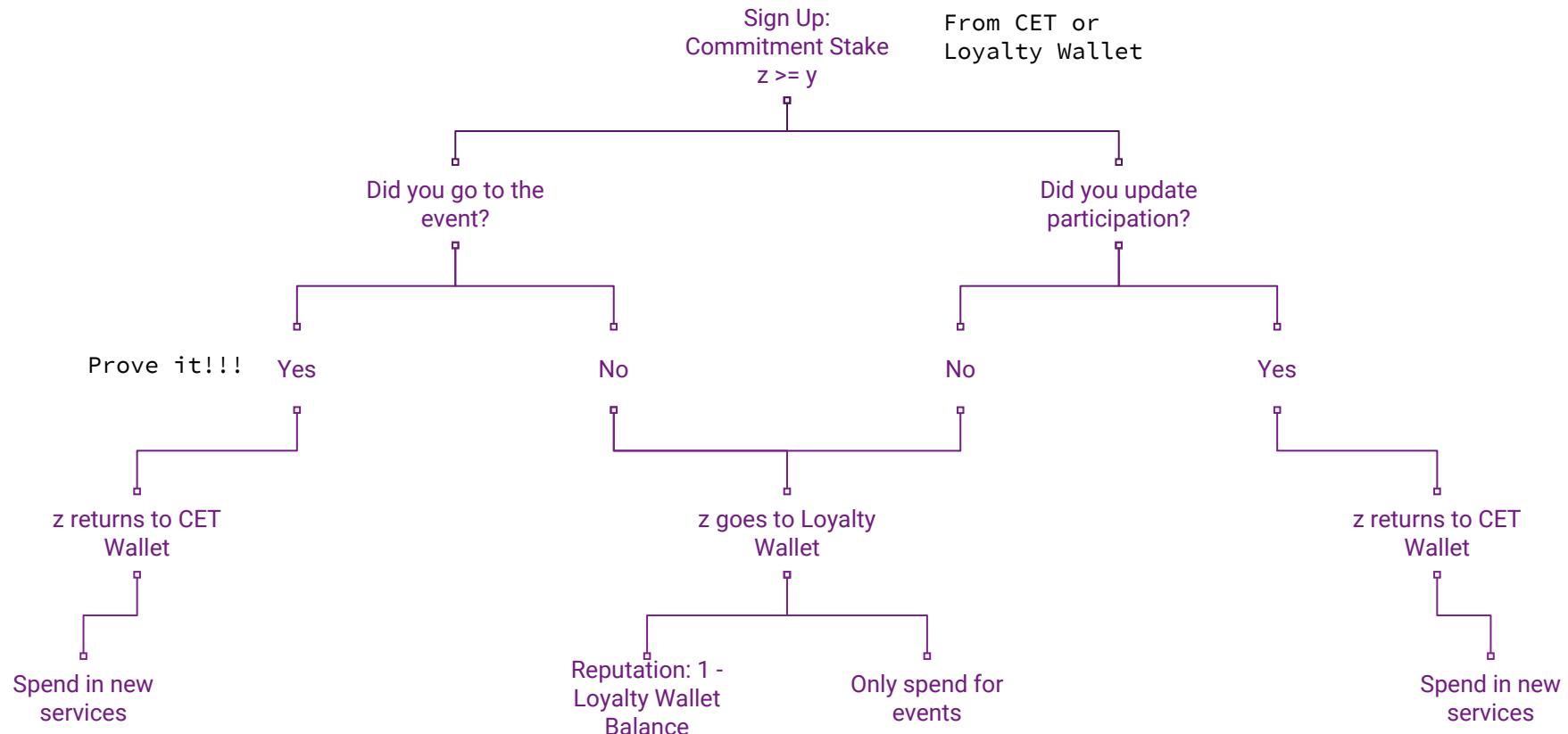
# CET: COMMUNITY ENGAGEMENT TOKEN

Rules of the game:

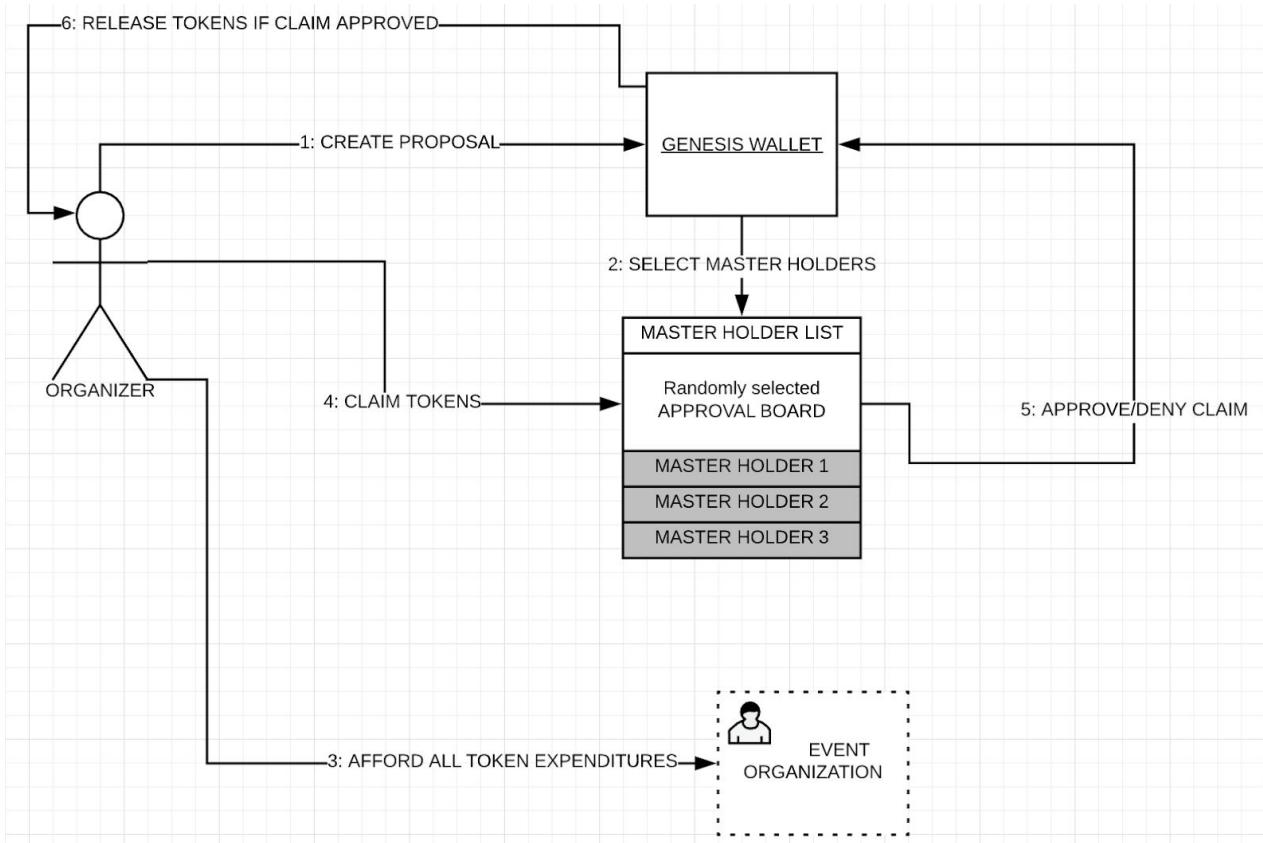
1. Register by pledging  $z$  (*commitment stake*) amount of CET
2. Do your best to collect back the *commitment stake*
  - a. Cancel if you can't go
  - b. Go to event and claim the CET back
3. Grow your community and earn CET

Is the *commitment stake* enough?

# SOMETHING NEW: CET WALLET VS LOYALTY WALLET



# CET GENESIS



HELP US TO DEVELOP AND  
SPREAD THE CET