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Proof of Witness Presence

Blockchain Consensus

for Augmented Democracy in Smart Cities

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How well is Democracy Working Nowadays?

Median voter turnout worldwide

67%

last 30 years

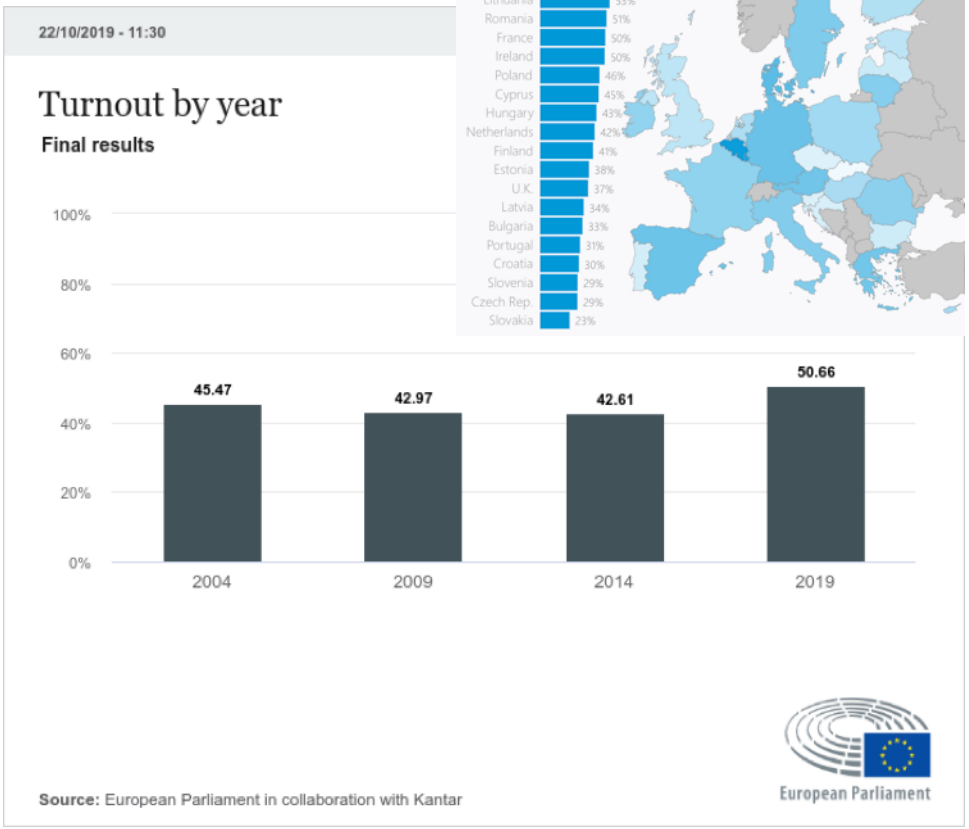
Average US voter turnout

65.4%

1908-2012

Voter turnout

EU elections 2019



How well is Democracy Working Nowadays?

Number of days for government formation

541 2010/11 Belgium	225 2017 Netherlands
70 2016 Ireland	161 2017 Germany

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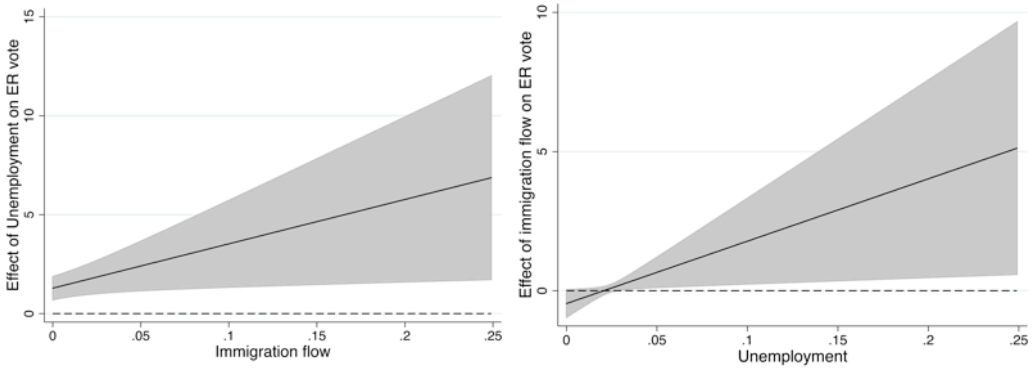
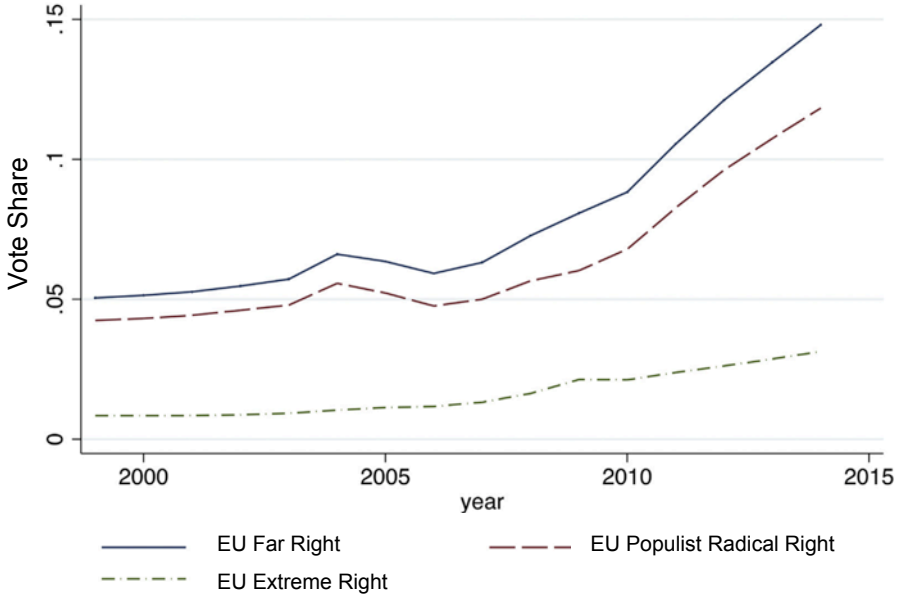
What is Wrong with Democracy (Nowadays)?

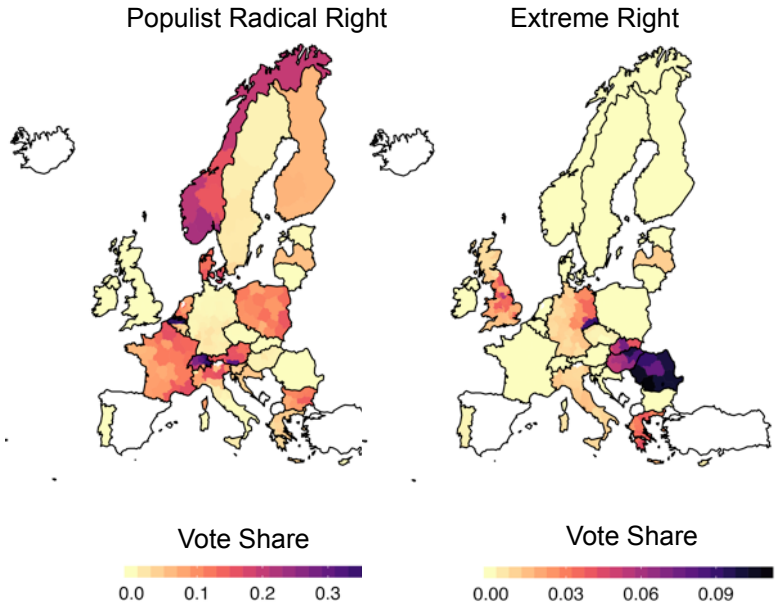
What is Wrong with Democracy (Nowadays)?

*Robust evidence that both **economic insecurity & social backlashes** are associated with rises in the vote shares for far-right parties in Europe [10]*

Effect of Unemployment & Immigration Flow on Extreme Right Vote

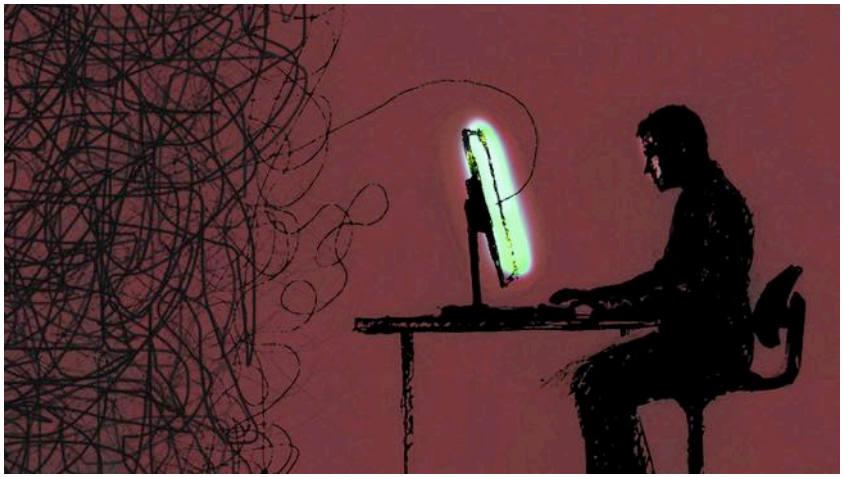






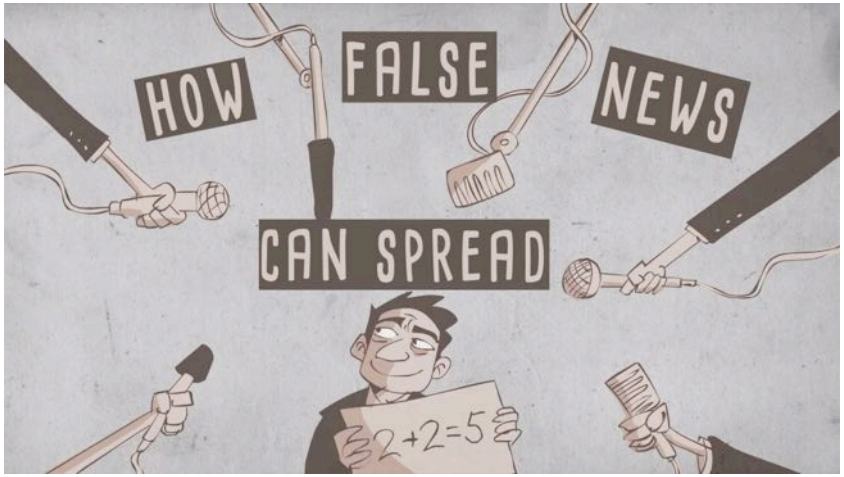
Freedom of Choice & Truth in the Digital Era

"*True control in communication comes from the actual control of information meaning & its interpretation.*" - Umberto Eco



Big data & centralized management of computer systems as a **tactical utility to control meaning & its interpretation**

Automation & pervasiveness of political propaganda, nudging & manipulation at **large scale**



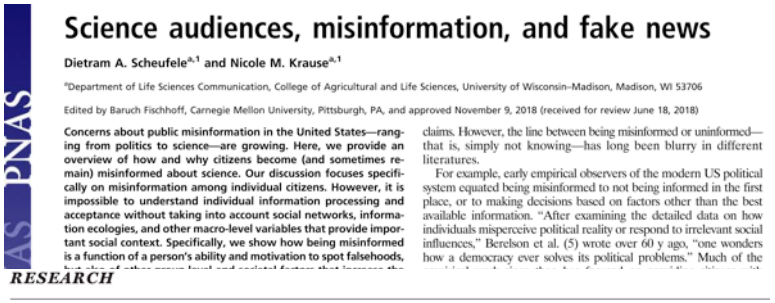
A Post-truth Political Establishment?

"*Falsehood diffuses significantly **farther, faster, deeper & more broadly** than the truth in all information*"

"***False political news are more pronounced** than news about terrorism, natural disasters, science, urban legends, or financial information*"

"***False news are more novel than true news** – people are more likely to share novel information*"

"***The greater likelihood of people to spread falsity more than the truth** is what drives the spread of false news, despite network & individual factors that favor the truth.*"



PNAS

Science audiences, misinformation, and fake news

Dietram A. Scheufele[a,1] and Nicole M. Krause[a,1]

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Edited by Baruch Fischhoff, Carnegie Mellon University, Pittsburgh, PA, and approved November 9, 2018 (received for review June 18, 2018)

Concerns about public misinformation in the United States—ranging from politics to science—are growing. Here, we provide an overview of how and why citizens become (and sometimes remain) misinformed about science. Our discussion focuses specifically on misinformation among individual citizens. However, it is impossible to understand individual information processing and acceptance without taking into account social networks, information ecologies, and other macro-level variables that provide important social context. Specifically, we show how being misinformed is a function of a person's ability and motivation to spot falsehoods,

claims. However, the line between being misinformed or uninformed—that is, simply not knowing—has long been blurry in different literatures.

For example, early empirical observers of the modern US political system equated being misinformed to not being informed in the first place, or to making decisions based on factors other than the best available information. "After examining the detailed data on how individuals misperceive political reality or respond to irrelevant social influences," Berelson et al. (5) wrote over 60 y ago, "one wonders how a democracy ever solves its political problems." Much of the

RESEARCH

SOCIAL SCIENCE

The spread of true and false news online

Soroush Vosoughi,[1] Deb Roy,[1] Sinan Aral[2]*

POLICY FORUM

SOCIAL SCIENCE

The science of fake news

Addressing fake news requires a multidisciplinary effort

By **David M. J. Lazer, Matthew A. Baum, Yochai Benkler, Adam J. Berinsky, Kelly M. Greenhill, Filippo Menczer, Miriam**

and the mechanisms by which it spreads. Fake news has a long history, but we focus on unanswered scientific questions raised by

gated about topics such as vaccination, nutrition, and stock values. It is particularly pernicious in that it is parasitic on standard news outlets, simultaneously benefiting from and undermining their credibility.

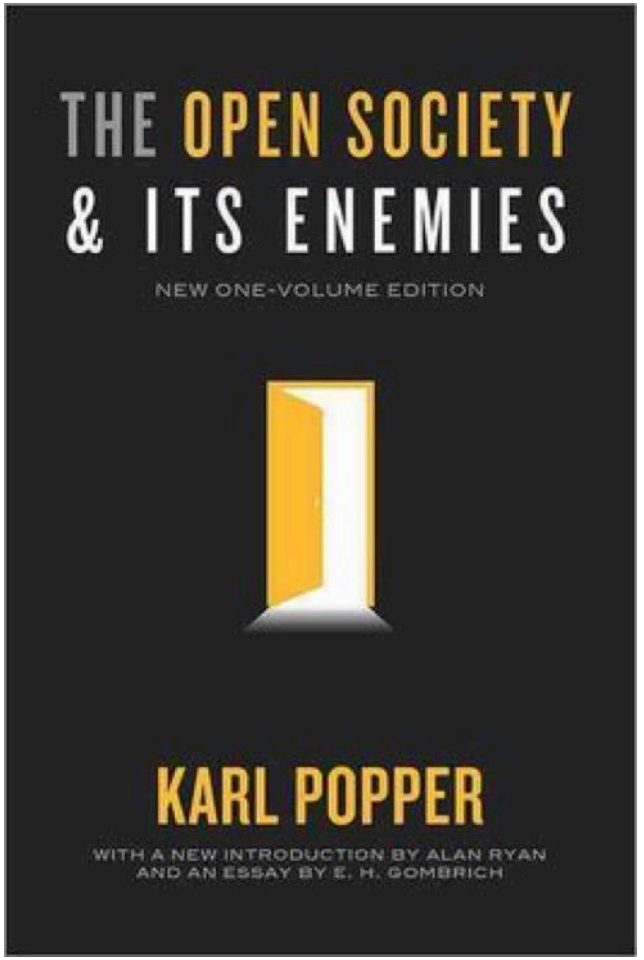
Some—notably First Draft and Facebook—favor the term "false news" because of the use of fake news as a political weapon (*1*). We have retained it because of its value as a scientific construct, and because its political salience draws attention to an impor-

Promising Voices

Foundations of Resilient Democratic Institutions

*"The defense of democracy must consist in **making anti-democratic experiments too costly for those who try them**; much more costly than a democratic compromise"*

*"We must plan for freedom, and not only for security, if for no other reason than that **only freedom can make security secure**"*



(Re)Establishing Sortition?

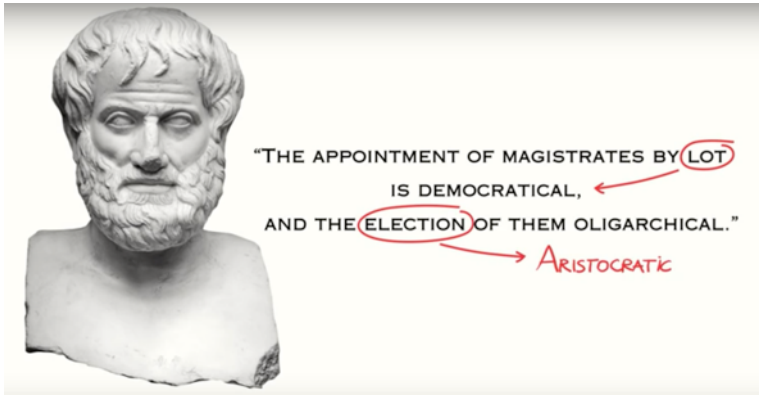
Elected public functions

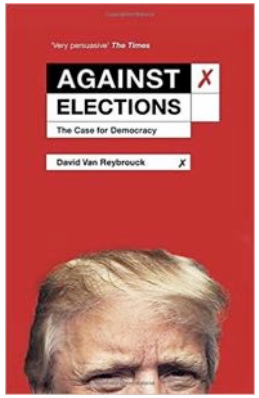
in Ancient Athens

100

out of 7000!

Rest: sortition





"… the systemic crisis of democracy can be remedied by giving sortition a fresh chance"

"Drawing lots is not irrational, it is arational, a consciously neutral procedure whereby political opportunities can be distributed fairly & discord avoided."

Sortition beyond Ancient Athens

Beyond Vulnerable Voting Mechanisms?

"…in nearly all political circumstances, whenever the problem concerned is complicated and/or controversial, majority voting can be ***inappropriate, inaccurate or even wrong****."*

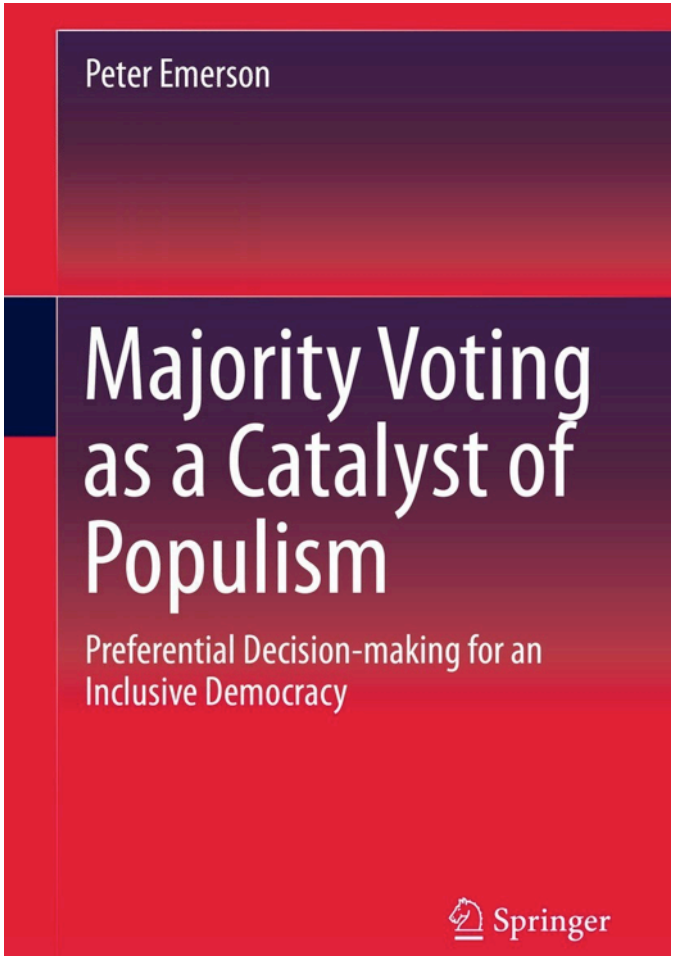
"If politics is an art of compromise, voting itself should be an act of compromise."

Alternative: Multi-option preferential voting

Methods: Borda, Condorcet, quadratic, etc.

Robust, inclusive, accurate

"Such a polity might be able to ensure, not the end of populism, but the curtailment of voting procedures, which give the populist greater and unfair chances of success."

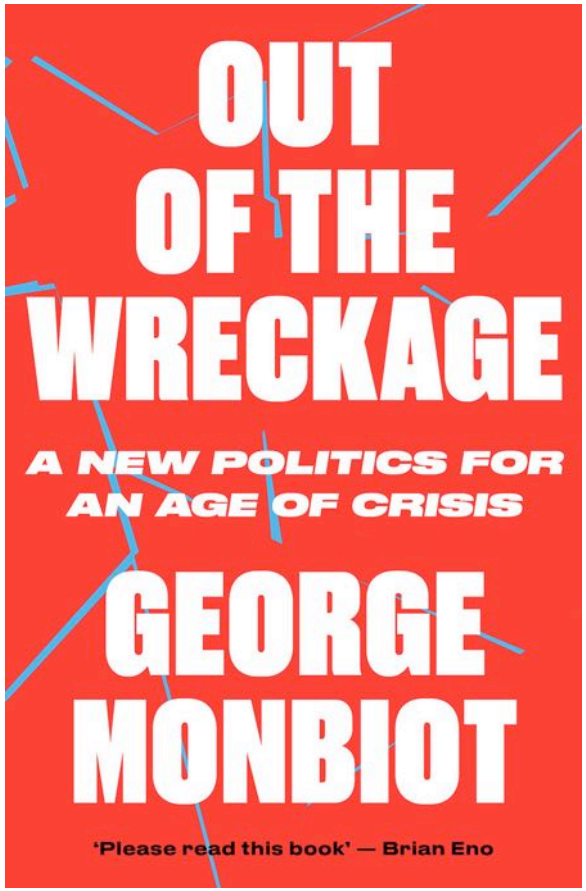


Participatory Democracy?

"*Don't rely on presenting vast & crude questions to a poorly informed electorate.* ***Continuous opportunities for political change****, above & beyond occasional elections*"

"Despite technological advances, the most powerful medium that we control is ***word-of-mouth****. We must come out from behind our social media accounts &* ***engage directly****."*

"*By rebuilding community … we will achieve something that paradoxically, we cannot realize alone:* ***self-reliance****. By helping each other, we help ourselves.*"



Governing the Commons without Top-down Regulation?

"There is no reason to believe that bureaucrats & politicians, no matter how well meaning, are better at solving problems than the people on the spot, who have the strongest incentive to get the solution right." – Elinor Ostrom

Challenges towards Digital Democracy

How to empower participation & engagement in the digital era?

How collective decisions can be made more fair, credible & legitimate?

How to move from power dividing to power sharing & citizens' sovereignty?

How to (re)establish trust on polity and a resilient inclusive (self-)governance?

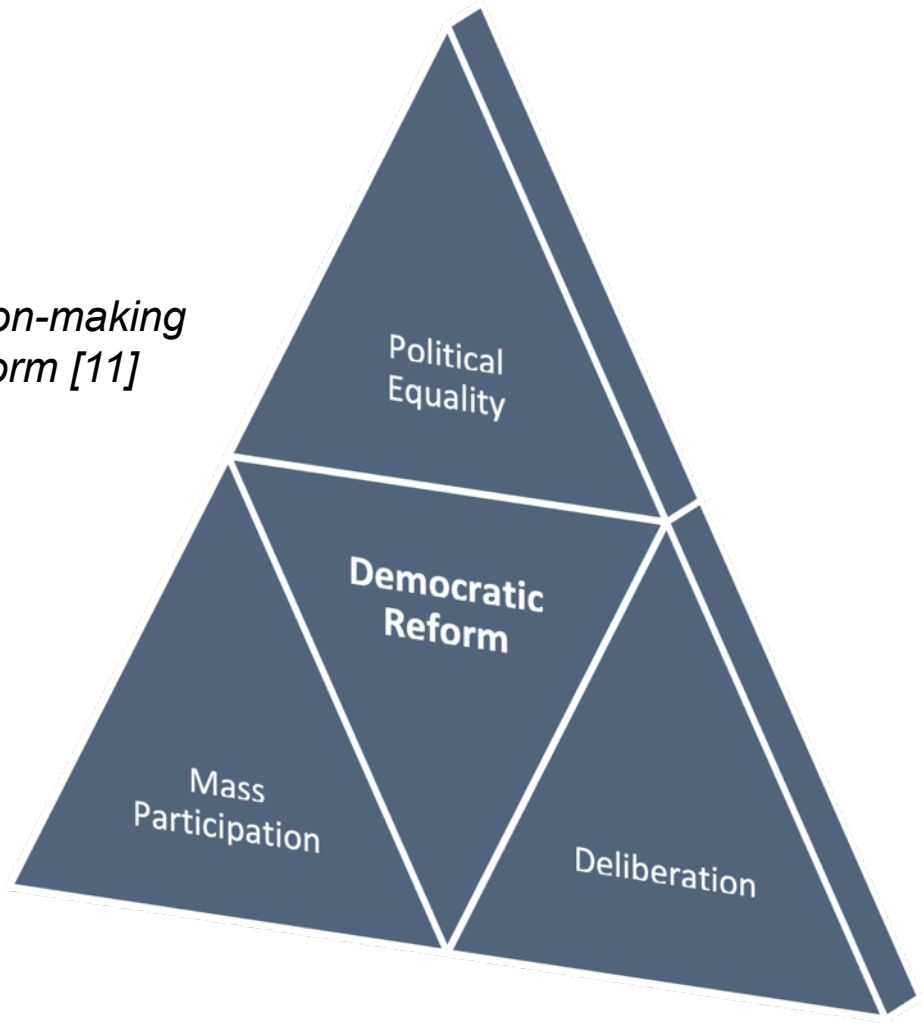
Breaking a Large Problem into Smaller Pieces

Overcoming the Trilemma of Democratic Reform

Localizing the scope *of collective decision-making to mitigate the trilemma of democratic reform [11]*

Broadening degree of freedom

by narrowing first the scope



Augmented Democracy in Smart Cities

Make citizens' decisions

subject of proving witness presence

Participation by securely verifying: *location, time, situation awareness*

Imagine community-level digital voting centers at any time & location experiencing a societal challenge – Casting a vote on spot turns out to be a responsible informed testimony, an intervention for an evidence-based solution.

Bring citizens' solutions to problems rather than problems to citizens

Reclaiming the public sphere of urban environments

A digital revive of a cyber-physical Agora

A Complex Techno-socio-economic Problem

How to master viable digital democracy systems?

A new research field?

Do we need "*democracy engineers*"?

Why distributed systems

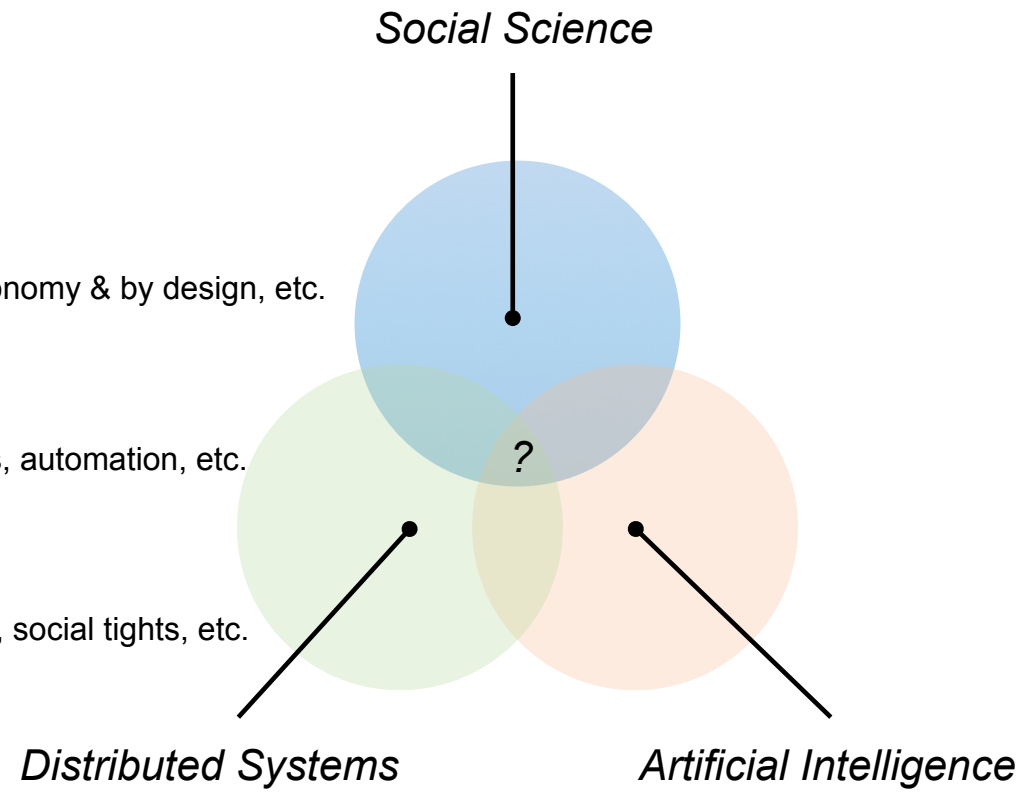
Resilient to manipulation, better preserve citizens' autonomy & by design, etc.

Why Artificial Intelligence

Domain knowledge gap, cognitive bandwidth problems, automation, etc.

Why Social Science

Understand incentives, collective behavior, consensus, social tights, etc.



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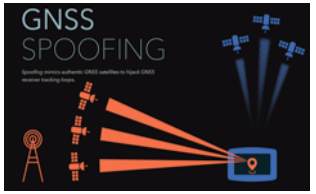
Secure Spatio-temporal Evidence with Blockchain

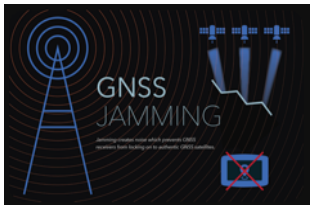
Proving location & time: localization mechanisms, sensor fusion, anomaly detection, social witnessing, etc.

GPS-based proofs of location are vulnerable

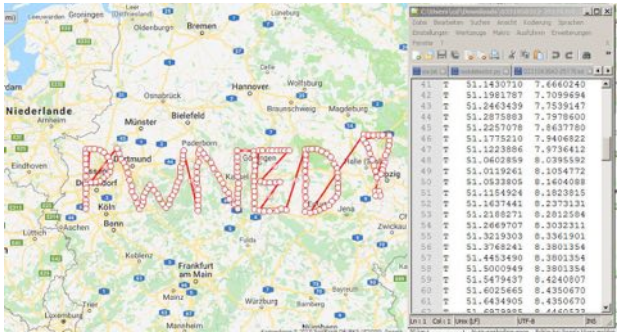
Mobile cellular networks as oracles: require roaming services

Promising alternatives: LPWAN & P2P ad hoc opportunistic networks





Proving situation awareness: contextual QR codes, challenge questions, puzzles, CAPTCHA-like tests, collaborative social challenges against social engineering attacks



Why blockchain?

Distributed trust & self-governance

Communities institutionalizing their own consensus mechanisms, e.g. permissioned vs. permissionless, etc.

Security & privacy mechanisms

Zero-knowledge proofs, homomorphic encyption, differential privacy, etc.

Incentive mechanisms

Crypto-economic models, multiple currencies for rewarding different community values

Approaches	GPS [76]	Mobile Cellular Network [103]	LPWAN [27]	P2P Ad Hoc Networks [35]
Infrastructure-independent	No	No	No	Yes
Decentralization	Low	Low	Medium	High
Access	Open	Closed	Open	Open
Management	Governmental-level	Enterprise-level	Community-level	Self-organized
Disaster Resilience	Medium	Medium	Medium	High
Coverage Range	Global	National	Urban	Localized
Indoor Coverage	No	Yes	Yes	Yes

A Consensus-driven Map of the World?

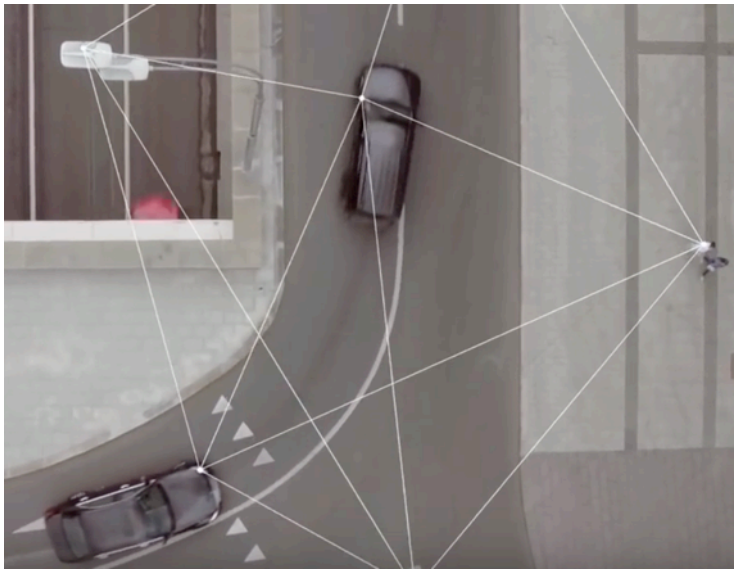
FOAM

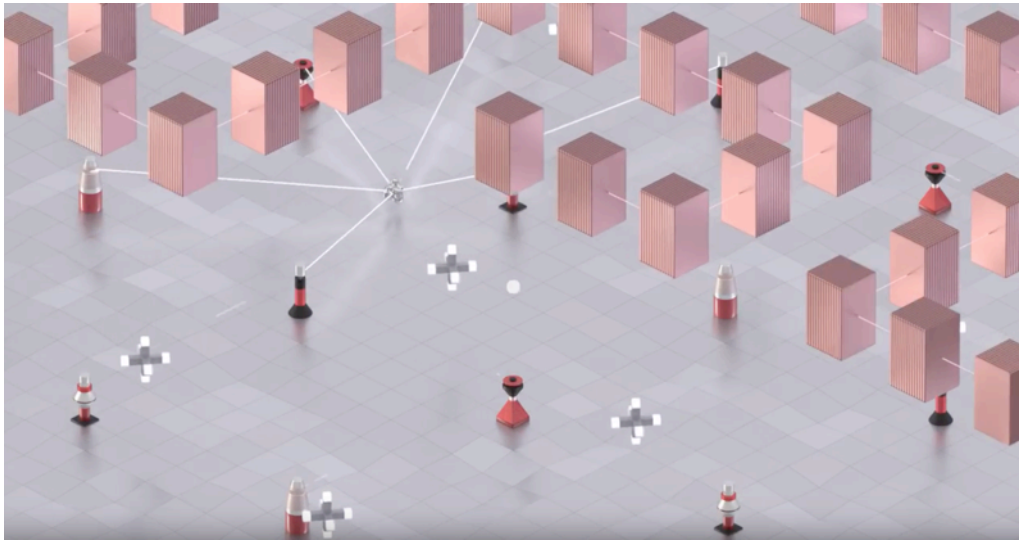
Source: https://www.youtube.com/watch?v=_Vr_cysyfOc

A Consensus-driven Map of the World?

Blockchain proofs of location with FOAM

Source: https://www.youtube.com/watch?v=_Vr_cysyfOc



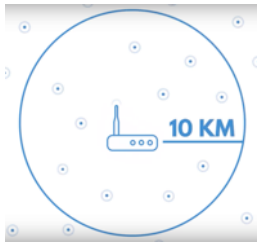


1. Open Decentralized Localization Infrastructure

Crowd-sourced location service providers

LoRa WAN radio beacons with long-range metropolitan coverage

Token curated registries: Stakes a safety deposit - FOAM token (cryptocurrency)



2. Consensus-based Zone Formation for Location Services

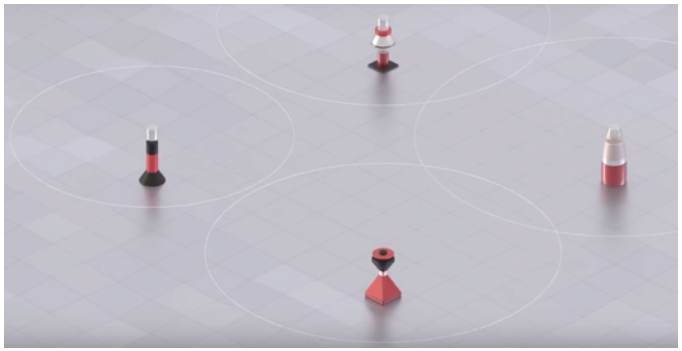
Searching for other zone anchors (radio beacons)

Discover & get connected

Exchange messages to synchronize their clocks

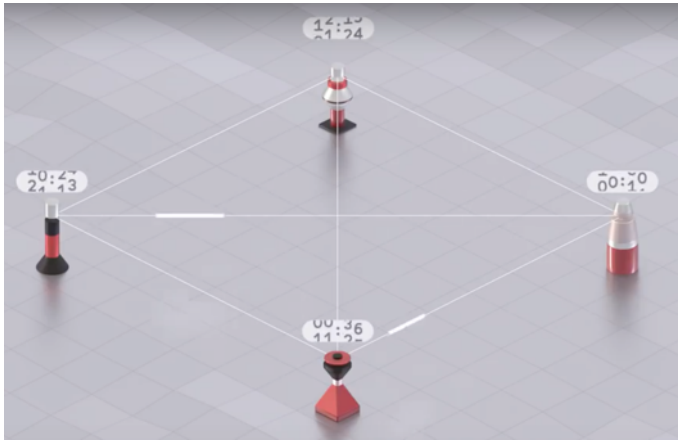
Signal attenuation & propagation times

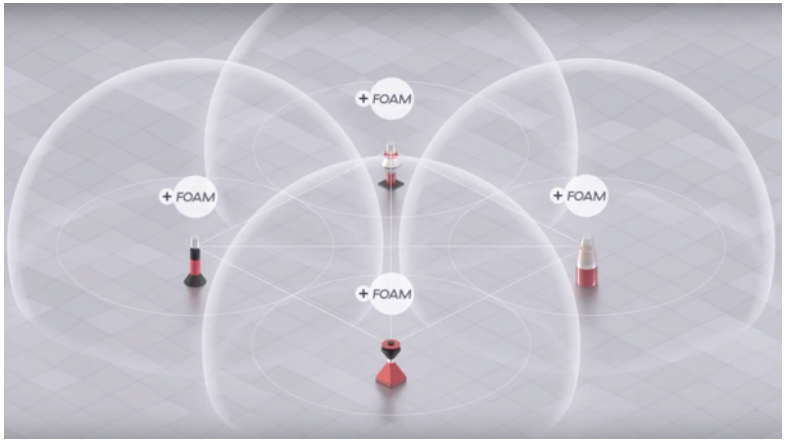
Byzantine fault-tolerant clock synchronization



A time consensus results in a decentralized zone for location services

Rewarding zone anchors with FOAM tokens





3. Verifying Presence Claims

Location customers: *Make presence claims*

Zone anchors: *Mine triangulations & verify presence claims*

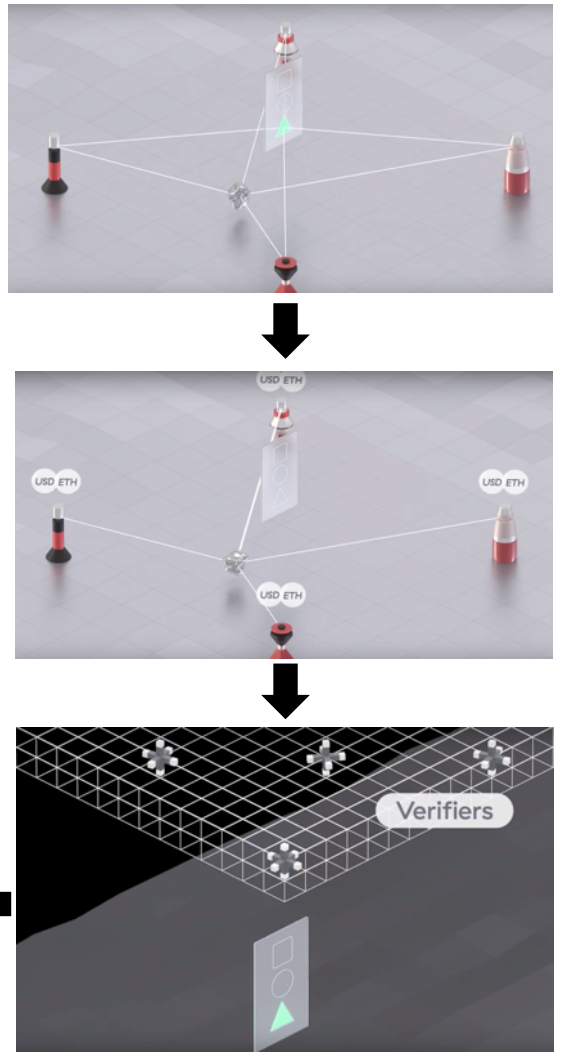
Distance detection by message travel times

Location customers reward zone anchors with a fee

Local blockchain storage:

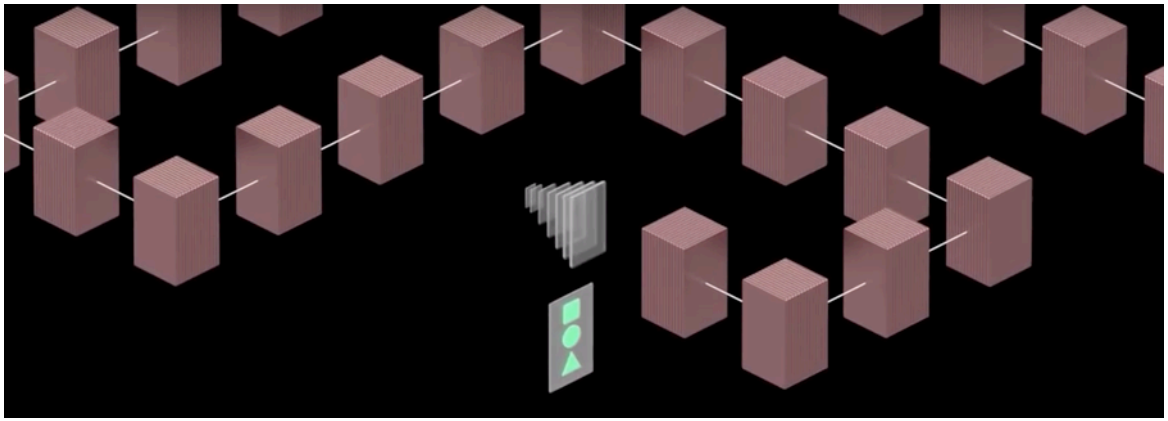
Reaching consensus of customers' location

Presence claims are further verified among zones to make sure that **zone anchors remain in sync**

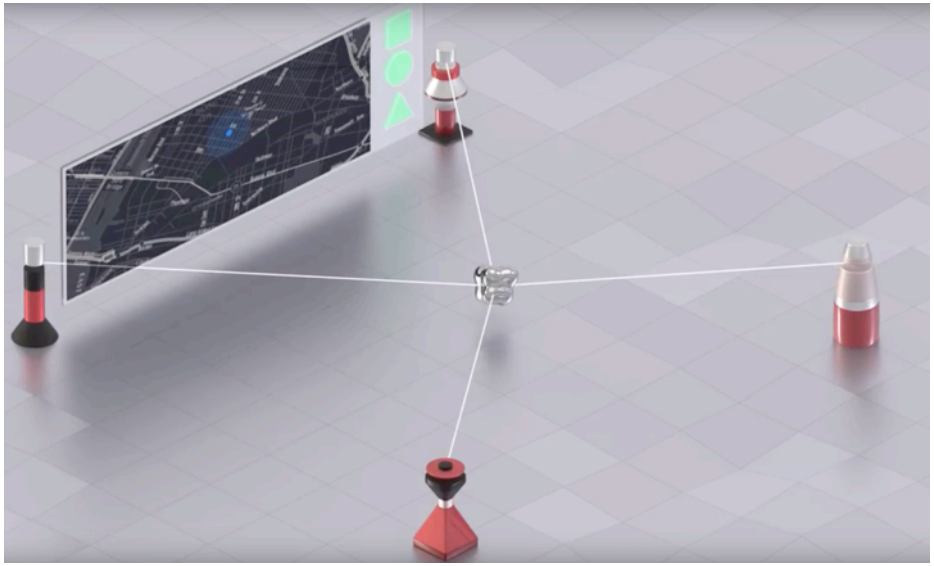


4. Publishing Proofs of Location

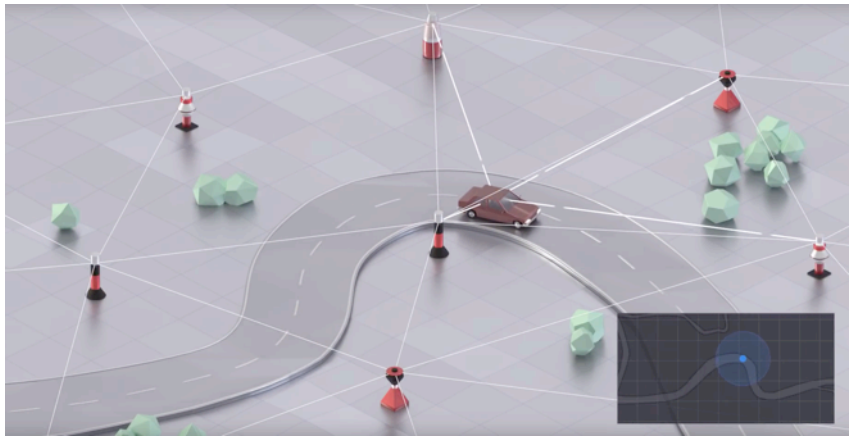
The verified presence claim is written into the Ethereum blockchain & **made public**



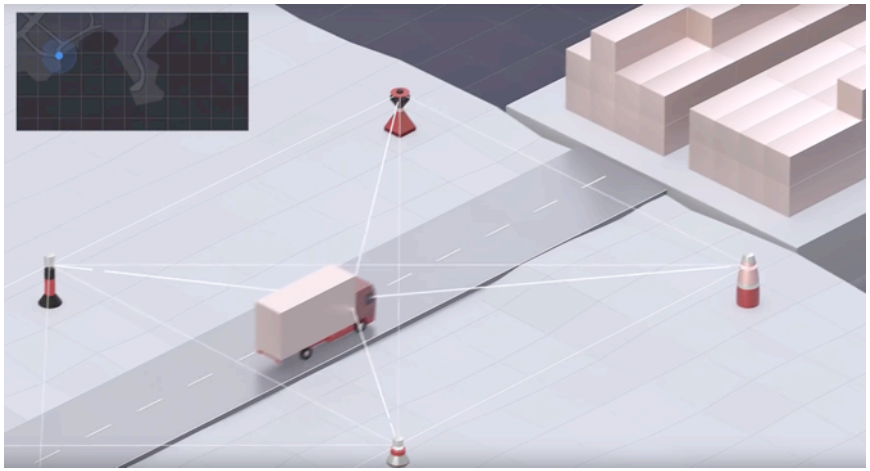
A consensus-driven map: Verified presence claims are made available to location customers via decentralized applications



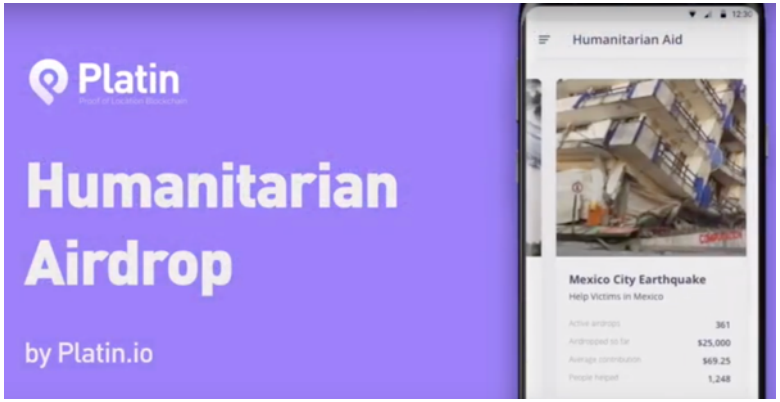
Decentralized Applications



Mobility & transport



Logistics & supply chain



A map of donations

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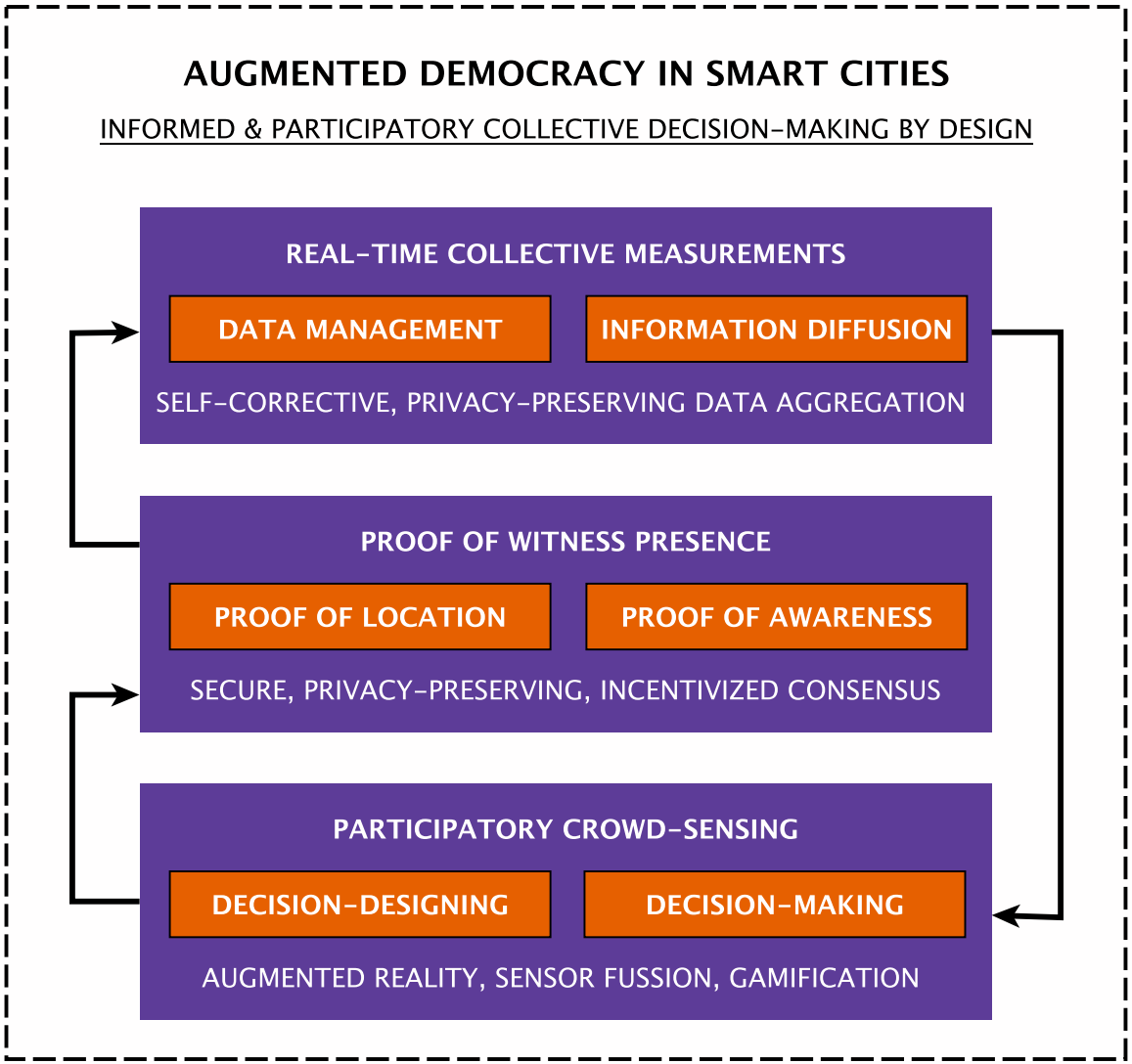
Building an Augmented Democracy System

smart-agora.org

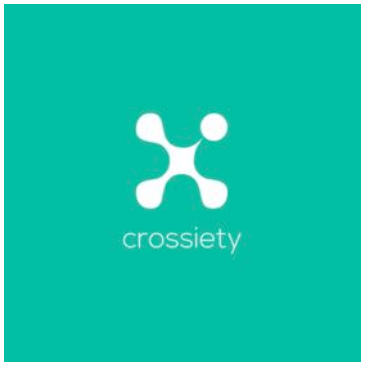
1st Prize at ETH Policy Challenge *Augmented Democracy Prize*

Architecture

Bringing 3 complex components together



Other Promising Initiatives



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The Smart Agora Platform

A crowd-sensing & collective decision-making platform

Collected data is by design subject of witness presence at points of interest

1. Web Dashboard: Interactive visual design of a location-based crowd-sensing campaign

2. Mobile App: Navigation & interaction in the urban physical space

3. Decentralized Data Analytics: Location-based real-time live feedback & accurate collective measurements

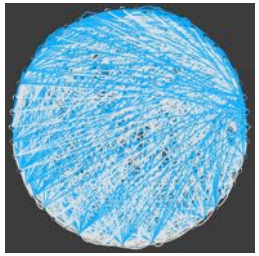
Real-time collective measurement maps

Proof of witness presence?

✔= network join & data aggregation

✖= network leave & reverse computation

DIAS dias-net.org



(Gossip-based) Discovery of new located citizens in points of interest

Data aggregation over the witness presence map

Dashboard

Mobile App

SMART AGORA

Campaign designer

smart-agora.org

Citizens

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Who can use Smart Agora?

Policy-makers, community representatives, citizens

(Self-)governance use cases – participatory budgeting, voting, petitioning, deliberation, etc.

Scientists

Citizen science, spatio-temporal data science, novel social experiments

Teachers

Active learning activities on the field

Dashboard

Mobile App

SMART AGORA

Campaign designer

smart-agora.org

Citizens

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Dashboard & Mobile App

smart-agora.org

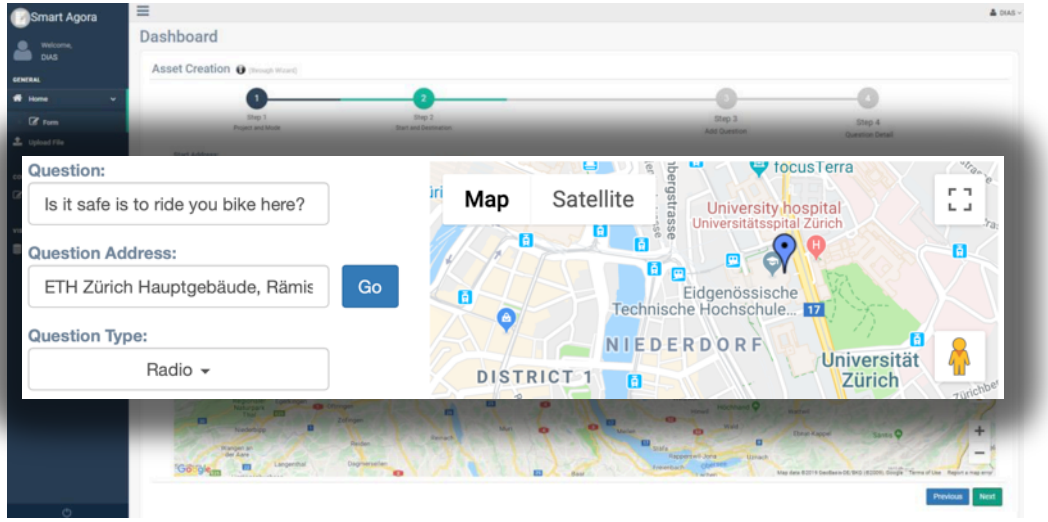
Citizens' navigation to point of interest:

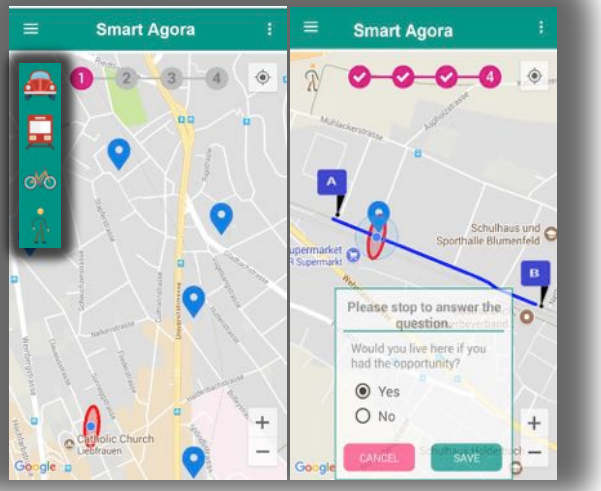
1. **Arbitrary**: Citizens choose the order with which they visit the points of interest
2. **Sequential**: Citizens must follow a given order to visit the points of interest
3. **Interactive**: The interaction of citizen at a point of interest determines the next one

Customizable localization radius & transport mean

Customizable mobile sensor data collection: different sensors, collection frequency, etc.

Design geo-located incentive mechanisms: Monetary rewards, crypto-currencies, etc.





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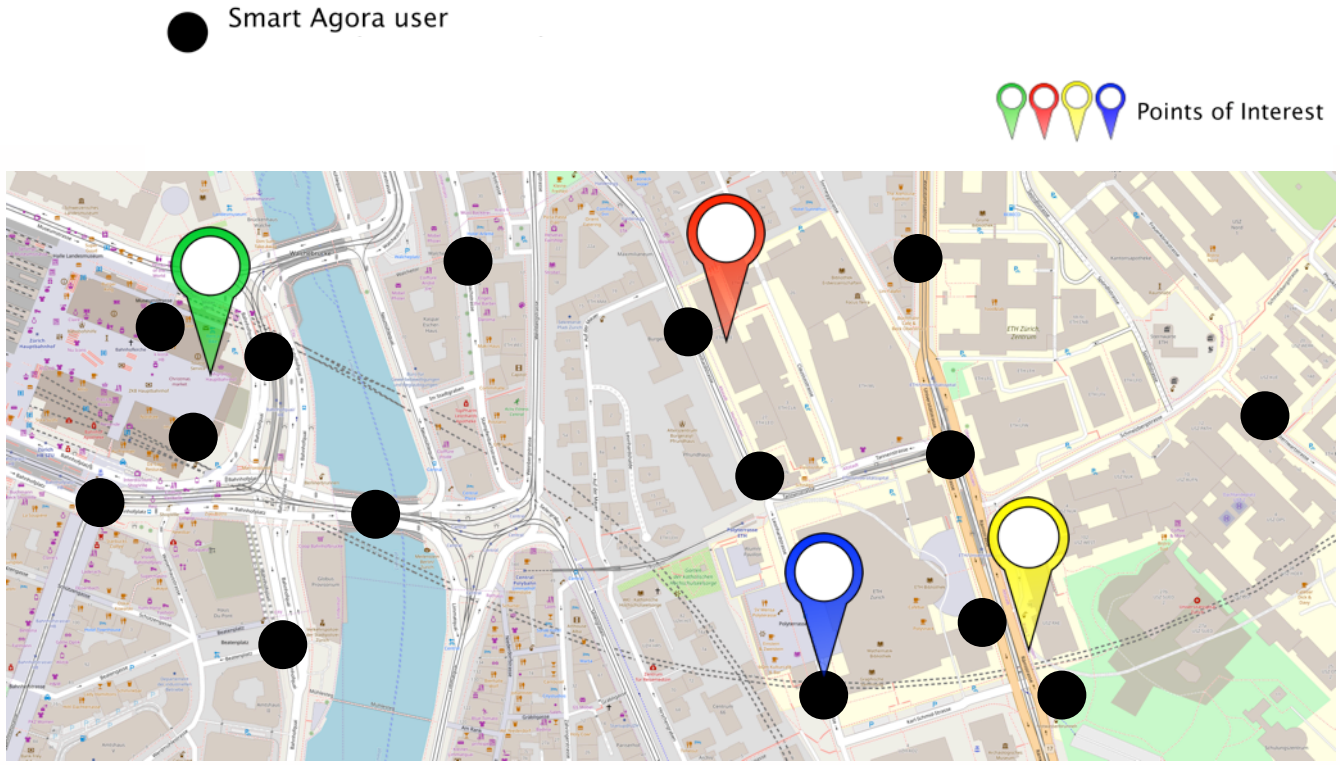
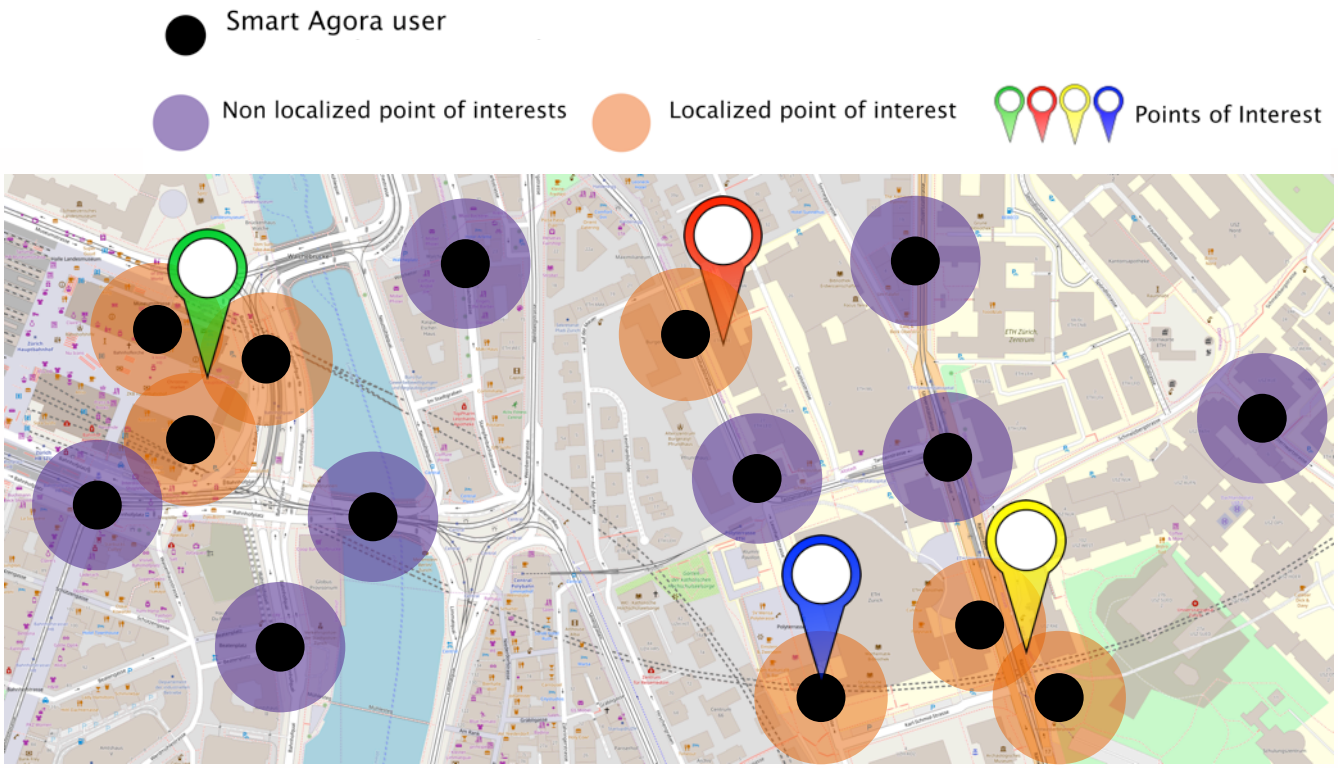
Real-time Collective Measurements Maps

Citizens move in a city with augmented points of interest



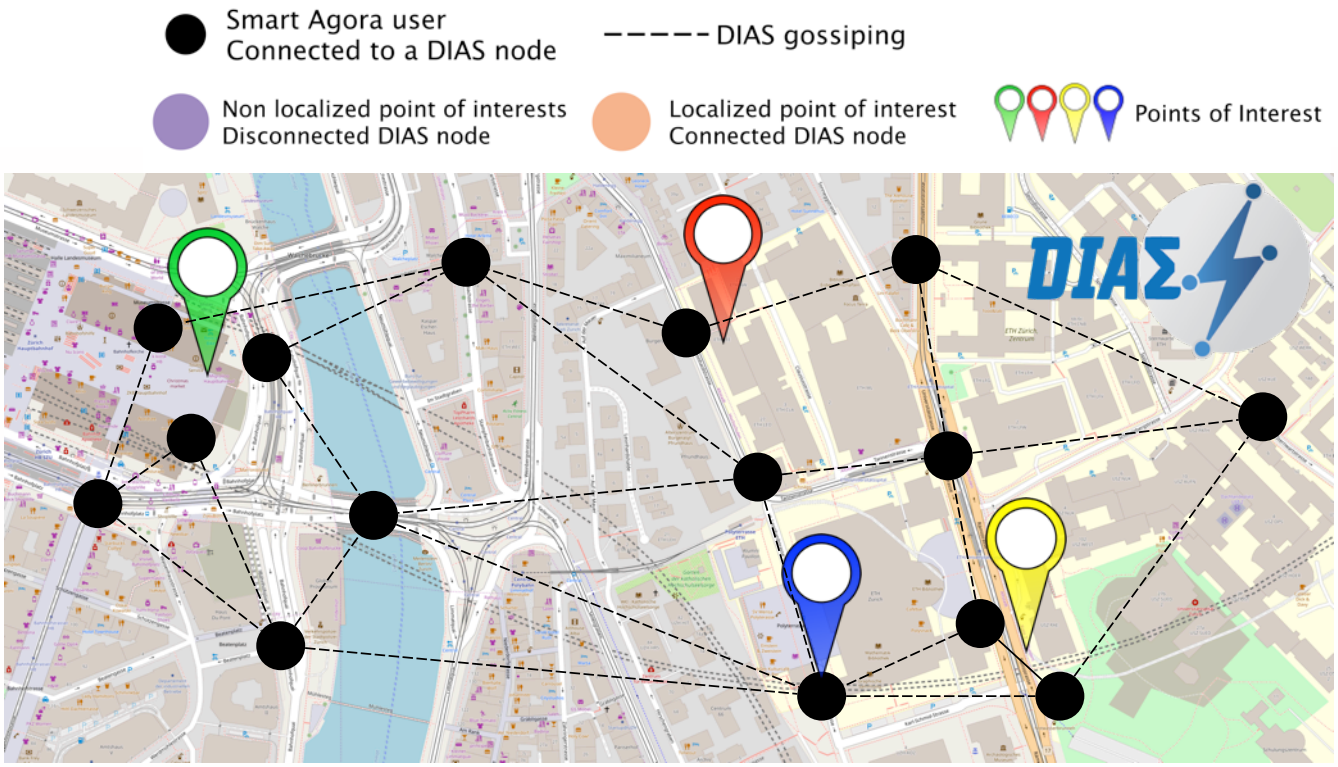
Real-time Collective Measurements Maps

Witness presence claims can be made & verified while…



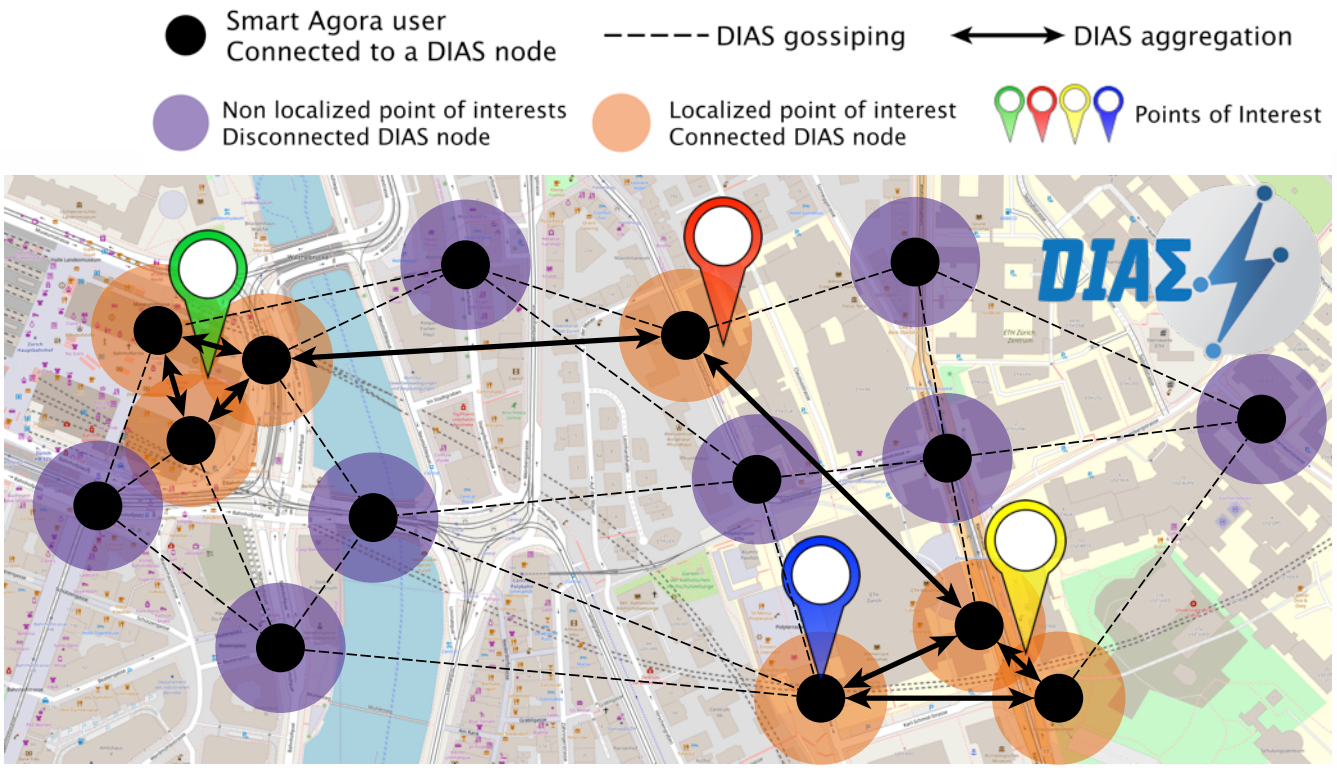
Real-time Collective Measurements Maps

…citizens are interconnected in a decentralized network with which data can be shared



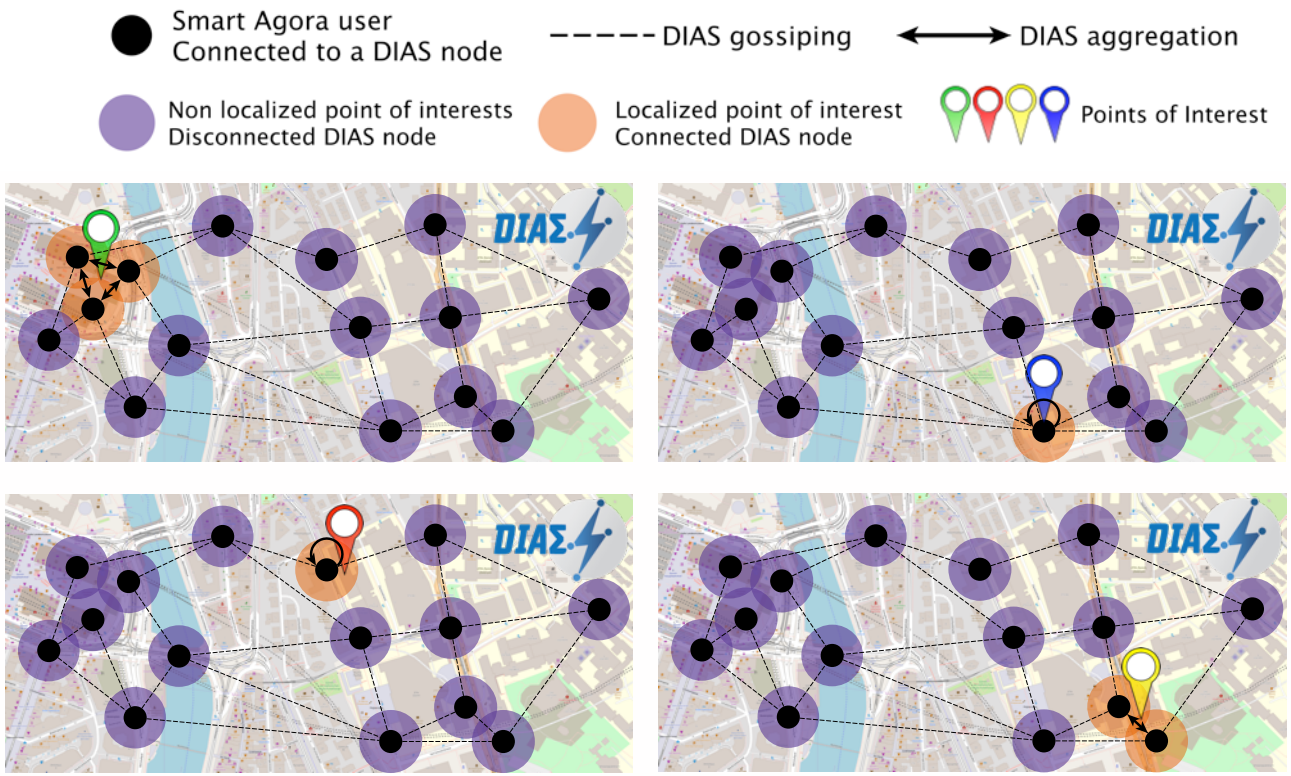
Real-time Collective Measurements Maps

Verified witness presence claims form a trusted domain for decentralized real-time data analytics



Real-time Collective Measurements Maps

Trusted domains for data sharing can be further localized by filtering out points of interest



UNIVERSITY OF LEEDS

Connecting the Dots

Real-world System Evaluation & Validation of Witness Presence

A Proof of Concept for Augmented Democracy

Systems perspective

Building an operational full-fledged testnet with 3 minimal requirements:

1. Realistic Smart City use-case for participatory crowd-sensing – sustainable transport usage
2. Proof of witness presence in 2 points of interest based on GPS
3. A real-time decentralized collective measurements map with high accuracy

Social perspective

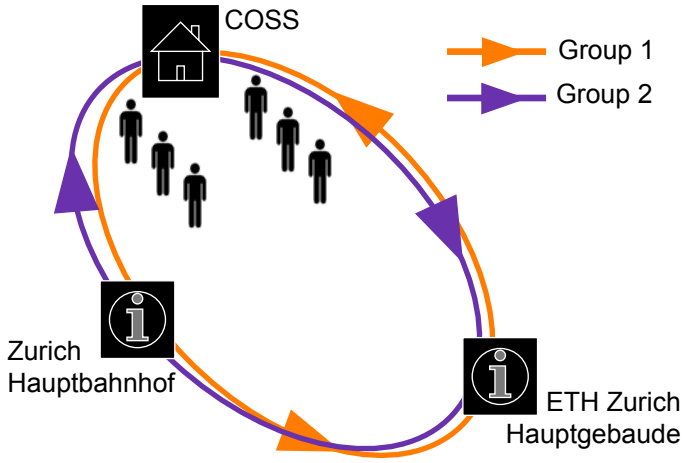
Validation of witness presence using empirical data – Can wisdom of the crowd work?

Use case: *Does witness presence of cycling risk match historical accident data?*

Operational testnet

Tested on 3.6.2010 between
13:00-14:00

2 groups each of **3 persons** visiting
2 points of interest in reverse order



Operational testnet

Tested on 3.6.2010 between 13:00-14:00

2 groups each of **3 persons** visiting **2 points of interest** in reverse order

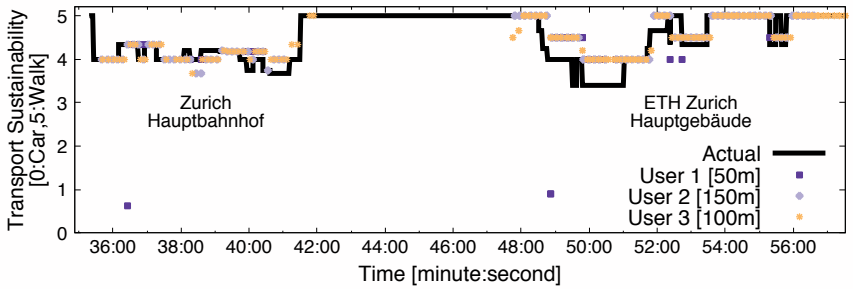
Each group member comes with a **50, 100 & 150 meters** localization radius to limit localization synchronicity effects

Emulation of join & leaves from the aggregation network

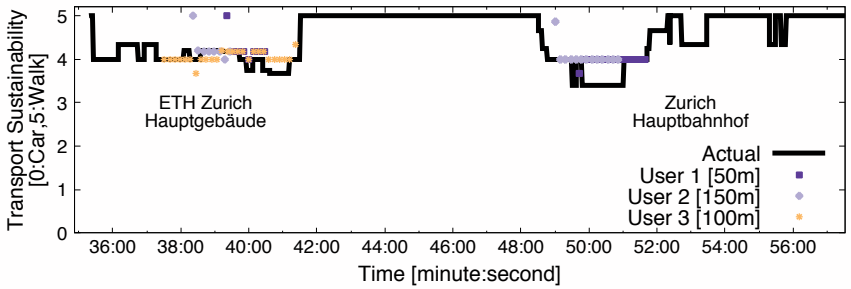
HETZNER Decentralized aggregation network deployment

Decentralized real-time estimations of transport sustainability match well the actual values!

Group 1



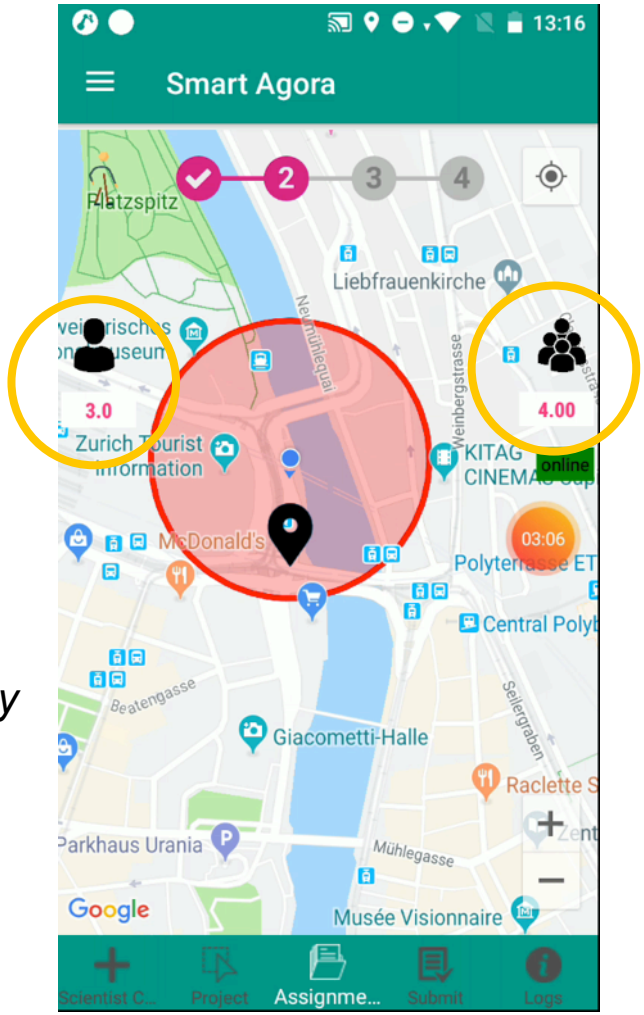
Group 2



Operational testnet

Group	Test User	Zurich Hauptbahnhof	ETH Zurich Hauptgebaüde
1	1	5. Walking	3. Tram
1	2	3. Tram	5. Walking
1	3	5. Walking	5. Walking
2	1	3. Tram	4. Bike
2	2	3. Tram	5. Walking
2	3	4. Bike	3. Tram
	Mean:	3.8	4.17

High sustainability of transport means with higher values for mobility to ETH Zurich



Witness Presence of Cycling Risk

Baseline – Empirical Accident Data

Continuous risk model estimation

Real-world accident data reported by Federal Roads Office at Swiss GeoAdmin

4 selected spots – extreme risk gradient

Treatment – Witness presence of risk

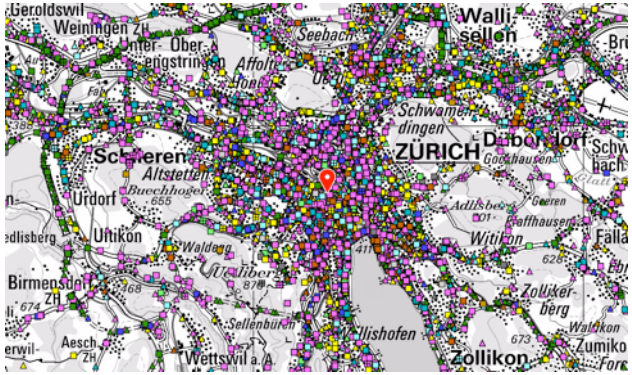
11 cyclers

Rating cycling risk at each spot

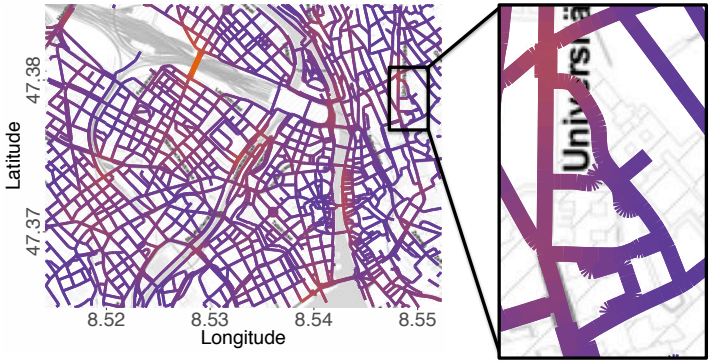
1. very safe to 5. very dangerous

Same bike, same time, same sequence

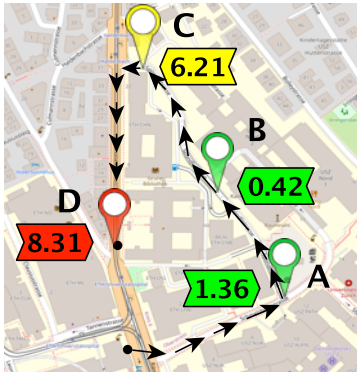
Accident data [2011-2017]



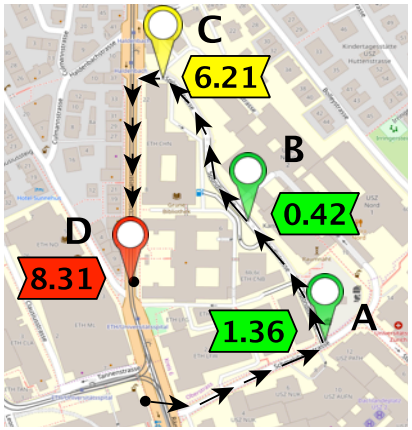
Continuous Risk Estimation Model



Selected Spots



Witness Presence of Cycling Risk



Spot A: Risk=1.36

Spot B: Risk=0.42

Spot A: Risk=6.21

Spot B: Risk=8.31

Locations	Test users:	1	2	3	4	5	6	7	8	9	10	11	Mean	Median	Actual cycling risk [42]
Spot A		2	2	2	1	1	1	1	2	2	1	2	1.55	2	1.36
Spot B		1	1	1	1	1	1	1	2	1	1	1	1.09	1	0.42
Spot C		2	1	1	1	2	3	1	3	4	2	2	2.0	2	6.21
Spot D		3	3	3	2	4	4	2	2	3	4	4	3.09	3	8.31

1. very safe to 5. very dangerous

Pearson correlation:	0.94	0.85
Spearman correlation:	1.0	1.0

High matching between the empirical risk map & perceived risk by witness presence

Synopsis

Take-away Messages & Future Perspective

Dissecting the complexity of democratic reform

Regional Smart City pilots as emerging paradigms & the means to scale up

Key idea: proof of witness presence

Harvest truth, filter for quality, encourage responsibility & evidence for effective policies

New inter-disciplinary science for democracy

Sustainable & viable (self-)governance as a complex techno-socio-economic problem

Blockchain as means for self-institutionalized societies

Bringing together consensus mechanisms, crypto-economic design & security/privacy for trust

Grand challenge for digital democracy: Autonomy vs. automation by responsible AI

Digital assistants with local & collective intelligence to mitigate limited cognitive bandwidth & domain knowledge

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ETH Policy Challenge organizers
Nervousnet development team
2018 ETH Zurich students of “Data Science in Techno-socio-economic Systems” course

Questions

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