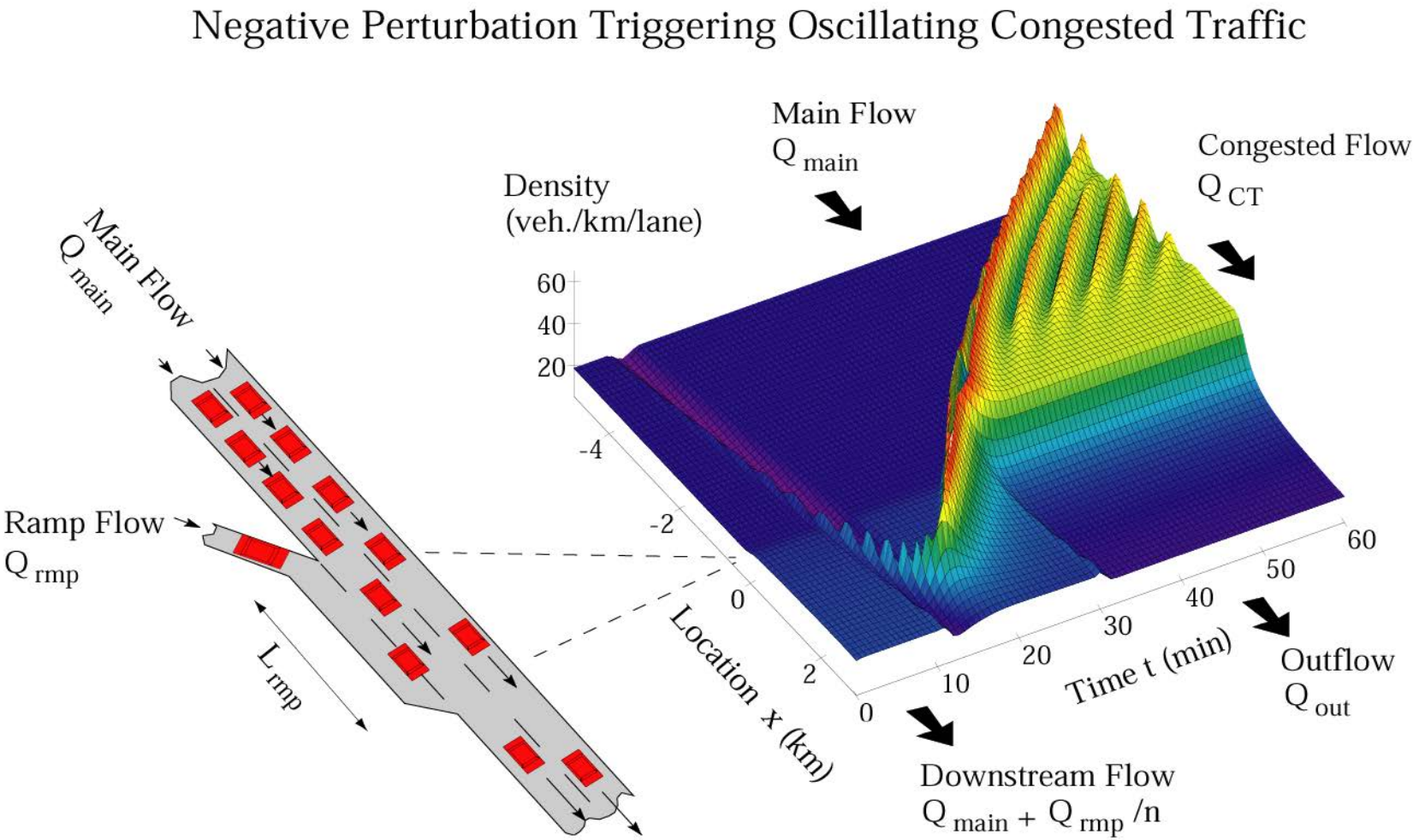
ETH zürich

Towards Digital Democracies and Societal Resilience: Upgrading Smart Cities with Collective Intelligence, and More

Prof. Dr.rer.nat. Dr.h.c. Dirk Helbing, ETH Zurich, Computational Social Science

with Anders Johansson, Martin Treiber, Arne Kesting, Stefan Lämmer, Martin Schönhof, Mark Ballandies, Marcus Dapp, Regula Hänggli, Stefan Klauser, Marcin Korecki, Renato Kurz, Sachit Mahajan, Richard Mann, Heinrich Nax, Evangelos Pournaras, Javier Argota Sanchez-Vaquerizo, and others

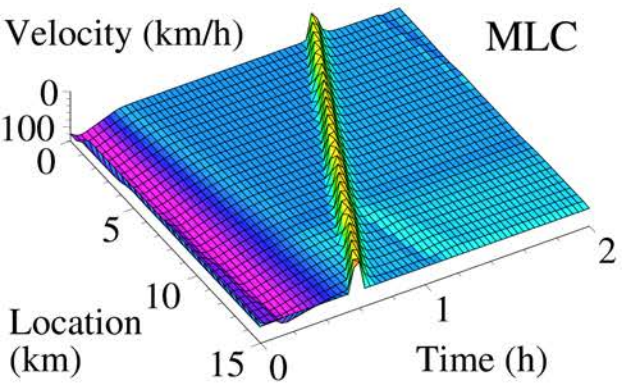
Complex Behavior of Traffic Flow

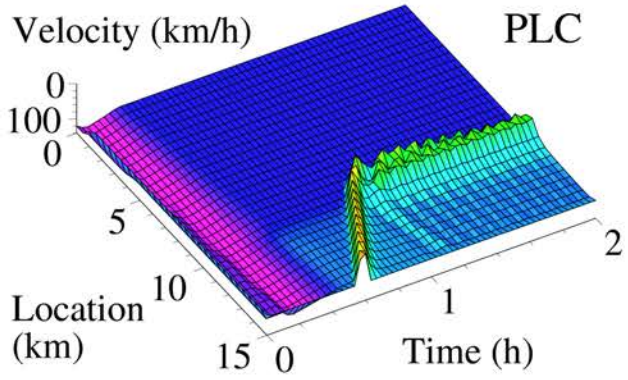


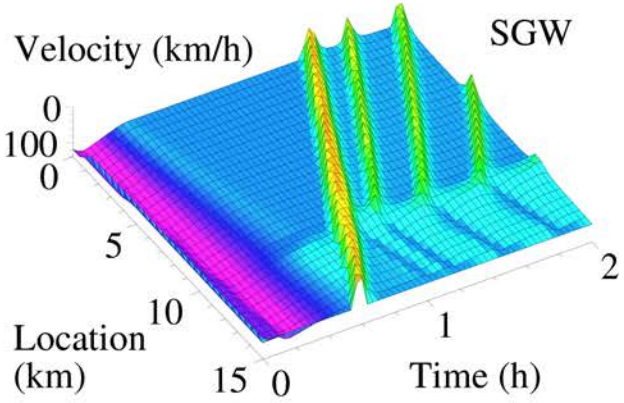
Perturbing traffic flows and, paradoxically, even *decreasing* them may sometimes cause congestion.

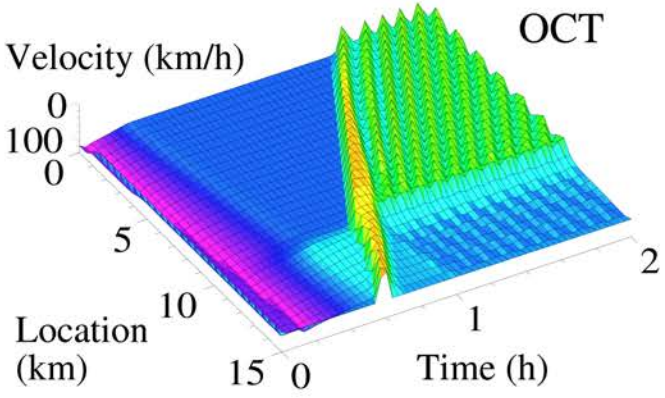
Phase Diagram of Congested Traffic States

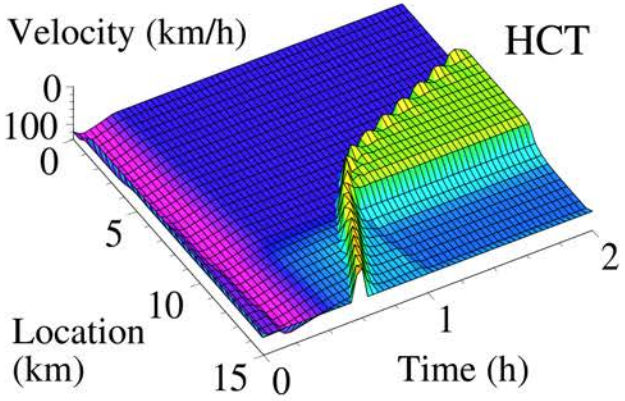
Congested Traffic States Simulated with a Traffic Model







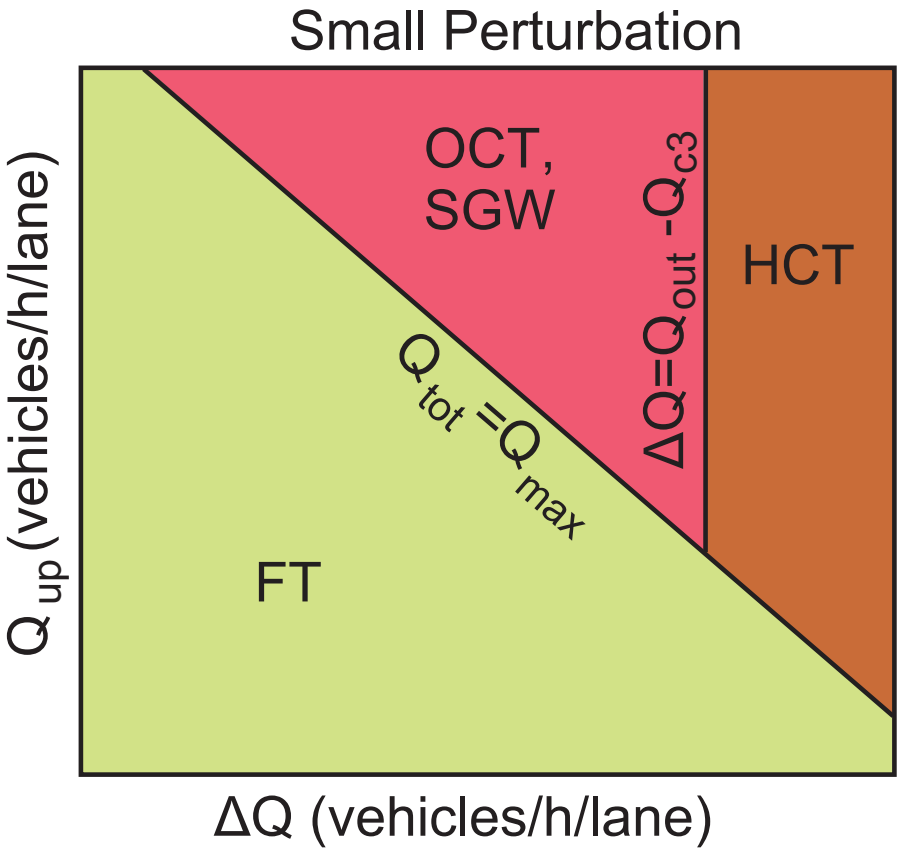


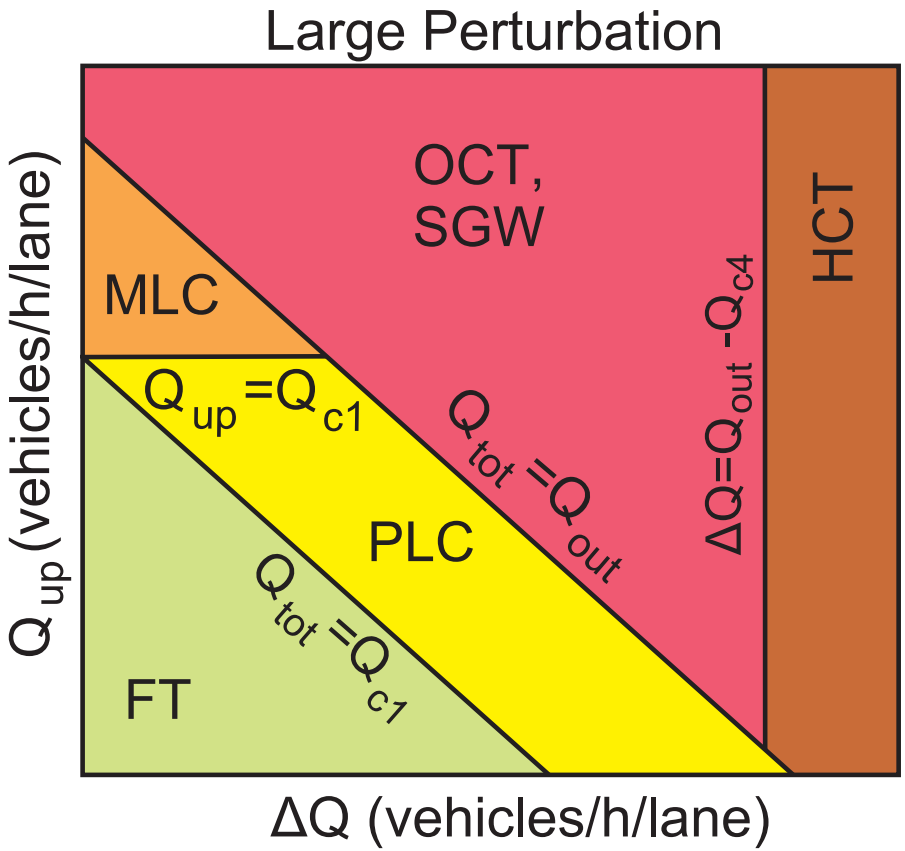


Phys. Rev. Lett. **82**, 4360 (1999).

Similar congested traffic states are found for several other traffic models, including “microscopic” car-following models.

Theoretical Phase Diagram of Traffic States and Universality Classes

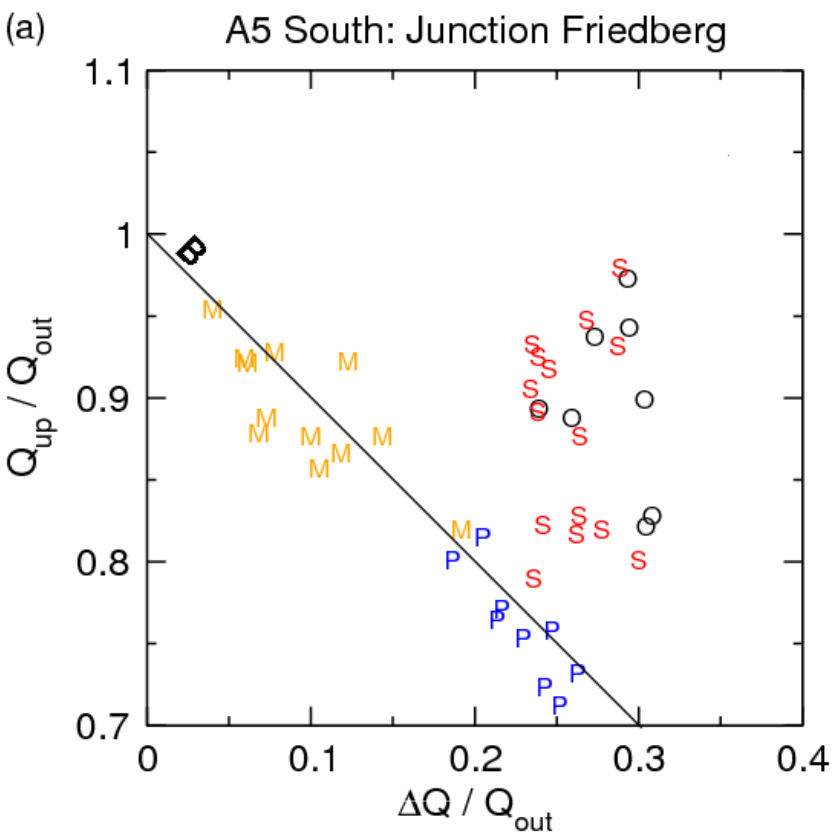


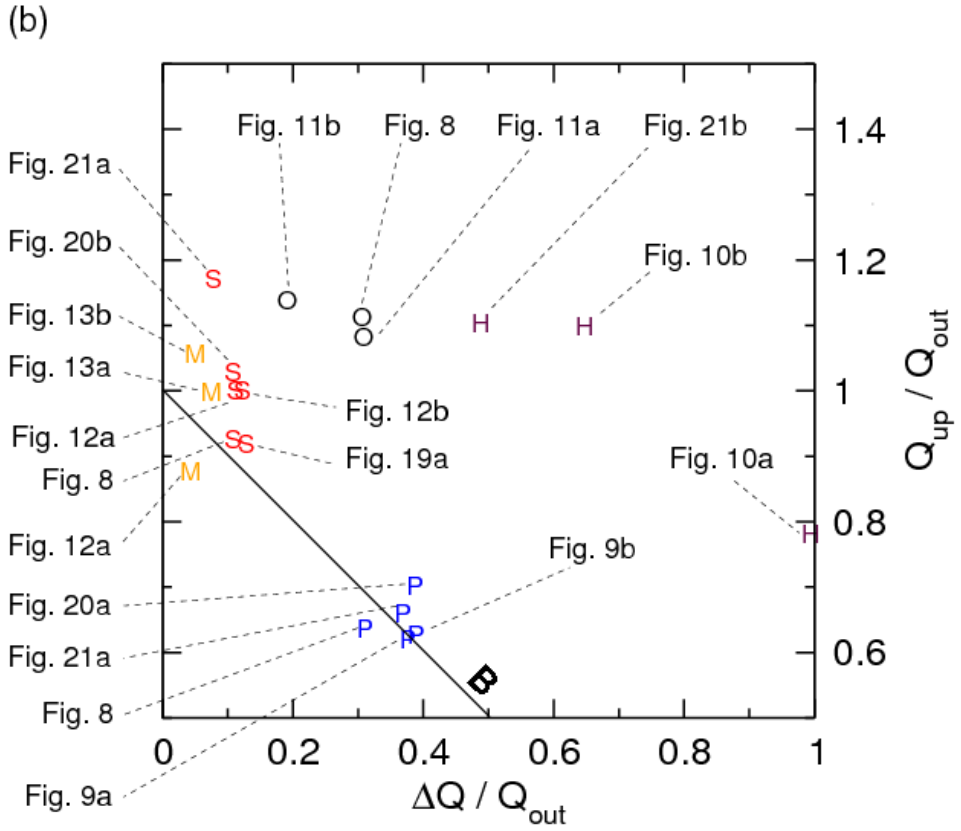


Phase diagrams are not only important to understand the conditions under which certain traffic states emerge. They also allow one to categorize the more than 100 traffic models into different universality classes. From the universality class that reproduces the empirically observed stylized facts, one may choose any representative, e.g. the simplest or the most accurate one, depending on the purpose.

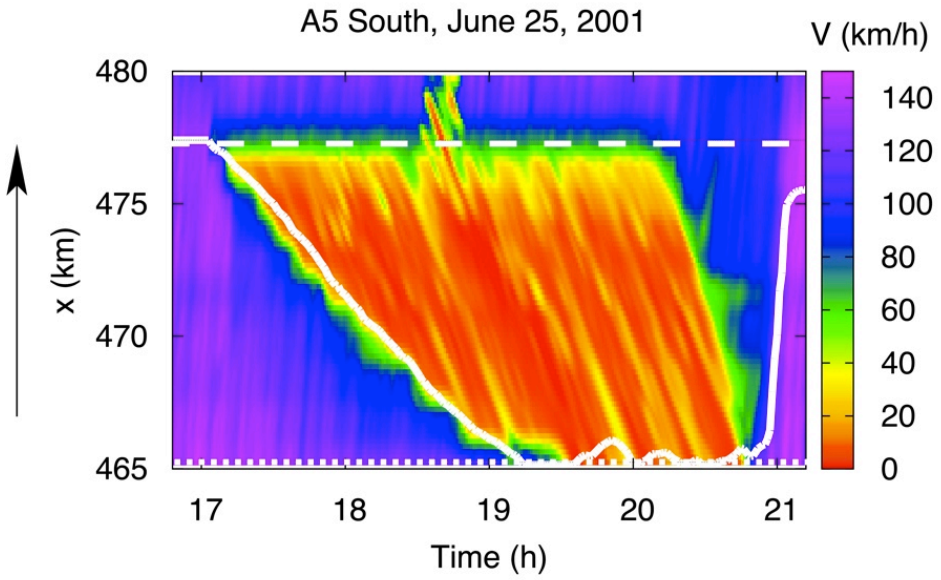
Empirical Phase Diagram for Scaled Flows

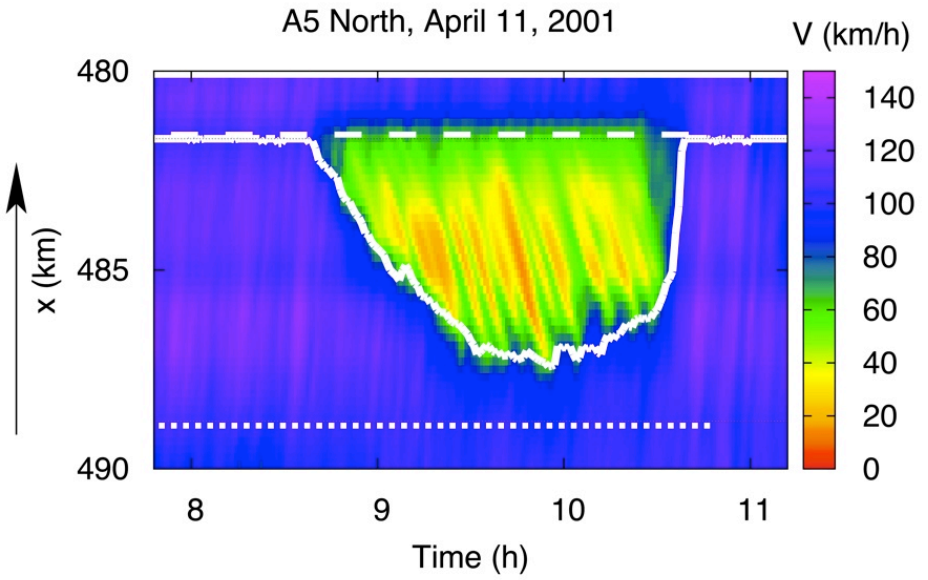
A scaling by the outflow, that varies from day to day, gives a clearer picture.





Traffic Congestion is Predictable





Traffic Physics

The European Physical Journal B

A selection of articles by Dirk Helbing

An Analytical Theory of Traffic Flow

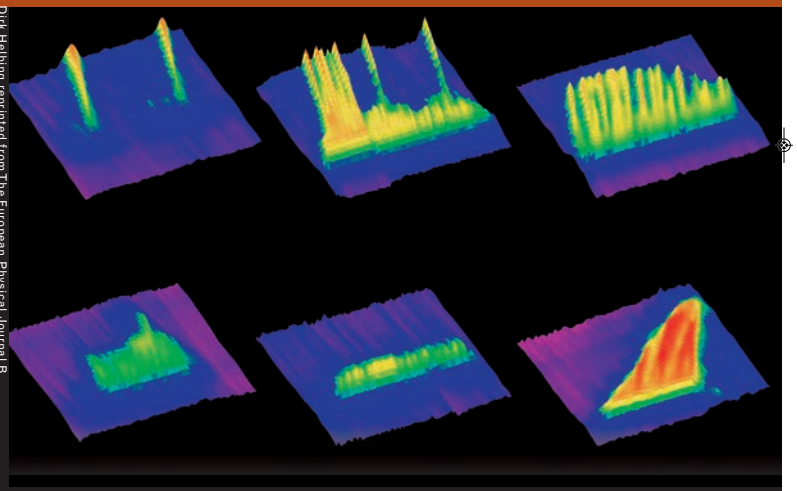
Printed on acid free paper

EPJ.org your physics journal

A selection of articles by Dirk Helbing reprinted from The European Physical Journal B

An Analytical Theory of Traffic Flow

A selection of articles by Dirk Helbing
reprinted from The European Physical Journal B



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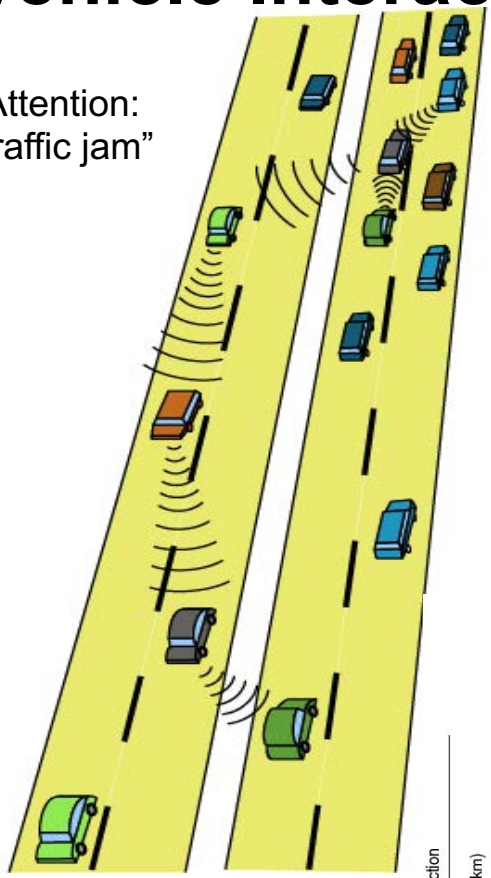
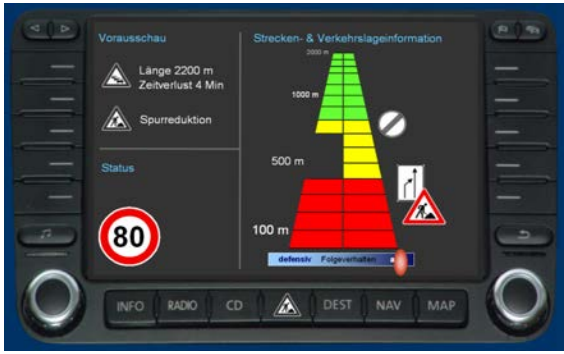
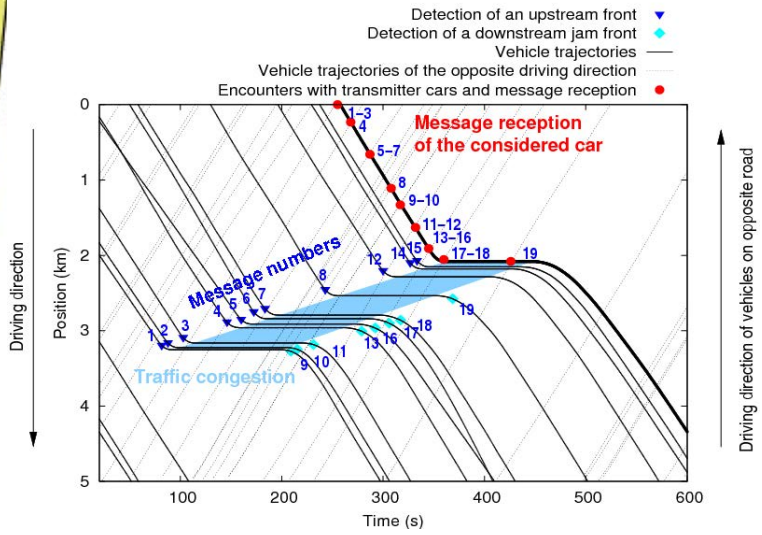
Freeway Traffic Control

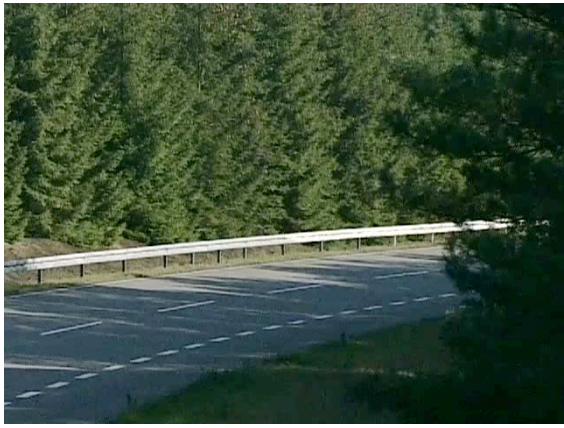
Cooperative Driving Based on Autonomous Vehicle Interactions



- On-board data acquisition („perception“)
- Inter-vehicle communication
- Cooperative traffic state determination (“cognition”)
- Adaptive choice of driving strategy (“decision-making”)
- Driver information
- Traffic assistance (higher stability and capacity of traffic flow)





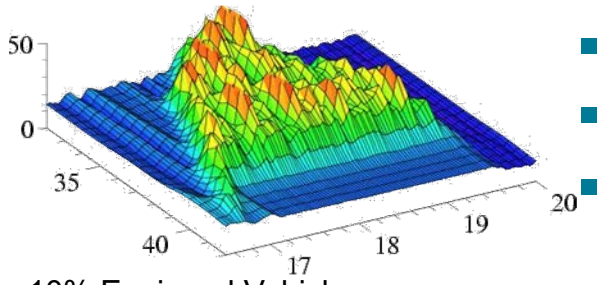


In: *Transportation Research Record* (2007)

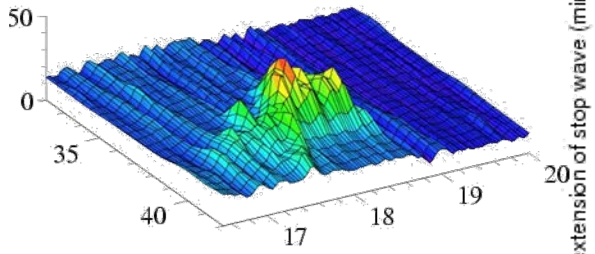
Overcoming Congestion by Real-Time Feedback

Enhancing Traffic Performance by Adaptive Cruise Control

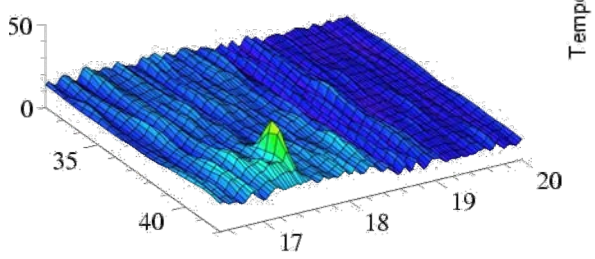
ρ(veh./km/lane)



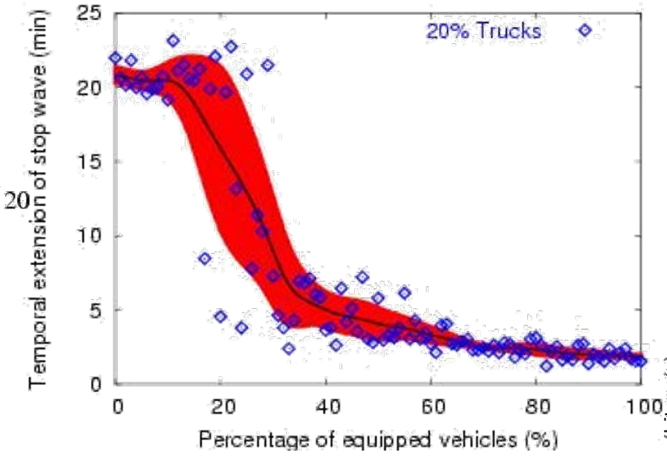
10% Equipped Vehicles

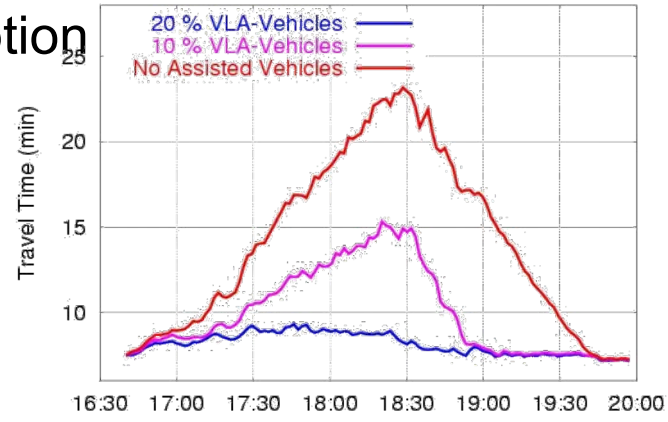


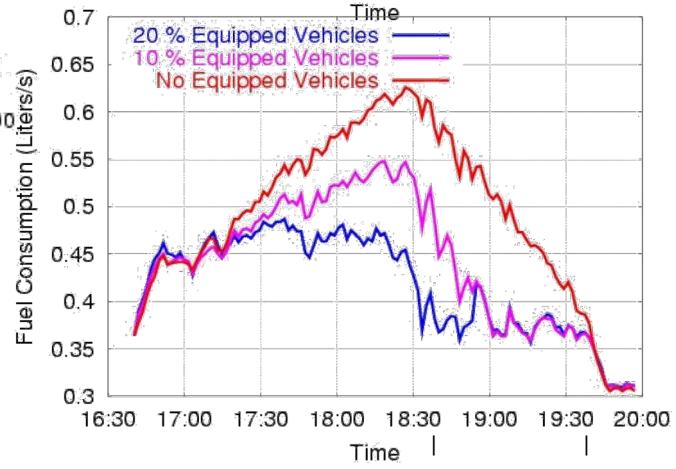
20% Equipped Vehicles



- Traffic breakdowns delayed
- Faster recovery to free traffic
- High impact on travel times
- Reduced fuel consumption and emissions







"Mechanism design"

Internet of Things

Mechanism Design: Modify Interactions with Real-Time-Measurements and -Feedback

With the Internet of Things, we can now make self-organization work, 300 years after Adam Smith's "invisible hand" concept!

Urban Planning vs. Enabling Self-Organization

The Noble Goals of Traffic Planning

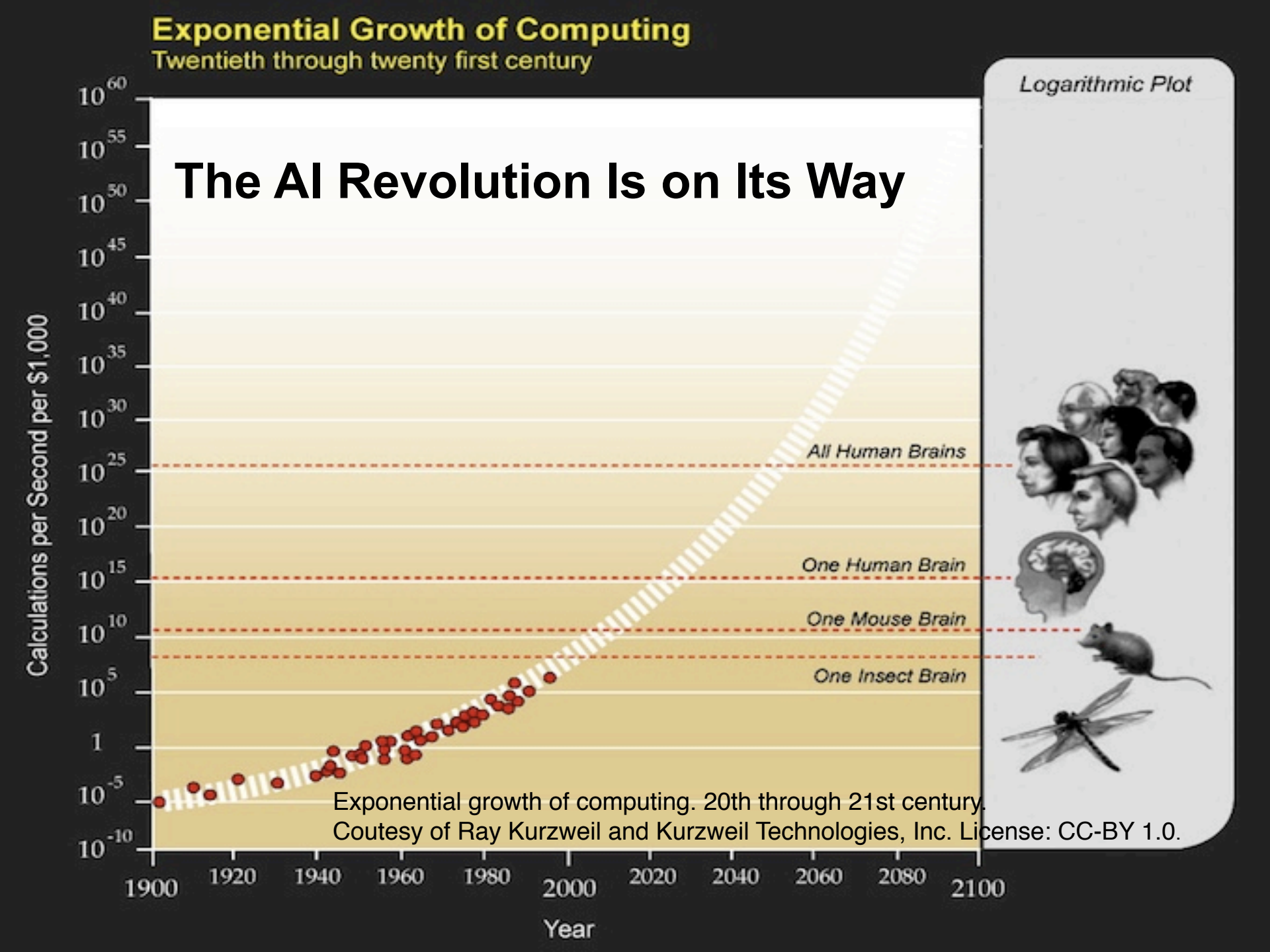
- Better mobility
- Less pollution
- Less noise
- Less traffic

But This Is Often the Reality …

… and This: Urban Gridlock

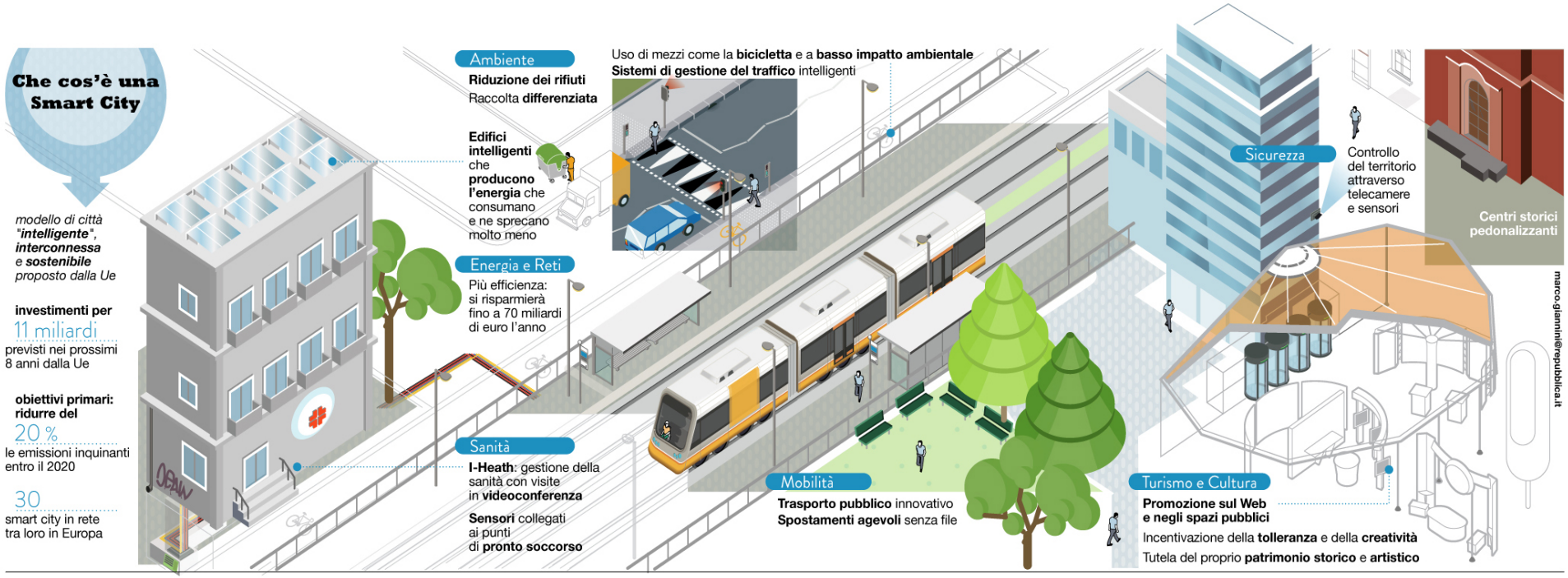
Can We Fix Traffic Congestion with Big Data and Super-AI?


IN 60 SECONDS...
1 NEW DEFINITION IS ADDED ON urban
1,600+ READS ON Scribd.
13,000+ HOURS MUSIC STREAMING ON PANDORA
12,000+ NEW ADS POSTED ON craigslist
370,000+ MINUTES VOICE CALLS ON skype
98,000+ TWEETS
20,000+ NEW POSTS ON tumblr.
THE LARGEST SOCIAL READING PUBLISHING COMPANY!!
New Craigslist Ads
320+ NEW twitter ACCOUNTS
13,000+ iPhone APPLICATIONS DOWNLOADED
100+ NEW Linked in ACCOUNTS
1 associatedcontent NEW ARTICLE IS PUBLISHED
THE WORLD'S LARGEST COMMUNITY CREATED CONTENT!!
QUESTIONS ASKED ON THE INTERNET...
100+ Answers.com
40+ YAHOO! ANSWERS
6,600+ NEW PICTURES ARE UPLOADED ON flickr
600+ NEW VIDEOS
50+ WORDPRESS DOWNLOADS
25+ HOURS TOTAL DURATION
70+ DOMAINS REGISTERED
695,000+ facebook STATUS UPDATES
125+ PLUGIN DOWNLOADS
60+ NEW BLOGS
168 MILLION EMAILS ARE SENT
694,445 SEARCH QUERIES
1,700+ Firefox DOWNLOADS
1,500+ BLOG POSTS
79,364 WALL POSTS
510,040 COMMENTS
Google
Google Search
GO-Globe.com



Exponential growth of computing. 20th through 21st century.
Coutesy of Ray Kurzweil and Kurzweil Technologies, Inc. License: CC-BY 1.0.

Smart Cities: Artificial Intelligence As Opportunity!
How Will Mobility and Logistics Change with AI?



Le Smart City

In Italia
- **Genova** *Progetto Expo 2015*
- **L'Aquila**

In Europa
- *Città olimpica di* **Londra**
- **Barcellona**
- **Amsterdam**

I numeri sul terremoto

FONDI STANZIATI
10,6 miliardi di euro i fondi complessivi stanziati dopo il sisma a L'Aquila

2,9 miliardi già erogati per affrontare l'emergenza

5,7 miliardi sono disponibili per la ricostruzione

FONDI SPESI
680 milioni già spesi per la prima emergenza

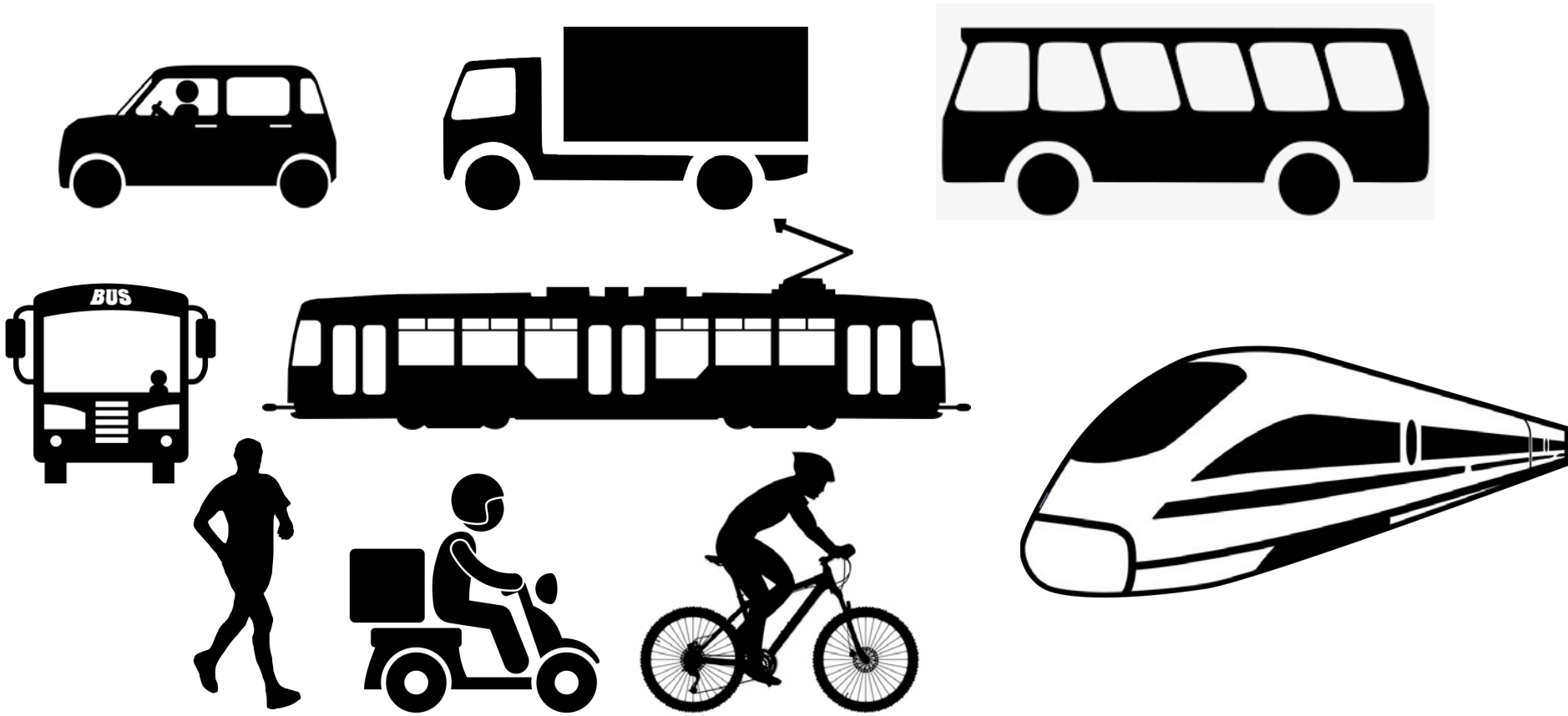
833 milioni hanno consentito di dare il via al progetto Case

284 milioni utilizzati per costruire i moduli abitativi provvisori (Map)

Self-Driving Vehicles, Autonomous Cars

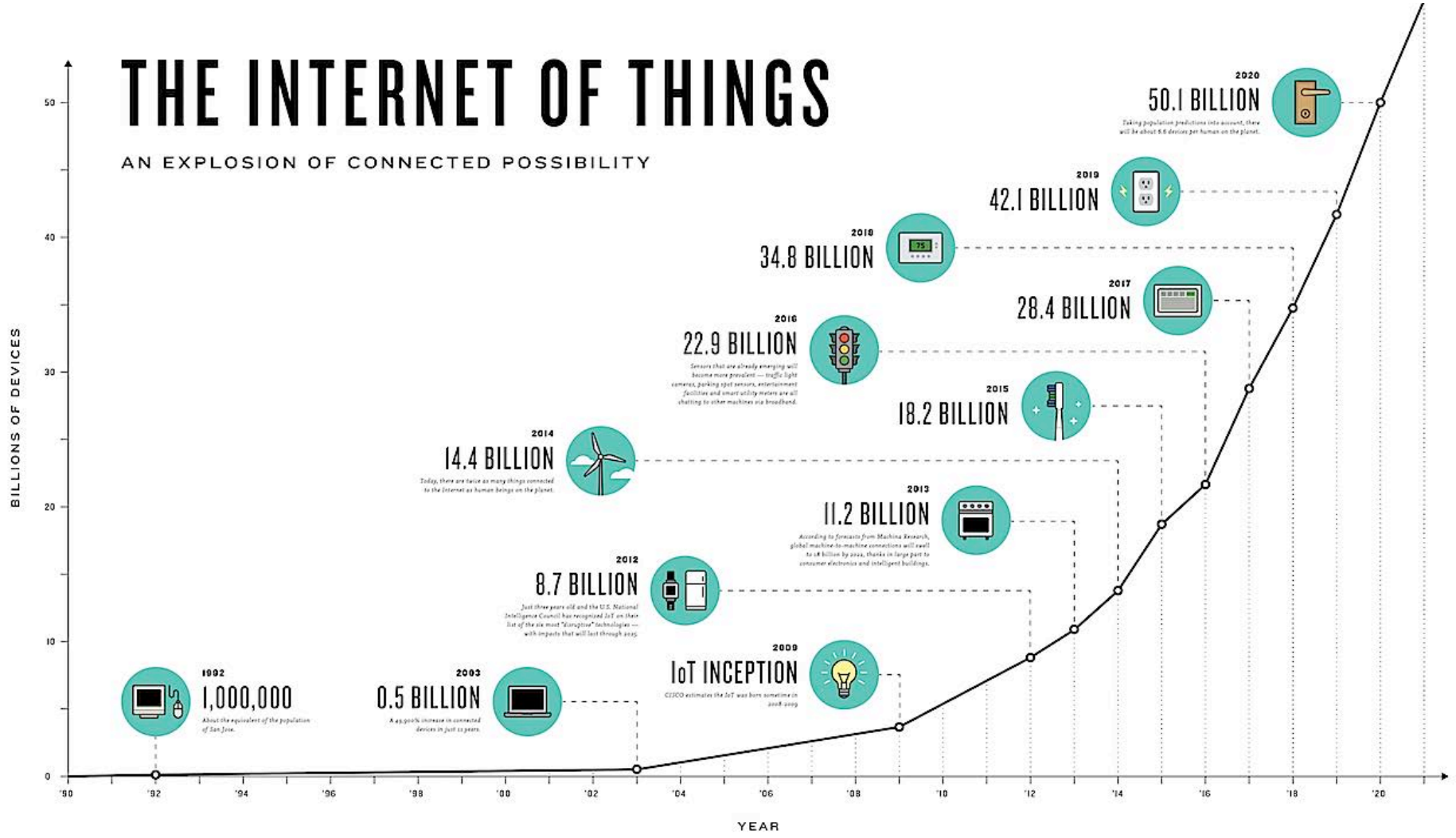
Automated Traffic Flow

Hybrid Traffic and Logistics of the Future

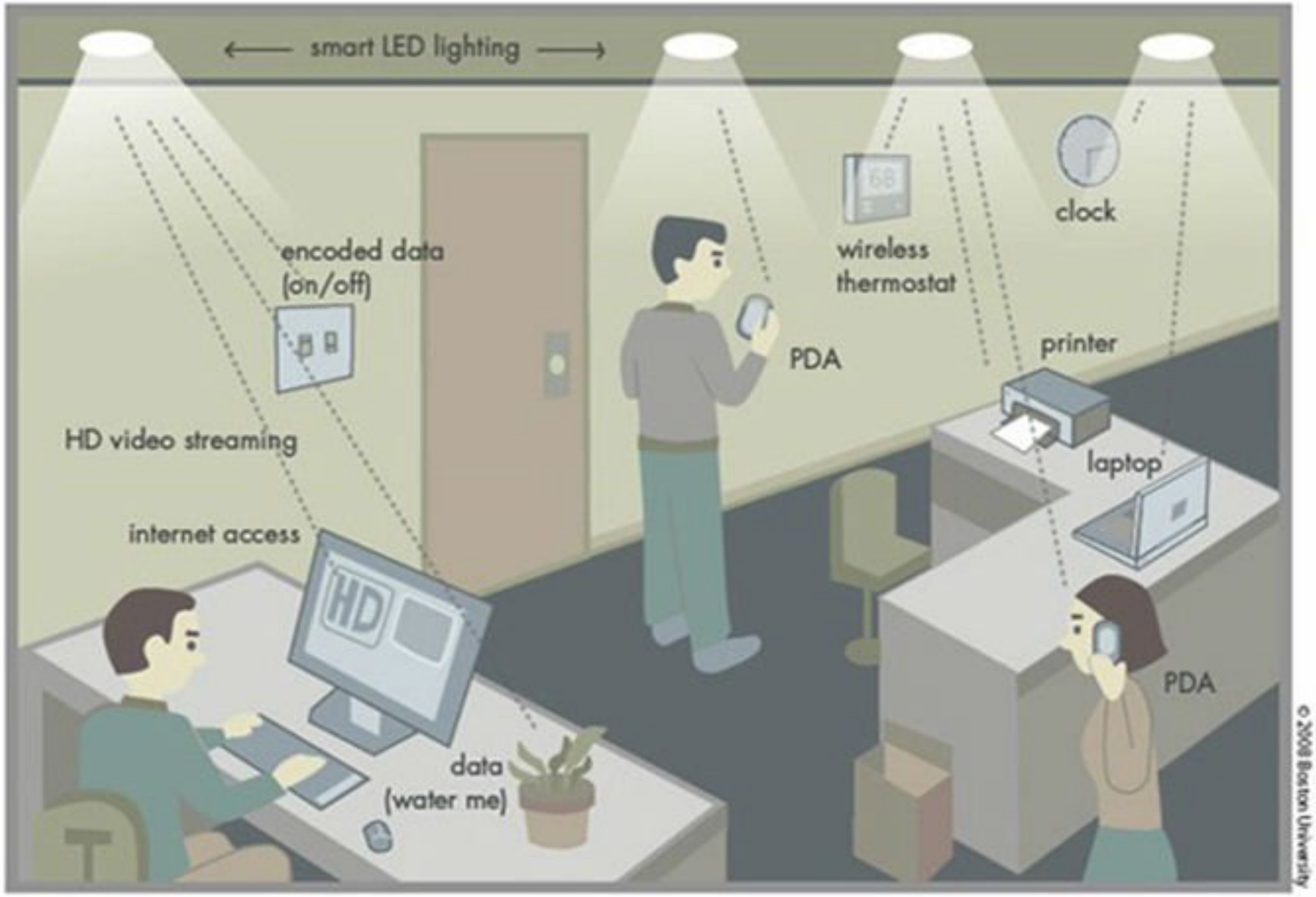


Could Cities Be Run Like Giant Machines?

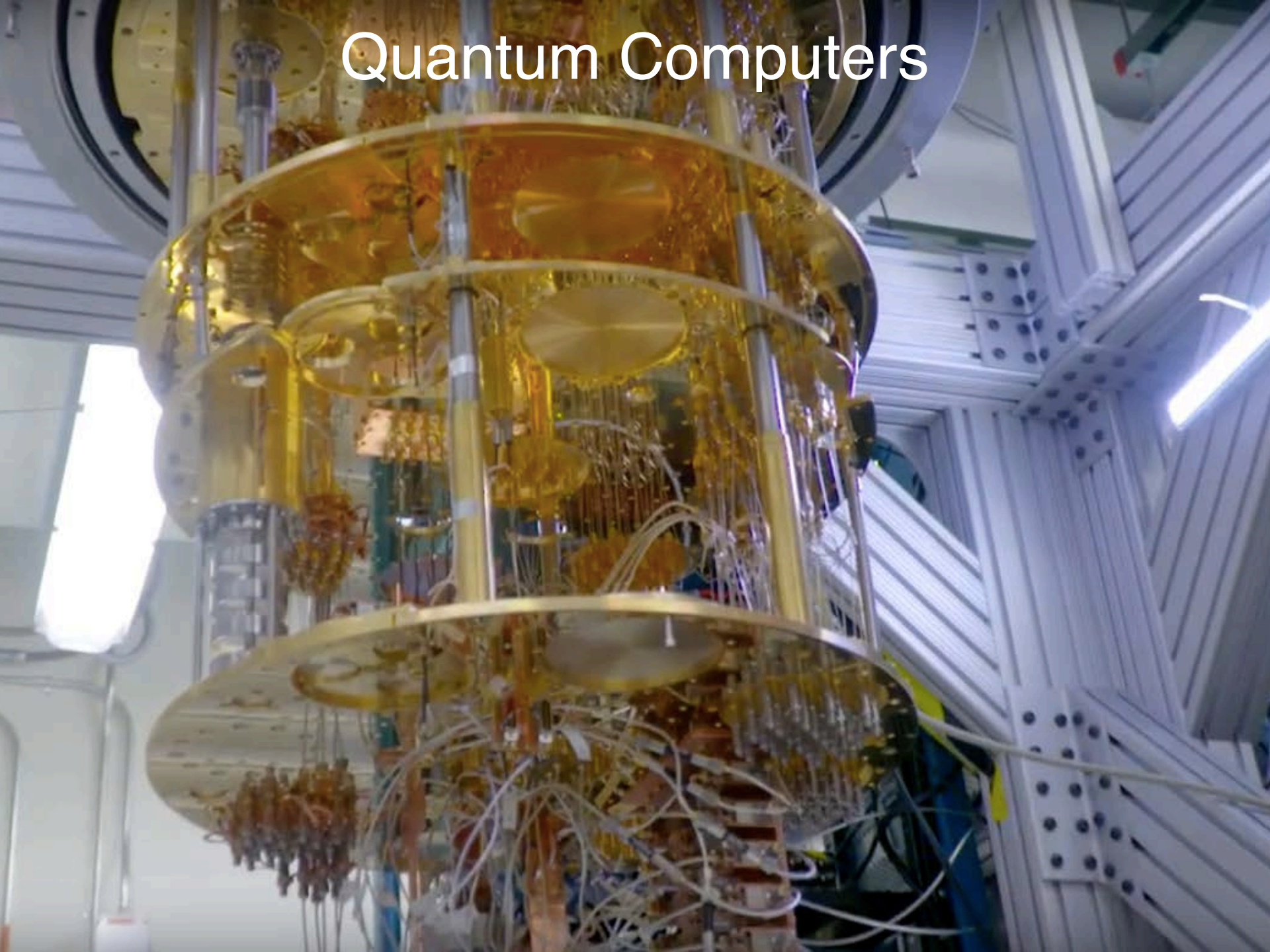
The World's Sensor Network is Growing Quickly




LOFI


smart LED lighting
encoded data
(on/off)
HD video streaming
internet access
data
(water me)
PDA
wireless
thermostat
clock
printer
laptop
PDA
HD
© 2008 Boston University

Quantum Computers



D-Wave Systems

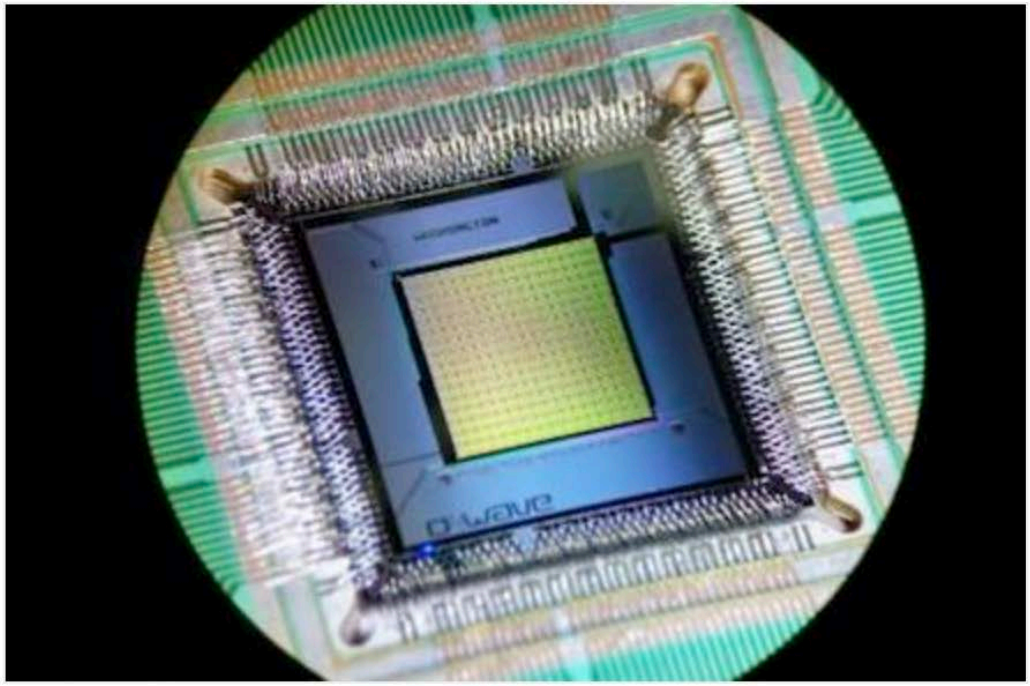
D-Wave Systems, Inc. [1]is a quantum computing company, based in Burnaby, British Columbia, Canada. D-Wave is the first company in the world to sell quantum computers.[citation needed]*citation needed*]

	D-Wave One	D-Wave Two	D-Wave 2X	D-Wave 2000Q[49][50]
Available	May 2011	May 2013	August 2015	January 2017
Code-name	Rainier	Vesuvius		
Qubits	128	512	1152	2048
Couplers	352		3000	5600
Josephson junctions	24,000		128,000	
I/O / control lines		192		
Operating temperature		0.02 K	0.015 K	
Power consumption		15.5 kW	25 kW	
Buyers	Lockheed Martin	Lockheed Martin Google/NASA/USRA	Lockheed Martin Google/NASA/USRA Los Alamos National Laboratory	Temporal Defense Systems Inc. Google/NASA/USRA[51] Volkswagen Group[52] Virginia Tech[53]

Google says its quantum computer is 100 million times faster than PC

Controversial D-Wave system gets thumbs up

By Iain Thomson in San Francisco 9 Dec 2015 at 01:31 87 SHARE

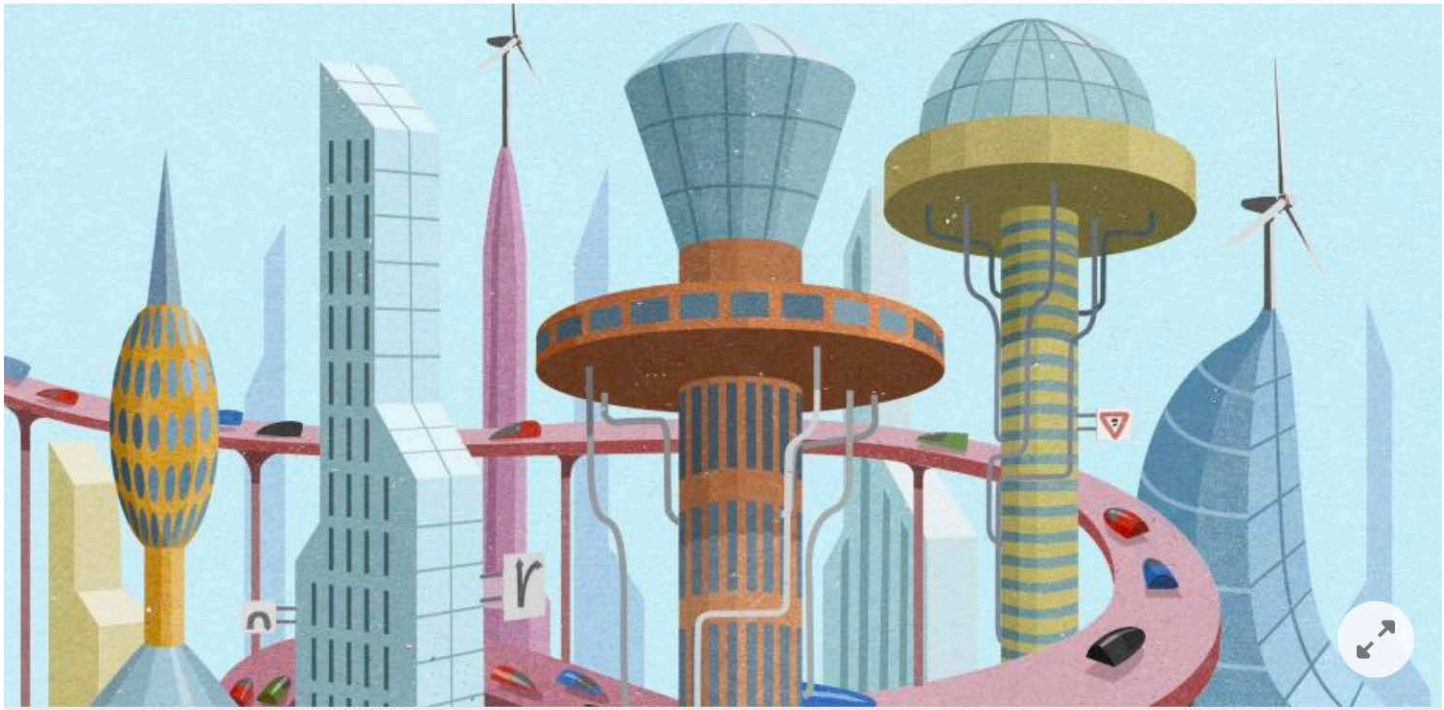


Two years ago Google and NASA bought a D-Wave 2X quantum computing system and the Chocolate Factory has now pronounced itself very pleased with the results.

MEINUNG WELT DER ZUKUNFT

Googles smarte Stadt, ein digitaler Alptraum

Von Henryk M. Broder | Veröffentlicht am 28.10.2017 | Lesedauer: 3 Minuten



Quelle: Getty Images/Ikon Images

Google will in Toronto ein voll vernetztes Testfeld für das Leben von morgen errichten: Eine Stadt vom Reißbrett, total vernetzt und überwacht wie eine moderne Justizvollzugsanstalt. Unserem Autor gruselt es.

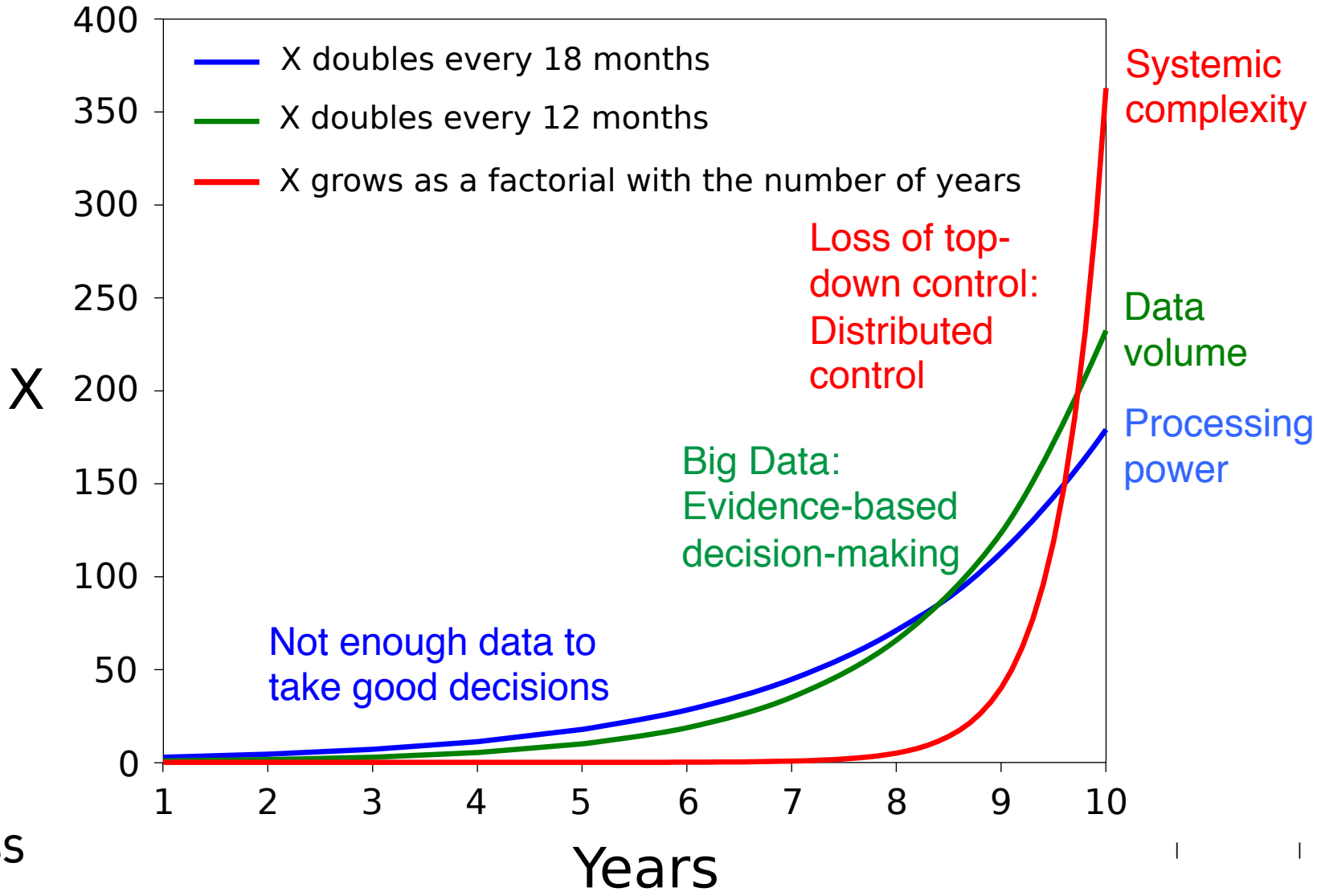
Report

Disrupting cities through technology

Thursday 17 – Saturday 19 March 2016 | WP1449

Mercer's 2015 Quality of Living Rankings[2]		
	City	**Country**
1	Vienna	Austria
2	Zürich	Switzerland
3	Auckland	New Zealand
4	Munich	Germany
5	Vancouver	Canada
6	Düsseldorf	Germany
7	Frankfurt	Germany
8	Geneva	Switzerland
9	Copenhagen	Denmark
10	Sydney	Australia

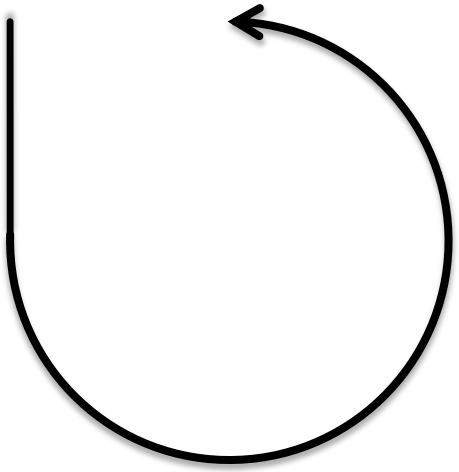
Exponential vs. Factorial Growth, Dark Data, Loss of Centralized Control



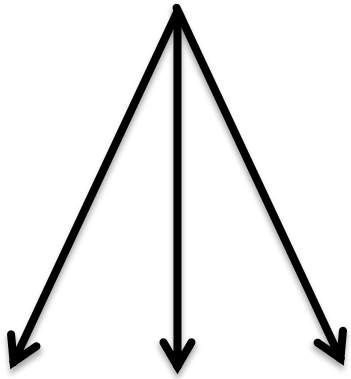
Cause and Effect in Networked Systems

Intended effect

Side effect



Feedback effect



Cascading effect

ETH zürich

Complex Systems Cannot Be Steered Like A Car!

Systemic Instabilities Causing Unwanted Traffic Jams – and Many Other Problems!

Engineered Breaking Points to Stop Cascades

The Sustainability Challenges Call for A More Resilient Society

Cities and regions are relevant organizational units for a resilient society

New paradigm:
From top-down power and control to empowerment and coordination

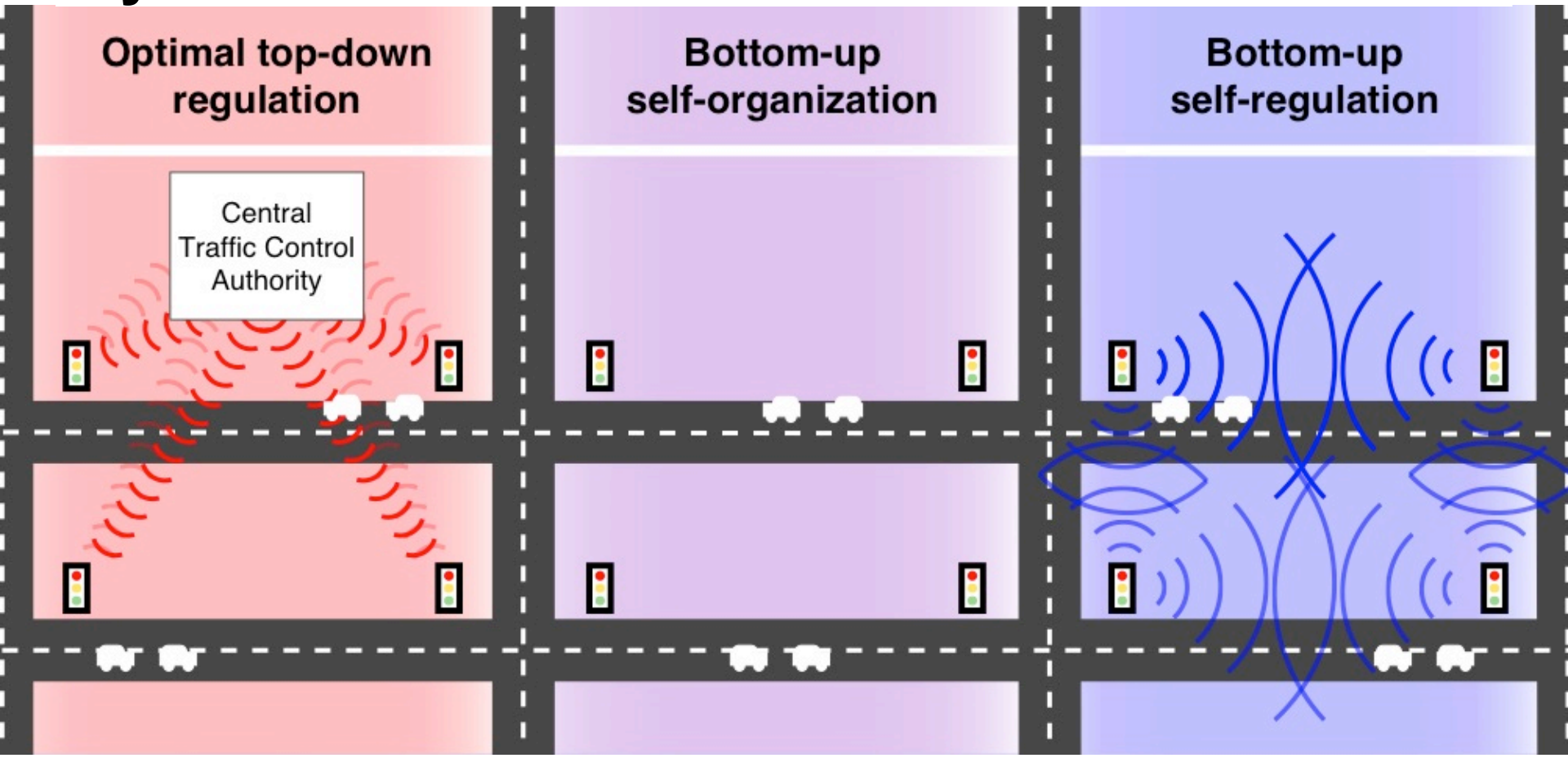
Co-creation, co-evolution, collective intelligence

(Image: dmd/ADAC)


www.MOTOR-TALK.de/blogs/andyrx

Traffic Light Control

Comparing 3 Ways to Organize a Complex System



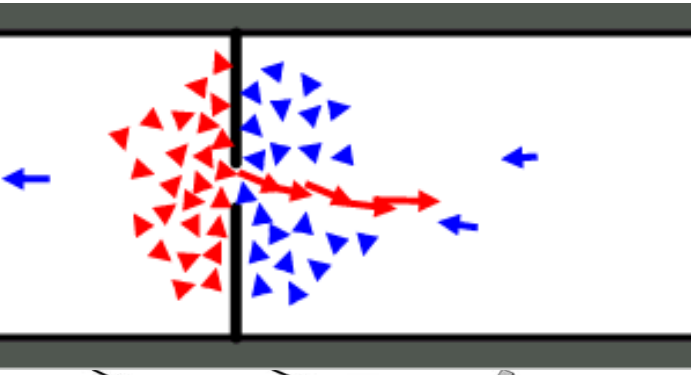
Central control, “benevolent dictator”

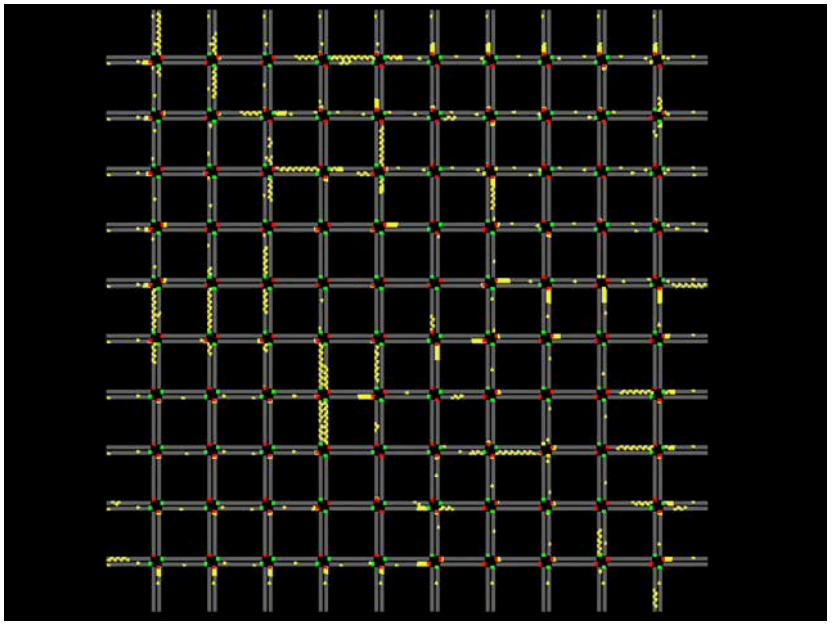
Travel time minimization, “homo economicus”

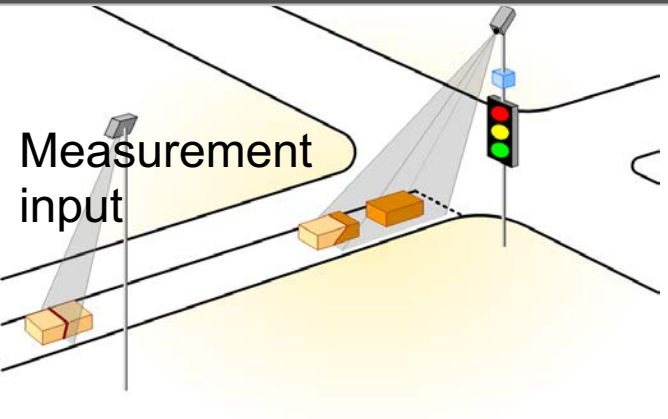
Same, but other-regarding coordination with neighbors

Decentralized Concept of Self-Organized Traffic Light Control

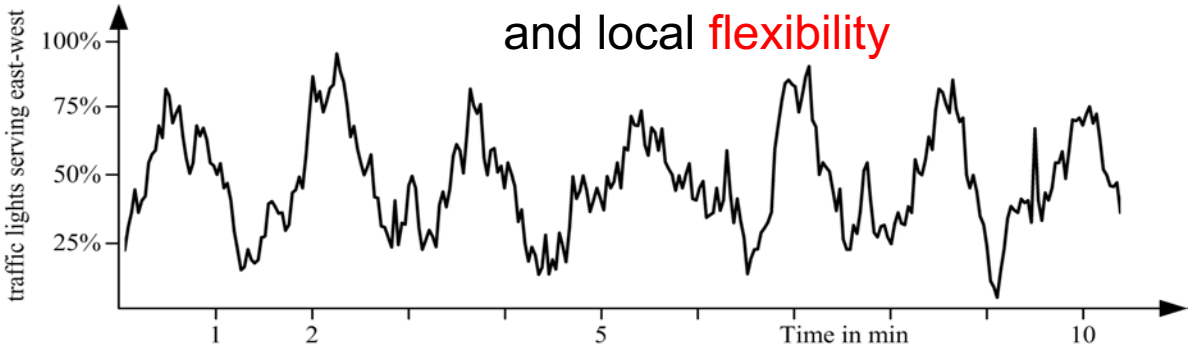
Inspiration: Self-organized oscillations at bottlenecks





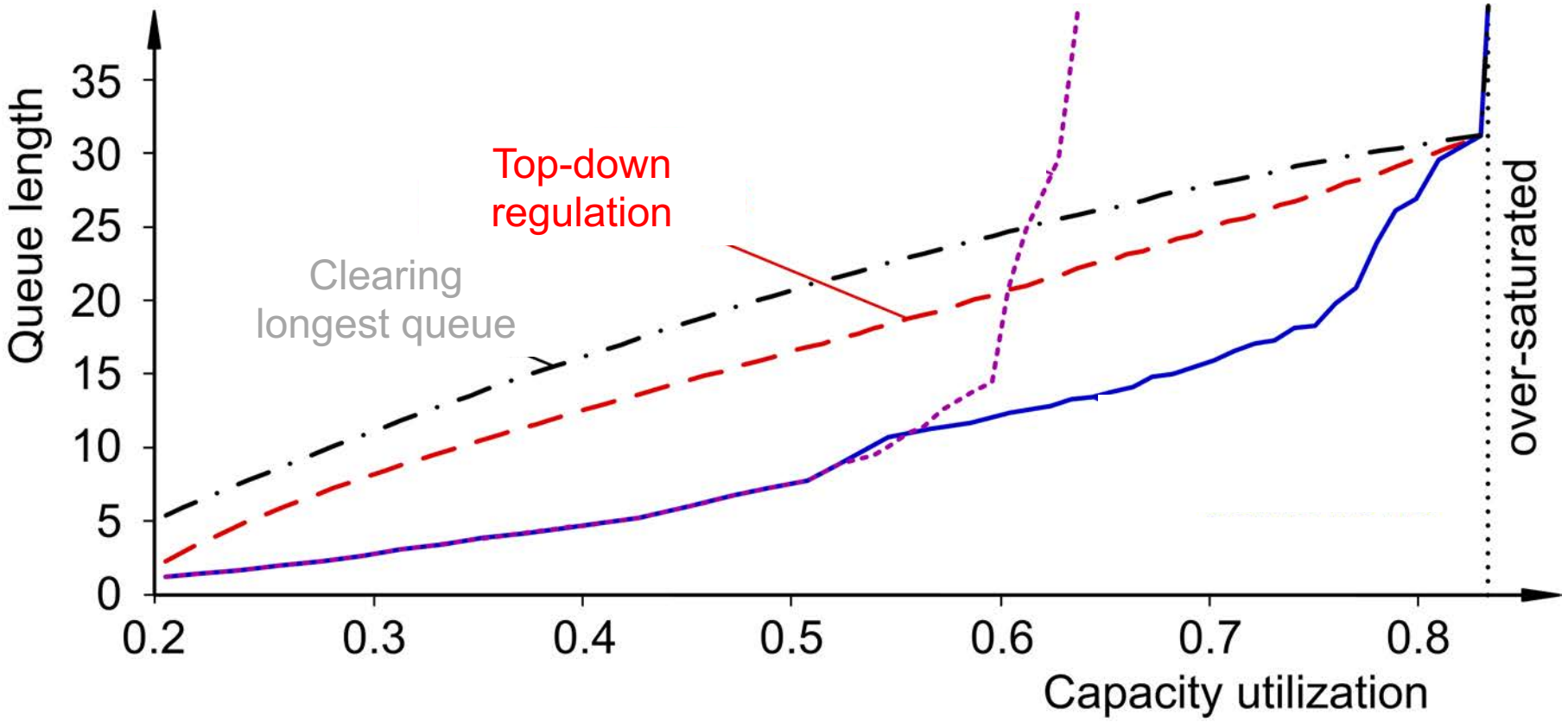


Optimal compromise between coordination and local flexibility

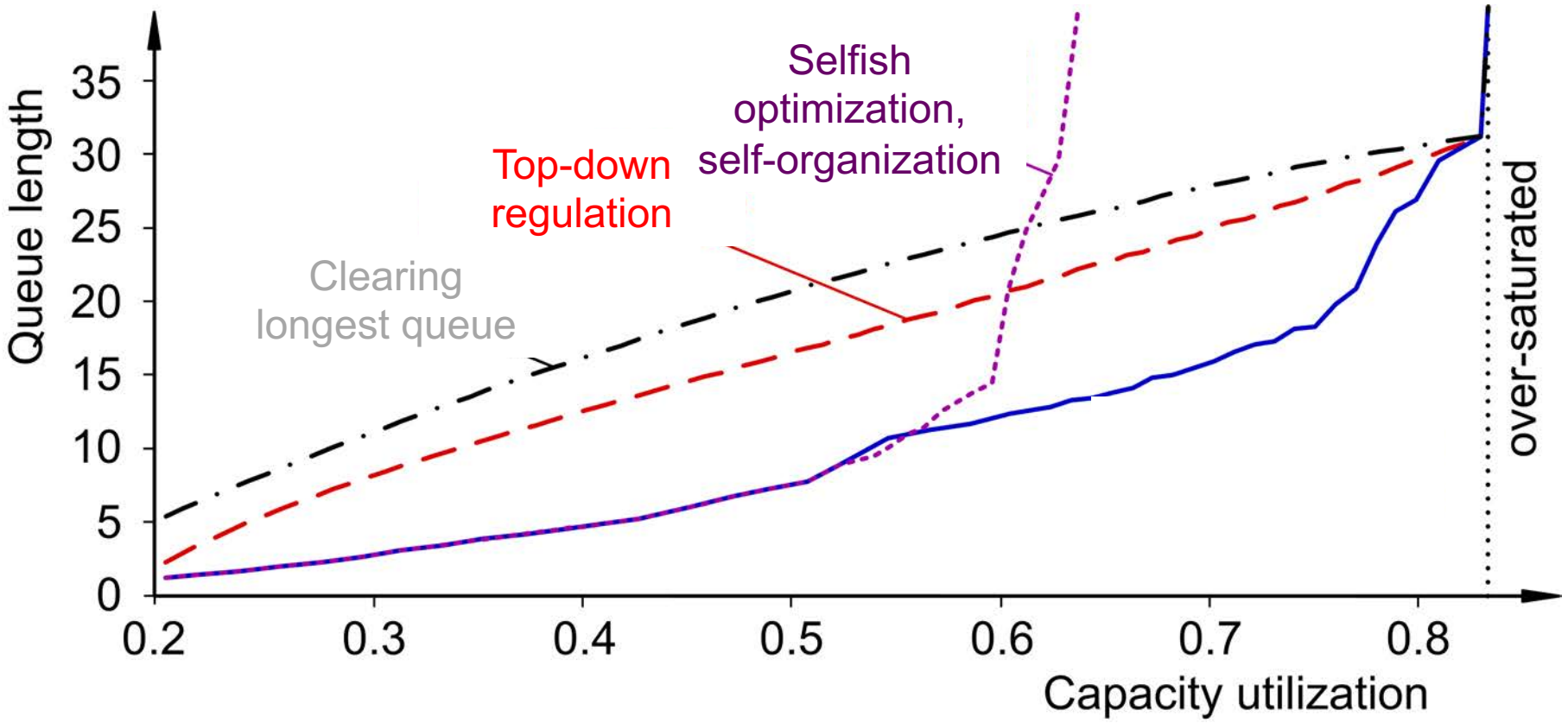


Published in *JSTAT* (2008)

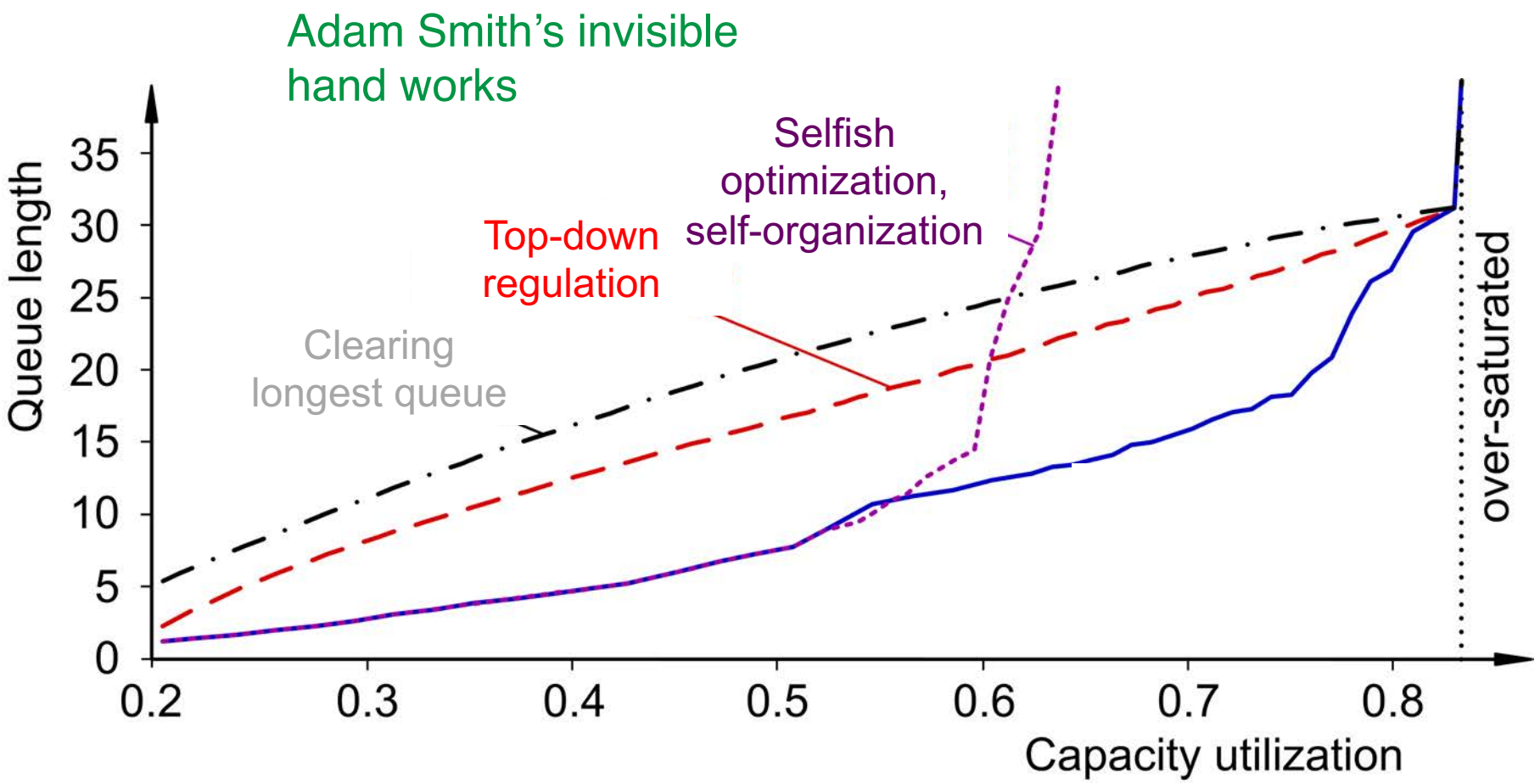
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



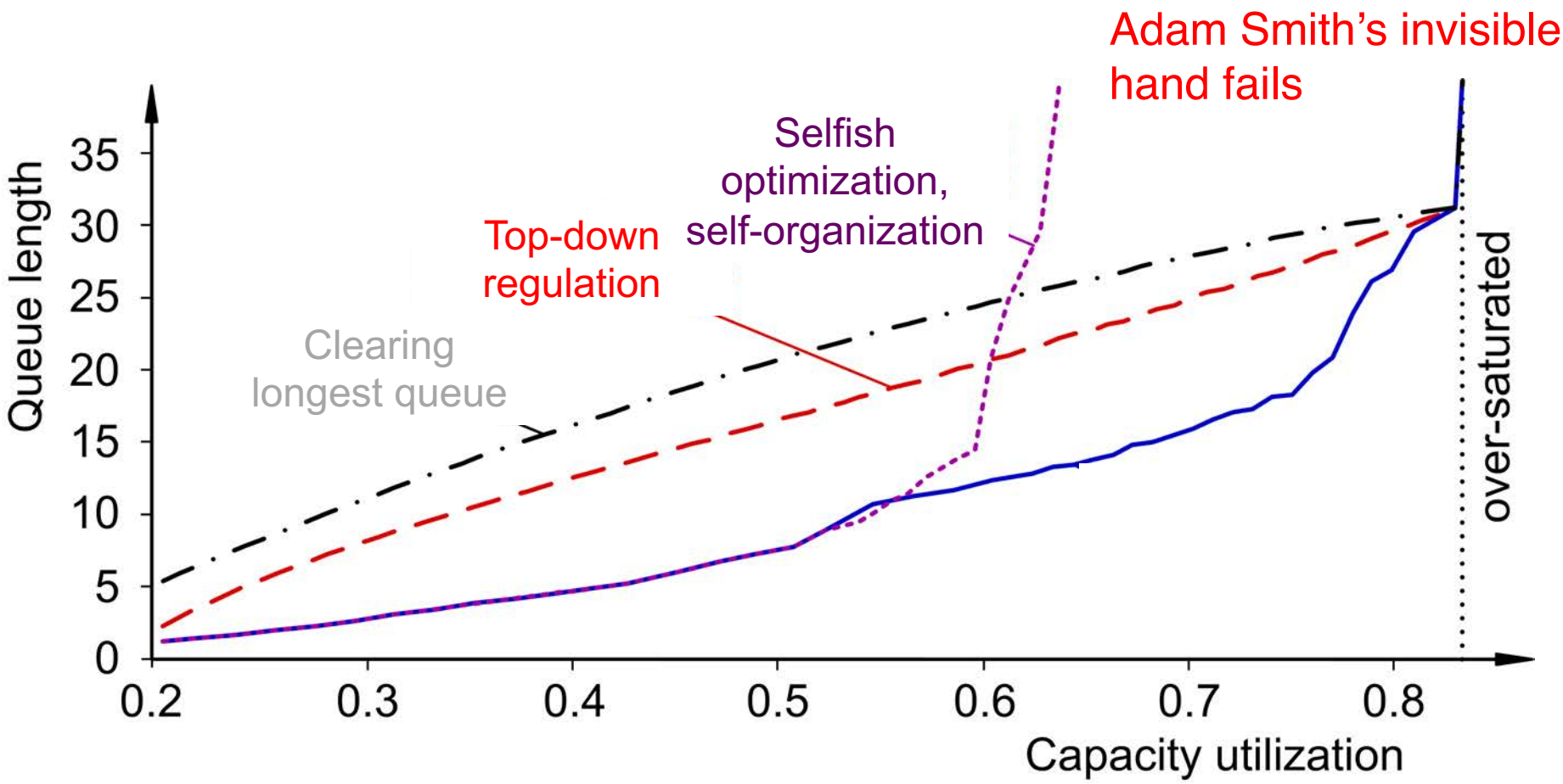
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



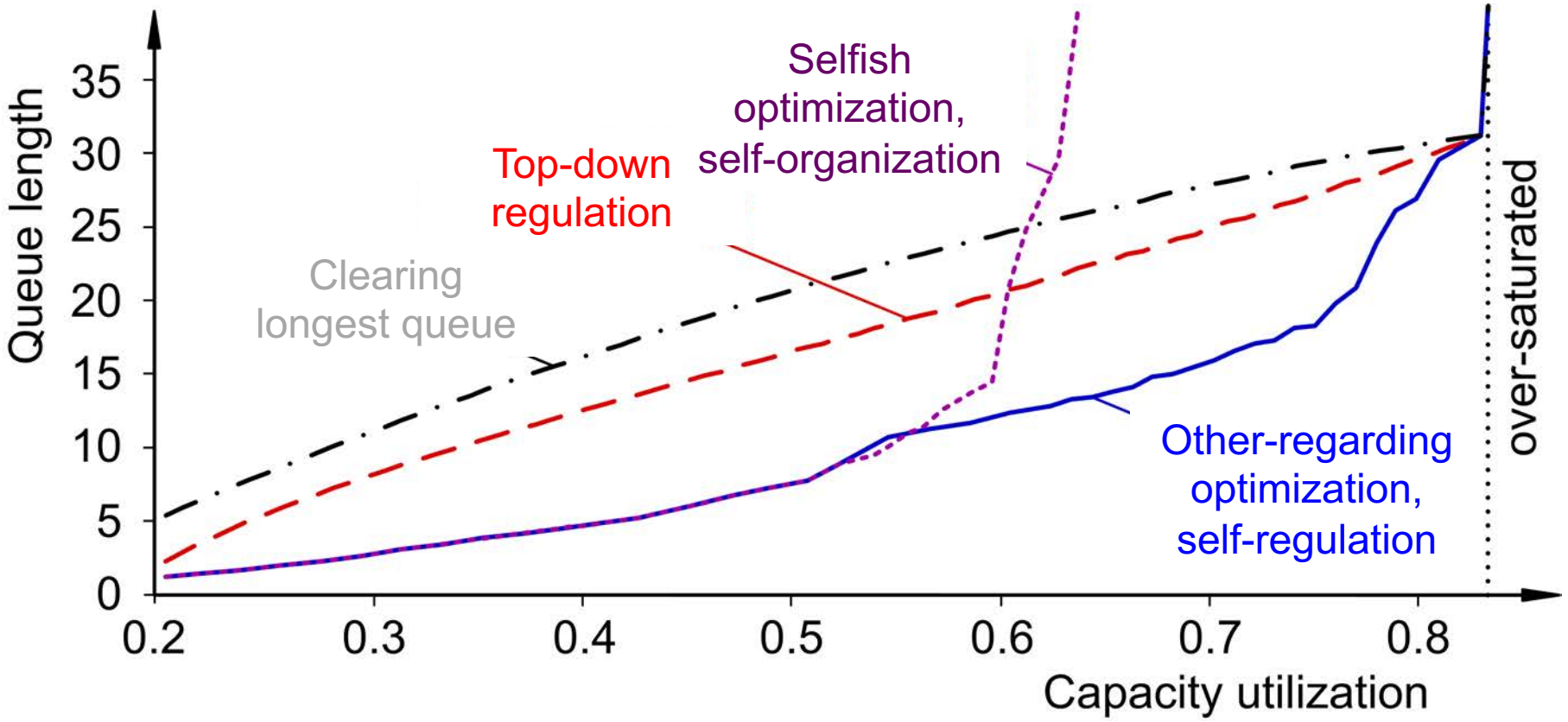
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



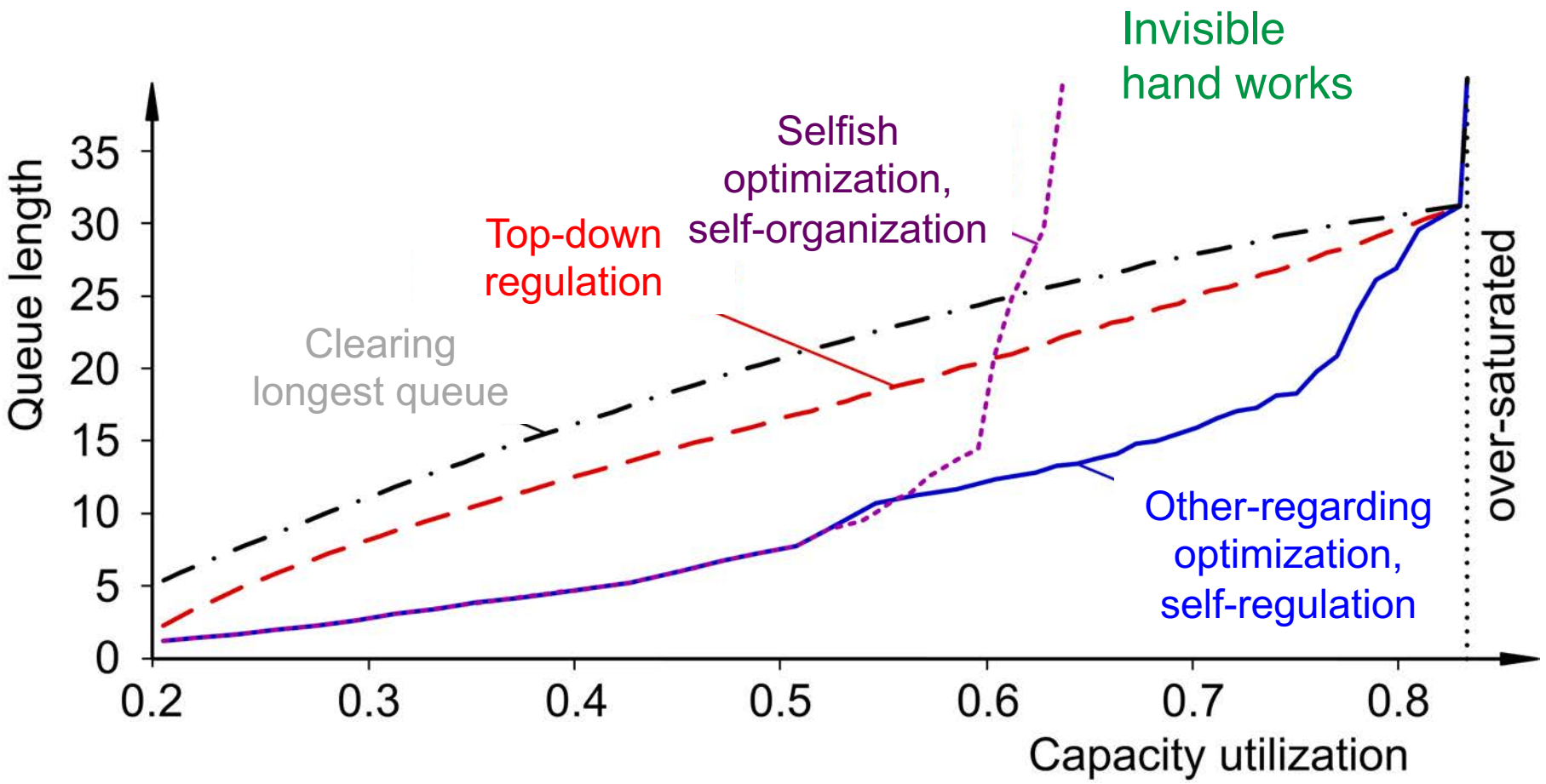
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



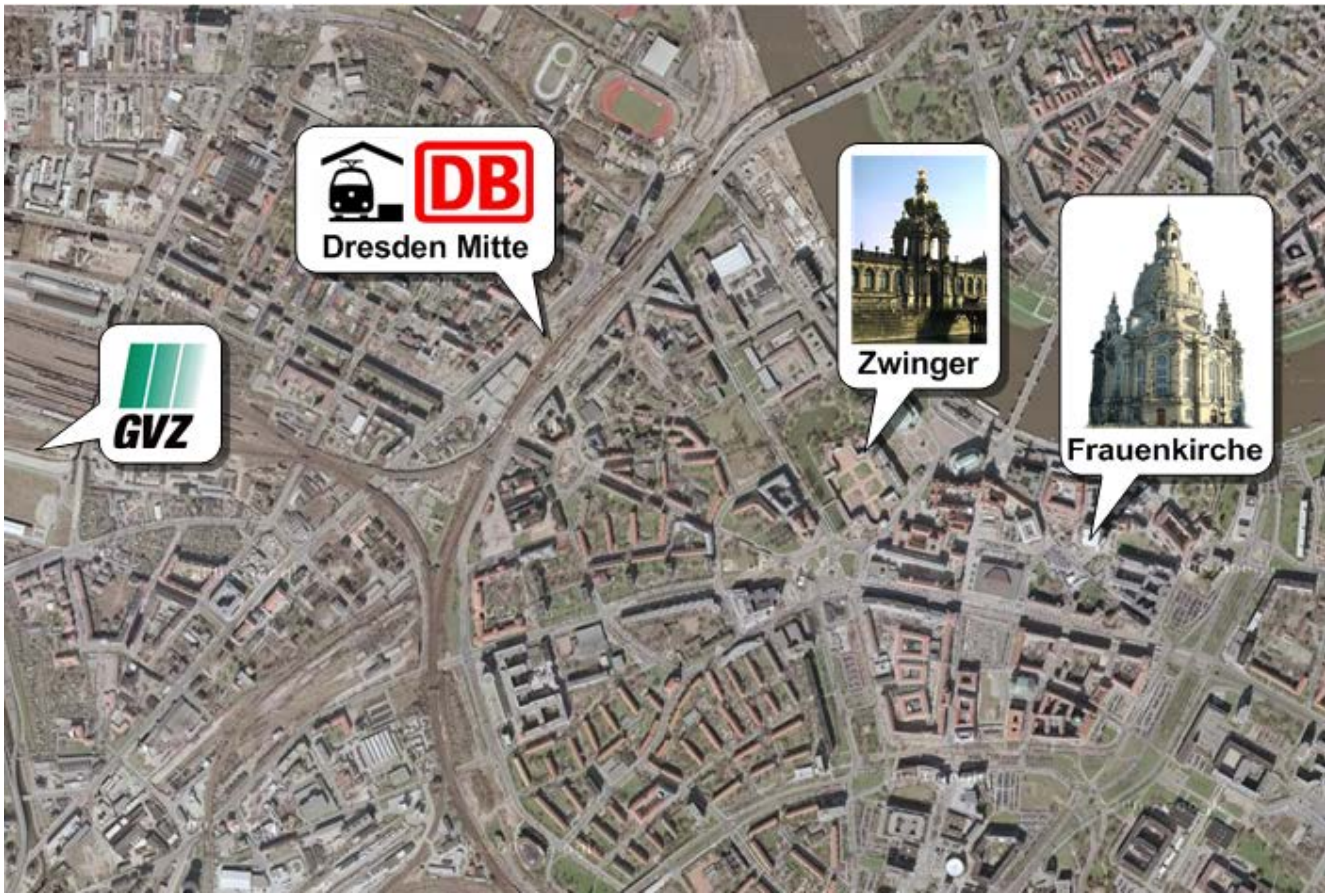
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



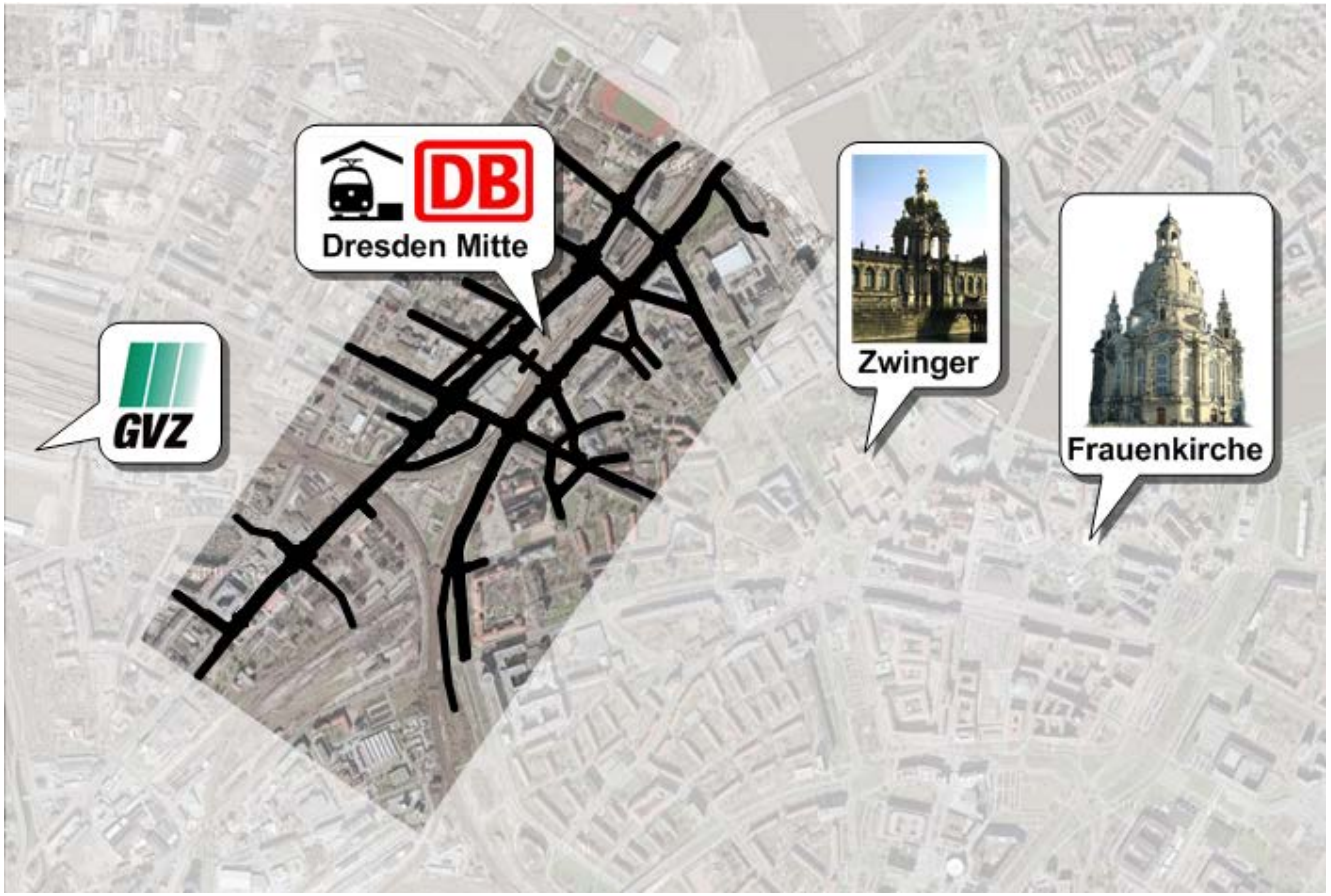
Bottom-Up Self-Regulation Can Outsmart Optimal Top-Down Control



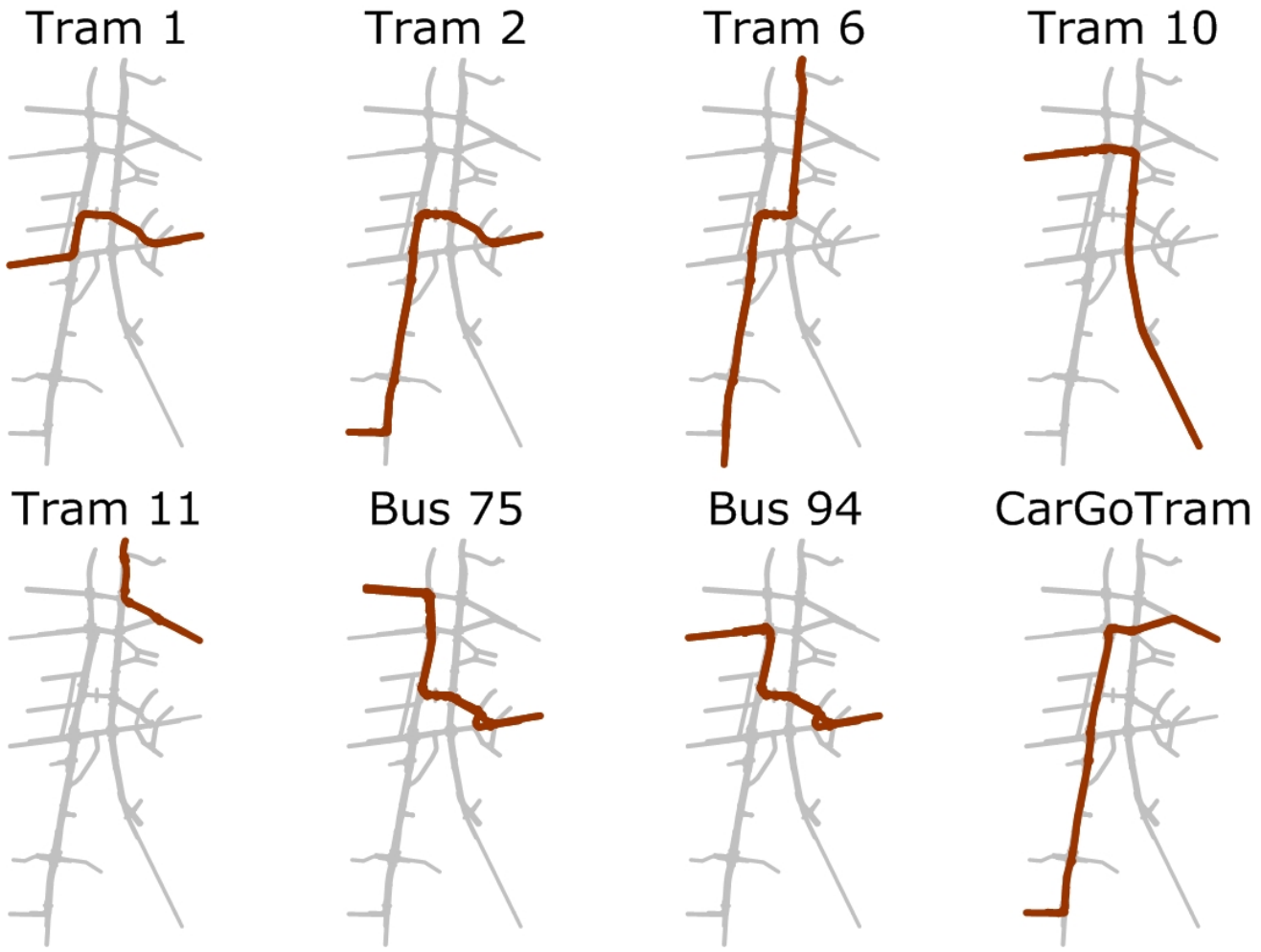
Towards Self-Organized Traffic Light Control in Dresden



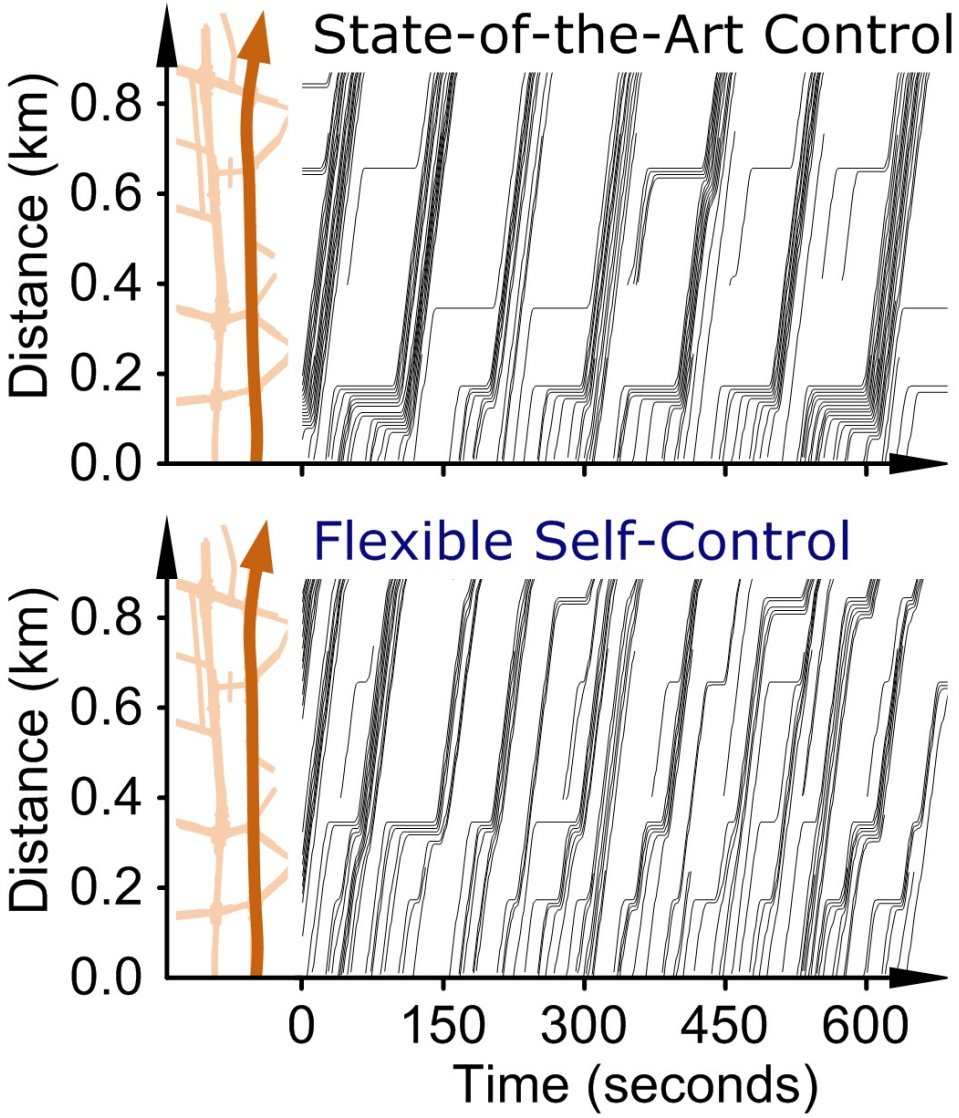
The Measurement and Control Area



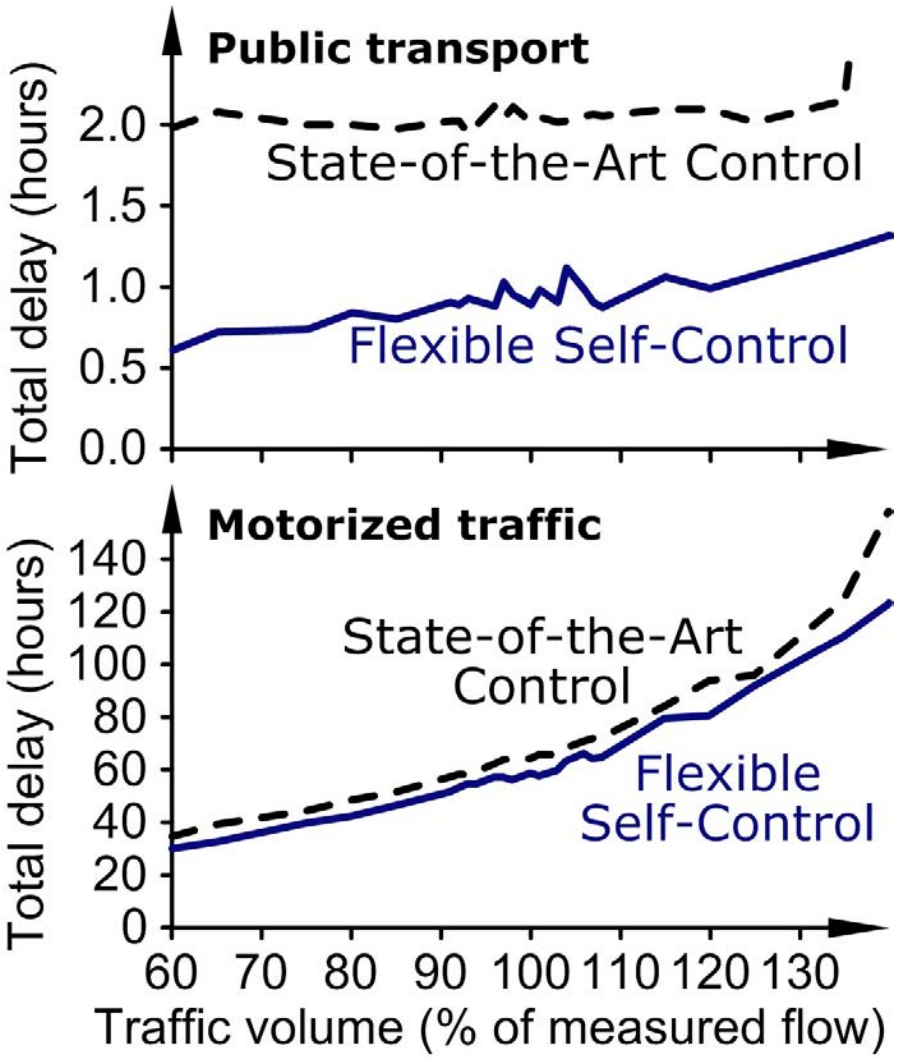
Disturbance of Traffic Coordination by Bus and Tram Lines



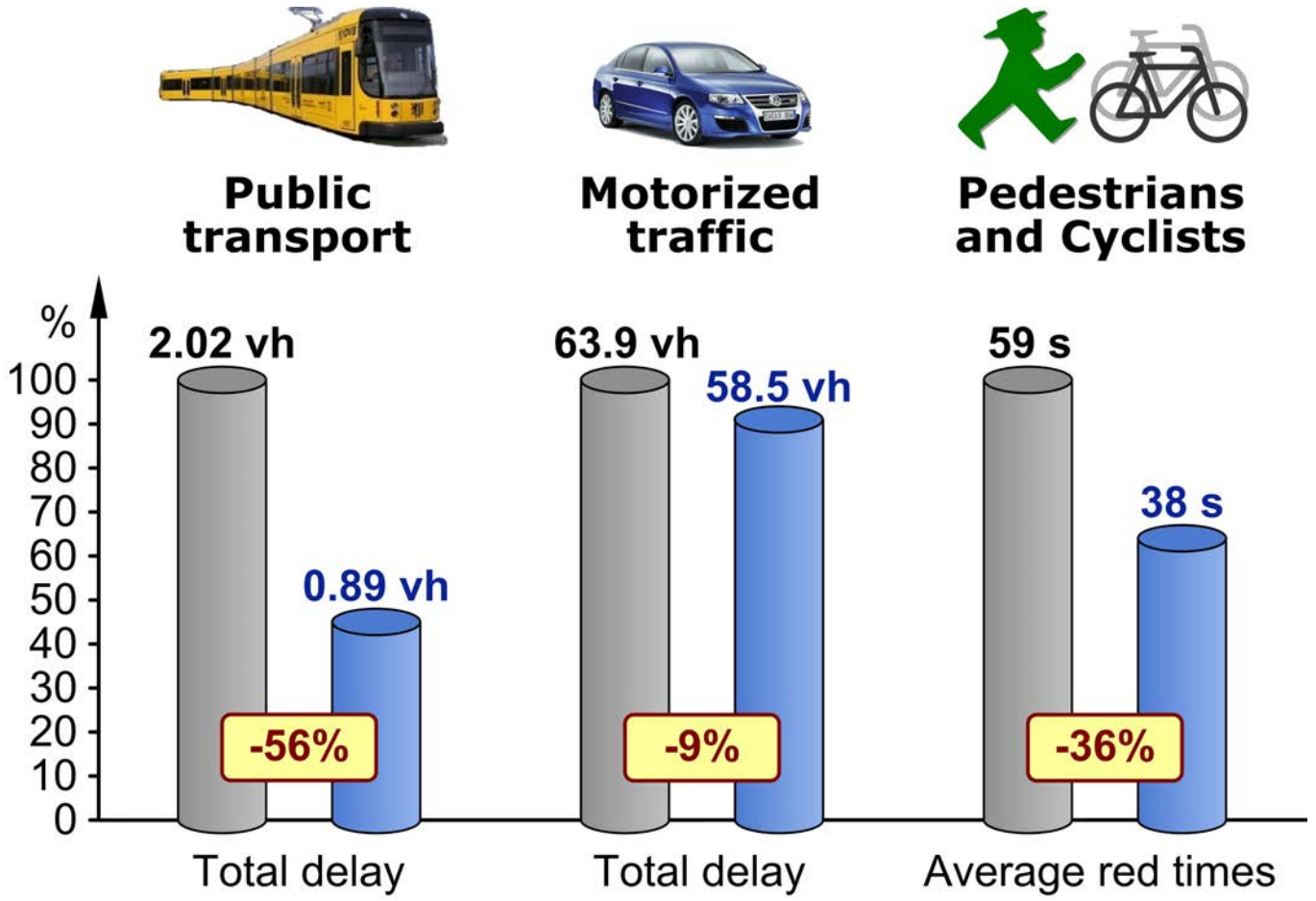
Synchronize Traffic by Green Waves or Use Gaps as Opportunities?



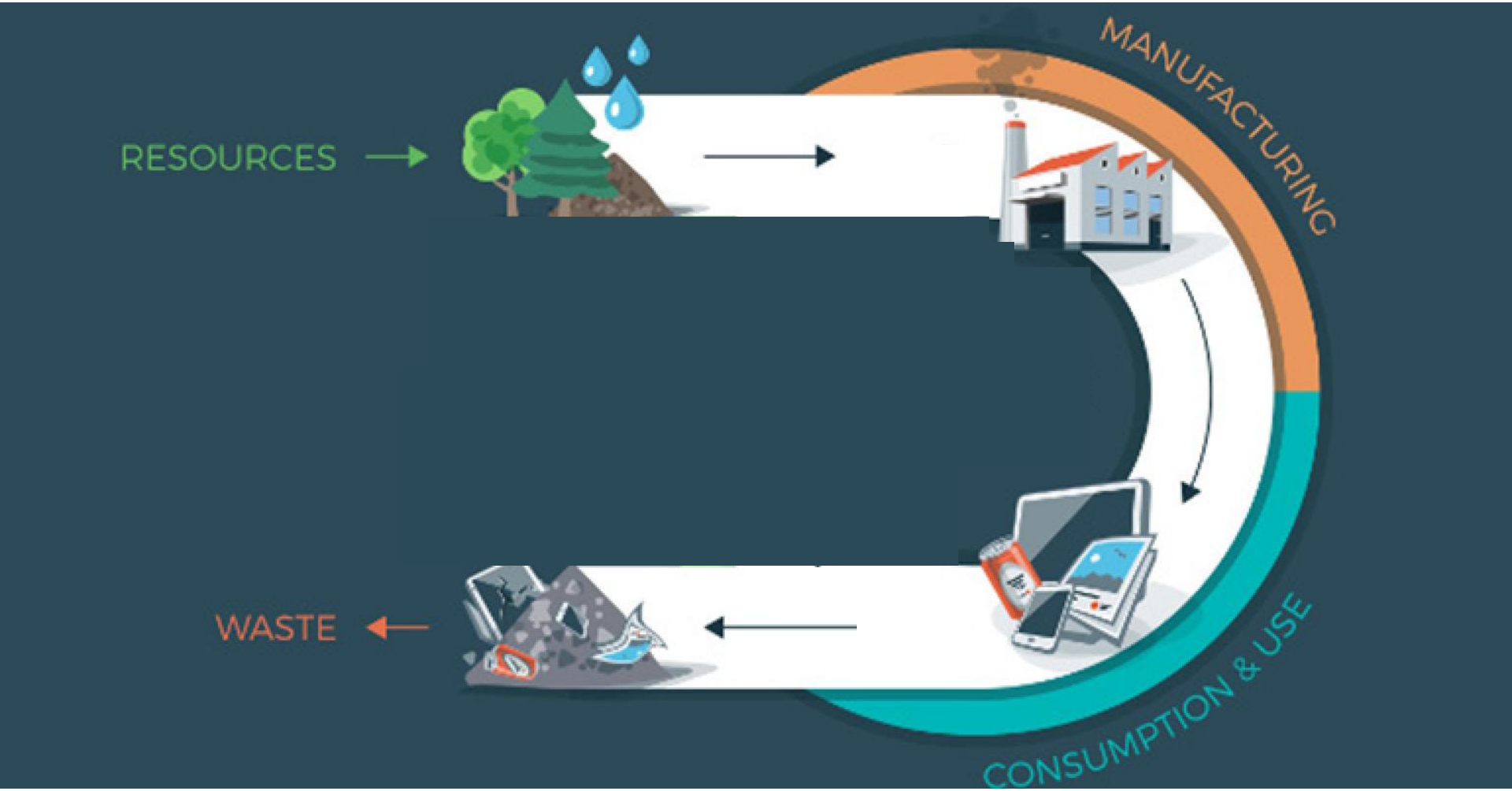
Performance in Dependence of the Traffic Volume



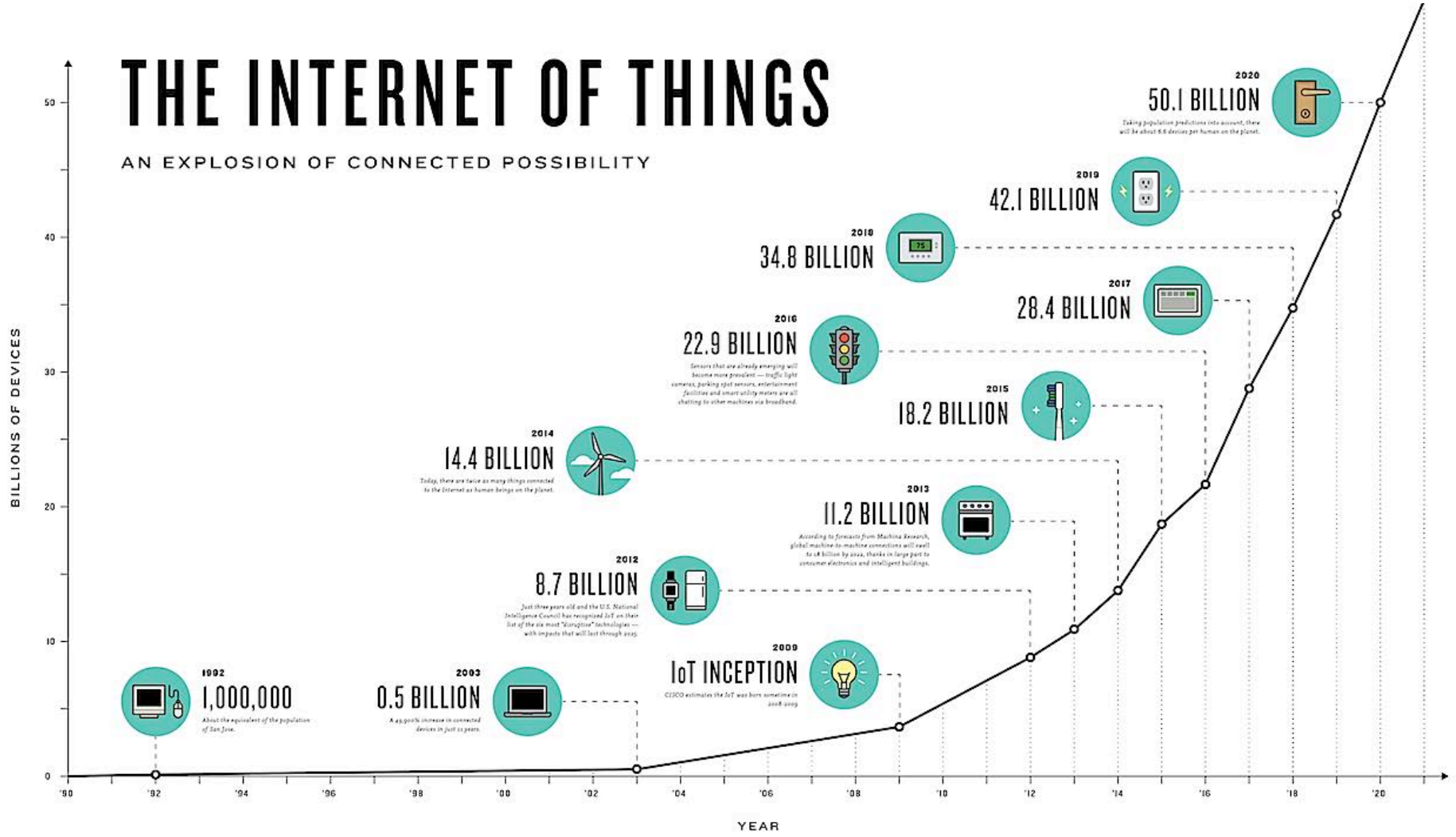
Gain in Performance

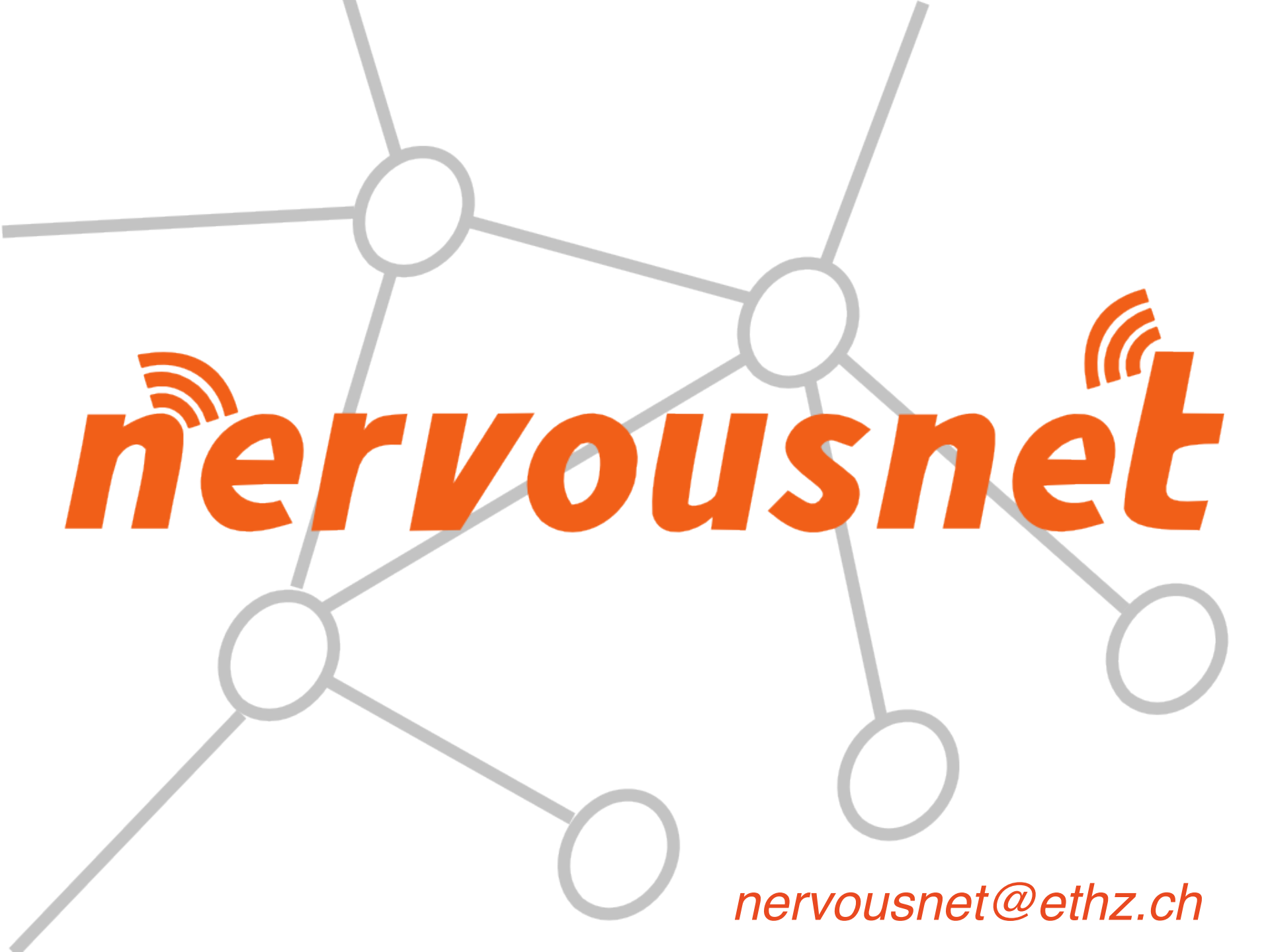


Socio-Ecological Finance FIN4+: Participatory sustainability


RESOURCES
MANUFACTURING
CONSUMPTION & USE
WASTE

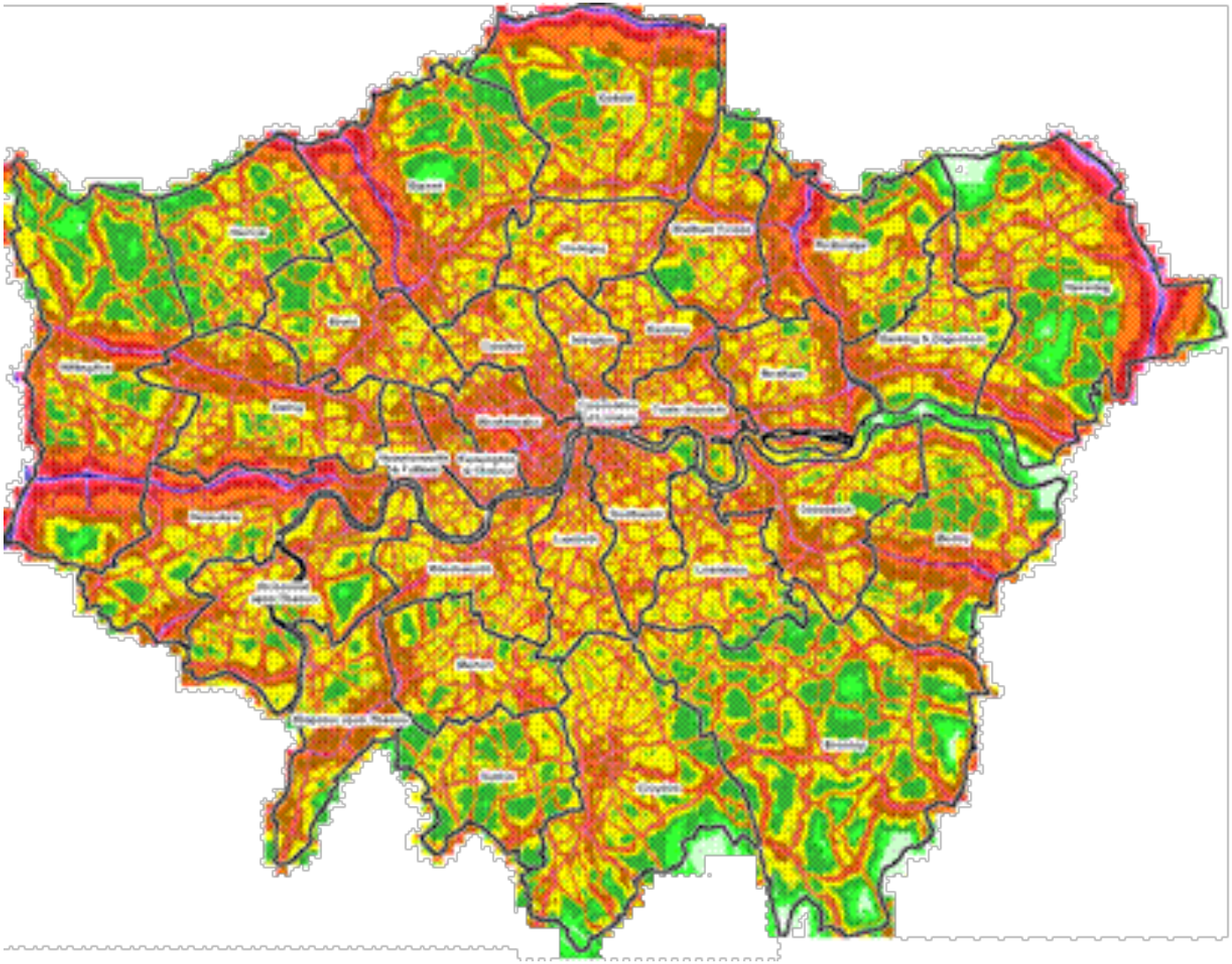

RESOURCES
MANUFACTURING
RECYCLING
CIRCULAR ECONOMY
WASTE
CONSUMPTION & USE


THE INTERNET OF THINGS
AN EXPLOSION OF CONNECTED POSSIBILITY
BILLIONS OF DEVICES
YEAR
1992
1,000,000
About the equivalent of the population of San Jose.
2003
0.5 BILLION
A 49,900% increase in connected devices in just 10 years.
2009
IoT INCEPTION
CISCO estimates the IoT was born sometime in 2008-2009
2012
8.7 BILLION
Just three years old and the U.S. National Intelligence Council has recognized IoT on their list of the six most "disruptive" technologies — with impacts that will last through 2025.
2013
11.2 BILLION
According to forecasts from Machina Research, global machine-to-machine connections will swell to 18 billion by 2024, thanks in large part to consumer electronics and intelligent buildings.
2014
14.4 BILLION
Today, there are twice as many things connected to the Internet as human beings on the planet.
2015
18.2 BILLION
2016
22.9 BILLION
Sensors that are already emerging will become more prevalent — traffic light cameras, parking spot sensors, entertainment facilities and smart utility meters are all chatting to other machines via broadband.
2017
28.4 BILLION
2018
34.8 BILLION
2019
42.1 BILLION
2020
50.1 BILLION
Taking population predictions into account, there will be about 6.6 devices per human on the planet.



nervousnet@ethz.ch

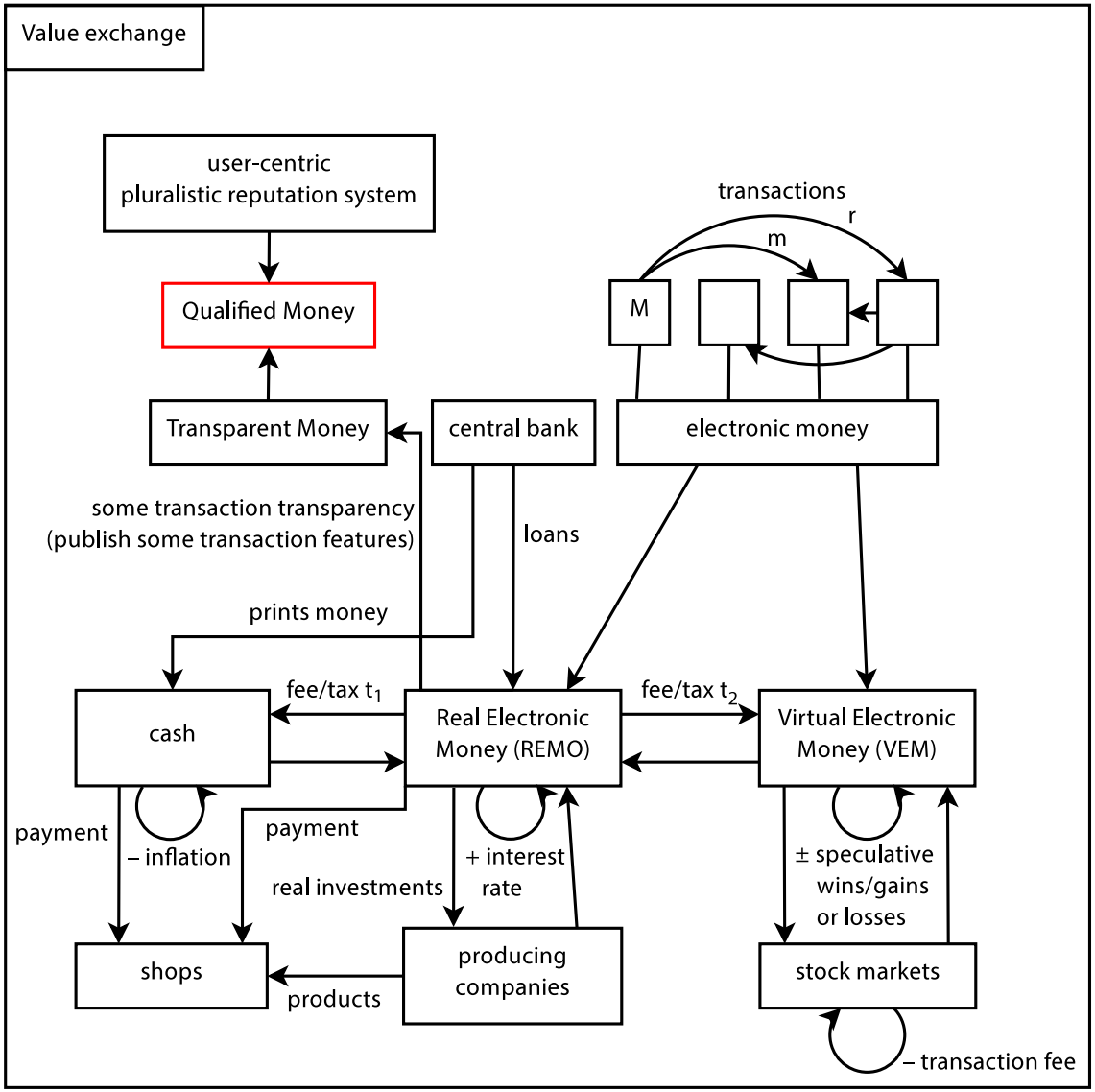
Mapping Noise and Other Externalities



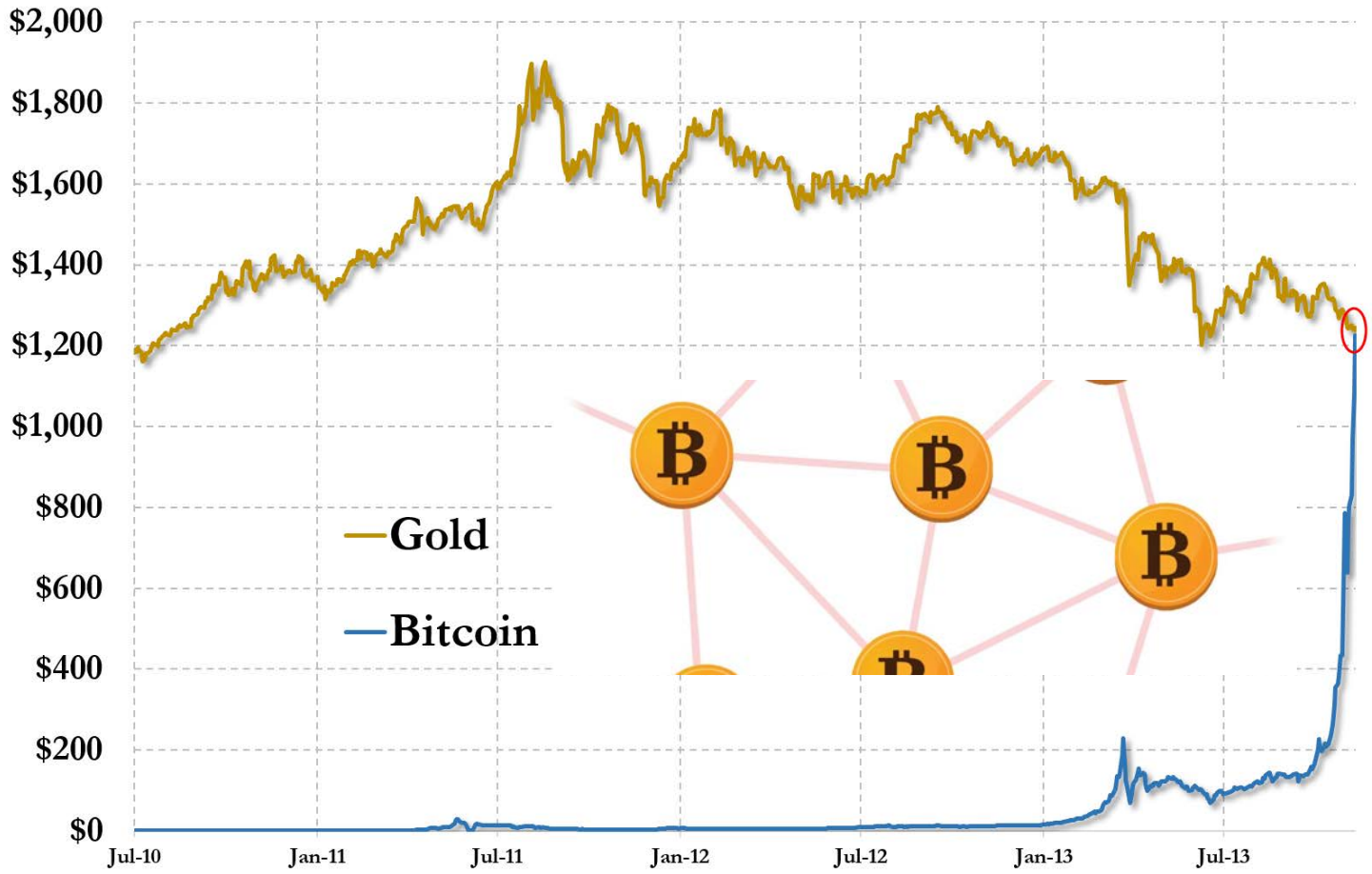
The No. 1 Principle

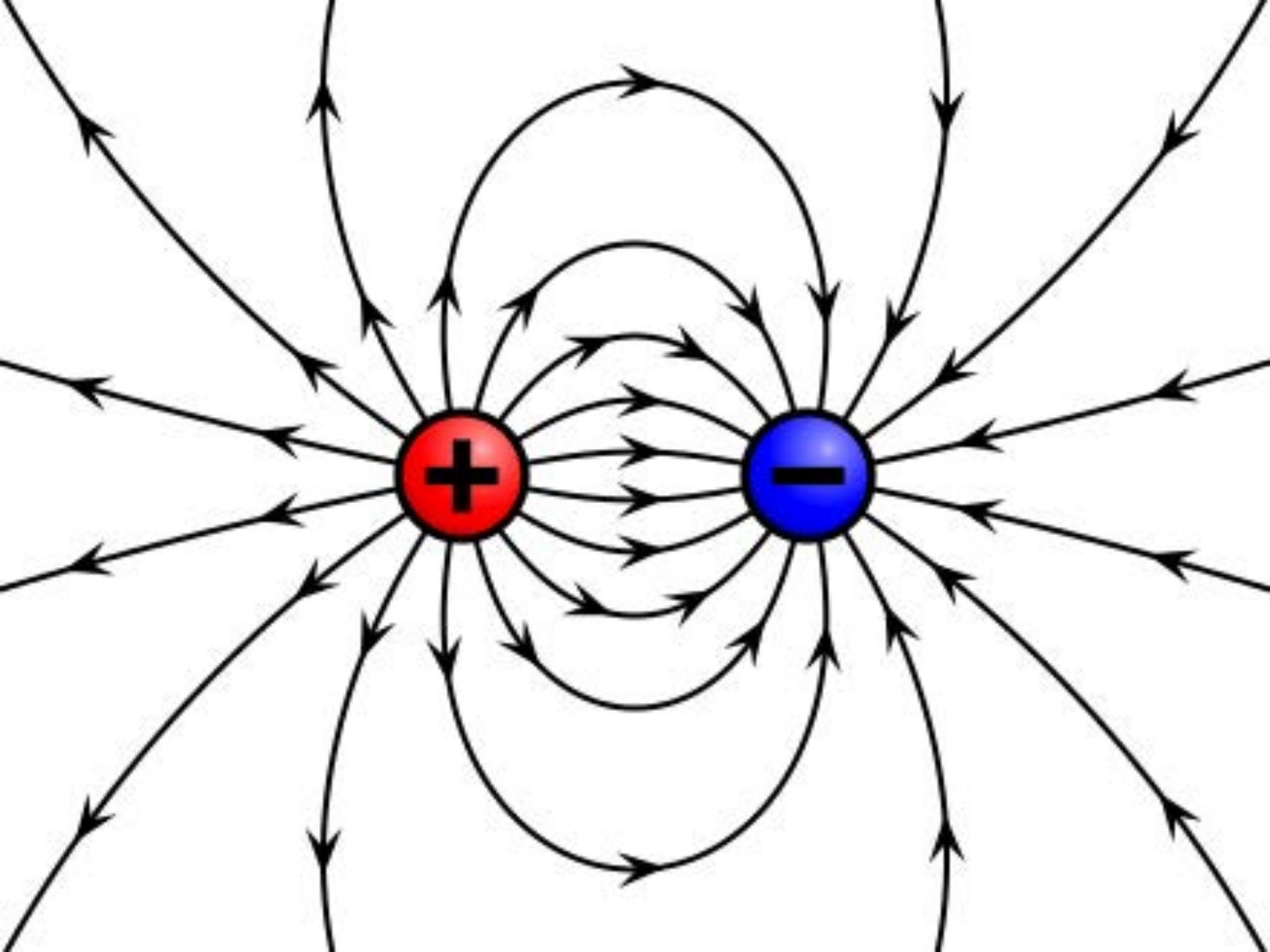
Increase positive externalities, reduce negative ones, and ensure fair compensation

Multi-Dimensional Reward System

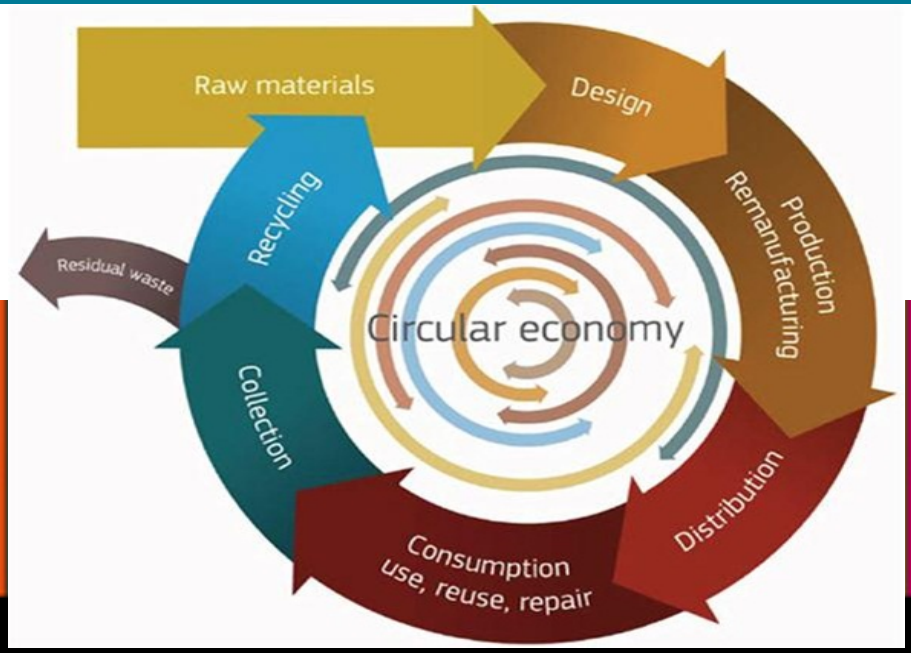


It is Now Possible to Create Such New Money(s), As BitCoin Has Shown





Circular Economy + Sharing Economy



A multi-dimensional approach

is a paradigm change





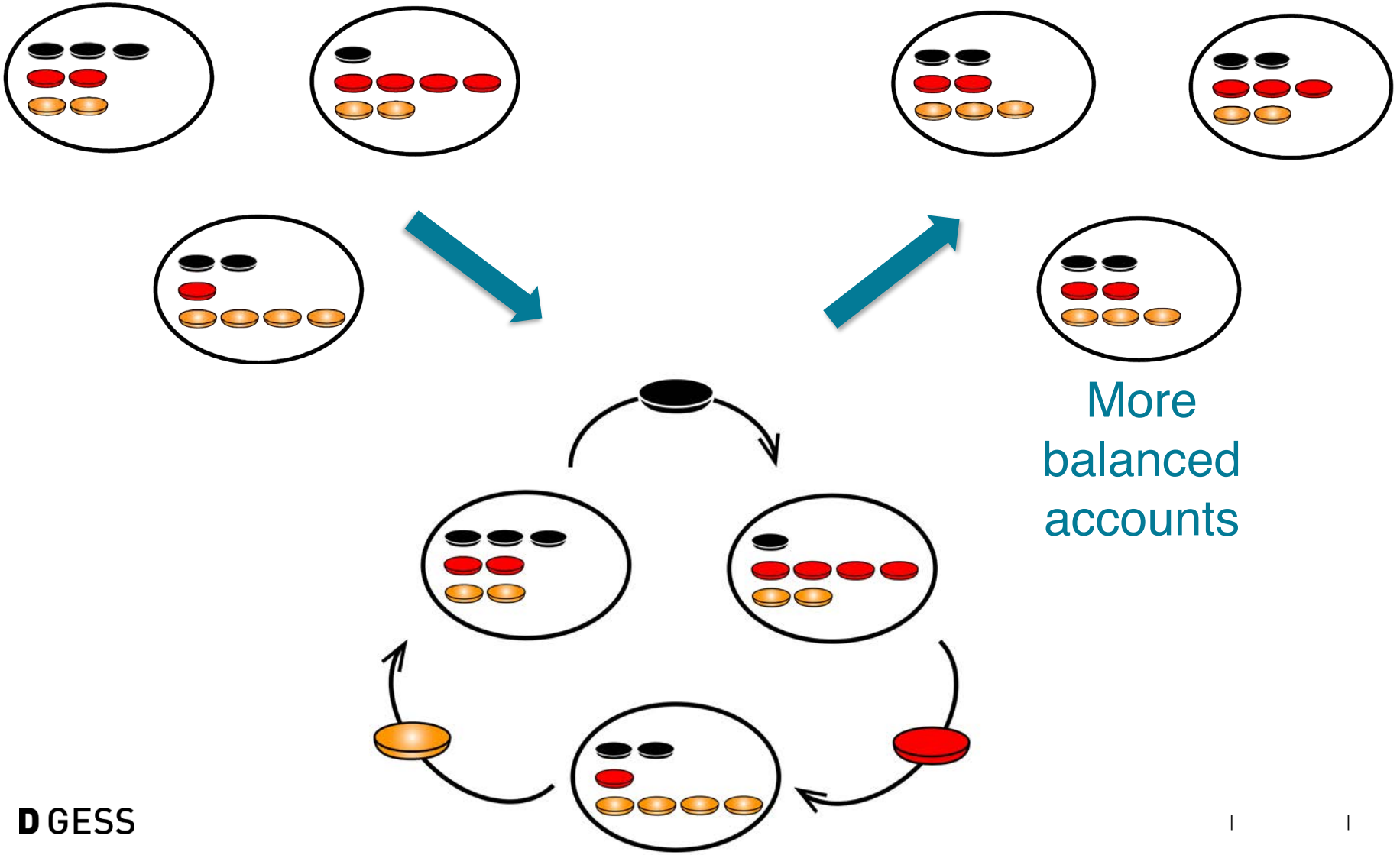


So Many Goals…

- Prosperity
- Sustainability
- Health
- Education
- Culture
- …

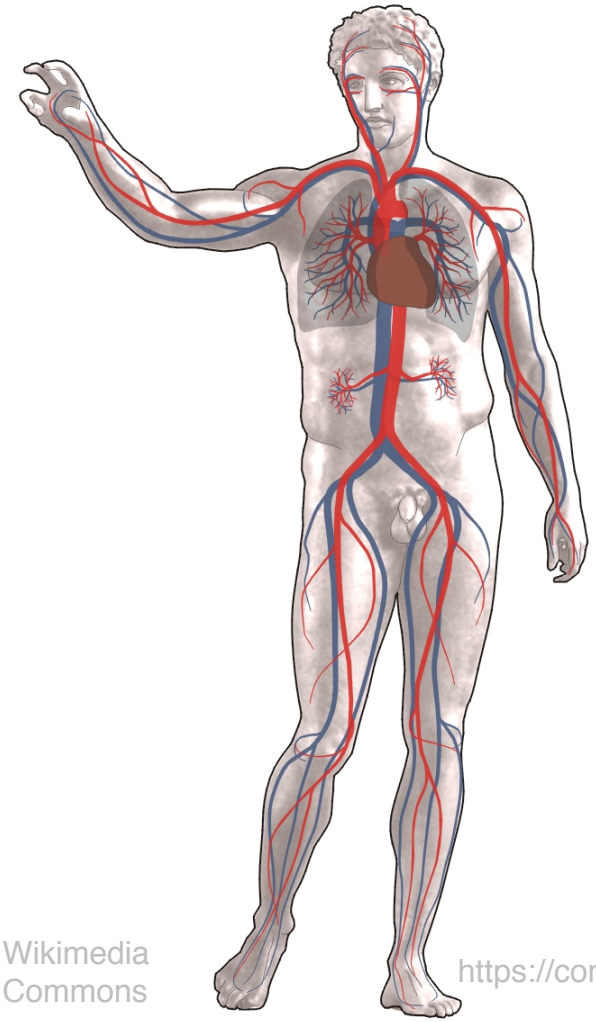
But optimization neglects all goals but one!

Finance 4.0: A Multi-Dimensional Finance System



With a multi-dimensional value (exchange) system, there are many more possibilities to find solutions that benefit all. The space of possible solutions is significantly increased.

Multi-Dimensional Feedback, Not One-Dimensional Control



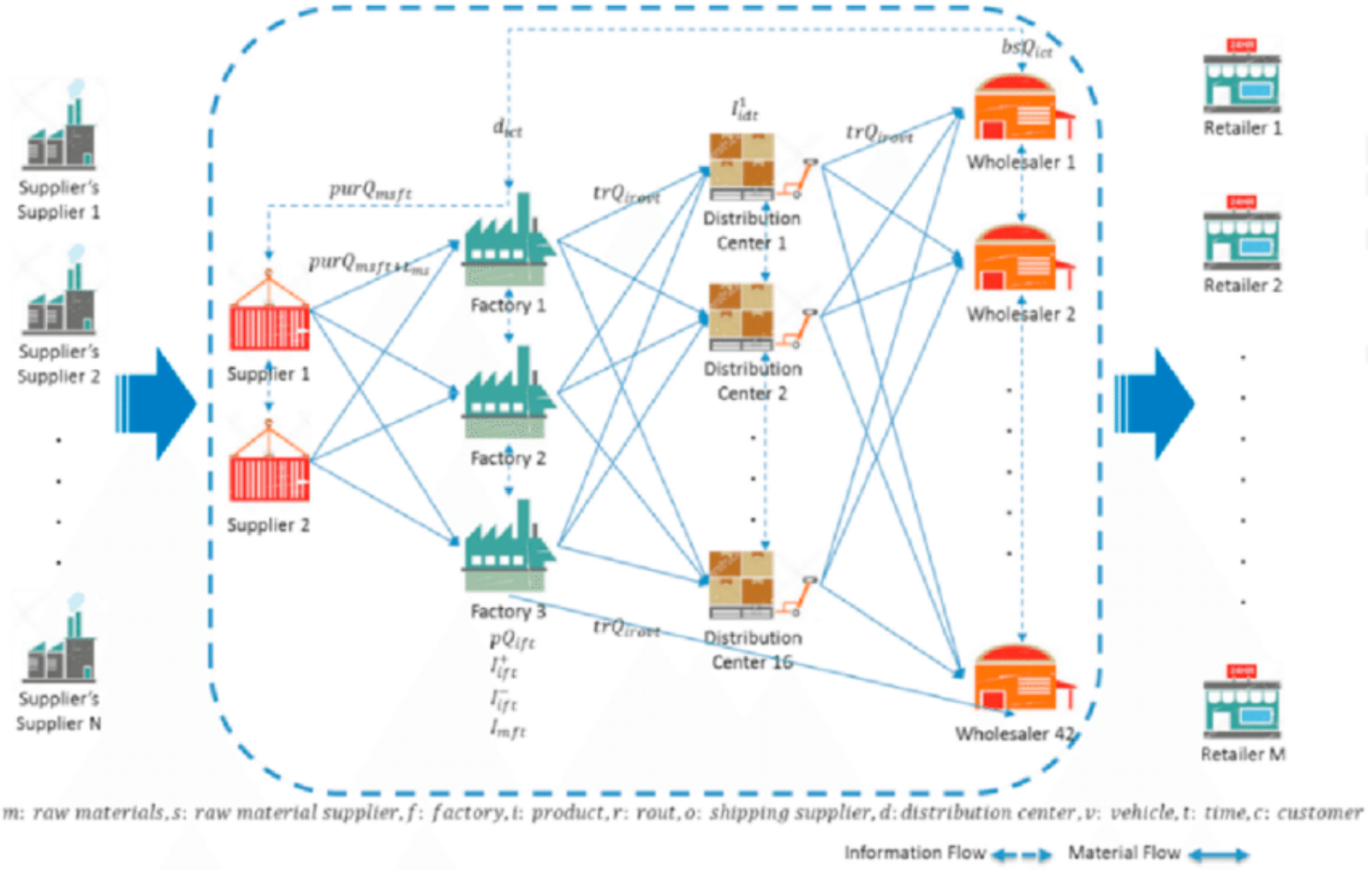
Wikimedia Commons

https://commons.wikimedia.org/wiki/File:Grafik_blutkreislauf.jpg

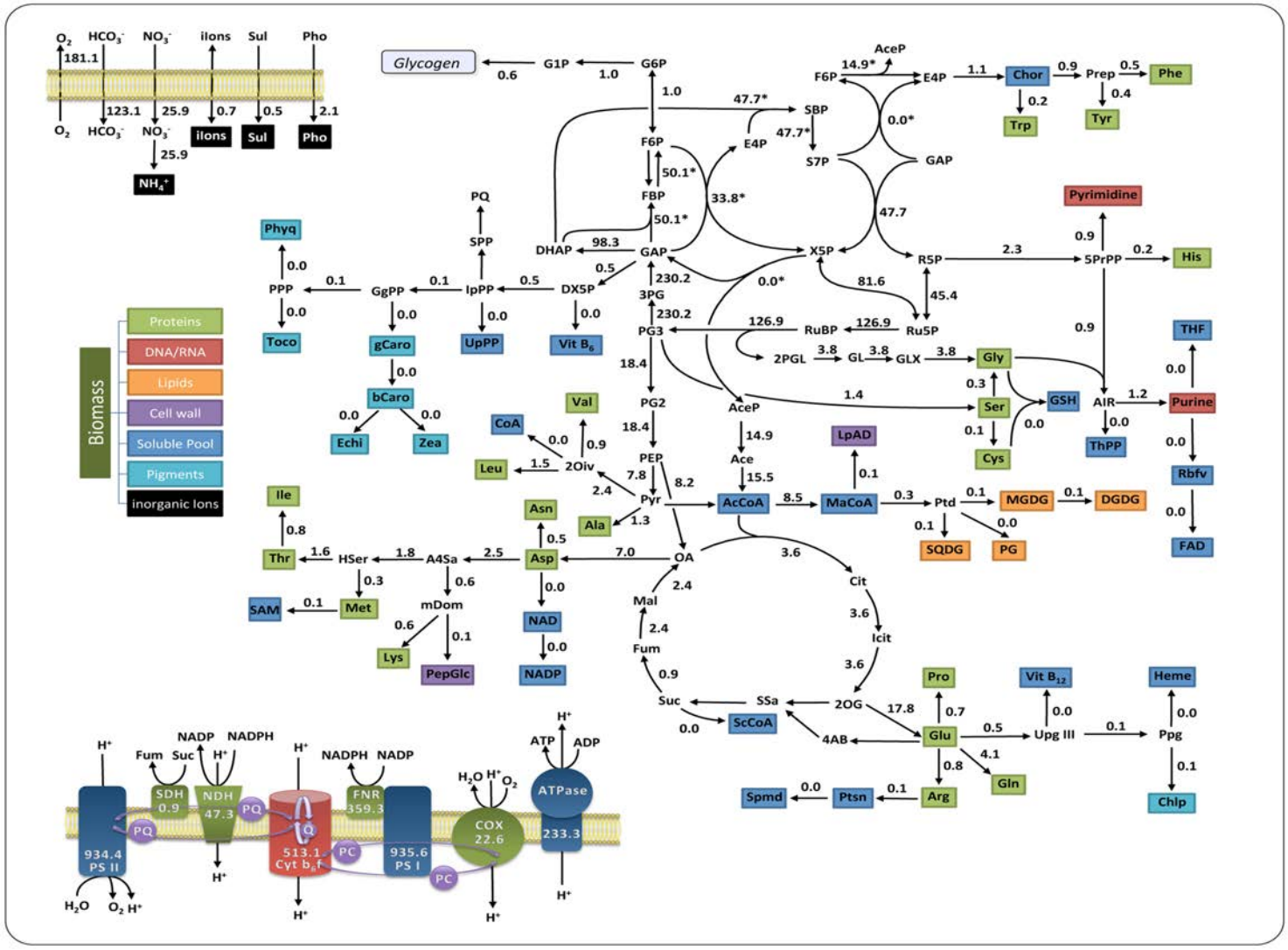
We are living not just on one thing, say water.

We need
- carbohydrates
- proteins
- vitamins
- minerals

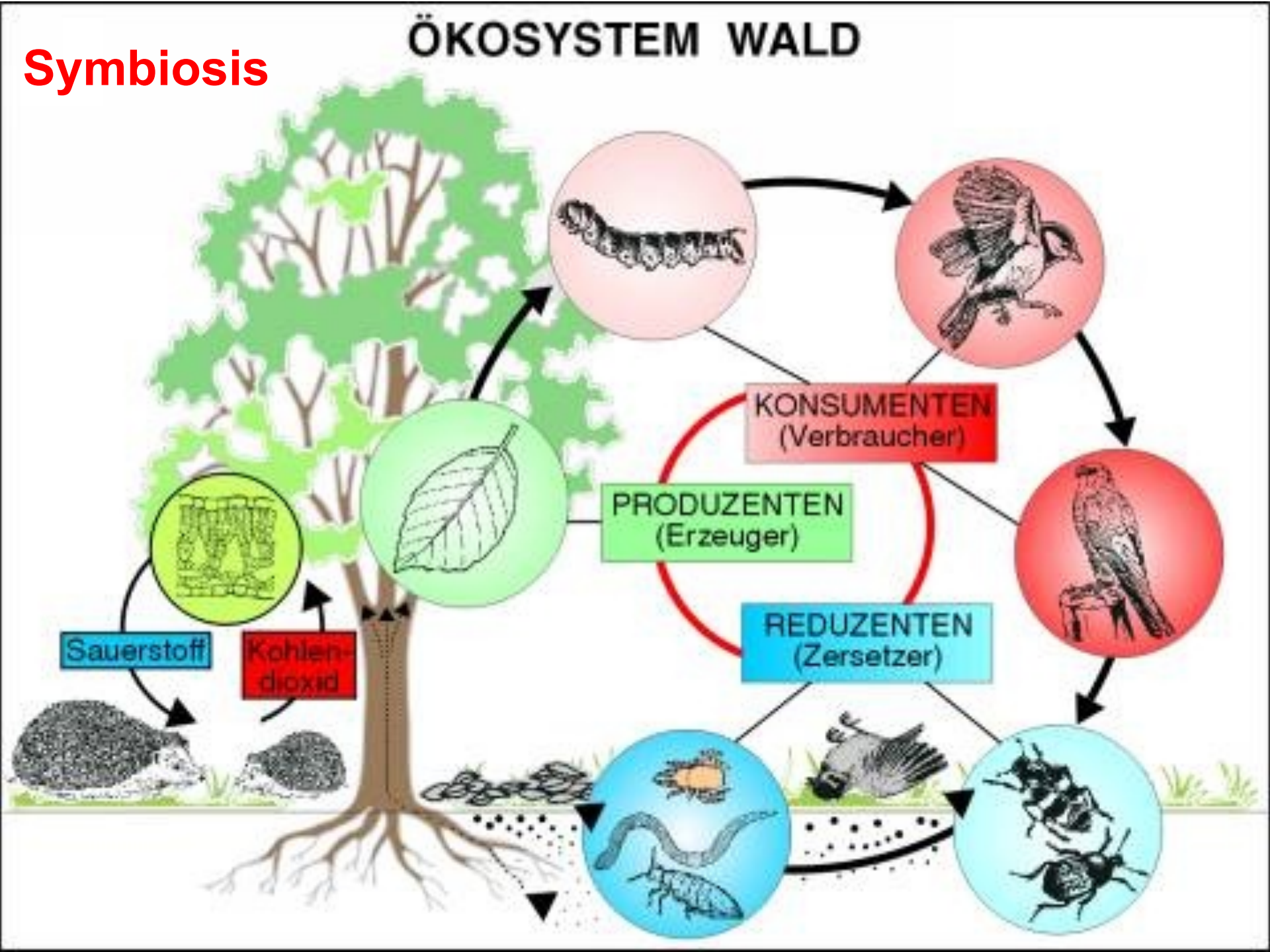
A Typical Supply Network Today



A Typical Metabolic Network



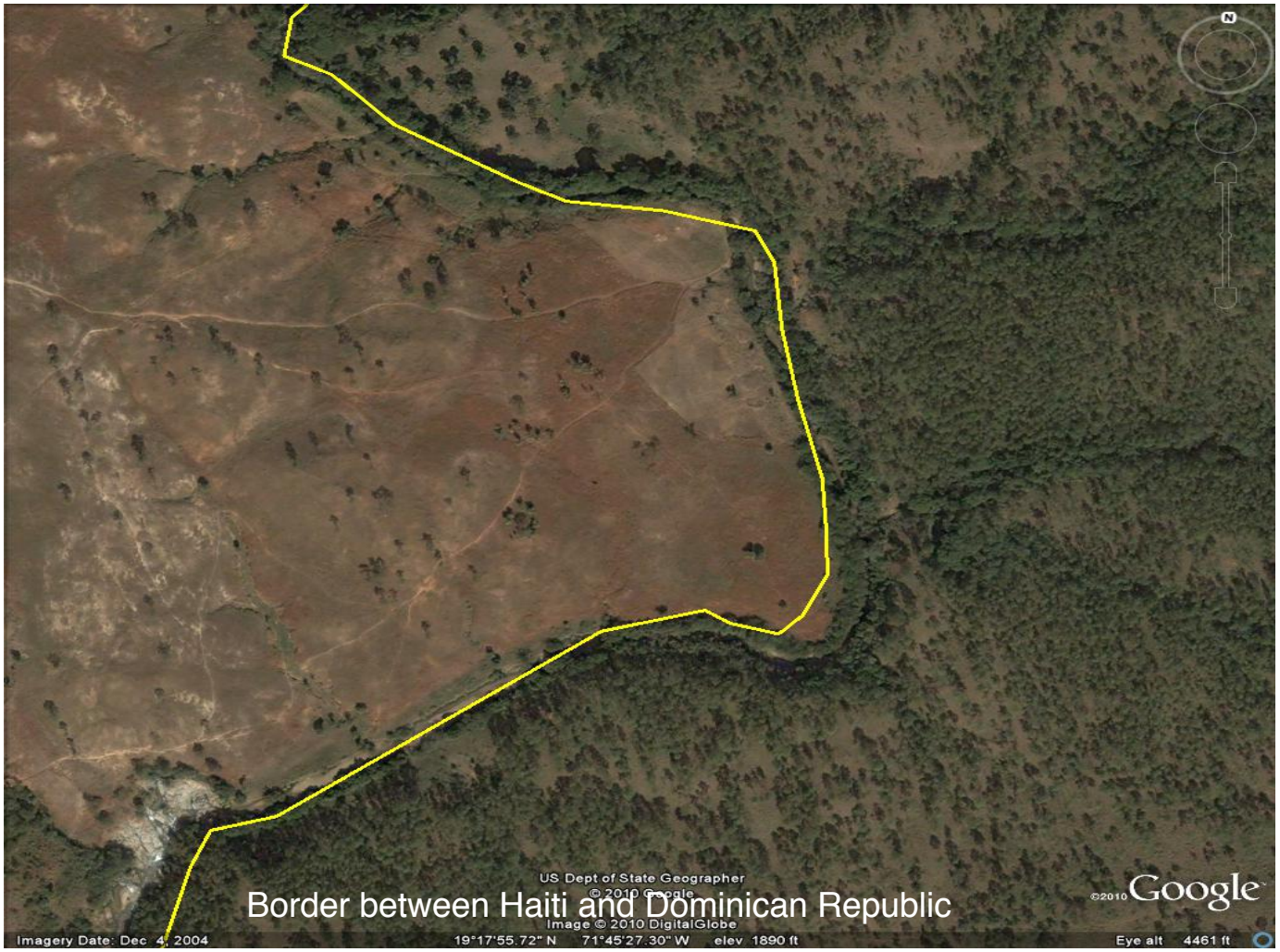
Symbiosis


ÖKOSYSTEM WALD
KONSUMENTEN
(Verbraucher)
PRODUZENTEN
(Erzeuger)
REDUZENTEN
(Zersetzer)
Sauerstoff
Kohlen-
dioxid

Social self-organization

Self-Governance Is Efficient, Given Proper Design Principles Are Followed

Tragedies of the Commons



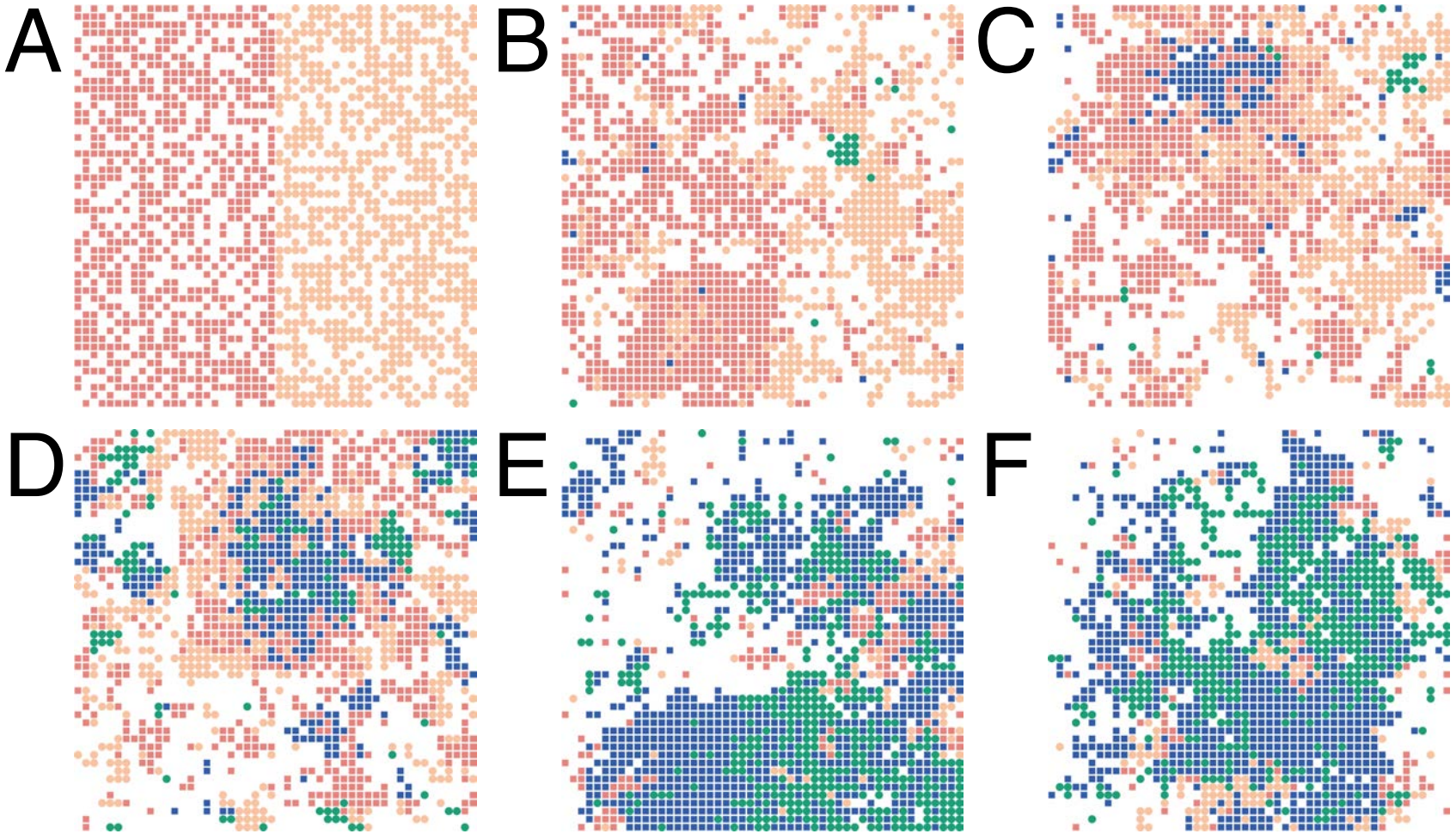
Border between Haiti and Dominican Republic

There are a number of decentralized mechanisms to promote cooperation and social order, and to overcome "tragedies of the commons"

Direct Reciprocity, Repeated Interactions

Reputation, Indirect Interactions

Emergence of “Networked Thinking”



T. Grund, C. Waloszek, DH, Scientific Reports 3, 1480 (2013)

From collective intelligence to digital democracy

A *NEW YORK TIMES* BUSINESS BESTSELLER

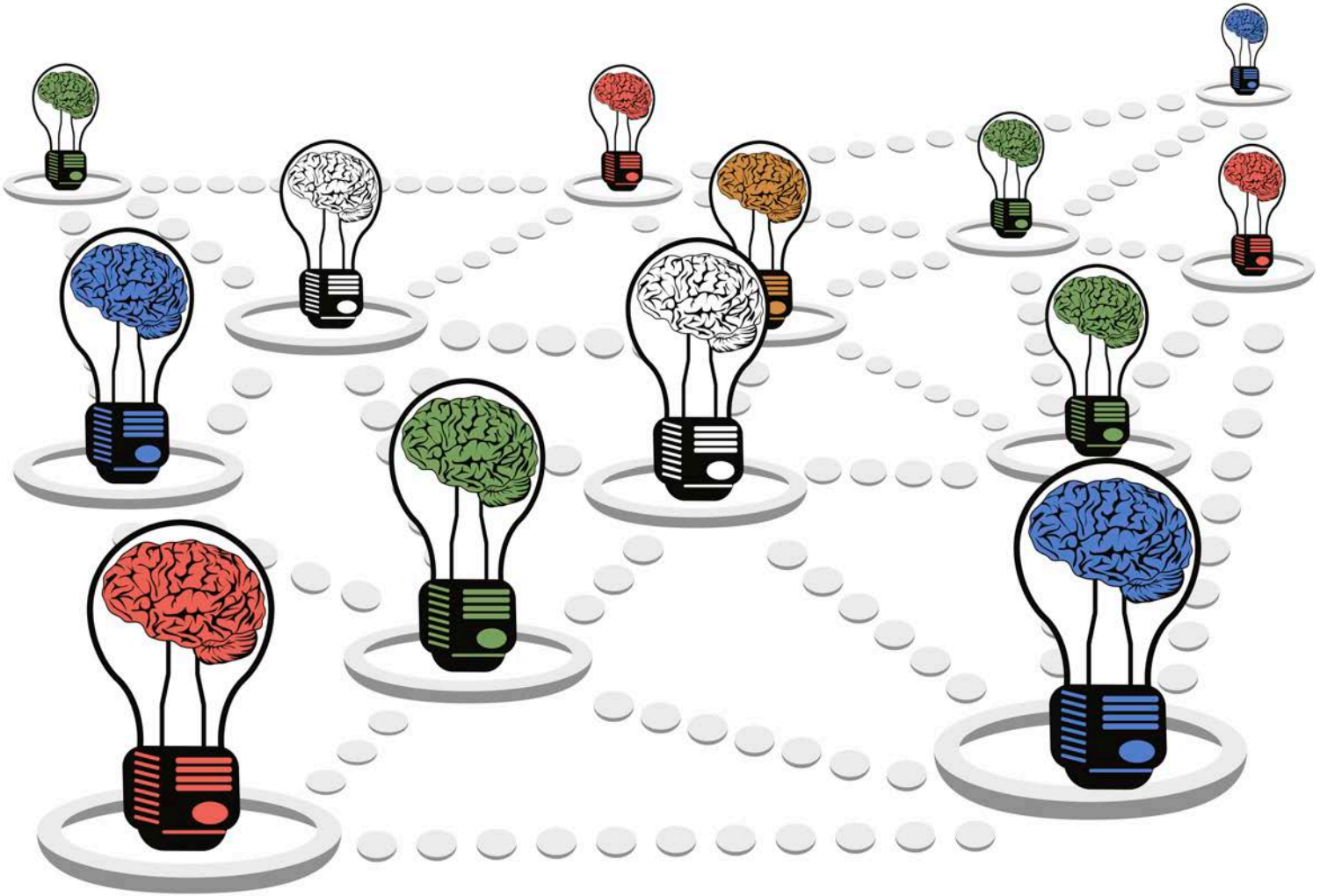
"As entertaining and thought-provoking as *The Tipping Point* by Malcolm Gladwell. . . . *The Wisdom of Crowds* ranges far and wide."
—*The Boston Globe*

THE WISDOM OF CROWDS

JAMES SUROWIECKI

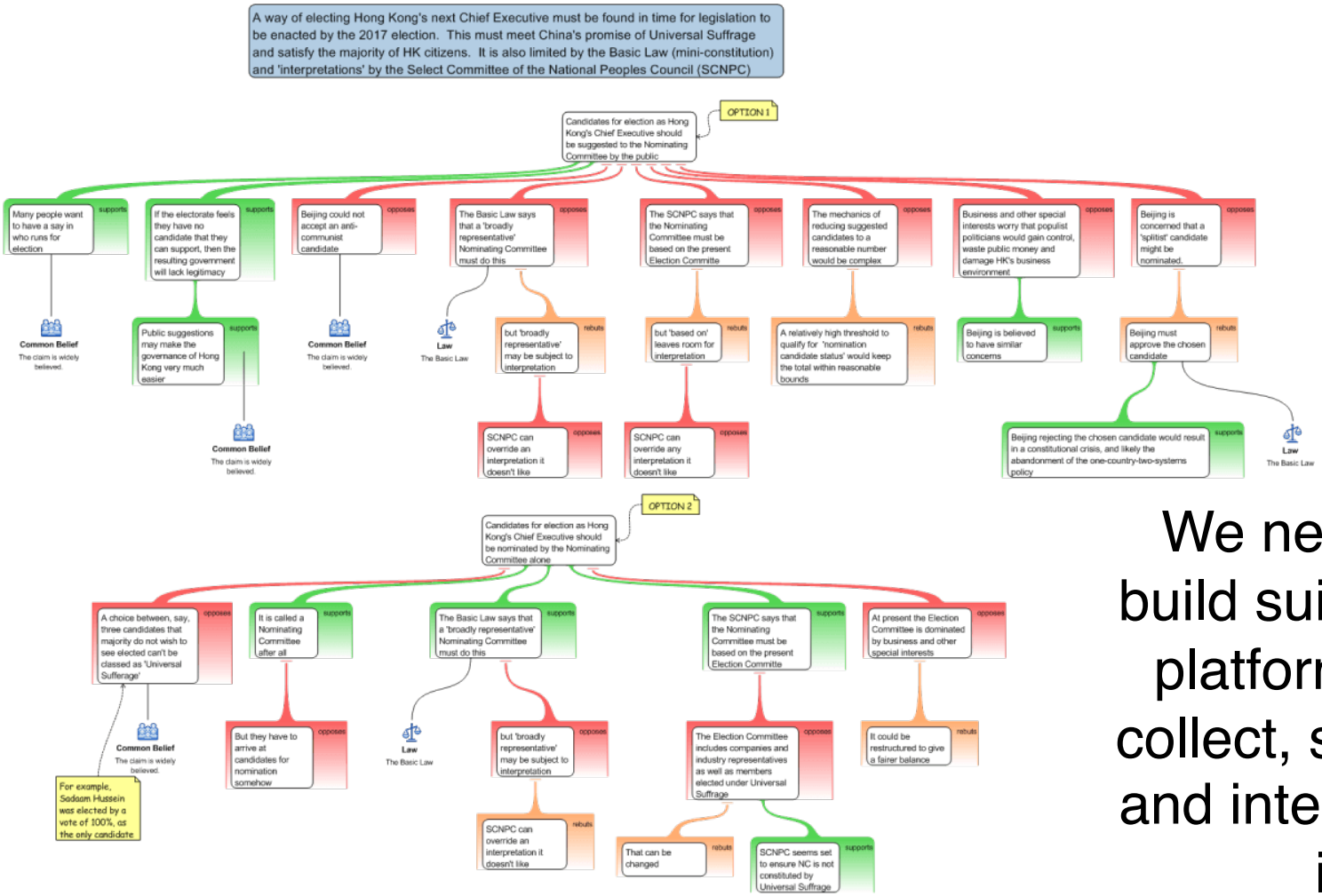
WITH A NEW AFTERWORD BY THE AUTHOR

Bring the Best Ideas of Many Minds Together, But How?



http://medialniproroci.blogspot.ch/2013/04/sharing-is-new-shoppingand-working.html

Massive Online Deliberation Platforms (MOODs)



We need to build suitable platforms to collect, share and integrate ideas

Combine Different Perspectives

REPORT

Evidence for a Collective Intelligence Factor in the Performance of Human Groups

Anita Williams Woolley[1,*], Christopher F. Chabris[2,3], Alex Pentland[3,4], Nada Hashmi[3,5], Thomas W. Malone[3,5]

+ See all authors and affiliations

Science 29 Oct 2010:
Vol. 330, Issue 6004, pp. 686-688
DOI: 10.1126/science.1193147

Meeting of Minds

The performance of humans across a range of different kinds of cognitive tasks has been encapsulated as a common statistical factor called *g* or general intelligence factor. What intelligence actually is, is unclear and hotly debated, yet there is a reproducible association of *g* with performance outcomes, such as income and academic achievement. **Woolley *et al.*** (p. **686**, published online 30 September) report a psychometric methodology for quantifying a factor termed "collective intelligence" (*c*), which reflects how well groups perform on a similarly diverse set of group problem-solving tasks. The primary contributors to *c* appear to be the *g* factors of the group members, along with a propensity toward social sensitivity—in essence, how well individuals work with others.

Diversity Wins, Not the Best

Leaderboard

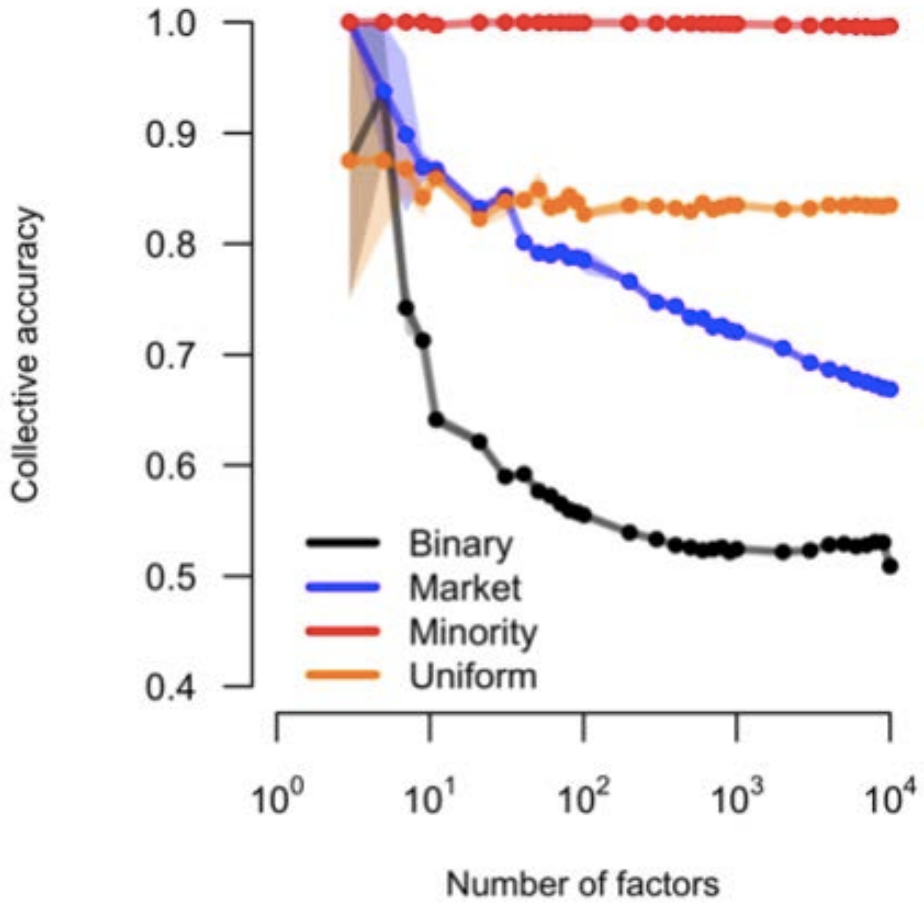
Display top 20 leaders.

Rank	Team Name	Best Score	% Improvement	Last Submit Time
1	BellKor's Pragmatic Chaos	0.8558	10.05	2009-06-26 18:42:37
Grand Prize - RMSE <= 0.8563				
2	PragmaticTheory	0.8582	9.80	2009-06-25 22:15:51
3	BellKor in BigChaos	0.8590	9.71	2009-05-13 08:14:09
4	Grand Prize Team	0.8593	9.68	2009-06-12 08:20:24
5	Dace	0.8604	9.56	2009-04-22 05:57:03
6	BigChaos	0.8613	9.47	2009-06-23 23:06:52
Progress Prize 2008 - RMSE = 0.8616 - Winning Team: BellKor in BigChaos				
7	BellKor	0.8620	9.40	2009-06-24 07:16:02
8	Gravity	0.8634	9.25	2009-04-22 18:31:32
9	Opera Solutions	0.8638	9.21	2009-06-22 05:53:30
10	xlvector	0.8639	9.20	2009-06-26 13:49:04
11	xiangliang	0.8639	9.20	2009-06-26 07:47:34
12	BruceDengDaoCiYiYou	0.8641	9.18	2009-06-02 17:08:31
13	Ces	0.8642	9.17	2009-06-24 14:34:14
14	majia2	0.8642	9.17	2009-06-23 08:07:50

Top-down and majority decisions obstruct collective intelligence

Wisdom of crowds requires independent exploration and then integration

Optimal Incentives: ”Minorities Report” Strategy Can Outperform Yes/No-Democracies and Markets!



R. Mann and DH: Optimal Incentives for Collective Intelligence, PNAS (2017)

Phase 1: Independent exploration

Phase 2: Information exchange

Phase 3: Integration

Phase 4. Voting

Notes: This is not about winning! It's about finding solutions that work for many people.

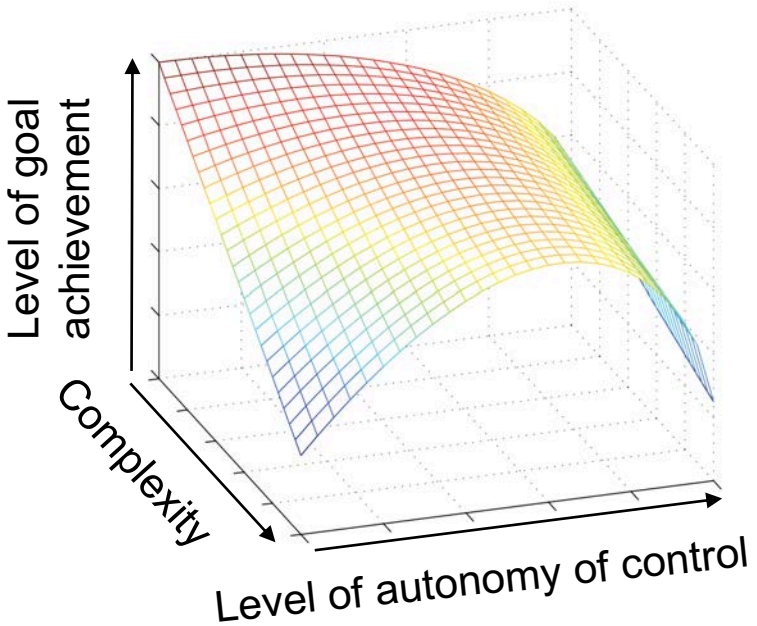
Not everyone must do the same, in fact, shouldn't!.

Everybody can play a different role to achieve a good solution.

The New Paradigm

Centralized Control and Its Limits

- Advantage of centralized control is large-scale coordination
- Disadvantages are due to
  - vulnerability of the network
  - information overload
  - wrong selection of control parameters
  - delays in adaptive feedback control
- Decentralized control can perform better in complex systems with heterogeneous elements, large degree of fluctuations, and short-term predictability, because of greater flexibility to local conditions and greater robustness to perturbations



(Windt, Böse, Philipp, 2006)

The Sustainability Challenges Call for A More Resilient Society

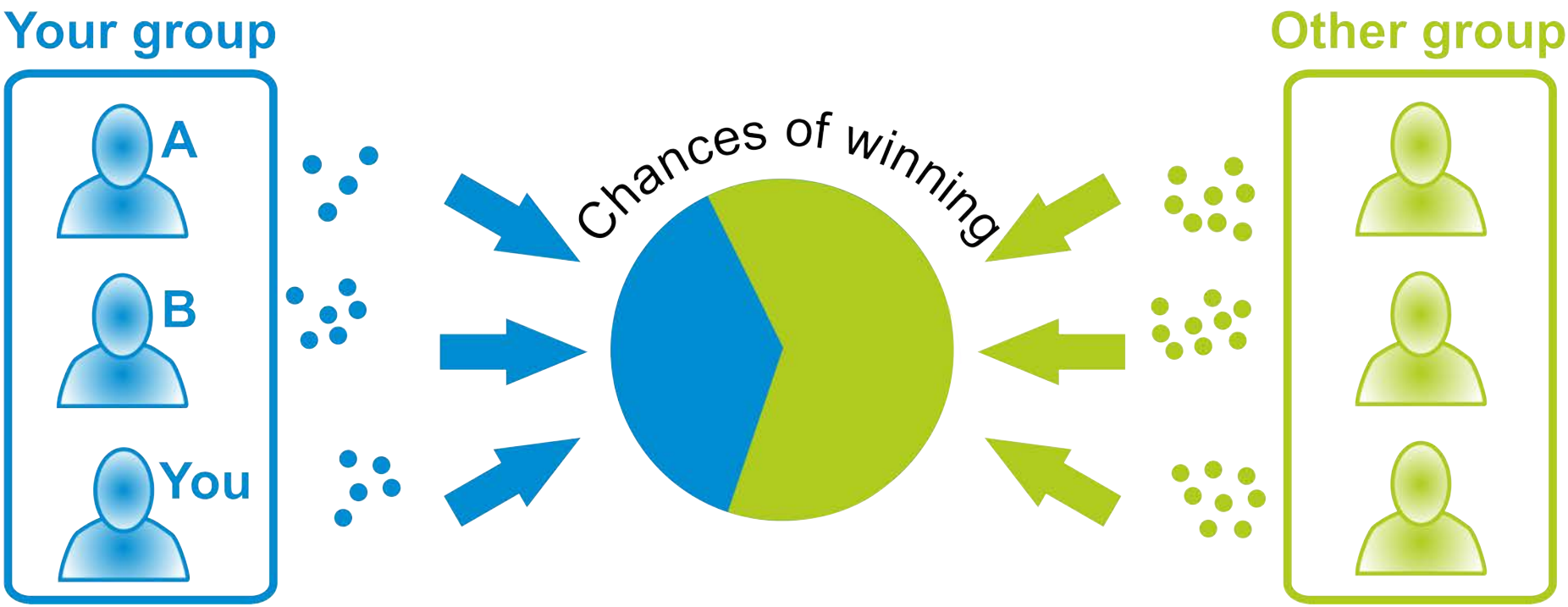
Cities and regions are relevant organizational units for a resilient society

Countering Global Problems Bottom-Up: City Olympics for Better Energy, Envioronmental and Climate Solutions

Catalyse mutual benefits


1
2
3
4
5
6
7
8
9

Competition Naturally Raises Everybody's Effort



Joint work of Michael Mäs and Dirk Helbing

Combining Competition and Cooperation

Combining the Success Principles of Various Systems

- Competition (capitalism)
- Collective intelligence (democracy)
- Experimentation and selection (evolution, nature)
- Intelligent design (AI)

THE CLIMATE CITY CUP

POWERED BY Climathon and FuturICT 2.0

Climate City Cup

Let's win together !

mobility

BIKE TO WORK

200km/h

recycling

#Hack4Climate

plants

#Hack4Climate 2017 was a success, with 100 hackers from 33 countries and 50 experts/partners. Check out the official -> after movie & -> best pictures. Get engaged by signing up for the newsletter, by contacting us per -> email and by following us on social media.

And stay tuned for #Hack4Climate 2018 at COP24.

Dates: 3-12/12/2018
Location: -> Katowice Poland
Presidency/more info: -> Polish Government

G20

nuclear energy

stay tuned with our newsletter:

newsletter.email

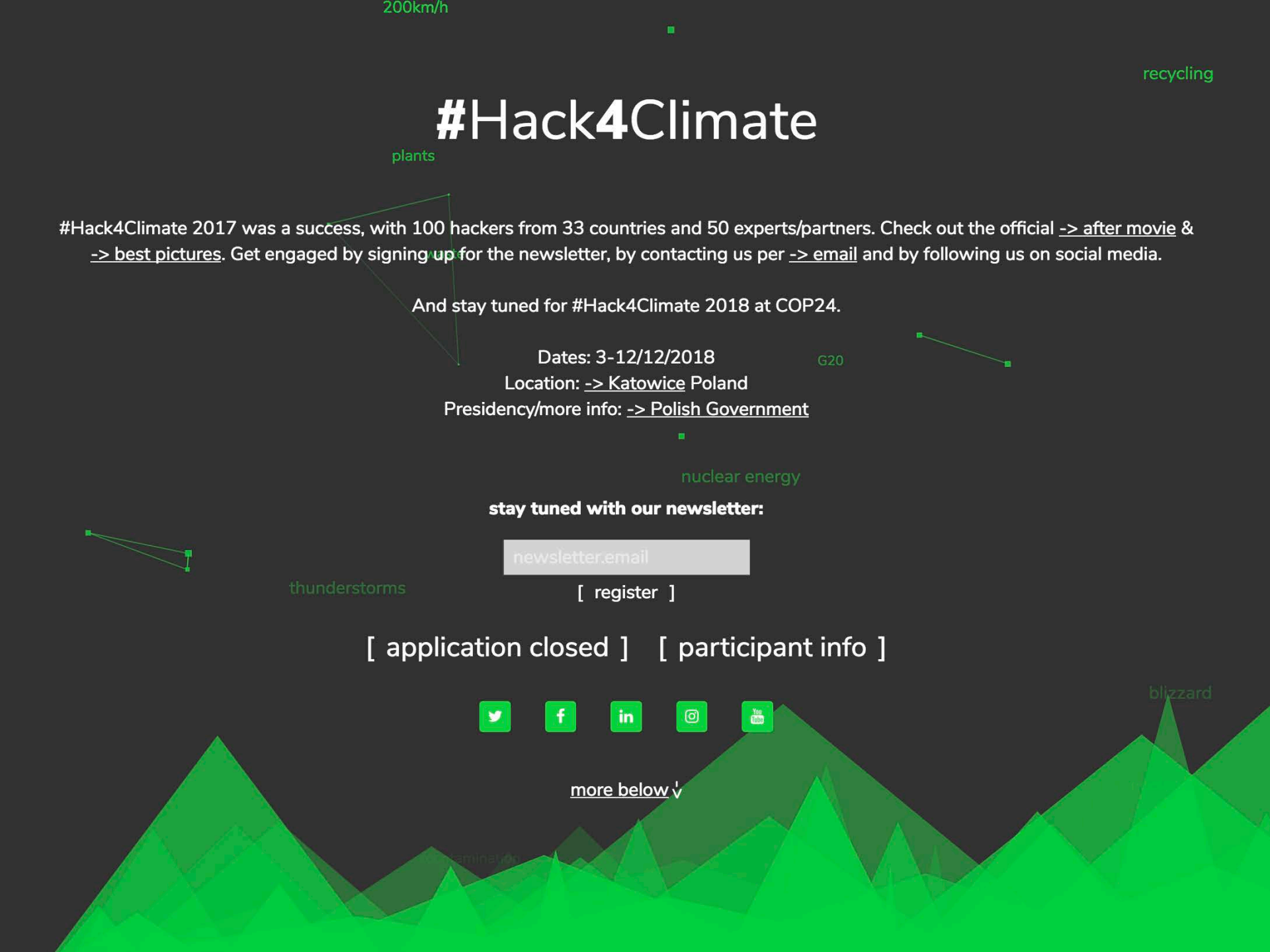
[register]

thunderstorms

[application closed] [participant info]

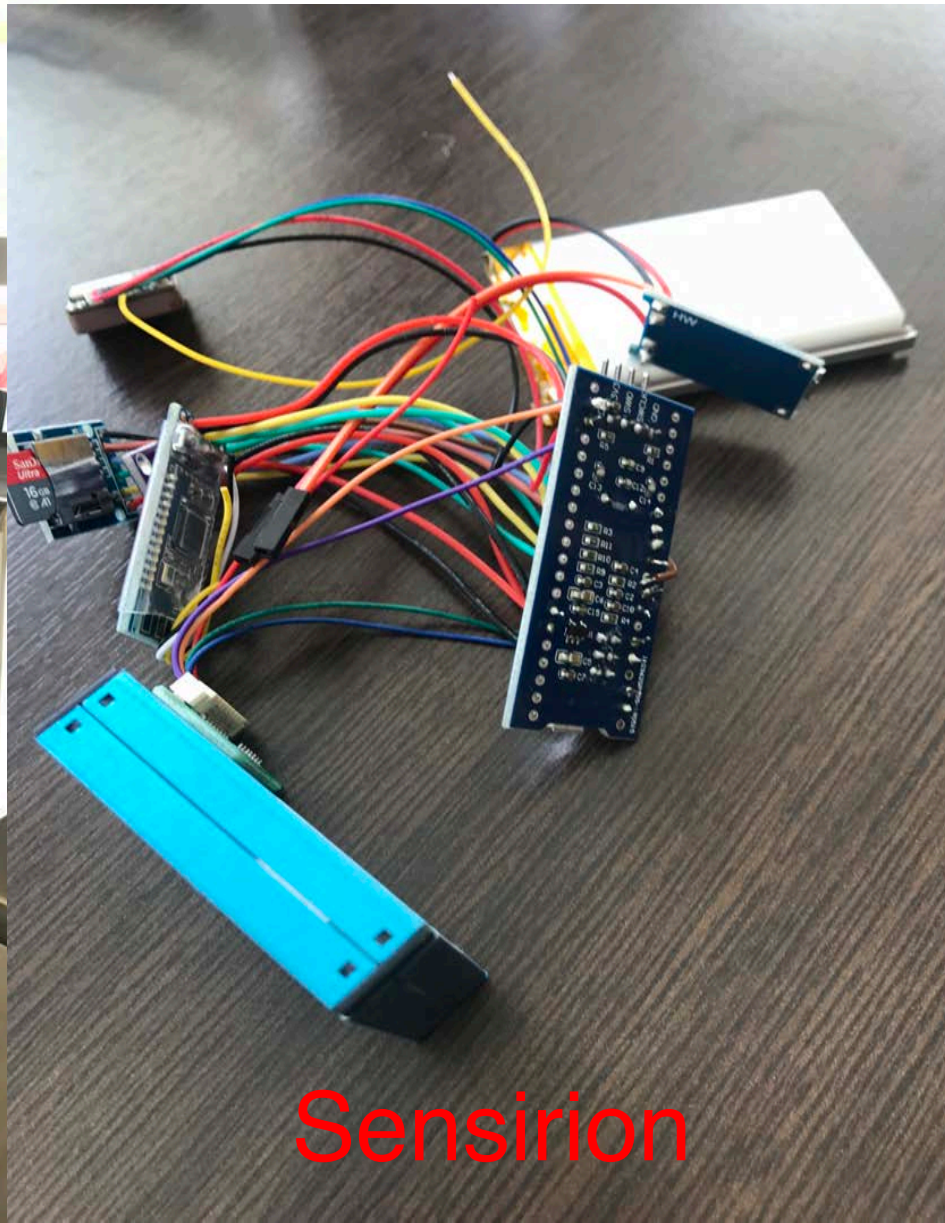
blizzard

more below



BLOCKCHAIN AND IOT SCHOOL

ETH ZÜRICH | 12-16 FEBRUARY | 2018



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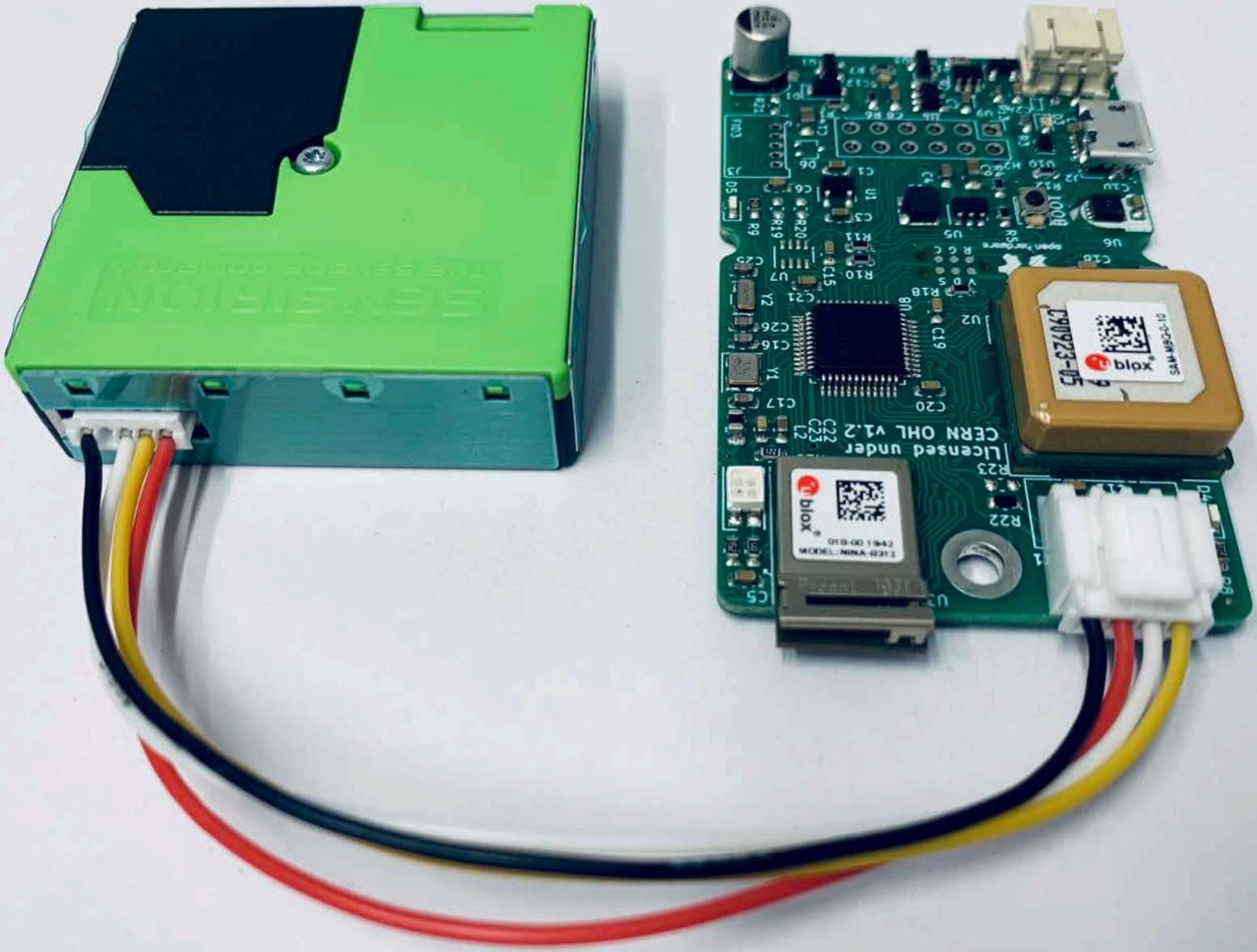
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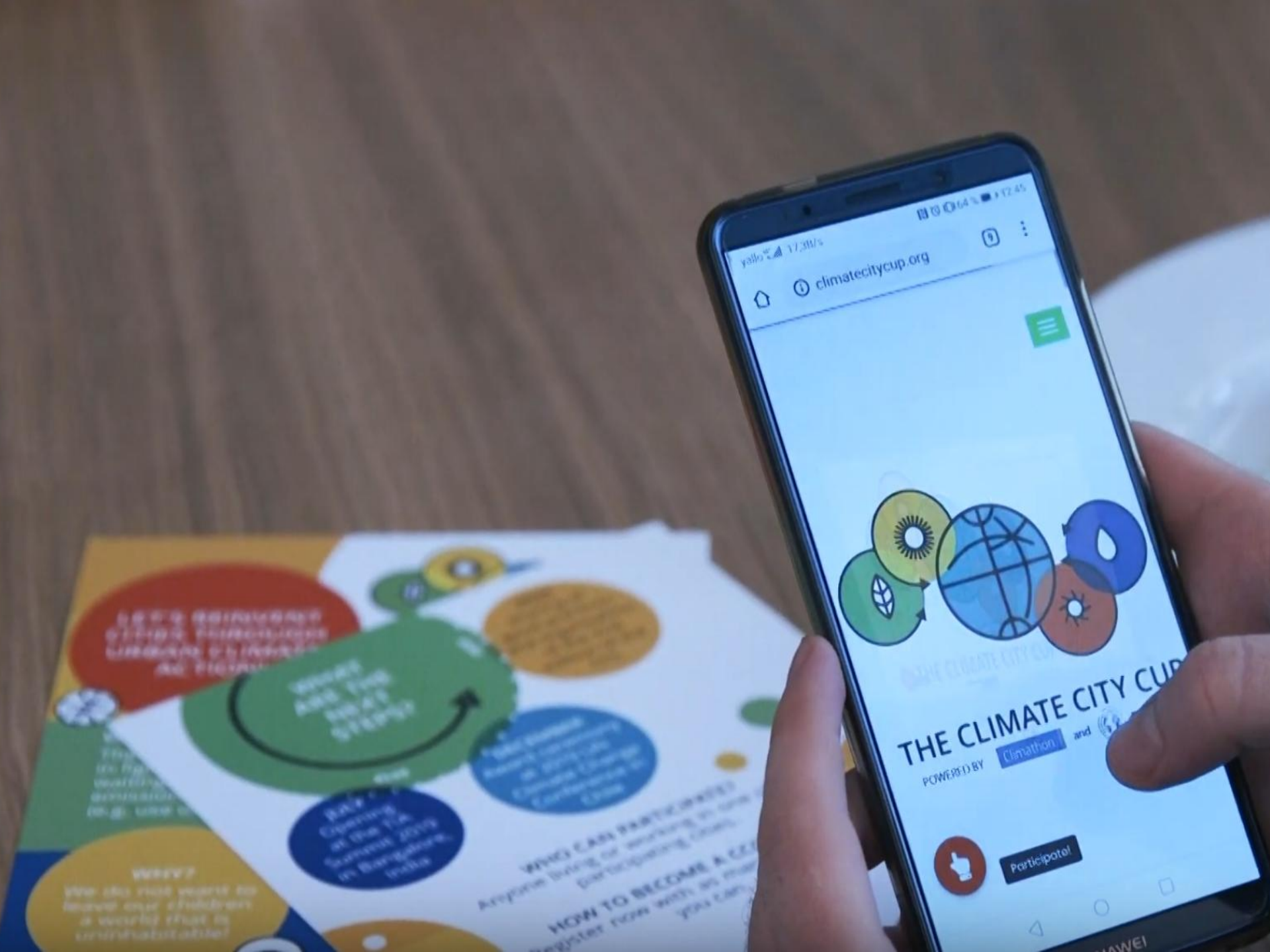
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Kyrgyzstan
Tajikistan
Tunisia
Syria
Iraq
Iran
Afghanistan
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Pakistan
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Algeria
Libya
Egypt
Saudi Arabia
Bangladesh
India
Niger
Mali
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Sudan
Eritrea
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Leaflet | Mapunity | Map Data © OpenStre

Glocalisation Rather than Globalisation

- Think global
- Act local (and diverse)
- Experiment
- Learn from each other
- Help each other

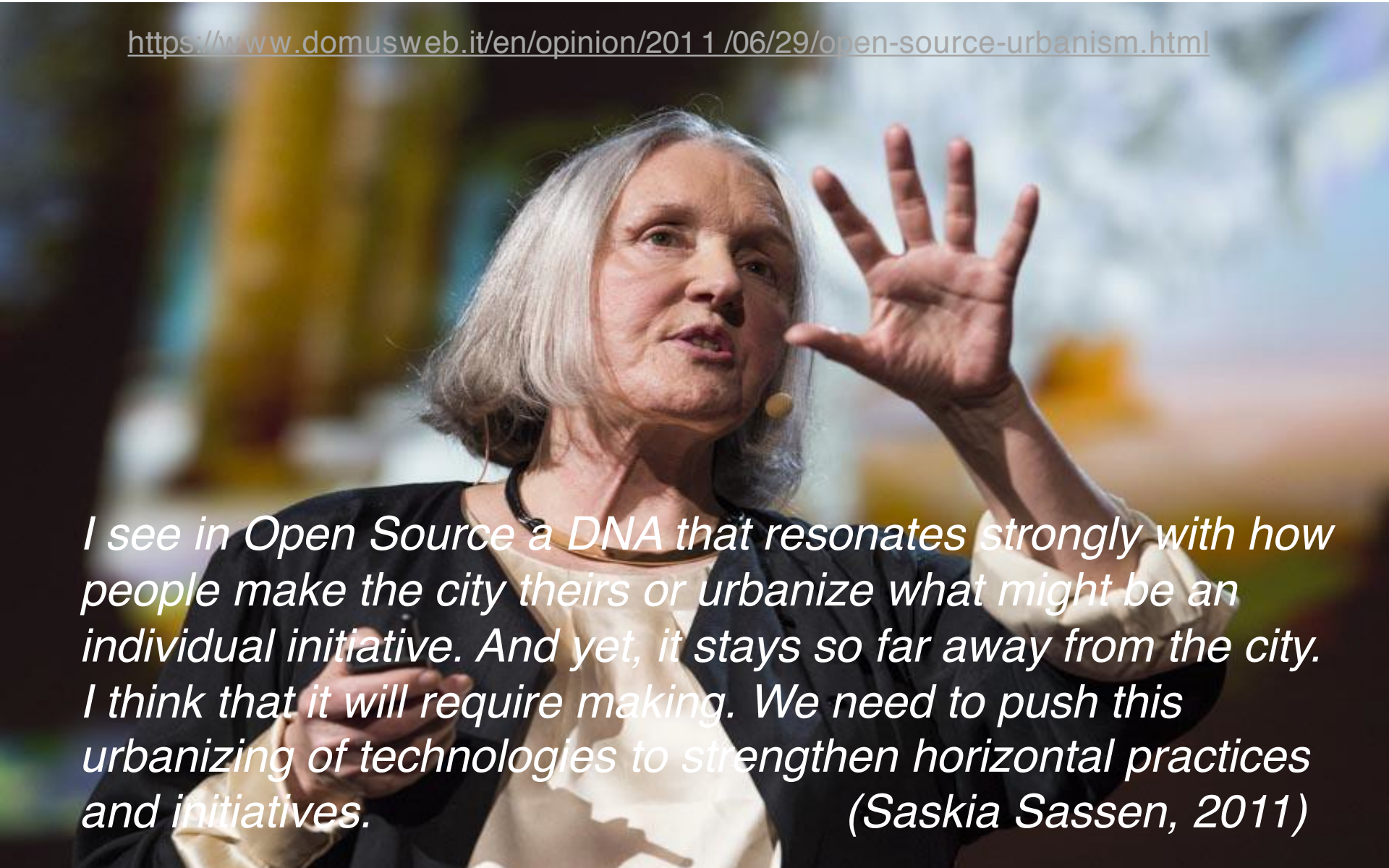
ETH zürich

The Emerging Concept of Open Source Urbanism

Sergei Zhilin
PhD Candidate
TU Delft, The Netherlands

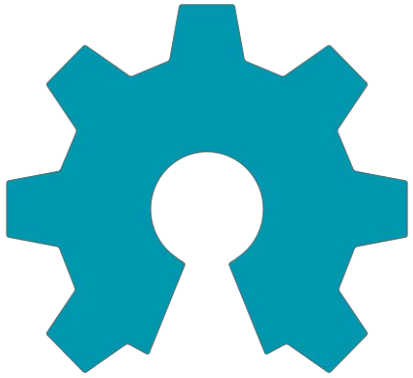
“Open Source Urbanism” in “New City Reader”

https://www.domusweb.it/en/opinion/2011/06/29/open-source-urbanism.html

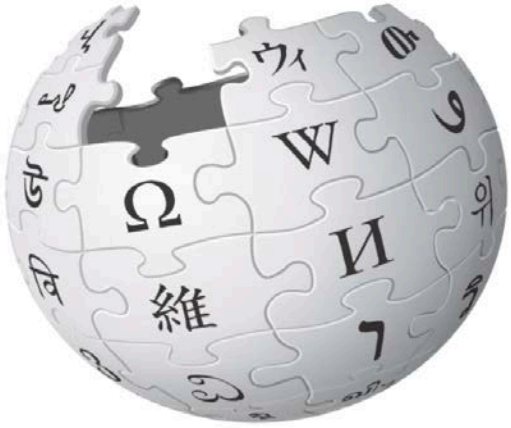


I see in Open Source a DNA that resonates strongly with how people make the city theirs or urbanize what might be an individual initiative. And yet, it stays so far away from the city. I think that it will require making. We need to push this urbanizing of technologies to strengthen horizontal practices and initiatives. *(Saskia Sassen, 2011)*

creative commons



open source hardware



WIKIPEDIA
The Free Encyclopedia

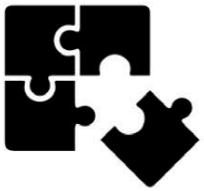
open source architecture

GitHub

Openness

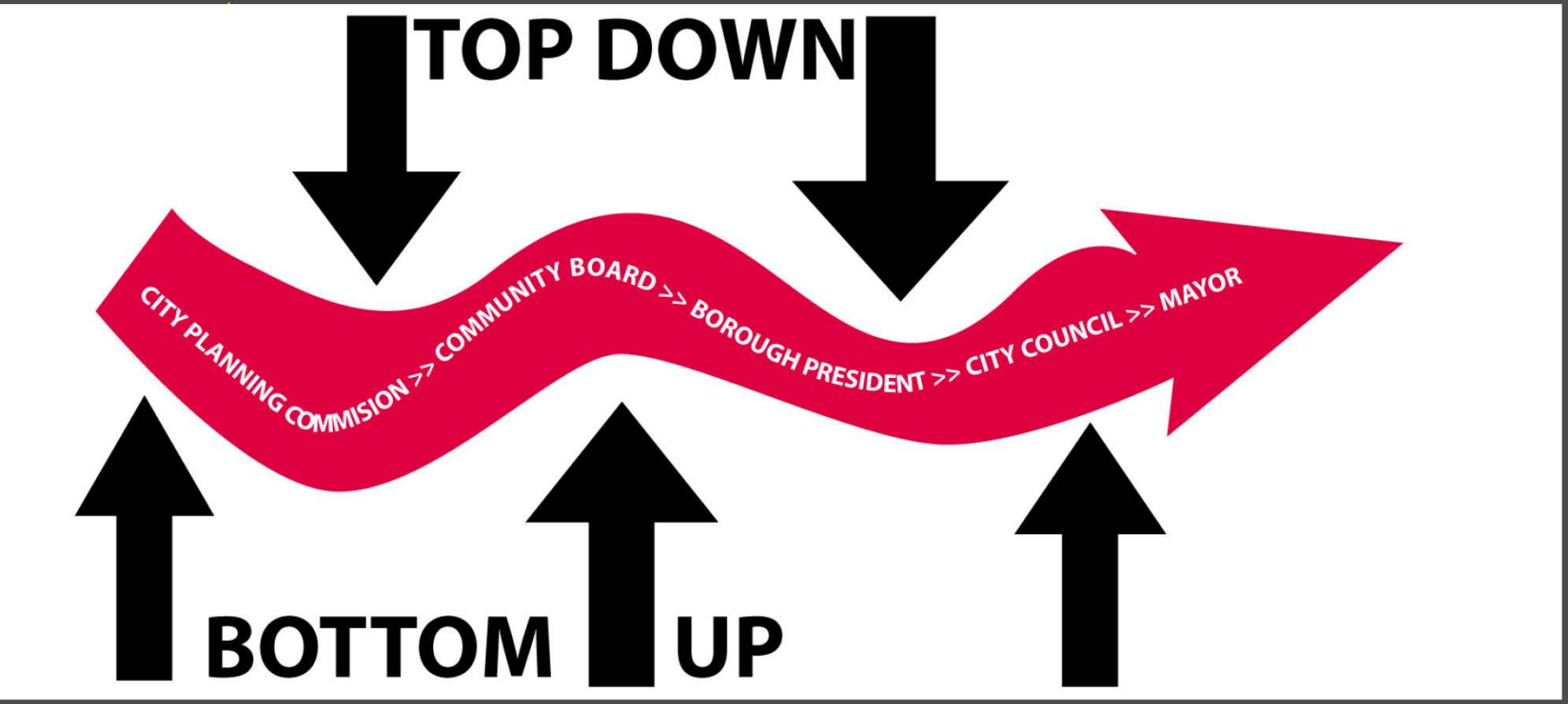
Collaboration

Modularity



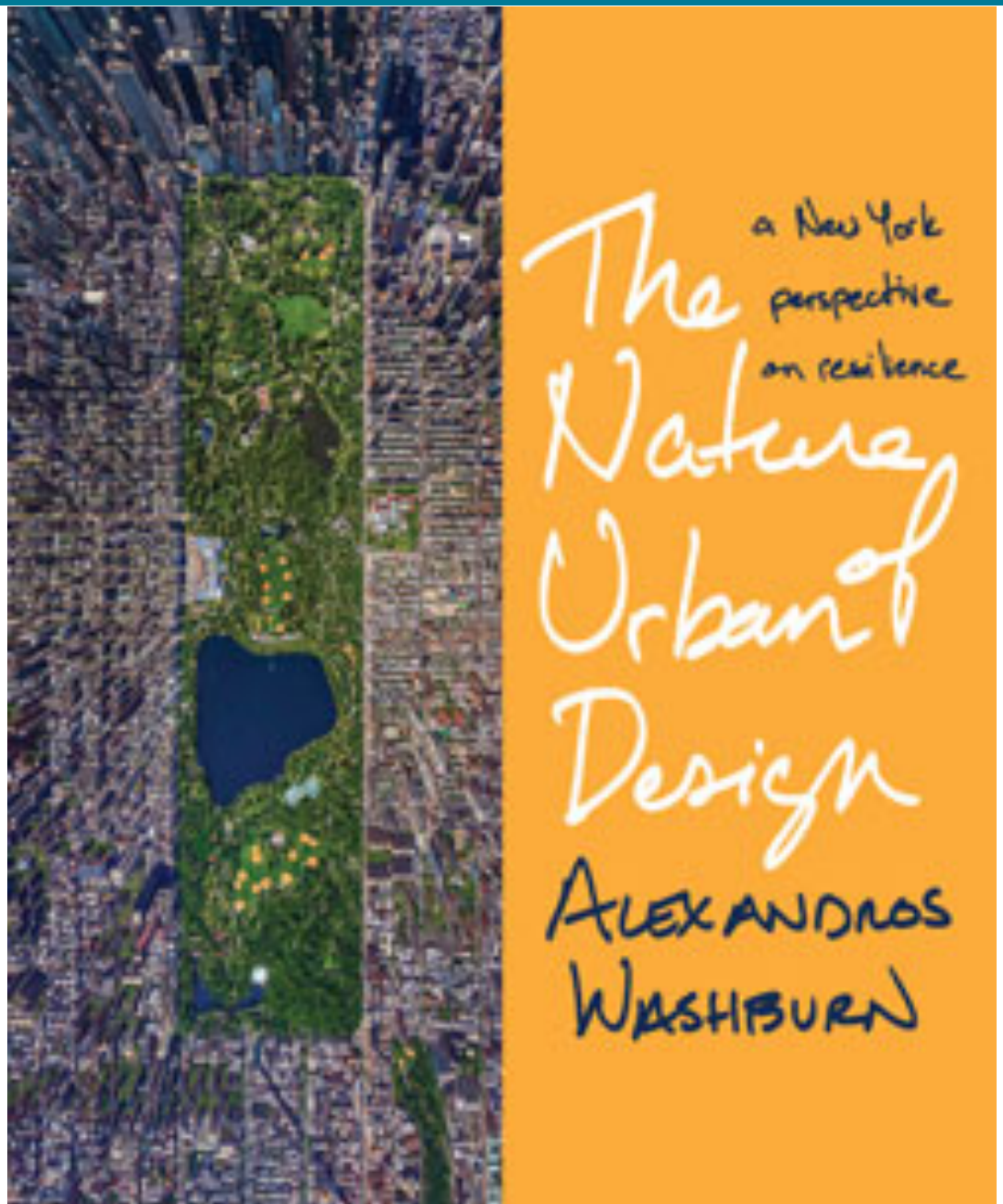
Granularity

Low-cost integration



Uniform Land Use Review Procedure

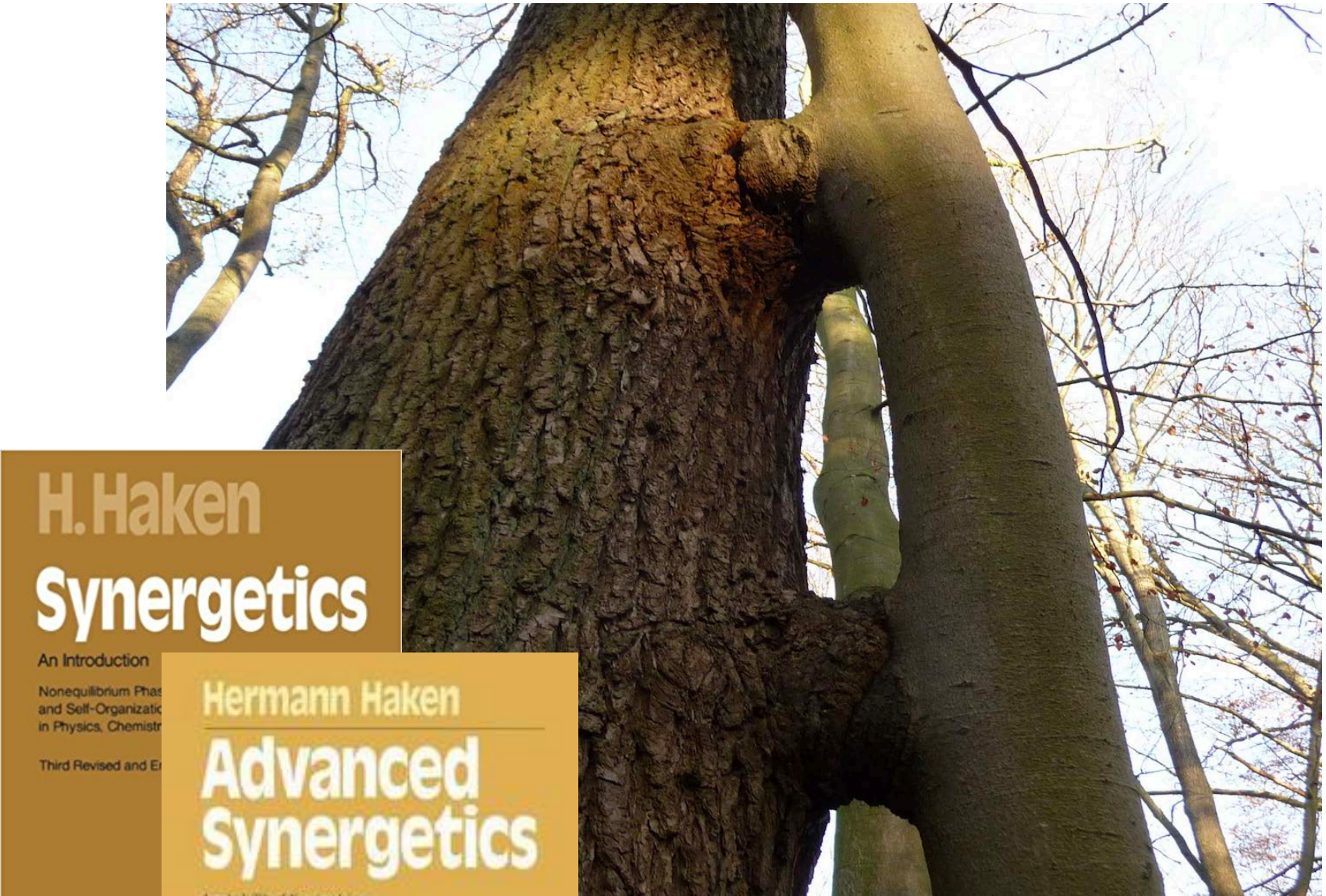
"Successful urban design requires the right combination of top-down and bottom-up involvement."



"I could not control anything, but I could influence everything"

Cybernetics + Synergy = CyberSyn?

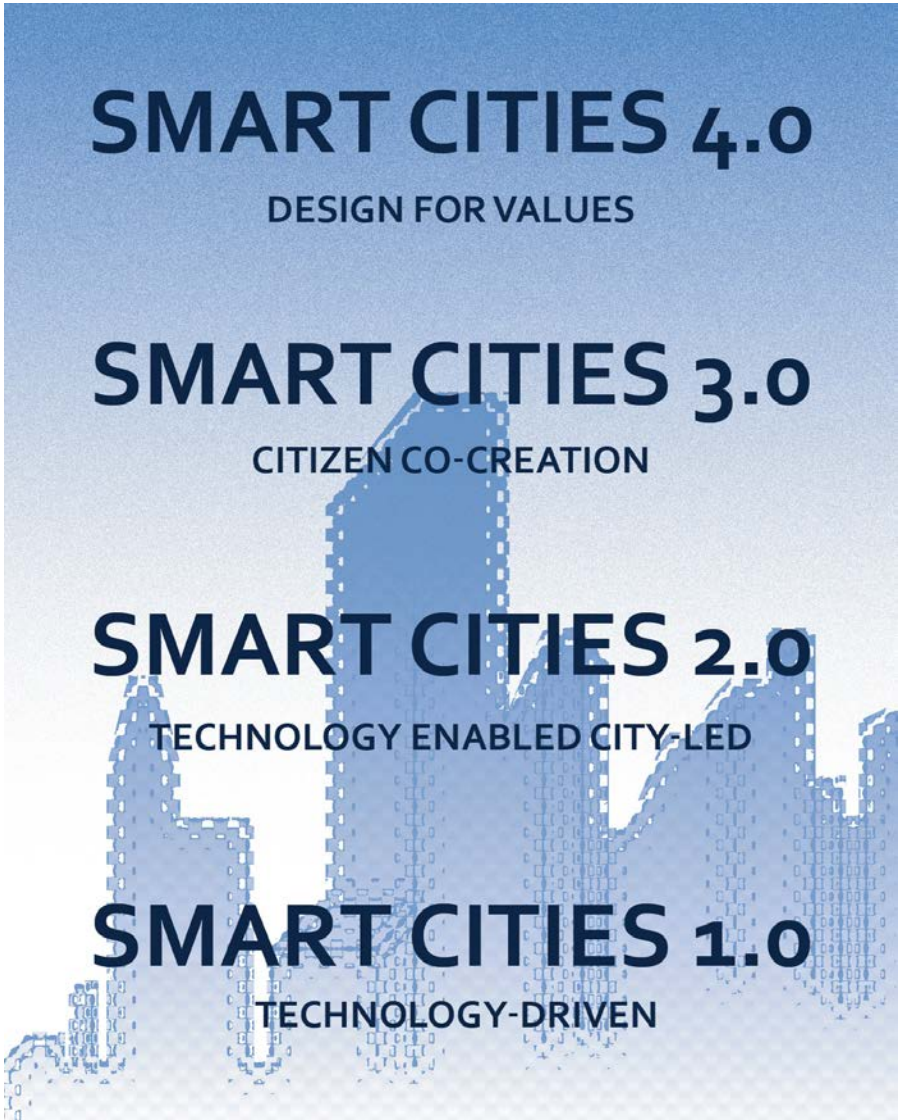
Synergy + Cybernetics = Synergetics!



Success Principles for A Complex World

- Co-learning
- Co-creation
- Co-ordination
- Co-operation
- Co-evolution

Upgrading Smart Cities with Collective Intelligence



Design for Values

- Privacy
- Self-determination
- Fairness
- Justice
- Dignity
- Happiness
- Wellbeing
- Safety
- Security
- Sustainability
- Health
- Friendship
- Solidarity
- Peace
- Usability
- Resilience
- Efficiency
- Flexibility

After Jeroen van den Hoven, with minor modifications by DH

Goals must be balanced (politically negotiated).
Otherwise, the approach is oversimplified, inadequate.

Design for Democracy

- Human rights, human dignity
- Freedom
- Self-determination
- Pluralism
- Protection of minorities
- Division of power
- Checks and Balances
- Participation
- Transparency
- Fairness
- Justice
- Legitimacy

Design for values, value-sensitive design

- Privacy
- ✓ Protection from misuse/exposure
- ✓ Right to be left alone

IMAGINECHINA/CORBIS

Many choices that people consider their own are already determined by algorithms.

Build digital democracy

Open sharing of data that are collected with smart devices would empower citizens and create jobs, say **Dirk Helbing** and **Evangelos Pournaras**.

Democracy by design

Food for thought