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EUROPEAN CENTRAL BANK

EUROSYSTEM

Artificial Intelligence in Industry and Finance

Focus Session on Fintech-Driven Automation in the Financial Industry

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Francis Gross

Senior Advisor
DG Statistics

The economy as

a network of contracts

connecting

a global population of parties

–

vision, architecture, infrastructure

What's the matter?

an excursion into the context:

economy, senses, brain, language, technology, data

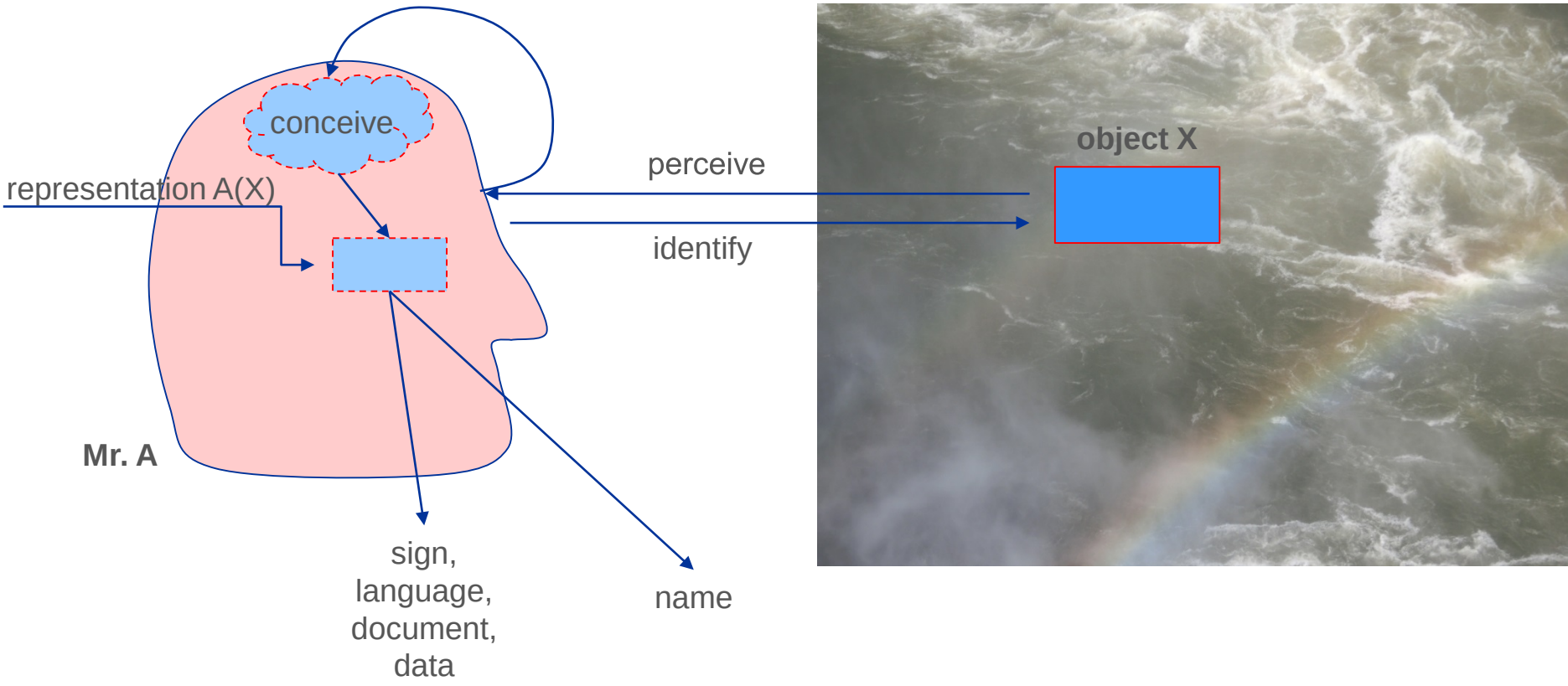
We live in Richard Dawkins' "middle world"

Biologist Richard Dawkins defines the "middle world" we live in:

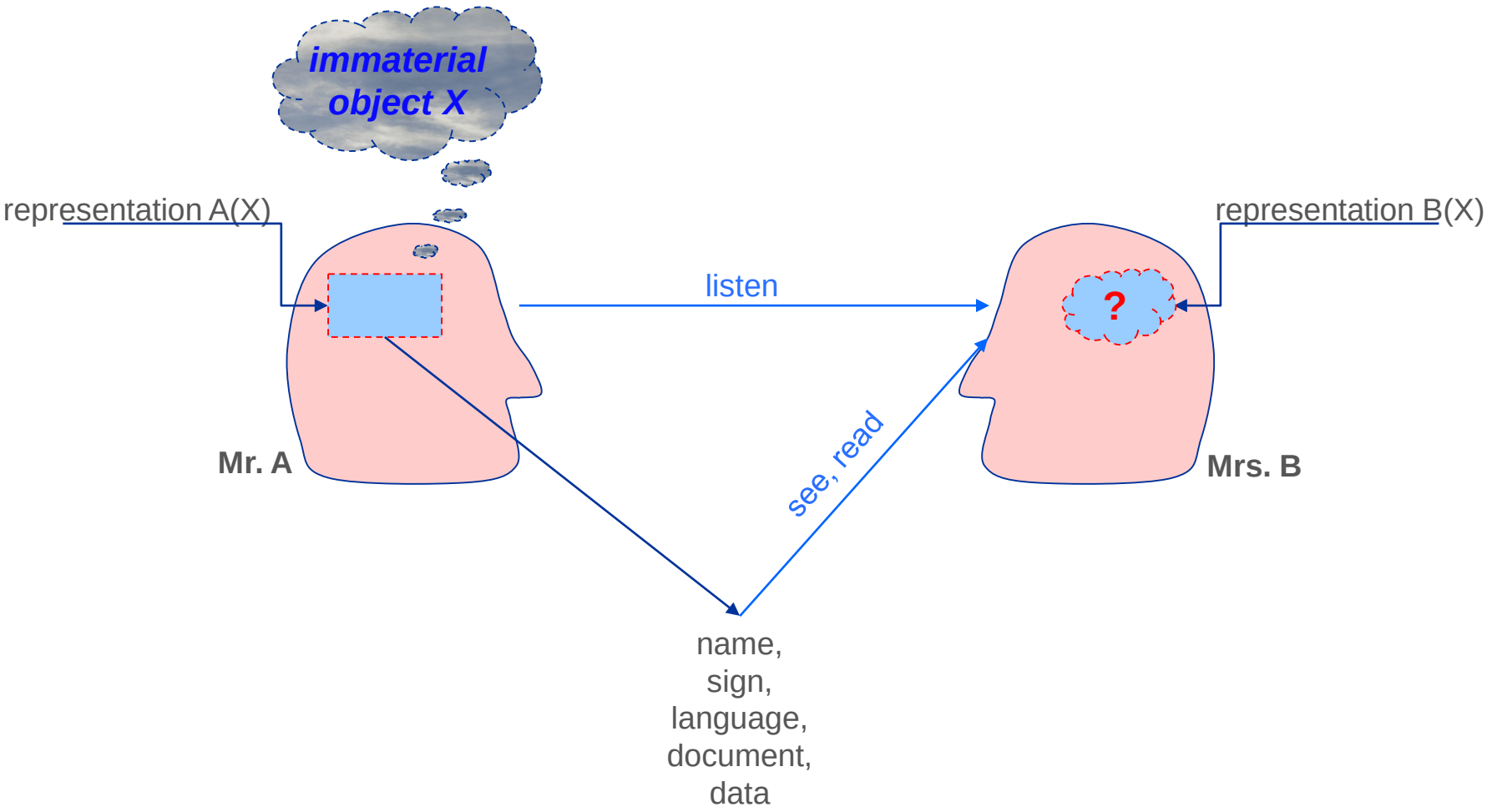
- The light spectrum our eyes can see
- The frequency range our ears can hear
- The time scales and speeds we can sense
- The number of items we can handle at a time

Evolution shaped our brains for the narrow range we need for survival in nature

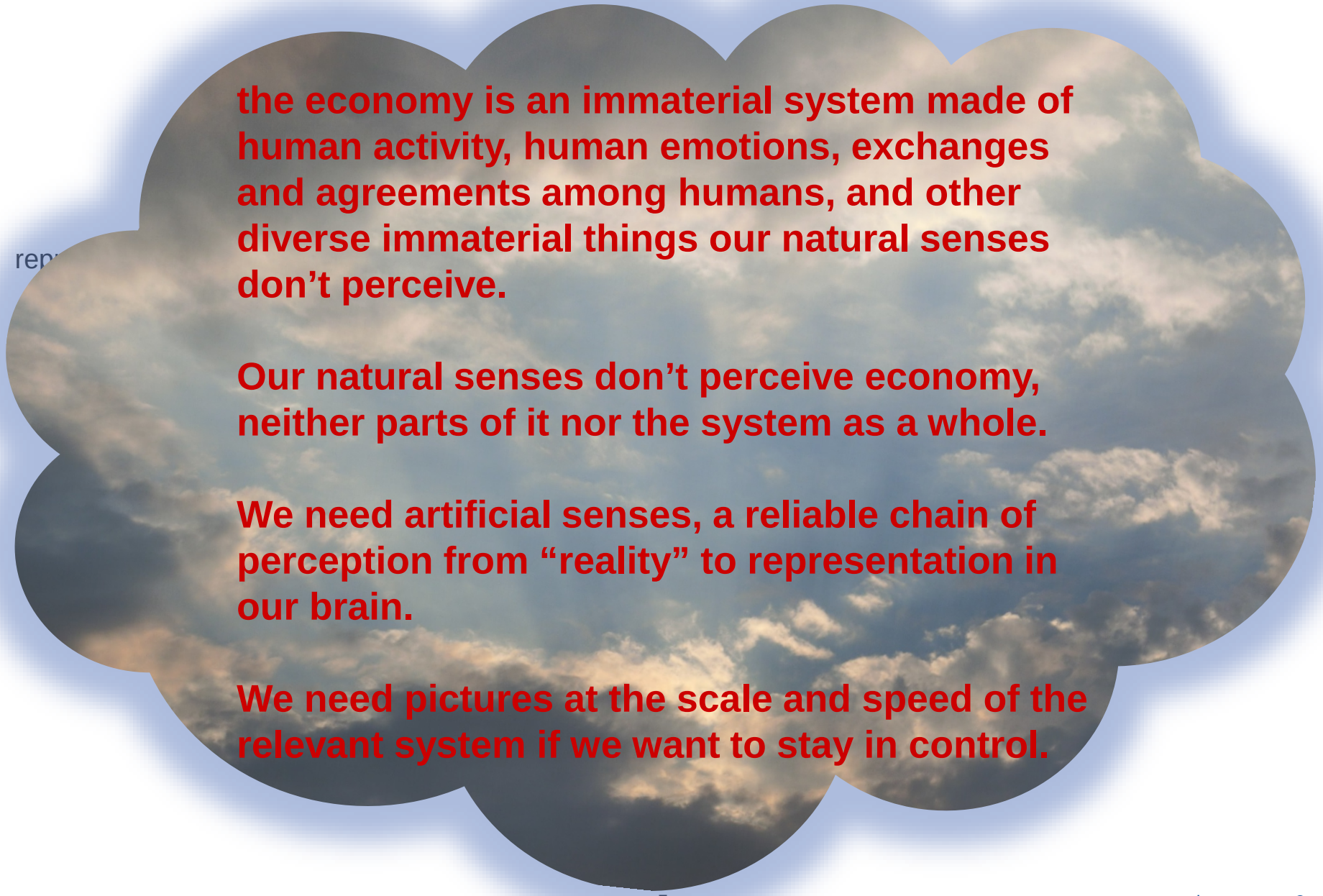
Object recognition and identification in a complex environment



Recognition and identification of immaterial objects



Many immaterial objects, many people, many interactions



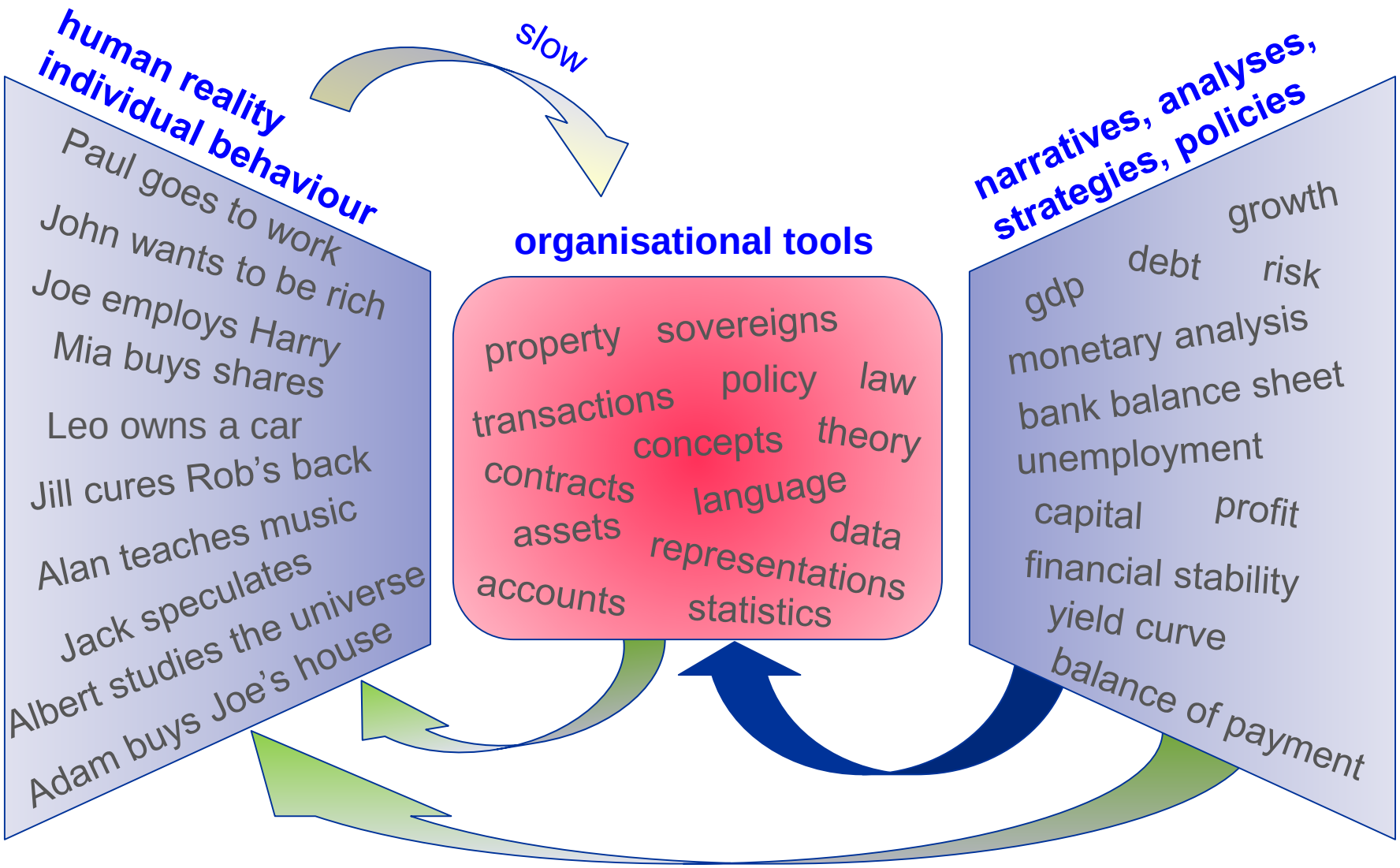
the economy is an immaterial system made of human activity, human emotions, exchanges and agreements among humans, and other diverse immaterial things our natural senses don't perceive.

Our natural senses don't perceive economy, neither parts of it nor the system as a whole.

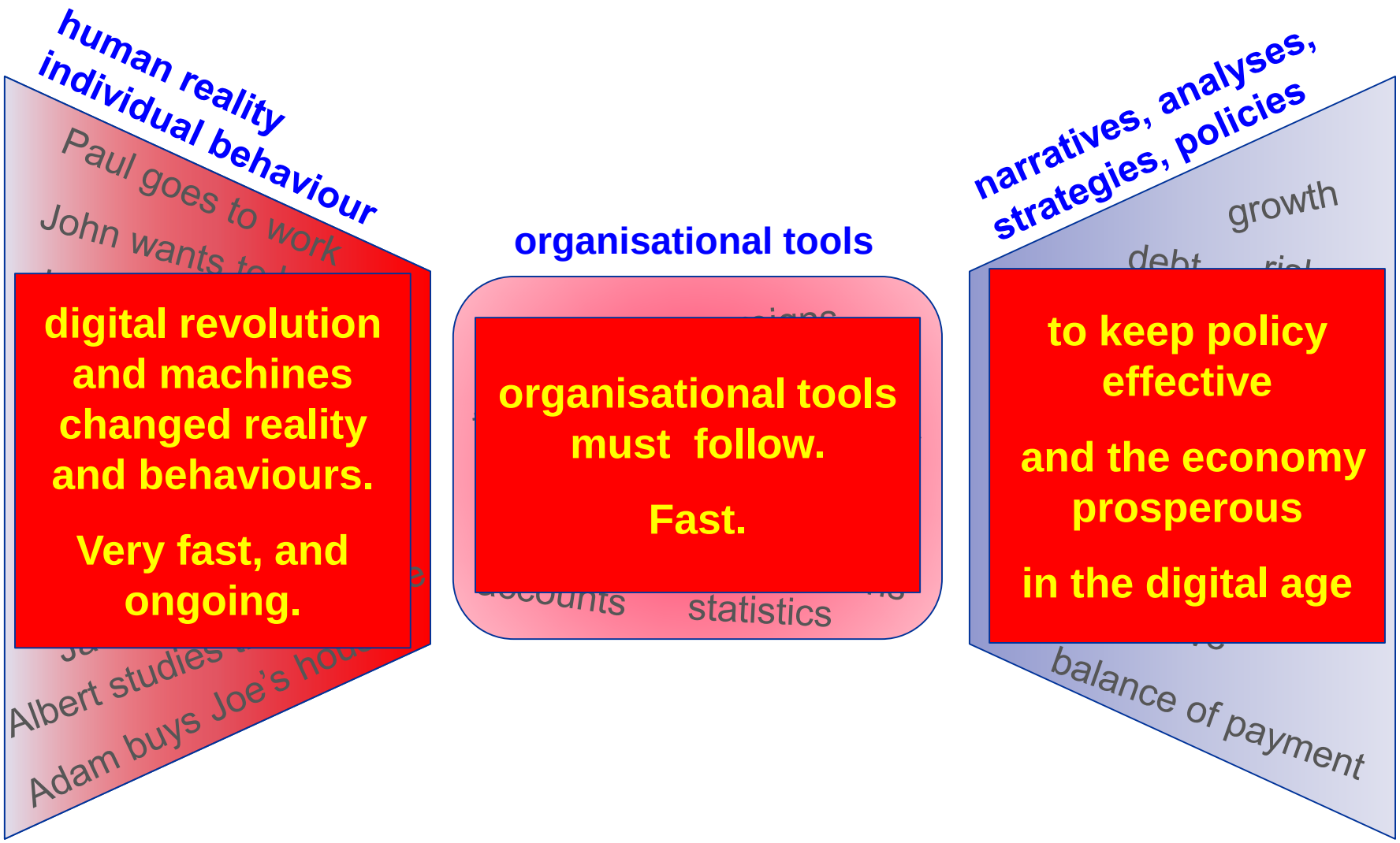
We need artificial senses, a reliable chain of perception from "reality" to representation in our brain.

We need pictures at the scale and speed of the relevant system if we want to stay in control.

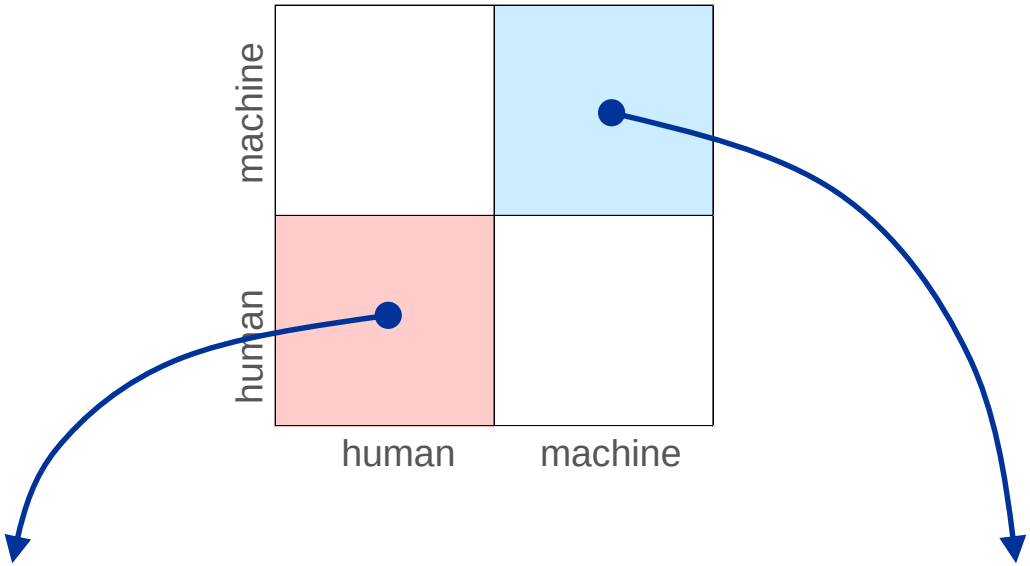
The economy, a complex system



The economy, a complex system – add speed, subtract distance



Human-to-human, machine-to-machine: two very different conversations



People exchange words.

If words are unclear
people can talk, ask, adjust.

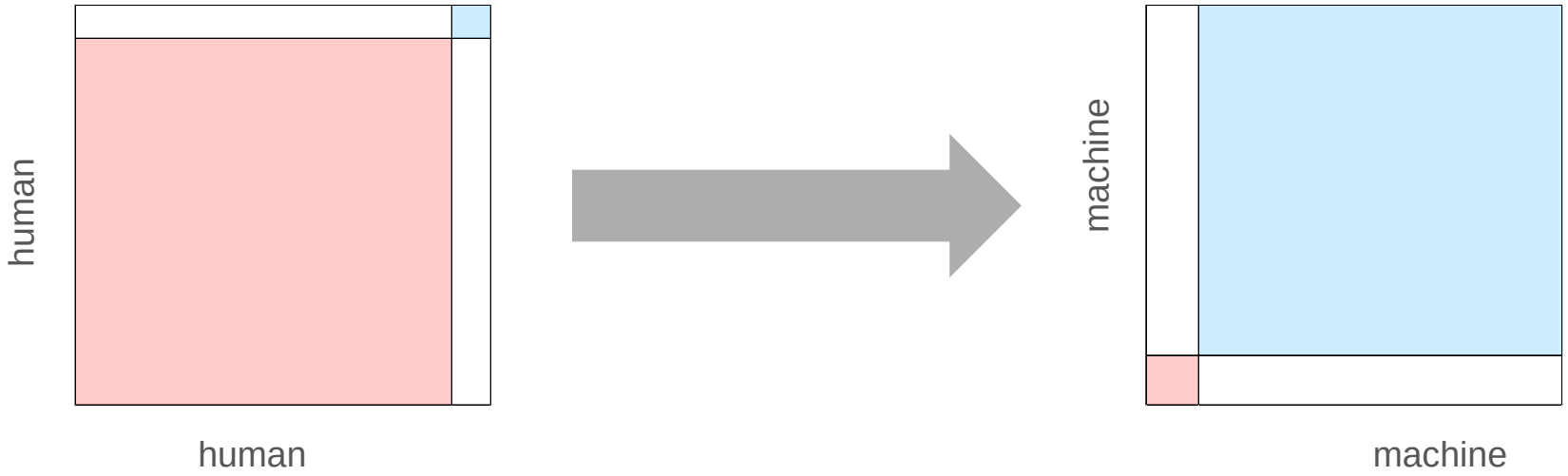
Machines exchange data.

If data is unclear
machines don't talk, ask, adjust;

they behave differently, e.g.
they simply stop or, worse,
they continue somehow.

Human-to-human, machine-to-machine: two very different conversations

Technology has shifted the human-machine interface



A look at military doctrine

US military doctrine, Directive 3000.09 from 2012:

- "human-in-the-loop": a human has the last call in a decision

When human brain capacity is dwarfed by machines' speed, data volumes, AI:

- How do we keep the "human-in-the-loop"?

DARPA's "Mosaic Warfare" foresees complexity itself as a weapon:

"*An orchestrated multitude of systems overwhelm the enemy by creating a range of simultaneous dilemmas in multiple domains*"

Language reflects human diversity – **BUT** – computers don't like diverse data

- Language shapes and expresses the identity of people and groups
- There are no limits to diversity in concepts and languages expressing them

Chinese 人人生而自由

Persian همهٔ افراد بشر آزاد به

English All human beings are born free

Three fundamentally different approaches to language…

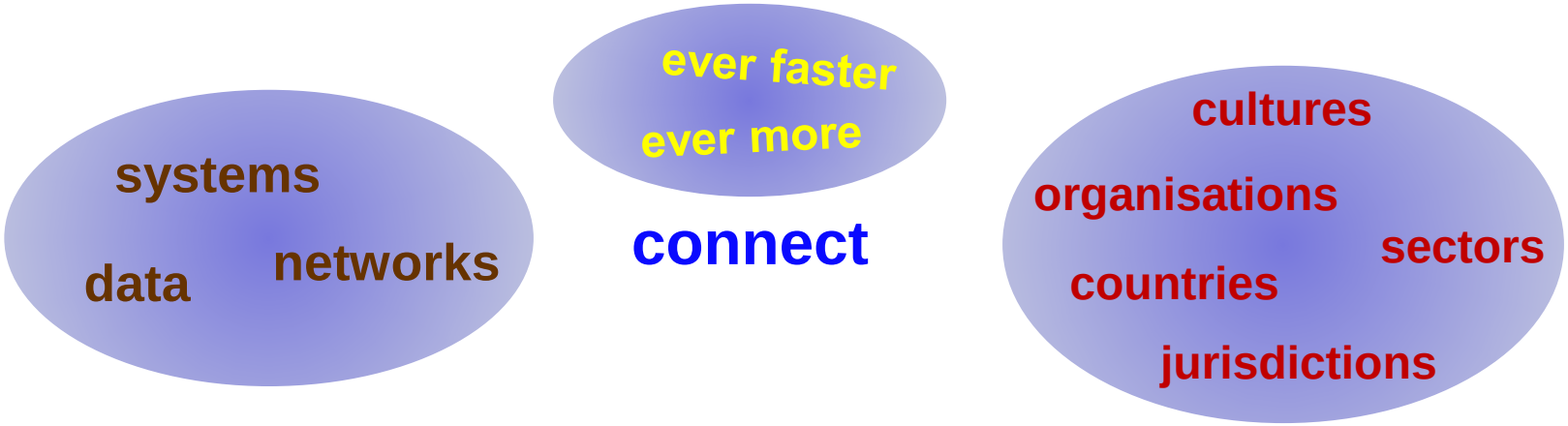
… and there are and were many more.

Data is language!

…as diverse as human language…

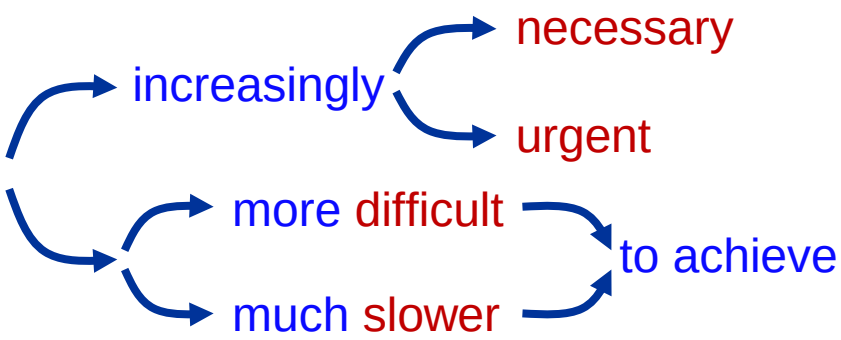
…but computers need it clear and homogeneous

Data as an obstacle to the delivery of the technology promise



Technology increases social complexity by connecting more diverse people

- more / more diverse data practices now interfere in larger networks…
- …making agreement on standards



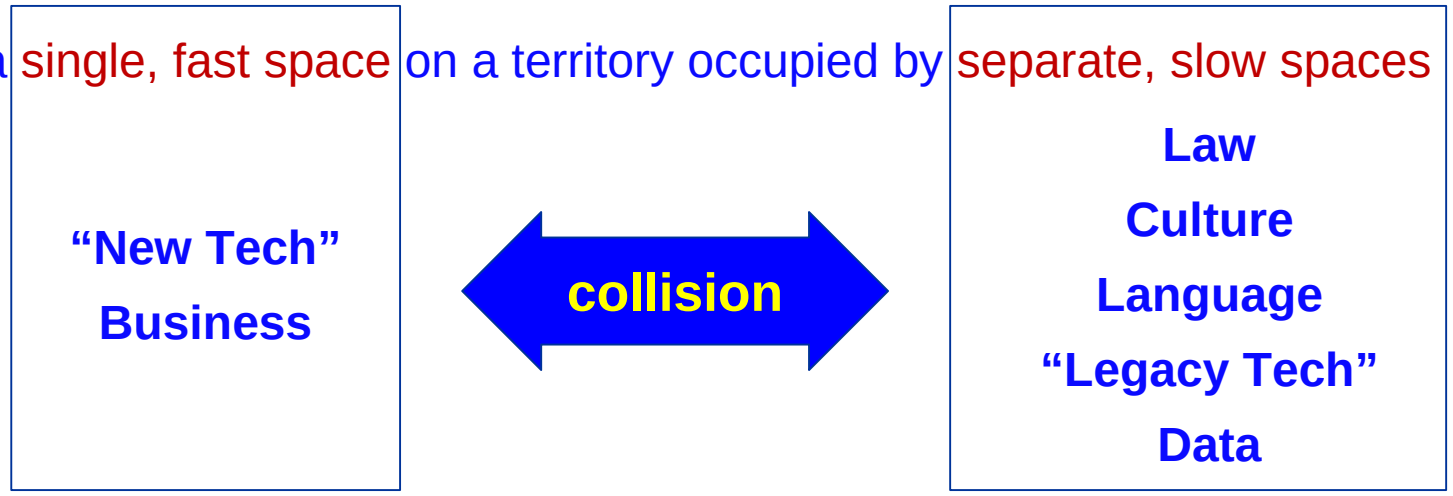
Technology creates a "Data-Tower-of-Babel" that impedes effectiveness

More IT can deliver value only if data quality improves

Fragmentation is relative: it happens when digitisation moves and data doesn't

Digitisation connects – cheaply and fast – real time – irrespective of geography

It creates a single, fast space on a territory occupied by separate, slow spaces



Business and Technology rush ahead, assuming that legacy is fit or will follow.

Instead, the new single, fast space finds that land under its feet is fragmented

Digital integration creates cost and risk by quickly widening the gap between slow-moving data reality and fast-moving data needs

“human-in-the-loop” in finance 2030 and beyond: how?

The challenge:

- To access with our senses an abstract system far outside our “middle world”
- To control with our brains a system far too complex for it

We manage well with matter, outside our range, although it is infinitely complex

Three components could keep the human in the loop::

- **Perception**: “Artificial Senses” at the scale and speed of the relevant system
- **Analysis**: reduce information to brain size, tailor it to the problem at hand
- **Action**: design what action and build the tools to do it

The Thomas Kuhn moment

We can’t cope “by hand” anymore, but…

… efforts to accelerate the old ways, just faster, more automated…

… are doomed to fail, ultimately, as technology races on

We must aim for more and drive a deeper movement

Three strategic moves towards a new paradigm:

- **Vision**: revisit our world view and theory of the matter we study
- **Architecture**: imagine the system as it could work, the “endgame”
- **Change**: practical, feasible, beneficial to all, with **transformational power**

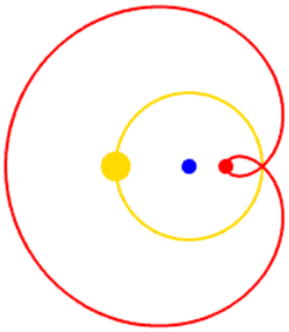
Academia and public powers must lead an intellectual and policy push,

Markets will do the rest: creativity will be unleashed, in an evolving frame

Vision

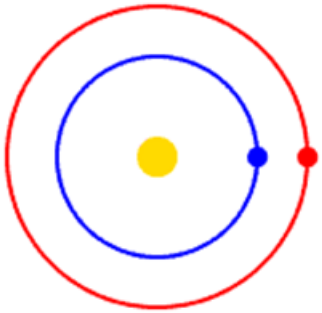
Vision: technical tool, not flight of fancy

- A way we choose to view the world
- A representation that structures our perception, shapes our action



The solar system
heliocentric (right)
vs.
Geocentric (left)

In red: orbit of Mars



- "*All models are wrong; some models are useful*" George E.P. Box, statistician
- "*It is the theory that decides what we can observe*" Albert Einstein
- "*Combining visions gives us more possibilities*" Hans Poser, philosopher

Source http://images.google.de/imgres?imgurl=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fe%2Fea%2FApparent_retrograde_motion.gif&imgrefurl=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FCopernican_Revolution&h=256&w=512&tbnid=d-2Q8WwFkk4YVM%3A&docid=_D5z93ryjK14lM&ei=YJslWLOZBqaIgAaf4KuwAg&tbm=isch&iact=rc&uact=3&dur=1353&page=0&start=0&ndsp=28&ved=0ahUKEwizydymlenPAhUmBMAKHR_wCiYQMwg8KBgwGA&bih=773&biw=1536

What vision of finance and the economy to design a measurement system?

Vision 1

A set of

Closed Systems

(national economies)

with

Perturbations

(international trade and investment)

VS.

Vision 2

A Global Network

of

Contracts

among a

Global Population

of

Agents

Vision 1

A set of

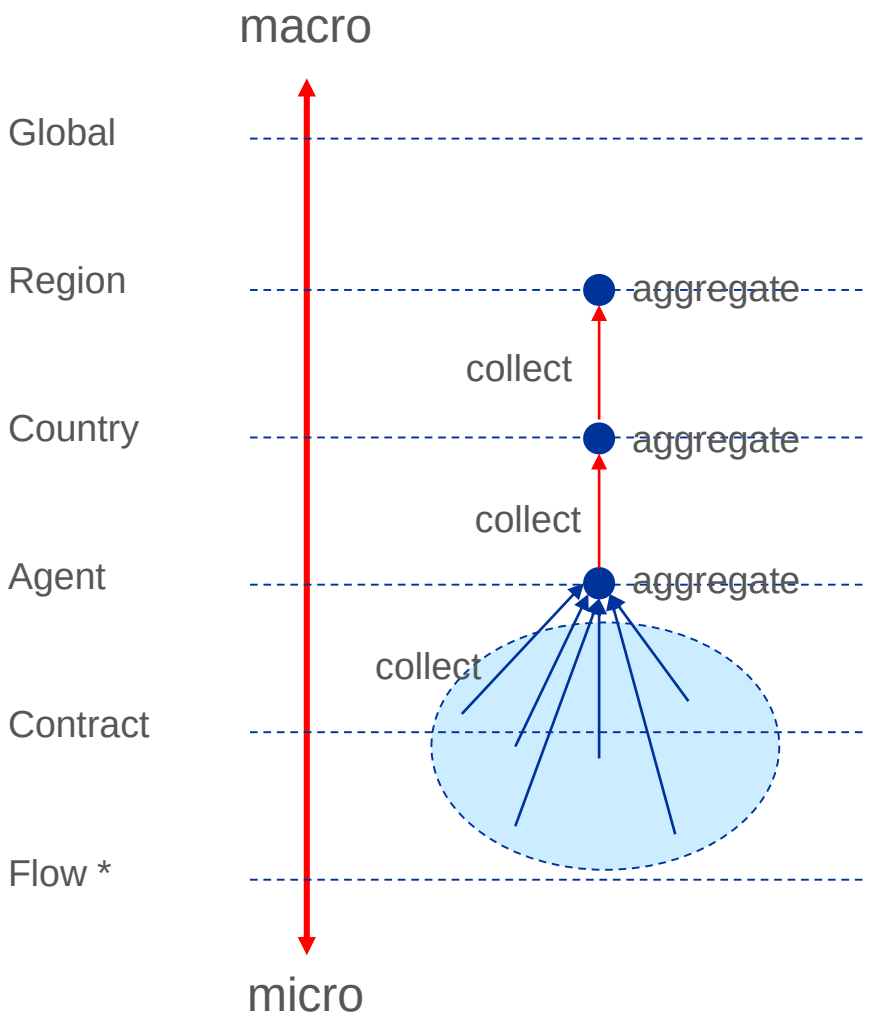
Closed Systems

(national economies)

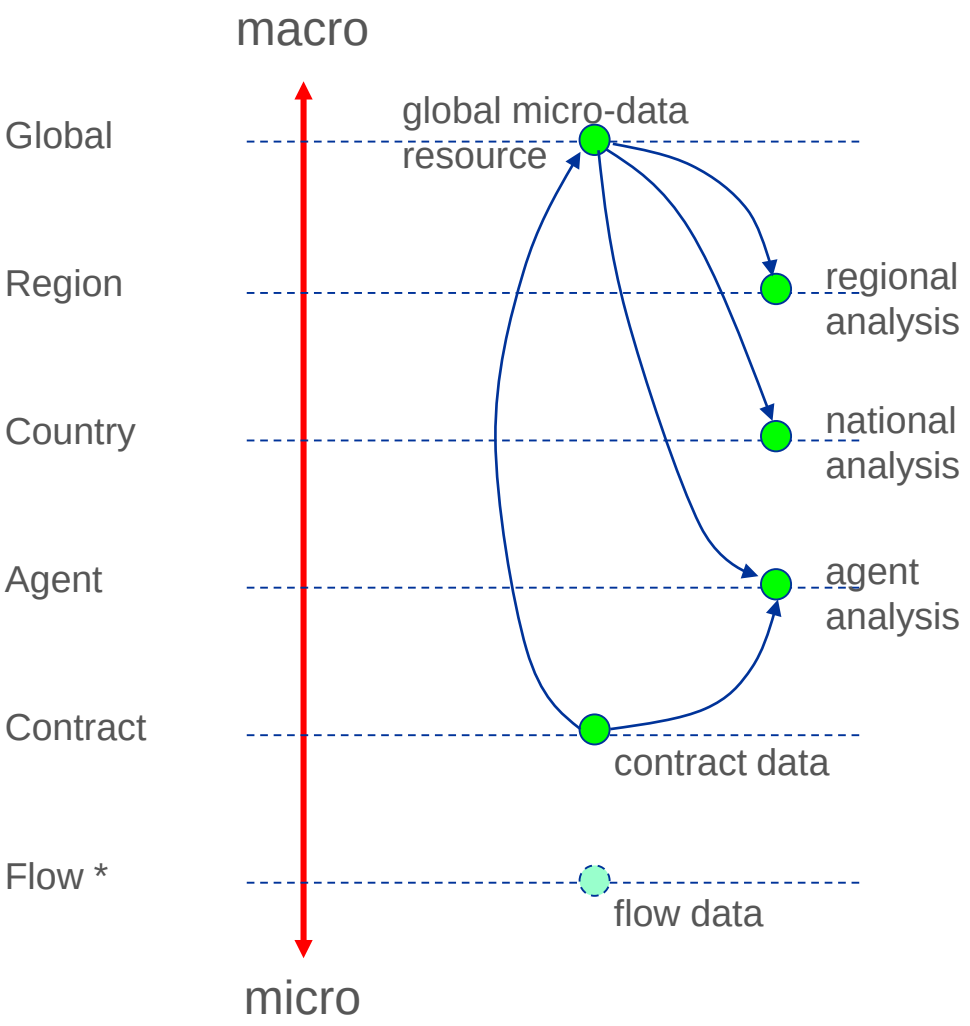
with

Perturbations

(international trade and investment)



* cash, goods, services



Vision 2

A Global Network

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Contracts

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Global Population

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Agents

* cash, goods

The substance we measure: what is real in a system of abstract, immaterial objects ?

An abstract thing becomes real when all across society agree upon it.

The most powerful and constant engine of social consensus is law:

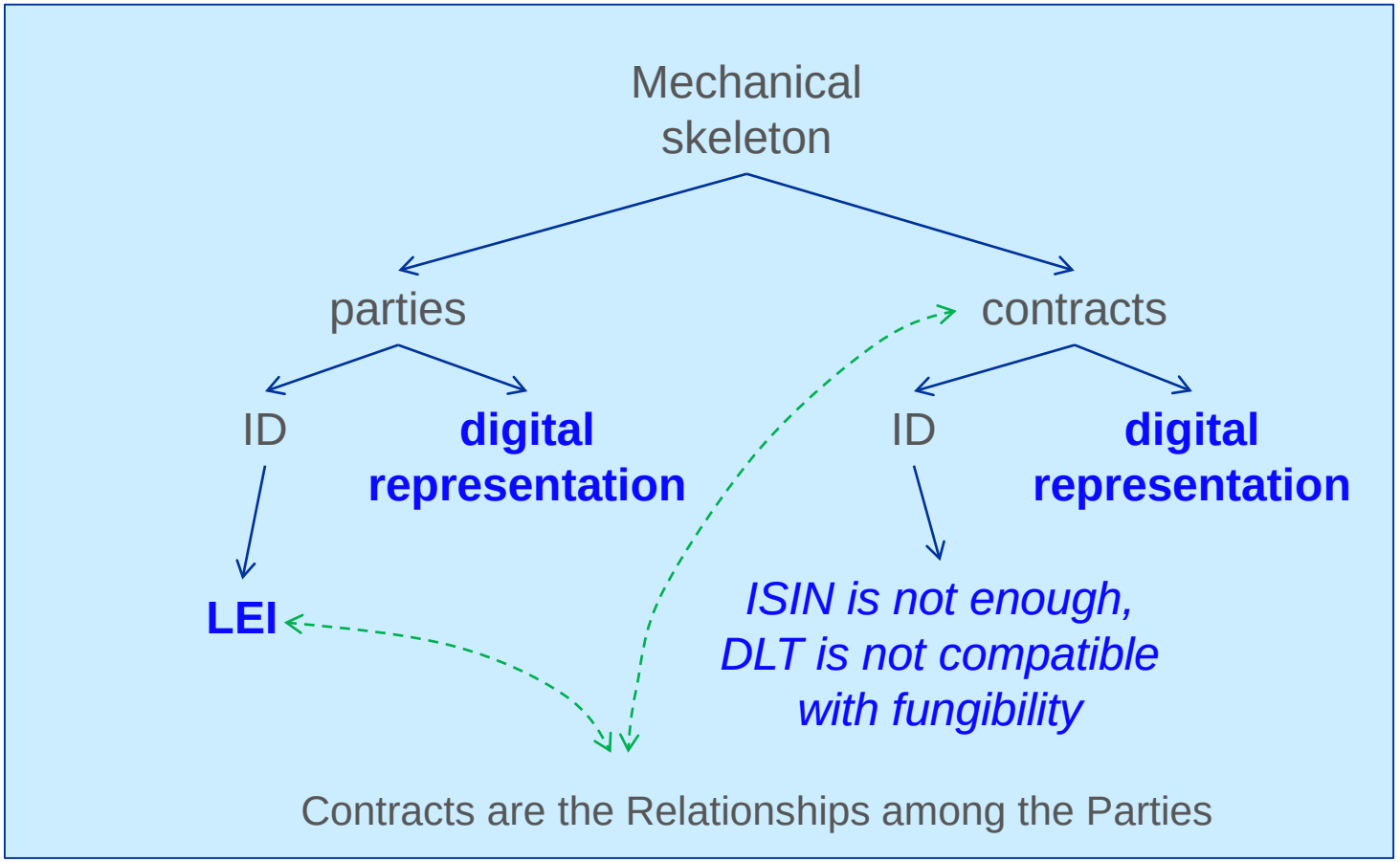
- Law confers a quasi-physical quality of reality, also on abstract objects
- Law confers existence and identity upon parties and contracts

Parties and contracts are abstract objects,

yet law makes them socially real – they are facts

- Law can mandate the way to represent abstract objects it makes into facts

The “mechanical skeleton” of the economy and finance - facts in the abstract system



Blue in the graph: registers making up the mechanical skeleton system.

the theoretical possibility

of a unified, machine-compatible

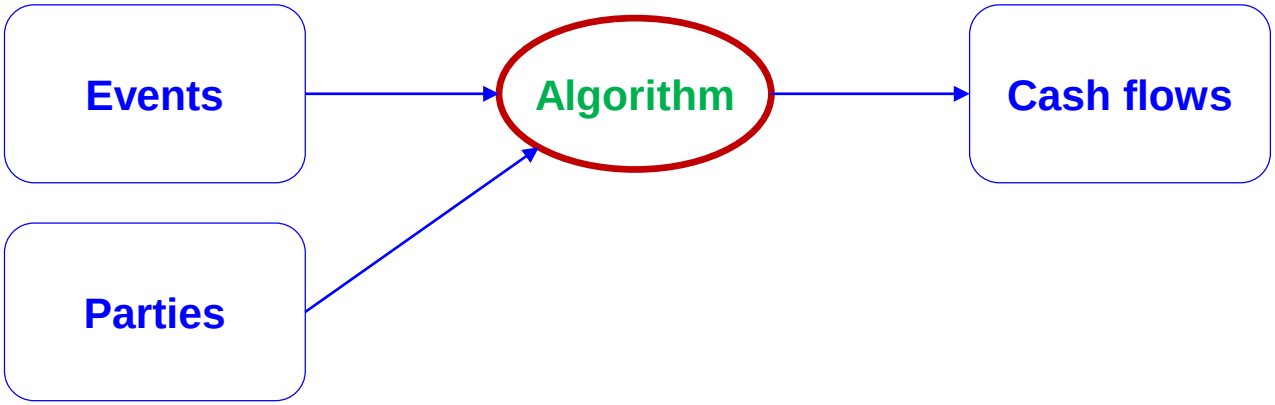
language for describing contracts

ACTUS: rigorous representation of a financial contract

Algorithmic **C**ontract **T**ype **U**nified **S**tandard – initially designed for financial contracts

The ACTUS logic:

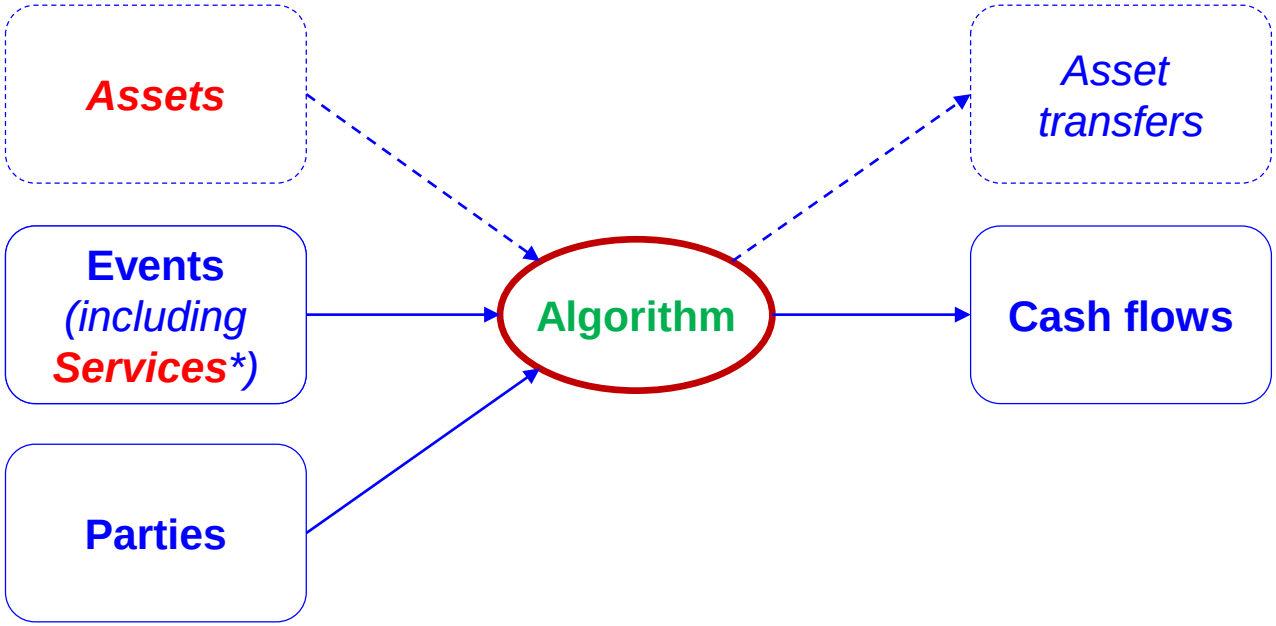
- The contract seen as a mathematical function that represents parties' agreement about
- who pays how much to whom, when and under what circumstances?



for more on ACTUS: www.actusfrf.org

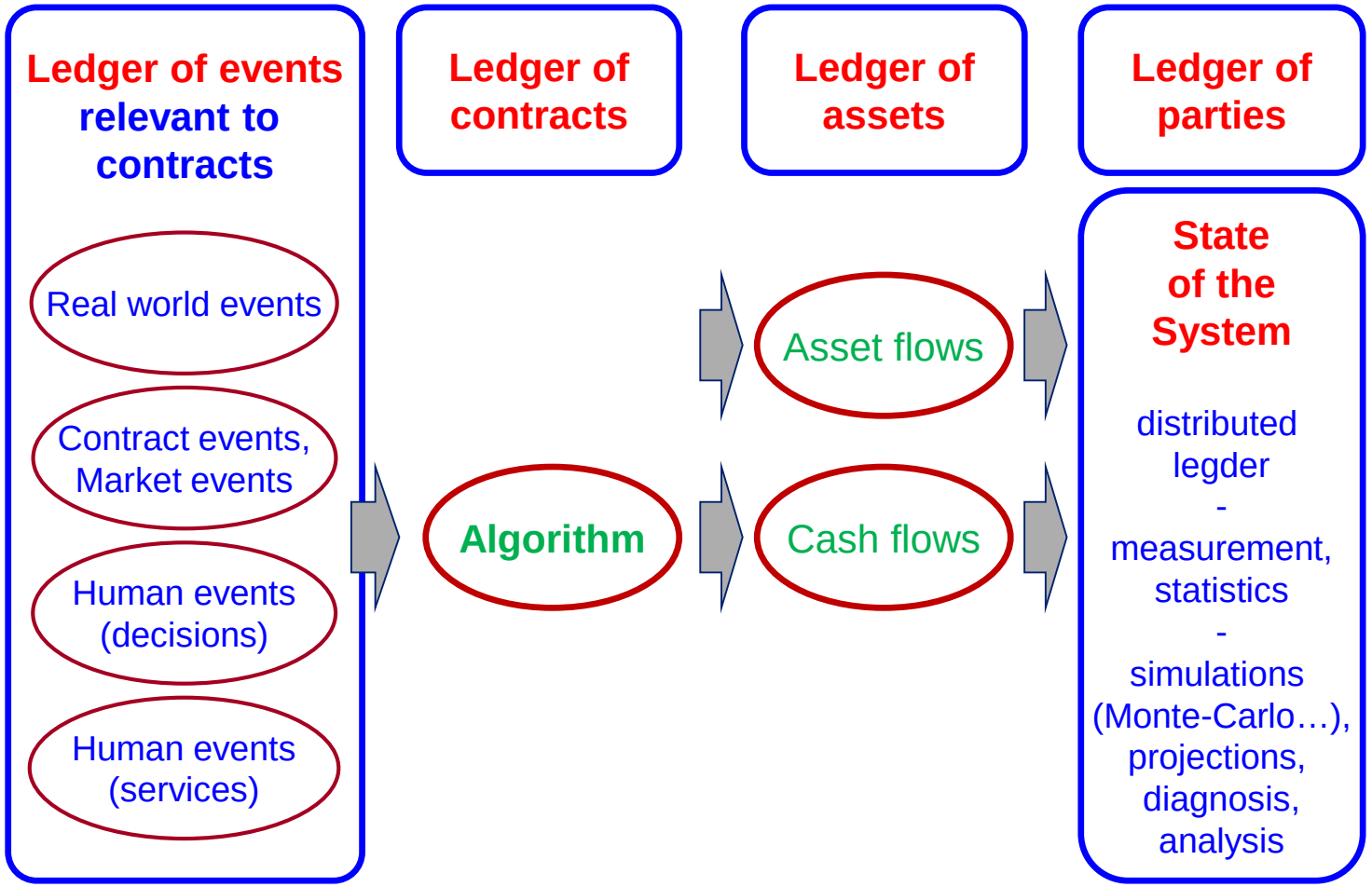
ACTUS could be generalised into a rigorous representation of any type of contract

ACTUS logic, generalised here to cover all types of contracts (goods, services)



** delivery of a service is treated as an event in this conceptual framework*

A suite of ledgers to represent populations of diverse contracts in a single language



Application

Vision 2

A Global Network

of

Contracts

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Network representation

- Each node: a party
- Each edge: a contract
- The network: a system, a graph

Simplification: an asset is itself a contract between the sovereign and holders, that asserts rights and duties attached to an object, for instance the title deed to a house.

Exogenous events drive the dynamics of the population of algorithms

Vision 2

A Global Network

of

Contracts

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Dynamics: the occurrence of events referenced in contracts, partly exogenous to the system, drives the system.

Events referenced in contracts can be driven by other events referenced in contracts and also by events external to the system.

The impact of an event X on the system might have to include the impacts of events triggered by event X, also outside the system. Realistic outcomes might require consideration of sufficiently complete scenarios.

Analysts organise events in scenarios, feed them into agent-based models

Vision 2

A Global Network

of

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Analysis: the analyst selects a universe of events, from within the ledger and from outside the system.

Events are formed into coherent, simple enough yet sufficiently complete scenarios (many: Monte Carlo) – there lies the art of the analyst.

AI could be a good technology for forming scenarios of events to drive simulations. A scenario industry could emerge.

Agent based model delivers statistics accessible to the brain.

Can we create scenarios for human excesses, panic? There will be limits.

Vision 2

A Global Network

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Agents

Types of Analysis could potentially include:

- stress tests, at the level of a party, a group of parties (e.g. a large bank) or the whole system.
- analysis of the footprint of contracts of a population of parties (e.g. the footprint of parties attached to the Greek sovereign is the Greek economy; the footprint of entities attached to Bank Holding X…)
- analysis of a market / type of business (e.g. corporate bond market)
- analysis of a party's or group of parties' exposures to an event: what impacts? Through which chains of contracts? Preventive measures?
- analysis of crisis situations; simulation and calibration of policy measures
- etc.

Vision 2

A Global Network

of

Contracts

among a

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Standardisation of contracts becomes possible at a very technical level

- New possibilities for regulation
- New possibilities for industry

Vision 2

A Global Network

of

Contracts

among a

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Computability issues might arise, must be studied:

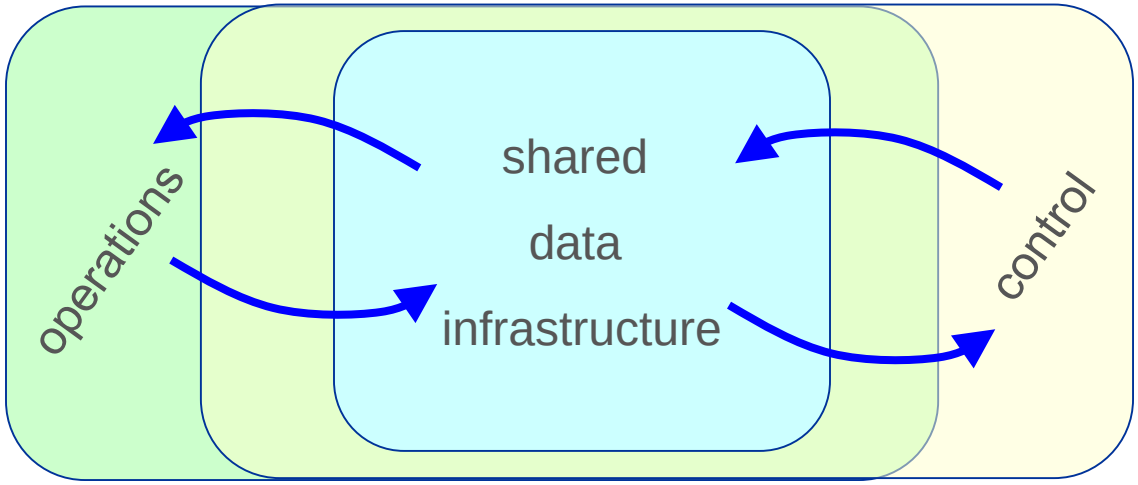
- Finite state machines?
- Discrete-event systems?
- Computing capacities? Quantum computing might come of age at the same time as this approach

Simple prototypes could be built as testbeds for learning:

- Simple types of contracts (e.g. loans)
- Smaller populations of parties and contracts
- With limited universes of events, internal and external.

Architecture

Industry and its regulators operate from a single, shared data infrastructure



The shared infrastructure could start thin and grow over time as:

- industry structures evolve
- regulators evolve
- technology develops
- humans learn

Change

With vision and architecture in mind, what strategy for change is possible?

The problem
- is deep, global, growing fast, potentially even to critical
- is beyond a single solution

A possible strategy: **feasible measures** with
- immediate **benefits to many**
- **transformational power**

Market forces will do the rest

Standardisation

has often been at the heart of such

deep transformational processes.

Bar code

Shipping container

Business English

The

Global Legal Entity Identifier System

a good place to start

Identity of legally anchored objects as a starting point

We could begin with global, universal coverage, mandated by law, of

The

Global LEI System

as a

Public Good Infrastructure

that offers a

globally standardised representation

of the

identity granted by local authority to a legal entity

and continue with contracts and their algorithmic representation,

build other distributed ledgers required: assets, events

and semantic infrastructures shared by authorities and industry

EUROPEAN CENTRAL BANK

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Francis Gross

Senior Adviser
Directorate General Statistics
European Central Bank
Sonnemannstrasse 22, D-60314 Frankfurt am Main
off: +49 69 1344 7513
mob: +49 160 746 84 82
fax: +49 69 1344 7056
email: francis.gross@ecb.int