Modelling Sustainable Systems and Semantic Web

Systems, Sustainability, Development

Lecture in the Module 10-202-2309
for Master Computer Science

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Sustainability and Challenges

What do you understand by **sustainability**

and what are the **challenges facing humanity** today?

Notes on Possible Responses

Climate change

- Importance of climate stress for the development of humankind.

Hans Carl von Carlowitz and his definition of sustainability.

- What problems faced the royal Polish and electoral Saxon chamberlain, mountain councillor and chief miner of the Ore Mountains (königlich-polnischer und kurfürstlich-sächsischer Kammer- und Bergrat sowie Oberberghauptmann des Erzgebirges)?

Notes on Possible Responses

17 Sustainable Development Goals (SDG)

- Important step of operationalisation in the context of a significant political process.
- It takes up the categorical imperative of Marx and the socialist movement to "Overthrow all conditions in which man is a degraded, a subjugated, an abandoned, a contemptible being."

  (Alle Verhältnisse umwerfen, in denen der Mensch ein erniedrigtes, ein geknechtetes, ein verlassenes, ein verächtliches Wesen ist.)

Notes on Possible Responses

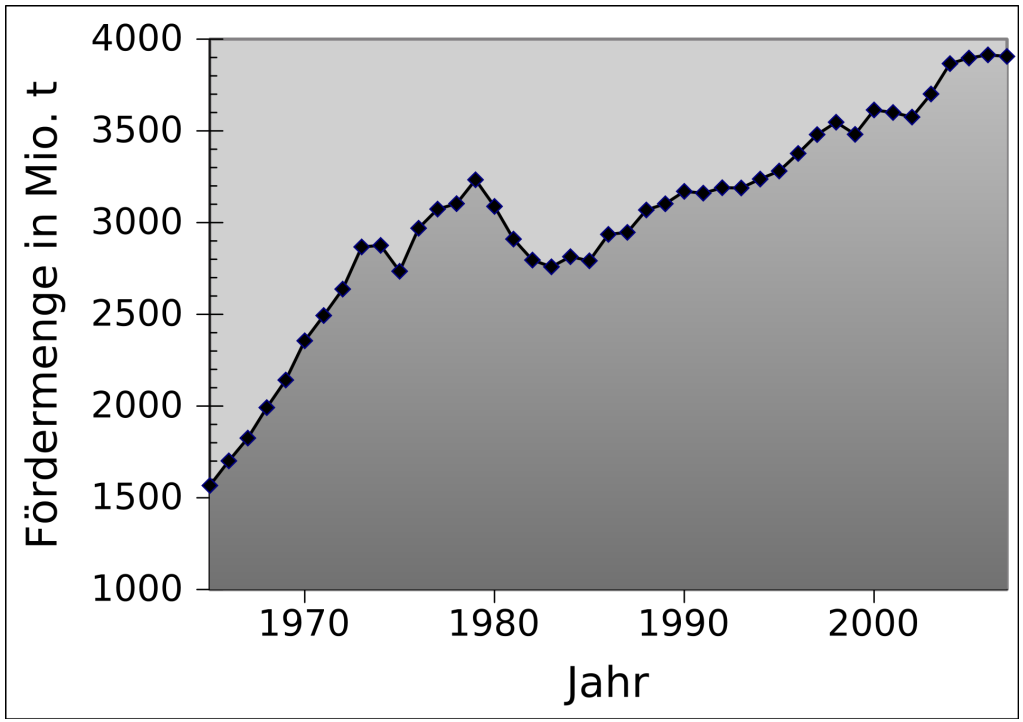
However, Marx' original states

> The critique of religion ends with the doctrine that *man is the highest being for man*, that is, with the *categorical imperative to overthrow all relations* in which man is a degraded, a subjugated, an abandoned, a contemptible being (MEW 1, 385).
>
> Die Kritik der Religion endet mit der Lehre, dass *der Mensch das höchste Wesen für den Menschen* sei, also mit dem *kategorischen Imperativ, alle Verhältnisse umzuwerfen*, in denen der Mensch ein erniedrigtes, ein geknechtetes, ein verlassenes, ein verächtliches Wesen ist.

This imperative is motivated by the relationship of man to man, thus it moves within a *specific system*, the social system, and does not thematise the relationship to "nature" (it is an early work by Marx).

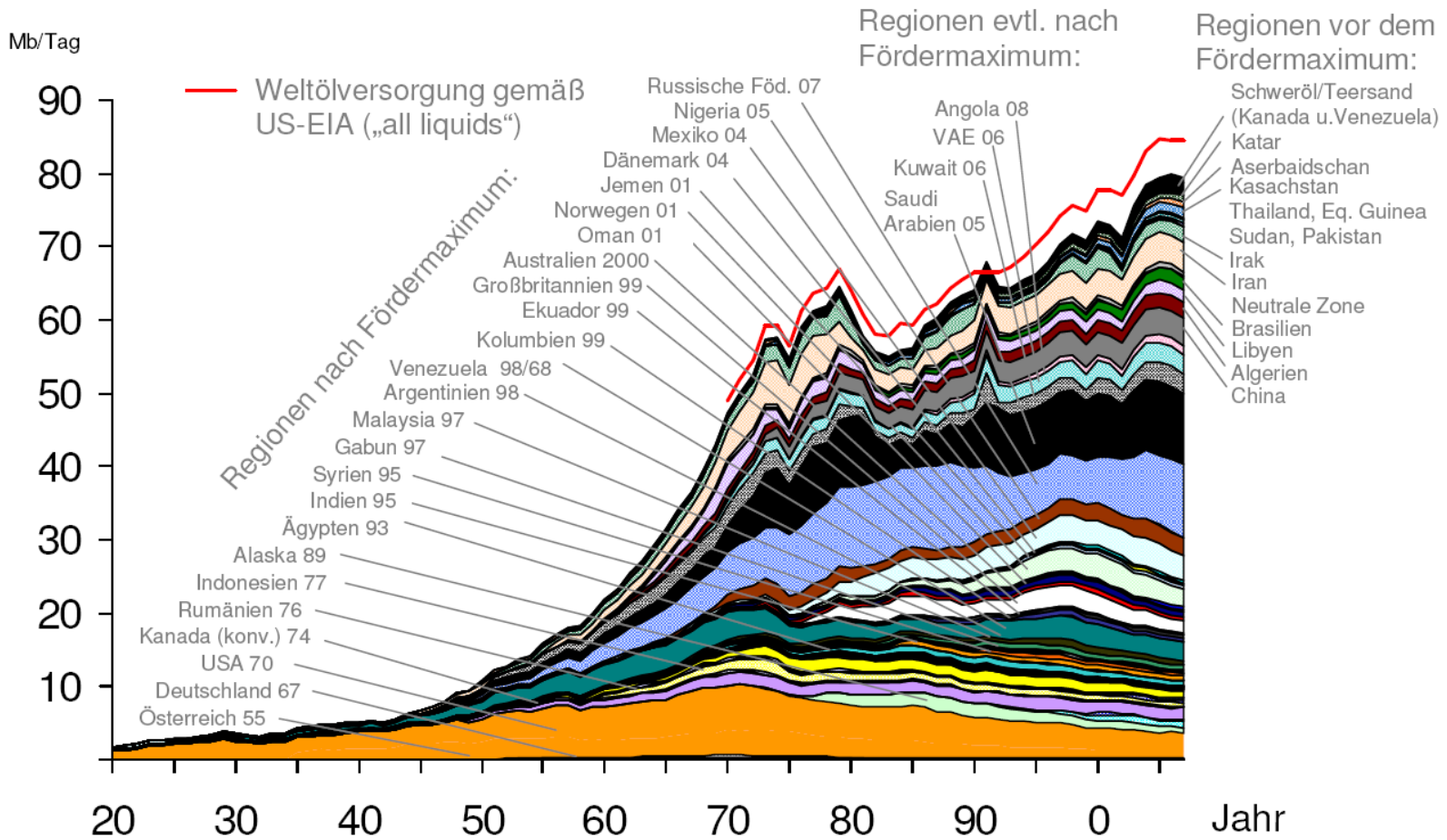
Digression: Analysing the Challenges using TRIZ

Peak Oil – Still an Issue?



World oil production 1967 – 2007. Source: Wikipedia

Peak Oil – Still an Issue?

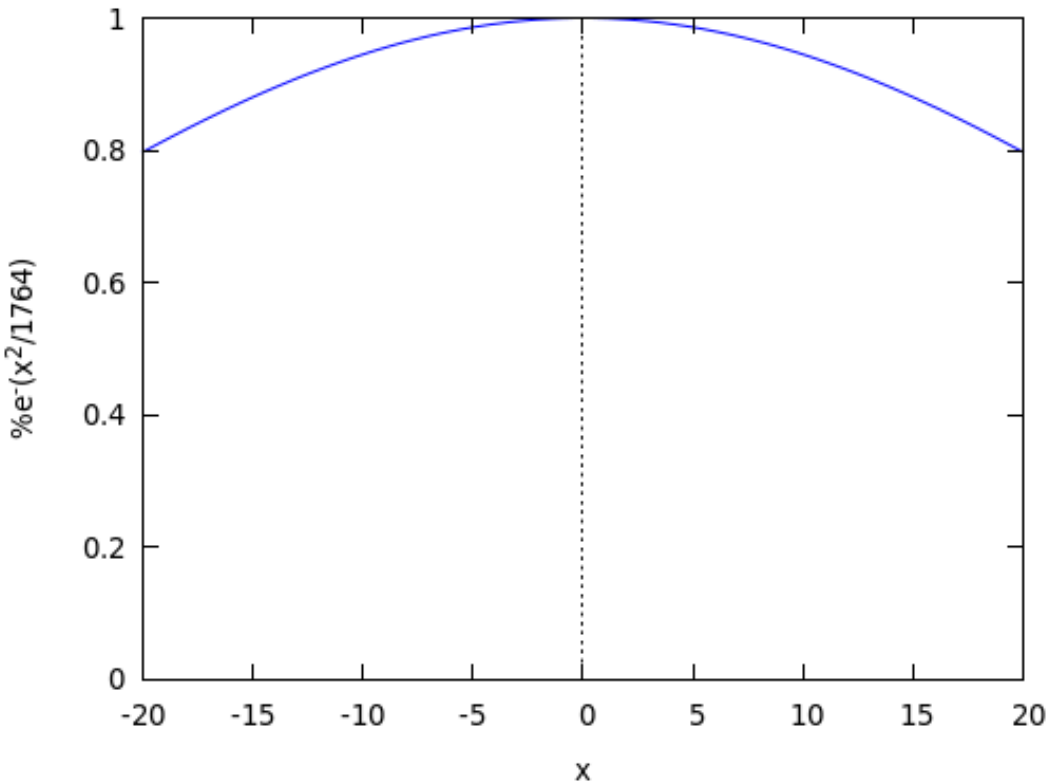


World oil production over the last 100 years. Source: Wikipedia

Analysing the Challenges using TRIZ

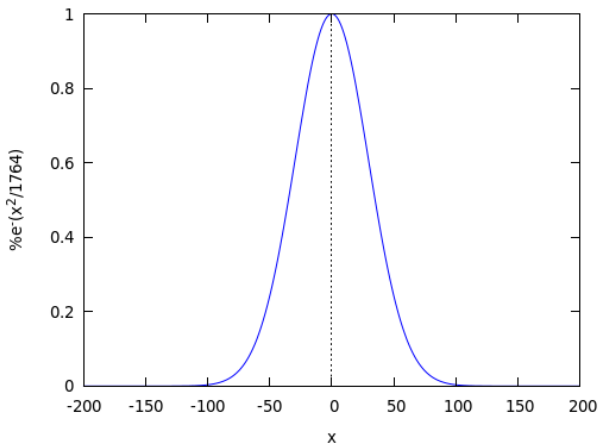
TRIZ rule – model and go to extreme parameter values.

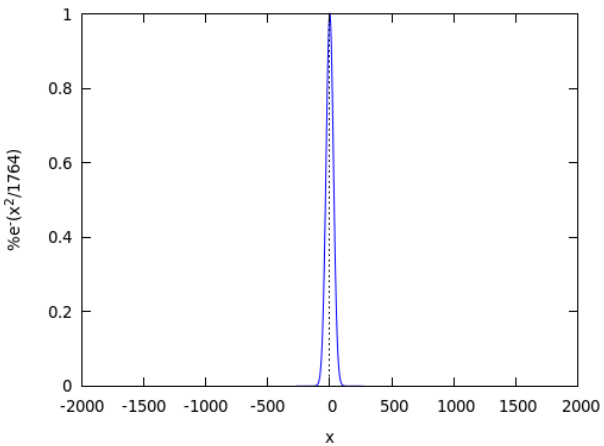
Here: Fitting of a Gaussian curve $f(t) = e^{\frac{-x^2}{1764}}$, such that 20 years before the maximum, 80% of the maximum is reached.



Analysing the Challenges using TRIZ

TRIZ rule – model and go to extreme parameter values.





Analysing the Challenges using TRIZ

The industry of the 20th century has brought us prosperity and wealth. but also

- Pollution, the hole in the ozone layer,
- Problems of extensive agriculture,
- Progressive desertification (Aral Sea),
- Insect extinction, global warming,
- Overexploitation of the rainforest ...

Fundamental insight: Economic activity based on fossil resources cannot be sustainable in the long term.

Problem: How can this insight be implemented into the negotiating and decision-making structures of the bourgeois world society?

Analysing the Challenges using TRIZ

- It is not (only) about "climate change", "species extinction" etc., but about the dynamics of the "fossil age" and the regenerative capacity of the nature we are "exploiting".
- Economies based on fossil resources cannot be sustainable in the long term.

Analysing the Challenges using TRIZ

Problem: The mode of production based on fossil resources is not sustainable.

It is useful and harmful at the same time:

- Useful (short term)
  - Makes life easier
  - Increases power of action
- Harmful (long term)
  - Undermines the conditions of existence of humanity.

Analysing the Challenge using TRIZ

We want to analyse the Challenge according to

- Operational time
- Requirements (Ideal Final Result)
- Historical Optimism
- System Level
- Central Instruments and
- Contradiction Approach

Analysing the Challenge using TRIZ

Operative time -2000 .. +2000

- **Ideal final result:** Complete transformation of the mode of production to cycles that use solely the dissipative material and energy throughput that is permanently supplied by sun.
- **Historical optimism:** For over 1000 years we have managed more or less well to transform the Earth's natural landscape into a cultural landscape.
- **System level:** Work as permanent confrontation with the global living conditions of humankind.
- **Central instruments:** Technology and science
- **Contradiction approach:** Technology and science in the current version are charged with the same contradictions as the mode of production – useful in the short term, harmful in the long term.

Analysing the Challenge using TRIZ

Operative time -200 .. +200

- **Ideal final result:** Technology and science must be transformed in such a way that primary cost-benefit thinking (at the level of the economic system) is replaced by closed-loop thinking as an essential element of the transformation of the mode of production (at the level of the supersystem).
- **Historical optimism:** In the last 200 years, we have always managed again and again to adapt bourgeois society to new conditions of technology and science.
- **System level:** Development of technology and science as essential instruments in shaping our global living conditions. (Supersystem as component!)
- **Central instruments:** Negotiation and decision-making structures of bourgeois society.
- **Contradiction approach:** Inability to take into account the long-term interests of humanity in the given power structures.

Analysing the Challenge using TRIZ

Operative time -20 .. +20

- **Ideal final result:** The structures of negotiation and decision-making of the bourgeois society have to be transformed in such a way that long-term human interests are better taken into account (super-super-system) and technology and science are oriented differently (super-system).
- **Historical optimism:** In the long term, this is a central part of the negotiating structures of bourgeois society (Starting from "liberty, equality, fraternity" of the French Revolution in 1789 to the UN "Declaration of Human Rights" in 1947 and Article 1 of the German Constitution (Grundgesetz)).
- **System level:** Negotiation and decision-making structures of the civil bourgeois society.

What does that mean? Let's use TRIZ first to deepen the analysis of the **relevant functions**.

Analysing the Challenge using TRIZ

Operative time: -20 .. +20
Operative zone: Global

- **Ideal final result:** In the negotiation and decision-making structures of bourgeois society, long-term human interests are better taken into account.
- **Resources:** The "Oil of the 21. Century"
- **System:** Negotiation and decision-making structures of bourgeois society **in the digital age**.
- **Functions:** ?

Goal-oriented, Planned Action in a Civil Society

- **Function:** Goal-oriented, planned action
- TRIZ function pattern: Tool – acts on – Object.
- Who is the *subject* of action?
- The fundamental problem is the question of the *external standpoint* of every planning approach. How does such an approach corresponds with structures of negotiation?
- Fundamental contradiction: negotiation and action (Verhandeln und Handeln).
- **Question:** How does negotiation work in civil society?

Negotiating in Civil Society

Questions:

- Who negotiates?
- How do we arrive at a common language and common terminology?
- What conditions for negotiation structures are to be taken into account?
- Close relation to level 2 of our definiton of technology – institutionalised procedures
- Such negotiation structures are a cultural achievement of bourgeois society.

Negotiation in a Digital Civil Society

Resolution of contradiction through separation in time:

- Successful **cooperative action** presupposes successful **negotiation**.
- But: Successful **negotiation** presupposes trust and thus successful **action**.
- Step-by-step transformation of separate actors in a competitive relationship into a cooperative synergetic structure in which the actors remain **subjects of action**.
  - Development of digital forms of description of cooperative networking: Supply Chain Management, Customer Relationship Management and Digital Networking reproduce relationships and quality issues at a new level.
  - Building, maintaining and managing common digital and non-digital infrastructures, the "Oil fields of the 21st century".

Negotiation in a Digital Civil Society

- These structures of cooperative action also increase the **expressiveness** and thus the **negotiation capacity** of these cooperating subjects who are bound to responsible action.
- The world is full of such chicken-and-egg problems that appear as irresolvable contradictions to **linear thinking**. The simple resolution lies in **dialectical thinking**.
- To implement the Ideal Final Result thus also **requires a different thinking**! (Gorbachev 1985, Potsdam Manifesto 2005)

Cooperative Action and the Foundations of Civil Society

What does this mean for the foundations of bourgeois civil society itself?

- **Freedom** is the (mental as well as social) ability to bind oneself responsibly. This includes *business capability* and *investment capability* (Geschäftsfähigkeit und Investitionsfähigkeit) in (legal) terms of civil society.
- **Equality** is rooted in the fundamental difference of the private procedural skills of the cooperative actors.
- **Fraternity** means "to overcome all relations in which man ..." is only the object of action.

Discussion and Questions

Systemic Structures

Systemic thinking means grouping closely interrelated processes into **systemic units**.

Such units as components are characterised by their eigentimes and eigenspaces in which stable, externally visible structures (limit cycles) reproduce themselves.

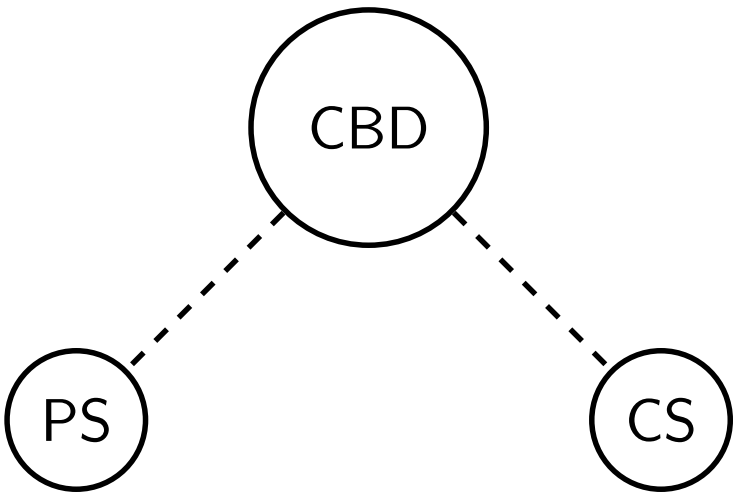
Combining such components into a new system means coupling these repetitive processes, usually resulting in systems whose characteristic eigentimes are common multiples of the eigentimes of the components.

Systemic Structures

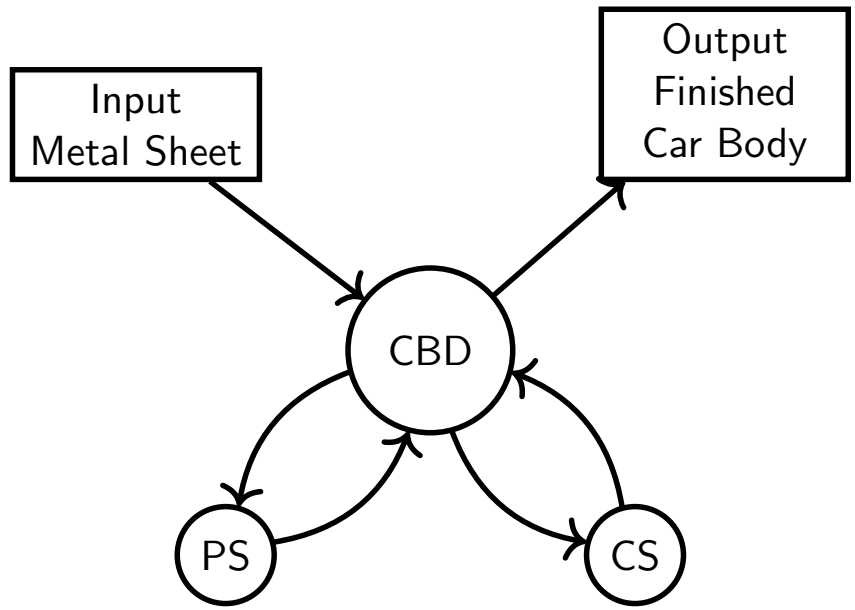
Of particular interest is the context in which fast-moving components are embedded in a slow-moving system. In this case, two clearly different dimensions of reduction to "essentials" arise: The external context can be considered largely static in the analysis of the components, while in the analysis of the external context, the behaviour of the components can be reduced to a statistical mean in which "chaotic noise" averages out and thus becomes irrelevant for the modelling at the level of the slow-moving system.

Systemic Structures

Example: A technical system with two components – the car body department of a car manufacturer with press subdepartment and coloring subdepartment.



Structural Organisation



Workflow Organisation

Systemic Structures

Spatial structures can be composed immersively, temporal structures can be projected submersively onto different time scales through Fourier transformations.

The temporal structures considered determine the reduction dimension and thus select the processes that are "essential" for the systemic context; the spatial structure of the flows of energy, matter and information moved in the process determines the spatial extent of the systemic context.

This does not only apply to models of technical or business systems but ...

Systemic Structures

... typically structures also models of socio-economic systems ...

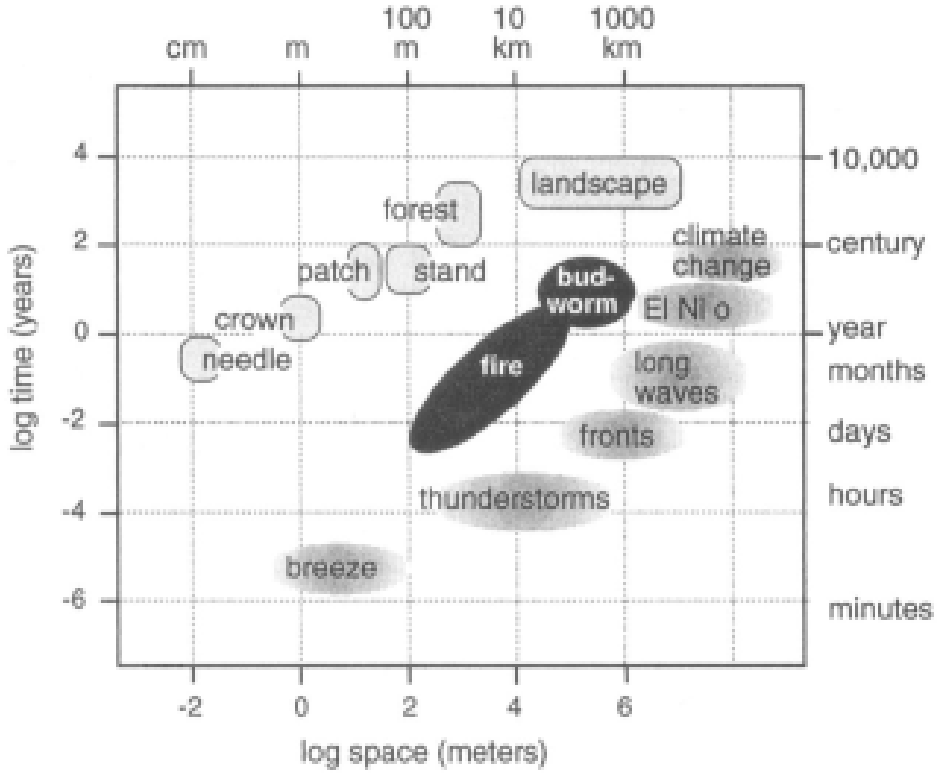


Diagram from (Holling 2001)

Systemic Structures

... of socio-cultural systems ...

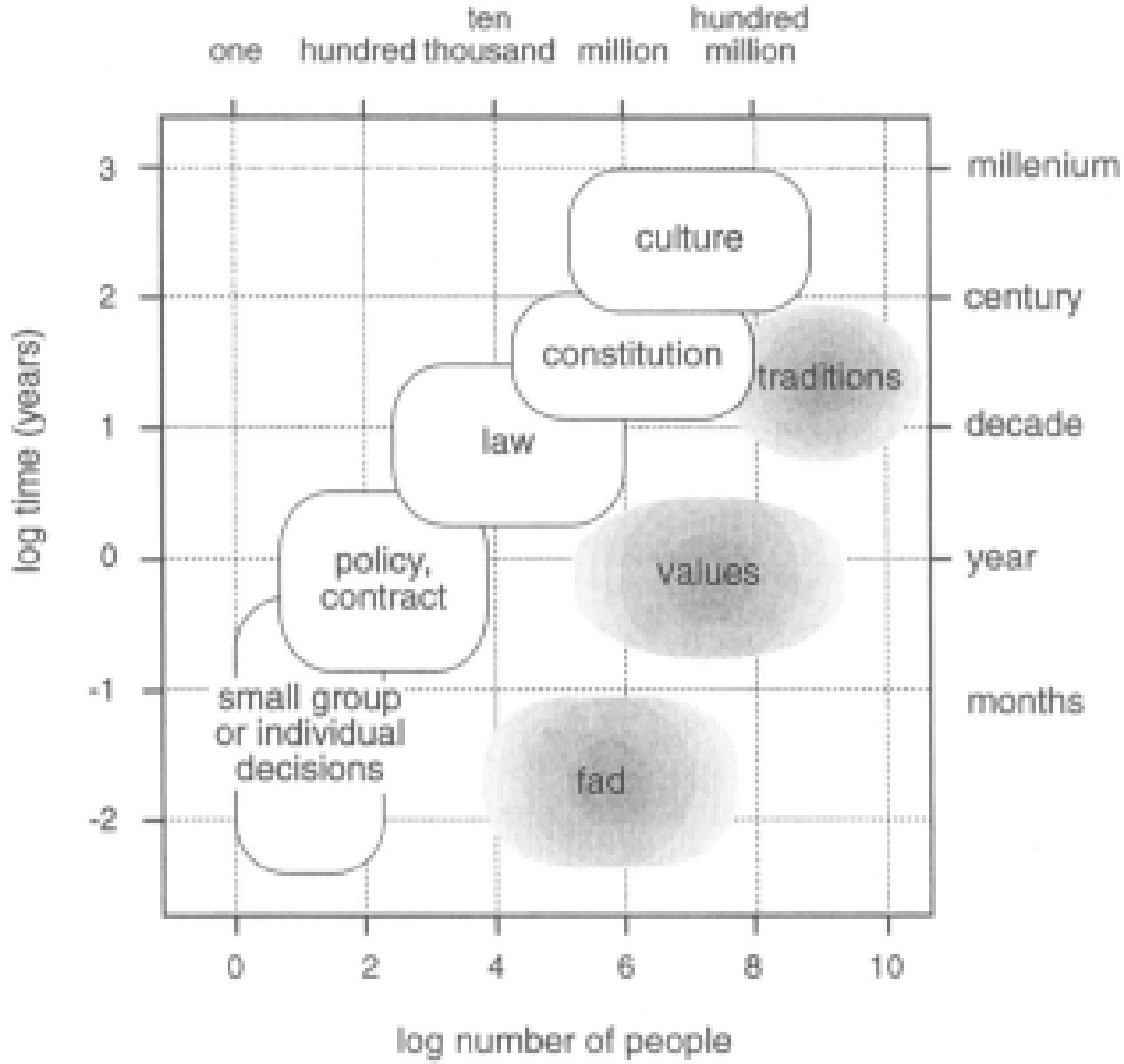


Diagram from (Helling 2001)

Systemic Structures

... and also of "natural" systems.

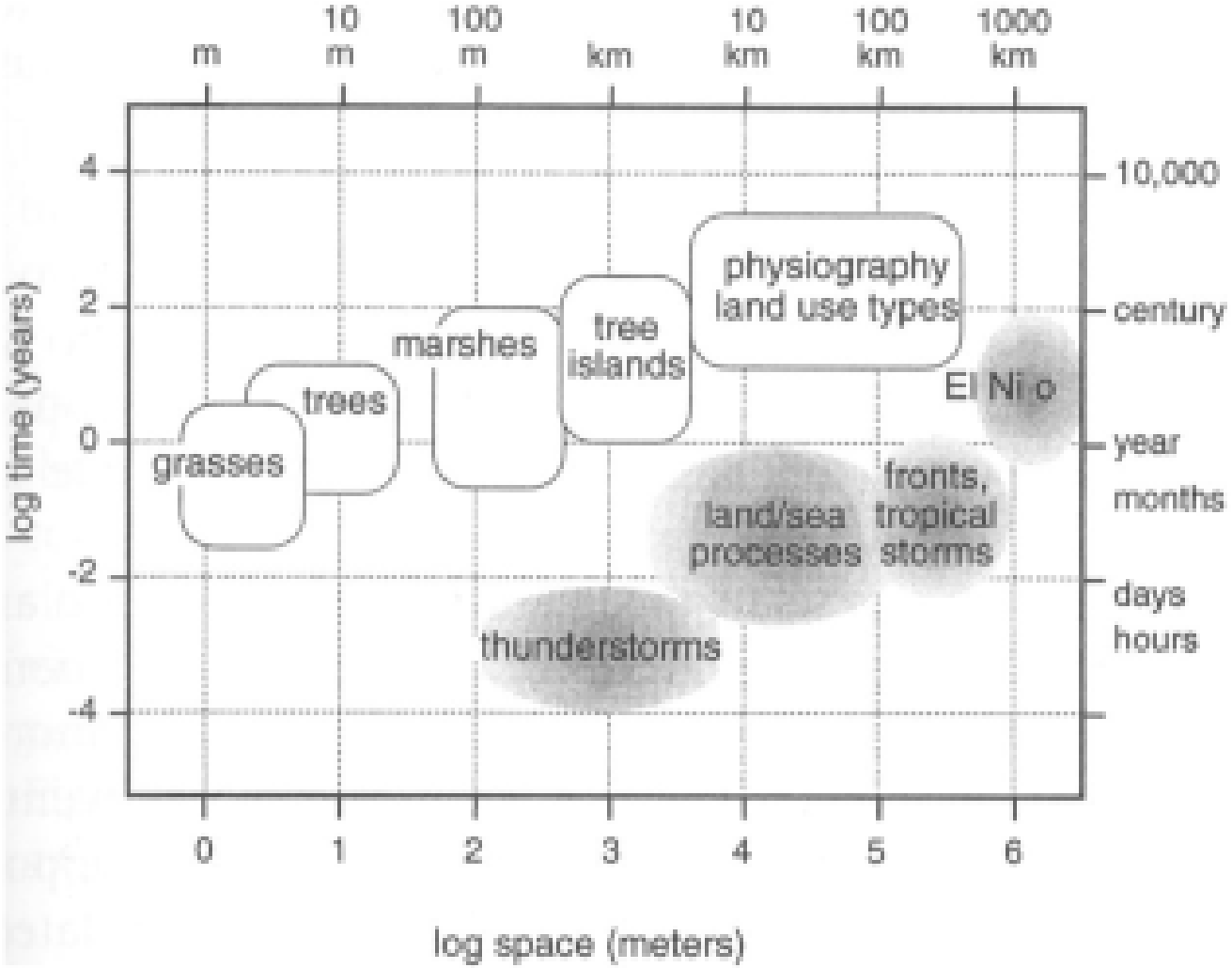


Diagram from (Holling 2001)

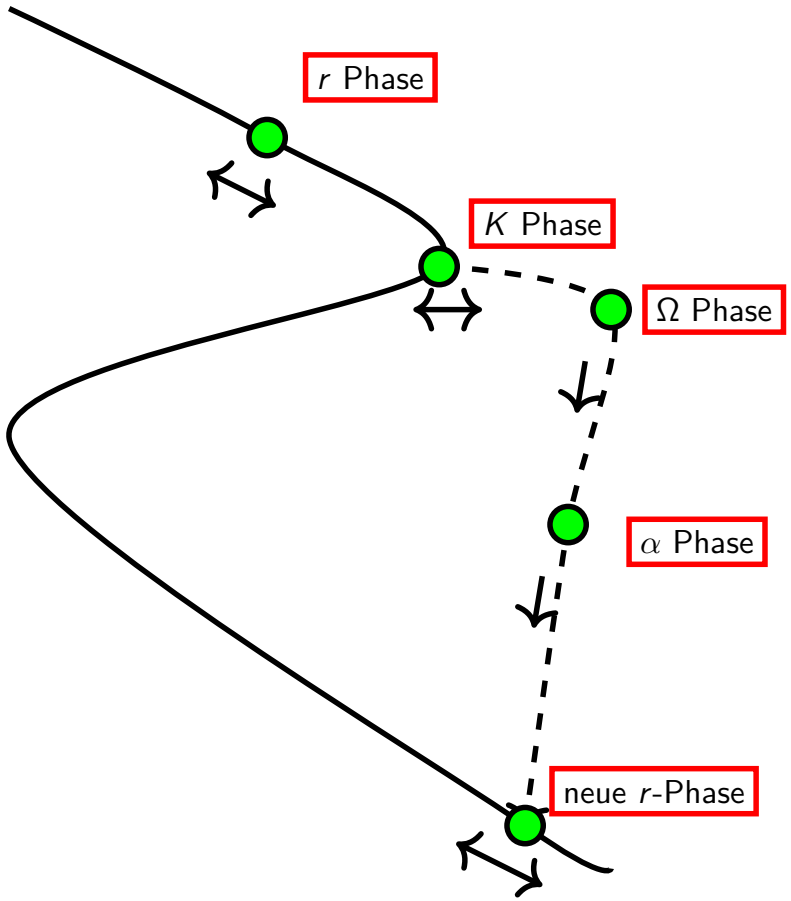
Development of Systemic Structures

Example: The press department is modernised, industrial robots are being used. How does that affect the other components of the systems?

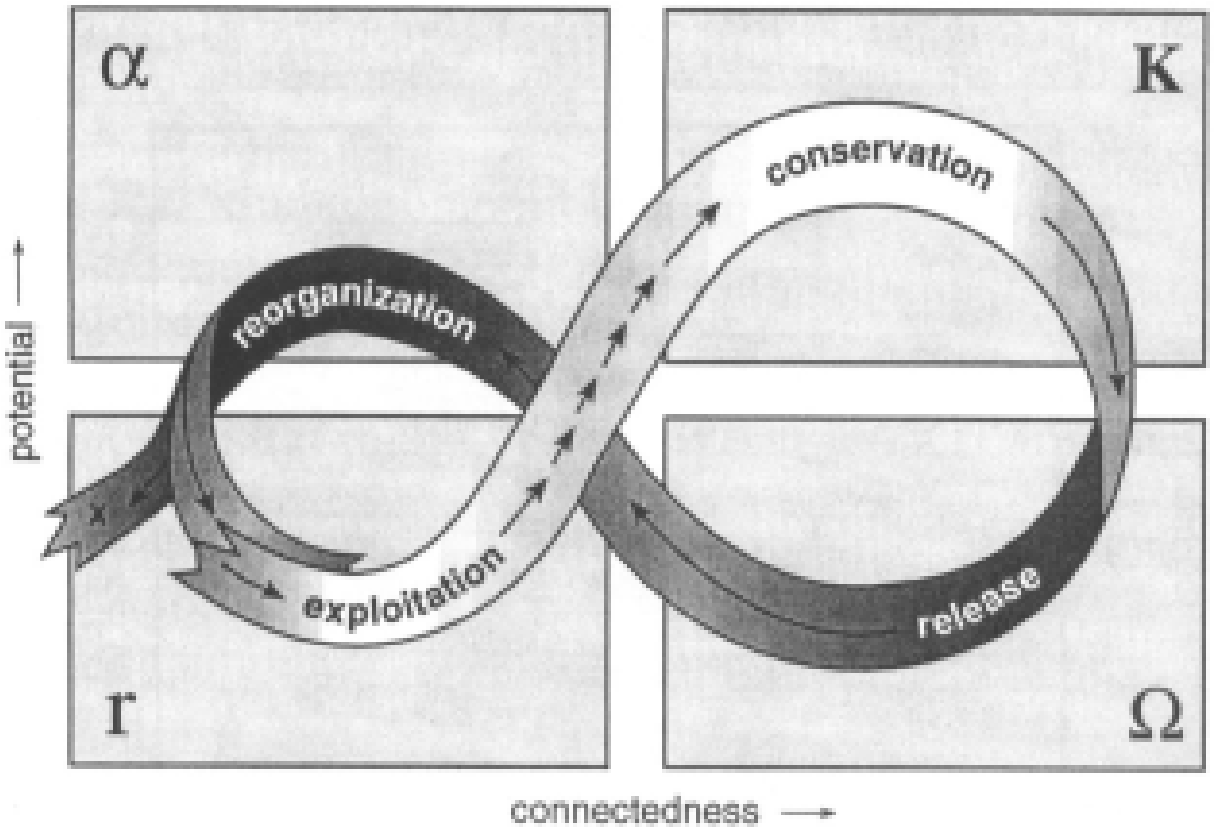
What scenarios are conceivable?

Development of Systemic Structures

Which typical scenarios are to be distinguished for systems that develop along an attractor?



Development of Systemic Structures



Development of Systemic Structures