Rethinking Systems Thinking:
Learning and coevolving with the world

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President, International Society for the Systems Sciences
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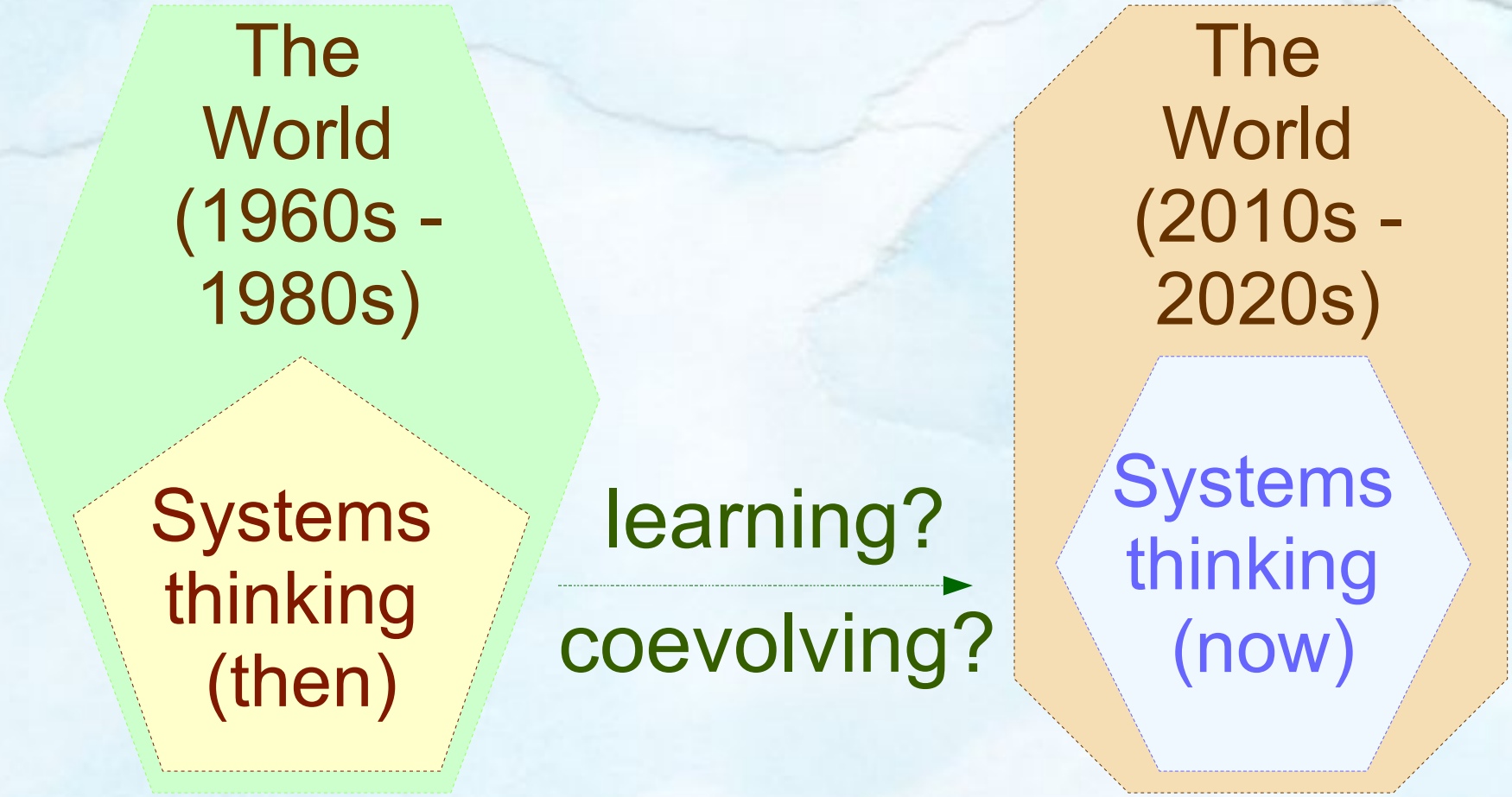
Is systems thinking *learning* and *coevolving* with the *world*?



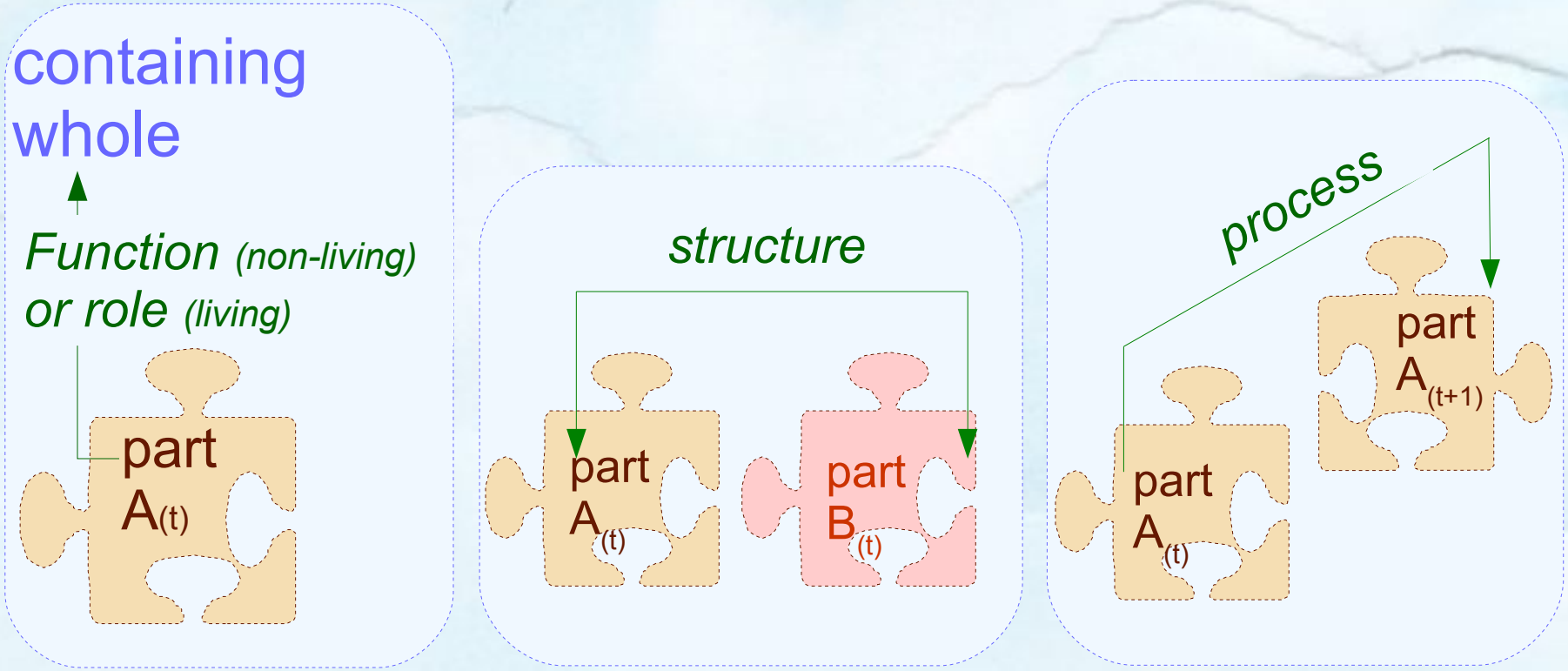
Proposal: Ways to rethink systems thinking

1. Reorient systems thinking beyond "parts and wholes" towards "learning and coevolving"
2. Learn where the service economy and the anthropocene are new, anticipating deutero and trito levels
3. Coevolve the episteme, techne and phronesis across systems thinking, for both the living and non-living

1. Reorient systems thinking beyond “parts and wholes” towards “learning and coevolving”

- 1.1 Overemphasis on whole-part and part-part relations may draw attention away from whole-whole relations
- 1.2 Learning and coevolving are features both in living and non-living systems
- 1.3 Intractability in complex systems may drive decomplexifying to enable learning and coevolving

Systems thinking is a perspective on wholes, parts and their relations

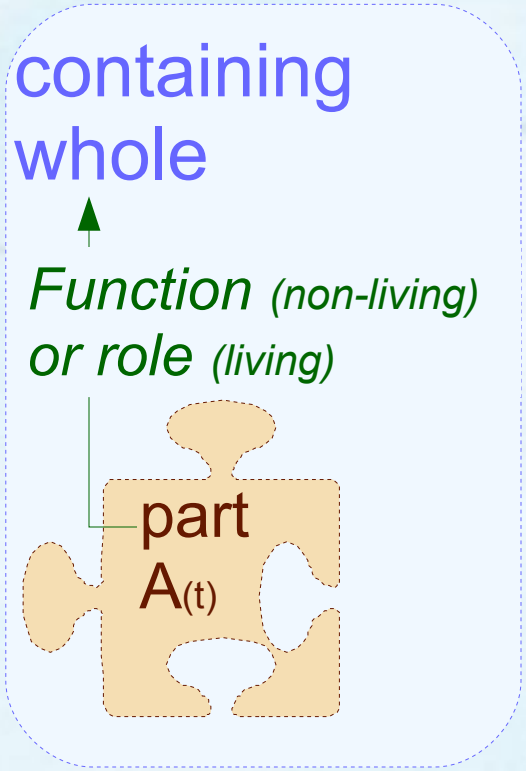


Function
"contribution of the part to the whole"

Structure
"arrangement in space"

Process
"arrangement in time"

Systems thinking: synthesis precedes analysis
(Ackoff 1981)



Synthesis precedes analysis
1. Identify a containing whole (system) of which the thing to be explained is a part.
2. Explain the behavior or properties of the containing whole
3. Then explain the behavior or properties of the thing to the explained in terms of its role(s) or function(s) within its containing whole.

Types of systems and models
(Ackoff and Gharajedaghi 1996)

Systems and models	*Parts*	*Wholes*
Deterministic	Not purposeful	Not purposeful
Animated	Not purposeful	Purposeful
Social	Purposeful	Purposeful
Ecological	Purposeful	Not purposeful

Purposive == goal-seeking	*Goals*: those ends that we can expect to attain within the period covered by planning.
	Objectives: those ends that we do not expect to attain within the period planned for but which we hope to attain later, and toward which we believe progress is possible within the period planned for.
Purposeful == ideal-seeking	*Ideals*: those ends that are believed to be unattainable but towards which we believe progress is possible during and after the period planned for.

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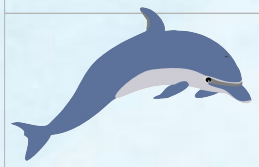
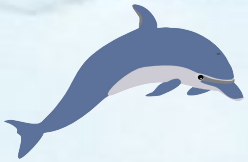
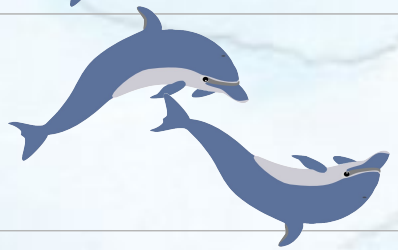
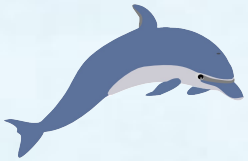
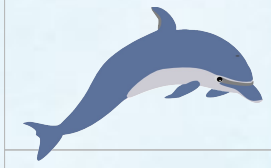
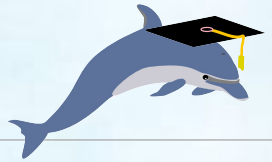
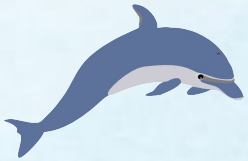
Learning types (Bateson, 1972)

System	External event	Behavioral pattern	Type	Learning process
			Learning 0 Specific response not subject to correction	No learning
			Learning I Change in specific response by correcting errors within a set of alternatives	Proto-learning
			Learning II Corrective change in set of alternatives, or in how sequence of experiences is punctuated	Deutero-learning
			Learning III Corrective change in *sets* of alternatives	Trito-learning
			Learning IV Phylogenesis (of tribe or species) with ontogenesis (of individual living being)	Genetic change

How Buildings Learn (Brand, 1994)

SITE

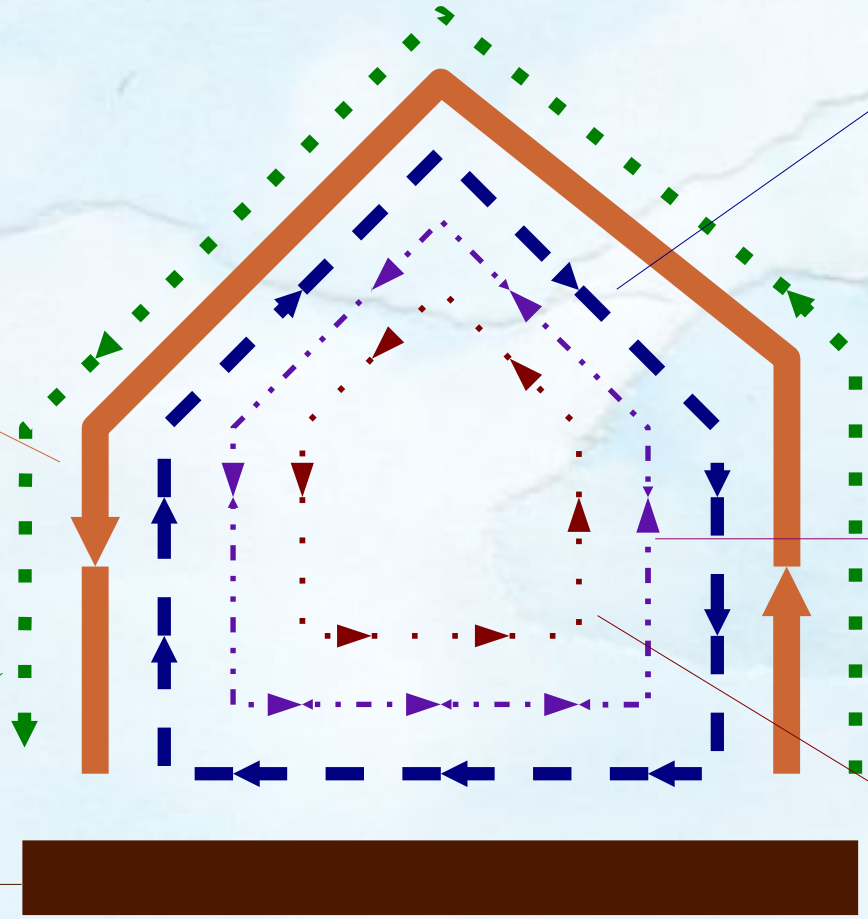
This is the geographical setting, the urban location, and the legally defined lot, whose boundaries outlast generations of ephemeral buildings. "Site is eternal", Duffy agrees.

STRUCTURE

The foundation and load-bearing elements are perilous and expensive to change, so people don't. These are the building. Structural life ranges from 30 to 300 years (but few buildings make it past 60, for other reasons).

SKIN

Exterior surfaces now change every 20 years or so, to keep up with fashion or technology, or for wholesale repair. Recent focus on energy costs has led to re-engineered Skins that are air-tight and better-insulated.



SERVICES

These are the working guts of a building: communications wiring, electrical wiring, plumbing, sprinkler system, HVAC (heating, ventilation, and air conditioning), and moving parts like elevators and escalators. They wear out or obsolesce every 7 to 15 years. Many buildings are demolished early if their outdated systems are too deeply embedded to replace easily.

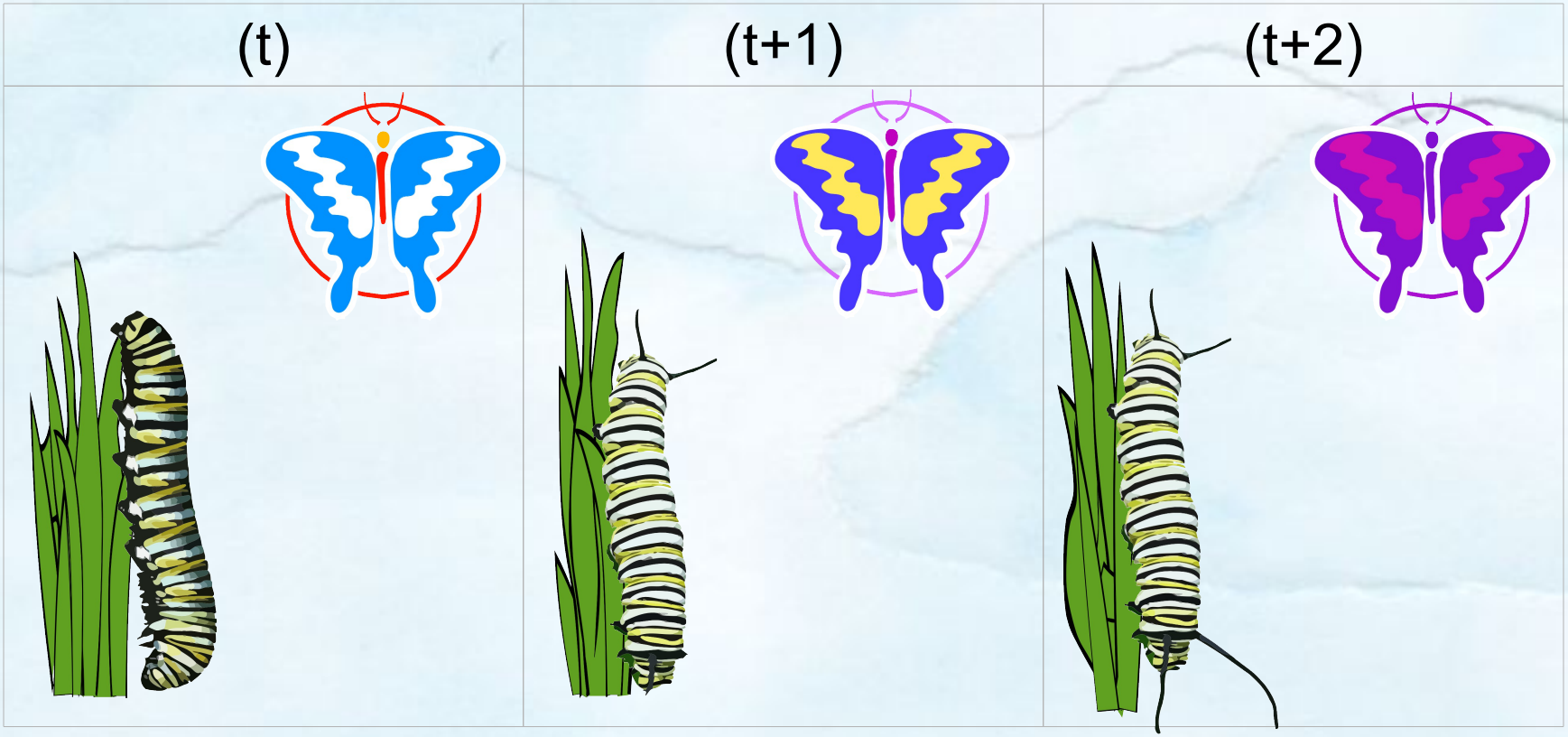
SPACE PLAN

The interior layout, where walls, ceilings, floors, and doors go. Turbulent commercial space can change every 3 years; exceptionally quiet homes might wait 30 years.

STUFF

Chairs, desks, phones, pictures; kitchen appliances, lamps, hair brushes; all the things that twitch around daily to monthly. Furniture is called mobilia in Italian for good reason.

Coevolution (Ehrlich (1968) → Brand (1974))



This [new] way of consists of examining the patterns of interaction not in an entire community, but between two groups of organisms which do not exchange genetic information but which do have a close and evident ecological relationship. Peter Raven and [Paul R. Ehrlich] called the evolutionary interaction within such systems “coevolution” in other to emphasize the reciprocal nature of the relationship.

Two-species Population Interactions (E.P. Odum, 1983)

	Type of Interaction	*Species*		*General nature of interaction*
		1	*2*	
	1. Neutralism	0	0	Neither population affects the other
"Negative interactions", types 2 through 4	2. Competition: direct interference type	-	-	Direct inhibition when common resources are in short supply
	3. Competition: resource use type	-	-	Indirect inhibition when common resource is in short supply
	4. Amensalism	-	0	Population 1 inhibited, 2 not affected
Both "positive interactions" and "negative interactions", types 5 and 6	5. Parasitism	+	-	Population 1, the parasite generally smaller than 2, the host
	6. Predation (including herbivory)	+	-	Population 1, the predator, generally larger than 2, the prey
"Positive interactions", types 7 through 9	7. Commensalism	+	0	Population 1, the commensal, benefits, while 2, the host is not affected
	8. Protocooperation	+	+	Interaction favorable to both but not obligatory
	9. Mutualism	+	+	Interaction favorable to both and obligatory

Legend:
0 indicates no significant interaction;
+ indicates growth, survival or other population attribute benefited (positive term added to growth equation);
- indicates population growth or other attribute inhibited (negative term added to growth equation)

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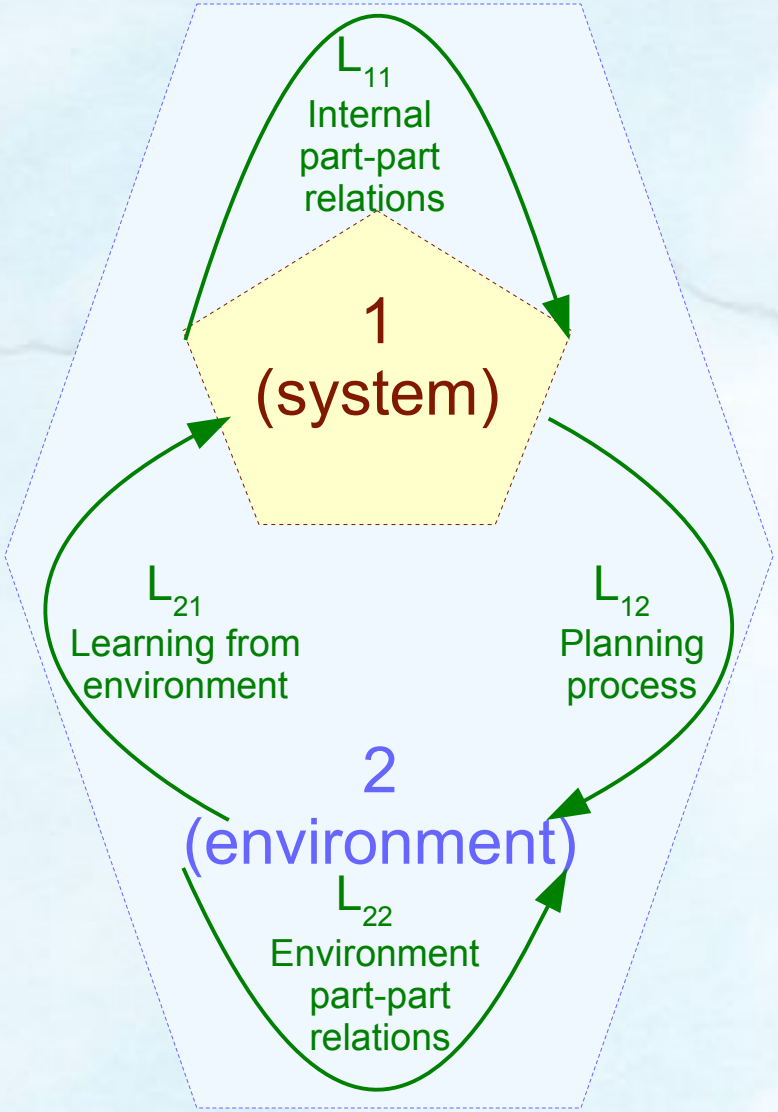
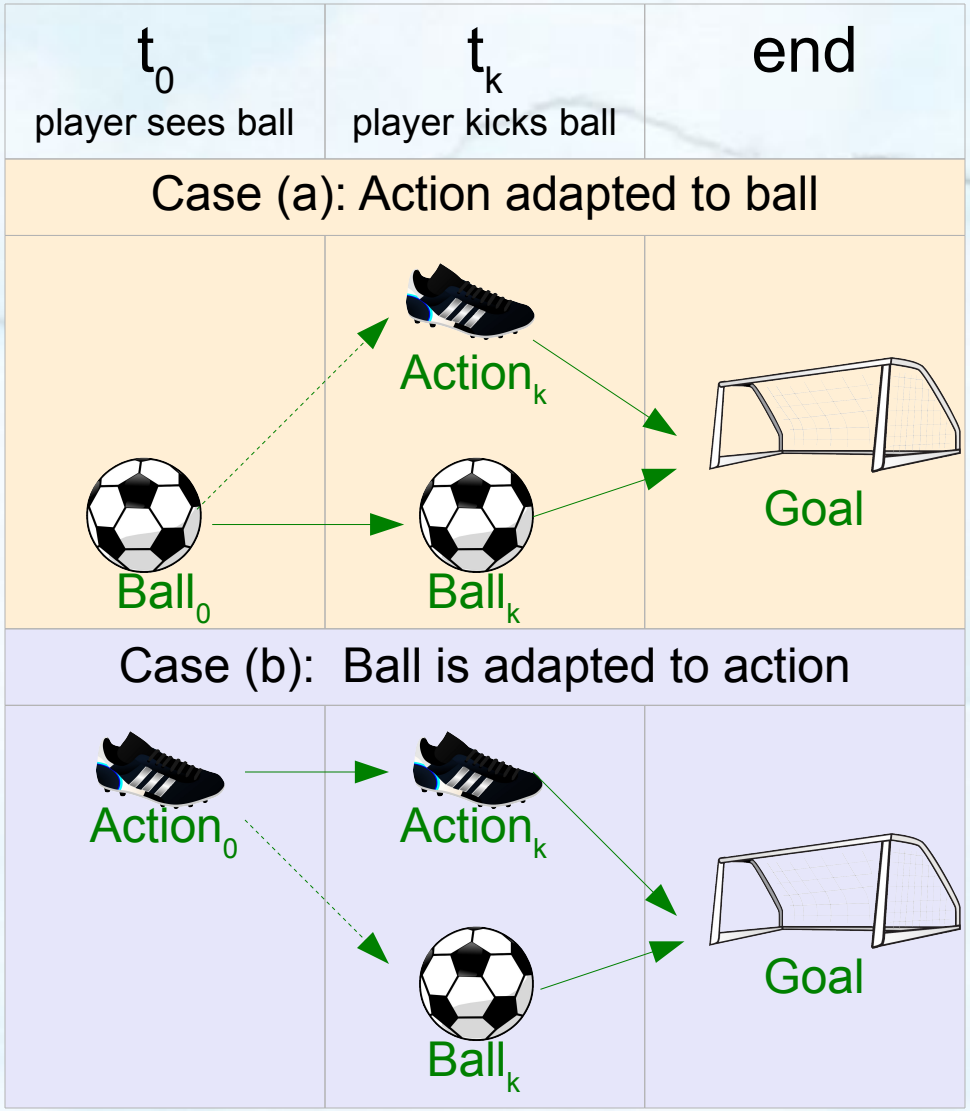
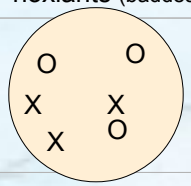
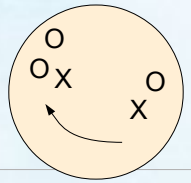
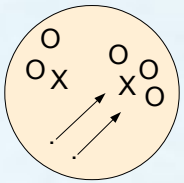
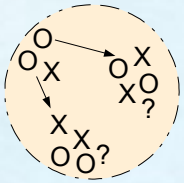
Open systems (Emery and Trist), directive correlation (Sommerhoff)

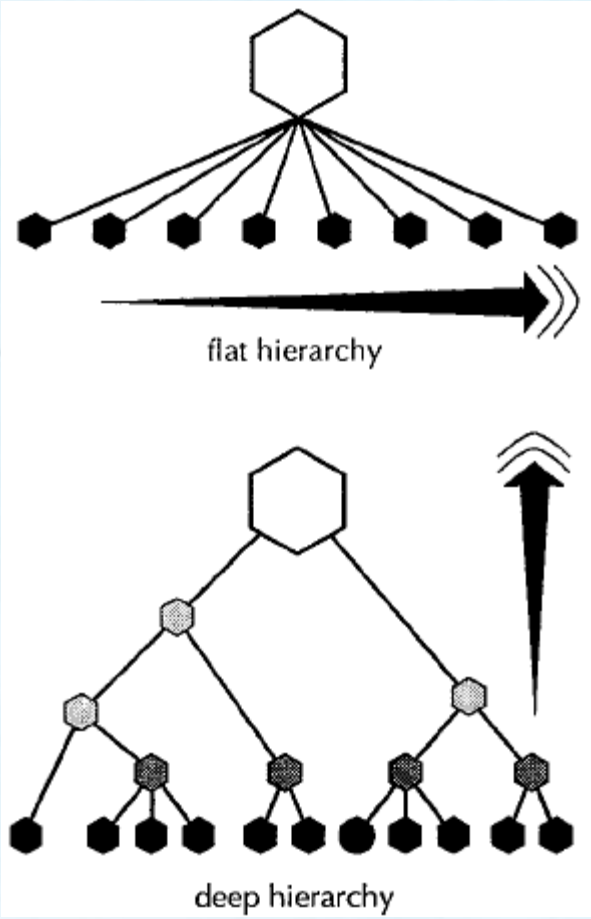




The Causal Texture of Social Environments – Extended fields of directive correlations (Emery and Trist)

	Where O = goals (goodies), X = noxiants (baddes)		Elements to know	Ideals	Forms of learning	Forms of planning
Type I. Random Placid		Goals and noxiants randomly distributed. Strategy is tactic. “Grab it if it's there”. Largely theoretical of micro, design, e.g. concentration camps, conditioning experiments. Nature is not random.	system	Homonomy – sense of belonging	conditioning	tactics
Type 2. Clustered Placid		Goals and noxiants are lawfully distributed – meaningful learning. Simple strategy – maximize goals, e.g. use fire to produce new grass. Most of human span spent in this form. Hunting, gathering, small village. What people mean by the “good old days”.	system, action	Nurturance – caring for	meaningful	tactics / strategies
Type 3. Disturbed Reactive		Type 2 with two or more systems of one kind *competing* for the same resources. Operational planning emerges to out-manoeuvre the competition. Requires extra knowledge of both Ss and E. E is stable so start with a set of givens and concentrate on problem solving for win-lose games. Need to create insturments that are variety-reducing (foolproof) – elements must be standardized and interchangeable. Birth of bureacractic structures where people are redundant parts. Concentrate power at the top – strrategy becomes a power game.	system, action, learning	Humanity – in broadest sense	problem solving	tactics / operational strategies
Type 4. Turbulent		Dynamic, not placid/stable. Planned change in type 3 triggers off unexpected social processes. Dynamism arises from the field itself, creating unpredictability and increasing *relevant uncertainty* and *its continuities*. Linear planning impossible, e.g. whaling disrupted reproduciton, people react to being treated as parts of machine. Birth of open systems thinking, ecology, and catastrophe theory.	system, action, learning, environment	Beauty – includes fitting together naturally	puzzle-solving	active adaptive planning

Complicatedness, complexity, gain



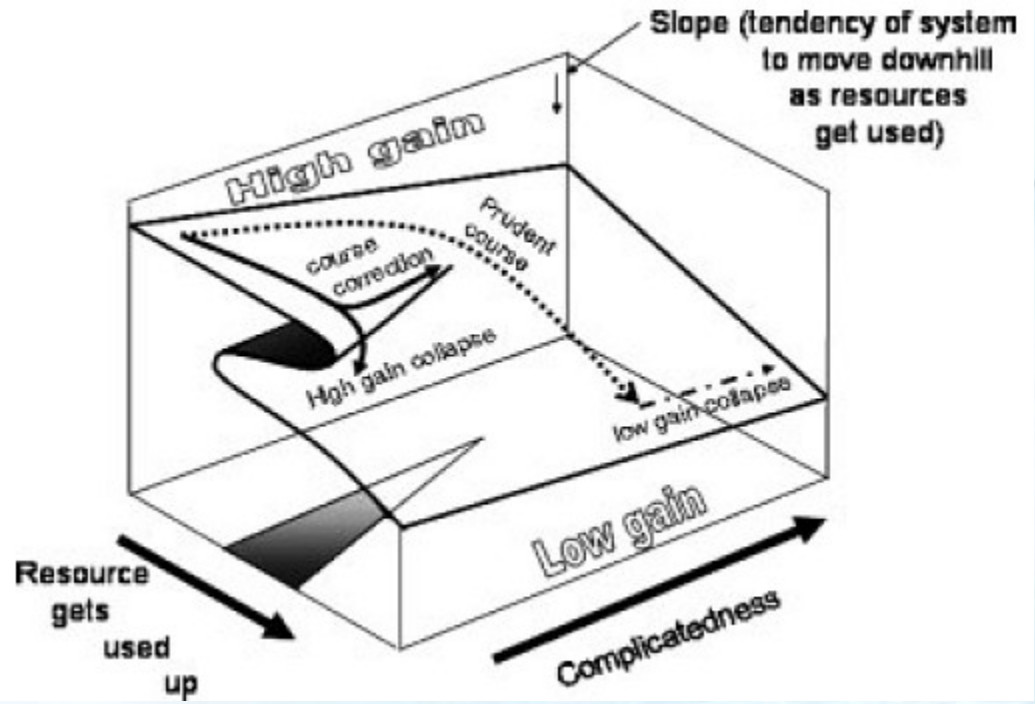


Figure 7. A representation of the tracks that lead from high to low to super low gain patterns. [Allen, Allen, Malek 2006]

Figure 3. The top hierarchy shows increases in complicatedness by increasing the structural elaboration. Structural elaboration is portrayed as widening the span in horizontal differentiation. The bottom hierarchy shows increasing complexity, by an elaboration of organization. New levels appear as new constraints emerge as limits to the positive feedbacks of the emergent process. Elaboration or organization increases hierarchical depth. [Allen, Tainter, Hoekstra 1999]

Proposal: Ways to rethink systems thinking

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2. Learn where the service economy and the anthropocene are new, anticipating deutero and trito levels
3. Coevolve the episteme, techne and phronesis across systems thinking, for both the living and non-living

2. Learn where the Service Economy and Anthropocene are New, Anticipating Deutero and Trito Levels

- 2.1 Cross-scale dynamics may discourage learning and coevolving when systems are resilient
- 2.2 The emphasis in service systems over industrial systems calls for infrastructure renewal with deutero and trito learning
- 2.3 Coevolving from Holocene to Anthropocene portends regime shifts where human systems can react or interact

Resilience

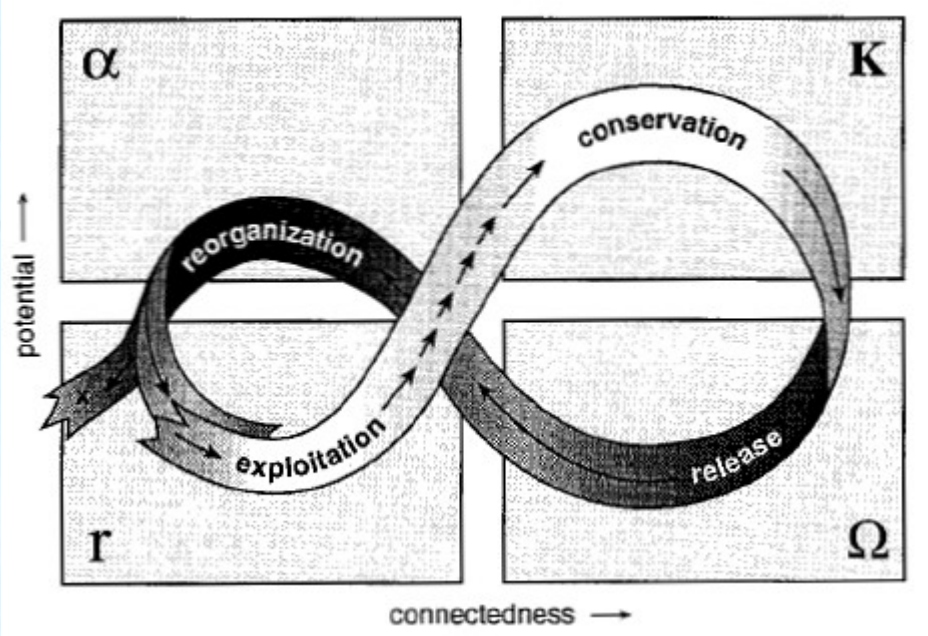

Figure 4. A stylized representation of the four ecosystem functions (r, K, Ω, α) and the flow of events among them.

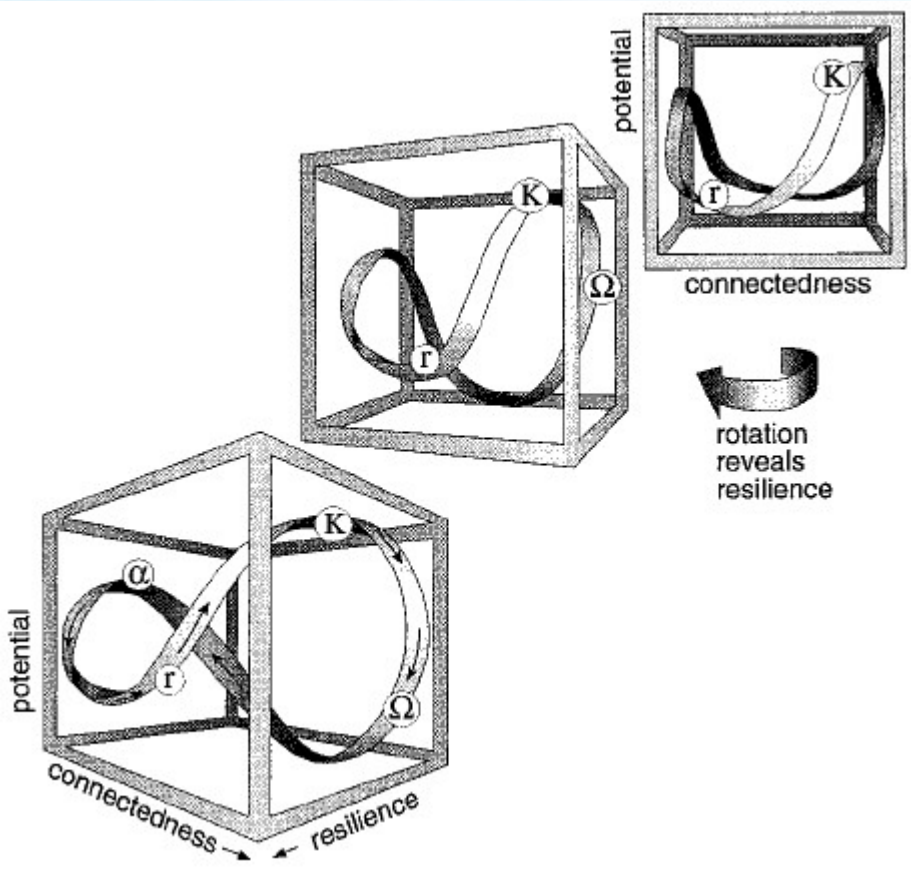

Figure 5. Resilience is another dimension of the adaptive cycle.

[Holling 2001]

Cross-scale relations and panarchy

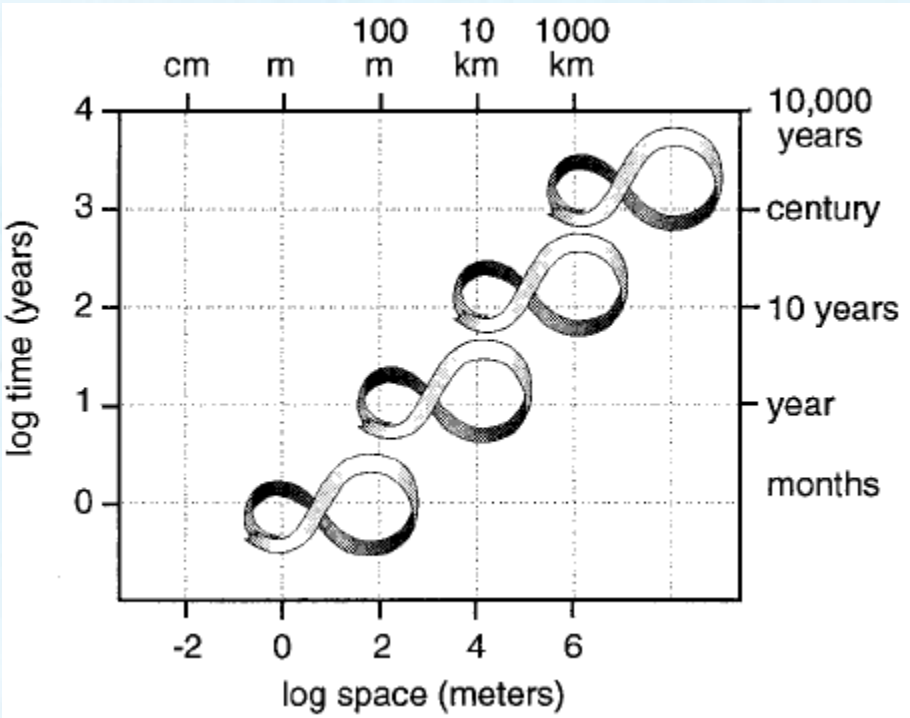

Figure 6. A stylized panarchy. A panarchy is a cross scale, nested set of adaptive cycles that indicates the dynamic nature of structures depicted in the previous plots.

[Holling 2001]

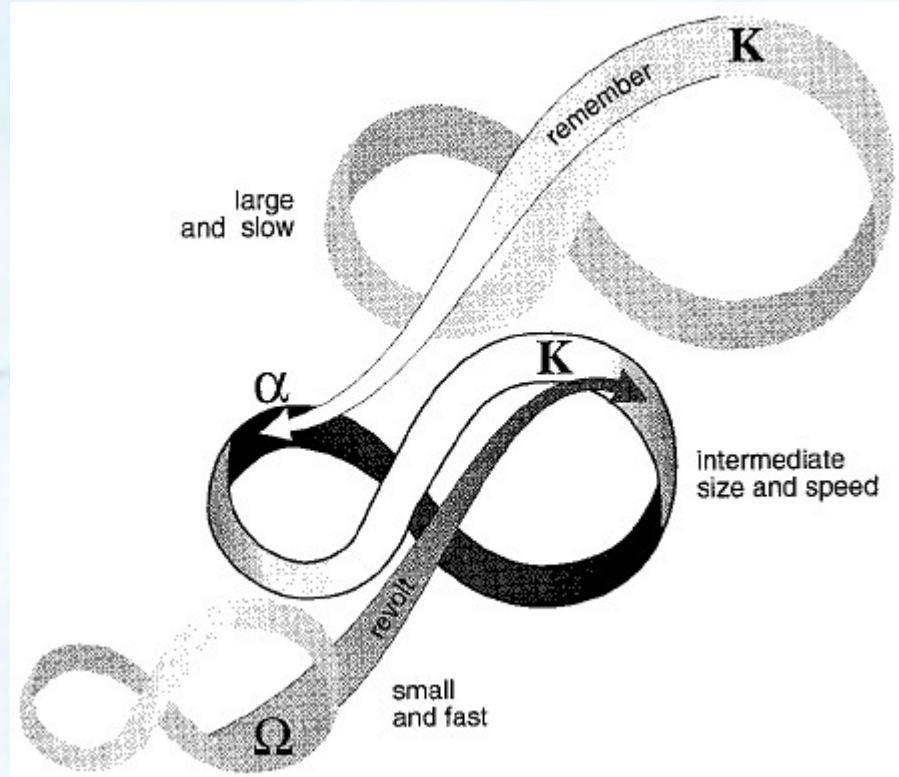

Figure 7. Panarchical connections. [....] the "revolt" connection ...can cause a critical change in one cycle to cascade up to a vulnerable stage in a larger and slower one. The ... "remember" connection ... facilitates renewal by drawing on the potential that has been accumulated and stored in a larger, slower cycle.

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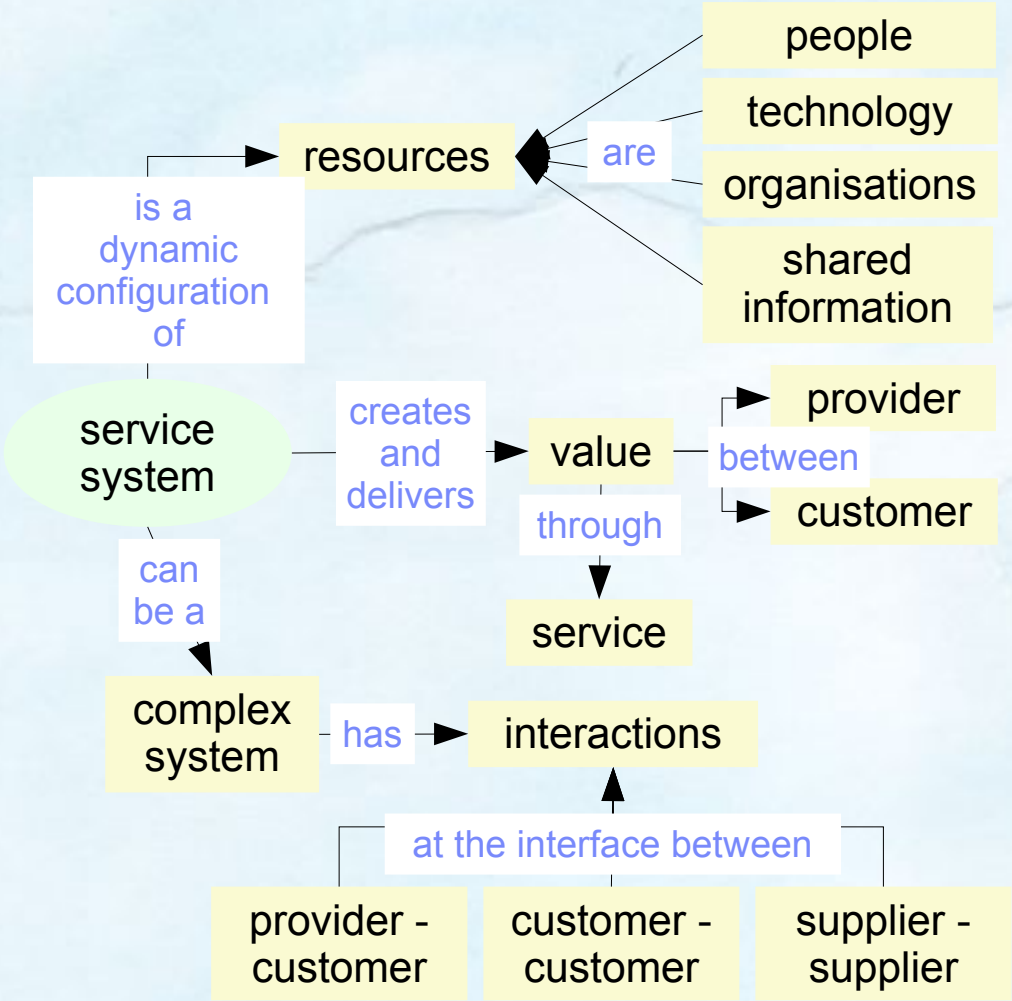
Human civilization is served by systems in technical, organizational and socio-political form

Systems that move, store, harvest, process	•Transportation	K
	•Water and waste management	1
	•Food and global supply chain	2
	•Energy and energy grid	3
	•Information and communications (ICT) infrastructure	4
Systems that enable healthy, wealthy and wise people	•Building and construction	5
	•Banking and finance	6
	•Retail and hospitality	7
	•Healthcare	8
	•Education (including universities)	9
Systems that govern	•Government (cities)	10
	•Government (regions / states)	11
	•Government (nations)	12

[Spohrer and Maglio 2010]

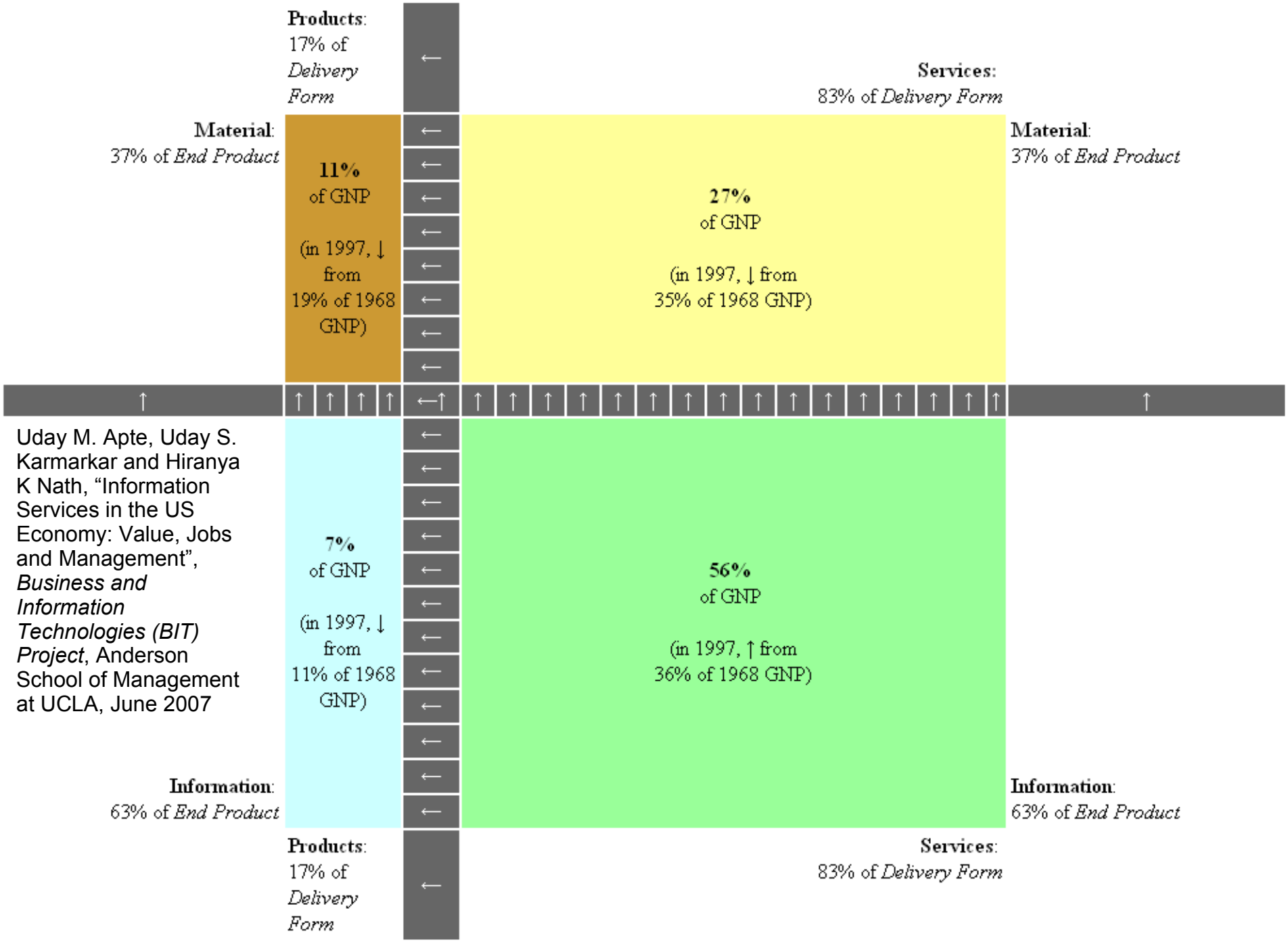
Service systems (Cambridge IfM and IBM, 2008)



A service system can be defined as a dynamic configuration of resources (people, technology, organisations and shared information) that creates and delivers value between the provider and the customer through service.

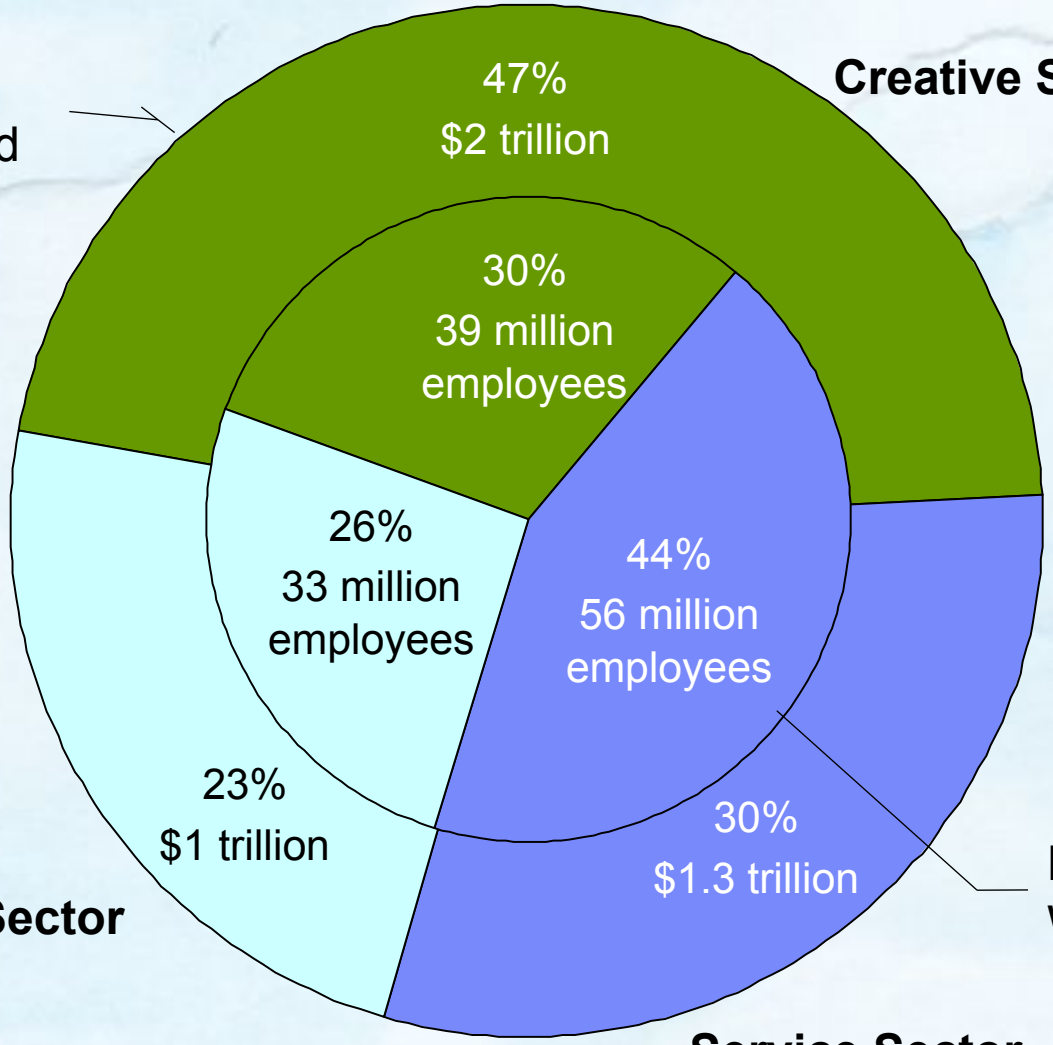
In many cases, a service system is a complex system in that configurations of resources interact in a non-linear way. Primary interactions take place at the interface between the provider and the customer. However, with the advent of ICT, customer-to-customer and supplier-to-supplier interactions have also become prevalent. These complex interactions create a system whose behaviour is difficult to explain and predict.
(IfM and IBM, 2008, p. 6)

Source: IfM, and IBM. 2008. *Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government.* Cambridge, UK: University of Cambridge Institute for Manufacturing. http://www.ifm.eng.cam.ac.uk/ssme/ .



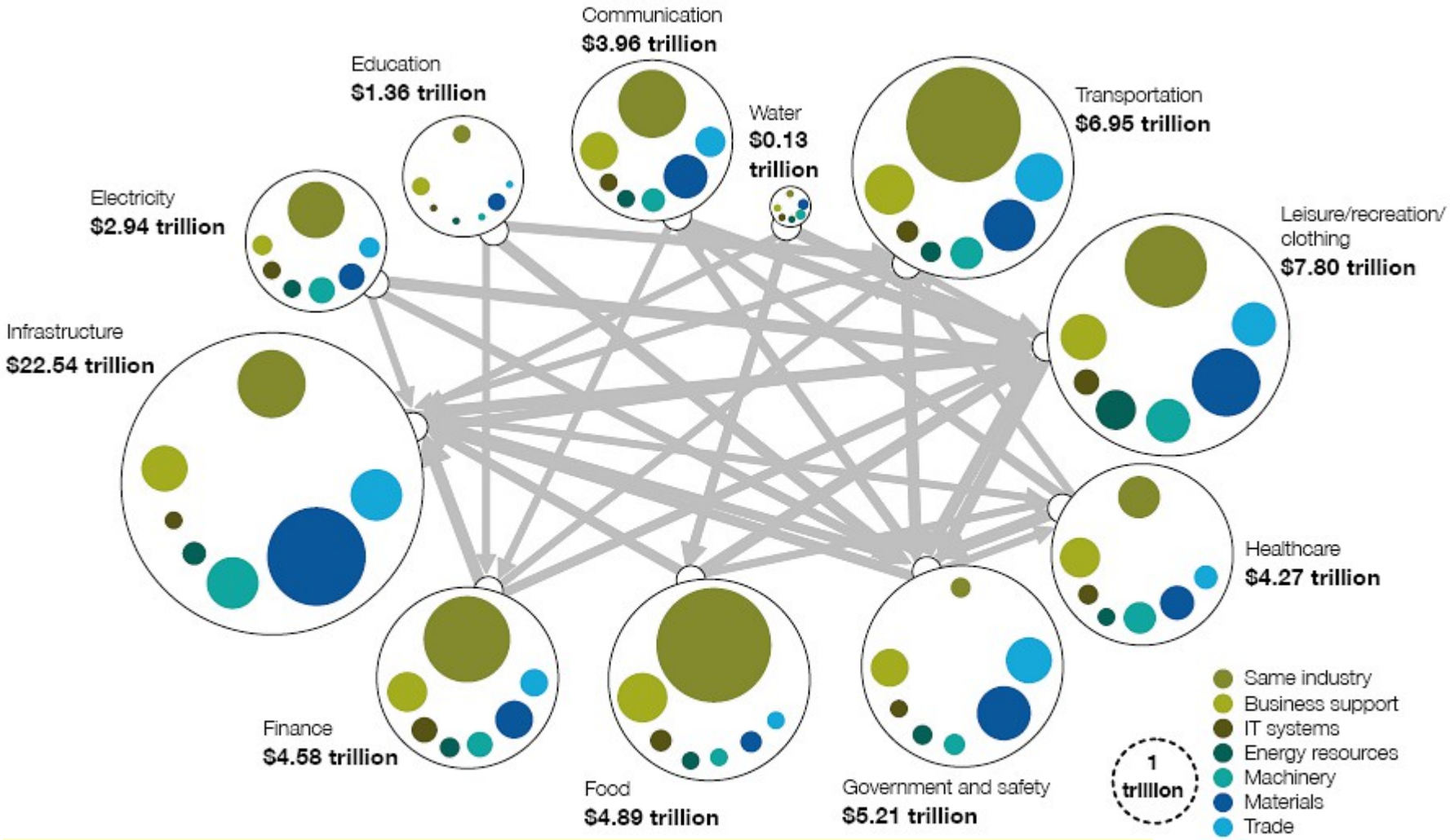
Uday M. Apte, Uday S. Karmarkar and Hiranya K Nath, "Information Services in the US Economy: Value, Jobs and Management", *Business and Information Technologies (BIT) Project*, Anderson School of Management at UCLA, June 2007

Creative class generates greater wealth per employee



Source:
Richard L. Florida (2004) *The flight of the creative class : The new global competition for talent.*

US$54 trillion system of systems -- IBM

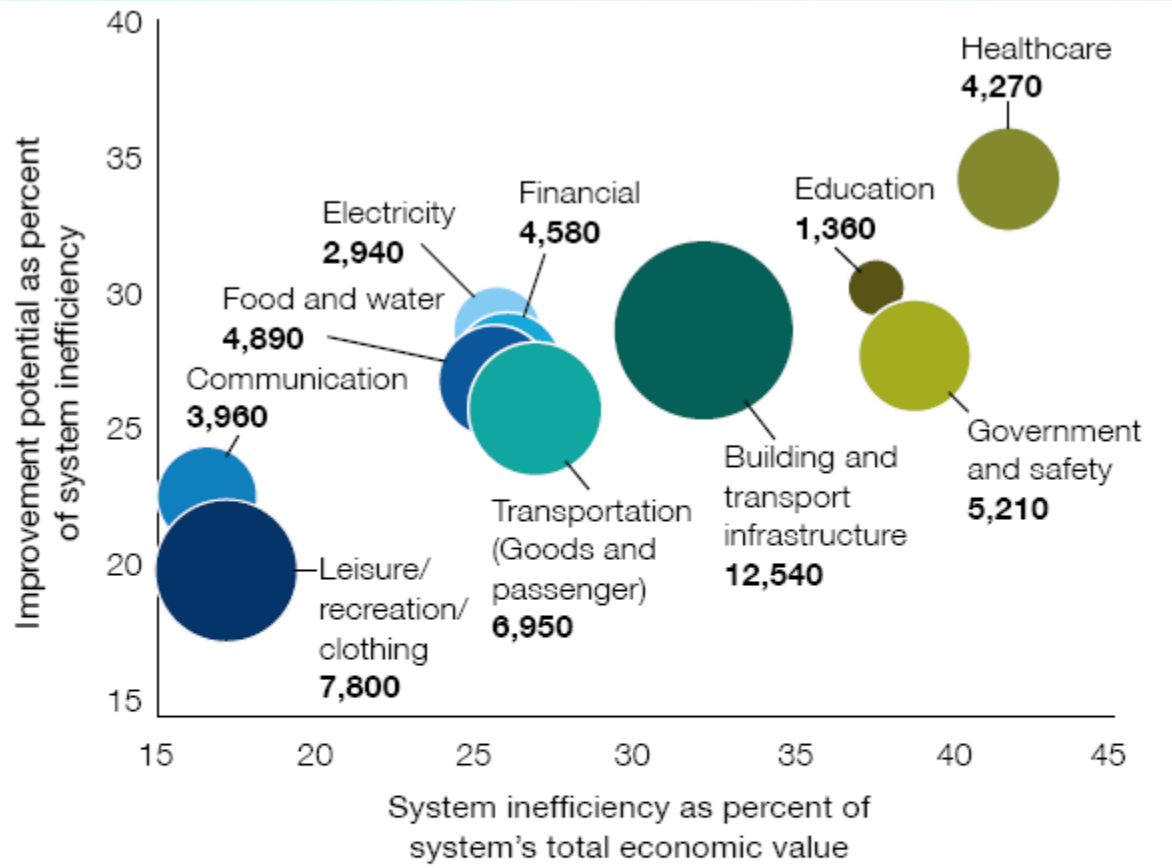


http://www-935.ibm.com/services/us/gbs/bus/html/ibv-smarter-planet-system-of-systems.html.

Note: Size of bubbles represents systems' economic values. Arrows represent the strength of systems' interaction.
Source: IBM Institute for Business Value analysis of Organisation for Economic Co-operation and Development (OECD) data.

Figure 1: We live and work within a complex, dynamic and interconnected US$54 trillion system of systems.

The world's $4 billion challenge -- IBM



Note: Size of the bubble indicates absolute value of the system in US$ billions
Source: IBM Institute for Business Value analysis based on inefficiency and improvement potential estimates reported during 2009 survey of 518 economists.

http://www-935.ibm.com/services/us/gbs/bus/html/ibv-smarter-planet-system-of-systems.html.

Figure 2: Of the US$15 trillion in inefficiencies within our global system, approximately US$4 trillion could be eliminated.

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The last glacial cycle of $\delta^{18}O$ (an indicator of temperature) and selected events in human history. The Holocene is the last 10000 years.

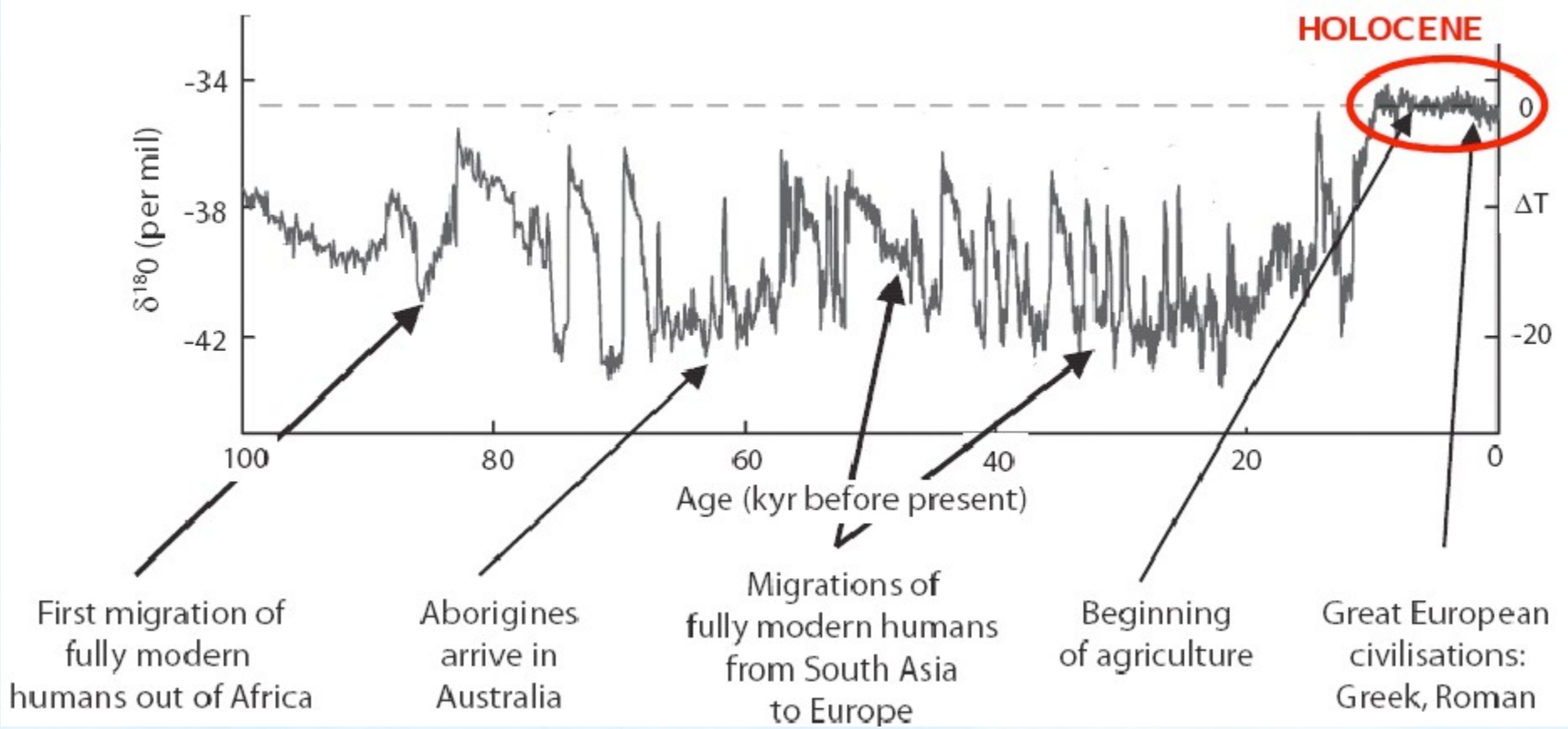


Figure 1 (adapted from Young and Steffen (2009), Rockström, J., W. Steffen, K. Noone et al. 2009. "Planetary Boundaries: Exploring the Safe Operating Space for Humanity." *Ecology and Society* 14 (2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32/.

Planetary Boundaries

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(I) Atmospheric carbon dioxide concentration (parts per million by volume) (ii) Change in radiative forcing (watts per metre squared)	350 1	387 1.5	280 0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1-1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the ocean (millions of tonnes per year)	11	8.5 - 9.5	-1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste, in the global environment, or the effects on ecosystem and functioning of Earth system thereof	To be determined		

Boundaries for processes in red have been crossed.

Table 1, Rockström, J., W. Steffen, K. Noone et al. 2009. "Planetary Boundaries: Exploring the Safe Operating Space for Humanity." *Ecology and Society* 14 (2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32/.

Beyond the boundaries

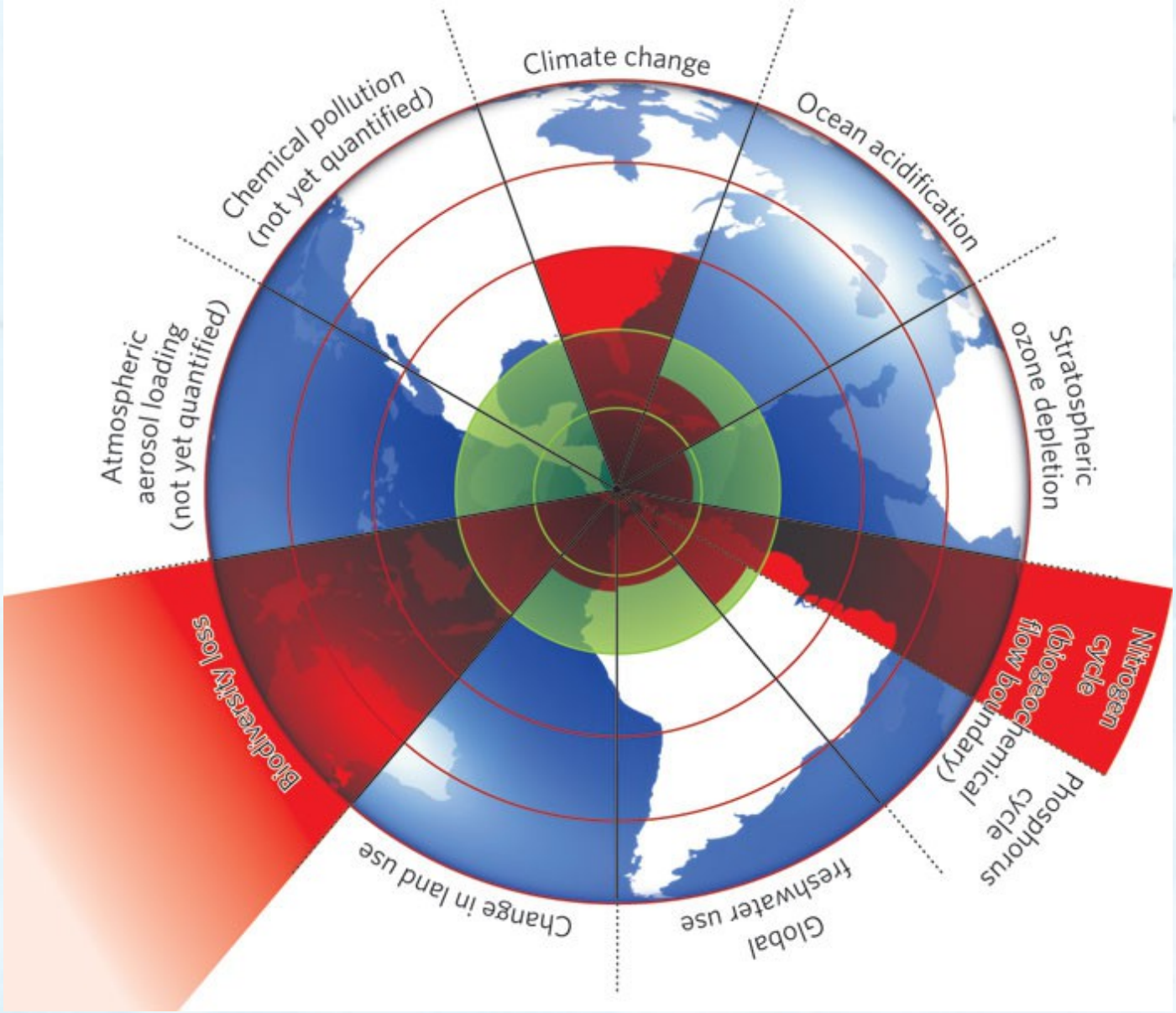


Figure 1.

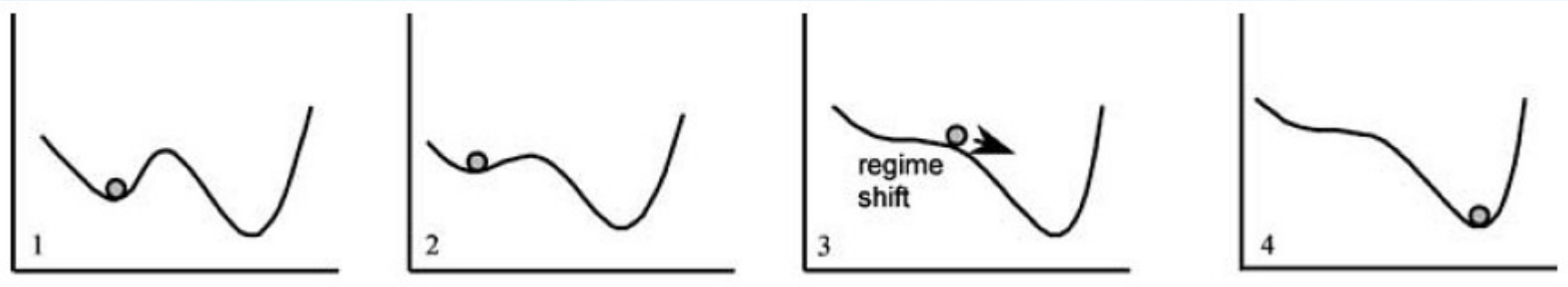
The inner green shading represents the proposed safe operating space for nine planetary systems.

The red wedges represent an estimate of the current position for each variable.

The boundaries in three areas (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

Rockström, Johan, Will Steffen, Kevin Noone, et al. 2009. "A Safe Operating Space for Humanity." *Nature* 461 (7263): 472–475. doi:10.1038/461472a. http://dx.doi.org/10.1038/461472a..

Regime shifts and thresholds



clear-water lakes	phosphorous accumulation in agricultural soil and lake mud	flooding, warming, overexploitation of predators	turbid-water lakes
coral-dominated reefs	overfishing, coastal eutrophication	disease, bleaching hurricane	algae-dominated reefs
grasslands	fire prevention	good rains, continuous heavy grazing	shrub-bushland
grassland	hunting of herbivores	disease	woodland
...	...	...	...

Figure 2 Alternate states in a diversity of ecosystems (1, 4) and the causes (2) and triggers (3) behind loss of resilience and regime shifts.

[Folke, Carpenter, Walker, Scheffer, Elmqvist, Gunderson and Holling 2004]

Proposal: Ways to rethink systems thinking

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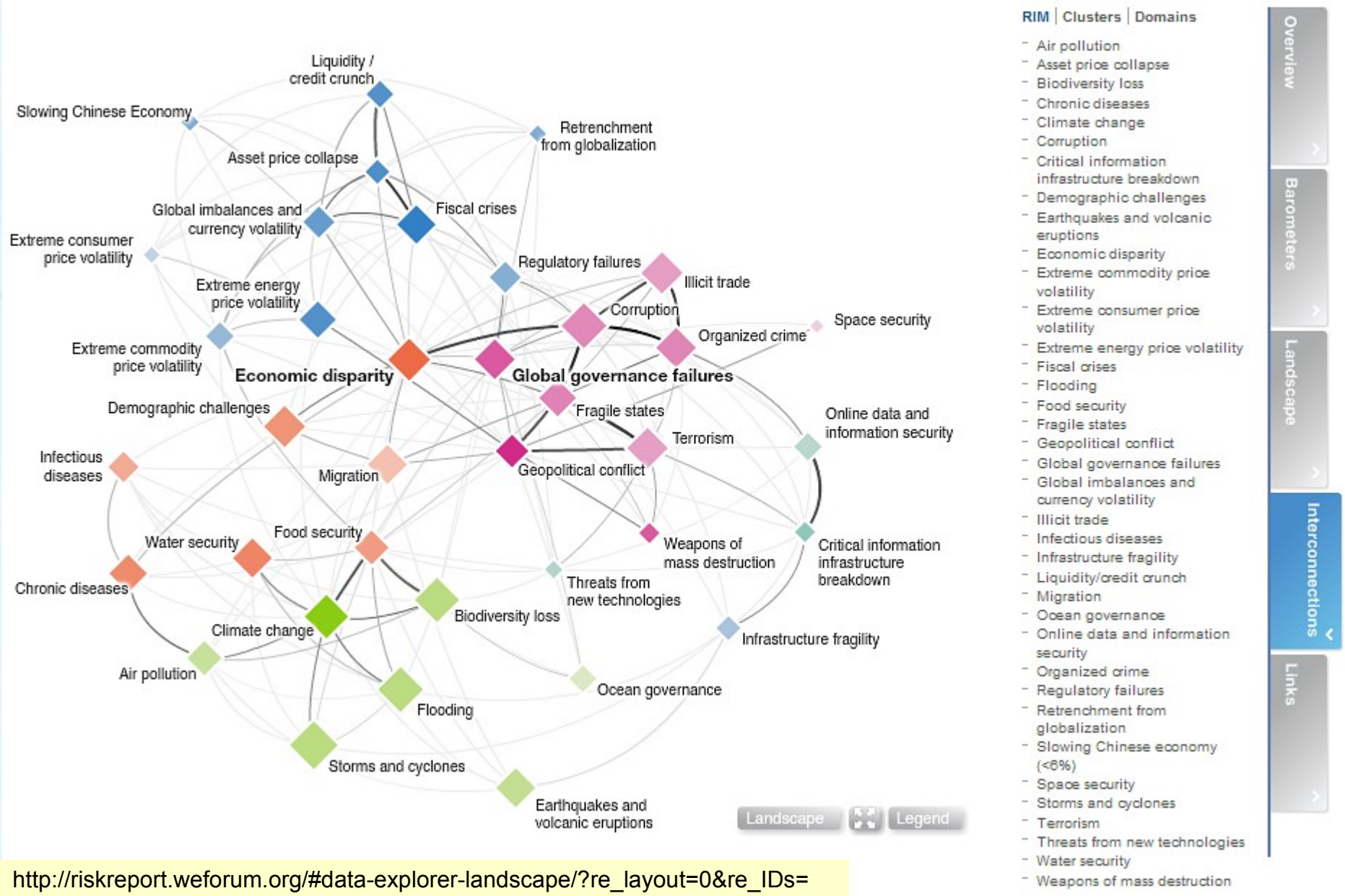
Interconnections – Global Risks 2011 – WEF



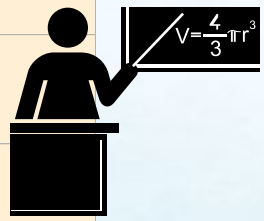
http://riskreport.weforum.org/#data-explorer-landscape/?re_layout=0&re_IDs=

Dark age ahead? (Jacobs, 2004)

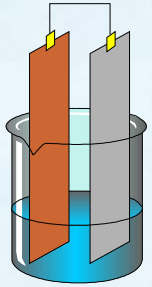
Dark ages are instructive, because they are extreme examples of cultural collapse and thus more clear-cut and vivid than cultural decay.

[Five] pillars of our culture that we depend on to stand firm … are in process of becoming irrelevant, and so are dangerously close to the brink of lost memory and cultural uselessness.

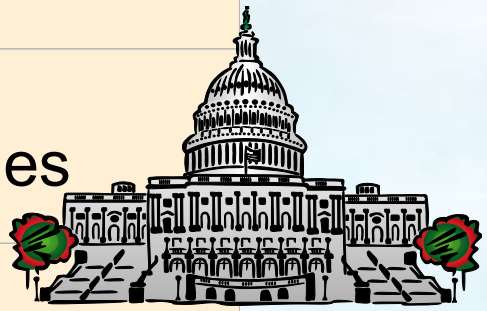
Community and family
(the two are so tightly connected the cannot be considered separately)



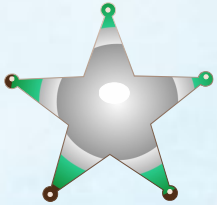
Higher education



The effective practice of science and science-based technology
(again, so tightly connected they cannot be considered separately)

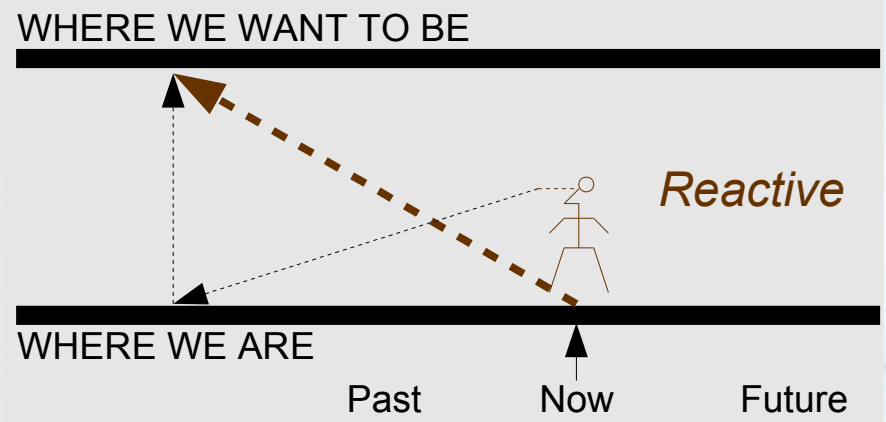


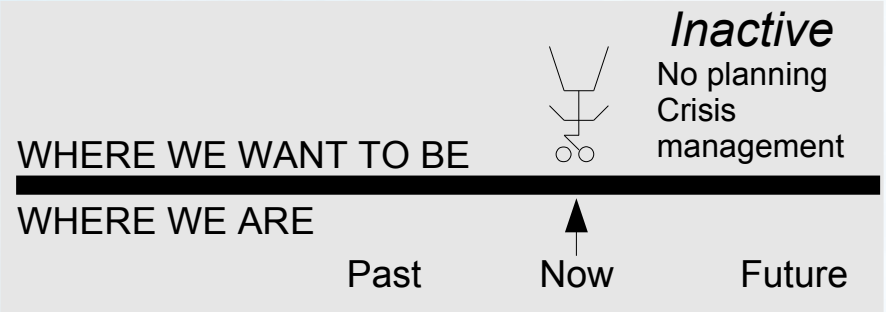
Taxes and government powers
directly in touch with needs and possiblities

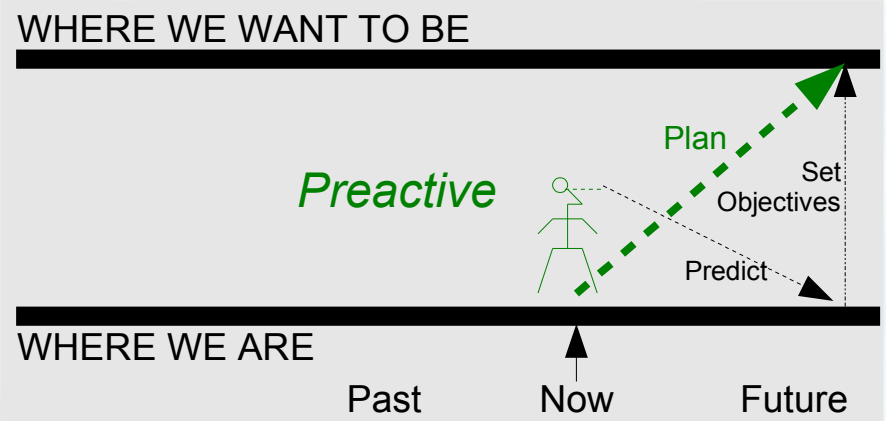


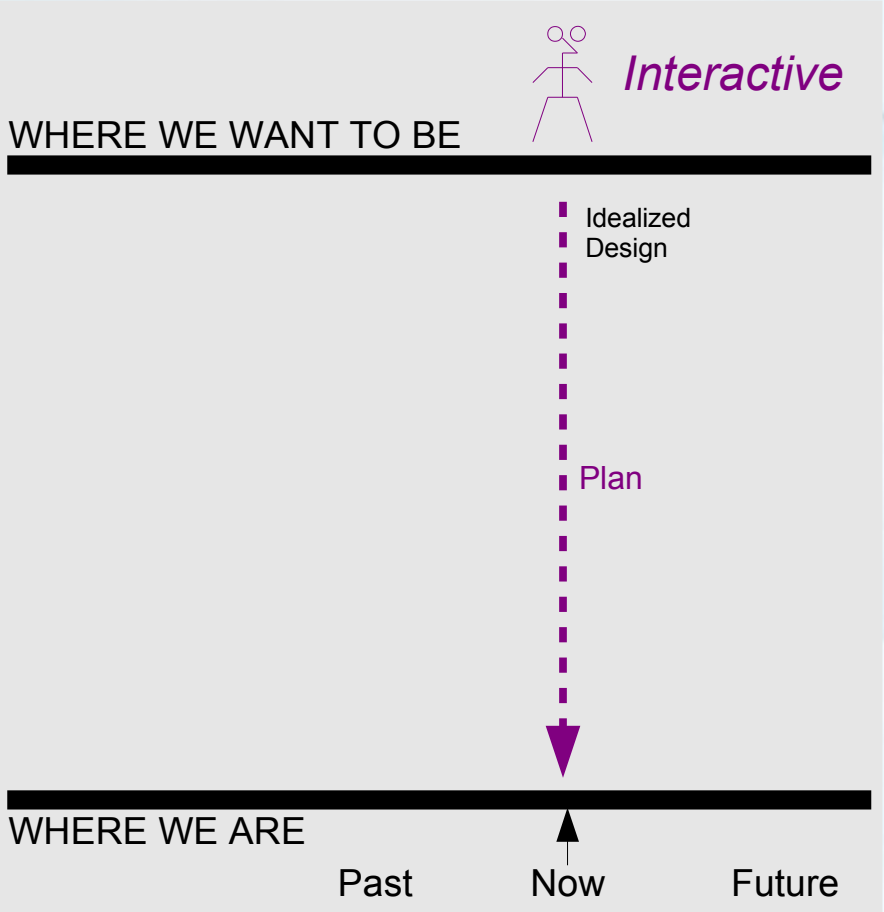
Self-policing by the learned professions

Reactive, inactive, preactive, interactive (Ackoff, 1999)









Types of errors? (Mitroff, 1999)

Type I error: Saying there are significant differences, when there are not.

Type II error: Saying there are no significant differences, when there are.

Type III error: Solving the "wrong problem" precisely when one should have solved the "right problem".

Five categories of solving the wrong problem precisely
1. Picking the wrong stakeholders
2. Selecting too narrow a set of options
3. Phrasing a problem incorrectly
4. Setting the boundaries/scope of a problem too narrowly
5. Failing to think systematically

Innovation (Drucker, 1992)

Innovation depends rather of what we might call "organized abandonment."

To get at the new and better, you have to throw out the old, outworn, obsolete, no longer productive, as well as the mistakes, failure, and misdirections of efforts of the past.

Think of the old medical saying: "As long as the patient eliminates there is a chance. But once the bowels and the bladder stop, death does not take long."

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Defining systems science(s) → science?

Primary intellectual virtue:	**Episteme**	**Techne**	**Phronesis**
Translation / interpretation:	Science (viz. epistemology)	Craft (viz. technique)	Prudence, common sense
Type of virtue:	Analytic scientific knowledge	Technical knowledge	Practical ethics
Orientation:	Research	Production	Action
Pursuits:	Uncovering universal truths	Instrumental rationality towards a conscious goal	Values in practice based on judgement and experience
Colloquial description:	**Know why**	**Know how**	**Know when, know where, know whom**

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	Invariable (in time and space)	Variable (in time and space)	Variable (in time and space)
	Context-independent	Context-dependent	Context-dependent
Pursuits:	Uncovering universal truths	Instrumental rationality towards a conscious goal	Values in practice based on judgement and experience
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Domains of systems thinking

Categories of systems thinking:	**Systems theory**	**Systems methods**	**Systems practice**
Primary intellectual virtue:	Episteme	Techne	Phronesis
Colloquial description:	Know why	Know how	Know when, know where, know whom
Systems thinking domains:	•Living systems theory •Hierarchy theory •Open Systems Theory •Viable System Model •Inquiring Systems •Critical Systems Theory •Panachy and ecological resilience	•System dynamics •Soft Systems Methodology •Interactive Planning •Action Research •Structured Dialogic Design •Strategic Assumption Surfacing and Testing •Search Conference •Deep Dialog	•Language Action Perspective •Appreciative Systems •Evolutionary Development •Systems Intelligence

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Paths to develop systems thinking

Episteme (e.g. theoretical science, codified principles)	**Techne** (e.g. methods and techniques, collaboration)	**Phronesis** (e.g. hands-on experience, values in practice)	*Proposed path for learning and coevolving*	*Case domains*
☐ (weak)	✔ (strong)	✔ (strong)	Induction: **Why** are the natures or behaviours of systems similar or dissimilar?	Service systems?
✔ (strong)	☐ (weak)	✔ (strong)	Abduction: **How** are future systems to be developed or improved over current systems?	Ecosystems?
✔ (strong)	✔ (strong)	☐ (weak)	Deduction: **When, where** and for **whom** are systems material and/or salient?	Governing / policy systems?

Physical and human systems can learn, if resources are reserved for long term maintenance (Brand, 1994)

The iron rule of planning is: **whatever a client or an architect says will happen with a building, won't.**

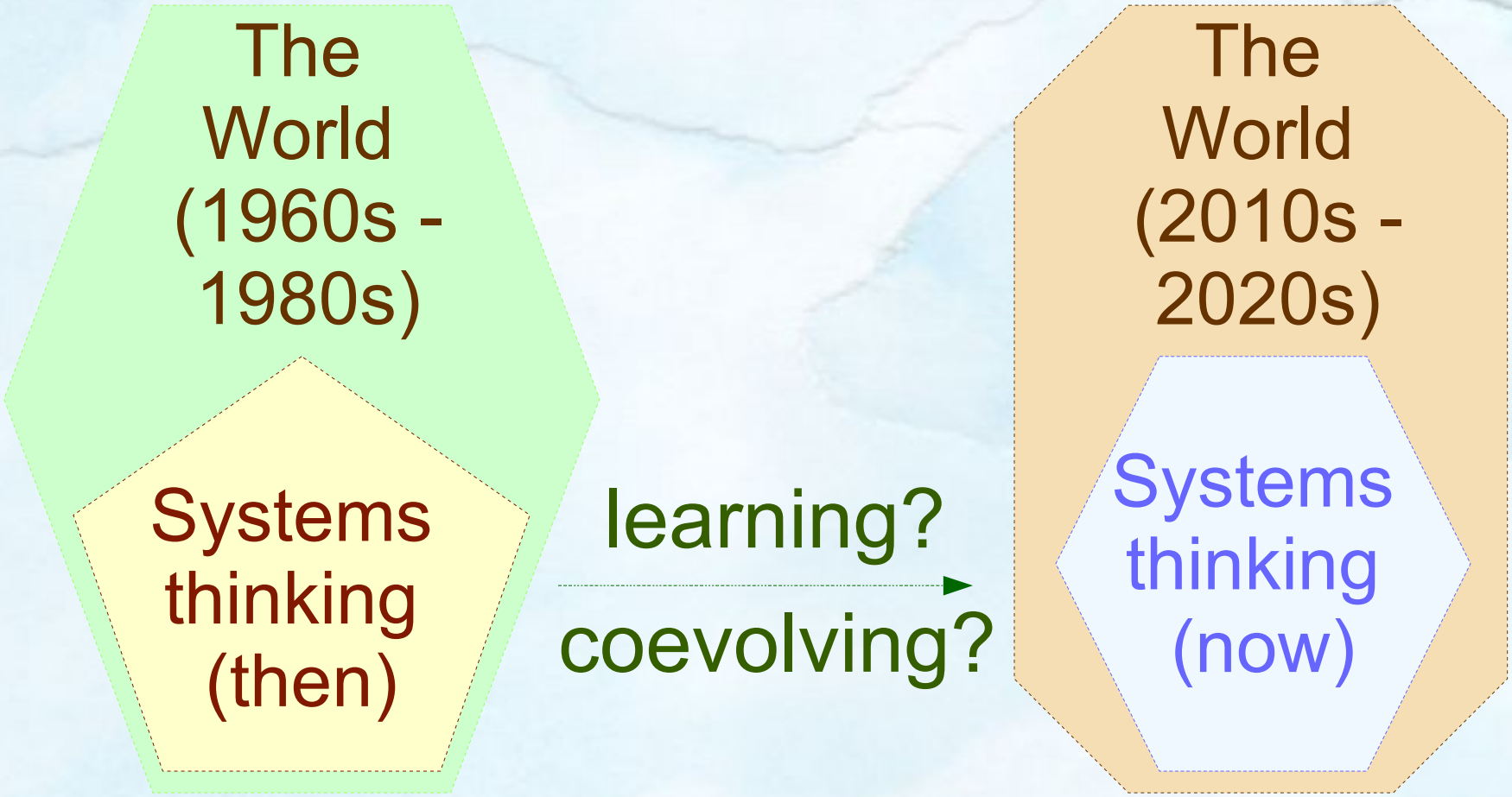
The major difference in a **"learning" building** is its **budget**.

Following Chris Alexander's formula, there needs to be **more money** than usual spent **on the basic Structure**, **less on finishing**, and **more on perpetual adjustment and maintenance**. The less-on-finishing part takes forceful management because the architect will want pizzazz in the finish, where it shows, and many artisans are not happy skimping on finish quality. [....]

I have suggested settling on a preliminary design and construction budget, with the architect getting a flat fee -- plus a generous bonus if budget and schedule are met. This encourages realism and rewards parsimony.

If you want a building to learn, you have to pay its tuition. [p. 190]

Is systems thinking *learning* and *coevolving* with the *world*?



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