

"Its not magic... but it feels like magic"
Doyne Farmer

Spm 9550: Emergence

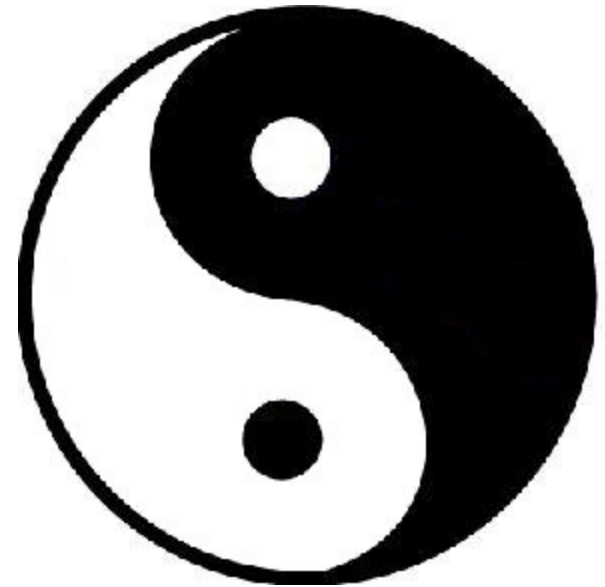
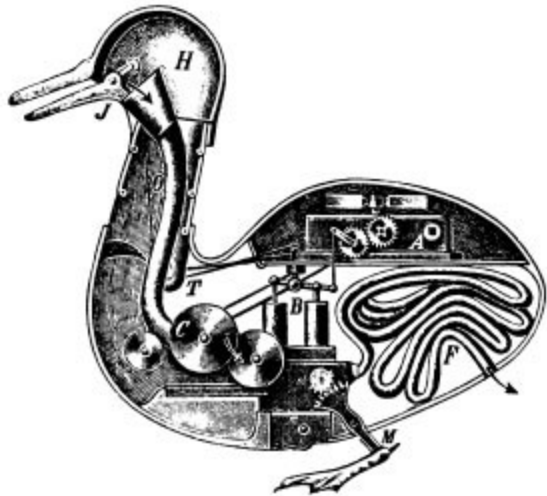
Dr. ir. Igor Nikolic

12-03-10

Lecture goals

- Students should be able to give an definition of Emergence / Emergent Properties
- Understanding how emergence appears from a reductionist and from a holistic perspective
- Understand the notion of system levels, agent, network and emergent system.
- Understand that the physical and social reality as we perceive it is a result of a continuous process of emergence from elementary particles up.

Reductionism vs Holism



Holism

- A system, be it physical, social or biological cannot be determined or explained by its component parts alone.
- The whole is more than the sum of its parts
- Extreme application of holism states that it makes no sense to examine the components, and that we should only study the system in its entirety.
- e.g. Climate change: Its baaaad, but what can we do about it ?

Reductionism

- a complex system is nothing but the sum of its parts, and that an account of it can be reduced to accounts of individual constituents.
- Two types
 - acceptable and useful reductionism
 - greedy reductionism.
- Greedy reductionism, often arises when reductionism is applied too far, claiming that everything can and must be explained by the smallest possible parts.
- e.g. Consciousness is nothing else but electrons moving around

D.C. Dennett. Freedom Evolves. Viking, New York, 2003.

Fruitful middle

- From Reductionism :
 - Yes, parts are useful and interact
 - Causal interaction between elements causes new types of phenomena (epiphenomena) to appear
- From Holism
 - Yes the whole is more than the sum of parts
 - “*More is different*” K. Kelly
 - Downward causation affects the parts

Emergent properties

- novel, qualitatively different features/properties in comparison to the features of the system's parts alone
- *cannot* be *only* reduced to the features of those parts and their relations.
- *Emergence is not a thing but a process*

Emergent properties are

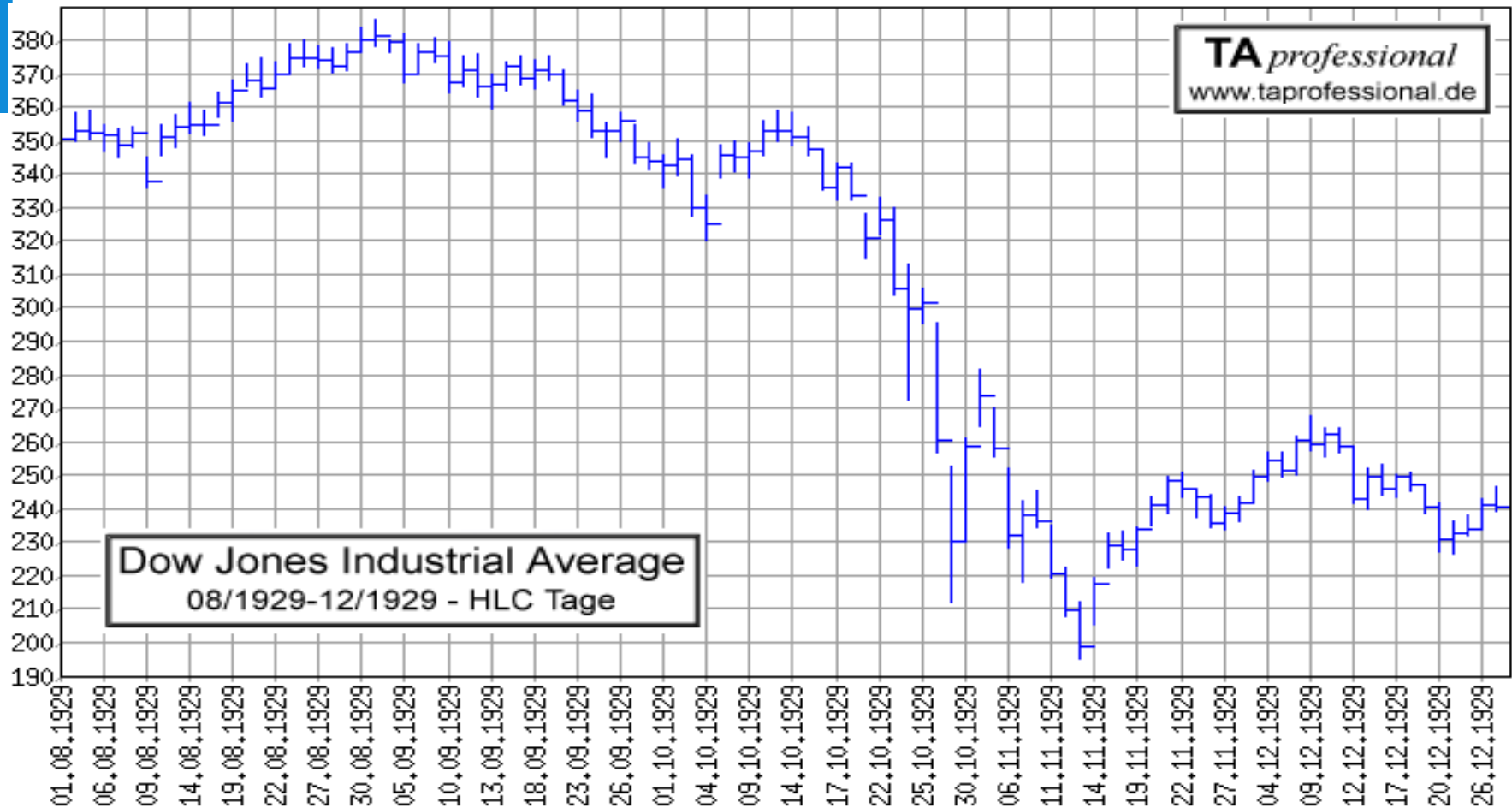
- interesting,
- non-obvious
- consequences of interaction between low-level properties.
- They are more easily understood in their own right than in terms of properties at a lower level.
- Can be desirable or undesirable

Two aspects of emergent properties

- They are lost when we break systems down into components
 - My heart or lungs, kidneys etc, spread out on a table are not alive
- When elements are removed from the system they lose the emergent properties
 - My hand can not type alone

Examples of “good” vs “bad” emergence

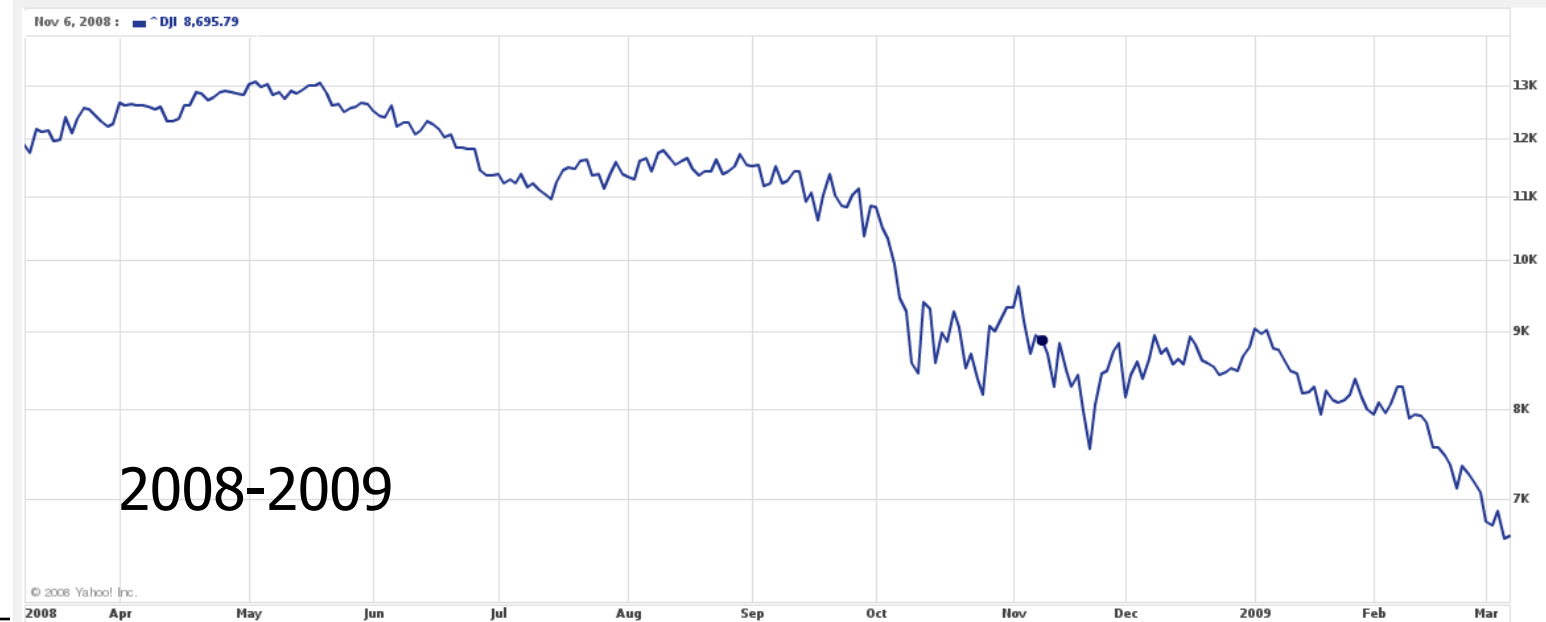
Emergence is not a thing but a process



Week of Aug 5, 1929 : ^DJI 344.84



Nov 6, 2008 : ^DJI 8,695.79



Levels

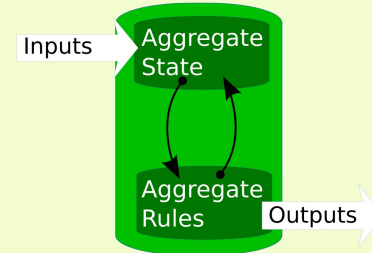
Observer

System property

Level of focus

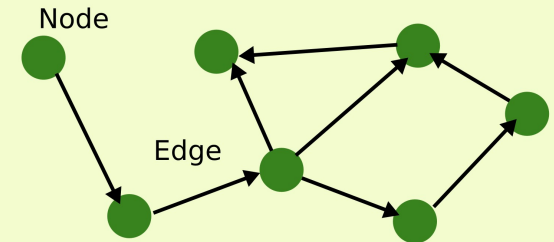
Emergent System : State and Behavior

- * Emergent behavior
- * Self organization
- * Robustness
- * Instability
- * Path dependence



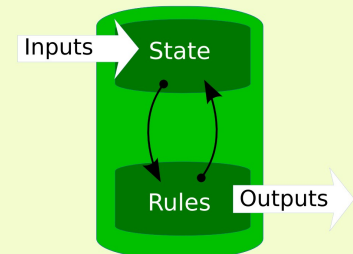
Network : Structure and Organization

- * Dynamics and Evolution
- * Topology



Agent : State and Behavior

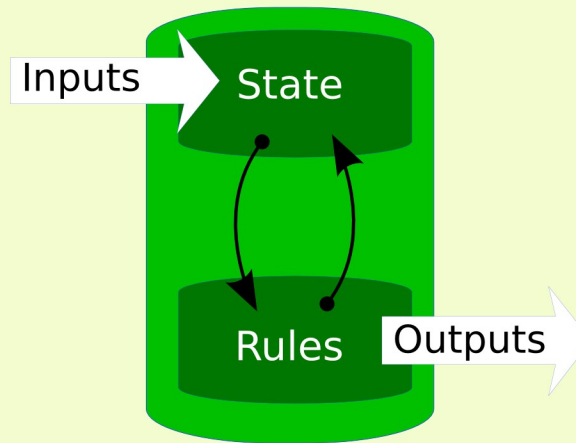
- * Adaptiveness
- * Agent diversity
- * Interface and protocol similarity



Agent level

Agent : State and Behavior

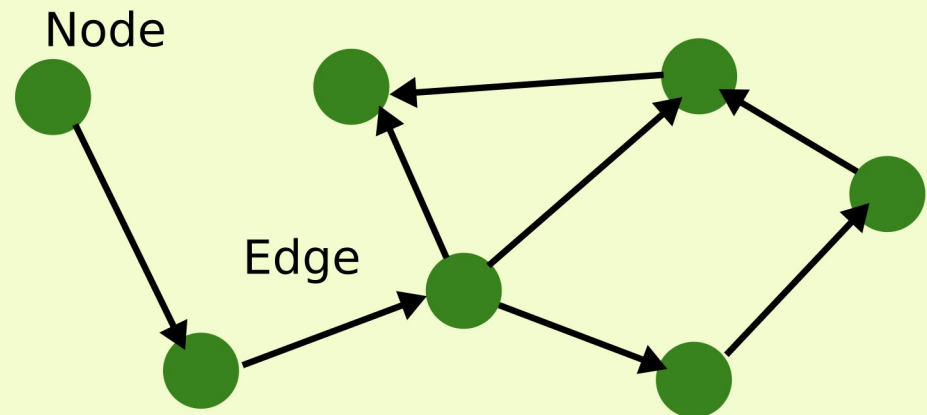
- * Adaptiveness
- * Agent diversity
- * Interface and protocol similarity



Network Level

Network : Structure and Organization

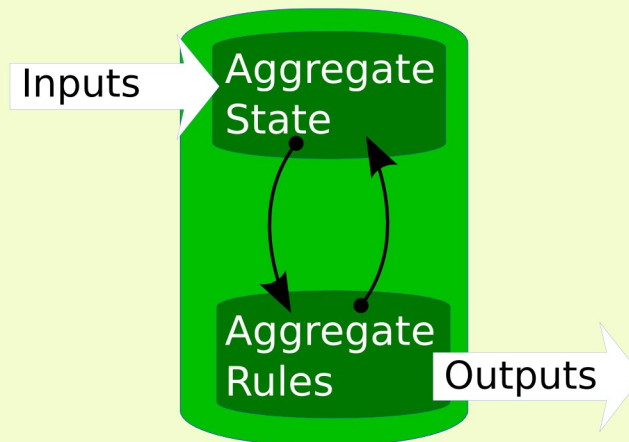
- * Dynamics and Evolution
- * Topology

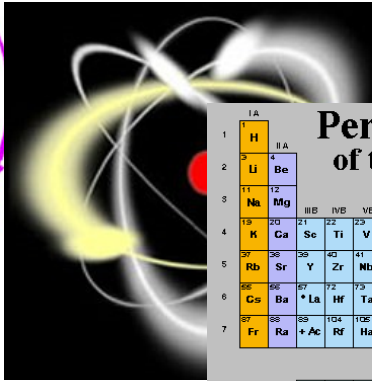
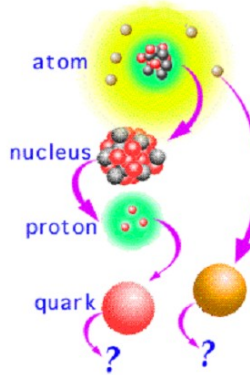


Emergent system level

System : State and Behavior

- * Emergent behavior
- * Self organization
- * Robustness
- * Instability
- * Path dependence



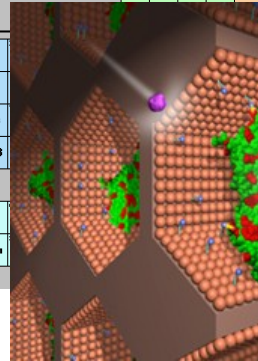


Periodic Table of the Elements

1	2																	10	11	12															
1	H																	He																	
3	Li	4	Be											B	C	N	O	F	Ne																
11	Na	12	Mg											Al	Si	P	S	Cl	Ar																
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
55	Cs	56	Ba	57	* La	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
87	Fr	88	Ra	89	+ Ac	104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Cn	113	Nh	114	Fl	115	Mc	116	Lv	117	Ts	118	Og

* Lanthanide Series
* Actinide Series

58	59	60	61	62	63
Ce	Pr	Nd	Pm	Sm	Eu
90	91	92	93	94	95
Th	Pa	U	Np	Pu	Am



<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/>

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Discovery vs Emergence

- There is a distinction between discovery and emergence:
- Discovery is a-temporal
 - a new species of animal can be found at any time by being present at a certain location at that specific time.
 - Darwin had to be at the right place and time to discover new species and thus “see” evolution.
- Emergence is the result of a process over time
 - Ecosystems *become* over time, bodies grow etc.

Patterns

- Levels are patterns
- Emergence makes novel patterns.
- The intuitive definition of emergence: “something new appears”
- Pattern formation: an observer identifies “organization” in a dynamical system
- Intrinsic emergence: the system itself capitalizes on patterns that appear
 - Patterns building on patterns

Enter Observer Dependence

- Levels / Patterns do not “exist” in the real world
- Emergence and patterns are in the eye of the beholder
- They are Observer Dependent...

