3. Essential entities and ideas of Systems Theory
- systems, holons, and their properties -

Self reference is the information about information, law about laws,
the knowledge about knowledge,
the testimony of higher level self organizations and understanding,
and at the end of life and consciousness.
NN

3.1 Introduction

Systems are as widespread as the universe in which we live. At one end they are as vast as the universe itself, but on the other side they are as small as a single atom, particle, etc. The smaller ones are always the elements of larger metasystems, and therefore A. Koestler has coined the name **holon**[1], and we will talk on this latter. Systems and holons appeared first in the form of natural beings, but with the emergence of humans other systems began to appear; at the beginning the simple ones and then increasingly more complex artificial, technical systems, - the **man made systems**. But only recently we have realized the common properties of these structures, their characteristics, of the processes taking place in these systems, both natural and man made - artificial. This **holistic unity** is seen only at a high level of abstraction of thorough knowledge, above a certain level of complexity of technical systems. Hence, only recently we started to see the need to develop **GST** and see the possibility of applications of such approaches as systems engineering, systems analysis, synthesis system, etc.

3.2 Definition of the system

As it was said in the first and second chapter in other words,

the system is a being[2] (B), which shows its existence by synergistic interaction of its own elements (E), [Bellinger 02].

This is not the only definition, but one of the best and shortest ones, but we will see in a moment that it is incomplete because it lacks the analytical side. Let us present therefore a mathematical definition below, the system - ***S*** defined as a set of (a collection, *a complex*) co-operating ***(R)*** with each other elements - ***E***, that creates a deliberately oriented whole.

$$\boldsymbol{S} = \boldsymbol{B}(\boldsymbol{E}, \boldsymbol{A}, \boldsymbol{R}), \quad \boldsymbol{E} = [E_1,...,E_n], \quad \boldsymbol{A} = [A_1,...,A_m], \quad \boldsymbol{R} = [R_1,...,R_r], \qquad (4.1)$$

where ***E*** is a collection of elements of the system, and – ***A*** is a collection of attributes (properties), ***R*** - a set of relationships between elements and attributes.

Interpreting this in general terms one can say that the system can consist of; $\boldsymbol{n > 1}$ elements – E, which may have $\boldsymbol{m \geq n}$ attributes - A, and may participate in $\boldsymbol{r \geq n\text{-}1}$ relations - R [Patzak82, s23].

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[1] **Holon** is a system that could operate independently while at the same time cooperating synergistically in the framework of a larger whole.

[2] **Being** or entity is an existing whole, not necessarily in a space-time, but often in the world of ideas, symbols.

As you can see, this is **complementary** to the verbal definition, but certainly not an exhaustive description of a whole variety of possibilities, as we will see in the next chapter. However, this is sufficient to understand the general statements of systemic concepts with a high level of abstraction, which can be formulated on the basis of the current state of systems theory and engineering and both of these definitions. However, in order to realize the broadness of the context we will apply these definition to, we need to remind ourselves that the components and systems themselves may be;

material, energetic, symbolic, computational, alive, aware, and self-conscious,

and also in any configuration of their types and elements. Hence, our general statements will refer to a broad class of **beings and objects**[3], from the hydrogen atom to the universe as a whole, which includes; matter, buildings, machinery, software, ecosphere, people, their attitudes, systems, ideas, etc.

3.3 Systemic hierarchy of the world

This definition of a system refers to a whole observable reality, both at physical and abstract and symbolic level. It's easy to guess from here that depending on the level of the system definition its detailed expression and articulation (also definitional one) as an entity , the articulation of its elements and attributes can sometimes be very different. According to one of the creators of GST Building (see [Blanchard 90]) it is necessary to distinguish at least nine hierarchical **levels of the existence** of systems, from each of which the new properties emerge, and here they are:

1.The level of "**static structures**" prevailing in geography and anatomy of the universe, which is dominated by properties such as movement and cohesion.

2.The level of simple dynamic systems such as "a **clock**" that contains a significant proportion of physics, chemistry and technology (*machinery, equipment*), where material properties are determined by the structure and process.

3.The level of so-called homeostatic type "**cybernetic**" systems based on the reception, transmission and interpretation of information.

4.The level of "**cells",** the self-sustaining systems - open ones, where life manifests itself.

5.The level of **"plants**", with the genetic - social structure creating a world of flora, with the main feature of the self growth and reproducibility.

6.The level of "**animals**", including the mobility, deliberate efforts, instincts and awareness.
7.The level of "**humans**" characterized by self consciousness and ability to manufacture, receive and interpret symbols.

8.The level of "**social organization**", where the contents and significance of communication, the value system, history, art, music, poetry and complex human emotions matter.

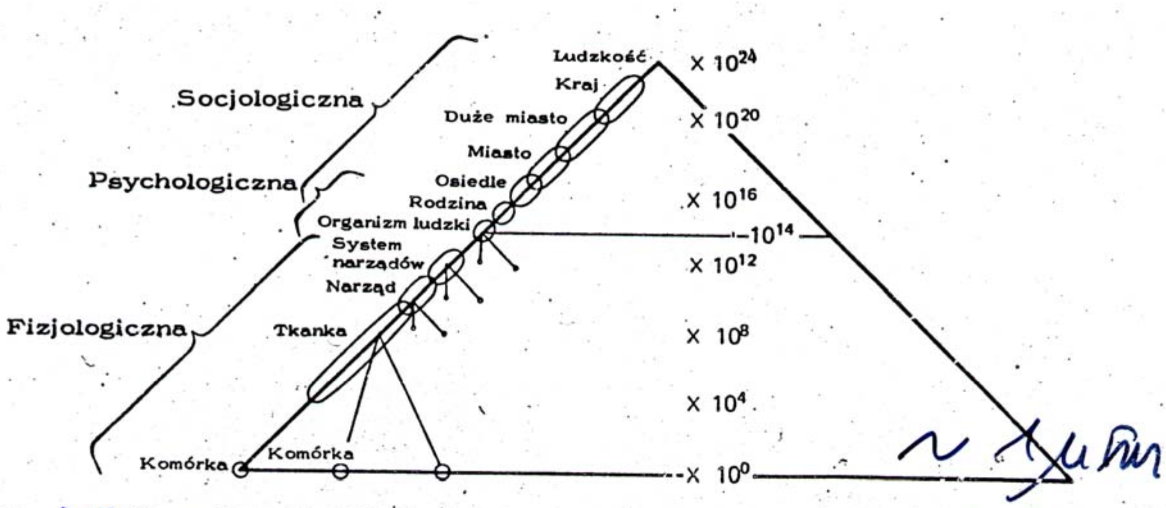
9.The level of "**unknown**", where structures and relationships can be postulated but the answers are not yet known objectively.

Another, even more general division of the surrounding reality is presented on Fig.3.1 in the form of pyramid of evolution [Cempel 98]. In this context the substance is an organized unit of matter, energy and awareness, and the range of its evolution stretches out from tthe primal energy and awareness of space, up to the spiritual substance. The successive development of this concept of substance, in connection to its life cycle, is presented in the new paper of the author [Cempel 08].

[3]As an **object we** will understand here the natural expression of the system.

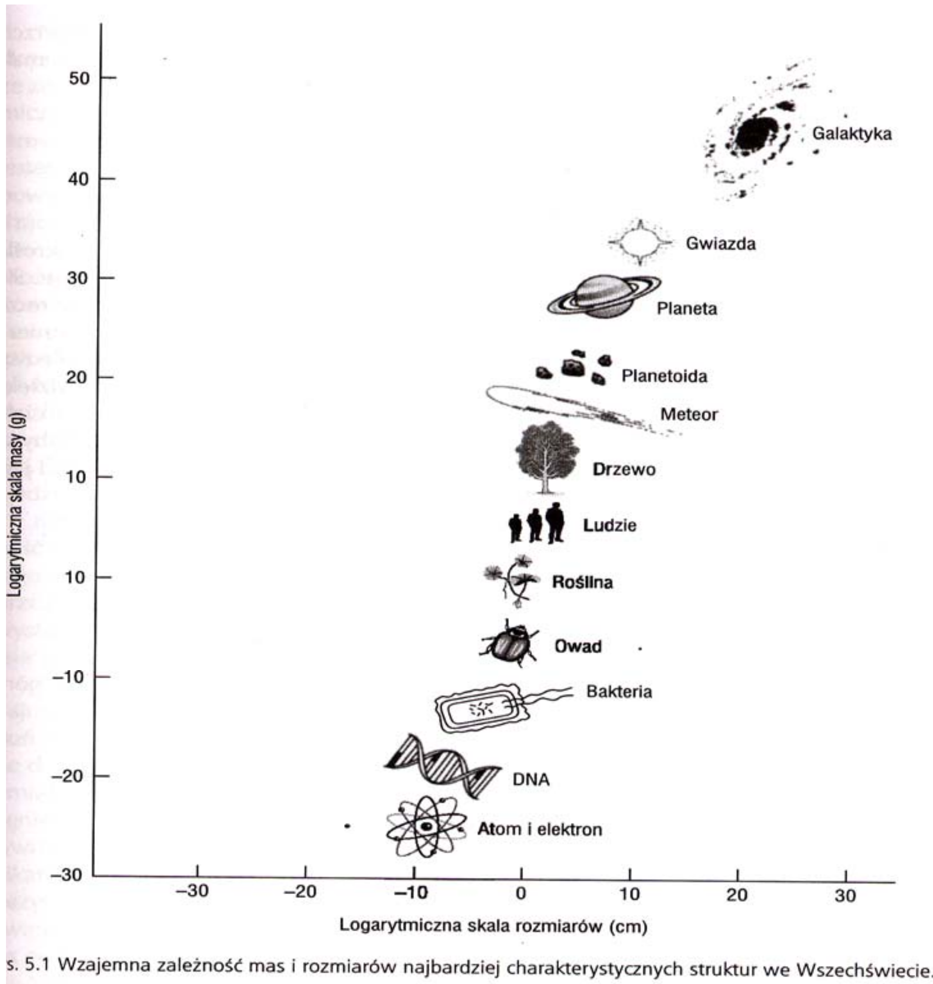
Fig. 3.1 The level of existence and the evolution of cosmic substance, [Cempel 98]].

It will be instructive here to study the human hierarchy, starting from single (**10^0 = 1**) cell and ending with the whole humanity (**10^{24}**), as it is shown on the Fig. 3.2, however, ignoring all the complexity of each organizational level of the hierarchy. More similar hierarchical examples can be found in [Skyttner 01, r3] too. And at the end of these systemic presentations of entire life in whole space, it is worthwhile to study the Fig. 3.3 showing characteristic entities of this world in the coordinates of their weight and size [Barrow05, s145]. As you can see on the figure all the entities, from the hydrogen atom to the galaxies are lying almost in straight line, which is said to be the consequence of the stability of the density of the atomic structure of our world.



Rys. ~~3.1.~~ Hierarchia ludzka. Wielkość podsystemów na każdym poziomie jest oznaczona przez wychodzące promienie, zaś zakres wielkości przez długości poszczególnych ogniw

Fig. 3.2 The systems and a metasystem of human hierarchy, [Klir 76].



s. 5.1 Wzajemna zależność mas i rozmiarów najbardziej charakterystycznych struktur we Wszechświecie.

Fig. 3.3. The most characteristic subsystems of our world in relation to their dimension and the mass, [Barrow 05].

Looking at the outlined above system hierarchies and their orderliness we can immediately realize the power of inference and generalization of GST, that it can express statements and rules for all of the aforementioned levels of the hierarchy of existence of Building's entity, from 1 to 9. From this brief review of the systemic image of the world it is implied that the systems in the universe are hierarchically organized, they create **hierarchies**. Moreover, at each new level of evolution new qualities not existing before emerge. Some scholars believe that this is an immanent feature of matter, the self-organization and the evolutionary emergence of new properties - the **emergence**, [Skyttner 01,s119], or also the **transcendence** [Wilber 97,s40]. The second feature possible to point out from this review, is the general feature of the systems themselves, on their own level of existence they are a self-functioning whole, and yetthey almost always form a part of greater **whole** and they have the functions of the lower row as their components. Such systems were called **holons** by **Koestler** in 1967, and a hierarchy built of them was called a holarchy [Wilber 97,s46]. Using this concept Wilber [Wilber 97,ch.5] introduced the deepest in understanding and its content four-quarters hierarchy (holarchy) of the world. The presented four dimensional model describes simultaneously the individual, collective, internal and external features of holons at various levels of the organization. The best example of such a holarchy is the natural environment or humanity. The latter systems are multilevel and multi-connecting and have a special name - **heterarchical**, as outlined on Fig. 5.15 in chapter 5 in the section on modeling.

3.4 Structural and the dynamic properties of systems

According to Winiwarter the theory of systems [Winiwarter86], the essence of existence and operation of the system at a given level of existence must be viewed and understood in the three aspects (a triangle);

a structure - a process – regulation (*causation***).**

what can be also illustrated in the form of equilateral triangle. In contrast, Capra in his recent monograph [Capra 03,s62] indicates a more general trinity and triangle of properties, being in continuous interaction and evolution, making understanding of the nature and operation of systems easier, i.e.;

the matter (a *material***) - the process (***including regulation***) - the form (***the structure, organization***).**

The first Winiwarter triangle is legitimate for a given type of system, but it seems that Capra's triangle applies to all systems, including bio-ware and human-ware types of systems. Let's take a look, therefore, in this spirit, at the classes or categories which systems described at the beginning by the nine levels of existence can be divided into. The division is usually performed because of a certain characteristic of the system, so it can be of any size , as for example in Table 3.1, [Patzak 82].

Cechy różniące systemy	Forma istnienia systemów		Objaśnienia
Dziedzina istnienia	Konkretny (materiał)	Abstrakcyjny (idea)	W większości systemy mieszane
Sposób powstania	Naturalny	Sztuczny	Sztuczne systemy socjotechniczne
Połączenie ze środowiskiem (meta systemem)	Otwarty (dynamiczny)	Zamknięty (meta stabilny)	Systemy rzeczywiste nie są zamknięte
Przewaga komponentów	Nieożywione Techniczne	Ożywione Społeczne	Objawiają się jako antropotechniczne i socjotechniczne
Określoność wejścia (wyjścia) stanu	Deterministyczne	Stochastyczne	Deterministyczne= prognozowalne, Stochastyczne prognoz. tylko probabilistycznie
Złożoność struktury: Połączeniowość – Rodzaj połącz. Liczba Połączeń	Jednorodne Mała	Wielorakie Duża	Na ogół mieszane
Złożoność struktury: Różnorodność – Rodzaj elementu Liczba elementów	Z jednej dziedziny Mała	Multi dziedziny Duża	Na ogół mieszane
Funkcja: Systemy abstrakcyjne	Modele	Klasyfikacyjne	Systemy równań różniczkowych Sysytemy filozoficzne.
Funkcja: Systemy konkretne	Materialne, energetycz.	Informacyjne	Na ogół wszystkie formy.
Charakter funkcji systemu	Liniowa Bez opóźnienia	Nieliniowa Z opóźnieniem	Aproksymacja, linearyzacja odcinkowa
Charakter stanu	Dyskretne	Ciągłe	Praktycznie jest przejście graniczne między nimi
zmienność w czasie: Funkcji – pasywna	Niezmienne	Zmienne	Np. zmiana dokładności
zmienność w czasie: Funkcji – aktywna		Funkcyjnie adaptacyj.	Wielocelowe serwomechanizmy istoty ożywione
zmienność w czasie: Struktury – pasywna	Nieelastyczne	Elastyczne	Z przełączeniem modułów
zmienność w czasie: Struktury – aktywna		Samoorganizujące się	Homeostat. systemy uczące się
Odporność zakłócenia	Niestabilne	Meta (stabilne) Równowaga płynna	Zależnie od przestrzeni obserwacji Ultra stabilne, Multistab.
Celowość	Nieożywione Programowe	Ożywione Celowo zorientowane Wartościowanie	Ewolucja,Teleologia Stawianie probl. filoz. Pytania egzystencjalne

Table. 3.1. System classification according to selected properties, [Patzak82].

At the front end of the table the relationship of a system with the environment or a **metasystem is highlighted**, while the systems themselves may be **closed** or **open**, exchanging the mass, energy and information with the environment. If we look at the organizational hierarchy of all systems presented above in this way, we can say that the higher the system is in the hierarchy, being a closed system, the less chance of survival it has. Moreover, it is very difficult to find a natural closed system, even a stone (*a rock - a very long lifetime*) probably does not qualify as the closed system because of the energy exchanged with the environment. It is always only a matter of exchange rates and/or processing (metabolism) of matter and energy. The same must be noted in relation to any part of the world as a system. Nevertheless, it is easy to think of abstract closed systems (*for example, in thermodynamics*) and they are very useful in understanding simple properties of matter, especially inanimate one. The important distinction between **static** systems or better **meta-stable** and **dynamic** systems should also be noted (Figure 3.3) . It is obvious that a closed system is meta stable and even if it was not static at the initial time, due to the validity ofII-principle of thermodynamics of non-decreasing **entropy**, sooner or later it will reach a state of equilibrium. Conversely, an open system can also be stable, because due to the exchange of mass, energy and information it is able to sustain its long life and its **identity**.

A very important dichotomy[4] of systems classification are **physical** systems manifesting their physical existence at any level of existence (*such as bio*), and **conceptual** systems being abstract and symbolic, they are the effects of thinking and of human activities. For the latter symbols are the attributes, and the ideas, plans, assumptions are examples of elements (sometimes also systems). Physical systems exist in physical space-time, while the conceptual systems in mental space, being an collection of organized ideas. A good illustration of such a system is a set of plans and specifications for the physical system, being called to life at the producer's factory.

An important feature of the structure of the system is its **complexity**, which can be characterized at least by two detailed features referring to the complexity of system's elements and their different connections. Another feature, the **connectivity**, represents the number of connections between elements and their variety . Another feature of the structure, the **diversity** stands for the number of elements of the system and their diversification. These structural features of systems with their possible further division is well-presented in a Figure 3.4.

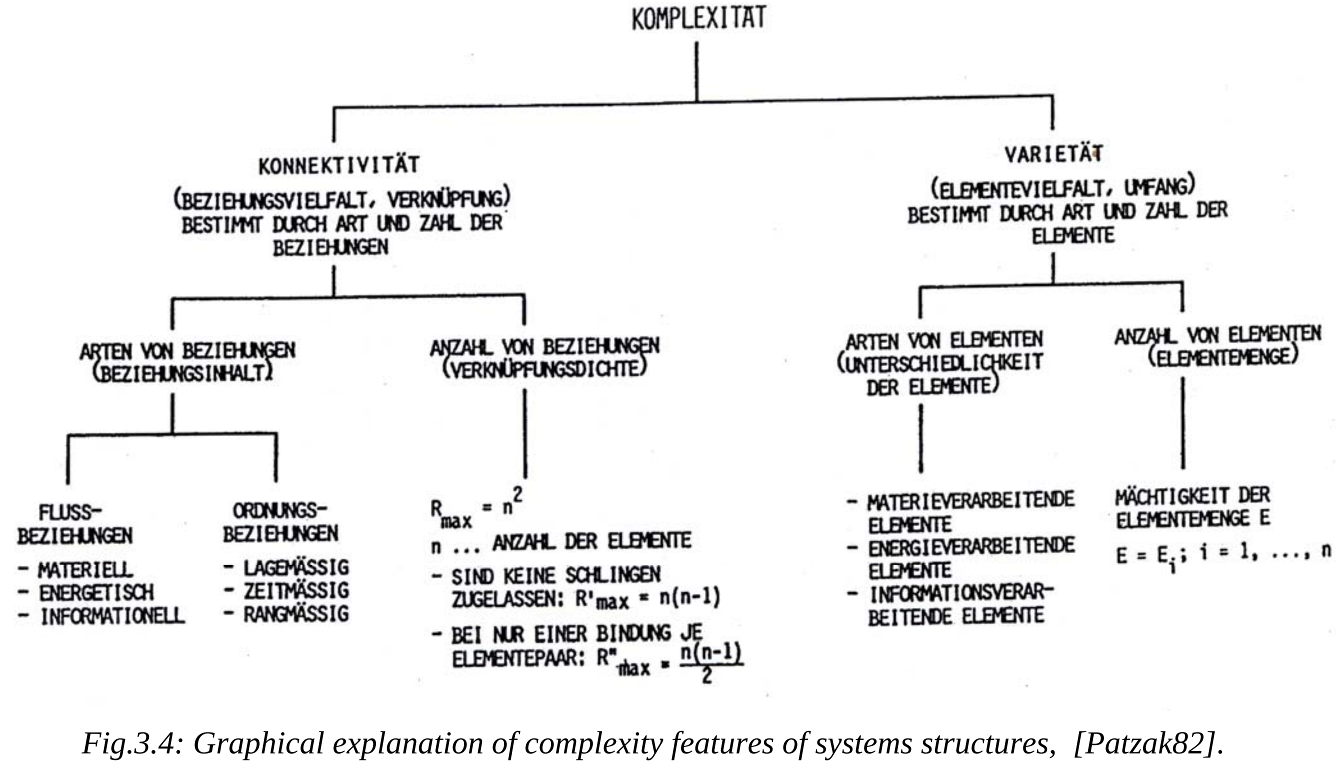


Fig.3.4: Graphical explanation of complexity features of systems structures, [Patzak82].

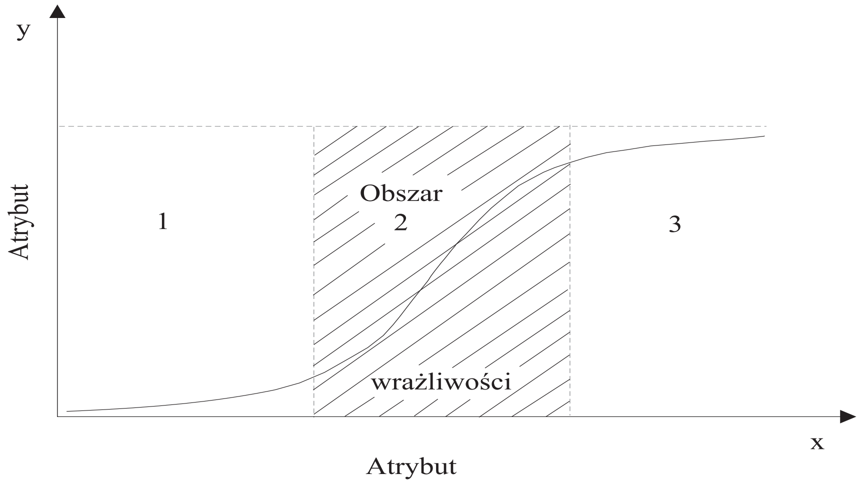
Generally, the complexity of systems reveals itself in three dimensions, as a complexity:

- **detailed** - a lot of different elements,
- **spatial** - size of the system (*time delay*),
- **dynamic** - negative (*stabilizing*) and positive (*destabilizing*) feedback.

These three characteristics altogether, in conjunction with finite speed of dynamic processes and information, give as a result a delay in response to a given action (*force*). What's more, the reaction occurs in another time and another place (*spatiality*), and sometimes the reaction of the system in 'the

[4] Dichotomy- two class division.

given conditions ' does not appear at all. The explanation of that lack of effect, as well as of many other important properties of complex systems is a **non-linearity** of relationships between the processes and / or attributes of systems. A good illustration of a non-linear relationship is a logistic function, or **sigmoid** one, presented in Figure 3.5.



Rys. 3.5.A causal non linear relation between the attributes of the system as the explanation of possible lack of reaction, (see areas 1 and 3).

Here, as you can see, despite the big changes of the cause **X** in the area 1 and 3 there will be no substantial changes to **Y**, that is, the cause and effect relationship will be hardly observable within the limits of observation error (+- 5%). If the external conditions of the operating system, such as outside temperature (*from the Arctic to Iraq*), change , then we will move to the 2nd range of variability and our system will show entirely other, new features. You can see from here how important the full identification of the system is, particularly when non-linear relationships are possible.

The nonlinearities in deterministic systems are not only the unrecognized behaviors as above, but what's more they are a random behavior, **chaotic[5] one**. Random behavior of many phenomena in nature, such as turbulence of liquid, is nothing strange, but the **deterministic chaos** is strange. It was discovered recently in a very simple models and deterministic systems, if they are non-linear and work in certain range of parameters. Such strange behavior of systems was sometimes seen in scientific research, but no one up to the time of Lorenz from MIT in the U.S. (*start of the 60's*) had investigated this matter thoroughly. Lorentz was lucky because he had in use one of the first computers, [Stewart 94], and at that time he worked with three very simple nonlinear differential equations for weather forecasting. It turned out that in certain range of the solution variables (the *weather*) they depended on the type of rounding effect and starting point. The impact of it was so strong, that Lorenz called it the butterfly effect, i.e. for example, that flatter of butterfly wings in Alaska (*rounding*) can change the weather in Boston. Later many of this type of chaotic behavior of deterministic systems were found, and chaotic mathematics was created as well as chaotic dynamics. We have learned to measure chaotic behavior, with such parameters like the Poincare measure. It was found also that the phenomenon of deterministic chaos is a close cousin of self similar structures, the so-called **fractals[6],** and that together they describe the so-called structure of irregularities. Additionally, in complex mechanical systems the , s nonlinearity is often the cause of **'leaking'** of energy from higher to lower vibrations modes, for example, it could be the cause of overturning of the ship with working crane in the sea, of the dynamic cracking of the aircraft plating and wings, and other effects [Nayfeh 00].

[5] Chaos = unordered phenomenon, impossible to predict.
[6]Fractals = geometric formations, self similar in different scales, for example, petal snow, well structured tree branch, coastline, etc.

Most antropotechnical and sociotechnical systems are inherently non-linear, and like all complex systems they are vulnerable to the occurrence of synergy. Thus, in reactions of these systems to change of external conditions or even to the weak interactions we should expect discontinuous behavior, or extra sensitivity, even for the actions of individual man. That is why the peace process of Gandhi in India led to the withdrawal of the British Empire from India. You might keep this in mind.

3.5 Evolutionary properties of the system

Having the characteristics of main properties of systems we can move on to the characteristics of the processes in which they occurred. These processes are determined by the dynamic properties of the systems themselves and by the properties of stimulation or extortions coming from their environment. We will therefore deal with the dynamic features of systems first. The first of such feature is the overall **volatility** of the system and it may involve the possibility of changes in the **structure** of the system itself as well as the change of the process in the system, in original structure. The close related feature to the previously discussed is the **stability** of the system, as the ability to preserve the state *(identity*) in the face of external disruption and internal extortion. Such changes usually occur in the face of external influences from the environment or from a metasystem. Hence, in this context the volatility of response to stimulation is identified. For a certain class of stimulation the reaction does not go beyond some set limits of system behavior, hence we say that the system is stable in the face of stimulations and maintains its state (*or identity*). On the other hand, the system can adjust (*to adopt*) to the nature and level of interference, then we say that the system is **flexible**, able to adapt to a wide range of stimulus flowing from the environment without changing the essence of its actions.

In this flexibility of systems we can distinguish a whole hierarchy of options. First, the system may be controlled externally by choosing appropriate action, or even internal structure. On a higher level of organization systems may have the ability to adapt with built-in feedbacks counteracting negative developments caused by the environment. Finally, at a yet higher level of alive systems (also homeostatic) features of self-regulation and self - organization are present where system can change (*build)* its own structure aimed to meet the demands posed by the environment (*such as fur in a cold climate*). **Self-organization** of the system includes the entire range of adaptability. The excellent means in adapting to changing environment is the **learning ability** of the system. In general the learning is a gradual improvement of system behaviour as a result of taking past experiences into account (*remembered information*). And Capra claims [Capra 03, s30], that cognition, learning, is a mental activity at all levels of life. In the same learning and self learning of systems the following stages or steps can be distinguished, [Patzak 82]:

• **remembering** - learning by heart (*memorize*), etc.
• **submission** - developing certain reflexes ,
• **learning through success** - searching through an entire range of possible states by method of trial and error in order to succeed
• **optimization** - as previously with remembering the best solutions,
• **imitation** - coping and remembering (*children*), education - as before, but with model present,
• **understanding** - to build one's own internal model of the system and experimenting with it.

The changing environmental conditions are a challenge for natural systems to perform optimally, to adapt their structure and reaction, to preserve the identity and to survival. But for systems artificially designed, man-made ones, it is a man who imposes goals, methods and measures of action to solve problems. Such systems can be roughly divided into classes as shown below.

Type of systems - a class - a description (*effect***) of action**

• **Object systems** - concrete or abstract - an object, product, the result, the yield, the objective of the work.

• **Goal systems**, abstract - they compile the hierarchy of intermediate objectives.

• **Program systems**, the abstract - they give a string of proceedings (*the process*) to obtain the objective.

•**Task systems** (*or operational*), concrete - an organization, or a device for achieving the goal.

As it was said earlier, the complex systems in the process of evolution have important property, learning, and/or self learning ability. Let's stop on this, as it also relates to students, people and systems (*organizations*) we create. Generally, in such systems one can find three types of behavior [Oconnor 97,p125];

1. **Without the possibility of learning**, if the system duplicates the same activity without paying attention to its results, the examples: some organizational social, ideological, religious, habits etc. This lack of learning may even be forced by special regulations and penalties, as in fundamentalist ideologies. We have full of examples of these in the history of mankind.
2. **Simple learning**, where there is a feedback between actions and their outcomes, but only in certain mental models that do not undergo changes. Examples: a method of trial and error in the goal quest to , learning specific skills.
3. **Generative learning** (*adaptation*), when the feedback allows us to change the model (*of view*) of the situation and respond to it in a way not seen before. Examples: **learning to learn**, questioning the basic assumptions, searching new strategies and class of action (*see OODA Loop, TRIZ*).

Let us note that the effect of learning can occur if we have a **feedback effect** in the form of action. Therefore, for the extensive systems and with a largely delayed reaction, such as climate, the effects of our actions will appear much later and in another place, for example the decreasing thickness of ice on the pole, or warming, ozone layer depletion, acid rain, etc. So we can learn only in terms of human generations, if **we are wise enough**.

3.6 The general systemic ideas

Basing on the review of systems presented, their properties and the development of modern science we can provide the following hierarchy of rules and general concepts being used in many specific sciences, and therefore useful in theory systems [Skyttner 01,p88].

• The **world view** is a great (*grand*) paradigm integrating philosophical beliefs and preferences in the community, including the scientific community.

• The p**aradigm** is a common method of creative thinking cultivated by the majority of members of the scientific community.

• The **theory** is a wide coherent explanatory scheme, including laws, rules, claims and hypotheses.

• The **law** is a generalization resulting from experimental observations, well motivated and accepted for a long time.

• THe **principl**e is a generalization resulting from the experiment but with less status than the law.

• The **theorem** - a generalization made in a formal, logical, and / or mathematical way.

• The **hypothesis** - a proposal which seems intuitively correct but requires verification and validation.

• The a**xiom** - an argument, a certainty, the assumption, usually impossible to prove, but is the starting point of considerations.

In the latest monograph of Skyttner [Skyttner 01,s92] and others,, many generalizing laws, principles, theorems received from various observed systems were collected from various sources. It is worthwhile to consult it, and we will take into account only the **general principles** which apply to all systems regardless of the field of existence. And here they are:

• Wilber's **principle of existence** : The reality consists of a whole / parts or holons on every level[Wilber97, s38].

• The p**rinciple of holism**: the system as a whole has properties not disclosed in any of its constituent parts, and vice versa. The parts of the system have properties not disclosed in a system as a whole. Holism functions also as a philosophical orientation, and this system property is more known as:

• The **principle of emergence**; any new organized whole gives rise to properties not known before, often at a different level. Sucrose as a combination of carbon, oxygen and hydrogen gives the taste of sweets, not known for its constituents.

• The s**ub-optimization principle**: If every subsystem considered separately is geared for maximum efficiency, the system as a whole will not reach maximum effectiveness. Thus, the whole system needs a certain redundancy of the effectiveness of existing components.

• The **grey principle** - Uncertainty (*darkness*): No system can be fully understood. See for example the Heisenberg's **uncertainty** principle in physics.

• The **principle of hierarchy:** complex phenomena are organized into multi-level hierarchies, and each level integrates many subsystems. Very complex systems are often seen as heterarchic (Fig.5.15), where each of the main actors is connected with each other, like in economy, civilization, environment, but these connections have different intensities.

• The **eighty / twenty principle**: In any large system, eighty percent of its output (*the product)* is created as a result of twenty percent of its capacity. This principle is also known as Pareto's principle, of an Italian economist of early 20 century, who found that 80% of contributions to the bank is owned by 20% of shareholders, the majority of evolutionary behavior manifests this principle too, [Bordalier 08].

• The principle of **redundancy** of resources: Maintaining the stability of the system in condition of disruption requires the redundancy of critical resources .

• The principle of **relaxation time**: the system stability is possible only if the average time between the disturbances is greater than the relaxation time.

• The principle of **negative feedback:** With an active negative feedback the system is invariant in reference to a wide range of distortion. In other words equi-finality is possible. And with its larger number, it is possible even to over-stiffen the system.

• The principle of **positive feedback**: With the active positive feedback various final states at the same initial conditions can be obtained in the system – multi-finality.

• The h**omeostatic principle**: system will live as long as its key variables remain within acceptable limits (*for example, physiological*).

• The **self-organization principle**: Complex systems have a self-organization property and their structure and behavior are mainly the result of the subsystems interaction.

• The **principle of survival**: the capacity to survive (*of life*) depends on the proper balance between autonomy of subsystems and their integration in the whole system, or in other words on the balance between stability and adaptation.

In regard to social systems with people it is worthwhile to cite here two additional rules proposed recently by Soros [Soros 99,s32]:

• The f**allibility principle**: Fallibility means that we are inherently nonperfect (*erroneous*) in our understanding of the world in which we live.

• The **reciprocal principle**: reciprocity says that our thinking actively influences the events in which we participate and which are the subject of our thinking.

That is why for example, economics can not be considered as a science in this sense like natural sciences, because the subject of research and thoughts may change his mind if he knows what we think about him, or what our intentions are. That an atom of hydrogen, a piece of metal, or a part of the machinery can not do.
So many laws and rules at this level of abstraction here seems to be enough, although in the already given sources much more can be found, especially about living systems and metasystems made of them, business associations, etc.

3.7 Summary

We started from the definition of the system and its complementary mathematical description, and then we identified areas of existence and following Boulding - main categories of systems. Although the abstraction level of systems view is high, we were able to describe many systemic, structural and dynamic properties,, which put our thinking about the world as a great holarchy, and sometimes heterarchy in order and make it more understandable. In case of such complex systems many common regularities in the form of rules, laws can be observed, that facilitate the understanding of the systems and transferring this knowledge to other areas of human activity. The most important of these statements, it seems, is the principle of self - organization of matter and any systems, the complementary principle of emergence and the principle of uncertainty.

3.7 Problems

1. Does the mathematical definition of the system include all the properties of systems?
2. Show the differences between a system and the holon?
3. Can you see the world as a hierarchy of beings, a holarchy of them or heterarchy?
4. The ecosystem is the multi level, self-balancing and self renewable flows of matter, energy and information, what type of system is it?
5. Show the other, alternative to Building's way of making hierarchy of systems, motivate the main idea.
6. What systemic relationships and why are most important in systems theory in your opinion?
7. What's the most important difference between technical, antropotechnical and socio-technical systems?
8. Please, show the systemic law(s) common to all systems.