LECTURE

4

Systems types
Special systems characteristics

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LECTURE 4 - OVERVIEW

Systems types based on the ability (easiness) to recognize them

Special types of systems

- Soft systems
- Virtual systems
- Epistemic systems
- Control systems
- Information systems
- Communication (transport) systems

TYPES OF SYSTEMS

Complete identification of a system is not available in practice

Usually it is not possible to choose, which parameter of the system will be described in detail, but it is based on the system itself.

Reasons:

- Complexity
- Uncontrollability

System types can be viewed based on the manageability of systems identification – the emphasis on one part of system identification

Remember the system definition

S=(A/F,R/P,M,γ,δ,I, E, C)

SYSTEM DEFINITION - SUMMARY

$S=(A/F,R/P,M,\gamma,\delta,I,E,C)$

- A is a set of elements / automata
- F is a set of functions of elements; F defines the ability of system.
- R is a set of relations among elements
- P parameters on relations
- γ is goal oriented behaviour
- δ is species / type focused behaviour (genetic code)
- I is system‘s identity
- E is system‘s ethics
- C is system‘s compethence

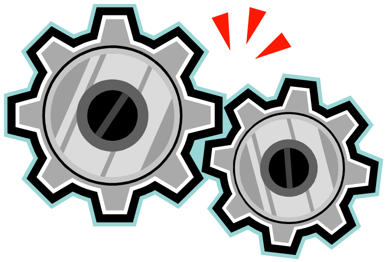
SYSTEM TYPES BASED ON PREVAILING PART OF IDENTIFICATION

Systems type class	Emphasized part of systems definition	Viewpoint for distinguishing systems type
a	A/F	Pragmatic characteristic of an element, type and level of production function
b	R/P	parameter on relationship, diferentiation of system dimension, orientation of processes
c	M	Based on the magnitude (cardinality) of the system – universal or special systems, e.g. adaptive, sensitive systems
d	γ	Based on elements of surroundings included in systems relations – introverted (epistemic) and extrovert (cooperating) systems = based on prevailing processes in goal behaviour
e	δ	Prevailing processes in the genetic code (genetic behaviour) – conservative or dynamic systems

CLASS A) SYSTEMS – PREVAILING ELEMENTS VIEWPOINT

Class a) systems

- Typical systems: Technical
  - Typical elements
    - Technical components,
    - Economical elements
    - Social elements
  - Differentiating carrier of the function
- With either homogenous or heterogenous elements
  - Can be layered systems – in heterogenous systems those elements that are homogeneous form sub-classes
- Clear differentiation between hard and soft systems



CLASS B) SYSTEMS – PREVAILING RELATIONSHIP VIEWPOINT

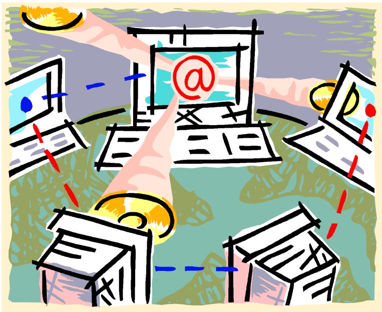
Typical systems

- Technological
  - emphasis on production process parameters
- Information
  - parameters of language, metrics, data carriers, hierarchy
- Control
  - parameters of superiority and subordination
- Communication (or transport)
  - Relation parameters with origin and goal

CLASS C) SYSTEMS – PREVAILING MAGNITUDE VIEWPOINT

Typical system types

- Universal
- Specialized
- Adaptive
- Sensitive
- Quickly responding (e.g. 1st level of signal function is activated)



CLASS D) SYSTEMS – PREVAILING GOAL VIEWPOINT

Typical system description

- Introvert (epistemic – recognizing itself)
  - or Extrovert (cooperating)

- Self-sustaining
  - or Open

CLASS E) SYSTEMS – PREVAILING GENETIC CODE VIEWPOINT

Typical system types

- Reduction
- Developing systems

Looking for strong functions, typical behaviour

SELECTED IMPORTANT SYSTEM TYPES

Soft systems

Virtual systems

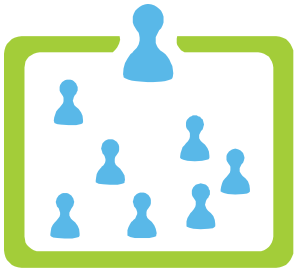
Control systems

Information systems

Communication (transport) systems

Soft systems

SOFT SYSTEMS - DEFINITION

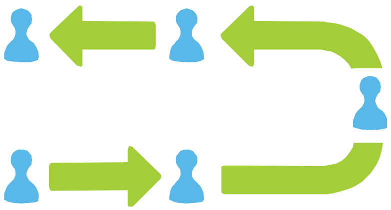


Soft system

- Is difficult to identify
- With non-recognized or undistinguishable structure

On the contrary Hard system

- system with distinguishable and explicitly presentable structure
- Can be modelled using formal means for the
  - Record of system structure
  - Record of systems dynamics
  - Solving of system analysis tasks
  - System projecting



SOFT SYSTEMS – SOFTNESS CRITERIA

The criteria for hardness or softness of the system is not based on its physical substance only

the measure how it can be objectively recognized and described using formal means

Similar to the level of managing system uncertainty

Typical examples of soft systems are systems recognized on social or socio-economical objects and systems of projects

Important factor – human (or other living being)

SOFT SYSTEMS – SOFTNESS

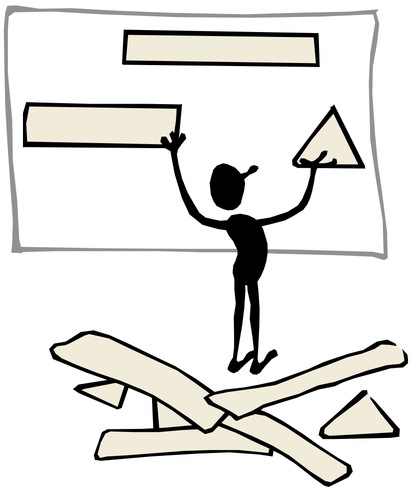
softness of the system is a characteristic of the original and characteristic of the model

- Softness of the original: incomplete recognition of both current states and future states

- Softness of the model: incompleteness of the identification (i.e. naming, metrics, meassurement) of the parts of system definition (elements, functions, relations, processes, goal behaviour, genetic code, etc.)

BASIC SOURCES OF SOFTNESS

- Inability to handle the system‘ uncertainty – i.e. to qualify values and their probability
- Origination of emergencies – i.e. unexpected manifestations or structure forms and uncertainty to identify their sources/causes



CONCEPT OF SOFTNESS

SOFTNESS := WHAT x WHERE x WHY x HOW

What – objective uncertainty, incompleteness of recognition of existing objects and tools for their control

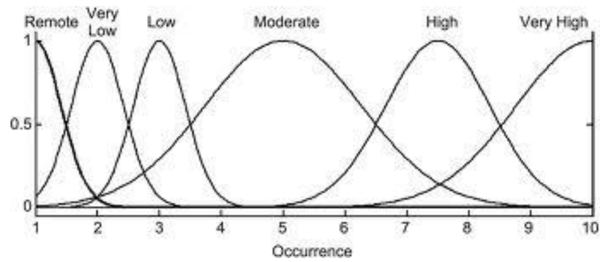
Where – environment, where the objective reality is assessed

Why – uncertainty subject to the sources of intelligence, result of unexpected values of functions and processes and result of influence of external constraining conditions, not enabling expected values of functions and processes and result of change in genetic prerequisites, adaptability of the object in changing environment

How – uncertainty of the occurrence

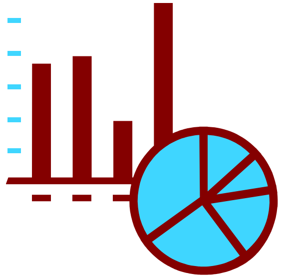
SYSTEM ENGINEERING WORK WITH SOFT SYSTEMS

Goal to (with regard to the softness) to identify, describe, control and use soft objects



Suitable tools:

- Statistics and probability
- Fuzzy sets
- Low resolution analysis (increasing entropy)
- Analysis of reduced interoperability
- Analysis of external conditions influence
- Analysis of system's creativity (ability to change the functions of elements, to create and cancel relationships, create and change goals



COMPARISON OF SOFT X HARD SYSTEMS

	SOFT SYSTEM	HARD SYSTEM
RESULTING IDENTIFICATION	Bad (uncertainly) structured	Well structured
USABILITY	Interpretative (for further interpretation)	Constructive („no need for discussion“)
FUNCTIONALITY (RELIABILITY)	Non-complete	Complete compatibility, regularity of interfaces

SOFT SYSTEMS

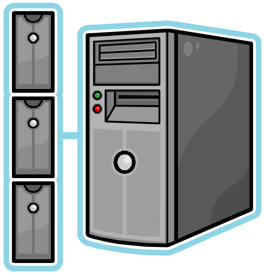
Ways how to sort soft systems, how to process the softness

- Expression of softness
  - Inaccuracy for measuring
  - Uncertainty of occurrence of phenomena (e.g. variables, processes, etc.)
  - Uncertainty of assigning effects to the set of elements, processes, etc.
  - Unpredictability of processes
- Softness can be identified on all parts of system definition (A/F, R/P, M, γ, δ, I)
- Behaviour of soft system either
  - Causes difficult controllability
  - or can be use in rational control of soft systems

SOFT SYSTEMS

Soft systems

- Manageability of soft systems can be solved using classification from informatics
  - Class-item
  - Whole-part
  - Master-slave
  - Client-server



- Description of softness
  - Carrier of softness
  - Form that is effected by softness
  - Source of softness
  - Available description of softness

SOFTNESS DIMENSIONS

Carrier of softness

- (A/F, R/P, M, γ, δ, I)

Form that is effected by softness

- Reliability
- Risk
- Vagueness in belonging to sets (we do not know what it is, where it is, but we definitely know it exists)
- Unexpected consequences (known cause, unknown result)

SOFTNESS DIMENSIONS

Sources of softness

- Failures
- Internal creativity (also due to e.g. artificial intelligence)
- External limiting conditions
- Grow of entropy

Available description of softness

- Diagnostics
- Probability
- Fuzzy sets

SOFT SYSTEMS METHODOLOGIES

Stressing necessity of complete understanding and describing of objects and their characters, even if not so formally accurate

Transfer of the methods is possible only on the level of examples (that are used as patterns, not direct instructions)

Disadvantages

- methodical non-homogeneity, that does not allow to find our fulfilment of set criteria, enumeration of effects and controlling the solution by formal methods

Rather pragmatic procedures, derived from experiences from solving particular problems, but also using some generalization of empiric procedures

soft algorithms – relative objective and rigorous usage of methods for managing uncertainty

SOFT METHODOLOGIES - SWOT ANALYSIS

Often used for planning of organization changes in the system

Uses 4 quadrant structure

- (IV. quadrant) **S** - Strenghts
- (I. quadrant) **W** - Weaknesses
- (III. quadrant) **O** - Opportunities
- (II. quadrant) **T** - Threats

Creates estimative picture of the situation in two time horizons – in present and in the near future (after doing the changes)

SOFT METHODOLOGIES – FORCE FIELD ANALYSIS

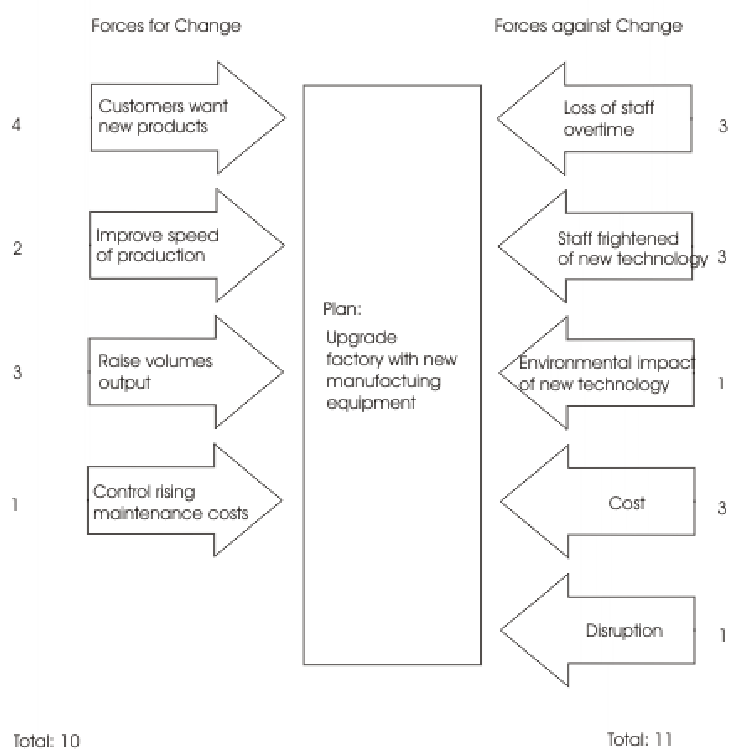
Used for planning of changes in the system

Analysing the pressures for and aga

Steps

- Describe your plan or proposal for change
- List all forces for change in one column, and all forces against change in another column.
- Assign a score to each force and displaying it in the graph as opposite forces

Figure 1
Force Field Analysis Example



Source: http://www.mindtools.com/pages/article/newTED_06.htm

SOFT SYSTEM METHODOLOGIES

Recommendations and procedures showing generalization of experiences form solving soft systems in practice

Example of methodologies

- System approach according Jenkins
- Checkland soft system methodology

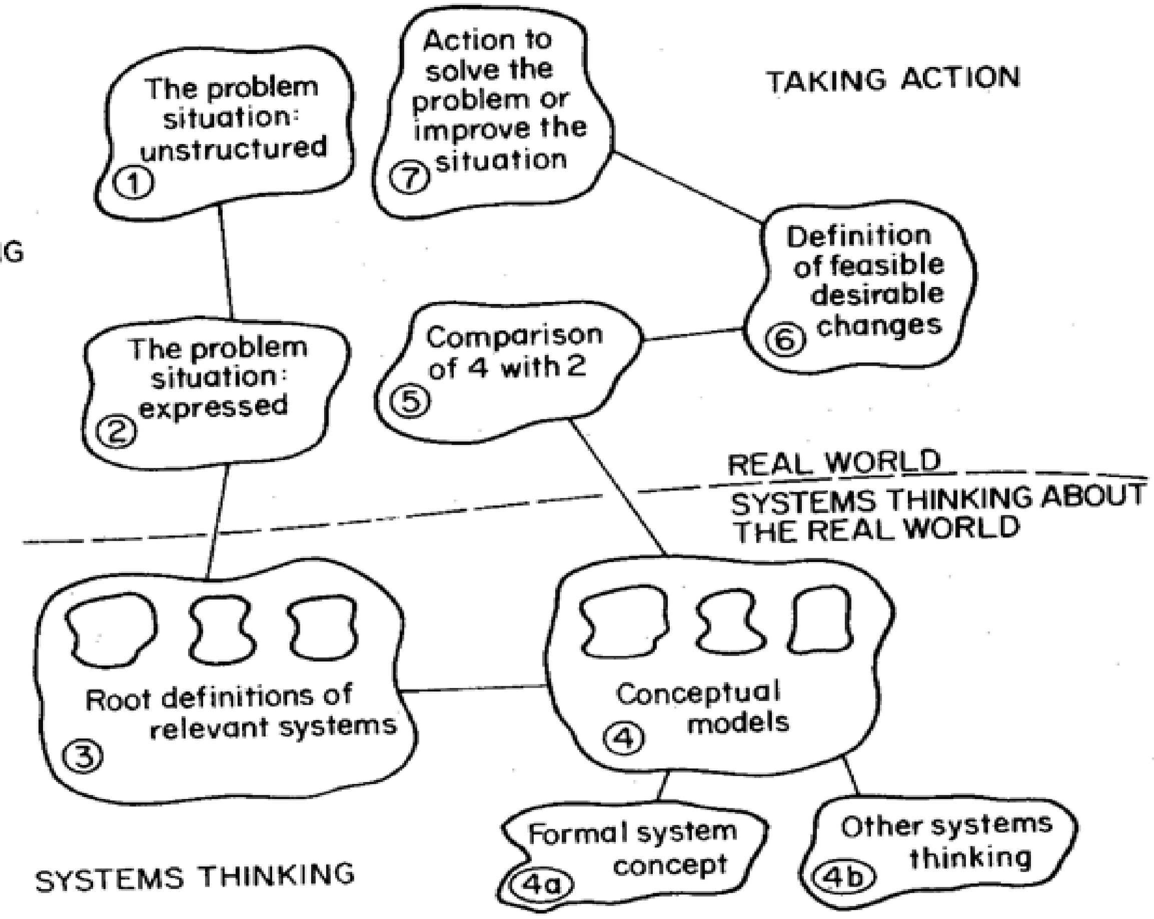
THE SYSTEM APPROACH ACCORDING JENKINS

Often used during project analysis of extensive technical and socio-technical works

Contains 4 main phases

- System analysis
- System project
- Implementation
- System operation

CHECKLAND METHODOLOGY



Source: http://teenskepchick.org/2012/08/31/systems-thinking-part-2-methodology/

Virtual systems

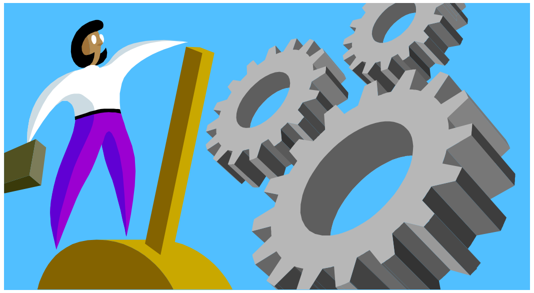
VIRTUAL SYSTEMS CHARACTERISTIC

Typical characteristics

- **Several possibilities of assignment of functions to elements**
- Maximal use of capacity of its parts
- Increase of flexibility in adaptation of goal behaviour according external conditions
- Increased presumptions of system survival, including using mutation or catastrophe
- Better cooperation of internal parts resulting in increase of capacity

VIRTUAL SYSTEM PREREQUISITIES

- **Existing system parts (elements) have similar functions**
- **It is possible to sequence the elements to form goal behaviour**
- **Capacity usage of the elements is variable in time (it is possible to substitute the elemments)**
- **System activation is due to external requirement, external imput**



VIRTUAL SYSTEMS FUNCTIONING

In case requirements do not request all available capacity at the same time

→It is possible to use the for-that-time unused capacities for other requirements without the need to increase capacity

(the ability to find acceptable usage for temporarily unused capacity is the sign of virtual system)

It is possible to apply virtual system on any type of system

VIRTUAL SYSTEM EXAMPLES

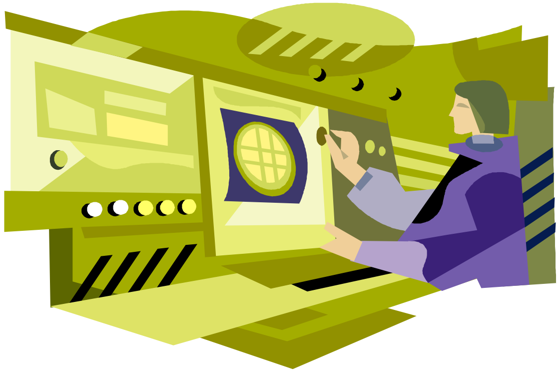
- Computer systems
- Integrated transport
- Matrix production control
- …

Control systems

CONTROL SYSTEMS

Used in cybernetics

Control = relation between the controlling (subject) and controlled (object) using image of the next state of object aiming to achieve desired (or prevent undesired) state



CONTROL SYSTEM CHARACTERISTICS

Elements of control system are special due to the assigned functions of

- Representation of current state of controlled object
- Transformation of this representation in the next state
- Usage of the model of the next state in changes of the object
- Verification of the real (realized) future state of the object

Requirement on the isomorphism of controlling and controlled objecs

- Can be based on adjusting the controlled object to the controlling subject
- Can be based on adjusting the elements and functions of controlling subject to the controlled object

COMPLIANCE WITH ISOMORPHISM REQUIREMENT

In the shape of control functions – dimension of demand factor and interpretation

- Demand factor in the shape of the function
- Demand factor in the control capacity
- Interpretation of controlled object status
- Interpretation of next state of controlled object
- Interpretation of activation
- Interpretation of control organization
- Interpretation of design (of the controlled object)

Additional functions in the control subject

Expanding of the control system functions

Hypertrophy (redundancy, overdesign) of the control subject

Communication systems

COMMUNICATION (TRANSPORT) SYSTEMS

Transferring subject (substrate) from one place to another via the infrastructure (network) using some type of carrier

Can be any type of transportation

- Physical
- Informatic

Identification of subject, network and carrier identifies the type of transport system

INFORMATION SYSTEMS

Address the range of strategic, managerial and operational activities involved in the gathering, processing, storing, distributing and use of information, and its associated technologies, in society and organizations

Process systems

- Supporting control of production functions – e.g. Traffic control, logistic processes, monitoring systems, etc.

Structural systems

- Structuring data – typically various databases

Thank you for your attention