SYSTEMS ANALYSIS

Introduction

Welcome

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- Information on this course including these presentations
  - www.k620.fd.cvut.cz (English version)
    - →Education →List of English courses →Systems analysis

Study materials

- Votruba Zdeněk: Systems analysis textbook
  - Available online on the web pages of the course, password protected

- Further literature e.g.:
  - James&Suyanne Robertson: Complete Systems Analysis
  - Reisig, Wolfgang; Rozenberg, Grzegorz: Lectures on Petri nets: Advances in Petri nets
  - London, Keith R: Decision tables

These slides

- To ease the understanding of the lectures
- Not meant as the basic study material!!!

This course

- Using higher viewpoint
- Not discussing details
- Different viewpoints!

Systems analysis

- System science
- Origin - the second quarter of 20. century
  - Reasons:
    - Over-specialization
    - Lack of mutual correspondence and understanding
    - Rediscovering basically the same
- HOLISTIC APPROACH
  - Before – (e.g. 19th century – reductionism)

Systems analysis

- Serves for identification and description of real world objects using tools and methods applicable in different areas to be able to work with them in the form of a model. This description is further used for. e. g. control, evaluation, etc. to be able to improve the performance, …

Is Systems analysis a science?

- Systems Sciences have their unique
  - Subjects of study
  - Data and knowledge
  - Meta-level

→ fulfill all the requirements of the full-fledged Science

- Fulfill requirements relating to:
  - Practical purposes
  - Measurability
  - Ability to be algorithmized
  - Ability to be standardized
  - Ability to be proved by evidence
  - Efficiency

→ they have also all the characteristics of the engineering branches of science

Systems sciences evolution

Catalyzed by the significant advances in

- Systems Thinking
- Mathematics
- Computer Science

Systems analysis - history

- SystemsThinking could be documented since ancient era
- Aristotle: **„The whole is more then a set of parts“**

- **Today‘s attitude – since 20th century**

Systems analysis suitable tasks

- **organized complexity**
- **heterogeneity**
- **Openness**

e.g. transport and telecommunication

Usage for different system types –from mathematical, technical up to sociological, biological,…

Approaches

- Inductive Approach - **General Theory of Systems (GTS)**
- Deductive Approach - **Mathematic Theory of Systems (MTS)**

What is a system?

- The role of a subject (investigator) is a key one
- Gaines ´s definition: **"System is any entity an investigator recognizes as the System".**
  (a bit provoking manner)
- Basic understanding
  Set of things and their mutual relations

  - not sufficient – missing behaviour, external evaluation, etc.

What is a system?

- Besides elements and their relations we need to know what the systém
  - Is doing
  - For whom,
  - …
- → Behavior, external viewpoint (identity),…

Identification of a system on an object – starting points I.

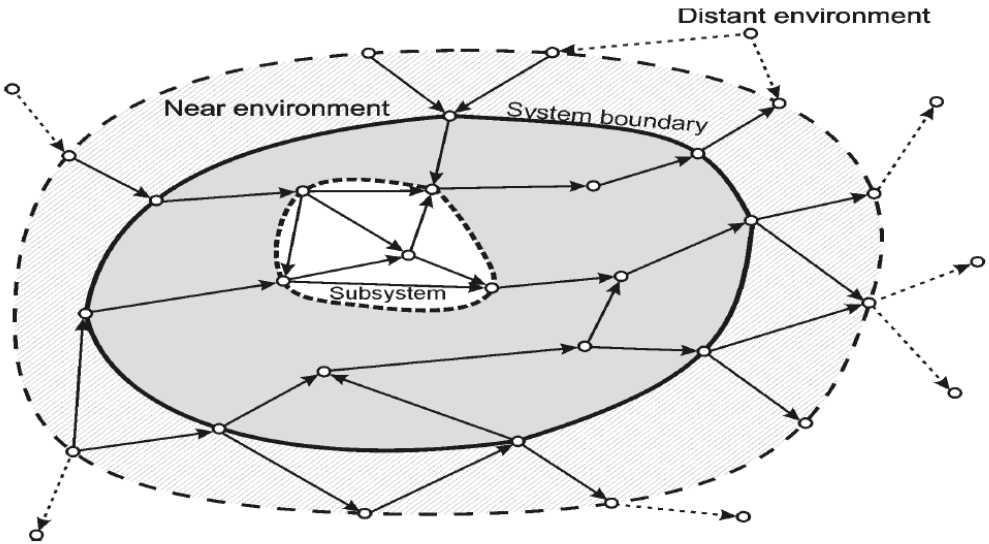
- There exists **subject** (observer)
- There exists something of his interest – **object**
- On the object the subject recognizes **variables**
- Independet variables – so call **base** (Subject – Object / variables /base (specific role of time) → **Source System)**
- Separation of variables on input and output ones – specification of neighborhood – placement of subject (as a rule to the neighborhood) → **Ordered / Neutral System** Evaluation of variables (continuous / crisp / fuzzy...

Identification of a system on an object – starting points II.

- Finding specific relations within the system which are **invariant against transforms of base**
- **Finding rules – Generative System**
- Subject eaims to describe the behaviour (processes)
- Finding the structure

Levels of distinguish

- Important input
- Means level of detail
- Can be done before the identification, during it, or iterative



Sentences

- Knowledge of the behaviour is not sufficient for finding the system structure
  - E.g. $y = 1$; $y = x / x$, (for $x \neq 0$).

- Structure, state of the system and state of the neighbourhood define the behaviour

Definitions – System's element

Elements of the System can be expressed as **Finite deterministic Automata:**

- $A = (X, Z, Z0, Y, \alpha, \beta)$
  - X,Z,Y are finite non-empty sets of inputs, internal states and outputs respectively; Z0 (subset of Z) is the initial state of automaton
  - $\alpha := Z \times X \rightarrow Z$ transmission function
  - $\beta := Z \times X \rightarrow Y$ output function
- Both (mapping) functions (α, β) generate the dynamics of element / automaton

Definitions

- **Element state** – inputs, outputs, internal states, states of elements functions
- **Transition** – change of state (value or function of the system)
- **System state:** „picture“ of the object in base variables
  - L – set of system variables
  - V – set of their values
  - State space S=LxV
- **Event -** change of state or time step
  The change of the state of element ai can initiate the transition of (at least one) successive element aj
  - An event occurred $OUT_{i,t} \rightarrow IN_{j,t}$ or $t \rightarrow t + 1$;

Definitions

- **Process** - chain of events
  - Serial (a single succession of events)
  - Parallel (two or more events take part in the same step of time)
  - Mixed
  - Alternative (an event uj is followed either by the event uk_a, or the event uk_b. The choice of the alternative is a result of certain condition testing

Definitions

- **Magnitude** M – set of all possible processes
- **Behavior** of the System – set of processes activated for inputs in a specified time interval and in a given state of the neighborhood (Set of Trajectories in State Space)

  Important subsets of behaviour:
  - γ - **goal oriented** (goal seeking) behaviour
  - δ - **species** / type focused **behavior** (**genetic code**)
- **Identity** – relation with the Neighbourhood

Definitions

- **Structure** is the set of elements and doubles of elements from the same set,
  - St = (A, (ai, aj)); i ,j = 1,2,.....n;
    $A \in (a1, a2, \ldots ai \ldots aj \ldots an)$; while doubles of elements express the existence of relations

- **Causality**: State of the System is independent on the future states

- Note: Relations are not holders of function! Elements carry the Functions. Relations, i.e. connections are specified by the set of parameters and by the set of domains of these parameters respectively

Formal system notation

- **System** $\rightarrow$ evaluated structure
- S = (A/F, R/P); where
  - A is a set of elements / automata A = (ak); k = 1.....n;
  - F is a set of functions α, β of elements; F = (αk, βk) defines the ability of system
  - R/P is a set of relations among elements Y$\rightarrow$ X and their parameters

Extended Inductive Definition of System

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

Extended Inductive Definition of System

S = (A/F, R/P, M,γ, δ, I)

- A/F is a set of elements and their functions
- R/P is a set of relations and their parameters
- M – magnitude = all processes
- γ – goal behaviour,
- δ – typical behaviour (genetic) code
- I – identity (how the system expresses itself towards the neighbourhood)

Identification of structured system

- 1. Choice of the level of distinguish
- 2. Choice / generation of the elements
- 3. Allocation of the functions to the elements, parameters of the elements
- 4. Definition of joined doubles of elements, chaining, introduction of the Structure, Metrics, parameters of the relations
- 5. Identification of the conditions for activation of processes
- 6. Identifications of processes, finding alternate processes
- 7. Stating the rules for identification of strong functions / processes and compactness, genetic code
- 8. Identification of the system‘s identity

- Thank you for your attention