Structural model

„the ***system*** is a structured whole that consists of elements selected deliberately and having certain functions as well as connections/ relationships among them; it is establised in order to achive determined goals or to solve problems”.

- elements: have determined attributes
- relationships

- sub-system (hierarchy of system levels)
- part-system

elements + relationships = System + Environment

Environment: group of *factors influencing the operation of the system*

input and output factors

Description of systems

- aim
- function
- resources
- extent
- status
- environment
- relationship with the environment

Description of structure

Static structure

- system element
- relationship
- hierarchy

Dynamic structure

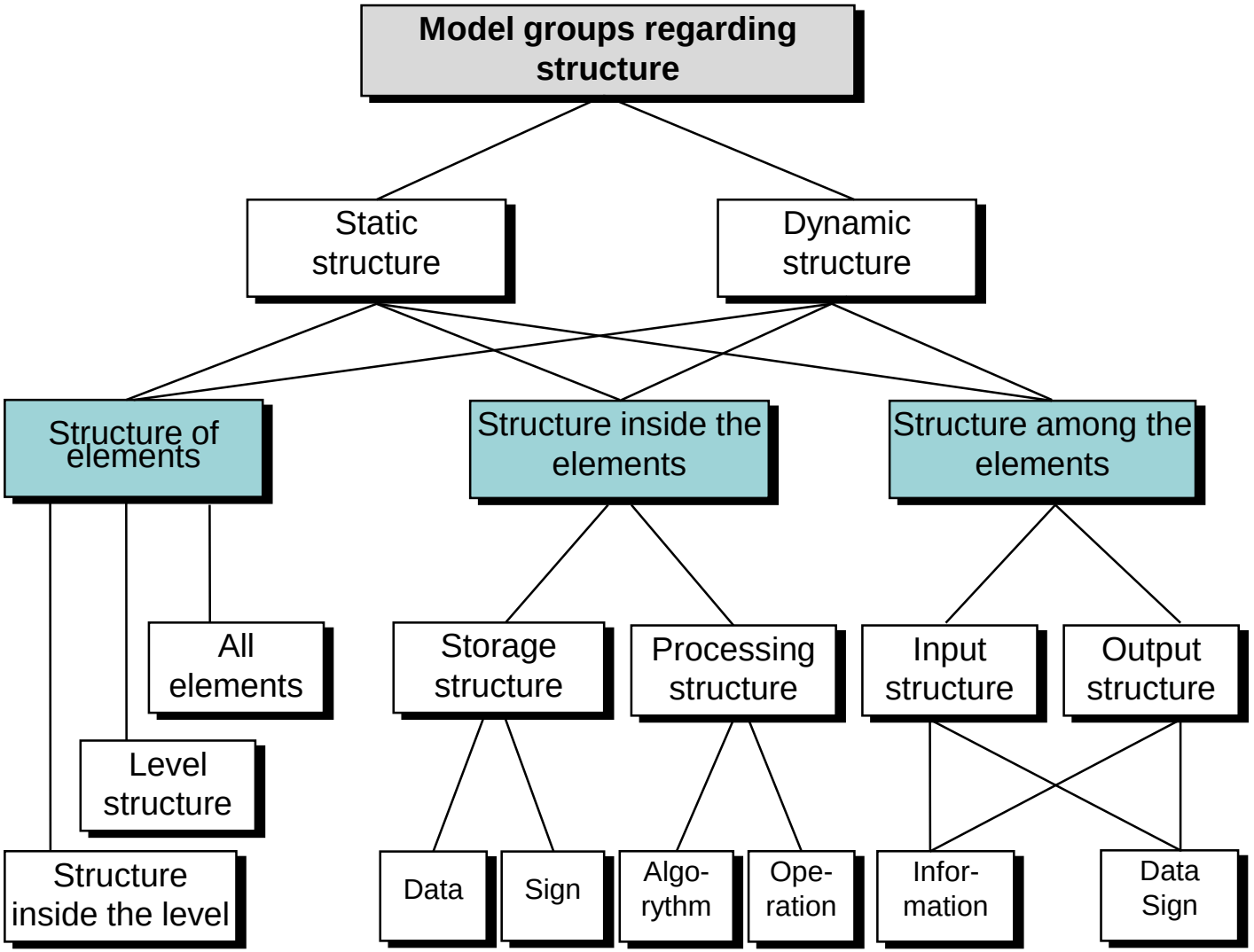
- operational structure
- adaptivity

Hierarchical structure (subordination)

- aim-hierarchy
- element - hierarchy
- relationship - hierarchy
- process - hierarchy

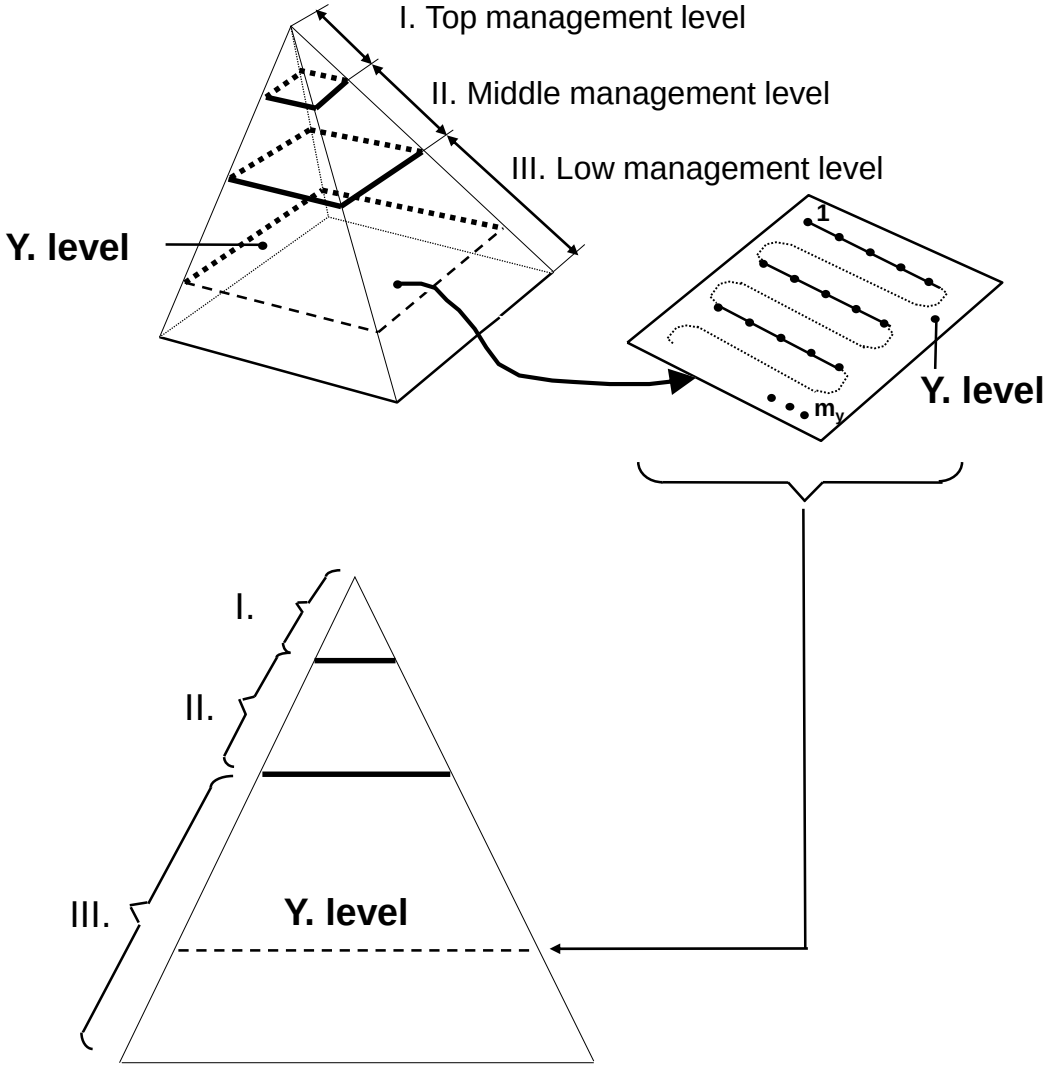
Type of systems

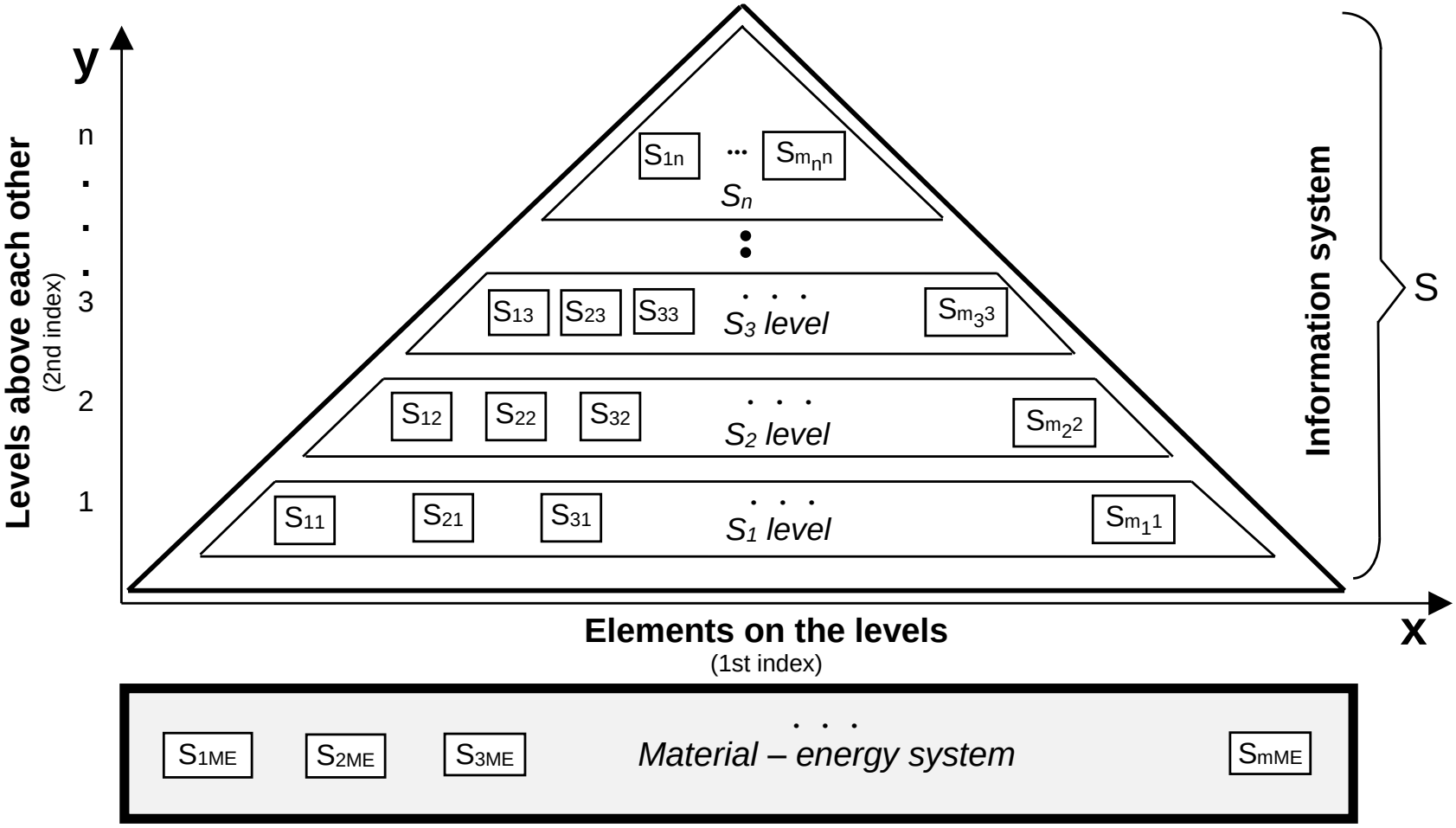
- Simple system
  - Complex system
- Closed system
  - Opened system
- Natural system
  - Human-built system
  - Human – machine systems
- Static systems
  - Dynamic system
- Deterministic system
  - Stochastic system


Model groups regarding structure
Static structure
Dynamic structure
Structure of elements
Structure inside the elements
Structure among the elements
All elements
Level structure
Structure inside the level
Storage structure
Processing structure
Data
Sign
Algo-rythm
Ope-ration
Input structure
Output structure
Infor-mation
Data Sign

Structure of elements

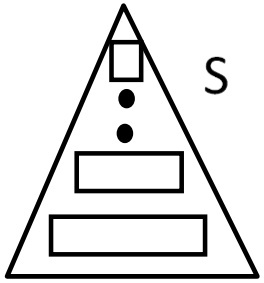
with consideration to management levels




y
n
3
2
1
Levels above each other
(2nd index)
S1n
Smnn
Sn
S13
S23
S33
S3 level
Sm33
S12
S22
S32
S2 level
Sm22
S11
S21
S31
S1 level
Sm11
Information system
S
Elements on the levels
(1st index)
x
S1ME
S2ME
S3ME
Material – energy system
SmME

Structure inside the elements

Notations according to element complexity

		Flow	Storage	Transformation		Flow
		Information (input)	Information	Algorithm	Operation	Information (output)
Element	S_{xy}	${}_{i}I_{S_{xy}}$	${}_{T}I_{S_{xy}}$	$A_{S_{xy}}$	$O_{S_{xy}}$	${}_{O}I_{S_{xy}}$
Level	S_y	${}_{i}I_{S_y}$	${}_{T}I_{S_y}$	A_{S_y}	O_{S_y}	${}_{O}I_{S_y}$
Whole system		${}_{i}I_{S}$	${}_{T}I_{S}$	A_{S}	O_{S}	${}_{O}I_{S}$

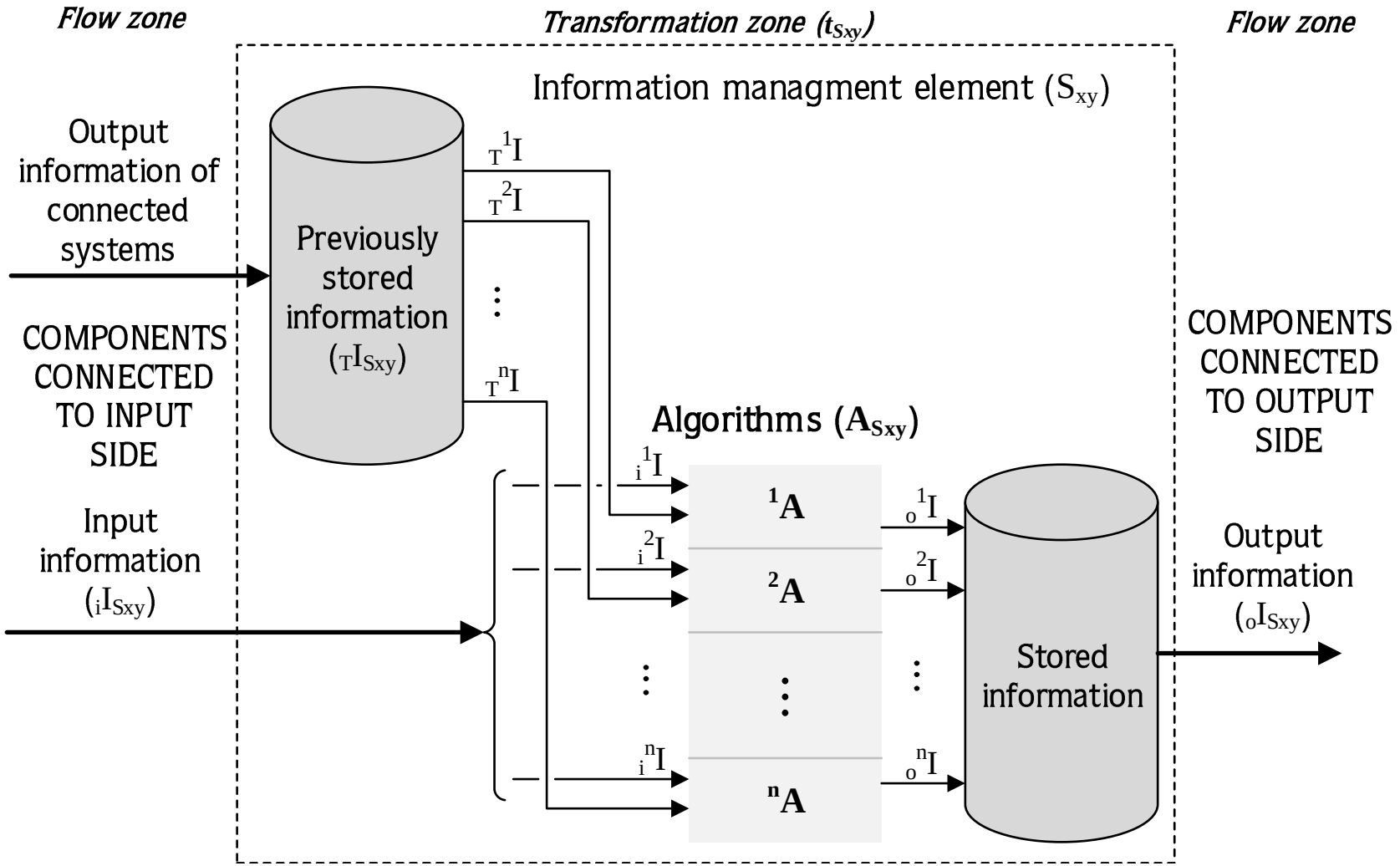
goal of information management element, input, output information

$${}_{o}I_{S_{xy}} = t_{S_{xy}}({}_{i}I_{S_{xy}}, {}_{T}I_{S_{xy}})$$

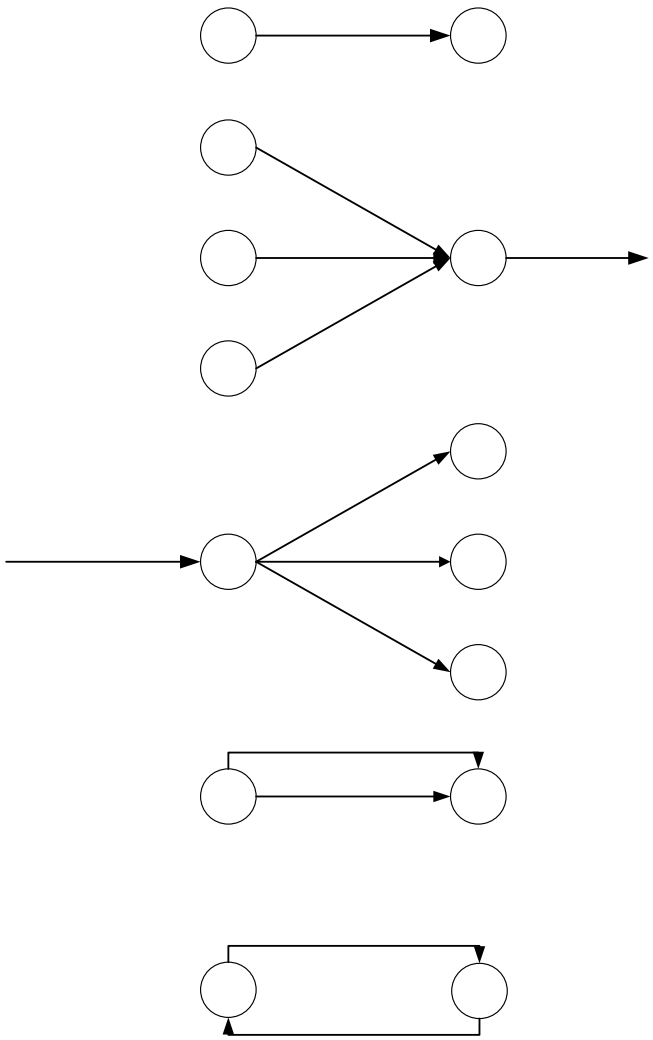
$${}_{o}{}^{2}I = {}^{2}A({}_{i}{}^{2}I, {}_{T}{}^{2}I)$$

$$A_{S_{xy}} = f(t_{S_{xy}})$$

$$O_{S_{xy}} = f(p, A_{S_{xy}})$$



Connection/relationship structure among the elements



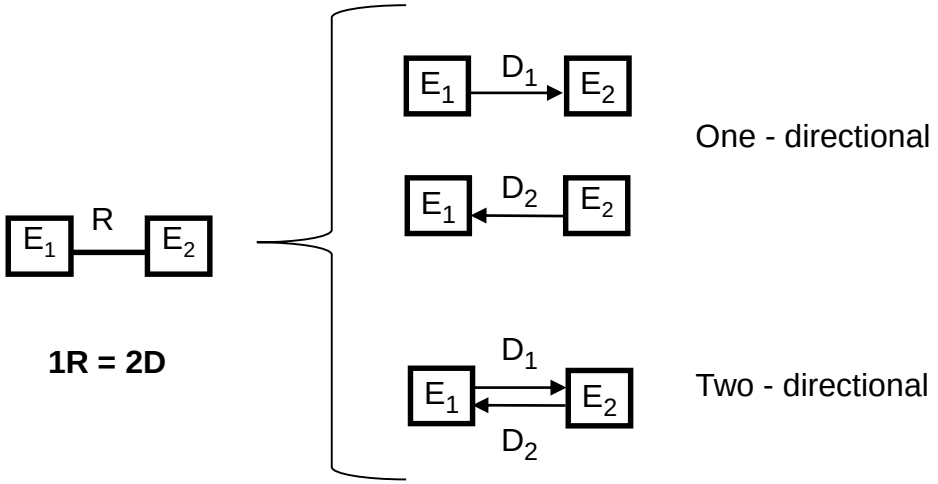
Type of connections

complexity, relations, directions

$$M = f(E,R)$$

$$R_L = \frac{E^2 - E}{2}$$

$$D_L = E^2 - E$$



$$M_R = \frac{R_V}{R_L}$$

RELATIVE COMPLEXITY

$0 < M_R < 1$

Notations used for modelling the connections between elements

UPPER LEFT INDEX: DYNAMIC

Second	**I**
Minute	**II**
Hour	**III**
Day	**IV**
Week	**V**
.	.
.	.

UPPER RIGHT INDEX: RELATIONSHIPS AMONG LEVELS

Upper level:	**U**
Equivalent level:	**E**
Lower level:	**L**

Material – energy level: **ME**

I

Information

LOWER LEFT INDEX:

DIRECTIVITY

Input:	**i**
Output:	**o**

CONTAINMENT:

Inner:	**b**
Outer:	**k**

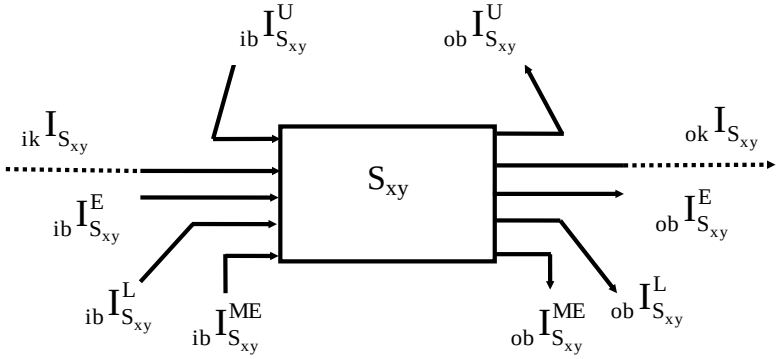
LOWER RIGHT INDEX: COMPLEXITY

In case of element: $\mathbf{S_{xy}}$

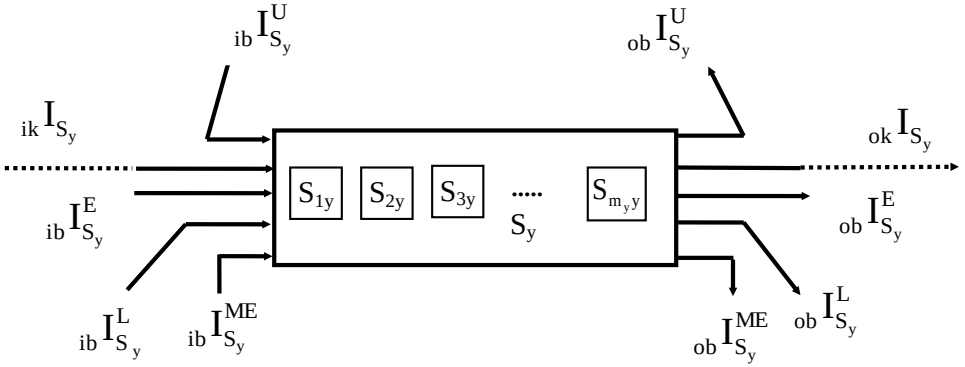
In case of level: $\mathbf{S_{y}}$

In case of the whole system: **S**

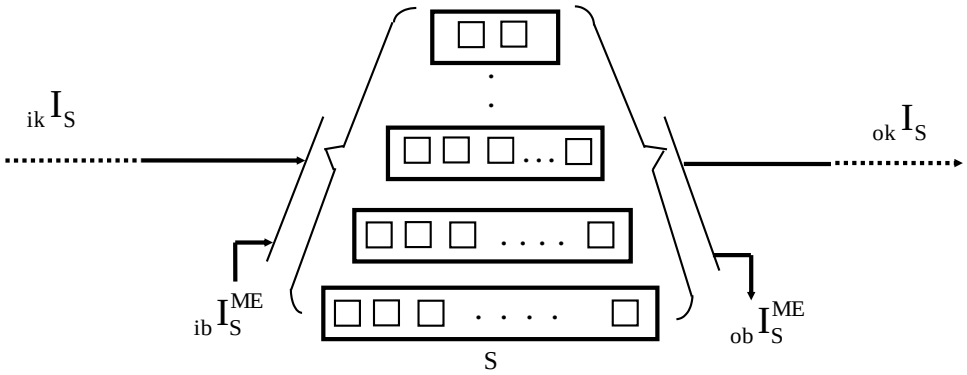
Model of connections/relationships among elements



in case of one element



in case of one level



in case of the whole system

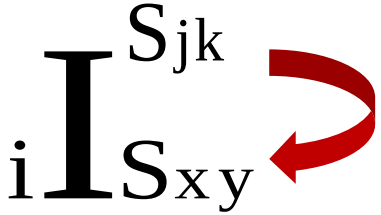
The connections can be analyzed according to the following criteria:

- directions
- quantity and groups of transmitted information (data)
- frequency of transmission (dynamics , time-cycle)
- technology of transmission
- cost of transmission
- time/duration of transmission (data aging)

information supply cost (data storage and transmission)

centralized – decentralized network

Simple marking of information flow between elements



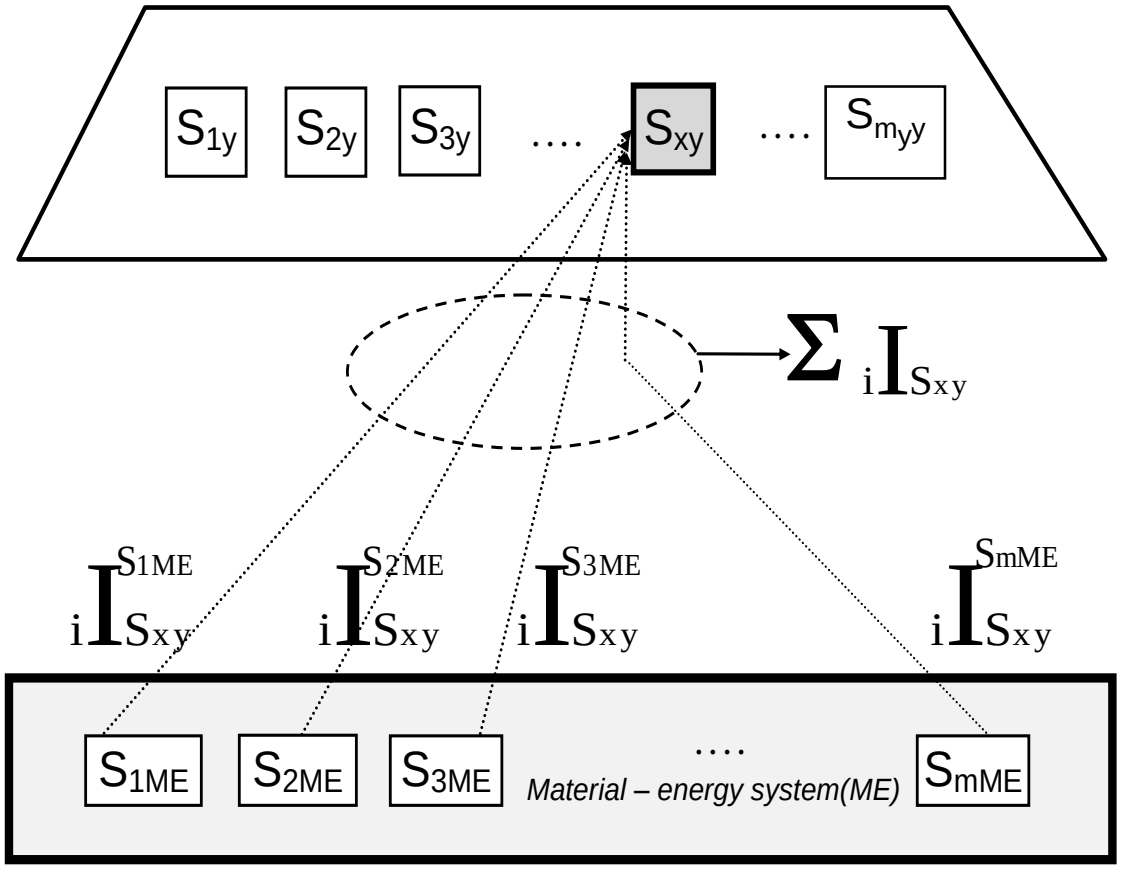
The information that is **<u>received by</u>** the level y. and element x. from level *k.* and element *j.*

The information that is **<u>transmitted by</u>** the level *y.* and element *x*. to the level *k.* and element *j.*

$$ {}_{o}I^{S_{jk}}_{S_{xy}} = {}_{i}I^{S_{xy}}_{S_{jk}} $$

symmetry

Totality of the information of a certain element



Dynamic structure

In transportation organizations the information management actions can be repeated

- per second (I),
- per minute (II),
- hourly (III),
- daily (IV),
- weekly (V),
- monthly (VI),
- annually (VII).

time cycles

Dynamics of element structure — **Is it working?** — $^{I,IV}S_{2k}$

Dynamics inside the element structure — **How is it working?**

Dynamics among the elements — **What kind of relationships does it have?**

Dynamic structural model of transportation information systems

- Dynamics of element structure and connections
between elements