THE INTERPRETATION OF THE ONTOLOGY FOR THE CONCEPTUAL REDESIGN OF SYSTEMS

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ABSTRACT

The paper deals with the Interpretation of sign chains written in the ontology GLB (Global Context), (Bila and Tlapak 2004), (Bila and Tlapak 2005) and (Bila, Tlapak and Jura 2006). The ontology has been proposed for the design of technical systems (including measurement and control systems). The mentioned topic belongs to problems of measurement and control systems design software support and may be discussed also in the field of the industrial automation. The described ontology has 4 strata: The stratum of Fields of Activities (F_{Act}), Principles 1 (Princ1), Principles 2 (Princ2) and the stratum of diagrams (state and sequential diagrams) written in language UML. A grammar of the ontology sign chains was formed. The kernel of the paper is concentrated on the construction of the assignment (φ) that associates grammatically correct sign chains and their semantic content (eventually the meaning) in the context of the solution of design problems and tasks.
The interpretation system is formed as a rule-based system (without sharp limitations). The right sides of rules are written in a special language (near to natural language) and there are formed as the interpretation process outputs (in the user interface). A cooperation with a human operator there is assumed. (The style and the structure of HCI (Human Computer Interface) are only briefly suggest in the paper.)
The development of ontologies for various expert fields is very frequent topic in informatics and engineering. The interpretation of expressions formed within the ontology is unavoidable for its effective utilisation. The paper introduces a small illustration of an interpretation system construction.

KEYWORD

Ontology, Conceptual Design, Redesign, Field of Activities, UML (Unified Modelling Language).

1. INTRODUCTION

The paper proposes the approach of Artificial Intelligence to support for conceptual design and redesign of a systems. The interest was shifted from formal means to semantic modelling and at this framework to effective description of the functions of the designed systems. This shift allowed to support a conceptual phase of the design and redesign process more competently and formal means of classical AI keep at the field of detailed design.
The ontology is a top of the semantic modelling which facilitate higher efficiency of semantic systems. There is mentioned interpretation system for ontology GLB which mediate relation between ontology and their user – designer.

2. LANGUAGES FOR REPRESENTATION OF ONTOLOGIES

From the list of "older" semantic formalisms which can nowadays be considered as ontologies, we mention only Bylander's consolidations (Bylander and Chandrasekaran 1988). Consolidations are graphic-symbolic formations that describe functions on the level of principles. In combination with Suh's axiomatic theory of design (Suh 1990), knowledge acquisition and knowledge representation were used to explain the system functions (Katai *et al.* 1995). They are still used, e.g., in systems for automatic identification of functional structures, (Kitamura *et al*. 2002) [5].

One of the most powerful means for representing ontologies is ONTOLINGUA, (Gruber 1993), (Gruber 1994). Its basic layer is done by KIF language (Knowledge Interchange Formate), (Michael 1991), which is a variant of predicate first order language with the syntax of LISP.

Of many of other languages for representation of ontologies, the following are widely used: OCML (Ontology Compositional Modelling Language), DAML-ONT (Darpa Agent Mark-Up Language-ONTology), OIL (Ontology Inference Layer) and DAML+OIL. Details, e.g., in (Svátek 2002).

3. STRUCTURE OF ONTOLOGY GLB

The ontology that has been developed for conceptual redesign of machine, instruments and device components, now will be pro posed.
The ontology denoted as a Global context (GLB) combines the features of general semantic networks and the features of UML language. The ontology is task-oriented and domain-oriented and contains three basic strata (with their sub-strata):

- GLB_{Expl} - stratum of Explanation,
- GLB_{Fact} - stratum of Fields of Activities,
- GLB_{Env} - stratum of Environment.

Stratum Fields of Activities (GLB_{FAct}) has 4 sub-strata (Principles): GLB_{Princ1} (name of principles), GLB_{Princ2} (specification of the principles), GLB_{Princ3}(state diagram UML – dynamical network of a states and operations, internal behaviour of the principles), GLB_{Princ4}(sequential diagram UML – incorporation in the wider area, external behaviour of the principles).

A structure of strata and sub-strata is shown in Fig. 1, which corresponds, to expression (1):

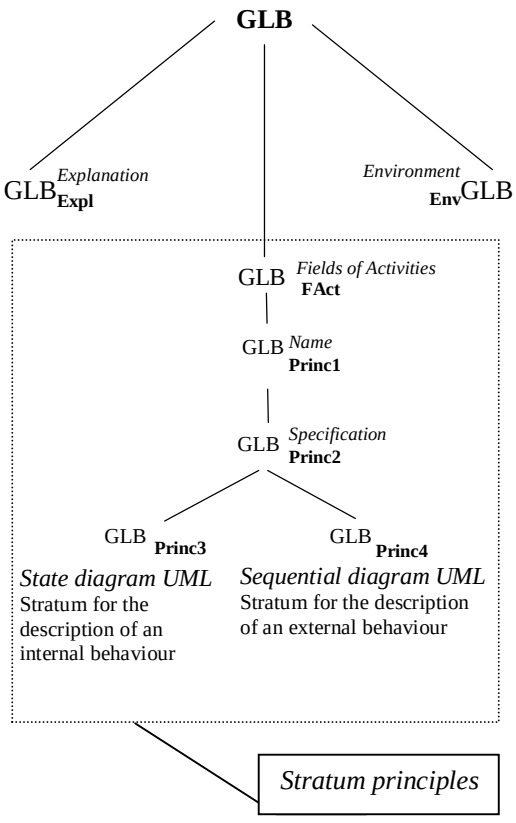

Fig. 1. Structure of ontology GLB.

$$\boldsymbol{GLB} = \langle GLB_{Expl}, GLB_{FAct}\langle GLB_{Princ1}\langle GLB_{Princ2} \langle GLB_{Princ3}, GLB_{Princ4}\rangle\rangle\rangle, GLB_{Env} \rangle, \quad (1)$$

Strata and sub-strata GLB_{FAct}, GLB_{Princ1}, GLB_{Princ2} , have the structure of algebras

$$GLB_p = \langle \boldsymbol{Fam_p}, \boldsymbol{F}\,(\boldsymbol{Fam_p}) \rangle, \quad (2)$$

Strata and sub-strata GLB_{Expl}, GLB_{Princ3},GLB_{Princ4}, GLB_{Princ5} a GLB_{Env} have the structure of models

$$GLB_p = \langle \boldsymbol{Fam_p}, \mathfrak{R}(\boldsymbol{Fam_p}) \rangle, \quad (3)$$

where $\boldsymbol{Fam_p}$ are the ground sets (the carriers) of models and algebras, ($p \in$ {Expl, FAct, Princ1, Princ2, Princ3, Princ4, Princ5, Env}, $\boldsymbol{F}(\boldsymbol{Fam_p})$ are systems of operations and $\mathfrak{R}(\boldsymbol{Fam_p})$ are systems of relations introduced in ground sets $\boldsymbol{Fam_p}$. Ground sets $\boldsymbol{Fam_p}$ of models and algebras will in this paper be called „families“, and their elements will be called "Formation Spaces " (denoted as *FS*). (The set of all ***Fam***s is denoted as ***FAM***.)

Note: Only fragments of an ontology from stratum FAct are demonstrated in this paper. Detailed information about ontology GLB is in (Bíla and Tlapák 2004), (Bíla 2005) and (Bíla, Tlapák and Jura 2006).

Stratum Field of Activities (FAct):
Carrier $\boldsymbol{Fam_{FAct}}$ contains formation spaces of the fields of activities (E.g.: Mechanics, Pneumatics, Hydromechanics etc.).

Stratum Principles 1 (Princ1):
Carrier $\boldsymbol{Fam_{Princ1}}$ contains formation spaces of the first layer of the principles (E.g.: Aggregation, Transformation, Relative Effects, Protection, Constructions etc.).

Stratum Principles 2 (Princ2):
Carrier $\boldsymbol{Fam_{Princ2}}$ contains formation spaces of the of the second layer of the principles (E.g.: Accumulation and Synthesis for first Principle Aggregation, or Joint, Filter and Bearing for principle Relative Effects, etc.).

Strata Principles 3 (Princ3), Principles 4 (Princ4):
Carrier $\boldsymbol{Fam_{Princ3}}$ contains states and transitions of the UML state diagrams and Carrier $\boldsymbol{Fam_{Princ4}}$ contains objects, events and conditions of sequence diagrams both related to given ontology.

4. GROUND SETS OF GLB COMPONENTS

4.1. Ground set Fam_{FAct}

$\boldsymbol{Fam_{FAct}}$ contains formation spaces of the type:

$\boldsymbol{Fam_{FAct}}$ = {**ME**, **PNU**, **HME**, **ELS, MSF, TCS, LGS, ORG, MAT, STRUCT…**}, (3)

with the following meaning:

ME … *Mechanics*,
PNU … *Pneumatics*,
HME … *HydroMechanics*,
ELS … *Electromagnetics and Electronics*,
MSF … *Mathematic, Symbolic and Formal* (formation spaces),
TCS … *Technological Constructions* (bridges, frames, boxes, join components, containers …),
LGS … *Legislation means* (conventions, decrees, imperatives),
ORG … *Organization* formation spaces,
MAT … *materials*,
STRUCT … *Structure* of components of a system (as a structure of interacting formation spaces)

4.2. Ground set Fam_{Princ1}:

Fam_{Princ1} contains formation spaces of the type:

$$Fam_{Princ1} = \{\textbf{Agg}, \textbf{Trns}, \textbf{Contr}, \textbf{Protc}, \textbf{Cnstr}, \textbf{R-Eff}, \textbf{Instr}, \textbf{Dam}, \textbf{Emb}, \textbf{Prod}\}, \quad (4)$$

with the following meaning:

Agg … *Aggregation*,
Trns … *Transformation*,
Contr … *Control*,
Protc … *Protection*,
Cnstr … *Constructions*,
R-Eff … *Relative Effects*,
Instr … *Instrumental*,
Dam … *Damage*,
Emb … *Embedding*,
Prod … *Production.*

4.3. Ground set Fam_{Princ2}:

Fam_{Princ2} contains formation spaces of the type

$$Fam_{Princ2} = \{ \text{Agg}\langle\textbf{Accum}, \textbf{Synth}\rangle, \text{Trns}\langle\textbf{ChCarr}, \textbf{ChCarrV}, \textbf{Transfer}, \textbf{Transms}, \textbf{ChBeh}, \textbf{ChVVal}\rangle, \text{Contr}\langle\textbf{Rep}, \textbf{Supp}, \textbf{Catal}, \textbf{Analog}, \textbf{Logic}, \textbf{F-Logic}\rangle, \text{Protc}\langle\textbf{ProtcProd}, \textbf{ProtcProp}, \textbf{ConsvState}\rangle, \text{Cnstr}\langle\textbf{Separ}, \textbf{Fix}, \textbf{Bear}, \textbf{Content}, \textbf{Join}, \textbf{Shape}, \textbf{Milieu}\rangle, \text{R-Eff}\langle\textbf{Filter}, \textbf{Joint}, \textbf{Bearing}\rangle, \text{Instr}\langle\textbf{Tool}, \textbf{Material}, \textbf{Means}\rangle, \text{Dam}\langle\textbf{Discard}, \textbf{Contamin}, \textbf{Destruct}\rangle, \text{Emb}\langle\textbf{InConstr}, \textbf{Include}, \textbf{Annex}\rangle, \text{Prod}\langle\textbf{Objects}, \textbf{UnivQual}, \textbf{UnivPower}\rangle\}, \quad (5)$$

with the following meaning:

Accum … *Accumulation* (Aggregation without change of the aggregated components),
Synth … *Synthesis* (Aggregation with a change of the aggregated components),
ChCarr … *Change of Energy Carriers*,
ChCarrV … *Change of Carrier Variables*,
Transfer … *Change of position* of energy matter with possible changes of the internal properties,
Transms … (*Transmission*) Change of position of energy matter without changes of the internal properties,
ChBeh …. *Change of Behavior*
ChVVal … *Change of Values* of descriptive Variables,
Rep … *Repression of an effect* (process, principle),
Supp … *Support of an effect* (process, principle),
Catal … *Catalysation* of an effect (process, principle),
Analog … *Analog control* of an effect (process, principle),
Logic … *Logic control* of an effect (process, principle),
F-Logic … *Fuzzy Logic* control of an effect (process, principle),
ProtcProd … *Protection of Products*,
ProtcProp … *Protection of Properties*,
ConsvState … *Conservation of a State*,
Separ ... *to Separate*,
Fix … *to Fix*,
Content … *to form* a volume,
Milieu … *to form a Milieu*,
Joint … *Joint*,
Bearing … generalized Bearing,
Means … (non special facilities to help an effect or action),
Discard … (to eliminate the existence),
Contamin … *to Contaminate*,
Destruct … *to Destruct*,
InConstr … *to embed* in a system and to use the functionality (of the embedded system or of both),
Include … *to embed without specified* utilisation of functionalities,
UnivQual … *production of Universal Qualities* (money, water, light, foodstuffs),
UnivPower … *production of Universal Powers* (electrical energy, heat).

Note 4.2.1: The lists of Fields of Activities and Principles in the strata introduced above are considered open and here contain a transparent collection of ontological components (especially for understanding the examples from Chapter 5.).

4.4. Strata "Principles 3" (Princ3), "Principles 4" (Princ4)

Stratum ***"Princ3"*** contains UML state diagrams and stratum ***"Princ4"*** contains UML sequence diagrams**.**

For each line FAct – Princ1 – Princ2 there is at least one state or sequence diagram (according to need). (In the final stage XML language is used to represent the diagrams from strata ***Princ3, Princ4***.)

5. INTERPRETATION OF ONTOLOGY

5.1. System of Interpretation

The final form of interpretation system is the collection of dictionaries with meanings of all grammatical correct sign chains:

Dictionary **semantic generators** + examples
E.g. : TCS, ME, PNU, Agg, Accum, etc.

Dictionary **basic chains** + examples
E.g.: STRUCT (Agg)

Dictionary **completed chains** + examples
E.g.: STRUCT (Agg(Accum))

Dictionary **composite chains** + examples
E.g.: STRUCT (Agg(Accum)) AND ELS (Trns(ChCarr)

Dictionary **inbuilt chains** + examples
E.g.: STRUCT (Agg(Accum) AND (Trns(ChCarr)

Dictionary **combination of all previous** + examples
E.g.: STRUCT (Agg(Accum) AND (Trns(ChCarr)

The examples provide an expressing aid and the matter for generalisation of described principles. User can generalise described principles from this verbal illustrations (examples) without need to put one into words. Then he can apply this principle directly, because he has formed cognitive structures like a tacit knowledge (Wagner & Sternberg 1986).

5.2 Display of the interpretation

There are many possibilities how to display the interpretation of sign chain to user. For example:

1. Sets (unifications and intersections and subsets).
2. Tree (logical derivational tree).
3. Expression (symbolical formal language)
4. Natural language
    a. dictionary of the concepts
    b. analogy and examples of the component chains

5.3. Interpretation of the Complete and Composite Sign Chains from chapter five.

The set of the following sign chains will be used in this sub-section as a frameworks for explanation of the interpretation system function. The set have been generated by a program (Bila, Tlapak and Jura 2006)and represent possible solutions for a non traditional energy source design.

1. STRUCT(Agg(Synth))
2. STRUCT(Trns(ChCarr))
3. STRUCT(Agg(Synth) AND Trns(ChCarr))
4. STRUCT(Agg(Synth) AND R-Eff(Filter))
5. STRUCT(Trns(ChCarr) AND R-Eff(Filter))
6. STRUCT(Agg(Synth) AND Trns(ChCarr) AND R-Eff(Filter))
7. ELS(Agg(Synth))
8. ELS(Trns(ChCarr))
9. ELS(R-Eff(Filter))
10. ELS(Agg(Synth) AND Trns(ChCarr))
11. ELS(Agg(Synth) AND R-Eff(Filter))
12. ELS(Trns(ChCarr) AND R-Eff(Filter))
13. ELS(Agg(Synth) AND Trns(ChCarr) AND R-Eff(Filter))
14. TCS(Agg(Synth))
15. TCS(Trns(ChCarr))
16. TCS(R-Eff(Filter))
17. TCS(Agg(Synth) AND Trns(ChCarr))
18. TCS(Agg(Synth) AND R-Eff(Filter))
19. TCS(Trns(ChCarr) AND R-Eff(Filter))
20. TCS(Agg(Synth) AND Trns(ChCarr) AND R-Eff(Filter))
21. STRUCT(Trns(ChCarr)) AND ELS(Trns(ChCarr))
22. STRUCT(Trns(ChCarr)) AND TCS(Trns(ChCarr
23. STRUCT(Trns(ChCarr)) AND TCS(Agg(Synth) AND Trns(ChCarr))
24. STRUCT(Agg(Synth) AND Trns(ChCarr)) AND TCS(Trns(ChCarr))
25. ELS(Trns(ChCarr)) AND TCS(Trns(ChCarr))
26. ELS(Trns(ChCarr)) AND TCS(Agg(Synth) AND Trns(ChCarr))
27. ELS(Agg(Synth) AND Trns(ChCarr)) AND TCS(Trns(ChCarr))

Now we explain gradually interpretation of some selected chains.:

1. STRUCT(Agg(Synth))		
Structure	**Aggregation**	**Synthesis**
mode of arrangement, or configuration accurately, arrangement itself (as such). From Latin base STA.	union, conjunction, composition, constitution, compound, assemblage, grouping. From Latin	Aggregation with a change of the aggregated components. Aggregation with added value. In context of aggregation it is the composing,

	aggregare which is composed of a – grex (flock).	arranging. From Greek synthesis (arrange) which is composed of syn- + ti-thémi (put, place), likeness with thema (subject, topic, and theme).
Change of the configuration with change of components.		
We use identical elements (components), but we assemble them in another way. It causes a gain of a new functionality of the line-up.		
Transition from the fixed pulley to a idle pulley.		
Interconnection of the speaker like a microphone.		

Table 1. interpretation of the sign chain: STRUCT(Agg(Synth))

2. STRUCT(Trns(ChCarr))			
Structure		**Transformation**	**Carriers of structure**
mode of arrangement, or configuration accurately, arrangement itself (as such). From Latin base STA.		Transmutation, shift, (qualitative) change From Latin trans = over, throw, in and Formare = form, shape, create. From Latin word forme, which arise by anagram from the Greek morfé.	Atoms, Elements, Bonds, Connectors, Divisors, etc.
The change of the configuration which causes better utilisation of a other form of energy transmission.			
The change of structure carriers-elements and bonds			

Table 2. interpretation of the sign chain: STRUCT(Trns(ChCarr))

3. STRUCT(Agg(Synth) AND Trns(ChCarr))			
Structure	**of**	**Aggregation**	**Synthesis**
mode of arrangement, or configuration accurately,. arrangement itself (as such). From Latin base STA.		union, conjunction, composition, constitution, compound, assemblage, grouping. From Latin aggregare which is composed of a – grex (flock).	Aggregation with a change of the aggregated components. Aggregation with added value. In context of aggregation it is the composing, arranging. From Greek synthesis (arrange) which

together with	**Transformation**	**Carriers of Structure**
	transmutation, shift, (qualitative) change From Latin trans = over, throw, in and formare = form, shape, create. From Latin word forme, which arise by anagram from the Greek morfé.	Atoms, Elements, Bonds, Connectors, Divisors, etc
A change of synthesis structure with a change of components..		
We use identical elements (components), but we assemble them in another way. It causes a gain of a new functionality of the line-up and utilisation of another energy principle.		

Table 3. interpretation of the sign chain: STRUCT(Agg(Synth) AND Trns(ChCarr))

4. STRUCT(Agg(Synth) AND R-Eff(Filter))			
Structure	**of**	**Aggregation**	**Synthesis**
mode arrangement, or configuration accurately, arrangement itself (as such). From Latin base STA.		union, conjunction, composition, constitution, compound, assemblage, grouping. From Latin aggregare which is composed of a – grex (flock).	Aggregation with a change of the aggregated components. Aggregation with added value. In context of aggregation it is the composing, arranging. From Greek synthesis (arrange) which is composed of syn- + ti-thémi (put, place), likeness with thema (subject, topic, and theme)
together with		Relative Effects	type Filter
		The effect, which is seen as effect only towards some another else point of	Filter, strainer. In the context of the relative effect it means probably any restrictions

	view. E.g. joint, any moving element, direct line etc.	like a (DOF) degree of freedom.
Change of the configuration with change of components. And this change cause, that some part of the structure is changing itself relatively to any other or others part. And this changing has any restrictions.		
We use identical elements (components), but we assemble them in another way to behave relatively to each others and with some restrictions.		
E.g.: Re-mounted system and make a joint.		

Table 4. interpretation of the sign chain:
STRUCT(Agg(Synth) AND R-Eff(Filter))

7. ELS(Agg(Synth))		
Electromagnetics and Electronics	**Aggregation**	**Synthesis**
Electro-magnetic and electronic field of Activities (to attract, to flow, to make a tension, to illuminate, to induce, …) its real components (resistors, transistors, motors, …)	Union, conjunction, composition, constitution, compound, assemblage, grouping. From Latin aggregare which is composed of a – grex (flock).	Aggregation with a change of the aggregated components. Aggregation with added value. In context of aggregation it is the composing, arranging. From Greek synthesis (arrange) which is composed of syn- + ti-thémi (put, place), likeness with thema (subject, topic, and theme)
The change of the arrangement of the electrical elements with their modification.		
We use identical electrical elements (components), but we assemble them in another way. It causes a gain of a new functionality of the line-up and utilisation of another energy principle.		
To produce electric charge.		
Interconnecting of transistors like a logical function, flip-flop etc.		
Interconnection of neurones which realise logical function, generalisation, discrimination, recognition etc.		

Table 5. interpretation of the sign chain:
ELS(Agg(Synth))

8. ELS(Trns(ChCarr))		
Electro-magnetics and Electronics	**Transformation**	**ELS Carriers**
Electro-magnetic and electronic field of Activities (to attract, to flow, to make a tension, to illuminate, to induce, …) its real components (resistors, transistors, motors, …)electric motor, coils, electromagnets, transformers, relays, semiconductors (transistors, diodes etc.) logic gates, microprocessors	transmutation, shift, (qualitative) change From Latin trans = over, throw, in and formare = form, shape, create. From Latin word forme, which arise by anagram from the Greek morfé.	Electrons, other particles, voltage, current, charge,
Transformation of carriers of electro-magnetic and electronic field of Activities The change of energy carriers (metal, silicon, biological etc.) requires a necessary change of components in electrical part of a system.		
Change of the configuration (voltage level, diameter of a wire etc.) which causes better utilisation of a other form of energy transmission.		

Table 6. interpretation of the sign chain:
ELS(Trns(ChCarr))

10. ELS(Agg(Synth) AND Trns(ChCarr))		
Electromagnetics and Electronics	Aggregation	Synthesis
Electro-magnetic and electronic field of Activities (to attract, to flow, to make a tension, to illuminate, to induce, …) its real components (resistors, transistors, motors, …)	union, conjunction, composition, constitution, compound, assemblage, grouping. From Latin aggregare which is composed of a – grex (flock).	Aggregation with a change of the aggregated components. Aggregation with added value. In context of aggregation it is the composing, arranging. From Greek synthesis (arrange) which is composed of syn- + ti-thémi (put, place), likeness with thema (subject, topic, and theme)

together with	Transformation	ELS Carriers
	transmutation, shift, (qualitative) change From Latin trans = over, throw, in and formare = form, shape, create. From Latin word forme, which arise by anagram from the Greek morfé.	Electrons, other particles, voltage, current, charge.
The synthesis of energy in the ELS field of activities is associated the change of carriers (in this field)		
We use identical electrical elements (components), but we assemble them in another way. It causes a gain of a new functionality of the line-up and utilisation of another energy principle.		

Table 8. interpretation of the sign chain: ELS(Agg(Synth) AND Trns(ChCarr))

5.4. Interpretation of the Composite Sign Chains From chapter five

21. STRUCT(Trns(ChCarr)) AND ELS(Trns(ChCarr))

This sign chain means that in the global arrangement of the system will happen the change of the structure carriers (bonds, atoms, connectors with external space). Concurrently are changed ELS carriers.

22. STRUCT(Trns(ChCarr)) AND TCS(Trns(ChCarr))

The change of structure carriers (atoms, elements, bonds, structure of bonds, integral structural property, e.g., "safety" or "quality", connectors) is associated with the change of carriers of TCS field of activities (walls, bridges, shaped surfaces, vessels, frames).

23. STRUCT(Trns(ChCarr)) AND TCS(Agg(Synth) AND Trns(ChCarr))

This sign chain is similar to that one in the example (22). Moreover - at the field of technological construction occurs the qualitative change of the configuration which go with change of energy carriers. Naturally, if we continue in the previous example, then evidently the change of energy carriers (e.g., from gravitational to pressure) is linked to need make a change at the technological construction. E.g., it is needed the vacuum closure of the cap (to weld it with container, to screw it by flange, etc.).

25. ELS(Trns(ChCarr)) AND TCS(Trns(ChCarr))

This sign chain means that the change of the energy carriers occurs concurrently with the both part of system - technological construction and electrical. It may be for example computational, where is combined with the change of energy carriers (change of amplitude or frequency) make a change at technological constructions (framework, wires etc.), which is important to, e.g., electromagnetic compatibility.

Other example is transmission line, where is, with change of energy carrier, (e.g. transformation to any other voltage level) need make a suitable change of the technological constructions (pylon, their fixing, diameter of wire etc.).

27. ELS(Agg(Synth) AND Trns(ChCarr)) AND TCS(Trns(ChCarr))

One of possible interpretation of the chain is:

"Energy synthesized in the structure of components of a system, is released and transformed (using a change of energy carriers) in activities of Electro-magnetic field. This process is supported by a special technological construction (which enables the change of energy carriers)."

This interpretation anticipates a device with special structure which enables accumulation and gradual transformation of energy (e.g. by changes of dielectric medium (dielectric constants)) from structure into voltage and current.

6. CONCLUSIONS

The development of ontologies is a critical point of contact between informatics and engineering. The goal of this article was to support the development of the effective ontology for computer aided problem solving in conceptual design and redesign of the systems.

The kernel of the paper was concentrated on the construction of the assignment (φ) associating grammatically correct sign chains and their semantic content (eventually the meaning) in the context of the solution of design problems and tasks.

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