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WHAT IS AN INDIVIDUAL CONCEPT?

Bernhard Thalheim (Kiel, Germany)

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Abstract. Concepts are the tools of every discipline, but also of every action and thought. Individual and personal concepts are probably the most difficult and at the same time the least explored of these concepts. We use this article to present an approach that can be used to capture these concepts both syntactically and in terms of usage. We use meta-hyper-networks as a basis for this.

In [31] we have presented a classification of the term "information" following the systematisation approaches of András Benczúr [4] and distinguish syntactic information by means of a form of entropy, semantic information due to the non-derivability of expressions from the existing logical toolbox, pragmatistic information defined by the concept of utility, and last but not least anthropomorphic information based on the need to answer a standing question. We want to turn to the foundation of the conception of the concept and concentrate on individual concepts.

1. Concepts, concepts, concepts, ...

Concepts are a central term in all spheres of life, science, engineering, thought, and action. There are therefore many attempts to define this term more precisely for the respective purpose. For the general approach, one can refer in particular to [6, 21, 23, 32] alongside the many disciplinary, philosophical and everyday life approaches.

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The conception of the “concept” is certainly one of the most overloaded conceptions in Computer Science. At the same time, it is also one of the least thoroughly researched. The enormous diversity and breadth of this concept has always been an obstacle. Mathematics follows a formal approach and therefore has no problem with this conception. Computer science, and Applied Computer Science in particular, is in a very different position here.

We know, for example, individual concepts such as ideas or other mental concepts, conceptual concepts, formal concepts, notions as encyclopedic concepts, linguistic referential terms, constructed concepts, generated concepts, empirical concepts, commonsense concepts, unconscious and preconscious concepts, ontological concepts, disciplinary concepts, and finally model concepts. This list shows the huge variety and we can ask ourselves whether we can find a systematic approach here at all.

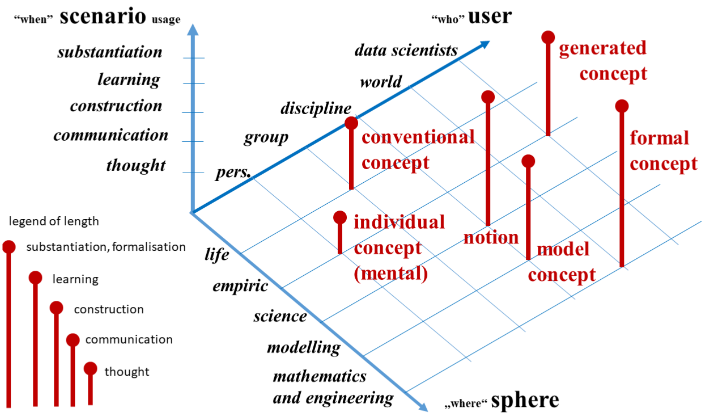

Figure 1. Systematisation of the diversity of terms

The rhetorical framework helps us here. As three main dimensions we consider “who”—“where”—“when”. The first dimension in Figure 1 describes the community of users of concepts. The second dimension describes the scenarios in which concepts are used. The third dimension then describes the application sphere. For example, generated and model concepts are first and foremost constructions, but for different users. Also, individual concepts they tend to be assigned to thinking first. As an encyclopedic background, notions are then transporters of disciplinary knowledge in sciences. We can also assign the other scenarios to the corresponding pillars, so that, for example, a model concept serves both communication and foundation in addition to its main function as a model construct.

The special feature of individual concepts

There is an almost unmanageable amount of literature on the conception of the concept, e.g. [12, 17, 22, 23]. Mostly concepts of a community, a discipline or a common world view of a sufficiently large community are understood, less often communicative concepts and even more rarely personal or better *individual concepts*. As an independent unit of thought, action, knowledge and cognition, *individual knowledge* comprises "the totality of the personal thinking skills that a person has acquired and which they are able to react and articulate for themselves under suitable circumstances" [28]. Concept-based thinking and acting makes very broad use of concepts, both preconscious or unconscious as well as conscious and often articulable.

Concepts can be understood as signs or can also be used communicatively. For the individual, however, they are individual and subjective products and self-contained units of experience, thought, learning, and self-reflection that a person can but not must express in verbal or non-verbal form. Individual concepts are cognitive content-backed structures that a person possesses and can activate. They can only be understood if the explanations of neuronal research (e.g. [10, 13, 14, 25, 26, 29]) are understood as a structuring form of concept formation beyond simplistic neural networks. Some of these neuronal complexes are labeled with a concept.

We want to formalize this approach with a two-step procedure with a language definition for representation of meta-hyper-networks in the first step and a concept assignment in the second step. However, we take into account that this is a special approach. Therefore, we first try to approach the representation of concepts in all due breadth and then to understand an expression as a derivation from this representation. It should be noted that the neural representation of concepts cannot be easily captured with the usual graphical structures such as mindmapping concept maps or graphs, which is why we first consider meta-hyper-networks.

2. Meta-hyper-networks as syntactic structuring background

Here we follow the ideas of modern philosophers and in particular I. Kant [20], who distinguished between *concepts of experience*, *concepts of understanding*, and *concepts of cognition and reasoning* for persons as well. Therefore, we first want to map these concepts structurally with meta-hyper-networks. Before we turn to a definition of meta-hyper-networks, we introduce graphs and hyper-graphs.

- Given a set of labels or structured markers L, e.g. partial property values of dimension m, $m \leq n$ in an n-dimensional property (or feature) space.

We assume that labels are unique for a (hyper-)graph except the empty label λ that is used for cases in which labelling is not essential.

- A *labeled directed graph* $\mathcal{G} = (N, E)$ consists of a finite set of nodes N labelled with markers from L and a labelled subset of $N \times N$ as edges E.
- Graphs can be extended to *hyper-graphs* $\mathcal{H} = (N, H)$ with labeled nodes N and a finite set of labelled hyper-edges H from $\bigcup_{j \geq 1} N^j$ [1], where a hyper-edge can also be a proper subset of another hyper-edge[2].

If we now compare graphs with hyper-graphs, the only difference between them is the Cartesian product and, if applicable, a containment relation of the marked hyper-edges. The question arises as to whether we can also consider graphs whose nodes or edges are themselves graphs. One can also give each hyper-edge an additional designation from a name space. In the simplest case, a network can be a hyper-graph with nodes consisting of hyper-nodes. This means that meta-hyper-graphs can also be defined inductively and the definitions in [3, 16, 30] can be simplified and restricted to a less general case with a simple syntactic structure. For the general introduction of *meta-hyper-networks* we prefer an inductive definition instead of the often used one, because with this definition the structure can be captured more generally.

- Any hyper-graph is a meta-hyper-network of level 1 (basis clause).
- Given meta-hyper-networks $\mathcal{M}_1 = (N_1, H_1), ..., \mathcal{M}_k = (N_m, H_m)$ of level at most i.
  A meta-hyper-network $\mathcal{M}$ at level $(i+1)$ consists of a set of labelled nodes N that is a subset of $\bigcup_{k=1}^{m} \mathcal{M}_k \cup \bigcup_{k=1}^{m} N_k \cup \bigcup_{k=1}^{m} H_k$ and a set of labelled meta-hyper-network edges H from $\bigcup_{j \geq 1} N^j$ (inductive clause).
  We assume that $\mathcal{M} = (N, H)$ cannot be a meta-hyper-network at level i (minimal leveling).
- Nothing is a meta-hyper-networks unless it is constructed from the basis clause and the inductive clause.

Networks also allow edges as node elements. However, we only use this starting from level 2 so that no cyclical structures are created. The difference to networks is the level. The difference to hyper-graphs is the node set, in which both existing nodes and edges are used as well as entire meta-hyper-networks.

[1] N^j denotes the j-ary Cartesian product of N.

[2] The class of hyper-graphs is already very powerful. For instance, concept lattices [11] are essentially hyper-graphs with assignments of property sets as subset from L to considered nodes and the containment relationship as an edge, where for convenience the entire property set is added as a maximum and the empty property set as a minimum.
The concept logic ("Begriffslogik") as a lattice [21] can be defined in an analogous way.

This construction represents a bottom-up alternative to the mostly contracted or top-down definitions and includes all forms known so far to us. In order to represent the human ability to create structures of any depth, we do not limit ourselves to a maximum level. The inductive definition also allows a simple planar representation as we can see in Figure 2. The example in Figure 2 il-

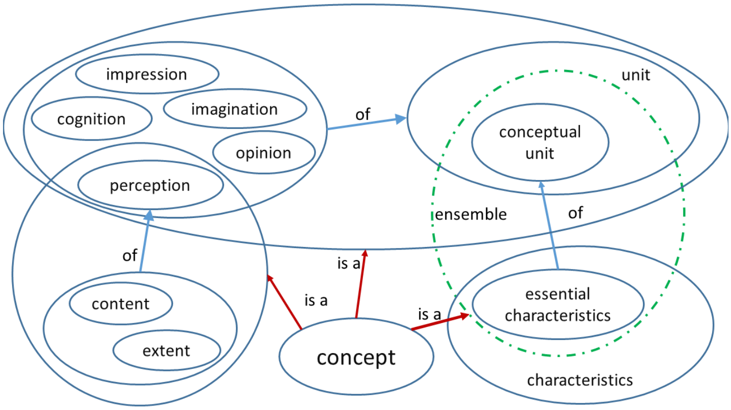

Figure 2. Three definitions of concept as meta-hyper-network of level 3:
(a) an ensemble of essential characteristics of a conceptual unit;
(b) cognition, impression, perception, imagination, and opinion of a unit;
(c) extent and content of a perception.

lustrates three competing definitions of concepts. This shows that (partially) equivalent or competing approaches can also be easily represented. We have also used collections or ensembles to define such a manifold within a term for a concept.

Meta-hyper-networks cover many other concepts. Relational database schemata are represented by hyper-graphs. Simple entity-relationship schemata are meta-hyper-networks of level 2. Extended ER schemata are such networks of any level. To simplify the definitions, we have omitted the integrity constraints that are explicitly specified for the three database schemata. The marking approach can also be used for this. Such a network can also capture complex structures clearly and comprehensibly, such as sentences with nested subsentences of any depth, as was practiced in Ulysses by J. Joyce or novels by T. Mann.

A meta-hyper-network is only a snapshot of the relatively rapid dynamic changes in individual concepts. We can represent the fast neuronal connections and decompositions of the connections by markers on edges and nodes, whereby a weighting can also be represented as in the neuronal process.

Analogously, the context can also be included by markers. If a node is underlaid with experiences or observations, then the experiences are witnesses[3] for the nodes, i.e. a node is underlaid with an *infon*[4] as a triple

$$(context,\ grain,\ witnesses)\ .$$

Grains[5] serve in labelled pointer semantics both as identifiers and references to other nodes for external and injectable incorporation and additionally as an index.

Figure 2 already represents a more complex view of the world, so one wonders how one then arrives at concepts that are communicated. The government and binding approach (e.g. [5, 8]) solves this problem with α and β rules, whereby a reduct is first filtered out of a concept world with α rules and then this reduct is cast into a communication frame with β rules. The reduct is called a (hyper-)*simplex* [7]. The simplex generalizes the view approach of database technology, in which the different alignments and individual perspectives of the respective users and forms of use are supported. With a hyper-simplex, an entire hyper-network can be created as a sheaf or homological algebra in categories resp. topological spaces. Typical such communication frames are the sentence constructions of natural languages, including sophisticated subordinate clause frames, references to other utterances and rephrasing. Application concepts can be filtered in analog form as (intension, extension) frames.

3. Concept arrangement

We assume that individual concepts are formed on the basis of a processing demand as a reaction to current and previous situations that an individuum and specifically a person experiences or has experienced. That means that concepts are based on previous and actual experiences, reprocessing, and knowledge. They are formed with a learned and constantly evolving meta-pattern of impression, imagination, cognition, and perception. Therefore, we can assume an existing and evolving meta-hyper-network $\mathcal{M}$ from which the concepts have been or will be formed intuitively or consciously depending on the requirements.

[3] Witnesses also allow random observations, i.e. generalise prototype or exemplar semantics.

[4] Infons are pieces of information that can be exchanged in a community. Pieces of information are structured data that are useful and meaningful for an agent in a given situation. They are naturally pre-ordered by the relation 'at least as informative as for agent A in a situation S or context ($I \preccurlyeq_{A,S} I'$). This pre-order contains a known-to-all infon $\top$ on one extreme and a minimal unknowable infon $\bot$. The infon algebra and logics has been a subject of our privacy research starting with [2] on the basis of [9, 21] (see https://www.researchgate.net/publication/329251528_Blockchain_09_Infrastructures-_Supporting_Privacy_Collection_of_Papers). We will generalise it for concepts.

[5] Grains are a relatively small annotatable physical or virtual granular particles of a substance that can be used for composition or development of other units.

Depending on the personality of a person, such individual concepts are also formed on the basis of life cases with the corresponding tasks, problems, background and objectives. We can characterize a personality through a profile [27] with the personality, education, and activity profiles. This also includes emotional assessments of current and particularly previous life situations.

Concepts can now be formed from the meta-hyper-network through focusing and association based on an interest and experience. This means that a concept can be understood as a direct node in a network or as a newly formed node in a network $\mathcal{M}$. We can therefore assume the same structuring simplex mechanism as for linguistic utterances. In this case, individual concepts are also made persistent and become indexed for actual use and later reuse, e.g. in form of memes. The experiences are also linked to infons and especially their witnesses. Ideas and opinions can also work without witnesses. It should be noted that individual concepts are not only fixed in the brain via neuronal structures, but are also involved in other neuronal agglomerates such as the human heart "brain" or the emotional system. All this gradually creates a world or system of individual concepts extending the structuring cybernetic approach of J. Piaget [28, 33]. This also brings us to a *second-order cybernetics* of concepts and further activities.

Concepts should be reused so that a special indexing mechanism should still exist. Indexing and referencing in grains does not have to be linguistic, it can also exist figuratively as imagens (e.g. general pictures) beside the logogens (e.g. symbols, icons, indexes) [19, 24]. We can even assume that they are not even linguistic, biolinguistic, or figurative, especially in the case that no communicative concepts as simplex are derived from them in whatever language. We distinguish between concepts and associative structures that do not form a concept themselves. This distinction is supported by the assignment of concepts to nodes. Associative structures then become edges.

It is also necessary to consider individual motoric concepts that cannot be explained either by intuitive and "fast" thinking or by "slow" and well-controlled thinking [18]. Individual concepts can also reflect processes and even evaluations of the success or failure of actions and concept worlds. In the event of success, they are also expanded automatically on the basis of stimuli, harmonisation, resonances, and energy flow, whereby a weighting is introduced in addition to the indexing. In addition, activation is supported depending on individual interest and impulse from an environment. This makes it possible, for example, to understand the intuitive and otherwise almost inexplicable motoric skills of a top soccer player. In addition, such individual concept worlds do not have to be free of contradictions, but should reflect the most diverse and competing perspectives or even daydreams, analogous to a geographical world with islands or peninsulas. The ideas and also the insights do not have to be true, but only plausible and partial concern-oriented and analog abstractions at a point in time in a situation.

Here we concentrate primarily on one *evolutionary* and *cybernetic-adaptive* form of the formation of individual concepts. The use of patterns can be assumed here. Analogous to the formation of simplexes,
a ***concept arrangement scheme*** is used with

(concept construct and annotation, extent, context, functionalization)

as one of the patterns for the formation of individual concepts. For the time being, we assume that the *concept construct* mechanism corresponds to that of simplex formation. The *annotation* can also be expressed as logogens or imagens, but will generally be more of a construction of indexes or a widely usable references. The *extent* is a combination of the infon witnesses associated with the construction of the simplex with a selection based on criteria of relevance, importance, necessity and typicality. The extent can also be empty for abstract thought concepts. The *context* results from the intentions, the situation, the concern and the social environment. The *functionalization* prepares the use of the concepts so that an externalization of the concepts can take place as well as a further use in other concept formations. This also includes functions for quick activation, internalisation, agglomeration, modification, grading, depositing, or archiving.

With the extent and the borrowings from the impressions and the ideas, a *meaning* and a *sense* of these concepts is also implicitly carried along for individual concepts. The meaning can, but does not have to be representable with appropriate (bio)linguistic means. Rather, a cognitive theory of meaning should be applied here (e.g. [15]). Functionalization is actually a preparation for use and must include both structural and operational aspects.

With the infon approach, we can also find a semantic or meaning background within this concept arrangement scheme. Infons are actually connectors to observation semantics. If we allow an empty set of witnesses, then an infon can also represent ideas as abstract basis concepts.

4. Building the space of individual concepts

Every individuum uses a large number of concepts. Effective use also requires efficient management of these concepts. Concepts are persisted in different ways. They can be pushed into the background and only emerge again thanks to an index mechanism. They could probably also be transferred to other neural agglomerates and thus stored and used in a different way than previously considered, e.g. for the intuitive management of situations. Concepts also integrate other concepts. They also rely on other concepts.

So far, there are only a few ideas about the space of individual concepts. We can add a hypothetical variant here that can provide an explanation for some processes, especially as the formation of concepts can also take place outside the brain. It seems that concepts are only formed with cognitive activity. However, the multitude of concepts formed in life also requires effective management. Concepts can also fade into the background, seemingly forgotten, reactivated in response to situations or thought processes. In addition, there are certainly other patterns that can be used to form concepts beside the concept arrangement scheme. The formation of concepts also depends on the social and cultural environment, on activities, external stimuli and observations, intellectual preconditions, preferences, dispositions, incidents, and experiences.

The space of individual concepts does not have to be consistent. It is rather coherent in individual parts and probably resembles a multi-facetted evolving patchwork quilt and a stacked geographical island world with hidden places, different superimposed buildings, and bridges. With every new concept and with every modification or re-evaluation of concepts, this space also changes.

In the following we try to structure and operationalize the concept arrangement scheme, knowing that many other such schemes could exist. An individual is sure to learn further schemes in the course of his or her life, thereby constantly developing his or her neural network and thus also the individual concept spaces. We use and generalise the conceptual logic of R. Kauppi [21] for this purpose.

The simplex mechanism as reduction and abstraction for meta-hyper-networks can be extended for concept spaces. For this purpose, we use a lattice approach with the derivation of properties of node pairs and the introduction of a lattice algebra, which can then be used to calculate further elements of such lattices.

The meta-hyper-network already provides a structure of nodes as a concept and edges as a relationship or association. Special basic nodes are infons. The context-dependent relationships include generalisation and specialisation relationships $A \preccurlyeq B$ as well as similarity relationships $\approxeq$[6] For example, the three views of the conception of a concept in Figure 2 are in a special similarity relationship. Not every node represents a concept. The linking of nodes and concepts is constantly changing and tends to be volatile. Therefore, a combination as a conjunction and a reduction to similarities is not also a concept. The concept space is therefore not a Boolean network, but rather full of holes. This can also be expressed with the relationship $\preccurlyeq$:

Homogeneity of two nodes and concepts: $A \overset{\exists}{\Cap} B := \exists X (A \succcurlyeq X \land B \succcurlyeq X)$

Compatibility of two nodes and concepts: $A \overset{\exists}{\Cup} B := \exists X (X \succcurlyeq A \land X \succcurlyeq B)$

[6]Generalisation, specialisation and as well similarity go beyond the traditional approach. Human logic and the handling of individual concepts cannot be grasped with the axiomatics of deductive systems. Induction, abduction, plausible and approximate reasoning and others must be added.

We assume here that X is a node of the meta-hyper-network $\mathcal{M}$. These two relationships can also be developed into negative relationships:

Inhomogeneity of two nodes and concepts: $A \overset{\exists}{\not\Cap} B := \neg\exists X(A \succcurlyeq X \wedge B \succcurlyeq X)$.

Incompatibility of two nodes and concepts: $A \overset{\exists}{\not\Cup} B := \neg\exists X(X \succcurlyeq A \wedge X \succcurlyeq B)$.

Further derived relationships would then be the following, whereby all these relationships would only be considered within a specific context:

divergency $\curlyvee := \overset{\exists}{\Cap} \wedge \overset{\exists}{\not\Cup}$ as splitting concepts,

isolation $\leftrightsquigarrow := \overset{\exists}{\not\Cap} \wedge \overset{\exists}{\not\Cup}$ as separatable concepts,

potential homogenisability $\between := \overset{\exists}{\Cap} \wedge \overset{\exists}{\Cup} \wedge \not\succcurlyeq \wedge \not\preccurlyeq$ as potential concept, and

heterogeneity $\curlywedge := \overset{\exists}{\Cup} \wedge \overset{\exists}{\not\Cap}$ as concept alternatives.

We can therefore also use minimality and maximality as axioms in a concept space within a context:

$$\vdash A \overset{\exists}{\Cap} B \leftrightarrow \exists X \forall Y (X \succcurlyeq Y \rightarrow (A \succcurlyeq Y \wedge B \succcurlyeq Y))$$

$$\vdash A \overset{\exists}{\Cup} B \leftrightarrow \exists X \forall Y (X \preccurlyeq Y \rightarrow (A \preccurlyeq Y \wedge B \preccurlyeq Y))$$

With this approach, we can also introduce an operationalisation for the concept space, which can also be imagined as an electrical or chemical connection of neuronal elements. As a further theoretical simplification, we introduce a conscious negation for an entire concept space, so that the "I don't know yet" can be represented with it. The corresponding algebra would then be a term algebra of expressions with these operations.

Product: $C = A \boxdot B \ := \ \forall Y (C \succcurlyeq Y \leftrightarrow (A \succcurlyeq Y \wedge B \succcurlyeq Y)))$

Sum: $C = A \boxplus B \ := \ \forall Y (C \preccurlyeq Y \leftrightarrow (A \preccurlyeq Y \wedge B \preccurlyeq Y))$

Negation: $B = \bar{A} \ := \ \forall X (X \succcurlyeq B \leftrightarrow X \overset{\exists}{\not\Cup} A)$

Difference: $C = A \boxminus B \ := \ \forall X (C \succcurlyeq X \leftrightarrow (A \succcurlyeq X \leftrightarrow B \overset{\exists}{\not\Cup} X))$

Quotient: $C = A \oslash B \ := \ \forall X (C \succcurlyeq X \leftrightarrow (A \succcurlyeq X \wedge B \overset{\exists}{\not\Cup} X))$

With such and certainly other operations we can now form reducts, so that a space of communication and interaction concepts can be derived from the individual concept space.

Further axioms would then be added, such as:

$$Ax_{\boxdot} \ \vdash \ A \overset{\exists}{\Cap} B \ \rightarrow \ \exists X (X = A \boxdot B)$$

$$Ax_{\boxplus} \ \vdash \ A \overset{\exists}{\Cup} B \ \rightarrow \ \exists X (X = A \boxplus B)$$

$$
\begin{aligned}
Ax_{Distrib} \vdash \; & ((A \boxdot B) \boxplus (A \boxdot C) \succcurlyeq A \boxdot (B \boxplus C)) \quad \wedge \\
& (A \boxplus (B \boxdot C) \succcurlyeq (A \boxdot B) \boxplus (A \boxdot C))
\end{aligned}
$$

$$
Ax_{-} \vdash \; \exists X (X \overset{\exists}{\not\Cup} A) \rightarrow \exists X (X = \bar{A})
$$

We have omitted the special context dependency here for the time being. Operators as meta-generalisations and for the abstraction of a cut-out of the space of individual concepts have also been neglected for the time being. However, they can be defined analogously, whereby we should consider a number of different forms of abstraction.

With such an algebra, we can also prepare the space of individual concepts for a calculation with macro operations. For this purpose, we will treat this space as an "thinging machine" by S. Al-Fedaghi [1]. There are many macro-operations for such a space. The following four operations in the Kantian approach [20] are the central ones:

Arrive: An observation or idea arrives to a concept space and results in an interpreted experience and imagination, i.e. becomes an individual concept of experience and impression.

Internalise: Individual concepts of experience are accepted, integrated with others, and made persistent and indexed in a concept space, i.e. become individual concepts of understanding.

Process: A collection of existing individual concepts are processed, handled, examined, and modified in order to be represented as individual perception and comprehension, i.e. it becomes then an individual concept of cognition and reasoning.

Externalise: A cut-out of individual concepts are processed for interaction and especially for communication. They are going to be used outside the space of individual concepts, i.e. they are used as a simplex-based concepts for interaction and communication.

5. Final remarks and summary

In this paper, we attempted to present an approach to the definition of individual concepts that goes beyond structuralism and functionalism. Our approach is based on the physical existence of concept networks and thus meta-hyper-networks. On such networks, concept networks are distilled abstractly and made accessible via indexing or referencing. To master these abstraction processes, concept arrangement schemata in particular can be conveniently used on the basis of tried and tested abstraction patterns. These patterns are constantly reviewed and expanded or replaced by better patterns.

We have refrained from taking a detailed look at examples here and have only presented the general theoretical basis, as this goes beyond the scope of a publication and is better presented in detail in a monograph, e.g. on modelology on the science and art of models and modelling.

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B. Thalheim
Prof. Dr. habil. em.
Christian-Albrechts University at Kiel
Kiel
Germany
bernhard.thalheim@email.uni-kiel.de