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One approach to the classification of business knowledge diagrams: practical view

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Abstract—**Diagrams are an effective and popular tool for visual knowledge structuring. Managers also often use them to acquire and transfer business knowledge. There are many currently available diagrams or visual modeling languages for managerial needs, unfortunately the choice between them is frequently error-prone and inconsistent. This situation raises the next questions. What diagrams/ visual modeling languages are the most suitable for the specific type of business content? What domain-specific diagrams are the most suitable for the visualization of the particular elements of organizational ontology? In order to provide the answers, the paper suggests light-weight specification of diagrams and knowledge content types, which is based on the competency questions and ontology design patterns. The proposed approach provides the classification of qualitative business diagrams.**

I. Introduction

KNOWLEDGE visualization proved to be an effective tool for knowledge creation, acquisition and transfer [5, 6, 13]. Diagrams [2] constitute the basis for visual knowledge representation and elaborated diagrammatic techniques typically form visual modeling languages [17]. In computer science these techniques are reflected in such languages as UML and IDEF. They are also integrated in software engineering methods, e.g. the Structured Analysis and Design Technique (SADT) and are organized by the architecture frameworks, such as the Zachman framework [28].

The focus of this paper is put on the realm of management. Manager also frequently use diagrams in their work [11, 18, 25] but the choice of diagrams is often error-prone and inconsistent [7].

For the effective choice of the visualization method, at least five perspectives should be considered [6]. These perspectives answer five key questions with regard to visualizing knowledge, namely:

1. What type of knowledge is visualized (content)?
2. Why should that knowledge be visualized (purpose, knowledge management process)?
3. For whom is the knowledge visualized (target group)?
4. In which context should it be visualized (communicative situation: participants, place/media)?
5. How can the knowledge be represented (method, format)?

The knowledge type perspective as the focus of the paper, can be used for identifying the type of knowledge with respect to its content. Any complex entity can be represented from several aspects (facets) and at different strata (layers) [13, 28]. The following question-based aspects can be proposed and differentiated [1, 6, 13, 28]:

WHAT-Knowledge: Conceptual representation.
WHAT_FOR-Knowledge: Strategic representation.
HOW_TO-Knowledge: Functional representation.
WHO-Knowledge: Organisational representation.
WHERE-Knowledge: Spatial representation.
WHEN-Knowledge: Temporal representation.
WHY-Knowledge: Causal representation.

Today, there is no validated prescriptive framework that links business diagrams with knowledge types and that offers specific diagram for particular knowledge types. This issue defines the first research question*: What diagrams/ visual modeling languages are the most suitable for the specific type of knowledge (content)?*

The second research question of the paper stems from the task of ontology visualization within different applications. Ontology is a formal, explicit specification of a shared conceptualization. Ontologies and corresponding semantic technologies are actively used for knowledge management, e-commerce, education and semantic web. Currently, each concept of ontology is represented with the same graphical representation independently of its meaning. Graphical representations of ontologies are concerned with the representation of concepts, relations or instances but do not consider a domain specific meaning [21]. Special ontology-based frameworks are developed in order to visualize ontology using domain-specific notations [20, 22, 26]. Some of these frameworks are oriented towards managers and must include knowledge of the currently available popular business diagrams/visual modeling languages with the associated semantics. It defines the second research question: *What diagrams/ visual modeling languages are the most suitable for the visualization of the particular ontology view (elements of ontology)?*

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II. Related work

Periodic table of visualization methods [23] provides a good top-level diagrams overview for managers. These authors decided that the classification dimensions should be easy to use and have some proven benefits. The organization principles were related to the situation in which the visualization is used (when?), the type of content that is represented (what?) the expected visualization benefits (why?), and the actual visualization format used (how?). As a result, the following five dimensions were suggested:

• *Complexity of Visualization:* Low to High, referring to the number of rules applied for use and/or the number of interdependences of the elements to be visualized.

• *Main Application or Content Area [how?,what?]:* Data, Information, Concept, Metaphor, Strategy, Compound Knowledge.

• *Point of View [when?]:* Detail (highlighting individual Items), Overview (big picture), Detail and Overview (both at the same time).

• *Type of Thinking Aid [why?]:* Convergent (reducing complexity) vs. Divergent (adding complexity).

• *Type of Representation [what?]:* Process (stepwise cyclical in time and/or continuous sequential), Structure (i.e., hierarchy or causal networks)

The authors organized these dimensions in the specific table of visualization methods. But we may conclude that while it is a very impressive result the values for these dimensions are rather general, overlapping and are specified insufficiently.

Lohse et al. [24] reported a structural classification of visual representations. These authors identified 11 major clusters of visual representations: graphs, tables, graphical tables; time charts; networks; structure diagrams; process diagrams; maps; cartograms; icons; pictures. Criteria for classification were represented using 10 anchor-point phrases: spacial-nonspacial; temporal-nontemporal; hard to understand-easy to understand; concrete-abstract; continuous-discrete; attractive-unattractive; emphasize whole-emphasizes parts; numeric-nonnumeric; static structure-dynamic process; convey a lot of information-convey little information. We may conclude that this classification mostly works with structural dimension. Semantic dimension of diagrams is not covered.

Some of the diagramming tools provide its own classifications of the templates. Visio 2010 (http://office.microsoft.com/en-us/visio/) provides the following 8 embedded categories: Business; Engineering; Flowchart; General; Maps and floor plans; Network; Schedule; Software and Database. Visio 2010 Online library (http://visiotoolbox.com/2010/templates.aspx): Application Architecture; Asset Management; Business Analysis; Business; Capacity Planning; Database Planning; Educational; Facilities; Financial; Human Resource templates et al. 25 categories totally. Smart Draw (http://www.smartdraw.-com/): Charts: Flowcharts, Project, Org; Education; Engineering; Forms; Mind Maps; Presentations; Timelines; Decision Trees; Cause & Effect Diagrams; Marketing Charts; Strategy & Planning et al. 29 categories totally. Our general conclusion is that Visio embedded categories do not cover all the knowledge types and have rather inconsistent classification criteria. Smart Draw categories are extremely overlapping, have different level of abstraction and also use inconsistent classification criteria.

Also there exist several enterprise architecture based classifications, e.g. Archimate [19], MEMO [10], IBM Enterprise framework or populated Zachman Framework (http://publib.boulder.ibm.com/infocenter/rsysarch/v11/topic/com.ibm.sa.bpr.doc/topics/r_IBM_Enterprise_fmwk.html). But these classifications and frameworks do not include all the types of diagrams used by managers and in general such taxonomies cover mostly IT-oriented diagrams and proprietary diagrams.

We also would like to mention some independent conceptual specifications for the popular business diagrams / visual languages [3, 14]. Unfortunately these descriptions do not involve all the popular business diagrams / visual languages. Also the existing specifications mostly incorporate the area of business processes, while the other areas are insufficiently specified.

III. Methodology And Results

We suggest to use ontology-based specifications for knowledge types and diagrams/visual modeling languages. Alignment between these two specifications will enable managers to choose diagrams for the particular knowledge type. Additionally it will provide opportunity to select the diagram for the specific competency question and for the visualization of the particular ontology view (elements of ontology).

In order to describe informally the knowledge types and to take a step towards the ontology-based specification we suggest to use competency questions technique [16].

Ontology-based knowledge types specification consists of a set of Ontology Design Patterns (ODP) [12]. ODP — a modeling solution to solve a recurrent ontology design problem. It is a template that represents a schema for specific design solutions. An ODP consists of a set of “prototypical” ontology entities that constitute the “abstract form” of a pattern, and of a set of metadata about its use cases, motivations, provenance, the pros and cons of its application, the links to other patterns, etc. Design solutions based on ODPs encode ontology entities that apply, specialize, or instantiate the prototypical entities defined by the schema. Some of the popular ready-made ODPs are represented at http://ontologydesignpatterns.org/. The other ODPs can be extracted from enterprise-related ontologies [4, 9, 27].

The suggested ideas are integrated in the method of business knowledge diagrams classification (Table 1).

Ontology-based diagram specification is based on the ideas of [15], but we suggest to use “light-weight” ontology-based specifications. They do not require the complete ontological model for every diagram, but conceptualize just the core elements of each diagram. The incompleteness of the specifications is justified by the purpose of the specification — the classification and the choice of modeling language.

Alignment between the two ontology-based specifications can be provided by means of ontology mapping/matching techniques and tools [8].

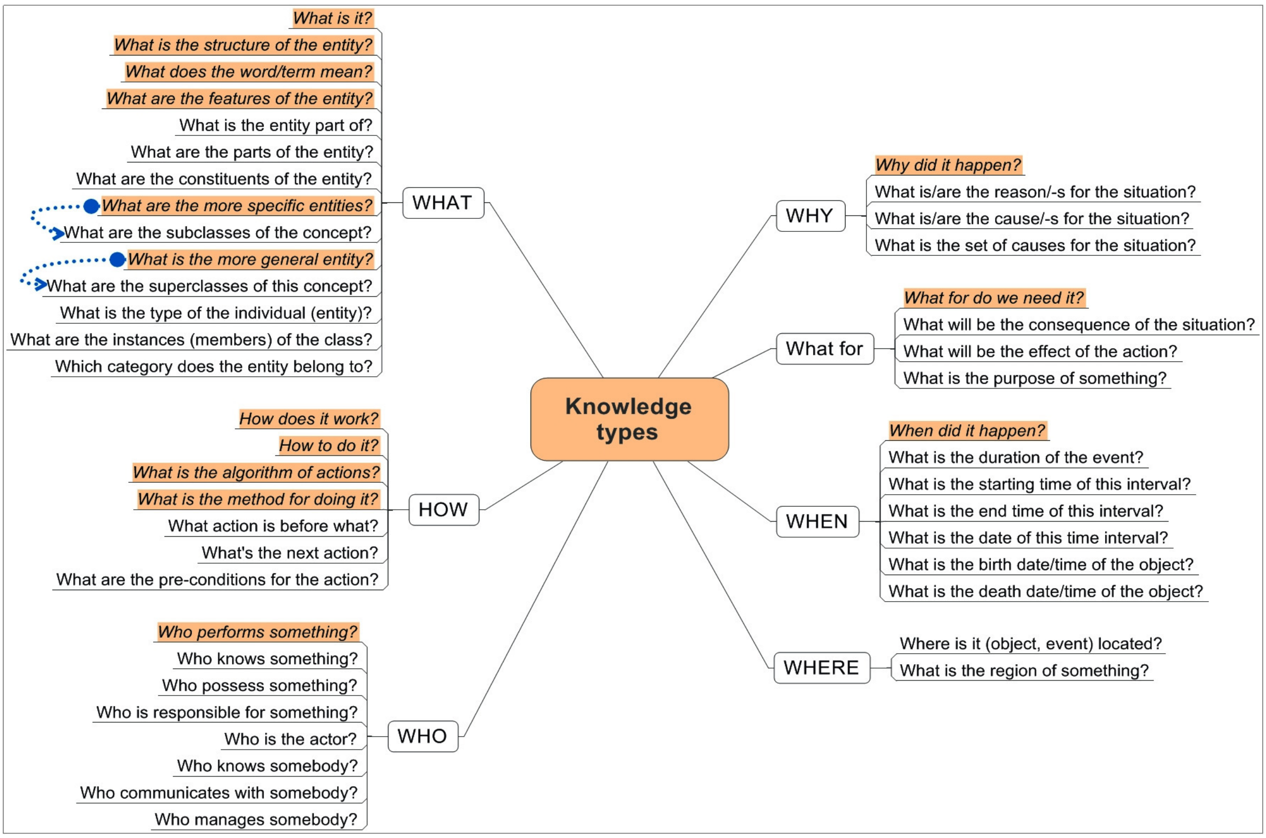
IV. Usage Scenarios

We can introduce three possible scenarios of results usage.

Scenario A (answering the first research question). The user choose the diagrams based on the competency ques-

Table I.
Method of business knowledge diagrams classification

№	Steps	Results
1	Define and describe the knowledge types using competency questions.	Informal description of the knowledge types is represented in Fig. 1.
2	Specify the chosen knowledge types using ODPs — each type of knowledge answering the concrete managerial question may be specified by ontology patterns	ODP specification of knowledge types is based on the Content ODP annotation schema and include the following elements: Pattern name, Intent, Competency questions, Diagram, Elements and examples, Source, Reusable OWL file, Submitted by. The incomplete list of the ODPs for several knowledge types can be found in Table II. Table III shows an example of the ODP specification. Knowledge types descriptions in terms of concepts and relationships can be developed based on the ODP specifications — see Fig. 2.
3	Identify diagrams, which will potentially correspond to the suggested knowledge types, e.g. from Visio, SmartDraw, [23] and provide ontology-based specifications of these diagrams.	Ontology-based specification of diagrams include: diagram name, thumbnail, brief description/purpose, Conceptual model (classes and properties), Conceptual model diagram. Table IV shows an example of the diagram specification.
4	Align ontology-based specifications of knowledge types and diagrams. The alignment is provided using the ontology-based specifications (see steps 2 and 3).	Example alignment between ontology-based specifications of knowledge type and diagram is shown in Table V.
5	Classify diagrams according to knowledge types based on the ODP alignment (from step 4).	The above-proposed approach helps us to work out the classification which may be useful for the practitioners in selecting the appropriate type of business diagram (Fig. 3).



**non-specific competency questions are highlighted (won't be directly relate to ODPs)*

Fig. 1. Knowledge types description using competency questions

tions only. If the competency question is non-specific ("voice of the customer") and doesn't directly relates to ODPs, then he/she selects all the diagrams associated with the knowledge type (which is associated with the chosen competency question. The choice among the suggested diagrams is based on the supported ODPs.

Scenario B (answer for the first research question). The advanced user may choose the diagrams using ODPs and the competency questions can be used for preliminary filtering.

Scenario C (answer for the second research question). The user or service wants to represent his/her ontology or ontology view using domain-specific visual language. Then

TABLE II.
THE LIST OF THE ODPS FOR THE KNOWLEDGE TYPES (INCOMPLETE)

Knowledge type	Ontology Design Patterns
WHAT-knowledge	"Part of", "Classification" *
	"Subclass", "Type" **
HOW-knowledge	"Action sequence" (Action + Sequence), "Controlflow" *, "Action pre-condition" (Source: [27])
WHO-knowledge	"Role-task", "AgentRole" *
WHAT-FOR-knowledge	"Help achieve" ODP (Source: [27])
WHEN-knowledge	"TimeInterval", "TimeIndexedSituation" *
WHERE-knowledge	"Place" *

Sources: * - http://ontologydesignpatterns.org/,
** - http://www.w3.org/TR/2004/REC-owl-features-20040210/

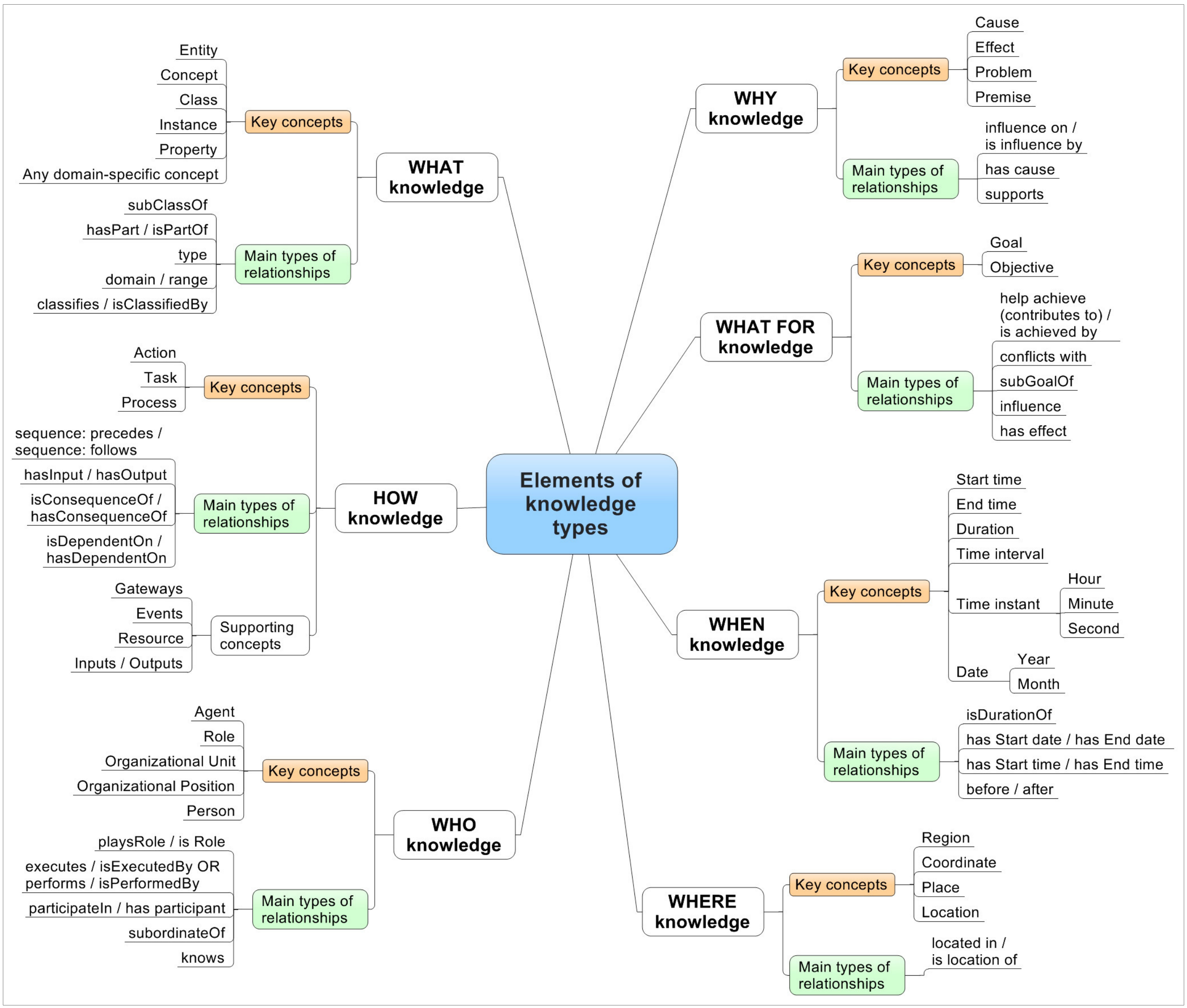


Fig. 2. The list of concepts and relationships for the knowledge types

is

TABLE III.
EXAMPLE ODP SPECIFICATION: "PART OF" ODP

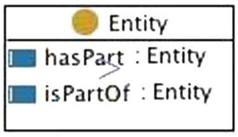
Pattern name: PART OF	
Intent: To represents entities and their parts	
Competency questions: What is this entity part of? What are the parts of this entity?	
Diagram: 	Elements and examples: *Entity* (owl:Class) Anything: real, possible, or imaginary, which some modeller wants to talk about for some purpose. *hasPart* (owl:ObjectProperty) A transitive relation expressing parthood between any entities, e.g. the human body has a brain as part. *isPartOf* (owl:ObjectProperty) A transitive relation expressing parthood between any entities, e.g. brain is a part of the human body. Example: Brain and heart are parts of the human body
Source: http://ontologydesignpatterns.org/wiki/Submissions:PartOf	
Reusable OWL file: http://www.ontologydesignpatterns.org/cp/owl/partof.owl	
Submitted by: ValentinaPresutti	

TABLE IV.
EXAMPLE DIAGRAM SPECIFICATION: ORGANIZATIONAL CHART

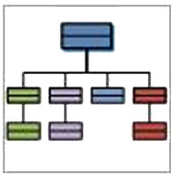
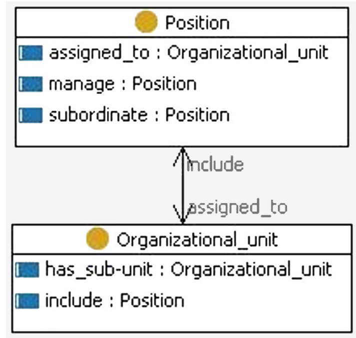
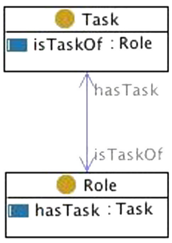
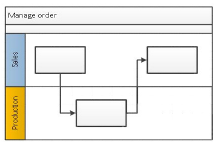
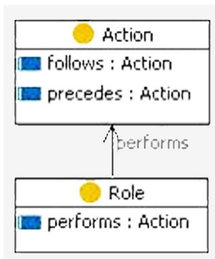
Name, Thumbnail	**Definition**	**Conceptual model**	
		Core elements	**Diagram**
Organizational chart 	A diagram that shows the structure of an organization and the relationships and relative ranks of its parts and positions/jobs.	Organizational unit, Position, Manage (EO) / subordinate relations, include/ assigned to has sub-unit	

TABLE V.
EXAMPLE ALIGNMENT BETWEEN WHO-KNOWLEDGE AND SWIM-LANE DIAGRAM SPECIFICATIONS

Knowledge type	**Competency question/-s**	**ODP**	**Diagram**	**Conceptual model**
WHO	Who performs smth? (informal) What roles are this task (action) of?	"Role task" ODP 	Swim-lane diagram 	

user aligns ontology which must be represented, with ontology-based descriptions of diagrams and then selects the appropriate diagrams for the ontology or ontology view based on the alignment.

V. DISCUSSION AND CONCLUSION

The main novelty of our approach is the mapping between knowledge types and popular business diagram types, which grounded on ontological specifications. Such the mapping together with the suggested informal descriptions of knowledge types can support managers, while working with visual models. Our novel classification is only the attempt as the list of diagrams for knowledge types is incomplete. Creation of the extended catalogue/repository for diagrams should be a collaborative effort. The suggested method of business knowledge diagrams classification can be used within this effort. ODP–based diagram classification method is also a

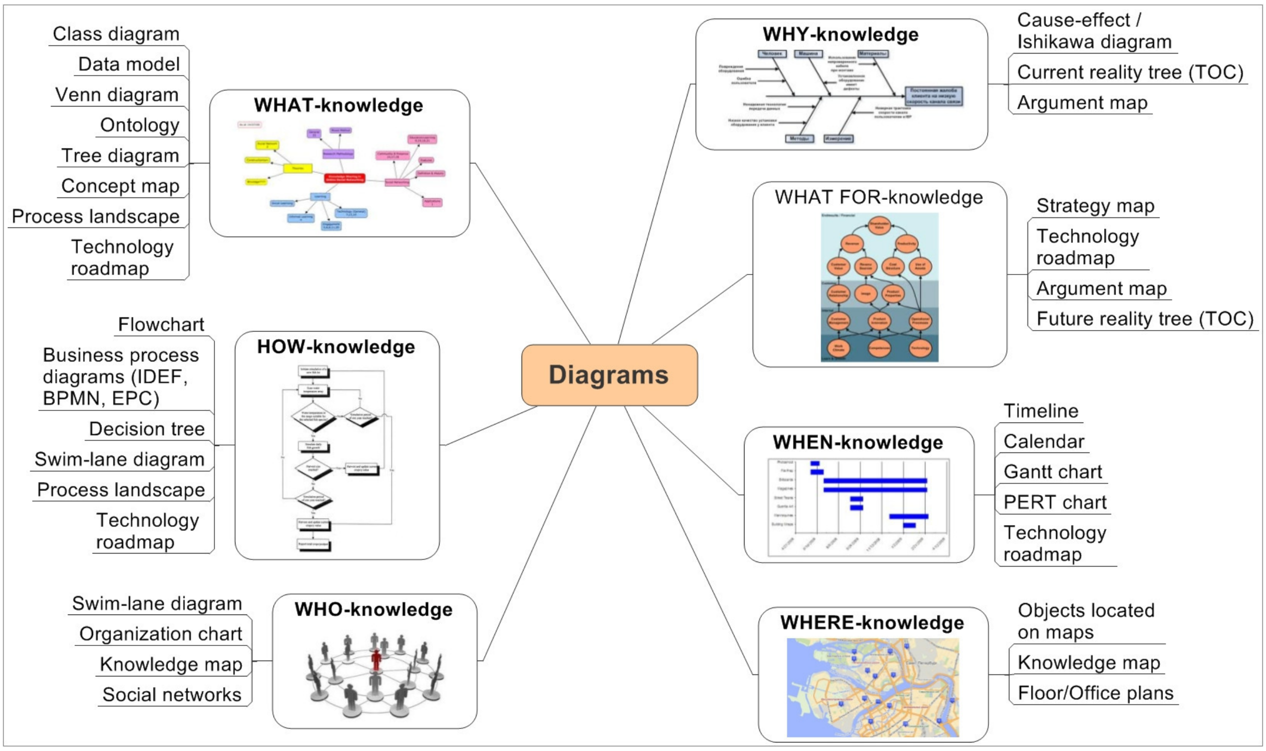


Fig. 3. Diagrams vs. knowledge types

contribution of the paper. Thesaurus based descriptions (synonyms) for ODPs and ontology-based diagram specifications can be a useful appendix (see WordNet). The suggested diagrams can be typically considered as diagram types, which may have a lot of variations and particular notations. We've tried to extract the most generic or prototypical inherent elements of diagram / visual modeling language. Additionally, informal description of knowledge types provides new classification the existing ODPs.

Such pattern-based approach can be considered as the first step towards ontologically founded usage of diagrams among managers. Business diagrams are typically describes some components of enterprise architecture. So according to the "Maturity Model" for Enterprise Architecture Representations [29] adhoc visual models of enterprise architecture correspond to the 1st level of maturity. This approach to enterprise architecture, though a natural, common and easy place to start, does not scale well. Any sizeable organization generally has more than one person or a single group doing enterprise. The ultimate goal is the design of a consistent organizational ontology or ontology network behind a collection of diagrams. This will allow organizations to have ontology-based knowledge repository with consistent domain-specific visual views.

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