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)?

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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)?
II. RELATED WORK

Periodic table of visualization methods [23] provides a
good top-level diagrams overview for managers. These au-
thors 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 visual-
ization is used (when?), the type of content that is repre-
sented (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 in-
terdependences of the elements to be visualized.

• **Main Application or Content Area [how?, what?]**: Data, In-
formation, 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 ta-
ble of visualization methods. But we may conclude that
while it is a very impressive result the values for these di-
simensions are rather general, overlapping and are specified
insufficiently.

Lohse et al. [24] reported a structural classification of vis-
ual representations. These authors identified 11 major clus-
ters of visual representations: graphs, tables, graphical ta-
bles; time charts; networks; structure diagrams; process dia-
agrams; maps; cartograms; icons; pictures. Criteria for classi-
ification were represented using 10 anchor-point phrases:
spacial-nonspacial; temporal-nontemporal; hard to under-
stand-easy to understand; concrete-abstract; continuous-dis-
crete; attractive-unattractive; emphasize whole-emphasizes
parts; numeric-nonnumeric; static structure-dynamic
process; convey a lot of information-convey little informa-
tion. 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 classifica-
tions of the templates. Visio 2010 (http://office.microsoft.com/en-us/visio/) provides the fol-
lowing 8 embedded categories: Business; Engineering;
Flowchart; General; Maps and Floor plans; Network; Sched-
ule; Software and Database. Visio 2010 Online library
Architecture; Asset Management; Business Analysis; Busi-
ness; 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; Engi-
neering; Forms; Mind Maps; Presentations; Timelines; Deci-
sion 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 classifi-
cation criteria. Smart Draw categories are extremely over-
lapping, have different level of abstraction and also use in-
consistent classification criteria.

Also there exist several enterprise architecture based clas-
sifications, e.g. Archimate [19], MEMO [10], IBM Enter-
prise 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 propri-
etary diagrams.

We also would like to mention some independent concep-
tual 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 insuffi-
ciently 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 vi-
sualization of the particular ontology view (elements of on-
tology).

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 prob-
lem. It is a template that represents a schema for specific de-
sign solutions. An ODP consists of a set of “prototypical”
ontology entities that constitute the “abstract form” of a pat-
tern, and of a set of metadata about its use cases, motiva-
tions, 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://ontolo-
gydesignpatterns.org/. The other ODPs can be extracted
from enterprise-related ontologies [4, 9, 27].

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

Ontology-based diagram specification is based on the
ideas of [15], but we suggest to use “light-weight” ontol-
ogy-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 specifi-
cation — the classification and the choice of modeling lan-
guage.
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 chooses the diagrams based on the competency ques-

<table>
<thead>
<tr>
<th>№</th>
<th>Steps</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Define and describe the knowledge types using competency questions.</td>
<td>Informal description of the knowledge types is represented in Fig. 1.</td>
</tr>
<tr>
<td>2</td>
<td>Specify the chosen knowledge types using ODPs — each type of knowledge answering the concrete managerial question may be specified by ontology patterns</td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Align ontology-based specifications of knowledge types and diagrams. The alignment is provided using the ontology-based specifications (see steps 2 and 3).</td>
<td>Example alignment between ontology-based specifications of knowledge type and diagram is shown in Table V.</td>
</tr>
<tr>
<td>5</td>
<td>Classify diagrams according to knowledge types based on the ODP alignment (from step 4).</td>
<td>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).</td>
</tr>
</tbody>
</table>

![Knowledge types description using competency questions](image)

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

<table>
<thead>
<tr>
<th>Knowledge type</th>
<th>Ontology Design Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHAT-knowledge</td>
<td>“Part of”, “Classification” *</td>
</tr>
<tr>
<td></td>
<td>“Subclass”, “Type” **</td>
</tr>
<tr>
<td>HOW-knowledge</td>
<td>“Action sequence” (Action + Sequence), “Controlflow” *, “Action pre-condition” (Source: [27])</td>
</tr>
<tr>
<td>WHO-knowledge</td>
<td>“Role-task”, “AgentRole” *</td>
</tr>
<tr>
<td>WHAT-FOR-knowledge</td>
<td>“Help achieve” ODPS (Source: [27])</td>
</tr>
<tr>
<td>WHEN-knowledge</td>
<td>“TimeInterval”, “TimeIndexedSituation” *</td>
</tr>
<tr>
<td>WHERE-knowledge</td>
<td>“Place” *</td>
</tr>
</tbody>
</table>


Fig. 2. The list of concepts and relationships for the knowledge types
TABLE III.
EXAMPLE ODP SPECIFICATION: “PART OF” ODP

<table>
<thead>
<tr>
<th>Pattern name: PART OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent: To represents entities and their parts.</td>
</tr>
<tr>
<td>Competency questions: What is this entity part of? What are the parts of this entity?</td>
</tr>
</tbody>
</table>

Diagram:

- **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.


Reusable OWL file: [http://www.ontologydesignpatterns.org/cp/owl/partof.owl](http://www.ontologydesignpatterns.org/cp/owl/partof.owl)

Submitted by: Valentina Presutti

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TABLE IV.
EXAMPLE DIAGRAM SPECIFICATION: ORGANIZATIONAL CHART

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

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

<table>
<thead>
<tr>
<th>Knowledge type</th>
<th>Competency question/s</th>
<th>ODP</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO</td>
<td>Who performs what? (informal) What roles are this task (action) of?</td>
<td>“Role task” ODP</td>
<td>Swim-lane diagram</td>
</tr>
</tbody>
</table>

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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
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 or organizational ontology or ontology network behind a collection of diagrams. This will allow organizations to have ontology-based knowledge repositories with consistent domain-specific visual views.

REFERENCES


Fig. 3. Diagrams vs. knowledge types


