On the Ontological Foundation of Conceptual Modelling

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• Questions raised by Wyssusek & ter Hofstede
• Bunge–Wand–Weber (BWW) propositions
• Mario Bunge's ontology
• The sign character of models
• Ontological assumptions (The FRISCO ontology)
• Discussion
Questions raised by Wyssusek & ter Hofstede

Questions / Discussion theses (Wyssusek & ter Hofstede)

• Ontological foundation of conceptual modelling – what does it mean and is it possible at all? (general discussion)

• Does the BWW Ontology provide a good and helpful foundation? (general discussion)

• Is the BWW Ontology based criticism on so-called "optional properties" justified? (special discussion)
Ontology vs. Conceptual Modeling
(foll. Wyssusek & ter Hofstede)

- **Ontology**\(^{(a)}\):
  a *philosophical discipline*, concerned with the study of “what exists” and of “what it means for something to exist”.

- **Ontology**\(^{(b)}\):
  a particular *ontological theory* that explains “what exists” and “what it means for something to exist”.

- **Ontology**\(^{(c)}\):
  “a *specification* of a *conceptualization*” (Gruber 1993).

- **Conceptual Modeling**:
  creation of a *representation* of a matter of interest in terms of *concepts* (and *relationships* between them).
## Ontologies vs. conceptual models

<table>
<thead>
<tr>
<th>Conceptual models</th>
<th>Ontologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• refer to <strong>one specific</strong> application project (or a few related ones)</td>
<td>• refer to an encompassing application domain (shared by many projects and applications)</td>
</tr>
<tr>
<td>• address mainly developers of <strong>one</strong> (or maybe few neighbour) project(s)</td>
<td>• address <strong>all involved people</strong> in one application domain</td>
</tr>
<tr>
<td>• can be <strong>changed</strong> according to project requirements</td>
<td>• rely on ontological <strong>commitment</strong> of heterogeneous groups</td>
</tr>
<tr>
<td>• maintain consistency and data integrity within <strong>one</strong> particular implementation</td>
<td>• control and standardise conceptualisation and terminology for many implementations</td>
</tr>
<tr>
<td>• should be extensible for <strong>related projects</strong></td>
<td>• must be <strong>open for extensions</strong> by not yet known projects</td>
</tr>
<tr>
<td>• are in the responsibility of <strong>one</strong> (or a few) modeller(s)</td>
<td>• are shared by <strong>many domain experts</strong> and developers of <strong>many projects</strong>, incl. forthcoming ones</td>
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</table>
Conceptual Modeling and Ontology

The standard line of reasoning:

1. The quality of conceptual models is hard to determine, since a theoretical foundation of conceptual modeling is missing.
2. Ontology\(^{(a)}\) provides us with the most fundamental, i.e., the most general knowledge about the (real) world.
3. Knowledge is mentally represented in the form of concepts.
4. Ontology\(^{(b)}\) is thus a source for the most fundamental, i.e., the most general concepts to be used in conceptual modeling.
5. Ontologically sound conceptual models provide us with representations that are faithful to the (real) world – which means that the conceptual models are of good quality.

Ontology\(^{(a)}\) – a philosophical discipline
Ontology\(^{(b)}\) – a particular ontological theory
Bunge–Wand–Weber (BWW) propositions

• An *Information System* is an artificial representation of a real-world system as perceived by humans. …

• *Information Systems development* is a transformation from some perceptions of the real world into an implementation of a representation of these perceptions.

• The world is viewed as made of things, or *objects*, that have *properties* by which they are known. A thing is modelled by a *functional schema* - a set of functions that assign values to properties. A possible combination of property values comprises a *state* of the thing. …

  .. This observation has led us to conclude that the formalisation of information systems concepts could be based on a theory of *representation of reality*. We turned, therefore, to *Mario Bunge's ontology* in order to obtain the formal foundation for modelling information systems. … [W-W 90a]

• An Information System will be said to be a *representation* of a real system if the Information System traverses the sequence of states $m_1, .. m_n$, such that $m_i = \text{rep} (s_i)$ when the real system traverses the sequence of states $s_1, .. s_n$. [W-W 88]
Implicit assumptions and consequences

• The real world can be *perceived* by humans and *represented* by Information Systems.

• Bunge's ontology is a summary of a certain philosophical world view comprising terms like *system*, *thing*, *substantial individual*, *composite and simple thing*, *property*, *state*, *event*, *interaction*, *environment* etc.

• *Conceptual models* are defined and structured according to the perceived given facts and structures of the "real world".

• BWW argue from a *realists'* point of view: Things "*are* there", "*possess* properties, states etc." and have just to be *perceived* and "*mapped*" to artificial models and representations which "*correspond*" to their originals in a homomorphic way.

  • Alternative positions are more careful: We cannot know what the real world is and how it is structured, how things are limited and structured, what are their inherent properties, states etc. All these are *attributions* of human observers.
The Bunge–Wand–Weber Ontology

Some of the so-called “ontological constructs” constituting the BWW ontology:

- **Thing**: The real-world is made up of things.
- **Property**: Things possess properties.
- **State**: A possible combination of property values of a thing.
- **Event**: A change of state of a thing.
- **System**: A thing that comprises a set of interacting things.
- **Class**: A set of things that possess a common property.
- **Kind**: A set of things that possess two or more common properties.
Criticism on the BWW approach

• *Bunge's* ontology reflects a *realist*, purely *materialist, phenomenological, scientifically exact* world view. Phenomena like *thing, individual, property, state, event, interaction, ...* are just taken to be *given*. (*"We perceive things as they are".*).

• *W&W*: There is no clear distinction between ontological and conceptual (e.g. set-theoretical) terms. E.g. *thing, event, action* are ontological, *class* and *kind* are conceptual (= not existing in the real world, but *mental* constructs).

• *W&W* say ontological entities cannot have "optional properties" – they either *have* the property or they *don't have* it.

• *NIAM / ORM* position: “A role is *mandatory* if and only if, for all states of the database, it must be recorded for every member of the population of the attached entity type; otherwise the role is *optional*” [Nijssen and Halpin 1989, p. 114].
The sign character of models

- Conceptions *mediate* between *domains* of the real world (= referents) and their *(software) representations* (cf. [FHL+98])
- Similarly, models (= conceptions) *mediate* between *originals* (= referents) and their *(software) representations*

Semiotic tetrahedron taken from the FRISCO report:
Individual objects in the semiotic triangle

Brown is a client of XYZ
Brown is 29 years old
Brown's address is ...
Brown is married ...

Conception of Brown
*Individual-Konzept*

Observer

Customer Brown
(as a physical person) -
*physical individual*

Representation of Brown
*symbolic individual*
(data record)

Brown  Charles  26-2-1973  M  25 High St., ...
Universalia in the semiotic triangle

<table>
<thead>
<tr>
<th>Name</th>
<th>First Name</th>
<th>Date of Birth</th>
<th>Gender</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>Charles</td>
<td>26-2-1973</td>
<td>M</td>
<td>25 High St., ...</td>
</tr>
<tr>
<td>Miller</td>
<td>Henry</td>
<td>2-12-1945</td>
<td>M</td>
<td>257 Lower St., ...</td>
</tr>
<tr>
<td>Smith</td>
<td>Alice</td>
<td>6-8-1983</td>
<td>U</td>
<td>151 Roma St., ..</td>
</tr>
</tbody>
</table>

**Intension** of concept *Person*

**Extension** of concept *Person*

**Representation** of an extension of concept *Person*
Consequences for analysis and modelling

• Objects are not given "ontologically" \textit{(a priori)} but evolve through the observation of some observer.

• Modelling (conceptualisation) is determined by the \textit{intentions} of \textit{involved humans}. Modellers are "reality constructors" (cf. [FZBK 92])

• \textit{Distinguishing} the \textit{semiotic aspects} helps avoiding misunderstandings and finding better structured development processes.

Example: What means \textbf{delete Brown}?

• Extinct a data record?
• Getting rid of a conception ("vaporization")?
• physical destruction?
Ontological assumptions

*(FRISCO-”Weltanschauung”)*

- **Assumption [a]:**
  The "world" exists, independent of our own existence, or of our cognitive and intellectual capabilities.

- **Assumption [b]:**
  Human beings are able to observe and perceive "parts" or "aspects" of the "world" (which we will call domains) with their senses, thus forming *perceptions* in their minds.

  Perceptions can be considered as specific patterns, generally changing in time.

- **Assumption [c]:**
  Human beings are able to form *conceptions* in their minds, as a result of current or past perception, by means of various cognitive or intellectual processes, such as recognition, characterisation, abstraction, derivation, and/or inner reflection. The collection of (relatively) stable and (sufficiently) consistent conceptions in a person's mind is called his or her *knowledge*.
Ontological assumptions (cont'd)

*(FRISCO-“Weltanschauung”)*

Assumption [d]:
A perceived domain may be conceived as composed of identifiable components, which we call *things*; they may overlap, contain each other or relate to each other in whatever empirical way.

- **Assumption [e]:**
  Some things are conceived as having a static existence (*states*), while others are conceived as changes of some state (*transitions*). Hence, a perceived domain may be conceived as having an existence in a *temporal* context.

- **Assumption [f]:**
  Some transitions may be conceived as being performed or brought about by some active things, called *actors*. Such a transition, called an *action*, is performed by that actor on passive things, called *actands*.

...  

- **Assumption [g]:**
  - Persons use *representations* to communicate their conceptions. These conceptions are represented in some *language* on some *medium*.

  *(From: FHL+ 98, p. 29 ff.)*
From the real world to representations

Perception \rightarrow \text{conceive} \rightarrow \text{Domain} \rightarrow \text{represent} \rightarrow \text{Representation} \rightarrow \text{Conception}

(cf. [FHL+98], p. 33)
FRISCO's starting point of an "IS ontology"

Legend: 
: is defined by
Conclusions

• There is no (IS-relevant) statement on the real world without conceptualisation.
• ⇒ Every ontology is a sort of conceptualisation
• So-called ontologies and conceptual models differ only in
  - scope
  - style
  - means / language
  - openness
  of conceptualisation.
• *Ontological Foundation* is the attempt to justify a certain formalism for building
  conceptual models by showing its *adequacy* and *appropriateness* to deal with a
  plausible description of (a part of) the real world.
• "Optional properties" are a question of "completeness" (going into details) of a
  conceptualisation – not of "ontological foundation".
## References


