Grounding for Ontological Architecture Quality: Metaphysical Choices

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1 Introduction

Information systems (IS) are getting larger and more complex, becoming ‘gargantuan’. IS practices have not evolved in step to handle the development and maintenance of these gargantuan systems, leading to a variety of quality issues. The community recognises that they need to develop an appropriate organising architecture and are making significant efforts [1]. Examples include the System Engineering Modeling Language (SysML), the Reference Model for Open Distributed Processing (RM-ODP) and 4+1 Architectural Blueprints [2]. Most of these follow IEEE 1471-2000’s [3] recommendation to use view models.

We believe that these efforts are missing a key component – an information grounding view. In this paper, we firstly describe this view. Then we suggest a way to provide an architecture for it – foundational ontologies – and a way of assessing them – metaphysical choices. We illustrate how the metaphysical choices are made and how this can affect information modelling.

2 Information Grounding

The basic elements of the information grounding view are not new. It can be linked to the discussion of a ‘Universe of Discourse’ (UoD) found as far back as Boole’s 1854 Laws of Thought [4]. The underlying idea is much older; that given some discourse there is a collection of things the discourse is about, i.e. its UoD. In the IS community the terminology was adopted for a different purpose (see e.g. ISO/TR 9007:1987 [5]). In this, a pre-existing system (discourse) is seen as containing a ‘Universe of Discourse Description’ (UoDD) which describes the UoD. What this suggests is that the information component of a new, yet-to-be-built, system can be developed by starting with its UoD and describing this, building the UoDD from the UoD. This suggests an attractive symmetry with models of a system; where a system model is a description of the system. And so the system model contains a description of a description of the UoD – creating a chain of descriptions.

For our purposes, we will talk about an ‘information grounding’ rather than a describing relation, where the elements of information in a system are grounded by the things the information is about (or expressed in the language of truthmakers [6,7], one can say by the things that make them true). From this new perspective, the UoD is more naturally called the 'information ground' of the system. This raises questions about exactly what the UoDD is. Is it the model of the information ground – the information ground model? Or is it the information in the system – the system information – which is grounded by the information ground? From a grounding perspective these are different; in the following sections we clarify this distinction.

There is a literature on the confusions that can arise around information grounding relations. Korzybski [8] talks of confusing the map with the territory. 20th century analytic philosophy cautions against use-mention confusion [9]. Lewis Carroll illustrates this in *Through the Looking-Glass* [10] with Alice's confusion at the Knight's discussion of Haddocks' Eyes (which uses a chain of information grounding levels). In these cases, the typical confusion is mistaking one level for its neighbor.

In IS development, it is common to make a similar kind of mistake and talk of a model at one time as if it modelled the system and another time as if it modelled the information ground. The RM-ODP architecture appears to do this; the 4+1 architecture, like many software focused approaches, appears to avoid consideration of the information ground almost entirely.

However, the problem goes deeper. Once the system is developed, the relationship between the information ground, the system (information) and the system (information) model is a clear case of an information grounding hierarchy. However, during development things are less clear. In the early stages, one works with design artefacts. One builds the information ground model and uses this to build the system model. But what legitimises this? The relation between the two cannot be simple grounding; the system itself grounds the system model and the information ground model is a design artefact – clearly not the system. The grounding relation is indirect, it is that the system information and the information ground model shared the same information ground, so are in some way isomorphic. The information grounding view will need to account for this kind of indirect isomorphic grounding.

There are other refinements that will be needed. For example, it is usual to represent the information ground outside the system. However, there are many cases where they overlap. (Davidson [11] makes a similar point about the use-mention distinction.) Obvious cases are operating systems, where the objects of interest (for examples, files) are clearly inside the system. Less obvious, but common, cases would be internet orders, which are processed almost completely online. In these cases, the order is inside the system. In these cases, the system information does not clearly map into a level in the information grounding hierarchy. This leads to a requirement for a more intricate mapping of the information grounding hierarchy onto the design models.

3 First-Third Person Divergence

The original UoD/UoDD literature and subsequent work assumes a simple grounding structure, where the UoDD inside the system is a simple model/description of the UoD (in our terms, that the system information is just an information ground model). However, the system is often an agent and as such the information content is not a simple description – so more than simple grounding is at play. We discuss two ways it is less simple: indexical and epistemic. There are others that need to be catered for, such as the deontic and doxastic aspects.

In philosophy, particularly philosophy of mind there is much debate about the relation between first and third person perspectives [12], and the reducibility of the first to the third person. One aspect of these are the indexicals typically linked to the first person (the most prominent being 'I', 'here' and 'now'), whose meaning depends upon the context of the utterance. These indexicals are also studied in philosophy of language, where Perry [13] made a convincing argument that they are irreducible.

There seems to be a similar phenomenon in information systems. Statements giving a person's age are linked to the 'now' time of utterance – 'Boris Johnson is 52 (now)' is true at the time of writing, but will be false when read in a few years. A typical information design manoeuvre is to talk about a static date of birth rather than dynamic age. This merely pushes back the need for the 'now' indexical; in order to recover the age, one needs to calculate the time between the date of birth and now. So it is no surprise that programming languages cater for this; C#'s DateTime.Now property being an example. In an analogous way, one may convert a mobile phone's dynamic 'here' location into static coordinates, but one still needs the equivalent of 'here' to find one's current location.

A business application often has a requirement for designed blindness – a restriction on its information about its domain. A topical example is name and age blindness in a curriculum vitae register – to avoid discrimination. We call what the system knows a 'first person epistemology' here – it is what the application as agent is designed to know. In [14] this is called just 'epistemology' and the designed blindness 'epistemic divergence'.

Hopefully the preceding discussion has both clarified what information grounding is and the kind of attention to detail needed to expose the underlying structure. We have developed a view that this exemplifies a wider problem of a lack of attention to fundamental meta-ontological issues that become particularly acute in gargantuan systems. It is a common theme among metaphysicians that metaphysics is unavoidable; that most positions involve an array of metaphysical assumptions [15,16]. And that if one does not make the effort to understand the choices one has made, then it is likely that they will be uninformed, often ill-formed. This view suggests a way forward.

4 Information Grounding Architectural Framework

The way forward is to use a framework in which these metaphysical issues, including information grounding, are explicitly addressed. One such framework is a foundational ontology; where this "defines a range of top-level domain-independent ontological categories, which form a general foundation for more elaborated domain-specific ontologies" [17].

However, the mere adoption of a foundational ontology in itself is insufficient to ensure the right level of quality. One also needs a framework from within which one can assess the metaphysical quality; whether and how the issues have been dealt with.

Within philosophy, there is not a consensus on the 'right' ontology. But there is a reasonable consensus on ways a particular ontology can be characterised. One is its position on ontological topics such as identity or space and time. These are useful headings under which to understand an individual foundational ontology. There is also a reasonable consensus on the range of metaphysical choices one can make. These can be helpful when deciding between foundational ontologies, as they can help to characterise commonalties and differences.

We have been developing a range of choices for a while. The choices (listed in **Error! Reference source not found.**) were first published in [18], and subsequently in

[19-21]. They have been discussed in [22]. Together these texts contain a quite detailed explanation of these choices, which we will not repeat here. There are undoubtedly refinements and additions that could (and should) be made to this list, but we have found it a useful starting point.

Choice 1	Choice 2	Related Topics
Endurantism	Perdurantism	Existence. Change.
Eternalism	Presentism	Existence. Change.
Single Space-Time Continuum	Separate Space and Time Continua	Change.
Modally Extended	Modally Flat	Modality/Possibility. Counterparts.
First Order Universals Only	Higher Order Universals	Existence.
Universals – Metaphysical Realism	Universals – Nominalism	Identity. Can two different universals have the same extension?
Particulars – Extensional Identity	Particulars - Coincident	Identity. Incudes mereology.
Materialism	Non-Materialism (Abstract)	Existence.
Branching Time	Linear Time	Existence. Possibility.

Table 1 Metaphysical Choices (BORO choices highlighted)

We now provide an example of how to characterise a foundational ontology using metaphysical choices, using one we are familiar with – the BORO ontology (for an example of how one could use the choices to compare two ontologies see [23]). It is useful to understand the external drivers for the choices. One way to frame these is in terms of concerns, topics and choices – we provide two examples below.

Reproducibility is key to science, one expects different scientists to be able to get the same results when reproducing experiments. Unfortunately, in the practice of domain modelling, there is little reproducibility of models, as expert domain modellers often have fundamental disagreements. This is a result, in large part, of a lack of criteria of identity, mechanisms for understanding identity and difference.

A more stringent (and potentially more useful) desideratum is intersubjectively reliable criteria of identity; a mechanism that different people can use to reliably arrive at and agree upon the same result. This is not a new idea. Quine worried about this reliability question and this motivated his metaphysical choices. Decock [24] explores this in some detail. BORO makes similar choices to Quine for similar reasons (BORO's choices are highlighted in **Error! Reference source not found.**). For example, Quine (like BORO) selects materialism to avoid abstract objects which are notoriously difficult to agree on. Like Quine, BORO settles on a four-dimensional spatio-temporal extensional criterion of identity. Unlike Quine (but like Lewis) BORO chooses modally flat possible worlds. Like Quine, BORO's types are extensional. So this single concern has motivated most of the choices.

One way to appreciate how the choices shape the foundational ontology is looking at the tools and techniques they enable. The space-time maps used in BORO analysis (an example in **Error! Reference source not found.**) provide a good example. Given that four-dimensional spatio-temporal extent is a criterion of identity for particulars, then this kind of map of spatio-temporal extents is a way of characterising their identity.

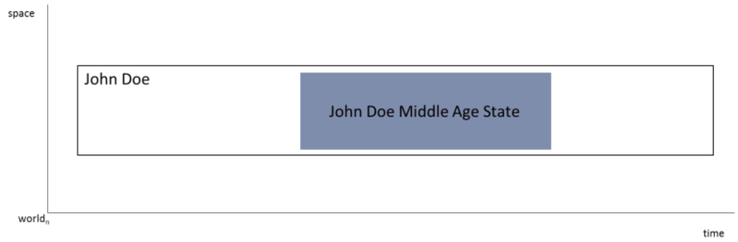

Fig. 1 An example of a BORO space-time map

This provides a clear way of visualising the ontological commitment, though one only available within a foundational ontology that has made these specific choices. Each object will occupy an area on the map (while objects can overlap no two objects can occupy the same exact area) – so one can unequivocally count the objects. One can also visualise mereological relations – overlaps and containments are clearly visible. This is analogous to the way Venn and Euler diagrams diagrammatically reason [25] over extensional sets, the way the spatial arrangement captures the identity criteria. Given BORO's space-time maps work with similar extensional identity criteria, then they could also be seen as a form of diagrammatical reasoning (see also Casati and Varzi's [26] Chapter 11 for the semantics of maps – though these are only spatial, they share some extensional characteristics).

5 Summary

We have highlighted the need for an information grounding view in IS architectures when working with gargantuan systems. We showed how this view reveals intricacies central to the structure of the IS development process that are missed by contemporary efforts. We have proposed foundational ontologies as architectures for the information grounding approach and shown how metaphysical choices can be used to assess them.

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