Towards Key Principles of Fact Based Thinking

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Abstract. In this paper, we present ten principles that, in our view, underlie and define the practice and science of 'Fact Based Thinking'. In itself, Fact Based Thinking underpins Fact Based Modelling (FBM) in all its forms. FBM has been around for decades, and has brought forth a number of meta-models and formalizations. The principles as discussed in this paper focus on Fact Based Thinking rather than on matters of representation and precise semantics, which have been elaborately discussed elsewhere. The principles presented are deliberately worded for broad use and inspirational purposes, rather than worked out in detail. As such, this paper suggests the initialization of further work rather than presenting a final result. The sketch of the principles presented aims to express the basics of Fact Based Thinking in a way that most members of the FBM community can feel at home with.

Keywords: Fact Based Modelling · Fact Based Thinking · Conceptual modelling · Knowledge engineering · Information systems

1 Introduction

Fact Based Modelling (FBM) has been around since the nineteen seventies, and though it has never become mainstream, it has been influential in education and research (in particular in Europe and Australia) and has both directly and indirectly helped in shaping current thinking about data, information, and knowledge as well as, of course, information and knowledge systems. One of the major achievements has also been a structural impact on the creation of the SBVR [13] standard for business rules.

In the history of FBM, a key role has been played by the ORM (Object Role Modelling) workshops, which in 2015 were renamed FBM workshops. Though a whole range of FBM related topics was addressed in these workshops (and in other, related ones, such as the EMMSAD workshops), there has been a strong emphasis on

C. Debruyne et al. (Eds.): OTM 2018 Workshops, LNCS 11231, pp. 77–86, 2019.
https://doi.org/10.1007/978-3-030-11683-5_8

the meta model, representations, formalisations, verbalisations etc., of the various FBM flavours; the broadly known ones including NIAM [1], ORM [2], FCO-IM [3], DOGMA [27] and cogNIAM (which integrates process and rules aspects fully on an FBM grounding).

While this work is invaluable for the FBM practice and community, the various specific representations and techniques have all been modestly successful in terms of practical adoption in “mainstream industry”. This set aside, most FBM enthusiasts, when asked, will tell us that they like and use the *way of thinking* of FBM even if in their professional practice they do not use (or are not facilitated to use) one of its actual techniques (and/or one of the tools supporting them, like cogNIAM Analyser, NORMA, or CaseTalk). In particular through the thousands of information and IT experts that have gotten to know FBM and FBM thinking in their academic or professional higher education, the perspective and ideas of FBM seem to be very much alive, even if they are relatively covert and “internalised”.

In line with the latter, the current paper takes the ‘Fact Based Thinking’ perspective and sums up what we believe to be the chief principles that make up the Fact Based Thinking core of FBM. They are put forward here as suggestions, to start further discussion. The general idea is that, at least to a reasonable extent, all FBM supporters, adepts, teachers and users will recognize the principles as key features of Fact Based Thinking underlying FBM in all its rich variety. After all, the thinking may underlie the modelling, but the models are the chief and vital, tangible end product of the application of FBM.

Why advocate these principles? Because they are key to the whole FBM effort and its ideas, and have been underemphasized in comparison with the details and pros and cons of meta-models and representations of separate FBM techniques/methods. Even more, when modellers are required to use, for example, the UML class diagram or ER notation, they can still follow Fact Based Thinking when developing the model [3, 4].

The principles underlying Fact Based Thinking are generally known within the FBM community, but have not been very clearly communicated as such in a comprehensive, manifesto-like way – which we believe is an interesting and useful thing to do. Arguably, the principles (possibly in a more mature form than the one presented in the current paper) are the most important part of what FBM is, and constitute its main impact on the world of conceptual modelling, information systems, and knowledge engineering. As such, this paper is also the result of a fundamental discussion on the future of FBM, as started during the OnTheMove conference FBM workshop in 2017.

The status of the principles put forward in this paper, is that they have been proposed by, and discussed among, a small group of ‘first generation’ FBM experts, while some comments on them have been received from a wider circle of FBM experts. We emphasise that the current set does not yet reflect a widely shared, explicit agreement among the FBM community at large. Instead, we hope this initial proposal may eventually lead to such established, explicitly phrased common ground. We aim to obtain further feedback on the current version of the principles and discuss them during this year’s FBM workshop, expecting to further develop and finalize this set of principles. The goal is to develop these into a proper Fact Based Thinking manifesto, which should then not only identify the key principles, but also provide evidence for the added value of using Fact Based Thinking in real world situations.

In the remainder of this paper, we will first present the current set of principles. We will then continue with a brief reflection on the consequences of these principles on the modelling method and associated tooling.

2 Principles of Fact Based Thinking

2.1 P1: Facts Are First Citizens

Facts are central to Fact Based Thinking and FBM. As a consequence, actual/example instances are "first citizens" in Fact Based Thinking. Facts, or "instance level statements", are an integral and crucial part of dealing with and describing the structures of the domain (in terms of [6]: the universe of discourse) being modelled. This principle is directly related to a basic and rather universal approach to abstraction: taking concrete examples from a domain (typically, verbalized expressions or statements) and creating a set of categories (type level concepts; not unlike a 'signature' as used in mathematical logic) and constraints (comparable to axioms) structuring the domain and providing coherence and cross-conceptual, type-level meaning for the domain. It is not only related to basic abstraction in logic, but also to notions of abstraction in cognition and language. Note that whether some concept is seen as instance level ('concrete') or type level ('abstract') is essentially a context-specific choice [7, p. 291-2].

2.2 P2: Models Should Be Evidence Based

In line with treating facts as first citizens, Fact Based Thinking is "evidence based" in the sense that it requires underlying evidence in terms of facts that express (f)actual observations about the domain to be modelled. Note that this is irrespective of the question whether this pertains to an existing domain, or an "imagined" (future) one. This works in a bi-directional fashion in that it is allowed for modellers to conceptualise in two directions, either: (1) from example facts to fact types (deriving/abstracting fact types from facts), or (2) from fact types to example facts (validating fact types through facts). In Fact Based Thinking, a good model is, once finished, always grounded in examples from the domain. This is important for both the conceptualisation process (a basis for well founded, manageable abstracting, and cognitive grounding in instances) as for meaningfulness and quality of results (models, descriptions). It provides not just "descriptive meaning" (intensional definition) but also an example set substantiating the description; "example meaning" (extensional definition[1]).

2.3 P3: Models Should Reflect the Communication About a Domain

In Fact Based Thinking, a model should reflect the communication about the domain being modelled. In other words, it "abstracts away" from communication medium specific considerations, such as technological platforms, etc., used for communication.

[1] See https://en.wikipedia.org/wiki/Extensional_and_intensional_definitions.

It also considers information and meaning to be present in communication between humans (or possibly other sentient beings), and not an objective representation of "reality" (whatever that may be). In line with Ogden and Richards [5], meaning involves referents; i.e. interpreting beings.

2.4 P4: Models Should Embed and Use the Language Used by Domain Experts

Fact Based Thinking not only reflects the communication about a domain, it more specifically reflects the language used (naturally) by the domain experts (knowledgeable members of the domain community). Both fact structures and terms used in fact types need to reflect the languages used to communicate about the domain. As a result, fact based models are sometimes referred to as "information grammars", capturing the communication structures by domain experts in communicating about the domain. For a model to be an information grammar specifically does not mean that the model would be a model of the *communication about the domain*. The model will still have to be a model of the actual *domain*.

The use of the domain expert's language is very explicitly reflected in the systematic and precise use of *verbalizations* in expressing FBMs (both at instance and type level), in particular in order to make validation of models possible without exposing domain experts to specialist diagrams. This principle can be effectively used even of non-FBM representations are used, like ER[2].

2.5 P5: The Use of Elementary Facts Is Strongly Favoured

An important part of the way Fact Based Thinking deals with linguistic statements (sentences and phrases) concerns the urgent preference for focusing on and working with Elementary Facts. Traditionally [1], the difference between a 'fact' and an 'elementary fact' is that an elementary fact cannot be simplified without loss of meaning. This should always be based on evidence (sample facts) from the domain. However, in line with principle P4, it remains up to the domain experts if they want to split a fact type or not. Nevertheless, this should always be a deliberate and conscious decision.

2.6 P6: Domain Knowledge Representation Is the Primary Use

The primary use for Fact Based Thinking is to produce *knowledge representations*; knowledge about the domain being modelled. Other uses, like database design, are also important but can be seen secondary to and derived from the independent, rational (i.e. logical) representation of information structures. Knowledge representation, usually classified as a branch of artificial intelligence, is the art and science that underlies all forms of (conceptual) modelling, and is heavily embedded in disciplines like data engineering, software engineering, knowledge engineering and, indeed, artificial intelligence. It can also be used, in various levels of formality, in information

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[2] See https://datavaultusergroup.de/wp-content/uploads/Hannover2017jpzwart.pdf.

management and knowledge management. Knowledge representation combines well established insights from fields like logic, mathematics, cognition, linguistics, and philosophy.

2.7 P7: No A-Priori Conceptualisation of Attributes

Fact Based Thinking does not include a-priori attribution of concepts (i.e. it does not use attributes as sub-items of entities, like for example UML and ER do). It considers such entity-attribute distinction to be arbitrary and driven by representation choices, and therefore not part of "pure" conceptual modelling. Instead Fact Based Thinking focuses on expressing all items in terms of facts, and the objects playing a role in these facts.

2.8 P8: Modelling Language and Procedure Are Two Sides of the Same Coin

In Fact Based Thinking, modelling language and modelling procedure are considered as two sides of the same coin. Fact Based Thinking integrates a structure (language, notation, metamodel) with a procedure: a stepwise process for creating a structure. The procedure serves as a set of guidelines for modellers and can be used for instruction and training. However, in its stricter form and use it is a protocol that safeguards the quality of the resulting model and the repeatability of the procedure (rendering the same results).

2.9 P9: Term Definitions Are an Integral Part of Models

Definition of terms, i.e. of the names of concepts/relations, are an integral part of a fact based models. In line with principle P3 and P4, Fact Based Thinking implies the use of terms from natural (domain) language, while combining such elements into fact statements. The meanings of the (individual) terms, as used in domain context, are essential building blocks for the meanings of composed models/structures. Therefore, description of those terms (in natural language, in the context of the domain) is a crucial and inherent part of Fact Based Thinking.

2.10 P10: Variation Between Specific Situations of Use

Fact Based Thinking is used in many different contexts, with differing goals. Every situation requires a situation-specific use. In other words, no "one-size-fits-all" notation, process, etc., but rather options and variations that balance effectiveness and efficiency for each specific situation of use, tuning the precise concepts, representations, procedures and tools used to specific goals and contexts of use.

3 Consequences for Fact Based Modelling Methods

Given the above suggested principles of Fact Based Thinking, we now reflect on their consequences towards FBM methods and tools. Of course, in formulating the candidate principles, we made sure that the existing FBM variations largely meet the stated principles. Nevertheless, it is still relevant to reflect on these consequences for at least two key reasons. Firstly, when using FBM in practice, one may be "forced" to use modelling languages and tools that were not created from a Fact Based Thinking perspective [4]. In such cases, it will be beneficial to know the (minimum) requirements needed for Fact Based Thinking, to best utilise the means at hand. Secondly, it will also allow us to clarify and motivate why an "ideal" FBM modelling language and procedure, has to provide the ability to be precise and specific in modelling. In discussing the consequences, we have clustered the principles in terms of related consequences.

3.1 Situational Variety and Methodological Integrity

As principle 10 states, Fact Based Thinking requires the ability to vary between specific situations of use. This means that a specific FBM flavour can still be dedicated to a specific class of situations, e.g. ontology engineering [8], or conceptual database design [2]. It does, of course, require these variations to be explicit about their intended purpose/scope, as well as offering options for situational adoptions, in the vein of situational method engineering [9].

Principle 8 refers explicitly to the need to have an integrated perspective on the modelling language used, and the modelling procedure. This "methodological integrity" between language and procedure, would suggest all FBM variations to at least provide a core description of a suitable modelling process as well as an associated modelling language. In cases where one is "forced" to combine Fact Based Thinking with the use of other modelling languages, an existing FBM procedure will have to be used, while elements such as example facts may have to be "stored" separate from the model and associated tool. The latter would also suggest that the development of a generic Fact Based Thinking modelling process and associated modelling concepts (i.e. a core common meta-model) could be beneficial as well.

3.2 Fact Based Evidence

Principles 1, 2 and 5 clearly point towards the need to be able to express example facts, and keep these as an integral part of a FBM model. As far as we know, most FBM variations indeed support this. However, when indeed using other notations (e.g. UML class diagrams), one may be forced to store such information separately. This is, of course highly undesirable. At the same time, there is an increasing awareness that the motivation of a model (in terms of e.g. purpose, intended audience, etc.), as well as the way it has been created, should be an integral part of a model (as a purposely created artefact) [10, 11] as well. As such, adding evidence and domain knowledge to a model in terms of concrete example facts may also be beneficial in other than FBM contexts.

3.3 Rich Verbalisations and Definitions in the Language of the Domain Experts

Principles 3 and 4, result in the need to be able to use rich verbalisations, expressed in the language of the domain experts, in FBM models. Again, as far as we know, all FBM variations support this, while languages such as ER and UML class diagrams provide no real obstacles in this regard and can be enhanced to fit this purpose. Example mappings from ORM to UML and cogNIAM to UML class diagrams also support this [2].

Principle 9 leads to the need to be able to include definitions of key terms, as a kind of a dictionary, in FBM models. This is not generally supported by all FBM variations. Most tools, however, do allow the addition of at least some extra explanation for fact types and/or object types. In future, however, it would be recommendable to make this into an explicit structure in modelling language(s) used for FBM.

An open question with regard to the use of verbalisations in the language of domain experts, is the level at which insights from the modelling process should actually lead to changes in the language used by the domain experts. For example, insights into the question whether a fact is elementary or not, knowledge about the existence of homonyms and/or synonyms within the group of domain experts, but also more fundamental ontological insights that may be concluded when using guidance from e.g. a foundational ontology [12]. However, in line with principles 3 and 4, such a choice has to remain in the hand of the domain experts, using evidence in terms of facts observed in the modelled domain (principles 1 and 2). At the same time, in the context of database design, there may be good arguments to more normatively manage elementarity of facts, as well as synonyms and homonyms [2].

3.4 Attribution and Decomposition

As stated in principle 7, Fact Based Thinking does not require an a-priori conceptualisation of attributes. There is no a-priori attribution of object types; no identifying one object type as being conceptually subordinate to another object type. Fact Based Thinking considers attribution to be arbitrary and driven by representation choices, and therefore not part of "pure" conceptual modelling. When having to combine Fact Based Thinking with a modelling language that traditionally uses attribution, one can simply refrain from using this.

A possible advantage of attribution is of course that the resulting models look, at first glance, simpler than FBM models traditionally do. After all, attribution enables the use of graphical abbreviations for the identified attributes. This is, indeed, a representational consideration.

As has been studied in the FBM community, attribution as provided by e.g. (standard) ER and UML does not scale well, in the sense that it does not enable a recursive, i.e. stepwise, decomposition of a complex domain into more detailed parts. This would require a recursive use of attribution [14, 17] to develop (purpose specific) recursively decomposed views on top of flat conceptual models.

In the context of e.g. enterprise architecture modelling [15], a clear distinction is made between views and (core) models, where views are tuned to the communicative/representational needs in specific situation [16]. This distinction would also enable FBM to make a clear distinction between the (flat) conceptual model, and (purpose/audience specific) derived views with attributions.

Where principle 7 clearly states that attribution is considered to be non conceptual and in general arbitrary and driven by representation choices, there is a need to further underpin/nuance this. For example, work on foundational ontologies [12] may provide guidance to identify "natural" attributions. The work reported in [14] also aimed to provide objective heuristics to use constraint patterns to identify natural attributions.

3.5 Expressiveness for Knowledge Representation

Principle 6 states that the primary use for Fact Based Thinking is knowledge representation. This implies that the modelling languages used for FBM should be expressive enough to express, for a given domain, all conceptually relevant knowledge. For FBM, this has resulted in logic based [18] as well as set-theory based [19], and even category-theory based [20] formalisations of the semantics of FBM models, including associated query and constraint language(s) [21, 22]. Principles 3 and 4, also have implications for the non-graphical query and constraint languages. In the context of FBM, this has resulted in a number of alternatives [21–23], essentially leading up to the SBVR standard [13]. These languages, embodying principles 3 and 4, are in a stark contrast to e.g. UML's OCL [24], which remains a sugared version of set theory at best.

The need for FBM to be expressive, in particular also in terms of graphical constraints, also leads to models that have a (apparent) high level of graphical complexity. Simply put, "people" (and sometimes even reviewers) argue against FBM by stating that UML and ER diagrams look much simpler. Here, it would be advisable for FBM to explicitly embrace the use of simpler views (diagrams) depicting the core fact structure, with fewer graphical constraints. In addition, it would also need to be clarified that when one wants to add more knowledge about a domain, the diagrams will (have to) become more complex. The latter is supported by Moody's work [25], stating that a graphical model needs to reflect the complexities of the domain being modelled, which he motivates in terms of Shannon and Weaver's information theory [26], in the sense that a model will need to reflect all information one wants to capture from a domain (given a modelling purpose).

4 Conclusion and Next Steps

In this paper, we presented ten candidate principles that collectively aim to define the essence of the practice and science of 'Fact Based Thinking', in order to underpin FBM in all its forms. We also discussed possible consequences on methods and tool development for FBM, based on these principles. Of course, the existing FBM flavours largely meet these requirements. However, especially when a dedicated FBM modelling language and/or tooling, cannot be used, these requirements can provide guidance in using available languages and tools.

The presented principles have deliberately only been sketched, as their elaboration and adoption should be part of a broader discussion in the FBM community. We hope this initial proposal will eventually lead to such established, explicitly phrased common ground.

The current list of principles has been formulated based on initial input from (next to the authors): John Bulles, Inge Lemmens, and Sjir Nijssen. We would like to thank these contributors.

As mentioned in the introduction, we aim to obtain further feedback on the current version of the principles during this year's FBM workshop, with the goal to further develop these principles in a kind of Fact Based Thinking manifesto. Beyond this, we also hope to, together with the FBM community at large, gather compelling evidence (in terms of documented real-world cases) of why Fact Based Thinking has a clear added value (in real world business terms) over other approaches.

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