An Introduction to the Business Ontology

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ABSTRACT

Based on the long-standing work of the Global University Alliance and its members, ontology is introduced for the business domain. This 'business ontology' incorporates all the constructs that can be found in the most popular business standards and frameworks. The business ontology's research and development journey is detailed; in terms of the how the research and findings came about, including the underlying academic design science that is informed by practitioners' industrial experiences. It explains the value of ontology, from which the need for the business ontology can be justified and gives it presence in business practice. The paper concludes with a discussion on the ontology's present status and future potential.

Keywords: *Business Ontology, Enterprise Standards, Folksonomy, Global University Alliance, LEADing Practice, Meta Meta Models, Meta Model, Meta Objects, Models, Structured Way for Working, Taxonomy, Templates*

INTRODUCTION: THE NEED FOR ONTOLOGY

Various Standards bodies, Organizations, Business frameworks, methods, approaches and or concepts have their own vocabulary. Each of these vocabularies has its own definition of terms, like what is strategy or what is a process. For example, OMG, which is the software standard body that created the Business Process Model Notation (BPMN) standard, has various standards that all have a different shape/notation, description as well as semantic relations around a process/activity. BPMN has a different shape/notation, description as well as semantic relations; than does Case Management Model Notations (CMMN) or even Value Delivery Model Language (VDML). All of these respected standards are from the same software standard body, but lack standardization between them. The same lack of standardization applies to most other frameworks, methods or approaches we studied. For example, The Open Group Architecture Framework (TOGAF) and Archimate are from the same organization, The Open Group. They do not only have multiple different objects, the objects they actually do have in common have different descriptions, rules and even semantic relationships for them, although both address

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enterprise architecture. Additionally, TOGAF and Archimate have different models i.e. views as well as meta models. When an organization adapts both the Architecture Framework TOGAF and the architecture software tool 'Archimate' from the same organization i.e. The Open Group, the modeling and architecture work would result in a low degree of maturity, which was found to be surprising to many organizations, regardless of how much work or money and organization would invest into such a project, portfolio or program due to the inconsistencies mentioned above. According to existing maturity modeling concepts such as Capability Maturity Model (CMM), the maturity level of organizations combining TOGAF with Archimate would be level 1, which is siloed – the lowest level.

The examples above illustrate the lack of (and need for) standard business terms, definitions, semantic rules and concepts. These represent the starting point of the academic interest of the Global University Alliance (GUA) in this topic. The first GUA research in 2004 identified that the lack of repeatable standards around business concepts within business modeling, engineering and architecture concepts resulted in unnecessary siloes, lack of reusability and many other modeling issues such as low maturity in organizations. The need to identify relevant reusable/replicable patterns and develop concepts that can be used by any organization, both large and small, regardless of its products/services, activities or industry, became apparent. In September 2004. At this point the research and analysis around business ontology was formally initiated. This included:

- Outlining the research questions
- Analyzing patterns, both in terms of what doesn't work (anti-patterns) and what works, again and again (best practice), and what are unique practices applied by leading organizations (leading practices).
- Identifying commonly used meta-objects and models used within the repeatable patterns
- Developing artifacts and templates that increase the level of re-usability and replication.

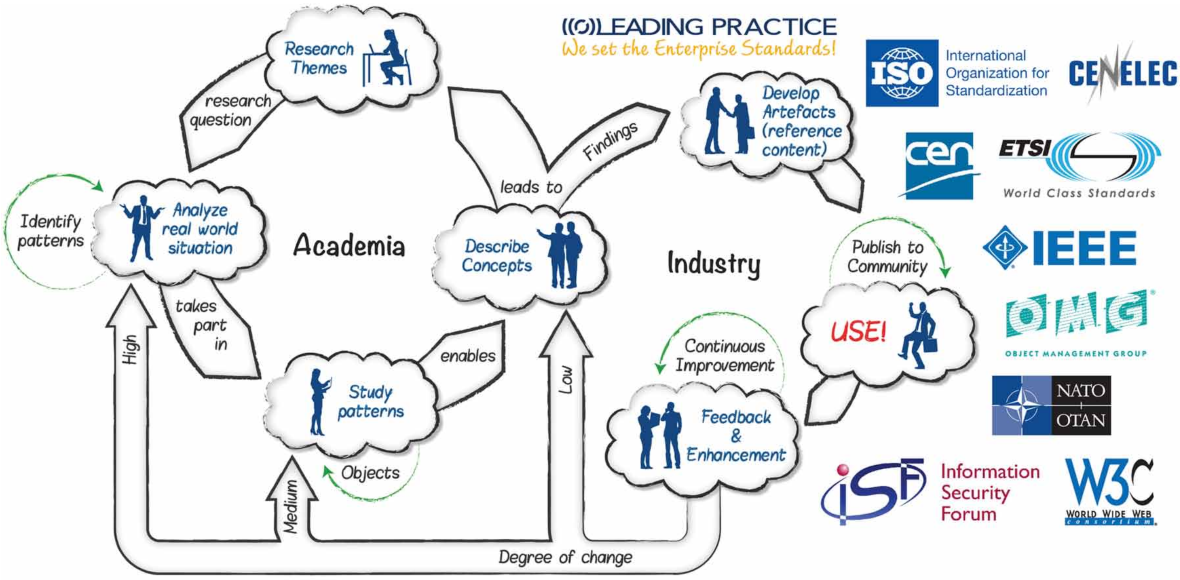
The next section discusses how the context (i.e. collaboration between academia and industry) in which the ontology was developed. Section three, explains the value of ontology in a business context, including the theoretical foundations for the business domain ontology that is than presented. We conclude with a summary.

ACADEMIA INDUSTRY DESIGN: A COLLABORATIVE PROCESS BETWEEN RESEARCH AND INDUSTRY

Arising from 5 years of previous work, the GUA was founded in 2004 as a non-profit organization and today (Nov, 2015) they are an international consortium consisting of over 450 universities, professors, lecturers and researchers. Their aim it is to provide a collaborative platform for academic research, analysis and development. As illustrated in Figure 1, they achieve this through defining clear research themes, with detailed research questions, where they analyze and study patterns, describe concepts with their findings. This again can lead to additional research questions/themes as well as the development of artifacts, which can then be used as reference content by practitioners and industry as a whole. The GUA collaborates with standards bodies such as:

- **ISO:** 'The International Organization for Standardization (French: Organisation Internationale de standardization)

Figure 1. Overview of the Academia Industry Design (AID) process used in the Global University Alliance and collaborative industry practitioners



- **CEN:** The European Committee for Standardization (CEN, French: Comité Européen de Normalisation).
- **IEEE:** Institute of Electrical and Electronics Engineers is the largest association of technical professionals with more than 400,000 members
- **OMG: Object Management Group:** Develops the software standards.
- **NATO:** North Atlantic Treaty Organizations (NATO's) with the 28 member states across North America and Europe and the additional 37 countries participate in NATO's Partnership for Peace and dialogue programs, NATO represents the biggest non-standard body that standardizes concepts across 65 countries.
- **ISF: The Information Security Forum,** Investigates and defined information security standards.
- **W3C: World Wide Web Consortium-**The W3C purpose is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web/Internet.
- **LEAD:** LEADing Practice, the largest enterprise standard body (in member numbers), which actually has been founded by the GUA. The LEADing Practice Enterprise Standards are the result of both the GUA research and years of international industry expert consensus and feedback on the artifacts and the repeatable patterns documenting their application in practice.

When academics, based on their research, build concepts and artefacts for practitioners, these concepts/artefacts need to be constructed rigorously to meet academic standards and be relevant for practitioners. Construction rigor is typically considered to be the domain of academia, although practitioners are also acknowledged to create knowledge and artefacts relevant to themselves and others (Nonaka, 1996). Academic artefact design methodologies have considered academia as a source of rigorously designed knowledge and artefacts, of which the relevance can be tested in practice. However, we observe an ever-growing involvement of practitioners in academic design science (DS). March & Smith (1996) hint towards an evaluation of academic artefacts in a real world setting, as in natural science. Hevner, March, Park and Ram (2004) consider the organisational context in which academic artefacts need to serve as a major influence on relevance. They explicitly discuss the evaluation of academic artefacts in the real world, through case studies and field studies. Peffers, Tuunanen, Rothenberger and Chatterjee (2008) identify practitioner feedback as an essential aspect of artefact evaluation in a real world setting. Finally, Sein, Henfridsson, Purao, Rossi and Lindgren (2011) model the design of rigorous and relevant artefacts as a collaborative process between academics and practitioners. In a first phase of their action-design-research (ADR) methodology, academics give the initial version of the artefacts to a small group of practitioners (e.g., a community/panel of experts). These practitioners provide valuable feedback that helps to mature the artefact. In a second phase, this improved artefact is applied by a larger group of practitioners, whose feedback will allow the academic to improve his artefact further. If this feedback requires no further modifications of the artefact, a final version of the artefact is published. Although ADR is a very mature methodology in academia-driven artefact design, it could be made more generic (generally applicable) by alleviating (eliminating) two implicit constraints (biases) present in all DS and ADR publications:

1. Academia is the single source of rigorously constructed knowledge
2. User requirements are invariable and provide a continuous improvement feedback loop to academia.

As regards the first point, although practitioners typically create knowledge (artifacts) that is (are) relevant for them in a specific organizational context, this does not necessarily imply that this knowledge cannot be generalized and applied in other organizational contexts. This generalization (and evaluation) would typically be the role of academia in this kind of knowledge creation scenario. There are multiple instances of such artifacts existing today. For example, the Boston Consulting Group (BCG) created a matrix in 1970 to help analyze organizations' product lines. This has enabled organizations to allocate resources as well as use it as an analytical tool in brand marketing, product management, strategic management, and portfolio analysis. While widely used, several academic evaluations have given feedback on its usage as a growth–share matrix. (Armstrong; Scott; Brodie; Roderick, 1994) A detailed academic study from Slater and Zwirlein (1992), analyzed 129 organizations. The conclusion of the study was that those who follow the BCG matrix as a portfolio-planning model for growth success had lower shareholder returns. The study concluded that the BCG matrix is a relevant and useful artifact, but it was applied incorrectly and should be applied in other general contexts. Such an evaluation would typically be the contribution of academia in this kind of knowledge creation scenario.

As regards the second point, in ADR, an academic artifact is handed over to practitioners as soon as they accept it. This approach does not account for new feedback when user requirements have changed and the artifact is no longer relevant in its current form. From requirement engineering, requirement modeling and requirement architecture it is known that user requirements continuously change. (Gotel and Finkelstein, 1994, Ralph and Wand, 2009) Therefore, what is needed in reality is an approach that allows for continuous artifact improvement/modification through continuous user feedback, and values user knowledge as valid (relevant) input (which could thus be made more rigorous).

A major difference between academia and practice is the way knowledge is acquired. Practitioners typically rely on Experience and Induction, while Academia use research, analysis, deduction and the scientific method. From the above discussion points, we could argue that the academia and practitioners are complementary in the following ways:

- **Rigor vs. Relevance:** we can determine that Academia does Rigor best, while Practitioners do Relevance best
- **Abstraction Level:** Academia typically designs solutions at the type level (concepts and solution for a type of problem) while Practitioners typically design solutions at instance level (solution for a particular problem)
- Knowledge creation processes in terms of developing artifacts should interlink between rigor and relevance, of which the rigor aspect can be analyzed in theory best and the relevance can be tested in practice best. Therefore:
    - Combining explicit knowledge to develop new explicit knowledge. Academia typically combines explicit knowledge at type or instance level to create new knowledge concepts at type level. Whereas the practitioners typically combine explicit knowledge at type or instance level to create new knowledge at instance level. The latter being described by Nonaka (1996)
    - **Internalization:** Converting explicit knowledge (e.g. books, standards) to tacit knowledge (e.g. personal knowledge). Academia typically teaches explicit knowledge to be transformed into tacit knowledge of students (e.g. practitioners). Whereas practitioners typically study academic concepts and non-academic solutions to develop competencies (tacit knowledge), which was also described by Nonaka (1996).
    - **Socialization:** Sharing tacit knowledge through interaction. Academia research share tacit knowledge in doing research and publications together. Whereas practitioners share tacit knowledge by doing things together (and learning from each other while doing). The knowledge creation mode involving only practitioners was also identified by Nonaka (1996)
    - **Externalization:** The need to convert tacit knowledge into explicit knowledge. Academia studies in this context, what practitioners do (at instance level) to create new knowledge at type level. Whereas practitioners sometimes document what they do, and sometimes share this content (e.g. industry standards, best practices).
    - **Feedback Loop:** There should be a loop of feedback and enhancement between academia and practitioners.

Figure 1 visualizes the knowledge creating processes in academia and practice and how they interact. Academics develop research questions, founded on the research themes they identified. They analyze real-world situations to answer their research question through the identification of patterns (e.g. laws of physics). These patterns are documented and combined with other knowledge (patterns and concepts) to build theories that might require additional concepts, which may lead to additional research themes. Industry practitioners will use these concepts and patterns to develop artifacts that will help them structure their knowledge about the business reality they experience. These artifacts will be published to peers (e.g., as standards), used and improved by them. These improvements, which may point towards user requirements that were not identified by academics, should feedback to academia. Since practitioners will mostly use the concepts embedded in the artifacts to document their knowledge, the expected impact of practitioner feedback on the elementary concepts of business is expected to be relatively low (i.e., New business concepts are not discovered that often). However, it is very likely that academics will observe new innovative ways of working with their artifacts in real-life situations, when observing the practitioners in the industry. Industry practitioners can also develop their own artifacts, which may contribute directly to the academic literature. The likelihood of this scenario is expected to be between that of identifying completely new concepts and discovering new application scenarios.

The next section discusses the value of ontology, this provides the theoretical foundations for the benefits of a business domain ontology that is presented afterwards.

THE VALUE OF ONTOLOGY

An *ontology* is an artifact, more precisely an intentional semantic structure that encodes the set of objects and terms that are presumed to exist in some area of interest (i.e. the universe of discourse or semantic domain), the relationships that hold among them and the implicit rules constraining the structure of this (piece of) reality.(Genesereth & Nilsson, 1987; Nicola Guarino & Giaretta, 1995) In this definition, *intentional* refers to a structure describing various possible states of affairs, as opposed to extensional, which would refer to a structure describing a particular state of affairs. The word s*emantic* indicates that the structure has meaning, which is defined as the relationship between (a structure of) symbols and a mental model of the intentional structure in the mind of the observer. This mental model is often called a *conceptualization* (Gruber, 1993). Semantics are an aspect of semiotics, like syntax, which distinguishes valid from invalid symbol structures, and like pragmatics, which relates symbols to their meaning within a context (e.g., the community in which they are shared). (Cordeiro & Filipe, 2004)

Ontologies can be categorized and classified according to several criteria (e.g., context, maturity) (von Rosing, Laurier, & Polovina, 2015b). When ontologies are classified according to their universe of discourse, we distinguish foundational, domain, task and application ontologies. (N. Guarino, 1997) *Top-level* or *foundational ontologies* cover a very broad area of interest as they describe very general concepts as space, time and matter that are needed in any field or domain. *Task* and *domain ontologies* all relate to a specific semantic domain (e.g., business process, infrastructure, data) or task (e.g., analysis, design). Domain and task ontology terms reuse or specialize top-level ontology terms. Finally, *application ontologies* relate to a very specific universe of discourse (e.g. business process design in a particular company, data analysis in a specific department). Their vocabulary can be built from scratch or defined as specializations of both domain and task ontology terms (Nicola Guarino, 1998). For example, if 'event' were an ontology construct for the business process domain and 'forecasting' would be a task ontology construct for analysis, 'event forecasting' could be an application ontology construct for business process analysis. This combination approach is expected to promote reuse; standardization and mutual understanding between applications, as the same domain and task construct definitions are reapplied across applications. Business ontology is an intentional semantic structure that has business as its universe of discourse. Business ontology research has long been focusing on two distinct axes. The first axis concentrated on the development methods for ontology engineering (from scratch) by practitioners (e.g., METHONTOLOGY, On-To-Knowledge, DOGMA, SENSUS), which enabled them to build their own corporate or enterprise ontologies. (Cardoso, 2007; Corcho, Fernández-López, & Gómez-Pérez, 2003; Lima, Amaral, & Molinaro, 2010) The second axis was dominated by the development of domain ontologies (e.g., REA, e3value, BMO, TOVE) by academics. (Fox, 1992; Geerts & McCarthy, 2002; Gordijn & Akkermans, 2001; Osterwalder, 2004) Standards bodies, which are mainly practitioner organizations, have recently started to build their own domain ontologies (e.g. FIBO). (Council, 2014)

THE BUSINESS ONTOLOGY: FORMALIZING A DOMAIN ONTOLOGY

All ontologies have a controlled vocabulary as a foundation. (Lassila & McGuinness, 2001) As the business ontology, of which the structure will be presented below, is an extensive ontology that has the ambition to cover all aspects of business (as opposed to academic ontologies), its terms are organized in a top-level domain and multiple intersecting subdomains (e.g., Business Competency, Business Process, Infrastructure). These subdomains have specific models i.e. views with clear defined meta objects.

In the following we will elaborate on the levels and how they are described, documented and structured. Starting with the object level, the models, meta models and then the meta meta model level.

Objects Involved with the Business Ontology

The Business Ontology is organized in a top-level domains and multiple intersecting subdomains with relevant objects. Where the categorization of objects according to its relevance and semantic relations enable the enterprise modeller, engineer or architect to use the object in its direct context and the next level enables the practitioner to relate it to the various models used.

The meta-objects create, describe, or equip objects. A meta-object defines an object's type, relation attributes, functions, control structures, etc. The 'Object Groups' group objects with a common purpose, goal, an aim, target, objective and sets. The Business Ontology meta objects can therefore be seen as the object class types with each of them having stereo types and sub-types. For example if we were to decompose i.e. break down the Business Process meta object we would find the following class types Process Area, Process Group, Process Steps, Process Activity, Event, Gateway, Process Flow (incl. Input/output), Process Rule, etc. Each of them has specific stereo types and as a part of the overall Business Ontology Taxonomy, does each of the

Table 1. Example of the overall Business Ontology Taxonomy, where the object class types 'process' have stereo types with clear definitions

Process	Process Area (categorization)	The highest level of an abstract categorization of processes.
	Process Group (categorization)	A categorization and collection of processes into common groups.
	Business Process	A set of structured activities or tasks with logical behaviour that produce a specific service or product.
	Process Step	A conceptual set of behaviours bound by the scope of a process which - each time it is executed - leads to a single change of inputs (form or state) into a single specified output. Each process step is a unit of work normally performed within the constraints of a set of rules by one or more actors in a role that is engaged in changing the state of one or more resources or enterprise objects to create a single desired output.
	Process Activity	A part of the actual physical work system which specifies how to complete the change in the form or state of an input, oversee or even achieve the completion of an interaction with other actors which results in the making of a decision based on knowledge, judgment, experience, and instinct.

mentioned stereotypes have a clear defined description. In Table 1 is an example of a breakdown of some of the process class types into their stereotypes.

As a part of the overall Business Ontology Taxonomy, each of the mentioned stereo types also have subtypes with clear definitions. These do not represent the only possible stereotypes nor the only possible subtypes. As discussed earlier, these represent the most common identified objects and descriptions used by the organizations. In Table 2 is an overview of an example of some of the most common identified subtypes.

One needs to remember that a 'process area' is not only the highest level of an abstraction of a process, it is also a categorization and thereby a grouping of processes. The most common process area groupings we found where ether according to their Operational Function e.g. Finance, HR, IT etc., or by their control functions e.g. governance, audit, evaluations etc. It could however also be categorized according to other principles such as Specialist Support Function e.g. procure to pay or hire to fire etc. While these subtype definitions would not be known for the most, defining end-to-end principle as specialist support functions that relate together, provided that they can be implemented "completely and correctly", goes already back many years to Paul Baran's 1960's work (Baran, 1960,2011). For all of the Table 1 mentioned class types, the Global University Alliance, identified the stereotypes as well as the subtypes. This has helped not only to document the most common object groups, the meta-objects related to a subdomain as well as illustrated the various types, but also the relationships between the objects and how they are used within various models/artefacts. Although relations are mainly defined that the level of meta-objects (e.g., in corporate ontologies), the business ontology contains a set of archetypal relations as illustrated in Table 1 and 2, which have been observed to apply to almost any business modelling, engineering and architecture concept. The usage of the objects within the various models will be discussed in the next section.

Structuring the Meta Objects within the Models of the Business Ontology

The Relationship between Business Ontology and Business Ontology Models/Artefacts is Now Described

When an organization decides to make use of ontology and semantics to lay the foundation of what we call 'the way of working'; this is so for a vast variety of purposes (and we will be

Table 2. Example of the overall Business Ontology Taxonomy, where the the object stereo types 'process area' has subtypes with clear definitions

Process Area (categorization)	The highest level of an abstract categorization of processes.	Mainstream Operational Function	Core to the mission of the organization and are focused externally onto the needs of the clients.
		Control (Audit and control) Function	Ensure management in all functions are operating in conformance with internal policy
		Specialist Support Function	Specialist tasks that assist operational functions in the major dimensions of their work. This for example can be end to end specialized functions.
		Service Giving Function	Centralized functions that may optionally be brought together on for example the basis of economies of scale

naming a few of them throughout this paper). However the most important purpose is the fact that – once there is established a specific and very clear definition for a meta object, for example – this definition will be available to all the relevant employees across organizational boundaries of the enterprise, after is has been documented and published for use. This means that a common understanding and consensus has been reached within the organization for what name a particular meta object has for whenever it's being referred to. This, of course, makes it a lot more practical for organizations to handle objects in the bigger picture. Not just for documenting, but also for using them when modelling, engineering and architecting concepts and solutions, regardless of business unit and/or business requirement. In the sense of semantics then, it allows us to accurately describe how a particular object relates to another particular object (regardless of object type or hierarchical location). This has to be defined as well, of course, but just like the ontology definitions, an organization must also in its semantic relationships reach a common understanding and consensus of how exactly each object relate to another. This is meticulous work and takes time and effort, but it is nevertheless extremely important to avoid common pitfalls.

Thus, we now know what to call a particular object, in our case we can choose for example to use the Process object. We can then relate a process measure (performance indicator) meta object to it (through the creation of our ontology). We can then show how the Process and Process measure meta object relate to a Business Ontology relevant meta object (because we have also defined a set of semantics that accurately describe how they influence and relate to one another). If we then create Business Ontology Artefacts where the relationship to a process measure is relevant, we would consequently be able to use the Business relevant meta object and place it in the Business Ontology Artefacts, both for information and documentation purposes as well as the ability to further on relate it to other aspects. We would most likely be identifying and listing (for example in columns in an excel spreadsheet) values such as the name of each Business relevant process meta object, where it is located, what resources it uses, etc.

Maps e.g. process map are always used within the concept of the Way of Thinking, the processes are captured and listed in such a map. It is a starting point of any model, to capture and list important and essential information around the organization or in our example the process, and we create a general overview of more or less anything that wishes to be captured in the map. Continuing from this path, once a map i.e. process map has been created, we would next create a process matrix for the purpose of relating the process measure meta object (in a row next to the columns in the excel spreadsheet) to the relevant Business relevant meta object. Matrices are almost always created within the concept of a structured Way of Working, because it is here we begin to actually take action and relate objects to each other. And keep in mind that whenever we're creating a matrix, we are actively using the information provided to us through the previous creation of a process map. The map provides us with the information that we need to create an efficient process matrix. By creating a process matrix, we then allow ourselves to directly and accurately identify which kind of process measure has an impact to the organization. This would be regardless of impact type, but it has to carry some importance because we expect to note down information that somehow has relevance to the organization. Bearing that in mind, it is therefore worth documenting on the business relevant meta object of the organization (regardless of business unit). Not only do we describe which process measure impacts which business process, we could also identify exactly how the process measure impacts the business process, where the impact occurs (location object), what are the consequences, and who is responsible (role object) and who is accountable (owner object) for acting upon this knowledge. Last, but not least, we could – if deemed necessary and/or beneficial – create a process model to build a visual representation of where these process measures would be relevant to the organization. Process models, as the name implies, are mostly used within the concept of process modelling or BPM, whereas other artefacts are used for other modelling concepts i.e. strategy, service, etc. But bear in mind, however, that a model that is independent if it is a purpose & goal model, competency model, service model, process model, application model, data model, platform model or an infrastructure model, it does make use of both the map and the matrices. The map and the matrices is our source of information; the model is how we would visualize this information. In Figure 2, we have illustrated an overview of the most common process artefacts. It is also worth mentioning that all the process templates listed are fully integrated and standardized between each other. Enabling full reusability of shared aspects occurs between the process artefacts, where 1 in Figure 2 shows the objects in the process maps and 2, the objects in the process matrices and 3 those of the process models. The specific process artefacts therefore do not only show which objects are within what artefact. It thereby specifies if it is a map, matrix or model, and it furthermore shows where the object of one artefact can be reused in another artefact. Showing where the objects have and should be integrated and standardized reveals that they are the same object.

The fact that most organizations do not have such integrated and standardized artefacts is the single source for the high cost of modelling, engineering and architecture and the low maturity of output. The purpose of having standardized Business Ontology Artefacts that address various business relevant concepts is to set out or describe how to organize and structure the viewpoints and business relevant objects associated with the various business disciplines and to bring them together to create a common understanding. As illustrated in Figure 3, the Business Ontology Models are specific representation of the real world objects.

The Business Ontology Meta Models

The Business Ontology Meta Models are the subclass of the Meta-Metamodel and have the purpose of describing the objects within the Models. The different Business Ontology Models are specific representations of the real world objects exemplified in Table 1 and 2. These objects'

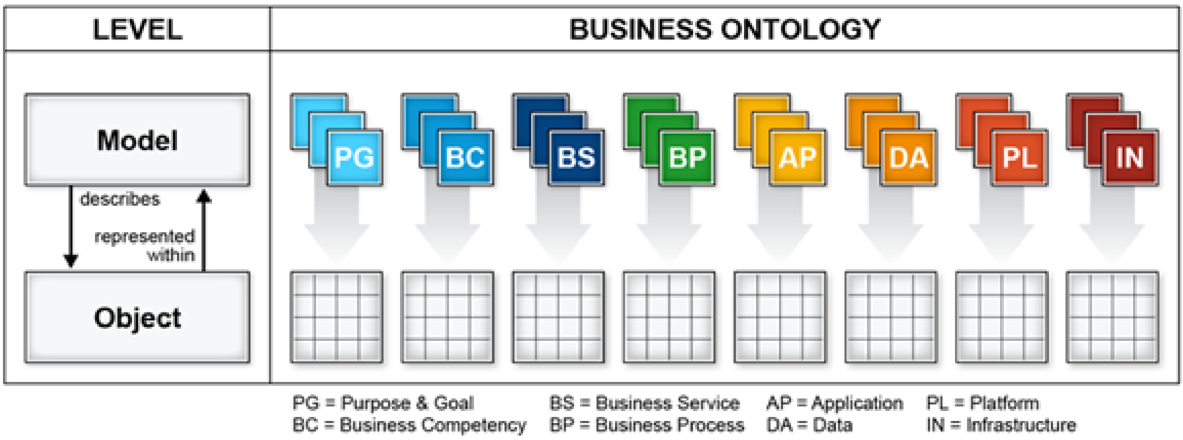
Figure 2. The most common process objects and artefacts that use these meta-objects

PROCESS (How)

OBJECTS	MAPS, MATRICES & MODELS														
	Performance (Pe)	Measurement & Reporting (MR)	Stakeholder (ST)	Business Competency/ Business Model (BC)	Operating (Op)	Object (Ob)	Workflow (WF)	Rule (Ru)	Process (P)	BPM Notations (BPMN)	Service (Se)	Application (A)	Application Service (AS)	Application Rules (AR)	Compliance (C)
Process Area (categorization)				2	1				1,2						
Process Group (categorization)				2	1				1,2	3			3		
Business Process				2	1				1,2	3			3		
Process Step									1,2	3		2	2,3		
Process Activity									1,2	3		2	3		
Events									1	3			3		
Gateways								2	1	3			3		
Object (business, information and data)						1,2				3	2				
Process Type (main, management or support)					2				1						
Process Flow (including input or output)							1,2			3	2				
Process Rules								1,2	2					2	1,2
Process Measurement (PPI)	1,2	1,2								3					
Process Owner			2		1,2				2						

1 = Map
2 = Matrix
3 = Model

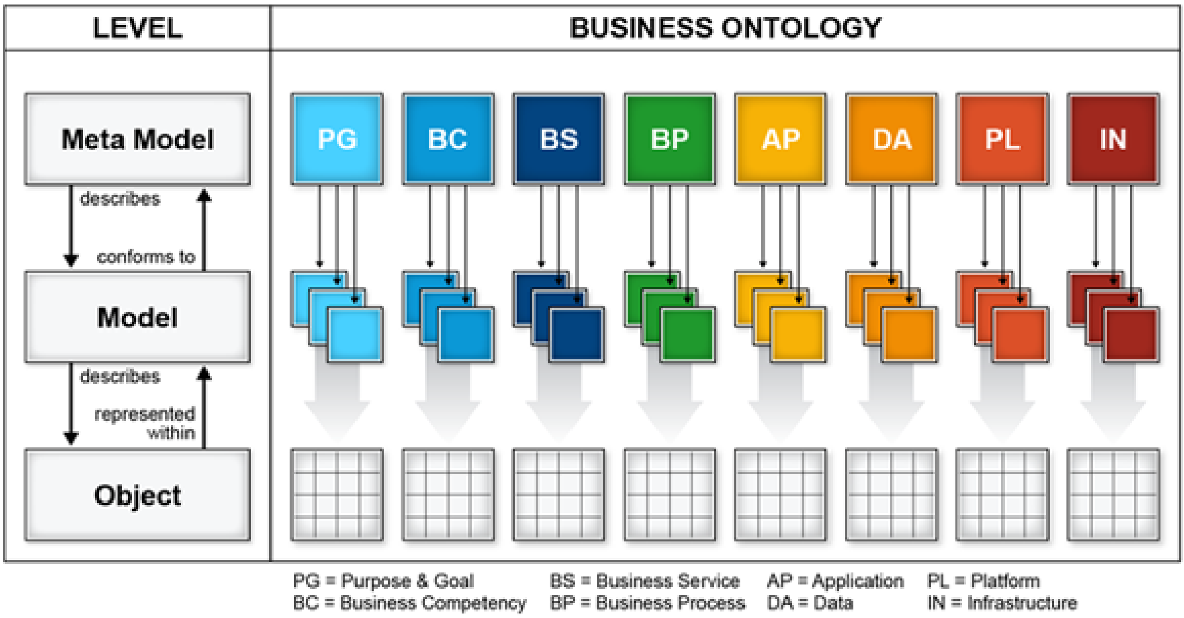
Figure 3. The Business Ontology and the relation to the objects and models



class types and subtypes can be determined through the rules of the semantic relations applied within the various models/artefacts discussed in the last section. Building integrated and standardized models that have the auxiliary concepts to produce the semantic richness needed by practitioners does however require fully integrated meta models. Meta models that incorporate multiple models/views use the semantic relations and their rules associated with the meta objects connectivity. This approach provides a structured mechanism that facilitates the developments of corporate (application) ontologies. For example, the link between the meta-object 'process' and the meta-object 'process measure' enables the practitioners to understand the performance expectations and measures associated with each process object it relates to. (practice, 2015) The process meta-objects shown in Table 1 and 2 intersect not only with multiple artefacts as illustrated in Figure 2, but also with several other relevant meta objects (e.g. organizational functions, services, risk, rules, data etc.). Consequently, they can be reused for entirely other modelling, engineering and architecture concepts besides process modelling. For example, the elicitation of risks, services and other aspects of business in several views e.g. models of business. Another example is the process meta-objects of Table 1 and 2 that relate to the process measure (performance indicator) meta-objects of table 6. Understanding the full semantic relations are considered an essential part for any practitioner working with and around various relevant enterprise modelling, engineering and architecture concepts. It is also the semantic relations that created the meta model and the meta meta model, identified through the Global University Alliance (GUA) analysis and research that provided the basis to assess the details of the business ontology, as each object that belongs to another category group can have a semantic relationship to any meta object. Consequently, a meta model specification that is missing one or more of these essential meta objects in its relationships will be considered to be malformed and incomplete. This approach is expected to provide a powerful tool to assist in the identification and capture of all relevant business aspects. As a part of our study to develop the meta model, we identified that all of the semantic relations where found in 8 groups, namely:

1. Purpose and Goal
2. Business Competency
3. Business Service
4. Business Process
5. Application

Figure 4. The Business Ontology and the relation to the objects, models and meta models



6. Data
7. Platform
8. Infrastructure.

These 8 groups became the basis of the Business Ontology Metamodels. They have the purpose of describing the objects within the Models and are the subclass of the Meta-Metamodel.

Although limited by the length allowed for this paper, we can share examples around specific patterns of meta-objects and relations that are within the mentioned groups.

1. The **Purpose and Goal Meta Model** contains the Meta-Objects relevant to the group, examples of these meta objects are: Driver (value/performance), Vision, Mission, Plan, Strategy (SBO), Goal, Objective, Value Indicator, Value Expectation, Value Proposition (S), Performance Indicator, Performance Expectation, Quality, Risk, Security, etc. All of the mentioned meta-objects relate semantically within the purpose and goal Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between performance drivers, which belong to the purpose and goal Meta Model Group and the other meta model group objects:
    - Performance Driver influences choices of Organizational Owner
    - The categorisation of Organizational Areas and Groups can be influenced by Performance Drivers
    - Performance Drivers influences the design of Business Processes
    - Events realize the various Performance Drivers
    - Performance Driver set criteria's for the direction of the Gateways
    - Performance Driver set criteria's for the execution of the Process Flow (incl. Input/output)
    - Performance Drivers set presentation criteria for the Process Role
    - Process Rules are set based on various Performance Drivers
    - Process Measurements (PPI) can be tracked and report against the Performance Drivers
    - Etc.

2. The **Business Competency Meta Model** contains the Meta-Objects relevant to the group, examples of these meta objects are: Organisational Area, Organizational Group, Organizational Function, Enterprise Capability, Resource, Actor, Role, Product, Location, Report, Timing, Revenue, Cost, etc. All of the mentioned meta-objects relate semantically within the Competency Meta Model Groups as well as with the other seven meta model groups. The relations between business competency meta model group and other meta model groups are given below:
    - Value Expectations influence decisions around Organizational functions
    - Organizational functions are directed by objects and goals
    - Organizational Functions are executed as a task within a Business Process
    - Organizational Functions create services
    - Organizational Functions can be measured with Performance Indicators (PI)
    - Compliance of organizational functions can be ensured through policies, regulations and rules
    - Etc.
3. The **Process Meta Model Group** contains the Meta-Objects relevant to the group, examples of these meta objects are: Process Area, Process Group, Business Process, Steps, Activities, Events, Gateways, etc. All of the mentioned meta-objects relate semantically within the Process Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between a business process, which belong to the Process Meta Model Group and the other meta model group objects:
    - Process Performance influences choices of Organizational Owner
    - The categorisation of Process Areas and Groups can be influenced by the organizational construct
    - Business Processes design is influences by Performance Drivers
    - Events realize the various Performance Drivers
    - Business Workflow set direction of the Gateways
    - Process Rules are set based on various Regulations, policies and guidelines
    - Process Measurements (PPI) can be tracked and report against the Goals and Objectives
    - Etc.
4. The **Service Meta Object Group** contains the Meta-Objects relevant to the group, examples of these meta objects are: Business Service, Application Service, Data Service, Platform Services, Infrastructure Services, etc. All of the mentioned meta-objects relate semantically within the Service Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between performance drivers, which belong to the Service Meta Model Group and the other meta model group objects:
    - Business Service is created by Organizational Functions
    - Business Service is realized by Business Processes
    - Business Service include Roles (users)
    - Business Service are regulated by Rules
    - Business Service is measured by Measures
    - Business Service is governed by Owners
    - Etc.
5. The **Application Meta Model Group** contains the Meta-Objects relevant to the group, examples of these meta objects are: Logical Application Component, Physical Application Component, Application Module, Application Feature, Application Function, Application Task, Application/System Report, etc. All of the mentioned meta-objects relate semantically within the Application Meta Model Groups as well as with the other seven meta model

groups. Below is an example of the semantic relations between Application Tasks, which belong to the Application Meta Model Group and the other meta model group objects:

- Requirements apply to Application Tasks
- Application Task design influenced by Value Expectation
- Application Task performance measured by Performance Indicator
- Business rules are applied to Application Tasks
- Compliance aspects partially or fully automated by Application Tasks
- Application Task partially or fully automates Business Process and Process Activities
- Gateways are automated by Application Task
- Application Task partially or fully automates business work flow (incl. input/output)
- Business Owners desire Application Task automation
- Application Task protected by Security
- Application Task bounds/bounded by Timing
- Etc.

6. The **Data Meta Model Group** contains the Meta-Objects relevant to the group, examples of these meta objects are: Logical Data Component, Physical Data Components, Data Entity, Data Objects, Data Table. All of the mentioned meta-objects relate semantically within the Data Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between Data Objects, which belong to the Data Meta Model Group and the other meta model group objects:
    - Data Object design influenced by Quality
    - Data Objects are created and consumes by Organizational Functions
    - Data Objects abide to Rules
    - Data Object enables Business Service
    - Data Object captures properties of Product
    - Data Objects are related to Business Processes and Activities
    - Data Objects changes state at an Event
    - Data Object measured by Performance Indicator
    - Data Objects are within Measurements
    - Data Object enables creation of Report
    - Data Object influences the design of Application Task
    - Data Object sequenced by Application/System Flow
    - Etc.
7. The **Platform Meta Model Group** contains the Meta-Objects relevant to the group; examples of these meta objects are: Logical Platform Component, Physical Platform Component, Platform Device, etc. All of the mentioned meta-objects relate semantically within the Platform Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between Platform Devices, which belong to the Platform Meta Model Group and the other meta model group objects:
    - Platform Device design influenced by Value and Performance Drivers
    - Devices are used by Roles
    - Platform Device subtype of Business Resource/Actor
    - Platform Device serves Location
    - Platform Devices generate and participate in a Business Process
    - Platform Device automates parts or full Business Services
    - Platform Device assumed or specified by Logical Application Component
    - Platform Device hosts Physical Application Component
    - Platform Device hosts Application Task

- Platform Device hosts Data Table
- Platform Devices participate within the Business Workflow
- Etc.

8. The **Infrastructure Meta Model Group** contains the Meta-Objects relevant to the group, examples of these meta objects are: Logical Infrastructure Components, Physical Infrastructure Components, Infrastructure Device, etc. All of the mentioned meta-objects relate semantically within the Infrastructure Meta Model Groups as well as with the other seven meta model groups. Below is an example of the semantic relations between Physical Infrastructure Components, which belong to the Infrastructure Meta Model Group and the other meta model group objects:
    - Logical Infrastructure Component design influenced by Performance Drivers
    - Logical Infrastructure Component performance measured by Performance Indicator
    - Logical Infrastructure Component selection and design influenced by Risk
    - Logical Infrastructure Component protected by Security
    - Logical Infrastructure Component serves a specific Location
    - Physical Infrastructure Components host Business Process engines (rules, measures etc.)
    - Automated Business Services reside on Physical Infrastructure Components
    - Etc.

The examples of the above mentioned semantic relations created the meta models and the meta meta model.

As a part of the Global University Alliance study and research we identified over 10.000 semantic relations that existed within most organisations, independent of size or industry. All these relationships between the objects are defined as illustrated in Figure 5 and 6 by decomposition and composition principles. The relations are structured to capture the Composition-Decomposition views in the business ontology. One such example is within the business process meta model,

Figure 5. Extract from the business process meta model composition attribute taxonomy

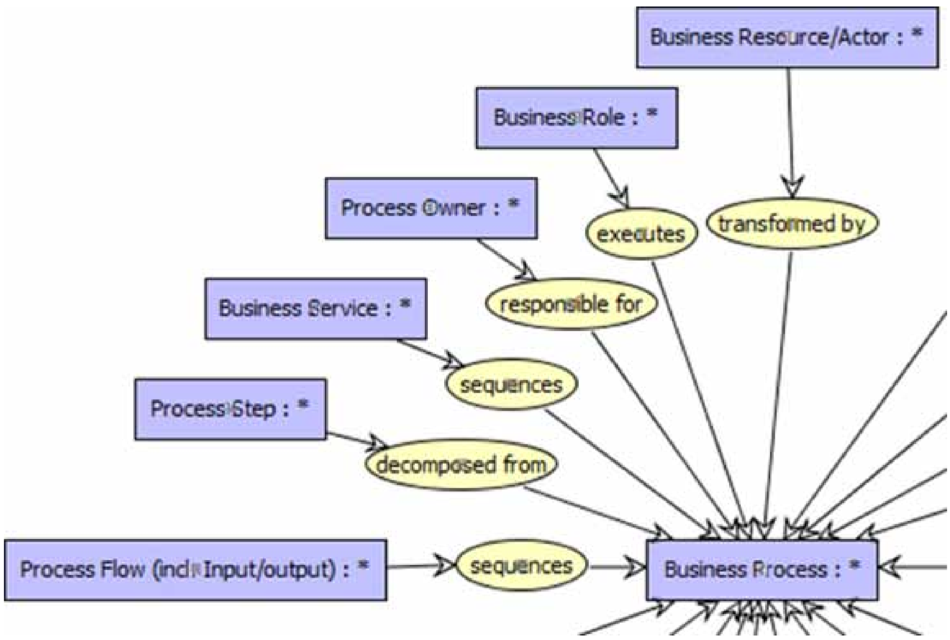
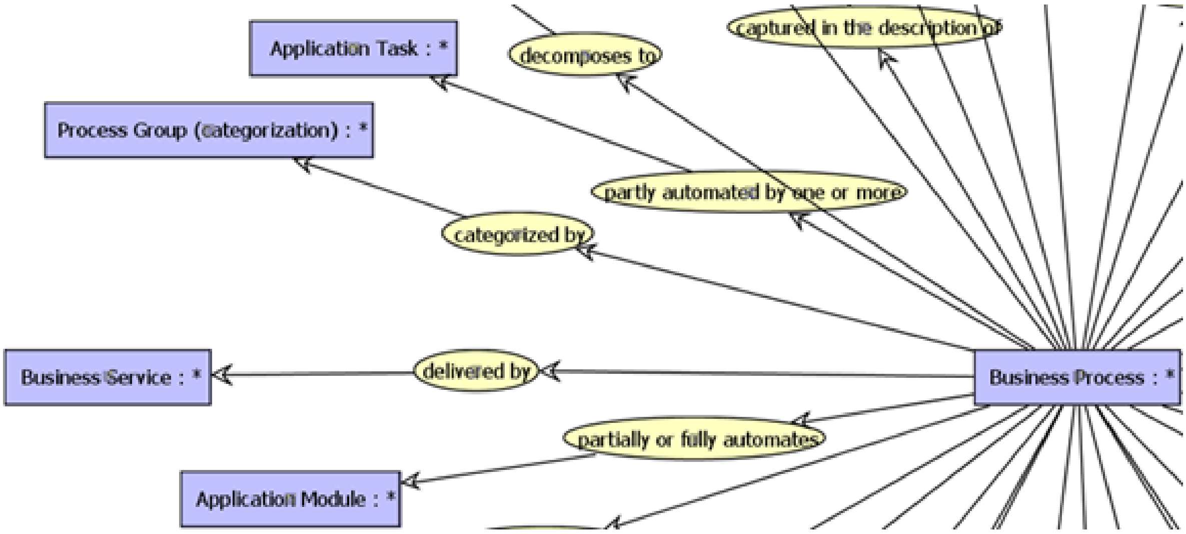


Figure 6. Extract from the business process meta model decomposition attribute taxonomy

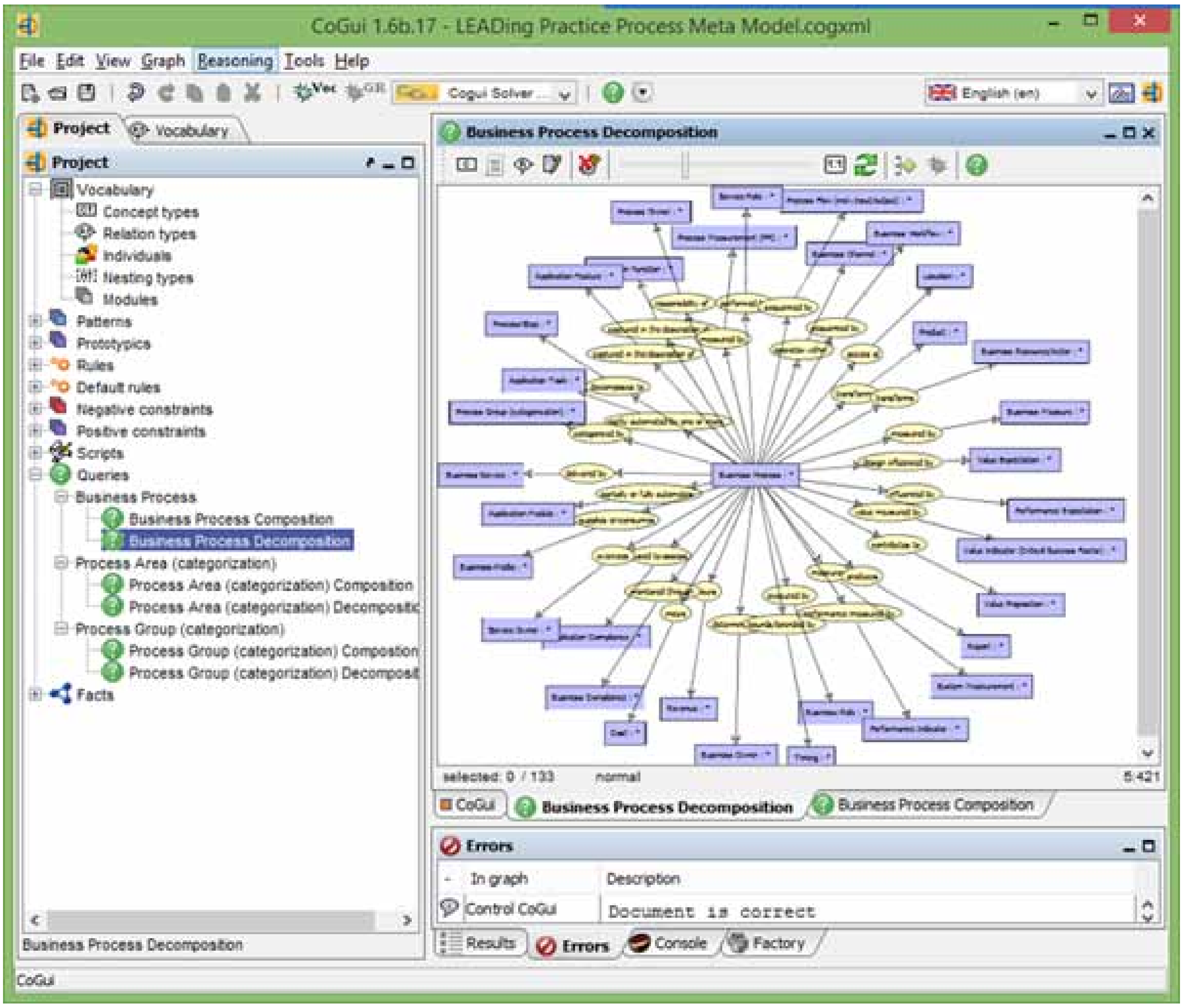


parts of which are illustrated in Figure 5 and Figure 6 for the composition and decomposition taxonomies respectively.

Meta model semantics is thereby added to these taxonomies, as each object is described by its relation to other objects through the ontological structure documented in the Business Ontology. Accordingly, for example, Business Process is delivered by Business Service. Although not shown here, Business Service is a subtype of 'Business Service Meta Object', thus properties (assertions) applied to this meta object would cascade to Business Service. Business Process is not on this hierarchical path thus would be unaffected. Of course, any properties applied to Business Layer Meta Object would affect them both. The same pattern applies to the object relations. Properties applied to super-object and relations are thereby reused at their sub levels. It also acts as the test that properties are not applied at too high a level, as that would highlight over-simplification through over-generalisation. Conversely when common properties are discovered at a common sub-level, then those can be generalised and reused over those objects. This generalisation and specialisation can be updated in the light of new best practices; notably those best practices are being applied through the Business Ontology rather than loosely on less formal foundations. The meta model understanding is assisted by how objects are linked to other objects (directly and indirectly) through their relations, thus adding context how the generalisations may be applied.

The Business ontology meta models can be explicated, illustrated and tested in tools. We have used Conceptual Graphs (CGs) through the CoGui software [Chein & Mugnier, 2008], [Polovina, 2007]. CGs provide like many other tools (such as META, SPARX, LEAD Tool, No Magic) a graphical interface and repository for first-order logic that enables the visualised objects and relations in the ontology to be articulated as a (class) hierarchy and, by linking (meta) objects to each other through their object relations, the direct and indirect interrelationships in and across the various business concepts can be discovered. It is the vehicle by which the Business Ontology and Semantics foundation can be expressed in meta models. Such an example is illustrated in the Figure 7, where using the CoGui CGs software the Process Meta Model, demonstrates a query of the business process, the Business Ontology with its detailed Meta Models can be used to query the individual meta objects semantically related. This enables the enterprise to test the conformity of their business models against the rich body of knowledge underpinned by the Business Ontology meta model and semantics.

Figure 7. Example of querying in the the process meta model

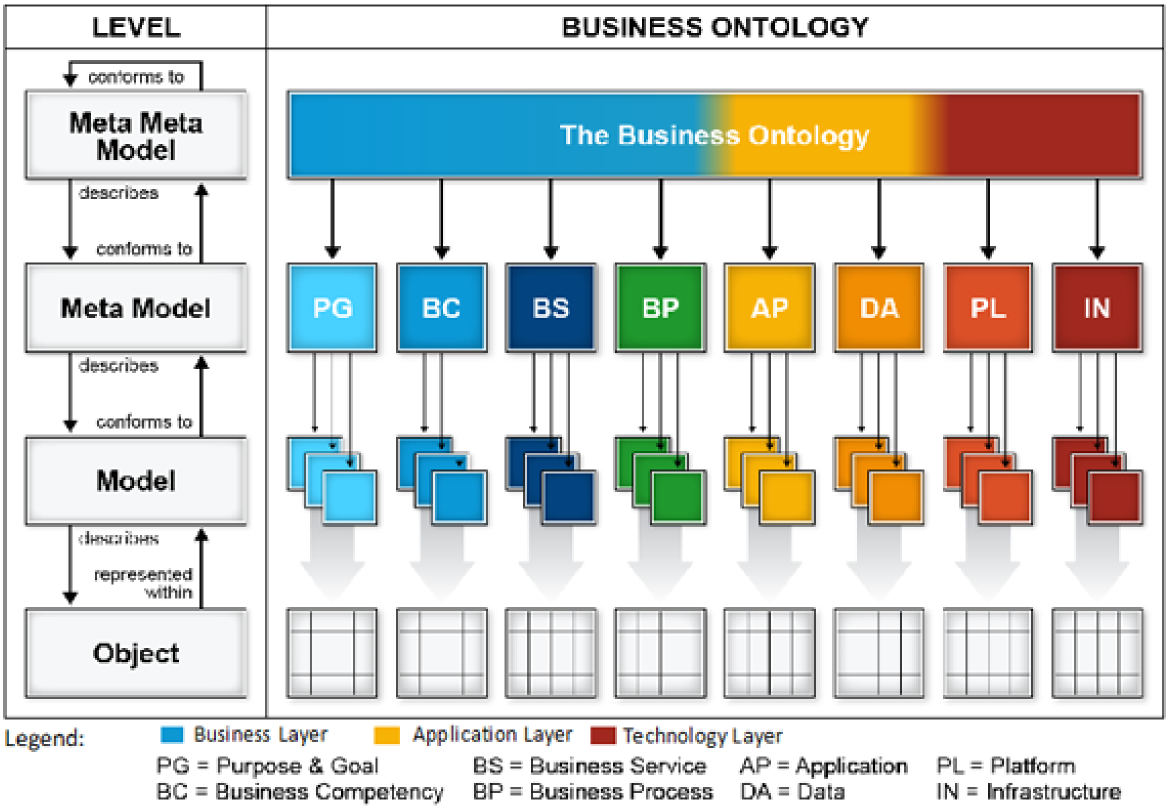


BUSINESS ONTOLOGY META META MODEL

The Business Ontology meta meta model defines the business domain, also with its relations to information concepts like applications and technology an describes the various Business Ontology meta models and their relations. The Business ontology meta meta model can just like the meta model be visually represented, enabling first-order logic that enables the visualised objects and relations in the ontology to be articulated as a (class) hierarchy and, by linking (meta) objects to each other through their object relations, the direct and indirect interrelationships in and across the various business concepts can be discovered. It is the vehicle by which the Business Ontology and Semantics foundation can be expressed in the meta meta model (see Figure 8).

Figure 9 shows an extract from the Business Meta Meta Model with a specific zoom into the process view. The process objects are shown as a stereo types, linking subtypes e.g. process steps, process activities (sub-objects) to the semantic possible related objects e.g. process rules, process owner. These relationships are polymorphic; properties affecting a super-object will cascade to *all* its sub-objects. Thus if we make an assertion about one part of the meta meta model i.e. the Process Meta Object of the meta meta model for example then that assertion will also apply to all its sub-objects. Note it does not apply the other way, thus for example an as-

Figure 8. The business ontology levels



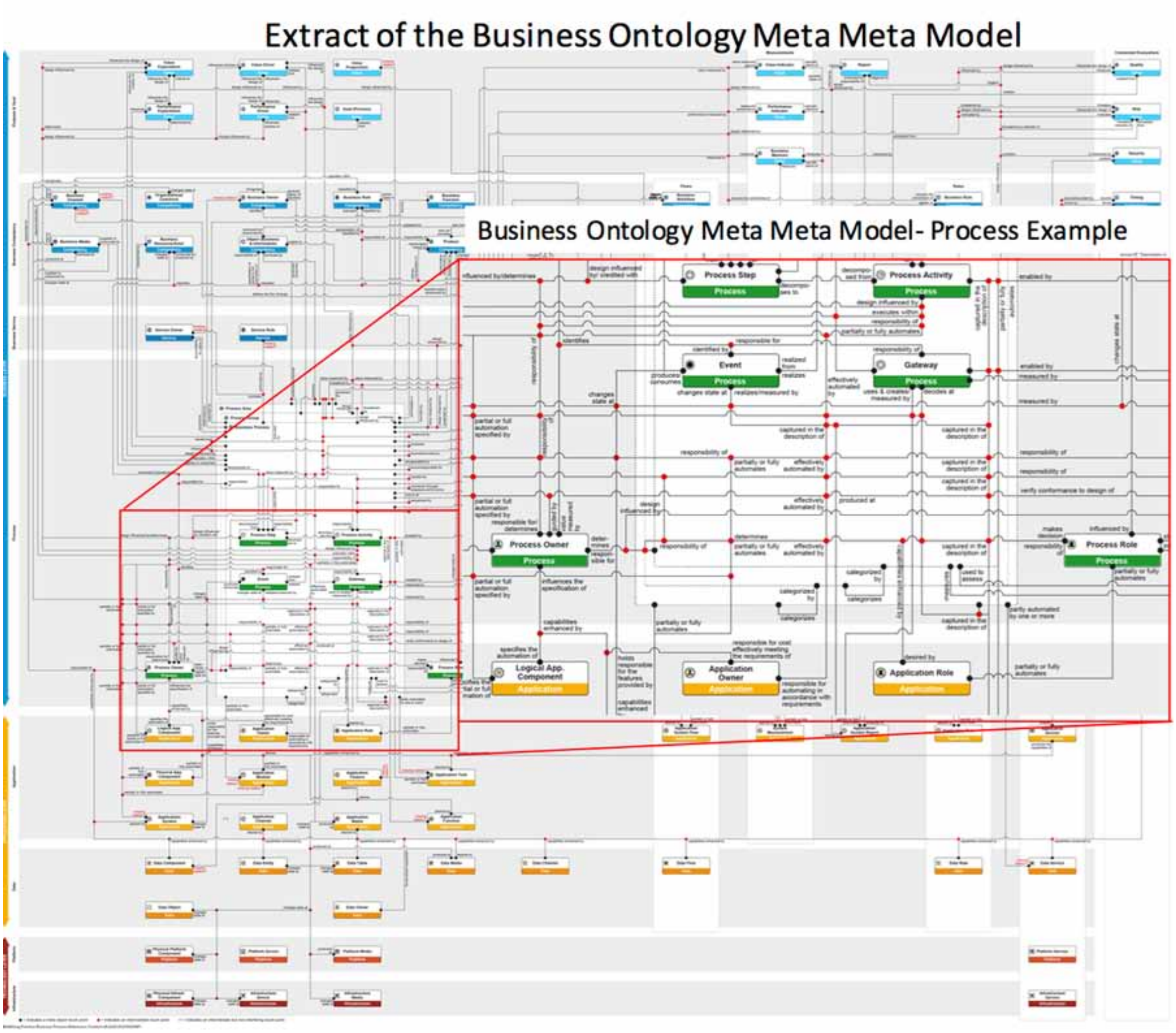
sentation made about a process owner will only affect that object. Otherwise it would wrongly affect everything that comes under all the Process Meta Objects and the Business Layer Meta Objects and therefore to the entire meta meta model! Consequently, we have the ability to apply reasoning at multiple levels and layers i.e. business, application and technology', of the Business Ontology and the meta meta model.

SUMMARY AND CONCLUSION

The business ontology is an empiric ontology, meaning that its roots lie in practice, as it and was developed by practitioners documenting their practical knowledge of the field rather than having knowledge originating from theory and academics specialized in a restricted area of business. Consequently, it is one of the few ontologies that has the ambition to cover all aspects of business.

In order to attain the desired level of completeness, the ontology is complemented with elicitation support such as guiding principles for creating, interpreting, analyzing and using enterprise engineering, modeling or architecture concepts within a particular domain and/or layers of an enterprise or an organization. The business ontology also offers a set of principles, views, artifacts/templates that have detailed meta-object relations and rules that apply to them e.g. how and where can the enterprise engineering, modeling or architecture concepts be related (and where not). As the business ontology has the ambition to support a large community, it is vendor neutral or agnostic as it can be used with most existing frameworks, methods and or approaches that have any of the meta-objects mentioned in this document. The mapping can be found online.

Figure 9. Extract of the Business Ontology Meta Meta Model illustrating the meta objects and the semantic relations across the layers



(LEAD, 2015) As the business ontology has been formalized in the OMG's MOF referred to earlier, it can be considered a Platform Independent Model (PIM), which stresses its neutrality.

By sharing knowledge within the community, practitioners have found and documented repeatable patterns for process related objects, structures as well as artifacts. This has led to the identification of cross-domain Meta Model Groups that provide additional structure to the ontology. Each of these Meta Model Groups has been formalized as a meta model that is orthogonal to the other meta-models, yet intersects with them through the meta meta model.

The ontology is also complemented with a framework that helps practitioners transform their (ontological) knowledge of an enterprise engineering, modeling or architecture subject into specific viewpoints i.e. models and (new) working methods. These models can be formalized in various models e.g. stakeholder map, operating model, value model, information model etc., while the working methods are the ends of which the data can be formalized at the meta object level. To be able to cope with the complexity of the real world, the framework offers practitioners the ability to (temporarily) simplify their (mental) models by taking partial views on their knowledge. These viewpoints, which are embedded in the meta models, are especially useful in the context of enterprise engineering, enterprise modeling, and enterprise architecture.

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