Rules and Software Architecture

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Abstract: The lack of a clear articulation of the nature of business rules hinders the identification of business rules in enterprise architectures and software architectures. This paper critiques the prevailing grounding of business rules in predicate logic as responsible for the failure of many architects to clearly identify business rules within their organizations. While predicate logic is a powerful basis for algorithms, for computation, it is an inadequately expressive foundation for identifying rules as distinct from facts, terms and processes. To express the nature of business rules, it is necessary to conduct an ontological analysis, rather than a logical analysis. This paper proposes a new basis for rule design in the notion of social rules by philosophical ontologist John Searle, with specific examples.
Keywords: business rules, ontology, enterprise architecture, predicate logic, first order logic.

1. Introduction

The first line of the Business Rules Manifesto reads: "Rules are a first-class citizen of the requirements world." [9] However, that the majority of enterprise systems lack a business rules component indicates that rules are still viewed as second-class citizens. This paper addresses the lack of clarity about the nature of business rules to help software architects identify more easily the rules already existing in their organizations.

Existing best practices for software design anchor the identification of architectural elements in the identification of distinct real-world elements. (Note 1) The Zachman Framework, for example, attempts to describe a framework for enterprise architecture in which "each of the architectural representations differs from the others in essence, not merely in level of detail". [8] In this framework, the data model implemented in a database is rooted in a "list of things important to the business", while program structure implemented in a software program is rooted in a "list of functions the enterprise performs". [2] In other words, the processes that describe functions of actors in the real-world are the basis for applications, and the things that are important to these processes are the basis for data model entities.

Despite extensive work on business rules, however, there is no similarly intuitive definition of the real-world elements that form the basis for business rules in system architecture. While every enterprise system includes rules implicitly, they are rarely isolated conceptually, and instead are conflated into the process or data description and, consequently, implemented in the application code or the database. This lack of adoption is partially due to a common architecture dualism – data and processes – that leaves no conceptual room for business rules. This paper seeks to draw on work done in philosophical ontology to more clearly articulate the scope of applicability of business rules.

This paper reviews the existing work to ground the design of business rules, which it critiques as grounding business rules in what is possible logically, not ontologically. Specifically, rules become formally indistinguishable from the definitions of predicate terms used by rules when logical implication (IF…THEN) provides the formal grounding of rules. The paper then proposes a new basis for rule design in the notion of social rules by philosophical ontologist John Searle. While current views of business rules see them as constraining facts, the analysis below affirms this notion as true logically, but inadequate ontologically. The result of the ontological analysis below is a definition of business rules according which constitutive rules generate and constrain *terms*, regulative rules constrain *activity*, and both types of business rules thus only *indirectly* constrain facts.

2. Business Rules Currently Defined

The Object Management Group adopted the SBVR standard (Semantics of Business Vocabulary and Business Rules) for business rules in 2005. "However", as one recent commentator noted, "even in this impressive piece of work, the core notions appear not to be defined as crisply as one would wish." [1] Business rules are currently defined by standards bodies and vendors of business rules engines in terms that are too broad. When definitions of business rules are too broad, enterprise architects can fail to identify specific business rules in their organization as distinct from data and processes.

For example, the Business Rules Group offers the following definition of business rules.

> A directive that is intended to influence or guide business behavior. Such directives exist in

> support of business policy, which is formulated in response to risks, threats or opportunities. [3]

Directives are instructions, and are much broader in scope than business rules. Faced with this definition, few enterprise architects are willing to divide their architecture into data, process, and directives. Similarly, Ross defines business rules as follows.

> Business rules are literally the encoded knowledge of your business practices. [3]

While this definition seeks to distinguish business rules from business practices, the basis of this distinction is certainly more precise than "encoded knowledge". Generic definitions are most often found in those provided by the vendors of business rule engines. Fair Isaac, for example, asserts that "Business rules can be anything your organization uses to make an operational decision." [11]

3. Survey of Theoretical Foundations of Business Rules

What accounts for the overly broad definitions given to business rules by the vendor and consulting community? The answer lies in the theoretical basis provided for business rules, which grounds business rules in various structures provided by first-order logic. The result is a scope for business rules that encompasses all that is *logically* possible within conditional or modal statements in first-order logic, without being limited by what is *ontologically* possible within an ontology of rules (such as is provided by Searle). Below is an overview of the current grounding of business rules in first order logic, followed by a discussion of the problematically broad scope this affords to business rules.

All theoretical foundations provided for business rules are united in the conception of business rules provided by the Business Rules Manifesto: "Terms express business concepts; facts make assertions about these concepts; rules constrain and support these facts." [9] Terms, facts and rules are all grounded in first-order logic, also known as predicate calculus.

Ross explains in his influential and helpful *Principles of the Business Rule Approach* that "the fundamental ideas of business rules are directly grounded in the basic constructs of predicate calculus," [3] and more specifically, "the central idea in predicate calculus – predicates – provide the formal basis for facts in the business rule approach". [3] Predicate calculus takes a functional approach to predication, by treating predicates as functions that map bare particular instances (x) to a predicate class of instances (F(x)). This hard distinction between class terms and terms for bare particulars or naked instances is central to predicate logic. For example, the fact "Acme Supply is a customer" is denoted in predicate logic as C(x), where C=Customer and the function maps to true when x=Acme Supply. Ross explains that "facts are taken to be true propositions in the sense of predicate calculus." [3]

The terms of facts are thus to be understood as the different roles played by symbols in predicate logic. Ross explains this in his theoretical discussion of terms: "In expressing rules (and, indeed, for predicate calculus in general), formal theory prescribes that a term must be exactly one of the following three kinds:…an individual thing…[such as] a particular person, place, item, concept, and so on – for example, 'Mary,' 'Memphis,' 'gold,' true, 5, and so on,…a variable…[or] a function". While a function corresponds to a logical connector such as + or -, "the name of an individual thing corresponds directly to an individual instance, and the name of a variable corresponds directly to a class. We mean *instance* and *class* in the straightforward sense of predicate calculus". (note 2) Ross provides as examples of classes, "person, city, metal, of-age and rank". [3]

But what terms count as instances and what terms count as classes? 'Mary' is cited as an instance, but isn't 'Mary' really a class term, specifically, M(x) where M=the class of all things named Mary? Why is name part of an instance while gender, for example, is a class to which an instance belongs? Perhaps this is what is meant by Ross and the name 'Mary" is used as an easier indication of a bare instance than simply x or 'thing', but what about 'gold', true and 5? Why is 'gold' an instance but 'metal' is a class? In other words, how can these instance terms express individual instances as distinct from classes, when a class is used to identify the instance? First order logic has difficulty identifying an instance as anything other than x or a 'thing' when everything about the instance has been stripped from the instance as so many classes. (note 3) While this point is not in contradiction to Ross' overall theory, but merely a point of inconsistency, it is a harbinger of greater problems to come.

Because of the indeterminate nature of bare instances, all meaning of facts (true propositions) in first order logic ultimately rests on the definitions of the class terms. Ross appropriately emphasizes the importance of such term definitions. All class terms must be basic, atomic and knowable, for Ross, and be defined as specifically as possible, with definitions managed by an analyst (referred to as a terminologist). As an example of the importance of defining terms, Ross cites a company with "six different (and conflicting!) definitions of *customer* from different parts of his organization". In such scenarios, explains Ross, a company must settle on a single definition, such as: "*Customer*: An organization or individual person that has placed at least one paid order during the previous two years". [3]

Rules, in this scheme, build on facts by constraining and supporting them. This understanding of rules is based on the form of logical implication expressed in predicate logic.

> At a theoretical level, rules are based directly on predicate calculus. More specifically, they are the IF-THEN connective of predicate calculus

(also known as the *implication connective* or *logical implication*). [3]

Ross uses the example – *If manager, then salaried employee* – to demonstrate the three types of business rules. This would be expressed in first order logic (using natural language instead of logical symbols) as follows: FOR ALL (x), IF M(x), THEN S(x) AND E(x), Where M=Manager, S=Salaried and E=Employee. When this example is defined as a *rejector rule*, then any newly introduced facts that would violate this rule (a manager who is not salaried or not an employee) are rejected from the system. When this example is defined as a *projector rule*, then any newly introduced fact that an employee is a manager would generate a deduced fact that the employee is salaried. When this example is defined as a *producer rule*, then it is used to query the factbase to learn if all managers are in fact salaried employees. These three types of rules are the three possible roles played by IF-THEN logical implications. [3] (note 4)

However, when placed side by side, the rule – "*If manager, then salaried employee*" – and the term definition – "*Customer*: An organization or individual person that has placed at least one paid order during the previous two years" – don't seem to play fundamentally different roles in an enterprise architecture. In fact, when the term definition is rephrased – *If organization or individual person and if at least one paid order placed during previous two years, then customer* – they appear to play identical roles. In other words, when rules are understood on the basis of the IF-THEN structure of logical implication and terms are understood on the basis of class terms in predicate logic and their definitions, *then rules formally encompass term definitions as well*. Given this grounding of rules in the structures of first order logic, one understands better the broad definitions used by the consulting and vendor communities in describing business rules, and the lack of understanding by enterprise architects of where business rules can be found in their own organizations.

Prominent ontologist Barry Smith makes this same argument in his important article, "Against Fantology".

> A dark force haunts much of what is most admirable in the philosophy of the last one hundred years. It consists, briefly put, in the doctrine to the effect that one can arrive at a correct ontology by paying attention to certain superficial (syntactic) features of first-order predicate logic as conceived by Frege and Russell. More specifically, it is a doctrine to the effect that the key to the ontological structure of reality is captured syntactically in the 'F*a*' (or, in more sophisticated versions, in the 'R*ab*') of first-order logic, where 'F' stands for what is general in reality and '*a*' for what is individual. Hence "fantology". Because predicate logic has exactly two syntactically different kinds of referring expressions — 'F', 'G', 'R', etc., and '*a*', '*b*', '*c*', etc. — so reality must consist of exactly two correspondingly different kinds of entity: the general (properties, concepts) and the particular (things, objects), the relation between these two kinds of entity being revealed in the predicate-argument structure of atomic formulas in first-order logic. [5]

While the SBVR standard and Dietz both seek to ground rules in the structures of modal logic as opposed to those of logical implication, the statements that can be made in modal logic are also far broader than what is usually meant by business rules and encompass the definitions of class terms. [1]

Adoption of business rules by enterprise architects would expand if architects could identify rules as intuitively as they can currently identify processes and entities. This requires an understanding of business rules not in terms of the logical possibilities of a particular structure of logic, but the more expressive ontological possibilities that are determined through an ontological analysis of rules. The remainder of this paper seeks to enable such intuitive identification of rules by drawing upon the work of philosophical ontologists towards an intuitive understanding of rules.

4. Ontology of Social Rules

John Searle attempts a philosophical reflection upon social reality in his landmark text, *The Construction of Social Reality*. [4] Social reality consists, Searle contends, of facts and rules. Already, one can see that Searle and the Business Rules Group are on common ground ("rules constrain and support…facts"). Searle proceeds to develop this view of social reality.

Facts are either brute facts or social facts. Brute facts are the physical facts in the world that are objective, and include such things as trees, buildings and cars. Social facts build on brute facts by assigning a role to brute facts which they play in a certain social context. A social fact could also be called an institutional fact, because it relies on the institutional context of a brute fact. For example, the value of a ten-dollar bill is a social fact because it relies on a social agreement. In the same way, the events of a couple dozen men throwing a ball at each other are brute facts, but ones which become social facts when encountered within the institutional context of baseball. As Searle summarizes the distinction, "Brute facts exist independently of any human institutions; institutional facts can exist only within human institutions." [4]

Rules are of two types: regulative and constitutive. Regulative rules regulate activities. Driving on the correct side of the road is an example of a regulative rule. Constitutive rules, on the other hand, create the very possibility of an activity. Searle provides the example of chess.

> Thus the rules of chess do not regulate an antecedently existing activity. It is not the case

> that there were a lot of people pushing bits of wood around on boards, and in order to prevent them from bumping into each other all the time and creating traffic jams, we had to regulate the activity. Rather, the rules of chess create the very possibility of playing chess. The rules are *constitutive* of chess. [4]

Institutional facts rely for their existence on both brute facts and constitutive rules. The structure of a constitutive rule, for Searle, is "X counts as Y in context C". That is, a brute fact is assigned an institutional role, becomes an institutional fact, when certain conditions are present. Searle provides criminal law as an example.

> The whole point of the criminal law is regulative, not constitutive. The point is to forbid, for example, certain antecedently existing forms of behavior such as killing. But to make the regulations work, there must be sanctions, and that requires the imposition of a new status on the person who violates the law. Thus the person who kills another (X term), under certain circumstances (C term), and is found guilty of so doing is now assigned the status of "convicted murderer" (Y term, and hence, institutional fact); and with that new status come the appropriate punishments. Thus the regulative "Thou shalt not kill" generates the appropriate constitutive "Killing, under certain circumstances, counts as murder, and murder counts as a crime punishable by death or imprisonment." [4]

Social rules, for Searle, can thus be found in every social situation, as either regulative or constitutive of the activity in that context. Business is, if nothing else, a social activity. Enterprise architects applying Searle's ontology will find social rules present in every business context. One could say that business rules are a particular type of social rule and are now able to emerge as first-class citizens in one's enterprise architecture.

5. Business Rules as Social Rules

With the foregoing ontological analysis of rules, we would make two important modifications to the prevailing theory of business rules.

First, a distinction should be made between brute terms and facts on the one hand and institutional terms and facts on the other. Clearly a customer is not a brute term. In the hands of Searle's ontology, Ross' definition of customer becomes a constitutive rule - *An organization or individual person that has placed at least one paid order during the previous two years counts as a customer* – in which the brute terms are organization, individual person, time and order, and the institutional term is customer. Individual persons and organizations (social groups, or societies) are brute physical terms that are intuitively basic, atomic and knowable to all. This grounding of ontology in what actually and merely exists in positive reality is central to ontology as the science of existence, of being. When ontological analyses do not begin with existence (with brute facts in Searle's terminology), it slips into essentialism, which asserts as basic entities which are derived.

While the distinction between brute and institutional facts provide hard criteria for determining whether terms are in fact basic and atomic (hard criteria which Dietz argues are missing from Ross' treatise), Ross in fact alludes to this distinction of brute facts in his discussion of defining terms. "Some approaches recommend that fundamental terms used in exactly their real-world sense (for example, person, time, and so on) need not be defined explicitly. This guideline can be followed with due caution". [3]

Second, a distinction should be made between constitutive rules which generate and constrain the institutional terms used in institutional facts, and regulative rules which constrain institutional activity, that is, transitions in those institutional facts. Working with the same example of a constitutive rule - *An organization or individual person that has placed at least one paid order during the previous two years counts as a customer* – a regulative rule would constrain the activity of customers - *if a customer purchases more than $100 worth of goods, shipping is free*. Notice that, while the Business Rules Manifesto asserts that "rules constrain and support…facts", in this ontology rules are only indirectly related to facts. Constitutive rules generate and constrain the institutional terms used in facts, while regulative rules constrain institutional activity. In other words, from an ontological perspective regulative rules are primarily dynamic constraints (constraints on transition between fact states), and not static constraints (constraints on the existence of certain facts). While many regulative rules can be analyzed down to static constraints, their primary ontological role is to regulate the activity, and thus state transitions, of the organization. The examples below expand on the examples provided thus far.

Brute Terms: *Individual; Organization; Time; Order*

Institutional Terms & Facts: *Customer; Employee; Manager; Person with Credit Score; Credit Rating Organization*

Constitutive Rule: *An organization or person that has placed at least one paid order during the previous two years counts as a customer; An organization that calculates credit scores of persons or organizations counts as a credit rating organization; A person counts as a person with credit score when a credit rating organization tracks the person*

Regulative Rule: *If a customer purchases more than $100 of goods, then shipping is free; If a person has a credit score of under 550, then the person cannot purchase goods*

In summary, the ontology provided by Searle of brute and institutional terms and facts, and constitutive and regulative rules, provides a more intuitive theoretical basis for the identification of rules by enterprise architects and those in the consulting and vendor communities. Enterprise architects can identify the brute, physical facts in their organizations (people with names and birth dates, buildings and other assets with addresses, etc) and know that remaining terms will be institutional (and thus subject to change) and must be mediated by constitutive rules. When such constitutive rules are collapsed conceptually into related business processes, or when the institutional terms generated by constitutive rules are collapsed into a catalog of all terms, then constitutive business rules are hidden in process models and in data models, respectively. Furthermore, enterprise architects can identify the regulative rules that constrain the activity of the organization in order to achieve its goals. When such regulative rules are collapsed conceptually into the processes they regulate, then they are hidden in process models.

6. Conclusion

While business rules have received a lot of support from vendors and standards bodies, they are still not well understood by most enterprise architects and software designers. This lack of general understanding is due to lack of clear articulation of the nature of business rules, so that enterprise architects can intuitively locate them in their organizations. This paper has reviewed the existing work to provide working definitions of business rules, and then proposed a new basis for rule design in the notion of social rules by philosophical ontologist John Searle. This new definition of business rules, as one case of social rules, should help enterprise architects and software architects more intuitively identify business rules in their organizations.

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[11] http://www.fairisaac.com/fic/en/our-approach/business-rules/

Notes

1. For example, the Business Rules Groups writes that "techniques of systems analysis" are intended "to provide methods for describing many aspects of a business or government agency". [10]
2. Ross explains later, "I will use *instance term* (for the name of an individual thing) and *class term* (for the name of a variable) in order to stay as close as possible to the true sense of predicate calculus." [3]
3. This weakness of first order logic is argued in detail by logician Henry Veatch in [6] and [7].
4. "In everyday English, rule is often assumed to carry the sense of constraint – that is, that something must be true or enforced. In formal logic, however, rule (that is, logical implication) does not necessarily carry that sense. The expression of a logical implication acts as a constraint only if we define it that way. Otherwise it is merely a test or query." [3]