Proving the System

Global Standard Machine-Readable Logic Framework for Business

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"He who loves practice without theory is like the sailor who boards a ship without a rudder and compass and never knows where he may cast." *Leonardo da Vinci*

"It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than a new system. For the initiator has the enmity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who gain by the new ones." *Niccolò Machiavelli*

Executive summary:

- XBRL-based financial reports are logical systems[1]. Said another way, such reports are not arbitrary, haphazard, illogical, or random.
- Changing one part of a system usually affects other parts of that system in predictable ways. This characteristic can be leveraged.
- A logical system is a set of statements that, when the logical system is functioning properly, are correct, consistent, valid, and sound. If the logical system is fully expressed, then the system is flexibly but also predictable. Because it is predictable, it is reliable.
- The set of all statements act as a "parity check" or a "check sum" to make sure that the system is functioning properly.
- If two different people can look at the same set of statements and reach the same conclusion as to whether the system is properly functioning, that is a useful feature.
- This idea is similar to double-entry accounting.
- If this idea can be scaled, then it would be of benefit to enterprises who seek to leverage logic to get computers to perform work.

[1] Charles Hoffman, *Understanding and Expressing Logical Systems*, http://xbrl.squarespace.com/journal/2019/9/25/understanding-and-expressing-logical-systems.html

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Changing one part of a system usually affects other parts of that system in predictable ways. Understanding how a system change impacts other aspects of the system is helpful in proving how to effectively control allowed system variability. If such variability is effectively controlled then a system can be both flexible and proven to be properly functioning.

The ability to accurately predict the impact of changes is what every system designer should be after: a well-defined system that by design provides for desired flexibility and predictability and thus performs with reliability.

An XBRL-based financial report is not only a machine-readable system; it also is a machine-readable logical system and has the potential to be well-defined logical system. A well-defined logical system, when fully expressed, should be properly functioning and demonstrably consistent, valid, sound, and complete.

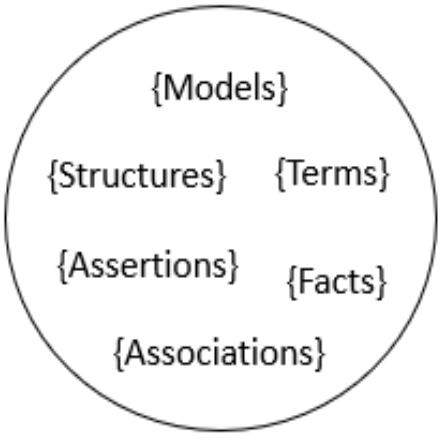
Theory

Predicate logic[2] is based on and extends propositional logic[3]. Propositional logic which is also known as statement logic is based on the truth value of some set of one to many propositions or statements. A statement is defined as "a proposition, claim, assertion, belief, idea, or fact about or related to the universe of discourse." A financial report is a logical system that contains a set[4] of statements[5]. That set of statements is essentially a "chain" or chain of reasoning[6].

As I explained[7], there are a plethora of terminologies used by philosophers, electrical engineers, designers of complex systems such as nuclear power plants, computer scientists, knowledge engineers, and other domains that have a need to explain logical systems in machine-readable form. It is my observation that each different approach to describing a formal system tends to have its own terminology for explaining what seems to be exactly the same thing, the explanations tend to not always be complete, and the explanations tend to be harder than necessary for a business professional to understand. However, the essence of what each

[2] Wikipedia, *First-order Logic*, https://en.wikipedia.org/wiki/First-order_logic
[3] Wikipedia, *Propositional Calculus*, https://en.wikipedia.org/wiki/Propositional_calculus
[4] Wikipedia, *Set Theory*, https://en.wikipedia.org/wiki/Set_theory
[5] *Understanding and Expressing Logical Systems*, http://xbrl.squarespace.com/journal/2019/9/25/understanding-and-expressing-logical-systems.html
[6] Constructing a Chain of Reasoning, http://xbrl.squarespace.com/journal/2019/9/26/constructing-a-chain-of-reasoning.html
[7] *Understanding and Expressing Logical Systems*, http://xbrl.squarespace.com/journal/2019/9/25/understanding-and-expressing-logical-systems.html

domain is doing is representing sets of statements that describe the models, structures, terms, associations, assertions, and facts that form a theory about some logical system.



And so, a **logical system is the set of statements** that can be chained together using logical connectors. These sets of models, structures, terms, assertions, associations, and facts are all forms of statements or propositions. The set of statements can be proven to be consistent, valid, sound, complete, and fully expressed; then the financial report logical system can be proven to be properly functioning. The financial report is then in equilibrium. If one statement within the system is changed in some way, it is typically the case that some other statement likewise must be changed in order to keep the financial report logical system of statements in equilibrium.

A well-defined logical system, when **fully expressed** and in equilibrium, should be properly functioning and demonstrably **consistent**, **valid**, **sound**, and **complete**.

- **Consistent**: No statement of the logical system contradicts another statement within that logical system.
- **Valid**: No false inference (logical deduction of a statement) from a true premise is possible.
- **Complete**: If a statement is true, then that statement can be proven; i.e. all statement exists in the system.
- **Sound**: If any statement is a theorem (an IF…THEN assertion) of the logical system; then the theorem is true.
- **Fully expressed**: If an important term exists in the real world; then the term can be represented within the logical system.

It is desirable to have a well-defined logical system that is fully expressed that is proven to be properly functioning and demonstrably consistent, valid, sound, and complete. This equilibrium is similar to the equilibrium of double-entry accounting.

More importantly, if business professionals can reliably create such machine-readable logical systems that will very likely have a very positive and significant impact on the functioning of an enterprise just as double-entry accounting had a significant impact on the enterprise.

An XBRL-based financial report which is comprised of an XBRL taxonomy plus an XBRL instance can borrow this idea from double-entry accounting. While the notion of a "double-entry XBRL taxonomy" is not a perfect one (and might even make knowledge engineers cringe), it does make an important point between allowed variability and the rules necessary to control and manage that variability. When information is added to an XBRL taxonomy, other information must also be added in order to control, manage, and ultimately channel business professionals to success.

And so, if a new term is added; then one or more new associations or assertions will likely also need to be added.

To be crystal clear, when I say logical system, I mean a **finite deductive first-order logic system**[8]. The point is to create a logical system that has high expressive capabilities but is also a provably safe and reliable system that is free from catastrophic failures and logical paradoxes. Axiomatic (Zermelo–Fraenkel) set theory[9] is used as contrast to naïve set theory[10]. All associations are expressed as directed acyclic graphs[11] that do not cause cycle problems. The closed world assumption[12] is made so that decidability is not a problem and to be consistent with relational databases. Negation as failure[13] is assumed to be clear. The unique name assumption[14] is made to be clear. Horn logic[15] to avoid logical paradoxes.

The object here is to agree on a logical system such that the logical system can be leveraged to perform practical, reliable, dependable work. This logical system could be limited to only financial reports. However, I believe that it could be expanded to the more general business report; the financial report being a specialization of the more general business report. The system must be consciously unambiguously and completely as is necessary and practical in order to achieve a specific goal or objective or a range of goals/objectives. The system should error on the side of practicality and safety and perhaps sacrifice expressiveness and therefore functionality if necessary.

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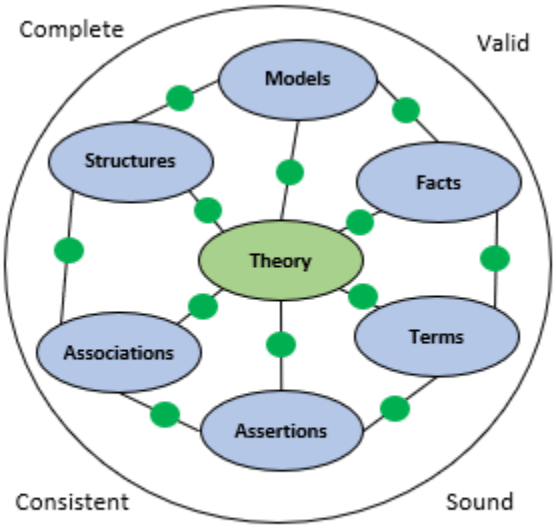
[8] Wikipedia, *First-order Logic, Deductive System*, https://en.wikipedia.org/wiki/First-order_logic#Deductive_systems
[9] Wikipedia, *Set Theory, Axiomatic Set Theory*, https://en.wikipedia.org/wiki/Set_theory#Axiomatic_set_theory
[10] Wikipedia, *Naïve Set Theory*, https://en.wikipedia.org/wiki/Naive_set_theory
[11] Wikipedia, *Directed Acyclic Graph*, https://en.wikipedia.org/wiki/Directed_acyclic_graph
[12] Wikipedia, *Closed World Assumption*, https://en.wikipedia.org/wiki/Closed-world_assumption
[13] Wikipedia, *Negation as Failure*, https://en.wikipedia.org/wiki/Negation_as_failure
[14] Wikipedia, *Unique Name Assumption*, https://en.wikipedia.org/wiki/Unique_name_assumption
[15] Wikipedia, *Horn Logic*, https://en.wikipedia.org/wiki/Horn_clause

Depicting all that I am trying to articulate graphically, perhaps it might look something like this:



Properly Functioning System

Now, this graphic communicates an idea, not a logical thing that can be measured. I would like to come up with a better graphic.

Think of this as a *complete* set of statements that have to be *consistent* and everything has to be *valid* and if you achieve this then the system is *sound*. If all those four constraints are met and the system is *fully expressed*, then the **system is functioning properly**. Two different people can look at the same set of statements and reach the same conclusion.

What is more, you can prove that the system is functioning properly, the full set of statements is like a “parity check” or a “check sum”.

I see this as having similarities to the double-entry accounting system.

Double-Entry Accounting

Single-entry accounting is how 'everyone' would do accounting. In fact, that is how accounting was done before double-entry accounting was invented. Double-entry accounting adds an additional important property to the accounting system, that of a clear strategy to identify errors and to remove the errors from the system. Even better, double-entry accounting has a side effect of clearly firewalling errors as either accident or fraud. This then leads to an audit strategy. Double-entry accounting is how professional accountants do accounting. Double-entry accounting was the invention of medieval merchants and was first documented by the Italian mathematician and Franciscan Friar Luca Pacioli.

Double-entry accounting is one of the greatest discoveries of commerce and its significance is difficult to overstate. Which came first, double-entry accounting or the enterprise? Was it double-entry accounting and what it offered that enable the large enterprise to exist; or did the large enterprise create the need for double-entry accounting[16]?

Can the ideas of double-entry accounting be applied to XBRL-based financial reports, allowing for a clear strategy to identify errors and remove the errors from the system?

Notion of a "Double-entry XBRL-based Financial Report"

Borrowing from the 800-year-old idea of double-entry accounting; an imperfect yet useful analogy can be made between double-entry accounting's benefits and the benefits of supporting all XBRL-based financial reports and the XBRL base taxonomy and XBRL extension taxonomies that describe such reports with the proper statements including terms, associations, and assertions to control and manage that allowed and beneficial variability/flexibility.

Financial reporting schemes[17] such as US GAAP, IFRS, GAS, IPSAS, and others are well understood to be robust financial reporting schemes that enable an economic entity to provide information about the financial condition and financial performance of the reporting economic entity.

Key to this process of creating a high-quality XBRL-based machine-readable report is to create what amounts to a "parity check" of assertions to establish that reported facts are complete, correct, in all respects possible using automated machine-based processes so that humans can focus on making sure these reports are correct where the machines cannot be helpful. This offers three benefits:

1. High-quality machine-readable descriptions of a financial report.
2. Automated processes can be used to verify financial report against that description.
3. Automated processes can use the description to effectively and reliably extract information from the report and also verify the integrity of reported information.

After all, this is the objective of going through the trouble of representing a financial report in machine-readable form, to **effectively** use that reported information in some down-stream process.

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[16] Ian Grigg, *Triple Entry Accounting*, *A Very Brief History of Accounting*, *Which Came First - Double Entry or the Enterprise*?, http://iang.org/papers/triple_entry.html

[17] *Comparison of Financial Reporting Schemes High-level Concepts*, http://xbrlsite.azurewebsites.net/2018/Library/ReportingSchemes-2018-12-30.pdf

Logical Systems

A **system** is a cohesive set of interrelated and interdependent parts that form a whole. Changing one part of a system usually affects other parts and the whole system with predictable patterns of behavior.

A **properly functioning system** will have the following characteristics all of which should be demonstratable: **consistent**, **valid**, **sound**, **complete**.

Logic is a set of principles that forms a framework for correct reasoning. Logic is a process of deducing new information correctly so that a chain of reasoning[18] can be created. Logic is a systematic way of thinking. Logic is about the correct methods that can be used to prove a statement is true or false. Logic tells us exactly what is meant. Logic allows systems to be proven. Logic is a tool. Logic is a common language that can be agreed upon, understood by all parties, and which therefore enables precise communication.

A system is said to be logical if the system follows the principles of logic. Therefore, a logical system is a system that follows the principles of logic.

A logical system[19] is a type of formal system[20]. To be crystal clear I mean a **finite deductive first-order logic system**[21]. The point is to create a logical system that has high expressive capabilities but is also a provably safe and reliable system that is free from catastrophic failures and logical paradoxes (world view): axiomatic (Zermelo–Fraenkel) set theory[22]; directed acyclic graphs[23]; closed world assumption[24]; negation as failure[25]; unique name assumption[26]; Horn logic[27]. (a.k.a. logical theory, strong ontology; see the ontology spectrum[28])

Ontologies and ontology-like things[29] can be used to represent logical systems.

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[18] *Constructing a Chain of Reasoning*, http://xbrl.squarespace.com/journal/2019/9/26/constructing-a-chain-of-reasoning.html
[19] Wikipedia, *Logical Systems*, https://en.wikipedia.org/wiki/Logic#Logical_systems
[20] Wikipedia, *Formal System*, https://en.wikipedia.org/wiki/Formal_system
[21] Wikipedia, *First-order Logic, Deductive System*, https://en.wikipedia.org/wiki/First-order_logic#Deductive_systems
[22] Wikipedia, *Set Theory, Axiomatic Set Theory*, https://en.wikipedia.org/wiki/Set_theory#Axiomatic_set_theory
[23] Wikipedia, *Directed Acyclic Graph*, https://en.wikipedia.org/wiki/Directed_acyclic_graph
[24] Wikipedia, *Closed World Assumption*, https://en.wikipedia.org/wiki/Closed-world_assumption
[25] Wikipedia, *Negation as Failure*, https://en.wikipedia.org/wiki/Negation_as_failure
[26] Wikipedia, *Unique Name Assumption*, https://en.wikipedia.org/wiki/Unique_name_assumption
[27] Wikipedia, *Horn Logic*, https://en.wikipedia.org/wiki/Horn_clause
[28] *Difference between Taxonomy, Conceptual Model, Logical Theory*, http://xbrl.squarespace.com/journal/2018/12/11/difference-between-taxonomy-conceptual-model-logical-theory.html
[29] Ontology-like things for industry, http://xbrl.squarespace.com/journal/2019/7/13/ontology-like-things-for-industry.html

In her book *An Introduction to Ontology Engineering*[30], C. Maria Keet, PhD, provides discussion about what constitutes a good and perhaps a not-so-good ontology. She discusses the notion that a syntax error in an ontology is similar to computer code not being able to compile. She discusses the notion of logical errors within an ontology-like thing which cause the ontology to not work as expected.

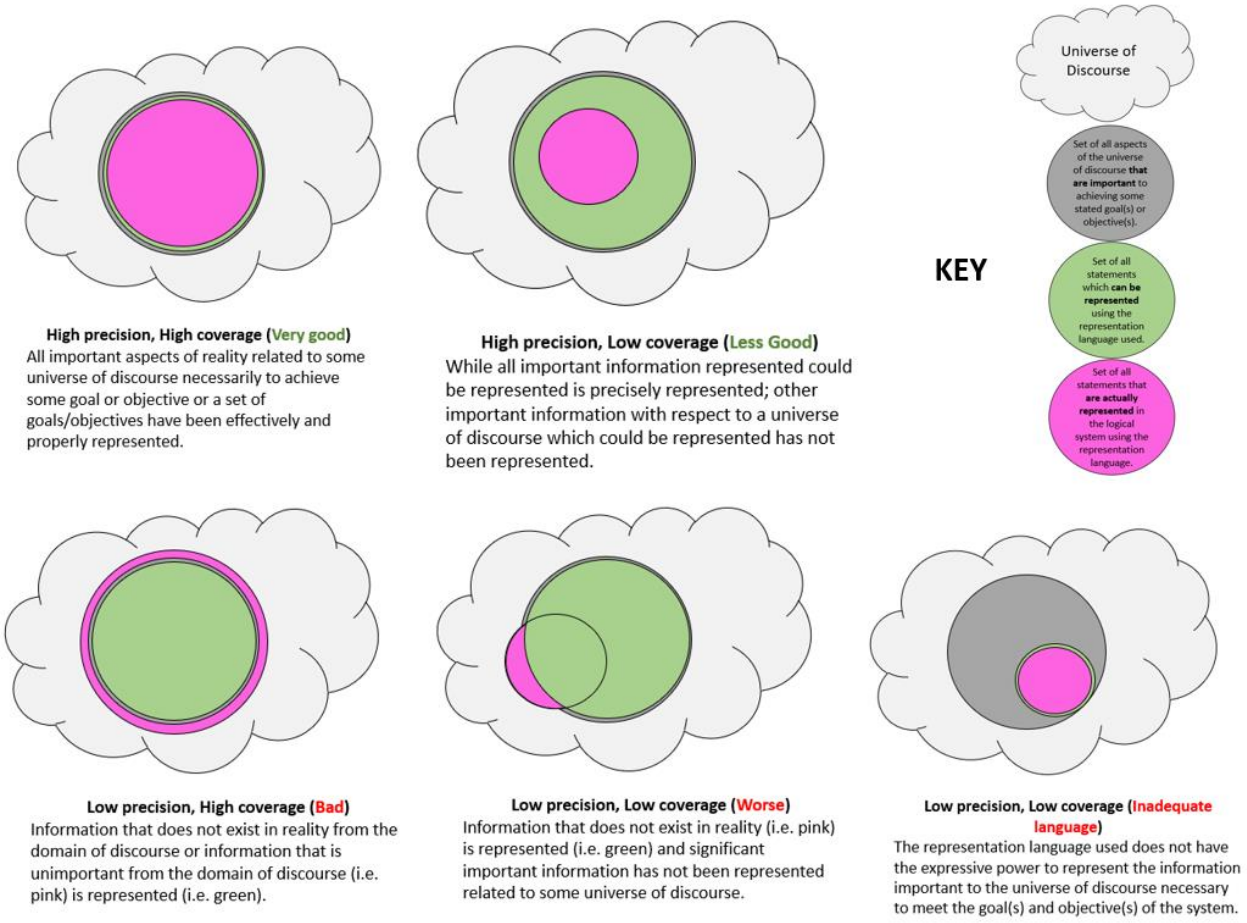
The models, structures, and statements of a theory relevant to a particular universe of discourse generally allows for some certain specific system flexibility/variability and as such must be consciously unambiguously and completely as is necessary and practical in order to achieve a specific goal or objective or a range of goals/objectives.

A logical system can have high to low ***precision*** and high to low ***coverage***. *Precision* is a measure of how precisely the information within a logical system has been represented as contrast to reality for the universe of discourse. *Coverage* is a measure of how completely information in a logical system has been represented relative to the reality for a universe of discourse.

The following diagrams were inspired by similar diagrams created by C. M. Keet[31]:

[30] C. Maria Keet, *An Introduction to Ontology Engineering*, pages 8-9, https://people.cs.uct.ac.za/~mkeet/files/OEbook.pdf

[31] Graphics inspired by C. Maria Keet, *An Introduction to Ontology Engineering*, pages 8-9, https://people.cs.uct.ac.za/~mkeet/files/OEbook.pdf#page=23



The notions of *precision* and *coverage* when it comes to judging whether an ontology or ontology-like thing is good or bad and provides a set of four graphics that drive this point. Precision can be low or high; coverage can likewise be low or high.

You get a good ontology when the precision of the ontology is high and the coverage of the ontology is high. *Precision* is a measure of how precisely you do or can represent the information of a domain within an ontology-like thing as contrast to reality. *Coverage* is a measure of how well you do or can represent a domain of information within an ontology-like thing.

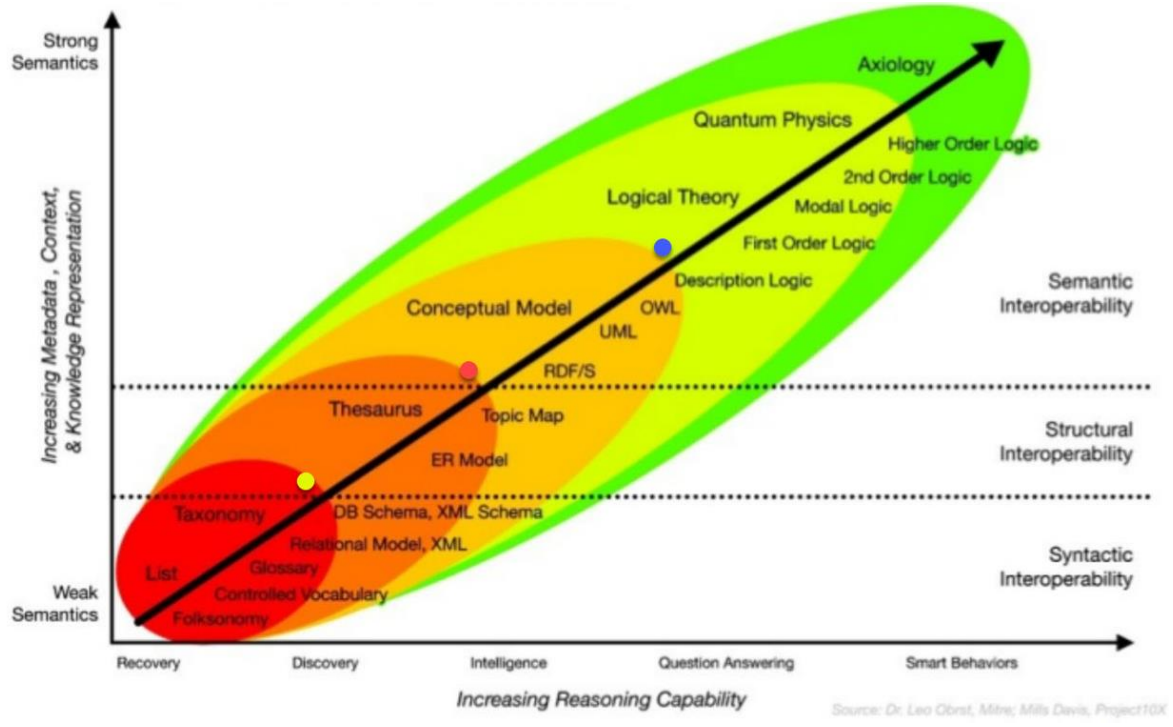
If you represent the things that you should represent (i.e. your coverage is good) and you do so such that the ontology-like thing accurately represents reality, then you get a good ontology-like thing. But if an ontology-like thing cannot do what it should be able to do then it is a bad ontology-like thing. And things can go wrong when you have high precision but not enough coverage or if you have low precision with high coverage or things can become really bad if neither your precision nor coverage are what you should have created given the goal you are trying to achieve.

And so, precision and coverage matter when it comes to creating an ontology-like thing.

Not all logic systems have all of the following characteristics, however, first-order predicate logics can be complete and consistent. Characteristics of a properly functioning logical system[32]:

#	Characteristic	Explanation
1	Consistent	No statement of the logical system contradicts another statement within that logical system.
2	Valid	No false inference (logical deduction of a statement) from a true premise is possible.
3	Complete	If a statement is true, then that statement can be proven; i.e. all statement exists in the system.
4	Sound	If any statement is a theorem (an IF…THEN assertion) of the logical system; then the theorem is true.
5	Fully expressed	If an important term exists in the real world; then the term can be represented within the logical system.

The following graphic shows the relative expressiveness of different types of ontology-like things[33]:



[32] Wikipedia, *Logic*, *Logical System*, https://en.wikipedia.org/wiki/Logic#Logical_systems
[33] Revisiting the Knowledge Representation Spectrum, http://xbrl.squarespace.com/journal/2019/10/9/revisiting-the-knowledge-representation-spectrum.html

Ontology-like Thing Spectrum

The following is a description of ontology-like things[34] and their relative expressiveness:

Expressive Feature	Dictionary, List, Glossary	Thesauri	Taxonomy	Ontology	Logical Theory
Terms					
Primitive terms	Term	Term	Term	Primitive Term	Primitive Term
Functional terms				Functional Term	Functional Term
Associations (relations)		Relation	Relation	Relation	Relation
Type relations (is-a)		Wider-narrower	General-special	Class-subclass	Class-subclass
Functional relations (has-a)				Has-a; part-of	Has-a; part-of
Property attribution (has-property)				Has-property	Has-property
Assertions (rules)					
Axioms				Axiom	Axiom
Theorems				Theorem	Theorem
Restrictions				Restriction	Restriction
Structures				Structure	Structure
Models				Model	Model
Facts				Individual; instance	Individual; Instance

[34] Ontology-like Things for Industry, http://xbrl.squarespace.com/journal/2019/4/27/ontology-spectrum.html

Forms are Not Variable

A form is a static, fixed system. Consider the following form:

Concept [Aspect]	Period [Aspect]	
	12/31/2020	12/31/2019
Property, Plant, and Equipment Subclassifications [Roll Up]		
Land	5,347,000	1,147,000
Buildings, Net	244,508,000	366,375,000
Furniture and Fixtures, Net	34,457,000	34,457,000
Computer Equipment, Net	4,169,000	5,313,000
Other Property, Plant and Equipment, Net	6,702,000	6,149,000
Property, Plant and Equipment, Net	295,183,000	413,441,000

By definition, the structure of a form cannot be changed. Therefore, forms can have limitations. But forms have other aspects which make useful. If you provided what amounts to a form to 1,000 different people and asked them to complete the form you would get perhaps 1,000 complete forms meaning that the values within the cells would contain some sort of value.

However, consider the following questions:

- What ensures that the value of each cell will be numeric?
- What ensures that the values of each subclassification of Property, Plant and Equipment, Net Total properly aggregate to the total for that classification?
- What is the units of the values?
- To which economic entity do the values relate?

Even within fixed systems you need rules.

Rules

Rules prevent "wild behavior".

The Merriam-Webster dictionary defines anarchy[35] as "a situation of confusion and wild behavior in which the people in a country, group, organization, community, etc., are not controlled by rules or laws." Rules prevent information anarchy[36].

Rules enable a knowledge bearer to describe information they are providing and verify that the information provided is consistent with that description. Rules enable a knowledge receiver to

[35] Anarchy definition, Merriam-Webster, http://www.merriam-webster.com/dictionary/anarchy
[36] *Understanding that Business Rules Prevent Anarchy*, http://xbrl.squarespace.com/journal/2016/7/15/understanding-that-business-rules-prevent-anarchy.html

understand the description of information provided by the knowledge bearer and likewise verify that the information is consistent with that description.

Rules guide, control, suggest, or influence behavior. Rules cause things to happen, prevent things from happening, or suggest that it might be a good idea if something did or did not happen. Rules help shape judgment, help make decisions, help evaluate, help shape behavior, and help reach conclusions.

Rules arise from the best practices of knowledgeable business professionals. A rule describes, defines, guides, controls, suggests, influences or otherwise constrains some aspect of knowledge or structure within some problem domain.

Don't make the mistake of thinking that rules are completely inflexible and that you cannot break rules. Sure, maybe there are some rules that can never be broken. Maybe there are some rules that you can break. It helps to think of breaking rules as penalties in a football game. The point is that the guidance, control, suggestions, and influence offered by rules are a choice of business professionals. The meaning of a rule is separate from the level of enforcement someone might apply to the rule.

A rule states a fact about the world (declarative rule). A rule can provide instructions (production rule).

The term **assertion** is a synonym for rule. A rule is a type of statement.

Variability

Consider again our example of a form. Now, suppose that someone completing this form had the line item “Airplanes”.

Concept [Aspect]	Period [Aspect]	
	12/31/2020	12/31/2019
Property, Plant, and Equipment Subclassifications [Roll Up]		
Land	5,347,000	1,147,000
Buildings, Net	244,508,000	366,375,000
Furniture and Fixtures, Net	34,457,000	34,457,000
Computer Equipment, Net	4,169,000	5,313,000
Other Property, Plant and Equipment, Net	6,702,000	6,149,000
Property, Plant and Equipment, Net	295,183,000	413,441,000

In a form-based system, the only logical place that “Airplanes” might fit into the fixed form shown above is within the line item “Other Property, Plant and Equipment, Net”. But further suppose that the value for “Airplanes” was $100,000,000. If that is the case, it might be more

appropriate to be able to add a line item to the form. For example, see how the line item "Airplanes" was added to the representation:

Concept [Aspect]	Period [Aspect]	
	12/31/2020	12/31/2019
Property, Plant, and Equipment Subclassifications [Roll Up]		
Land	5,347,000	1,147,000
Buildings, Net	244,508,000	366,375,000
Furniture and Fixtures, Net	34,457,000	34,457,000
Computer Equipment, Net	4,169,000	5,313,000
Airplanes	100,000,000	100,000,000
Other Property, Plant and Equipment, Net	6,702,000	6,149,000
Property, Plant and Equipment, Net	395,183,000	513,441,000

Humans have no problem understanding the intension behind what is shown above. But computers are dumb beasts that need the dynamics of what is going on carefully laid out so that they can properly interpret the intension of what is going on.

Second, when you allow the sort of variability that is shown where, let's say, 1,000 different system users are allowed to make adjustments; how to you manage, control, and therefor channel all 1,000 different system users to make this sort of adjustment consistently and correctly?

So, in order to enable the ability to add new line items using a form, the following sorts of tasks need to be performed:

- The concept "Airplanes" would need to be defined.
- The data type of the concept "Airplanes" needs to be specified.
- The fact that "Airplanes" is a subclassification of the classification "Property, Plant and Equipment" needs to be specified.
- The rule which explains that "Airplanes" is included in the aggregation of "Property, Plant and Equipment, Net" needs to be specified.

The four bullet points are good examples but perhaps not an exhaustive list of all the information which a computer needs to be guided into functioning correctly just to make it so that new information might be added to a form.

Patterns of Variability

In the form example we have provided, the information within the form amounts to a roll up of some set of line items to some total. But a roll up is not the only organization of information that you might see in a form. Here are other mathematical patterns of relationships:

Roll forward: (Ending balance = Beginning balance + Changes)

Land Changes [Line Items]	Period [Axis]	
	2010-01-01 - 2010-12-31	2009-01-01 - 2009-12-31
Roll Forward of Land [Roll Forward]		
Land, Beginning Balance	1,147,000	1,147,000
Land, Additions	1,992,000	400,000
Land, Disposals	(193,000)	(200,000)
Land, Translation Difference	2,401,000	(200,000)
Land, Ending Balance	5,347,000	1,147,000

Adjustment: (Restated balance = Originally Stated Balance + Adjustments)

Prior Period Adjustments [Line Items]	Report Date [Axis]	Period [Axis]
		2009-12-31
Prior Period Adjustments to Retained Earnings [Adjustment]		
Retained Earnings (Accumulated Losses), Origionally Stated	Reported March 21, 2010 [Member]	4,000
Changes in Accounting Policy	Reported March 18, 2011 [Member]	3,000
Correction of an Error	Reported March 18, 2011 [Member]	(1,000)
Retained Earnings (Accumulated Losses), Restated	Reported March 18, 2011 [Member]	6,000

In addition to mathematical patterns of relationships there are non-mathematical patterns of relationships:

Inventory Policies [Line Items]	Period [Axis]
	2010-01-01 - 2010-12-31
Inventory Policies [Set]	
Inventory Valuation Method	Cost
Description of Inventory Components	Proin elit sem, ornare non, ullamcorper vel, sollicitudin a, lacus. Mauris tincidunt cursus est. Nulla sit amet nibh. Sed elementum feugiat augue. Nam non tortor non leo porta bibendum. Morbi eu pede.
Inventory Cost Method	FIFO

Subtotal and Variability

Financial reporting schemes tend to provide a certain amount of latitude in terms of the subtotals that might be used to report financial information. For example, an income statement might be multistep and include a subtotal for “Gross Profit” or could be single step

and not explicitly provide that line item. Balance sheets might be classified[37] for most organizations but certain other organizations such as banks and insurance companies report using unclassified (or order of liquidity) balance sheets[38]. Still other organizations might report using a liquidity-based balance sheet because they in bankruptcy.

Income statement with gross profit[39]:

CONSOLIDATED AND COMBINED STATEMENTS OF OPERATIONS	Period [Axis]		
	2016-01-01 - 2016-12-31	2015-01-01 - 2015-12-31	2014-01-01 - 2014-12-31
CONSOLIDATED AND COMBINED STATEMENTS OF OPERATIONS			
Net sales	1,572,275,000	1,502,958,000	1,537,610,000
Cost of goods sold	773,550,000	727,120,000	779,678,000
Gross profit	798,725,000	775,838,000	757,932,000
Operating expenses			
Selling, general and administrative	600,804,000	604,018,000	602,755,000
Research and development	48,804,000	45,977,000	44,243,000
Intangible amortization	6,608,000	6,617,000	6,687,000
Restructuring charges	1,673,000	1,643,000	
Income from operations	140,836,000	117,583,000	104,247,000
Interest expense, net	49,908,000	60,294,000	63,529,000
Other (income) expense, net	1,706,000	25,139,000	(1,348,000)
Income before income taxes	89,222,000	32,150,000	42,066,000
Income tax expense	39,707,000	27,994,000	16,700,000
Net income	49,515,000	4,156,000	25,366,000

Income statement without gross profit[40]:

[37] Classified balance sheet, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/516537_D.html
[38] Unclassified balance sheet, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/516621_D.html
[39] Income statement with gross profit, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/517191_D.html
[40] Income statement without gross profit, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/517195_D.html

CONSOLIDATED STATEMENTS OF INCOME	Period [Axis]		
	2016-01-01 - 2016-12-31	2015-01-01 - 2015-12-31	2014-01-01 - 2014-12-31
CONSOLIDATED STATEMENTS OF INCOME			
Revenues			
Transaction	278,400,000	336,800,000	337,400,000
Redemption	993,600,000	1,028,400,000	1,053,200,000
Finance charges, net	3,639,700,000	2,871,200,000	2,303,700,000
Marketing services	2,019,700,000	2,006,500,000	1,438,700,000
Other revenue	206,700,000	196,800,000	169,900,000
Total revenue	7,138,100,000	6,439,700,000	5,302,900,000
Operating expenses			
Cost of operations (exclusive of depreciation and amortization disclosed separately below)	4,276,800,000	3,814,400,000	3,218,800,000
Provision for loan loss	940,500,000	668,200,000	425,200,000
General and administrative	143,200,000	138,500,000	141,500,000
Regulatory settlement		64,600,000	
Earn-out obligation			105,900,000
Depreciation and other amortization	167,100,000	142,100,000	109,700,000
Amortization of purchased intangibles	345,000,000	350,100,000	203,400,000
Total operating expenses	5,872,600,000	5,177,900,000	4,204,500,000
Operating income	1,265,500,000	1,261,800,000	1,098,400,000
Interest expense			
Securitization funding costs	125,600,000	97,100,000	91,100,000
Interest expense on deposits	84,700,000	53,600,000	37,500,000
Interest expense on long-term and other debt, net	218,200,000	179,500,000	131,900,000
Total interest expense, net	428,500,000	330,200,000	260,500,000
Income before income tax	837,000,000	931,600,000	837,900,000
Provision for income taxes	319,400,000	326,200,000	321,800,000
Net income	517,600,000	605,400,000	516,100,000

Alternative Disclosure Approach and Variability

Alternative approaches exist for representing disclosures within a financial statement[41]. While professional judgement oftentimes comes into play when determining which alternative disclosure approach might be the most appropriate, when a specific alternative is selected the structure of that disclosure, the representation of the information, is objective.

So, for example, a reconciliation of the statutory tax rate to the effective tax rate can be created by reconciling the dollar amount or the percentage. But every dollar amount reconciliation is a roll up and every percentage reconciliation is a roll up.

[41] Disclosure Best Practices, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/DisclosureBestPractices.aspx

Reconciliation using dollar amount[42]:

	Years Ended December 31,		
	2016	2015	2014
Amounts computed at statutory federal rate	$ (91,818)	$ (55,799)	$ (31,441)
Stock-based compensation and other permanent differences	3,065	1,752	1,417
R&D credits	(3,390)	(3,782)	(2,420)
Change in valuation allowance	27,583	4,580	37,106
State taxes	272	742	(5,092)
Contingencies	361	2,247	—
Foreign rate differential	64,065	48,456	4
Other	1,203	2,134	426
Income tax expense	$ 1,341	$ 330	$ —

Reconciliation using percentage[43]:

	Year Ended December 31,		
	2016	2015	2014
Provision for income taxes at statutory rate	35.0%	35.0%	35.0%
(Decreases) increases resulting from:			
Federal tax credits	(4.1)	(9.5)	(3.3)
Change in valuation allowance	0.2	(24.9)	(14.9)
State tax expense, net of federal benefit	(3.8)	(5.3)	0.9
Meals and entertainment	0.1	0.2	0.1
Stock-based compensation expense	(18.0)	0.6	3.5
Change in fair value of preferred stock warrants	1.0	1.9	1.0
Non-deductible interest	—	0.1	0.1
Domestic production activity deduction	—	(2.2)	(2.3)
Change in uncertain tax positions	1.9	2.4	—
Foreign rate differential	(31.8)	0.6	—
Foreign rate inclusion	4.5	0.2	—
Other	0.2	(0.9)	(2.3)
Effective income tax rate	(14.8)%	(1.8)%	17.8%

Unreported High-level Line Items and Variability

Certain high-level financial report line items are typically always reported including “Assets”, “Liabilities and Equity”, “Equity”, “Revenues”, “Net Income (Loss)”, “Net Cash Flow”, “Net Cash Flow from Operating Activities”, and so forth.

Other high-level financial report line items are less commonly explicitly reported such as “Noncurrent Assets”, “Noncurrent Liabilities”, etc. However, it is possible and often necessary to logically derive the values of unreported high-level financial report line items whether they are or are not explicitly reported.

On the other hand, when too many high-level line items are not explicitly reported then it becomes increasingly challenging to reliably derive the value of unreported high-level financial report line items.

[42] Reconciliation using dollar amount, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/512832_D.html
[43] Reconciliation using percentage, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/512831_D.html

Assets roll up with noncurrent assets explicitly included[44]:

Consolidated balance sheets	Period [Axis]	
	2016-02-27	2015-02-28
Consolidated balance sheets		
Assets		
Current assets:		
Cash	13,609,000	24,994,000
Accounts receivable, net	28,843,000	24,319,000
Inventory	86,435,000	83,724,000
Prepaid expenses	8,692,000	7,895,000
Income taxes receivable	157,000	1,698,000
Deferred tax assets, net		3,256,000
Other current assets	8,695,000	11,056,000
Total current assets	146,431,000	156,942,000
Noncurrent assets:		
Property and equipment, net	176,117,000	169,053,000
Goodwill	202,815,000	202,815,000
Trade names	228,368,000	229,433,000
Deferred financing costs, net	6,068,000	7,742,000
Noncurrent deferred tax assets, net	2,090,000	1,739,000
Other assets	1,879,000	1,333,000
Total noncurrent assets	617,337,000	612,115,000
Total assets	763,768,000	769,057,000

Assets roll up without noncurrent assets line item[45]:

CONSOLIDATED BALANCE SHEETS	Period [Axis]	
	2016-12-31	2015-12-31
CONSOLIDATED BALANCE SHEETS		
Assets		
Current assets:		
Cash and cash equivalents	153,225,000	95,697,000
Accounts receivable, net	2,129,000	
Inventory	1,316,000	
Prepaid expenses and other current assets	1,905,000	1,186,000
Total current assets	158,575,000	96,883,000
Property and equipment, net	1,038,000	738,000
Intangible assets, net	2,103,000	
Restricted cash	97,000	97,000
Other long-term assets	204,000	
Total assets	162,017,000	97,718,000

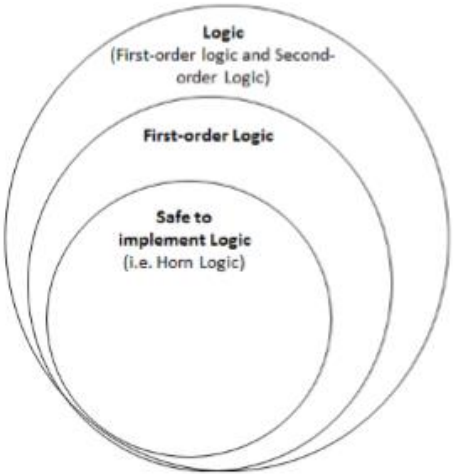
[44] Assets roll up with noncurrent assets included, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/516633_D.html
[45] Assets roll up without noncurrent assets line item, http://xbrlsite-app.azurewebsites.net/DisclosureBestPractices/Exemplars/516628_D.html

Processing

Sets of statements can be processed in numerous ways. Fundamentally, the statement in a logical system are declarative as opposed to procedural and logic programming[46] is used to process the statements. Prominent logic programming implementations include:

Implementation	Explanation
PROLOG[47]	Prolog, or PROgramming LOGIC is a commonly used processing paradigm. Prolog uses backward chaining but can be made to do forward chaining.
DATALOG[48]	Datalog is a subset of Prolog which uses Horn Logic. Similarly, Datalog can use either backward or forward chaining.
CLIPS[49]	CLIPS is a logic programming tool that is forward chaining and that has additional features beyond what Prolog seems to provide.
Answer Set Programming (ASP)[50]	Answer Set Programming (ASP) is a more modern implementation of logic programming that tries to solve problems with Prolog. ASP uses stable model semantics[51] and well-founded semantics[52].

The issue with Prolog and that Datalog and Answer Set Programming try and solve relates to the safety of the logic used. Not 100% of first-order logic is implementable in software because logical paradoxes can result and therefore catastrophic system failures are possible. A subset of logic called Horn Logic[53] solves this issue.



[46] Wikipedia, *Logic Programming*, https://en.wikipedia.org/wiki/Logic_programming
[47] Wikipedia, *Prolog*, https://en.wikipedia.org/wiki/Prolog
[48] Wikipedia, *Datalog*, https://en.wikipedia.org/wiki/Datalog
[49] Wikipedia, *Clips*, https://en.wikipedia.org/wiki/CLIPS
[50] Wikipedia, *Answer Set Programming*, https://en.wikipedia.org/wiki/Answer_set_programming
[51] Wikipedia, *Stable Model Semantics*, https://en.wikipedia.org/wiki/Stable_model_semantics
[52] Wikipedia, *Well-founded Semantics*, https://en.wikipedia.org/wiki/Well-founded_semantics
[53] Wikipedia, *Horn Clause*, https://en.wikipedia.org/wiki/Horn_clause

A financial report is a logical system that contains a set of safe statements which follow the rules of Horn Logic. Statements can be organized into structures. Structures can be organized into models. A model is an allowable interpretation of a theory which describes the logical system. That system follows other rules and makes other assumptions to make the system as safe and reliable as possible but at the same time tries to maximize the capabilities of the logic used to express the statements. Axiomatic (Zermelo–Fraenkel) set theory is used as contrast to the more problematic naïve set theory. All associations are expressed as directed acyclic graphs that do not cause cycle problems. The closed world assumption is made so that decidability is not a problem and to be consistent with relational databases. Negation as failure is assumed to be clear. The unique name assumption is made to be clear.

And so, a financial report is an interpretation of an expression of the financial position and financial performance of an economic entity. That interpretation can be read by some logic programming implementation which can determine if that interpretation is a properly functioning logical system.