Special Theory of Machine-based Automated Communication of Semantic Information of Financial Statements

Understanding how to interpret and otherwise interact with machine readable XBRL-based financial information explained in simple terms

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“An error does not become truth by reason of multiplied propagation, nor does truth become error because nobody sees it. Truth stands, even if there be no public support. It is self sustained.” Mahatma Gandhi

Executive summary:

- XBRL-based digital financial reports are machine-readable logical systems\(^1\).
- Financial reports are fundamentally based on the double entry accounting model, the accounting equation, and are intentionally designed to have innate characteristics such as mathematical interrelationships to achieve the notion of articulation which is where one report element is intentionally defined on the bases of other elements in order to achieve the interconnectedness of the four primary financial statements.
- These characteristics provide significant leverage to software engineers designing computer software intended to work with XBRL-based digital financial reports.
- XBRL-based digital financial reports can be proven to be properly functioning logical systems that are consistent, precise, and complete using automated machine-based processes that take into account the inherent variability of financial reports.
- Demonstrably properly functioning XBRL-based digital financial reports provide empirical evidence as to how to effectively communicate the semantics of reported financial information.
- These demonstrably properly functioning logical systems do not prove all that is sufficient to provide a theory of how semantic information must be communicated; but it does prove what is necessary for such semantic information to be communicated effectively.
- Perhaps an academic or mathematician or more knowledgeable party can bridge the gap between what is necessary, which I have demonstrated, and what is sufficient.

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In their paper, *Towards a Theory of Semantic Communication*\(^2\), Jie Bao et. al. lament that a generic model of semantic communication has still largely remained unexplored after six decades. They go on to point out that their paper may form a “foundation for a general theory of semantic communication.”

I would tend to agree on both counts.

Further, I have pointed out\(^3\) that there are numerous domains that have created methods and approaches to representing information in some sort of machine-readable form and exchanging that information with someone else for some purpose. Unfortunately, in my view, each of those domains tends to use different terminology for describing what amounts to the same process, describe how their systems work with differing levels of thoroughness and completeness, and none of these explanations is particularly approachable to nontechnical business professionals trying to understand the process.

Yet this capability to effectively automate the exchange of information using machine-based processes is of increasing importance in what people are calling “The Fourth Industrial Revolution”\(^4\)” or the “Age of AI”\(^5\)”.

Being that AI (artificial intelligence) is driven by data and information; being that there is increased competition in this realm; being that achieving commercial quality information exchange capabilities appears quite useful to me; it just seems to me that business professionals would want to understand how to effectively enable reliable machine-based automated communication and to be able to discuss this topic effectively with information technology professionals.

And so, I am writing this paper to explain this topic as best that I can specifically for financial reporting. Granted, I am not a PhD in knowledge engineering or computer science or anything else for that matter. However, I do have some skill and extensive experience in this area and I am a professional accountant and understand financial reporting quite well. I would invite academics to do two things. First, I would invite them to more formally improve upon my informal attempt to explain this topic. Second, I would invite them to endeavor to tackle the

\(^{2}\) Jie Bao et.al., *Towards a Theory of Semantic Communication*, page 1, [https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf](https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf)


\(^{5}\) PBS, Frontline, In the Age of AI, [https://www.pbs.org/video/in-the-age-of-ai-zfwzwb/](https://www.pbs.org/video/in-the-age-of-ai-zfwzwb/)
broader general theory of semantic communication which I wish that I could have leveraged 20 years ago when I started working with XBRL.

The objective of this paper is to provide a theory of semantic communication as it relates to financial statements in terms a professional accountant can understand. Then, I will give several financial statement related examples that helps the reader understand how the theory works. Finally, as appendices to this paper I will provide the underlying background information that would help a reader motivated to understand the details to do so.

The approach is that of “standing on the shoulders of giants” or "discovering truth by building on previous discoveries." I leverage systems theory, graph theory, model theory, set theory, and most importantly logic which is the basis for all of the other theories and is innately understandable to business professionals.

It is assumed that a reader of this document is familiar with the basics of financial reporting and basic mathematics.

Understanding the Problem

The following problem description was inspired by a similar sort of description by Harry S. Delugach, Associate Professor of Computer Science, in a presentation, Common Logic Standards Development, (page 7). Fundamentally, a financial statement serves this purpose:

Two economic entities, A and B, each have information about their financial position and financial performance. They must communicate their information to an investor who is making investment decisions which will make use of the combined information so as to draw some conclusions. All three parties (economic entity A, economic entity B, investor) are using a common set of basic logical principles (facts, statements, deductive reasoning, etc.), common financial reporting standard terms and associations between terms (terms, associations, structures, assertions for a reporting scheme US GAAP, IFRS, IPSAS, etc.), and a common world view so they should be able to communicate this information fully, so that any inferences which, say, the investor draws from economic entity A's information should also be derivable by economic entity A itself using common basic logical principles, common financial reporting standards (terms, associations, structures, assertions), and common world view; and vice versa; and similarly for the investor and economic entity B.

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This problem has been effectively solved for hundreds of years via the use of paper-based and human readable general-purpose financial statements. Today there is a new opportunity. That new opportunity is to automate this process using machine-readable financial information.

To be crystal clear, financial statements I am describing are not, should not, and need not be forms. Rather, financial reporting schemes used to create the financial statements I am describing intentionally allow variability in how economic entities provide the quantitative and qualitative information about the economic entity. Report creators are allowed to “reshape” or “alter” or other such modifications within a specific set of boundaries.

This specific use case is clearly articulated in the conceptual frameworks of both US GAAP\(^7\) and IFRS\(^8\) and really cannot be disputed. Those less familiar with financial reporting may find my exploration of FASB’s SFAC 6 *Elements of Financial Statements*\(^9\) helpful.

Finally, it is worth pointing out that financial reporting schemes have five things in common that can be leveraged in the communication of financial statement information and are unique to financial reporting schemes:

- **First**, at the foundation of every financial reporting scheme is the double-entry accounting model\(^10\). Simply stated, that model is: **DEBITS = CREDITS**. It is a mathematical model. (If you don't understand this model, this video is helpful\(^{11}\))
- **Second**, building on the double-entry accounting model is the accounting equation\(^12\): **Assets = Liabilities + Equity**.
- **Third**, every financial reporting scheme defines a core set of interrelated elements of a financial statement that are fundamentally grounded in some form of the accounting equation. For example, the Financial Accounting Standards Board (FASB) defines these ten elements of a financial statement in SFAC 6\(^{13}\); Assets, Liabilities, Equity, Comprehensive Income, Investments by Owners, Distributions to Owners, Revenues, Expenses, Gains, Losses. Then, additional elements are defined based on that core set.

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\(^11\) YouTube, 2016 Debit Credit Theory Accounting Rap Song from O’Neill High School, [https://www.youtube.com/watch?v=PHanSCcMb_I](https://www.youtube.com/watch?v=PHanSCcMb_I)


- **Fourth**, every financial reporting scheme has what is called "articulation". Articulation is the notion that the elements of a financial statement are interrelated and therefore depend on one another and so the four core statements; the balance sheet, the income statement, the changes in equity and the cash flow statement are all mathematically interrelated. Articulation is explained very methodically by the FASB in SFAC 6\textsuperscript{14}.

- **Fifth**, every financial report has inherent variability that is the result of explicitly allowing intermediate components of a financial report (i.e. subtotals) to be combined in appropriate but perhaps different ways depending on the needs of the reporting economic entity. Again, this is explained in detail within SFAC 6\textsuperscript{15}.

These five special characteristics of a financial reporting scheme and therefore of a financial statement created using such a financial reporting scheme offers benefits above and beyond the general communication of words and numbers. As such, this paper focuses on the special case of communication of financial statement information as contrast to the more general communication of information. However, it is believed that general communication of semantic information can also benefit from the ideas presented in this paper.

### Graphic of Problem Statement

In their paper, *Towards a Theory of Semantic Communication*\textsuperscript{16}, Jie Bao et. al. provide a visual description of the communications of information a copy of which I show below:

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\textsuperscript{14} ibid, page 21 – 22, "Interrelation of Elements-Articulation"

\textsuperscript{15} Ibid, page 47, paragraph 77.

\textsuperscript{16} Jie Bao et.al., *Towards a Theory of Semantic Communication*, page 5, Fig. 2. Semantic Information Source and Destination, [https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf](https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf)
In the diagram, they assign variables and work through the mathematics of the problem of exchanging information from a sender to a receiver successfully. I will make the problem of communicating financial information (a) more representative of how communication of XBRL-based financial information works today and (b) easier for business professionals to understand.

The following is my visual description of the communication of financial information that is inspired by the description provided by Jie Bao. Et.al.:

The general idea of my visual image is the same as Jie Boa et. al., however there are some specific differences that are intentional and make the communication of financial information easier.

First, Jie Boa et. al. state that the world view of the information sender (W_s) and receiver (W_r) are perhaps different and then reconciled. This is similar for the inference procedure (I_s, I_r) and background knowledge (K_s, K_r). What I am trying to communicate is the notion that as many differences as possible would be eliminated from the communications problem. As such, the “World View”, the “Inference Logic” and as much of the “Background Knowledge” as possible would be agreed to in advance of any financial statement information exchange. Both the information bearer and information receiver agree on the world view, inference logic, and background information in advance as part of the information exchange process. However, information can be extended but the extension information is carefully associated with the common shared background knowledge.

The “message” of this overall system is the general purpose financial report which is likewise a man-made logical system. There is nothing natural about a general purpose financial report,
the idea was created by humans to serve a purpose. That purpose is to effectively exchange information about the financial position and financial condition of an economic entity. Initially, that was done on clay tablets. Then on papyrus. Then paper. Then e-paper. Now XBRL-based digital format. That digital format, the logical system, is consciously configured to make it machine-readable by software applications. Graphically, the “message”, the general purpose financial report, is a provably properly functioning logical system (a.k.a. logical theory) which is consistent, complete, and precise:

I have demonstrated this by representing the accounting equation\(^\text{17} \) and SFAC 6\(^\text{18} \) in the XBRL technical syntax, walking through all the things that can impede the communication process, and mitigating each impediment.

Fundamentally, it is the conscious intension of this logical system to safely, reliably, and otherwise successfully communicate financial information. The stakeholders fundamentally agree to eliminate all possible features that introduce potential failure and to leverage all possible features that lead to success. Fundamentally, the goal is to succeed. This is done by agreeing to agree. The specifics of how new information is carefully added to the common shared background knowledge is explained in a later section.

**Principles**

Principles help you think about something thoroughly and consistently. Overcoming disagreements between stakeholders and even within groups of stakeholders is important and principles can help in that communications process. The following principles make clear

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important considerations when communicating financial information in machine-readable form:

- A general-purpose financial report is a high-fidelity, high-resolution, high-quality information exchange mechanism. Its intension is to, as best as practical, to faithfully represent a set of claims made by an economic entity about the financial position and financial performance of an economic entity. (i.e. a financial report is not arbitrary, is not random, is not illogical)
- Prudence dictates that using information from a financial report should not be a guessing game.
- All formats conveying the same set of financial information should convey the exact same meaning regardless of the information format be that format paper, e-paper, or some machine-readable format.
- Explicitly stated information or reliably derived information from information bearers is preferable to requiring information receivers to make assumptions.
- The double entry accounting model enables automation of processes that allow for the detection of information errors and to distinguish errors (unintentional) from fraud (intentional).
- The accounting equation, “Assets = Liabilities + Equity” is the foundation of every financial reporting scheme. There are various other forms of this equation which are semantically equivalent including, “Net Assets = Assets – Liabilities”
- Catastrophic logical failures are to be avoided at all cost as they cause systems to completely fail.
- Nothing about processing information within this financial report logical system can be a “black box”. The innerworkings must be explainable and justifiable, providable in a human-readable manner. Information provenance must be knowable and traceable.

It would be, in my personal view, highly unlikely that anyone that fundamentally desires to effectively communicate machine-readable to disagree with any of the principles.

**Logical Systems (a.k.a. Logical Theory)**

There are many approaches which can be used to describe something logically. A logical system (a.k.a. logical theory) is one such approach which enables a community of stakeholders trying to achieve a specific goal or objective or a range of goals/objectives to agree on important common models, structures, and statements for capturing meaning or representing a shared understanding of and knowledge in some universe of discourse.

**A financial report is a logical system.** Financial reports represent economic phenomena in words and numbers. A financial report is a faithful representation of a set of claims made by an
economic entity about the financial position and financial performance of an economic entity. (i.e. a financial report is not arbitrary, is not random, is not illogical).

A logical system can be explained by a logical theory. A logical theory is an abstract conceptualization\(^\text{19}\) of specific details of some domain. The logical theory provides a way of thinking about a domain by means of deductive reasoning to derive logical consequences of the theory. A logical theory is made up of a set of models, structures, terms, associations, assertions, and facts\(^\text{20}\) along with some finite set of mathematical operators. In very simple terms,

- **Logical theory**: A *logical theory* is a set of models that are consistent with and permissible per that logical theory.
- **Model**: A *model*\(^\text{21}\) is a set of structures. A model is a permissible interpretation of a theory.
- **Structure**: A *structure* is a set of statements which describe the associations and assertions of the structure. (A structure provides context.)
- **Statement**: A statement is a proposition, claim, assertion, belief, idea, or fact about or related to the universe of discourse to which the logical theory relates. There are four broad categories of statements:
  - **Terms**: Terms are statements that define ideas used by the logical theory such as “assets”, “liabilities”, and “equity”. (a.k.a. report elements)
  - **Associations**: Associations are statements that describe permissible interrelationships between the terms such as “assets is part-of the balance sheet” or “operating expenses is a type-of expense” or “assets = liabilities + equity” or “an asset is a ‘debit’ and is ‘as of’ a specific point in time and is always a monetary numeric value”. (a.k.a. relations)
  - **Assertions**: Assertions are statements that describe expectations that tend to be IF...THEN...ELSE types of relationships such as “IF the economic entity is a not-for-profit THEN net assets = assets - liabilities; ELSE assets = liabilities + equity”. (a.k.a. rules)
  - **Facts**: Facts are statements about the numbers and words that are provided by an economic entity within their financial report. For example, “assets for the consolidated legal entity Microsoft as of June 20, 2017 was $241,086,000,000

expressed in US dollars and rounded to the nearest millions of dollars. (a.k.a. items)

A financial report has a finite set of statements (structures, terms, associations, assertions, and facts) within the report. The set of statements is definite. That definite set of statements forms a model. (With any field of knowledge, the critical concepts of the field are embedded in the definitions of the field's technical terms. The term 'statement' in financial reporting is different than that same term 'statement' as is being used here.)

A logical system is said to be consistent if there are no contradictions with respect to the statements made by the logical theory.

A logical theory 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.

If the models, structures, terms, associations, assertions, and facts have high precision and high coverage, and if all the statements within the logical system are consistent; then the logical system can be proven to be properly functioning. If you have a properly functioning logical system then you can create a chain of reasoning 22.

Finally, when information is exchanged it is important to agree on a world view. You can agree on the terms, structures, associations, assertions and facts; but nothing tells us how each of these statements will be processed, understood, or managed within a specific system. This could be different in different systems. As such, some certain amount of the world view must be agreed to. Stakeholders should be conscious of these potential differences and agree on specific aspects of a common world view.

Finally, nothing about processing information within this logical system can be a “black box”. The innerworkings must be provided in a human-readable manner. Information provenance must be knowable and traceable. Auditable algorithms are essentially ones that are explainable. Algorithms, including artificial intelligence, used by the enterprise or for accounting, reporting, auditing, and analysis needs to be explainable artificial intelligence 23.

23 ACCA, Narayanan Vaidyanathan, Explainable AI: Putting the user at the core, https://www.accaglobal.com/uk/en/professional-insights/technology/Explainable_AI.html
Explainable AI (XAI) provides insight into how the software algorithms reached its conclusions, an understandable “line of reasoning”.

**Distilling Problem Down to Logic and Math**

Rather than look at all the different moving pieces of this puzzle as being from different silos; I choose to leverage the best practices, safest practices, and create a solid, powerful, practical, and reliable system that business professionals can effectively understand and leverage by using other proven systems. Business professionals need not understand each individual theory, only that the theory has been proven. Equilibrium is achieved by weaving the appropriately selected other systems based on the goals and objectives agreed to by the stakeholders of the information exchange mechanism. Testing and a conformance suite24 which is agreed to by system stakeholders explains how the system works to business professionals.

A logical system25 is a type of formal system26. To be crystal clear what I am trying to create is a finite model-based deductive first-order logic system27. “Finite” as opposed to “infinite” because finite systems can be explained by math and logic, infinite systems cannot. “Model-based” is the means to address the necessary variability inherent in the required system. “Deductive”, or rule-based, as contrast to inductive which is probability based which is not appropriate for this task. “First-order logic” because first-order logic can be safely implemented within software applications and higher order logics are unsafe. “System” because this is a system. “Proof theory” because all of this can be proven mathematically which helps tune the system.

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 which cause the system to completely fail to function. To avoid failure, computer science and knowledge engineering best practices seems to have concluded that the following alternatives are preferable:

- **Systems theory**: A system28 is a cohesive conglomeration of interrelated and interdependent parts that is either natural or man-made. Systems theory explains logical systems. Systems have patterns.

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24 Conformance suite, [http://xbrlsite.azurewebsites.net/2019/Prototype/conformance-suite/Production/index.xml](http://xbrlsite.azurewebsites.net/2019/Prototype/conformance-suite/Production/index.xml)
• **Logical theory:** (a.k.a. logical system) There are many approaches to representing “ontology-like things” in machine-readable form, a logical theory being the most powerful (ontology + rules). Theories describe patterns. (see the ontology spectrum\(^{29}\))

• **Proof theory:** The ideas of proof theory\(^{30}\) can be used to verify the correctness of logical systems and computer programs working with those machine-readable logical systems using mathematics\(^{31}\). Proofs verify theories.

• **Model theory:** Model theory is a way to think about flexibility. Safer finite model theory\(^{32}\) is preferable to general model theory. Models provide flexibility.

• **Set theory:** Set theory is foundational to logic and mathematics. Axiomatic (Zermelo–Fraenkel) set theory\(^{33}\) is preferred to naïve set theory.

• **Graph theory:** Directed acyclic graphs\(^{34}\) are preferred to less powerful “trees” and graphs which contain cycles that can lead to catastrophic problems caused by those cycles.

• **Logic:** Logic is a formal communications tool. Horn logic\(^{35}\) is a subset of first-order logic and is the basis for Prolog\(^{36}\). Datalog\(^{37}\) is a subset of Horn logic (function free) which is immune from logical paradoxes should be used as contrast to more powerful but also more potentially problematic first order logic features. Note that deductive reasoning is leveraged for the process of creating a financial report and not inductive reasoning (i.e. machine learning).

• **World view:** The following are common issues which appear when implementing logical systems in machine-readable form, the safest and most reliable alternatives are:
  - closed world assumption\(^{38}\) (used by relational databases) is preferred to the open world assumption which can have decidability issues;
  - negation as failure\(^{39}\) (used by relational databases) should be explicitly stated;
  - unique name assumption\(^{40}\) (used by relational databases) should be explicitly stated;

Business professionals are (a) not capable of having precise discussions of these sorts of issues with software engineers, (b) don’t care to have such technical discussions about these sorts of

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\(^{34}\) Wikipedia, Directed Acyclic Graph, [https://en.wikipedia.org/wiki/Directed_acyclic_graph](https://en.wikipedia.org/wiki/Directed_acyclic_graph)


\(^{40}\) Wikipedia, Unique Name Assumption, [https://en.wikipedia.org/wiki/Unique_name_assumption](https://en.wikipedia.org/wiki/Unique_name_assumption)
issues with software engineers, (c) are not interested in the theoretical or philosophical or religious debates that commonly exist related to these alternatives, (d) if the alternatives were **appropriately articulated to a business professional**, who tend to be very practical, they would most often error on the side of safety and reliability.

As such, we have made all of the above decisions which are consistent with modern logic programming paradigms such as Prolog\(^{41}\), LPS\(^{42}\), DataLog\(^{43}\), Efficiently Computable Datalog\(^{44}\), Why3\(^{45}\), Alt-Ergo\(^{46}\), HETS\(^{47}\), and Answer Set Programming\(^{48}\). Business professionals can simply use this system if they desire to do so, they don’t need to reinvent the wheel.

A logical system or logical theory can be made flexible precisely where they need to be flexible using model theory\(^{49}\).

Model theory essentially allows for any number of permissible interpretations of the logical theory, referred to as models. There are various forms of model theory including first order model theory\(^{50}\), finite model theory\(^{51}\), and the consciously and intentionally very safe finite first order model theory.

It is not important to understand the specific details of model theory, although it is very helpful to have a basic understanding\(^{52}\). I am not trying to prove the mathematics or logic of model theory; as I understand it that has already been proven.

What I am trying to do is apply the most powerful but also the safest, most reliable version of system theory, graph theory, model theory, set theory, logic, etc. in order to have the most expressive system possible that is also very safe and well behaved.

I can provide empirical evidence in the form of working representations of what I would call a finite model-based deductive first-order logic system using the global standard XBRL technical

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\(^{42}\) Imperial College, Department of Computing, LPS, [http://lps.doc.ic.ac.uk/](http://lps.doc.ic.ac.uk/)


\(^{44}\) Nichola Leona et.al., *Efficiently Computable Datalog Programs*, [https://www.mat.unical.it/kr2012/shy.pdf](https://www.mat.unical.it/kr2012/shy.pdf)


\(^{46}\) OCamlPro, Alt-Ergo, [https://alt-ergo.ocamlpro.com/](https://alt-ergo.ocamlpro.com/)


\(^{50}\) Stanford University, First Order Model Theory, [https://plato.stanford.edu/entries/modeltheory-fo/](https://plato.stanford.edu/entries/modeltheory-fo/)


\(^{52}\) LessWrong, Very Basic Model Theory, [https://www.lesswrong.com/posts/F6BrJFkgEhh22rFsZ/very-basic-model-theory](https://www.lesswrong.com/posts/F6BrJFkgEhh22rFsZ/very-basic-model-theory)
syntax language. Several of these examples have also been represented using Prolog; the XBRL and Prolog language representations yielding the same result.

All the characteristics of the logical system that I point out are “necessary” meaning that they must exist within the logical system. What I cannot prove is that the characteristics are “sufficient” to prove that the logical system is provably consistent, precise, and complete. Perhaps a mathematician can provide this proof. But, in my view, the empirical evidence goes a long way towards proving this logical theory. Whether it goes far enough is up to others to determine.

Think Knowledge Graph

A knowledge graph is one approach to storing information within a knowledge base. Knowledge graph is more or an analogy or buzz word dreamed up by in 2012 to describe the functionality you get when you use a set of web standards. A knowledge graph has four core building blocks:

- **Resolvable Identity**: a unique web address is assigned to each term in the form of an individual resource identifier (IRI). The IRI becomes the Rosetta stone for identity resolution allowing anyone to link data wherever it resides to one master identifier, eliminating the need to continually map information.

- **Ontologies**: data modeling is a communications process to ensure a shared understanding of requirements between business stakeholders and applications developers. The Web standard uses conceptual data models (ontologies) to describe what the information means as well as how terms are connected (associations). These ontologies link the meaning of information to business glossaries that can be directly translated into physical information structures.

- **Triple Expression**: the triple expression method (subject-predicate-object) is similar to classical conceptual modeling approaches. The subject denotes a resource, the predicate denotes traits or aspects of the resource, and expresses a relationship between the subject and the object. As such, information is defined at its most granular level.

- **Business Rules**: Data quality and structural business rules are linked to the ontologies to ensure that meaning is shared. The logic of these rules is captured and expressed as executable models and consistently enforced across all systems and processes.

Knowledge graphs is one of many different possible implementation approaches. Imagine a knowledge graph that exists within a digital distributed ledger and can be edited somewhat like a wiki.
Very Basic Model Example

The following is a very basic model of the accounting equation that I represented using XBRL and Prolog:\(^{53}\):

To understand this very basic model in detail, please read the documentation\(^{54}\). The essence of what you see is one structure defined using the functional term “Balance Sheet [Abstract]” that has three simple terms “Assets”, “Liabilities”, and “Equity”, and one assertion “Assets = Liabilities + Equity”.

This very basic model example is not enough to create an actual financial statement but it does represent a demonstrably complete, precise, and consistent logical system. Here is an example of a knowledge graph for that logical system:

\(^{53}\) Charles Hoffman, CPA, Accounting Equation, http://xbrlsite.azurewebsites.net/2020/Core/master-ae/

Slightly More Complex, but still Basic Model Example

The following is a slightly more complex, but still pretty basic model that represents what is articulated by the FASB in SFAC 6 related to the elements of a financial statement:\n
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Again, the best way to understand all the details are to read the documentation\textsuperscript{56}. The essence of the representation, again both in XBRL and Prolog, are three interconnected structures, ten terms, and three rules defined by SFAC 6.

Again, this slightly more complex, but still pretty basic model is a demonstrably complete, precise, and consistent logical system.

**Four Statement Model Example (Common Elements of Financial Statement)**

The following is again another slightly more complex model\textsuperscript{57}, still pretty basic model that expands on the FASB’s SFAC 6 adding additional elements that no professional accountant could really dispute:

\textsuperscript{56} Charles Hoffman, CPA, SFAC 6 Documentation, \url{http://xbrlsite.azurewebsites.net/2020/Core/master-sfac6/Documentation.pdf}

\textsuperscript{57} Charles Hoffman, CPA, Common Elements of Financial Statement (Four Statement Model), \url{http://xbrlsite.azurewebsites.net/2019/Core/master-elements/}
Again, the documentation provided helps one understand the representation in detail. What you see are four interconnected structures, 20 terms, four assertions, 29 facts, and a plethora of associations.

**MINI Financial Reporting Scheme**

The accounting equation example, the SFAC 6 example, and the Four Statement Model example were created because they are grounded in well understood accounting ideas but were small enough to understand all the moving pieces of the puzzle without the need of automated processing to prove that everything works as would be expected. Humans can simply look and see that everything works as expected.

The MINI Financial Reporting Scheme example takes a significantly larger step toward what an actual financial report might look like. While the MINI Financial Reporting Scheme might look relatively small, don’t be fooled by its simplicity. The MINI example contains 100% of the use cases that one will ever find in an XBRL-based digital financial report. The example was intentionally engineered to be a comprehensive test of XBRL-based financial reports. This example is explained in the document, *Proving Financial Reports are Properly Functioning Logical Systems*. It is also compared and contrasted to the smaller examples and then to a complete 10-K financial report of Microsoft. I believe that this helps the reader bridge the gap between the smaller examples and larger, actual financial reports.

Looking at these examples, patterns emerge.

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Patterns Documented with Standard Business Report Model (SBRM)

Examining the patterns\(^{61}\) of the first four examples, an additional small financial reporting scheme representation\(^{62}\), and reconciling all examples to a full 10-K financial statement of a public company in the document *Proving Financial Reports are Properly Functioning Logical Systems*\(^{63}\), shows that all of these financial report related representations (a) follow the documented logical system of a financial report and (b) point out an even more detailed model of a business report and financial report that is documented in the forthcoming OMG standard, *Standard Business Report Model (SBRM)*\(^{64}\).

While the more detailed patterns are quite helpful at arriving at the fundamental description of a logical theory of a financial report; it is the logical theory of a financial report itself which explains how to effectively communicate semantic information. That high-level theory explains what statements must be communicated and that those statements must be consistent, complete, and precise.

Finally, the impediments to a properly functioning logical system document the properties that must exist within a logical system for it to be considered proper functioning.

- Improper XBRL presentation relations associations
- Improper use of a class of line item as if were some different class
- Inconsistent or contradictory reported information
- Improper structure of disclosures
- Machine-readable reporting checklist of required disclosures

When all of these impediments are overcome, then semantic information can be effectively communicated. Note that (a) improper language syntax, in this case XBRL, is a given and (b) does not tend to be a problem because of the rigorous conformance suite used which effectively guarantees interoperability because 100% of the conformance suite is automated.

And so, to effectively communicate semantic information the five impediments described above simply need to be mitigated. Empirical evidence exists that shows the reliable detection

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\(^{61}\) YouTube, *The Science of Patterns*, https://www.youtube.com/watch?v=kh6KMW8J3RQ
of these impediments, the correction of the impediment, and the resulting properly functioning logical system, the XBRL-based digital financial report.

But none of this necessarily guarantees that every model that needs to be created can be created and how to control would could be an arbitrarily large set of finite models.

**Arbitrarily Large Set of Finite Models**

No one would really dispute that it is possible to effectively exchange information from some sender to some receiver if the machine-readable message is a form and both the sender and receiver of the information have exactly the same world view, use the inference logic (basically no inference logic is really necessary), and have the same knowledgebase.

For example, take this very simple form:

<table>
<thead>
<tr>
<th>Property, Plant and Equipment Subclassifications [Line Items]</th>
<th>Period [Axis]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018-12-31</td>
</tr>
<tr>
<td><strong>Property, Plant and Equipment [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td>Property, Plant and Equipment, Gross [Roll Up]</td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td>1,000</td>
</tr>
<tr>
<td>Buildings</td>
<td>1,000</td>
</tr>
<tr>
<td>Equipment</td>
<td>4,000</td>
</tr>
<tr>
<td>Property, Plant and Equipment, Gross</td>
<td>6,000</td>
</tr>
<tr>
<td>Accumulated Depreciation</td>
<td>0</td>
</tr>
<tr>
<td>Property, Plant and Equipment</td>
<td>6,000</td>
</tr>
</tbody>
</table>

If every economic entity were required to report the roll up of property, plant, and equipment subclassifications in exactly the same manner using exactly the same concepts and still used the same world view and inference assumptions I think it would be easy to understand that the communication of such information in machine-readable form would be trivial.

However, that is not the way financial reporting schemes work. For example, the following is a possible allowed interpretation of what amounts to the breakdown of the subclassifications of property, plant and equipment:

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What is different between the first example and the second example is the subclassifications of the line items that are actually disclosed. Note that in the above representation the subclassifications “Land” and “Buildings” have been combined and that “Equipment” has been disaggregated and “Computer Equipment” and “Manufacturing Equipment” have been reported.

This sort of variability is common in financial reports and can make it more challenging for those who desire to make use of the information reported to do so effectively. Even though one could effectively argue that the two examples of property, plant, and equipment disclosures would be quite easy to compare; it is easy to grasp that if, say, the sub total and the grand total concepts were also changed that could make using the information more challenging.

So, the fact that for the past 10 years thousands of U.S. public companies have created literally tens of thousands of reports using XBRL and have submitted the reports to the U.S. Securities and Exchange Commission is evidence that it is possible to represent both models of the subclassifications of things such as property, plant, and equipment effectively.

However, can the information be used effectively by financial analysts?

Complains about information quality, the excessive use of extension concepts, and other such complaints that tend to be rather general in nature (as compared to very precise and specific complains). Also, the goal is not to complain; rather, the objective is to effectively communicate financial information between the sender/creator of the information and the receiver/analyst that would like to actually make use of the reported financial information.
The next section shows that it is possible to reliably extract information from a digital financial report if the appropriate machine-readable statements are provided within the financial report logical system.

**Extending Models and Providing Important Properties**

Essentially, the primary financial statements and the related policies and disclosures provided in the disclosure notes can be represented using any allowed alternative model. This does not mean that disclosures can be “random” or “illogical” or completely “arbitrary”. Rational thinking does play a role here. What is allowed can be a bit subjective because the existing financial reporting standards can be ambiguous in some areas. But, given some interpretation of the financial reporting standards whether a disclosure is allowed or not allowed can be quantified into some finite set of possible disclosures. That finite set of possible disclosures can be represented using the XBRL technical syntax.

So intuitively, one could imagine that it is possible to represent the finite set of possible information representations into some number of what would amount to forms for each possible representation alternative allowed for each possible disclosure. Potentially a lot of work, but certainly possible.

But how do those that wish to use the information reported within a specific disclosure actually locate that specific allowed alternative disclosure within the set of all disclosures which make up a financial statement? It is possible to actually physically name each of those possible disclosures67.

And so how does XBRL-based financial reporting satisfy both the needs of economic entities reporting information and the needs of analysts to consume that information? The short answer is consciously, skillfully, and consistently.

The ESMA’s use of “wider-narrower” association and “anchoring” is one possible approach68. Although, this approach has always existed in XBRL via the “general-special” association. So, for example, two things are necessary to satisfy the property, plant, and equipment example shown previously.

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First, some explicit structure is necessary to anchor to. For example, here are a set of “general-special” relations represented in a prototype XBRL taxonomy:

Then second, once the context is clear (i.e. which structure you are working within), then new associations can be established per the model of the reporting economic entity relative to the base model of the financial reporting scheme:

In this manner, any extended concept that is defined relative to some existing base model concept can be understood correctly per the “wider-narrower” or “general-special” association and anchoring to that existing concept.

That works when there is some base taxonomy report element that can be anchored to. But what about a completely new structure?

This is a completely new structure which has an existing report element from the base taxonomy as part of that new structure:
Finally, below you see a completely new structure that is in no way associated with any existing report element that is defined within the base financial reporting scheme model:

<table>
<thead>
<tr>
<th>Finished Goods Subclassifications [Line Items]</th>
<th>2018-12-31</th>
<th>2017-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finished Goods [Roll Up]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Foxtrot</td>
<td>300</td>
<td>550</td>
</tr>
<tr>
<td>Product Golf</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Product Hotel</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Product India</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Finished Goods [Roll Up]</td>
<td>600</td>
<td>700</td>
</tr>
</tbody>
</table>

But just because some new completely new structure with completely new report elements does not mean that nothing is known about the new structure.

When a new extension is created, there are exactly four possibilities of how that new idea can be associated to some potentially existing idea:

- More general idea
- More specific idea
- Similar idea
- Completely new Idea

Even if the idea is completely new, because of the fundamental primitive building blocks of XBRL-based reports, every completely new thing must be (per XBRL syntax rules as restricted by SEC EDGAR Filing manual rules) represented using one of the primitive building blocks provided by XBRL.

Below you see those primitive building blocks:
For brevity, some possibilities are not shown. But this makes the point that there is a finite set of primitive structures that can be used to create anything that is possible to add to a financial reporting scheme. No XBRL-based model can add any new ideas at the first two layers. It is only below those first to layers that creators of an extension can work with.

I have provided mappings of the XBRL-based report objects to the hierarchy above for both the accounting equation\(^\text{69}\) and SFAC 6\(^\text{70}\) examples. See the last page of the documentation.

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\(^\text{69}\) Accounting Equation example, Documentation, page 13, [http://xbrlsite.azurewebsites.net/2019/Core/master-ae/Documentation.pdf#page=13](http://xbrlsite.azurewebsites.net/2019/Core/master-ae/Documentation.pdf#page=13)

Modifying Existing Associations

In addition to creating a new disclosure by extending the information of a base taxonomy with new information, it is possible to modify existing associations, correctly or incorrectly, and represent disclosures using alternative approaches.

For example, consider the following long-term debt maturities disclosure:

<table>
<thead>
<tr>
<th>Long-term Debt Maturities [Line Items]</th>
<th>2018-12-31</th>
<th>2017-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matures in One Year</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Matures in Two Years</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Matures in Three Years</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Matures in Four Years</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Matures in Five Years</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Matures Thereafter</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td><strong>Long-term Debt</strong></td>
<td><strong>6,000</strong></td>
<td><strong>1,000</strong></td>
</tr>
</tbody>
</table>

Above the disclosure is represented as a roll up of a set of items to a total.

Below you see an alternative representation based on the fact that numerous public companies represent this same disclosure by modifying the set of associations, dropping the total, and simply providing information about the maturities without the total:

<table>
<thead>
<tr>
<th>Long-term Debt Maturities [Line Items]</th>
<th>Period [Axis]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matures in One Year</td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Two Years</td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Three Years</td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Four Years</td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Five Years</td>
<td>1,000</td>
</tr>
<tr>
<td>Matures Thereafter</td>
<td>5,000</td>
</tr>
</tbody>
</table>

The point is not about whether either the version of the disclosure with the roll up total or the version without the total are both allowed or not. The point is that per model theory, it is possible to represent both representations or any other alternative that a public company creating this disclosure might come up with.
Representing the disclosure effectively and whether a represented disclosure is or is not permissible per financial reporting rules and practices are two different questions.

**Proper Use of Subclassifications**

A taxonomy is not, or should not, be simply a list of terms. An XBRL taxonomy, at a very minimum, should provide a comprehensive set or sets of associations between terms that document the proper use of the term. Consider this example of a cash flow statement:

![Cash Flow Statement Table]

Note that in the example above, the line items “Additional Long-term Borrowings” and “Repayment of Long-term Borrowings” are part of “Net Cash Flow Financing Activities”. Contrast that to the example below which uses those two line items as part of “Net Cash Flow from Investing Activities”.

While for this specific example it is probably the case that every professional accountant would recognize that additional borrowings and repayments should be part of financing activities and not investing activities. But the obvious mistake was used to make a specific point.

How exactly do you communicate within an XBRL taxonomy where line items can, and cannot, be used? How do you know that something is a current asset and not a noncurrent asset?

Taxonomies have long been tools for representing this sort of information in the form of a hierarchy of “general” and “special” relations or perhaps “wider” or “narrower” concepts in the form of a thesaurus.

The same information can, should, and in fact must be articulated within an XBRL taxonomy or any other logical system that hopes to be effective and have the remotest chance of working effectively to communicate information represented in machine-readable form. For example,
consider the following XBRL definition relations that represent “general-special” relations between concepts in order to assist users creating extension taxonomies and software engineers to assist in the process of using the right line items within the right associations within a financial report.

And so the proper use of subclassifications or “general-special” relations or “wider-narrower” relations are necessary to create quality financial report scheme relations and likewise financial reports that are correctly represented per that financial reporting scheme.

**Controlling Logical System and Keeping it Properly Functioning**

All the examples work the same and distill down to what can be described by the statements of a financial report logical system. All such logical systems work the same regardless of the number of terms, associations, structures, assertions, and facts. The best example to describe the functioning of the system is the “Slightly More Complex, but still Basic Model Example” (FASB’s SFAC 6 Elements of Financial Statements) because it is small enough to still get your
head around but big enough to see what causes the logical system to be properly functioning, what causes the logical system to function improperly, and how to distinguish the difference 71.

Control of a system is described by classical control theory 72. Systems can be open or systems can be closed. Advantages of closed systems is better control, stable performance, and guaranteed performance. Control of a financial report system and being able to define proper functioning system and keep such systems in control is desirable.

Based on all the things that can go wrong with the system, the following is the set of specific characteristics that can be employed to control the logical system and keep it properly functioning:

- Using the notion of "report element categories"
- Used the report element categories and organized them consistent with a set of strict "model structure rules"
- Used “derivation rules” (I used to call these impute rules) to overcome unreported financial report line items
- Used "consistency rules" to overcome contradictions or inconsistencies in reported facts
- Used "reporting styles" to facilitate model variability. (i.e. arbitrarily large set of finite models)
- Explicitly named “disclosures” so that they can be referred to.
- Using the notion of “information model” and "concept arrangement patterns".
- Using the notion of “disclosure mechanics rules” to specify the proper representation of a specific disclosure.
- Using the notion of “type-subtype” or “wider-narrower” or “general-special” relations to explicitly represent these relations.
- Using the notion of “mapping rules” to explicitly represent certain specific relations.
- Using the notion of “disclosure rule” or “reporting checklist” specifies the circumstances when each specific disclosure is required to be reported.

Use of these characteristics to control the logical system is demonstrated by the most current SFAC 6 Elements of Financial Statements representation in XBRL 73 and explained in the

document *Impediments to Creating Properly Functioning XBRL-based Reports*\(^74\). Details are explained in the video, *Compensating for US GAAP and IFRS XBRL Taxonomy Design Choices*\(^75\).

As such, it was these specific features which are included in the Standard Business Report Model (SBRM)\(^76\) in order to control a business report logical system to keep that system properly functioning.

Finally, in order to test 100% of the information model patterns that would exist within such a system and to prove that each information model pattern functioned as expected and interacted properly with other information model patterns, a proof was created as a comprehensive test\(^77\).

### Proof based on Empirical Evidence

When Rene van Egmond and I first created the *Financial Report Semantics and Dynamics Theory*\(^78\) back in 2012 we offered a proof that provided empirical evidence for that theory. Today, we can offer an improved proof based on 10 years of empirical evidence.

There are two similar, but separate, sets of XBRL-based reports that are used to prove that the logical theory of an XBRL-based report works as is expected.

The **first set** is a set of 10-K and 10-Q XBRL-based financial reports of 5,716 public companies that have been submitted to the U.S. Securities and Exchange Commission and are all publicly available\(^79\). These were used to test the fundamental accounting concept relations of the financial reports.

The **second set** is the last 10-K financial report of 5,555 public companies that have been submitted to the U.S. Securities and Exchange Commission and are likewise all publicly available.

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\(^{75}\) *Compensating for US GAAP and IFRS XBRL Taxonomy Design Choices*, [https://youtu.be/sKs02VjFJgw](https://youtu.be/sKs02VjFJgw)


available\textsuperscript{80}. These were used to test the disclosure mechanics and reporting check list of each report.

The first set shows that of the 5,716 reports:

- Over 99.9% of all reports were valid XBRL technical syntax.
- 99.24% (124,790 relations) of all fundamental accounting relations were consistent with expectation.
- .76% (962 relations) were not consistent with expectation and each of the errors was manually examined and determined to be an error in the facts reported by the public company\textsuperscript{81}.
- 89.1% of all reports were 100% consistent with each of the fundamental accounting concept relations rules.

Excel-based extraction tools were created for 4,060 reports or 68% so anyone can rerun these tests\textsuperscript{82}.

For this first set, there are exactly six causes of errors and each error has a specifically identifiable task that would cause the error to be corrected and then be consistent with expectation:

1. **Fact** error in report. A report contained one or more errors in the facts reported within the report. To make this logical system consistent, the fact in the report simply needs to be corrected.

2. **Assertion** error in knowledge base. While we are unaware of any assertion errors in the knowledge base containing assertions (i.e. because all such errors were fixed because they were under our control); if there were an error in the assertion used to test facts, the assertion would be in error. To make this logical system consistent, the assertion in the knowledge base simply needs to be corrected.

3. **Association** error in knowledge base. A report contained one or more association errors in either the base taxonomy or the extension taxonomy. To make this logical system consistent, the association simply needs to be corrected.

4. **Structure** error in knowledge base (i.e. reporting style used is incorrect). A report could use the wrong structure (reporting style) to evaluate the report. To make this logical system consistent, the structure (reporting style) simply needs to be corrected.

\textsuperscript{80} Last 10-K submitted to SEC by public companies as of March 31, 2019, \url{http://www.xbrlsite.com/site1/2018/10k/rss.xml}

\textsuperscript{81} Negative results from tests, \url{http://xbrlsite.azurewebsites.net/2019/Library/2019-03-31_FAC-ErrorDetails.zip}

\textsuperscript{82} Excel-based extraction tool, \url{http://xbrl.squarespace.com/journal/2018/1/11/further-updated-and-expanded-xbrl-based-financial-report-ext.html}
5. **Rules engine** error. The rules engine used to process the report and test its facts against the knowledge base could be flawed. To make this logical system consistent, the rules engine algorithms simply need to be corrected.

6. **Structure** missing (i.e. reporting style does not exist). A report could be unique and a reporting style does not exist for the report. To make this logical system consistent, a new structure (reporting style) simply needs to be added and then used by the report.

Once the terms, associations, structures, assertions, and facts are brought into equilibrium for a report; then the report would be consistent and a properly functioning logical system. This process is repeated for each report.

For the second set, there are more possibilities for inconsistencies and only approximately 68 disclosures were tested in each 10-K of the anticipated perhaps 500 to 1,500 possible disclosures. So, the testing is not as complete. And, the testing is not based on sound statistical testing so I cannot say that a sampling of disclosures was tested. However, there is no evidence to lead me to believe that I am missing something important. And so, what testing was done did show that, similar to the first set, there are specifically identifiable errors and specifically identifiable tasks that would cause the errors to be corrected and then cause the report fact to be consistent with the knowledge base. The categories of error are very similar and so they will not be repeated here.

**Conclusion**

The Department of Philosophy of Texas State provides this excellent differentiation between a condition that is *necessary* and a condition that is *sufficient*:

A **necessary condition** is a condition that must be present for an event to occur. A **sufficient condition** is a condition or set of conditions that *will produce the event*. A necessary condition must be there, but it alone does not provide sufficient cause for the occurrence of the event. Only the sufficient grounds can do this. In other words, all of the necessary elements must be there.

To effectively communicate the semantics of financial statements it is necessary to:

- Agree on a specific common shared world view.
- Agree on a specific common shared inference logic.

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83 Texas State, Department of Philosophy, *Confusion of Necessary with a Sufficient Condition*, [https://www.txstate.edu/philosophy/resources/fallacy-definitions/Confusion-of-Necessary.html](https://www.txstate.edu/philosophy/resources/fallacy-definitions/Confusion-of-Necessary.html)
• Agree on a specific common background knowledge.
• Agree to extend the common background knowledge terms, associations, structures, and assertions properly (i.e. in permissible ways).
• Communicate the semantics of facts using the above agreed specific items.
• Physically transport those logical statements (structures, terms, associations, assertions, facts) using some syntax effectively.
• Prove that the logical statements are consistent, complete, precise and therefore that the financial statement is a properly functioning logical system.

Any lack of agreement or flaws will require additional steps to be taken in order to effectively communicate the semantics of financial information and to use that communicated information effectively. “Hope” and “wishful thinking” or “good intensions” are not sound engineering principles and will never help in achieving successful communication of semantic information. Effective engineering creates the possibility of successful communication of information. Business professionals should not need to be concerned with the engineering details, they simply need to use the system and the system should be reliable and safe.

Empirical evidence, in my view, seems to prove what is necessary to exchange semantic information, the “words” and “numbers”, contained in financial reports. Since general business reports are likewise made up of “words” and “numbers” this proof may likewise apply to general business reports.

* * *

The following appendices below provide additional detailed information that supports statements made and provide additional details related to information conveyed in the body of this document above.

* * *

Appendix: Plethora of Approaches to Representing Logical Systems

There is a plethora of approaches to representing what amounts to a logical system. Logical systems are used in philosophy, mathematics, electrical engineering, computer science, design of nuclear power plants and other complex physical systems, etc. What makes this harder than necessary to understand is that all these different logical systems use different terminology to describe the pieces that make up the logical system. But all of these explanations are fundamentally grounded in formal logic that was created about 2,500 years ago.
The *Book of Proof*\(^{84}\) explains the fundamentals of sets, set theory, logic, logical systems, logical statements, deduction, and other related topics. Logic was invented by Aristotle in the 4\(^{\text{th}}\) century BCE. Logic is a discipline of philosophy and is the foundation for many things such as set theory, mathematics, computer science, electronics. A proof is a communications tool that is based on logic.

To make logic more useful, they make it more formal. A first step in this direction was propositional logic\(^{85}\) or statement logic, now referred to as propositional calculus. The purpose of propositional logic was to help people reason about the world. Fundamentally, it was about proving if statements were true or false and deducing new statements and creating a chain of reasoning\(^{86}\).

But propositional logic had some limitations and so predicate logic\(^{87}\), or predicate calculus, was created. As I understand it, predicate calculus added three things to propositional logic: the notions of variables, predicates, and qualifiers. Predicate calculus seems to have been an extremely useful tool because you could then logical systems and construct models.

When computers were invented, predicate logic and models became way more useful. But you have to get the computer to understand the logic.

In their book, *Algebraic Models for Accounting Systems*\(^{88}\); Jose Garcia Perez, Savador Cruz Rambad, Robert Nehmer, and Derek J. S. Robinson point out the following:

"In order to formalize a language, there must be a specification of the signs and symbols of the formal language, as well as a specification of the permissible manipulations of the symbols."

Logic was getting increasingly powerful and useful as a tool. A distinction was created between first-order logic\(^{89}\) and higher-order logics. First-order logic was easier and safer to use in computer systems and higher-order logics where harder to control and could be unsafe. Model theory\(^{90}\) added to the capabilities of first-order logic.

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\(^{84}\) Richard Hammack, Book of Proof (Third Edition),


Appendix: Requirements for Effective Exchange of Information

The following are several explanations of what it takes to exchange information effectively.

HL7

HL7, or Health Level Seven, published a video *Introduction to Health Level Seven*[^hl7] which summarizes three things that are necessary to achieve “interoperability” or effectively exchange information. Those three things are:

- **Technical interoperability**: Moving data from system A to system B.
- **Semantic interoperability**: Ensuring that system A and system B understand the data in the same way.
- **Process interoperability**: Enabling business processes at organizations housing system A and system B to work together.

**Common Logic, Helsinki principle (ISO TR 9007:1987)**

Those creating common logic[^commonlogic], which ultimately became an ISO standard, point out that:

- Any meaningful exchange of utterances depends upon the prior existence of an agreed set of semantic and syntactic rules.
- The recipients of the utterances must use only these rules to interpret the received utterances, if it is to mean the same as that which was meant by the utterer.

**Towards a Theory of Semantic Communication**[^towards]

The paper Towards a Theory of Semantic Communication points out that there are three levels involved with creating effective communication between computer systems:

- “LEVEL A. How accurately can the symbols of communication be transmitted? (The technical problem.)
- LEVEL B. How precisely do the transmitted symbols convey the desired meaning? (The semantic problem.)


[^towards]: Jie Bao et.al., *Towards a Theory of Semantic Communication*, page 1, [https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf](https://pdfs.semanticscholar.org/fa34/3407847eea1f7e8bb8d3d7489b6945e2b0b2.pdf)
LEVEL C. How effectively does the received meaning affect conduct in the desired way? (The **effectiveness problem**.)

There are many different representations of this same information. The pattern is that in order to achieve meaningful automated communication between machine-based systems you need:

1. A physical format to move the information from one system to the other (i.e. **technical syntax interoperability**)
2. A logical language represented within that physical format and statements about the structures, associations, assertions, and facts using that logical language (i.e. **semantic interoperability including structural interoperability**)
3. Agreed upon process (i.e. **process interoperability**)

The actual physical exchange and communication of information requires only #1 and #2; but to effectively use the information you also need #1. An example of process interoperability is how are amended reports handled.

**Shawn Riley**

This is a description of the four levels of interoperability provided by Shawn Riley\(^4\). Here are those four levels:

- **Foundational** (Level 1): Establishes the *inter-connectivity requirements* needed for one system or application to securely communicate data to and receive data from another.
- **Structural** (Level 2): Defines the *format, syntax and organization of data exchange* including at the data field level for interpretation.
- **Semantic** (Level 3): Provides for *common underlying models and codification of the data* including the use of data elements with standardized definitions from publicly available value sets and coding vocabularies, providing shared understanding and meaning to the user.
- **Organizational** (Level 4): Includes *governance, policy, social, legal and organizational considerations* to facilitate the secure, seamless and timely communication and use of data both *within and between* organizations, entities and individuals. These components enable shared consent, trust and integrated end-user processes and workflows.

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Appendix: Relationship between Knowledge Representation and Reasoning Capabilities

The following graphic shows the relationship between knowledge representation capabilities and reasoning capabilities of a machine-based system:

![Spectrum for Knowledge Representation and Reasoning Capabilities](image)

Fundamentally, there is a direct correlation between the ability for a software application to mimic human reasoning and the approach and language used to represent the knowledge that drives the software application. A machine-readable logical theory has the most powerful reasoning capabilities.

Appendix: Ontology-like Thing Spectrum

Representing knowledge can be done, as pointed out in the previous section, using many different knowledge representation schemes and forms a spectrum. This spectrum is documented in knowledge

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engineering textbooks and referred to as the ontology spectrum\(^{96}\). Others use the term “ontology-like thing” which I also prefer\(^{97}\).

The following graphic was inspired by a similar graphic\(^{98}\) by Deborah L. McGuinness and the same graphic in the textbook Ontology Engineering\(^{99}\) by McGuinness and Elisa Kendall which I modified to adjust the terms used to describe the graphic:

![Ontology Spectrum Diagram](https://example.com/ontology_spectrum_diagram.png)

The point is that when you move from left to right in the spectrum the expressive power increases. In brief, simple terms:

- Dictionaries define “terms” (simple terms, atomic terms).
- Thesauri and taxonomies expand on the knowledge of the terms, adding formal information about “associations” between the terms.
- Ontologies expand expressive capabilities further by adding the capability to represent “facts”, the ability to represent information about properties (type of association), value restrictions (type of property), and construct functional terms a.k.a. “structures”.
- Logical theories expand knowledge even further by enabling the articulation of mathematical “assertions”.

---


Again, keep in mind that this is a brief, simple explanation of what is going on. All of this fits into the fundamental pieces of any logical theory or logical system: models, structures, associations, assertions, and facts.

Appendix: Distinguishing Between Good, Less Good, Worse, and Bad Ontology-like Things

In her book *An Introduction to Ontology Engineering*\(^{100}\) (PDF page 23), C. Maria Keet, PhD, provides discussion about what constitutes a good and perhaps a not-so-good ontology. There are three categories of errors she discusses:

- Syntax errors
- Logic errors
- Precision and coverage errors

Syntax errors and logic errors are rather obvious. Precision and coverage are less obvious. 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.

Keet provided an excellent graphic that explains precision and coverage in her textbook. I modified that graphic and created the following two graphics:

---

High precision, High coverage (Very good)
All important aspects of reality related to some universe of discourse necessarily to achieve some goal or objective or a set of goals/objectives have been represented.

The graphic above shows a logical system that has high precision and high coverage. The graphics below show that same graphic as contrast to other graphics where either the precision or coverage or both where out of whack:

High precision, Low coverage (Less Good)
While all important information represented could be represented is precisely represented; other important information with respect to a universe of discourse which could be represented has not been represented.

Low precision, High coverage (Bad)
Information that does not exist in reality from the domain of discourse or information that is unimportant from the domain of discourse (i.e. pink) is represented (i.e. green).

Low precision, Low coverage (Worse)
Information that does not exist in reality (i.e. pink) is represented (i.e. green) and significant important information has not been represented related to some universe of discourse.

Low precision, Low coverage (Inadequate)
The representation language used does not have the expressive power to represent the information important to the universe of discourse necessary to meet the goal(s) and objective(s) of the system.
The point is that one needs to consciously understand that a system is both logically consistent and that the precision and coverage are appropriate to reach the conclusion that the system is consistent and therefore properly functioning.

Appendix: Double-entry Accounting.

Single-entry accounting is how ‘everyone’ would do accounting. In fact, that is how accounting was done for about 4,000 years before double-entry accounting was invented. Double-entry accounting was the invention of medieval merchants and was first documented by the Italian mathematician and Franciscan Friar Luca Piccoli\(^{101}\) in 1494. The section related to double-entry accounting was translated into English in 1914\(^{102}\).

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.

Which came first, double-entry accounting or the enterprise? It is hard to overstate the impact of double-entry accounting on the evolution of the complex global enterprise\(^{103}\).

Appendix: Foundational Mathematical Equation for Double-Entry Accounting

The foundational basis of double-entry accounting is straightforward. Quoting David Ellerman from his paper *The Math of Double-Entry Bookkeeping: Part I (scalars)*\(^{104}\):

> “Given an equation \(w + \ldots + x = y + \ldots + z\), it is not possible to change just one term in the equation and have it still hold. Two or more terms must be changed.”

And so, the left-hand side of the equation “\(w + \ldots + x\)” (the DEBIT side) must always equal the right-hand side of the equation “\(y + \ldots + z\)” (the CREDIT side) in double-entry accounting. The reason that double-entry accounting is used, as contrast to single-entry accounting, is double-entry accounting’s capability to detect errors and to distinguish an error from fraud.

---

Of course, there are a lot of details associated with setting up and operating an accounting system appropriately, but the fundamental feature is that DEBITS must equal CREDITS and if they don’t, then something is up which needs to be investigated and corrected.

If you desire to learn more about double-entry accounting, see Colin Dodd’s rap song, Debit Credit Theory (Accounting Rap Song)\(^\text{105}\).


While the model “Debits = Credits” or the notion of basically using two single entry ledgers and synchronizing them to detect errors or fraud is useful; additional power is provided to double-entry accounting via the accounting equation\(^\text{106}\) which is:

“Assets = Liabilities + Equity”

The accounting equation within the double-entry accounting is the fundamental basis for financial accounting. By definition, every financial reporting scheme\(^\text{107}\) has this high-level model at its core.

**Appendix: Ledgers and Journals, Stocks and Flows**

Another important piece of double-entry accounting is explained well in David Ellerman’s article, *The Math of Double-Entry Bookkeeping: Part II (vectors)*, is ledgers and journals\(^\text{108}\).

Many accountants use the terms “ledger” and “journal” incorrectly. This works the same for general and special ledgers and journals. This is the relationship between a ledger and a journal:

---

\(^{105}\) YouTube, Colin Dodd’s rap song, Debit Credit Theory (Accounting Rap Song), [https://www.youtube.com/watch?v=j71Kmxv7smk](https://www.youtube.com/watch?v=j71Kmxv7smk)


Ledgers summarized balances. For example, the general ledger summarizes account balances. Journals record the transactions which make up the changes between ledger balances. Other terms used for the relationship shown above are “roll forward” or “movements” or “stocks and flows” or “account analysis”. All three of these terms basically explain the following equation:

“Beginning balance + Additions - Subtractions = Ending balance”

Balance sheet accounts are stocks. Roll forwards of the beginning and ending balances of balance sheet accounts are flows. The income statement is a flow of net income (loss). The cash flow statement is a roll forward of the net change in cash and cash equivalents. The statement of changes in equity is a roll forward of equity accounts.

Many transactions, events, circumstances, and other phenomenon are recorded as transactions in a journal, make their way to a ledger, and then end up in the primary financial statements or within disclosures which detail the line items of the primary financial statements. Much of this information is part of the two trees which make up the roll ups of “Assets” and “Liabilities and Equity”. However, other there are other trees that can make up the complete “forest” of a financial report. For more information about the “forest” and the “trees” of a financial report, see the document *Leveraging the Theoretical and Mathematical Underpinnings of a Financial Report*109. That document also has some good information related to triple-entry accounting which I am not going to get into here.

As pointed out in the document *General Ledger Trial Balance to External Financial Report*110, each balance sheet line item has a roll forward. While perhaps not reported externally, these roll forwards can be quite helpful internally to verify that a financial report has been created correctly.

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Appendix: Summary Table and Comparison of Results

The following is a table which summarizes and contrasts the results obtained by creating XBRL-based machine-readable information for each of the logical systems that were used to analyze the incremental logical systems and then synthesize an approach to controlling variability:

<table>
<thead>
<tr>
<th>Terms</th>
<th>SFAC 6</th>
<th>Common Elements</th>
<th>MINI Reporting Scheme</th>
<th>Microsoft 2017 10-K</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10</td>
<td>20</td>
<td>126</td>
<td>491</td>
</tr>
<tr>
<td>Structures</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>Assertions (Rules)</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Facts</td>
<td>3</td>
<td>13</td>
<td>29</td>
<td>183</td>
</tr>
<tr>
<td>Terms defined</td>
<td>3</td>
<td>10</td>
<td>20</td>
<td>126</td>
</tr>
<tr>
<td>Structures defined</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>Assertions defined</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Facts provided</td>
<td>3</td>
<td>13</td>
<td>29</td>
<td>183</td>
</tr>
</tbody>
</table>

The following sections provide details of each increment in the analysis process and how each increment contributes to the synthesis of an approach to overcoming specific impediments and effectively control the variability inherent in a financial report.

Appendix: Accounting Equation Logical System Proof

The accounting equation is a rather simple and straight-forward logical system that no one would really dispute. The accounting equation is well documented, well understood, and has been around for hundreds of years. Because there are so few terms, structures, associations, assertions, and facts it is easy to get your head around the fact that the accounting equation is a properly functioning logical system without the help of a machine to verify that the logical system is consistent, complete, and precise.

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111 Accounting equation represented using XBRL, [http://xbrlsite.azurewebsites.net/2019/Core/master-ae/](http://xbrlsite.azurewebsites.net/2019/Core/master-ae/)
114 Mini financial reporting scheme represented using XBRL, [http://xbrlsite.azurewebsites.net/2019/Prototype/mini/documentation/](http://xbrlsite.azurewebsites.net/2019/Prototype/mini/documentation/)
Above you see three terms; “Assets”, “Liabilities” and “Equity”; one assertion “Assets = Liabilities and Equity”; one structure “Balance Sheet”; and three facts, “5,000”, “1,000”, and “4,000”. There are also three associations that explain that each of the three terms are part of the structure. All of this explained in machine-readable terms effectively using XBRL\textsuperscript{117}. Human-readable and machine-readable documentation\textsuperscript{118} is provided to help anyone trying to understand the representation. Each logical system provides similar documentation.

This small, simple accounting equation logical system can help one understand how logical systems function and also see and understand exactly what can go wrong within a logical system.

Below are six possible permutations and combinations of states that might possibly exist in this small accounting equation logical system:

\[\text{Assets} = \text{Liabilities} + \text{Equity}\]

\[\text{Assets} = 5,000\]
\[\text{Liabilities} = 1,000\]
\[\text{Equity} = 4,000\]

\textbf{Balance Sheet}

\textbf{Accounting Equation}

\textsuperscript{117} XBRL instance with connected XBRL taxonomy schema and XBRL linkbases, http://xbrlsite.azurewebsites.net/2019/Core/master-ae/instance.xml
\textsuperscript{118} Accounting Equation documentation, http://xbrlsite.azurewebsites.net/2019/Core/master-ae/
State (1) is that the logical system is consistent, complete, and precise and therefore the system is provably properly functioning. State (2) shows a logical system that is incomplete because the assertion “Assets = Liabilities + Equity” is not included in the system and therefore erroneous facts could exist but you would not know they were erroneous, or at least people could disagree, because the assertion is missing. State (3) is complete, but both inconsistent because assets does not equal liabilities plus equity and imprecise because assets should equal liabilities plus equity in the real world per the provided assertion. State (4) is questionably incomplete because the fact liabilities of 1,000 is not provided within the system; however, because the assertion exists and because the other two facts assets and equity exist the fact liabilities can be deducted using the rules of logic, the other two facts, and the assertion. State (5) both the fact liabilities and the assertion are not provided so that it is impossible to deduce the fact liabilities using the rule because the assertion is not provided. State (6) is consistent in that per the assertion “Assets = Liabilities” assets and liabilities are equal; however, the assertion “Assets = Liabilities” is imprecise because in the real world “Assets = Liabilities + Equity”.

All of these permutations are important to keep in the back of your mind because these are exactly the same sorts of errors that can exist in every one of these intermediate steps and more importantly within a real XBRL-based financial report.
Appendix: SFAC 6 Logical System Proof

SFAC 6\(^{119}\), which is provided by the FASB and part of the conceptual framework for US GAAP financial reporting, is used for the next incremental step. I could have used the conceptual framework that defines IFRS elements of a financial statement, in fact I did that also\(^{120}\).

However, (a) there is no reason to include both US GAAP and IFRS because they are essentially identical, (b) the IFRS Foundation makes it hard to get to the documentation and the FASB makes it easy and free, and (c) I had to pick one so I picked US GAAP. This is documented similar to the accounting equation\(^ {121}\).

And so here is a screen shot of the logical system explained by SFAC 6 below. Note that it is essentially identical to the accounting equation in that it defines terms (10 terms in this case as contrast to the accounting equation’s 3 terms), assertions (3 assertions in this case as contrast to the accounting equation’s 1 assertion), structures (3 structures in this case as contrast to the accounting equation’s 1 structure), and facts (13 facts in this case as contrast to the accounting equation’s 3 facts). But the principles for the logical system are exactly the same.

\[
\begin{align*}
\text{Assets} &= 3,500 \ (T1); \ 0 \ (T0) \\
\text{Liabilities} &= 0 \ (T1); \ 0 \ (T0) \\
\text{Equity} &= 3,500 \ (T1); \ 0 \ (T0) \\
\text{Revenues} &= 7,000 \\
\text{Expenses} &= 3,000 \\
\text{Gains} &= 1,000 \\
\text{Losses} &= 2,000 \\
\text{Comprehensive income} &= 3,000 \\
\text{Investments by Owners} &= 1,000 \\
\text{Distributions to Owners} &= 500 \\
\text{Assets} &= \text{Liabilities} + \text{Equity} \\
\text{Comprehensive Income} &= \text{Revenues} - \text{Expenses} + \text{Gains} - \text{Losses} \\
0 &= (\text{Equity}^{T0} + \text{Revenue}^{P1} - \text{Expenses}^{P1} + \text{Gains}^{P1} - \text{Losses}^{P1} + \text{Investments by Owners}^{P1} - \text{Distributions to Owners}^{P1}) + \text{Liabilities}^{T1} - \text{Assets}^{T1}
\end{align*}
\]


\(^{120}\) IFRS elements of a financial statement, http://xbrlsite.azurewebsites.net/2019/Core/core-ifrs/

\(^{121}\) SFAC 6 documentation, http://xbrlsite.azurewebsites.net/2019/Core/core-sfac6/
I am not going to provide all the permutations and combinations of possible states that might exist for the logical system can be inconsistent, incomplete, and imprecise; all of the possibilities described by the accounting equation still exist.

However, I will introduce a new possibility of something that can go wrong. Because you now have more than one structure it is possible to use a term in the wrong structure. For example, a term defined for use within the income statement might be inadvertently used on the changes in equity instead.

And so, above you see what would be considered a properly functioning logical system. It is a bit larger than the accounting equation, you can still get your head around this and so you don’t need a machine-based process to help you, but you can see that it is slightly more complicated and if you created a lot of these you might see how a machine-based system that automates the process of verifying that all the moving pieces of the puzzle are correct and that the logical system is properly functioning could be useful.

Appendix: Four Statement Model and Common Elements of Financial Statement Proof

The four statement model and common elements of a financial statement was defined by me because neither the FASB nor IASB defined this in their conceptual framework although as you dig deeper into either US GAAP or IFRS conceptual framework you see the notion of a cash flow statement emerging. You also see the notions of “current” and “noncurrent” emerging. You also see the notion of “controlling interest” and “noncontrolling interest” emerging in the standards. I combined all of these ideas into one document.

Finally, I wanted to more formally introduce the notions of the roll forward with which every accountant is very familiar. The roll forward is distinguished from the better understood roll up in that a roll up aggregates some whole into its mathematical parts. Whereas a roll forward literally “rolls forward” a balance sheet account balance from one point in time to some other future point in time. Usually, a roll forward is used to reconcile the balance of the beginning balance sheet line item to the ending or currently reported balance sheet line item.

And so now we have the complete four statement model that is very familiar to financial analysts that analyze financial statements and the accountants that create those statements. Here is that screen shot:

---

Because the number of terms and therefore reported facts is increasing and because the number of structures is increasing you can see that it gets just a little more complicated to verify the four statement model and common elements of a financial report manually simply by looking at it. It is possible, but again you may begin seeing why automated machine-based approaches might be helpful.

Appendix: MINI Financial Reporting Scheme Logical System Proof

Inspired by a prior example\(^{123}\), by the notion of a special purpose financial statement\(^ {124}\) as contrast to a general purpose financial statement\(^ {125}\), by the need to still keep things as simple as possible, but to point out what a complete financial statement looks like I created the Mini

\(^{123}\) Trial balance to external financial report, \url{http://xbrlsite.azurewebsites.net/2019/Core/core-trialbalance/}
\(^{124}\) XBRL-based Special Purpose Financial Statements, \url{http://xbrl.squarespace.com/journal/2019/11/26/xbrl-based-special-purpose-financial-statements.html}
\(^{125}\) Case for the XBRL-based General Purpose Financial Statement on One Slide, \url{http://xbrl.squarespace.com/journal/2019/2/10/case-for-xbrl-based-general-purpose-financial-reporting-on-o.html}
Financial Reporting Scheme. This example combines the characteristics of other examples that I had into one complete set.

I cannot show one simple diagram that shows a financial report created using the MINI financial reporting scheme is consistent, complete, precise, and therefore properly functioning. Such a list of terms, associations, structures, assertions, facts, and images would be too large for one report. The best I can do is to show somewhat of a “dashboard” that tries to convey that same information for larger numbers of terms, structures, associations, assertions, and facts into a useful user interface with the ability to “drill down” to details you wish to view:

<table>
<thead>
<tr>
<th>Component (Network/Table)</th>
<th>Status</th>
<th>Count of Relations</th>
<th>XBRL Technical Syntax Rules</th>
<th>Model Structure Rules</th>
<th>Business Rules</th>
<th>Roll Up Rules</th>
<th>Other Manual Review Tasks</th>
<th>Other Rules and Best Practice Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001 - Document - Document Information</td>
<td>Completed</td>
<td>10</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>1002 - Document - Entity Information</td>
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<td>5</td>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>1101 - Statement - Balance Sheet</td>
<td>Completed</td>
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<td>OK</td>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>1102 - Statement - Income Statement</td>
<td>Completed</td>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>1103 - Statement - Cash Flow Statement</td>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>1104 - Statement - Changes in Equity</td>
<td>Completed</td>
<td>6</td>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>2110 - Disclosure - Nature of Business Note</td>
<td>Completed</td>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>2120 - Disclosure - Basis of Reporting Note</td>
<td>Completed</td>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>2130 - Disclosure - Significant Accounting Policies Note</td>
<td>Completed</td>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>2300 - Disclosure - Cash and Cash Equivalents Note</td>
<td>Completed</td>
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<td>OK</td>
<td>OK</td>
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<td>OK</td>
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<td>OK</td>
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<tr>
<td>2400 - Disclosure - Receivables Note</td>
<td>Completed</td>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>

A second application provides similar information. There are two important points that are made by pointing these two software interfaces that are essentially doing exactly the same thing. First, note that the software interfaces are completely different but essentially provide the same information. This is important because what is going on is that software uses the machine-readable terms, structures, associations, assertions, and facts to dynamically generate the user interface. Second, two software tools used the same machine-readable logically articulated rules to reach exactly the same conclusion about the consistency, completeness, and precision of the logical system that is driving the software.

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126 Mini financial reporting scheme represented using XBRL, [http://xbrlsite.azurewebsites.net/2019/Prototype/mini/documentation/Index.html](http://xbrlsite.azurewebsites.net/2019/Prototype/mini/documentation/Index.html)
There is one final aspect that is very much worth pointing out. I showed you one “dashboard” that provides an organized means if interacting with one report. So, how would that work for having an entire repository of reports? Think of something similar to the SEC EDGAR System that contains the financial reports of thousands of reporting economic entities over a period of many years?

To go along with the MINI financial reporting scheme, I created a prototype repository\(^\text{128}\) into which financial reports creating using the scheme would be put and a validation dashboard for the repository of financial reports\(^\text{129}\):


This MINI financial statement repository is similar to the EDGAR Dashboard\textsuperscript{130} provided by XBRL Cloud for XBRL-based reports submitted by public companies to the SEC.

But there is one very big difference between my MINI financial report repository and the SEC EDGAR repository that can be explained in one word: control.

The point of the MINI financial report repository is to explain you can get 100% of reports included within the repository 100% correct consistent, complete, and precise and to accurately explain the impediments to achieving that objective. The objective is to be able to create a system that can be used with special purpose and general purpose financial reporting schemes to get Sigma Level Six\textsuperscript{131} quality of 99.99966%. With that level of information quality, the information can be usable by automated machine-based processes for analysis of the information or down stream use of the information in some other manner.

But first, there is one final incremental level of proving that a financial report is a properly functioning logic system that I need to explain.

**Appendix: Microsoft 2017 10-K Financial Report Logical System Proof**

It was a small leap to move from the small accounting equation logical system to the SFAC 6 elements of a financial statement logical system. It was likewise a small leap from SFAC 6 to the four statement model and common elements of a financial report that I defined. It was a bit of a larger leap from the four statement model to the MINI financial reporting scheme that I created. It is likewise a significant leap from the MINI financial reporting scheme to the actual XBRL-based 10-K financial report created by Microsoft and submitted to the U.S. Securities and Exchange Commission\textsuperscript{132}.

But the leap is only in terms of the volume of terms, associations between terms, assertions between terms, structures used to organize associations and assertions, and the number of facts described by the logical system of terms, associations, assertions, structures, and facts. The **principles** and **philosophies** behind the accounting equation example, the SFAC 6 example, the four statement example, the MINI financial reporting scheme example, and the actual Microsoft 10-K report submitted to the SEC are identical.

\textsuperscript{130} XBRL Cloud, EDGAR Dashboard, \url{https://edgardashboard.xbrlcloud.com/edgar-dashboard/}
\textsuperscript{131} Wikipedia, *Six Sigma, Sigma Levels*, \url{https://en.wikipedia.org/wiki/Six_Sigma#Sigma_levels}
\textsuperscript{132} Summary of Human Readable Renderings, bullet point 2, Microsoft, \url{http://xbrl.squarespace.com/journal/2019/3/23/summary-of-human-readable-renderings.html}
The leap from the one Microsoft 10-K report and the entire EDGAR system repository of reports is nothing more than another increase in volume with no change in principles and philosophies.

The Microsoft 2017 10-K has exactly 194 structures. This is a breakdown of those structures by concept arrangement pattern\(^\text{133}\) and by SEC reporting level:

<table>
<thead>
<tr>
<th>Concept Arrangement Pattern</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text Block</td>
<td>89</td>
</tr>
<tr>
<td>Set</td>
<td>64</td>
</tr>
<tr>
<td>Roll Up</td>
<td>31</td>
</tr>
<tr>
<td>Roll Forward</td>
<td>9</td>
</tr>
<tr>
<td>Roll Forward Info</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEC Level</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Disclosure Detail</td>
<td>102</td>
</tr>
<tr>
<td>Level 3 Disclosure Text Block</td>
<td>47</td>
</tr>
<tr>
<td>Level 2 Policy Text Block</td>
<td>23</td>
</tr>
<tr>
<td>Level 1 Note Text Block</td>
<td>22</td>
</tr>
</tbody>
</table>

Of the 194 structures in the Microsoft 10-K, I have rules that verify only 49 of those which amounts to about 100 structures\(^\text{134}\). Remember that most parts of an SEC are reported three times; once as a Level 1 Note Text Block, again as a Level 3 Disclosure Text Block, and again as a Level 4 Disclosure Detail. The exception are the document and entity information and the primary financial statements which are not provided as text blocks. Policies are reported twice; once in a Level 1 Note Text Block that contains the significant accounting policies and again as the Level 2 Policy Text Block for the individual policies. I would estimate that I am verifying 94 structures; about half of the report. Estimating precisely is tricky because it is unclear what the appropriate level of validation is necessary for Level 1 Note Text Blocks which are presentation related and Level 2 Policy Text Blocks. The only way to really find out is to actually undertake the task to verify 100% of an entire report which is on my list of things to do.

The bottom line is this: everything that I am attempting to verify is provably verifiable using machine-based automated processes. To be crystal clear, I am not saying that automated processes can be used to “audit a report” or “verify that every detail of the report is 100% correct”. What I am saying is that 100% of the mathematical relations (assertions) can be verified as being correct using automated processes, 100% of the structural relations can be verified as being correct using automated processes, 100% of the associations can be verified as being correct using automated processes but only if the rules have been represented appropriately in machine-readable form.


And so, what does this mean for the Microsoft 10-K logical system? It means that all that stands between the XBRL-based report as it exists now and me being able to say that the report is a provably properly functioning logical system is for me or someone else to represent about 100 sets of rules in machine-readable form. I already have software applications, two actually, that can process the rules. The terms, associations, structures, and facts all exist.

**All that is missing are the assertions or rules.**

### Appendix: Variability Caused by Alternative Intermediate Components

While financial reports created using some financial reporting scheme must fit within the elements of a financial statement defined by the financial reporting scheme; financial reports are not forms. Specific variability consciously created, is anticipated, and is explicitly allowed in robust financial reporting schemes such as US GAAP, IFRS, IPSAS, GAS, FAS, and others.\(^{135}\)

By far, the most variability that exists within a set of financial statements exists on the statement of financial performance (income statement). For example, SFAS 6 discusses the notion of intermediate components\(^ {136}\) of comprehensive income:

> "Examples of intermediate components in business enterprises are gross margin, income from continuing operations before taxes, income from continuing operations, and operating income. Those intermediate components are, in effect, subtotals of comprehensive income and often of one another in the sense that they can be combined with each other or with the basic components to obtain other intermediate measures of comprehensive income."

Basically, variability can be caused by choosing to report different common subtotals or by choosing to report specific line items rather than other line items. For example, a balance sheet can be classified, order of liquidity, liquidation basis reporting net assets, etc. An income statement can be single step, multi step, be specific to an accounting activity such as interest-based reporting or insurance-based reporting.

I refer to these different "subtotals and specific line items" as the notion of a reporting styles\(^ {137}\). This variability is not random or arbitrary; it is logical. There are commonly used reporting style patterns and less commonly used patterns. In essence, each of these patterns is simply a different structure or structures which combined specific terms, associations, and assertions.

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\(^{136}\) FASB, SFAC 6, page 47, paragraph 77.

Professional judgement is used to determine the line items that are reported within the framework of a financial statement that has been described above. Professional judgement is used to understand what reporting style structures are permissible and when exactly it is best to use one permissible reporting style structure as opposed to some other permissible reporting style structure. Sometimes the decision can be completely arbitrary based on personal preference. The structure itself, however, is objective and subject to the rules of mathematics, mechanics, and logic and are not open to interpretation or professional judgement. Further, it is never allowable to use a structure that is not permissible.

Appendix: Overcoming Impediments to Properly Functioning Financial Report Logical Systems

The best way to understand how to create a properly functioning financial report logical system is to understand the specific possible impediments to creating such a logical system and countermeasures which can be used to overcome each impediment. This section performs that function by pointing out each specific impediment and how the impediment can be overcome using automated machine-based processes.

Note that this section does not address obvious omissions of assertions, reporting erroneous facts, imprecise assertions that are not grounded in reality, and other such obvious issues caused by incomplete, imprecise, or clearly inconsistent statements that result in an improperly functioning logical systems. Our focus here is on patterns of impediments that have been problematic but are covered by well understood and very basic knowledge engineering principles.

Improper XBRL technical syntax

The first impediment is improper XBRL technical syntax. This impediment has been successfully overcome using automated processes by (a) XBRL International’s creation of a conformance suite that explicitly defines what is permissible XBRL technical syntax and (b) software vendors testing their software using that provided conformance suite. The results are demonstratable. XBRL-based financial reports submitted to the U.S. Securities and Exchange Commission are demonstratable 99.9% conformant with the XBRL International technical syntax conformance suites.

And so, the XBRL International XBRL technical syntax conformance suites overcome the impediment of improper XBRL technical syntax.

Improper XBRL presentation relations associations

While XBRL calculation relations and XBRL definition relations are explicitly covered by the XBRL International conformance suite, XBRL presentation relation associations are not covered as they are not part of the XBRL technical specification. The permissible relations are logical to a very large degree but there are some relations which can be effectively reasonably disputed. However, accounting
professionals should not need to have a debate about the permissible and impermissible relations. As such, overcoming this impediment simply boils down to specifying which of the following relations are permissible and which are not:

<table>
<thead>
<tr>
<th>Child</th>
<th>Network</th>
<th>Table</th>
<th>Axis</th>
<th>Member</th>
<th>LineItems</th>
<th>Abstract</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Network]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>[Table]</td>
<td>0</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>[Axis]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>[Member]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>[LineItems]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>[Abstract]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>142</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>[Concept]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

It is less important which of the logically reasonable relationships are specified as permissible and more about simply putting these permissible associations, whatever they are determined to be, into machine-readable form and enforced by software applications consistently.

Here is an example of an extreme, even pathological, of a set of relations which would be permissible in the absence of rules making these relationships impermissible:\[139\]:

Contrasting the pathological example above with the more commonly used example\[140\] makes it clear why the pathological example is, well, pathological:

---

\[139\] Pathological example of XBRL presentation relations,

\[140\] More commonly used example,
If you cannot see the difference, the pathological example is a set of Level 2 Policy [Text Block]s that form an indented hierarchy whereas the more commonly used example is simply a flat list with no hierarchy within the list of [Text Block]s. The list of [Text Block]s is flat.

To think about this issue, ask yourself the question, “What is the logical difference between the first approach and the second approach?” If there is no logical explanation between two things, then it is likely the case that only one of the two alternatives are necessary.

And so, explicitly agreeing on the permissible and disallowed associations between each category of report element and then putting that information into machine-readable form will overcome this impediment.

**Improper use of a class of line item as if were some different class**

FASB, in SFAC 6\(^{141}\), points out that the, “Elements of financial statements are the building blocks with which financial statements are constructed—the classes of items that financial statements comprise.” The notion of “class” and “subclass” is well understood in knowledge engineering. Essentially, something cannot be two different things; for example, if something is an “Asset” it cannot also be a “Liability”.

Again, both a positive and a negative example will make the point clear. The following is an example of what is considered a permissible cash flow statement per the MINI financial reporting scheme\(^ {142}\):

---


The following is not a permissible cash flow statement:\textsuperscript{143}:

\begin{center}
\begin{tabular}{|l|c|}
\hline
\textbf{Cash Flow Statement [Line Items]} & Period [Axis] \\
\hline
\hline
\hline
\textbf{Net Cash Flow [Roll Up]} & \\
\hline
Collection of Receivables & 3,000 \\
Payment of Accounts Payable & (2,000) \\
\textbf{Net Cash Flow Operating Activities} & 1,000 \\
\hline
\textbf{Net Cash Flow Financing Activities [Roll Up]} & \\
Additional Long-term Borrowings 2 & 6,000 \\
Repayment of Long-term Borrowings 2 & (1,000) \\
\textbf{Net Cash Flow Financing Activities} & 5,000 \\
\hline
\textbf{Net Cash Flow Investing Activities [Roll Up]} & \\
Capital Additions of Property, Plant and Equipment 2 & (5,000) \\
\textbf{Net Cash Flow Investing Activities} & (5,000) \\
\hline
Net Cash Flow & 1,000 \\
\hline
\textbf{Cash and Cash Equivalents, Beginning Balance} & \\
& 3,000 \\
Cash and Cash Equivalents, Ending Balance & 4,000 \\
\hline
\end{tabular}
\end{center}

\textsuperscript{143} Not a permissible cash flow statement, \\
Note the difference between the permissible and the impermissible cash flow statements; the line items in the permissible and impermissible have been switched. In the permissible version, the line items for additional long-term borrowings and repayment of long-term borrowings are rolled up into “Net cash Flow Financing Activities” whereas in the impermissible version they roll up to “Net Cash Flow Investing Activities”.

So, how do you know that the first statement that I say is permissible is actually permissible and that the second is not permissible? If you go to the XBRL taxonomy[^4] for these relations you can see that the XBRL presentation relations somewhat informally specify that additional borrowings and repayments are part of “Net Cash Flow Financing Activities”:

You can more formally see these relations per the XBRL definition relations and per the XBRL calculation relations. Here are the XBRL definition relations:\footnote{Entry Point for Viewing MINI XBRL Taxonomy, \url{http://xbrlsite.azurewebsites.net/2019/Prototype/mini/base-taxonomy/mini-entryPoint.xsd}}

And so, the MINI financial reporting scheme XBRL taxonomy formally specifies allowed associations between terms within a structure.

These associations provide information for software applications which allows the application to determine if an error was made in the use of a line item within the wrong class of high-level financial reporting element.

The improper use of a line item to represent one thing when it is designed to represent something else is an all-to-common error found in XBRL-based financial reports submitted by public companies to the SEC. This type of error is not unique to the SEC, it is inherent in any system that allows variability. With the allowed variability it is necessary to provide rules so that the variability can be effectively controlled.
And so, the way to overcome the impediment of a reporting economic entity using a line item of one class to report a fact related to some other class of line item is to explicitly define the class-subclass or types of class associations within a base XBRL financial reporting taxonomy.

**Inconsistent or contradictory reported information**

Looking at this balance sheet you will not find an error\(^\text{146}\):

<table>
<thead>
<tr>
<th>Balance Sheet [Line Items]</th>
<th>Period [Axis]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018-12-31</td>
</tr>
<tr>
<td><strong>Assets [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Current Assets [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td>Cash and Cash Equivalents</td>
<td>4,000</td>
</tr>
<tr>
<td>Receivables</td>
<td>2,000</td>
</tr>
<tr>
<td>Inventories</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Current Assets</strong></td>
<td>7,000</td>
</tr>
<tr>
<td>Property, Plant and Equipment</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Assets</strong></td>
<td>13,000</td>
</tr>
<tr>
<td><strong>Liabilities and Equity [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Liabilities [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td>Accounts Payable</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Current Liabilities</strong></td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Noncurrent Liabilities [Roll Up]</strong></td>
<td>6,000</td>
</tr>
<tr>
<td>Long-term Debt</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Noncurrent Liabilities</strong></td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Liabilities</strong></td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Equity [Roll Up]</strong></td>
<td></td>
</tr>
<tr>
<td>Retained Earnings</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Equity</strong></td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Liabilities and Equity</strong></td>
<td>13,000</td>
</tr>
</tbody>
</table>

\(^{146}\) Proper balance sheet,
Also, if you look at this set of financial highlights, they also seem quite reasonable even though the error was designed to really stand out:

<table>
<thead>
<tr>
<th>Financial Highlights [Line Items]</th>
<th>Period [Axis]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018-01-01 - 2018-12-31</td>
</tr>
<tr>
<td>Assets</td>
<td>13,000</td>
</tr>
<tr>
<td>Long-lived Assets</td>
<td>60,000</td>
</tr>
<tr>
<td>Sales</td>
<td>4,000</td>
</tr>
<tr>
<td>Operating Income (Loss)</td>
<td>2,000</td>
</tr>
<tr>
<td>Net Income (Loss)</td>
<td>2,000</td>
</tr>
<tr>
<td>Net Cash Flow</td>
<td>1,000</td>
</tr>
<tr>
<td>Capital Additions of Property, Plant and Equipment</td>
<td>5,000</td>
</tr>
</tbody>
</table>

But digging in a little further, or it actually might be obvious that something is unusual about the relation between assets and long-lived assets. If you look more closely you see that the concept used to represent the line item “Long-lived Assets” is “mini:NoncurrentAssets”.

---

Yet, the balance sheet structure signals no error and neither does the financial highlights structure signal an error. Each of those individual structures appears correct. However, if you cross check the information between reported structures then the inconsistency becomes crystal clear.

What exacerbates this issue is when important consistency cross check rules are left out of the logical system altogether.

| FAC_BS1_BalanceSheetBalances (evaluation 2) | satisfied | $Assets=5000 = $LiabilitiesAndEquity=5000 |
| FAC_BS7_AssetsEqualsCurrentPlusNoncurrentAssets (evaluation 1) | notSatisfied | $Assets=13000 = $AssetsCurrent+7000 + $AssetsNoncurrent+6000 |
| FAC_BS7_AssetsEqualsCurrentPlusNoncurrentAssets (evaluation 2) | notSatisfied | $Assets=6000 = $AssetsCurrent+5000 + $AssetsNoncurrent+1000 |
| FAC_BS3_LiabilitiesEqualsCurrentPlusNoncurrentLiabilities (evaluation 1) | satisfied | $Liabilities=7000 = $LiabilitiesCurrent+1000 + $LiabilitiesNoncurrent+5000 |

If important consistency cross check rules are neglected to be included within a logical system, then manual human effort is needed to detect what can be hard to find inconsistencies and contradictions within an XBRL-based financial report. Only about 89% of public companies that submit XBRL-based financial statements to the SEC have all of their high-level financial report line items in order\(^\text{148}\). That means that about 11% have one or more inconsistencies or contradictions within their reported financial information. On a per relation basis it does not seem quite as bad with 99.24% of all high-level financial report relations being what you would expect them to be. But that .76% leads to 926 errors in the some 125,752 relations tested of 5,716 entities. While this error rate is vastly better when only manual effort was used to detect such inconsistencies and contradictions, the error rate is still to high and needs to be about 99.99966% correct, Sigma Level 6, in order for the information to be reliable for automated analysis processes.

To mitigate this impediment, consistency cross check rules need to be created. And because of reporting variability, it is not the case that one set of consistency cross check rules can be applied to every reporting economic entity. When variability exists, that variability needs to be taken into account and different assertions need to be provide based on which structures are used to report information by an economic entity\(^\text{149}\).

And so, to overcome the impediment of contradictory or inconsistent reported information, the use of fundamental accounting concept continuity cross checks can be used.

**Improper structure of disclosures**

Imagine how complicated it is for an economic entity such as Microsoft to get every one of its 194 disclosure structures as is intended by the US GAAP XBRL Taxonomy. The fact that it seems like about


89% of all such disclosures are created correctly is a testament to the attention to detail of the professional accountants creating these reports. However, 89% is not remotely good enough. What if 100% was achievable? Well, 100% is achievable. Below you see one rule for one disclosure, Long-term Debt Maturities:

The above rendering was generated from the XBRL definition relations that specify the rules for the disclosure. Different software applications can provide the rule information to users in whatever form they might desire.

Verification of each structural rule for each disclosure can be organized into an easy to understand and use dashboard for visualizing the state of consistency with or inconsistency from the expected result. Below you see disclosure rules for all 30 disclosures that are provide in the MINI financial reporting scheme reference implementation report:


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Matures in One Year</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Two Years</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Three Years</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Four Years</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Matures in Five Years</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Matures Thereafter</td>
<td></td>
<td>5,000</td>
</tr>
</tbody>
</table>

If you examine the disclosure rules you will see that this disclosure is incorrectly created because the structural and mechanical rules specify that the disclosure is (a) supposed to be a roll up and that (b) the total of that roll up should be represented using the concept “mini:LongtermDebt”.

Now, this is not to say whether a US GAAP or IFRS disclosure of long-term debt maturities is required to include the total long-term debt line item and be a roll up or if it is acceptable to alternatively provide simply the set of annual maturities without the total. An analysis of all of the approximately 6,000 US public companies that report using US GAAP indicated that the best practice is, in fact, to include the line item for total long-term debt and have a roll up computation that aggregates the individual line items to the total.

If you look at the example again you might note that the total line items to not agree with the total long-term debt amount of $6,000. What is shown is what would aggregate to a total of $10,000 for total long-term debt. See how helpful the total is in preventing errors in a financial report? That is likely why the total line item is included as a best practice.

But suppose it was allowed for the set of items to be disclosed without the total. All that would need to be done is to create another disclosure, say “LongTermDebtMaturitiesWithoutTotal” and then to create a new set of rules and then the MINI financial reporting scheme would reflect that it is perfectly fine to provide this specific disclosure with or without the roll up total of the maturity line items.

As such, in order to provide a countermeasure to having a reporting entity to provide a disclosure incorrectly it is critically important to explicitly and clearly specify what is considered to be a permissible disclosure structure. You will note that the rules also include relations between the necessary Level 1 Note Text Block, the Level 2 Policy Text Block, and the Level 3 Disclosure Text Block to the Level 4 Disclosure detailed information that is required to be reported.
Appendix: Financial Reports are Not Forms

General purpose financial statements are essentially “complex messages with variability”. As explained by the FASB in SFAC 6, variability is an intentional, inherent characteristic of a financial statement. For example, per SFAC 6, page 47, paragraph 77:\footnote{154}

“Examples of intermediate components in business enterprises are gross margin, income from continuing operations before taxes, income from continuing operations, and operating income. Those intermediate components are, in effect, subtotals of comprehensive income and often of one another in the sense that they can be combined with each other or with the basic components to obtain other intermediate measures of comprehensive income.”

That statement describes the “intermediate components” that contribute to the variability of a financial report.

A financial report is essentially a “graph” as defined by graph theory\footnote{155}. A graph is a mathematical structure used to model pairwise relations between objects. Graphs don’t really exist in the real world, but they are used to describe real world objects to things like computer software.

It would be appropriate to call a financial report a “knowledge graph” and an XBRL-based financial statement is a machine-readable knowledge graph. A “tree” is special type of graph. So, let’s use the term “tree”. And so, imagine a financial report as a “tree” of information. Here is a tree.

\[ \begin{array}{c}
\text{And here is a “forest” of financial reports (i.e. a set of trees, for example the SEC EDGAR system might be considered a “forest” of financial reports:}
\end{array} \]

\footnote{154} Ibid.\footnote{155} Wikipedia, Graph Theory,
But really, the forest ABOVE is not really a good representation of US GAAP or IFRS forest of financial reports. The forest above assumes that all the “trees” are the same, which they are NOT because of the inherent variability of a financial report. And so, a “forest” of US GAAP or IFRS financial reports might better be represented by something more like this:

Due to the inherent variability of financial reports, they are not all the same. Yes, they have similarities and have patterns. But financial reports are not, and should not, be forms like the first forest. As I pointed out, this is explained clearly in SFAC 6.

But you can find patterns in the forest that is full of trees, the trees can be put into “sets” that have similarities. For example, they might look something like this:
One might be tempted to call the forest seven different types of “forms” because unlike the one pattern in the first forest, we have seven patterns and therefore seven different types of forms. But this would not be accurate.

Professional accountants creating XBRL-based financial reports can “move things around” and so trees will look different, they will have variability. The US GAAP XBRL taxonomy provides TERMS (e.g. “Cash and Cash Equivalents” or “Net Income (Loss) or such); provides ASSOCIATIONS (e.g. “Cash and Cash Equivalents” is a type-of “Current Asset”); provides STRUCTURES (e.g. the “Balance Sheet” is a structure, the “Income Statement” is a structure); provides ASSERTIONS or RULES (e.g. the roll up rules for “Current Assets” is a rule).

And so, professional accountants can “move things around” within an XBRL taxonomy used to represent a financial report. But, they can also create completely NEW terms, associations, structures, and assertions.

And so, if accountants creating financial reports can “move things around” because a financial report is not a form; then how exactly do you CONTROL those movements so that the result is not anarchy or chaos, but the effective exchange of information with the allowed variability of a financial report contemplated by the FASB?

Clearly, financial reports are not completely arbitrary, they are not illogical, they are not random. Financial reports are logical as are the TERMS, ASSOCIATIONS, STRUCTURES, and ASSERTIONS that support the FACTS conveyed by the financial report. How exactly do you do that? WHAT are the types of problems that might occur?

The problems that can occur include (you can use the GRAPHIC below to understand what I am trying to explain):

1. Using a TERM within the wrong STRUCTURE. (e.g. below using the term “Assets” that is meant for structure #1 within structure #3)
2. Using a TERM with an inappropriate ASSOCIATION. (e.g. below associating “Assets” with “Gains” which is inappropriate for the three given structures, but could possibly be fine within some other structure)
3. Adding a new TERM inappropriately. (e.g. adding the specialized Asset “Cash and Cash Equivalents” but then someone using the information uses it incorrectly because it was not properly “grounded” in the base taxonomy as being an “Asset”).
4. Inadvertently duplicating an existing TERM. (e.g. Add the term “Sales” which has exactly the same meaning as the existing term “Revenues”)
5. A violation of an ASSERTION. (i.e. facts do not follow the specified assertions provided by the model)

For more details, see the representation of SFAC 6 in XBRL.156

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It may seem absurd to contrast a simple model such as SFAC 6 with a significantly larger model such as the financial report of Microsoft. But in reality, the issues are exactly the same. Further, every stakeholder (creator of report, reviewer of report, analyst using report) have the same concerns related to the movement or creation of new terms, associations, structures, assertions.

**Appendix: Virtuous Cycle**

When a system works right, it creates a virtuous cycle\(^\text{157}\).