Theory-driven Semantic-oriented Financial Report Construction System

By Charles Hoffman, CPA (March 12, 2023) DRAFT

> *"…my writing will be useful for you and many others, especially those that want to acquire property honourably and not transgress against God or his fellow man.[1]"* Benedikt Kotruljević of Dubrovnik

Because of the crude, rudimentary tools accountants used at the time; the accountant of the 20th century will be remembered as being rather primitive. That statement might not make sense to the reader at this moment, but by the time you finish this document you will, perhaps, believe that the statement could possibly be true. But the reader might very likely be convinced of the statement's truth when they see the tools and ecosystem of the 21st century in operation. And you will not need to wait very long for such modern, 21st century tools for the construction of general-purpose financial reports.

Theory-driven semantics-oriented financial reporting is an approach that focuses on adding logical components such as statements, disclosures, policies and reported facts to financial reports. Additionally, relationships connect the fragments of such financial reports together in a way that permits things like navigation between the financial report logical components. The logic of the financial report is consistent with and complies with financial reporting rules articulated by some financial reporting scheme.

Theory-driven financial reporting is especially well suited to process-oriented techniques that tend to be used for constructing financial reports. Well established and understood good practices-based approaches to creating financial reports (i.e., patterns) can be leveraged by software applications to augment the skills of an accountant creating such financial reports.

When contrast to the current "canvas-based" or presentation oriented "table-based" approach where the creator of a financial reports works with presentation oriented technical artifacts such as tables, columns, rows, and cells; that a tool, such as a word processor, used to create such reports; a theory-driven semantics-oriented financial reporting construction tool understands the statements, disclosures, policies, and other financial reporting logical artifacts with which accountants work. As such, where word processors and electronic spreadsheets cannot actually assist accountants in the construction of a financial report; when using a theory-driven semantics-oriented financial reporting approach then software applications can actually understand financial reporting rules; the effective augmentation of the financial reporting knowledge of the accountant creating a financial report using such a tool is quite believable.

[1] Lazareti Hub, Benedikt Kotruljević, https://lazaretihub.com/en/biography/benedikt-kotruljevic

But what does “theory-driven” and “semantic-oriented” actually mean? How exactly does such a system work? How exactly will financial reporting processes be better, faster, and/or cheaper? How exactly will accountants’ benefit?

The purpose of this document is to answer those questions.

Theory-driven

When I first contemplated trying to describe what I was creating; I used the term “**model-driven**”. But after additional thought, I did not believe that model-driven was the appropriate term. To help understand what term is appropriate, consider this spectrum that I obtained from Emanuel Derman’s book, *Models. Behaving. Badly*[2] which I have paraphrased as follows:

- A **metaphor** describes something less understandable by relating it to something that is more understandable.
- A **model** is a specimen that exemplifies the ideal qualities of something. Models tend to simplify. There tends to always be gaps between models and reality. Models are analogies; they tend to describe one thing relative to something else. Models still need a defense or explanation.
- A **theory** describes absolutes. Theories are the real thing. A theory describes the important objects of its focus. A theory does not simplify. Theories are irreducible, the foundation on which new metaphors can be built. A successful theory can become a fact. A theory describes the important essence of the world and tries to describe the principles by which the world operates. A theory can be right or wrong, but it is characteristic by its intent: the discovery of essence. A theory can be proven to be correct or incorrect.

And so, what I am doing with XBRL-based digital financial reporting is closer to being a theory than it is to being a model. But more about this later and you can decide for yourself if I am working with a model or working with a theory.

Finally, recognize that my theory relates to the semantics, dynamics, mechanics, and logic related to the financial report itself. My theory is summarized in the document *Logical Theory Describing Financial Report*[3]. The theory provides a framework into which information related to a financial reporting scheme that is then used to create a report fits into.

To be very explicit, my theory is not a theory that covers 100% of the principles and practices of financial accounting and financial reporting. The theory covers only the report itself. And what is described is the logic of the report itself. The theory is a logical schema of a financial report and contains logical information that helps software make use of the information contained with the report.

Semantic-oriented

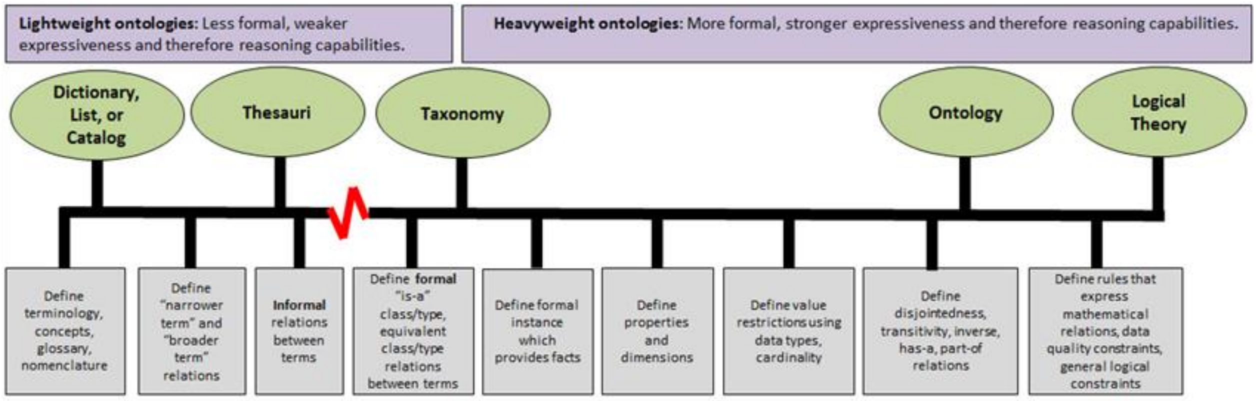
And so, again for contrast, I want to provide a spectrum of the possible approaches to articulating the logic, or semantics, or meaning of a financial report.

[2] Emanuel Derman, *Models. Behaving. Badly*., Chapter 2 Metaphors, Models, and Theories, page 33.

[3] Charles Hoffman, CPA, *Logical Theory Describing Financial Report (Terse)*, http://xbrlsite.com/seattlemethod/LogicalTheoryDescribingFinancialReport_Terse.pdf

The graphic below[4] is inspired by a similar graphic created by Deborah L. McGuiness and a graphic created by Dr. Leo Obrst. The intent of the graphic is to point out the spectrum of tools that can be used for knowledge representation.

Fundamentally, what is being represented in my theory is about the knowledge of the logical artifacts that describe, in the form of a theory, how a financial report works. Theories are more powerful than even heavyweight ontologies. But you can turn an ontology into more of a theory by adding rules (i.e., the reason SHACL was created to overcome the limitations of OWL). And so, this gives the reader an idea as to the relative power of different approaches to representing knowledge:


Lightweight ontologies: Less formal, weaker expressiveness and therefore reasoning capabilities.
Heavyweight ontologies: More formal, stronger expressiveness and therefore reasoning capabilities.
Dictionary, List, or Catalog
Thesauri
Taxonomy
Ontology
Logical Theory
Define terminology, concepts, glossary, nomenclature
Define "narrower term" and "broader term" relations
Informal relations between terms
Define **formal** "is-a" class/type, equivalent class/type relations between terms
Define formal instance which provides facts
Define properties and dimensions
Define value restrictions using data types, cardinality
Define disjointedness, transitivity, inverse, has-a, part-of relations
Define rules that express mathematical relations, data quality constraints, general logical constraints

Inspired primarily by this graphic: Deborah L. McGuinness, *Ontologies for the Modern Age*, Slide 4, https://www.slideshare.net/deborahmcguinness/ontologies-for-the-modern-age-mcguinness-keynote-at-iswc-2017

Dr Leo Obrst, *Ontology Spectrum*, https://slideplayer.com/slide/697642/

The bottom line is that the most powerful approach to representing knowledge within that spectrum is the logical theory. Heavyweight logical theories are understandable to both technical professionals and business professionals such as accountants, auditors, and financial analysts. There are many different approaches that can be used to represent these logical theories such as ontologies + rules or graphs of nodes and edges or simply representing a set of logic connections[5]. Fundamentally, financial reports are knowledge graphs[6].

But all this boils down to expressing the most logic possible as formally as possible as to maximize understandability which will maximize the functionality of software applications which can then be built to process that logical information.

But the power must be balanced with effectiveness. It is important that these powerful knowledge-based systems work reliably and predictably; they need to be free from catastrophic failures caused by things like logical paradoxes or infinite loops.

Note that theories can be proven to be true or false using what is known as a proof[7]. If the logic of the theory is represented in machine-readable form, that proof can be effectively automated.

[4] Ontology Spectrum, http://xbrlsite.azurewebsites.net/2019/Library/OntologySpectrum.jpg

[5] Wikipedia, *Logical Connective*, https://en.wikipedia.org/wiki/Logical_connective

[6] Charles Hoffman, CPA, *Financial Report Knowledge Graphs*, http://xbrlsite.azurewebsites.net/2021/Library/FinancialReportKnowledgeGraphs.pdf

[7] Richard Hammack, *Book of Proof*, https://cse.unl.edu/~choueiry/S11-235/files/BookOfProof.pdf

Logic and Knowledge Graphs

A knowledge graph (a.k.a. semantic network[8]) represents the logic related to real-world entities (i.e., objects, events, situations, or concepts) and illustrates the relationship between them. Accountants have an innate understanding of logic.

We communicate logic using knowledge graphs all the time. When you go to a whiteboard and draw circles and squares and connect them with lines with arrows you are drawing a graph and communicating knowledge. Those circles, squares, lines, and arrows are intuitively understandable and very expressive[9].

Purpose of a General-Purpose Financial Report

A general-purpose financial report is used to communicate information. A general-purpose financial report is a true and fair representation of information about an economic entity. A financial report is not the actual economic entity, it merely conveys fairly high-fidelity information about an economic entity that is generally of very high-quality. Consider the following description of the purpose of a general-purpose financial report:

> 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, inductive reasoning, etc.), common financial reporting standard concepts and relations (i.e. US GAAP, UK 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 basic logical principles, common financial reporting standards (concepts and relations), and common world view; and vice versa; and similarly for the investor and economic entity B.

There is no natural way to represent an economic entity the way it “really is” in the real world; there are just certain purposeful selections of specific aspects of an economic entity, call them abstractions or models, that provide a useful enough simplification that satisfies some specific goal we might have. That is the nature of a general-purpose financial report, to represent information about an economic entity for a specific purpose. That representation is good enough to be useful. General-purpose financial reports can be provided in human readable form and/or machine-readable form.

Financial report knowledge graphs that are machine readable can be interrogated systematically and logically using machine-based processes. You can prove that the financial reports are properly functioning, true and fair representations of the information of an economic entity.

Controlled Flexibility

And so, financial reports tell a story. That story is about the financial position and financial performance of a reporting economic entity. That story must be “true” and “fair”.

[8] Wikipedia, *Semantic Network*, https://en.wikipedia.org/wiki/Semantic_network

[9] Charles Hoffman, CPA, *Logic and Knowledge Graphs*, http://www.xbrlsite.com/mastering/Part02_Chapter05.A1_LogicAndKnowledgeGraphs.pdf

The information conveyed by that story should be the same whether a traditional human readable report is used as the medium or whether a machine-readable knowledge graph is used as the medium.

Financial reports are not "standard forms". Report models can be modified or "customized" by reporting entities which can use different "subtotals", different disclosure "alternatives", and even report additional disclosures which the economic entity feels is important to understanding that specific economic entity. That flexibility is a feature of financial reporting schemes such as US GAAP and IFRS.

But while financial reports are not "standard forms", they are also not "random". Financial reports are customizable[10]. There are patterns. There are "good practices" and "best practices". There are also poor practices which should be avoided. Customization must be kept within the boundaries of good and best practices and poor practices are to be avoided.

When a report model can be modified/customized, the "wild behavior" of accountants creating reports and report models must be controlled and preferably even eliminated, keeping report models within permitted boundaries. While permitted boundaries can be defined differently by, say, different CPA firms or even different accountants within the same CPA firm; patterns exist and those patterns can be leveraged.

A financial reporting scheme represented using a machine-readable theory which is then used to represent a report model for a report created by an economic entity in machine readable form serves multiple purposes:

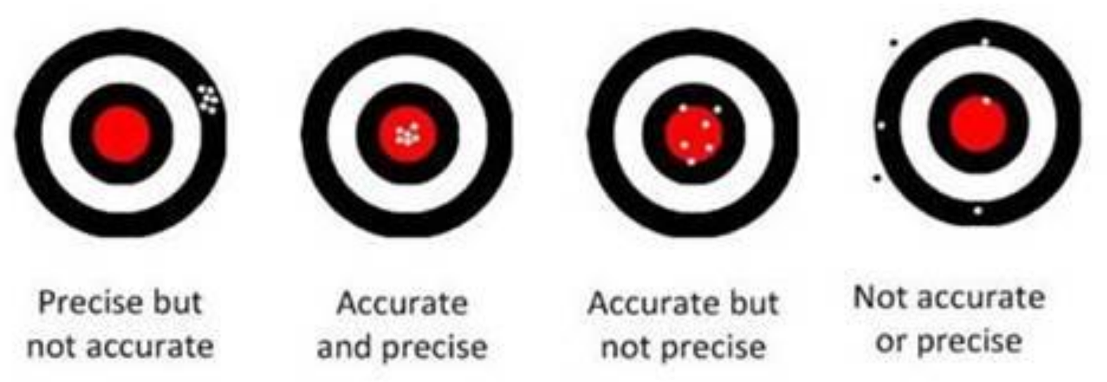
- **Description**: It is a clear and should be complete description of a report model (specification of what is permitted); created by standards setters or regulators or anyone else specifying a report. And obviously the clear and complete description should represent accounting and reporting rules precisely and accurately.
- **Construction**: It is a guide to the creation of a report based on that permitted report model description whereby a human can be assisted by software applications utilizing that machine readable description of permitted report models.
- **Verification**: The actual report constructed can be verified against the clear, complete description assisted by software applications utilizing that machine readable description.
- **Extraction**: Information can be effectively extracted from machine readable reports and report models assisted by software utilizing that machine readable clear and complete description.

Note that the machine-readable version of the report model description and report can be automatically converted from the machine-readable format to a human readable format using automated processes.

To reiterate; a machine-readable representation of a financial reporting scheme in a theory must be ***clear***, ***complete***, and reflect accounting and reporting rules ***precisely*** and ***accurately***[11].

[10] *The Seattle Method*, https://digitalfinancialreporting.blogspot.com/2022/12/the-seattle-method.html

[11] What is Accuracy?, https://www.adamequipment.com/aeblog/what-is-accuracy



Traditionally, financial reporting schemes have been represented in books and can often be unclear. The US GAAP and IFRS XBRL taxonomies are, as they are represented today, are not clear as they really could be or need to be, they are not complete, they are missing rules. Those XBRL-based taxonomies are not complete theories. However, they can be supplemented and reorganized to create complete theories.

And so, one needs a provably reliable method to control the details of a financial report.

Seattle Method

The *Seattle Method*[12] is a proven, industrial strength, good practices, standards-based pragmatic approach to creating provably high quality XBRL-based general purpose financial reports that builds on the Venetian Method of double entry bookkeeping and adapting it for the information age explained in simple terms that are generally understandable to a motivated accountant.

The *Seattle Method* specifies what is minimally necessary for a financial report to be properly functioning when represented in machine-readable form using the XBRL technical syntax. The *Seattle Method* offers a framework that can be expanded to add additional information to a theory.

Explaining the *Seattle Method* is beyond the scope of this document. Please refer to the Seattle Method documentation to better understand the *Seattle Method*.

Additional information is provided by *Ten Keys to Creating a Universal Digital Financial Reporting Framework*[13].

Financial Reporting Scheme Information in Machine Readable Form

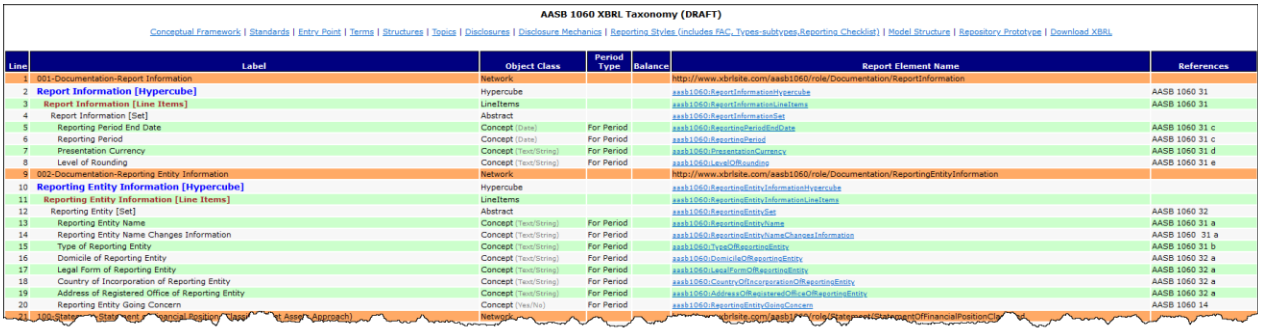
For a financial report to be created per some financial reporting scheme; certain specific information related to that financial reporting scheme must be represented in machine readable form. That representation must be clear, complete, precise, and accurate as described in the last section.

A working proof of concept machine-readable representation of a financial reporting scheme (a theory) using the XBRL technical syntax was created for Australian Accounting Standards, AASB 1060[14].

[12] Charles Hoffman, CPA, *Seattle Method*, http://xbrlsite.com/seattlemethod/SeattleMethod.pdf

[13] *Ten Keys to Creating a Universal Digital Financial Reporting Framework*, https://digitalfinancialreporting.blogspot.com/2023/02/ten-keys-to-creating-universal-digital.html

[14] AASB 1060 Financial Reporting Scheme, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/aasb1060/base-taxonomy/aasb1060_ModelStructure2.html



AASB 1060 XBRL Taxonomy (DRAFT)

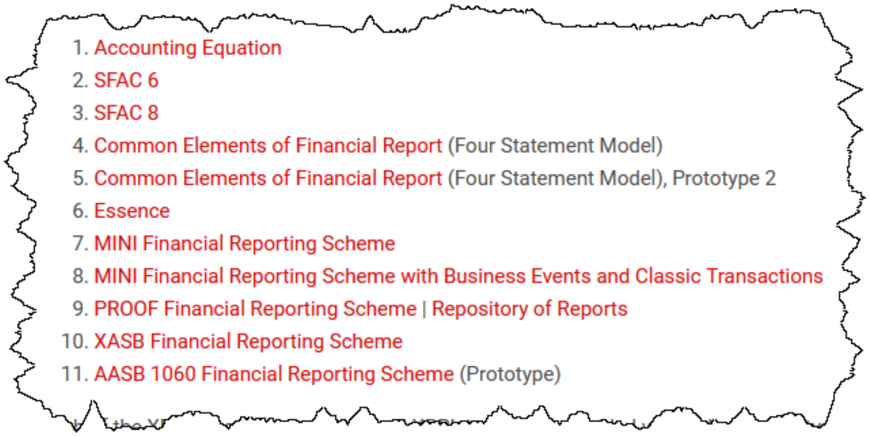
Conceptual Framework | Standards | Entry Point | Terms | Structures | Topics | Disclosures | Disclosure Mechanics | Reporting Styles (includes FAC, Types-subtypes,Reporting Checklist) | Model Structure | Repository Prototype | Download XBRL

Line	Label	Object Class	Period Type	Balance	Report Element Name	References
1	001-Documentation-Report Information	Network			http://www.xbrlsite.com/aasb1060/role/Documentation/ReportInformation	
2	**Report Information [Hypercube]**	Hypercube			aasb1060:ReportInformationHypercube	AASB 1060 31
3	**Report Information [Line Items]**	LineItems			aasb1060:ReportInformationLineItems	AASB 1060 31
4	Report Information [Set]	Abstract			aasb1060:ReportInformationSet	
5	Reporting Period End Date	Concept (Date)	For Period		aasb1060:ReportingPeriodEndDate	AASB 1060 31 c
6	Reporting Period	Concept (Date)	For Period		aasb1060:ReportingPeriod	AASB 1060 31 c
7	Presentation Currency	Concept (Text/String)	For Period		aasb1060:PresentationCurrency	AASB 1060 31 d
8	Level of Rounding	Concept (Text/String)	For Period		aasb1060:LevelOfRounding	AASB 1060 31 e
9	002-Documentation-Reporting Entity Information	Network			http://www.xbrlsite.com/aasb1060/role/Documentation/ReportingEntityInformation	
10	**Reporting Entity Information [Hypercube]**	Hypercube			aasb1060:ReportingEntityInformationHypercube	
11	**Reporting Entity Information [Line Items]**	LineItems			aasb1060:ReportingEntityInformationLineItems	
12	Reporting Entity [Set]	Abstract			aasb1060:ReportingEntitySet	AASB 1060 32
13	Reporting Entity Name	Concept (Text/String)	For Period		aasb1060:ReportingEntityName	AASB 1060 31 a
14	Reporting Entity Name Changes Information	Concept (Text/String)	For Period		aasb1060:ReportingEntityNameChangesInformation	AASB 1060 31 a
15	Type of Reporting Entity	Concept (Text/String)	For Period		aasb1060:TypeOfReportingEntity	AASB 1060 31 b
16	Domicile of Reporting Entity	Concept (Text/String)	For Period		aasb1060:DomicileOfReportingEntity	AASB 1060 32 a
17	Legal Form of Reporting Entity	Concept (Text/String)	For Period		aasb1060:LegalFormOfReportingEntity	AASB 1060 32 a
18	Country of Incorporation of Reporting Entity	Concept (Text/String)	For Period		aasb1060:CountryOfIncorporationOfReportingEntity	AASB 1060 32 a
19	Address of Registered Office of Reporting Entity	Concept (Text/String)	For Period		aasb1060:AddressOfRegisteredOfficeOfReportingEntity	AASB 1060 32 a
20	Reporting Entity Going Concern	Concept (Yes/No)	For Period		aasb1060:ReportingEntityGoingConcern	AASB 1060 14

The working prototype of AASB 1060 represents, I figure, about 20% of the information necessary for that financial reporting scheme. Why 20%? Only 20% was created because I was the only person working on this project and there is much, much more than what can be handled by one accountant. However, for the 20% of the XBRL-taxonomy that was created; that 20% is clear, complete, precise, and accurate as best that can be achieved by one person. More work is necessary to complete this financial reporting scheme or create other such financial reporting schemes.

But this does provide a map that helps others create such XBRL-based representations of financial reporting schemes in the form of a theory. In addition, several other prototype financial reporting schemes have been represented[15].

To understand how to create a theory, start with a small theory such as the accounting equation, grow your theory to say SFAC 6 or other incremental examples, study the PROOF which contains a complete set of logic that might appear within a theory that describes a base financial reporting scheme; this will incrementally grow your understanding of how to create a machine readable theory that can the drive the construction of a financial report.



1. Accounting Equation
2. SFAC 6
3. SFAC 8
4. Common Elements of Financial Report (Four Statement Model)
5. Common Elements of Financial Report (Four Statement Model), Prototype 2
6. Essence
7. MINI Financial Reporting Scheme
8. MINI Financial Reporting Scheme with Business Events and Classic Transactions
9. PROOF Financial Reporting Scheme | Repository of Reports
10. XASB Financial Reporting Scheme
11. AASB 1060 Financial Reporting Scheme (Prototype)

In addition, these machine-readable XBRL taxonomies and reference implementations of reports can be used to test software that is being created to implement theory-driven, semantic-oriented financial report creation systems.

[15] *General Purpose Financial Reporting Support for XBRL*, https://digitalfinancialreporting.blogspot.com/2023/02/general-purpose-financial-reporting.html

Special Purpose Logic/Reasoning/Rules Engine

To process the theory and to use the financial reporting scheme rules and other metadata, one needs some sort of logic/reasoning/rules/insights engine. Auditchain's Pacioli[16] is such an engine. Pacioli is a cloud-based platform build using SWI PROLOG[17]. There are different approaches to implementing such a reasoner which I will not get into here, but you do need one that understands the theory, the more powerful the reasoning capabilities the better, but you also want to avoid catastrophic failures at all cost.

There are many general purpose reasoners but to make them usable by business professionals, they need to be specialized. Why? Otherwise, they are too hard to use because they are too general. Pacioli and other such tools can be used to generate a proof of the logic of a base financial reporting scheme and a report model and report created per that financial reporting scheme.

Proving Theory

And so, I claim that I can construct a true and fair financial report using this theory-driven semantics-oriented financial report construction approach. But, can I prove that the financial report that was created is correct?

To answer this question, let me first point out something. Let's say that you have created a financial report using some other approach. Can you prove to me that that report is correct? What approach would you create to verify that the report is correct? Likely that involves having a team of accountants manually performing steps to prove that report is correct. Some of that manual effort can be automated to let a computer based system augment the skills of the accountants.

First, let me define "correct" clearly. As I have stated, this approach, this theory is about the financial report itself. To define "correct", let me first state what is NOT included in the definition of correct:

1. I am NOT auditing the numbers that are contained in the report. I am not tying reported numbers to the general ledger trial balance.
2. I am NOT stating that everything that SHOULD BE included in the report by the reporting economic entity HAS BEEN included. It is impossible to prove FULL INCLUSION.
3. I am NOT stating that FALSE INFORMATION will be detected. It is impossible to prove FALSE INCLUSION.
4. I am NOT stating that other information that can ONLY be tested and verified by human beings is being verified.

Be real here. Computers cannot perform magic.

The following is a summary of some examples of the sorts of things that can be effectively proven using automated machine-based processes:

[16] Pacioli Logic and Rules Engine, https://docs.auditchain.finance/auditchain-protocol/pacioli-logic-and-rules-engine

[17] SWI Prolog, https://www.swi-prolog.org/

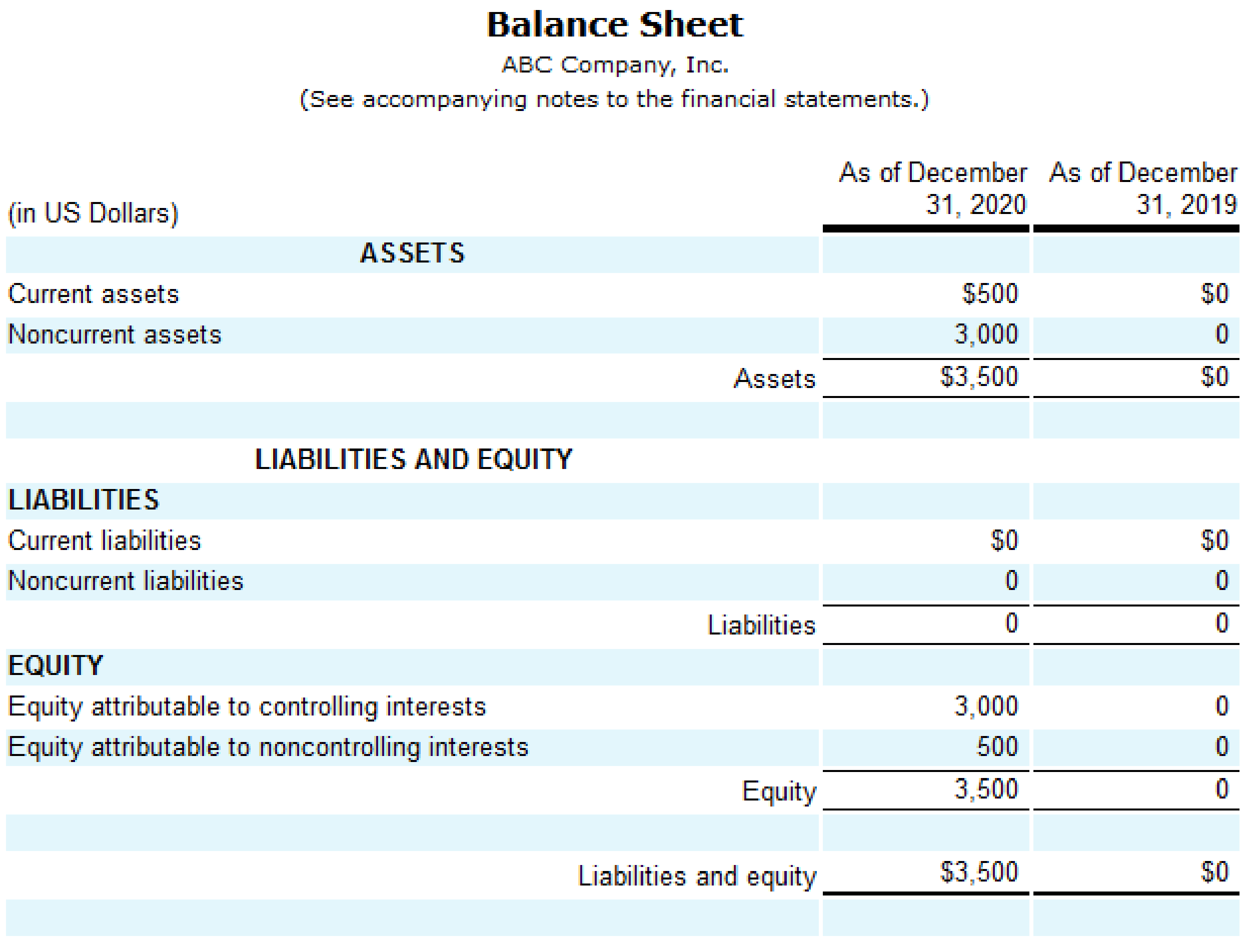
1. Software can effectively read the technical syntax that is used to represent the report model and report. If there is some issue, you will be notified of the issue so that the issue can be corrected, then proceed to the next step.
2. Software can effectively read the report model logic. If there is some issue, you will be notified so the issue can be corrected, then proceed to the next step.
3. The math of the report is verified to be 100% correct.
4. There are no contradictions or inconsistences per the reported high level financial concepts. Examples include:
    a. Assets = Liabilities + Equity (your balance sheet balances)
    b. Profit (Loss) = Profit (Loss) Attributable to Noncontrolling Interests + Profit (Loss) Attributable to Controlling Interests
    c. Net Cash Flow foots correctly
5. The line items of the financial report beneath the high level line items are organized correctly per the accounting standards. For example, you are not using "Investments by Owners" on the income statement.
6. The disclosures you have created follow good practices.
7. The report includes all the obvious disclosures. For example, if you are reporting "Inventories" on your balance sheet, you also have an inventories policy, you provide the required breakdown of inventory subcomponents, and such.

The financial report can only be tested to be consistent with the rules that are included in the theory. For example, if the theory states that "a balance sheet is a required disclosure"; and a balance sheet is found; then the report is deemed to be properly functioning. If balance sheets are deemed by the theory to be required to balance (i.e. Assets = Liabilities and Equity) and facts are reported and they do, in fact, balance; then the report is proven to be properly functioning.

Basically, the point is this: The fundamental goal is for the theory proof to always return a value of TRUE. It is to the extent that rules can be added and have been added, it is to that extent that the theory can be proven and that the financial report is properly functioning.

Here is a prototype report as an example[18]:

[18] Example financial report, http://www.xbrlsite.com/seattlemethod/golden/proof/reference-implementation/instance-RENDERED.html



Balance Sheet

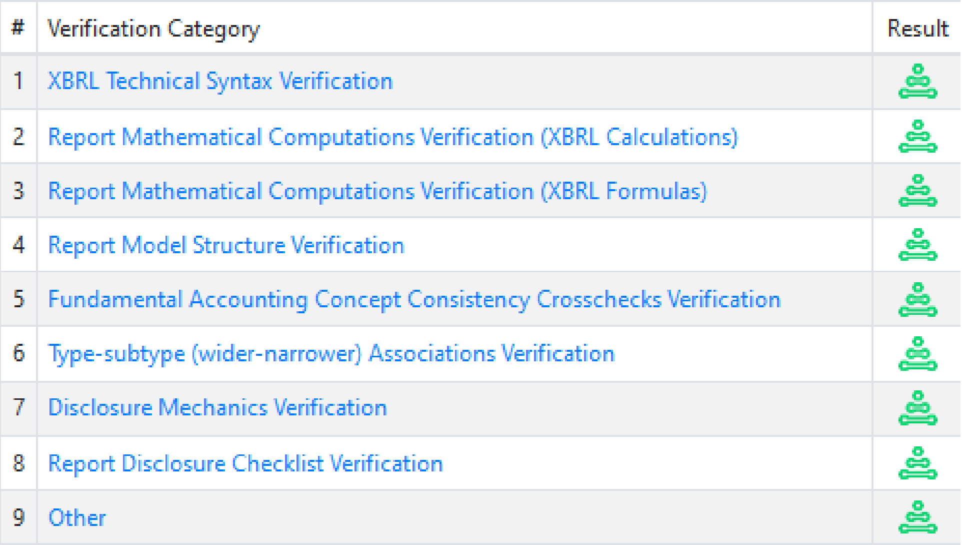
ABC Company, Inc.

(See accompanying notes to the financial statements.)

(in US Dollars)	As of December 31, 2020	As of December 31, 2019
ASSETS		
Current assets	$500	$0
Noncurrent assets	3,000	0
Assets	$3,500	$0
LIABILITIES AND EQUITY		
LIABILITIES		
Current liabilities	$0	$0
Noncurrent liabilities	0	0
Liabilities	0	0
EQUITY		
Equity attributable to controlling interests	3,000	0
Equity attributable to noncontrolling interests	500	0
Equity	3,500	0
Liabilities and equity	$3,500	$0

And here is a sample technically oriented verification report (meaning, better versions of this information can be provided to help verify that everything is OK)[19]:

[19] Pacioli Technical Analysis, https://auditchain.infura-ipfs.io/ipfs/QmNUY15G1dhTXYCpyUyvqYWZ33Nc6mKRUDz7GDgLFonaPs/



#	Verification Category	Result
1	XBRL Technical Syntax Verification	✓
2	Report Mathematical Computations Verification (XBRL Calculations)	✓
3	Report Mathematical Computations Verification (XBRL Formulas)	✓
4	Report Model Structure Verification	✓
5	Fundamental Accounting Concept Consistency Crosschecks Verification	✓
6	Type-subtype (wider-narrower) Associations Verification	✓
7	Disclosure Mechanics Verification	✓
8	Report Disclosure Checklist Verification	✓
9	Other	✓

From the above summary in the actual technical analysis, you can get to all the details that justify that the report is properly function or indicates that there is some sort of inconsistency with the rules that are used to prove the report.

Features, Benefits, and Advantages

Keep in mind that one should be comparing and contrasting this new approach to constructing a financial report with other currently known approaches as opposed to some idealized and unrealistic approach. Others might have you believe that some new approach is not better if the approach is not "auto-magically" generated, say, directly from an accounting system. So, does your current system auto-magically generate a provably properly functioning financial report directly from your accounting system information? Probably not.

The following is a summary of some of the features related to this financial report creation approach, the benefits of that feature, and the advantages derived as a result of that feature:

Feature	Benefit	Advantage
Software augments the skills of an accountant creating the report similar to how a calculator augments an accountant's ability to do math.	Higher quality financial reports. Reduction of the cases of noncompliance.	Reduce costs of creating reports due to fewer quality problems; better report creation processes.
Interacting with report is like interacting with a pivot table.	Working with and getting information from the report is significantly better. Improved user experience.	Enhanced analysis capabilities which leverage the digital nature of the report.
Report can be reliably converted to XBRL syntax.	If you need to provide an XBRL-based report to a regulator; this approach can meet that need without "bolting on" an additional process which results in additional work.	Reduced cost of creating your financial reports.

Connection between the financial report and the financial reporting standards.	User of the financial report understands the reported information better. There is increased clarity.	Enhanced financial literacy due to easy and direct access to reporting standards from financial report.
Complete system specifically designed for creating financial reports	Reduction of many of the monotonous tasks related to the creation of financial reports.	Reduced costs, reduction of time to create reports, reduction of manual effort.
Use of templates, canonical models specific to an industry, and other good practices based tools.	Reduction of the skills and experience necessary to effectively create a high-quality financial report.	Reduction of costs, reduction of errors, reduction of noncompliance issues,
Ability to document institutional knowledge in global standard machine readable form.	Institutional knowledge can be retained by the economic entity rather than leave the entity when accounting staff changes jobs.	Reduction of training costs, reduction of errors. Retention of important institutional knowledge.
No reliance on IT department.	Accounting professionals have 100% control of their financial reporting processes.	Reduction of dependencies on external parties, entire process can be operated and maintained by accounting department.
Separation of rules and reports.	Enhanced internal controls.	Reduction of potential errors or fraud.
Creation of both human readable and machine-readable reports.	One process can be used to create report.	Reduction of duplication of effort. No need to maintain multiple processes.
Controlled flexibility.	Ability to create process "guardrails". Flexibility where you need it, not where you don't.	Improved quality.
Industrial strength	Ready for any size enterprise, large or small.	Reliability.

While the above table does not provide an exhaustive list of the features, benefits, and advantages of a theory-driven semantic-oriented approach to constructing a financial report; I hope it does give you an idea of the types of this that this approach makes better, faster and/or cheaper for accountants.

Existing Theory-driven, Semantic-oriented Tools

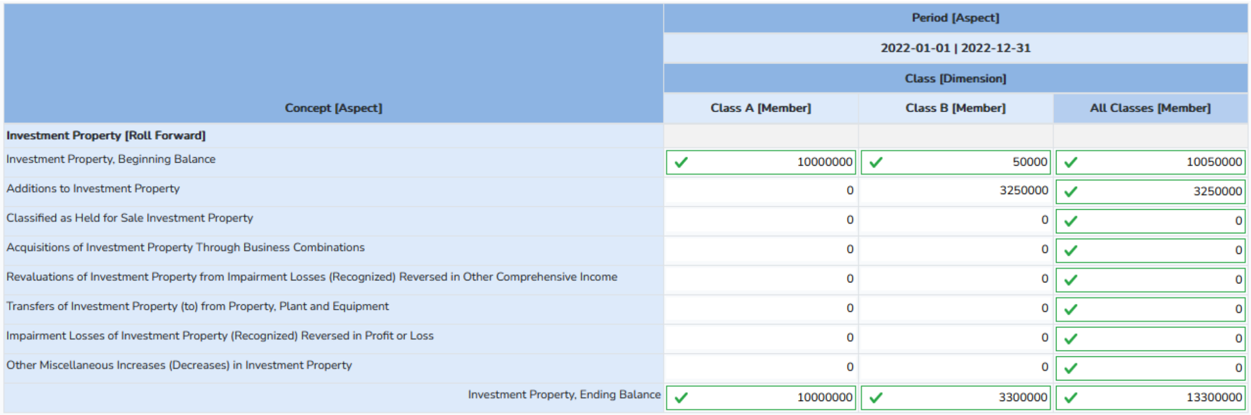
Software and systems evolve[20]. No one knows exactly the time frame for when software will become broadly available or the exact features of the ecosystem withing that software operates. But there are cluses. One really good clue that can be leveraged to understand what might occur is to have a look at CAD/CAM software and BIM[21]. Architects, engineers, and designers have already been through this change when the machine-readable blueprint was digitized.

[20] Charles Hoffman, *Evolution of a System*, http://xbrlsite.com/2023/Library/EvolutionOfSystem.pdf

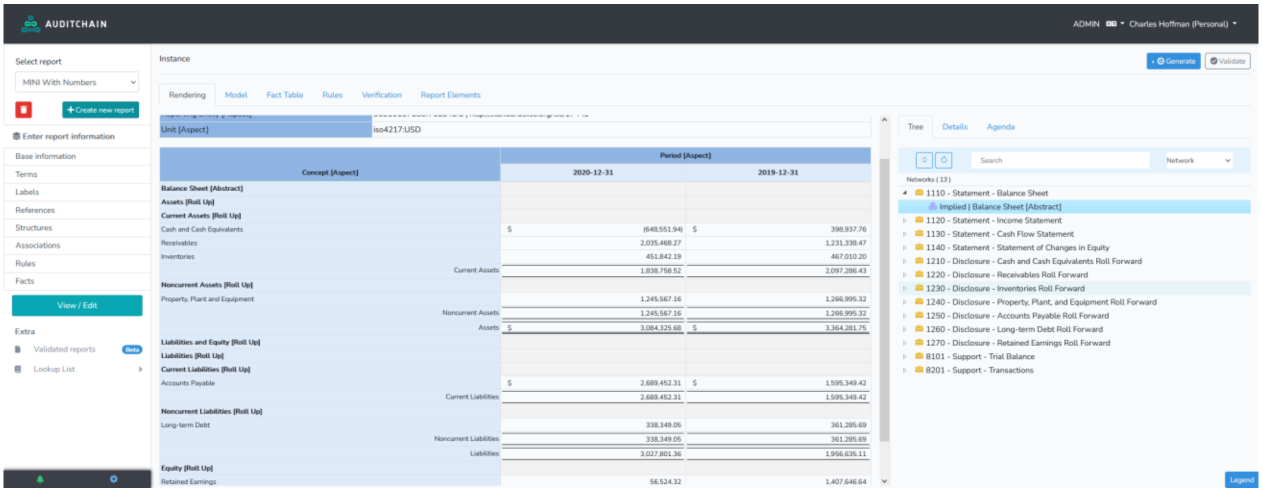
[21] *Using Difference Between CAD/CAM and BIM to Understand How to Create Financial Reporting Expert Systems*, https://digitalfinancialreporting.blogspot.com/2023/03/using-difference-between-cadcam-and-bim.html

But some software does exist. Thus far during a period of five years I have helped multiple software engineers understand how to create this software and the software engineers have helped me to implement these ideas and get them to work effectively and reliably.

Auditchain Luca[22] is an example of a theory-driven, semantic-oriented tool for the construction of financial reports. This YouTube playlist, *World's First Expert System for Creating Financial Reports*[23], can help you see this tool in action.



	Period [Aspect]		
	2022-01-01 | 2022-12-31		
	Class [Dimension]		
Concept [Aspect]	Class A [Member]	Class B [Member]	All Classes [Member]
Investment Property [Roll Forward]			
Investment Property, Beginning Balance	✓ 10000000	✓ 50000	✓ 10050000
Additions to Investment Property	0	3250000	✓ 3250000
Classified as Held for Sale Investment Property	0	0	✓ 0
Acquisitions of Investment Property Through Business Combinations	0	0	✓ 0
Revaluations of Investment Property from Impairment Losses (Recognized) Reversed in Other Comprehensive Income	0	0	✓ 0
Transfers of Investment Property (to) from Property, Plant and Equipment	0	0	✓ 0
Impairment Losses of Investment Property (Recognized) Reversed in Profit or Loss	0	0	✓ 0
Other Miscellaneous Increases (Decreases) in Investment Property	0	0	✓ 0
Investment Property, Ending Balance	✓ 10000000	✓ 3300000	✓ 13300000



Unit [Aspect] iso4217:USD

	Period [Aspect]	
Concept [Aspect]	2020-12-31	2019-12-31
Balance Sheet [Abstract]		
Assets [Roll Up]		
Current Assets [Roll Up]		
Cash and Cash Equivalents	$ (648,551.94)	$ 398,937.76
Receivables	2,035,468.27	1,231,338.47
Inventories	451,842.19	467,010.20
Current Assets	1,838,758.52	2,097,286.43
Noncurrent Assets [Roll Up]		
Property, Plant and Equipment	1,245,567.16	1,266,995.32
Noncurrent Assets	1,245,567.16	1,266,995.32
Assets	$ 3,084,325.68	$ 3,364,281.75
Liabilities and Equity [Roll Up]		
Liabilities [Roll Up]		
Current Liabilities [Roll Up]		
Accounts Payable	$ 2,689,452.31	$ 1,595,349.42
Current Liabilities	2,689,452.31	1,595,349.42
Noncurrent Liabilities [Roll Up]		
Long-term Debt	338,349.05	361,285.69
Noncurrent Liabilities	338,349.05	361,285.69
Liabilities	3,027,801.36	1,956,635.11
Equity [Roll Up]		
Retained Earnings	56,524.32	1,407,646.64

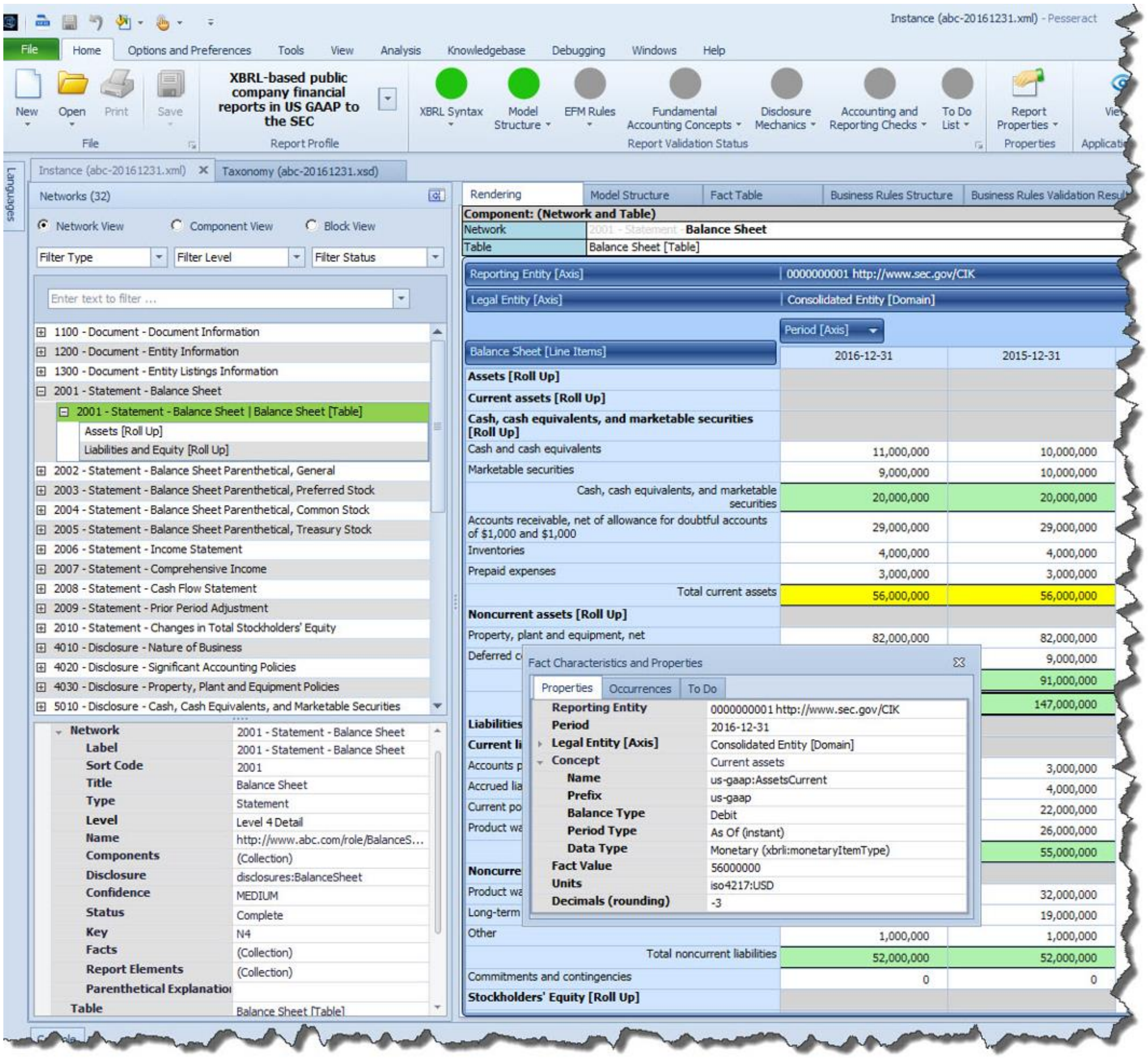
Networks (13)

- 1110 - Statement - Balance Sheet
  - Implied | Balance Sheet [Abstract]
- 1120 - Statement - Income Statement
- 1130 - Statement - Cash Flow Statement
- 1140 - Statement - Statement of Changes in Equity
- 1210 - Disclosure - Cash and Cash Equivalents Roll Forward
- 1220 - Disclosure - Receivables Roll Forward
- 1230 - Disclosure - Inventories Roll Forward
- 1240 - Disclosure - Property, Plant, and Equipment Roll Forward
- 1250 - Disclosure - Accounts Payable Roll Forward
- 1260 - Disclosure - Long-term Debt Roll Forward
- 1270 - Disclosure - Retained Earnings Roll Forward
- 8101 - Support - Trial Balance
- 8201 - Support - Transactions

[22] Auditchain Luca, https://dev.auditchain.finance/

[23] YouTube, *World's First Expert System for Creating Financial Reports*, https://www.youtube.com/playlist?list=PL80qjzvfqwtNuTekdlRy0rhaHEDIXkOh3

Pesseract[24] is a working proof of concept that can be used to verify and view financial reports using this approach:



- 1100 - Document - Document Information
- 1200 - Document - Entity Information
- 1300 - Document - Entity Listings Information
- 2001 - Statement - Balance Sheet
  - 2001 - Statement - Balance Sheet | Balance Sheet [Table]
    - Assets [Roll Up]
    - Liabilities and Equity [Roll Up]
- 2002 - Statement - Balance Sheet Parenthetical, General
- 2003 - Statement - Balance Sheet Parenthetical, Preferred Stock
- 2004 - Statement - Balance Sheet Parenthetical, Common Stock
- 2005 - Statement - Balance Sheet Parenthetical, Treasury Stock
- 2006 - Statement - Income Statement
- 2007 - Statement - Comprehensive Income
- 2008 - Statement - Cash Flow Statement
- 2009 - Statement - Prior Period Adjustment
- 2010 - Statement - Changes in Total Stockholders' Equity
- 4010 - Disclosure - Nature of Business
- 4020 - Disclosure - Significant Accounting Policies
- 4030 - Disclosure - Property, Plant and Equipment Policies
- 5010 - Disclosure - Cash, Cash Equivalents, and Marketable Securities

Network	2001 - Statement - Balance Sheet
Label	2001 - Statement - Balance Sheet
Sort Code	2001
Title	Balance Sheet
Type	Statement
Level	Level 4 Detail
Name	http://www.abc.com/role/BalanceS...
Components	(Collection)
Disclosure	disclosures:BalanceSheet
Confidence	MEDIUM
Status	Complete
Key	N4
Facts	(Collection)
Report Elements	(Collection)
Parenthetical Explanatio	
Table	Balance Sheet [Table]

Component: (Network and Table)	
Network	2001 - Statement - Balance Sheet
Table	Balance Sheet [Table]

Reporting Entity [Axis]	0000000001 http://www.sec.gov/CIK
Legal Entity [Axis]	Consolidated Entity [Domain]

Balance Sheet [Line Items]	2016-12-31	2015-12-31
Assets [Roll Up]		
Current assets [Roll Up]		
Cash, cash equivalents, and marketable securities [Roll Up]		
Cash and cash equivalents	11,000,000	10,000,000
Marketable securities	9,000,000	10,000,000
Cash, cash equivalents, and marketable securities	20,000,000	20,000,000
Accounts receivable, net of allowance for doubtful accounts of $1,000 and $1,000	29,000,000	29,000,000
Inventories	4,000,000	4,000,000
Prepaid expenses	3,000,000	3,000,000
Total current assets	56,000,000	56,000,000
Noncurrent assets [Roll Up]		
Property, plant and equipment, net	82,000,000	82,000,000
Deferred c		9,000,000
		91,000,000
		147,000,000
Liabilities		
Current li		
Accounts p		3,000,000
Accrued lia		4,000,000
Current po		22,000,000
Product wa		26,000,000
		55,000,000
Noncurre		
Product wa		32,000,000
Long-term		19,000,000
Other	1,000,000	1,000,000
Total noncurrent liabilities	52,000,000	52,000,000
Commitments and contingencies	0	0
Stockholders' Equity [Roll Up]		

Reporting Entity	0000000001 http://www.sec.gov/CIK
Period	2016-12-31
Legal Entity [Axis]	Consolidated Entity [Domain]
Concept	Current assets
Name	us-gaap:AssetsCurrent
Prefix	us-gaap
Balance Type	Debit
Period Type	As Of (instant)
Data Type	Monetary (xbrli:monetaryItemType)
Fact Value	56000000
Units	iso4217:USD
Decimals (rounding)	-3

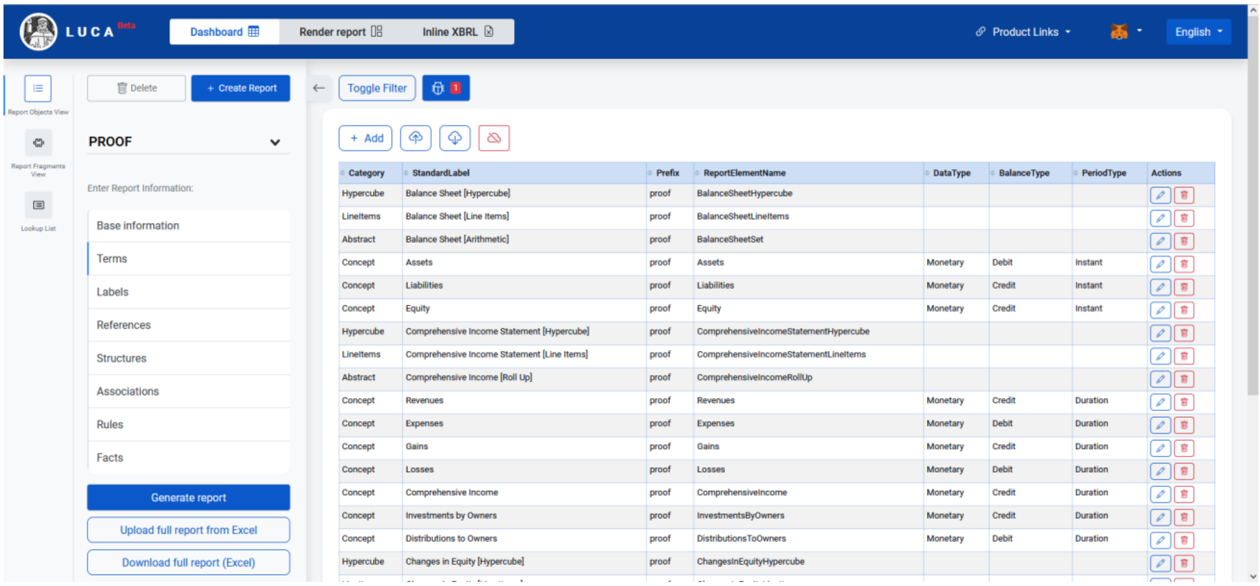
General Luca[25] is another cloud-based tool for creating XBRL-based financial reports that are created using the Seattle Method. It has not implemented 100% of the logic the I represent in financial reporting scheme theories, but it does use the same fundamental data model as Auditchain's version of Luca.

Both Excel and JSON files are exchangeable between Auditchain's version of Luca, and General Luca. There are several different versions tools for creating reports. This version of Luca also can be used to create Inline XBRL reports.

[24] Pesseract, http://pesseract.azurewebsites.net/

[25] General Luca, https://general.luca.report/

This version of General Luca still needs a lot of work, but its foundations are solid and this might be something worth keeping your eye on.



Category	StandardLabel	Prefix	ReportElementName	DataType	BalanceType	PeriodType	Actions
Hypercube	Balance Sheet [Hypercube]	proof	BalanceSheetHypercube				✎ 🗑
LineItems	Balance Sheet [Line Items]	proof	BalanceSheetLineItems				✎ 🗑
Abstract	Balance Sheet [Arithmetic]	proof	BalanceSheetSet				✎ 🗑
Concept	Assets	proof	Assets	Monetary	Debit	Instant	✎ 🗑
Concept	Liabilities	proof	Liabilities	Monetary	Credit	Instant	✎ 🗑
Concept	Equity	proof	Equity	Monetary	Credit	Instant	✎ 🗑
Hypercube	Comprehensive Income Statement [Hypercube]	proof	ComprehensiveIncomeStatementHypercube				✎ 🗑
LineItems	Comprehensive Income Statement [Line Items]	proof	ComprehensiveIncomeStatementLineItems				✎ 🗑
Abstract	Comprehensive Income [Roll Up]	proof	ComprehensiveIncomeRollUp				✎ 🗑
Concept	Revenues	proof	Revenues	Monetary	Credit	Duration	✎ 🗑
Concept	Expenses	proof	Expenses	Monetary	Debit	Duration	✎ 🗑
Concept	Gains	proof	Gains	Monetary	Credit	Duration	✎ 🗑
Concept	Losses	proof	Losses	Monetary	Debit	Duration	✎ 🗑
Concept	Comprehensive Income	proof	ComprehensiveIncome	Monetary	Credit	Duration	✎ 🗑
Concept	Investments by Owners	proof	InvestmentsByOwners	Monetary	Credit	Duration	✎ 🗑
Concept	Distributions to Owners	proof	DistributionsToOwners	Monetary	Debit	Duration	✎ 🗑
Hypercube	Changes in Equity [Hypercube]	proof	ChangesInEquityHypercube				✎ 🗑

Implementing Software

Over the years I have tried to figure out the best approach to implementing theory-driven semantic-oriented financial report creation software[26]. The following is a concise summary of what I have discovered. There is no one right or wrong answer. Personal preferences, fads, trends, misinformation, and other factors play a role in determining the best approach. Each approach is a basket of pros and cons.

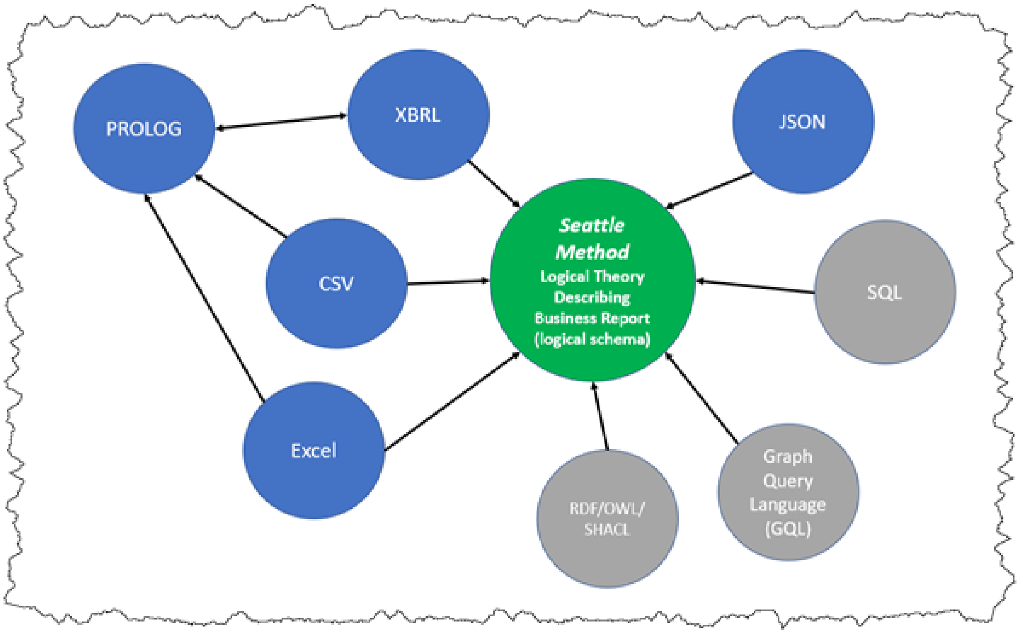
- There tends to be three general approaches to representing machine-readable knowledge graphs and none of these really can be considered wrong:
    - **The W3c Semantic Web Stack**[27]. This approach is one of the more flexible approaches, but working with RDF, while flexible, is like working in assembly language. This is not a problem if you build layers of functionality and expose functionality to users at the right level.
    - **Graph Databases**[28]. Graph databases are powerful tools and coming of age, but there are not a enough people that have years of experience with graph databases so skills and experience can be hard to find. ISO is creating a graph query language standard which is expected to be completed in a few years.
    - **MODERN PROLOG**. PROLOG[29] and in particular DATALOG[30] which is a safer subset of PROLOG are very powerful, I know they work because I helped Auditchain implement Pacioli using PROLOG which does everything that I needed done. But PROLOG skills can

[26] Implementing Knowledge Graphs, http://xbrl.squarespace.com/journal/2021/9/20/implementing-knowledge-graphs.html
[27] Wikipedia, *Semantic Web Stack*, https://en.wikipedia.org/wiki/Semantic_Web_Stack
[28] Wikipedia, *Graph Database*, https://en.wikipedia.org/wiki/Graph_database
[29] Wikipedia, *Prolog*, https://en.wikipedia.org/wiki/Prolog
[30] Wikipedia, *Datalog*, https://en.wikipedia.org/wiki/Datalog

be rather rare and while PROLOG was created way back in 1978; it has an extremely well built out ecosystem, particularly SWI PROLOG[31].

- **SQL**: Yes, all this can be implemented in relational databases effectively. But I am not qualified to have an opinion if this is a good idea or a bad idea in terms of performance, maintenance, etc. A lot of people understand and like relational databases and I do know that this can work.

I can report that it is very possible to convert 100% of the logic represented and stored in the Seattle Method logical model, within XBRL, and between all of the following technical syntax formats shown below:


PROLOG
XBRL
JSON
Seattle Method
Logical Theory Describing Business Report (logical schema)
CSV
SQL
Excel
RDF/OWL/ SHACL
Graph Query Language (GQL)

Conclusion

A theory-driven semantics-oriented approach to constructing financial reports using tools that are especially created for creating financial reports (as contrast to a word processor or electronic spreadsheet which has no knowledge of financial reporting) is a better way to create financial reports. In my personal view, this theory-driven semantics-oriented approach to creating financial reports will serve the institution of accounting for the next 500 years.

For more details, please see *The Great Transmutation*[32].

[31] SWI Prolog, https://www.swi-prolog.org/

[32] Charles Hoffman, CPA, *The Great Transmutation*, http://xbrlsite.azurewebsites.net/2022/Library/TheGreatTransmutation.pdf