Special Purpose Logical Spreadsheet for Accountants

Professional tool for accountants, auditors, and analysts which addresses the limitations and inherent risks when making use of traditional spreadsheets

By Charles Hoffman, CPA (June 7, 2023) DRAFT

The electronic spreadsheet[1] has been commercially available for more than 40 years and is an appropriate solution for many tasks commonly performed by accountants, auditors, and analysts. First introduced by VisiCalc[2], enhanced by Lotus 1-2-3[3], perfected by Microsoft Excel[4], and tuned for the internet by Google Sheets[5]; electronic spreadsheets are a "Swiss Army Knife" type of tool.

Contemporary or "traditional" electronic spreadsheets have their advantages; but they also have their disadvantages. A general lack of spreadsheet creation methodologies leads to non-uniform spreadsheets as a result. This lack of "best practices" then leads to spreadsheets that are notoriously plagued by errors (84 percent of spreadsheets contain some kind of materially significant error), auditing the spreadsheets tends to be very difficult, and underlying spreadsheet business models that are difficult to understand. All of these characteristics lead to spreadsheet maintenance nightmares. Most of us that have tried to understand and use a spreadsheet created by someone else understands that daunting task. These disadvantages are amplified as the complexity of what is represented by the spreadsheet increases. Extracting information for analysis across multiple spreadsheets can be very challenging, if not impossible.

Gartner estimates that the average Fortune 1000 company uses 800 spreadsheets to prepare its financial statements for regulatory reporting[6]. Recall as we have stated above, 84% of spreadsheets contain some kind of material error. A Forbes article says 90% of spreadsheets have errors[7].

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[1] Wikipedia, Spreadsheet, https://en.wikipedia.org/wiki/Spreadsheet
[2] Wikipedia, *VisiCalc*, https://en.wikipedia.org/wiki/VisiCalc
[3] Wikipedia, *Lotus 1-2-3*, https://en.wikipedia.org/wiki/Lotus_1-2-3
[4] Wikipedia, *Excel*, https://en.wikipedia.org/wiki/Microsoft_Excel
[5] Wikipedia, *Google Sheets*, https://en.wikipedia.org/wiki/Google_Sheets
[6] Gartner, *XBRL Will Enhance Corporate Disclosure and Corporate Performance Management*, https://unstats.un.org/unsd/nationalaccount/workshops/2008/newyork/IG22.PDF
[7] Forbes, *Sorry, Your Spreadsheet Has Errors (Almost 90% Do),* https://www.forbes.com/sites/salesforce/2014/09/13/sorry-spreadsheet-errors/?sh=5ea0cc7156ab

But there might just be a better spreadsheet. There is a need for a professional spreadsheet tool. This new tool will not replace all traditional spreadsheets; they would be a supplemental tool that can be used when appropriate.

The notion of a logical spreadsheet is not new. The first logical spreadsheet was created by Frank Kriwazek at Imperial College in the early 1980s and was called LogiCalc[8]. What a logical spreadsheet is and how it is implemented can vary but generally their purpose is to extend or improve upon the functionality of contemporary or "traditional" spreadsheets.

Targeted mainly at financial analysts, Quantrix helps one understand the difference between a basic spreadsheet such as Excel and a more professionally oriented tool. Quantrix provides a comparison between the Quantrix Modeler and Excel[9] and points out the following three key differences:

- Limitations of Excel as spreadsheet complexity and dimensionality increases
- Limitations of the "spreadsheet paradigm"; benefits offered by a modeling-based approach
- Modeling agility, simplicity, transparency, and ability to automate tasks offered by Quantrix as compared to Excel's capabilities.

While the flexibility of an Excel spreadsheet can be hard to beat; that flexibility is a double-edged sword. That flexibility loved by business professionals is cursed by IT professionals that have to deal with the many spreadsheets created by business professionals. Spreadsheet maintenance and support can be a nightmare.

Is it time to move beyond the contemporary spreadsheet and offer a more professional tool for accountants, auditors, and analysts for certain specific types of tasks?

Complex spreadsheets become inherently inflexible and even brittle as they grow in size. Complex, large, and multidimensional spreadsheets become increasingly prone to error and harder to use and maintain.

While using a modeling paradigm has it benefits over the traditional spreadsheet paradigm; Quantrix also has limitations:

- Quantrix does not support the XBRL global standard[10].
- Quantrix cannot be used to create reports.
- Quantrix is not a logical spreadsheet, it is effectively a multidimensional matrix; it does separate the model, the rules, and the facts (data); it is more like a pivot table.
- Quantrix does not appear to have appropriate support for text or prose.

And so, what would this logic spreadsheet be like? What could you use it for? Why would it be better than traditional electronic spreadsheets?

Imagine a special purpose tool, a logical spreadsheet designed specifically for accountants, auditors, and analysts. A professional tool for accountants, auditors, and analysts which addresses the limitations and inherent risks when making use of traditional spreadsheets. The tool can output global standard XBRL and conforms to the Standard Business Report Model (SBRM). Both models and facts can be imported, output, and exchanged using that standard technical syntax and other formats like Excel and JSON.

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[8] Stanford University, Michael Kassoff ana Andre Valente, *An introduction to logical spreadsheets*, http://logic.stanford.edu/publications/kassoff/introtologicalspreadsheets.pdf

[9] Quantrix, *Quantrix and Excel: 3 Key Differences*, https://quantrix.com/quantrix-whitepapers/quantrix-and-excel/

[10] Quantrix, Luca Erzegovesi, *Using XBRL and Quantrix Modeler to Analyze Financial Statements – Part 1*, https://quantrix.com/QuantrixandXBRL.pdf

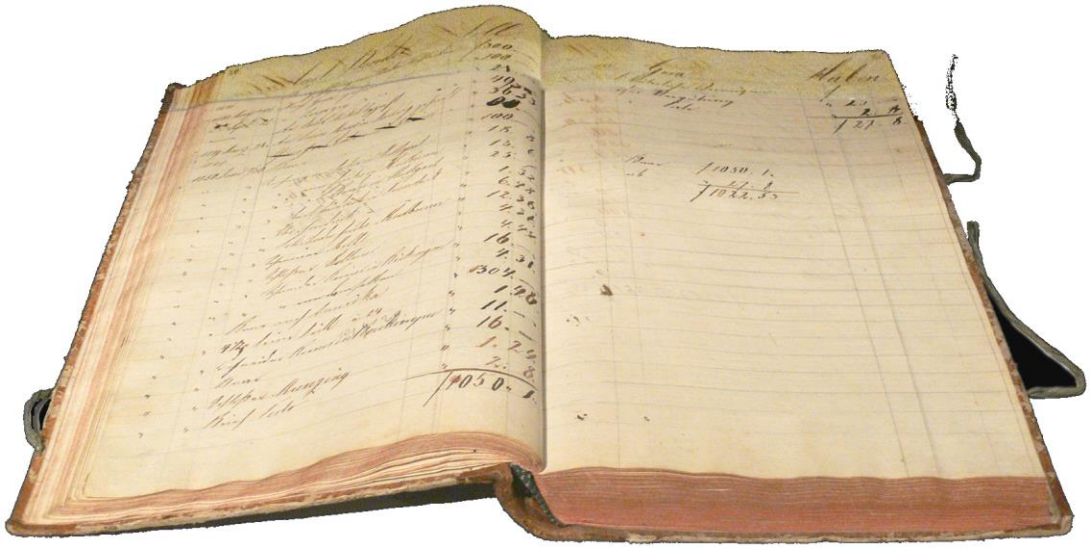
Rather than having one company provide tools that read these logic spreadsheets, imagine 30+ different off-the-shelf tools, maybe more.

Let us take a little deeper look into spreadsheets.

Ledgers and Spreadsheets

Early farmers began documenting information using clay tablets in the earliest form of human writing ever discovered called Cuneiform. They partitioned their clay tablet into rows, columns, and cells. The spreadsheet below documents an account of barley distribution[11]:

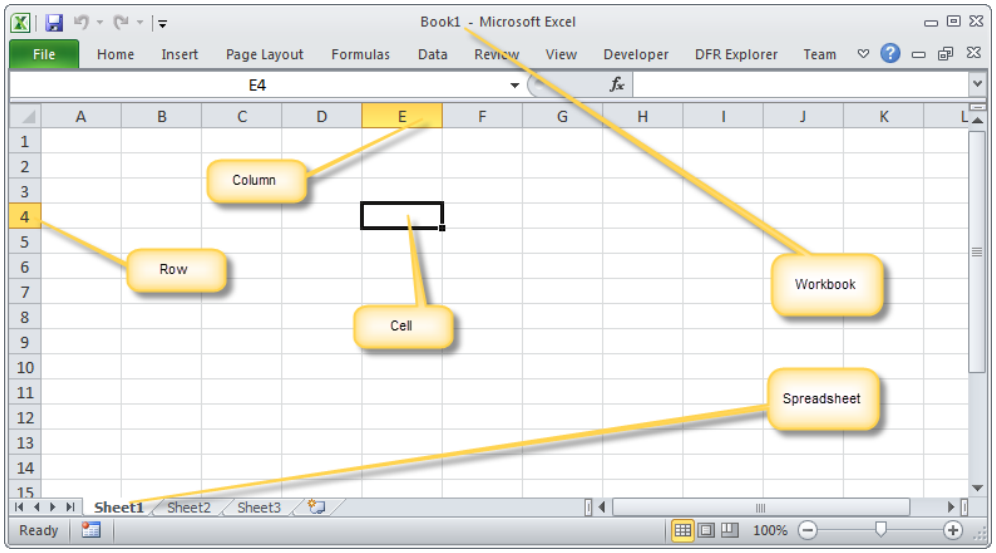
The spreadsheet paradigm is useful and which comes from these medieval tools for collecting and processing information. The information age demands a more modern version of these paper-based ledgers and spreadsheets.



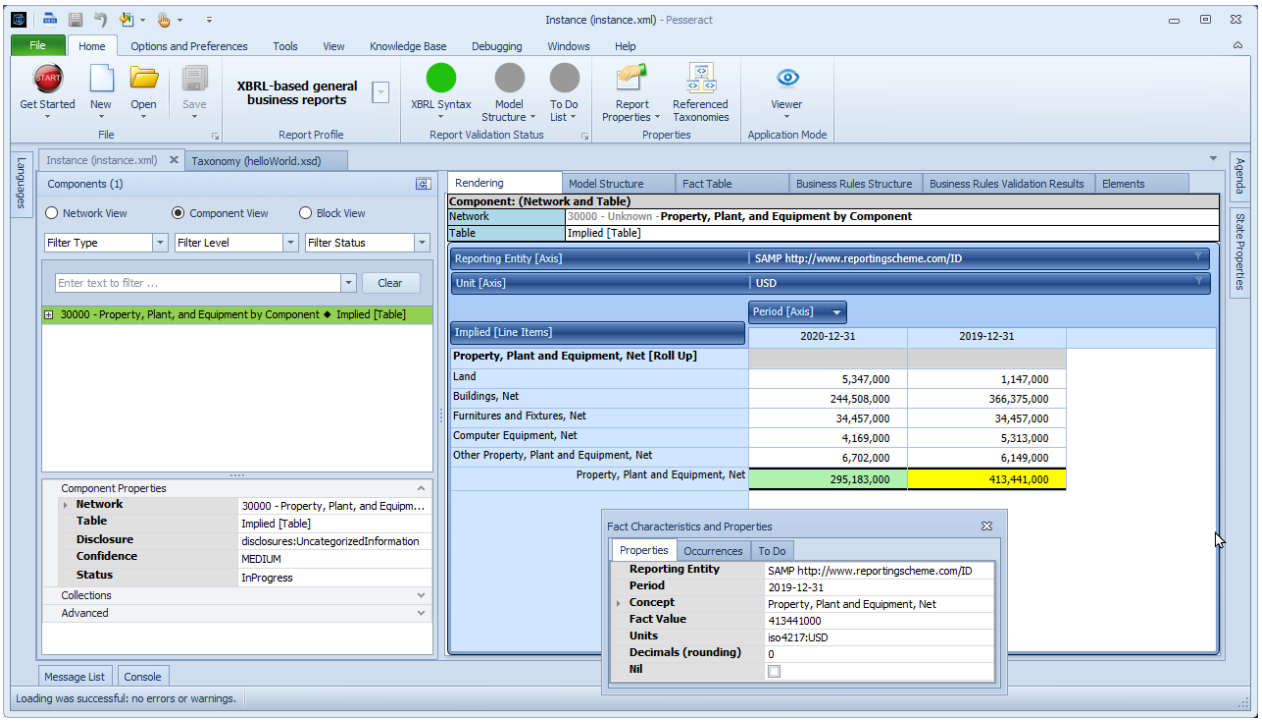
[11] Metropolitan Museum, Proto-Cuneiform tablet with seal impressions: administrative account of barley distribution with cylinder seal impression of a male figure, hunting dogs, and boars, https://www.metmuseum.org/art/collection/search/329081

But to be useful to professional accountants and auditors these modern tools need to be approachable to the accountants and auditors that must perform work using these tools. After all, if a tool is to be useful it must be usable.

Traditional electronic spreadsheets use presentational related artifacts to interact with the software. Things like “workbooks” and “sheets” and “rows” and “columns” and “cells”.



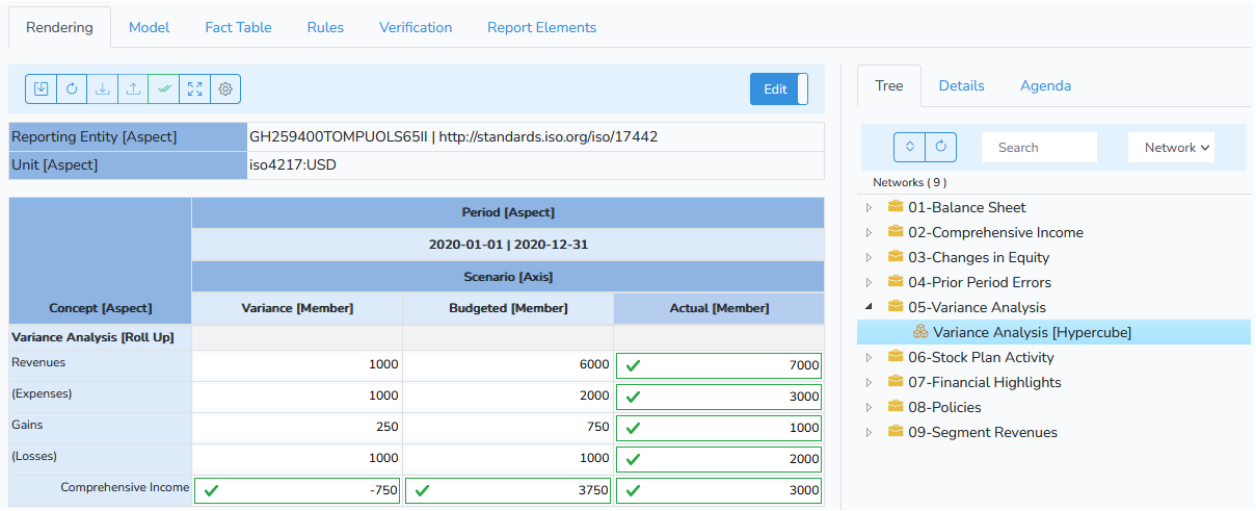
But a logic spreadsheet is different. A logic spreadsheet has information related artifacts such as “structures” and “models” and “rules” and “facts”. I would not consider this a logical spreadsheet, but it gives you an idea of what the GUI/UX could be like (i.e. easy to understand, relate to, and work with):[12]



[12] Pesseract Screen Shots, https://photos.app.goo.gl/cWeZYaMBEbmSSm7v8

Pesseract is a working proof of concept that was used to figure out and prove the logical model of a business report and financial report. Pesseract is very good at viewing reports, but you cannot create reports with Pesseract. Also, Pesseract is a desktop application in an era when people are preferring cloud-based software.

Auditchain's Luca[13] improves upon Pesseract in that (a) it is cloud based, (b) it can be used to create reports, and (c) it supports all of the logic of the *Seattle Method*[14]. Part of Luca is Auditchain's Pacioli which is a prolog based logic engine[15].



Samples, Examples, Prototypes

You can get a sense of the types of information that can be modeled using Luca from the *Showcase of Reports*[16] that I created. Additionally, have a look at the accounting and auditing working papers, schedules, and models including financial reporting scheme examples[17].

You can get a better idea of the sorts of models that can be created from my Golden Examples[18] which starts with smaller less sophisticated examples and gets progressively more and more complex and sophisticated which have each been tested and proven to work using Luca. Further, the Golden Examples include some prototype accounting schedules, audit working papers, and financial analysis models all created using Luca.

At this point I am not sure that I would consider Luca a fully functional logical spreadsheet but it does have many of the characteristics that a logical spreadsheet would have.

Let me describe some of the key ideas that were used to create Pesseract, Luca, and Pacioli to better help the reader understand what I am going for in terms of a logical spreadsheet. Fundamentally, a logical spreadsheet must:

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[13] Auditchain, Luca, https://dev.auditchain.finance/
[14] Charles Hoffman, CPA, *Seattle Method*, http://xbrlsite.com/seattlemethod/SeattleMethod.pdf
[15] Auditchain, *Pacioli Logic and Rules Engine*, https://docs.auditchain.finance/auditchain-protocol/pacioli-logic-and-rules-engine
[16] Showcase of Reports, http://www.xbrlsite.com/mastering/Part04_Chapter07.1_ShowcaseOfReports.pdf
[17] *Accounting and Auding Working Paper Examples*, https://xbrlsite.azurewebsites.net/2023/Prototypes/AccountingAndAuditingWorkingPapersExamples.pdf
[18] Golden Examples, http://www.xbrlsite.com/mastering/Part04_Chapter07.G2_GoldenExamples.pdf

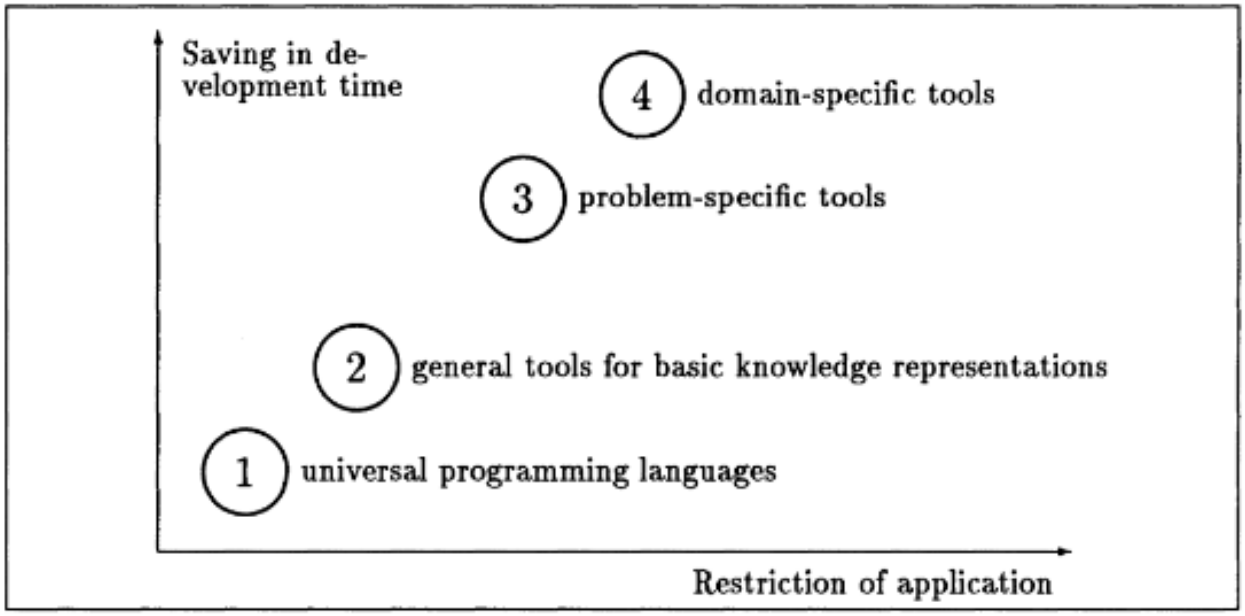
1. Improve upon the electronic spreadsheet. Specifically, it addresses the limitations and inherent risks of using traditional electronic spreadsheets.
2. Be easy for business professionals to use.
3. Make things better, faster, and cheaper for professional accountants, auditors, and analysts.

The following sections help the reader understand the approach that I took and my thought process used to determine what a professional oriented logical spreadsheet might need to look like and why.

General Purpose Tools versus Special Purpose Tools

In his book, *Systematic Introduction to Expert Systems*[19], Frank Puppe provides the graphic below. The graphic basically points out that **universal, general tools** are less restrictive but cost more to create than more specialized **domain-specific tools**.

Universal general tools being more costly to create and more difficult to create and tend to be harder to use because they are more flexible and serve more use cases. Domain specific tools are easier to create and much, much easier for business professionals to use because of the restrictions. They also tend to be less costly to create because the software functionality is specific.



So, a "restriction" is not a flaw. The "restriction" is what makes the tool easier to use and cost less and make easier to develop. You don't need the universe of all possible options for a specific domain; you only need to create what that specific domain needs. As long as you get these restrictions correct, they really are not "restrictions" of the domain specific tool, they are the "boundaries" of the domain. You don't need them.

Technical people don't typically understand these business domain boundaries. Many times, to play it safe technical people tend to add flexibility in order to make certain that business domain user needs are being met. But this flexibility comes at a cost. Additional costs are incurred to create the flexibility

[19] Frank Puppe, *Systematic Introduction to Expert Systems*, page 11, https://books.google.com/books?id=_kKqCAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

and software is harder to use because business professionals need to figure out which option they should use.

Business domain people do understand the boundaries if they think about them. Many business professionals cannot properly articulate the appropriate boundaries or restrictions unless they are properly guided through that process. This communications problem tends to lead to software that costs more to create than is necessary and harder to use than necessary.

This is not an either-or choice. Sometimes universal tools are very appropriate. Other times domain-specific tools are appropriate. Being conscious of these dynamics will lead to the right software being created and the appropriate level of usability. Universal tools are not a panacea. Unconsciously constricting a domain-specific tool when it would have been better to create a more universally usable tool also can be a mistake one makes.

Today, everyone is competing at the "universal tool" level and not one of those universal tools is usable by business professionals. *Computational Professional Services*[20] is a vertical; but it is an incredibly WIDE (i.e., horizontal) vertical market. Tools like PROLOG and Protégée and Neo4j are general tools and great for technical professionals. But they are not really approachable by business professionals.

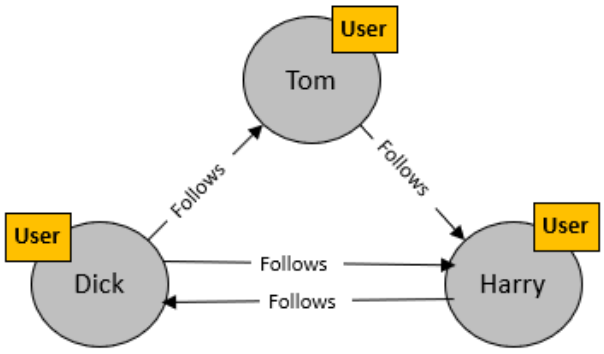
Knowledge Graph

Knowledge graphs are innately understandable by business professionals. We communicate 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. These informal knowledge graphs like this have been used by humans to communicate information for quite some time.

Knowledge is the understanding or interpretation of information. Knowledge relates to terms, structures, associations, rules, facts, and skills acquired by a person through experience or education that relates to the theoretical or practical understanding of something.

A **graph**, in formal terms, is a set of vertices and edges. In less intimidating language, a graph is a set of nodes and the relationships that connect the nodes together. Graphs represent things as nodes and the ways in which those things relate to one another and the rest of the world as relationships.

A graph is a general-purpose communications tool that allows us to model all sorts of scenarios in terms that are innately understandable to humans. One thing that can be represented in the form of a graph is knowledge. This is a simple graph of knowledge, or a **knowledge graph**:



[20] Charles Hoffman, CPA, *Computational Professional Services*, http://xbrlsite.azurewebsites.net/2020/library/ComputationalProfessionalServices.pdf

A knowledge graph[21], also known as a semantic network, represents a network of real-world things (entities)—i.e., objects, events, situations, or concepts—and illustrates the relationship between them. This information can be visualized as a graph structure.

Knowledge graphs are rich in terms of expressiveness but still innately understandable by humans but knowledge graphs can also be read and understood by machines such as computers.

A general-purpose **financial report** conveys knowledge about the financial status, financial performance, and liquidity of an economic entity. For example, here is a small fragment of a financial report knowledge graph:

Statement [Line Items]	Period [Axis]		
	2016-07-01 - 2017-06-30	2015-07-01 - 2016-06-30	2014-07-01 - 2015-06-30
Net income	21,204,000,000 [2,3]	16,798,000,000 [1]	12,193,000,000
Other comprehensive income (loss):			
Net unrealized gains (losses) on derivatives (net of tax effects of $(5), $(12), and $20)	(218,000,000)	(238,000,000)	559,000,000
Net unrealized losses on investments (net of tax effects of $(613), $(121), and $(197))	(1,116,000,000)	(228,000,000)	(362,000,000)
Translation adjustments and other (net of tax effects of $9, $(33), and $16)	228,000,000	(519,000,000)	(1,383,000,000)
Other comprehensive loss	(1,106,000,000)	(985,000,000)	(1,186,000,000)
Comprehensive income	20,098,000,000	15,813,000,000	11,007,000,000

The information conveyed in a financial report is a set or collection of many small fragments like the fragment above. Those report fragments have patterns. For example, the Microsoft 10-K filed with the SEC has 194 fragments or "blocks" of information[22].

The information contained within a financial report can also be seen as or represented as a knowledge graph that is readable by both machines and by humans. While the formatting of the information within a financial report is different than the formal vertices and edges of a graph; I think that it is rather easy to see or perceive that a financial report is a knowledge graph.

As I have pointed out, a financial report is a knowledge graph[23]. Likewise, accounting working papers and schedules, audit working papers and schedules, and financial analysis models are also knowledge graphs.

Logical Theory

Sensemaking[24] is the process of determining the deeper meaning or significance or essence of the collective experience for those within an area of knowledge. That deeper meaning or essence is patterns within an area of knowledge. Those patterns can be used to develop a theory.

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[21] IBM, *What is a Knowledge Graph?*, https://www.ibm.com/topics/knowledge-graph

[22] Knowledge Graph of Microsoft 10-K, http://xbrl.squarespace.com/journal/2021/7/12/knowledge-graph-of-microsoft-10-k-financial-report.html

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

[24] Sensemaking, http://xbrl.squarespace.com/journal/2021/11/18/sensemaking.html

A logical theory enables a community of stakeholders trying to achieve a specific goal or objective or a range of goals/objectives to agree on important logical statements used for capturing meaning or representing a shared understanding of and knowledge in some area of knowledge.

The objective is to agree in order to achieve a goal or range of goals. Fundamentally, it is the conscious intension of this logical system to safely, reliably, and otherwise successfully communicate information. The stakeholders fundamentally agree to eliminate all possible features that introduce potential failure and to leverage all possible features that lead to provable success.

A system is a cohesive conglomeration of interrelated and interdependent parts that is either natural or man-made. A paradigm is a model, perspective, or set of ideas that form a worldview underlying the theory and methodology of a particular domain. A pattern is any form of correlation between the states of elements within a system. Patterns are structural prescriptions to which model artifacts are meant to conform. Logic is innately understandable by business professionals. Weaving all this together into a fabric, burying technical complexity and exposing only what the business user needs enables the creation of a powerful system that is flexible enough and easily approachable by business professionals.

The document *Logical Theory Describing Financial Report*[25] describes the financial report knowledge graph high level model. The logical theory describes the report model itself, not the information about the economic entity creating the report. That information goes into the report model.

A financial report can be thought of as a knowledge graph[26]. Using properly functioning software, that knowledge graph can be converted into many different forms depending on whether a human is using the information or whether a machine is using the information.

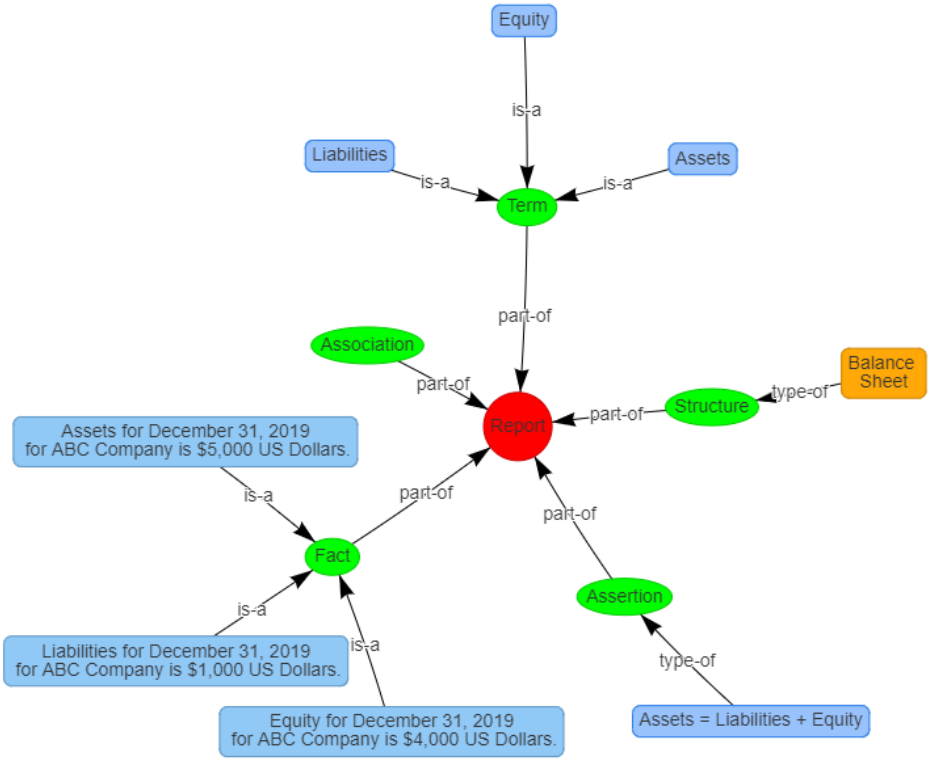
Visualizing Graph of Knowledge

The precise visualizations provided by software tools that implement a graph of knowledge can be different. Colors can be used to enhance visualizations. Different shapes can be used for showing edges (nodes). Visualizations might be laid out in a variety of different ways. There is not necessarily one standard visualization.

Here is information related to the accounting equation and three facts reported within that report model represented in the form of a labeled directed acyclic graph:

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

[26] Financial Report Knowledge Graph, http://xbrlsite.azurewebsites.net/2021/Library/FinancialReportKnowledgeGraphs.pdf



Here is that same information presented in a manner that might be more familiar to professional accountants:

Balance Sheet [Abstract]	Period [Axis] 2020-12-31
Balance Sheet [Abstract]	
Assets	5,000
Liabilities	1,000
Equity	4,000

Balance Sheet

Consistent

Complete

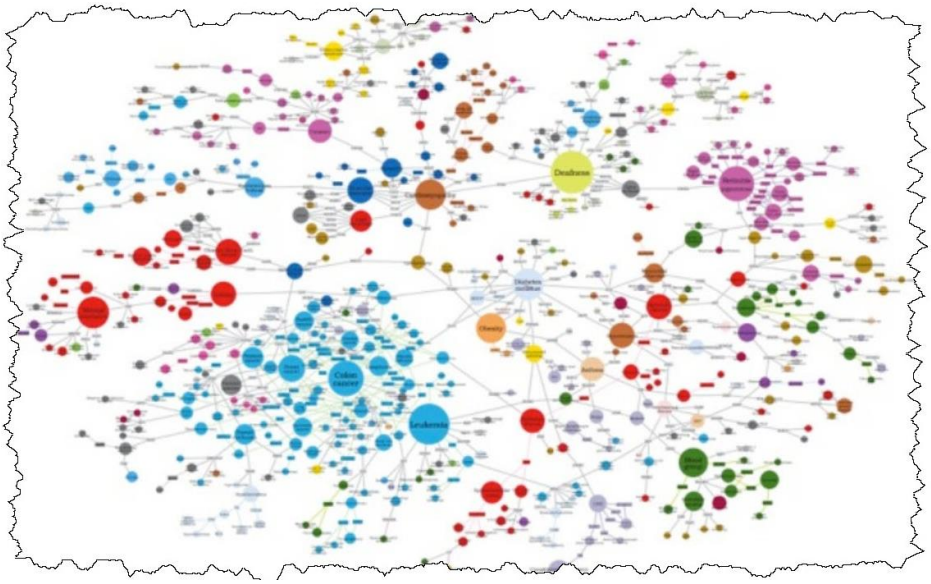
Precise

1

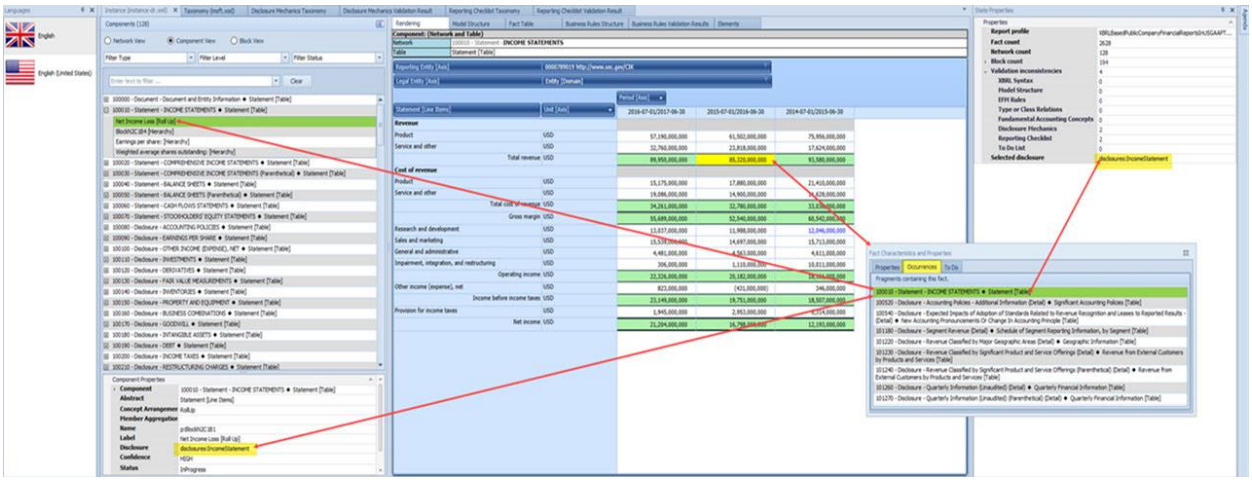
Assets = 5,000
Liabilities = 1,000
Equity = 4,000
Assets = Liabilities + Equity

Result	Rule
Pass	$Assets = $Liabilities + $Equity

And so, a knowledge graph of a financial report, accounting working paper, audit schedule, or financial analysis model might look something like this for a machine to use or when displayed in a general-purpose software application:



But you can take the high-level model of a specific area of knowledge, such as financial reporting, and organize that financial report knowledge graph to look like something more familiar to the members of that area of knowledge and then same information shown above might look like this for a human to make use of:



Basically, the two different views help understand the difference between a general purpose software application which shows colored circles, line and such and a that is generally useful across many different areas of knowledge and a special purpose software application which would only be useful to one specific area of knowledge.

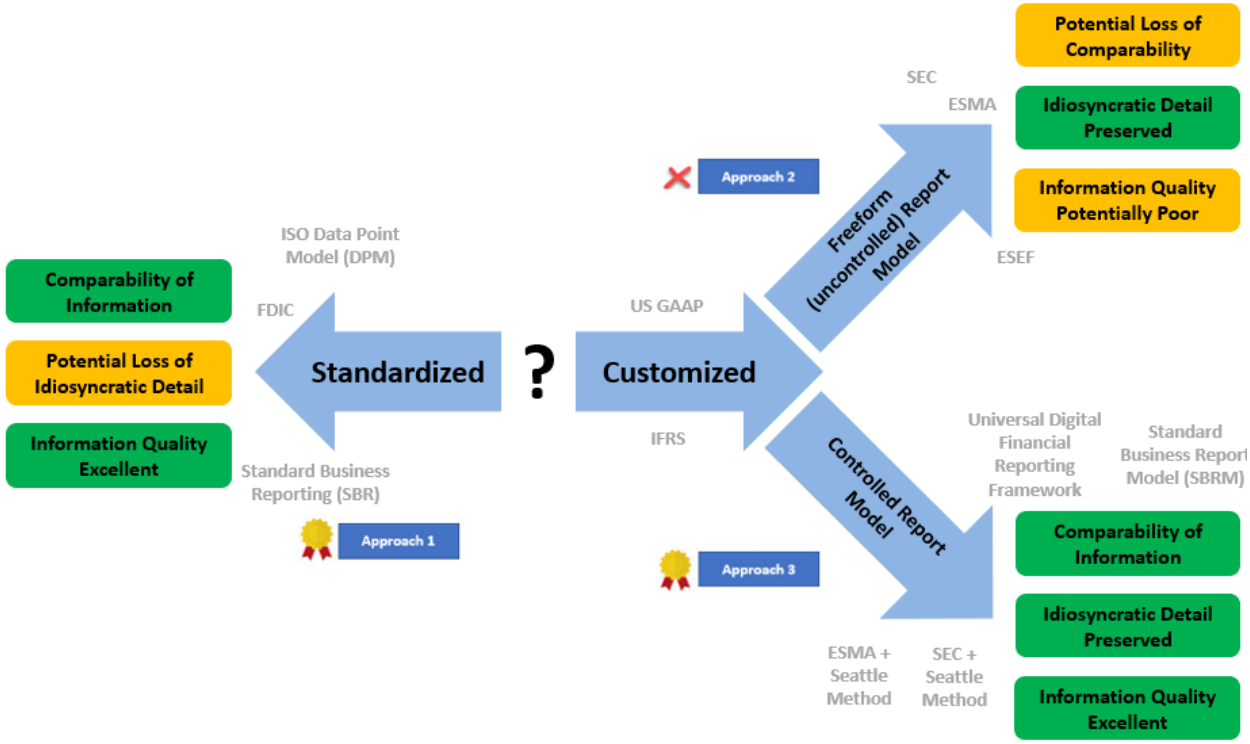
Control and Flexibility

US GAAP and IFRS based financial reports are not forms. The *Seattle Method*[27] is an approach to managing flexibility. The *Seattle Method* is a proven, industrial strength, good practices, standards-based pragmatic approach to creating provably high quality XBRL-based general purpose digital financial reports when reporting entities are permitted to modify the report model.

[27] *Seattle Method*, http://xbrlsite.com/seattlemethod/SeattleMethod.pdf

The focus of the *Seattle Method* is financial reporting using financial reporting schemes such as US GAAP, IFRS, UK GAAP, and other schemes where the preparer of a financial report is permitted to modify the report model. Because modification of the report model is allowed, those modifications must be controlled to keep the modifications within permitted boundaries.

Without control, there can be no automation, no repeatable processes. Rules provide control. Control leads to high quality. High quality leads to effective automation. Accountants manage the rules.



Machine readable rules are used to control systems. In addition, the rules describe the system and are available for software applications to use in order to provide functionality to using software to interact with machine readable financial reports. Rules do the following:

- Elimination of "**wild behavior**" by accountants when report model can be modified
- **Description** of report (specification of what is permitted); created by standards setter or regulator or anyone else specifying a report
    - Machine ***readable form***
    - Machine readable form converted to ***human readable form***
- **Create** report based on description (assisted by software utilizing machine readable description)
- **Verify** that report has been created per description (assisted by software utilizing machine readable description)
- **Extract** information from report per report description (assisted by software utilizing machine readable description)

Like financial reports; accounting working papers, audit working papers and schedules, and financial analysis models are likewise customizable. They are not forms. However, best practices can be used to create canonical representations of forms that can be used as the base templates. Then, those canonical base templates can be extended with more information or have information removed to meet the specific needs of a specific economic entity, a specific accountant, or specific auditor.

Financial reports and the accounting and auditing working paper artifacts used to create those reports are not unique individual “art projects”. Comprehensible artifacts tend to be preferred.

Logical Patterns Language

You can think of all this in terms of what amounts to a logical pattern language. The following narrative describes at a high level what is going on:

Effectively, the *Seattle Method* provides a fixed method for representing (i.e., modeling) financial accounting, reporting, auditing, and analysis related events, experience, and information in machine readable form in a manner that the information is understandable by both humans and machines. It starts with terms, sets of relationships, sets of rules that govern the relationships, other rules that describe what is permitted, and how to represent facts within this logical scheme so that information is understandable to machine-based processes and at the same time understandable by humans. You can think of the *Seattle Method* as a pattern language with exactly the appropriate level of flexibility in exactly the right areas such that things represented using that pattern language are always "computable" because the foundational "container" of terms, relationships, rules, and facts never change. They are just patterns entirely known and understood by the method. As such, software can be constructed and then used to effectively reason over the sets of structures, associations, rules, and facts represented within different models because the sense-making machinery that is "baked-in" to the capabilities of the Seattle Method logical pattern language. The "fixed" way of defining the logical patterns provides us with this consistently useful method for defining or exploring complex information logic that always exists within the "guardrails" or "bumpers" provided by definitions of what is permitted and what is not permitted by, say, some specific financial reporting scheme represented using this approach.

Different people have different views on how all this can be implemented within software. How these logical patterns are implemented can be an arbitrary decision made for any number of reasons. There are multiple technology stacks that might be used to implement these logical patterns.

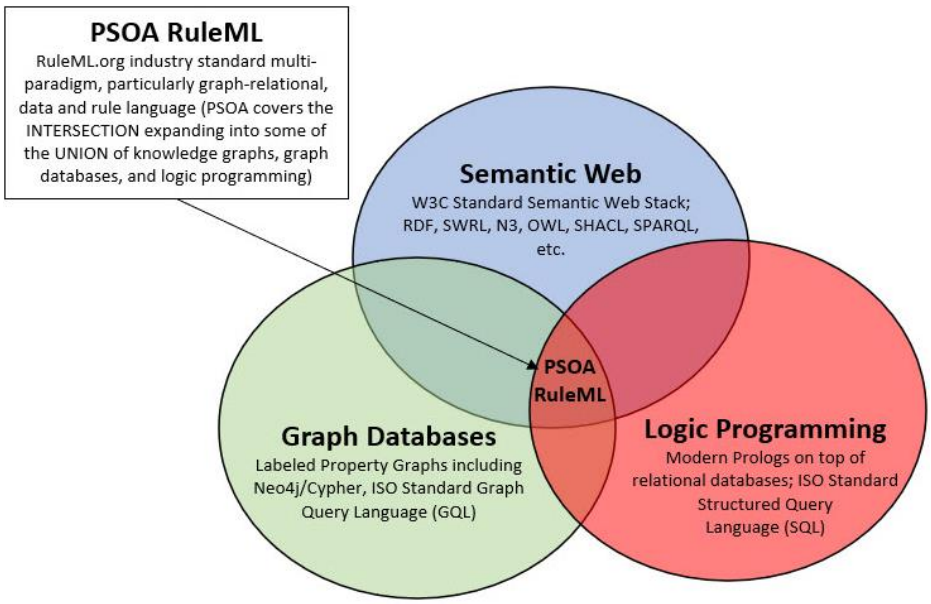
Multiple Technology Stacks

All that accounting knowledge that is created by skilled accountants with many years of experience needs to be physically represented using some technical format in some physical form. That machine readable information once created needs to be maintained and otherwise curated to keep the knowledge in usable form and correct. Software also needs to be able to effectively process that knowledge without catastrophic failure of the software.

The different primary technical approaches for physically creating this machine-readable knowledge tends to take one of three forms[28]. Those forms are: Semantic Web, Graph Databases, and Logic Programming.

The following graphic shows these three primary approaches but more importantly it points out that each of the approaches can be converted to the other approaches quite easily, or could if the logical information (those logical patterns) represented within by any approach is within the bounds of what can be represented by the other two technical formats.

[28] Implementing Knowledge Graphs, http://xbrl.squarespace.com/journal/2021/9/20/implementing-knowledge-graphs.html



Technical formats tend to be driven by arbitrary preference, fad, trends, politics, and even misinformation and it is highly likely that behavior pattern will continue into the foreseeable future.

Process Control

Because, as we pointed out, financial reports are not static forms and therefore individual economic entities are allowed to make specific modifications to models; those modifications need to be controlled in order to maintain information quality. Said another way, permissible modifications to the model must be crystal clear to those making such modifications.

The "container" is fixed. But what can go into the container is flexible and can be adapted to different financial reporting schemes or different work paper templates or different approaches to representing auditing schedules.

Control + Rules = Effective Automation (High Quality)

If a process cannot be controlled then the process simply cannot repeatedly and reliably output high-quality. If process output is not high-quality, automation cannot possibly be effective.

So, control of a process is necessary in order for the process to be effective. How do you control a process? You control a process using rules. Manual processes are controlled by rules that are read by humans. Automated processes are controlled by rules that are readable by both machines (i.e., to execute the process) and humans (i.e., to make sure the rules are right).

Who creates these machine-readable rules that are used to control processes that yield effective automation? Accountants must create these rules because the rules tend to be accounting oriented. Technical rules tend to relate to syntax and such technical rules can be hidden from business professionals. What is left is the business logic and accounting rules that are used to control information and control process workflow. As such, the creation of machine-readable rules must be "self-service". Business professionals must be empowered to create, adjust, maintain, and otherwise manage the rules that are used to control and therefore effectively automate processes.

Once you have the machine-readable rules, you need software that can process the rules; this is sometimes called a rules engine or reasoning engine or a semantic reasoner.

Lean Six Sigma

Lean Six Sigma[29] is a discipline that combines the problem-solving methodologies and quality enhancement techniques of Six Sigma[30] with the process improvement tools and efficiency concepts of Lean Manufacturing[31]. Born in the manufacturing sector, Lean Six Sigma works to produce products and services in a way that meets consumer demand without creating wasted time, money and resources.

Specifically, Lean is 'the purposeful elimination of wasteful activities.' It focuses on making process throughout your company faster, which effects production over a period of time. Six Sigma works to develop a measurable process that is nearly flawless in terms of defects, while improving quality and removing as much variation as possible from the system.

Quality and the lack of quality both have a cost. The 1-10-100 Rule is related to what's called "the cost of quality." Essentially, the rule states that prevention is less costly than correction is less costly than failure. It makes more sense to invest $1 in prevention, than to spend $10 on correction. That in turn makes more sense than to incur the cost of a $100 failure[32].

A logical spreadsheet includes process control mechanisms that guarantee high quality at the level of six sigma which is 99.99966% error free.

Lean Six Sigma, while invented by the manufacturing sector is also usable during the process of constructing a financial report.

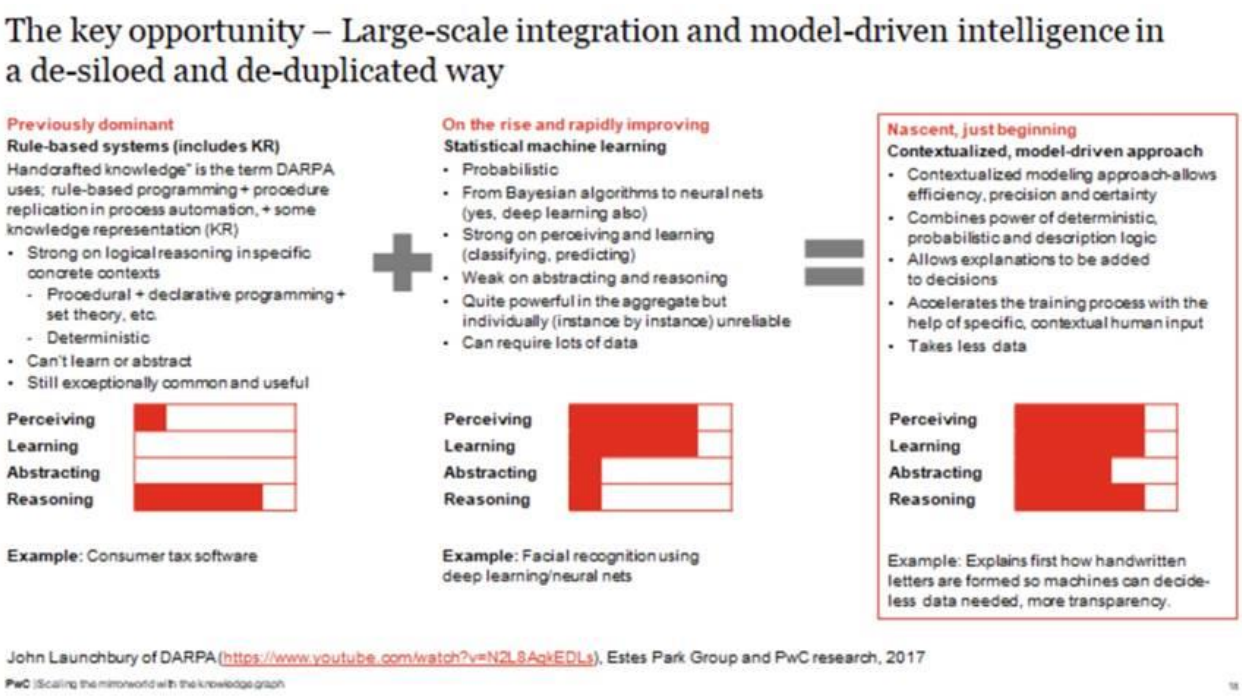
To learn more about Lean Six Sigma techniques, principles, tools, and philosophies I would recommend the chapter *Lean Six Sigma*[33] of *Mastering XBRL-based Digital Financial Reporting*.

Hybrid Explainable Artificial Intelligence

Key to leveraging a machine-readable knowledge graph is the capability to process that knowledge graph effectively and reliably without catastrophic and unpredictable software failure. The more knowledge in a knowledge-based system, the more the knowledge-based system can do for the users of the system. Rules-based artificial intelligence, machine learning, and LLMs like OpenAI's GPT-4 and Google's PaLM 2 can help augment the skills of accountants. This is not necessarily an "either/or" type decision. If rules-based and patterns-based and LLM-based systems are properly combined, the most powerful result can be achieved.

Alan Morrison explains the differences and the possibilities in the article, *What is the relation between Semantic Web and AI*?[34] The best solution with the most power combines that capabilities of rules-based and statistical-based pattern-based systems. This graphic from that article helps to communicate the possibilities:

[29] Wikipedia, *Lean Six Sigma*, https://en.wikipedia.org/wiki/Lean_Six_Sigma
[30] Wikipedia, *Six Sigma*, https://en.wikipedia.org/wiki/Six_Sigma
[31] Wikipedia, *Lean Manufacturing*, https://en.wikipedia.org/wiki/Lean_manufacturing
[32] Michael Canic, *The Cost of Quality: The 1-10-100 Rule*, https://www.makingstrategyhappen.com/the-cost-of-quality-the-1-10-100-rule/
[33] Charles Hoffman, CPA, *Lean Six Sigma*, http://www.xbrlsite.com/mastering/Part01_Chapter02.K_LeanSixSigma.pdf
[34] Quora, Allan Morrison, What is the relation between Semantic Web and AI?, https://www.quora.com/What-is-the-relation-between-Semantic-Web-and-AI/answer/Alan-Morrison



Both over estimating and under estimating the capabilities of artificial intelligence have negative consequences. *The AI Ladder*[35], by Rob Thomas and published by O'Reilly Media, is by far the best resource that I have run across related to getting your head around artificial intelligence. Here is a summary of why AI projects fail:

- **Lack of understanding**. 81% of business leaders to not understand AI.
- **Bad data**. Not having a handle on your data is completely paralyzing. Your AI is only going to be as good as your data.
- **Lack of the right skills**. The lack of the right skills on part of both business professionals and information technology professionals is problematic.
- **Trust**. Trusting the recommendations made by your artificial intelligence software is a must. AI should not be a black box; business professionals need justification mechanisms that support conclusions.
- **Culture**. *The Technology Fallacy*[36] points out that digital transformation involves changes to organizational dynamics and how work gets done. AI will enable entirely new business models which were impossible in the past.

Implementing AI is hard work. Getting AI right involves the right tools, the right skills, and the right mindset.

Similar to how a calculator augments the capabilities of an accountant to do math; artificial intelligence will augment the skills and capabilities of accountants, auditors, and analysts. But artificial intelligence must make things better, faster, and/or cheaper to be useful.

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[35] O'Reilly Media, Rob Thomas, *The AI Ladder*, https://www.oreilly.com/online-learning/report/The-AI-Ladder.pdf
[36] Deloitte, Gerald C. Kane, Anh Nguyen Phillips, Jonathan R. Copulsky, and Garth R. Andrus, *Technology Fallacy*, https://www2.deloitte.com/us/en/pages/human-capital/articles/the-technology-fallacy.html

The bottom line is that deductive reasoning[37], inductive reasoning[38], and abductive reasoning[39] are all tools that can be used by professional accountants in performing work. Sometimes the accountant will perform the reasoning and other times the accountant will be assisted by software applications. It is important to understand and pick the right tool for the task.

Accounting, reporting, auditing, and analysis cannot be a black box. Explainable AI (XAI)[40] is necessary. Explainable artificial intelligence (XAI) emphasizes the capabilities of the algorithm not just in providing an output, but also in sharing with the user the supporting information relating to the line of reasoning used by the system to reach the conclusion it reached.

Standing on the Shoulders of Giants

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. The system is controlled. To avoid failure, computer science and knowledge engineering best practices seems to have concluded that the following alternatives are preferable:

- **Systems theory**: A system[41] is a cohesive conglomeration of interrelated and interdependent parts that is either natural or man-made. Systems theory explains logical systems. Systems have patterns.
- **Logical theory**: There are many approaches to representing logical systems in machine-readable form, a logical theory being the most powerful (ontology + rules). Theories describe patterns. (see the ontology spectrum[42])
- **Proof theory**: The ideas of proof theory[43] can be used to verify the correctness of logical systems and computer programs working with those machine-readable logical systems using mathematics[44]. Proofs verify theories. Machine readable logical theories can be proven using automated processes.
- **Model theory**: Model theory is a way to think about flexibility. Safer finite model theory[45] is preferable to general model theory. Models provide flexibility.
- **Set theory**: Set theory is foundational to logic and mathematics. Axiomatic (Zermelo–Fraenkel) set theory[46] is preferred to naïve set theory.

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[37] Wikipedia, *Deductive Reasoning*, https://en.wikipedia.org/wiki/Deductive_reasoning
[38] Wikipedia, *Inductive Reasoning*, https://en.wikipedia.org/wiki/Inductive_reasoning
[39] Wikipedia, *Abductive Reasoning*, https://en.wikipedia.org/wiki/Abductive_reasoning
[40] ACCA, *Explainable AI: Putting the user at the core*, https://www.accaglobal.com/uk/en/professional-insights/technology/Explainable_AI.html
[41] Wikipedia, *Systems Theory*, https://en.wikipedia.org/wiki/Systems_theory
[42] *Difference between Taxonomy, Conceptual Model, Logical Theory*, http://xbrl.squarespace.com/journal/2018/12/11/difference-between-taxonomy-conceptual-model-logical-theory.html
[43] Stanford University, *The Development of Proof Theory*, *The Aims of Proof Theory*, https://plato.stanford.edu/entries/proof-theory-development/#AimProThe
[44] Samuel R. Buss, *An Introduction to Proof Theory*, https://math.ucsd.edu/~sbuss/ResearchWeb/handbookI/ChapterI.pdf
[45] Wikipedia, *Finite Model Theory*, https://en.wikipedia.org/wiki/Finite_model_theory
[46] Wikipedia, *Set Theory, Axiomatic Set Theory*, https://en.wikipedia.org/wiki/Set_theory#Axiomatic_set_theory

- **Graph theory**: Directed acyclic labeled property graphs[47] 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[48] is a subset of first-order logic and is the basis for Prolog[49]. Datalog[50] is a subset of Horn logic (function free PROLOG) 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 which exchange information in machine-readable form, the safest and most reliable alternatives are:
    - **closed world assumption**[51] (used by relational databases) is preferred to the open world assumption which can have decidability issues;
    - **negation as failure**[52] (used by relational databases) should be explicitly stated;
    - **unique name assumption**[53] (used by relational databases) should be explicitly stated;
- **Dimensional fact model**: The dimensional fact model[54] provides a clear and exhaustive representation of multidimensional concepts. XBRL Dimensions specifies a dimensional fact model.
- **Pattern Logic**: Pattern Logic[55] is a new, modern approach to thinking about how to implement logic (models, structures, associations, rules, facts) within software. While most implementation approaches are grounded by an axiomatization of human intuition in symbols, pattern logic is grounded by the systematic development of patterns that anticipate this intuition.
- **Logical Theory Describing Financial Report**: The *Logical Theory Describing Financial Report*[56] is a logical conceptualization of the mechanical, mathematical, structural, and logical aspects of general purpose and special purpose financial reports for the purpose of representing such reports digitally using XBRL and other technical syntaxes.
- **Standard Business Report Model (SBRM)**: The Standard Business Report Model (SBRM)[57] formally documents a logical conceptualization of a business report in both human-readable and machine-readable models.

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[47] Wikipedia, *Directed Acyclic Graph*, https://en.wikipedia.org/wiki/Directed_acyclic_graph
[48] Wikipedia, *Horn Logic*, https://en.wikipedia.org/wiki/Horn_clause
[49] Wikipedia, *Prolog*, https://en.wikipedia.org/wiki/Prolog
[50] Wikipedia, *Datalog*, https://en.wikipedia.org/wiki/Datalog
[51] Wikipedia, *Closed World Assumption*, https://en.wikipedia.org/wiki/Closed-world_assumption
[52] Wikipedia, *Negation as Failure*, https://en.wikipedia.org/wiki/Negation_as_failure
[53] Wikipedia, *Unique Name Assumption*, https://en.wikipedia.org/wiki/Unique_name_assumption
[54] Wikipedia, Dimensional Fact Model, https://en.wikipedia.org/wiki/Dimensional_fact_model
[55] Patterns Language, *Pattern Logic*, https://patternslanguage.com/pattern-logic
[56] Charles Hoffman, CPA, *Logical Theory Describing Financial Report (Terse)*, http://xbrlsite.com/seattlemethod/LogicalTheoryDescribingFinancialReport_Terse.pdf
[57] OMG, *Standard Business Report Model (SBRM)*, https://www.omg.org/intro/SBRM.pdf

- **XBRL technical syntax physical format**: The Extensible Business Reporting Language (XBRL)[58] is the international standard for the electronic representation of business reports. A financial statement is a specialization of the more general business report.

These theories, models, techniques, and principles have been created over many years and must be considered when trying to implement knowledge-based systems related to financial accounting, reporting, auditing, and analysis.

Deliberate and rigorous testing using real world business use cases is the best proof that a system works as would be expected.

Computational Professional Services

So why is all this important? ***The Great Transmutation***[59] is about a paradigm shift in financial accounting, reporting, auditing, and analysis. People refer to this paradigm shift in different ways. Here are how some people package this paradigm shift:

- MIT refers to this as **Algorithmic Business Thinking**[60]
- Carnegie Mellon University refers to this as **Computational Thinking**[61]
- Harvard University refers to this as **Regulation, the Internet Way**[62]
- Vanderbilt University refers to this as **Regulation 2.0**[63]
- The Data Coalition calls this **Smart regulation**[64]
- Tim O'Reilly Founder and CEO O'Reilly Media Inc. calls it **Algorithmic regulation**[65]
- Deloitte refers to this as "**The Finance Factory**" and **Digital Finance**[66]
- Robert Kugel of Ventana Research calls it "**Digital Finance**"[67]
- The government of Norway calls this "**Nordic Smart Government and Business**"[68]

[58] XBRL International, XBRL Essentials, https://specifications.xbrl.org/xbrl-essentials.html
[59] Charles Hoffman, CPA, *The Great Transmutation*, http://xbrlsite.azurewebsites.net/2022/Library/TheGreatTransmutation.pdf
[60] MIT, Accelerating Digital Transformation with Algorithmic Business Thinking, https://executive.mit.edu/course/accelerating-digital-transformation-with-algorithmic-business-thinking/a056g00000URaaQAAT.html
[61] Carnegie Mellon Center for Computational Thinking, https://www.cs.cmu.edu/~CompThink/
[62] Harvard University, Regulation, the Internet Way, https://datasmart.ash.harvard.edu/news/article/white-paper-regulation-the-internet-way-660
[63] SSRN, *Regulation 2.0: The Marriage of New Governance and Lex Informatica*, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2746229
[64] Smart Regulation, http://xbrl.squarespace.com/journal/2012/11/12/smart-regulation-graphic-shows-the-big-picture.html
[65] Tim O'Reilly Founder and CEO O'Reilly Media Inc., Open Data and Algorithmic Regulation, https://beyondtransparency.org/chapters/part-5/open-data-and-algorithmic-regulation/
[66] Deloitte, *Finance 2025: Digital transformation in finance*
Our eight predictions about digital technology for CFOs, https://www2.deloitte.com/us/en/pages/finance-transformation/articles/finance-digital-transformation-for-cfos.html
[67] Robert Kugel, *The Rising Expectations for Finance Analytics*, https://www.linkedin.com/pulse/rising-expectations-finance-analytics-robert-kugel/
[68] Nordic Smart Government and Business, https://nordicsmartgovernment.org/

I refer to all this as ***Computational Professional Services***[69]. (There might be a better term, but that is the term I am currently using).

Imagine a set of high-quality knowledge graphs organized into the form of a knowledge portal[70]. Imagine that the knowledge portal is enhanced by blockchain technology. Imagine that the knowledge graphs physical syntax is based on global standards and that the information within those knowledge graphs is also based on standards[71].

Imagine a system that is simple and elegant to use, rather than a poorly thought-out kludge.

Trying to understand what is going on by trying to plug the changes that you see into the current paradigm of accounting, reporting, auditing, and analysis is like walking around the city of Chicago with a map of New York City to try and find your way. Using the appropriate map, such as a map of New York City, would work better.

Electronic spreadsheet-based processes are fundamentally flawed. How exactly is "smart regulation" or "algorithmic regulation" going to magically work with traditional electronic spreadsheets? It simply cannot work with traditional electronic spreadsheets. Something like a logical spreadsheet is necessary.

Need for Clarity

A financial reporting scheme represented digitally using an XBRL taxonomy 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 and/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.

None of this will be created by itself and stakeholders that do participate in the creation of these digital systems need to be clear as to the goal or goals these systems are to achieve.

The same clarity required within XBRL-based financial reports is also necessary in the supporting accounting and auditing working papers and schedules. A logic oriented professional spreadsheet can supplement the toolset of professional accountants doing work in the information age.

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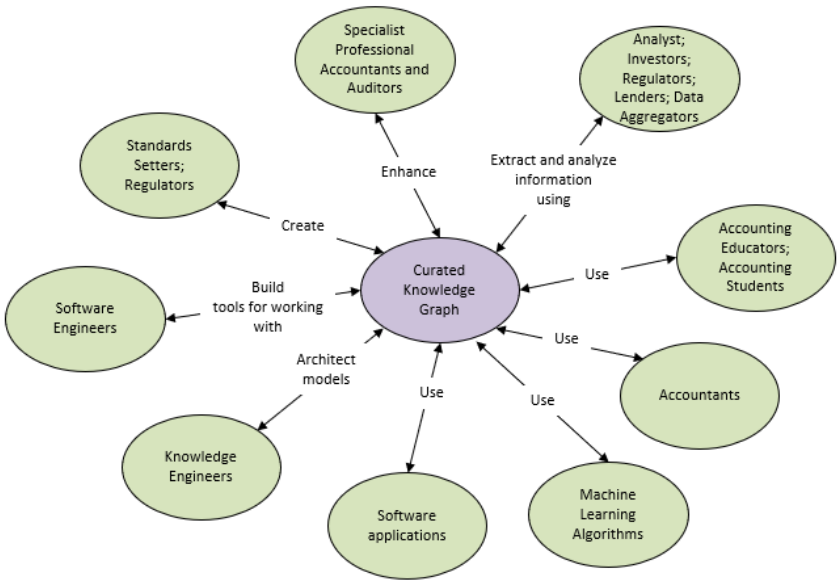
[69] Computational Professional Services, http://www.xbrlsite.com/mastering/Part00_Chapter01.A1_ComputationalProfessionalServices.pdf

[70] Data Science Central, Kurt Cagle, *From Knowledge Graphs To Knowledge Portals*, https://www.datasciencecentral.com/from-knowledge-graphs-to-knowledge-portals/

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

Avoiding Silo Thinking

The system should not be thought of as a "silo" of one stakeholder, rather the system is the set of all stakeholders. This graphic gives you an idea of the stakeholders related to the area of knowledge referred to as financial accounting, reporting, auditing, and analysis:



Orchestration is necessary to maximize the potential benefits that such a system might provide. High quality curated and maintained business logic represented in machine readable form will drive the future of accounting, reporting, auditing, and analysis.

Conclusion

By carefully and deliberately burying complexity that professional accountants, auditors, and analysts would otherwise struggle with "under the hood" of the system and exposing well-thought-out logical artifacts in a well-defined model; then elegant, easy to use, and powerful software can be provided to those uses to solve not every problem, but rather a set of very specific problems. Business professionals work with structures rather than atoms. Business professionals get a prepackaged set of behaviors. These structures and prepackaged behaviors help guide these business professionals to success.

Try the software and reach your own conclusion.

The Great Transmutation is underway. We have outgrown what we have but we have not created what we need to replace what we have yet. Change will be messy. Spreadsheet based processes that are currently in use are fundamentally flawed. New modern approaches are necessary to overcome these current limitations and the inherent risks associated with those limitations. Logical spreadsheets will very likely be the professional tool of choice for accountants, auditors, and analysts in the information age.

If you are not sure where to start your journey into the future, I would suggest starting here on my blog, *The End (Start Here)*[72].

[72] *The End (Start Here)*, http://xbrl.squarespace.com/journal/2022/4/4/the-end-start-here.html