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Financial Report Knowledge Graphs

A nontechnical explanation of knowledge graphs in the context of financial reporting for professional accountants

By

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1. Introduction

Knowledge graphs are a tool of the information age in which we all now find ourself. As we transition from an industrial economy into a digital economy during this fourth industrial revolution[1]; the tools we use need to change to be updated for the current times.

What exactly is a knowledge graph[2]? At the core of every machine-readable knowledge graph is a machine-readable knowledge model. A knowledge model is a collection of interlinked logical statements that describe the terms, structures, associations, rules, and facts that make up that knowledge graph. Knowledge graphs put information into context via linking and logical oriented metadata and this way provide a framework for data integration, solving problems, information analysis and sharing of that machine-readable information.

Financial reports are knowledge graphs.

When you try and understand knowledge graphs you often tend to run across explanations in terms of products that are offered. Three excellent resources that explain knowledge graphs in terms of specific product implementations include:

- *The Knowledge Graph Cookbook: Recipes that Work*[3] (uses the W3C standard Semantic Web Stack; this approach uses RDF, SWRL, OWL, N3, SHACL, SPARQL, and other such W3C standard technologies for representing data, ontologies, and rules[4])
- *Graph Databases*[5] (uses the Neo4j graph database and graph compute engine, which will very likely become an ISO standard graph query language[6])

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1 *Adapting to Changes Caused by the Fourth Industrial Revolution*, http://xbrl.squarespace.com/journal/2019/8/4/adapting-to-changes-caused-by-the-fourth-industrial-revoluti.html

2 Ontotext, *What is a Knowledge Graph?*, https://www.ontotext.com/knowledgehub/fundamentals/what-is-a-knowledge-graph/

3 *The Knowledge Graph Cookbook: Recipes that Work*, http://xbrl.squarespace.com/journal/2021/6/27/the-knowledge-graph-cookbook-recipes-that-work.html

4 W3C, *Semantic Web*, https://www.w3.org/2001/sw/wiki/Main_Page

5 *Graph Databases*, https://neo4j.com/neoassets/graphbooks/Graph_Databases_2e_Neo4j.pdf

6 *New Query Language for Graph Databases to Become International Standard*, https://neo4j.com/press-releases/query-language-graph-databases-international-standard/

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- *Systematic Introduction to Expert Systems*[7]*: Knowledge Representation and Problem-Solving Methods* (uses programming logic, PROLOG, for which is an ISO standard[8])

A significant portion of the information in this resource comes from those three excellent resources. If you want additional details after reading this document, those three books are worth looking into. Those three resources provide information about implementing knowledge graphs within specific software applications.

Either of these three problem solving logic paradigms[9] can be employed effectively to represent financial reports. Further, the global standard XBRL[10] technical syntax can be bi-directionally serialized into or out of any of these three paradigms.

A financial report is a knowledge graph. I will explain what I mean by that in this document. A financial report is also a type of logical system and a specialization of a business report. You could interact with financial report knowledge graphs using general-purpose tools for processing any knowledge graphs.

But there are significant advantages to using special-purpose tools, tuned specifically for financial report knowledge graphs, when you want to interact with a financial report knowledge graph. These special-purpose tools are easier for business professionals to use and offer all the power of a general-purpose tool such as a graph database and a graph compute engine.

To create a specialized logical conceptualization of a financial report from a general logical conceptualization of a knowledge graph we use three steps:

1. Logical theory or logical system
2. Logical conceptualization of a business report which builds on and is a type of logical theory.
3. Logical conceptualization of a financial report which builds on but is a type of business report.

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[7] Frank Puppe, *Systematic Introduction to Expert Systems: Knowledge Representation and Problem-Solving Methods*, https://www.google.com/books/edition/_/_kKqCAAAQBAJ

[8] ISO, *ISO/IEC 13211-1:1995*
Information technology — Programming languages — Prolog — Part 1: General core, https://www.iso.org/standard/21413.html

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

[10] XBRL International, *XBRL Standard*, https://www.xbrl.org/the-standard/

The logical conceptualization of a financial report is knowledge that can be stored in the form of a graph. As such, a financial report is a knowledge graph.

All this will be explained in this resource. Let's start by breaking down the terms "knowledge" and "graph".

1.1. Overview

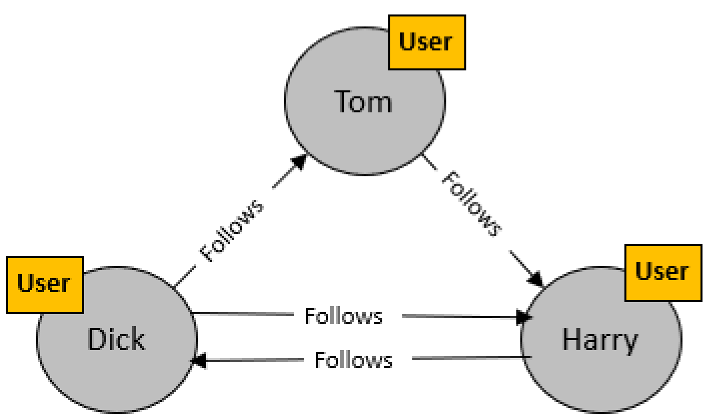
We communicate using knowledge graphs. When you go to a whiteboard and draw circles and squares and connect them with lines with arrows you are drawing a graph and communicating knowledge. Those circles, squares, lines, and arrows are intuitively understandable and very expressive. These informal knowledge 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 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**:



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A knowledge graph[11], 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 fragment of a financial report:

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 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.

Let's start to expand on our understanding of knowledge graphs by looking at two terms: knowledge and graph.

1.2. Knowledge

The following graphic perhaps provides the best visual explanation as to the difference between data, information, knowledge, insight, and wisdom[12] that I have run across:

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

[12] Tumblr, *Information isn't Power*, https://random-blather.com/2014/04/28/information-isnt-power/

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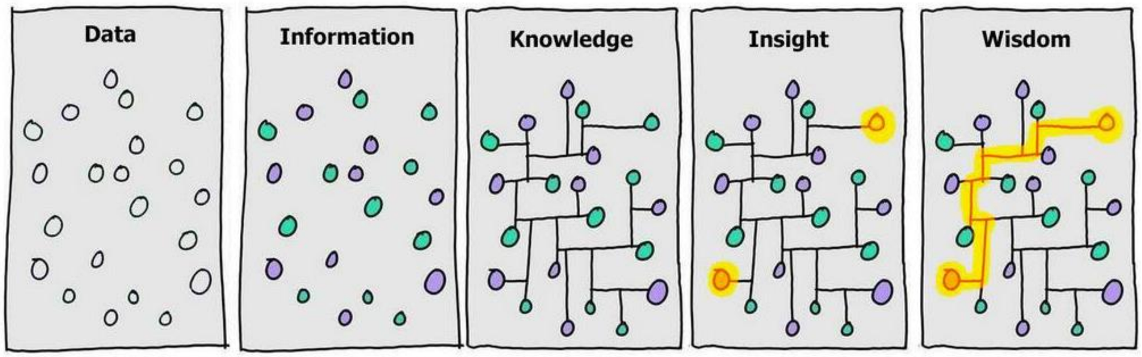

There are specific differences between data, information, knowledge, insight, and wisdom[13]:

- **Data**: The basic compound for intelligence is data. Data are measures, observations, symbols, phenomenon, utterances, and other such representations of the world around us presented as external signals and picked up by various sensory instruments and organs. *Simplified: data is raw facts and numbers*.
- **Information**: Information is produced by assigning relevant meaning related to the context of the data to the data. *Simplified: information is data in context*.
- **Knowledge**: Knowledge is the understanding or interpretation, a justifiable true belief, of information and approach to act upon the information in the mind of the perceiver. *Simplified: knowledge is the interpretation of information*.
- **Insight**: Insight is the first step in putting information and knowledge to work for you.
- **Wisdom**: Wisdom embodies awareness, insight, moral judgments, and principles to construct new knowledge and improve upon existing understanding. *Simplified: wisdom is the creation of new knowledge*.

The difference between *data* and *information* is that data is the raw numbers and words where information is data in context. This is important to understand as most problems faced by accountants are an information problem, rather than a data problem. Getting data is easy. Knowing what that data represents and how the data fits together is more difficult. Representing information in the form that a machine

[13] Wikipedia, *DIKW Pyramid*, retrieved February 24, 2016, https://en.wikipedia.org/wiki/DIKW_Pyramid

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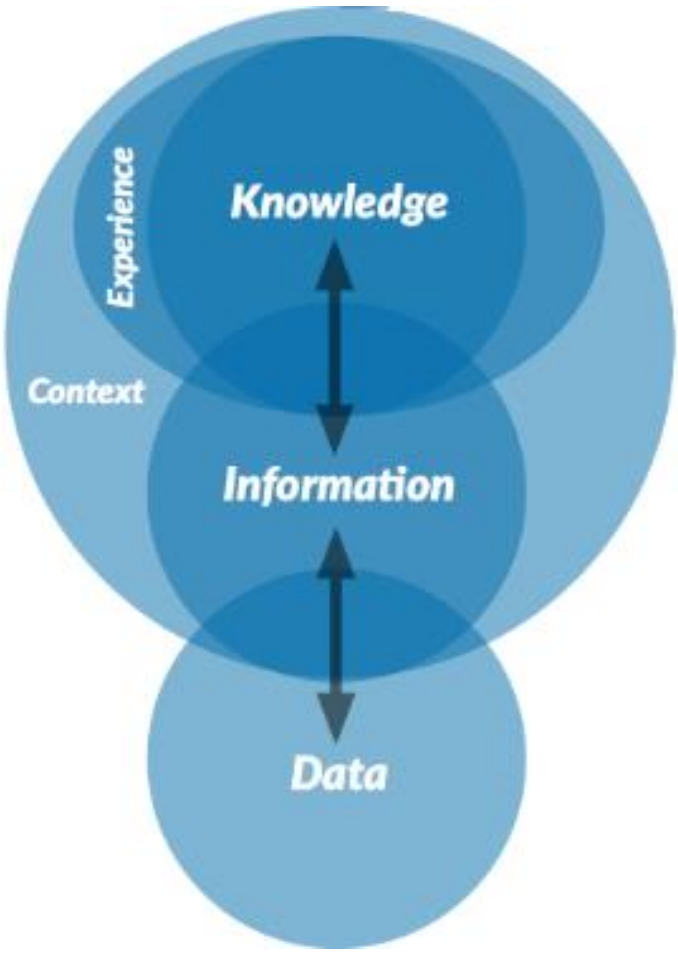
such as a computer can understand and use that information safely and effectively is difficult.

Knowledge is a set of data and information and a combination of skill, know-how, experience which can be used to improve the capacity to take action or support a decision making process.

Insight and wisdom are related to putting information and knowledge to work for you.

The following graph created by Shawn Riley shows the important to understand differences between data, information, and knowledge[14].



The important point to understand here is that it takes the skill and experience of human professionals to create information and knowledge and put that knowledge into the proper context.

14 Shawn Riley, *Machine Learning versus Machine Understanding*, https://www.linkedin.com/pulse/machine-learning-vs-understanding-shawn-riley/

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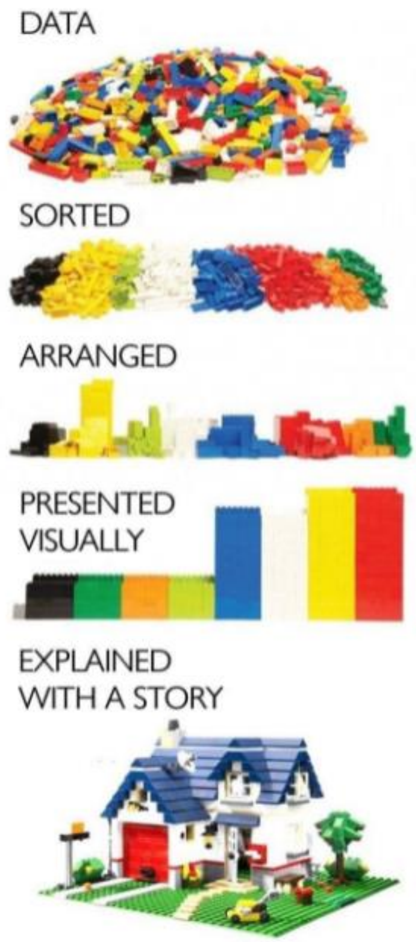
Another very interesting graphic posted by Mark Cossey[15] is this which shows the value and therefore power of classification[16]:



The point that I am trying to make is that there is a very significant difference between data, information, and knowledge. Or focus is on information and knowledge, not data.

1.3. Tools for Representing Knowledge

There are a number of different tools that can be used to effectively represent knowledge. Below you see a spectrum of such tools with the least powerful tools on the left and increasing in power to the right:

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[15] LinkedIn, Mark Cossey, https://www.linkedin.com/feed/update/urn:li:activity:6839928291433029632/

[16] *Understanding the Power of Classification*, http://xbrl.squarespace.com/journal/2019/5/14/understanding-the-power-of-classification.html

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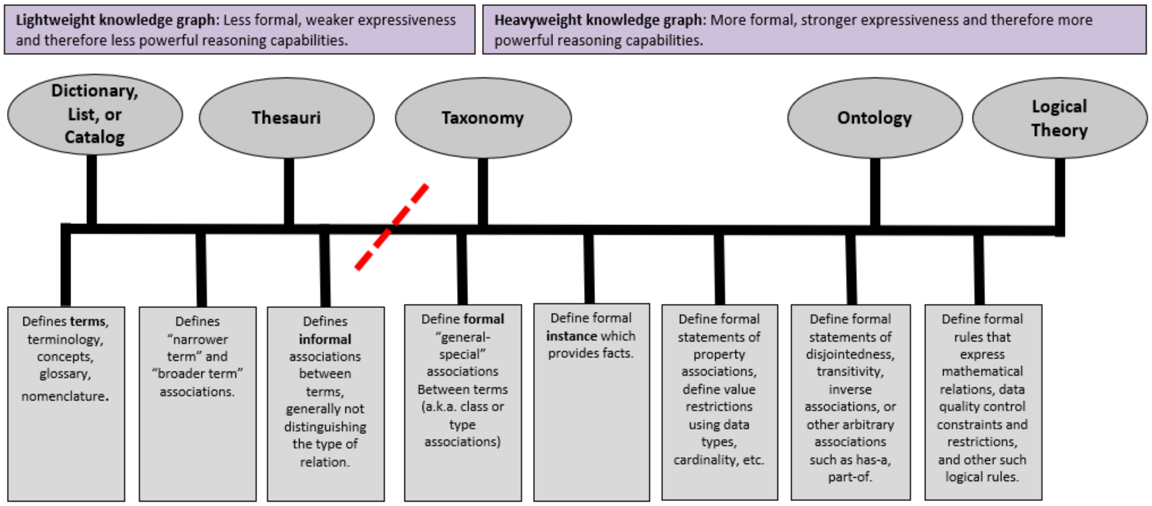


Inspired primarily by Deborah L. McGuinness, ***Ontologies for the Modern Age,*** Slide 4, https://www.slideshare.net/deborahmcguinness/ontologies-for-the-modern-age-mcguinness-keynote-at-iswc-2017

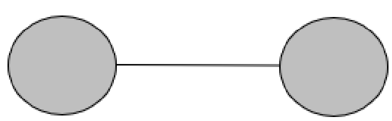
When representing knowledge, the right tool should be used for the job. A logical theory is the easiest way to enable business professionals to understand a logical system because business professionals have an innate understanding of logic. When representing the logic of a financial report, the power of a logical theory is necessary.

1.4. Graphs

When I use the term graph, I am referring to the term in the context of graph theory[17] which is a discipline of mathematics. Wikipedia's definition of graph theory and graph is:

> In mathematics, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects.

This is a very simple graph:



Just like most other things, graphs have a jargon. In formal graph jargon, the circles are referred to as **edge** and the line is referred to as a **vertex**.

Others in other areas use different terminology to refer to exactly the same idea. Here are synonyms for the notions of *edge* and *vertex*:

[17] Wikipedia, *Graph Theory*, https://en.wikipedia.org/wiki/Graph_theory

Edge	Entity	Node	Point	Report element
Vertex	Relationship	Line	Path	Association

Reconciling this to something you might know from grammar[18],

- **Noun**: naming words; person, place, or thing. (represented as an edge)
- **Verb**: doing words; action or doing (represented as a vertex)
- **Adjective**: describes a noun (property of an edge)
- **Adverb**: describes a verb (property of a vertex)

A graph can have can have one or more paths between points; paths can have loops or cycles, circuits, as well as can have self-loops, and paths can go in one direction or both directions.

To better understand graphs, let's look at some subtle but very important differences between some different types of graphs.

If we take the time to consciously formalize the rules related to graphs and understand those rules these communications tools become more effective and they can even be understood by computer software applications.

1.5. Trees

A **tree** is a special type of graph. Most people are more familiar with trees than graphs. A tree is what is called an undirected graph because the items in a tree are connected by exactly one path. This is important to understand because it means that trees are safer than other types of graphs which can contain cycles. But trees have a limitation in that an edge can appear only once in a tree and a tree always has exactly one root edge. Also, because trees are undirected, they provide less information and so they are less powerful in terms of expressiveness.

The following is an example of a graph that is also a tree:

[18] Teaching Resource, https://www.teachstarter.com/au/teaching-resource/nouns-verbs-adjectives-adverbs-posters/

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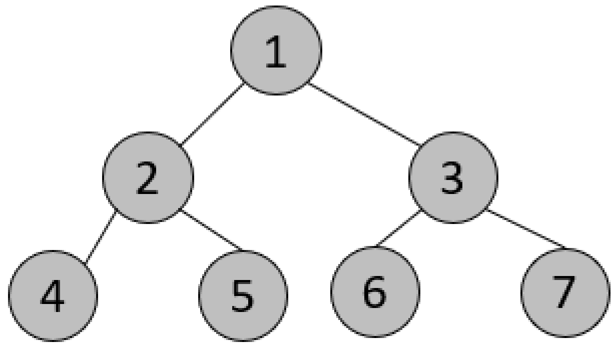
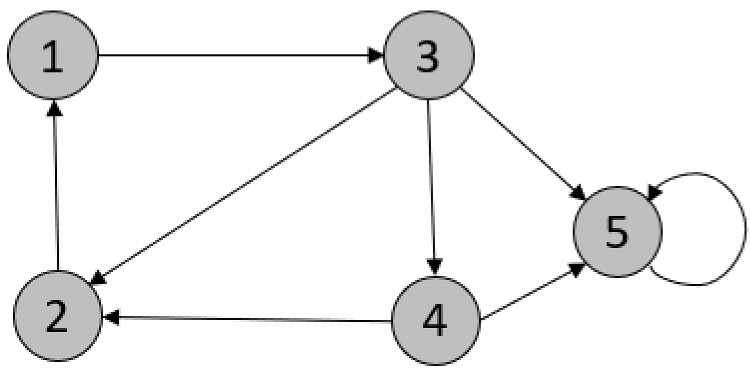


Notice the root, node number 1 and that ever other node that appears is unique. Notice also that there is no direction associated with the lines that appear between the nodes.

1.6. Directed Graph

A **directed graph** is a special type of graph that provides a direction on each vertex. For example, below you see a directed graph:



Note that each vertex (line) has an arrow that points in a specific direction; that is what makes the graph a directed graph. Note edge (node) number 5 which has an arrow that points to itself; that is a cycle. Cycles like that can cause issues such as causing an infinite loop. Those sorts of issues can be solved by using a directed acyclic graph that does not allow such cycles which we will cover next.

Directed graphs are more powerful than trees but because of the possibility of a cycles, they can be unsafe for certain things.

1.7. Directed Acyclic Graph

A **directed acyclic graph** (DAG) is an even more special type of graph that provides a direction on each vertex and you are guaranteed not to have any cycles in the graph. This makes the graph very save as there

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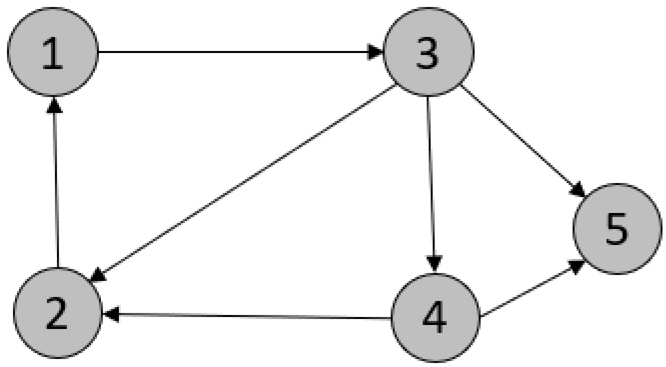
is not a possibility of creating infinite loops that can break software applications. For example, below you see a directed acyclic graph:



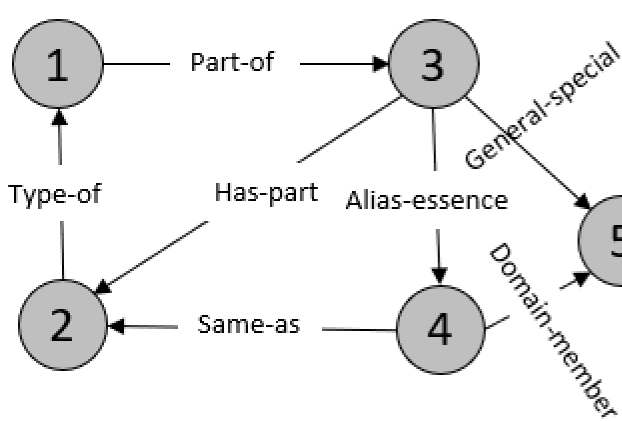
Note again that each vertex has an arrow which specifies a direction and that there are no cycles making this a directed acyclic graph. Note that there is not one specific edge (node) that can be considered the root of the graph.

But note that you don't have any information about the nature of the vertices (lines). What if information was provided about the relationships in the graph as communicated by the vertices (lines)?

1.8. Labeled Directed Acyclic Property Graph

A **labeled directed acyclic property graph** specifies a type of vertex for each association between any two edges. Specifying that feature, the nature of the relationship, provides additional information that is useful in working with a graph.

For example, below you see a labeled directed acyclic graph:



Note the labels that explain each vertex in the graph. You can, for example, query a graph for those relationship types. Labeled directed

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acyclic graphs have the most power in terms of expressiveness but are also very safe to use because they are guaranteed not to contain any cycles which can lead to catastrophic failure when read by a machine-based process.

1.9. Typed Directed Acyclic Property Graph

Now I am getting over my head, but this seems to have a profoundly important impact on functionality and query speed. There seems to be a difference between a "labeled property graph" and a "typed property graph". Also, there seems to be a critically important difference between RDF graphs and graph databases. Seems that RDF graphs are typed, but you cannot add properties. Seems that labeled property graphs are more flexibly, but that flexibility might not be needed and it impacts functionality and query speed.

This is maddeningly difficult for a business professional to understand. But, reading this article *Labeled vs Typed Property Graphs — All Graph Databases are not the same*[19] and understanding TypeDB[20] are important. Strongly typed graph databases seem very compelling. "TypeDB provides a strong type system for developers to break down complex problems into meaningful and logical systems. Through TypeQL, TypeDB provides powerful abstractions over low-level and complex data patterns."

This seems like incredibly important stuff but I don't really understand it as well as I would like to. And frankly, most software engineers don't seem to understand it well either which makes this problematic. Finally, how does something like PROLOG fit into this comparison.

1.10. 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:

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[19] Medium, *Labeled vs Typed Property Graphs — All Graph Databases are not the same*, https://medium.com/geekculture/labeled-vs-typed-property-graphs-all-graph-databases-are-not-the-same-efdbc782f099

[20] Vaticle, Strongly Typed Database, https://vaticle.com/

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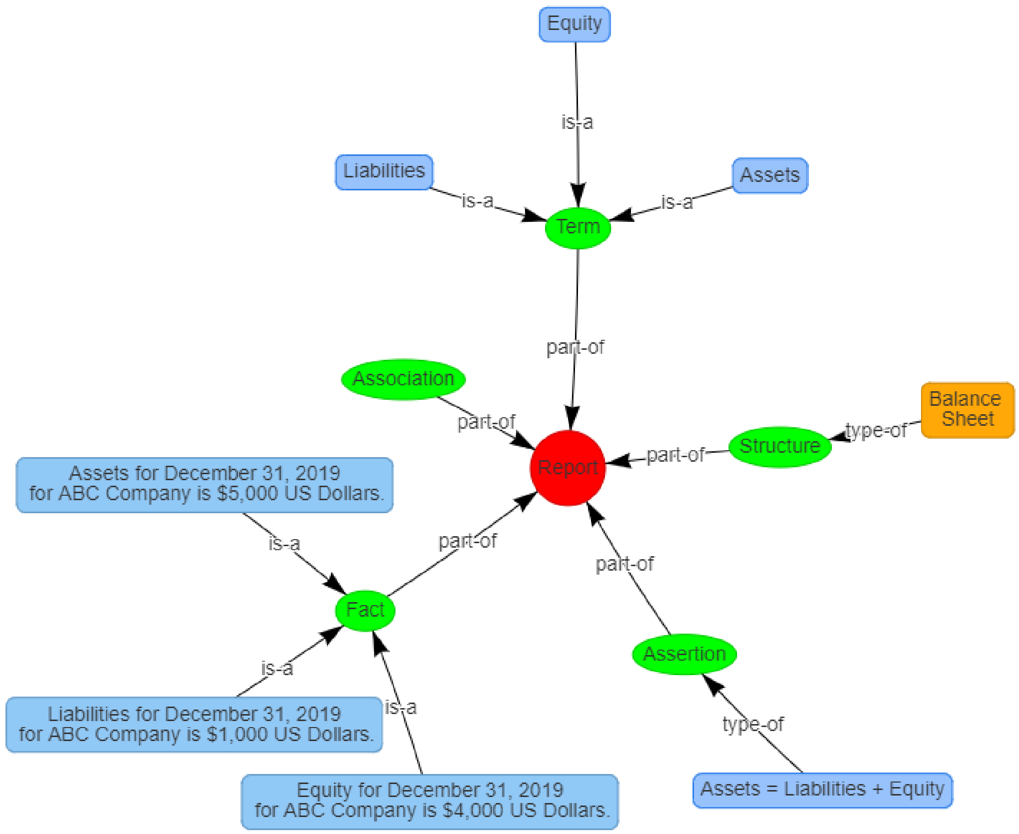
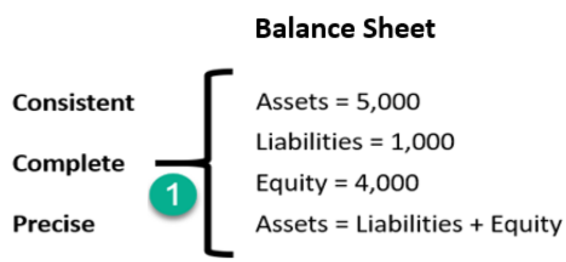


Here is that same information presented in a manner that might be more familiar to professional accountants:

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

Result	Rule
Pass	$Assets = $Liabilities + $Equity



1.11. Special-purpose Knowledge Graph

Knowledge graphs are general-purpose tools that can be modified and turned into special-purpose tools by adding a specific logical model that both constraints and controls the functionality of the general-purpose model.

Converting from a general-purpose tool to a special-purpose tool has two consequences. First, special-purpose tools are less functional and

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less flexibly than general-purpose tools. Secondly, special-purpose tools are an order of magnitude easier to use that a general-purpose tool.

If you give up flexibility that you don't need then you lose nothing but you gain ease of use. That is the benefit of creating special-purpose tools.

This is what a special-purpose financial report knowledge graph might look like:

Reporting Entity [Axis]	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442
Unit [Axis]	USD
	Period [Axis]
Comprehensive Income Statement [Line Items]	2020-01-01/2020-12-31
Comprehensive Income [Roll Up]	
Revenues	7,000
(Expenses)	(3,000)
Gains	1,000
(Losses)	(2,000)
Net Income	3,000

Label	Report Element Class	Period	Balance	Preferred Label Role	Name
Comprehensive Income Statement [Hypercube]	[Table]			Standard Label	proof:ComprehensiveIncomeStatementHypercube
Comprehensive Income Statement [Line Items]	[LineItems]			Standard Label	proof:ComprehensiveIncomeStatementLineItems
Comprehensive Income [Roll Up]	[Abstract]			Standard Label	proof:ComprehensiveIncomeRollUp
Revenues	[Concept] Monetary	For Period	Credit	Standard Label	proof:Revenues
(Expenses)	[Concept] Monetary	For Period	Debit	Negated Label	proof:Expenses
Gains	[Concept] Monetary	For Period	Credit	Standard Label	proof:Gains
(Losses)	[Concept] Monetary	For Period	Debit	Negated Label	proof:Losses
Net Income	[Concept] Monetary	For Period	Credit	Standard Label	proof:NetIncome

#	Reporting Entity	Period	Concept	Fact Value	Unit	Rounding	Parenthetical Explanations
1	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442	2020-01-01/2020-12-31	Revenues	7000	USD	0	
2	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442	2020-01-01/2020-12-31	(Expenses)	3000	USD	0	
3	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442	2020-01-01/2020-12-31	Gains	1000	USD	0	
4	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442	2020-01-01/2020-12-31	(Losses)	2000	USD	0	
5	GH259400TOMPUOLS65II http://standards.iso.org/iso/17442	2020-01-01/2020-12-31	Net Income	3000	USD	0	

Label	Rendered Value	Op	Reported Value	Calculated Value	Balance	Result	Name
Comprehensive Income Statement [Line Items]							proof:ComprehensiveIncomeStatementLineItems
Comprehensive Income [Roll Up]							proof:ComprehensiveIncomeRollUp
Revenues	7,000	+	7,000		Credit		proof:Revenues
(Expenses)	(3,000)	-	3,000		Debit		proof:Expenses
Gains	1,000	+	1,000		Credit		proof:Gains
(Losses)	(2,000)	-	2,000		Debit		proof:Losses
Net Income	3,000		3,000	3,000	Credit	Verified	proof:NetIncome

Can you see the knowledge graph in the different representations of information? Think dynamic pivot table.

Next, let us apply the general ideas of a knowledge graph to financial reports.

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1.12. Control

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". That story is a "signal" your organization sends.

The information conveyed by that story (contained in that signal) 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". There are patterns. There are "good practices" and "best practices".

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 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 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.

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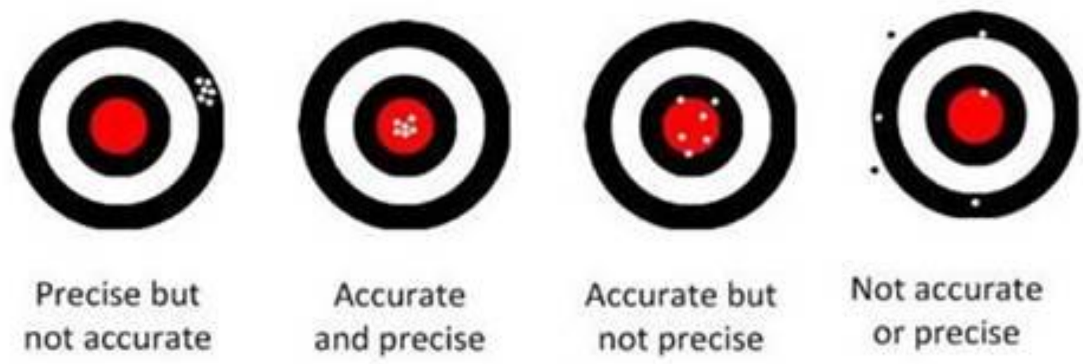
- **Extraction**: Information can be effectively extracted from machine readable reports and report models assisted by software utilizing that machine readable clear and complete description.

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 an XBRL taxonomy must be ***clear***, ***complete***, and reflect accounting and reporting rules ***precisely*** and ***accurately***[21].



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 the really could be or need to be, they are not complete, they are missing rules.

Further, US GAAP and IFRS reporting rules are sometimes ambiguous, but that lack of clarity can be "worked around" by a skilled and experienced accountant that understands accounting and reporting principles and the existing rules well and if they have the right skill and experience they can create "sensible" alternatives considering the ambiguous (i.e. not clear) articulation of the rules by standards setters and regulators.

Whether accounting and reporting rules are in human readable form or machine readable form; these knowledge graphs should be clear, complete, accurate, and precise. The advantage of machine readable form is that the process can be more formalized and tasks and processes can be automated.

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

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1.13. Graphs vs Relational Databases

In his paper, *At Its Core: How Is a Graph Database Different from a Relational One?*[22], Philipp Brunenberg summarizes the fundamental difference between graph databases and relational databases: "Graph and relational databases differ in one fundamental design principle: Graphs do have a concept of a relationship and relational don't. That's why a graph database can manage interconnected data much more efficiently. Still, both have their reasons for existence: Graphs perform better and are more intuitive to use when analyzing an entire context close to a single data point — potentially with multiple hops. However, if the exploration of highly joined and densely connected data is not a requirement, a relational model may serve the needs similarly well."

In the hands of someone with no skills or experience working with knowledge graphs; they tend to produce clumsy, ugly, barely functional output. But in the hands of a skilled craftsmen, knowledge graphs can produce works of utility, elegance, beauty, and durability.

2. Financial Report Knowledge Graph

In the previous section we summarized the general ideas related to knowledge graphs. We pointed out that a graph is a very expressive communications tool and one thing that can be communicated using a graph is knowledge.

In this section we apply those general ideas to the specific use case of financial reports.

There are no natural representations of the world the way it "really is," just many purposeful selections, abstractions, and simplifications, some of which are more useful than others for satisfying a particular goal.

Financial reports are knowledge graphs of the logic conveyed by the information within the financial report. A problem arises when a knowledge graph of a financial report is less capable masquerades as more capable or fully capable knowledge graph of meaning. Professional accountants and auditors need to be able to tell the difference between the two.

A financial report tells a story. That story is a signal conveyed to regulators, investors, or others. The human readable and machine readable versions of that story should be the same. The machine

[22] Philipp Brunenberg, *At Its Core: How Is a Graph Database Different from a Relational One*?, https://towardsdatascience.com/at-its-core-hows-a-graph-database-different-from-a-relational-8297ca99cb8f

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readable version of the story should be saying the same thing as the human readable version.

2.1. Function of a General-purpose Financial Report

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 use case 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.

Financial report knowledge graphs can be interrogated systematically and logically using machine-based processes.

2.2. Essence of a General-purpose Financial Report

A general-purpose financial report is a high-fidelity, high-resolution, high-quality information exchange mechanism. The report is a compendium of complex logical information required by statutory requirements and regulatory rules plus whatever management of an economic entity wants to voluntarily disclose. The report represents

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quantitative and qualitative information about the financial condition and financial performance of an economic entity. There are a number of different financial reporting schemes that might be used to create a general-purpose financial report such as US GAAP, IFRS, IPSAS, GAS, FAS, etc.[23].

Financial reports are not uniform[24]. Financial reports are not forms; they have variability. This consciously allowed variability is an essential, characteristic trait of robust reporting schemes such as US GAAP, IFRS, and others. This allowed variability contributes to the richness, high-fidelity, and high-resolution of reported financial information that is unique to an industry sector, a style of reporting, or an economic entity. This variability is a feature of such reporting schemes. Different reporting styles, different subtotals used to aggregate details, and using some specific approach given a set of allowed alternatives are examples of variability. Variability does not mean "arbitrary" or "random". There are known identifiable patterns.

Rules are used to articulate allowed variability and "channel" creators of financial reports in the right direction and therefore control variability, keeping the variability within standard limits. That keeps quality where it needs to be. Rules enable things like preventing a user from using a concept meant to represent one thing from unintentionally being used to represent something different.

Further, the discipline of describing something in a form a computer algorithm can understand also assists you in understanding the world better; weeding out flaws in your understanding, myths, and misconceptions about accounting and reporting standards.

2.3. Economic Entity Report Model

Because each financial report can be different, each financial report created by each economic entity essentially has its own specific report model. However, all financial reports fit into one financial report metamodel that is described by the *Logical Theory Describing Financial Report*[25].

[23] *Financial Reporting Schemes*, http://xbrlsite.azurewebsites.net/2020/master/ElementsOfFinancialStatements.pdf

[24] *Essence of Accounting*, http://xbrlsite.azurewebsites.net/2020/Library/EssenceOfAccounting.pdf

[25] Charles Hoffman, CPA, et al, *Logical Theory Describing Financial Report*, http://accounting.auditchain.finance/framework/LogicalTheoryDescribingFinancialReport.pdf

It is that logical conceptualization of a financial report that turns a general-purpose knowledge graph into a special-purpose knowledge graph. To use this special-purpose knowledge graph, professional accountants need only understand the fundamentals of knowledge graphs, understand the logic of a financial report, and understand the financial report metamodel which is used to create all financial report models for every economic entity.

To create a standard financial report logical conceptualization, we want to build on top of a business report logical conceptualization because a financial report is a special type of the more general business report.

2.4. Logical Theory Explained in Simple Terms

A system can be explained by a logical theory. A logical theory is an abstract conceptualization[26] of specific important details of some area of knowledge. The logical theory provides a way of thinking about an area of knowledge by means of deductive reasoning to derive logical consequences of the logical theory.

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 statements used for capturing meaning or representing a shared understanding of and knowledge in some area of knowledge.

A logical theory is made up of a set of *models*, *structures*, *terms*, *associations*, *rules*, and *facts*. In very simple terms,

- **Logical theory**: A *logical theory* is a set of models that are consistent with and permissible per that logical theory.
- **Model**: A *model*[27] is a set of structures that are consistent with and permissible interpretations of that model.
- **Structure**: A *structure* is a set of logical statements which describe the structure.
- **Logical statement**: A *logical statement* is a proposition, claim, assertion, belief, idea, or fact about or related to the area of knowledge to which the logical theory relates. There are four broad categories of logical statements:
  - **Terms**: *Terms* are logical statements that define ideas used by the logical theory such as "assets", "liabilities", "equity", and "balance sheet".

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[26] Wikipedia, *Conceptual Model*, https://en.wikipedia.org/wiki/Conceptual_model

[27] Wikipedia, *Model Theory*, https://en.wikipedia.org/wiki/Model_theory

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- **Associations**: *Associations* are logical statements that describe permissible interrelationships between the terms such as "assets is part-of the balance sheet" or "operating expenses is a type-of expense" or "assets = liabilities + equity" or "an asset is a 'debit' and is 'as of' a specific point in time and is always a monetary numeric value".
- **Rules**: *Rules* are logical statements that describe what tend to be IF…THEN…ELSE types of relationships such as "IF the economic entity is a not-for-profit THEN net assets = assets - liabilities; ELSE assets = liabilities + equity".
- **Facts**: *Facts* are logical statements about the numbers and words that are provided by an economic entity within a business report. For example, the financial report, a type of business report, might state "assets for the consolidated legal entity Microsoft as of June 20, 2017 was $241,086,000,000 expressed in US dollars and rounded to the nearest millions of dollars.

Fundamentally, a logical theory is a set of logical statements. Those logical statements can be represented in human-readable form or they could be expressed in machine-readable form. Once in machine-readable form, those logical statements can be interrogated using software applications. To the extent that this can be done effectively; software tools can assist professional accountants, financial analysts, and others working with those logical statements.

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

A logical theory can have high to low **precision** and high to low **coverage** with respect to describing a logical system.

Precision is a measure of how precisely the information within a logical theory has been represented as contrast to reality of the logical system for the area of knowledge. *Coverage* is a measure of how completely information in a logical theory has been represented relative to the reality of the logical system for the area of knowledge.

When a logical system is consistent and it has high precision and high coverage the logical system can be considered a **properly functioning**

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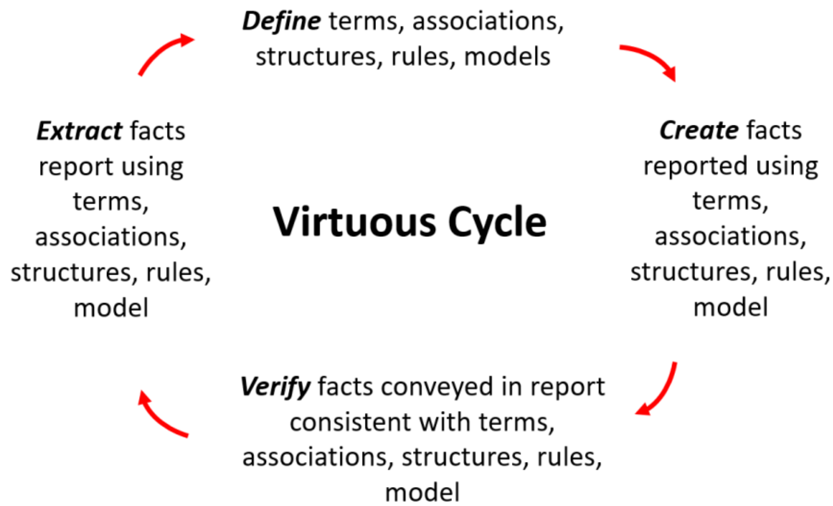
logical system. When a system is working right, it creates a virtuous cycle[28].



A logical theory conveys knowledge and that knowledge can be represented within a knowledge graph. For more detailed information related to logical theories and logical systems, please see *Logical Systems*[29].

2.5. Logical Theory Describing Business Report

The business report metamodel is simply a logical system that is based on a standard logical conceptualization of a business report, the *Standard Business Report Model* (SBRM)[30]. A financial report model is a type of business report model.

The following is an overview of the business report metamodel explained in simple terms.

[28] Charles Hoffman, CPA, *Virtuous Cycle*, http://xbrl.squarespace.com/journal/2020/4/29/virtuous-cycle.html

[29] Charles Hoffman, CPA, *Logical Systems*, http://www.xbrlsite.com/mastering/Part02_Chapter05.A_LogicalSystems.pdf

[30] OMG, *Standard Business Report Model* (SBRM), https://www.omg.org/intro/SBRM.pdf

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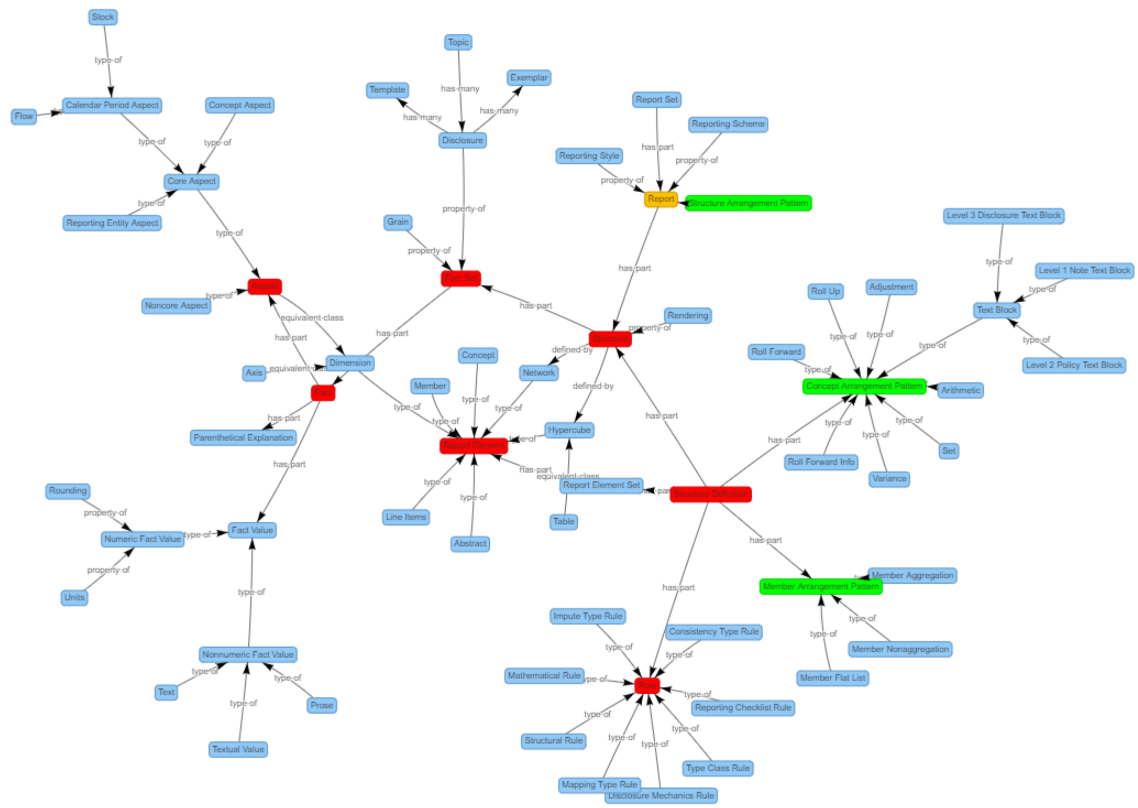

For a more detailed explanation of the *Standard Business Report Model* (SBRM), please see the *Narrative Explaining the Logical Conceptualization of a Business Report*[31].

2.6. *Logical Theory Describing Financial Report*

The financial report metamodel is simply a standard business report model that is further constrained to provide additional artifacts exclusive to financial reports and additional constraints and restrictions. Remember, all financial reports fit into one financial report metamodel that is described by the *Logical Theory Describing Financial Report*[32].

Additional artifacts that are added to the SBRM to meet the needs of a a financial report include:

- Topics
- Disclosures

31 *Narrative Explaining Logical Conceptualization of a Business Report*, http://accounting.auditchain.finance/sbrm/SBRM-Narrative.pdf

32 Charles Hoffman, CPA, et al, *Logical Theory Describing Financial Report*, http://accounting.auditchain.finance/framework/LogicalTheoryDescribingFinancialReport.pdf

- Fundamental accounting concepts
- Reporting styles
- Specific type-subtype associations
- Specific consistency rules
- Specific derivation rules
- Templates
- Exemplars

Financial report models can be made unique for each financial reporting scheme including US GAAP and IFRS[33]. A complete inventory of the logical objects that might exist in a financial report is provided by the PROOF representation[34].

2.7. Logical Schema

A financial report knowledge graph can be explained by a logical schema[35]. That logical schema is a data model or structure of a specific area of knowledge expressed independently of a particular database implementation or product. The logical schema constrains and restricts the logical model.

2.8. Very Simple Example of Financial Report Model

We will provide a very basic example of a financial report model to strengthen your understanding of financial report models.

A very simple example of a financial report model is the **accounting equation**. Here is a description of the accounting equation financial report model in both human-readable terms and machine-readable terms using XBRL[36]:

Terms: Three simple terms are defined: Assets, Liabilities, Equity. One complex term is defined, Balance Sheet.

Structure: One structure is defined, the Balance Sheet, and identified using the term Balance Sheet.

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[33] Financial Reporting Schemes, http://accounting.auditchain.finance/reporting-scheme/index.html

[34] PROOF representation, http://accounting.auditchain.finance/reporting-scheme/proof/documentation/Index.html

[35] Wikipedia, *Logical Schema*, https://en.wikipedia.org/wiki/Logical_schema

[36] Charles Hoffman, *Accounting Equation*, http://xbrlsite.azurewebsites.net/2020/master/ae/

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Associations: The three terms Assets, Liabilities, and Equity are associated in that they are all PART-OF the structure balance sheet.

Rules: A mathematical assertion is made that "Assets = Liabilities + Equity".

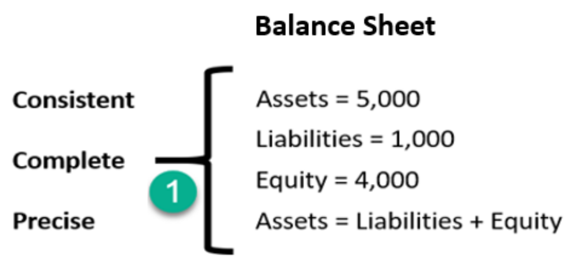
Facts: Instances of three facts are established to exercise the model: Assets of $5,000; Liabilities of $1,000; Equity of $4,000.

Model: All of the terms, associations, rules, structures, and facts describe the model. We created only one model, or permissible interpretation, of the financial report model.

(As accountants know, if you reverse the equation using the rules of math to "Equity = Assets - Liabilities" and change the term "Equity" to "Net Assets"; then you get another permissible interpretation or model. But we are not using that permissible version of the accounting equation within this financial report model.)

Because this is a very simple example with only a few logical statements it is easy to get your head around this specific financial report model and see that it is consistent, complete, and precise. As expected, you see three facts described by three terms which are related to one structure and the one rule is consistent with expectation:

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



Result	Rule
Pass	$Assets = $Liabilities + $Equity

As the size of the financial report model increases it becomes increasingly more challenging to verify that the logical system is properly functioning using manual processes. We will discuss the types of things that can go wrong with a system in a later section. Essentially, the models, terms, structures, rules, and facts form a labeled directed acyclic graph or knowledge graph such as this simplified knowledge graph which describes the system we are discussing:

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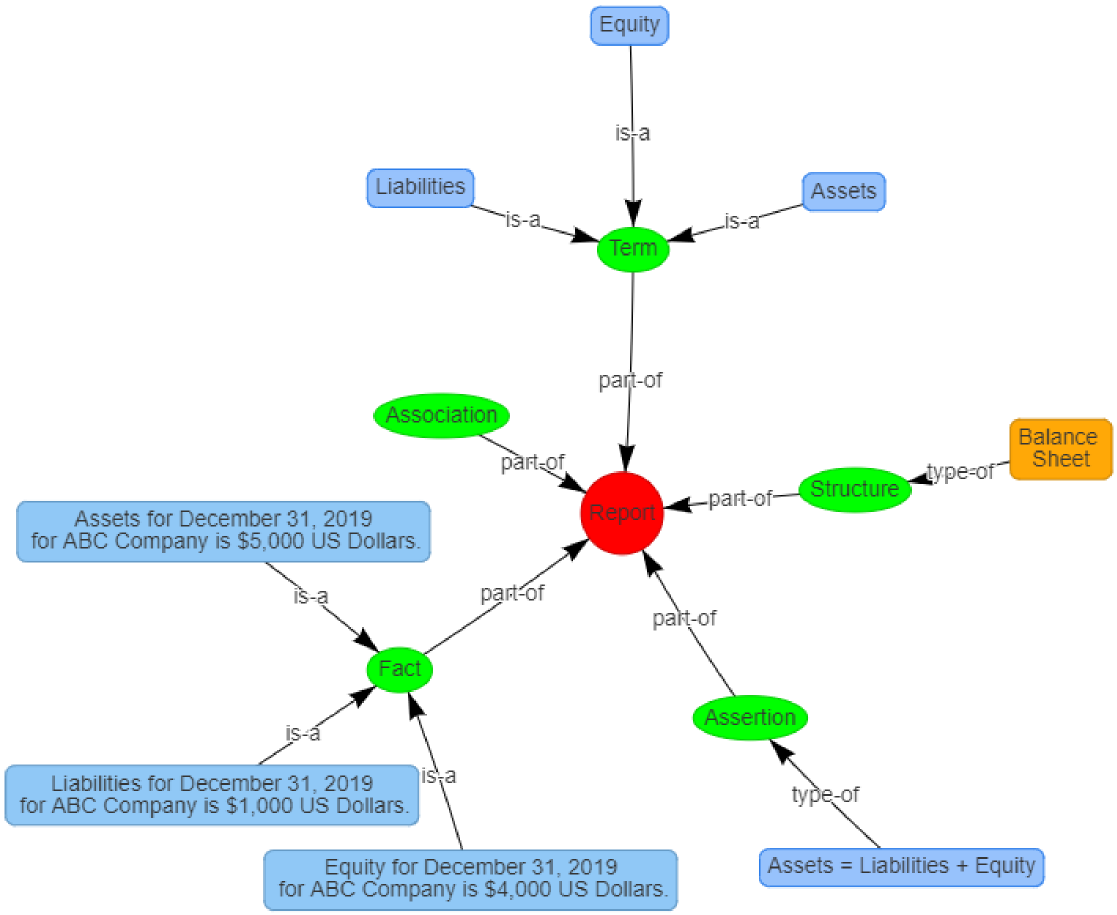

Hopefully you get the general idea from this simplified wireframe representation of our logical system as a knowledge graph.

While a typical financial report is significantly larger (i.e. the Microsoft 2017 10-K[37] is made up of 194 structures; 2,035 facts; 3,296 associations; etc.) every financial report works the same as this very simple example but just has more pieces.

2.9. Financial Report Logical Conceptualization in Simple Terms

The logical conceptualization of a financial report builds on top of the logical conceptualization of the more general business report. The financial report logical conceptualization takes the general business report logical conceptualization as it's base and adds additional artifacts, constraints, and restrictions related only to financial reporting. For

[37] Microsoft XBRL-based Report Analysis, http://xbrl.squarespace.com/journal/2020/4/13/microsoft-xbrl-based-report-analysis.html

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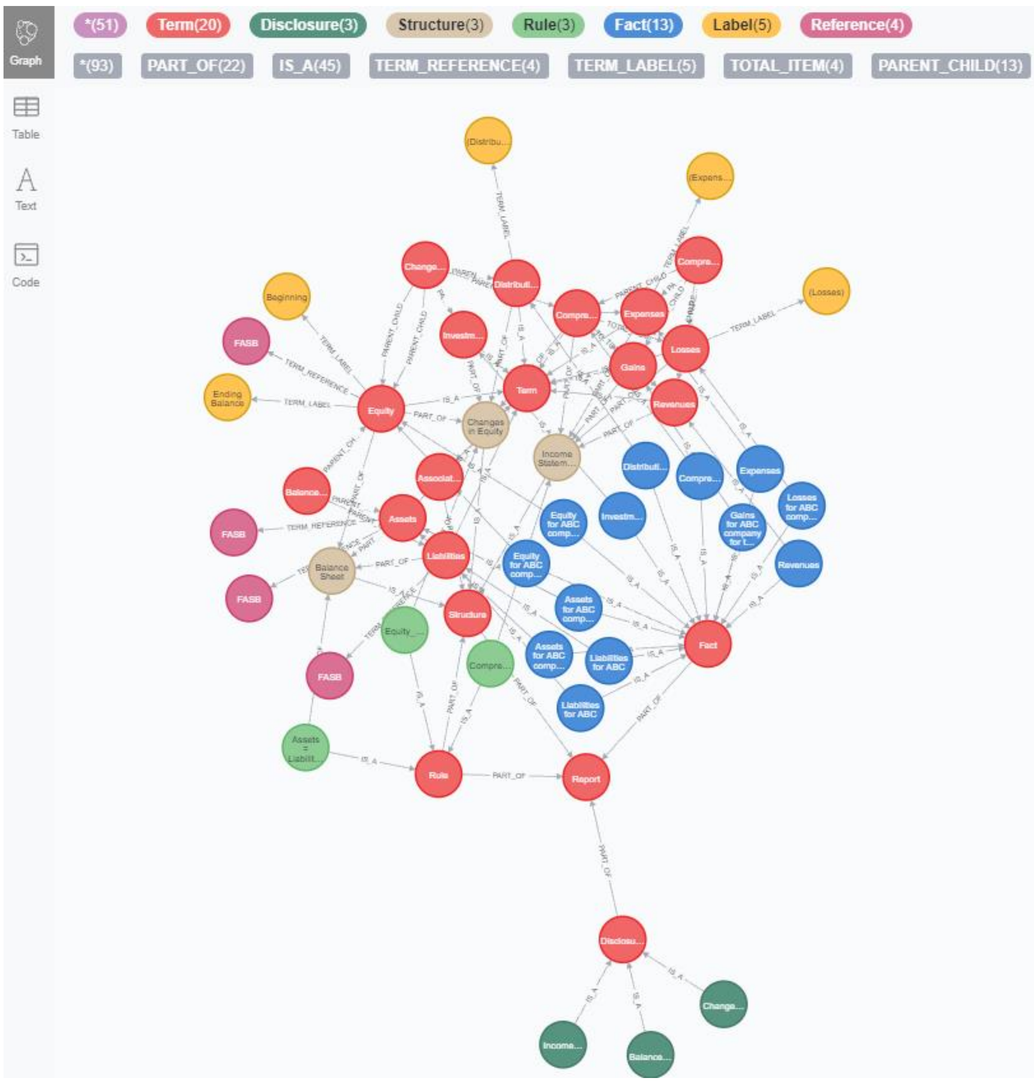
example, financial reports are constrained by the double-entry accounting model, the accounting equation, and other characteristics of financial reporting.

If you want more information about the financial report logical system at this point, I would encourage you two watch the YouTube.com video playlist *Understanding the Financial Report Logical System*[38].

2.10. Visualizing the Financial Report Knowledge Graph

When you work with a financial report knowledge graph in a general-purpose tool for working with any knowledge graph from any area of knowledge, what you see might look something like the following:



38 YouTube.com, Charles Hoffman, CPA, *Understanding the Financial Report Logical System*, https://www.youtube.com/playlist?list=PLqMZRUzQ64B7EWamzDP-WaYbS_W0RL9nt

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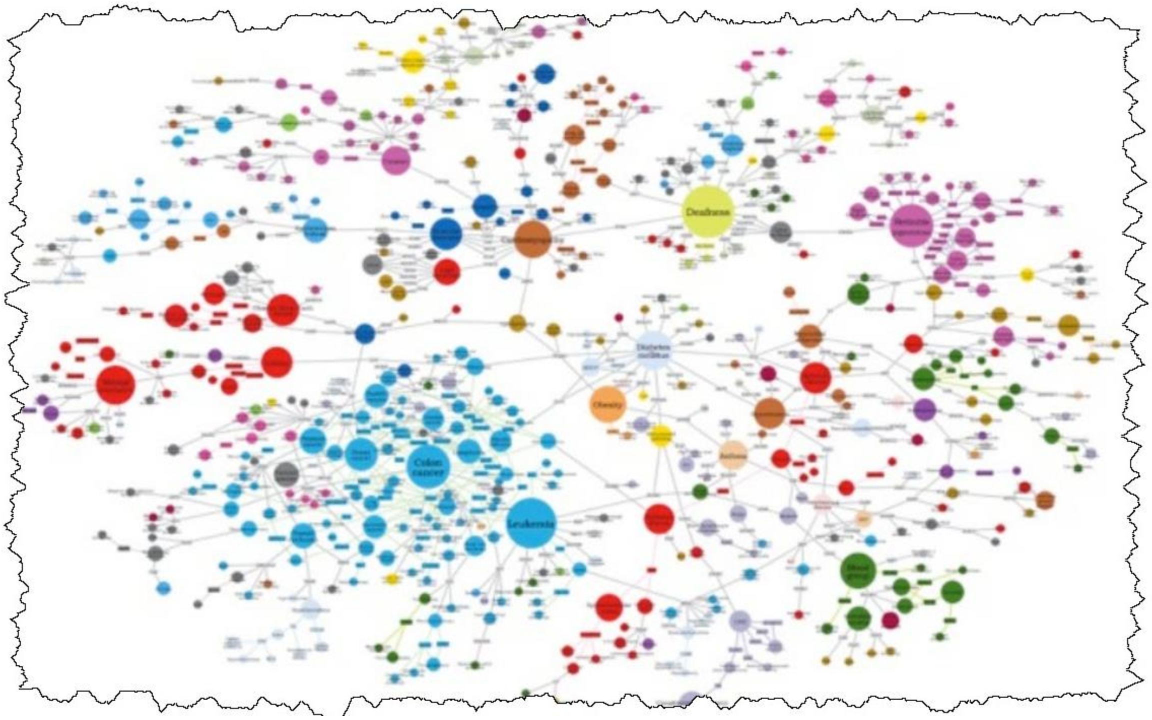
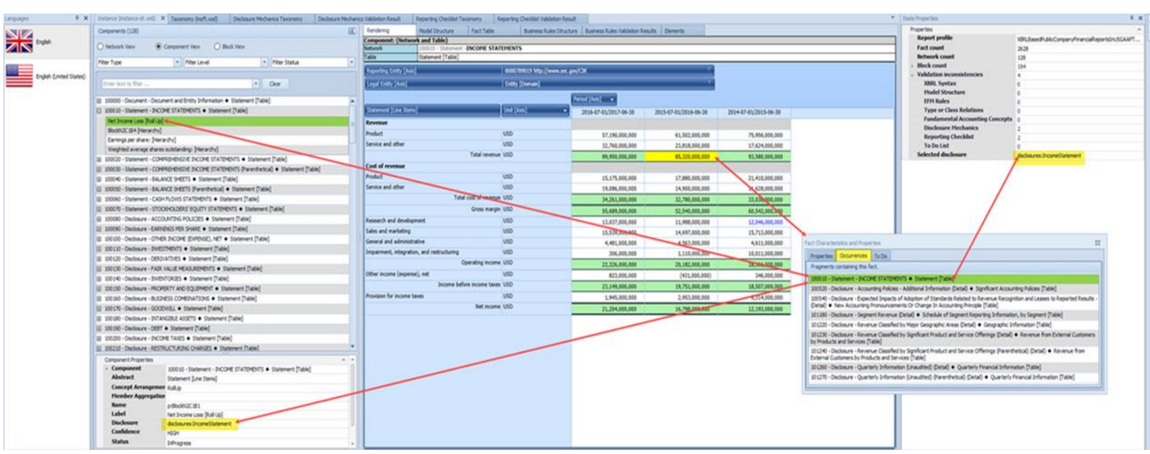
Above you see the knowledge graph of a smaller prototype financial report as seen within Neo4j which is a graph database.

A more comprehensive financial report might look as follows:



If you look at the same knowledge graph of information about a financial report in a special-purpose tool for working with such financial report knowledge graphs, it might look something like this[39]:



[39] *Pesseract*, http://xbrlsite.azurewebsites.net/2021/library/KnowledgeGraph_Pesseract.jpg

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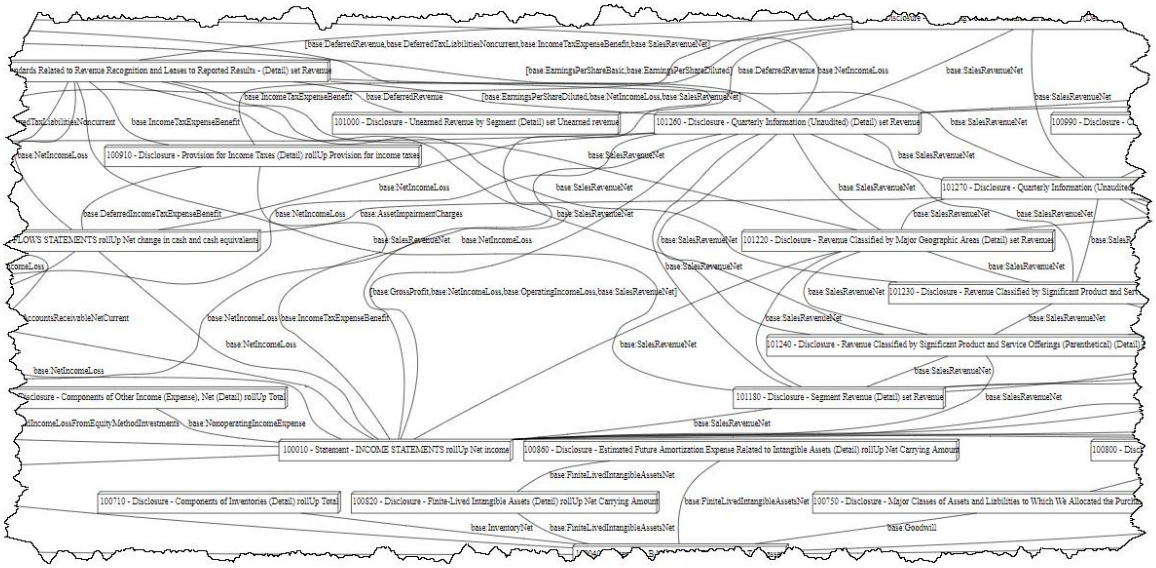
A specialized tool such as Pacioli[40] understands all those edges and vertices within the knowledge graph and the labeled directed acyclic graphs that are represented and can use this information to dynamically work with the financial report logical model. Here is an example of how Pacioli sees a financial report knowledge graph[41]:



If you have the right tools, you can view a comprehensive knowledge graph of the Microsoft 10-K for 2017[42] for which a significant amount of information has been represented for the financial report knowledge graph.

This raises an important point that every financial report knowledge graph must be represented in some physical form, some technical format.

This knowledge graph was represented using the global standard XBRL technical syntax. That standard XBRL technical syntax was simply converted to the PROLOG format which is how Pacioli is implemented and processes the financial report knowledge graph.

[40] *Pacioli Power User Tool*, http://xbrl.squarespace.com/journal/2021/6/29/pacioli-power-user-tool.html

[41] Pacioli report from a financial report knowledge graph, http://accounting.auditchain.finance/demonstrations/msft/blocksGraph.html

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

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2.11. XBRL-based Digital Financial Reports

XBRL is a global standard technical syntax that is used in over 60 countries for representing financial reports. Teaching you to use XBRL is not in the scope of this resource because good software applications will completely abstract the XBRL technical syntax away from professional accountants.

But, if you do want to understand more details about XBRL, there are four helpful resources which you might find helpful:

- *Very Basic XBRL Technical Primmer*[43]: Provides basic information that helps you get started with the XBRL technical syntax.
- *Essentials of XBRL-based Digital Financial Reporting*[44]: Provides essential ideas that you should keep in mind as you are working with XBRL-based digital financial reports.
- *The XBRL Book: Simple, Precise, Technical*[45]: Comprehensive technically oriented guide to XBRL.
- *XBRL Specification*[46]: The definitive guide to the XBRL technical syntax specification.

As you can see, the XBRL technical format was supplemented by other logical artifacts to enhance functionality. To enhance the reliability, trust, and provenance of information reported using the XBRL format we leverage digital distributed ledgers provided by a blockchain.

2.12. Financial Report Levels

To clearly and precisely understand XBRL-based digital financial reporting, it helps to think of the spectrum of financial reports in terms of levels similar to how levels are helpful in understanding the capabilities of self-driving cars[47].

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43 Charles Hoffman, CPA, *Very Basic XBRL Technical Primer*, http://www.xbrlsite.com/mastering/Part00_Chapter01.B_XBRLPrimer.pdf

44 Charles Hoffman, CPA, Essentials of XBRL-based Digital Financial Reporting, http://xbrlsite.azurewebsites.net/2021/essentials/EssentialsOfXBRLBasedDigitalFinancialReporting.pdf

45 Ghislain Fourny, *The XBRL Book: Simple, Precise, Technical*, https://www.amazon.com/XBRL-Book-Simple-precise-technical/dp/B08RQZJ6VK

46 XBRL International, *XBRL 2.1 Specification*, https://specifications.xbrl.org/work-product-index-group-base-spec-base-spec.html

47 Truecar, The 5 Levels of Autonomous Vehicles, https://www.truecar.com/blog/5-levels-autonomous-vehicles/

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The term "self-driving" means different things to different people so it makes it difficult to have a precise conversation about that topic. But breaking the description into a spectrum of descriptions is very helpful to the communication process.

This is similarly true for the levels of an XBRL-based digital financial report. Below we will break down a financial report into helpful levels[48] that will enable a precise and clear discussion. We will provide a very brief description, a little bit of information, and a link to specific examples that instantiate a report per each specific level.

The marginal difference between each level is very helpful in providing the reader with a solid understanding of the different levels.

Here is an overview of the levels related to financial reporting as I see them beginning with the least functional in terms of both human and machine use of the information from with a financial report.

- **Level 0**: Not machine readable. *An example of Level 0 is a clay tablet, papyrus, or paper as the report medium*.
- **Level 1**[49]: Machine readable, nonstandard, structured for presentation. *PDF, HTML, or XHTML are examples of Level 1*.
- **Level 2**[50]: Machine readable, nonstandard, structured for meaning, no taxonomy (a.k.a. dictionary), no rules, no report model. *An XBRL-based report without an XBRL taxonomy schema, without XBRL relations and resources, and without XBRL Formulas is an example of Level 2*.
- **Level 3**[51]: Machine readable, global standard syntax, structured for meaning, with taxonomy (a.k.a. dictionary), incomplete rules, incomplete high-level report model. *An XBRL-based report with a XBRL taxonomy schema, with XBRL relations and resources, but without XBRL Formulas is an example of Level 3.*
- **Level 4**[52]: Machine readable, global standard syntax, structured for meaning, with taxonomy (a.k.a. dictionary), complete set of

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48 Financial Report Levels, http://xbrl.squarespace.com/journal/2021/4/5/financial-report-levels.html

49 Level 1 financial report example, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/proof/reference-level1/

50 Level 2 financial report example, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/proof/reference-level2/

51 Level 3 financial report example, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/proof/reference-level3/

52 Level 4 financial report example, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/proof/reference-level4/

rules provided, incomplete high-level report model. *An XBRL-based report with a XBRL taxonomy schema, with XBRL relations and resources, and with XBRL Formulas that completely describes the report is an example of Level 4*.

- **Level 5**[53]: Machine readable, global standard syntax, structured for meaning, with taxonomy (a.k.a. dictionary), complete set of rules provided, complete global standard high-level report model, yields PROVEN properly functioning system and UNDERSTANDABLE report information. *An XBRL-based report with all the characteristics of Level 4, plus consistency cross checks, type-subtype relations, consistent modeling of XBRL presentation relations, information that describes the correct representation of every disclosure within the report, and a reporting checklist that describes all required disclosures is an example of Level 5*.
- **Level 6**: All of Level 5 PLUS blockchain-anchored XBRL to increase trust. *An XBRL-based report with all the characteristics of Level 5, plus information within a digital distributed ledger that assures no one has tampered with the report is an example of Level 6*.
- **Level 7**: All of Level 6 PLUS blockchain-anchored accounting transactions and events. *An XBRL-based report with all the characteristics of Level 6, plus information that indicates that assures no one has tampered with transactions is an example of Level 7*.

There is something very important to note here. The set of logical statements that is used to specify/describe how a report should be created (say by a regulator or standards setter), used to actually create a report (say an accountant), verify that the report was created consistently to the specification/description (say an accountant or software application used by an accountant), independently confirm that the report was created consistently with the specification/description (say by an independent auditor), or extract information from the created report (say by a financial analyst or regulator) are all the same set of logical statements.

[53] Level 5 financial report example, http://xbrlsite.azurewebsites.net/2021/reporting-scheme/proof/reference-level5/

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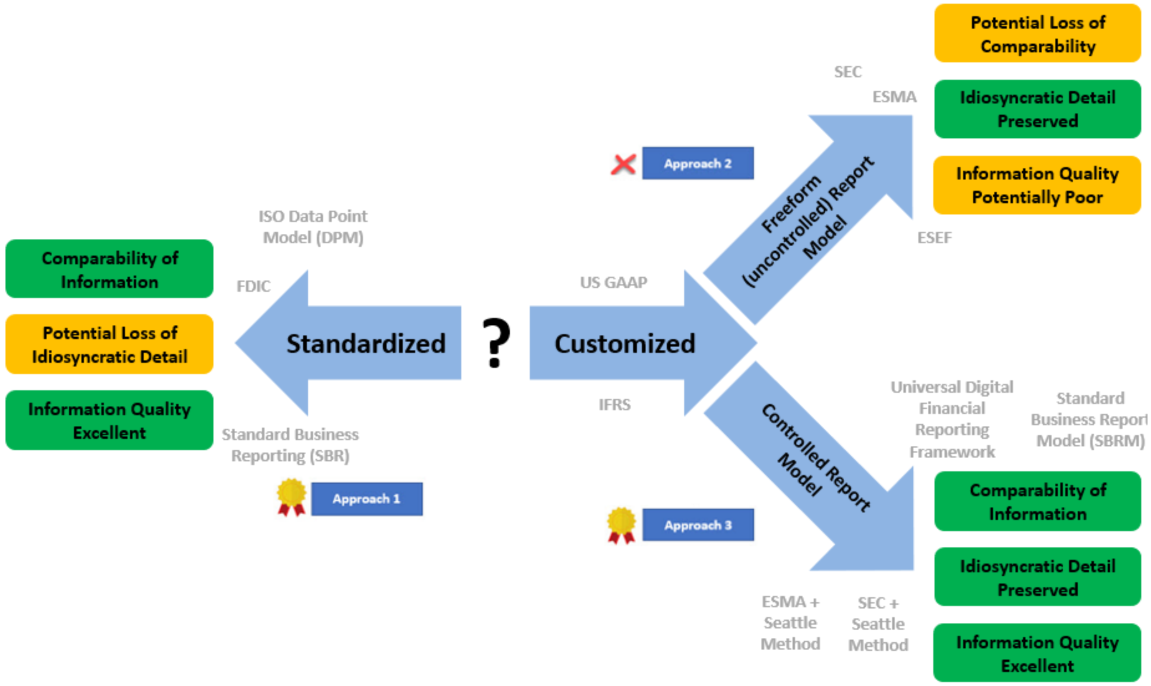
2.13. Reporting Approaches

The paper *Critical Reflection on XBRL: A "Customisable Standard" for Financial Reporting?*[54], breaks reporting into two approaches: standardized reporting and customized reporting. I modified this breakdown slightly breaking customized reporting into two distinct approaches, "freeform customization" and "controlled customization". I then reflected the three approaches in the following graphic inspired by the graphic in the referenced paper[55]:



This yields three distinct modeling approaches:

- **Standard form model**: No modifications are allowed to the report model.
- **Freeform, Uncontrolled model**: Modifications are permitted to report model, but those modifications are not controlled in any way. As such there is no differentiation between permitted and unpermitted modifications to the model.
- **Controlled model**: Modifications are permitted to report model and a mechanism is provided to control report model

[54] Reporting Approaches + XBRL Approaches + Implementation Approaches, http://xbrl.squarespace.com/journal/2021/12/30/reporting-approaches-xbrl-approaches-implementation-approach.html

[55] Taxonomy creation approaches, http://xbrlsite.azurewebsites.net/2022/library/TaxonomyApproachesSeattleMethod.jpg

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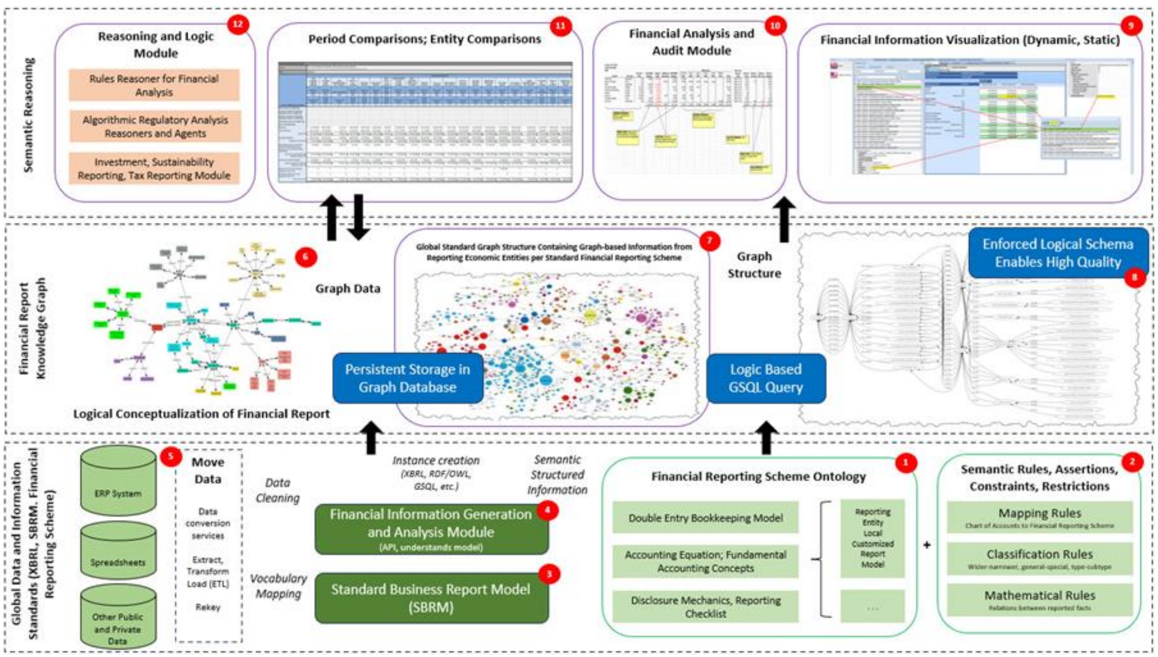
modifications; permitted and unpermitted report model modifications are clearly delineated and control mechanisms keep report model modification within permitted boundaries.

Effectively, uncontrolled customization of report models simply will not work.

2.14. Knowledge Graph System

As best as I can understand it and describe it, what will exist in the future is a knowledge graph system[56] for financial reporting. This is a graphic of the components of the big picture as I see it, a knowledge graph system for financial reporting[57]:



Such a knowledge graph system is made up of knowledge assemblies.

2.15. Knowledge Assembly

A knowledge assembly[58] is a set of knowledge graphs. A knowledge graph is a machine-readable structured representation of knowledge

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56 *Knowledge Graph System*, https://digitalfinancialreporting.blogspot.com/2023/07/knowledge-graph-system.html

57 *Knowledge Graph System for Financial Reporting*, https://digitalfinancialreporting.blogspot.com/2023/07/knowledge-graph-system-for-financial.html

58 *Knowledge Assembly*, https://digitalfinancialreporting.blogspot.com/2023/08/knowledge-assembly.html

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(semantics) related to a particular area of interest. So, a knowledge assembly is a machine-readable network of things and relations between things. The things and relations are classified or grouped in helpful/useful ways. Semantics is the science of giving meaning to data. Knowledge assemblies are about semantics which is data in context, a.k.a. information. Knowledge = ontology (things and relations between things) + rules (assertions, restrictions, constraints). A knowledge assembly can be explained using a logical theory or logical schema that verifies/validates the knowledge assembly. Knowledge assembly terminology is grounded in the more approachable and innately understandable terminology of logic and philosophy, not the technical jargon/terminology of computer science.

2.16. Global Standard Knowledge Assembly

My PROOF[59] (and my other examples[60]) provides examples of a global standard XBRL-based knowledge assembly[61] of a financial reporting scheme, a financial report model created by a reporting economic entity using that financial reporting scheme, and a financial report using that financial report model that is based on the financial reporting scheme. That entire knowledge assembly is validated using a rules engine that is specialized for this specific type of knowledge assembly to verify that the report and report model are complete, consistent, and precise. This mechanism is described by the Seattle Method.

That knowledge assembly contains data and meta data related to financial accounting and financial reporting. The physical syntax of the entire knowledge assembly is global standard XBRL. The XBRL technical syntax is used to define logical terms, structures, associations, assertions, restrictions, constraints, and facts.

The logical model of a financial report is part of that assembly. Key portions of the conceptual framework of a financial reporting scheme is a part of the knowledge assembly. The different reporting styles permitted by that financial reporting scheme is part of the knowledge assembly. Wider-narrower (a.k.a. type-subtype or general-special)

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[59] *PROOF Financial Reporting Scheme* (Prototype), http://www.xbrlsite.com/seattlemethod/platinum/proof/base-taxonomy/proof_ModelStructure.html

[60] *PLATINUM XBRL-based Financial Report Examples*, https://digitalfinancialreporting.blogspot.com/2023/07/platinum-xbrl-based-financial-report.html

[61] *Global Standard Knowledge Assembly*, https://digitalfinancialreporting.blogspot.com/2023/08/global-standard-knowledge-assembly.html

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relations are part of the knowledge assembly. Fundamental accounting relations that are universal to a specific reporting style is part of the knowledge assembly. How to compute financial ratios used to analyze financial information reported per that financial reporting scheme are part of the knowledge assembly. Rules are declarative in nature.

2.17. Best Practices

A **best practice** (a.k.a. good practices) based method that I am calling the *Seattle Method*[62] was created in order to effectively create XBRL-based financial reports that are provably properly functioning logical systems.

Using this method, enterprises can reliably and effectively stream a high-quality machine-readable XBRL-based global standard knowledge graph of a complete, consistent, and provably correct general purpose financial statement. Further, an entire record-to-report process can be automated effectively. This method provides both the flexibility and the control necessary to effectively hit this target within an enterprise.

The target of this method is Level 5 and above. Below Level 5 the functionality what we generally need from such reports in terms of quality and effective use of reported information in automated machine-based processes is not good enough. It is possible to create a Level 4 XBRL-based report that is properly functioning. Level 5 provides a guarantee that the Level 4 financial report is properly functioning within a provides specification articulated with a complete set of rules. Level 5 measures quality whereas Level 4 quality is essentially based on what amounts to luck or hope which are not effective engineering techniques.

2.18. Modern Accounting

As explained in *Computational Professional Services*[63], unprecedented human-machine collaboration will be made possible using knowledge graphs.

Humans are very capable of carrying out financial accounting, reporting, auditing, and analysis steps and performing tasks. Leveraging knowledge graphs, mechanical devices can also be created to carry out such steps and perform tasks. For example, a vending machine is such a device. A calculator is also such a device. Computers via the software

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

[63] Charles Hoffman, CPA, Computational Professional Services, http://accounting.auditchain.finance/library/ComputationalProfessionalServices.pdf

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programs they run can likewise carry out steps and perform tasks. Machines will augment humans enabling humans to do what they do best and machines to assist in the steps and tasks that they do best. Entire record-to-report processes can be controlled and therefore automated[64].

Algorithmic Business Thinking[65] will help professional accountants think about the steps and tasks they perform in new ways.

Accounting processes will be modernized for the information age[66].

2.19. Expert System for Creating Financial Reports

One of the uses of a financial report knowledge graph is to create an expert system for constructing financial reports[67]. A logic/rules/reasoning/knowledge/insights engine[68] is used to enforce the logical schema[69] of the financial report knowledge graph.

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64 *Effective Automation of Record to Report Process (Iteration #4)*, http://xbrl.squarespace.com/journal/2021/1/25/effective-automation-of-record-to-report-process-iteration-4.html

65 *Algorithmic Business Thinking*, http://xbrl.squarespace.com/journal/2021/9/22/algorithmic-business-thinking.html

66 *Modernizing Accounting for Dummies*, http://xbrl.squarespace.com/journal/2021/9/22/modernizing-accounting-for-dummies.html

67 *Expert System for Creating Financial Reports Explained in Simple Terms*, http://xbrlsite.azurewebsites.net/2022/Library/ExpertSystemForCreatingFinancialReports.pdf

68 *Pacioli: an XBRL Knowledge Engine*, http://xbrl.squarespace.com/journal/2022/2/19/pacioli-an-xbrl-knowledge-engine.html

69 *Logical Schema of Financial Reports*, http://xbrlsite.com/seattlemethod/LogicalSchemaOfFinancialReports.pdf