

# Understanding Logical Systems for Accountants, Auditors, and Analysts

*Important information about how to think about structured information like XBRL, artificial intelligence, digital ledgers and their impact on accounting, reporting, auditing, and analysis in order to thrive in the information age*

By Charles Hoffman, CPA (October 25, 2023) (Work in Progress)

As explained in *The Great Transmutation*<sup>1</sup>, a transformation is taking place in the areas of knowledge related to financial accounting, reporting, auditing, and analysis. This change is significant and other areas of knowledge are also being impacted.

To best understand this change, one needs to modify their perspective. To modify one's perspective it is important to understand what a logical system is and how logical systems work.

Financial accounting and reporting are not natural, meaning it would not exist in nature unless it was created. Financial accounting and reporting were created by humans to serve a need. During the industrial era which we are leaving, tasks and processes were performed first using tools such as paper ledgers and many humans manually moving information. Those paper-based processes gave way to computer-based processes to a large degree and the number of humans needed to operate those systems was reduced.

Another significant change is underway which will lead to even more automation. And this automation will be a good thing because the current volume of information, the complexity of that information, and the pace that information moves is overwhelming current approaches to financial accounting, reporting, auditing, and analysis.

What is enabling this transformation to occur now is the information technology which has been created beginning around the 1950s and has been improving ever since, the global network provided by the internet that is inexpensive and available to all, and the following three technologies which are maturing and are being perfected which are:

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<sup>1</sup> Charles Hoffman, CPA, *The Great Transmutation*,  
<http://xbrlsite.azurewebsites.net/2022/Library/TheGreatTransmutation.pdf>

- **Structured machine-readable information** such as XBRL, RDF+OWL+SHACL and the other semantic web technologies, graph databases, PROLOG, and relational database systems which can all be thought of as ways to represent “graphs of knowledge” (a.k.a. knowledge graphs);
- **Artificial intelligence** technologies including deductive reasoning, inductive reasoning, and abductive reasoning;
- **Immutable digital distributed ledgers** that allow for the creation and effective operation of what amounts to public databases.

To appreciate and properly and precisely understand what changes will occur how to respond to these changes it is best if one understands accurately what a logical system is and how logical systems work.

Further, this transition is a natural step, the next step, in the long evolution of financial accounting and reporting that has already spanned 7000 years and will undoubtedly be important for the coming 7000 years in some, perhaps different, form.

Financial accounting and reporting are a **universal technology of accountability**<sup>2</sup>. This universal technology of accountability is grounded, even ingrained, in medieval traditions. Yet this universal technology of accountability is going to be impacted by structured information, artificial intelligence, immutable digital distributed ledgers, and other such technologies. And they should be. Those same technologies that are causing the ever-increasing volume and complexity of information at an ever-increasing pace that is overwhelming accountants, auditors, and analysts is also the solution to that “information overload” that you are experiencing.

Working with the logical system of financial accounting and the tasks and processes within that logical system can change, and inevitably will change. We are no longer where we were...but we have not yet arrived where will eventually end up. The change process will be messy.

Sensemaking

Understanding what a logical system is and how they work will help financial accountants, auditors, and analysis navigate effectively through these turbulent waters.

## Logical Systems

This section provides a comprehensive introduction to the notion of a logical system, explains what a logical system is, the building blocks of logical systems, and other information that helps you create a framework for understanding the change that is occurring.

To begin, let’s look at the two words: logic and system.

### Logic

Logic is a set of principles that form a framework for correct reasoning. Logic is a process of deducing information correctly. Logic is a formal communications tool. Logic is used to represent meaning which is referred to as semantics.

Logic allows you to reason over some knowledge representation. Logic allows you to create a chain of reasoning, to interact with that knowledge representation.

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<sup>2</sup> *Universal Technology of Accountability*, <https://digitalfinancialreporting.blogspot.com/2023/02/universal-technology-for-accountability.html>

There are three general types of reasoning: deductive reasoning, inductive reasoning, and abductive reasoning. There tend to be three reasoning chaining strategies: sequential, forward chaining, backward chaining.

In the past, virtually 100% of the reasoning performed by accountants, auditors, and analysts was performed by those humans using their minds. Beginning with tools such as the mechanical calculator and the accounting machine<sup>3</sup>; such tools have augmented our ability to process logic.



Other tools such as the computer, computerized accounting system, and the electronic spreadsheet augmented the skills of accountants, auditors, and analysts; allowing them to perform these tasks and processes better, faster and cheaper.

New tools are being developed now and will continue to be developed that augment more of the ability of bookkeepers, accountants, auditors, and analysts and augment their capabilities to do their work. Fundamentally what these tools do is process logic. All this "stuff" can be organized into a system.

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<sup>3</sup> Wikipedia, *Accounting Machine*, [https://en.wikipedia.org/wiki/Accounting\\_machine](https://en.wikipedia.org/wiki/Accounting_machine)

## System

A system<sup>4</sup> (a.k.a. formal system<sup>5</sup>) is a cohesive conglomeration of interrelated and interdependent parts that is either natural or human-made. There are natural systems that exist in nature. Or, a system can be created by humans. A logical system is a type of system.

Systems thinking<sup>6</sup> is a discipline for seeing wholes. Systems thinking is a framework for seeing interrelationships and dependencies rather than just “things”. Systems thinking helps the thinker see patterns of change rather than static snapshots.

A system enables a community of stakeholders (i.e. have a stake in that system) trying to achieve some goal or objective or range of goals/objectives to realize those goals/objectives using that system.

A logical theory or logical conceptualization can be used to describe and agree on important logical details related to the shared understanding for some area of knowledge in order to implement a logical system that works effectively for the purposes desired from that system.

A logical theory is used to explain (provides a logical conceptualization for) and test a logical system. There are many approaches to representing logical systems in machine-readable form, a logical theory being the most powerful. A logical theory describes logical patterns. A logical theory provides a logical schema for the logical system.

## Area of Knowledge

An **area of knowledge** is a highly organized socially constructed aggregation of shared knowledge for a distinct subject matter. An area of knowledge has a specialized insider vocabulary, underlying assumptions (axioms, theorems, constraints), and persistent open questions that have not necessarily been resolved (i.e. flexibility is necessary).

Accounting is an area of knowledge. You can explain aspects of the accounting area of knowledge, such as the nature of a financial report, using a logical theory which explains a logical model. A logical theory can be tested and proven by providing a proof.

Knowledge can be represented in human-readable form, in machine-readable form, or in a machine-readable form that can be effectively converted into human-readable form.

You can think about an area of knowledge as being characterized in a spectrum with two extremes:

- **Kind area of knowledge:** clear rules, lots of patterns, lots of rules, repetitive patterns, and unchanging tasks.
- **Wicked area of knowledge:** obscure data, few or no rules, constant change, and abstract ideas.

An area of knowledge can have aspects of both extremes, but tends to lean toward one side of the spectrum or the other. Accounting tends to lean more toward the “kind” end.

Another term for area of knowledge is a knowledge domain or simply domain.

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<sup>4</sup> Graham Berrisford, *150 systems thinking terms*, <https://www.linkedin.com/pulse/systems-thinking-terms-concepts-graham-berrisford/>

<sup>5</sup> Wikipedia, *Formal System*, [https://en.wikipedia.org/wiki/Formal\\_system](https://en.wikipedia.org/wiki/Formal_system)

<sup>6</sup> *Systems Thinking*, <https://digitalfinancialreporting.blogspot.com/2023/09/systems-thinking.html>

## ***Knowledge Acquisition***

A key ingredient of a logical system is machine readable knowledge (logic) that the system makes use of. Some people refer to this knowledge as metadata. The power of a logical system is proportional to the high-quality metadata available within that system. What is not in dispute is the need for this "thick metadata layer" and the benefits of that metadata in terms of getting a logical system, such as a software application, to be able to perform useful and meaningful work for the user of that logical system.

But what is sometimes disputed is *how* to most effectively and efficiently get that thick metadata layer. There are two basic approaches to acquiring knowledge that makes up this thick metadata layer:

- **Have the computer figure out what the metadata is:** This approach uses artificial intelligence, machine learning, and other high-tech approaches to detecting patterns and figuring out the metadata. (pattern-based approach<sup>7</sup>; algorithms find patterns in data and infer rules on their own; uses inductive reasoning which is based on probability and can never be guaranteed to be right)
- **Tell the computer what the metadata is:** This approach leverages the skills and experience of human experts within an area of knowledge and knowledge engineers to piece together the metadata so that the metadata becomes available in the logical system. (rules-based expert systems approach)<sup>8</sup>: representing processes or systems using logical rules; systems are highly reliable because the system is based on reliable rules; uses deductive reasoning)

Because involving humans in the process of acquiring knowledge, knowledge acquisition can be slow and tedious, much of the future of computer systems depends on breaking the knowledge acquisition bottleneck and in codifying and representing a large knowledge infrastructure.

However, this is not an "either/or" question. Both manual and automated knowledge acquisition methods can be used together. Manually created knowledge representations are used to prime the pump; then machine learning can build on that foundation. Then humans and machines can work together to tune the machine-readable knowledge.

Both rule-based and machine learning knowledge acquisition approaches have pros and cons. Rules-based can mean certainty; however, creating the rules can be time consuming. Machine learning knowledge acquisition can be very efficient; but work best if the system you are using them to model has a high tolerance to error. Machine learning type of systems work best for:

- capturing associations or discovering regularities within a set of patterns;
- where the volume, number of variables or diversity of the data is very great;
- relationships between variables are vaguely understood; or,
- relationships are difficult to describe adequately with conventional approaches.

Machine learning basically uses probability and statistics; correlations<sup>9</sup>. This is not to say that machine learning is a bad thing. It is not, machine learning is a tool. Any craftsman knows

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<sup>7</sup> *Machine Learning*, <https://www.firmai.org/documents/Machine%20Learning%20Bird's-eye/>

<sup>8</sup> *Understanding Knowledge Based Systems*, <http://xbrl.squarespace.com/journal/2017/5/3/understanding-knowledge-based-systems.html>

<sup>9</sup> Kalev Leetaru, *Our Entire AI Revolution Is Built On A Correlation House Of Cards*, <https://www.forbes.com/sites/kalevleetaru/2019/04/20/our-entire-ai-revolution-is-built-on-a-correlation-house-of-cards/>

that you need to use the right tool for the job. Using the wrong tool will leave you unsatisfied<sup>10</sup>.

Hybrid systems that combine both approaches will very likely work the best; skilled and experienced humans working with powerful software, working as a team, will be more successful than humans and computers working independently<sup>11</sup>.

## **Orchestration**

Within a logical system, similar to how a conductor of an orchestra coordinates the music coming from a group of musicians, there is a need for orchestration. In fact, it is orchestration that turns a bunch of "stuff" into a coordinated, well-functioning logical system. Conscious orchestration maximizes system harmony and minimizes system dissonance. The conscious orchestration eliminates wild behavior of system stakeholders.

Rules prevent wild behavior. The Merriam-Webster dictionary defines anarchy<sup>12</sup> as "a situation of confusion and wild behavior in which the people in a country, group, organization, etc., are not controlled by rules or laws." Rules prevent information anarchy.

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

Technical syntax rules arise from the best practices of information technology professionals. Business domain semantic rules arise from the best practices of knowledgeable business professionals. A business rule is a rule that describes, defines, guides, controls, suggests, influences or otherwise constrains some aspect of knowledge or structure within some area of knowledge.

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

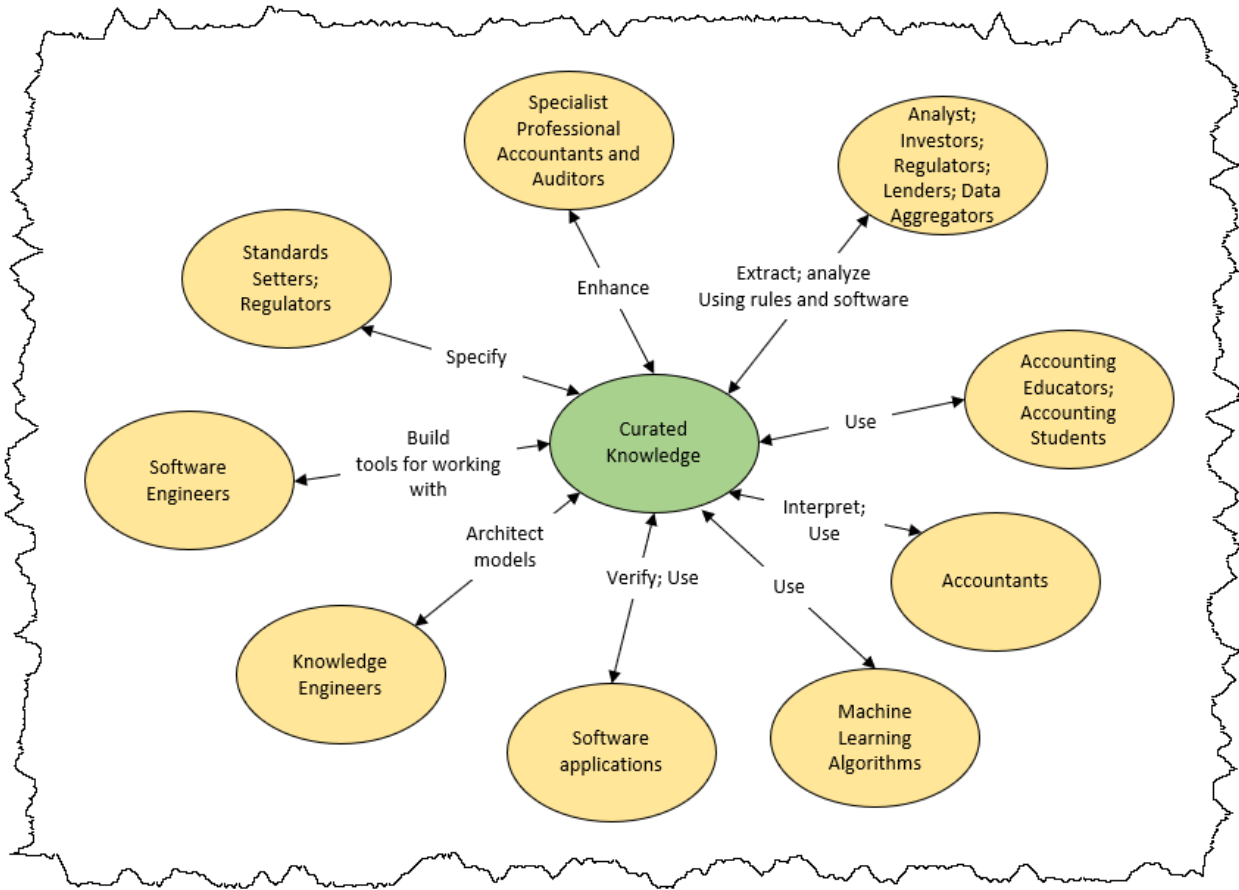
Rules provided in the form of machine-readable curated knowledge, often referred to as "metadata", provide the necessary orchestration for a logical system that serves a group of stakeholders in achieving their goals and objectives; maximizing harmony, minimizing dissonance within the logical system.

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<sup>10</sup> Gil Press, *This Week In AI Stats: Up To 50% Failure Rate In 25% Of Enterprises Deploying AI*, Forbes, <https://www.forbes.com/sites/gilpress/2019/07/19/this-week-in-ai-stats-up-to-50-failure-rate-in-25-of-enterprises-deploying-ai/>

<sup>11</sup> *AI + HI = Transformation*, <https://digitalfinancialreporting.blogspot.com/2023/04/ai-hi.html>

<sup>12</sup> Anarchy definition, Merriam-Webster, <http://www.merriam-webster.com/dictionary/anarchy>



### **Thick Layer of Machine-Readable Curated Knowledge**

Some people say that data is the new oil.<sup>13</sup> In fact, *The Economist* declares this in the article, "The world's most valuable resource is no longer oil, but data"<sup>14</sup>. Other people say, "If data is the new oil, then metadata is the new gold."<sup>15</sup>

If you read this article, *Data Curation: Weaving Raw Data into Business Gold (Part 1)*<sup>16</sup>, the author uses crude oil, refined gasoline, and racing fuel as a metaphor to explain the value of metadata. Metadata is simply data about data. Machine readable knowledge brings logical systems to life.

In his book, *Everything Is Miscellaneous*, David Weinberger explains the three orders of order:

- **First order of order.** Putting books on shelves is an example the first order of order.

<sup>13</sup> Joris Toonders, *Data Is the New Oil of the Digital Economy*, Wired, <https://www.wired.com/insights/2014/07/data-new-oil-digital-economy/>

<sup>14</sup> The Economist, *The world's most valuable resource is no longer oil, but data*, <https://www.economist.com/leaders/2017/05/06/the-worldsmost-valuable-resource-is-no-longer-oil-but-data>

<sup>15</sup> Julian Ereth, *If data is the new oil, then metadata is the new gold*, <https://www.eckerson.com/articles/if-data-is-the-new-oil-metadata-is-thenew-gold>

<sup>16</sup> Bill Schmarzo, *Data Curation: Weaving Raw Data Into Business Gold (Part 1)*, <https://www.digitalistmag.com/cioknowledge/2019/04/29/data-curation-weaving-raw-data-into-business-gold-part-1-06197968>

- **Second order of order.** Creating a list of books on the shelves you have is an example of second order of order. This can be done on paper or it can be done in a database.
- **Third order of order.** Adding even more information to information is an example of third order of order. Using the book example, classifying books by genre, best sellers, featured books, bargain books, books which one of your friends has read; basically, there are countless ways to organize something.

Third order removes the limitations which people seem to assume exist when it comes to organizing information. Weinberger says this about the third order of order:

“In fact, the third-order practices that make a company's existing assets more profitable, increase customer loyalty, and seriously reduce costs are the Trojan horse of the information age. As we all get used to them, third-order practices undermine some of our most deeply ingrained ways of thinking about the world and our knowledge of it.”

Understanding the third order of order is a sign that your mental map has been modified. Today, most business professionals don't really understand artificial intelligence. Consider the following from *The AI-Ladder*:<sup>17</sup>

- **Lack of understanding.** 81% of business leaders do 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* 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.

All of the above issues will eventually be sorted out. And when the issues are sorted out, then the pace of change will increase dramatically. Will you be ready?

## Building Blocks of a Logical System

This section was inspired by the article, *Elements of Logic*<sup>18</sup>. For more background details, please see this blog post *Elements of Logic for Accountants*<sup>19</sup>. An area of knowledge can describe the important logic of that system using these logical system building blocks.

There tends to be several different sources of explanations of the elements of logic: philosophy, ontology and knowledge engineers, and computer scientists<sup>20</sup>. These explanations tend to be inconsistent, many are incomplete, and most are either too high level to be useful or provide too much details which becomes overwhelming for business professionals and accountants.

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<sup>17</sup> O'Reilly, Rob Thomas, *The AI-Ladder*, <https://www.oreilly.com/online-learning/report/The-AI-Ladder.pdf>

<sup>18</sup> OpenAI, *Elements of Logic*, <https://chat.openai.com/share/b2d1dc31-4afd-49e1-8fd2-33b0d651890a>

<sup>19</sup> *Elements of Logic for Accountants*, <https://digitalfinancialreporting.blogspot.com/2023/10/elements-of-logic-for-accountants.html>

<sup>20</sup> Graham Berrisford, *Easing the Terminology Torture*, <https://www.linkedin.com/pulse/eaba-meta-model-challenge-graham-berrisford/>

This explanation of the elements of logic is tuned specifically for accountants, auditors, and analysts and is intended to help them understand how to think about XBRL-based digital financial reports. This is my current best take:

## ***Elements of Logic***

The **elements of logic** are the fundamental **building blocks** of logical theories that describe the logical conceptualization of some natural or man-made logical system.

- **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 conceptualization relates. A logical statement is a declarative sentence. Not all sentences are statements; for example, a question such as "What is your name?", or a command such as "Stop!", are not statements. There are five broad universal categories of logical statements:
  - **Terms:** Terms are important logical statements that define ideas or "things" used by a logical conceptualization. For example, "assets", "liabilities", "equity", and "balance sheet" are things or ideas used in a logical conceptualization.
  - **Associations:** Associations are important logical statements that describe permissible interrelationships between the terms such as "assets are 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". Associations can be grouped into two broad universal groups:
    - **"Is-a"** (a.k.a. general-special, association, type-subtype, class-subclass, equivalent-class)
    - **"Has-a"** (a.k.a. part-of, has-part, part-whole, composition, aggregation)
  - **Rules:** Rules (a.k.a. assertions, restrictions, constraints) are important logical statements that describe what tend to be convertible into 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". One rule can be connected to another rule using logic gates<sup>21</sup> (AND, OR, NOR, NAND, XOR, XNOR, NOT) to form complex logical statements. Rules can assert mathematical relationships or derive mathematical relationships to form new facts.
  - **Facts:** Facts are important logical statements that are known to be true. In the context of databases and knowledge representation, facts are often used to represent known information. Facts are logical statements about the numbers and words that are provided by an economic entity within a financial report. For example, the financial 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.
  - **Properties:** Properties are important logical statements about the qualities and traits of a model, structure, term, association, rule, and fact.
- **Axioms:** Axioms are foundational logical statements that are fundamentally accepted as being true per some logical system.

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<sup>21</sup> Logic Gates: The Building Blocks of Digital Circuits, <https://www.linkedin.com/pulse/logic-gates-building-blocks-digital-circuits-deekshith-kumar/>

- **Theorems:** Theorems are logical statements that are determined to be true per logical steps that can be taken to arrive at a conclusion using axioms, other theorems, or facts.
- **Restriction:** Restrictions are a special type of axiom or theorem that is imposed by some authority which chooses to restrict, constrain, limit, or otherwise impose some range on some logical artifact.
- **Classification:** Classification is the grouping of logical artifacts into sets.
- **Logical structure:** A logical structure is as set of logical statements which describe the structure. An "infor" which is defined by *Situation Theory*<sup>22</sup> is a unit of information<sup>23</sup>. An infor is a type of logical structure. An infor is a useful, convenient unit or "set" of information.
- **Logical model:** A logical model is a set of specific important structures that are consistent with and permissible interpretations of that model. Models add flexibility to logical conceptualizations.
- **Logical conceptualization:** A logical conceptualization is a set of important models that are consistent with and permissible per that logical conceptualization. A logical conceptualization is made up of a set of models, structures, terms, associations, rules, and facts.
- **Logical theory:** A logical theory is described per some logical conceptualization forms a logical theory that explains what is permitted and what is not permitted per a logical conceptualization which is made up of a set of logical models, structures, terms, associations, rules, and facts.
- **Logical system:** A logical system can be explained by a logical theory. A logical theory is an abstract conceptualization 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 system described by a logical theory and described by a logical conceptualization enables a community of stakeholders trying to achieve a specific goal or objective or a range of goals/objectives for an area of knowledge to agree on important logical statements used for capturing meaning or representing a shared understanding of and knowledge in some area of knowledge.

## ***Properly Functioning Logical System***

A logical conceptualization must be **consistent** (as opposed to inconsistent, making contradictory statements), **complete** (as opposed to incomplete, leaving a piece out), and **precise** (as opposed to imprecise, describing an area of knowledge incorrectly).

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.

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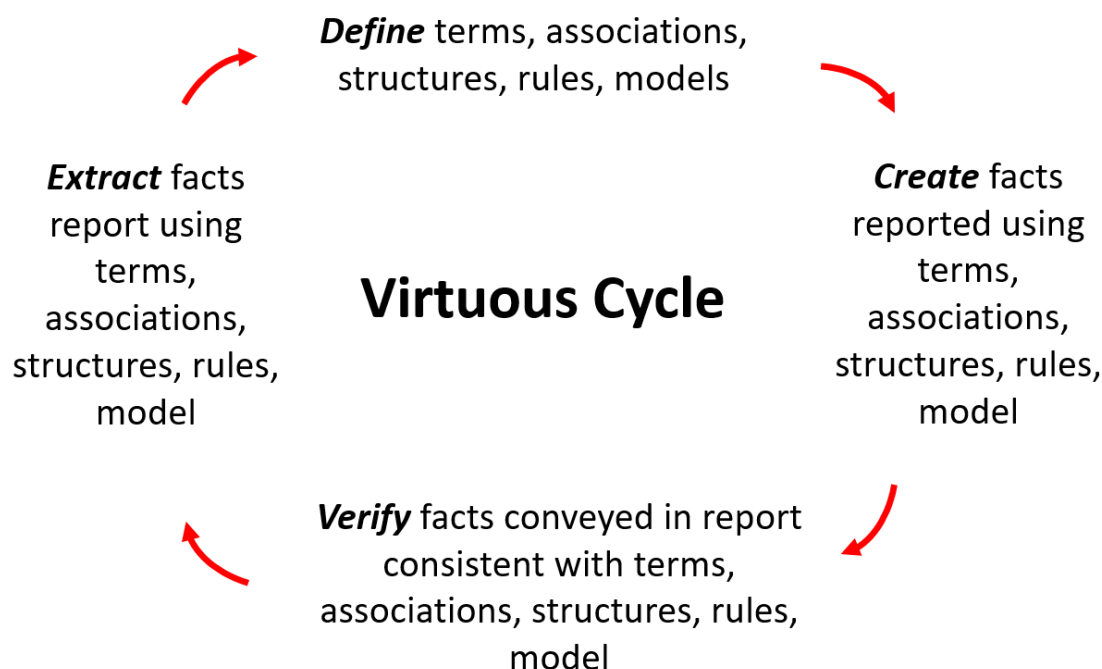
<sup>22</sup> *Describing Situation Semantics using Situation Theory* ,  
<https://digitalfinancialreporting.blogspot.com/2023/10/describing-situation-semantics-using.html>

<sup>23</sup> *Describing Situation Semantics Using Situation Theory*,  
<https://digitalfinancialreporting.blogspot.com/2023/10/describing-situation-semantics-using.html>

*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.

## ***Virtuous Cycle***

When a logical system is consistent and it has high precision and high coverage the logical system can be considered a properly functioning logical system. When a logical system is properly functioning, it creates a virtuous cycle<sup>24</sup>.



A logical theory conveys knowledge and that knowledge can be represented within a knowledge graph.

## ***Sensemaking***

Sensemaking<sup>25</sup> is the process of determining the deeper meaning or significance or essence of the collective experience for those within an area of knowledge. Sensemaking is a tool. You can use sensemaking to construct a map you can share with others. Sensemaking is the art of analyzing, understanding, clarifying, untangling, organizing, and synthesizing. The process of sensemaking involves<sup>26</sup>:

- Looking for logical patterns in information
- Making connections among different things within a system
- Synthesizing lots of information and categorizing it into small chunks
- Think about the big picture
- Think about the "why" of a situation
- Organizing and untangling things

<sup>24</sup> Charles Hoffman, CPA, *Virtuous Cycle*, <http://xbrl.squarespace.com/journal/2020/4/29/virtuous-cycle.html>

<sup>25</sup> *Sensemaking*, <http://xbrl.squarespace.com/journal/2021/11/18/sensemaking.html>

<sup>26</sup> YouTube.com, *Introduction to Sensemaking*, <https://www.youtube.com/watch?v=tACQQcSuG74>

Sensemaking is a way of thinking. Accountants, auditors, and analysts need to think slightly differently about accounting systems, accounting working papers, audit schedules, analysis models, and other such tools. Think of these tools as logical systems in order to get computer software applications to be able to interact with these artifacts of financial accounting in order to serve their needs.

## Simple Example of Logical System

A very simple example of a logical system will help you better understand what a logical system is. The simple logical system we will use to explain logical systems to you now is the accounting equation.

### *Accounting Equation*

Every accountant understands the idea of the accounting equation; the accounting equation is foundational to financial accounting and reporting. One version of the accounting equation is<sup>27</sup>:

$$\text{Assets} = \text{Liabilities} + \text{Equity}$$

Yes, there are a number of different forms of the accounting equation such as "Net Assets = Assets - Liabilities". And this introduces you to an important building block of a logical system which is the notion of a model. Each different model might have different terms, structures, and rules. Here is the logical system "Assets = Liabilities + Equity" represented using the building blocks of a logical system:

- **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.
- **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, assertions, structures, and facts describe the model. We created only one model, or permissible interpretation, of the logical theory. (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.)

Because this is a very simple example with only a few statements it is easy to get your head around this system 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:

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<sup>27</sup> Wikipedia, *Accounting Equation*, [https://en.wikipedia.org/wiki/Accounting\\_identity](https://en.wikipedia.org/wiki/Accounting_identity)

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

Result	Rule
Pass	$\$Assets = \$Liabilities + \$Equity$

### Balance Sheet

Consistent

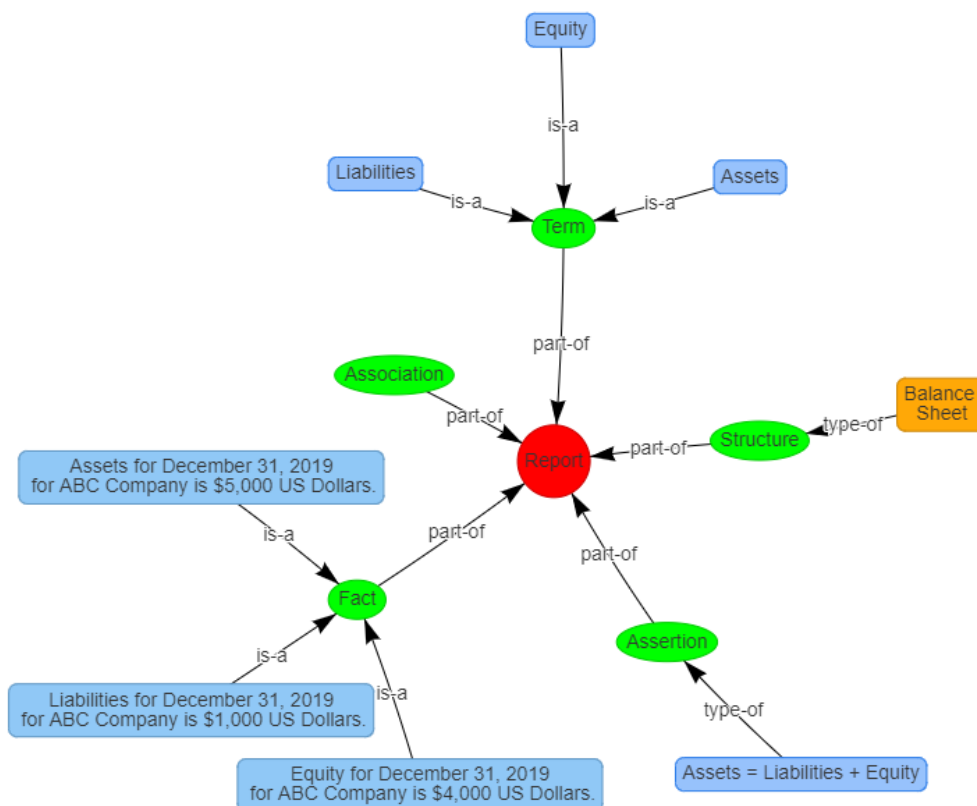
Complete

Precise

1

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

However, as the size of the logical system increases it becomes increasingly more challenging to verify that the logical system is properly function using manual processes. Essentially, the models, terms, structures, rules, and facts form a directed acyclic graph such as:



While a typical financial report is significantly larger than the logical system for the accounting equation; for example the Microsoft 2017 10-K is made up of 194 structures as contrast to the accounting equation's one structure; every financial report works the same as this very simple example but just has more pieces.

### Representing Logical System in Machine Readable Form Using XBRL

To help you further understand the notion of a logical system and how information about a logical system can be represented in machine readable form; I will now explain the accounting

equation logical system again and show you the technical artifacts used to represent this logical description using the global standard technical format, XBRL<sup>28</sup>:

Line	Report Element Category	Period Type	Balance	Report Element Name
1	<b>01-Balance Sheet</b>	Network		<a href="http://xbrlsite.com/ae/role/BalanceSheet">http://xbrlsite.com/ae/role/BalanceSheet</a>
2	<b>Balance Sheet [Hypercube]</b>	Table		ae:BalanceSheetHypercube
3	Balance Sheet [Line Items]	LineItems		ae:BalanceSheetLineItems
4	Balance Sheet [Arithmetic]	Abstract		ae:BalanceSheetArithmetic
5	Assets	Concept (Monetary)	As Of Debit	ae:Assets
6	Liabilities	Concept (Monetary)	As Of Credit	ae:Liabilities
7	Equity	Concept (Monetary)	As Of Credit	ae:Equity

Component: (Network and Hypercube)	
Network	01-Balance Sheet ( <a href="http://luca.auditchain.finance/report/role/BalanceSheet">http://luca.auditchain.finance/report/role/BalanceSheet</a> )
Hypercube	Balance Sheet [Hypercube]

Reporting Entity [Aspect]	GH259400TOMPUOLS65II   <a href="http://standards.iso.org/iso/17442">http://standards.iso.org/iso/17442</a>
Unit [Aspect]	iso4217:EUR

Concept [Aspect]	Period [Aspect]	
	2022-12-31	
Balance Sheet [Arithmetic]		
Assets	€	5,000
Liabilities		1,000
Equity		4,000

You can use the technical artifacts provided to explore the representation of this logical system; but explaining the details is beyond the scope of this document. To understand the XBRL-based information, consider working through the *Very Basic XBRL Primer*<sup>29</sup> and the most current version of *Essentials of XBRL-based Digital Financial Reporting*<sup>30</sup>.

While an understanding of XBRL-based reports is not necessary for understanding logical systems, it can be very helpful.

## ***XBRL is a Knowledge Graph***

XBRL is a global standard approach to represent a knowledge graph in machine readable form. Obviously, a full financial report knowledge graph is far more complex and sophisticated than the accounting equation; however, the basic ideas are exactly the same for both the very basic example which was provided and a complete general purpose financial report.

Effectively, XBRL is a global standard approach to creating a knowledge assembly<sup>31</sup>. A knowledge assembly is a set of knowledge graphs. A knowledge graph is a machine-readable structured representation of knowledge (semantics). A knowledge graph system<sup>32</sup> is a set of knowledge graphs represented using some physical format in the form of a knowledge assembly of some sort.

<sup>28</sup> Accounting Equation represented using XBRL,

[http://www.xbrlsite.com/seattlemethod/platinum/ae/ae\\_ModelStructure.html](http://www.xbrlsite.com/seattlemethod/platinum/ae/ae_ModelStructure.html)

<sup>29</sup> Very Basic XBRL Primer, [http://www.xbrlsite.com/mastering/Part00\\_Chapter01.B\\_XBRLPrimer.pdf](http://www.xbrlsite.com/mastering/Part00_Chapter01.B_XBRLPrimer.pdf)

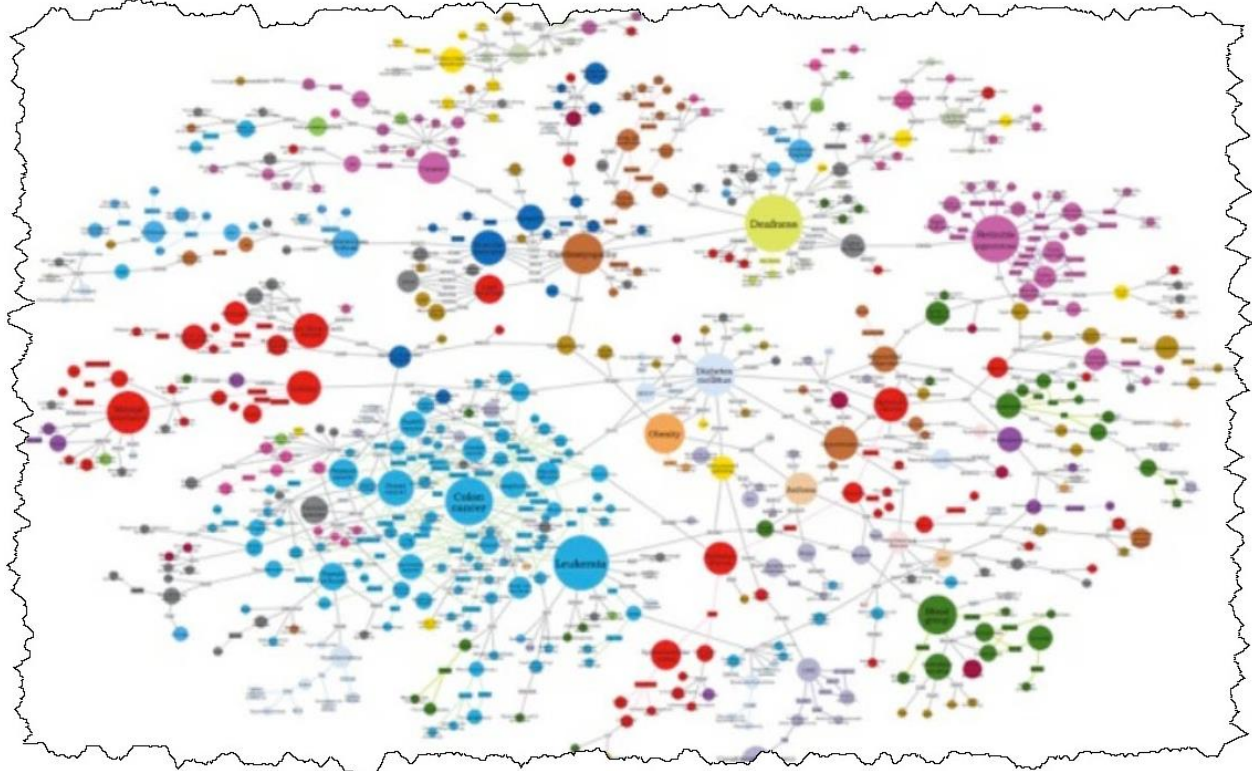
<sup>30</sup> *Essentials of XBRL-based Digital Financial Reporting (Platinum)*,

[http://www.xbrlsite.com/seattlemethod/platinum/EssentialsOfXBRL\\_PLATINUM.pdf](http://www.xbrlsite.com/seattlemethod/platinum/EssentialsOfXBRL_PLATINUM.pdf)

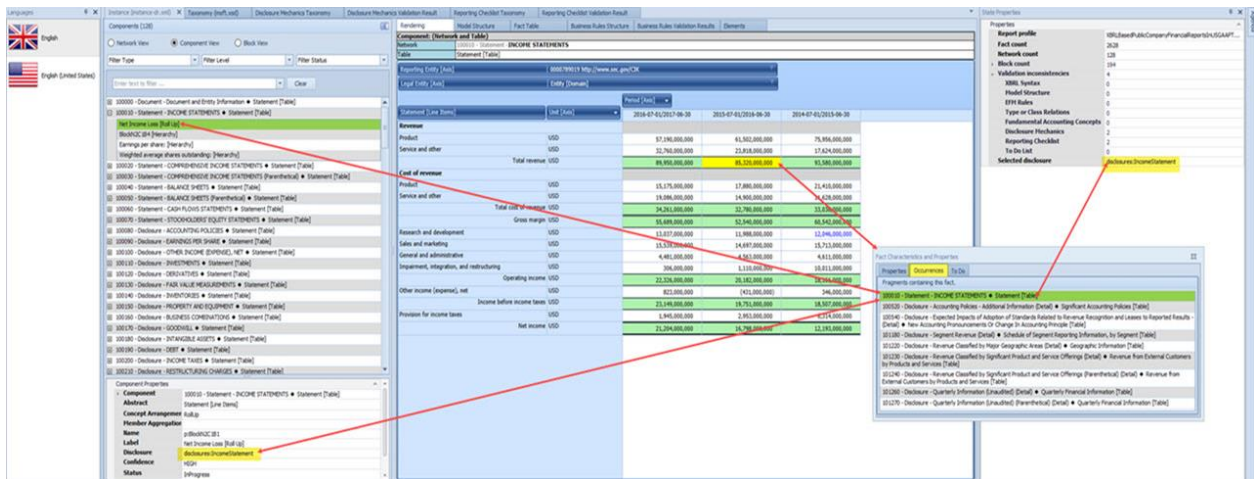
<sup>31</sup> Knowledge Assembly, <https://digitalfinancialreporting.blogspot.com/2023/08/knowledge-assembly.html>

<sup>32</sup> Knowledge Graph System, <https://digitalfinancialreporting.blogspot.com/2023/07/knowledge-graph-system.html>

A more comprehensive general purpose financial report might look as follows in some general tool for representing knowledge graph information (a graph hairball)<sup>33</sup>:



If you look at the same knowledge graph system of information about a financial report in a special-purpose tool for working with such general-purpose financial report knowledge graphs, it might look something like this<sup>34</sup>:



Software uses the knowledge graph system represented as a knowledge assembly and a logical model of the information within the knowledge graph system to generate a much more useful rendering of the information in a form that is usable by accountants, auditors, and analysts. But that information is also readable and understandable by software applications.

<sup>33</sup> Graph Hairball, <https://digitalfinancialreporting.blogspot.com/2023/09/graph-hairball.html>

<sup>34</sup> Pesseract, [http://xbrlsite.azurewebsites.net/2021/library/KnowledgeGraph\\_Pesseract.jpg](http://xbrlsite.azurewebsites.net/2021/library/KnowledgeGraph_Pesseract.jpg)

## ***Quality and Lean Six Sigma Techniques and Principles***

Logical systems can leverage Lean Six Sigma principles, philosophies, and techniques. Lean Six Sigma<sup>35</sup> is a discipline that combines the problem-solving methodologies and quality enhancement techniques of Six Sigma<sup>36</sup> with the process improvement tools and efficiency concepts of Lean Manufacturing<sup>37</sup>. 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<sup>38</sup> 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<sup>39</sup> 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. For additional details, please refer to Lean Six Sigma<sup>40</sup>.

## ***Moving on to More Complex Logical Systems***

The accounting equation logical system was provided to be a small logical system that you can easily get your head around to understand the ideas of a logical system. Small logical systems and larger logical systems all work the same way.

To continue to understand logical systems and grow your understanding I have created a set of progressively larger logical systems and a bunch of business use cases and test cases to assist you in your learning process.

The progressively larger logical systems can be found in the form of prototype financial reporting schemes on this blog post, *PLATINUM XBRL-based Financial Report Examples*<sup>41</sup>. The use cases and test cases can be found in this blog post, *PLATINUM Business Use Cases, Test Cases, Conformance Suite*<sup>42</sup>.

All of this builds into a representation of a real financial reporting scheme, AASB 1060<sup>43</sup>, a financial reporting scheme for small and medium sized enterprises. About 20% of the financial reporting scheme has been represented. This can help accountants, auditors, and analysts get their heads around logical systems.

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<sup>35</sup> Wikipedia, *Lean Six Sigma*, [https://en.wikipedia.org/wiki/Lean\\_Six\\_Sigma](https://en.wikipedia.org/wiki/Lean_Six_Sigma)

<sup>36</sup> Wikipedia, *Six Sigma*, [https://en.wikipedia.org/wiki/Six\\_Sigma](https://en.wikipedia.org/wiki/Six_Sigma)

<sup>37</sup> Wikipedia, *Lean Manufacturing*, [https://en.wikipedia.org/wiki/Lean\\_manufacturing](https://en.wikipedia.org/wiki/Lean_manufacturing)

<sup>38</sup> YouTube.com, *Lean Six Sigma in 8 Minutes*, <https://youtu.be/s2HCrhNVfak>

<sup>39</sup> YouTube.com, *Six Sigma in 9 Minutes*, <https://youtu.be/4EDYfSI-fmc>

<sup>40</sup> Charles Hoffman, CPA, *Lean Six Sigma*, [http://www.xbrlsite.com/mastering/Part01\\_Chapter02.K\\_LeanSixSigma.pdf](http://www.xbrlsite.com/mastering/Part01_Chapter02.K_LeanSixSigma.pdf)

<sup>41</sup> *PLATINUM XBRL-based Financial Report Examples*, <https://digitalfinancialreporting.blogspot.com/2023/07/platinum-xbrl-based-financial-report.html>

<sup>42</sup> *PLATINUM Business Use Cases, Test Cases, Conformance Suite*, <https://digitalfinancialreporting.blogspot.com/2023/07/platinum-business-use-cases-test-cases.html>

<sup>43</sup> *AASB 1060 Financial Reporting Scheme*, [http://xbrlsite.azurewebsites.net/2021/reporting-scheme/aasb1060/base-taxonomy/aasb1060\\_ModelStructure2.html](http://xbrlsite.azurewebsites.net/2021/reporting-scheme/aasb1060/base-taxonomy/aasb1060_ModelStructure2.html)

Line	Label	Object Class	Period Type	Balance	Report Element Name	References
1	001-Documentation-Report Information	Network			<a href="http://www.xbrlsite.com/aasb1060/role/Documentation/ReportInformation">http://www.xbrlsite.com/aasb1060/role/Documentation/ReportInformation</a>	
2	Report Information [Hypercube]	Hypercube			<a href="#">aasb1060:ReportInformationHypercube</a>	AASB 1060 31
3	Report Information [Line Items]	LineItems			<a href="#">aasb1060:ReportInformationLineItems</a>	AASB 1060 31
4	Report Information [Set]	Abstract			<a href="#">aasb1060:ReportInformationSet</a>	
5	Reporting Period End Date	Concept (Date)	For Period		<a href="#">aasb1060:ReportingPeriodEndDate</a>	AASB 1060 31 c
6	Reporting Period	Concept (Date)	For Period		<a href="#">aasb1060:ReportingPeriod</a>	AASB 1060 31 c
7	Presentation Currency	Concept (Text/String)	For Period		<a href="#">aasb1060:PresentationCurrency</a>	AASB 1060 31 d
8	Level of Rounding	Concept (Text/String)	For Period		<a href="#">aasb1060:LevelOfRounding</a>	AASB 1060 31 e
9	002-Documentation-Reporting Entity Information	Network			<a href="http://www.xbrlsite.com/aasb1060/role/Documentation/ReportingEntityInformation">http://www.xbrlsite.com/aasb1060/role/Documentation/ReportingEntityInformation</a>	
10	Reporting Entity Information [Hypercube]	Hypercube			<a href="#">aasb1060:ReportingEntityInformationHypercube</a>	
11	Reporting Entity Information [Line Items]	LineItems			<a href="#">aasb1060:ReportingEntityInformationLineItems</a>	
12	Reporting Entity [Set]	Abstract			<a href="#">aasb1060:ReportingEntitySet</a>	AASB 1060 32
13	Reporting Entity Name	Concept (Text/String)	For Period		<a href="#">aasb1060:ReportingEntityName</a>	AASB 1060 31 a
14	Reporting Entity Name Changes Information	Concept (Text/String)	For Period		<a href="#">aasb1060:ReportingEntityNameChangesInformation</a>	AASB 1060 31 a
15	Type of Reporting Entity	Concept (Text/String)	For Period		<a href="#">aasb1060:TypeOfReportingEntity</a>	AASB 1060 31 b
16	Domicile of Reporting Entity	Concept (Text/String)	For Period		<a href="#">aasb1060:DomicileOfReportingEntity</a>	AASB 1060 32 a
17	Legal Form of Reporting Entity	Concept (Text/String)	For Period		<a href="#">aasb1060:LegalFormOfReportingEntity</a>	AASB 1060 32 a
18	Country of Incorporation of Reporting Entity	Concept (Text/String)	For Period		<a href="#">aasb1060:CountryOfIncorporationOfReportingEntity</a>	AASB 1060 32 a
19	Address of Registered Office of Reporting Entity	Concept (Text/String)	For Period		<a href="#">aasb1060:AddressOfRegisteredOfficeOfReportingEntity</a>	AASB 1060 32 a
20	Reporting Entity Going Concern	Concept (Yes/No)	For Period		<a href="#">aasb1060:ReportingEntityGoingConcern</a>	AASB 1060 14
21	100-Statement-Statement of Financial Position, Classified (Net Assets Approach)	Network			<a href="http://www.xbrlsite.com/aasb1060/role/Statement/StatementOfFinancialPositionClassified">http://www.xbrlsite.com/aasb1060/role/Statement/StatementOfFinancialPositionClassified</a>	
22	Statement of Financial Position, Classified [Hypercube]	Hypercube			<a href="#">aasb1060:StatementOfFinancialPositionClassifiedHypercube</a>	AASB 1060 25 a
23	Statement of Financial Position, Classified [Line Items]	LineItems			<a href="#">aasb1060:StatementOfFinancialPositionClassifiedLineItems</a>	AASB 1060 35
24	Net Assets [Roll Up]	Abstract			<a href="#">aasb1060:NetAssetsRollUp</a>	
25	Assets [Roll Up]	Abstract			<a href="#">aasb1060:AssetsRollUp</a>	AASB 1060 9
26	Current Assets [Roll Up]	Abstract			<a href="#">aasb1060:CurrentAssetsRollUp</a>	AASB 1060 37
27	Cash and Cash Equivalents	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:CashAndCashEquivalents</a>	AASB 1060 35 a
28	Trade and Other Current Receivables	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:TradeAndOtherCurrentReceivables</a>	AASB 1060 35 b
29	Current Tax Assets	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:CurrentTaxAssets</a>	AASB 1060 35 m
30	Other Current Financial Assets	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:OtherCurrentFinancialAssets</a>	AASB 1060 35 c
31	Current Inventories	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:CurrentInventories</a>	AASB 1060 35 d
32	Current Biological Assets	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:CurrentBiologicalAssets</a>	AASB 1060 35 h
33	Other Miscellaneous Current Assets	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:OtherMiscellaneousCurrentAssets</a>	AASB 1060 36
34	Disposal Group Classified as Held for Sale	Concept (Monetary)	As Of Debit		<a href="#">aasb1060:DisposalGroupClassifiedAsHeldForSale</a>	AASB 1060 36

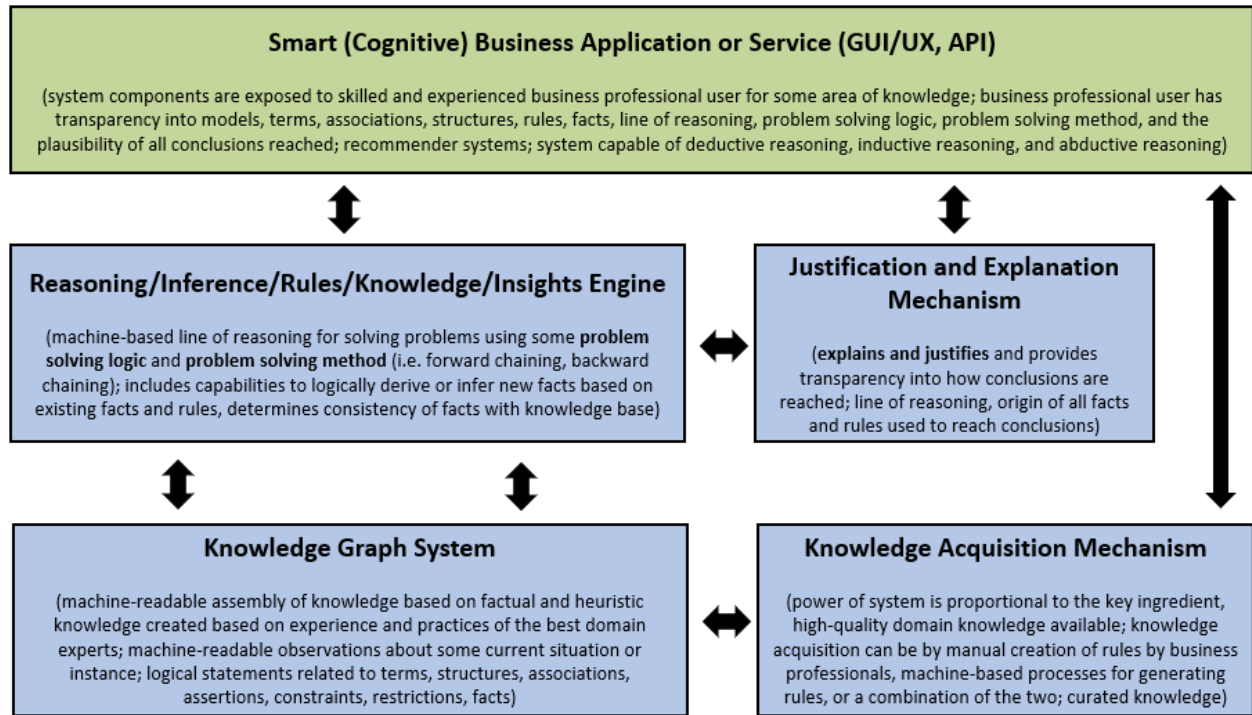
## Software Components

Logical systems can be implemented in software applications that run on computers. This section describes the components of a knowledge-based system also referred to as a “smart” business application or service.

### Components of Logical System

Simply put, a knowledge-based system or a “smart” business application or service is a system that draws upon the knowledge of skilled and experienced human experts in an area of knowledge that has been represented their knowledge in machine-readable form. That knowledge is stored in a **fact database** and **knowledge base**. The system applies **problem solving logic** using a **problem-solving method** to solve problems that normally would require human effort and thought to solve. The knowledge-based system supplies an **explanation and justification mechanism** to help system users to understand the **line of reasoning** used and support **conclusions reached** by the knowledge-based system and presents that information to the user of the system.

Nothing is a “black box”, rather every aspect of every decision made by a logical system is completely understandable to the business professional using the system. Below is a graphic of the components of a knowledge-based logical system:



## Best Practices

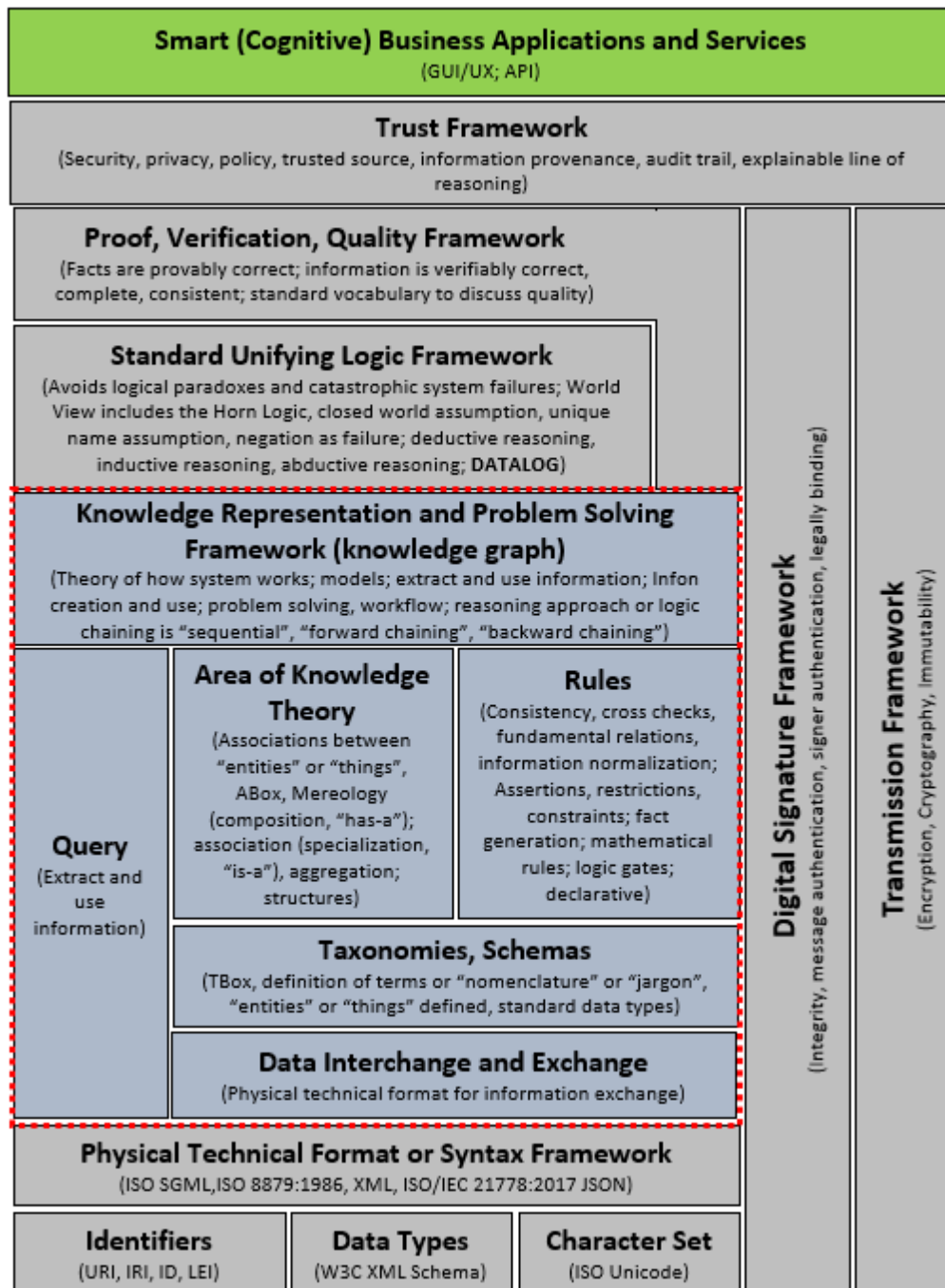
A best practice is a method or technique that has been generally accepted as superior to any other known alternatives because it produces results that are superior to those achieved by other means or because it has become a standard way of doing things.

## Complete System

*Irreducible complexity* is a term used to describe a characteristic of complex systems whereby the complex system needs all of its individual component systems in order to effectively function<sup>44</sup>. In other words, it is impossible to reduce the complexity of a system (or to further simplify a system) by removing any of its component parts and still maintain its functionality objective.

The *Law of Conservation of Complexity* states that complexity cannot be removed from a system; but complexity can be moved. Every application has an inherent amount of irreducible complexity. The question is, who will have to deal with that complexity: the logical system user, the software developer building the software, or the software platform developer that will be used by the software developer?

<sup>44</sup> *Problem Solving Systems*, <https://digitalfinancialreporting.blogspot.com/2023/10/problem-solving-systems-work-in-progress.html>



## Elegant, Simple Software Systems

A kluge is a term from the engineering and computer science world that refers to something that is convoluted and messy but gets the job done. Elegance is the quality of being pleasingly ingenious, simple, neat. Elegance is about beating down complexity. Creating something complex is easy. Creating something simple and elegant is hard work.

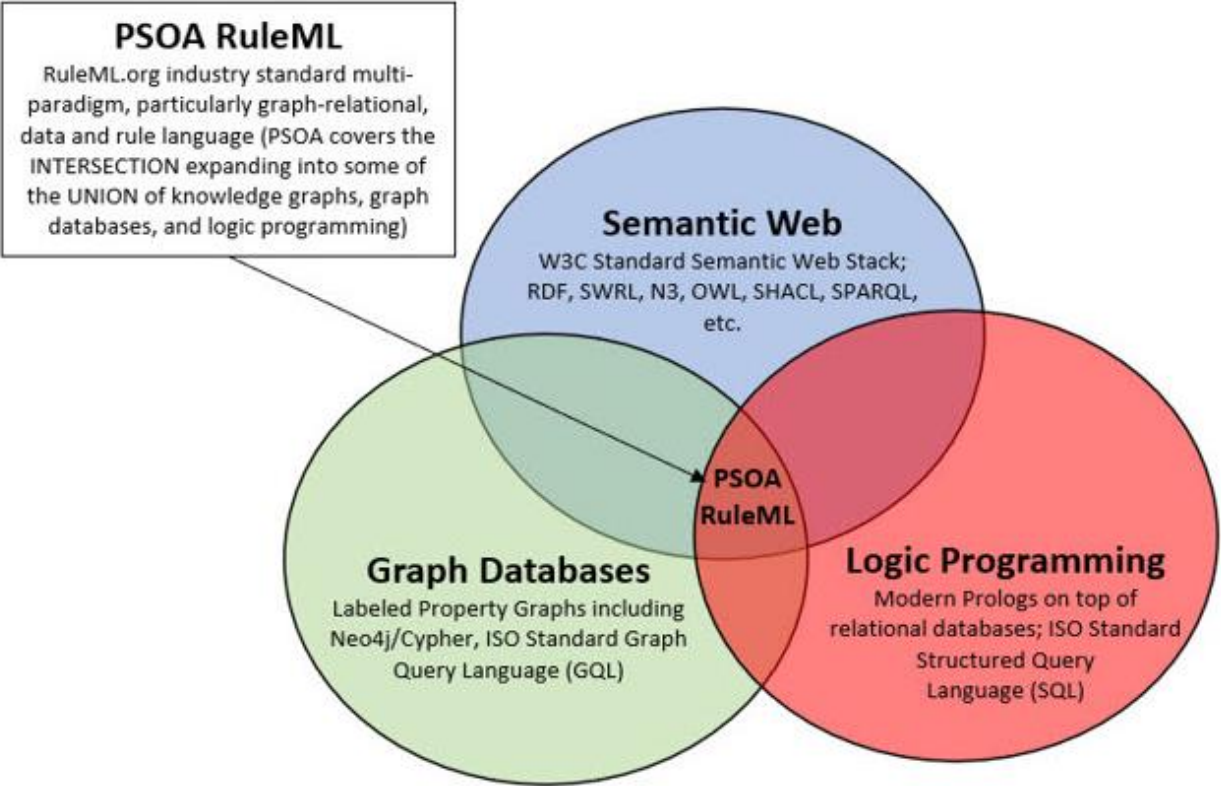
# Software Implementation Approaches

There are three primary approaches to implementing logical systems within a software application. Those three approaches are:

- Semantic Web approach
- Graph databases
- Logic programming

Different software developers have arbitrary preferences as to which implementation approach they use to create logical software systems. As such, there are multiple different software stacks which exist within different organizations.

Key to accountants, auditors, and analysts getting what they need from software applications is having the right skills and experience to communicate effectively with software engineers<sup>45</sup>. This will allow for precise and detailed conversations between the experts of some area of knowledge and software engineers that create the software business professionals need.



# Embracing Complexity

As was said by Paul Anderson, "I have yet to see any problem, however complicated, which, when looked at in the right way, did not become still more complicated."<sup>46</sup>

<sup>45</sup> Logical Systems for Business Professionals, <https://digitalfinancialreporting.blogspot.com/2023/09/logical-systems-for-business.html>

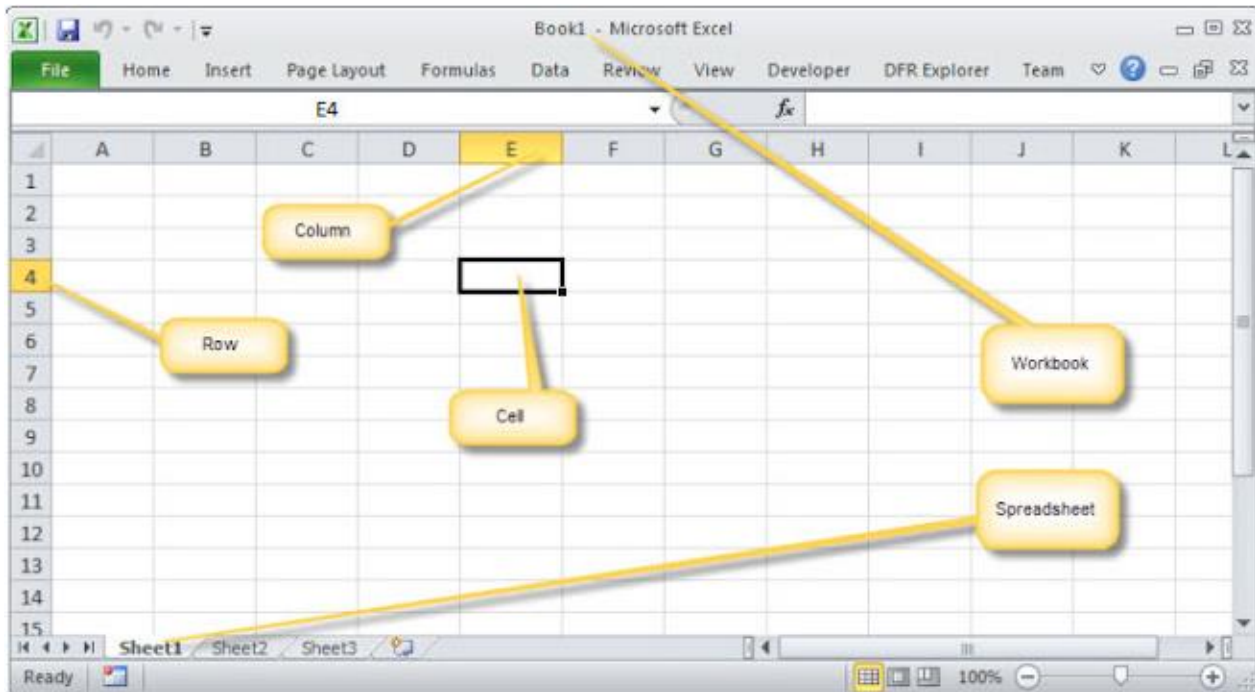
<sup>46</sup> Embracing Complexity, <https://medium.com/@Tonyseale/embrace-complexity-conclusion-fb8be6f39deb>

Artificial intelligence and software applications augmenting the skills of human experts is a powerful ideal that has been simmering for many years now. These ideas will be released in the form of logical systems that serve their human masters.

Today's systems of chaotic jumbles of databases built using a silo mentality contemplated prior to the existence of our internetworlded world will be replaced by new and improved versions of those systems. "Simple" is not about doing simple things. Simple is the ultimate sophistication. Simple is elegant. **Simplicity** is about "dumbing down" a problem to make the problem easier to solve. **Simple** is about beating down complexity in order to make something simple and elegant; to make sophisticated things simple to use rather than complex to use. Creating something that is simple takes discipline, knowledge, conscious effort, attention to detail, and is hard work. Complexity needs to be embraced and properly handled to make software implementations of logical systems both useful because they perform useful work and approachable to business professionals that need to use that software.

## Modern Spreadsheet

An electronic spreadsheet is a logical system. That spreadsheet is described using the elements of logic. Terms such as "workbook", "spreadsheet", "row", "column", and "cell" are used to describe the logic of an electronic spreadsheet system.



A very good thing about the logic of an electronic spreadsheet logical system is that the terms used are familiar to any accountant, auditor, or analysts that has used a paper spreadsheet.

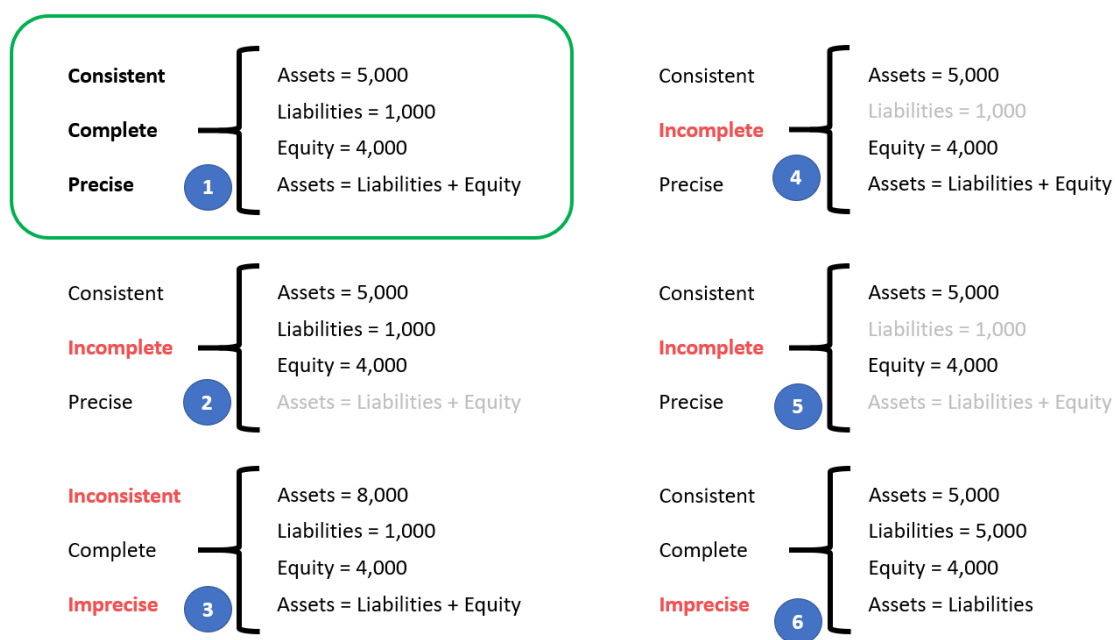
But there is a downside. While an electronic spreadsheet is a logical system; that logical system is oriented to the presentation of information within the spreadsheet. This is as contrast to being oriented to the meaning of the information provided by the spreadsheet.

What is needed is a more modern approach to electronic spreadsheets<sup>47</sup>. Imagine, if you will, accounting schedules and audit working papers<sup>48</sup> that are logical systems based on the meaning of the information within the spreadsheet as contrast to how the accountant creating the spreadsheet arbitrarily decided to present that information. Imagine general purpose financial reports as being both human readable as they are today, but also readable and understandable by software applications<sup>49</sup>. Imagine a more modern approach to building a working trial balance<sup>50</sup> or expert systems for creating financial reports<sup>51</sup>. Some professional accountants are going to be the Freemasons of the Information Age<sup>52</sup>.

## What Can Go Wrong? Impediments to a Properly Functioning Logical System

A good way to understand a properly functioning logical system is to know what can go wrong with that system so the system can provide countermeasures to make sure those things do not go wrong.

The following set of graphics provides a summary of the impediments to a properly functioning logical system specific to the very simple Accounting Equation logical system. First the properly functioning system is shown for contrast, then what can go wrong is shown:



<sup>47</sup> Modern Spreadsheet, <https://digitalfinancialreporting.blogspot.com/2023/05/modern-spreadsheet.html>

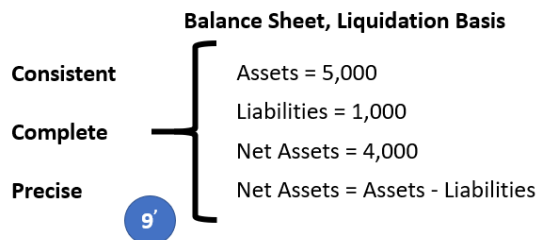
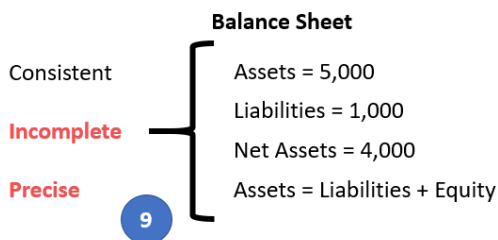
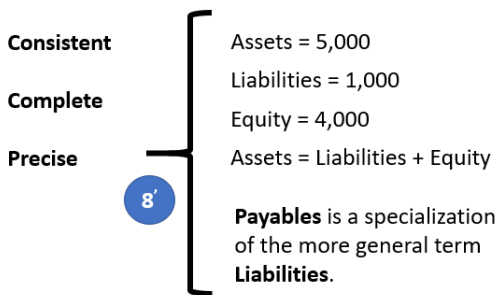
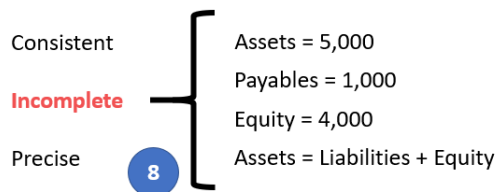
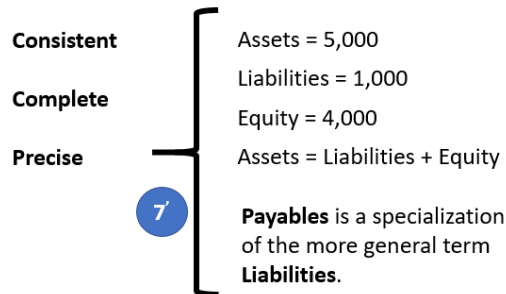
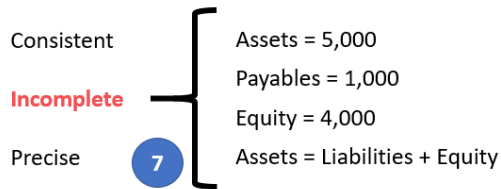
<sup>48</sup> Semantic Accounting and Auditing Working Papers, <https://digitalfinancialreporting.blogspot.com/2023/05/semantic-accounting-and-auditing.html>

<sup>49</sup> Digital Twin for Financial Status and Performance of Economic Entity, <https://digitalfinancialreporting.blogspot.com/2023/09/digital-twin-for-financial-status-and.html>

<sup>50</sup> Modern Working Trial Balance, <https://digitalfinancialreporting.blogspot.com/2023/05/modern-working-trial-balance.html>

<sup>51</sup> World's First Standards Based Expert System for Creating Financial Reports, <https://digitalfinancialreporting.blogspot.com/2023/01/worlds-first-standards-based-expert.html>

<sup>52</sup> Freemasons of the Information Age, <https://digitalfinancialreporting.blogspot.com/2023/10/freemasons-of-information-age.html>



In the following sections I want to make some adjustments to the logical system which make the logical system either inconsistent, incomplete, or imprecise and explain why the system is then not a properly functioning logical system. I made videos that explain each of these impediments to a properly functioning logical system which you can see in this video playlist, *Understanding the Financial Report Logical System*<sup>53</sup>.

Before we get to the improperly functioning logical systems, let's take one final look at the properly functioning logical system so that you can use that as a baseline for comparing and contrasting the properly functioning and improperly functioning logical systems so that you can understand the sorts of errors that can occur.

### **State 1: Properly Functioning Logical System**

For completeness, I want to start by mentioning again our properly functioning logical system which is consistent, complete, and precise. It can be helpful to contrast other states to this state to understand the difference between properly functioning logical systems and improperly functioning systems.

<sup>53</sup> Understanding the Financial Report Logical System, [https://www.youtube.com/playlist?list=PLqMZRUzQ64B7EWamzDP-WaYbs\\_WORL9nt](https://www.youtube.com/playlist?list=PLqMZRUzQ64B7EWamzDP-WaYbs_WORL9nt)

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

Result	Rule
Pass	$\$Assets = \$Liabilities + \$Equity$

### Balance Sheet

**Consistent**  
**Complete**  
**Precise**

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

Again, this is considered a properly functioning logical system because (a) all the statements within the system are **consistent**; (b) the set of statements that describe the system is **complete**; and (c) the information conveyed by the system is **precise** in its representation of reality. Further, we are formally declaring this “reality”<sup>54</sup> to be our base understanding.

Also, we need to be explicit. We defined three terms “Assets”, “Liabilities”, and “Equity”.

Now, you may know what those three terms are; but a computer does not. You have to define what you work with relative to something that you know. Imagine our system defines four terms, “fac:Assets”, “fac:Liabilities”, “fac:Equity”, and “fac:LiabilitiesAndEquity”<sup>55</sup>. You understand your system but you have to map every external system into your system<sup>56</sup>. Your internal system understands more than the accounting equation system (i.e. you have LiabilitiesAndEquity). You have to be able to compute that value based on some other system’s information<sup>57</sup>. It is perfectly reasonable for our system to create a concept LiabilitiesAndEquity and compute that value even though the accounting equation logical system does not have that explicit value.

The point is that different economic entities have different models; but all models of a financial reporting scheme are reconcilable from/to one another in some manner<sup>58</sup>.

## State 2: Incomplete Coverage by Rules

The logical system #2 below is intended to show exactly the same information as our #1 properly functioning logical system, except that #2 leaves out the rule “Assets = Liabilities and Equity” which is showed as grayed out (i.e. because it is assumed to be missing from the logical system).

Coverage is a measure of how well you do or can represent a domain of information within a logical system. “Do” is about using the tools you have correctly and effectively. “Can” is about the capabilities of the tools you are using to represent the rule.

For example, if your logical system neglects to include the rule “Assets = Liabilities + Equity” or if your tools don’t provide the capabilities to allow you to represent that rule; then there is the possibility that the facts being represented to be represented incorrectly and the system will not detect the inconsistency. As such, that logical system has **incomplete coverage**.

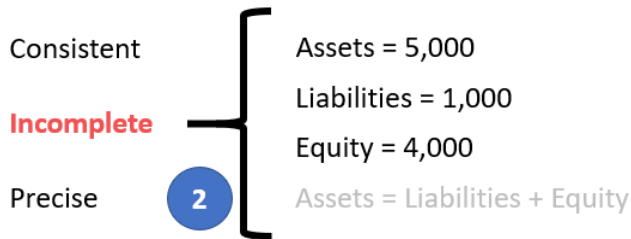
<sup>54</sup> YouTube, *Reality*, <https://youtu.be/eq2Jw6waaCI>

<sup>55</sup> Fundamental accounting concepts, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/fac.xsd>

<sup>56</sup> Mapping from accounting equation to fundamental accounting concepts in our system, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/fac-mapping-definition.xml>

<sup>57</sup> XBRL Formula to derive the value for LiabilitiesAndEquity, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/fac-ImputeRule-LiabilitiesAndEquity-formula.xml>

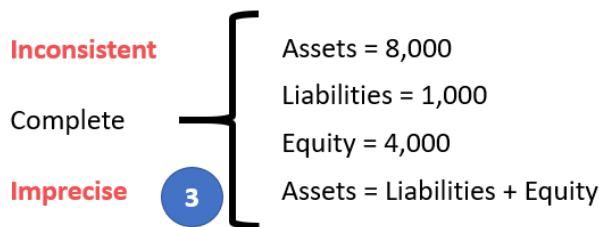
<sup>58</sup> Charles Hoffman, CPA, *Special Theory of Machine-based Automated Communication of Semantic Information of Financial Statements*, <http://xbrl.squarespace.com/journal/2019/12/30/special-theory-of-machine-based-automated-communication-of-s.html>



While this specific state #2 does have the Assets, Liabilities, and Equity facts consistent with the absent rule; the system is still incomplete because the coverage can be improved by adding the missing rule. If that missing rule is added, then the logical system can be considered complete again.

### State 3: Inconsistent and Imprecise

All the statements in the system must be consistent for the logical system to be considered properly functioning. If statements are inconsistent, the logical system is not properly functioning. In this system #3, the values for Assets, Liabilities, and Equity are inconsistent with the rule "Assets = Liabilities + Equity". From looking at the information provided, it is impossible to know exactly which of the three facts are incorrect; it is only possible to understand that the statements made within the logical system is inconsistent. It could be the case that the rule is incorrect.



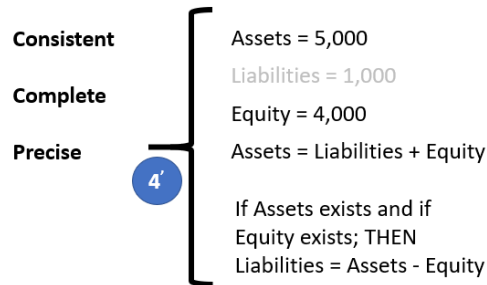
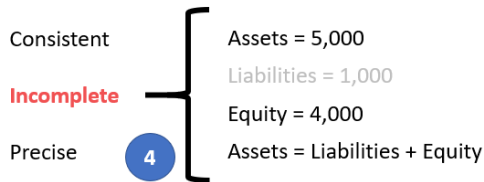
However, given that we know from state #1 that the value for Assets is 5,000 and not 8,000; the facts in this system is imprecise because the fact for Assets does not reflect reality.

### State 4: Unreported Facts

In state #4, the situation is that the economic entity representing information in their report neglected to include the fact for Liabilities. Whether it is the case that a fact can, or cannot, be left unreported is a decision that can be made by the stakeholders of the system.

If it is the case that it is decided that the fact "Liabilities" can be omitted if both Assets and Equity are reported; then you must provide a rule to derive the value of Liabilities when that fact is not reported. Below you see that the system has been adjusted in state #4' to add the rule "IF Assets exists and if Equity exists; THEN Liabilities = Assets - Equity"<sup>59</sup>. (NOTE that this rule should actually be "IF Assets exists and if Equity exists and if not(exists) Liabilities; THEN Liabilities = Assets - Equity")

<sup>59</sup> Here is the impute or derivation rule that would be added to the accounting equation logical system for this situation, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/ImputeRule-Key-1-Code-BS-Impute-01-formula.xml>



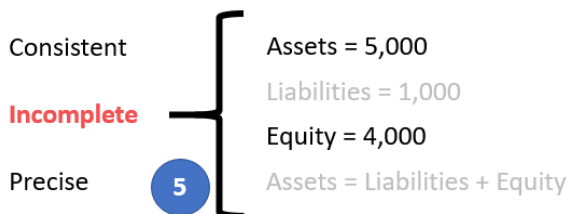
If it were likewise true that either Assets<sup>60</sup> or Equity<sup>61</sup> could also be left unreported, similarly derivation rules could be created for each of those facts. Note that XBRL Formula chaining<sup>62</sup> can be used to physically derive unreported facts if any one of these three facts remain unreported. Note that it is impossible to derive missing information if any two of the facts remain unreported. Adding the derivation rule makes the system complete.

Allowing certain line items of a report to go unreported specifies the need to create rules to derive missing information. Or saying this another way, omitting the possibility of unreported facts negates the need for creating derivation rules.

A second downside of allowing unreported facts is that you lose the parity check or cross check if facts can go unreported. Said another way, it would be considered best practice to not leave important high-level financial report line items to go unreported.

### State 5: Incomplete

Similar to state #4, in state #5 the logical system is incomplete because both (a) the fact Liabilities is unreported and also (b) the consistency rule "Assets = Liabilities + Equity" is missing from the logical system. Because both a fact and the rule are missing from the logical system, it would be impossible to deduce the value of Liabilities in this case. There is not enough information in the logical system to allow Liabilities to be derived. At a minimum, a consistency crosscheck rule<sup>63</sup> plus the derivation rule to impute Liabilities<sup>64</sup> would be necessary.



Again, consistent with state #4; Assets and Equity would require similar rules and there is no parity check of reported information.

<sup>60</sup> XBRL Formula rule for deriving Assets, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/ImputeRule-Key-3-Code-BS-Impute-03-formula.xml>

<sup>61</sup> XBRL Formula rule for deriving Equity, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/ImputeRule-Key-2-Code-BS-Impute-02-formula.xml>

<sup>62</sup> Deriving Facts Using XBRL Formula Chaining (Example), <http://xbrl.squarespace.com/journal/2019/4/24/deriving-information-using-xbrl-formula-chaining-example.html>

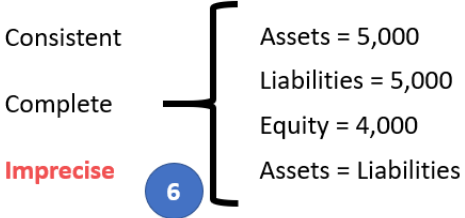
<sup>63</sup> XBRL Formula consistency crosscheck rule Assets = Liabilities + Equity, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/Consistency-5-Code-BS01-formula.xml>

<sup>64</sup> XBRL Formula derivation rule to impute Liabilities, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/ImputeRule-Key-1-Code-BS-Impute-01-formula.xml>

### State 6: Imprecise

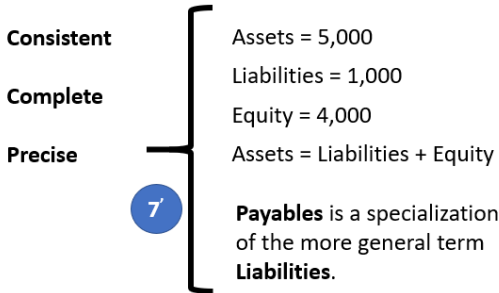
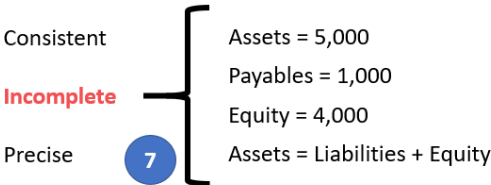
A logical system is a true and fair representation of some agreed upon realism. **Precision** is a measure of how precisely you do or can represent the information of a domain within a logical theory. The reality that we formalized in state #1 indicates that "Assets = Liabilities + Equity". Yet, in the state #6 example, the rule "Assets = Liabilities" was provided. Further, the values of Assets and Liabilities are, in fact, consistent with the rule that has been provided.

Remember that in state #1 we formalized our truth to be that "Assets = Liabilities + Equity". As such, this logical system can be described as being imprecise. To make this logical system precise, all that needs to be done is to fix the rule.



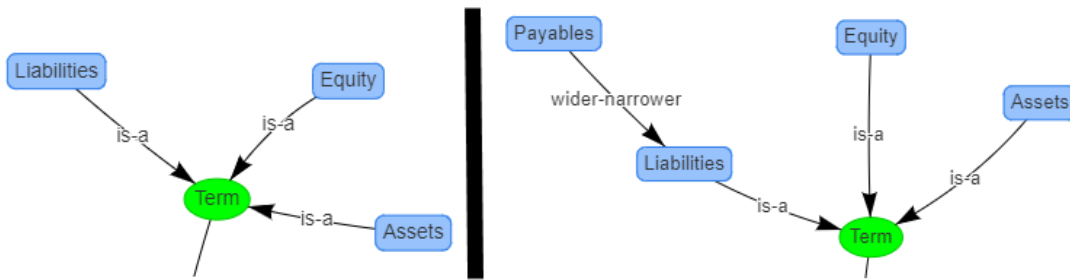
### State 7: Extension Concept

In state #7 on the left, what we are trying to convey is that the economic entity reported the fact for Liabilities using the extension concept "Payables" that it had created. If a fact is represented using an extension concept created by a reporting entity; then a "general-special" or "wider-narrower" or "class-equivalentClass" association must be created to indicate to software applications of the relationship so that information can be used correctly. State #7' on the right, the rule "Payables is a specialization of the more general term Liabilities" has been added to the logical system which allows the system to operate effectively<sup>65</sup>.



And so, the graphic below shows a fragment of the knowledge graph on page 9 above before and after the information that "Payables is a specialization of the more general term Liabilities," was added. On the left you see State 7, the taxonomy before the information was added and on the right you see "Payable" being added as an extension concept indicating that there is a "wider-narrower" relationship between Payables and Liabilities. Therefore, a machine based process can utilize the information per State 7' because the process understands Liabilities in the taxonomy, understands the "wider-narrower" relationship therefore knowing that "Payables" is a type of Liability.

<sup>65</sup> XBRL Definition relations showing example of a mapping rule, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/fac-mapping-definition.xml>

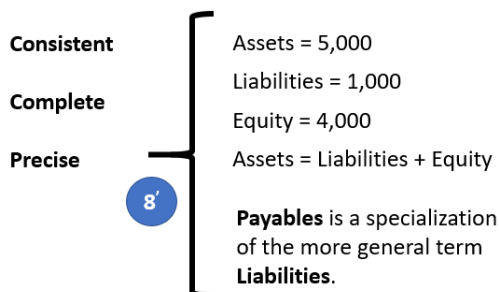
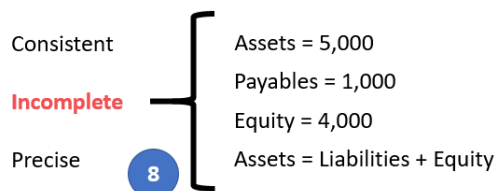


### State 8: Base Taxonomy Wider/Narrower Concept Use

State #8 on the left below is similar to state #7 in that a different concept is used to report a fact; but while state #7 focuses on using an extension concept; state #8 points out that using a wider or narrower base taxonomy concept gives exactly the same result.

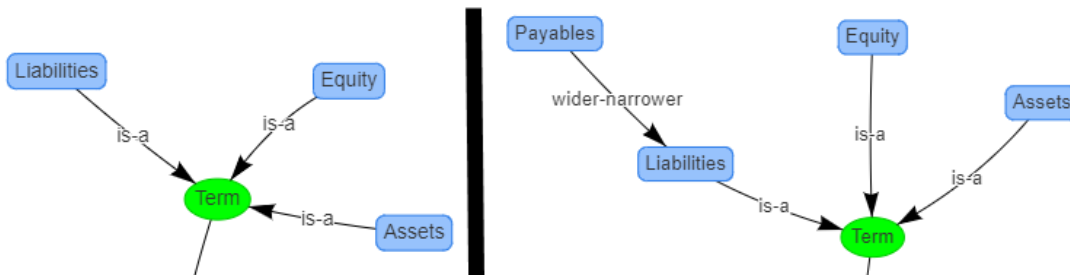
Now, our base state #1 does not have the concept "Payables"; but let's assume for a moment that it does have the concept "Payables". Also suppose that there was no information in the base logical system indicating the relationship between "Payables" and any other concept. If a fact is represented using a BASE TAXONOMY CONCEPT by a reporting entity; then a "general-special" or "wider-narrower" or "type-subtype" association must exist in that base taxonomy to indicate that some concept is a permissible alternative for some other concept.

State #8' on the right adds the rule "Payables is a specialization of the more general term Liabilities"<sup>66</sup>.



And so, the graphic below shows a fragment of the knowledge graph on page 9 above before and after the information that "Payables is a specialization of the more general term Liabilities," was added. On the left you see State 8, the base taxonomy before the information was added and on the right you see "Payable" being added as an extension concept indicating that there is a "wider-narrower" relationship between Payables and Liabilities. Therefore, a machine based process can utilize the information per State 8' because the process understands Liabilities in the base taxonomy, understands the "wider-narrower" relationship therefore knowing that "Payables" is a type of Liability.

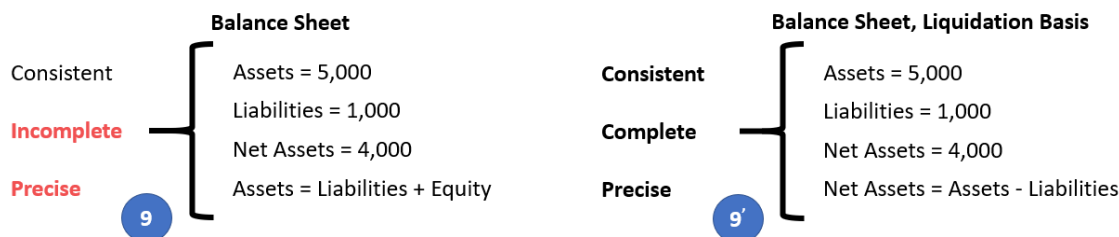
<sup>66</sup> XBRL Definition relations showing example of a mapping rule, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/fac-mapping-definition.xml>



## State 9: Defining a Completely New Structure

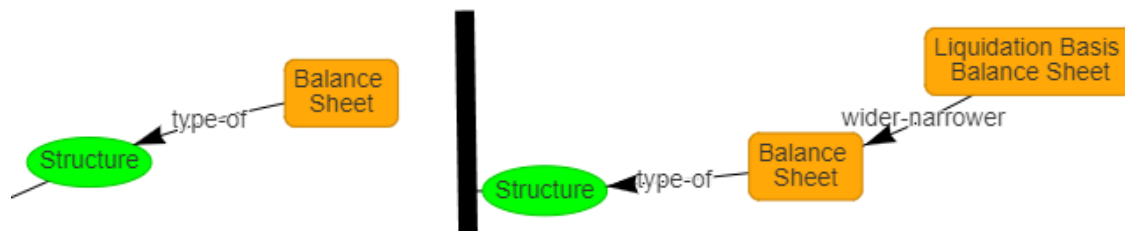
State #9 below on the left focuses on the structure as contrast all the prior examples which focused on the terms and rules. If a new structure is created, the new structure must be referenced to the base taxonomy and the new structure needs to be explained using machine-readable rules<sup>67</sup>. Even base taxonomy structures need to be defined in order to be referred to<sup>68</sup>. When you say "Balance Sheet" you know what that means. But a machine does not know.

A base taxonomy should (a) provide all necessary structures separately, not intermingle different models in the same set of associations and (b) define what each structure must look like. Remember, computers are like babies and need to be led by the hand in order to understand the details you need them to understand.



Finally, in our case we have only one disclosure, the Balance Sheet. In our case, the Balance Sheet is always required to be reported per this logical system. As such, that rule is stated in a machine-readable reporting checklist<sup>69</sup>. Other logical systems with more disclosures will have more rules relating to when a disclosure is required to be provided in a report.

Similar to how "Payables" was added as an extension of the terms in the logical system; we can extend the structures to include a "Liquidation Basis Balance Sheet" structure which is a specialization of a Balance Sheet:



<sup>67</sup> XBRL Definition relations used to represent structure rules, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/dm-1355-rules-def.xml>

<sup>68</sup> XBRL taxonomy schema used to define "Balance Sheet", <http://xbrlsite.azurewebsites.net/2020/core/master-ae/disclosures.xsd>

<sup>69</sup> XBRL Definition relations used to represent a reporting checklist or disclosure rules, <http://xbrlsite.azurewebsites.net/2020/core/master-ae/reporting-checklist-rules-def.xml>

And such, an automated process will be able to understand the new structure because it is related to an existing structure. Other structures could be added and only identified as a type of structure.

\* \* \*

# Appendices

The following is additional helpful information that can help business professionals get their heads around logical systems.

## **Symbolic Systems**

Stanford University has a unique undergraduate or graduate major offering called the Symbolic Systems Program<sup>70</sup>.

So, what is a symbolic system? Per the associate director of the program when interviewed by The Stanford Daily<sup>71</sup>:

“[The major is] a combination of studying the human mind ... and the intelligence of machines and of the design interaction that happens between them, [as well as] how those things can inform each other,” said symbolic systems associate director Todd Davies ’84 M.S. ’85 Ph.D. ’95 in an interview with The Daily.

A symbol is something that represents something else. Symbols can be arranged into structures such as lists, hierarchies, or networks and these structures show how symbols relate to each other.

A **symbolic system** is essentially a system built with symbols such as natural language, programming languages, mathematics, or formal logic. Symbolic artificial intelligence<sup>72</sup> uses symbolic systems and rules to restrict systems to operate within permitted boundaries and to reason against the system.

An interesting thing is that symbolic systems are understandable by both humans and by computers.

You can get a more detailed understanding of symbolic systems from the Stanford Bulletin<sup>73</sup> which describes the course. Cognitive science<sup>74</sup> is somewhat similar to symbolic systems. Computational linguistics<sup>75</sup> is also somewhat similar.

Why is this important?

In his book *Saving Capitalism*<sup>76</sup>, Robert Reich describes three categories that all modern work/jobs fit into:

- **Routine production services** which entail repetitive tasks,
- **In-person services** where you physically have to be there because human touch was essential to the tasks,
- **Symbolic-analytic services** which include problem solving, problem identification, and strategic thinking that go into the manipulation of symbols (data, words, oral and visual representations).

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<sup>70</sup> Stanford University, *Symbolic Systems Program*, <https://symsys.stanford.edu/about/span-dig-deep-solve-complex-problems>

<sup>71</sup> Stanford University, *The Stanford Daily*, <https://www.stanforddaily.com/2019/01/23/unique-to-stanford-symbolic-systems/>

<sup>72</sup> Wikipedia, *Symbolic Artificial Intelligence*, [https://en.wikipedia.org/wiki/Symbolic\\_artificial\\_intelligence](https://en.wikipedia.org/wiki/Symbolic_artificial_intelligence)

<sup>73</sup> Stanford University, *Stanford Bulletin*, <https://exploreddegrees.stanford.edu/schoolofhumanitiesandsciences/symbolicsystems/>

<sup>74</sup> Wikipedia, *Cognitive Science*, [https://en.wikipedia.org/wiki/Cognitive\\_science](https://en.wikipedia.org/wiki/Cognitive_science)

<sup>75</sup> Wikipedia, *Computational Linguistics*, [https://en.wikipedia.org/wiki/Computational\\_linguistics](https://en.wikipedia.org/wiki/Computational_linguistics)

<sup>76</sup> Robert Reich, *Saving Capitalism*, page 204-206), <https://www.amazon.com/Saving-Capitalism-Many-Not-Few/dp/0345806220>

In describing the third category, symbolic-analytic services, Mr. Reich elaborates:

“In essence this work is to rearrange abstract symbols using a variety of analytic and creative tools - mathematical algorithms, legal arguments, financial gimmicks, scientific principles, powerful words and phrases, visual patterns, psychological insights, and other techniques for solving conceptual puzzles. Such manipulations improve efficiency-accomplishing tasks more accurately and quickly-or they better entertain, amuse, inform, or fascinate the human mind.”

Think Computational Law<sup>77</sup> and Computational Audit<sup>78</sup>. Many tasks in accounting, reporting, auditing, and analysis are related to symbolic-analytic services and rearranging abstract symbols. As I pointed out a while back, the "Learn to code" is a hysteria and is misguided. If you want to understand things like how artificial intelligence actually works and how it will impact accounting, reporting, auditing, and analysis; study symbolic systems.

A logical system is a type of symbolic system. A logical theory can describe a logical system; for example, the *Logical Theory Describing Financial Report*<sup>79</sup> describes the financial report logical system. Not only is a financial report a type of logical system; that logical system can be readable and understandable by both humans and by machines.

## ***Knowledge Based Systems (Artificial Intelligence)***

The document *Expert System for Creating Financial Reports*<sup>80</sup> outlines the vision of a rules-based expert system for creating financial reports that leverages explainable artificial intelligence (XAI)<sup>81</sup>. This vision is based on working software applications, working proof of concepts, reverse engineering of XBRL-based financial reports submitted to the SEC.

There are two approaches to **artificial intelligence** and, as I have said before, the right approach should be used for the given job<sup>82</sup>. The two approaches are:

- **Rules-based systems** (symbolic systems, good at reasoning, expert systems, three basic types)
  - **Classification or diagnosis type:** helps users of the system select from a set of given alternatives.
  - **Construction type:** helps users of the system assemble something from given primitive components.
  - **Simulation type:** helps users of the system understand how some model reacts to certain inputs.
- **Patterns-based systems** (non-symbolic systems, good at learning, machine learning which can be supervised or unsupervised, five basic types<sup>83</sup>)
  - **Clustering algorithms:** categorize or group things

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<sup>77</sup> *Computational Law*, <http://xbrl.squarespace.com/journal/2020/8/24/computational-law.html>

<sup>78</sup> *Computational Audit*, <http://xbrl.squarespace.com/journal/2020/8/25/computational-audit.html>

<sup>79</sup> *Logical Theory Describing Financial Report*, [http://www.xbrlsite.com/mastering/Part02\\_Chapter05.B\\_LogicalTheoryDescribingFinancialReport.pdf](http://www.xbrlsite.com/mastering/Part02_Chapter05.B_LogicalTheoryDescribingFinancialReport.pdf)

<sup>80</sup> Charles Hoffman, CPA, *Expert System for Creating Financial Reports*, <http://xbrlsite.azurewebsites.net/2022/Library/ExpertSystemForCreatingFinancialReports.pdf>







<sup>81</sup> *Effective Automated Information Exchange and Explainable AI (XAI)*, <http://xbrl.squarespace.com/journal/2022/3/21/effective-automated-information-exchange-and-explainable-ai.html>

<sup>82</sup> *Use the Right Artificial Intelligence Approach for the Job*, <http://xbrl.squarespace.com/journal/2019/7/12/use-the-right-artificial-intelligence-approach-for-the-job.html>

<sup>83</sup> EDUCBA, *Machine Learning Models*, <https://www.educba.com/machine-learning-models/>

- **Explanatory algorithms:** explain the relationships between variables
- **Ensemble learning algorithms:** use multiple models
- **Similarity algorithms:** compute the similarity of pairs of things
- **Dimensionality reduction algorithms:** reduces variables in a dataset

Another helpful breakdown of pattern-based systems is provided by the article *Top Machine Learning Algorithms for Prediction: A Short Summary*<sup>84</sup>.

Name	Type	Description	Advantages	Disadvantages
Linear Regression		-The best fit line through all data points	-Easy to understand -you can clearly see what the biggest drivers of the model are.	-sometimes too simple to capture complex relationships between variables, -Tendency for the model to overfit.
Logistic Regression		-The adoption for linear regression to problems of classification	-Easy to understand	-sometimes too simple to capture complex relationships between variables, -Tendency for the model to overfit.
Decision Tree		-A graph that uses branching method to match all possible outcomes of a decision	-Easy to understand and implement.	-Not often used for prediction because it's also often too simple and not powerful enough for complex data.
Random Forest		- Takes the average of many decision trees. Each tree is weaker than the full decision tree, but combining them we get better overall performance.	-A sort of „wisdom of the crowd“, Tend to result in very high quality results. -Fast to train	-Can be slow to output predictions relative to other algorithms. -Not easy to understand predictions.
Gradient Boosting		-Uses even weaker decision trees that increasingly focused on „hard examples“	-High-performing	-A small change in the future set or training set can create radical changes in the model. -Not easy to understand predictions.
Neural Networks		-Mimics the behaviour of the brain. NNs are interconnected Neurons that pass messages to each other. Deep Learning uses several layers of NNs to put one after the other.	-Can handle extremely complex tasks. No other algorithm comes close in image recognition.	-very very slow to train. Because they have so many layers. Require a lot of power. -Almost impossible to understand predictions.

<sup>84</sup> Medium, *Top Machine Learning Algorithms for Prediction: A Short Summary*, [https://medium.com/@webadmin\\_46735/top-machine-learning-algorithms-for-predictions-a-short-overview-5ed1ff6942ff](https://medium.com/@webadmin_46735/top-machine-learning-algorithms-for-predictions-a-short-overview-5ed1ff6942ff)

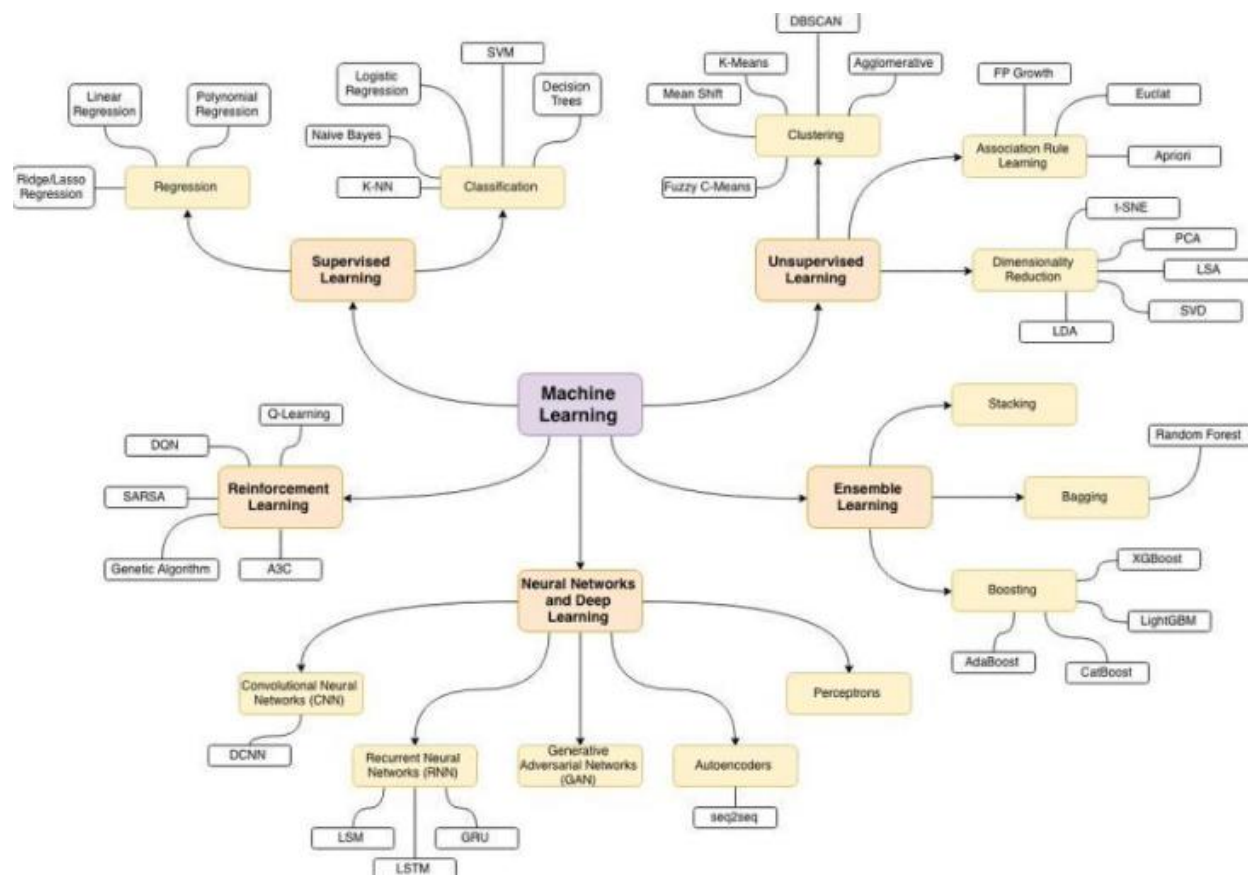
Currently, the expert systems working proof of concepts and commercial software that I have created and experimented with only leverage rules-based systems. But it is pretty clear that machine learning offers additional capabilities that will be inevitably leveraged.

Pacioli<sup>85</sup> is a logic/rules/reasoning/knowledge/insights engine. Frankly, I don't know exactly what to call Pacioli. At first, I called Pacioli a logic/rules/reasoning engine. Then I referred to it as a knowledge engine<sup>86</sup>. Now I am contemplating that Pacioli is an insights engine. For now, I consider Pacioli a logic/reasoning/rules/knowledge/insights engine in order to be complete, I guess.

Pacioli has three roles. The first role of Pacioli is to enforce the financial report logical schema and return information about where a financial report might be violating that logical schema. This is helpful in the process of creating XBRL-based financial reports.

The second role of Pacioli is to leverage the machine-readable logical schema to work with the information that makes up the financial report knowledge graph<sup>87</sup>.

The third role of Pacioli, which similarly leverages the machine-readable logical schema and financial report knowledge graph is effectively extracting information for financial analysis.



<sup>85</sup> Auditchain, *Pacioli Logic and Rules Engine*, <https://docs.auditchain.finance/auditchain-protocol/pacioli-logic-and-rules-engine>

<sup>86</sup> *Pacioli: an XBRL Knowledge Engine*, <http://xbrl.squarespace.com/journal/2022/2/19/pacioli-an-xbrl-knowledge-engine.html>

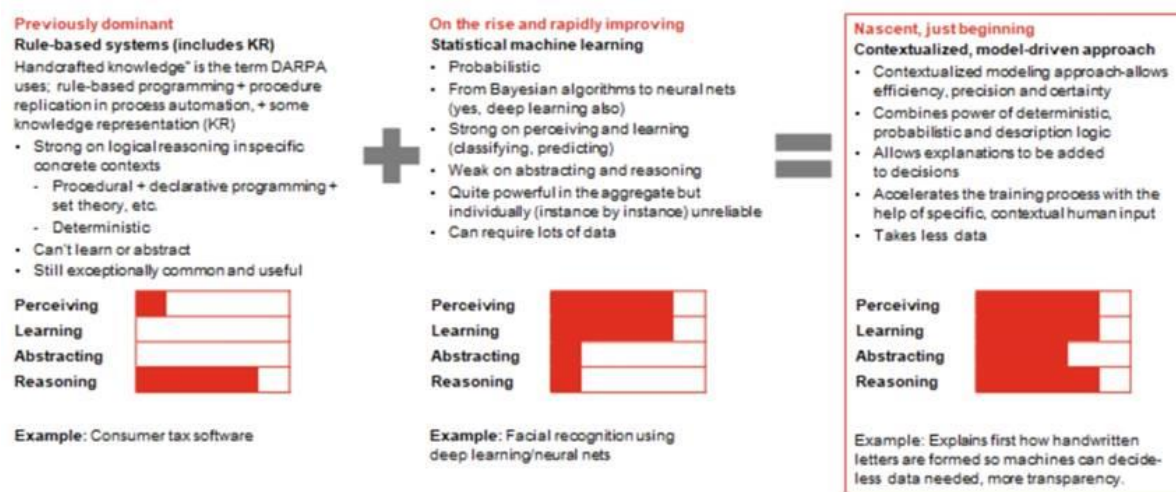
<sup>87</sup> Charles Hoffman, CPA, *Financial Report Knowledge Graphs*, <http://xbrlsite.azurewebsites.net/2021/Library/FinancialReportKnowledgeGraphs.pdf>

## Programmed Ability to Process Information

Both symbolic systems and non-symbolic systems offer useful capabilities<sup>88</sup>. Be sure to understand the capabilities of these different approaches and use the right tool for the job.

DARPA and PwC do an excellent job of explaining the capabilities of artificial intelligence. This presentation<sup>89</sup>, video<sup>90</sup> and this article<sup>91</sup> provide a summary worth reading.

### The key opportunity – Large-scale integration and model-driven intelligence in a de-siloed and de-duplicated way



John Launchbury of DARPA (<https://www.youtube.com/watch?v=N2L8AqkEDLs>), Estes Park Group and PwC research, 2017

PwC (Scaling the mirrorworld with the knowledge graph)

The graphic above shows three approaches to implementing artificial intelligence or the programmed ability to process information. Auditchain's Pacioli is a "rule-based system" that uses "handcrafted knowledge" that I created (the LEFT SIDE). Statistical machine learning will be added (the MIDDLE) to Pacioli over time most likely. Ultimately, where Auditchain and others will end up is on the RIGHT side which is the combined capabilities of rules-based systems and statistical machine learning. I suspect that this will occur within three to five years.

Here is another explanation that was inspired from a DARPA presentation<sup>92</sup>. Artificial intelligence is defined as a "**programmed ability to process information**". Sure, software like, Excel and Word can process "stuff"; but they don't really understand anything about accounting, reporting, auditing, or analysis. By "understand", this is what is meant, paraphrasing from the DARPA explanations of these terms:

- **Perceive:** ability to perceive rich, complex, subtle information.
- **Learn:** ability to learn about that information within a specific environment such as within a financial report.

<sup>88</sup> Richa Bhatia, *Understanding the difference between Symbolic AI & Non Symbolic AI*, <https://analyticsindiamag.com/understanding-difference-symbolic-ai-non-symbolic-ai/>

<sup>89</sup> DARPA, *A DARPA Perspective on Artificial Intelligence*, <https://www.darpa.mil/attachments/AIFull.pdf>

<sup>90</sup> YouTube.com, *A DARPA Perspective on Artificial Intelligence*, <https://youtu.be/-O01G3tSypU>

<sup>91</sup> Quora, Alan 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?ch=2&oid=180785119&srid=Mru&target\\_type=answer](https://www.quora.com/What-is-the-relation-between-Semantic-Web-and-AI/answer/Alan-Morrison?ch=2&oid=180785119&srid=Mru&target_type=answer)

<sup>92</sup> DARPA, *A DARPA Perspective on Artificial Intelligence*, <https://www.darpa.mil/attachments/AIFull.pdf>

- **Abstract:** ability to create new meaning from existing information.
- **Reason:** ability to plan, ability to decide, ability to verify.

The following graph shows where most software currently is today in terms of helping accountants get their jobs done in terms of accounting knowledge (i.e. basically, you can think of this is the manual tasks and processes that is being done now)



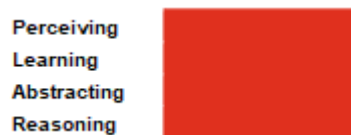
But this is where something like Auditchain's Pacioli is in terms of perceiving, learning, abstracting, reasoning when it comes to the information within a financial report: (Pacioli can do this NOW using my "handcrafted knowledge" a.k.a. standard machine-readable rules represented using XBRL)



The next graphic shows where Pacioli might ultimately go when statistical machine learning is combined with the rules-based system. The rules-based system's handcrafted rules act as a starter set of the rules needed to make the statistical machine learning work. Basically, the rules-based system focuses on what it can do best and the statistical machine learning focuses on what it can do best and the result is a combination of the two approaches: (Auditchain will be here in three to five years in my view)



The final graphic is what full automation looks like. To understand what "full automation" is one would need to understand the specific details of what is being automated. But also keep in mind that while automation might be possible for some things, for other things it really is not realistic or even necessary to automate to derive value from automation. Making a process 50% more efficient or even 25% more efficient or only 10% more efficient is still quite valuable.



To summarize, there are three very important points to remember here. First, the right artificial intelligence should be used for each automation task. Second, handcrafted metadata is necessary to make automation actually work. Finally, while it is easy to discuss automation in general high level terms; when you actually automate something you need to work with the details of what is being automated.

## **Models**

Without a model you have an undifferentiated mass of data<sup>93</sup> where there is no way which data can or should interact with other data. A model has little or no significance without the data to describe that model. But put the data and the model together and you get a dynamic web of information that seems almost magical.

Further, models can be used to turn general functionality into specific functionality to make systems easier to use. General functionality tends to be harder to use because it is more flexible because it needs to be more flexible because it is general.

Any large group trying to understand a complex phenomenon will find that process challenging. Models helps areas of knowledge make sense of unorganized information.

A model is an abstract description of something that hides certain unimportant details and illuminates other important details. Models help a group trying to describe an area of knowledge to do so effectively. Models do achieve this in the following important ways:

1. Models help groups of people in an area of knowledge to communicate.
2. Models describe, explain, and make predictions about that area of knowledge.
3. Models describe primitive phenomenon. Those primitive descriptions can then be used to describe complex phenomenon that is based on the primitive descriptions.
4. Models provide a way to orchestrate and mediate when you have multiple viewpoints. It is hard enough to get any two people to agree completely agree about something, let alone a significantly larger group. Models help groups represent commonalities while also understanding and exploring their differences.

Formal models are used in many different areas of knowledge when precision and objectivity are necessary. Models are not "black-and-white". Models organize human thought. Good models offer flexibility where flexibility is necessary.

A model is effectively a logical system. Let's walk you through a simple explanation of a logical system and how you can use a theory to describe such a system.

### **Standard Business Report Model (SBRM)**

The Object Management Group (OMG) is taking XBRL-based business reports to a new level, leveraging what has been learned from creating XBRL-based financial reports over the past 10 years. The Standard Business Report Model (SBRM)<sup>94</sup> is described as follows:

"SBRM formally documents a logical conceptualization of a business report in both human-readable and machine-readable models."

SBRM goes on to explain that through the use of standard models, business experts can define the structure and content of their reports and extensions using high-level logical business report objects, possibly presented in the form of semantic spreadsheets and pivot tables rather than with lower level technical syntax.

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<sup>93</sup> *Graph Hairball*, <https://digitalfinancialreporting.blogspot.com/2023/09/graph-hairball.html>

<sup>94</sup> *Object Management Group and Standard Business Report Model (SBRM)*, <http://xbrl.squarespace.com/journal/2019/6/25/object-management-group-and-the-standard-business-report-mod.html>

While XBRL has mainly been employed for financial reporting, leveraging the nature of financial accounting rules<sup>95</sup>; digital business reporting will benefit from the capabilities pioneered by XBRL-based financial reporting. Further, business reporting will not be limited to only one syntax but rather the arbitrary preferred syntax of can be used and systems can still be consistent with one conceptual model of a business report.

Financial reporting will likewise benefit from SBRM because SBRM helps business professionals and technical professionals constructing systems where flexible reporting is a requirement to effectively control variability and still have high-quality information exchanges.

## Further Reading

For more information please see:

- **Converging Paths to a Modern Approach to Financial Accounting, Reporting, Auditing, and Analysis**<sup>96</sup>
- **Logical Theory Describing Financial Report**<sup>97</sup>
- **Processing Logical Systems**<sup>98</sup>
- **Computer Empathy**<sup>99</sup>
- **Mastering XBRL-based Digital Financial Reporting**<sup>100</sup>
- **Special Purpose Logical Spreadsheet for Accountants**<sup>101</sup>

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<sup>95</sup> Charles Hoffman, *Leveraging the Theoretical and Mathematical Underpinnings of a Financial Report*, <http://xbrlsite.azurewebsites.net/2018/Library/TheoreticalAndMathematicalUnderpinningsOfFinancialReport.pdf>

<sup>96</sup> *Converging Paths to a Modern Approach to Financial Accounting, Reporting, Auditing, and Analysis*, <https://digitalfinancialreporting.blogspot.com/2023/09/converging-paths-to-modern-approach-to.html>

<sup>97</sup> *Logical Theory Describing Financial Report*, [http://www.xbrlsite.com/mastering/Part02\\_Chapter05.B\\_LogicalTheoryDescribingFinancialReport.pdf](http://www.xbrlsite.com/mastering/Part02_Chapter05.B_LogicalTheoryDescribingFinancialReport.pdf)

<sup>98</sup> *Processing Logical Systems*, [http://www.xbrlsite.com/mastering/Part05\\_Chapter08.A\\_ProcessingLogicalSystems.pdf](http://www.xbrlsite.com/mastering/Part05_Chapter08.A_ProcessingLogicalSystems.pdf)

<sup>99</sup> *Computer Empathy*, [http://www.xbrlsite.com/mastering/Part00\\_Chapter01.C\\_ComputerEmpathy.pdf](http://www.xbrlsite.com/mastering/Part00_Chapter01.C_ComputerEmpathy.pdf)

<sup>100</sup> *Mastering XBRL-based Digital Financial Reporting*, <http://xbrl.squarespace.com/mastering-xbrl/>

<sup>101</sup> Charles Hoffman, CPA, *Special Purpose Logical Spreadsheet for Accountants*, <http://www.xbrlsite.com/2023/Library/SpecialPurposeLogicalSpreadsheetsForAccountants.pdf>