

Closing the Skills Gap:

Specifics as to what professional accountants need to learn to survive and thrive in the digital age of accounting, reporting, and auditing

By Charles Hoffman, CPA (Charles.Hoffman@me.com)

Last Revised – January 31, 2018 (DRAFT)

“I skate to where the puck is going to be, not where it has been.” Wayne Gretzky, legendary Canadian hockey star.

Executive summary:

- Changes that will be brought about by what is being called “the artificial intelligence revolution” among other terms will unquestionably be significant. It is not useful to overstate or understate the impact¹.
- A gap exists between what professional accountants understand today and what they need to understand to survive and thrive in the digital age of accounting, reporting, and auditing.
- This gap in understanding capabilities of technologies such as artificial intelligence makes it difficult for professional accountants to grasp the changes that are not only inevitable but are imminent.
- Undergraduate and graduate college curriculums need to be updated for these changes. Continuing professional education offered likewise needs to be updated.
- The “learn to code” hysteria is not the right answer. Having professional accountants become more proficient with information technology or computer skills is likewise not the right answer for most professional accountants.
- Computers work per the rules of mathematics. Mathematics works per the rules of logic. The primary gap that needs to be filled is for professional accountants to gain a sound understanding of how computers actually work and the skills necessary to leverage these very useful tools of the digital age of accounting, reporting, and auditing appropriately. Understanding the basics of logic is the key to prospering in the digital age.
- Business logic can be used by professional accountants and other business professionals who have little or no formal training in logic. A sound understanding of business logic enables effective communications with information technology professionals.
- The artificial intelligence revolution will not only impact accounting professionals, rather all business professionals will be impacted. Closing this knowledge gap sooner rather than later can help position professional accountants as leaders for the digital age of accounting, reporting, and auditing.

¹ Charles Hoffman, *Getting Ready for the Digital Age of Accounting, Reporting and Auditing: a Guide for Professional Accountants*, <http://xbrlsite.azurewebsites.net/2017/Library/GettingReadyForTheDigitalAgeOfAccounting.pdf>

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Ripe for change

The institution of accountancy is ripe for change. A perfect storm has formed that has enabled changes that will significantly change not only the institution of accountancy, but almost everything. Old, approaches can be replaced by new more efficient and effective approaches. To understand this, professional accountants need to understand that a paradigm shift has occurred; old maps will not work to understand the coming changes. Work tasks will be transformed.

A Perfect Storm

Accounting, which has existed for 10,000 years², even before the creation of formal number systems, is constantly evolving. The institution of accountancy is about to go through another significant phase in that evolution process. Professional accountants who adapt will thrive.

Professional accountants, whose jobs seem secure, are perhaps feeling threatened by technology. This threat by artificial intelligence and other technologies, perhaps, generates fear, uncertainty, doubt and maybe even dread within many different job categories. However, as long as professional accountants are willing and able to adapt to these changes, most professional accountants should be well-positioned to create more value than ever, augmented by machines that they understand how to work with and leverage.

A perfect storm has formed which is driving change not only for the institution of accountancy; rather this change will impact virtually every institution, every organization, every person, and every process. Universal connectivity enabled by the internet brings everything together into one interconnected network of information. Powerful computer hardware that can run powerful software provides almost limitless possibilities. Maturing technologies and techniques such as artificial intelligence that offer increased capabilities for computers to solve problems. Mature and standardized business domain business logic, such as US GAAP and International Financial Reporting Standards (IFRS) that enable precise communication of very complex information. Machine-readable knowledge such as the US GAAP and IFRS XBRL Taxonomies that is useable by both machines and by humans to precisely understand complex knowledge.

Business Professionals Augmented by Machines

Some call it *The Digital Industrial Revolution*³. Others refer to the changes as *Industry 4.0*^{4,5}. And others call it the *Artificial Intelligence Revolution*^{6,7}. You might have heard other terms to

² Wikipedia, *History of Accounting*, retrieved June 10, 2017, https://en.wikipedia.org/wiki/History_of_accounting

³ National Public Radio, TED Radio Hour, *The Industrial Revolution*, retrieved May 4, 2017, <https://www.npr.org/player/embed/524731597/524879464>

⁴ Cornelius Baur and Dominik Wee, McKinsey & Company, *Manufacturing's Next Act*, <http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act>

⁵ PriceWaterhouseCoopers, *Industry 4.0: Building the digital enterprise*, <http://www.pwc.com/gx/en/industries/industry-4.0.html>

describe the rapid technology changes that are occurring around the world. It does not really matter what you call it. What is important to understand is that work will be performed differently in the very near future. Changes will occur and the changes will be significant.

Professional accountants and other business professionals will team with computers more to get work done. This teaming is natural. This teaming is much like how professional accountants use calculators to augment their capabilities to perform mathematics more efficiently.

The Economist predicts⁸ that 94% of accounting jobs will be replaced by computers over the next 20 years. That percentage is 98% for accounting clerks, audit clerks, and bookkeepers. While predictions may, perhaps, be overstated; change to some degree is not only inevitable, that change is imminent.

Techno-optimists tend to overstate what change will bring. Overzealous predictions are not helpful. On the other hand, business professionals tend to understate what change will bring, minimizing productivity increases that might be possible because, perhaps, they don't particularly care for change or because they really don't understand the technology enough to make accurate predictions.

This paper strives to cut through the rhetoric and provide professional accountants with the information they need to understand, evaluate, and leverage the maturing technologies which will surely have a very significant impact on every business professional and every company in business today. This paper provides details about specific skills professional accountants need to acquire in order to even understand the changes that are inevitable and imminent related to accounting, reporting, and auditing.

Antiquated Old School Accounting, Reporting, and Auditing Practices and Procedures

The following are descriptions of the current state of accounting, reporting, and auditing processes that are generally used today.

Accounting

⁶ Steven Levy, *Wired, The AI Revolution is On*, https://www.wired.com/2010/12/ff_ai_essay_airevolution/

⁷ Wired, The President in Conversation With MIT's Joi Ito and WIRED's Scott Dadich, *Barack Obama, Neural Nets, Self-driving Cars, and the Future of the World*, <https://www.wired.com/2016/10/president-obama-mit-joi-ito-interview/>

⁸ The Economist, Jan 18, 2014, *The future of jobs: The onrushing wave*, <http://www.economist.com/news/briefing/21594264-previous-technological-innovation-has-always-delivered-more-long-run-employment-not-less>

Blackline⁹, an accounting process automation software vendor, describes the accounting process:

“Most finance organizations still cope with a rigid accounting system. Their accountants do basic bookkeeping until the end of the accounting period, with their noses kept to the grindstone to close the books accurately and on time. Every company accountant will attest to the hardships of their period-end tasks, working long days into late evenings, and eating lunch and dinner at their desks. Exhausted to the point of burnout, they’re more likely to make errors at a time when data accuracy counts most.”

“While technology has revolutionized the modern business world, the record-to-report process has remained unchanged since the days of Lotus Notes and 18in paper. ERP systems and spreadsheets are still the only traditional tools available to today’s accounting and finance professionals, and while this is accepted by many as **“the way it’s always been done,”** it results in a time-consuming, inefficient process that is fraught with risk. Talented accountants are spending most of their time performing rote tasks that take them away from value-adding activities, like the enhanced analysis and strategy that drew them to this profession in the first place.”

“With transaction volumes increasing exponentially, however, throwing more resources at the problem is no longer an effective or sustainable solution. And with staff mired in mundane, low-value tasks, engagement is on the decline at a time when focusing on analysis and increasing productivity is more important than ever.”

This is not a unique description of the accounting process.

Reporting

By all accounts, the process of creating an external financial report is an extremely inefficient and outdated process. Here is a list of how some describe that process:

- The CFA Institute calls for “...greater efficiencies within the current inefficient system” [of creating financial reports]¹⁰.
- The consultancy Gartner points out, “...average Fortune 1000 company used more than 800 spreadsheets to prepare its financial statements”¹¹
- Ventana Research says, “...for larger companies, assembling the periodic external reports typically is an inefficient and error-prone process.”¹²

⁹ Blackline, Accounting Process Automation, <https://www.blackline.com/accounting-process-automation>

¹⁰ CFA Institute, *DATA AND TECHNOLOGY: TRANSFORMING THE FINANCIAL INFORMATION LANDSCAPE*, June 2016, <http://www.cfapubs.org/doi/pdf/10.2469/ccb.v2016.n7.1>

¹¹ Nigel Rayner, Neil Chandler, *XBRL Will Enhance Corporate Disclosure and Corporate Performance Management*, April 23, 2008, <http://unstats.un.org/unsd/nationalaccount/workshops/2008/newyork/IG22.PDF>

- PriceWaterhouseCoopers points out, "...old school manual processes..." and "commonly cut and pasted, rekeyed, or manually transferred into word processing and spreadsheet applications used for report assembly and review process steps"¹³

While the process of creating an external financial report might not seem inefficient when being measured against current practices, procedures, processes, and mentalities of those thinking that the way financial reports are created is "the only way" to create such reports; and while it is hard to measure the effectiveness and efficiency of new practices, procedures, and processes because they don't exist yet; when new practices, procedures, and processes do exist the increase in productivity will be measurable and clear, and they will be substantial.

Auditing

In their paper, *Imagineering Audit 4.0*¹⁴, Jun Dai and Miklos A. Vasarhelyi point out that for a number of reasons auditors are not keeping up with advancing technology:

"Traditional manual audits (Audit 1.0) have existed for centuries fulfilling many needs. Although the IT audit (Audit 2.0) emerged in the 1970s, and most all businesses are currently computer based, only about 15 percent of auditors are IT enabled. This delay of IT adoption can be partially attributed to the conservatism and rigidity of the profession, as well as the calcifying effect of increasingly obsolete regulation, but also to the lack of quality tools that would allow traditional auditors to automate the functions that they currently perform manually."

"The map is not the territory"

The territory is changing. A paradigm shift has occurred. But accountants and auditors are using the same map, or mental model, to think about accounting and auditing. That map is outdated. As Stephen Covey pointed out in his seminal book, *The Seven Habits of Highly Effective People*¹⁵, it is like being in Chicago and having a map of Detroit and trying to use that map of Detroit to make it to a specific location in Chicago. It is very frustrating and tends to be ineffective.

In order to understand the changes that are occurring we first need to help professional accountants update their mental map for thinking about computers, accounting, reporting, and auditing. The paradigm has already shifted, the world has changed and there is no going back.

¹² Robert Kugel, Ventana Research: Making XBRL Reporting Easy, February 13, 2009,

<http://businessfinancemag.com/technology/ventana-research-making-xbrl-reporting-easy>

¹³ Mike Willis, PriceWaterhouseCoopers, Disclosure management: Streamlining the Last Mile, March 2012,

<https://www.pwc.com/gx/en/xbrl/pdf/pwc-streamlining-last-mile-report.pdf>

¹⁴ Jun Dai and Miklos A. Vasarhelyi (2016) *Imagineering Audit 4.0*. Journal of Emerging Technologies in Accounting: Spring 2016, Vol. 13, No. 1, pp. 1-15.; <http://aaajournals.org/doi/abs/10.2308/jeta-10494>

¹⁵ Stephen R. Covey, *The Seven Habits of Highly Effective People*, page 23.

Rearranging Abstract Symbols

Computers sometimes seem to perform magic. But computers are really simply machines that follow very specific instructions. Skilled craftsmen, who wield their tools effectively, providing the correct machine-readable instructions, create what seems to be magic.

In his book *Saving Capitalism*¹⁶, Robert Reich describes three categories that all modern work/jobs fit into:

- **Routine production services** which entails 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).

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.”

Many tasks in accounting, financial reporting, and auditing are related to symbolic-analytic services.

Shelly Palmer breaks work tasks down in another way¹⁷. He points out that almost every human job requires us to perform some combination of the following four basic types of tasks:

- Manual repetitive (predictable)
- Manual nonrepetitive (not predictable)
- Cognitive repetitive (predictable)
- Cognitive nonrepetitive (not predictable)

Manual involves using one's hands or physical action to perform work. *Cognitive* involves using one's brain or mental action or a mental process of acquiring knowledge/understanding through thought, experience, use of the senses, or intuition. Predictable manual or cognitive

¹⁶ Robert B. Reich, *Saving Capitalism*, Alfred A. Knopf, page 204-206, (see a summary from *The Work of Nations* here http://www.oss.net/dynamaster/file_archive/040320/e8eb8748abfe77204a145d5fbcc892fb/QSS1993-01-37.pdf#page=6)

¹⁷ Shelly Palmer, *The 5 Jobs Robots Will Take Last*, <https://www.linkedin.com/pulse/5-jobs-robots-take-last-shelly-palmer>

tasks can be automated. Unpredictable manual or cognitive tasks cannot be automated. He gives the example of an assembly line worker that performs mostly manual repetitive tasks which, depending on complexity and a cost/benefit analysis, can be automated. On the other hand, a CEO of a major multinational conglomerate performs mostly cognitive nonrepetitive tasks which are much harder to automate.

Ledgers, Tables, Spreadsheets, and Financial Reports are Abstract Ideas

A balance sheet and an income statement are abstract ideas invented by humans. The stuff in the report is symbols. Rearranging abstract symbols, such as the creation of such financial reports, can be achieved using human-based processes and tools or using machine-based processes and tools. Likely a combination of human and machine based processes will be employed in the future; humans performing the tasks they do best, computers performing tasks that they do best.

Accounting was invented around 10,000 years ago, about 5,000 years before the invention of numbers and writing¹⁸. Before the invention of paper, tokens were used to keep track of transactions. During the age of paper, marks on the surface of the paper were used to perform the task of accounting and reporting. In the digital age, bits in some sort of database are used to perform accounting and reporting tasks. Accounting, double entry bookkeeping, and financial reports are all inventions of merchants to perform some task necessary to enable commerce.

There is nothing natural about the ledger¹⁹. A ledger was an invention of man. The columns in a ledger are abstractions. The numbers and other information that go into the columns are symbols. The ledger is a useful idea. Professional accountants have used ledgers for many, many years.

A table²⁰ is likewise a useful idea, an abstraction. A table has rows. A table has columns. A table has cells which are the intersection of a row and a column. So actually, do you realize that a table can have way, way more than rows, columns, and cells? What about groups of rows. And how about groups of columns. What about a row that spans more than one column. You might not have known that there is actually a standard specification which describes tables, the CALS Table Model²¹. The spreadsheet²² is likewise an abstract idea.

¹⁸ Wyzant, Introduction to accounting, <https://www.wyzant.com/resources/lessons/accounting/introduction>

¹⁹ Wikipedia, *Ledger*, retrieved August 8, 2017, <https://en.wikipedia.org/wiki/Ledger>

²⁰ Wikipedia, *Table (Information)*, retrieved August 8, 2017, [https://en.wikipedia.org/wiki/Table_\(information\)](https://en.wikipedia.org/wiki/Table_(information))

²¹ Wikipedia, *CALS Table Model*, retrieved August 8, 2017, https://en.wikipedia.org/wiki/CALS_Table_Model

²² Wikipedia, *Spreadsheet*, retrieved August 8, 2017, <https://en.wikipedia.org/wiki/Spreadsheet>

Why would someone create a written specification for a table? Well, that is how you make it so machines can read a table and that tables created on one machine can also be read on another different machine. A specification explains how to create tables consistently, the patterns necessary to get a machine to be able to work with an electronic version of a table.

Harnessing the power of the dumb beasts

Computers are dumb beasts. However, if a skilled craftsmen uses the right tools; a computer can seem to perform magic.

Computers are General Purpose Machines

Professional accountants need to understand some fundamentals about how these machines that we call computers work and about their true capabilities.

Computers are machines. The first mechanical computers, called tabulating machines²³, were created in the 1900s. Since then the effectiveness and efficiency of those machines have improved by orders of magnitude. But fundamentally the machines we use today are no different than mechanical tabulating machines of the past. The key word here is machine.

A computer has two distinct parts: hardware and software. What makes computers such a unique and compelling tool is not the hardware, although that is very important; it is the software. Most machines tend to do one thing. Computers are extremely useful tools because by changing only software you can make the computer do different things. And because software is flexible, you can make a computer perform many, many different tasks. Computers are general purpose machines.

Computers are Dumb Beasts

Important to understanding how to get computers to do what you want is understanding how computers actually work. The strengths of computers and the obstacles that get in the way of using computers were summarized well by Andrew D. Spear²⁴; here is his list with some modifications made by me:

Fundamental strengths/capabilities of computers:

- **store** tremendous amounts of information reliably and efficiently
- **retrieve** tremendous amounts of information reliably and efficiently
- **process** stored information reliably and efficiently, mechanically repeating the same process over and over

²³ Wikipedia, *Tabulating Machine*, https://en.wikipedia.org/wiki/Tabulating_machine

²⁴ Andrew D. Spear in his document, *Ontology for the Twenty First Century: An Introduction with Recommendations*, page 4

- make information **instantly accessible** to individuals and more importantly other machine-based processes anywhere on the planet in real time

Major obstacles to harnessing the power of computers:

- **business professional idiosyncrasies**; different business professionals use different terminologies to refer to exactly the same thing
- **information technology idiosyncrasies**; information technology professionals use different technology options, techniques, and formats to encode and store exactly the same information
- **inconsistent domain understanding** of and technology's limitations in expressing interconnections within a domain of knowledge
- **computers are dumb beasts**; computers don't understand themselves, the programs they run, or the information that they work with

Keep in mind that the information business professionals are trying to store and make use of is becoming more complex than what they have been storing in relational databases or spreadsheets for the past 50 years. For example, a financial report is complex information that is very difficult to store in a relational database and query across millions of such reports efficiently.

Standards Minimize but Don't Eliminate Idiosyncrasies

Standards can be created to minimize the idiosyncrasies of both business professionals and information technology professionals. A complete discussion of how standards can be useful in minimizing idiosyncrasies is beyond the scope of this document. But I will point out that standard shipping containers, uniform product codes, standard electrical outlets, standard measurement tools, and other such standards are quite useful.

That said, people will be people. Fads, trends, personal preferences, fallacies, misinformation and other dynamics impact people's choices. They always have and they always will.

As such, it is highly unlikely that you can get everyone to agree on something ever. So, multiple options can be a very good thing. Whether someone's needs are truly different or perceived to be different; having multiple alternatives rather than one single alternative can be a very good thing.

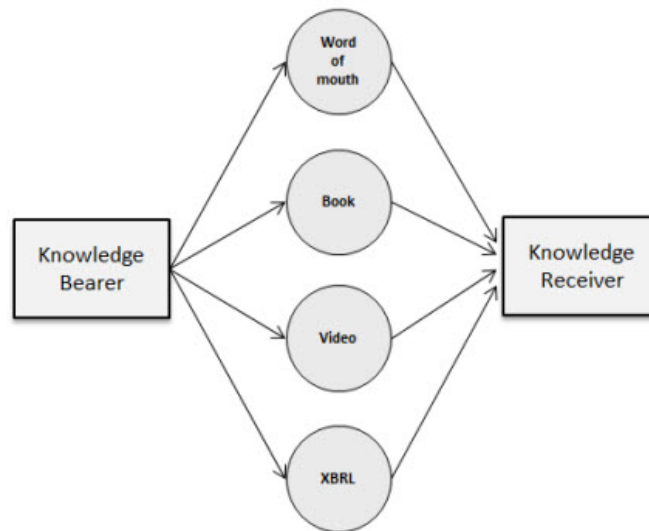
Except, when it is not. Agreeing to agree is great when it is possible.

There is truly art and science involved in properly balancing something to get that something to work in equilibrium.

The important thing to keep in mind is that standards do exist and when employed appropriately they can save a lot of time and money.

Role of Standards

The role of standards tends to be misunderstood and often under appreciated. These standards make things easier. There are many different standards such as intermodal shipping containers²⁵, universal product codes, the metric system, JPEG photo format, MPEG audio format, etc. Simply put, standards make things easier for users. XBRL is a global standard knowledge media²⁶.



In order to make use of a knowledge media effectively, the following three conditions must be satisfied:

1. **Easy for knowledge bearer to represent information:** The effort and difficulty required for the knowledge bearer to successfully formulate the knowledge in the medium must be as low as possible.
2. **Clear, consistent meaning:** The meaning conveyed by the knowledge bearer to the knowledge receiver must be clear and easily followed by human beings and be consistent between different software applications. The result cannot be a "black box" or a guessing game and users of the information should not be able to derive different knowledge simply by using a different software application.

²⁵ Wikipedia, *Intermodal shipping container*, https://en.wikipedia.org/wiki/Intermodal_container#Specifications

²⁶ *Understanding that XBRL is a Knowledge Media*, <http://xbrl.squarespace.com/journal/2017/1/16/understanding-that-xbrl-is-a-knowledge-media.html>

3. **High-quality information representation:** The form in which the knowledge is represented to the receiver must be as good as possible. The quality must be high whether the knowledge receiver is a human-being or an automated machine-based process. Sigma level 6²⁷ is a good benchmark, 99.99966% accuracy.

Classification Systems

Things in the world are defined by their relations to one another; these explicit relations matter in creating logical definitions. A classification system is a logical grouping of something based on some similarity or criteria. A classification system is a communications tool. A classification system structures information. A classification system can be informal or formal, more rigorously or less rigorously created, readable/usable by computers, or not. A classification system can be a controlled vocabulary. Classification systems can be categorized as follows:

- A **dictionary** or list is a classification system that tends to provide descriptions without much, or any, structure. Dictionaries or lists simply provide a flat inventory of terms with no relations expressed between the terms. (But even a dictionary classifies terms into noun, verb, adverb, etc.)
- A **taxonomy** is a classification system which tends to provide descriptions and a limited amount of structure generally in the form of one hierarchy into which some list of terms is categorized. Categories are basically sets. A taxonomy is a tree of categories of things with only one relation expressed so terms appear in only one location in a hierarchy of categories. A creator of a taxonomy creates concepts, creates coherent definitions for those concepts, and puts concepts into “buckets” or categories.
- An **ontology** is a classification system which tends to provide descriptions and multiple structures and therefore tends to have more than one hierarchy into which terms are categorized. So an ontology can be thought of as a set of taxonomies. An ontology can express many different types of relations which includes traits/qualities of each term. An ontology is less like a tree and more like a graph²⁸ (network theory). This distinction is very important. The creator of an ontology identifies and establishes models explaining how things in a given ontology are related to one another, the kinds of relationships that exist, the rules of the model. If an ontology provides enough information, it can describe a conceptual model.

²⁷ Wikipedia, *Sigma Levels*, retrieved February 24, 2016, https://en.wikipedia.org/wiki/Six_Sigma#Sigma_levels

²⁸ Wikipedia, *Network Theory*, retrieved February 24, 2016; https://en.wikipedia.org/wiki/Network_theory

Understanding Metadata; Third Order of Order

Putting data into a database is helpful. But if you don't construct your database correctly you might not have a solid foundation to build upon. While data is important, the real power of computers comes from adding metadata to your data.

David Wenberger's book *Everything Is Miscellaneous*²⁹ explains that there are three orders of order:

- **First order of order.** Putting books on shelves is an example the first order of order.
- **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. You can use the paper or database list to locate books.
- **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.

The solution to the information overload problem is to create more information: metadata. Metadata³⁰ is simply data that provides information about other data. Machine-readable metadata adds perspective and context to data. People sometimes get into philosophical debates about what is data and what is metadata, but this is to completely miss the point.

This is what you need to know about metadata. Metadata is a good thing. More metadata is better. Standard metadata is even better. An example of metadata is the card catalog of a library. Metadata is generally organized into some sort of classification system. There are three types of metadata³¹:

- **Descriptive:** describes and identifies information
- **Structural:** organizes the types and parts of information and how the parts are related to one another
- **Administrative:** provides other information that helps use some sort of system.

Acquiring a Thick Metadata Layer

A key ingredient to a computer-based system is metadata. The power of a computer system is proportional to the high-quality metadata available. What is not in dispute is the need for a

²⁹ David Wenberger, *Everything Is Miscellaneous*, https://books.google.com/books?id=KDDwp8zXCQMC&printsec=frontcover&dq=everything+is+miscellaneous&source=bl&ots=LJ55ZUklBG&sig=LMz39YbfNW1siYVT_O3TrryoHNQ&hl=en&ei=pctGTbniNYvksQOpkuTBCg&sa=X&oi=book_result&ct=result&sqi=2#v=onepage&q&f=false

³⁰ Wikipedia, *Metadata*, <https://en.wikipedia.org/wiki/Metadata>

³¹ YouTube, *Basics of Metadata*, <https://www.youtube.com/watch?v=-0vc6LeVa14>

"thick metadata layer" and the benefits of that metadata in terms of getting a computer to be able to perform useful and meaningful work.

But what is sometimes disputed is *how* to most effectively and efficiently get that thick metadata layer. There are two basic approaches to getting 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.
- **Tell the computer what the metadata is:** This approach leverages business domain experts and knowledge engineers to piece together the metadata so that the metadata becomes available.

Because knowledge acquisition can be slow and tedious, much of the future of computer systems depends on breaking the metadata 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.

There is a lot of talk about neural networks³² enabling things like machine learning³³ and deep learning³⁴. There are two important points that business professionals tend to miss or software vendors creating such software tend to leave out of their sales pitches. First, the amount of training³⁵ that is necessary to get a neural network to work correctly. The training process is time consuming, expensive and error prone.

Second, because the automated process is error prone; there are good uses for neural networks figuring out the “thick layer of metadata”, and there are very bad uses. One description of what neural networks are best for is the following:

Neural networks are universal approximators, and they work best if the system you are using them to model *has a high tolerance to error*. One would therefore not be advised to use a neural network to balance one's check book! However they work very well 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.

³² A Basic Introduction To Neural Networks, <http://pages.cs.wisc.edu/~bolo/shipyard/neural/local.html>

³³ Wikipedia, Machine Learning, retrieved August 29, 2016, https://en.wikipedia.org/wiki/Machine_learning

³⁴ Wikipedia, Deep Learning, retrieved August 29, 2016, https://en.wikipedia.org/wiki/Deep_learning

³⁵ Hugo Larochelle, et. al., Deep Learning and Applications in Neural Networks, <http://www.slideshare.net/hammawan/deep-neural-networks>

And so, the probability of a neural network figuring out something like the US GAAP Financial Reporting XBRL Taxonomy is basically zero. However, that said; if such metadata is created and then that human-created metadata is used to then train neural networks the probability that the neural network can create something useful goes up dramatically.

So, again, this is not an “either-or” proposition. This is about using the right tool for the right job and not being misguided by snake oil salesmen who don’t have your interest in mind.

Business Rules are Metadata

The Merriam-Webster dictionary defines anarchy³⁶ 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.” Business rules prevent information anarchy³⁷. Business rules are metadata.

Business rules guide, control, suggest, or influence behavior. Business 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. Business rules help shape judgment, help make decisions, help evaluate, help shape behavior, and help reach conclusions.

Business 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 problem domain.

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 are a choice of business professionals. The meaning of a business rule is separate from the level of enforcement someone might apply to the rule.

A business rule states a fact about the world (declarative rule). A business rule can provide instructions (production rule). Business rules are metadata.

Artificial Intelligence

Artificial intelligence³⁸ is a branch of computer science. There are many good descriptions of artificial intelligence³⁹. Here is one good definition:

³⁶ Anarchy definition, Merriam-Webster, <http://www.merriam-webster.com/dictionary/anarchy>

³⁷ *Understanding that Business Rules Prevent Anarchy*, <http://xbrl.squarespace.com/journal/2016/7/15/understanding-that-business-rules-prevent-anarchy.html>

³⁸ *Introduction to Artificial Intelligence Terminology*, <http://xbrl.squarespace.com/journal/2016/7/21/introduction-to-artificial-intelligence-terminology.html>

Artificial intelligence is the automation of activities that we associate with human thinking and activities such as decision making, problem solving, learning and so on.

Another more neutral term than artificial intelligence is the term machine intelligence⁴⁰ which has the same meaning. Think of these tools as narrowly focused employees with great memories that are very good at performing one specific repetitive task well, over, and over, and over. Literally, like a machine.

Those trying to make artificial intelligence work over the past 40 or so years have had limited success⁴¹. But that is changing. People are putting the pieces together and the technologies created from AI research are now available to experiment with. If expectations are not set too high, very useful functionality for limited, narrow problems can be successfully created. Both under estimating or over estimating the capabilities the computer software will be able to achieve can have catastrophic consequences.

One good example of using artificial intelligence is driverless cars. Many people get confused as to what is truly achievable and practical when it comes to driverless cars. Driverless cars are on the streets of Singapore today⁴². While still in prototype mode now to work out details, by 2018 these taxis are anticipated to be commercially available. Uber is testing autonomous cars in Pittsburg⁴³. Attempting to have a driverless car navigate the streets of a large city is a different problem than having a driverless truck navigate from one major city to another city on a freeway.

One of the best ways to understand the true capabilities of artificial intelligence is to try it out. Go test drive a Tesla which has driver-assist features.

Artificial intelligence programs that provide expert-level proficiency in solving problems by bringing to bear a body of knowledge about specific tasks are called knowledge based systems or expert systems. Artificial intelligence programs work using metadata.

There are two types of artificial intelligence, specialized and generalized:

- **Specialized:** An example of specialized artificial intelligence is programming a computer to play chess. The software performs one specific task. Specialized artificial intelligence is fairly easy to achieve.

³⁹ AlanTuring.net, *What is Artificial Intelligence?*,

http://www.alanturing.net/turing_archive/pages/reference%20articles/What%20is%20AI.html

⁴⁰ Shivon Zilis and James Cham, Harvard Business Review, *The Competitive Landscape for Machine Intelligence*, <https://hbr.org/2016/11/the-competitive-landscape-for-machine-intelligence>

⁴¹ John F. Sowa, *Why Has AI Failed? And How Can it Succeed?*, <http://www.jfsowa.com/pubs/micai.pdf>

⁴² Reuters, *First driverless taxis hit the streets of Singapore*, <http://www.reuters.com/article/us-autos-selfdriving-singapore-idUSKCN1100ZG>

⁴³ The Atlantic, *Anybody Can Test a Driverless Car in Pennsylvania*, <http://www.theatlantic.com/technology/archive/2016/09/anybody-can-test-a-self-driving-car-in-pennsylvania/499667/>

- **Generalized:** An example of generalized artificial intelligence is the sort of science-fiction stuff you see in the movies. With generalized artificial intelligence, computers can perform multiple tasks or be generally intelligent. Why do you only see this in the movies? Because generalized artificial intelligence is extremely hard to make work.

Generalized artificial intelligence is 50 to 100 years in the future if you ask most experts. And general intelligence might not even be achievable. But specialized artificial intelligence is here today.

Expert Systems

Expert systems⁴⁴ is a branch of artificial intelligence. Expert systems, also called knowledge based systems or simply knowledge systems, are computer programs. The following is one definition of an expert system:

Expert systems are computer programs that are built to mimic human behavior and knowledge. Expert systems are for reconstructing the expertise and reasoning capabilities of qualified experts within some limited, narrow domain of knowledge in machine-readable form. A model of the expertise of a domain of knowledge of the best practitioners or experts is formally represented in machine-readable form and the expert system reaches conclusions or takes actions based on that information when trying to solve some problem. The computer program performs tasks that would otherwise be performed by a human expert.

Expert systems are the most commercially successful applications of artificial intelligence research⁴⁵. There are currently thousands of expert systems employed world-wide in industry and government. Expert systems are driven by metadata.

Frank Puppe explains in his book *Systematic Introduction to Expert Systems*⁴⁶ that there are three general categories of expert systems:

- **Classification or diagnosis type:** helps users of the system select from a set of given alternatives. The system tends to be instructional in nature.
- **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 or create predictions based on the system.

⁴⁴ Understanding the Components of an Expert System, <http://xbri.squarespace.com/journal/2016/5/24/understanding-the-components-of-an-expert-system.html>

⁴⁵ Edward Feigenbaum et. al, *KNOWLEDGE-BASED SYSTEMS IN JAPAN*, <http://www.wtec.org/loyola/kb/execsum.htm>

⁴⁶ Frank Puppe, *Systematic Introduction to Expert Systems, Knowledge Representations and Problem-Solving Methods*, page 11 (Note that you can read Parts I and II on Google Books here, <https://books.google.com/books?id=kKqCAAQBAJ>)

The assembly of a financial report can be assisted by a construction-type expert system. Helping professional accountants understand what goes into that financial report can be assisted by a classification-type expert system. Creating forecasts and projections of future financial reports can be assisted by simulation-type expert systems.

Business Rules Engine

A business rules engine is a style of writing software. Anything achievable by a business rules engine is achievable by general functional programming. But, business rules engines can have an advantage in certain cases. For example, when you want to separate business logic from program logic and allow business professionals to control and maintain business rules.

A business rules engine, or rules engine, is a mechanism for executing business rules. Rules engines are optimized to figure out what rules apply to what facts and the order rules should be run and result is some consequence based on the facts and rules. A rules engine is a non-trivial application to create. The stronger the problem solving logic of the rules engine supports, the more powerful the rules engine.

Creating an Expert System or Knowledge Based System

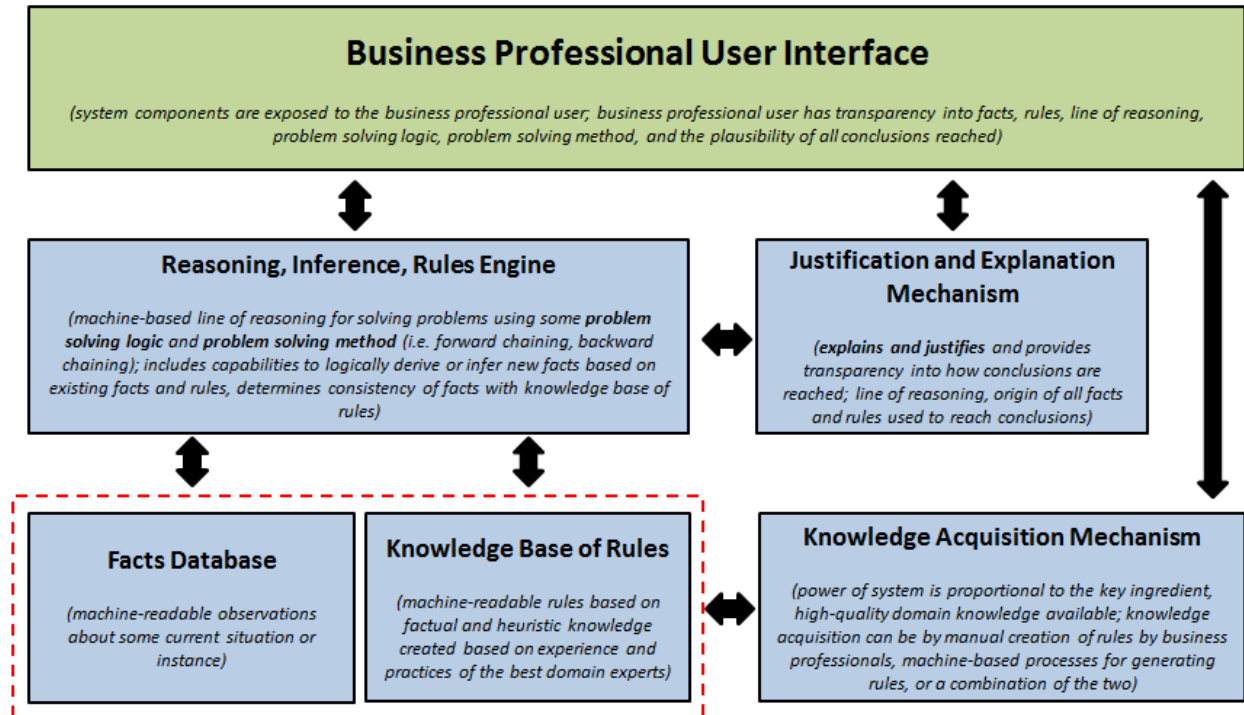
Creating a knowledge based system involves the transformation of machine-readable instructions in such a way as to explain to a machine how a system works and how to make a system work the way you want that system to work.

Then, brick-by-brick, much like building a house, business domain experts and software engineers can create tools that automate certain types of tasks in that process. Humans encode information, represent knowledge, and share meaning using machine-readable patterns, languages, and logic.

Components of a Knowledge Based System (Expert System)

Simply put, a **knowledge based system** is a system that draws upon the knowledge of human experts that has been represented in machine-readable form and 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.

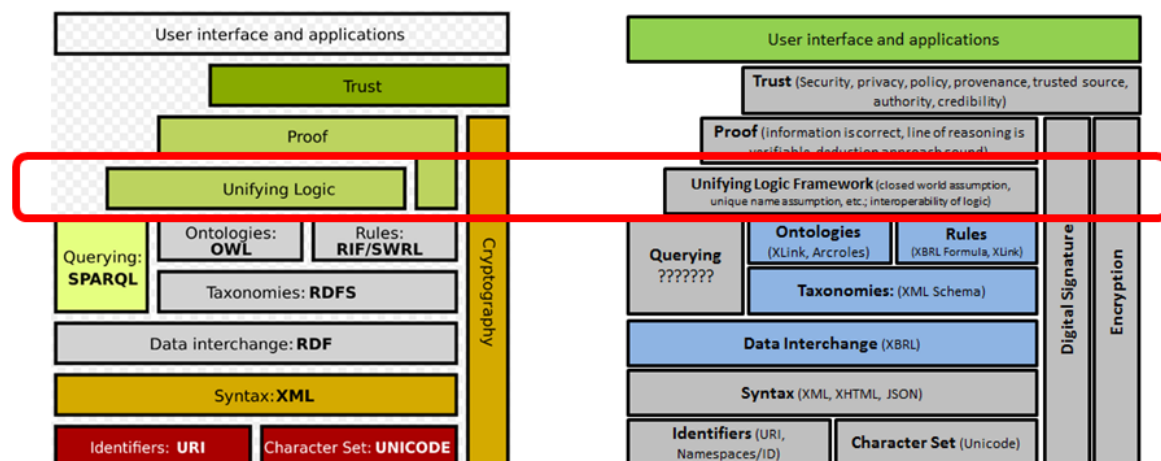
Nothing is a “black box”, rather every aspect of every decision made by a system is completely understandable to the business professional using the system. Below is a graphic of the components of a knowledge based system:



Multiple Technology Stacks

As was stated earlier; arbitrary preferences, fads, trends, misinformation, and many other things influence how information technology professionals solve the same problem. As such, there will always be multiple technology stacks as opposed to every information technology professional using exactly the same approach to solving what amounts to be exactly the same problem.

Consider the comparison of these two technology architecture stacks⁴⁷: Semantic Web Stack and XBRL Stack:



⁴⁷ Unifying Logic Framework for Business, <http://xbrl.squarespace.com/journal/2017/11/26/unifying-logic-framework-for-business.html>

Each of the technical architecture stacks has a problem solving logic. The Semantic Web Stack on the left calls it a “Unifying Logic” and the XBRL Stack calls it a “Unifying Logic Framework”.

The problem solving logic for the Semantic Web Stack is defined by the technical syntax offered by RDFS, OWL, RIF/SWIRL, SHACL. For the Semantic Web Stack, those technical syntaxes provide the boundaries for the problem solving logic. For the XBRL Stack, there really are no real boundaries outlined at all for the problem solving logic. Even if someone could provide the specifics of the problem solving power offered by RDFS, OWL, and RIF/SWIRL, SHACL; that list undoubtedly would not be understandable to professional accountants or other business professionals. But if business professionals are supposed to control and maintain business rules, then those business logic boundaries would best be clear and understandable. The bottom line here is that the boundaries of a problem solving logic should be understandable.

Representing business domain knowledge

Skilled craftsmen using the right tools can get the dumb beasts to perform magic. But it is not really magic that is occurring; it just seems like magic. What is really going on is shared realities are being created in order to leverage to capabilities of these machines in order to make things better, faster, and cheaper. The goal is to increase productivity.

Shared View of Reality to Achieve a Specific Purpose

In his book⁴⁸ *Data and Reality*, William Kent provides an excellent summary that discusses the realities of sharing information. In Chapter 9: *Philosophy* in the Third Edition and Chapter 12: *Philosophy* in the first edition (which is available online) he paints a picture of why you want to go through the trouble of sharing information using machine-based processes and the realities of what that takes. This is what William Kent points out which I have paraphrased as it relates to financial reporting:

To create a shared reality to achieve a specific purpose: To arrive at a shared common enough view of "true and fair representation of financial information" such that most of our working purposes, so that reality does appear to be objective and stable so that you can query information reliably, predictably, repeatedly, safely.

Meaningful information exchange that is reliable, repeatable, predictable, safe, cost effective, easy to use, robust, scalable, secure when necessary, auditable (track provenance) when necessary.

⁴⁸ William Kent, *Data and Reality*, Technics Publications, (See this resource which has CHAPTER 12: Philosophy from the first version of this book, <http://www.bkent.net/Doc/darxrp.htm>)

Prudence dictates that using the information contained in a digital financial report should not be a guessing game. Safe, reliable, repeatable, predictable, reuse of reported financial information using automated machine-based processes is obviously preferable to a guessing game.

The effective meaningful exchange of information is created by skilled craftsmen that know their craft well. The craftsmen balance the system, bringing the system into equilibrium to achieve some specific purpose. Creating this shared view of reality which allows this specific purpose to be achieved has benefit to the financial reporting supply chain.

That purpose should be clearly defined so that everyone understands the objective and exactly what the system can, and cannot, deliver.

Principles help you think about something thoroughly and consistently. Overcoming disagreements between stakeholders and even within groups of stakeholders is important. Agreement between stakeholder groups and within stakeholder groups contributes to harmony. Lack of agreement contributes to dissonance. Principles help in the communications process.

I would argue that a first step, if not the first step, of arriving at harmony is outlining the interests, perceptions, positions, and risks of each constituency/stakeholder group.

A "stakeholder" is anyone that has a vested interest. Another term for stakeholder is "constituent". A "constituent" is a component part of something.

Foundational to arriving at harmony is having a common conceptual framework including a set of consistent principles or assumptions or world view for thinking about the system. For example, accounting and financial reporting have such a conceptual framework including principles/assumptions such as "materiality" and "going concern" and "conservatism".

This "framework for agreeing" helps the communications process which increases harmony and decreases dissonance. This is about bringing the system into balance, consciously creating the appropriate equilibrium/balance.

Business Rules Should Be Controlled and Maintained by Business Professionals

Business professionals create and maintain business rules. As Article 9 of the *Business Rules Manifesto*⁴⁹ states, business rules are of, by, and for business people; not information technology people.

⁴⁹ *Business Rules Manifesto*, <http://www.businessrulesgroup.org/brmanifesto.htm>

- 9.1. Rules should arise from knowledgeable business people.
- 9.2. Business people should have tools available to help them formulate, validate, and manage rules.
- 9.3. Business people should have tools available to help them verify business rules against each other for consistency.

Rather than creating tools that only information technology professionals can use because the tools are so complicated; business professionals need to demand software tools that properly expose functionality that exposes business rules to business users such that business users are working with business domain knowledge, not technical details that should have been buried deeply within the software applications.

Business professionals need to understand the *Law of Conservation of Complexity*⁵⁰ which states that complexity can never be removed from a system, but complexity can be moved. The *Law of Conservation of Complexity* states: "Every application has an inherent amount of irreducible complexity. The only question is: Who will have to deal with it - the user, the application developer, or the platform developer?"

General Types of Business Rules

At their essence, business rules articulate information about something or about the relationship between one thing and some other thing. Some examples that can help you better understand exactly what business rules are:

- **Assertions:** For example asserting that the balance sheet balances or "Assets = Liabilities + Equity".
- **Computations:** For example, calculating things, such as "Total Property, Plant and Equipment = Land + Buildings + Fixtures + IT Equipment + Other Property, Plant, and Equipment".
- **Constraints:** For example, specific behavioral constraints that control when it is appropriate to create, update, or remove information.
- **Continuity cross-checks:** For example, if a fact is used that fact does not conflict with or contradict other facts.
- **Process-oriented rules:** For example, the disclosure checklist commonly used to create a financial statement which might have a rule, "If Property, Plant, and Equipment exists, then a Property, Plant and Equipment policies and disclosures must exist."
- **Regulations:** Another type of rule is a regulation which must be complied with, such as "The following is the set of ten things that must be reported if you have Property, Plant

⁵⁰ Understanding the Law of Conservation of Complexity, <http://xbrl.squarespace.com/journal/2015/5/24/understanding-the-law-of-conservation-of-complexity.html>

and Equipment on your balance sheet: depreciation method by class, useful life by class, amount under capital leases by class ..." and so on. Many people refer to these as reportability rules.

- **Instructions or documentation:** Rules can document relations or provide instructions, such as "Cash flow types must be either operating, financing, or investing."
- **Relations:** How things can be related, such as whole-part relations. For example, how the business segments of an economic entity are related.

Scaling Business Rules

Managing business rules becomes more complex as the number of rules increase. Scaling business rules is important. Using a decision model based approach can help manage large sets of business rules. The article, *How DMN Allows Business Rules to Scale*⁵¹ points out four primary problems that you run into:

- **The 'Rush to Detail':** business rule development encourages policy makers to focus on rule implementation prematurely, before they have considered the broader goals and structure of their business decisions and to what extent they will be automated. This approach is like starting to build a house by laying bricks, rather than drawing plans and establishing foundations.
- **Poor Dependency Management:** a growing and poorly understood set of inter-dependencies between rules causing changes to have unintended consequences—making the rule set brittle and reducing its agility.
- **Insufficient Transparency:** the bewildering size of a rule set, use of technical (rather than business) terms and style for expressing rules and a poor connection between rules and their business context (their rationale and place in the business process)—making the meaning and motivation of rules more obscure.
- **Lack of Growth Management:** poor discipline about the scope, quality and placement of rules that are added to the rule set—making it hard to find rules and leading to 'stale' rules and duplicates.

Separating Business Rules from Code

Historically, business logic and application logic have been intermingled in software algorithms. Whenever business logic changed, it took a programmer to make the change in business logic in software algorithms. To do that, business professionals had to explain the new business logic to programmers then programmers would need to make the change in algorithms.

⁵¹ Jan Purchase, *How DMN Allows Business Rules to Scale*, November 19, 2015, <http://blog.luxmagi.com/2015/11/how-dmn-allows-business-rules-to-scale/>

But that is changing. Business logic and application logic should be separated. Business professionals should be able to control business logic and change aspects of how software works by changing the business logic as business needs dictate.

Separating business logic from application logic is achieved by representing business rules that control the business logic of software in machine-readable form that is understandable by and under the control of business professionals. Then, a different type of software can be created and used; a business rules engine.

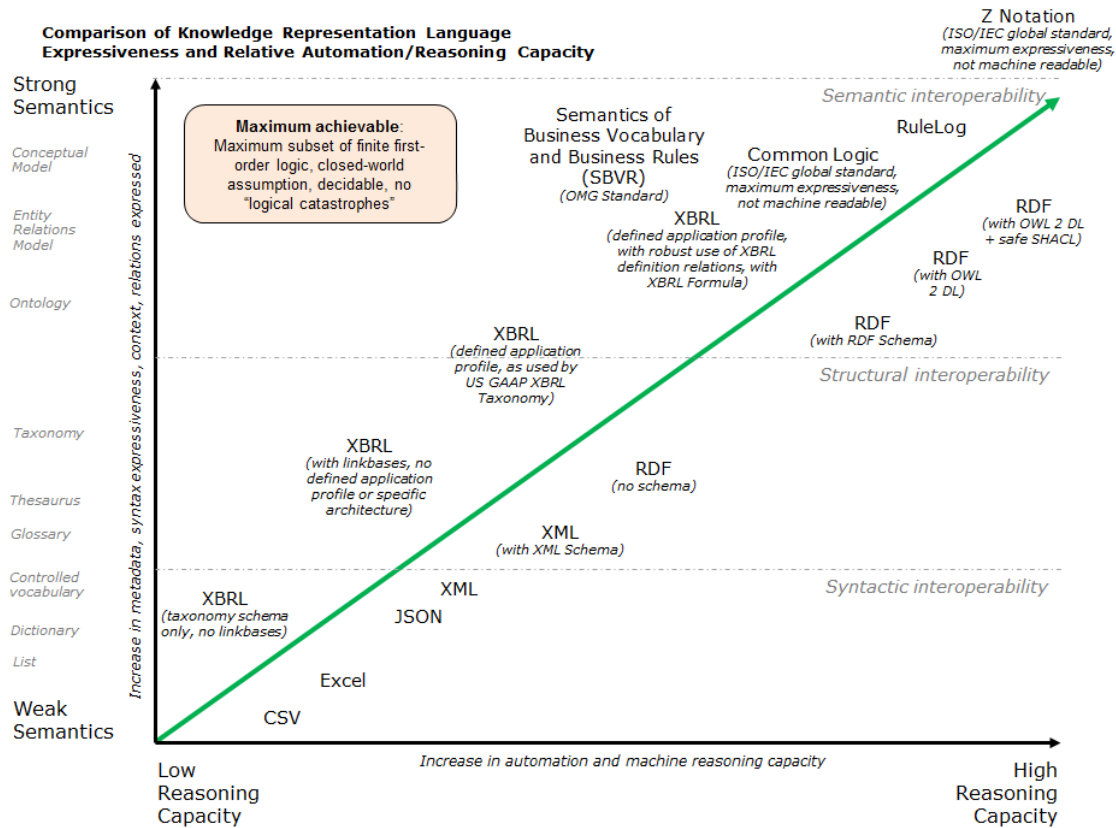
Problem Solving Method

There are basically two primary problem solving methods: forward chaining and backward chaining. Each method has pros and cons. Forward chaining can do everything that backward chaining can do; but backward chaining cannot do everything that forward chaining can do. It is best to use both approaches, applying each when circumstances dictate⁵².

Problem Solving Logic

Problem solving logic can best be described by two things: (a) the expressive power of the logic and (b) the safety of the logic to avoid catastrophic failure. The power of a problem solving logic is directly related by an ability to express rules. Different technical syntax support different problem solving logic. The following graphic compares and contrasts the relative expressive power of different syntax that can be used to express rules.

⁵² *Differentiating Forward and Backward Chaining*, <http://xbrl.squarespace.com/journal/2016/5/27/differentiating-forward-and-backward-chaining.html>



Inspired by similar comparisons from *An Intrepid Guide to Ontologies* <http://www.mkbergman.com/data/2007/05/16/> and *Semantics Overview* <http://prezi.com/prwxi8pc3ln/semantics-overview/>

Technical Syntax is Not Really Relevant to Business Professionals


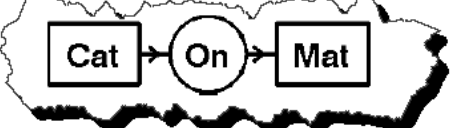
Arbitrary preferences, fads, trends, misinformation, and many other things influence how information technology professionals solve the same problem. How a problem is solved by information technology professionals is less important to business professionals. What is important is for business professionals to properly define a problem and having the maximum capabilities to solve the problem, maximum safety of the system, and maximize the usability of the system by business professionals.

- **Syntax** is how you say something
- **Semantics** is the meaning behind what you said, the business logic

How to Say "A cat is on a mat."

John Sowa provides a simple example that makes a profound point. How to you represent the notion that "a cat is on a mat" in various technical syntax forms⁵³. Here are the examples he provides:

⁵³ John F. Sowa, *Common Logic: A Framework for a Family Of Logic-Based Languages*, page 2-3, <http://www.ifsowa.com/ikl/SowaST08.pdf>

	$\Sigma_x \Sigma_y \text{Cat}_x \cdot \text{Mat}_y \cdot \text{On}_{x,y}$
$\exists x \exists y \text{Cat}(x) \wedge \text{Mat}(y) \wedge \text{On}(x,y)$	<pre>SELECT FIRST.ID, SECOND.ID FROM OBJECTS FIRST, OBJECTS SECOND, SUPPORTS WHERE FIRST.TYPE = "Cat" AND SECOND.TYPE = "Mat" AND SUPPORTS.SUPPORTER = SECOND.ID AND SUPPORTS.SUPPORTEE = FIRST.ID</pre>
$(\text{exists } ((x \text{ Cat}) (y \text{ Mat})) (\text{On } x \ y))$	$[\text{Cat } *x] [\text{Mat } *y] (\text{On } ?x \ ?y)$
	<p>A cat is on a mat.</p>

Which of these syntax do you find the easiest to read? Which syntax conveys the most meaning to you? Which of these technical syntax would be easiest for a business professional to work with? How hard is it to convert one syntax to another syntax if the logic is the same? One approach is to use logic symbols⁵⁴ to represent words. Another approach is to use a controlled natural language to explain logic.

Differences between Ontologies, Rules, and Schemas

Ontologies and business rules are overlapping rather than disjointed⁵⁵. Ontologies, rules, and schemas are all approaches to representing knowledge and each approach has strengths and weaknesses⁵⁶. The primary challenge relating to figuring out the best approach to use to represent knowledge, as pointed out by John Sowa in his paper *Fads and Fallacies about Logic*⁵⁷, is not technical at all. Most issues relate to an even more formidable challenge related

⁵⁴ Wikipedia, *Logic Symbols*, https://en.wikipedia.org/wiki/List_of_logic_symbols

⁵⁵ Benjamin Grosz, *Survey of Knowledge Representations for Rules and Ontologies*, page 4, <http://coherentknowledge.com/wp-content/uploads/2013/05/Ontolog-Forum-talk-OF-surveyKR-20131024-BNG.pdf>

⁵⁶ Silvie Spreeuwenberg, *The Semantic Web and the Business Rules Approach ~ Differences and Consequences*, <https://www.brcommunity.com/articles.php?id=b257>

⁵⁷ John F. Sowa, *Fads, Misinformation, Trends, Politics, Arbitrary Preferences, and Standards*, <http://www.ifsowa.com/pubs/fflogic.pdf>

to fads, trends, arbitrary preferences, politics, fallacies, misinformation, and alternative completing standards.

Approaches to representing knowledge can be placed into three broad groups: *ontologies*, *rules*, and *schemas*. The purpose of each of these is to represent some problem domain or conceptual model of some sort. The following is a summary of the essence of each of these three approaches to representing knowledge:

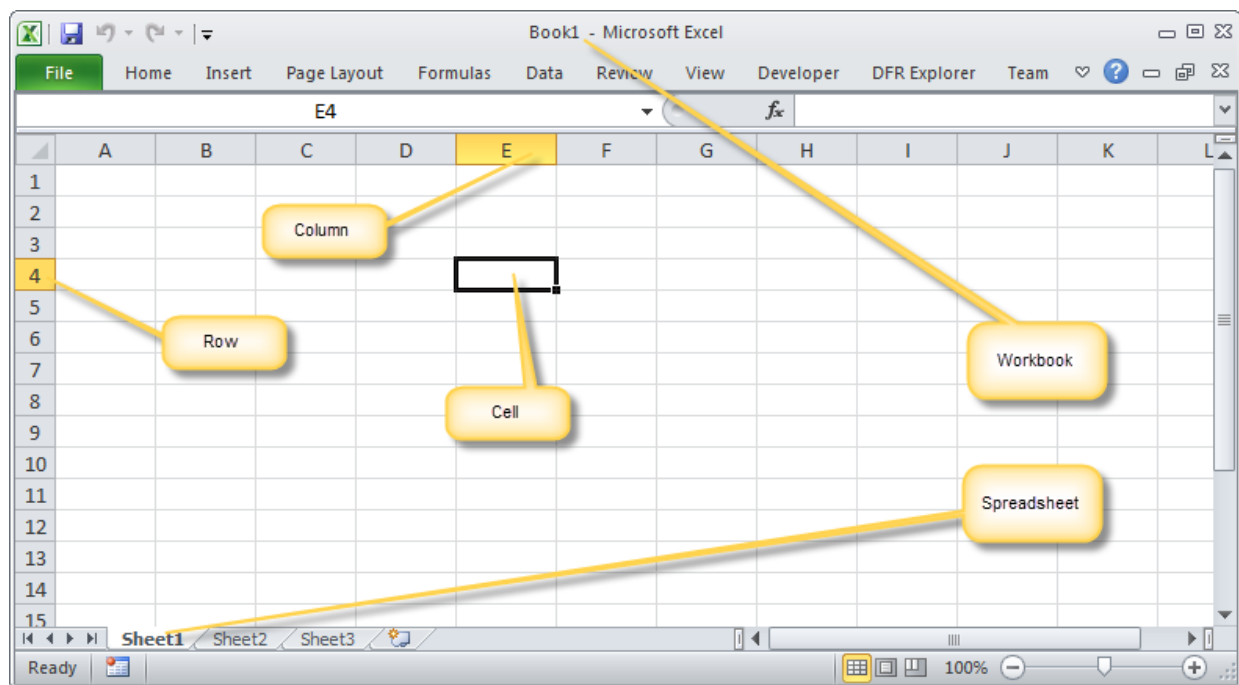
- **Ontology:** An ontology is generally a subset of knowledge that is definitional in nature and focuses on defining terminology and categories/subcategories/properties of terms and the relations between the categories/subcategories/properties. An ontology is a collection of taxonomies. Ontologies are axiom-based.
- **Rules:** Rules are assertions or statements which have an IF...THEN format that have logical implication. The set of rules can be definitional in nature and therefore in essence ontological. A rule (or assertion, statement) can be TRUE or it can be FALSE. Rules are model-based.
- **Schema:** A schema is an outline, diagram, or model that tend to describe structure. To examples of schemas are a database schema which describes the structure of data in a database and XML Schema which is used to describe the structure of an XML document.

Too many people are in either the “ontology” camp or the “rules” camp or the “schema” camp to the exclusion of all other alternatives which tends to create silos and each camp acting dogmatic. This is not helpful to business professionals trying to solve problems practically.

Business professionals should focus on logic and the problem solving logic provided by a system rather than the implementation details. If rich enough, an ontology, a set of rules, or a schema can be used to represent a conceptual model.

Using Conceptual Models

Business professionals work with conceptual models every day. For example, the workbooks, spreadsheets, rows, columns, and cells of an electronic spreadsheet are a conceptual model. The ease and simplicity of an electronic spreadsheet allows the average business professional to make use of this helpful tool.



Differentiating a Notion/Idea/Phenomenon, a Name, and a Preferred label

It is important to understand and properly differentiate between the following three things:

- **Notion, idea, phenomenon:** something that exists in reality that needs to be represented
- **Name:** helps computers uniquely identify some notion/idea/phenomenon that is a representation of reality within some machine-readable conceptual model
- **Preferred label:** alternative ways used to refer to name

Confusing these three things can cause problems when trying to create a conceptual model. Two things that are genuinely different should have two different names. However, if one thing is given two names when the one thing really is two different preferred labels problems can occur.

Power of Agreement

It is only through deliberate, methodical, rigorous and conscious collaboration, cooperation and coordination by the participants of the financial reporting supply chain that XBRL-based digital financial reporting will work safely, reliably, predictably, repeatedly, effectively, and efficiently. This objective will not be achieved by accident.

Consider the definitions of arbitrary and standard:

- **Arbitrary:** based on random choice or personal whim, rather than any reason or system; depending on individual discretion (as of a judge) and not fixed by law
- **Standard:** used or accepted as normal; something established by authority, custom, convention, law, regulation, or general consent as a model or example

US GAAP contains many, many standard terms. For example, Equity, Assets, Liabilities, etc. The US GAAP XBRL Taxonomy names these terms, providing a standard. A common obstacle to creating a working dictionary of concepts and relations between those concepts is disagreement as to those definition and relations. Agreement by all stakeholders through deliberate, methodical, rigorous and conscious collaboration, cooperation, and coordination can help overcome this obstacle.

Differentiating the Important from the Unimportant

The following terms help one understand the difference between an important nuance and an unimportant negligible difference.

- **Nuance:** a subtle but important difference in or shade of meaning, expression, or sound; a subtle but important distinction or variation
- **Subtle:** so delicate or precise as to be difficult to analyze or describe but important; hard to notice or see but important; not obvious but important
- **Negligible:** so small or unimportant as to be not worth considering; insignificant; so small or unimportant or of so little consequence as to warrant little or no attention

Business professionals can best differentiate important nuances from unimportant negligible differences. They do not do it perfectly and the only real way to make sure things are right is testing and experimentation.

Conceptual models, ontologies, and theories are about getting the salient aspects of a problem domain right. One needs to take a pragmatic view of the world because it is impossible to describe every single aspect of the real world. Such frameworks only need to represent the important things and serve as a “wireframe” or a “substrate” of reality. Getting bogged down in unimportant, insignificant, or inconsequential details at best serves no purpose, at worst can cause unnecessary complexity.

Difference between Simplistic and Simple

Anyone can create something that is sophisticated and complex. It is much harder to create something that is sophisticated and simple. Simple is not the same thing as simplistic. "Simple" is not about doing simple things. Simple is the ultimate sophistication. Simple is elegant.

- **Simplicity:** Simplicity is “dumbing down” a problem to make the problem easier to solve.
- **Simple:** 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 conscious effort and is hard work.

Difference between a Requirement and a Policy

Sometimes things are required, other times things are a choice. Yet in other times setting some policy eliminates certain options which could have been previously considered.

- **Policy:** a course or principle of action adopted or proposed by a government, party, business, or individual; definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions
- **Requirement:** a thing that is needed or wanted; something that is essential or that must be done
- **Choice:** an act of selecting or making a decision when faced with two or more possibilities; the act of choosing; the act of picking or deciding between two or more possibilities
- **Option:** a thing that is or may be chosen; the opportunity or ability to choose something or to choose between two or more things

Any time a business professional is presented with an alternative complexity increases because the business professional then must choose between the available alternatives. As the number of choices increases, complexity increases. Choices must be managed. Flexibility when it is not necessary is not a feature, it is a bug.

Differentiating between Objective and Subjective

There is a difference between something that is objective and something that is subjective.

- **Objective:** not influenced by personal feelings or opinions in considering and representing facts; based on facts rather than feelings or opinions; not influenced by feelings; facts are objective.
- **Subjective:** based on or influenced by personal feelings, tastes, preferences, or opinions; based on feelings or opinions rather than facts; relating to the way a person experiences things in his or her own mind; opinions are subjective.
- **Judgment:** the ability to make considered decisions or come to sensible conclusions; an opinion or decision that is based on careful thought; judgment is subjective.

Remember, computers are machines. Computers have no intelligence until they are instructed by humans. Computers only appear smart when humans create standards and agree to do things in a similar manner in order to achieve some higher purpose. It is easy to agree on things that tend to be objective. It is harder to agree where there is subjectivity. It is extremely difficult to impossible to get a machine to exercise judgment. A machine such as a computer can only mimic what humans tell the machine to do via machine-readable information.

Difference between Explicit and Implicit

In the process of agreeing, it is important to understand the difference between what is important and what is unimportant in that process of agreeing. It is likewise important to understand the difference between telling a machine something and requiring the machine to figure something out:

- **Explicit:** stated clearly and in detail, leaving no room for confusion or doubt; very clear and complete; leaving no doubt about the meaning.
- **Implicit:** implied though not plainly expressed; understood though not clearly or directly stated.
- **Ambiguous:** open to more than one interpretation; having a double meaning; able to be understood in more than one way; having more than one possible meaning; not expressed or understood clearly.
- **Derive or Impute:** assign (a value) to something by inference from the value of the products or processes to which it contributes; to deduce a conclusion about some fact using some other fact or facts and logical reasoning.

Machines do well with information which is explicitly provided. When information is not explicitly provided, software developers either make a choice or have to figure out ways to allow a business professional making use of the software to make a choice. Every time a software developer or business professional has to make an interpretation because something is ambiguous, there is the possibility that some unexpected or incorrect interpretation can be made. Not being explicit causes confusion and turns using ambiguous information into a guessing game.

Information robots

During the 1900s many routine, mundane manual tasks were automated using machines including sophisticated robots. Now, many routine, mundane cognitive tasks will be automated.

Process Robotics is Disrupting Accounting and Finance

In the video, *Finance in a Digital World and the Impact on CFOs*⁵⁸, John Steel who leads the finance transformation practice of Deloitte makes the statement,

"Five years from now there is either no CFO or the CFO is playing a different role."

John's view is consistent with what the AICPA and Journal of Accountancy is saying which is that technology is poised to change the accounting profession⁵⁹.

In the video, John goes on to say, "Digital is having a tremendous impact and it's quite disruptive." In the video he goes over trends that are occurring. One of those trends is process robotics. John uses the term "lights out finance" meaning a finance that is completely automated. Now, we may never get to where the lights are completely out, but digital will involve automation of many existing manual processes.

A key word here is "disruptive". As pointed out by *The Innovators Dilemma*⁶⁰, there are two types of innovation: sustaining and disruptive. *Sustaining innovation* meets customer's current needs, making incremental improvements in quality and efficiency of current processes. *Disruptive innovation* is about meeting future needs of customers.

Process robotics is about automating accounting, clerical, administrative, and other such tasks using software robots. Artificial intelligence technology drives these software robots. It really is a lot like how physical robots were employed to replace humans in manufacturing processes such as the process of building cars. Software robots cannot automate all tasks but certainly there are tasks which can be automated. As an example, Blackline offers an accounting process automation product⁶¹ and FlexRule offers a general process robotics platform⁶².

We don't want to overstate what innovations such as process robotics will provide. But we likewise don't want to understate the impact either. This is not about computers taking over the world. The way it will work is that you will have humans augmented by machine capabilities, much like an electronic calculator enabling a human to do math quicker, will empower professional accountants and others who know how to leverage those machines.

Underlying the process robotics will be intelligent software agents that interact with each other and with humans to get work done.

⁵⁸ SAP, *Finance in a Digital World and the Impact on CFOs*, <http://events.sap.com/sapandasug/en/session/32172>

⁵⁹ AICPA News Update: *Technologies are poised to reshape the accounting landscape*, <http://xbrl.squarespace.com/journal/2017/7/7/aicpa-news-update-technologies-are-poised-to-reshape-the-acc.html>

⁶⁰ YouTube, *The Innovator's Dilemma*, <https://www.youtube.com/watch?v=yUAtIQDllo8>

⁶¹ Blackline, *Accounting Process Automation*, <https://www.blackline.com/accounting-process-automation>

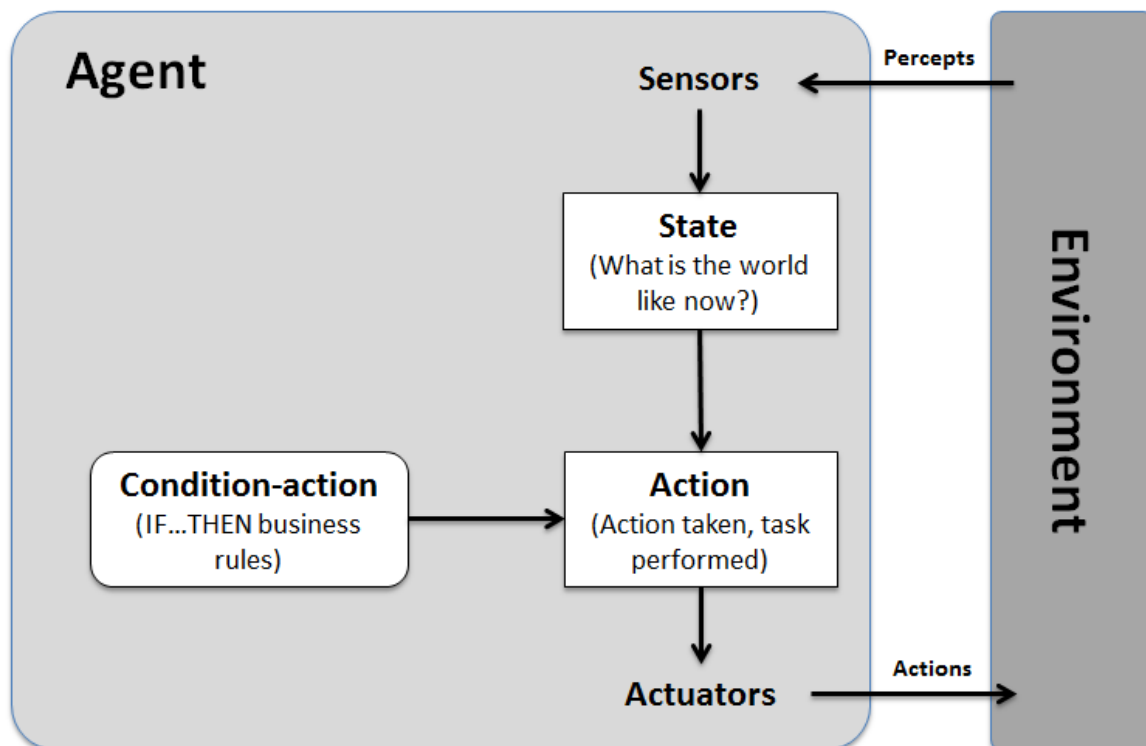
⁶² FlexRule, *Business Logic Platform*, <http://www.flexrule.com/solution/>

Understanding Artificial Intelligence and Intelligent Software Agents

Artificial intelligence is the automation of activities that we associate with human thinking and activities such as decision making, problem solving, learning and so on. An intelligent software agent⁶³ is software that assists people and acts on their behalf. Intelligent agents work by allowing people to:

- delegate work that they could have done to the agent software,
- perform repetitive tasks,
- remember things you forgot,
- intelligently find, filter and summarize complex information,
- customize information to your preferences,
- learn from you and even make recommendations to you.

An **agent** is an entity capable of **sensing** the **state** of its **environment** and **acting** upon it based on a set of specified **rules**. An agent performs specific tasks on behalf of another. In the case of software, an agent is a software program. There are many different types of intelligent software agents⁶⁴.



⁶³ Comprehensive Introduction to Intelligent Software Agents, http://xbrlsite.azurewebsites.net/2017/IntelligentDigitalFinancialReporting/Part01_Chapter02.7_ComprehensiveIntroductionToIntelligentSoftwareAgents.pdf

⁶⁴ Wikipedia, *Intelligent Agent*, Retrieved July 24, 2016; https://en.wikipedia.org/wiki/Intelligent_agent

A simple reflex agent looks up what it should do from a **list of rules** in response to its perception to the environment. This is the algorithm of simple reflex agent⁶⁵:

Function Simple-Reflex-Agent (percept) returns action

- **persistent:** *rules*, a set of condition-action rules
- *state* <<<< Interpret-Input (*percept*)
- *rule* <<<< (Rule-Match (*state*, *rules*))
- *action* <<<< *rule*.Action
- **return** *action*

The document *Comprehensive Introduction to Intelligent Software Agents*⁶⁶ goes into significantly more detail on the topic of intelligent software agents.

Categories of Intelligent Software Agent Functionality

The functionality of an intelligent software agent can be classified into groups, or categories:

- **Reactive agent:** A reactive agent is capable of maintaining an ongoing interaction with the environment and responding in a timely fashion to changes that occur in it.
- **Pro-active agent:** A pro-active agent is capable of taking the initiative; not driven solely by events, but capable of generating goals and acting rationally to achieve them.
- **Deliberative agent:** A deliberative agent symbolically represents knowledge and makes use of mental notions such as beliefs, intentions, desires, choices and so on. This is implemented using a belief-desire-intension model.
- **Hybrid agent:** A hybrid agent is one that mixes some of all the different architectures.

Every intelligent software agent falls into one of those four categories.

Categories of Intelligent Software Agent Sophistication

Intelligent software agents can be grouped as to the level of sophistication offered by the agent:

- **Generic agent:** An agent is anything that perceives an environment through sensors and acts or reacts upon the environment through effectors.
- **Simple reflex agent:** A simple reflex agent looks up what it should do from a list of rules in response to its perception to the environment.

⁶⁵ Hugo Larochelle, *Intelligence Artificielle*, Retrieved July 24, 2016; <https://www.youtube.com/watch?v=TUHAVbaBllg>

⁶⁶ Charles Hoffman and Rene van Egmond, *Comprehensive Introduction to Intelligence Software Agents*, http://xbrlsite.azurewebsites.net/2017/IntelligentDigitalFinancialReporting/Part01_Chapter02.7_ComprehensiveIntroductionToIntelligentSoftwareAgents.pdf

- **Model-based reflex agent:** A model-based reflex agent is the same thing as a simple reflex agent except that a model-based reflex agent has a model of how the environment evolves.
- **Goal-based agent:** A goal-based agent has a goal or set of goals that it actively pursues in accordance with an agenda (so this type of agent is proactive, not just reactive). A goal based agent has a representation of the current state of the environment and how that environment works. The agent pursues policies or goals that may not be immediately attainable. And so, goal based agents do not live merely in the moment. These agents consider different scenarios before acting on their environments, to see which action will probably attain a goal. This consideration of different scenarios is called search and planning.
- **Utility-based agent:** A utility-based agent is a more sophisticated type of goal-based agent that also rates each possible scenario to see how well it achieves certain criteria with regard to production of the good outcome, therefore it is more adaptive. A utility measure is applied to the different possible actions that can be performed in the environment. The utility-based agent will rate each scenario to see how well it achieves certain criteria with regard to the production of a good outcome. Things like the probability of success, the resources needed to execute the scenario, the importance of the goal to be achieved, the time it will take, might all be factored in to the utility function calculations.

Every intelligent software agent falls into one of those groups in terms of sophistication of functionality offered.

Benefits of an Expert System

Benefits from the use of expert systems include:

- **Reduced costs by using automation:** elimination of routine, boring, repetitive, mundane, mechanical, rote tasks that can be automated
- **Increased uniformity:** consistent answers from the same question or facts; computers are good at performing repetitive, mechanical tasks whereas humans are not; computers do not make mistakes and are good at repeating exactly the same thing each time; performance level is consistent
- **Reduced down-time:** computer based expert systems are tireless and do not get distracted
- **Increased availability:** computer based expert systems are always available simultaneously in multiple places at one time; you get quick response times and can replace absent or scarce experts; convenient

- **Diligence and tenacity:** computers excel at paying attention to detail; they never get bored or overwhelmed and they are always available and will keep doing their job until the task is complete with the same attention to detail
- **Basis for training:** the best practices of the best practitioners can be available to those that are new to and learning about a domain of knowledge
- **Longevity and persistence:** computer based expert systems do not change jobs or retire so knowledge gathered by an organization can remain within that organization
- **Productivity:** computer based expert systems are cheaper than hiring experts and costs can be reduced at the same time that quality increases resulting in increased productivity
- **Multiple opinions:** Systems can integrate the view of multiple experts within a system and choose between the preferred view of multiple expert opinions in the same system
- **Objectivity:** computers apply the same inductive and deductive logic consistently; emotion and personal preferences can be eliminated where they should be eliminated; expert systems do not discriminate
- **Easier dissemination of knowledge:** expert systems are software and metadata and therefore once you have that software and metadata reproducing another version is trivial and the incremental cost is extremely low

In a knowledge based or expert system; knowledge is explicitly represented and can be evaluated, knowledge is permanent, knowledge is easily replicated, and the system is consistent. Operating costs of an expert system are low. Financial report creation software of the future will be an expert system which operates similar to how CAD/CAM software for creating blueprints.

Disadvantages of Expert Systems

Everything has advantages and disadvantages. The following can be disadvantages of expert systems:

- **Initial cost:** the initial cost of creating an expert system can be high; the primary cost is for creation of the expert knowledge which is used by the system
- **Maintaining knowledge:** human experts constantly update their knowledge through interaction with other experts, new ideas, common sense, etc.; expert systems have to be maintained to keep knowledge current
- **Garbage in, garbage out:** an expert system is only as good as the machine-readable knowledge which the system uses
- **No common sense:** humans have common sense, expert systems do not
- **Lacks human touch:** expert systems are computer application and have the same characteristics of a computer; they have no compassion, no intuition, cannot exercise real judgment, etc.

- **Inflexibility:** a system, once set up, is inflexible or rather only flexible to the extent that new knowledge is added to the system
- **Restricted:** an expert system usually has expertise in one specific domain of knowledge and is therefore restricted to that specific knowledge

To make expert systems work effectively, disadvantages must be overcome and expert systems should be used to solve problems they are truly capable of solving. Setting the right expectations is important.

Understanding the Benefits of Double-entry Accounting

Single-entry bookkeeping⁶⁷ is how 'everyone' would do accounting. In fact, that is how accounting was done before double-entry bookkeeping was invented.

Double-entry bookkeeping⁶⁸ adds an additional important property to the accounting system, that of a clear strategy to identify errors and to remove them from the system. Even better, it has a side effect of clearly firewalling errors as either accident or fraud. This then leads to an audit strategy. Double-entry bookkeeping is how professional accountants do accounting.

Double-entry bookkeeping, documented by the Italian mathematician and Franciscan Friar Luca Pacioli⁶⁹, is one of the greatest discoveries of commerce, and its significance is difficult to overstate.

Which came first, double-entry bookkeeping or the enterprise⁷⁰? Was it double-entry bookkeeping and what it offered that enable the large enterprise to exist; or did the large enterprise create the need for double-entry bookkeeping?

Accountants think differently than non-accountants. Non-accountants don't realize this and accountants seem to forget. The quality difference between the set of "stuff" that makes up a financial report and all the support for that financial report tends to be much higher than the quality level of non-financial information, or rather, information that is managed by a non-accountant. Why? Because double-entry bookkeeping is ingrained in the processes and procedures of accountants.

Accountants need to keep this in mind as they design digital financial reporting.

⁶⁷ Wikipedia, *Single-entry Bookkeeping System*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Single-entry_bookkeeping_system

⁶⁸ Wikipedia, *Double-entry Bookkeeping System*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Double-entry_bookkeeping_system

⁶⁹ Wikipedia, *Luca Pacioli*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Luca_Pacioli

⁷⁰ Ian Grigg, *Triple Entry Accounting, A Very Brief History of Accounting, Which Came First - Double Entry or the Enterprise?*, http://iang.org/papers/triple_entry.html

Business logic

Business professionals have an innate understanding of logic. This understanding can be employed to make it easier to work with machines.

Difference between Assuming and Deriving Information

Assuming new information and logically deriving new information from other information is not the same thing. When one make an assumption⁷¹ you “take it upon oneself” or “lay claim to” or “take for granted” some fact or statement as being true. When you derive new information using logical processes however, there is a logically supportable or logically defensible line of reasoning that (a) follow the rules of logic and (b) result in some new but supportable true fact or statement.

Fundamentals of Logic

Professional accountants use logic informally every day. For example, something that you probably learned in school is BASE; beginning balance + additions – subtractions = ending balance. If you know any three facts, you can always find the forth fact.

Here is an example of logic. Suppose you were trying to find the subtractions from some account.

1. You know that the *beginning balance* of the account is \$5,000
2. You know that the *additions* to the account was \$1,000
3. You know the *ending balance* of the account is \$2,000
4. You know that beginning balance + additions – subtractions = ending balance
5. You can derive the fact that the *subtractions* to the account are \$4,000 using the information provided in #1, #2, #3, and #4 and using the rules of logic

In this example you are using logic to reliably derive the subtractions from some account even though you do not know the actual value of the subtractions. And in doing so you are adding new information to your base of knowledge.

There is an important point to recognize here. Logic is the process of deducing information correctly; logic is not about deducing correct information. Consider the example above again. Suppose you were give incorrect information for the beginning balance of the account you are analyzing, that the beginning balance was \$9,000 rather than \$5,000 as stated above.

Our deduction that the subtractions are \$4,000 is now untrue. But the logic is perfectly correct; the information was pieced together correctly, even if some of that information was false.

⁷¹ Merriam-Webster, Assumption, <https://www.merriam-webster.com/dictionary/assumption>

Understanding the distinction between correct logic and correct information is important because it is important to follow the consequences of an incorrect assumption.

Ideally, we want both our logic to be correct and the facts we are applying the logic to, to be correct. But the point here is that correct logic and correct information are two different things.

If our logic is correct, then anything we deduce from such information will also be correct.

Logical Statements

In logic, a statement is a sentence that is either true or false. You can think of statements as pieces of information that are either correct or incorrect. And therefore, statements are pieces of information that you apply logic to in order to derive other pieces of information which are also statements.

Here are some examples of statements:

- “Assets = Liabilities and equity”, i.e. the accounting equation⁷².
- “Beginning balance + additions – subtractions = ending balance”, i.e. as stated above and the definition of a roll forward.
- “Originally stated balance + adjustments = Restated balance”
- Some types of revenue are operating.
- Assets for the consolidated entity as of the balance sheet date of December 31, 2016 is \$45,000.

A financial report discloses facts. One fact in a report is distinguishable from another fact in the report by the characteristics of each of the two facts. One fact in a report can be related to another fact in a report and the relation between those two facts should be consistent with expectations which are established by rules.

Logic is about the correct methods that can be used to prove that a statement is true or false. To prove that a statement is true, we start with statements other statements that are proven to be true and use logic to deduce more and more complex statements until finally we obtain a statement that we are looking to determine if the statement is true or false. Of course some statements are more difficult to prove than others; in this resource we will concentrate on statements that are easier to prove to help you learn the basics of logic. But the point is this: In proving that statements are true, we use logic to help us understand statements and to combine pieces of information to produce new pieces of information.

⁷² Wikipedia, *Accounting Equation*, retrieved June 2, 2017, https://en.wikipedia.org/wiki/Accounting_equation

As your skills grow you can create increasing complex statements.

A financial report is complex logical information⁷³. XBRL-based financial reports are machine-readable structured information.

Conditional Statements

Another way to represent statements is in the IF...THEN format. These are called conditional statements. Here is an example of a conditional statement⁷⁴.

- IF Assets = Liabilities and Equity; THEN the balance sheet balances.

Note that you may not be able to reverse a conditional statement. For example, the above conditional statement reversed would be:

- IF the balance sheet balances; THEN Assets = Liabilities and Equity.

The “IF” part of a conditional statement is called the *hypothesis* and the “THEN” part is called a *conclusion*. There are other terms that are used such as the *antecedent* and *consequent*.

Logical Inference

Logical inference is the process of deriving new information from one or more existing pieces of information, deducing a conclusion about that information using the rules of logic. For example,

- Suppose you know that Assets = \$2,000
- Suppose you know that Current assets = \$500
- Suppose you know that Assets = Current assets + Noncurrent assets

Using the information provided above, you can use the rules of logic to derive the value of Noncurrent assets to be \$1,500 because Assets (\$2,000) = Current assets (\$500) + Noncurrent assets (UNKNOWN); but using the rules of math you solve for the value of the UNKNOWN; Assets (\$2,000) – Current Assets (\$500) = Noncurrent assets (UNKNOWN); finally you get to Noncurrent assets = \$1,500.

You are not guessing. You are using logic to determine, accurately, what the value of Noncurrent Assets is based on other facts that you know.

⁷³ Charles Hoffman, *Processing Complex Logical Information or Structured Knowledge*, <http://xbrl.squarespace.com/journal/2017/4/22/processing-complex-logical-information-or-structured-knowled.html>

⁷⁴ Wikipedia, *Material Conditional*, retrieved June 2, 2017, https://en.wikipedia.org/wiki/Material_conditional

Setting the Right Expectation

Logic has limitations⁷⁵. Business professionals need to understand these limitations so that they understand what computers can and cannot do, what is hard and what is easy to implement using computers, and to otherwise set their expectations appropriately. Remember, computers cannot perform magic. Computers fundamentally follow the rules of mathematics which follow the rules of logic. It really is that straight forward.

It is more difficult, but not impossible, to get computers to effectively work with information such as the following:

- fuzzy expressions: “It **often** rains in autumn.”
- non-monotonicity: “Birds fly, penguin is a bird, but a penguin does not fly.”
- propositional attitudes: “Eve **thinks** that 2 is not a prime number.” (It is true that she thinks it, but what she thinks is not true.)
- modal logic
 - possibility and necessity: “It is **possible** that it will rain today.”
 - epistemic modalities: “Eve **knows** that 2 is a prime number.”
 - temporal logic: “I am **always** hungry.”
 - deontic logic: “You **must** do this.”

While it is possible to implement this sort of functionality within computer systems using technologies such as probabilistic reasoning⁷⁶, those systems will be less reliable and significantly more difficult to create. On the other hand, probabilistic reasoning can provide value. The bottom line is this: what are the effective boundaries of the system?

Final Thoughts about Logic

It is important to understand why you want to take the time to understand logic. Here are the primary reasons:

- Applying logic correctly helps you understand what something means.
- The rules of inference provide a system which can be used to reliably derive new information from existing information.
- Logic helps you not only understand the meaning of statements; it also helps you reliably produce new meaningful statements.
- Computers work based on the rules of mathematics. Mathematics works based on the rules of logic.

⁷⁵ Martin Kuba, Institute of Computer Science, OWL 2 and SWRL Tutorial, Limitations of First-order logic expressiveness, <http://dior.ics.muni.cz/~makub/owl/>

⁷⁶ Wikipedia, Probabilistic Logic, retrieved August 28, 2016, https://en.wikipedia.org/wiki/Probabilistic_logic

Logic is the glue that holds sets of statements together and helps you understand the exact, precise meaning of statements. Logic is a common language that can be agreed upon which enables communication.

Logic helps you get to true and unambiguous meaning and helps you reconcile your true and unambiguous meaning to the true and unambiguous meaning of others. Computers are machines that work using the rules of logic.

Logic helps to keep everyone on the same page.

Conclusion

Professional accountants need to understand how to think critically, systematically, deliberately, rigorously, and methodically about how computers work and how to get computers to do what you want them to do.

Machine intelligence is real and a tool that can, and will, be leveraged by professional accountants. Human and machine collaboration is how work will be performed in the future.

Professional accountants already have many of the skills that they need such as procedural thinking, systematic problem solving, and systems thinking. They need to add to those skills a few other skills such as technological empathy or understanding how a computer sees the world and abstract thinking.

Next steps

The next step is to dig into the next level of detail. That next level can be found in *Intelligent XBRL-based Digital Financial Reporting*⁷⁷.

⁷⁷ Charles Hoffman and Rene van Egmond, *Intelligent XBRL-based Digital Financial Reporting*, <http://xbrl.squarespace.com/intelligent-xbrl/>