

Understanding Knowledge Based Systems

a comprehensive introduction to knowledge based systems for accounting and other business professionals

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The Information Age

- We live in the information age where we increasingly rely on **computer based processes**
- Every business professional needs to have a **basic understanding** how these systems work, the limits of their capabilities of the systems, and the leverage these systems can provide
- This presentation provides that basic understanding

Expert Systems or Knowledge Based Systems

- Expert systems is a branch of artificial intelligence. Expert systems, also called knowledge-based systems or simply knowledge systems, are computer programs.
- **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.

Knowledge Based System

- These three terms mean the same thing:
 - Knowledge based system
 - Expert system
 - Knowledge system

Basic Overview of Essence as to How Knowledge Based Systems Work

- **Structured information** (as opposed to unstructured information)
- **Standard formats** (as opposed to proprietary formats)
- **Computers performing reasoning** (using computer based *problem solving logic* and *problem solving methods*)
- **Leveraging** the above, **manual human-based work** is converted into **automated machine-based work**
- Being **realistic** as to what really can, and cannot, be automated (i.e. not all expertise can be or is worth automating)

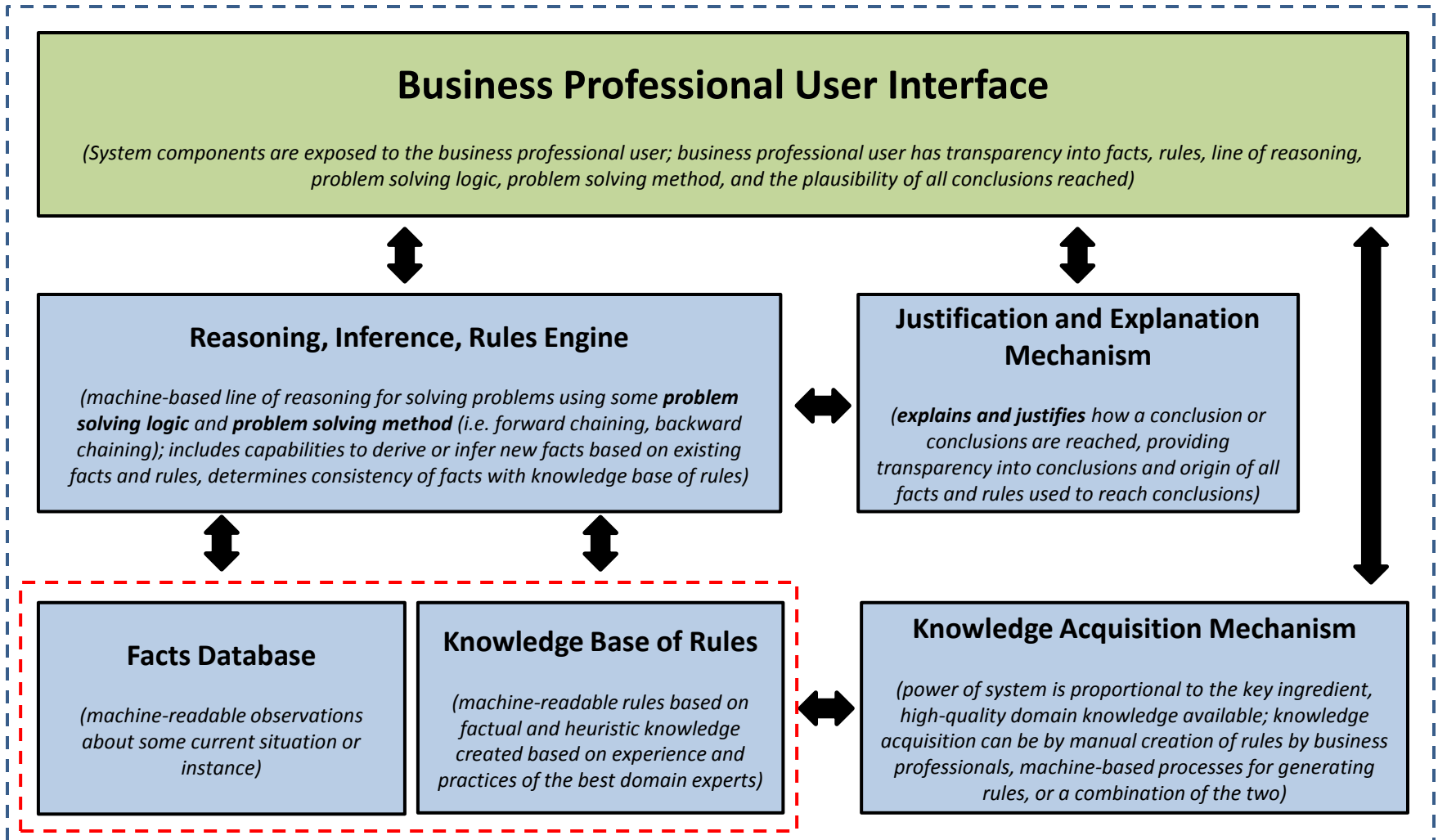
Description of a Knowledge Based System

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 support conclusions reached by the knowledge base system and presents that information to the user of the system.

Humans and Computers Augmenting Each Other

- Who is the world chess champion today; a computer or a human? In 1997, IBM's Deep Blue took the title. IBM, Deep Blue, <http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/>
- Today, a computer is no longer the world chess champion. Neither is a human. Today, a team of computers and humans working together can beat any computer or any human working alone.
- That is how the power of computers will be harnessed in the Digital Age; **by human and computer teamwork.** Human are good at some tasks; not as good at other tasks. Computers are good at some tasks; not as good at other tasks. Teaming humans and computers together and leveraging the strengths of each is how work will get done in the future.

Components of a Knowledge Based System



Components of a Knowledge Based System

- **Fact database**
 - Facts (observations), facts are basically current knowledge
- **Knowledge base of rules**
 - Terms, relations, rules
- **Reasoning/inference/rules engine**
 - Problem solving logic (specific safe, reliable subset of first-order logic)
 - Problem solving method (forward chaining, backward chaining)
- **Justification and explanation mechanism**
 - Justifies and explains conclusions
 - Origin of facts and specific rules used to reach conclusion
- **Knowledge acquisition mechanism**
 - Manually acquired knowledge (i.e. business professionals create)
 - Machine learning (capabilities are over stated generally)

Database of Facts

- A **fact database** is a set of observations about some current situation or instance. The fact database is "flexible" in that the facts apply to the current situation. The fact database is machine-readable.
- An example of a fact database is information reported a single financial report, a set of financial reports, or the entire set of financial reports in the SEC EDGAR system.
- *An XBRL instance is a fact database.*

Knowledge Base of Rules

- A **knowledge base of rules** is a set of universally applicable rules created based on experience and knowledge of the practices of the best domain experts. Rules are generally articulated in the form of IF...THEN statements or a form that can be converted to IF...THEN form.
- At the highest level the knowledge base of rules contains a conceptual model, definitions of things that make up that model, and relationships between the things in the model (types of things, structure of things, parts of things, mathematical relations between things, etc.).
- A knowledge base of rules is "fixed" in that its rules are universally relevant to all situations covered by the knowledge base. Not all rules are relevant to every situation. But where a rule is applicable it is universally applicable. All knowledge base information is machine-readable.
- Rules are declarative in order to maximize use of the rules and make it easy to maintain rules. Knowledge that makes up the knowledge base is acquired using manual or automated knowledge acquisition processes.
- *An XBRL taxonomy is a knowledge base of rules.*

Reasoning/Inference/Rules Engine

- **Reasoning/inference/rules engine:** A reasoning engine provides a machine-based line of reasoning for solving problems. The reasoning engine processes facts in the fact database and rules in the knowledge base. A reasoning engine is also an inference engine and takes existing information in the knowledge base and the fact database and uses that information to reach conclusions or take actions. The inference engine derives new facts from existing facts using the rules of logic.
- The reasoning engine is a machine that processes the information. A reasoning engine has a specific *problem solving logic* and uses some *problem solving method*.
- *An XBRL Formula processor, if built correctly, can be a reasoning engine and can perform logical inference.*

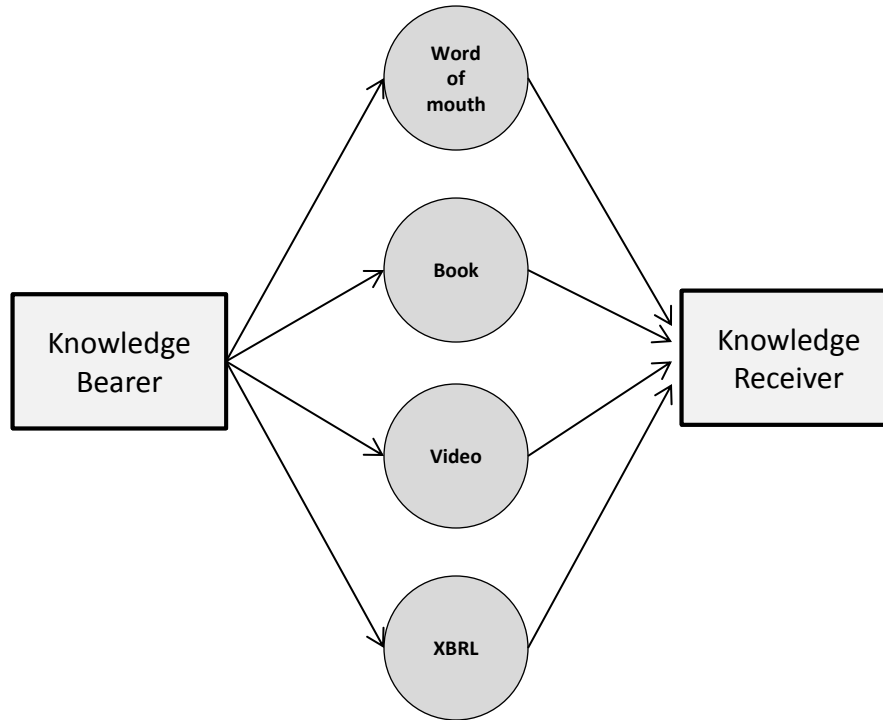
Justification and Explanation Mechanism

- When an answer to a problem is questionable, we tend to want to know the rationale behind the answer. If the rationale seems plausible, we tend to believe the answer. The **justification and explanation mechanism** explains and justifies how a conclusion or conclusions are reached. It walks you through which facts and which rules were used to reach a conclusion.
- The justification and explanation mechanism is the results of processing the information using the reasoning/inference/rules engine and justifies why the conclusion was reached. The explanation mechanism provides both provenance and transparency to the user of the knowledge based system so that the user of the system understands the origin of all facts and rules.

Knowledge Acquisition Mechanism

- The power of a knowledge base system is proportional to the key ingredient of that system: high-quality domain knowledge available in machine-readable form. **Knowledge acquisition** can be by manual creation of rules by business professionals, machine-based processes for generating rules, or a combination of the two.
- Generally earlier in the lives of knowledge based systems rules are created by business professionals then when enough training data is available, machine-based processes can then be used to create additional rules based leveraging existing rules.

Knowledge Media



The graphic above shows a **knowledge bearer** on the left which imparts some knowledge to a **knowledge receiver** on the right via some **knowledge media**. Just a few knowledge media are shown. XBRL is a knowledge media.

Advantages and Disadvantages of Different Knowledge Media

- **Direct contact between knowledge bearer and knowledge receiver:** With some media you need direct contact between the bearer and receiver of knowledge. For example, with Word of mouth you generally need direct contact. With a Book, a Video, or XBRL you don't need direct contact.
- **User control over information access:** Word of mouth, Book, and Video all tend to be sequential access to the information. You tend to receive information in a specific order. With XBRL, it is easy to reorder or reconfigure information. The user can easily control of the order of information access.
- **Verifiability of information:** Verifying the information you receive is possible using any media. However, because XBRL is machine-readable; automated testing can be used to verify information and experimentation is easy. For example, I can test the complete set of XBRL-based public company financial filings using software in a matter of a few hours. Word of mouth, Book, and Video media is not machine-readable.
- **Testing information ambiguity:** Because XBRL is machine-readable in terms of meaning but Word of mouth is not machine-readable and Book and Video are not machine-readable in terms of meaning; XBRL can be used to measure the ambiguity of information conveyed. The effects of vagueness and poorly articulated information can be made very clear using testing, and so such ambiguity can be minimized between the knowledge receiver and knowledge bearer.
- **Information fidelity:** Fidelity is the degree of exactness with which something is copied or reproduced. With Word of mouth the fidelity tends to be maximized because the bearer and receiver are communicating directly. If there are issues in understanding, questions can be asked. With a Book or Video, there tends to be a bit less fidelity. With XBRL, because information is converted from what is more an analog (paper) to a digital representation, there might be a loss of fidelity if the digitization is not done well. It is sort of like the difference between a record which is analog, a CD which is digital format, and a MP3 which is compressed digital format. The price you pay for the smaller MP3 files is lost fidelity, but what is lost is the frequencies far beyond a human's ability to hear. Everything is a tradeoff.
- **Reach versus richness:** In their book *Blown to Bits*, Philip Evans and Thomas S. Wurster point out the new economics of information. In the past, you could have reach or richness, but typically not both at the same time. The internet completely changed this economic equation. Reach is access to information. Richness to quantity, timeliness, accuracy and variety of information. Word of mouth tends to be the richest information, but the reach can be lower. Books have excellent reach, but less richness. With XBRL you can have excellent reach and richness.

Using a Knowledge Media

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

- **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.
- **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.
- **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 6 is a good benchmark of quality; 99.99966% accuracy.

Global Standard, General Purpose, XBRL-based, Knowledge Based System

- XBRL offers a global standard XBRL-based general purpose business reporting knowledge based system
- The system is generalized to business reporting, but can also be specialized to financial reporting
- Snap out one XBRL taxonomy, snap in another, and the system still works with a different set of knowledge
- You can build upon the platform/framework provided by XBRL to expand on base functionality
- Think *semantic spreadsheet*

Advantages of Knowledge Based Systems

- **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

Disadvantages of Knowledge Based 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

Processing Complex Logical Information

- A financial report is **complex logical information**
- A financial report was unstructured, now XBRL enables the information to be structured in a global standard format
- A financial report is a set of fragments
- Disclosures in a financial report have many logical, mechanical, and mathematical relationships that can be represented as machine-readable rules

World's First Expert System for Creating Financial Reports

- You can watch a video which shows the world's first expert system for creating financial reports:
 - <http://xbrl.squarespace.com/journal/2017/4/27/worlds-first-expert-system-for-creating-financial-reports.html>
- You can read about the rules that drive the system in the document *Blueprint for Creating Zero-Defect XBRL-based Digital Financial Reports*
 - <http://xbrl.azurewebsites.net/2017/Library/BlueprintForZeroDefectDigitalFinancialReports.pdf>

Knowledge Based System has One Domain Expertise

- Each of these systems does one thing
 - IBM Deep Blue: **Chess**
(<http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/>)
 - IBM Watson: **Jeopardy**
(<https://www.youtube.com/watch?v=Xcmh1LQB9I>)
 - Google DeepMind AlphaGo: **Go**
(<http://www.bbc.com/news/technology-35761246>)