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Cognitive Computing Creates Value In Healthcare and Shows Potential for Business Value

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Abstract

This research paper examines cognitive computing relative to how businesses in healthcare may use cognitive systems to analyze big data to create a competitive advantage. It explains the underlying technologies, such as machine learning and natural language processing, and gives an overview of the technology driving the world's most popular cognitive computing system, IBM Watson. It examines case studies that show businesses applying cognitive systems to derive value from big data and discusses how this may be used to develop business value and provide analysis for strategic processing. It also touches on challenges of cognitive computing. The paper concludes with lessons learned and future research.

Executive Summary

Cognitive computing systems are communicative self-learning machines that can help businesses, especially those in healthcare, the focus of this paper, make sense from big data. With the push towards big data and analytics, cognitive computing becomes key to assisting in decision making. As part of the strategic process to create business value, cognitive computing helps deal with the explosion of data and provides business leaders with new ways develop a competitive advantage.

Cognitive systems are not without challenges. One major challenge is the fear that cognitive systems can take people's jobs as these systems can automate work. A second significant challenge is that cognitive systems can invade the privacy of people and violate the HIPAA privacy law. Despite these challenges, cognitive computing remains an emerging technology that can satisfy important needs for businesses. IBM recently launched a consulting practice dedicated to a cognitive computing business. International Data Corporation, a respected provider of market intelligence for information technology professionals, predicts that by 2018 half of consumers will regularly interact with services based on cognitive computing. The promise of solving important problems for businesses and delivering innovative treatments to patients makes cognitive computing a viable emerging technology despite the challenges.

This research paper examines cognitive computing relative to how businesses in healthcare can use cognitive systems to analyze big data for a competitive advantage. It explains the underlying technologies, such as machine learning and natural language processing, and gives an overview of the technology driving the world's most popular cognitive computing system, IBM Watson. It examines case studies that show businesses applying cognitive systems to get knowledge from big data and discuss how this may be used to develop business value and

provide analysis for strategic processing. It also touches on challenges of cognitive computing.

1. Cognitive Computing

Accenture defines "cognitive computing" as information systems and applications that can sense, comprehend, and act. Sense means to perceive the world and collect data; comprehend means to analyze and understand the information collected; and act means to make informed decisions and provide guidance based on this analysis in an independent way (Bataller; Harris, 2015). Dr. John Kelly (2013), Senior Vice President at IBM Research, defines cognitive computing as systems that learn at scale, reason with purpose and interact with humans naturally. In mid-2014 a cross-disciplinary group of experts led by Sue Feldman at Synthexis and Hadley Reynolds at NextEra Research gave a non-proprietary definition of cognitive computing that could be used as a benchmark by the IT industry, researchers, the media, technology users and buyers. This group defined cognitive computing as systems that redefine the nature of the relationship between people and their increasingly pervasive digital environment (Synthexis, 2015). Cognitive computing is an idea that self-learning machines interface with humans in a natural way to solve complex problems. Without cognitive computing, the healthcare industry is solely reliant on the capacity of humans to operate specialized tools and spreadsheets to analyze data.

2. Reasons for Cognitive Computing

2.1 Massive Data

There is an extensive amount of data within the healthcare field that is available to be analyzed and utilized in diagnostic and treatment plans. Healthcare data currently expands faster than any human can make sense of it (Selvakumar, 2015). Also, this data is continually updating and changing in the medical field. This massive and shifting data creates a major problem because physicians cannot promptly analyze the magnitude of evolving data available. Dr. Olivier Lichtarge, professor of molecular and human genetics at Baylor Medical Center, said: "Even reading five papers per day, it could take me nearly 38 years to completely understand all of the research already available today." And Dr. Lichtarge was referring to the research of only one kind of protein when he made that statement (Henschin, 2014). In an age where we have so much information so readily available to humans, the challenge in the 21st century is information overload and subsequent 'analysis paralysis'. The reality of this dilemma creates inefficiency as highly skilled practitioners are spending time searching for relevant data instead of utilizing the skills for which they have been trained and educated extensively in medical school. Also, it is reasonable to assume that the probability of errors increases when there is more information to synthesize and process. Given the limitations of the human brain the potential for missed opportunities and discoveries is a logical conclusion. Even if all of the above were able to be refuted, the reality and risk of burnout with such a massive amount of information could substantially increase.

2.2 Complexity of data formats and finding meaning in data

Another problem is related to the complexity of the data available, which renders the scientist in a position of 'looking for a needle in a haystack.' The reality and intricacies of modern science and medicine necessitate a multi-faceted approach to disease and health. Treatments need to be tailored to an individual's unique molecular and genetic patient profiles. The success or failure of new oncological treatment approaches often depends on the presence, absence or expressivity of specific molecular or genetic markers. To illustrate this point, consider treatments that are drawn from a diverse array of scientific fields, such as biochemistry, molecular genetics and pathology to name a few. Even further, just accurately defining the problem is increasingly challenging in constantly and rapidly evolving scientific disciplines. Clinical scientists and physicians are competing against advancements and scientific progress. The reality is that current research becomes outdated so quickly. The complexity becomes even greater when the quality of human life is at stake.

2.3 Competing Priorities

There is a counter-intuitive nature in the current healthcare environment. The demand from both government and patient advocacy groups call for more personalized and efficacious treatment options. President Obama announced his plan to start the Precision Medicine Initiative (PMI) in the 2015 State of the Union Address. Shortly after this announcement, patients, patient advocate groups, scientists, and industry leaders gathered at the White House where they listened to President Obama speak about his vision of moving the U.S. into an era where medical treatment gets tailored to each patients' genetic makeup (Hudson, 2015). At the same time, government and patient advocacy groups also want to reduce both cost and burden. Competing priorities of cost, quality of life and clinical efficacy present challenges that can only be met by technological advances. The field of project management has taught that time, cost, scope and quality are all related. If you want to improve quality, you need to spend more time and money. The only way to balance these competing priorities is through the adoption and utilization of new technologies such as cognitive computing in health care.

3. Major Characteristics of Cognitive Computing

Cognitive Computing solutions can capture and connect big data so that they can create value from information found while continuously learning because of the inherent capacity to change (Bataller, C., & Harris, J., 2015). Figure 1 demonstrates how the major characteristics work in concert which can lead to the strategic processing of big data.

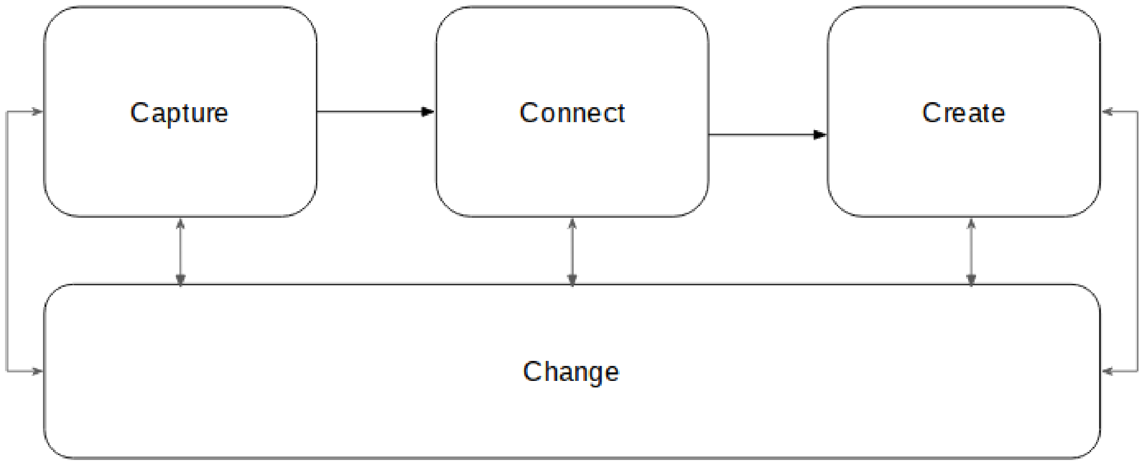

Figure 1: Major Characteristics (Bataller, C., & Harris, J., 2015**)**

3.1 Capture

Cognitive computing can capture massive amounts of data in one search and store it so that the data is available for strategic analysis. This characteristic is critically important as Gartner estimates that the world's information will grow by 800 percent over the next five years (Kelly 2015). To illustrate the value of capturing massive data, consider that a cognitive system can download all published medical information related to any topic of interest to a researcher. Cognitive computing is also capable of the autonomous capturing of multi-structured data. Capturing of multi-structured data means cognitive systems can capture more than the data contained in tables. To elaborate on the point of obtaining multi-structured data consider the scenario where cognitive computing can capture all images of radiology studies performed at a hospital, catalog them and save them to a database. Furthermore, it can tag this multi-structured data for it to be cataloged and available for later use. Another attribute is that cognitive computing on a user's behalf can sense if there is updated data and capture the latest research available. An essential capturing feature is the ability to create up-to-date physician lists to utilize in planning a clinical trial. Capturing multi-structured massive data and making it available for strategic processing is a principal characteristic of cognitive systems (Bataller, 2015).

3.2 Connect

Connecting disparate data is a fundamental characteristic of cognitive computing. Cognitive applications can connect an image to medical literature or to clinical trial data. According to IBM, the Watson-based cloud service can focus on identifying patterns in genome sequencing and link that information to medical data to reveal insights that can help oncologists develop treatments that will work individually with a patient's DNA (Gaudin, 2014). Equally important is that cognitive applications connect with humans in a natural way to help them digest integrated data through interactive dialog. An essential characteristic of cognitive computing is connecting different data to find new information, and then presenting that new information in a way that is easy to understand (Bataller, 2015).

3.3 Create

Cognitive computing can create new knowledge, products, or services. With cognitive computing, new solutions are found and presented in a probabilistic way. Humans do not necessarily receive specific answers but are offered potential solutions to their question or problem and can select the most appropriate solution given the context. The capacity to create is underpinned by the cognitive system’s autonomous capability to change over time, or learn dynamically. Change is a notable characteristic demonstrated in cognitive computing. An essential point to note is the autonomous nature in which cognitive computing applications can change. Traditional computer applications require new programs to handle change. Writing new programs takes significant time and the monetary costs are substantial. With cognitive computing, change happens autonomously as systems continuously learn with algorithms. Thus, timely and costly updates associated with writing new programs are avoided. Cognitive computing handles change with less help from humans. Moreover, cognitive systems by autonomously changing can keep data up to date more efficiently than traditionally programmed systems (Bataller, 2015).

4. Major Technologies in Cognitive Computing Systems

4.1 Natural Language Processing

Natural Language Processing (NLP) performs an essential role in cognitive systems to handle multi-structured data. A few of the main tasks NLP conducts over multi-structured data are:

- evaluating semantics,
- finding links,
- organizing words, and
- giving answers

Corpus refers to all the data stored in a cognitive application and is sometimes called the knowledge-base. NLP technologies identify the semantics of words, phrases, sentences, paragraphs, and other grammatical parts in the multi-structured data found in the corpus. Cognitive systems combine a knowledge-base (corpus) of various multi-structured data sources. Moreover, an essential use of NLP in cognitive systems is to recognize the statistical patterns and provide the linkages in unstructured text so that the meaning of big data are evaluated in the correct context. NLP refers to the group of technologies that allow computer systems to organize the meaning of words and to generate natural language answers. It is a set of methods that elicit answers from a knowledge-base. These methods determine the meaning of a word, phrase, sentence, or paragraph by knowing the grammatical rules. Furthermore, these methods can extract proper names, locations, actions, or events to uncover the relationships between and across big data. Cognitive systems rely on dictionaries, repeated patterns of familiar words, and other contextual clues to give probable answers based from multi-structured data. In summary, Natural Language Processing (NLP) is a computer system's capacity to make sense of multi-structured data (Hurwitz, 2015).

4.2 Machine Learning

Cognitive computing applications rely on models generated by machine learning algorithms. The machine learning process starts with raw data and ends up with a model derived from that data (Chappell, 2015). The brain of cognitive computing systems is the result of machine learning algorithms functioning in concert to produce models based off big data. Because of machine learning, cognitive computing systems can improve with experience. Machine learning can refer to computer systems that can learn based on data. According to "A Few Useful Things to Know about Machine Learning" (2012) while machine learning is far from simple, it is based on representation, evaluation, and optimization. Representation involves the use of a classifier element expressed in a formal language that a computer can handle and understand. Evaluation consists of a function required to mark or assess the good and bad classifiers. Optimization represents the method used to search among these classifiers within the language to find the highest scoring ones (Garcia, 2014). Machine learning algorithms discover patterns in massive and complex data which are difficult for humans to recognize. Discovering patterns is an essential function in the machine learning process. It applies statistical techniques to large amounts of data, looking for the best pattern for a problem. It then generates code that can repeatedly recognize that pattern. This generated code is a model, and cognitive applications can call on a model to solve a problem. Figure 2 shows how machine learning follows a systematic process that generates models which cognitive computing systems use to strategically process big data. The following illustrates how machine learning algorithms create models that are used by cognitive applications:

1. System receives raw data. Models are more accurate with more raw data.
2. Data pre-processing modules are applied to raw data. This cleans and structures the raw data. Pre-processing and preparing the data is an iterative process. Humans need to teach the system about the data.
3. Machine learning algorithms are applied over prepared data. This process continues until the algorithms produce the desire output. The candidate model is the software code that produces the desire output. The model implements the algorithm.
4. The chosen model is deployed to an application. Deployment is different depending on the application.

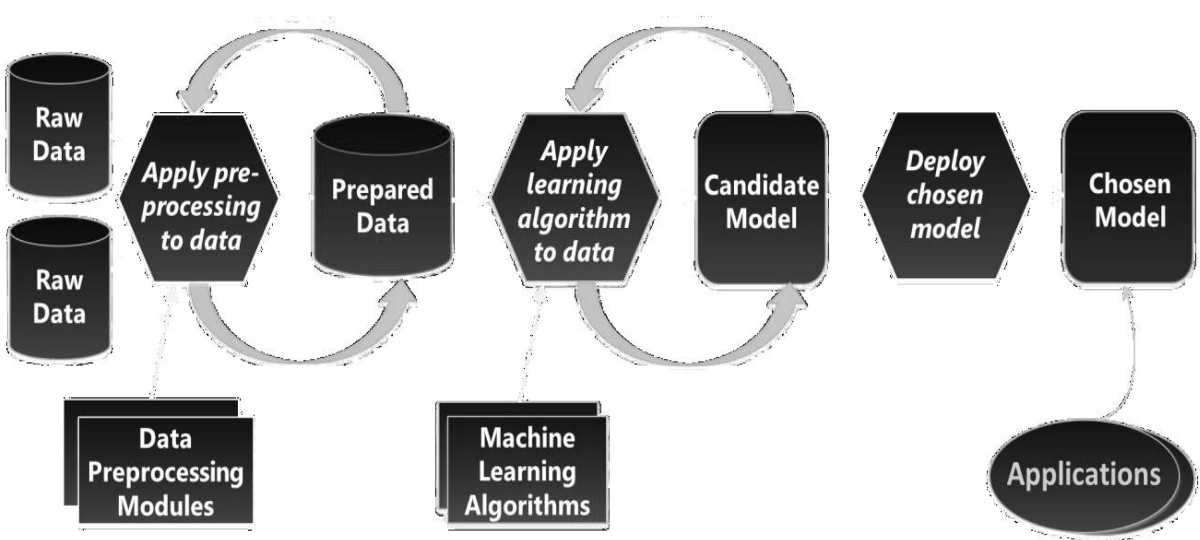

Figure 2 Machine Learning (Chappell, 2015)

4.3 Big Data Storage and Analytics

Cognitive computing systems use big data to derive answers to questions. The part of the cognitive system that holds all this huge and varied data is called the corpus. Traditional database systems cannot support the corpus of cognitive systems because of the size and variety of data. As such, big data storage and analytics are critical to cognitive systems. Big data is an expression used to represent a massive data set having a complex structure (unstructured or semi-structured) that is hard to store in traditional database systems. Unstructured data does not have a defined length, organization, or metadata. Examples of unstructured data are text, video, and image files that are not organized in a repository (Hurwitz, 2015). Semi-structured data has metadata, but is not organized in tables or in a database. Moreover, big data refers to data that is not only too big but also changes at a very fast speed. Without big data storage technology, cognitive computing would not have a place to put data. Big data storage contains the corpus, or, knowledge-bases of cognitive systems. Also, big data analytics is the part of cognitive systems that enables the system to make sense of the data in the knowledge-base. Machine learning algorithms get deployed to the analytics part of big data systems. Because of the speed at which analytics can handle data, cognitive systems can quickly draw insights. Cognitive systems rely on big data storage and analytics to capture and make sense of the massive data pools used to interact with humans and propose thoughtful solutions to complex problems (Hurwitz, 2015). The corpus of cognitive systems resides in big data storage while machine-learning algorithms of cognitive systems reside in the area of big data analytics.

5. Software Architecture of IBM's Watson

Natural Language Processing, Machine Learning Algorithms, and Big Data Storage and Analytics are the major technologies that operate within cognitive computing architecture. The architecture of IBM Watson, the most well-known cognitive computing system, describes how a question flows through such a system.

5.1 DeepQA architecture

DeepQA is the architecture of IBM Watson. DeepQA is a massively parallel probabilistic evidence-based architecture (Ferrucci et al., 2010). Massively parallel means that many technologies and services execute at the same time. Probabilistic evidence-based means that answers are compared and assigned scores. The higher a score, the more likelyhood of a correct answer. This architecture allows IBM Watson to capture messy data and connect it to create meaningful outcomes. An essential consideration is that DeepQA is a partnership of technologies and services where each contributes to a different methodology to address problems in its domain (Brasil, 2001). Figure 3 shows the major components and processes in Watson's DeepQA architecture. The following is a brief explanation of each component in DeepQA:

- A question enters DeepQA.
- Question Analysis is the first critical service. The Question Analysis service analyzes and if necessary decomposes the question for further processing in Hypothesis Generation.
- Query Decomposition determines the number of hypothesis generation service threads to run.
- Hypothesis Generation is the second critical service. Multiple threads of the Hypothesis Generation service are executed in parallel. The Hypothesis Generation service generates possible answers to the question. Answers are generated for each Hypothesis Generation Service that is executing. Answer Sources are information retrieved from primary search.
- Soft Filtering narrow candidate answers to the top 20%.
- Hypothesis and Evidence Scoring performs a second search on the top 20%. Evidence

Sources are information retrieved from a second search. Deep Evidence Scores are given to candidate answers after thorough examination of the evidence in support of all possible answers.

- Synthesis combines the candidate answers and passes them to the Final Merging and Ranking service.
- The Final Merging and Ranking service is the final major service in DeepQA. This service merges and assigns a confidence score to answers. Trained Models assign confidence scores to answers. The answer with the highest score is presented as the final answer to the question.

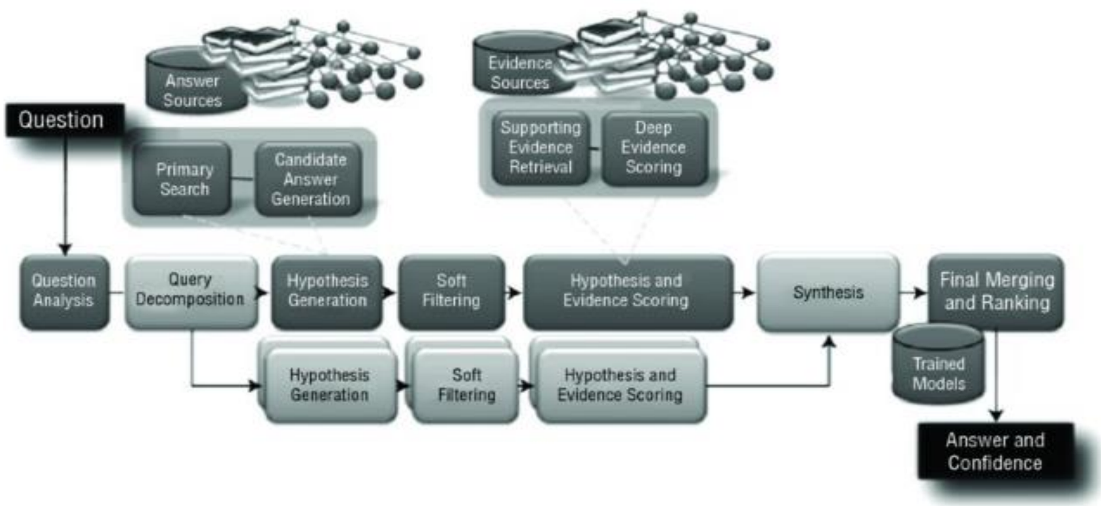

Figure 3: Watson's DeepQA Architecture (Ferrucci et al, 2010).

The following steps illustrate the flow of a question through DeepQA:

1. A question enters the pipeline. Question Analysis finds the Lexical Answer Type, Focus, and Keywords. See Figure 5.

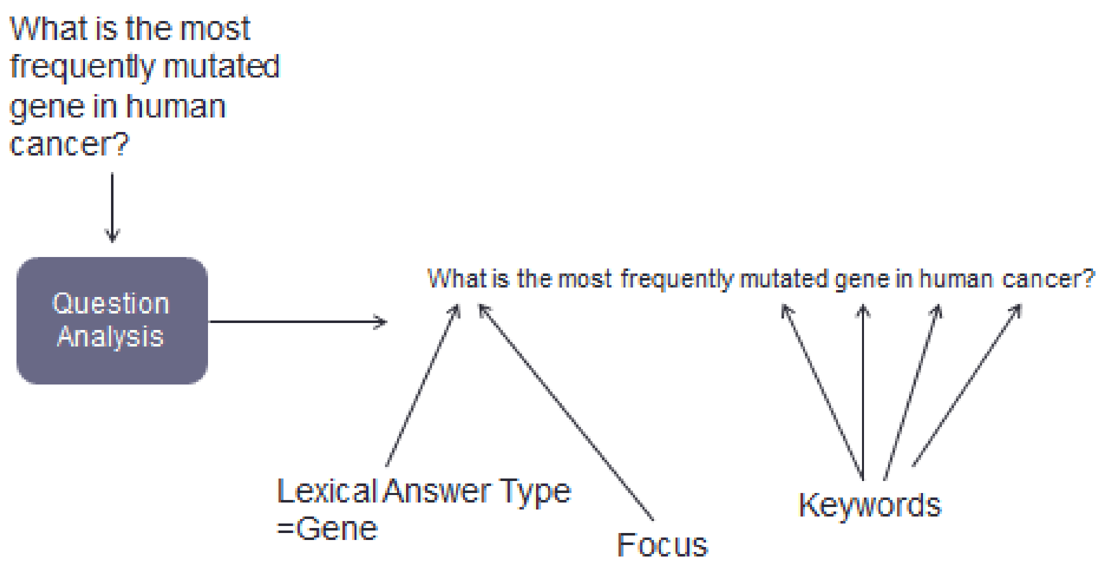

Figure 5: Question Analysis

2. Decomposition is not necessary to find the answer to the question. Hypothesis Generation begins with Primary Search which returns content using the Lexical Answer Type and Keywords. Candidate Answer Generation analyzes the content from Primary Search. After Candidate Answer Generation there is a list of candidate answers. See Figure 6.

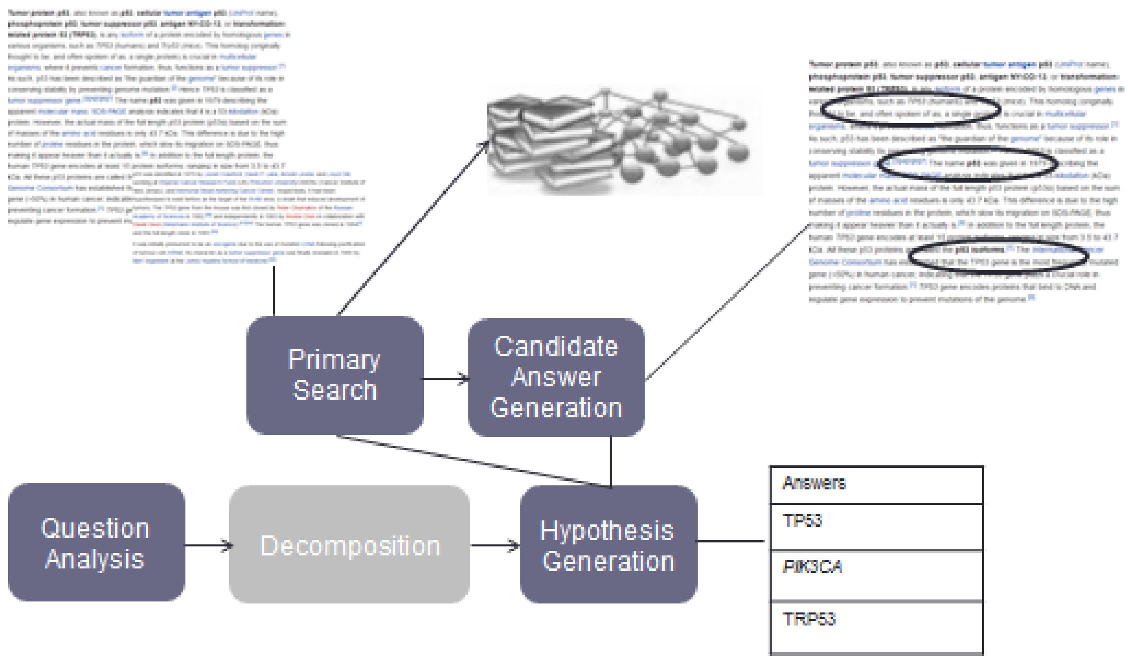

Figure 6: Hypothesis Generation

3. Soft Filtering reduces the number of candidate answers. Correct answers move down the pipeline for further analysis. See Figure 7.

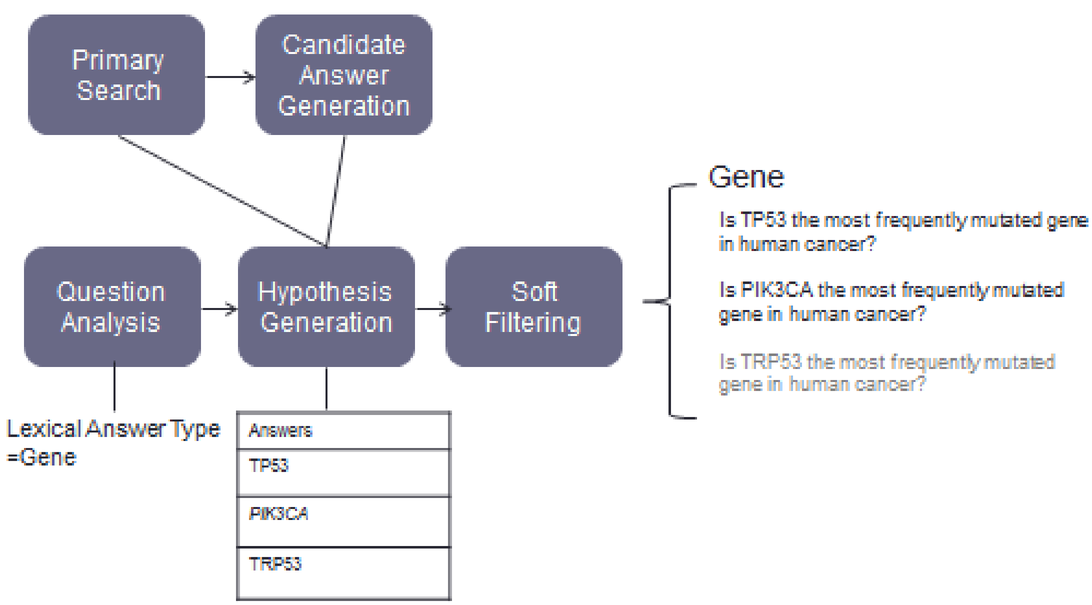

Figure 7: Soft Filtering

4. Hypothesis and Evidence Scoring performs a second search called Evidence Support Retrieval. Content is retrieved using candidate answers which passed Soft Filtering. Deep Evidence Scoring calculates and assigns scores to each candidate answer. See Figure 8.

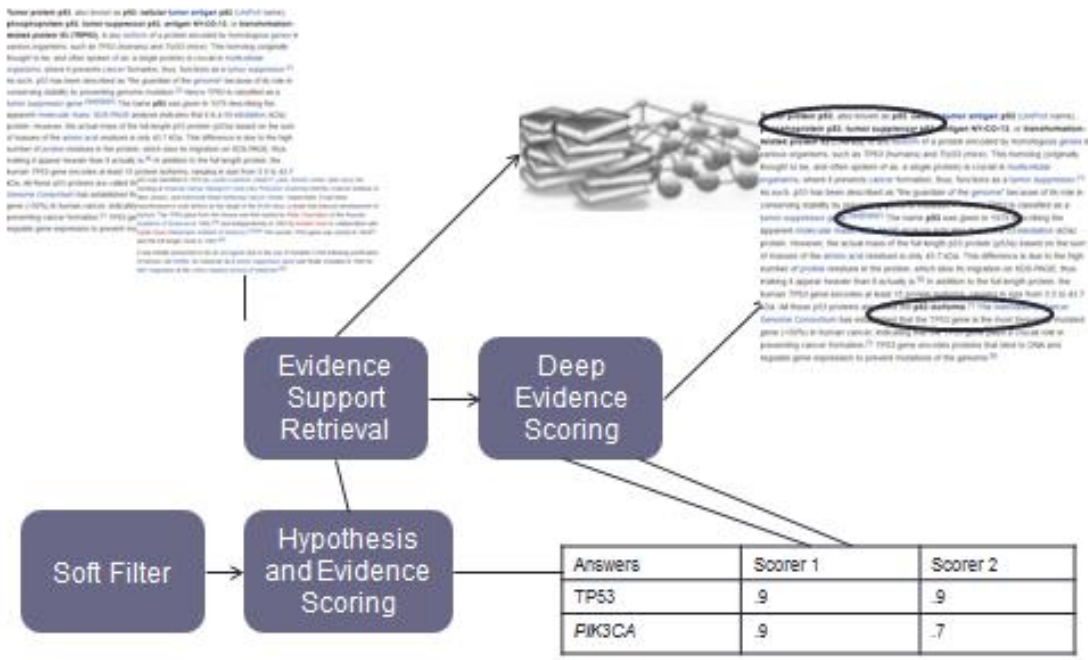

Figure 8: Hypothesis and Evidence Scoring

5. Hypothesis and Evidence Scoring pushes candidate answers and scores to Final Merging and Ranking. Synthesis is not required because the question was not decomposed. Final Merging and Ranking uses Trained Models to calculate a confidence score and rank the candidate answers with the most likely correct answer at the top. TP53 is the most correct answer to the question “What is the most frequently mutated gene in human cancer?” See Figure 9.

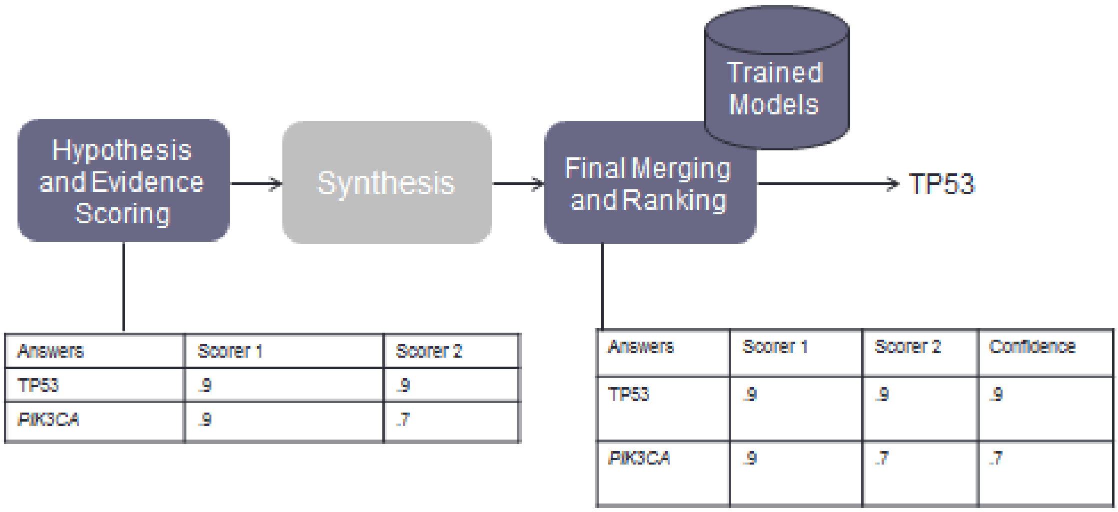

Figure 9: Final Merging and Ranking

DeepQA is the heart of IBM Watson. Watson's DeepQA architecture is a pipeline of services. Question-Analysis, Hypothesis Generation, and Deep Evidence Scoring are critical services in the pipeline.

5.2 Question-Analysis Service

Question-Analysis is the first major service under consideration in the DeepQA architecture. At this spot in the pipeline, Watson tries to understand the meaning of a question and determines how the other components in the pipeline process the query. NLP is the primary technology source at this stage. A strategic purpose of Question-Analysis is to decompose sentences so that Watson appropriately searches its massive knowledge-base for correct answers (Hurwitz, 2015; Ferrucci 2010). Classification, Lexical Answer Type (LAT), Focus, Relation Detection, and Decomposition are five principal components for successful Question-Analysis (Hurwitz, 2015):

1. <u>Classification</u> determines the type of question, such as definition, fact-based, or

mathematical.

2. Lexical Answer Type (LAT) determines the type of answer, such as a name of a movie, person, or city.

3. Focus helps see between noun or verb phrase questions.

4. Relation detection is throughout the pipeline but is especially important at this point because it helps find the relationship between words.

5. Decomposition refers to determining the need to decompose words and sentences for additional processing.

5.3 Hypothesis Generation Service

In Hypothesis Generation, the results from Question-Analysis are used to formulate candidate answers by searching Watson's corpus, or knowledge-base. A broad interpretation of Hypothesis Generation is that this part of the pipeline is about finding solutions. An essential consideration is that the candidate solutions must prove correct. Primary Search and Candidate Answer Generation are the two major parts at this stage in the pipeline. Primary search relies on several types of search engines to retrieve content from Watson's corpus. An important note is that the aim of Primary Search is to return a plethora of content that is relevant to the question. During Candidate Answer Generation, the content supplied by Primary Search is analyzed to produce a list of candidate answers. Consider that this list is expected to also contain many candidate answers. The rest of the components in the pipeline will narrow down the list of candidate answers. Hypothesis Generation relies on Primary Search and Candidate Answer Generation to get relevant content based on the question and then generates a list of many candidate solutions, which get further processed downstream by Soft Filtering and Evidence Scoring in Watson's DeepQA pipeline as shown in Figure 3. (Hurwitz, 2015; Ferrucci 2010).

5.4 Final Merging and Ranking

Final Merging and Ranking is the final major service in the pipeline before Watson answers a question. Candidate answers are screened and filtered many times before reaching this stage in the pipeline. Scores are given to candidate solutions by machine learning algorithms that provide a thorough examination of the evidence in support of all possible answers. Additionally, machine learning algorithms can retrieve more evidence. The score on an answer evolves as more evidence is discovered at this stage. IBM found that overall effectiveness is better when these scoring algorithms run parallel to one another. The scoring and estimation phase involves a series of checks and balances and scorer algorithms working together to find answers to a question. Machine Learning algorithms are the primary technologies at this part in the pipeline (Hurwitz, 2015; Ferrucci 2010). There are four main algorithms involved in the scoring process: Passage Term Match, Skip Bi-Gram, Textual Alignment, Logical Form Answer Candidate Scorer (LFACS) (Hurwitz, 2015):

1. <u>Passage Term Match</u> assigns a score by matching the unstructured text between questions and answers.
2. <u>Skip B-Gram</u> assigns a score based on relationships between unstructured text.
3. <u>Textual Alignment</u> takes into account word order when assigning a score.
4. <u>Logical Form Answer Candidate Scorer</u> (LFACS) considers the composition of the unstructured text when assigning a score.

Figure 4 summarizes this part of the pipeline by clearly showing that the main machine learning algorithms which are simultaneously executed in the Deep Scoring service and highlights an important note which is that these "scorer" algorithms run in parallel.

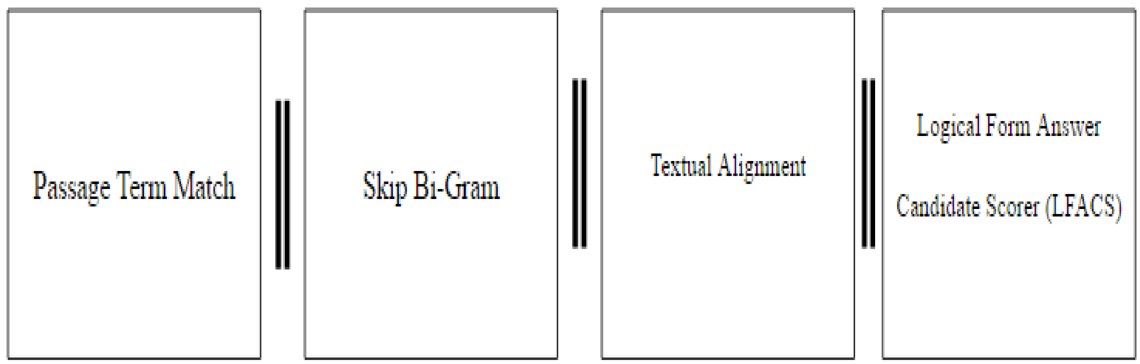

Figure 4: Four Primary Algorithms (Hurwitz, 2015)

6. Real World Applications of Cognitive Systems

This paper next presents brief examples of how this architecture is applied in real world situations. The real world situations are examples of early adopters using cognitive systems and show how these systems help create value.

6.1 Streamline the Authorization Process for Medical Treatment

WellPoint, Inc., a managed healthcare company, applied cognitive technologies to get value from big data. WellPoint, in collaboration with IBM, created a cognitive computing application, which was named "Cancer Care Quality Program" to create efficiencies in the review process for medical procedures and treatments. The review process for medical procedures and treatments is time-consuming. One potential cause is the amount of data that is analyzed and synthesized in considering authorization requests for treatments and procedures. An additional benefit of this cognitive system was to assist oncologists in choosing evidence-based treatment. The cognitive system provided such value that the program is expanding across the country. As of July 2014, the "Cancer Care Quality Program" resides in Indiana, Kentucky, Missouri, Ohio, Wisconsin, and Georgia. By early to mid-2015, this program was expected to expand to additional states, such as New York, Connecticut, Maine, New Hampshire, and Virginia (Doyle-Lindrud, 2015;Verdon, 2014). The "Cancer Care Quality Program" demonstrated to WellPoint that cognitive computing can generate efficiencies in the authorization process of new treatments, and provide decision support to oncologists.

6.2 Create Data-Driven Treatment Plans

Cognitive computing used big data at Memorial Sloan-Kettering Cancer Center (MSKCC) to find evidence-based diagnostic and treatment plans. MSKCC is a research institution, which specializes in cancer treatments. IBM helped MSKCC pilot a cognitive system that compared a patient's specific medical information against the standard of care guidelines, published research, genetic data, and other patient records to choose the best evidence-based diagnostic and treatment plans. Although the tool had originally been built to focus on breast and lung cancers, it has since been expanded to include colon, prostate, bladder, ovarian, cervical, pancreatic, kidney, liver, and uterine cancers, melanoma, and lymphoma. MSKCC continues to pilot this cognitive computing application to penetrate big data that led to treatment plans backed by ample evidence (Doyle-Lindrud 2015).

6.3 Train and Provide Decision Support

Cognitive computing is using big data to train and support researchers at MD Anderson Cancer Center. The cognitive system is named Oncology Expert Advisor (OEA). Which used IBM's Watson increasingly advanced smart machine to discover personalized treatments for cancer patients by comparing disease and treatment histories, genetic data, scans and symptoms against the vast universe of medical knowledge. Physicians were apprehensive at first when they saw one of their peers is a cognitive computing system, Watson. In time, these same doctors saw Watson as a partner in synthesizing medical literature to formulate an evidence-based treatment plan. Watson can assist physicians in making personalized treatments in real-time. Physicians analyze medical and clinical data by asking Watson to reveal patterns related to certain conditions. For example, a physician can ask Watson for the latest treatment plan for a patient with bladder cancer that expresses certain genes. Physicians can then read the literature that Watson used to support a treatment plan. Without Watson, researchers could spend weeks before finding personalized treatments. This collaboration between physicians and Watson demonstrates that cognitive computers can work alongside professionals. The man and machine collaboration are working so effectively that there are plans to expose the Oncology Expert Advisor to oncologists across the country. Researchers worked with cognitive systems to penetrate the extensive and diverse nature of medical literature (Eunjung, 2015).

6.4 Recommend Personalized Care and Treatment Plans

Researchers at the Cleveland Clinic are piloting a cloud-based cognitive computing application to study the human genome to find personalized cancer treatments. The human genome is incredibly complex while medical treatment plans continuously evolve. Matching specific treatments according to genes is a highly difficult task for any physician. Cognitive computing can help researchers penetrate the size and complexity of genomics to find personalized medicine. According to the Cleveland Clinic, doctors don't have the time or the technology to examine precise treatments for individual patients based on their type of cancer along with their unique DNA. Researchers at the Cleveland Clinic want to correlate data from genome sequencing based on information contained in medical journals, reports, and clinical trials. A cognitive application can assist researchers in this task by ingesting all available medical and clinical information and then allow researchers to analyze this information in natural language. According to IBM, Watson can capture patterns in genome sequencing and connect that to medical and clinical data. This use of cognitive computing is a good example of cognitive computing augmenting the capacity of humans. Dr. Charis Eng, the chairwoman of the Lerner Research Institute's Genomic Medicine Institute, believes cognitive computing can enable the acceleration of new discoveries and bring forward new breakthroughs in personalized medicine. This cloud-based pilot using Watson is an ongoing program between IBM and the Cleveland Clinic to improve the use of big data in healthcare (Gaudin, 2014).

6.5 Enhance Existing IT Infrastructure to Improve Predictive Analytics

CVS Health is building a pilot cognitive computing application to gain value from big data. CVS plans to extend its internal strength in predictive analytics. Predictive analytics applies regression analysis over historical data to make forecasts about the future. The goal is to combine cognitive computing capabilities with predictive analytics to generate a range of services for healthcare companies. At first, the services will focus on identifying people at risk for declining health, advocating healthier habits, and recommending cost effective primary care and outpatient providers. CVS partnered with IBM to improve on its existing IT asset, predictive analytics. Combining internal IT assets with cognitive computing is a good example of how institutions can augment current IT architecture. Adopting cognitive computing is not an all or nothing decision, or 'retire this application' first type decision. Cognitive computing systems can augment existing IT architectures to improve services. CVS Health is early in the process of delivering an entirely new suite of valuable applications to other healthcare institutions by leveraging components of cognitive computing systems that enhance their internal predictive analytics (Cozza, 2015).

6.6 Reduce Costs to Plan a Clinical Trial

Planning clinical trials is a challenging process. Data must be found and combined from many sources to pick physicians to participate in trials. Data also is used to predict how soon clinical trial sites can start and how soon physicians can enroll patients. Icon is a clinical research organization that provides solutions and services to the pharmaceutical industry. Icon is looking for solutions that can lower the costs of planning a clinical trial. As such, they have partnered with IBM to create a cognitive system to improve the process of planning clinical trials. Icon is piloting a cognitive system that can read scientific protocols that describe the clinical studies and recommend enrollment timelines based on similar protocol documents. This step to compare a large number of similar protocol documents adds value, but the issue is that there are not enough resources and time to complete this step. Cognitive computing has the potential to accelerate clinical trial planning (Power, 2015). This cognitive system pilot results are anticipated in 2016 (Alsumidaie, 2015).

6.7 Integrate Disparate Business Processes and Goals

IBM, Epic Systems, and the Mayo Clinic are forming an alliance to create value from big data using the power of cognitive computing. Epic Systems stores massive amounts of patient health records. Epic will share their patient records with IBM's Watson. Data service and usage agreements are needed to comply with HIPAA. Data also must be de-identified before being exposed to Watson. The goal is that Watson will mesh patients' records with all the other big data stored in its vast knowledge-base to inform clinical decisions in near real-time. The point that this analysis is in near real-time showcases cognitive computing's capacity to convert to big data for strategic processing, which in turn leads to value. Also, Mayo Clinic can tap into this curated data from Watson to match patients with clinical trials. Cognitive computing is leading to compelling alliances across healthcare, which can help make medical treatments more aligned to personal needs. This example also demonstrates cognitive computing's broad appeal for converting big data to value and opportunity. Mike Rhodin, a senior executive at IBM Watson, believes these partnerships are early examples of the kind of cognitive computing collaborations that can "deliver personalized treatment by connecting conventional sources of patient data with the growing pools of dynamic and constantly growing healthcare information" (Jayanthi, 2015).

6.8 Establish Personalized Wellness Coaches

Welltok is a healthcare company that is using cognitive computing to motivate people to make healthy decisions. Welltok's cognitive computing coach called Cafewell offers people a way to find personalized activities, health information, and exercise management programs designed to optimize their health. The cognitive coach even persuades consumers with rewards for positive behavior change (Thompson, 2015). The cognitive system aggregates big data from a variety of different sources, like the other cognitive systems given in the examples of real world applications. NLP technologies are essential in this particular application because they allow for an interactive dialog with the cognitive technology assistant. An interactive dialog reduces the complexity of getting to relevant content. Welltok's version of a cognitive system learns dynamically as well. The application learns from interactions with their users and also from new data as time passes. An executive at Welltok believes that cognitive computing technologies, like NLP, can create “a fun and engaging way for consumers to ask questions in their own vernacular." He also says that people can get intelligent responses that get smarter all the time, based on repeated interactions with the consumer" (Thompson, 2015). Cognitive computing can help people make healthier choices by connecting them to relevant health information. Welltok empowers people to make positive health changes driven by user-centric, intelligent recommendations made possible through cognitive computing (Fraser; Sarkar, 2015).

6.9 Reduce the Burden of Living with a Chronic Condition

There is a need to help people manage chronic conditions. Intermountain Health is piloting a cognitive cloud to meet this need. Intermountain Healthcare is a not-for-profit health system that offers a broad range of clinics and services. This cognitive cloud pilot allows Intermountain Health to make sense of big data by finding and presenting meaningful insights in an understandable manner to patients managing a chronic condition. Additionally, the data in Intermount Heath's cognitive cloud is always updated with the latest information. Patients with chronic diseases can access this cognitive cloud to receive understandable and accurate medical information about their condition. Edward Clark, Chair of Pediatric Clinical Program at Intermountain, is piloting a cognitive cloud solution because of the technology's ability to process semi-structured data to deliver personalized recommendations in real time. Intermountain Health is piloting a cognitive cloud that processes their big data to improve the healthcare of people managing chronic conditions (Keating, 2015).

7. Case Studies on Cognitive Computing

The case studies are a more in depth review of institutions using cognitive systems. The institutions in the case studies are further along in using cognitive systems compared to the examples in the real world applications.

7.1 Accelerate Research

P53 is a crucial protein in researching treatments for cancer. The P53 protein exists in half of all cancers. In research circles, P53 is known as the “tumor suppressor” or the “guardian of the genome.” P53 responds to the detection of genomic problems by increasing the expression of hundreds of other proteins to try to fix the errors, or if that is not possible, it can even cause a cell to destroy itself, saving the neighboring cells and the life of the individual (Picton 2014). Drug researchers aim to identify targets that turn P53’s signaling mechanism on and off. There are over 500 plus targets that are believed to interfere with the signaling mechanisms of P53. Experiments to find a target can take months and understanding the larger impact can even take years. Scientists at Baylor College of Medicine believe that links between specific proteins could hold the answer to innovative new cancer treatments. Dr. Olivier Lichtarge, a professor at Baylor, thinks it is impossible to understand all of the research already available today on this protein" (Henschin, 2014). Over 310,000 published articles reference the type of proteins researchers study. Because of the massive amount of relevant data, the discovery process is slow. Researchers need help sorting through all the published literature to narrow the focus of their research. As a result, Baylor College of Medicine (BCM) partnered with IBM to create a cognitive computing application. BCM and IBM created the Knowledge Integration Toolkit (KnIT). KnIT analyzed massive volumes of scientific articles, connected information, and ranked candidate links on P53; a workflow (capture, connect, create) typical in cognitive computing applications. Ultimately, KnIT accelerated the research process and contributed to researchers conducting experiments on the most promising candidates (Picton 2014). The hope is the most promising candidates will lead to new treatments for cancer.

7.2 Improve Diagnostics

The echocardiogram (ECHO) is a standard diagnostic test in cardiology. The results of ECHOs are eventually transcribed in a spreadsheet of approximately 1500 data points and doctors at Mount Sinai Hospital manually review these results in a spreadsheet. Because of the volume of data generated from echocardiograms, doctors use less than 1% of all data available to make a diagnosis. This reduces the potential accuracy of the diagnosis. Cognitive computing platforms offer a new approach to analyzing large volumes of data and identifying potential and unrealized patterns of cardiovascular function and disease (Saffrontech, 2014). Dr. Partho Sengupta, Director of Cardiac Ultrasound Research and Associate Professor of Medicine in Cardiology at The Mount Sinai Hospital, believed he needed a better way to accurately identify disease patterns from echo tests to improve diagnostics. Specifically, Dr. Partho Sengupta wanted to distinguish between cardiomyopathy and pericarditis. Cardiomyopathy directly impacts the heart muscle and often leads to heart failure. Pericarditis refers to the irritated tissue around the heart but does not result in heart failure. Treatment plans are different depending on the condition. For pericarditis, the treatment may include medication. However, if the diagnosis is cardiomyopathy the patient may need a pacemaker. Misdiagnosis of these diseases can be very expensive. Dr. Sengupta, therefore, looked a cognitive computing system to increase the diagnostic accuracy of these medical conditions (Saffrontech, 2014). Dr. Sengupta launched a blind study comprising 15 patients with pericarditis and 15 patients with cardiomyopathy. Participating physicians overall had a 56% accuracy rate of diagnostic accuracy. Dr. Sengupta distinguished the conditions with 76% accuracy. The cognitive system had a 90% accuracy rate. Traditional tools used by doctors to analyze ECHO tests, like R's program C-trees, resulted in only 54% accuracy. Drawing on a cognitive system's capability to dynamically learn from data, a cognitive computing application can help cardiologists identify patterns and classify distinct disease states quickly and accurately (Saffrontech, 2014).

8. Key Themes from Cognitive Computing Systems Used in Real-World Applications

8.1 Augment Human Cognition

The most important theme revealed in real world applications of cognitive systems is that cognitive computing maximizes human potential. Physicians with the help of a cognitive computing application penetrated big data to create value. Skip Snow, an analyst at Forrester Research, believes cognitive computing could improve access to knowledge and increase scientifically-based decision capabilities because doctors will not have to read thousands of journal reports published every month. Instead, computers will process these reports for them, and doctors could ask questions "in a sort of two-way fashion, and get answers quickly" (Thompson, 2015). Doctors can get answers quickly through an interactive dialogue using natural language with a cognitive application. The applications enhance physicians’ abilities to include more literature when deciding on treatment plans supported by data, and doctors can apply more research that in turn provide personalized treatment plans. The real world applications also show that cognitive computing can help alleviate humans from burdensome tasks, like data collection and preparation. Cognitive computing systems can acquire big data and prepare it for deeper analysis. Capturing and preparing big data allows humans to focus more time on critical and creative thinking, and less time on non-value, but necessary steps. Another way that cognitive computing augments humans is subtle. Cognitive computing helps humans analyze big data with less bias because they offer a purely logical assessment of evidence which reveals to humans cases when they are acting contrary to what the evidence shows. The real world applications of cognitive computing demonstrate man and machine relationships that enhance the capacity of humans to accomplish great challenges.

8.2 Automate Knowledge Ingestion and Synthesis

Another significant theme demonstrated is cognitive systems autonomous ingestion and synthesis of data. Ingestion refers to how cognitive systems receive and store data. Independent ingestion and synthesis are challenging tasks for humans. This work can take hours to complete. Often the screens to manage the data ingestion are complicated to use. With cognitive computing, data ingestion and synthesis happens behind the scenes. This masks the complexity of acquiring big data which is incredibly useful. Humans can start performing analysis much sooner when ingestion and synthesis occur in the background. Cognitive computing shows a capability to ingest all kinds of data, including images from x-rays and patient charts and machine output. The cognitive systems did not breakdown as file formats became diverse. Moreover, the capability to keep data current was clear. Cognitive computing does not only perform a one-time bulk load of raw data. But they can sense when new data needs to be ingested and synthesized. This feature is critical when providing decision support to doctors in near real-time about personalized care plans. Autonomous ingestion and synthesis of big data are critically important features of cognitive systems. This reduces the lead time for analysis, hides the complexity of ingesting raw data, and ensures the most current data for decision support.

8.3 Systems Continuously Learn

Cognitive computing systems continuously learn from people and data which is beneficial to processing big data for a competitive advantage. Because cognitive systems dynamically learn, they keep up with the pace of business. Cognitive systems (Bataller, 2015) can learn from experience and change their handling of big data based on those learnings. In today's highly competitive world, business processes must adapt rapidly to the external environment. Cognitive systems partially rose from the need for more flexibility and dynamic systems. Every interaction with humans improves the cognitive system's capacity to help. Also, cognitive systems avoid the cumbersome process of reprogramming them to accommodate changes in business processes. Although this was not clearly evident from the real world applications, if cognitive systems required new programming instructions every time medical literature changed or questions became more complex, doctors would not see the systems as true collaborators. The dynamic learning capability was apparent in the cognitive computing systems described. Cognitive computing systems are self-learning in that they are like curious students who given educational materials, can learn by themselves (Bataller, 2015). The capability to continuously learn keeps pace with the fast speed of changing business processes and avoids the downtime associated with re-programming traditional computer systems.

9. Potential Business Value

9.1 Cost of Not Knowing

When considering the business value of cognitive computing, decision-makers can start by asking themselves what is the cost of not knowing (Kelly, 2013). For instance, what is the cost of a pharmaceutical company not discovering molecules to treat unmet diseases? In a human sense, imagine the well being of patients struggling with an unmet disease. The patient waits for this discovery to improve their quality of life. There is also a tangible value to not knowing. Consider the loss of revenue when a competitor brings a new product to market based on information that was there all along just waiting to be found. On the other hand, think about the opportunity for growth by making that discovery that leads to a new product or service. Cognitive computing can help businesses find hidden patterns in data. These hidden patterns can lead to the next big product or service, which in turn leads to business growth. Keep in mind that the competition is continuously looking for that competitive edge. There is a cost of not improving the lives of people suffering from disease and a cost to companies that lose to their competition. Decision-makers should weigh the cost of not knowing, and look at examples where cognitive computing has led to knowledge assets.

9.2 Deeper Insights to Differentiate

Data exists that is not used to generate business value. This data is "dark data"; data which is not analyzed. John Kelly, Vice President for IBM Research, told over 300 neuroscience researchers, computer scientists, startup executives, and academics interested in cognitive computing that 80% of all data is dark and unstructured. By 2020, that number will be 93%" (Babcock, 2015). Gartner defines "dark data" as data assets that organizations collect, process, and store during regular business activities, but fail to apply for other purposes. Cognitive computing systems use cutting-edge technologies such as NLP, machine learning algorithms, and big data storage to unmask and comprehend "dark data" that can lead to deeper insights (Bataller, C., & Harris, J., 2015). One reason this data is not analyzed is there are not enough people to perform the analysis. Cognitive computing elevates employees' capacity to analyze big data. Cognitive computing ultimately can boost the creativity and productivity of professionals and their teams (Spohrer, 2015). With cognitive computing, business can penetrate big data to find novel insights without increasing and straining employees.

9.3 Preparing for More Data from Internet of Things

Businesses are already not getting enough value from data, and soon more data will hit enterprises as more devices connect to the World Wide Web. Interconnected devices called the Internet of Things, allows data to be collected and shared from many sources. As raised in the previous discussion on "dark data," there simply are not enough people to handle the amount of data presented to businesses. There is little argument that executives believe that information is valuable to gain competitive advantages. Previous investments in big data technology demonstrate that senior decision-makers understand the value of information. There is now a new need for cognitive computing to handle the next generation of data as more devices become connected to the Internet. Cognitive computing has demonstrated its unique capability to devour massive amounts of data. Humans can then interface in a natural way to understand what patterns and insights may exist. If business leaders want to maintain even competitiveness in a rapidly changing environment, then new investments in cognitive computing are necessary. Cognitive computing has demonstrated in the real world applications that it is the technology to extract value from big data.

9.4 Efficiency and Effectiveness Gains

Businesses are constantly looking for efficiency and effectiveness gains. Employees create annual objectives based on executing projects that lead to gains in efficiency or effectiveness. Cognitive computing clearly shows advantages in saving time in capturing and connecting data in the real world applications. The opportunity to increase the productivity and creativity of professionals with the help of cognitive computing assistants is becoming a reality

(Spohrer, 2015). Consider how cognitive systems searched, found, and captured vast amounts of published medical journals. Tasks like this could take weeks for even the most experienced data scientists. The cognitive system accomplished such tasks in minutes. Also, considering the potential for "human error" in trying to capture massive amounts of multi-structured data is not that difficult. Cognitive computing raises the effectiveness by significantly reducing the likelihood of human error. There are business processes that can benefit from cognitive computing's ability to save time and reduce errors. In addition, consider the time required to synthesize all available published literature on a particular topic. Researchers again could spend weeks just trying to integrate research before even starting an analysis. With cognitive systems, the synthesis of literature is completed in minutes, which means researchers can get started more quickly on the analysis of actual problem. Cognitive systems can create efficiencies and effectiveness at critical stages in the information handling and processing.

9.5 Eliminate Waste

Eliminating waste from processes is also an annual initiative for most businesses. Waste describes tasks that do not add value to an overall process, tasks that are error prone, or tasks that take much longer to complete than expected. Cognitive systems can automate certain tasks that do not add value. In this way, people can tackle tasks that will generate value. With cognitive systems, updates are much less stressful. Often upgrading systems to keep current with changes requires taking the system down and programming new instructions. The tasks of programming new instructions are rarely successful on the first try and often even after several tries. Because cognitive systems are built to evolve, errors and corresponding downtime associated with updating systems are avoided. Data discovery and preparation are examples of processes that take much longer. As shown in the real world applications of the cognitive systems, data discovery and preparation is automated, which in turn reduces the lead-time before starting to solve the actual problem. Cognitive computing can automate and even eliminate business tasks that are traditionally slow to complete or prone to error, which accelerate business and reduces waste.

9.6 Maximizing Human Potential

The most significant value cognitive computing can have on business is the capability to maximize human potential. Corporations spend exorbitant amounts of money on training people to reach peak performance. Cognitive computing is built to augment human intelligence. Researchers can use data in analyses, which would otherwise not be included. This data can elevate the potential of discovery to lead to better treatment outcomes. Cognitive computing can help people find the next innovation or breakthrough resulting in tremendous business growth. The acceleration of research was a typical scenario demonstrated by application of cognitive systems. An employee can use cognitive systems to increase their knowledge in selected domains leading to better job performance and better decision-making. Cognitive computing provides time for creative thinking about improving business processes and products. Employees can spend more time on tasks with greater potential to generate value and maximize human potential by increasing the ability to solve complex problems and make better decisions.

10. Challenges of Cognitive Computing

Cognitive computing is not without challenges, which can block the value. One major barrier is that people fear cognitive systems will take away jobs. Technology can indeed automate tasks that can lead to job losses. However, cognitive systems can result in new jobs. In fact, another challenge is the lack of trained professionals to manage and support cognitive systems. IBM is collaborating with several academic institutions to enhance learning curricula to develop the next generation of cognitive computing professionals. There are also privacy concerns related to cognitive systems. Personal information gets captured without permission if humans do not de-identify the data before they input it in the cognitive system. Because cognitive systems can learn from experience and data, there is potential to teach cognitive systems to spot potential privacy problems. In this way, humans and cognitive systems can work together to ensure a safer and more secure cyberspace. Fears of job loss and invasions of privacy are real concerns that challenge the adoption of cognitive computing systems. But, cognitive computing can open new career opportunities and can enhance privacy. Every new era of technology, from the industrial age to the Internet era, has had a tremendous impact on the world. Productivity rises and falls, professions change, new professions emerge, and certain professions become obsolete. Cognitive computing certainly has the potential to have such an extensive impact on the entire segment of knowledge-based occupations (Spohrer, 2015).

11. Lessons Learned

Cognitive computing is poised to play a larger role in clinical research. Clinical trials are essential in clinical research. They reveal the efficacy and effectiveness of new drugs. New treatments for unmet medical needs are the result of successful clinical trials. Cognitive computing can optimize clinical research by strategically processing clinical trial data. There are three ways that cognitive systems can accelerate timelines, improve compliance, and enhance data analysis. First, a cognitive application can speed up the time to create protocols, which are scientific documents that describe in detail a clinical study. By reading historical protocols, a cognitive computer can create templates of protocols to accelerate the authoring of protocol documents. Second, a cognitive application can improve compliance to a protocol during the execution of a clinical trial by ensuring that data collected from patients are appropriate according to the trial's protocol. Third, cognitive computing can reduce the complexity of data analysis. A cognitive application can allow scientists to penetrate clinical trial data using natural language. Data analysis often means learning complicated software and writing sophisticated queries. Analysts learn how to adapt to the computer. With cognitive computing, computers learn how to adjust to analysts by processing natural language. Clinical trials produce massive amounts of structured and unstructured data about the efficacy and effectiveness of a drug. Cognitive computing can strategically process clinical trial data to help decision-makers decide on the efficacy and effectiveness of candidate drugs.

12. Future Research

Future research in cognitive computing can follow two paths. One path can focus on improving foundational technologies, such as natural language processing and machine learning algorithms. Researchers can enhance NLP so that cognitive systems can hold fluid conversations. NLP can be enhanced to sense emotions, and change communication styles depending on emotional states. For example, a cognitive application could sense when a student does not fully grasp a concept and provide more analogies. Advancements in Machine Learning Algorithms can make training cognitive systems easier. Teams of experts will not have to spend many hours training cognitive systems. An ambitious goal of researchers is the development of machine learning algorithms that let cognitive systems learn completely by reasoning over data. A second path will focus on the development of an entirely new kind computer architecture called Neurosynaptic. Neurosynaptic is architecture based on neurons and synapses in the human brain. The goal of this research is to develop computer systems that simulate the activities in the human brain. As Neurosynaptic architectures evolve, there will be continuous incremental improvements on the foundational technologies that comprise cognitive systems.

13. Conclusion

Cognitive computing can improve patient, research, and business outcomes. Through interactive dialog between machines and humans the appropriate solutions can be found to complex problems. An interactive dialog allows machines and humans to drill-down on problems in a natural way. The real world applications demonstrate that cognitive computing is a practical technology that when applied to big data can generate outcomes of value and utmost importance. Cognitive computing has traveled from concept to idea, to lab, and to practical applications. The KnIT case study showed that answers are reliable, and humans can have confidence in the solutions suggested by cognitive systems. KnIT also showed that machines can actively contribute to advancing science by supporting researchers in formulating appropriate research questions. The echocardiogram case study shows that there is data that gets lost in analysis; when this data is captured and connected, researchers can create personalized treatments that lead to better outcomes. Businesses will continue to examine how early adopters are applying cognitive computing to real-world problems and opportunities. Cognitive computing capabilities have broad appeal because cognitive technologies can create process improvements on a diverse set of business flows.

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