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INFORMATION SYSTEMS
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Big Data in the Information Age: Exploring the Intellectual Foundation of Communication Theory

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Abstract

Big Data are structured, semi-structured, unstructured, and raw data that are revolutionizing how we think about and use information in the 21st century. Big Data represents a paradigm shift from our prior use of traditional data assets over the past 30+ years, such as numeric and textual data, to generating and accessing petabytes and beyond of images and social media. Traditional databases stored only structured data consisting of letters and numbers, but in the era of Big Data a need arose to incorporate unstructured data as part of overall information management. The shift to Big Data started with the Internet boom of the mid to late 1990s and the "rich data" that could be collected through semi-structured and unstructured petabytes of behavioral, image, textual, and social media data. Social media, such a Facebook, Twitter, Wikis, Blogs, YouTube, etc., has also changed our view of data. Big Data is a relatively nascent field of study that has spawned the development of new hardware, software, and database architectures to handle the large volume of structured and unstructured data. However, the foundation for the exploration and analysis of Big Data is as old as the Information Age itself and is rooted in the field of communications. In this paper, the authors show how communication theory has developed in parallel with the development of the Information Age and how the application of convergent theories resulted in Big Data producing Business Intelligence.

Keywords: Big Data, Information Age, Communication Theory, Business Intelligence, ADIK, Web 2.0

1. INTRODUCTION

The history of Big Data is the history of the development of the computer from the first simple data processing machines to the large-scale data centers of the modern Information Age organization. It is also the history of communication theory. Communication theory is the foundation for analyzing and understanding data. The use of communication theory allows data to be combined, processed, and organized into information; then analyzed and transformed into knowledge culminating into the core of Business Intelligence (BI). Without the use of communication theory, data collected and stored by companies would be of little value. It is therefore vital for students, researchers, and practitioners in the fields of Information Systems (IS) and Information Technology (IT) to have a working knowledge of communication theory.

This paper explores how communication theory plays an important role in understanding Big Data and its influence upon BI. We start by defining what are Big Data, BI, and the Information Age organization. We explain the differences between data, information, and knowledge, and distinguish how they contrast. With this basic understanding of data and information, the discussion moves into the basics of communication theory. A brief history of the Information Age follows with a smattering of historical chronology and a brief literature review of selected subject matter experts and their respective theories. This leads to an examination of why and how communication theory applies to the clear and cogent transmission of information, and its logical relationship and transference to Big Data. Finally, we conclude with a brief look ahead into the social dimensions and future of Big Data.

What is Big Data?

Big Data is structured, unstructured, and raw data stored in multiple disparate formats that ultimately resulted in a paradigm shift in how we think of data. Traditional databases store only structured data consisting of letters and numbers (transactional data), but in the era of Big Data a need arose to store semi-structured and unstructured data. The shift to Big Data started with the Internet boom of the mid-1990s and the "rich data" that could be collected through e-commerce transactions (Noah & Seman, 2012). The unstructured data from e-commerce sites includes data on what items the user viewed, such as click-through data and sub-transactions. Social media also changed our view of what data are. Companies such as Facebook capture and store photos, video clips, sound bits, "likes," and instant messages. To store and process Big Data new highly scalable, available and low latency database systems are needed (Noah & Seman, 2012). Big Data systems often have databases in the petabyte range; a petabyte is equal to 1,000 terabytes or 10^{15} bytes. To turn Big Data into actionable information new ways of exploring and analyzing data were needed. This complex analytical process manifested itself into the role of Business Intelligence.

Business Intelligence

Business Intelligence (BI) is the process of generating actionable information from raw data. BI is not a technology; it is a combination of hardware, architectures, tools, methods, and databases (Turban, Sharda, Delen, & King, 2011). Modern BI allows decision makers to analyze real-time or near real-time data to make better decisions and to act on those decisions. The purpose of BI is to transform companies into Information Age data driven organizations. The term "business intelligence" has been used since the late 1950s but modern BI systems only became possible with the advent of the data warehouse in the 1990s. The predecessor to the BI system was the Management Information Systems (MIS) of the late 1960s and 1970s. MIS were reporting systems that provided simple static, often times printed, two-dimensional reports (Turban, et al., 2011). The MIS lacked analytics and any changes to the reports that required a specialized programmer to modify the computer code. With the advances in technology the MIS systems of 1960s and 1970s gave way to the Executive Information Systems (EIS) of the 1980s. The advent of the personal microcomputer in the 1980s allowed the transformation of the MIS system from static reports to a more dynamic system. Users were able to generate ad-hoc reports and view reports that allowed the user to drill down from a high level overview or summary to detailed lower levels. The EIS also provided advanced features such as forecasting, predictions, and trending analysis (Turban, et al., 2011). By the mid-1990s, the EIS had become more powerful and were being used by mid-level management, as well as executives. The term "Business Intelligence" started to appear in technology journals and as common parlance within the popular media. The modern BI systems were developed to take advantage of "Big Data" created by the Internet, e-commerce, organizational textual documentation, social media, and traditional transactional data through the large-scale data warehouse. By 2005, BI systems were incorporating advanced analytics such as data mining, semantic analysis, and artificial intelligence (Turban, et al., 2011). BI is integrated into most large-scale software systems such as SAP, PeopleSoft, and IBM Cognos. What started out as a simple reporting tool for executives turned into a powerful system that allowed employees at all levels to be "data driven." BI evolved into creative and innovative analytics for problem-solving and decision-support.

Information Age organizations are data driven entities that use analytics to transform information into insight and action (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011). LaValle and co-authors identified three stages that organizations go through to become data driven Information Age organizations. The first stage is the aspirational; the organization uses tools more like those of the EIS than BI. The aspirational organization is focused on using technology to increase automation processes and cutting costs, as they do not have the resources in place to use analytics (LaValle, et al., 2011). The second stage is the experienced phase in which organizations start to build on the efficiencies gained in the aspirational stage (LaValle, et al., 2011). Organizations in the experienced stage further optimize their information systems and technology by developing BI to collect more data, analyze it, and act upon it (LaValle, et al., 2011). The final stage is the transformed stage. The transformed organization derives a competitive advantage from the use of BI and analytics (LaValle, et al., 2011). The transformed organization is less focused on cost cutting and optimization and more focused on the strategic use of analytics (LaValle, et al., 2011) by implementing analytics across a wide range of functions and through all levels of the organization. The Information Age organization captures, analyzes, and uses data to drive revenue growth and profits. Data are used not just to guide future strategies but also to guide day-to-day operations, providing decision-support and solving problems.

2. THE AGE OF INFORMATION: THE SCIENCE, TECHNOLOGY, AND BUSINESS

The Information Age, otherwise known to many as the Information Era, the Computer Age, or the Digital Revolution is a phenomenon that did not occur overnight. It is a concept directly linked to the computing, electronics, engineering, science, and communications reformation from the analog system to the digital system, characterizing the current age by the ability of individuals to transfer information freely and to have instant access to information previously unavailable or difficult to locate. Information Technology (IT), the overall concept of digital technologies used to process, store, and transport information, has provided vast benefits to many, such as the ability to control, access, share and manage data, information, and knowledge transfer; all powerful and progressive concepts.

It is equally important to remember that the emergence of a new and important paradigm does not always represent the same significance to all and indeed true to history, opposition opinions have surfaced as well. For example, some have asserted that the overwhelming bombardment of information via easy access to multiple media has manifested itself as information silos, human isolation, and slaves to technology, particularly by those inexplicably and singularly driven to it. And the have-nots, those with neither funds nor access or those not interested in technological progress, internalized an even greater fear that they will be left even farther behind and perhaps, jobless. Standage (1998, p. 212) suggested that concerns and fears "are the direct consequences of human nature, rather than technology." These opposition views all have merit and deserve to be explored, researched, and examined for the important adversarial positions they represent to the future of the Information Age, therefore as space allows several will be included in the discussion. However, the emergence of the Information Age, through selected technological inventions, theories, theorists, and historical situations culminating in the business, social, and cultural benefits, now known as "Big Data," will be examined here.

Most agree that the period of Information is generally said to have begun in the latter half of the 20th century and continues through the present; although the precise date varies, because of the difficulty in pinpointing the specific dates for the global and public use of personal computers, Internet, e-mail, cell phones, personal communications devices, and social networking sites. Therefore, many dates for the important contributing factors to the spread of information within the common man's routine implementation are approximate and widely recognized as such. It is generally accepted that the Information Age was embraced and accepted by the masses since the late 1980s and into the 21st century, although the intellectual concepts and original inventions were developed somewhat earlier in the 20th century.

Another important matter that arose from the emergence of the Information Age was the overarching need to define the construct of information. Just what is information? And how does it apply to this context? Raw data is not information. Data is not information until it is collected, saved, stored, organized, transmitted, received, and understood. Data certainly must have meaning, hopefully the same meaning to both the sender and the receiver. Shannon's (1948) contribution to our understanding of this process was his development of the *Transmission Model of Communication* (Figure 1) that revolutionized our understanding of transmissions by radically introducing the construct of digitizing information. Shannon opened the door to early Big Data development through his theory of a digital communication infrastructure and network that was cleaner, faster, more efficient, and generally an error-free mode than the analog process of an ordinary arithmetic computer or calculator.

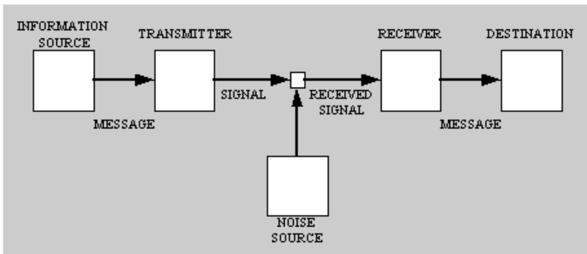

Figure 1. Transmission Model of Message Communication (Shannon, 1948)

Concisely paraphrased, the communication process works when a message is coded by the sender in a language that has meaning to the receiver, and the receiver can confirm the message as understood by returning feedback to the sender. This information transmittal process appears very simple to accomplish, but it is not as easy as it sounds as there are many codes, signs, symbols, languages, intuitions, sensory, and cultural perceptions incorporated into the message. All have applicable subjective meanings making it a very tricky undertaking to ensure that the message sent makes it through a certain amount of noise, interference, or distortion from outside sources; and equally challenging to ensure that when it is received it is truly decoded and comprehended as originally intended. Although Shannon was specifically focused on the technological and mathematically quantitative problem of developing a relatively error-free and accurate transmission model; his co-author and research partner, Warren Weaver, was particularly interested in conveying meaning and applying understanding to the message. Figure 2 represents and addresses Weaver's interest in the semantic and the effectiveness problems of the message, by adding a feedback loop to the communication model (Shannon & Weaver, 1949).

Not merely content to explain the process of communication, Shannon (1948) provided us with the term 'bit' to quantify the tiniest amount of explicit data possible in the form of a single binary unit. When collected, organized, and evaluated, 'bits' may even be determined as a set of facts. Overall, information is commonly accepted as the result of processing, manipulating, and organizing data in a way that adds to the knowledge and learning of the person receiving it. And from data through information to knowledge, Liebowitz (2006, p. 78) cleverly reminded us that the discipline of Knowledge Management (KM) is continually challenged with "apply[ing] more rigor to the field so that it becomes more of a science and less of an art."

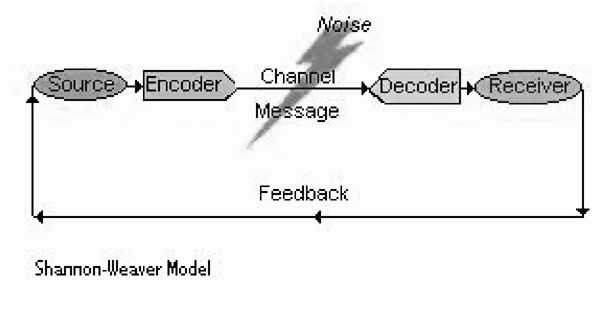

Figure 2. Shannon's Communication Model Appended with Weaver's Feedback Loop (Shannon & Weaver, 1949)

Furthermore, it is important to note that not all information is communicated through digitally recorded media or is computer generated. Other types of information, such as visual, aural, vocal, written, recorded, sensory, physical, tactile, signs, symbols, semiotics, language, instruction, knowledge, meanings, perceptions, feelings, intuition, cultural, and so many other things that when coded, transmitted, received, interpreted, and understood have specific and subjective meaning to human beings. In addition, all people in some way routinely convey, receive, share, and store countless types of information, regardless of whether or not we are computer scientists or professional librarians. In its most basic form, information is just a message received and understood because it has application. Knowledge occurs when the information becomes meaningful, is understood, and learned. However, as previously stated, this phenomenon did not happen overnight; a series of critical and sometimes disruptive events had to occur to generate this important historical transition.

3. HISTORY OF THE INFORMATION AGE

Many factors in the United States signaled the emergence of a new era. For example, most agree that during the mid-1950s through the 1960s, the number of Americans holding white-collar jobs, professional, office staff, administrative, and sales, slowly started to exceed the number of people holding blue-collar jobs, those that were manufacturing-oriented and manual labor-driven (Toffler, 1984). In his book, "White Collar: The American Middle Class," Mills (1951, p. 182) referred to this middle class change commencing during the mid-1950s as a shift to marketing, sales, and service asserting that, "In a society of employees dominated by the marketing mentality, it is inevitable that a . . . great shift from manual skills to the art of servicing people, personal or even intimate traits of employees are drawn into the sphere of exchange and become commodities in the labor market." Mills argued that this change in the American labor force signaled that the Industrial Age was coming to an end and a new era was beginning to emerge as the Western world shifted into an information service driven economy.

During World War II and continuing thereafter, the U.S. Federal Government recognized the need for higher technologies to enhance the protection of its borders and citizens and to stabilize and further its dominance as a world power. This need for power and control incentivized Government agencies to collaborate with universities and non-profit think tanks whom together conceptualized and developed large main frame computers to process and organize data previously processed manually, enabling electronic document output and transfer and the eventual transmissions of local emails between networks and systems. Technology abounded from 1946 when the first general purpose electronic digital computer was developed (U.S. patent filed in 1947), known as the Electronic Numerical Integrator and Computer (ENIAC) funded by the U.S. Army and developed in collaboration with the University of Pennsylvania, originally designated as a post-WW II top secret project (Gertner, 2012). Built upon the research of Bell Labs in the late 1940s, the mass production of silicon transistors, a low cost key element of most modern electronics, appeared in the 1954 when Texas Instruments commercialized and mass produced the first transistor radios (Gertner, 2012). These inventions, among others, were instrumental in jump-starting the decline of blue-collar labor driven employment and were key in transitioning the workforce to white-collar service positions. Toffler (1984) chronicled these newsworthy events as "farms, factories, and floppies" in his book, "The Third Wave."

Concurrently, corporations continued their own research and development toward independent commercialization beginning with electronic typewriters, calculators, processors, and by the end of the 20th century eventually culminating in the miniaturization of computer hardware to a manageable, personal, and transportable size. The creation of the originally narrow-focused local Internet provided a way to connect computers together as part of a limited Government or a corporate network, and software developers were encouraged and incentivized to create new systems, productivity enhanced products, and personal applications. Berners-Lee's invention of the World Wide Web in 1989 permitted the Internet experience to be a global network available to everyone at little or no cost and at a remarkable speed eventually becoming the generally accepted platform for moving information. Table 1 (see Appendix) illustrates an approximate timeline of selected emerging inventions and significant activities highlighting the fundamental progress of the Information Age.

Not only were jobs and careers slowly changing, but large factories and manufacturing facilities were starting to implement tools and fixed machines to do the work traditionally performed by humans. In the 1960s, the U.S. Government implemented widespread use of computers, but it was not until the 1970s that they were introduced to corporate employees and in the 1980s on a more widespread and substantial offering to the general public. The earliest form of the Internet appeared in 1969 and limited networked email soon followed in 1971. But it was the first appearance of the personal computer in the late 1970s and the introduction of the World Wide Web in 1989 that propelled the Internet into full-scale operation by 1992. Dumb terminals of the 1980s were replaced by desktop computers in the 1990s and laptops during the onset of the millennium. Cell phones arrived in 1984, became cost effective, prevalent, and widely accepted in the 1990s subsequently emerging as Smartphones in the 2000s. Other personal assistance and communications devices followed shortly thereafter. The digital Information Age had begun in earnest and thanks to the arrival of the global Internet, Pandora's Box was forever opened and there was no turning back.

Theorists, educators, and consultants quickly emerged because these ever-evolving digital, Internet, and cyberspace phenomena had to be critically explained to the rest of us. Vast sources of information technology and communication tools became a significant part of the economy and these new innovations rapidly overwhelmed our psyche. For example, computers, microcomputers, computerized machinery, broadband, fiber optics, communications satellites, Internet, software, biometrics, robots, and other personal communications devices altered not only Governments, business, and industry forever, but also changed personal lives, careers, families, cultures, and societies, as well. Fears of the unknown needed to be quelled, training needed to be provided, and overall explanations for the technology, scientific, business, social, economic, environmental, and cultural changes were warranted. Although this paper highlights only a few of the important Information Age theorists, the list in Table 2 (see Appendix) illustrates a brief timeline of some of their significant accomplishments that contributed to this new era of information, thereafter, illuminating our understanding of this inevitable and unavoidable adventure into the future. The dates listed are directly associated with the theorists' publications and are not intended to reflect any other significant events other than those discussed in this paper.

Emergence of Big Data

By 2004, Web 2.0 made its appearance in the form of social media, blogs, wikis, images, photos, rich site summaries (RSS), aggregate feeds, and other social-cultural behavioral transmissions that quickly augmented and often surpassed email as the primary form of electronic communication. Providing the public with an interactive form of consumer participation, such as commercial online ordering, banking, shopping, bill-paying, stock trading, game-playing, in addition to alerting a select group of followers or the public in general of an individual's every move, became addictive and self-perpetuating (Borkovich, 2011). And that was just the software. Innovative, creative, and attractive hardware had to keep up, as well. A computer that was once the size of an entire floor became room-sized; then personalized and desk-sized; then portable and lap-sized; then a tablet and palm-sized; and finally wrist-sized and positioned within the corner of an eye-glass frame; soon to become even smaller and more compact. Modern computers can perform just about anything a user or consumer wants and needs. Big Data had arrived, and we embraced it; but after the giddy glow of excitement had abated, the construct of information overload quickly became a sobering reality.

Information Overload

Information overload, a term coined by Gross (1964, p. 856) and popularized by Toffler (1970), refers to the difficulty a person can have understanding an issue and making decisions that can be caused by the presence of too much information. It is a bombardment to the senses, causing confusion, distraction, disorientation, and lack of responsiveness long before assessing the validity of the content or recognizing the risk of misinformation. The anxiety and frustration caused by information overload can lead to a blind acceptance of all data, news, tweets, blogs, definitions, headlines, photos, social commentary, scores, trades, prices, RSS alerts, etc.; or an overwhelming outright rejection of all incoming data; or perhaps a paralytic response akin to a collaborative shutdown within the perceived safety of an information silo (Borkovich, 2012). This new paradigm shift (Kuhn, 1960) to Big Data continues to contribute to the effect of information overload and will require greater scrutiny and study as individuals learn to cope with the overwhelming daily bombardment of data. Furthermore, in order to prevent or at least manage this inevitable overload, organizations must continually seek advanced technologies to process and cope with voluminous amounts of data to support strategic Business Intelligence, competitive analysis, and decision-making.

4. IT IS THE BUSINESS: INFORMATION DOES MATTER

Carr (2003) in his well-known article, *IT Doesn't Matter,* argued that information technology is no longer relevant. The days of getting ahead by having the latest server or the newest network are gone, Information Technology (IT) is a commodity and Information Systems (IS) are part of the cost of doing business (Carr, 2003). Carr's argument is valid if the definition of IT focuses only on technology, servers, switches, and other systems that make up the traditional IT infrastructure. If we view IT in terms of the Information Age organization, we find that not only does IT matter but it represents the life blood infrastructure of the business. The storage of data, the retrieval of information, and the creation of knowledge are key business processes for any Information Age organization.

The Information Age organization is highly interconnected with customers, suppliers, and employees. IT and IS are an integral part of the organization in which people, processes, and technology-driven data come together to form knowledge. In the Information Age organization "the interaction between systems and humans become more collaborative" and "the [information] system also acts as an extension of the human ability to store and process knowledge" (Davenport, 2000, p. 169). This idea was further developed in Debons' (2008) Augmented Data, Information, and Knowledge (ADIK) system in which IS augment human intellect. IT is the business for the Information Age organization, but we must first define what are data, information, and knowledge as well as examine how they relate to each other. We will explore the social dimensions of IT using the social network theory, and then examine some of the problems the Information Age organization faces with the storage and retrieval of data.

Data, Information, and Knowledge: What are the differences?

The distinctions between data, information, and knowledge are important to understand for our study of the Information Age organization. It is only when we see how these three terms are related, but different from each other, that the value of IT becomes apparent.

Debons (2008, p. 4) described data as "the collection of numbers, measurements, and simple signals that surround us every day." Examples of data include a person's name, a social security number, a house number, or a street sign. For the Information Age organization data are the raw materials of the Information System (IS). In the IS data are the characters stored in database files or records.

Information is created when the data are given a structure and organization (Debons, 2008). The number 42 is data, but when we learn that the number represents an age, and that age is related to the name John Smith, who lives in Anytown, USA, information is created. Information is stored in records in a database file. A record for John Smith may look like the depiction in Table 3.

John	Smith	42	Anytown	USA

Table 3. Sample Record in a Database File

Knowledge is formed when patterns are found within the information (Debons, 2008). When the data are analyzed, it is disclosed that the population of Anytown is 6,540 people, Smith is the most common last name and half the population of Anytown is past the age of 42. Meaning has been applied to the information created from the data; and knowledge resulted from the learning process. More information is also known about John Smith: he has a common last name; and he is younger than 3,270 other people in Anytown. This new information was gleaned only by extracting, sorting, collating, and analyzing the raw data stored within the IS.

Augmented Data, Information, and Knowledge (ADIK) systems bring together data and information to create knowledge. An ADIK system "include(s) people, technology, and the functions/procedures that bring these together to achieve a goal" (Debons, 2008, p. 70). In the ADIK system knowledge is created when data are organized to form information and patterns are recognized in the information (Debons, 2008). The augmentation occurs when the system is used to allow someone to solve a complex problem more rapidly than one otherwise could (Debons, 2008). The ability to solve complex problems rapidly is the core of what Information Age organizations do. Figure 3 depicts Debons' visual conceptualization of a feedback loop to determine the sender's and receiver's understanding and meaning attributed to transmitted information.

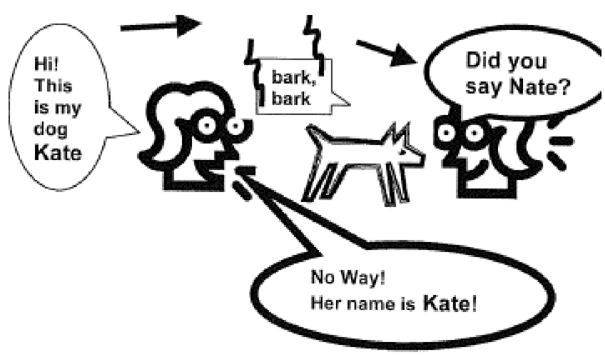

Figure 3. Debons' (2008, p. 21) Visual Conception of Feedback Loop

Why IT Matters: The Information Age Organization.

The Information Age organization is knowledge-centric and relies on IT not just to process transactions and store data but also to create and transfer knowledge. Developing an information and knowledge-centric focus is a necessity for all organizations, not just the typical information-centric actuarial-type industries, such as health care, banking, and insurance.

Davenport (2000) showed how the business environment changed for the manufacturing sector. Advanced enterprise systems allow manufacturers to be agile and respond to market changes. Davenport (2000, p. 164) explained that "a truly robust sense and response capability also requires process integration throughout the supply chain." To obtain a high level of integration with supply chain partners advanced Knowledge Management (KM) and Information Systems (IS) are needed. The Information Age organization also needs to know who its competitors are, who potential partners are, and when the two are the same. The amount of data collected and stored needs to be properly managed to turn it into actionable information and knowledge. The Information Age organization requires advanced technology systems to manage this wealth of data. Davenport (2000, p. 173) explained: "For the first time in the history of information systems, it will be possible to connect hard data and soft information and knowledge." There is also a need to "develop an ability to identify what information is really worth its users' time" (Davenport, 2000, p. 164). Without IT and IS it would not be possible to mine the raw data to create information, much less to analyze it and see all the patterns relevant to the problem that needs to be solved.

Information Technology (IT) and IS are at the heart of every Information Age organization. Pemsel and Widen (2010) show how KM is important to the construction industry by arguing that to stay competitive, project-based organizations such as construction need to retain and make good use of knowledge. In the construction industry like most project-based industries, knowledge is tacit; it is stored in the experience of the employees. Pemsel and Widen found that "firms want to turn tacit knowledge into explicit knowledge, and then they want to transfer it to the firm" (Pemsel & Widen, 2010, p. 127). In a project-based organization, it is often the tacit knowledge of the project manager that determines if a project will be profitable or not. The project manager's experience combined with data from other projects is needed to bid properly on a project. By storing this knowledge, the company can build up a knowledge base or knowledge system that will grow over time and allow the company to make better decisions. When organizations do not invest in or maintain IS, they run the risk of losing valuable knowledge. And when an employee leaves a company that does not have a KM system, it is equally critical that the experience of that employee will be lost. The information stored needs to be retrievable and used in a systematic manner, as merely collecting the data and not acting on it adds no value to the organization.

Social Dimensions of Big Data

As we have seen, Information Technology (IT) and Information Systems (IS) are an interaction and interdependency of people and processes to turn data into information, information into knowledge, and knowledge into results. For the Information Age organization, "Knowledge creation and learning can be regarded as a social and dynamic process; it is not solely the transfer of information and data" (Pemsel & Widen, 2010, p. 123). Knowledge is also a social-cultural phenomenon that is transmitted through social networks and not just by the computer networks that transmit data.

Sasidharan (2006) examined the relationship between the level of social connectivity and success in implementing large-scale IS. The study used a social network analysis to measure how social connectivity and large-scale IS implementation are related. A social network model "views individuals as being embedded within an organization, enmeshed in a network of concrete interpersonal relations and structures" (Sasidharan, 2006, p. 33). The social connections measured in the study explained how the users were connected to each other, which parties they approached for advice and assistance, and to whom they provided help. The research found that organizations with a high level of social connectivity were more successful at implementing large-scale IS. Sasidharan (2006, p. 105) concluded, "It is not knowledge gathered at training but knowledge transferred in the organization workplace that influences implementation success." The findings in Sasidharan's research were consistent with Pemsel and Widen, who stated that knowledge is more than the transmission of information; and with Debons who showed that IT and IS systems only augment human knowledge and do not replace it. Communicating by moving data, developing information, and creating knowledge produces results.

5. LOOKING AHEAD: THE FUTURE OF BIG DATA IN THE INFORMATION AGE

Virtually any type of data required can be delivered instantaneously, and any business, organization, or academic institution that wants to stay competitive has no choice but to continually embrace new forms of technology. Ironically, the improvements made to any technology face the danger of a paradigm shift and the possibility that a new invention will render the old obsolete. The nascent emergence of new disciplines, such as cybersecurity, robotics, biometrics, and others are empirical proof of this continual digital advancement, fostered by the emergence of Big Data, coupled with the burgeoning requirement for advanced Business Intelligence, and supported by analytics.

6. CONCLUSION

Big Data and Business Intelligence (BI) are best understood when examined through the lens of communication theory. Information is not static, it is the result of a process in which data are transmitted, received, and understood. This is the model developed by Shannon in 1948 that inspired the early Management Information Systems (MIS). Shannon's model unveiled a unit of information called a 'bit' that transmitted from the sender to the receiver by assembling several bits to form information within a system. The early MIS system simply arranged data into static reports that were easier for people to view than the large tables of unsorted data. The modern BI system is an application of Debons' Augmented Data, Information, and Knowledge (ADIK) model. ADIK is a process in which data are transformed into actionable information and knowledge is created and learned. The augmentation is the use of analytics and artificial intelligence to allow people to a have a better understanding of complex problems, enabling the human interface to arrive more efficiently and confidently at better data driven solutions (Debons, 2008). The ability to turn data into actionable knowledge relies on the interaction of people, processes, technology, and systems. Knowledge is a socio-cultural construct transmitted through social networks as well as computer networks. People receive information from BI systems, apply meaning and take action based upon that information; and through this learning process create knowledge through understanding and by communicating it to others. For without the implementation of communication theory in concert with the analytical ability and creativity of the human element, data, *big or otherwise,* will remain literally and explicitly locked within its digital, virtual, or physical confines; or dwell tacitly memorialized within a mortal brain silo of a figurative data warehouse, *forever*.

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Appendices

Table 1. Information Age – Historical Time Line of Relevant Innovations

Type	Description	Date Invented/Widespread Use
ENIAC	First general purpose electronic digital computer	1946 [1]
Transistor	Invention/Commercialized by Texas Instruments	1947 / 1950s [2]
Designation of the 'Bit'	Binary Code for Ones and Zeros	1948 [3]
More "White Collar" than "Blue Collar" workers in U.S.	"Industrial Age" coming to an end; Moving into "Information Age"	1956 [3]
Computer Systems	Government Use	1960s [4]
Earliest form of Internet	Limited Government Use	1969 [4]
Email	Limited Government Use	1971 [4]
Personal Computer	Limited Business Use	Late 1970s [3]
Personal Computers	Public Use	1970s / 1980s [3]
Timesharing	Outsourcing Services	1970s / 1980s [5]
Mobile Phone	Motorola	1983 [5]
World Wide Web	Invention	1989 [4]
Computers in Homes	Widespread Public Use	1980s / 1990s [5]
Laptop	Widespread Public Use	1990s [5]
World Wide Web	Globalization	1996 [5]
Cellular Phones	Globalization	1990s / 2000s [5]
Webcams/Digital TV	Widespread Public Use	1990s / 2000s [5]
Broadband Mainstreamed	Widespread Public Use	2000s [5]
Wireless Networking	Widespread Public Use	Early 2000s [5]
GPS Mainstreamed	Widespread Public Use	Mid 2000s [5]
Satellite Radio	Widespread Public Use	2003 [5]
Digital Radio	Widespread Public Use	2004 [5]
HDTV	Widespread Public Use	Mid 2000s [5]
Smart Phones	Widespread Public Use	Mid 2000s [5]
Internet Population	Over 1 Billion	2005 [3]
Cell Phones	Over 3 Billion	2008 [3]
Semi- & Autonomous Robots; Biometrics	Gov't., Academia, & Health Care Use	2001 - Current [6]
Web 2.0	Interactive, User-Created Web Content	Approx. 2004 - Current [7]
Big Data	Structured, Semi- & Unstructured Data	Approx. 2005 - Current [8]

1. US Army Research Lab (ARL): http://ftp.arl.mil/~mike/comphist/eniac-story.html
2. Texas Instruments: www.ti.com/corp/docs/company/history/timeline/semicon/1950/docs/54commercial.htm
3. Computer History: http://www.computerhistory.org/internet_history/internet_history_80s.shtml
4. DARPA & Internet Timeline: http://www.darpa.mil/Docs/Internet_Development_200807180909255.pdf
5. Inventors - 20th Century of Technology Decade by Decade: http://inventors.about.com/od/timelines/a/twentieth_5.htm
6. NASA - ISS - DARPA: http://www.nasa.gov/mission_pages/station/main/robonaut.html
7. Web 2.0 term coined by DiNucci (1999, p. 32); popularized in 2004: User-generated content of social media in a virtual community.
8. Big Data appeared shortly after the emergence of Web 2.0 (Kimball, 2011)

Table 2. Information Age – Historical Time Line of Relevant Theories

Theorist	Publication	Description	Publication Date
Shannon, C. E. & Weaver, W.	"The Mathematical Theory of Information"	Transmission Model of Communication	1948; 1963; 1998
Kuhn, Thomas	"Structure of Scientific Revolutions (3rd Ed.)"	History of Normal Science; & Paradigm Shift	1960; 1970; 1996
Simon, Herbert	"Theories of Bounded Rationality" & "Human Problem Solving" (with Allen Newell)	Human Cognition; Bounded Rationality; Satisficing; Design Trees (Parallel & Binary); Fragmentation	1972
Toffler, Alvin	"The Third Wave"	Iron; Industrial; & Information Ages	1984
Beniger, James	"The Control Revolution: Technological and Economic Origins of the Information Society"	Crisis Leads to Controversy; Loss of control brings forth technology innovation and change	1986
Utterback, James	"Mastering the Dynamics of Innovation"	Dominant Model succeeds but is not always the best choice	1994
Negroponte, Nicholas	"Being Digital"	Changes from analog to digital (atoms to bits)	1995
Christensen, Clayton	"The Innovator's Dilemma: the Revolutionary Book That Will Change The Way You Do Business"	Rationales for Great Companies' Failures	1997; 2000; 2003
Carr, Nicholas	"Does IT Really Matter"; "Does IT Matter? Information Technology and the Corrosion of Competitive Advantage"; & "The End of Corporate Computing"	Strategic IT; Tech is Not the Advantage; Process is the Advantage	2003; 2004; 2005
Von Hippel, Eric	"Democratizing Innovation"	Share Information; Open Source Code; Must Disclose for Long Term Solutions & Success	2005
Debons, Anthony	"Information Science 101"	ADIK System; EATPUT: Event, Acquisition, Transmission, Processor, Utilization, Transference	2008