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Business Intelligence and Analytics Evolution, Applications, and Emerging Research Areas

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Abstract*: Business intelligence and analytics (BI&A) has emerged as an important area to generate radical discoveries or new technologies by researchers, reflecting the magnitude and impact of data-related problems to be solved in contemporary business organizations. The Big Data technology and services market represents a fast-growing multibillion-dollar worldwide opportunity and is expanding rapidly. This introduction on Business Intelligence Research first provides a framework that identifies the evolution, applications, and emerging research areas of BI&A. BI&A 1.0, BI&A 2.0, and BI&A 3.0 are defined and described in terms of their key characteristics and capabilities. Current research in BI&A is analyzed and challenges and opportunities associated with BI&A research and education are identified. We also report a study of research topics based on related academic and industry publications. Finally, the goal of this research comprise proposed BI&A research framework that can be applied to various high-impact applications such as Improving E-Commerce and Market Intelligence, Improving E-Government and Politics 2.0, Improving Research in Science and Technology, Improving Healthcare, Public Health, and Wellbeing, Improving Security, Public Safety and Law Enforcement, Optimizing Business Processes, Optimizing Cities and Countries, Optimizing Machine and Device Performance, and Financial Trading. By mapping important facets of the current BI&A knowledge landscape an area of substantial intrinsic merit , we hope that proposed work will benefit the nation as a whole and will contribute substantially to the improvement in the US economy, national security, public health, job growth and the environment .

Keywords: **Business Intelligence and Analytics, Big Data Analytics, Radical Discovery, Market Intelligence, National Security, Job Growth.**

I. INTRODUCTION

The opportunities associated with data and analysis in different organizations have helped generate significant interest in BI&A, which is often referred to as the techniques, technologies, systems, practices, methodologies, and applications that analyze critical business data to help an enterprise better understand its business and market and make timely business decisions. In addition to the underlying data processing and analytical technologies, BI&A includes business-centric practices and methodologies.

A recent IDC forecast shows that the Big Data technology and services market will grow at a 27% compound annual growth rate (CAGR) to $32.4 billion through 2017 - or at about six times the growth rate of the overall information and communication technology (ICT) market. There are expected to be 4.4 million people employed worldwide in positions directly involved with big data analysis by next year. But this won't be enough. By next year, 70% of US businesses will either have a data strategy in place or will be planning one for the near future, according to one survey. The number of colleges offering courses related to big data analysis continues to grow rapidly.

According to McKinsey Global Institute there will be a shortage of talent necessary for organizations to take advantage of big data. By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions.

II. BUSINESS INTELLIGENCE AND ANALYTICS EVOLUTION: KEY CHARACTERISTICS AND CAPABILITIES

The term intelligence Business intelligence became a popular term in the business and IT communities only in the 1990s. In the late 2000s, business analytics was introduced to represent the key analytical component in BI [1]. More recently big data and big data analytics have been used to describe the data sets and analytical techniques in applications that are so large (from terabytes to exabytes) and complex (from sensor to social

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media data) that they require advanced and unique data storage, management, analysis, and visualization technologies. In this article we use business intelligence and analytics (BI&A) as a unified term and treat big data analytics as a related field that offers new directions for BI&A research.

A. Business Intelligence and Analytics 1.0

Data management and warehousing is considered the foundation of BI&A 1.0. Design of data marts and tools for extraction, transformation, and load (ETL) are essential for converting and integrating enterprise-specific data. Database query, online analytical processing (OLAP), and reporting tools based on intuitive, but simple, graphics are used to explore important data characteristics. Business performance management (BPM) using scorecards and dashboards help analyze and visualize a variety of performance metrics. In addition to these well-established business reporting functions, statistical analysis and data mining techniques are adopted for association analysis, data segmentation and clustering, classification and regression analysis, anomaly detection, and predictive modeling in various business applications. Most of these data processing and analytical technologies have already been incorporated into the leading commercial BI platforms offered by major IT vendors

Among the 13 capabilities considered essential for BI platforms, according to the report by [2], the following eight are considered BI&A 1.0: reporting, dashboards, ad hoc query, search-based BI, OLAP, interactive visualization, scorecards, predictive modeling, and data mining. A few BI&A 1.0 areas are still under active development based on the [3] BI Hype Cycle analysis for emerging BI technologies, which include data mining work benchs, column-based DBMS, in-memory DBMS, and real-time decision tools [4]. Academic curricula in Information Systems (IS) and Computer Science (CS) often include well-structured courses such as database management systems, data mining, and multivariate statistics.

B. Business Intelligence and Analytics 2.0

Since the early 2000s, the Internet and the Web began to offer unique data collection and analytical research and development opportunities. The HTTP-based Web 1.0 systems, characterized by Web search engines such as Google and Yahoo and e-commerce businesses such as Amazon and eBay, allow organizations to present their businesses online and interact with their customers directly. In addition to porting their traditional RDBMS-based product information and business contents online, detailed and IP-specific user search and interaction logs that are collected seamlessly through cookies and server logs have become a new gold mine for understanding customers' needs and identifying new business opportunities. Web intelligence, web analytics, and the user-generated content collected through Web 2.0-based social and crowd-sourcing systems [5] have ushered in a new and exciting era of BI&A 2.0 research in the 2000s, centered on text and web analytics for unstructured web contents. An immense amount of company, industry, product, and customer information can be gathered from the web and organized and visualized through various text and web mining techniques. By analyzing customer clickstream data logs, web analytics tools such as Google Analytics can provide a trail of the user's online activities and reveal the user's browsing and purchasing patterns. Web site design, product placement optimization, customer transaction analysis, market structure analysis, and product recommendations can be accomplished through web analytics. The many Web 2.0 applications developed after 2004 have also created an abundance of user-generated content from various online social media such as forums, online groups, web blogs, social networking sites, social multimedia sites (for photos and videos), and even virtual worlds and social games. In addition to capturing celebrity chatter, references to everyday events, and socio-political sentiments expressed in these media, Web 2.0 applications can efficiently gather a large volume of timely feedback and opinions from a diverse customer population for different types of businesses. Many marketing researchers believe that social media analytics presents a unique opportunity for businesses to treat the market as a "conversation" between businesses and customers instead of the traditional business-to-customer, one-way "marketing" [6]. Unlike BI&A 1.0 technologies that are already integrated into commercial enterprise IT systems, future BI&A 2.0 systems will require the integration of mature and scalable techniques in text mining (e.g., information extraction, topic identification, opinion mining, question-answering), web mining, social network analysis, and spatial-temporal analysis with existing DBMS-based BI&A 1.0 systems.

C. Business Intelligence and Analytics 3.0

Whereas web-based BI&A 2.0 has attracted active research from academia and industry, a new research opportunity in BI&A 3.0 is emerging. As reported prominently in an October 2011 article in [7], the number of mobile phones and tablets (about 480 million units) surpassed the number of laptops and PCs (about 380 million units) for the first time in 2011. Although the number of PCs in use surpassed 1 billion in 2008, the same article

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projected that the number of mobile connected devices would reach 10 billion in 2020. Mobile devices such as the iPad, iPhone, and other smart phones and their complete ecosystems of downloadable applications, from travel advisories to multi-player games, are transforming different facets of society, from education to healthcare and from entertainment to governments. Other sensor-based Internet-enabled devices equipped with RFID, barcodes, and radio tags (the "Internet of Things") are opening up exciting new steams of innovative applications. The ability of such mobile and Internet-enabled devices to support highly mobile, location-aware, person-centered, and context-relevant operations and transactions will continue to offer unique research challenges and opportunities throughout the 2010s. Mobile interface, visualization, and HCI (human–computer interaction) design are also promising research areas. Although the coming of the Web 3.0 (mobile and sensor-based) era seems certain, the underlying mobile analytics and location and context-aware techniques for collecting, processing, analyzing and visualizing such large scale and fluid mobile and sensor data are still unknown. No integrated, commercial BI&A 3.0 systems are foreseen for the near future. Most of the academic research on mobile BI is still in an embryonic stage. Although not included in the current BI platform core capabilities, mobile BI has been included in the Gartner BI Hype Cycle analysis as one of the new technologies that has the potential to disrupt the BI market significantly [4]. The uncertainty associated with BI&A 3.0 presents another unique research direction for the IS community.

III. BUSINESS INTELLIGENCE AND ANALYTICS APPLICATIONS: FROM BIG DATA TO BIG IMPACT

Several global business and IT trends have helped shape past and present BI&A research directions. International travel, high-speed network connections, global supply-chain, and outsourcing have created a tremendous opportunity for IT advancement. In addition to ultra-fast global IT connections, the development and deployment of business-related data standards, electronic data interchange (EDI) formats, and business databases and information systems have greatly facilitated business data creation and utilization. Recently, the Big Data era has quietly descended on many communities, from governments and e-commerce to health organizations. With an overwhelming amount of web-based, mobile, and sensor generated data arriving at a terabyte and even Exabyte scale [8], new science, discovery, and insights can be obtained from the highly detailed, contextualized, and rich contents of relevance to any business or organization. In addition to being data driven, BI&A is highly applied and can leverage opportunities presented by the abundant data and domain-specific analytics needed in many critical and high impact application areas. Several of these promising and high-impact BI&A applications are presented below, with a discussion of the data and analytics characteristics, potential impacts, and selected illustrative examples or studies: (1) ecommerce and market intelligence, (2) e-government and politics 2.0, (3) science and technology, (4) smart health and well-being, and (5) security and public safety.

A. Improving E-Commerce and Market Intelligence

The excitement surrounding BI&A and Big Data has arguably been generated primarily from the web and e-commerce communities. Significant market transformation has been accomplished by leading e-commerce vendors such Amazon and eBay through their innovative and highly scalable ecommerce platforms and product recommender systems. Major Internet firms such as Google, Amazon, and Facebook continue to lead the development of web analytics, cloud computing, and social media platforms. The emergence of customer-generated Web 2.0 content on various forums, newsgroups, social media platforms, and crowd-sourcing systems offers another opportunity for researchers and practitioners to "listen" to the voice of the market from a vast number of business constituents that includes customers, employees, investors, and the media [5]. Unlike traditional transaction records collected from various legacy systems of the 1980s, the data that e-commerce systems collect from the web are less structured and often contain rich customer opinion and behavioral information. For social media analytics of customer opinions, text analysis and sentiment analysis techniques are frequently adopted [9]. Various analytical techniques have also been developed for product recommender systems, such as association rule mining, database segmentation and clustering, anomaly detection, and graph mining [11].. Long-tail marketing accomplished by reaching the millions of niche markets at the shallow end of the product bitstream has become possible via highly targeted searches and personalized recommendations [10].

B. Improving E-Government and Politics 2.0

The advent of Web 2.0 has generated much excitement for reinventing governments. The 2008 U.S. House, Senate, and presidential elections provided the first signs of success for online campaigning and political

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participation. Dubbed "politics 2.0," politicians use the highly participatory and multimedia web platforms for successful policy discussions, campaign advertising, voter mobilization, event announcements, and online donations. As government and political processes become more transparent, participatory, online, and multimedia-rich, there is a great opportunity for adopting BI&A research in e-government and politics 2.0 applications. Selected opinion mining, social network analysis, and social media analytics techniques can be used to support online political participation, e-democracy, political blogs and forums analysis, e-government service delivery, and process transparency and accountability [12]. For e-government applications, semantic information directory and ontological development (as exemplified below) can also be developed to better serve their target citizens.

C. Improving Research in Science and Technology (Astrophysics and Oceanography, To Genomics and Environmental Research)

Science and research is currently being transformed by the new possibilities big data brings. Many areas of science and technology (S&T) are reaping the benefits of high-throughput sensors and instruments, from astrophysics and oceanography, to genomics and environmental research. To facilitate information sharing and data analytics, the National Science Foundation (NSF) recently mandated that every project is required to provide a data management plan. Cyber-infrastructure, in particular, has become critical for supporting such data-sharing initiatives.

D. Improving Healthcare, Public Health, and Wellbeing

Much like the big data opportunities facing the e-commerce and S&T communities, the health community is facing a tsunami of health- and healthcare-related content generated from numerous patient care points of contact, sophisticated medical instruments, and web-based health communities. Two main sources of health big data are genomics-driven big data (genotyping, gene expression, sequencing data) and payer–provider big data (electronic health records, insurance records, pharmacy prescription, patient feedback and responses). The expected raw sequencing data from each person is approximately four terabytes. From the payer–provider side, a data matrix might have hundreds of thousands of patients with many records and parameters (demographics, medications, outcomes) collected over a long period of time. The computing power of big data analytics enables us to decode entire DNA strings in minutes and will allow us to find new cures and better understand and predict disease patterns. Just think of what happens when all the individual data from smart watches and wearable devices can be used to apply it to millions of people and their various diseases. The clinical trials of the future won't be limited by small sample sizes but could potentially include everyone. Big data techniques are already being used to monitor babies in a specialist premature and sick baby unit. By recording and analyzing every heart beat and breathing pattern of every baby, the unit was able to develop algorithms that can now predict infections 24 hours before any physical symptoms appear. That way, the team can intervene early and save fragile babies in an environment where every hour counts. What's more, big data analytics allow us to monitor and predict the developments of epidemics and disease outbreaks. Integrating data from medical records with social media analytics enables us to monitor flu outbreaks in real-time, simply by listening to what people are saying.

E. *Improving Security, Public Safety and Law Enforcement*

Since the tragic events of September 11, 2001, security research has gained much attention, especially given the increasing dependency of business and our global society on digital enablement. Researchers in computational science, information systems, social sciences, engineering, medicine, and many other fields have been called upon to help enhance our ability to fight violence, terrorism, cyber crimes, and other cyber security concerns.

Facing the critical missions of international security and various data and technical challenges, the need to develop the science of "security informatics" was recognized, with its main objective being the development of advanced information technologies, systems, algorithms, and databases for security related applications, through an integrated technological, organizational, and policy-based approach [15]. BI&A has much to contribute to the emerging field of security informatics. Security issues are a major concern for most organizations. According to the research firm International Data Corporation, large companies are expected to spend $32.8 billion in computer security in 2012, and small- and medium-size companies will spend more on security than on other IT purchases over the next three years [13].

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Intelligence, security, and public safety agencies are gathering large amounts of data from multiple sources, from criminal records of terrorism incidents, and from cyber security threats to multilingual open-source intelligence. Companies of different sizes are facing the daunting task of defending against cybersecurity threats and protecting their intellectual assets and infrastructure. Processing and analyzing security-related data, however, is increasingly difficult. A significant challenge in security IT research is the information stovepipe and overload resulting from diverse data sources, multiple data formats, and large data volumes. Current research on technologies for cybersecurity, counter-terrorism, and crime fighting applications lacks a consistent framework for addressing these data challenges. Selected BI&A technologies such as criminal association rule mining and clustering, criminal network analysis, spatial-temporal analysis and visualization, multilingual text analytics, sentiment and affect analysis, and cyber attacks analysis and attribution should be considered for security informatics research.

F. Understanding and Optimizing Business Processes

Big data is also increasingly used to optimize business processes. Retailers are able to optimize their stock based on predictions generated from social media data, web search trends and weather forecasts. One particular business process that is seeing a lot of big data analytics is supply chain or delivery route optimization. Here, geographic positioning and radio frequency identification sensors are used to track goods or delivery vehicles and optimize routes by integrating live traffic data, etc. HR business processes are also being improved using big data analytics. This includes the optimization of talent acquisition Moneyball style, as well as the measurement of company culture and staff engagement using big data tools.

G. Improving and Optimizing Cities and Countries

Big data is used to improve many aspects of our cities and countries. For example, it allows cities to optimize traffic flows based on real time traffic information as well as social media and weather data. A number of cities are currently piloting big data analytics with the aim of turning themselves into Smart Cities, where the transport infrastructure and utility processes are all joined up. Where a bus would wait for a delayed train and where traffic signals predict traffic volumes and operate to minimize jams.

H. Optimizing Machine and Device Performance

Big data analytics help machines and devices become smarter and more autonomous. For example, big data tools are used to operate Google's self-driving car. The Toyota Prius is fitted with cameras, GPS as well as powerful computers and sensors to safely drive on the road without the intervention of human beings. Big data tools are also used to optimize energy grids using data from smart meters. We can even use big data tools to optimize the performance of computers and data warehouses.

I. Financial Trading

High-Frequency Trading (HFT) is an area where big data finds a lot of use today. Here, big data algorithms are used to make trading decisions. Today, the majority of equity trading now takes place via data algorithms that increasingly take into account signals from social media networks and news websites to make, buy and sell decisions in split seconds.

IV. BUSINESS INTELLIGENCE AND ANALYTICS RESEARCH FRAMEWORK

Foundational Technologies and Emerging Research in Analytics The opportunities with the abovementioned emerging and high-impact applications have generated a great deal of excitement within both the BI&A industry and the research community. Whereas industry focuses on scalable and integrated systems and implementations for applications in different organizations, the academic community needs to continue to advance the key technologies in analytics. Emerging analytics research opportunities can be classified into five critical technical areas (big) data analytics, text analytics, web analytics, network analytics, and mobile analytics all of which can contribute to BI&A 1.0, 2.0, and 3.0. The classification of these five topic areas is intended to highlight the key characteristics of each area; however, a few of these areas may leverage similar underlying technologies.

A. Text Analytics

A significant portion of the unstructured content collected by an organization is in textual format, from e-mail communication and corporate documents to web pages and social media content. Text analytics has its academic roots in information retrieval and computational linguistics. In information retrieval, document representation

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and query processing are the foundations for developing the vector-space model, Boolean retrieval model, and probabilistic retrieval model, which in turn, became the basis for the modern digital libraries, search engines, and enterprise search systems [14]. In computational linguistics, statistical natural language processing (NLP) techniques for lexical acquisition, word sense disambiguation, part-of-speech-tagging (POST), and probabilistic context-free grammars have also become important for representing text [16]. In addition to document and query representations, user models and relevance feedback are also important in enhancing search performance. Leveraging the power of big data (for training) and statistical NLP (for building language models), text analytics techniques have been actively pursued in several emerging areas, including information extraction, topic models, question answering (Q/A), and opinion mining. Information extraction is an area of research that aims to automatically extract specific kinds of structured information from documents.

Opinion mining refers to the computational techniques for extracting, classifying, understanding, and assessing the opinions expressed in various online news sources, social media comments, and other user-generated contents. Sentiment analysis is often used in opinion mining to identify sentiment, affect, subjectivity, and other emotional states in online text. Web 2.0 and social media content have created abundant and exciting opportunities for understanding the opinions of the general public and consumers regarding social events, political movements, company strategies, marketing campaigns, and product preferences [9]. In addition to the above research directions, text analytics also offers significant research opportunities and challenges in several more focused areas, including web stylometric analysis for authorship attribution, multilingual analysis for web documents, and large-scale text visualization.

B. Web Analytics

Over the past decade, web analytics has emerged as an active field of research within BI&A. Building on the data mining and statistical analysis foundations of data analytics and on the information retrieval and NLP models in text analytics, web analytics offers unique analytical challenges and opportunities.

A major emerging component in web analytics research is the development of cloud computing platforms and services, which include applications, system software, and hardware delivered as services over the Internet. Based on service oriented architecture (SOA), server virtualization, and utility computing, cloud computing can be offered as software as a service (SaaS), infrastructure as a service (IaaS), or platform as a service (PaaS).

C. Network Analytics

Network analytics is a nascent research area that has evolved from the earlier citation-based bibliometric analysis to include new computational models for online community and social network analysis. Grounded in bibliometric analysis, citation networks and co-authorship networks have long been adopted to examine scientific impact and knowledge diffusion. Recent network analytics research has focused on areas such as link mining and community detection. In link mining, one seeks to discover or predict links between nodes of a network. Within a network, nodes may represent customers, end users, products and/or services, and the links between nodes may represent social relationships, collaboration, e-mail exchanges, or product adoptions. One can conduct link mining using only the topology information [17]. Techniques such as common neighbors, Jaccard's coefficient, Adamic Adar measure, and Katz measure are popular for predicting missing or future links. The link mining accuracy can be further improved when the node and link attributes are considered.

D. Mobile Analytics

As an effective channel for reaching many users and as a means of increasing the productivity and efficiency of an organization's workforce, mobile computing is viewed by respondents of the recent IBM technology trends survey (IBM 2011) as the second most "in demand" area for software development.

Mobile computing offers a means for IT professional growth as more and more organizations build applications. With its large and growing global install base, Android has been ranked as the top mobile platform since 2010. New mobile analytics research is emerging in different areas (e.g., mobile sensing apps that are location-aware and activity-sensitive; mobile social innovation for m-health and m-learning; mobile social networking and crowd-sourcing; mobile visualization/HCI; and personalization and behavioral modeling for mobile apps). In addition, social, behavioral, and economic models for gamification, mobile advertising, and social marketing are under way and may contribute to the development of future BI&A 3.0 systems.

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V. CONCLUSION

Through BI&A 1.0 initiatives, businesses and organizations from all sectors began to gain critical insights from the structured data collected through various enterprise systems and analyzed by commercial relational database management systems. Over the past several years, web intelligence, web analytics, web 2.0, and the ability to mine unstructured user generated contents have ushered in a new and exciting era of BI&A 2.0 research, leading to unprecedented intelligence on consumer opinion, customer needs, and recognizing new business opportunities. Now, in this era of Big Data, even while BI&A 2.0 is still maturing, we find ourselves poised at the brink of BI&A 3.0, with all the attendant uncertainty that new and potentially revolutionary technologies bring. Research is intended to serve, in part, as a platform and conversation guide for examining how the Information Systems (IS) discipline can better serve the needs of business decision makers in light of maturing and emerging BI&A technologies, ubiquitous Big Data, and the predicted shortages of data-savvy managers and of business professionals with deep analytical skills.

A new vision for IS may be needed to address this and other questions. By highlighting several high-impact applications such as Improving E-Commerce and Market Intelligence, Improving E-Government and Politics 2.0, Improving Research in Science and Technology, Improving Healthcare, Public Health, and Wellbeing, Improving Security, Public Safety and Law Enforcement, Optimizing Business Processes, Optimizing Cities and Countries, Optimizing Machine and Device Performance, Financial Trading.

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Javed Mohammed was born in Hyderabad, India, in1990. He received his Master's Science in Computer Science from NewYork Institute of Technology About to pursue PhD in Geospatial Computing from Texas A&M Corpus Christi. Presently taking advanced courses in Computer Science from Massachusetts University of Technology (MIT) & Harvard University.

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He is currently serving on the editorial board of " International Journal of Computer Science, Engineering and Applications (IJCSEA); as a Technical program committee member of "4th International Conference on Advances in Computing, Communications and Informatics"; as a Program committee member of "Fifth International conference on Computer Science, Engineering and Applications"; as judge for peer-reviewed presentations at prestigious International Conferences; and was invited to White House AAPI <WhiteHouseAAPI@ed.gov> to attend the Asian American and Pacific Islander (AAPI) Heritage Month Opening Ceremony. Mr. Mohammed also organized a Presidential Initiative on "Second Annual National Day of Civic Hackathon".

Mr. Mohammed is a member of Association for Computing Machinery (ACM) ;Ground Water Protection Council (GWPC); National Society of Professional Engineering; SAS Data Management; Association of Environment and Engineering Geologists (AEG); Information System Security Association (ISSA); American Society of Administrative Professionals (ASAP); Big Data Innovation Group; and Fracfocus.