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Where We are with Enterprise Architecture

Leila Halawi
halawil@erau.edu
Management Information Systems
Embry-Riddle Aeronautical University
Daytona Beach, FL, USA

Richard McCarthy
richard.mccarthy@quinnipiac.edu
Computer Information Systems
Quinnipiac University
Hamden, CT, USA

James Farah
jfarah@ju.edu
Davis College of Business
Jacksonville University
Jacksonville, FL USA

Abstract

Enterprise architecture has been continuously developing since the mid-1980s. Although there is now 35 years of research and use, there is still a lack consistent definitions and standards. This is apparent in the proliferation of so many different enterprise architecture frameworks. Despite the significant body of research, there is a need for standardization of terminology based upon a meta-analysis of the literature. Enterprise architecture programs require commitment throughout an organization to be effective and must be perceived to add value. This research offers an initial basis for researchers who need to expand and continue this research topic with an actual meta-analysis, and for practitioners who would like to use an efficient method for EA projects.

Keywords: Enterprise Architecture (EA), frameworks.

1. INTRODUCTION

Enterprise architecture (EA) is in its adolescent phase (Bucher, Fischer, Kurpjuweit, & Winter, 2006; Schelp, & Stutz, ,2007; Steenbergen, & Brinkkemper, 2008). Like an adolescent, to some it is surprising in its capabilities and to others merely a drain on resources. Enterprise architecture is not new; however, it is also not a mature discipline. We still have not developed a standard definition for what it means to an organization. You will find many definitions in the literature and this is disputably since EA draws on several associated domains and disciplines, such as systems engineering, organizational science, industrial engineering and information systems (Laplame, Gerber, Der Merwe, Zachman, De Vries & Hincklemann, (2016); Jallow, Demian, Anumba, & Baldwin, 2017). EA began in the 1980s and has evolved as a method for overseeing the information technology resources inside an organization (Steenbergen, & Brinkkemper, 2008). Its importance continues to grow (Boar, 1999). De Vies et al. (2014) and Laplame (2012) offered further specific definitions and debate on the significance and

meaning of EA. Deriving from the fields of software engineering, software architecture, and systems engineering, the EA field struggles to distinguish itself and prove that it is a valuable undertaking that is able to generate significant value to the organization.
In the 1980s, IBM started to explore ways to illustrate the organization in an apportioned, isolated, and integrated approach (Carlson,1979; Carlson, 1980; Zachman, 1987). John Zachman (1987) launched his "Framework for Information Systems Architecture" which was later known as the "Framework for Enterprise Architecture, (ZFEA)" afterward "Enterprise Architecture—A Framework™," then the "Zachman Framework for Enterprise Architecture," followed by the "Zachman Enterprise Architecture Framework," and lastly as the "The Zachman Enterprise Framework.
Various present EA frameworks were inspired by the ZFEA such as the Extended Enterprise Architecture Framework (E2AF), Enter- prise Architecture Planning (EAP), the Federal Enterprise Architecture Framework (FEAF) and the Integrated Architecture Framework (IAF) (Schekkerman, 2004).

In 1987, the Object Management Group was established and started the Common Object Request Broker Architecture (CORBA).

In 1992, Sowa and Zachman (1992) extended the original version of the Zachman "Framework for Information Systems Architecture." Also in 1992, Steven Spewak published *Enterprise Architecture Planning Developing a Blueprint for Data, Applications, and Technology*, and promoted the data-centric method. Spewak and Hill (1992) highlighted the need to examine what we do as part of an EA effort, distinct from recognizing corporate business goals and how IT enables business goals.

Schekkerman (2005) conducted a survey by the Institute for Enterprise Architecture Development. He reported that 95% of organizations appreciated the significance of EA and that EA can focus on IT alignment, business change, and a transformation road map. Nonetheless, some organizations placed varying levels of emphasis on architecture themes, such as enterprise architecture (15%), technology infrastructure architecture (15%), security architecture (15%), information systems architecture (14%), information architecture (13%), software architecture (11%), and less on business architecture (10%), and governance architecture (7%).

EA produces a different background to present decision-making in the IT world. It permits the corporation to dispute customary methods that stop change and to mold enabled situations that interrupt older patterns of control whilst reinventing their critical inputs in a novel way. EA involves a socio-technical base, where the human part is interlocked with the technological part while forming a framework for an efficient organizational system (Applebaum, 1997; Cherns, 1976; Trist, Higgin, Murray, & Pollock, 1963). In its operational configuration, EA offers a paradigm for IT that outlines and connects data, hardware, software, and communications means, as well as sustaining the enterprise (Richardson, Jackson & Dickson,1990). EA is valuable to any organization, as it offers the blueprints to advance and create an information system and IT inside an organization. EA is a practice and developing field meant to advance the administration and operation of complex organizations and their information systems. Many believe that EA may occupy a primary part facilitating the design of future enterprises (Lapalme, Gerber, Van der Merwe, Zachman, Vries, Hinkelmann (2016).

Zachman (1987, 1999), occasionally described as the father of EA, declared that stating how to describe EA produces problems, as a series of architectural interpretations and depictions exist, instead of a sole architecture. The immaturity of EA (approximately 20 years) has resulted in the lack of a consistent definition. Zachman viewed EA as a collection of basic, descriptive artifacts that establish the knowledge substructure of the organization (2000a). Even though EA is useful and is taught in universities around the world, there are no industry-standard terms to define the boundaries of EA as a conceptual framework, as an applied framework, and as a set of constructs.

The objective of this research is to examine the theoretical and applied foundations of EA in regards to two of its main prominent features: (a) the techno-centric aspect of EA, followed by (b) its interdisciplinary makeup that comprises business, engineering, information sciences, and project management, among others. The purpose of the paper is to expand the advancing an EA frameworks to continue to move towards demonstrating that it provides a positive return on investment for organizations. To this objective, this research in progress will generate the subsequent contributions:

- It discusses the center and scope of EA by defining the boundaries of what EA should adopt.

- It reviews the existing frameworks to propose a unified framework that can be used to generate significant value to the organization.

The remainder of this paper is organized as follows: the literature review, discussion of the needs for standardization, and the resulting issues.

2. LITERATURE REVIEW

2.1. The Era of Enterprise Architecture

In 1997, interest in EA was mounting in both the government and business sector. Zachman not only declared that the era of EA is here, he also declared EA as the issue of the era (Zachman, 1987). The U.S. government's view was in alignment with Zachman's statement. In January of 1998, the CIO Council Strategic Plan, directed by the Clinger-Cohen Act of 1996, guided the advancement and protection of a Federal Enterprise Architecture to exploit the advantages and uses of information technology within the government.

In 2012, OMB Circular A-130, "Management of Federal Information Resources" was reviewed and re-released, including communication comparable to the 1997 OMB memo. The reviewed Circular A-130 defined EA as the precise depiction and record of the existing and anticipated connections amongst industry and management processes and information technology. It explains the present architecture and intended architecture to incorporate the guidelines and principles and systems life cycle information to enhance and sustain the situation that the organization desires to produce and sustain by controlling its IT portfolio. Moreover, the EA should present a plan that will allow the company to sustain its existing situation and additionally function as the roadmap for evolution to its intended setting.

Beznosov (2000), in his technical report on information EA problems and perspectives offered a discussion on the various definitions for EA as does the draft *Enterprise Architecture Body of Knowledge* (EABOK) presented by Hagan (2004). The EABOK assumed that EA encompasses illustrations of industry practices or processes, data, computing systems for mission-related and business support, networks and additional technology substructure for both the existing and intended architectures. The EA comprised a standard profile, security specifications, and an evolution or transition plan. EA is connected to the organization strategic plans and is a main base for investing decisions.

2.2. Enterprise Architecture and Frameworks Defined

Typically, an enterprise is outlined as an established business or organization to produce a product or extend a service.

The IEEE Standard 1471-2000 (2000) defines architecture as the structural configuration of a system represented in its pieces, their connections to each other, the ecosystem, and the driving principles for development and growth. Architecture is the outline of any arrangement of structure, whether physical or conceptual, actual, or virtual. Architecture has several meanings in the systems engineering community where Rechten (2001) defines architecture as the top down description of the structure of the system, while Maeir (1998) defines architecture as the set of information that defines a system's value, cost, and risk. Bernard (2006) defined enterprise architecture from a program and documentation perspective.

A framework is a method to understanding EA. Accordingly, it is also a method to understanding the dynamics of an enterprise. A framework is a configuration, outline, or a plan. A framework is a group of assumptions, views, guidelines, and measures that document a method to describing realism. Frameworks help individuals organize and assess comprehensiveness of integrated models of their organizations (Armour, Kaisler, & Bitner, 2007). Frameworks suggest an enterprise structure through which organizations advance. An EA framework is consequently a way of sense-making in the composite ecosphere of change, in the domain of EA (Bernus, Noran, & Molina, 2015)..

EA is the architecture that illustrates an enterprise as an arrangement of distinctive information systems, with connections (combination points) to each other and the environment (Hagan, 2004). Additionally, EA has to include discourse on the standards directing the design and growth of the information systems and IT.

EA builds the capability to identify and determine the lasting appeals to mix, configure, transform, and sensitize the business to technology and to the market.

There have been many definitions of EA presented by various researchers. EA has been defined as a theoretical framework of how an enterprise is created, outlining its main elements and the connections among these elements (Rood, 1994). According to Armour et al. (2007), EA is a meta-architecture that comprises many information systems and their relations (technical infrastructure). Yet, since it may also encompass additional views of an organization—which can incorporate work, process, and information—it is at the top level in the architecture pyramid. Chung and McLeod (2002) presented EA as a thorough mockup of an enterprise, a principal sketch, which works as a planning, configuration, and mixing guide and force for an enterprise. The Electronic Government Act of 2002 described EA as the strategic information resource that outlines the mission, the needed data to achieve the mission, along with the technologies needed to execute the mission. Perks and Beveridge (2003) outlined EA as the group of strategic and architectural elements that embody the information, corporate system, and technical architectures. The Open Group defined EA as the harmony across all the different components that make up an enterprise and how those components connect (Schekkerman, 2004). EA is the chain of practices, procedures, methods, and relationships needed to initiate an enterprise-wide inclusive and dependable IT architecture for supporting the enterprise's business activities (Kaisler, Armour & Valivullah, 2005). EA also incorporates the provisional procedures for applying innovative technologies in response to the varying mission needs. The Meta Group, which merged with Gartner in 2005, described EA as the holistic expression of an organization's key business and processes.

The EA should contain a standard architecture, a target architecture, and a migration outline (U.S. Department of Commerce, 2007). Thus, EA is recognized as the central initiative—either in part or as a whole—extended to its suppliers, partners, or customers, including the standards governing its design and growth (Open Group, 2003 & 2009) (Winter, & Schelp, 2008) (Zachman, 2000a). EA involves both corporate strategy and technology [29] [36] (U.S. Department of Commerce, 2007). EA has a process model that guides the EA development (U.S. Department of Commerce, 2007).

Schekkerman (2008) asserted that EA is a comprehensive manifestation of the organization, a principal proposal that represents a collaboration force amongst phases of business planning such as goals, ideas, schemes, and governance principles. EA focuses on attributes of business operations such as business terms, enterprise configuration, procedures and data; parts of mechanization such as information systems and databases; and the supporting technological infrastructure of the business (Schekkerman, 2005)

According to Zachman (1997), Armour, Kaisler, and Bitner (2007), the Open Group Architecture framework (TOGAF) (2003, 2009), and Langenberg and Wegmann (2004), EA is a significant tool for operationalizing and instigating policies and strategies. The primary motive behind the need of an EA is to provide the basis for future technological expansion and to verify the current technology and process structures of an enterprise. EA encompasses a collection of exceptionally precise information and artifacts for future re-use. It allows companies to attain the exact balance between IT competence and business innovation. It can also decrease development, support and maintenance costs, increase portability of applications, develop interoperability, and offer an improved capability to tackle key enterprise-wise issues such security, governance, privacy, and mobilization (Open Group, 2003). EA is also considered the blueprint of the architectural framework that drives and communicates the business strategy and information systems visions (Armour, Kaisler, & Bitner, (2007)

Though there are numerous definitions of enterprise architecture, each points to the need for a framework to act as a coordinating function. Frameworks coordinate the varying levels of organizations and information systems and serve as a planning tool for prioritizing IT resource allocation.

2.3. Enterprise Architecture Frameworks

Enterprise architecture frameworks (EAFs) have been utilized to design, plot, and supervise broad enterprise deployments for more than three decades. EAFs are significant instruments employed by systems engineers and are vital to describing enterprise information architectures. They are progressively used as a surrogate for managing whole organizations, or in other words, enterprises. Enterprises denote complex, multi-disciplinary, socio-technical systems.

An enterprise architecture framework (EAF) represents a methodology to support an organization in certifying that its principal systems meet particular common tasks or objectives.

Given that the motivation for adopting enterprise architecture is to control change and intricacy, it is significant that one may overlook the need to retain and develop the architecture itself (Magoulas, Hadzic, Saarikko, & Pessi, 2012).

Enterprise architecture models or frameworks are created to help managers better understand the organization's assets, operations, and production, resulting in improving decision-making. EA involves numerous forms of architectures, each with its unique structure of deliverables, analysis methods, processes, and participants. Due to the significance of the role of EA in the existing business environment, numerous enterprise architectural frameworks have been created and suggested by researchers and practitioners such as Zachman's IS Framework (1987) the Index Model (Boar, 1999, TOGAF (2003), and DoDAF, among others.

Enterprise architecture is envisioned to deliver the essential plasticity to complete change in the fast-paced IT and corporate environments (Cook, 1996; Veasey, 2001; Watson, 2000). Enterprise architecture offers a stage to steadily address all the activities in the organization and several linked concerns, such as the information and technology that maintains the business processes and activities.

There are many EA frameworks (EAF) available to assist the architects in their work (Sage & Cuppan, 2001). Matthes (2011) stated that there is about 50 different EA frameworks. In his publication, Matthes offers a comprehensive review of 34 EA frameworks, founded on distinctly structured and well defined principles. Existing EA frameworks have some shortcoming and inadequacies. These setbacks influence the absence of standard EA framework and its implementation in any enterprise

A sample by developers of the frameworks and industry is presented in Table 1.

Table note. Also for NIST are the following:
DRAGON 1 (Open Group)
BRM (Sanjeev Mishra)
OBASHI
SOMF (Michael Bell)
ASSIMPLER (Mandar Vanarse)
PEAF (Kevin Smith)
Avancier Methods (AM)
Dynamic Enterprise
Extended Enterprise Architecture Framework (E2AF, Schekkerman)
EACOE (https://eacoe.org/)
Index Model (Boar, 1999)
BPTrends EA (Harmon, 2007)
Model Driven Architecture (MDA) (Miller, Ambler, Cook, Mellor, Frank, & Kern,2004).

Integrated Architecture Framework (IAF)

Table 1. Enterprise architecture frameworks

Consortia	Government	Defense	Open Source	Proprietary
TOGAF	EASAAF (European)	AGATE (France)	MEGAF	Zachman
ARCON	GEA (Queensland)	DNDAF (Canada)	Praxeme	SAP Enterprise Architecture Framework
GERAM	TEAF (U.S. Treasury)	DoDAF (US)	SABSA	IFW (IBM Information Framework)
IDEAS Group	NORA (Dutch)	MODAF (UK)		SAM
ISO 19439	FEAF (U.S. Federal CIO Council, 2006)	NAF (Nato)	TRAK	Purdue Enterprise reference architecture (Theodore Williams)
RP-ODP	FDIC (U.S. Federal Deposit Insurance)	NASCIO		IAF (Capgemini)
	NIST (U.S. National Institute of Standards and technology)			DYA (Sogeti) *See also Table note.

2.4. Enterprise Architecture Perspectives

2.4.1. The federal government perspective. The history of EA in the U.S. federal government may best be reviewed by examining the regulations and actions taken by Congress in the past 20 years. As we know, Zachman was a primary contributor in the U.S. Department of Defense's (DoD) effort to initiate EA in 1994, which was formerly identified as the Technical Architecture Framework for Information Management (TAFIM) (Sessions, 2007). Inside the DoD, the usage of architecture encompasses a large area, starting with the creation of TAFIM. In 1996, Congress approved a bill recognized as the Clinger-Cohn Act of 1996, or the Information Technology Reform Act, which instructed all federal agencies to employ IT planning processes to develop the efficacy of IT investments. This act assisted in the evolution and development of enterprise architecture frameworks. These included the Federal Enterprise Architecture (FEA), and Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR), which was renamed as Department of Defense Architecture Framework (DoDAF) (U.S. Federal CIO Council, DoD Deputy Chief Information Officer, 2005).

2.4.2. The private sector perspective. The emerging discipline of enterprise architecture is traced to Zachman (1987). According to Zachman (1987), several reported disputes included (a) the management of complexity in the distributed computing environment and (b) multiple and differing methodologies to systems architecting that decreases complication within the design of IT-enabled systems. EA offers the basis for high-performing enterprises to implement their strategies. Additionally, it aids in breaking down complications while driving change by aligning business, technology, and strategies, and ultimately improving decision-making. Moreover, according to Hoogervorst (2004) there is a bigger need for an integrated design of the enterprise.

3. CONCLUSION

The advancement of the discipline is revealed in numerous existing scientific publications. Within three decades, Gampfer, Jurgens, Muller and Buchkremer (2018) identified about 4000 journal articles and conference papers of which EA is a main subject. The review of EA uncovers numerous interpretations and definitions of EA where some concentrate on mission, strategy, and vision (Rood, 1994), while others concentrate on the aspects of business and resulting technology. In addition, the focus of EA research has shifted from understanding EA in the early years to managing EA today.

At present, organizations still struggle with the number of various disintegrated models, tools and frameworks and methods recommended to them by numerous disciplines and researchers, and the subsequent agreement is less than consistent (Doucet et al., 2008).

Despite the benefits that enterprise architecture claims to provide, for more than a decade, writers and organizations raised concerns about enterprise architecture as an effective practice.
To provide an integration model, recommendations can be made for future development of a unifying framework for enterprise architecture. These include the following:

1. The manner in which EA is defined varies, so we need to identify a common definition of the terms enterprise and framework in the context of enterprise architecture research.
2. The scholarly literature indicates that enterprise architecture frameworks presuppose different disciplinary frameworks. So, within our future project, the architecture of the models and their interrelationships will be investigated. The results will be used to develop a unified framework.

The EA community is presently broken by industry (IT/systems engineering, industrial, public sector, defense, service businesses, scientific/applied research and by schools of thinking. Academia, research society, Industry Associations in addition to government bodies need to get together to work on advancing the body of knowledge, and resolve all ambiguities in this field (Bernus,Noran & Molina, 2015). Our future research will develop and review a standard taxonomy of enterprise architecture that will pave the way for EA as a freestanding discipline. We will review closely GERAM, the sense-making instrument that may be utilized by anyone working on the development of their own respective architecture frameworks. Bernus, Noran & Molina (2015) stipulated that GERAM may be a significant baseline meta-framework for EA.

EA projects comprise two principal methods: an Enterprise Architecture Framework (EAF), and an Enterprise Architecture Implementation Methodology (EAIM) (Rouhani, Mahrin, Nikpay, Ahmad & Nikfard, 2015). The use of an enterprise architecture framework within an organization requires a commitment to an enterprise architecture program and a culture conducive to its maintenance. Although frameworks can provide a useful guide and standardize documentation, they also can be viewed as requiring additional processes within the organization. The value of an enterprise architecture program must therefore be demonstrated. EA frameworks define processes that must be followed, so the processes must support the needs of the organization. Enterprise architecture frameworks look to be comprehensive in scope, though most have been criticized for failing to address key components of an information technology program. Significant differences exist within the myriad of frameworks, so sifting through all of them to pick which one most closely aligns with an organization's needs can be burdensome. Any enterprise must weigh the benefits and drawbacks when considering adopting or adapting EA.

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Dangers of Distracted Driving by Mobile Phone Users: An Experimental Approach

Hoon S. Choi
choihs@appstate.edu

Jason Xiong
xiongjj@appstate.edu

B. Dawn Medlin
medlinbd@appstate.edu

Computer Information Systems & Supply Chain Management
Appalachian State University
Boone, NC 28608

Abstract

Using mobile phones while driving has been dramatically increasing for the last years, causing fatal accidents on roads. Although prior studies on mobile distraction while driving have investigated this issue, they focused on the relationship between using texting or calling and safe driving based on self-reported survey data. In order to fill the gap, this research investigates the impact of various distractions, including voice calling, texting, social network service (SNS), and selfie, on the level of potential dangers imposed by each distraction, employing a driving simulator which has rarely been used in the prior studies. The major findings include that each mobile distraction imposes a different level of potential dangers to drivers: using SNS causes the largest danger in driving, followed by texting, calling, and selfie.

Keywords: Distracted Driving, Multitasking, Mobile Distractions, Safe Driving, Mobile Phones

1. INTRODUCTION

Driving is a complex task that requires drivers to perform various cognitive, physical, sensory and psychomotor skills (Young, Regan, & Hammer, 2007). Distracted driving has been a part of the history of driving automobiles that began in the mid-1800s. However, mobile phones enabling drivers to perform multiple tasks, which is called mobile distractions, have added a new chapter to the history. Mobile distractions can be defined as any activity that diverts a person’s attention away from the primary task of driving. This definition therefore includes any activity that occurs while a driver is using a mobile phone. As smart phone’s capabilities have increased and advanced technologies have been introduced more than texting and receiving telephone calls, drivers have increased opportunities for deadly results. Notably, as smartphone functions expand and social media platforms become more widely adopted and regularly used, some drivers cannot seem to turn away from their apps and phones while behind the wheel.

With today’s pervasive use of mobile cell phone devices, multitasking behavior has become commonplace at work, in the classroom, and everywhere else, including even on the road (González & Mark, 2004; Kraushaar & Novak, 2010; Stephens & Davis, 2009). Technology through cell phone use has increased the opportunity for multitasking, which may include more than the action of driving and texting and talking, it can also include multiple actions on the phone such as calling and texting, sending pictures, and preforming other activities which would include multiple multitasking functions or activities. However, when using mobile phone while driving, a driver may not only be less efficient but also can make more risky mistakes. Therefore, simple distractions from using the phone can create dangerous actions such as speeding up and slowing down, lane changes that result in collisions with other vehicles, and even fatal car crashes.

This research investigates the potential impact of mobile distractions based on the theory of multitasking, which has been widely used in various behavioral studies (Salvucci & Taatgen, 2008) and provides a theoretical lens to examine how using mobile phone affects driving performance and causes dangerous situations on the road.

2. LITERATURE REVIEW

Distracted Driving

The National Highway Traffic Safety Administration (NHTSA) defines distracted driving as "any activity that diverts a driver's attention away from the task of driving" (Ranney, Mazzae, Garrott, & Goodman, 2000). Thus, any distraction in driving can be classified as distracted driving. The distractions can be categorized into four groups, which are visual distractions, auditory distractions, biomechanical distractions, and cognitive distractions (Ranney et al., 2000). Visual distraction includes looking at anywhere else other than the road ahead. It also includes looking at the screen of the mobile phone. Auditory distraction includes actions like responding to a cell phone and turning off an alarm clock. Biomechanical distraction includes using hands to turn on/off the radio, rolling down a window, and adjusting the mirror. Finally, cognitive distraction includes thinking about other things while driving (Ranney et al., 2000). It is obvious that one distraction can have more than one distractions. For example, playing mobile games while driving (Postelnicu, Machidon, Girbacia, Voinea, & Duguleana, 2016) can cause all the aforementioned distractions. These distractions have been a primary reason for accidents on roads. According to the National Traffic Safety Administration, 37,461 lives were lost on the U.S. roads in 2016, an increase of 5.6 % from 2015. Of these, 3,450 were reportedly due to distracted driving (NHTSA, 2018).

Mobile Distractions

Human multitasking behavior while driving is not a new phenomenon. Historically, drivers have multitasked as they attempted to tune into their favorite radio station, apply make up on the way to work and simultaneously eat and drive. However, the impact of mobile distractions are far more substantial than the traditional ones. Currently, there are 266 million cell phone users in the United States as of 2017 (PYMNTS, 2017). The amplified use of mobile phones along with the increased triggers and pressures of work and private life have transformed multitasking from occasional usage to a habit (Adler & Benbunan-Fich, 2015) even while driving, which can invite enormous dangers into the driving environment. Even for experienced drivers, the risk of a crash or near-crash increased significantly if they were dialing on a cell phone (Klauer et al., 2014).

Driving is a highly complex task that involves many sensory functions as well as psychomotor skills (Young et al., 2007). Therefore, texting and calling as well as performing other mobile distractive activities are a significantly dangerous behavior. According to research by AT&T's "It Can Wait,"(AT&T, 2018) campaign, however, 7 in 10 people are engaging in smartphone activities while driving, and the distracted driving has become a "habit," for 1 in 3 drivers.

The significance of mobile distractions has attracted attention from researchers in both practice and academia. Regan, Lee, and Young (2008) suggested that distracted driving results in two different forms of hazards. The first is the "driver distraction," which occurs when the primacy of the social role "driver" affects the person's on-road behavior. The second is "distracted driving," which occurs when circumstances act to divert attention from the driving task. Nemme and White (2010) utilized an extended theory of planned behavior (TPB) to predict the factors that could lead to the reading of and sending of text messages. They identified that driver's attitude is the most important predictor in sending and reading text messages. Caird, Johnston, Willness, Asbridge, and Steel (2014) conducted a meta-analysis and found that typing and reading text messages while driving adversely affected a series of activities related driving, including eye movements, reaction time, lane positioning, and speed. Haddington and Rauniomaa (2011) utilized video recording analysis that includes mobile phone usage while driving, particularly in the pre-beginning stage of answering the phone. They reported that the mobile phone activity could be a potential danger to safe driving. Adopting an experimental approach, Hancock, Lesch, and Simmons (2003) found that in-vehicle technologies erode performance safety margins and could potentially distract drivers from controlling their vehicles. Nasar, Hecht, and Wener (2008) extended Hancock and colleagues' study and further confirmed that usage of mobile devices are dangerous for both drivers as well as pedestrians. Based on their survey data from 40 students, Levy, Pashler, and Boer (2006) identified that the break reaction time increases when stimulus onset asynchrony was reduced. Similar results were found in a later study (Levy & Pashler, 2008). Watson and Strayer (2010) found that although the majority of individuals would experience decreased performance in driving while talking on a cell phone, some people might not have any performance decrease due to performing dual tasks. It has also been found that the performance of conducting dual tasks may be increased with proper training (Gugerty, 2011).

Although many prior studies investigated diverse aspects of mobile distractions while driving, few focused on comparing the level of potential dangers by different mobile distractions. In addition, they mainly considered calling and texting but did not examine new mobile activities with smartphones, such as taking a selfie and using social network services (SNS). In terms of research methodology, they mostly used self-reported survey data, which may not be enough to explain a realistic behavior of the driver using their mobile phone for various activities. To fill in the research gaps, we investigates the impact of various mobile distractions by adopting the use of a driving simulator. W compare the significance of the distraction to understand which mobile distractions imposed the more or most danger to the driving environment.

3. CONCEPTUAL FORMATION

Multitasking Theory

Multitasking can be defined as "performing two or more tasks at once" (Salvucci & Taatgen, 2008), which are composed of three dimensions (Benbunan-Fich, 2012). The first component are causal antecedents, which includes individual preferences and situational demands. Individual preferences include the way people perceive and think about the specific tasks and a specific way to solve the issues. Temporal perception can be divided into monochronic and polychromic (Hall, 1959). People who have polychromic time will more likely engage in multitasking behaviors (Benbunan-Fich, 2012). In the context of driving, thus, monochronic drivers may prefer to drive without doing anything else, while polychronic drivers tend to do other tasks such as mobile phone use while driving. Situational demands are the second component. While driving people may feel the pressure to use mobile phones and other technologies. For instance, drivers must ask themselves on a regular basis if they are going to miss their best friend's message regarding plans for the weekend or preform other activities like immediately posting a selfie and information while driving. Finally, patterns of enhancement shift is the third component of the theory. It suggests that multitasking behaviors will happen if there are internal or external triggers. In driving situations, there may an internal desire to use mobile phones. The driver may want to play a video game or send a text. Individuals in the car can create an external trigger, asking the driver to change a music selection on their smartphone, which is connected to the vehicle's music player.

Hypothesis Development

This study adopts the theory of multitasking as its framework for developing hypotheses: as individuals are obviously undertaking more than one task when using a mobile phone while driving. According to the theory, multitasking generally decreases processing speed for a principal tests and increase errors (Spink, Cole, Waller, & technology, 2008) as well as increasing a psychological stress, which may be an additional distraction to deter processing of the principal task. One of the reasons that multitasking decreases task performance is frequent switching between tasks. People need to set up a different cognitive set when switching to another task. The switching negatively affects working memory of the people, which is known as the most important factor to predict performance on multitasking (Otto, Wahl, Lefort, & Frei, 2012). Another influential factor is task complexity. As people process more diverse, complex tasks simultaneously, they perceive more difficulties in multitasking (Czerwinski, Horvitz, & Wilhite, 2004) and therefore, taking more time to process but making more mistakes. The central-bottleneck (CB) theory lends support to the aforementioned discussion. According to the theory, certain mental operations cannot be performed at the same time (Levy et al., 2006). Therefore, when people are in multitasking situations, their performance including accuracy and speed tends to decrease.

As discussed, it is expected that the level of the performance decrease is determined by diversity and difficulty of tasks. As people have to conduct more diverse and difficult tasks, they are more likely to make more mistakes and take more time to complete the entire tasks. In the context of mobile distractions while driving, it is expected that the four mobile distractions have different level of diversity and difficulty.

In this study, five scenarios were selected, including driving with no distraction, snapchatting while driving, texting while driving, taking a selfie while driving, and talking over the phone and driving. Those combinations are the most common mobile phone activities while driving (AT&T, 2015). Concerning SNS, Snapchat is selected to represent the activity. Snapchat is a multimedia social messaging application that allows users to share pictures and messages to friends. There are about 191 million daily active users of Snapchat in 2018 (@StatistaCharts, 2018). Especially, college students use that while driving and thus, has been shown to be a major reason for car accidents (Vaysberg, 2015). One of the reasons for using Snapchat while driving is its unique feature, which allows user to post a picture with current speed, which is called a "Geofilter" (Atchley & Strayer, 2017), potentially motivating drivers to use Snapchat while driving (Boudette, 2016; McNabb & Gray, 2016).

Snapchatting requires frequent switching between various tasks, causing multiple distractions while driving such as visual distractions, cognitive distractions, and manual distractions (Martell, 2018). For example, drivers have to look at their screen when Snapchatting, which takes their vision away from the road (i.e., visual distraction). In addition, drivers need to think about the content received or sent via Snapchat, which creates another distraction (i.e., cognitive distractions). In order to use Snapchat, lastly, drivers have to type holding the phone, which means at least one of the hands will be off the steering wheel (i.e., Manual distractions). Therefore, Snapchatting would impose more diverse distractions than any other mobile distractions and consequently, creating more dangers. Thus, we propose the following hypothesis:

H1: Snapchatting while driving is more dangerous than other mobile phone activities while driving.

Prior studies commonly reported that texting while driving adversely affects the reaction time and lane positioning in driving (Caird et al., 2014). In addition, they illustrated that the negative effect is more significant than making a phone call (Nelson, Atchley, & Little, 2009; Owens, McLaughlin, & Sudweeks, 2011). In terms of multitasking theory, texting is more difficult than calling, imposing more visual and manual distractions. For example, a drive in order to read something must divert their eyes from the vehicle windshield and use multiple keys to manually type in texts. Typing is a substantially more diverse task than calling, which simply creates cognitive distraction for conversation and the manual distraction of holding a mobile phone. Thus, we propose the following hypothesis:

H2: Texting while driving is more dangerous than calling while driving.

Many drivers take selfies while driving and then post the pictures on their SNS (Chae, 2017; Qiu, Lu, Yang, Qu, & Zhu, 2015). Although little extant literature concerning distracted driving discussed about its effect on driving performance, taking a selfie while driving would create a significant distraction because the driver will have to look at the mobile phone screen and focus in order to take the selfie. Compared to calling, the drivers more frequently look at the screen to operate and see the camera while less frequently to see it when texting. This discussion suggests the following hypothesis:

H3: Taking a selfie while driving is more dangerous than calling, but less dangerous than texting while driving.

As many prior studies have found, making phone calls while driving creates a distraction (Collet, Guillot, & Petit, 2010; Tison, Chaudhary, & Cosgrove, 2011; K. M. White, Hyde, Walsh, & Watson, 2010; M. P. White, Eiser, & Harris, 2004). These findings correspond to the concept of multitasking. For example, calling creates an additional task in a driving situation because they have to listen to someone they talk with, understand, prepare their answers, and answer (i.e., cognitive distraction) as well as hold the phone while talking (i.e., manual distraction). Therefore, the following hypothesis is proposed.

H4: Calling while driving is more dangerous than driving with no distractions.

4. METHODOLOGY

Experimental Design

We conducted a laboratory experiment to test the proposed hypotheses. We constructed a driving simulator using a Logitech G29 racing wheel and City Car Driving software, which is a car simulation game (Figure 1). The software provided a more realistic driving environment than general car simulation video games that emphasize unrealistic racing components for fun. In the software, users had to follow all traffic rules such as speed limit adherence and signaling lane changes. Subjects participated in the experiment reported that the simulator provided a realistic driving environment (3.6 out of 5.0).

Figure 1. Driving Simulator

Before the experiment, a pilot test was administered to detect potential issues in the experiment design with six subjects. Based on the pilot test, we revised the experiment's design in terms of session time, driving difficulty, driving environment (e.g., town or highway), weather, vehicle types (e.g., sedan or SUV), and traffic conditions. The experiment is composed of five sessions with the four mobile distractions (i.e., stimulus) in the hypotheses and one session without distractions in order to measure the impact of mobile distractions on driving performance. Each experiment with the five sessions took approximately 60 minutes to complete. The driving environment was set to a highway environment with moderate traffic entering the highway but the environment where few external distractions existed. This allowed us to measure the impact of mobile distractions, minimizing the other distractions.

The experiment adopted a within-subject design to test the different effects of mobile distractions on driving performance. This is an adequate design for our study in that it can rule out individual differences in subjects and test the effect of treatment conditions, which are the four mobile distractions.

Subjects

From December 2017 to January 2018, a pre-screening survey was initially administered, and eighty-eight samples were collected at a state university. In order to select adequate subjects, the researchers controlled relevant factors to driving performance, such as gender, age, driving experience, car accident experience, and smartphone use experience while driving. Thirty subjects who had similar demographics and driving experience were selected for the final study. All participants had experience in the use of mobile phones while driving for calling, texting, selfies, and SNS with no car accident experiences. They were also Snapchat users, which is one of the most popular SNSs in the U.S. and used for the experiement. Table 1 illustrates their profile.

Table 1. Subject Profile

Category	Group	Frequency	
Gender	Males	15	
	Females	15	
-	**Average**	**Min**	**Max**
Age	21.4	20	27
Driving Experience	5.87	3	11

Experiment Procedure

Before the driving simulation session, a practice session was held to train the participants on how to use the simulator and the driving wheel. After the practice session, five tasks were randomly administered to rule out possible time effect, which experiment subjects can be more proficient at a task as they complete more instances and thus, tend to present superior performance in the later sessions (Gravetter & Forzano, 2018). In the driving experiment, it is possible that they performe better at the end of the experiment because they may become more proficient by experiencing the same driving environment.

In the *no distraction session*, subjects were asked to drive the simulator without any mobile phone use, fully focusing on driving. In the *calling session*, they talked with one of our researchers and were asked several simple questions. All subjects received the same questions in order to control for possible external effects on driving performance. One example of the questions asked includes, "What did you eat for dinner last night?". In the *texting session*, one of our researchers asked several questions via texts. In the *selfie session*, subjects took several selfies when the session leader asked. After taking each selfie, they set their mobile phone back to their home page. They took 5 selfies that required approximately four minutes. Lastly, the subjects were asked to post some of the selfies on their Snapchat Story section with short comments in the *snapchat session*. The subjects typed the same caption on each of the pictures to control the length and/or complexity of the captions.

After all five tasks had been completed, post interviews were conducted to collect quantitative data about their feelings and opinions of the experiment. In the interview, particularly, the researchers focused on the relationship between mobile distractions and driving performance.

Measurement

In the five task sessions, the distractions were implemented for the same amount of time which was approximately four minutes in length. The time factor is important because as the subjects might face a mobile distraction for a longer time, they would likely make more mistakes. Since the purpose of our study was to understand the impact of different mobile distractions, we controlled the time of each distraction.

The simulation software, City Car Driving, used in the experiment provided data concerning driving performance and safe driving such as the types and the number of violations and accidents. The significance of each violation is measured by the amount of a monetary fine for the violation. As an example, driving in the opposite lane is defined as a far more significant violation than not turning on a direction light when changing lanes. In order to measure the distractions, we considered both the number of violations (i.e., frequency) and the total amount of monetary fines due to the violation (e.g., significance).

Analysis Results

The proposed hypotheses were tested using a repeated measure ANOVA design. This is adequate to test behaviors of the same individuals over different conditions (Brady, Bourdeau, & Heskel, 2005).

First, the hypotheses were tested using the number of violations as the dependent variable. Before testing the hypothesis, we examined violations of sphericity with Mauchly's test of sphericity. Mauchly's test was significant (p=0.04) and thus, we applied the correction factor epsilon (ε) to the degree of freedom. Because the Greenhouse-Geisser estimate of sphericity (ε =0.768) was larger than 0.75, we employed the Huynh-Feldt correction. The main effect of mobile distractions was significant ($F_{3.616,\ 101.249} = 16.179$, $p < 0.01$, $\eta^2=0.366$), indicating a statistically meaningful difference in the number of violations across different mobile distractions. As illustrated in Figure 2, using Snapchat while driving caused more violations than any other mobile distraction (*M*=7.500, *SD*=1.241). This corresponds to Hypothesis 1, which predicted the largest distraction of using Snapchat. In the post hoc comparisons performed with Bonferron, adjustment for multiple comparisons, however indicated that the difference between using Snapchat and texting is not statistically significant, while its differences from the rest of the distractions are significant ($p < 0.001$). This result partially supports Hypothesis 1.

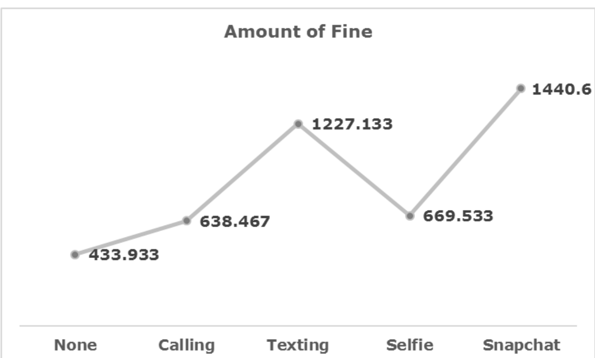
Figure 2. Means for Number of Violations

Concerning Hypothesis 2, the subjects experienced more violations in the *texting session* (*M*=6.267, *SD*=0.922) than the *calling session* (*M*=3.200, *SD*=0.714). This difference was statistically significant in the post hoc comparisons ($p<0.01$). Therefore, Hypothesis 2 is supported.

Testing Hypothesis 3, taking a selfie (*M*=3.100, *SD*=0.712) caused fewer violations than calling (*M*=3.200, *SD*=0.714) and texting (*M*=6.267, *SD*=0.922). In the post hoc comparisons, the difference between taking a selfie and texting is statistically significant ($p<0.01$) but not between taking a selfie and calling ($p>0.05$). This result partially supports Hypothesis 3, predicting that taking a selfie imposes more distractions than calling, but less than texting. Lastly, although subjects committed more violations when they were calling (*M*=3.200, *SD*=0.714) than when they had no mobile distraction (*M*=2.033, *SD*=0.357), the difference was not statistically significant ($p>0.05$).

In addition, we tested the hypotheses based on the amount of fines in U.S. dollars caused by the violations. The Mauchly's test of sphericity for this analysis indicated no violation of sphericity ($p = 0.524$). The main effect of different mobile distractions was significant ($F_{4,\ 15.389} = 15.389$, $p < 0.001$, $\eta^2=0.355$). Figure 3 presents the means for the amount across the five tasks.

Figure 3. Means for Amount of Fine



The amount of the fines caused by using Snapchat (*M*=1440.600, *SD*=2347.541) is the largest followed by texting (*M*=1227.133, *SD*=181.990), taking selfie (*M*=669.533, *SD*=151.610), calling (*M*=638.467, *SD*=158.500), and no distraction (*M*=433.933, *SD*=75.782).

Although there are differences across the five task sessions, some differences were not found to be statistically significant. For instance, using Snapchat and texting imposed statistically more distractions than calling and taking a selfie in terms of the fine amounts. However, the difference between calling and taking a selfie was not statistically significant in the post hoc comparisons ($p>0.05$). In addition, the amount of the fine caused by calling and taking a selfie was not statistically higher than driving without a mobile distraction ($p>0.05$). Table 2 summarizes the hypothesis test result.

Table 2. Hypothesis Test Result

Hypo.	Prediction	Result
H1	Snapchatting while driving is more dangerous than other mobile phone activities while driving.	**Partially Supported**
H2	Texting while driving is more dangerous than calling while driving.	**Supported**
H3	Taking selfie while driving is more dangerous than calling but less than texting while driving.	**Partially Supported**
H4	Calling while driving is more dangerous than driving with no distractions.	**Not Supported**

5. DISCUSSION AND CONCLUSION

This study investigated the impact of various mobile distractions on driving performance and safe driving adopting the multitasking theory and a driving simulator. Particularly, it examined the mobile distractions that prior studies had barely considered, such as Snapchatting and taking selfies, which have become a popular activity.

Concerning the impact of using Snapchat while driving, we found that it imposes more dangers (i.e., more violations and fines) than the other distractions. Although the difference from texting is not statistically significant, the actual number of violations and the dollar amount of the fines are higher than any other distractions in the experiment. As previously noted, texting is a highly dangerous mobile distraction. Although texting caused fewer violations (*M*=6.267) than Snapchatting (*M*=7.5), the difference between the two is not statistically significant. This implies that texting is a highly distractive, dangerous action compared to the other mobile distractions. In the post-interview, most subjects mentioned that typing in both texting and Snapchatting was the most difficult and distractive to their driving because it requires them to hold, look at, and type on their mobile phone. Accordingly, texting is found to be more dangerous than calling while driving, corresponding to the extant literature (Nelson et al., 2009; Owens et al., 2011).

The experiment result concerning the impact of taking a selfie is mixed in the comparisons using the number of violations and the amount of fines. Although the subjects committed slightly fewer violations (*M*=3.1) than calling (*M*=3.2), the amount of the fines were higher (*M*=669.533) than calling (*M*=638.467). This indicates that taking a selfie causes serious violations such as crossing over into other driver's lanes. However, taking a selfie is less distractive than both texting and Snapchatting.

Although the subjects committed more violations when they were calling (*M*=3.2) than no distraction (*M*=2.033), the difference was not statistically significant in the post hoc comparisons (p>0.05). This does not correspond to the extant literature (Collet et al., 2010; Tison et al., 2011; K. M. White et al., 2010; M. P. White et al., 2004). One of the possible explanations for this unexpected finding is that the subjects are young, who are somewhat proficient in completing simple multitasking activities (Willingham, 2010). Compared to other mobile phone activities, such as texting and Snapchatting, calling is substantially simple; once clicking an icon on the screen, they can perform the task without additional distractions. In the post interview, most subjects stated that it was easy to talk on their phones during the experiment because they have more experience with calling than other mobile phone activities while driving. This is supported by the finding of Gugerty (2011), reporting that the performance of conducting dual tasks may be increased with proper training and experience. Another explanation can be that the driving environment was that of a highway with controlled entrances, and thus relatively simpler than a busy downtown area or city where many other vehicles such as buses and taxis would have been involved. A statistically significant difference may have been found if there were more external factors that the subjects had to pay attention to, such as traffic signals, signs, and other vehicles entry and exit points.

6. LIMITATIONS AND FUTURE RESEARCH

This study has several limitations, mainly concerned with research design and subjects used in the experiment. First, although this is one of the first attempts to examine the impact of mobile distractions using a driving simulator, which can provide more realistic results than a survey instrument, it is different from a real driving situation. As some subjects indicated, for example, the driving wheel of the simulator was smaller and thus, more sensitive than a real driving wheel. In the future, researchers who investigate this issue may consider preparing a more realistic driving simulator with advanced technologies (e.g. virtual reality).

Second, the subjects did not include a diverse group in terms of their demographics. Some unexpected findings (e.g., no significant difference between calling and no distraction) may be derived from the characteristics of the subjects who are highly young and proficient at multitasking. Future studies may investigate diverse groups in the area of demographics in order to compare how mobile distractions are affected by age and other demographic factors.

Lastly, future studies may consider additional mobile distractions, such as emailing and web browsing that drivers frequently conduct while driving. Although this study considered novel distractions that extant literature did not consider (e.g., Snapchatting and selfie), there are more mobile phone activities that might be considered. According to a survey conducted by AT&T (2015), for instance, 33% and 28% of drivers respectively have used email and web browser while driving. The comparisons among various mobile distractions would extend the spectrum of multitasking theory and the understanding of the distractions while driving.

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Changes in the Information Technology Field: A Survey of Current Technologies and Future Importance

Jeffrey Cummings
cummingsj@uncw.edu

Thomas Janicki
janickit@uncw.edu

Management Information Systems
University of North Carolina Wilmington
North Carolina NC 28403

Abstract

The constantly changing nature of the information technology field can make it challenging for professionals to remain current. This study attempts to address this issue by analyzing the importance of current technologies across organizations as well as anticipated change going forward. A survey designed with a panel of information technology professionals was distributed to evaluate technologies in the areas of database, programming languages, networking/communication, cloud computing and operating systems. The results from the survey are then compared to prior studies evaluating the same areas from the past 15 years (surveys from 2003, 2008 and 2013). Results suggest a move toward more open source technologies, virtualization and cloud computing.

Keywords: IT Skills, IT Technologies

1. INTRODUCTION

Information Technology (IT) professionals continue to be in high demand. According to the United States Bureau of Labor Statistics (2018), computer and technology jobs are expected to grow by 13 percent between 2016 and 2026. This is higher than the average of all occupations. Specific job categories reported by the Bureau of Labor Statistics indicate a variety of occupations continue to be in high demand. These include Information Security Analyst (+28%), Software Developers (+22%) Web Developers (+15%) Data Base Analyst (+11%) and System Analyst (+9%). In addition to the specific job categories the specific knowledge sets within and between the categories continue to grow.

The challenge we face as IT professionals is the field is constantly changing and we are required to stay relevant. Research has examined the skills needed for both graduating students and IT professionals in the past. The research presented in this paper focuses on the latter to understand how professionals can stay abreast on the common technologies and software currently being used in organizations. This study examines a breadth of topics including specific applications/programming languages being used (e.g., MySQL, C#, Python, etc.) to general technologies and topics important to organizations today (e.g., virtualization, data analytics, cloud services, etc.).

The current study expands on previous research conducted to assess organization needs over the past 15 years (Janicki et al., 2004; Janicki et al. 2009, Cummings, et. al., 2014). The goal of the current study is to evaluate the current changes in technologies and skills needed by IT professionals. Additionally, as this is an extension of prior research, the study aims to show trends in organizational needs

2. LITERATURE REVIEW

There has been a variety of approaches taken to understand the shifting technology needs within the IT industry. Burns et. al, (2018) approached this challenge by reviewing the technology related job placement listings on the internet over a four month period. Their findings indicated that potential employers are very interested in 'soft skills' such as communications and teamwork as well as specific technical skills. On a similar basis, Sala (2011) examined the technology needs through the lens of IT recruiters. Sala's results indicate a strong need for programmers/developers, project managers and help desk support. Gallaher, et. al (2011) also reported on IT recruiters and their perspectives of IT.

Likewise the research by Aasheim et. al (2009) also indicated that soft skills were desired by IT executives for entry-level IT professionals. Their research was based on a survey of IT managers and workers across the United States. Interesting although they desired soft skills as well as technical skills, they indicated that knowledge of primary business functions (accounting, finance, etc.) was less important.

Mills et. al. (2016) approached their research of employer needs by looking at the course offerings in the technology areas by AACSB schools. They were specifically interested in looking at the changing environment for big data, visualization and business data analytics. Thus, their research builds on the perceived newer technology needs that are being taught at AACSB schools.

Other approaches have included surveying recent graduates was a technique employed by Legier et. al (2013) and Dillion and Kruke (2008). Legier et. al (2013) reported on jobs of their graduates which included end user support, management of computer systems and software development. Alternatively, the research by Dillion and Kurke (2008) took the approach of matching graduates with the AIS (Accounting Information Systems) model curriculum. Another approach was to focus on recent alumni (Auken et al. 2011). While these approaches are useful, there are still gaps in the evaluation of experienced practitioners concerning current and anticipated skills needed.

The goal of this research was to survey a wide range of IT professionals with varying levels of experience and identify their current and future technology skills and knowledge required for success in the IT field. This paper extends the survey by Janicki et al. (2004; 2009) and Cummings et al. (2014) which longitudinally assessed the changing needs of the IT community. In more detail, we consider the current technology needs in the areas of databases, programming languages, networking, and operating systems platforms, as well as the anticipated changes in the near future. Finally, we evaluate how these needs have changed compared to the previous studies in 2003, 2008, and 2013. As an interesting sideline, our original research included mobile operating systems like "Palm Pilot" which was originally believed to have continued importance with respondents never anticipating the iPhone operating systems to be developed shortly after our 2013 survey. Needless to say, the technologies surveyed have changed over the past 15 years.

3. METHODOLOGY

Similar to prior studies (Janicki et al., 2004; Janicki et al. 2009 Cummings, et. al., 2014), the survey was developed over a four phase process represented by Figure 1.

Phase I
During this phase, a roundtable discussion was conducted with a corporate advisory board at the university. The advisory board consists of 25 members that represent regional and national organizations of varying sizes (10 employees to over 1000 employees). These members are primarily employees from their respective organization's IT department and interact with many of the technologies included in the survey. The respondents are not entry-level employees but more IT managers who manage and hire entry-level IT professionals. The roundtable goals were to understand what areas were important to IT professionals while identifying major technology areas. Faculty from the Information Systems and Information Technology department

at a large, regional university lead the roundtable discussions.

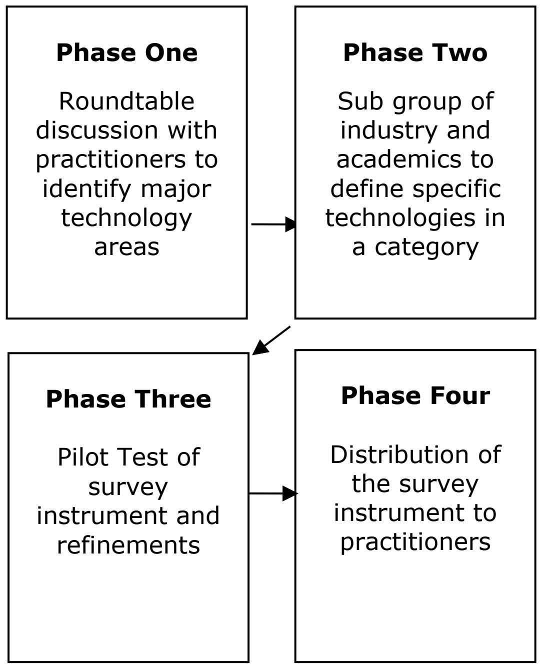

Figure 1: Survey Methodologies Stages

During the first roundtable discussions, a faculty representative worked with advisory board members to identify major trends or changes in technology in their respective fields. Following this discussion, the group walked through previous surveys from the prior studies to evaluate relevancy in the current market as well as expanding in areas not covered in previous studies. The first roundtable discussion resulted in the following categories for technological areas:

- Operating Systems Platforms
- Networking/Communication (Both Software/Hardware)
- Databases
- Development Languages
- Cloud Platforms

Based on these categories, a second roundtable discussion was conducted during phase II.

Phase II

During this phase, the broad categories from Phase I were evaluated to develop sub-categories of the technological areas. This discussion occurred during the following advisory board meeting after researchers made adjustments based upon the results from Phase I. In this phase, specific technologies (including brand names) were identified within each category. The groups went through several iterations and 'pilot testing' with other industry professionals, to ensure all possible sub-categories were captured and there was consistency across areas. The final list of technologies/software was chosen by IT professionals based on their direct experience and thoughts as well as ongoing importance.

For example, professionals evaluated the networking category and specific technologies and brands were included as a subcategory. These included:

- Cisco
- Linux/Unix Family
- Virtualization
- VOIP
- Windows

The remainder of the survey was also developed in this phase. Since the target audience is industry professionals, questions centered on whether the technology is currently being used and what the future importance of the technology is. Due to the evolving nature of the IT field, the sub group of academics and industry professionals decided to only focus on a two-year time horizon. The industry professionals felt the scale needed to be adjusted to combine extremely important and more important into one measure. This resulted in a change from the original surveys (which was on a 5 point scale) to a 4 point scale of Important to Not at All (see scale in Table 1 below).

Expected importance to your job in two years
Not at All
Less Important
Same
More Important

Table 1: **Expected Importance Scale of Particular Technologies in two years**

This scale was used across all categories except for the "Development Languages" category. For this category, the scale used was "level of knowledge desired" to capture the current needs of the employer. After the sub category selection was complete, the survey instrument was finalized and included general questions such as company size, organization type, employee functional area and general demographics (age, gender, location, company size, industry, job title).

Phase III
A pilot test was conducted to ensure that the survey questions were clear to participants and that the average completion time was 10 minutes or less. A preliminary survey request was emailed to industry professionals, which directed them to complete the online survey. Twenty-six completed the survey during the pilot test.

The average completion time was below 10 minutes and based upon feedback, minor changes were made to the survey instrument and it was deemed ready for distribution.

Phase IV
The last phase included sending the survey to over 2500 IT professionals throughout the US. The survey was distributed to a list of IT managers and above by a professional marketing firm. The survey targeted individuals currently in an IS/IT field. The survey pool consisted of only those directly working with the technologies while supervisors/managers were excluded from the pool. A total of 54 professionals completed the survey.

4. SUMMARY STATISTICS

Individuals from a variety of organizational roles participated in the survey (see Table 2).

Organizational Role	%
Business/Systems Analysis	16.5%
Networks/Security	16.5%
Software Development	15%
Project Management	6%
Database Admin/Analyst	5%
Data Analyst	5%
IT Strategy	2%
Management	2%
Other IT	32%

Table 2: Organizational Role

Demographics
30% of participants were female and 70% were male. This is an increase of 10% in females participating compared to the 2013 survey. Participants had a variety of educational backgrounds with 12% holding Bachelors of Science and 40% with a Master's in a technology related degree. This is also an increase of over 20% of the respondents with Master Degrees when compared to the 2013 survey. The survey was also completed by those without a technical degree with 14% with a BS and 14% with a master's degree. The remaining respondents held either an Associate or High School Degree. Across all participants, the average tenure within the field was 6 years and employees were at the current employer for 4.5 years.

Participants from a variety of organization types and sizes completed the survey. Over half of the participants came from organizations larger than 1000 employees and a majority identified their organization as being a Corporation. Tables 3 & 4 detail the size and type of the respondent's organization.

Number of Employees	%
<11	4%
11-100	21%
101-499	23%
500-999	11%
1000-9999	26%
10000+	9%

Table 3: Size of the organizations

Organization Type	%
Corporation	41%
LLC	28%
Education	11%
Healthcare	9%
Government	7%
Non or Not for Profit	4%

Table 4: Organization Type

5. RESULTS

In the subsequent sections, the averages across the various categories are evaluated to understand the future importance.

5.1 Operating Systems Platform Expectations
As in the past surveys, expectations of five different OS Platform (including Mobile Platforms) were surveyed to understand their importance over the next 2 years.

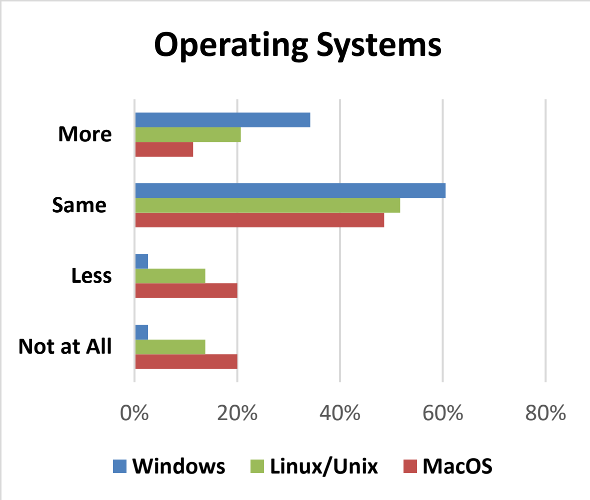

Figure 2: Expected Importance of Windows Platforms

As with previous surveys, the Windows platform was rated as the highest importance followed by Linux/Unix. MacOS still trails rated with the third highest importance in operating systems (see Figure 2).

Mobile operating systems were also evaluated. iOS appears to have a greater importance compared to Android. However, both rated high with the importance over the next 2 years staying the same or increasing for both iOS and Android at 90% and 67%, respectively. The lower importance of Android may be due to the participants in the study stating they more frequently use iOS compared to Android. Figure 3 shows the results for mobile operating systems.

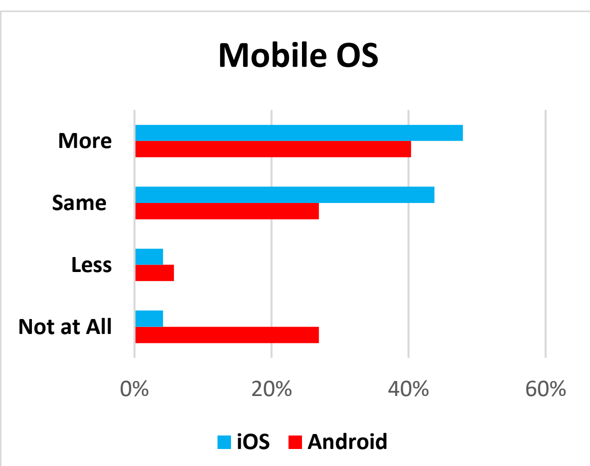

Figure 3: Expected Importance of Android & iOS Platforms

5.2 Networking/Communication

With the Networking and Communication category, the survey captured both software and hardware. For example, software technologies such as Windows Networking were included as well as hardware products like Cisco Technologies. The goal of doing so was to understand if there are benefits of certifications in a particular technology.

Windows networking continues to be important in this category with 88% stating the importance going forward will remain the same or increase (see Figure 4). However, virtualization had the highest rating of increased importance at over 40%, showing a potential need for professionals with virtualization experience going forward. For a comparison of all the technology in this category, see Figure 4.

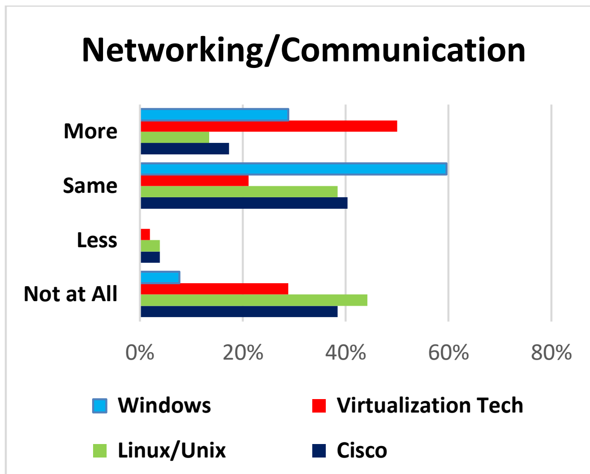

Figure 4: Expected Importance of Networking/Communication Software

5.3 Databases

The number of respondents for the database category were reduced to 38, as many of the respondents did not work with database technologies. Thus, the respondents that were excluded did not have experience with databases and could not judge their importance going forward.

For the remaining participants, MS SQL was rated the highest database platform having the highest importance moving forward with 74% stating the importance will either remain the same or increase in the next two years. MySQL followed this closely at 61% while Oracle and DB2 decreased in importance form previous studies (see comparison in the next section) (see Figure 5 for the MS SQL and MySQL results).

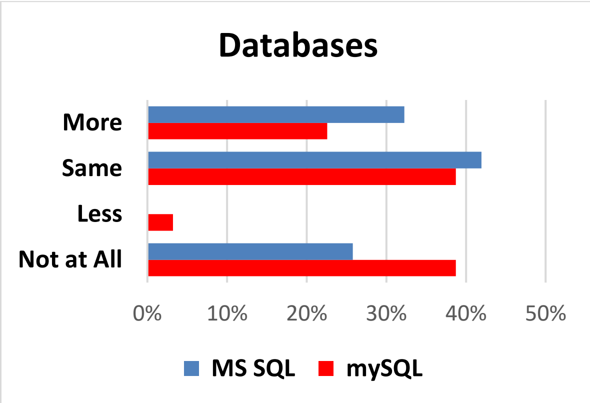

Figure 5: Expected Importance of MS SQL and MySQL Server

5.4 Cloud Platform

In the previous study (Cummings et. al, 2014), cloud platform technologies were introduced into the survey. The survey again asked the importance to understanding cloud technologies moving forward. The results (see Figure 6) suggest mixed results for the importance of cloud technologies in the next couple of years. While slightly over 50% of respondents feel AWS and Azure importance will remain the same or greater in the next two years, the results suggest Google Cloud and Salesforce will be less important moving forward. The results from the current study and the prior study will be compared and discussed further in the subsequent sections.

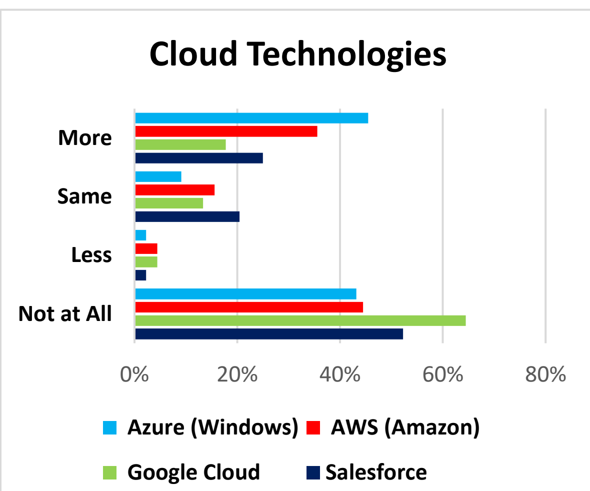

Figure 6: Cloud Platform Rankings of Importance

5.5 Development Languages

Development languages were evaluated differently from the previous categories. Participants were asked to rate the level of knowledge needed across 13 different programming languages. The scale included no experience (rating 1), fundamental (rating 2), working (rating 3) and expert (rating 4). Results are included in Table 5 below:

Rank	Product	Rating
1	JavaScript	2.41
2	HTML 5	2.29
3	CSS 3	2.18
4	C#	2.00
5	XML	2.00
6	jQuery	1.82
7	ASP.NET MVC	1.76
8	PHP	1.65
9	Java	1.59
10	ASP.NET	1.59
11	C++	1.41
12	Python	1.35
13	JSP	1.18

Table 5: Development Language Level of Knowledge Importance

The results suggest professionals should not have expert knowledge in one specific language. However, web development languages appeared to be important as participants suggested a fundamental to working knowledge in JavaScript, HTML4 and CSS3. It should be noted that many of languages were rated closely.

6. COMPARISON TO PRIOR SURVEYS

This research parallels prior surveys of IT workers conducted in 2013, 2008 and 2003. The prior surveys were similar to the current with slight adjustments. These included changing the scale by removing "extremely important" and only have "more important" based on feedback from the panel. Additionally, technologies were added as well per advisory board suggestions.

The subsequent sections compare the changes to levels of importance across the previous surveys. All tables display the importance ranking which was calculated as follows: 5 for extremely important, 4 for more important, 3 for same importance, 2 for less important and 1 for not at all. Since the scale for the current study was changed to 4 points (i.e., extremely important was removed), the importance rankings for 2018 have been adjusted to be representative of a 5-

point scale for comparison reasons. Additionally, programming languages is excluded because of the question changes to this technology area. (Note, a '--' in the tables below indicates any products that were not surveyed in the respective year.)

6.1 Operating System Platforms
There was an increase in importance across all operating systems platforms compared to 2013. Interestingly, the largest increase was from the iOS platform suggesting the continued importance of mobile platforms. In fact, iOS and Windows had equivalent scores of importance this year for the first time. Another significant finding was the increased importance of Linux/Unix, which had the second largest increase behind iOS. This increase may be from a variety of reasons from the open source nature of Linux to it use on various hardware devices. Further research is needed to understand the exact reasons behind these increases.

Product	2018	2013	2008	2003
Windows	4.1	3.8	3.9	3.9
iOS	4.2	3.1	--	--
Android	3.5	3.1	--	--
Linux/Unix	3.6	2.9	2.6	2.9
Mac OS	3.2	2.6	1.5	--

Table 6: Operating Platforms Rankings of Importance

6.2 Networking & Communications
An interesting finding in this category was the only product appearing to increase in importance from the prior study was Windows (see Table 7 for details). Virtualization fell slightly in importance from previous years but remains important to organizations moving forward. Linux/Unix remained the same from the previous study. Surprisingly, Cisco products appeared to fall the most from 2013. This may be from the availability/popularity of other networking technologies available or participants this year may not use these technologies in their existing position. Further analysis of the data confirmed that survey respondent this year did not currently use Cisco technologies in their organization, which may explain the drop in importance. VOIP dropped slightly from the previous study.

Product	2018	2013	2008	2003
Windows	3.9	3.7	3.5	3.9
Virtualization	3.6	3.7	--	--
VOIP	3.2	3.4	--	--
Cisco	3.0	3.2	2.4	3.9
Linux/Unix	2.8	2.8	2.3	2.9

Table 7: Networking/Communication - Rankings of Importance

6.3 Databases
Within database products, both MS SQL Server and PostgreSQL increased from previous years. The increase in PostgreSQL and the consistent importance of MySQL suggest the increase popularity of open source within organizations (which may also be the reason for the results concerning Linux). DB-Engine (https://db-engines.com/en/) is an online resource ranking database products by popularity, jobs available, number of technical discussions, etc. This site found an increased popularity of PostgreSQL, doubling in popularity from 2013 to 2018. Other products remained consistent from previous studies.

Product	2018	2013	2008	2003
MS SQL Server	3.6	3.3	3.0	3.6
MySQL	3.2	3.3	2.1	2.1
Oracle	2.8	2.8	2.7	2.9
IBM DB2	2.2	2.2	1.8	1.6
PostgreSQL	2.6	2.1	1.6	1.6

Table 8: Database Rankings of Importance

6.4 Cloud Technologies
Cloud technologies were originally introduced to the survey in 2013 which now gives us the opportunity to analyze the change in importance over the past 5 years (see Table 9). There appears to be a shifting importance from Google to AWS and Azure compared to the previous survey. Salesforce also appears to be gaining importance since the 2013 survey.

Product	2018	2013
AWS	3.2	2.6
Azure	3.3	2.6
Google	2.4	2.9
Salesforce	2.8	2.2

Table 9: Cloud Rankings of Importance

7. CONCLUSIONS

Technologies and their importance in the field continually change and IT professionals must stay abreast to this changing world to remain competitive. Much like prior studies, the current results suggest the importance of Microsoft products remains across many of the categories analyzed. However, increased importance in PostgreSQL and consistent importance in Linux suggest that open source technologies are gaining importance.

Under operating systems, mobile continues to increase with importance. iOS had significant gains in importance with participants suggests that iOS importance will remain the same or increase in the next 2 years. We also see the importance of Virtualization remaining consistent (with a slight decrease) as well as Windows in the Networking and Communication category.

The results from programming languages remained similar to the prior survey that showed an increased importance of web based technologies. However, the top programming languages did change. The 2013 survey had ASP.Net, PHP and C# as the top programming language professionals should have a fundamental knowledge in. The current suggests more general knowledge in web programming is important. This is reflected in the top languages being JavaScript, HTML5 and CSS3.

Finally, we were able to compare cloud computing to the prior survey to understand any differences in importance from 5 years ago. As previously mentioned, there appears to be a shift in importance toward AWS and Azure when compared to Google.

8. FUTURE RESEARCH AND REMARKS

Future research includes adapting the current survey as technologies change. While we tried to capture as many different technologies, we are still limited on number of technologies surveyed. We focused on the suggestions of the advisory board to the technologies they felt were significant in the future expanding the technologies surveyed and including additional employers.

There were some limitations to the current study worth noting. Compared to previous studies, we approached this study by reaching out beyond the east coast for participants. However, many of the participants came from eastern US. In subsequent studies, we will continue to strive for a broader set of participants. Another limitation concerns the categories chosen to evaluate. While there are numerous emerging technologies, we limited the technologies in the survey to those identified by the advisory board. As data analytics continues to gain importance, future studies will examine the importance of these technologies moving forward.

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