

Summer 8-12-2014

# Genres of Inquiry in Design Science Research: Applying Search Conference to Contemporary Information Systems Security Theory

Mala Kaul

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**GENRES OF INQUIRY IN DESIGN-SCIENCE RESEARCH: APPLYING SEARCH CONFERENCE TO  
CONTEMPORARY INFORMATION SYSTEMS SECURITY THEORY**

BY

MALA KAUL

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree

Of

Doctor of Philosophy

In the Robinson College of Business

Of

Georgia State University

GEORGIA STATE UNIVERSITY  
ROBINSON COLLEGE OF BUSINESS  
2014

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## ACCEPTANCE

This dissertation was prepared under the direction of the MALA KAUL Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctoral of Philosophy in Business Administration in the J. Mack Robinson College of Business of Georgia State University.

Richard Phillips, Dean

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## ABSTRACT

# **Genres of Inquiry in Design-Science Research: Applying Search Conference to Contemporary Information Systems Security Theory**

BY

Mala Kaul

August 2014

Committee Chair: Dr. Richard Baskerville

Major Academic Unit: Computer Information Systems

This dissertation investigates the core subject of knowledge in design-science research (DSR). In contrast to natural and social sciences that are more explanatory in nature, design-science research is concerned with solving complex practical problems that are ill-defined or of a “wicked” nature. At the same time, as in any research activity, design-science research is also concerned with the production of knowledge. In the process of design-science research, the researcher must act as both designer and scientist. Design knowledge is distinct from scientific knowledge, however, and must be evaluated against a different set of criteria. Since the DSR process is iterative the scope of DSR knowledge can evolve, abstracting general (nomothetic) knowledge from situated (idiographic) artifacts or, alternately, applying abstract knowledge to situated settings. General knowledge is different from situated knowledge and must be evaluated accordingly.

In the current design-science literature, situated (idiographic) knowledge is associated with design, and abstract (nomothetic) knowledge is associated with science. This dissertation proposes that design can be abstract and that science can be situated in scope. The purpose of the dissertation is to identify the problems with the current conceptualization of contributions in DSR, offer an alternative view of the design-science paradigm as one having multiple genres of inquiry, provide the criteria for framing and evaluating design-science contributions, and describe how this will help address some of the current debate and clarify the current discourse.

The dissertation is structured in three parts. Part I employs a theoretical argument to develop a framework for these genres of inquiry in design-science research and demonstrates how the evaluation criteria for design-science research studies change as the research moves from one genre to another. Part II is an empirical study that uses a search conference method to apply the bindpoint model (Baskerville and Lee 2013), an explanatory design theory to the problem of information security risk resulting from consumerization and BYOD (bring your own device). Part III reflects on the learning from the theoretical and the practical discourse and provides the contributions and opportunities for future research.

This dissertation contributes to the design-science field by providing a more nuanced understanding of the contributions and evaluation criteria of design-science research. It contributes to the Information Systems (IS) security field by providing a design theory for managing BYOD security. Lastly, it contributes to Information Systems research methods by introducing the search conference method as a viable approach for theorizing and for evaluating design-science contributions.

## ACKNOWLEDGEMENTS

I would like thank Dr. Lars Mathiassen, Dr. Veda Storey and Dr. Merrill Warkentin for serving on my committee and for always being there to help and guide me. I am extremely grateful for the time that they so generously made for me. Their insightful advice and encouraging feedback were crucial in helping me develop and complete this dissertation. From them I have learned the art and science of scholarship.

I would especially like to extend a heartfelt thank you to my advisor Dr. Baskerville who made this a thought-provoking and rewarding experience. He spent countless hours guiding and advising me and also sharing his keen insights. It was inspiring to watch him “think” and “synthesize” and I greatly appreciate how he nurtured my interest in conceptual work. He was always available to share his advice, even when he was in different parts of the world or sitting at an airport. I would like to thank him for all that he has done for me these past four years. I am so fortunate to have had the opportunity to learn so much from him. His guidance and support were invaluable in my scholarly journey.

I would like to thank the entire faculty in CIS and CEPRIN. I have been so fortunate to learn so much from each one of you. Thank you to Dr. Ramesh for always being there to provide advice and to Dr. Stucke who always had a cheerful smile and a solution to every problem. I reserve a special thank you for Dr. Veda Storey for being not only my committee member but also my colleague, mentor, and friend. To my friends and PhD colleagues, I extend a big thank you for your help and support through these years.

I could not have done this without the support of my family and deeply value their support and patience. A special thank you to my husband Sandeep who provided the encouragement to get me started and has kept me motivated to seeing this through. The biggest thank you goes to my son Raghav and daughter Ragya, for always supporting me and for cheering me on with “You can do it, Mom!” even when I could not give them much of my time. Finally to my parents Indira and Jagat Bamroo, thank you for believing in me through the years. Your love and blessings have played an integral role in this process.



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## 1 INTRODUCTION AND OVERVIEW

Design-science research is increasingly being acknowledged as an important research paradigm in Information Systems research. This recognition is supported by significant efforts to establish the methodological and theoretical grounding for the appropriate conduct and articulation of such research. However, despite these efforts, there is still limited consensus on what constitutes a good contribution in design-science research. The realm of design focuses on the artifact as the contribution, whereas the realm of science favors design theory. Current design-science thinking assigns primacy to either the artifact or to theory, to design or to science. Knowledge is marginalized in this presentation. This dissertation offers an alternate viewpoint by focusing on the primacy of the knowledge contribution of design-science research. The purpose of the dissertation is to show how the contribution of design-science research is clarified by centering on knowledge.

This dissertation shows that different forms of knowledge emerge throughout the life cycle of a design-science project and derive a framework that describes the characteristics of these different types of knowledge that are the output of design-science studies. These different kinds of knowledge accompany different goals and boundaries and must therefore be evaluated according to different criteria. Therefore, the dissertation also develops evaluation criteria to address the different viewpoints on knowledge contributions of design-science research. By offering a pluralistic framework for approaching the conduct, articulation, and evaluation of design-science research studies, the dissertation shows that several advantages would accrue.

Section 1.1, “Theoretical Discourse,” provides the motivation and rationale for employing this pluralistic view of design-science research in order to better position and evaluate such research efforts. Based on this motivation, the overall research objective is described. Section 1.2, “Practical Discourse,” provides a description of the business problem. Section 1.3 provides a structure of the dissertation and, finally, Section 1.4 provides a summary of the key contributions and why they are important.

## **1.1 Theoretical Discourse**

Design-science research is an approach for conducting research in Information Systems. Over the past few years, the focus in IS moved from its technological origins in information technology (IT) to the managerial and social aspects that recognized a more systemic view. Coinciding with the call to return to the IT artifact (Orlikowski and Iacono 2001) and the call for professional relevance of IS research (Benbasat and Zmud 2003; Hirschheim and Klein 2003), there has been momentum in IS research toward recognizing and formalizing design-science research as an alternative to behavioral or social science research (Hevner and Chatterjee 2010; Vaishnavi and Kuechler 2004). Significant efforts have been made to establish the foundations of design-science as a research paradigm (Hovorka 2010; Iivari 2007) and to clarify its epistemological positioning (Goldkuhl 2012; Gregor and Hevner 2011; Niehaves et al. 2012). There has also been much scholarly activity (and debate) around defining design-science research characteristics, design methodologies, design theorizing, proposing evaluation criteria (Hevner et al. 2004; Pries-Heje et al. 2008), and articulating its knowledge outcomes (Gregor and Hevner 2013; Vaishnavi and Kuechler 2007).



Despite these efforts in formalizing its epistemological and methodological base, design-science research has yet to make a substantial impact within IS research as attested by the limited number of publications in IS journals. As an example, “the total number of design-science publications in *MISQ* since 2006 accounts for less than 5 percent of the total publications in the journal” (Goes 2014, p. iv). Gregor et al. (2013) contend that “[d]esign-science research has yet to attain its full potential impact on the development and use of Information Systems due to gaps in the understanding and application of design-science research concepts and methods” (p. 337). As publication rates edge up cautiously, design-science scholars continue to discuss the lack of clarity around what constitutes a good design-science research contribution. The design view favors the development of an artifact, while the science view favors the development of abstract knowledge. Gregor and Hevner (2013) refer to the design-theory camp (Gregor and Jones 2007; Markus et al. 2002; Walls et al. 1992; Walls et al. 2004) and the pragmatic-design camp (Hevner et al. 2004; March and Smith 1995; Nunamaker Jr and Chen 1990), with the two camps placing comparatively more emphasis on design theory or artifacts, respectively, as research contributions.

The tension between design and science within this paradigm is most apparent in efforts to articulate and analyze the role of theory and its use and development throughout the various stages of design-science research studies (e.g., Goldkuhl 2004; Gregor and Jones 2007; Pries-Heje et al. 2008; Vaishnavi and Kuechler Jr 2007; Walls et al. 1992). Much debate remains around whether, in addition to artifacts, a theoretical contribution is central to, or even necessary, in design-science research studies (e.g., Baskerville et al. 2010; Gregor and Hevner 2013; Österle et al. 2010). Echoing the supposed contradiction between design and science, this debate distinguishes between the research contributions demonstrated by the utility and elegance of the

design solution as presented by the artifact and the contrasting creation of abstract knowledge (Goldkuhl 2012; Gregor and Hevner 2013).

Design-science research has a dual mandate – the utilization and application of knowledge (and theory) for the creation of novel or innovative artifacts that engender change or improvement in existing situations or problem spaces and the generation of new knowledge. This is accomplished by the ability of design-science research to produce knowledge and change (Simon 1996). The process of design-science research is iterative and incremental. Therefore, knowledge production and artifact generation, while concomitant, may not necessarily be synchronous. Knowledge building may occur through reuse of past artifacts, creation of new ones, reflection about the design process or about the artifact, or even in design instruction (Cross 1982), thus resulting in different types of knowledge creation. The concept of reflection has been articulated by Schön (1983) and Mathiassen (1998). In design-science research, such knowledge-in-action emerges through the study of designs and design processes (Mathiassen and Puroo 2002; Puroo et al. 2008). The artifacts generated can take several forms, such as constructs, models, methods and instantiations (March and Smith 1995), technological rules, design principles (Markus et al. 2002; Sein et al. 2011), and design theories (Gregor and Jones 2007; Walls et al. 1992).

The differing positions in design-science research arise for a number of reasons. First, there is a difference in the goals of design versus the goals of science (Gregor and Hevner 2013). Design is generally associated with the construction or instantiation of an artifact or more specific/idiographic knowledge, while science is usually associated with the theoretical aspect of the research or the more generalizable/nomothetic form of knowledge. Second, design is generally associated with pragmatic knowledge, while science carries the notion of rigor. Third,

the term *design* can be used either as a noun, indicating an artifact or product view, or as a verb, indicating more of a process view. Therefore, deriving an understanding from a design-science study will be based on what the knowledge is, that is, what is being acquired – is it knowledge represented by the artifact, does it pertain to learning from the process of designing the artifact, or does the knowledge relate to how the artifact interacts with the environment that it is placed in? This ambiguity is compounded by the complex and iterative nature of the design process. Moreover, since design-science is a research lens and not a specific method, the inquiry process could have a number of different entry points into research and follow a number of potentially different paths (Peppers et al. 2007).

The differences between the goals of design and science are expressed in terms of *utility* and *truth*. For example, *design* centers on the creative and experiential knowledge of the designer, the key to which is *utility*, whereas *science* centers on efforts to produce rigorous, justifiable knowledge, the key to which is *truth*. The focus of design uses knowledge to create a new world, whereas the focus of science is to study the world to create new knowledge (Verkerke et al. 2013). Such apparent contradictions seem to shape the essence of this newer research paradigm, developing research that makes meaningful design *and* science contributions in a way that is beyond just the “science of design” or “designing with science.” It involves creating knowledge through the analysis of a given design problem, synthesis of solutions based on this analysis, and evaluation of the solution.

While the design of novel artifacts is considered more valuable by some (Hevner et al. 2004; March and Smith 1995), for others, science is more important because it yields valuable theories (Gregor and Jones 2007; Walls et al. 1992). There is yet another viewpoint (that of Goldkuhl 2004; Venable 2006) that lies between these two extremes, one that recognizes the

importance of design theories but does not insist on a kernel theory-based grounding of design theories (Fischer et al. 2010). In analyzing the respective contributions valued by the design-oriented view and the science-oriented view, it would appear that the more abstract the form of knowledge contribution, the more scientific it is considered, while the more specific the knowledge contributions, the more it corresponds to the design view. Yet, design is inherently abstract, although it is true that a particular instantiation of a design may be very specific. Similarly, scientific knowledge can be more or less abstract. Both perspectives in this lingering dispute assume that one of these definitive views of a design-science research paradigm will prevail.

There is a general association of design with relevance and science with rigor. In the design-science research literature, design is generally associated with the building and evaluation of the artifacts that provide relevance, while science is generally associated with the theorizing aspects of design-science and reflective of rigor (Hevner 2007; Hevner et al. 2004). The tension between design and science becomes pronounced due to this dual nature of design-science research. Yet design, though inherently creative, can be conducted rigorously. Similar tensions between engineering design and a more creative user-centered design have been found in the human-computer interaction (HCI/CHI) community, where it has been demonstrated that creative design can be pursued rigorously (Wolf et al. 2006). Although design-science is used in fields such as education, human-computer interaction, and engineering design, the theoretical discussion in this dissertation is restricted to design-science research in Information Systems.

This research argues that seeking to resolve the design-science debate by giving primacy to any one aspect of design-science research, be it design or science, will not resolve the problem. Rather, the primacy of knowledge is crucial to resolving any debate, since design-

science research can result in building knowledge from the interaction of the design and science processes. Moreover, the focus on the knowledge process will also address a third form of tension in design-science research – the design product versus the design process debate. The focus on knowledge will yield clarity in terms of knowledge goals, since knowledge is inherent in the designed product, the design process, and in the critical reflection of the process of designing the product (artifact). For example, the product viewpoint sometimes conflates the artifact with design and the theory with science (Fischer et al. 2010). By focusing instead on the knowledge processes of design-science studies, the research shows how the artifact is intertwined with both science and design and how the theories are also intertwined with both design and science.

In order to address the above identified sources of tension in design-science research, this research advances an alternate viewpoint to the current conceptualization of design-science research. Design-science research is primarily a research lens, and the ultimate objective of research is knowledge. By unpacking the design aspect from the science aspect of design-science research, it is possible to find that design can be abstract or specific, and similarly, science can also be abstract or specific. Given the iterative nature of the design-science research process, it is possible that the research process at a particular moment can be more focused on the design process, and at another moment, it can be more focused on the science process; similarly, at one moment the research process could be focused on developing abstract knowledge, and at another moment, it could be developing more situated or specific knowledge. This conceptualization presents design-science research as a multifaceted paradigm in which the knowledge in artifacts and theories can develop and benefit from their dependence on each other. These moments of different types of research can be considered as genres or modes of inquiry.

## 1.2 Practical Discourse

In today's business environment, connectivity is a key commodity for all business people regardless of their level in the enterprise. In order to stay connected, many individuals use their own mobile devices such as phones, tablets, or laptops in business settings. This phenomenon, known as BYOD (bring your own device), has been aided by the increasing availability of high-performance devices, connectivity to the Internet, and productivity tools. BYOD has significant benefits for both individuals and their employers (Lee et al. 2013). Research from Dell estimates that BYOD can extend workplace flexibility and add as many as 460 productivity hours a year for each mobile employee by enabling ubiquitous access to the enterprise systems and data.<sup>1</sup> BYOD usage by employees varies from 40 percent to 75 percent, depending on the region and industry.<sup>2</sup> According to Washington-based market research firm Osterman Research, there are now nearly twice as many personally owned iPhones, iPads, and Android devices that are brought into the workplace by individuals than corporate-issued counterparts.<sup>3</sup>

Although BYOD is a widespread phenomenon, it has many associated risks. If the enterprise opens up its systems without due precautions, it becomes vulnerable to the risk of data loss and other exposures of its IT systems. Lost or stolen devices create a key concern for data security. Individuals and organizations are also concerned about the impact of BYOD on personal privacy and organizational confidentiality (Lee et al. 2013). This balance between security and privacy is a key challenge that needs to be addressed within the overall BYOD policy structure (Lee et al. 2013; Smith et al. 2011). Given the extent of the problem and its

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<sup>1</sup> <http://www.telegraph.co.uk/technology/mobile-phones/9646349/Smartphones-and-tablets-add-two-hours-to-the-working-day.html>, accessed August 7, 2014.

<sup>2</sup> Ibid.

<sup>3</sup> [http://docs.media.bitpipe.com/io\\_10x/io\\_106764/item\\_609873/The%20Need%20for%20IT%20to%20Get%20in%20Front%20of%20the%20BYOD%20Problem%20pdf.pdf](http://docs.media.bitpipe.com/io_10x/io_106764/item_609873/The%20Need%20for%20IT%20to%20Get%20in%20Front%20of%20the%20BYOD%20Problem%20pdf.pdf), accessed August 7, 2014.

rapidly advancing pace, it is essential that strong fundamental principles be developed for BYOD security management, since these are needed to provide a bedrock for the overall security policy and infrastructure of the organization.

This research aims to speak to this challenge by providing a basis for the overall security framework that will address the security challenges that organizations face due to complexities created by BYOD. In design-science research, the process of design theorizing involves mapping the design problem to one or more design solutions and arriving at an optimal solution to manage the problem. The research problem confronting us is the necessity to conduct design theorizing in the highly complex sociotechnical environment pertaining to BYOD. The specific objective of the design theorizing activity in this research is to address the organizational adaptation of its information infrastructure to be able to securely interact with individually provided Information Systems.

Generally, in organizational settings, security is implemented in the Information Systems by confining the behavior of the system using well-formed security controls that guide the functioning of the system in a predictable manner (Baskerville 1992). However, in the contemporary technological landscape, the environment is complex and fast changing. Therefore, there must be an alternate method to predictable security controls. A recent design theoretic explanation for addressing security in complex and dynamic environments provided by Baskerville and Lee (2013) proposes the use of a bindpoint model that computes the BYOD risk instead of using predictable security controls. Through an illustrative case, Baskerville and Lee suggest that this theory could be applied in a BYOD scenario. While this design theory provides a persuasive argument, testing it empirically will not only enable evaluation of the theory but also potentially guide a solution to a problem of a complex nature. Hanseth and Lyytinen (2010)

propose a design theory to address the dynamic complexity in shared, open, heterogeneous and evolving socio-technical systems of information infrastructures (IIs) and “illustrate their design principles by analyzing the history of Internet exegesis” (p. 1). Although this theory is promising due to its focus on the shared and evolving Information Systems, the theory has yet to be evaluated empirically to investigate whether it can be applied to the BYOD context. Using a design theorizing approach (Baskerville and Pries-Heje 2010; Walls et al. 1992), this research applies the bindpoint model and the infrastructural components of the complex adaptive system theory to derive design principles for the design of secure BYOD systems.

Current Organizational Information Systems interacting with individually furnished devices and systems are complex adaptive systems. The CAS theory (Hanseth and Lyytinen 2010; Holland 1995) provides a theoretical framing device (kernel theory), to apply (and develop) the bindpoint model (Baskerville and Lee 2013) for designing robust and secure information infrastructures that can address the security issues arising from BYOD. The CAS theory helps to apply adaptive thinking, while the bindpoint design theory helps to view each component (within an information infrastructure) in a simple way that interacts with another component within the larger information infrastructure.

In terms of the problem domain, the research scope is limited to extending a general-purpose solution to address the problem of BYOD security. Therefore, there is a certain level of abstraction to the design solution evaluated and refined in this dissertation. The practical discourse provides an evaluated general framework, a set of design principles, and accompanying rules for application in BYOD security settings. In this case, the term “general” is used in a definition similar to van Aken’s (2004) “technological rule,” which he defines as “a chunk of general knowledge linking an intervention or artefact with an expected outcome or



performance *in a certain field of application*” (p. 24). He adds that the term “general” “means that it is not a specific solution for a specific situation, but a general solution for a type of problem” (p. 24). The set of solutions that this dissertation presents is at a level of abstraction that makes it “transferable.” The design-science research in this dissertation does not attempt to produce an instantiation of a BYOD security system. That task is reserved for future research.

The dissertation focuses on BYOD security as one result of consumerization on the organization. Other aspects of consumerization, such as cloud computing, are not the focus of this research. There are other aspects of importance in designing organizational information infrastructures (such as improved usability, hedonic attributes, and others) that are not examined in this dissertation, since the research focus is on security design only.

### **1.3 Structure of the Dissertation**

*Part I of the dissertation is conceptual.* It comprises the theoretical discourse and offers a pluralistic viewpoint of the design-science research paradigm that enables a more nuanced treatment of design-science research studies as they proceed through iterations of development. This part introduces the terminology and the concepts that help identify and analyze the goals and scope of the knowledge processes in design-science research. This analysis yields two dualities that aid in understanding the differing ways in which the knowledge claims of design-science studies can be justified and evaluated. These two dualities lead to four distinctly different styles of approaching the process of inquiry in design-science research. These four styles help to explain the interoperation of differing knowledge processes and goals present in design-science studies. The presence of multiple styles of knowledge is illustrated with two examples of design-science research studies. These examples demonstrate how different paths to knowledge accrual may be employed in design-science research studies; they also show that

these different paths lead to different kinds of knowledge contributions. Further, these examples illustrate how the criteria for justifying and evaluating the knowledge in design-science can change as the study processes evolve, and they elucidate the application of the relevant evaluation guidelines for the different forms of knowledge contributions.

Part I is structured as follows. First, a review of the literature in Chapter 2 provides a background of current perspectives on design and scientific contributions and the role of knowledge in design-science research. This is followed by Chapter 3, which develops the discourse offering an alternate, multigenre viewpoint for framing design-science contributions. This chapter then describes the development of the multigenre framework and articulates the evaluation guidelines for each of the genres. Chapter 4 illustrates the application of the multigenre framework using two exemplar design-science research studies. Finally, Chapter 5 concludes Part I with a discussion of learning from the theoretical discourse, the contributions to research and practice, and related limitations and implications.

*Part II is an empirical study* that uses a design-science research lens to determine a solution for the problem of organizational information security risk management resulting from the phenomenon of consumerization and BYOD (bring your own device). A research methodology called “search conference” is applied to evaluate and extend a design theory in the context of information security risks arising due to consumerization and the BYOD phenomenon. This section has three functions: 1) to report the results of the research study on BYOD security; 2) to provide a demonstration of design theorizing; and 3) to apply an established future-oriented, participative, strategizing technique called search conference for the purpose of design theorizing and to demonstrate how search conferences can be used for collaborative designing and collaborative theorizing.

Part II is structured as follows. First, the BYOD landscape and the problem setting are described in Chapter 6. Chapter 7 provides a review of the literature and the theoretical framing that will guide the development of design theory for BYOD security. Following this, Chapter 8 describes the research approach and provides a detailed review of the search conference methodology, its main use in participative strategizing, and its adaptation for design theorizing. Chapter 9 describes the employment of search conference for adapting an existing design theory for BYOD, along with the conduct of the search conference and its findings. Chapter 10 wraps up the practical discourse with a discussion of learning from this study, the contributions of the empirical study to practice and theory, and related limitations and implications.

*Part III provides a discussion on the learning from Parts I and II, describes the key contributions* of this research, illustrates its theoretical and practical implications, and outlines the path for future research. This section is structured as follows. Chapter 11 describes the knowledge goals that the theoretical discourse seeks to advance. It examines how the multigenre framework proposed in Part I of the study extends the current thinking in design-science methodology and its implications specifically for the evaluation and justification of knowledge. Then it examines the development of design theorizing using an empirical study in Part II. It relates the findings of the empirical study conducted in Part II in the context of the multigenre framework developed in Part I and shows how different forms of knowledge goals require different forms of evaluation. Chapter 12 discusses what was learned from the reflections on both the theoretical discourse and the practical discourse. Chapter 13 concludes the dissertation by summarizing the contributions of this research and describing potential future research on this subject.

## 1.4 Summary of Contributions

This dissertation contributes to the ongoing discussion in the area of design-science research methodology and design theorizing by offering empirical and theoretical evidence in support of a multigenre perspective of design-science research. The dissertation relates to both research and practice and therefore combines a theoretical discourse with a practical discourse. Part I advances a multidimensional lens for design-science research inquiry with the objective of providing clarity on the different type of knowledge that can be created during the design-science research process. Consequently, different evaluation criteria are needed to validate different kinds of knowledge production. Design-science is “fundamentally a problem-solving paradigm” (Hevner et al. 2004, p. 76). It is therefore appropriate for engaged research practices where the “researcher actively pursues the solving of pertinent and practical problems in a local context.”

Part II of the dissertation applies design-science research for the evaluation of a design theory in a practical setting with the aim of solving a particularly complex problem of information security in the BYOD context. The resulting contribution of this study is as follows: First, the research provides empirical evidence to demonstrate how to develop a method to address BYOD security. The bindpoint model is evaluated and refined to derive design principles for addressing BYOD security. For these principles, a set of design rules is provided for designing information security systems for BYOD security. These rules may be of considerable interest to practitioners as a tool to help streamline inter-organizational processes and to design secure Information Systems in dynamic contexts such as BYOD. Second, a framework for examining BYOD in future research is offered. This framework would assist researchers in investigating BYOD requirements for adaptive enterprise design. Third, a general

model for using search conferences is provided. This framework may serve as a template for similar initiatives in other Information Systems research contexts.

Finally, in terms of contribution to the design-science research knowledge-base, the practical discourse in Part II of this dissertation demonstrates how a design-science research project can move through different genres of inquiry resulting in different types of knowledge. Thus, it provides an empirical example of the conceptual framework that is developed in Part I.

Overall, the theoretical and practical parts of the dissertation provide the development of a conceptual frame and accompanying evaluation criteria followed by an empirical case regarding IS security, which illustrates the application of the framework and the criteria. It is intended that collectively, Parts I and II will be useful in addressing the debate around the design and science aspects of design-science research, provide a useful solution for a contemporary security issue, and demonstrate the novel use of the search conference, thus contributing to both research and practice. Part III synthesizes what has been learned from Parts I and II by analyzing the practical discourse on BYOD in terms of the theoretical discourse on genres of inquiry. This section also reflects on what has been learned in the practical and theoretical discourse and summarizes the contributions of this research as well as possibilities for future research.

**PART I: THEORETICAL DISCOURSE: GENRES OF INQUIRY IN DESIGN-  
SCIENCE RESEARCH**

## 2 THEORETICAL BACKGROUND OF DESIGN-SCIENCE RESEARCH

This chapter examines how design-science research has been defined in the literature while paying specific attention to the descriptions of the design, science, and knowledge aspects of design-science research. It also describes the best-known design-science methodology frameworks and summarizes the seminal views on design theorizing.

### 2.1 Definition of Design-Science Research

The origins of the Information Systems design-science research tradition can be traced to Simon's *The Sciences of the Artificial* (1996). Simon defined design as the process by which designers “[devise] courses of action aimed at changing existing situations into preferred ones”; he distinguished it from “natural sciences and social sciences, [which] try to understand reality, [whereas] design-science attempts to create things that serve human purposes” (p. 55).

In recent years, design-science research has become prominent in Information Systems research and has garnered a paradigmatic status. Simon's definition of design-science has been described as “the process of *exploration through design* in order 1) to explore new solution alternatives to solve problems, 2) to explain this explorative process, and 3) to improve the problem-solving process” (Holmström et al. 2009). Design-science research is a “lens,” or set of synthetic and analytic techniques and perspectives, for conducting Information Systems research (Vaishnavi and Kuechler 2004). “Design-science research involves the creation of new knowledge through design of novel or innovative artifacts (things or processes that have, or can have, material existence) and analysis of the use and/or performance of such artifacts along with reflection and abstraction – to improve and understand the behavior of aspects of Information Systems” (Vaishnavi and Kuechler 2004). Hevner et al. (2004) state that “the design-science

paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts, including constructs, models, methods, and instantiations” (p. 75).

Mathiassen and Nielsen (2008) define design-science in terms of relevance to practitioners as follows: Design research is focused on “*designing* various forms of artefacts with the purpose of supporting stakeholders engaged in IS practices” (p. 6).

Iivari and Venable (2009) define design-science research “as a research activity that invents or builds new, innovative artifacts for solving problems or achieving improvements, that is, design-science research creates new means for achieving some general (unsituated) goal, as its major research contributions. Such new and innovative artifacts create new reality, rather than explaining existing reality or helping to make sense of it” (p. 4). According to Hevner and Chatterjee (2010), design-science research can be defined as: “a thing or process by which a designer answers questions relevant to human problems, thereby contributing new knowledge to add to the body of scientific evidence and new knowledge creation. The artifact is both useful and fundamental in understanding that problem” (p. 5). Venable and Baskerville (2012) define design-science as “research that invents a new purposeful artefact to address a generalized type of problem and evaluates its utility for solving problems of that type” (p. 142).

From the above, three key aspects of design-science research emerge: 1) the design, analysis, and evaluation of new or innovative artifacts; 2) the purpose of addressing a generalized type of problem; and 3) the creation of new knowledge. Therefore, for the purpose of this dissertation, design-science research is defined as:

*A set of analytical and synthesizing techniques that involve the design, construction, analysis, and evaluation of new or innovative artifacts, with the purpose of addressing a generalized type of problem and resulting in the creation of new knowledge.*



## 2.2 Outputs of Design-Science Research

Design-science research is considered fundamentally different from both the theory-building and theory-testing approaches, which model themselves after the natural sciences and seek explanation based on observation. According to Hevner et al. (2004), “design-science ... creates and evaluates IT artifacts intended to solve identified organizational problems” (p. 77). According to Peffers et al. (2007), such artifacts may include constructs, models, methods, and instantiations (Hevner et al. 2004; March and Smith 1995), social innovations (van Aken 2004), and new properties of technical, social, and/or informational resources (Järvinen 2007b). Thus, a design-science research artifact “includes any designed object with an embedded solution to an understood research problem” (Peffers et al. 2007).

Walls et al. (1992) define an additional component in such research – meta-requirements. They discuss theory development as an integral part of the design-science research process. However, there is no perfect agreement in the literature on the outcomes of design-science research. Vaishnavi and Kuechler (2004) note, “Even within design research communities there is lack of consensus as to the precise objective – and therefore the desired outputs – of design research.” Below is a summary of the different types of design-science research contributions.

March and Smith (1995) describe four types of IT artifacts that are produced through the design-science research process; these are commonly stated as design-science research outcomes.

**Constructs:** Constructs comprise the formal or informal conceptualization of the problem and the solution within a domain. They “provide the language in which problems and solutions are defined and communicated” (Hevner et al. 2004). Entities, attributes, relationships, identifiers, and constraints are examples of formalized constructs in semantic data modeling

(March and Smith 1995). Consensus, participation, and satisfaction are examples of informal constructs pertaining to the operationalization of cooperative work (Kraemer and King 1988) as described by March and Smith (1995).

**Methods:** Methods are algorithms or guidelines that explicate how to perform a task to solve a problem. They provide guidance on how to search the solution space in order to solve problems (Hevner et al. 2004). Methods can also demonstrate feasibility, enabling the assessment of an artifact's suitability to its intended purpose. They also "enable researchers to learn about the real world, how the artifact affects it, and how users appropriate it" (Hevner et al. 2004). Methods can be formalized as mathematical algorithms or be stated informally in the form of best practices or approaches to address a problem or guidelines (Hevner et al. 2004; March and Smith 1995). For example, Storey et al. (2008) design an information search methodology termed "CONQUER" (CONtext-aware QUERy processing), which improves the semantic content of Web queries.

**Models:** A model is a set of propositions or a representation describing the relationship between constructs. Models use constructs to represent the link between the design problem and its solution space. For example, the entity–relationship model (Chen 1976) provides the problem definition for an information system design task and provides a solution to the requirements definition task. In natural science, models can be used to represent phenomena in terms of the relationship between constructs. However, in design-science, although models may describe a link between constructs, they are concerned more with utility than with truth, as in the case of natural science models (March and Smith 1995). Thus, they must be useful for designing; further, they generally represent a certain level of abstraction and may therefore be silent on exact details (March and Smith 1995).

**Instantiations:** Instantiations operationalize constructs, models, and methods in their environment. Therefore, they can be used to provide a demonstration of the feasibility and effectiveness of models and methods. They can then become objects of study leading to learning about the behavior of the artifact in its environment. However, an instantiation may precede the development and formalization of construct methods and models and may be based on prior knowledge or intuition. In such a case, the study and use of the instantiated artifact can lead to the formalization of constructs, methods, or a model (March and Smith 1995).

In their seminal paper on design-science research methodology, Hevner et al. (2004) follow March and Smith's (1995) classification of the design-science artifact. Hevner et al. (2004) state, "We include not only instantiations in our definition of the IT (information technology) artifact but also the constructs, models, and methods applied in the development and use of Information Systems. We do not include people or elements of organizations in our definition nor do we explicitly include the process by which such artifacts evolve over time" (p. 82).

**Design propositions:** Romme (2003) proposed the notion of design propositions that explicate design knowledge in the form of scientific propositions in order to produce knowledge that is both actionable as well as open to validation. These propositions can take the form of causal statements or rules, such as "In situation S, to achieve outcome O, perform action A." These propositions can be grounded in empirical research as well as tested, learned, and applied. This definition of design-science output attempts to link or bridge the *process* aspect of design with the *variance* aspect of science by providing a common vocabulary. Romme (2003) clarifies that design propositions refer to preliminary formulated design rules, whereas design rules refer

to propositions that have been successfully tested in practice or through experimentation and that are grounded in empirical evidence.

***Technological rules:*** According to van Aken (2004), “[T]he mission of design-science is to develop knowledge for the design and realization of artefacts, that is, to solve construction problems, or to be used in the improvement of the performance of existing entities, that is, to solve improvement problems” (p. 224), and a typical design-science research product is a *technological rule*. van Aken (2004) modifies Bunge’s (1967) definition of a technological rule, that is, “an instruction to perform a finite number of acts in a given order and with a given aim” (p. 132), as follows: “a chunk of general knowledge linking an intervention or artefact with an expected outcome or performance in a certain field of application” (p. 228). From van Aken’s definition, it is clear that his conceptualization of the generalizability of the technological rule is somewhat moderated to be tested for applicability in a specific context.

Van Aken describes the “field-tested” and “grounded” technological rule as Mode 2 knowledge, or knowledge that is not just “purely academic and mono-disciplinary (Mode 1 knowledge)” but rather, “multidisciplinary and aimed at solving complex and relevant field problems” (Van Aken 2005). Here he diverges from the definition of Mode 2 knowledge from Gibbons et al. (1994) that is context-specific and does not yield generalizable knowledge. He argues that technological rules can be evaluated in specific settings but that the knowledge can be transferable to other similar contexts.

***New properties of technical, social, or informational resources:*** Järvinen (2007b) describes new properties of technical, social, or informational resources as design-science outputs. He argues that “advances in technical, human (organizational), and informational resources offer an opportunity to build new innovative artefact(s)” (p. 1389). For example, in

addition to the utility function of technological innovations, technology can be used innovatively to create products for hedonic uses. Further, he distinguishes between knowledge resident in the technological artifact from tacit knowledge or expertise of humans. His argument for expanding the scope of design-science artifacts to include human and informational resources beyond Hevner et al.'s (2004) description of design-science outputs is based on centralizing the knowledge function of the design artifact. According to Järvinen (2007b), design-science knowledge can be contributed not only by the technological system, but also through interaction with humans and with informational data and knowledge.

***Design principles:*** Following Dasgupta (1996), (Purao 2002) defines design principles as “any technique or frame of reference about a class of artifacts or its characteristics that facilitates creation, manipulation and modification of artifactual forms” (p. 21). Design principles form the foundations of a design theory (Walls et al. 1992). Describing Walls’ design theory, Markus et al. (2002) state: “A design theory comprises 1) a set of user requirements derived from kernel theory, 2) principles governing the development process, and 3) principles governing the design of a system (that is, specifying and implementing its features)” (p. 182). They offer a design theory for emergent knowledge processes as a set of principles that lends guidance to developers and provides rules for selecting appropriate features for designing systems with unstructured or emergent requirements (Markus et al. 2002).

***Design patterns:*** Although not explicitly described as artifacts in the design-science literature, design patterns can serve as both *inputs to the design-science process and results of the process*. Gregor and Jones (2007) note that “[t]he *design patterns* approach arose in architecture (Alexander et al. 1977) and sought to describe a particular problem within a context, the forces arising from that context, and a solution that resolves those forces. Design patterns

have found application in a range of disciplines as diverse as object-oriented design (Gamma et al. 1995), systems analysis (Fernandez 1998), and the architecture of enterprise systems (Fowler 2002)” (p. 318). Holmström et al. (2009) suggest that design patterns are the “documentation of successful solution designs or means-ends propositions, that is, solution designs where the required number of intended consequences have been confirmed and a satisfactory number of unintended consequences co-opted” (p. 75). For example, Kolfschoten and De Vreede (2009) describe the development and evaluation of a design-science research effort that uses design patterns to create and transfer collaborative work practices that can be enabled by group support systems.

In the process of the activity of designing, designers draw upon their knowledge, experience, and expertise of the design domain. A large proportion of the activity of designing includes reusing and reworking existing designs. In Information Systems, such knowledge about previous designer outcomes exists prevalently in the form of design patterns (Fach 2001; Vaishnavi and Kuechler 2007). Patterns are well-accepted and effective in software engineering because such knowledge is gained through design experience and can be reused for new designs through the structural specification of system architectures (Shaw 1991). The basic notion is that there are fundamental elements in designs. A design pattern names, labels, abstracts, and identifies the key aspects of a common design structure that makes it useful for creating a reusable object-oriented design (Gamma et al. 1995).

At its simplest level, design patterns are metaphors for reusable behaviors and structures that have occurred in previous design activities (Fach 2001). Patterns invite experiential reuse that provides the link to design knowledge (Purao et al. 2003). Patterns do not require limitation of the designer’s creativity (Goel 1997; Schmidt et al. 1996), nor do they require the automation

of design. Instead, they emphasize the aspects that are quintessential to human knowledge transfer. The idea of reuse of the elements of the design itself is a desirable one. For example, service-oriented architecture is a high-level design architecture aimed at providing reuse to developers, and the services one chooses could have patterns that are related (Schmidt 1995). From a design-science contribution perspective, design patterns are especially useful because, while design patterns may emerge from empirical observations, they can also have a normative function. Therefore, patterns help the designer connect theory, empirical evidence, and experience with the design problem.

**Theories:** There is much debate regarding theories as an artifact or the output of design-science research. Although their framework describes Information Systems development rather than design-science research, Nunamaker Jr and Chen (1990) describe the development of a design theory as the final stage of the systems development research process. Walls et al. (1992) prescribe an Information Systems design theory (ISDT) that “integrates normative and descriptive theories into design paths intended to produce more effective Information Systems” (p. 36). On the other hand, March and Smith (1995) state that “[r]ather than producing general theoretical knowledge, design scientists produce and apply knowledge of tasks or situations in order to create effective artifacts” (p. 253). Thus, they espouse that the ultimate objective of design-science research activities is to construct or produce an artifact (constructs, models, methods, instantiations) and to then evaluate it by determining how well the artifact performs.

Following Walls et al. (1992), develop theory-based design principles for emergent knowledge processes and state that the “value of an IS design theory is to reduce developers’ uncertainty by restricting the range of allowable system features and development activities to a more manageable set, thereby increasing the reliability of development and the likelihood of

success, and to stimulate research” (p. 181). The idea of “better theories” as an output of design-science research is based on Puro (2002) and Rossi and Sein (2003). Gregor and Jones (2007) stress the importance of expressing design knowledge as design theories. Kuechler and Vaishnavi (2008) believe that “kernel theories can both *inform* DSRIS [design-science research in Information Systems] efforts and *can in turn be refined and developed by* DSRIS” (p. 490). According to Winter (2008), “Although theory building is not design-science research, theories as ‘intermediate’ artefacts need to be included in the system of relevant artefacts for IS design-science research.” In Puro et al. (2008), Storey notes that “[a] theory base that can drive the need for an artifact is most useful in guiding the design of the actual artifact” (p. 534). Venable (2006) states that theorizing is an essential output of design-science research and should be in the form of utility theories.

### 2.3 Distinguishing Design and Science in Design-Science Research

The difference between design and science has been significantly analyzed in the design-science literature. Herbert Simon made an argument on the dissimilarity between science and design in his famous writings on design (Simon 1996). He does not argue that researchers must abandon the idea of scientific methods as a ground for design, but he does advocate that these methods have limitations and that the research should only talk about “bounded rationality” when it comes to design. He also clarifies the important distinction between the nature of the “real” world (the realm of science) and the artificial world (the realm of design). Rittel and Webber (1973) argue that real-world problems have the characteristic of being “wicked problems,” and as such, they are not “solvable” and have to be approached using completely different means. Schön (1983) developed a similar but more radical idea. According to Schön (1983), people try to use “technical rationality” to solve problems that are not “solvable,” or, to



be more precise, that are not even “problems.” He claims that design is about “problem setting,” not about “problem solving.” Rather than a scientific view of design, he proposed “reflective practice,” or the “epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict” (p. 49), arguing that design is all about “messy situations.”

According to Cross (2001), early design methodologists have attempted to distinguish design from science. Alexander (1964) states, “Scientists try to identify the components of existing structures, designers try to shape the components of new structures” (p. 130). Cross (2001) quotes Gregory (1966) as follows: “The scientific method is a pattern of problem-solving behavior employed in finding out the nature of what exists, whereas the design method is a pattern of behavior employed in inventing things ... which do not yet exist. Science is analytic; design is constructive” (p. 50). Simon (1996) distinguishes [the science of] design from natural sciences as follows: “[T]he natural sciences are concerned with how things are ... design on the other hand is concerned with how things ought to be” (pp. 132-133). It must be noted in this definition that Simon is referring to the science of design.

Hubka and Eder (1987) define design-science as an aggregation of knowledge in the area of design, which includes concepts of technical information and of design methodology. Further, they note that design-science includes knowledge related to the phenomena of the systems that are to be designed, as well as related to the design process. Cross reaffirms that Hubka and Eder’s definition of design-science “extends beyond ‘scientific design,’ in including systematic knowledge of design process and methodology as well as the scientific/technological underpinnings of design of artefacts” (Cross 2001 p. 3).

Cross describes design knowledge as knowledge

about the artificial world and how to contribute to the creation and maintenance of that world. Some of it is knowledge inherent in the activity of designing, gained through engaging in and reflecting on that activity. Some of it is knowledge inherent in the artefacts of the artificial world (e.g., in their forms and configurations – knowledge that is used in copying from, reusing or varying aspects of existing artefacts), gained through using and reflecting upon the use of those artefacts. Some of it is knowledge inherent in the processes of manufacturing the artefacts, gained through making and reflecting upon the making of those artefacts. And some of each of these forms of knowledge can also be gained through instruction in them” (Cross 2001 p. 5).

This passage describes three different kinds of design-related knowledge: knowledge of the design domain, knowledge about the design contribution (product), and knowledge of the design process or the process of designing. Therefore, design knowledge encompasses all aspects, including “build and evaluate” and “theorize and justify.”

## 2.4 Distinguishing Design-Science Research from Routine Design

Vaishnavi and Kuechler (2004) distinguish design-science research from other design efforts by emphasizing the production of new knowledge. These latter design efforts that Vaishnavi and Kuechler (2004) refer to as “routine design” may be conducted using state-of-the-art technologies and result in state-of-the-art products. Another aspect of differentiation between design-science research and routine design is the element of risk, or the unknowns that are acceptable in design-science research but are usually avoided or minimized in the conduct of routine design (Vaishnavi and Kuechler 2004). According to Hevner et al. (2004), routine design differs from design-science research in the application of existing knowledge for solving organizational problems. They identify “the key differentiator between routine design and design research” to be “the clear identification of a contribution to the archival knowledge-base of foundations and methodologies” (p. 81). Hevner and Chatterjee (2010) point out that clearly identifying and articulating the knowledge contribution of design-science research is crucial

since it is this knowledge contribution that distinguishes design-science research from design efforts resulting in state-of-the-art design practice. According to them, “if the [design] team documents that their new ‘artifact’ is better, faster or more optimal through rigorous evaluation methods and comparison with similar artifacts, then new knowledge is indeed created and this would be considered design-science research. But if no new knowledge is created, then this would be considered applying best practices and conducting routine design” (p. 7). Iivari (2007) distinguishes design-science from practitioner-led construction of IT artifacts in two ways. His first distinction lies in the scientific evaluation of the constructed artifact. Second, he suggests the specification of a “reasonably rigorous constructive research method for building IT artifacts” (p. 51).

## **2.5 Role of Knowledge in Design-Science Research**

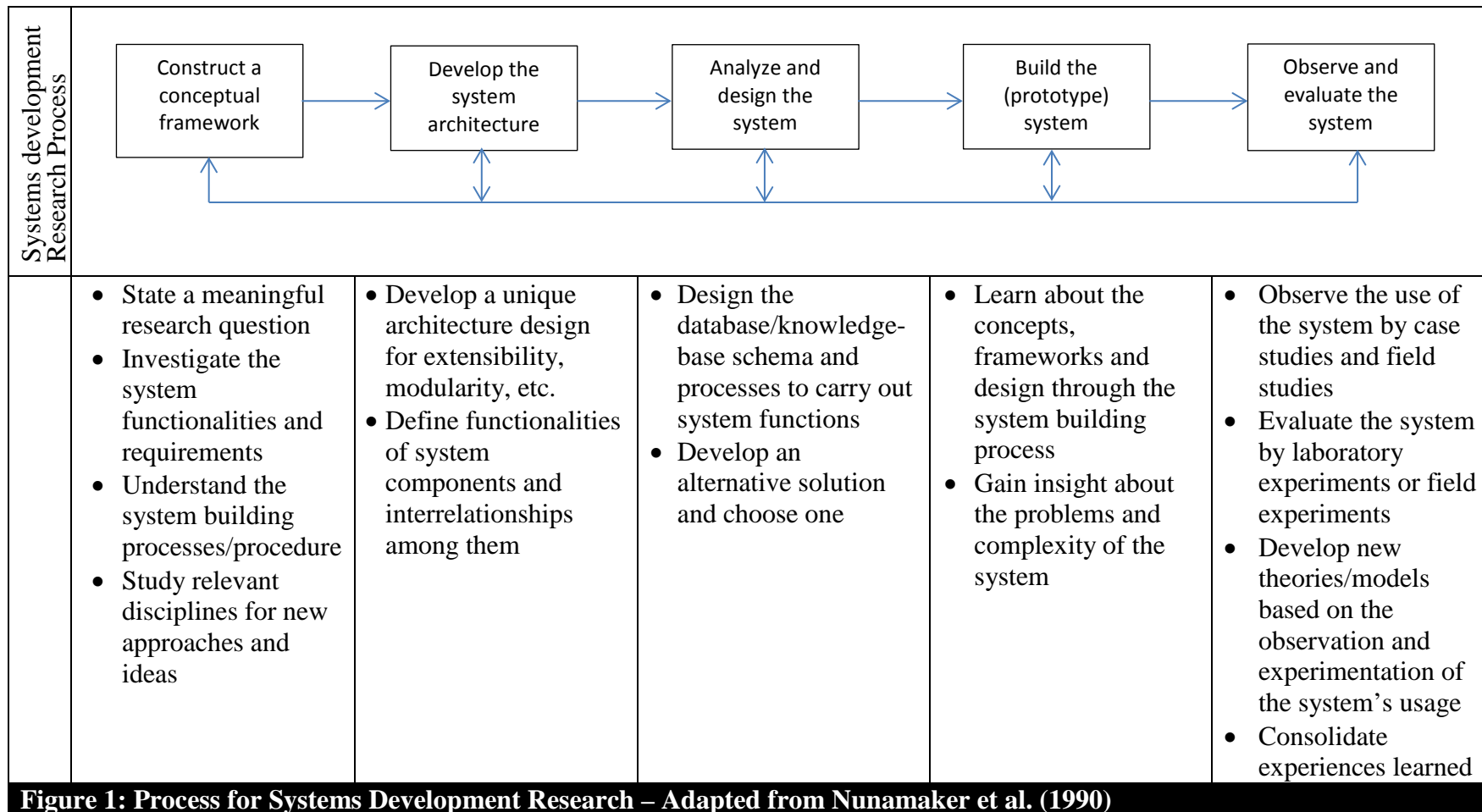
This section describes key aspects of the seminal design-science frameworks, including those pertaining to design theorizing, while paying special attention to the role of knowledge in these frameworks. These viewpoints are listed chronologically.

### **2.5.1 Systems development in Information Systems research (Nunamaker Jr et al. 1990)**

Nunamaker Jr et al. (1990) describe an engineering approach to systems development in Information Systems research and formalize it as a five-step approach that comprises the following iterative steps: 1) construct a conceptual framework, 2) develop system architecture, 3) analyze and design the system, 4) build the (prototype) system, and 5) observe and evaluate the system. This methodological framework clearly acknowledges that different types of contributions result from the references the development of technological artifacts as well as development of theory. In terms of using theory as input to the process, they advocate that design “involves the understanding of the studied domain, application of relevant scientific and

technical knowledge, the creation of various alternatives and the synthesis and evaluation of proposed alternative solutions” (p. 99). According to the authors, “A design should be based on theory and abstraction (modeling)” (p. 100).

Regarding the role of theory-building as a result of the design process, they discuss the theory-building efforts resulting from Step 1, which is the development of a conceptual framework. They find that the conceptual framework leads to theory-building for systems development. Further, in Step 5, they state, “[D]evelopment is an evolutionary process. Experiences gained from developing the system usually lead to further development of the systems, or even the discovery of new theory to explain newly observed phenomena” (p. 100). The centrality of knowledge depicted by the multigenre approach to design-science research aligns with the recognition of the centrality of knowledge in different stages of systems development by Nunamaker et al. They state, “[T]he pivotal role of system development in this scheme is the result of the fact that the developed system serves both as a proof-of-concept for the fundamental research and provides an artifact that becomes the focus of expanded and continuing research. Contributions at each stage of the life cycle obviously contribute to *fuller scientific knowledge of the subject*” (p. 92). Figure 1 below depicts their methodological framework for the process of Information Systems development research.



### 2.5.2 Information systems design theory (Walls et al. 1992; Walls et al. 2004)

In 1992, Walls et al. proposed the Information Systems design theory (ISDT). The authors distinguished natural and social science theories from design-science theories as follows: “The goal of the scientific theory is to understand or predict natural phenomena while the purpose of the design theory is to guide artifact creation” and argued that design theories should be based on kernel theories that were drawn from natural/social sciences. Further, they posited an ISDT as “a prescriptive theory which integrates normative and descriptive theories into design paths intended to produce more effective Information Systems” (p. 36). They stated that since design was both a noun and a verb, a design theory necessarily has two components – one that pertains to the design product and the other that pertains to the design process. They defined seven components of a design theory; four of these components refer to the design product and three to the design process. These components are as follows:

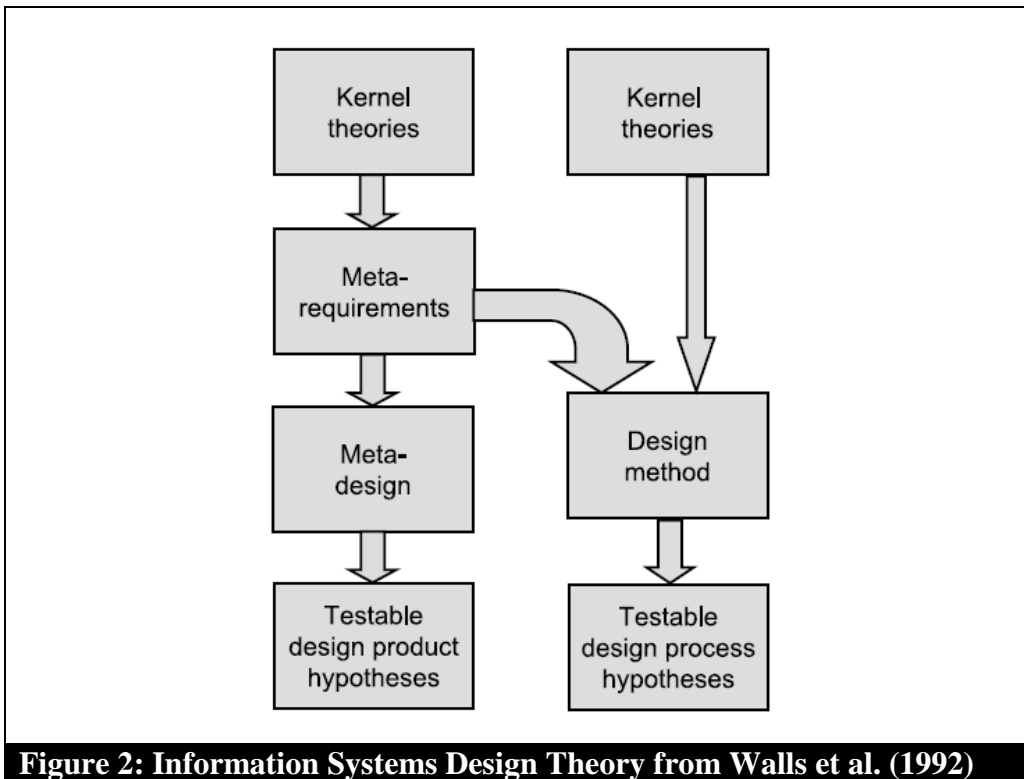
#### **Design product-related:**

1. Meta-requirements are the class of goals to which the theory applies.
2. Meta-design describes the class of artifacts hypothesized to meet the meta-requirements.
3. Kernel design product theories are theories from natural and social sciences that govern design requirements.
4. Testable design product hypotheses are used to test whether the meta-design satisfies meta-requirements.

#### **Design process-related:**

5. Design method is a description of the procedures for constructing the artifact.

6. Kernel-design process theories are theories from natural or social sciences that inform the design process.
7. Testable design process hypotheses are used to verify whether the design method leads to an artifact that is consistent with meta-design.



**Figure 2: Information Systems Design Theory from Walls et al. (1992)**

### 2.5.3 Design-science research in Information Systems and the three cycle model (Hevner and Chatterjee 2010; Hevner 2007; Hevner et al. 2004)

One of the most seminal papers in design-science research is the 2004 research essay in *MIS Quarterly* authored by Hevner, March, Park, and Ram (Hevner et al. 2004) at the invitation of then-editor-in-chief Allen Lee. The fundamental goal of the paper is to provide an understanding of the design-science process (Figure 3 below), and further, to provide guidelines for the conduct, evaluation, and presentation of design-science studies (Table 1 below). This paper describes research in Information Systems as being characterized by two distinct but

complementary paradigms: behavioral science and design-science. According to Hevner et al. (2004), the design-science paradigm is viewed basically as a build-and-evaluate cycle where “knowledge and understanding of the problem domain and its solution are achieved through the building and application of the designed artifact” (p. 75). The artifact is constructed according to an intended purpose and its performance can then be compared to its purpose. It replaces the simple natural scientific method of falsification with a simple design scientific method of failure.

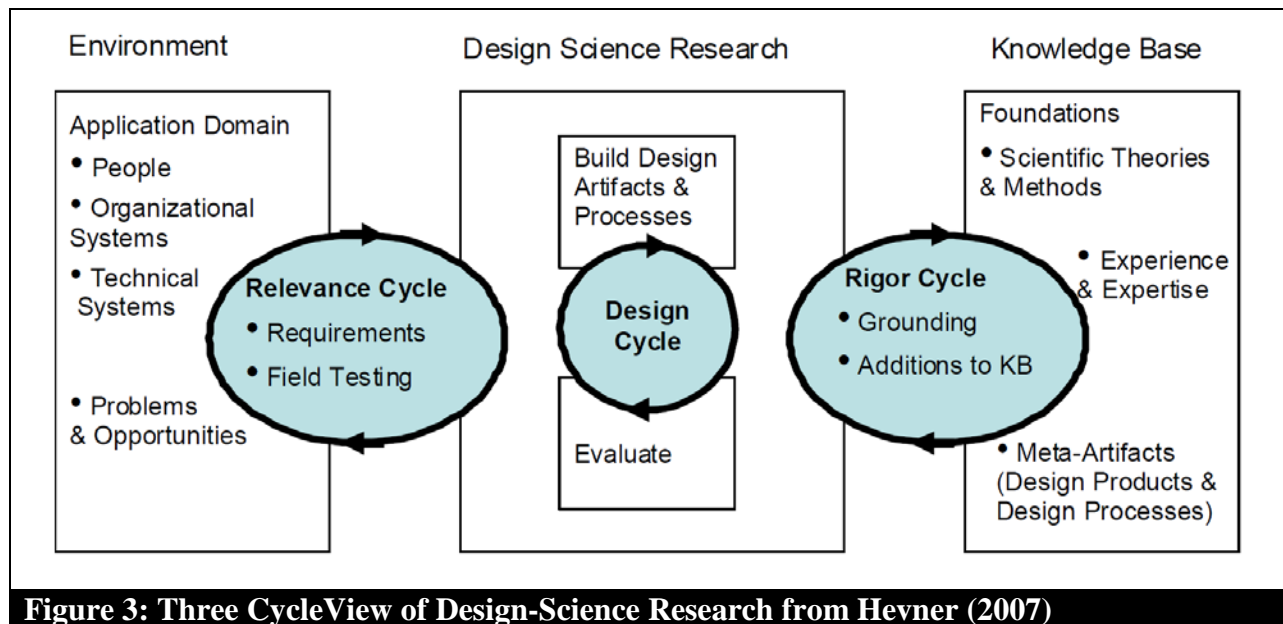
Hevner et al. (2004) distinguish between behavioral science and design-science as follows: “In behavioral science, methodologies are typically rooted in data collection and empirical analysis techniques; in design-science, computational and mathematical methods are primarily used to evaluate the quality and effectiveness of artifacts; however, empirical techniques may also be employed” (p. 80-81). Thus, in the natural sciences the most typical approach is to deduce hypotheses from theories and conduct testing to determine the validity of the hypotheses. In design-science, the approach is to deduce an artifact from a kernel theory, build the artifact, and conduct an evaluation to determine if the artifact justifies its theoretic function.

Design-science is valued because it delivers both conceptual knowledge and practical problem solutions as natural outcomes of the paradigm. Hevner’s (2007) three cycle model (shown in Figure 3 below) shows three cycles: the design cycle, the rigor cycle, and the relevance cycle. The figure shows how the design cycle interacts with both the rigor cycle and the relevance cycle to deliver foundational knowledge as well as applied solutions as a result of the “build and evaluate” part of the design cycle.



Hevner (2007) notes that, in the design cycle, “the requirements are input from the relevance cycle and the design and evaluation theories and methods are drawn from the rigor cycle.” (p. 91). Further, he adds that “it is important to understand the dependencies of the design cycle on the other two cycles, while appreciating its relative independence during the actual execution of the research” (p. 91).

This separation of design from knowledge is interesting to note. The primary focus of design-science research, then, is on the design cycle, and the research outcomes are focused more on improvement of an artifact in a specific domain as the primary research concern, while the quest for “broader, more general, understanding of theories and phenomena surrounding the artifact” is considered “as an extended outcome” (p. 91).



**Figure 3: Three Cycle View of Design-Science Research from Hevner (2007)**

On the next page, Table 1 lists the seven guidelines that describe the fundamental characteristics of good design-science research.

| <b>Table 1: Design-Science Research Guidelines from Hevner et al. (2004)</b> |   |
|--|---|
| <b>Guideline</b>   | <b>Description</b>  |
| Guideline 1: Design as an Artifact   | Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.  |
| Guideline 2: Problem Relevance   | The objective of design-science research is to develop technology-based solutions to important and relevant business problems.  |
| Guideline 3: Design Evaluation   | The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.   |
| Guideline 4: Research Contributions  | Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies. |
| Guideline 5: Research Rigor  | Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.                                 |
| Guideline 6: Design as a Search Process                                      | The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.                         |
| Guideline 7: Communication of Research                                       | Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.   |

#### 2.5.4 General Design Cycle (Vaishnavi and Kuechler 2004; Vaishnavi and Kuechler Jr 2007)

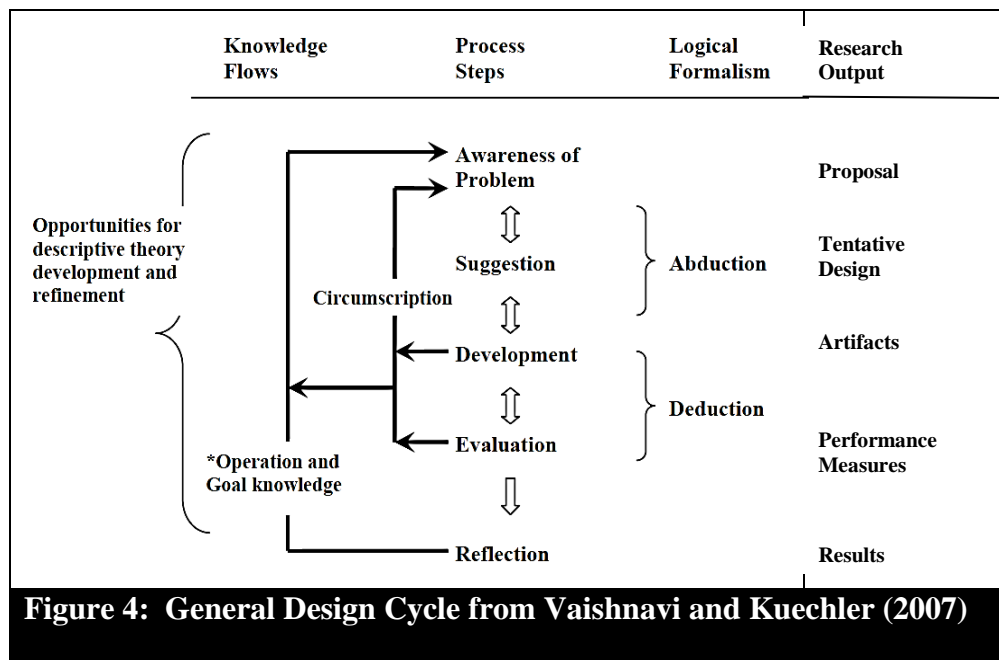
Vaishnavi and Kuechler (2004) apply the Takeda et al. (1990) General Design Cycle to design-science research and describe a framework for the process of conducting design-science research. They describe the design-science cycle in five steps that occur iteratively. These steps are:

1. *Awareness and definition of the problem.* The awareness or initiation of the problem can be inspired by the latest developments in industry, from a reference discipline, or

- even from reading something of interest in another allied discipline. Awareness will result in a formal or informal proposal for research.
2. *Suggestion of a solution.* This is a creative step that involves envisioning the functionality of the new system and a proposed design that will address that functionality. It results in the development of a tentative design (solution).
  3. *Development of the solution.* This step undertakes further refinement of the tentative design and the implementation of the design. The importance of this step lies in the novelty of the design rather than state-of-the-art construction of the artifact. The implementation of the artifact is important to the extent of establishing proof-of-concept.
  4. *Evaluation.* This step requires the evaluation of the artifact according to the criteria of performance provided in the proposal and includes analysis of the behavior of the artifact. The research effort does not end here but may give rise to several cycles leading back to the Suggestion phase armed with additional information about the behavior of the artifact. The explanatory hypotheses that are developed here are usually amended and refined based on further cycles of improvement.
  5. *Conclusion.* This stage is typically a result of “satisficing” (Simon 1972) or a “good enough” solution and includes the articulation of the new knowledge. These steps are depicted in Figure 4 below. An important aspect of this framework is that it offers a distinct step for the communication and articulation of the results as described in the Conclusion stage.

Kuechler and Vaishnavi (2011) stress that “[t]he element that defines research, at least for academia, is *the production of new knowledge*” (p. 129). The knowledge contributions from the production of new knowledge are indicated by the arrows labeled “Circumscription,” “Operational and Goal Knowledge,” and “Awareness of Problem.” According to Vaishnavi and Kuechler (2007), circumscription is a formal logical process that helps to generate an “understanding that could only be gained from the specific act of construction.” They further state,

Applicability of knowledge can only be determined through the detection and analysis of contradictions ... The research process when interrupted and forced back to Awareness of the problem in this way (through circumscription), contributes valuable constraint knowledge to the understanding of the always-incomplete-theories that abductively motivate the research. The creative, cognitive processes of reflection and abstraction make knowledge contributions of operational principles and possibly design theories. (p. 13)



### 2.5.5 Design theorizing in Information Systems (Gregor 2006; Gregor and Jones 2007)

Gregor (2006) describes five different types of theory in Information Systems: Type 1 – Theory for Analyzing; Type 2 – Theory for Explaining; Type 3 – Theory for Predicting; Type 4 – Theory for Explaining and Predicting; and Type 5 – Theory for Design and Action.

According to Gregor and Jones (2007), “The distinguishing attribute of theories for design and action is that they focus on ‘how to do something.’ They provide explicit prescriptions on how to design and develop an artifact, whether it is a technological product or a managerial intervention” (p. 313). Eight distinct components of design theories are identified: 1) purpose and scope, 2) constructs, 3) principles of form and function, 4) artifact mutability, 5) testable propositions, 6) justificatory knowledge (kernel theories), 7) principles of implementation, and 8) an expository instantiation.

While Cross (1982) believes that design work can proceed without reflection on theory since design knowledge resides in products themselves, Gregor and Jones (2007) argue that expressing design knowledge in the form of design theories is required to confer the required degree of rigor. They posit that “[d]esign work and design knowledge in Information Systems (IS) is important for both research and practice” (p. 312). However, their Type 5 theory is only described in terms of a design method to instantiate the meta-design in a particular problematic situation and does not explicitly address the prescription of the meta-design to meet the meta-requirements (Venable 2006).

### 2.5.6 Activity framework for design-science research (Venable 2006)

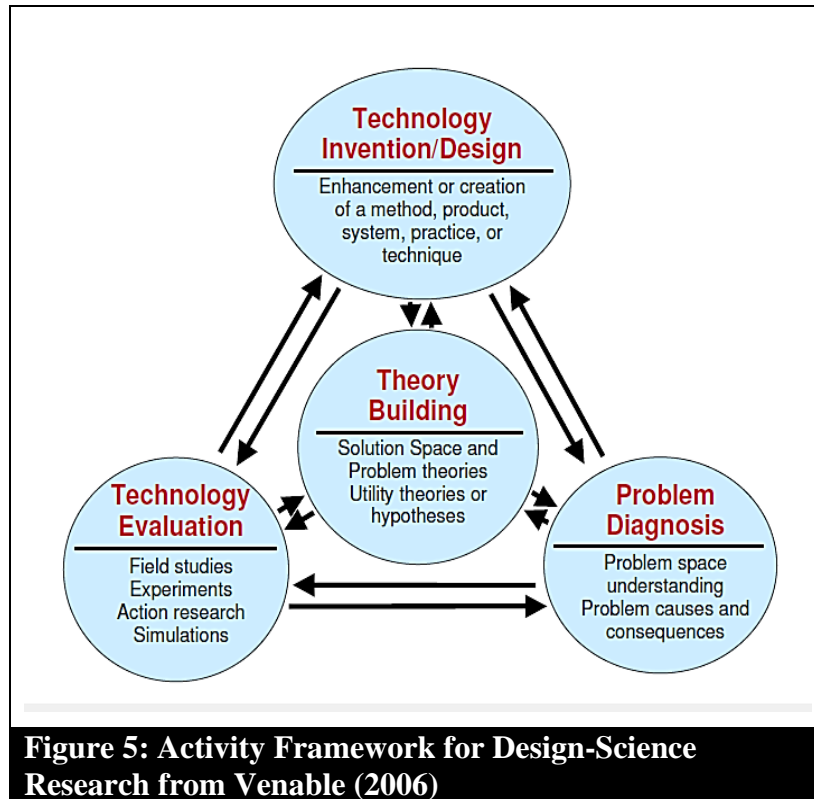
According to Venable (2006), “theorizing and theory building occur before, during, throughout, and at the end and as a result of design-science research” (p. 15). Theorizing may be initiated by an idea from a number of possibilities such as:

- Recombining ideas and conceptualizations of problem spaces
- Realizing new possibilities for solutions
- Recombining existing solutions/technologies
- Imagining new technologies
- Realizing new applications for existing technologies

Venable's approach to design theorizing differs somewhat from that of Walls et al.

(1992). First, he does not believe that a design theory must necessarily incorporate a kernel theory, since explanations of *how* and *why* solutions work are not relevant. Second, he does not deem it necessary that a design method per Walls et al. (1992) needs to be part of a design theory unless the design method itself is the resultant artifact. Third, he does not see the requirement of testable hypotheses. Finally, he diverges from Walls et al. (1992) and Gregor and Jones (2007) in their claims that design theory must be *prescriptive*. Rather, he argues that a design theory must be *predictive* about the utility or the effectiveness or efficiency of applying the technological solution to solve the problem.

In his design theorizing framework (Figure 5 below), he shows how theory-building is central to the design-science research process that includes: problem diagnosis, technology invention (design), and technology evaluation.

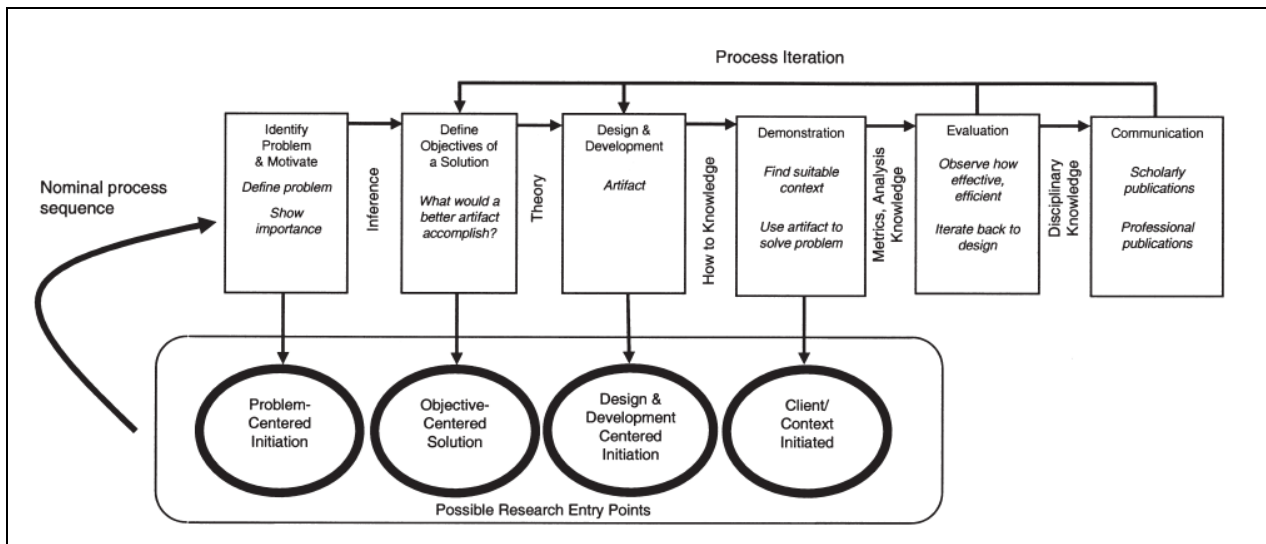


### 2.5.7 Design-science research methodology (Peppers et al. 2007)

Peppers et al. (2007) developed the design-science research methodology (DSRM) as a framework for conducting design-science research and as a mental model for presenting it. The methodology comprises the following six steps: 1) problem identification and motivation, 2) definition of the objectives for a solution, 3) design and development, 4) demonstration, 5) evaluation, and 6) communication. Although the process is linear, it provides four distinct entry points into the research process: 1) problem-centered initiation, 2) objective-centered solution, 3) design and development motivated initiation, and 4) client/context initiation. The entire process is iterative and provides opportunity for feedback and improvement. In contrast to Vaishnavi and Kuechler's (2007) General Design Cycle, there is no known entry point into design-science research during evaluation or communication stages in the DSRM process. This may be a gap in the model, since communication of results could potentially lead to further design-science

research opportunities. Similarly, evaluation of existing design-science projects may yield ideas for new design-science projects or even initiate the adaptation of the design-science solution in a different domain.

Regarding the role of knowledge, it is evident from the DSRM framework (Figure 6 below) that knowledge is central to the design-science research process and theoretical knowledge is stated as an input to the design process. The communication of the knowledge resulting from the process in Step 6 is described as the communication of “the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness.” The design artifacts are defined as “constructs, models, methods, or instantiations or new properties of technical, social, and/or informational resources” that could conceptually be “any designed object in which a research contribution is embedded in the design” (p. 55). The development of a design theory as an output of the design-science research process is not explicitly specified.



**Figure 6: Design-Science Research Methodology from Peffers et al. (2007)**

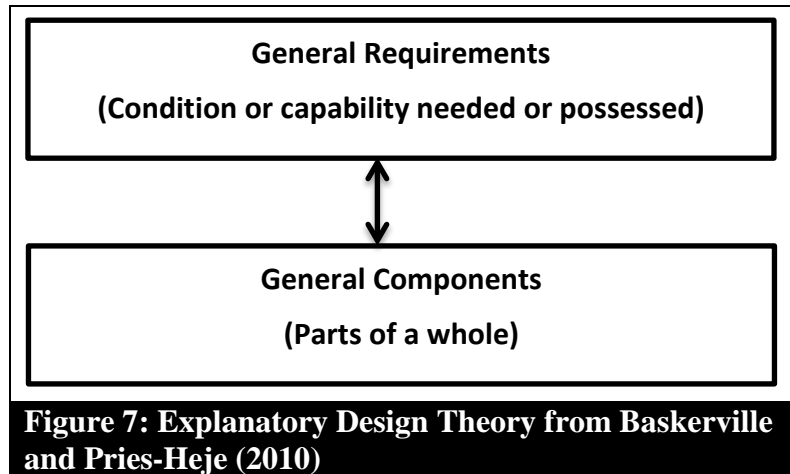


### 2.5.8 Contributions to design-science research (March and Storey 2008)

March and Storey (2008) propose six distinct requirements of a design-science research contribution: 1) identification and clear description of a relevant organizational IT problem, 2) demonstration that no adequate solutions exist in the extant IT knowledge-base, 3) development and presentation of a novel IT artifact (constructs, models, methods, or instantiations) that addresses the problem, 4) rigorous evaluation of the IT artifact enabling the assessment of its utility, 5) articulation of the value added to the IT knowledge-base and to practice, and 6) explanation of the implications for IT management and practice. This description of the design-science contributions clearly articulates the importance of the value-addition through knowledge. There is no explicit mention of a theory as artifact.

### 2.5.9 Explanatory design theory (Baskerville and Pries-Heje 2010)

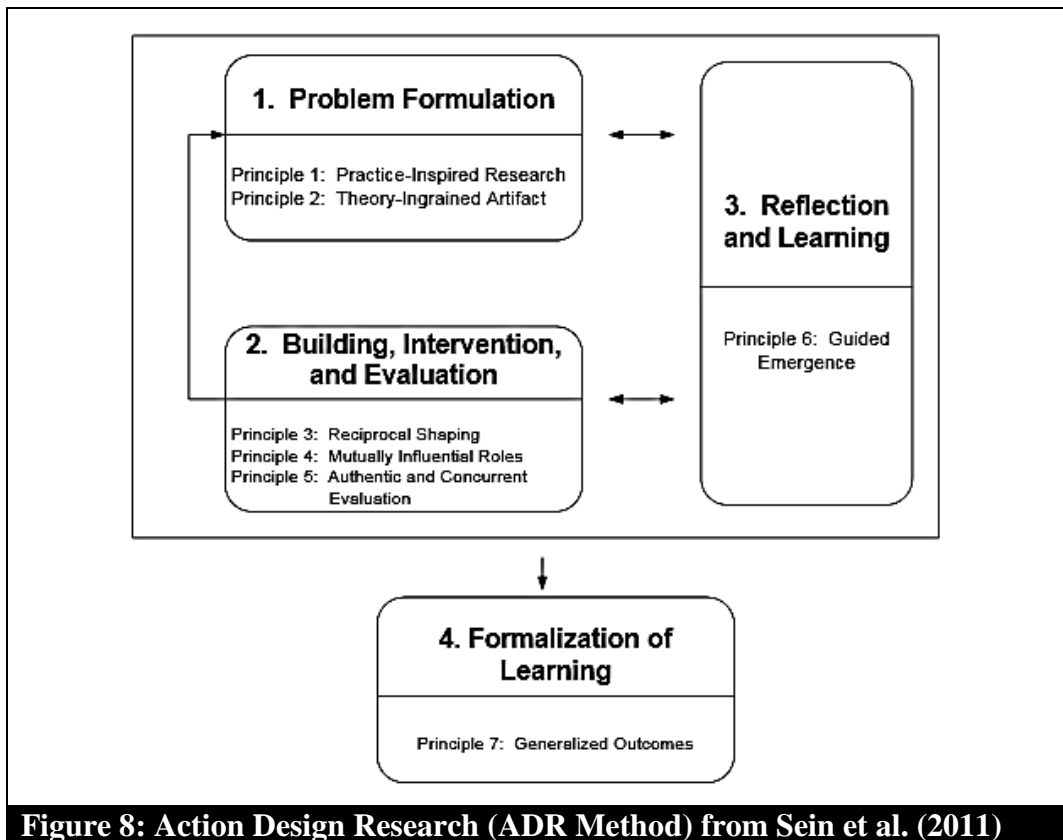
Simon (1996) explains that in design-science, functional explanations can provide an explanation of the functioning of the “inner environment” based on the requirements of the “outer environment.” Using this characteristic of functional explanations, Baskerville and Pries-Heje (2010) provide a simple and elegant formulation of explanatory design theories that can be described in terms of a generalized functional relationship between generalized components (meta-design) and generalized requirements (meta-requirements) (see Figure 7 below). Baskerville and Pries-Heje (2010) distinguish between design practice theory, which explains *how to design something*, and explanatory design theory, which explains *why a generalized set of requirements is satisfied by a generalized set of object features*. The explanatory design theory explains why a component is being constructed into an artifact.



### 2.5.10 Action design research (Sein et al. 2011)

Sein et al. (2011) provide a framework that incorporates the interventionist element of action research (Baskerville and Wood-Harper 1998; Davison et al. 2004; Mathiassen 2002; Susman and Evered 1978) with design-science research. The objective of combining design-science with action research is to address the dual challenges of evaluating design-science artifacts in specific organizational settings while at the same time constructing and evaluating artifacts that can address a general class of problems. Sein et al. (2011) provide a framework called action design research (ADR) that allows for the emergence of the design-science artifact from its interaction within the organizational context through an iterative cycle comprising problem formulation, building and evaluation of the artifact, and reflection/learning. Due to the very *specific* or *situated* nature of the knowledge emerging from the implementation of an artifact in an organizational setting, the challenge for ADR is then to produce generalizable knowledge. This is accomplished through a three-stage process called formalization of learning. In this step, the research moves from the specific-and-unique to generic-and-abstract as follows: 1) generalization of the problem instance, 2) generalization of the solution instance, and 3)

derivation of design principles from the design research outcomes. Sein et al. (2011) emphasize that the outcome of such research must be the definition of innovative design principles that reflect generalizability for a class of problems. Since ADR is aimed at combining an action research intervention resulting in abstract or generalized design-science knowledge, the knowledge goals of ADR are directed toward both the research as well as the practitioner.



## 2.6 Research terms and concepts

This research is motivated by the prevalent assumption in the design-science research community that design and science *can* be combined and that (particularly in the Information Systems discipline) exciting contributions emerge when the two come together. What is missing, though, is the means to describe these contributions and the processes that have led to

them. To address this gap, four “genres of inquiry” are defined to better understand the more refined nuances of design-science studies.

## 2.7 Defining “genres of inquiry”

The philosophy of science offers diverse perspectives that individual researchers can bring to their research activities. These perspectives permit researchers to construct research paradigms from myriad ontological and epistemological positions. The common examples of positivism, interpretivism, and critical research are typically foundations on which to drive associated “modes of inquiry” (Bonner 2010; Kim 2003). Such modes can include experimental exploration, hypothetical modeling, taxonomy development, and others (Hacking 2012). However, design-science is a unique paradigm that drives practices that differ from previous modes of inquiry (Iivari 2007). Churchman (1971), for example, delineates five modes of inquiry based on the five individual philosophies of Leibniz, Locke, Kant, Hegel, and Singer.

Design-science does not fit well into any of these modes for at least two reasons. First, design-science can incorporate any (or, as shown below, all) of these modes into its studies. Second, design-science engages in remaking and recreating reality. It embraces an element of design creativity in its reasoning and integrates this material creativity with science. As with other creative human activities, design-science researchers often use a style of thinking, or a manner of finding out, which Hacking (2012) refers to as *genres of inquiry*. The concept of genres of inquiry entails stylistic aspects in the articulation of methods of reasoning. These styles of articulation assist in explaining the knowledge activities in creative forms of scientific inquiry, such as design-science research, because “[e]ach genre of inquiry asks different questions about lived experience and requires different methods of inquiry” (Hart 2000).

Different genres of inquiry not only invoke different philosophical assumptions, but they also invoke different styles of articulation. These articulation styles subtly communicate the way research is shaped differently at different times. Bazerman (1988) suggests that the standards of a genre can help a researcher by clarifying the way in which a particular community will receive new work. Because a single design-science study can span multiple genres of inquiry, it needs requisite variety in its justification and evaluation approaches. That is, differing genres of inquiry in any single study produce knowledge in differing ways requiring differing kinds of criteria to properly justify and evaluate the study results (Hart 2000).

Design-science cannot be viewed as a particular paradigm or a singular approach with a unique set of knowledge criteria. It is often neither positivist, interpretivist, nor critical, but rather an interdependent combination of such paradigms. As a result, the styles of articulation can vary and evolve within a single design-science study. Because design-science studies can engage in iterative processes, such evolving styles, and the underlying shifts in philosophical assumptions, become obscured by the more apparent cycles. It is problematic to assign a design-science study to a single genre of inquiry because a single genre will not have the requisite variety in criteria or guidelines to adequately analyze and evaluate the complete study.

To address this problem, a pluralistic view is proposed, in which there is coexistence of multiple genres of inquiry within each design-science study. A design-science study may traverse the space of one or more genres of inquiry as it proceeds. Such pluralist views and diversity of research methods are already recognized in both Information Systems research (Landry and Banville 1992; Robey 1996), and action research (Baskerville and Wood-Harper 1998). However, this research shows how design-science research is remarkable in productively co-positioning multiple genres of inquiry within each study.

Justification and evaluation are a critical part of design-science research (Hevner et al. 2004). Researchers need acceptable criteria to justify their knowledge claims. The researchers’ audience also needs such criteria to evaluate the credibility of these results. Given the pluralism of design-science research studies, this creates challenges in performing the justification and evaluation of any new knowledge. The challenges arise in the different sets of criteria that are needed to evaluate different parts of a design-science study’s knowledge process. This research proposes a more nuanced approach to justifying and evaluating a design-science study that recognizes that research processes may shift from one genre of inquiry to another as the work unfolds. This approach can help researchers recognize such shifts and the accompanying need for adjusting the justification and evaluation criteria in design-science studies accordingly.

Table 2 summarizes the key terms used in this research.

**Table 2: Summary of Key Terms**

| <b>Term</b>   | <b>Description</b>  |
|---------------|---|
| Creativity    | The faculty of being inventive, imaginative; of, relating to, displaying, using, or involving imagination or original ideas as well as routine skill or intellect, esp. in literature or art (OED Online 2013).   |
| Duality       | The condition or fact of being dual, or consisting of two parts, natures, etc.; twofold condition (OED Online 2013).<br><br>This research adopts the usage of this term in accordance with the academic literature: Duality is a view that similar to the notion of holism, which can be found in philosophical approaches such as in systems theory (Laszlo and Clark 1972), complexity theory (Downey and Fellows 1999) dialectical holism (Hick and Murray 2009) and varieties of holism in pragmatism and contextualism (Rescher 1999). Dualities are interdependent and characterized by emergent powers, so that any one aspect cannot exist independently but rather as a whole. |
| Design (verb) | To make drawings for the construction or creation of something according to certain aesthetic criteria; to make plans for the production of a product according to structural or functional criteria; to conceive, devise, plan something immaterial as a scheme, system, program, etc. (OED Online 2013).  |

|                 |  |
|-----------------|--|
|                 | <p>In the academic literature, the term connotes the act of planning or creating something for a specific purpose, a process that is goal-oriented and where the goal is solving problems, meeting needs, improving situations, or creating something new or useful (Friedman 2003).</p> <p><i>to design</i> – to create a design in an environment [where the designer operates] (Ralph and Wand 2009).</p>   |
| Design (noun)   | <p>A plan or scheme conceived in the mind and intended for subsequent execution; the preliminary conception of an idea that is to be carried into effect by action; a project (OED Online 2013).</p> <p>In keeping with the Information Systems literature, this research uses the term to connote the process by which designers “[devise] courses of action aimed at changing existing situations into preferred ones” (Simon 1996); knowledge in the form of techniques and methods for performing the mapping of (function space) functional requirements to (an attribute space) an artifact satisfying the set of functional requirements (Vaishnavi and Kuechler Jr 2007); a specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying the set of requirements, subject to constraints (Ralph and Wand 2009).</p>  |
| Research (noun) | <p>Systematic investigation or inquiry aimed at contributing to knowledge of a theory, topic, etc., by careful consideration, observation, or study of a subject. In later use also: original critical or scientific investigation carried out under the auspices of an academic or other institution (OED Online 2013).</p> <p>Like science, definitions for the term research can vary with context. One clear definition in the IS literature is cited from the UK Research Assessment Exercise: “However, ‘Research’ for the purpose of the RAE is to be understood as original investigation undertaken in order to gain knowledge and understanding. It includes work of direct relevance to the needs of commerce, industry, and to the public and voluntary sectors; scholarship; the invention and generation of ideas, images, performances, artefacts including design, where these lead to new or substantially improved insights; and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes, including design and construction. It excludes routine testing and routine analysis of materials, components and processes such as for the maintenance of national standards, as distinct from the development of new analytical techniques. It also excludes the development of teaching materials that do not embody original research” (Paul 2008, p. 326).</p> |
| Research (verb) | <p>To engage in research upon (a subject); to investigate or study closely (OED Online 2013).</p>  |
| Science         | <p>The state or fact of knowing; knowledge or cognizance of something specified or implied; also, with wider reference, knowledge (more or less</p>  |

|   |   |
|---|---|
|   | <p>extensive) as a personal attribute (OED Online 2013).</p> <p>The usage of the term <i>science</i> varies widely according to social and political contexts (Gieryn 1983; Moisaner and Stenfors 2009). In Information Systems, the academic term is just as subject to the same breath of interpretation as in the fields of philosophy of science, sociology of science, and the history of science (Lee 2004). This research follows the usage of the term as conceptualized by Lincoln &amp; Guba (1985), who regard science as an intellectual and practical activity that incorporates systematic methodology and knowledge based on coherent concepts that are anchored to evidence (Blumer 1931; Scott and Briggs 2009).</p>   |
| Nomothetic  | <p>Relating to or concerned with the study or discovery of the general laws underlying something (OED Online 2013).</p> <p>This research adopts the term as used in the academic literature: knowledge processes that produce general theories or concepts that cover the entire classes of a given case (Allport 1962).</p>  |
| Idiographic   | <p>Concerned with the individual, relating to or descriptive of single and unique facts and processes (OED Online 2013).</p> <p>The connotation is similar in the academic literature: Knowledge processes that involve the study of particular cases (Bullock et al. 1988).</p>  |
| Knowledge   | <p>The fact of knowing or being acquainted with a thing, person, etc.; acquaintance; familiarity gained by experience (OED Online 2013).</p> <p>This paper focuses on a broad view of scholarly knowledge. This encompassing view takes in scholarly knowledge based on <i>erklären</i> (the causal explanations common in positivist science), as well as scholarly knowledge based on <i>verstehen</i> (the shared understanding common in interpretive science) (Lee 1994). In this research, design knowledge is considered scholarly because it not only relates to design theories (Goldkuhl 2004; Hevner et al. 2004), but also to the instrumental outcomes of design-science, such as product designs, implementation plans, and construction processes (Carlsson 2006).</p> |
| <p>Because the focus of this work is on knowledge processes, the following concepts are used in particular ways related to these processes.</p> |   |
| Knowledge processes   | <p>Activities in a research study that develop or support development of original knowledge.</p>  |
| Knowledge goals   | <p>Design knowledge goals are generative and creative; scientific knowledge goals are conventional and systematic. Design-science is characterized by duality present in essential <i>knowledge goals</i>.</p>  |
| Knowledge scope   | <p>An idiographic knowledge scope is local and pertaining to a particular case or problem; a nomothetic knowledge scope is global and applicable to a general class of cases. Design-science is characterized by duality present in essential <i>knowledge scope</i>.</p>   |
| Knowledge role  | <p>The purpose or purposes served by artifacts in design-science studies in</p>   |



|                    |   |
|--------------------|---|
|                    | relation to the knowledge claims of the study.  |
| Knowledge claims   | A statement asserting original knowledge arising from the research study. The knowledge process establishes the merit of the knowledge claim  |
| Knowledge criteria | Concepts regarding the quality of knowledge. Criteria are necessary for researchers to justify their knowledge claims and for their audience to evaluate these claims   |
| Knowledge moment   | A unit of knowledge processing, triggered by a specific need for knowledge and addressed by the specific delivery of the knowledge in a manner that is aligned with a given context.  |
| Genre of inquiry   | Stylistic aspects in the articulation of methods of reasoning that arise in the context of the philosophical assumptions. The standards of a genre that help a designer/researcher by clarifying the way in which a particular community will receive new work. |

## 2.8 Dualities in design-science research

Design-science exhibits two key dualities that assist in explaining the presence of plurality in its genres of inquiry. This section reviews the literature that defines the different aspects of each duality, describes the differing nature of knowledge, highlights contrasting conventions for justifying and evaluating knowledge, and details existing work that describes each composite duality.

This research adopts Giddens’ concept of duality from structuration theory (Giddens 1979; Giddens 1984), wherein two conceptually different elements are interdependent and no longer separable. “Duality, as interpreted by Giddens, draws structure and agency closer together and stresses their interdependence without going as far as to merge them into a single entity” (Jackson 1999, p. 550). Duality is distinguishable from dualism because “dualism – the division of an object of study into separate, paired elements – is widespread in economic and social theorizing: key examples are the divisions between agency and structure, the individual and society, mind and body, values and facts, and knowledge and practice” (Jackson 1999, p. 545). If design and science are regarded as a dualism, these objects appear as contestants in a

struggle for primacy. Instead, dualities are interdependent, and characterized by their mutually shaped emergent powers, so that any one aspect cannot exist independently of the other; rather, both exist together as a whole. If design and science are regarded as a duality, they appear as cooperating forces, which, while still opposites, are interdependent, intertwined, and reshaped by each other.

Each of the two dualities is represented as a continuum between extremes. This representation permits us to conceptualize the influence of different aspects of the dualities on different knowledge processes. Knowledge processes at the extreme ends of the continua are indeed unlikely, but the representation permits us to consider the interdependencies between knowledge processes that tend toward one aspect or another.

Recognizing and understanding the duality of design and science is useful for the analysis of design-science studies and the subsequent identification of appropriate criteria to apply during the justification and evaluation phases of a design-science study. While appropriate, these should not be regarded as the *only* criteria. An entire branch of philosophy, epistemology, is dedicated to the study of criteria for knowledge processes. The best criteria will be more pragmatically dependent on the exact context of the study (Moisander and Stenfors 2009; Overton 1991). However, the suggested criteria below arise in the Information Systems literature or are found frequently cited in that literature.

### **2.8.1 Knowledge goals: distinguishing design and science**

The first duality is present in the very name of design-science research and represents the tension between the sometimes contradictory goals of science and design.

*Design*, used as a verb, refers to the act of planning or creating something for a specific purpose; as a noun, the word refers to the product of the design process. An extensive analysis of some 30 definitions of the verb “design” uncovers design elements such as creation, planning, organizing, and optimizing (Ralph and Wand 2009). Designing is a goal-driven human activity that comprises creativity, requirements, and constraints. It involves understanding the problem requirements, utilizing the designers’ knowledge and experience, evaluating design alternatives, and formulating a design solution. Simon (1996), in *The Sciences of the Artificial*, describes the act of designing as “devising the course of action that changes an existing state into a preferred one” (p. 111).

The activity of designing aims to produce knowledge imbued with both analytical rigor and innovation. In particular, Information Systems design-science is related to the systems design employed in designing organizations and their systems. Such designs involve combining analytical modes of thinking with creative modes to develop artifacts that solve complex, multivariate problems in elegant and unique ways. In design-science studies, design knowledge can proceed, not only from the creation of new kinds of artifacts, but also from the process of designing such new kinds of artifacts. As a designer establishes the goals of a design process, new knowledge can arise about design problems, design solutions, and methods or approaches to the design task.

***Design knowledge criteria.*** The central criterion for design knowledge is the production of an acceptable similarity between expected and observed performance (Petroski 2009). The knowledge is useful in designing artifacts that will accomplish the intended outcome. Because the knowledge is functional, success or failure of its future results is paramount. Designing involves using contemporary information to predict a future state before the means of its

achievement is available (Jones 2009). Designers first imagine a future and then visualize how to get there. As a result, the highest qualities of design knowledge are associated with an individual designer: *creativity, innovativeness, and originality*. Such knowledge may arise as a personal artistic production without reasoning (Martin 2009).

**Science** is a systematic investigation and validation resulting in new knowledge. The notion of science has a frequent, but discordant, linkage to the notion of truth. According to Goles and Hirschhiem (2000, p.251), “for something to be considered scientific it must use the agreed set of conventions – the scientific method of inquiry.”

The science-centric view generally recognizes knowledge as a more collective and shared property. Science aims to produce knowledge that meets high standards of validity and/or reliability (Glanville 1999). Information systems design-science is related to computer science and engineering, as well as to the social sciences employed in organizations and management. Such behavioral and social sciences rarely produce law-like explanations, but rather explanations that are contextualized in human behavior, and contingent on carefully bounded ranges of philosophy and/or probabilistic claims of causality.

In design-science studies, scientific knowledge can proceed from two sources: 1) the study of the behavior of artifacts, and 2) the presence of artifacts in natural and social situations. Specifically, as a social system interacts with a new artifact, new knowledge can arise about the social system itself.

**Science knowledge criteria.** An overarching criterion for science is the trustworthiness of its knowledge. A more positivist view of science often aligns with nomothetic forms of science (see below), such as laboratory or field experimental methods. The predominant criterion for truth is *internal validity*, whereas the criterion for neutrality is *objectivity* (Lincoln

and Guba 1985). Less positivist views align with idiographic forms of science (see below), such as case studies, grounded theory, ethnography, or action research. Here, the criterion for truth moves to *credibility*, and the criterion for neutrality becomes *confirmability* (Guba 1981).

*The design-science duality* relates to the effort to establish rigor in Information Systems design-science studies. For example, design methods and design theories that guide design requirements and the design process seek to formalize design-related knowledge (Walls et al. 1992). Despite these efforts, the role of theory and its relationship to design-science continues to draw discussion about what constitutes scientific design knowledge (Gregor and Hevner 2013; Lee et al. 2012). This focus on the science component may have overshadowed the fundamental primacy of the designer's knowledge, which is widely acknowledged in the design literature. The creative aspect of designing is important because it is the very essence of such research. Most observers of the design process recognize that it is messy and disorderly, difficult, multidimensional, and problematic. It defies an easy description, so that design process reviews in software engineering often represent a "faked rationality" (Parnas and Clements 1986).

These contradictions between design and science are epitomized in the failed efforts to "scientize" design with design methods (Cross 2001, p. 53). According to Grant (1979, p. 46), "the act of designing itself is not and will not ever be a scientific activity." The result is the recognition that a method might be vital to science, but not to design. Designing is itself a nonscientific or a-scientific activity that is not repeatable. The designer's knowledge is central to the design process, regardless of whether the processes are analytic or synthetic, symbolic or real, or based on theory or practice (Owen 1998). Experience plays a key role in designing, as it does in any knowledge-based activity (Robillard 1999). A challenge of design-science is to

accommodate and respect both the creative and experiential knowledge of the designer and the efforts to produce rigorous, justifiable, knowledge.

Conceptualizing design-science as a duality is intended to highlight the importance of the design and science aspects of this research paradigm without minimizing the individual aspects of design and science. Viewing design-science as a duality helps emphasize the interdependence and softens the tension between the seemingly opposed nature of the knowledge goals of design and science. Both design and science involve knowledge goals; however, these goals are quite contrasting and somewhat contradictory. Design knowledge goals are generative and creative, although tempered by requirements and constraints. Scientific knowledge goals are conventional and systematic, although favored by novelty. Hence, design-science is characterized by a duality present in the essential *knowledge goals* inherent in its process for making meaningful contributions.

### 2.8.2 Knowledge scope: distinguishing the nomothetic and idiographic

Given that the name of the paradigm is *design-science*, researchers must be cautious not to overload that duality with too many extraneous assumptions. For example, confusion ensues when the knowledge from *science* is conflated with *general* and the knowledge from *design* is conflated with *particular*. The distinction is important because it regards the *scope* of knowledge in both science and design. The philosophy of science uses the term *nomothetic* to regard knowledge claims that regard a class of phenomena and *idiographic* to regard knowledge claims that pertain to particular instances (Allport 1962):

“ ... the idiographic/nomothetic distinction involves the differences between individuals (or particulars) and universals (or general properties) ... [it] is a philosophical artefact, for every science is both nomothetic and idiographic.”  
(Bunge 1999, p.21, 33)

Nomothetic claims tend toward reductionism in theories: valuing parsimony and limiting the number of constructs or variables in causal statements. Idiographic claims tend toward contextualizing theories: valuing richness from larger numbers of constructs in causal statements (George and Bennett 2005). Because this general distinction in the different scopes of scientific knowledge is widely accepted in the philosophy of science<sup>4</sup> (e.g., Nagel 1961), it inhabits discussions about the scope of scientific knowledge in many diverse fields, such as chemistry (e.g., Lamza 2010), education (e.g., Deno 1990), geography (e.g., Fattorini 2007), history (e.g., Malewski and Topolski 2009), psychology (e.g., Franck 1982), sociology (e.g., Gerring 2006), and others. Recognizing this duality between parsimony and richness in design-science, Briggs and Schwabe (2011) argue that, although a relatively parsimonious theory with competitive explanatory power is preferable, increasing the explanatory power of a theory through “the addition of more constructs, axioms, or propositions to a theory” would yield a “contribution, even if it were less parsimonious” (p. 97).

The parallel distinction between the differing scopes of design knowledge is also found in the seminal work on design theory. Walls et al. (1992) distinguish design theories as those applying to a class of designs. Other design-science authorities distinguish local versus general statements (Järvinen 2007a; van Aken 2004). Local statements are usually addressed to the instance at hand, whereas general statements address a class of such instances. For example, van Aken describes general knowledge in terms of “the development of scientific knowledge to solve a class of managerial problems, in other words, the development of abstract knowledge” (van

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<sup>4</sup> The distinction is usually attributed to the German philosopher Windelband: “Windelband too would recognize two classes of science, the nomothetic (seeking general laws) and the idiographic (dealing with structured pattern)” (Allport, G.W. 1962. “The General and the Unique in Psychological Science,” *Journal of Personality* (30:3), pp. 405-422.).

Aken 2004 p. 220). It is possible to broaden a local statement to make it general, but then it ceases to be local. Likewise, it is possible to narrow a general statement to make it local, but then it ceases to be general. Referring to the nomothetic aspect of design, Friedman (2003) quotes Warfield (1990 p. 100) when defining the generic aspect of design as “that part of the process of design that is indifferent to what is being designed, being applicable whatever the target may be.” In contrast, the idiographic or specific aspect of design is “that part of the design process that is particular to the target class.”

Like knowledge goals, knowledge scope involves a separate nomothetic–idiographic distinction that presents a duality that inhabits the production of knowledge spanning across the design-science duality. The knowledge criteria that characterize the extremes of the nomothetic–idiographic duality are further developed below.

*Nomothetic* knowledge processes aim to produce general theories or concepts that cover the entire set of classes of a given case. Allport (1962) tempers the usage of the term nomothetic from the notion of universal (which rarely holds under modern scrutiny) to “an identifiable section of the population” (p. 406). Van Aken’s (2004) definition of design theories aligns with this. He finds that “a technological rule is typically not totally general, but applicable to a certain application-domain, a class of problems” (p. 229). Walls et al.’s (1992) definition of design theories also defines design theories addressing a “class of problems.” In design-science research studies, researchers derive nomothetic knowledge through processes that involve abstract thinking. Such abstract thinking considers the kind of problem at hand or the kind of solution that might be effective for a given problem. Nomothetic processes not only help the researcher to borrow from previously established knowledge, but also require the development of knowledge about kinds of problems and solutions, and the relationships among them.



***Nomothetic knowledge criteria.*** The highest qualities in nomothetic knowledge are recognized from criteria such as *applicability, generalizability, external validity, transferability, consistency, reliability, and dependability* (Guba 1981). All of these criteria acknowledge that the knowledge should be useful, not just for a single phenomenon, but also for similar phenomena (that is, for a class or kind of phenomena).

***Idiographic*** knowledge processes involve the study of particular cases such as persons, social groups, or works of art (Bullock et al. 1988). Idiographic knowledge processes aim to produce specific concepts for the problem setting and (potential) artifact at hand. In a design-science study, researchers derive idiographic knowledge through processes that involve practical thinking about the specific situation faced by the designer. This highly applied mode of thinking involves deciding exactly how to solve the particular problem at hand, perhaps without regard to other settings or solutions. Idiographic processes help the designer to think creatively about a unique situation and to develop knowledge about new, never before encountered situations and solutions.

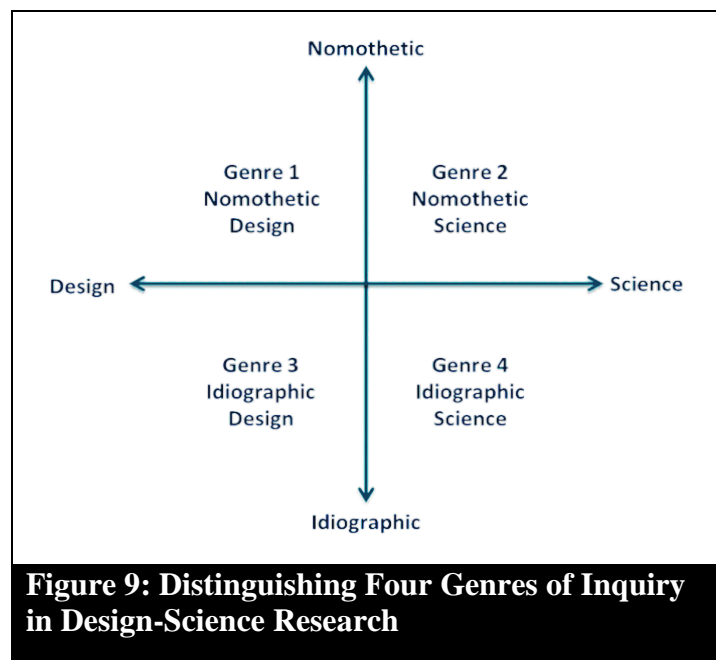
***Idiographic knowledge criteria.*** The highest qualities in idiographic knowledge are recognized from their satisfactory explanations that provide an understanding of the phenomenon in question (Goldstein and Goldstein 1978). Value is ascribed to the knowledge of concrete and unique properties, rather than general properties (Windelband and Oakes 1980). The knowledge is useful because the explanations and understanding penetrate the complexity of a highly multivariate event, providing insights that enlighten society. Because the phenomena are not repeatable, criteria focus on how the knowledge is distilled from the phenomena. Examples of such criteria include methods such as *prolonged engagements, persistent observation,* and

*triangulation* (Lincoln and Guba 1985), or principles such as *contextualization*, *dialogical reasoning*, *sensitivity to multiple interpretations*, and *suspicion* (Klein and Myers 1999).

***The nomothetic–idiographic duality.*** The process of design-science studies often invokes both nomothetic and idiographic knowledge scope. Knowledge building may occur through reuse of past artifacts, creation of new ones, reflection about the design process or about the artifact, or even design instruction (Cross 1982). Several methodologies have been extended whereby design-science research is considered as a process occurring through several successive phases. Designers, however, do not always traverse these steps sequentially and, based upon their experience and/or creativity, may analyze, synthesize, and evaluate them cyclically or even simultaneously. In many cases, it is only after a designer synthesizes a solution that it becomes possible to detect and understand important issues and requirements of the given problem (Suwa et al. 2000). This phenomenon is known as “analysis through synthesis” (Lawson 2006). Moreover, through the build-and-evaluate process, designers might discover that the solution to a specific design problem is generalizable to design solutions for similar situations. The actual knowledge used in the design process may be very specific or highly abstract, depending upon the complexity of the design and the stage of the designing process (Simon 1972).

### 3 PLURALISTIC VIEW OF DESIGN-SCIENCE RESEARCH: MULTIPLE GENRES OF INQUIRY

Design-science studies can produce contributions that contrast in both: 1) *knowledge goals*, and 2) *knowledge scope*. These two dualities are used to derive four genres of inquiry of knowledge production that operate in design-science studies. Specifically, these genres of inquiry emerge from the dualities of knowledge goals (contributions) to design and science, and knowledge scope (idiographic and nomothetic) as shown in Figure 9.



Similar to literary genres, design-science genres of inquiry are not mutually exclusive; neither are they stable. Design-science research can be an iterative and cyclical process. The evolutionary aspect of design-science research can be seen in the design process, the design product, and even the designer’s perspective. The iterative nature of design-science studies (Hevner et al. 2004) permits an evolutionary journey of the study across different goals, with respect to both: 1) the design product, and 2) the associated knowledge goals. Moreover, design-science studies are situated in real-world problems that further drive this evolutionary journey.

This iterative and evolutionary nature of design-science research can place design-science studies in different genres of inquiry at different times throughout the project's life cycle. These instances are referred to as *knowledge moments* in the research process. This paper's notion of a knowledge moment is adapted from knowledge management (Herder et al. 2003), where a knowledge moment is defined as a unit of knowledge processing, triggered by a specific need for knowledge and addressed by the specific delivery of the knowledge in a manner that is aligned with a given context. For example, at a particular moment, the context of a study might call for a creative design knowledge process with more characteristics of a design aspect in its genre of inquiry, whereas, at another moment, the research might demand more focus on the science aspect in order to deliver the knowledge needed.

This momentary change between contrasting knowledge goals in design-science studies is important because the criteria for validating this knowledge will differ depending upon the moment. A design-science study, article, or report cannot be classified as one knowledge type because there is no one ideal knowledge category of design-science research. Instead, the knowledge contributions of the study may involve articulating each of the genres of inquiry that it might momentarily occupy, with respect to the distinct knowledge criteria appropriate for each of those genres.

Because the four genres of inquiry proposed below are based on dualities, they represent *continua tendencies* (not categories): a momentary locus that design-science research may occupy. At one moment a design-science study may occupy one genre, whereas at other knowledge moments, it might exhibit characteristics of other genres. For example, a knowledge moment might tend to be more science and less design or tend to be more idiographic and less nomothetic.

Thus, the knowledge goals and the contributions in design-science studies can differ from moment to moment and from genre to genre. It is important to visualize design-science studies as knowledge moments in different genres of inquiry, since the method of conducting research, justifying it, evaluating it, and articulating the contributions varies from genre to genre. These genres proceed from the presence of the two dualities whose contrasting goals and scope can place knowledge across one or more genres. The collective dualities embody the fundamental kinds of knowledge production in design-science studies.

The basis in dualities also means that the different kinds of knowledge processes are interdependent in design-science studies. The science-tending knowledge moments depend on the outcomes of the design-tending knowledge moments (and vice-versa). Similarly, the nomothetic-tending knowledge moments depend on the outcome of the idiographic-tending knowledge moments (and vice versa). The two dualities describe a four-way dialectic through which design-science knowledge processes proceed as the study unfolds.

Table 3 summarizes the knowledge goal and knowledge scope of each genre. The remainder of this chapter details each of these four genres of inquiry including their distinctive goal and scope, nature of knowledge, and quality criteria.

**Table 3: Four Genres of Inquiry: Nature and Dynamic Criteria for Justification and Evaluation of Design-Science Knowledge**

|                 |             | Knowledge Goals   |  |
|-----------------|-------------|---|--|
|                 |             | Design Knowledge  | Scientific Knowledge   |
| Knowledge Scope | Nomothetic  | <p style="text-align: center;"><b>Genre 1</b><br/><b>Nomothetic Design Knowledge</b></p> <p>Nature: Knowledge applicable to a general class of problems. Examples of the resulting artifact are constructs, methods, models, design principles, technological rules, and design theory.</p> <p>Available nomothetic criteria: Applicability, generalizability, external validity, transferability, consistency, reliability, dependability.</p> <p>Available design criteria: Production of an acceptable similarity between expected and observed performance, creativity, innovativeness, and originality.</p>  | <p style="text-align: center;"><b>Genre 2</b><br/><b>Nomothetic Scientific Knowledge</b></p> <p>Nature: Generalized knowledge and generalized theories about natural or social settings and how these settings interact with classes of artifacts.</p> <p>Available nomothetic criteria: Applicability, generalizability, external validity, transferability, consistency, reliability, dependability.</p> <p>Available scientific criteria: Internal validity and objectivity.</p>  |
|                 | Idiographic | <p style="text-align: center;"><b>Genre 3</b><br/><b>Idiographic Design Knowledge</b></p> <p>Nature: Knowledge necessary for the research and development of a product. The knowledge role of the artifact is one of materializing or embodying this knowledge.</p> <p>Available idiographic criteria: Satisfactory explanations that provide an understanding of the design and its setting, prolonged engagements, persistent observation, triangulation, contextualization, dialogical reasoning, sensitivity to multiple interpretations, and suspicion.</p> <p>Available design criteria: The production of an acceptable similarity between expected and observed performance, creativity, innovativeness, and originality.</p> | <p style="text-align: center;"><b>Genre 4</b><br/><b>Idiographic Scientific Knowledge</b></p> <p>Nature: Knowledge to understand the underlying causes, structures, and generative mechanisms responsible for observed patterns in the study.</p> <p>Available idiographic criteria: Satisfactory explanations that provide an understanding of the design and its setting, prolonged engagements, persistent observation, triangulation, or principles such as contextualization, dialogical reasoning, sensitivity to multiple interpretations, and suspicion.</p> <p>Available scientific criteria: credibility and confirmability.</p> |

### 3.1 Genre of Inquiry 1: Nomothetic Design

A nomothetic design moment produces knowledge applicable to an identifiable section of a given population. This knowledge devises a concrete action that changes an existing situation into a preferred one. Further characteristics of this knowledge type include:

**Goal and scope.** In nomothetic design theorizing, knowledge processes aim to produce general knowledge about a class of designs. Nomothetic design produces elements such as meta-requirements, meta-designs, and knowledge about design processes.

**Nature of knowledge.** The knowledge processes devise a course of design action such that it is applicable to a general class of problems. Examples of the resulting artifact are constructs, methods, models, design principles, technological rules, and design theory. The knowledge role of such artifacts is one of materializing or embodying the generalized knowledge developed within the genre.

**Quality criteria.** The quality criteria for knowledge in Genre of Inquiry 1 include a mix of the criteria for nomothetic knowledge and design knowledge described earlier. These include applicability, generalizability, external validity, transferability, consistency, reliability, dependability, the production of an acceptable similarity between expected and observed performance, creativity, innovativeness, and originality (Guba 1981; Jones 2009; Martin 2009; Petroski 2009).

### 3.2 Genre of Inquiry 2: Nomothetic Science

A nomothetic science moment proceeds from a systematic and validated study of an identifiable section of the population or a similar class of cases. Further characteristics of this knowledge type include:

**Goal and scope.** In nomothetic science, knowledge processes aim at producing both nomothetic knowledge and scientific knowledge. Researchers seek to develop generalized knowledge and generalized theories about natural or social settings and how these settings interact with classes of artifacts.

**Nature of knowledge.** The role of knowledge is to represent truth in a way that has been proven or validated. The knowledge role of the artifact lies in the provision of a laboratory or field experiment with results that provides concrete validation (proof). The relevant theory is typically a natural or behavioral theory rather than a design theory. The objective of science is to interpret the relationships posited between constructs that are advanced by the scientific community and assess whether the knowledge is supported by adequate validation.

**Quality criteria.** The quality criteria for knowledge in Genre of Inquiry 2 include a mix of the criteria for nomothetic knowledge and scientific knowledge described earlier. These classic scientific criteria include applicability, generalizability, external validity, transferability, consistency, reliability, dependability, internal validity, and objectivity (Guba 1981; Lincoln and Guba 1985).



### 3.3 Genre of Inquiry 3: Idiographic Design

Idiographic design provides knowledge that is applicable to a particular problem setting or artifact that devises a course of action changing an existing situation into a preferred one.

Further characteristics of this knowledge type include:

**Goal and scope.** In this genre of inquiry, knowledge processes aim at producing both design knowledge and idiographic knowledge. Researchers seek to use their design knowledge and methods to produce an ideal artifact for a specific problem.

**Nature of knowledge.** The knowledge goals do not go beyond that necessary for the research and development of the necessary product. The knowledge role of the artifact is similar to Genre of Inquiry 1: embodying the knowledge developed within the genre. Unlike Genre of Inquiry 1, the scope of this role does not go expressly beyond the particular instance at hand.

**Quality criteria.** The quality criteria for knowledge in Genre of Inquiry 3 include a mix of the criteria for idiographic and design knowledge. These include satisfactory explanations that provide an understanding of the design and its setting, research employing prolonged engagements, persistent observation, triangulation, or principles such as contextualization, dialogical reasoning, sensitivity to multiple interpretations, and suspicion (Goldstein and Goldstein 1978; Klein and Myers 1999; Lincoln and Guba 1985; Windelband and Oakes 1980). Further criteria include the production of an acceptable similarity between expected and observed performance, creativity, innovativeness, and originality (Jones 2009; Martin 2009; Petroski 2009).

### 3.4 Genre of Inquiry 4: Idiographic Science

An idiographic science moment is a systematic and validated study of a particular problem setting or artifact. Further characteristics of this knowledge type include:

**Goal and scope.** Knowledge processes aim at producing idiographic scientific knowledge. The goal of idiographic science is to examine the properties, functionality, utility, or effect of an artifact. It can also develop an improved understanding of the process of designing or the activities of the designers. Design studies may draw from parallel design fields and may study the design methodology, the actual design constructs, or the implications of design by conducting an in-depth examination of the interaction of a specific design artifact within a specific setting. The key research objective is to scientifically examine, articulate, and explicate knowledge related to the design process or the artifacts it produces.

**Nature of knowledge.** The ultimate objective is the generation of scientific knowledge. Idiographic scientific knowledge goes beyond establishing patterns of events; rather, it seeks to understand the underlying causes, structures, and generative mechanisms responsible for the observed patterns (Tsoukas 1989).

Research techniques might be similar to change experiments, action research, case studies, ethnography, and so forth. Here, the knowledge role of the artifact is that of a vehicle for studying how behavior in the setting might shift as a result of the artifact's introduction.

**Quality criteria.** The quality criteria for knowledge in Genre of Inquiry 4 include a mix of the criteria for idiographic and scientific knowledge described earlier. These are satisfactory explanations that provide an understanding of the design and its setting, research employing prolonged engagements, persistent observation, triangulation, or principles such as

contextualization, dialogical reasoning, sensitivity to multiple interpretations, and suspicion (Goldstein and Goldstein 1978; Klein and Myers 1999; Lincoln and Guba 1985; Windelband and Oakes 1980). Further criteria include credibility and confirmability (Guba 1981; Lincoln and Guba 1985).

## 4 TWO ILLUSTRATIVE CASES

While idiographic design and nomothetic science are the more commonly identifiable in design-science research literature, the central motivation of this conceptual discussion is to unpack the complexity in diverse design-science research settings and to develop a clearer understanding of genres where a research study may have idiographic science goals or nomothetic design goals. In order to make these alternate genres more tangible, two exemplar design-science studies are analyzed to demonstrate their journey across the different genres and to justify the knowledge delivered. This justification enables us to evaluate the knowledge processes using the genres of inquiry and their related criteria. The cases illustrate the ways in which the genres of inquiry are interdependent.

For each example, this paper describes the study's main contributions, its kernel theories, and the artifacts produced. Then, the most important knowledge moments, including the knowledge goals, the related knowledge scope, and concomitant genre of inquiry are identified. Finally, the way in which these examples satisfy the relevant criteria for each knowledge moment is specified.

### 4.1 Illustrative Case 1: CyberGate (Abbasi and Chen 2008)

A Design Framework and System for Text Analysis of Computer-Mediated Communication

Abbasi and Chen's (2008) CyberGate study proposes a design framework for text analysis for computer-mediated communication (CMC) systems such as email, discussion forums, and chat. This framework embodies a set of general design principles for a class of systems that can support ideational, textual, and interpersonal analysis of computer-mediated text: "[W]e propose meta-requirements and a meta-design necessary to support CMC text

analysis” (p. 816). In addition to the framework, the authors provide guidelines for the selection of the features and visualization techniques for CMC text analysis systems.

This key contribution builds upon the Walls et al. (1992) model for the formulation of an IS design theory. The authors’ main kernel theory is Systemic Functional Linguistic Theory (SFLT). The authors instantiate their design theory in an instance artifact named CyberGate. They evaluate the artifact using Enron’s email database.

Consistent with their declared anchor in the Walls et al. (1992) concept of a design theory, the main knowledge goal of the CyberGate research is to produce nomothetic design knowledge (Genre of Inquiry 1). The study produces nomothetic design elements such as meta-requirements, meta-designs, and knowledge about design processes. The knowledge role of the design framework and associated guidelines is embodied in the instantiation of the CyberGate system and in a field test of CyberGate using the Enron email database. The testing of formally enunciated hypotheses provides concrete validation (proof) of the CMC text analysis design theory.

The researchers justify that the knowledge arising from this nomothetic design is consistent with the quality criteria of Genre of Inquiry 1. The design knowledge from the framework is generalizable to text analysis systems (See Table 3. p. 816) and consistent with the kernel theory and SFLT (Halliday 1994). SFLT provides three meta-functions: ideational, interpersonal, and textual, which lead to the three meta-requirements defined in the design framework. By designing and testing an instantiated system (CyberGate) they demonstrate dependability. There is similarity between the expected and observed performance. In six of the nine sub-hypotheses, the results of the experiments comparing the performance of CyberGate against the baseline performance of the support vector machine were significant at the alpha

level of .01 (See Table 7. p. 831). The design delivers an innovative application of CMC theories to novel areas. The research certainly demonstrates at least incremental creativity (See pp. 819-820).

Although the knowledge generated by the nomothetic design process delivers the main knowledge goal, the research exhibits different kinds of knowledge moments at other times. For example, the guidelines of the CMC text analysis systems framework were used to develop an instantiation of the CyberGate system. This design of a single instance of a CMC text analysis system requires an idiographic design knowledge moment (Genre of Inquiry 3). The aim of the knowledge process in Genre of Inquiry 3 is the application of design knowledge and methods to produce an ideal artifact for a specific purpose. The scope of knowledge in this genre moves from addressing a general class of problems to a particular, idiographic instance. Genre of Inquiry 3 (idiographic design) has parallels in the design-science research activity that March and Smith (1995) refer to as *artifact development*. The role of knowledge in this artifact development in CyberGate is to provide a rigorous basis for the fundamental principles (in this case, the design framework). Basing the design of the artifact on sound design principles ensures that the design is well grounded. It also validates the fundamentals of the design principles.

The design of the CyberGate system based on the guidelines emerging from the design framework (See p. 821) echoes Hevner et al.'s (2004) Guideline 1, "Design as an Artifact." CyberGate does not include a full-grown information system encompassing "people, organizational elements or the process by which such artifacts evolve" (Hevner et al. 2004, p. 82); rather, it provides a representation of an instance of the CMC-text analysis system. The discussion of the features incorporated in the design of CyberGate demonstrates its functionality (See pp. 821-826).

In terms of the quality criteria for Genre of Inquiry 3, Abbasi and Chen (2008) present a complex software system that implies their prolonged engagement with this study. They offer satisfactory explanations and use these to justify the selection of various features for CyberGate (See pp. 821-823). The test operation of CyberGate demonstrates similarity between the expected features of a text analysis system and the proposed software artifact. They also provide substantial details and output demonstrating the functioning of the various visualization techniques that are part of the system's features (See pp. 823-826). The design also exhibits creativity in such features as its "writeprints" and "inkblots" (See p. 824). This demonstration of CyberGate's functionality provides an evaluation that demonstrates how its features do, in fact, work.

There is another distinctively different knowledge moment in the process of applying the CyberGate system in a practical setting (the Enron database), which "illustrates how CyberGate can be used for data characterization of CMC text" (p. 826). At that moment in the research process, the work requires a study of an individual case of CyberGate use. This process involves idiographic science (Genre of Inquiry 4) because the knowledge goal is scientific (systematic generation of knowledge based on evidence) and the knowledge scope is idiographic (the evaluation of a single instance). To examine the actual design of CyberGate, and the implications of theory-based design of the systems, the authors conduct an in-depth examination of the interaction of a specific design artifact (CyberGate) within a specific setting (Enron email database). The research process in this moment involves scientifically examining, articulating, and explicating knowledge related to the process of designing a specific instance of CMC text analysis systems based on the SFLT-supported design framework. This genre of inquiry echoes Simon's (1996) conceptualization of the artifact as an interface between the "inner environment

or the organization of the artifact itself” and the “outer environment or the surroundings in which it operates” (p. 7).

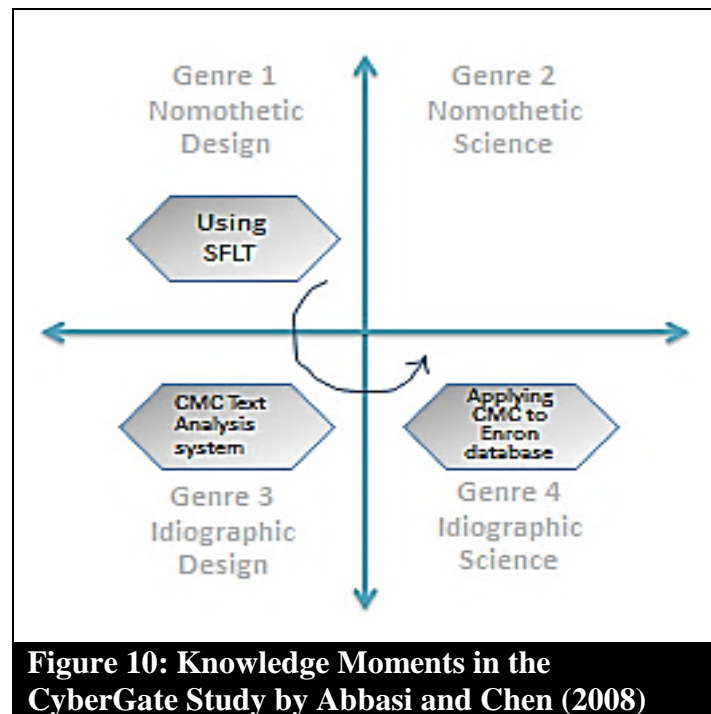
The quality criteria for validation of scientific knowledge in Genre of Inquiry 4 is demonstrated through persistent observation (“Clearly this dramatic alteration is attributable to a change in Author B’s job functions” (See p. 828)) and measurement of the visualization results (writeprints, inkblots, MDS plots, and parallel coordinates (See p. 827)). Triangulation of the results occurs in the comparison of CyberGate results against baseline results from a support vector machine through “experiments, where the writeprints or ink blots technique was compared against support vector machine (SVM)” (see p. 827). The researchers detail where the actual results do not match the expectations (“Error analysis on inkblots’ misclassified messages revealed that the higher performance of SVM was likely attributable to its ability to better classify the small percentage of messages that were in the gray area between topics” (See p. 831)). Credibility and confirmability have been ensured through a rich description and by providing a chain of evidence linking the data and the observations to the results.

Although there may be other knowledge moments, this research identifies three different genres of inquiry in the study. The main knowledge goal of the CyberGate paper is to produce nomothetic design knowledge (Genre of Inquiry 1). This knowledge is justified by its consistency with its kernel theory, but further justification drives distinctively different knowledge moments. To justify dependability, the authors required an idiographic design (Genre of Inquiry 3). The artifact development gave rise to a different knowledge moment with different criteria. The researchers justify their idiographic design knowledge by providing explanations of the design feature set, the similarity between expected and design features, and the creative elements among the design features. To justify the similarity between the expected



and observed performance, an instantiation case is required. Consequently, a different knowledge moment, idiographic science (Genre of Inquiry 4), arises with different knowledge goals and scope. This knowledge is justified with persistent observation, triangulation, credibility, and confirmability.

Figure 10 below illustrates the shifting of the knowledge moments in the CyberGate design-science study. This shift in knowledge moments is not necessarily a planned staging by the researcher; rather, it is a shift in the type of knowledge in the research and the concomitant way in which that knowledge is being evaluated.



## 4.2 Illustrative Case 2: The Variety Engineering Method (Rosenkranz and Holten 2011)

### Analyzing and Designing Information Flows in Organizations

The main contribution in Rosenkranz and Holten's (2011) variety engineering method (VEM) is the reconstruction of the conceptual language aspects of the viable systems model (VSM) (Beer 1989). The researchers consolidate the constructs of the conceptual modeling language (and their relationships) into a language-based meta-model. They assign the conceptual language to representational language views and provide the general steps for modeling an organization's information flows using Beer's VSM.

Working forward from the VSM, the researchers offer a running case to illustrate the steps in VEM. This case is grounded in a number of field studies (detailed in previous publications) that demonstrate the various stages and iterations of the development process. As proof-of-concept, the researchers instantiate VEM as a software tool: an instance artifact that can infer the information channels from the systems perspective model.

The main knowledge goal of the VEM study is to extend the VSM with language views. The research process aims to analyze the interaction of the artifact (the VEM model as well as the technical prototype) in multiple field settings in order to conduct a rigorous evaluation and to extend the VSM with language views. This process delivers distinct nomothetic science knowledge moments (Genre of Inquiry 2). For example, the VEM method was developed by drawing on theoretical concepts from organization theory, systems theory, and cybernetics. The motivation for doing so was to "specify and formalize the VSM," thereby making VSM "accessible for formal analysis, enhancement and critique" (p. 38). The study has nomothetic

science knowledge moments when formalizing the specification of the underlying VSM by extending a language-based meta-model and by applying the VEM “in different field studies both with and without the prototype tool support” (p. 39).

Comparing this knowledge process to the quality criteria for nomothetic science shows applicability in the field studies resulting in the configuration and redesign of VEM (see Table 3, pp. 41-43). Although the researchers acknowledge that subjectivity is an inherent problem in field studies, they also conducted micro-evaluations by applying “VEM in different field studies in different stages of its development, both with and without the prototype tool,” in order to rigorously demonstrate the applicability of VEM (see p. 39). The meticulous threading of VSM into VEM provides consistency and internal validity. The scientific knowledge is generalizable to the mapping of organizational information flows. Transferability is demonstrated by the evaluation of the model in field studies in different organizational environments such as banking, healthcare supply chains, and construction (See Table 3. p. 41).

While the knowledge generated by the above nomothetic science process may deliver the main knowledge goal, the research has different kinds of knowledge moments at other times. For example, the authors propose a general method to address the problem of analyzing and designing information flows in organizations. The method consists of a modeling language providing constructs and their relationships, action guidelines, and a step-by-step procedure model explicating the process of how to analyze and design information flows (see p. 13). Although the authors stress that the research is aimed at producing an efficient artifact rather than new general theoretical knowledge (see p. 13), they do examine a general problem and suggest a general process model. Therefore, the research goals and scope at this moment in their study align with Genre of Inquiry 1, nomothetic design.

Consider this process in light of the quality criteria for nomothetic design. By providing a meta-model, defining the constructs of the VEM, and defining the relationship between the constructs, the study provides a platform for generalizability. In order to make the model transferable to other similar situations of analyzing and mapping the information flows, the study provides detailed steps and guidelines in Section 5.5 (see pp. 35-38). However, any demonstration of this transferability is deferred to a subsequent research project. The authors also state that their meta-model can be analyzed and compared with meta-models of other interpretations of the VSM (Siau and Rossi 1998). By applying the VEM in different field studies and developing it further during the various recursions, the authors were ultimately able to arrive at a level of utility that demonstrates the similarity between expectations and achieved performance. The study demonstrates at least incremental creativity by using an innovative approach (see Table 3, pp. 41-43).

At a different moment, the research process involved configuration of VEM in the healthcare supply chain case presented in Section 5 (see p. 25). This single instance of the VEM system requires an idiographic design knowledge moment (Genre of Inquiry 3). The knowledge process aims to apply the VEM method to model the information flows in the exemplar supply chain. The scope of knowledge in this genre of inquiry moves from addressing the “general problem of analyzing and designing information flows in organizations” (p. 13), to specifically developing “a prototype for tool support as a technical realization of the method in a working system (instantiation)” (p. 13). The role of knowledge in this artifact development is to provide a proof of concept of the VEM and to refine the model through iterations between Genre of Inquiry 3 (idiographic design) and Genre of Inquiry 1 (nomothetic design). Basing the design of the VEM method on sound design principles not only ensures that the design is well grounded,

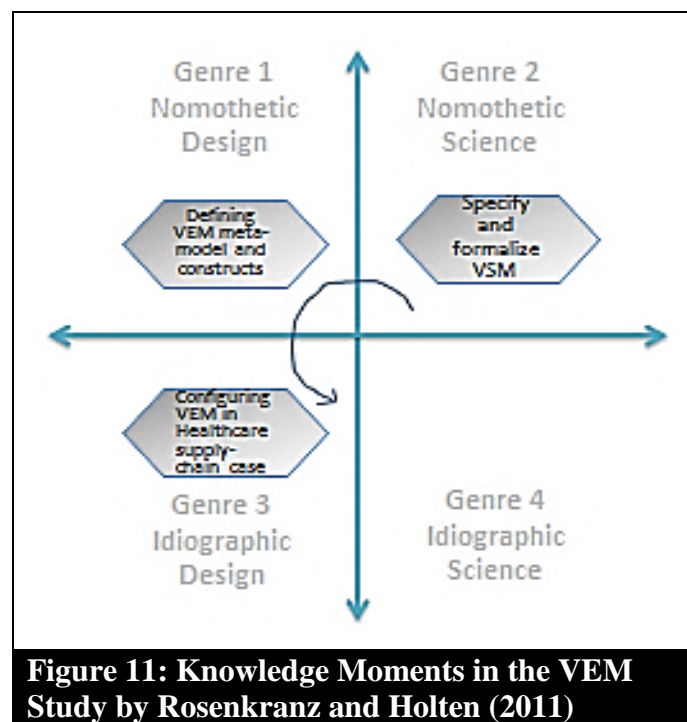
but also helps strengthen the fundamentals of the design principles through a validation of the VSM and associated language notations. The instantiation of the VEM method provides a representation of an instance within the context of a healthcare supply chain case based upon Hevner et al.'s (2004) Guideline 1. The step-by-step description of the healthcare supply chain case demonstrates VEM's functionality. In addition, the researchers develop a software tool that automatically infers information channels from the system perspective model (See Figure 10. p. 40).

In terms of the quality criteria for Genre of Inquiry 3, Rosenkranz and Holten (2011) explain and justify the construction of the VEM method (See Section 5 pp. 25-38) using a running example. This extensive example of VEM's construction provides persistent observation, prolonged engagement, and contextualization. This example is the instantiation of the Arvato case. Extensive details and output are provided to show the construction and application of VEM (See pp. 25-50), including the language notations (See Appendices A1, A2, A3). There is convincing evidence that the features of the VEM work as expected. This evidence shows how the artifact delivers an acceptable similarity between expected and observed performance.

Although there may be other knowledge moments in this example, this paper has identified three different genres of inquiry present in the study. The main knowledge goal of the VEM paper is to produce nomothetic science knowledge (Genre of Inquiry 2). This knowledge moment is justified by its consistency, internal validity, and generalizability. Claims of applicability and transferability depend on further justification from distinctively different knowledge moments. In order to justify this applicability and transferability, the authors constructed a meta-model, a method, and a general language for situating VEM in applied

settings. By engaging this nomothetic design (Genre of Inquiry 1) process, the study laid the groundwork for situating VEM in an applied setting. This knowledge process is justified by seeking transferability, similarity between expectations and achieved performance, and creativity. The need to convincingly justify the models meant making an artifact of idiographic design (Genre of Inquiry 3). This development of a design for a prototype artifact gave rise to different justification and evaluation criteria. The researchers justify their idiographic design knowledge by its persistence with a prolonged running example, its suitability for the prototype context, and an acceptable similarity between expected and observed performance.

Figure 11 below shows the knowledge moments for the VEM study.



**Figure 11: Knowledge Moments in the VEM Study by Rosenkranz and Holten (2011)**

## 5 DISCUSSION OF THE THEORETICAL DISCOURSE

The two examples reveal how a single design-science study spans different genres of inquiry during its research process. They demonstrate that, as the needs of the study drive the researchers from one genre of inquiry to another, the knowledge goals and knowledge scope of the research processes change. Likewise, the knowledge justification or evaluation criteria changes when each different knowledge moment arises. These changes are neither capricious nor opportunistic, but are instead driven by the interdependence of different knowledge moments in design-science studies. It would be difficult to advocate for a methodology for changing the knowledge moment. It is not so much that design-scientists try to change the knowledge moment. It is the need of the research and the different type of knowledge that moves the study to a different genre.

Any design-science study may find it necessary to conduct groundwork in original, generalizable scientific findings (Genre of Inquiry 2, nomothetic science), use this original groundwork to develop new design principles or a new design theory (Genre of Inquiry 1, nomothetic design), justify its validity by developing a prototype (Genre of Inquiry 3, idiographic design), and then justify the utility of the prototype by testing it in an experimental setting (Genre of Inquiry 4, idiographic science).

Design researchers do not choose between these genres, but rather build a research process by using each of them as the study requirements unfold. The knowledge processes of these different genres create a multiparadigmatic characteristic in design-science in which different kinds of knowledge processes become intertwined in interdependent ways. This multiparadigmatic characteristic in design-science studies means that researchers must be careful not to fall prey to the urge to be overly consistent in the criteria they use to justify the knowledge

their processes produce. At one moment, their knowledge processes may need to fit the mold and the criteria of nomothetic science. In another moment, their knowledge processes may need to fit the mold and the criteria of idiographic design. Likewise, the audience for design-science studies must be prepared to evaluate the products of different knowledge moments according to the criteria appropriate for each moment.

Because of its multiparadigmatic characteristic, it is neglectful to criticize only the scientific rigor in design-science processes (such as methodology and evidence). An emphasis on science may have been understandably motivated by the need to acquire status as a research paradigm equivalent to science (e.g., Simon 1996). However, overlooking the design aspect lessens awareness of the complex, creative, and generative knowledge processes involved in design. It has also reduced the awareness of the rich and varied role of knowledge in both the design process and the science process. Similarly, it is neglectful to criticize design-science only on the classic model of nomothetic studies. This viewpoint is useful in seeing how a deductive model of design theory pronounces a generalized form of design knowledge. But this emphasis neglects the critical role of instance designs and naturalistic studies that invoke more idiographic forms of scholarly knowledge.

One powerful feature of design-science arises in the interdependence of knowledge processes arising at different points in time and at different points in the spectrum of nomothetic and idiographic design and science. Knowledge processes in design-science are not intended to be consistent in nature, but they should be cooperative and symbiotic in delivering the knowledge necessary for the overall goals of the study. Furthermore, a good design-science study should be able to justify the products of its important knowledge moments based upon the appropriate criteria for the assumptions and goals of these knowledge moments. Such



justification requires the appreciation of the complexity of knowledge developed in design-science studies.

These studies can range across a rich landscape of knowledge forms that correspond to different characteristics and quality criteria. Consequently, justifying or evaluating the knowledge of a design-science study requires invoking differing criteria for differing kinds of knowledge produced at differing knowledge moments during the research. These criteria are *dynamic* in the sense that the appropriate evaluation criteria are variously selectable depending upon the genre of inquiry operating at the knowledge moment. Table 3 summarizes the identifying nature for determining a genre of inquiry's knowledge moment, as well as the dynamic criteria for evaluating the knowledge produced at a given knowledge moment.

Design-science studies necessarily conjoin design and science. At first glance, this appears to be the conceptual union of different mental faculties. Design is often a creative and generative mental activity, whereas science is often deductive and analytical. Design is perceived as being “inherently non-propositional (generative design as a mode of art production) under the domain of a propositional activity (analytical research), resulting in logical difficulties” (Groat and Wang 2002 p. 105). The recognition of how the interdependence of design and science unfolds in one scholarly discipline (design-science) helps overpower these potential logic problems for both design and science.

In social science, such paradigmatic distinctions as those between genres of inquiry inhabit both theory and methodology (Burrell and Morgan 1979). In design-science studies, the genre distinctions mainly inhabit the differing processes that produce knowledge. One further parallel is apparent. In social science, nomothetic approaches appeal to the scientific instincts common in the natural sciences, such as the hypothetico-deductive experimental approaches. A

nomothetic-dominant genre of inquiry will lead to questions about whether more idiographic approaches, such as more inductive in-depth case studies, action research, or grounded theory, really qualify as social science. A parallel schism may occur in design-science research, where questions may arise about whether action-oriented studies of creativity in design really qualify as design-science research. This debate could easily extend to question the scientific value in the use of scientific approaches to design that result in important, but unique, designed artifacts. Such questions are surprising, since the foundations of design research and the sciences of the artificial arise precisely from such design studies. The idiographic genres lend themselves easily to theory-guided abductive generalizations based upon observations in individual cases (Salvatore and Valsiner 2010). They are a proven means of acquiring generalized design knowledge.

The genres-of-inquiry matrix provides a means of comparing the role of research to that of design. The recognition of the role of design, which is fundamental to the design discipline, has been studied extensively in other domains. Articulating the role of knowledge provides a basis for delineating the different forms of the design-science knowledge process. This articulation provides a better appreciation of how each form can enrich design-science knowledge, be it design-related or more scientific. Thus, one contribution of this work is to clarify the relationships between design studies and other forms of research, as suggested by the genres-of-inquiry matrix in design-science.

The knowledge criteria derived from the genres of inquiry operate at a knowledge production level, as opposed to a paradigmatic level. Hevner et al. (2004), for example, provide defining guidelines as requirements for *conducting* design-science research, which is complementary to the criteria defined in this paper that provide a means for *justifying and*

*evaluating* the quality of the processes producing various *kinds of knowledge* in design-science research.

It is likely there will be the presence of multiple genres of inquiry in most design-science studies. The researcher is engaged in creating an artifact and theorizing about it. These different kinds of knowledge, that come out at different times in the intellectual activity, are more specific at certain points of time and more general at other points of time. This means that design-science researchers face the need to justify their different knowledge contributions in different ways within any single study. Any design-science study's contributions will typically be a collective of knowledge produced within different genres of inquiry. The diverse nature of this collective means that important contributions are produced in a process where the logic anchors one knowledge claim that arises from idiographic design to a second knowledge claim that arises from nomothetic science, all from within a single empirical design-science study. Both originators and reviewers of design-science studies must be prepared for such differing justifications for knowledge claims within a continuous thread of logic. In design-science studies, it is not usually possible to deliver, in any meaningful way, only the knowledge claims from within a single genre of inquiry. Often attempts to do so will not deliver a sufficient body of contribution to win appraisal as a significant achievement. As a result, design-science studies might seem shallow and faulty when represented only as either design or science. It is the intertwining of knowledge claims from differing genres of inquiry into a single thread of logic that leads to significant contributions. The CyberGate and VEM cases above illustrate successful ways to build reports of this logic.

To an extent, the dualities have developed because of the paradigmatic forces that guide scientific peer review. The theory orientation of powerful forms of behavioral research can drive

evaluation criteria to focus on theory. Consequently, design-science reviewers might minimize the value of the creativity and utility underlying an elegant design and instead emphasize only the scientific truth. These tensions endure in the Information Systems community. An understanding of the genres of inquiry developed and articulated in this research provides practical value to those involved in design-science, its reporting, and its evaluation. Different modes of inquiry are relevant to different stages or processes of a design-science study. Perception of these differing knowledge moments (as the research evolves through one or more genres of inquiry) permit a research designer to attend to the differing aspects of knowledge quality.

Such understanding will help research designers avoid, for example, attempts to establish nomothetic science validity for knowledge developed in an idiographic design knowledge moment. Similarly, a carefully prepared report of a design-science study can better guide a research evaluator through the quality criteria appropriately developed in each important knowledge moment. By specifying genre transitions and how the criteria are met, a design-science report will help reviewers evaluate the quality of the knowledge delivered and justified by the study. This understanding of the dynamic nature of diverse knowledge genres in design-science will also help make this form of research more approachable and less confusing to novice researchers.

The genre-of-inquiry matrix helps guide researchers in conducting a quality design-science study by justifying their knowledge on the assumptions and goals appropriate to the moment. It also helps in evaluating the knowledge processes against the appropriate criteria for those assumptions and goals. The presence of multiple genres of inquiry, and the concomitant presence of dynamic knowledge criteria, is an interesting feature in design-science studies. To

an extent, it helps explain the confusion surrounding the simultaneous presence of systematic science, creative design, law-like generalizations, and single-case instances. The multiparadigmatic characteristic of design-science brings to the forefront the dynamic nature of knowledge moments. They can occur continuously in a single study, making it helpful to justify the quality of knowledge using the identifiable genres of inquiry knowledge moments. It is possible that other forms of research engage in such differing forms of knowledge moments in more subtle ways. Further study is needed to assess whether this phenomenon is unique to design-science or common to a differing degree across other research approaches.

The production of knowledge-bearing artifacts from design-science studies is well understood. Gregor and Hevner (2013), for example, describe how these artifacts embody knowledge claims in terms of their levels of contribution, their descriptive versus prescriptive nature, and the maturity of preexisting knowledge in both the problem and solution domains. The dynamic nature of the genres of inquiry in typical design-science studies describes the differing ways of reasoning throughout such studies that produce the kinds of knowledge-bearing artifacts described in Gregor and Hevner (2013). An understanding of the momentary and dynamic nature of knowledge production in design-science studies diminishes the expectation that a particular genre of inquiry will undergird a particular kind of knowledge claim embedded in a design-science artifact. Design-science studies switch genres of inquiry from knowledge moment to knowledge moment as the study advances. Researchers might expect that the most important knowledge claims from a design-science study might align with certain moments during its knowledge production. For example, prescriptive knowledge claims might arise directly from knowledge moments in the nomothetic design or idiographic design genres. But it is unlikely that one particular knowledge moment of reasoning (one particular genre of inquiry)

completely explains an important knowledge claim or artifact. Rather, it would be explained by the unique pattern in the genres of inquiry that progressed in the process of the design-science study. For example, in Gregor and Hevner's (2013) terms, if a design-science study produced a Level 3 Invention, the researcher should recognize that the study cannot be entirely evaluated according to criteria applicable to Genre of Inquiry 1 (nomothetic design). The study is most likely to have engaged in other genres of inquiry as part of the process of producing a Level 3 Invention knowledge-bearing artifact.

Focusing on the dynamics of knowledge production through genres of inquiry and their quality clarifies how knowledge is central in design-science. The two contrasting dualities that inhabit design-science facilitate the articulation of the four genres of inquiry in knowledge production and illuminate the varying contrast in the kinds of knowledge that are important. A designer's knowledge is central to design, and a scientist's knowledge is central to science. In design-science studies, the researcher must be equipped with expertise in all four consequent genres of inquiry. As a result, excellence in design-science requires much knowledge versatility. Specifically, it requires understanding the genres of inquiry, the knowledge moments, the natural progression of a design-science study, and the most effective evaluation criteria available for justifying knowledge.

## PART II: PRACTICAL DISCOURSE: AN IS SECURITY THEORY

Design-science research is a research paradigm that employs an artifact-build and artifact-evaluate cycle in place of more traditional natural science methods (Hevner et al. 2004). A core element of design-science is design theory, a different kind of theory distinctive from natural science theory. Natural science theories describe the current and past states of reality. Design theories are prescriptive in the sense that they describe both a desirable future state of reality and explain how that future state of reality might be achieved through the development of an artifact (Walls et al. 1992).

In the natural sciences, theorizing involves the specification of universal statements in a way that permits them to be tested against observations in reality (Gregor and Jones 2007). In design-science, design theorizing also involves the specification of universal statements. However these universal statements map universal solutions to universal problems; that is, they explain the relationship between a class of potential solutions and a class of existing problems (Walls et al. 1992). The potential nature of this relationship means that design theorizing must often be conducted in a cyclical fashion such that a solution can be created in an experimental way in order to test whether the solution operates favorably against the problem. Hence, the build-and-evaluate cycle enables observations in reality to inform the theorizing. As a result, theorizing in design-science can be both more complex and more experiential than theorizing in the natural sciences.

Descriptive theories, such as those in the natural sciences, are anchored to past and present observations. They aim at an understanding of our past and current reality. Prescriptive theories, such as those in design-science, are future-oriented. Since they deal with finding solutions to problems, they cannot only be anchored to past and present observations, but must also depend on predictions of the future states of (improved) reality. Such future states may



indeed even be reshaped by the artifacts that are the outcomes of design-science. Predictions of future states of reality that are based on the continuation of the patterns of past states are difficult to justify with traditional scientific logic (Lee and Baskerville 2003). For design-science, such suppositions depend on the elements of the problems remaining similar, the elements of the solutions remaining similar, and the relationships between problems and solutions remaining similar (Baskerville and Pries-Heje 2010). The future orientation is expected to improve or find a solution to an existing problem.

The innate difficulties with the future-dependent nature of design theories can be deeply exacerbated when dealing with rapidly changing technologies and complex social environments. For example, the intersection of mobile technologies, cloud technologies, consumerization of information technology, and social networking has created an incredibly complex, extremely dynamic, and fast-changing technical environment for many organizations where individuals (employees and customers) apply their own devices when interacting with organizational systems (Soebhaash et al. 2013). It reflects the complexity that is following the impact of technology commoditization on individuals and the professions (Gannon 2013), the impact of big data on individuals and professions (Rust and Huang 2014), and the “increasing communicative power of individuals, communities, organizations, nations and regions” (Dutton et al. 2004 p. 28). This highly complicated environment is developing as a set of complex sociotechnical problems for information security within Organizational Information Systems, in particular, the security problems incorporated in bring-your-own-device (BYOD) (Thomson 2012).

The research problem is the necessity to conduct future-oriented design theorizing in the highly complex sociotechnical environment pertaining to BYOD. *The specific objective of the*

*design theorizing activity in this research is to address the organizational adaptation of its information infrastructure to be able to securely interact with individually provided Information Systems.* Generally, Organizational Information Systems security is implemented through restrictive behavior of the system by employing well-formed security controls that result in predictable performance of the system (Baskerville 1992). However, the complex and fast-changing technological environment requires alternate approaches to managing security.

A fairly new, and as yet untested, theory for managing security in complex and dynamic environments is extended by Baskerville and Lee (2013). They extend a bindpoint model for organizational and Individual Information System interaction. Based on the parameters of the interconnecting systems at the instance of the interaction, the security stance is computed. This computational risk model replaces the use of predictable security with an instantaneously computed risk posture. As an illustrative case, Baskerville and Lee apply the model to a BYOD applied in a BYOD scenario.

Hanseth and Lyytinen (2010) propose a design theory to address the dynamic complexity in shared, open, heterogeneous, and evolving socio-technical systems of information technology or information infrastructures (IIs). This theory has yet to be evaluated empirically to investigate for applicability in the BYOD context. This study uses a design theorizing approach (Baskerville and Pries-Heje 2010; Walls et al. 1992) to apply the bindpoint model and the infrastructural component of the CAS theory for the design of secure BYOD systems.

A host of individuals bringing in computing mobile devices into an organization creates a high degree of complexity, and this complexity gets compounded when these devices are frequently swapped out for new models with different capabilities. The devices could be used for either personal or work use. The devices are supported by sophisticated infrastructure in

terms of networks and operating systems, making them into autonomous functional systems. In this scenario, the complex adaptive system (CAS) theory (Hanseth and Lyytinen 2010; Holland 1995) can help provide an adaptive theoretical framing device (kernel theory), to apply (and develop) the bindpoint model (Baskerville 2013) for designing robust and secure information infrastructures to address the security issues arising from BYOD. The CAS theory helps to apply adaptive thinking, while the bindpoint design theory helps to view each component (within an information infrastructure) in a simple way that interacts with another component within the larger information infrastructure.

Next, an empirical study is conducted to understand the key issues relating to BYOD security to evaluate the application of the bindpoint model. The study uses an approach called *search conference*, which is adapted as a collaborative, future-oriented, design theorizing methodology. Search conference is an experiential technique that stimulates active adaptations for turbulent environments (Williams 1979). It has been widely used in participatory settings and has been found to be ideal for uncertain and turbulent environments where surprising disruptions yield chaos. The empirical study contributes to three key areas: 1) BYOD security, 2) design theorizing using a multigenre perspective, and 3) the search conference research approach. The rest of this section is structured as follows:

Chapter 6 describes the problem setting of BYOD. Chapter 7 provides the background of the CAS theory and the bindpoint model that will be evaluated as a solution for the problem of BYOD security. Chapter 8 details the research approach, including a review of the search conference methodology, its main use in participative strategizing, and its adaptation for design theorizing. Chapter 9 describes the employment of search conference for the adaptation of a design theory and the bindpoint model for BYOD, along with the conduct of the search

conference and its findings. Chapter 10 concludes Part II with a discussion of learning from this study, the contributions to practice and theory, and related limitations and implications.

## 6 THE BYOD PROBLEM SETTING

Organizational information security concerns arise from dynamic changes in the technological landscape. More recently, consumerization has changed the computing environment such that new forms of technology are being brought into the organizational setting by individuals. One of the contexts within which consumerization has become a focal topic for organizations is BYOD, or bring your own device.<sup>5</sup> This phenomenon has emerged due to consumerization-led improvements in the computing capabilities of devices such as smart phones and tablets and the availability of high-speed networks (Moschella et al. 2004). According to industry reports, organizations have been swept into the wave of acceptance and adoption of BYOD (Bradley et al. 2012; Willis 2013).<sup>6</sup>

### 6.1 Consumerization and BYOD

The terms “consumerization” and “BYOD” are often used interchangeably. For example, consumerization is referred to as “privately-owned IT resources such as devices or software that are used for business purposes” (Niehaves et al. 2012 p. 1). However, consumerization and BYOD are distinct concepts. In practice, consumerization is the phenomenon in which a trend has origins in the consumer market and subsequently spreads to the business world. In Gartner’s information technology glossary, consumerization has been

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<sup>5</sup> There are currently numerous variants of the term “BYOD.” Some of these variations draw on “what” is being brought into the computing environment. These variations on the BYOD terminology include BYON (bring your own network), BYOS (bring your own systems), BYOApp (bring your own application), and BYOT (bring your own technology). Some of the variations of BYOD are drawn from the source of origination of the device and include OYOD (own your own device), HYOD (here is your own device), and CYOD (choose your own device). The lens of information infrastructure addresses all of these variations. Also, this research comprehensively includes the general impact of all of these variants on organizational security. Therefore, for the sake of simplicity, the term “BYOD” will be used in the rest of the paper.

<sup>6</sup> [http://www.cisco.com/web/about/ac79/docs/re/BYOD\\_Horizons-Global.pdf](http://www.cisco.com/web/about/ac79/docs/re/BYOD_Horizons-Global.pdf) and <http://www.wired.com/2014/02/new-platforms-riding-mobility-wave-mean-new-business-value/>.

defined as “the specific impact that the pervasiveness of consumer-originated technologies has on enterprises. It reflects how enterprises will be affected by, and can take advantage of, new technologies and models that originate and develop in the consumer space, rather than in the enterprise IT sector.”<sup>7</sup> Harris et al. (2012) distinguish between consumerization from the individual’s perspective, the organization’s perspective, and the market’s perspective.<sup>8</sup> This research follows their view of consumerization as a combination of the three different perspectives – how employees consume IT, how markets offer IT, and how IT departments deploy and maintain IT (Harris et al. 2012). This allows us to examine the effects of technological advances at the intersection of the individual and the workplace.

BYOD can be viewed as one effect of the more general phenomenon of the consumerization of IT and refers to the use of personally owned device(s) for work purposes (Moschella et al. 2004). The devices used by individuals are “consumer-grade” (Mann et al. 2013). Due to these advances in powerful multifunctional mobile devices such as smartphones and tablets with intuitive interfaces, individuals are increasingly bringing in the technology that they use for personal productivity into the workplace. This includes mobile devices such as laptops, smartphones, and tablets, as well as social media applications and other cloud-based services (Mann et al. 2013).

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<sup>7</sup> <http://www.gartner.com/it-glossary/consumerization>, accessed June 4, 2013.

<sup>8</sup> Individual’s perspective: Individual’s usage of, and familiarity with, devices and applications in his or her personal life that are useful when applied to the individual’s job; experiences gained from personal life are seamlessly transferred and expected in the workplace.

Organization’s perspective: the plethora of devices and applications used within the corporate firewall that may not be part of a company-sanctioned list and/or have not been formally approved and that may be seen as either a threat or an opportunity.

Market’s perspective: every device and application that originates in the consumer market and that, at least originally, was not targeted to be used in addition to, or in lieu of, enterprise IT.

## 6.2 Impact of BYOD

Corporate managers welcome BYOD because it brings such benefits as the convenience of working from anywhere, a willingness to work after hours, and increased productivity (Copeland and Crespi 2012). Despite these advantages, a number of characteristics of BYOD can create security concerns. First, although these devices are used by individuals at work, they remain under the control of the individual at all times, even outside of work (Mansfield-Devine 2012). Second, individuals not only use their devices both within and outside the workplace but also access the organizational network both within and outside the workplace. Third, these devices are configured according to their personal requirements, may carry a variety of applications and personalized content, and may be susceptible to use by those with whom the individual shares the device, such as a friend or family member. Fourth, these devices have a relative lack of constancy. For example, because newer and more powerful devices frequently become available, individuals may decide to buy new devices. Similarly, individuals may download and start using new applications on their devices. They may change the service provider for their Internet services. Finally, the recent trend is for individuals to own more than one mobile device – for example, a laptop, a smartphone, and a tablet, all of which may be accessed for personal use or work.<sup>9</sup> These characteristics of BYOD can result in a number of issues such as blurring of personal and work use of mobile devices, heterogeneous configurations, risks from device loss, and governance issues. These are described below.

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<sup>9</sup> [http://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Borderless\\_Networks/Unified\\_Access/byodwp.html](http://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Borderless_Networks/Unified_Access/byodwp.html)

### 6.3 Blurring of personal and work use

At any point of time, when people use their devices for work, they expect a seamless transition across devices and support for multiple devices. This expectation creates a duality in terms of device usage when individuals use their mobile devices to access an organizational information system. This duality arises from the fact that the ownership and control of the device remain with the individual, yet the onus of providing connectivity and managing security rest on the organization. This aspect of BYOD distinguishes it from consumerization. A key problem arising from the consumerization of IT is therefore the problem of security arising from BYOD and from the pressure on the organization to provide secure access to people bringing in their own device while at the same time safeguarding its own (the organization's) information infrastructure. This challenge is especially difficult for an organization, since there can potentially be exponential growth in the number of configurations that it would need to support in addition to managing its own systems.

Implementation of mobile technology in organizations entails information security concerns (Scheepers and Scheepers 2004). Niehaves et al. (2012) note that the use of BYOD mobile devices increases risks for corporate information security, increases the complexity of integration with enterprise systems, increases process risk in IT systems, and increases compatibility and reliability issues. Moreover, the level of connectivity (increased number of points of entry into the system) is related to the level of security risk (Loch et al. 1992). In this scenario, organizations wrestle with providing access to their Information Systems. At the same time, they must maintain the confidentiality not only of their own information, but also of the data that they collect from individuals, employees, customers, suppliers, and other business partners with whom they interact. Faced with an array of different types of devices, systems, and



applications requiring access to its network, systems, and devices, organizations are retroactively looking for solutions to manage security and privacy-related concerns arising due to BYOD.

#### 6.4 Dynamically changing technology; heterogeneous configurations

The easy availability of newer technology is one of the key issues with BYOD. This availability results in an ever-changing multitude of different device types, which have not only different operating systems, but also different variations and versions of operating systems. A concern for organizations “operating in a BYOD environment is finding a secure and effective way to deploy applications and software to various devices while meeting the organization’s security framework.”<sup>10</sup> Whereas corporate IT departments were previously faced with supporting a narrow range of laptops and devices, they are now faced with increasing fragmentation in device types and operating systems, and the potential configurations that can result from this variation. A recent survey by OpenSignal in 2013<sup>11</sup> found 11,868 distinct Android devices alone. Over the past few years, a number of different versions of the Android operating system have become available,<sup>12</sup> at least eight of which are commonly in use. This makes both technical support as well as security management extremely complex.

<sup>10</sup> [http://vmblog.com/archive/2013/01/28/thin-client-model-and-byod.aspx#.U4KFyKjD\\_IU](http://vmblog.com/archive/2013/01/28/thin-client-model-and-byod.aspx#.U4KFyKjD_IU), accessed May 25, 2014.

<sup>11</sup> <http://opensignal.com/reports/fragmentation-2013/fragmentation-2013.pdf>, accessed June 2, 2014.

<sup>12</sup> Android versions 1.0 and 1.1 were not publicly named. Currently available Android OS releases include Cupcake (Android 1.5), Donut (Android 1.6), Éclair (Android 2.0 & 2.1), Froyo (Android 2.2), Gingerbread (Android 2.3), Honeycomb (Android 3.0 & 3.1), IceCream Sandwich (Android 4.0), three different versions of Jellybean (Android 4.1, 4.2, and 4.3), and, most recently in fall 2013, KitKat (Android 4.4). <http://android.stackexchange.com/questions/11400/what-are-the-names-of-the-various-versions-of-the-android-os-and-how-are-these>, accessed June 2, 2014.

## 6.5 Device loss

Another type of security risk arises from the likelihood of devices being stolen, misplaced, or lost (Miller et al. 2012). Since the devices have the capability to store large volumes of data and have advanced computing capabilities, misplacing or losing the devices may result in access being provided to unintended entities. The person(s) who has physical access to the device not only has access to the data that is stored in any form on the device, but also may have access to any online accounts (such as office productivity accounts, email accounts, cloud-based application accounts, and transactional accounts) that are enabled through the device. Moreover, these “smart” devices can also provide access to stored geographical locations and access to networks for which the credentials are stored. Laptops created similar concerns in the past;<sup>13</sup> however, the rapidly increasing number of mobile devices such as smartphones and tablets and their portability and size combined with their multipurpose capabilities multiplies the security and privacy concerns.

## 6.6 Lack of organizational control/governance issues

The bring-your-own landscape has also resulted in the blurring of lines between the personal and professional use of technology (Harris et al. 2012). Moreover, employees may be unaware of corporate policies regarding BYOD policies. One of the solutions currently offered to address this concern is the multitenancy or partitioning of devices provided by mobile device management (MDM) solutions. The MDM solution suffers from some drawbacks. First, the deployment and effectiveness of the solution is largely dependent on the ultimate device owner. If the device is owned by the individual, the organization may not have complete control over the

<sup>13</sup> <http://www.ctia.org/docs/default-source/default-document-library/july-2013.pdf?sfvrsn=0>, accessed May 6, 2014.

deployment of the MDM solution. Second, the MDM solution creates a dependency of the organization on external entities such as the MDM provider and the mobile device provider, both of whom have varying capabilities that evolve over time. Third, even with an MDM solution in place, there is a possibility of data leakage between the two partitions that must be prevented. In any case, it is difficult for the organization to consistently provide a uniform level of security through MDM solutions. Further, security policies are far less likely to be enforced over technology that the organization does not own. As soon as organizational systems interact with technology that the organization does not control, the data on the individual-owned devices is not under its control (Miller et al. 2012).

Additionally, security policies are far less likely to be enforced over technology that the organization does not own. According to Miller (2012), implementation of corporate security policies limits the devices' functionality, for example, by blocking downloads or certain applications. Consequently, regulations are difficult to enforce on privately owned devices, making these devices more prone to potential violations of corporate information security policies (Miller et al. 2012). Lebek et al. (2013) point out that "the integration of privately owned devices into corporate network facilitated malware intrusion such as viruses, worms, and trojans" (p. 3).

Thus, BYOD opens up a multiplicity of potential security holes, a problem compounded by the possibility of human errors, which has been noted as one of the top security threats in the literature (Loch et al. 1992; Warkentin and Willison 2009; Willison and Warkentin 2013). Since BYOD is a fairly recent phenomenon, there is limited academic research in this area, much of it focused around its adoption and use. While there is a growing interest in the security and privacy aspects of BYOD, most of the current security-related research pertaining to BYOD is

focused on the privacy concerns of individuals/employees. There is limited research concerning how organizations can design their systems securely to address concerns arising as a result of BYOD. Therefore, BYOD provides an interesting area in which to examine organizational security.

## 7 THEORETICAL BACKGROUND FOR SECURITY DESIGN THEORY

A fundamental aspect of BYOD is the unique configuration of the individuals' devices. People configure and use their mobile devices according to their own needs. This individualization includes not only the device configuration but also the different applications that the devices may hold at any point in time, the capabilities that have been enabled, the data that the device stores, and other devices and systems that a particular device is linked to. The result is a personalized configuration of devices, applications, personal preferences, and procedures that individuals can employ when using their own devices that amounts to an information system. Moreover, this unique configuration may change dynamically. Any time a person brings in a device, he or she may also be bringing in a system as well as a network. Therefore, this dissertation extends the concept of BYOD to that of the Individual Information System (IIS). An IIS can be defined as “a system in which individual persons, according to idiosyncratic needs and preferences, perform processes and activities using information, technology, and other resources to produce informational products and/or services for themselves or others” (Baskerville 2013 p. 3).

According to Baskerville and Lee (2013), two key factors that have catalyzed the growth of Individual Information Systems are technological autonomy and experiential design.

### 7.1 Technological autonomy

Baskerville and Lee (2013) found that technical or technological autonomy was represented in a number of ways in the literature. They summarize the following ways that it has been described: “as a characteristic of a nation state or culture (Albuquerque 2007; McOmber 1999), as a characteristic of subsidiaries and outsourcing service providers (Frost 2001), as a

characteristic of professional associations (de Leede et al. 2002), and as a characteristic of individual, practicing professionals (Fitzgerald and Ferlie 2000; Mitcham 2009)” (p. 4).

Technological autonomy refers to the degree of independence with which workers within an organization command the architecture of their own IIS. Technological autonomy is valuable among professionals because their subject-area expertise is important in making judgments about choosing professional technologies (Fitzgerald and Ferlie 2000; Frost 2001). Other similar notions pertaining to the (increase of the) individual’s comfort level and abilities in independently manipulating technology for his or her own requirements can be found in the concept of “digital natives” (Prensky 2001) or the “technological savvy” (Mahmood et al. 2004).

Many organizations are contending with the presence of workers’ own devices in the workplace (Kennedy 2013). Therefore, the Organizational Information Systems must be configured in order to interact with a particular device provided by the individual workers. Individually owned devices provide an interface between the Organizational/Enterprise Information System (OEIS) and the IIS. An employee-provided interface to an IIS creates more complexity than merely providing the organization with a device. The Organizational Information Systems are required to interface with individual systems that carry a high degree of individuality and variability resulting from technological autonomy.

## 7.2 Experiential design

Experiential design occurs when the process of design merges with the experience of the artifact being designed. The design emerges as much from the construction and use of the artifact as vice versa (Baskerville 2011; Baskerville 2013). Experiential designs are dynamic in the sense that they can be tried and changed. While an IIS may be as complex as a larger OEIS, these individual systems do not result from a formal, rational design process; rather, they develop

as a result of specific individual needs, capabilities, and available resources at any point in time. As a result, these IISs are extremely varied and often present unstandardized configurations of information technology. These systems are always handy to the owners, who may change any aspect of them to suit their requirements. According to Baskerville (2011), “the design goals for IISs are also different. These design goals often include not only utilitarian goals, but also hedonistic goals and desires for particular social outcomes. The design goals may also include value, enjoyment, and even status enhancement” (p. 5).

IISs are also bounded both socially and geographically to particular sets of information and communication technology. The individual designer operates within a confined sociotechnical context. Purchase decisions are highly influenced by the individual’s social and professional networks. Family, neighbors, and coworkers may influence component selection through their own past choices and their advice to the designer about their future choices. The design components are chosen from mass-market devices, usually at very low cost. These devices are consequently highly standardized and reconfigured for the most general individual use. Yet the designer tries to achieve a very personalized system by using these standard components. As a result, such systems often have complicated and inefficient workarounds to make the various components work together to achieve the individual goals and aims of the designer.

This context creates a setting for a design process that involves an explorative patchwork approach to designing the IIS architecture in which the designer is both designing and experiencing the design results at the same time (Baskerville 2011). This situation differs from one in which a designer designs a complete entity in a formal, abstract space separately from its realization and for whom the experience of the results is post hoc. This process of experiential

design is important in accommodating interactions with organizational systems because of its idiosyncratic results and continuous adaptation. Experiential design is necessarily explorative because system components are continuously being disconnected and reconnected in different ways. This exploration results in highly emergent systems, often with very short-term planning and operating horizons.

### 7.3 Individual Information Systems

The concept of Individual Information Systems (IISs) has been recognized in Information Systems literature on experiential computing (Yoo 2010; Yoo et al. 2010). IISs have a highly variable scope, idiosyncratic processes, and often non-standard configurations of information technology. Various facilities are accessible to an individual through Internet connections that might be regarded as an individual cloud in an IS sense, but which is broader than just cloud computing (Fingar 2009). Part of this cloud is typically provided by employers and extends access to publications and regulations, customer and vendor data, online professional tools, and virtual meeting resources. Thus the IIS is a conglomerate of hardware, facilities, and processes similar to that of any organizational information system. One difference however, is the relatively changing nature of the IIS with potentially frequent changes in hardware and facilities. This emergent feature of the IIS becomes even more pronounced as it interacts with the organization's information infrastructure.

### 7.4 Organizational information infrastructures

Many organizations today process information on shared systems. But these architectures have been shared across supply chains with suppliers and business customers. These previous shared information system architectures have been shared with other organizations. The reliance on cloud computing and software-as-a-service has also increased the



sharing of computing between organizations (Fingar 2009). It is no longer adequate to view the complex conglomerate of technology, applications, people, and processes in an organization in terms of systems. Rather, more appropriately, such “a shared, open, heterogeneous and evolving socio-technical system” (Hanseth and Lyytinen 2010 p. 1) would be the information infrastructure (II) with which the devices that individuals bring in and the associated OEIS would interact.

An information infrastructure has been defined as “a network of independent, mostly privately-owned, man-made systems and processes that function collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services” (Rinaldi et al. 2001 p. 12). In the context of information communication technologies and organizations, Strader et al. (1998) identify some components common to information infrastructures. Information infrastructures have a global information network providing access and connectivity to the external environment, electronic connections between the Information System within the organization and its connections with its partners and customers, and access to the organization’s operational data and intra-organizational information system support including software development, process support, electronic data interchange (EDI), decision support, database support, telecommunications, local area networks (LANs), computer hardware, and a network interface.

According to Star and Ruhleder (1996), an infrastructure demonstrates specific properties. A specific characteristic of an information infrastructure is embeddedness. An infrastructure is part of a number of other structures such as social arrangements and technologies. Additionally the embeddedness and linkages are transparent, as the infrastructure operates as a whole. Therefore, an infrastructure transparently supports the tasks. The

infrastructure has a spatial or temporal reach beyond a single event or on-site practice. An information infrastructure shapes and is shaped by the conventions of communities of practice. The information infrastructure is modified by standards and connects with other infrastructures in a standardized manner. An information infrastructure emerges from an existing installed base. The infrastructure functions as a seamless entity, and specific aspects of the infrastructure only become noticeable when functionality breaks down.

Edwards et al. (2007) stress the dynamic and complex nature of infrastructures. They describe

organizations (in part) as being information processors. People, routines, forms, and classification systems are as integral to information handling as computers, Ethernet cables, and Web protocols. The boundary between technological and organizational means of information processing is mobile. It can be shifted in either direction, and technological mechanisms can only substitute for human and organizational ones when the latter are prepared to support the substitution. (p. 3)

Hanseth and Lyytinen (2010) emphasize that IIs provide an appropriate context for design “since they exemplify a complex ecosystem that may evolve and need to adapt to requirements that may be unknown or emerging” (p. 4).

## 7.5 Complex adaptive systems (CAS) theory and why an information infrastructure (II) is a CAS

This research argues that an information infrastructure is not simply a system. Rather, it is a complex adaptive system (CAS). According to (Holland 1995) a complex adaptive system is one that has multiple factors which interact in nonlinear ways and over time adapt and emerge into a coherent form, without any singular entity deliberately managing or controlling it..

Benbya and McKelvey (2006) argue that Information Systems development projects should be envisaged as *complex adaptive systems* so as to cope with the challenges of evolutionary complexity in changing environments. They find that complex adaptive systems are large systems with heterogeneous and interrelated components. They characterize complex adaptive systems as self-organizing systems with emergent and evolving complexity. A necessary function of such systems is adaption to learning when new issues necessitate identification, interpretation, articulation and resolution in real time (El Sawy and Majchrzak 2004).

Hanseth and Lyytinen (2010) argue that information infrastructures are complex adaptive systems and must therefore be designed according to the principles of the complex adaptive system theory. Using this theory as a basis for deriving design principles for designing general information infrastructures, they find that any design for a viable information infrastructure must have the following two requirements:

1. To ensure the creation of a viable installed base for infrastructure use, which they deal with as a problem of bootstrapping, and
2. To ensure infrastructure adaptability, which they deal with through the notion of flexibility.

## 7.6 Applying the CAS theory and the bindpoint theory to the BYOD context

In the case of consumerization, and especially BYOD, bootstrapping and development of the installed base is a given, and therefore not an issue. Rather, the design issue emerges from the unplanned adoption and growth of usage. Therefore, the key concern in BYOD design pertains to the *adaptability of the infrastructure* to address security issues. Since BYOD creates a dynamic situation, this research draws on the bindpoint theory as an explanatory design theory. The bindpoint model (Baskerville and Lee 2013) is an explanatory design theory that describes the design of security features on a computational rather than predictable basis.

Due to need for control, security design is traditionally based on predictability. In complex situations where there are many-to-many connection points and security requirements may be more dynamic and may not be predictable. In such situations, one possible mechanism for designing security features could be computed at the interacting bindpoints. These bindpoints represent dynamic intersections between different information systems. The bindpoint occurs when the IIS connects to an II, in this case the OEIS. The bindpoint is not simply a connection; rather, it is the dynamic and emergent interconnection between the individual and organizational IS. A bindpoint represents a unique context that is created through the interconnection of any two nodes of information systems. Since the connection is a system-to-system connection, it may affect the emergent goals, affordances, and constraints of the connecting systems. This idea aligns with the concept of emergence in CAS.

The connection of the IIS and the II creates a form of crossroad or intersection between multiple systems. This intersection is not merely the entry or exit point for service or process. As a bindpoint, it becomes the condition of an IIS after binding to the II. Concomitantly, it also becomes the condition of the II after binding to the IIS. In settings where many IISs are bound to

an II, bindpoints are frequent and diverse. This can mean that the II is subject to constant redesign arising in the constellation of associated bindpoints (Baskerville and Lee 2013). The bindpoint is a new context, not a just a simple connection. It can affect a diverse array of inputs and outputs for both the II and the IIS through the web of connections between them. While the bindpoint theory (Baskerville and Lee 2013) describes bindpoints in the context of security, the concept of bindpoints can be also be visualized as the interactions in a cloud computing environment.

Baskerville and Lee (2013) note:

A bindpoint elaborates the way in which the IIS and II interact and which creates a new connection or context between the two. The result is similar to the notion of a bindpoint in a computer game. When a character in a game encounters or uses an object, both the character and the object may be taken to a new place in the game. The new place is the bindpoint (Griffiths et al. 2003). Importantly, bindpoints may be too innumerable to predict every permutation of the elements, but they must be computable.” (p. 7).

While computability is not a direct substitute for predictability in such settings, a metalogic based on cellular automata can be used to create a bounded computability setting that will substitute a fixed set of rules (Moldoveanu 2008). For example, instead of invoking a fixed set of security rules, connecting systems could follow a secure protocol to exchange architectural information and compute their bindpoint based on compatibility and requirements for features. Baskerville and Lee (2013) state the bindpoint model as an explanatory design theory in the following way: *“In conditions of emergent complexity, requirements for security controls can be satisfied by components using a metalogic to bound computability”* (p. 7). Then the design problem shifts to the metalogic for binding the emergent complexity of the OEIS/IIS connections in a way that enables security to become computable, even if not predictable. One approach to such a metalogic involves replacing system endpoints with bindpoints and computing the instantaneous security of an IIS from the bindpoint to the endpoint.

To determine the applicability of the cellular automata (CA) model postulated by Moldoveanu (2008), this research starts out to identify a discernible pattern, to postulate a dynamic process in which the global pattern is generated through the interaction of individual elements of the bindpoint web. According to Moldoveanu (2008) guidance on the similarity of CA to rule-based models, the bindpoint design theory satisfies all three criteria. Firstly, CA-based models require a set of local elements which can take on  $N$  possible values, which in the case of bindpoint design theory are represented by the multiplicity of device nodes at the bindpoint, which can take multiple values as well. Secondly, CA-based models require a set of rules that prescribe the state of each individual model. In the case of bindpoints, these can be represented by the rules from the organization that can determine the nature of the link to the IIS. Finally, CA-based models require a list of boundary conditions for the model. These are met by the boundary conditions set by the OEIS systems, which determine the parameters of access for the IIS system. Hence, the bindpoint model satisfies the three conditions of a CA model and can be regarded as one.

## 8 EMPIRICAL METHODOLOGY: SEARCH CONFERENCE

This chapter comprises the dissertation's research approach and research methodology and also describes the research context, design, and conduct, including data collection and data analysis. The research approach defines the general direction of the research. It also provides the reason the specific research methodology, the search conference method, was appropriate for this research. The research methodology describes in detail the theoretical background of the search conference method, discusses how and why it has been applied in the past, and evaluates its potential for this research.

### 8.1 Research Approach: *Engaged Scholarship*

This study examines the security implications of the BYOD phenomenon from an organizational perspective. A pragmatic approach is appropriate for this study. The objective of this research is firmly entrenched in understanding, explaining, and devising a potential solution to a complex workplace issue. Therefore, the research must necessarily be informed by, and also inform, practice. In order to conduct a research study about a complex problem with the intent to advance both theory and practice, the mode of enquiry that is needed converts the information obtained by the researcher in interaction with the practitioner into actions for addressing problems in the practitioner domain (Van de Ven 2007, p. 9). Baskerville and Wood-Harper (1996) point out that Information Systems is a highly applied field with strong vocational elements (p. 235), and they argue that a mix of practice and theory is needed for usable and relevant knowledge to be produced. This research is therefore best suited for engaged scholarship. Engaged scholarship is a participative form of research used to obtain the perspectives of different key stakeholders (such as researchers, clients, sponsors, and practitioners) in studying complex problems by leveraging different kinds of knowledge to

produce keener insights (Van de Ven 2007, p. 9). Design-science research has been noted as a type of engaged scholarship (Mathiassen and Nielsen 2008; Van de Ven 2007). Design-science research offers a rigorous and meaningful contribution to practice and theory, in the form of an IT artifact and its evaluation (Gregor 2006).

## 8.2 Research Methodology: *Search Conference*

Braa and Vidgen (1999) suggest that “in the fast changing IS environment, small scale action case interventions, focused on a specific technique or method, are valuable” (p. 40). In order to better *understand* the complexity of the BYOD impact on organizations’ IIs and to apply the bindpoint model for designing BYOD security, a search conference approach is used. A search conference is a method for participative strategic planning in environments that are characterized by turbulence, volatility, and uncertainty (Dingsyør and Moe 2008). The search conference approach relies on “getting the whole system in the room,” and on self-organizing groups that confront this system’s new goals or threats (Axelrod 1992; Williams 1979). It is an effective participatory and self-managed method that involves bringing together members of the system (with probably conflicting, or at least differing, views) to develop robust goals and action plans for any kind of strategic planning (Emery and Purser 1996; Fuller et al. 2000). It is a participative process that involves collectively solving a complex problem, creating a desirable future scenario, and determining appropriate actions (Axelrod 1992).

Traditionally, search conferences have been used to affect change. By engaging key decision-makers and different stakeholders in the discussion, problem solving, and planning process, search conferences enable open communication, an exchange of diverse views, and an effective way to expand knowledge in a collaborative environment. Search conferences have been used as a mechanism for using dialogue to “engage participants in a vision-based approach



for identifying emerging models, strategies, and directions addressing challenges in (Internet) software development” (Baskerville et al. 2003 p. 71). Search conferences are a research approach to help find solutions to complex problems. Therefore, they are very useful in developing learning through discussion and deliberation, especially in settings where the objective of the exchange is to look at a problem from multiple viewpoints while engaging the opinions of different experts.

### 8.2.1 Why search conference?

Search conference is a useful method of engaged research that aligns well with in-context Information Systems research (Braa and Vidgen 1999). The scope of this research is sufficiently focused and the theoretical model that is to be evaluated is well defined. Although search conferences are traditionally grounded in action research, they can also be effectively used to garner involvement from the participants for cases where the (research) objective is oriented more toward learning rather than systemic change. In scenarios that are not action research cases, and where the involvement of participants remains finite, both in terms of duration as well as the general level of organizational involvement, a search conference can be a fast and economic way to engage experts from organizations to examine a research problem.

The objective of this particular research engagement on BYOD security design theorizing does not necessitate any changes within a particular organization; rather, the objective of conducting a search conference is to understand and affect the development of a design theory. With this research objective, the search conference method aligns very closely with the action case method (Braa and Vidgen 1999), since it requires a lower level of participation from the organization than is generally needed for action research yet despite these constraints, there is still an orientation toward building the future through purposeful change (Braa and Vidgen

1999). The evaluation of the bindpoint model for BYOD security design does not necessitate a high level of organizational commitment from any particular organization. Nor is the intention of the research to affect idiosyncratic change in a local situation. Rather, the *objective of this research is to develop a general understanding of a phenomenon and aims at purposeful change that is more general*. Therefore a search conference is conducted with participants from multiple organizations. Compared with an action research engagement, the search conference enables faster access to (multiple) organizational representation and involvement, especially since the research topic is one of common interest to almost all organizations facing similar challenges.

### 8.2.2 Theoretical background of search conference approach

The roots of the search conference methodology can be traced to the Tavistock Institute in the 1940s. The first search conference was designed and developed in the 1960s by Fred Emery and Eric Trist for organizational change management related to the merger of Bristol Aero Engines, a jet engine pioneer, and Siddeley, a piston company (Fuller et al. 2000). The merged company, Bristol Siddeley, was competing with Rolls Royce, and the task of the search conference was to create a unified strategy, mission, leadership, and values for the merged entity. The search conference was conducted in Bristol, United Kingdom, over five-and-a-half days and included eleven members (Fuller et al. 2000).

The search conference as originally developed by Emery and Trist has evolved over time to come in a number of different flavors, the unifying purpose being a method of bringing together people from diverse backgrounds for collectively planning and managing strategic change (Emery and Purser 1996; Fuller et al. 2000; Weisbord et al. 2000). A map providing the different forms of group interventions that evolved from the original search conference is provided in Appendix A. Bunker and Alban (1997) describe a number of such participative

methods of systems change such as search conference (Emery and Purser 1996), Future Search (Weisbord et al. 2000), Real-Time Strategic Change (Jacobs 1997), ICA Strategic Planning Process (Spencer 1989), The Conference Model (Axelrod 1992), real-time work design (Dannemiller and Jacobs 1992), participative design (Cabana 1995; Cabana et al. 1995), and large-scale interactive events (Dannemiller and Jacobs 1992). Fuller et al. (2000) add appreciative inquiry (Cooperrider and Whitney 2005; Whitney and Cooperrider 1998) to this list.

While these methods have been used for action and intervention in organizational/social settings, they are strongly grounded in theory. Quoting Bunker and Alban (1997), Fuller et al. (2000) note that search conference methods are theoretically rooted in systems theory (Bertalanffy 1968), socio-technical systems theory (Emery and Trist 1965), values theory (Maslow 1943), social psychology (Lewin 1951), and group dynamics (Bion 1952).

A search conference aims to develop a discourse that aligns the various stakeholder value propositions in a way that co-joins the system's actors (Flood 2010). It may deliver a strategic framework that aligns various improvement strategies such as benchmarking or value-added partnerships (Aughton 1996). Search conferences provide a means to deal with strategy-setting in messy, problematic situations, often those involving environmental turbulence, volatility, and disruptive change that threaten the system (Aughton 1996; Babüroglu and Ravn 1992; Cabana et al. 1995; Dingsyør and Moe 2008; Selsky et al. 2013). The method has been used effectively for social, environmental, and economic problem solving, community development and also by organizations for testing new initiatives, developing new strategies and dealing with changing scenarios such as mergers. It is especially effective in complex situations where the diverse perspectives may be conflicting or for developing new strategies in emergent and evolving environments (Rehm et al. 2002).

The democratic principles of search conferences have been adapted and used in diverse settings (Jiménez et al. 1997) including community awareness and development projects (Schafft and Greenwood 2003; Schusler et al. 2003), organization design (Cooperrider et al. 1999; Fuller et al. 2000; Pasmore 1995; Purser 1998), education (more than 60 Future Searches documented in higher education by Warzynski (2004) at Cornell University), policy development (Pelletier et al. 1999), and for projects at Fortune 500 companies (such as “A Model for Re-Designing Product Lines” at Ikea, creative product development at Microsoft, and strategic planning at such companies as Motorola, 3M, Boeing, and PWC).

### 8.2.3 Search conference and other group techniques

The entire search conference process that includes designing the conference, conducting it to collect data, engaging in discussion, learning, and implementing a better future scenario echoes action research closely (Babüroglu and Ravn 1992). Although search conference is a participative method, it must be distinguished from other participative events such as idealized design (Ackoff 1979) and soft systems methodology (Checkland 1989), which though participative, are not search conferences (Jiménez et al. 1997).

The search conference could also be confused with group techniques such as Delphi studies, focus groups, and other nominal group techniques. However, there are some key differences between search conferences and other group techniques with regards to their structure, purpose, and suitability. For example, in group techniques such as focus groups and Delphi studies, participants focus on precise statements of future outcomes, and the issues or outcomes under discussion are treated as discrete (Williams 1979). However, in a search conference, the participants themselves collectively determine present scenarios and possible future trends and map the path to future outcomes (Williams 1979). Methods such as focus

groups, pilot tests, and survey feedback are also considerably slower and lack the ability to generate creativity, innovation, and commitment from participants (Fuller et al. 2000). The advantage in using a search conference over conducting focus groups for each of the above perspectives is that the search conference allows for bringing the entire system into the room, for an exchange of different views in order to solve a problem, and for participants to devise a desired future by looking at the problem from different angles and collectively finding common ground.

Another key distinguishing aspect of search conferences is the bringing together of diverse and *potentially conflicting opinions* in order to find a common constructive ground. The process is called a “search” because it brings people together to explore possibilities or search for a desirable future for their organization (Warzynski 2004) or community (Schusler and Decker 2002). The search conference is unique in that it has no presenters, lectures, speeches, or training sessions. Everyone is provided an opportunity to speak, and words are recorded in a common place such as a white-board or chart paper for everyone to see (Rehm et al. 2002).

### 8.2.4 Advantages of the search conference approach

The search conference has several advantages over data collection approaches such as interviews, focus groups, surveys, and other group techniques. The search conference approach is economical in terms of the time and effort that the researcher and the participants in the research process are required to expend. Rather than spending time on making multiple trips to conduct interviews on different occasions with different interviewees, search conferences bring these different individuals to a common forum at a common time, saving valuable time for both the researcher and the participants. The process of interacting with sets of individuals in different contexts is avoided, and the researcher is saved the task of attempting to create connections between the conversations held with different individuals at different times. Moreover, this saves the researcher (and interviewees) additional investments in interview time that may result from revisits or follow-up interviews with the previous interviewees for clarifications that are based upon new insights or differing viewpoints gathered from subsequent interviewees.

In a search conference, one can see the dynamic of the conversations in progress. These conversations may result in either strengthening and confirming certain viewpoints or differing viewpoints. This process may result in one or more viewpoints, but the researcher would be able to either revisit a discussion or clarify any points raised during the course of the search conference. The analysis of data collected during the search conference may necessitate further follow-up conversations between the researcher and the participants. However, the opportunity for the back-and-forth discussion during a search conference does allow for substantial savings in time and effort compared with interviews, while providing a richer dataset than a fixed questionnaire or survey would be able to collect. Search conferences can thus compress the data

collection within a finite timeframe, instead of relying on an indefinite relay of information back and forth between the participants.

Apart from time and effort, there is also a smaller monetary cost associated with the single location for data collection and participation. This advantage is critical to drawing in stakeholders to discuss relevant issues. “Evidence suggests that group interventions can shorten decision-making cycle times, generate creative responses and strategies, and increase commitment to action” (Worley et al. 2011, p. 4).

The search conference approach has a high likelihood of success, since these workshops can create a high amount of energy as the topics are collectively discussed. Since everybody is interested in the same topic, the participants offer distinct perspectives on an area that they or their organizations are particularly invested in. These varying perspectives create an energetic debate wherein individuals can draw off each other’s energy. The discussion process improves upon the interview, which simply provides a uni-directional outlet for the participants to convey their thoughts on the topic. In the search conference, the participants can not only express, but also refine and develop their insights on the topic.

Search conferences function better than focus groups in that they provide a wider perspective to the problem at hand. Since search conferences bring different viewpoints to the table for discussion, innovation, and planning, they can be useful for exploration, design, evaluation, or implementation (Axelrod 1992). Search conferences are especially critical where knowledge of the topic area is limited because the interaction of different involved parties goes beyond abstract theorizing and into the area of actual planning. The parties brought together in a search conference are not there merely as delegates of their organizations, but rather as important

persons whose roles are critical to the planning process. From these conferences, actual instrumental frameworks can emerge (Rehm et al. 2002).

Worley et al. (2011) assert that “organization effectiveness derives from the explicit and tacit interactions among suppliers, customers, regulators, managers, employees, and other stakeholders. To change the effectiveness of a system, therefore, requires getting the whole system in the room.” Further, the authors state that, “bringing together diverse stakeholders is perhaps the most referenced design principle of large group interventions. That is, as many different, relevant stakeholder groups as possible should be brought into the conference with the intent of bringing the maximum number of perspectives to bear on the issue, problem, or opportunity” (p. 5).

### 8.2.5 The search conference process

As with any long-enduring methodology, there are many variants in the literature on the process of conducting a search conference.

Williams (1979) describes a five-session process:

1. Identifying the broad trends with regards to the problem being addressed, such as the impact of technology, uncertainty, threats, and so forth
2. Explaining why and how the organization or industry came into existence and the factors that influenced development or change
3. Determining the broad aims that should be pursued in the future, devising desirable futures
4. Dividing the work among subgroups concentrating on different needs or problems and their resolution



5. Reviewing the work of the subgroups and making plans for implementing change strategies

Emery and Purser (1996) also use five phases, but they frame their phases a bit differently than Williams' sessions:

1. The future in the past and present. What is happening in the social environment?
2. The past in the present. Where did we come from?
3. The past and present in the future. What is desirable?
4. Creating a desirable future. Action plans incorporating the best of the past, present, and future.
5. The future in action. Action creates diffusion.

Cabana et al. (1995) describe a three-phase model for search conferences:

1. Discovery of the system environment
2. Discovery of the system
3. Discovery of an action plan to reconcile the system with its environment

Nielsen (2006) explains how timing reconciles such five-phase approaches with the basic three-phase model described above by Cabana et al. (1995). She apportions the timing of the five phases of the search conference into thirds:

1. One-third of the search conference time is for allocated for the examination of the uncertain and turbulent environment.
2. One-third of the search conference time is set aside for the search for the systems past and present in order to develop the most desirable system.
3. One-third of the search conference time is spent on action planning.

Warzynski (2004) describes a case study of a search conference with nine steps, which include four steps for breaks and meals:

1. Introduction, objectives, and explanation of the logistics of the conference (15 minutes). Participants interview each other for three minutes per question. In this example, six questions take 36 minutes. Given time to move from chair to chair, this part of the exercise normally takes about 45 minutes.
2. Participants organize the information by themselves (10 minutes).
3. Break (15 minutes).
4. Participants work with other people who have the same question and aggregate and categorize their ideas or themes (60 minutes).
5. Lunch (60 minutes).
6. Group presentations: 20 minutes for each group (120 minutes, or two hours).
7. Break: during the break participants engage in a voting exercise to identify their priorities for key questions, with the facilitator tallying the results (15 minutes).
8. The group engages in an action planning exercise to develop the first cut of project plans (60 minutes).
9. The facilitator leads a short discussion on participant reactions to the exercise process and results and determines next steps (30 minutes).

Aughton (1996) wraps the search conference itself within a three-step process that provides a larger framework for the search conference:

1. Preparation and planning for the search conference
2. Conducting the search conference
3. Implementing the strategic action plan produced by the search conference

### 8.2.6 Applying the search conference for design theorizing

The process of designing the search conference, conducting it to collect data, engaging in discussion, and learning to implement a better future scenario echoes closely with action research (Babüroglu and Ravn 1992). Therefore, search conferences can be applied effectively to accomplish both the action and the research goals of action research projects. However, search conferences can also be used effectively and independently for either research or action. In addition to affecting change or problem solving, the knowledge-producing aspect of constructivist research approaches such as action research (and design-science research) derive from the application of the scientific method to social/organizational issues in order to develop more complete theories that can provide insight and potential solutions (Babüroglu and Ravn 1992).

Search conferences can aid in such knowledge generation in that they are future-oriented, communicative activities that identify the state of the world as well as desirable futures and means for their realization (Babüroglu and Ravn 1992). For example, Babüroglu and Ravn (1992) describe knowledge production through “futures theory with the participation of stakeholders associated with the practical implications of the theory and the role of search conferences in the construction and validation of such organizational/social development theories.

The research problem confronting us is the necessity to conduct future-oriented design theorizing in such a highly complex sociotechnical environment. Therefore, for this research, the *search conference* is adopted as a collaborative, future-oriented, design theorizing methodology. Including experts in the search conference from multiple organizations in the testing and

evaluation of the bindpoint model for BYOD security design serves to strengthen the generalizable application of the design theory.

### 8.2.7 Considerations in conducting the search conference

**Planning.** The smooth operation of the search conference depends on meticulous planning of every aspect of the process, including envisioning the design of the conference, participants, time frames, logistics, outcomes, and even contingencies (Axelrod 1992). Details of the planning that was conducted for the search conference in this research are provided in Appendix B.

**Structure.** Axelrod (1992) suggests that structure is a key factor in ensuring successful conference outcomes. The outline of events and tasks related to the conference can be planned ahead, and any materials that will be used or handed out such as workbooks, presentations, or notes can be prepared ahead.

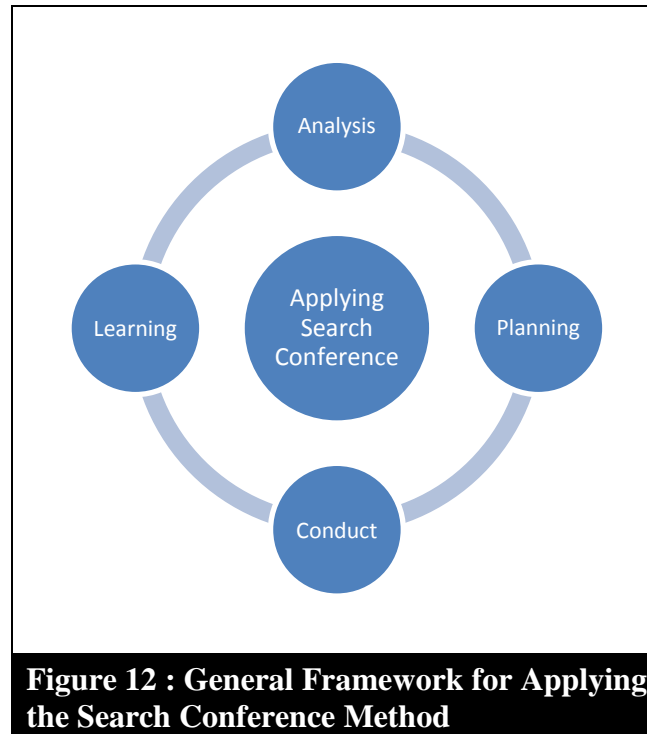
**Time management.** Pacing the activities during the event is also important in ensuring proper utilization of the researchers', participants', and volunteers' time and also in guaranteeing smooth transitions between different activities during the conference. Axelrod (1992) found that with regards to time management, a challenging pace yields better outcomes. The time given to each group to report their findings should also be limited so as to prevent boredom for other groups and to keep them engaged (Axelrod 1992).

**Recording.** Care must be taken in recording the proceedings both in an unobtrusive manner as well as by using a number of different methods. The recording must enable a natural flow of discussions and processes so that the participants do not feel inhibited about their discussions, nor should they be “performing” or proving the information that they feel is

expected from them. Especially in a larger group, using both audio and video recording will enable the researcher to distinguish at a later time the details of the discussion and to whom the discussion is to be attributed to.

### 8.2.8 The actual search conference process

In order to conduct a search conference, guidance was sought from the literature. As described above, there are many different variations of conducting the search conference process. The key question was “how” to plan the process. Aughton (1996) provides a general overall framework that includes three steps: preparation and planning the conference, conducting the search conference, and implementing the action plan. This framework assumes that the requirements leading to the search conference are well defined and that all that remains is the exercise of planning and conducting the conference. Since the task that the search conference is intended to address includes inquiry *and* action, substantial effort is required *prior* to planning and execution, in order to determine “what” needs to be planned for. This step is analogous to “diagnosis” in action research (Susman and Evered 1978) or “discovery” in appreciative inquiry (Fuller et al. 2000). It involves more than just a problem diagnosis; it also includes a potentially iterative assessment of possible solutions as well as determining the general objective and plan of the search conference. The term “analysis” reflects the tasks to be addressed prior to planning. Overall then, the search conference will include: analysis, planning, conduct, and learning. Each of these steps is described below. Figure 12 below provides a general framework for applying the search conference method.



**Analysis.** Analysis includes all evaluation and activities related to research that are conducted prior to the search conference design. The analysis examines the actual problem that the search conference is addressing. The results from the analysis will define the structure of the conference and how it will be conducted. For example, the analysis phase will determine the purpose of the search conference. Is the search conference being conducted to elicit the requirements, is it being used to develop or design a solution, or is it being used to evaluate a design solution? Such an analysis will help define who the relevant stakeholders are. The analysis will also help design the conduct of the conference itself. It will help determine if there is a demonstration involved. Analysis will also help decide if the search conference is being conducted for problem solving, decision-making, change implementation, or a combination of any of these activities. In this research, the analysis phase coincided with the initial theoretical development and the set the purpose and design of the search conference.

**Planning.** This phase includes planning activities and processes prior to the search conference, during the conference and after the conference. The first step is to design the conference and includes how it will be conducted, where it will be held, and who will attend the conference. Planning includes the identification and recruitment of the participants. Prior to the actual recruitment of the participants, the recruitment material also needs to be prepared. The recruitment material provides all details such as the purpose and outline of events, what the participants can expect, why they should attend, and any logistical information that they may need. Details of the planning process for this research are included in Appendix B.

**Conduct.** This phase involves the execution of the conference for the purpose that was defined in the analysis phase and based on the design developed during the planning phase. This step will largely contribute toward the data that will be generated during the search conference. The conduct of the search conference is the procedure that includes all activities that have been planned, starting with setup through the actual conference and including the windup procedures as well the recording the proceedings. During the conduct of the conference, the researcher has a dual role of facilitator as well as researcher. The conduct of the conference extends beyond the conference to include any completion related to the recording of the proceedings and collation of the different types of data collected during the conference, such as photographing any charts or other materials used; analyzing any workbooks utilized during the workshop, notes taken, and surveys conducted; and making transcriptions of any audio material.

**Learning.** This phase includes all evaluation and learning that emerges from the processes during the conduct of the search conference. These include both theoretical and practical learning. Learning emerges from the researcher's experience – the experience during the conference as well as that gained in subsequent iterative cycles that will include analysis and

synthesis of all the different types of data, and also the theorizing process following the conference. Learning during the search conference is not restricted to merely learning about the problem at hand that the search conference sought to address. Since the process is future-oriented, learning can be about the “past,” or “what was”; the “present,” or “what is”; and the “future,” or “what is to be.” Since this is a design-science research process, the learning can regard both the theory and practice aspects of the problem. Another form of learning that occurs pertains to what worked or did not work during the search conference process and how it can be improved. To assist in this form of learning, the participants were asked to fill out a brief survey of a few questions that would help to assess and improve design and conduct of future search conference efforts.

### **8.2.9 Applying search conference for BYOD**

The research context defines the background or the environment in which the research was carried out and how it was planned, designed, and conducted. Following this is a description of the data collection and analysis.

### **8.2.10 Research context and determining search conference participants**

In order to identify the appropriate participants for the search conference, an assessment of the problem scenario and identification of key stakeholders is required. As technology pushes personally owned smart devices with wide-ranging capabilities and numerous applications configured in unique and idiosyncratic ways into the workplace, organizations are rushing to put together usage policies for these devices. Although the rising popularity and acceptance of BYOD has been spurred by benefits to both individuals and employers, BYOD raises security and privacy concerns for both organizations and individuals (Miller et al. 2012).



Security considerations primarily pertain to organizations, while privacy considerations pertain to individuals (Miller et al. 2012). In this scenario, the organization is also responsible for maintaining the confidentiality of its own data as well as the information provided by employees, individual users of its systems, its business partners, and other organizations and entities that use its systems or whose information it holds. Thus, the particular problem at hand is that of information security, and the context for examining the problem is the BYO scenario. In view of the security concerns created by the bring-your-own phenomenon, the essential question is: How can organizations understand and manage how their sensitive information is being accessed and used in changing digital environments? One possible solution to this problem was to use a bindpoint model for designing the organization's information infrastructure architecture, policies, and frameworks so as to minimize security risks arising from BYOD. In order to address the above question and conduct a rigorous evaluation of the model from all possible perspectives, a search conference was to be conducted to garner the opinions of experts who are involved in the different aspects of the BYOD problem in their respective organizations and who face these challenges in their respective lines of work.

Further, the key stakeholders connected with this problem scenario must be identified. Dhillon and Backhouse (2001) suggest a socio-organizational perspective of Information Systems security. IS security has been defined as “the protection of information resources of a firm, where such protection could be through both technical means and by establishing adequate procedures, management controls and managing the behavior of people” (Dhillon and Torkzadeh 2006 p. 299). Managing BYOD security would therefore involve a number of areas in the organization including management, IT, and security professionals.

In the past, the IT function in organizations was charged with managing interoperability, enabling smooth functioning of business processes, and ensuring value generation from information and data. Now, in addition to serving these functions, IT must also be prepared to address challenges arising from the BYOD phenomenon. BYOD brings in a new set of considerations for management, such as information architecture changes, standardization of identification across devices, bandwidth allocation to employee activities, and ensuring that Information Systems are available on mobile devices. Information architects are also deeply involved in BYOD security, since systems architecture delivers the functionality of the IT systems within the bounds that security imposes and the aims and the goals that information management provides.

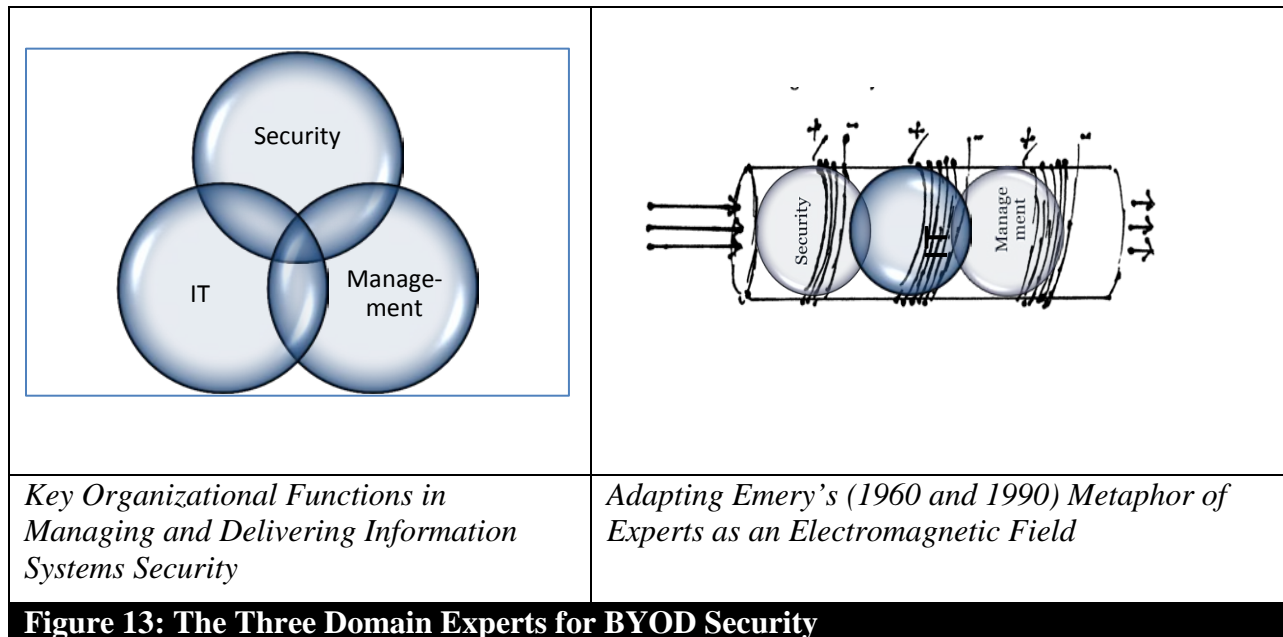
In addition to architectural concerns, organizations need to address strategic risks, including security-based concerns such as identity management, providing and monitoring access to organizational systems through a multitude of devices with a variety of configurations, policies for new devices and operating systems, privacy issues arising from blurring of personal and professional use of devices, ownership of the contents of mobile devices, and compliance issues. For example, some security concerns identified through recent surveys<sup>14, 15</sup> include enforcing security policies for mobile devices, lost or stolen devices containing sensitive data, sensitive data confidentiality and integrity, protection when accessed or stored on a mobile device, threat management on a mobile device, supporting new device types, and creating security policies for mobile devices. Hence, security professionals are concerned with all the requirements, needs, and goals to prevent these devices and technology provided by individuals

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<sup>14</sup> <http://www.esg-global.com/blogs/a-multitude-of-mobile-security-issues/>, accessed November 16, 2013.

<sup>15</sup> <http://www.webroot.com/shared/pdf/byod-mobile-security-study.pdf>, accessed November 16, 2013.

from corrupting the security of the data and systems of the organization. Thus, the three key functions charged with managing and delivering secure systems functionality in ever-changing computing environments include IT managers, system architects, and information security personnel.



Getting a better understanding of the problem would improve the quality of any solution that was designed to address the problem. The objective was to evaluate whether the bindpoint model provided a satisfactory solution to the BYOD problem and if not, then what the hypothesis would be for the model not to work and how the bindpoint model could be refined to make it work. In order to examine the security issues related to BYOD and the impact on an organization's information infrastructure, it becomes necessary to consider the technical, managerial, and security issues.

According to Weisbord (1992), Emery's metaphor for the role that experts played in the conduct of a search conference was that of an electromagnetic field, where the dialogues (between the different stakeholders) would act as positive-negative poles keeping the search

conference in motion toward the twin goals of joint strategy and focused thinking. These different areas of work where BYOD has implications were identified above as technical, managerial, and security domains. Following Emery's metaphor, the search conference for research evaluation involves experts from the three functions described in Figure 13 above. Therefore, information architects, security professionals, and senior business leaders (at the CIO/CTO/CISO level) who were decision-makers for their organization's BYOD policies were invited to the search conference.

### 8.2.11 Determining group size for the search conference

Search conferences can range from eight to 2,000 members (Bryson and Anderson 2000). Gilmore and Barnett (1992) state that large-group dynamics begin once a group exceeds 15 to 20 participants. They point out that while large groups are helpful they carry certain considerations that may limit their productivity. Specifically, they note the difficulty in managing group discussions, especially when the discussion becomes more animated. They find that large groups typically require a higher level of moderator involvement, and it takes an experienced moderator to control the group without engaging in continual efforts at discipline. Further, high levels of moderator involvement are not desirable for research purposes.

Multigroup discussions are known to work best when the different groups of participants in each of the groups are limited and do not exceed 10 persons (Eitington 2007). A smaller group size allows for more airtime for everyone and encourages greater willingness to contribute (Eitington 2007). Moreover, it permits a certain degree of depth to the discussion while still capitalizing on the multiplicity of perspectives. From a data collection perspective, a manageable group size allows the discussion to proceed uninterrupted and naturally yields richer results. Also, the researcher can spend more time observing and studying the proceedings rather than disciplining and moderating the discussion.

Nielsen and Landauer (1993) created a mathematical model based on results of six different projects and demonstrated that six evaluators (participants) can uncover 80 percent of the major usability problems within a system, and that after about 12 evaluators, this diagnostic number tends to level off at around 90 percent (Guest et al. 2006). Romney et al. (1986) found that a group size of as few as four individuals could yield extremely accurate information with a high confidence level (.999) if they possessed a high degree of domain expertise. A study by

Guest et al. (2006) found that six interviews was consistent with Morse's (1994) recommendation for phenomenological studies.

Having identified that application of the bindpoint model would require the interaction between three organizational roles associated with BYOD security – management, IT architects and information security – based on guidance from the literature, the appropriate group size for the search conference was derived to be in the range of six to 12 participants, the ideal number being nine participants. Further these participants would need to provide domain expertise. The literature suggests that the researcher recruit at least 20 percent more participants in order to account for last-minute dropouts or no-shows, especially since, in this case, the participants were all senior business executives with busy schedules. Thus, the group size sought for the search conference was between two to five experts for each of the three domains.

The participants were invited following formal approval by the institutional review board. The invitation materials are enclosed in Appendix C, and the initial question list is enclosed in Appendix F. The recruitment process was conducted to get 15 confirmed participants. It included phone, email, and in-person invitations. Ultimately, 15 participants confirmed participation, 13 attended and one participant had to leave early. This provided us with 12 participants (four from each domain). All of the participants were based in the Southeastern region of the United States; they represented a number of industry verticals, including education, energy, finance, telecommunications, healthcare, and IT consulting. Participants held senior management positions in their organizations; the majority of the participants were at the CIO/CTO & CISO levels and had an average work experience of more than 10 years. Participant details are provided in Table 4 below.

**Table 4: Search Conference Participant Details**

| <b>Participant</b> | <b>Participant Group</b> | <b>Industry</b>      | <b>Designation</b>                       | <b>Experience in years</b> |
|--------------------|--------------------------|----------------------|--|----------------------------|
| A                  | Security                 | Education            | CSO                                      | 15+                        |
| B                  | Security                 | Education            | CTO                                      | 10+                        |
| C                  | Security                 | Telecom              | Enterprise Architect                     | 15+                        |
| D                  | Security                 | Consultancy Services | CISO                                     | 10+                        |
| E                  | IT Architecture          | Energy               | Senior Engineer, Entrepreneur            | 7+                         |
| F                  | IT Architecture          | IT Services          | Project Manager, Regional Head           | 8+                         |
| G                  | IT Architecture          | Education            | Educator, Ex-CIO                         | 20+                        |
| H                  | IT Architecture          | Healthcare           | Entrepreneur, ex-CTO, ex-Chief Architect | 25+                        |
| I                  | Management               | Financial            | Solution General Manager                 | 8+                         |
| J                  | Management               | Consultancy Services | Senior Manager                           | 10+                        |
| K                  | Management               | Mobile Tech          | Director, Mobile Solutions               | 15+                        |
| L                  | Management               | Healthcare           | Business Owner                           | 20+                        |

### 8.2.12 Structuring search conference discussions

A key consideration in conducting the search conference is acquiring the participation of the various stakeholders. One method that could be used is to follow a fishbowl approach for conducting the discussions. Fishbowls are described as an old Zuni Indian technique<sup>16</sup> of conducting discussions in which one group conducts a discussion while all other participants remain silent observers. This method allows different stakeholders of a problem to share views that may be somewhat contradictory and is oriented toward enabling learning. Fishbowls can be used for many purposes. They can be used for problem solving by allowing alternate groups of views listen to and critique the other. They can also generate divergent views and allow these views to be expressed and heard for the purpose of team building (Eitington 2007).

From the design perspective, especially where multiple stakeholders with differing requirements exist, fishbowls can be extremely effective in collectively analyzing divergent views and deciding on the relative importance of these views to the design problem. The technique also serves as an ice-breaker and is therefore useful in getting people into action very quickly (Eitington 2007), which is helpful and economical from a research perspective. Taylor (2007) noted that fishbowls have been used for organizing discussions and fostering engagement by group work specialists in counseling (Furr and Barret 2000; Hensley 2002), business (Smart and Featheringham 2006), and education (Kong 2002; Priles 1993; Slade and Conoley 1989).

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<sup>16</sup> Loveland, J., and Loveland Link, J.L. Unpublished adaptation of a model from Zuni tribal council talking circles, 2001.



### 8.2.13 Fishbowl configurations

Fishbowls can be configured in a number of different ways. Typically, some members, who most commonly represent a common viewpoint or domain, form an inner circle and carry out a discussion of their viewpoint, unimpeded by others in the room. The remaining participants observe the proceedings and listen. The inner group can be assigned a specific topic of discussion; once the assigned time limit for the deliberations is over, the observers can be assigned either to respond to or to comment upon the discussions by the inner group (Eitington 2007). This process can be repeated for other groups. In an alternate configuration, multiple fishbowls can operate simultaneously. However, the objectives of the research will determine the configurations.

Another point of note is the composition of the fishbowls. As mentioned earlier, each fishbowl comprises a certain number of participants. Fishbowls can be constructed as homogenous or heterogeneous fishbowls. A homogenous fishbowl example would be one where each fishbowl has participants representing the same domain – for example, all security experts, all IT experts, or all architects. A heterogeneous fishbowl would comprise members from different domains that are working together as a group – for example, each fishbowl may have employees from one organization representing all the functions (say security, IT, and business functions) of that one organization. The other fishbowls would comprise similar, though heterogeneous, representations from other organizations.

In this research, both homogenous and heterogeneous models of fishbowls were adopted as required. Initially, for problem definition and re-articulation, homogenous fishbowls were structured by domain expertise, resulting in three fishbowls – a security fishbowl, an IT architecture fishbowl, and an IT management fishbowl, each comprising four members. During

the theoretical evaluation phase, a heterogeneous fishbowl configuration was adopted, to get the “systems viewpoint.” Three fishbowls were created, each fishbowl having at least one member representing expertise in one domain.

### 8.3 Search Conference Process: Data Collection

Five volunteers assisted the researcher with the data collection and managing the proceedings. Of these volunteers, three were graduate/post-graduate research students engaged in qualitative research, and two volunteers were following security and information assurance. The researcher had multiple roles during the search conference – that of presenter, facilitator, participant, and observer.

The search conference began with welcoming the conference participants and getting their permission for audio and video recording of the proceedings on the informed consent forms, since that was the primary mode of data collection. The methodology of the conference was then shared with the participants. This step was followed by an explanation of the ground rules of how the search conference would be conducted and how the fishbowl approach would be used for breakout discussions. After this step, the participants formally introduced themselves to the other participants, and the main proceedings began.

The initial presentation discussed the background of the BYOD scenario and how the BYOD scenario has changed the computing environment. After sharing the current status of BYOD adoption and its advantages, the researcher presented her understanding of the problems resulting from this situation. Then the participants were grouped into three groups, each of which comprised participants representing an interest perspective (architectural, security, or business) who were asked to discuss their views of the BYOD problem. A fishbowl approach was adopted in creating these breakout groups and engaging them in discussion.

From this discussion, the research problem was confirmed. Following this, the bindpoint model for designing BYOD security was presented and explained using an example. The participants were then regrouped into groups representing “systems.” This second breakout comprised three groups. Each group was made up of at least one expert from each of the three expertise domains – information security, information architects, and information managers – thus constituting a “system.” These groups undertook the task of critiquing how the bindpoint model could be used to design BYOD security and discovering any potential problems with the model. They discussed what problems might arise in the application of the model and tried to come up with scenarios in which the model might not work. They were asked to identify three problems with the existing model and its application in their individual organizational settings. They were also asked to suggest ways in which the model should be changed from its current form. Each group independently evaluated the model using flip charts. The entire process was also recorded and photographed. A sample flip chart page is shown in Appendix D.

In order to enable a holistic viewpoint, during the first round of discussions, the participants were divided into groups of three, representing their respective perspectives. The security professionals from different organizations formed one group, the IT architects formed another group, and the business managers formed the third group. During each fishbowl session, each panel of “experts” questioned the problems that had been presented, argued the relative importance of each and came up with their list of the most important problems. Once all three fishbowl discussions were completed, all participants reconvened and collectively discussed the problems that each group of experts had identified. In doing so, they discussed the business impact of technical changes as well as the impact of business and IT decisions on security problems, and vice versa.

The search conference employed a number of data collection methods to help capture the all aspects of the conference. The proceedings were audio- and video-recorded. One of the volunteers, who was a student specializing in ethnographic studies, was assigned the task of making notes and observations. The participants used a combination of discussions and brainstorming using flip charts. Both forms of discussions were captured during the video recording. Since there were simultaneously three different groups discussing the topic from their perspectives, each group was individually recorded by a volunteer. Further, participants were provided flip charts and white-boards as a common place for the group to note their discussion points as well as key points emerging from their discussions. Also, the entire session involving the simultaneous breakouts was recorded by the fourth volunteer. Additionally, there were still photographs taken of the flip charts that were used for brainstorming. During the consolidation of the discussion by the breakout groups, the information that was discussed was reviewed by the researcher and the adviser to provide the summary of the discussions to the participants.

### **8.3.1 Presentation of the BYOD problem**

The search conference investigated and evaluated the validity of the bindpoint model and its utility in its application to BYOD security. The process involved bringing three different perspectives into the room – management, Information Systems security, and Information Systems architecture. These are the three elements that come together in a bring-your-own setting. Management has dual requirements and goals for accommodating devices and technology and developing policies related to BYOD – the first is in regard to such devices and technology that belong to individuals, employees, customers, suppliers, and other business associates; the second pertains to the devices and technology that the organization furnishes for its own employees or customers. This distinction plays an important role in ownership,

especially since bring-your-own settings are notoriously associated with extreme blurring of personal and professional use.

A poll of the participants' attitudes and behavior regarding the dual usage of technology revealed that all participants agreed that lines between personal and professional use of technology were becoming blurred. A majority of the participants acknowledged using the same laptop for work and personal use and using the same mobile phone for both personal and work-related calls. Many participants maintained distinctions between personal and work accounts or personas on their mobile devices. Almost all participants admitted to taking work calls or checking work emails at home, over weekends, and during holidays. Many participants used mobile devices, especially phones, to look for directions or follow up on social media updates. Another interesting note was that many of the participants were using the same applications such as Skype and Dropbox for both personal and work purposes. Interestingly, only a few participants used completely different accounts in Dropbox. Most participants had only one Dropbox account for personal and official storage, but maintained separation through different virtual folders. One of the points that truly captured the spirit of blurred work and personal lives was regarding the usage of a professional networking site for personal reasons.

### 8.3.2 Elaboration of the design requirements

The search conference generated a large volume of data in a variety of forms – audio, video, photographs, notes, and flip chart sheets. The analysis is presented as follows:

The first round of fishbowls discussed the BYOD problems that were to be addressed by the bindpoint model. The problem was examined from each of the three stakeholder perspectives, namely, security, IT architecture, and managerial. These fishbowl sessions served to clarify the problem definition since the effectiveness of the solution lies in the appropriate definition of the solution requirements. The findings from the first series of fishbowl discussions are enclosed as Table 5 below.

| <b>Table 5: Summary of Findings from Problem Discussion</b> |   |
|---|---|
| <b>Expert Group</b>   | <b>Findings from first round of Fishbowls</b>   |
| Security Fishbowl   | <p>For the security group, three areas of topics surfaced:</p> <ul style="list-style-type: none"> <li>- These were focused on end users, human relations, and interdependence.</li> <li>- There was a focus on data, how to protect it, how to govern it.</li> <li>- Finally, there was focus on the device: location awareness, privacy protection, and proper configurations.</li> </ul>  |
| Architecture Fishbowl                                       | <p>For the IT group, the main concerns were :</p> <ul style="list-style-type: none"> <li>- Overhead cost, standards, supporting, licensing.</li> <li>- There were concerns about agility and the need to be nimble, for example, how to cope with change and diversion.</li> <li>- There were risk management concerns regarding classification, granularity, authentication, and access control.</li> <li>- There was also discussion on usable security.</li> </ul> |
| Management Fishbowl   | <p>In the management area, new security concerns deriving from BYOD came up:</p> <ul style="list-style-type: none"> <li>- The major concern was complexity.</li> <li>- Another major concern related to legal problems.</li> <li>- Another concern regarded minimizing the risk to internal resources and at the same time, protecting the employee.</li> </ul>   |

### 8.3.3 Presentation of the solution (bindpoint model)

Following this problem discussion, the bindpoint model was presented as a solution. The participants were then regrouped, this time by system, with representatives from each of the three stakeholder groups. Each “system” independently evaluated the bindpoint model by examining how it could be applied in the organizational setting. Next, the “systems” critiqued the model to isolate in which situations the model would *not* be applicable and why it would not work. They

also discussed the requirements of a working model. The evaluation that proceeded during the second series of breakout discussions (systems view) is discussed below.

#### 8.3.4 Evaluation of the (solution) bindpoint model

Conceptually, the bindpoint model provides a simple solution to a complex problem of computing security in the bring-your-own setting. Especially, it has the advantage of addressing security risks in unknown conditions by replacing security rules in predictable scenarios with rules computed instantaneously in unknown combination settings, thereby expanding the scope of a security net and potentially reducing security risks in unknown settings. Still, some limitations emerged during the evaluation of the model by industry experts from multiple domains. Some limitations include complexity, implementation concerns arising due to the cost factor, uncertainty in the model post access, provision for revocation of devices, and privacy concern.

Limitations to the model arose from three basic causes. These included cost and complexity limitations. The participants quickly agreed that the bindpoint theory would need to include design principles to manage these critical factors that plague BYOD engineering.

*Well, that's just the other point I was going to say. What impact would this have on the cost if I try and set this up? Remember the BYOD, from the executive side was, "It's going to save us money." I got to put this bindpoint solution and I got to spend more money? No, I don't think that's what I want to do. So, part of it is: how do you going to make it cost-effective?*

*Right, and complexity leads to issues like: how would you detect breaches, and how do you know? It's a computed thing. Yes, okay, but how do you know what happened that resulted in a possible access which shouldn't have happened? Logging becomes also more complex. What are the events that you're logging really?*



In addition, the conference focused on the limitations of current infrastructure and technology. These issues included data alignment, data consistency, device-related concerns, and governance mechanisms.

*How do you handle the revocation of devices and how do you handle lost devices and lost data? This doesn't ... The way we saw it, it covers allowing access or not allowing access, but it doesn't cover after the fact, after the access had been given, if there's data and devices. An example: how do bindpoints handle that?*

Finally the conference discovered problems with BYOD security and privacy that were not addressed in the existing bindpoint theory. These included concerns for both the individuals who were bringing these devices and the enterprise.

*The other thing I could say, one of the issues you all struggled with on the security side is: do you want to spread out the layers in a defensive depth? Or in this case, it looks like you're really going to be packaging that all in one location, this bindpoint. So, does that in fact increase the vulnerability because you have one place to go to hack in to this stuff as opposed to other several points?*

When the search conference entered its final phase, the “re-theorizing” of the design theory itself, a number of new design principles, previously untreated in the bindpoint theory, began to surface. Design principles need to be added to the theory to address the limitations that surfaced in the first part of the search conference. The entire conference converged on the management of risk and complexity.

The central design principle that arose for the management of complexity was the need for graduated implementation. The design theory would need to encompass the implementation of one small section of the system revision at a time. The notion was to grow the complexity in a gradual and controlled way.

*It is a complex issue, but we've dealt with these complex issues before. So how did we manage that? And, in many ways, this is just another level of*

*abstraction that we are putting in. And so what have we done in other cases to make that happen effectively? So, look at those past attempts. Again graduated implementation, you know, don't try to boil the ocean.*

The central design principle that arose for the management of risk extended the bindpoint concept of calculation within cellular automation by dynamically calculating policies in the context of the effect of a new bindpoint on an index of overall system risk.

*What helped me today was the computational aspect of it. Really, everybody hates the FICO score [a credit quality rating] ... But the interest rate you're going to get on loans pretty much depends on that. ... it somehow gets computed ... there are a lot of things that go into computing it. But, it's sort of become the standard at some point and it's ultimately measuring risk. ... You're talking about is big data, so all of these variable attributes are going to be collected by these firms and then turned into whatever index you are saying.*

### 8.3.5 Learning from the search conference

The search conference concluded with this focus on governance, risk assessment, and the management of complexity. Following the search conference, the streams of data collected during the conference were analyzed hermeneutically in order to derive the participants' interpretation of the original bindpoint design principles and to derive the revisions to these principles (or elaboration of the principles) that were reflected in the action plans of the participants.

An iterative analysis of the data revealed that there were some considerations that would be important to ensure that the bindpoint model could be effectively applied for designing a BYOD security system. These included cost and complexity considerations, infrastructure and technological considerations, and general security management considerations. These considerations would need to be synthesized to reframe the bindpoint model more comprehensively in order to make it generally more efficient and universally applicable in any

setting of BYOD security systems. These characteristics that emerged from the data analysis are described in Table 6 below, and some representative quotes are provided in Appendix E.

| <b>Table 6: Examples of Design Considerations Emerging from Data</b> |                             |   |   |
|--|-----------------------------|---|---|
| <b>Design Goal</b>   | <b>Design Consideration</b> | <b>Design Problem</b>   | <b>Example of this characteristic in the data</b>   |
| Managing Cost & Complexity   | Cost                        | The cost of applying the BYOD model for designing the system should be minimal in order to justify its acceptance and incorporation into the current organizational information system. | <i>“How would you address the cost? I think it got almost embedded in the application cost that that would be part—If you have a separate cost, I think you’re going to be dead in the water. But, if you can have that integrated into a now ... or somehow figure out how to get that into something that already exists as opposed to having a new or an entire set of programs that you actually have to purchase and obtain.”</i>  |
|  | Complexity                  | The complexity of the computation process should be minimal; implementation of the system should be possible in a piecemeal fashion.  | <i>“So, one of the ways to simplify it perhaps would be to not think of the overall application of it, but think of applying it to a subset of the problem. So, maybe ... and you can create subsets all kinds of different ways, but one way maybe you just deal with who and how they’re trying to establish a bindpoint and who will establish a bindpoint. Maybe you initially don’t deal with when and why and all those other things that you can think of, where. Maybe you do, but if you try to apply this to a subset it might be a better chance of dealing with it, initially at least, because otherwise it’s just too complex to solve. Perhaps the best thing that we could think of was: if there is enough of a seed of implementation of this, and there was enough of a success with that seed, it will probably prompt innovation on part of people who want to make money off this, which is how things happen anyway.”</i><br><br><i>“I think if we could have a prototype on a subset (of the computational model) that was successful and of course then we started creating our own architecture and how we would implement this.”</i> |
| Managing Infrastructure & Technology Requirements                    | Data Alignment              | It should be possible to align the information captured at the bindpoint with potential access paths and to log these so as to be able to trace breaches.                               | <i>“How would you detect breaches, and how do you know? It’s a computed thing. Yes, okay, but how do you know what happened that resulted in a possible access which shouldn’t have happened? Logging also becomes more complex. What are the events that you’re logging really?”</i>   |

|                               |                    |   |  |
|-------------------------------|--------------------|---|--|
|                               | Computation        | The computation of the bindpoint must be achieved in a time-sensitive manner.   | <i>Can you do it in a time-sensitive manner? We know people don't want to spend much time after they've clicked on something, wait for something to happen probably three seconds. So, can you actually manipulate the information quickly enough? I think you can, but the problem is going to be to generate those kinds of systems to do that."</i>                 |
|                               | Device Management  | Device identification and management of device access must be possible.   | <i>"How do you handle the revocation of devices and how do you handle lost devices and lost data? This doesn't ... The way we saw it, it covers allowing access or not allowing access, but it doesn't cover after the fact, after the access had been given, if there's data and devices. An example: how do bindpoints handle that?"</i>                             |
|                               | Communication      | Communication challenges must be effectively managed.   | <i>Yeah, that would be a significant challenge. And we know the other nature of the interactions we're working with go back to the communications level. We learned in BYOD already is that some of these are going to go through multiple communications domains. So how do you do that?"</i>   |
| Managing Individual's Privacy | Individual Privacy | Privacy of sensitive information would need to be maintained and potential for loss of privacy through mosaicing should be minimized. | <i>"I was going to say, the level of intimacy that the person has with the resource provider. You know, you ask my employer, what are the different attributes about me? If I set up, sign up from a stray mail account, mail dot com, do I really want to give them (the organization) more other than my password? Do they really need my intimate information?"</i> |

## 9 ADAPTATION OF SECURITY THEORY: RE-THEORIZING OF THE BINDPOINT MODEL

This chapter describes how the evaluation of the bindpoint model for its application to BYOD security through the search conference brought up the need to refine and re-theorize the model. Further, the design principles needed to be adapted in order to make them applicable to BYOD security. As an extension of the current bindpoint model, each of the new design principles was further developed into design rules or guidelines that would aid the design of an organizational information system supporting BYOD security. These design rules emerged from the search conference data and are further supported by the literature.

### 9.1 Development of the Design Principles for BYOD Security

The design principle forming the basis of the Baskerville and Lee bindpoint model states that in conditions of emergent complexity, requirements for rule-based predictability (that is, security controls) can be satisfied by components using metalogic to bound computability. This principle of computing the security risk is intended to allow or prevent access to Organizational Information Systems based on conditions acceptable to both the organizational system and the individual system. This principle was designed to accomplish the following two general requirements/design goals:

1. To maintain security in the presence of idiosyncratic autonomy
2. To maintain stability in the presence of experiential design

BYOD has been spurred by capabilities provided to the individual from constantly improving and powerful technologies (devices, networks, capabilities, applications). These capabilities result in a computing environment that is very dynamic. An analysis of the BYOD

context demonstrates that the technological systems furnished by individuals are very complex and heterogeneous and can change frequently and unpredictably. Therefore, for the organizational systems (that these individually furnished systems interact with), the need for security must be managed in a way that provides for security and stability in the organizational information system but, at the same time, is flexible to adapt to these complex, heterogeneous systems that can change frequently and unpredictably.

The evaluation of the bindpoint model reiterates the need for designing security in organizational infrastructures in a manner that will ensure security. However, it is not possible to know all the different combinations or new conditions that might arise in the computation of the system bindpoints. Therefore, the need for stability of the system must be redefined as the stability of the system across the bindpoints; this stability will be achieved through flexibility. The design requirement for BYOD security must therefore include flexibility while ensuring security, thus providing the following two design goals:

1. Minimize risk for organizational systems
2. Provide flexibility in the organizational systems to adapt to interactions with new or changing technology (Hanseth and Lyytinen 2010)

In designing systems security, one of the problems that arises is that of complexity.

Therefore, one more design goal emerges:

3. Provide ease of use and simplicity in accessing and using Organizational Information Systems (Saltzer and Schroeder 1975; Schroeder et al. 1977)

These requirements emerge in synthesizing the concerns that arose from the search conference. By mapping these concerns against the original design requirements, it is clear that

the landscape of BYOD is dynamic and evolving. In such a scenario, maintaining stability of the system will not be possible without incorporating flexibility into the system design. Based on the above design requirements, the following three key design principles emerge:

1. The first key principle is to design security based on computation of risk, which is in turn based on the interaction of the software agents of the individual systems and the organizational system.
2. The second principle is to design for flexibility.
3. The third principle is to make the design simple and easy to implement and use.

An analysis of the evaluation of the bindpoint model through the search conference emphasizes these principles. A comparison of the original theory and revised theory is provided in Table 7 below.

| <b>Table 7: Design Theorizing Components of Bindpoint Model for BYOD Security</b> |  |   |
|---|--|---|
| <b>Design Theory Development Stage</b>  | <b>Original Bindpoint Model</b>  | <b>Revised Bindpoint Design Theory</b>  |
| <b>Design Goals</b>   | Connecting Individual Information Systems to the Organizational Information Systems  | Connecting Individual Information Systems to Organizational Information Systems in the context of BYOD  |
| <b>Design Requirements in the BYOD Context</b>                                    | <ul style="list-style-type: none"> <li>- Maintain security in the presence of idiosyncratic autonomy</li> <li>- Maintain stability in the presence of experiential design</li> </ul> | <ul style="list-style-type: none"> <li>- Minimize security risk for organizational systems in the context of BYOD</li> <li>- Provide stability in the organizational systems by incorporating flexibility to adapt to interactions with new or changing BYOD technology</li> </ul>                              |
| <b>Kernel Theory</b>  | <ul style="list-style-type: none"> <li>- Cellular automata</li> </ul>  | <ul style="list-style-type: none"> <li>- Complex adaptive systems</li> <li>- Cellular automata</li> </ul>   |
| <b>Design Principles</b>  | Bounded computability replaces rule based predictability   | <ul style="list-style-type: none"> <li>- To design security based on computation of risk from the interaction of the software agents of the individual systems and the organizational system</li> <li>- To design for flexibility</li> <li>- To make the design simple and easy to implement and use</li> </ul> |



## 9.2 Development of the Design Rules for BYOD Security

Hanseth and Lyytinen (2010) note the following elements of design theories: “(1) a set of design goals shared by a family of design problems; (2) a set of system features that meet those goals; and (3) a set of design principles and rules to guide the design so that a set of system features is selected to meet chosen design goals” (p. 5). While design principles provide broad guidelines on how the design is to be expressed in terms of functionality, these principles can be “detailed into design rules that formulate in concrete terms how to generate and select desired system features as to achieve stated system goals” (p. 5).

Peffer et al. (2007) note that the literature has recognized the importance of design rules in providing the guidance for design-science research (Archer 1984; Fulcher and Hills 1996; Hevner et al. 2004; Reich 1995) and for justifying it (Nunamaker Jr and Chen 1990; Walls et al. 1992)” (p. 50). According to Peffer et al. (2007), Hevner et al. (2004) provide practice rules for conducting design-science research in the IS discipline in the form of seven guidelines that describe characteristics of well-carried-out research. Archer (1984) believed that design could be codified, even the creative part of it, and that designers can approach design problems “systematically” by looking at functional-level problems such as goals and requirements and by progressing toward more specific solutions (Peffer et al. 2007). Thus, design rules can provide systematic guidance for helping link the general goals with the general requirements.

van Aken (2004) describes design theorizing in terms of *technological rules*. He describes these technological rules as the “scientific knowledge that is required to solve a class of managerial problems” (p. 220), which he defines as abstract knowledge. Design rules are detailed solution-oriented guidelines for the design process (Romme and Endenburg 2006).

Plsek et al. (2007) note that design rules help convert tacit knowledge into actionable knowledge.

Romme (2003) defines design rules as heuristic statements that can be expressed in the form: *To achieve outcome Y, in situation S, something like X might help*. In the context of organizational design, Plsek et al. (2007) suggest that experts tend to think using such heuristic rules, and organizational change design rules can be used by managers to implement design changes in an organization. Hanseth and Lyytinen (2010) state that design rules govern the designer's behavior, thereby influencing the system design.

The literature suggests that it is important that the design principles that were refined above must be detailed explicitly in the form of rules, or specific guidelines on *how to* select the appropriate features and characteristics of design for the BYOD security system (Hanseth and Lyytinen 2010; Plsek et al. 2007; Romme and Endenburg 2006). Therefore, the design principles from the revised bindpoint theory are further examined in view of the findings that emerged from the analysis of the search conference data. From this analysis, a set of guidelines is developed for applying the bindpoint model for organizational security in the BYOD context. These rules are grounded in the findings from the search conference as well as in the systems design and development literature. A summary of these rules and the associated design principles for these rules are presented in Table 8. Subsequently each rule is described in more detail.

**Table 8: Development of Design Rule Set**

| Design Principles   | Applying Design Principles to the Design of Secure Systems | Design Rules  |
|---|--|---|
| To design security based on computation of risk from the interaction of the software agents of the individual systems and the organizational system | Integrate security with IS                                 | 1. Integrate security design and development with IS design and development   |
|   | Continuous protection of information                       | 2. Principle of continuous protection of information  |
|   | Secure failure   | 3. The principle of secure failure also applies here in that it involves a rollback mechanism that can return the system to a secure state  |
|   | Economic security  | 4. The principle of economic security   |
|   | Threshold decision   | 5. Acceptable security<br>6. Establish and adhere to minimum required performance standards<br>7. External authority that provides a risk score (like a credit card score) and manages device/rule revocation                         |
| To design for flexibility   | Reduce complexity  | 8. Modularity<br>9. Least common mechanism<br>10. Design for secure evolution   |
| To make the design simple and easy to implement and use   | Simplicity   | 11. Rule of simplicity – Ockham’s razor, “Plurality should not be assumed without necessity”<br>12. Common principles for standard design and access<br>13. Efficiently mediated access to resources<br>14. Procedural implementation |
|   | Fast and easy to use                                       | 15. Performance security  |

### 9.3 Design Rules for BYOD Security

**Rule 1: Integrate security design into Organizational Information Systems.** Despite its importance in the functioning of Information Systems, traditionally, security was not considered a functional requirement (Dubois and Mouratidis 2010). However, separating the development of security systems from Information Systems development can result in conflicting goals and requirements (Baskerville 1992; Devanbu and Stubblebine 2000). It is therefore important not only to integrate security design with Organizational Information Systems design but also to do this as early as possible. Siponen et al. (2006) find that security design methods cannot operate independently of Information Systems design methods. Specifically, Baskerville (1992) states that the security design techniques must also integrate with the general systems design techniques.

Moreover, this integration should be done as early as possible to avoid redesign issues. Security functions that are added to a pre-existing system require analysis to ensure that they will perform with the level of trustworthiness intended (Benzel et al. 2005). Also, any new security functionality should not negatively impact the existing systems into which they are integrated, either in terms of functionality of the existing systems or in terms of speed of performance (Dubois and Mouratidis 2010).

**Rule 2: Design for continuous protection of information.** Information should be secure throughout change as it pertains to “interface, functionality, structure, or configuration” (Levin et al. 2007). Consistent protection reduces the maintenance costs and prevents small changes in one part of the system from interfering with the integrity of the algorithm elsewhere.

**Rule 3: The principle of secure failure.** Fundamentally, the principle requires that any failure of the system should not allow the security of the system to be impinged; that is, the system should maintain security even in the event of a failure. This condition requires that the system is capable of detecting any failure that may occur and is able to take appropriate measures to safeguard itself from a violation of its security, whether through a reconfiguration of the system to maintain security or through a rollback to a secure state.

**Rule 4: The principle of economic security.** Computations are usually resource-intensive, and security based on computation can create an overhead on the time required for the computation and ultimately the processing power required to support the computation. A search conference participant notes:

*How would you address the cost? I think it got almost embedded in the application cost and that would be part of it. If you have a separate cost, I think you're going to be dead in the water. But, if you can have that integrated in to a now ... or somehow figure out how to get that into something that already exists as opposed to having a new or an entire set of programs that you actually have to purchase and obtain.*

*Well, that's just the other point I was going to say. What impact would this have on the cost if I try and set this up? Remember the BYOD, from the executive side was, "It's going to save us money." I got to put this bindpoint solution and I got to spend more money? No, I don't think that's what I want to do. So, part of it is: how do you going to make it cost effective?*

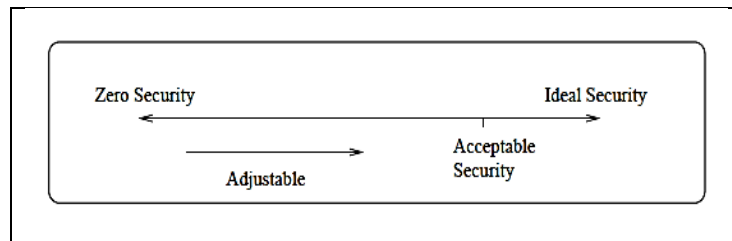
**Rule 5: Acceptable Security.** This rule requires that the level of privacy and performance the system provides should be consistent with the users' expectations (Benzel et al. 2005). Based on the organizational privacy policy, the system should provide for mechanisms for the adjustment of the level of disclosure that the users are comfortable with and that the organization is willing to accept. Although an ideal level of security is preferred, it may be expensive to achieve; a lower-cost solution that provides an acceptable, if not ideal, level of security may be preferred (Du and Zhan 2002). Moreover, the users may not be willing to disclose information

to the level of detail required by the system. Therefore, requiring disclosure of limited information about the private data for better performance is often acceptable in practice (Du and Zhan 2002). For example, in statistical disclosure control, individually identifying information can be protected against recognition of subjects while still providing as much information as possible under these restrictions (Willenborg and De Waal 2001). The system design could also provide the option of a default minimum state of system for unsecure access with minimum/basic functionality and/or access to information or data that does not require secure access.

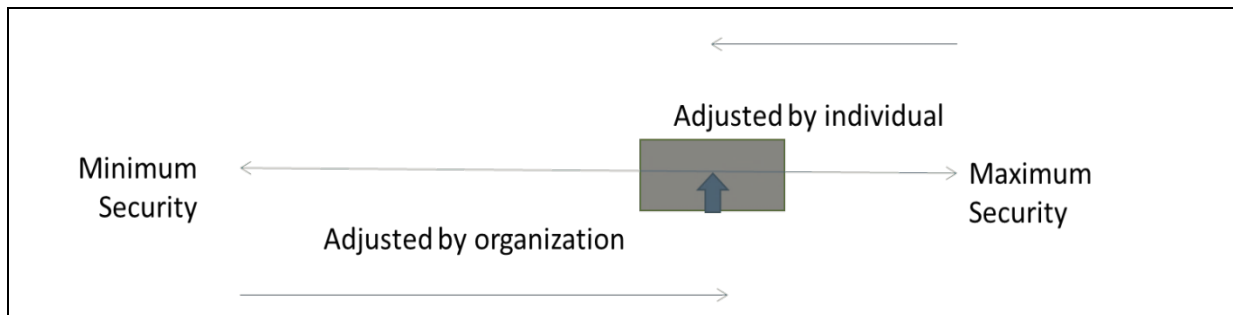
Further, the design must provide that the decision regarding acceptable security is a choice for both the user and the organization. In this way, both parties to the bindpoint computation have the option to select a threshold level of risk that they are comfortable with; then, the computation permits a go/no-go decision. Thus, the organizational system could provide selected levels of availability into the system based on confidentiality and security requirements, matched against the level of information that the user or their device settings are willing to share in order to be permitted entry.

Du and Zhan (2002) provide a model for acceptable security that is shown in Figure 14 below. In the context of the bindpoint model for BYOD security, the design rule would provide for a level of security that was acceptable to both the entities connecting at the bindpoint. The “ideal security,” then, is the tradeoff between the levels of access that the organization can provide balanced against the tradeoff that the individual is willing to make in terms of surrendering his or her privacy or control over the individual system to the organization in order to be able to access the organizational system (Smith et al. 2011). This tradeoff would allow for a staggered form of access and availability to the individual, who would not have to completely relinquish personal information and control to the organization. The model for this *negotiated*

and acceptable level of security that is adapted from the Du and Zhan (2002) model is presented below in Figure 15.



**Figure 14: Model of Acceptable Security from Du and Zhan (2002)**



**Figure 15: Bindpoint Model of Acceptable Security – Adapted from Du and Zhan (2002)**

One of the concerns that the bindpoint model raised was the issue of individual privacy. Participants felt that the process of security computation required the provision of detailed information attributes pertaining to the technology being used in order for the bindpoint access to be computed. As one search conference participant pointed out:

*I was going to say, the level of intimacy that the person has with the resource provider. You know, you ask my employer, what are the different attributes about me? If I set up, sign up from a stray mail account, mail dot com, do I really want to give them (the organization) more other than my password? Do they really need my intimate information?*

There was a level of discomfort in not knowing which attributes related to their personal technology would be captured in order for the organizational information system to grant access to the connectivity.

*I think the point you're making, which is a critical one, is how does this affect the privacy on the individual's side? Because in order for this to work, you got to have all that stuff exposed—because you don't know what it's going to be. So if you don't know what it is, it all has to be available, which then opens up the issue of privacy.*

Moreover, participants were quite uncomfortable with the potential misuse of such information in the future. They were concerned that in the world of “big data,” the personal information that they shared in the form of information attributes related to the connection between the individual and organizational system might somehow be mined, raising privacy concerns.

*And, it'll be amazing how much personal information is out there on you already. And that's what, in the back of my mind, I'm always thinking, “I'm leaving a nugget of information over here on the web, over here ... And they're data mining it ... if someone's data mining it. I know he's over here now, and he's over here now. They could stitch it all together.*

Therefore, by providing the option of an acceptable level of security, the organization will allow individuals to make an educated decision in regard to information-sharing versus the level of access they are permitted.

**Rule 6: Establish and adhere to minimum required performance standards.** Even in the absence of external review, the system should develop an intrinsic criterion for evaluating trustworthiness and security. As one search conference said:

*Yeah, that would be a significant challenge. And we know the other nature of the interactions we're working with are go back to the communications level. We learned in BYOD already is that some of these are going to go through multiple communications domains. So how do you do that?*



A key challenge is to navigate multiple communication domains for BYOD so that there is clear and untrammelled communication between devices and availability of enterprise services such as email. Given the multitude of system boundaries that must be seamlessly traversed, new systems of communication or new protocols may need to be evolved to address the challenge of communication.

**Rule 7: External authority that provides a risk score (like a credit card score).** The search conference discussion found that for a bindpoint computation, trust would increase if a risk score was provided by a third party rather than by the organization. The organizational system would then have a choice whether to proceed with the connection, as would the individual. The validation of the score must be verified by an external and independent authority or agency keeping track of both persons and their devices and having a security score for them. For example, such an authority would keep track of when a device was acquired, who sold it, when it was lost or not used anymore, who owned and used it, and whether that person was trustworthy. This external agency could also keep track of the operating system and applications on the devices. This external agency would provide services similar to those performed by credit agencies.

According to the participants:

*This (risk) score comes from computing authority that we trust. So, they can't just present the score to us and we say, "Yes," they're in.*

*So our thoughts were that the EIS side of it and the IIS side of it, both of these systems could present the current state (at the bindpoint) to an authority. We can determine what things we call a state, but let them present the current state, the computed score that says allow or disallow. I think that is not that difficult to implement.*

*The beautiful thing I like about that is that you're protecting both the IIS from the EIS and vice versa.*

Further, with regards to the provision of this risk score by a trusted third party, a participant states:

*But, one of the differences in this is that credit score bureaus are getting information from lots of other places and making an independent and trustworthy calculation. In one of these two models, you're basically back to network access control, where you're asking an agent running on the device, "Is it trustworthy or not?" And so, if you're asking the device if they're trustworthy, there's your problem.*

*I mean, it's okay, but I think it still boils down to different companies choosing what score, or what standards, they want to implement. For a company that's more global, their users or employees might need a good score to be in different parts of the world. But if I'm only focused here, if somebody accesses my system in another country has a low score, no access.*

*It depends on what you want to give them access to also. That's where you have this categorization of data.*

Moreover, this would also address the design requirements for handling device revocation or device loss.

*How do you handle the revocation of devices and how do you handle lost devices and lost data? This doesn't ... The way we saw it, it covers allowing access or not allowing access, but it doesn't cover after the fact, after the access had been given, if there's data and devices. An example: how do bindpoints handle that?*

Having an external authority manage and provide scores for individuals and devices would address this.

**Rule 8: Modularity.** Parnas et al. (1984) provide the following specific goals for modularity:

- Simplicity in module structure will ensure that it can be understood. This also aligns with the rule of minimizing complexity below.
- Change in any of the modules will not affect the other modules, which can function as black boxes.

- Changes made in any modules should result in minimal modification of interfaces of frequently/widely used modules.
- It is possible to make a major change as a result of independent changes to individual modules.

Further, Levin et al. (2007) advise that in regard to “the design of secure systems, in addition to ‘function’ as a basis, modular refinement based on trust, trustworthiness, privilege, or security policy can provide significant strength and clarity to a design” (p. 5). For example, the authors recommend that modularity be considered in the:

- Allocation of policies to systems in a network
- Allocation of a system’s policies to layers
- Separation of system applications into processes with distinct address spaces
- Separation of processes into subjects with distinct privileges, based on rings

Since the calculation at the bindpoint is computationally intensive, the algorithm for this should be developed using the notion of modularity, so that if in the future the computation mechanism is improved upon, it will be easier to apply the replacement without disrupting the system.

***Rule 9: Least common mechanism.*** Saltzer and Schroeder (1975) define the least common mechanism as one that will

minimize the amount of mechanism common to more than one user and [will be] depended on by all users. Every shared mechanism (especially one involving shared variables) represents a potential information path between users and must be designed with great care to be sure it does not unintentionally compromise security. Further, any mechanism serving all users must be certified to the satisfaction of every user, a job presumably harder than satisfying only one or a few users. (p. 1283)

This is an important rule to observe in applying bindpoint security and must be used with care to create appropriate balance, since this rule is restrictive and limits sharing. Sharing resources provides a channel along which information can be transmitted.

***Rule 10: Design for Secure Evolution.*** This rule is specifically important for the successful application of the bindpoint model, especially due to the wide range of different devices, operating systems, applications, usage, and other factors that may potentially “collide” with the organizational system. Moreover, the rapid changes and evolution in technology can result in new and even unknown combinations of system configurations seeking to connect with the organizational systems. A system that is designed for secure evolution must be able to “facilitate the maintenance of its security properties in the face of changes to its interface, functionality, structure or configuration” (Levin et al. 2007 pp. 7-8). It is suggested that the design would replace the need for fixed parameters with configurable parameters that could be dynamically reconfigured when required and be kept scalable by planning for the future addition of network connections, processors, or other computing devices (Levin et al. 2007).

***Rule 11: Simplicity – Reduce complexity.*** While complexity is a byproduct of the inevitable drive for security, this complexity can itself make the system insecure by creating new points of vulnerability. Complexity can be thought of as the number of technical elements [in a system], their connections, and rate of change. Ockham’s razor also suggests that there is no inherent need for complexity in IS, arguing that simplicity should instead be preferable. Saltzer and Schroeder (1975) recommend following the principle of “economy of mechanism” by keeping the design as simple and small as possible, especially in security systems. They note that errors in design and implementation usually emerge in cases of unauthorized access rather than during normal usage. Simple designs enable these flaws to be investigated and corrected

faster. Moreover, simple design makes future architectural changes easier. It also reduces vulnerabilities – fewer “moving parts” equate to fewer and more well-defended “targets.”

**Rule 12: Efficiently mediated access to resources.** A control mechanism for each subset of the policy should be accessible through the most efficient interface possible. This guideline helps ensure a balance between flexibility and performance. The architectural design of the bindpoint model will include both hardware and software components. Access mechanisms allocated to the hardware (or lowest layer) will provide more efficient performance compared with access mechanisms implemented through software, which can provide more flexibility (Schroeder and Saltzer 1972). Therefore, finding an appropriate balance to determine the most efficiently mediated access to the organizational systems will improve system performance and increase use.

**Rule 13: Procedural implementation.** Since this is a complex problem, a graduated implementation of the system is suggested to reduce complexity. In the literature, various perspectives to technological implementations have been forwarded. Stoddard and Jarvenpaa (2000) distinguish evolutionary, or gradual, staged models of change involving incremental change (Gould and Eldredge 1977) from revolutionary or radical change, which results in transformations over a very brief period of time (Orlikowski 1993). Liker et al. (1987) provide four options for socio-technical changes:

*All-at-once.* Liker et al. (1987) describe an all-at-once scenario as an ambitious, comprehensive set of radical changes. This approach constitutes a complete, potentially exhaustive set of social and systemic changes that eschew piecemeal reforms in favor of a holistic approach. In this approach, technical changes and social changes are applied concurrently. While their study did not find this approach to be successful, it is not entirely

without merit. Such approaches can be useful in situations with time-to-market considerations and can potentially lead to synergies between social and technological change. In the case of a BYOD security implementation, it may be more prudent to adopt a less radical approach in favor of a more incremental approach.

*Technical systems first.* In this approach, the technical systems changes are applied, and the organizational process changes follow once the technical system is stable. The advantage of this approach is that resources are not split between technical and social changes; however, the technical system design could potentially constrain the social system (Liker et al. 1987).

*Social system first.* Prioritizing social change allows an organization to modify its structure, internal relationships, and hierarchy before implementing technological advancements. This approach can provide a superior organizational context within which technologies operate, which helps the technologies to be integrated and used in more appropriate or cost-effective ways (Liker et al. 1987).

*Gradual, staged sociotechnical change.* Liker et al. (1987) suggest an incremental approach where organizational and technological changes are concurrently designed and implemented to reduce uncertainty and have a higher chance of success in organizational change management. Translating this to the design of BYOD security, since Information Systems are sociotechnical systems, it is posited that a graduated, staged approach would have a higher likelihood of success. Moreover, moving from the abstract to the specific, such an incremental approach to design would reduce the impact of changes and simplify the process.

The search conference findings support a staged approach to applying this model.

Participants stated:

*It is a complex issue, but we've dealt with these complex issues before. So how did we manage that? And, in many ways, this is just another level of abstraction that we are*

*putting in. And so what have we done in other cases to make that happen effectively? So, look at those past attempts. Again graduated implementation, you know, don't try to boil the ocean.*

Another participant suggested:

*But we also realized that almost everything that we start off with, in a complex world is a complex problem. And it's just the evolution of the world that would simplify this. "So, one of the ways to simplify it perhaps would be to not think of the overall application of it, but think of applying it to a subset of the problem. So, maybe ... and you can create subsets all kinds of different ways, but one way maybe you just deal with who and how they're trying to establish a bindpoint and who will establish a bindpoint. Maybe you initially don't deal with when and why and all those other things that you can think of, where. Maybe you do, but if you try to apply this to a subset it might be a better chance of dealing with it, initially at least, because otherwise it's just too complex to solve. Perhaps the best thing that we could think of was: if there is enough of a seed of implementation of this, and there was enough of a success with that seed, it will probably prompt innovation on part of people who want to make money off this, which is how things happen anyway.*

*I think if we could have a prototype on a subset (of the computational model) that was successful and of course then we started creating our own architecture and how we would implement this.*

**Rule 14: Performance security.** The principle of performance security states that security mechanisms should be constructed so that they do not degrade system performance unnecessarily. The principle requires the clear prioritization and articulation of the requirements of performance and security (Levin et al. 2007). This rule aligns closely with acceptable security, the difference being that this rule determines the acceptable level of security versus performance tradeoff decisions required to be clearly defined for the organizational systems. Levin et al. (2007) state that this rule is intended for the designers to carefully consider the specific policy requirements that will provide maximum security but incur the lowest overhead by incorporating hardware level security that will provide higher efficiency while trading off flexibility.

**The system must be able to address the requirements for security and computation in a time-effective manner.** Computation speed can be improved by generally reducing redundancies and inefficiencies in computation. Systems should be created in a barebones fashion to ensure that both managers and users of the system use applications that interact with the system as little as possible, preventing unnecessary computations and processes from delaying desired outputs. Similar to the notion of minimal “dead time” and the reduction of “latency jitters” in control loops in real-time systems construction (Kopetz 2011), the lag time between the capture of the system states of the individual system and the response to the individual (and organizational) systems following the bindpoint computation must be kept at the minimum. The actual process will run through various stages, including, but not limited to, request for access, capture of system state, computation of security, determination of response, and communication of response, among some of the key processing steps. Applying this rule to the BYOD scenario would mean that the time lag between the initial request for access and the communication of the response to that request should be fast enough so that there is a minimum time delay in access and also that there are no new vulnerabilities created during the wait time.

For example, one of the participants states: *“We cannot wait for the risk score.”*

Another participant adds:

*The idea of using score to manage risk definitely has a lot of potential, but I think that it needs to be nimble. It needs to be quick response because you can't make ... So how is that gonna be done? We can wait for a FICO score because we can wait for fifteen minutes, here and there. But the computation is ... the computation processing cards, the system is ... I think we would probably need an IBM device.*

Another speaker asks:

*Can you do it in a time-sensitive manner? We know people don't want to spend much time after they've clicked on something, wait for something to happen probably three seconds. So, can you actually manipulate the information quickly enough? I think you can, but the problem is going to be to generate those kinds of systems to do that.*



While some of the rules may seem to be contradictory, these guidelines will work harmoniously when considered as a whole in designing a specific instance of a bindpoint-supported security system that provides the appropriate balance between performance and flexibility, and at the same time, is adaptable for changes that may arise in the future. Thus, these rules provide a future-oriented design solution that can be used to implement the model in a simple, elegant manner to provide security and at the same time flexibility to be adapted to future scenarios that may be unknown.

## 10 DISCUSSION OF THE PRACTICAL DISCOURSE

Firms are being transformed by the significant changes in the computing environment, as well as consumerization (Moschella et al. 2004). Consumerization has brought into the organization a number of tools that were originally intended for individual use, such as social networking, social media, and cloud-based applications (Gens et al. 2011). One of the manifestations of consumerization is the BYOD phenomenon (Moschella et al. 2004). BYOD has created and facilitated new forms of work by enabling “anywhere, anytime” access to organizational resources, colleagues, and peers, but it also enables improved communication and the ability to work remotely and to multitask. Widespread access to the Internet and cheaper and more powerful multipurpose and smart devices have given boost to the BYOD phenomenon (Moschella et al. 2004). It has also given rise to technical autonomy and experiential design by individual users resulting in individual systems that can interact with Organizational/Enterprise Information Systems in ways that are innovative on the one hand, yet have created concerns about implications on the other (Baskerville and Lee 2013). This widespread network of interconnected technologies, systems, people, and processes is a rapidly evolving information infrastructure that has both technological and social components.

One contemporary situation has been the increasing complexity of Information Systems belonging to individuals, in which individuals have ever more powerful computing resources at hand and possess an increasing level of familiarity and comfort with technology that leads them to configure personalized Information Systems that are dynamic in nature (Lyytinen and Yoo 2002). Newer devices, network capabilities, and software applications are acquired very frequently. Rather than the enterprise pushing technology adoption, consumerization provides the technology push (Andriole 2012), and organizations are faced with the pressure not only to

keep their own systems up-to-date but also to be able to interact securely with new configurations of individual systems.

This dynamic and environment necessitates a flexible design that can adapt to the complexity of such infrastructures. Information infrastructure-related design cannot be determined in absolute terms with a static design product. Systems must be designed to be stable and robust, yet robustness is best afforded by pliability and the ability to evolve, as in any ecosystem (Hanseth and Lyytinen 2010; Hanseth et al. 1996). Complexity theory offers stability at the “edge of chaos” (Gilchrist 2000). While improving individual autonomy in computing, these Individual Information Systems must be able to interact with organizational systems in a safe and secure manner. An effective design theory is therefore required to manage this connection and allow the interaction to proceed smoothly, while at the same time preventing undesirable results such as small-scale interoperability issues and more serious security gaps. In the current BYOD scenario, Organizational and Enterprise Information Systems (OEIS) have complicated and inefficient methods to manage their interaction with Individual Information Systems (IIS).

In traditional OEIS, security is simply a function of predictability in systems operations. This predictability allows the designers to troubleshoot and manage any issues with the system. In an IIS, however, managing security is more complex than simply providing a device that fits neatly within the pre-established organizational or enterprise-level paradigm. In fact, these devices might function as more than inputs to the OEIS – they serve as the employer’s window into the IIS by expanding the system to include individual entertainment systems, personal communications, retail purchasing, personal finance, and other components of the individual cloud.

There are three characteristic nodes involved in OEIS-IIS integration that need to be addressed by any coherent design methodology. The first, an “air gap,” refers to a node where there is a lack of electronic connection between two elements. The second, an “endpoint,” refers to the terminal position on a system that facilitates the flow of information between an individual end user and the organization; the endpoint is considered the weakest link for security (Shropshire et al. 2006; Warkentin et al. 2004). Warkentin and Willison (2009) note that employees or other individuals who interact with an organization’s network and its information assets create an insider threat. Such “Employees can initiate great harm to the confidentiality, integrity, or availability of the IS” through deliberate or careless acts (Warkentin and Willison 2009). Therefore, endpoint security has traditionally been critical in managing organizational security risks. The endpoint security comprises the organizational policies, procedures, and practices for securing the endpoint of the network connections (Shropshire et al. 2006). Examples include user devices and enterprise servers. The third node is the “bindpoint,” a characteristic of the new context proposed by Baskerville and Lee. These bindpoints not only function as the node where OEIS and IIS connect, but also as nodes that change the characteristics of both Individual and Organizational Information Systems.

A coherent design methodology must carefully balance its elements along two functional axes: the issue of security versus individual autonomy and stability versus user experience (UX). The bindpoint theory provides the advantages of flexibility and adaptability in dynamic scenarios represented by the BYOD phenomenon and the general trend towards ongoing changes in requirements for organizations in the current environment. Since information infrastructures are complex adaptive systems, designing information architectures and any artifacts, whether technological or procedural, must necessarily afford flexibility and adaptability to allow the

information infrastructure to evolve and grow. Even though standards may be created to support security and privacy requirements, technology and its usage will continue to evolve. The conceptualization of the individual and organizational interactions as bindpoints within an infrastructure that is a complex adaptive system will enable self-organizing evolution.

Extant literature has stressed the growing importance of technological autonomy (ubiquitous computing), universal access, and universal use of the II (Racherla and Mandviwalla 2013). The growing use of technology by individuals blurs the lines between the personal and work-related use of technology (Gant and Kiesler 2002). While recent discussions highlight the growing interest in BYOD phenomenon (Shim et al. 2013), research in this area is still developing. Most of the recent studies on BYOD center on the individual's use of BYOD devices. For example, research examines how security, privacy, and legal concerns affect employees' intentions to use BYOD mobile devices (Lebek et al. 2013), the lack of security awareness, and the need for mobile device security awareness and training (Harris et al. 2013). However, this research is from the perspective of individual adoption. There is somewhat limited discussion in the academic literature concerning the impact of BYOD on the organization. Moreover, there is a need for further research into organizational security concerns arising due to BYOD, as evidenced by discussion in the practice literature.

This study addresses these gaps in the literature on organizational security issues arising from BYOD by empirically examining a potential design solution for modeling BYOD security architecture as a computable bindpoint. Further, this research contributes to both the practical and research problem by evaluating and analyzing the existing theory, refining the design principles, and developing design rules for its application to provide a useful and practical solution for the information security challenges faced by organizations. Future design-science

research is needed to test the design rules in a specific organizational setting, perhaps through a case study or prototype development, and explore the utility of such design theories that are a product of search conferences.

Finally, from a methodological perspective, this study provides a demonstration of how search conference can be used to evaluate a design-science research study. The BYOD scenario represents an incredibly complex, extremely dynamic, and fast-changing technical environment because it intersects with mobile technologies, cloud technologies, consumerization of information technology, and social networking. There are serious design theorizing difficulties in cases where the solution to the problem becomes future-dependent on rapidly changing technologies and complex social environments. The use of search conference for theorizing in such a highly complicated environment suggests that this established, future-oriented, participative, strategizing technique will be suitable for the purpose of design theorizing in such settings.

### **PART III: REFLECTIONS AND LEARNING FROM THE THEORETICAL AND PRACTICAL DISCOURSES**

## **11 REFLECTIONS ON THE BYOD ANALYSIS USING THE GENRES OF INQUIRY**

This chapter provides reflections on the discourse in Parts I and II of the dissertation. First, Section 11.1 discusses the theoretical study conducted in Part I, following which Section 11.2 reflects on the practical study conducted in Part II.

### **11.1 Unpacking the Duality of Design-Science and Nomothetic-Idiographic Research**

The research problem addressed in Part I of this dissertation has its roots in the differences that arise from the seemingly different characteristics and demands of design and science. These differences are evident in the continuing discussions on the dichotomy between design and science. As a recent example, Farrell and Hooker's (2012) recent opposition to the conventional view that "design and science are distinct types of intellectual study and production" was followed by a rebuttal from Galle and Kroes (2014) that design and science are significantly distinct, albeit related, concepts (Galle and Kroes 2014). Providing an alternate viewpoint of the differences in the viewpoints on design-science, McKay and Marshall (2007) suggest that such differences may result due to differences in the conceptualization of the role of science in design-science. They note that some design-science scholars, particularly those from North America, adopt an  $S_1$  view of science (that knowledge must be accumulated by methods of science associated with the worldview of positivism), while other scholars, particularly those from Europe and Australia, subscribe to the  $S_2$  view of science (which deems knowledge scientific if it is systematic and rigorous in its conduct and claims to knowledge generation).

In the design-science research literature, design is usually associated with "build-and-evaluate" activities, and science is associated with "justify and theorize" activities (Baskerville et al. 2009; Hevner et al. 2004; March and Smith 1995). As such, the different contributions from



design-science research are hierarchically classified as ranging from the most concrete at the lowest level to the most abstract at the highest level (Gregor and Hevner 2013). Examples of these design-science outputs are instantiated artifacts at the lowest level; design principles, methods, models, and mid-range theories at the moderate level; and grand theories at the highest level of abstraction. This difference in views has resulted in an active discussion regarding the relative importance of the design and scientific contributions. Implicit in this viewpoint of design-science research is the equation of design with construction and science with the abstract.

This conflation of “science and design” with the “level of abstraction” may, in part result from the lack of clarity between design and science. Since both design and science co-occur in design-science research, it may be tempting to consider them similar. Galle and Kroes (2014) very succinctly differentiate between nomothetic, or more abstract, science and nomothetic, or abstract, design as follows: “A scientific theory, although it may itself be considered an artefact, does not in general represent or express an idea of an artefact so as to enable anyone to make an instance of that artefact” (as in a design artifact).

The key distinction between design and science lies in the nature of the knowledge produced. According to Galle and Kroes (2014), “both design and science may produce symbolic artifacts: theories (and other products of science) are symbolic artefacts just as artefact proposals are. However, the theories of science are cognitive-descriptive, while the artefact proposals of design are practical-prescriptive” (pp. 27-28). Since the knowledge production in design is distinctly different from that in science, each must be evaluated on the objective that is hoped to be accomplished when employing either design or science.

*It is important to recognize that what seems to be one axis of duality – that between design and science – is in fact two distinct axes.* The first duality is between design and science. The other duality that is often conflated along with the notion of design (often referred to as practice (Goldkuhl 2004)) and science, is that of the level of abstraction of the design-science research contribution (Hevner et al. 2004; Kuechler and Vaishnavi 2008; Purao 2002). The duality between the more abstract, or the nomothetic, and the more situated, or the idiographic, is distinct from the duality between design and science. Table 9 below depicts how the duality of design-science can become conflated with the duality of local versus general.

Unpacking these two dualities can lead to more nuanced and precise outcomes. One of these dualities is that of knowledge scope – a design-science research output can be either more abstract, or generalizable, or more situated and in an instantiated form. It must be noted that this axis, the axis of knowledge scope, is a continuum rather than two extremes. The reason for this is twofold: first, the contribution can be more or less generalizable, and second, the design-science research process is an iterative process; through the iterations, the resulting contribution may evolve and develop in different directions of abstraction depending upon the thought processes and the creativity of the designer(s). Often this may result in a number of contributions at different stages: some of these contributions may be more idiographic in nature while other contributions may be more abstract. For example, in the ADR method (Sein et al. 2011), the initial design, development, and implementation of the artifact occur in a situated organizational setting, while the subsequent abstraction of generalized knowledge occurs later.

The second duality is that of knowledge goals that could be either design-oriented or science-oriented. This axis is also a continuum rather than discrete, since the design aspect of design-science research may be driven by scientific theories and processes or result in scientific

knowledge. During the process of iterative development, the knowledge applied and created may be more design-oriented or more scientific. This knowledge may be useful for different purposes. For example, in the empirical study, the application of the bindpoint model for the design of secure BYOD interactions in an organizational setting pertains to architectural design knowledge of *how to design systems for BYOD security*. On the other hand, the scientific examination of the BYOD security model by conducting applicability checks through a search conference pertains to scientific knowledge intended *to validate the hypothesis that applying the BYOD security model would indeed address the problem of securing organizational systems from risks arising due to BYOD*.

Distinguishing these two dualities allows for an appreciation of the nomothetic and idiographic aspects of both design and science. An understanding of these dual imperatives of knowledge goals (design and science) and knowledge scope (nomothetic and idiographic) allows for a better appreciation of the different types of knowledge contributions from design-science research. Moreover, this distinction between the knowledge scope and goals becomes necessary, since the same criteria cannot be applied to evaluate design qualities and scientific aspects, just as the same criteria are not applicable for generalizability or applicability.

Distinguishing these two axes permits a more accurate evaluation based upon the knowledge goals and scope of the design-science research activity. Also, as mentioned above, there may be different contributions requiring evaluation during the iterative design-science research process. This evaluation of contributions can be conducted by, and therefore can be useful to, not only the design-science researcher, but also to the reviewer evaluating the potential contribution of the publication and dissemination of the DSR endeavor. By demonstrating that design-science studies can be viewed using a pluralistic viewpoint, *the potential for innovative*

*and novel research to be evaluated against the appropriate criteria provides it a better likelihood of being recognized for its merit.* The pluralistic viewpoint acknowledges that although design-science aims at providing general design solutions for a general class of problems, methodologically, design-science research may apply idiographic methods in the iterative life cycle and journey towards a solution. This provides due recognition for the idiographic aspects of design-science research.

The difficulty in describing DSR studies and articulating their contributions within a compressed amount of space is a problem that has been noted in the literature (Gregor and Hevner 2013). The genres framework provides the option, if desired, to explicate and articulate a particular iteration of the study in greater depth, since it is possible to justify and articulate the knowledge contributions from that mode of inquiry. Therefore, although it is not advocated that each design-science research be broken down into smaller components to yield multiple publications, nevertheless it is possible to elaborate on the work in a specific genre that provides significantly innovative and interesting knowledge.

**Table 9: Abstraction of Knowledge versus Type of Knowledge**

| Outputs of Design-Science Research      |   |  | Contribution Level | Knowledge Scope Conflated with Knowledge Goal | Knowledge Scope Distinguished from Knowledge Goal |
|---|---|--|--------------------|---|---|
| Emergent theory supporting a phenomenon | General explanatory/Kernel theory   | Well-developed design theories about embedded phenomena including mid-range and grand design theories  | Level 3            |   | Nomothetic or More Abstract                       |
| Knowledge as operational principles     | Mid-range theories: <ul style="list-style-type: none"> <li>• Design-relevant explanatory/predictive theory (DREPT) (more abstract than ISDT)</li> <li>• Information systems design theory (ISDT)</li> </ul> | Nascent design theory – Operational principles or architecture including constructs, models, methods, design principles, technological rules | Level 2            |   | Idiographic or Situated                           |
| Artifact as situated implementation     | Artifact  | Situated artifacts – Instantiated software products or implemented processes   | Level 1            |   | Idiographic or Situated                           |
| From Purao (2002)                       | From Kuechler and Vaishnavi (2012)  | From Gregor and Hevner (2013)  |                    |   |   |

## 11.2 Design Theorizing in the Context of Genres of Inquiry

There are a number of different frameworks for the design-science research process (Hevner and Chatterjee 2010; Hevner et al. 2004; Nunamaker Jr et al. 1990; Peffers et al. 2007; Sein et al. 2011; Vaishnavi and Kuechler 2007). Each of these frameworks provides methodological guidance on the design-science research process. The frameworks also recognize the role of theory in the design-science research process. Yet not all of them consider design theory an essential contribution. Beck et al. (2013) note that “many existing design-science research attempts pay less attention in generating an original theoretical contribution that goes beyond problem-solving IT artifacts (Carlsson 2006; Gregory and Muntermann 2011; Hevner et al. 2004; Winter 2008).” There is still little agreement about whether a theoretical contribution in addition to a design artifact is essential in design-science research. In a recent *MIS Quarterly* editorial (2014), Goes states:

In design science research, the main concern is not to test or create new theories, although the constructs and methods that are created can lead to these. Rather, the main objective is to create knowledge through meaningful solutions that survive rigorous validations through proof of concept, proof of use, and proof of value. Therefore, it is absolutely not a requirement of successful design-science manuscripts to have an explicit tie to theory. (pp v-vi)

On the other hand, it is suggested that “Every DSRIS [design-science research in Information Systems] effort should be targeted to produce an artifact that is a (partial) solution to an acknowledged business information technology problem. *In addition, it produces a ‘design theory’ that prescribes the requirements for a class of artifacts to address similar problems*” (emphasis added) (Kuechler and Vaishnavi 2011, p. 126). While avoiding the argument around the mandatory nature of theory development in design-science research, this research supports the general view in design-science research that design theory bears an important role in design-science research (Venable 2006). This view is evidenced by the burgeoning body of literature on

theory and theorizing in design-science research (Baskerville and Pries-Heje 2010; Gregor and Jones 2007; Kuechler and Vaishnavi 2012; Markus et al. 2002; Venable 2006), to which this dissertation aims to contribute.

Design theory can form the basis for design-science research in the form of kernel theories (Walls et al. 1992) or justificatory knowledge (Gregor and Jones 2007), or it can emerge as a resultant contribution of the research process. Kuechler and Vaishnavi (2012) affirm that “theory can be both *an input to design* (kernel theories, design-relevant explanatory/predictive theories) *and an output of design* (design theories)” (Gregor et al. 2013). As outputs of the design-science research process, design theories can provide explicit prescriptions on how to design and develop artifacts that can achieve some specific purpose (Gregor et al. 2013).

Design theorizing can take a number of possible routes. The development of design-science research theories can emerge from the abstraction of knowledge following the design and evaluation of a class of similar artifacts. Alternately, the abstraction of theory can also emerge from the evaluation of theories in the context of a class of problems and reflection. Iivari (2014) describes two analogous strategic approaches focused on the development (construction) of meta-artifacts in design-science research. He describes these two approaches as Strategies 1 and 2. “In the first strategy, a researcher constructs or builds an IT meta-artefact as a general solution concept to address a class of problem. In the second strategy, a researcher attempts to solve a client’s specific problem by building a concrete IT artefact in that specific context and distils from that experience, prescriptive knowledge to be packaged into a general solution concept to address a class of problems” (p., 1).

Although much knowledge is being accumulated about design-science research methodology as well as design theory, there is limited literature about *how to theorize* in the

design-science research process and develop such design theories (Beck et al. 2013; Gregory and Muntermann 2011). Gregor et al. (2013) note that design theorizing through abstraction and reflection can be grounded in different forms of reasoning and may be deductive, based on prior theory; inductive, based on design processes; or abductive, based on making sense of observations and referring to prior theory. However, there is relatively little guidance available on “*how to develop design theories based on design-science research*” (Gregor et al. 2013 p. 2). Specifically, there is a gap in the literature on the exact process of “reflection and abstraction” of design theorizing (Gregor et al. 2013 p. 2).

Part II focuses on addressing this gap in the design theorizing literature to conduct and empirical demonstration of future-oriented design theorizing in the IS security domain in the context of BYOD. The research in Part II evaluates and refines an explanatory design theory (Baskerville and Lee 2013) following Baskerville and Pries-Heje (2010) and Walls et al. (1992). Through the application of abductive thinking and abstraction/reflection, the validity and applicability of a potential design solution – the bindpoint model – is evaluated. Based on the hermeneutic analysis of the data from a search conference involving BYOD domain experts, as well as support from the literature, the bindpoint model is re-theorized as a general-purpose solution for designing BYOD security. Weick (1989) explains that improvement in theory can result only from improvement in the theorizing process, and that “we cannot improve the theorizing process until we describe it more explicitly, operate it more self-consciously, and decouple it from validation more deliberately” (p. 1). Therefore, in addition to the evaluation and refinement of the bindpoint model, the *process of (re)theorizing* is described below to contribute to this gap in the literature.



In terms of research method, the search conference approach, an established future-oriented, participative, strategizing technique, was used for the purpose of design theorizing. Prescriptive theories are future-oriented with the intent of improvement. Prescriptive design theories are aimed at designing a solution for a problematic scenario that is complex in nature. Moreover, the BYOD problem involves a number of different stakeholders. The search conference would be able to provide a “systems view” to the theorizing. This is akin to Ackoff’s (1974) notion that in order to convert problems in a mess to a desirable future state, the people who hold a stake in the performance of the system must necessarily be involved in redesigning the system. The concept of a more desirable future state is well-accepted in the action research literature (Susman and Evered 1978). Without becoming entangled in the discussion on the similarities and differences between action research and design research (Iivari and Venable 2009; Järvinen 2007a), the notion of future-oriented improvement aligns with the goal changes and improvement in design-science research (Purao 2002).

The general process for design theory evaluation and refinement in this research followed the steps summarized in Table 10 below. Each of these steps was iterative and took multiple passes. It must be noted that there are other potential paths to theorizing, and the theorizing could potentially have emerged as a synthesis of the learning derived through a number of different instances of BYOD applications.

**Table 10: General Sequence of Steps during Theorizing Process  
(there was iteration during each step)**

|    |   |
|----|---|
| 1. | From general problem requirement → Derive general design requirements                         |
| 2. | From general design requirements → Derive specific design goals (to fulfill the requirements) |
| 3. | From specific goals → Derive design principles  |
| 4. | From design principles → Derive design rules  |

### **Step 1: General design requirements**

The requirements pertaining to the BYOD problem emerged from multiple iterations of the problem definition. Since this problem was fairly recent with limited research, all sources of information on this problem area were investigated. The problem facing practitioners was investigated in detail utilizing discussions with practitioners including industry experts. A detailed review of literature was conducted and included both practitioner and academic literature. The key problems resulting from BYOD phenomenon were synthesized. BYOD was found to be a major area of concern for organizations from the perspective of management, technological and application-oriented concerns, and security risks.

### **Step 2: General design goals**

The focus of this research was narrowed to the question: “How to manage BYOD security risks from the organizational perspective?” Through the search conference, the problems were again presented to different stakeholders, discussed, critiqued, and further synthesized.

The process of theory selection involved an analysis of potential design or scientific theories that could be applied to solve the problem. In the literature, the design theory of the

bindpoint model was found to be a good fit for addressing architectural concerns arising from the interaction of the Individual Information Systems and the Organizational Information Systems.

This theory could potentially be applied to any such scenario involving architectural design pertaining to one-to-many or many-to-many interactions. For example, it could be applied to cloud-computing architecture, grid-computing architecture or other scenarios involving distributed computing. Thus the bindpoint model seemed appropriate for BYOD security. Moreover, the use case described in the theoretical model was based on a BYOD scenario. Therefore, the bindpoint model was identified as a theoretical basis for BYOD security.

### **Step 3: General design principles**

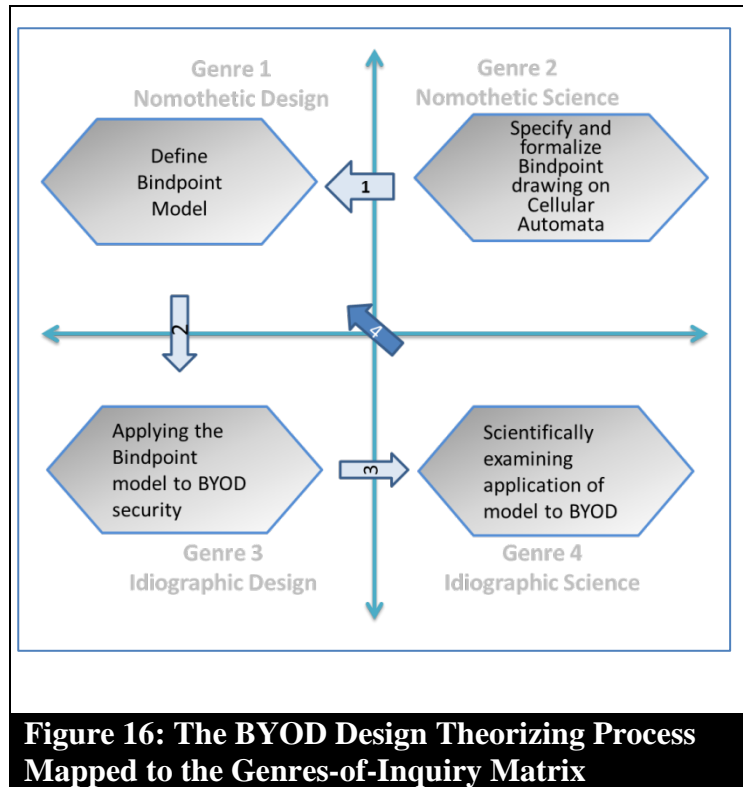
The original bindpoint model from Baskerville and Lee (2013) defined two primary design requirements: 1) to provide security in the presence of individual autonomy, and 2) to provide stability in the presence of experiential design. It drew on the kernel theory of cellular automata and conceptualized the interaction of the individual and organizational systems as instances of connections in which the risk could be computed from a set of parameters accompanying each node at the bindpoint or connection.

### **Step 4: General design rules**

Walls et al. (1992) suggest that design theories must be subject to empirical investigation. While the evaluation was primarily conducted during the search conference, the refinement emerged both during the search conference and subsequent to it. The refinement included going through the transcripts to develop the rules and also going through the literature to support the rules. In some cases, commonalities were found in the rules, and these were combined to make the rule more general.

In synthesizing the theoretical discourse in Part I with the design theorizing cycle in Part II, it becomes evident how the theorizing functioned at different levels of abstraction at different points of time. Although the objective of the BYOD research was design-oriented, the process was scientific as well. The BYOD design theorizing study demonstrates how design-science research activity can operate at different levels of abstraction at different stages in the process and how it can be focused more on the scientific aspects of theorizing at some times and on the design aspects at other times. Moreover, these aspects are not categorical and the process can demonstrate characteristics with varying degrees of duality.

To demonstrate this movement, changes in knowledge goals and the varying degrees of duality in the design theorizing process are mapped to the genres of inquiry matrix and evaluated below. The mapping is presented in Figure 16 below. It must be noted here that the stage prior to arrow #1 occurred outside this research and was part of the research process described in Baskerville & Lee (2013). Consequently, the stage in Genre 2 has been depicted here for demonstration purposes only and not been evaluated. A description of the movement of the research through the different genres and evaluation of this research based on the criteria for each genre follow.



### 11.3 Movement of the Design Theorizing Process through the Different Genres of Inquiry

The above figure demonstrates how the design theory development, evaluation, and refinement of the bindpoint model theorizing process travel through different genres.

#### 11.3.1 Genre 1: Nomothetic design

The process for bindpoint theorizing started in Genre 1 or nomothetic design. It involved the theorizing and specification of Baskerville and Lee's (2013) bindpoint model, which is an explanatory design theory articulated in terms of a functional relationship between the general requirements of Individual Information Systems interacting with Organizational Information Systems and a general design of replacing predictable rules with computation of risk. Described in an abstract form, it could be applicable to a number of different problem areas occurring

involving interaction with Organizational Information Systems, such as cloud computing, grid computing, or BYOD interactions. This theoretical development was based on the Individual Information System. The bindpoint theory was described with a laboratory scenario in a university setting using a BYOD case.

### **11.3.2 Between Genre 1 (nomothetic design) and Genre 3 (idiographic design)**

Subsequently, in this dissertation research, the bindpoint theory was more narrowly focused as a model that could be applied to a specific class of problems, which was security issues arising due to BYOD. This theoretical focus, while still abstract, was narrower than its original conceptualization; therefore, one can see how the inquiry and theorizing process moved down along the nomothetic idiographic continuum. The theorizing was still more nomothetic than idiographic. Since the inquiry pertaining to the application of the bindpoint model to the BYOD problem related to the evaluation of a model that could be used in any BYOD setting, rather than an instantiated systems solution being evaluated in a specific organizational context, the inquiry process would be considered to lie somewhere along the midpoint of the nomothetic–idiographic continuum.

This research demonstrates how the development of design-science knowledge artifacts cannot be assigned to categorization in absolute terms pertaining to nomothetic or idiographic scope; rather, the process of theorizing and artifact development and evaluation can be carried to different genre spaces during the iterations of development and maturity. This inability to characterize scope also means that the genres themselves are not categories that are totally nomothetic or idiographic, but that the process could be “more nomothetic” or “more idiographic” in scope.

### **11.3.3 Genre 4: Idiographic science**

Subsequent to justifying the bindpoint as an explanatory design theory in the context of BYOD, theorizing makes the transition to the scientific process of evaluation. The evaluation process of the bindpoint model using the search conference lies in Genre 4, the idiographic scientific genre. The search conference was an experiment that occurs in a social-scientific setting. The scientific aspect of design-science research results from an assessment of the designed artifact to find out whether the knowledge is supported by adequate validation. Therefore the design-science research inquiry at this stage lies in the provision of a laboratory or field experiment with results that provide concrete validation (proof). A scientific investigation and validation are expected to result in new knowledge.

### **11.3.4 Back to Genre 1: Nomothetic design**

From Genre 4 the process moves back to Genre 1, a movement that requires reshaping the design theory. In this genre, the level of abstraction of the design artifacts was fairly general. The model was refined, and associated design principles were adapted based on the evaluation that emerged from the findings of the search conference. These principles led to the development of design rules for guiding the design and construction of security systems for managing security in the BYOD context. Though the rules provide specific guidance for BYOD, they are general enough to be applied to the design of any security system that must address BYOD security.

## **11.4 Evaluation of the Inquiry Process in the Practical Discourse against the**

### **Evaluation Criteria Developed in the Theoretical Discourse**

The evaluation criteria for each of the genres of inquiry have been defined in Part I. Here the research examines the design theorizing process as it moves through the different genres of

inquiry in Part II against the criteria of evaluation that are drawn from Part I to see if it was justified.

#### **11.4.1 Genre 1: Nomothetic design**

The nature of knowledge in Genre 1 is applicable to a general class of problems. The artifacts in this genre are constructs, methods, models, design principles, technological rules, and design theory. In this study, the artifact was an explanatory design theory (both in the original and revised form). The artifacts derived through the research process included the refined set of principles and the design rules that emerged from the hermeneutic process of going through the data collected through the search conference as well as from design principles in the literature.

The evaluation criteria for nomothetic inquiry are applicability, generalizability, external validity, transferability, consistency, reliability, and dependability. When evaluated against these criteria, the original bindpoint model needed to be refined in order to be applicable. The level of abstraction of the original and revised model, accompanying design principles, and the design rules are generalizable to the design and development of any organizational security in the BYOD context. Gregor and Hevner (2013) suggest that offering “artifacts at an abstract level mean[s] that they can be operationalized in a number of other unstudied contexts, thus greatly increasing the external validity of the research” (p. 341). Moreover, the industry experts in the search conference evaluating the model represented a wide variety of industry settings. The criteria for design evaluation include the demonstration of an acceptable similarity between expected and observed performance, creativity, innovativeness, and originality. On the whole, the search conference committee was satisfied that the revised model would address the major concerns arising from BYOD and that it demonstrated a strong potential for instantiation as a



prototype. The solution offered by the model is a novel and innovative design concept and addresses a particularly wicked problem.

#### **11.4.2 Genre 3: Idiographic design**

Focusing the model in the BYOD context made the applicability of the model narrower and more specific, and it must be evaluated against the criteria for Genre 3 even though it does not qualify as full-fledged idiographic design. (An example of a purely idiographic design inquiry would be the instantiation of the design rules in the form of a prototype system that tested out some aspects of the design functionality in a specific setting.)

The knowledge role of an idiographic design artifact is one that materializes or embodies the design knowledge in a product. The output of this research did not move to the required level of granularity to qualify it as idiographic research. However, the analysis of the bindpoint model in the BYOD context was able to provide satisfactory explanation in terms of both design and setting. The logical reasoning and argumentation demonstrated that it would be an acceptable solution to the problem.

#### **11.4.3 Genre 4: Idiographic science**

In Genre 4, the nature of knowledge produced seeks to understand the underlying causes, structures, and generative mechanisms responsible for observed patterns in the study. The criteria for idiographic inquiry aim at producing satisfactory explanations that provide an understanding of the design and its setting. In Genre 4, the bindpoint model was examined scientifically in a social setting to evaluate the applicability of the model to BYOD settings using an engaged approach involving participation from industry experts from three stakeholder domains. Moreover, this model was replicated using three different “systems” groups. The

scientific criteria for Genre 4 include credibility and confirmability. In this case, the search conference evaluation was able to offer credibility through analysis by experts and confirmability to the extent of what would work and would not work in the model.

## 12 LEARNING FROM REFLECTIONS ON THE THEORETICAL AND PRACTICAL DISCOURSE

This chapter discusses the learning based on the reflections of the theoretical and practical discourse and how this may confirm, negate, extend or impact the current discourse in the literature.

### 12.1 Learning from Reflections on the Theoretical Discourse

The purpose of the dissertation was to address the lack of clarity in positioning design-science research. In Part I, the dissertation discussed how a multi-genre view of design-science research that was based on the centrality of knowledge rather than on a typology of design-science research outputs would provide clarity on the contribution of design-science research. Further, it was described how an appropriate identification of the contribution worked concomitantly with appropriate evaluation criteria. The lack of clarity was created by differing scholarly viewpoints that were either design-focused, favoring the artifact, or science-focused, favoring theory.

Unpacking the inherent dichotomy between design and science enabled the focus of the inquiry to align on the centrality of knowledge. Ultimately, design-science research is an approach or set of techniques that is aimed at producing new and credentialed knowledge. The methods, approach, and path to acquiring that knowledge through design-science research may differ from other more explanatory or descriptive research approaches in that design-science is more oriented towards improvement and prescriptive knowledge. *Yet, knowledge is the end goal of research*; therefore unpacking the duality of design from science allows for an examination into the specific aspects of design-science research that makes it valuable and useful as a research approach. Since design-science research aims at improvements and innovations, any

development of an improvement and/or innovation would benefit from an evaluation in its environment or compared to the purpose for which it is intended. This requires separation of the design and science aspects of the research while recognizing their relative importance and co-dependence.

The differing positions in design-science research arise primarily due to the inherently dichotomous nature of design-science, which results in three different tensions. The first tension results from the different goals and methods of design and science. Design is generally associated with the construction of an artifact that is usually instantiated and evaluated in a situated scenario yielding specific or idiographic knowledge. Science, on the other hand, is usually associated with the abstract, theoretical aspect of the research, yielding generalizable, or nomothetic, knowledge. The second tension arises because design provides pragmatic outputs while science carries the notion of rigor. Third, the term *design* can be used either as a noun, indicating an artifact or product view, or as a verb, indicating a process view. The multigenre framework enables the evaluation of the design-science *output*. Therefore, deriving an understanding from a design-science study will be based on the knowledge that is being acquired – is it knowledge represented by the artifact, does it pertain to learning from the process of designing the artifact, or does the knowledge relate to how the artifact interacts with the environment that it is placed in?

Due to the applied nature of design, design-science research as a research method has suffered from a clear lack of identity. The “design methods movement” (Cross 2001) was aimed at making design more scientific, providing rigor and bringing design-science research to a paradigmatic level. Yet, as Eder (2012) points out, “[D]esign itself cannot be a science, and although it may involve the use of scientific knowledge, and even scientific methods,” design

also uses “a host of other, unscientific information, experience, [and] judgment.” The design process must allow for creativity (Cross 2001; Iivari 2007), intuition (van Aken 2004), serendipity (Iivari 2007), and opportunism (Visser 1994). Iivari (2007) suggests that “because of the creative element, it is difficult to define an appropriate method for the design-science activity of artifact building” (p. 50). Despite this difficulty, he notes that the “rigor of constructing IT artifacts distinguishes design-science from the *practice of artifact construction*” (p. 50). However, as Iivari acknowledges, practitioners may also conduct rigorous design activities and may employ research to come up with better designs. An appropriate evaluation must be able to distinguish design-science research output from a state-of-the-art design.

As in other applied sciences, there is a duality in design-science between practice and theory. Goldkuhl and Lind (2010) refer to this duality as a dichotomy between “empirical design practice producing situational knowledge and artifacts” and “meta-design (within design research) producing abstract design knowledge” (p. 49). Thus they arrive at the distinction of two types of design practice: “1) design practice that produces situational design knowledge and concrete artifacts and 2) design practice that produces abstract design knowledge.” Following Pelz (1978), Carlsson (2007) distinguishes between the instrumental and conceptual aspects of science and research outputs, both of which he finds relevant for IS research. Of these two types, he finds the instrumental use of knowledge more relevant for design-science research. This duality has been recognized as a distinction in focus on outputs of the design-science research process as being either pragmatic designs or design theory (Gregor and Hevner 2011). March and Smith (1995) distinguish between basic and applied sciences and find that as an applied science, the main output of design-science is situational or credentialed knowledge of tasks resulting in design artifacts rather than general theoretical knowledge. Hevner et al. (2004)

describe the development of design-science knowledge through the building and application of the designed artifact.

Gregor and Hevner (2013) attempt to reconcile these different viewpoints on what constitutes a design-science contribution by providing a three-level contribution framework that ranges from situated artifacts to models and mid-range theories to grand theories. *Disentangling design from science reveals that the design-science duality is caused by not one, but two dichotomies – one of knowledge type (design/science) and the other of knowledge scope (nomothetic/idiographic).* This recognition is novel and significant, because it confronts the current thinking in design-science literature that links design with the artifact view and science with the theory view. While design has been acknowledged as local or general, the conceptualization of design inquiry occurring along two different dimensions, that of design-science and at the same time that of nomothetic-idiographic, has, in the research for this dissertation, not been visualized in the literature. Recognizing that design can be nomothetic (or idiographic) and that science can be idiographic (or nomothetic), extends the current view of design-science. *This distinction is important because it provides the opportunity for design-science research to accommodate different paths to the attainment of research goals and provides the ability to appropriately evaluate and validate the different forms of contributions that can accrue through these different paths.* By directing the focus to the knowledge output from design-science studies, this dissertation reconciles and extends the different viewpoints about “what constitutes a design-science research output,” thus demonstrating that design-science research can be *both relevant and rigorous*.

From a pragmatic perspective, many design initiatives are intended to address a particular problem. The development of an artifact is initially intended to address this local problem.

Winter (2008) discusses the situational adaptation of instantiations to improve the generalizability of research. During the cycle of development and evaluation, a generalizable solution may be developed. Alternately, a solution developed for addressing a particular design issue could be refined or evaluated for cases similar to the initial problem space and could ultimately lead to the development of a meta-artifact or a generalizable/transferable design solution. While recognizing the importance of generalizable results from a design-science study, Niederman and March (2012) state that “*individual design-science studies can provide the opportunity to develop lessons learned for both design content and process*” and can be effectively applied to the “*first round of theory building*” (p. 8). They define two different types of design artifacts: those that “constitute information system capabilities” (which aligns with the conceptualization of idiographic knowledge) and “IT artifacts that are used to develop information system capabilities” (which aligns with the conceptualization of nomothetic knowledge).

Such idiographic design knowledge or theory is distinct from more nomothetic or macro-design-science, which aims to produce knowledge or theory about a general class or category of problems, as opposed to a single problem (Iivari 2007; Walls et al. 1992). The scope of this latter form of research is nomothetic. While the idiographic–nomothetic distinction parallels such distinctions in both social science and natural science, it manifests differently in design-science because design-science is itself different from social or natural science. The prescriptive nature of design-science brings a focus on the aim of the prescribers: to inform the immediate, individual design task at hand, or to inform a broader class or collection of design tasks.

In either of these scenarios, whether the design-science scope is nomothetic or idiographic, knowledge is generated. The important aspect is that knowledge is *central* to

research because there is learning in both directions of this dimension. *The duality in respect of the scope of design-science therefore lies in the transferability of the design solution.* In the case of scientific knowledge, the distinction between the local and the general is anchored to the main purpose for employing the scientific approach. Is the purpose of the scientific aspect to learn only about the exact problem at hand (idiographic scientific knowledge), or is it to learn about this kind of problem (or the human settings for such problems) in general (nomothetic scientific knowledge)? In the case of design knowledge, the distinction between local and general is anchored to the main purpose of the design activity. Is the purpose to develop a solution for a class of problems (nomothetic design knowledge) or is the purpose to instantiate a solution in a specific setting (idiographic design knowledge)?

The movement of design-science studies through different genres resolves the tension between idiographic and nomothetic design knowledge that is often evidenced in the debate between artifacts as instantiations versus artifacts as theories. The multigenre framework shows how design knowledge production can be moved in either direction – from more general knowledge to more local knowledge, or alternately from more local knowledge to more general knowledge. This movement along the knowledge scope axis supports Iivari's (2014) two strategies for generating design-science knowledge:

In the first strategy, a researcher constructs or builds an IT meta-artefact as a general solution concept to address a class of problem. In the second strategy, a researcher attempts to solve a client's specific problem by building a concrete IT artefact in that specific context and distils from that experience prescriptive knowledge to be packaged into a general solution concept to address a class of problem. (p. 1)

The movement of design-science studies from more localized to more general knowledge therefore supports design-science studies that are conducted using an action design research (ADR) approach (Sein et al. 2011). Using an ADR approach would initially generate local



knowledge of an artifact implemented or instantiated in an organizational setting. Subsequent to its evaluation and perhaps further iterations to affect improvement, generalized knowledge principles may be abstracted. Such design contribution can be valuable at the local level, in the form of the design artifact (March and Smith 1995), but it can also be more valuable as a research output at a more general level, in the form of knowledge that can be transferred to a similar class of problems (Eden and Huxham 1996).

The key contribution of this research has been to offer a pluralistic viewpoint of the design-science research method as a solution for positioning and articulating the research contributions of design-science studies. This multifaceted viewpoint, presented as a framework depicting different modes of design-science inquiry, makes it possible to highlight the important aspects of design-science studies as they yield emergent forms of knowledge. It also allows for, and encourages, different approaches for conducting design-science research, thereby furnishing different paths yielding innovative artifacts and knowledge and then validating such knowledge using a suitable lens. Just as different topographies may be better suited to different forms of transportation, offering an umbrella of different routes for conducting design-science research may yield rich new types of research outputs. Thus, the multigenre design-science inquiry framework extends the different methodologies and strategies for conducting design-science research by providing a mechanism to appropriately evaluate different approaches to generate design-science knowledge and its resultant contributions.

Further, by explicating knowledge scope as a continuum rather than by defining specific levels of abstraction, the framework accounts for the iterative nature of design-science inquiry. This aspect of design-science is further exemplified through the empirical BYOD study, which demonstrates how a design-science contribution can be more abstract (and less specific) or less

abstract (and more specific) at different stages. Thus, the necessity of having to categorize the design artifacts under development or evaluation in a specific typology is avoided. Similarly, the description of the knowledge goal dimension as a continuum allows the demonstration of the evolutionary journey of the design inquiry process in a manner such that the design-science study can focus more on the scientific aspect at one point in time or focus more on the designing aspect at another.

This pluralistic viewpoint has strong implications for both research as well as practice. The multidimensional view of design-science provides an alternative to the current viewpoint that specifically categorizes knowledge contributions from resultant design products. By providing a process view of the design-science research process, the multigenre framework augments the design product view with the design process view, thus providing recognition for a richer understanding from such forms of inquiry. This has important implications regarding the debate in design-science research, since providing a way to incorporate both the product and process aspects creates a knowledge path for the designed artifact and design theories that are depicted in the framework by Walls et al. (1992). It also provides recognition for the instantiated knowledge (Sein et al. 2011), consequently leading to more precise definitions of the outcomes. From a practical perspective, it encourages design-science research efforts in unique and novel situations and provides for generalizable (transferable) and applicable design knowledge. In describing the relevance of Information Systems research, Mathiassen (2002) states that the objective of designing “normative propositions or artefacts, e.g., guidelines, standards, methods, techniques, or tools” is “to create knowledge that can be used to plan, guide, or improve practice” (p. 60). Thus, while the outcome may be instantiated in the form of an artifact, the knowledge goal remains central. The embeddedness of design product in organizational or other

social settings may not only improve the relevance of design-science outcomes, but may also provide organizations access to rigorously acquired design knowledge that routine organizational activities may not grant.

## **12.2 Learning from Reflections on the Practical Discourse**

As a demonstration of a theoretical argument developed in this dissertation, the empirical research in Part II was aimed at providing and applying the multigenre inquiry and evaluation framework to a particularly complex and challenging problem that is emerging in organizations as a result of the BYOD phenomenon. Design-science research is generally a fairly long and involved research process that can involve teams of people working on a project over a number of years. This particular study focused on the justify-and-theorize aspect of design-science research by evaluating a design model using a participatory approach called search conference. The implications of this study need to be assessed against three criteria: 1) the evaluation of a design model in the context of the multigenre framework, 2) the suitability of the design model to BYOD security, and 3) the utility of search conference for evaluation and design theorizing.

The multigenre framework for design-science inquiry effectively brings the build-and-evaluate activity and the theorize-and-justify activity under one umbrella. Design by its very nature operates at a certain level of abstraction. It deals with describing general functional relationships between generalized requirements and a generalized solution space. To an extent, the solution space is even more abstract. As Simon (1996) points out, the most important aspect of the functional relationship is the properties of the “outer environment” that the “inner environment” seeks to address. The operationalization of research pertaining to such problem-solving can not only take a number of different paths, but can also manifest in a number of different ways.

Due to the very nature of the ill-structured problem, there could potentially be a number of design requirements that are not clearly identifiable, and therefore, the problem definition may be incomplete. This incomplete definition may initially lead to a partial solution. The problems themselves may not fully manifest until the first few rounds of the design, resulting in reiterations. While this reiterative process has been recognized in the literature, the process may oscillate between design formulation, evaluation, reflection, and sense-making. It is then the choice of the designer as to which path is to be followed. Also, the designer has the option to be as specific or as abstract with a solution as he or she wishes. Each of these directions will again entail different routes and processes.

For example, there were multiple routes open to evaluating the bindpoint model. One possible path was the application of the model in a specific organizational setting similar to an ADR study. Another possibility was to construct a prototype of software with perhaps limited functionality and conduct laboratory testing to assess it. Another route could have been to develop various scenarios and conduct an experiment. Still another scenario could have been to develop a set of process rules and evaluate those. The bindpoint model was applied and evaluated for BYOD security in this study. Other possibilities might have been to evaluate it under other dynamic, interactional settings, such as for cloud computing, network management, or computational resource allocation. Still other possibilities might have called for evaluation in alternate applications, such as in multimedia interactions, education, or healthcare.

Similarly, multiple paths are open to finding a solution to BYOD security. The bindpoint model was just one possible solution. Following any of the design options would lead to different trajectories in the context of the multigenre design-science inquiry. Assuming that all of the above were examples of design-science inquiry, the manifestation of the process and the

result would be a function of the designer's choices. Therefore the trajectory or trajectories that a design-science project would follow are determined by the designer and the designer's interpretation. Moreover, within each genre, the design action can also be impacted by the designer's knowledge and experience, which is unique to the designer. The genre framework therefore serves a dual purpose: on the one hand, it provides the designer with a broad reference frame for the type of design artifact that is possible in that mode of inquiry; on the other hand, it provides the designer with the latitude to create an artifact as he or she sees the design space. Similarly for a user or reviewer, the genre provides a perspective with which to view and assess the designer's work.

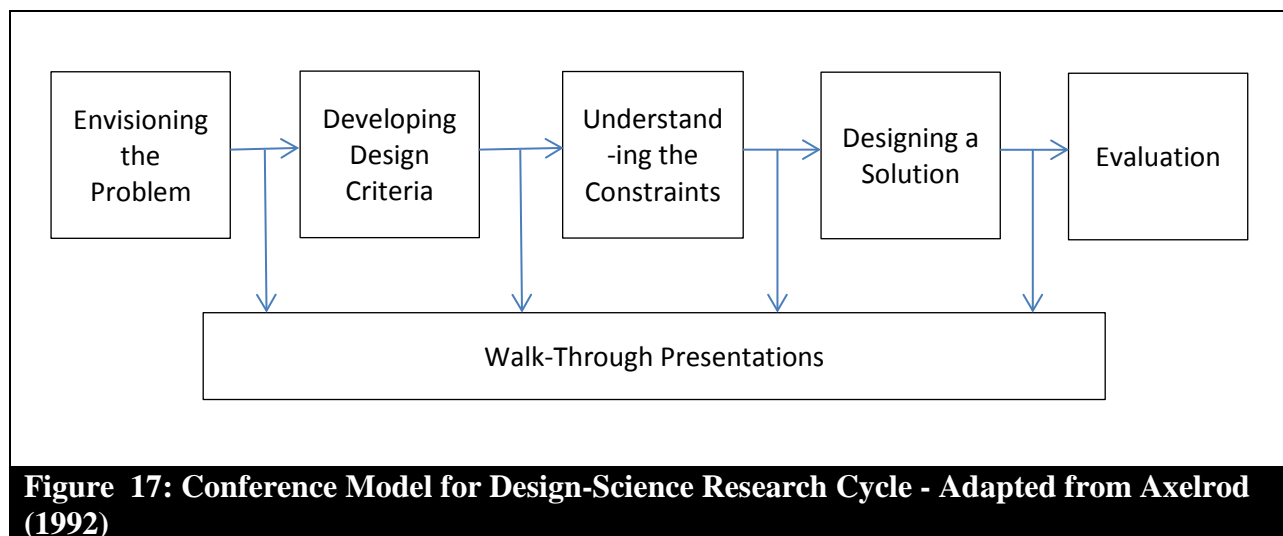
It is more than likely that until the design-science field reaches more maturity, much of the work in design-science research will likely be concentrated in Genres 2, 3, and 4 (which are nomothetic design, idiographic design, and idiographic science, respectively), with few studies making contributions of significance to Genre 1 (nomothetic science). The studies that adopt kernel theories as their base would continue to draw upon the type of knowledge in Genre 1 as inputs to their research. Design theorizing efforts would most likely lie along the plane between Genres 2 and 4, (nomothetic design that is evaluated in idiographic science settings), while artifact instantiations in specific organizational settings may occur primarily in Genre 3 (idiographic design). It would be possible to see artifact instantiations of a more general level (Genre 2, nomothetic design) occur at a research institution, perhaps. It is possible, though perhaps not very likely, to find a design-science research study remain fastened to only one genre, but these more generalizable inquiries would likely remain in Genre 2 (nomothetic design), perhaps moving through levels of abstraction that were slightly more nomothetic or slightly more idiographic, though not specific enough to move to Genre 3. The direction of the

journey of the study would depend upon whether the study was initiated at a more abstract level and then deductively tested or was developed more inductively using a grounded approach. Regardless of which direction the research takes, all knowledge contributions are valuable and must be evaluated appropriately.

The importance of applying the theoretical framework to the BYOD security study shows that the choice of evaluation approach was driven by the objective to get a more general perspective of whether the bindpoint model would be able to, at least theoretically, address problems arising due to BYOD. This approach called for reiterating the problem space and developing a better understanding of the requirements specific to BYOD security. Further, and more practical, questions include: 1) How could the bindpoint model be applied? 2) What would work if the existing model was applied and what would not work? and 3) What would need to be done to make the model work? Against these objectives and assumptions, the resultant knowledge contribution would need to demonstrate whether it met the above objectives, what the utility of this knowledge was, and where it was able to provide a functional explanation of the relationship between the model and the problem. To this extent, the results of the study address these objectives by reporting these findings. However, the objective of the study was not just to explain through testing but also to theorize, which resulted in the restatement of the design principles and the development of the design rules for enacting the principles. Providing empirical support as well as theoretical support to existing design principles can help develop a better understanding of the requirements and lead to the development of a more grounded solution in the form of the design principle.

In this scenario, the search conference proved especially effective. The design of the search conference was especially planned so as to get a comprehensive view of the problem. By

gaining inputs from three different types of experts – security, business, and technical – each of these perspectives of the problem could be examined through the homogenous fishbowls. At the same time, having the whole system in the room enabled a holistic view by allowing for any interactions or cross-purposes to emerge naturally. Moreover, the context was important in developing a refined understanding of the problem space. Inviting a group of experts who were all wrestling with similar issues resulted in animated discussions providing rich insights into the problem. Such participatory conferences could potentially be used in any phase of a design-science research cycle and for the design of any kind of artifact or theory. It would not be a stretch to use the search conference as a design-science method, and one option for this could be to conduct a series of conferences akin to Axelrod’s (1992) Conference Model, which comprises a series of search conferences, where each conference could be used for a specific task: 1) envisioning the problem, 2) developing design criteria (requirements), 3) understanding the constraints, 4) collaboratively designing a solution based on the vision, requirements, and constraints, and, finally, 5) evaluation.



## 13 CONCLUSION

This chapter discusses the research and practical contributions in the areas of design-science, Information Systems security and search conference. It also discusses limitations as well as future research opportunities.

### 13.1 Contributions

Although there is much activity in design-science research to develop clarity around its methodological processes and design theorizing, there is a gap in clear guidelines on the articulation of the knowledge contributions of different types of design-science research. By delineating the different types of knowledge contributions that result from the different knowledge goals and scope of design-science research, this research has proposed a framework for evaluating different genres of design-science outputs. The framework provides a pluralistic perspective of design-science research.

Different design perspectives carry different development and evaluation assumptions for the designer and evaluator. Consequently, different sets of assumptions held by researcher/designers will manifest themselves in different approaches to design and result in different types of design output. The framework can be used to provide a shared understanding of perspective to both the researchers/designers and the users (or reviewers) of such knowledge. This shared understanding will provide a reference frame of expectations for each genre of inquiry and will therefore be of use to the designer/researcher in the development and articulation of the design and associated knowledge outputs.

The option of multiple genres can provide designers with alternate options to orient their thinking. Such a framework could be a source of inspiration and creativity for designers. The framework helps provide a stronger positioning for idiographic forms of design-science research



that are often considered less rigorous, as they may be missing a strong generalized theory output.

The theoretical contribution of the BYOD case study is to provide an empirical evaluation of the bindpoint design theory that has not been tested before, to refine the design principles, and to develop a set of rules for applying the bindpoint model in organizational settings. These design principles are expected to be an important theoretical contribution to the field of BYOD security for a number of reasons.

From the design-science and software engineering perspectives, examining the applicability of the model by using a cross-organizational expert pool demonstrates the transferability of the design principles to a number of different industry settings. Operationalizing these principles by translating them into an accompanying set of rules will hopefully be useful in providing guidance to systems architects and at the same time provide an agenda for design research, whether it is in artifact construction or evaluation.

From the BYOD security perspective, this study provides a design option for secure interactions between organizations and individuals. The findings and insights provide many opportunities for further work in this area that would be of much interest to both researchers and developers. The model extends possibilities for the development of a fast computational engine with co-located parameters for computing a security risk score. The computational logic could potentially be extended to other scenarios. The model also provides future research and development opportunity for an attribute-based access control system. This area would be of much interest to both research and practice.

This research pertains to the use of search conference as a useful tool for conducting engaged research. Search conference, of which there are several variants (Leith 2004), has been

used successfully in policy research and by practitioners in a wide variety of scenarios. The use of this technique within a design-science framework for the purpose of collaboratively developing a design theory is novel: as an expansion in design-science methodology, in search conference methodology, and in participative design methodology.

This research demonstrates how search conferences can be used as a research method in research endeavors including theory validation and artifact evaluation. Moreover, search conference can be used for participative design theorizing and is especially helpful in generating future-oriented theories in dynamic and volatile environment, especially where the problem is not clearly understood. The technique can also be used in the participative design of instances of the theory in the form of instantiated artifacts.

Having been used effectively in data collection, it has been demonstrated how search conference can be used in any boundary-spanning scenario, including requirements elicitation, thus extending its capabilities through any stage of the research process, from requirements to evaluation, especially in an engaged research context. Participation is both a knowledge-sharing and a knowledge-producing activity (Baum 1999). Since the search conference brings multiple viewpoints into the room, it encourages thinking about the problem globally or from a holistic viewpoint before considering its application locally (Fuller et al. 2000). As an example, in this research, search conference was demonstrated to be an effective method for both design theorizing and for evaluation of design-science in Genre 2 as well as Genre 4. Search conferences can also aid in the conduct of “applicability checks” to evaluate research objects that practitioners find “important” and “applicable” to their work and thus increase research relevance (Rosemann and Vessey 2008).

## 13.2 Limitations and Future Research

Future research is needed to investigate whether the dynamics of the genres of inquiry operate in research paradigms other than design-science. Empirical testing of the effectiveness of the genres of inquiry in Information Systems design-science studies needs to be carried out, perhaps using available methodologies such as action design research (Sein et al. 2011) or soft design-science research (Baskerville et al. 2009). Finally, it is likely that useful insights could be gained from the investigation and analysis of other important perspectives of design knowledge such as complexity.

The study of BYOD security in this dissertation pertains to design theorizing and maintains a level of abstraction in order to make it transferable, it opens up considerable opportunity for further research at a more idiographic level. Some examples of future research opportunities are described below.

A prototype system can be developed and tested to compute the risk factor, given various combinations of system states of the individual and organization systems. A prototype can provide a useful demonstration of not just the utility of the bindpoint model (as demonstrated by the model evaluation through the search conference) but also the workability of the computational solution. Although more situated and idiographic, this form of evaluation can provide justificatory knowledge through the construction and testing of an instantiation of the theoretical model. Such research will align with the idiographic design research mode described in Genres 3 and 4.

Another way to evaluate the effectiveness of the theory or the prototype would be to conduct a research inquiry in an organizational setting using real-life security scenarios. The prototype can also be evaluated in organizational settings through other methods. One potential

method is to evaluate the accuracy and speed of security computations by comparing predictions of the security state using a rule set and computation of security using adjacent security states of the individual and organizational bindpoints.

The design principles and design rules that were developed in this research as an extension of the bindpoint design theory proposed by Baskerville and Lee (2013) create rich opportunities for evaluation leading to further refinement and development of the theory as well as utility in practical application of the theoretical model.

The search conference included participants that represented a vertical slice of the organization as well as key stakeholders. In future research, participatory design techniques that include individuals and users who would bring in their devices could be included in the search conference. The individual viewpoint can be incorporated to develop instantiations of the design theory.

### **13.3 Summary**

This research analyzes the dual notions of design knowledge and scientific knowledge along with the dual notions of nomothetic knowledge and idiographic knowledge in design-science research. The significance of the design process and the central role of knowledge are investigated. These activities lead to the distinction of four genres of inquiry of design-science, articulation of the knowledge goals for each, and identification of the interdependence of these genres. An examination of two exemplar design-science studies reveals how each study spans multiple genres of inquiry. Guided by an understanding of the study's knowledge goals and scope, the moments in its research process, and the particular genre of inquiry in the moment, the dissertation shows how the knowledge advanced can be justified and evaluated against the criteria applicable to that genre of inquiry.

The practical discourse uses design-science research as a lens to examine the problem of BYOD in the organizational context. This study draws on the bindpoint model of organizational and individual interactions as an explanatory theory for the application of BYOD security. The model is evaluated through a search conference comprising three different groups of domain experts, including information security professionals, IT architects, and Information Systems managers. The design theorizing process includes the refinement of the bindpoint model, articulation of revised design principles, and the development of an accompanying set of design rules. An examination of this process reveals its journey across different genres. Finally, the process is analyzed against the evaluation criteria for different genres of design inquiry that are developed in the theoretical discourse in Part I.

In theoretical terms, the dissertation articulates how a design-science study, considered in its entirety, is embodied by interdependent moments of one or more of four different species of knowledge process. Each knowledge process is defined by its knowledge goals and its knowledge scope. These types of knowledge moments are represented by genres of inquiry that can lie along two continua. A design-science study frequently consists of multiple distinct knowledge processes.

Various forms of design-science theorizing arise in the course of research studies that involve designing or producing an artifact. One implication of the genres-of-inquiry matrix is the ability for a researcher to identify whether the theorizing is idiographic or nomothetic. As with other forms of knowledge processing, theorizing is contextualized by its scope. There are differing criteria for nomothetic or idiographic knowledge production. Incorporating theorizing concepts such as parsimony versus richness suggests an opportunity to extend or elaborate the genres criteria for the theorizing aspect in design-science.

In practical terms, the results of this study should be useful to researchers who are undertaking a design-science study and need to understand how to appropriately justify the quality of the knowledge processes. The genres-of-inquiry matrix provides a refined approach to justifying and evaluating design-science by explaining how each knowledge moment entails differing evaluation criteria. Similarly, for a reviewer of design-science studies, the genres-of-inquiry matrix can help identify the elements needed to assess the validity of a study procedure and outcome. The genres-of-inquiry matrix can also help researchers divide the reporting of a complex and extensive design-science study into logically separate papers. Separating and reorganizing the reports according to cohesive threads of knowledge moments could help produce multiple, separate, but coherent reports of distinctly different contributions arising from a single design-science study.

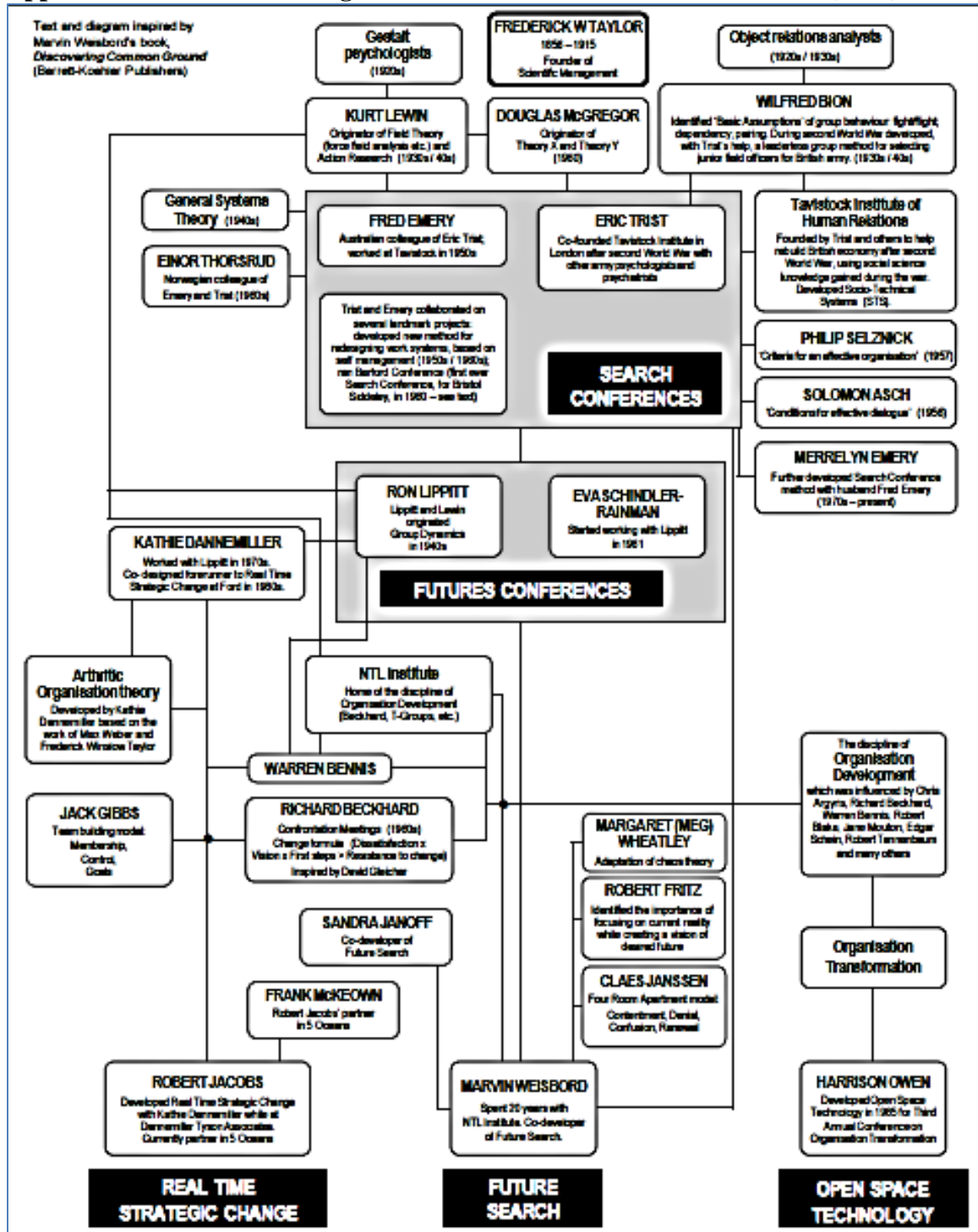
The significance of these contributions arises not only in explaining how design-science researchers can justify and evaluate their work. It can also help make this form of research more approachable and less confusing to novice researchers. An understanding of the dynamics of knowledge criteria in design-science helps to explain a study's complexity and to clarify the way in which the scholarly community will receive such work. A good understanding of the changing knowledge criteria in the design-science process can help avoid certain pitfalls. One such pitfall, for example, would be a futile attempt to apply the same knowledge criteria throughout a design-science study without realizing that the genres have changed from moment to moment.

As an additional contribution, the search conference that has traditionally been used for strategy development and participative planning is demonstrated as a technique for collaboratively developing a future-oriented explanatory design theory. As a participative

scholarship approach, search conference is a long-standing research method. However, this dissertation introduces this well-established and existing research method as a novel way to do engaged research (Van de Ven 2007), as a novel approach for design-science research, and as a novel approach for design theorizing. It is hoped that the findings from this research will be of use to both researchers and practitioners. Overall, the combination of results from this research in design-science, BYOD security, and search conference use should be useful in progressing the development and evaluation of design-science research, encouraging the application of the bindpoint theory, and furthering the use of search conferences in Information Systems research, specifically in design-science research.

APPENDICES

Appendix A: Historical Background of Search Conferences from Leith (2004)





**Appendix B: Search Conference Planning Considerations**

|   |   |
|---|---|
| <p>Planning for items prior to conference</p> | <p><i>Potential participants</i></p> <p>The selection of participants utilized a systematic process called “peer reference system” (Rich et al. 1999) Rich, Hemlock and Martin 1999). Similar to the concept of “snowball” sampling, the peer reference system involved an iterative process of asking knowledgeable members of the community for the names of other respected community members. However, unlike snowballing, <i>the process is deliberate</i> rather than random, since participants are carefully selected experts in their respective knowledge domains.</p> <ul style="list-style-type: none"> <li>• <i>Identify potential participants.</i> The first step is to determine the number of different stakeholder groups and the specific expertise that will be required for the study. This task is part of the research design; the groups emerge during the analysis phase of the search conference and can be refined either through a pilot workshop or through pilot interviews. Appropriate participants would be individuals with the required expertise in the area of research. For example, in this research, the domain area was information security, specifically related to BYOD issues. The stakeholder groups identified for the research were Information Systems architects, Information Systems managers. and information security professionals. Other research may require individuals with other specific expertise.</li> <li>• <i>Identify organizations to contact.</i> In this step, the appropriate organizations that can provide potential participants are identified. For example, in this research, organizations that were local and could easily attend the search</li> </ul> |
|---|---|

conference without the burden of commuting from a different city were identified. Only local area organizations were contacted.

- *Identify individuals within those organizations.* Acquiring participation for the search conference can be one of the most effort-intensive tasks in the search conference process. The biggest challenge lies in identifying individuals with the required expertise within a number of organizations and then planning the search conference at a time that is mutually convenient to the researcher as well as to the required number of participants, who may be from diverse organizations. The participants are usually individuals with exceedingly busy schedules, and their only incentive to be part of the research is a deep interest in the problem that the researcher is investigating. One possible way to address this issue is to identify the different stakeholder groups from the same organization. This provides the participants a pluralistic viewpoint of the phenomenon under investigation and also the incentive to participate as a group.

The researcher must be very resourceful in exploring all possible avenues for gaining and acquiring participation. For this study, participants through the industry, contacts of various faculty members, the industry partners of the university, and personal contacts within the industry were contacted and cold calls and emails to local area companies were made.

- *Prepare invitation materials (email & brochure).* Some of the basic information that the invitation material must include is:
  - The topic that the search conference is about

- The search conference's importance and relevance
- The stakeholder expertise being sought
- How the search conference will be helpful to participants (why should the individual participate)
- Date, time, and duration
- Agenda and what to expect during the search conference
- Location and directions

The brochure for the BYOD Search Conference is included.

***Potential Location***

Is the location within the organization or external to participants?

*Type of location (this is very important).* The location must be able to accommodate the size of the group participating in the conference. It should be large enough to accommodate participants and also allow for breakout areas. In a small to medium-sized conference that is for research purposes, these breakouts must be part of the conference area so that the researcher is able to seamlessly navigate between multiple breakouts and also be able to moderate multiple breakout sessions. The room should be well-lit and well-ventilated so that participants are comfortable in that environment for the entire duration of the conference. Appropriate lighting is acknowledged as a factor in improving comfort level within an environment. Additionally, lighting is important to ensure good quality of video-recording. A well-appointed location emphasizes to the participants the significance of the event and demonstrates that due care

|   |  |
|---|--|
|   | <p>has been taken in organization. Ideally, the location should be away from noisy and busy areas so that the voice recording is clear and so that the conference itself does not cause any disturbance to regular routine in the neighboring locations. For example, a large classroom near an active student area would not serve as a good location.</p>  |
| <p>Planning for activities during and after the search conference</p> | <p>Planning for activities during the search conference relies on a team that will support the researcher. This team could potentially comprise members of the team working on a research project, student assistants, or other volunteers.</p> <p>For this research, the team was carefully made up of volunteers who were known to the researcher. Each of the members of the support team was assigned to task(s) that appropriately utilized their skillsets. The search conference was primarily the mode for data collection. Therefore, it needed to be video- and audio-recorded. There were breakouts designed to allow for discussion and deliberation over the validity and applicability of the theoretical model. Each of these breakouts was supported by two volunteer recorders in addition to the researcher.</p> <p>Other activities included :</p> <ul style="list-style-type: none"> <li>• Booking the venue</li> <li>• Checking AV</li> <li>• Arranging supplies</li> </ul> |



**Data Collection:**

- General recording (video) as well as still shots of conference including snapshots of flip charts & whiteboard (this is data)
- Breakout group discussion recording (very clear audio is needed here to capture group discussion and individual comments clearly so as to assign them appropriately during data analysis)
- Observation notes (this is exceedingly important for qualitative research and also to provide additional learning for future search conferences)
- Need to determine how many volunteers needed to support time-keeping, moderator duties, and recording duties

**Wind up:**

- Collect and inventorize all data that is collected, ensure that all the necessary documentation is in order such as waiver forms/signed consent forms, notes, surveys collected during and at the end of search conference, flip chart sheets
- Return any borrowed supplies or materials or any extras (such as AV equipment, flip charts, markers, etc.)

**Appendix C: Sample Search Conference Brochure  
(Brochure for BYOD case study)**

|   |  |   |  |
|---|--|---|--|
|  <p style="text-align: center;"><b>Research Workshop on BYOD Security</b><br/>11:00 a.m. – 2:00 p.m. November xx<sup>th</sup> 2013, Atlanta, GA</p> <p style="text-align: center;"><b>INVITATION</b></p> <p>Dear Participants,</p> <p>You will no doubt be interested in our workshop aimed at innovating novel techniques for managing security in BYOD settings. This is an opportunity to collaborate with small management teams from several organizations having similar challenges. We will explain the core issues, share a new framework, and apply/adapt the framework to your organization. It is an opportunity to acquire revolutionary approaches to BYOD security first.</p> <p>This highly interactive, discussion-based workshop will enable the exchange of three different perspectives: architectural perspective, security perspective, and managerial perspective. Ideally there would be three participants representing the above functions from each company. Bringing these three cross-functional perspectives together will help in understanding all aspects of BYOD and the associated challenges. The focus will be on how organizations can adapt their information infrastructures to the complexity of issues arising due to individuals bringing in their devices, networks and information systems to the workplace.</p> <p>Topics of discussion include:</p> <ul style="list-style-type: none"> <li>- Risks associated with BYOD</li> <li>- Policies and frameworks for addressing BYOD</li> <li>- Designing organizational information infrastructures to address BYOD security issues</li> </ul> <p>This half-day lunch workshop will provide you an opportunity to network with professionals from the same area who might face similar issues. Any data that is collected during this workshop will be aggregated to ensure individual and organizational anonymity. In addition to providing a forum for the exchange of this topical issue, a report of the proceedings of this workshop will be provided to the participants. The workshop is part of the University Research Stream on Information Infrastructure Security Risk from BYOD. Participation is by invitation only.</p> <p>The workshop will be meeting between 11:00 am and 2:00 pm on Friday, November xx<sup>th</sup>.</p> <p>We will be in touch with additional information. Meanwhile, feel free to let us know if you have any questions.</p> <p>Thank you and we look forward to your participation.</p> <p>Workshop organizers:</p> <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;"> <p><b>Dr. Richard Baskerville</b><br/>Professor<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, GA 30302<br/><a href="http://www.cs.gsu.edu/rbaskerville/">http://www.cs.gsu.edu/rbaskerville/</a><br/>Tel: +1 404.413.7362 Fax: +1 404.413.7394</p> </td> <td style="width: 50%;"> <p><b>Mala Kaul</b><br/>Doctoral Candidate,<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, Georgia 30302<br/><a href="mailto:mkaul1@gsu.edu">mkaul1@gsu.edu</a><br/>Mobile: 678-491-6762</p> </td> </tr> </table> | <p><b>Dr. Richard Baskerville</b><br/>Professor<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, GA 30302<br/><a href="http://www.cs.gsu.edu/rbaskerville/">http://www.cs.gsu.edu/rbaskerville/</a><br/>Tel: +1 404.413.7362 Fax: +1 404.413.7394</p> | <p><b>Mala Kaul</b><br/>Doctoral Candidate,<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, Georgia 30302<br/><a href="mailto:mkaul1@gsu.edu">mkaul1@gsu.edu</a><br/>Mobile: 678-491-6762</p> |  <p><b>Location</b></p> <div style="border: 1px solid black; padding: 5px;"> <p>Manners Room (Room 710)<br/>7<sup>th</sup> Floor, Robinson College of Business<br/>35 Broad St. NW<br/>Atlanta, GA 30303</p> </div> <p>The J. Mack Robinson College of Business is located at 35 Broad Street on the corner of Marietta and Broad streets. It is one block northwest of Robert W. Woodruff park in downtown Atlanta.</p> <p>For street view, please click the link below:<br/><a href="http://goo.gl/maps/L886g">http://goo.gl/maps/L886g</a></p>  <p><b>Directions</b></p> <p><b>From south of Atlanta on Interstate 75/85 Northbound</b><br/>Exit at Edgewood Avenue (Exit 248B) and turn left onto Edgewood. Go through seven traffic lights on Edgewood. You will cross the Five Points Intersection where Marietta, Peachtree and Edgewood meet. After crossing Peachtree Street, Edgewood flows into Marietta Street. Broad Street is the first street on the right. Turn onto Broad Street.</p> <p><b>From north of Atlanta on Interstate 75/85 Southbound</b><br/>Exit at Courtland Street (Exit 249A). Follow Courtland Street south to Edgewood Avenue. Go right on Edgewood through three traffic lights. You will cross the Five Points Intersection where Marietta, Peachtree and Edgewood meet. After crossing Peachtree Street, Edgewood flows into Marietta Street. Broad Street is the first street on the right. Turn onto Broad Street.</p> <p><b>From east of Atlanta on Interstate 20 Westbound</b><br/>Exit at Capitol Avenue (Exit 58A) and turn right onto Capitol. Stay on Capitol, which changes names to Piedmont Avenue, as you pass MLK Jr. Drive. Turn left onto Decatur Street. Go to the fifth red light, one block north of Peachtree Street, and turn right onto Broad Street. (Decatur Street becomes Marietta Street as it crosses Peachtree Street.)</p> <p><b>From west of Atlanta on Interstate 20 Eastbound</b><br/>Exit at Windsor/Spring Street (Exit 56B) and go straight to the third traffic light. Take a left on Central Avenue. Stay on Central Avenue until you reach Decatur Street (several blocks). Turn left onto Decatur Street. Go to the third red light, one block north of Peachtree Street, and turn right onto Broad Street. (Decatur Street becomes Marietta Street as it crosses Peachtree Street.)</p> <p><b>Parking</b></p> <p>Parking is available across the street from the college at the Bennett Brown Commerce Building</p> |
| <p><b>Dr. Richard Baskerville</b><br/>Professor<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, GA 30302<br/><a href="http://www.cs.gsu.edu/rbaskerville/">http://www.cs.gsu.edu/rbaskerville/</a><br/>Tel: +1 404.413.7362 Fax: +1 404.413.7394</p>  | <p><b>Mala Kaul</b><br/>Doctoral Candidate,<br/>Department of Computer Information Systems<br/>J. Mack Robinson College of Business<br/>Georgia State University<br/>Atlanta, Georgia 30302<br/><a href="mailto:mkaul1@gsu.edu">mkaul1@gsu.edu</a><br/>Mobile: 678-491-6762</p>  |   |  |



**REGISTRATION FORM**

Please fax this form to 404-413-7394 or e-mail a copy to [mtaui1@gsu.edu](mailto:mtaui1@gsu.edu) by November 10<sup>th</sup> 2013

NAME: .....

ORGANIZATION: .....

ADDRESS: .....

TEL: ..... FAX: ..... E-MAIL: .....

DIETARY REQUEST: .....

Will you be attending the Workshop on November xx<sup>th</sup> 2013?

Yes

No

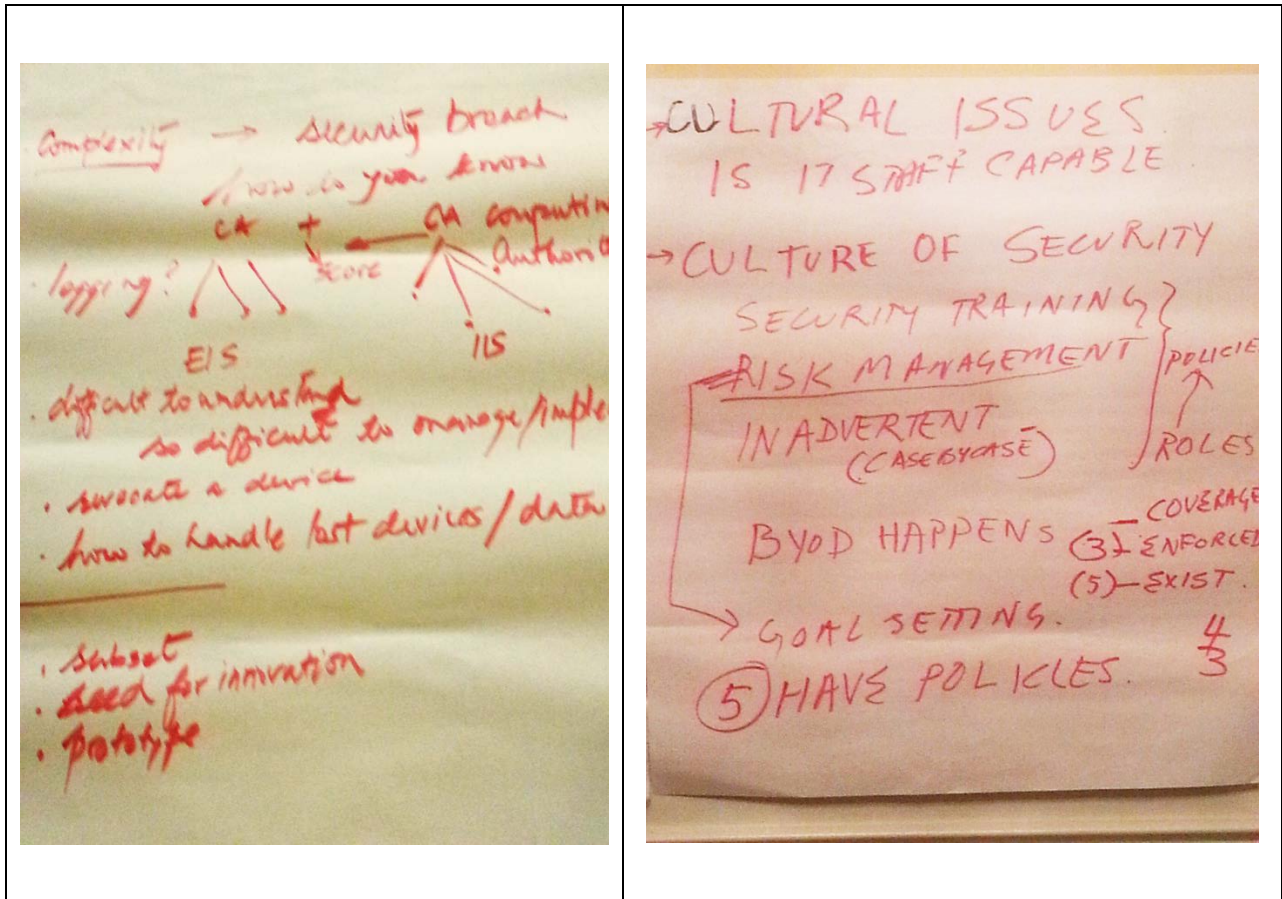
No, but I would like to receive further information about the project or future events



**Agenda**

| Time                               | Topic                          |
|------------------------------------|--------------------------------|
| 11:00 a.m. – 11:15 a.m.            | Welcome and Overview           |
| 11:15 a.m. – 12:15 p.m.            | Understanding the BYOD Problem |
| 12:15 p.m. – 12:45 p.m.<br>(Lunch) | One Possible Solution          |
| 12:45 - 1:30                       | Discussion And Future Scenario |
| 1.30 – 2:00                        | Conclusion                     |

Appendix D: Sample Flip Chart Images from the Search Conference





## **Appendix E: Selected Representative Quotes from the Search Conference**

### **Communication concerns**

*Yeah, that would be a significant challenge. And we know the other nature of the interactions we're working with go back to the communications level. We learned in BYOD already is that some of these are going to go through multiple communications domains. So how do you do that?*

### **Computation concerns**

*"It's a complex problem and complexity leads to issues like: how would you detect breaches, and how do you know? It's a computed thing. Yes, okay, but how do you know what happened that resulted in a possible access which shouldn't have happened? Logging also becomes more complex. What are the events that you're logging really?"*

*"The other challenge is: can you do it in time sensitive manner? We know people don't want to spend much time after they've clicked on something, wait for something to happen probably three seconds. So, can you actually manipulate the information quickly enough? I think you can, but the problem is going to be to generate those kinds of systems to do that."*

### **Device-related concerns**

*"How do you handle the revocation of devices and how do you handle lost devices and lost data? This doesn't ... The way we saw it, it covers allowing access or not allowing access, but it doesn't cover after the fact, after the access had been given, if there's data and devices. An example: how do bindpoints handle that?"*

### **Cost concerns**

*“How would you address the cost? I think it got almost embedded in the application cost and that would be part of it. If you have a separate cost, I think you're going to be dead in the water. But, if you can have that integrated in ... or somehow figure out how to get that in to something that already exists as opposed to having a new or an entire set of programs that you actually have to purchase and obtain.”*

### **Privacy concerns**

One of the concerns that the bindpoint model raised was the issue of individual privacy. Participants felt that the process of security computation required the provision of detailed information attributes pertaining to the technology being used in order for the bindpoint access to be computed.

*“I was going to say, the level of intimacy that the person has with the resource provider. You know, you ask my employer, what are the different attributes about me? If I set up, sign up from a stray mail account, mail dot com, do I really want to give them (the organization) more other than my password? Do they really need my intimate information?”*

There was a level of discomfort in not knowing which attributes related to their personal technology would be captured in order for the organizational information system to grant access to the connectivity.

*“I think the point you're making, which is a critical one, is how does this affect the privacy on the individual's side? Because in order for this to work, you got to have all that stuff*

*exposed—because you don't know what it's going to be. So if you don't know what it is, it all has to be available which then opens up the issue of privacy.”*

Moreover, participants were quite uncomfortable with the potential misuse of such information in the future. They were concerned that in the world of “big data,” the personal information that they shared in the form of information attributes related to the connection between the individual and organizational system might somehow be mined, raising privacy concerns.

*“And, it'll be amazing how much personal information is out there on you already. And that's what, in the back of my mind, I'm always thinking, “I'm leaving a nugget of information over here on the web, over here ... And they're data mining it ... if someone's data mining it. I know he's over here now, and he's over here now. They could stitch it all together.”*

### **Complexity**

*“So those are kind of our list of things that why it would not work, but we also realized that almost everything that we start off with, a complex world is a complex problem. And it's just the evolution of the world that would simplify this.”*

*“So, one of the ways to simplify it perhaps would be to not think of the overall application of it, but think of applying it to a subset of the problem. So, maybe ... and you can create subsets all kinds of different ways, but one way maybe you just deal with who and how they're trying to establish a bindpoint and who will establish a bindpoint. Maybe you initially don't deal with when and why and all those other things that you can think of, where. Maybe you do, but if you try to apply this to a subset it might be a better chance of dealing with it, initially at least, because otherwise it's just too complex to solve.*

*Perhaps the best thing that we could think of was: if there is enough of a seed of implementation of this, and there was enough of a success with that seed, it will probably prompt innovation on part of people who want to make money off this, which is how things happen anyway. I think if we could have a prototype on a subset (of the computational model) that was successful and of course then we started creating our own architecture and how we would implement this.”*

## Appendix F: Initial Question List

### *BYOD Case Study*

#### *Part A – General “Bring your Own Device (BYOD)” Phenomenon related questions*

1. What are the security, connectivity and portability issues pertaining to individual systems that are brought in to your organization by:
  - a. Employees
  - b. Clients
  - c. Visitors
2. What are the differences in these issues pertaining to:
  - a. Smartphones vs. laptops and tablets
  - b. Bringing in device vs. bring in network
3. What are the platform-related implications of BYOD for the developers/system support in your organization?
4. What are the anticipated areas of innovation/improvement/change in the capabilities of mobile technology in the next few years that may affect your organization’s Information Systems?
5. What is your perspective on mobile device management in your organization?
6. What are the account and other information management issues pertaining to mobile device use in your organization?

*Part B – Specific Questions relating to the proposed Bindpoint Theory for addressing  
BYOD*

1. What are the ways in which Individual Information Systems are brought in into your organization?
2. What are the current policies in place in your organization for these individual systems to interact with the Organizational Information Systems?
3. How is the current Organizational Information System designed to provide or restrict access to individually owned systems?
4. To what extent does the Individual-Organizational bindpoint theory explain the interaction of the organizational systems interactions with individual owned systems at your organization?
5. How accurately does the Individual-Organizational bindpoint theory describe the interaction of the organizational systems interactions with individual owned systems at your organization?
6. What might be a way in which you could apply this theory to address a BYOS scenario in your organization?
7. What might be some possible scenarios where the bindpoint theory may not apply?
8. Do you foresee any situations where this theory might result in an unintended consequence?
9. How does this theory need to be adapted to make this theory working your organization
10. This theory will not work because – Please discuss hypothesis
11. How could we change this theory

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