The applicability of Information System Ontology to Design Science Research

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Abstract

Although Design Science Research (DSR) is gaining prominence within the Information System (IS) discipline as a valid research paradigm, it is methodologically yet in its genesis. DSR's lack of detailed, specific and prescriptive methodological guidance is particularly felt by novice DSR researchers. Motivated by this observed methodological shortcoming, the goal underpinning this study is to validate a detailed DSR methodology – the DSR Roadmap (Alturki et al., 2011). This paper more narrowly considers the applicability and suitability of IS deep structure ontology to Information System Design Science Research IS DSR, and related potential for enriching the DSR Roadmap.

The ontology of the deep structure of IS is suggested to be integrated into IS DSR as it supports design aspects that design researchers need to complete in Design Research. The paper demonstrates how the IS deep structure ontology constructs can be used in Design Research to formulate complete design specifications, which constitute and then implement the content of Information System Design Theory (ISDT) elements. The inclusion of IS deep structure ontology into the DSR Roadmap is achieved by mapping between the IS deep structure ontology constructs and the ISDT elements.

The benefits from the inclusion of IS deep structure ontology into IS DSR is twofold. The first is that the inclusion makes the construction of Design Theory (ISDT) easier by generalizing the content of the IS deep structure ontology constructs. The second is that IS deep structure ontology establishes a common language that helps the design researchers better, specifically, and more easily communicate their designs to the practitioners. This helps to operationalize ISDT in a particular context dealing with a specific problem. The first and second benefits represent an abstraction and instantiation, respectively.

1. Introduction and Objective

Design Science Research (DSR) has become an accepted approach for research in the Information Systems (IS) discipline (Iivari, 2007; Kuechler & Vaishnavi, 2008), with dramatic recent growth in related literature[1] (Goldkuhl & Lind, 2010). Though this literature reflects healthy discussion, it quickly reveals a lack of consensus on even the fundamentals; e.g. DSR methods (Peffers et al., 2007; Winter, 2008) or DSR outputs (Gregor & Hevner, 2010; Offermann et al., 2010), indicating that DSR is yet in its genesis (Iivari & Venable, 2009; Kuechler & Vaishnavi, 2008) as a research approach in IS.

Views and prescriptions on the methodology of DSR appear disparate, e.g. (Baskerville et al., 2009; Hevner, 2007; Nunamaker et al., 1991; March & Storey, 2008; Peffers et al., 2007; Rossi & Sein, 2003; Vaishnavi & Kuechler, 2004; Venable, 2006a). Little effort has been made thus far to consolidate, synthesize and harmonize (to the extent possible) collective DSR methodological knowledge. Archival analysis by Indulska and Recker (2008) of studies that claim to conform to the Hevner et al. (2004) guidelines (which has been widely cited as a seminal paper providing guidance for DSR), reveals only few instances of actual application of the guidelines provided. Further, Walls, et al. (2004) observe how few papers explicitly address their Information System Design Theory; which is an output of DSR. Winter observes "the lack of a commonly accepted reference process model for design research" (2008, p. 470) suggesting that the lack of a more complete methodology is a key gap in DSR. Recently, Venable investigated the opinions of IS scholars on the importance of Hevner, et al.'s (2004) guidelines, noting "extensive disagreement on what guideline areas should be used as criteria and standards for evaluation" (2010, p. 121) of DSR research, implying that either the existing guidelines are not sufficiently clear, or they are at too high a level of abstraction and hence difficult to implement, especially by apprentice researchers. Consequently, pragmatic guidance for novice DSR researchers is scarce and often conflicting.

Observations have shown a lack of detailed guidance and methodological shortcomings for DSR. Hence, there appears to be a need for a structured, detailed, integrated and valid DSR methodology in the IS discipline. Such perceptions have been the motivator for the current study. Prior work in this area, by Alturki et al. (2011), resulted in the DSR Roadmap, which is a preliminary attempt to address this lack of a structured and detailed methodology for the conduct of IS DSR. The Roadmap is useful as inter-relates and harmonizes various otherwise seemingly disparate, overlapping or conflicting concepts reported in the literature. Although the principal objective of this research is the development of the Roadmap for conducting DSR in the IS discipline, the current paper focuses on the applicability and suitability of IS deep structure[2] ontology to Design Research[3].

The close attention to design definitions in widely accepted DSR literature reveals that design in Information System Design Science Research (IS DSR) is either a process, or a product/output (Hevner et al., 2004; Walls et al., 1992) introduced in a general form. The

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[1] Strong, relatively recent interest in DSR (Kuechler & Vaishnavi, 2008; Samuel-Ojo et al., 2010) has stimulated journal special issues (e.g. 2008 MISQ 32:4 (March & Storey, 2008)); and specialized conferences in the area (e.g. DESRIST begining in 2006).

[2] We assume the reader is familiar with internal and external IS views proposed by Wand and Weber (Wand & Weber, 1990b; Weber, 1997). IS Deep structure, part of internal view, describes the characteristics of the real-world phenomena that the IS is intended to represent such as Entity Relationship Diagrams.

[3] "[D]esign research is aimed at creating solutions to specific classes of relevant problems by using a rigorous construction and evaluation process, design science reflects the design research process and aims at creating standards for its rigour" (Winter, 2008, p. 471). Kuechler and Vaishnavi (2008) have a similar view, and see DSR in the IS field as research with design as either a topic or method of investigation; for more details see Alturki et al. (2012).

design has not been specified in terms of which constructs should be considered. Further, as a process, all methodologies in the DSR literature have not defined detailed steps for the design activity. As an output, there are definitions for the many output forms, including: methods, models, and design theory (Hevner et al., 2004; March & Smith, 1995). Information System Design Theory (ISDT), as an instance of design theory output is selected as one of the main components for the DSR Roadmap because it is the most comprehensive DSR output (Alturki et al., 2011). However, ISDT is not in a form that allows practitioners to directly build the intended system. Instead, practitioners are required to transform the abstract knowledge in the ISDT's elements into many forms until it is ready to implement and program (or be read by a machine[4] (Wand & Weber, 1993, 1995; Weber, 1997).

The seminal work on IS deep structure ontology (Wand & Weber, 1993, 1995; Weber, 1997) has been used extensively in IS for a range of purposes (Green & Rosemann, 2000). The main objective, in the current paper, is to investigate the inclusion of IS deep structure ontology (Wand & Weber, 1993, 1995; Weber, 1997) into the IS DSR Roadmap (Alturki et al., 2011). The outcome sought is to build a bridge (linkage) between the DSR Activities and Cycles' component (design as process) and ISDT component (design as output) in the Roadmap. The inclusion of IS deep structure ontology into the DSR Roadmap is conducted by mapping between the IS deep structure ontology constructs and the ISDT elements. If the result is a worthwhile mapping between ISDT's elements and the IS deep structure ontology constructs, then, IS deep structure ontology could be used effectively in the IS DSR methodology, i.e. the Roadmap.

Such an outcome is important as design researchers' need of a list of design constructs which they can utilize to develop a comprehensive and easy to implement design. These design constructs are expected to bridge design as process and design as product. This could be considered as one of the gaps in IS DSR which may result from an absence of DSR ontology constructs. The paper demonstrates how IS deep structure ontology constructs can be used in Design Research to formulate complete design specifications, which establish and then implement the content of the ISDT elements. Thus, IS deep structure ontology provides design researchers with most, if not all, the design constructs that are needed for an entire Design Research project.

The benefit from the inclusion of IS deep structure ontology can be viewed from two positions. First, its inclusion will ease the construction of Design Theory, ISDT, by generalizing the content of the IS deep structure ontology constructs. Second, the IS deep structure ontology will enable the establishment of a common language to aid design researchers in communicating, specifically and easily, their designs to the practitioners. The final outcome will assist to operationalize ISDT in a particular context that addresses the management of a specific problem. The first and second positions represent abstraction and instantiation, respectively.

The remainder of the paper proceeds as follows. In the next section we introduce the required literature which covers three main areas. Firstly, Design Science Research Roadmap as DSR methodology and briefly discuss the issues surrounding it. Secondly, we give an overview of design nature to define design activity in DSR observing that there is not enough specification for this activity. Finally, IS deep structure ontology constructs is briefly explained. The section following, explains why Information System Deep Structure Ontology is applicable in Design Research. Section four illustrates how IS deep structure ontology can be injected into the Design Research cycle and shows how the inclusion of IS deep structure ontology is conducted by mapping exercise between IS deep structure ontology constructs and ISDT's elements, and then shows the results of this mapping. This writing concludes by summarizing its contributions and future work.

[4] From here onwards we prefer to use 'read by machine' to be consistence with Wand and Weber's terminology.

2. Literature Review

This section is divided into three main parts: (1) Design Science Research Roadmap and its components; (2) An overview of design nature; and (3) IS deep structure ontology constructs.

2.1. A Design Science Research Roadmap

Though there have been valuable contributions in the DSR literature towards the development of a DSR methodology (Table 1 in Alturki et al. (2011, p. 113) summarizes past IS DSR methodology contributions), a detailed, holistic, validated and widely accepted methodology for conducting DSR to guide IS researchers (especially novices) is yet to be established. The value from, and lack of, a detailed DSR methodology and related accepted concepts and terminology, has been widely recognised (Indulska & Recker, 2008; Peffers et al., 2007; Purao et al., 2008; Winter, 2008).

Alturki et al.'s (2011) DSR Roadmap is a preliminary attempt to address this lack[5]. The Roadmap is a structured and detailed methodology for the conduct of IS DSR; a general guide for IS design researchers to carry out IS DSR comprising reasonably detailed activities. The Roadmap usefully inter-relates and harmonizes various otherwise seemingly disparate, overlapping or conflicting concepts reported in the literature. It covers the entire DSR lifecycle, from the early 'spark' of a design idea, through to final publication.

Structurally, the Roadmap consists of four main interrelated components (see Figure 1 in (Alturki, et al., 2011) for a detailed representation): (A) Activities and Cycles; (B) Output - ultimately, Information System Design Theory - ISDT (Gregor & Jones, 2007); (C) Risk Management; and (D) Central Design Repository (CDR). Component (A) incrementally populates and draws from component (D) which ultimately contributes to component (B). Component (C) and Component (A) are executed in parallel, both again using component (D). Consequently, components (B) and (D) are the sources that contribute to both the environment and the knowledge-base. Though each component is further explained following, we have constrained discussion here to those aspects of the Roadmap necessary as background for understanding key ideas presented in this paper.

2.1.1 Component A: DSR activities and cycles

This component focuses on the detailed DSR activities, and covers the main steps needed to conduct DSR. The relationships between these steps and other components of the Roadmap are presented in detail in Alturki et al. (2011). This component consists of sixteen steps commencing from how the DSR is initiated, through to the publication of DSR output. These steps are complex, rather than linear. They have many feedbacks loops and decision points, while also being subject to change as the Roadmap evolves. Table 1 summarizes all steps in this component.

Table 1 Summary of Steps in Component A (adapted from Alturki et al. (2011))

	Step	Description
1	Document the Spark of an Idea/Problem	DSR is informed either by practitioners in an environment, where the needs come from; or by researchers based on the knowledge base, where possible new solutions or extensions are suggested. Researchers' creativity based on available resources is another possibility for a DSR starting point
2	Investigate and Evaluate the Importance of the	Researchers must investigate pre-existing knowledge and solutions to insure they do not simply replicate past work of others 'routine design' or prior research (Hevner, et al., 2004; Venable,

[5] Partially validated, the Roadmap is acknowledged to be highly preliminary and tentative in parts; having the potential to benefit from extensive further critique, elaboration and validation, this paper aiming to contribute to that goal.

	Problem/Idea	2006b) to insure DSR produces new knowledge. This step could involve consideration of the type of problem and may involve searching the existing knowledge-base, or collecting primary data through empirical work. Research should stop if the problem has already been solved, or if it is found to be unimportant for the targeted environment.
3	Evaluate the New Solution Feasibility	A critical question to ask here is "*Is it possible to produce a new solution*?" Feasibility is thus a critical early consideration, in order to increase the likelihood of success.
4	Define Research Scope	The initial research scope and ultimate objectives are defined in this step. Since knowledge from DSR is generated through the design process (Owen, 1998; Vaishnavi & Kuechler, 2004), the scope and ultimate objective are revisited frequently for refinement, as the research evolves.
5	Resolve Whether within the Design Science Paradigm	Researchers judge whether the research falls under the DS paradigm or not. Researchers must understand their objective precisely, and compare it to the DSR paradigm; on the one hand to insure they intend doing DSR (Baskerville, Lyytinen, Sambamurthy, & Straub, 2010), and on the other hand to discover the value of their design.
6	Establish Type (IS Design Science vs IS Design Research)	DSR in IS can be seen as one or both of two types: (1) IS Design Science and (2) IS Design Research[6]. Based in this distinction, researchers judge their research. This distinction is important for researchers to consider when planning and scoping their work and intended contributions.
7	Resolve Theme (Construction, Evaluation, or Both).	Deciding on construction, evaluation, or both, is a key decision, having substantive implications for planning and related activities.
8	Define Requirements	This step specifies necessary skills, knowledge, tools and experience required for the project, or hardware/software resources. These requirements may be obvious, may be identified through empirical work, or may necessarily become apparent with the passage of time and design iteration.
9	Define Alternative Solutions	This step is creative, because a new solution is imagined. The defined solution is tentative and needs to be built, instantiated, and evaluated. It defines the candidates' solutions and then investigates the optimization of this solution.
10	Explore Knowledge Base for Support for Alternatives	This step entails exploring the knowledge-base in order to discover a 'kernel theory' (Walls, et al., 1992) that supports the defined alternative solution (from previous step), if such theory exists. Gregor and Jones (2007, p. 327) refer to kernel theory as justificatory knowledge which is "explanatory knowledge that links goals, shape, processes, and materials".
11	Prepare for Design and/or Evaluation.	This step encompasses planning for solution construction and evaluation activities. Methods for constructing the defined alternative solution are selected at this step. The step also includes preparation of functional specifications and metrics or criteria, to evaluate the significance and performance of a solution or an artifact.
12	Develop (Construction)	This step includes design and development of a solution for an existing problem/foreseen need, and/or a novel artifact is constructed. This step also includes the determination of the artifact's functionality, architecture and properties, then building an instantiation which is the physical artifact.
13	Evaluate	Once the artifact is built, it becomes the object of the evaluation activity. The evaluation activity compares the performance of a solution to criteria or metrics, or functional specifications (Cole, Purao, Rossi, & Sein, 2005; Vaishnavi & Kuechler, 2004) in the targeted environment defined before. The aim of evaluation is to decide not 'why' or 'how', but 'how well' the artifact works (March & Smith, 1995). The new system must be verified as (1) working correctly without shortcomings, and (2) performing required functions according to the defined requirements.
14	"Artificial" Evaluation	The designed solution or artifact is tested in a limited way where it may pass on to external evaluation or return to the design step for refinement before entering the same loop again (Venable, 2006a).
15	"Naturalistic" Evaluation.	This is the 'real' test where the invented designed solution or artifact is tested in a real-life setting to check its validity (Venable, 2006a), based on metrics defined in step eleven.
16	Communicate Findings	Reaching this step means the design solution/artifact has passed the tests in the evaluation activity and can be published and communicated. Researchers must effectively report/communicate results, contributions, limitations, and new knowledge gained during the construction and design of the DS artifact, to communities of both researchers and practitioners. Establishing a contribution to knowledge, over what was known previously, is important.

[6] "[D]esign research is aimed at creating solutions to specific classes of relevant problems by using a rigorous construction and evaluation process, design science reflects the design research process and aims at creating standards for its rigour" (Winter, 2008, p. 471). Kuechler and Vaishnavi (2008) have a similar view, and see DS research in the IS field as, research with design as either a topic or method of investigation; for more details see Alturki et al. (2012).

2.1.2 Component B: Output of the DSR

A design theory is “something in an abstract world of man-made things, which also includes other abstract ideas such as algorithms and models” (2007, p. 320). This component represents the results of DSR deriving from use of the Roadmap. Alturki et al. (2011) argue that Information System Design Theory (ISDT) (Gregor & Jones, 2007) is the ultimate and most comprehensive output of DSR. The ISDT (Gregor & Jones, 2007) consists of eight elements: (1) purpose and scope, (2) constructs, (3) principle of form and function, (4) artefact mutability, (5) testable proposition, (6) justificatory knowledge, (7) principles of implementation, and (8) expository instantiation. We return to ISDT later in the paper.

2.1.3 Component C: Central Design Repository (CDR)

Since DSR entails much iteration, documentation in DSR is important to codify circumstances of all successful and failed attempts, while progressing the DSR. The CDR consists of two separate parts, the design- *product* and the design *process*. The former codifies knowledge about an artifact such as properties, functions, and structure; the second part is knowledge about the process of how to build and implement a designed solution or artefact as an instantiation. The ISDT elements (Gregor & Jones, 2007) (as the output of the DSR, as depicted in the Roadmap) are incrementally populated from the content of the CDR, element by element during design progression, or at one time when the DSR is complete. The full content of the CDR or part of it could be an object for the last step in component (A), to communicate the discovered knowledge through publication.

2.1.4 Component D: DSR Risk Management

Risk in DSR is “a potential problem that would be detrimental to a DSR project’s success should it materialize” (Pries-Heje, Baskerville, & Venable, 2008, p. 330). Risk management in DSR relates to and overlaps with all of the Roadmap steps. Researchers/designers should be aware, define, document and monitor any possible risk associated with each step in DSR. While there are potential dangers during DSR, researchers could avoid or mitigate risks if s/he could predict them. Pries-Heje et al. (2008) propose a framework to address risk management in DSR through four tasks: (1) Risk Identification, (2) Risk Analysis, (3) Risk Treatment and (4) Risk Monitoring. We agree that Pries-Heje et al.’s work complements DSR methods and Risk Management frameworks, thus risk management is incorporated in the DSR Roadmap for completeness.

2.2. The Nature of the Design in Information Systems Design Science Research

Though most DSR methodological writings mention ‘Design’ as a key step in conducting DSR, none explains the design in depth. Design researchers would benefit much from the existence of accepted and well understood design constructs to both promote a comprehensive design, as well as ease communication and implementation. In this section we briefly present an overview of the nature of design. Design definitions here range from broad to narrow.

According to the DSR literature, ‘design’ is “from the Latin désigńare, which means to point the way” (Purao, 2002, p. 4). Generally, design is a search activity that aims to find the best solution to important unsolved problems (Hevner et al., 2004). Simon (1996) sees design as creating options that are filtered and excluded until the design’s requirements are fulfilled. Design could have different meanings, including the performing of design, the constructed artefact, or the utility set in the artefact[7] (Purao, 2002). Design includes creating new things, solving problems and moving to desired situations from less preferred situations (Goldkuhl, 2004). It involves building a solution intended to resolve a problem (Peffers et al., 2007).

Simon (1996) describes an artefact as a meeting point – an interface - between the inner and outer environments. The inner environment is “the substance and organization of the artefact itself” (p. 6). The outer environment is “the surrounding in which the [artefact] operates”. The artefact will achieve its anticipated objectives if the inner environment is suitable for the outer environment. The artefact’s goals link the inner to the outer environment. The artifact’s behaviour is forced by both its inner and outer environments; the artefact is ‘structurally coupled’ to its environment. The bringing-to-be of an artefact components and their organization, which interfaces in a desired manner with its outer environment, is the design activity (Vaishnavi & Kuechler, 2004). The outer and inner environments are connected through the afferent (input) channel and efferent (output) channel. The former “receives information about the environment”; the latter “acts on the environment” (Simon, 1996, p. 121).

Specifically, design activity describes an artefact’s organisation and functions (Simon, 1996) and design is "[t]he use of scientific principles, technical information and imagination in the definition of a structure, machine or system to perform pre-specified functions with the maximum economy and efficiency" (Fielden cited in Walls et al. (1992), pp. 36-37). Design is “shaping artefacts and events to create a more desirable future” (Boland cited in March & Storey (2008), p. 725)

Design is a construction action and results in a product. Walls et al. (1992) see design as both noun and verb, because it is a target object that will be constructed and an action that fulfils the targeted design requirements. It describes the world as acted upon (processes) and the world as sensed (artefacts) (Hevner et al., 2004). Alexander (1969) cited in Walls et al. (1992) distinguishes between scientists and designers. While the role of scientists is to discover the components of interesting systems, the role of designers is to shape those components; synthesis is the essence of the design process.

Preceding definitions of design are intentionally general; they consider design a creative process (Hevner el al. 2004; Simon, 1996), which they leave to the creativity of design researchers. While we accept and value these high level definitions, we believe there is merit in exploring potential from more specific and prescriptive guidance in a more constrained and specific area of design. The more specific and more constrained area of design with which we are interested helps design researchers building and then operationalizing Design Theory.

Therefore, it is desirable to propose design constructs for IS DSR for design researcher s, especially asthe design activity becomes much clearer and more commonly understood. Thus, the provision of a language to communicate design specifications for IS DSR is a goal of the current study. This aspiration is the motivating factor for investigating the applicability of IS deep structure ontology constructs for IS DSR. However, before presenting the details of this investigation, an overview of IS deep structure ontology constructs is described.

2.3. An Overview of IS Deep Structure Ontology Constructs

This section explains IS deep structure ontology constructs proposed by Wand and Weber (Wand & Weber, 1990a, 1990b, 1993, 1995; Weber, 1997) based on the seminal work of Bunge (1977, 1979). Ontology is concerned of the structure of the real-world; it is a school of thought that studies the existence of things. IS deep structure ontology defines the “set of

[7] In this paper we are interested in the first two meanings.

constructs that are necessary and sufficient to describe the structure and behaviour of the real world" (Wand & Weber, 1990b, p. 63). Since the ontology concerns the structure of the real-world, it is relevant to perceive IS from two points of view: 1) as IS represents the real world, the ontology provides the basic things in the real-world that IS ought to be able to symbolize; 2) IS itself as an object in the real world because IS are also things in the real-world, hence the ontology provides a basis for modelling (Wand & Weber, 1990a). Both views are important to our argument but we are mainly concerned with the first view because it enriches our discussion directly. This set of core ontological concepts can be used to illustrate the structure and behaviour of a designed IS which is representational of the real-world. This set of ontological constructs is used to judge the quality of grammars that are used to describe the real-world (Weber 1997a). No grammar can represent all ontological constructs (see Table 2); the real-world representation will be incomplete. This deficiency may lead to incomplete scripts generated using these grammars.

Wand and Weber propose three models for IS deep structure: 1) representation model, 2) state track model, and 3) decomposition model. Herein we focus on the representation model because it the bottleneck in this proposal. The representation model defines a set of constructs (Table 2) which are thought by Wand and Weber to be necessary and sufficient to describe the structure and behaviour of the real world in which IS operate. Wand and Weber believe these constructs have the ability to serve as the basis for any IS development (Routine Design explained later in the paper) representation language.

Table 2 Information System Deep Structure Ontological Constructs

Construct	Explanation
Thing	A thing is the elementary unit in the BWW ontological model. The real world is made up of things. Two or more things (composite or simple) can be associated into a composite thing.
Properties	Things possess properties; A property is modelled via a function that maps the thing into some value. A property of a composite thing that belongs to a component thing is called a hereditary property. Otherwise it is called an emergent property. Some properties are inherent properties of individual things called intrinsic. A property that is meaningful only in the context of two or more things is called a mutual or relational property. Attributes are the names that we use to represent properties of things.
State	The vector of values for all property functions of a thing.
Conceivable state space	The set of all states that the thing might ever assume.
State law	Restricts the values of the property function of a thing to a subset that is deemed lawful because of natural laws or human laws.
Lawful state space	The set of states of a thing that comply with the state law of the thing. It is usually a proper subset of a conceivable state space.
Event	A change of state of a thing. It is effected via a transformation.
Event space	The set of all possible events that can occur in the thing.
Transformation	A mapping from a domain comprising states to a co-domain comprising states.
Lawful transformation	Define which events in a thing are lawful.
Lawful event space	The set of all events in a thing that are lawful.
History	The chronological ordered states that a thing traverses.
Coupling	A thing acts on another thing if its existence affects the history of the other thing. The two things are said to be coupled or interact.
System	A set of things is a system if, for any bi-partitioning of the set, coupling exists among things in two subsets.
System composition	The things in the system.
System environment	Things that are not in the system but interact with things in the system.
System structure	The set of coupling that exist among things in the system and things in the environment of the system.
Subsystem	A system whose composition and structure are subsets of the composition and structure of another system.
System decomposition	A set of subsystems such that every component in the system is either one of the subsystem in the decomposition or is included in the composition of one of the subsystems in the decomposition.

Level structure	Defines a partial order over the subsystem in a decomposition to show which subsystems are component of other subsystems or the system itself.
Stable state	A state in which a thing, subsystem or system will remain unless forced to change by virtue of the action of a thing in the environment (an external event)
Unstable state	A state that will be changed into another state by virtue of the action of transformation in the system.
External event	An event that arises in a thing, subsystem or system by virtue of the action of some thing in the environment on the thing, subsystem or system. The before-state of an external event is always stable. The after-state may be stable or unstable.
Internal event	An event that arises in a thing, subsystem or system by virtue of lawful transformation in the thing, subsystem or system. The before-state of an internal event is always unstable. The after-state may be stable or unstable.
Well-defined event	An event in which the subsystem state can always be predicted given the prior state is known.
Poorly defined event	An event in which the subsequent state cannot be predicted given the prior state is known.
Class	A set of things that possess a common property.
Kind	A set of things that possess two or more common properties.

Based on Wand and Weber's assertion, this set of constructs may be applicable to use with Design Research because it shares with normal IS development many aspects and has the same ultimate output which is the IS. We propose to use IS deep structure ontological constructs in order to address the gap mentioned in the introduction; the need to transform ISDT into a form that becomes easy to implement and read by machine. It is recognised that we may need additional new constructs for aspects that are particular to Design Research such as kernel theory/justificatory knowledge, un/conceivable problem/need, goals etcetera. The main difference with these aspects is that they are abstracted/virtualized not available in real world.

3. Why Information System Deep Structure Ontology is applicable in Design Research?

Obviously, following from the preceding definitions of design in section 2.2, we argue that the ultimate objective of DSR in the IS discipline is IS artefact design in response to unsolved problems or to satisfy un/conceivable needs. This objective may include many intermediate forms of artefact, such as method, before constructing a complete IS. In this section we present our argument for the applicability and inclusion of the ontology of IS deep structure developed by Wand and Weber (Wand & Weber, 1990b, 1993, 1995; Weber, 1997), in IS DSR. The argument rests on two key points: (1) IS consists of Routine Design and Design Research; and (2) the integration between the DSR Roadmap Activities component and ISDT component.

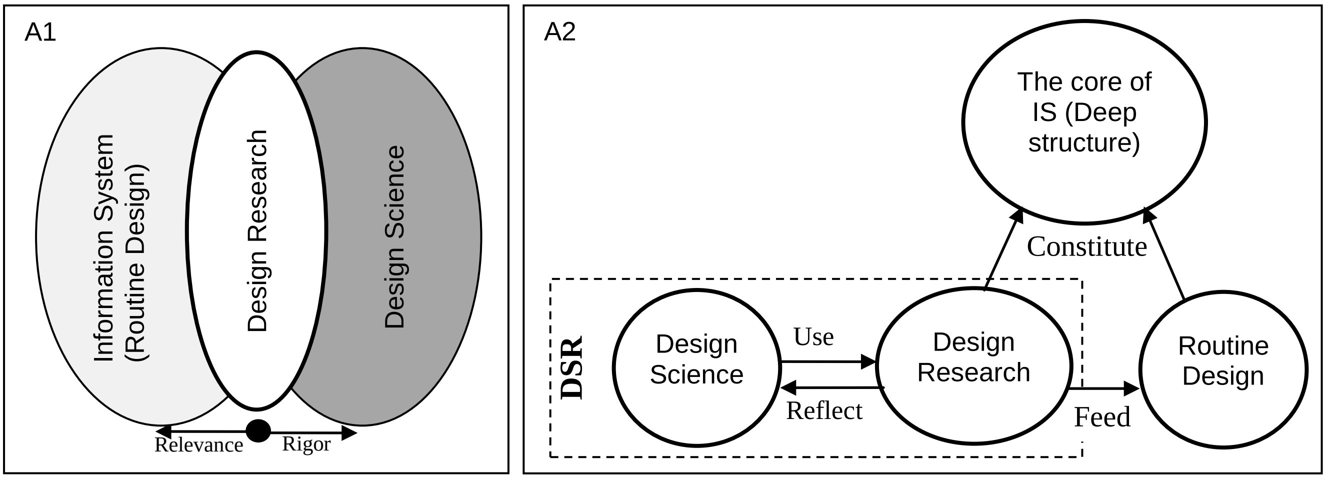

Figure 1. The overlap between Design Science, Design Research, and Routine Design in IS discipline

For the first point, Alturki et al (2012) argue that IS Design Research, as a type of DSR, is a part of IS discipline. More specifically, they argue that IS deep structure is divided into two parts: 1) Routine Design, and 2) Design Research. Figure 1 depicts this notion and can be viewed from left to right as it demonstrates the relationship between IS discipline (deep structure), and DSR (Design Science and Design Research) and Routine Design. Figure 1 has two views, box A1 and box A2, which explain this relation. In A1 view, the light grey oval represents the Wand and Weber view of the IS core which is equivalent to Routine Design. The white oval is the Design Research which presents a specific part of the IS core and functions as a bridge between practice and academia. The Design Research represents the abstract knowledge developed by researchers that is adopted and converted by practitioners to a specific problem solution. This type of research has two sides of interest; research relevance and research rigor. The last part of the A1 view of the figure is Design Science, dark grey oval, which presents the work of academics. This part is related to how to conduct DSR properly; this part is a methodology for the Design Research[8].

The A2 view of Figure 1 illustrates how DSR (Design Science and Design Research), and Routine Design interact with each other in IS (deep structure). This view could be best looked from left-to-right as this represents the normal flow of IS research progression. Design Science is used in conducting Design Research and Design Research may feed back to contribute to the Design Science process. Both Design Research and Routine Design constitute IS deep structure. Design Research feeds Routine Design by developing an abstract knowledge. Routine Design implements this abstract knowledge and converts it to actual working IS; executable codes.

The other notions that support the integration between Design Research and IS deep structure are the suitability between DSR and the core of IS from representation point of view, and the transformational nature in IS and DSR; for details see Alturki et al (2012).

Based on the good fit between DSR and IS mentioned above, we could logically argue that anything applicable for IS deep structure is also applicable to Design Research and Routine Design. Consequently, we propose the ontology of IS deep structure developed by Wand and Weber (1993, 1995) and Weber (1997) is applicable to Design Research as well.

For the second point, the integration between the DSR Roadmap Activities component and ISDT component (Alturki et al., 2011), there is a need to establish a common language between these two components. Based on the work presented in (Alturki et al., 2011) and (Alturki et al. 2012), ISDT[9] proposed in (Gregor & Jones, 2007) is the ultimate and most comprehensive objective/output of DSR. The DSR Roadmap activities component develops the design knowledge, and the ISDT component codifies/documents design knowledge. In other words, the ISDT component results from the DSR Roadmap activities component. Piirainen and Briggs (2011) believe that DSR methodology mirrors the structure of the design theory. They "claim that the DSR methodology and DT [Design Theory] complement the DSR framework and give additional guidance" (p. 50). This suggests the need for a map between the DSR Roadmap activities component and ISDT component that will enable more direct and clearer interactions between them. It is proposed that the Wand and Weber IS ontology offers the desired bridge.

The mapping between the DSR Roadmap activities component and ISDT component supports the inclusion of IS ontology to Design Research as common language. Design, the most important phase of Design Research, is where the knowledge emerges. The design could be seen from two points of view: 1) output/product and 2) activities/process. For the

[8] Figure 1 puts 'Design Science' on a par with 'Design Research'. While this may be appropriate early in the genesis of an approach or paradigm, once established, 'Design Science' should move to the background and become a very small relative to 'Design Research'. In example, methodological research constitutes a very small proportion of research in the behavioral sciences.

[9] The author is aware of other Design Theory writings (Baskerville & Pries-Heje, 2010; John Venable, 2006b; Walls et al., 1992, 2004).

former, Table 2 in (Gregor & Jones, 2007) depicts the elements of ISDT. It is clear that core elements such as construct and principle of form and function are about the actual design of an artefact. These elements are about the structure, properties, functions, and requirements etcetera of an artefact. In addition to this, Meyer (1990, p297) mentions that a theory "may be viewed as a formal language, or more properly a meta language, defined by syntactic and semantic rules". Thus, ISDT can be viewed as a language for DSR. The question here is: Is ISDT as DSR formal language complete and clear (unambiguously specified)? Can design researchers populate the elements of ISDT easily?

For the design as process, DSR Roadmap has been developed to help design researchers conduct DSR. One of the Roadmap's components is the activities component which contains a step about design and development of a solution for a real foreseen problem/need or novel artefact for unforeseen problem/need. March and Smith (1995, p. 254) define development as "the process of constructing an artefact for a specific purpose". The constructed solution, an artefact, varies in its essence based on how a researcher sees what the artefact means; there is little consensus on what exactly constitutes the artefact. Some scholars see the IT artefact as 'executing code' while others view the artefact as embedded knowledge in the executing code (Baskerville, 2008). This step also includes determination of the artefact's functionality, architecture and properties, then building an instantiation which is the physical artefact (Goldkuhl & Lind, 2010; Gregor & Jones, 2007; Hevner et al., 2004; Järvinen, 2007; March & Smith, 1995; Orlikowski & Iacono, 2001; Peffers et al., 2007; Purao, 2002; Walls et al., 1992).

Since the two views of the design, product and process, are the two sides of the coin, the association between them is very advantageous. This association will work as a bridge between design activity and ISDT components. From one hand, since ISDT is formal language about abstract design knowledge, this linkage using IS deep structure ontology could be considered as a tool to achieve generalizability in the form of ISDT. This mapping helps to populate and enrich the elements of ISDT easily and fully because there are many elements of ISDT about actual structure, and provides consistency between the design as a process in the activities component of the Roadmap and as product results from DSR; which is ISDT component in the Roadmap. On another hand, association helps to operationalize ISDT in a particular context dealing with a specific problem. By using the ontology constructs of IS deep structure such as; thing, state, and transformation (Wand & Weber, 1990a, 1993, 1995; Weber, 1997), researchers will have most of needed constructs to produce complete design theory and then build an artefact.

At this stage it is difficult to assert that IS deep structure ontology constructs needs additional new constructs for aspects that are particular to Design Research such as kernel theory/justificatory knowledge, un/conceivable problem/need, or goals etcetera. The main difference with these aspects is that they are abstracted/virtualized not available in real world. However, if IS DSR is intended to be a representation of un/conceivable real-world problem/needs and a representation of a solution (Alturki et al., 2012), design researchers should use constructs which are able to represent and symbolize these views of the real-world. IS deep structure ontology will explicitly strengthen the design of artefacts and make them easier to implement. We suggest the ontology of IS deep structure could be used in the design activity because this ontology gives most if not all constructs which researchers need to complete in the design phase. Subsequent section highlights how IS deep structure ontology can assist with the design to answer the questions above and try to achieve proposed advantages, which is a central message of this paper.

4. An Integration between Information System Ontology and Design Research

This section is divided into three main subsections. In subsection 4.1, we illustrate how IS deep structure ontology is interwoven with the Design Research cycle, thereby conveying a main contribution of the paper. In the next subsection we present how the inclusion of IS deep structure ontology into the DSR Roadmap is conducted by mapping between IS deep structure ontology and the ISDT elements. If we can prove a good mapping between ISDT's elements, as ISDT is the output of IS DSR, and constructs of IS deep structure ontology, IS deep structure ontology can be used in the IS DSR methodology; i.e. the Roadmap. The result of the mapping exercise is shown in the last subsection, 4.3. It must however be noted that the mapping activity is highly tentative. And though subsection 4.2 may be considered a separate contribution, it is believed prerequisite to subsection 4.3, and necessary for readers to understand subsection 4.3 which is the primary contribution of this paper.

4.1. Design Research Cycle with Information System Deep Structure Ontology

Our strategy here is to use two figures, Figure 2 and Figure 3, to explain how IS deep structure ontology can be integrated into IS DSR. The two figures relate to each other. Figure 3 is more detailed and can be considered a lower level representation of Figure 2 which is a more abstract level. Following, each figure is explicated in more detail.

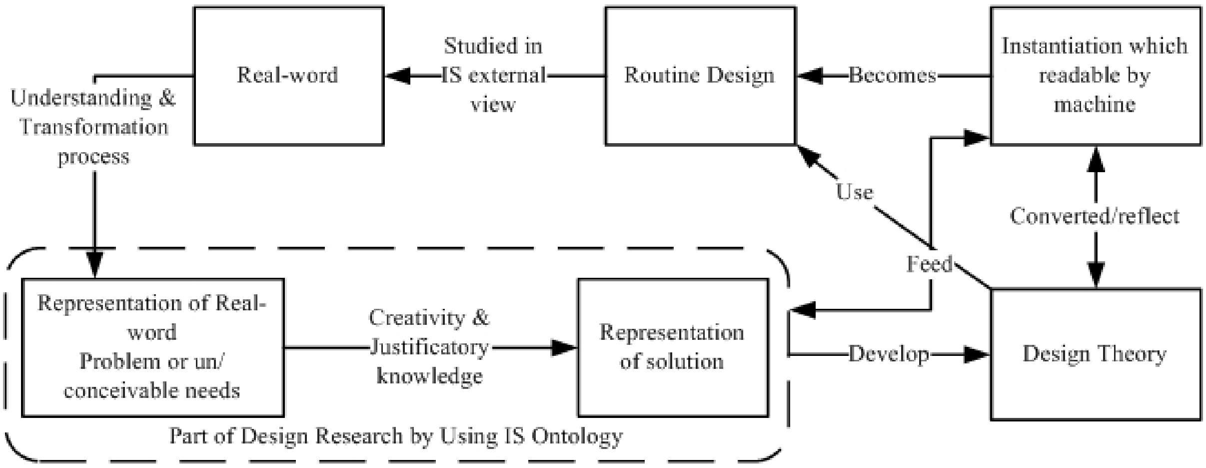

Figure 2: IS Ontology with Design Research Cycle

Figure 2 depicts how the IS deep structure ontology could be integrated into the DSR cycle; it depicts this integration at a high level. Design researchers could use IS deep structure ontology to represent conceivable/unconceivable[10] problem/need, and then solution/innovation. These two representations populate the design theory, the elements of the ISDT as adopted in this work; generating the abstract knowledge. This abstract knowledge will be tested and proved by developing an instantiation. Emerging knowledge from instantiation construction could complete and amend the design theory; ISDT elements. Subsequently, if the instantiation is successfully constructed, new knowledge emerges. This developed emerging knowledge becomes available to practice for use; this knowledge becomes the focus and input for Routine Design. Finally, a new phenomenon is created which could be a subject for IS researchers to study from an external view of IS (Wand &

[10] Conceivable means a design may target problem/need that people experience; unconceivable means a design may target problem/need that is not in the horizon. Unforeseeable/seeable might be equivalent to unconceivable/conceivable, respectively.

Weber, 1995; Weber, 1997). The research from IS external view may again spark a new design idea, which initiates a new IS DSR cycle. All boxes in Figure 2 have equivalent parts DSR Roadmap activities except Routine Design and Real-word boxes.

Figure 3 combines Figures 1 and 2, with additional specifications, thereby, helping to explain the integration of the IS deep structure ontological constructs. The three axes in Figure 3 relate to: 1) Innovation (Y axis), 2) Reality (Y axis), and 3) Representation (X axis). The Y axis symbolizes both innovation and reality, with innovation ranging from low to high, and reality ranging from real systems to abstract systems. There is also correspondence between the levels of innovation and abstractness; for example, the lower levels of innovation are associated with the real systems, and the higher levels of innovation are associated with the abstract systems. Representation is reflected on the X axis, with the degree of representation in IS construction increases from left (low) to right (high). The figure also combines the two main IS deep structural parts, as shown in Figure 1: Design Research and Routine Design. The Design Research and Routine Design are both related to the three axes.

In order to better explain Figure 3, let us start with Routine Design (blue part) as it represents the normal and basic IS development. Routine Design starts with analysing a real system to convert it into different types of transformations using different language grammars such as ERD, flowchart etcetera then the last form is automated (code) which is readable by computers/machines (Wand & Weber, 1993, 1995; Weber, 1997); the objective here is the automation by representing the real system in IS. There is no need to seek for new knowledge to find solution or produce new knowledge from solution. The used grammars in this transformation are normally have good consistency with IS ontological but with deficiencies which are responsible of some IS shortcomings, e.g. two or more objects in the real are represented by one thing in IS (Weber, 1997). In short the Routine Design takes existing system and converts it to another object called IS which has representations of the real situation. The reader should note that Routine Design only starts from real world as shown in Figure 3.

Design Research in contrast (yellow part) could spark from two possible worlds: part of Real world and virtual world[11]. For the former (see the box titled Real World in Figure 3), Design Research starts from existent important unsolved but foreseen problem/need. Design researchers should represent the problem/need for two main reasons: 1) to help them in discovering a design solution, and 2) to emphasize the importance of problem/need since it is unlikely a complete and good design will result if design researcher's efforts are wasted in the wrong parts of the problem space (Verschuren & Hartog, 2005). Without representing all aspects of focused problem/need in the IS DSR scope, design researchers may unable to produce a comprehensive[12] design; it could happen serendipitously if they are really lucky. The best problem/need representation design researchers develop, the best design they may construct.

For the latter sparks which is virtual world (see the box titled Virtual World in Figure 3), there is no existent problem or need in current setting but through the creativity of a design researchers a problem/need could be envisaged. Thus, the representation in this case is crucial and might be more important than the representation in the former case.

[11] The real world and the virtual world contain a range of problems and needs that can be imagined or are beyond the imagination.

[12] We acknowledge and agree with one reviewer's comments, specifically, that it is unnecessary to represent all aspects of a problem to produce a good design. The reviewer identifies Ciborra's (1994) 'tinkering' concept as a very important path, and perhaps the only one, for innovative systems design. From our perspective, although this concept is not totally congruent with our thinking, it is a valuable and effective enhancement process when shortcomings in the design exist.

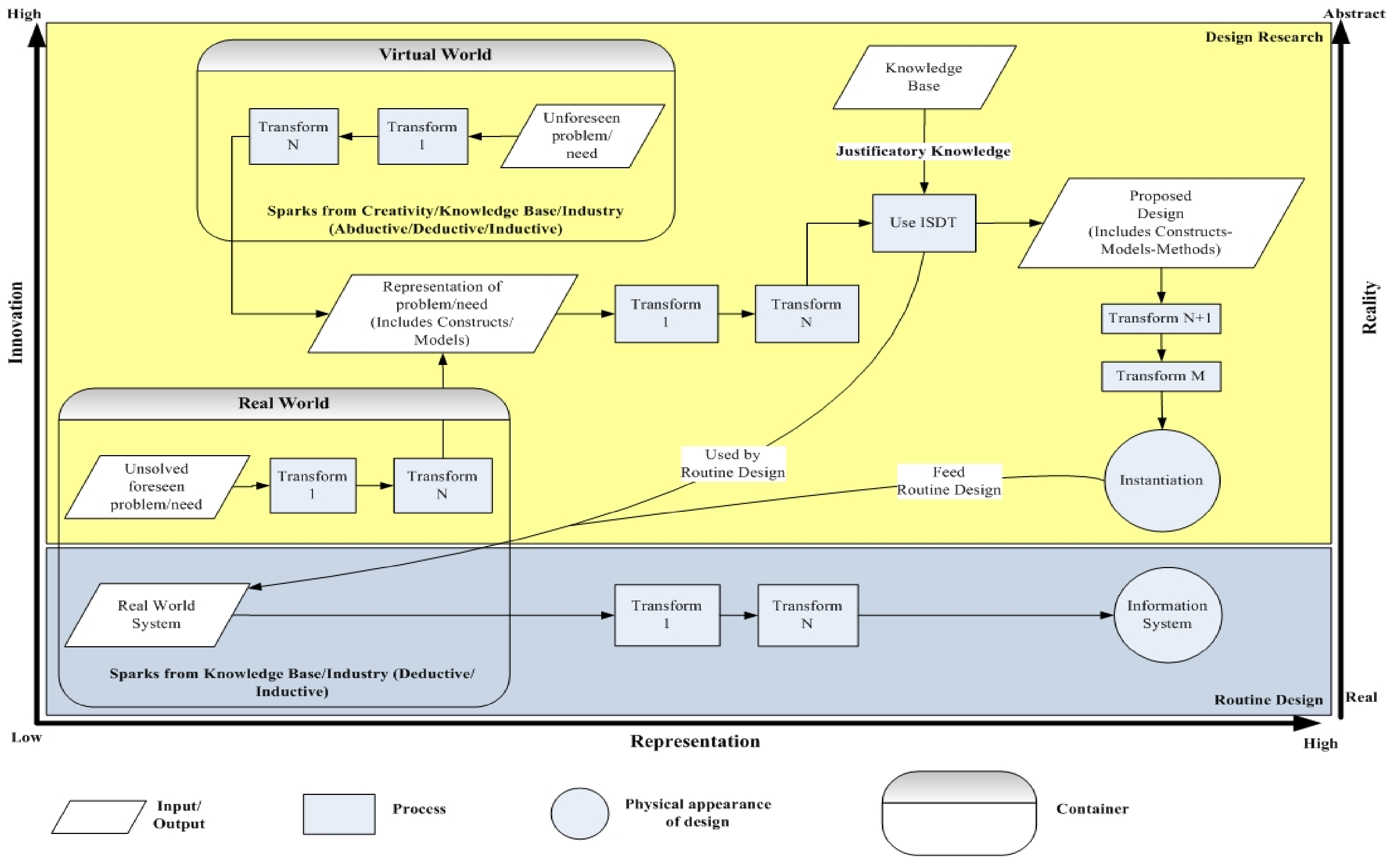

Figure 3: Specification of the integration of IS ontological constructs

Subsequently, both two sparks, part of Real world and virtual world, have identical solving problem process. They go through different types of transformation similar as Routine Design, but with three differences which are the solution process, problem nature, and the output. For the first difference, the Design Research finds solution through build and evaluate processes. In case of problem nature, since the problem/need here is not solved or satisfied, there is a need to investigate the knowledge base to find a knowledge or guidance for solution. This knowledge is called justificatory knowledge/kernel theories (Gregor & Jones, 2007; Walls et al., 1992) which is part of representation and one form of transformation processes. The last difference between Design Research and Routine Design is an output; Design Research produce ISDT rather than just IS though IS itself could be a part of ISDT. Once the design in Design Research is instantiated successfully, the problem/need and ISDT become existent and part of the real world. In other word, the output of Design Research becomes an input of Routine Design as depicted by curve line between yellow and blue parts in Figure 3. The different intermediate outputs (such as constructs, models, and methods) could be developed during the Design Research period.

Although different types of transformation in Design Research are applied, there are no common or acceptable constructs that allow design researchers in IS DSR to be very specific about their design in order to help them to populate the output of Design Research which is design theory; ISDT structure. This issue is what we mention in section which we raise some questions to think about: Is ISDT as DSR formal language complete and clear (unambiguously specified)? Can design researchers populate the elements of ISDT easily? Next subsection tries to address this issue.

4.2. The IS Deep Structure Ontology and Information System Design Theory Elements Mapping Exercise

In this section we investigate the mapping between ISDT's elements and IS deep structure ontological constructs trying to specify ISDT elements and may constitute a language for DSR language. As depicted vertically on the right of Figure 3 above, there are different types of transformation to instantiate the design knowledge in ISDT because the ISDT knowledge is an abstract and therefore is not ready for practice use directly. This entails to investigate the elements of ISDT to answer the questions above;

The procedure of the examination has been done in two main steps: (1a). the process starts with distilling key aspects in each element of ISDT by braking down each element of ISDT into small micro building blocks. (1.b). It also goes through IS deep structure ontology constructs, listed in Table 1, one by one and have done close reading to get sufficient understanding. 1a and 1b are relatively similar to work in (Green & Rosemann, 2000; Rosemann et al., 2006). The objective of this extraction is to help us in the mapping exercise between ISDT elements and IS deep structure ontology constructs to conclude the applicability of IS deep structure ontology constructs to Design Research. (2) The researcher tries to link the micro building blocks of ISDT's main eight elements with IS deep structure ontology constructs; results are shown in Table 2 below.

Three possible conclusions are expected as the researcher envisages ISDT and IS deep structure ontology constructs in master-details (parent-child) relationship; see Figure 4:

1. IS deep structure ontology constructs fit totally into all ISDT elements and could be used as it is without any changes. Every element of ISDT has at least one construct of IS deep structure ontology constructs and all IS deep structure ontology constructs are mapped to ISDT's elements.
2. IS deep structure ontology constructs fit into ISDT elements but with some deficiencies and need some changes. Some of ISDT's elements may have not any constructs of IS deep structure ontology constructs or not all IS deep structure

ontology constructs are mapped to ISDT's elements. Intuitively, this possibility is most likely to be the result of this mapping exercise.

3. IS deep structure ontology constructs does not fit totally into ISDT elements.

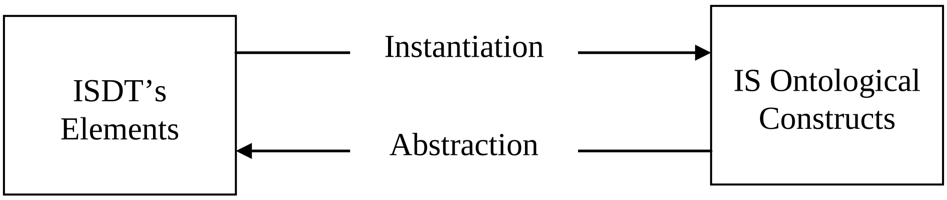

Figure 4: The relationship between ISDT's Elements and IS ontological constructs

There is an important issue here which is since rationale of this exercise is that ISDT and IS deep structure ontology constructs have master-details (parent-child) relationship, is it acceptable to find one IS deep structure ontology construct belongs to more than one ISDT's elements? If yes, this means ISDT has not parsimony quality. However, if it is not acceptable, this means there are some overlaps between ISDT's elements.

4.3. Results From the Mapping Exercise Between IS Deep Structure Ontology and Information System Design Theory Elements

Table 3 is the result of the mapping exercise explained in the previous section. The first two columns in Table 3 illustrate micro building blocks in each element of ISDT. The third column shows the result of mapping exercise between key aspects in each element of ISDT and IS deep structure ontology constructs. The third column has the constructs mapped to one the main eight ISDT elements based on micro building blocks of these elements. The last column contains comments on this mapping exercise showing missing parts in either side of the mapping exercise. This column is the author's judgment and shows if there is need for new constructs.

Table 3. IS Deep Structure Ontology Mapped to ISDT Elements

Element	key aspects in ISDT elements	IS ontology constructs	Comments
Purpose and scope	- Design meta requirements. - Design goals. - Design Scope/Boundaries. - Context/Environment which artefacts is intended to operate.	System – system environment – input (component/state) - external event/transformation – output (component/state)	Nothing is clearly about meta requirements and goals.
Constructs	- Most basic level of ISDT. - Represent physical phenomena. - Represent abstract terms. - Decomposition. - Entities of interest.	Thing – attributes – property - state (stable/unstable) – system composition.	There is a need for construct to designate abstract things
Principles of form and function	- Principles define structure, organization, functioning - Functions - Properties - Features/attributes - "Blue print"/architecture - Relations.	Conceivable state space- lawful state space - Class - kind – coupling – system - subsystem – aggregate – system structure –system decomposition – level structure - internal event - transformation – lawful transformation – transfer function.	Need more consideration to make a decision regarding need for new constructs.

Artefact mutability	- The degree of mutability of designed artefact - Changes in system state and changes that affect the basic form or shape of the artefact.	Equilibrium – History.	Need more consideration to make a decision regarding need for new constructs.
Testable proposition	- Proposition: "if a system or method that follows certain principles is instantiated then it will work or etc" – heuristic propositions. - Generality in terms of context and time.	Event – event space – lawful event space - transformation – lawful transformation - transfer function – well-defined event – poorly defined event.	Need more consideration to make a decision regarding need for new constructs.
Justificatory knowledge	- Theories the link mechanism for a number or all aspects of the designed theory/artefact. - It may come from NS/SS/design theory/practitioner-in-use theory/evidence-based justification such as AR.	Law (natural and human) – state law	Need more consideration to make a decision regarding need for new constructs.
Principles of implementation	- Process of how to build an artefact and bring it to the reality - How to implement it in practice.	NA	
Expository instantiation	- "A realistic implementation contribute to the identification of potential problems in a theorized design and in demonstrating that the design is worth considering" - Instantiated afrtifacts are things in the physical world, while theory is an abstract expression of ideas about the phenomena in real world.	NA	

It could be concluded from Table 3 that ISDT is a high level specification of design knowledge which confirms the definition of a design theory. Gregor and Jones (2007, p. 320) define a design theory as "something in an abstract world of man-made things, which also includes other abstract ideas such as algorithms and models". Though ISDT is complete and clear, there is an issue in terms of its direct applicability to the practice. ISDT is in a general form and which does not allow practitioners to build intended system directly. Practitioners need to transform ISDT into many forms till it becomes ready to implement and read by machine. These forms are depicted in Figure 3 between ISDT and its instantiation. This could be considered one of the gaps in DSR which may result from absence of design ontology. Therefore, it is desire to adapt IS deep structure ontology in order to establish common language that helps design researchers to communicate their design with practitioners specifically.

It proves that there is a reasonable good mapping between ISDT's elements and IS deep structure constructs. There are many constructs mapped into one element which means the elements of ISDT are more general than the IS deep structure constructs which confirms our initial expectation in regard to the three possibilities mentioned above. For instance, principles of form and function element is mapped to many IS constructs. This confirms the master-details (parent-child) relationship between ISDT's elements and IS deep structure ontology constructs expected before conducting the mapping exercise.

Furthermore, the map exercise shows that there is a need for some new ontological constructs for aspects that are particular to Design Research. For example, there is no one constructs in IS deep structure ontology represents abstract things such as imagined thing which is not in the reality, or kernel theory/justificatory knowledge. The solution here might be initiating two versions from each construct; one to represent the reality which is the current IS deep structure ontological constructs and the second is for virtual world which depends on design researchers' creativity.

Interestingly, the last two elements of ISDT have not any constructs mapped to them. These two elements are optional; Principles of Implementation and Expository Instantiation. For latter, it is not surprise because it represents the IS itself which is the result of constructs representation. For the former it is complex to justify. Deep thinking of this situation based on what this element mean, and authors' understanding of DSR as process and product, this element of ISDT could be pull it and stretch across the first six elements of ISDT. The rationale behind this is that all IS deep structure constructs used in the mapping exercise actually represents this element. Gregor and Jones (2007, p. 320) believe that a "design theory instantiated would have a physical existence in the real world".

Therefore, the ISDT could be divided into three layers: 1) contains the first six elements of ISDT, 2) contains the seventh element of ISDT, and 3) contains the last element of ISDT. Figure 5 demonstrates these three layers and how the Principles of Implementation and Expository Instantiation elements are moved from the first layesr into the second and third layers, respectively. Moving towards third layer represents the specification, however, moving opposite way stands for generalization. Design Research could start from any layer and develop the other layers subsequently. In reality, design researchers go through these three layers interchangeably. Recently, Kuechler and Vaishnavi (2012) propose 'A Framework for Theory Development in Design Science Research: multiple perspectives'. Using this framework, we can find that the first and the third layers are located in this framework. The second layer which emerges from IS deep structure ontology constructs may fit between design theory and artefact components in their framework. This layer is consistence with this framework, and Figure 5 may fit and injected nicely to the framework.

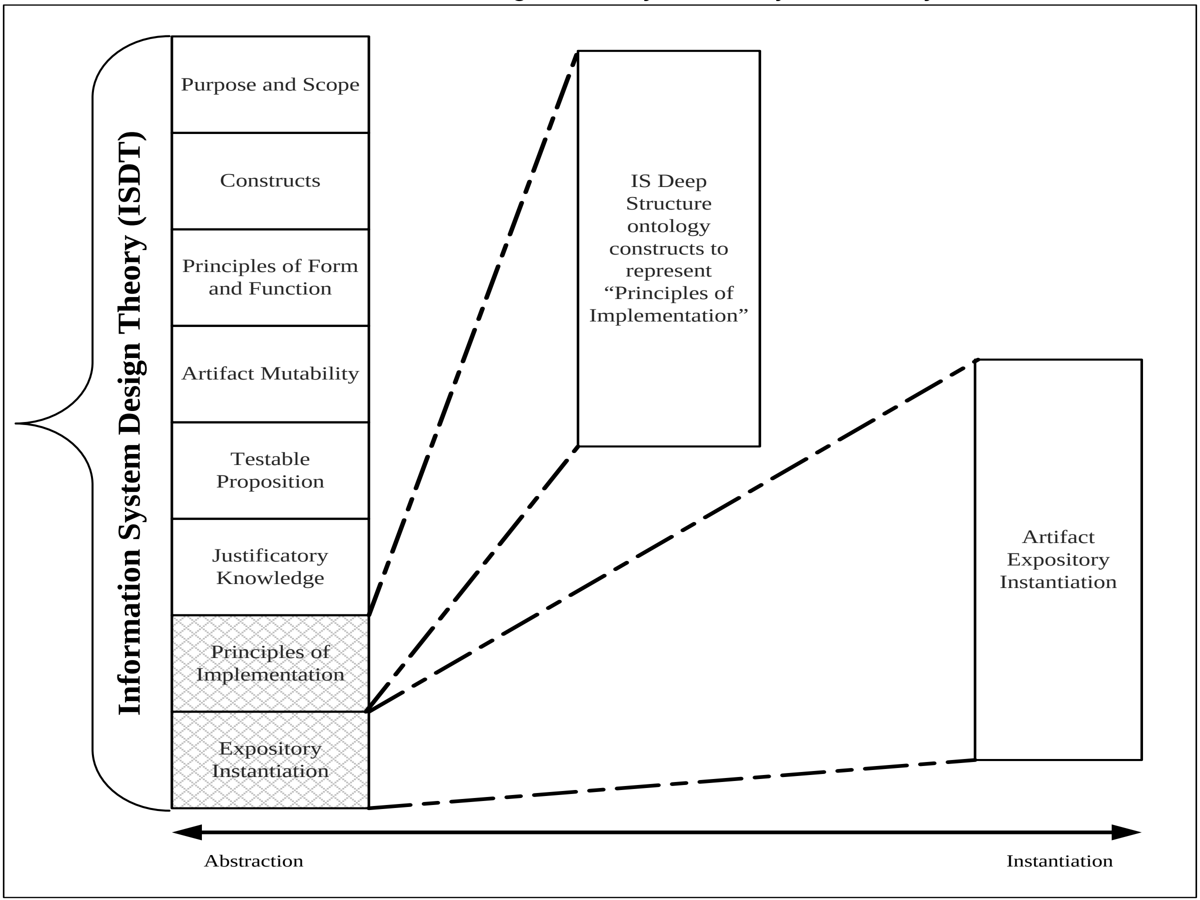

Figure 5: The three layers of Information System Design Theory (ISDT)

5. Conclusion

In this writing we have shown how it is motivated by the observed methodological shortcomings. The aim of the paper is to examine the applicability and suitability of IS deep structure ontology to Design Research. This investigation is about use IS deep structure ontology (Wand & Weber, 1993, 1995; Weber, 1997) in the Roadmap in order to provide design researchers with needed tools to complete in a Design Research easily. This objective is part of the principal objective of this research which is the development of detailed, validated, integrated, and complete methodology for conducting DSR in IS discipline; DSR Roadmap (Alturki et al., 2011).

The definitions of design have been highlighted since it is a key step in the DSR. Although we accept and value these definitions it has been observed that they are at high level and none explains the design phase in depth. The paper proposes using IS deep structure ontology constructs proposed in (Wand & Weber, 1990a, 1990b, 1993, 1995; Weber, 1997) as design specification constructs.

Mainly, the paper shows how IS deep structure ontology is integrated with the Design Research methodology. Furthermore, results and learned lessons from the inclusion of IS deep structure ontology constructs into DSR Roadmap by conducting mapping activity between IS deep structure ontology constructs and ISDT's elements have been discussed. These results can be summarized as follow:

- There is a good mapping between ISDT's elements and IS deep structure constructs. There are many constructs mapped into one element which means the elements of ISDT are more general than the IS deep structure constructs.
- For ISDT instantiation, practitioners need to transform ISDT into many forms till it becomes ready to implement and read by machine. Therefore, it is desire to adapt IS deep structure ontology in order to establish common language that helps design researchers to communicate their design with practitioners specifically.
- For ISDT abstraction, ISDT can be established by generalizing IS deep structure ontology constructs
- The mapping activity shows that there is a need for some new ontological constructs to satisfy the special nature of knowledge in Design Research.
- It shows the ISDT could be divided into three layers: the first contains the first six elements of ISDT, the second contains the seventh element of ISDT, and the third contains the last element of ISDT.

We believe this work contributes to the knowledge by opening the door to integrate seminal and robust IS work, IS deep structure ontology, with relatively new IS Design Research area. It enriches IS DSR work towards building complete IS DSR methodology. This work helps in the theorizing process when we move from instantiation (artifact) into abstraction (ISDT), and in the operationalization and implementation when we move from abstraction (ISDT) into instantiation (arifact).

For future work there might be a need to consider all three models (representation model, state track model, and decomposition model) as proposed by Wand and Weber. Since, the mapping activity is ongoing and partial results reported, highly tentative, there is a need to rigorously confirm these results. Furthermore, the idea in this paper needs to be tested. This could be done by taking an existing ISDT and investigating the possibility of building its specification using the constructs of IS deep structure ontology.

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