An Activity Domain Perspective on Design Science in IS Research

Abstract
Although design science in IS (DSR) has been researched for a long time, concerns about its scientific foundation remain. To this end, the purpose of this contribution is to explore DSR from the alternative perspective of achieving communal meaning among actors about artefacts involved in IS design. Even though this issue is one of the hardest to address in practice, it is by and large unattended in DSR. The inquiry is done with the Activity Domain Theory as a guiding lens; a theory which was developed over many years in my work with coordinating large development projects in the telecom industry. Its central construct is the activity domain; a practice inspired entity in which communal meaning and artefacts are co-constructed in pursuit of fulfilling social needs. From this perspective, central aspects of DSR are investigated, such how to conceptualize ISs, IT-artefacts, and the application environment; the build and evaluation of IT-artefacts; operationalization; ontological and epistemological considerations; and the scientific foundation of DSR. In conclusion, I claim that the suggested approach opens up a new line of inquiry, which may advance DSR beyond its current state of play.

Keywords: Design Science Research, activity domain, activity modalities, communal meaning, communalization, epistemology, ontology**.**

1 INTRODUCTION

On April 11th, 2002, a meeting took place at Ericsson, a major supplier of telecommunication equipments worldwide. The purpose of the meeting was to agree on a common information model for requirement management, to be implemented in an IT system. Participants (LT, A, B, C, D, E, G) came from different areas in Ericsson – radio, telecom platform, application development, IT development. The following is a verbatim excerpt from the discussion (Taxén, 2003, p. 194):

- LT: All the time at UAB [the telecom platform area], it was very useful to separate between these two types of requirements.
- A: Between what?
- LT: Between 'input' requirements and 'detailed' requirements, because they had been working like that for a long time and we couldn't do without them.
- B: But isn't it also that those input requirements are compiled from, I should say, from requirement from different issuers? Because that is also one thing to remember, that you compile several requirements into one requirement if they are similar.
- LT: Yeah, that's the task for the product management.
- B: We need to understand that too, that's the thing that can happen at each product management level to do that kind of work.
- C: OK, yes.
- E: But one thing we need here is flexibility in use of the system, because we have different needs, different history, and different practice in different organizations.
- LT: It would be nice to agree on something. If we can only agree that there is something called requirements then I think we are lost.
- B: But we can agree that we have customer requirements...
- LT: and design requirements...
- D: decomposed requirements and whatever.

- E: For me at the moment... on the level we are discussing right now we don't care about this 'detailed' requirements, decomposed or system requirements. I know what it is, for me.

The discussion continued in the same vein without reaching consensus. The outcome of the meeting was amply summarized by the chairman:

- G: The thing is that we are discussing one thing in a model that has like 200 objects and it takes two hours. This is not the way to do it, it's impossible.

This scenery illustrates an omnipresent and exceedingly challenging problem to solve in system development – that of achieving communal meaning among participants about what to do in a particular situation. The term 'communal meaning' was coined by Bruner: "By virtue of this actualization in culture, meaning achieves a form that is public and communal rather than private and autistic" (Bruner, 1990, p. 33).

Why is this relevant for design science research (DSR) in Information System (IS)? An obvious reason is that we cannot expect an IS to contribute efficiently in the application environment if actors cannot agree on what kind of information is to be managed in the IS. A main reason, however, for attending communal meaning in DSR concerns the scientific foundation for DSR. Many scholars contend that this foundation is unsettled (e.g. Purao, 2002; Lee, 2010; Goldkuhl 2012b, 2013). For example, Purao states that

> Over the years, in spite of important writings about design research… philosophical underpinnings of this form of research have been largely unexplored. Without adequate scientific foundations, research in the technology of information systems … continues to be a lost child still searching for its scientific home. (Purao, 2002, p.1)

The issue of communal meaning has not, to the best of my knowledge, been treated systematically in DSR. Thus, there is an opportunity to explore the scientific foundation of DSR from a hitherto untried viewpoint, which might contribute to enhancing the "ongoing confusion and misunderstandings of DSR's central ideas and goals" (Gregor & Hevner, 2013, p. 338).

Motivated by these reasons, the purpose of this paper is to make an inquiry into DSR with communal meaning as a line of argument throughout. The inquiry will be done from a perspective called the Activity Domain Theory (ADT). This theory was conceived in my work with coordinating complex system development tasks at Ericsson. I noted that artefacts relevant for coordination could be grouped into certain categories or dimensions (Taxén, 2003; 2009). Every situation was *about* something; there was always some kind of work object involved towards which actions were directed. Artefacts like information models signified a distinct *spatial* dimension; much like a map used for orientation in a specific situation. Other artefacts such as business processes, workflows, interaction diagrams, etc., seemed to signify a *temporal* dimension. Documentations of rules, norms, routines, etc., had a *stabilizing* character, showing "this is how we do things around here", while still other artefacts, like contracts, specifications, interfaces between IT systems, etc., had a *transitional* character; they were used in coordinating the work between various work areas like marketing, development, production, after sales, and the like. A final observation was that artefacts associated with these dimensions were all *context* dependent. For example, a product was characterized quite differently in the market and the development areas depending on what actors considered relevant for the particular area.

Once cognized, these dimensions – subsequently called the *activity modalities* – were noticed in a variety of different situations. An insight eventually grew that their genesis might be neurobiological, expressing fundamental human capacities for coordinating actions:

- *Objectivation* – attending to an object.

- *Spatialization* – orienting oneself spatially in a specific situation.
- *Temporalization* – anticipating actions and their consequences.
- *Stabilization* – learning to act relevantly in various situations.
- *Transition* – refocusing attention to another object.
- *Contextualization* – foregrounding relevant things and ignoring irrelevant ones.

The activity modality construct is posited to conceptualize necessary capacities for coordinating individual actions, such as moving arms and legs in a harmonious way to achieve a certain goal. The term "activity modality" is deliberately chosen to connote with "sensory modality", indicating that sensations arriving through our sensory organs need to be integrated into an actionable totality, structured along the dimensions given by the activity modalities (Taxén 2015).

When several persons coordinate their actions in order to achieve a common goal, the same individual capacities for coordination are of course utilized; individuals do not change biologically only because they are acting together. However, in order to succeed in acting collectively, individual lines of action must be fitted together into what Blumer and Clark call "joint action" (Blumer, 1969; Clark, 2005). This means that communal meaning, constructs, models, method, artefacts, language or any other element used in joint action, need to be made into *communal assets*. I will call this process "communalization" in the sense "the act or process of making communal"[1]

Communalization is manifested both in the environment and in each individual mind. The community thus constructed is conceptualized as the *activity domain* in ADT. Stated differently, activity becomes communalized in terms of that which is relevant for the activity (contextualization), what the activity is *about* (objectivation), the *spatial* structure of the activity (spatialization), the *temporal* ordering of actions (temporalization), how to perform *proper actions* (stabilization), and how the activity is *related to other activities* (transition). Thus, the activity domain construct enables a way to reconcile individual and social actions:

> Action is social insofar as, by virtue of the subjective meaning attached to it by the acting individual (or individuals), it takes account of the behavior of others, and is thereby oriented in its course (Schütz, 1967, p. 144)

The paper proceeds with a description of the "context of discovery" in which ADT was conceived and articulated. An account of the research design leading to the theory is given, after which ADT is explained by two concrete examples; a guitar quartet giving a concert, and the ancient activity of mammoth hunting. Next, ADT is used as a guiding lens for interpreting the very same context where it was conceived, i.e. the Ericsson practice. Thus, this practice is seen as a "context of justification" of ADT, even though the contexts of discovery and justification were intertwined in practice.

The core of the paper, the knowledge contribution to DSR, is discussed in relation to the Hevner et al (2004) paper, focusing on some crucial aspects of DSR: the conceptualization of ISs, IT-artefacts, and application environment; the build and evaluation of IT-artefacts; operationalization; ontological and epistemological considerations; and the scientific foundation of DSR. In doing so, contributions from the literature are included when relevant. The final section discusses the findings, state limitations, and suggests topics for future research. In conclusion, I contend that the ADT approach has potential to open up interesting and productive new lines of research in DSR since it relates to the *sine qua non* for our existence – our biological nature. If this connection is lost, DSR theorizing, however ingeniously conceptualized, may nevertheless be void of practical relevance.

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[1] Webster's Third New International Dictionary

2 CONTEXT OF DISCOVERY

In the late 1990s Ericsson was developing the 3rd generation of mobile systems. The challenges posed by this endeavour were unprecedented in terms of technology, size, development methods, and IT-support:

> The total technical changes being implemented in this project are enormous. Using traditional methods then the scope of change implemented in single steps will be too large and cannot be managed (Overall project manager, Dec 1999) (Taxén, 2003, p. 144)

As its peak, around 140 projects and subprojects worked on different parts of the system. One particular part was the so called Main Switching Centre node, which involved about 1000 persons, distributed on 22 subprojects and 18 design units worldwide. These units were coordinated from two places called the S-domain (in Stockholm, Sweden), and the A-domain (in Aachen, Germany) (see Figure 1):

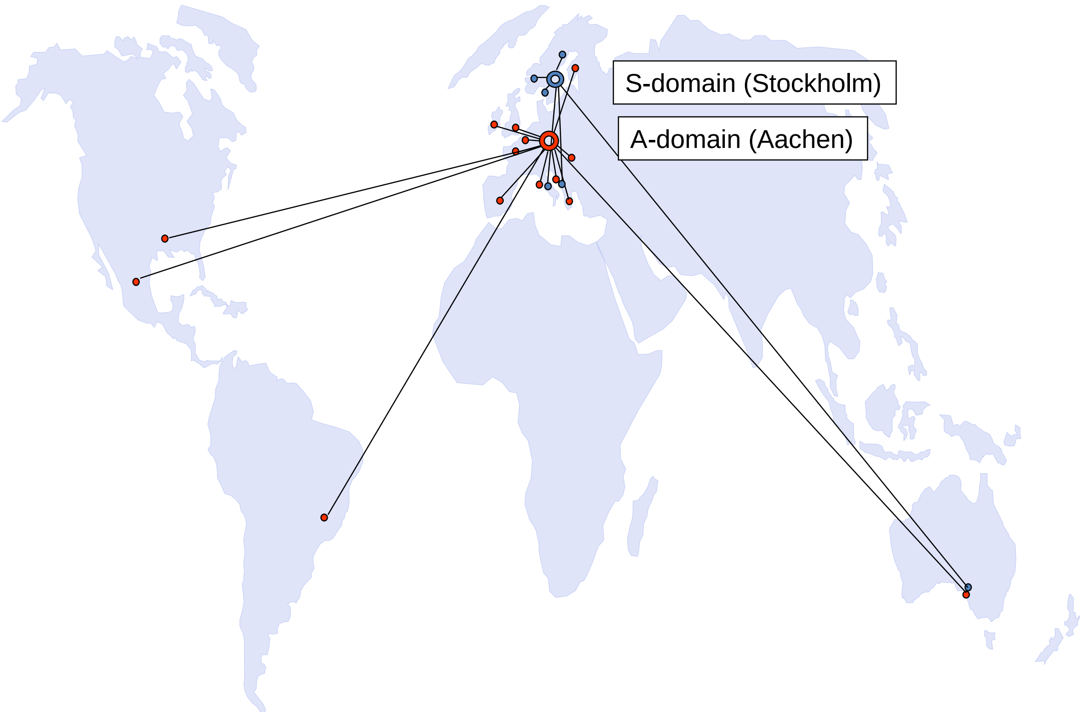


Figure 1: Distribution of the development of the 3rd generation of mobile systems

In order to convey a sense for the complexity of this project, a so called integration plan for the MSC node is shown in Figure 2:

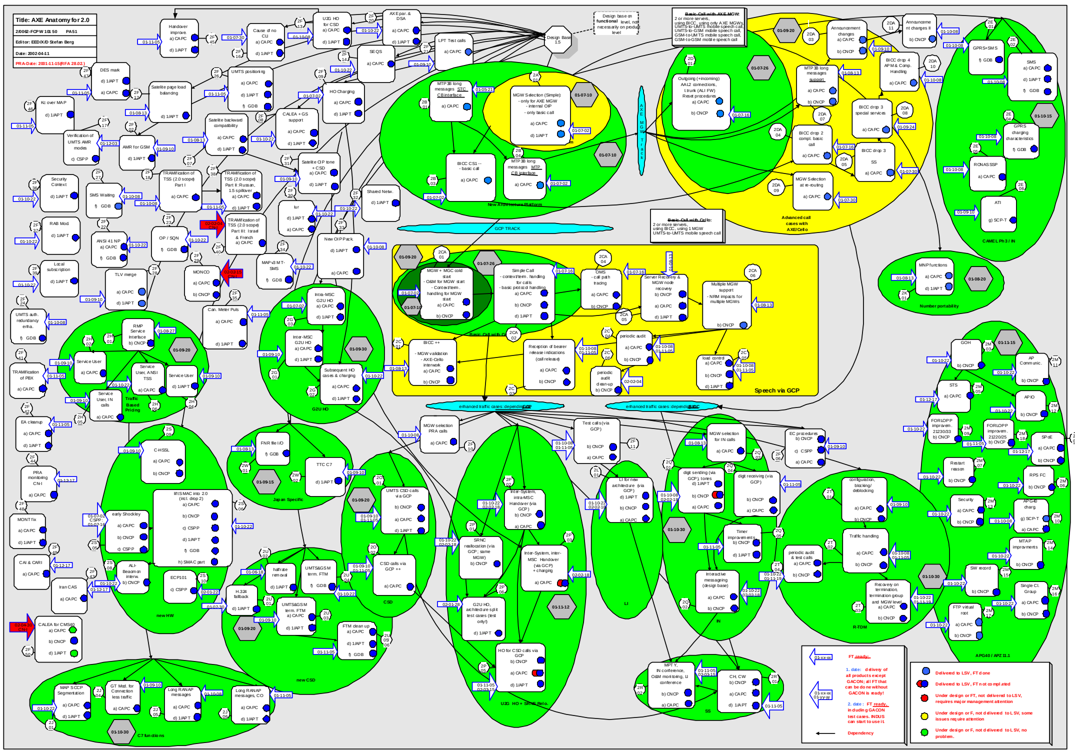


Figure 2: Integration plan for the MSC node

Each white square signifies a work package in which a sub-project delivers a tested functionality to integration and verification of the whole system. The lines indicate dependencies; from basic functionalities at the top and progressing step by step to the full functionality at the bottom of the figure. Ellipses signify major functional groups such as locating the mobile, handover between mobile cells, storing mobile owner data, etc. The small dots in each work package show, in a traffic-light manner, the status of the package, such as “under design for function test”, “requires major revision”, “delivered to system test”, and the like.

The Matrix IT system

It was soon realized that keeping track of all work packages being delivered to system integration required extensive IT-support. With the introduction of modern, object-relational databases in the mid-1990s, quite new information management capabilities became available. In one sub-project, coordinated from the S-domain, a decision was taken in 1997 to try this new technology out. A particular IT system called Matrix was acquired for this purpose.[2] Matrix was a multi-tier, web-technology based, generic purpose information management system, on top of which organizational specific IT applications could be developed. In the following, I will refer to systems like Matrix as “IT design-bases”, since they are prerequisites for IT applications. As will be clarified later in the paper, IT design-bases cannot be evolved into ISs. Only IT applications can be an element in the formation of ISs.

In summary, the environment in which ADT was conceived can be characterized as highly complex, globally distributed, and constantly changing. Thus, it is a paradigmatic example of the kind of environment DSR need to face in order to be relevant for practitioners in large service- or product development companies.

[2] Now, an integral part of the Dassault Enovia PLM (Product Lifecycle Management) suite (see https://en.wikipedia.org/wiki/Dassault_Syst%C3%A8mes)

3 RESEARCH DESIGN

The research involved in developing ADT can be structured into three overlapping periods: *inception* stretching from the early 1970s to 1998, *conceptualization* between 1998 and 2003, and *application* from 2003 to present.

During these years I moved regularly between the perspectives of practitioner and researcher, with the same Ericsson practice as the target; however differently contextualized depending on which perspective was foregrounded. As pointed out by Iivari, the "construction of innovative IT artifacts … is not a monopoly of the research community, but practitioners may also do it … If a practitioner applies the same rigor as an IS researcher, he/she is essentially a researcher" (Iivari, 2007, pp. 50-51).

As practitioner, my interest was to develop useful models, methods and tools supporting projects. Thus, the relevance aspect of DSR was in focus. As a researcher, my focus was on developing knowledge about the same practice; to understand it better: which were the main problems we had, what could be done to solve them, how could the practice be conceptualized, how can achieved knowledge be validated, and so on. Thus, the rigour aspect of DSR was dominant in this perspective.

Inception 1970 – 1998

During this period, the practitioner perspective was prevailing, in which I acquired a deep and detailed knowledge about the often chaotic practice of developing complex systems. I had no research intentions. However, I wished to understand and improve this practice against a background of dialectical thinking, which I had been interested in for long. Gradually, the first nascent signs of ADT began to materialize as, for example, in a conference contribution (Taxén, 1995) and an Ericsson internal report titled "A Conceptual Framework for Development of Complex Systems" (Taxén, 1997).

Conceptualization 1998- 2003

This period is characterized by a frequent change of focus between the practitioner and academic perspectives. I worked on my PhD thesis simultaneously as contributing to the implementation of the Matrix IT system in the organization. However, the emphasis was on research. The main research question in my PhD was (Taxén, 2003):

> When developing complex systems subject to changing presumptions, the coordination of the development tasks is a crucial activity. A Framework has been developed and deployed in the development organization at Ericsson with the intention of supporting the coordination. The purpose of this study is to develop knowledge of the impacts of the Framework on the coordination task. The main research question is: What are the impacts on coordination from the Framework?

The "Framework" was in fact a first attempt to operationalize ADT as it was developed at that time (see Figure 3):

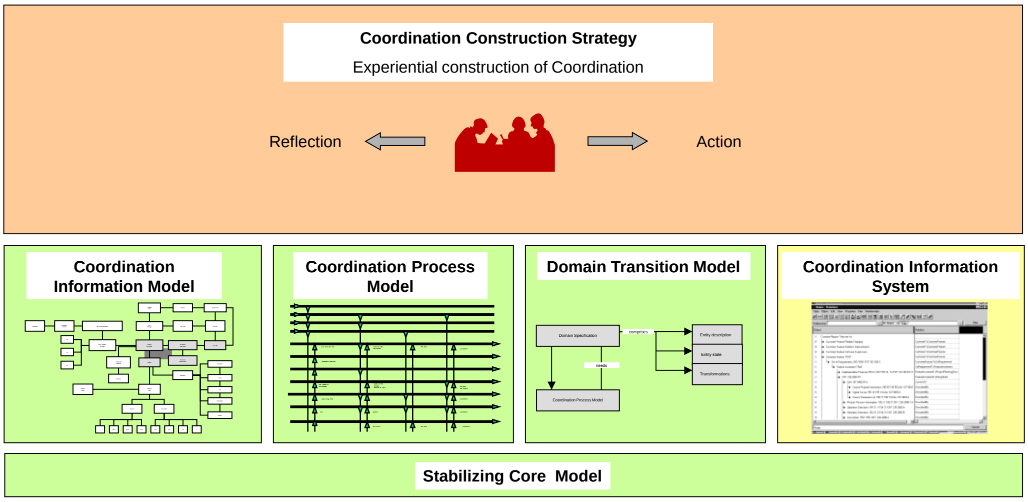


Figure 3: The Framework in my thesis (Taxén, 2003, p. 11). The various models are seen as expressions of the activity modalities.

The research was carried out as a qualitative, longitudinal single-case study based on four detailed research questions with anticipated reconstructive, explanatory, and transformational knowledge contributions. 18 interviews, each lasting around an hour and half, were recorded, transcribed and analysed with the grounding theory method (Strauss & Corbin, 1998). Interviewees were project managers, customers, methods & tools coordinators, configuration managers, and a Matrix vendor consultant. The conclusion of my thesis was that the emerging ADT and its operationalization as illustrated in Figure 3 provided a profound knowledge contribution towards understanding the Ericsson practice (Taxén, 2003).

Application 2003 –

During this period, which is by and large focused on the academic perspective, ADT has been elaborated and applied as a guiding lens in variety of areas such as Product Lifecycle Management (Taxén & Svensson, 2005), software development (Taxén, 2006; Taxén & Petterson, 2010), project management (Taxén & Lilliesköld, 2008; Taxén & Lilliesköld, 2011), alignment of business and knowledge strategies (Taxén, 2009b), organizational science (Taxén, 2011), knowledge integration (Taxén, 2012), conceptualization of Information Systems (Taxén, 2015b), socio-technical systems (Taxén, 2015c), and neuroscience (Taxén, 2015).

To summarize, ADT has evolved over a long period. Baskerville & Myers have recently coined the term "design ethnography" in which the researcher "goes beyond observation and actively engages with people in the field" (Baskerville & Myers, 2015, p. 23). As I understand, this describes well my work during these years, with the addition that the same person acted both as a practitioner and researcher.

4 THE ACTIVITY DOMAIN THEORY

In order to illustrate the ADT, I will make use of two examples: a guitar quartet giving a concert, and a mammoth hunt. The motivation behind including these examples is twofold. First "we must understand the simple. Then, and only then, is it possible to continue and grasp the complex!" (Goldkuhl, 2002, p. 1). The guitar concert example is, hopefully, simple enough for explaining the fundamental characteristics of ADT. Second, the mammoth hunt example illustrates that the activity modalities were highly relevant also in that activity, which presumably took place some 30 000 years ago, Thus, regardless of whether we play a guitar, hunt mammoths or participate in developing ISs in contemporary, organizational settings, the same modalities are employed.

The guitar concert

In Figure 4, a guitar concert is illustrated. What is required for the activity to be carried out?

Figure 4: A guitar concert

A first prerequisite is that the players have well-built guitars to play on. This presumes that certain elements are worked out between the activities of building and playing, such as the placement of the bars on the neck, the number of strings, the string tensions, and so on. Typically, this is a lengthy process that stabilizes only after much experimentation and interaction between players and guitar builders. Ultimately, however, this process depends on the neurobiological ability of actors to refocus attention from one activity to another; in this case from the guitar playing to guitar building (the *transition* modality).

Next, each player must be proficient in playing his voice in the music. This is accomplished only after long and arduous practicing, which involves the player, the instrument and most likely a musical score like the one in Figure 5:

Figure 5: A score for a bass guitar

In order to play this piece of music, the left and right hand movements must be coordinated. To begin with, the temporal dimension must be grasped, as shown by the sequence of notes from left to right. Also, a sense for the duration of each note, as signified by the stems and dots, must be obtained (the *temporalization* modality). Further, the spatial positions of notes in relation to the staff (above, below, distance between notes, etc.) need to be associated with a corresponding position on the guitar neck where the proper string shall be pressed (the *spatialization* modality). Also, various signs must be acknowledged, such as the *mf* indicating mezzo forte, the 𝄢 signifying the F-clef, and the # showing that the key is e-minor. These signs indicate habituated norms of playing, thus lending a certain stability to the activity (the *stabilization* modality). Eventually, musician and his instrument may form a dialectical unity so tightly intertwined that playing becomes virtually effortless:

> There no longer exist relations between us. Some time ago I lost my sense of the border between us…. I experience no difficulty in playing sounds…. The cello is my tool no more (the cellist Mstislav Rostropovich, quoted in Zinchenko, 1996, p. 295).[3]

When in performance, each player must be able to focus on the object of the activity – the concert (the *objectivation* modality). This necessitates that players can distinguish relevant things from irrelevant ones (the *contextualization* modality). The concert hall, the other players, the audience, scores, instruments, and more, are undoubtedly relevant for the concert, while, for example, the books in the bookshelf behind the quartet can be safely ignored.

When each player is fluent in coordinating his own actions, the separate voices in the quartet needs to be coordinated by fitting together individual ways of playing; a process called "joint action" by Blumer (1969) and Clark (2005). Joint action requires some kind of socially recognized common identity, for example, a score as in Figure 6:

Figure 6: The score as a common identifier

As can be seen, the score has the same basic layout as individual voices; except that these are now aligned both diachronically (vertically as spatial distances between notes) and synchronically (horizontally in time). Thus, the same modalities are actuated both in individual and joint playing. Moreover, individual voices are meaningful only in the activity as a whole. If each voice is played in solitude, the music becomes void of meaning.

The process of achieving joint action in playing implies a communalization of the concert activity. The score becomes a communal asset along with the construction of communal meaning among players. It is striking that the specific layout of the score is more than 1000 years old, first devised by the Italian monk Guido d'Arezzo. This is a strong indication that the form of the score is somehow attuned to our biological constitution; otherwise it would not have persisted for so long. Obviously, elements like the score are imperative for coordinating socially organized activity. In the sequel, I will call such elements "common identifiers".

Importantly, the label "common" is applicable to external elements only, not the in-

[3] However, this exquisite example of coordination between a fluent player and his instrument does not in any way mean that they somehow lose their identities. Rostropovich and his cello remain different ontological entities, no matter how tightly integrated they might be.

ternals of brains, which are always unique.[4] The communality of the score in Figure 6 lies in its function of coordinating individual actions. Thus, the construction of communality may proceed without leaving any traces whatsoever on the score. Often, though, players place their own, individual markings on their scores in order to alleviate the communalization process.

The mammoth hunt

If we consider quite a different kind of activity, that of a mammoth hunt in ancient times, we can see that the modalities are at play also here (Figure 7).

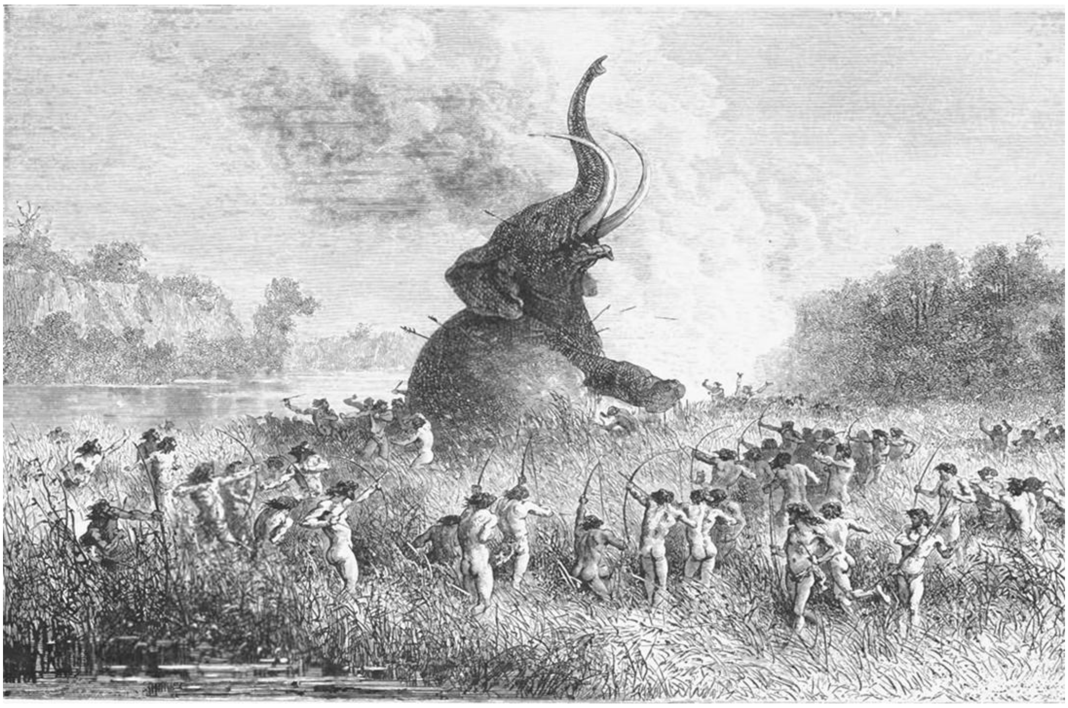


Figure 7: Illustration of a mammoth hunt. Source: Original wood engraving by E Bayard; in (Bryant & Gay, 1983).

Clearly, the mammoth is the object in focus of the activity; the common identifier. Around this, each participant must contextualize the situation; what is relevant and what isn't. For example, hunters, bows, arrows, actions, shouts, gestures, and other hunters are certainly relevant, while the beetles and other insects in the trees in the background can safely be ignored.

The hunters need to orient themselves spatially in the context, recognizing how relevant things are positioned in relation to themselves. They must also understand how actions should be carried out in a certain order, which requires a temporalization capability. Moreover, arrows cannot be shot ad hoc. Shooting in a wrong direction may result in other hunters being hit rather than the mammoth. Hunters must learn how to perform appropriate mammoth hunting; something that will be accrued after participating in many successful, and, presumably, some less successful, mammoth hunts. Eventually, this habituation lends a sense of stability to the activity, which need not be questioned as long as it works.

The hunting activity is typically related to other activities such as cutting the pray

[4] In the literature, expressions like shared understanding, common meaning, social brain, distributed mind, and the like, are commonplace. However, we need to be precise about the terms we use (Goldkuhl, 2002). Concepts indicating that parts of individual minds can be somehow shared and distributed ultimately run into unsolvable epistemological problems.

into pieces and prepared it for eating. This cooking activity has its own motive – to satisfy hunger- and object, which happens to be the same as for the hunting activity, the mammoth. However, here other aspects of the mammoth are contextualized as relevant, such as which parts of the mammoth are edible. This requires a capability to refocus attention from one activity to another, and understand how they are related.

4.1 Main features

The two examples indicate that the activity modalities provide a foundation for understanding the deep structure of activity, regardless of which particular surface form activities takes in a particular time and space. This strengthens the claim that the genesis of the modalities is to be found in the neurobiological constitution of humankind. To illustrate this claim, imagine that a guitar player or a mammoth hunter get a lesion in the hippocampal / entorhinal areas of their brains. Since these areas are vital for spatial orientation (O'Keefe & Nadel, 1978; Witter & Moser, 2006), they will be unable to participate in the activity.

Activity structured by the activity modalities is called *activity domains* in ADT. The central idea of this construct is that communal meaning evolves together with the usage of relevant artefacts, regardless of whatever brand these may be. Thus, the external, physical and tangible manifestations of the activity modalities are only half of the story. Equally important is the intangible, internal manifestations of communalization in the minds of each actor, intrinsically bound to the individual's idiosyncratic interpretations of these artefacts. Thus, the activity modalities provide a link between the internal, individual, neurobiological realm of each actor, and the social realm in which the actor is coordinating her actions with others in pursuit of common goals.

A distinguishing feature of the activity domain is its fractal nature. Activity domains may employ other domains, as in the guitar play-build example. By focusing on the transition modality, the interaction between domains can be elaborated. Thus, any activity can be structured as interrelated activity domains, regardless of the specific nature of the domain; much like the DNA provides a common structure for all living organisms. Finally, it should be emphasized that the modalities are necessary, but certainly not sufficient for pursuing an activity. Other human aspects not considered here, like communication, trust, emotions, individual intentions, power structures, and more are certainly important to consider as well.

4.2 Theoretical influences

The foremost theoretical inspiration of ADT is the notion of praxis as the nexus of human activity (Bernstein, 1999; Seo & Creed, 2002). Praxis has been articulated by the notion of "activity" in the Russian Theory of Activity (e.g. Leont'ev, 1978), which has heavily influenced ADT.

However, Activity Theory has some fundamental problems (Toomela, 2000; 2008): it assumes a unidirectional view of social – individual relationships rather than a dialectical one; it downplays the fundamental role of the individual in forming activity, and it has a fragmented understanding of mind, including the neurobiological prerequisites for enabling action. As summarized by Stetsenko:

> In the search for principles that connect mind and activity, the idea that the human mind does not have its own structure and its own logic of development, distinct from the structure of object-related activity, has been lost. (Stetsenko, 1999, p. 246)

Thus, the relative negligence of the individual in Activity Theory means that it cannot elucidate the construction of communal meaning, which is of main concern for ADT.

Besides Activity Theory, ADT has been influence by the pragmatist philosophy (e.g. Thayer, 1982; Goldkuhl, 2012; 2012b), critical realism (e.g. Mingers et al, 2013; Leonardi, 2013) and integrationism (e.g. Harris, 1981; Hutton & Pablé, 2011).

5 CONTEXT OF JUSTIFICATION

This section exemplifies how ADT may be used as a guiding lens for inquiries. The example is from the very same context where ADT was conceptualized, i.e., the Ericsson practice. The focus is on construction of the S- and A- domains (see Figure 1), i.e. how these were communalized.

In the mid-1997, the construction of the S-domain in Stockholm began. An ex-post analysis indicated that this process could be roughly divided into three phases: *exploration*, *trust boosting* and *expansion* (Taxén, 2003; Figure 8).

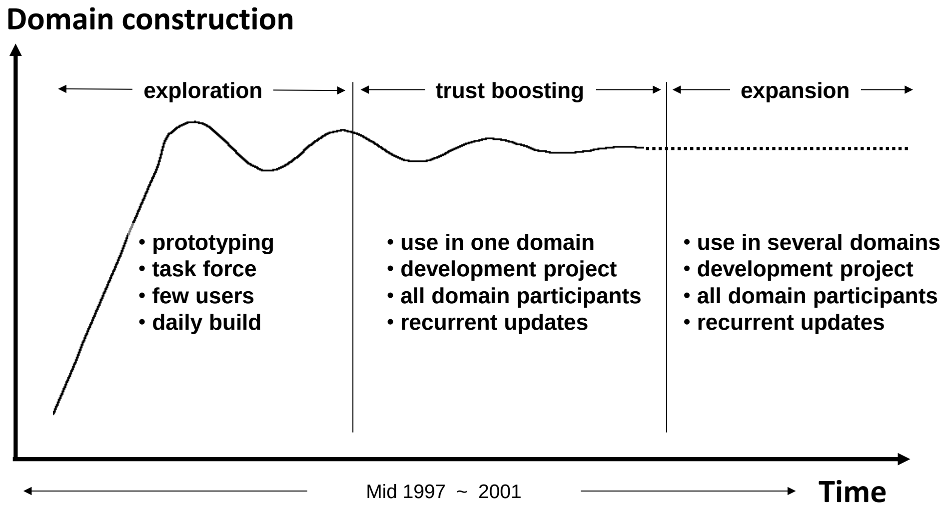


Figure 8: The domain construction process

Exploration

In this phase, which took about a year and a half, a “proto-domain” was constructed in a “work-bench” installation of the Matrix IT system, i.e. outside the real projects. The first task was to develop IT support for managing requirements. The work was carried out by a small “task force” consisting of user representatives (a requirement manager, a configuration manager[5], and the project manager), an expert from the vendor of Matrix, and a domain architect (this author). The domain architect acted as a liaison person between the project and the Matrix expert.

A first version of an information model for requirement management was worked out and implemented in Matrix, which meant that the general purpose IT system acquired from the vendor was gradually turned into an Ericsson specific IT application. Individual requirements were loaded into this application from requirement specification documents. Reports and on-line information were evaluated by users. If the result was not satisfactory, the information model was changed and implemented anew. In a series of meetings, the model and its implementation were gradually elaborated in a more or less “daily build” manner. An example of the requirement management information model, some way into this process, is shown in Figure 9. As can be seen, quite many detailed decisions had to be worked out on the way.

[5] This person is responsible for the process of handling changes systematically in order to maintain the integrity of the system over time.

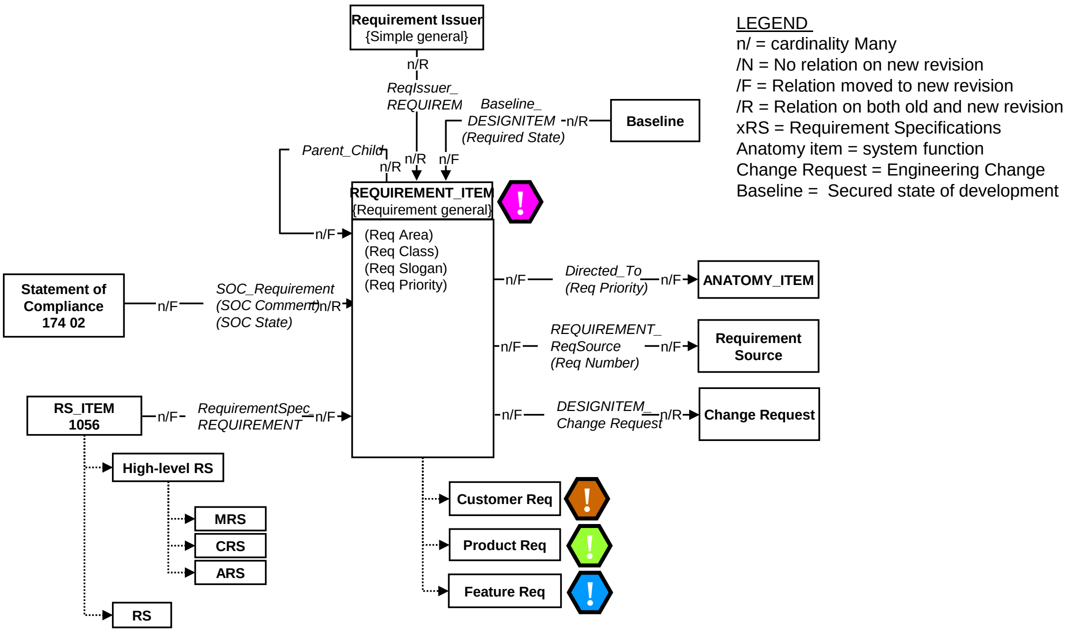


Figure 9: An information model for requirement management

Trust boosting

The start of this phase was a decision in Oct 1998 to use Matrix in a real project. The traditional way of working was closed down, and project data were loaded into the IT application. A major issue in this phase, which took about 9 months, was to get globally dispersed actors (see Figure 1) to accept the new way of working; something which was heavily dependent of the performance of Matrix world-wide[6]. A dedicated development team was now driving the domain construction. Immediate, personalized support was provided to users. Also, several other management areas, such as test management, change control, and progress control, were included in the application (see Figure 10).

[6] Actually, performance problems nearly terminated the entire Matrix venture in late 1999, when it turned out that the tool was more or less unusable at a development unit in Australia. This was amended only with the introduction of a new, servlet web-based technology in the system.

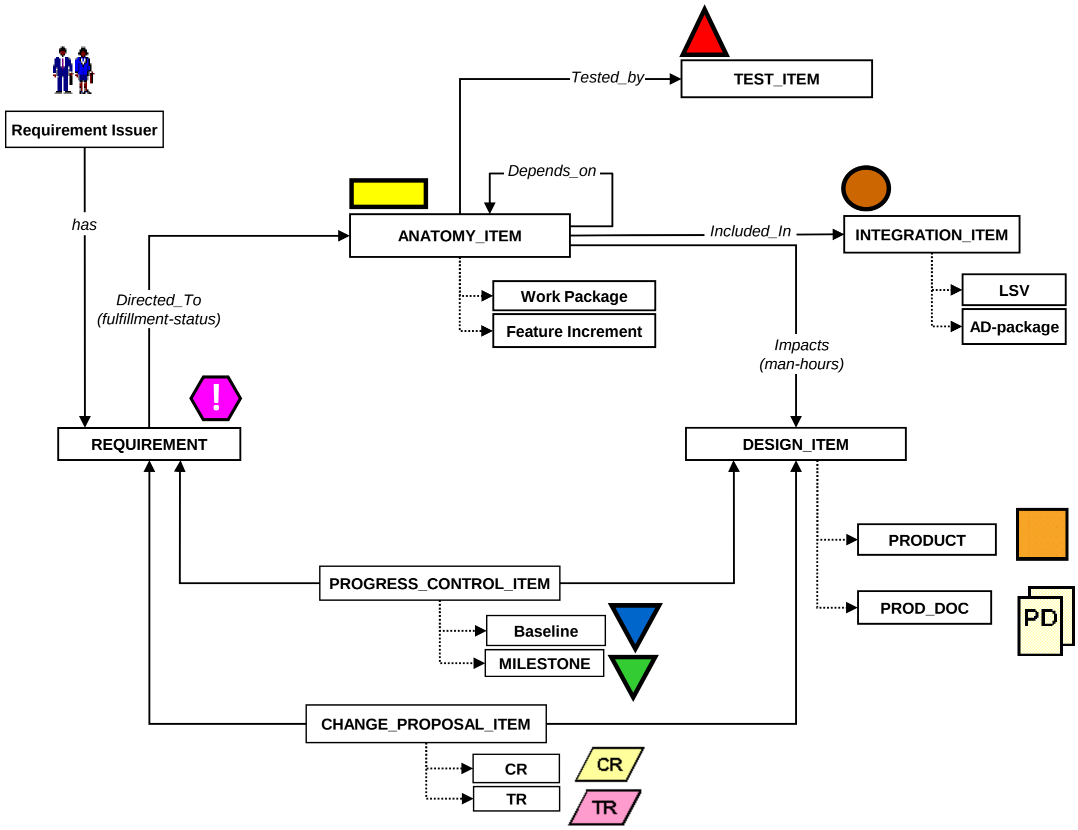
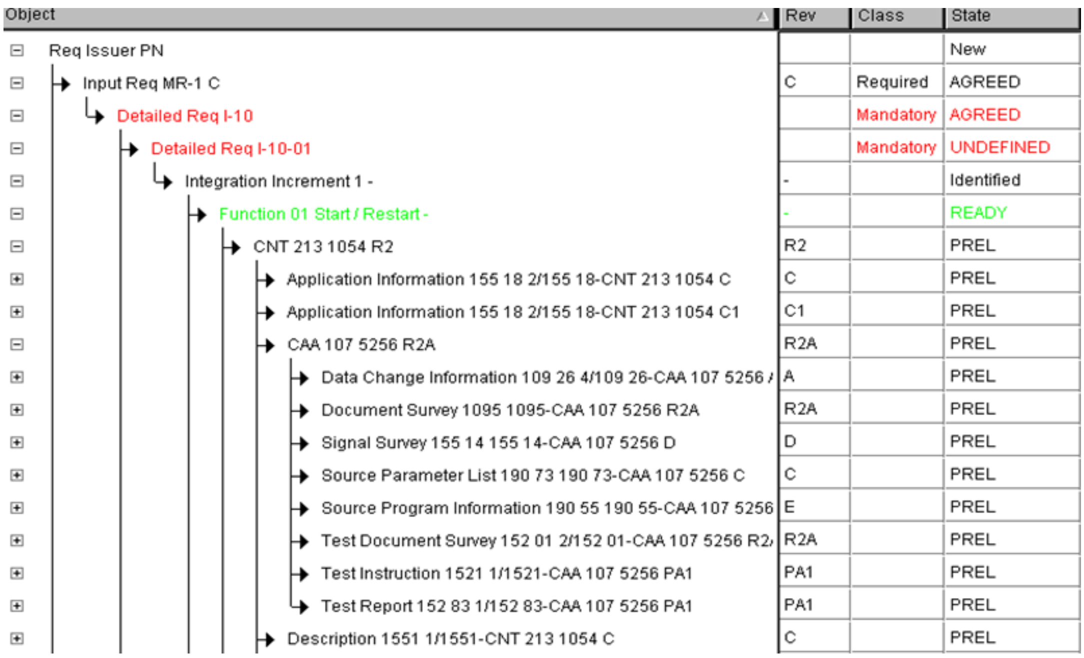


Figure 10: The information model for the S-domain (high level view)

The implementation of the model in Figure 10 in the IT application is illustrated in Figure 11. This snapshot shows how individual requirements can be traced all the way from the organization issuing the requirement ("PN") down to system modules contributing to the realization of the requirement ("CNT", "CAA") and the software code ("Source Program Information"):



Object	Rev	Class	State
Req Issuer PN			New
Input Req MR-1 C	C	Required	AGREED
Detailed Req I-10		Mandatory	AGREED
Detailed Req I-10-01		Mandatory	UNDEFINED
Integration Increment 1 -	-		Identified
Function 01 Start / Restart -	-		READY
CNT 213 1054 R2	R2		PREL
Application Information 155 18 2/155 18-CNT 213 1054 C	C		PREL
Application Information 155 18 2/155 18-CNT 213 1054 C1	C1		PREL
CAA 107 5256 R2A	R2A		PREL
Data Change Information 109 26 4/109 26-CAA 107 5256 /	A		PREL
Document Survey 1095 1095-CAA 107 5256 R2A	R2A		PREL
Signal Survey 155 14 155 14-CAA 107 5256 D	D		PREL
Source Parameter List 190 73 190 73-CAA 107 5256 C	C		PREL
Source Program Information 190 55 190 55-CAA 107 5256	E		PREL
Test Document Survey 152 01 2/152 01-CAA 107 5256 R2/	R2A		PREL
Test Instruction 1521 1/1521-CAA 107 5256 PA1	PA1		PREL
Test Report 152 83 1/152 83-CAA 107 5256 PA1	PA1		PREL
Description 1551 1/1551-CNT 213 1054 C	C		PREL

Figure 11: Project data loaded in Matrix

Expansion

In this phase, which started around year 2000, several projects were included in the S-domain. In addition, a new domain, the A-domain in Aachen, was established. Although the A-domain also used Matrix, the databases were physically separated. The information model for the A-domain is shown in Figure 12:

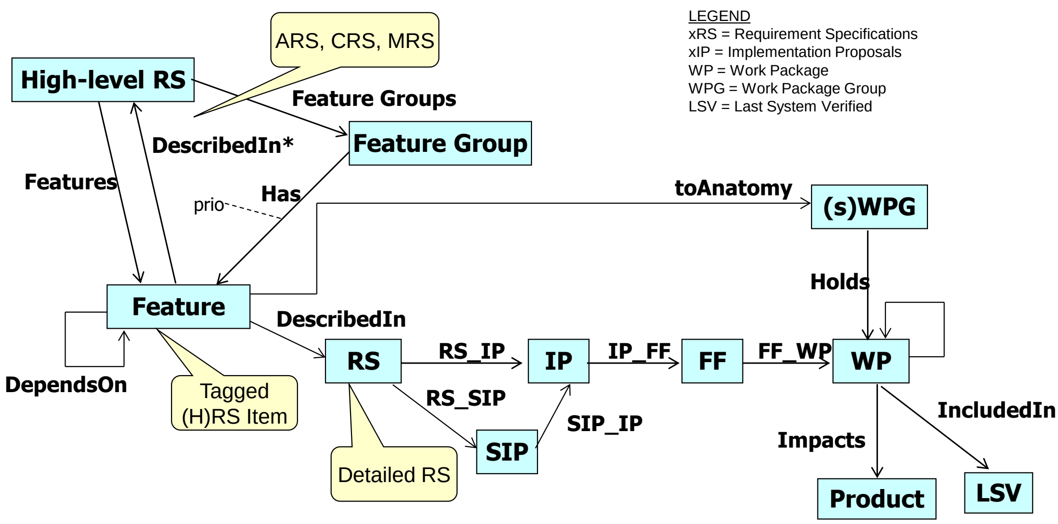


Figure 12: The information model for the A-domain (high level view)

As can be seen, the S-domain and A-domain were constructed quite differently in spite of working in the same 3G project. Some entities, though, had to be synchronized in the transition between these local domains and the global coordinating domain illustrated in the integration plan in Figure 2. Examples of such entities are the work package ("Work Package" in Figure 10 and "WP" in Figure 12)[7], the latest tested system verified ("LSV" in both figures) and the delivered product ("Product" in both figures).

Analysis

Communalization

From an ADT perspective, the domain construction process illustrated in Figure 8 is seen as a process in which communal meaning, the IT artefact (the IT application build on top of Matrix), and IT related artefacts (the information models in Figure 9, Figure 10, and Figure 12) are simultaneously and dialectically co-constructed. In this process, the tangible elements, the IT application and the models, are seen as common identifiers, enabling the fitting together of individual lines of action.

A main issue in the communalization process is that manifestations of communal meaning cannot be observed, since these are confined to the brains of each individual. It is not possible to see on a particular artefact what kind of construction process it has been involved in. Thus, if communal meaning is excluded from the analysis, the full complexity of the domain construction is overlooked. Similarly, as the discussion in the Introduction of the paper shows, it is not possible to construct communal meaning without the IT application and the information models. One reason is that "as the level of detail increases, disagreements begin to surface" (Bititci & Muir, 1997, p. 366). Just talking will not solve this issue.

[7] Amazingly, not even the names of these entities were agreed upon.

Activity modalities

The information models in Figure 9, Figure 10, and Figure 12 are seen as manifestations of the spatialization modality since they signify relevant entities, their characteristics, and relations to each other. Moreover, they also signify the external, tangible contexts of the domains, resulting from contextualization communalization of the domains. It is striking that the S and A-domains were constructed so differently in spite of belonging to the same total 3G project. This is an indication of the difficulties of communalization over too large a scope.

The IT artefact

Communalization is an integrated process in which participants, IT applications, and models are ceaselessly modified. A coarse estimation is that several hundreds of iterations were needed only in the exploration phase of the S-domain before a sufficient communalization had been reached. The IT applications and the IT design-base they are dependent on, must be designed to enables this. The experiences from the 3G projects indicated that some essential characteristics are as follows (Taxén, 2007):

- Fast build and evaluation cycles. The design of the Matrix design-base enabled quick and easy modifications of the IT application, even when the system was up and running. In most other systems at that time, a change such as adding an attribute on an entity, or changing the cardinality on a relationship, required closing down the database and recompiling the software. Such a manoeuvre usually takes a long time (a matter of hours rather than minutes), which in practice meant that the construction of domains according to the process in Figure 8 would be severely aggravated.
- Efficient global access to information through lean clients and servlet based web-techniques.
- Providing user defined reports. This might sound like a minor issue, but in fact, the ability to provide dedicated reports was a major enabling feature.
- On-line "discussion groups" for commenting on Change Request (a formalized way of making changes).
- Compliance between icons in the IT application and the information models.

In addition, Matrix enabled all entities in Figure 9 to be managed in the same application. No interfaces between management areas were needed, which was paramount for implementing changes. Traditionally, the various management areas in Figure 9 were implemented in different tools; requirement management in one tool, product management in another, managing engineering change orders in a third, and so on. This required designing and maintaining interfaces between these tools; something which is extremely difficult to do when things change.

Although a strict evaluation according to rigorous standards was not carried out during the research process, it was clear that the results of constructing domains in the way described above were profound. The level of traceability indicated in Figure 11 had never before been achieved at Ericsson. Moreover, this result was reached with fewer resources and in shorter time as compared with similar information management projects, based on other IT systems and following a more traditional waterfall development process. Some project managers claimed that the development of the Mobile Switching Centre would not have been possible without this support:

> Especially for the execution part I think we would not have been able to run this project without the tool. I think if you simply look at the number of work packages, the number of products that we have delivered, the number of deliveries that we have had, if we

would have had to maintain that manually, that would have been a sheer disaster (Project manager; Taxén, 2003, p. 232).

6 KNOWLEDGE CONTRIBUTION TO DSR

This section discusses how ADT and the experiences from the Ericsson practice may contribute to DSR knowledge. In doing so, I will concentrate on crucial aspects of DSR according to the framework suggested by Hevner et al. (2004; see Figure 13). The motivation for choosing this particular DSR conceptualization is it "has had a tremendous impact on IS research" (Goes, 2014, p. iii) since it was published in 2004.

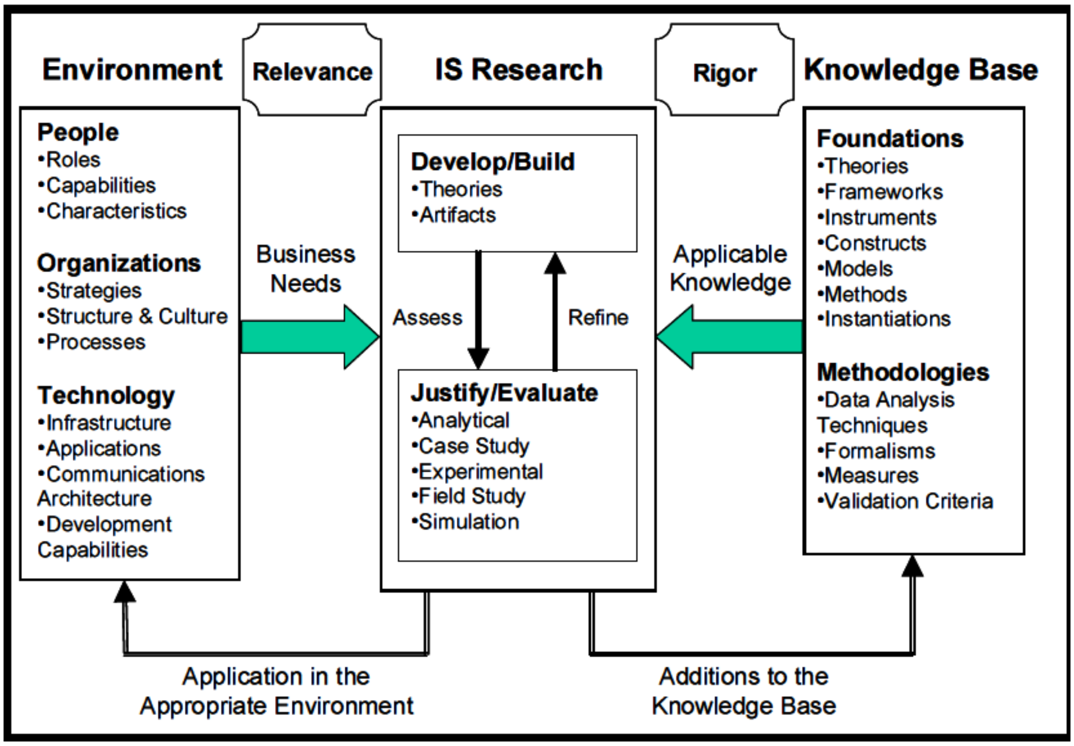


Figure 13: DSR framework (adapted after Hevner et al., 2004, p. 80)

The Knowledge Base provides "the raw material from and through which IS research is accomplished" (Hevner et al., 2004, p.80). Gregor & Hevner (2013) identifies two types of useful knowledge in this base: Ω – descriptive knowledge, and Λ – prescriptive knowledge, see Figure 14:

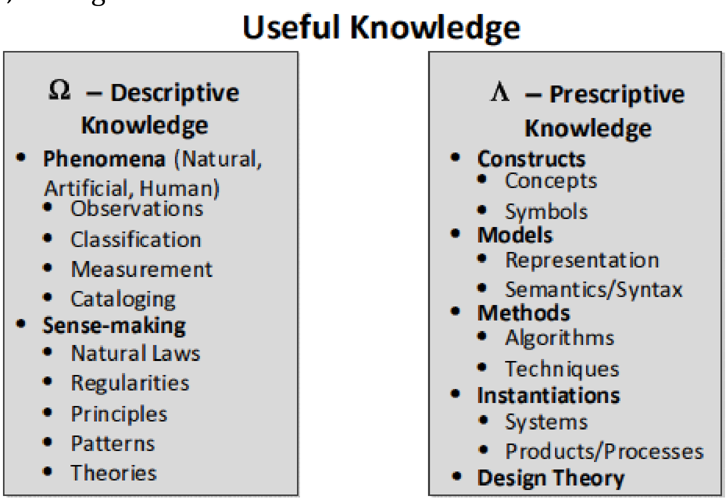


Figure 14: Useful DSR knowledge (adapted after Gregor & Hevner, 2013, p. 344)

In addition to these types, I will use a third type as suggested by Iivari; the conceptual one (denoted ϕ in this paper):

> The research goal at the conceptual level is essentialist: concepts and conceptual frameworks at this level aim at identifying essences in the research territory and their relationships (Iivari, 2007, p. 46).

The reason for including ϕ-type knowledge is that I want to distinguish essentialist knowledge from Ω-type descriptions, which I understand as related to immediate, sensuous phenomena.

6.1 IT artefacts and Information Systems (φ)

The nature of the IT artefact, the "core subject matter" of the IS field according to Orlikowski and Iacono (2001), has been debated extensively in the IS community without reaching closure (e.g. Benbasat & Zmud, 2003; Orlikowski & Iacono, 2001, Paul, 2007; Alter 2015). For example, Alter proposes that vastly "inconsistent definitions of the term 'the IT artifact' in leading journals and conferences demonstrate why it no longer means anything in particular and should be retired from the active IS lexicon" (Alter, 2015, p. 47).

A major hurdle appears to be confusion about the social character of the IT artefact; the fact that its main functionality is to inform people. There have been many attempts to address this issue. For example, Silver and Markus suggest that the IT artefact is a "sociotechnical assemblage", which has "both technical and social design features" (Silver and Markus, 2013, p. 82). Therefore, the IT artefact is better regarded as a *SocioTechnical artefact*. This conceptualization is motivated by the fact that "even without a change in the technical components, a change in a social dimension can produce a very different artifact" (ibid., p. 83). An example of a social design feature is "the intended users" (ibid., p. 83). Thus, the artefact is conceptualized as consisting of technologically invariant parts, and parts that change depending on its context of use.

Another conceptualization emanates from *sociomateriality*, which posits "the inherent inseparability between the technical and the social" (Orlikowski & Scott, 2008., p. 454). Any distinction of humans and technologies is analytical only, and "done with the recognition that these entities necessarily entail each other in practice" (ibid., p. 456). The social and the material are inextricably related: "there is no social that is not also material, and no material that is not also social" (Orlikowski, 2007, p. 1437). Thus, the IT-artefact cannot exist as an independent object; neither can the social, and, consequently, the individual. It is only in relation to each other that they come into existence.

In contrast, the structuralist position posits that elements of human culture must be understood in terms of their relationship to a larger, overarching structure. Here, the IT artefact is seen an *ensemble*, by which is meant "the material and organizational features that are socially recognized as bundles of hardware and/or software" (Sein et al., 2011, p. 38). A "technology as structure"-view of the ensemble artefact is proposed, in which "structures of the organizational domain are inscribed into the artifact during its development and use" (ibid., p. 38) [8]. In this conceptualization, the context, in which the IT-artefact is used, somehow modifies the artefact.

If these conceptualizations are applied to the guitar concert example, it is immediately clear that they do not make sense in that activity. According to the SocioTechnical artefact view, the guitar artefact remains technically invariant but changes "socially" depending on who is playing on it or in which setting the playing takes place.

[8] Inscribe – to write or carve (words or symbols) on something, especially as a formal or permanent record (Oxford Dictionaries: http://www.oxforddictionaries.com/)

The sociomaterial view claims that the player and the guitar interpenetrate each other, and that any distinction between is "analytical" only. The ensemble view holds, for example, that structures of the concert hall somehow carve itself onto the guitar.

So, it seems that we are left with two alternatives. Either, the IT artefact is a particular kind of artefact that is only possible to fathom by emblematic IS theories. Thus, the scope of IS theories is limited to IT artefacts, and not to "simpler" designed artefacts like guitars, knives, microwave ovens, and the like. The other alternative is that theories applicable to these more obvious kinds of artefacts cannot elucidate the nature of the IT artefacts, in which case there is no way to proceed from the simple to the more complex (Goldkuhl, 2002). Neither of these alternatives is satisfactory. For example, how should the demarcation line between IS relevant and IS non-relevant theories be drawn? It should be possible to use the same theoretical perspective on IT artefacts as well as on other artefacts.

Part of the problem appears to be the superficial conceptualization of the human actor. The individual is often subdued under the "social" or even the artefact itself. For example, Lee et al. define a 'social artifact' as "an artifact that consists of, or incorporates, relationships or interactions between or among individuals" (Lee et al., 2015, p. 9). Other examples can be found in sociomaterial accounts, where "human" and "social" are often conflated, such as in this quoute: "… the material/technical and the human/social…" (Cecez-Kecmanovic et al., 2014, p. 810).

It is clear that there is a need to better understand how humans are informed by and uses the IT artefact. We must be vigilant against category mistakes, i.e., semantic or ontological error in which things belonging to a particular category are presented as if they belong to a different category (Ryle, 1949). If we posit that the IT artefact is in principle no different than any other designed artefact, we may concentrate our theoretical concerns to its social facet; how the IT artefact may inform people in action. As Goldkuhl points out, there is no "need to put humans inside the boundary of the IT artefact in order to make these artefacts social" (Goldkuhl, 2013b, p. 94).

The Information System

The process of turning an artefact from something new and strange into a useful tool for an individual can be seen as an *equipment* formation process, in which an artefact passes from a state of being *present-at-hand* to *ready-at-hand* (Heidegger, 1962; cf. also Riemer and Johnston, 2013). Equipment is encountered in terms of its use in practices rather than in terms of its properties: "our concern subordinates itself to the 'in-order-to' which is constitutive for the equipment we are employing at the time" (Heidegger, 1962, p. 98). In this process, the tool recedes, as it were, from "thingness" into equipment, when the in-order-to aspect – what the tool can be used for – takes precedence. The essential change of interacting with an artefact – be that a guitar, cello or an IT artefact – takes place in the brain of the individual:

> [External] aids or historically formed devices are *essential elements in the establishment of functional connections between individual parts of the brain*, and that by their aid, areas of the brain which previously were independent become the components of a single functional system (Luria, 1973, p. 31; italics in original)

In this way, the IT artefact becomes *informative* only when an individual has made it into equipment for himself. Thus, the very same artefact may result in vastly different equipments in actors without leaving any traces on the artefact. It is not possible to decide if a particular IT artefact is equipment for an individual only by visual inspection of it. Only by examining the history of that artefact in a particular context, can its informative qualities for the individual be validated.

When the same IT artefact is used by several individuals in an activity domain, it needs to be made into a communal asset. This is achieved by fitting together individual equipments as exemplified by the construction of the S-domain at Ericsson. It should be remembered though, that the IT artefact is physically the same for all actors. The user interface shown in Figure 11 does not change because several actors look at it. There is nothing in the artefact that can be traced back to individual equipment formation.

What does this mean for the conceptualization of the IS? Paul proposes that the "IS is what emerges from the usage and adaptation of the IT and the formal and informal processes by all of its users" (Paul, 2007, p. 195). In ADT, an IS is seen as an IT artefacts, which has gone through a communalization process, i.e. it has become as a *communal asset*. Consequently, there is nothing external we can point to and say "This is the IS!" since the definition involves individual minds. ISs so defined will have profound implications for DSR.

IT related artefacts

In their definition of the IT artefact, Hevner et al. (2004) include constructs, models, methods and instantiations, i.e., the real, running system. In ADT, these elements are seen as *related* to the IT artefact in ADT but not included in it. The term 'IT artefact' is retained for the instantiated system. An IT artefact "is a physical artifact based on technology" (Goldkuhl, 2013b, pp. 93-94). Moreover, Hevner et al. (2004) maintains that a constructed artefact "embodies the designer's knowledge of the problem and solution" (ibid, p. 99)"[9]. Certainly, all elements in the Knowledge Base are pertinent to the design of the artefact, but these elements are not *embodied* in it. 'Embodying' knowledge, for example, indicates a 'transportation' view of knowledge as possible to move from the designer to the artefact. This is clearly at odds with the epistemological foundation of ADT (see the section 6.5 Ontology and epistemology).

Knowledge contribution (φ)

The IT artefact is a physical artefact based on information technology. In this sense, it is not different from any other artefact. Its specificity lies in its designed function – to inform people. The IS is a communal asset, inextricably bound to the individual; without individuals, no IS. IT related artefacts are not included in the term "IT artefact".

6.2 Develop and justify (φ)

Development and justification in DSR concern "theories that explain or predict phenomena related to the identified business need" (Hevner et al., 2004, p. 79). Such needs emanate from the environment, which is described as "the problem space … in which reside the phenomena of interest. For IS research, it is composed of people, (business) organizations, and their existing or planned technologies... Framing research activities to address business needs assures research relevance" (ibid.).

Concerning relevance, problems addressed by DSR are *wicked* (Hevner et al., 2004, p. 81). Such problems are characterized by

- unstable requirements based upon ill-defined environmental contexts
- complex interactions among subcomponents of the problem and its solution
- inherent flexibility to change design processes as well as design artefacts
- a critical dependence upon human cognitive abilities to produce effective solutions
- a critical dependence upon human social abilities to produce effective solutions

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[9] Embodying something means to "give a tangible or visible form to (an idea, quality, or feeling) (http://www.oxforddictionaries.com/)

The 3G project from Ericsson described earlier exhibits all these characteristics. Thus, this project may serve as a paradigmatic example of what kind of relevance DSR need to address.

According to ADT, the environment is conceptualized as a collection of interdependent activity domains, including the environment itself. Thus, business needs and problems are defined against a background of activity domains. As an example, the environment of 3G project can be seen as a collection of activity domains defined by the subprojects indicated by the white squares in Figure 2.

Such a conceptualization of the environment implies that any activity, from the smallest ones when two people interact, to large, interorganizational cooperation, can be seen as activity domains. The interdependencies between domains imply that the "local", internal communalization in a domain needs to be reconciled with the external, "global" communalization of the domain which depends on the local domain. So, for example, the marketing division in a car manufacturing company may have specific methods, tools and "marketing" language. Nevertheless, this communalization has to be externally reconciled with other divisions like product development, production or after sales support in the overall organization.

There are contributions in the DSR literature advocating constructs similar to the activity domain. For example, Goldkuhl (2013) maintains that the notion of "practice" should be a cornerstone in DSR. A practice is conceptualized as an "embodied, materially mediated arrays of human activity centrally organized around shared practical understanding" (Schatzki, 2001, p. 2). Another example is the so called "work system", which has been promoted by Alter (e.g. Alter, 2006; 2013; 2015). A work system is "a system in which human participants and/or machines perform processes and activities using information, technology, and other resources to produce products/services for internal or external customers" (Alter, 2013, p. 26)

Although similar in purpose and a pragmatic view on knowledge, ADT differs from the practice and work system conceptualizations in some vital aspects: ADT takes its point of departure in the individual actor; it emphasizes the construction of communal meaning; the activity modalities provide a recurrent structure of activity domain enabled by the transition modality; and the fundamental aspect of contextualization is found only in the ADT.

Knowledge contribution (φ)

ADT conceptualizes the environment as a collection of interdependent activity domains, thus suggesting that the activity domain is an appropriate unit of analysis for theorizing the environment in DSR.

6.3 Build and evaluate (Λ)

DSR addresses research through the "*building* and *evaluation* of artifacts designed to meet the identified business need" (Hevner et al., 2004, pp. 79-80; italics in original). The experiences from the Ericsson case indicate that two major types of IT artefacts need to be built and evaluated: the IT design-base, and the IT application. The IT-design-base is built as a generic system, potentially applicable in a large group of different environments, like the Matrix system used in the 3G project. Other examples are systems for the designing ERP (Enterprise Resource Management) applications, with SAP R/3 as probably the most prominent one. Such systems can be bought from commercial vendors as a basis for developing IT applications on top of them, usually with extensive consultant assistance.

The IT design-base can be seen as an instantiated "meta-artefact" (Walls et al., 1992; Iivari, 2003; Iivari, 2015). Meta-artefacts support the development of IS artefacts and can be divided into "meta-artifacts for the IS product and meta-artifacts for the ISD (information systems development) process" (Iivari, 2003, p. 575). Examples of meta-artefacts for IS products are

> technical implementation resources such as application domain-specific software components, application frameworks, application packages, ERP systems, development environments, IS generators, or their prototypes, which can be used in the technical implementation of an IS artifact, and also more abstract models and principles such as various architectural models, analysis and design patterns, and application-dependent design principles for use in the design and implementation of the IS product (Iivari, 2003, p. 575)

A distinguishing factor between meta-artefacts and applications is that "no prefabricated commercial software product is an information system as such" (Iivari, 2003, p. 571). According to the ADT view, only applications contribute to the communalization process. As a consequence, meta-artefacts and applications follow quite different build/evaluation trajectories.

Building and evaluation of design-bases

The build of a design-base is done outside the specific problem space, and should acknowledge the activity modalities. Concrete manifestations of the modalities should be easily recognized and managed in applications built on top of the DB. Obviously, the Matrix IT system had some of these qualities. For example, the implementation of the information models manifesting the spatialization modality, as exemplified in Figure 10, could be readily done with Matrix so called Business Modeller; a graphical interface for defining types of entities, relationship types, attribute types, and the like. Similarly, temporalization, stabilization and transition could be managed, albeit not always straightforwardly. However, the one modality that could not be implemented was contextualization; the ability to characterize information entities differently depending on their relevance in a particular domain.

Meta-artefacts like IT design-bases "are extremely difficult to validate in practice" (Iivari, 2003, p. 576). One reason is the problem of tracing a particular result in the environment to the IT design-base, since many factors are involved in communalization. Evaluation of such IT artefacts can be done only by collecting and analysing experiences from many applications in different environments.

Building and evaluation of applications

Design always begins with something existing; a given prerequisite. There might be simpler cases where an application is built on a well-established design-base, like a relational database. In such cases, building and evaluation may be performed on application and design-base separately.

Usually, however, applications are built on top of design-bases. The mode of building may vary: choosing from predefined patterns of "best practice", settings parameters in an ERP-system, developing dedicated software products, or using design-base application modelling functionalities. In such cases, evaluation needs to attend the mutual interdependencies between the design-bases and applications. In addition, all aspects of communalization need to be accounted for in the evaluation of IT applications.

Reconceptualizing 'build'

The ADT perspective implies that build cannot be confined to the IT artefact only. 'Build' needs to be reconceptualized as construction of *the entire activity domain*. In the DSR literature, some scholars advocate a similar approach. For example, Dahlbom claims that we should conceive our discipline in terms of "using information technology" instead of "developing information systems" (Dahlbom, 1996, p. 34). This corresponds well with the equipment view of IS as suggested above. Purao et al. urge IS design researchers to pay more attention to "the work practices of organizational participants relevant to the context in which the IT-artifact is realized" (Purao et al., 2013, p. 77). Design research should be expanded “towards a more situation, organization and user aware approach” (ibid., p. 78). This means to “more fully take into account the work context of the IT artifact” (ibid., p . 97).

Goldkuhl advocates “co-design” of artefact and work context: “design of an IT artefact also implies design of its context” (Goldkuhl, 2013b, p. 95). ADT concurs with this approach. However, the notion of ‘context’ needs to be problematized. According to ADT, contextualization takes precedence over context. External manifestations of contextualization (what is usually referred to as the context) result from communalization of the contextualization modality. Thus, contexts cannot be designed in the same manner as IT artefacts since there is no “context artefact” to be designed. The focus should be on designing applications in such a way as all activity modalities are supported, including contextualization.

Knowledge contribution (Λ)

Two types of IT artefacts need to be considered in build and evaluate: the IT design-base and the IT application. The design-base should be built in such a way that the construction of communal meaning in the environment is alleviated. The application is built in the environment, thus contributing to the construction of communal ISs. In these builds, elements from the knowledge base, in particular meta-artefacts, contribute to the integrated construction of activity domains. However, it is crucial to recognize that both types of IT artefacts *remain artefacts* during the construction process. The transformation of applications into communal ISs takes place in individual minds.

6.4 Operationalization (Λ)

According to Swanson and Chermack (2013), the operationalization of theory is an explicit connection between the conceptualization of the theory and practice. Operationalization enables the theory to be empirically confirmed.

In ADT, operationalization implies that models, methods, constructs, and instantiations should be designed in accordance with the modalities and their interdependencies. In doing so, we posit that operationalized constructs are harmonized with our neurobiological predispositions for coordinating actions. To illustrate this claim, we may consider process models. These are interpreted in ADT as manifestations of the temporalization modality, since they signify sequences of actions. In addition, process models also need to connect with entities they are operating on. Such entities are seen as manifestations of the spatialization modality (as illustrated, for example, in the information model in Figure 10).

A widely adapted notation for business processes is BPMN (Business Process Model and Notation; see e.g. Recker, 2010). In Figure 15, an example of a business process in BPMN is shown.

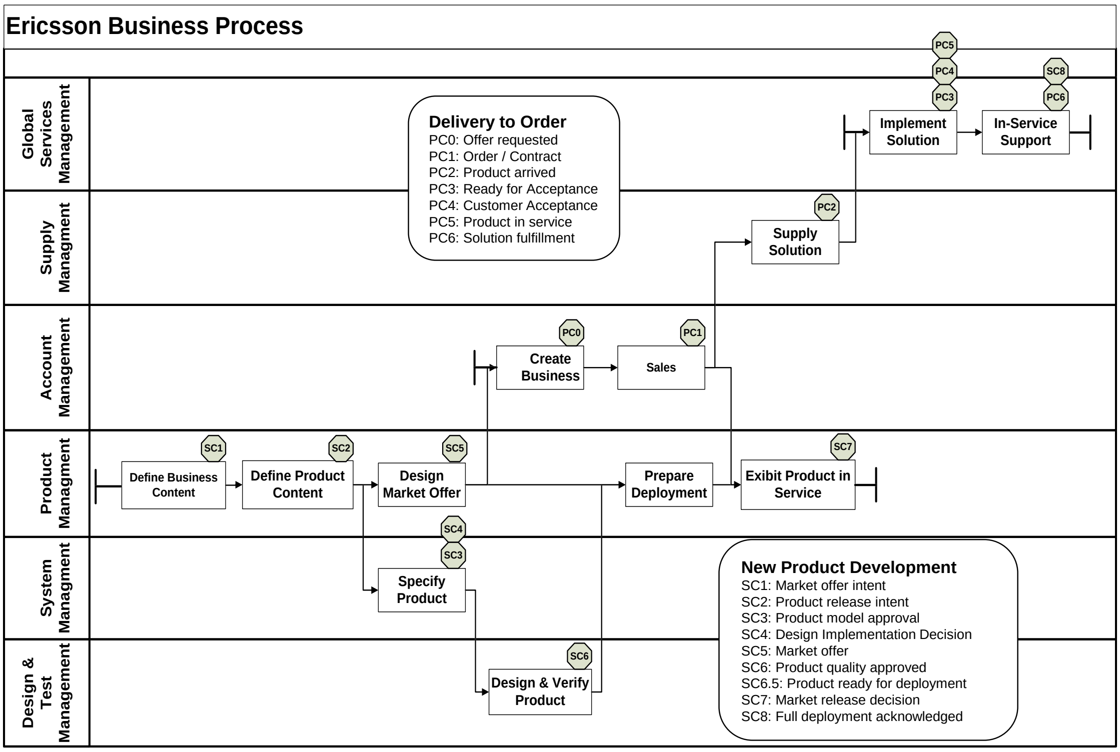

Figure 15: A business process described in BPMN

As can be seen, BPMN is focused on activities. The entities ("Business Content", "Product Content", "Market Offer", and so on) are less emphasized, and scattered all over the model. Thus, it is difficult for actors to see how spatialization and temporalization interact, which hampers the construction of communal meaning and thus the communalization process.

An alternative way of illustrating processes was devised at Ericsson already in the 1990s (see Figure 16).

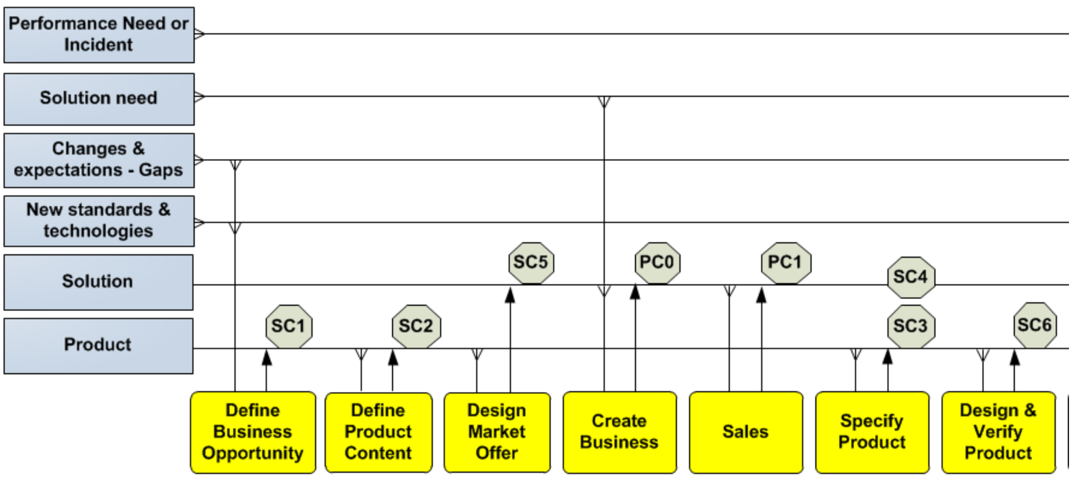

Figure 16: The same business process in "score" notation (partly cropped).

In this model, the focus is on entity progress. Activities (temporalization) are lined up horizontally and entities vertically. The interaction between these is illustrated by the "score" part, where down-arrows signify input to activities, and up-arrows output from the same activities, causing state changes in entities. Thus, manifestations of temporalization and spatialization are distinctly separated.

The score model was used extensively in some projects at Ericsson. The model appeared to be intuitively easier to apprehend, although a strict scientific evaluation was not made. A compelling observation is the resemblance of the score model to the musical score in Figure 6, thus indicating that the process score is better aligned with the activity modalities than the BPMN notation.

Knowledge contribution (Λ)

Operationalization of ADT should be done in accordance with the activity modalities.

6.5 Ontology and epistemology (φ)

According to Purao, DSR needs to be explicit about its ontological and epistemological foundations:

> To claim legitimacy, the design research tradition must identify its underlying beliefs and assumptions including, first, clarification of the nature of knowledge it creates in terms such as theory-building or theory-testing; and second, articulation of fundamental world-views such as the ontological and epistemological stance. (Purao, 2002, p. 5)

Ontological assumptions concern "the very essence of the phenomena under investigation" (Burell & Morgan, 1979, p. 1), while epistemological assumptions are about "the grounds of knowledge – about how one might begin to understand the world and communicate this as knowledge to fellow human beings" (ibid). Ontological assumptions are prerequisites for epistemological investigations; we need to comprehend phenomena before we can become knowledgeable about them.

Several scholars suggest that DSR should be based on the Popperian/Habermas' three-world ontology (Iivari, 2007; Gregor & Jones, 2007; Gregor & Hevner, 2013). World 1 is about material nature, World 2 about consciousness and mental states, and World 3 about products of human social action (Iivari, 2007, p. 41). However, the three-world ontology has been criticized on several points[10]. Searle insists that we "live in one world, not two or three or twenty-seven" (Searle, 1997, p. 88). Moreover, this ontology encourages a 'compartmental' way of thinking, where entities are located in a particular world. For example, Gregor & Jones state that "theory as an abstract entity belongs to World 3" (Gregor & Jones, 2007, p. 321). However, one may question if theories should not also belong to World 2 as conceived in a person's mind before it is materialized in World 3.

The Popperian/Habermas' is not applicable to ADT. The human capability to contextualize implies that we don't experience things as objectively given. The nature of an object is "constituted by the meaning it has for the person or persons for whom it is an object" (Blumer, 1969, p. 68). This meaning is not intrinsic to the object but "arises from how the person is initially prepared to act toward it" (ibid., p. 68-69). Thus, the world is not "made of things"; neither do these things "possess" properties (Weber, 2012, p. 3). Rather, we confer properties onto perceived, actionable objects according to what is relevant in a certain situation.

Concerning epistemology, ADT puts "individual experience at the centre of its theoretical concerns" (Hutton & Pablé, 2011). A coherent epistemology from this point of departure has been developed in the *integrationism* approach to language and communication (e.g. Harris, 1981; 1996; 2004; 2009):

> The mind has as one of its principal functions the contextualized integration of present, past and future experience. That is its constructive role in the evolution of humanity. That is where knowledge comes from, the *fons et origo*. There is no hidden or more basic source (Harris, 2009, p. 161; italics in original)

[10] A thorough critique of Popper's three-world ontology is provided by Dykes (2003).

Knowledge is not a matter of gaining access to something outside residing in World 1 (material things) or World 3 (human-made entities); rather it is acquired in action:

> [All] knowledge is internally generated by the human capacity for sign-making; the external world supplies input to this creative process but does not predetermine the outcome; signs and, hence knowledge, arise from creative attempts to integrate the various activities of which human beings are capable (Harris, 2009, p. 162)

A similar stance is taken by Polanyi: "[All] knowing is action—that it is our urge to understand and control our experience which causes us to rely on some parts of it subsidiarily in order to attend to our main objective focally" (Polanyi, 1975, p. 2).

This means that humans and their environment are considered as distinct, yet inextricably related and co-constructing each other in the integration of activity. However, knowledge is possible only if there is a physical, non-human world, existing independently of humans:

> I know, for example, that on my way home, by the time I have moved up into third gear from the traffic lights by the bridge, it is time to start signalling for my right turn by the church on the next corner. My daily journey is one continuous process of self-communication, even though much of the sign-making involves public landmarks. But what is public about them is their physical presence, not their semiological function. The church does not mean 'turn right here' except with respect to that temporally integrated sequence of events which my journey consists in. (Harris, 1996, p. 173)

Knowledge contribution (φ)

The individual is the point of departure for ontological and epistemological inquiries. The integrationism approach to language and communication provides a coherent ontological and epistemological foundation for ADT, and, consequently, DSR.

6.6 Scientific foundation (φ)

According to Gregor & Hevner, a key problem, which hinders DSR from having a more striking influence on the IS field, "is less than full understanding of how DSR relates to human knowledge" (Gregor & Hevner, 2013, p. 338). Accordingly, there is an uncertainty about where to theorize in DSR (Chatterjee, 2015). Behaviour sciences theorize the environment; the "human element of IS" (Chatterjee, 2015, p. 2). Design sciences focus on "the rest of the information system: IT-artifacts including hardware, software, procedures and data" (ibid). But how can these sciences be reconciled in DSR? Chatterjee, referring to Simon (1996), suggests a third arena for theorizing:

> [There] is the middle, which might be referred to as the "interaction". This is where Simon's "inner" and "outer" work collides. … We must theorize here, the middle and understand the interaction and its effects (Chatterjee, 2015, p. 9).

Chatterjee proposes Activity Theory for theorizing the "middle". The use of Activity Theory in design contexts has been thoroughly investigated by Kuutti (1996) and other scholars (e.g. Boedker, 1991; Baerentsen, 2000; Baerentsen & Trettvik, 2002; Korpela et al., 2000). However, as discussed earlier, Activity Theory has some fundamental problems in explaining the individual – social relationship, which makes it unsuitable for this purpose according to ADT.

In ADT, the "middle" is seen as individual equipment construction. The environment (the "outer") is conceptualized as activity domains. The IS emerges in the communalization process, where individual equipments are fitted together; thus making the IT artefact into a communal asset. Operationalization of ADT implies certain guidelines for designing IT artefacts (the "inner"), based on the activity modality construct.

Knowledge contribution (φ)
Obviously, conceptualizing the scientific foundation of DSR in term of several different types of theories is problematic; not least because these must be reconciled in some way. In contrast, ADT provides one coherent theory for explaining the relationship between the human (outer), the IT artefact (inner) and the interaction between them (middle). Thus, ADT is a possible scientific foundation for DSR.

7 DISCUSSION

The design of rigorous and relevant IT artefacts is in all essence a collaborative effort, even if new design ideas and inventions originate from individual designers. This brings the issue of communal meaning construction to the fore. In order to discuss what this means for DSR, the Hevner et al. (2004) framework is re-conceptualized as in Figure 17:

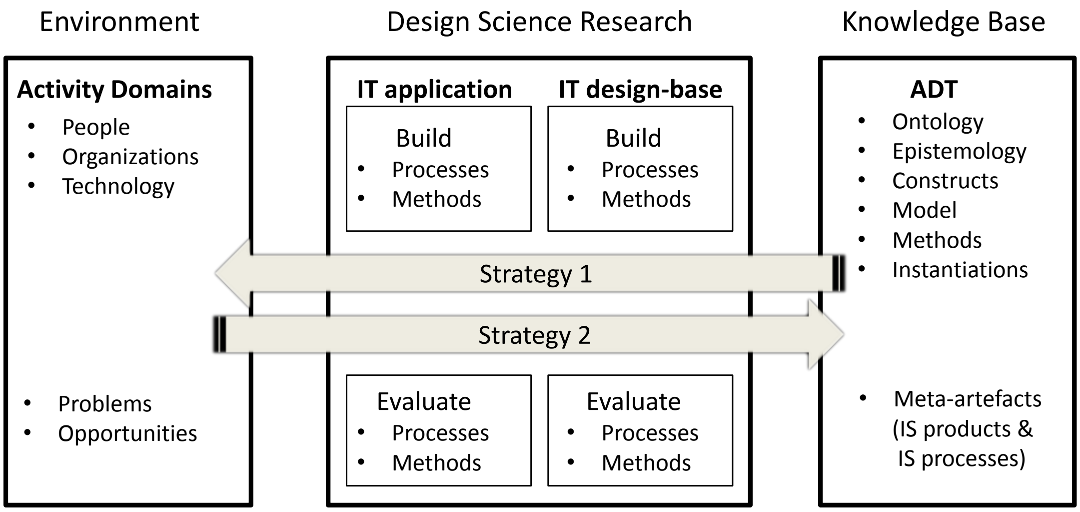

Figure 17: Illustrating DSR from the ADT perspective (adapted from Hevner, 2004; 2007)

In line with Goldkuhl (2013), DSR is seen as a practice (Schatzki, 2001) interacting with two other practices: the environment and the Knowledge Base. The environment practice provides problems and opportunities for DSR, as well as the arena for validating its relevance. The Knowledge Base practice ensure the rigour of DSR in terms of theories, ontologies & epistemologies, constructs, models, methods, and instantiations. In addition, the Knowledge Base includes meta-artefacts supporting the development of IS artefacts (Walls et al., 1992; Iivari, 2003, 2015). The DSR practice includes two sub-practices: build and evaluation of IT design-bases, and build and evaluation of IT applications on top of IT design-bases.

According to Iivari, two strategies need to be distinguished in DSR. In Strategy 1, researchers construct an IT meta-artefact as a general solution concept, possibly to be instantiated into a specific solution concept or a concrete IT artefact to be adopted and used in a specific context (Iivari, 2015, p. 107). In Strategy 2, researchers attempt to solve a client's specific problem by building a concrete IT artefact in a specific context, and distil from that experience prescriptive knowledge to be packaged into a general solution concept to address a class of problem (ibid.)

The environment practice
March & Smith state that research in IT "must address the design tasks faced by practitioners. Real problems must be properly conceptualized and represented" (March & Smith, 1995, p. 251). This requires concrete and sufficiently detailed descriptions of practitioner's environments. However, in extant DSR contributions, the environment is conceptualized in quite general terms as composed of people, organizations, and

technology (e.g. Silver et al. 1995, Hevner et al., 2004, Hevner, 2007). I contest that this level of description is adequate for assessing DSR relevance.

In ADT, the environment practice is seen as a constellation of mutually interdependent activity domains. As the examples from the S- and A-domains in the 3G project indicate, the construct of the activity domain enables the environment to be described in sufficient detail for validating DSR relevance; a relevance which differs, depending on how the artefact is communalised in each domain. So, for example, if the artefact is an ERP application, this might be highly relevant in a financial department of an organization, but less relevant in a product development unit in the same organization.

The Knowledge Base practice

The ADT provides the general framework for DSR activities. Models, methods and instantiations, should adhere to the activity modalities; regardless of whether these are meta-artefacts or not, in order to alleviate communalization in activity domains.

The DSR practice

For ADT, research following Strategy 1 is focused on operationalization of the activity domain and the activity modality constructs into general solution concepts. For example, operationalizing temporalization may be done as the score process model Figure 16 and evaluated in research towards extant models such as the one in Figure 15. Another example would be to build an instantiation deliberately designed in accordance with the activity modalities. In particular, the implementation of contextualization would be in focus, since this aspect is virtually non-existing in contemporary IT systems.[11] Another possible outcome of Strategy 1 is IT meta-artefacts that may be instantiated as IT design-bases such as ERP or PLM systems. This would move DSR contributions a further step towards practical relevance, since such design-bases are abundant for designing organizational-wide IT applications.

In research following Strategy 2, experiences from building and evaluating concrete IT applications and IT design-bases are used to ground and further elaborate ADT. For example, such research may find that the current conceptualization of the activity modalities is inadequate and needs to be modified. Other results would be meta-artefacts additions to the Knowledge Base, such as methods and models for alleviating the communalization process. One candidate of such meta-artefacts is the "system anatomy" model, conceived at Ericsson in the 1990s and deliberately devised to alleviate communal construction (e.g. Taxén & Petterson, 2010; Taxén & Lillieskõld, 2011). The integration plan in Figure 2 is an example of this kind of model.

Regardless of which strategy is followed, ADT comprises the entire DSR scope, from environment to the Knowledge Base. The same theory permeates the environment, the Knowledge Base, and DSR, thus avoiding the problem of reconciling separate (behavioural) theories for environment, and (constructive) theories for design. The overall focus on communalization means that the design of IT artefacts cannot be done separately from the construction of communal meaning. The ultimate target for design is the activity domain in which IT artefacts are communalized into relevant means for improving practice.

Limitations and future research

As a nascent theory, ADT may be characterized as 'prescience' as defined by Corley and Gioia as "the process of discerning or anticipating what we need to know and, equally important, of influencing the intellectual framing and dialogue about what we

[11] Contextualization is still, some fifteen years after the 3G project, a blind spot in extant IT design-bases like PLM or ERP systems.

need to know. An orientation toward prescience holds some promise for advancing our craft of theory development" (Corley and Gioia, 2011, p. 13). Obviously, there are several areas which need to be addressed, such as:

- DSR rigour requires the construct of activity modalities to be validated in neuroscientific research. This requires collaboration "over the wall" between the IS and neuroscientific disciplines, something that can be hard to achieve.[12]
- So far, no IT artefact has been built in accordance with the ADT. The Matrix design-base used at Ericsson was designed according to the object-orientation paradigm (e.g. Rumbaugh, 1991).
- A crucial question for the ADT is its transferability. The empirical validation of ADT is so far done only in a single-case study. Are the experiences from Ericsson possible to transfer to other settings?
- The two strategies for DSR suggested by Iivari (2015) are contrasted along 16 dimensions. A relevant topic for future research would be to articulate these strategies further from the ADT perspective. In such a work, the experiences form the 3G project can be used as a third example of Strategy 1 in addition to the two examples reported in the literature (Iivari, 2015, p. 108).
- Since applications are built on top of IT design-bases, several issues for DSR immediately crop up: should there be one application built for all domains in the environment, or specific ones for each domain? If several are built, should these be built on the same physical design-base or separate ones? Which is the optimal balance between communality across the entire organization and local adaptations to suit each domain?
- The fundamental role of communication in joint action is not treated. Neither are other aspects such as trust, emotions, personal motives, power structures, etc.

Certainly, additional research targets can be conceived in order to advance ADT from prescience to a more mature theory.

8 CONCLUSIONS

The ADT approach provides a way to reconceptualize crucial aspects of DSR from an alternative perspective, which have not been explored so far in DSR – that of communal meaning. In doing so, the focus is moved from the design of IT artefacts to communal construction of activity, conceptualized as activity domains. In conclusion, I contend that the ADT approach has potential to open up interesting and productive new lines of research in DSR, simply because it connects with the *sine qua non* for our existence as biological creatures. If this connection is lost, DSR theorizing, however ingeniously conceptualized, may nevertheless be void of practical relevance. By adhering to our inherent capacities for ordinary, every-day actions, ADT can be seen as a call for reconceptualising what we already know; illustrating the maxim "Discovery consists of seeing what everybody has seen and thinking what nobody has thought" (Albert Szent-Gyorgyi).

[12] In Taxén (2015) a first move into grounding in the neural realm is attempted.

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