Using Digital Infrastructures to Conceptualize Sensing and Responding in Human-Computer Interaction

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Abstract. This paper extends existing Information Systems perspectives towards Human-Computer Interaction (HCI) to consider HCI within Digital Infrastructures (DI) – heterogeneous and evolving systems comprising both IT and its design and user communities. Using the example of a new interface that has significantly decreased call handling times for sales and support agents (knowledge workers within a contact center), the paper finds that DI create an amount of flexibility that enables employees to shape tools over time. It argues that DI are a useful concept for HCI, as they stress the socio-technical and evolving nature of IT artefacts.

Keywords: Digital infrastructures · Information Systems · Call centers

1 Introduction

The field of Information Systems (IS) research is focused on "questions regarding the development, use and implications of information and communication technologies in organizations" [1]. It has strong roots in the social sciences and thus looks at how IT, people and organizations interact with and shape each other [e.g. 2–4]. Thus, there is a significant tradition of Human-Computer Interaction (HCI) research in the field [5–8]. Such research, however, faces the challenge to differentiate itself within the broader field of HCI research. This paper supports this effort as it takes up Benbasat's [5] suggestion "to treat technology as more than a static, objective, tool-like entity" (p. 19).

IS researchers are increasingly conceptualizing their objects of research as digital infrastructures (DI). Tilson et al. [9] define these as "shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities" (p. 748 f.), arguing that they will play a "pivotal role (…) in shaping the future uses of IT" (p. 749). Such research, however, is often constrained to the areas where the concept originated. Thus, it may be beneficial to apply the concept of DI to research on HCI.

From a practical point of view, well designed interfaces and a good support of the existing workflow are key features for Information Systems (IS) in organizations. This paper reports on a wider research project with BT plc that is focused on how the company uses DI to increase its organizational agility – its "ability to sense relevant change and

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respond readily" [10]. It takes up the view of IS in organizations as DI as it looks at the way developers and users interact with a tool to better support sales agents in its call centers. The research question is: How do DI support sensing and responding for employees and customers? The paper finds that DI create an amount of flexibility that enables employees to shape tools over time. Furthermore, it argues that DI are a useful concept for HCI, as they stress the socio-technical and evolving nature of IT artefacts. Such a view extends existing IS perspectives towards HCI [5] to consider human-computer interaction within digital infrastructures. This contribution is necessary as today's knowledge workers increasingly rely upon complex arrays of different evolving technology within their work tasks [11], drawing upon these portfolios in sensing and responding to tasks.

2 Conceptualizing DI for HCI

This paper follows the tradition of socio-technical Information Systems (IS) research. This section will discuss relevant prior research from the field of HCI as well as HCI based research in the field of IS, before outlining new conceptualizations of IS deemed relevant for HCI research in IS.

2.1 HCI Literature Review

HCI literature often refers to the *experience* of enterprise users of IT systems, and how they are often fragmented across multiple devices, platforms, legacy systems and vendors, with humans themselves acting as the "glue" connecting these disjointed information systems [12]. As a result, it is observed that within large service organizations, IT support functions are increasingly turning to user-centered approaches as a means of improving user productivity, increasing business velocity and in general making enterprise solutions more appealing to users [12]. In McCreary et al.'s previous paper [13], the opportunities of utilizing big data collected within the normal every-day practices within organizations is outlined as an input to user-centered approaches to developing enterprise IT, however it needs to be augmented by traditional UX methods (observations, participatory design sessions, surveys etc.) to be meaningful. The term "Thick Data", meaning "ethnographic approaches that uncover the meaning behind Big Data visualization and analysis" [14] has been coined to attempt to discover the "stories" the big data is telling us. This is a difficult procedure, but the paper states that sociotechnical systems theory and macro ergonomics offer a way of connecting this disparate data and provide a theoretical model for understanding the holistic user experience, and to enable IT developers to understand how their "technology" impacts other elements of the users' world [13]. Its importance is again underlined by Wang [14] in her comment: "Thick Data is the best method for mapping unknown territory. When organizations want to know what they do not already know, they need Thick Data because it gives something that Big Data explicitly does not—inspiration. The act of collecting and analyzing stories produces insights."

Culen and Kriger [15] outline a rationale for using Design Thinking and HCI Design to shape conditions for long-term "health" of IT intensive organizations. They also underline the point that there is a necessity for organizational culture to be receptive to innovation and change, arguing that "HCID will not be lasting without the presence of supportive, and larger, top-down changes". This theme is reinforced by Aldarbesti et al. [16] commenting: "For a successful implementation, IS projects always require power realignments; understanding the impact of organizational culture, and a conducive environment within the organization."

Li [17] observes that the interfaces of large IT systems are hard to change due to the scale and legacy of the software, which can be traceable many years back. The implementation of such systems involves huge investment and takes a very long period of time – and it may be hard to enforce user adoption of new developments when old habits are ingrained in the users. To assist this, understanding of user emotions and hedonics play an important role in adopting and optimizing IT usage in workplace, and as such constitute an important consideration of the human agent's needs and motivations within the DI. Therefore improvement of the social and emotional perspective of the enterprise systems should improve employees' adoption rate of the information technology, leading to improved productivity [17]. Our case study demonstrates how user motivation, users' willingness to affect change and business objectives combined to create a new interface which is satisfying and effective to use, allowing more effective sensing of customer issues and appropriate and timely responses.

2.2 IS Research on HCI

Benbasat [5] discusses how IS researchers can make a significant contribution to the wider field of HCI. He argues that discussions at a low level of detail (response times, colors etc.) are best left to other HCI researchers, who are better prepared to contribute to these. IS research, on the other hand, "should be focusing on topics that reflect 'higher level' designs such as those that impact decision making, virtual groups, company-customer relationships and other matters that are in line with a management focus in MIS" (p. 17). Specifically with regards to interfaces, he argues researchers should "treat technology as more than a static, objective, tool-like entity" (p. 19), namely "as a social actor in communication" (ibid.). One example for such an approach in HCI is the paper by Al-Natour and Benbasat [18], who see IT artifacts as social actors whose characteristics are manifested within the context of interactions. Bloomfield and Vurdubakis [6] reflect on the way technology is recognized as such as users construct a boundary between the social and the technical. This boundary is by no means universal, but subject to sense-making practices among the users.

The question of how to conceptualize IS in organizations has also been discussed in the broader field of IS research [e.g. 19, 20]. This is partly due to the fact that employees tend to build portfolios of services they use, rather than relying on a few monolithic systems [11]. Consequently, the view of the monolithic system itself has been questioned. This paper argues that, as digitization has separated information from a fixed medium for storage and transfer, more flexible, modular IS are possible [20]. This increases generativity, "a system's capacity to produce unanticipated change through

unfiltered contributions from broad and varied audiences" [21], as e.g. systems can communicate with each other via APIs.

Specifically, the concept of DI is increasingly used in IS research (e.g. Tilson et al.'s [9] paper has been quoted 113 times according to a recent database search). Yet such research is often constrained to the areas where the concept originated, e.g. mobile communication [22] or the iOS ecosystem [23] – despite Tilson et al.'s broad call for IS research that aims at a "better understanding of the ways in which infrastructural change shapes IT governance, IS development, and promotes new effects across all levels of analysis" (p. 758 ff.). As Yoo [24] points out, IS research in general needs "a more precise and nuanced understanding of the nature of digital technology that enables and constrains activities that produce generative innovations." (p. 231). This paper hopes to drive such an understanding by applying the concept of DI to the area of HCI. Thus, the IS at the center of the study will be seen as part of a heterogeneous, evolving sociotechnical system as per Tilson et al.'s definition of DI. The research question is: How do DI support sensing and responding for employees and customers?

Following the research question, the conceptual framework looks first at the DI involved in this case. As we have seen, Mathiassen and Sorensen [11] argue that IT in organizations should be seen through a service rather than a systems lens as users increasingly rely on "configurations of heterogeneous information processing capabilities" (p. 313). In order to conceptualize these portfolios of services from an IS perspective, this paper applies the concept of digital infrastructures. These are heterogeneous and evolving, i.e. they can be made up of a variety of different systems that are added and adapted over time and are often adapted according to ad-hoc needs. Consequently, it may not be possible to develop them according to a central plan. DI are also seen as sociotechnical systems. The systems consist of technology as well as the "user, operations, and design communities" who are a crucial part of the system, as they change it by engaging with it and adapting it over time.

3 Research Design

This paper reports on a case study conducted within BT, a telecommunications company in the UK, between 2014 and 2015 as part of a larger research project on organizational agility. Overall, 40 interviews and 10 observation sessions of BT employees were conducted. A small number of documents deemed relevant by interviewees was also considered – these included screenshots of relevant tools as well as some emails. The case study focused on some specific projects that seem to show successful changes to BT's agility. This paper looks at one of these projects, the development and use of SalesTool (a pseudonym) in call centers. Interviews were typically 45 min to 1 h in length. Besides this, 10 employees in the call centers were observed at their workplaces, using a variety of tools. All interviews and notes from observation sessions were transcribed and analyzed using ATLAS.ti. Data was then analyzed using thematic analysis [25], following a hybrid approach of theory-driven and data-driven codes.

3.1 Case Study

The case study concentrates on the development of DI as an evolution of user needs, business needs and IS developments, concentrating on the development of a CRM tool to enhance its usability and effectiveness. Previously, agents working in the company's call centers were using a CRM system for all the information processing related to their job. The need for a better solution became apparent as the operation of the previous CRM system used to manage orders caused a number of issues, for example:

"The trouble is that all of the data is locked into the [system] database, which is unwieldy and difficult [to access]" (CIO team – Product consultant).

"*So once you've done with that, you then go into orders and start building the order. But with [this system], you almost manually have to [do] all of these little bits, you have to put [them] on. You have to go into this catalogue*[1] *first and then you would search for the broadband packages…. It's not very user friendly*" (Sales Advisor).

At the same time, it was found that customers were able to submit orders through the company's web portal faster than agents did through the CRM system:

"*We were finding an order journey [online] was taking 4 min, and on [the CRM system] it was taking double – 8, 9 min. We were like "why are we doing this?*" *It does not make sense that we've got one journey for customers and one for agents*." (Online capability specialist)

A new tool (here called SalesTool) was therefore developed for agents working in the call centers. The idea came from one of the sales agents:

"*I think it was the Chief Executive …. So, not small fry, really big fry… He used to do these roadshows and get feedback from agents, and one of the feedbacks in one of his sessions was "if bt.com is easy enough for our customers, why don't we just use that for agents?" So I think that's where the idea came from… I think it came from the agent feedback."* (Online capability specialist)

This was planned as an additional layer on top of the existing tool, but with a simpler, more intuitive interface:

"*Effectively, it's a layer or platform that sits before [CRM system]. [SalesTool] and [the public web portal] are based on the same off-the-shelf framework, and we tailor [SalesTool] slightly more to suit some of the agent activities and things that they do, so the agent can do a little bit more in [SalesTool] than the customer can do with [the web portal]."* (Online capability specialist)

Thus, SalesTool was created as an added layer on top of the existing system. While it accesses the same database, it uses the interface from the company's public web portal, modified and extended to match agents' needs.

Specifically, agents are supported with a linear workflow following the order journey customers go through during a typical call. Throughout the process, SalesTool gives them exactly the information they need, e.g. relevant customer data, or reminders of

[1] There are categories to choose from (e.g. broadband), and then lists of items within these categories. As commented by the agent observed, there were more than 11 pages of results in the "broadband" category (each with a number of items on it), although only a handful of items are actually used. Agents also commented that it was unclear how the results are sorted.

what they have to tell customers. This includes legal disclaimers that agents must include. This is illustrated in the screenshot of the system (Fig. 1).

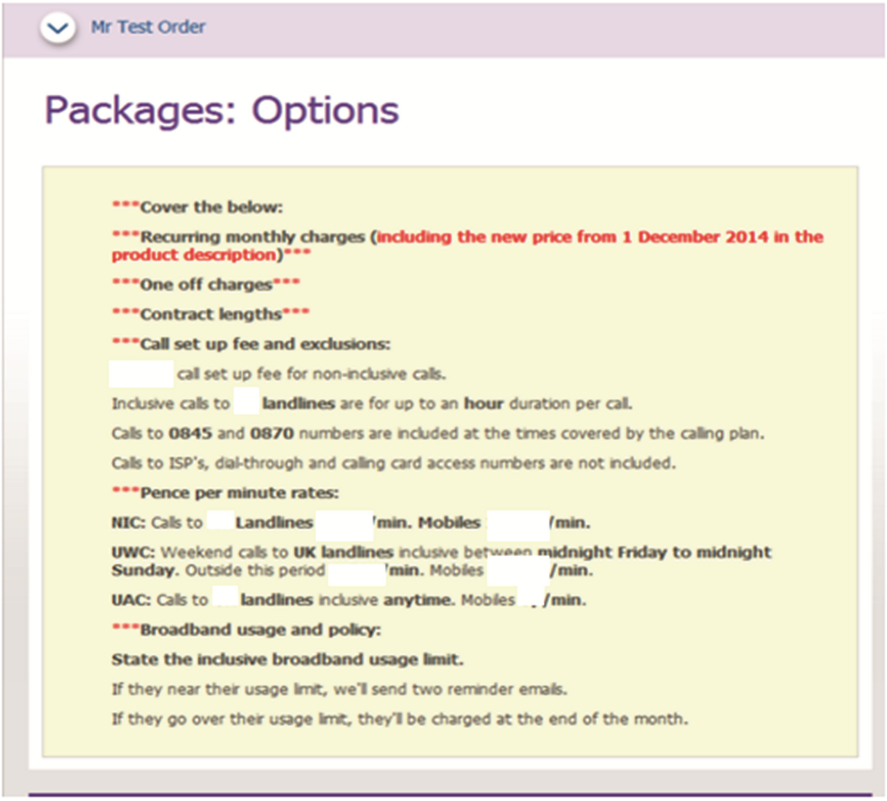

Fig. 1. Screenshot of SalesTool (redacted)

The Benefits of SalesTool. SalesTool led to a number of expected and unexpected improvements, which were observed post-implementation, for example:

- Agent Training time was reduced from 3 months to 10 days.
- Call Handling time was reduced by 20 % (target was 50 %).
- Sales conversion rate increased 6 % (not anticipated).
- Sales attachment rate increased 6 % (not anticipated) (source, BT Manager via email).

Interviewees also commented on significant increases in speed when working with the new tool:

Q: *Would you say the experiences with [SalesTool] are good in general?*

A: Yeah, they're very good. Good system, but it's a good way of making a terrible system acceptable.

Q: I heard it saves dramatic amounts of time.

A: Yeah. I would suggest it saves an average maybe 400 s CHT [call handling time] per call. An old order to place line, broadband, TV would take about 45 min.

These days, you're talking 20, half an hour tops. Half the time for those ones." (Sales center manager)

The main difference that was commented on by agents is that the tool made their work a lot easier:

"*I've gone through training with new entrants quite a few times now, and they just find it so much simpler, they're used to placing online orders in general, to shopping, things like that.*" (Sales center team leader)

In particular, the tool follows the script of a normal sales call and shows the exact information needed at each stage:

"If you look at [SalesTool], everything is exactly where it should be said. You're talking about purchases for TV, it will tell them when you actually order that product, whereas on [previous system] it was just – you told them (according to what you thought best)." (Technical sales specialist)

Because of this simplicity, training time has also gone down significantly:

Q: So how long is the training now vs. in the old days?

A: Now, it's 3 weeks in classroom and 6 weeks of support on the phone. Previously, the training varied, so some advisors would come in just with a two day, really quick burst. Some advisors, it would take a year for them to be fully up to speed with [previous system]. (Sales manager)

Another consequence of the simplified work flow was that agents have more time to focus on the customer rather than on their tools:

"I remember having a conversation with some of the advisors when we first trained on [previous CRM system] – say hello to the customer, have the conversation, but then turn away from the computer, because it was that much information that you had to remember you had to do, you would forget about the conversation, whereas now, they can do both at once". (Sales center team leader)

As the system is an extension of the existing CRM system, there are still some conflicts over which tool to use at what time. This is especially true in teams that are working on more complex cases:

"So the amount of time that we still have to use [previous system] – when it first came out, we had a [previous system] "naughty list" – anyone who was using [previous system] was slapped on their hands. But now we realize that we do need to use it, so everyone is on the list! For Retentions [SalesTool] is fantastic, but [previous system] is still key. I don't know what the percentage is, but I would suggest it is probably 70:30 – if you're skilled in [previous system]. Problem is, not everyone is, so for them it's pretty much 100 % [SalesTool] or we transfer someone else. (Sales center manager).

4 Analysis

This section will apply the conceptual framework outlined above to the data of the case study in order to answer the research question, "How do DI support sensing and

responding for employees and customers?" It evaluates the new system before looking at the role of DI.

Evaluation of the New System. The main difference between SalesTool and the previous CRM system it complements is the interface. While the old tool has a traditional database interface (see the description of the catalogue given above), SalesTool is based on the UI of the company's customer-facing web portal and thus has a much simpler interface with fewer options and a clear order in which interaction takes place.

Consequently, SalesTool is also much better at supporting the workflow of sales agents ("*everything is exactly where it should be said*", as one interviewee put it). It achieves the observed improvements in call handing time by building upon the existing workflow and supporting agents by giving them exactly the information they need, when they need it. In contrast, the previous CRM system did not support the workflow, but showed data the way it was stored in the system, so that agents had to jump between different tabs while entering data. They also had to keep track of what they did, e.g. remembering which of the legal disclaimers they had already read.

As we have seen, SalesTool led to a number of improvements, especially around reducing training and call handling times, as mentioned in the email quoted above and confirmed by interviewees. An additional bonus was that sales agents felt they had more time to focus on the customer rather than on their tools. Agents observed for the case study generally liked the tools, e.g. because it is simpler to use.

While SalesTool has improved work, there are still issues, especially around the question of how SalesTool should coexist with the previous CRM tool and when agents should use one over the other. Due to the modular nature of the tool (since it is an added interface over the existing CRM), there is also the question how the tool should be further developed in the future, i.e. whether an entirely new system would be desirable or feasible at some point (Technical sales specialist).

Digital Infrastuctures. Looking at this case from a Digital Infrastructures perspective, we can identify an infrastructure that consists of:

- The previous CRM system. This has evolved to be the main tool used for processing orders, even though this was not the intended purpose of the tool.
- SalesTool as a later modification of the DI to facilitate the agents' workflow.
- Sales agents in the call centers using the tools and e.g. negotiating which tool to use for which purpose.
- Data (e.g. from real time analytics) supporting agents in their work, e.g. by displaying a customer's history when they call.

This infrastructure clearly shows the qualities of being heterogeneous and evolving as described by Tilson et al. [9]: Tilson et al. mention "an installed base" (p. 748) of IT capabilities that DI build upon. This is evident in this case, as SalesTool was built as an extension to the existing CRM system. The development of SalesTool started because one user had the idea to create it as a simplified interface. Thus, we see how users in a DI can affect its design. Furthermore, the interface of the *old* DI was the foundation for the design of the new, as the system had to process the same data as in the previous

system. Lastly, the new interface also drew on the DI of the company web portal. In this case, the company website can be seen as a kind of installed base for the design of the new interface. This change was achievable because of new technology – website systems using technologies like HTML and browsers – which the previous CRM application preceded. These systems were able to take the existing data out of its context and present it in a context that is more familiar to the users in the call centers, but that also made it possible to support their workflow more directly, by displaying the right information at the right time.

Thus we see how the users have played a key role in the design of this system. It makes sense to see it as a DI, which, as we have seen consists of technology as well as the "user, operations, and design communities" [9]. Such a development as SalesTool may not have occurred if it had been planned as a centralized, monolithic system according to a design plan. As BT allowed for an element of adaptability (by encouraging employees to submit ideas), and as they used flexible technology to implement it (the existing database along with a new web interface), SalesTool could be developed on top of the extant CRM system and has led to the improvements described above.

Thus the answer to the question of how DI support sensing and responding for employees and customers is that they create an amount of flexibility that enables employees to shape tools over time. Moreover, conceptualizing IS as DI enables us to focus on such socio-technical processes, rather than seeing IT as static tools.

5 Discussion

This part of the paper summarizes the findings from the case study and relates them to the literature, as discussed above. With regards to the specific case discussed here, we have seen that the DI creates an amount of flexibility that enables employees to shape tools over time. The design of SalesTool is working well because of some good decisions that have been made, namely using the metaphor of the company's web portal, supporting the agents' workflow and allowing for the adaptation and evolution of an existing system.

This paper has limitations in that it only looks at one system in one organization. While it is hoped that the findings will be applicable beyond this case, further research using this concept would be beneficial for developing an understanding of the socio-technical, evolving nature of IT artefacts in organizations.

Applying the concept of DI to HCI research in IS has shown to be useful in this case, for two reasons: Firstly, it helps extend the use of the concept of DI into new areas not traditionally associated with it. As we have seen, areas like HCI in the context of a large company can be described as evolving DI. This paper hopes to encourage future research along similar lines. In addition, it strengthens the theoretical position of IS researchers on HCI, as the theory of DI is a powerful concept to be applied in future research.

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