Journal of the Association for Information Systems

Volume 26 | Issue 1 Article 8

2025

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Recommended Citation

Yeow, Adrian; Lim, Wee-Kiat; and Faraj, Samer (2025) "Digital Infrastructure Development Through Digital Infrastructuring Work: An Institutional Work Perspective," *Journal of the Association for Information Systems*, 26(1), 66-94.
DOI: 10.17705/1jais.00900
Available at: https://aisel.aisnet.org/jais/vol26/iss1/8

Journal of the Association for Information Systems (2025) **26**(1), 66-94
doi: 10.17705/1jais.00900

RESEARCH ARTICLE

ISSN 1536-9323

Digital Infrastructure Development Through Digital Infrastructuring Work: An Institutional Work Perspective

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Abstract

Being able to understand and characterize the digital infrastructure development (DID) process has become even more pressing today due to the rapid advent and implementation of new digital infrastructure (DI) in organizations as well as since the COVID-19 crisis. While information systems (IS) research has begun to recognize the institutional nature of such digital infrastructures, there remains a gap in our understanding of how such developments unfold from an institutional perspective. Through our field study of a digital infrastructure development project involving the implementation of an enterprise-wide electronic medical record system at a large US medical facility, we show how the tensions in the DID process were linked to the institutional work these organizational actors performed when they attempted to disrupt and protect the hospital's institutional arrangement. We introduce the "digital infrastructuring work" concept to describe the combinations of digital object work, DI relational, and DI symbolic work enacted during DID. Specifically, digital object work reveals how material institutional work is directed at multiple DI elements. Our findings also highlight how organizational actors combine DI relational work and DI symbolic work with digital object work to shape the overall DI. As such, our study shows how organizational actors go beyond symbolic and discursive forms of institutional work, and digital object work in particular, to achieve DID outcomes. Future research could explore digital infrastructuring work in different organizational and technological settings.

Keywords: Institutional Work, Case Study, IT Infrastructure Management, Digital Infrastructure Development, Interpretive, Digital Objects, Digital Materiality

Matthew Jones was the accepting senior editor. This research article was submitted on December 21, 2020, and underwent six revisions.

1 Introduction

Digital infrastructures (DIs) are an increasingly significant feature of modern economies that have permeated our social, organizational, and physical environments (Baskerville et al., 2020; El Sawy et al., 2010). DIs develop more quickly and dynamically than other infrastructures, as demonstrated by the rapid adoption of new technologies. Examples include the organizational use of big data analytics and artificial intelligence and the innovative adaptations of existing systems that have been used to cope with the COVID-19 crisis (Brynjolfsson et al., 2020; Linacre, 2020). Given their dynamism and importance, there is a strong research motivation to understand how DIs emerge and evolve from a sociotechnical perspective (Edwards et al., 2009; Hanseth et al., 1996; Henfridsson & Bygstad, 2013; Star & Ruhleder, 1996).

Current DI research has highlighted various challenges in the DI development (DID) process regarding, for example, enterprise systems implementation and platform deployments (Tilson et al., 2010). In particular, the problems of embeddedness and the "paradox of change" highlight the tensions between seeking stability in installed infrastructures and accommodating the changes arising from new systems (Fürstenau et al., 2019; Henfridsson & Bygstad, 2013; Tilson et al., 2010). However, DI research often focuses on social interactions during the design stage or stakeholder management and inadvertently relegates the technical work to the background. While some IS studies provide a more granular understanding of the nature and elements of DI (Hanseth & Lyytinen, 2010; Kallinikos et al., 2013; Yoo et al., 2010), these concepts have not been incorporated into DI research. Viewing DIs as inherently institutional (Baskerville et al., 2020), we adopt an institutional work perspective to analyze the tensions and challenges in DID. Specifically, we argue that institutional work may be a productive lens as it recognizes the roles of both social and technical actions in influencing the institutional links between elements of the DI and other aspects of its institutional context (Lawrence & Suddaby, 2006), which in turn shape the DID process. Thus, our research question is: What types of institutional work are enacted during DID in organizations and how does this influence the DID process?

The empirical basis of our research is a DID project involving the implementation of a next-generation enterprise-wide electronic medical record (EMR) platform in a large US hospital system. We zoomed into the troubled implementation at one clinic to demonstrate how the tensions in the DID process corresponded to organizational actors' institutional work, which involved various elements of the DI. Specifically, we introduce digital infrastructuring work as a type of institutional work to characterize the combinations of digital object work, DI relational work, and DI symbolic work that organizational actors enacted during DID. We show how these three forms of digital infrastructuring work are linked to the DID process by explicating how they relate to the respective DI elements and DID project levels. We theorize how each form of digital infrastructuring work may be enacted in other DID projects as well as how the three forms may be sequenced to complement each other to achieve specific DID outcomes. Our findings thus show how DID implementation activities have institutional importance and that the concept of digital infrastructuring work can be built upon to theorize institutional work enacted in other digital contexts.

The rest of this paper proceeds as follows. In the next section, we present our theoretical framework, encompassing our conceptualization of DID, which was built on DI research, and relate it to the institutional work perspective. Next, we discuss the empirical settings and our research methods. We then present our findings on the institutional work enacted during the DID project. We end with a discussion of the key theoretical insights and the contributions of our findings to DI and institutional work research.

2 Theoretical Framework

2.1 Digital Infrastructure Development (DID) Research

To understand DID, we first draw on IS literature to define and summarize the structure and properties of DI. IS research has studied DIs that vary in size, function, scope, and across multiple contexts (Hanseth & Braa, 2001; Karhu et al., 2018; Koutsikouri et al., 2018; Pipek & Wulf, 2009; Star & Ruhleder, 1996). We adopt Tilson et al.'s (2010) definition of DI as "an evolving sociotechnical arrangement comprising an installed base of heterogeneous digital objects, systems, processes, and their users that enable the focal entity to function."

The DI's inherent properties are based on its basic building block—the digital object, which is defined as "an object whose component parts include one or more bitstrings" (p. 1285), where "bitstrings" refer to program files or data files (Faulkner & Runde, 2019). Structurally, we adapted Hanseth and Lyytinen's (2010) framework, which conceptualizes DI as recursively composed of three nested elements—digital objects (while Hanseth & Lyytinen, 2010, referred to this element as digital capability, we noted that it is more consistent with extant literature to refer to this as digital object as per Faulkner & Runde, 2019), digital applications, and digital platforms—as well as the interfaces that connect these elements together (Fürstenau et al., 2019; Wimelius et al., 2021). (See Table 1 for DI elements.)

A "digital object" is the first level DI element and it enables user(s) to perform a specific set of actions. An example would be a text editor. The DI element in the next nested level is the "digital application." A digital application comprises various combinations of digital objects to meet a set of specified user needs and/or to perform a set of specific bounded tasks. An example of a digital application is a software module that manages financial capabilities such as accounting, budgeting, and costing (Fürstenau et al., 2019). The third level is the "digital platform," which is the largest and most complex DI element. It refers to a semi-closed, highly complex suite of digital applications and/or objects organized by a set of frameworks to address a family of generic functional specifications, which meet the needs of heterogeneous user communities. An example of a digital platform is an ERP package that contains a framework to organize different functional systems like sales, finance, or human resource modules to meet the needs of different user groups within an enterprise.

Table 1. DI Elements

	Description	References
Digital object (first-level DI element)	A digital object is an object (1) whose component parts include one or more bitstrings where bitstrings refer to program files or data files and (2) that enables user(s) to perform a specific set of actions.	Hanseth & Lyytinen, 2010, Faulker & Runde, 2019
Digital application (second-level DI element)	A digital application comprises a suite or various combinations of digital objects to meet a set of specified user needs and/or to perform a set of specific bounded tasks.	Fürstenau et al., 2019; Hanseth & Lyytinen, 2010
Digital platform (third level-DI element)	A digital platform refers to a semi-closed, highly complex suite of digital applications and objects organized by a set of frameworks to address a family of generic functional specifications that meet the needs of heterogeneous user communities.	Hanseth & Lyytinen, 2010
Digital interface (connecting DI element)	A digital interface refers to a specific DI element that enables the different DI elements to be recursively interconnected.	Ghazawneh & Henfridsson, 2013; Hanseth & Lyytinen, 2010
Digital Infrastructure (DI)	"An evolving sociotechnical arrangement comprising an installed base of heterogeneous digital objects, systems, processes, and their users that enable the focal entity to function." The installed base is made up of multiple, nested elements—digital platforms, digital applications, and digital objects.	Bowker & Star, 1999; Hanseth & Lyytinen, 2010; Tilson et al., 2010

An ensemble of these DI elements does not make up the DI, however, unless they are connected. Thus, the DI element "digital interface" enables different DI elements to be recursively interconnected. These digital interfaces are also called gateways (Hanseth & Lyytinen, 2010) and are considered boundary resources (Ghazawneh & Henfridsson, 2013). Examples of digital interfaces include APIs[1] and messaging systems. In addition to these elements, an established DI typically has an installed base, which is the existing configuration of digital objects, digital applications, and digital platforms (Hanseth & Lyytinen, 2010; Star & Ruhleder, 1996) that can be interconnected through digital interfaces to other platforms, applications, and objects. The installed base of a DI paradoxically enables and constrains the DI's openness since new applications or platforms can only be integrated and made compatible with the installed base using agreed-upon standards and digital interfaces (Bowker & Star, 1999; Tilson et al., 2010).

There is significant interest in DID, as prior research shows that understanding change is key to managing DIs given the dynamic character of its elements and its inherent generativity (Henfridsson & Bygstad, 2013; Lyytinen et al., 2018; Monteiro et al., 2014; Tilson et al., 2010). Current DID studies focus on a range of issues from sociotechnical design challenges to social interactions among stakeholders with respect to the DI standard-setting work (Sahay et al., 2019; Star & Ruhleder, 1996; Tilson et al., 2010).

First, research shows that DID involves technical work comprising two distinct operations on a DI. The first operation involves configuring new structural and organizational relations among the DI elements and its digital interfaces to other platforms, while also reconfiguring existing relations (Tilson et al., 2010; Yoo, 2012). The second operation involves changing the elements within the current DI through other digital objects. This reflects the digital objects' self-referential nature, in that DID requires digital objects to access, assemble, and stabilize other digital objects within the DI elements (Kallinikos et al., 2013; Yoo et al., 2010). Often, this operation also leads to the introduction of new DI elements or the revision of existing ones and related practices within its immediate context, such as the types of data for administrative processing (Sahay et al., 2019; Ure et al., 2009). Together, these two operations in DID sensitize us to the technical (re)configuring and computational work that is involved in the design phase while keeping in mind the "shifting interdependencies" of new relations and the new capacity of digital objects within the ecology of its immediate and external systems (Kallinikos et al., 2013; Yoo et al., 2010).

Second, DID research also shows that DI and its elements are "embedded" in existing social arrangements so that their functionalities and the uses of the elements are directly and indirectly interlinked

[1] An API is a digital object that contains definitions and protocols that specify how different software components can be integrated.

with social arrangements, such as norms, practices, organization processes, roles, and rules (Pipek & Wulf, 2009; Star & Ruhleder, 1996; Vaast & Walsham, 2009). Thus, DID also involves social actions that intersect social practices and the DI elements (Edwards et al., 2009). As a result, the DI not only enables but is also enabled by these social arrangements (Faulkner & Runde, 2019; Kallinikos et al., 2013). At the same time, a DI's connectivity to other infrastructures is dependent on liminal standards, which are contingent on standard-setting actions, e.g., negotiations among DI stakeholders to resolve the tensions between global standards (such as on data) and local flexibility (Eaton et al., 2015; Henfridsson & Bygstad, 2013; Hepsø et al., 2009). In turn, these changing standards may affect the connectivity and effectiveness of the DI.

Third, because the DID process often uncovers tensions between infrastructural changes and their embedded processes and social practices, some DID studies have focused on aligning processes during the use phase. These processes usually involve extensive negotiations among the affected social groups while designing new digital applications and processes within existing DIs. This, in turn, may lead to conflicts and ongoing challenges for the DID (Fürstenau et al., 2019; Wimelius et al., 2021). For example, the DID process may get stuck or even break down due to failed attempts to align organizational processes and practices with changes in the DI (Bygstad and Øvrelid, 2020). In some cases, existing DI owners and opposing application designers may engage in tit-for-tat strategic actions—DI owners may roll out standardized classifications to extend functions and new services that are in turn resisted by opposing actors through new workaround applications and the mobilization of their supporters (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013; Koutsikouri et al., 2018).

Tilson et al. (2010) suggest that this tension in DID points to an inherent challenge in managing and developing DI, the so-called "paradox of change." This refers to the need to maintain or restore the DI's installed base's stability to enable the DI's generative capacity to change (Tilson et al., 2010). Thus, DID, on the one hand, requires malleable digital objects and digital applications to provide the DI's generativity (Henfridsson & Bygstad, 2013). On the other hand, it also requires the installed base to have "settled" sociotechnical arrangements to maintain its stability (Edwards et al., 2009; Fürstenau et al., 2019). At the element level, DID needs to keep the installed DI stable, so that they can innovate by connecting new digital objects and applications. Similarly, at the organizational and social level, DID involves bringing about negotiated standards and processes, which provide the basis for common digital interfaces and shared processes for DI to operate smoothly, thus ensuring social stability.

In summary, the current literature shows that DID can be understood as a process involving technical work acting on the elements of existing and new DIs that are embedded in nested arrangements. It is a complex process that involves, on the one hand, know-how to configure the relations among these elements with the DI's installed base and external platforms and, on the other hand, the knowledge of social practices that are intertwined with these changes. This is further complicated by the paradox of change inherent in DIs, whereby the stability of its installed base and standards must be balanced against its generative capabilities and evolving functions and scope.

While these insights on the complex dynamics of DID are useful, most DID research focuses on the social interactions (e.g., negotiations) during the technical design work phase (Ure et al., 2009), the standard-setting among high-level stakeholders (Henfridsson & Bygstad, 2013), or the process development phase (Bygstad and Øvrelid, 2020). As a result, the actors' technical work does not feature in the main analysis of these studies (with the exception of Karhu et al., 2018), and serves mainly as the backdrop for social interactions. As a result, it is not clear how the combination of social and technical actions undertaken by organizational actors influences the conflicts and tensions between new DI elements and existing organizational arrangements. It is then even less clear how such actions interact with one another to shape the DID process. More importantly, while it recognizes the sociotechnical nature of DI, existing research has not carefully considered the institutional aspects of DID.

2.2 Institutional Work and DI

Understanding the dynamics of change and stability has been the preoccupation of institutional analysis in IS studies (Currie, 2011; Hinings et al., 2018). Indeed, scholars have suggested that DIs are inherently institutional in nature (Baskerville et al., 2020; Hinings et al., 2018; Markus, 2017), pointing to the influence of large-scale DIs (such as e-commerce, web services, and e-payment arrangements) on organizations' and individuals' lives, which supports the argument that a growing number of institutional arrangements are digital in nature (Giraldo-Mora et al., 2019; Hinings et al., 2018; Tilson et al., 2021).

At the same time, institutional scholars have suggested that the work of rendering digital objects, applications, and platforms "infrastructural," or what we refer to as DID, is also institutional because much of the standard-setting work and social stability efforts deal with the legitimacy of novel systems and innovative uses of DIs (Garud et al., 2002; Nielsen et al., 2014; Orlikowski & Barley, 2001; Sahay et al., 2019). For example, builders of novel DIs like blockchain technology work on managing its legitimacy challenges in the financial industry (Hinings et al., 2018). At the same time, DID research focused on organizational DI projects has also shown that such projects cannot escape from institutional pressures (Hansen & Baroody, 2020; Nielsen et al., 2014) because the change that ensues is capable of "settling" into and fusing with the organizational status quo, involving "structures, activities and action at multiple levels of analysis" (Hinings et al., 2018, p. 53). As such, we argue that researchers should analyze how organizations manage the DID process from an institutional angle (Hinings et al., 2018) and draw mainly from the institutional work perspective to make sense of the phenomenon.

In its focus on *how* actors engender institutional change, the institutional work perspective highlights the dynamic and emergent character of the DID process, as well as the distributed nature of institutional work. Thus, diverse groups of actors may sometimes act in coordination and, at other times, in uncoordinated ways. Actors may also combine actions or respond to one another's efforts so that their net effect may lead to varying degrees of change or stability (Delbridge & Edwards, 2008; Lawrence et al., 2011). We argue that institutional work as a perspective also provides a framework to consider the social and technical, particularly how the latter reveals the material elements in DID that are subject to actors' behaviors. Over the next few paragraphs, we describe the various ways to characterize institutional work and relate it to IS research.

Broadly, institutional work is defined as "behaviors actors engage in to maintain, create or disrupt institutions" (Lawrence et al., 2011). Research on institutional work mainly follows this foundational typology, often highlighting the different types of actions associated with each intended institutional outcome (i.e., creation, disruption, and maintenance) (Lawrence & Suddaby, 2006). For example, in dealing with legal issues across jurisdictions, global law firms have redirected normative networks during creative institutional work to legitimize the practices they have engaged in overseas that might be contested in their "home" communities (Smets et al., 2012).

Institutional analysis has begun to move beyond characterizing institutional work according to the intended outcomes, as mentioned above. This shift came about as researchers discovered other ways of understanding the complex nature of work committed to changing or preserving the institutional order. One emerging stream of research highlights the qualities immanent in institutional work, specifically its *symbolic, relational, and material properties* (Hampel et al., 2017; Lieftink et al., 2019; Svensson & Gluch, 2017).

Symbolic work refers to actions that use elements such as narratives, identities, categories, rules, and scripts in institutional work. Studies of symbolic work often include theorization, where organizational actors frame an issue or an action in ways that support or undermine a cause, whether it is for changing or maintaining the status quo (Currie et al., 2012; Greenwood et al., 2002). This includes acts other than making something meaningful (e.g., theorization of why change is better); organizational actors may choose to cast it as meaningless by highlighting how new things do not fit with prevailing paradigms. For example, to resist the change in regulation concerning financial markets in Europe, large international banks and other organizational actors in their coalition have constructed "incommensurables" that specify how the proposed changes from regulators are incompatible with the idiosyncratic nature of existing practices (Weiss & Huault, 2016).

Relational work refers to actions that rely on the interactions among organizational actors to produce institutional outcomes. Studies in relational work illustrate how organizational actors engage one another through coalitions or rivalries that leave an institutional impact (Lawrence et al., 2002; Lieftink et al., 2019; Ozcan & Gurses, 2018). Relational work involves strategic action that requires social skills and the mobilization of organizational actors in powerful social positions (Battilana et al., 2009; Fligstein, 1997). Social skills often involve convincing and negotiation, especially in terms of legitimizing points of view and building a shared understanding of the situation (Fligstein, 1997). Rather than directly engaging, actors may choose to disengage, i.e., perform "avoidance work" to resist change in more subdued and subversive ways (Xiao & Klarin, 2019).

The use of material elements in institutional work is an emerging area of research. *Material work* refers to purposive actions that mobilize the physical and more obdurate aspects of the institutional environment. It is also capable of creating and disrupting, as well as repairing and restoring the institutional order (Lawrence & Suddaby, 2006). Compared to symbolic and relational work, material work studies are fewer and more recent (De Vaujany et al., 2018; Sielbert et al., 2017). This small but growing stream of research recognizes organizations as being materially situated, and their built environment can impinge upon decisions, actions, and the institutional order (Guthey et al., 2014). They highlight that purposive actions also involve the more obdurate elements in the institutional environment, including the use of physical objects (Monteiro & Nicolini, 2015), space (Sielbert et al., 2017), and geographical locations (Lawrence & Dover, 2015). Research on material work has also included elements with a digital nature (Raviola & Norbäck, 2013; Svensson & Gluch, 2017; Thorseng & Grisot, 2017; Wahid & Sein, 2014). For example, when understood as ensembles of digital objects, websites are created and deployed not only to ensure the continuity of both newly installed and legacy practices but also to extend the reach of these practices to a new or wider audience (Monteiro & Nicolini, 2015; Raviola & Norbäck, 2013). Others explore how actors draw on various "social inscriptions" within digital applications and healthcare systems as part of their institutional work to create and legitimize new practices (Sahay et al., 2019; Thorseng & Grisot, 2017). This material-digital profile of institutional work is especially important for understanding the DID process because it highlights how the technical work that organizational actors perform during DID will involve digital objects and their configurations within existing and new DIs, even as they enact symbolic and relational work.

How institutional work maintains, creates, and disrupts the status quo or the institutional arrangement symbolically, relationally, and materially depends on the contextual settings. At its core, an institutional arrangement functions under the influence of the mix of institutions that bear upon a phenomenon. More concretely, it guides how actors are organized and interact with each other (Koskela-Huotari & Vargo, 2016; Sajtos et al., 2018), defining the roles they play (Mena & Suddaby, 2016; Thorseng & Grisot, 2017), as well as their membership and boundaries (Lawrence et al., 2011) during institutional work. From this perspective, an institutional arrangement has been expressed in various ways, such as frames, norms, practices, and patterns (Guillemette et al., 2017; Hargrave & Van de Ven, 2006; Zietsma & McKnight, 2009).

The construct of "institutional arrangement" has been an integral part of the institutional toolkit,[2] with its constitution enjoying considerable conceptual flexibility depending on the research context. An institutional arrangement can also relate to emerging types of configurations, including digital institutional infrastructures, digital organizational forms, and digital institutional building blocks (Hinings et al., 2018). While it may vary from single actors to social collectives even as large as societies, its analytic utility comes through when it is specific to the institutional context under which the analysis is performed (Hargrave & Van de Ven, 2006). For example, it was clear that the institutional arrangement in the Guillemette et al. (2017) study pertained to the IT function in a healthcare organization, on which institutional work was being performed.

In summary, the institutional work perspective provides a means to better understand the technical work that is under-researched in sociotechnical research on DID by attending to the symbolic, relational, and especially the material dimensions of purposive actions during the DID process. In addition to highlighting the established and taken-for-granted (i.e., institutional) nature of DI, using the institutional work perspective also unpacks how the different types of work actors engage in to achieve their outcomes may bring about both intended and unintended consequences for the DI. Stated differently, while current DID research may consider development challenges as issues of social interactions among designers or senior management stakeholders vis-à-vis its infrastructure evolution, the institutional work perspective considers such challenges in the form of relational, symbolic, and material actions that may intentionally or unintentionally disrupt institutional links within the installed base and new DI elements. The material actions, in particular, make more visible the technical work that has been understudied in DID research.

3 Methods

To understand how the DID process is linked to institutional work, we report on an in-depth longitudinal field study of a healthcare DI project within a hospital system. We first provide the context of our empirical setting to help readers appreciate the institutional changes related to this DID project, particularly those in the hospital ambulatory diabetes clinic, the focal site of our study.

This case study had several attributes that fit our research question. First, this was not a project that developed a de novo infrastructure. As a result, it faced significant challenges when the new EMR platform had to connect to two existing platforms in the DI. Second, this project occurred within the healthcare industry, a sector that continues to face the ongoing challenge of integrating EMR systems with other technologies due to the fragmented and contested nature of healthcare organizations (Hansen & Baroody, 2020; Scott et al., 2000). As such, even though this case study took place more than 10 years ago, the challenges and insights are still relevant for today's healthcare organizations and their DI projects (Daly, 2016). Third, the authors had direct access to the project and were able to gain a privileged view and bring the "coalface experience" (Barley, 2008) into how institutional work occurred through mundane DID project activities.

3.1 Empirical Setting

The setting for our study was the development of a new digital platform—an ambulatory EMR (AEMR) platform—within a private, not-for-profit academic

[2] See for example, studies such as Seo and Creed (2002) and Lawrence and Suddaby (2006), as well as, more recently, Mena and Suddaby (2016) and Hinings et al. (2018).

hospital system, Centralsys. Centralsys (pseudonym) is a large US mid-Atlantic hospital managing 200,000 patient visits a year. There were two main stakeholders, the Centralsys hospital administration and the School of Medicine (SOM). SOM (pseudonym) is a public medical school and its faculty serve as clinicians for the private practices at Centralsys. SOM's subsidiary—SOM University Physicians Inc. (SUPI) (pseudonym) — coordinates and supports SOM clinical activities by managing Centralsys' private practices' revenue and billing processes.

The vision for the new healthcare DI and its contestation: In 2006, the new Centralsys CEO envisioned a new healthcare DI (with the new AEMR as its core) that would rein in the existing disparate, idiosyncratic administrative processes embedded in its institutional arrangement. This new DI particularly impacted the administrative processes in the SOM-led ambulatory clinics that operated as de facto independent practices. The AEMR was to be implemented in the new centralized ambulatory service center managed by Centralsys' hospital administration to enable the ambulatory patient and clinic data to be integrated with the hospital databases.

The CEO's plan to rework the institutional arrangement (including the existing DI and established organizational practices in ambulatory clinics) represented a direct challenge to SOM's ingrained inpatient-centric care model. SOM clinicians saw themselves as "bedside-to-practice" providers that translate cutting-edge clinical research into the best patient care, and they actively opposed the plan. Furthermore, the reworked arrangement would cut SUPI's revenue derived from its registration and billing support to SOM-led clinics. As reported in our previous study (Yeow & Lim, 2017), because of the fierce opposition from SOM, only a partially working pilot system was deployed in three ambulatory clinics *outside* Centralsys' hospital compound after two years. This study follows the intense efforts of the AEMR project team to finally implement the AEMR platform in the diabetes clinic, the first ambulatory clinic located within the Centralsys hospital. The institutional arrangement at the clinic is outlined below.

The institutional arrangement at the Diabetes Clinic and how the AEMR implementation was stalled: Our description is not meant to map out the entire institutional arrangement at the diabetes clinic; rather, we use the institutional arrangement as a "sensitizing concept" (Charmaz, 2014) to help us attend to how established diabetes clinic practices were tied to specific actors and DI elements before and during the implementation (DID) process. This helped us understand how attempts at changing and keeping the arrangement led to specific outcomes. Specifically, we treat the various digital platforms and their connections with the established SUPI and Centralsys practices as part of the clinic's institutional arrangement.

The diabetes clinic utilized a "one-stop-shop" care-delivery approach where a patient could consult multiple specialists in a single visit. Before the AEMR implementation, a new patient was registered twice: first, manually in SUPI's IDX registration and scheduling systems and, second, after the appointment was scheduled, in the Centralsys' STAR registration system. During the appointment, the diabetes clinic staff checked the patient's insurance status, which had to be verified by SUPI and prepared individually for the multiple clinic consultations. After consultation, the specialists would file their individual paper clinical notes and paper charge forms for the clinical encounter and hospital services. Because the SOM specialists belonged to different private practices under SUPI, the hardcopy clinical encounter forms were separately processed by the respective SUPI professional billing offices for data entry into the IDX billing system. The clinic billing staff only processed the Centralsys hospital service charge forms into the STAR billing module.

With AEMR, the diabetes clinic staff were expected to use the new integrated platform under the new organizational practices for all registration, appointment, and billing, removing all paper-based processes. (See Appendix Figures A1 and A2 for the DI and processes in the diabetes clinic before and after AEMR.)

Unfortunately, the AEMR team failed to integrate the relevant digital objects and digital applications across the AEMR, STAR, and IDX platforms. Worse, clinic staff had to revert to paper-based processes because the AEMR could not handle patient billing digitally. This reversion became a major bottleneck in the clinic. The billing challenge was further exacerbated by errors in the AEMR, such as incorrect billing rules that reduced the clinic's revenue. This led to major dissatisfaction among the diabetes clinic staff, clinicians, and patients alike. The SOM Dean intervened, demanding Centralsys' management to "cease and desist" from further AEMR implementation. Three months after the AEMR was implemented in the diabetes clinic, the AEMR project came to a "screeching halt" in September 2008 (Centralsys CIO interview).

3.2 Data Collection

The data primarily came from our semi-structured interviews and observations at the diabetes clinic and AEMR project team sites, supplemented with archival data from media and internal publications. Our case study followed the "ethnography of infrastructure" approach (Star, 1999; Star & Bowker, 2006), as it surfaced the otherwise invisible work performed in information systems, where the actions of the Centralsys AEMR team, SUPI team, and other related technical teams illuminated how various forms of institutional work intertwined with aspects of the healthcare DI while it was built.

Interviews: Data collection began in 2007 when we negotiated access with the Centralsys CIO to study the implementation of the AEMR. The Centralsys CIO served as the sponsor for this research project as he was interested in understanding the impact of the new AEMRS on the clinics. In total, two of the authors conducted three rounds of interviews—in 2007, 2009, and 2010—and completed 51 formal interviews with 22 interviewees from Centralsys, SOM, SUPI, and the AEMR team. The interviews ranged from half an hour to 1.5 hours. They focused on the interviewees' experience of the project events. While a protocol was used for the initial interviews (e.g., background of interviewee, their role, and the events related to the beginning and earlier phase of the AEMR project), the latter interviews focused mainly on the challenges of the project implementation. (See Table 2 for the breakdown of the interviews by organization and phases.) Although our interviews were conducted intensively over three sessions from 2007 to 2010, the participants' accounts were invariably vulnerable to memory slips and other social psychological biases, such as retrospective interpretation. We attempted to mitigate this limitation by triangulating such accounts among interviewees and with observation notes, as well as with documents, such as internal reports, meeting minutes, and news reports.

Observations and archival data: As part of the access agreement, one of the authors was embedded in the AEMR team as an observer and experienced multiple phases of the implementation from mid-July 2007 to May 2008. During this period, he spent an average of 2-3 days at the project team office and two to three days at the clinics per week. The fieldwork location was determined by the project schedule (e.g., he would be at the project team office when there were important team meetings, and at the clinic during training sessions or after implementation to observe the users). He spent an average of 4-5 hours a day at the AEMR team office and implementation sites during the key implementation periods. He observed and took notes at various meetings where key players from Centralsys and SOM, SUPI, and the AEMR team interacted. As different issues were discussed at various levels, he attended meetings held with the steering committee (comprised of senior management from Centralsys, SOM, and SUPI), the advisory committee (comprised of senior clinicians and operations members), the platform project, and subproject levels. Each meeting lasted one to two hours. Observations from the meetings were written in the field notes. Over time, the author built sufficient rapport with the project team and clinic staff to the extent that he was able to generate extensive field notes through informal interviews and attending casual gatherings at the project sites (e.g., lunches, breaks, and office festivities). These meetings, field notes, and informal interview data provided insights into the actions of the various actors. He also collected archived minutes of other key meetings, documents (e.g., planning, internal reports), and media articles to enrich the interview and observation data. (See Table 3 for a summary of the observations and documents.)

Table 2. Interview Data

Interviews (breakdown by organization and phases)		
2007		
Organization / level	**No. of interviews**	**No. of interviewees**
Centralsys, SOM, and SUPI (steering committee)	11	4
AEMR platform project management	10	5
AEMR subproject staff	12	10
Subtotal	***33***	***19***
2009-2010		
Centralsys, SOM, and SUPI (steering committee)	8	6
AEMR platform project management	6	6
AEMR subproject staff	4	3
Subtotal	***18***	***15***
Grand total	**51**	**22**

Table 3. Summary of Observations and Documents

Observations	**Project team**	**Clinics**
Field visits	8	90
Meetings	48	9
Documents	Official project meeting minutes, internal reports, and project issue database	

3.3 Data Analysis

First, we constructed a chronological case study of the AEMR project using data from the interview transcripts, field observation notes, and meeting minutes (Langley, 1999). We narrowed our analytical focus to the patient billing and registration processes at the diabetes clinic, as they were representative of the critical issues that led to the stalled DID. Next, we iterated between the data and different theoretical lenses to understand why the DID was stalled (Charmaz, 2014; Corbin & Strauss, 2015). As a result of these theoretic-empiric iterations, we narrowed our scope to reviewing the literature on DI and institutional work, which helped us understand how and why the AEMR project had been stalled (Berente & Yoo, 2012). Specifically, we found that the interviews and meeting minutes revealed two key DI challenges that impacted the registration and billing processes: data harmonization and bidirectional link challenges.

Using these key DI challenges as our focus, we conducted the first round of coding of the organizational actors' (AEMR, SUPI, and Centralsys teams) actions. We coded each action in terms of who performed it (the organizational actor), their intent, their actions, and if there were DI elements involved (as per Table 1). Two of the authors were involved in this round of coding: the authors coded the data separately and then worked together to discuss the differences in their interpretation of codes and to consolidate the codes according to the categories that formed our first-order codes (See Table 4, Column 3). In the next round of coding of actions, we compared the first-order action codes with Hampel et al.'s (2017) framework of institutional work. We found that the coded actions could be broadly mapped to Hampel et al.'s (2017) symbolic work, relational work, and material work. However, given that most institutional work studies do not focus on digital objects or occur in the context of digital infrastructures (e.g., Eaton et al., 2015; Thorseng & Grisot, 2017), we were open to seeing emergent themes from the data. As such, for each of the categories, we iterated between the literature and our data to develop the second-order codes and aggregate concepts.

In the case of material work, we probed the specific institutional work done by organizational actors that directly related to DI elements (i.e., the digital platform with its attendant digital objects, applications, and interfaces). Following this analysis, we found a new form of material work that emerged from the data, which we termed "digital object work." Specifically, "digital object work" comprised three second-order categories: "reprogramming structures," "connecting to installed base," and "injecting changes to installed base."

In the case of DI relational work, we noted that while they resembled existing institutional actions such as avoidance work, mobilization, and negotiating, these institutional actions were DI-specific in terms of the specific DID targets and DID project level in which they were enacted. Thus, we coded DI relational work as comprising "avoiding" (targeted at digital object work at the subproject level), "negotiating" (targeted at agreements for digital object work at subproject and platform levels), and "mobilizing" (targeted at reengaging actors at the platform and steering committee levels).

Likewise, for DI symbolic work, we noted that while some actions resembled the institutional work research notions of "theorization" or "constructing incommensurables," our symbolic actions appeared to be qualitatively different, in that they were linked to specific DI elements. We term the aggregate concept DI symbolic work, comprising "asserting embedded rigidity" (linked to digital objects), "incommensurability" (linked to digital interfaces), and "undermining" (linked to digital platforms). (See Table 4 for the codes' data structure.

We then explicated the key theme of digital infrastructuring work,[3] which comprises specific DI digital object work (reprogramming structures, connecting to installed base, and injecting changes to installed base), DI relational work (avoiding, negotiating, mobilizing), and DI symbolic work (asserting embedded rigidity, incommensurability, undermining). We noted that the symbolic and relational work arose from direct interactions with or because of digital object work on the DI. This grounded approach gave us the confidence to label these actions as DI-specific institutional work. Finally, we reviewed and juxtaposed the digital infrastructuring work against the specific DI elements and project structures (steering committee, platform project, and subproject teams). (See Appendix Tables A3 and A4 for detailed data). We developed theoretical insights based on that analysis to understand how these interactions shaped the outcomes of the project.

[3] Our concept of digital infrastructuring work differs from Star and Bowker's (2006) and Pipek and Wulf's (2009) concept of infrastructuring, in that we focus on the material, symbolic, and relational actions that create, disrupt, or maintain the institutional arrangement linked to existing DIs, while their focus is on the ongoing activities required to make infrastructure work for the focal users. As such, our concept is more specific and focuses on the type of infrastructure (digital) and its application (institutional work).

Table 4. Data Structure

Aggregate concept	Second-order codes	First-order codes	Definition of second-order code
Digital object work (a form of material institutional work that mobilizes different DI elements to change or maintain the existing DI)	Reprogramming structure	• Creating new data definitions and structures in digital objects and applications • Enforcing new data structures digital objects and applications • Building new guidelines for implementing new data structures	Actions that create a new standardized structure for the digital objects residing on the new and the existing DIs.
	Connecting to installed base	• Establish scope and basis for links to the installed base • Developing and mapping links' interface scope • Testing the effectiveness of links	Actions that construct new sociotechnical arrangements made up of both new and installed DI by mobilizing the different systems' digital interfaces.
	Injecting changes to installed base	• Introducing new updates and changes to the installed digital platform (base) that interfere with DID • Requesting links to work with updates in the installed digital platform	Actions that introduce upgrades and changes to the existing digital platform to interfere with the efforts to connect the new digital platform to the DI's installed base.
DI relational work (a form of relational institutional work where organizational actors act to enable or disrupt collaboration across the DID project teams to change or maintain the existing DI)	Avoiding	• Inactive in development • Refusing to participate and complete required DID tasks • Delaying the completion of DID tasks	Actions that resist DID tasks in a subdued manner in that actors choose to disengage.
	Negotiating	• Developing agreements among parties for active collaboration	Actions that involve strategic interactions among actors to influence each other for or against the DID.
	Mobilizing	• Actively engaging with actors to collaborate for DID • Requesting additional resources from counterparts for DID • Escalating DID issues to senior management at higher project forums	Actions that use social skills to engage actors in powerful social positions in the DID.
DI symbolic work (a form of symbolic institutional work where organizational actors employ discursive actions linked to different DI elements to maintain or change the existing DI)	Asserting embedded rigidity	• Invoking the embeddedness of digital objects with existing institutional practices • Problematizing the DID's disruption to existing practices	Actions that defend the existing localized structure of their databases (digital objects) due to its strong embedded relationship with existing institutional practices.
	Incommensurability	• Claiming that the digital platform's interfaces and link with existing institutional practices and arrangement make it incommensurate with new digital interfaces	Actions that specify how new digital interfaces and links are incompatible with existing platform's interfaces and links with existing institutional practices.
	Undermining	• Arguing that new infrastructure vision is not viable due to the new platform's lack of existing functions • Arguing that the new infrastructure vision is ineffective due to the new platform's impact of increasing inefficiency	Actions that use theorizing to cast the new digital platform's role as meaningless.

Table 5. Overview of Types of Digital Infrastructuring Work in Each Challenge

DI challenges \ Digital infrastructuring work	Digital object work	Digital relational work	Digital symbolic work
Data harmonization	Reprogramming structures	Avoiding Mobilizing Negotiating	Asserting embedded rigidity
Bidirectional linking	• Connecting to the installed base • Injecting changes to the installed base		• Incommensurability • Undermining

4 Findings

We consider how the AEMR project stalled after DID was implemented in the diabetes clinic by focusing on the two critical DI challenges faced by the AEMR team. These challenges involved (1) data harmonization, which is related to connectivity and standards, and (2) bidirectional linking, which is related to the paradox of change. Next, we unpack the digital infrastructuring work observed in each of the challenges. We show that digital infrastructuring work includes the digital object work enacted by the different groups of organizational actors along with DI relational and DI symbolic work to achieve their DID goals. See Table 5 for an overview of the different types of digital infrastructuring work occurring for each challenge. Finally, we explain how their efforts led to the eventual outcome discussed above.

4.1 Critical DI Challenges

Data harmonization across different payor plan databases: The AEMR project's data harmonization challenge revolved around standardizing the AEMR platform's patient payor plan database with the existing patient payor plan databases in the IDX and STAR platforms that stored the patient's insurance plans (such as name of plan, coverage, and validity) and were linked to the registration and billing processes. The AEMR platform was not able to replace the IDX's registration and scheduling processes, nor could it be integrated with the different billing systems if its payor plan database structure was too different from the IDX and STAR payor plan databases.

Unfortunately, the IDX and STAR payor plan databases supported different organizational practices. In particular, the IDX database was more restrictive and prescriptive than the STAR database because it had to support professional fee billing that accepted different parts of 1,200 named insurance plans. On the other hand, the STAR database had only 200 payor plans and even allowed users to use free text entry for the plans. Its focus was on efficiency in supporting internal hospital billing practices, such as charges for supplies, laboratory tests, and radiology services.

Given this situation, the AEMR team had to work with the IDX and STAR teams to create a common payor plan database structure (through the new AEMR platform) that all three platforms could adopt in all ambulatory clinics. This standardization effort was highlighted as the AEMR team's priority task and was supposed to start in August 2006 (according to the project minutes).

Bidirectional linking and APIs: While the database harmonization was to ensure data standardization across platforms, the AEMR platform also needed bidirectional links so that it could send and receive patient and clinical data from the IDX and STAR platforms. Without the bidirectional links, data could not be synchronized across the platforms, even if the AEMR, IDX, and STAR teams successfully implemented the common payor plan database.

Bidirectional links were to be enabled by the digital interface—the API. For the new AEMR platform to connect to the existing installed base of the STAR and IDX platforms, the AEMR, IDX, and STAR teams had to first share their platforms' APIs with one another so that all parties knew the method and the programming code used for data exchange. Next, they needed to agree on what data from which databases would be sent and received and how to use the APIs. The data and location specifications of the API were closely tied to the clinic's existing and designed institutional practices. In this way, the APIs, like the payor plan database, were embedded within the existing institutional arrangement.

However, unlike the database, each API (digital interface) was specific to each version of the digital platform. This meant that even when the platform remained the same, differences in the underlying programming codes of the APIs could disrupt data exchange between the versions. Thus, in building the bidirectional links using APIs, the AEMR team's challenge was to manage the tension between the new and existing platforms. More specifically, changing the ambulatory clinic's DI required the current installed platforms to remain stable enough so that the AEMR team could connect the new AEMR platform to them; so that the AEMR could replace the installed platforms in the ambulatory clinics. (See Appendix Tables A1 and A2 for components of the Centralsys DI (before AEMR implementation) and the additional DI components in the planned AEMR.)

4.2 Digital Infrastructuring Work in Data Harmonization

In this section, we elaborate and discuss how digital infrastructuring work—i.e., digital object work (*reprogramming structures*), DI symbolic work (*asserting embedded rigidity*), and DI relational work (*avoiding, mobilizing, and negotiating*)—unfolded in the data harmonization challenge.

Reprogramming structures: In this type of digital object work, the organizational actors focused on creating a new standardized structure for the data residing on the new and the existing digital platforms to support the new organizational practices envisioned as part of the AEMR project. As highlighted above, this digital object work required the new and existing payor plan databases to be compatible, as they were tightly intertwined with their respective organizations' institutional practices.

As part of reprogramming the digital structure, the organizational actors conducted the following activities. First, the AEMR team had to work with the existing platforms' IT teams to review their different database structures and propose a set of commonalities.

Second, the teams needed to negotiate which aspects of their structures were critical to their existing organizational practices and which aspects could be removed. The AEMR project director mentioned this in their meeting with the physician advisory group:

> *Integration is the "dark side" of the project ... It is critical on this campus as we have an awful disparate system. ... We need to get the interfaces and payor plan master files to work with hospital sites. We need to cross matched [sic] them and we are trying to get the plans coordinated with STAR.* (December 4, 2007, meeting minutes).

However, a senior analyst on the AEMR team pointed out that: "The thing is that SUPI and Centralsys have separate needs and it is hard to get them to agree on the way that should be" (AEMR senior analyst interview). Despite the difficulties, the AEMR team managed to get both SUPI and Centralsys to agree to prioritize and collaborate on the common database structure analysis in late January 2007. As a result, while they were able to design most of the core parts of the common database structure, further analysis was needed to produce the complete database structure and for SUPI and Centralsys to edit their respective database structures accordingly.

From these activities, we observed that part of the reprogramming structure work required organizational actors involved in the existing infrastructure to build some level of consensus around the standardized database structure, which served as the blueprint to harmonize all the different databases. At the same time, the organizational actors needed to ensure that all the actors purposively leveraged the reprogrammability and editability of the database (i.e., digital capability), such that all the databases were harmonized according to the common database structure.

Asserting embedded rigidity: Both the IDX and STAR teams used *asserting embedded rigidity* work to respond to the AEMR team's reprogramming structure work. This DI symbolic work involved organizational actors defending the existing localized structure of their databases due to its strong embedded relationship with existing institutional practices. It was a response to the immediate pressure by the AEMR team to edit and change their existing database structures.

Asserting embedded rigidity work involved legitimizing the actors' refusal to change their database structures because they needed to retain the embedded relationships between their digital objects, platforms, and organizational practices. In the IDX team's case, they informed the AEMR team that after a comprehensive analysis, their payor plan database supported only SUPI's professional fee billing process. The IDX team thus rescinded their agreement to AEMR's proposed common database structure, arguing that their database structure could not be harmonized with AEMR's database structure.

The STAR team reacted similarly at a later point of the project (April 2007) when they compared the proposed common database structure to their existing database structure and realized that it would entail significant editing and reprogramming work to modify their current payor plan database. For example, they would have to build more payor plans in their database (see quote below). Moreover, they would have to create additional data fields since their database stored much fewer details compared to the IDX database.

> *IDX has about 1,200 [forms] while STAR has 300. The glaring discrepancy is that both billing systems have the same number of providers. The [IDX team] and [STAR team] are dragging their feet to resolve these discrepancies and it is just making the interfacing difficult and very challenging.* (AEMR project manager interview)

Adopting these changes would have severely disrupted Centralsys' inpatient processes that the STAR platform also supported. Thus, like the IDX team, the STAR team defended the need for their current database structure to remain the same, given how tightly embedded their digital objects and platform were with the established organizational practices.

In sum, *asserting embedded rigidity* was a major challenge for the DID process, as it interfered with standardization attempts. In contrast to institutional work that attempted to utilize the digital objects' reprogrammability and editability, organizational actors that sought to maintain the existing DI chose to highlight the rigidity of the digital objects' embedded relationships within the institutional arrangement. This rigidity legitimated these organizational actors' refusal to adopt a common standard and to edit their digital objects accordingly.

Avoiding and mobilizing: In addition, the IDX team responded to the AEMR team's reprogramming of digital structure work by *avoiding*, a type of DI relational work, involving delayed participation in the work on the common payor plan definitions. To counter this, the AEMR team enacted the DI relational work of *mobilizing* by escalating the issue to the AEMR project steering committee level. The steering committee agreed with the AEMR team that the standardized database structure was critical to the project. As such, the steering committee ordered both the IDX and STAR teams to restart work on the payor plan mapping. These actions enabled the AEMR team to continue with their digital object work.

However, this cycle was repeated when the AEMR team's attempt to make progress with the new digital object work was met by continued avoidance by the IDX team. The January 2007 meeting minutes noted that "to date, no inter-entity effort has emerged despite the numerous discussions." The AEMR team also complained that the IDX representative did not provide significant inputs and did not have any authority to negotiate the changes. Again, this led to another round of escalation through the AEMR team's *mobilizing* of senior representatives from SUPI to join the IDX team. As a result, the AEMR team was able to complete part of the common database structure.

Negotiating: The IDX team continued to stall the project, however, by failing to provide further inputs to the common database plans. This halted the entire data harmonization process. To restart the process, the AEMR team had to use different DI relational work—namely, *negotiating* directly with both the IDX and STAR teams. After several rounds of negotiations, the AEMR team managed to get the IDX and STAR teams to perform database harmonization for 25 selected payor plans to test the impact of these changes on their current organizational processes. This enabled the AEMR team to secure a minor success, but they faced ongoing difficulty in pushing for a common database structure for the rest of the plans.

4.3 Digital Infrastructuring Work in Bidirectional Linking

The bidirectional link challenge required other digital infrastructuring work—i.e., digital object work (*connecting to the installed base* and *injecting changes to the installed base*) and DI symbolic work (*incommensurability* and *undermining*) combined with the DI relational work (*avoiding, mobilizing, and negotiating*) identified earlier.

Connecting to the installed base: In relation to the bidirectional link challenge, the AEMR team worked on *connecting to the installed base*. This was critical because, on one level, the new AEMR platform served to replace both the IDX and STAR platforms in the Centralsys ambulatory clinics. On another level, it needed to be digitally connected to the two existing platforms to enable the new AEMR practices. *Connecting to the installed base* involved deploying the different platforms' APIs to connect both new and installed DI so that new organizational practices become practical and taken for granted.

This comprised three key activities. First, the AEMR team met with the IDX and STAR teams to understand the scope of the connection. Some examples of what was discussed include what APIs were required and how this scope was affected by the organizational policies (e.g., clinic compliance policy may influence what patient data may be shared).

> *We have a unique model for [AEMR]. Here we have bidirectional interfaces with two systems [STAR and IDX] … and this is a new thing for [AEMR] as they have only interfaced with STAR or IDX but not both together… So, they are familiar with some of this based on their previous experiences at other sites, but we are the only client where they have to integrate with both STAR and IDX using bidirectional interfaces.* (AEMR senior analyst interview)

Second, using the established scope, the AEMR team worked with the IDX and STAR teams to determine the specific interface requirements for each API, including fixing the data file formats and mapping the correct data source and destination. This occurred in April 2007, when the AEMR team was attempting to finish this work with the IDX team:

> *We try to send only those fields that are truly needed for registering the patient. With multiple bidirectional interfaces, we need to understand how much information is exchanged. So, we ask questions from the users of the current system, we do conference calls, brainstorm together to figure out who is impacted.* (AEMR senior analyst interview)

Finally, the AEMR team built and tested the bidirectional links with each of the existing platforms by testing the data exchange. Unfortunately, this was only completed with the STAR platform in July 2007, but not with the IDX platform.

In sum, for organizational actors to carry out *connecting to the installed base*, they needed to be able to gain an in-depth understanding of how the current installed digital platforms operate (in terms of scope and specific data requirements) so that they could determine how their new digital platform could work together with existing platforms. Once that was achieved, the organizational actors could start to connect their platforms via the APIs. However, for the first two steps to be successful, the DI's installed base needed to be stable.

Injecting changes to the installed base: In response, the IDX team enacted *injecting changes to the installed base* sabotaging, as the AEMR team saw it, the work of *connecting to the installed base* work (see quote below). Specifically, this involved changing versions of the digital platforms that in turn affected the APIs used for connection work. In 2007, the IDX team decided to coincide its platform version upgrade with the AEMR team's building of the bidirectional links using the API for the current version. The IDX team pointed out that as the AEMR and new IDX platforms would go live around the same time, there was no need for a stopgap bidirectional link to the existing IDX platform. To complicate matters, the IDX upgrade was implemented as a phased rollout, where some ambulatory clinics used the upgraded IDX platform while others continued to work with the existing IDX platform. The following quote shows how that affected the AEMR team:

> *The SUPI team have been invited to all our project meetings and they have detailed involvement. But recently they just informed us that they will be upgrading their IDX's visit management module on September 10,'07 that is directly counter to AEMR's schedule. We told them that we are writing interfaces to their IDX and that it is not common for software apps to write interfaces to "future" software. We asked if they could delay their upgrading but their answer to us was simply "No. We have to do what we have to do.*" (AEMR project director interview)

These activities of *injecting changes to the installed base* essentially changed the installed DI from a stable configuration to a dynamic one, which significantly disrupted the AEMR team's *connecting to the installed base* in various ways. By implementing the IDX upgrade in parallel with the AEMR platform, a situation was created where any teething problems in the IDX upgrades could negatively impact the AEMR platform and vice versa. Furthermore, requesting that the AEMR team build their connection with a new API meant that the AEMR team could not practically test the connections since the upgraded IDX platform had not been implemented. IDX's *injecting changes to the installed base* by phasing its rollout of the IDX upgrades meant that the AEMR platform could only have partial connections to the existing digital platform. As a result, it could only be used in clinics with the upgraded IDX platform.

Thus, the organizational actors' work of *injecting changes to the installed base* through the IDX platform upgrade and new API disrupted the AEMR team's work of building the digital connection, effectively applying a reverse of the paradox of change.

In summary, whereas the AEMR team enacted digital object work aimed at supporting the DID process and introducing a new digital platform, the digital object work enacted by the IDX and STAR teams focused on the more immediate concerns of maintaining the existing platforms in the DI. These latter two types of digital object work reflected significant tensions between the AEMR team and the STAR team, as well as with its SUPI, SOM, and IDX stakeholders, as they sought to counter the AEMR team's attempts at connecting to the installed base.

Incommensurability and undermining: The AEMR team's digital object work was quickly met by the IDX team's avoiding work (as described in the previous section) and two types of DI symbolic work—*incommensurability* and *undermining*. Incommensurability was enacted by the IDX team arguing that the interface development might not be possible because their billing policies and regulatory compliance requirements (i.e., parts of the existing institutional arrangement) were incommensurable with STAR's and AEMR's policies. This issue was also escalated to the steering committee level, where the SUPI CIO used the DI symbolic work of *undermining* to argue against the need for integrating the platforms. He suggested that the vision of the new architecture that placed AEMR as the main infrastructure for ambulatory clinics was not viable and it was also an ineffective design. The SUPI CIO stated:

> *The potential negative impact of integrating the registration and scheduling in the AEMR on the revenue cycle is greater than the functionality and benefits of having that integrated design. The IDX system had more efficient processes … so 94% of our eligibility requests are automatically updated in the [patient] system without human intervention. This is not available in the new AEMR platform.*

Furthermore, he pointed out that the current DI was also less risky than the new AEMR since they did not know how well the new platform would work.

Combining digital object work with DI relational work: Despite the IDX team and SUPI CIO engaging in such symbolic work, the AEMR team had a mandate from the AEMR steering committee to continue with their *connecting to the installed base* work. Again, like the data harmonization challenge, they combined that with *mobilizing* at the platform project level to bring the IDX team back to project meetings. When that was stymied by the IDX team's *injecting changes to the installed base*, the AEMR team escalated it to the AEMR project director, who then *negotiated* with the senior management at the platform project level to adjust the IDX team's API requirements. As one of the AEMR project managers pointed out: "We have to go over them to higher levels to reset these perceptions to be fair to everyone."

However, due to the IDX team's ongoing *injecting changes to the installed base*, the AEMR team had no choice but to take a pause in that development and focus their digital object work on the STAR platform's link. Ultimately, the AEMR team could not directly connect with IDX to support direct billing for the AEMR charges.

Epilogue: By the end of the project, only 25 out of more than 1,000 plans were harmonized. With no direct bidirectional links established between the AEMR and IDX platforms, the AEMR platform could not send billing charges digitally and had to rely on sending printed charges to the billing offices for manual entry into the IDX and STAR platforms (Appendix Figure A2). This paper-based billing process created operational issues in the diabetes clinic, as discussed above.

5 Discussion

In this paper, we apply the lens of institutional work to help us better understand how organizational actors contribute to and mitigate tensions between change and stability during DID. Our findings reveal the process through which purposeful actions of organizational actors in a large-scale DID project shaped the new DI and, in turn, the institutional arrangement. We refer to their actions as *digital infrastructuring work*, which we define as "a combination of digital object, relational, and symbolic institutional work that actors engage in to maintain, create, or disrupt the institutional arrangement in which the DI is embedded." We summarize the forms of digital infrastructuring work below.

The first is "digital object work"—a form of material institutional work that mobilizes different DI elements to change or maintain the existing DI. We identify three types of digital object work directed at different DI elements: (1) *reprogramming structure* that targets digital objects and applications, (2) *connecting to the installed base* that targets interfaces, and (3) *injecting changes to the installed base* that targets the platforms. (See Table 5, Column 2). These types of digital object work involve complex collaboration among diverse actors working on multiple DI elements (e.g., digital objects) (Kallinikos et al., 2013; Yoo, 2012). More importantly, digital object work requires more than just technical skills; for DID to work, it must be combined with DI relational and symbolic work.

"DI relational work" is a form of relational institutional work where organizational actors enable or disrupt collaboration across the DID project teams to change or maintain the existing DI. We identify three types of DI relational work that occur at different DID project levels: (1) *avoiding*, which occurs at the subproject team level; (2) *negotiating*, which occurs both at the subproject team and platform project levels; and (3) *mobilizing*, which occurs at both the platform project and steering committee levels.

The third form of digital infrastructuring work is "DI symbolic work"—a form of symbolic institutional work where organizational actors employ discursive actions linked to different DI elements to maintain (or change) the existing DI. The organizational actors enacted three types of DI symbolic work at different DID project levels. Each type of DI symbolic work was discursively linked to a specific DI element i.e., (1) *asserting embedded rigidity* was enacted at the subproject team level and targeted the digital objects linked to existing practices, (2) *incommensurability* was enacted at the subproject team level and targeted interface development, and (3) *undermining* was enacted by actors at the platform project and steering committee levels and targeted the entire new platform. We first discuss key theoretical insights on digital infrastructuring work, followed by contributions to DID and institutional work research, and finally, our conclusions.

5.1 Theorizing Digital Infrastructuring Work During DID

Our analysis of the digital infrastructuring work led us to develop a theoretical framework that links different forms of digital infrastructuring work to the DI elements and the DID project structure. (See Table 6)

Table 6. DI Elements, DI Project Levels, and Digital Infrastructuring Work

<table>
<tr><th>DID project levels / DI elements</th><th>Subproject teams</th><th>Platform project teams</th><th>Steering committee</th></tr>
<tr><td>Digital objects</td><td rowspan="2">Digital object work: Reprogramming structure work
DI symbolic work: Asserting embedded rigidity
DI relational work: Avoiding and negotiating</td><td rowspan="3">DI relational work: Negotiating and mobilizing</td><td rowspan="3">DI relational work: Mobilizing</td></tr>
<tr><td>Digital applications</td></tr>
<tr><td>Digital interface</td><td>Digital object work: Connecting to installed base
DI symbolic work: Incommensurability
DI relational work: Avoiding and negotiating</td></tr>
<tr><td>Digital platforms</td><td>Digital object work: Injecting changes to installed base</td><td colspan="2">DI symbolic work: Undermining</td></tr>
</table>

Digital object work's relationship with project levels and DI elements: Unlike other forms of digital infrastructuring work, digital object work is enacted solely by organizational actors in the subproject teams due to the technical role they play in DID projects; therefore, such work would not be expected to be undertaken by actors in management roles who may lack the necessary skills. Whereas other DID and institutional work studies have included technical workers in their analysis (e.g., Fürstenau et al., 2019), their main interest has been these workers' social and/or discursive actions, not their technical work. Our study, in turn, shows that technical work can carry institutional significance. While digital object work is unlikely to be limited to the three types that we have observed, it can be generalized to other DI contexts and actions tied to specific DI elements. For example, *reprogramming structure work* could apply to other technical tasks that are aimed at changing specific DI digital objects and applications to support new practices, such as changing a scheduling algorithm to standardize how appointments or meetings are scheduled across an enterprise system. Likewise *connecting to the installed base* could apply to other work dealing with APIs, middleware, or other digital interface devices.

More importantly, the analysis of digital object work using these three types may provide insight on the institutional impact. Thus, while reprogramming structure and connecting to the installed base enables the DI to evolve and change (Hanseth & Lyytinen, 2010; Tilson et al., 2010), injecting changes to the installed base does the opposite by interfering with the scaling and modification of the current DI. In other words, while digital object work may engender changing digital objects, their institutional and DID impacts are varied, as they are contingent upon the type of DI elements that are targeted. Future research could enrich our framework by identifying other technical work specific to the DID context and uncover new types of digital object work.

DI relational and symbolic work's relationship with project levels and DI elements: Compared to digital object work, DI relational and symbolic work can be enacted by different project levels and target different DI elements. However, there are nuances to how they are enacted. Table 6 reveals that DI relational work was absent at the digital platform element for all project levels and DI symbolic work, although enacted across all DI elements, was absent at the subproject level for the digital platform element and absent for the platform project team and steering committees for all DI elements except the digital platform element. There are two plausible explanations. First, our case study covers the implementation phase of the DID project that focused on integrating the specific elements of the new platform to existing platforms. Thus, with less direct coordination work and interactions among the subproject level regarding the platform, there was less need for DI relational and symbolic work. This would also be a plausible explanation for the lack of digital platform-related DI relational work at the higher project levels. Second, the symbolic work to legitimize the need for the DID project could have been completed during its setup and acquisition phases. As a result, the only DI symbolic work we observed during this phase was enacted at the platform project and steering committee levels that challenged the legitimacy of the new platform.

Put together, our framework in Table 6 suggests that DI relational and symbolic work could theoretically be enacted at different levels of the project and be used to target different DI elements. When and how DI relational and symbolic work is enacted would depend on the specific *DID phase* and *what DI elements* the project teams are engaged in changing, updating, or integrating. For example, in an earlier phase of a DID project, we might observe DI symbolic work and relational work in the steering committee and platform project teams where they could focus on establishing the need for a new DI platform or specific system. Like digital object work, we believe that future research could surface other specific types of DI relational and symbolic work in addition to those observed in our study.

Sequence of digital infrastructuring work: The final insight that may be less apparent involves the sequence of the different forms of digital infrastructuring work and how that relates to the type of organizational actors that undertake them. Our study showed two types of organizational actors with different goals at this phase of the DID project: "change actors" (e.g., AEMR team), or those who enacted digital infrastructuring work to support DID change, and "maintenance actors" (e.g., IDX team), or those who enacted digital infrastructuring work to maintain existing platforms. The sequence of digital infrastructuring work during the implementation phase started with change actors enacting mainly digital object work. Tensions between the change actors and maintenance actors led to DI relational and symbolic work to address the ongoing tensions and contestation. Of interest is that change actors at the subproject level focused mainly on digital object work and enacted DI relational work in response to the DI relational work and digital object work from maintenance actors. The change actors then escalated their DI relational work to more senior change and maintenance actors at the platform project and steering committee levels.

Given the nature of large IT projects, we theorize that this sequence of digital infrastructuring work could plausibly be generalized to other DID projects during the implementation phase. That said, the sequence of digital infrastructuring work in other phases (such as the earlier phases of a DID project) could also begin with change actors enacting DI symbolic work, followed by DI relational work, before engaging in specific digital object work. Thus, the sequence of digital infrastructuring work could possibly relate to the institutional challenges inherent in a specific phase of a DID project. Regardless, we would argue that each sequence of digital infrastructuring work would require organizational actors to skillfully combine DI relational and symbolic work with the digital object work (Fligstein, 1997; Lawrence & Suddaby, 2006).

5.2 Theoretical Implications of Digital Infrastructuring Work

Our study contributes to recent IS research that highlights the institutional nature of DI (Baskerville et al., 2020; Hinings et al., 2018; Sahay et al., 2019). Specifically, we take an institutional work approach to shed light on the mundane development work involved in implementing a large DI. We argue that it is through tracing the development process where digital objects, applications, platforms, and interfaces are either added, changed, removed, or maintained that we can better understand the dynamics of DID.

By adopting an institutional work perspective, we begin to explain why certain actors' technical and social actions during the implementation phase may be strategic despite seeming mundane or inscrutable from a typical project management view. Specifically, our findings show that organizational actors maintaining existing platforms can choose to strategically exploit the paradox of change principle (which requires the installed base to be stable and rigid) (Tilson et al., 2010) to make it harder for the new platform to work. At other times, the organizational actors could exploit the same principle in reverse by changing the installed base so that the digital interfaces become unstable, making it hard for the new platform to connect with the installed base. These actions, which show that the paradox of change does not have a consistent effect in DID, are clearly strategic when viewed from the institutional work perspective. Thus, whether an organizational actor selects installed base stability or change depends on the institutional outcomes they are attempting to achieve.

Second, because digital infrastructuring work analytically separates material, relational, and symbolic work and clarifies how each is linked to the DI elements, this nuanced view of the organizational actors' actions sheds light on how specific DI elements are configured as part of the institutional arrangement (e.g., organizational practices) in this context and on their impact on the DID outcome. For example, in our study, the payor plan database structure—a digital object—was intimately linked to the existing practices of registration and billing for the diabetes clinic. This finding resonates with Faulkner and Runde's (2019) point that the digital object is subject to relational and performative attributes depending on its social position. In our context, the institutional arrangement is linked to the configuration of digital objects, applications, and interfaces found in the new and old digital platforms.

Third, the material focus of digital infrastructuring work highlights the importance of studying institutional change at the digital object level. This resonates with Kallinikos et al.'s (2013) argument that our understanding of how DI change should combine digital objects with human actions and practices and not focus on the "standards or design and governance of digital ecosystems" only (Tiwana & Konsynski, 2010). At the same time, we extend Kallinikos et al.'s (2013) point by being more specific about the types of digital objects found within a DI. Toward that goal, we apply Hanseth and Lyytinen's (2010) categorization of the DI elements to extend our understanding of how digital infrastructuring work is linked to different aspects of the DI.

Our digital infrastructuring work also complements existing research on DID projects and "infrastructuring" by expanding the analytical focus on users to include the perspectives of the developers and implementation teams (Aanestad et al., 2014; Monteiro et al., 2014; Pipek & Wulf, 2009). Just as IS research on IT and organizational change has recognized the importance of adopting a holistic approach to study both the development and use of systems (Leonardi & Barley, 2008), our study also problematizes the actors involved in mundane development and implementation project activities to show how their activities and project structures can shape the DID process. Specifically, our framework shows how DI-specific relational and symbolic actions were linked to the project's organizational structures to leverage relational and symbolic support and authority found at those higher project levels. Organizational actors enacting DID in institutionally fragmented contexts such as healthcare organizations will need to be aware of how project structure and context influence the effectiveness of their digital infrastructuring work (Hansen & Baroody, 2020; Hepsø et al., 2009). Future research could highlight how this unfolds in other DID contexts—for example, when actors are organized in a nonhierarchical or even distributed structure (e.g., digital platforms involving peer organizations).

Finally, the digital infrastructuring work enacted by organizational actors to maintain the existing platforms and resist DID efforts resonates with studies at the digital platform and ecosystem level. For example, studies show how platform owners contested with other platforms and their own ecosystem collaborators over DI interfaces (e.g., APIs) (Eaton et al., 2015; Karhu et al., 2018). While the DI interface development project served as the site of resistance in these studies and our study centers on the implementation of the platform in an existing DI, we show similar dynamics of contestation and conflict, albeit through institutional work. Instead of digital interfaces serving as the backdrop to actors' interactions (Eaton et al., 2015), we show how digital interfaces are part of the material institutional work enacted by actors on both sides of the contest (Karhu et al., 2018). Further, we add to this stream of research to show that while material work is necessary, it alone is not sufficient since it presents only a partial view of DID. As discussed above, our framework suggests that digital object work is usually part of a larger portfolio of institutional work because it requires the support of DI symbolic and DI relational work to deal with the emergent challenges and tensions in the DID process. Future research should examine the extent to which type of digital object work would feature prominently in other DID contexts, as well as the interplay among the three forms of digital infrastructuring work.

5.3 Contribution to Institutional Work in IS

Our findings contribute to institutional work in IS by identifying the types of institutional work that focus on changing DIs (i.e., digital infrastructuring work). While current studies have begun to highlight how digital objects can be mobilized by actors as part of institutional work (Monteiro & Nicolini, 2015; Svensson & Gluch, 2017), our notion of digital object work expands the current debate to consider material work that draws on the properties of the digital objects, applications, platforms, and interfaces (Hanseth & Lyytinen, 2010), to build, change, and maintain DIs.

In contrast to existing research, our study reveals that the role of digital technology in institutional work is more than just a trigger for institutionalization (Davidson & Chismar, 2007) or a container for inscriptions of organizational practices (Thorseng & Grisot, 2017). Rather, the properties of DI elements (e.g., reprogrammability, editability, self-referential) and how they are configured and linked to new and existing DIs are critical aspects of such institutional work (Raviola & Norbäck, 2013). Our study thus provides institutional work researchers with a new theoretical vocabulary to describe how institutional work is enacted in other digital contexts, and to account for digital materiality in their theorizing (Dover & Lawrence, 2010; Hinings et al., 2018).

In our case, our theorizing gives us a more granular understanding of how digital materials contribute to nondiscursive tensions in institutional work. For example, studies on institutional work that see DI projects as a trigger for discursive actions may focus on how change actors create and negotiate database standards and end their analysis when those standards have been agreed upon (Hanseth et al., 1996). Our study, however, showed that institutional work does not end there. Instead, change actors had to conduct further nondiscursive forms of institutional work—such as digital object work and DI relational work—to ensure that the change was institutionalized.

Finally, the strategic way that various groups of actors carried out their different actions demonstrates a key insight for contested institutional work: work may be directed not only at pursuing each group's institutional outcomes but also at disrupting the efforts of opposing groups. In some cases, the disruption requires "mirroring" (e.g., reciprocating relational work with relational work); in other cases, it requires a different type of work (e.g., DI relational vs. digital object work). Such strategic enactment of digital infrastructuring work to achieve their institutional goals potentially opens new avenues for IS institutional work research. Future research, for example, could identify other combinations of DI symbolic and DI relational work in other DID projects and examine how they unfold in contexts with more complex groupings of organizational actors with diverse, overlapping interests and agendas or where there may be collaboration with competition (Fürstenau et al., 2019).

5.4 Conclusion

In this paper, we sought to address the question of what types of institutional work are enacted during DID in organizations and how this influences the DID process. Our study explicates how digital infrastructuring work as a form of institutional work is enacted during DID. Digital infrastructuring comprises digital object work, DI relational work, and DI symbolic work. Digital object work sheds light on the technical aspects of DID, showing how organizational actors, in developing and connecting different DI elements (from objects and applications to interfaces and platforms) modify or maintain DIs. In turn, DI relational and DI symbolic work focus on the social interactions and discursive actions that help or hinder digital object work.

By taking an institutional view, we contribute to theory building on the sociotechnical understanding of DIs by making technical work and its complex relations to the social and discursive aspects of DID more visible. Specifically, our nuanced framework connects the various forms of digital infrastructuring work, from the material-digital elements of DI to organizational practices and the project structures embedded in DID. In so doing, our study highlights the institutional significance of DID. It lays the groundwork for understanding how different types of institutional work interact with each other and with the specific project context, offering insights into the mechanisms through which DIs evolve as part of the institutional arrangement across various organizational settings.

Furthermore, our study shows that digital infrastructuring work—first initiated by change actors and followed by maintenance actors in response to emergent tensions in the institutional arrangement—comprises a complex interplay of actions and reactions, underlining the strategic and contested nature of institutional work in the context of DID. Our analysis suggests that the effectiveness of digital infrastructuring work is contingent upon the ability of organizational actors to skillfully combine digital object work with relational and symbolic work to navigate the challenges created by other actors during the DID.

In this way, our paper deepens our theoretical understanding of institutional work in DID. Future research could build on our findings to explore digital infrastructuring work in different organizational and technological settings.

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Appendix

Institutional Context of Centralsys and the Diabetes Clinic

As one can tell from the description in the empirical setting (Section 3.1), the existing institutional arrangement in the diabetes clinic's patient registration and billing processes comprised a convoluted mix of two platforms interpenetrated by multiple medical-professional, operational, and regulatory requirements and processes across SUPI and Centralsys, enacted by the patients, the clinic staff, and the SOM specialists. Specifically, we briefly discuss how the diabetes clinic's institutional arrangement is linked to the institutional complexity of the Centralsys hospital system (i.e., the medical-professional, operational, and regulatory elements present in this system). On the medical-professional front, the diabetes clinic's medical director and specialists were informed by the best practices of their respective medical fields, and they determined their clinical processes with respect to patient care. Operationally, they worked part-time at the clinic, which was registered as a nonprofit / 501(c)(3) entity under SUPI, which acted as their professional billing provider to Centralsys. At the same time, the clinic manager, nurses, and other clerical staff who worked full-time at the diabetes clinic were Centralsys employees and were part of its ambulatory operations. Centralsys also imposed its charges and fees for services rendered by its staff (e.g., laboratory and nursing). The clinic manager, in consultation with the medical director, determined the administrative processes. However, since the diabetes clinic operated on Centralsys hospital premises, some clinic processes had to conform to the rules and requirements stipulated by the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO), a professional accreditation body of healthcare organizations and programs in the US.

Figure Legend:

- Large white rectangles—platform and their applications
- Gray boxes—processes
- Ellipses—staff
- Small white boxes—functions used by staff.
- Cylinders—digital objects supporting the functions.
- Orange boxes—workarounds used by staff.

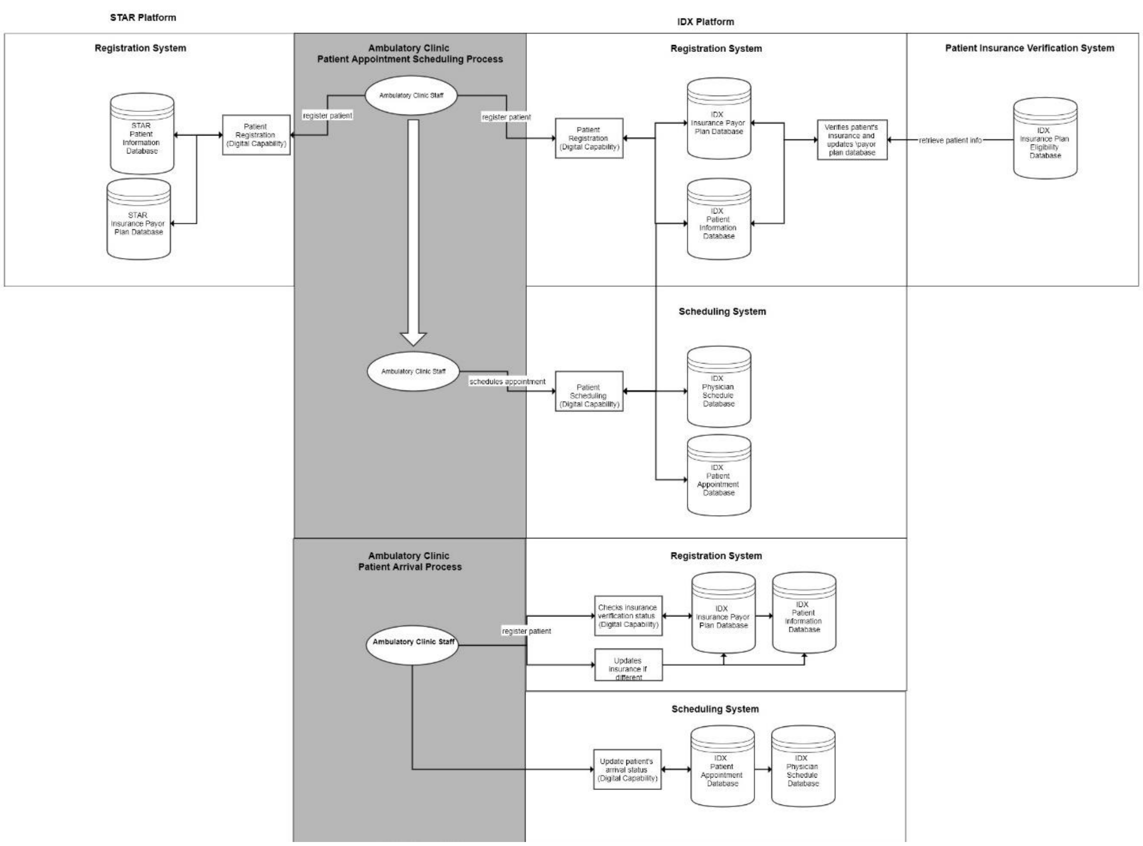

Figure A1a. DI and Processes in the Diabetes Clinic—Before AEMR (Top Part)

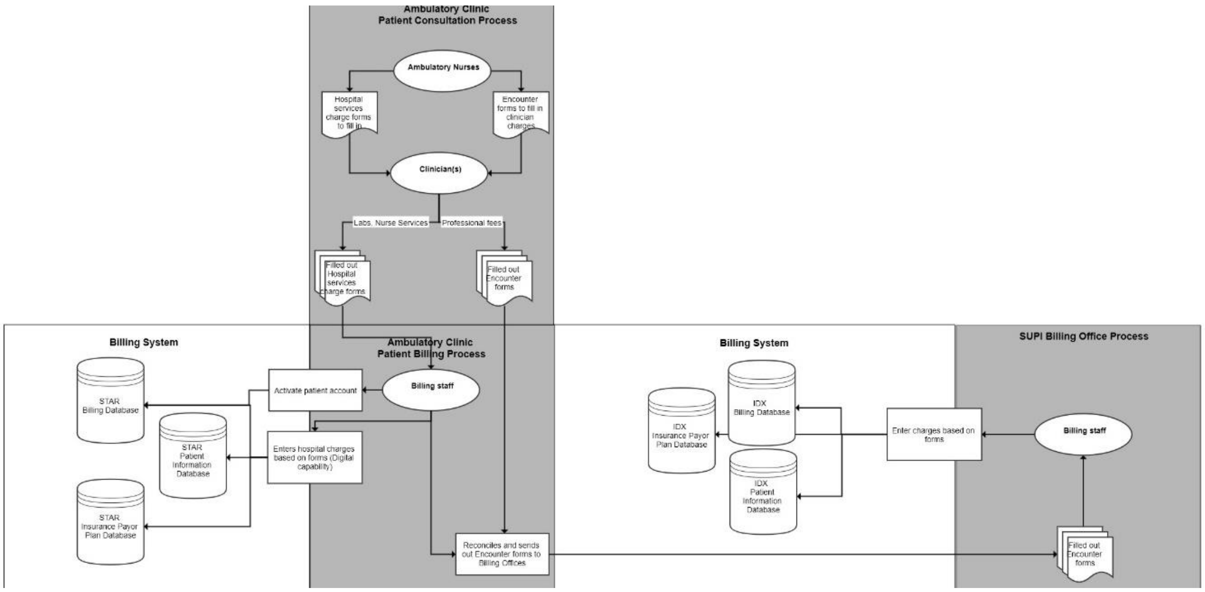

Figure A1b. DI and Processes in the Diabetes Clinic—Before AEMR (Bottom Part)

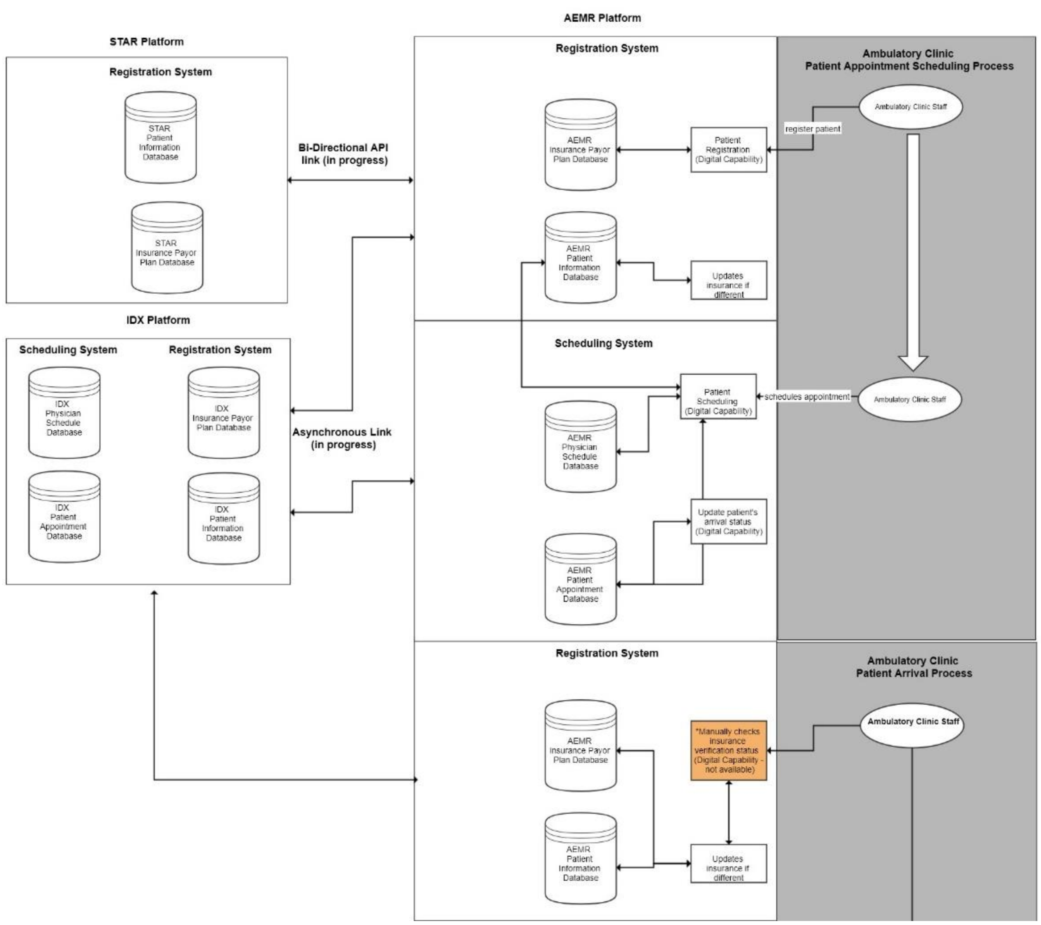

Figure A2a. DI and Processes in the Diabetes Clinic—After AEMR (Top Part)

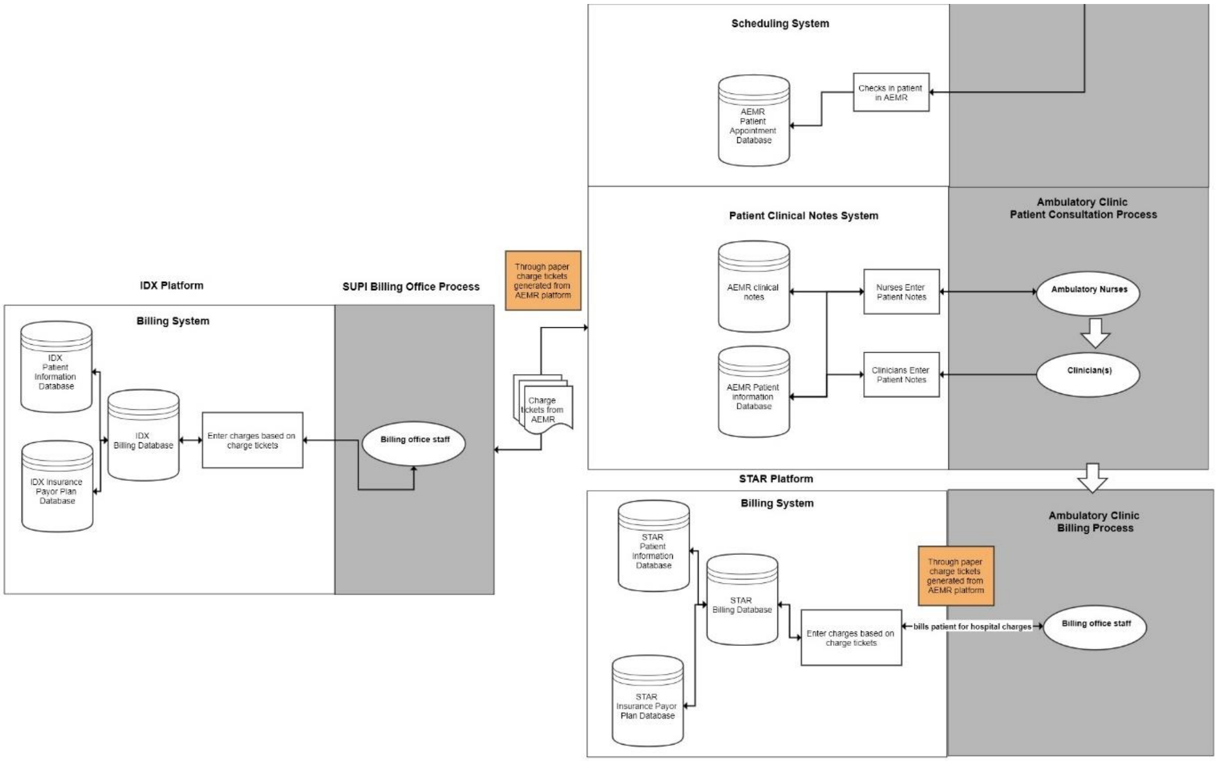

Figure A2b. DI and Processes in the Diabetes Clinic—After AEMR (Bottom Part)

Table A1. Elements of Centralsys DI (Before AEMR Implementation)

Digital platform	**Digital applications**	**Digital objects**
IDX platform (operated by SUPI IT team)	IDX registration system	• Register ambulatory patients (patient information database and insurance payor plan database) • Verify patient insurance status (patient insurance payor plan database) • Update patient insurance status (patient insurance payor plan database)
	IDX scheduling system	• Patient scheduling of appointments (physician schedule database and patient appointment database) • Update patient arrival status (Patient appointment database)
	IDX patient insurance verification system	• Verify patients’ insurance with insurance company (insurance plan eligibility database)
	IDX billing system	• Enter professional fee charges (billing database, patient information database, and insurance payor plan database) • Bill insurance companies (billing database, patient information database, and insurance payor plan database)
STAR platform (operated by Centralsys IT team)	STAR registration system	• Register hospital patients (including ambulatory patients using clinics housed in hospital) (patient information database and insurance payor plan database)
	STAR billing system	• Enter hospital fee charges (billing database, patient information database, and insurance payor plan database) • Bill insurance companies (billing database, patient information database, and insurance payor plan database)

Table A2. Elements of Centralsys DI (Planned for Post-AEMR Implementation)

Digital platform	Digital applications	Digital objects
AEMR platform (operated by Centralsys AEMR team)	AEMR registration system	• Register ambulatory patients (patient information database and insurance payor plan database) • Verify patient insurance status—manually (patient insurance payor plan database). Update patient insurance status (patient insurance payor plan database)
	AEMR scheduling system	• Patient scheduling of appointments (physician schedule database and patient appointment database) • Update patient arrival status (patient appointment database)
	AEMR clinical notes system	• Enter patient clinical notes (AEMR clinical notes and patient information database)
AEMR platform and IDX platform	Across both platforms' registration, scheduling systems as well as clinical notes and billing systems	• Bidirectional link to transfer patient scheduling, registration, clinical notes data between IDX and AEMR platforms (API)
AEMR platform and STAR platform	Across both platforms' registration, clinical notes, and billing systems	• Bidirectional link to transfer patient registration, clinical notes data between STAR and AEMR platforms (API)

Table A3. Digital Infrastructuring Work in Data Harmonization (Chronological Order)

When	Who	Where	Digital infrastructuring work	
August 2006	AEMR team	Subproject team	**Reprogramming structures**: Managed data definitions and structures of payor plans and patient account master files to ensure interoperability between AEMR billing and existing billing systems	Digital object work
August 2006 to October 2006	IDX team	Subproject team	**Avoiding**: Inactive in developing the common payor plan definitions. **Asserting embedded rigidity**: Invoked "specific" nature of context and system, implying that changes should not be made.	DI relational work; DI symbolic work
November 2006	AEMR Project Director	Steering committee	**Mobilizing:** Escalated the issue to senior management of Centralsys and SUPI that IDX and STAR teams were not willing to negotiate and collaborate.	DI relational work
November 2006	SUPI CIO	Steering committee	**Asserting embedded rigidity:** Resisted the efforts by AEMR team to compromise on the common payor plans because it may affect current processes	DI symbolic work
January 2007	AEMR team	Subproject team	**Reprogramming structures:** Reviewed the different payor plans, with broad strategy achieved at the end of January.	Digital object work
January 2007	IDX team	Subproject team	**Avoiding:** Being intentionally unable to complete required tasks. SUPI's lack of participation made it hard for the team to make any concrete decisions.	DI relational work
February 2007	AEMR Project Director	Platform project team and steering committee	**Mobilizing:** Escalated the issue to ask for more resources from SUPI and more involvement in the work of analyzing and mapping the payor plans.	DI relational work
Mid-February 2007 to March 2007	AEMR team IDX team STAR team	Subproject team	**Reprogramming structures:** Managed to get Centralsys and SUPI to supply detailed payor plan specifications and guidelines that included: • Strategy for payor plans mapping where both SUPI (IDX) and Centralsys (STAR) teams will work to adjust their plans. • Set up a specification sheet for STAR team to gather information needed to retrieve benefit plan information from payors. • Currently reviewing the Payor Guides from IDX team for build in AEMR. This resource provides a detailed view of various benefit plans under each payor and referral/authorization rules for services.	Digital object work

April 2007	STAR team	Subproject team	**Asserting embedded rigidity:** Problematized the disruption where STAR team realized its payor plans were not only much smaller than IDX but also had very limited plan details.	DI symbolic work
April 2007	IDX team	Subproject team	**Avoiding:** IDX team had new definitions for payor plans (and design changes) and stopped providing inputs to the common payor plans.	DI relational work
May 2007	AEMR team	Subproject team	**Negotiating:** Followed up with both teams to achieve agreement on working on the subset of 25 payor plans.	DI relational work
October 2007	AEMR	Subproject team	**Reprogramming structures:** The first 25 payor plan test was completed but there was huge resistance to push towards the 1,000 payor plans.	Digital object work

Table A4. Digital Infrastructuring Work in Bidirectional Linking (Chronological Order)

When	Who	Where	Digital infrastructuring work	
August 2006	AEMR team	Subproject team	**Connecting to installed base**: Met to establish the baseline of the bidirectional link: scope of the interface, data mapping, and system compatibility.	Digital object work
August 2006 to October 2006	IDX team SUPI CIO	Subproject team Steering committee	**Avoiding:** Took a longer time to evaluate and assess technical scope of bidirectional links. **Incommensurability:** Claimed that they had different billing policies and compliance codes. **Undermining**: Suggested that the vision of the new architecture with AEMR as the main infrastructure for ambulatory clinics was not viable and that the vision is an ineffective design compared to current system architecture.	DI relational work; DI symbolic work; DI symbolic work
Jan. 2007	AEMR team	Subproject team	**Connecting to installed base:** Finished mapping the interface scope with STAR team but was still waiting for IDX team's input.	Digital object work
February 2007 to March 2007	AEMR Project Director	Platform project team	**Mobilizing:** Met with IDX team representative in attempt to bring them back to the project.	DI relational work
March 2007 to April 2007	IDX team	Subproject team	**Injecting changes to installed base:** There were dependencies on database and link development and specific approach to the interface development.	Digital object work
April 2007	AEMR team	Subproject team	**Connecting to installed base:** Faced issues working with IDX requirements for link development and live data tests.	Digital object work
April 2007	AEMR Project Director	Platform project team	**Negotiating**: Met with IDX and SUPI senior members to manage the requirements that IDX team had given as part of development.	DI relational work
June 2007 to July 2007	IDX team	Subproject team	**Injecting changes to installed base:** IDX team in charge of their platform upgrade planned to begin their upgrade in a phased rollout one month before AEMR implementation in October 2007. This made the IDX upgrade run directly parallel to the AEMR pilot implementation.	Digital object work
	IDX team	Subproject team	**Injecting changes to installed base:** Informed AEMR team that the bidirectional link needed to be developed to work with their upgraded system. Refused to allow the link to work with their existing system as a stop-gap measure.	Digital object work
July 2007	AEMR team	Subproject team	**Connecting to installed base:** Continued to develop and test the bidirectional links with IDX and STAR teams (As of May 2008, the link was still not completed).	Digital object work
August 2007	AEMR team	Subproject team	**Connecting to installed base:** Developed an asynchronous batch interface between the AEMR and the IDX platforms. This link would have incrementally updated the AEMR patient and billing databases with IDX system data. But the billing link was not available.	Digital object work

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