Digital Infrastructures of Facilities Management

How Data Systems and Work Environments Affect Each Other

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DIGITAL INFRASTRUCTURES OF FACILITIES MANAGEMENT: HOW DATA SYSTEMS AND WORK ENVIRONMENTS AFFECT EACH OTHER

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Introducing digital objects in facility management enables professionals to coordinate operation and management tasks. However, using digital objects is not a "neutral" matter. Instead, digital objects shift the distribution of responsibilities and create new ways of visualising professionals' work performance that create frustrations and discontent among the facility managers. Building on ethnographic fieldwork and inspiration from the Science and Technology Studies field, the study investigates a case concerning the operation and management of an office building in Copenhagen, Denmark. Findings show that the operation and management professionals get frustrated when the technical and digital systems of the building cannot solve the issues experienced by the building users. Limited access to systems obstructs the professionals in their work, and the systems create distance between the building and the means to solve the experienced problems. The study suggests paying more attention to digital systems' effects on professionals' mental health within facility management.

Keywords: digital infrastructure; FM; mental work environment; S&T studies

INTRODUCTION

Digital objects have an increasingly strong presence in the facility management sector. Facility managers and other operations and maintenance (OM) professionals work with many digital objects, such as building management systems (BMS), geographical information systems (GIS), building information modelling (BIM), internet of things (IoT), and 3D visualisations (Kazado *et al.,* 2019). The introduction of digital objects creates new ways of visualising information, tracking the progress of the construction process, and shifting responsibilities (Whyte and Lobo, 2010) that may cause meaningless work routines and stressful situations for the users. Although several authors examine the development and use of digital objects in the facility management sector (e.g., Stride *et al.,* 2020; Pärn *et al.,* 2017), research has been lacking on the effects of digital objects on the mental work environment of OM professionals.

Frequently, digital strategies and development initiatives promoted by politicians and professional actors refer to these digital objects as unproblematic (Ministry of

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Transport, Building and Housing, 2019), as if the transfer or the visualisation of data happens "neutrally" without influencing the software users. However, studies from the 2010s suggest this is not the case (e.g., Whyte and Lobo, 2010; Neff *et al.,* 2010; Jaradat *et al.,* 2013). For example, Whyte and Lobo (2010) state that digital objects do not "just" convey information across professions. Instead, digital objects establish new visibilities, possibilities of control, intervention, evaluation of performance, functions, roles, and distribution of responsibility. Digital objects are not "neutral" but displace roles and responsibilities and enable new actions taken by the users. To understand the use of digital objects better, we must study the effects of their introduction into the facility management industry and their use in companies and projects. This paper conceptualises digital objects and the practices with which they are applied as "digital infrastructures" (Whyte and Lobo, 2010) in which professional practices create and share digital objects across locations, media, and time.

The point of departure for this paper is a case about the management and coordination of the indoor environment in an office building in Denmark since it, in practice, involves the use of digital objects in work. Building users no longer control the indoor environment in modern office buildings. Instead, OM professionals primarily manage it through digital systems: in this case, a building management system (BMS) and a task management system (TMS). Since the technical complexity of modern office buildings is high, many installations support maintaining a comfortable indoor environment. For example, the digital systems help the OM professionals monitor and manage the temperature, airflow, and CO2 levels. It could involve installations for ventilation, heating, cooling, and solar screening. Because of the large size of many office buildings, BMS connects the many installations in a centrally controlled system that regulates the indoor environment. In comparison, TMS helps the OM professionals handle the many tasks concerning such a complex building.

According to Forman and Sørensen (2019), there are typically four "subsystems" that form part of building automation: 1) The physical building and its installations, 2) sensors and meters that are embedded in the building, 3) servers, networks, interfaces, and algorithms that process and transform the collected data, and 4) the practices of people responding to information in the systems. The four subsystems clearly show how digital objects in the form of servers, networks, interfaces, and algorithms connect technical objects such as sensors and meters in the building with the social practices of those working with the information. What we denote as a "digital infrastructure." This paper describes the relationships between digital and technical objects and their roles in practice and, for that purpose, adopts Forman and Sørensen's (2019) approach to indoor environment management, which regards building automation as a network-based technology embedded in a heterogeneous and distributed actor-network.

As the indoor environment management in office buildings today comprises increasingly digital and technical objects, it places additional pressure on the OM professionals. As demonstrated by studies of architectural practices (Jaradat and Whyte, 2013), the demands for implementing digital objects may lead to a need for systematisation. Systematisation can be distracting from the employee's competencies and core tasks. Jaradat and Whyte (2013) show how the demands of digitalisation shift architects' professional identity and result in the loss of meaning in solving problems as part of their core tasks. According to Olsén (2008), when employees experience systematising their work as meaningless, it contributes to a poor mental work environment.

This paper draws on Olsén's (2008) description of the mental work environment. Olsén focuses on the core tasks of the professionals' work. Professionals may experience repeated meaningless deviations, distractions, or interruptions of their core tasks negatively, contributing to a poor mental work environment. This paper discusses whether the relationship between OM professionals, digital infrastructures, and technical installations possibly impacts the involved professionals' mental work environment.

Focusing on how OM professionals work with digital objects and technical installations, this paper leans on discussions within the field of Science and Technology Studies (STS) and actor-network theory (ANT) that go back to the 1980s. Within STS and ANT, several authors examine the relationship between humans and computers, or humans and machines (e.g., Ehn, 1988; Goodwin, 1993; Hutchins, 1995; Latour, 1986; Lave, 1988; Suchman, 1987).

Based on studies of the design and use of the first photocopying machines, Suchman (1987) shows the difference between humans and machines or humans and computers. Designers programme machines and computers according to "plans" - formal rules and explicit courses of events within which the machine or computer can act. According to Suchman, people also draw on plans - for example, when using recipes, manuals, or checklists. Unlike machines and computers, people act in "situated actions" (Suchman, 1987), where we sense and assess the course of events as the activity takes place and while the circumstances of the situation change.

People do not solve complex tasks individually, such as steering a naval vessel into a harbour (Hutchins, 1995). However, accomplishing complex tasks relies on the distributed action of many elements. Hutchins (1995) suggests studying "cognition in the wild," where many actors, in his case, actively participate in the successful mooring of a large naval vessel, such as trained quartermasters, maps, intercom systems, and specific organisation at the bridge. Navigation from this perspective involves a distributed and collective way of knowing across human and technical elements.

Like Suchman's notion of plans, Akrich and Latour (1992) present a group of terms that they call "scripts." The process of "inscription" is when designers (not limited to official designers but may also include other stakeholders) design machines with specific users or use situations in mind. Machines and computers contain expectations and assumptions about the user's interests, competencies, motives, aspirations, and political prejudices (Akrich, 1992). Woolgar (1990) expands the understanding of what designers "inscribe" into systems by including political and moral connotations in the design of computers. Designers "configure" (Woolgar, 1990) the users in specific ways based on usability trials, design suggestions, and development strategies. In this way, systems contain assumptions about the users and expectations of the users' practices.

Based on these analytical points, this paper focuses on understanding the relationship between indoor environment systems and the practices of OM professionals. The designers of the indoor environment systems have inscribed certain expectations and anticipations about roles, collaboration, practices, and strategies within which the OM professionals navigate their tasks and solve problems in distributed actor-networks. Based on this relationship, this paper examines how the interface between the systems and the professional practices leads to unexpected work processes that pressure the OM professionals.

METHOD

Case Description

This paper draws on empirical material that centres on the operations and maintenance of an office building in Copenhagen, Denmark. The building is owned by a prominent developer with a portfolio of properties and is rented out to a tenant organisation. The building is a traditional, modern office building with office spaces, reception, and a restaurant. The facades contain large glass surfaces that the office workers cannot open. A centrally controlled ventilation system ventilates the offices through a building management system (BMS). The BMS also controls solar screening outside the fixed glass facades. Inside, radiators integrated into the floor (convectors) heat the offices and ventilation valves in the ceiling heat, cool and ventilate the offices. The BMS likewise controls heating, cooling, and ventilation. The building design with fixed glass facades, centrally controlled heating, ventilation, and solar screening entails that the office workers cannot change the temperature or increase ventilation by themselves. On the other hand, the OM professionals have access to BMS and can change the settings.

When the paper refers to the OM professionals, the reference concerns a site manager of the building owner organisation and a consultant of the tenant organisation. An agreement between the building owner and tenant organisation dictates that the building owner is responsible for the operations and maintenance of the building components and common areas. In contrast, the tenant organisation is responsible for the operations and maintenance of the office spaces. Therefore, the site manager is primarily responsible for the technical installations integrated into the building and the building components. Meanwhile, the consultant is primarily responsible for the interior surfaces and installations in the office spaces. The site manager is responsible for the operations and maintenance of this building and three other buildings, while the consultant is only responsible for this building. It is crucial for both the building owner and tenant organisation that the indoor environment is comfortable. Office workers occupy the building, and the indoor environment supports their work. Therefore, ensuring a comfortable indoor environment is critical for OM professionals.

In addition to the BMS, the OM professionals also use a task management system (TMS) to coordinate tasks concerning the control of the indoor environment. The building owner organisation has implemented the TMS for most of the properties in their portfolio. The organisation requests tenants and suppliers to use the TMS as much as possible as the system helps them coordinate, document and plan operations and maintenance tasks across properties. In the TMS, the site manager, suppliers, craftsmen, and tenants (in this case, the consultant) can order, register, and plan OM tasks.

This analysis builds on ethnographic fieldwork (Pink *et al.,* 2010) involving three interviews with professionals from the building owner organisation (among these the site manager) and four interviews with collaborators from other organisations (among these the consultant). The interviews were audio-recorded and transcribed. As a supplement to the interview data, access to the TMS provided insight into details about the communication and coordination of OM tasks.

Empirical Observations

This study describes issues and experiences surrounding infrastructure management and control of the indoor environment, from the discontent of office workers to the work practices and systems (BMS and TMS) of the OM professionals responding to changes in temperature or airflow in the technical installations. After analysing the relations that appear among the many actors, a discussion follows on which possible effects the relations may have on the mental work environment of the OM professionals.

Experience in Indoor Environment and Indoor Environment Systems

When the office workers in the building experience drought, cold, heat, or other uncomfortable elements, they usually contact the consultant in the in-house OM organisation. Subsequently, the consultant contacts the site manager because most installations are integrated into the building. The consultant enters a task in the TMS, where the problem can be described in a short text format. Such texts could be “it is generally too warm in the room” or “suffer from draught.” The consultant can add a location on a floor plan or describe where the issue seems. The site manager receives the task in his inbox in the TMS and opens the BMS to change the settings, for example, the temperature. In the BMS, the site manager looks at diagrams of technical installations, short texts with abbreviations for the BMS components, and values for the airflows and temperatures concerning, for example, how the ventilation system performs. In the BMS interface, the site manager changes a value from 24 to 23 degrees Celsius for the room’s air supply temperature.

The numbers on the screen in front of the site manager are collected through sensors and meters in different locations in the building connected via cables and the internet. Based on diagrams, descriptions, and hierarchical breakdown of floors and rooms in the building, the site manager reads the location of the specific component in the BMS and the meaning of the value, then navigates (Hutchins, 1995) based on the information he reads on the screen, the message from the consultant, his familiarity with the building and the specific sensors and meters from his inspection rounds. From the screen, he gets information about the components’ performance while drawing on his knowledge about potentially dysfunctional sensors requiring service.

In TMS, the site manager answers the consultant with a message. For example, “the temperature is changed from 24 to 23 degrees Celsius.” The consultant gets the message in his inbox and can inform the office workers about the task’s progress. In some cases, the experience of the dissatisfying indoor environment does not match up with the representation of the indoor environment in the BMS, i.e., levels of CO2, airflow and humidity. In such cases, the two OM professionals place small mobile loggers in selected places to potentially find proof of the claims about chill or warmth. The consultant states:

> “Even though we measure and do something, we cannot get anywhere because we do not really know what we should do. Then we sometimes have placed a logger in an attempt to log for a longer period to see whether the temperature fluctuates that much. Often, it turns out actually that there is not anything to do. It is a little hard in reality.”

The consultant expresses frustrations because the infrastructure does not help him solve the issue of chills or warmth. In other words: the consultant’s tools, as inscribed in the BMS and TMS, do not create satisfying results and possibly affect the mental work environment of the site manager.

Business Strategies and Obstacles in System Access

A year before the fieldwork, the site manager's responsibility only concerned one office building. Under the fieldwork's mandate, the building owner organisation has provided the site manager with the responsibility of several office buildings. Initially, the site manager focused all his time and energy on the building on which this paper focuses. This presence made it possible for the site manager to talk with the consultant often. The OM tasks were coordinated and solved face-to-face instead of online across the TMS. The site manager and the consultant were satisfied with the day-to-day "chitchat." With the introduction of TMS and BMS, the building owner organisation has obliged the site manager to carry out OM tasks for more buildings than one. During the fieldwork, the site manager was responsible for three properties, including around 65.000 m2. Because the site manager needs to take care of three buildings, the primary communication between the site manager and the consultant happens through the TMS.

When the site manager was more present in the building, the consultant lost his access to the TMS. His password suddenly did not work for some reason. He contacted the building owner's helpdesk service to get help. It took weeks before the consultant gained access again. The disconnection from a system that the building owner requires the consultant to use can seem frustrating for the consultant. Likewise, the consultant also lost access to the BMS. Even though the consultant was not responsible for the BMS, he had had access to the system and, in some situations, changed the settings to accommodate a poor indoor environment. However, the consultant lost access because of an update to the software. The consultant states:

> "At one point, something needed to be reorganised in the software, and then suddenly, I could not gain access. Now, [the building owner] has tried a couple of times, and I have gained some access, but our firewall will not allow me to download the needed files. There are still some problems. I have just informed them again the day before yesterday that we have to get it fixed since it actually is quite annoying."

Data security issues continue to prevent the consultant from accessing the TMS and the BMS. The case shows how the site manager and the consultant navigate in situated actions (Suchman, 1987) based on many types of information from digital systems, loggers, office workers, and their bodily experiences of being in the office spaces. Knowing about the indoor environment for them is to measure it through sensors and meters and obtain proof confirming or denying the claims about a poor indoor environment. They are integrated into an infrastructure where their only space for action concerning solving indoor environmental issues is through technical descriptions, values, and installations. Frustrations appear when the site manager and the consultant attempt to solve problems concerning the indoor environment, but their actions within the infrastructure do not help them solve the problems. Similarly, the office workers might be frustrated because they cannot adjust to the indoor environment - the infrastructure cuts them off and allow access to the OM professionals.

The case also shows how the network around the core tasks of the two professionals has increased over time. Although they had the opportunity to coordinate and solve OM tasks in person, the increasing responsibilities of the site manager shifted their interaction primarily with the TMS. Furthermore, the many digital objects (e.g., TMS and BMS) and technical objects (e.g., sensors, meters, and installations) create a distance between the experienced issues concerning the indoor environment and the professionals' ability to affect it. Simultaneously, when the professionals lose access to the systems, they have difficulty carrying out their core tasks. The practices of the OM professionals may lead to potentially problematic situations concerning their mental work environment. The following section discusses some of these potential issues.

FINDINGS

The analysis demonstrates how rationalisation logic permeates these situations. The design of the office building is optimised to ensure a comfortable indoor environment. However, the designers obtain this through a sealed building envelope and technical systems that regulate the indoor environment, preventing the office workers from regulating the indoor environment themselves according to local needs. A TMS gathers all data about OM tasks in one place, making it easy to order, plan for and estimate future costs. However, TMS brings demands for documentation and new ways of being accountable for the OM professionals' data. It seems that the building owner organisation regards it as possible for one site manager to supervise several properties using TMS, the logic being that fewer people can handle more using the system.

However, what is the other side of the coin? Does the TMS bring information overload, new work procedures, and a need for new competencies that pressure the employees? The case shows that the response time increases drastically when the coordination goes from happening in-person to involving tasks described in the TMS. In the TMS, the tasks await the busy schedule of the site manager before he can react to them. The response time on issues increases as the consultant experiments with loggers over extended periods. The need for proof makes the process slow. A prolonged response time may lead to conflicts between impatient, discontent office workers and a frustrated consultant trying to measure and push for adjustments in the technical settings of installations.

The site manager and the consultant remain trapped in an infrastructure that only allows for specific ways of approaching the indoor environment. The designers of the building and the systems, including the site manager and the consultant themselves, inscribe (Akrich, 1992) this specific way of approaching the indoor environment into the infrastructure. The inscriptions lock the consultant, for example, in a worldview where he can only act according to measurements and suggestions for technical interventions. The control of the indoor environment becomes a “measurable discipline,” and the sensors, meters and loggers gain authority. However, when issues arise that do not fit the worldview, for example, office workers experiencing a poor indoor environment even though the consultant cannot read any negative signals from the BMS, the consultant is lost.

The office workers can quickly become “unruly” and “uncontrollable,” and the “shortcomings” in the system cannot be corrected. The measurements visualise specific aspects of the indoor environment and both reduce and amplify these aspects (Latour, 1999) while simultaneously documenting and proving the existence of certain actors, such as CO2. The consultant may experience a clash between worldviews as frustrating since he cannot locate the problem or, worse yet, solve it. Moreover, office workers may be irritated by the continuously changing reference measurements and limitations of the building design and technical installations. In their configuration (Woolgar, 1990) of the infrastructure, system builders have made no room for handling local needs for changes to the indoor environment.

As the control of the indoor environment moves from the consultant's hands and eyes (Latour, 1986) to the digital and technical systems such as BMS and TMS, it creates a distance between the operator and the operated. Instead of adjusting thermostats in specific rooms in the building, the site manager now adjusts numbers on a screen with the possibility of doing it in another building, possibly in another country. Control of the indoor environment shifts geographically and temporally and becomes more distributed among several actors. Are our facility management professionals becoming more distanced from the physical buildings they operate and maintain?

When we develop and work with digital and technical systems, are we introducing longer and longer chains of actors into the operations and maintenance of buildings? How long can the chains become before they break? Because these systems hold such power as essential nexuses of information about the indoor environment and control over it, access to these systems becomes even more crucial. Even though the examples from the case where the consultant did not have access to the systems may seem banal, if the instances repeat themselves in critical situations, it might significantly affect the consultant's stress level. Lack of access may also result in a state of helplessness. The consultant can see the problem and knows how to fix it but cannot access the systems to do anything about it. Such helplessness may result from the division of responsibility, technical discrimination from the systems, or a lack of competencies to remedy the situation.

The consultant and the site manager are "men of the system." They become part of an infrastructure of digital and technical objects that focuses primarily on measurements of the indoor environment. Knowledge about the indoor environment is distributed among the many actors, and the possibilities of actions are enhanced and limited by this network of actors. In the upkeep of a good indoor environment, the consultant and the site manager may regard the office workers and their practices as "disturbances" to the system. Potentially, there can become conflicts in the interface between the practices of the office workers and the practices of the consultant, which might negatively affect the mental work environment for all of them.

CONCLUSIONS

This analysis describes potential tensions concerning the mental work environment of two OM professionals. Their connectedness to technical and digital objects leaves them a narrow set of options when confronted with indoor environmental issues. The worldview inscribed in the digital infrastructure permeating the work of the OM professionals does not fit the worldview of the building occupants (the office workers). It may potentially pressure the OM professionals' mental work environment. Furthermore, repeated disconnections from crucial systems contribute to frustrations and powerlessness for the consultant.

This paper contributes to research with a combination of analytical perspectives based on STS, ANT and literature on mental work environments to study the work of facility management professionals. In an age where the number of digital and technical objects constantly increases in our professional work, understanding these objects' effect on people's mental health is crucial.

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REFERENCES

Akrich, M (1992) The de-scription of technical objects, *In*: W E Bijker and J Law (Ed.), *Shaping Technology / Building Society: Studies in Sociological Change*, Cambridge, MA: MIT Press, 205-224.

Akrich, M and Latour, B (1992) A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies, *In*: W E Bijker and J Law (Ed.), *Shaping Technology / Building Society: Studies in Sociological Change*, Cambridge, MA: MIT Press, 259-264.

Ehn, P (1988) *Work-Oriented Design of Computer Artifacts*, Stockholm: Arbetslivscentrum.

Forman, M and Sørensen, N L (2019) When buildings become intelligent - a network analysis of building automation, operation and competencies, *In*: D Johansson, H Bagge and Å Wahlström (Eds.) *Cold Climate HVAC 2018: Sustainable Buildings in Cold Climates*, Springer Proceedings in Energy, 557-568.

Goodwin, C (1993) *Perception, Technology and Interaction on a Scientific Research Vessel Research Report*, University of South Carolina.

Jaradat, S, Whyte, J and Luck, R (2013) Professionalism in digitally mediated project work, *Building Research and Information*, **41**(1), 51-59.

Kazado, D, Kavgic, M and Eskicioglu, R (2019) Integrating building information modelling (BIM) and sensor technology for facility management, *Journal of Information Technology in Construction (ITcon)*, **24**, 440-458.

Latour, B (1999) Circulating reference: Sampling the soil in the Amazon Forest, *In*: *Pandora's Hope: Essays on the Reality of Science Studie*s, Harvard, Mass.: Harvard University Press, 24-79.

Latour, B (1986) Visualisation and cognition, *Knowledge and Society*, **6**(6), 1-40.

Lave, J (1988) *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life*, Cambridge: Cambridge University Press.

Ministry of Transport, Building and Housing (2019) *Strategi for Digitalt Byggeri*, Copenhagen: The Danish Ministry of Transport, Building and Housing.

Neff, G, Fiore-Silfvast, B and Dossick, C S (2010) A case study of the failure of digital communication to cross knowledge boundaries in virtual construction, *Information Communication and Society*, **13**(4), 556-573.

Olsén, P (2008) Hvis vi bare ku' få fred til at passe vores arbejde… - om mening, forandring og psykisk arbejdsmiljø Tidsskrift for arbejdsliv, **10**(4), 043-058.

Pink, S, Tutt, D, Dainty, A and Gibb, A (2010) Ethnographic methodologies for construction research: Knowing, practice and interventions, *Building Research and Information*, 38(6), 647-659.

Pärn, E A, Edwards, D J and Sing, M C P (2017) The building information modelling trajectory in facilities management: A review, *Automation in Construction*, **75**, 45-55.

Stride, M, Hon, C K, Liu, R and Xia, P (2020) The use of building information modelling by quantity surveyors in facilities management roles, *Engineering, Construction and Architectural Management*, **27**(8), 1795-1812.

Suchman, L A (1987) *Plans and Situated Actions: The Problem of Human-Machine Communication*, Cambridge: Cambridge University Press.

Whyte, J and Lobo, S (2010) Coordination and control in project-based work: Digital objects and infrastructures for delivery, *Construction Management and Economics*, **28**(6), 557-567.

Woolgar, S (1990) Configuring the user: The case of usability trials, *The Sociological Review*, **38**(1), 58-99.

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