# Accounting for Information Infrastructure as Medium for Organizational Change

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**ABSTRACT**

The last few decades have seen extensive changes in how organizations rely on Information Technology (IT) to account for key aspects of their operation. Understanding accounting as a process through which organizational reality is shaped, Information infrastructures (II) offers a means for analyzing the role of IT in organizational change and how IT over time shapes how organizations account for what they are doing. We investigate changes to organizational II at the University of Sydney's Fisher Library from 1963 to 1975, following the introduction of manual automation systems, the use of mainframe computers, and the introduction of minicomputers into the fabric of the organization. At Fisher Library, II changed two key functions the library is accountable for providing information on: (1) What items does the library hold? and (2) Where is a specific item when it is not on the shelf? We demonstrate that II becomes visible as a thing when it is of interest to organizational change, whereas over time, II sinks into the organization, becoming a transparent medium that is nonetheless shaping organizational reality. This paper uses Fritz Heider's theory of thing and medium to describe how over time IT changes an organizations account for key aspects of its operation.

**KEYWORDS**

Heider, Information Infrastructure, Information Technology, Library, Organizational Change, Media Theory

## Introduction

This article focuses on information technology (IT) including early forms of data processing (Beniger 1986) and digitalization (Cortada 2007) as a means through which organizations account for key aspects of their operation. Moving beyond the disciplinary home of accounting history we use an outwardly looking approach (McWatters 2014, 2017) to analyze the role of information infrastructures and their implications for what organizational accounting that relies on them can make visible. We develop an interdisciplinary lens for investigating how over time IT shapes accounting in organizations as part of socio-technical systems (Checkland and Holwell 1998; Star and Bowker 2010).

Information infrastructures (IIs) (Chandler and Cortada 2000; Edwards 2003; Star and Ruhleder 1996) have transformed organizations (Bátiz-Lazo and Wardley 2007), as they have made possible different forms of organizational communication (Yates 1989; Hoof 2020), enabled new ways of management (Nolan 2000), and facilitated novel kinds of insights about

organizational processes (Zuboff 1988; Yates 2005). IIs change the way organizations operate, as well as the way organizations are able to see and comprehend themselves. We extend the concept of II from Information Systems with a media-theoretical perspective, in order to investigate how IT changes what kind of information organizations can capture about their activities and thus how organizations can account for what they are doing (Hoof 2015). Over time II shapes and changes what information is recorded by an organization affecting how organizations organize and control organizational processes. We demonstrate how II as a medium allow for accounting techniques to develop. For an accounting and management audience it highlights how such modified accounting systems are related to and thrive organizational change.

Using this approach to the University of Sydney's Fisher Library, we demonstrate the role of II in relation to two key aspects the library is accountable for: *What items does the library hold?* and *Where is a specific item when it is not on the shelf?* How these two key questions are asked and how they can be answered changed over time, as social and material circumstances unfold. Our case of Fisher Library demonstrates the role of II as part of an organization's ability to capture and account for processes within an organisation. We investigate how information and communication systems shape the perception of what can be accounted for and subsequently become information as part of accounting practices (Boyns 2008). Approaches that focused on the history of accounting showed how the rise of mechanical accounting has fundamentally changed accounting (e.g. Wootton and Kemmerer 2007). We expand upon such earlier research by analyzing how over time the introduction of computers changed accounting practice (Yates 1994). We argue that media of accounting have to be investigated as part of a broader II that underpins and makes possible different forms of accounting by turning specific aspects into formalized and categorized information that can be processed by accounting systems.

Our research uses an interdisciplinary approach to investigate how over time IT shaped and changed the way how organizations account for key aspects of their operation. We first develop our theoretical foundation, introducing the concept of II on the foundation of a media-theoretical perspective. Using this foundation, we track changes in II at a large educational and research library in Australia, following the introduction of automation technologies and computing into the fabric of the University of Sydney's Library between 1963 and 1975. We draw from Heider's (1926) media theory, investigating how II is both a medium and a thing when unpacking the role of IT in how organizations ability to account for key aspects of their operation changes over time.

## IT and Organizational Change

Looking at changes to organizations and ways of organizing that occurred over the last few decades, IT and the professional cultures and negotiations linked to IT have been tremendous forces in shaping as well as driving these changes (Bátiz-Lazo 2018; Gugerli 2018); however, historical research on organizational IT over longer timescales is sparse, often focusing on individual 'maestros' orchestrating IT within an organization (e.g. McKenney et al. 1995), on the adoption of mainframe computer systems into large corporations (e.g. Haigh 2001), or on the development of IT from an industry perspective of technological progress (Aspray and Campbell-Kelly 1996; Ceruzzi 2003; Cortada 2004, 2006, 2007). This research has produced few descriptive models that either describe IT-related organizational change as cascades (McKenney et al. 1995), as phases of recurring technology adoption processes (Nolan 2000), or from a general systems perspective (Porra et al. 2005). In this paper, we offer a novel lens

for understanding long-term, IT-related organizational change, combining the idea of II with a media-studies perspective. In the following section, we first introduce the concept of II, which we then extend using a media-theoretical lens.

### *Information Infrastructures*

Research on IIs in Information Systems is mature, investigating IIs in different settings, such as customer relationship management (Ciborra and Haseth 1998), architecture tools (Gal et al. 2008), financial mortgage securization (Kaniadakis and Constantinides 2014), criminal justice (Iannacci 2010), or health (McLoughlin et al. 2016). For the purpose of our study, IIs offer a means for understanding IT in relation to long-term organizational changes: 'IIs [...] typically stretched across space and time: they [...] endure over long periods (decades rather than years)' (Monteiro et al. 2013, 576). The concept of II is thus suitable for investigating the long-term consequences of IT for organizations. Taking an II perspective requires researchers to understand IT in relation to organizational change beyond the currently often-dominating, project-based timeframe of months to a few years (Leonardi and Barley 2010; Ribes and Finholt 2009). While some studies simply refer to the copper cables, fibre networks, and satellites forming the backbone of data transmission through the Internet as IIs (Shade 1998), most researchers understand IIs as socio-technical systems encompassing technology as well as the practices that are sustained by and related to IT (e.g. Bygstad 2010; Clarke and Wigan 2018 Hanseth and Lyytinen 2016; Iannacci 2010). We also build on a socio-technical conception of II, as organizational change involves, besides technology, social actors, organizational structures, and work processes. We specifically draw on the definition provided by Hanseth and Lyytinen (2016) for our conception of II:

> [We] define an II as a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities. (Hanseth and Lyytinen 2016, 4)

This definition explicitly includes the designers and developers involved in the creation of II and thus allows us to investigate beyond users the role of the people involved in the creation of IT artefacts used as part of II.

Much of the existing research on II builds on the concept of infrastructures developed by Star and Ruhleder (1996). While Star and Ruhleder describe infrastructure as characterized by aspects such as embeddedness or the embodiment of standards, for our purpose, the most important aspect of II pointed out by Star and Ruhleder is *transparency*. They argue that in day-to-day use, II is generally not recognized, as it 'invisibly supports those tasks' (113) that the II is designed to support. II as part of the daily organizational routines becomes invisible and stable as long as these routines and 'transparent-to-use' (113) work arrangements can fulfil their organizational functions. This, however, requires a research lens that enables us to observe the otherwise invisible effects of IT as part of socio-technical systems. To approach such a 'tricky' (Star and Bowker 2010, 231) object of study, we turn to media studies as a disciplinary lens interested in the relational character of media 'between [the] background and foreground' (233) and how this alters cultures, logics, and processes tied to organizational media. Understanding II as a medium thus offers us a means for unpacking the long-term effects of IT as part of II.

### *Information Infrastructure as a Medium*

Media studies enable an understanding of IT as part of a wider social and cultural history of

organizational infrastructure that forms how information can be processed, understood, and perceived (Hoof and Boell 2019). This approach helps to broaden the focus from a single technology or device to a more complex perspective on organizational change, as connected to changing forms of administrative 'grey media' (Fuller and Goffey 2012) 'that allow for the possibility of exchange over space' (Larkin 2013, 327). Looking at II as an instable, ever-shifting and contested organizational arrangement, we understand II as a medium that by its very form structures the relationship between organizational perception and information. Here, we rely on a media studies perspective that understands media as instances that mediate, such as light or electricity (McLuhan 1964).

Media are therefore anything that enables communication, the exchange of information, or the logistics of goods. For instance, economic historian Innis' (1927) analysis of the fur trade in Canada looked at the existing network of lakes and rivers as a medium for transportation and communication that was vital for the fur market to flourish, but at the same time determined its scope, scale, and temporality. As media form 'multiple, overlapping and perhaps contradictory infrastructural arrangements' (Star and Bowker 2010, 230), organizational media are not only the result of current managerial decisions, but they are also part of a longer media history (Huhtamo and Parikka, 2011). Thus, modern organizational media form IIs that are compounds of different media technologies, including paper-based media such as forms and cards, mechanized devices such as typewriters or digital media, and communication devices (Gitelman 2014; Kittler 1999). They are not simple neutral facilitators for communication or for circulating and storing information; rather, they are constitutive in forming the way organizations operate (Yates 1989), for example by shaping a visual culture of decision-making that mediates managerial practices within organisations (Hoof 2020).

As an organizational medium, II is designed to be 'as invisible as possible, while leaving pointers to make it visible when it needs to be repaired or remapped' (Star and Bowker 2010, 230–231); thus, when II sinks into the fabric of the organization, it becomes transparent. Here, we rely on Fritz Heider's (1926) media theory of thing and medium to describe how changes to technology and organizational structures are perceived. Heider enables us to focus on how modes of perception change when a thing becomes transparent and thus turns into a medium that allows for a certain form of perceiving the world.

### *Heiders' Conception of the Perception of Thing and Medium*

Heider's distinction between thing and medium argues that a medium enables perception through it. In contrast, things are the object of interest seen through a medium (Boell and Hoof 2015). Accordingly, a *thing A* is only perceivable through another *thing B,* which thus becomes a *medium* through which we then perceive *thing A.* Thus, any 'thing' such as a sheet of glass or a body of air can be understood both as a thing and as a medium. Which one it is depends on where the attention goes. If the attention goes *through it* to give us knowledge of things beyond, we speak of a *medium*. Now, what can be a medium for what else depends on the inner logic of that thing. For instance, the inner logic of a sheet of glass is determined by its material grounding as a compound of melted sand. It can be a suitable medium for light, while at the same time it is less suitable to transmit sound, as soundwaves that travel through a sheet of glass get distorted or altered by the inner molecular structure of glass as a medium. As this example makes apparent, Heider's (1926) differentiation between thing and medium is not dualist, where something is either a thing or a medium, but always relational.

While the inner logic of a thing is no longer perceived when a thing becomes a medium, the inner logic of things persists. Thus, as IT becomes a medium through which day-to-day

operations are carried out, the inner logic of the thing acting as a medium persists. Heider's epistemology can therefore account for IT as part of organizational change in two ways: on the one hand, ITs are *things* that themselves are the object of organizational change; on the other hand, when IT becomes embedded into the practices of the organization, it turns into transparent II. IT is then a *medium* that makes visible information about the organization required to account for core functions of the organization. We draw on this understanding of medium to analyze the relation of transparency and opacity of IT as a 'historically contingent' (Bowker 1996, 58) process that alters the way through which the organization accounts for core functions. From this perspective, II is ever changing, not only in terms of its technological dimension, but also in how it is addressed and perceived within an organization. II is the result of different media devices, organizational negotiations, and norms associated with past media use. II as a medium enables certain perceptions of the world, while excluding others by determining which phenomena are defined as relevant and thus constituting information for the organization (Boell 2017).

## Accounting for Items at the University of Sydney's Fisher Library

Arguably, IIs play an important role in all kinds of organizations. One type of organization where II is essential and visible is a library. Our case, the University of Sydney's main library, also known as *Fisher Library*[1], engaged in automation early on, when most of the ideas around library automation were just evolving in the US (Bryan 1966a, b; de Gennaro 1983).[2]

Two key aspects the library is accountable for are: *What items does the library have?* and *Where is a specific item when it is not on the shelf?* These two aspects are managed by cataloguing and circulation. The main responsibility of the Cataloguing department is thus creating and maintaining an index of items held by the library, so that patrons and library staff can locate items at a particular book shelf. Finding this location is generally achieved by consulting the catalogue, using criteria such as author names, titles, or subject headings; however, individual books may be taken out of the library for a specific duration. The responsibility of the Circulation department is thus to keep track of books as they are borrowed from the library. For this, Circulation keeps a record of which books are currently taken out of the library by which patrons. We follow the development of Fisher Library from 1963 to 1975 a period during which the library saw growth of more than 230% in both the numbers of items available for borrowing as well as items borrowed (Table 1).

**Table 1.** Overview of the development at Fisher Library from 1964 to 1975 in terms of items held by the Library as well as loans made from the library.

| Year | Number of Items held by the Library | Number of Loans made from Library |
|---|---|---|
| *1964* | 887,005 | 212,516 |
| *1965* | 946,777 | 282,648 |
| *1966* | 1,009,910 | 325,539 |
| *1967* | 1,098,435 | 359,565 |
| *1968* | 1,188,521 | 430,270 |
| *1969* | 1,263,088 | 471,607 |
| *1970* | 1,336,930 | 494,845 |
| *1971* | 1,410,900 | 540,923 |
| *1972* | 1,716,971 | 544,879 |
| *1973* | 1,808,918 | 559,635 |
| *1974* | 1,923,433 | 527,817 |
| *1975* | 2,062,725 | 573,207 |

Source: Fisher Library Rare Books Collection, Annual Report of the Librarian.

### *Emergent Use of Automation Technology in the Cataloguing Department*

In the early 1960s, due to increased funding for university libraries, the library's collection expanded quickly as it 'acquired several exceptional collections' (Connell 1995, 129) to add to its already existing collection. In 1963, when Harrison Bryan was appointed new head librarian, there was a backlog of about 200,000 items awaiting cataloguing (ARL 1963, 5). Besides the task of clearing the backlog created by the acquisition of other collections, the library also needed to index new material acquired on an ongoing basis.[3] This, however, put pressure on cataloguing to produce an increasing number of index cards for the library catalogue, so that newly acquired material could be made available to the users. It was a situation where the existing II at Fisher Library was no longer capable of mediating seamless organizational operation and accountability. Established routines, practices, and devices used at Fisher Library ceased to be transparent II, as they became seen as hindering one core function the library is accountable for.

In the 1960s and 70s the term *automation* turned into an umbrella term that promised accelerating routines and processes within organizations, but was also connected to fears of the degradation of work through means of automation, by taking away organizational knowledge from the employees and monopolizing it on the side of the management (Braverman 1974). Like with many other industries, the early 1960s had the first libraries in the US starting to look at automation as a means to improve their operations (c.f. Bryan 1966a, b; Markuson 1964).

Thus, in line with developments abroad, the management of the Fisher Library looked at automation as a possibility for coping with the pressures it faced. But automation was also seen more broadly as a means 'to make the library a more active organism' (King et al. 1963, 6) as it helped in overcoming 'the fallibility and limit of human memory' (King et al. 1963, 3) and improved the quality of service. Routinized local practices closely tied to the existing II at Fisher Library became perceived as potentially benefiting from opportunities arising out of new ways of data processing.

In the early 1960s, the only means to search through the library's collection was the card catalogue listing all books indexed by the Cataloguing department. To maintain this II, multiple copies of an index card had to be typed for each book, in order to make it searchable by categories such as author name, title, and subject. Furthermore, two additional copies were required for the *shelf list*, an internally kept index used to account for all of the material held by the library, and for the union catalogue at the Australian National Library. The existing II was

suitable for maintaining access to a moderately expanding collection of books and consequently was not able to handle the sharp increase of new items added to the library's collection.

To be able to keep the II in good shape, the first move was thus to speed up indexing. Consequently, in 1963 when the library obtained its first photocopier machine, the *Xerox 914* photocopier was used for

> producing multiple copies of catalogue cards. This process has made it possible to handle an increased intake [of books] with no corresponding increase in the typing strength. (ARL 1963, 5)

This use of mechanical multiplication of catalogue cards meant that typing capacity could be used for the production of cards for an increased number of indexed items instead of producing multiple copies of otherwise identical catalogue cards.

### *Emergent Use of Automation Technology in the Circulation Department*

The second aspect where the library came under pressure was the Circulation department, as the 1960s saw an increase in overall student numbers, while at the same time, the attractiveness of the new Fisher Library building 'was bringing about a substantial increase in library use' (Radford and Barry 1966, 228). Thus, the library had to deal with an increasing number of loans made from its collection. From 1963 to 1967, the amount of loans that were made from Fisher Library almost doubled (Radford 1966).[4] Regarding circulation, the library is accountable for ensuring that items are returned in a timely manner. Previous II supporting the circulation of items became insufficient for achieving this and the library turned to automation as a means for 'coping effectively with the tremendous volume of circulation' (Radford and Barry 1966, 228). In its search for a solution, the library decided to introduce the *Brooklyn Circulation System* (Birnbaum 1960). This installation of an *IBM* punched-card system at Fisher Library used two types of cards to account for the loan process. The first card was filled out by the patron borrowing a book and required details about the book and the borrower.[5] Library staff then took the card from patrons, checked it for accuracy, and stamped on it the number of a second, pre-numbered transaction card which was inserted into the back of the book for the duration of the loan.

To achieve automation of the identification of overdue books, some of the information written on the borrower card collected from a patron was punched onto the card using an *IBM 26 Printing Card Punch,* thus making the information machine readable.[6] Using an *IBM 82 Sorter* and an *IBM 77 Collator,* cards could then be mechanically sorted in order to identify loan cards of overdue books. This enabled a high degree of automation for identifying and notifying patrons with overdue books; however, it also changed the II of the circulation department, as it led to the introduction of 'a team of *IBM* punched card operators and sorter and collator machine operators' (Interview with Diana Kingston 2018).[7] This change in II thus standardized the information kept about loans, which also made it possible to perceive library operations in new ways. For instance, the library could analyze student borrowing patterns, enabling a detailed account of the books borrowed by students (Radford 1966) by having, for the first time, exact numbers of loans made throughout the year during study terms and vacation periods, as well as analyzing loan patterns made for various subject categories and how these were distributed over Fisher's undergraduate (UG) collection and the research collection (Radford 1966). Finally, as equipment costs associated with the *IBM* punched card installation and staff salaries were known, the library could calculate the average cost per loan transaction (Radford and Barry 1966).[8]

### *Intersecting Information Infrastructures between Circulation and Cataloguing*

Both the *Xerox* machines and the *IBM* punched-card installation enabled an increase in the library's efficiency in the production of catalogue cards and in handling the high volume of loans; however, as both the number of books held by the library and the number of students increased, access to the library's catalogue became problematic. In 1966, the head librarian described this situation as congestion around the catalogue.[9] In addition to patrons, library staff members also needed access to the catalogue when they added new index cards as the library's collection grew by thousands of books every month.

The library therefore sought a new way to decrease congestion around the card catalogue. As a solution to this problem, the library produced a first spiral-bound UG catalogue in 1966 (Bryan 1966c). This catalogue had the advantage that it could be consulted in other parts of the library and thus helped to draw users away from the card catalogue, thereby reducing congestion.

The creation of the printed catalogue drew from the II put in place as part of the IBM punched-card installation for circulation as

> a committee of the professional staff investigated the feasibility of a near-print catalogue for the UG library, run off from a record created by the Library punched-card installation. (ARL 1964, 6)

Using existing key-punch equipment in the Circulation department, the creation of the catalogue made visible the IT put in place as part of the II for one department of the library to facilitate the improvement of the II in another department of the library. This was a new way of perceiving the organization and its operation drawing from possibilities offered by IT.

> This catalogue was [...] a deliberate exercise in automation, which, however simple in itself, would assist in orienting the Library towards increasing its use of modern data processing equipment. (Preface of the preliminary edition of the first printed UG catalogue)

As the quote from the preface of the first printed UG catalogue highlights, it was well understood that this was a watershed moment for Fisher Library, as it enabled the creation of organizational knowledge and expertise in using IT for organizational purposes. Equally important, the production of the printed catalogue required the library to create for the first time a machine-readable record of parts of its holdings, which were then computer processes:

> The text was produced by offset duplication from a computer-printed master copy. Computer input in the form of punched cards was produced on the unit record equipment used in the Fisher circulation system. The computer programme included alphabetizing and re-arranging the format of the entries. (Preface of the preliminary edition of the first printed UG catalogue)

It was not long until the library realized that such machine-readable data could also be manipulated and used to account for more than the initially conceived purpose. Less than a year later, in 1967, data generated by the IBM punched-card system was computer processed to print a list of overdue books held by academic staff (ARL 1972, 33). As there were no sanctions in terms of fines for academic staff holding on to books 'almost indefinitely' (ARL 1967, 10), the printed list of academics was used to restrict issuing stack passes to the library.[10] Using the list as a deterrent, the library could ensure that 'all items were accounted for – for the first time for many years' (ARL 1967, 10). Likewise, from 1972 onwards, data from the UG catalogue would also be used to print lists for stocktake purposes.

### *Changes to the Organizational Structure*

1966 not only saw the beginning of the library's encounter with computing, with the first printed UG catalogue, but it was also the year where 'more books were received than ever before' (ARL 1966, 1). In 1966, 63,133 items were added to the library's collection; by 1967, this figure had further grown to 88,525 items. Thus in 1967, the head librarian realized that this trend was unsustainable for the Cataloguing department, stating that

> there was a real danger that the present staff, following present methods, would not be able to handle the normal intake of material [requiring the library to be] re-assessing its current methods to see what further economies in processing can be effected. (ARL 1967, 6)

One possible means the librarian envisaged was to make use of cataloguing already undertaken in other places, such as by the Library of Congress (King et al. 1963).

To facilitate the necessary transformation of organizational II, the head librarian established the position of Systems Librarian. This position was to examine and document existing work practices related to organizational II and advise the librarian in the use of computing equipment:

> The Systems Librarian is responsible directly to the Librarian. Her duties encompass the design of systems, particularly those involving computer applications, and recommending as to the method of their implementation. In addition, she is responsible for collecting and maintaining a comprehensive file of documents relating to existing systems in the Library. (LIB 1968, No. 3)

In 1968, Dorothy Peake became the first systems librarian, with one of her first tasks being to write the necessary assembly language code[11] to process the printing of the UG catalogue (ARL 1968, 18). Thus, the library could move production of the UG catalogue from the external commercial operator to the University's own *Basser Computing Center*[12] in the Physics department, operating an *IBM 1401-7040*.[13] When Peake left for a position at the University of New South Wales (UNSW) in 1969, a new position of *Systems Officer* (library) was created and filled by Mary Ellen Jacob. This position was transferred to the Deputy Principal's office (LIB 1969, No. 6) as there was a perceived

> need to co-ordinate more closely the computer requirements of the non-academic Departments. Certainly, one result of the appointment made has been to strengthen considerably the links with the computer facilities operated by the Registrar and the Accountant respectively. (ARL 1969, 23)

While the responsibility of the position of *Systems Officer* was with the Deputy Principal, the work was undertaken at Fisher Library, where Jacob undertook her day-to-day work (LIB 1969, No. 6). In 1970, a Programmer, Andrea Penhall, was hired to assist the Systems Officer in her work. The proximity to the Registrar's *IBM 360/20* computer not only encouraged the development of new programs intended to run on this computer, but it also motivated the conversion of all existing programs from machine-dependent *MAP* assembly code to machine-independent code written in *COBOL*.[14]

In 1971, the responsibilities of both positions (Systems Officer and one Programmer) were transferred back to library and converted to two Senior Programmer positions, as Mary Ellen Jacob became head of the *Technical Services* division (LIB 1973, No. 4). By 1972, the library had transformed computing into the fabric of the organization, as the *Systems Office* was established as separate organizational unit under *Technical Services*. Finally, the position of the Systems Officer was re-established in 1973 and occupied by Dagmar Schmidmaier as head of the library's Systems Office.

The position of *Systems Officer* and subsequently the *Systems Office* were created as means for the library to assess its current procedures with the aim of identifying means to use automation for improving 'economies in processing' (ARL 1967, 6). In the late 1960s, the most pressing issue was the library's ability to account for receiving and processing a rapidly increasing amount of material.

### *Using External Standards for Advancing the Local Information Infrastructure*

As a means to improve operations, the library looked at an electronic catalog system, which eventually would lead to the creation of a master bibliographic file. Work began in 1969, when the Library's *Systems Officer* started consultations with both staff from the *Technical Services* division and the *Reader Services* division (ARL 1969, 23). The decision to design the catalogue as an online system was influenced by a study visit to the US by Owen E. Slight, the head of the library's Technical Services division. Between September and December 1969, Slight visited the *Massachusetts Institute of Technology* to observe their work on project *Intrex,* described by the head librarian as the 'most sophisticated existing operations in this area' (ARL 1970, 25). Upon his return, Slight insisted not only that an electronic catalog system can directly be developed as an online system, but also that the catalogue data should use a *MARC* (Machine Readable Cataloguing) compatible record standard from the Library of Congress (ARL 1970, 25; ARL 1972, 33). Using a *MARC*-compatible standard was perceived as enabling an online system where existing cataloguing records created elsewhere could be acquired and used by the library, thus reducing the amount of cataloguing work that had to be done in-house. This was considered especially useful for the conversion of all of the entries in the existing card-based catalogue, which by 1970 already consisted of 1,336,930 items (ARL 1972), to a machine-readable format.

In 1970, the library began to experiment with online keying of catalogue information through a remote terminal linked to a computer service bureau (ARL 1970, 25). For this purpose, cataloguers wrote

> by hand on a MARC type format worksheet [that was then…] keyed to machine-readable from by trained typists – i.e. data entry by direct terminal online onto disc at IBM's Rosebery centre. (document provided in addition to interview by Diana Kingston 2018)

Data entry thus shifted from a manual process producing punched cards to *MARC* forms (Figure 1) entered via an *IBM CALL/360 system* using an *IBM 2741 terminal* for data entry. Data was submitted from the terminal to the IBM computer center that was situated six kilometers away at Rosebery, an industrial area near the Sydney airport. Here, the data was recorded on disk and transferred to tape on a weekly basis for further processing at the University's Basser Computing Center (LIB 1973, No. 4).

Using the terminal, data entry started to include material acquired for the research collection, in addition to material added to the UG collection. The objective of this was

> to create and maintain a machine-readable record of all current catalogue data. The immediate priority was to produce catalogue cards for this material. (LIB 1973, No. 4, 5)

The first printed catalogue cards based on data entered into the online system were produced using the Registrar's *IBM 360/20* computer in February 1972; however, the initial range of characters printable was limited and in July a new print chain made possible 'an increased range of characters' (ARL 1972, 18). By November, the card system was fully operational, producing 2,000-3,000 index cards each week. Apart from automating the printing of cards,

the system was also 'producing catalogue cards in filing sequence for the NAME & SERIALS Catalogues' (LIB 1973, No. 4, 5), which the librarian described in terms of rationalization as a means 'saving of some hundreds of hours of clerical time per year in checking and sorting card batches for filing' (ARL 1972, 37).

The library was now maintaining two machine-readable records of its holdings one for the UG catalogue and a second for the creation of index cards. Thus, in order to maintain the regular production of the printed author-oriented UG catalogue at the Basser Computing Center, data needed to be converted from the new system running on the Registrar's *IBM 360/20* and punched onto cards for further processing at the Basser Computing Center (LIB 1973, No. 4, 8).[15] Using this data, the library produced in 1972 the first printed *Reference List*, which was a specialized subject list for material in Fisher's UG collection and branch libraries. Machine-readable data was thus used to facilitate a second pathway for identifying material in the library's UG collection besides the already existing alphabetic author index. Finally, as the number of copies held of a book was added to the dataset, data could also be processed to account for lost or stolen books through printed stocktake lists for the UG collection from 1972 onwards (ARL 1972, 33).

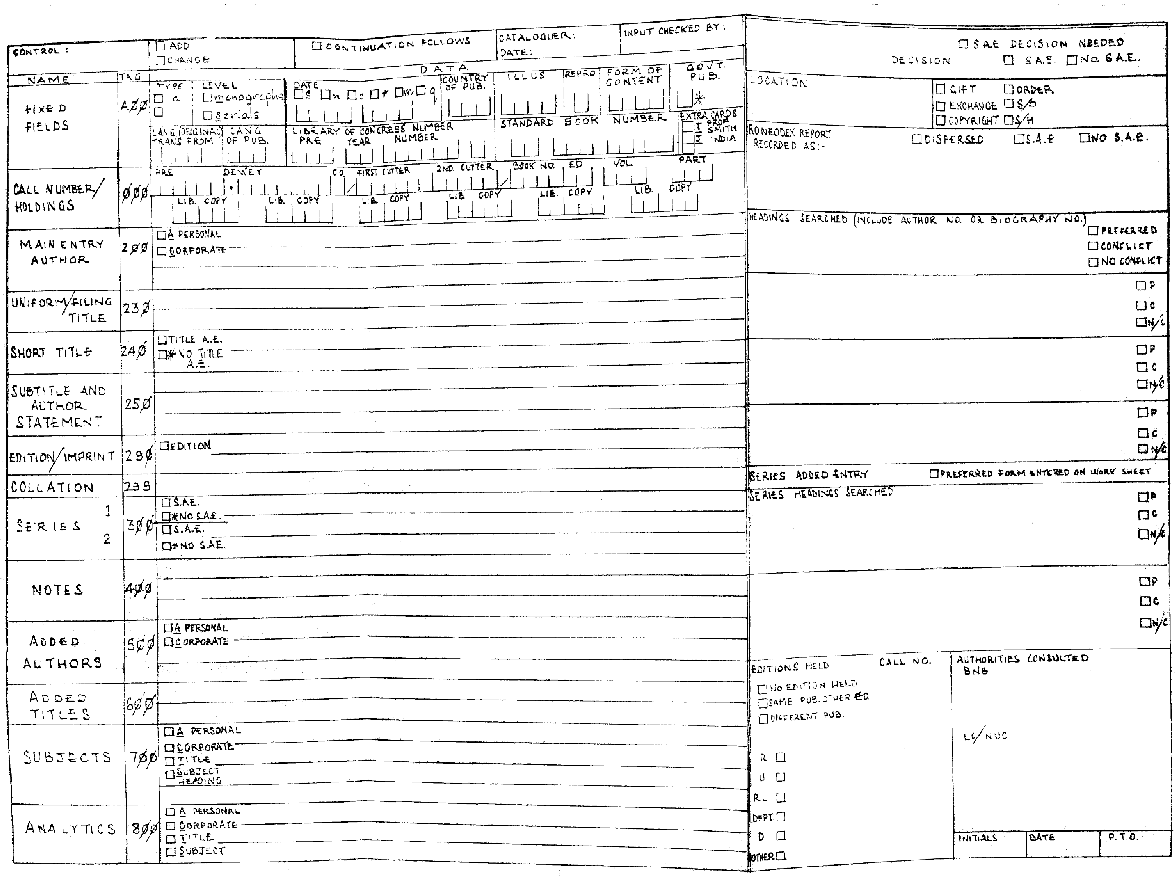


**Figure 1.** Form used for the creation of MARC records.
Source: Fisher Library Rare Books Collection, Cataloguers Manual for Data Input.

Involving the *MARC*-standard computing was not only a tool-like solution to immediate problems the library's organization was facing, but it was also part of an emerging II that started to replace existing practices within the library. The new *MARC* standard used to account for items not only represented a scalable transparent-to-use solution to an organizational problem, but it also changed how the organization gathered and processed

information. II enabled the organization to revise and stabilize its routines by synchronizing Fisher's cataloguing system with an internationally available standard. Consequently, the new devices, procedures and protocols as part of the II sunk back into the fabric of the organization as a transparent-to-use medium.

### *Adding Minicomputers to Fisher's Information Infrastructure*

During the early 1970s, computing at Fisher Library was on the rise and so was the number of loans made at the library, with total loans more than double the number of less than a decade ago.[16] Thus, organizational routines tied to the *IBM* punched-card circulation system were reaching their capacity. The II used for processing loans from the library ceased to be a transparent-to-use solution that would seamlessly function as an organizational medium, as it became the site for organizational negotiations and change. To address the new problem, the library aimed for further automation of loan processing. The major shift was the introduction of a barcode system that would help to account for items in loan circulation. Barcodes offered an automated solution that originally stemmed from the world of railroad logistics and after the mid 1970s became widely used at supermarket checkout systems (Girschik 2010). Once again, the new solution was first introduced to the UG collection.[17]

Ideas about a computer-based circulation system for handling loans made from the UG library were first expressed in 1973 (LIB 1973, No. 4, 7). The new circulation system for the UG library was based on barcode labels attached to all books for identification purposes (McKendrick 1975). In addition, all borrowers received a barcoded borrower card (Figure 2). The system thus no longer required the user to fill out a borrower form, as data about both the user and the book were already on disk; however, in order to make such a system work, all books in the UG library needed to be accountable through barcodes. So the Cataloguing department needed to attach a barcode to the record kept for each book and end-processing required attaching a physical barcode label to the book before it was ready for shelving in the library.

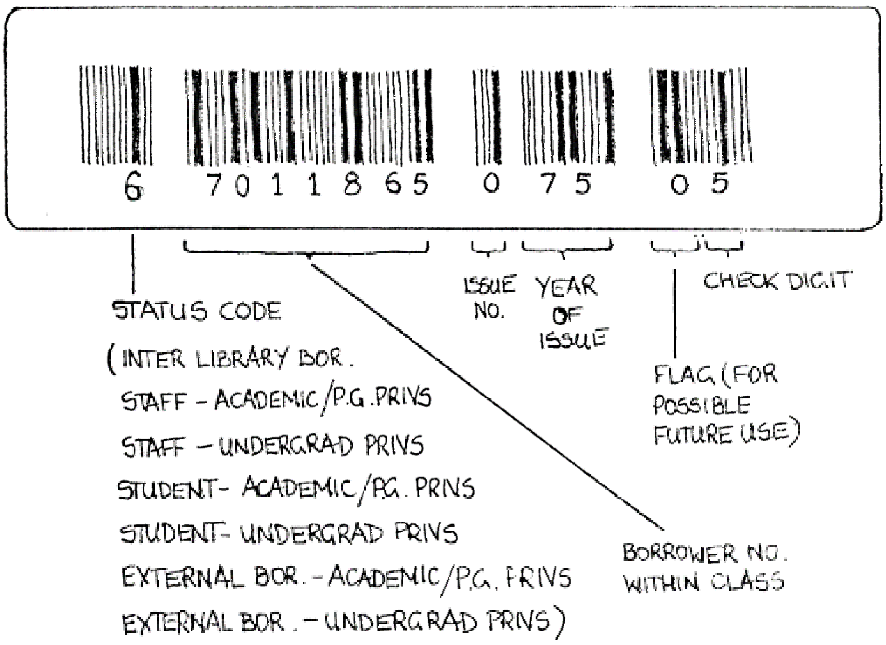


**Figure 2.** Barcodes of Borrower Labels.
Source: McKendrick (1975)

For the introduction of the barcode system, the library engaged in the first computing operation of its own. Like many other organizations in the 1970s the library looked at much more affordable minicomputers to support its operations (Nolan 2000). In November 1974, the library's first minicomputer arrived: a *Data General 840/1200* dual system. The operation of the system involved library staff using a *Libramatic light-pen terminal* for reading the barcode label of a user and then the barcode of the book to be borrowed. The system then printed a label for the patron, showing the transaction number for the loan.

While loan processing was done online on the library's minicomputer, processing of overdue books and calculation of fines for users was still done offline using batch processing on the mainframe system at the University's Basser Computing Center. Thus, overdue notices and fines were processed on the mainframe system, which then produced data on users with outstanding fines, that was put back onto the library's minicomputer (Schmidmaier 1975).

Even though the objective of the online system was 'to improve service to the library's users by responding more quickly and accurately to their requests' (Schmidmaier 1975, 15) the computer-based system was not simply a better version of the punched-card installation. The *mini-Libramatic System* (16) fundamentally altered operations throughout the library:

> As an ongoing activity supporting on-line our system, cataloguing, and processing and circulation procedures have been modified so that new books entering the Library are labeled before shelving. (McKendrick 1975, 36)

This change in procedures thus questioned the way the library was operating more generally, raising the question of looking at the library's processes:

> we have not gone for [sic] enough in looking at our operations and asking why we have certain rules and do things in certain ways. Many of these operations are simply accepted because it has always been done that way, because that has been the best way in the manual system. (Schmidmaier 1975, 18)

The introduction of new IT devices and systems not only resulted in changes on a departmental level with the introduction of the *Systems Office*, but increasingly also affected organizational change at an intra-departmental level as processes in various units within the library had to be changed in order to accommodate the II needs in different parts of the library. IT-based loan processes altered the II used to generate data about overdue books and how this data could be processed from punched cards to an electronic format. Local work arrangements, such as the practice of filling out borrower cards that were used to stabilize the loan system, were integrated into the new barcode-based system. The *mini-Libramatic System* became a medium as the barcode system made local work arrangements transparent and thus enabled new perspectives on other aspects of interest to the organization. As the above remark by Schmidmaier indicates, this had far-reaching consequences for perceiving the library and the practices it was engaged in. Over time, as II evolved, Fisher Library began to account for its operations in new ways that questioned existing operations and as a result led to further changes of the library's II.

## Using Heider to Analyze Information Infrastructures

Applying Heider's (1926) notion of thing and medium for looking at the II at Fisher Library, it is apparent that the *things* used to account for the organizational practices of circulation and

cataloguing are changing over time. At the same time as *things* used to account for key functions at Fisher library are changing, so is what can be perceived through these things when they become *media* that facilitate and stabilize the work arrangements within the library and its patrons.

The question '*What items does the library have?*' was initially dealt with by paper-based II. It involved index cards with information typed onto them, that were sorted into different sections of drawers of the card catalogue, in order to allow the identification of items by authors, titles, or subjects. Albeit the catalogue consisted of bulky furniture and index cards that one had to browse through extensively to find the relevant information, the bulky part became a transparent medium. By using *Xerox* machines to duplicate an initially created card for an item, thereby reducing the chance of typing errors and therefore inconsistencies, information provided about items was perceived as more consistent across the catalogue than before.

Later, when congestion around the catalogue became an issue, the library combined paper-based with a computational II. It introduced punched cards to account for all items in the UG catalogue. These cards could then be sorted by a computer to create a list of all items in alphabetical order by author names. Printing this listing and binding it into a book brought a finding aid into being, that could be placed into different parts of the library. It addressed the problem of congestion by drawing users away from the index-card-based catalogue. The introduction of machine-readable data about the library's items thus altered the way items could be accounted for and how the library fulfilled its duty towards its patrons. Moreover, machine-readable data also changed what could be perceived about these items: first, items could only be located by author names and not by title or subject; second, entries included only minimal information about each item required to locate the item on library shelves, excluding most of the information contained on the index cards; and finally, the machine-readable data was limited to single-case characters, with shortened names and call numbers (LIB 1973, No. 4, 8). Thus, the printed UG catalogue as a newly introduced 'thing' stabilized the existing II by addressing the problem of congestion. After it became part of the routines of cataloguing, the UG catalogue became a transparent-to-use medium that allowed a different perception of the inventory of the library.

The introduction of the UG catalogue was a first attempt at an overarching standard that would allow combining and integrating different devices of the existing cataloguing system into a new II. Going forward towards a bibliographic master file containing standardized and thus interchangeable information about all items held by the library, the library needed to change the data recorded about each item. Here, we see the library drawing from the external *MARC* standard, using preformatted *MARC* cataloguing forms in order to create an electronic record for each item that was then printed by the computer onto index cards.

This changed how items were accounted for, as existing local work arrangements of the librarians to search and locate items were replaced by and fed into a bibliographic master file that was conceived as a universally applicable information format. Now a machine-readable record was the primary 'thing' representing items, which was then used to produce physical index cards. This electronic record also changed the II as a medium, as it enabled new ways of perceiving items held by the library. For instance, it enabled the creation of printed lists that became useful for the purpose of accounting for lost or stolen items as part of stocktake activities in the library; and it enabled the library to hold academic staff members accountable the items kept for extensive durations. The standardized master file thus not only helped to integrate different devices into the II, but it also offered new possibilities to cluster and compare data about the library, as they were now all based on the same standard, making it

easy to relate different sets of data. This is evident in the library's desire to make use of *MARC* records produced elsewhere for the purpose of creating an electronic record of the items already held by the library.

Likewise, the II related to the second question, '*Where is a specific item when it is not on the shelf?*' also changed. Initially, items not currently on the shelf were perceived through sets of punched cards that physically represented these items. Cards were then sorted at regular intervals to identify borrower cards of overdue books and thereby enable the library to hold patrons with overdue books accountable. As a medium, this installation enabled new ways of analyzing borrowing patterns over subject categories and over time, throughout study terms, as well as average costs associated with a single loan transaction (Radford 1966). Later, the machine-readable catalogue, in conjunction with barcodes and the *mini-Libramatic System*, enabled the library to perceive patrons with outstanding items at the point of borrowing; thus, the medium also changed the scope of how the library was able to account for items. Previous boundaries were permeated by now having the means to reach out in new ways to borrowers who would not return items.

Heider's concept of thing and medium can also be applied to understand IT itself as a medium through which the library and its operations are perceived. In the case of Fisher Library, as IT became part of the fabric of the library, the library was increasingly perceived as a set of systems supporting routines, that can be optimized through the uses of automation. Over time, IT eventually led to a perception of existing manual practice as something that has to be questioned in order to find better ways to handle the library's operations. Thus, on the one hand, IT itself is a thing in the form of punched cards, computer programs, mainframe computers, and minicomputers, while on the other hand, IT is also a medium through which the library perceives its own processes and its increasing ability to draw from IT as a vehicle for organizational change.

### *Cycles of Transparency and Opacity*

Combining the idea of cycles from transparency to opacity and back, we add to the concept of transparency in infrastructure studies. Heider's media theory enables us to distinguish between different phases within organizations, as aspects of the II become visible as things and again disappear when II acts as a medium (Hoof 2015). While IIs are structures that have to be constantly stabilized, using Heider we also see how perception of an organization changes when II becomes transparent and thus a medium through which further changes of the organization are mediated. We see how parts of the II at some points become opaque and with it the logic embedded into the II. Over time, as the II becomes mundane and immersed in day-to-day activities (Maurer 2015), the inner logic of II disappears from view as II becomes transparent again, giving way to perceiving other parts and aspects of the organization.

To understand II as going through cycles of transparency and opacity thus expands beyond current research on II that is mainly interested in explaining its stability and durability. While existing research emphasizes the importance of breakdowns as points in time when II becomes visible and is adjusted to meet new demands (Bygstad 2010; Star and Ruhleder 1996; Star 2010), we focus on the relations of invisibility and visibility as a way to describe the ever-changing modes of perception within an organization.

According to Heider, II is also observable as medium when it is transparent-to-use. When II is understood as medium, II enables the perception of things, such as organizational activities, procedures, or data about items in very specific ways. For instance, II as a medium is visible in the form of *MARC* forms used for cataloguing, as printed UG catalogues, or as barcoded

borrower cards. II understood as medium is thus observable even in the absence of breakdowns, in terms of what it records and enables to be seen for different organizational actors.

Heider thus sensitizes II studies to a subtler approach for investigating II by paying attention to what is perceivable or not and hence indicating the presence of II and what it is able to account for. Like the sheet of glass or the body of air used as examples at the beginning of this paper, II becomes visible by analyzing the effect it has in shaping the perception of aspects of interest to the organization. Thus, the ability to make II visible as a medium does not necessarily hinge on breakdowns occurring.

### *The Role of II in Organizational Change*

Heider explains how IT as part of II is both a thing that is of interest to organizational change as well as a medium through which the organization itself is seen. This has implications when looking at organizational change.

First, we can see that IIs are always emergent, even if they are designed and designated to support a particular organizational function. Over time, II that is put in place to account for one function will interlink with II that is designed to account for different organizational functions. In the Fisher case, expertise and records created for handling machine-readable data in the circulation department fed back into the cataloguing department when the first printed UG catalogue was created and the production of computer-printed catalogue cards was encouraged. Later, we see a reversal back from cataloguing to circulation when expertise in using computer terminals and digital databases laid the foundation for building an online borrowing system. Not only is this an example of building organizational knowledge and expertise, but more importantly, we see a merger of two initially quite distinct IIs in cataloguing and circulation into one II. For Fisher's online circulation system to work, the system needed to interface with the II originally designed to account for locating books through the catalogue; therefore, the II underpinning the circulation function of the library became integrated with the II of the catalogue, in order to keep track of loans for items taken from the library.

Second, as IIs evolve, new organizational roles and practices emerge that undermine the existing functional structure of an organization. II is thus not only a means to account for certain functions, but it is also drives organizational change, as organizations have to adapt their structures as well as work practices to the emerging needs of II. In the case of Fisher Library, initial, small efforts in automation over time built up to quite dramatic changes in the organization and its operation. II thus reached much deeper into the fabric of the organization than what is visible when looking at traditional organizational structures. As we can see in the case description, the introduction of the *Systems Office* and the *Systems Officer* are obvious examples of a changing organizational structure; however, the introduction of first, manual data processing and later, electronic computing had a much more profound influence on the library's fabric, as they required other departments to adjust their existing routines and work practices. For instance, cataloguing shifted from using typewriters and *Xerox* machines for producing index cards to data entry on *MARC* forms and online terminals. Other departments were affected as well when the *mini-Libramatic System* was introduced: End-Processing had to start attaching barcode labels to books; User Services increasingly relied on machine-produced catalogues and other finding aids; and

> the Circulation Department had to establish and staff an additional service point to respond to an increased load, type and intensity of questions and appeals from library users. (Interview with Diana Kingston 2018)

In particular, the last change exemplifies that organizational changes resulting from evolving II often cannot be fully anticipated. While the need to put barcodes on books was anticipated as part of the introduction of the *mini-Libramatic System*, the need to establish and staff a new service point came as a surprise (Interview with Diana Kingston 2018). This also emphasizes that anticipated gains in efficiency related to the introduction of automation technology will need to be balanced against the possibility that additional resources may be required for handling unanticipated outcomes associated with changes to II.

As IT has its own agency, it acts in often unforeseeable ways when its specific materiality, culture, and history become part of an organization (Hoof and Boell 2019). While from a managerial perspective, the newly introduced IT devices have been discursively framed as technologies of automation and control, the sociomaterial negotiations (Orlikowski 2007) that were triggered by the introduction of the IT worked quite differently. Besides formalizing and centralizing organizational practices, standardization also increased informal spaces and practices within the organization. So, the understanding of the introduction of new IT infrastructure as automation is only one side of the coin; the other side is that an increase of informal work arrangements is needed to stabilize II.

## Conclusion

Our paper made two important contributions to the study of II and organizational change from an accounting perspective. First, we introduce an approach for analyzing IT-related organizational change and their effects on accounting in timeframes beyond the IT project level. Drawing from media studies, II can be understood as a medium that shapes organizational change, as it enables a specific perception of an organization. IIs not only shape work routines, but also structure the ways in which members of an organization account for organizational practices and thus how they take these practices for granted (Luhmann 1969; Ciborra and Hanseth 1998; Eriksson et al. 2018). Accordingly, IIs are not merely technological systems or socio-technical systems, but they also act as media that fundamentally change the way an organization is able to perceive itself and account for its operation. IIs are bound to their specific materiality as things that determine an inherent logic as medium (e.g. Innis 1951; McLuhan 1964) that then becomes the site of sociomaterial negotiations. When looking at IIs over time, we see those processes as partly 'instantiated in discourse' (Gitelman 2014, 2), as well shaped through practices of infrastructuring (Schabacher 2013; Star and Bowker 2010). II become formative in the creation of new forms of organizational media, giving rise to information 'that casts new light on the basic conditions underlying the operations of the organization' (Kallinikos 2006, 112). In our example, the logic of paper-based media that were closely related to the culture of the library as a world of books started to compete with the logics of data processing and the rising culture of IT specialists. This more fundamentally changed the way the organization saw itself and accounted for items accessible in Fisher Library.

Second, as II are often understood as transparent and invisible, the question of how IIs are to be studied is ongoing (Bowker et al. 2010; Karasti and Blomberg 2018). We demonstrate that using a media-theoretical perspective, II becomes visible and thus empirically observable not only at points of breakdown. II is always both 'thing' and 'medium' and thus IIs are always visible through the effects they have on the ability to account for things through them. Points of breakdown are important, as they reveal the character of II as thing. At these points in time, the way in which IIs enable the perception of organizational functions and processes becomes the focus of negotiations, tinkering, and adjustments. In Heider's sense, we are able to see the

inner workings of a medium as it becomes opaque and therefore a thing that is itself the object of our observation; however, when II turns back into a transparent medium, the embedded 'cognitive routines' (Luhmann 2011, 250) still exist and are observable through their effects on what II enables to be perceived. IIs thus have important consequences not only for *how* organizations can account for matters that are of interest to the organization, but also *what organizations can account for* in the first place. We thus demonstrate that IT changed organizational communication and accounting practices (Boyns 2008; Wootton and Kemmerer 2007) in a way that has lasting consequences for how organizations are able to see and account for key aspects of their operation. These changes are by no means located within a specific unit of the organization as over time IT enabled accounting is also related to changes in organizational structures, the use of standards and the execution of work practices. Accounting is thus not a set of defined activities aiming towards a definite goal, such as improving efficiency. Rather accounting is an ever shifting epistemological concept that defines and makes plausible what efficiency is and how it can be established and achieved for key functions of an organization.

Monteiro et al. (2014) have emphasized the need for long-term approaches when studying II. The reason for this is that when IIs are only studied when they are designed or at moments of breakdown, we can only see them as *things*; however, in the long run, the inner logic of an II shapes organizational structures, routines, and processes and thereby enables new forms of how organizations can account for what they are doing. To reveal these effects of II as *medium* requires a long-term research approach, especially as we demonstrated that II can be understood as going through cycles of transparency and opacity.

Our research also has implications for organizational and management theory, as it reveals that changing forms of II have far-reaching consequences for how organizations account for what they are doing that only become fully understood years after their implementation. Therefore, it is not sufficient to understand the introduction of IT devices as a project that is restricted to a specific timespan when a new function is implemented into the organization, such as in our case automation of specific aspects of circulation or cataloguing. Rather, II is part of a wide-reaching epistemological system that gradually changes the way an organization is able to perceive itself and to account for what it is doing. II may lead to the creation of new organizational routines and practices and II may blur boundaries between previously independent organizational functions as they become more closely interconnected over time. Thus, our findings call into question concepts that understand the introduction of accounting technology into organizations as a sequence of single IT projects that implement different technologies. One can even prolong our argument to the contemporary discussion on digitalization, as our case shows that it is not solely the technological core of a media technology that characterizes such processes. Thus, we need to be more cautious when framing organizational change as driven by new media technology as a sequence of ruptures between, for example, analogue and digital technologies, or paper-based and computational media. Instead, we need to take into account that organizational media are always part of a historical, emerging media network (Hoof and Boell, 2019; Hoof 2020) and that the introduction of new IT devices is better understood if we focus on the processes that unfold as part of such interventions into organizations.

## Notes

1. The library is housed in a purpose-built, nine-level building at the university's main campus in Camperdown Sydney (Slight 1967).

2. Our historical account is based on archival resources that include the following: (1) The library publishes annual reports (ARL – Annual Report of the Librarian 1963-1975) outlining changes happening throughout different departments of the organization. (2) The library also has detailed records on its day-to-day operations in the form of regular information bulletins (LIB – Library Information Bulletin 1963-1975). (3) Librarians published a number of articles on their automation efforts, where they describe various systems in detail, including their development and their operation (Bryan 1966a, b, c; McKendrick 1975; Radford 1966; Radford and Barry 1966; Schmidmaier 1975; Slight 1967).
3. For example, in 1962, 55,849 items were added to the library, which was described as a 'slow down' in collection building by the head librarian, put in place in order to cope with the ongoing indexing of new material as it arrived.
4. The number of loans made grew steadily over the following years to 212,516 in 1964; 282,648 loans in 1965; 325,539 in 1966; and 359,565 in 1967. (Source: ARL 1967)
5. In the further course of this article, we refer to this card as the borrower card as it contained information about the patron borrowing an item as well as details about the item borrowed.
6. The process is called 'punching' as it creates small holes in the card at pre-defined spaces. 'The information normally punched into each card comprises: call number, date due, transaction number, and a code number to present the status of the borrower (staff, student or inter-library). In addition, cards for loans to members of the academic staff are punched with the borrower's number.' (Radford and Barry 1966, 229)
7. Diana Kingston worked at Fisher Library from 1963 to 2004. Between 1974 and 1982, Kingston was the head of the circulation department.
8. Radford and Barry (1966) calculated a total cost of 7 cents per loan transaction, which was reduced to 4.3 cents per loan transaction once collected fines were factored in.
9. The head librarian described the situation as 'very difficult for readers […] to achieve satisfactory access' (Bryan 1966c, 200).
10. 'In 1966 a program was devised to produce a print-out, arranged by staff number, of all such overdue loans. It was made a condition of issue of a 1967 stack pass that any academic staff member return or account for all items so recorded in his or her name.' (ARL 1967, 10)
11. The computer processing the data was an IBM 7040 system. As with many of the early mainframe computer systems, programming was undertaken in machine code directly manipulating registers processing data; hence, Dorothy Peake wrote programs in the assembly code for the IBM 7040, called MAP 7040.
12. The name 'Basser Center' stems from Adolph Basser, who donated £50,000 towards 'Silliac', the university's first computer. It was based on the John von Neumann architecture of the 'Illiac' computer at the University of Illinois and was operational between 1956 and 1968. (Source: Connell 1995, 265)
13. The IBM 1401-7040 installation was a dual computer system. This installation was common during the mainframe era as the IBM 1401 was used for handling the input and output of data processed by the IBM 7040. Using such an installation ensured effective use of the much more powerful IBM 7040 for processing data (Ceruzzi 2003).
14. COBOL (common business-oriented language) was a widely adopted computer programming language that allowed the writing of programs in a way that was independent of the hardware architecture of a particular computer.
15. Data for both systems were structured differently, with data for the newer system including much more detail on each item. The older system, running at the Basser Computing Center, also worked on a different character set and only supported uppercase letters. Conversion of data from one system to the other was considered 'difficult' and 'more complicated than desirable' (LIB 1973, No. 4, 4).
16. Loans made from the Fisher Library (Source ARL 1972 Appendix D): 1964 - 212,516; 1966 - 325,539; 1968 - 430,270; 1970 - 494,845.
17. The UG collection was picked because it was contributing the bulk of the loans made at the library and it had a simple loan structure with a fixed one-week loan duration and non-renewable loans (McKendrick 1975). Furthermore, a machine-readable record of the items held in the UG library already existed, going back to the creation of the printed UG catalogue in 1966.

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## References

### *Primary sources*

*ARL - Annual Report of the Librarian* 1963-1975, Rare Books Collection, Fisher Library. Sydney: The University of Sydney Library.

*LIB - Library Information Bulletin* 1963-1975, Rare Books Collection, Fisher Library. Sydney: The University of Sydney Library.

### *Secondary sources*

Aspray, W., and M. Campbell-Kelly. 1996. *Computer. A History of the Information Machine*. New York: Harper Collins.

Bátiz-Lazo, B. 2018. *Cash and Dash. How ATMs and Computers Changed Banking*. Oxford: Oxford University Press.

Bátiz-Lazo, B., and P. Wardley. 2007. "Banking on Change: Information Systems and Technologies in UK High Street Banking, 1919-1969." *Financial History Review*, 14, 177-205.

Beniger, J. 1986. *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge: Harvard University Press.

Birnbaum, H. 1960. *I.B.M. Circulation Control at Brooklyn College Library*. New York: I.B.M. Corporation.

Boell, S. K. 2017. "Information: Fundamental positions and their implications for information systems research, education and practice." *Information and Organization* 27: 1–16.

Boell, S. K., and F. Hoof. 2015. "Using Heider's Epistemology of Thing and Medium for Unpacking the Conception of Documents: Gantt Charts and Boundary Objects." *Proceedings of the 12th Annual Meeting of the Document Academy* 2 (1): 1–14.

Bowker, G. C. 1996. "The History of Information Infrastructures: The Case of the International Classification of Diseases." *Information Processing & Management* 32 (1): 49–61.

Bowker, G. C., K. Baker, F. Millerand, and D. Ribes. 2010. "Toward Information Infrastructure Studies: Ways of Knowing in a Networked Environment." In *International Handbook of Internet Research*, edited by J. Hunsinger, L. Klastrup, and M. Allen, 97–117. Dordrecht: Springer.

Boyns, T. 2008. "Accounting, Information, and Communication Systems." In *The Oxford Handbook of Business History*, edited by G. Jones and J. Zeitlin, 447–469. Oxford: Oxford University Press.

Braverman, H. 1974. *Labor and Monopoly Capital. The Degradation of Work in the Twentieth Century*. New York: Monthly Review Press.

Bryan, H. 1966a. "Automation in Libraries." *Australian Library Journal* 15: 24–38.

Bryan, H. 1966b. "Automation in Action." *Australian Library Journal* 15: 127–140.

Bryan, H. 1966c. "A First Computer-Printed Catalogue for N.U." *Australian Library Journal* 15: 200–201.

Bygstad, B. 2010. "Generative Mechanisms for Innovation in Information Infrastructures." *Information and Organization* 20: 156–168.

Ceruzzi, P. E. 2003. *A History of Modern Computing*. 2nd ed. London: MIT Press.

Chandler, A. D., and J. W. Cortada. eds. 2000. *A Nation Transformed by Information: How Information has Shaped the United States from Colonial Times to the Present*. Oxford: Oxford University Press.

Checkland, P., and S. Holwell. 1998. *Information, Systems and Information Systems: Making Sense of the Field*. Chichester: Wiley.

Ciborra, C. U., and O. Hanseth. 1998. "From Tool to Gestell: Agendas for Managing the Information Infrastructure." *Information Technology & People* 11 (4): 305–327.

Clarke, R., and M. Wigan. 2018. "The Information Infrastructures of 1985 and 2018: The Sociotechnical Context of Computer Law & Security." *Computer Law and Security Review* 34 (4): 677–700.

Connell, W. F. 1995. *Australia's First: A History of the University of Sydney (Vol 2)*. Sydney: University of Sydney in association with Hale & Iremonger.

Cortada, J. 2004. *The Digital Hand Vol I: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries*. Oxford: Oxford University Press.

Cortada, J. 2006. *The Digital Hand Vol II: How Computers Changed the Work of American Financial, Telecommunications, Media, and Entertainment Industries*. Oxford: Oxford University Press.

Cortada, J. 2007. *The Digital Hand Vol. III: How Computers changed the Work of American Public Sector Industries*. Oxford: Oxford University Press.

Edwards, P. 2003. "Infrastructure and Modernity: Force, Time, and Social Organization in the History Sociotechnical Systems." In *Modernity and Technology*, edited by T. J. Misa, P. Brey, and A. Feenberg, 185–225. Cambridge, MA: The MIT Press.

Eriksson, O., P. Johannesson, and M. Bergholtz. 2018. "Institutional Ontology for Conceptual Modeling. *Journal of Information Technology* 33 (2): 105–123.

Fuller, M., and A. Goffey. 2012. *Evil Media*. Cambridge, MA: The MIT Press

Gal, U., K. Lyytinen, and Y. Yoo. 2008. "The Dynamics of IT Boundary Objects, Information Infrastructures, and Organisational Identities: The Introduction of 3D Modelling Technologies into the Architecture, Engineering, and Construction Industry." *European Journal of Information* 17 (3): 290–304.

de Gennaro, R. 1983. "Perspectives on Three Decades of Library Automation and Networking in the U.S." In *Increasing Productivity through Library Automation*, edited by A. H. Helal and J. W. Weiss, 73–100. Essen: Gesamthochschulbibliothek Essen.

Girschik, K. 2010. *Als die Kassen lesen lernten. Eine Technik- und Unternehmensgeschichte des Schweizer Einzelhandels.* München: C.H. Beck.

Gitelman, L. 2014. *Paper Knowledge: Toward a Media History of Documents*. Durham: Duke Press.

Gugerli, D. 2018. *Wie die Welt in den Computer kam. Zur Entstehung digitaler Wirklichkeit*. Frankfurt a. M.: Fischer.

Haigh, T. D. 2001. "Inventing Information Systems: The Systems Men and the Computer." *Business History Review* 75: 15–61.

Hanseth, O., and K. Lyytinen. 2016. "Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet." In *Enacting Research Methods in Information Systems Vol* 3, edited by L. P. Willcocks, C. Sauer and M.C. Lacit, 104–142. Cambridge: Palgrave Macmillan.

Heider, F. 1926. „Ding und Medium." *Symposion, Philosophische Zeitschrift für Forschung und Aussprache* 1: 109–157.

Hoof, F. 2020. *Angels of Efficiency. A Media History of Consulting*. New York: Oxford University Press.

Hoof, F. 2015. "Medien managerialer Entscheidungen. Decision-Making 'at a Glance'." *Soziale Systeme. Zeitschrift für soziologische Theorie* 20 (1): 23–51.

Hoof, F., and S. K. Boell S. 2019. Culture, Technology, and Process in 'Media Theories': Toward a Shift in the Understanding of Media in Organizational Research. *Organization* 26 (5): 636–654.

Huhtamo, E., and J. Parikka. 2011. *Media Archaeology: Approaches, Applications, and Implications*. Berkley: California University Press.

Iannacci, F. 2010. "When is an Information Infrastructure? Investigating the Emergence of Public Sector Information Infrastructures." *European Journal of Information Systems* 19: 35–48

Innis, H. A. 1927. *The Fur-Trade of Canada*. Toronto: Oxford University Press.

Kallinikos, J. 2006. "Information out of Information: On the Self-Referential Dynamics of Information Growth." *Information Technology & People* 19 (1): 98–115.

Karasti, H., and J. Blomberg. 2018. "Studying Infrastructuring Ethnographically." *Computer Supported Cooperative Work* 27: 233–265.

Kaniadakis, A., and P. Constantinides. 2014. "Innovating Financial Information Infrastructures: The Transition of Legacy Assets to the Securitization Market Innovating Financial Information Infrastructures: The Transition of Legacy Assets to the Securitiza." *Journal of the Association for*

*Information Systems* 15: 244–262.

King, G. W., H. P. Edmundson, M. M. Flood, M. Koghen, R. L Libby, D. R. Swanson, and A. Wylly. 1963. *Automation and the Library of Congress. A survey sponsored by The Council on Library Resources, Inc*. Washington: Library of Congress.

Kittler, F. A. 1999. *Gramophone, Film, Typewriter*. Stanford: Stanford University Press.

Larkin, B. 2013. "The Politics and Poetics of Infrastructure." *Annual Review of Anthropology* 42: 327–43.

Leonardi, P. M., and S. R. Barley. 2010. "What's Under Construction Here? Social Action, Materiality, and Power in Constructivist Studies of Technology and Organizing." *The Academy of Management Annals* 4: 1–51.

Luhmann, N. 1969. *Legitimation durch Verfahren*. Neuwied: Luchterhand.

Luhmann, N. 2011. *Organisation und Entscheidung*. Wiesbaden: VS Verlag.

Markuson, B. E. ed. 1964. *Libraries and Automation*. Washington: Library of Congress.

Maurer, B. 2015. *How Would You Like to Pay? How Technology Is Changing the Future of Money*. Durham: Duke University Press.

McKendrick, S. 1975. "The University of Sydney Library's On-Line Circulation Control Systems – A Workshop Case Study." *LASIE: Library Automated Systems Information Exchange* 6: 35–54.

McKenney, J. L., D. G. Copeland, and R. O. Mason. 1995. *Waves of Change: Business Evolution through Information Technology*. Boston, MA: Harvard Business School Press.

McLoughlin, I., K. Garetty, R. Wilson, A. Dalley, and P. Yu. 2016. "Doing Infrastructural Work. Information Infrastructure Projects." *Scandinavian Journal of Information Systems* 28 (2): 28–56.

McLuhan, M. 1964. *Understanding Media. The Extensions of Man*. New York: McGraw-Hill.

McWatters, C. S. 2014. "Historical accounts, conversations and contexts." *Accounting History Review* 24 (1): 1–5.

McWatters, C. S. 2017. "Historians but not necessarily so." *Accounting History Review* 27 (3): 219–221.

Monteiro, E., N. Pollock, O. Hanseth, and R. Williams. 2013. "From Artefacts to Infrastructures." *Computer Supported Cooperative Work* 22: 575–607.

Nolan, R. L. 2000. "Information Technology Management." In *A Nation Transformed by Information. How Information Has Shaped the United States from Colonial Times to the Present*, edited by A. D. Chandler and J. W. Cortada, 217–256. Oxford: Oxford University Press.

Orlikowski, W. J. 2007. "Sociomaterial Practices: Exploring Technology at Work." *Organization Studies* 28: 1435–1448.

Porra, J., R. Hirschheim, and M. S. Parks. 2005. "The History of Texaco's Corporate Information Technology Function: A General Systems Theoretical Interpretation." *MIS Quarterly* 29: 721–746.

Radford, N. A. 1966. "Student Borrowing from a University Library." *Australian Library Journal* 15: 154–160.

Radford, N. A., and J. E. Barry. 1966. "I.B.M. Punched Card Circulation at Sydney University Library." *Australian Library Journal* 15: 228–234.

Ribes, D., and T. A. Finholt. 2009. "The Long Now of Technology Infrastructure: Articulating Tensions in Development." *JAIS: Journal of the Association of Information Systems* 10: 375–398.

Schabacher, G. 2013. "Mobilizing Transport. Media, Actor-Worlds, and Infrastructures." *Transfers. International Journal of Mobility Studies* 3 (1): 75–95.

Schmidmaier, D. 1975. "Objectives of On Line Circulation Control Systems." *LASIE: Library Automated Systems Information Exchange* 6: 15–21.

Shade, L. R. 1998. "A Gendered Perspective on Access to the Information Infrastructure. *Information Society* 14 (1): 33–44.

Slight, O. E. 1967. "Sydney University Library Moves its Research Collection." *Australian Library Journal* 16: 240–244.

Star, S. L., and G. C. Bowker. 2010. "How to Infrastructure." In *Handbook of New Media: Social Shaping and Social Consequences of ICTs, Updated Student Edition*, edited by L. A. Lievrouw and S. Livingstone, 230–246. London: Sage.

Star, S. L. 2010. “This is Not a Boundary Object: Reflections on the Origin of a Concept.” *Science, Technology and Human Values* 35: 601–617.

Star, S. L., and K. Ruhleder. 1996. “Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces.” *Information Systems Research* 7: 111–34.

Wootton, C. W., and B. W. Kemmerer. 2007. “The Emergence of Mechanical Accounting in the U.S., 1880-1930.” *Accounting Historians Journal* 34 (1): 91–124.

Yates, J. 1989. *Control through Communication: The Rise of System in American Management*. Baltimore: Johns Hopkins University Press.

Yates, J. 1994. “Evolving Information Use in Firms, 1850-1920.” In *Information Acumen*, edited by L. Bud-Frierman, 26–50. London: Routledge.

Yates, J. 2005. *Structuring the Information Age: Life Insurance and Technology in the Twentieth Century*. Baltimore: Johns Hopkins University Press.

Zuboff, S. 1988. *In the Age of the Smart Machine: The Future of Work and Power*. New York: Basic Books.