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Technology-mediated Control: Case Examples and Research Directions for the Future of Organizational Control

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Abstract:

This study explores the emerging topic of technology-mediated control (TMC), which refers to an organization's using digital technologies to influence workers to behave in a manner consistent with organizational objectives. The popular press has discussed many mobile apps, digital sensors, software algorithms, and other technologies that support, or automate, managerial control processes. Building on the rich history of research on organizational and information systems (IS) control and on ubiquitous technology, we explore how TMC approaches have increasingly begun to replace traditional, face-to-face control relationships. In particular, we analyze four illustrative case examples (UPS, Uber, Rationalizer, and Humanyze) to propose a detailed research agenda for future study in this important new topic area.

Keywords: Technology-mediated Control, Organizational and IS Control, Ubiquitous Technology, Big Data, Algorithmic Management, Case Examples, Future Research Directions.

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1 Introduction

The organizational and information systems (IS) literature broadly defines control as any attempt to align individual behaviors with organizational objectives (e.g., Kirsch, 1997; Ouchi, 1979; Wiener, Mähring, Remus, & Saunders, 2016). Research has frequently argued that organizations need to exercise control to regulate or adjust employees' and other stakeholders' behaviors in order to motivate them and ensure that they fully apply their capabilities to achieve the desired objectives (Kirsch, 1997). Such research commonly investigates the antecedents of managers' control choices and the performance implications of such choices (Cardinal, Kreutzer, & Miller, 2017; Wiener et al., 2016). While control research offers important insights from many contexts such as IS projects (e.g., Gregory, Beck, & Keil, 2013), marketing exchange relationships (e.g., Crosno & Brown, 2015), and innovation management (e.g., Chenhall & Moers, 2015), it has almost exclusively focused on the human interaction between controllers (e.g., project managers) and controllees (e.g., project team members) and, thus, largely neglected technology's role in control processes.

Separately, organizations have increasingly begun to employ ubiquitous technology solutions in an effort to facilitate increased process efficiency, improve managerial decision making, and create innovative business opportunities (Lindgren, Andersson, & Henfridsson, 2008; Wixom & Ross, 2017). By directing the data that mobile applications, wearable devices, and Internet-of-things (IoT) sensors collect into smart algorithms, managers can obtain a real-time, in-depth view into their organizations' operations (Alharthi, Krotov, & Bowman, 2017). Commonly, the collected data offer detailed insights into how workers perform in business processes, and many forward-looking organizations already leverage these new digital capabilities to not only respond to emerging market demands but also monitor and direct workers' behavior.

In this study, we explore the intersection between control activities and ubiquitous technology, which we refer to as technology-mediated control (TMC), and propose a future research program on the topic. We define TMC as the managers' using digital technologies as a means to influence workers to behave in a way that concurs with organizational expectations. Here, technology can act either as a managerial tool that provides useful insights regarding worker behavior or it as a proxy for human controllers by independently monitoring and guiding controllees without human intervention. TMC can have particular valuable in organizations where employees have become more geographically disbursed and mobile (Wiener & Cram, 2017). Also, given the steady increase in labor costs, one may consider TMC a more cost-effective control approach than the traditional human-centered approach (e.g., Kavadias, Ladas, & Loch, 2016). In this context, a recent article from *The New York Times* predicted that "using big data and algorithms to manage workers will not simply be a niche phenomenon. It may become one of the most common ways of managing the American labor force" (Scheiber, 2017).

One can find an example of TMC in the transportation company Uber. Since its formation in 2009, Uber has established a global "ride-sharing" network that has transformed the personal transportation industry by connecting individuals who drive privately held vehicles with prospective passengers (Bonnet & Westerman, 2015; Bock & Wiener, 2017). A key factor contributing to the success of Uber's business model concerns the way that the company guides its drivers' behavior (Rosenblat & Stark, 2016). More specifically, in contrast to traditional taxi companies with their local offices and human dispatchers, Uber manages its driver network through a mobile app. The company uses the app to encourage drivers to work longer hours, to avoid bad driver habits (e.g., phone use when driving, exceeding the speed limit), and to track customer feedback ratings.

Although using TMC offers significant benefits to organizations such as Uber, which includes automating and cost-effectively personalizing control processes, past commentators have also pointed out the "dark side" to technology in general (e.g., Tarafdar, D'Arcy, Turel, & Gupta, 2015) and technology-mediated control in particular (e.g., Vieira da Cunha, Carugati, & Leclercq-Vandelannoitte, 2015). For example, using TMC may negatively influence workers' motivation and wellbeing (Anthes, 2017; Tarafdar et al., 2015) and create privacy and ethical issues (Marabelli, Hansen, Newell, & Frigerio, 2017). Another potential drawback concerns the opacity of control algorithms (Demetis & Lee, 2018). Here, the increasing use of machine learning can lead to control situations in which controllers "may not understand, or be fully responsible for, what their algorithms do" (Markus, 2017, p. 235). Further, we know little about the longer-term effectiveness of TMC approaches and the multi-level sociotechnical conditions that influence their effectiveness (Markus, 2017). In general, one can expect TMC use's broader implications (both benefits and drawbacks) to depend on the specific control context and TMC approach that a company uses.

Against this backdrop, in this study, we identify various promising directions for future research on TMC. In order to derive such a research agenda, we first identify the key features inherent in different TMC approaches. With these key features in mind, we then introduce and examine four illustrative TMC case examples (Humanyze, Uber, UPS, and Rationalizer) in order to identify patterns that suggest promising research directions. On this basis, we outline a detailed research agenda for TMC, which includes eight associated research questions. We organize the research agenda using "CIMO-logic" (Denyer, Tranfield, & van Aken, 2008) as a means to distinguish TMC phenomena's fundamental aspects.

2 Conceptual Foundations

In this study, we draw on two distinct study areas: 1) IS control and the broader literature on organizational control and 2) ubiquitous technology. We outline each area below, which includes key concepts, major themes, and gaps that exist in the current literature. On this basis, we then discuss TMC and its distinguishing features.

2.1 Organizational and Information Systems (IS) Control

The organizational and IS literature typically views control as dyadic in the sense that it involves a controller and a controllee (or group of controllees). The controller carries out specific activities to regulate or adjust the controllee's behaviors and align them with organizational objectives (Das & Teng, 1998; Jaworski, 1988; Kirsch, 1997; Ouchi, 1979; Wiener et al., 2016). In this behavioral view of control, one can divide the generic exercising-control process into four major steps: 1) specifying appropriate behaviors, 2) monitoring controllee's behaviors (by direct observation or via indirect means), 3) evaluating controllee performance; and 4) rewarding or sanctioning controllees (Eisenhardt, 1985; Kirsch, 2004).

Past IS control research has drawn on organizational control concepts and applied them in IS contexts (and IS projects in particular) in order to examine the characteristics and the effectiveness of different control approaches (Cram et al., 2016a). In doing so, researchers have examined various concepts to clarify what, how, and why organizations employ controls, including formal and informal control modes (input, behavior, outcome, clan, and self-control), control style (coercive vs. enabling), and control purpose (value appropriation vs. value creation) (e.g., Heumann, Wiener, Remus, & Mähring, 2015; Kirsch, 1997; Wiener et al., 2019). We summarize key control concepts along with their subconcepts in Table 1.

Although managers commonly apply organizational control concepts in IS projects, Cram et al. (2016a) also recognize other areas in IS where individuals apply control principles, such as information security, technology outsourcing, and strategy. As such, the concepts in Table 1 pertain not specifically to IS project control but to organizational and IS control phenomena more broadly. In considering the links between these control concepts, past research has positioned the various concepts to be largely independent from one another. Accordingly, it has positioned the control relationship to represent *who* control involves, the different control subprocesses to represent *when* controllers employ control, control purpose to represent *why* controllers use control, control modes to represent *what* controls controllers put into place, and control style to represent *how* controllers implement controls (Wiener et al., 2016, 2019).

On this conceptual basis, past organizational and IS control research has identified many useful theoretical and practical insights. For example, studies that focus on control in IS projects suggest that managers tend to select different controls at different project stages to account for changing context factors, such as uncertainty, trust, and communication (e.g., Kirsch, 2004). In addition to selecting different control modes, managers endeavor to fine-tune their portfolio of controls over time often in response to performance issues (e.g., Choudhury & Sabherwal, 2003; Gregory et al., 2013). Further, past research recognizes the ethical and socio-emotional pitfalls that can result from managers who do not know about the potential downside of controls that constrain workers and hamper their autonomy (e.g., Cram & Wiener, 2018).

However, as yet, resarch on control in general has almost exclusively focused on the direct interaction between human controllers and controllees and, thus, largely neglected the role of technology in control processes (Wiener & Cram, 2017). A possible explanation for this omission relates to the strong roots of the IS control literature in the organizational control literature (e.g., Das & Teng, 1998; Jaworski, 1988; Ouchi, 1979). On a related note, control researchers have relied heavily on the concept of control modes, which became popular at a time when technology had a different role in organizations than it does today. Thus, it remains unclear whether existing control concepts, which include recently added concepts such as control purpose (Wiener et al., 2019), can sufficiently capture the characteristics of control approaches that today's technology-focused organizations use.

Table 1. Key Control Concepts

Concept	Subconcept	Definition / Description	References
Control relationship (*who*)	Controller	The source of control activities—often a direct supervisor of the controllee (e.g., a line manager)	Kirsch (1996, 1997)
	Controllee	The target of control activities—often a subordinate of the controller (e.g., a project manager)	
Control process (*when*)	Specification	Information about desired controllee behavior (e.g., a manager establishing formalized performance targets for employee tasks)	Eisenhardt (1985), Kirsch (2004)
	Monitoring	Observation/measurement of controllee behavior (e.g., a manager observing the execution of daily tasks by employees)	
	Evaluation	Assessment of controllee behavior (e.g., a manager comparing actual employee performance against expected employee performance)	
	Reward/Sanction	Pay, bonuses, promotion, or demotion that result from a controllee's compliance/violation (e.g., an employee receiving a bonus payment for meeting productivity targets)	
Control purpose (*why*)	Value appropriation	Controls implemented with the intention of monitoring controllee behavior in order to reduce agency risks (e.g., using controls to minimize the opportunity for controllees to act opportunistically, such as taking too many breaks while on the job)	Wiener et al. (2019), Dekker (2004), Gulati & Singh (1998)
	Value creation	Controls implemented with the intention of coordinating worker activities in order to enhance their application of knowledge and skills (e.g., controls to facilitate controllee interactions, such as regular meetings to share best practices)	
Control modes (*what*)	Formal input, behavior, and outcome control	Explicit activities that a controller conducts to regulate the activities of controllees (e.g., a written sequence of steps to be followed by controllees)	Choudhury & Sabherwal (2003), Kirsch (1997), Ouchi (1979)
	Informal clan and self-control	Implicit determinants that a controller promotes to encourage goal-directed controllee behavior (e.g., shared norms and values to facilitate teamwork)	
Control style (*how*)	Coercive (or authoritative)	The design of control processes/technologies in a way that coerces controllee effort and compliance during task execution (e.g., enforcing corporate rules in a unilateral manner)	Adler & Borys (1996), Heumann et al. (2015), Wiener et al. (2016)
	Enabling	The design of control processes/technologies in a way that enables controllees to better master their tasks (e.g., providing controllees with transparency on the rationale behind control processes)	

2.2 Ubiquitous Technology

The growth in technology use in organizations has significantly transformed business models and contributed to improved decision making (Anthes, 2017; Davenport, Barth, & Bean, 2012; Loebbecke & Picot, 2015) in a broad range of areas, such as healthcare (Ward, Marsolo, & Froehle, 2014), transportation (Uzunca, Rigtering, & Ozcan, 2018), supply chains (Sanders, 2016), sports organizations (Mondello & Kamke, 2014), government (Kim, Trimi, & Chung, 2014), and the Internet of things (IoT) (Mills, Watson, Pitt, & Kietzmann, 2016). In particular, the increasing rate with which organizations have adopted ubiquitous technologies embedded in sophisticated computing devices in both office and mobile environments has played a key role in this transformation (Lindgren et al., 2008; Lyytinen & Yoo, 2002; Vodanovich, Sundaram, & Myers, 2010). Such technology features a distributed nature (i.e., infrastructure does not exist in a single location), large scale (i.e., in terms of users, geographies, variety/volume of data), and high speed (i.e., data flows on a real-time basis) (Andersson & Lindgren, 2005; Chen, Chiang, & Storey, 2012; Lindgren et al., 2008; Lyytinen & Yoo, 2002; Yoo, 2010).

In ubiquitous technology environments, organizations collect data from an ever-expanding quantity and variety of sources, such as mobile applications, embedded sensors, and wearable devices. Past research suggests that much such data has a contextual nature, which various organizational actors could find useful (Lindgren et al., 2008). In particular, the recent growth in IoT technologies that enable digital data streams on the status of machines, medical devices, lighting, and utilities has enhanced the insights that managers can gain on day-to-day operations, which includes insights into employees' actions (Stankovic, 2014).

Two data types associated with ubiquitous technology environments seem to be particularly relevant from a TMC perspective: behavioral and emotional/physiological data. The former refers to externally observable data that relates to what people do, the movements they make (e.g., packing a box, operating a machine), where they are, with whom they interact, and how they interact with others and their environment (Michael & Miller, 2013). The latter refers to an individual's internal, biological characteristics, which includes data on human attributes (e.g., heartbeat, neural activities), and the human body's responses to external stimuli, such as eye movements or facial expressions. Although research has begun to emerge on how organizations may use these data types (e.g., Gal, Jensen, & Stein, 2017; Galliers, Newell, Shanks, & Topi, 2017; Lee, Kusbit, Metsky, & Dabbish, 2015; Loebbecke & Picot, 2015), little research has substantively focused on how ubiquitous technology can help organizations control workers' behavior.

2.3 Technology-mediated Control (TMC)

Given that organizations have increasingly begun using ubiquitous technologies to control the behavior of their workforce, we frame the intersection between these two concepts and propose an agenda for future research. We refer to the phenomenon as technology-mediated control (TMC), which we define as managers' using ubiquitous technologies as a means to influence workers to behave in a way that concurs with organizational expectations. In this context, we need to distinguish between two basic types of TMC (see Figure 1).

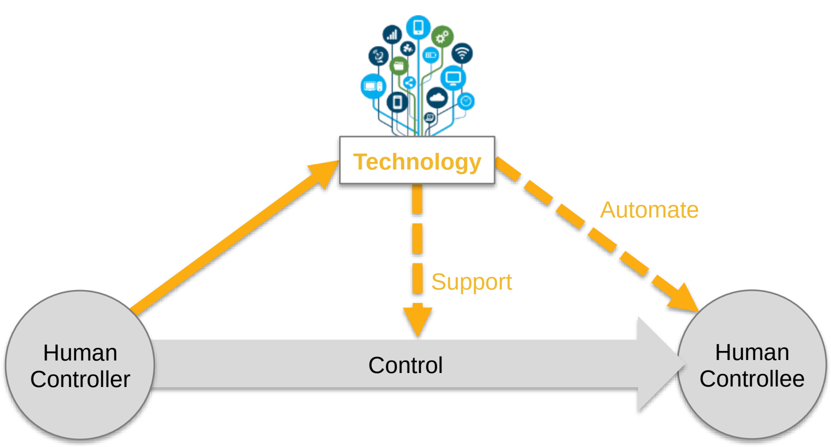

Figure 1. Basic TMC Types (Support vs. Automate)

First, one can use technology to *support* managerial control processes by acting as a monitoring tool that provides useful insights to managers regarding subordinate behavior. For example, the global logistics company United Parcel Service (UPS) equips its trucks with sensors that collect detailed data about drivers' behavior. UPS managers then use this data to ensure that drivers behave in a manner that concurs with pre-specified guidelines and rules[1]. Second, one can use technology to *automate* managerial control processes by acting as a proxy for human controllers. For example, the transportation company

[1] Past research on boundary-spanning practices, such as Lindgren et al. (2008), recognize the knowledge and learning benefits that ubiquitous computing environments can provide to managers. Corresponding studies focus primarily on general work practices as opposed to control activities.

Uber uses a mobile app to guide, monitor, evaluate, and reward or sanction drivers' behavior without any substantive human intervention.

One should recognize that using technology to support control processes does not entirely represent a new phenomenon. For example, enterprise software systems (e.g., SAP ERP) include automated controls, which help ensure that employees follow predefined organizational processes and adhere to established business rules and standards. However, we argue that existing TMC approaches show several unique characteristics that set them apart from traditional, system-based controls. First, while enterprise systems can usually only collect cross-sectional, behavioral data (e.g., who entered what data), TMC approaches rely on ubiquitous technologies, such as embedded sensors, which can capture the minutiae of workers' behavior (Marabelli et al., 2017). Second, some TMC approaches collect not only behavioral data but also physiological and emotional data (Whelan, McDuff, Gleasure, & vom Brocke, 2018), which allows one to obtain distinct and potentially valuable new insights. Third, while system-embedded controls often focus on monitoring workers' behavior (value appropriation), some TMC approaches, such as the one that Uber uses, primarily fulfill a coordination purpose (value creation). Relatedly, enterprise systems tend to enforce static rules, such as forcing users to provide certain information before they can move on to the next process step. In contrast, TMC approaches allow context-sensitive rules/controls (which one still apply without any human involvement). For example, Uber uses complex algorithms to determine and inform drivers about so-called "surge pricing zones" that require more drivers at a particular point in time due to a temporary spike in customer demand (Rosenblat & Stark, 2016).

3 TMC Case Examples

In order to establish a guide to promising future research opportunities related to TMC, we first examined how various firms actually used TMC in practice to identify exemplar patterns and issues in real-life TMC applications that represent promising lines of inquiry for future research. Based on the procedure we outline below, we selected four case examples for this analysis. Although we recognize that our approach may not uncover all possible elements that characterize efforts to study TMC issues, we focus on deriving broad and representative research opportunities to establish a valuable knowledge foundation. In Section 3.1, we discuss how we selected the four case examples and collected and analyzed our data.

3.1 Case Selection

Drawing on the organizational/IS control and ubiquitous technology literature, we developed a framework to assist in case selection (see Table 2 below). We developed the framework not to classify all possible aspects of TMC activities but to help identify a set of distinct and representative case examples that we could use to develop a broad-based agenda for future research. After reviewing the literature, we selected two categories that represent "salient attributes of phenomena" (Gregor, 2006, p. 623): one category specific to control (i.e., control purpose; see Section 2.1) and one category specific to ubiquitous technology (i.e., data types/variety; see Section 2.2). We selected these two categories because they likely shape how controllees perceive the TMC approach in use and because of the potentially distinct TMC applications that could emerge from different control purposes and data types. We considered other options, such as control modes, as well but found them less useful in distinguishing among different TMC applications (e.g., most applications tend to rely on a mix/portfolio of control modes). As we indicate above, in each category we selected, the existing literature has identified two underlying elements: value appropriation versus value creation (control purpose) and behavioral data versus emotional/physiological data (data type). We used this two-by-two framework to distinguish between the varied TMC approaches that practitioners employ and, thus, select four TMC case examples that represent different applications and contexts (see below). Specifically, we sought one case example for each possible combination (i.e., one case each for TMC that primarily represented 1) a value-appropriation control purpose alongside behavioral data, 2) a value-creation control purpose alongside behavioral data, 3) a value-appropriation control purpose alongside emotional/ physiological data, and 4) a value-creation control purpose alongside emotional/physiological data). Here, we recognize that a single TMC approach may have elements from both a value-appropriation and a value-creation control purpose, which concurs with past research, such as Wiener et al. (2019), that recognizes that the two control purposes often coexist but that one typically dominates the other. Thus, we deemed it acceptable to select cases that had a significant proportion of elements from one category (even if elements existed in the other category as well).

3.2 Data Collection & Analysis

In order to identify suitable cases to derive our future research agenda, we searched for TMC examples in the popular press (e.g., *Fortune*, *The New York Times*, *Time*, *Washington Post*) using keywords such as “algorithmic management”, “employee monitoring”, and “technology control”. We targeted these outlets because we wanted to find up-to-date examples that had a clear association with both organizational and worker perspectives on TMC use. We did not seek to identify all existing reports but rather some representative accounts.

We collected data via an archival approach using secondary data. In our study’s specific context, secondary data refers to company-related data that exists in the public domain, such as newspaper articles, books, press releases, and practitioner reports (Boslaugh, 2007; Palvia, Mao, Salem, & Soliman, 2003). Past commentators have argued that analyzing secondary data constitutes a legitimate research method when one adopts a systematic approach (Johnston, 2014).

After reviewing various information sources on various TMC applications and in conjunction with the case-selection framework that we outline above (see Section 3.1), we decided to focus our analysis on the following four representative TMC examples: Humanyze, Uber, UPS, and Rationalizer. Given these cases have a distinct nature in meaningful ways (see Table 2), we used them to develop a broad-based future research agenda.

Table 2. Case Selection Framework and Selected TMC Case Examples

Control purpose	Value creation (coordination)	**Uber**	**Humanyze**
	Value appropriation (monitoring)	**UPS**	**Rationalizer**
		Behavioral data	Emotional/physiological data
		Data type	

For each selected case, we conducted online inquiries into each company’s history, operating environment, and key business processes. We collected at least five separate accounts of each TMC application to triangulate and corroborate the reported information (Patton, 2002). Here, whenever possible, we supplemented the identified press articles with research papers (e.g., Rosenblat & Stark, 2016; Whelan et al., 2018). We collected 32 publications (totaling 858 pages) related to the TMC approaches that the four case companies used (we discuss the collected sources in detail in Table A1 in the Appendix).

To analyze our case data, we first re-read the collected documents several times in order to clearly understand how each organization employed TMC. We then worked together to compile detailed case summaries. Next, we and a student assistant reviewed the case data and compiled independent lists of emerging issues in and across the four cases that could form a basis for future research. The concepts that we derived from the control and ubiquitous technology literature informed this process. Furthermore, to present the agenda in a structured manner, we integrated these concepts into Denyer et al.’s (2008) “CIMO framework”, which comprises four core dimensions: context, interventions, mechanisms, and outcomes (see Table 3 for details).

Table 3. CIMO Framework (based on Denyer et al., 2008)

Dimension	Description
Context (C)	Internal and external *context* factors that can influence behavioral change (e.g., organizational setting and control purpose, controller-controllee relationship, data volume, variety and velocity).
Interventions (I)	Technological and managerial *interventions* that controllers have at their disposal to influence controllee behavior (e.g., control systems and processes, performance management, control modes and style).
Mechanisms (M)	The generative *mechanisms* that the interventions trigger in a certain context and that fuel behavioral change at an individual level (e.g., awareness, competition, feedback).
Outcomes (O)	An interventions business-oriented *outcomes* at an organizational level (e.g., improved performance, lower error rate, reduced cost).

Past studies in IS, such as Henfridsson and Bygstad (2013), have adopted frameworks similar to CIMO. By employing the CIMO framework to present the research agenda (see Section 4), we focus on precisely specifying the most promising research directions. To do so, we must distinguish the relevant *contextual* factors in TMC activities from the technological and managerial *interventions* and the generative *mechanisms* from business-oriented *outcomes* (Denyer et al., 2008; Pawson & Tilley, 1997). As such, the CIMO framework “can be seen as offering a general template for the creation of solutions for a particular class of field problems” (Denyer et al., 2008, p. 395).

Again, we focus not on capturing every possible research opportunity related to TMC but on highlighting unique patterns, organizational challenges, and potentially promising research paths that emerged from our case examples. We summarize each case below (also refer to Table A2 in the Appendix in which we discuss each case-specific TMC approach in more detail).

3.3 Case Overview

3.3.1 Humanyze

Humanyze has developed a “next-generation” company ID badge that collects data on employees’ location, movement, and voice (Waber & Kane, 2015). Specifically, four key types of sensors power the badge’s data collection: 1) a Bluetooth sensor used to measure employees’ location and to see who is close to whom, 2) an infrared scanner that reveals when two employees face each other, 3) two microphones that perform real-time voice analytics to record variables such as voice tone and volume, and 4) an accelerometer that measures employee movement to see how engaged they are in conversations (Noyes, 2015). The organization analyses the data the badge collects to determine patterns in individual and group behaviors. Based on the analysis results, managers can conduct secondary interventions, such as changing the design of office spaces and/or encouraging employees to interact in novel ways (Bosanac, 2015; Waber & Kane, 2015). In addition to management reports, Humanyze “allows each employee to set up their own, personalized feedback reports including metrics such as body language or how much time they spend in conversations” (Noyes, 2015). Corporate customers have benefited from using Humanyze’s badge technology in several ways, such as improved productivity due to more effective knowledge sharing and reduced turnover due to improved employee satisfaction (Bosanac, 2015; Heath, 2016; Waber & Kane, 2015). For example, the Bank of America used the technology in their call centers, which enabled the organization to increase productivity by 23 percent and decrease turnover by 28 percent (Waber & Kane, 2015).

3.3.2 Uber

Uber operates in the highly competitive personal transportation industry. To minimize the need for costly and time-consuming interactions between Uber managers and drivers, the company relies on a mobile app to collect data on and direct drivers’ behavior (Rosenblat & Stark, 2016). Indeed, Uber’s business model focuses on the ability to quickly facilitate matches between customers who need a ride and available nearby drivers. This approach concurs with the broader notion of platform-based value creation (Parker, Van Alstyne, & Choudary, 2016), which the way in which Uber uses TMC to manage its workforce facilitates. Uber’s organizational structure differs in comparison to many traditional organizations in that Uber’s drivers work as independent contractors rather than formal employees. This distinction has resulted in lower pay and fewer benefits for drivers and recent driver-led legal inquiries and strikes. Further, the fact that Uber does not employ drivers creates an unconventional manager-subordinate relationship as drivers have the autonomy to choose when and how long to work (Kessler, 2016). Through its mobile app, Uber uses a broad range of psychology-influenced interventions to control drivers’ behavior (Scheiber, 2017). From a financial perspective, it provides signing bonuses to new drivers that meet preliminary ride targets (e.g., complete 25 rides) (Scheiber, 2017). The company introduced this intervention (during which it offers the simple encouragement “You’re almost halfway there, congratulations!”) in response to growing concerns about new drivers leaving the platform. Uber also offers guaranteed fare programs where drivers earn an hourly rate during set periods provided they meet objectives such as accepting a minimum proportion of ride requests, work for a minimum period, and complete a minimum number of trips (Kessler, 2016). This pay structure can hinder a driver’s ability to accept jobs from competitors. Also, the company uses surge fares (i.e., increased costs for riders during high-volume periods) to incentivize drivers to work during busy times (Kessler, 2016).

3.3.3 UPS

UPS delivers more than 15 million packages per day to more than 220 countries and territories worldwide (Hullinger, 2015). Since many UPS employees drive delivery trucks, it is difficult for managers to accurately view their daily activities using traditional, managerial-oversight techniques. As a result, in 2008, UPS started to equip trucks with GPS tracking devices and sensors to collect detailed data on drivers' behavior, such as speed, seatbelt use, and how frequently the truck travels in reverse (Ernst, 2010; Hullinger, 2015). At the end of each day, the devices send the collected data to a central repository for analysis and management review (Goldstein, 2014). When managers observe deviations from company rules and best practices, they can follow up with drivers to correct their behavior. Moreover, the company uses sensors installed in trucks' interior to provide drivers with automated guidance on how to load the truck and the best route to deliver packages (Woyke, 2018). The automated guidance to the drivers has resulted in fewer errors when drivers load packages onto the trucks (Woyke, 2018) and greater route efficiency (Ernst, 2010). In addition, equipping trucks with sensors in key areas, such as brakes and other wearing parts, enabled UPS to reduce truck idle time, fuel consumption, and maintenance costs (e.g., Ernst, 2010; Terdiman, 2010).

3.3.4 Rationalizer

Developed by Dutch electronics firm Philips in cooperation with Dutch bank ABN AMRO, the Rationalizer technology focuses on reducing trading risk in financial markets by alerting traders to intense emotions that can compromise objectivity and rationality (Djajadiningrat, Geurts, Munniksma, Christiaansen, & de Bont, 2009; Economist, 2009; Fernandez, 2011; Whelan et al., 2018). The technology measures galvanic skin response via a bracelet (called EmoBracelet) alongside a saucer-shaped display (called EmoBowl) (Fernandez, 2011). Galvanic skin response refers to a change in the electrical resistance of the skin, which various stimuli, such as anger or elation, can cause. On this basis, the technology can determine when the user has heightened emotions but not if the emotions are negative or positive (Economist, 2009). When the bracelet measures a trader experiencing such an emotional state (e.g., due to a significant fluctuation in stock price), it alerts the wearer by emitting a light pattern and illuminating the display in a deep red color. These signals warn individuals who wear the bracelet that their emotions may prevent them from making rational decisions (Philips, 2009). When individuals' emotional state returns to normal and they can make more objective decisions, the light pattern of the bracelet changes and the display reverts to a soft orange color (Fernandez, 2011; Whelan et al., 2018). From a business standpoint, the Rationalizer technology can help investors lower trading risk due to improved trader decision making that avoids irrational, emotional actions (Djajadiningrat et al., 2009; Philips, 2009; Whelan et al., 2018).

4 Future Research Agenda

In this section, we summarize the research opportunities that we identified from analyzing the four TMC case examples that we introduce above. We identified various common patterns and trends across the cases that we believe represent the broader TMC issues and, therefore, offer valuable opportunities for future research. As we note in Section 3, we present these opportunities along the dimensions of the CIMO framework (context, interventions, mechanisms, and outcomes). While we recognize that the identified patterns/trends do not represent an exhaustive list, they provide a foundation from which to expand TMC research going forward.

4.1 Context

TMC research opportunities associated with the CIMO framework's "context" dimension relate to the role of internal and external context factors. For example, when comparing the four TMC case examples, we can see that Uber and UPS use *company-specific* approaches (i.e., the TMC approach is specific to an individual organization), whereas both Humanyze and Rationalizer represent *technologies* that companies can use to exercise TMC (i.e., multiple organizations can adopt the approach). Similarly, the four cases also vary considerably in terms of who fulfills the controller and controllee roles. For example, the Humanyze technology usually sees use in traditional, hierarchical control relationships between managers and employees. At Uber and UPS, managers act as controllers and drivers as controllees with the important difference that UPS drivers are employees (hierarchical relationship), while Uber drivers are independent contractors.

As we note in Section 2.1, the extant control literature focuses on examining controllers (i.e., managers) who directly oversee controllees' behavior (i.e., subordinate). However, in reviewing the case examples, we found that this traditional controller-controllee relationship becomes more complex with TMC since it involves additional participants such as technology designers and data scientists (Gal et al., 2016). Therefore, an interesting line of inquiry for future research concerns the role that managers play in the TMC context. For example, organizations such as Uber have increasingly shifted power and operational responsibilities into the hands of those that design and monitor TMC tools (and the related data), which inherently decreases the role of the traditional manager/controller. If managers do not understand or do not get a say in the underlying TMC algorithms' configuration, control shifts to the data scientists and/or technology designers. For instance, Gal et al. (2017, p. 7) suggest that:

> *Algorithmists can serve as impartial auditors of algorithms, as internal quality checks, etc. Algorithmists, thus, are not just data scientists, but the human translators, mediators, and managers of algorithmic rationality.*

To address this challenge, future studies should increasingly consider these new control actors as both controllers that control the "end user" via TMC algorithms and controllees that report to traditional managers. Here, we also need to understand how the controller role differs between TMC settings where organizations still largely use technology for support purposes (e.g., Humanyze and UPS) versus settings where they use technology to automate managerial control processes (e.g., Uber). With regard to the latter, Sheridan and Parasuraman (2005, p. 124) suggest that:

> *There is a belief among many automation engineers that one can eliminate human error by eliminating the human operator. To the extent a system is made less vulnerable to operator error, it is made more vulnerable to designer error…and given that the designer is also human, this simply displaces the locus of human error. In the end, automation is really human after all*

Therefore, a promising direction for future research includes the following research question (RQ):

> **RQ1**: How does TMC use alter the controller's role?

Relatedly, it remains unclear how organizations can balance the extent to which traditional managers make design choices and configuration decisions for TMC algorithms versus technology designers and scientists, who may have more autonomy. For example, Markus (2017) notes, "humans should always be kept in the loop during the operation and evolution of the algorithms" (p. 234); still, in the TMC context, it remains unclear whether that human monitor should be a traditional controller or someone else. Further, by relying on machine learning, the algorithm designers—not to mention the managers themselves—may no longer clearly understand what the TMC algorithms actually do (Burrell, 2016; Dahiyat, 2010; Diakopoulos, 2016). Or, "while practitioners may initially deploy advanced automation in support of professionals and experts, they may eventually redesign the work, taking humans out of the loop entirely or replacing experts with lower-skilled workers whose incentives, compensation, and control competencies differ markedly from those who did the work before" (Markus, 2017, p. 236).

From this perspective, future research could investigate how one can initiate TMC applications to ensure they align managers' understandings and intentions and to minimize the risk that controllees will misinterpret their outputs (cf. Mähring, Wiener, & Remus, 2018). This governance and accountability over algorithms will be increasingly important as TMC applications advance in organizational scope and complexity (e.g., Ananny & Crawford, 2016; Diakopoulos, 2016). Indeed, prior research "suggests that people are not very effective at monitoring and overriding automation" (Markus, 2017, p. 233). Two important areas include complacency (e.g., overreliance due to low suspicion) and bias (i.e., a tendency to ascribe greater power and authority to automated aids than to other sources of advice). Interestingly, Parasuraman and Manzey (2010) found that one can observe complacency and bias in both novices and experts, which presents challenges to organizations who may simply seek to train managers to better monitor the steadily growing collection of algorithms. Therefore, we suggest future research examine the following research question:

> **RQ2:** To what extent and how do context factors (including human traits and tendencies) jeopardize, or facilitate, the alignment between TMC approaches and managers' intentions?

4.2 Interventions

The interventions dimension concerns the technological and managerial interventions that organizations use to influence controllees' behavior. When considering the four TMC case examples we examined, each relies on a distinct ubiquitous technologies to influence behavior: wearable devices (Humanyze and Rationalizer), mobile apps (Uber), and “intelligent” trucks (UPS). Yet, three of the case organizations (Humanyze, UPS, and Rationalizer) use technology mainly to collect controllee-related data, which they then use as a basis to evaluate controllees’ behaviors. Thus, these organizations primarily use technology to support managerial control processes. In contrast, Uber leverages technology to automate control processes with the mobile (driver) app serving as a proxy for the human controller.

In traditional controller-controllee relationships, managers may interact with subordinates on a regular basis to receive feedback and ensure transparency on control choices, referred to as an enabling control style (see Table 1 in Section 2.1). However, as fully automated TMC approaches grow in popularity in organizations, the use of an enabling control style will likely diminish. For example, at Uber, few if any direct interactions occur between company managers and drivers. As a result, drivers cannot discuss concerns or suggestions they may have about the mobile app’s controls with management. This approach to control largely concurs with a coercive control style (see also Table 1) and allows less control flexibility and transparency (Adler & Borys, 1996; Heumann et al., 2015). Therefore, we suggest future research examine the following research question:

> **RQ3:** How can one design (automated) TMC applications to enable interaction with controllees and feedback on control processes?

In a similar vein, eliminating controllee feedback could result in static and ineffective controls as the prior literature has found that a controller’s use of an enabling control style and adjusting control mechanisms in response to changing context factors play a pivotal role in increasing control effectiveness (Choudhury & Sabherwal, 2003; Cram, Brohman, & Gallupe, 2016b; Remus, Wiener, Saunders, Mähring, & Kofler, 2016). Indeed, except for Uber, we found few indications across the other three case examples about how the organizations had refined or improved their TMC designs over time. Although the TMC designs were all relatively new and the organizations could well have made improvements behind the scenes, it nevertheless presents a unique challenge to TMC designers to initiate and enact these changes with little direct input from controllees themselves. In response to this challenge, future research should seek to uncover how organizations can make incremental improvements to TMC, also referred to as control dynamics (Wiener et al., 2016), without relying on traditional face-to-face contact. Options include websites for controlees to submit comments or suggestions (Lee et al., 2015) and firm liaisons to allow managers to interact directly with end users and, thus, collect and discuss user feedback. Therefore, we suggest future research examine the following research question:

> **RQ4:** How do TMC applications evolve over time and what triggers their ongoing adjustment/refinement?

4.3 Mechanisms

The mechanisms dimension focuses on the generative mechanisms that (technological and managerial) interventions trigger and lead to individual-level behavioral changes. We identified several interesting patterns. First, controllees seem likely to view the TMC approaches that depend on emotional/physiological data (Humanyze and Rationalizer) as intrusive and invading their privacy, which, in turn, may fuel resistance behavior. For example, to get users to buy in, Humanyze spends significant time explaining to users what data it collects, how it analyzes data, and who gets to see what data. Also, the company gives each individual employee the option to opt out and use a “placebo badge” instead (Noyes, 2015). Relatedly, evidence suggests that UPS drivers perceive the monitoring technology as restricting their autonomy, which results in their feeling frustration (Goldstein, 2014; Woyke, 2018). A UPS driver commented: “You can’t let it feel like it's an attack on your own personal…. You can’t look at it that way ‘cause you'll get so frustrated that you won't even want to do it anymore” (Goldstein, 2014). Here, Uber even seems to go one step further by leveraging gamification strategies as a key mechanism to “nudge” its drivers (e.g., “Are you sure you want to go offline? Demand is very high in your area. Make more money, don’t stop now”), and to create competition among them (e.g., “Unfortunately, your driver rating last week was below average.”). Potential drawbacks from using such gamification strategies include drivers feeling manipulated and overloaded due to the “flood” of messages and notifications that Uber sends its drivers via various channels on a daily basis.

To that end, other future research could focus on studying the negative impacts that TMC has on individual workers. Such explorations might consider TMC scenarios that involveertain concerns around morale, creativity, staff turnover, propensity to resist TMC, and users who employ workarounds to avoid

TMC. Similar to research examining compliance and non-compliance with information security policies (e.g., Moody, Siponen, & Pahnila, 2018), this stream of research could examine the factors that lead employees to not comply with the controls inherent in, or derived from, TMC applications. Therefore, we suggest future research examine the following research question:

> **RQ5:** What are the potentially negative impacts of TMC on worker well-being, as well as their performance?

Second, the role of transparency varied considerably across the four TMC case examples we analyzed. For example, two TMC approaches (Humanyze and Rationalizer) relied on transparency as a central mechanism to influence controllee behavior. In particular, with Humanyze, controllees receive detailed feedback on their behaviors along with information on top-performing peers' behaviors, which spurred competition among employees and promoted them to exercise self-control. Similarly, with Rationalizer, controllees receive information about their emotional state, which helps them effectively exercise self-control. Conversely, controllees perceived the two TMC approaches that adopt a more coercive control style (Uber and UPS) to lack control transparency, which contributed to their feeling frustrated and that they lacked autonomy.

Despite TMC transparency's potential benefits, attempts to increase transparency may have limitations and lead to unintended consequences (Ananny & Crawford, 2016). For instance, employees using the Humanyze ID badge could intentionally engage in activities (e.g., walking around the office, talking to different people) that the algorithm values only to manipulate their personal ratings in the system. Relatedly, Uber drivers with detailed knowledge on the company's TMC algorithms could develop coping strategies and engage in workarounds and, thereby, potentially "fool" the control system and compromise its overall effectiveness.

In order to extend this line of inquiry, future research should consider what forms of TMC transparency workers value (e.g., data collected vs. algorithm functioning) and what implications poor TMC transparency has on workers. Although the resulting insights will likely depend on the specific TMC approach in place, better understanding the impact that transparency choices have on workers could provide valuable insights into best practices for TMC-related communication and manager awareness. Therefore, we suggest future research examine the following research question:

> **RQ6:** What role does TMC transparency play in ensuring compliant controllee behavior and in preventing negative socio-emotional side effects?

4.4 Outcomes

The outcomes dimension considers the opportunities for research at an organizational level that pertain specifically to TMC interventions' business-oriented outcomes. The TMC case examples we examined point to a broad spectrum of organizational outcomes that range from productivity and efficiency gains to quality-related improvements. Still, in traditional control contexts (characterized by superior-subordinate control relationships), TMC seems to focus on increasing employee productivity and operational efficiency (e.g., Humanyze and UPS). In this regard, Uber represents an interesting example of a non-traditional control context (i.e., involving freelance workers) where automation and gamified managerial control processes allows the company to not only exercise effective control over its workforce but also yield a mix of cost and quality-related advantages along with seemingly infinite scalability. A potential limitation regarding the latter relates to drivers being increasingly dissatisfied with the way in which Uber treats them, which leads to high turnover rates and declining profitability. At least to some extent, we observed similar problems at UPS, which has an equally (if not more so) coercive TMC approach.

As we indicate above, adopting TMC applications led the case companies to realize benefits including reduced employee turnover (e.g., Humanyze), cost efficiencies and business-model scalability (e.g., Uber), and improved productivity (e.g., UPS). While the expectation that they will attain such organizational benefits fundamentally drives organizations to adopt TMC, it remains unclear whether a wide range of organizations can generate these benefits directly result from a TMC initiative or if they constitute context-specific benefits that only a small subset of firms under particular circumstances can attain. For example, relevant factors may include specific industry characteristics, organizational structures, and geographical locations that best suit TMC. In part, corresponding studies may also focus on determining whether and how one can transfer TMC approaches that organizations have already successfully deployed in a particular context to other contexts. For example, the gamification strategies that Uber's driver app uses may or may not be effective in an environment with permanent employees (as opposed to independent contractors) or with workers who engage in more knowledge-intensive activities. Therefore, we suggest future research examine the following research question:

RQ7: How and under what conditions can an organization benefit from TMC adoption?

According to our case examples, when employing TMC, organizations need to consider ethical issues. Ethical issues deal in part with the individual-level impacts on workers (as discussed above) but also with broader organizational concerns around choices made in the implementation, oversight, and accountability for TMC initiatives. Therefore, future research should investigate the range of ethical challenges that exist with different TMC approaches (e.g., value creation vs. value appropriation) and how organizations can cope with these challenges. Such studies could examine design choices in TMC tools, particularly those that attempt to intentionally manipulate users' behavior. For example, the Uber app has received criticism for incentivizing drivers to "always keep going" (e.g., via forward dispatching and earning targets) and for placing "buttons" associated with desired behaviors more prominently in the app. As Markus (2017) points out, this sort of algorithmic tool has the "potential to coerce people and to create inequality among people and organizations" (p. 240).

Other examples of ethical challenges exist in regard to the security of TMC data in terms of confidentiality, integrity, and availability. In analyzing our cases, we found various assurances that organizations provided to controllees on such matters, including Humanyze not revealing individual-level data to managers. However, as the quantity of collected data increases, the opportunities to glean valuable insights may increasingly conflict with controllees' interests. Similarly, a particular concern involves the risk that someone will hack or leak data. In this context, future research could examine the information-security threats and vulnerabilities associated with TMC applications. Overall, this direction echoes past calls for research, including Markus (2017), who suggests that "we have much work to do understand the consequences of such systems and to inform practitioners about when (not) to use algorithms, how to govern them, and how to provide due process to the people and groups affected" (p. 240). Therefore, we suggest future research examine the following research question:

RQ8: How can organizations ethically engage in TMC initiatives?

5 Conclusion

In this paper, we explore the emerging topic of TMC, which involves using mobile apps, digital sensors, software algorithms, and other technologies to collect data and analyze workers' behavior as a means to support or automate how organizations manage control. By drawing together past perspectives on organizational/IS control and ubiquitous technology, we examine how TMC has gradually begun to replace traditional control relationships between human controllers and controllees. In particular, based on analyzing four illustrative case examples (Humanyze, Uber, UPS, and Rationalizer) of TMC use in practice, we identify patterns and trends that represent promising avenues for future research. For instance, we examine how TMC has caused the controller's role to change, how one can refine TMC applications over time, and the role of ethics in TMC. Thus, with this study, we contribute to the dialogue on the changing nature of work in the current digital age by shedding light on the growing influence that digital technologies have on control workers' behavior and by providing guidance and inspiration for future study in this increasingly important and forward-looking field.

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Appendix

Table A1. Summary of Case Example Data Sources

Case	Data sources	Data quantity	Publication outlet
Humanyze	Bosanac (2015)	2 pages	*Canadian Business*
	Carey (2017)	3 pages	*TechWorld*
	Heath (2016)	3 pages	*The Washington Post*
	Kimura (2016)	3 pages	*CBC News*
	King (2017)	5 pages	*Raconteur*
	Kyte (2015)	2 pages	*Going Concern*
	Lindsay (2015)	8 pages	*Fast Company*
	McLaughlin (2017)	4 pages	*Daily Mail*
	Noyes (2015)	9 pages	*CIO*
	Waber (2013)	240 pages	*Book*
	Waber & Kane (2015)	7 pages	*MIT Sloan Management Review*
Uber	Addady (2016)	1 page	*Fortune*
	Davey (2017)	5 pages	*Quartz*
	Eadicicco (2016)	2 pages	*Time*
	Griffen (2016)	4 pages	*The Independent*
	Kessler (2016)	6 pages	*Fast Company*
	Lee et al. (2015)	10 pages	*ACM Conference on Human Factors in Computing Systems*
	Rosenblat (2018)	271 pages	*Book*
	Rosenblat & Stark (2016)	27 pages	*International Journal of Communication*
	Scheiber (2017)	23 pages	*New York Times*
	Shu (2017)	3 pages	*Tech Crunch*
	Singal (2017)	1 page	*New York Magazine*
UPS	Ernst (2010)	4 pages	*Automotive Fleet*
	Goldstein (2014)	5 pages	*NPR*
	Hullinger (2015)	9 pages	*Mental Floss*
	Terdiman (2010)	7 pages	*CNET*
	Woyke (2018)	7 pages	*MIT Technology Review*
Rationalizer	Djajadiningrat et al. (2009)	11 pages	*Proceedings of the Design and Semantics of Form and Movement*
	Economist (2009)	1 page	*The Economist*
	Fernandez (2011)	160 pages	*Doctoral Thesis*
	Philips (2009)	8 pages	*Philips*
	Whelan et al. (2018)	7 pages	*MIT Sloan Management Review*
	Total	**858 pages**	

Table A2. Summary of TMC Approaches

Dimension	Humanyze	Uber	UPS	Rationalizer
TMC type	*Support*	*Automate*	*Support*	*Support*
Industry (characteristics)	Any industry	Personal transportation (high competition)	Logistics/package delivery (high competition)	Finance/online stock trading (high time pressure)
Context Technology details	“Smart” ID badge equipped with sensors	Mobile (driver) app	GPS tracking equipment and sensors	Emotion-sensing bracelet (and display)
Control relationship	• Manager (controller) • Employees (controllee)	• Manager (controller) • Freelance drivers (controllee)	• Manager (controller) • Employed, unionized drivers (controllee)	Home-based stock traders (controller and controllee)
Control purpose	• Value creation (productivity improvement)	• Value creation (demand-supply matching)	• Value appropriation (rule enforcement)	Value appropriation (risk reduction)
Data volume	• High (voice, location, movement data)	• High (e.g., GPS and transaction data)	• High (e.g., GPS and 200+ sensor data)	High (galvanic skin response data)
Data variety	• Behavioral data • Emotional/ physiological data	• Behavioral data	• Behavioral data	Emotional/ physiological data
Data velocity	• Real-time data (‘batch’ analysis)	• Real-time data collection/analysis	• Real-time data (“batch” analysis)	Real-time data collection/analysis
Interventions Control process	• ID badge used for controllee monitoring • Data as basis for controllee evaluation (and specification of controls)	• Driver app enables automation of all four control steps	• Sensors used for controllee monitoring • Data as basis for controllee evaluation	• Bracelet used for controllee monitoring • Controls pre-specified in technology
Control modes	• Behavior control (e.g., behaviors of top-performers) • Self-control (e.g., setting of individual goals)	• Input control (e.g., driver activation and deactivation) • Behavior control (e.g., driver directions, forward dispatching) • Outcome control (e.g., earning targets, guaranteed fares)	• Behavior control (e.g., truck loading, seat-belt use)	• Behavior control (e.g., taking time-out) • Self-control (e.g., based on individual standards)
Control style	• Enabling (controllee empowerment and control transparency)	• Coercive (enforcement of compliant behavior)	• Coercive (enforcement of compliant behavior)	• Enabling (controllee empowerment and control transparency)

Table A2. Summary of TMC Approaches

Mechanisms (examples)	• Feedback on behavior and performance • Competition among employees and self-control • Perceived privacy concerns	• Work gamification (driver motivation and competition) • Perceived lack of control transparency • Frustration • Feeling of being manipulated • Communication and information overload	• Self-efficacy • Perceived lack of work autonomy • Frustration	• Awareness of emotional state • Self-control • Perceptions of intrusiveness
Outcomes (examples)	• Improved employee productivity • Reduced turnover	• Effective matching of demand and supply • Improved service quality • Cost efficiency and scalability • Decreased working morale and high turnover rates	• Increased driver productivity • Improved driver safety (and truck availability) • Reduced operational costs • Decreased working morale	• Reduced trading risk • Improved decision-making

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