# Cat and Mouse Game: Patching Bureaucratic Work Relations by Patching Technologies

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This article uses findings from a field study of the world's largest guaranteed employment scheme (NREGA) in India to understand how digital technology mediates work relations and power dynamics within a bureaucracy. In this initiative, upper-level bureaucrats in the south Indian state of Andhra Pradesh built a digital network to remove local discretion at the "last mile" of an implementation of NREGA. I show how digital infrastructure affords actors at both the first and last mile opportunities to modify software to control as well as subvert certain practices. This article refers to this dialectic phenomenon as "governance by patching" and defines it as a socio-technical instantiation of a top-down process that focuses on small changes, iterative, and political process for positive change. Governance by patching is, therefore, neither a purely technical process nor an exclusively administrative one. Rather, it refers to the ability to fix unanticipated problems that arise in the implementation of governance programs by altering the socio-technical systems. The struggle for power continues, but on the new digital terrain.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; • **Applied computing** → Law, social and behavioral sciences → **Sociology**

KEYWORDS: Patching; Governance; ICTD; bureaucracy; last-mile; NREGA; infrastructures

## 1 INTRODUCTION

In this article, I examine the technology-based governance interventions of the world's largest guaranteed employment scheme, the National Rural Employment Guarantee Act (NREGA) in the South Indian state of Andhra Pradesh (Andhra) [57]. This project has received widespread attention; and the Andhra intervention of using digital technologies to govern has both reduced "corruption" and been lauded as a model to be replicated [34, 46, 57, 71]. However, most studies of the use of digital technology in governance projects seek to measure outcomes; in so doing, they rarely aim to substantiate [6, 10, 11, 43, 84]. By examining the mechanisms used in these programs, and with a particular focus on the design of technology and its associated politics within the state bureaucracy, this article draws attention to the socio-technical systems that impact-assessments often overlook.

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Andhra Pradesh offers a productive site for examining how digital technology affects work relations within the state, as it is India's most digitally innovative state and has led the way for using technology to solve governance problems in global south. In this paper, I refer to the administrators of the NREGA as upper-level bureaucrats, and the NREGA employees who carry out implementation at the last mile as the street-level bureaucrats [44] Development programs designed by upper-level bureaucrats do not often benefit the poor because of governance problems [20, 21]. Political will and good design of policy are critical, but they are often not enough to neutralize and overcome implementation challenges that occur because of resistance from local elites. The development economist Lant Pritchett powerfully characterized India as a "flailing state," by which he means that the upper-level bureaucrats are unable to "maintain sufficient control of the administrative apparatus" to deliver government services despite "democracy and strong capability at the state level" [62]. Within this context, there is growing excitement about the use of digital technology to overcome problems of governance by allowing upper-level bureaucrats to control the street-level bureaucrats and politicians. In India, many large technical systems dubbed "e-governmental platforms" have been rolled out, using the justification that they would improve accountability and have a positive impact on the lives of the poor [7, 10, 25, 26, 43]. From the existing development literature, we have an increasing sense for the politics of what drives states to invest in digital technology and whether the use of digital technologies has an impact on outcomes. However, we do not yet understand the underlying mechanisms behind these technologies [10, 43, 45, 49, 51, 52, 55]. This is because existing studies tend to blackbox the use of digital technology and do not examine the politics that went into shaping these investments.

Most studies of digital technology use in governance projects seek to measure outcomes; in so doing, they rarely pay attention to the incremental technological changes, which both advance and impede the effects they aim to substantiate [10, 11, 43, 5, 16, 28, 29].

To the extent that iteration is thought about, it is thought about technologically, like the sort idealized in Silicon Valley technology entrepreneurship under the "fail fast" slogan [55]. The tendency to "render technical" or "rendering entrepreneurial" has been magnified by increased reliance on the use of information technologies to solve problems of development [35]. The criticism is that these designers or technology determinists or apolitical developmentalists do not think comprehensively, that is, politically, about problems and solutions [5, 27]. Hence, their solutions distract attention or aggravate the existing issue [42]. To focus only on the technical iterations of a system or the overarching policy decisions misses the critical way in which these two dimensions interact and could lead to what is referred to as "Moore's law solutions" [8].

In this article, I propose a novel way to understand the mechanism that permits states to repeatedly fix problems that arise in implementation. I call this mechanism "governance by patching." By patching, state bureaucracies can continuously adapt their informational infrastructures to the changing realities of implementation. Further, patches make extremely specific changes, not general changes to policy guidelines. In addition, they typically do not fix problems in one shot, because the full scope of the problem is usually not fully known at first.

I borrow the term from software development and explicitly focus on the socio-technical and political processes around patching to understand how digital technology mediates work relations within a state bureaucracy. In software development, patching refers to the ongoing need to maintain software systems by continually and routinely fixing problems. Patches are bits of code targeted to fix specific parts of a larger software system that are not functioning as originally

planned. Patches are fundamentally incremental fixes rather than one-time solutions, whether applied to software systems or systems of governance [19].

While patches in software refer solely to technical changes, the process of altering the rules of a government program requires both technical patches and a fine-grained ability to respond to local conditions through new administrative processes. Governance by patching is, therefore, neither a purely technical process nor an exclusively administrative one, but rather refers to the ability to fix unanticipated problems that arise in the implementation of governance programs by altering the socio-technical systems.

Overall, the process of governance by patching has three features:

- Top Down: The patch sender is at a higher level than (i.e. has jurisdiction over) the patch receiver.
- Fine Grained Changes: Patches are extremely specific and make focused changes to policy.
- Iterative: The patches are repeatedly authored and sent based on new realities. They are part of a continuous cycle of fine-grained changes to the implementation.

This article focuses on tracing the changes to technology and mapping how these changes affect bureaucratic relations within a state. It shows how upper-level bureaucrats designed digital technologies to control street-level bureaucrats, how they were resisted by the street-level bureaucrats, and the subsequent reworking of socio-technical systems by upper-level bureaucrats to deal with those resistances—in essence, the cat-and mouse game between the bureaucrats.

The article's contributions to CSCW research are two-fold. First, patching, as I will demonstrate, offers an analytic framework that helps us build informational infrastructure when the "process requires constant attention to possibilities of breakdown of socio-technical arrangements" to discover how work relations are mediated through changes in socio-technical arrangements [69]. Second, patching helps us to see how technologies impact work relations by iterating on small details. While each patch may only have a limited local significance, the cumulative impact of such continued engagement would be transformative in fundamental ways, and the tactic is more likely to lead to effective and just platforms, particularly when there is asymmetry of power.

## 2 RELATED WORK

The concept of patching builds on the work of informational infrastructures, i.e., materialities of infrastructure that are revealed through ethnographies of the state.

In the CSCW literature, infrastructure is a "broad category referring to pervasive enabling resources in the networked form" [4, 18] and "informational infrastructure" is seen as an "ongoing processes involved in the production and circulation of documents" [22, 33]. Informational infrastructure is not "built" but "growing" [36, 37]. Assembling information infrastructures is not always "planned, orderly and mechanical", instead they are often messy and dynamic [36,37]. Scholars have used the term "infrastructuring" as a way to emphasize the continuing nature of infrastructure development and usage, starting with the moment that the infrastructure first becomes visible to its users [3, 11, 61,72]. Although this theoretical work on infrastructure has largely been in the context of organizational information technology practices, it also applies across other contexts [54]. The idea of *public information infrastructure* opens up the possibility for different "publics" to both assemble and become controlled by these information infrastructures

[22]. Studies have examined how informational infrastructures from the state render it "legible" and help to mediate relations between the state and citizen: to classify who is poor, who is a citizen, and a migrant. [2, 39, 65, 66, 70, 72, 73, 74]. Similarly, studies have reversed this gaze and shown how informational infrastructures allow citizens to see the state, often making it appear "distant, opaque and seamful" [13, 15, 23, 30, 49, 65]. I add to this literature by looking at changes in informational infrastructures that play out within a state bureaucracy.

But what causes infrastructure to change? There are two broad themes that drive change: the first, which is intrinsic to the human condition, is the inability to plan/design/foresee structures that last. Studies have looked at changes to infrastructures owing to "care," "grafting," "jugalbandi," "logistics," and "everyday maintenance" [36,37, 38, 69] The second incentives for change are those that are intrinsic to the technology caused by its affordances. They are characterized by "erosion, breakdown, and decay" and focus on repair of these infrastructures [67, 75]. I extend this work by considering conflict and contestation as opposed to "organic growth" or "breakdown" as reasons for changes in infrastructure. The context of conflict that I study is the continuous political fighting that exists within the state bureaucracy. These conflicts manifest in the technologies of control used by the bureaucracy.

Recent anthropological work on the state has brought attention to the materiality of this informational infrastructure as regards everyday state documents and how they play a central role in state making [27, 32, 31]. Bureaucratic writing is a technique of control that had a colonial motivation to manage local native functionaries [32]. The upshot of this attention to writing is that it is not merely a function that the state performs. Writing and circulation of documents, these scholars argue, is what actually constitutes the state [47]. Tracing changes in documents reveals how power works and how documents mediate social relations. I extend this gaze by looking at changes in digital technologies, including documents and how these informational infrastructures circulate. But when these information infrastructures circulate, they have to "contend with asymmetric power relations and struggles for control between different actors" [69,76]. Paying attention to changes in these technical artifacts reveals the fight for control. Thus, while repair is about trying to maintain the information infrastructure to preserve the original intent and design, patching is about modifying the existing information infrastructure to accommodate unanticipated uses because of resistance.

As much as the welfare program they helped to implement and the people who deployed them, the digital technologies instantiated in NREGA incorporated politics. Therefore, in order to understand how those contestations play out between the bureaucrats, we need to look at how technology evolves in response to iterations in the exercises of power [78]. In the analysis that follows, I ask how and why did upper-level bureaucrats make changes in the technology the program uses? How did the changes in the technology affect the discretion of the street-level bureaucrats [6]? And how did these changes shape the ability of the upper-level bureaucrats to retain control of the implementation of NREGA at the last mile?

## 3   METHODS AND CASE

This paper is based on my study of the NREGA, an ethnographic study lasting a total of 18 months. The bulk of the research was done between 2011 and 2012, with follow-up visits in the summer of 2016 and 2017. The data for this paper comes largely from my observations during the initial phase in 2011 and 2012. The follow-up visits did not change what I observed and only

deepened my conviction that what I observed was valid in terms of how central digital technology to the Andhra's governance strategy.

I used a variety of approaches to collect data, including participant observation, unstructured and semi-structured interviews, a survey administered in fifteen villages, content analysis of documents, and archival work in the assembly archives in Andhra Pradesh. I wanted my work to capture the situated essence of what was going on, not suggest that what I discovered in Andhra Pradesh was true everywhere. Moreover, I was not merely interested in studying the impact of "solutions": I wanted to understand the mechanisms used to implement those solutions and why those mechanisms were chosen.

I relied on a multi-sited approach as I attempted to follow the social moorings of information technologies [9, 48]. What it means to be in the field can be particularly complicated when the reach of technology use in the state denies you the luxury of being in one place. I trace the use of technology in Hyderabad and in two sub-district administrative blocks (referred to as Mandals) in Chittoor district, one block in Srikakulam district, and one block in the Kurnool district, all in the state of Andhra Pradesh. To understand how documents mediated work relations, I focused on production and circulation of documents, which took me beyond the office. The setting for my interviews, for example, was extremely important, as several bureaucrats spoke differently depending on whether our interaction happened at the office, at their house, or in a different setting.

I started my study by spending time in Chittoor, a region of Andhra Pradesh where the inhabitants speak Tamil, my mother tongue. I used the assistance of auditors who knew both Tamil and Telugu in the initial months. My interactions with upper-level bureaucrats were carried out predominantly in English. Eventually, thanks to this immersive experience in Telugu and to the close relation between Telugu and Tamil, I came to be relatively fluent in Telugu.

I also hired a translator who spoke both Tamil and Telugu as both a traveling companion and a translator. My interactions with street-level bureaucrats were carried out in English, Telugu and in Tamil. I wrote daily field notes and recorded and transcribed some of my interviews. Most of the accounts used as data for this paper were from my field notes, as it was not possible to always record the interactions with the bureaucrats, as they were not just from interviews, but from participant observation, through an extended period. One of the higher-level bureaucrats told me, "Of course you get access to only certain spaces. We let you see what we want you to see." It was a constant struggle to understand what was going on and I developed several alternate strategies.

I was interested, in particular, in understanding the governance strategy of NREGA and in examining work relations between the various levels of state bureaucracy. I attended several internal meetings of state-level bureaucrats and witnessed the day-to-day operations of the bureaucracy. I also attended more than 25 meetings (some of which were over 12 hours long), videoconferences, workshops, and political rallies at the village, administrative block, and state levels. In the end, I conducted over 100 semi-structured interviews with bureaucrats working at the village, regional, state, and national levels as well as NREGA workers. In addition, I lived with NREGA workers and "worked" as a day laborer and have gained insights into the process through regular discussions over the year of fieldwork as well as by shadowing the bureaucrats in their everyday work. The data for this article is comprised mainly of participant observation and semi-structured interviews with upper-level bureaucrats, street-level bureaucrats, and designers from a private company who developed the software. The questions that framed this particular paper, emerged out of the field work. I did not go into the field knowing the salience of the technological infrastructure in managing the program.

The idea for patching first occurred to me in a meeting with a senior bureaucrat in Andhra Pradesh. I was sitting in the office of the principal secretary of rural development, an upper-level bureaucrat in Hyderabad. He was having a brainstorming meeting with a group of software engineers from a company contracted by the Andhra Pradesh government. They were presenting their latest design change to the software system. The topic was about making changes to the digital attendance register, referred to by them as the electronic muster roll. The discussion focused on figuring out a software change which would involve making a particular field "read only." They were trying to restrict who had access to modify that field. I understood the technical discussions, having previously worked at a large software company myself, but missed the larger significance of what they were up to. Only after multiple meetings and after I left the field did I understand the broader significance of their focus. In ethnography, the research site never leaves the researcher. It has been several years since I left Andhra Pradesh, but I return constantly in my mind as I sift through my data, interpret my experiences, and write up my analysis. The commitment to ethnography truly does not stop with fieldwork but continues long afterward. I came to understand that these small details not only mattered, but these seemingly inconsequential changes in administrative processes were central to fixing the problems of NREGA's last mile governance and had consequence to the implementation.

## 3.1 Limitations

Even though the analysis in this paper primarily examines work relations within the bureaucracy, there were two omissions in my broader ethnographic study that are worth bringing up. One, my work was fixated on the implementation of the program at the last mile and did not examine the work of the upper-level bureaucrats outside this program. That is, my project took for granted the political will that allowed the reformist bureaucrats to use digital technology to implement the program, but it did not examine the political and economic cost of that elsewhere. Second, although rural women's participation in NREGA was high, my analysis lacked a gender lens to understand how the implementation was differentially experienced. Third, the paper assumes that the political will is a given, and there is support for NREGA in Andhra Pradesh that has survived changes in political party changes in the state, but there are differences in the political administration's strategies in how they administered NREGA.

## 3.2 The National Rural Employment Guarantee (NREGA)

The National Rural Employment Guarantee (NREGA) aims to provide each household with at least 100 days per year of wage employment. NREGA, a rural right to work program, was passed as a national law in India in 2005 [41]. It promises the right to a basic safety net for the poor by guaranteeing employment in rural India. Household members must be willing to do manual labor at the government-approved minimum wage. The work typically consists of building agricultural bunds or canals, and other labor-intensive government projects carried out on public lands. It has two broad goals: one is to provide employment, and the other is to build useful rural infrastructure.

Andhra Pradesh, like all Indian states, is administered through the hierarchy Figure 1 illustrates. The state is divided into districts. Within each district there are sub-district blocks. The blocks are further divided into gram panchayats and then into villages. Finally, within villages are habitations, which are often segregated by caste.
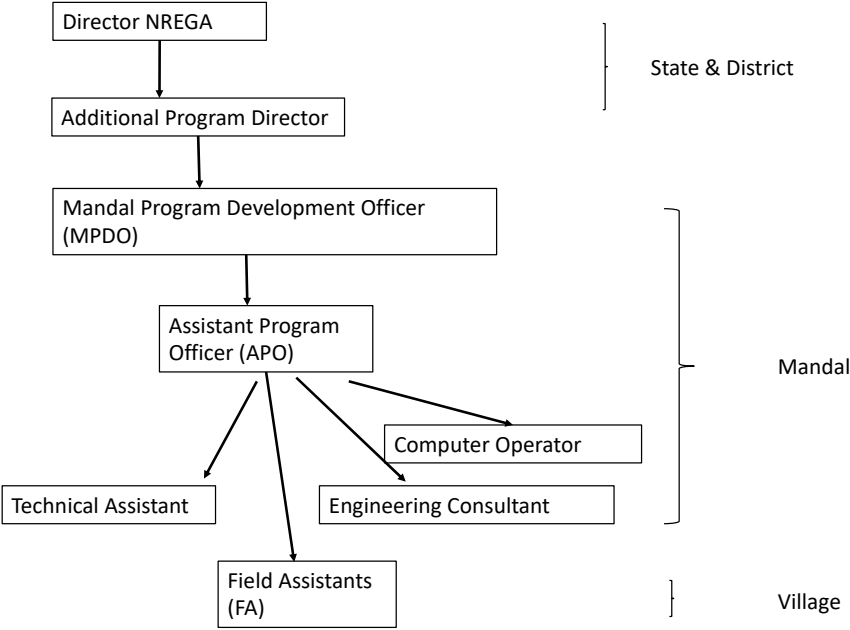
Fig. 1. Structure of NREGA Administration in Andhra Pradesh

Figure 1 shows the hierarchy of the implementing bodies for the NREGA program in Andhra Pradesh. The administration of NREGA operates at different levels of the hierarchy. The four tiers of administration are the state, district, mandal, and village levels. In Andhra Pradesh, there has been an effort since the late 1990s to outsource the work of the state to outside agents and contractors [43]. The NREGA bureaucracy continued that trend of employing contract labor. With the exception of the mandal program development officer (MPDO), the entire bureaucracy at the mandal level is a temporary work force. Frontline bureaucrats are not recruited through the civil service. While there has been a struggle to unionize the front-line bureaucrats and to fight for permanent status, there has been a strong push back from the upper-level bureaucrats, and ultimately the politicians as well, against yielding frontline bureaucrats that power. Village-level agents are controlled at the mandal level. The NREGA bureaucracy has no offices at the village level. There is a district office with administrators, but their role is limited to storing documentation and rubber-stamping projects that come up and down the hierarchy.

Decisions about projects are made at the mandal level. The mandal has an office that is sometimes called the MPDO office. Each village typically has a field assistant (FA), who assigns work, maintains attendance registers, and makes all key decisions at the field level. Field assistant is an important position at the village level; it is an administrative position and not part of the village panchayat.

The technical side of the program, planning the actual work, is done by two other administrative positions at the mandal level, the technical assistant (TA) and the engineering consultant (EC). Appointments to these two positions are made at the state level, again to ensure

independence from local political influences. The people who fill them are also temporary contract employees and often have a diploma, and in some cases, engineering degrees.

Although NREGA work is standard and "simple," the technical assistants and engineering consultants still need to know how to read engineering diagrams. Their role is to plan projects and take measurements. Engineering consultants handle projects that require technical expertise. They focus more on the planning aspect of the work. On the other hand, technical assistants measure the work done on job sites, because the NREGA pays workers based on the amount of work they do rather than the number of hours they work. Even so, workers are expected to stay the whole day at the worksite. The technical assistants maintain measurement books that document the dimensions of the work. Essentially, technical assistants do the job contractors used to do before NREGA.

The most critical actor at the sub-district level is the computer operator. The computer operator is responsible for digitizing all the records. The operators play a critical role in the implementation of NREGA in Andhra Pradesh, which relies on information technology to control program implementation. In sum, NREGA governance at the last mile is a highly systemized hierarchy administered from the top to tightly control oversight and practices. However, as we will see, various local forces are constantly pushing against that governance, creating a fluid dynamic that requires adaptation and adjustment.

In India, implementation of government programs at the last mile suffers because of two factors: first, the intentions of bureaucrats at the top do not translate into effective policies at the bottom, because they do not have an adequate understanding of local realities; and second, upper-level bureaucrats lack the capacity to effectively regulate the work of their subordinates at the last mile. In particular, the problem of the last mile is political. It refers to the inability of upper-level bureaucrats to deal with political resistance at implementation at the local level due to collusion between street-level bureaucrats and politicians [40].

In Andhra Pradesh, upper-level bureaucrats viewed the problem as located at the "last-mile," and in response, they sought to centralize control over the implementation of NREGA and to eliminate any discretionary power among the street-level bureaucrats [6]. The upper-level bureaucrats sought to control NREGA through a particular political and technological vision that was focused on controlling documents and work processes. The fundamental premise of such control was that the upper-level bureaucrats' monitoring of subordinates would lead to better compliance with the rules of the system. Two principles guided the use of technology to centralize control: to increase the visibility of work done at every level of the bureaucracy and to control "micro-practices" at the field level, by enforcing and updating rules programmatically.

## 4  FINDINGS

The concept of governance by patching comes from Raju, the chief architect of and the former principal secretary of NREGA in Andhra Pradesh. He told me that time after time, year after year, project after project, he saw the same problem: money from the central government was earmarked for people in the villages but it never reached them. This problem occurs because local government officials and politicians siphoned it away before it reached the intended beneficiaries. Raju's idea was to centralize the implementation of the NREGA in Andhra Pradesh. When I asked him how that might happen, he said that the first thing to do would be to increase the visibility of field-level work so that bureaucrats like him from state capitals such as Hyderabad could see what is happening in the field.

Understanding the impact of technology requires understanding the local actors. Raju identified three categories of local actors in the Food for Work Program, a comparable national-level Indian development program: local politicians, engineers, and contractors.

Raju said,

*"I found three kinds of vested interests: politicians who get the works sanctioned are bringing the works to the village so that they have a share in it, engineers who implement the works and make the estimates, and contractors [who hire workers]. I have found that development programs in the past have been driven through and through by these vested interests."*

A study of the Food for Work program in Andhra Pradesh corroborated Raju's analysis: it found enormous misappropriation of the program's funds at the last mile, mainly by contractors, engineers, and politicians [17]. Further, Deshingkar and colleagues note that in that program, upper-level bureaucrats were better monitored and rewarded than street-level bureaucrats. They write that "the Indian system of public administration" is "relatively weakly" monitored "among the frontline officials whose actions and incentives are arguably most crucial to the livelihoods of very poor people" [17].

During my field work, I observed that the pressures from local politicians on street-level bureaucrats were immense. The bureaucrats told me that it was often hard to get a government job without the support of the local politician.

As Vivek Srinivasan, notes, politicians spend a lot of money to win local elections.

"*This involves campaign expenditure as well as money spent in distributing gifts to secure votes. It is commonly understood that presidents [sarpanches and elected officials] considered this money as 'investment' that has to be recovered from various schemes when they hold political office. . . . These[,] put together, created a strong incentive for Panchayat presidents to indulge in corruption in NREGA and other programs*" [77].

I heard local politicians talk about their need to spend money to bribe local citizens for votes. So it is not surprising that local politicians often try to control street-level bureaucrats to redirect development funds intended for public works towards their private ends. As Raju described, this often happened through the support of local contractors, who were the people in charge of implementing government programs.

In this paper, when I discuss the contest between the upper-level bureaucrats and the street-level bureaucrats, the reader should bear in mind that the local politicians colluded with the street-level bureaucrats.

The designers of NREGA program were acutely aware of this problem and sought to ban contractors from becoming NREGA employees. Yet in practice, enforcing this part of the law required tremendous efforts by NREGA senior administrators. The actors at the last mile, included street-level bureaucrats, contractors, politicians, and workers.

In pre-digital days, upper-level bureaucrats updated the rules by issuing circulars and government orders, which were typically issued at the state level, to provide detailed guidelines determining what is allowed under each program. The circulars are paper documents that travel down through the bureaucratic hierarchy: they are very detailed and control the micro-practices of the program. Guidelines include specifying the wage rate to be paid, the type of work allowed, the days in which work can be completed, changes in payment scheme, hiring procedures, and changes in formats to use for documentation.

However, my conversations with the upper-level bureaucrats revealed that these paper-based circulars ran into a number of problems. According to them, street-level bureaucrats could deny having received the circulars or could misinterpret them; communication could be delayed as the

order traveled through the postal system and down the bureaucratic hierarchy resulting in ignoring orders; finally, the effectiveness of the circulars was pitted against the local bureaucrat's lack of incentive to take action on them. Upper-level bureaucrats sought to address each of these problems with digital solutions.

The software system upper-level bureaucrats used to implement the program made it easy for them to modify circulars through software updates. Software patches perform the same function as paper circulars: they announce updates to a particular policy that are designed to address a problem or update practices in the field. Given this similarity, the transition from paper to software patches should have been feasible, especially since a software patch has a far greater likelihood of being effective — no one can pretend that they have not received a software patch.

In what follows, I look at five cases that illustrate how upper-level bureaucrats develop patches for problems within NREGA, who develops them, how street-level bureaucrats have sometimes thwarted the attempts of their supervisors to acquire greater control over their work processes, and how upper-level bureaucrats are attentive to such resistance and act to release new governance patches to deal with it. First, I will describe the sociotechnical processes of constant patching by upper-level bureaucrats, in their responses to resistance from street-level bureaucrats. The upper-level bureaucrats initiated these iterations in an effort to tighten control over the implementation, while also responding to the actions of the street-level bureaucrats. Second, I will turn our focus to the digitization of one administrative document of crucial significance to the management and maintenance of NREGA: the paper-based muster roll.

## 4.1 The Software Patch: Controlling Which Projects Are Done

To see how a software patch works, consider the case of a popular type of project undertaken through the NREGA: maintenance of irrigation canals. Upper-level bureaucrats realized that heavy rains made it impossible to audit a certain type of canal repair work because water covers up evidence of repairs. Yet local bureaucrats often chose canal repair as the type of work to be accomplished during the rainy season. In pre-digital days, upper-level bureaucrats would issue circulars disallowing canal work during a particular season in a particular district. But there was no way to ensure that these circulars were followed in the field. Because such changes are easy to make, upper-level bureaucrats now have the ability to fine-tune the system on an ongoing basis. They can control the type of NREGA work that is done based on the season and on local conditions. Today, a software patch deletes canal work from the list of approved works in a particular region during the rainy season.

The centralized power that upper-level bureaucrats gained on work allocation had another benefit: it enabled street-level bureaucrats to cope with local pressure from politicians who used to leverage their local access to street-level bureaucrats to implement their favorite projects. After the projects became digitally controlled, street-level bureaucrats could simply refuse to accommodate such requests, as they did not have the power to decide the project locally. Making changes in the software to create a new type of project in the software system requires approval from upper-level bureaucrats. While some street-level bureaucrats complained to us about their inability to make such decision, they also noted the benefits of not having to face pressure from local politicians. However, I also found cases where street-level bureaucrats did not install these new patches. This discrepancy highlighted a technical issue related to how these patches were updated.

## 4.2    The Update Patch: Rapid and Documented Delivery of Software Updates

Initially, software patches were often distributed via CDs and as mail attachments to the administrative block computer centers. The first iteration of the patches thus mirrored the functionality of the circulars, in that human intervention was required to install the patches. As the upper-level bureaucrats found out, however, the field-level computer operators installed the patches selectively. One computer operator explained to me the mechanism he used: upon receiving a patch, he would look at the list of changes in the metadata file accompanying the patch, and if he found something undesirable, he would delay installation. The metadata file is a human-readable text document, typically sent along with a software update, to alert the users to changes in the functionality of the software. The computer operators found another way to make use of this file: they read it so as to determine which patches to avoid. This discretionary power of the computer operators was possible because the patches had to be manually installed.

The upper-level bureaucrats soon discovered this behavior and made further changes, preventing the need for human intervention by automatically updating the software if the system detected an internet connection. Thus, the system could be updated instantly. The transfer of the software to the internet eliminated the communication delays, as well as the manual process of circulating CDs. But the offline world still had to be integrated with the online one; the offline-online separation caused problems for the upper-level bureaucrats and opportunities for the lower bureaucrats. When the software was offline, local officials could make changes and then upload them to the server. One computer operator told me that he would physically disconnect their computers from the internet and then call and complain, saying that he was not able to connect and was working off the older, offline version. In essence, he would use the "extra time" to process pending cases and only then update to the latest version. This pattern of behavior also happened elsewhere. As before, the upper-level bureaucrats eventually discovered this behavior and implemented a patch to eliminate the software's offline functionality as a way to deal with these transgressions. Now, to make any changes, the operators must be connected to the internet.

In spite of this cat-and-mouse game, the process of uploading software patches to fine-tune the operations of a large government program ultimately gives upper-level bureaucrats immense and immediate power to control the implementation on the ground, which may not always be desirable. As the literature on "street-level bureaucrats", pioneered by Lipsky, points out that the street-level bureaucrats, may need to have discretion in interpreting the policies [44]. Eliminating this discretion at the street-level means it may not be possible to understand the particularities faced by individual circumstances. Again, while these tussles between different levels of the bureaucracy occurred in the terrain of technology, I found that paying attention to changes in software revealed a political struggle for control.

## 4.3    Attendance Register Patches: Attempts to Prevent the Forging of Documents

I also found that in focusing the attention on one document, the attendance register, we could more closely identify the intricacies of the relationship between the content of these patches and how they are implemented in Andhra. The muster roll is an attendance register that records the presence of workers at a field site. The document typically records work, over a two-week period, for twenty workers at one NREGA work site, along with the workers' signatures or thumb impressions. The thumb impression is an auditing tool to ensure that the attendance was captured accurately by the front-line bureaucrat and to ensure that the worker was present. Muster rolls are typically stored at the local administrative block office. Muster rolls record who worked, how much they worked, where they worked, and what they worked on. Every two weeks the street-

level bureaucrats aggregate the muster roll; workers are then paid based on the amount of work done, using a piece-rate basis that is tethered to the minimum wage. Because payment is tied to this document, records of every work session in the muster roll must be signed by the worker, the field assistant, and the local administrative block program officer, in order for them to be considered valid. The NREGA thus stands on the muster roll. The muster roll is a bureaucratic technology that both depends on and becomes part of the infrastructure of governance.

The muster rolls were not just records of work done by the worker, but also seemed to capture trails of transgressions. One of the upper-level bureaucrats commented that the most common fraudulent practices involved manipulation of worker attendance records in muster rolls kept by field supervisors [56]. Recent studies examining performance of development programs in Andhra have frequently reported that the street-level functionaries fudged the muster roll to include "ghost workers" — by using fake names, by duplicating the names, which would appear on multiple sites at the same time, by exaggerating the number of days worked, or by under-reporting work [17, 57, 58]. The paper-based documents thus contributed to an administrative problem: they did not allow for "real-time checks." Bureaucrats responded by attempting to implement a digital solution that would allow for "real-time monitoring of all program activities" [56].

The first step was to digitize muster rolls. Most states used the services of the central government's software arm, the National Informatics Center (NIC). However, Andhra Pradesh bypassed NIC and used a private software company, Tata Consultancy Services, to install the company operated computer centers in every administrative block of the state. This decision enabled Andhra Pradesh bureaucrats to have greater control over implementation of the new software system [43].

NREGA bureaucrats in Andhra Pradesh were dependent on the software system the developers from Tata Consultancy Services built to control the everyday functioning of the program. Tata Consulting Service representatives visited the office of the principal secretary daily to discuss recent updates to the software. While most visitors to the office of the state's rural development office (even visitors from other state departments) had to wait in line to meet with the principal secretary (i.e., the director) of the bureaucracy that managed the program, software representatives from Tata Consultancy Services had easy access to the office without any prior permissions or authorizations.

The digital system helped upper-level bureaucrats remotely track work done under the auspices of NREGA. For example, they could see how many NREGA workers showed up to a worksite on a particular day. They could also monitor the time it took street-level bureaucrats to complete individual tasks. The software automatically gathered metadata about when data about individual tasks was updated. Access to fine-grained data about the attendance of NREGA workers enabled upper-level bureaucrats to compare the performance of different administrative blocks. This system gave them leverage to put pressure the bureaucrats of administrative blocks that weren't performing as well as others. Senior bureaucrats organized frequent video conferences in which the performance of individual administrative blocks and districts were often the subject of discussion. They also held monthly review meetings at the district level to further analyze performance. The pressure trickled down: administrative block bureaucrats held weekly meetings to ask individual field assistants questions about why there were so few workers coming to work on a particular week and compared the numbers of workers in other villages.

Digitization made it possible to create software tools that checked for inconsistencies in the data that was entered. Prior to digitization, there was no automatic way to check the veracity of

these documents. This monitoring was accomplished by a form of software triangulation. For example, upper-level bureaucrats could run a software query to discover when the same workers were recorded as working on multiple sites on the same day. If there were any transgressions, the offending administrative block and district officers were issued "show cause" notices and were subjected to disciplinary actions.

In one public meeting of a social audit I attended, the entire team of street-level bureaucrats from a nearby administrative blocks attended. They had no official reason to be there, as it was not their audit. When I asked them why they were there, they told me that they had come to learn about the type of issues that were being raised at the audit. They wanted to know the current priorities of the social auditors. During these audits, social auditors had started using sophisticated software queries to look for patterns. The street-level bureaucrats did not have access to the software code, but just by attending the social audit meetings, they were reverse engineering the type of queries that the auditors had used to find misappropriations. The street-level bureaucrats then used that information to develop strategies in the field for avoiding the disciplinary actions that were being imposed on their counterparts in the neighboring block.

One of the potential responses of learning the priorities of upper-level bureaucrats is greater adherence to the rules. But these street-level bureaucrats were also attending this meeting to discover which rules to follow and which to ignore. This action is evidence that as social auditors tried to focus on a particular type of transgression, street-level bureaucrats tried to escape that gaze by learning which patterns their employers were identifying. This cat-and-mouse game has implications for patching. Patching depends on the ability of the upper-level bureaucrats to learn from the field, but this may not always happen. The point here is not that patching is always possible, but it shifts the attention to focus on small details that concern how technology can mediate work relations.

Street-level NREGA bureaucrats also shared information through organized channels. Those who were temporary workers had a union that focused on salary and benefit demands. However, the workers had also set up informal communication channels among themselves. The field assistants were all connected to each other using the mobile phones their supervisors had given them to track their work. I saw them constantly using group text messages to exchange information and build solidarity. While I was not privy to the content of the internal communication among these teams, I got a sense of it in my conversations with the leaders of the union. In one discussion, one of the district field assistants, who was a union leader, told me there was a conscious shift in the type of actions some of these street-level bureaucrats were engaging in. Previously, their transgressions had consisted of cheating workers out of their wages by altering the muster roll, but over time, field assistants have shifted to making money on materials. A Society for Social Audit and Transparency report corroborated this shift.

## 4.4 Attendance Register Patches: Attempts to Prevent the Forging of Documents

Upper-level bureaucrats also had to contend with pressures from local politicians who felt that NREGA had diminished their power. The appointment of village-level field assistants is one of the key ways to control what happens at the last mile in the NREGA program. Because of this, upper-level bureaucrats took control of the hiring of the employees who reported to them. To the extent that it was possible to do so, they hired temporary employees to run the program. Street-level employees such as technical assistants, engineering consultants, and computer operators all had to appear at the state headquarters in Hyderabad for job interviews. Two positions were excluded from this requirement: mandal program development officer (the senior bureaucrat at the

administrative block level) and field assistant. The former is a permanent employee who is part of the regular bureaucracy that the state loans to the NREGA for a period of time. Field assistant is a village-level position.

In the past, the appointment of field-level functionaries in development programs was left to locally elected political representatives. To gain control of the hiring of field assistants, upper-level bureaucrats created a computer algorithm to choose employees. The algorithm restricts who can be appointed to those in the top bracket of number of days worked during the previous year for NREGA.

I relied on conversations with district-level officials to see how this worked and understand whether they found the automatic system of algorithmic hiring to be a hindrance or a help. Their responses varied depending on the place and the local political situation. In one case, the program director at the district level told me that the software was a boon, because they could hide behind the algorithm when a local politician insisted that they appoint a person they favored. They can tell the politician to appeal to upper-level bureaucrats, since the computer program excludes them from hiring decisions and there is no way to override the program locally.

In some districts, however, when a politician's choices have not been honored, they have blocked the appointment of field assistants and refused to accept the selection when their signature was needed. Such resistance has meant that field-assistant positions have not been filled in many places where the local political power is too strong [57]. Not being able to hire local field assistants means effectively shutting down NREGA functioning in that village. Ultimately, upper-level bureaucrats were forced to settle on a compromise whereby the algorithm would pick the top three field-assistant candidates and the local politicians would select among them.

## 4.5 Attendance Register Patches: Attempts to Prevent the Forging of Documents

One way that the upper-level bureaucrats attempted to gain control over muster rolls was by speeding up the process of data collection. Attendance data was now directly captured at the field site using mobile phones instead of using PCs at the administrative block computer centers. The attendance data, once entered on the phone by the field assistant, was automatically uploaded to central servers that were accessible to the upper-level bureaucrats. This step magnified the "legibility" of the muster roll: upper-level bureaucrats now had on-demand access, as well as the ability to see the number of workers at the work site. The software company that developed the software to provide the mobile-based muster roll included the rationale for this transition to mobile phones in a report. The immediacy of the data collection process facilitated through mobile phones put pressure on the field assistants to report the data daily. The availability of real-time data made it possible to create additional oversight in the form of supervisors, who were tasked with visiting work sites and verifying official reports, on behalf of the upper-level bureaucrats. To facilitate this live audit, field assistants were required to take attendance in the morning by a certain time, and supervisors were randomly assigned to audit the work site the very same day. Each supervisor would get a message with the work site location and corresponding attendance report to audit. In the view of the upper-level bureaucrats, without the timely information gathered through the mobile phone, it would have been possible for the field assistant to add fictitious names at the end of the day, but the possibility of immediate cross-verification made this extremely risky.

But the upper-level bureaucrats had another problem: how could they ensure supervisors were actually going to the work site and doing the mandated inspecting? Geolocation tracking seemed to offer the solution for this concern. Each work site in the state was surveyed and tagged with its

GPS location. Phones given to the supervisors had GPS tracking. Supervisors were instructed to send the attendance verification from the field site, so that their location travelled as metadata along with the attendance details. A location-based deviation report was automatically generated based on data harvested from the trips that the supervisor made to the field. These deviation reports, which could instantly be seen by each district program director, showed the supervisor's exact location on a map and their distance from the field site. These reports were expected to function as an administrative deterrent: if supervisors knew that their visits would be visible to the upper-level bureaucrats, they would be motivated to actually visit the work site and not to take the risk of fudging muster rolls.

Upper-level NREGA bureaucrats had recruited supervisors from other rural development departments to take on the responsibility of inspecting work sites. There were simply too many work sites to inspect, and the NREGA bureaucracy did not already employ enough staff to complete these visits. Supervisors did not want to do the extra work, as they felt that they had nothing to do with the NREGA and resisted the location-based monitoring of their work. The reports showed that supervisors chose to update the attendance report from their offices, which were several kilometers away from the field location. The representatives of the software company in charge of building the system told me that the field-level bureaucrats were reluctant to even use the tool but were forced to by the upper-level bureaucrats. Supervisors, who had less latitude to refuse, instead tried to blame the system. When a report showed deviation, the supervisors initially claimed that it was not because they failed to visit the work site, but rather because of patchy network connectivity in the rural areas, which prevented them from sending updates directly from the field site. After some back and forth, the supervisors' next tack was to find fault with the original survey process used to tag work sites. Supervisors reported that the original locations of the field sites were not recorded properly, and thus the whole exercise was pointless, since the deviation reports could not be trusted.

As a result of these complaints, two steps were taken by the upper-level bureaucrats. First, the work sites were GPS-tagged again. Second, a software fix was implemented to enable the GPS locations to be cached on the phone and uploaded later when network connectivity became available. This caching feature enabled the supervisors to record the location of the field site even without network service, and the attendance data was automatically sent with the location whenever the device detected the network. Technology helped upper-level bureaucrats eliminate the need for supervisors to upload the data, thus their discretion. Caching was an instance of patching, which was a direct reaction to an act of resistance.

Patches to both the software and the process of distributing and rationalizing bureaucratic labor were part of the cat-and-mouse dynamic. Digitizing the muster roll allowed upper-level bureaucrats to create software queries to detect patterns of bogus entries in the muster roll. The effects of the creation of these automated queries by upper-level bureaucrats manifested as questions to the street-level bureaucrats at the social audits. The street-level bureaucrats learned to recognize these question patterns by attending audits of neighboring administrative block and by communicating with each other across these different administrative blocks, often using the state-provided mobile phones. As a result, these software queries could not be static, and the upper-level bureaucrats had to constantly modify them in order to stay ahead of the field hacks. The process of recording daily attendance at the work site also went through a number of iterations. Attendance was originally recorded using PCs. Before long, attendance was taken at the work site using mobile phones, primarily to deal with problems of collusion at the computer center. This change enabled upper-level bureaucrats to create a new process of appointing

supervisors to inspect work sites and produce visit reports. The problem shifted to one of monitoring the supervisors and their visit reports. Upper-level bureaucrats used GPS-enabled phones to ensure that the supervisors actually visited the work sites. Even after GPS technologies were implemented, the process of patching was ongoing, as supervisors continued to find ways to resist the upper-level bureaucrats' efforts to automate and surveil their work on the ground. Features like local caching were added to make up for gaps in network connectivity. The process by which the software system was updated changed as well, also in response to field hacks. Offline systems of bureaucratic control, such as the use of CDs, were ultimately replaced with fully connected solutions.

## 5   DISCUSSION

We have seen that patching is a process of adapting information infrastructures to deal with problems of implementation. In the case we have discussed, patching is inherently about using technology to shape work practices by upper-level and street-level bureaucrats. The patches take place and are instantiated in the materiality of technology (e.g. software code, hardware devices) and, as a result, bureaucratic procedures are reconfigured. First, patching concerns policy implementation. Second, a patch is typically discovered through the action of implementing and thus cannot be known a priori. Third, patching is about finding a way to respond to local resistance to implementation. In other words, patching is about dealing with power in implementation. Fourth, patches are top-down but they can also be reactive, issued in response to resistance from "below". They can also—as needed—anticipate problems in implementation. Finally, it is only in relation to the implementation of a policy that patches can be identified.

In the sections below, I elaborate on these takeaways and discuss implications for informational infrastructures within non-cooperative governmental work settings.

### Changing informational infrastructure via contestations within the state

My findings demonstrated that changes in informational infrastructure were a result of contestations within the state. We learned that technology mediated the struggles between the different levels of the bureaucracy. I showed how digitization did not solve implementation problems in one shot but was a process of continuous patching that included changes in administrative processes. Through increased visibility and control of the "micro-practices" of work done by street-level bureaucrats, this digital infrastructure allowed upper-level bureaucrats enhanced remote surveillance, bypassing the existing "chain of command" form of management. It had been envisioned that the system would centralize power through technology in order to eliminate discretionary leverage at the street-levels of the bureaucracy. What my fieldwork revealed, however, was a constant struggle to control the digital system: the street-level bureaucrats found creative ways to thwart the intentions of the upper-level bureaucrats. As I showed, there was a constant struggle over time, a kind of "cat-and-mouse game" between different levels of bureaucracy as the upper-level and the street-level bureaucrats grappled to gain control over the software system. In the end, agency was not removed from local politics; it was constantly renegotiated through efforts by local politicians and local bureaucrats on the one side, and upper-level administrators on the other, in order to control the technological instruments. Local actors managed to defend their power and some of their ability to extract rents in the last mile. Further, as I have shown, technology can be resisted and re-purposed to unanticipated political ends by different actors.

In the study of the use of digital technology, we need to integrate the duality of sustenance - building and breaking - and focus on the acts of patching. I agree that repair is a critical concept for understanding digital infrastructures, but I would add that it is not just in breakdowns, or when something does not work, that we need to pay attention. While repair is about trying to maintain the infrastructure to preserve the original intent and design, patching is about modifying the existing infrastructure to accommodate unanticipated uses that result from contestation.

### Power, materiality and subversion

The evolving story of the patch helps us see informational infrastructure as a fundamentally iterative process subject to all kinds of influences, benign or otherwise. The material affordances of infrastructure shape practices differently. Yet within digital infrastructure, as I saw in the study of NREGA in Andhra Pradesh, opportunities for eliminating local discretion can often arise or be manufactured more easily since the infrastructure is more malleable. The same malleability that allows for patching also affords opportunities for circumventing the patches. But there is a tension here: by focusing on the malleability of infrastructure, one risks undervaluing the ways in which infrastructure is designed. How, then, do design intentions translate into material infrastructure on the ground?

There are two shifts in materiality I want to bring into focus: the shift from a paper to an electronic form of control and a subsequent shift within the digital realm. While both shifts reflect the intentions and ability of the bureaucracy to eliminate local discretion, I argue that to understand the implications of what transpired, one must look at the evolution of these material changes, which often seem insignificant. The automatic generation of muster rolls has created major headaches both for the bureaucracy and for NREGA workers, who are silent sufferers in this situation. The process of generating musters centrally has inadvertently yielded *more* agency to the street-level bureaucrats, who are able to *hide behind the computer* or "foot dragging" after committing transgressions, a finding other have found in different contexts [12, 14]. The digital system is thus facilitating and blocking transparency at the same time [13, 24, 30, 50]. While the use of a technical system makes it easy for upper-level bureaucrats to control those at street-levels, the constant tweaking of the system shows that technical fixes continue to be subverted. But upper-level bureaucrats in Andhra Pradesh were willing to spend the time to constantly design new processes and technologies to overcome this resistance.

What gets digitized and what gets left out is the result of a compromise among upper-level bureaucrats [48]. The decisions upper-level bureaucrats make about which forms get digitized and where to focus their attention are governed by political considerations, which is a limitation of patching that is controlled by upper-level bureaucrats.

## 6 CONCLUSION

In this article, I have argued for attention to the quotidian practices of the use of digital technology in managing work relations between upper-level bureaucrats and street-level bureaucrats in Andhra Pradesh. This study complicates the assumption that the willingness to use technology in governance is an indication that the state is interested in reducing corruption [10]. I find that the benefits of technology are far more complicated than they seem and that they need to be assessed in their particularities. Further, I have shown that technology can be resisted and re-purposed to unanticipated political ends by different actors, and so to understand real political effects, attention must also be paid to how and why changes in technology are produced, and resisted, over time.

This article argued that analysis of technology in governance — which focuses only on the technical specifications of a system, or on the overarching policy decisions — misses critical ways in which these two dimensions interact [1]. Instead, by asking why and how technology actually changes over time, I show how technology mediates politics within the state [83]. In so doing, I find that technology mediated the struggle for discretionary space within a centralized state-bureaucracy, which resulted in iterative, and at times contentious, patching of the governance process. Technology does not merely amplify the power of those who deploy it; the choice and the type of technology matters, as it has real effects that are evident both at the higher levels of bureaucratic administration and on the ground, in the day-to-day lives of citizens and workers [80, 81, 82].

Patching offers an analytic framework that helps us build informational infrastructure when the "process requires constant attention to possibilities of breakdown of socio-technical arrangements" [69]. While each patch may only have a limited local significance, the cumulative impact of continued engagement would be transformative in fundamental ways, and the tactic is more likely to lead to effective and just platforms, even when there is asymmetry of power. Patching is about changing power equations, albeit focused on small changes. The local system of power is very difficult to penetrate and transform, not because of inertia, but because of counter strategies from powerful factions at the local last mile [60] [63].

By foregrounding these design changes, this article moves from thinking about the need for change as evidence of a failure to plan and instead considers the need for governance by patching as a crucial and necessary feature of a functional, ongoing design process. By tracing the mechanisms of technology and their use over time within a state bureaucracy, the article argues that the use of technology to solve governance problems cannot be seen or studied as a one-time fix. This raises further questions about who decides which infrastructures should be patched. Can patches be made transparent and subjected to oversight? Currently, most discussions regarding technological interventions are focused on evaluating technical effectiveness. I argue for a shift in focus to those who design the patches as well as the technical design of the patches to understand how and why "patches" evolve over time. This framework challenges the centrality of designers in the act of design and calls for a sustained democratic design process that includes non- technical aspects at the center [59]. This has implications for both intervention and evaluation strategies as well as for understanding the ongoing and processual nature of infrastructuring digital technologies with government work.

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