From Margins to Seams: Imbrication, Inclusion, and Torque in the Aadhaar Identification Project

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ABSTRACT
Problems of marginalization and inclusion are central to HCI scholarship and impact in the world, but are badly named in the binary models of access that currently dominate the field. Building on prior work in ICTD and infrastructure studies, this paper explores the problem of inclusion through historical and ethnographic study of Aadhaar, India's biometrics-based national identification project. We illustrate tensions between Aadhaar users' ability to register, authenticate and successfully deploy their registered identity to participate in the Public Distribution System (PDS), a government scheme that provides subsidized food grains to the Indian poor. We argue that rather than an all-or-nothing state, inclusion in ICTD infrastructures is an ongoing and fragile *process*, achieved (unevenly) at the seams of multiple interconnected systems. Finally, we show that questions of (effective) inclusion are determined not just at margins of a system (who is in and who is out) but also through the artful and often challenging negotiation of the seams that run through and connect complex distributed infrastructures.

Author Keywords
Inclusion; infrastructure; access; ICTD; materiality; bureaucracy; biometrics; India

ACM Classification Keywords
H.m. Miscellaneous.

INTRODUCTION

HCI and ICTD research on (in)equality of access has slowly shifted from the digital divide – a binary of 'haves' and 'have-nots' differentiated by physical access to ICT – to digital inequality, a more nuanced approach that considers factors such as infrastructural means (electricity, bandwidth, connectivity, etc.), digital literacy and user competence, and social and technical support networks [1,8,13,15]. However, while the question of access has moved from a technology-centered narrative to a use-oriented one, its formulation persists as a binary, predicated on an all-or-nothing distinction between connection or disconnection, use or non-use, inclusion or exclusion. Furthermore, this research on digital inequality has remained largely separate from scholarship in infrastructure studies and HCI, which deals with systemic design and implementation issues that create conditions of marginalization and uneven impact in large-scale infrastructural development, use, and change [4,50–53]. In this regard, effective access is determined not only by contextual sociotechnical factors (as evident in the digital inequality literature), but also by the interactions of ICT solutions with the preexisting systems and infrastructures that they build on and connect to (as articulated by the infrastructure studies literature).

This paper builds on these two domains of scholarship to argue that rather than an all-or-nothing state, inclusion in ICTD infrastructures is an ongoing and fragile *process*, achieved (unevenly) at the seams of multiple interconnected systems. Here, we are borrowing the language of seams from the recent work of Vertesi, who argues that, "Unlike the metaphor of the boundary, or even a sense of layering, the language of seams and seamfulness posits that each system lies in messy and even unarticulated local overlap with other systems" [64:269]. Many users or user groups are not completely outside the purview and boundaries/margins of ICTD infrastructures, rather they are awkwardly situated in the interstitial or seamful spaces that emerge when attempts are made to layer an ICTD intervention on top of preexisting systems and arrangements that they build on and connect to. This layering is messy, partial, and inevitably requires ad hoc patchwork to bring the seams of these multiple systems into local alignment. Some users are better equipped in artfully navigating these seams to get their work done than others. Thus, inclusion, as a fraught and ongoing process, may have multiple and highly variable outcomes, which can change over time and across places for differentially competent user groups. We ask how, when, and where users are included in an ICTD infrastructure, rather than focusing on whether a user has access to it or not. Furthermore, we

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will document the consequences of exclusion in these moments and places.

Empirically, our arguments draw on our ongoing program of ethnographic fieldwork around Aadhaar, India's biometrics-based national identification project. Launched in 2010 with the ambitious goal of enrolling 1.25 billion people, Aadhaar uses three biometric modalities – ten fingerprints, two iris scans, and a facial photograph – and basic demographic information (name, age, gender, and residential address) to assign a unique 12-digit number to every enrolled resident [58]. Currently the largest biometric database in the world with more than one billion users [37], the efficacy of Aadhaar (and many of its challenges) rest on the long-standing dream of unique, secure, and non-duplicate identification – a dream that is challenged in particular by the experience of socially, economically, and infrastructurally marginal groups, as described further in this paper. The practical importance of Aadhaar and its failures in turn rest on its imbrication or uneven layering with extant systems and infrastructures. Our particular case follows the experience of below poverty line (BPL) families seeking to enroll, authenticate, and deploy their Aadhaar identities to secure benefits under the Public Distribution System (PDS), a social welfare scheme that provides subsidized food grains to the Indian poor.

This paper considers the Aadhaar-enabled PDS database as an ICTD infrastructure and explores access to subsidized food grains as an outcome of being included into this infrastructure. Inclusion into Aadhaar-enabled PDS is contingent on a family's ability to first *enroll* all family members into Aadhaar, then add Aadhaar numbers into their family records on the PDS database (through a process called *seeding*) and finally, *authenticate* the Aadhaar identity of one family member to successfully access the family's monthly PDS entitlement. Before Aadhaar, access to PDS entitlement was contingent on family's ability to show a ration card, a paper-based identification document, every month to the ration shop dealer [49]. Thus, in Aadhaar-enabled PDS, we encounter a previously standalone bureaucracy relying on paper-based identification practices interfacing with Aadhaar. Through this case study, we offer a story of partial overlaps between the infrastructural seams of Aadhaar and PDS and the emergent "seamful spaces" [64] between them. These spaces are navigated by users who "work creatively with and across" [64:264] the seams of Aadhaar and PDS. We argue that infrastructural seams are central to the dynamics of inclusion. They add force and energy to particular paths of inclusion and use, while limiting or subtracting it from others. Inclusion is the process of successful navigation across seamful spaces between ICTD interventions and the preexisting systems that they interact with and build upon.

The paper that follows opens by reviewing work in HCI and infrastructure studies that helps unpack the dynamics and consequences of large-scale system interventions in bureaucratic identification practices. We then turn to the process of inclusion in Aadhaar-enabled PDS and explore the three crucial processes outlined above: enrollment, seeding, and authentication. We conclude by discussing how complexities of inclusion may challenge and limit otherwise promising interventions in ICTD.

LITERATURE REVIEW

From the use of permanent patronyms in written records of state-citizen transactions in 14th and 15th century England [46] to the 19th century introduction of fingerprinting in colonial India [7,47], the challenge of unique identification has a long and ambivalent history in modernist practices of governance and control. While much has been made of the negative consequences of such projects, recent work in development studies has argued for secure and reliable identity as a prerequisite for inclusion and empowerment of poor and marginalized populations around the world [5,55]. Szreter articulates the "right to registration" as a human right to argue that without the ability to prove one's identity the "discourse of entitlements, functionings, and capabilities" remains irrelevant "for the world's anonymous poor" [48:67]. In 2014, the World Bank started the Identification for Development (ID4D) Initiative, advocating the use of biometrics to address the challenges of unique identification [66]. Thus, the registration of unique and stable identities is increasingly imagined as the first step towards inclusion in modernist development projects of citizen empowerment.

Set against this hopeful vision, however, are a number of thorny realities. The first concerns the potential abuse of such systems, in particular the complex issues around invasion of privacy and surveillance that such efforts at a unified and centralized identity standard have raised [12,25,44]. These issues include fears around the 'social sorting' of populations [25], and designing limitations in linking databases that use such centralized identity databases. The second concerns the serious implementation barriers that efforts at integrated system development face – perhaps especially with regard to poor and marginalized populations whose prior participation in formalized public and private systems has been partial, limited, and disempowering. These barriers create tensions between individuals' ability to register and authenticate their identity, and deploy this registered identity to participate in more effective state-citizen transactions. We now turn to literature within postcolonial computing and infrastructure studies to situate our analysis of these barriers.

Transnational HCI and Postcolonial Computing

Research on transnational HCI, postcolonial computing, and computing at the margins [1,13,19,33] has paid significant attention to the uneven transfer and appropriation of ICTD infrastructures. Assumptions of ubiquitous and consistent infrastructures, and empowered

and competent users have been problematized in design considerations of adapting ICT emanating from the West to solve problems in non-Western contexts [1,42]. HCI has already recognized the cultural specificity of ICT with development of methods like 'user-centered' and 'community-centric' design [26,65].

However, postcolonial computing scholars have revealed presumptions of "the logic of a God's eye view and an agentic designer" [33:8] in these methods to turn the design process itself into an object of study. They also challenge the adequacy of geography-based socioeconomic and techno-infrastructural dualisms between developed and developing countries as analytic resources to theorize the difference in patterns of using ICTD solutions. Instead, they consider design and transfer of technology "as a complex practice of translation," which requires "purposeful, partial, and situated work that legitimately translates ways of life into technological needs and mandates" [33:7–8]. Exemplifying this translation, Ahmed et al. [1] have extended the concept of "residual categories" developed by Star and Bowker [51]. Residual categories engender double silencing of life stories of people who are left behind in the implementation of classification systems. Leveraging this concept, Ahmed et al. [1] have coined "residual mobilities" to articulate the double silencing of involuntary migration, displacement, and disruption in the discourse on seamless mobility. Similarly, Suchman [54] has emphasized located accountability in the artful integration of ICT solutions with preexisting systems to facilitate the emergence of new practices and things in reconfigurations of familiar environments and forms of actions.

Studies of State Infrastructures

A growing body of work in infrastructure studies suggests that tensions between design and use are central to modern infrastructural projects of all types. Star and Ruhleder have shown how "Infrastructure does not grow de novo; it wrestles with the 'inertia of the installed base' and inherits strengths and limitations from that base" [52:113]. They show that infrastructures are sunk into other sociotechnical arrangements, learned through membership in a community of practice, invisibly support tasks, and become visible upon breakdown. Once appropriated, infrastructures engender a sociotechnical culture [3,17], "a language to be learned, a way of tuning into the desire and sense of possibility expressed in the very materials of infrastructure" [22:337]. Studies of infrastructure have also highlighted the uneven appropriation of infrastructures across places and times [4,10]. This unevenness in appropriation may result from infrastructural breakdowns at different times and places or the inability of certain user groups to participate in this emergent sociotechnical culture.

Hanseth and Lundberg [14] have highlighted the complex relations and dependencies that link "new" digital infrastructures to pre-existing systems and arrangements (including paper-based ones) developed to accomplish the same work. Their insight is especially important in studying the use of digital infrastructures within state bureaucracies because documents play a central role in organizing their work processes [16,18,48]. Harper [16] has argued that documents instantiate control by aligning perspectives and activities within and beyond organizations. Sharma and Gupta illustrate that documents are central to "how the state comes to be imagined, encountered, and reimagined by the population" [48:12]. Hull has argued for the integrative function of documents, emphasizing "the way documents link to people, places, things, times, norms, and forms of sociality" [18:255]. Thus, documents signify preexisting relationships within a bureaucracy that resist efforts of digital interventions to create paperless work procedures.

Bridging the dichotomy between the design and real-world use of infrastructures, Pipek and Wulf have coined the term "infrastructuring" to emphasize the ongoing processes and reconfigurations by which settled systems and procedures are used, sustained, and reworked when aligned with digital infrastructures to accommodate breakdown, innovation, and change, across multiple "points of infrastructure" [35:458]. This emphasis is further developed by Vertesi [64], who conceptualizes seamful spaces to articulate the uneven and partial overlaps between heterogeneous infrastructures and systems. She describes how two robotic spacecraft research teams located at different institutional centers in the US and Europe creatively maneuver within and across various infrastructural seams (email, teleconferencing, social media, etc.) to accomplish their work.

Vertesi's argument resonates with the work of Lampland and Star [21] who contend that infrastructures are held together by imbrication. Like a good stone fence in New England, imbrication presents "an evocative picture of uncemented things producing a larger whole" [21:20]. These things may range from discourses, work, and architecture to actions, and standards/quantifications/models. This uneven arrangement of heterogeneous things changes over time and across places as the whole is edited/rearranged. "A keystone at one time – a rigid standard, say – may become a minor interchangeable end stone at another, later time" [21:20–21]. Seamful spaces emerge within the changes in the nature of this imbrication and are situated in between the seams of heterogeneous systems and infrastructures interacting with each other. These seams delimit the functional capabilities of an infrastructure (what it can do in relation to other systems) and all users are not equally competent in navigating them. This results in diverse lived experiences of inclusion/exclusion for users who may get stuck within these seamful spaces.

Bowker and Star [4] have conceptualized "torque" to address this lived experience of users at the seams. They assert that since no real-world classification systems can

ever fully satisfy the requirements of consistency, completeness, and division into mutually exclusive categories, classification systems should be analyzed according to their points of tension, friction, and breakdown. For system users, these breakdowns are commonly experienced as "torque" – situations when "the 'time' of the body and of [its] multiple identities cannot be aligned with the 'time' of the classification system" [4:190]. Beyond its poignant implications for problems of representation and social justice, torque is an analytic resource to describe the lived experience of excluded users of an infrastructure-in-use [50].

Inclusion emerges as a process in the challenges of creating a seamless layer of an ICTD intervention on top of the work processes of its installed base. As this intervention is put to use, its operation as a layer inevitably turns seamful with partial and messy overlaps with its installed base [52]. This changes the nature of the imbrication [21] that holds the installed base together. The shift in the nature of imbrication and the seamful spaces [64] – particular points of disjuncture, tensions, frictions, and breakdowns – in infrastructuring [35] play a crucial role in determining how users get their work done within and across the seams of the ICTD intervention and its installed base. Thus, in order to describe inclusion as a process, we will follow how the infrastructural processes designed to seamlessly align the ICTD intervention with its installed base are implemented and follow their impact on the ability of the users to make use of this new infrastructure.

Our work extends these past lines of HCI and social scientific work in three ways. First, we articulate the need to develop a process-oriented approach to the patterns and challenges of inclusion that always accompany large-scale infrastructural development and change. Second, we connect infrastructure studies with ICTD research by focusing on the partial overlaps between processes of building and maintaining ICTD infrastructures as factors that contribute to their uneven appropriation. Finally, we portray imbrication and infrastructural seams as active agents in determining how users are included into a new ICTD infrastructure facilitating particular patterns of use while constraining others.

In the next section, we follow the seamful spaces between Aadhaar and PDS. These spaces illustrate how users may be awkwardly situated between the infrastructural processes of Aadhaar-enabled PDS and how their inclusion may vary over time, places, and breakdowns in these processes. Finally, we will use the multiple outcomes of inclusion as a process to address the nature of Aadhaar's deployment and its limitations in its current and projected manifestations.

STORIES FROM THE FIELD

Setting up Aadhaar

The government's initial interest in creating a biometrics-based identification system for all Indians was dominated by national security concerns. After the Kargil War in 1999, the National Democratic Alliance (NDA) government, in power between 1999 and 2004, proposed plans for building a National Register of Citizens (NRC) to differentiate between citizens and illegal immigrants in India. These plans involved creation of a biometrics-based National Population Register of all residents and then, populating the NRC after ascertaining citizenship [27,40]. However, the rationale for using biometrics changed with the United Progressive Alliance (UPA) coming to power in 2004. The UPA cited social security as the justification for implementing Aadhaar [30]. The most significant difference between these projects is attribution of citizenship. While the NRC was intended to distinguish between citizens and non-citizens [40], Aadhaar envisaged voluntary enrollment into a new identity platform and made no claims about the citizenship of its users [58].

The Unique Identification Authority of India (UIDAI) has implemented Aadhaar with an hourglass architecture –

> where minimal standardization at the waist of a layered architecture (e.g. the IP layer of the internet) enables burgeoning innovation above (e.g. apps) and below (e.g. wireless, wired networks, etc.) it. [... In Aadhaar's case,] the waist consists of the Aadhaar number – a unique identifier for every individual – and authentication services linked to this number. Below the waist lies innovation in design, in this case biometrics devices that can capture fingerprints and iris data. [...] Above the waist lies any application that might require an identity verification service [31:224].

This design lends itself into multiple possibilities of using Aadhaar by the government as well as private agencies. Aadhaar is posited as mechanism to foster the government's social and political accountability to millions of residents whose identities were previously unrecognized by Indian bureaucracy [58]. It is also projected to combat corruption in social welfare disbursement by removing intermediaries. For example, addressing rampant corruption and leakages in PDS, UIDAI has noted that, "Several opportunities to manipulate the [PDS] system exist with widespread collusion across the supply chain. […] 'For every Rs 4 spent on the PDS, only Rs 1 reaches the poor'" [56]. Aadhaar is projected to resolve this problem by unique identification of PDS beneficiaries, which will in turn enable accurate tracking of the real offtake of subsidized food grains. Given that Aadhaar is also a 'clean' database devoid of duplicate entries [63], it is used to provide demographic data (name, age, gender, and address) of enrollees to other agencies and guarantee their uniqueness.

Aadhaar relies on biometrics for unique identification because the basic demographic information is not sufficient

to de-duplicate the entire population of India [63]. The UIDAI Committee on Biometrics also notes that, "identity documents that rely only on demographic fields and personal reference checks are surrogates of identity and are vulnerable to forgery, falsification, theft, loss and other corruptions. […] Hence, it is necessary to enroll all residents along with their biometrics and build a clean database for the purposes of a National Identity system" [63:52]. Aadhaar is posited as a resource for entity resolution; a root identity from which all other domain specific identities (Driver's license number, ration card, etc.) can eventually be derived [60]. Thus, in the plans of reforming social welfare, Aadhaar operates as a layer on top of all databases of social welfare schemes and each of their records has to be seeded with an Aadhaar number to remove all duplicate and fraudulent records.

Making Aadhaar work as a layer on top of the PDS requires seamless integration of three infrastructural processes that hold this imbrication together. During *enrollment*, residents provide their information to one of the several possible Aadhaar enrolling agents – a loose grouping that includes both public and private agencies [6]. During *seeding*, Aadhaar numbers of PDS beneficiaries are seeded into PDS database to ensure that they are real, unique, and eligible beneficiaries of the scheme [62]. During *authentication*, Aadhaar identity of beneficiaries is verified by the UIDAI before disbursing entitlement [59]. These processes are designed to ensure that the ration shop dealer issues food grains to real beneficiaries and does not manipulate records of the last mile delivery of PDS entitlements. The field accounts below outline patterns of inclusion and exclusion that follow from each of these three infrastructural processes.

Methods

From June to December 2015, we conducted fieldwork on Aadhaar's implementation across various locations in India, including Delhi, Bangalore, Chandigarh, and Lucknow. This included field observations of All-Hands meetings and group discussions organized by NGO representatives on Aadhaar-related issues with more than 50 semi-structured interviews conducted in English and Hindi with lawyers, Aadhaar technology designers, activists protesting the project (such as members of the 'Right to Food' campaign [68] who work on PDS), NGO representatives involved in helping residents use Aadhaar, and finally, residents at various stages of the three processes. All respondents were adults and our interviews covered respondents' backgrounds, experiences of dealing with Aadhaar, and their opinions on financial/social utility and the possible futures of using Aadhaar. During this time, the first author also enrolled into Aadhaar and authenticated himself using a One-Time-Password (OTP) sent to his mobile number to get his Aadhaar information printed on a plastic card, which is now a valid proof of identity in India.

Conducting ethnographic research on Aadhaar is a challenge because of its scale that spans across the geography of a country as infrastructurally and socio-economically diverse as India. Given the constraints of length of this paper, we will only provide a snapshot of our work with excerpts from news stories and conversations with technology designers and activists that situate the seamful spaces between Aadhaar and PDS. Their opinions reflect specific standpoints with regard to the usability of Aadhaar and juxtaposing them together allows for a more nuanced understanding of the shift in the nature of the PDS imbrication because of Aadhaar. All respondents have been anonymized and their affiliations and location masked to protect privacy. The seamful spaces outlined below do not imply that PDS used to work perfectly before Aadhaar or that Aadhaar-enabled PDS excludes all beneficiaries. These stories present a situated view of using Aadhaar in PDS to foreground tensions, frictions, and breakdowns that emerge in the universal use of Aadhaar in state-citizen interactions.

Enrollment

The first challenge of inclusion in Aadhaar-enabled PDS is enrollment into Aadhaar. Enrollment entails mandatory collection of biometric and demographic data. Other parameters collected include conditional data fields: the name and Aadhaar number of father/husband/guardian and mother/wife/guardian, and optional data fields: mobile number and email address. Aadhaar numbers are sent by post to unique enrollees at their residential address after biometric de-duplication.

While enrollment has worked seamlessly for most residents, the process has been problematic for others. For example, enrollment of manual laborers has raised challenges because their eroded fingerprint "normally produces poorer biometric samples" [63:44]. Rao, in her study of a Delhi-based NGO helping homeless people enroll into Aadhaar, has noted:

> Lost fingers, damaged fingertips, and rubbed-off skin contours made fingerprints unrecognizable to a system [Aadhaar] that posits healthy, young bodies as the norm. Age, exposure to nature, and hard manual labor had worn off those marks that were perceived as infallible signs of physical individuality. The first effort at encoding usually failed [43:74].

Recognition of these problems mandated a technical fix of collecting iris scans during enrollment to improve inclusivity and accuracy [63]. While technology designers consider possibilities of exclusion as statistical errors that need to be minimized, the activists focus on life stories of people who face enrollment issues to argue that Aadhaar is rigged to exclude those who it is supposed to help the most. We will now focus on two strategic decisions for implementing enrollment that have had significant impact on Aadhaar-enabled PDS. The first is voluntary enrollment

and the second is voluntary consent to enable UIDAI to share user information with outside agencies [58].

Over the years, whether Aadhaar enrollment is voluntary or mandatory has been in flux given the plans of seeding [41]. This is not just in terms of the bureaucratic and legislative determination of the process, but also how it plays out in practice (who among the enrollees are compelled to enroll). Linking Aadhaar with welfare benefits such as PDS in practice has meant that beneficiaries are made to choose between enrollment or forfeiting benefits [41]. Accounting for this connection between Aadhaar and welfare services, the Supreme Court of India issued its first interim order on the Aadhaar case on 23 September 2013 stating that:

> No person should suffer for not getting the Aadhaar card in spite of the fact that some authority had issued a circular making it mandatory and when any person applies to get the Aadhaar Card voluntarily, it may be checked whether that person is entitled for it under the law and it should not be given to any illegal immigrant [23].

If enrollment into Aadhaar is voluntary, then the government cannot completely shift to Aadhaar-enabled PDS. As the Court notes, this shift will alienate citizens who do not have an Aadhaar number. Moreover, if Aadhaar is issued to illegal immigrants then it cannot be used as evidence of citizenship necessary for eligibility to social welfare. Thus, for Aadhaar-enabled PDS to work, enrollment has to be mandatory and the enrollee should be an Indian citizen. The Aadhaar Bill passed in March 2016 has stated that the government may require a welfare beneficiary to undergo enrollment – voluntary enrollment is thus null and void [28]. However, the Supreme Court is still hearing the Aadhaar case [24] and the constitutional validity of this Bill has been challenged in the Court [38,39]. The controversy over enrollment continues and the PDS bureaucracy has been assigned the work of ascertaining citizenship of PDS beneficiaries during seeding.

With regard to voluntary consent to seeding, the Aadhaar enrollment form asks the following Yes/No question: "I have no objection to the UIDAI sharing information provided by me to the UIDAI with agencies engaged in delivery of public services including welfare services" [57]. Some issues emerged when the first author marked 'No' in response to this question during his enrollment:

> As I was leaving the enrollment office, I looked at my receipt and realized that the enrolling agent had entered "Yes" to the voluntary data-sharing question. When I mentioned this to him and he responded, 'That question has to be answered yes. Otherwise, you won't be able to connect Aadhaar with any government service.'
>
> 'What does that mean? Why can't we enter No?' I asked.
>
> 'The answer to this question is yes… 100% of the time. You cannot say no, otherwise what is the point of having Aadhaar number?' Although I can exercise consent in individual future instances of seeding, but, generally, there is no barrier to my enrollment into any welfare scheme. [First Author, Fieldnotes, 17 October 2015].

This experience is not unique. The enrolling agent usually does not enter 'No' as a response to the voluntary data-sharing question. Documenting the bureaucratic hassles of registering their marriage with Aadhaar, Anand and Udupa, who are based out of Delhi and have actively resisted using Aadhaar in their bureaucratic interactions, have noted:

> [W]hen we received a slip acknowledging our enrolment, it showed that we had in fact given consent. When we asked the person who was enrolling us about this, his response was […] that the software would not allow him to enroll us unless he indicated that we consented to share our information [2].

If enrollees do not consent to data sharing by the UIDAI, then seeding their demographic information into other databases such as the PDS database should technically not be possible.

These stories of voluntary enrollment and consent provide insights into frictions between implementation of Aadhaar and its use as an identification mechanism for PDS. From the perspective of PDS bureaucracy, all beneficiaries should have an Aadhaar number and should consent to data sharing during enrollment. Otherwise, seeding PDS database with Aadhaar numbers would be impossible and using other forms of identification (for people without an Aadhaar number) will leave room for redundancies and duplicates defeating the plans of using Aadhaar for entity resolution. However, mandating Aadhaar enrollment and consent for data sharing complicates the surveillance and invasion of privacy concerns around Aadhaar that are currently being heard by the Supreme Court. Thus, enrollment and consent provide conditions of possibility for inclusion into Aadhaar-enabled PDS. At the same time, they exclude beneficiaries who face enrollment issues and those who do not wish to enroll or provide consent to data sharing. The first set of challenges to inclusion in Aadhaar-enabled PDS is the voluntariness of enrollment and consent.

Seeding

The next challenge for Aadhaar-enabled PDS is seeding Aadhaar numbers of beneficiaries into the PDS database. Seeding happens through two mechanisms – inorganic and organic seeding. Inorganic seeding involves computationally comparing demographic data on beneficiaries in Aadhaar database with their demographic data in the seeded database (e.g., PDS). If entity resolution

is possible within predefined parameters of accuracy, Aadhaar numbers are added to the seeded database. However, "the process of matching two datasets electronically becomes very difficult" [62:6]. Thus, organic seeding is preferred and beneficiaries have to re-enroll into the seeded database. It involves door-to-door campaigns, organization of camps, data collection at points of service delivery (e.g., ration shops), or via a text message sent by beneficiaries with their Aadhaar numbers to re-enroll from their mobile number on record in the seeded database.

UIDAI is not involved in organic seeding; bureaucracies for individual welfare services are expected to perform seeding for their own databases [62]. For PDS, this data collection is performed by ration shop dealers who later upload Aadhaar data on beneficiaries to the PDS database. Given the uneven proliferation of biometric readers and internet connectivity in India, the bureaucratically preferred way of collecting Aadhaar data is filing photocopies of UIDAI-issued Aadhaar letters sent by post to beneficiaries after their enrollment. Since PDS entitlements are issued on the basis of the number of members in a BPL family [29], all members are required to have Aadhaar numbers. During our fieldwork in urban slums of Delhi, we encountered cases where some members were not enrolled into Aadhaar and post seeding, they were removed from the PDS database. The most common reason for this was that they were travelling when the enrollment camp was organized. This has led to a bureaucratic account of their family with lesser number of members on the PDS database reducing the quantity of their entitlement.

There are also occasions when people have not received their Aadhaar letters. "As Ashok Pal Singh [Deputy Director General of UIDAI (2010 – 2014)] recollects, 'India Post never took us seriously when we told them that in a short time frame, one million Aadhaars will be generated daily […]'. Very soon, the printed letters piled up, and people were waiting for months to receive them" [31:43]. There are newspaper reports on delay of delivery of Aadhaar letters [11,32,36] which should be delivered within 90 days of enrollment. The reasons range from staff crunch at the Post Office [11] and incomplete addresses and wrong pin codes [36] to the failure in uploading enrollment data in time [32]. These reports document issues with the final delivery of Aadhaar letters as well as troubles with data entry during enrollment. UIDAI resolved this issue by letting enrollees download an e-Aadhaar letter using an OTP sent to their mobile number on record in the Aadhaar database [61]. However, these e-Aadhaar letters, at times, do not seem to have the same bureaucratic validity as Aadhaar letters – despite containing identical information. One explanation for this unevenness is that, "The postman is a government employee, and his delivery of the letter is considered as an official verification of one's address" [31:43].

To contextualize the bureaucratic significance of Aadhaar letters, we will delve deeper into the strategic design decision of treating Aadhaar as a digital number. Kairav, a member of Aadhaar's design team based out of Bangalore, recounts:

> In 2009 June, when we were brainstorming, we were actually thinking of a card. Identity card. Somebody said, 'what is it in a card? What do we want?' It is about a number, isn't it?' And it was number ever since. […] Your card is a proxy identity. A card can't be your identity. You lose a card you lose your identity? […] We said this is a great time to leapfrog and say, 'Don't bother! Just make it completely a digital identity. […] That is all you need.' Because existing system [the Indian bureaucracy] will continue to ask for Aadhaar card? As if, there is a card. [Kairav, Personal Communication, 24 September 2015].

For Kairav, there is no difference between a person and their identity. The Aadhaar number is simply a digital record that allows residents to certify that they are who they say they are. On a similar note, Pranay, another member of design team from Bangalore, pointed out a different problem with cards:

> By the time we would have rolled out 50% of the cards… in say, three years… the chip would have already been outdated and there would have been something new on the market. You see, hardware is software-calcified. Numbers as a soft entity are a lot easier to manage than cards! [Pranay, Personal Communication, 25 August 2015].

For Pranay, the Aadhaar letter/card is indicative of a calcified /material manifestation of a digital number. Within these design viewpoints, if a street-level bureaucrat has a biometric reader connected to internet, then the Aadhaar letter is futile for authenticating identity. Kairav recounted the following experience to establish the 'futility' of the Aadhaar letter:

> I went to RTO [Regional Transport Office] for renewal of [driving] license. And [the RTO officer] said, 'Where is your identity proof?' […] So, I gave him my Aadhaar copy [e-Aadhaar letter]. He said, 'Is this original?' It was not original. There is nothing called original. You can print it five times! So, I looked at it and said, 'This [letter] is color… laminated!' He said, 'Oh! Okay then it must be original.' I had printed that on an inkjet printer and laminated it. I was wondering… My God! Is this all it takes to verify identity? No wonder it is all fake! You can be anyone. It is all about your confidence. Because I was confident, he was also like it must be right [Kairav, Personal Communication, 24 September 2015].

While the e-Aadhaar letter worked for Kairav, it created a different set of challenges for Ganga, who works as a maid

in Bangalore. When we first spoke with her, she had been waiting for her Aadhaar letter for almost two years. Since her enrollment in 2013, Ganga had made a number of visits to her enrollment agency and has even asked for help from her local Member of Legislative Assembly. Despite her efforts, the letter was nowhere to be found. "I don't know who else to ask. They said that I should check in the post office, but which post office? Nobody tells me that" [Ganga, Personal Communication, 21 September 2015]. We tried to resolve this problem by printing her e-Aadhaar letter, but she told us a few days later that the printout was not accepted when she tried to seed her Aadhaar number into PDS database. "They need the original letter. That letter has a bigger emblem [of the government]! They won't accept this printout" [Ganga, Personal Communication, 23 September 2015].

Since many have not received their Aadhaar letters, welfare bureaucracies have also started accepting the plastic Aadhaar cards for seeding. These cards can cost anywhere between □ 30 (~50 cents) to □ 200 (~$3) depending upon the vendor. Color printouts of e-Aadhaar letters also cost anywhere between □ 10 (~15 cents) to □ 100 (~$1.5) at cyber cafés. On the other hand, UIDAI has continuously clarified that there is no difference between these material manifestations of Aadhaar. Recently, the Director General of UIDAI, Ajay Bhushan Pandey, issued a statement, "[T]he downloaded Aadhaar card printed on ordinary paper is perfectly valid for all uses. If a person has a paper Aadhaar card, there is absolutely no need to get his/her Aadhaar card laminated or obtain a plastic Aadhaar card […] by paying money" [34]. This statement is reminiscent of discussions that envision Aadhaar as a digital number. In practice, however, the lived experience of Ganga and Kairav tell a different story of how Aadhaar is imbricated with multiple material manifestations in the work of a routinely paper-based Indian bureaucracy.

These stories of seeding illustrate not only the slow process of change in the way bureaucracies attribute value to paper-based documents, but also how fraught inclusion can become for some users who are not as 'confident' as others in front of a street-level bureaucrat. Seeding highlights new tensions in the process of inclusion in Aadhaar-enabled PDS in two ways. First, seeding could be partial leading to a bureaucratic account of BPL families with lesser number of members to feed. Thus, by extension, inclusion of families in Aadhaar-enabled PDS is also partial unless Aadhaar numbers of remaining family members are also seeded. Second, our detour into design considerations for treating Aadhaar as a digital number captures the frictions that emerge in the reconfiguration of the value of Aadhaar letters by the PDS bureaucracy that has previously relied on paper-based identification. Aadhaar turns material not only in its deployment and representation, but also in its consequences (e.g., barriers in proving PDS eligibility). Such dynamics shape the experience of inclusion/exclusion for different users. The insistence of a bureaucrat to treat Aadhaar as a material document (which has an 'original' form) excludes Ganga from seeding. Conversely, Kairav's anecdote about laminated e-Aadhaar letter illustrates the dynamics of the exercise of cultural capital in using Aadhaar for bureaucratic recognition. Torque [4] is experienced in both cases, but in opposite ways. While Kairav is pushed forward, Ganga is pulled back as they attempt to use e-Aadhaar letters.

Authentication

Finally, authenticating their Aadhaar identity every month has become a challenge for many beneficiaries of Aadhaar-enabled PDS. There are five types of user authentications supported by UIDAI – where demographic information, mobile number, and biometric information are used individually or collectively to certify an Aadhaar user's identity depending upon the level of security expected or required [59]. For example, Type 1 authentication, the least secure, involves an authenticating agent comparing demographic data provided by the user with their demographic data stored in the Aadhaar database. Type 2 authentication relies solely on a One-Time-Password (OTP) sent to the mobile number provided during enrollment (although, it is an optional field). The remaining three types (Type 3, 4, and 5) use biometric data (iris scans and fingerprints), combined with demographic data and OTPs.

These authentication types are the outcome of relying on the body for certifying identity. As Kairav pointed out, "Imagine going to an airport and the police officer simply takes an impression of your best finger with a reader, matches it your Aadhaar, and you're done! No need for the extra hassle of carrying IDs. You are who you are, rather than what a piece of paper says about who you are" [Kairav, Personal Communication, 24 September 2015]. However, in practice, authentication has not worked so seamlessly. For example, while enrollment requires a combination of fingerprints and iris scans for unique identification, authentication currently relies only on fingerprints, which has created barriers for user groups such as manual laborers and the elderly.

Authentication will become necessary to avail PDS benefits as plans for using Aadhaar continue to unfold. In some states, ration shop dealers are providing beneficiaries with food grains after biometrically authenticating them using Point of Sale (POS) machines with biometric readers. This has been challenging in many places because of the lack of a working internet connection or a continually functional POS machine. News stories have reported troubles of ration shop dealers with authentication using fingerprints [9,20,67]. States, such as Andhra Pradesh, have been implementing biometrics-based authentication for PDS beneficiaries since 2013 and were more prepared than others such as Rajasthan, which began this process in 2016 [9,20]. Khera, an academic protesting the use of Aadhaar in

PDS, has noted that, even in Andhra Pradesh, there are significant rates of "biometric mismatch" where authentication has regularly failed for some beneficiaries and they "may have to re-enrol for Aadhaar" [20]. Yadav reports a poignant ordeal of Hanja Devi, a 68-year-old woman, to illustrate "teething problems" in deploying authentication in Rajasthan [67]:

> Hanja Devi […] needs a stick to walk. She trekked four kilometres to the ration shop from her village Karanpura for the third time in three days [in late March] to buy 35 kilos of wheat at Rs 2 [3 cents] a kilo. […]
>
> The machine had recognised the fingerprints on her pale weathered hands in February, but it failed to do so on that day. She first put her thumb, and after that got rejected, her index finger. Both times a pre-recorded voice rang out: *Aap ka Aadhaar sahi nahi hai*. Your Aadhaar is incorrect. […] The older villagers in the queue sounded exasperated with the repeated Aadhaar authentication errors. 'We have tried with one, two, all ten fingers,' said a man in his 50s. '*Bas naarh daalni baaki hai*. Should we put our necks also into the device?'
>
> That day too, Hanja Devi went back without any foodgrain [67, emphasis in original]

Apart from biometrics, authentication can be performed using OTPs or manual verification. From the perspective of PDS bureaucracy, manual verification reinstates the ration shop dealer as a powerful intermediary and brings back corruption in last mile delivery of PDS entitlements. On the other hand, the use of OTPs raised some emergent issues in the group discussions that we conducted in urban slums of Delhi where POS machines were not being used at the time. We met Juniya during one of these discussions. She asked us for help in figuring out what happened with the enrollment of her two children. Both were enrolled at a camp six months ago, but had not received their Aadhaar letters by post. When we tried to download e-Aadhaar letters of her children, we realized that the mobile number that she had provided during their enrollment was not the number that she had with her. Juniya's case is not unique. Many of our respondents did not keep track of the mobile numbers they provided during enrollment. As Sita, a Right to Food campaign activist [68], accompanying us explained, "Whenever I take a number from them, within months, I cannot reach them on that number. It is so difficult to keep a track of the number that they currently have and is working" [Sita, personal communication, 23 November 2015]. The reasons for this change ranged from stolen/lost/damaged phones to unaffordable roaming rates and non-payment of phone bills.

We explained to Juniya the need for a stable mobile number for the purpose of Aadhaar authentication and that it was possible to update mobile numbers for her children in the Aadhaar database. All she had to do was to visit a permanent Aadhaar enrollment center. She told us that her encounters with Aadhaar's implementation had only been through enrollment camps and she was assured that her children's Aadhaar letters would be delivered to her address. Since their letters had not arrived, she hadn't been able to seed their Aadhaar numbers into her family's PDS record. She asked us for the address of one of these permanent enrollment centers. We also asked the group if they knew about permanent enrollment centers. None of them, except the activists, knew about them and they had not considered updating their mobile numbers until we explained the various types of authentication to them. With an overwhelming focus on biometrics, the other authentication types have received lesser attention in the popular imagination of Aadhaar.

These stories illustrate challenges in implementing each type of authentication. Despite designed redundancies, when biometric authentication fails, disbursement either reverts to manual identity checks [20] reinvigorating the concerns around corruption or beneficiaries are simply denied their entitlements. Thus, seeding does not guarantee inclusion as beneficiaries may be excluded because of authentication errors. Infrastructural factors, e.g., lack of consistent and functional POS machines and working internet connection in certain places, raise more challenges for authentication than enrollment. While enrollment had to be performed only once for most enrollees, authentication is a recurrent process and is required every month for PDS disbursement. Finally, the reliance of authentication on mobile numbers (an optional field during enrollment) and their instability in marking digital identity for migrant labor populations creates a new seamful space between enrollment and authentication.

DISCUSSION

Our field stories reveal important challenges and instabilities in using Aadhaar for PDS, which challenge any simplistic story of registration, participation, and access. Inclusion in Aadhaar-enabled PDS is not simply a matter of one-time processes such as enrollment and seeding. Rather, inclusion is experienced every month by beneficiaries who undergo authentication to access their PDS entitlements. The seamful spaces between Aadhaar and PDS instantiate the challenges that necessarily confront inclusion as ICTD infrastructures are extended to marginalized populations such as BPL families. Users who are enrolled and included in Aadhaar may be excluded from the Aadhaar-enabled PDS because of seeding troubles. Even with successful seeding, users might be excluded because of authentication errors. Finally, without an Aadhaar identity, citizens may be excluded from social welfare and other citizenship entitlements altogether, despite eligibility and past access to these entitlements. These seamful spaces indicate not only partial overlaps between Aadhaar and PDS, but also the

periodic breakdowns and frictions between infrastructural processes of using Aadhaar for any social welfare scheme. Simultaneously, they reveal a series of wider tensions and challenges that confront HCI and post-colonial computing work more generally.

In foregrounding infrastructural seams and imbrication, this paper contributes to the evolving research in transnational HCI and postcolonial computing. First, seamful spaces and imbrication offer initial set of resources to articulate inclusion as a process and bring attention to the challenges of seamlessly layering an ICTD intervention on top of preexisting systems. Inclusion is not a binary or end in itself; rather both inclusion and exclusion are ongoing, negotiated, and highly situated processes enacted by multiple stakeholders of an ICTD infrastructure. Inclusion and exclusion are therefore not clear and mutually exclusive states, and the same users or groups may fluctuate or stand awkwardly between them. Second, it shows that imbrication is an important agent in the uneven appropriation of ICTD infrastructures, affording certain paths of infrastructural development while limiting others. The shifting character of imbrication to accommodate an ICTD intervention manifests diverse outcomes of inclusion that mutate over time and places. Finally, it documents the invisible work demanded of users at the seams as they seek to overcome the barriers that partial and selective inclusion, even of putatively 'universal' systems like Aadhaar, periodically throws up.

Our field stories also illustrate how a paper-based standard for identification (the ration card) is slowly being replaced by a digital standard for identification (Aadhaar). This replacement shows how the PDS imbrication has, in the words of Lampland and Star, shifted "in character over time as the whole is edited or rearranged" [21:20] because of Aadhaar. A keystone in the work of PDS at one time – the ration card – is slowly turning into a minor interchangeable end stone as Aadhaar is increasingly used to identify PDS beneficiaries. This shift in character of the imbrication and the seamful spaces it manifests actively determine how and who among the PDS beneficiaries are included or excluded from Aadhaar-enabled PDS. In this sense, our stories illustrate the need for artful navigation of seams and connections that are internal to this imbrication. We have not dealt with the double silencing of residual BPL families that do not have a ration card, despite eligibility, and have been excluded from PDS irrespective of its connection with Aadhaar. Thus, questions of (effective) inclusion are determined not just at margins of a system (who is in and who is out) but also through the artful and often challenging negotiation of the seams that run through and connect complex distributed infrastructures.

With the proliferating use of Aadhaar as an identification mechanism, street-level bureaucrats have slowly started accepting e-Aadhaar letters. Conversely, Kairav's anecdote about his use of laminated e-Aadhaar letter suggests that the 'perceived' agency of certain documents becomes greater in bureaucratic setups if they are laminated. Here, lamination and exercise of cultural capital is used to maneuver between the rules of a bureaucratic culture that are unevenly applied for different citizens. As our fieldwork went on, plastic Aadhaar cards were also turning into mundane everyday objects present in wallets and purses of our respondents. These different material manifestations of Aadhaar offer two insights. First, they account for the entrenched role of materiality of documents within bureaucracies. They are embedded within and foreground diverse understandings of Aadhaar's bureaucratic function and its user experience. Second, they show that infrastructural change in the workings of bureaucracies has many moving parts with their own pasts and futures and these individual futures do not simply align at the same time. User groups are located at diverse stages of this asynchronous infrastructural change. Identifying these groups over time and across places and creating new affordances to accommodate them should inform designing inclusive ICTD interventions.

We began this paper by outlining the shift from a technology-oriented understanding of access (digital divide) to a use-oriented discourse on inclusion (digital inequality) and our work has outlined a process-oriented approach to inclusion. These different approaches offer unique tools to analyze appropriation of ICTD solutions. One does not replace the other; they add further nuances to our ability as analysts to frame inclusion as a problem. Focusing on access to technology reminds us how ICT solutions have material ends and need to be physically accessible to be used. Thinking about patterns of use in specific sociocultural environments orients us towards the contextual affordances and constraints that determine ICTD appropriation. Unpacking inclusion as a process involves paying attention to the messy and partial overlaps between ICTD interventions and their installed bases. The emergent tensions, frictions, and breakdowns in infrastructuring an ICTD intervention are resources to map the shift in character of the imbrication that holds the installed base together. This shift (re)configures conditions of inclusion and exclusion for users who are differentially competent in interacting with this imbrication. Since digital technologies constantly evolve in response to their patterns of use, the imbrication of an ICTD intervention with its installed base remains in a continuous transition. Thus, by framing inclusion as a process, we can describe and elucidate the nature of this transition as it varies over time and places. We can further capture the torque experienced by users at the seamful spaces within this shift and the invisible work they perform to overcome the barriers enacted by the limits of infrastructuring.

Aadhaar is not just about access, or even inclusion, but about how the Indian state recognizes its citizens and conversely, how citizens are able to claim their rights as

citizens. In this sense, Aadhaar is different from other ICTD interventions that emphasize information, markets, or voice [42,45]. Given the attempts at making Aadhaar as close to mandatory as possible in last mile delivery of welfare services in India [28], exclusion from Aadhaar-enabled services, in time, will severely impede the life chances of users at the seams. This problematizes the master narrative of inclusion as an outcome of identification in the right to registration discourse [55]. While unique identification may be a starting point for inclusive ICTD solutions, the ultimate success and impact of such projects depends on how they achieve, authenticate, and maintain registration. This requires critical inquiry into "points of [identity] infrastructure" [35] where integration of such projects with the state bureaucracy turns seamful.

CONCLUSION

Infrastructures do not exist in isolation. They are discursively and materially woven into a plethora of other infrastructures and installed bases. Thus, any attempt at building an ICTD intervention requires attention to how, where, and when does it fit into preexisting systems of organizing work. This paper has attempted to develop (or at least suggest) inclusion as a process with a range of possible outcomes in the analysis of an inclusive ICTD solution. In conclusion, we offer a maxim, *study the imbrication*, to call attention to the seamful spaces amid processes of designing and using ICTD infrastructures. Infrastructural seams intersect with installed bases as an infrastructure comes together in practice, but the torque experienced by users at the seamful spaces between them remains unique and specific. The present paper has offered a first introduction to inclusion as a creature and output of imbrication. Future work will carry this forward into additional theoretical, methodological, and ethnographic research around the nature of the shift in the character of imbrication and its consequences.

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REFERENCES

1. Syed Ishtiaque Ahmed, Nusrat Jahan Mim, and Steven J Jackson. 2015. Residual Mobilities: Infrastructural Displacement and Post-Colonial Computing in Bangladesh. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, ACM, 437–446.
2. Ankita Anand and Nachiket Udupa. 2015. How to Get Married Without an Aadhaar Number. *Caravan Magazine*. Retrieved from http://www.caravanmagazine.in/vantage/how-get-married-without-aadhaar-number
3. Wiebe E. Bijker. 1995. *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. MIT Press, Cambridge, MA.
4. Geoffrey Bowker and Susan Leigh Star. 1999. *Sorting Things Out: Classification and its Consequences*. MIT Press, Cambridge, MA.
5. Keith Breckenridge and Simon Szreter (eds.). 2012. *Registration and Recognition: Documenting the Person in World History (Proceedings of the British Academy)*. Oxford University Press, Oxford.
6. Sujata Chaturvedi. 2014. *Resident Enrollment Process Version 2.2.1*. Delhi. Retrieved from http://uidai.gov.in/images/mou/resident_enrolment_process_ver_2.2.1.pdf
7. Simon A Cole. 2001. *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Harvard University Press, Cambridge, MA.
8. Paul DiMaggio, Esther Hargittai, Coral Celeste, and Steven Shafer. 2004. From Unequal Access to Differentiated Use: A Literature Review and Agenda for Research on Digital Inequality. In *Social Inequality*, Kathryn Neckerman (ed.). Russell Sage Foundation, New York, 355–400.
9. Jean Drèze. 2015. JAM and the Pursuit of Nirvana. *The Wire*. Retrieved from http://thewire.in/2015/11/06/jam-and-the-pursuit-of-nirvana-14873/
10. Paul N Edwards. 2003. Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems. In *Modernity and Technology*, Thomas J Misa, Philip Brey and Andrew Feenberg (eds.). MIT Press, Cambridge, MA, 185–225.
11. Express News Service. 2013. Aadhaar gives hard time to postman. *The New Indian Express*. Retrieved from http://newindianexpress.com/cities/hyderabad/article1460030.ece
12. Graham Greenleaf. 2010. India's national ID system: Danger grows in a privacy vacuum. *Computer Law & Security Review* 26, 5: 479–491.
13. Rebecca E. Grinter, Michael L. Best, W. Keith Edwards, and Elizabeth D. Mynatt. 2010. *Computing at the Margins: Report from NSF Sponsored Workshop*. Atlanta, Georgia. Retrieved from http://www.computing-margins.org/
14. Ole Hanseth and Nina Lundberg. 2001. Designing Work Oriented Infrastructures. *Computer Supported Cooperative Work (CSCW)* 10, 3–4: 347–372.
15. Eszter Hargittai. 2002. Second-Level Digital Divide: Differences in People's Online Skills. *First Monday* 7, 4. Retrieved from http://firstmonday.org/ojs/index.php/fm/article/view/942/864
16. Richard Harper (ed.). 1998. *Inside the IMF: An*

Ethnography of Documents, Technology and Organisational Action. Academic Press, New York.

17. Thomas P Hughes. 1983. *Networks of Power. Electrification in Western Society, 1880-1930*. The Johns Hopkins University Press, Baltimore/London.
18. Matthew S Hull. 2012. Documents and Bureaucracy. *Annual Review of Anthropology* 41, 1: 251–267.
19. Lilly Irani, Janet Vertesi, Paul Dourish, Kavita Philip, and Rebecca E Grinter. 2010. Postcolonial Computing: A Lens on Design and Development. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 1311–1320.
20. Reetika Khera. 2016. On Aadhaar Success, It's All Hype - That Includes The World Bank. *NDTV*. Retrieved from http://www.ndtv.com/opinion/yes-aadhaar-is-a-game-changer-in-wrecking-welfare-schemes-1434424
21. Martha Lampland and Susan Leigh Star. 2009. *Standards and their Stories: How Quantifying, Classifying, and Formalizing Practices shape Everyday Life*. Cornell University Press, Ithaca.
22. Brian Larkin. 2013. The Politics and Poetics of Infrastructure. *Annual Review of Anthropology* 42: 327–343.
23. Legal Correspondent. 2013. Final hearing on Aadhaar card on Oct. 22. *The Hindu*. Retrieved from http://www.thehindu.com/news/national/final-hearing-on-aadhaar-card-on-oct-22/article5214215.ece
24. Legal Correspondent. 2015. Supreme Court extends Aadhaar use to more schemes while saying it's purely voluntary. *The Hindu*. Retrieved from http://www.thehindu.com/news/national/aadhaar-purely-voluntary-says-supreme-court-but-extends-its-use-to-more-schemes/article7765893.ece
25. David Lyon. 2009. *Identifying citizens: ID cards as Surveillance*. Polity, Cambridge.
26. Gary Marsden, Andrew Maunder, and Munier Parker. 2008. People are People, but Technology is not Technology. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 366, 1881: 3795–3804.
27. Taha Mehmood. 2008. Notes from a contested history of National Identity Card in India: 1999-2007. *South Asia Citizens Web*. Retrieved from http://www.sacw.net/article391.html
28. Ministry of Finance. 2016. *The Aadhaar (Targeted Delivery of Financial and Other Subsidies, Benefits and Services) Bill*. PRS Legislative Research, India. Retrieved from http://www.prsindia.org/billtrack/the-aadhaar-targeted-delivery-of-financial-and-other-subsidies-benefits-and-services-bill-2016-4202/
29. Prachi Mishra. 2013. Financial and Distributional Implications of the Food Security Law. *Economic and Political Weekly*, 28–30. Retrieved from http://www.epw.in/journal/2013/39/national-food-security-act/financial-and-distributional-implications-food-security
30. National e-Governance Division. 2011. *Saaransh: Compendium of mission mode project under National e-Governance Plan*. New Delhi. Retrieved from http://deity.gov.in/sites/upload_files/dit/files/Compendium_FINAL_Version_220211(1).pdf
31. Nandan Nilekani and Viral Shah. 2015. *Rebooting India: Realizing a Billion Aspirations*. Penguin Books India, Gurgaon.
32. Neelam Pandey. 2013. Govt cracks the whip on firms behind delay in delivery of Aadhar cards. *Hindustan Times*. Retrieved from http://www.hindustantimes.com/India-news/NewDelhi/Govt-cracks-the-whip-on-firms-behind-delay-in-delivery-of-Aadhar-cards/Article1-1040585.aspx
33. Kavita Philip, Lilly Irani, and Paul Dourish. 2012. Postcolonial Computing: A Tactical Survey. *Science, Technology & Human Values* 37, 1: 3–29.
34. PIB. 2016. UIDAI cautions public against sharing of their Personal Information with unauthorized Agencies for Printing PVC (Plastic) Aadhaar Card. *Press Information Bureau, Government of India*. Retrieved from http://pib.nic.in/newsite/PrintRelease.aspx?relid=138755
35. Volkmar Pipek and Volker Wulf. 2009. Infrastructuring: Toward an Integrated Perspective on the Design and Use of Information Technology. *Journal of the Association for Information Systems 10*, 447–473.
36. PTI. 2013. Andhra Pradesh Postal Department faces problems in delivery of Aadhaar card. *NDTV*. Retrieved from http://www.ndtv.com/article/south/andhra-pradesh-postal-department-faces-problems-in-delivery-of-aadhaar-card-341913
37. PTI. 2016. Aadhaar enrolment crosses 1 billion mark: Ravi Shankar Prasad. *India Today*. Retrieved from http://indiatoday.intoday.in/story/aadhaar-enrolments-hit-100-cr-boost-for-welfare-schemes-govt/1/635013.html
38. PTI. 2016. Jairam Ramesh moves Supreme Court against treating Aadhaar bill as money bill. *The Hindu*. Retrieved from http://www.thehindu.com/news/national/jairam-ramesh-moves-supreme-court-against-treating-aadhaar-bill-as-money-bill/article8446997.ece
39. Vanya Rakesh and Sumandro Chattapadhyay. 2016. Aadhaar Act as Money Bill: Why the Lok Sabha isn't

Immune from Judicial Review. *The Wire*. Retrieved from http://thewire.in/2016/05/09/identity-of-the-aadhaar-act-supreme-court-and-the-money-bill-question-34721/

40. R. Ramakumar. 2010. The Unique ID Project in India: A Skeptical Note. In *Ethics and Policy of Biometrics*. Springer-Verlag, Berlin and New York, 154–168.
41. Usha Ramanathan. 2013. Mandatory or not? The government's flip-flop show. *The Statesman*. Retrieved from http://www.thestatesman.com/news/13706-mandatory-or-not-the-government-s-flip-flop-show.html
42. Nimmi Rangaswamy and Nithya Sambasivan. 2011. Cutting Chai, Jugaad, and Here Pheri: towards UbiComp for a global community. *Personal and Ubiquitous Computing* 15, 6: 553–564.
43. Ursula Rao. 2013. Biometric Marginality. *Economic and Political Weekly* 48, 13: 72–77. Retrieved from http://www.epw.in/review-urban-affairs/biometric-marginality.html
44. Ursula Rao and Graham Greenleaf. 2013. Subverting ID from above and below: The uncertain shaping of India's new instrument of e-governance. *Surveillance & Society* 11, 3: 287–300.
45. Nithya Sambasivan, Gulzar Azad, Paul M Aoki, and Saswati Saha Mitra. 2016. "We Call It Hi-Fi": Exposing Indian Households to High Speed Broadband Wireless Internet. *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development*, ACM, 3:1-3:11.
46. James C Scott. 1998. *Seeing like a State: How Certain Schemes to improve the Human Condition have Failed*. Yale University Press, New Haven.
47. Chandak. Sengoopta. 2003. *Imprint of the Raj: How Fingerprinting was born in Colonial India*. Macmillan, London.
48. Aradhana. Sharma and Akhil Gupta (eds.). 2006. *The Anthropology of the State: A Reader*. Blackwell Publishing, Malden, MA.
49. Tarangini Sriraman. 2011. Revisiting Welfare: Ration Card Narratives in India. *Economic and Political Weekly* 46, 38: 52–59. Retrieved from http://www.epw.in/journal/2011/38/special-articles/revisiting-welfare-ration-card-narratives-india.html
50. Susan Leigh Star. 2006. Orphans of Infrastructure: Engendering, Commodifying, and the Making of Non-People. *Stanford University Event Calendar*. Retrieved from http://events.stanford.edu/events/97/9744/
51. Susan Leigh Star and Geoffrey C Bowker. 2007. Enacting Silence: Residual Categories As a Challenge for Ethics, Information Systems, and Communication. *Ethics and Information Technology* 9, 4: 273–280.
52. Susan Leigh Star and Karen Ruhleder. 1996. Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. *Information Systems Research* 7, 1: 111–134.
53. Susan Leigh Star and Anselm Strauss. 1999. Layers of Silence, Arenas of Voice: The Ecology of Visible and Invisible Work. *Computer Supported Cooperative Work (CSCW)* 8, 1–2: 9–30.
54. Lucy Suchman. 1993. Working Relations of Technology Production and Use. *Computer Supported Cooperative Work (CSCW)* 2, 1: 21–39.
55. Simon Szreter. 2007. The Right of Registration: Development, Identity Registration, and Social Security—A Historical Perspective. *World Development* 35, 1: 67–86.
56. UIDAI. *UID and PDS System*. New Delhi. Retrieved from https://www.uidai.gov.in/images/resource/uid_and_pds.pdf
57. UIDAI. Aadhaar Enrolment / Correction Form. *uidai.gov.in*. Retrieved January 1, 2015 from https://uidai.gov.in/images/uid_download/enrolment_form.pdf
58. UIDAI. 2010. *UIDAI Strategy Overview: Creating a Unique Identity Number for Every Resident in India*. New Delhi. Retrieved from https://uidai.gov.in/images/commdoc/other_doc/Strategy_Overveiw-001.pdf
59. UIDAI. 2011. *Aadhaar Authentication Framework (Version 1.0)*. New Delhi. Retrieved from http://uidai.gov.in/images/authDoc/d2_authentication_framework_v1.pdf
60. UIDAI. 2014. *Aadhaar Technology and Architecture: Principles, Design, Best Practices, & Key Lessons*. New Delhi. Retrieved from https://uidai.gov.in/images/AadhaarTechnologyArchitecture_March2014.pdf
61. UIDAI. 2014. E-Aadhaar. *eaadhaar.uidai.gov.in*. Retrieved January 1, 2016 from https://eaadhaar.uidai.gov.in/
62. UIDAI. 2015. *Standard Protocol Covering the Approach and Process for Seeding Aadhaar Numbers in Service Delivery Databases*. New Delhi. Retrieved from http://uidai.gov.in/images/commdoc/aadhaar_seeding_october_2014_v098_14112014.pdf
63. UIDAI Committee on Biometrics. 2009. *Biometrics Design Standards for UID Applications*. New Delhi. Retrieved from https://uidai.gov.in/UID_PDF/Committees/Biometrics_Standards_Committee_report.pdf

64. Janet Vertesi. 2014. Seamful Spaces: Heterogeneous Infrastructures in Interaction. *Science, Technology & Human Values* 39, 2: 264–284.

65. Karel Vredenburg, Ji-Ye Mao, Paul W Smith, and Tom Carey. 2002. A Survey of User-centered Design Practice. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 471–478.

66. World Bank Group. 2016. *Identification for Development: Strategic Framework*. Washington DC. Retrieved from http://pubdocs.worldbank.org/pubdocs/publicdoc/2016/2/179901454620206363/Jan-2016-ID4D-Strategic-Roadmap.pdf

67. Anumeha Yadav. 2016. Rajasthan presses on with Aadhaar after fingerprint readers fail: We'll buy iris scanners. *Scroll.in*. Retrieved from http://scroll.in/article/806243/rajasthan-presses-on-with-aadhaar-after-fingerprint-readers-fail-well-buy-iris-scanners

68. 2014. Right to Food Campaign. *righttofoodcampaign.in*. Retrieved August 5, 2016 from http://www.righttofoodcampaign.in/about